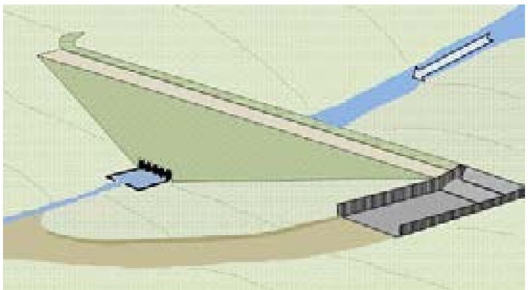

# Prefeasibility Investigation into Flood Mitigation Storage Infrastructure

## Report

## for the Brisbane River Catchment

**December 2014**

Great state. Great opportunity.

Queensland Government

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1. Panorama from Kangaroo Point during the Brisbane River flood, 1893. Image courtesy of the Queensland State Archives, Digital Image ID 3071
2. Ipswich City Centre, January 2011. Photographer: Nathaniel Cliff. Image courtesy of the Queensland State Library archives. Collection Reference 28205.
3. Schematic diagram of a flood detention dam.
4. Rubbish awaiting collection on an un-named Chelmer street. Photographer: Liam Gordon. Image courtesy of the John Oxley Library, Queensland State Library archives, Collection Reference 28210

This publication has been compiled by the Department of Energy and Water Supply

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# Preface

On 2 April 2014, the Premier announced that there would be an investigation of potential new dams and the raising of Wivenhoe Dam to further protect Brisbane and Ipswich from future floods. This announcement stemmed from the provision to Cabinet of the Wivenhoe and Somerset Dams Optimisation Study (WSDOS) report (DEWS 2014).

WSDOS focussed on options for operational strategies to be employed at Wivenhoe and Somerset Dams (as required by the Queensland Floods Commission of Inquiry (QFCoI) Final Report Recommendation 17.3; QFCoI 2012).

The Wivenhoe and Somerset Dams Optimisation Study identified that:

- Wivenhoe and Somerset dams have considerably reduced the peak flood flows of every flood since combined operation commenced in the late 1970s and would have reduced the peak flood flows of every major flood on the historical record
- when compared to current operations under the 2013 Flood Manual (Seqwater 2013b), increasing flood mitigation storage (either by lowering the full supply volume or by raising the *Dam Safety Strategy* trigger level) has a greater impact on reducing flood inundation than does increasing downstream target flows during flood operations.

These factors highlighted the importance of flood storage.

The resulting Prefeasibility Investigation into Flood Mitigation Storage Infrastructure (PIFMSI) project is a review of potential infrastructure options that could provide significant flood mitigation benefits for properties downstream of Wivenhoe Dam in the major population centres in the Brisbane and Bremer River catchments.

The study is multidisciplinary, involving geotechnical, engineering, hydrological, environmental, social, economic, land, water resource management and impacted infrastructure considerations.

This project is a prefeasibility level assessment. Estimated costs and benefits are indicative only and will require further analysis at the feasibility assessment stage of analysis.

The study has identified several preferred scenarios that warrant further feasibility assessment. The scenarios include both single infrastructure development solutions and solutions of combined infrastructure developments and operational strategies.

# Acknowledgments

The Department of Energy and Water Supply (DEWS) would like to thank officers from the following organisations who undertook significant assessments as part of the study:

- Seqwater
- Department of Science, Information Technology, Innovation and the Arts
- Department of State Development, Infrastructure and Planning
- Department of Transport and Main Roads

DEWS would like to thank officers from the following organisations who provided data and information used in the assessments undertaken as part of the study:

- Brisbane City Council
- Ipswich City Council
- Somerset Regional Council
- Lockyer Valley Regional Council

# Glossary

## Terms

| | |
|---|---|
| **AAD** | Average Annual Damage – the total damage caused by all floods over a long period of time divided by the number of years in that period (CSIRO 2000) |
| **AAI** | Average Annual Impact – the total impact caused by all floods over a long period of time divided by the number of years in that period |
| **Act** | *Water Supply (Safety and Reliability) Act 2008* (QLD) |
| **AFC** | Acceptable Flood Capacity for a referable dam – varies dependent on the hazard category (DEWS 2013) |
| **AEP** | Annual Exceedance Probability – is a measure of the likelihood (expressed as a probability) of a flood event reaching or exceeding a particular magnitude in any one year. A 1% (AEP) flood has a 1% (or 1 in 100) chance of occurring or being exceeded at a location in any year |
| **AHD** | Australian Height Datum |
| **AMTD** | Adopted Middle Thread Distance – The distance in kilometres, measured along the middle of a watercourse that a specific point in the watercourse is from the watercourse's mouth or junction with the main watercourse (BoM 2010) |
| **BCR** | Benefit cost ratio |
| **BRCFS** | Brisbane River Catchment Flood Study |
| **CAPEX** | Capital expenditure |
| **EL (mAHD)** | Elevation (in metres) above the Australian Height Datum |
| **EPBC Act** | *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) |
| **Flood mitigation manual (Flood Manual)** | A flood mitigation manual approved under section 371E(1)(a) or 372(3) of the *Water Supply (Safety and Reliability) Act 2008* (QLD) |
| **FOSM** | Flood Operations Simulation Model (refer Seqwater 2014b) |
| **Floodplain** | Area of land adjacent to a creek, river, estuary, lake, dam or artificial channel, which is subject to inundation by the PMF. (CSIRO 2000) |
| **FSV** | Full Supply Volume – maximum normal water supply storage volume of a reservoir behind a dam |
| **GIS** | Geographic Information System |
| **GCDP** | Gold Coast Desalination Plant |
| **GL** | Gigalitres = 1,000,000,000 litres |

| | |
|---|---|
| **GoldSim** | A multi-purpose simulation software package that can be used for dynamic modelling of complex systems in business, engineering and science applications |
| **Hydrograph** | A graphical representation of the variation of discharge with respect to time |
| **Hydrologic / Hydrology** | Relating to rainfall and runoff |
| **Hydraulic** | Relating to flow characteristics – level, depth, velocity and extent and combinations thereof |
| **Hydrodynamic** | Relating to time-variant hydraulic characteristics |
| **IQQM** | Integrated Quantity and Quality Model for water resource planning |
| **LiDAR** | LiDAR (combination of the words light and radar) is a remote sensing technology that measures distance by illuminating a target with a laser and analysing the reflected light |
| **LOS** | Level of service refers to objectives specifying the level of performance that SEQ residents can expect from their bulk water supply system |
| **ML** | Megalitres = 1,000,000 litres. |
| **MWRP** | Water Resource (Moreton) Plan 2007 (Qld) |
| **$m^3/s$** | Cubic metre per second - unit of measurement for flow or discharge |
| **NC Act** | *Nature Conversation Act 1992* (Qld). |
| **NPDOS** | North Pine Dam Optimisation Study. |
| **NPV** | Net Present Value. |
| **OPEX** | Operational expenditure. |
| **PCG** | Project Control Group. |
| **PICC** | Property and Infrastructure Cabinet Committee |
| **PIFMSI** | Prefeasibility Investigation into Flood Mitigation Storage Infrastructure for the Brisbane River Catchment. |
| **PMF** | Probable Maximum Flood – the largest flood that could conceivably occur at a particular location, resulting from the PMP. (CSIRO 2000) and Australia Rainfall and Runoff, 2003 (IEAust, 2003) |
| **PMP** | Probable Maximum Precipitation – the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of year, with no allowance made for long-term climatic trends. (CSIRO 2000; IEAust 2003) |
| **PMPDF** | Probable Maximum Precipitation Design Flood |
| **QFCoI** | Queensland Floods Commission of Inquiry |

| | |
|---|---|
| **RCC** | Roller compacted concrete |
| **RE** | Regional Ecosystem |
| **SEQ** | South East Queensland |
| **SEQ bulk water supply system** | The system supplying water to water service providers in SEQ. Currently made up of 12 SEQ water storages, raw water treatment plants and associated bulk water distribution mains (including the Northern Pipeline, Southern Regional Pipeline, Eastern Pipeline Inter-connectors), the Western Corridor Recycled Water Scheme, and the Gold Coast Desalination Plant. |
| **SEQ water storages** | Key water supply system storages:<br>• Wivenhoe Dam<br>• Somerset Dam<br>• North Pine Dam<br>• Leslie Harrison Dam<br>• Lake Kurwongbah<br>• Baroon Pocket Dam<br>• Ewen Maddock Dam<br>• Cooloolabin Dam<br>• Wappa Dam<br>• Lake Macdonald<br>• Hinze Dam, and<br>• Little Nerang Dam |
| **spp.** | Abbreviation for plural of species |
| **SRTM** | Shuttle Radar Topographic Mission |
| **Stochastic flood event** | Statistically generated synthetic flood event. Stochastic flood events include variability in flood input parameters (eg. temporal and spatial rainfall patterns) compared to design flood events. Stochastic flood events by their method of generation exhibit a greater degree of variability and randomness compared to design flood events (See also *Design flood event*) |
| **Synthetic flood event** | See *Stochastic flood event* |
| **TEC** | Threatened Ecological Communities |
| **URBS** | Unified River Basin Simulator |
| **WATHNET** | A contraction of Water Headworks Network, a suite of programs capable of simulating the operation of a wide range of water supply headworks and transfer systems serving urban, industrial, irrigation and in-stream demands. |
| **WRP** | Water Resource Plan |
| **WSDOS** | Wivenhoe and Somerset Dams Optimisation Study. |

## Abbreviations of organisations and agencies

| | |
|---|---|
| **ANCOLD** | Australian National Committee on Large Dams |
| **Aurecon** | Engineering consultant |
| **BCC** | Brisbane City Council |
| **BoM** | Bureau of Meteorology |
| **DATSIMA** | Department of Aboriginal and Torres Strait Islander and Multicultural Affairs |
| **DEWS** | Queensland Department of Energy and Water Supply |
| **DNRM** | Queensland Department of Natural Resources and Mines |
| **DPC** | Queensland Department of the Premier and Cabinet |
| **DSDIP** | Queensland Department of State Development, Infrastructure and Planning |
| **DSITIA** | Queensland Department of Science, Information Technology, Innovation and the Arts |
| **DTMR** | Queensland Department of Transport and Main Roads |
| **EDQ** | Economic Development Queensland (business unit of DSDIP) |
| **ICC** | Ipswich City Council |
| **GHD** | Engineering consultant |
| **IEAust** | Engineers Australia (formerly known as the Institution of Engineers Australia) |
| **IWSC** | Irrigation and Water Supply Commission Queensland (former government agency) |
| **LVRC** | Lockyer Valley Regional Council |
| **QWRC** | Queensland Water Resources Commission (former government agency) |
| **Seqwater** | South East Queensland bulk water authority, trading as Seqwater |
| **SMEC** | Engineering consultant |
| **SMEHA** | Snowy Mountain Hydro-Electric Authority (former Commonwealth authority) |
| **SRC** | Somerset Regional Council |

# Executive Summary

## ES1. Scope and purpose

- This report documents the assessment of the potential to improve flood mitigation in the Brisbane River floodplain through the development of new flood mitigation storages, upgrades to Wivenhoe Dam to increase its flood storage volume and an upgrade to the Wivenhoe Dam fuse plug spillway to enable implementation of the Wivenhoe and Somerset Dams Optimisation Study (WSDOS) Urban 4 operational alternative.
- The investigation is at pre-feasibility level, with limitations in terms of scope and timelines available to complete the work. The aim of the investigation was to prioritise one or more scenarios for further feasibility assessment.

## ES2. Technical assessments

- Five options were considered for upgrades to Wivenhoe Dam whilst seven new sites were considered worthy of preliminary engineering assessment.
- Upgrades to Wivenhoe and Somerset Dams to meet dam safety requirements were included in all options (i.e. principally to enable passing of the current estimate of the Probable Maximum Flood (PMF)).
- Concept designs and indicative cost estimates, along with preliminary environmental, and social impact assessments were produced for each of the Wivenhoe Dam upgrade options (refer Chapter 8) and the seven new sites (refer Chapter 7).
- Apart from engineering considerations, issues such as infrastructure impacts/relocations, land acquisitions, land use changes, cultural heritage, environmental and social impacts have been considered. The significance of issues varies across sites, but no critical issues have been identified that would rule out any of the most beneficial options from further investigation.
- Capital costs for options to upgrade Wivenhoe Dam (including dam safety upgrades) are:
    - $325m for Option 1a (base case) – existing Wivenhoe Dam and Somerset Dam configurations and Urban 3 operating option arising from the WSDOS investigation
    - $399m for Option 1b - Urban 4 operating option arising from the WSDOS investigation and associated upgrades to the existing fuse plug spillway
    - $535m for Option 2 (1.5 m raising of Wivenhoe Dam)
    - $881m for Option 3 (4 m raising of Wivenhoe Dam)
    - $1,373m for Option 4 (8 m raising of Wivenhoe Dam)
- The four most promising new dam sites were on the Brisbane River near Linville, on Emu Creek near Harlin, on lower Warrill Creek near Willowbank and on the Bremer River near Mt Walker. The former two sites would mitigate flood inflows to Wivenhoe Dam, with benefits to both Brisbane and Ipswich. The latter two sites would primarily mitigate flood flows in Ipswich.
- A ‘dry’ flood mitigation storage on the Brisbane River near Linville would provide flood storage of 348,000 ML up to the spillway crest level (that historic floods would not exceed) and a maximum flood storage volume of 767,000 ML to accommodate the PMF.

  The capital cost has been estimated at about $430m.

- The same site near Linville could be developed as a 570,000 ML water supply storage with maximum flood storage above full supply of 602,000 ML to accommodate the PMF. This would enable the water supply storage in Wivenhoe Dam to be reduced by up to 40% (466,000 ML) and its flood mitigation compartment to be increased correspondingly, without affecting water supply security. The total additional flood storage in the two dams would be up to 1,068,000 ML.

  The capital cost has been estimated at about $580m.
- A ‘dry’ flood mitigation storage on Emu Creek near Harlin would provide flood storage of 107,000 ML up to the spillway crest level (that historic floods would not exceed) and a maximum flood storage volume of 191,000 ML to accommodate the PMF.

  The capital cost has been estimated at a little under $300m.
- A ‘dry’ flood mitigation storage on Warrill Creek near Willowbank (Bremer River catchment) would provide flood storage of 125,000 ML up to the spillway crest level (that historic floods would not exceed) and a maximum flood storage of 207,000 ML to accommodate the PMF.
- The capital cost for this site would range from around $440m (dam on a shorter alignment) to a little over $520m (if co-located with the Southern Freight Rail project (i.e. combined dam and rail embankment on a longer alignment). Approximately $60m of this higher estimate has been attributed to the rail project.
- A ‘dry’ flood mitigation storage on the Bremer River near Mt Walker would provide flood storage of 40,000 ML up to the spillway crest level (that historic floods would not exceed) and a maximum flood storage volume of 65,000 ML up to the top of embankment to accommodate the PMF.

  The capital cost has been estimated at about $140m.
- Scenarios for more detailed modelling and economic assessment were developed by combining several configurations of the four most promising new sites (Brisbane River near Linville, Emu Creek near Harlin, lower Warrill Creek near Willowbank and Bremer River near Mt Walker) with the five options for upgrading Wivenhoe Dam. This created 47 scenarios.
- Basin-wide hydrologic modelling of the 47 scenarios indicates that significant mitigation of historic floods can be achieved (refer Chapter 9). For scenarios that have the greatest net present values, the modelling indicates peak flow reductions at Moggill of up to 40%.
- Scenarios involving WSDOS Urban 4 operations of Wivenhoe Dam would result in the existing emergency spillway becoming a part of flood operations during large flood events rather than during rare and extreme flood events, meaning it may be used more frequently than it was originally designed. This is not consistent with world practice for use and operation of fuse plugs. Such operations would expose downstream communities to reduced flood mitigation performance in the event of another flood before reinstatement of the fuse plug, and would require the operational engineers to operate the dam spillway gates in conjunction with triggering of the fuse plugs – an action for which there is no previous operational experience.

## ES3. Benefit cost assessment

- The Department of State Development, Infrastructure and Planning (DSDIP) brought together the relevant input on estimated capital and operating costs, timing of expenditure and estimates of benefits and other costs from relevant consultancies and assessed the net present value (NPV) and benefit-cost ratio (BCR) for all 47 scenarios (refer Chapter 10).

- The potential savings in flood damages and impacts for the 47 scenarios were assessed using the same methodology as WSDOS (refer Chapter 10). The average annual flood damages costs for the base case (current dam operations including Urban 3) are estimated at around $112m per year. Many of the examined scenarios reduce these costs by $49m–$80m per year (40% to 70%).
- Table ES1 summarises the top nine ranked scenarios based on ranking by present value and benefit-cost ratio. In addition, it includes scenarios for an 8 m raising of Wivenhoe Dam and the lower Warrill Creek flood storage (both of which are outside the top nine ranked scenarios from a benefit cost perspective) for comparison purposes.
- The results are highly sensitive to the discount rate. When using a 4% rather than 7% real discount rate, 30 (rather than 4) of the 47 scenarios analysed have a positive NPV.
- Figure ES1 indicates that for many of the historical floods, the top nine scenarios are approaching the maximum mitigation that can be achieved by options based on Wivenhoe Dam with or without a dam near Linville (i.e. that mitigate flood flows from upstream of Wivenhoe Dam only).
- Table ES2 shows the estimated reductions in peak flow and numbers of buildings inundated for a reoccurrence of each of the six largest historical floods for the top nine ranked scenarios plus the 8 m Wivenhoe Dam raising and lower Warrill Creek flood storage scenarios.

## ES4. Conclusions

- The nine top ranked flood mitigation development scenarios involve potential works at Wivenhoe Dam with or without a dam on the upper Brisbane River near Linville.
- The highest ranked scenarios with positive NPVs and BCRs greater than 1 are those involving lower capital expenditure and relatively modest benefits (i.e. the 1.5 m raising of Wivenhoe Dam at $534m and upgrades to allow implementation of WSDOS Urban 4 operations at $399m).
- More significant benefits (still with positive NPVs and BCRs greater than 1) can be obtained through investments in the order of $750m–$900m for upgrades to Wivenhoe and Somerset dams and construction of either a flood mitigation or water supply dam near Linville.
- In the top nine scenarios, the greatest benefits can be achieved with large investments ($880m–$1,100m) involving a raising of Wivenhoe Dam with or without a dam near Linville.
- Analysis indicates that with appropriate infrastructure in place, potentially 8,000–10,000 fewer buildings would be inundated in Brisbane and Ipswich in a reoccurrence of any of the three largest historical Brisbane River dominated floods when compared to the current situation.
- In order to reduce flooding in Ipswich from Bremer River dominated floods such as 1887, 1974 and 2013, it would be necessary to invest in a lower Warrill Creek (near Willowbank) and perhaps a Bremer River (near Mt Walker) storage(s).
- While significant reductions in flood levels (up to 4 m) at Ipswich can be achieved in Bremer River dominated floods, the costs of Bremer River catchment storage options significantly outweigh the estimated tangible benefits.
- Upgrades to allow implementation of WSDOS Urban 4 operations are not supported for further investigation due to operational and performance issues outlined earlier.
- All scenarios would require the necessary dam safety upgrades and modifications to existing dams to be able to pass PMFs. As part of this work, there will need to be detailed risk assessments and consideration of flood emergency response and planning control measures for communities immediately downstream of Wivenhoe Dam.

- As part of future upgrades for Somerset Dam, Seqwater has suggested considering increasing the maximum safe level of Somerset Dam beyond EL 112 mAHD.
- It will be necessary to engage more fully with relevant agencies so that designs can be optimised e.g. with the Department of Transport and Main Roads in regard to the Brisbane Valley Highway and its possible diversion to downstream of Wivenhoe Dam to reduce costs and Somerset Regional Council in regard to Brisbane River (near Linville) dam impacts.
- Further feasibility assessment is required to complete value engineering assessments and better quantify the costs, benefits and risks before a preferred scenario could be identified. In order to address some of the above issues, it would be appropriate to prepare a strategic overview of Wivenhoe and Somerset Dam upgrade alternatives for addressing dam and community safety risks, structural design issues, ease of operation and ability to accommodate potential future increases in PMF.
- Chapter 11 outlines estimated timeframes for the full implementation of a preferred flood storage infrastructure development scenario including all dam safety requirements for Wivenhoe and Somerset Dams. Depending on the preferred scenario chosen, it is likely to take 6–7 years for the completion of a new flood storage while more complex work such as associated with upgrades to Somerset and Wivenhoe Dams could take 7–10 years.

## ES5. Limitations

- The scenario assessments are preliminary only with both the costs and benefits being determined at a pre-feasibility level of accuracy. More detailed further investigations would be necessary to confirm whether any scenario should be implemented.
- While use of historical floods is a good indicator for benefit cost assessments, the use of the more comprehensive Brisbane River Catchment Flood Study hydrologic and hydraulic models (both of which are expected to be available in mid-2015) would improve the analysis by incorporating impacts of larger and smaller floods e.g. there would be better account of Brisbane River versus Bremer River dominated floods.
- Comprehensive risk assessments need to be undertaken (particularly for scenarios involving proposed modifications to Wivenhoe Dam) to quantify the potential risks to population centres immediately downstream (i.e. Fernvale and Lowood) during extreme events.
- The costs and benefits of some scenarios could be significantly refined through further investigation by optimising concept designs and scenarios, potentially making additional scenarios feasible. In particular, potential flood mitigation infrastructure in the Warrill Creek catchment could become more attractive through the reconsideration designs to accommodate the alignment with the Southern Freight Rail Corridor and relocation of high voltage power lines.

## ES6. Recommendations

1. Proceed to feasibility level assessments (including detailed risk assessments) for various combinations of dam safety upgrades for Wivenhoe and Somerset dams, Wivenhoe Dam raisings and a new dam near Linville.
2. Further investigate mitigation infrastructure for Bremer River dominant floods, in particular the lower Warrill Creek (near Willowbank) site to determine whether its economics can be improved.
3. Further refine combinations of the existing and new selected dams with varying modes of operation to determine more accurate cost estimates and flood mitigation benefits for Brisbane and Ipswich.

## Table ES1 Top nine ranked scenarios plus the 8 m Wivenhoe Dam raising and lower Warrill Creek flood storage scenarios

| Scenario Number | Description (Top 9 ranked scenarios plus 8 m Wivenhoe Dam raising and lower Warrill Creek flood storage scenarios) | Number of properties impacted by acquisitions | Estimated Capital Cost [1]<br>$m | Reduced damages and impacts cost (over 40 years @ 7% real discount rate) [2]<br>$m | Present value of cost [3]<br>$m | Net Present Value (7% real discount rate) [4]<br>$m | Benefit Cost Ratio |
|---|---|---|---|---|---|---|---|
| FS02 [5] | Alternative Urban 4 Operations<br>– infrastructure improvements to existing emergency spillway<br>– install a second emergency spillway | 214 | $399 | $107 | $41 | $65.7 | 2.60 |
| FS03 | Raise Wivenhoe Dam by 1.5 m<br>– install a second emergency spillway<br>– optimise flood operations | 214 | $535 | $262 | $196 | $65.8 | 1.34 |
| FS04 | Raise Wivenhoe Dam by 4.0 m<br>– install a second emergency spillway<br>– optimise flood operations | 235 | $881 | $387 | $427 | -$40 | 0.91 |
| FS05 [5] | Raise Wivenhoe Dam by 8.0 m | 297 | $1,373 | $527 | $751 | -$224 | 0.70 |
| FS06 | 125,000 ML lower Warrill Creek Dam near Willowbank<br>– lower Warrill Creek Dam constructed to be a dry flood mitigation dam.<br>– existing Wivenhoe Dam operations | 110<br>(15 houses) | $461 [6] | $108 | $372 | -$264 | 0.29 |
| FS16 | Existing Wivenhoe Dam plus new 350,000 ML dam near Linville<br>– dam near Linville constructed to be a dry flood mitigation dam<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville | 49<br>(14 houses) | $754 | $361 | $344 | $17 | 1.05 |
| FS 20 | Raise Wivenhoe Dam by 1.5 m plus new 350,000ML dam near Linville<br>– dam near Linville constructed to be a dry flood mitigation dam<br>– raise existing emergency spillway by 1 metre<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville | 263<br>(14 houses) | $964 | $510 | $519 | -$9 | 0.98 |
| FS26 | Existing Wivenhoe Dam plus new 570,000 ML dam near Linville<br>– dam near Linville constructed to be a water supply storage<br>– lower Wivenhoe Dam to 60 per cent full supply volume<br>– install a second emergency spillway on Wivenhoe Dam<br>– no net loss to South East Queensland Water Supply Security | 49<br>(25 houses) | $900 | $531 | $467 | $64 | 1.14 |
| FS27 | Existing Wivenhoe Dam plus new 510,000 ML dam near Linville<br>– dam near Linville constructed to be a water supply storage<br>– lower Wivenhoe Dam to 75 per cent full supply volume<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville<br>– no net loss to South East Queensland Water Supply Security | 49<br>(24 houses) | $870 | $438 | $444 | -$6 | 0.99 |
| FS28 | Existing Wivenhoe Dam plus new 570,000 ML dam near Linville<br>– dam near Linville constructed to be a water supply storage<br>– lower Wivenhoe Dam to 75 per cent full supply volume<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville | 49<br>(25 houses) | $900 | $441 | $467 | -$26 | 0.94 |
| FS36 | Raise Wivenhoe Dam by 1.5 m plus new 570,000 ML dam near Linville<br>– dam near Linville constructed to be water supply dam<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville<br>– Wivenhoe Dam lowered to 60% full supply volume | 263<br>(min 25 houses) | $1,110 | $577 | $634 | -$56 | 0.91 |

Notes:

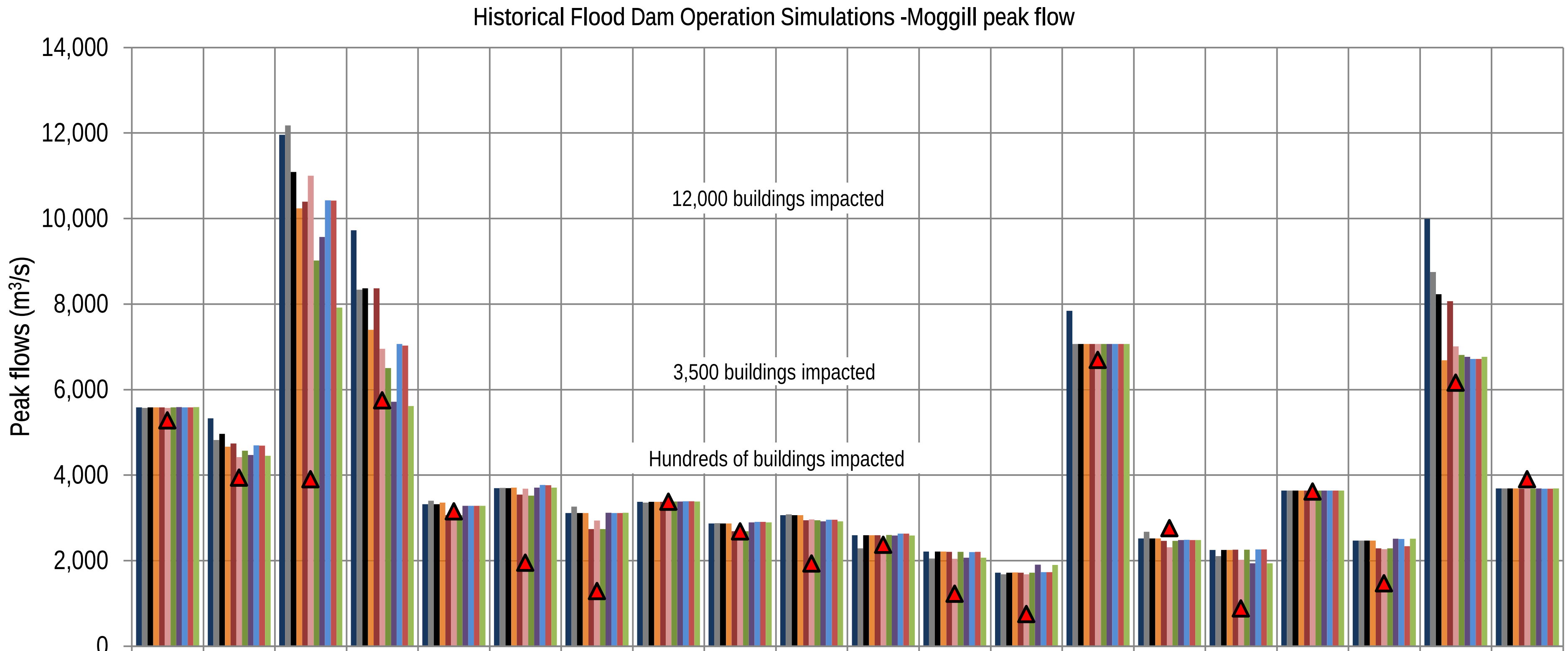
1. Estimated capital cost includes the cost of necessary dam safety upgrades for Wivenhoe Dam with the exception of catchment scenario no. FS06 (refer Note 6).
2. Compared to the Base Case (FS01).
3. Includes capital and operating and maintenance costs and residual value (60 years of remaining useful life added back as partial offset to initial capital cost).
4. Reflects NPV at real discount rate for 40 years operational phase.
5. Table includes FS02 however it is not proposed to be considered further due to concerns over operation of Wivenhoe Dam under WSDOS Urban 4. FS05 included for comparison purposes only.
6. Cost for lower Warrill Creek dam only.

**Table ES2 Modelled reduction in peak flood flow at Moggill and estimated reduction in number of buildings inundated compared to current operations of existing infrastructure (i.e. FS01) - 6 largest historical floods**

| Scenario Number | Description (Top 9 ranked scenarios plus 8 m Wivenhoe Dam raising and lower Warrill Creek flood storage scenarios) | Estimated Capital Cost [1] $m | Flood event and percentage reduction in peak flow (and in number of buildings inundated) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | January 1887 [2] | February 1893 [3] | February 1893 [4] | January 1974 [2] | January 2011 | January 2013 [2] |
| FS02 | Alternative Urban 4 Operations<br>– infrastructure improvements to existing emergency spillway<br>– install a second emergency spillway | $399 | 0.1%<br>(10) | -1.8%<br>(-990) | 14.3%<br>(3,560) | 9.9%<br>(1,270) | 12.4%<br>(3,660) | -0.1%<br>(0) |
| FS03 | Raise Wivenhoe Dam by 1.5 m<br>– install a second emergency spillway<br>– optimise flood operations | $535 | 0.0%<br>(0) | 7.2%<br>(3,890) | 14%<br>(3,460) | 9.9%<br>(1,270) | 17.6%<br>(5,440) | 0%<br>(0) |
| FS04 | Raise Wivenhoe Dam by 4.0 m<br>– install a second emergency spillway<br>– optimise flood operations | $881 | 0.0%<br>(0) | 14.4%<br>(7,810) | 23.9%<br>(5,780) | 9.9%<br>(1,270) | 33.1%<br>(8,150) | 0%<br>(0) |
| FS05 | Raise Wivenhoe Dam by 8.0 m | $1,373 | -0.1% | 45.9% | 42.2% | 9.9% | 32.3% | 0% |
| FS06 | 125,000 ML lower Warrill Creek Dam near Willowbank<br>– lower Warrill Creek Dam constructed to be a dry flood mitigation dam.<br>– existing Wivenhoe Dam operations | $461 [5] | 21.2%<br>(970) | -0.1%<br>(-40) | 5.0%<br>(910) | 4.2%<br>(970) | 4.2%<br>(1200) | 17.1%<br>(280) |
| FS16 | Existing Wivenhoe Dam plus new 350,000 ML dam near Linville<br>– dam near Linville constructed to be a dry flood mitigation dam<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville | $754 | 0.0%<br>(0) | 13.1%<br>(7,110) | 14.0%<br>(3,470) | 9.9%<br>(1,270) | 19.3%<br>(5,660) | 0.1%<br>(0) |
| FS 20 | Raise Wivenhoe Dam by 1.5 m plus new 350,000ML dam near Linville<br>– dam near Linville constructed to be a dry flood mitigation dam<br>– raise existing emergency spillway by 1 metre<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville | $964 | 0.0%<br>(0) | 24.6%<br>(11,850) | 33.1%<br>(7,110) | 9.9%<br>(1,270) | 31.9%<br>(7,970) | 0.1%<br>(0) |
| FS26 | Existing Wivenhoe Dam plus new 570,000 ML dam near Linville<br>– dam near Linville constructed to be a water supply storage<br>– lower Wivenhoe Dam to 60 per cent full supply volume<br>– install a second emergency spillway on Wivenhoe Dam<br>– no net loss to South East Queensland Water Supply Security | $900 | -0.1%<br>(-10) | 20.0%<br>(10,220) | 41.2%<br>(8,280) | 9.9%<br>(1,270) | 32.3%<br>(8,030) | 0.1%<br>(0) |
| FS27 | Existing Wivenhoe Dam plus new 510,000 ML dam near Linville<br>– dam near Linville constructed to be a water supply storage<br>– lower Wivenhoe Dam to 75 per cent full supply volume<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville<br>– no net loss to South East Queensland Water Supply Security | $870 | -0.1%<br>(-10) | 12.8%<br>(6980) | 27.3%<br>(6,270) | 9.9%<br>(1,270) | 32.8%<br>(8,110) | 0.1%<br>(0) |
| FS28 | Existing Wivenhoe Dam plus new 570,000 ML dam near Linville<br>– dam near Linville constructed to be a water supply storage<br>– lower Wivenhoe Dam to 75 per cent full supply volume<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville | $900 | -0.1%<br>(-10) | 12.9%<br>(7,020) | 27.7%<br>(6,270) | 9.9%<br>(1,270) | 32.8%<br>(8,100) | 0.1%<br>(0) |
| FS36 | Raise Wivenhoe Dam by 1.5 m plus new 570,000 ML dam near Linville<br>– dam near Linville constructed to be water supply dam<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville<br>– Wivenhoe Dam lowered to 60% full supply volume | $1,110 | -0.1%<br>(-10) | 33.8%<br>(15,100) | 42.3%<br>(8,430) | 9.9%<br>(1,270) | 32.3%<br>(8,030) | 0.1%<br>(0) |

Notes:

1. Estimated capital cost includes the cost of necessary dam safety upgrades for Wivenhoe Dam with the exception of catchment scenario no. FS06 (refer Note 5).
2. 1887, 1974 and 2013 floods were dominated by Bremer River flows and the floods in which in the Lower Warrill Creek Dam has the most flood mitigation benefit to Ipswich.
3. First flood in February 1893 that peaked on the 5 February 1893 (BoM 2014c).
4. Third flood in February 1893 that peaked on 19 February 1893 (BoM 2014c).
5. Cost for lower Warrill Creek dam only.




| | 1887.01 | 1890.03 | 1893.01 | 1893.02 | 1893.06 | 1898.01 | 1898.03 | 1908.03 | 1931.01 | 1955.03 | 1959.11 | 1971.02 | 1973.07 | 1974.01 | 1983.06 | 1989.04 | 1996.04 | 1999.02 | 2011.01 | 2013.01 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FS01 | 5582 | 5326 | 11959 | 9727 | 3320 | 3692 | 3111 | 3374 | 2866 | 3064 | 2593 | 2215 | 1721 | 7845 | 2516 | 2247 | 3638 | 2470 | 9995 | 3688 |
| FS02 | 5574 | 4823 | 12180 | 8338 | 3401 | 3699 | 3263 | 3357 | 2875 | 3079 | 2286 | 2052 | 1681 | 7065 | 2673 | 2105 | 3638 | 2466 | 8752 | 3690 |
| FS03 | 5582 | 4962 | 11092 | 8370 | 3320 | 3692 | 3113 | 3374 | 2866 | 3064 | 2593 | 2215 | 1721 | 7065 | 2516 | 2247 | 3638 | 2468 | 8233 | 3688 |
| FS04 | 5582 | 4665 | 10241 | 7399 | 3359 | 3707 | 3116 | 3374 | 2870 | 3064 | 2593 | 2215 | 1721 | 7065 | 2516 | 2247 | 3638 | 2470 | 6687 | 3688 |
| FS16 | 5582 | 4738 | 10394 | 8368 | 3062 | 3546 | 2735 | 3377 | 2687 | 2945 | 2595 | 2203 | 1721 | 7065 | 2461 | 2253 | 3638 | 2290 | 8069 | 3685 |
| FS18 | 5573 | 4419 | 11001 | 6957 | 3087 | 3680 | 2935 | 3359 | 2687 | 2966 | 2286 | 2041 | 1682 | 7065 | 2315 | 2021 | 3638 | 2267 | 7010 | 3686 |
| FS20 | 5582 | 4571 | 9017 | 6506 | 3062 | 3518 | 2736 | 3380 | 2687 | 2945 | 2599 | 2203 | 1721 | 7065 | 2461 | 2253 | 3638 | 2290 | 6808 | 3685 |
| FS26 | 5589 | 4468 | 9570 | 5718 | 3283 | 3709 | 3118 | 3383 | 2893 | 2918 | 2588 | 2069 | 1905 | 7065 | 2481 | 1938 | 3639 | 2510 | 6767 | 3686 |
| FS27 | 5587 | 4697 | 10427 | 7068 | 3285 | 3769 | 3112 | 3387 | 2904 | 2958 | 2631 | 2202 | 1732 | 7065 | 2485 | 2260 | 3639 | 2508 | 6714 | 3685 |
| FS28 | 5587 | 4692 | 10418 | 7028 | 3284 | 3765 | 3111 | 3387 | 2904 | 2958 | 2631 | 2203 | 1732 | 7065 | 2481 | 2260 | 3639 | 2335 | 6717 | 3685 |
| FS36 | 5589 | 4452 | 7915 | 5616 | 3283 | 3709 | 3118 | 3383 | 2893 | 2918 | 2588 | 2069 | 1900 | 7065 | 2481 | 1938 | 3639 | 2510 | 6767 | 3686 |
| Downstream Catchment | 5276 | 3934 | 3897 | 5741 | 3146 | 1944 | 1286 | 3372 | 2680 | 1929 | 2368 | 1222 | 745 | 6688 | 2756 | 874 | 3609 | 1466 | 6154 | 3900 |

Historical Events

**Figure ES1 Comparative hydrologic performance of top nine scenarios against the base case (FS01)**

# Chapter 1 Background

This chapter provides background to the Prefeasibility Investigation into Flood Mitigation Storage Infrastructure (PIFMSI) for the Brisbane River catchment beginning with the January 2011 floods and subsequent Wivenhoe and Somerset Dams Optimisation Study (WSDOS) which arose out of the Queensland Floods Commission of Inquiry (QFCoI).

The chapter covers the overall purpose and scope of PIFMSI, previous investigations of dams in SEQ which informed the study, the governance and project management arrangements for PIFMSI and the relationship of the study with other recent and ongoing studies including the Brisbane River Catchment Flood Study (BRCFS).

## 1.1 The January 2011 flood event

The rainfall experienced across south east Queensland (SEQ) in January 2011 produced one of the largest floods recorded in the Brisbane River (based on records dating back to the late 1800s). The resulting floods were the largest experienced at Wivenhoe and Somerset dams since they were constructed in 1983 and 1955 respectively.

At 3am on 13 January 2011, the Port Office gauge on the Brisbane River peaked at 4.46 mAHD. This was the highest level recorded at this location since the January 1974 flood event peak of 5.45 mAHD (refer Table 1.1).

Further upstream of the Port Office, the recorded peak in 2011 was the highest on record for several locations (although not all stations have records extending back to the 1800s). For those locations where records do extend back to at least 1893, the values in Table 1.1 indicate that the 2011 flood was the 4th or 5th highest on record. Table 1.2 also shows that the highest flood on record (1893) produced levels that were approximately 5 m higher than those of 2011.

**Table 1.1 January 2011 flood heights - Brisbane River**

| Location | Peak level January 2011 (mAHD) | Status | Previous historical record (mAHD) |
|---|---|---|---|
| Cooyar Creek | 9.48 | Higher than previous record | 9.33 (1974) |
| Savages Crossing | 24.42 | Highest since records began (1959) | 23.79 (1974) |
| Mt Crosby | 26.18 | 5th highest on record | 32.00 (1893) [1] |
| Centenary Bridge | 12.07 | 4th highest on record | 17.90 (1893) [1] |
| Brisbane City (Port Office) | 4.46 | Highest since 1974 | 8.35 (1893) [1]<br>5.45 (1974) |

Notes:

1. First flood of February 1893 that peaked 5 February 1893 (BoM 2014c).

Source: Seqwater 2013a, Appendix B2

The Bremer River also experienced the highest flood levels since the 1974 event, as shown in Table 1.2.

**Table 1.2 January 2011 flood heights - Bremer River**

| Location | Peak level January 2011 (mAHD) | Status | Previous historical record (mAHD) |
|---|---|---|---|
| Rosewood | 7.50 | 2nd highest on record | 7.62 (1974) |
| Ipswich [1] | 19.25 | 4th highest on record | 24.5 (1893) [2]<br>23.6 (1893) [3]<br>20.7 (1974) |

Notes:

1. Can be influenced by Brisbane River levels.
2. First flood of February 1893 that peaked 5 February 1893 (BoM 2014c).
3. Third flood of February 1893 that peaked 19 February 1893 (BoM 2014c).

Source: Seqwater 2013a, Appendix B2

The Bureau of Meteorology (BoM) web page *Queensland Flood Summary 2010 onwards* (BoM 2014a) describes the period as follows:

*'Southeast Queensland had experienced very much above average to highest on record rainfall for the month of December. Further rainfall then followed in the first week of January, saturating the catchment area.*

*By the 7th of January a combination of weather systems centred themselves over land over the Burnett River catchment area. These systems combined to produce heavy rainfall and major flooding in the Mary River catchment and about the Sunshine Coast before moving southward into the Pine and Brisbane River catchments. Heavy to very intense rainfall from the 9th to the 12th of January resulted, causing rapid creek rises and extreme flash flooding in the Lockyer Valley and major river flooding in the Brisbane and Bremer Rivers.*

*Record flood heights were recorded at various locations along Lockyer and Warrill Creeks and the Bremer and the upper Brisbane River. Peak river levels on the Bremer River at Ipswich and along the Brisbane River between Mt Crosby and Brisbane city remained below the 1974 flood level.'*

## 1.2 Wivenhoe and Somerset Dams Optimisation Study

The Wivenhoe and Somerset Dams Optimisation Study (WSDOS) was initiated in response to recommendation 17.3 of the Queensland Floods Commission of Inquiry (QFCoI) Final Report (QFCoI 2012). Recommendation 17.3 was to investigate a wide range of options, which prioritise differing objectives, for the operational strategies to be employed at Wivenhoe and Somerset dams during floods.

The results of WSDOS identified that:

1. Wivenhoe and Somerset dams have considerably reduced the peak flow of every flood since combined operation commenced in the late 1970s and would have reduced the peak flow of every major flood on the historical record.
2. Increasing flood mitigation storage (by either lowering the full supply volume (FSV) or raising the trigger level for the *Dam Safety Strategy*) has a greater impact on reducing flood inundation than does increasing downstream target flows (i.e. the timing of releases and release rates) during flood operations when compared to the then current operations under the Revision 11 (Seqwater 2013b) Flood Manual.

These factors highlight the importance of flood storage for flood mitigation in the Brisbane and Bremer River catchments.

## 1.3 Purpose and scope of study

The Prefeasibility Investigation into Flood Mitigation Storage Infrastructure (PIFMSI) has reviewed potential infrastructure options that could provide further significant flood mitigation benefits for properties downstream of Wivenhoe Dam in the major population centres in the Brisbane River catchment.

PIFMSI was announced by the Honourable Campbell Newman MP, Premier of Queensland on 2 April 2014 following the provision of the WSDOS report (DEWS 2014) to the State Government in March 2014.

The options investigated in PIFMSI include:

1. Potential new flood retention storages:
    a) in both the Bremer River and Lockyer Creek catchments for local flood mitigation benefits (e.g. for Ipswich, Gatton and Laidley) and attenuation of flows contributed to the Brisbane River downstream of Wivenhoe Dam
    b) upstream of the Wivenhoe and Somerset dams in the upper Brisbane River catchment areas
2. A potential new water supply dam on the upper Brisbane River near Linville[1] that could offset supply from Wivenhoe Dam and enable the flood storage compartment in the latter to be increased by lowering its full supply volume.
3. Augmentation/raising of Wivenhoe Dam, including:
    a) shorter term dam upgrades that may allow modified operations to achieve flood mitigation benefits similar to those of WSDOS alternative Urban 4
    b) longer term upgrades to meet requirements of dam safety regulation regarding passage of the probable maximum flood (PMF) whilst also allowing modified operations to achieve flood mitigation benefits similar to those of WSDOS alternative Urban 4
    c) raising Wivenhoe Dam to increase the flood storage compartment including that available for dam safety requirements.

Other potential options to supplement the SEQ Bulk Water Supply System include:

- raising Borumba Dam
- connecting Wyaralong Dam to the SEQ Bulk Water Supply System.

However, these options were not investigated as part of PIFMSI given:

- the likely significant cost of raising Borumba Dam and of providing for water treatment and connection the SEQ Bulk Water Supply System
- the similar treatment and connection costs for Wyaralong Dam, and the likely need to harvest water from Logan River to deliver a suitable increase in SEQ Bulk Water Supply System yield.

[1] A dam site on the Brisbane River near Linville is considered to be the most promising for water supply because of its large catchment size (approximately 2,000 $km^2$) and its suitability for a large storage. Considering the limited timeframe for this project and the complexity of required assessments for water supply dams, the site near Linville is the only water supply dam site proposed for consideration under PIFMSI. Other possible water supply dam sites may be flagged for assessment should the site on the Brisbane River near Linville prove unfeasible.

The aim of PIFMSI was to prioritise one or more scenarios for further feasibility assessment.

PIFMSI was a prefeasibility level assessment to decide whether or not to progress options/scenarios to full feasibility assessment. Therefore, the study has:

1. been limited to a desk-top analysis - e.g. there has been no entry onto properties for onsite geological surveys or other detailed engineering or environmental (including social and cultural heritage) assessments
2. been based on hydrologic assessments of historical flood events only
3. assumed that all new dams would be ungated dams[2]
4. prepared estimated costs which are indicative only.

Further analysis will be required at the feasibility assessment stage to incorporate both historical and stochastically generated flood events in the hydrologic assessments.

## 1.4 Past investigations

There have been numerous studies and investigations of dam sites across the Brisbane River catchment over the past 40–50 years. Most of these studies have been for the purpose of identifying potential sites for urban and/or irrigation water supply storages. These studies were generally carried out by or for the state government water resources agency of the day.

PIFMSI was primarily a desk-top study and, while limited site visits were undertaken, the study overall has relied on these past studies and investigations for more detailed information (especially information on site geological conditions for those sites taken through to conceptual designs).

All past studies that could be sourced were reviewed in preparation for PIFMSI. The previous reports considered are summarised in Table 1.3.

[2] The provision of new gated dams would require extensive work to design gate operating rules. Any new gated dam would have to be operated in co-ordination with the Wivenhoe Dam gates during floods and would therefore significantly complicate the operating rules for Wivenhoe and Somerset dams. It was not feasible to investigate gated dam options and develop and test operating rules for these types of structures within the available project timeframe.

**Table 1.3 Previous reports**

| Site | Report Name | Year | Organisation |
|---|---|---|---|
| Bremer River | Report on the Bremer River damsite AMTD 70.0 km yield and flood studies | 1981 | Queensland Water Resources Commission (QWRC) |
| Bremer River | Seismic refraction reconnaissance survey on Bremer River 67.7km and 70.0km damsites | 1981 | Queensland Department of Mines (QDM) |
| Bremer River/Warrill Creek | Bremer River and tributaries basin 143 possible water supplies - appraisal study | 1979 | QWRC |
| | Initial appraisal of the flood problem and prospects for flood mitigation in the Moreton Shire | 1975 | M.W. Moss (consulting engineer) |
| Emu Creek | A report on preliminary investigations for Emu Creek damsite at 6.7M | 1968 | Snowy Mountains Hydro-Electric Authority (SMHEA) |
| Upper Brisbane River near Linville | Brisbane River AMTD 282.1km Linville damsite investigation | 2006 | SunWater |
| | Appraisal report on dam site at Brisbane River AMTD 282.1km (Linville) | 1991 | Water Resources Commission (WRC) |
| | A report on preliminary investigations for Brisbane River damsites at 175.3M and 175.5M. | 1968 | SMHEA |
| Warrill Creek | Seismic refraction reconnaissance survey on Warrill Creek damsite | 1982 | QDM |
| Tenthill Creek (Lockyer Valley) | Tenthill Creek damsite at AMTD 29.8 km report on streamflow generation and yield analysis | 1986 | QWRC |
| | Further progress report on Lockyer Valley water resources investigation | 1982 | QWRC |

## 1.5 Project management and governance

The Department of Energy and Water Supply (DEWS) had overall responsibility for the study and preparation of this report. Completion of PIFMSI however, relied on input from a number of agencies (refer Figure 1.1). In particular, the study received substantial input from Seqwater with respect to hydrologic modelling of flood mitigation options and scenarios; and water supply modelling using the SEQ Regional Water Balance Model (WATHNET).

### 1.5.1 Project Control Group

An intergovernmental Project Control Group (PCG) chaired by the Director-General of DEWS was established. The key role of the PCG was to provide strategic guidance and direction for the prefeasibility investigation, ensure agreed milestones and timeframes were met and ensure entities understood their role in delivering on the Government's commitment.

Membership of the PCG, in addition to the DEWS chair and membership, included senior and executive officers from:

- Seqwater
- the Department of the Premier and Cabinet (DPC)
- the Department of State Development, Infrastructure and Planning (DSDIP)
- the Department of Natural Resources and Mines (DNRM)
- the Department of Science, Information Technology, Innovation and the Arts (DSITIA)
- the Department of Transport and Main Roads (DTMR).

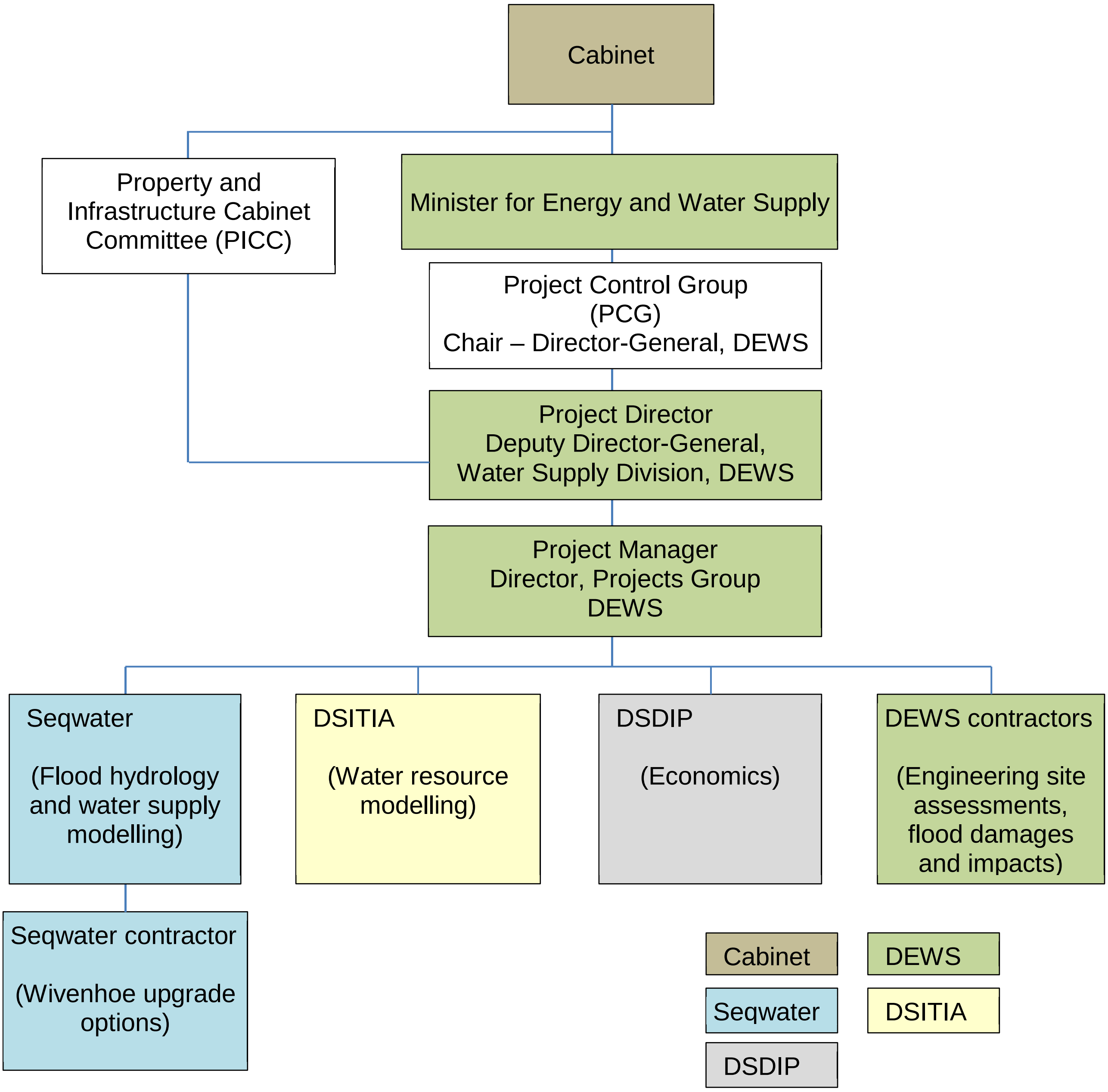



**Figure 1.1 PIFMSI project management and governance**

### 1.5.2 Property and Infrastructure Cabinet Committee (PICC)

As shown in Figure 1.1, in addition to the project governance arrangements established within and across the key agencies, PIFMSI came within the scope of the Property and Infrastructure Cabinet Committee (PICC) as a potential key/major infrastructure project.

In mid-2014, based on the progress of PIFMSI to that point, PICC endorsed a shortlist of potential new dam sites which covered the upper Brisbane River, Bremer River and Lockyer Creek catchments for continued prefeasibility assessment. These shortlisted sites included:

- Upper Brisbane River near Linville
- Emu Creek near Harlin
- Bremer River near Mt Walker
- Lower Warrill Creek near Willowbank

- Upper Warrill Creek near Aratula
- Tenthill Creek near Caffey
- Laidley Creek near Thornton.

## 1.6 Relationship with other recent/ongoing studies

PIFMSI is relevant to:

- the implementation of WSDOS and dam safety works requirements for current Urban 3 operations and understanding such requirements for potential Urban 4 operations
- the undertaking of the Brisbane River catchment studies, comprising:
  - the Brisbane River Catchment Flood Study (BRCFS) being led by DNRM
  - the Brisbane River Catchment Floodplain Management Study (BRCFMS) and Management Plan (BRCFMP) being led by DSDIP, and may impact
- the SEQ water security program to be developed by Seqwater.

### 1.6.1 Brisbane River catchment studies

The BRCFS will result in improved hydrologic and hydraulic models for the Brisbane River. The hydrologic and hydraulic models will be used to determine flood parameters for the Brisbane River catchment downstream of Wivenhoe Dam, including inundation depth, extent and duration of flooding and flow velocity. The hydrologic and hydraulic assessments undertaken by the flood study will provide important information to better plan for and minimise the impacts of future floods in the Brisbane River catchment. The flood study is due to be completed in late 2015[3].

The Brisbane River Catchment Floodplain Management Study utilise outputs from the BRCFS to identify flood risks, and assess various options to increase community resilience to floods in the Brisbane River catchment. The floodplain management study is due for completion in late 2017.

Both the BRCFS and BRCFMS will inform the preparation of the BRCFMP that would guide land use planning and development.

### 1.6.2 The SEQ Water Security Program

The water security program will facilitate the achievement of the desired level of service objectives for SEQ as outlined in the Water Regulation 2002 (Qld) and is anticipated to be completed by Seqwater in mid-2015. The water security program will outline future water infrastructure needs, demand management measures and responses to drought conditions.

[3] Given that the revised BRCFS hydraulic model was not available for PIFMSI, the hydraulic model developed by Brisbane City Council (BCC 2009) was used to assess Brisbane River peak flows from 3,000 $m^3/s$ to 38,000 $m^3/s$ (at the Brisbane Port Office gauge)

# Chapter 2 Flood mitigation opportunities

This chapter describes the Brisbane River catchment and the flood mitigation options considered in the Prefeasibility Investigation into Flood Mitigation Storage Infrastructure (PIFMSI).

## 2.1 Brisbane River catchment

The Brisbane River catchment is bounded by the Great Dividing Range to the west and a number of smaller coastal ranges to the east and the north. The headwaters are at the northern extent of the catchment, bounded by the Brisbane Range approximately 120 km north west of Brisbane City (Middelmann et al. 2001).

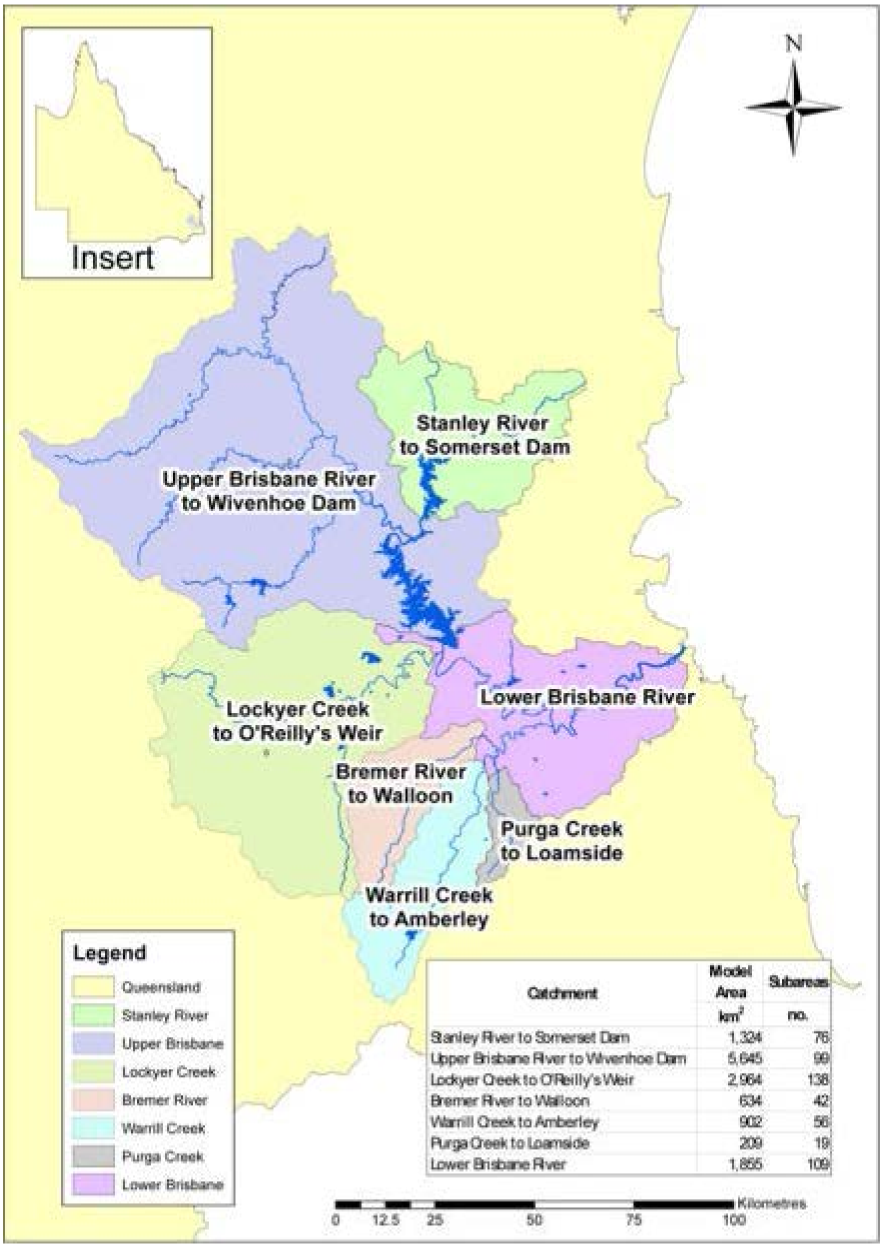
The Brisbane River catchment (see Figure 2.1) has an area of approximately 14,000 $km^2$ - around half of which discharges into the Brisbane River downstream of Wivenhoe Dam - and comprises seven main sub-catchments as follows:

- Sub-catchments discharging upstream of Wivenhoe Dam:
  - Upper Brisbane River
  - Stanley River
- Sub-catchments discharging downstream of Wivenhoe Dam
  - Lockyer Creek
  - Bremer River
  - Warrill Creek
  - Purga Creek, and
  - Lower Brisbane River (includes the metropolitan creeks of Ipswich and Brisbane).

## 2.2 Flooding characteristics of the Brisbane River catchment

Flooding in the Brisbane River catchment is complex given the size of the catchment, the number of contributing tributaries and the presence of existing flood mitigation storages (chiefly Wivenhoe and Somerset dams). The Brisbane River catchment being located in a sub-tropical region is susceptible to sustained periods of heavy rainfall (generally associated with cyclonic influences, rain depressions or with 'East-Coast Low' events). Heavy rainfall in any one of the major tributaries or from a number of tributaries can produce flooding within the Brisbane River catchment.

Flooding in the lower Brisbane River can be impacted by tidal and storm surge influences especially for smaller or minor floods (e.g. the peak flood level in Brisbane for the January 2013 flood event occurred the day before the arrival of the flood peak due to the occurrence of a higher king tide).




| Catchment | Model Area km² | Subareas no. |
|---|---|---|
| Stanley River to Somerset Dam | 1,324 | 76 |
| Upper Brisbane River to Wivenhoe Dam | 5,645 | 99 |
| Lockyer Creek to O'Reilly's Weir | 2,964 | 138 |
| Bremer River to Walloon | 634 | 42 |
| Warrill Creek to Amberley | 902 | 56 |
| Purga Creek to Loamside | 209 | 19 |
| Lower Brisbane River | 1,855 | 109 |

Source: Seqwater 2013a, Figure 6.1

**Figure 2.1 Brisbane River sub-catchments**

Flooding in the Brisbane River catchment can be characterised as:

i. **local flooding:** This type of flooding may affect a local community and may or may not be part of broader regional or sub-regional flooding.

ii. **broadscale (regional, sub-regional or sub-catchment) flooding:** This type of flooding occurs when heavy rainfall occurs over wide areas of the catchment including tributaries and sub-catchments (e.g. Lockyer Creek, Bremer River). Local flooding can be exacerbated by backwater effects where water backs up streams and drainage networks to slow the outflow of flood waters and raise flood levels.

The focus of this investigation is to reduce the broadscale flooding impacts on Brisbane and Ipswich.

Major flooding in Ipswich (defined by BoM (2014b) as a flood level greater than 11.7 m AHD at David Trumpy Bridge) can result from Brisbane River floods alone (due to backwater flooding); from Bremer River floods alone; or from a combination of both (Babister M 2011a).

Babister (2011a) found that during coincident Bremer and Brisbane River floods, Brisbane River backwater flooding can add 5 m to the flood height at Ipswich.

### 2.2.1 Historic floods

Earliest flood records following European settlement in 1824 note a significant flood on the Bremer River at Ipswich in 1840 and a very large flood on the Brisbane River at Brisbane in 1841.

The estimated volumes of some larger historic floods (dating back to 1887) are presented in Table 2.1 (rounded down to the thousand ML).

**Table 2.1 Selected historic flood inflow volumes (post 1887)**

| Flood event | Historic flood inflow volumes (ML) [1] | | | |
|---|---|---|---|---|
| | Sub-catchments upstream of Wivenhoe Dam | | Sub-catchments downstream of Wivenhoe Dam | |
| | Stanley R at Somerset Dam | Brisbane R at Wivenhoe Dam [2] | Lockyer Ck at O'Reillys Weir | Bremer R at Ipswich |
| Jan 1887 | Not calculated | Not calculated | 398,000 | 590,000 |
| Feb 1893 [3] 1st Flood | 1,440,000 | 3,413,000 | 546,000 | 250,000 |
| Feb 1893 [3] 3rd Flood | 630,000 | 2,085,000 | 699,000 | 526,000 |
| Mar 1955 | 546,000 | 1,201,000 | 142,000 | 113,000 |
| Jan 1974 | 714,000 | 1,967,000 | 659,000 | 676,000 |
| Feb 1976 | Not calculated | Not calculated | 103,000 | 215,000 |
| May 1996 | Not calculated | Not calculated | 565,000 | 434,000 |
| Feb 1999 | 452,000 | 1,399,000 | 49,000 | 66,000 |
| Jan 2011 | 822,000 | 2,710,000 | 589,000 | 481,000 |
| Jan 2013 | Not calculated | Not calculated | 275,000 | 350,000 |

Notes:

1. Volumes generally based on Seqwater's URBS hydrologic model calculations. Some volumes based on reverse routing especially for inflows into Somerset and Wivenhoe dams.
2. Inflow volume into Wivenhoe Dam includes contribution from the Stanley River sub-catchment.
3. Three floods occurred in February 1893. The first peaked on 5 February, the second on 13 February and the third on 19 February. The second February 1893 flood was lower than the first and the third and did not factor into the ten largest historical floods listed in Table 2.1 (BoM 2014c).

Source: Seqwater 2014a, attachment

## 2.3 Flood mitigation opportunities

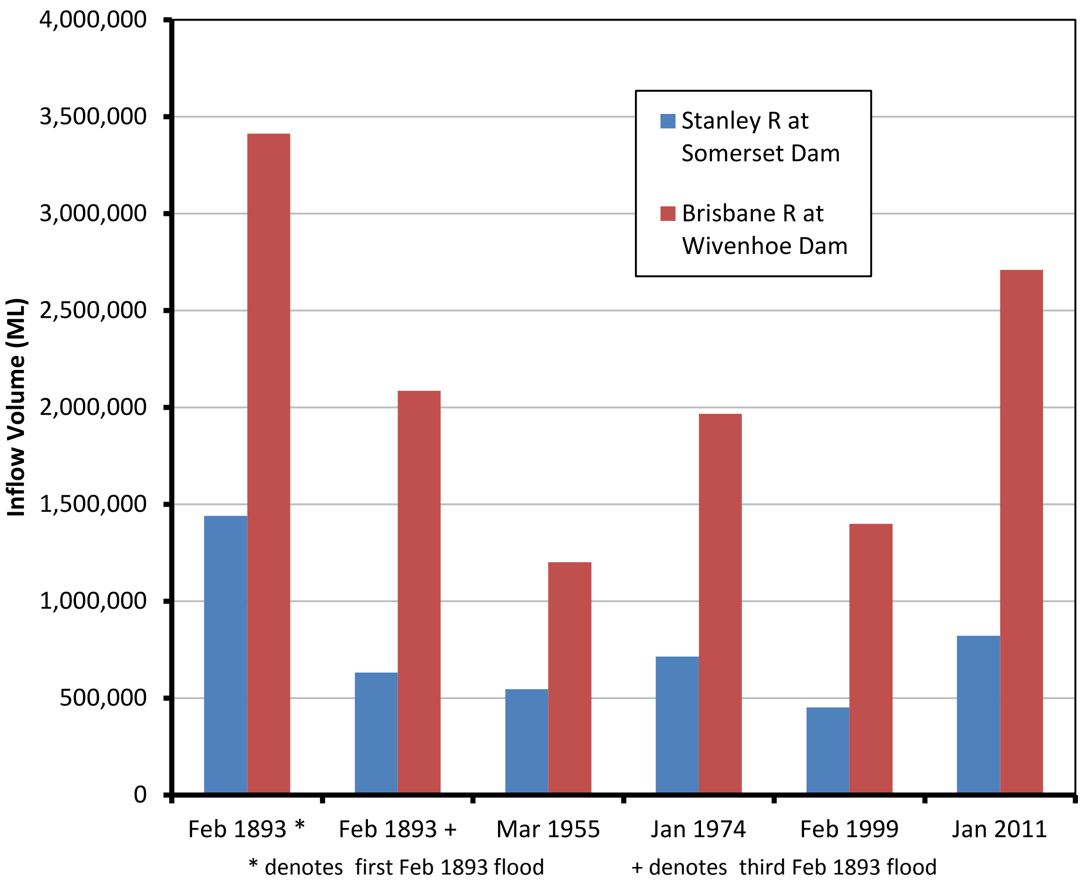
Preliminary assessments carried out by GHD (2011) indicated that in order to provide any impact on flood volumes in the Brisbane River, flood retention dams in the order of 500,000–700,000 ML storage volume would be required across the Brisbane River catchment.

### 2.3.1 Sub-catchments upstream of Wivenhoe Dam

The upper Brisbane and Stanley rivers drain an area of approximately 7,000 km$^2$ (including the catchment of Somerset Dam) into Wivenhoe Dam. The major tributaries of the Upper Brisbane River - Cooyar, Emu and Cressbrook creeks - drain in a south-easterly direction and join the Brisbane River upstream of its junction with the Stanley River, just below Somerset Dam (Seqwater 2013a).

Flood volumes for historic flood events (see Table 2.1) range from approximately 1,200,000 ML for the 1955 flood event to approximately 3,400,000 ML for the 1893 (first recorded flood) event. The volumes of significant historic floods in the Stanley and Upper Brisbane rivers are shown in Figure 2.2.

Notes:




Note:

1. Flood volumes shown are inflow flood volumes for selected flood events at the specified location.

Source: Seqwater 2014a, attachment

**Figure 2.2 Historic flood volumes for the Brisbane River catchment upstream of Wivenhoe Dam**

The Brisbane River catchment upstream of Wivenhoe Dam already has significant flood mitigation storage volume (in excess of 2,000,000 ML) in place at Somerset and Wivenhoe dams.

New flood mitigation storages located upstream of Wivenhoe Dam would provide more flood mitigation capacity but do not improve ‘catchment command’, i.e. they would have no influence on the magnitude of floods originating in catchments downstream of Wivenhoe but could reduce the effects of coincidental flooding as necessary releases from Wivenhoe could be minimised.

### 2.3.2 Sub-catchments downstream of Wivenhoe Dam

Sub-catchments downstream of Wivenhoe Dam account for approximately half of the entire Brisbane River catchment. The Brisbane River catchment downstream of Wivenhoe only has 5% of the combined water supply and flood storage volume of the combined Wivenhoe and Somerset dams (4,233,087 ML). New flood mitigation storages located on tributaries downstream of Wivenhoe would enhance the ‘command’ of the overall catchment but only moderately sized storage sites exist.

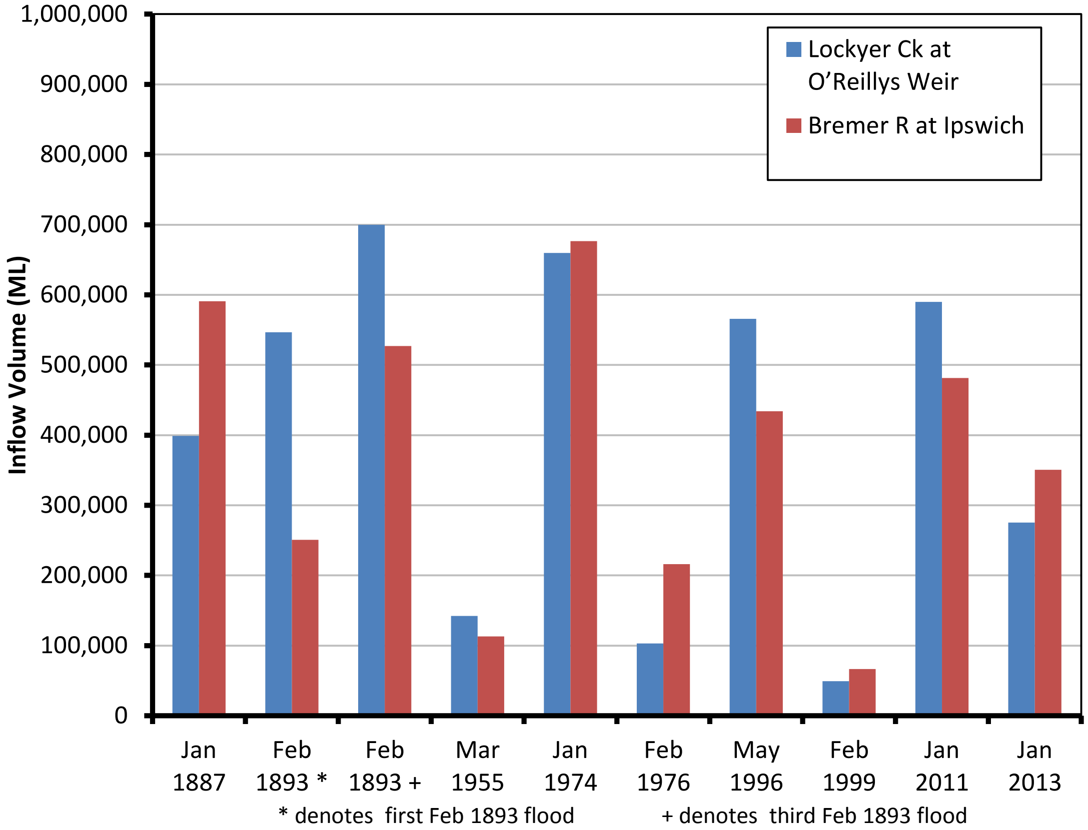
The two largest sub-catchments downstream of Wivenhoe Dam are the catchments of Lockyer Creek and the Bremer River which together account for over 70% of the Brisbane River catchment area downstream of Wivenhoe Dam.

**Lockyer Creek**

In the lower catchment, Lockyer Creek forms the largest tributary of the Brisbane River in terms of catchment size, commanding an area of around 2,964 $km^2$ (Seqwater 2013a). Lockyer Creek drains into the Brisbane River immediately downstream of Wivenhoe Dam near Lowood. Lockyer Creek has a number of major tributaries including Murphys Creek, Flagstone Creek, Sandy Creek, Gatton Creek, Laidley Creek and Buaraba Creek.

The upper parts of the Lockyer Creek catchment to the south and west are generally steep and forested while the lower floodplains are used for intensive agriculture with a number of small population centres located across the area (ICA 2011; Healthy Waterways 2013).

Flood volumes for historic flood events in the Lockyer Creek catchment (see Table 2.1) range from approximately 50,000 ML for the 1999 flood event to approximately 700,000 ML for the 1893 (third flood) flood event. These flood volumes are shown in Figure 2.3.




Notes:

1. Flood volumes shown are inflow flood volumes for selected flood events at the specified location

Source: Seqwater 2014a, attachment

**Figure 2.3 Historic flood volumes for the Brisbane River catchment downstream of Wivenhoe Dam**

No significant water storages have been constructed in the Lockyer Valley apart from Lake Atkinson, Lake Clarendon and Lake Dyer (approximately 62,000 ML combined volume). There is however significant natural floodplain storage (in the order of hundreds of thousands of megalitres) in lower Lockyer Creek prior to its entry into the Brisbane River downstream of Wivenhoe Dam.

A limiting factor for the location of new water storages within the Lockyer Valley is the potential impact to agriculture through the inundation of highly fertile floodplains.

## Bremer River

The second largest tributary of the Brisbane River downstream of Wivenhoe Dam is the Bremer River, which commands a catchment area of around 1,869 km$^2$ (Seqwater 2013a). The tributaries of the Bremer River have their headwaters in the Little Liverpool range to the southwest, and drain in a north easterly direction into the Bremer River, which drains into the Brisbane River at Moggill (ICA 2011). Bremer River has a number of major tributaries including Warrill Creek and Purga Creek.

The Bremer River catchment is generally steep and lightly forested, except the lower north-eastern areas which drain through the City of Ipswich (ICA 2011; Healthy Waterways 2013).

Flood volumes for historic flood events in the Bremer River catchment (see Table 2.1) range from approximately 70,000 ML for the 1999 flood event to approximately 680,000 ML for the 1974 flood event. These flood volumes are also shown in Figure 2.3.

No significant water storages have been constructed in the Bremer River catchment apart from Lake Moogerah (84,000 ML storage volume). Given the size of historic flood events for Bremer River only floods (without any coincident Brisbane River flooding), any increase in flood storage within the catchment has the potential to provide significant flood mitigation benefits to Ipswich.

**Other sub-catchments**

Other sub-catchments of the Brisbane River downstream of Wivenhoe Dam include the Mid Brisbane, Lower Brisbane, Oxley Creek, Enoggera/Breakfast Creek, Norman Creek and Bulimba Creek.

## 2.4 Sizing of infrastructure

It is impossible to mitigate all floods (i.e. up to and including the PMF) that could affect Ipswich and Brisbane. The potential size of a PMF event for the Wivenhoe Dam catchment alone is currently estimated to be five times greater (based on peak inflow rate) than the 1893 flood; the largest recorded historical flood (URS 2013).

This investigation has focussed on mitigating the range of floods that have been experienced historically (i.e. from 1887 to 2013). The recent January 2011 flood was assessed as having an annual exceedance probability (or annual likelihood of occurrence) of 1 in 120 for Brisbane and approximately 1 in 100 for Ipswich with the current dams in place (Babister M 2011a, 2011b). This investigation has aimed at providing a flood mitigation benefit to Ipswich and Brisbane for floods up to this order of magnitude.

Due to the volumes of these historic floods (in the range of hundreds of thousands to millions of megalitres), it is necessary to provide very large flood storage volumes within the catchment (either as single stand-alone storages or combinations of storages) to achieve flood mitigation benefits in Ipswich and Brisbane.

This investigation has used historical sub-regional and regional floods to determine which sites have significant flood mitigation potential.

## 2.5 Broad infrastructure option types

Options for infrastructure to provide flood mitigation benefits therefore are essentially based on providing more flood storage and ensuring this additional storage is large enough and appropriately located such that its benefits are maximized. In the Brisbane River catchment more flood storage could be achieved by:

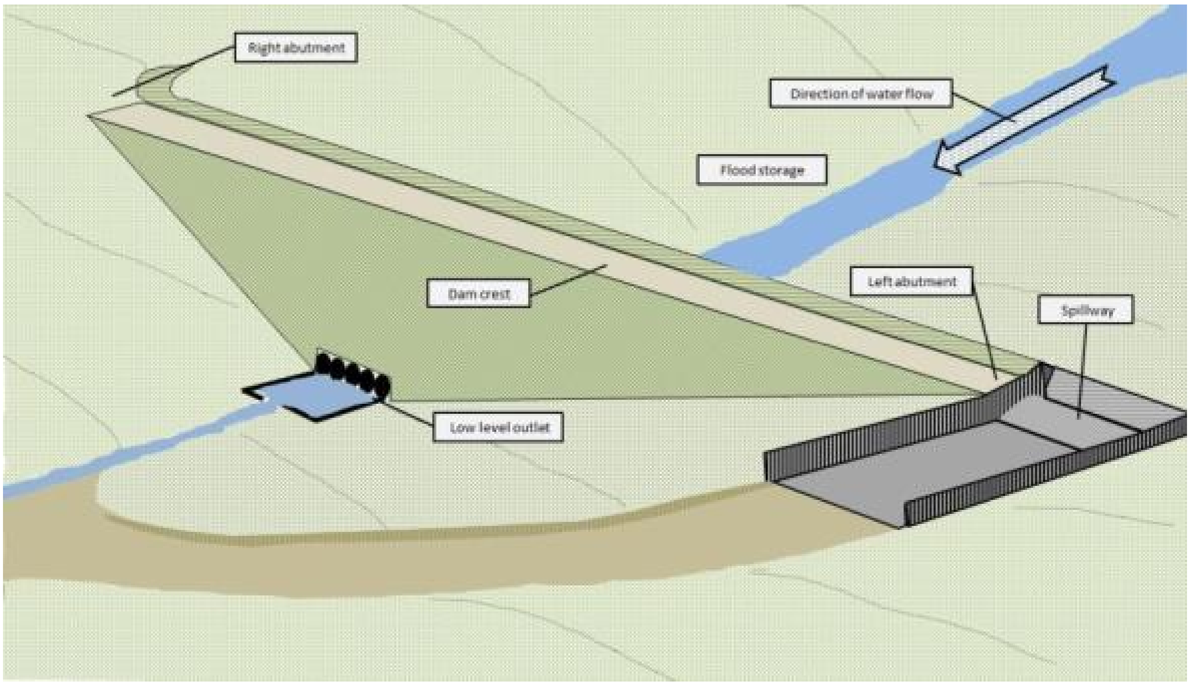
- the construction of new flood mitigation storages
- construction of substitution water supplies to allow more of the existing capacity of Wivenhoe Dam to be used for urban flood mitigation
- Wivenhoe Dam raising/dam safety improvements to improve its dam safety and provide additional flood mitigation storage

For this investigation, all new dams have been assumed to have ungated spillways (i.e. free overfall) and, on flood mitigation dams – uncontrolled bottom outlets. Actively managed spillways and outlets would not only add additional cost to each option/structure, but would introduce complexity to combined dam operations that are beyond the scope of this investigation.

### 2.5.1 New flood mitigation storages

Flood storage is typically provided by retention (flood mitigation) dams. Such dams typically have no water supply compartment and need to be kept empty (or dry) in readiness for a significant flood event. These structures typically have permanently open (ungated) low level outlet works with a relatively low flow capacity. Attenuation of the incoming flood peak is achieved by temporarily storing a significant portion of the flood with release over a longer period via the permanently open low level outlet works. Major floods greater than the capacity of the low level outlet works would be passed over a spillway.

A typical configuration of a flood mitigation dam showing specific features is shown in Figure 2.4.

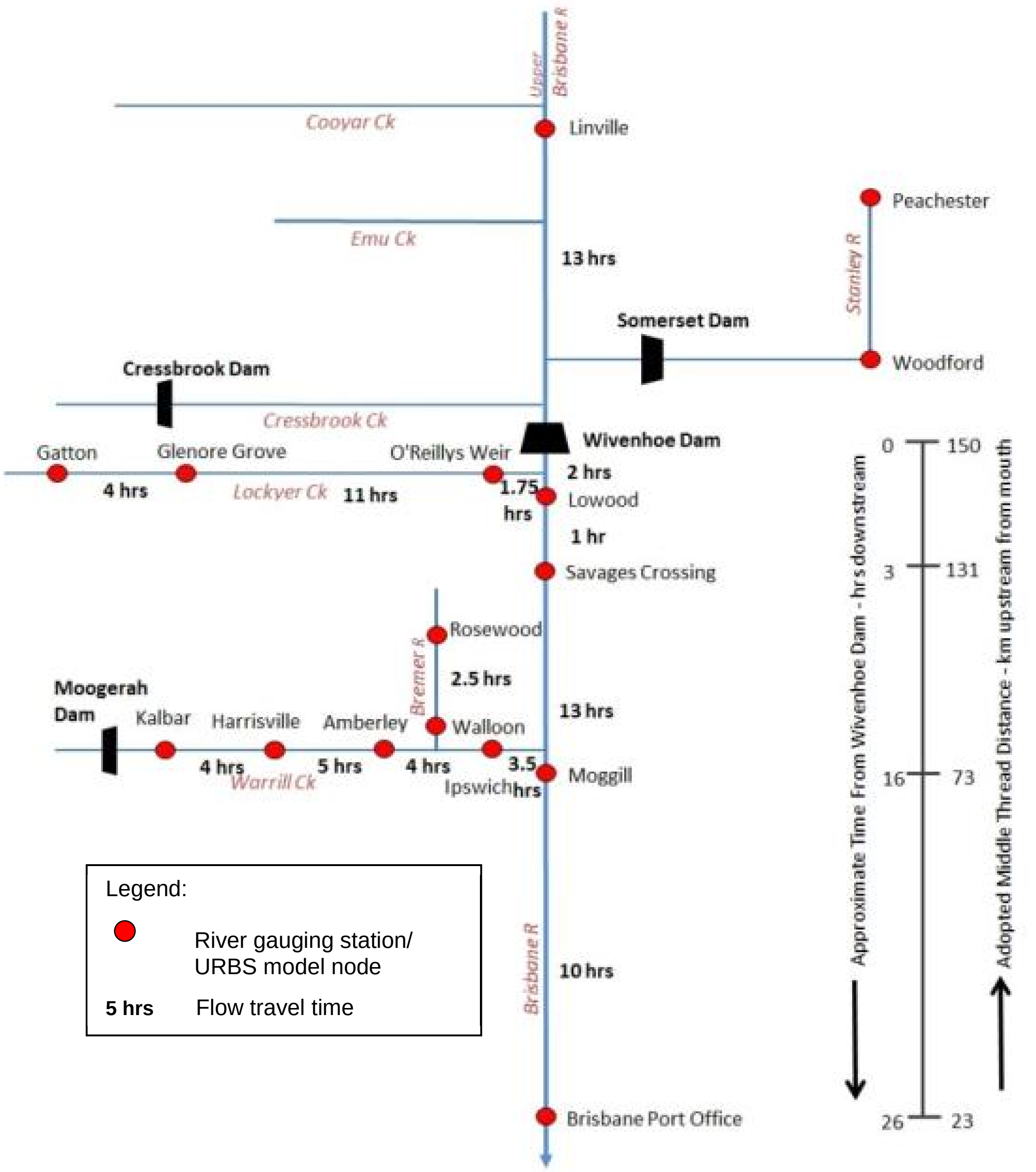



Notes:

1. When referring to left and right sides of any water storage structure the point of reference is as viewed looking downstream.

**Figure 2.4 Typical flood mitigation dam configuration**

Delaying and lowering peak flows can have its own issues, as longer discharge periods for individual sub-catchments may, in a complex catchment like the Brisbane River, result in more coincident flows in some flood events. Figure 2.5 shows approximate travel times for releases from Wivenhoe Dam to reach key locations along the Brisbane River. This gives some indication of the possible interaction of delayed discharges between catchments and the potential for exacerbating flooding in some instances.




Source: Based on Seqwater 2013b, Appendix M and GHD 2011, Figure 1

**Figure 2.5 Brisbane River – approximate travel times**

### 2.5.2 Substitution water supplies

Substitution water supplies refers to storages which could substitute (or offset) the water supply volume currently provided by existing dams. In this way substitution water supply storages allow the water supply volumes in existing dams to be lowered and the corresponding increase in storage volume to be allocated for flood mitigation purposes with no net reduction in the water supply yield of the system.

Given Wivenhoe Dam's significant strategic command of a major proportion of the overall Brisbane River catchment (i.e. almost half of the catchment), substitution water supplies considered in this investigation have been in conjunction with lowered full supply volumes in Wivenhoe Dam.

The only option for creating a substitution supply considered in this investigation is the potential dam site on the Brisbane River above Wivenhoe Dam near Linville.

Other options to supplement the water supply capacity in SEQ include:

- raising of Borumba Dam
- connection of Wyaralong Dam to the water supply network.

These options were not investigated in PIFMSI for the reasons given in the section on investigation scope (refer section 1.3).

Options considered for the site at Brisbane River near Linville include both a flood mitigation and a water supply storage – noting that the water supply option will also provide some flood mitigation benefit on its own as well as allowing an increase in the flood storage compartment of Wivenhoe Dam.

### 2.5.3 Wivenhoe Dam raising/dam safety improvements

Finally, raising Wivenhoe Dam to achieve flood mitigation benefits and dam safety improvements has been investigated. Wivenhoe Dam requires dam safety improvements to be completed by 2035 under the legislation although it is currently anticipated that such work would be completed by the mid-2020s. Also, as reported in WSDOS, Alternative Urban 4 (or similar) operational strategy cannot be considered for implementation without further understanding and addressing the potential dam safety implications.

Hence, for this investigation, a number of options for improving dam safety and increasing the flood mitigation capacity of Wivenhoe Dam have been investigated (by Seqwater) as follows:

- current dam with no crest raising but additional spillway to pass PMF – with WSDOS Urban 3 strategy (base case)
- current dam with no crest raising but additional fuse plug spillways to pass PMF – with WSDOS Urban 4 strategy (i.e. raised dam safety trigger level)
- various raisings of the dam crest (from 1.5 m to 8 m) with additional spillway/fuse plug spillways to pass the PMF.

# Chapter 3 Methodology

## 3.1 Introduction

This chapter provides an overview of the methodology adopted for identifying, assessing and shortlisting potential flood mitigation infrastructure options for the Prefeasibility Investigation into Flood Mitigation Storage Infrastructure (PIFMSI).

## 3.2 PIFMSI methodology

The key components of the PIFMSI methodology included:

- Site identification and shortlisting, flood mitigation scenario development and overall project management and report preparation undertaken by the Department of Energy and Water Supply (DEWS)
- Flood hydrology assessments undertaken by Seqwater
- Water supply assessments undertaken by the Department of Science, Information Technology, Innovation and the Arts (DSITIA) and Seqwater
- New sites assessment undertaken by DEWS
- Wivenhoe Dam upgrades assessment undertaken by Seqwater
- Cost-benefit/economic assessment of the scenarios by the Department of State Development, Infrastructure and Planning (DSDIP).

The methodology comprised the following key steps:

1. Identification of potential new flood storages/dam sites based on previous reports and topographical review of the catchments.
2. Screening of potential new flood storages/dam sites based on their potential to impact a significant proportion of the historical flood event volumes as estimated at the sub-catchment scale (i.e. at Wivenhoe Dam inflow, Lockyer Creek at O'Reillys Weir, Bremer River at Walloon, Warrill Creek at Amberley and Purga Creek at Loamside), as well as practical considerations of likely impacts versus benefits.
3. Determination of nominal storage development volumes to enable meaningful reductions in peak outflows for the historical flood events.
4. Verification that the nominal storage volumes defined in Step 3 are topographically achievable for the shortlisted sites using Shuttle Radar Topographic Mission (SRTM) data.
5. Catchment scale (i.e. Upper Brisbane River, Bremer River and Lockyer Creek catchments) flood routing with the nominal size dams to determine catchment outflow hydrographs and define the storage required for flood mitigation.
6. For the dam near Linville water supply offset option, determination of the possible reduction in the Wivenhoe Dam full supply volume (FSV) that could be made whilst maintaining the yield of the SEQ Bulk Water Supply System.
7. Site assessments of the shortlisted flood storage/dam sites comprising conceptual designs (including drawings), geotechnical assessments, land acquisition requirements, infrastructure relocation, environmental, social/cultural heritage and agricultural land impacts and estimates of cost; determine the PMF/PMPDF to inform spillway sizing for the shortlisted dams.
8. Formulation and assessment of Wivenhoe Dam augmentation options to determine conceptual designs (including drawings); cost estimates and relevant impacts.

9. Assessment of flood mitigation performance of new storage sites and Wivenhoe Dam augmentation options.
10. Identify potential future flood storage/dam development scenarios comprising combinations of shortlisted new flood storages/dam sites and Wivenhoe Dam augmentation options.
11. Brisbane River Basin scale historical flood simulations of all identified scenarios to assess the flood mitigation potential in the mid and lower Brisbane River catchment.
12. Assessment of flood damage and flood impact cost reductions based on historical floods.
13. Scenario evaluation comprising benefit-cost calculations for the scenarios based on integrated assessment of flood damage and flood impact reductions and estimated costs.

The key components of the PIFMSI and the responsible agencies are summarised in Figure 3.1.

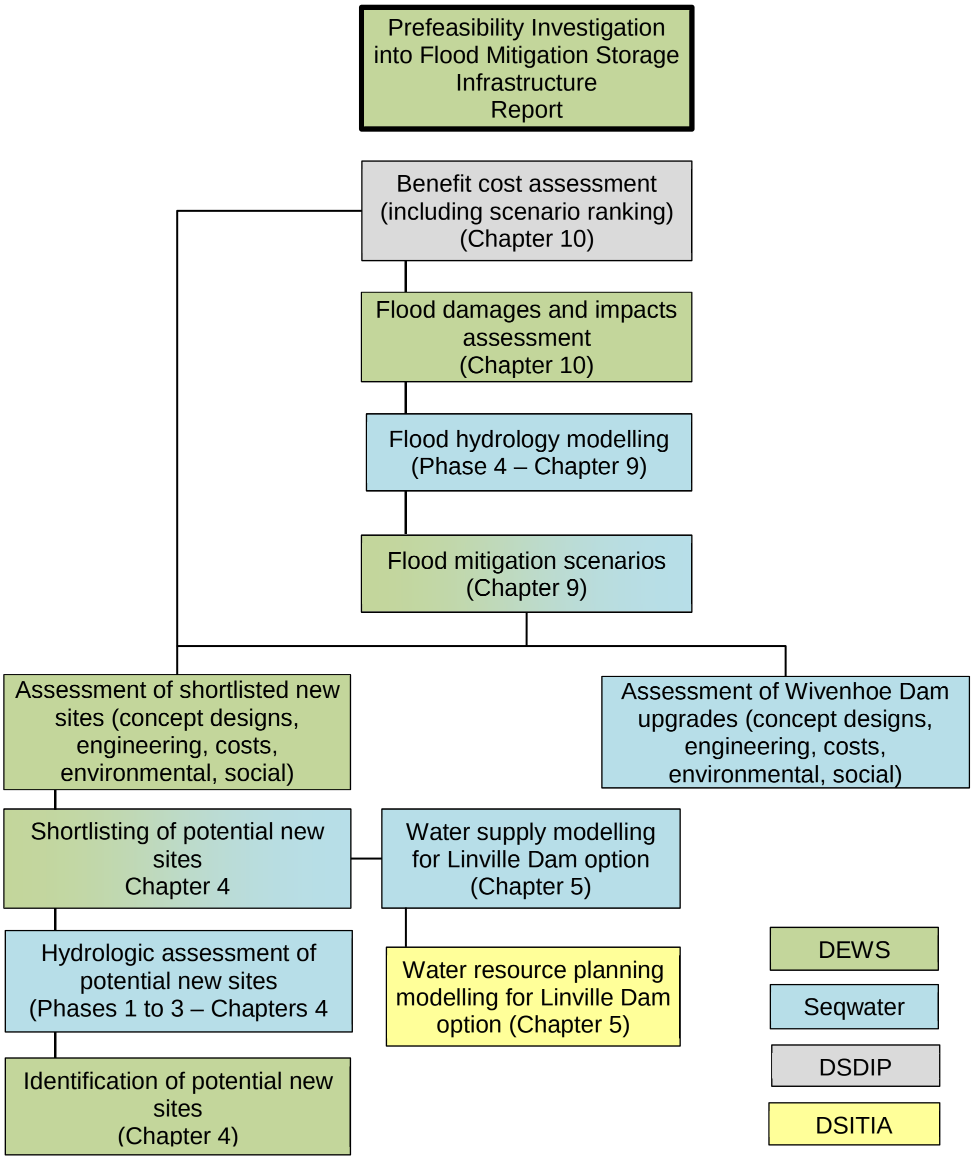



**Figure 3.1 PIFMSI key Tasks and responsibilities**

## 3.3 Site identification (Step 1)

From more than 40 years of past technical and engineering reports, previously investigated water supply dam sites across the Brisbane River Basin were considered as flood mitigation dams (refer to Chapter 4 for further detail).

In addition to existing reports, satellite imagery and topographical maps of the Brisbane River Basin were assessed for locations with suitable topographical features for dam development. Up to 39 locations (including Wivenhoe Dam) were identified for further consideration as flood mitigation dams sites, based on previous assessment or the presence of terrain suitable for dam construction.

A single site would be unlikely to deliver the flood mitigation benefits sought across the range of floods. Hence it was assumed that multiple sites would need to be considered.

Sites which had potential to allow for water supply offset (and thereby allow increased flood mitigation storage at Wivenhoe Dam) with minimal need for new pumping and water treatment infrastructure were also identified.

## 3.4 Flood hydrology assessment (Steps 2, 3, 5 & 11)

The flood hydrology assessment was undertaken in four phases, with assessment scale increasing through dam site, sub-catchment, and catchment/basin scale. Comprehensive hydrologic assessment was necessary to determine potential flood mitigation benefits. A risk was the potential for a new dam on the Bremer River or Lockyer Creek to worsen flooding in the lower Brisbane River due to delayed tributary flows coinciding with releases from Wivenhoe Dam.

Undertaking the assessment in multiple phases at increasing catchment scale allowed a progressive refining of the originally identified potential sites on a hydrologic basis.

All four phases of flood hydrology assessments used historical floods. The four phases were:

Phase 1. Screening of potential dam sites based on estimated historical flood event volumes at each site. Using the Seqwater Unified River Basin Simulator (URBS) model, the flood volumes were estimated at each site for each of the nine largest historical floods for the sub-catchment to indicate each site's potential to influence a significant proportion of the total flood volume at the representative sub-catchment 'outlets' (i.e. Brisbane River at Wivenhoe Dam inflow, Lockyer Creek at O'Reillys Weir, Bremer River at Walloon, Warrill Creek at Amberley and Purga Creek at Loamside). Sites capable of influencing less than approximately 5% of the total sub-catchment flood volume affected were eliminated (refer to Seqwater technical memorandum nos. 001 and 002; Seqwater 2014a).

Phase 2. Preliminary routing for indicative volumes of flood mitigation storage required. Each of the dam sites shortlisted in Phase 1 were remodelled using the nine largest historical floods for their respective sub-catchments to give indicative storage volumes required to achieve a target reduction in peak outflow at the dam site. Three outlet scenarios were assessed for each site to identify potential variations in the degree of flood mitigation due to the hydraulic performance of a structure at the site (refer to Seqwater technical memorandum nos. 003, 004 and 005; Seqwater 2014a).

Phase 3. Brisbane River basin sub-catchment scale (i.e. Upper Brisbane River, Bremer River and Lockyer Creek catchments) flood routing was undertaken using the URBS model to assess the potential benefit of approximate dam configurations on the sub-catchment outflows or inflows to Wivenhoe Dam and derive a list of selected dam sites where a meaningful reduction in sub-catchment outflow could be achieved. This assessment was also based on the largest historical floods (refer to Seqwater technical memorandum no. 006; Seqwater 2014a).

Phase 4. Brisbane River basin scale flood simulation using URBS and the Seqwater Flood Operation Simulation Model (FOSM) to model the combined influence of modified flood hydrographs in combination with Wivenhoe Dam flood operations to assess the overall effect on peak flood flows in the mid and lower-Brisbane River and peak levels in the Bremer River at Ipswich (refer to Seqwater technical memorandum no. 008; Seqwater 2014a).

## 3.5 Water supply offset assessment (Step 6)

Sites identified as having potential to offer water supply offset benefits with minimal additional infrastructure requirements were further screened based on inspection of previous reports, topographical maps and geotechnical information.

Using the Moreton (Water Resource) Plan 2007 (Qld), Integrated Quantity and Quality Model (IQQM) simulations were undertaken to establish the required full supply volume (FSV) for a potential water supply offset dam near Linville to maintain security of supplies from Mt Crosby, with no worsening of environmental flow objectives. Relevant assessments were undertaken for a potential permanent reduction of Wivenhoe Dam to 85%, 75% or 60% FSV. As a result, three full supply levels were determined for the Linville water supply offset dam for further assessment.

Following the IQQM simulations, stochastic modelling using the SEQ Regional Water Balance Model (WATHNET) was undertaken for the defined Linville Dam FSVs and concurrent Wivenhoe Dam FSV reductions to verify that SEQ level of service (LOS) yields could be maintained (refer to Chapter 6 for further detail).

## 3.6 Engineering, environmental impact and cost assessment of new sites (Step 7)

Engineering, environmental impact and estimated cost assessments were undertaken for each shortlisted site, including for the proposed water supply offset dam near Linville (SMEC 2014). Site and impact assessments were based on:

- desktop review of available topographic, geological and geotechnical information
- searches of various online databases, such as Queensland Globe, the Wildlife online database and the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) protected matters search tool
- desktop assessment of land use, cultural heritage, environmental and social impacts based on likely inundation extents and durations, land acquisition, infrastructure loss/replacement and assumed designed elements, supplemented by high level site inspections from publically accessible vantage points.

Site assessment included development of preliminary concept designs for each site, including selection of the preferred dam axis, review of the hydrological and hydraulic aspects of the site, selection of the preferred dam type, preliminary spillway and outlet sizing and development of preliminary dam cross-sections and general arrangements.

In sizing the preliminary spillway, initial estimates using approximate formulas for the PMPDF (Malone T 2011) and the PMF (Nathan et al. 1994) were made by DEWS for the Phase 2 shortlisted dam sites. Given significant deviations between these estimates, Seqwater derived the PMPDF inflow hydrographs for the four dam sites considered most promising, using rainfall data and hydrological models. The conservative estimate (i.e. the PMPDF – Malone T 2011) was used for the remaining dam sites.

The final component of site assessment was project cost estimation. This comprised estimation of a prefeasibility level cost which included all construction costs, land acquisition and infrastructure relocations and general indirect costs for each of the dam sites/configurations. The estimated cost for dam development was used for benefit cost assessments of the options/scenarios.

## 3.7 Wivenhoe Dam augmentation/raising assessment (Steps 8 & 9)

Seqwater led the prefeasibility assessment of options for Wivenhoe Dam augmentation/raising. This assessment included consideration of:

i. the longer term upgrades necessary to meet the dam safety regulatory requirements of safely passing the probable maximum flood (PMF)
ii. upgrades that may allow modified operations to achieve flood mitigation benefits similar to WSDOS alternative Urban 4
iii. potential raising of Wivenhoe Dam to increase the available flood mitigation storage (which would include (i) and negate the need for (ii)).

Five Wivenhoe Dam augmentation options were assessed including:

1a. WSDOS alternative Urban 3 (i.e. *Dam Safety Strategy* trigger level at EL 75.0 mAHD). No raising of the dam crest. Third spillway built to pass PMF.
1b. WSDOS alternative Urban 4 (i.e. *Dam Safety Strategy* trigger level at EL 76.2 mAHD). Additional fuse-plug spillway capacity to pass PMF.
2. Flood operations with *Dam Safety Strategy* trigger level at EL 76.2 mAHD. Wivenhoe Dam crest raised 1.5 m to EL 81.6 mAHD. Existing fuse-plug crest raised 1 m. Additional fuse-plug spillway capacity to pass PMF.
3. Flood operations with *Dam Safety Strategy* trigger level at EL 77.0 mAHD. Wivenhoe Dam crest raised 4 m to EL 84.1 mAHD. Existing fuse-plug crest raised as required. Additional fuse-plug spillway capacity to pass PMF.
4. Flood operations with *Dam Safety Strategy* trigger level at EL 80.0 mAHD. Wivenhoe Dam crest raised 8 m to EL 88.1 mAHD. Existing fuse-plug crest raised as required. Additional fuse-plug spillway capacity to pass PMF.

Seqwater (and external contractor) reviewed all available data including inflow data and operational requirements, giving consideration to:

- limitations of the existing radial gated spillway
- limitations of the fuse-plug auxiliary spillway
- limitations to raising the main and left hand embankment
- limitations to raising the saddle dams.

Design flood events were routed through the storage to allow the development of the gross dimensions for the proposed options. Flood routing was undertaken in order to define for each option the adopted crest height (including any freeboard allowance) and the spillway dimensions (including sill levels, depth, gate heights, width and locations).

Rating curves were developed for all of the spillways to allow assessment of the flood mitigation provided by each option.

Preliminary designs were developed for each option using the defined spillway configurations.

Using the preliminary designs, preliminary cost estimates were prepared for each of the Wivenhoe Dam augmentation options.

## 3.8 Scenario development (Step 10)

Scenario development involved collation of relevant combinations and permutations of options (i.e. water supply offset dams, dry flood mitigation dams and Wivenhoe Dam augmentation options) for testing through basin scale hydrologic modelling (refer to section 3.4).

## 3.9 Scenario evaluation (Steps 12 & 13)

Scenarios were ranked on the basis of net present values and benefit cost ratio assessments which incorporate consideration of capital and operational expenditures and the reduction of flood damages and impacts associated with implementation of the scenarios.

Average annual damages and impacts were calculated using the WSDOS Integrated Assessment Methodology (IAM) tool (Aurecon 2014) with appropriate modifications described in Chapter 10. This assessment was undertaken based only on historical floods.

# Chapter 4 Potential flood mitigation storage sites

This chapter describes the process followed for this study to identify and shortlist potential flood mitigation storage sites across the Brisbane River catchment.

This chapter outlines the identification and shortlisting including:

- review of previous investigations
- topographic mapping and storage curve derivation
- identification of potential flood storage sites
- preliminary shortlisting of potential flood storage sites.

Potential new water supply dams to offset the water demand on Wivenhoe Dam and thereby allow a greater portion of the storage at Wivenhoe Dam to be allocated to flood mitigation are discussed in Chapter 5.

## 4.1 Identification

Investigations into dam sites for water supply purposes generally focus on sites which have a good hydrologic yield (i.e. the amount of water that can be reliably extracted on a sustainable basis) and relatively deep storages in order to minimise losses to evaporation. Dam sites for purely flood mitigation/retention purposes are not constrained by these requirements. As such, sites which may have been overlooked or not identified in previous water supply investigations may be suitable for flood mitigation purposes.

The emphasis of this study has been on the identification of sites where reasonably large storages could be potentially constructed in order to derive an appreciable flood mitigation benefit for the urban areas of Brisbane and Ipswich (refer section 2.3, *Flood mitigation opportunities*).

### 4.1.1 Previous investigations

Previous investigations on potential dam sites within the Brisbane River catchment have generally focussed on storages for either irrigation and/or urban water supply with flood mitigation being a secondary consideration.

Therefore for the Prefeasibility Investigation into Flood Mitigation Storage Infrastructure (PIFMSI), previous investigation reports were re-examined and additional assessment tools utilised in order to fully identify potential flood mitigation storage sites with a view to determining those sites with the greatest potential for future development as flood mitigation storages.

Numerous investigations have been carried out previously on potential dam sites within the Brisbane River catchment. The earliest study dealing with flood mitigation measures for the Brisbane River was reported by Pennycuick (1899). This report had been commissioned by the Queensland Government following the disastrous 1893 floods. The report included a proposal for the construction of a substantial water storage (for water supply and flood mitigation purposes) on the Brisbane River at the junction with Middle Creek (approximately 40 km upstream of the present location of Wivenhoe Dam).

Following the Federation Drought (1898–1903), a dam site was mooted for the Stanley Gorge on the Stanley River (near Little Mt Brisbane) as part of considerations for augmenting Brisbane's water supply by the Brisbane Board of Waterworks (cited in EHA 2010).

A report commissioned following the 1931 flood recommended the construction of a dam near Little Mt Brisbane (the present Somerset Dam) for both water supply and flood mitigation purposes (QBoI 1934).

Following completion of Somerset Dam in 1959, the next significant investigation of potential dam sites within the Brisbane River catchment occurred in the mid to late 1960s. These investigations were undertaken by the Snowy Mountains Hydro-Electric Authority (SMHEA) for the Irrigation and Water Supply Commission Queensland (IWSC), focussing on a number of dam sites mainly for the purpose of water supply for irrigation.

The dam sites considered by the SMHEA were:

- Brisbane River AMTD 282.1 km and AMTD 282.4 km near Linville (SMHEA 1968a)
- Emu Creek AMTD 10.8 km (SMHEA 1968b)
- Tenthill Creek AMTD 29.8 km (SMHEA 1969a)
- Lockyer Creek AMTD 109.9 km (SMHEA 1969a)
- Laidley Creek AMTD 50.5 km (SMHEA 1969a)
- Ma Ma Creek AMTD 21.2 km (SMHEA 1969a)
- Cooyar Creek AMTD 12.4 km (SMHEA 1969b)

Concurrent to the SMHEA investigations, further studies were being carried out by the Co-ordinator-General’s Department (CoG 1971) on a dam site on the Brisbane River at AMTD 150.2 km (present Wivenhoe Dam). Construction of Wivenhoe Dam commenced in the late 1970s and was completed in 1984.

During the 1970s and 1980s investigations (mostly preliminary in nature) were carried out by the IWSC (later known as the Queensland Water Resources Commission) on a number of dam sites in the Lockyer and Warrill valleys. These investigations were mainly focused on providing water for irrigation or to supplement groundwater in those areas.

Sites identified included:

- Bremer River AMTD 67.7 km and AMTD 70.0 km near Mt Walker (QWRC 1979)
- Franklin Vale Creek AMTD 11.6 km (QWRC 1979)
- Western Creek AMTD 21.8 km (QWRC 1979)
- Purga Creek AMTD 31.3 km (QWRC 1979)
- Warrill Creek AMTD 64.4 km (QWRC 1979)
- Black Duck Creek AMTD 4.0 km (GHD 1990)
- Blackfellow Creek AMTD 16.3 km (GHD 1990)

Following the decision in December 1989 not to proceed with the construction of Wolffdene Dam, the Water Resources Commission undertook investigations in relation to dam sites within South East Queensland (SEQ) to meet future urban water supply needs (WRC 1991a). This investigation included a re-evaluation of the dam site(s) on the Brisbane River AMTD 282.1 km and AMTD 282.4 km (near Linville) (WRC 1991c), as well as identifying a further site within the Brisbane River catchment on the Stanley River AMTD 86.2 km (near Peachester) (WRC 1991b).

Further investigations of potential new water storages in SEQ were conducted in 2006 and 2011 however no further sites within the Brisbane River catchment were identified (GHD 2006; 2011).

### 4.1.2 Initial advice to Government

As part of its consideration of the outcomes of the Wivenhoe and Somerset Dams Optimisation Study (WSDOS), the Queensland Government was provided advice on potential infrastructure solutions to improve dam safety and mitigate flooding in the urban areas of Brisbane and Ipswich (refer section 1.3 *Purpose and scope*). This advice was provided along with the completed WSDOS report (DEWS 2014) and focussed on potential sites across the Brisbane River catchment where flood mitigation storages could be constructed.

The initial identification of potential new dam sites was based chiefly on an initial scan of previous investigation reports (refer section 4.1.1). Dam sites were selected based on having a significant catchment area and being capable of having a large storage constructed at that location.

In order to give an indication of the potential for flood mitigation storages that might be possible, a representative selection of potential infrastructure development options spread across the Brisbane River catchment were chosen as below:

1. Wivenhoe Dam – raising (Brisbane River at AMTD 150.2 km)
2. a new dam on the upper Brisbane River AMTD 282.3 km near Linville
3. a new dam on Cooyar Creek AMTD 12.4 km near Benarkin National Park
4. a new dam on Emu Creek AMTD 10.8 km near Harlin
5. a new dam on the Bremer River AMTD 70.0 km near Mt Walker
6. a new dam on the Stanley River AMTD 86.2 km near Peachester
7. a new dam on Tenthill Creek AMTD 29.8 km near Caffey
8. a new dam on Lockyer Creek AMTD 109.9 km near Murphys Creek
9. a new dam on Cressbrook Creek AMTD 40.1 km near Kipper.

The Premier and the Minister for Energy and Water Supply announced on 2 April 2014 that the Queensland Government would consider these options to lessen the impacts of future major floods.

### 4.1.3 Further site review

At the commencement of the PIFMSI, a more comprehensive approach to potential site identification using topographic information and other data held by DEWS was undertaken.

This more comprehensive approach was possible because of the hydrologic modelling capability developed by Seqwater post 2011 and the work undertaken for WSDOS. The availability of the Seqwater hydrologic model (URBS) for the Brisbane River catchment enabled the testing of a larger number of sites than would otherwise have been the case within the study timeframe.

This allowed the additional flood mitigation storage sites that were identified to be tested against a range of historical floods to determine the more favourable flood mitigation storage sites for further investigation.

#### 4.1.3.1 Topographic mapping

Contour maps were produced for the entire Brisbane River catchment using elevation information available through 'Queensland Globe'[4]. Contour maps were produced with 10 m contour intervals at a sufficiently large scale to help identify:

- locations of confinement or constriction within the watercourse where the dam wall length would be minimised and hence minimise the capital cost of the dam.
- relative storage size (i.e. a combination of the area inundated by the storage and the depth of the storage).
- catchment area for potential flood storages.

#### 4.1.3.2 Sites identified following further review

From previous reports, topographic mapping, other information held by DEWS, a total of 39 potential flood mitigation storage locations were identified (Figure 4.1). Further detail of the 39 locations identified is provided in Table A1, Appendix A. The locations identified ranged from those that could have a significant influence alone to those that would need to operate in conjunction with a number of other storages within the catchment.

#### 4.1.3.3 Updating of storage curve information

Initial hydrologic screening of potential flood storage locations used existing storage curve information (i.e. plots of storage volume versus height and inundated area versus height) where available. Existing storage curve information was obtained from previous investigation reports and other data held by DEWS. Older storage curve information was converted from imperial to metric units.

Where existing storage curve information was not available, new storage curves were calculated using GIS tools and based on the best available topographic information. At the time of the study, the best available topographic information available for the Brisbane River catchment is the digital elevation model derived from Shuttle Radar Topographic Mission (SRTM) data. The SRTM digital elevation model is based on 30 m grid spacing.

Whilst more recent higher resolution (in terms of vertical accuracy), LiDAR based digital elevation models are available for selected areas within the Brisbane River catchment, only the SRTM based digital elevation model covers the entire area encompassing all 39 potential dam sites and their entire flood storage areas.

Later in the study, for the seven shortlisted sites for engineering site assessments (Chapter 7), storage curve information was updated using the SRTM data.

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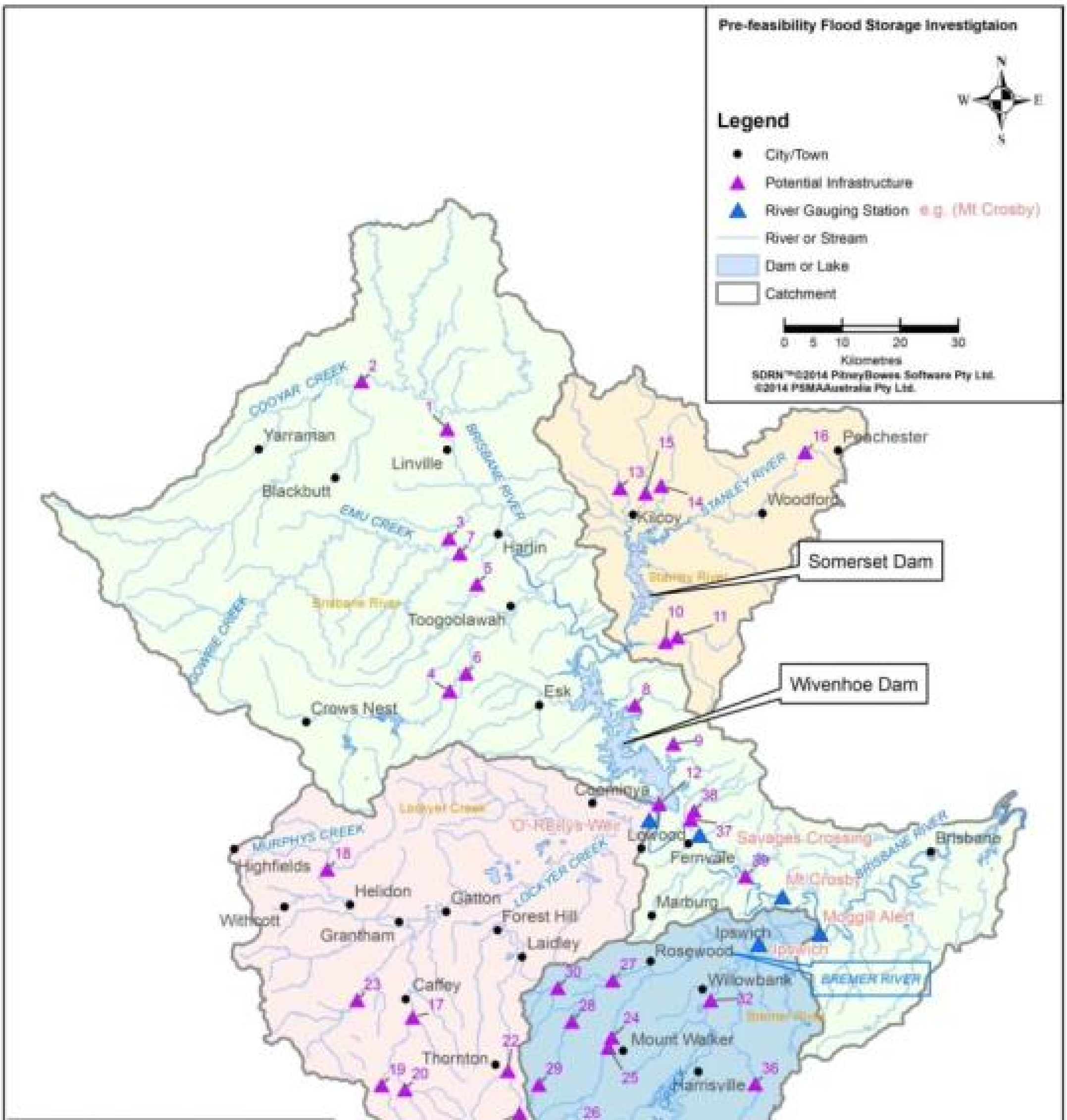
[4] 'Queensland Globe' is a freely available GIS mapping and data application that enables access to maps, data and imagery of Queensland, including Queensland Government-owned data and data used under licence from other parties.




| ID NO | STREAM NAME /AMTD km |
|---|---|
| 1 | Brisbane River (Linville) 282.3 |
| 2 | Cooyar Creek 12.4 |
| 3 | Emu Creek 10.8 |
| 4 | Cressbrook Creek 40.1 |
| 5 | Ivory Ck 12.2 |
| 6 | Cressbrook Creek 33 |
| 7 | Maronghi Creek 10.7 |
| 8 | Middle Creek 5.3 |
| 9 | Northbrook Creek 14.2 |
| 10 | Reedy Creek 7.1 |
| 11 | Reedy Creek 9.9 |
| 12 | Brisbane River (Wivenhoe raising) 150.2 |
| 13 | Sheep Station Creek 9.9 |
| 14 | Sandy Creek 19.7 |
| 15 | Kilcoy Creek 16.9 |
| 16 | Stanley River (Peachester) 86.2 |
| 17 | Tenthill Creek 29.8 |
| 18 | Lockyer Creek 109.9 |
| 19 | Black Duck Creek 4 |
| 20 | Blackfellow Creek 16.3 |

| ID NO | STREAM NAME/ AMTD km |
|---|---|
| 21 | Laidley Creek 50.5 |
| 22 | Laidley Creek 41 |
| 23 | Ma Ma Creek 21.2 |
| 24 | Bremer River 67.7 |
| 25 | Bremer River (Mt Walker) 70 |
| 26 | Bremer River 88.1 |
| 27 | Western Creek (Grandchester) 8 |
| 28 | Franklin Vale Creek 11.6 |
| 29 | Gehrke Creek 7.8 |
| 30 | Western Creek 21.8 |
| 31 | Upper Warill Creek 64.4 |
| 32 | Lower Warrill Creek (Willowbank) 13.9 |
| 33 | Reynolds Creek (Moogerah Dam) 15.3 |
| 34 | Reynolds Creek 23 |
| 35 | Coulson Creek 4.3 |
| 36 | Purga Creek 31.3 |
| 37 | England Creek 1.3 |
| 38 | England Creek 2.4 |
| 39 | Brisbane River 110.1 |

**Figure 4.1 Initially identified potential flood storage locations**

## 4.2 Initial shortlisting

### 4.2.1 Sites not assessed further under PIFMSI

Of the 39 potential sites identified in Section 4.1.3 (Table A1, Appendix A) four were excluded from the first pass hydrologic screening process (i.e. Phase 1 flood hydrology assessment). The four sites excluded were:

- Wivenhoe Dam raising (Brisbane River at AMTD 150.2 km)
- England Creek AMTD 1.3 km
- England Creek AMTD 2.4 km
- Brisbane River AMTD 110.1 km

Options to raise Wivenhoe Dam were considered separately by Seqwater and were therefore excluded from Phase 1 flood assessments.

The two sites on England Creek were identified as the potential location for a new water supply storage that could offset reductions in water supply storage in Wivenhoe Dam, thus allowing some of the water supply storage in Wivenhoe Dam to be allocated for flood mitigation. A dam in the order of 150,000 ML capacity could be constructed on England Creek but it would have a limited catchment of its own and would need to be supplemented by transferring (most likely by pumping, perhaps via a connection to the Splityard Creek Dam pump storage system) water from Wivenhoe Dam. Given the complexity of this pumping requirement a robust assessment was not feasible within the timeframe of this study and these two sites were excluded from further consideration under PIFMSI. However, an England Creek Dam would not incur the in-stream losses that the Cooyar and Emu Creek Sites would incur in delivery to Wivenhoe Dam and given its close proximity to Wivenhoe Dam (Figure 4.1) pumping costs may not be excessive. The two sites on England Creek could therefore warrant further consideration as part of any future feasibility studies following PIFMSI.

The site identified on the Brisbane River AMTD 110.1 km exists at a natural constriction in the river. In order to be of any benefit for flood mitigation the size of a storage required at this site would potentially inundate land upstream as far as Wivenhoe Dam. This would have significant impacts on the town of Fernvale as well as on agricultural land downstream of Wivenhoe Dam around Wivenhoe Pocket. Due to these significant impacts, this site was excluded from further consideration under PIFMSI.

### 4.2.2 First pass screening process (Phase 1 flood hydrology and DEWS review)

Under Phase 1 hydrological analysis, the 35 remaining sites were screened based on their ability to influence a significant portion of the estimated historical flood event volumes at representative catchment ‘outlets’ (points of interest).

A summary of the Phase 1 hydrological analysis is presented in the following sections of this chapter. Further details of this screening process, including limitations are provided in Seqwater technical memorandum nos. 001 and 002 (Seqwater 2014a).

The identified dam sites were divided into two groups for screening:

- those downstream of Wivenhoe Dam in the Bremer River catchment (13 potential sites) and Lockyer Creek catchment (7 potential sites)

- those upstream of Wivenhoe Dam in the Upper Brisbane catchment (11 potential sites) and Stanley River catchment (4 potential sites).

### 4.2.3 Historical floods

The largest 20 floods (for peak flow in the mid and lower Brisbane River) from the last 127 years were previously considered in basin scale modelling for WSDOS (DEWS 2014). These same floods were adopted for consideration under PIFMSI. These floods were in years 1887, 1890, three floods from 1893, two floods from 1898, 1908, 1931, 1955, 1959, 1971, 1973, 1974, 1983, 1989, 1996, 1999, 2011 and 2013.

These floods may not necessarily be the largest historical flood at each of the dam sites. Thus, additional floods thought to have potential to be more significant at the dam sites have also been considered at some sites.

### 4.2.4 Dam sites in the Bremer River and Lockyer Creek catchments

The specific objectives for the Phase 1 assessments of potential dams in the Bremer River and Lockyer Creek catchments are to understand the potential influence of new dams on peak flows:

- in the Bremer River at Ipswich
- in Lockyer Creek at O'Reillys Weir, near the junction with the Brisbane River.

#### 4.2.4.1 Bremer River catchment

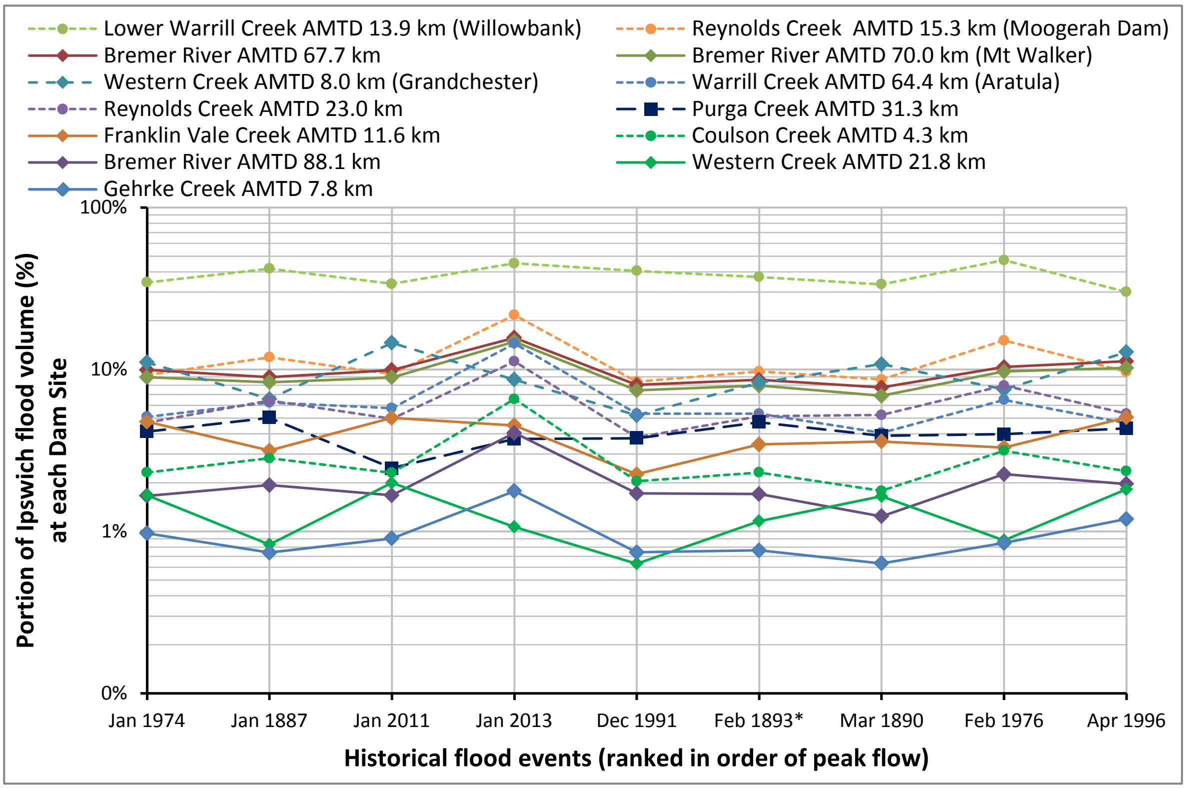
Thirteen potential dam sites were identified in the Bremer River catchment.

In addition to the 20 largest historical floods (for peak flow in the mid and lower Brisbane River), three additional historical floods of interest for Bremer River flooding were added to the list of floods to consider for dam option screening (January 1947, February 1976, and December 1991) as these were significant floods for this catchment.

The total Bremer River catchment area to Ipswich is 1,869 $km^2$. For each of the Bremer River identified dam sites, the Seqwater technical memorandum no. 001 (Seqwater 2014a) summarises the estimated average contribution of each dam catchment to the 23 historical flood volumes and flows at intermediate locations (i.e. Bremer River at Walloon, Warrill Creek at Amberley and Purga Creek at Loamside) in the Bremer River catchment.

The 9 largest historical floods in the Bremer River catchment, in terms of estimated peak flow in the Bremer River at Ipswich (peak >1,450 $m^3/s$), were selected from the 23 largest historical floods to assess the contributions of individual dam site catchments to the overall flood volume at Ipswich.

Figure 4.2 presents the flood volume at each of the potential dam sites as a portion (percentage) of the total flood volume at Ipswich for each of the nine largest Bremer River flood events. The advantage of this plot is that the trend of the relative contribution across multiple events is identifiable.




Notes: The y-axis of this plot is on a log scale.

* Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).

**Figure 4.2 Significant Bremer River floods and flood volume at each dam site as a percentage of the flood volume at Ipswich (David Trumpy Bridge)**

A summary of the indicative effectiveness of the potential Bremer River dam sites for flood mitigation is presented in Table 4.1. The indications of potential effectiveness are based on Figure 4.2, other considerations described following Table 4.1 and the more detailed information in Seqwater technical memorandum no. 001 (Seqwater 2014a).

**Table 4.1 Potential dam sites in Bremer River catchment – Phase 1 screening for indicative effectiveness for flood mitigation**

| Site | Indication of effectiveness for flood mitigation |
|---|---|
| Bremer River AMTD 67.7 km | 9 to 11% of flood volume at Ipswich – worth further consideration |
| Bremer River AMTD 70.0 km near Mt Walker | 9 to 11% of flood volume at Ipswich – worth further consideration |
| Bremer River AMTD 88.1 km | < 3% of flood volume at Ipswich – unlikely to be effective |
| Western Creek AMTD 8.0 km near Grandchester | 5 to 11% of flood volume at Ipswich – worth further consideration |
| Franklin Vale Creek AMTD 11.6 km | < 5% of flood volume at Ipswich – unlikely to be effective |
| Gehrke Creek AMTD 7.8 km | < 2% of flood volume at Ipswich – unlikely to be effective |
| Western Creek AMTD 21.8 km | < 2% of flood volume at Ipswich – unlikely to be effective |
| Warrill Creek AMTD 64.4 km near Aratula | 5 to 10% of flood volume at Ipswich – worth further consideration |
| Lower Warrill Creek AMTD 13.9 km near Willowbank | 30 to 40% of flood volume at Ipswich – worth further consideration |
| Reynolds Creek AMTD 15.3 km (Moogerah Dam) | 8 to 11% of flood volume at Ipswich – worth further consideration |
| Reynolds Creek AMTD 23 km | 5 to 10% of flood volume at Ipswich – unlikely to be effective beyond Moogerah Dam |
| Coulson Creek AMTD 4.3 km | Generally < 5% of flood volume at Ipswich – unlikely to be effective |
| Purga Creek AMTD 31.3 km | 2 to 6% of flood volume at Ipswich – unlikely to be effective |

Sites that contribute less than 5% of the total flood volume (based on historical floods) at Ipswich were considered to have little potential for flood mitigation and thus generally excluded from further consideration in the study. Further considerations were as follows.

On its own, a dam in the headwaters of Warrill Creek AMTD 64.4 km is likely to have only a marginal impact on the peak flood volumes at Ipswich. However, in combination with Moogerah Dam, it could potentially provide some effective flood mitigation, as high rainfall often occurs in the headwaters along the mountain ranges. A dam in the headwaters of Warrill Creek may also have potential to supplement local irrigation water supplies although this study has not assessed its potential yield.

Moogerah Dam is an existing dam and as such the potential to increase its flood mitigation capacity may be limited by engineering feasibility. Investigation of Moogerah Dam augmentation was not considered to be warranted at this stage given its location upstream of the Lower Warrill Creek site that has a far greater potential flood mitigation benefit.

Based solely on volume contributions, the site on Reynolds Creek AMTD 23 km appears worth considering. However, as Moogerah Dam is located immediately downstream of this site, and the current Moogerah Dam attenuates peak flows from this part of the catchment, the benefit of a new dam on Reynolds Creek is unlikely to extend much beyond Moogerah Dam.

For subsequent phases of hydrological assessment (determination of inflow/outflow hydrographs) of the potential dam sites on the Bremer River at AMTD 67 .7 km and AMTD 70 km, the AMTD 67.7 km site was considered to be representative of both sites for the purpose of this study. Hence Seqwater technical memorandum nos. 003, 006 and 008 (Seqwater 2014a) refer only to the Bremer River AMTD 67.7 km site. However, an engineering review of the Bremer River AMTD 67.7 km and AMTD 70 km sites found that the latter had better foundation conditions (Bruvel, FJ 1981). Therefore, engineering, environmental impact and cost assessments (Chapter 7) have been based on the AMTD 70 km site and the Bremer River at AMTD 70 km is the site referred to in the remaining sections of this report.

An alternative location for the Lower Warrill Creek AMTD 14.6 km site at has also been considered to facilitate amalgamation with the proposed Southern Freight Railway line crossing of Warrill Creek (Chapter 7). However, the flood hydrology (inflow/outflow hydrographs) for the AMTD 13.9 km site was considered to be representative of both sites for the purpose of this study. Seqwater technical memorandum nos 003, 006 and 008 (Seqwater 2014a) regarding subsequent phases of hydrological assessment therefore refer only to the Lower Warrill Creek AMTD 13.9 km site.

The Bremer River catchment sites carried through for further consideration were therefore:

- Bremer River AMTD 70.0 km (near Mt Walker)
- Western Creek AMTD 8.0 km (near Grandchester)
- Warrill Creek AMTD 64.4 km (near Aratula)
- Lower Warrill Creek AMTD 13.9 km/AMTD 14.6 km (near Willowbank)

#### 4.2.4.2 Lockyer Creek catchment:

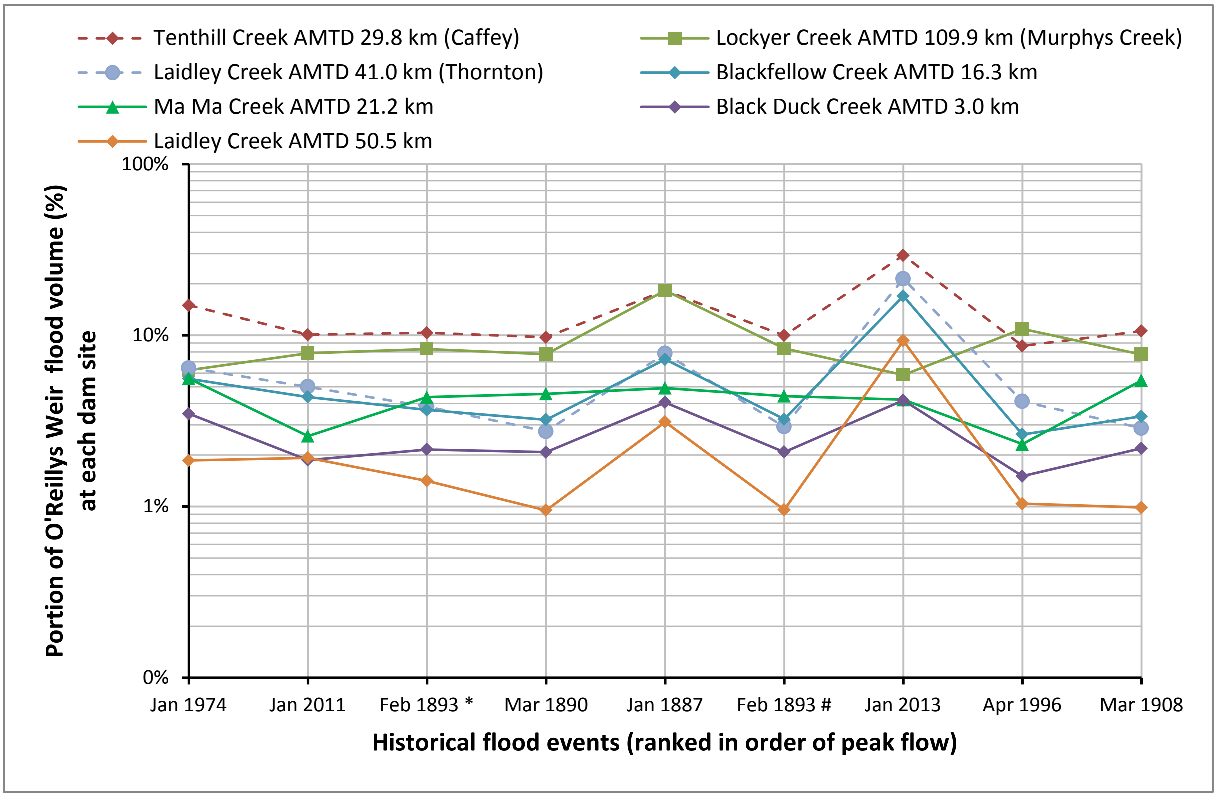
Seven potential dam sites were identified in the Lockyer Creek catchment.

The 20 largest historical floods (for peak flow in the mid and lower Brisbane River) were considered for dam option screening.

The total Lockyer Creek catchment area to O'Reillys Weir is 2,964 $km^2$. The average contribution of each of the identified Lockyer Creek dam site catchments to the 20 largest historical flood volumes and flows from the Lockyer Creek catchment upstream of O'Reillys Weir is indicated in the Seqwater technical memorandum no. 001 (Seqwater 2014a).

The 9 largest Lockyer Creek catchment floods for estimated peak flow at O'Reillys Weir (peak >2,000 $m^3/s$) were selected from the 20 largest historical flood floods to assess the contributions of each dam catchment to the overall flood volume at O'Reillys Weir.

Figure 4.3 presents the flood volume at each of the potential dam sites as a portion (percentage) of the total volume at O'Reillys Weir for each of the nine large Lockyer Creek flood events. Again, the advantage of this plot is that trend of the relative contribution across multiple events is identifiable. Overall, it can be seen that there is significant variance of the potential influence of flood mitigation dam sites on catchment scale flooding in Lockyer Creek due to spatial variability of rainfall.




Notes: The y-axis of this plot is on a log scale.

* Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c)

\# First flood of February 1893 that peaked 5 February 1893.

**Figure 4.3 Significant Lockyer Creek floods and flood volume at each dam site as a percentage of the flood volume at O'Reillys Weir**

A summary of the indicative effectiveness of the potential Bremer River dam sites for flood mitigation is presented in Table 4.2. The indications of potential effectiveness are based on Figure 4.3 other considerations described following Table 4.2 and the more detailed information in Seqwater technical memorandum no. 001 (Seqwater 2014a).

**Table 4.2 Potential dam sites in Lockyer Creek catchment – Phase 1 screening for indicative effectiveness for flood mitigation**

| Site | Indication of effectiveness for flood mitigation |
|---|---|
| Tenthill Creek AMTD 29.8 km (near Caffey) | 9 to 12% of flood volume at O'Reillys Weir – worth further consideration |
| Lockyer Creek AMTD 109.9 km (near Murphys Creek) | 6 to 11% of flood volume at O'Reillys Weir – worth further consideration |
| Black Duck Creek AMTD 3.0 km | < 4% of flood volume at O'Reillys Weir – unlikely to be effective |
| Blackfellow Creek AMTD 16.3 km | Generally < 7% of flood volume at O'Reillys Weir – unlikely to be effective |
| Laidley Creek AMTD 50.5 km | Generally < 3% of flood volume at O'Reillys Weir – unlikely to be effective |
| Laidley Creek AMTD 41.0 km (near Thornton) | Generally < 7% of flood volume at O'Reillys Weir – unlikely to be effective |
| Ma Ma Creek AMTD 21.2 km | <6% of flood volume at O'Reillys Weir – unlikely to be effective |

Sites that contribute less than 5% of the total flood volume (based on historical floods) at O'Reillys Weir were considered to have little potential for flood mitigation. Further considerations were as follows.

The catchment of the Tenthill Creek AMTD 29.8 km (near Caffey) site includes the Blackfellow Creek and Tenthill Creek headwaters. A dam at this location may have potential to supplement local irrigation water supplies although this study has not assessed its potential yield.

The Laidley Creek AMTD 41.0 km (near Thornton) site is considered ineffective for the PIFMSI investigation interests i.e. to mitigate peak flow at O'Reillys Weir. However, a dam at this location may have merit for local scale flooding such as to reduce flooding at Laidley.

The Lockyer Creek AMTD 109.9 km site (near Murphys Creek Township) was eliminated from further consideration due to issues (and anticipated significant costs) associated with the Toowoomba railway line (West Moreton System) that runs through the site and its significantly smaller water storage potential (for agricultural and water supply uses) compared to the Tenthill Creek AMTD 29.8 km site. By comparison, the Lower Warrill Creek site has issues with a railway reserve crossing the site although was carried through for further consideration as it had a significantly greater flood mitigating potential (refer to Table 4.1).

The Lockyer Creek catchment sites carried through for further consideration were therefore:

- Tenthill Creek AMTD 29.8 km (near Caffey)
- Laidley Creek AMTD 41.0 km (near Thornton)

### 4.2.5 Dam sites in the Upper Brisbane and Stanley River catchments

For the potential new dams upstream of Wivenhoe Dam or Somerset Dam the key point of interest is to understand their potential influence on the combined peak inflow from the Upper Brisbane and Stanley River on the combined Somerset Dam and Wivenhoe Dam flood operations. The total Upper Brisbane River catchment area to Wivenhoe Dam excluding Stanley River catchment is 5,645 $km^2$. The Stanley River catchment area to Somerset Dam is 1,324 $km^2$. The total catchment area to Wivenhoe Dam is 6,969 $km^2$.

New flood mitigation dams upstream of Wivenhoe Dam or Somerset Dam would not directly mitigate peak flows in the lower Brisbane River because Wivenhoe Dam releases in combination with downstream catchment flows will continue to be the main influence on downstream river flows.

The objective of new flood mitigation dams upstream of Wivenhoe Dam would primarily be to delay and attenuate flows into Wivenhoe Dam. This would only provide benefits for those large floods which trigger the *Dam Safety Strategy* at Wivenhoe Dam. Specifically, if the rate of flood inflow into the dams could be delayed and attenuated in large flood events, the magnitude of releases required from Wivenhoe Dam in the *Dam Safety Strategy* could potentially be reduced.

In general, peak inflows into Somerset Dam often arrive earlier than the peak inflows into Wivenhoe Dam (refer Seqwater 2014b, Appendix A inflow hydrographs). In this context, there is substantial likelihood that new flood mitigation dams in the Stanley River catchment may actually be detrimental for the Wivenhoe Dam and Somerset Dam flood operations and overall flood mitigation for the downstream reaches of the Brisbane River. Specifically, new flood mitigation dams in the Stanley River catchment would delay the rate of inflow into Somerset Dam and increase the probability of peak inflows into Somerset Dam from the Stanley River coinciding with peak inflows into Wivenhoe Dam from the Upper Brisbane River. For large floods, when Wivenhoe Dam is being operated in the *Dam Safety Strategy*, this would likely result in larger releases being required from Wivenhoe Dam.

In contrast, the Upper Brisbane River catchment has longer travel time from the headwaters to Wivenhoe Dam. New flood mitigation dams in the headwaters of the Upper Brisbane River may slow the rate of inflow into Wivenhoe Dam. This may provide benefit in large flood events when Wivenhoe Dam is being operated in the *Dam Safety Strategy*.

A summary of the catchment areas at potential new Upper Brisbane River catchment and Stanley River catchment dam sites relative to the total Wivenhoe Dam catchment area is presented in Seqwater technical memorandum no. 002 (Seqwater 2014a). Where the dam catchment is a small part of the overall Wivenhoe Dam catchment area, it can generally be inferred that dams at these locations would be ineffective in materially influencing peak inflows to Wivenhoe Dam.

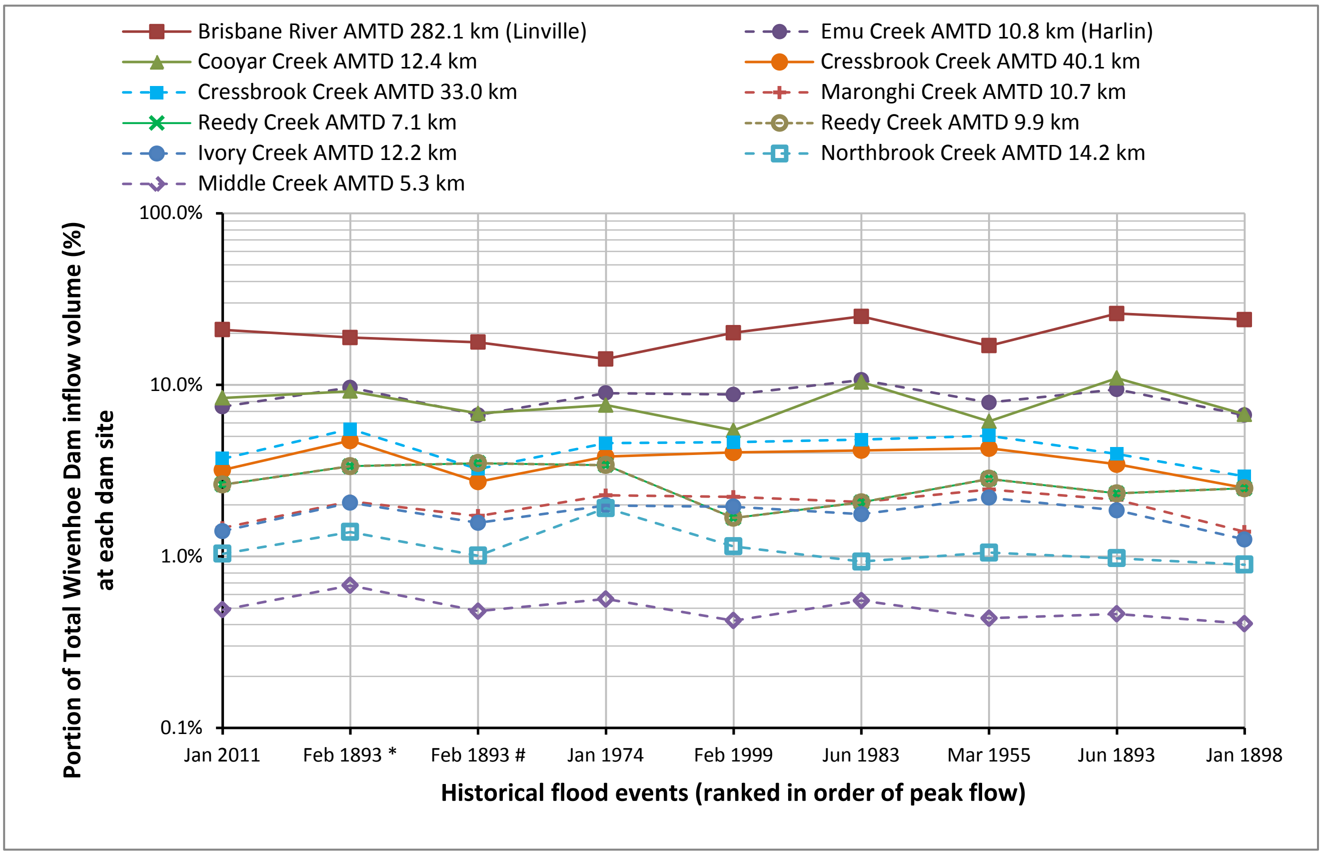
#### 4.2.5.1 Upper Brisbane River catchment

Eleven potential dam sites were identified in the upper Brisbane River catchment.

The 9 largest historical floods for the Upper Brisbane River catchment floods in terms of estimated peak inflow to Wivenhoe Dam (excluding the Stanley River catchment) were selected from the 20 largest historical floods considered for WSDOS (for peak flow in the mid and lower Brisbane River- section 4.2.3). These 9 largest floods were used to assess the contributions of the individual dam catchments to overall flood volume at Wivenhoe Dam.

A notable aspect for the selected floods in the Upper Brisbane River is that relative contribution to total volume to Wivenhoe Dam from the Upper Brisbane River catchment and from the Stanley River catchment is quite variable. This means that potential new flood mitigation dams to attenuate Upper Brisbane River flood flows could have variable influence on the way that Wivenhoe Dam and Somerset Dam are operated in different flood events.

Figure 4.4 presents the flood volume at each of the potential dam sites as a portion (percentage) of the total volume to Wivenhoe Dam (including Stanley catchment flood volume) for each of the nine largest historical flood events for the Upper Brisbane River. This plot shows the trend of the relative contribution across multiple events.




Notes: The y-axis of this plot is on a log scale.

* Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c)

\# First flood of February 1893 that peaked 5 February 1893.

**Figure 4.4 Significant Upper Brisbane floods and flood volume at each dam site as a percentage of the total flood volume at Wivenhoe Dam**

**Table 4.3 Potential dam sites in Upper Brisbane River catchment – Phase 1 screening for indicative effectiveness for flood mitigation**

| Site | Indication of effectiveness for flood mitigation |
|---|---|
| Brisbane River AMTD 282.3 km (near Linville) | 15 to 25% of flood volume to Wivenhoe Dam – worth further consideration |
| Cooyar Creek AMTD 12.4 km | 5 to 10% of flood volume to Wivenhoe Dam – worth further consideration |
| Emu Creek AMTD 10.8 km (near Harlin) | 7 to 10% of flood volume to Wivenhoe Dam – worth further consideration |
| Cressbrook Creek AMTD 40.1 km | < 5% - unlikely to be effective (note 2) |
| Ivory Ck AMTD 12.2 km | < 2% - unlikely to be effective |
| Cressbrook Creek AMTD 33.0 km | < 5% - unlikely to be effective (note 2) |
| Maronghi Creek AMTD 10.7 km | < 2% - unlikely to be effective |
| Middle Creek AMTD 5.3 km | < 1% - unlikely to be effective |
| Northbrook Creek AMTD 14.2 km | < 2% - unlikely to be effective |
| Reedy Creek AMTD 7.1 km | < 4% - unlikely to be effective |
| Reedy Creek AMTD 9.9 km | < 4% - unlikely to be effective |

A summary of the indicative effectiveness of the potential dam sites in the Upper Brisbane River catchment for flood mitigation is presented in Table 4.3. The indications of potential effectiveness are based on Figure 4.4, other considerations described following Table 4.3 and the more detailed information in Seqwater technical memorandum no. 002 (Seqwater 2014a).

Sites that contribute less than 5% of the total flood volume at Wivenhoe Dam, were considered to have little potential for flood mitigation and were thus excluded from further consideration in the study. Further considerations were as follows.

As the Cooyar Creek AMTD 12.4 km site is located upstream of the dam site on the Brisbane River at AMTD 282.3 km (near Linville), there is likely to be little benefit in considering both sites together. Hence, the site on Cooyar Creek at AMTD 12.4 km was proposed to be considered only as an alternative to the Brisbane River AMTD 282.3 km site should development of this site be unfeasible from an engineering or environmental/social impact perspective.

The results of initial hydrological assessments indicate that potential dams on Cressbrook Creek may be of marginal interest. However, as two dams already exist in the Cressbrook Creek catchment that would already provide some degree of flood mitigation, it is considered unlikely that a new dam downstream of the existing dams would provide much additional flood mitigation benefit.

The upper Brisbane River catchment sites carried through for further consideration were therefore:

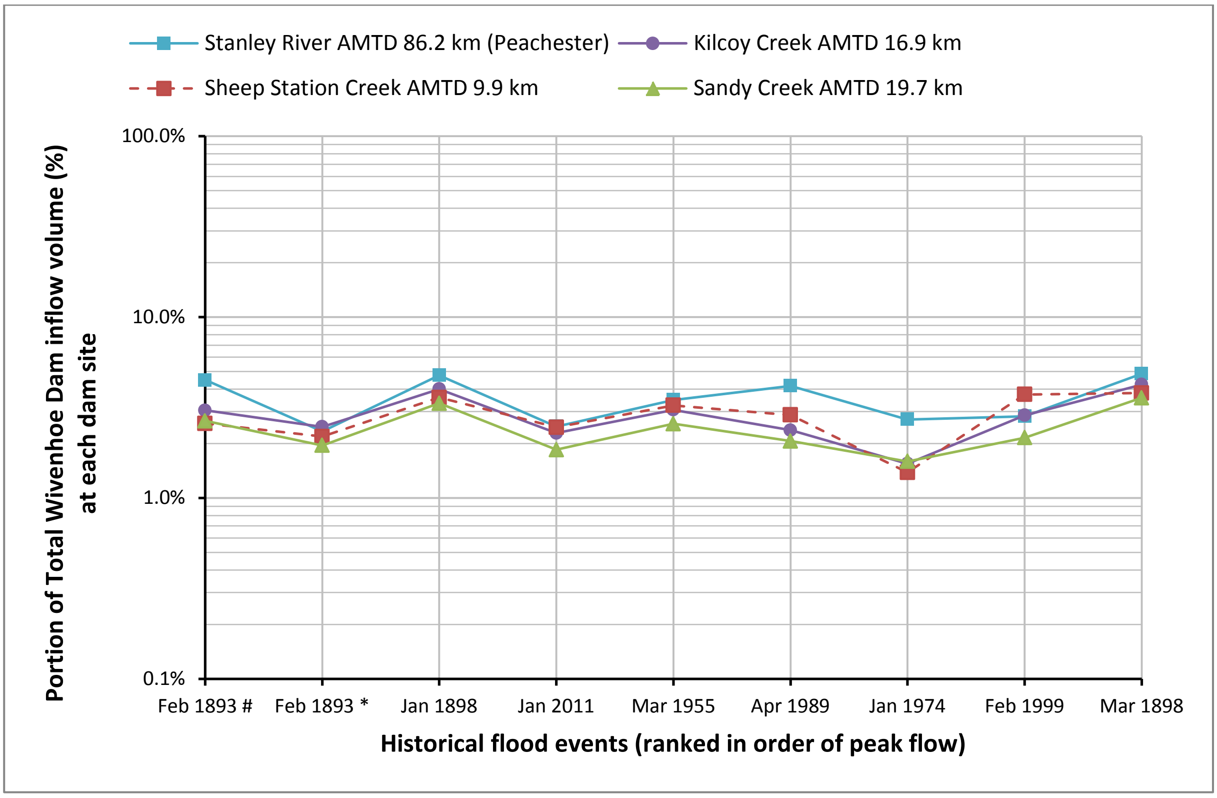
- Brisbane River AMTD 282.3 km (near Linville)
- Emu Creek AMTD 10.8 km (near Harlin)

#### 4.2.5.2 Stanley River catchment

Four potential dam sites were identified in the Stanley River catchment.

The 9 largest historical floods in Stanley River catchment in terms of estimated peak inflow to Somerset Dam were selected from the 20 largest historical Brisbane River catchment floods considered for WSDOS (for peak flow in the mid and lower Brisbane River – refer section 4.2.3). These nine floods were used to assess the contribution of each dam catchment to the overall flood volume at Wivenhoe Dam.

Figure 4.5 presents the flood volume at each of the potential dam sites as a portion (percentage) of the total volume to Wivenhoe Dam (including Stanley catchment flood volume) for each of the 9 largest historical Stanley River flood events. This plot also shows the trend of the relative contribution across multiple events.




Notes: The y-axis of this plot is on a log scale.

* Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).

\# First flood of February 1893 that peaked 5 February 1893 (BoM 2014c).

**Figure 4.5 Significant Stanley River floods and flood volume at each dam site as a percentage of the total flood volume at Wivenhoe Dam**

A summary of the indicative effectiveness of the potential Stanley River catchment dam sites for flood mitigation is presented in Table 4.4. The indications of potential effectiveness are based on Figure 4.5 and the more detailed information in the Seqwater technical memorandum no. 002 (Seqwater 2014a).

**Table 4.4 Potential dam sites in Stanley River catchment – Phase 1 screening for indicative effectiveness for flood mitigation**

| Stream | Indication of effectiveness for flood mitigation |
|---|---|
| Sheep Station Creek AMTD 9.9 km | < 4% - of flood volume to Wivenhoe Dam<br>- unlikely to be effective |
| Sandy Creek AMTD 19.7 km | < 3% - of flood volume to Wivenhoe Dam<br>- unlikely to be effective |
| Kilcoy Creek AMTD 16.9 km | < 3% - of flood volume to Wivenhoe Dam<br>- unlikely to be effective |
| Stanley River (near Peachester)<br>AMTD 86.2 km | < 5% - of flood volume to Wivenhoe Dam<br>- unlikely to be effective |

In general, the information suggests that none of the potential dam sites in the Stanley River catchment are likely to be effective for flood mitigation. Therefore, no Stanley River catchment sites were carried through for further consideration.

## 4.3 Summary of sites for further assessment

Following the assessments outlined in this chapter, the sites considered appropriate for further assessment were:

- Wivenhoe Dam (Brisbane River at AMTD 150.2 km)
- Brisbane River AMTD 282.3 km (near Linville)
- Emu Creek AMTD 10.8 km (near Harlin)
- Tenthill Creek AMTD 29.8 km (near Caffey)
- Laidley Creek AMTD 41.0 km (near Thornton)
- Bremer River AMTD 70.0 km (near Mt Walker)
- Western Creek AMTD 8.0 km (near Grandchester)
- Warrill Creek AMTD 64.4 km (near Aratula)
- Lower Warrill Creek AMTD 13.9 km/AMTD 14.6 km (near Willowbank)

The site on Cooyar Creek at AMTD 12.4 km was proposed to be considered only if the Brisbane River AMTD 282.3 km site proves to be unfeasible.

# Chapter 5 A new water supply offset dam

This Chapter discusses the option of providing a new water supply dam in the Brisbane River catchment to enable reallocation of some of the water supply storage volume of Wivenhoe Dam to flood mitigation without impacting on water supply security.

## 5.1 Options for increasing water supply storage volume

In the Wivenhoe and Somerset Dams Optimisation Study (WSDOS) for economic analysis purposes, augmentation of the yield of the SEQ bulk water supply system was assumed to occur through the construction of a new desalination plant. However, desalination plants have high capital and ongoing operational costs. Increasing system yield by constructing a new desalination plant and pipeline connections to the bulk water supply system would be in the order of several billion dollars (based on the costs of constructing the Gold Coast Desalination Plant).

A cheaper new water supply source such as the construction of a dam on the Brisbane River near Linville could be a viable proposition due to the combined flood mitigation benefits arising from being able to reduce the FSV at Wivenhoe Dam and the flood routing/storage benefit provided by the new dam.

## 5.2 Reducing the FSV of Wivenhoe Dam

Wivenhoe Dam was constructed for a dual purpose, water supply and flood mitigation.

Wivenhoe Dam commands a catchment area of some 7,000 $km^2$, or around half that of the total Brisbane River catchment area. No other existing SEQ dam or single identified dam site, commands such a large proportion of the Brisbane River catchment. This, plus its five spillway crest gates and flood storage capacity has enabled Wivenhoe Dam to significantly reduce downstream flood damage and impacts, particularly for Brisbane.

The flood mitigating capability of Wivenhoe Dam could be increased if some of Wivenhoe Dam's water supply storage capacity could be reallocated to flood storage. As part of the WSDOS, reductions of the Wivenhoe Dam FSV to 85%, 75% and 60% of the design FSV in combination with eight operational alternatives for Wivenhoe and Somerset Dams were considered. However this reduced the water supply available from the dam and required a bringing forward of new water supply infrastructure. The WSDOS concluded that, within the level of accuracy of the Net Present Cost assessments for all the options considered, and dependent on several significant assumptions, permanent reduction in the FSV of Wivenhoe Dam for flood mitigation could not be justified (DEWS 2014).

A major advantage in being able to lower the FSV of Wivenhoe Dam is the ability for increased flood mitigation independent of where rain falls in upstream catchment areas. Individual flood storages constructed upstream of Wivenhoe Dam would only be able to mitigate flooding from the catchment areas commanded by such storages.

At full supply level (EL 67.0 m AHD), Wivenhoe Dam has a FSV of approximately 1,165,000 ML. Water releases from Wivenhoe Dam supplement natural flows in the Brisbane River and supply water to the Mount Crosby Water Treatment Plants (East Bank and West Bank) via Mount Crosby Weir, approximately 60 km downstream (URS 2013).

The ultimate storage capacity of the dam above full supply level (before overtopping of the embankment occurs at EL 80 m AHD) is 1,967,000 ML which includes storage for flood mitigation and for dam safety. The combined water supply and flood storage volume of Wivenhoe Dam is a little over 3,000,000 ML.

The current Wivenhoe and Somerset Dams flood manual requires that following a flood event a release plan should be determined with the aim of reducing impacts downstream as soon as reasonably possible, while returning both dams to near their full supply level within seven days. The increased flood storage in Wivenhoe Dam would make this more difficult to achieve for extreme floods as it would require either bigger release flow rates or longer durations of release.

## 5.3 Potential new water supply dams

The Brisbane River system is at a mature state of development and additional take from the system is limited by the end of system environmental flow objective of the *Water Resource (Moreton) Plan 2007 (Qld)* (MWRP).

The development of a new dam/s in the Brisbane River system to provide significant additional water for consumption is thus unlikely to be viable without a change in the MWRP limitations. However, a new water supply dam/s could be constructed to offset the demand on Wivenhoe Dam, enabling some of its water supply storage to be reallocated to flood storage i.e. a reduction in the FSV of Wivenhoe Dam. There would be no increase in take for water supply from the system.

New dams in the Brisbane River system upstream of Wivenhoe Dam could release water to gravity feed via the natural stream to Wivenhoe Dam and on to Mt Crosby for treatment. This would be a significant advantage over other new dams (to offset the reduction in supply available from Wivenhoe Dam) that would require the construction of a new water treatment plant or pumping to Mount Crosby for treatment. Dams in the upper Brisbane River catchment would also act to reduce the flood peak into Wivenhoe Dam with potential benefit downstream.

Dam sites identified with some promise for this purpose included:

- Brisbane River AMTD 282.3 km (near Linville)
- Emu Creek AMTD 10.8 km (near Harlin)
- Cooyar Creek AMTD 12.4 km

Sites on the Brisbane River near Linville nominally at AMTD 282.1 km and AMTD 282.4 km have been investigated in some detail in the past. A site in this vicinity would have a catchment area of some 2,000 $km^2$, more than twice that of the Emu Creek site (catchment area 920 $km^2$) or the Cooyar Creek site (catchment area 960 $km^2$) and would be capable of development up to around 660,000 ML capacity. Based on a site inspection from publicly accessible areas, available topographic and geotechnical information; a dam alignment on the Brisbane River at AMTD 282.3 km was considered the most promising and selected for consideration under this study. Engineering and impact assessments of a dam at this site are addressed in Chapter 7.

Water supply dams on Emu Creek and Cooyar Creek may warrant further consideration should the Brisbane River AMTD 282.3 km site not be a viable engineering option to progress to feasibility assessment.

However, Emu Creek and Cooyar Creek dam sites are unlikely to offer comparable hydrologic benefits available from the Brisbane River site near Linville. Hence, these sites have not been considered further for water supply purposes in this report.

A dam on England Creek (downstream of Wivenhoe Dam) might also enable some reduction of Wivenhoe Dam FSV or provide additional water supply if the MWRP constraints were changed. However this option would require supplementation from Wivenhoe Dam (likely by pumping). Due to the complex nature of this option, it was not feasible to carry out a robust assessment within this study (Section 4.2.1). However, it could warrant further consideration as part of any future feasibility studies following PIFMSI.

## 5.4 Dam on the Brisbane River at AMTD 282.3 km

For the purposes of this prefeasibility assessment, a possible new dam upstream of Linville (at AMTD 282.3 km) was considered the best option for more detailed assessment.

### 5.4.1 Objective

The principal objective for the potential new dam is to maintain the existing water supply security from the Wivenhoe Dam/Somerset Dam/Mt Crosby Weir system, with no worsening of environmental flow indicators in the MWRP, while the FSV of Wivenhoe Dam is reduced.

### 5.4.2 Dam configuration

For reasons including the following, an ungated spillway was assumed for the purpose of this study with the crest at the full supply level of the dam:

- Although gates would provide greater flood mitigation capability, the principal purpose of a Brisbane River dam near Linville acting in this mode is to offset water supply demand on Wivenhoe Dam.
- Gates would incur significant additional cost.
- Gates on a Brisbane River dam near Linville would add further complexity to the operation of Wivenhoe and Somerset Dams.

Further detail regarding the selection of spillway size is given in Chapter 6. Engineering and environmental assessments and estimated costs of the dam are provided in Chapter 7.

### 5.4.3 Outlets and dead storage

Two valved outlets equivalent to those at Wivenhoe Dam were assumed for water supply and environmental baseflow requirements and dead storage was assumed as 10% of the storage volume up to full supply level.

### 5.4.4 Operating rules adopted for the water security assessment

Given the difference in catchment size, flood storage in Wivenhoe Dam will have greater potential to mitigate floods than flood storage in the Brisbane River AMTD 282.3 km dam. Therefore, to maximise the flood mitigation potential of Wivenhoe Dam, the modelling assumed that storage in a Brisbane River dam near Linville was maintained at a practical maximum by only releasing for water supply when Wivenhoe and Somerset Dams were drawn down to 40% of their combined FSV.

Releases were then made as required to maintain the combined capacity of Wivenhoe and Somerset Dams at 40% of existing FSV. Releases for water supply from Somerset Dam to Wivenhoe Dam were only made when Wivenhoe Dam approached dead storage.

In addition to releases to Wivenhoe Dam, releases were made from Linville Dam up to 10 or 30 ML/d of inflow to the proposed dam, depending on the size of the proposed dam. These releases were made for environmental purposes and to maintain the performance of existing downstream entitlements.

### 5.4.5 Water supply security

Using the MWRP Integrated Quantity and Quality Model (IQQM) extended to 2011, DSITIA determined three sizes of the Brisbane River AMTD 282.3 km dam to act in conjunction with three reduced Wivenhoe Dam FSVs (60%, 75% and 85% of the design FSV respectively, as were considered for WSDOS) (Table 5.1).

These dam sizes were determined using the following criteria:

- No failure in supply of the high priority entitlements in the mid-Brisbane River system for the period 1889–2011.
- Water Resource Plan (WRP) end-of-system Environmental Flow Objectives were met for the WRP period 1889–2000.
- WRP Water Allocation Security Objectives were met for the WRP period 1889–2000.

Should development of the Brisbane River AMTD 282.3 km dam proceed, it would need to comply with the WRP of the time.

**Table 5.1 Potential Brisbane River AMTD 282.3 km dam and Wivenhoe Dam combinations**

| Wivenhoe Dam FSV | Brisbane River AMTD 282.3 km water supply storage capacity (ML) |
|---|---|
| 100% | No Linville |
| 60% | 570,000 |
| 75% | 510,000 |
| 85% | 240,000 |

Using the SEQ Regional Water Balance Model (WATHNET) and a stochastically generated climate data set based on a historic period of record from July 1890 to June 2007, Seqwater, in conjunction with DSITIA, verified that regional water supply level of service (LOS) objectives could be maintained for the Table 5.1 combinations whilst maintaining the existing LOS yield of around 230,000 ML/a. Level of service (LOS) refers to objectives specifying the level of performance that SEQ residents can expect from their bulk water supply system. The 230,000 ML/a LOS yield was based on the modelling conditions which were appropriate at the time of determination.

### 5.4.6 Probability of initial filling

Table 5.2 indicates that the probability of initial filling of the Brisbane River AMTD 282.3 km dam in its first few years is quite low. However, the empty portion of the FSV would provide additional flood mitigation at the dam compared to the dam being full at the start of the flood.

The reduction of the FSV of Wivenhoe Dam would be staged to align with progressive initial filling of the Brisbane River AMTD 282.3 km dam. Once the Brisbane River AMTD 282.3 km dam was initially filled Wivenhoe Dam would permanently retain its corresponding reduced FSV.

For the purposes of this study it has been assumed that the flood mitigation benefits from the Brisbane River AMTD 282.3 km dam would not be significantly reduced in the years that it took to fill. This may not be a conservative assumption, particularly for the FSV 240,000 ML dam and would need further consideration in any next stage of assessment.

**Table 5.2 Probability of initial filling of a dam at Brisbane River AMTD 232.3 km**

| FSV<br>(ML) | Probability of initial filling in a number of years | | | Number of years for a probability of initial filling of 50% |
|---|---|---|---|---|
| | 2 years | 5 years | 10 years | |
| 240,000 | 26% | 59% | 91% | 5* |
| 510,000 | 11% | 33% | 59% | 8* |
| 570,000 | 7% | 29% | 58% | 9* |

* Rounded to nearest year

### 5.4.7 Flood mitigation

The potential flood mitigation benefits of the reduced Wivenhoe Dam FSVs are assessed in Chapter 6.

Even when operating fully in the water supply/demand offset mode, the Brisbane River AMTD 282.3 km dam would also provide some flood attenuation at the dam, i.e. peak outflow over the spillway would be less than the peak inflow to the dam. This aspect is considered in Chapter 6 in combination with the flood mitigation benefit from the reduction in the FSV of Wivenhoe Dam.

### 5.4.8 Options carried through to scenario assessments

The options outlined in Table 5.3 were carried through for assessment of their flood mitigation benefit either acting individually or in combination with other options (Chapter 6).

**Table 5.3 Water supply options adopted for further assessment under PIFMSI**

| Option No. | Reduced Wivenhoe Dam FSV | Dam on the Brisbane River at AMTD 282.3 km | |
|---|---|---|---|
| | | FSV<br>(ML) | Time to fill<br>(years) |
| 1 | 85% | 240,000 | 5 |
| 2 | 75% | 510,000 | 8 |
| 3 | 60% | 570,000 | 9 |
| 4 | 75% | 570,000 | 9 |

Notes:

1. Option 4 was added as a sensitivity assessment of a more conservative approach to allow for inaccuracies in determinations.
2. The tabled options all comply with current MWRP objectives, maintain the yield of the SEQ bulk water supply system (Table 5.1) and meet level of service requirements.

# Chapter 6 Hydrological assessment of dam sites

This chapter outlines the hydrologic assessments undertaken of the endorsed dam sites (shortlisted in Chapter 4 (but excluding Wivenhoe Dam)) aimed at further refining the number of sites for further analysis.

It summarises the purpose and results of Phases 2 and 3 of the hydrological assessments carried out by Seqwater. Seqwater technical memorandums Nos. 003, 004, 005 and 006 (Seqwater 2014a) provide further details and information on the limitations of these assessments.

In Phase 2, the indicative volumes of flood mitigation storage required to mitigate historical floods was estimated.

In Phase 3, assessments were made of the potential benefit of approximate dam configurations on both the local dam catchment outflow and flood flows in key sub-catchments of the Brisbane River basin.

## 6.1 Phase 2 flood hydrology

### 6.1.1 Purpose

Phase 2 hydrological assessments were an assessment of the required volume of each dam, up to spillway crest level, such that historical floods could be routed through a low level outlet without flow over the main spillway.

Phase 2 considered only the potential dry flood mitigation dams. It did not consider the potential Brisbane River AMTD 282.3 km dam acting as a water supply dam. This option is considered in Chapter 5 and section 6.2.5.

The following outlet/spillway configuration was adopted at all sites:

- a low level ungated outlet comprising a number of conduits sized to pass the historical floods at or before the storage level in the dam reaches the spillway crest level
- an ungated spillway capable of passing the probable maximum precipitation design flood (PMPDF) (assessed in Chapter 7).

The larger the conduits, the greater is their discharge capacity resulting in the volume of the dam required being smaller and the cost of the dam also being be lower. However the larger the conduits are, the lesser is the flood attenuation via the conduits. A trade-off is therefore required.

Phase 2 hydrological assessments did not consider the passing of extreme floods through the dam greater than those on historical record. These extreme floods would be passed through a spillway and additional height of dam will be required above the spillway crest to achieve this (Refer to the engineering assessments documented in Chapter 7).

### 6.1.2 Potential flood mitigation dam sites

Eight potential flood mitigation dam sites were short listed for further consideration under PIFMSI (Chapter 4, sections 4.2.4–4.2.5) as listed in Table 6.1.

**Table 6.1 Shortlisted dam sites**

| Catchment | Dam site |
|---|---|
| Bremer River | Bremer River AMTD 70.0 km (near Mt Walker) |
| | Western Creek AMTD 8.0 km (near Grandchester) |
| | Warrill Creek AMTD 64.4 km (near Aratula) |
| | Lower Warrill Creek AMTD 13.9 km/14.6 km (near Willowbank) |
| Lockyer Creek | Tenthill Creek AMTD 29.8 km (near Caffey) |
| | Laidley Creek AMTD 41.0 km (near Thornton) |
| Upper Brisbane River | Brisbane River AMTD 282.3 km (near Linville) |
| | Emu Creek AMTD 10.8 km (near Harlin) |

### 6.1.3 Method of Analysis

A brief summary of the Phase 2 hydrology method of analysis is as follows:

- The flood inflow hydrograph for each dam was determined (URBS model).
- Preliminary rating curves were developed for three low level flood outlet sizes at each dam assuming inlet control.
- For each of the three low level outlet capacities at each site, the peak flood level in each dam resulting from the nine largest historical floods (refer to sections 4.2.4.1, 4.2.4.2 and 4.2.5.1) was determined (GoldSim reservoir routing model). No release via the spillway was considered. The spillway crest level was set at the peak storage level determined.
- The low level outlet rating curves were reviewed by the consultant (SMEC) engaged to carry out the engineering assessments of the potential new dams. Some reductions in the outlet capacity due to tailwater effects resulted for the lower Warrill Creek site. However, no reworking of Phase 2 modelling was warranted as the resulting variations were considered within the accuracy required for a prefeasibility assessment, although sensitivity assessments were carried out in Phase 4 analysis for the dam at lower Warrill Creek with a revised rating curve and presented in Seqwater technical memorandum No. 008 (Seqwater 2014a).

### 6.1.4 Results

Flood attenuation at the dam, peak storage volume and peak level in the dam, for three outlet sizes at each short listed potential dam for the nine largest historical floods are presented in Seqwater technical memorandums nos. 003, 004 and 005 (Seqwater 2014a).

The results of Phase 2 were reviewed by the Department of Energy and Water Supply (DEWS) and the smallest outlet size considered at each site was adopted for the purpose of the PIFMSI, as these outlet sizes resulted in the largest attenuation of peak flow at each site for an expected relatively small additional cost of dam.

Exceptions to the adoption of the smallest outlet size were:

- the Laidley Creek AMTD 41 km site for which an outlet rating curve (headwater level versus discharge) and a storage curve (storage volume versus water level) was available and adopted for the Phase 3 hydrological assessments

- the lower Warrill Creek AMTD 13.9 km/14.6 km site where the outlet rating curve for the smallest outlet size was considered unrealistic and a new rating curve was developed for an outlet size between the smallest and second smallest considered.

Should development of any options be proposed then a more robust optimisation of low level outlet size would be required.

A summary of flood attenuation at the dam and peak storage volume and level in the dam for the critical historical flood for the adopted outlet size for each of the short listed potential dams is presented in Table 6.2. This data is presented for all 9 floods considered at each site in Seqwater technical memorandum nos. 003, 004 and 005 (Seqwater 2014a). It needs to be recognised that although these are the critical floods at the dams for determination of the dam size they may not be the critical floods in subsequent phases of assessment i.e. at the catchment outlets or for basin wide considerations.

### 6.1.5 Site eliminated under Phase 2 hydrological assessments

Based on the peak storage volume determined, the Western Creek AMTD 8.0 km site (near Grandchester) was eliminated from further consideration due to the large number of houses impacted and impacts on the railway line to Toowoomba and heritage listed buildings including the Grandchester Railway Complex.

### 6.1.6 Further issues

Some of the more significant issues identified in Seqwater technical memorandum nos. 003, 004 and 005 (Seqwater 2014a) and in DEWS review of the results of the Phase 2 hydrological assessments are as follows.

#### 6.1.6.1 Warrill Creek AMTD 64.4 km

A key factor for this site is that there is not much storage at water levels up to 15 m above the stream bed (that is, a dam at least 15 m high would be required to start to gain an appreciable increase in storage volume). As a consequence, with the assumed outlet ratings, many flood events would simply pass through the dam without much attenuation. To more effectively use this dam site and mitigate a larger range of floods, it would be necessary to consider a more strategically designed outlet structure (and corresponding rating) to utilise more temporary storage at higher levels. However this was not done for this study.

#### 6.1.6.2 Lower Warrill Creek AMTD 13.9 km/AMTD 14.6 km

The lower reaches of Warrill Creek have floodplain storage (between Churchbank Weir and the potential lower Warrill Creek dam) that currently provides some attenuation of peak flood flows in Warrill Creek (particularly for moderate floods in the order of 400 $m^3$/s to over 1,000 $m^3$/s). The flood inflow hydrographs used in this assessment were extracted from the existing conditions URBS hydrology model at the dam location that is downstream of the floodplain storage. The potential dam on lower Warrill Creek will drown and effectively replace the floodplain storage. Hence, the results in this assessment are potentially optimistic as they include the effect of the floodplain storage and the potential dam. This anomaly was remedied for Phase 3 hydrological assessments.

**Table 6.2 Storage and flood attenuation characteristics of potential new flood mitigation dams**

| Dam site | Critical flood event | Inflow volume (ML) | Peak inflow to dam (m³/s) | Peak outflow at dam (m³/s) | Peak flow reduction (%) | Peak storage volume (ML) | Peak storage level (mAHD) |
|---|---|---|---|---|---|---|---|
| Bremer River AMTD 67.7 km (near Mt Walker) [3] | Jan 1974 | 67,277 | 624 | 156 | 75 | 40,368 | 71.7 |
| Western Creek AMTD 8.0 km (near Grandchester) | Jan 1974 | 74,709 | 677 | 180 | 73 | 43,156 | 65.2 |
| Warrill Creek AMTD 64.4 km (near Aratula) | Jan 2013 | 50,667 | 711 | 133 | 81 | 32,652 | 133.3 |
| Lower Warrill Creek AMTD 13.9 km (near Willowbank) [1,2] | Jan 1887 | 247,279 | 1,770 | 391 | 78 | 130,000[1] | 42.8 |
| Tenthill Creek AMTD 29.8 km (near Caffey) | Jan 1974 | 98,595 | 885 | 256 | 71 | 49,715[4] | 199.6 |
| Laidley Creek AMTD 41.0 km (near Thornton) | (Note 5) | (Note 5) | (Note 5) | (Note 5) | (Note 5) | (Note 5) | (Note 5) |
| Brisbane River AMTD 282.3 km (near Linville) | Feb 1893 [6] | 604,374 | 3,104 | 956 | 69 | 348,139 | 157.4 |
| Emu Creek AMTD 10.8 km (near Harlin) | Feb 1893 [7] | 201,364 | 1,461 | 489 | 67 | 107,087 | 148.6 |

Notes:

1. The data in Table 6.2 is based on Seqwater technical memorandum nos. 003, 004 and 005 (Seqwater 2014a) with the exception of the peak storage volume for the Lower Warrill Creek AMTD 13.9 km site that was revised from 145,015 ML to 130,000 ML in subsequent modelling with a peak storage level of EL 42.8 mAHD. A later more accurate storage volume/elevation relationship indicated that a the storage volume coinciding with a storage level of EL 42.8 mAHD was 125,000 ML, although further reworking of the hydrological assessments was not considered to be warranted given the prefeasibility level of this study.
2. A Lower Warrill Creek site at AMTD 14.6 km was also considered in the engineering assessments (Chapter7 and SMEC 2014). The hydrological assessment of the AMTD 13.9 km site was considered to be representative of both sites for the purpose of this study.
3. Although the flood hydrology was carried out for the Bremer River AMTD 67.7 km site, an engineering review of the Bremer River AMTD 67.7 km and AMTD 70 km sites found that the latter had better foundation conditions (Bruvel, FJ 1981). The hydrological assessment of the AMTD 67.7 km site was considered to be representative of both sites for the purpose of this study. The peak storage level of EL 75.9 mAHD (the Spillway crest level was set to for the engineering assessments - Chapter7 and SMEC 2014) for the AMTD 70 km site was therefore determined from the storage volume/elevation relationship for this site with a peak storage volume equivalent to that determined for the AMTD 67.7 km site.
4. A later more accurate storage volume/elevation relationship, determined for the Tenthill Creek AMTD 29.8 km site, indicated that a the storage volume coinciding with a storage level of EL 199.6 mAHD was 52,500 ML, although reworking of the hydrological assessments was not considered to be warranted given the prefeasibility level of this study.
5. The Laidley Creek AMTD 41.0 km dam option was assessed in Phase 3 hydrological assessments only (bypassed Phase 2 hydrological assessments).
6. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
7. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).

### 6.1.6.3 Coincident flows

While the Phase 2 assessments show that moderate to significant attenuation of flood flows may be possible at these dam sites, the amount of attenuation may reduce further downstream due to runoff from local unmitigated catchment areas downstream of the dams and will depend on the relative phasing of the mitigated flow contributions and the unmitigated flows. This is assessed in Phase 3 hydrological assessments.

The effect of the attenuated and delayed flows on the operations of Wivenhoe Dam has been considered in Phase 4 hydrological assessments.

## 6.2 Phase 3 flood hydrology

### 6.2.1 Purpose

The Phase 3 hydrological assessments provide a catchment scale indication of the potential effect of new flood mitigation dams on flood flow hydrographs in sub-catchments of the Brisbane River basin.

These assessments do not provide an indication of the ultimate effect of these dams at the 'Basin' scale (such as flows in the mid Brisbane River and lower Brisbane River or levels at Ipswich with all catchments contributing) which all depend on the flood operations of Wivenhoe Dam. The ultimate basin scale benefits were assessed in the Phase 4 hydrological assessments (section 9.3).

The Phase 3 assessment of flood mitigation potential addressed:

- the effect on flood peaks and hydrograph shape immediately downstream of the potential dam site (confirming consistency of assessments from Phase 2)
- the effect on flood peaks and hydrograph shape at key locations of interest (Table 6.4) which are important influences for the operations of Wivenhoe Dam.

The hydrographs at the key locations from Phase 3 assessments were input to the Phase 4 Basin scale hydrological assessments.

### 6.2.2 Potential flood mitigation storage sites considered and key locations of interest

Following short-listing on the basis of the Phase 1 and Phase 2 hydrological assessments, seven of the new sites (i.e. in addition to Wivenhoe Dam) remained for assessment under Phase 3 as depicted in Table 6.3.

**Table 6.3 Storage sites considered in Phase 3 hydrological assessments**

| Catchment | Dam site | Dam site catchment area ($km^2$) |
|---|---|---|
| Bremer River | Bremer River AMTD 70.0 km (near Mt Walker) | 193[1] |
| | Warrill Creek AMTD 64.4 km (near Aratula) | 116 |
| | Lower Warrill Creek AMTD 13.9 km/14.6 km (near Willowbank) | 859 |
| Lockyer Creek | Tenthill Creek AMTD 29.8 km (near Caffey) | 376 |
| | Laidley Creek AMTD 41.0 km (near Thornton) | 114 |
| Upper Brisbane River | Brisbane River AMTD 282.3 km (near Linville) | 1,996 |
| | Emu Creek AMTD 10.8 km (near Harlin) | 911 |

Notes:

1. Catchment area quoted is based on Bremer River AMTD 67.7 km which was used as a surrogate for Bremer River AMTD 70 km (Refer to Section 4.2.4.1)

A summary of the key locations of interest and URBS models used for this analysis is shown in Table 6.4.

**Table 6.4 Key locations of interest within the URBS models**

| Catchment | Key points of interest | Catchment area ($km^2$) | Relevant URBS models to the key locations of interest |
|---|---|---|---|
| Bremer River | Bremer River at Ipswich (David Trumpy Bridge) | 1,869 | • Bremer River to Walloon (634 $km^2$)<br>• Warrill Creek to Amberley (902 $km^2$)<br>• Purga Creek to Loamside (209 $km^2$)<br>• ~ 124 $km^2$ of the Bremer River catchment downstream of the location of the above models represented within the lower Brisbane URBS model |
| Lockyer Creek | Lockyer Creek at O'Reillys Weir | 2,964 | Lockyer Creek to O'Reillys Weir |
| Lower Brisbane River | Brisbane River at Moggill [1] | 1,855 | Lower Brisbane (excluding upper Brisbane (above Wivenhoe Dam), Lockyer Creek, Stanley River and Bremer River catchments) |
| Upper Brisbane River | Upper Brisbane River Inflow to Wivenhoe Dam | 5,645 | Upper Brisbane River (includes section of Stanley River catchment downstream of Somerset Dam) |

Note:

1. The flow at Moggill from rainfall over the catchments downstream of Wivenhoe Dam (including the lower Brisbane River catchment from Wivenhoe Dam to Moggill) is of interest to provide a measure of the flow that new dams can influence that Wivenhoe Dam operations cannot influence.

### 6.2.3 Method of Analysis

Phase 3 assessments were carried out in two parts:

- Part 1 considered 12 catchment scenarios (Table 6.5) that included the potential dry flood mitigation dam options and combinations thereof. The results were reviewed with the least effective new storage sites identified and excluded from further analysis (i.e. not carried through to Phase 4). Note that the term 'catchment scenarios' refers to the individual Brisbane River sub-catchments, namely upper Brisbane River, Bremer River, Lockyer Creek, and lower Brisbane River, as represented in the hydrological (URBS) models and not to the entire Brisbane River Catchment.
- Part 2 considered the Brisbane River AMTD 282.3 km dam (near Linville), acting as a water supply dam (to provide offset water supply yield to allow reduction of Wivenhoe Dam full supply volume (FSV)). This dam was considered both acting alone or in combination with Emu Creek AMTD 10.8 km dam acting as a dry flood mitigation dam (catchment scenario nos. 13–28 – Table 6.12)

### 6.2.4 Phase 3 hydrology - Part 1

#### 6.2.4.1 Catchment scenarios

The 12 catchment scenarios indicated in Table 6.5 were selected as being the more promising of the possible combinations for assessment under this phase.

**Table 6.5 Phase 3 - Part 1 modelled catchment scenarios**

| Scenario No | Catchment | Dam Site/s |
|---|---|---|
| SC01 | Bremer River | Bremer River AMTD 70.0 km (near Mt Walker) |
| SC02 | | Warrill Creek AMTD 64.4 km (near Aratula) |
| SC03 | | Lower Warrill Creek AMTD 13.9/14.6 km (near Willowbank) |
| SC04 | | Bremer River AMTD 70.0 km (near Mt Walker) and Lower Warrill Creek AMTD 13.9/14.6 km (near Willowbank) |
| SC05 | | Bremer River AMTD 70.0 km (near Mt Walker) and Warrill Creek AMTD 64.4 km (near Aratula) |
| SC06 | | Bremer River AMTD 70.0 km (near Mt Walker), Warrill Creek AMTD 64.4 km (near Aratula) and Lower Warrill Creek AMTD 13.9/14.6 km (near Willowbank) |
| SC07 | Lockyer Creek | Tenthill Creek AMTD 29.8 km (near Caffey) |
| SC08 | | Laidley Creek AMTD 41 km (near Thornton) |
| SC09 | | Tenthill Creek AMTD 29.8 km (near Caffey) and Laidley Creek AMTD 41 km (near Thornton) |
| SC10 | Upper Brisbane River | Brisbane River AMTD 282.3 km (near Linville) |
| SC11 | | Emu Creek AMTD 10.8 km (near Harlin) |
| SC12 | | Brisbane River AMTD 282.3 km (near Linville) and Emu Creek AMTD 10.8 km (near Harlin) |

#### 6.2.4.2 Floods considered

Catchment scenario nos. 01–09 were assessed against 11 historical floods, which included the 9 largest historical floods for both Lockyer creek and Bremer River respectively, ranked by estimated peak flow. These are the same historical events used during the Phase 2 assessment.

Catchment scenario nos. 10–12, which refer to the upper Brisbane River catchment dam options, were assessed against the nine largest historical floods (ranked by estimated peak flow in the upper Brisbane River catchment at the inflow into Wivenhoe Dam). These are the same historical events used during the Phase 2 assessment.

This Phase 3 - Part 1 hydrology does not consider the passing of extreme floods through the dam greater than those on historical record. These floods would be passed through a spillway (refer to section 6.1.1) and additional height of dam will be required above the spillway crest to achieve this (Refer to the engineering assessments documented in Chapter 7).

#### 6.2.4.3 Outlet rating curves

A relationship between storage volume and outflow, to be used as input for the modelling, was required for each dam.

The storage volume versus discharge curves used for each of the dams are presented in Appendix A of Seqwater technical memorandum no. 006 (Seqwater 2014a).

### 6.2.4.4 Flood attenuation at the dams

Table 6.6 and Table 6.7 show the modelled percentage reduction in peak flows at the location of the potential new dams (with the dam in place and adopted outlet configuration).

**Table 6.6 Bremer, Warrill and Lockyer potential storages - percentage reduction of peak flow at dam location**

| Flood event | Bremer River AMTD 70 km | Upper Warrill Creek AMTD 64.4 km | Lower Warrill Creek AMTD 13.9/14.6 km | Tenthill Creek AMTD 29.8 km | Laidley Creek AMTD 41.0 km |
|---|---|---|---|---|---|
| January 1887 | 69% | 64% | 73% | 64% | 15% |
| March 1890 | 46% | 28% | 49% | 42% | 5% |
| February 1893 [1] | 37% | 11% | 18% | 43% | 19% |
| February 1893 [2] | 47% | 34% | 49% | 46% | 4% |
| March 1908 | 36% | 11% | 22% | 40% | 10% |
| January 1974 | 75% | 66% | 73% | 71% | 32% |
| February 1976 | 68% | 59% | 66% | 49% | 33% |
| December 1991 | 71% | 59% | 72% | 15% | 77% |
| April 1996 | 63% | 13% | 31% | 46% | 27% |
| January 2011 | 76% | 55% | 52% | 65% | 35% |
| January 2013 | 78% | 81% | 67% | 76% | 43% |

Notes:

1. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
2. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).

**Table 6.7 Upper Brisbane catchment potential storages - percentage reduction of peak flow at dam location**

| Flood event | Brisbane River AMTD 282.3 km | Emu Creek AMTD 10.8 km |
|---|---|---|
| February 1893 [1] | 69% | 59% |
| February 1893 [2] | 71% | 67% |
| June 1893 | 71% | 60% |
| January 1898 | 64% | 27% |
| March 1955 | 68% | 61% |
| January 1974 | 68% | 65% |
| June 1983 | 75% | 70% |
| February 1999 | 72% | 70% |
| January 2011 | 77% | 69% |

Legend for Table 6.6 and Table 6.7

| | |
|---|---|
| Dark green | >75% reduction |
| Light green | 51% - 75% reduction |
| Peach | 25% - 50% reduction |
| Yellow | 10% to 24% reduction |
| White | <10% reduction |

Notes:

1. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
2. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).

The dam inflow and outflow hydrographs estimated for each of the historical events are presented in Appendix B Seqwater technical memorandum no. 006 (Seqwater 2014a).

The results suggest that all of the potential storages could provide moderate to significant attenuation of large flood flows at the site locations. However, as mentioned in section 6.1.6.3, the amount of attenuation may reduce further downstream of the dam sites due to runoff from local unmitigated downstream catchment areas and will depend on the relative phasing of the mitigated flow contributions from different tributaries in the catchments.

Therefore, historical peak flows were determined for the key locations listed in Table 6.4, both without and with the dams in place for catchment scenario nos. 01–12.

### 6.2.4.5 Flood attenuation at Ipswich from dams in the Bremer River catchment

Table 6.8 and Figure 6.1 present a comparison of the influence of each relevant catchment scenario to the peak flow in the Bremer River at Ipswich. The plotted points in Figure 6.1 represent the historical flood events modelled for each catchment scenario and linear trendlines have been added to assist with the identification of the catchment scenarios that provide the largest benefit.

**Table 6.8 Percentage attenuation of Bremer River peak flows at Ipswich**

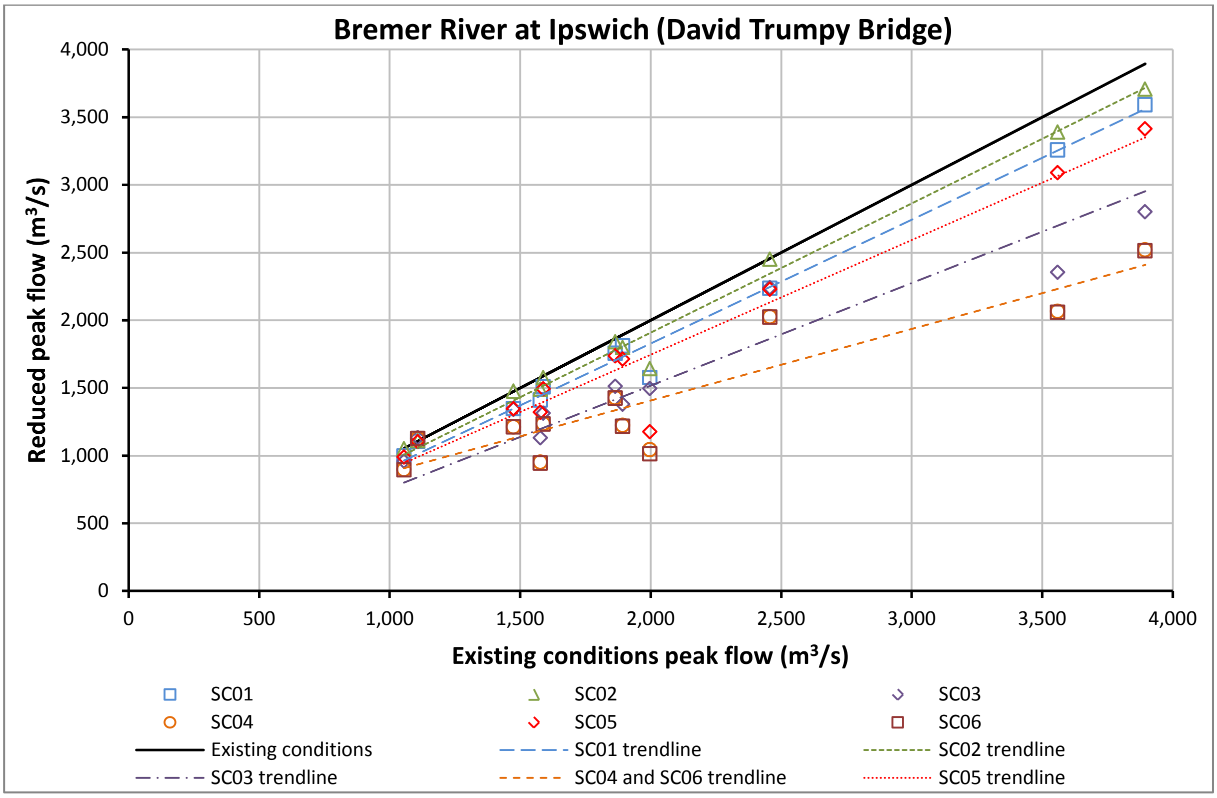
| Catchment scenario / Flood event | SC01 | SC02 | SC03 | SC04 | SC05 | SC06 |
|---|---|---|---|---|---|---|
| | Bremer River AMTD 70 km | Upper Warrill Creek AMTD 64.4 km | Lower Warrill Creek AMTD 13.9 km/ 14.6 km | Bremer River AMTD 70 km and Lower Warrill Creek AMTD 13.9 km/ 14.6 km | Bremer River AMTD 70 km and Upper Warrill Creek AMTD 64.4 km | Bremer River AMTD 70 km, Lower Warrill Creek AMTD 13.9 km/14.6 km and Upper Warrill Creek AMTD 64.4 km |
| January 1887 | 9% | 5% | 34% | 42% | 13% | 42% |
| March 1890 | 5% | 1% | 17% | 22% | 6% | 22% |
| February 1893 [1] | 6% | 0% | 9% | 15% | 6% | 15% |
| February 1893 [2] | 6% | 1% | 19% | 24% | 7% | 24% |
| March 1908 | 0% | 0% | -2% | -2% | 0% | -2% |
| January 1974 | 8% | 5% | 28% | 35% | 12% | 36% |
| February 1976 | 11% | 6% | 28% | 40% | 16% | 40% |
| December 1991 | 4% | 5% | 27% | 35% | 9% | 36% |
| April 1996 | 9% | 0% | 9% | 18% | 9% | 18% |
| January 2011 | 9% | 0% | 9% | 18% | 9% | 18% |
| January 2013 | 21% | 18% | 25% | 48% | 41% | 49% |

Notes:

1. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
2. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).

**Legend**

| | |
|---|---|
| Dark green | >75% reduction |
| Light green | 51% - 75% reduction |
| Peach | 25% - 50% reduction |
| Yellow | 10% to 24% reduction |
| White | <10% reduction |




**Scenario descriptions:**

SC01: Bremer River AMTD 70 km

SC02: Upper Warrill Creek AMTD 64.4 km

SC03: Lower Warrill Creek AMTD 13.9 km/14.6 km

SC04: Bremer River AMTD 70 km and Lower Warrill Creek AMTD 13.9 km/14.6 km

SC05: Bremer River AMTD 70 km and Upper Warrill Creek AMTD 64.4 km

SC06: Bremer River AMTD 70 km, Upper Warrill Creek AMTD 64.4 km and Lower Warrill Creek AMTD 13.9 km/14.6 km

**Figure 6.1 Influence of catchment scenarios on Bremer River peak flows at Ipswich (SC01–06)**

For Bremer River flow at Ipswich, little attenuation benefit is evident for flood events with a peak flow less than 1,500 $m^3$/s. For instance, the February 1893 (first flood) and March 1908 flood events, which were small floods for Bremer River, produced modelled peak flows of 1,055 $m^3$/s and 1,109 $m^3$/s respectively (without dams in place). During these events, all catchment scenarios provide negligible to very minor flood peak attenuation benefits, as observed from Table 6.8 and Figure 6.1.

Subject to the accuracy of the elevation – storage data and the assumed outlet ratings, the results indicate that:

- A potential dam at lower Warrill Creek AMTD 13.9 km/14.6 km is the most effective single storage option (catchment scenario nos. 01–03) for attenuating Bremer River flood flows at Ipswich. This dam could potentially provide moderate to significant attenuation of large flood flows in the Bremer River at Ipswich.
- Catchment scenario no. 04 (Bremer River AMTD 70 km and lower Warrill Creek AMTD 13.9/14.6 km dams in place) could provide significant attenuation for large floods, of a similar magnitude to catchment scenario no. 06, which assumes three dams in place (Bremer River AMTD 70 km, upper Warrill Creek AMTD 64.4 km and lower Warrill Creek AMTD 13.9/14.6 km).

- In terms of timing of the flood peak, it appears that the timing of the hydrograph peak remains largely the same. This occurs because catchment runoff from downstream of the potential new dams would still dominate the peak flow at Ipswich. In general, the flood water volume temporarily stored in the mitigation dams is released during the receding limb of the hydrograph, which has a flatter slope than the existing case.
- The potential dam on Warrill Creek at AMTD 64.4 km is relatively ineffectual in mitigating the peak flow at Ipswich.

The Warrill Creek AMTD 64.4 km site was not carried through to Phase 4 hydrological assessments.

The hydrographs for catchment scenario nos. 01–06 at Ipswich are shown in Appendix C of Seqwater technical memorandum no. 006 (Seqwater 2014a).

No assessment of the impacts of the peak flood levels has been undertaken for Ipswich in the Phase 3 hydrological assessments. Water levels at Ipswich are affected by backwater effects from the Brisbane River. Therefore, the impact of these catchment scenarios to the flood level at Ipswich may not follow the same pattern as the flood flows. Estimating the flood levels for these catchment scenarios is not a simple exercise and the concurrent flood in the Brisbane River needs to be factored in the analysis.

Flood levels at Ipswich (David Trumpy Bridge) were determined as part of the Phase 4 basin scale hydrological assessments (refer to Section 9.3.1.3)

#### 6.2.4.6 Flood attenuation at O'Reillys Weir from potential dams in Lockyer Creek catchment

Table 6.9 and Figure 6.2 present a comparison of the influence of each relevant catchment scenario on the peak flow in Lockyer Creek at O'Reillys Weir. The plotted points in Figure 6.2 represent the historical flood events modelled for each catchment scenario and linear trendlines have been added to assist with the identification of the catchment scenarios that provide the largest benefit.

**Table 6.9 Percentage attenuation of Lockyer Creek peak flows at O'Reilly's Weir**

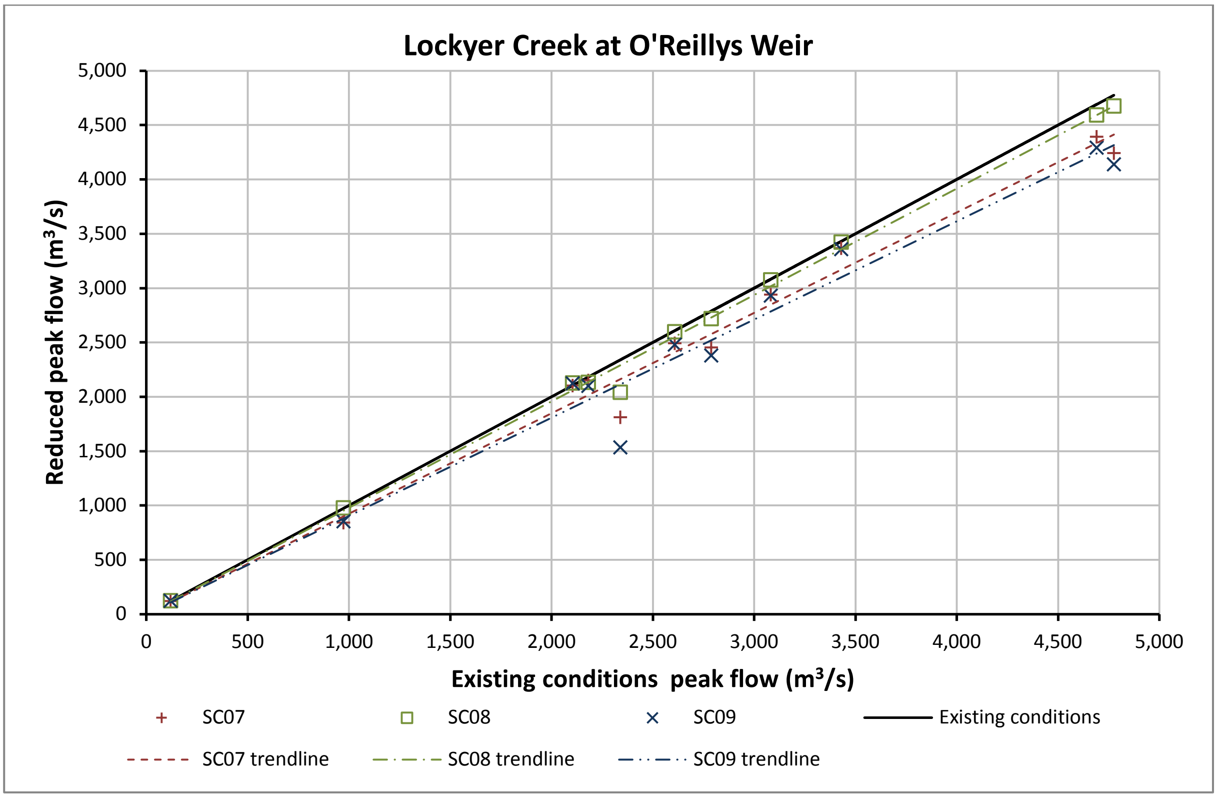
| Catchment scenario / Flood event | SC07 | SC08 | SC09 |
|---|---|---|---|
| | Tenthill Creek AMTD 29.8 km | Laidley Creek AMTD 41 km | Tenthill Creek AMTD 29.8 km Laidley Creek AMTD 41 km |
| January 1887 | 12% | 3% | 15% |
| March 1890 | 5% | 0% | 5% |
| February 1893 [1] | 5% | 1% | 5% |
| February 1893 [2] | 2% | 0% | 2% |
| March 1908 | 0% | -1% | -1% |
| January 1974 | 11% | 2% | 13% |
| February 1976 | 14% | 0% | 13% |
| December 1991 | 1% | -2% | -1% |
| April 1996 | 1% | 2% | 4% |
| January 2011 | 6% | 2% | 9% |
| January 2013 | 23% | 13% | 34% |

Legend:

| | |
|---|---|
| Dark green | >75% reduction |
| Light green | 51% - 75% reduction |
| Peach | 25% - 50% reduction |
| Yellow | 10% to 24% reduction |
| White | <10% reduction |

Notes:

1. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
2. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).




**Scenario descriptions:**

SC07: Tenthill Creek AMTD 29.8 km

SC08: Laidley Creek AMTD 41 km

SC09: Tenthill Creek AMTD 29.8 km and Laidley Creek AMTD 41 km

**Figure 6.2 Influence of catchment scenarios on Lockyer Creek peak flows at O'Reilly's Weir (SC07–09)**

For Lockyer Creek at O'Reillys Weir, attenuation benefits are evident for flood events with a peak flow in excess of 2,000 $m^3/s$ (Figure 6.2).

Subject to the accuracy of the elevation – storage data and the assumed outlet ratings, the results indicate that:

- The Lockyer Creek flood mitigation storage options assessed provide limited attenuation of large flood flows at O'Reillys Weir.
- A potential dam at Tenthill Creek AMTD 29.8 km is the most effective single storage option (catchment scenario nos. 07–08) for attenuating flood flows at O'Reillys Weir.
- Little additional attenuation of flood flows is generally achieved combining a potential dam at Laidley Creek AMTD 41 km with a potential dam at Tenthill Creek AMTD 29.8 km (catchment scenario no. 09). This is understandable given the limited storage volume of a potential dam on Laidley Creek AMTD 41 km of 5,200 ML compared to a storage volume of 52,500 ML for a potential dam at Tenthill Creek AMTD 29.8 km.
- The Lockyer Creek catchment is subject to significant rainfall variability, with many tributaries contributing to its flow. Therefore, the potential dams, located in two of the Lockyer Creek tributaries, do not appear to provide significant benefit for the attenuation of peak flows for the entire Lockyer Creek catchment, as the attenuation benefit is heavily reliant on the rainfall falling over these specific tributaries. For many historical floods where the majority of the rainfall did not concentrate over either Tenthill Creek or Laidley Creek, the overall attenuation benefit for Lockyer Creek flow at O'Reillys Weir is minimal.

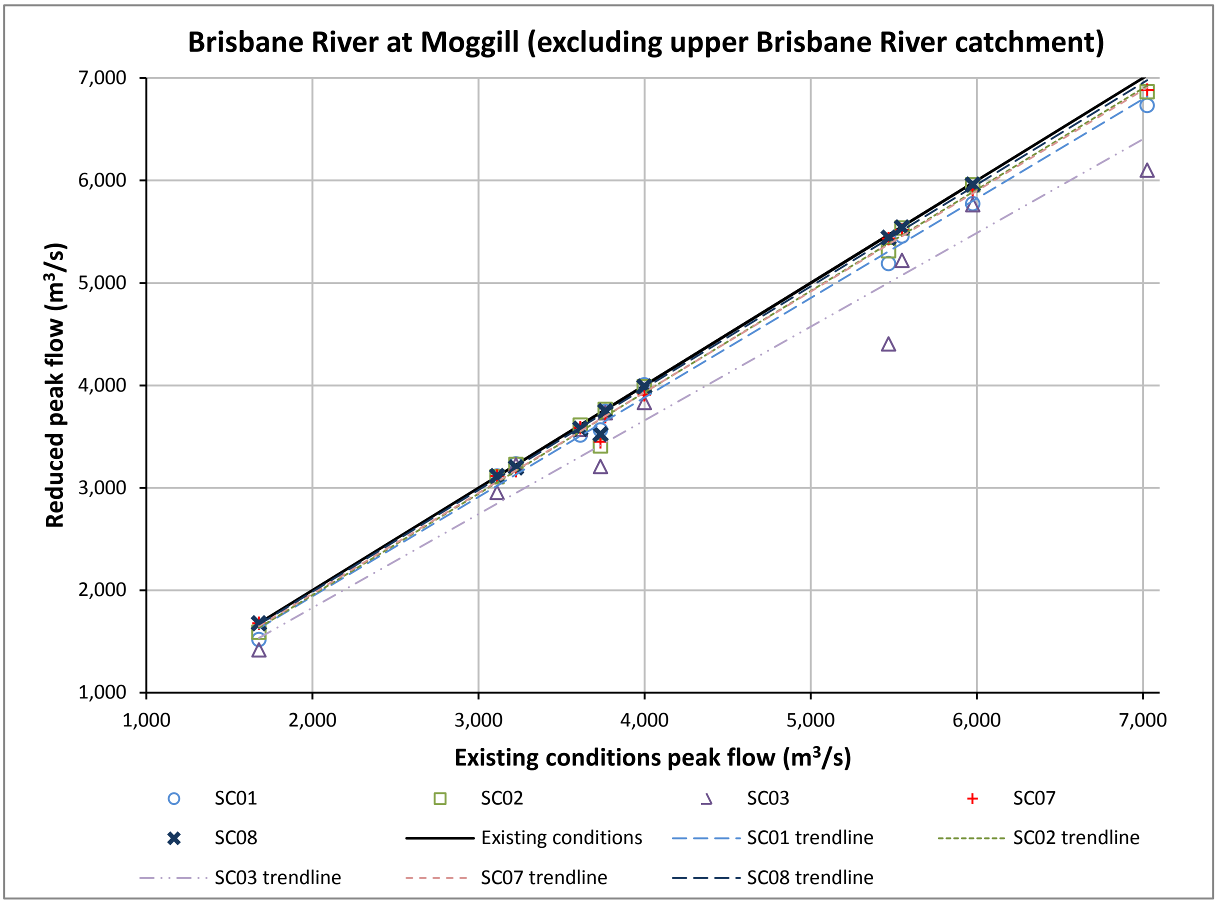
Neither Tenthill Creek AMTD 29.8 km potential storage nor Laidley Creek AMTD 41 km potential storage was carried through to Phase 4 hydrological assessments.

The hydrographs for catchment scenario nos. 07–09 at O'Reillys Weir are shown in Appendix C of Seqwater technical memorandum no. 006 (Seqwater 2014a).

#### 6.2.4.7 Flood attenuation at Moggill from potential dams downstream of Wivenhoe Dam (excluding upper Brisbane River catchment)

The flow at Moggill from rainfall over the catchments downstream of Wivenhoe Dam (including the lower Brisbane River catchment from Wivenhoe Dam to Moggill) is of interest to provide a measure of the flow that new dams can influence that Wivenhoe Dam operations cannot influence.

Figure 6.3, Figure 6.4 and Table 6.10 present a comparison of the influence of each catchment scenario on the peak flow in the Brisbane River at Moggill. The plotted points in Figure 6.3 and Figure 6.4 represent the historical flood events modelled for each catchment scenario and linear trendlines have been added to assist with the identification of the catchment scenarios that provide the largest benefit.




**Scenario descriptions:**

SC01: Bremer River AMTD 70 km

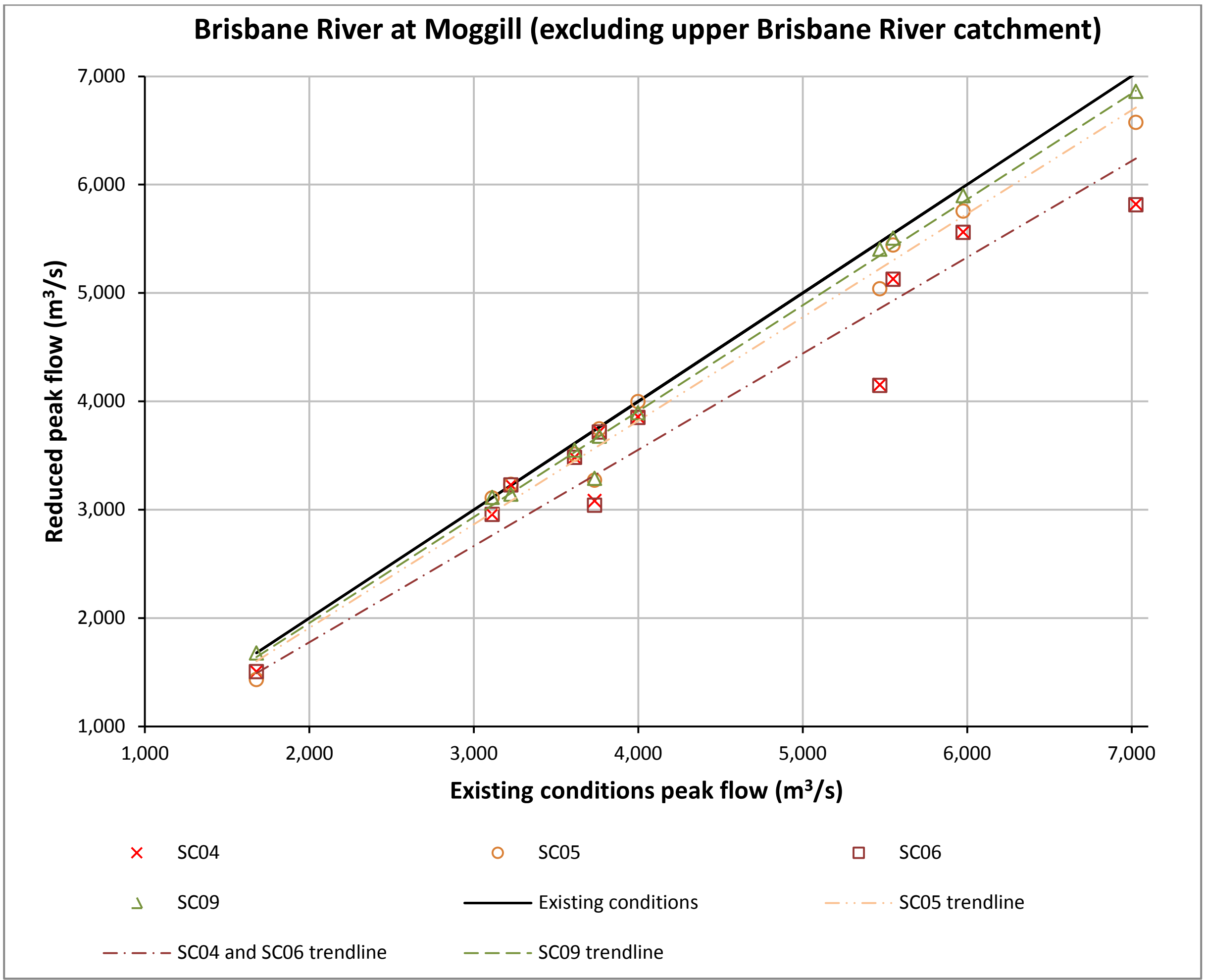
SC02: Upper Warrill Creek AMTD 64.4 km

SC03: Lower Warrill Creek AMTD 13.9 km/14.6 km

SC07: Tenthill Creek AMTD 29.8 km

SC08: Laidley Creek AMTD 41 km

**Figure 6.3 Influence of catchment scenarios (single storages) on Brisbane River peak flows at Moggill (excluding Brisbane River catchment flows from upstream of Wivenhoe Dam)**




**Scenario descriptions:**

SC04: Bremer River AMTD 70 km and
Lower Warrill Creek AMTD 13.9 km/14.6 km

SC05: Bremer River AMTD 70 km and
Upper Warrill Creek AMTD 64.4 km

SC06: Bremer River AMTD 70 km,
Upper Warrill Creek AMTD 64.4 km and
Lower Warrill Creek AMTD 13.9 km/14.6 km

SC09: Tenthill Creek AMTD 29.8 km and
Laidley Creek AMTD 41 km

**Figure 6.4 Influence of catchment scenarios (multiple storages) on Brisbane River peak flows at Moggill (excluding Brisbane River catchment flows from upstream of Wivenhoe Dam)**

**Table 6.10 Percentage attenuation of Brisbane River peak flows at Moggill**

| Catchment scenario / Flood event | SC01 | SC02 | SC03 | SC04 | SC05 | SC06 | SC07 | SC08 | SC09 |
|---|---|---|---|---|---|---|---|---|---|
| | Bremer River AMTD 70 km | Warrill Creek AMTD 64.4 km | Lower Warrill Creek AMTD 13.9 km/14.6 km | Bremer River AMTD 70 km Lower Warrill Creek AMTD 13.9 km/14.6 km | Bremer River AMTD 70 km Warrill Creek AMTD 64.4 km | Bremer River AMTD 70 km Warrill Creek AMTD 64.4 km Lower Warrill Creek AMTD 13.9 km/14.6 km | Tenthill Creek AMTD 29.8 km | Laidley Creek AMTD 41 km | Tenthill Creek AMTD 29.8 km Laidley Creek AMTD 41 km |
| January 1887 | 5% | 3% | 19% | 24% | 8% | 24% | 1% | 1% | 1% |
| March 1890 | 0% | 0% | 4% | 4% | 0% | 4% | 2% | 0% | 3% |
| February 1893 [1] | 1% | 0% | 1% | 1% | 0% | 1% | 2% | 0% | 2% |
| February 1893 [2] | 2% | 0% | 6% | 8% | 2% | 8% | 1% | 0% | 1% |
| March 1908 | 0% | 0% | 0% | 0% | 0% | 0% | 2% | 1% | 3% |
| January 1974 | 4% | 2% | 13% | 17% | 6% | 17% | 2% | 0% | 2% |
| February 1976 | 10% | 5% | 15% | 10% | 15% | 10% | 0% | 0% | 0% |
| December 1991 | 0% | 0% | 5% | 5% | 0% | 5% | 0% | 0% | 0% |
| April 1996 | 3% | 0% | 1% | 4% | 3% | 4% | 1% | 1% | 2% |
| January 2011 | 3% | 0% | 4% | 7% | 4% | 7% | 1% | 0% | 1% |
| January 2013 | 5% | 9% | 14% | 17% | 12% | 19% | 8% | 6% | 12% |

Notes:

1. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
2. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).

**Legend**

| | |
|---|---|
| Dark green | >75% reduction |
| Light green | 51% - 75% reduction |
| Peach | 25% - 50% reduction |
| Yellow | 10% to 24% reduction |
| White | <10% reduction |

Subject to the accuracy of the elevation – storage data and the assumed outlet ratings, the results indicate that:

- A potential dam on lower Warrill Creek AMTD 13.9 km/14.6 km is the most effective option of catchment scenario nos. 01–03 and 07–08 (which represent single dams) for attenuating flood flows at Moggill. This dam could potentially provide small to moderate attenuation of large flood flows at Moggill.
- Catchment scenario nos. 04–06 and 09 represent potential storage combinations of two or three storages. For the large historical floods, catchment scenario no. 04 (storages at Bremer River AMTD 70 km and lower Warrill Creek AMTD 13.9 km/14.6 km) could provide moderate attenuation, of similar magnitude to catchment scenario no. 06, which assumes three storages in place (Bremer River AMTD 70 km, Warrill Creek AMTD 64.4 km and lower Warrill Creek AMTD 13.9 km/14.6 km).
- With the exception of the 2013 event, the modelling of historical floods for Lockyer Creek storage options (catchment scenario nos. 07–09) suggests that these options would generally provide minimal attenuation of large flood flows at Moggill.
- The analysis suggests that the timing of the peak of the hydrograph largely remains the same. This occurs because catchment runoff from downstream of the potential new dams would still dominate the peak flow at Moggill. In general, the flood water volume temporarily stored in the mitigation dams is released during the receding limb of the hydrograph, which has a flatter slope than the existing case. However, it is also possible that during events with two consecutive peaks of similar magnitude, such as the 1976 historical flood where the first peak was the highest, the peak flood flow may shift from the first peak to the second peak.

The hydrographs for the location of Moggill for catchment scenario nos. 01–09 are shown in Appendix C of Seqwater technical memorandum no. 006 (Seqwater 2014a).

Note that the Phase 3 hydrologic assessment for Moggill has only considered the impact on flows from potential dams on the downstream Brisbane River tributaries, excluding the Upper Brisbane River catchment. The influence of these dams in combination with Wivenhoe Dam releases has been investigated in Phase 4 assessments.

#### 6.2.4.8 Flood attenuation of inflow to Wivenhoe Dam (excluding inflow from Somerset Dam catchment) from potential upstream dams

Catchment scenario nos. 10–12 investigated the Brisbane River AMTD 282.3 km (near Linville) and Emu Creek AMTD 10.8 km (near Harlin) storage options as dry flood mitigation dams to assess the potential benefit to reduce peak inflows into Wivenhoe Dam (excluding inflows from Somerset Dam).

Table 6.11 and Figure 6.5 present a comparison of the influence of each relevant catchment scenario on the peak inflow into Wivenhoe Dam. The plotted points in Figure 6.5 represent the historical flood events modelled for each catchment scenario and linear trendlines have been added to assist with the identification of the catchment scenarios that provide the largest benefit.

**Table 6.11 Percentage attenuation of peak inflows to Wivenhoe Dam (excluding inflows from Somerset Dam catchment)**

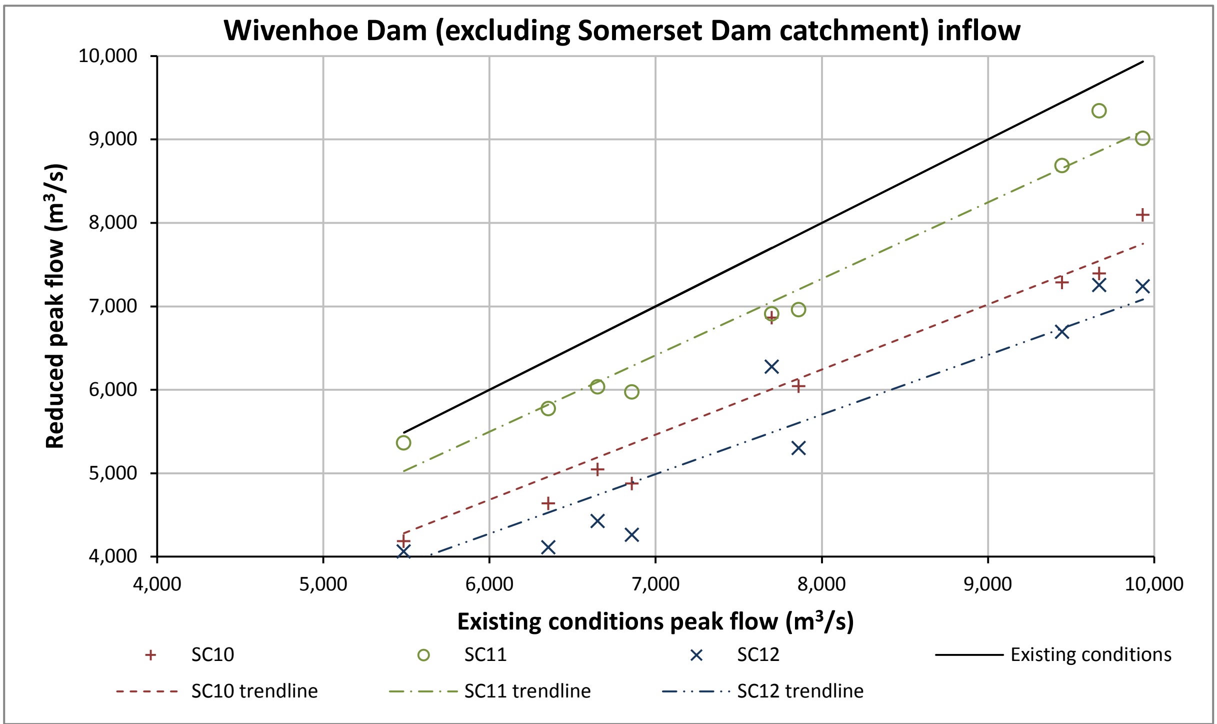
| Catchment scenario / Flood event | SC10 Brisbane River AMTD 282.3 km | SC11 Emu Creek AMTD 10.8 km | SC12 Brisbane River AMTD 282.3 km Emu Creek AMTD 10.8 km |
|---|---|---|---|
| February 1893 [1] | 23% | 8% | 29% |
| February 1893 [2] | 19% | 9% | 27% |
| June 1893 | 27% | 9% | 35% |
| January 1898 | 24% | 2% | 26% |
| March 1955 | 24% | 9% | 33% |
| January 1974 | 11% | 10% | 19% |
| March 1983 | 29% | 13% | 38% |
| February 1999 | 23% | 11% | 33% |
| January 2011 | 24% | 3% | 25% |

Legend:

| | |
|---|---|
| Dark green | >75% reduction |
| Light green | 51% - 75% reduction |
| Peach | 25% - 50% reduction |
| Yellow | 10% to 24% reduction |
| White | <10% reduction |

Notes:

1. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
2. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).




**Scenario descriptions:**

SC10: Brisbane River AMTD 282.3 km

SC11: Emu Creek AMTD 10.8 km

SC12: Brisbane River AMTD 282.3 km and Emu Creek AMTD 10.8 km

**Figure 6.5 Influence of catchment scenarios on Wivenhoe Dam peak inflows (excluding inflows from Somerset Dam catchment)**

Subject to the accuracy of the elevation – storage data and the assumed outlet ratings, the results indicate that:

- A potential flood mitigation dam at Brisbane River AMTD 282.3 km is the most effective single storage option (catchment scenario no. 10) for attenuating flood inflows into Wivenhoe Dam. This dam could provide moderate to significant attenuation of large flood inflows to Wivenhoe Dam.

- Catchment scenario no. 12 represents a combination of the two potential upper Brisbane River flood mitigation dams. This combination could provide a more significant attenuation of large flood inflows to Wivenhoe Dam Inflow.
- The analysis suggests that the timing of the peak of the hydrograph largely remains the same. This occurs because catchment runoff from downstream of the potential new dams still dominates the time of the peak flow into Wivenhoe Dam.

The hydrographs for the Wivenhoe Dam Inflow for catchment scenario nos. 10–12 are presented in Appendix C of Seqwater technical memorandum no. 006 (Seqwater 2014a).

The potential for flood mitigation dams in the upper Brisbane River catchment to attenuate peak flood flows from Upper Brisbane River may not necessarily translate to reduction in peak flows in the mid Brisbane River or lower Brisbane River.

The effect of the attenuated and delayed upper Brisbane River flows on the operations of Wivenhoe Dam (to evaluate the effect on peak flood flows in the Brisbane River downstream of Wivenhoe Dam) was investigated in Phase 4 hydrological assessments.

#### 6.2.4.9 Sites eliminated under Phase 3 – Part 1 assessments

The following sites were eliminated from further consideration under PIFMSI in consideration of the Phase 3 – Part 1 hydrological assessments, as discussed previously within this section:

- Tenthill Creek AMTD 29.8km
- Warrill Creek AMTD 64.4 km
- Laidley Creek AMTD 41 km

### 6.2.5 Phase 3 hydrology - Part 2

Phase 3 - Part 2 hydrological assessments consider the Brisbane River AMTD 282.3 km dam (near Linville), acting principally as a water supply dam (to provide offset water supply yield to allow reducing of Wivenhoe Dam FSV). However, even when operating as a water supply dam, the Brisbane River AMTD 282.3 km dam would also provide some flood attenuation at the dam, i.e. peak outflow over the spillway would be less than the peak inflow to the dam. This aspect was considered in combination with the flood mitigation benefit from the reduction in the FSV of Wivenhoe Dam in the Phase 4 assessments. Phase 3 assessments only determine the inflows to Wivenhoe Dam.

The selection of the Brisbane River AMTD 282.3 km (near Linville) dam site and the FSVs of a dam at this site acting in combination with Wivenhoe Dam reduced FSVs, as adopted for the Phase 4 hydrological assessments, is addressed in Chapter 5.

Note that the potential Brisbane River AMTD 282.3 km dam was assumed to be full to the FSV at the start of each hydrological analysis, unlike the dry flood mitigation dams that were assumed to be empty at the start of each hydrological analysis.

The Brisbane River AMTD 282.3 km dam was considered acting alone or in combination with Emu Creek AMTD 10.8 km acting as a dry flood mitigation dam (catchment scenario nos. 13–28 – Table 6.12)

#### 6.2.5.1 Brisbane River AMTD 282.3 km dam - spillway widths considered

The flood attenuation achieved and dam cost are both reliant on the spillway width. The narrower the spillway, the greater the flood attenuation but the higher the dam wall needs to be to prevent overtopping in extreme floods. In any future feasibility assessment the spillway width should be optimised considering these factors. Spillway widths of 160 m and 200 m were considered to be representative of the likely range of suitable widths and were adopted for Phase 3 – Part 2 hydrological assessments.

#### 6.2.5.2 Combined Brisbane River AMTD 282.3 km and Emu Creek dams catchment scenarios

Table 6.12 depicts the catchment scenarios considered for these Phase 3 - Part 2 hydrological assessments.

**Table 6.12 Phase 3 - Part 2 modelled scenarios**

| Catchment scenario | Brisbane River AMTD 282.3 km dam | | | Wivenhoe Dam FSV | Emu Creek AMTD 10.8 km modelled |
|---|---|---|---|---|---|
| | FSV (ML) | FSL (mAHD) [1] | Spillway width (m) | | |
| SC13 | 660,000 [2] | 166.3 | 160 | 60% | No |
| SC14 | 660,000 [2] | 166.3 | 200 | 60% | No |
| SC15 | 570,000 | 164.5 | 160 | 60% | No |
| SC16 | 570,000 | 164.5 | 200 | 60% | No |
| SC17 | 510,000 | 163 | 160 | 75% | No |
| SC18 | 510,000 | 163 | 200 | 75% | No |
| SC19 | 240,000 | 153 | 160 | 85% | No |
| SC20 | 240,000 | 153 | 200 | 85% | No |
| SC21 | 660,000 [2] | 166.3 | 160 | 60% | As a dry flood mitigation dam |
| SC22 | 660,000 [2] | 166.3 | 200 | 60% | As a dry flood mitigation dam |
| SC23 | 570,000 | 164.5 | 160 | 60% | As a dry flood mitigation dam |
| SC24 | 570,000 | 164.5 | 200 | 60% | As a dry flood mitigation dam |
| SC25 | 510,000 | 163 | 160 | 75% | As a dry flood mitigation dam |
| SC26 | 510,000 | 163 | 200 | 75% | As a dry flood mitigation dam |
| SC27 | 240,000 | 153 | 160 | 85% | As a dry flood mitigation dam |
| SC28 | 240,000 | 153 | 200 | 85% | As a dry flood mitigation dam |

Notes:

1. Of necessity, the hydrological studies were commenced prior to the engineering studies. A more accurate storage curve (storage volume versus water level) was available for the engineering assessments of the Brisbane River AMTD 282.3 km site than was available for the hydrological assessments. The FSLs depicted in this table may therefore differ slightly from those used for the engineering assessments. Reworking of the hydrological assessments was not considered to be warranted given the prefeasibility level of this study.
2. The modelling for a 660 000 ML capacity Brisbane River AMTD 282.3 km dam was carried out as a sensitivity assessment. Based on cases assessed in previous reports this was thought to be the potential upper limit of development at this site, although it is now considered that the site could be developed to greater capacity if required. The results of the modelling for this capacity dam (catchment scenario nos, 13–14 and 21–22) are not therefore presented in this report.

#### 6.2.5.3 Floods considered

Catchment scenario nos. 13–28 were assessed against the nine largest historical floods (ranked by estimated peak flow in the Upper Brisbane River catchment at the inflow into Wivenhoe Dam). These are the same historical events used during both the Phase 2 assessments and Part 1 of the Phase 3 assessments.

Phase 3 - Part 2 hydrological assessments do not consider the passing of floods through the dam greater than those on historical record. This is addressed in the engineering assessments documented in Chapter 7.

#### 6.2.5.4 Storage curves

The storage volume versus discharge curves used for each of the dams are presented in Appendix A of Seqwater technical memorandum no. 006 (Seqwater 2014a).

#### 6.2.5.5 Attenuation at the Brisbane River AMTD 282.3 km dam site (SC13–SC20)

Table 6.13 depicts the flood attenuation at the location of the Brisbane River AMTD 282.3 km dam site for three FSVs of the dam, each modelled with two spillway widths (catchment scenario nos. 15–20), for each of the historic floods considered. Note that results for Catchment scenario nos. 13–14 are not presented (refer to Note 2 to Table 6.12).

Figure 6.6 depicts the flood attenuation at the location of the Brisbane River AMTD 282.3 km dam site graphically (for catchment scenario nos. 15, 17 and 19) with linear trendlines added to assist with the identification of the catchment scenarios that provide the largest benefit. Note that catchment scenario nos. 16, 18 and 20 that have a 200 m spillway width are not presented in Figure 6.6 (refer to section 6.2.5.6).

**Table 6.13 Percentage attenuation of Brisbane River peak flows at the AMTD 282.3 km dam site**

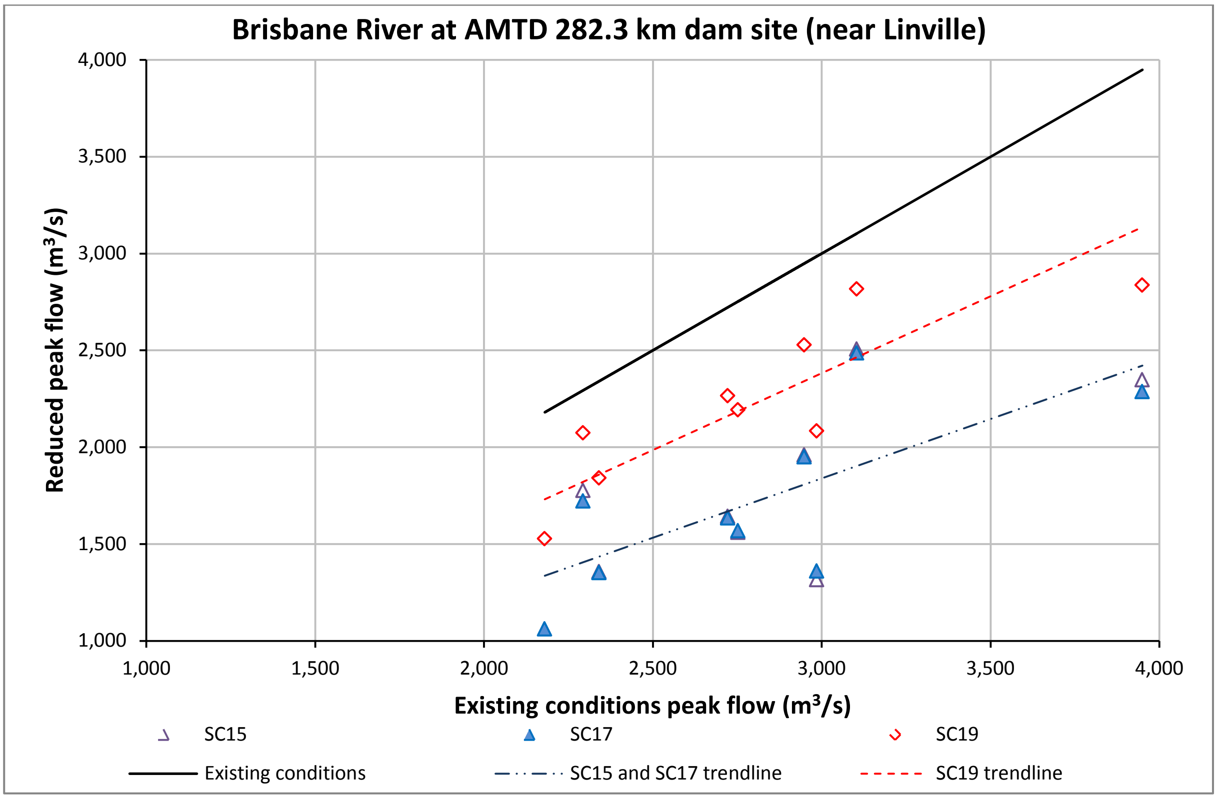
| Catchment scenario / Flood event | SC15 | SC16 | SC17 | SC18 | SC19 | SC20 |
|---|---|---|---|---|---|---|
| | Brisbane River AMTD 282.3 km FSV 570,000 ML | | Brisbane River AMTD 282.3 km FSV 510,000 ML | | Brisbane River AMTD 282.3 km FSV 240,000 ML | |
| | Spillway width 160 m | Spillway width 200 m | Spillway width 160 m | Spillway width 200 m | Spillway width 160 m | Spillway width 200 m |
| February 1893 [1] | 19% | 16% | 20% | 17% | 9% | 7% |
| February 1893 [2] | 34% | 29% | 34% | 29% | 14% | 11% |
| June 1893 | 40% | 34% | 40% | 34% | 17% | 13% |
| January 1898 | 23% | 18% | 25% | 21% | 10% | 7% |
| March 1955 | 54% | 49% | 51% | 47% | 30% | 26% |
| January 1974 | 42% | 37% | 42% | 37% | 21% | 17% |
| June 1983 | 56% | 51% | 54% | 49% | 30% | 25% |
| February 1999 | 43% | 38% | 43% | 37% | 20% | 16% |
| January 2011 | 41% | 38% | 42% | 40% | 28% | 24% |

Notes:

1. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
2. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).

**Legend**

| | |
|---|---|
| dark green | >75% reduction |
| light green | 51% - 75% reduction |
| orange | 25% - 50% reduction |
| yellow | 10% to 24% reduction |
| white | <10% reduction |




__Scenario descriptions:__

SC15: Brisbane River AMTD 282.3 km (FSV 570,000 ML, 160 m spillway)

SC17: Brisbane River AMTD 282.3 km (FSV 510,000 ML, 160 m spillway)

SC19: Brisbane River AMTD 282.3 km (FSV 240,000 ML, 160 m spillway)

**Figure 6.6 Influence of catchment scenarios on Brisbane River peak flows at AMTD 282.3 km dam site**

Subject to the accuracy of the elevation – storage data and the assumed outlet ratings, the results indicate that:

- All scenarios show evidence of moderate to significant attenuation at the Brisbane River AMTD 282.3 km dam site.
- Catchment scenario nos. 19–20, which assume a FSV of 240,000 ML seem to be the least effective of all the options, consistently providing less attenuation benefit than the other scenarios.
- The presence of the dam results in a time delay between peak inflow and peak outflow of between 5–12 hours.
- As expected the options with a spillway width of 160 m produce a larger attenuation.
- It is hard to assess which is the most effective scenario at this stage of the analysis; however, it appears that catchment scenario nos. 15 and 17 consistently provide greater reductions to the peak flows for the majority of the historical floods modelled.

The hydrographs for the Brisbane River AMTD 282.3 km dam for catchment scenario nos. 13–20 are presented in Appendix D of Seqwater technical memorandum no. 006 (Seqwater 2014a).

The amount of flood attenuation further downstream will depend on the relative phasing of the flow contributions from different tributaries in the catchment. Therefore an assessment of the impact of these scenarios on the inflow to Wivenhoe Dam was undertaken (refer section 6.2.5.7).

#### 6.2.5.6 Adopted Spillway width for the Brisbane River AMTD 282.3 km dam

Sunwater (2006) found in previous investigations for a dam on the Brisbane River at AMTD 282.1 km that there was little relative difference in estimated dam costs (for a roller compacted concrete dam) for spillway widths ranging from 160 m to 200 m for each of four FSVs considered (58,200 ML, 186,000 ML, 420,000 ML and 663,000 ML).

In consideration of the above, the prefeasibility level of this study and that the options with a spillway width of 160 m produce a larger attenuation, spillway widths of 160 m only were adopted for the purpose of PIFMSI. This is reflected Phase 4 hydrological assessments (Chapter 9) and the engineering assessments (Chapter 7). However, the 570,000 ML capacity dam was also costed with a spillway width of 200 m as a sensitivity assessment.

Hence, although 200 m spillway widths were modelled in Phase 3 – Part 2 hydrological assessments, the results are not presented herein with the exception of Table 6.13 where results are included to provide a relative measure.

#### 6.2.5.7 Attenuation of Wivenhoe Dam inflows (excluding inflows from Somerset Dam catchment) by Brisbane River AMTD 282.3 km dam

Table 6.14 depicts the flood attenuation of Wivenhoe Dam inflows (excluding inflows from Somerset Dam catchment) for catchment scenario nos. 15, 17 and 19, for each of the historic floods considered. Note that results for catchment scenario nos. 13–14, 16, 18 and 20 are not presented (refer to Note 2 to Table 6.12 and section 6.2.5.6).

Figure 6.7 depicts this graphically with linear trendlines added to assist with the identification of the catchment scenarios that provide the largest benefit.

**Table 6.14 Percentage attenuation of peak flow at Wivenhoe Dam inflow (water supply dam only scenarios)**

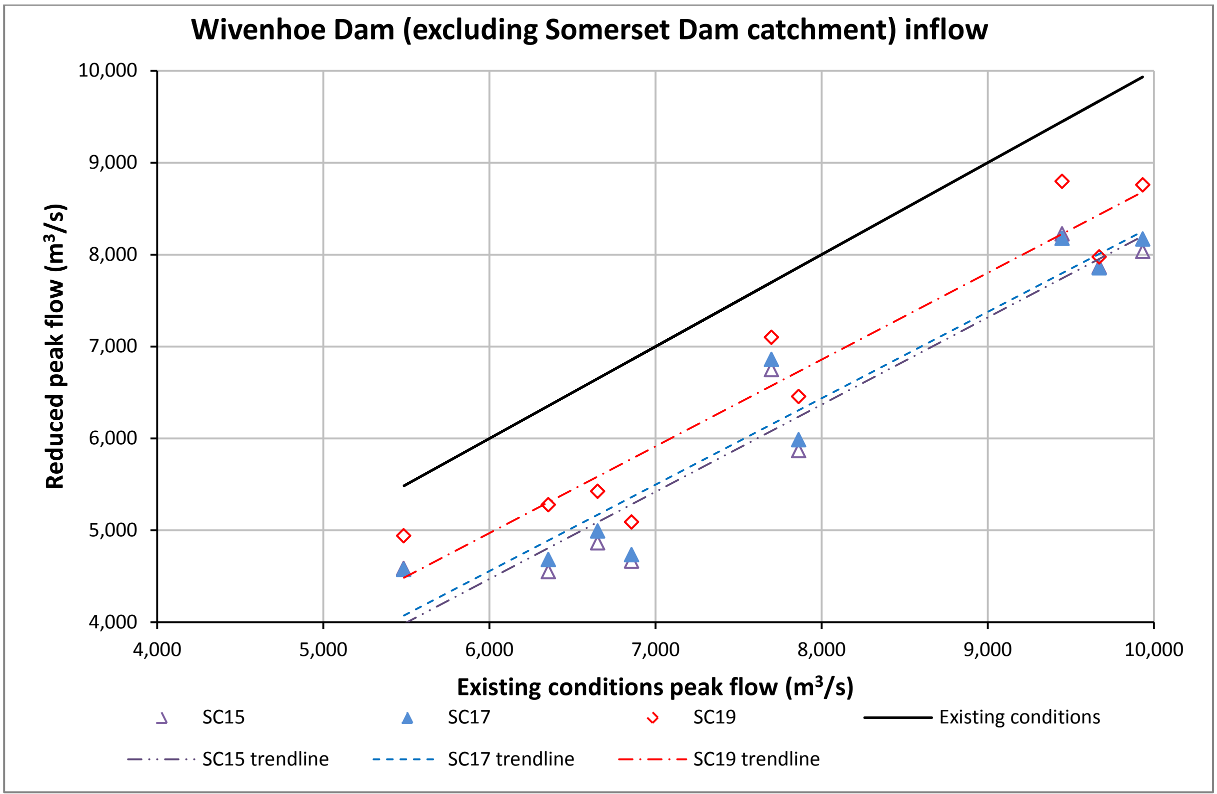
| Catchment scenario / Flood event | SC15<br>Brisbane River AMTD 282.3 km FSV 570,000 ML spillway width 160 m | SC17<br>Brisbane River AMTD 282.3 km FSV 510,000 ML spillway width 160 m | SC19<br>Brisbane River AMTD 282.3 km FSV 240,000 ML spillway width 160 m |
|---|---|---|---|
| February 1893 [1] | 13% | 13% | 7% |
| February 1893 [2] | 19% | 18% | 12% |
| June 1893 | 28% | 26% | 17% |
| January 1898 | 16% | 17% | 10% |
| March 1955 | 27% | 25% | 18% |
| January 1974 | 12% | 11% | 8% |
| June 1983 | 32% | 31% | 26% |
| February 1999 | 25% | 24% | 18% |
| January 2011 | 19% | 19% | 18% |

Legend:

| | |
|---|---|
| Dark green | >75% reduction |
| Light green | 51% - 75% reduction |
| Orange | 25% - 50% reduction |
| Yellow | 10% to 24% reduction |
| White | <10% reduction |

Notes:

1. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
2. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).




**Scenario descriptions:**

SC15: Brisbane River AMTD 282.3 km (FSV 570,000 ML, 160 m spillway)

SC17: Brisbane River AMTD 282.3 km (FSV 510,000 ML, 160 m spillway)

SC19: Brisbane River AMTD 282.3 km (FSV 240,000 ML, 160 m spillway)

**Figure 6.7 Influence of catchment scenario nos. 15,17 and 19 on Wivenhoe Dam peak inflows (excluding inflows from Somerset Dam catchment)**

Subject to the accuracy of the elevation – storage data and the assumed outlet ratings, the results indicate that:

- All scenarios would appear to provide moderate attenuation for the Wivenhoe Dam inflow hydrograph.
- Catchment scenario no. 19, which has a FSV of 240,000 ML, appears to be the least effective out of all the options, consistently providing less attenuation benefit than the other scenarios.
- This analysis suggested that the timing of the peak of the hydrograph largely remains the same. This occurs because catchment runoff from downstream of the potential new dams would still dominate the time of the peak flow into Wivenhoe Dam.

The hydrographs for Wivenhoe Dam Inflows for catchment scenario nos. 13 to 20 are presented in Appendix E of Seqwater technical memorandum no. 006 (Seqwater 2014a).

#### 6.2.5.8 Attenuation of Wivenhoe Dam inflows (excluding inflows from Somerset Dam catchment) by Brisbane River AMTD 282.3 km dam and Emu Creek AMTD 10.8 km dam

Catchment scenario nos. 23, 25 and 27 assume a water supply dam is in place at Brisbane River AMTD 282.3 km in conjunction with a dry flood mitigation dam at Emu Creek AMTD 10.8 km.

Table 6.15 depicts the flood attenuation for catchment scenario nos. 23, 25 and 27, for each of the historic floods considered. Note that results for catchment scenario nos. 21–22, 24, 26 and 28 are not presented (refer to Note 2 to Table 6.12 and section 6.2.5.6)

Figure 6.8 depicts this graphically with linear trendlines added to assist with the identification of the catchment scenarios that provide the largest benefit.

**Table 6.15 Percentage attenuation of peak flow at Wivenhoe Dam inflow (water supply dam and flood mitigation dam scenarios)**

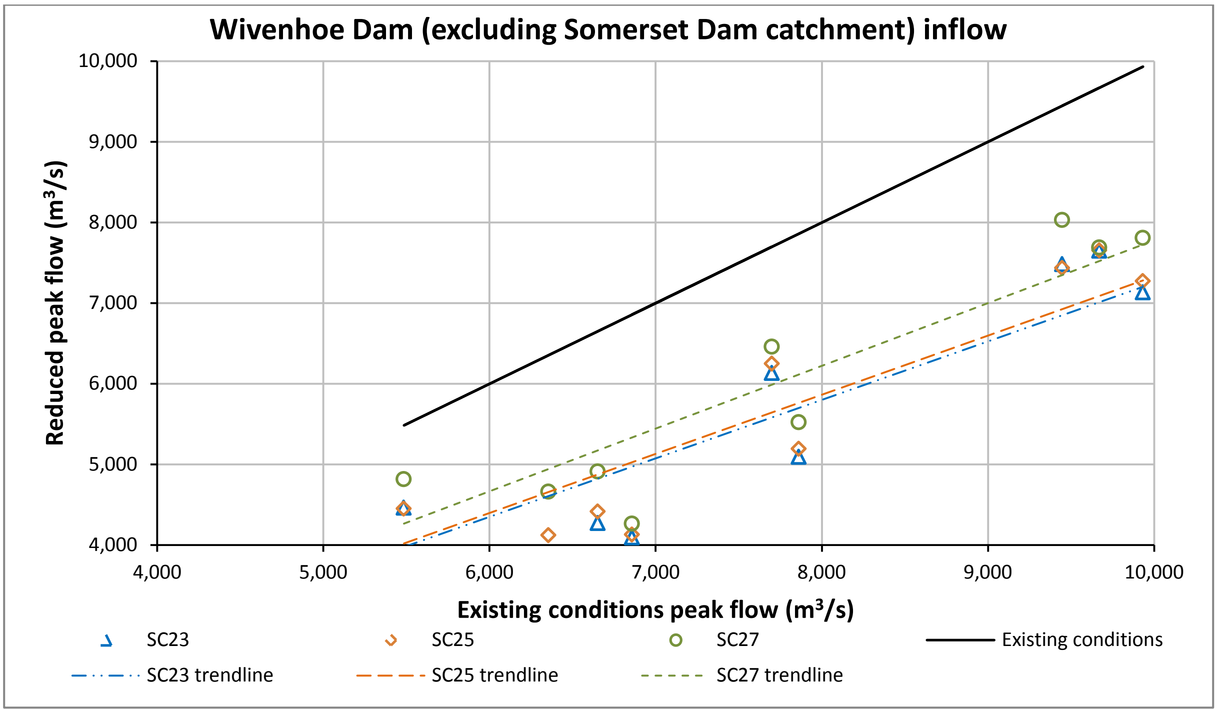
| Catchment scenario / Flood event | SC23 Brisbane River AMTD 282.3 km dam with FSV 570,000 ML spillway width 160 m and Emu Creek AMTD 10.8 km | SC25 Brisbane River AMTD 282.3 km dam with FSV 510,000 ML spillway width 160 m and Emu Creek AMTD 10.8 km | SC27 Brisbane River AMTD 282.3 km dam with FSV 240,000 ML spillway width160 m and Emu Creek AMTD 10.8 km |
|---|---|---|---|
| February 1893 [1] | 21% | 21% | 15% |
| February 1893 [2] | 28% | 27% | 21% |
| June 1893 | 37% | 35% | 27% |
| January 1898 | 19% | 19% | 12% |
| March 1955 | 36% | 34% | 26% |
| January 1974 | 20% | 19% | 16% |
| June 1983 | 40% | 40% | 38% |
| February 1999 | 35% | 34% | 30% |
| January 2011 | 21% | 21% | 20% |

Legend:

| | |
|---|---|
| Dark green | >75% reduction |
| Light green | 51% - 75% reduction |
| Peach | 25% - 50% reduction |
| Yellow | 10% to 24% reduction |
| White | <10% reduction |

Notes:

1. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
2. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).




**Scenario descriptions:**

SC23: Brisbane River AMTD 282.3 km (water supply dam FSV 570,000 ML, 160 m spillway) and

Emu Creek AMTD 10.8 km (flood mitigation dam - storage volume of 107,000 ML to spillway level)

SC25: Brisbane River AMTD 282.3 km (water supply dam FSV 510,000 ML, 160 m spillway) and

Emu Creek AMTD 10.8 km (flood mitigation dam - storage volume of 107,000 ML to spillway level)

SC27: Brisbane River AMTD 282.3 km (water supply dam FSV 240,000 ML, 160 m spillway) and

Emu Creek AMTD 10.8 km (flood mitigation dam - storage volume of 107,000 ML to spillway level)

**Figure 6.8 Influence of catchment scenario nos. 23,25 and 27 on Wivenhoe Dam peak inflows (excluding inflows from Somerset Dam catchment)**

Subject to the accuracy of the elevation – storage data and the assumed outlet ratings, the results indicate that:

- All scenarios appear to be providing moderate to significant attenuation for the Wivenhoe Dam inflow.
- The contribution of Emu Creek AMTD 10.8 km dam to the reduction of peak flows ranges from approximately 2% to 10%, depending on the historic event modelled.
- Catchment scenario no. 27 which assumes FSV of 240,000 ML for a potential dam at Brisbane River AMTD 282.3 km seems to be the least effective out of all the options, consistently providing less attenuation benefit than the other scenarios.
- It appears that catchment scenario no. 23 would provide greater reductions to the peak flows for the majority of the historical floods modelled.

This analysis suggests that the timing of the peak of the hydrograph largely remains the same. This occurs because catchment runoff from downstream of the potential new dams would still dominate the time of the peak flow into Wivenhoe Dam.

The hydrographs for Wivenhoe Dam Inflows for catchment scenario nos. 21–28 are presented in Appendix E of Seqwater technical memorandum no. 006 (Seqwater 2014a)

#### 6.2.5.9 Sites eliminated under Phase 3 – Part 2 assessments

No sites were eliminated from further consideration under PIFMSI in consideration of the Phase 3 – Part 2 hydrological assessments. All three FSVs of the potential Brisbane River AMTD 282.3 km dam acting as a water supply dam (570 000, 510 000 and 240 000 ML)were carried through to the Phase 4 hydrological assessments acting individually or in combination with Emu Creek Dam as a dry flood mitigation dam.

## 6.3 Summary of sites for further assessment

Following the Phase 2 and Phase 3 assessments outlined in this chapter, the sites considered appropriate for further assessment were:

- Wivenhoe Dam (Brisbane River at AMTD 150.2 km)
- Brisbane River AMTD 282.3 km (near Linville)
- Emu Creek AMTD 10.8 km (near Harlin)
- Bremer River AMTD 70.0 km (near Mt Walker)
- Lower Warrill Creek AMTD 13.9 km/AMTD 14.6 km (near Willowbank)

The site on Cooyar Creek at AMTD 12.4 km would only be considered only if the Brisbane River AMTD 282.3 km site proves to be unfeasible from an engineering perspective.

# Chapter 7 Engineering Assessments

This Chapter describes the engineering prefeasibility assessments of the seven selected potential flood storage infrastructure sites (refer Chapter 4). DEWS engaged consultants SMEC to carry out engineering assessments on the seven selected sites. A further detailed assessment can be found in SMEC (2014).

Engineering assessments were carried out for seven potential sites upstream of Wivenhoe Dam and on downstream tributaries of the Brisbane River as shown in Figure 7.1.


**Figure 7.1 Locality map of the seven potential infrastructure sites**

Only four of the seven sites (that is Brisbane River near Linville, Emu Creek near Harlin, Bremer River near Mt Walker and lower Warrill Creek near Willowbank) were included in the final scenario assessments (refer Chapters 9 and 10).

Each of the sites was considered for potential to act as a 'dry' flood mitigation storage. The site on the Brisbane River near Linville was also assessed as a water supply storage (to offset a lowered full supply volume in Wivenhoe Dam).

Storage volumes to spillway crest level and low level outlet capacities for the dry flood mitigation dams were determined in Chapter 4. Full supply volumes (FSVs) for the water supply dams were determined in Chapter 5.

The remaining three sites (Tenthill Creek AMTD 10.8 km near Caffey, Laidley Creek AMTD 41 km near Thornton and upper Warrill Creek AMTD 64.4 km near Aratula) were excluded from further consideration as flood mitigation storages under this investigation for reasons outlined in Chapters 4 and 6, although the engineering assessments for these three sites are still included here given that engineering assessments commenced prior to the sites being excluded based on their flood mitigation effectiveness.

## 7.1 Methodology

The site assessments cover the following issues at a pre-feasibility level of detail:

- engineering considerations
- geotechnical assessment
- concept drawings
- estimated costs
- infrastructure impacts/relocations
- land acquisitions
- land use
- cultural heritage, environmental and social impacts.

The methodology for the site assessments is based primarily on desktop review of existing information, with preliminary site inspections. No detailed field investigations or collection of primary data has been completed at this stage, although these would be required if further assessment proceeds.

Key data inputs have included:

- Previous reports prepared for some of the potential dam sites.
- Topographic data: LiDAR 0.25 m contour information (where available) and Shuttle Radar Topography Mission (SRTM) derived contours.
- Published geological mapping.
- Searches of various online databases, such as the Wildlife online database and the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) protected matters search tool.
- Land acquisition site inspections covered 2,619 km of travel, with additional inspections required to verify relevant property sales where possible. Roadside drive-by inspections were carried out on all impacted properties were public road access was possible. Impacted and assessed sites totalled 328, with an additional 35–40 relevant and adjacent sales also inspected.
- State and local government land use information.

## 7.2 Dam configurations assessed

Across the 7 sites, 13 dam configurations have been assessed in this investigation as listed in Table 7.1.

**Table 7.1 Summary of assessed dam configurations**

| Catchment | Location | Dam configuration | Site catchment area ($km^2$) | Local Government Area |
|---|---|---|---|---|
| Upper Brisbane River | Brisbane River (near Linville) AMTD 282.3 km | 348,000 ML flood mitigation dam | 1,995 | Somerset Regional Council |
| | | 240,000 ML water supply dam, spillway width 160 m | | |
| | | 510,000 ML water supply dam, spillway width 160 m | | |
| | | 570,000 ML water supply dam, spillway width 160 m | | |
| | | 570,000 ML water supply dam, spillway width 200 m | | |
| | Emu Creek (near Harlin) AMTD 10.8 km | 107,000 ML flood mitigation dam | 911 | |
| Bremer River | Lower Warrill Creek (near Willowbank) AMTD 13.9 km | Option A, shortest dam wall alignment, 125,000 ML flood mitigation dam | 859 | Ipswich City Council and Scenic Rim Regional Council |
| | Lower Warrill Creek (near Willowbank) AMTD 14.6 km | Option B1, railway alignment. 125,000 ML flood mitigation dam with railway on downstream berm and abutment-style spillway | | |
| | | Option B2, railway alignment. 125,000 ML flood mitigation dam with railway upstream of dam crest with over-toppable embankment section | | |
| | Bremer River (near Mt Walker) AMTD 70 km | 40,000 ML flood mitigation dam | 175 | Scenic Rim Regional Council |
| | Upper Warrill Creek (near Aratula) AMTD 64.4 km | 32,600 ML flood mitigation dam | 116 | |
| Lockyer Creek | Laidley Creek (near Thornton) AMTD 41.0 km | 5,200 ML flood mitigation dam | 114 | Lockyer Valley Regional Council |
| | Tenthill Creek (near Caffey) AMTD 29.8 km | 52,500 ML flood mitigation dam | 336 | |

## 7.3 Design objectives

The general dam design objectives for the sites assessments were to (at a prefeasibility level):

- meet the requirements for dam safety
- achieve a pre-determined design flood storage volume that provides flood mitigation benefits downstream
- allow flood flows up to the largest historical flood to pass through the structure (via low level outlet conduits) without overtopping the spillway
- allow extreme floods to pass through the structure (via the outlets, spillway and in some cases over-toppable wall section).

- minimise impacts to the environment, communities, property, and existing infrastructure.
- estimate and optimise the direct costs (dam construction and operation, land acquisition and infrastructure relocation) for each site, as input to cost/benefit analysis.

## 7.4 Site summaries

Details of the seven storage sites that were assessed are summarised in the following sections. The summaries outline details of both the potential dam structures and their corresponding storage areas.

### 7.4.1 Brisbane River AMTD 282.3 km

The site is located on the Brisbane River, approximately 4 km north of Linville, and 75 km north-west of Caboolture. A locality plan of the site is shown in Figure 7.2.

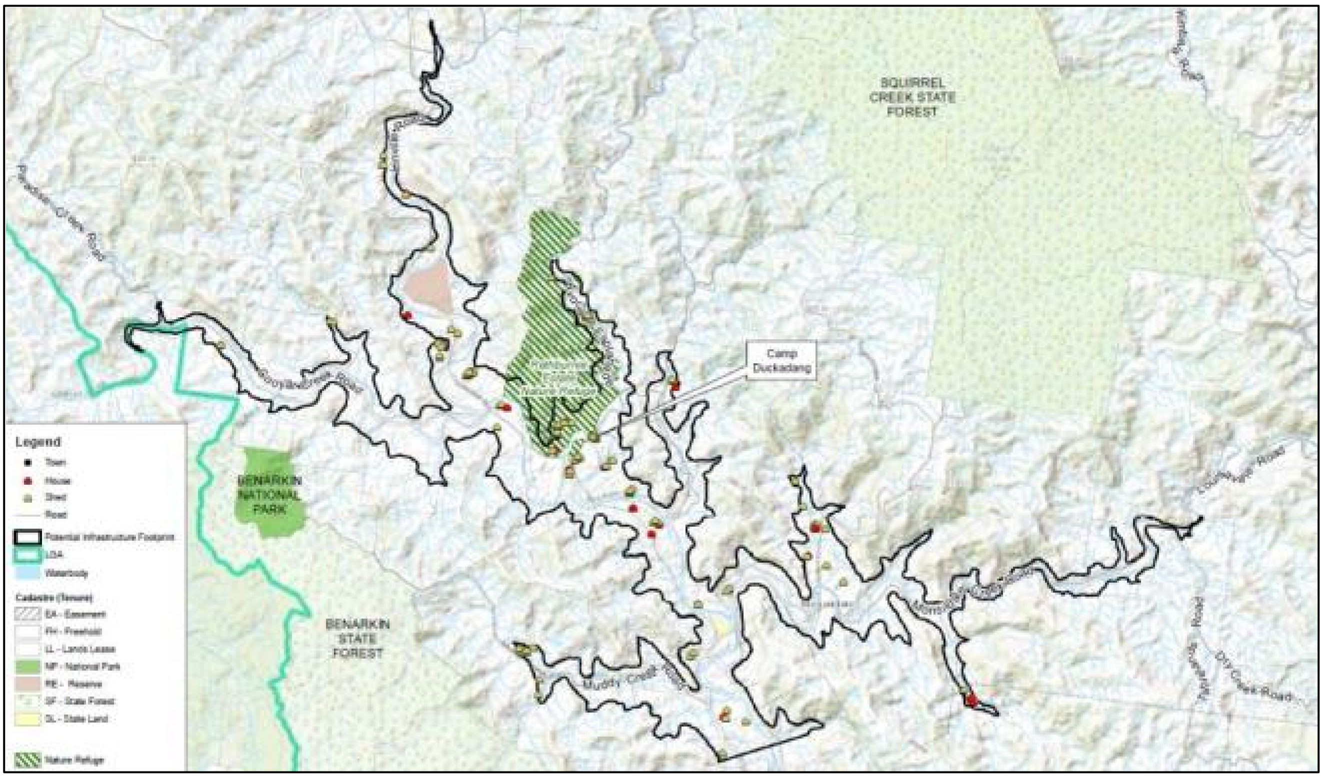



**Figure 7.2 Locality plan – Brisbane River AMTD 282.3 km**

Key aspects of the site include:

- The storage is situated in a relatively narrow valley immediately east of Benarkin State Forest and south of Squirrel Creek State Forest.
- A small saddle occurs beyond the right abutment of the dam, on the eastern side of Linville Road
- Muddy Creek enters the Brisbane River approximately 0.5 km upstream of the dam axis, and the confluence of Monsildale Creek and Brisbane River is approximately 2.2 km upstream of the dam axis.

Five dam configurations were considered for the Brisbane River AMTD 282.3 km site. Four of these configurations involve developing the site as a water supply dam with flood attenuation provided through the spillway configuration, and one configuration involves developing the site purely as a 'dry' flood mitigation storage.

The water supply configurations were based on options to offset the demand on Wivenhoe Dam, enabling some of Wivenhoe Dam's water supply storage to be reallocated to flood storage i.e. a reduction in the FSV of Wivenhoe Dam.

Figure 7.3 shows the site looking downstream of the proposed dam axis.

**Figure 7.3 View looking downstream near dam site - Brisbane River AMTD 282.3 km**

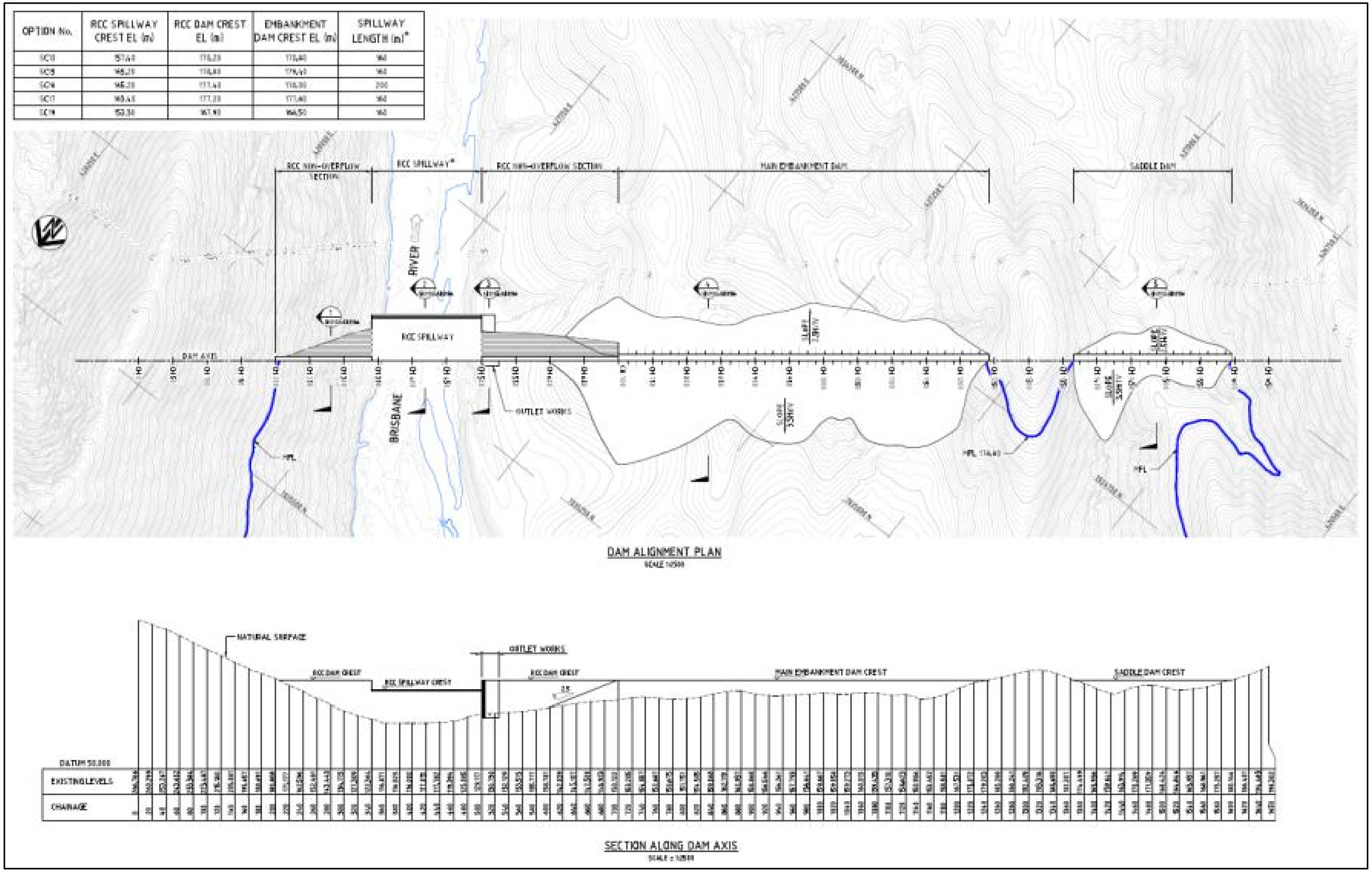
#### 7.4.1.1 Dam structure

The proposed arrangement for the water supply and flood mitigation dam configurations at the Brisbane River AMTD 282.3 km site comprises:

- Approximately 60–70 m high roller compacted concrete (RCC) dam located across the river channel flanked by a zoned-earthfill dam on the right abutment.
- Overflow spillway located centrally in the riverbed, discharging into a flip bucket and plunge pool dissipator.
- Outlet works located within the RCC section located on the right side of the river channel.

Refer to SMEC 2014 for further detail.

Typical general arrangement and section along the dam axis (for both water supply and flood mitigation dam configurations) is shown in Figure 7.4. Typical cross sections of the dam structure for the 350,000 ML flood mitigation dam option are shown in Figure 7.5. Typical cross sections of the dam structure for water supply dam options (FSVs 240,000–570.000 ML) are shown in Figure 7.6.



| OPTION No. | RCC SPILLWAY CREST EL (m) | RCC DAM CREST EL (m) | EMBANKMENT DAM CREST EL (m) | SPILLWAY LENGTH (m)* |
|---|---|---|---|---|
| SC10 | 157.40 | 176.20 | 175.80 | 160 |
| SC13 | 145.20 | 178.40 | 179.40 | 160 |
| SC14 | 145.20 | 177.40 | 174.00 | 200 |
| SC17 | 145.40 | 177.20 | 177.40 | 160 |
| SC19 | 153.30 | 167.90 | 166.50 | 160 |



**Figure 7.4 General arrangement of potential dam (flood mitigation or water supply) – Brisbane River AMTD 282.3 km**

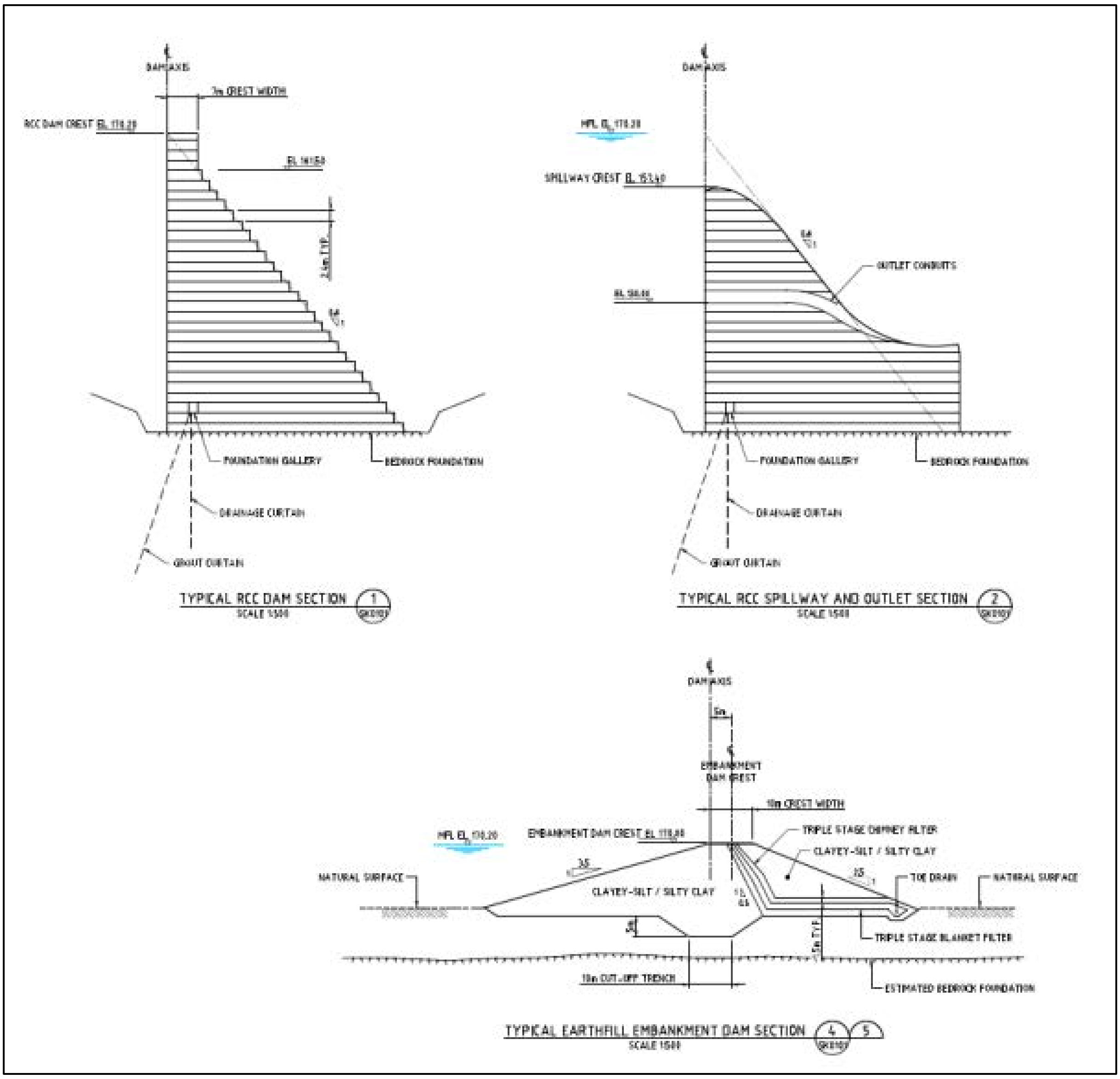



**Figure 7.5 Typical cross sections for flood mitigation dam option – Brisbane River AMTD 282.3 km**

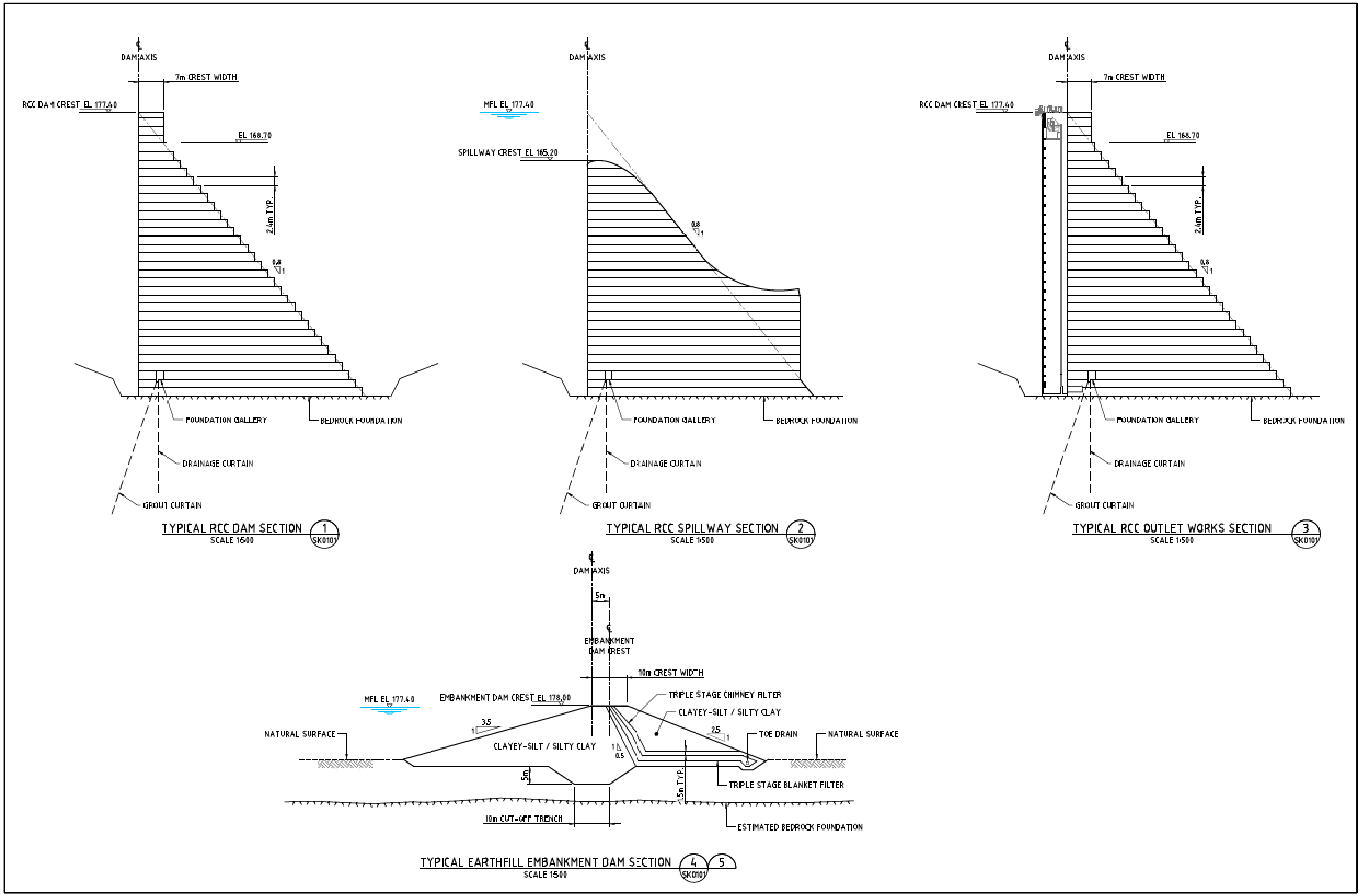



**Figure 7.6 Typical cross sections for water supply dam options – Brisbane River AMTD 282.3 km**

#### 7.4.1.2 Infrastructure impacts

Road deviations with a total length of 0.9 km would be required as a consequence of a potential flood mitigation dam. Consultation with the Department of Transport and Main Roads (DTMR) indicates that there are no state controlled roads or proposed roadworks impacted by a potential dam (for both flood mitigation and water supply dam configurations).

No road deviations would be required as a consequence of potential water supply dam configurations (FSVs 240,000–570,000 ML).

The road system is typical of a hilly rural area. The roads generally follow the creek lines in the valleys. The highest priority road is Linville Road which follows the Brisbane River and is a two lane sealed road with multiple concrete sections at the river crossings as low bridges or causeways/floodways. A typical causeway crossing is shown in Figure 7.7.

**Figure 7.7 Ford crossing immediately downstream of Brisbane River/Monsildale Creek confluence**

For the water supply options the inundation zone would be permanently inundated, therefore roads would be severed at the inundation extents. Alternative access to properties outside the inundation zone is available from existing roads.

For the flood mitigation dam configuration, a new two lane road would be required to deviate around the western (right) abutment of the dam to swing back down to the existing Linville Road. The length of this sealed road would be approximately 900 m. Services would be similarly deviated. Access to properties outside the inundation zone can be retained via other roads during flood events.

#### 7.4.1.3 Agricultural impacts

Grazing was identified as the major land use likely to be impacted within the inundation area (refer SMEC 2014 for further details).

#### 7.4.1.4 Social impacts

Between 14 and 25 residences have been identified within the inundation area (depending on the level chosen for the dam) as shown in Table 7.2.

**Table 7.2 Houses impacted for each dam configuration – Brisbane River AMTD 282.3 km**

| Dam configuration | Inundation level[1] (mAHD) | No of houses impacted [2] |
|---|---|---|
| 350,000 ML flood mitigation dam<br>240,000 ML flood mitigation dam | 157 | 14 |
| 510,000 ML flood mitigation dam | 168 | 24 |
| 570,000 ML water supply dams<br>(160 m and 200 m spillway widths) | 170 | 25 |

Notes:

1. Based on maximum modelled historical flood level with the dam in place {refer to Table 18, Seqwater technical memorandum no. 006 (Seqwater 2014)}.
2. Excludes sheds and outbuildings.

Lions Club facility Camp Duckadang is located on Avoca Creek Road within the inundation area, on land donated to the club in the 1970s. This community facility has a number of residential, management and amenities buildings located across the property. Recreation and sporting areas, including tennis courts, were also noted. The camp would be impacted by any permanent inundation or flood mitigation option.

#### 7.4.1.5 Cultural heritage

A search of the Aboriginal and Torres Strait Islander Cultural Heritage Database identified no records of cultural heritage values within the potential inundation area. Further, no registered cultural heritage bodies were identified. The Department of Aboriginal and Torres Strait Islander and Multicultural Affairs (DATSIMA) advise that the records may not conclusively capture all indigenous heritage significance and therefore should not be relied upon to contain all relevant and necessary information. The naming of Camp Duckadang after a local Aboriginal elder indicates the potential for places or features of indigenous heritage significance in the local area.

Areas associated with the Jinibara People Protected Areas Indigenous Land Use Agreement (ILUA) were identified along Monsildale Creek, on the easternmost extent of the inundation area.

No sites or features were recorded on the Queensland Heritage Register within the study area. A search of the Australian heritage database (incorporated within the EPBC protected matters search) however identified a slab hut in the local area. The location of this hut would need to be confirmed in subsequent investigations and it may be outside the inundation area. Refer to SMEC 2014 for further details.

#### 7.4.1.6 Environmental impacts

Regional ecosystem (RE) mapping shows a total of seven regional ecosystems potentially impacted by the inundation area. This includes areas of ‘endangered’ or ‘of concern’ regional ecosystems (refer SMEC 2014 for detail) including:

- Endangered *Eucalyptus tereticornis* woodland on Quaternary alluvium (RE 12.3.3)
- Of Concern *Eucalyptus crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora* spp., *Eucalyptus melanophloia* woodland on sedimentary rocks (RE 12.9-10.7)
- Endangered *E. melanophloia*, *E. crebra* woodland on sedimentary rocks (RE 12.9-10.8).

One Threatened Ecological Community (TEC), the 'Lowland Rainforest of Subtropical Australia', was indicated in an *Environmental Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) protected matters search for the local area. However, no REs corresponding to this TEC are mapped within the inundation area.

A small patch of essential habitat was identified at Picnic Creek Reserve in Qld habitat mapping (essential habitat and koala bushland). Further, a significant area of essential habitat was mapped within the Rathburnie Estate Nature Refuge to the north of the inundation area. No other wildlife habitat is mapped within the inundation area.

A review of the Wildlife Online database and the EPBC Act protected matters search has identified approximately 45 species potentially within the inundation area including a number of endangered and vulnerable species listed under the *Nature Conservation Act* (Qld) (NC Act) and the EPBC Act.

Picnic Creek in the upper part of the inundation area is governed by the Environmental Protection Policy 2009 'Upper Brisbane River Environmental Values and Water Quality Objectives (July 2010)'.

A review of the Ecosystem Health Monitoring Program data for 2012 indicated 18 native fish species which are considered to have the potential to occur in the Upper Brisbane River and tributaries (refer SMEC 2014 for further details).

### 7.4.2 Lower Warrill Creek AMTD 13.9/14.6 km

Two locations have been assessed. The identified site was located on Warrill Creek at approximately AMTD 13.9 km (Figure 7.8). However, a railway reserve (Southern Freight Railway Corridor) crosses the proposed lower Warrill Creek storage site immediately upstream of the proposed dam wall (AMTD 14.6 km), with plans to construct the railway at some stage in the future. Preliminary discussions between DEWS and DTMR have led to the proposal to co-locate the railway across the dam wall.

In order to assess the implications of the flood mitigation dam infrastructure and the railway, various options have been designed and costed, namely:

- Option A – flood mitigation dam only (AMTD 13.9 km) with over-toppable embankment section
- Option B1 – flood mitigation dam with railway on downstream berm and abutment-style spillway (AMTD 14.6 km)
- Option B2 – flood detention dam with railway upstream of dam crest with over-toppable embankment section (AMTD 14.6 km)

Key aspects of the site include:

- The storage is situated in a wide valley immediately west of the Teviot Ranges and north-east of Mount Walker.
- The left abutment of the dam is located adjacent to the Cunningham Highway, which runs along the western side of the storage.
- The right abutment is accessed from Middle Road.
- Willowbank Raceway is located immediately west of the potential storage near the dam axis.
- Two high voltage power lines cross the proposed inundation area, one immediately upstream of the proposed dam wall, and the other at the headwaters of the storage.

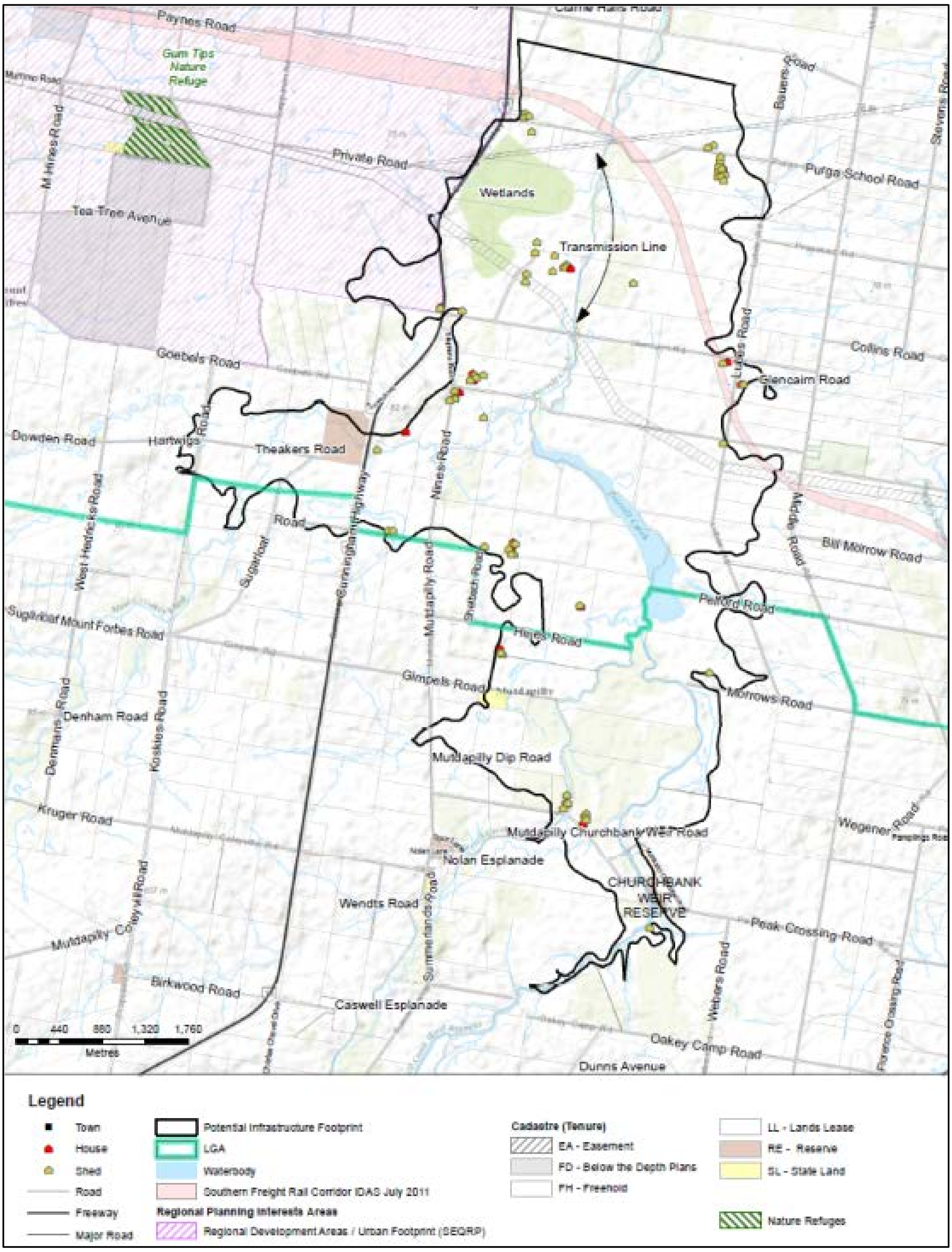



**Figure 7.8 Locality plan - lower Warrill Creek AMTD 13.9/14.6 km**

Figure 7.9 shows the site looking towards the left abutment.

**Figure 7.9 View looking towards left abutment from right abutment slightly upstream of dam axis – lower Warrill Creek AMTD 13.9 km**

#### 7.4.2.1 Dam structure

The preferred dam option is a zoned earthfill dam, based on it's less expensive construction, likelihood of sufficient sources of material onsite and being more 'forgiving' on a poorer quality foundation (not requiring extensive excavation). Refer to SMEC 2014 for further detail.

The spillway arrangements adopted are summarised in the table below, with Option B1 having a 200 m wide spillway located at the left abutment and Options A and B2 having a wide over-toppable section with RCC protection.

**Table 7.3 Spillway arrangements adopted – lower Warrill Creek AMTD 13.9/14.6 km**

| Dam configuration | Spillway width (m) | Head to pass PMF [1] (m) | Max flood level [2] (mAHD) | Dam crest level [3] (mAHD) |
|---|---|---|---|---|
| Option A AMTD 13.9 km | 1,500 | 2.9 | 45.7 | 46.3 |
| Option B1 AMTD 14.6 km (on railway alignment) | 200 | 7.6 | 50.4 | 51.0 |
| Option B2 AMTD 14.6 km (on railway alignment) | 1,500 | 2.9 | 45.7 | 51.0 |

Notes:

1. Height of water over the spillway crest level to pass the PMF.
2. Elevation of the maximum flood level within the storage to pass the PMF flow (= Head to pass PMF + spillway crest level).
3. Dam crest level = maximum flood level (PMF) + 0.6 m 'dry' freeboard

Typical general arrangement and cross sections of the dam structure for Option A (AMTD 13.9 km) are shown in Figure 7.10 and Figure 7.11. Typical general arrangements and cross sections of the dam structures for Options B1 and B2 are shown in Figure 7.12 and Figure 7.13.

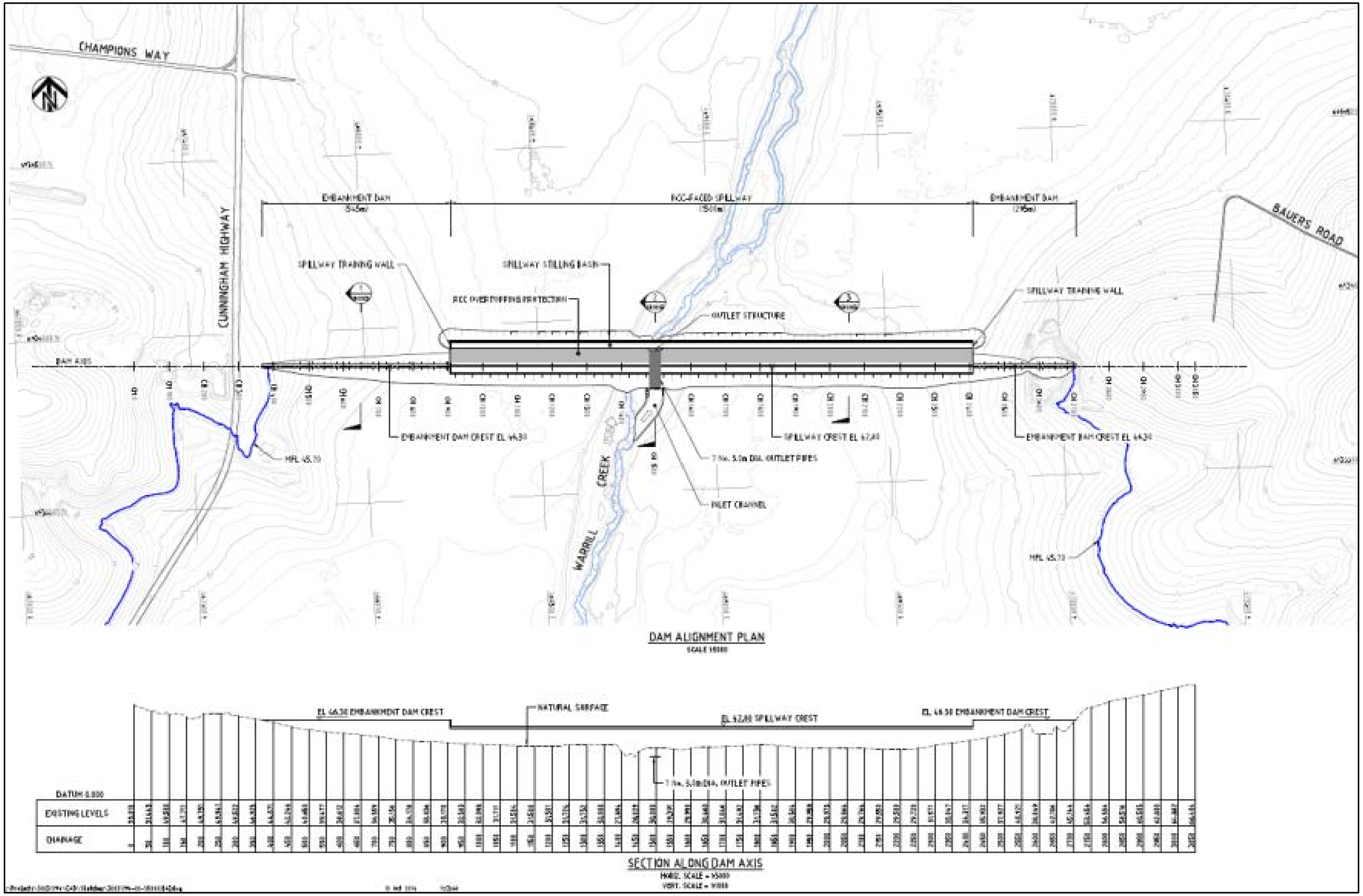



**Figure 7.10 General arrangement of potential flood mitigation dam, Option A - lower Warrill Creek AMTD 13.9 km**

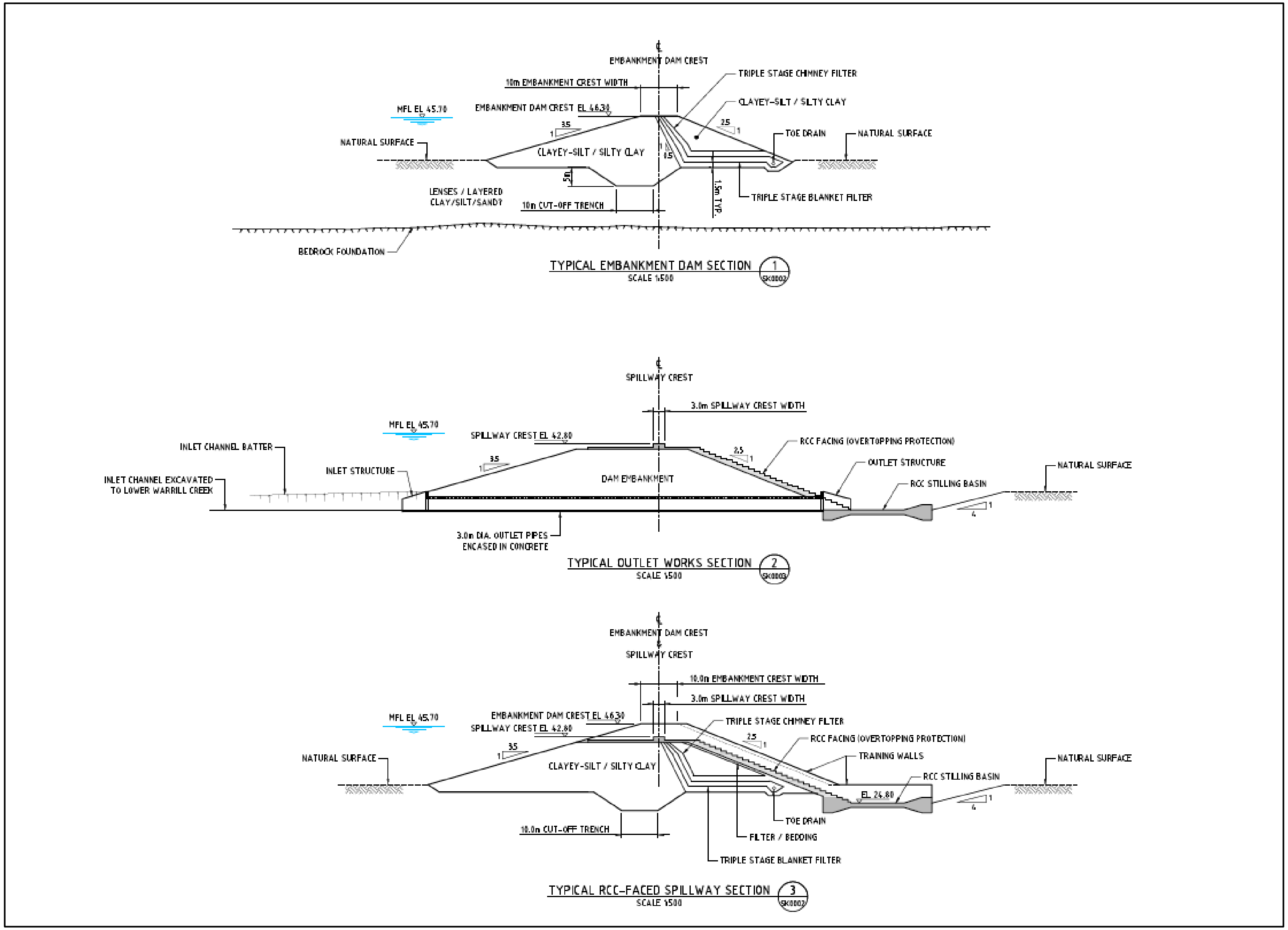



**Figure 7.11 Typical cross sections for potential flood mitigation dam, Option A - lower Warrill Creek AMTD 13.9 km**

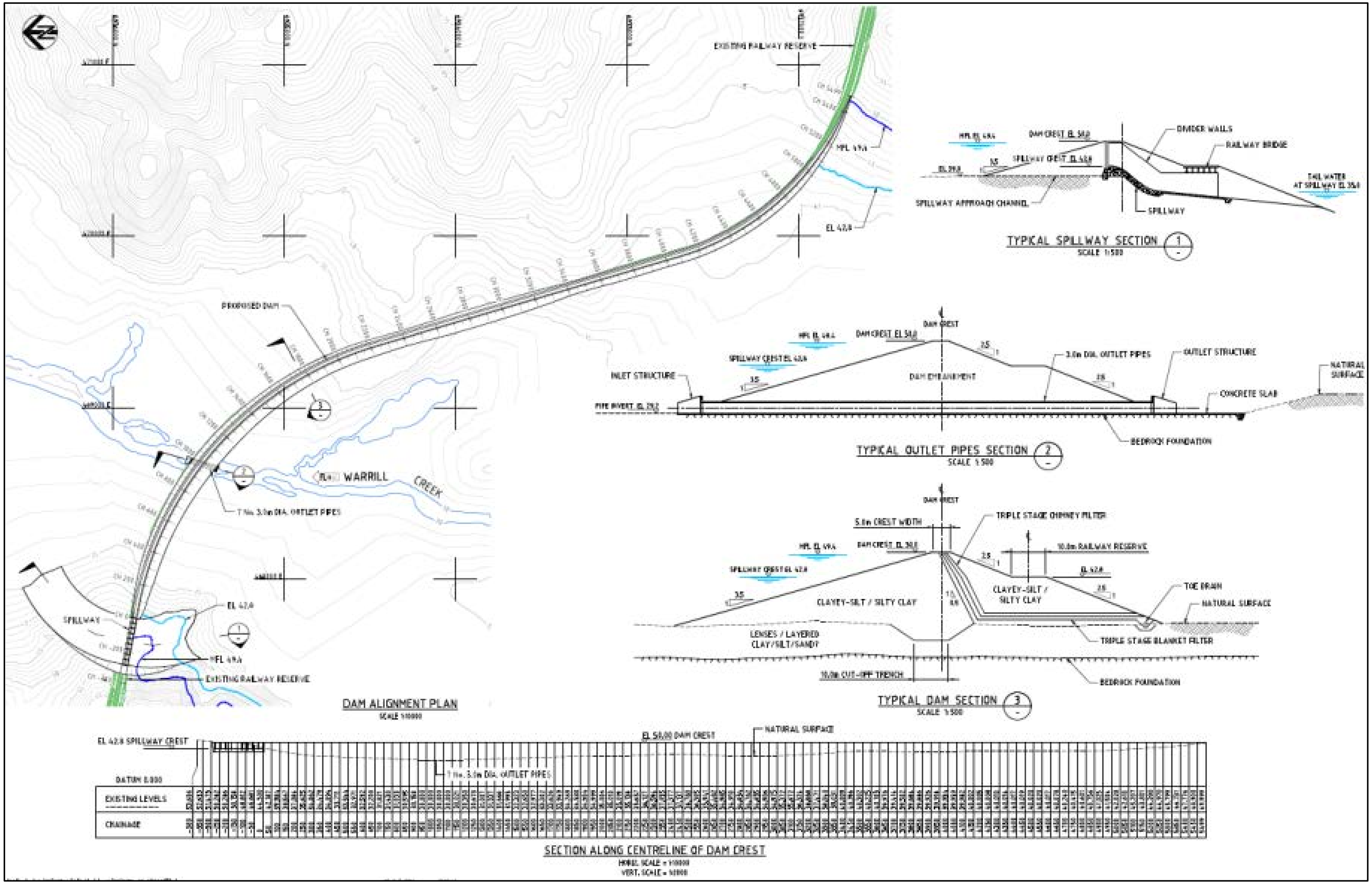



Figure 7.12 General arrangement and typical cross sections for potential flood mitigation dam, Option B1 - lower Warrill Creek AMTD 14.6 km

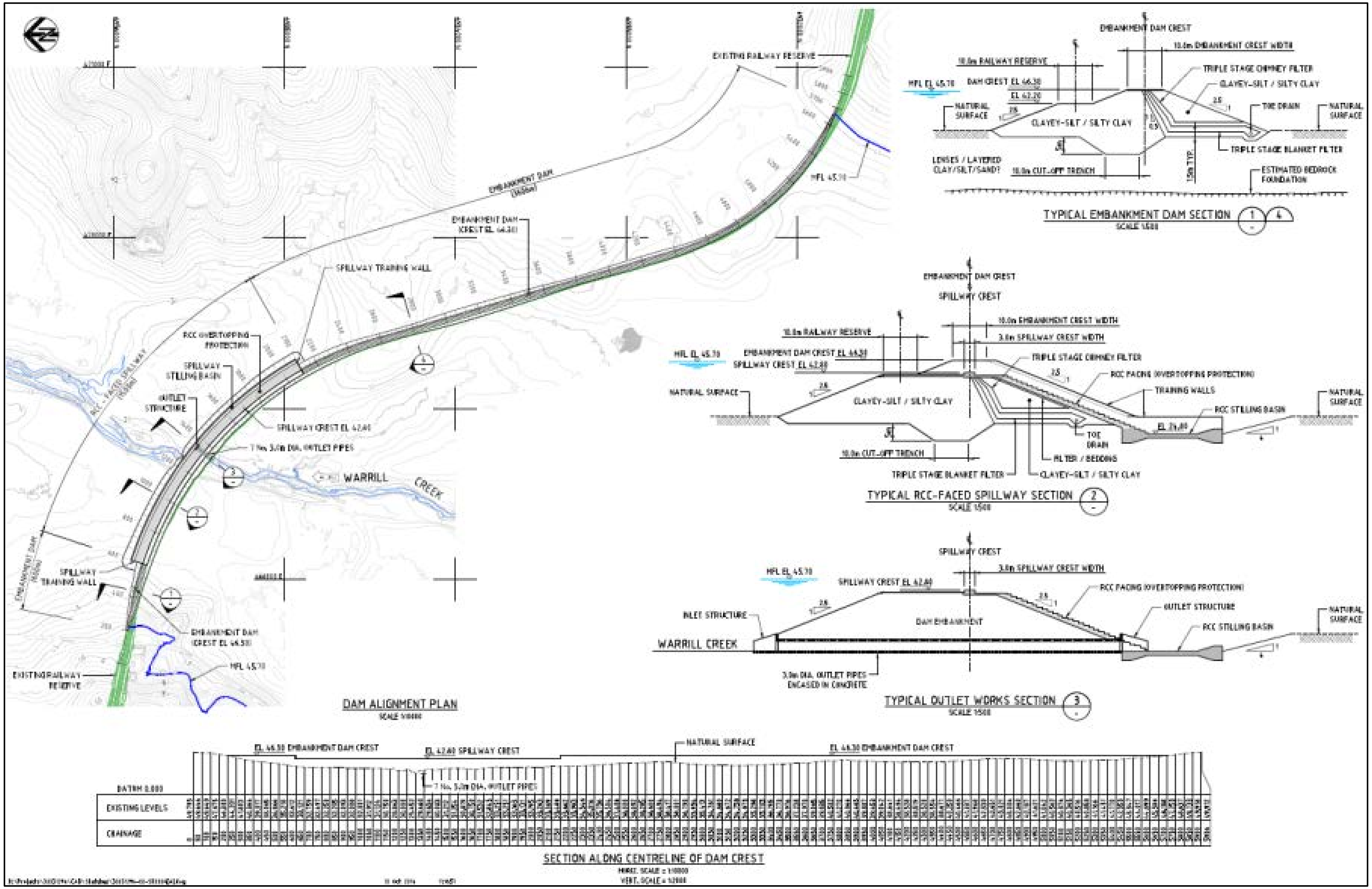



**Figure 7.13 General arrangement and typical cross sections for potential flood mitigation dam, Option B2 - lower Warrill Creek AMTD 14.6 km**

#### 7.4.2.2 Infrastructure impacts

The proposed Willowbank Industrial Park development (an ultimate industrial estate development of 550 ha) adjoins the potential flood storage at AMTD 13.9 km/14.6 km on the western side of the storage fronting the Cunningham Highway. Consultations with Economic Development Queensland (EDQ), a business unit of the Department of State Development, Infrastructure and Planning, who are developing the industrial park and with DTMR identified a proposed future re-alignment of the Cunningham Highway along the frontage of the industrial park site as part of access considerations to the new development. EDQ has indicated the desire to limit impacts of a potential flood storage on the proposed Willowbank Industrial Park. The impacts of a potential flood storage on the proposed Willowbank Industrial Park are relatively minor and the proposed re-alignment of the Cunningham Highway west of the current alignment provides a potential opportunity to create a dual purpose road and levee which could ensure a flood immunity for the proposed industrial estate for the 1% AEP flood event. Limiting the impacts of a potential flood storage on the proposed industrial estate should be investigated further should the site progress to more detailed feasibility investigation.

The major road affected by the potential storage is the Cunningham Highway, which is part of the National Route system and as such the target criteria for new works is to provide immunity for the 1% Annual Exceedance Probability (AEP) event. This is the major truck route between Sydney and Brisbane. The highway runs along the western edge of the inundation line. The data review of the provided storage performance for historical floods shows the historical flood events have a maximum water level at EL 42.8 mAHD. With this in mind the road level is therefore set to a minimum of EL 43 mAHD.

A cost allowance has been made under this assessment for a deviation of the Cunningham Highway to the west of a potential flood storage (total length of 4.2 km). Given the proposed DTMR re-alignment of the Cunningham Highway in the vicinity of a potential flood storage, it will be necessary to have further consultation with DTMR should the site progress to more detailed feasibility investigation.

The inundation zone affects two high voltage power transmission lines, a 110kV and 220kV.

Two options were investigated as possible treatments, the relocation/deviation of the lines downstream of the dam or building up of the ground level and raising the lattice towers to place the feet of the towers above the EL42.9 mAHD and to retain the clearance to the crest level, however if the PMF eventuates the clearance to the wires would be reduced by 6 m.

The first solution involves the re-routing of the transmission lines downstream of the dam. The location of the towers would be integrated to the spillway and the proposed rail alignment. Both of the high voltage power transmission lines would follow this alignment. This is the shorter deviation than around the south.

The alternative of lifting the lattice towers onto earth mounds built up to the crest level was investigated to get the towers out of the inundation and to lift the wires well above the crest level in case of boating/emergency access during the flood events. The mounds require accessibility for heavy vehicles therefore appropriate grades off the side slopes would be required.

The lifting of the towers appears feasible if the mounds are up to 4–5 m, however the levels of the valley indicate that the majority of the towers would have to be lifted 10 m. There would be approximately 15 towers to be raised at this level. One tower is currently located in the proposed rail corridor and so would also require extensive works for relocation above the dam wall and rail line. The existing ground level is approximately EL 33 mAHD.

The preferred solution is the relocation of the lines around the inundation area to provide better access to the towers and increased safety in times of inundation.

#### 7.4.2.3 Agricultural impacts

Grazing was identified as the major land use likely to be impacted within the inundation area (refer SMEC 2014 for further details).

#### 7.4.2.4 Social impacts

Fifteen houses would be impacted by a potential flood storage, with no difference between the options assessed.

The Churchbank Weir Recreational Reserve is located to the east of the inundation area. This reserve provides recreational amenity and access for recreational fishing in the east branch of Warrill Creek.

Mutdapilly State School is located outside of the inundation area to the south west. The School is accessed by Mutdapilly Churchbank Weir Road, and the Cunningham Highway.

#### 7.4.2.5 Cultural Heritage

A search of the Aboriginal and Torres Strait Islander Cultural Heritage Database identified three records, located approximately 350 m to the north-west of the proposed western abutment. DATSIMA advises that accuracy in these records is not guaranteed, and therefore extra diligence is required when operating in these locations. Furthermore, the records may not conclusively capture all Indigenous heritage significance, and therefore should not be relied upon to contain all relevant and necessary information.

No sites or features were recorded on the Queensland Heritage Register within the study area. However, review of the Ipswich City Council Planning Scheme Overlay: Character Places (incorporating adjacent areas of the Scenic Rim Local Government Area) identified two heritage places within the inundation area:

- Farm House, Main House, 368-396 Peak Crossing Churchbank Weir Road Mutdapilly (location of house to be confirmed, unlikely within study area): Identified Heritage Place
- Churchbank Weir- Weir and recreation reserve: Identified Heritage Place.

Refer to SMEC 2014 for further details.

#### 7.4.2.6 Environmental impacts

Regional ecosystem mapping shows a total of eight regional ecosystems potentially impacted by the inundation area. This includes areas of ‘endangered’ or ‘of concern’ regional ecosystems (refer SMEC 2014 for detail) including:

- Endangered *E. tereticornis* woodland on Quaternary alluvium (RE 12.3.3)
- Endangered *Melaleuca irbyana* low open forest on sedimentary rocks (RE 12.9-10.11).

A small number of wetlands recognised as ‘Matters of state environmental significance’ are also mapped within the inundation area.

An EPBC Act protected matters search indicated that the Swamp Tea-tree (*M. irbyana*) Forest of South-east Queensland TEC has the potential to occur at the site as the corresponding regional ecosystems are both mapped within the area. Two further TECs, the Lowland Rainforest of Subtropical Australia and the White Box-Yellow Box-Blakely’s Red Gum Grassy Woodland and Derived Native Grassland were indicated in this search however no corresponding REs were mapped and these TECs are therefore considered unlikely to occur.

Qld ‘Protected Plants Flora Trigger Survey’ maps indicate that a significant portion of the inundation area would be subject to survey requirements should the lower Warrill Creek site be progressed.

Qld habitat mapping (essential habitat and koala bushland) shows isolated patches of mapped habitat for echidna and koala. The Flinders Goolman Estate is located to the east of the inundation area; however there are no mapped or otherwise discernible fauna movement corridors through the inundation area.

A review of the Wildlife Online database and the EPBC Act protected matters search has identified approximately 30 species potentially within the inundation area including a number of endangered and vulnerable species listed under the NC Act and the EPBC Act.

A review of the Ecosystem Health Monitoring Program data for 2012 indicated 20 native fish species which are considered to have the potential to occur in Warrill Creek and tributaries. Refer SMEC 2014 for further details.

### 7.4.3 Bremer River AMTD 70 km

The site is located on the Bremer River, approximately 26 km south-west of Ipswich and 5 km north-west of Coleyville. A locality plan of the site is shown in Figure 7.14.

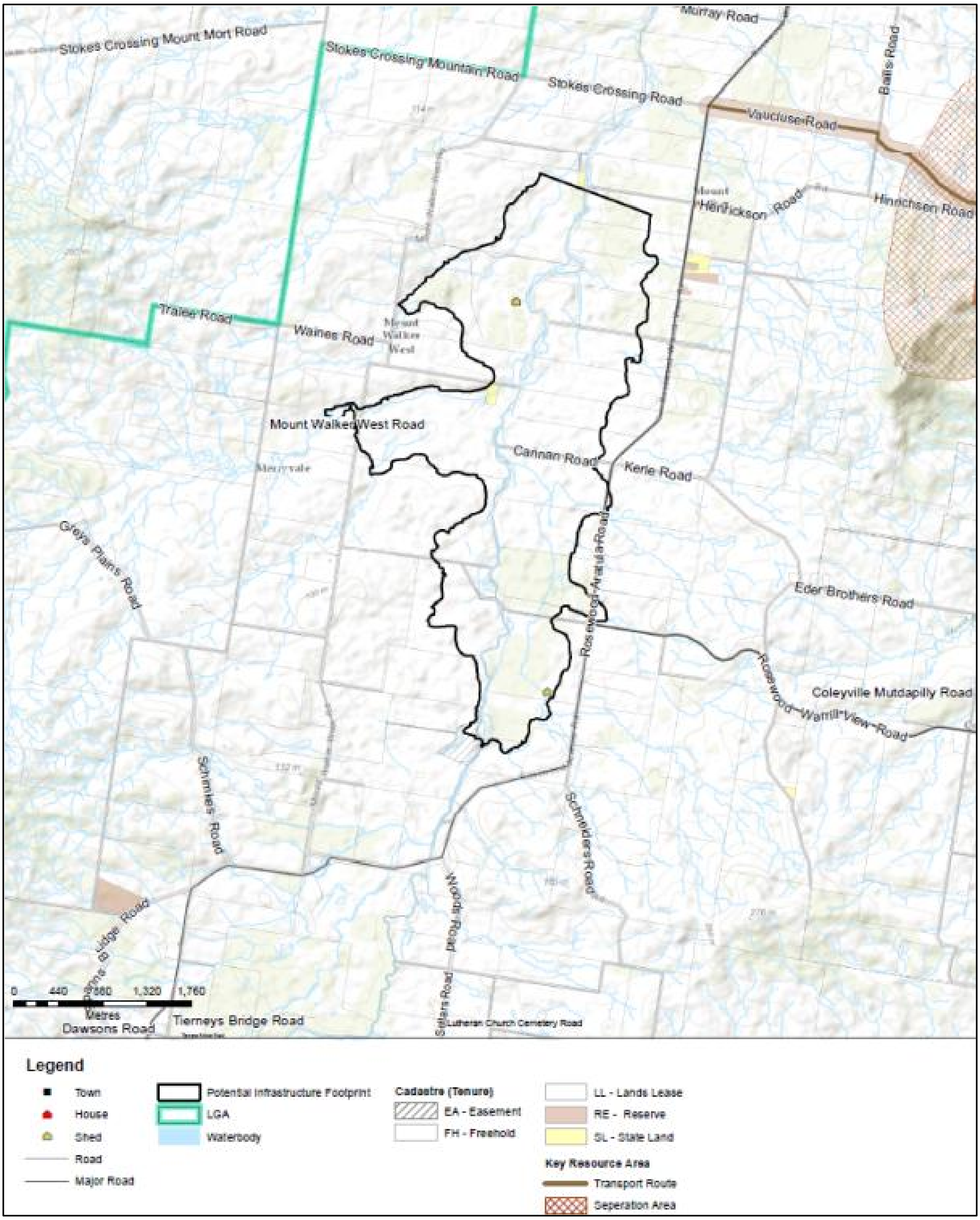



Figure 7.14 Locality plan - Bremer River AMTD 70 km

A view of the Bremer River channel near the site is shown in Figure 7.15.

**Figure 7.15 View of Bremer River channel**

Key aspects of the site include:

- The storage is situated in a wide valley immediately west of Mount Walker.
- The left abutment of the dam is located near to the Mount Walker West Road, south of Mount Mort Road.
- The right abutment is located adjacent to the Rosewood-Warrill Road near the intersection of Hinrichson Road.

#### 7.4.3.1 Dam structure

The preferred option is a zoned earthfill dam, based on it's less expensive construction, likelihood of sufficient sources of material onsite and being more 'forgiving' on a poorer quality foundation (not requiring extensive excavation). Refer to SMEC 2014 for further detail.

Typical general arrangement and cross sections of the dam structure are shown in Figure 7.16 and Figure 7.17.

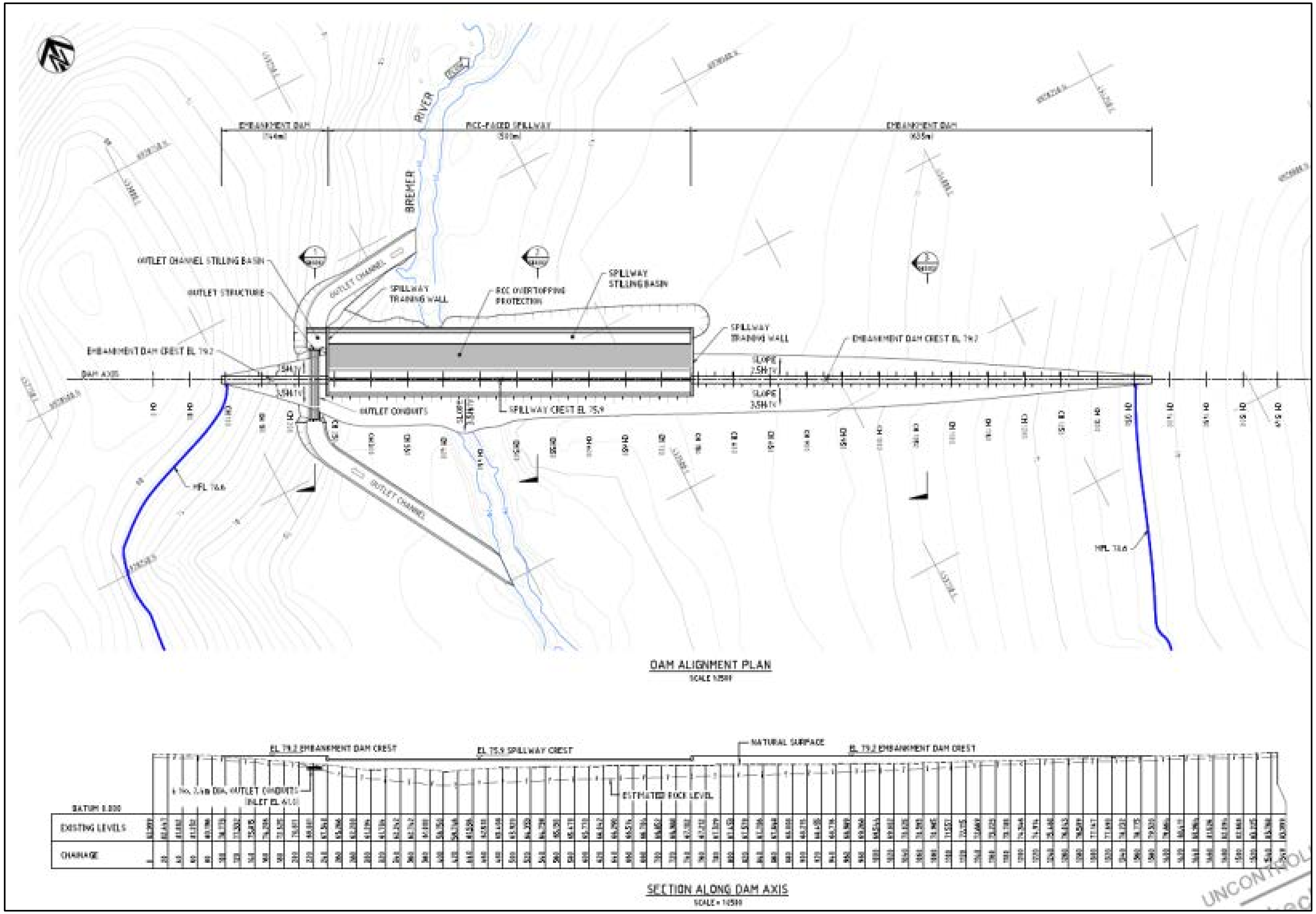



Figure 7.16 General arrangement of potential flood mitigation dam - Bremer River AMTD 70 km

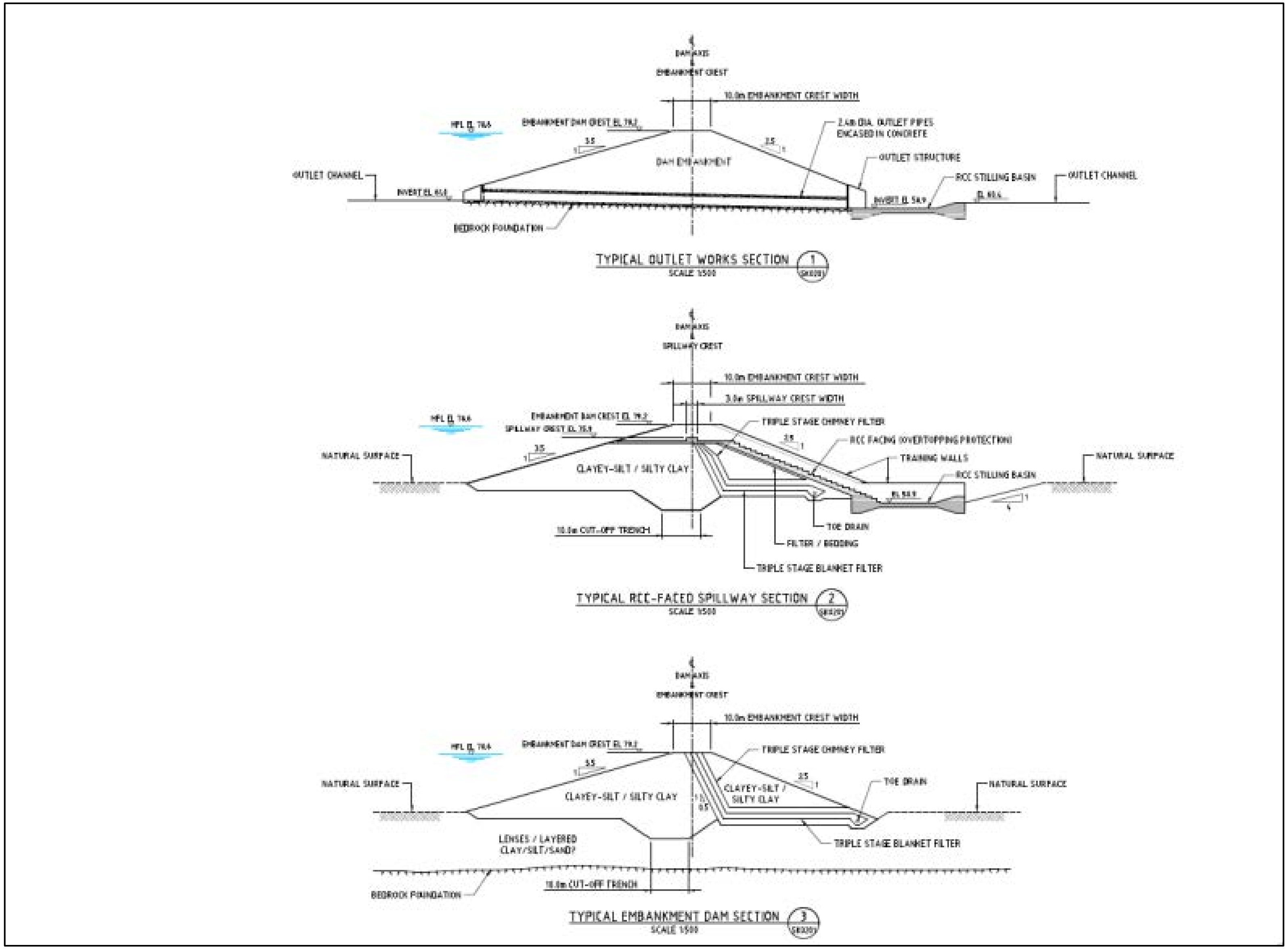



**Figure 7.17 Typical cross sections of potential flood mitigation dam - Bremer River AMTD 70 km**

#### 7.4.3.2 Infrastructure impacts

No road deviations have been allowed in the present investigations as a consequence of a potential flood mitigation dam.

The road system is atypically a grid pattern with the Bremer River bisecting the two longitudinal roads of Rosewood-Warrill View Road and Mount Walker West Road. At the southern end of the inundation zone, Rosewood-Aratula Road changes to an east west alignment and crosses the Bremer River. Of these two roads Rosewood-Warrill View Road/Rosewood-Aratula Road is sealed and Mount Walker West Road is a gravel road.

There are three crossings of Rosewood-Warrill View road by the potential storage at EL 80 mAHD. One is at the southern end where Rosewood-Aratula Road changes direction and the other two are at the intersections of Kerle Road and Rosewood-Aratula Road. Each of the sections is approximately 500 m long sections.

Each of these sections is at, or near the limit of the inundation area, and expected inundation would be minimal. As mentioned earlier the road system is a grid and if a section is cut access to either side is available via other roads.

Consultation with DTMR has raised potential impacts to the state controlled Rosewood-Warrill View Road. DTMR have raised the possibility of the need to raise the Rosewood-Warrill View Road if alternative access roads are not of a suitable standard. No cost allowance has been made under this assessment for a raised Rosewood-Warrill View Road. Should this site progress to more detailed feasibility investigations, further consultation with DTMR will be required to agree to an acceptable solution.

Power lines affected by the proposed inundation are lower voltage aerial cables generally located over agricultural land. They service the local farms. The depth of water at the Cannan Road transverse crossing is up to 6 m for the 1% AEP flood event. The recommendation is to raise the poles by 6 m to maintain the clearance at these spans. The other affected line is at the southern end of the inundation zone where inundation is minimal and there is low risk of contact with the live wires. Therefore it is recommended to retain the supply as is.

#### 7.4.3.3 Agricultural impacts

Grazing and cropping were identified as the major land uses likely to be impacted within the inundation area (refer SMEC 2014 for further details).

#### 7.4.3.4 Social impacts

No residential buildings were identified in the area.

#### 7.4.3.5 Cultural Heritage

A search of the Aboriginal and Torres Strait Islander Cultural Heritage Database identified no records of cultural heritage values within the potential inundation area. Further, no registered cultural heritage bodies were identified. However, DATSIMA advises that the records may not conclusively capture all indigenous heritage significance and therefore should not be relied upon to contain all relevant and necessary information. The registered Cultural Heritage body identified through the DATSIMA search is the Jagera Daran Pty Ltd.

No sites or features were recorded on the Queensland Heritage Register within the study area nor were records found in any local or national heritage databases. However, the Mount Walker Historic Cemetery is located immediately to the east of the inundation area, on Rosewood-Aratula Road. A homestead located to the west of the inundation area on Mount Walker West Road was also identified as likely to have heritage significance.

#### 7.4.3.6 Environmental impacts

No essential habitat is mapped within the inundation area.

Regional ecosystem mapping shows a total of four regional ecosystems potentially impacted by the inundation area. This includes areas containing endangered *E. tereticornis* woodland on Quaternary alluvium (RE 12.3.3) (refer SMEC 2014 for detail).

Regional ecosystem 12.3.3 may be consistent with the EPBC Act Threatened Ecological Community Swamp Tea-tree (*M. irbyana*) forest of SEQ, which is listed as critically endangered. Notably this species was identified in nearby ecological investigations associated with the proposed Mount Walker Quarry.

An EPBC Act protected matters search indicated two further TECs as potentially occurring in the area including the Lowland Rainforest of Subtropical Australia and White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland may occur, however no corresponding REs are mapped within the study area.

A review of the Wildlife Online database and the EPBC Act protected matters search has identified approximately 29 species potentially within the inundation area including a number of endangered and vulnerable species listed under the NC Act and the EPBC Act (refer to SMEC 2014 for further detail).

### 7.4.4 Emu Creek AMTD 10.8 km

The site is located on Emu Creek, approximately 8 km west of Harlin. A locality plan of the site is shown in Figure 7.18.

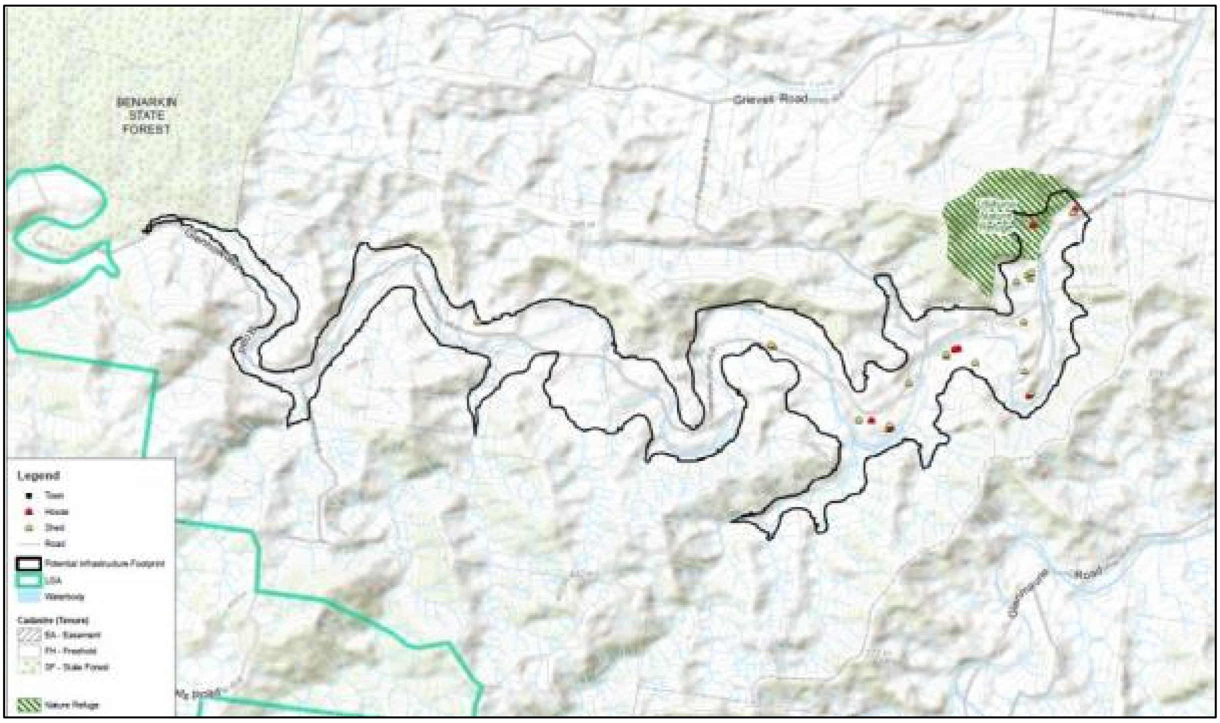



**Figure 7.18 Locality plan - Emu Creek AMTD 10.8 km**

A view looking upstream near the dam site is shown in Figure 7.19.

Figure 7.19 View looking upstream near dam site - Emu Creek AMTD 10.8 km

Key aspects of the site include:

- The storage is located in a relatively narrow valley, with side slopes of around 2H:1V on the left abutment and 4H:1V on the right abutment
- Glenhowden Road is located within the valley, and crosses Emu Creek via a ford located approximately at the proposed dam site
- The proposed dam site is located in the Ukikuna Nature Reserve, and the headwaters of the flood inundation area extend to the Benarkin State Forest.

#### 7.4.4.1 Dam structure

Based on the topography of the dam axis, the requirements of the spillway configuration and the availability of construction materials, an RCC dam is the preferred option for the Emu Creek site. Refer to SMEC 2014 for further detail.

Typical general arrangement and cross sections of the dam structure are shown in Figure 7.20 and Figure 7.21.

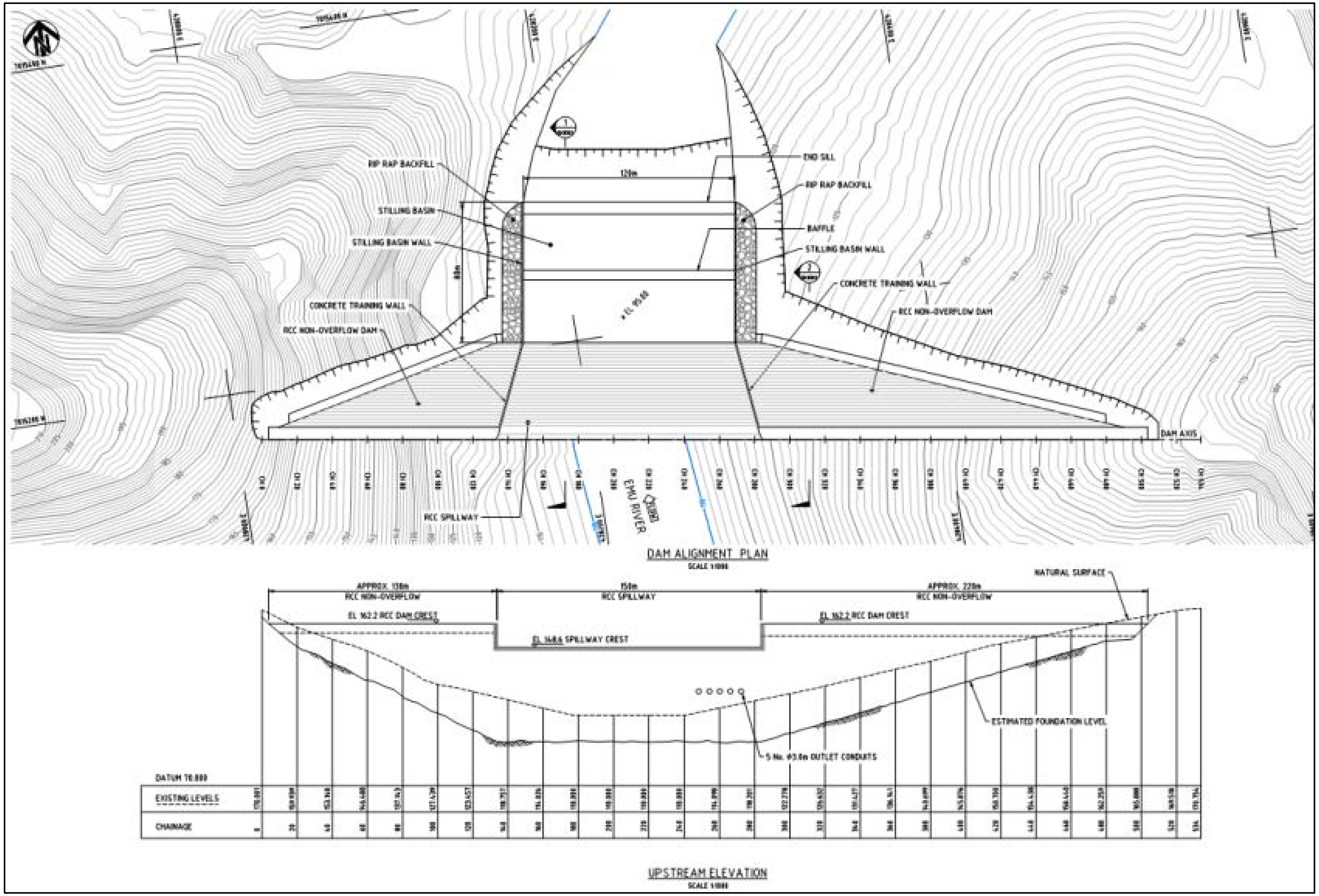



**Figure 7.20 General arrangement of potential flood mitigation dam - Emu Creek AMTD 10.8 km**

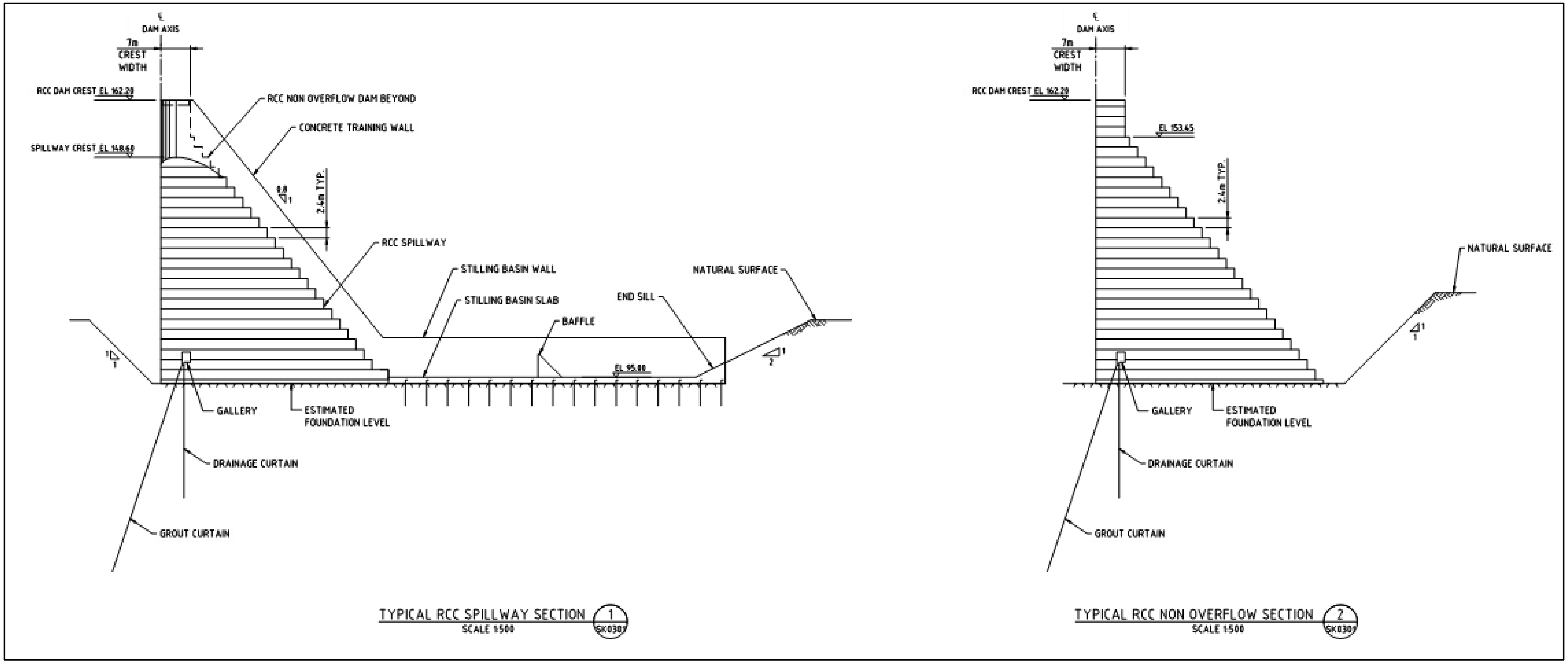



**Figure 7.21 Typical cross sections of potential flood mitigation dam - Emu Creek AMTD 10.8 km**

#### 7.4.4.2 Infrastructure impacts

Road deviations with a total length of 0.7 km would be required as a consequence of a potential flood mitigation dam. Consultation with DTMR indicates that there are no state controlled roads or proposed roadworks impacted by a potential dam.

The road system is typical of a hilly rural area. Glenhowden Road generally follows the creek line in the valley. The road is an unsealed gravel road with multiple river crossings comprising causeways, weirs and floodways. The road is located adjacent in the most part to the creeks and rivers within the inundation zone. Branching off Glenhowden Road are gravel tracks to access pastures which are within the inundation zone.

Glenhowden Road would be severed by a potential storage at the eastern end and alternate access to the other end of Glenhowden Road is from Blackbutt or via Forest Drive and Clancy and Emu Creek Campground track from Benarkin/Blackbutt.

A 700 m gravel access track deviation around the western abutment of the dam would be required to maintain access to Glenhowden Road. The track would double as access to the residence just downstream of the dam footprint.

#### 7.4.4.3 Agricultural impacts

Grazing is the major land use within the storage area however Benarkin State Forest contains areas of Hoop pine plantation and pockets of native vegetation.

The western extent of the area of interest is within the Darling Downs Priority Agricultural Area (PAA). Small pockets of Strategic Cropping Land (SCL) are mapped within the area (refer SMEC 2014 for further details).

#### 7.4.4.4 Social impacts

Seven houses would be impacted by a potential flood storage.

There are a number of recreational and camping areas within the area of interest. Clancy's camping area and the Emu Creek camping and day use areas are located on the north bank of Emu Creek, at the southernmost extent of Benarkin State Forest. A section of the Bicentennial National Trail follows Emu Creek, which is located immediately west of the inundation area.

#### 7.4.4.5 Cultural Heritage

A search of the Aboriginal and Torres Strait Islander Cultural Heritage Database identified no records of cultural heritage values within the potential inundation area. Further, no Aboriginal Party of registered cultural heritage bodies were identified for this area. However, DATSIMA advises that the records may not conclusively capture all indigenous heritage significance and therefore should not be relied upon to contain all relevant and necessary information.

No sites or features were recorded on the Queensland Heritage Register within the study area, though the Bicentennial National Trail is in the vicinity of the study area.

#### 7.4.4.6 Environmental impacts

Regional ecosystem mapping shows a total of six regional ecosystems potentially impacted by the inundation area. This includes areas of 'endangered' or 'of concern' regional ecosystems (refer SMEC 2014 for detail) including:

- Endangered *E. tereticornis* woodland on Quaternary alluvium (RE 12.3.3)

- Of Concern *E. crebra*, *E. tereticornis*, *Corymbia intermedia* woodland on metamorphics +/- interbedded volcanics (RE 12.11.14)
- Of Concern *E. melanophloia*, *E. crebra* woodland on metamorphics +/- interbedded volcanics (RE 12.11.8).

Two TECs, the Lowland Rainforest of Subtropical Australia and White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, were indicated as potentially occurring within the storage area in an EPBC Act protected matters search for the local area. However, no REs corresponding to these TECs are mapped within the inundation area.

Potential habitat for the Platypus (iconic species under the Nature Conservation Wildlife Regulation), is located along Emu Creek. Habitat for the Black Breasted Button Quail and the Brush-tailed Rock-wallaby (listed as vulnerable in both the EPBC Act and NC Act) is also located in close proximity to the inundation area.

A review of the Wildlife Online database and the EPBC Act protected matters search has identified approximately 28 species potentially within the inundation area including a number of endangered and vulnerable species listed under the NC Act and the EPBC Act.

Ten listed plant species or suitable habitat may occur within the local area including the Hairy-joint Grass, leafless tongue orchid, and Mt Berryman Phebalium.

The Ukikuna Nature reserve is located on the eastern extent of the storage area, and would be partially inundated, with the dam wall on its eastern boundary. A small portion of Benarkin State Forest located on the north extent would also be affected by the storage.

Emu Creek and tributaries are governed by the Environmental Protection Policy 2009 'Upper Brisbane River Environmental Values and Water Quality Objectives (July 2010)'.

A review of the Ecosystem Health Monitoring Program data for 2012 indicated 18 native fish species which are considered to have the potential to occur in the Upper Brisbane River and tributaries. Refer to SMEC 2014 for further details.

### 7.4.5 Upper Warrill Creek AMTD 64.4 km

The site is located on Warrill Creek, approximately 46 km south-west of Ipswich and 4 km north-west of Aratula. A locality plan of the site is shown in Figure 7.22. A view looking upstream towards the dam site is shown in Figure 7.23.

Key aspects of the site include:

- The storage is situated in a wide valley, adjacent to Main Range National Park.
- The potential dam structure comprises a main (northern) embankment and a saddle (southern) embankment
- The main embankment location has abutment slopes in the order of 3.7H:1V and the saddle dam location has abutments slopes in the order of 10H:1V.
- The ridge separating the two embankments has a peak around EL 155 mAHD.
- Rosewood-Aratula Rd passes through the footprint of the saddle (southern) embankment.

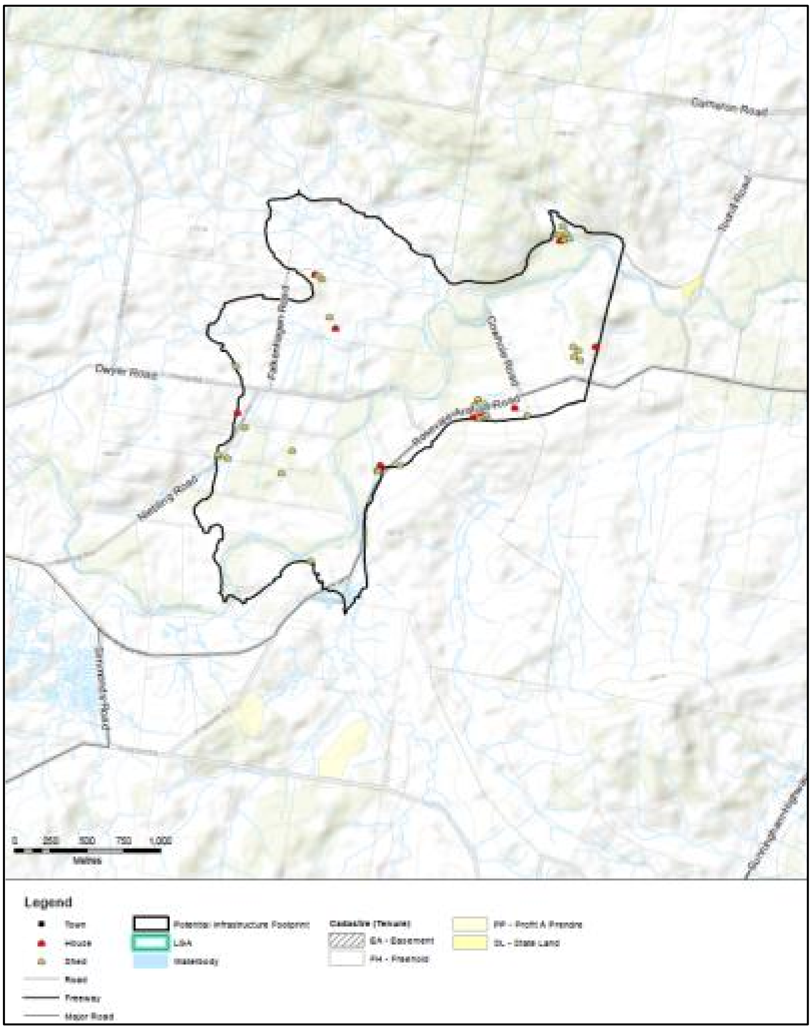



**Figure 7.22 Locality plan - upper Warrill Creek AMTD 64.4 km**

**Figure 7.23 View looking upstream towards dam site - upper Warrill Creek AMTD 64.4 km**

### 7.4.5.1 Dam structure

The preferred option is a zoned earthfill dam, based on it's less expensive construction, likelihood of sufficient sources of material onsite and being more 'forgiving' on a poorer quality foundation (not requiring extensive excavation). Refer to SMEC 2014 for further detail. Typical general arrangement and cross sections of the dam structure are shown in Figure 7.24 and Figure 7.25.

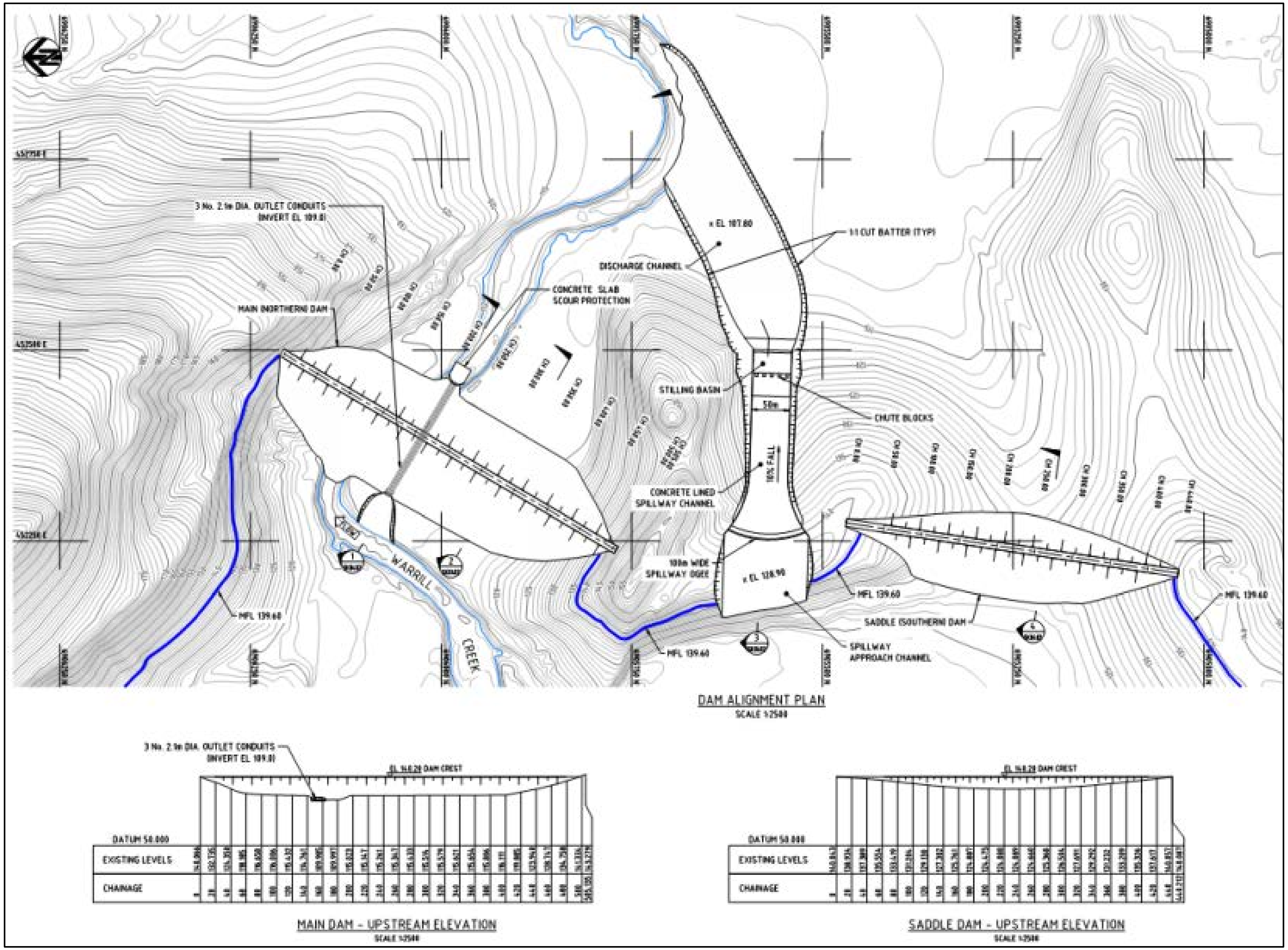



**Figure 7.24 General arrangement of potential flood mitigation dam – upper Warrill Creek AMTD 64.4 km**

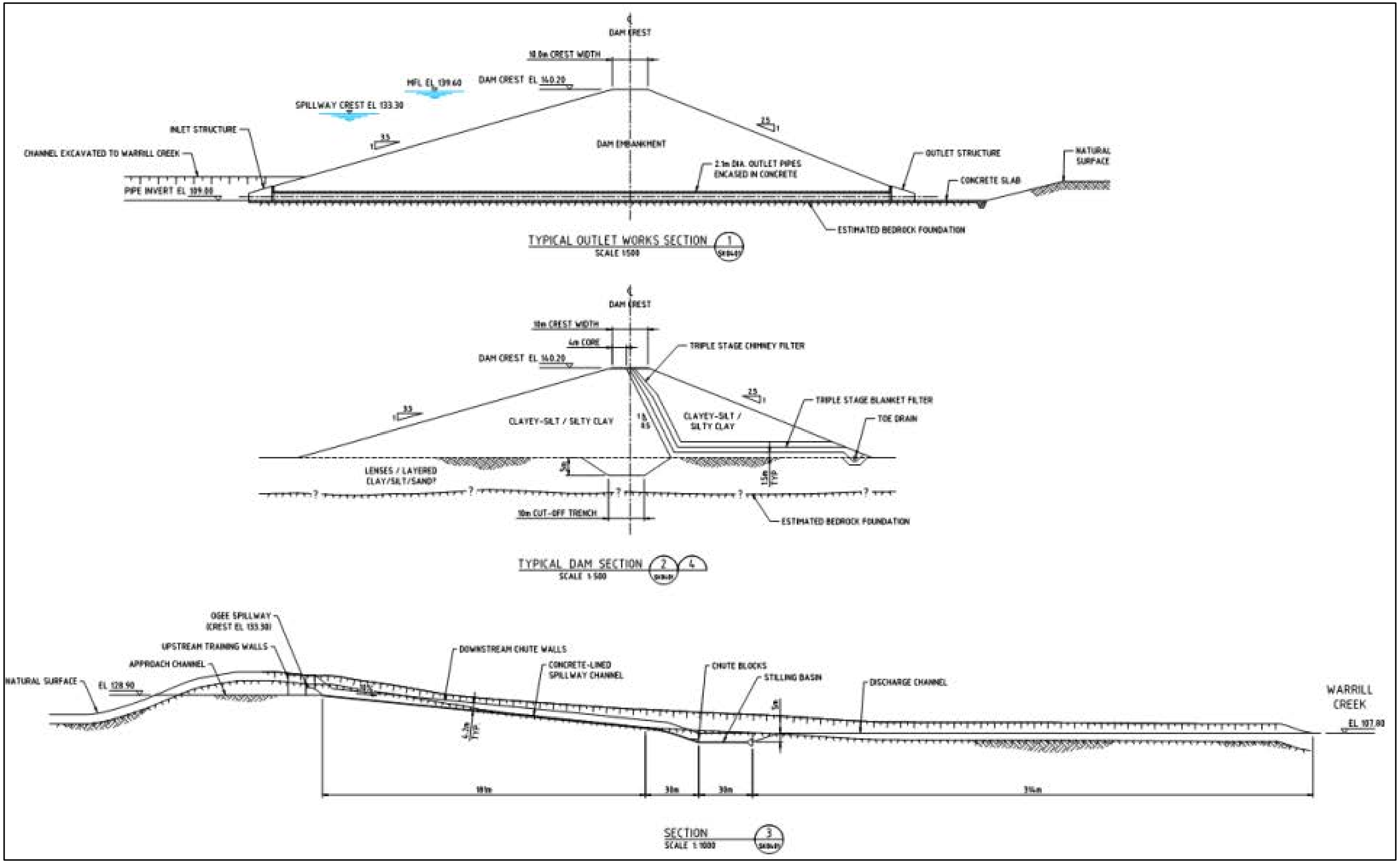



**Figure 7.25 Typical cross sections of potential flood mitigation dam - upper Warrill Creek AMTD 64.4 km**

#### 7.4.5.2 Infrastructure impacts

Road deviations with a total length of 5.4 km would be required as a consequence of a potential flood mitigation dam. Consultation with DTMR indicates that there are no state controlled roads or proposed roadworks impacted by a potential dam.

The road system consists of Rosewood-Aratula Road as the spine to side roads connecting to agricultural properties and rural residences. The highest priority road is Rosewood-Aratula Road which generally follows Warrill Creek. Niebling Road is the only road crossing of Warrill Creek. The side roads which are affected by the inundation limits are: Niebling Road; Falkhagen Road; Dwyer Road; Simmonds Road; and Cowhole Road.

The main spine of Rosewood Aratula Road would need to deviated to maintain the link between Aratula and Tarome. Two sections of the Rosewood Aratula Road would be required to be deviated around the storage limit. The two lengths are 3.6 km of road and a 50 m long bridge for the eastern deviation and 1.8 km and 20 m bridge around the aquaculture farm. In each section an intersection would be required.

This site covers a very narrow, but fertile area of creek and river flats which if impacted by permanent or infrequent flooding would result in major local and regional disruption to propagation, packaging, distribution, wholesale and retailing enterprises. A number of these businesses are located inside the inundation area, and locally at Aratula and environs.

#### 7.4.5.3 Agricultural impacts

The primary land uses within the local area are grazing and cropping with an aquaculture facility in the south (upstream of the inundation area).

#### 7.4.5.4 Social impacts

Nine houses would be impacted by a potential flood storage.

#### 7.4.5.5 Environmental impacts

Regional ecosystem mapping shows a total of three regional ecosystems potentially impacted by the inundation area, all of which are listed as ‘least concern’ (refer SMEC 2014 for detail).

Two TECs, the Lowland Rainforest of Subtropical Australia and White Box-Yellow Box-Blakely’s Red Gum Grassy Woodland and Derived Native Grassland, were indicated in an EPBC Act protected matters search for the local area. However, no REs corresponding to this TEC are mapped within the inundation area.

Hairy-joint grass (*Arthraxon hispidus*), listed as vulnerable under both the NC Act and EPBC Act, may occur along the creek, particularly near the less cleared sections of the creek. However there is no mapped essential habitat for this species within the study area.

A review of the Wildlife Online database and the EPBC Act protected matters search has identified approximately 31 species potentially within the inundation area including a number of endangered and vulnerable species listed under the NC Act and the EPBC Act.

A review of the Ecosystem Health Monitoring Program data for 2012 indicated 20 native fish species which are considered to have the potential to occur in the Upper Brisbane River and tributaries. Refer to SMEC 2014 for further details.

### 7.4.6 Laidley Creek AMTD 41 km

The site is located on Laidley Creek, approximately 40 km south-west of Ipswich and 2 km south-east of Thornton. A locality plan of the site is shown in Figure 7.26.

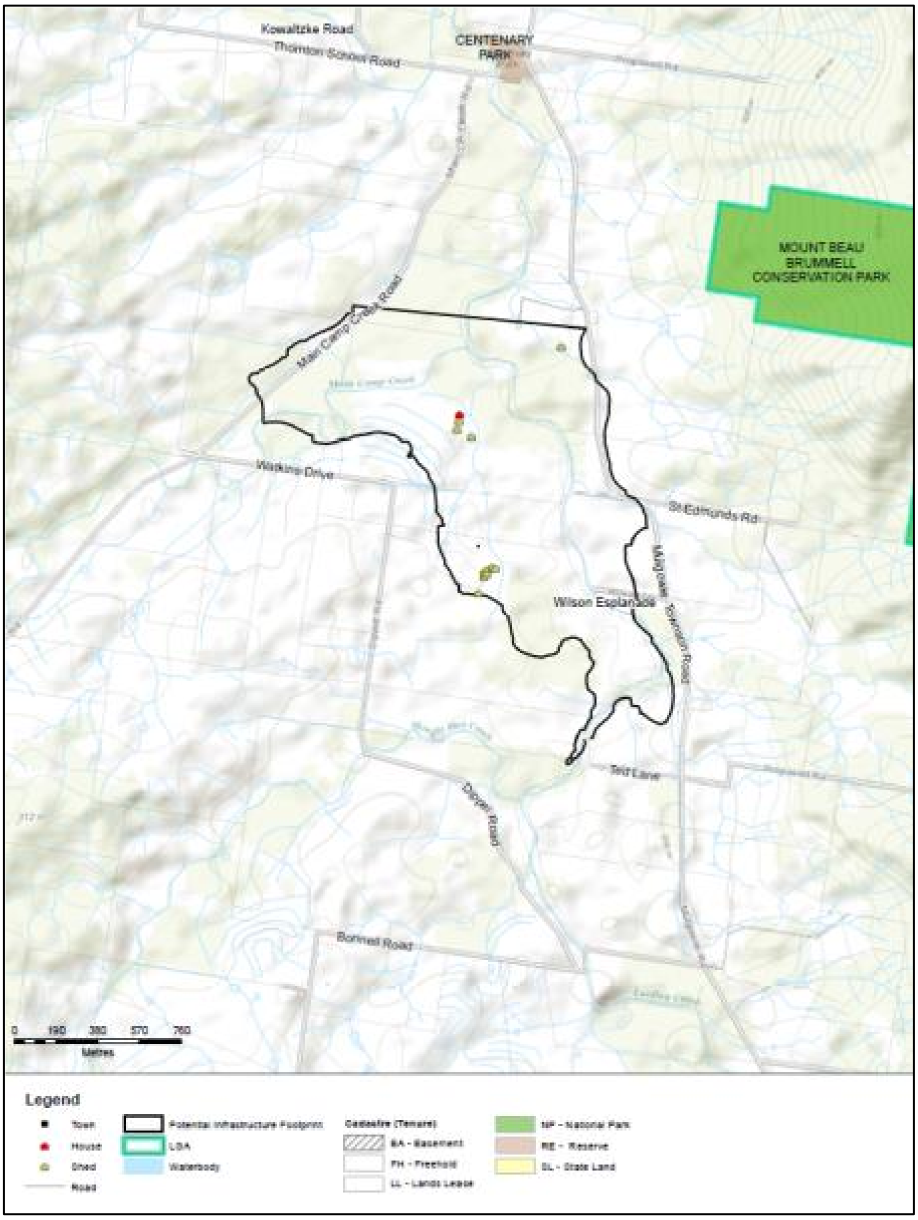



**Figure 7.26 Locality plan - Laidley Creek AMTD 41 km**

A view of the Laidley Creek channel is shown in Figure 7.27.

Figure 7.27 Laidley Creek channel

Key aspects of the site include:

- The proposed dam site is situated immediately downstream of the confluence of Laidley Creek and Main Camp Creek, allowing the structure to attenuate flows from both creeks.
- The left abutment of the dam is located adjacent to Main Camp Creek Road, with an average slope of 9.6H:1V.
- The right abutment, located adjacent to the Mulgowie Road, has an average slope of 14H:1V.

#### 7.4.6.1 Dam structure

The preferred option is a zoned earthfill dam, based on it's less expensive construction, likelihood of sufficient sources of material onsite and being more 'forgiving' on a poorer quality foundation (not requiring extensive excavation). Refer to SMEC 2014 for further detail.

Typical general arrangement and cross sections of the dam structure are shown in Figure 7.28 and Figure 7.29.

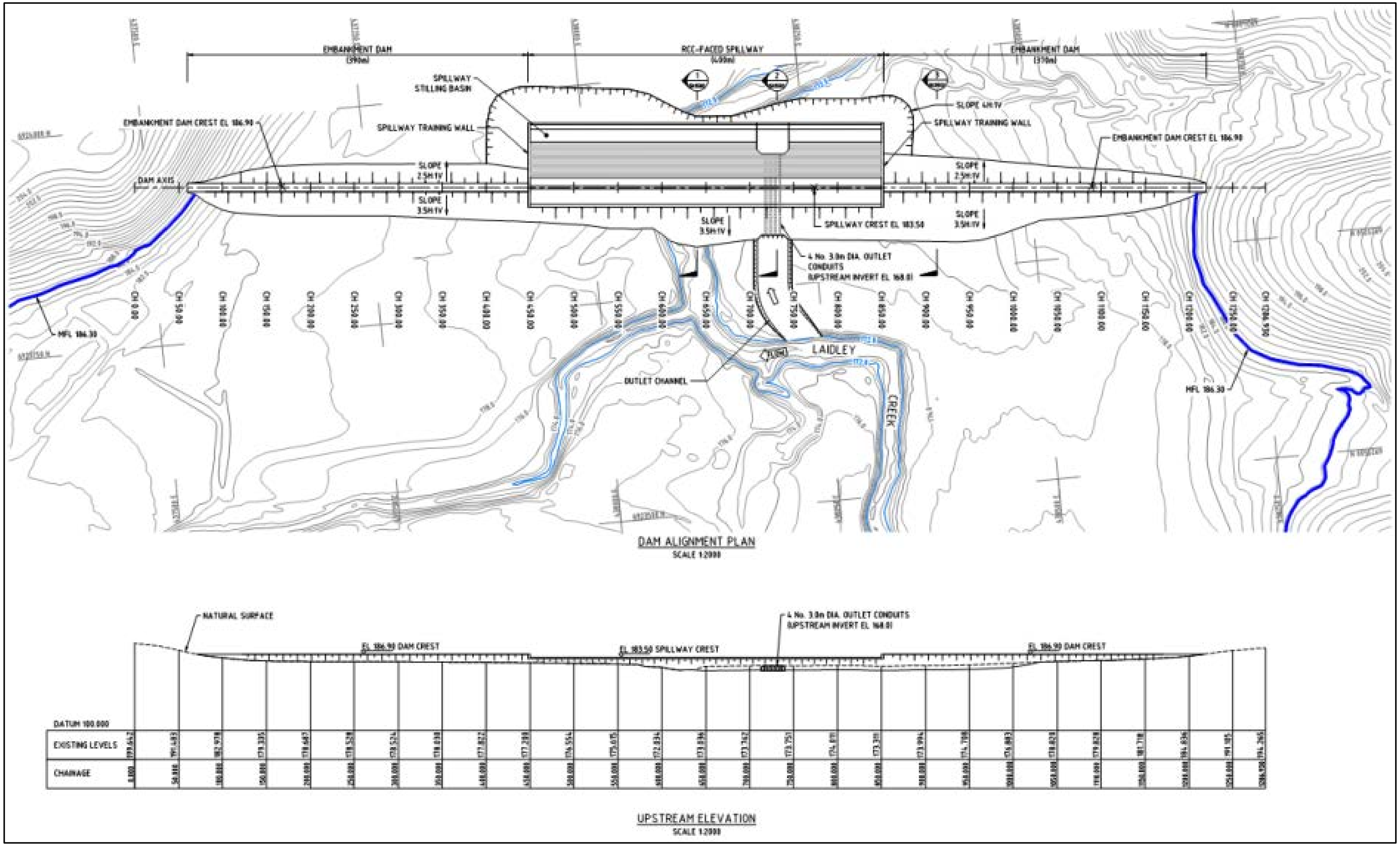



**Figure 7.28 General arrangement of potential flood mitigation dam - Laidley Creek AMTD 41 km**

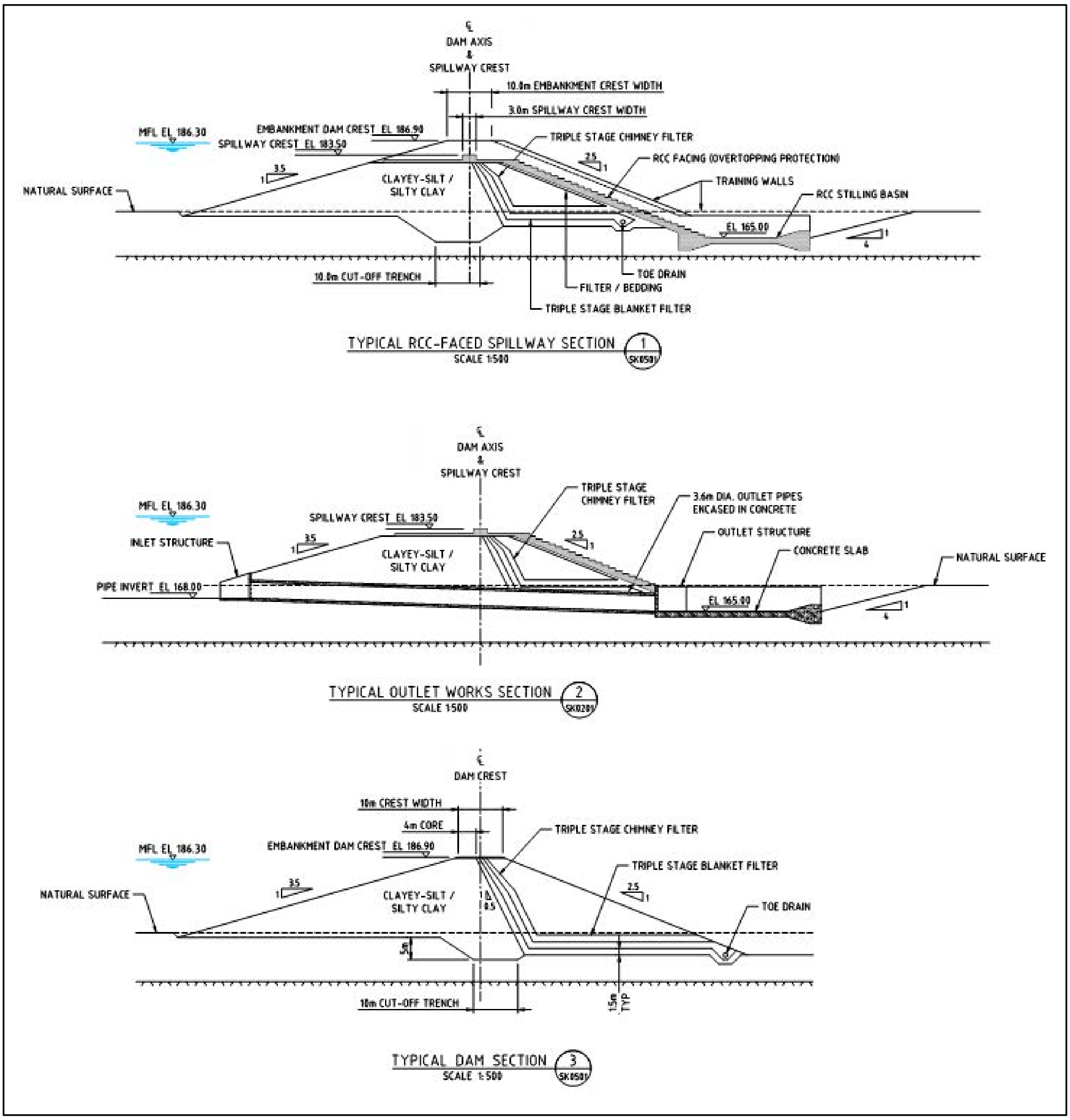



**Figure 7.29 Typical cross sections of potential flood mitigation dam - Laidley Creek AMTD 41 km**

### 7.4.6.2 Infrastructure impacts

Road deviations with a total length of 7 km would be required as a consequence of a potential flood mitigation dam.

The road system consists of Mulgowie Road as the spine to side roads connecting to agricultural properties and rural residences. The highest priority road is Mulgowie Road which generally follows Laidley Creek on the eastern side. Main Camp Creek Road follows along Main Camp Creek on the western side of the storage. The connections between the two roads are Watkins, Dippel and Bonnel Roads through the inundation zone.

Deviations of Mulgowie Road (3 km section) to the east of the inundation area and Main Camp Creek Road (1.3 km section) to the west of the inundation area would be required. These roads extend further upstream than the inundation zone providing access to the agricultural land and rural residences in the upper valleys. A 20 m long bridge is allowed for on Main Camp Creek Road.

Consultation with DTMR indicates the potential for slips and subsidence for a deviation of Mulgowie Road onto the higher slopes above the inundation area to the east. No additional cost allowance has been made for the Mulgowie Road deviation under this assessment to address this aspect but would require more detailed consideration if the site was further investigated.

A further two lane sealed road deviation (2.7 km length) off Main Camp Creek Road to link to Dippel Road and through to Bonnel Road would be required to maintain access to the upper reaches on Bonnel Road. The link road would then comprise of the only access to Bonnel Road during floods. The existing road is to be retained which provides access of Mulgowie Road in normal operation.

#### 7.4.6.3 Agricultural impacts

Numerous irrigation enterprises, both Travelling and Pivot irrigation systems were noted across the inundation area. In a number of cases these water systems were powered from banks of solar panels located across the impacted properties, these banks of panels would be need to be relocated, or compensation for the loss assessed.

With the substantial number of irrigation licences utilised across the area, careful consideration in the calculation of compensation for the loss of those licences would be required. There has been no allowance made for this loss as licence details are not readily available at this point of the project.

This site covers a narrow, but fertile area of creek and river flats which if impacted by permanent or infrequent flooding would result in major local and regional disruption to fodder, horticultural and cropping enterprises. The majority of these enterprises are located inside the inundation area, and therefore relocation would impracticable, once away from the fertile creek and river areas. It was noted that almost the entire inundation area was entirely devoted to, and available for, cultivation, cropping and diary enterprises: Very little second quality land was noted across the affected area.

#### 7.4.6.4 Social impacts

One house would be impacted by a potential flood storage.

The Thornton State Primary School located downstream of the dam has approximately 40 students currently in attendance according to the school’s website.

Based on information available online, a bed and breakfast establishment is located on Mulgowie Road, just on the edge of the inundation area but not within the mapped inundation extent.

The Edmund Adventure Education Centre is located just outside the inundation area, at the base of Mt Beau Brummell. Access to this educational facility is via Mulgowie Road and St Edmunds Road.

#### 7.4.6.5 Cultural Heritage

A search of the Aboriginal and Torres Strait Islander Cultural Heritage Database identified no records of cultural heritage values within the potential inundation area. However, DATSIMA advises that the records may not conclusively capture all indigenous heritage significance and therefore should not be relied upon to contain all relevant and necessary information.

The registered Cultural Heritage Body identified through the DATSIMA search is the Jagera Daran Pty Ltd.

No sites or features were recorded on the Queensland Heritage Register within the study area. However, Mt Beau Brummell, located to the east of the inundation area, is on the register of the National Estate.

#### 7.4.6.6 Environmental impacts

The Mt Beau Brummell Conservation Park is located to the east of the inundation area.

The inundation area lies between two ridges running north-south, fauna may move across the inundation area, though east-west habitat connectivity is lacking. Mt Beau Brummell is entered on the Register of the National Estate, for 'it's scenic and recreational values, and for its value as a natural habitat.'

Regional ecosystem mapping shows a total of two regional ecosystems potentially impacted by the inundation area (refer SMEC 2014 for detail) including:

- Of Concern *Eucalyptus moluccana* open forest on sedimentary rocks (RE 12.9-10.3).

Two TECs, the Lowland Rainforest of Subtropical Australia and White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, were indicated in an EPBC Act protected matters search for the local area. However, no REs corresponding to this TEC are mapped within the inundation area.

A review of the Wildlife Online database and the EPBC Act protected matters search has identified approximately 34 species potentially within the inundation area including a number of endangered and vulnerable species listed under the NC Act and the EPBC Act. Refer to SMEC 2014 for further detail.

## 7.4.7 Tenthill Creek AMTD 29.8 km

The site is located on Tenthill Creek, approximately 18 km south-west of Gatton and immediately upstream of the township of Mount Sylvia (Figure 7.30).

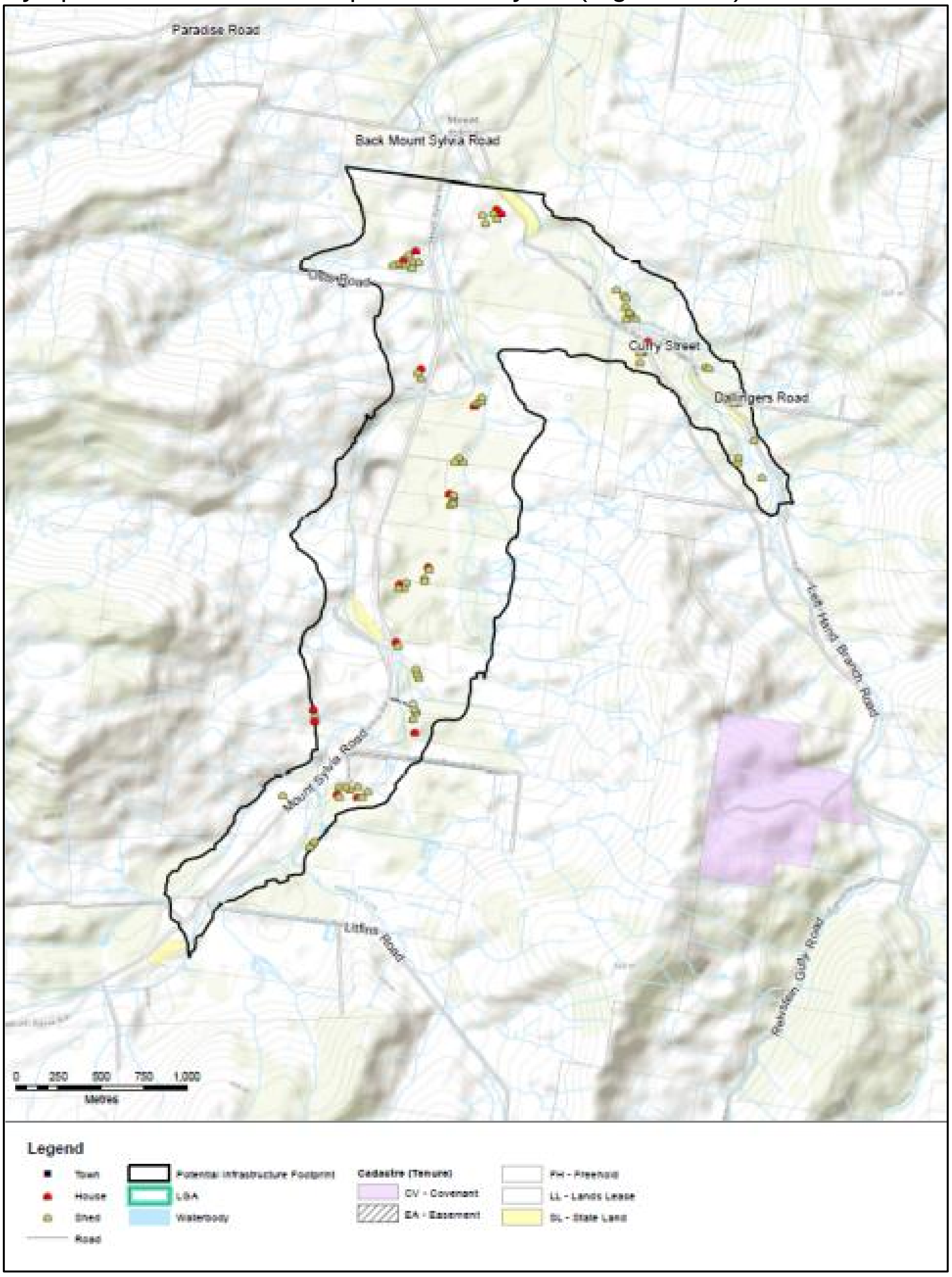



**Figure 7.30 Locality plan - Tenthill Creek AMTD 29.8 km**

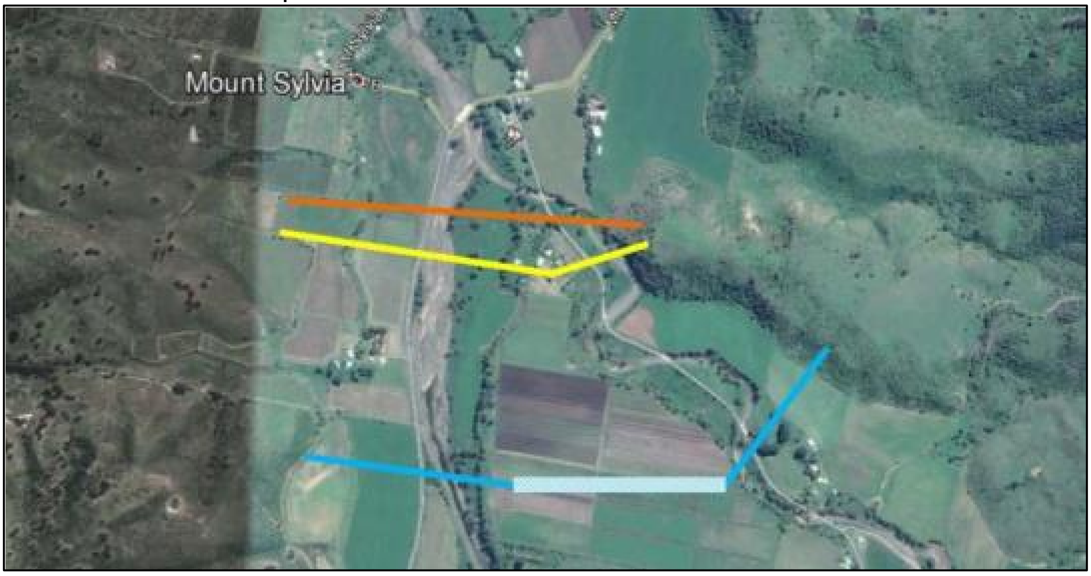
Key aspects of the site include:

- The left abutment is relatively flat, with a slope in the order of 7.7H:1V.
- The right abutment is formed by a sandstone outcrop, and in places is near vertical.
- The right abutment is adjacent to Left Hand Branch Road.

### 7.4.7.1 Dam structure

The proposed dam site is located immediately upstream of the confluence of Tenthill and Blackfellow Creek.

The site traverses both creeks, which are separated at the dam site by an alluvial terrace. The top level on this terrace is around EL 183 m, which is around 12 m above the riverbed but lower than the proposed spillway crest level of EL 199.6 m. Figure 7.31 shows the dam alignments considered as part of the assessments.




Note: Adopted alignment highlighted in yellow

**Figure 7.31 Dam alignments considered - Tenthill Creek AMTD 29.8 km**

The preferred option is a zoned earthfill dam, based on it's less expensive construction, likelihood of sufficient sources of material onsite and being more 'forgiving' on a poorer quality foundation (not requiring extensive excavation). Refer to SMEC 2014 for further detail. Figure 7.32 shows a view of the site looking towards the left abutment.

**Figure 7.32 View looking looking along dam axis towards left abutment –Tenthill Creek AMTD 29.8 km**

Typical general arrangement and cross sections of the dam structure are shown in Figure 7.33 and Figure 7.34.

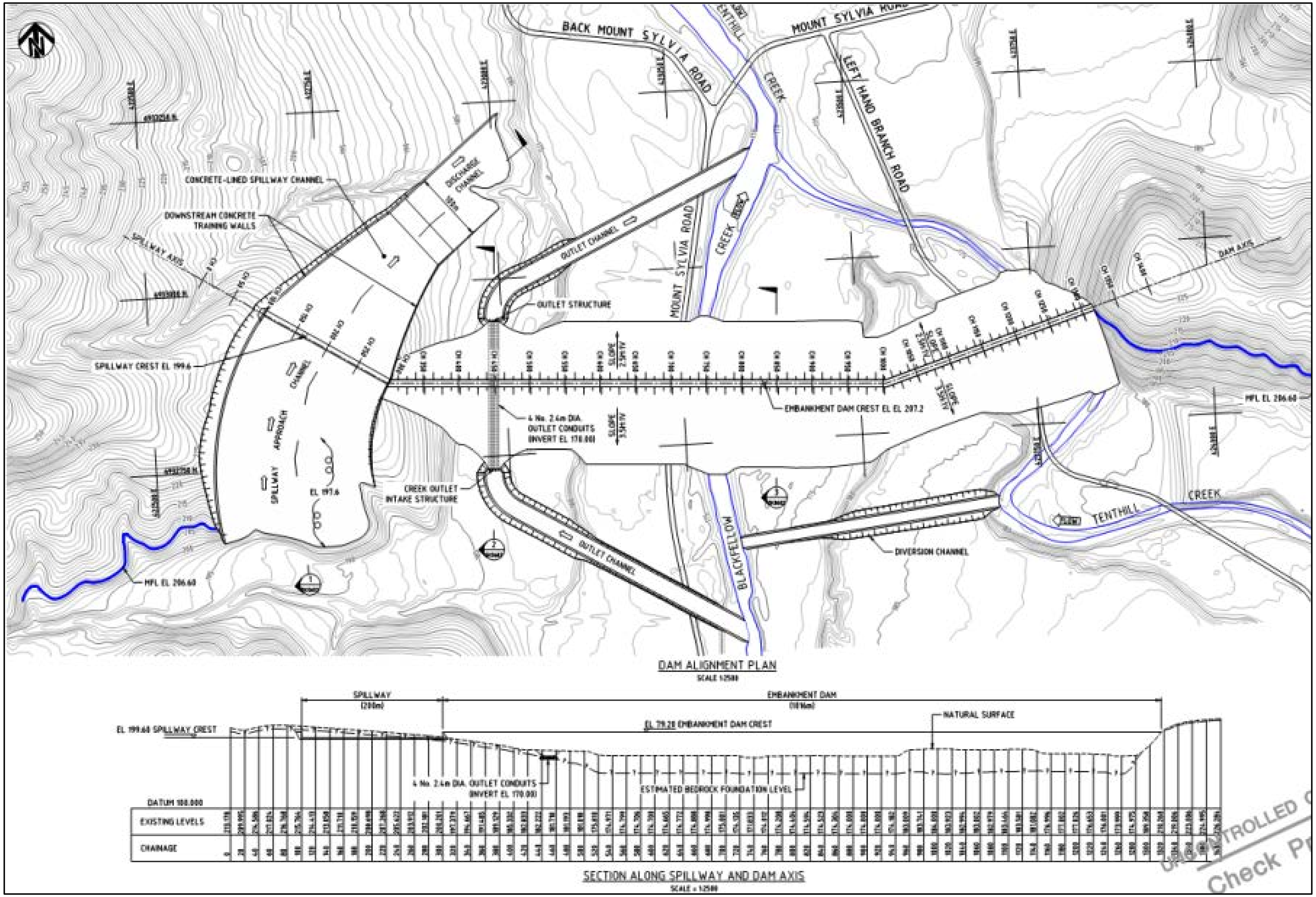



**Figure 7.33 General arrangement of potential flood mitigation dam - Tenthill Creek AMTD 29.8 km**

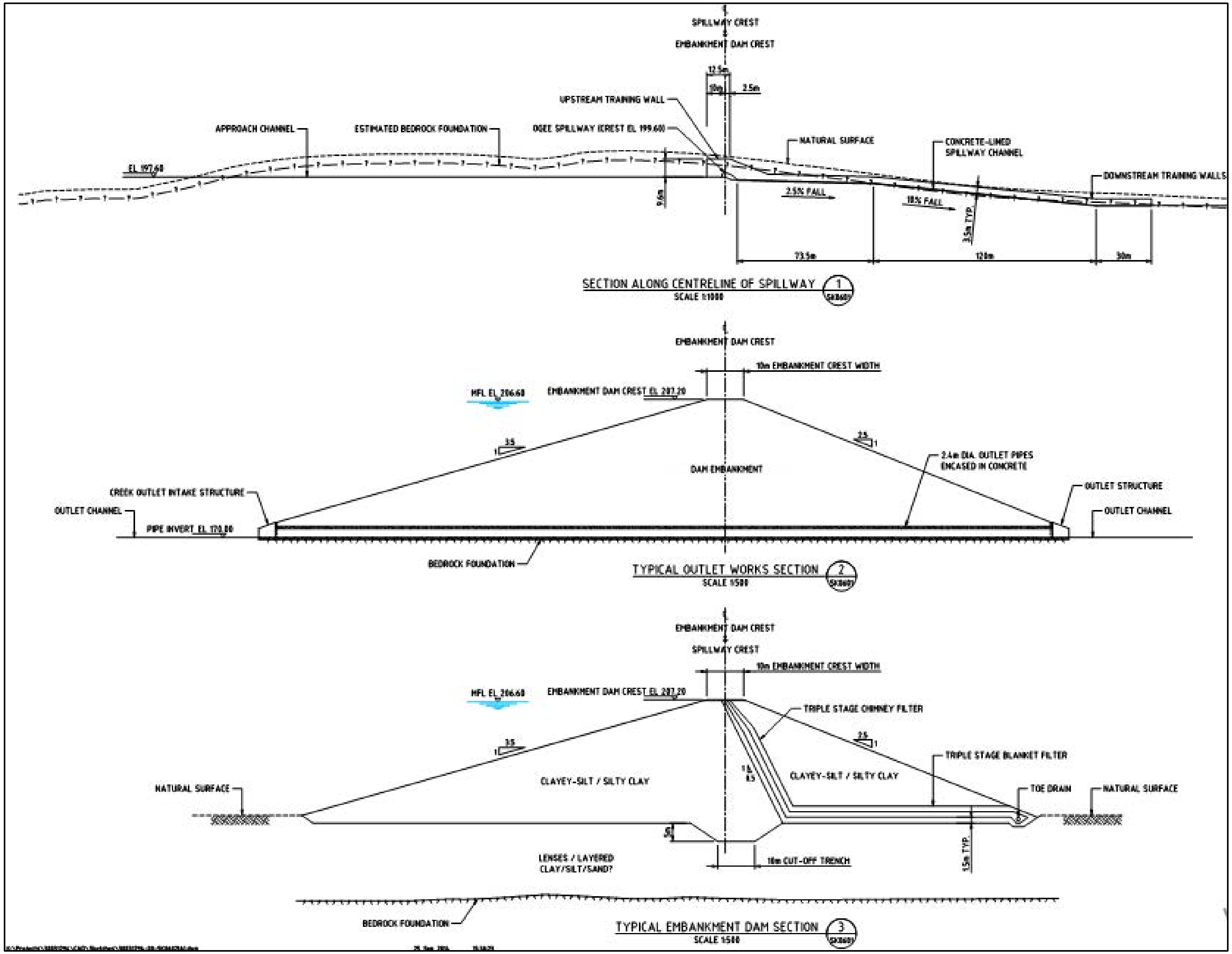



**Figure 7.34 Typical cross sections of potential flood mitigation dam - Tenthill Creek AMTD 29.8 km**

#### 7.4.7.2 Infrastructure impacts

Road deviations with a total length of 9.5 km would be required as a consequence of a potential flood mitigation dam.

Left Hand Branch Road ends in the upstream reaches of Tenthill Creek and connects the agricultural properties along Left Hand Branch Road and Reivstein Gully Road to Mount Sylvia. A similar two lane sealed road would be required to be deviated around the eastern side of the inundation area. The length of the deviated road is 3.9 km.

Mount Sylvia Road connects to the upper reaches of the valleys of Blackfellow Creek and Black Duck Creek. The creek confluence is above the inundation line so these two roads are to be retained as they connect rural properties and the national park facilities. There is an alternative connection for these two roads via West Haldon Road which connects to Gatton Clifton Road and through to Gatton. Even though there is an alternate connection, an allowance has been made as part of this investigation for a deviation of the Mount Sylvia Road to the west of the inundation area. The length of the deviated road is 5.6 km and has been costed as part of the infrastructure relocation costs as a two lane sealed road.

Consultation with DTMR has raised potential impacts to the Mount Sylvia Road crossing of Tenthill Creek immediately downstream of the potential dam. This crossing is of a relatively low flow capacity and further investigation would be required to determine whether the low level outlet works of a potential dam would exacerbate flooding of the existing road crossing. These investigations have not been carried out under this assessment but would need to be carried out if this site is further investigated. No cost allowance has been made under this assessment for an upgraded Mount Sylvia Road crossing of Tenthill Creek.

#### 7.4.7.3 Agricultural impacts

This site covers a very narrow, but fertile area of creek and river flats which if impacted by permanent or infrequent flooding would result in major local and regional disruption to agricultural enterprises. A number of these agricultural businesses are located inside the inundation area.

#### 7.4.7.4 Social impacts

An estimated 17 houses would be impacted by a potential flood storage.

The Mt Sylvia State Primary School is located to the north, downstream of the potential dam structure.

#### 7.4.7.5 Cultural Heritage

A search of the Aboriginal and Torres Strait Islander Cultural Heritage Database identified no records of cultural heritage values within the potential inundation area. However, DATSIMA advises that the records may not conclusively capture all indigenous heritage significance and therefore should not be relied upon to contain all relevant and necessary information.

#### 7.4.7.6 Environmental impacts

No protected areas are defined in the immediate storage area or surrounds with the majority of the storage area having been cleared for crops or grazing.

Regional ecosystem mapping shows a total of four regional ecosystems potentially impacted by the inundation area. This includes areas of 'endangered' or 'of concern' regional ecosystems (refer SMEC 2014 for detail) including:

- Endangered Semi-evergreen vine thicket with *Brachychiton rupestris* on sedimentary rocks (RE 12.9-10.15)
- Endangered *Acacia harpophylla* open forest on sedimentary rocks (RE 12.9-10.6)
- Of Concern *E. crebra* +/- *E. tereticornis*, *C. tessellaris*, *Angophora* spp., *E. melanophloia* woodland on sedimentary rocks (RE 12.9-10.7)
- Of Concern *E. moluccana* open forest on sedimentary rocks (RE 12.9-10.3).

This area is also mapped as essential habitat, and as a bioregional corridor, connecting north and south of the storage area.

Three TECs, the Critically Endangered Lowland Rainforest of Subtropical Australia, the Critically Endangered White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland and the Endangered Brigalow (*A. harpophylla* dominant and codominant), were indicated in an EPBC Act protected matters search for the local area.

A review of the Wildlife Online database and the EPBC Act protected matters search has identified approximately 32 species potentially within the inundation area including a number of endangered and vulnerable species listed under the NC Act and the EPBC Act (refer to SMEC 2014 for further detail).

Tenthill Creek and Blackfellow Creek are within the Lockyer Creek catchment and subject to the Environmental Protection Policy 2009 'Lockyer Creek Environmental Values and Water Quality Objectives (July 2010)'.

## 7.5 Cost estimates

Estimates of cost for dam construction, land acquisition and relocation of infrastructure were prepared for each dam site including for some sites costing of multiple dam configurations. This information is presented in Table 7.4.

**Table 7.4 Summary of costs and other information for each dam site**

| Location | Storage volume (ML) | | Dam type [2] | Spillway width (m) | Inundation level [3] (mAHD) | CAPEX ($m) | | | | OPEX ($m) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Up to spillway crest level | Maximum[1] | | | | Design and construct | Infrastructure relocations | Land acquisition | TOTAL | |
| Brisbane River (near Linville) AMTD 282.3 km | 240,000 | 672,100 | WS | 160 | 157 | 355.3 | 0.5 | 44.8 | 400.6 | 3.6 |
| | 348,000 | 766,800 | FM | 160 | 157 | 387.1 | 5.6 | 36.2 | 428.9 | 1.7 |
| | 510,000 | 1,096,000 | WS | 160 | 168 | 499.1 | 0.5 | 44.8 | 544.4 | 3.6 |
| | 570,000 | 1,172,400 | WS | 160 | 170 | 528.0 | 0.5 | 46.5 | 575.0 | 3.6 |
| | 570,000 | 1,121,600 | WS | 200 | 170 | 510.3 | 0.5 | 46.5 | 557.3 | 3.6 |
| Emu Creek (near Harlin) AMTD 10.8 km | 107,000 | 191,000 | FM | 150 | 149 | 276.7 | 0.6 | 15.3 | 292.6 | 0.4 |
| Lower Warrill Creek (near Willowbank) AMTD 13.9 km | 125,000 | 207,300 | FM | 1,500 | 42 | 249.1 | 141.3 | 50.0 | 440.4 | 0.5 |
| Lower Warrill Creek (near Willowbank) AMTD 14.6 km | 125,000 | 394,000 | FM | 200 | 42 | 405.5 | 141.3 | 50.0 | 596.8 | 0.5 |
| | 125,000 | 207,300 | FM | 1,500 | 42 | 330.9 | 141.3 | 50.0 | 522.2 [4] | 0.5 |
| Bremer River (near Mt Walker) AMTD 70 km | 40,000 | 65,000 | FM | 500 | 76 | 124.0 | 0.5 | 13.9 | 138.4 | 0.5 |
| Upper Warrill Creek (near Aratula) AMTD 64.4 km | 32,600 | 66,500 | FM | 100 | 133 | 139.0 | 43.2 | 17.2 | 199.4 | 0.5 |
| Laidley Creek (near Thornton) AMTD 41.0 km | 5,200 | 12,200 | FM | 400 | 183.5 | 86.4 | 49.0 | 14.0 | 149.4 | 0.5 |
| Tenthill Creek (near Caffey) AMTD 29.8 km | 52,500 | 93,700 | FM | 200 | 199.6 | 265.5 | 62.0 | 24.5 | 352.0 | 0.5 |

Notes:

1. Volume up to embankment crest level (less free board); based on safely passing PMF.
2. Dam type is either water supply (WS) dam or flood mitigation (FM) dam.
3. Inundation level is based on modelled maximum historical flood level with the dam in place (Seqwater 2014a). In some cases based on nearest contour interval.
4. Of the costs shown here, approximately $61m is attributable to the Southern Freight Rail Corridor proponent, making the net cost for flood mitigation purposes $461m. The preferred lower Warrill option is to co-locate the dam wall and the rail embankment. This option is approximately $21m more expensive than building the dam and rail embankment separately.

## 7.6 Key Outcomes

- Across the 7 sites, 13 dam configurations have been assessed regarding the engineering feasibility of developing flood mitigation storages in South East Queensland to reduce flood impacts on Brisbane and Ipswich.
- Four sites (Brisbane River near Linville, Lower Warrill Creek near Willowbank, Bremer River near Mt Walker and Emu Creek near Harlin) are feasible and provide moderate to significant flood mitigation benefits.
- Three sites (Upper Warrill Creek near Aratula, Laidley Creek near Thornton and Tenthill Creek near Caffey), while still feasible, have lower flood mitigation benefits due to their relatively small flood storage volume. (Note, the Laidley Creek dam site may have local benefits which have not been evaluated.)
- Apart from engineering considerations, issues such as infrastructure impacts/relocations, land acquisitions, land use changes, cultural heritage, environmental and social impacts have been considered. The significance of issues varies across sites, but no critical issues have been identified that would rule out any of the four most beneficial options from further investigation.
- For dry flood mitigation storages, most impacts to infrastructure, land use, environmental and social values are limited in extent (close to the dam wall location and the existing stream bed) and/or duration (inundation would only occur during major floods and only last for several days). Thus the incremental impacts of the storages are generally minor. For water supply storages the impacts are greater, as the inundation would be semi-permanent.
- Preliminary cost estimates have been prepared for all 13 dam configurations. These estimates include construction and operation costs for the potential storages, land acquisition, infrastructure relocations and investigation/management costs. Costs vary significantly between sites, depending on site characteristics and the scale of the storages that are feasible.

# Chapter 8 Seqwater dams

Upgrading of the existing Wivenhoe and Somerset Dam system was included as a potential strategy for increasing flood mitigation for Brisbane River reaches downstream of Wivenhoe Dam.

## 8.1 Overview

The existing configuration of Wivenhoe and Somerset dams provides flood mitigation when the dams are operated together. Hence the potential to increase flood mitigation must consider works necessary for both dams in order to meet dam safety criteria and achieve practical flood operations of the dams.

The recent investigations for WSDOS and previous reviews of both dams had identified that the existing configuration of Wivenhoe Dam and Somerset Dam have inadequate flood capacity to meet the regulatory guidelines for Queensland and the Australian Guidelines produced by ANCOLD. This is largely due to several revisions of estimates of the Probable Maximum Precipitation (PMP) by the Bureau of Meteorology and the consequential changes to the estimated Probable Maximum Flood (PMF) that have occurred since the initial design and construction of the dams. The WSDOS investigations, utilising advanced methods to assess a wide range of potential floods, also more clearly identified that the potential for Somerset Dam failure to cause a cascade failure of Wivenhoe Dam will be a key consideration for the upgrade planning of the dams to meet dam safety regulatory criteria.

An important philosophy to be considered for upgrade options to increase the flood mitigation benefits provided by the existing dams is that any upgrade should also address existing deficiencies to reduce dam safety risks and comply with current standards. On this basis, the study for providing increased flood mitigation using Wivenhoe and Somerset Dams has developed concepts for the upgrade works necessary for both dams to safely pass the PMF and meet all state and national regulatory upgrade requirements. Further concepts for the upgrade works have been investigated to increase the flood mitigation storage capacity in Wivenhoe Dam.

For the study findings in relation to project costs, it is important to understand the following differences:

- The total project cost to implement the works is the combined cost to upgrade Wivenhoe and Somerset Dams to meet dam safety criteria (which must occur prior to 2035 regardless of any other works) plus the cost of providing increased flood storage in Wivenhoe Dam for flood mitigation
- The benefit/cost economic assessment for increasing flood mitigation considers only the incremental cost of providing increased flood storage in Wivenhoe Dam for flood mitigation.

The base case for comparison of options in the study is the flood mitigation that can be achieved with the existing configuration of the dams with flood operations incorporating the Urban 3 operating option arising from the WSDOS investigation. This represents close to the optimised operation of the existing infrastructure, given that WSDOS has recognised that some fine tuning of the Urban 3 operating option is still required to achieve full optimisation.

The study has assessed upgrade works to reduce risks for potential implementation of the Urban 4 operating option arising from the WSDOS investigation. It is important to note that while the upgrade works will reduce risks for the Urban 4 operating option, it is not possible to feasibly eliminate all risks and therefore some disadvantages for the Urban 4 option will remain such as the frequent triggering of fuse plug spillway.

## 8.2 Scope of upgrade options

The general scope of upgrade options for Wivenhoe Dam is summarised in Table 8.1.

**Table 8.1 Summary of scope of upgrade options investigated**

| Dam Option | Dam Safety Upgrade for PMF capacity | Flood Operations | Wivenhoe Dam Crest (EL mAHD) |
|---|---|---|---|
| Wivenhoe-1a | Augment spillway capacity with additional fuse plug spillway bays, and strengthening Somerset Dam. | Urban-3 | Existing crest 80.1 |
| Wivenhoe-1b | | Urban-4 | Existing crest 80.1 |
| Wivenhoe-2 | | Urban-5 | Raise 1.5 m to 81.6 |
| Wivenhoe-3 | | Urban-6 | Raise 4.0 m to 84.1 |
| Wivenhoe-4 | | Urban-7 | Raise 8.0 m to 88.1 |

Notes:

1. Existing main dam crest level is EL 80.1 mAHD. Saddle dam crest level is EL 80.0 mAHD. Raised Wivenhoe Dam options similarly assumed main dam crest level would be 0.1 m higher than saddle dams.
2. The current design Full Supply Level (FSL) of EL 67.0 mAHD and corresponding Full Supply Volume (FSV) of 1,165,000 ML was adopted for all these options.

## 8.3 Wivenhoe Dam operation assumptions

To assess the spillway dimensions and hydraulic capacity necessary to pass PMF events it was necessary to assume operating parameters for flood operations. The operating concepts applied in this study were developed from operating options assessed in the WSDOS investigations (Seqwater 2014b, and DEWS 2014).

For the Wivenhoe-1a dam configuration, the flood operations were based on the Urban 3 option assessed in the WSDOS investigation. To be consistent with the WSDOS investigation this option excluded consideration of a *Rural Strategy*.

For the Wivenhoe-1b dam configuration, the flood operations were based on the Urban 4 option assessed in the WSDOS investigation. To be consistent with the WSDOS investigation this option included consideration of a *Rural Strategy*.

For the Wivenhoe-2 to Wivenhoe-4 dam configurations, the assumed flood operations were modified to utilise the increased flood storage that would be available for flood mitigation with a raised dam embankment crest level. The flood operations concepts expanded the flood storage allocated for the Urban Flood Mitigation Strategy up to adopted higher trigger levels for the *Dam Safety Strategy*. The way in which the flood storage allocated to the Urban Flood Mitigation Strategy would be utilised applied the same concepts as the Urban 3 option (from WSDOS). This means that the increased flood storage would be assigned to targeting flows at Moggill in the range of 4,000–6,000 $m^3/s$ which provides greater benefit to minimise Urban Flooding. These options excluded consideration of a *Rural Strategy*.

It is important to note that the assumed flood operations for the Wivenhoe-2 to Wivenhoe-4 dam configurations were assessed as a potential way to operate the dams but may not necessarily be the optimal operating rules. However, the assumed operating strategies were deemed sufficient for the prefeasibility study. A detailed optimisation study to identify the most suitable flood operations for Wivenhoe Dam with increased flood mitigation storage capacity would need to be undertaken as part of future studies and an options development study.

The estimated total dam storage for options Wivenhoe-2 to Wivenhoe-4 were calculated by mathematical extrapolation of the Wivenhoe Dam storage data. These estimates will need to be more accurately calculated using survey data as part of future studies.

The specific operating parameters that were applied for the flood routing simulations for the different options with increased flood mitigation storage in options Wivenhoe-2 to Wivenhoe-4 included:

- raising the trigger level for the *Dam Safety Strategy*
- modifying the *Urban Strategy* guide curve for target flow at Moggill
- modifying the *Dam Safety Strategy* guide curve for dam releases
- modifying the interaction line that guides the operation of Somerset Dam.

The adopted trigger levels for the *Dam Safety Strategy* and corresponding flood storage volumes above and below these levels are presented in Table 8.2.[5] For options that considered lowering of the full supply level of Wivenhoe Dam, the trigger levels for the *Dam Safety Strategy* were not changed from those shown in Table 8.2, and the additional storage gained from lowering the water supply storage was assumed to be reserved for the *Urban Strategy*. The additional flood storage gained from lowering the full supply level is summarised in Table 8.3.

**Table 8.2 *Dam Safety Strategy* trigger levels**

| Dam Option | Operating Option | *Dam Safety Strategy* Trigger Level (EL mAHD) | Available storage EL 67 mAHD to Dam Safety trigger (ML) [1] | Available storage Dam Safety trigger level to dam crest level (ML) [1] |
|---|---|---|---|---|
| Wiv-1a | Urban 3 | 75.0 (0.7 m below lowest fuse plug) | 1,066,000 | 900,000 |
| Wiv-1b | Urban 4 | 76.2 (0.5 m above lowest fuse plug) | 1,263,000 | 703,000 |
| Wiv-2 [2] | Urban 5 | 76.2 (0.5 m below lowest fuse plug) | 1,263,000 | 1,037,000 |
| Wiv-3 [2] | Urban 6 | 77.0 (1.0 m below lowest fuse plug) | 1,401,000 | 1,483,000 |
| Wiv-4 [2] | Urban 7 | 80.0 (1.0 m below lowest fuse plug) | 1,966,000 | 1,989,000 |

Notes:

1. Scope to reconsider in the feasibility study the relativity of the sizes of the dam safety and flood mitigation storage compartments.
2. These options raise the levels of the existing fuse plug embankments.

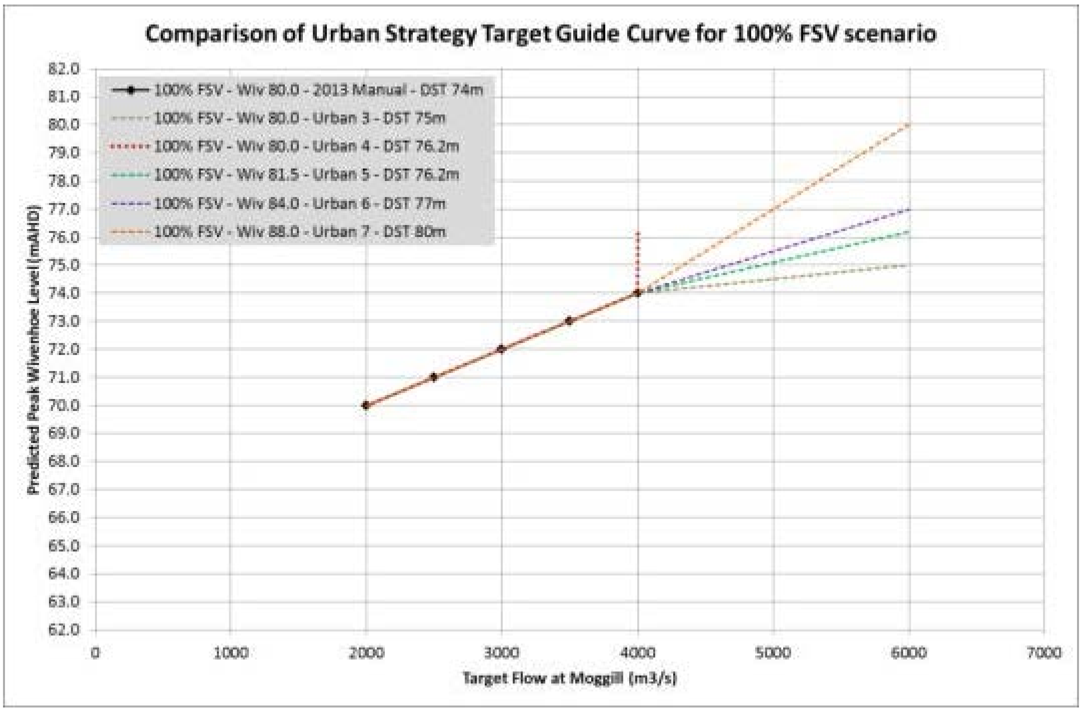
**Table 8.3 Additional urban flood mitigation storage from lowering full supply level**

| Lowered Full Supply Level option (as % of current FSV) | Increase in flood storage for *Urban Strategy* (ML) |
|---|---|
| 85% FSV | 176,000 |
| 75% FSV | 288,000 |
| 60% FSV | 464,000 |

The adopted target flow (at Moggill) guide curves that would be applied in the *Urban Strategy* operations for each of the Wivenhoe Dam options for 100% FSV are presented in Figure 8.1. The approach to adapt the *Urban Strategy* guide curve for lowered full supply level scenarios was the same as the approach utilised in the WSDOS investigations.

The adopted release flow guide curves that would be applied in the *Dam Safety Strategy* operations for each of the Wivenhoe Dam options for 100% FSV are presented in Figure 8.2. The approach to adapt the *Dam Safety Strategy* guide curve for lowered full supply level scenarios was the same as the approach utilised in the WSDOS investigations.

[5] The appropriate balance of flood storage between the *Urban Strategy* and the *Dam Safety Strategy* shall be reconsidered in a further feasibility study.




Note:

1. DST – *Dam Safety Strategy* trigger

**Figure 8.1** ***Urban Strategy*** **guide curve for 100% FSV**

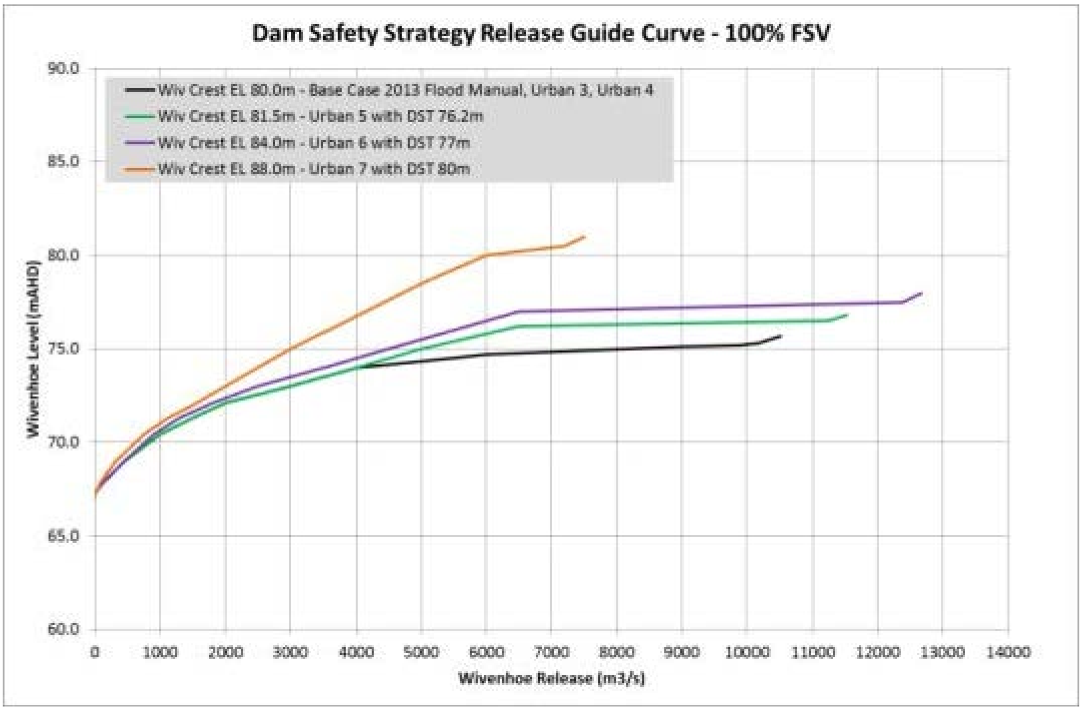



**Figure 8.2** ***Dam Safety Strategy*** **guide curve for 100% FSV**

The Wivenhoe Dam – Somerset Dam Interaction line that guides the operations of Somerset Dam relative to levels in Wivenhoe Dam was adapted for each of the options for raising the Wivenhoe Dam Crest Level. The Interaction line was adapted so that the top point of the line would be adjusted to the new dam crest level for Wivenhoe Dam as presented in Figure 8.3.

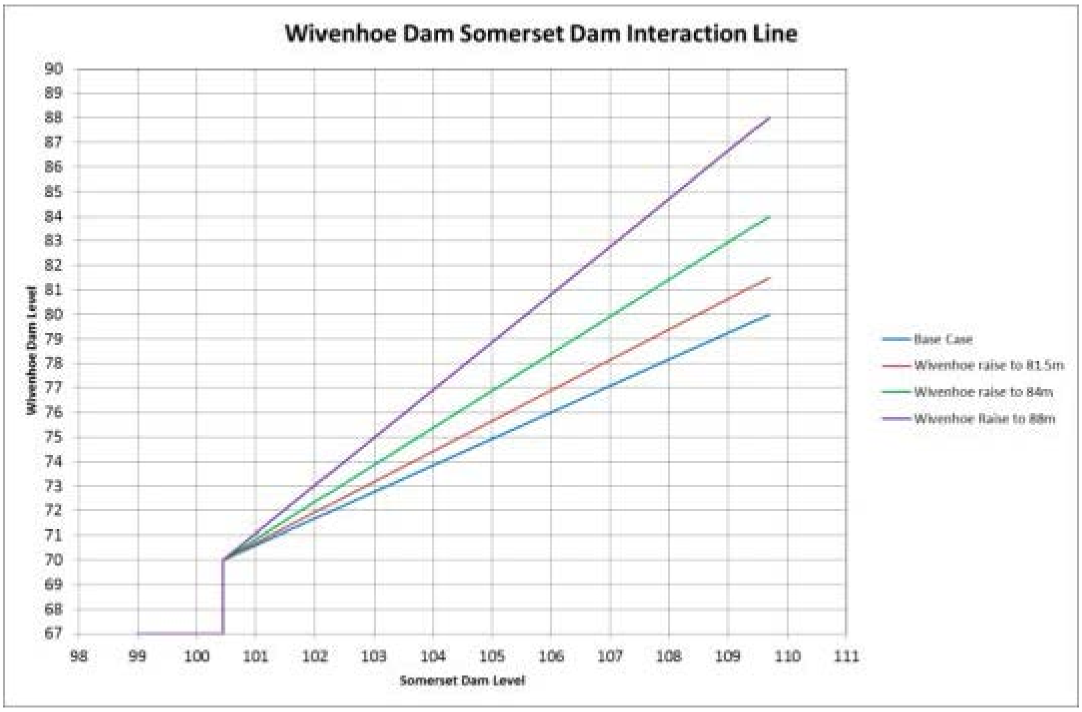



**Figure 8.3 Wivenhoe Dam – Somerset Dam interaction line**

## 8.3.1 Summary of Wivenhoe Dam operating storage assumptions

Figure 8.4 is a chart representation of the increased storage available for the different dam upgrade options with a breakdown showing the use of the storage for allocation to water supply, and the range of strategies and procedures for flood operations. This chart also shows the different trigger levels for the upgraded fuse plug spillway configuration for each option. Further information regarding the adopted trigger levels of the fuse plug spillways for each of the Wivenhoe Dam upgrade options is presented later in this chapter.

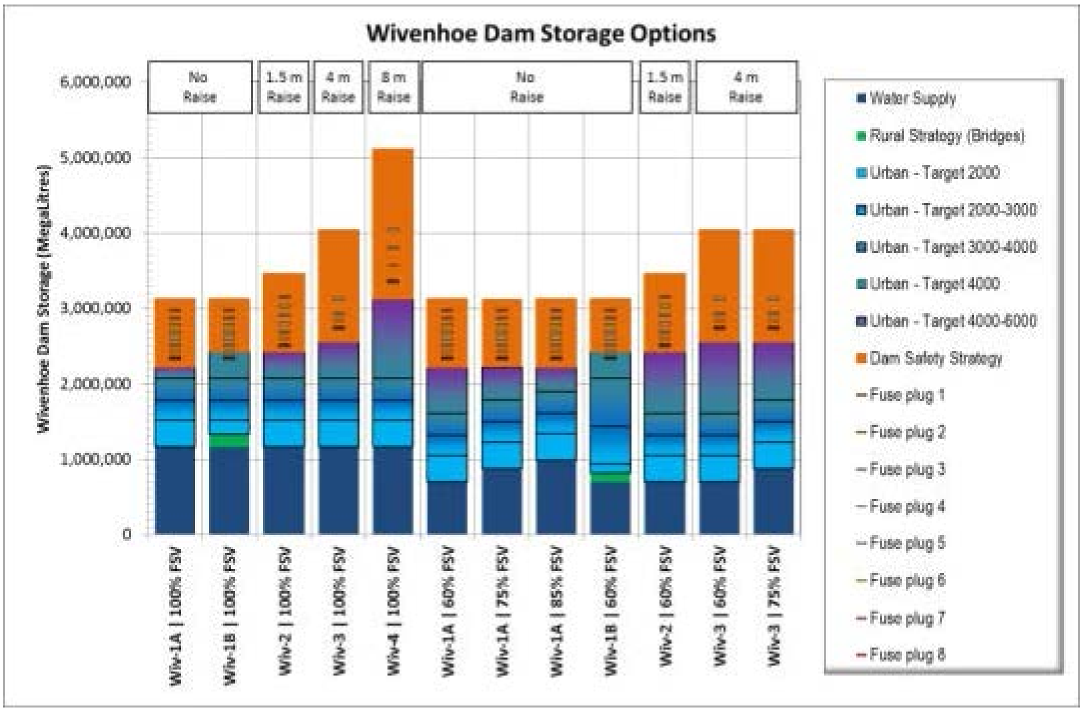



**Figure 8.4 Wivenhoe Dam storage options**

## 8.4 Wivenhoe and Somerset Dam Flood Upgrade Options Feasibility Study

Flood operation simulations were undertaken by Seqwater for:

- extreme floods to assess the capacity to pass PMF floods
- historical floods to assess flood mitigation benefits
- design floods to assess the indicative probability of triggering the fuse plugs

Seqwater engaged consultants GHD to undertake an Upgrade Options Feasibility Study. The study process is summarised below:

- review the available documentation and background data
- option scoping workshop and initial concept development
- develop preliminary design for each option
- preliminary design review
- preliminary assessment of upstream impacts
- develop preliminary option costs and prepare a study report.

The Wivenhoe Dam upgrade feasibility study is a preliminary investigation based on desktop methods with existing data. Additional geotechnical field investigations and further studies are needed to determine the final feasibility of any option.

Seqwater completed the flood routing assessments to assess required spillway capacity to pass PMF floods after the Option Scoping Workshop and Initial Concept Development work was undertaken by GHD.

### 8.4.1 PMF spillway capacity concepts

The conceptual approach to upgrade Wivenhoe Dam, built upon the concept envisaged for a Stage 2 upgrade by the Wivenhoe Alliance in 2003–2005, is to construct a new 'tertiary' fuse plug spillway at Saddle Dam 2.

A fuse plug spillway was considered to be the most cost effective upgrade option for providing acceptable flood capacity at Wivenhoe Dam with due consideration of the site topography and constraints. Alternative spillway options such as fuse gate spillways or widening of the existing main spillway would be significantly more expensive.

The recent flood studies undertaken by Seqwater for the WSDOS investigations recalibrated the hydrology models for the Brisbane River Basin and developed an integrated model to simulate the combined Wivenhoe Dam and Somerset Dam operations. The updated catchment flood hydrology has resulted in revised estimates of the PMF inflow hydrographs even though the estimates of the PMP rainfall depths have not changed. The latest estimates of the PMF inflow hydrographs for Wivenhoe Dam are now in the order of 60,000 $m^3/s$ for the peak flow including the outflow from Somerset Dam. Somerset Dam outflows are dependent on the existing hydraulic capacity of Somerset Dam spillway.

The spillway capacity upgrade concepts adopted for this investigation were based on an approach assuming that:

- for large widths of additional fuse plug spillway the upgrade would consider a fuse plug spillway at Saddle Dam 2 with a fully lined spillway downstream chute and cut-off

- for relatively small widths of additional fuse plug spillway the upgrade would consider widening of the existing fuse plug spillway at the right abutment.

Each of these options presents specific risks and consequences with associated design and operational challenges which will have to be considered further in any subsequent feasibility assessment this project. Some of these are detailed in Table 8.19.

### 8.4.2 PMF flood routing approach

The routing of PMF flood events was completed by Seqwater using the Flood Operation Simulation Model developed for the WSDOS investigation. The model was modified to enable assessment of up to eight fuse plug spillway bays at Wivenhoe Dam.

The PMF routing assessments were undertaken assuming the initial dam level was at Full Supply Level with all gates operational and the gates initially closed at the start of the flood event. This assumption of all gates operational departs from the "Fall-back" option in the Queensland AFC guidelines (DEWS 2013).

This departure from the "Fall-back" option was based on the findings of the Portfolio Risk Assessment for Wivenhoe Dam (URS, 2013) which concluded that due to the available backup systems at the dam the combined probability of an initiating flood and gate failure was not the critical risk. The risk assessment event trees identified that the combined probability of the initiating flood event and the probability of one or all gates failing was less than the combined probability of the same initiating flood event and all gates being operational. In the risk assessment, it was assumed that all gates are operational.

Sensitivity analyses for the PMF routing were also undertaken because the WSDOS investigations (Seqwater 2014) identified a number of limitations with key assumptions (e.g. the initial storage level) for the conventional assessment of PMF flood levels. The following sensitivity analysis cases were considered:

- Case 1 – Starting above FSL at the maximum level possible to have the gates closed, with the gates closed;
- Case 2 – Starting significantly above FSL at a level just below the lowest fuse plug trigger level with the gates fully open; and
- Case 3 – Starting at FSL with 20% of spillway gates (i.e. one gate) inoperable.

### 8.4.3 Spillway capacity Wivenhoe-1a and 1b (no raise options)

For the option to upgrade Wivenhoe Dam to pass the PMF with no raising of the dam crest, the flow capacity of the existing main spillway and right abutment fuse plug spillway would remain unchanged. This option was developed to provide PMF capacity by the construction of a 300 m fuse plug spillway at Saddle Dam 2. The new fuse plug spillway would have an ogee shaped sill with a crest level at EL 67 mAHD (similar to the existing fuse plug spillway). The downstream impacts of a large fuse plug spillway at Saddle Dam 2 are described in later sections of this chapter.

For the Wivenhoe-1b option, the existing fuse plug spillway would be upgraded with an extension of the downstream training walls and apron slab and provision of a downstream cut off. These would be provided to mitigate risk of backward erosion failure modes for the spillway and dam and allow for the possible frequent triggering of the lowest fuse plug embankment.

The assumed key parameters and estimated probability of triggering the breaching of the existing and new fuse plug spillway are summarised in Table 8.4.

**Table 8.4 Fuse plug spillway parameters for Wivenhoe-1a and 1b options**

| Fuse plug bay | Location | Bay Width (m) | Trigger Level (EL mAHD) | Trigger AEP | |
|---|---|---|---|---|---|
| 1 | Existing Right Abutment | 34 | 75.7 | 1 in 700 | Wiv-1a |
| | | | | 1 in 30 | Wiv-1b |
| 2 | Existing Right Abutment | 64.5 | 76.2 | 1 in 2,000 | Wiv-1a |
| | | | | 1 in 900 | Wiv-1b |
| 3 | Existing Right Abutment | 65.5 | 76.7 | 1 in 5,000 | Wiv-1a |
| | | | | 1 in 2,000 | Wiv-1b |
| 4 | New Saddle Dam 2 | 60 | 77.2 | 1 in 12,000 | Wiv-1a |
| | | | | 1 in 10,000 | Wiv-1b |
| 5 | New Saddle Dam 2 | 60 | 77.7 | 1 in 30,000 | |
| 6 | New Saddle Dam 2 | 60 | 78.2 | 1 in 60,000 | |
| 7 | New Saddle Dam 2 | 60 | 78.7 | 1 in 100,000 | |
| 8 | New Saddle Dam 2 | 60 | 79.2 | 1 in 140,000 | |

A plot of the critical 36 hour PMF inflow and outflow hydrograph is presented in Figure 8.5.

For the Wivenhoe-1a and Wivenhoe-1b options the peak outflow (estimated at 55,000 $m^3/s$) is approximately 92% of the peak inflow. There would be relatively minor attenuation of the peak inflow because of the limited flood storage capacity available between the dam safety trigger and the dam crest relative to the volume of the PMF flood.

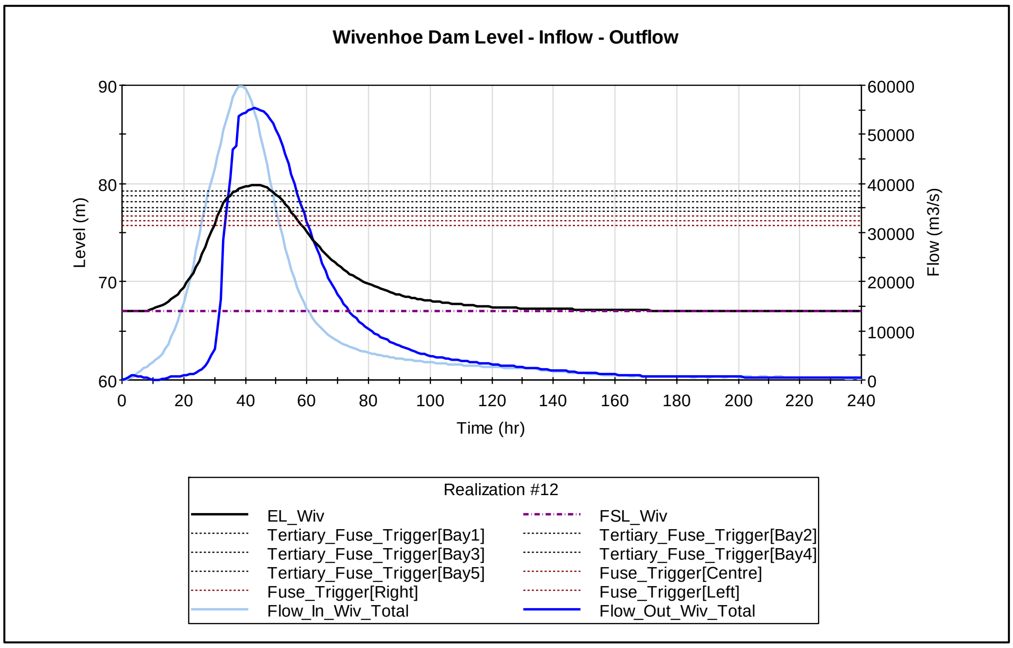



**Figure 8.5 Critical PMF hydrograph for Wivenhoe-1a and 1b options**

The results of sensitivity analyses for the PMF routing are summarised in Table 8.5. These results indicate that Option 1a and 1b would be relatively insensitive to the initial starting reservoir level for the PMF events due to the large spillway capacity of the options and the relatively minimal attenuation of the PMF flood through Wivenhoe Dam. The sensitivity analysis for the PMF cases result in very small depths of overtopping of the dam. A risk analysis will be necessary for any future design to assess the final spillway capacity requirement.

**Table 8.5 PMF routing sensitivity analyses – Wivenhoe-1a and 1b options**

| PMF routing case | PMF level (EL mAHD) | Difference (m) |
|---|---|---|
| Conventional – start level FSL (67 mAHD), and all gates operable | 79.85 | - |
| Case 1 – start level EL 73 mAHD, and gates fully closed | 80.02 | +0.17 |
| Case 2 – start level EL 75.6 mAHD, and gates fully open | 80.10 | +0.25 |
| Case 3 – start level EL 67 mAHD, and 20% gates inoperable | 80.19 | +0.34 |

### 8.4.4 Spillway capacity Wivenhoe-2 (1.5 m raise option)

For the option to upgrade Wivenhoe Dam to pass the PMF with a 1.5 m raising of the dam crest, the flow capacity of the existing main spillway and right abutment fuse plug spillway would remain relatively unchanged. To provide increased flood mitigation the existing fuse plug embankments would be raised by 1 m. Additional flow will pass through the existing fuse plug spillway for extreme events due to the increased spillway head at the raised dam crest level. The main spillway would be fitted with a new streamlined baffle structure to improve flow hydraulics at higher heads for the raised dam crest level. The baffle structure would also allow the spillway to limit loads on the spillway gates for extreme events and allow them to be raised clear of the flow.

This option was developed to provide PMF capacity by the construction of a 200 m fuse plug spillway at Saddle Dam 2. The new fuse plug spillway would have an ogee shaped sill with crest level at or around EL 67 mAHD (similar to the existing fuse plug spillway). The downstream impacts of a large fuse plug spillway at Saddle Dam 2 are described in later sections of this chapter.

The assumed key parameters and estimated probability of triggering the fuse plug spillway are summarised in Table 8.6.

**Table 8.6 Fuse plug spillway parameters for Wivenhoe-2 option**

| Fuse plug bay | Location | Bay Width (m) | Trigger Level (EL mAHD) | Trigger AEP |
|---|---|---|---|---|
| 1 | Existing Right Abutment | 34 | 76.7 | 1 in 800 |
| 2 | Existing Right Abutment | 64.5 | 77.2 | 1 in 2,000 |
| 3 | Existing Right Abutment | 65.5 | 77.7 | 1 in 8,000 |
| 4 | New Saddle Dam 2 | 50 | 78.3 | 1 in 20,000 |
| 5 | New Saddle Dam 2 | 50 | 78.9 | 1 in 45,000 |
| 6 | New Saddle Dam 2 | 50 | 79.5 | 1 in 80,000 |
| 7 | New Saddle Dam 2 | 50 | 80.1 | 1 in 130,000 |

A plot of the critical 36 hour PMF inflow and outflow hydrograph is presented in Figure 8.6. For the Wivenhoe-2 option the peak outflow, estimated as 52,000 $m^3/s$, would be approximately 87% of the peak inflow. The 1.5 m raise of the dam crest level for this option would increase the maximum flood storage volume and would provide a slight increase in the amount of attenuation of the PMF flood through Wivenhoe Dam.

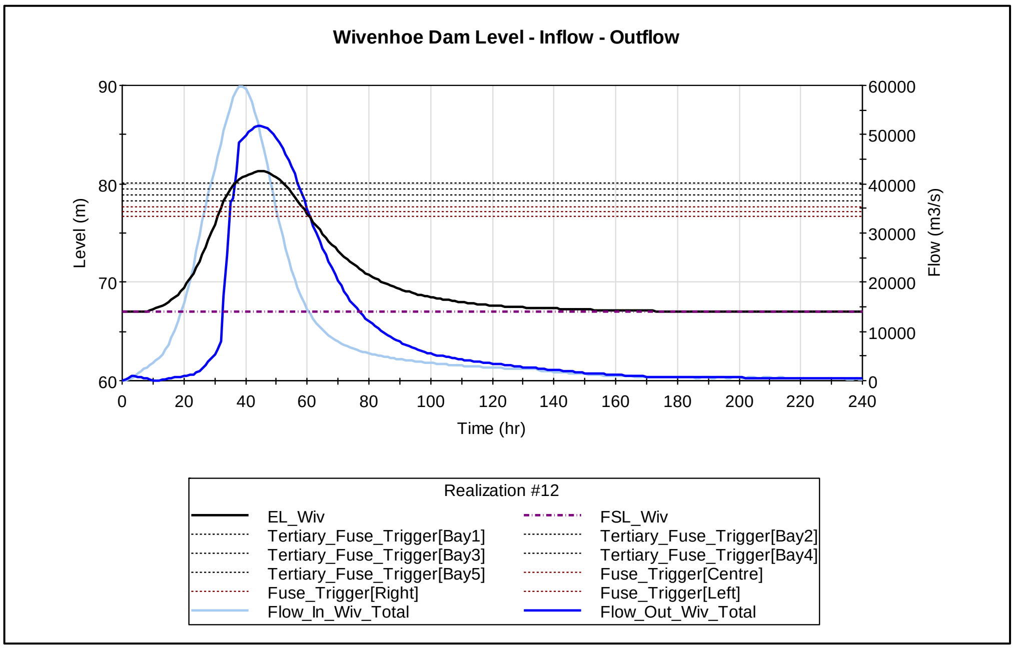



**Figure 8.6 Critical PMF hydrograph for Wivenhoe-2 option**

The results of sensitivity analyses for the PMF routing are summarised in Table 8.7. These results again indicate that this option would be relatively insensitive to initial starting level for PMF events due to the large spillway capacity provided by the three spillways and the relatively minimal attenuation of the PMF flood through Wivenhoe Dam. Because the sensitivity analysis PMF cases would result in very small depths of overtopping of the dam, a risk analysis will be necessary for any future design work to assess the final spillway capacity requirement.

**Table 8.7 PMF Routing Sensitivity Analyses – Wivenhoe-2 option**

| PMF routing case | PMF level (EL mAHD) | Difference (m) |
|---|---|---|
| Conventional – start level FSL (EL 67 mAHD), and all gates operable | 81.25 | - |
| Case 1 – start level EL 73 mAHD, and gates fully closed | 81.51 | +0.26 |
| Case 2 – start level EL 75.6 mAHD, and gates fully open | 81.61 | +0.36 |
| Case 3 – start level EL 67 mAHD, and 20% gates inoperable | 81.64 | +0.39 |

### 8.4.5 Spillway capacity Wivenhoe-3 (4.0 m raise option)

For the option to upgrade Wivenhoe Dam to pass the PMF with a 4.0 m raising of the dam crest level, the flow capacity of the existing main spillway would remain relatively unchanged. The main spillway would be fitted with a new streamlined baffle structure to improve flow hydraulics at higher heads between EL 77 mAHD and the new maximum flood level of EL 84 mAHD. To make best use of the increased flood storage for flood mitigation it would be desirable to extend the top of the existing radial gates. It was assumed from discussions with GHD that the existing spillway gates may potentially be extended by 2 m. This would allow the main spillway gates to be kept fully closed (when necessary for flood mitigation) at lake levels up to EL 74.7 mAHD (allowing 300 mm freeboard to the top of gates).

For this option it was assumed that the existing fuse plug ogee concrete crest level at EL 67 mAHD could be retained. This assumption will need further engineering analyses to assess whether this is feasible due to the additional loads on the structure. The higher flow that would pass through the existing fuse plug spillway due to the increased spillway head up to the raised dam crest level will induce negative crest pressures and additional uplift on the concrete crest structure.

The crest level of the existing fuse plug embankments would be raised. The PMF spillway capacity would be provided with an additional fuse plug spillway bay constructed adjacent to the existing fuse plug bays.

The assumed key parameters and estimated probability of triggering the fuse plug spillway are summarised in Table 8.8.

**Table 8.8 Fuse plug spillway parameters for Wivenhoe-3 option**

| Fuse plug bay | Location | Bay Width (m) | Trigger Level (EL mAHD) | Trigger AEP |
|---|---|---|---|---|
| 1 | Existing Right Abutment | 34 | 78.0 | 1 in 2,000 |
| 2 | Existing Right Abutment | 64.5 | 78.5 | 1 in 4,000 |
| 3 | Existing Right Abutment | 65.5 | 79.0 | 1 in 12,000 |
| 4 | Right Abutment | 70.0 | 80.0 | 1 in 45,000 |

A plot of the critical 36 hour PMF inflow and outflow hydrograph is presented in Figure 8.7. For the Wivenhoe-3 option the peak outflow, estimated as 43,000 $m^3/s$, would be approximately 72% of the peak inflow. The 4.0 m raise of the dam crest level for this option would significantly increase the maximum flood storage and would provide a notable increase in the amount of attenuation of the PMF flood through Wivenhoe Dam.

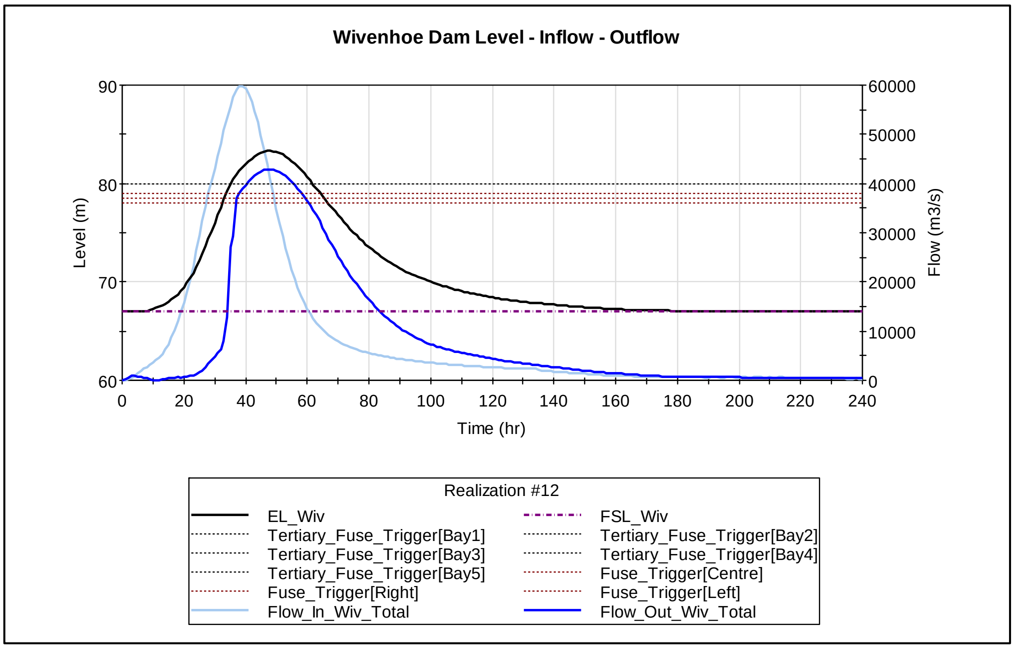



**Figure 8.7 Critical PMF hydrograph for Wivenhoe-3 option**

The results of sensitivity analyses for the PMF routing are summarised in Table 8.9. These results indicate that this option becomes more sensitive to the initial starting level for PMF events due to increased reliance on the temporary storage volume to provide attenuation of the PMF flood through Wivenhoe Dam.

**Table 8.9 PMF Routing Sensitivity Analyses – Wivenhoe-3 option**

| PMF routing case | PMF level (EL mAHD) | Difference (m) |
|---|---|---|
| Conventional – start level FSL (EL 67 mAHD), and all gates operable | 83.31 | - |
| Case 1 – start level EL 73 mAHD, and gates fully closed | 84.01 | +0.70 |
| Case 2 – start level EL 75.6 mAHD, and gates fully open | 84.09 | +0.78 |
| Case 3 – start level EL 67 mAHD, and 20% gates inoperable | 83.70 | +0.39 |

### 8.4.6 Spillway capacity Wivenhoe-4 (8.0 m raise option)

Significant modification to the existing main spillway would be necessary for the option to raise Wivenhoe Dam crest level by 8.0 m. The concept scoping and initial option development workshop identified that to make best use of the existing spillway structure and outlet works, would involve:

- retaining the existing ogee crest profile, chute and flip bucket
- removal of existing spillway gates
- strengthening of the existing spillway piers, and construction of new spillway piers in the centre of each bay, and construction of a large concrete baffle above the spillway bays. Effectively this would convert the existing spillway to operate as sluices (orifice flow regime) at lake levels above EL 71 mAHD.
- installation of ten (4 m wide x 14 m high) vertical lift gates.

GHD completed preliminary hydraulic calculations of the conceptual main spillway arrangement. The revised spillway gate rating for this conceptual arrangement is presented in Figure 8.8.

The upgraded main spillway arrangement for this option would limit the maximum capacity of the main spillway to approximately 11,000 $m^3$/s for a maximum lake level at EL 88 mAHD.

At lake levels in the range of interest to perform flood mitigation operations the maximum capacity of the main spillway would be approximately 4,500 $m^3$/s at lake level EL 70 mAHD up to 8,000 $m^3$/s at lake level EL 77 mAHD which would provide sufficient flexibility to regulate releases to meet downstream river flow objectives.

At lake levels in the range of EL 64 mAHD–EL 67 mAHD, the maximum capacity of the main spillway would be approximately 1,800–3,000 $m^3$/s which would retain sufficient release capacity to drawdown the lake level to potential lowered temporary full supply levels.

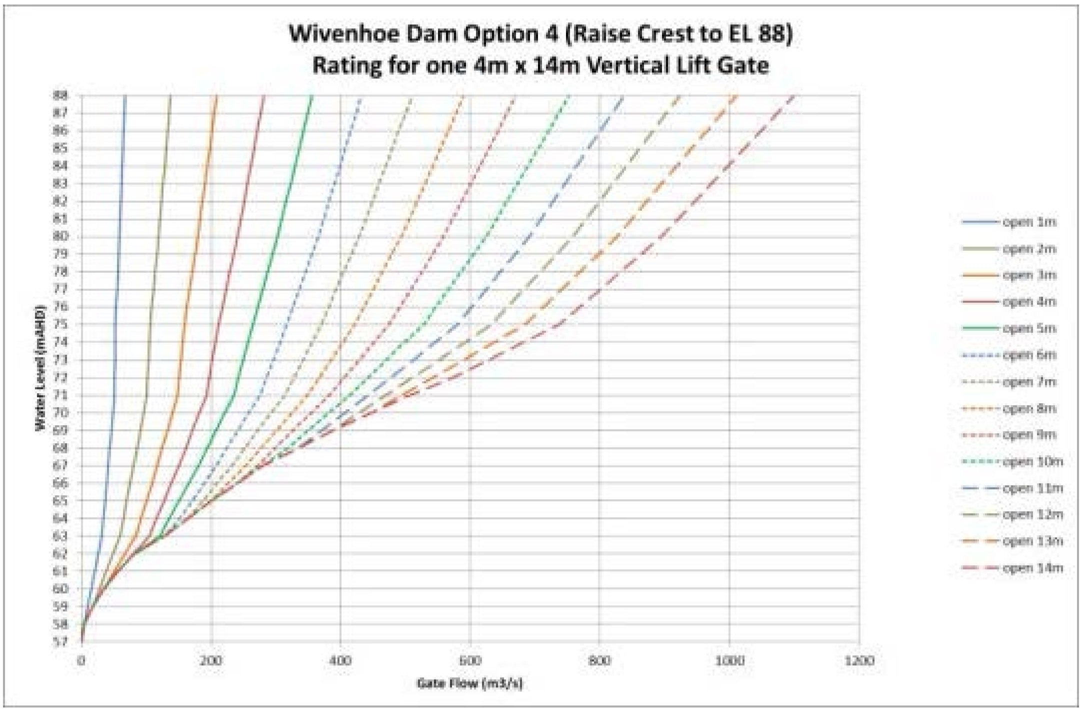



**Figure 8.8 Spillway gate rating for Wivenhoe-4 option**

For this option it was assumed that the existing fuse plug ogee concrete sill would need to be raised to EL 70 mAHD in order to:

- ensure that the sill acts as a hydraulic control for lake levels up to EL 88 mAHD
- to limit the maximum spillway head and unit discharge of flow through the spillway bays when the fuse plugs trigger
- to limit the potential downstream surge flow when the fuse plugs trigger.

Significant further analyses will be required in any future design work to optimise the level of the fuse plug sill and dimensions of the fuse plug bays for this option.

The existing fuse plug embankments would be replaced with new fuse plug embankments with higher crest levels. PMF capacity would be provided with an additional fuse plug spillway bay constructed adjacent to the existing fuse plug bays.

The assumed key parameters and estimated probability of triggering the fuse plug spillway are summarised in Table 8.10.

**Table 8.10 Fuse plug spillway parameters for Wivenhoe-4 option**

| Fuse plug bay | Location | Bay Width (m) | Trigger Level (EL mAHD) | Trigger AEP |
|---|---|---|---|---|
| 1 | Existing Right Abutment | 34 | 81.0 | 1 in 2,000 |
| 2 | Existing Right Abutment | 64.5 | 82.0 | 1 in 5,000 |
| 3 | Existing Right Abutment | 65.5 | 83.0 | 1 in 20,000 |
| 4 | Right Abutment | 65.0 | 84.0 | 1 in 50,000 |

Note this option has the fuse plug sill level raised to EL 70 mAHD.

For this option, the critical PMF event changes to a 48 hour PMP duration rainfall event. The critical 48 hour PMF inflow and outflow hydrograph is presented in Figure 8.9.

For the Wivenhoe-4 option the peak outflow, estimated as 39,000 $m^3/s$, would be approximately 70% of the peak inflow. The 8.0 m raise of the dam crest level for this option would significantly increase the maximum flood storage and would provide a notable increase in the amount of attenuation of the PMF flood through Wivenhoe Dam.

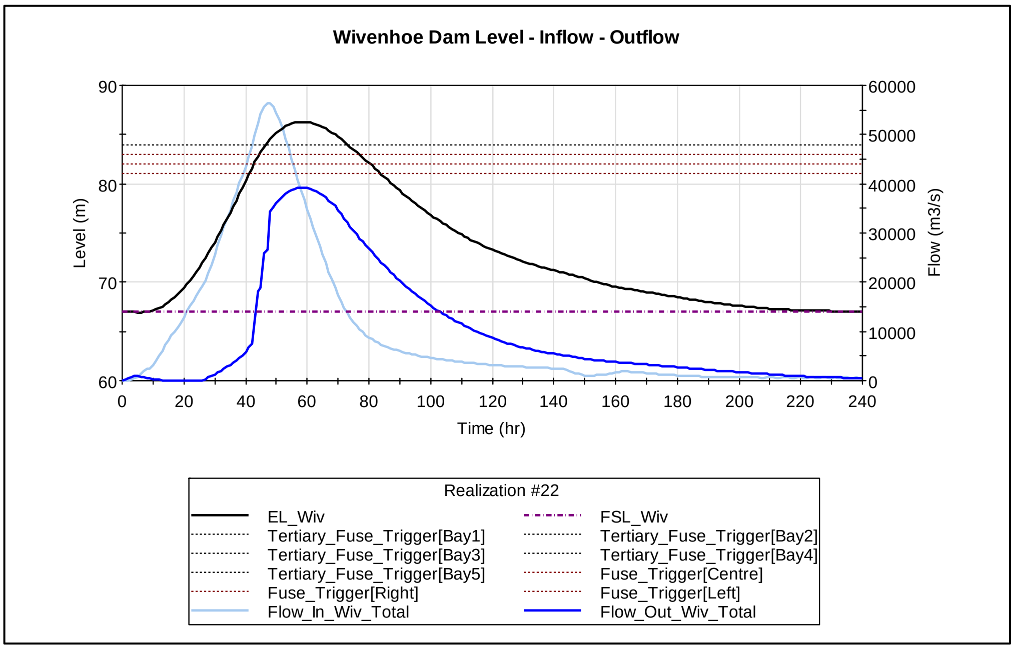



**Figure 8.9 Critical PMF hydrograph for Wivenhoe-3 option**

The results of sensitivity analyses for the PMF routing are summarised in Table 8.11. These results indicate that this option becomes more sensitive to initial starting level for PMF events due to increased reliance on the temporary storage volume to provide attenuation of the PMF flood through Wivenhoe Dam.

**Table 8.11 PMF routing sensitivity analyses – Wivenhoe-4 option**

| PMF routing case | PMF level (EL m AHD) | Difference (m) |
|---|---|---|
| Conventional – start level FSL (EL 67 mAHD), and all gates operable | 86.30 | |
| Case 1 – start level EL 73 mAHD, and gates fully closed | 87.46 | +1.16 |
| Case 2 – start level EL 75.6 mAHD, and gates fully open | 87.67 | +1.37 |
| Case 3 – start level EL 67 mAHD, and 20% gates inoperable | 86.62 | +0.32 |

## 8.5 Somerset Dam Operations, PMF capacity, flood mitigation opportunity, and uncertainties

For the purpose of this study the simulations of flood operations assumed that the operations of Somerset Dam would aim to limit the flood level in Somerset Dam to EL 109.7 mAHD (the top point on the existing Interaction Line in the Flood Manual). The same operating assumption was applied for each of the different Wivenhoe Dam upgrade options.

The simulations, which assumed all eight sluices would be operational, showed that even if flood operations aim to limit the Somerset Dam Lake level to EL 109.7 mAHD, it is not possible to prevent this level being exceeded for extreme flood events. The calculated PMF headwater flood levels in Somerset Dam would approach EL 112 mAHD due to the magnitude of PMF inflows into Somerset Dam and the restricted capacity of the current spillway to pass extreme flood flows. On this basis it will be necessary to strengthen Somerset Dam to be safe for flood levels up to at least EL 112 mAHD.

The upgrade options assessment study identified that there would be a relatively small incremental cost, compared to the total project cost estimate, to upgrade Somerset Dam to be safe for flood levels higher than EL 112 mAHD. Increasing the maximum safe level of Somerset Dam beyond EL 112 mAHD provides an opportunity to optimise the operating rules for Somerset Dam to make use of the increased flood storage and improve overall flood mitigation benefits. This opportunity has not yet been considered in this study and remains as an unrealised opportunity that should be investigated in future studies to optimise the preferred options. It is notable from the Somerset Dam upgrade cost curve for a range of different maximum safe levels indicates that strengthening the dam would be a relatively low cost way to increase flood mitigation storage. By way of example, increasing the safe level from EL 109.7 mAHD to EL 113.5 mAHD would provide approximately 400,000 ML of increased flood storage.

The simulations of flood operations for this study assumed that the Somerset Dam sluice flow capacity would be the same as the existing sluices. The options to raise Wivenhoe Dam and increase flood mitigation storage will have a corresponding impact on the tail water level at Somerset Dam. This could reduce the flow capacity of the sluices. This potential impact will need to be investigated as part of integrated planning and engineering design of the upgrades for Wivenhoe Dam and Somerset Dam.

## 8.6 Conceptual design of the Wivenhoe Dam upgrade options

Pre-feasibility level design of the Wivenhoe Dam upgrade options was undertaken by GHD.

It is important to note that there is a significant difference in the design approach for the Wivenhoe Dam upgrade options compared to the design approach for the new dam options described in other chapters of this report. For the new dam options, the design is significantly limited by available data, but the design of a new dam at a greenfield site has less constraints for the overall configuration of the structure.

In contrast, the design approach to upgrade Wivenhoe Dam has the benefit of extensively more available data (from previous investigations and design reports) but significantly more constraints imposed to modify the configuration of the existing dam. In particular, the optimal design for a dam upgrade will often seek to make best use of existing dam features. The constraints to minimise risks to dam safety during construction and to ensure water supply and flood operations could continue during construction are also important.

Specific technical information for the Wivenhoe Dam and Somerset Dam upgrade prefeasibility designs are documented in a separate technical report (GHD, 2014). Major aspects of the designs are summarised herein.

A summary of the key upgrade works for each option is presented in Table 8.12 for Wivenhoe Dam and Table 8.13 for Somerset Dam.

There are a large range of key issues that were considered to inform the design concepts. A brief summary of these issues is outlined below.

## 8.7 Key Issues

The limitations for the existing radial gated spillway are important constraints associated with any raising of the dam. These include:

- overtopping of the gates
- the impact of the baffle plate installed under the service bridge
- the road bridge across the spillway upstream of the gates
- the interaction of the service bridge with high flows through the spillway
- flooding of the hydraulic control room
- overtopping of the concrete gravity training walls
- scour in the plunge pool and unlined channel from increasing flows through the spillway
- the ability to upgrade the existing spillway structures to support the increased loads
- the stability of the overall gravity dam section for raised flood levels
- preventing flood flows through the inlet chamber and access stairwells.

The limitations for the fuse plug auxiliary spillway are important constraints associated with any raising of the dam or spillway modification. Another key constraint is the desirable maximum frequency of fuse plug operation. These fuse plug spillway constraints include:

- the maximum height of the training wall lining, upstream and downstream of the ogee crest
- scour of the unlined chute once the fuse plugs initiate, with high tailwater levels (main gates fully open) and low tailwater levels (main spillway gates at minimum setting to prevent gate overtopping)
- drawdown through the upstream spillway chute following the initiation of one or all of the fuse plugs
- the design of the ogee crest and the impacts of additional head from dam raising

- the road bridge impact on flows
- the surge of water created by the initiation of a fuse plug in the downstream areas
- ensuring sequential operation of the fuse plugs.

The considerations for raising the main and left hand embankment include:

- maintaining the filter integrity and internal drainage capacity
- the stability of the dam embankments under the increased loads
- the impact of diverting the Brisbane Valley Highway from across the crest of the dam
- the alluvium under the toe of the main embankment
- piping above the top of the clay core
- connection of the embankment to the abutment at Cormorant Bay
- impacts on the Visitor Information Centre.

The considerations for raising the saddle dams include:

- managing the piping risk during flood events,
- the stability of the saddle dam embankments under the increased loads
- the weathered rock foundations, the lack of grouting and the need to manage seepage beneath the embankments
- linking Saddle Dam 1 with Cormorant bay and closing of the Brisbane Valley Highway cutting
- the impact on houses downstream of Saddle Dam 2 if the tertiary spillway is to be constructed.

It is important to note that while the above issues have been considered to varying extents in the pre-feasibility design, due to time or data limitations, not all of the issues have been addressed to the extent of 'completed' engineering feasibility assessment or the inclusion of all potential works items in cost estimates.

The identified key concepts and issues to raise the dam embankments to higher dam crest levels include:

- 1.5 m raise (for option Wivenhoe-2) could be constructed with a new parapet wall on the dam crest. This would require demolition of the existing wave/parapet wall and excavation of the dam crest to construct a larger wall with sufficient strength to withstand the increased water loads and to provide adequate detail of the connection of the wall to the embankment filters to mitigate piping failure risk. Due to the extent of works required on the dam crest, it is considered likely, and has been assumed in the cost estimates that temporary diversion of the Brisbane Valley Highway will be necessary.

  The impacts of a higher parapet wall on the dam crest to allow over-dimensioned vehicles to pass over Wivenhoe Dam (after the works are completed) has not yet been confirmed and would be a potential constraint to this design option.
- To raise the dam crest by 4.0 m or 8.0 m (for options Wivenhoe-3 and Wivenhoe-4) it has been assumed that the embankment raise would be constructed using a conventional downstream raise of the embankment. This will require a temporary diversion of the Brisbane Valley Highway. Significant savings in earthfill quantities, construction time, and cost could be possible if the Highway could be permanently diverted off the dam crest.

General arrangement plan sketches of each of the options are presented in Figures 8.10–8.14.

A significant number of additional pre-feasibility design sketches for specific details of the work components are available in the GHD technical report (GHD 2014).

## Table 8.12 Wivenhoe Dam upgrade options – Summary upgrade works

| Option | Main Spillway | Existing Fuse plug | Embankment | Saddle Dam 1 | Saddle Dam 2 | New Saddle Dam |
|---|---|---|---|---|---|---|
| 1a | No change | No change | No change | Reconstruct embankment with internal filters and construct downstream secant pile cut-off to EL 45 mAHD. | Construct 300 m wide fuse plug spillway comprising 5 bays each 60 m wide with ogee crest sill. Concrete lined chute and downstream cut-off. | Not applicable |
| 1b | No change | Extend training walls 100 m downstream and concrete apron to end of extended training walls. Secant pile erosion cut-off at downstream end of apron slab to prevent back erosion. | | | | |
| 2 | Install deflector plate above existing gates and strengthen the concrete structures. Closure gates to seal end of highway bridge. Raise the concrete embankment retaining walls to EL 81.5 mAHD. | Remove fuse plug embankments, strengthen base slabs and the divider walls. Reinstate and raise fuse plug embankments 1 m. Raise divider walls and training walls 1 m. | Excavate crest and construct new reinforced concrete parapet wall to raise dam crest to EL 81.5 mAHD. | Reconstruct embankment with internal filters to raised dam crest level at EL 81.5 mAHD and construct downstream secant pile cut-off to EL 45 mAHD. | Construct 200 m wide fuse plug spillway comprising 4 bays each 50 m wide with ogee crest sill. Concrete lined chute and downstream cut-off. | Not applicable |

Table continued next page.

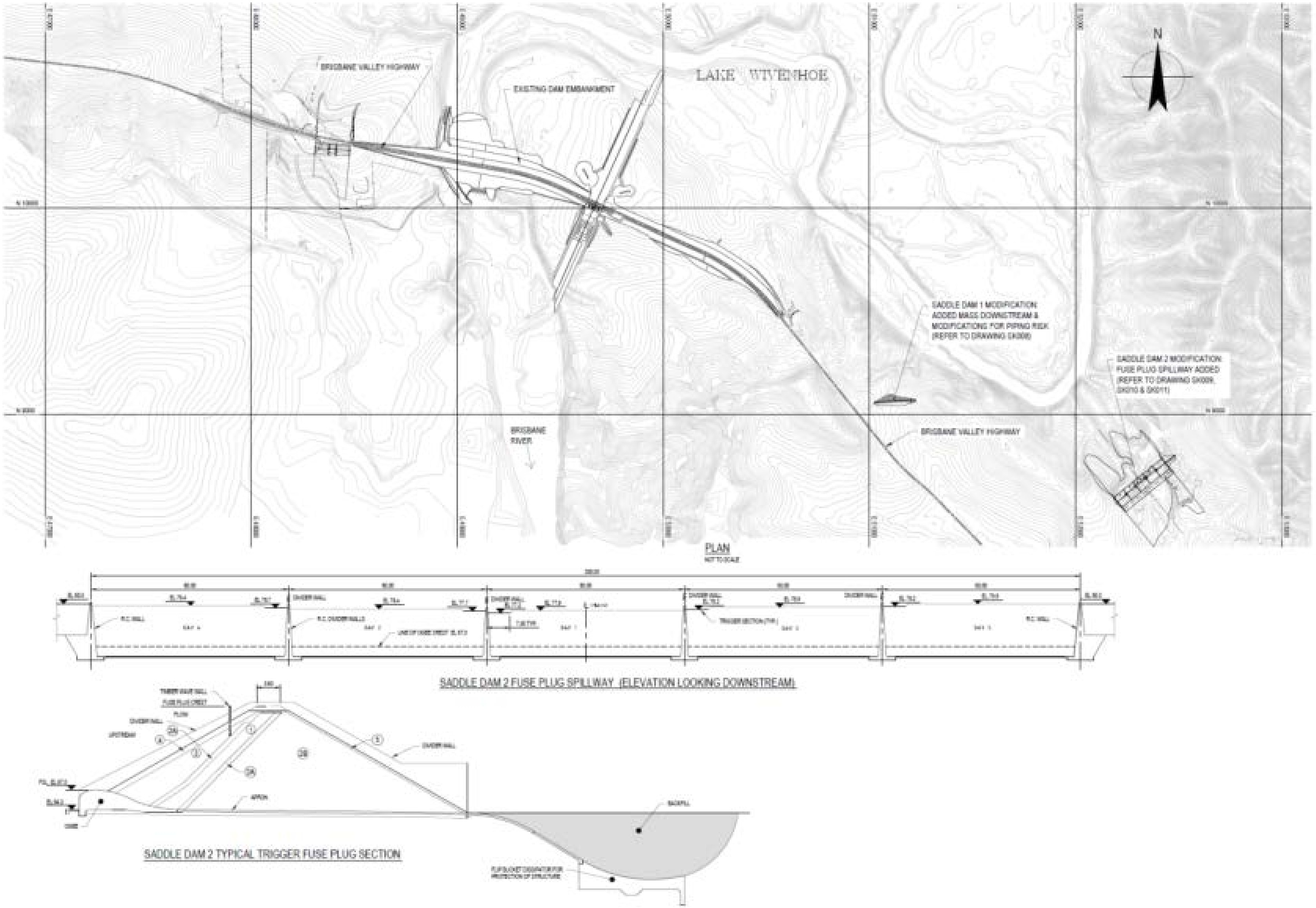
**Table 8.12 Wivenhoe Dam upgrade options – Summary upgrade works (contd)**

| Option | Main Spillway | Existing Fuse plug | Embankment | Saddle Dam 1 and 2 | New Saddle Dam |
|---|---|---|---|---|---|
| 3 | Demolish bridges. Raise spillway piers and walls with new road and service bridges. Install deflector plate between concrete piers in front of the radial gates. Extend radial gates 2 m. Raise spillway embankment retaining walls to EL 84 mAHD. Install post tensioned anchors to strengthen spillway. Raise gantry crane 4 m. Relocate services. | Remove fuse plug embankments, strengthen base slabs, spillway crest and divider walls. Widen spillway chute to construct new additional 70 m wide fuse plug bay on right side. Construct new fuse plug embankments. Raise divider walls and spillway training walls. Construct new right side training wall. Remove and construct new highway bridge. | Demolish existing parapet walls. Raise embankment to EL 84 mAHD with fill placed on the downstream face of the embankment, reinstate rockfill facing, excavate the dam crest to extend the clay core and filters up to the new crest level. Relocate existing services. | Reconstruct embankments with internal filters to raised dam crest level at EL 84 mAHD and construct downstream secant pile cut-off to EL 45 mAHD. | New Saddle Dam at 'Coominya Saddle' (approximately 7 km north west of the existing dam). Crest EL 84 mAHD. |
| 4 | Remove five radial gates and replace with 10 vertical lift sluice gates (4 m wide x 14 m high). Install new pier in centre of each bay. Provide mass concrete deflector on upstream side, between baulk and sluice gate slots, and downstream of sluice gates for stability and flow control. Raise spillway embankment retaining walls to EL 88 mAHD. Install anchors to strengthen spillway. Raise gantry crane 8 m. Relocate services. | Remove fuse plug embankments, strengthen base slabs, spillway crest and divider walls. Widen spillway chute to construct a new additional 70 m wide fuse plug bay on right side. Construct new fuse plug embankments. Raise divider walls and spillway training walls. Construct new right side training wall. Remove and construct new highway bridge. | Demolish existing parapet walls. Raise embankment to EL 88 mAHD with fill placed on the downstream face of the embankment, reinstate rockfill facing and extend the clay core and filters up to the new crest level. Relocate existing services. | Reconstruct embankments with internal filters to raised dam crest level at EL 88 mAHD and construct downstream secant pile cut-off to EL 45 mAHD. | New Saddle Dam at 'Coominya Saddle' (approximately 7 km north west of the existing dam). Crest EL 88 mAHD. |

Options Wivenhoe-2 to Wivenhoe-4 will require temporary diversion of the Brisbane Valley Highway during construction. The temporary diversion would cross the Brisbane River downstream of the dam.

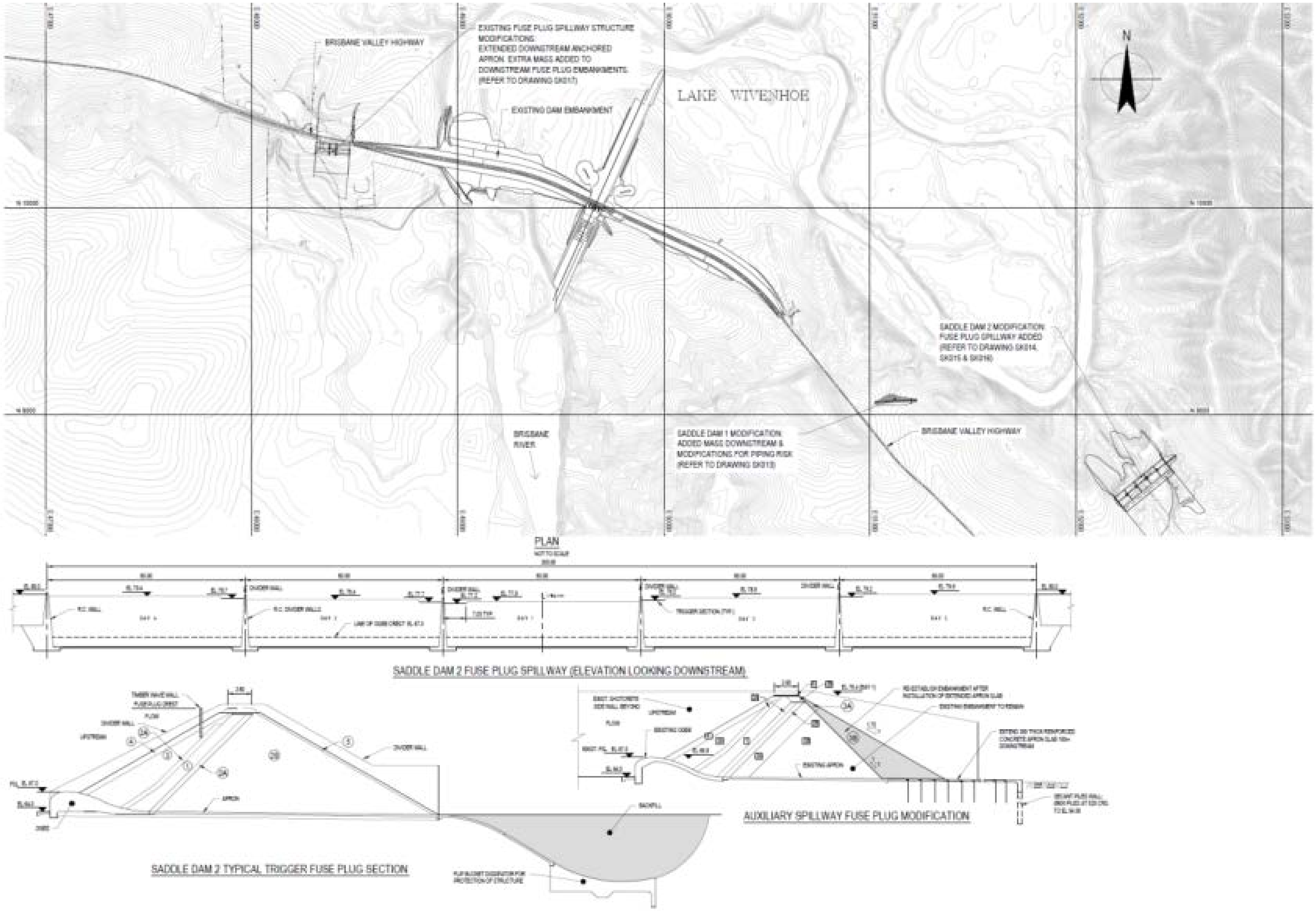
**Table 8.13 Somerset Dam PMF upgrade – Summary upgrade works**

| Option | Stability Strengthening | Abutments | Dissipator Slab | Training Walls | Gates, and hydraulic improvements |
|---|---|---|---|---|---|
| Design for a maximum water level of EL 109.7 mAHD | Install post tensioned anchors in the concrete gravity dam wall to increase sliding and overturning resistance. | Excavate the rock groins at the toe of the wall to the design profile. Construct a concrete lined and anchored toe slab and return wall to contain and direct overtopping flows back to the river. | Concrete a 300 mm thick concrete overlay over existing energy dissipator slab, install floor anchors and pressure relief drainage.<br><br>May require temporary cofferdam to construct works. | Remove existing backfill and replace with free draining material. Strengthen base of training walls by constructing a concrete buttress for the walls. | Not applicable. |
| Design for a maximum water level of EL 110.8–113.5 mAHD | Increased number of post tensioned anchors required to achieve satisfactory sliding and overturning stability. | Increased excavation and concrete quantities for the toe slab and return wall to cater for more the increased overtopping flow. | As above. Slight increase to magnitude of strengthening works. | As above. Slight increase to magnitude of strengthening works. | Remove counterweights, replace gate winches and reconfigure gate to allow increased rotation by further 25 degrees. Locking mechanism to lock gates in fully open position. Install upstream side deflector plate. Flow splitters extending up from bridge deck. Install plate to close gap between gate skin plate and bridge deck on downstream underside of bridge. |
| Design for a maximum water level of EL 115 mAHD. | As above with additional works to strengthen the bridge and deck to cater for horizontal and vertical water loads on the bridge. | | | | |



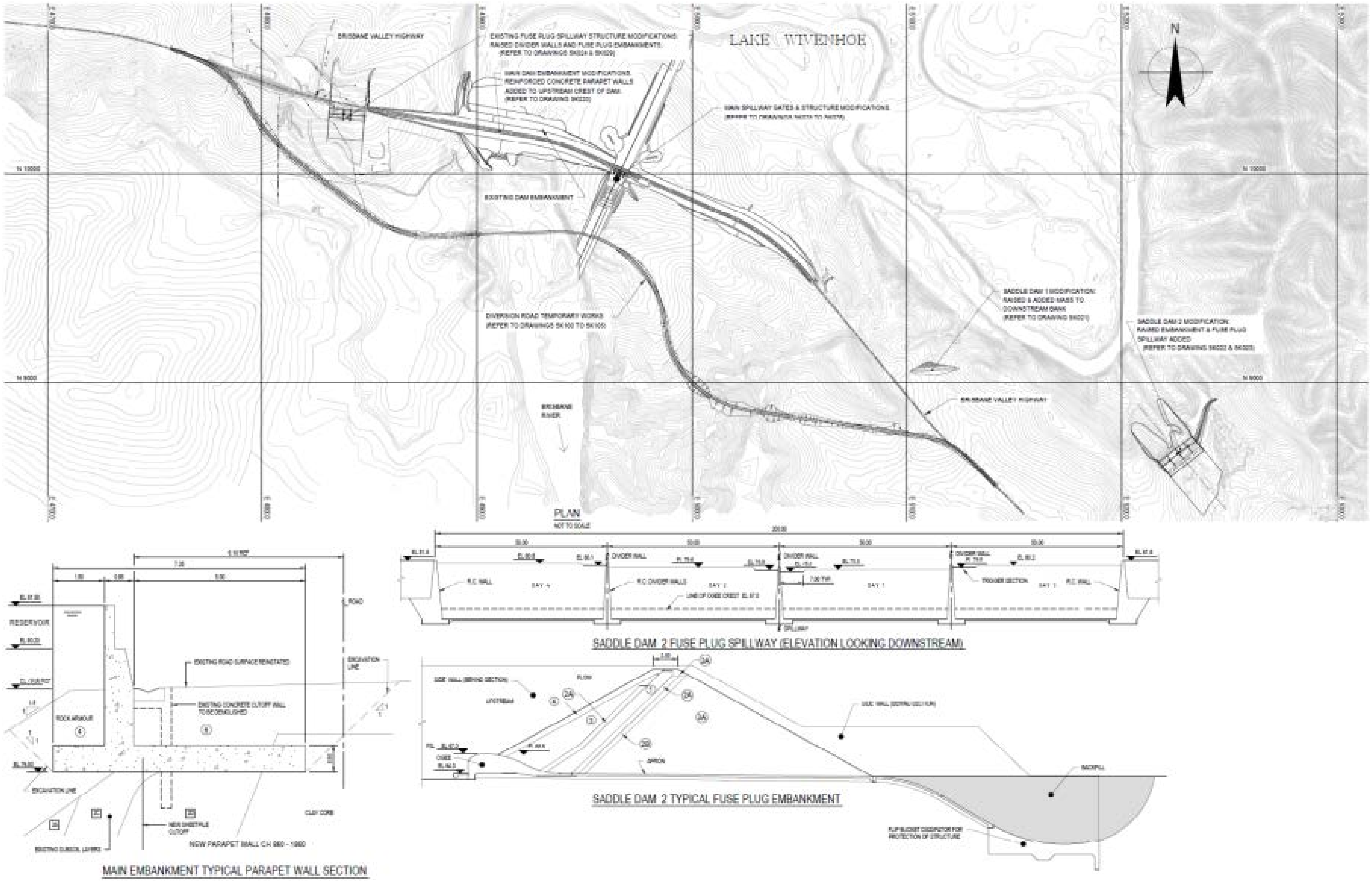

Source: GHD 2014a

**Figure 8.10 General arrangement for Wivenhoe-1a option**



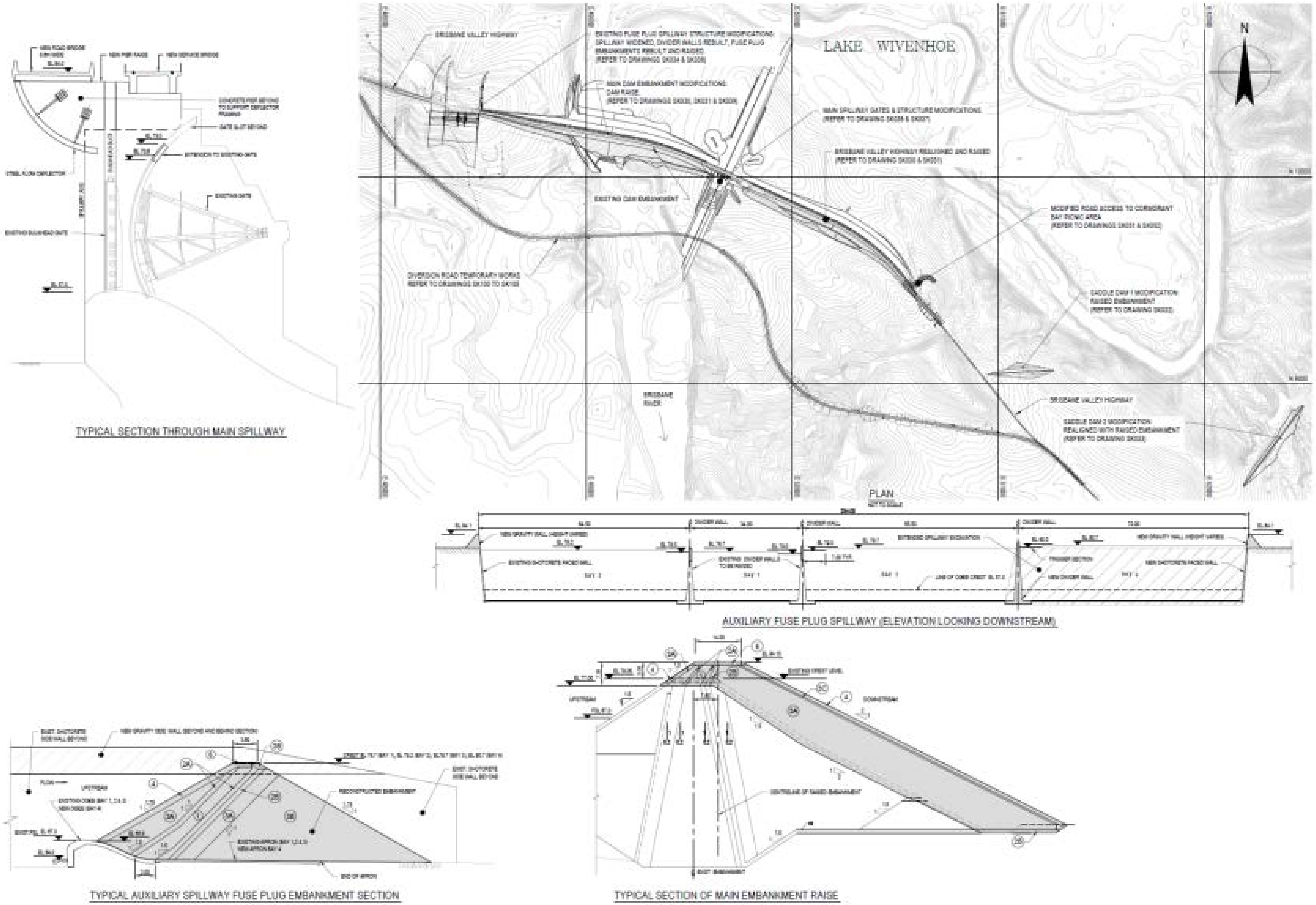

Source: GHD 2014a

**Figure 8.11 General arrangement for Wivenhoe-1b option**



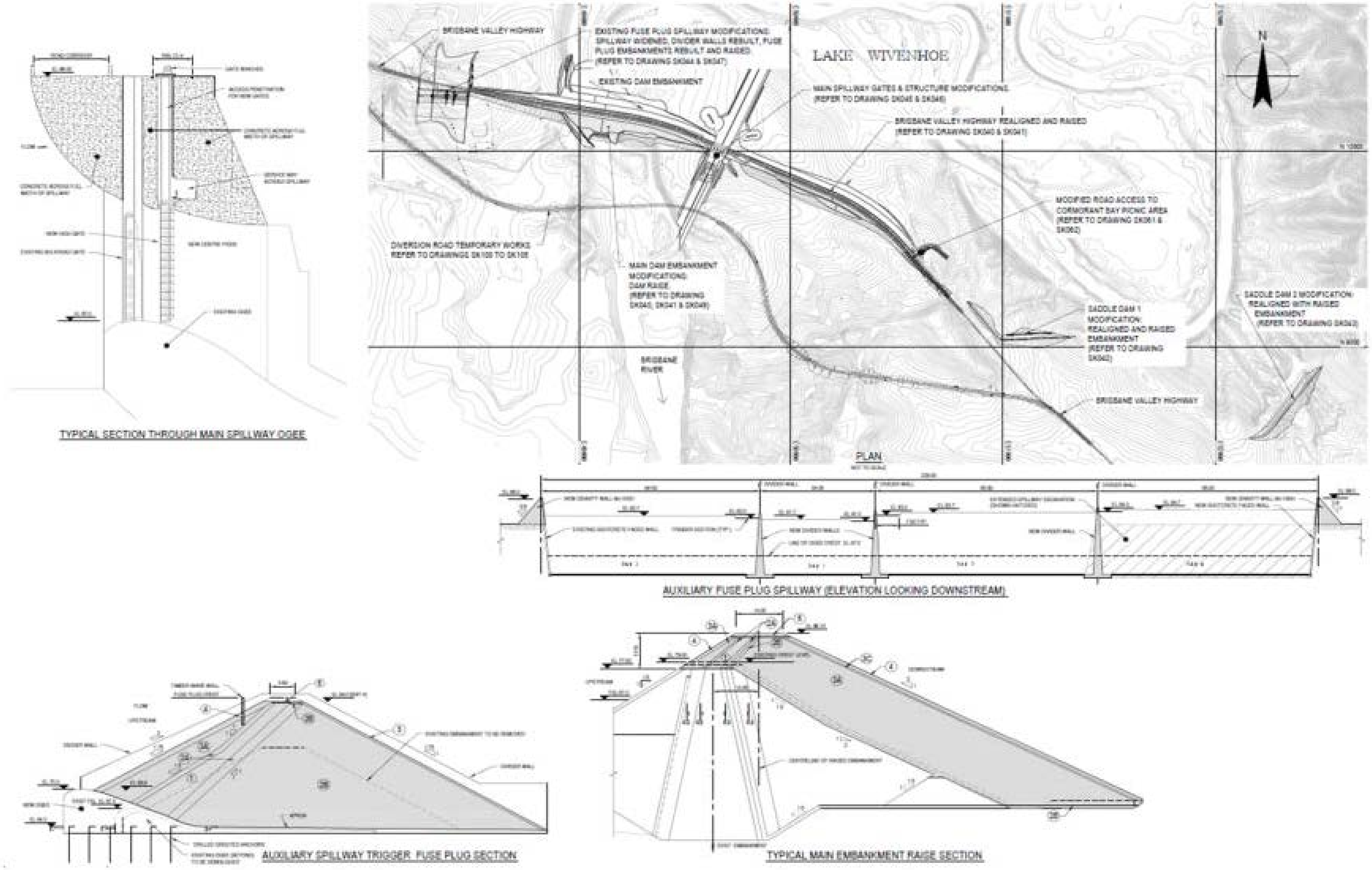

Source: GHD 2014a

**Figure 8.12 General arrangement for Wivenhoe-2 option (1.5 m raise)**




Source: GHD 2014a

**Figure 8.13 General arrangement for Wivenhoe-3 option (4.0 m raise)**




Note: New saddle dam at Coominya 'Saddle' not shown.

Source: GHD 2014a

**Figure 8.14 General arrangement for Wivenhoe-4 option (8.0 m raise)**

## 8.8 Impacts upstream of Wivenhoe Dam and Somerset Dam

The options to increase flood mitigation storage in Wivenhoe Dam will provide greater capacity for temporary storage of flood water and increase the reservoir flood levels in Wivenhoe Dam in large to extreme flood events. The impacts on reservoir flood levels will be more significant for the options with higher dam crest level (Wivenhoe-2, 3, and 4).

For uniform comparison between the new dam options and options to raise Wivenhoe Dam, the 1 in 100 AEP flood level for each dam has been adopted as the basis for preliminary assessment of upstream impacts. The preliminary estimates of 1 in 100 AEP flood levels in Wivenhoe Dam for each upgrade option are presented in Table 8.14. These indicative estimates may change depending on further engineering design and optimisation of the flood operations rules.

**Table 8.14 Option impacts on 1 in 100 AEP flood level upstream of Wivenhoe Dam**

| Option | 1 in 100 AEP flood level (mAHD) preliminary estimate | Relative Increase of 1% AEP reservoir inundation area hectares |
|---|---|---|
| 1a Base Case | 75 | Not Applicable |
| 1b | 76 | 770 |
| 2 | 76 | 770 |
| 3 | 77 | 1580 |
| 4 | 79.5 | 3730 |

For the dam flood operation assumptions used in this study, the flood levels upstream of Somerset Dam would not significantly change across the range of options to upgrade Wivenhoe Dam.

### 8.8.1 Upstream flooding impacts on infrastructure

Advice from CS Energy has identified that reservoir flood levels exceeding EL 78 mAHD would be a significant risk to the Splityard Creek hydroelectric power station. Flooding of the power station would prevent electricity generation for weeks or months until electrical equipment and other damage is repaired. Minor flooding impacts to the power station occur at about EL 76 mAHD but these are relatively insignificant. The probability of reaching EL 78 mAHD from the simulation results is summarised in Table 8.15.

The magnitude of the increased flood level for the Wivenhoe-4 option (8 m raise) is significant and imposes a substantial increase to the risk of flooding for the power station. Further investigation of the flood risk will be necessary. For this study a nominal allowance has been included in the cost estimates for the Wivenhoe-4 option (8 m raise) to construct works at the power station to mitigate flooding risk to the power station.

**Table 8.15 Probability of flood level upstream in Wivenhoe Dam reaching EL 78 mAHD**

| Option | AEP of exceeding EL 78 m | Probability over 50 year period |
|---|---|---|
| 1a | 1 in 50,000 | 0.1% |
| 1b | 1 in 10,000 | 0.5% |
| 2 | 1 in 10,000 | 0.5% |
| 3 | 1 in 2,000 | 2.5% |
| 4 | 1 in 50 | 64% |

The impacts of increased reservoir flood levels on roads around the reservoir are summarised in Table 8.16. This has identified that existing roads and culverts will be inundated by higher 1 in 100 AEP flood levels in Wivenhoe Dam.

Significant extents of the existing road network would already be inundated at 1% AEP flood for the base case, and inundated at much lower more frequent flood levels. For example, the lowest known bridge level upstream of Wivenhoe Dam at APM Conroy Bridge is at EL 69.6 mAHD (refer existing Flood Manual for Wivenhoe Dam operations), which is only 2.6 m above full supply level.

It is not certain to what extent roads would need to be upgraded or alternatively if no upgrade and acceptance of increased inundation could be considered. This will require consultation with Transport and Main Roads and Somerset Regional Council to establish a policy position. Costs have been estimated on the conservative basis that the incremental inundation extents would be upgraded.

**Table 8.16 Upstream flood impacts on roads**

| Option | Potentially impacted highway (km) | Potentially impacted main roads (km) | Potentially impacted local roads (km) | Potentially impacted bridges 10 m width (km) | Potentially impacted culverts 12 m width (km) | Potentially impacted culverts 24 m width (km) |
|---|---|---|---|---|---|---|
| Wiv-1b and Wiv-2 | 3.55 | 14.35 | 14.91 | 0.545 | 0.02 | 0.035 |
| Wiv-3 | 5.02 | 16.89 | 18.32 | 1.015 | 0.205 | 0.035 |
| Wiv-4 | 8.05 | 22.53 | 23.50 | 1.125 | 0.205 | 0.035 |

### 8.8.2 Environmental impacts upstream of Wivenhoe Dam

A preliminary assessment using desktop methods has been undertaken to identify potential impacts of increased flood levels in Wivenhoe Dam on different categories of potentially environmentally sensitive ecosystems, vegetation communities, and habitat for fauna. A summary of the identified areas is presented in Table 8.17.

**Table 8.17 Upstream flood impacts on ecosystems and vegetation communities**

| Option | Potentially impacted 'endangered' RE area (ha) | Potentially impacted 'of concern' RE area (ha) | Potentially impacted 'least concern' RE area (ha) | Potentially impacted 'non-remnant' vegetation (ha) | Total potentially impacted area (ha) |
|---|---|---|---|---|---|
| Wiv-1b and Wiv-2 | 9.0 | 11.0 | 37.6 | 711.5 | 769 |
| Wiv-3 | 13.2 | 22.1 | 76.4 | 1467.4 | 1579 |
| Wiv-4 | 26.0 | 49.7 | 173.6 | 3484.6 | 3734 |

The assessment identified that the area of inundation provides suitable habitat for a number of protected species, most notably the: vulnerable, long nosed-potoroo, koala, along with a number of bird species of special least concern, platypus and short-beaked echidna.

There are a number of EPBC listed species in the impacted areas including:

- A number of migratory bird species
- A number of fish species
- *Coeranoscincus reticulatus* (Three-toed Snake-tooth Skink)
- *Delma torquata* (Collared Delma)
- *Furina dunmalli* (Dunmall's Snake)
- *Dasyurus maculatus maculatus* (Spotted-tailed Quoll - southern subspecies)
- *Phascolarctos cinereus* (southeast Queensland bioregion) koala (southeast Queensland bioregion)

- *Potorous tridactylus tridactylus* (Long-nosed Potoroo)
- *Chalinolobus dwyeri* (Large-eared Pied Bat, Large Pied Bat)
- *Dasyurus hallucatus* (Northern Quoll)
- *Petrogale penicillata* (Brush-tailed Rock-wallaby
- *Pteropus poliocephalus* (Grey-headed Flying-fox)

While these species have habitat in the area, it is not expected that there will be a significant impact because the areas will not be permanently inundated.

### 8.8.3 Social impacts upstream of Wivenhoe Dam

Desktop searches of the Department of Aboriginal and Torres Strait Islander and Multicultural Affairs (DATSIMA) Cultural Heritage Database, the National Native Title Tribunal (NNTT) Native Title Register, the Department of Environment and Heritage Protection (DEHP) Queensland Heritage Database and the Commonwealth Department of the Environment (DoE) Australian Heritage Database were undertaken for the project area. From these searches it was determined that the increased flood inundation areas would be unlikely to impact any registered[1] culturally or historically important areas.

For options Wivenhoe-1b and Wivenhoe-2, it is estimated that 214 properties would be partly or fully impacted. The area to be acquired for these options would be approximately 732 ha.

For option Wivenhoe-3, it is estimated that 235 properties would be partly or fully impacted. The area to be acquired for this option would be approximately 1,501 ha.

For option Wivenhoe-4, it is estimated that 297 properties would be partly or fully impacted. The area to be acquired for this option would be approximately 3,521 ha.

These estimates exclude land that is already owned by Seqwater.

## 8.9 Cost estimates

The prefeasibility study cost estimates for the options to upgrade Wivenhoe Dam for dam safety and increased flood mitigation as well as the upgrade of Somerset Dam for dam safety are summarised in Table 8.18.

The cost estimates are best estimates (50$^{th}$ percentile) and are a “Class 4” level estimate as per the Association for the Advancement of Cost Engineering International (AACEi). These estimates indicatively represent:

- 1% to 15% level of maturity of the project definition
- sufficient for pre-feasibility study
- low bound accuracy in the order -30%
- high bound accuracy in the order of +50%

The increased reservoir flood levels upstream of Wivenhoe Dam will inundate land that may need to be acquired. The estimates of land acquisition have excluded land parcels in the increased 1 in 100 AEP flood inundation areas that are already owned by Seqwater.

[1] Caboonbah homestead was recently removed from the Heritage Register after it destroyed by fire in 2009.

**Table 8.18 Cost estimate summary**

| Option | Dam Upgrade | Land Costs | Infrastructure relocation | Total Wivenhoe + Somerset Upgrade |
|---|---|---|---|---|
| Somerset safe level EL 112.3 m | $63m | n/a | n/a | *Refer below* |
| Wivenhoe-1a | $262m | n/a | n/a | $325m |
| Wivenhoe-1b | $288m | $29m | $19m | $399m |
| Wivenhoe-2 | $423m | $29m | $19m | $535m |
| Wivenhoe-3 | $718m | $37m | $63m | $881m |
| Wivenhoe-4 | $1,097m | $56m | $157m | $1,373m |

Notes:

1. Somerset Dam and Wivenhoe-1a are only for a dam safety upgrade and provide no additional flood mitigation storage and flood mitigation benefit
2. Somerset Dam upgrade excludes land costs and infrastructure costs at this stage. Costs for land infrastructure relocation may be necessary depending on the final upgrade option design and corresponding operating rules.
3. Wivenhoe-2, 3, and 4 upgrade options are for dam safety upgrade combined with increased flood mitigation storage and flood mitigation benefit.

Operating costs would be relatively minor as the incremental costs above existing operating costs for Wivenhoe and Somerset Dam would generally be limited minor incremental activity for dam surveillance monitoring and maintenance.

Operating costs are estimated to be in the order of $50,000 per year with no material difference between each of the options.

## 8.10 Minimum timeframe to upgrade Wivenhoe and Somerset Dam

It is estimated that at least 2 years of planning and design would be required before the construction of the Somerset Dam upgrade could commence. It is estimated that the construction of the Somerset Dam upgrade would require 2–3 years to deliver to allow for the staging necessary to safely manage flood risk during delivery. This is based upon a linear program where design is completed, approvals obtained and construction commenced after completion of the design and approvals process. Alternative project delivery methods may allow this program to be compressed.

Given the scale of the Wivenhoe Dam upgrade options it estimated that at least 3 years of planning and design would be required before the construction of the Wivenhoe Dam upgrade could be commenced. It is estimated that the construction of the Wivenhoe Dam upgrade would require 3–5 years to deliver to allow for the staging necessary to safely manage flood risk during delivery. This estimate is based on the recent Hinze Dam Stage 3 project which was a similar scale to the Wivenhoe Dam upgrade options. Alternative project delivery methods may allow this program to be compressed.

The primary construction difficulty will be maintaining at least the existing spillway capacity throughout the life of the construction activities.

## 8.11 Downstream impacts

The Wivenhoe Dam upgrade options that raise the dam crest and increase the flood mitigation storage provide a corresponding increase in the capacity for temporary storage of floodwater during flood events. This additional temporary storage will produce significant benefits to reduce peak flooding extents along the Brisbane River downstream of Wivenhoe Dam and adjacent to the lower reaches of Bremer River.

Potential adverse impacts on downstream flooding also need to be considered carefully. Temporarily storing greater volume of flood water in Wivenhoe Dam to provide flood mitigation during large events will result in the need for a higher rate of release to drain the dam to FSL after the flood peak. In other words, the greater flood volume stored significantly increases releases required during the drain down phase of flood operations to return the dam levels to full supply level within seven days.

The potential impacts of higher draindown release rate and volume include:

- Potential for increased duration of inundation of downstream bridges
- Potential for increased risk of river bank ‘wet flow’ failures (bank slumping) due to increased flow rate and volume in the draindown phase for large floods. This will require further investigation to assess the significance of potential impacts on river bank stability, and may require investment to improve resilience of river banks such as revegetation initiatives.

### 8.11.1 Extreme flood downstream impacts for a fuse plug spillway at Saddle Dam 2

The impacts of dam operations and various spillway configurations on downstream flooding in extreme flood events will also require careful consideration to assess the most suitable option for the dam safety upgrade to safely pass PMF flood events.

The Wivenhoe-1a, 1b, and 2 options have been conceptually designed to include a relatively large fuse plug spillway at Saddle Dam 2. The flow path distance from Saddle Dam 2 to Savages Crossing is approximately 5 km. The flow path distance from existing fuse plug spillway along the main river channel to Savages Crossing is approximately 19 km. In extreme flood events, the flood flows through the new fuse plug spillway at Saddle Dam 2 would have a much shorter travel distance to Fernvale than flows from the main spillway and the existing fuse plug spillway.

For the options with a fuse plug spillway at Saddle Dam 2, the flood routing simulations indicate that the peak PMF flow at Fernvale (Savages Crossing) is unlikely to exceed the peak PMF flow that would occur for a no-dams scenario. However, the PMF outflow hydrographs simulated in this study and shown in Figure 8.15 indicate the rate of rise and timing of reaching critical evacuation levels for Fernvale could occur significantly earlier than would be the case for a no-dams scenario. Hydrographs for a 1 in 50,000 AEP flood which is close to the largest flood that the existing Wivenhoe Dam spillways can pass are presented in Figure 8.16.

A fuse plug spillway at Saddle Dam 2 could have potentially significant implications for emergency planning and evacuation preparedness for the Fernvale community. The feasibility of upgrading Wivenhoe Dam to pass PMF with a new fuse plug spillway at Saddle Dam 2 will require significant further investigations with hydrodynamic modelling to better define flood velocities and timing of downstream flood level rise. It is possible that the impact to the Fernvale area of a large spillway with multiple fuse plug embankments may prove to be a significant constraint, or possibly an unviable option.

For the options assessed in this study, it may be necessary from a public safety perspective to consider a preference for increased fuse plug spillway capacity only at locations near the existing fuse plug, such as the Wivenhoe-3 option.

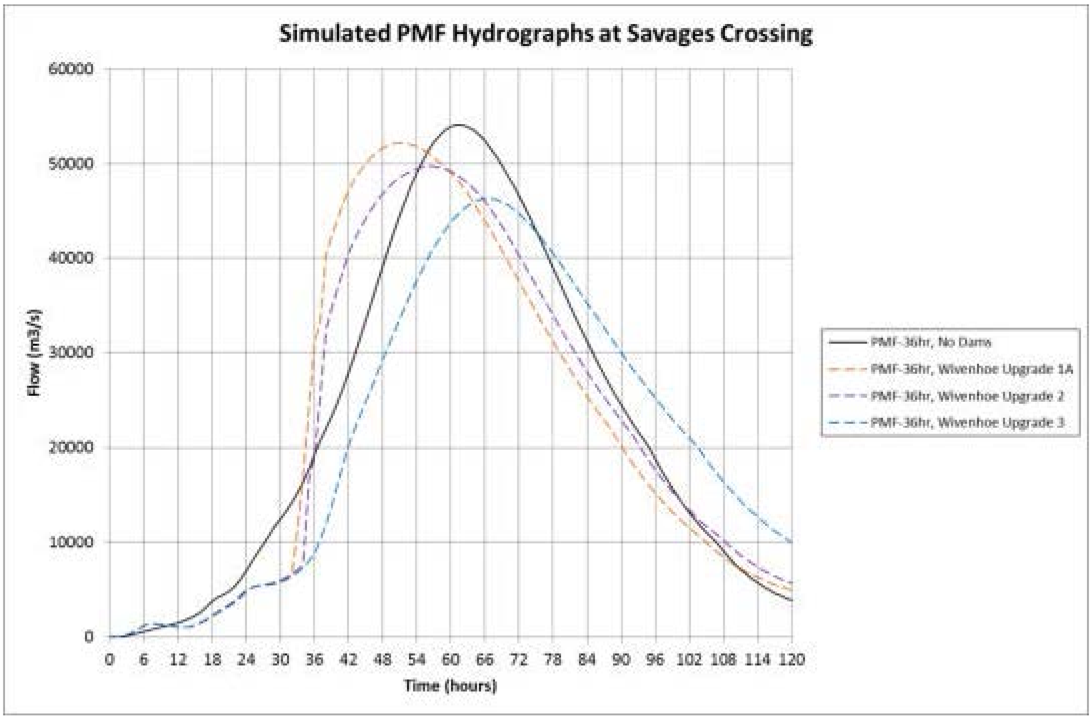



**Figure 8.15 PMF Hydrograph at Savages Crossing near Fernvale**

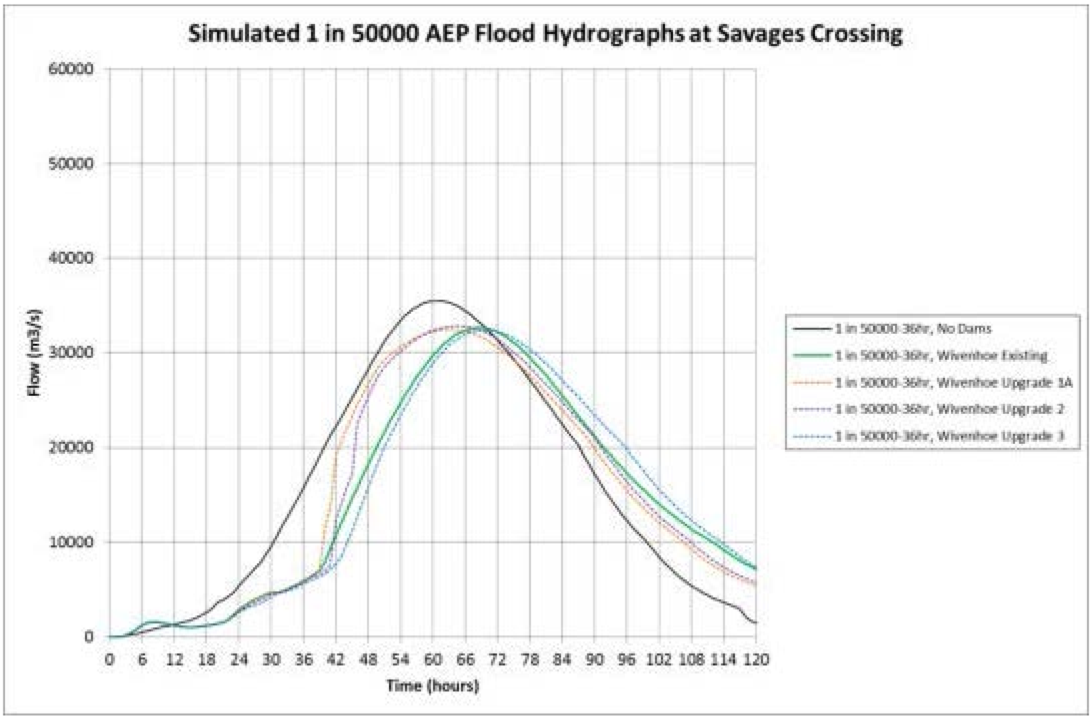



**Figure 8.16 Hydrograph for 1 in 50,000 AEP flood at Savages Crossing near Fernvale**

## 8.12 Summary of key risks and opportunities

The pre-feasibility study has identified a range of risks and opportunities to upgrade Wivenhoe Dam and Somerset Dam for dam safety and to increase the flood storage available in Wivenhoe Dam for flood mitigation. A summary of key risks and opportunities is presented in Table 8.19.

The risks vary across the range of options and Seqwater considers that the further investigations and assessments are required to assess risks and opportunities. This would preclude identification of a preferred option for dam safety upgrade at this stage of investigation.

Seqwater also advises that the Wivenhoe-1b option with dam operations based on the Urban-4 option from the WSDOS investigations (allowing fuse plug to trigger before spillway gates are fully open) would be risky to operationalise, and inconsistent with worldwide practice. This option should be considered as an undesirable approach to increase flood mitigation benefits from Wivenhoe Dam operations.

**Table 8.19 Summary of key risks and opportunities**

| Option | Key Risks (Design Issue or Potential Constraint) |
|---|---|
| Wivenhoe-1a<br>(No Raise, New Saddle 300 m fuse plug spillway to pass PMF) | Rate of triggering fuse plug bays and short travel distance from Saddle fuse plugs to Fernvale, pose very significant risk to rate of rise of extreme floods in Fernvale with implications for practical emergency response. <u>This may be a practical flaw with this option.</u><br>Drawdown of spillway flow profile for new fuse plug spillway may affect triggering. May extension of divider walls and increased upstream approach channel excavation to address this issue. |
| Wivenhoe-1b<br>(No Raise, New 300 m fuse plug spillway at Saddle Dam to pass PMF plus additional erosion protection at existing fuse plug spillway)<br>*WSDOS URBAN 4* option. | Fuse plug spillway at Saddle Dam – Fernvale impact issues as described above for Option 1a.<br>Works to existing fuse plug reduce erosion risks for dam safety, but does not eliminate downstream river erosion associated with more frequent triggering of the fuse plugs for Urban 4 dam operations option. This option to operate Wivenhoe with deliberate triggering of the lowest fuse plug before gates are fully open remains a risk for dam operation and management.<br>Not aligned to good dam engineering and dam operations practice (no precedents known, and many experts would warn against this).<br>Has increased operational risk due to uncertainty that this may not achieve the estimated 'theoretical benefits' in real floods.<br>Will still produce downstream erosion damage to the river with a wide range of implications and while the annualised cost may be small, the reputation damage to Seqwater may be significant. |
| Wivenhoe-2<br>(1.5 m raise with Parapet, New 200 m fuse plug spillway at Saddle Dam to pass PMF) | Fuse plug spillway at Saddle Dam – Fernvale impact issues as described above for Option 1a.<br>Parapet wall and other geometric constraints for main road over the dam crest may not meet criteria for over dimension heavy vehicle transport along the highway. This can be mitigated by using partial or complete embankment raise, however, this may be more costly. |
| Wivenhoe-3<br>(4 m raise with downstream raise of embankment, extend existing gates, structural and hydraulic improvements at main spillway, widen existing fuse plug spillway with additional bay) | Structural aspects for main spillway stability and radial gates support strength (i.e. trunnion pins and boxes, piers etc) due to extension of gates (water loads on the gates).<br>Cofferdam likely to be necessary to enable removal and rebuild of existing fuse plug embankments.<br>Hydraulic design of fuse plugs is required to ensure operation at the required levels to account for drawdown effects. |

Note: Table continued next page.

**Table 8.19 Summary of key risks and opportunities (contd)**

| Option | Key Risks (Design Issue or Potential Constraint) |
|---|---|
| Wivenhoe-4<br>(8 m raise with downstream raise of embankment, convert main spillway to sluice outlets with ten gates, structural and hydraulic improvements at main spillway, widen existing fuse plug spillway with additional bay) | Significant structural limitations to cater for cross-valley seismic loading (additional weight of main spillway at higher levels).<br>Additional hydraulic analysis with smaller gates and larger fuse plug sections may mitigate the cross valley seismic loading.<br>Cofferdam will likely be necessary to enable removal and rebuild of existing fuse plug embankments.<br>Hydraulic design of fuse plugs is required to ensure operation at the required levels to account for drawdown effects. |
| Somerset Dam upgrade | Uncertainty in the foundation geology and scour potential from overtopping flows. Further studies may allow the refinement of the assumed protection and anchoring works. |
| Opportunities | |
| All Wivenhoe Dam Raising Options | Potential cost and time savings opportunities if the Brisbane Valley Highway could be permanently diverted to route downstream of the dam. |
| All Wivenhoe Dam Upgrade Options | Potential to optimise fuse plug spillway geometry, hydraulics, but also needs to ensure downstream surge rates are acceptable for downstream impacts. |
| Somerset Dam Upgrade | Optimise the design safe storage level and flood operating rules in conjunction with design and optimisation of Wivenhoe Dam upgrade. There may be potential to store more flood water in Somerset Dam, subject to upstream impacts, which could further improve downstream flood mitigation benefits. |

# Chapter 9 Flood infrastructure development scenarios

This chapter describes the development of flood mitigation infrastructure scenarios (comprising combinations of infrastructure options) and the results of basin scale hydrological assessments (i.e. Phase 4 flood hydrology assessments) to determine overall flood mitigation effects of these scenarios.

## 9.1 Scenario identification

As part of the Phase 3 flood hydrology assessments, which entailed catchment scale flood routing of historical floods through seven potential flood mitigation dam sites and combinations thereof, four potential dam sites (Emu Creek AMTD 10.8 km, Brisbane River AMTD 282.3 km (near Linville), Bremer River AMTD 70 km and lower Warrill Creek AMTD 13.9 km /14.6 km) were shortlisted for further assessment. These four dam sites were shortlisted because they showed potential for meaningful reductions in catchment outflows for historical floods (refer Chapter 6).

The dam site at Brisbane River AMTD 282.3 km was considered as a potential water supply offset dam in addition to its consideration as a 'dry' flood mitigation dam. As noted in Chapter 5, a water supply dam at Brisbane River AMTD 282.3 km would allow the full supply volume (FSV) of Wivenhoe Dam to be reduced, thereby increasing the available flood storage in Wivenhoe Dam (this is beneficial in that flood storage at Wivenhoe Dam would command a greater catchment than a flood storage upstream at AMTD 282.3 km). Water supply hydrology assessments identified four potential Brisbane River AMTD 282.3 km FSV/Wivenhoe Dam FSV combinations.

A third set of options, comprising five Wivenhoe Dam upgrade alternatives was developed by Seqwater (refer Chapter 8) and included in the scenarios.

The infrastructure options forming the basis of the scenarios considered in the Phase 4 hydrological assessments are summarized in Table 9.1 and Table 9.2.

**Table 9.1 PIFMSI shortlisted new infrastructure options**

| 'Dry' flood mitigation dams | | |
|---|---|---|
| Name | Stream name | AMTD |
| Bremer River(near Mt Walker) | Bremer River | 70.0 km |
| Lower Warrill Creek (near Willowbank) | Warrill Creek | 13.9 km/14.6 km |
| Emu Creek (near Harlin) | Emu Creek | 10.8 km |
| Brisbane River (near Linville) [1] | Brisbane River | 282.3 km |
| **Water supply dam** | | |
| Name | Brisbane River AMTD 282.3 km FSV (ML) | Wivenhoe Dam FSV [2] (ML) |
| Brisbane River AMTD 282.3 km (near Linville) | 240,000 | 990,420 (85%) |
| | 510,000 | 873,900 (75%) |
| | 570,000 | 699,120 (60%) |
| | 570,000 | 873,900 (75%) |

Notes:

1. The site on the Brisbane River at AMTD 282.3km (near Linville) was considered for two purposes (a 'dry' flood mitigation dam and a water supply dam) with hydrological assessments undertaken for both.
2. For each FSV considered for a water supply dam at Brisbane River AMTD 282.3 km a corresponding FSV for Wivenhoe Dam was modelled. The figure in brackets corresponds to the percentage of Wivenhoe Dam FSV; the 100% FSV for Wivenhoe Dam is 1,165,000 ML.

**Table 9.2 Wivenhoe Dam upgrade options**

| Wivenhoe Dam upgrade/augmentation | |
|---|---|
| Option [1] | Description |
| Wivenhoe-1a | • No Wivenhoe Dam crest raise.<br>• Third spillway built to pass PMF.<br>• Flood operations retain *Dam Safety Strategy* trigger at EL 75 mAHD (WSDOS alternative Urban 3). |
| Wivenhoe-1b | • No Wivenhoe Dam crest raise.<br>• Additional fuse plug spillway capacity to pass PMF.<br>• Flood operations raise *Dam Safety Strategy* trigger to EL 76.2 mAHD (WSDOS alternative Urban 4). |
| Wivenhoe-2 | • 1.5 m Wivenhoe Dam crest raise to EL 81.6 mAHD.<br>• Raise existing fuse plug embankment crests by 1 m.<br>• Additional fuse plug spillway capacity to pass PMF<br>• Flood operations raise *Dam Safety Strategy* trigger to EL 76.2 mAHD (new Urban 5 option) |
| Wivenhoe-3 | • 4.0 m crest raise to EL 84.1 mAHD<br>• Raise existing fuse plug embankment crests as required<br>• Additional fuse plug spillway capacity to pass PMF<br>• Flood operations raise *Dam Safety Strategy* trigger to EL 77 mAHD (new Urban 6 option). |
| Wivenhoe-4 | • 8.0 m crest raise to EL 88.1 mAHD<br>• Raise existing fuse plug embankment crests as required<br>• Additional fuse plug spillway capacity to pass PMF<br>• Flood operations raise *Dam Safety Strategy* trigger to EL 80 mAHD (new Urban 7 option). |

Notes:

1. All options also include works to address other dam safety risk such as saddle dam embankment.

## 9.2 Scenario development

The Brisbane River basin features multiple contributing tributaries/sub-catchments, two large population centres and multiple smaller towns established on potentially affected floodplains and flows which are influenced by the operation of Wivenhoe and Somerset dams. Given this complexity, a broad range of scenarios covering these variable influences was required to be assessed to shortlist flood mitigation options.

Whilst the scenarios adopted for basin scale assessment did not include every possible combination of options[1], a significant number of scenarios (47) were identified on the basis of screening the range of practical options that were most likely to have a meaningful influence on flood levels at the basin scale.

The 47 scenarios adopted for basin scale hydrological assessment are presented in Table 9.3. This table provides an overview of the scenarios showing the variable Wivenhoe Dam options, including the dam configuration, raised height, FSV and operational strategy, as well as the new flood mitigation storages or water supply offset options considered.

[1] The total number of possible combinations/scenarios would have totalled 210 when assuming a Wivenhoe Dam upgrade was certain and taking into account that multiple dam near Linville options or Wivenhoe Dam upgrade options could not be implemented simultaneously.

### Table 9.3 PIFMSI scenarios for basin scale assessment

| Scenario No. | Wivenhoe Dam | | | Bremer R. AMTD 70.0 km | Lower Warrill Ck AMTD 13.9 km/14.6 km | Brisbane R. AMTD 282.3 km (near Linville) | | | | Emu Ck AMTD 10.8 km |
|---|---|---|---|---|---|---|---|---|---|---|
| | Configuration (Note 1) | Upgrade option | FSV (%) | | | Flood mitigation | Water supply dam FSV (ML) | | | |
| | | | | | | | 240,000 | 510,000 | 570,000 | |
| FS01 (base case) | Wivenhoe-1a | Existing | 100 | | | | | | | |
| FS02 | Wivenhoe-1b | Existing | 100 | | | | | | | |
| FS03 | Wivenhoe-2 | Raised | 100 | | | | | | | |
| FS04 | Wivenhoe-3 | Raised | 100 | | | | | | | |
| FS05 | Wivenhoe-4 | Raised | 100 | | | | | | | |
| FS06 | Wivenhoe-1a | Existing | 100 | | | | | | | |
| FS07 | Wivenhoe-1b | Existing | 100 | | | | | | | |
| FS08 | Wivenhoe-2 | Raised | 100 | | | | | | | |
| FS09 | Wivenhoe-3 | Raised | 100 | | | | | | | |
| FS10 | Wivenhoe-4 | Raised | 100 | | | | | | | |
| FS11 | Wivenhoe-1a | Existing | 100 | | | | | | | |
| FS12 | Wivenhoe-1b | Existing | 100 | | | | | | | |
| FS13 | Wivenhoe-2 | Raised | 100 | | | | | | | |
| FS14 | Wivenhoe-3 | Raised | 100 | | | | | | | |
| FS15 | Wivenhoe-4 | Raised | 100 | | | | | | | |
| FS16 | Wivenhoe-1a | Existing | 100 | | | | | | | |
| FS17 | Wivenhoe-1a | Existing | 100 | | | | | | | |
| FS18 | Wivenhoe-1b | Existing | 100 | | | | | | | |
| FS19 | Wivenhoe-1b | Existing | 100 | | | | | | | |
| FS20 | Wivenhoe-2 | Raised | 100 | | | | | | | |
| FS21 | Wivenhoe-2 | Raised | 100 | | | | | | | |
| FS22 | Wivenhoe-3 | Raised | 100 | | | | | | | |
| FS23 | Wivenhoe-3 | Raised | 100 | | | | | | | |
| FS24 | Wivenhoe-4 | Raised | 100 | | | | | | | |
| FS25 | Wivenhoe-4 | Raised | 100 | | | | | | | |
| FS26 | Wivenhoe-1a | Existing | 60 | | | | | | | |
| FS27 | Wivenhoe-1a | Existing | 75 | | | | | | | |
| FS28 | Wivenhoe-1a | Existing | 75 | | | | | | | |
| FS29 | Wivenhoe-1a | Existing | 85 | | | | | | | |
| FS30 | Wivenhoe-1b | Existing | 60 | | | | | | | |
| FS31 | Wivenhoe-1a | Existing | 60 | | | | | | | |
| FS32 | Wivenhoe-1a | Existing | 75 | | | | | | | |
| FS33 | Wivenhoe-1a | Existing | 75 | | | | | | | |
| FS34 | Wivenhoe-1a | Existing | 85 | | | | | | | |
| FS35 | Wivenhoe-1b | Existing | 60 | | | | | | | |
| FS36 | Wivenhoe-2 | Raised | 60 | | | | | | | |
| FS37 | Wivenhoe-3 | Raised | 60 | | | | | | | |
| FS38 | Wivenhoe-2 | Raised | 60 | | | | | | | |
| FS39 | Wivenhoe-3 | Raised | 60 | | | | | | | |
| FS40 | Wivenhoe-1a | Existing | 60 | | | | | | | |
| FS41 | Wivenhoe-1a | Existing | 60 | | | | | | | |
| FS42 | Wivenhoe-1a | Existing | 75 | | | | | | | |
| FS43 | Wivenhoe-1b | Existing | 60 | | | | | | | |
| FS44 | Wivenhoe-1b | Existing | 60 | | | | | | | |
| FS45 | Wivenhoe-1b | Existing | 75 | | | | | | | |
| FS46 | Wivenhoe-2 | Raised | 60 | | | | | | | |
| FS47 | Wivenhoe-3 | Raised | 75 | | | | | | | |

Notes:

1. Wivenhoe Dam raisings/upgrade options areas per those listed in Table 9.2.

**Legend:**

Indicates inclusion of the infrastructure option in the catchment scenario.

## 9.3 Basin level flood routing of scenarios (Phase 4 hydrology)

The Unified River Basin Simulator (URBS) model outputs from the Phase 3 hydrological assessments and the Flood Operation Simulation Model (FOSM)[2] were used by Seqwater to model the influence of modified flood hydrographs in combination with Wivenhoe Dam flood operations. This modelling enabled assessment of the overall effect on peak flood flows in the mid and lower-Brisbane River at the key locations of Savages Crossing and Moggill and peak levels in the Bremer River at Ipswich (refer Table 9.4).

**Table 9.4 Key locations and results of interest**

| Catchment | Key location and result of interest |
|---|---|
| Mid Brisbane River | Mid Brisbane peak flow at Savages Crossing |
| Bremer River | Bremer River peak level at Ipswich (David Trumpy Bridge) |
| Lower Brisbane River | Brisbane River peak flow at Moggill |

Of the 47 scenarios, FS01 represents the 'no change' scenario, FS01 comprises Wivenhoe Dam configuration 1a and represents the existing dam system, optimised and operated using the alternative Urban 3 option. Alternative Urban 3 was a preferred operational option from the Wivenhoe and Somerset Dams Optimisation Study (WSDOS) and is proposed to be implemented in the 2014 Flood Manual (Revision 12). Hence for the PIFMSI, FS01 has been considered as the 'Base Case' against which all other scenarios have been compared.

The operating strategies that relate to each upgrade option for Wivenhoe Dam are labelled Urban 4 to Urban 7 (refer Table 9.2). All scenarios are detailed in Seqwater technical memorandum no. 008 (Seqwater 2014a).

### 9.3.1 Results

Tables 9.5–9.7 and Figures 9.1–9.12 show the performance of each of the 47 scenarios for the 4 largest historical floods (February 1893[3], February 1893[4], January 1974 and January 2011) in the Brisbane River basin at the 3 key locations (Savages Crossing, Moggill and Ipswich). This information has been extracted from Seqwater technical memorandum no. 008 (Seqwater 2014a) which presents the results for all 20 historical floods modelled.

In Figures 9.1–9.12, the colours represent the different new flood mitigation or water supply offset dam configurations while the different patterns represent the different Wivenhoe Dam upgrade options.

The range of differences in peak flow/height values between each scenario and scenario FS01 represents the potential improvement in flood mitigation that could be expected due to the construction of new infrastructure and/or raising of Wivenhoe Dam for the historical floods modelled.

For Tables 9.5 to 9.7 the top 20% of scenarios (in terms of performance for each historical flood modelled) have been highlighted.

[2] Developed using GoldSim for WSDOS.
[3] First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
[4] Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).

#### 9.3.1.1 Brisbane River at Savages Crossing

Table 9.5 shows the percentage attenuation of peak flows at Savages Crossing in comparison with the peak flow for the Base Case (FS01).

**Table 9.5 Percentage attenuation of peak flow at Savages Crossing**

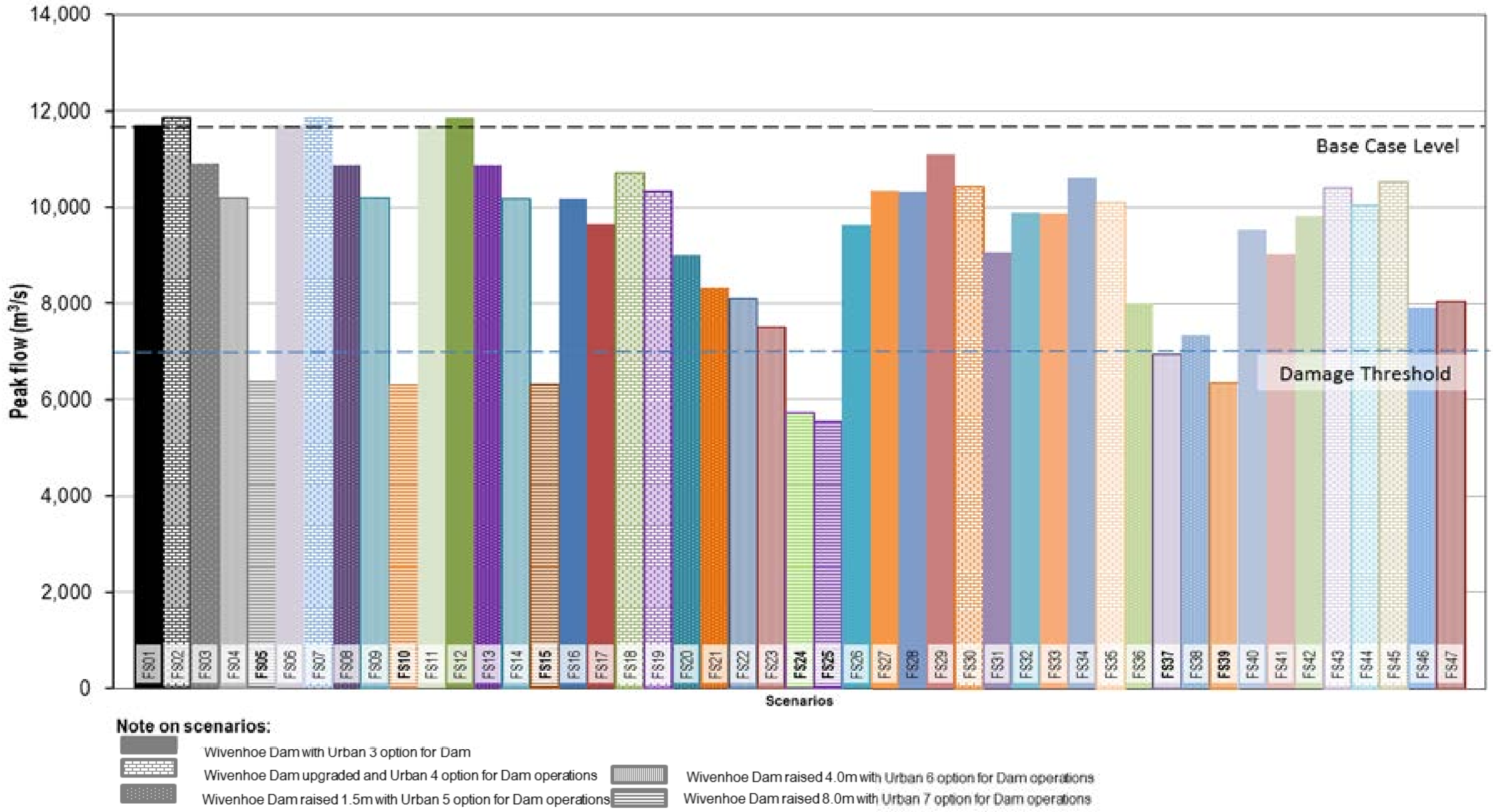
| Scenario | February 1893 [1] flood | February 1893 [2] flood | January 1974 flood | January 2011 flood | Average of twenty largest floods [3] |
|---|---|---|---|---|---|
| FS02 | 0.0% | 0.0% | 0.0% | 13.0% | 0.7% |
| FS03 | 7.0% | 14.0% | 27.0% | 21.0% | 3.8% |
| FS04 | 13.0% | 24.0% | 31.0% | 46.0% | 6.3% |
| FS05 | 46.0% | 38.0% | 38.0% | 48.0% | 8.8% |
| FS06 | 0.0% | 1.0% | 0.0% | 1.0% | 1.3% |
| FS07 | -1.0% | 12.0% | 26.0% | 19.0% | 1.3% |
| FS08 | 7.0% | 15.0% | 28.0% | 35.0% | 5.7% |
| FS09 | 13.0% | 27.0% | 32.0% | 46.0% | 7.3% |
| FS10 | 46.0% | 42.0% | 39.0% | 47.0% | 9.6% |
| FS11 | 0.0% | 1.0% | 0.0% | 1.0% | 1.5% |
| FS12 | -1.0% | 12.0% | 26.0% | 16.0% | 1.6% |
| FS13 | 7.0% | 15.0% | 29.0% | 35.0% | 6.0% |
| FS14 | 13.0% | 28.0% | 33.0% | 46.0% | 7.7% |
| FS15 | 46.0% | 42.0% | 40.0% | 47.0% | 9.8% |
| FS16 | 13.0% | 16.0% | 17.0% | 24.0% | 7.7% |
| FS17 | 18.0% | 22.0% | 30.0% | 42.0% | 10.1% |
| FS18 | 9.0% | 26.0% | 33.0% | 41.0% | 7.3% |
| FS19 | 12.0% | 42.0% | 35.0% | 43.0% | 9.2% |
| FS20 | 23.0% | 34.0% | 33.0% | 43.0% | 11.1% |
| FS21 | 29.0% | 38.0% | 36.0% | 46.0% | 12.1% |
| FS22 | 31.0% | 36.0% | 34.0% | 49.0% | 11.5% |
| FS23 | 36.0% | 38.0% | 39.0% | 48.0% | 12.8% |
| FS24 | 51.0% | 42.0% | 41.0% | 49.0% | 12.7% |
| FS25 | 53.0% | 45.0% | 41.0% | 50.0% | 13.4% |
| FS26 | 18.0% | 35.0% | 34.0% | 48.0% | 4.8% |
| FS27 | 12.0% | 26.0% | 30.0% | 45.0% | 4.3% |
| FS28 | 12.0% | 26.0% | 30.0% | 45.0% | 4.8% |
| FS29 | 5.0% | 13.0% | 24.0% | 21.0% | 3.1% |
| FS30 | 11.0% | 52.0% | 41.0% | 52.0% | 6.6% |
| FS31 | 23.0% | 37.0% | 36.0% | 48.0% | 5.6% |
| FS32 | 16.0% | 38.0% | 33.0% | 48.0% | 6.2% |
| FS33 | 16.0% | 34.0% | 33.0% | 48.0% | 6.1% |
| FS34 | 9.0% | 20.0% | 30.0% | 28.0% | 5.3% |
| FS35 | 14.0% | 55.0% | 41.0% | 53.0% | 7.0% |
| FS36 | 32.0% | 39.0% | 39.0% | 48.0% | 6.0% |
| FS37 | 41.0% | 40.0% | 39.0% | 48.0% | 6.5% |
| FS38 | 37.0% | 42.0% | 39.0% | 48.0% | 6.9% |
| FS39 | 46.0% | 42.0% | 41.0% | 48.0% | 7.5% |
| FS40 | 19.0% | 37.0% | 39.0% | 47.0% | 6.5% |
| FS41 | 23.0% | 40.0% | 40.0% | 47.0% | 7.0% |
| FS42 | 16.0% | 34.0% | 36.0% | 47.0% | 7.2% |
| FS43 | 11.0% | 52.0% | 41.0% | 52.0% | 7.3% |
| FS44 | 14.0% | 56.0% | 41.0% | 52.0% | 7.6% |
| FS45 | 10.0% | 49.0% | 41.0% | 49.0% | 9.3% |
| FS46 | 32.0% | 40.0% | 41.0% | 47.0% | 7.5% |
| FS47 | 31.0% | 40.0% | 39.0% | 47.0% | 8.0% |

Notes:

1. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
2. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).
3. The average of percentage attenuation across all historic floods modelled for each scenario (last column) has been provided simply to give an indication of the variability across the 20 historic floods modelled as the results for only the 4 largest floods are given in the table. This average is not a definitive indicator of scenarios that should be considered further and has been provided for the purposes of this table only. Decisions on which scenarios should be considered further need to be based on the outcomes of the damages and economic analyses.

Legend: Top 20 % of scenarios

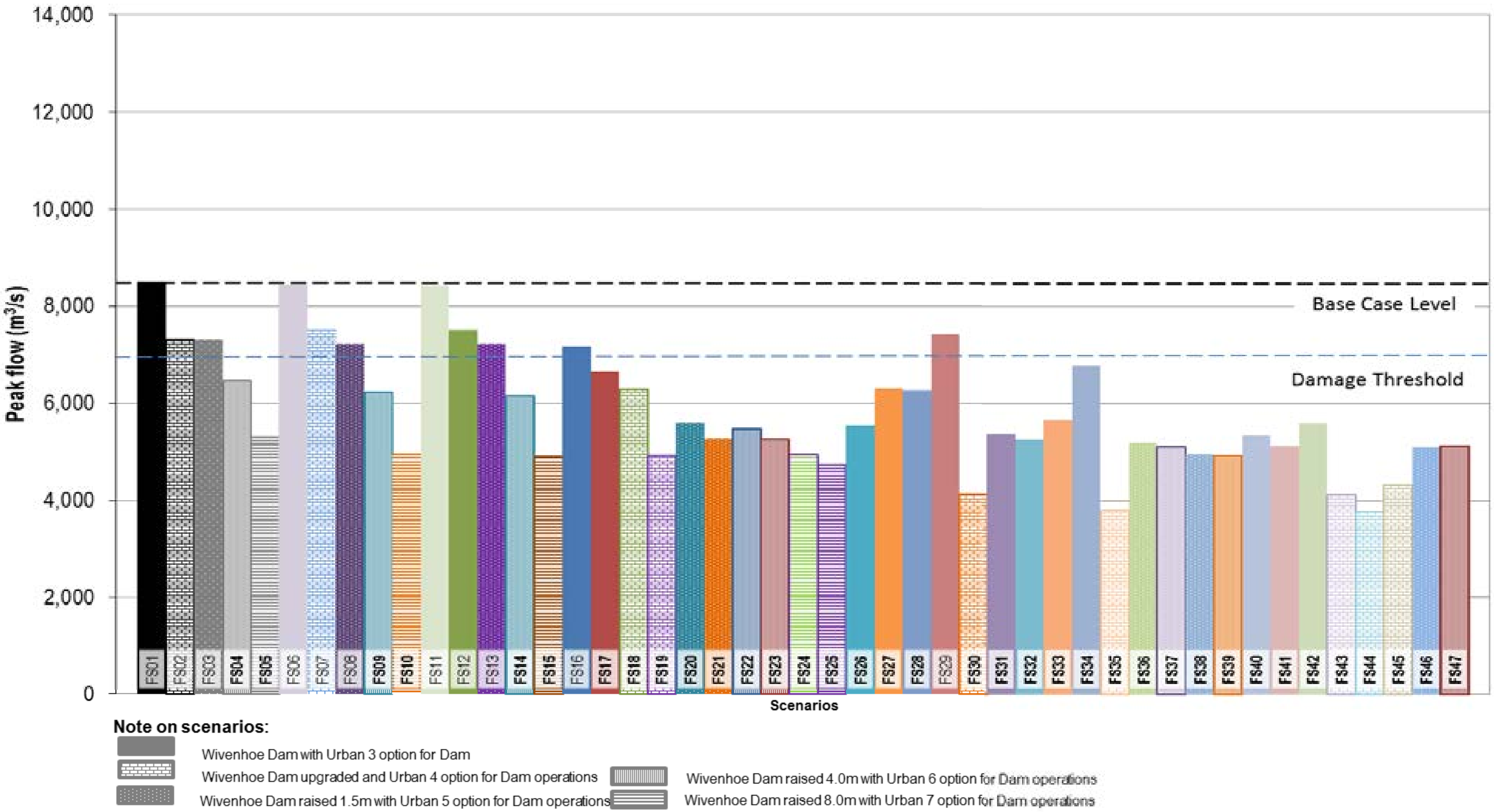
Figures 9.1 to 9.4 compare the expected peak flows in the Brisbane River at Savages Crossing for the four largest historical floods at this location for the 47 scenarios.




Notes:

1. Simulated peak flows.
2. Damage threshold as defined in Seqwater 2014b.

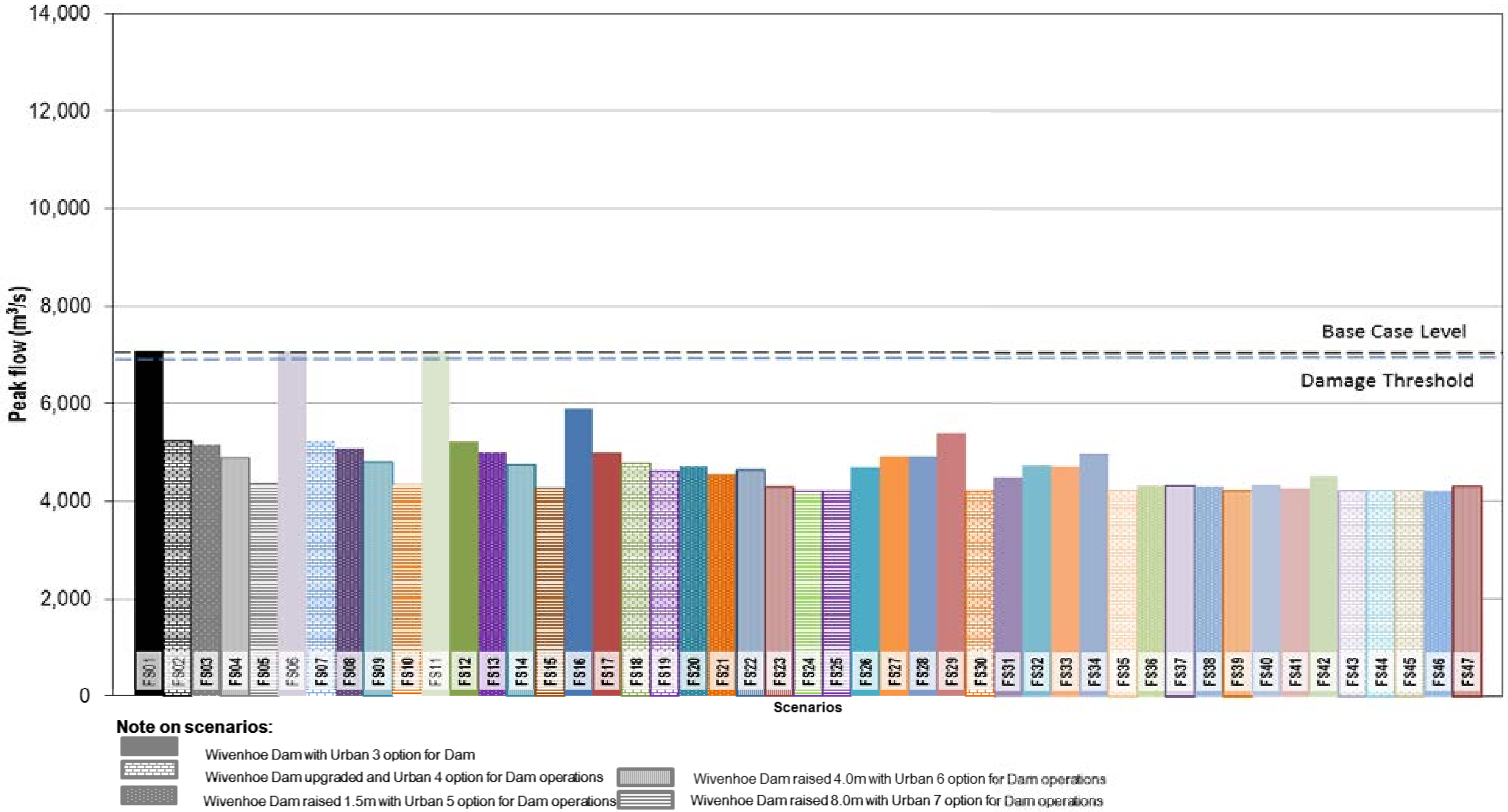
**Figure 9.1 February 1893 (first flood) comparison of peak flows at Savages Crossing**




Notes:

1. Simulated peak flows.
2. Damage threshold as defined in Seqwater 2014b.

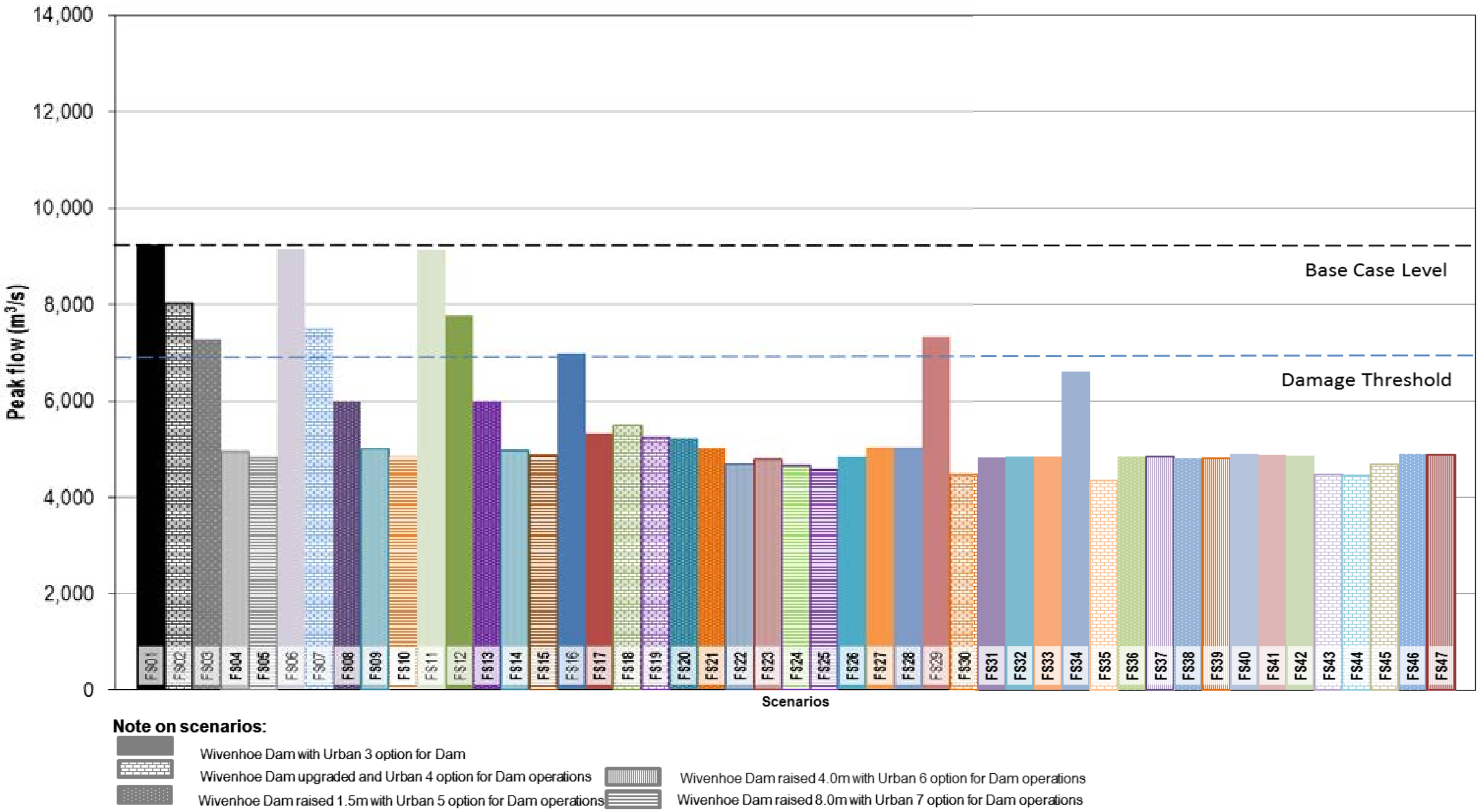
**Figure 9.2 February 1893 (third flood) comparison of peak flows at Savages Crossing**




Notes:

1. Simulated peak flows.
2. Damage threshold as defined in Seqwater 2014b.

**Figure 9.3 January 1974 flood comparison of peak flows at Savages Crossing**




Notes:

1. Simulated peak flows.
2. Damage threshold as defined in Seqwater 2014b.

**Figure 9.4 January 2011 flood comparison of peak flows at Savages Crossing**

### 9.3.1.2 Brisbane River at Moggill

Table 9.6 shows the attenuation of peak flows at Moggill compared to the Base Case (FS01).

**Table 9.6 Percentage attenuation of peak flow at Moggill**

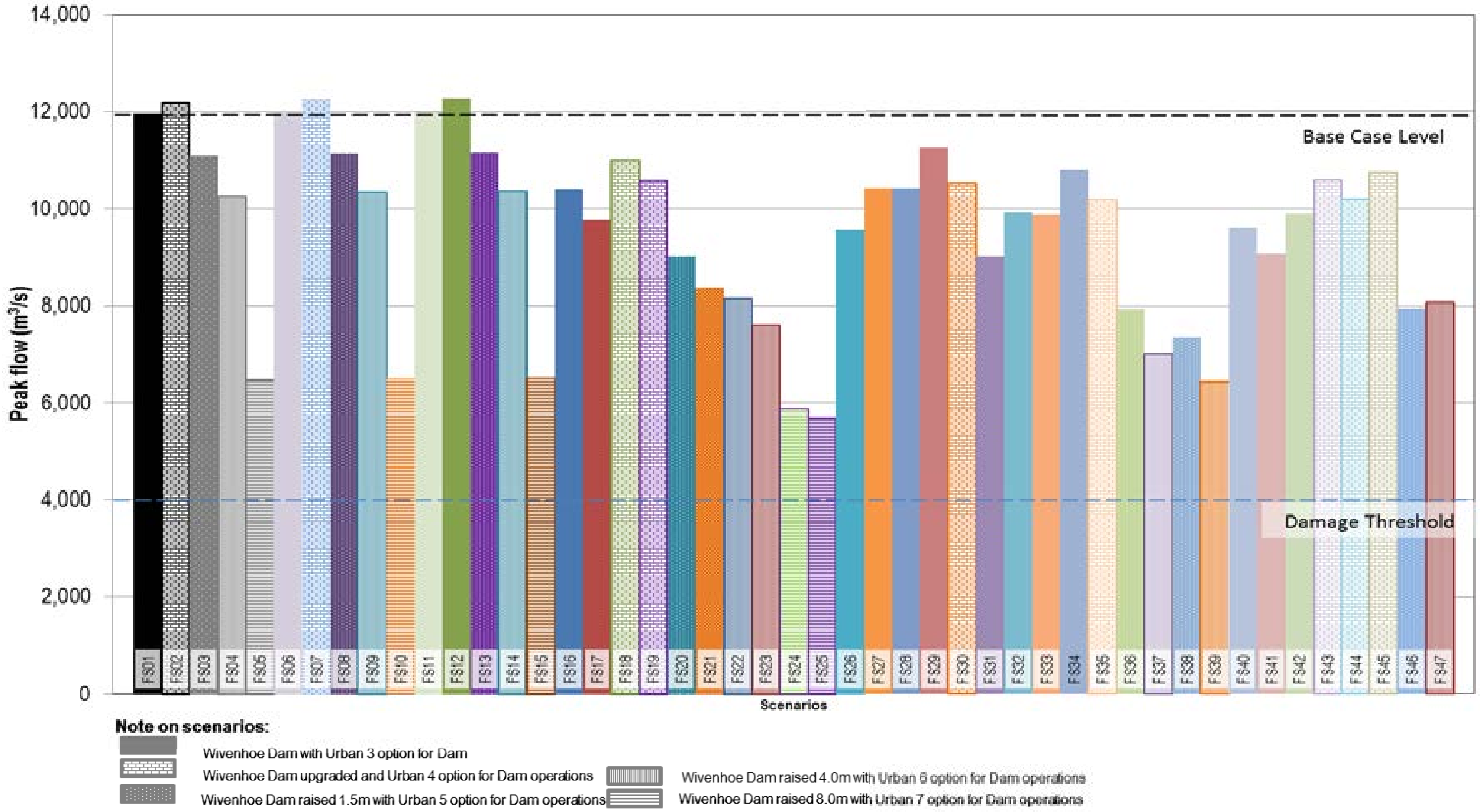
| Scenario | February 1893 [1] flood | February 1893 [2] flood | January 1974 flood | January 2011 flood | Average of twenty largest floods [3] |
|---|---|---|---|---|---|
| FS02 | 0.0% | 0.0% | 0.0% | 12.0% | 0.6% |
| FS03 | 7.0% | 14.0% | 10.0% | 18.0% | 2.8% |
| FS04 | 14.0% | 24.0% | 10.0% | 33.0% | 4.6% |
| FS05 | 46.0% | 42.0% | 10.0% | 32.0% | 6.7% |
| FS06 | 0.0% | 5.0% | 4.0% | 4.0% | 3.3% |
| FS07 | -2.0% | 17.0% | 22.0% | 18.0% | 5.6% |
| FS08 | 7.0% | 18.0% | 22.0% | 28.0% | 6.1% |
| FS09 | 14.0% | 29.0% | 22.0% | 34.0% | 7.4% |
| FS10 | 46.0% | 44.0% | 22.0% | 34.0% | 9.3% |
| FS11 | 0.0% | 6.0% | 4.0% | 6.0% | 4.0% |
| FS12 | -3.0% | 16.0% | 24.0% | 18.0% | 6.2% |
| FS13 | 7.0% | 18.0% | 25.0% | 30.0% | 6.9% |
| FS14 | 13.0% | 30.0% | 26.0% | 35.0% | 8.2% |
| FS15 | 46.0% | 43.0% | 26.0% | 35.0% | 10.0% |
| FS16 | 13.0% | 14.0% | 10.0% | 19.0% | 5.5% |
| FS17 | 18.0% | 22.0% | 10.0% | 33.0% | 7.2% |
| FS18 | 8.0% | 28.0% | 10.0% | 30.0% | 8.2% |
| FS19 | 12.0% | 35.0% | 10.0% | 31.0% | 9.5% |
| FS20 | 25.0% | 33.0% | 10.0% | 32.0% | 7.9% |
| FS21 | 30.0% | 36.0% | 10.0% | 33.0% | 8.7% |
| FS22 | 32.0% | 42.0% | 10.0% | 35.0% | 8.5% |
| FS23 | 36.0% | 42.0% | 10.0% | 36.0% | 9.4% |
| FS24 | 51.0% | 42.0% | 10.0% | 34.0% | 9.2% |
| FS25 | 52.0% | 42.0% | 10.0% | 35.0% | 9.5% |
| FS26 | 20.0% | 41.0% | 10.0% | 32.0% | 6.7% |
| FS27 | 13.0% | 27.0% | 10.0% | 33.0% | 4.6% |
| FS28 | 13.0% | 28.0% | 10.0% | 33.0% | 5.0% |
| FS29 | 6.0% | 13.0% | 10.0% | 17.0% | 2.9% |
| FS30 | 12.0% | 42.0% | 10.0% | 36.0% | 6.5% |
| FS31 | 25.0% | 42.0% | 10.0% | 32.0% | 7.1% |
| FS32 | 17.0% | 40.0% | 10.0% | 33.0% | 6.2% |
| FS33 | 17.0% | 40.0% | 10.0% | 33.0% | 6.3% |
| FS34 | 10.0% | 21.0% | 10.0% | 24.0% | 4.4% |
| FS35 | 15.0% | 42.0% | 10.0% | 37.0% | 6.7% |
| FS36 | 34.0% | 42.0% | 10.0% | 32.0% | 7.4% |
| FS37 | 41.0% | 42.0% | 10.0% | 32.0% | 7.8% |
| FS38 | 39.0% | 42.0% | 10.0% | 33.0% | 8.0% |
| FS39 | 46.0% | 42.0% | 10.0% | 33.0% | 8.4% |
| FS40 | 20.0% | 40.0% | 26.0% | 35.0% | 10.0% |
| FS41 | 24.0% | 42.0% | 26.0% | 35.0% | 10.4% |
| FS42 | 17.0% | 37.0% | 26.0% | 36.0% | 10.0% |
| FS43 | 11.0% | 47.0% | 26.0% | 39.0% | 10.1% |
| FS44 | 15.0% | 47.0% | 26.0% | 39.0% | 10.8% |
| FS45 | 10.0% | 47.0% | 26.0% | 39.0% | 12.0% |
| FS46 | 34.0% | 42.0% | 26.0% | 35.0% | 10.8% |
| FS47 | 33.0% | 41.0% | 26.0% | 35.0% | 10.2% |

Notes:

1. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
2. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).
3. The average of percentage attenuation across all historic floods modelled for each scenario (last column) has been provided simply to give an indication of the variability across the 20 historic floods modelled as the results for only the 4 largest floods are given in the table. This average is not a definitive indicator of scenarios that should be considered further and has been provided for the purposes of this table only. Decisions on which scenarios should be considered further need to be based on the outcomes of the damages and economic analyses.

Legend: Top 20 % of scenarios

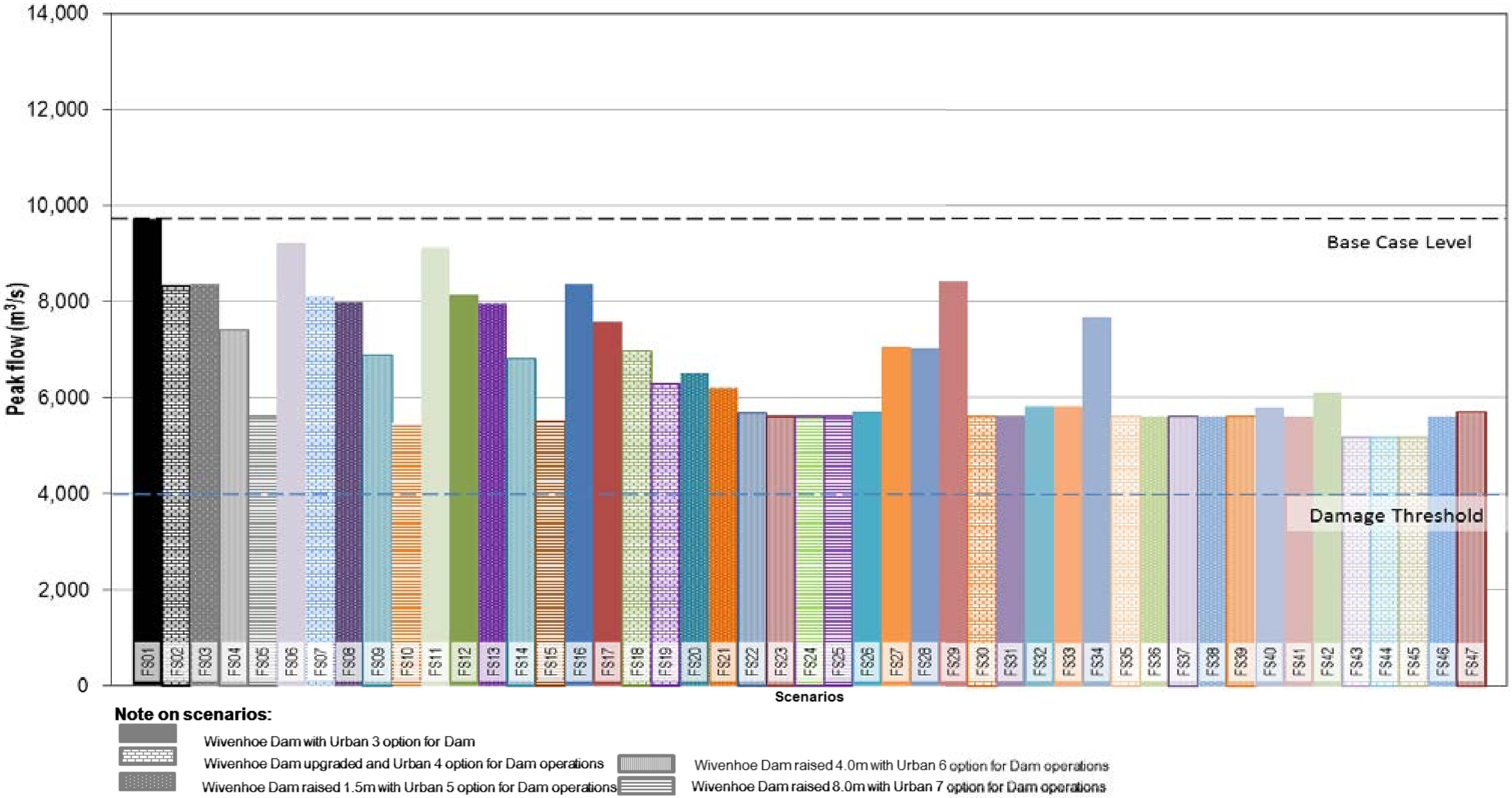
Figures 9.5 to 9.8 compare the expected peak flows in the Brisbane River at Moggill for the four largest historical floods at this location for the 47 scenarios.




Notes:

1. Simulated peak flows.
2. Damage threshold as defined in Seqwater 2014b.

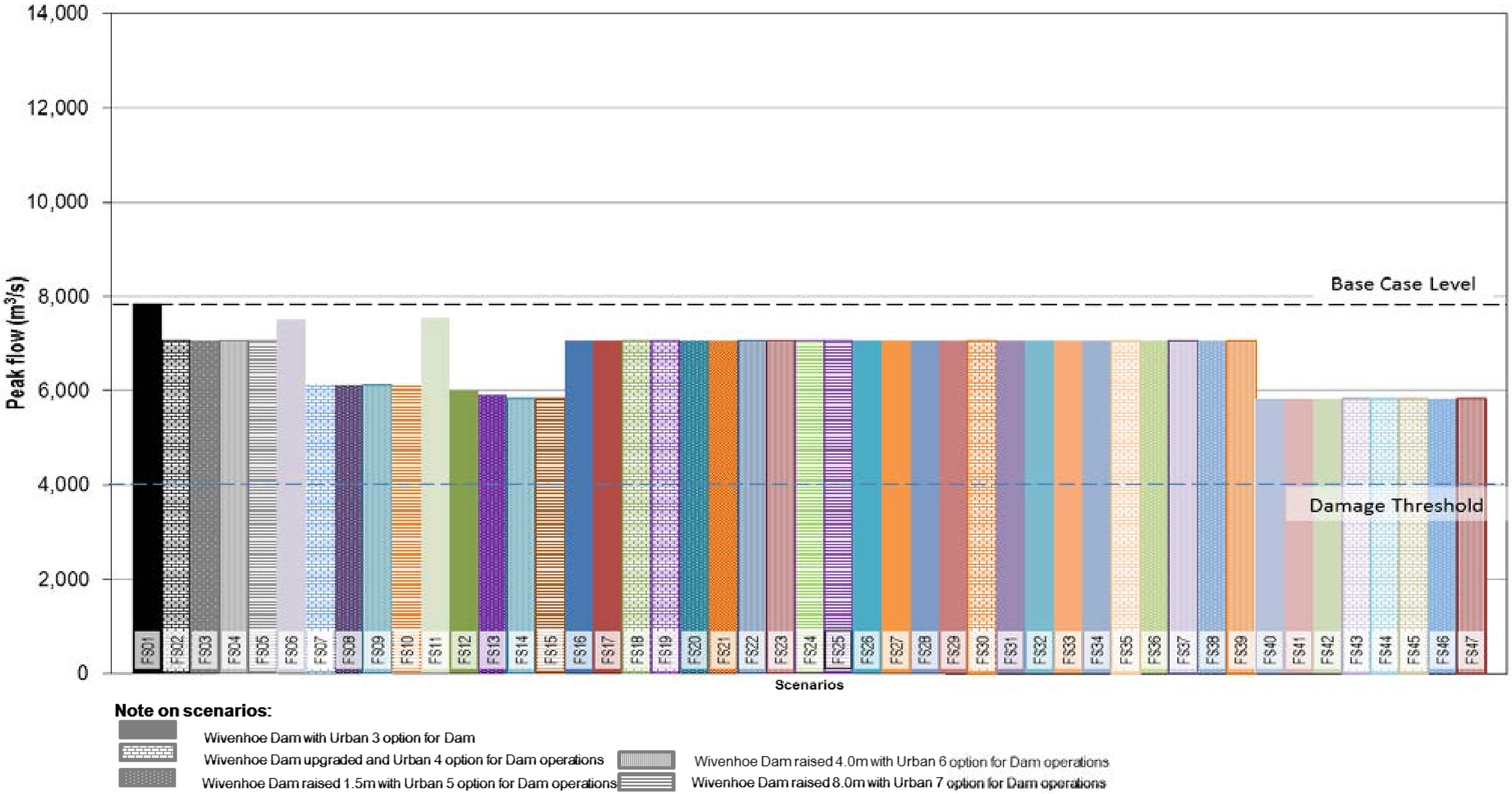
**Figure 9.5 February 1893 (first flood) comparison of peak flows at Moggill**




Notes:

1. Simulated peak flows.
2. Damage threshold as defined in Seqwater 2014b.

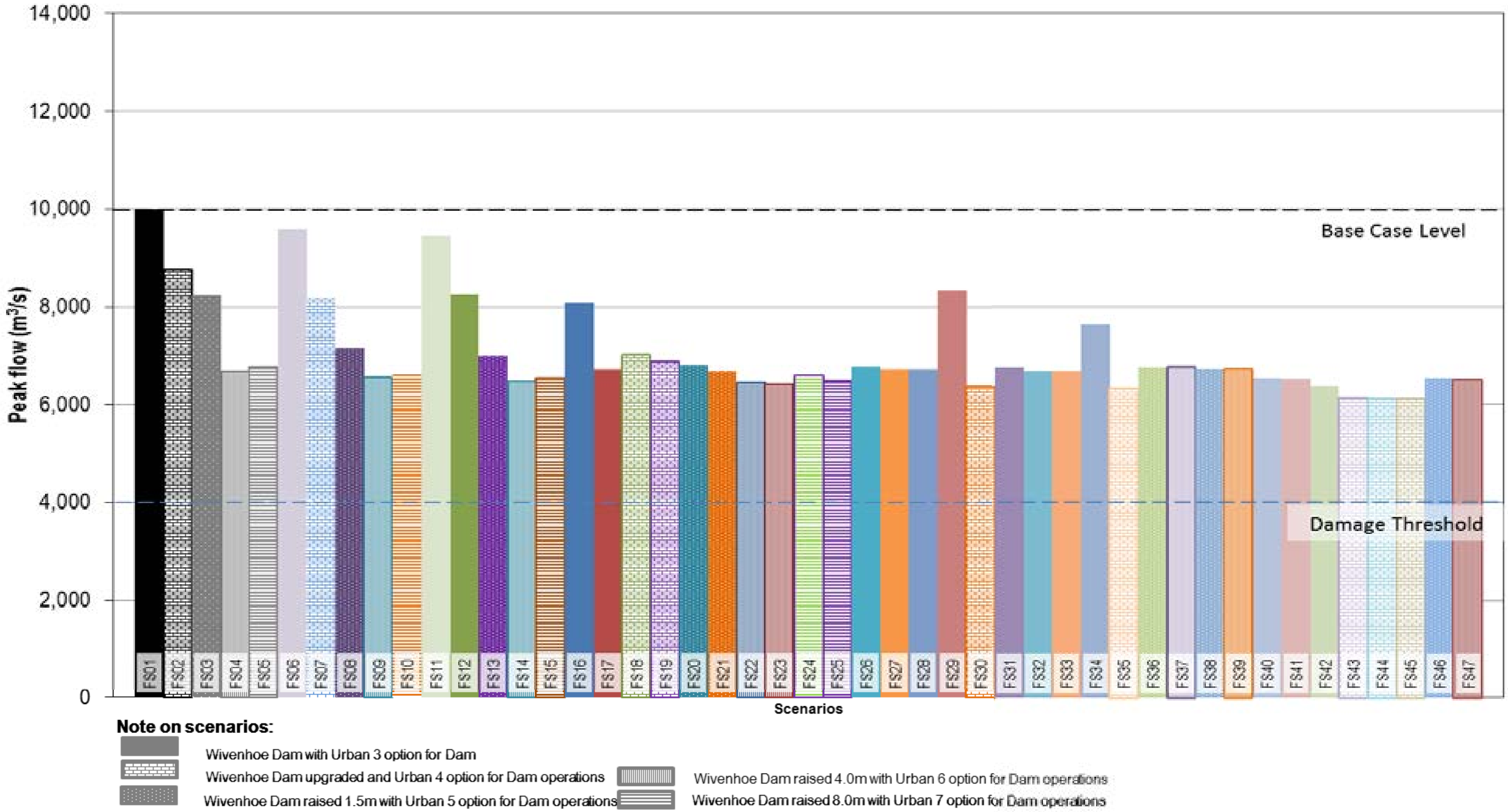
**Figure 9.6 February 1893 (third flood) comparison of peak flows at Moggill**




Notes:

1. Simulated peak flows.
2. Damage threshold as defined in Seqwater 2014b.

**Figure 9.7 January 1974 flood comparison of peak flows at Moggill**




Notes:

1. Simulated peak flows.
2. Damage threshold as defined in Seqwater 2014b.

**Figure 9.8 January 2011 flood comparison of peak flows at Moggill**

#### 9.3.1.3 Bremer River at Ipswich

Table 9.7 shows the reduction in peak water level at Ipswich compared to the Base Case (FS01).

**Table 9.7 Reduction in peak level (in metres) at Ipswich compared to the Base Case (FS01)**

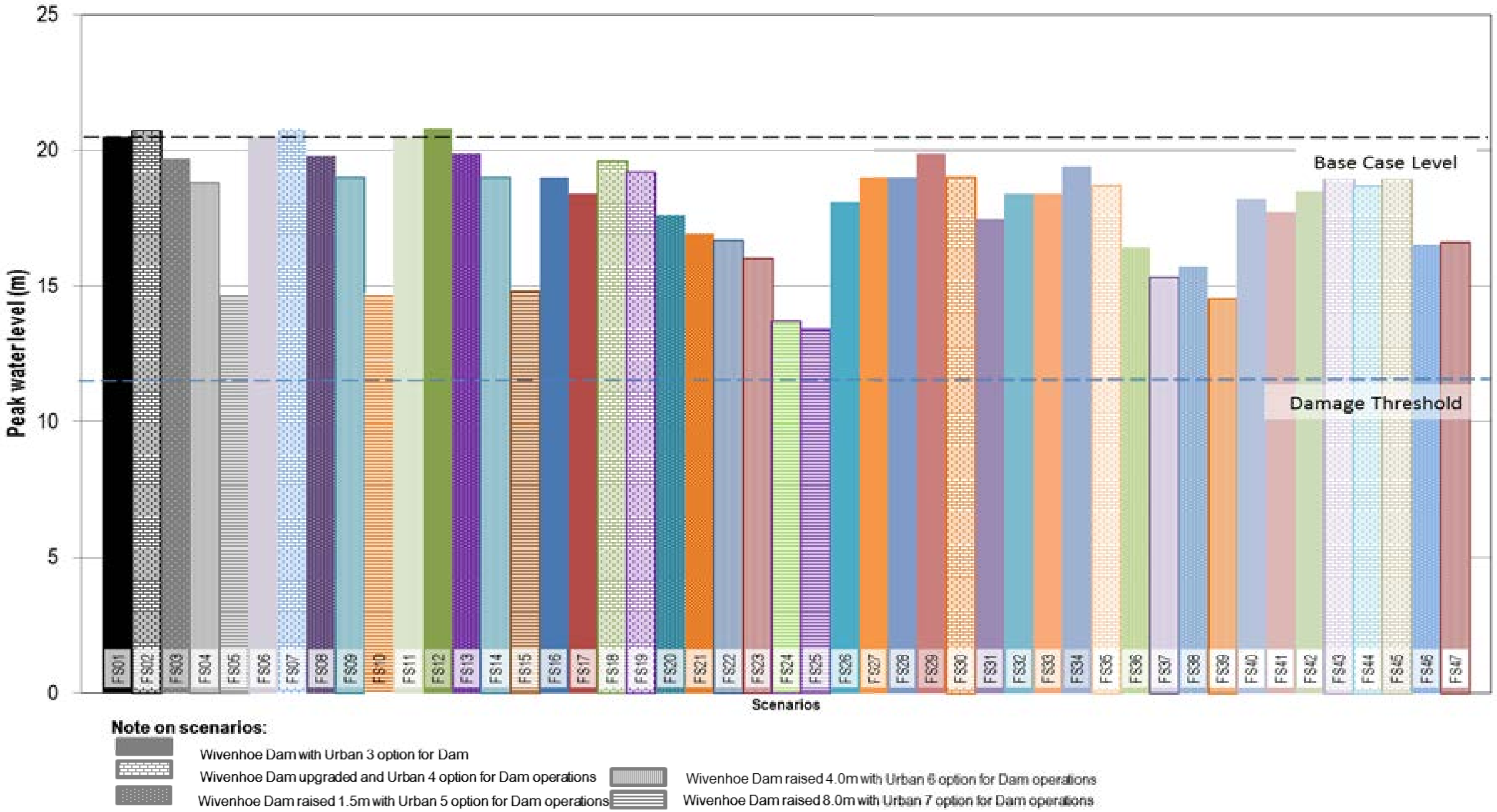
| Scenario | January 1887 Flood | February 1893 [1] flood | February 1893 [2] flood | January 1974 flood | January 2011 flood | Average of twenty largest floods [3] |
|---|---|---|---|---|---|---|
| FS02 | 0.00 | 0.00 | 0.00 | 0 | 0.8 | 0 |
| FS03 | 0.00 | 0.80 | 1.30 | 0 | 0.7 | 0.1 |
| FS04 | 0.00 | 1.70 | 2.20 | 0 | 0.8 | 0.2 |
| FS05 | 0.00 | 5.90 | 2.70 | 0 | 0.7 | 0.5 |
| FS06 | 3.80 | 0.00 | 0.90 | 3.4 | 0.7 | 1 |
| FS07 | 3.40 | 0.30 | 2.10 | 3.1 | 1.2 | 1 |
| FS08 | 3.40 | 0.70 | 2.10 | 3.1 | 1.2 | 0.9 |
| FS09 | 3.40 | 1.50 | 3.20 | 3.1 | 1.2 | 1 |
| FS10 | 3.30 | 5.80 | 3.80 | 3.1 | 1.2 | 1.2 |
| FS11 | 4.90 | 0.00 | 1.10 | 4.2 | 0.9 | 1.3 |
| FS12 | 4.50 | 0.30 | 2.10 | 3.9 | 1.6 | 1.3 |
| FS13 | 4.40 | 0.60 | 2.10 | 3.9 | 1.6 | 1.2 |
| FS14 | 4.40 | 1.50 | 3.40 | 3.9 | 1.7 | 1.4 |
| FS15 | 4.40 | 5.70 | 4.10 | 3.9 | 1.6 | 1.6 |
| FS16 | 0.00 | 1.50 | 1.10 | 0 | 0.8 | 0.3 |
| FS17 | 0.00 | 2.10 | 1.90 | 0 | 0.9 | 0.4 |
| FS18 | 0.00 | 0.90 | 2.20 | 0 | 0.9 | 0.4 |
| FS19 | 0.00 | 1.30 | 2.30 | 0 | 0.9 | 0.4 |
| FS20 | 0.00 | 2.90 | 2.30 | 0 | 0.9 | 0.4 |
| FS21 | 0.00 | 3.60 | 2.40 | 0 | 1 | 0.5 |
| FS22 | 0.00 | 3.80 | 2.70 | 0 | 0.9 | 0.5 |
| FS23 | 0.00 | 4.50 | 2.70 | 0 | 1 | 0.5 |
| FS24 | 0.00 | 6.80 | 2.70 | 0 | 0.9 | 0.6 |
| FS25 | 0.00 | 7.10 | 2.70 | 0 | 0.9 | 0.7 |
| FS26 | 0.00 | 2.40 | 2.70 | 0 | 0.7 | 0.4 |
| FS27 | 0.00 | 1.50 | 2.40 | 0 | 0.8 | 0.3 |
| FS28 | 0.00 | 1.50 | 2.50 | 0 | 0.8 | 0.3 |
| FS29 | 0.00 | 0.60 | 1.30 | 0 | 0.7 | 0.2 |
| FS30 | 0.00 | 1.50 | 2.70 | 0 | 1 | 0.4 |
| FS31 | 0.00 | 3.00 | 2.70 | 0 | 0.7 | 0.5 |
| FS32 | 0.00 | 2.10 | 2.60 | 0 | 0.8 | 0.4 |
| FS33 | 0.00 | 2.10 | 2.60 | 0 | 0.8 | 0.4 |
| FS34 | 0.00 | 1.10 | 2.10 | 0 | 0.8 | 0.3 |
| FS35 | 0.00 | 1.80 | 2.70 | 0 | 1 | 0.4 |
| FS36 | 0.00 | 4.10 | 2.70 | 0 | 0.7 | 0.5 |
| FS37 | 0.00 | 5.20 | 2.70 | 0 | 0.7 | 0.5 |
| FS38 | 0.00 | 4.80 | 2.70 | 0 | 0.8 | 0.6 |
| FS39 | 0.00 | 6.00 | 2.70 | 0 | 0.8 | 0.6 |
| FS40 | 4.40 | 2.30 | 4.00 | 3.9 | 1.6 | 1.5 |
| FS41 | 4.40 | 2.80 | 4.20 | 3.9 | 1.6 | 1.6 |
| FS42 | 4.40 | 2.00 | 4.00 | 3.9 | 1.7 | 1.5 |
| FS43 | 4.40 | 1.30 | 4.20 | 3.9 | 1.9 | 1.5 |
| FS44 | 4.40 | 1.80 | 4.20 | 3.9 | 1.9 | 1.6 |
| FS45 | 4.40 | 1.10 | 4.20 | 3.9 | 1.9 | 1.5 |
| FS46 | 4.40 | 4.00 | 4.10 | 3.9 | 1.6 | 1.6 |
| FS47 | 4.40 | 3.90 | 4.10 | 3.9 | 1.6 | 1.6 |

Notes:

1. First flood of February 1893 that peaked on 5 February 1893 (BoM 2014c).
2. Third flood of February 1893 that peaked on 19 February 1893 (BoM 2014c).
3. The average of percentage attenuation across all historic floods modelled for each scenario (last column) has been provided simply to give an indication of the variability across the 20 historic floods modelled as the results for only the 4 largest floods are given in the table. This average is not a definitive indicator of scenarios that should be considered further and has been provided for the purposes of this table only. Decisions on which scenarios should be considered further need to be based on the outcomes of the damages and economic analyses.

Legend: Top 20 % of scenarios

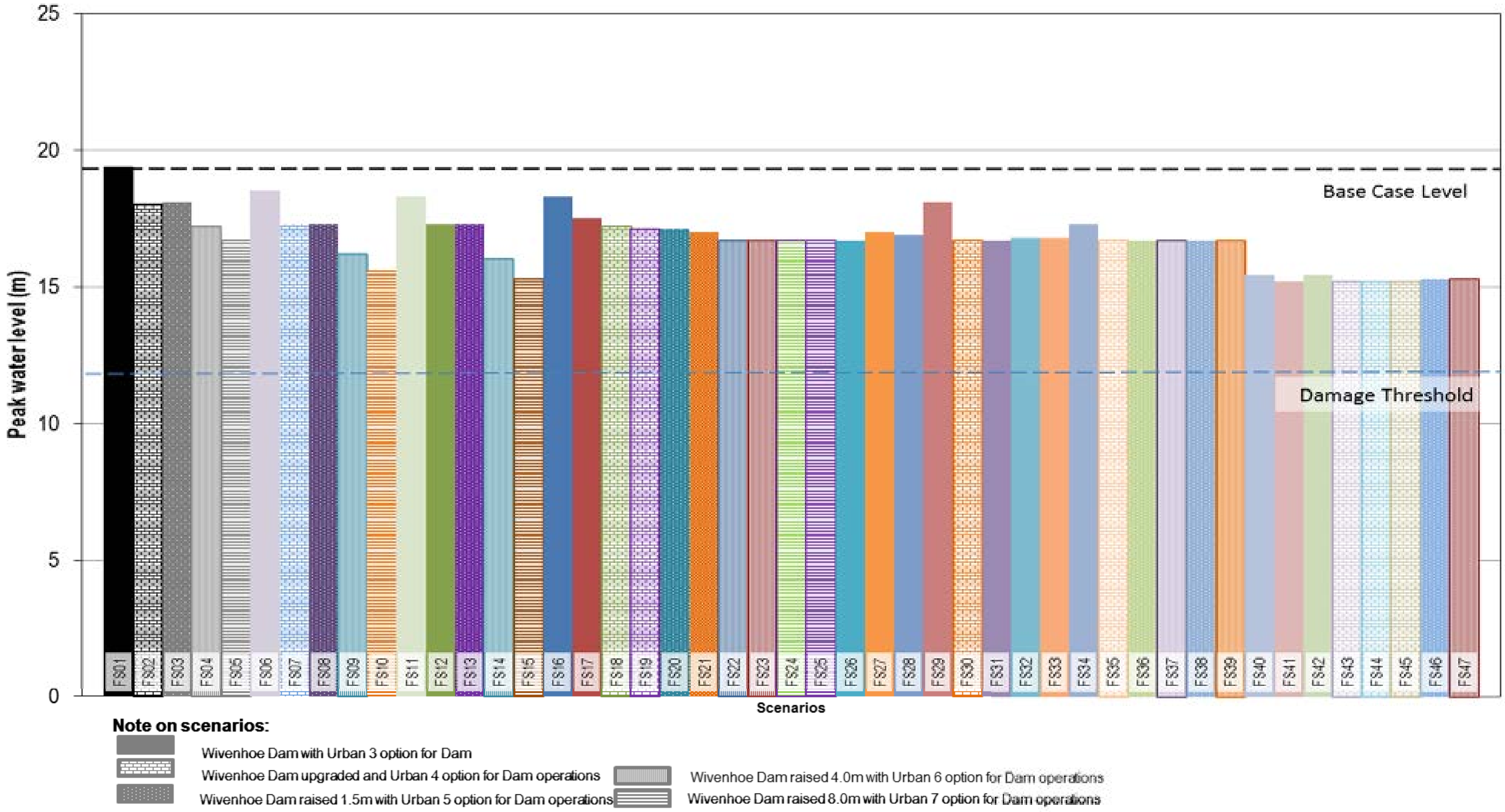
Figures 9.9 to 9.12 compare the expected peak level in the Bremer River at Ipswich for the four largest historical floods for the 47 scenarios.




Notes:

1. Simulated peak levels.
2. Damage threshold as defined in Seqwater 2014b.

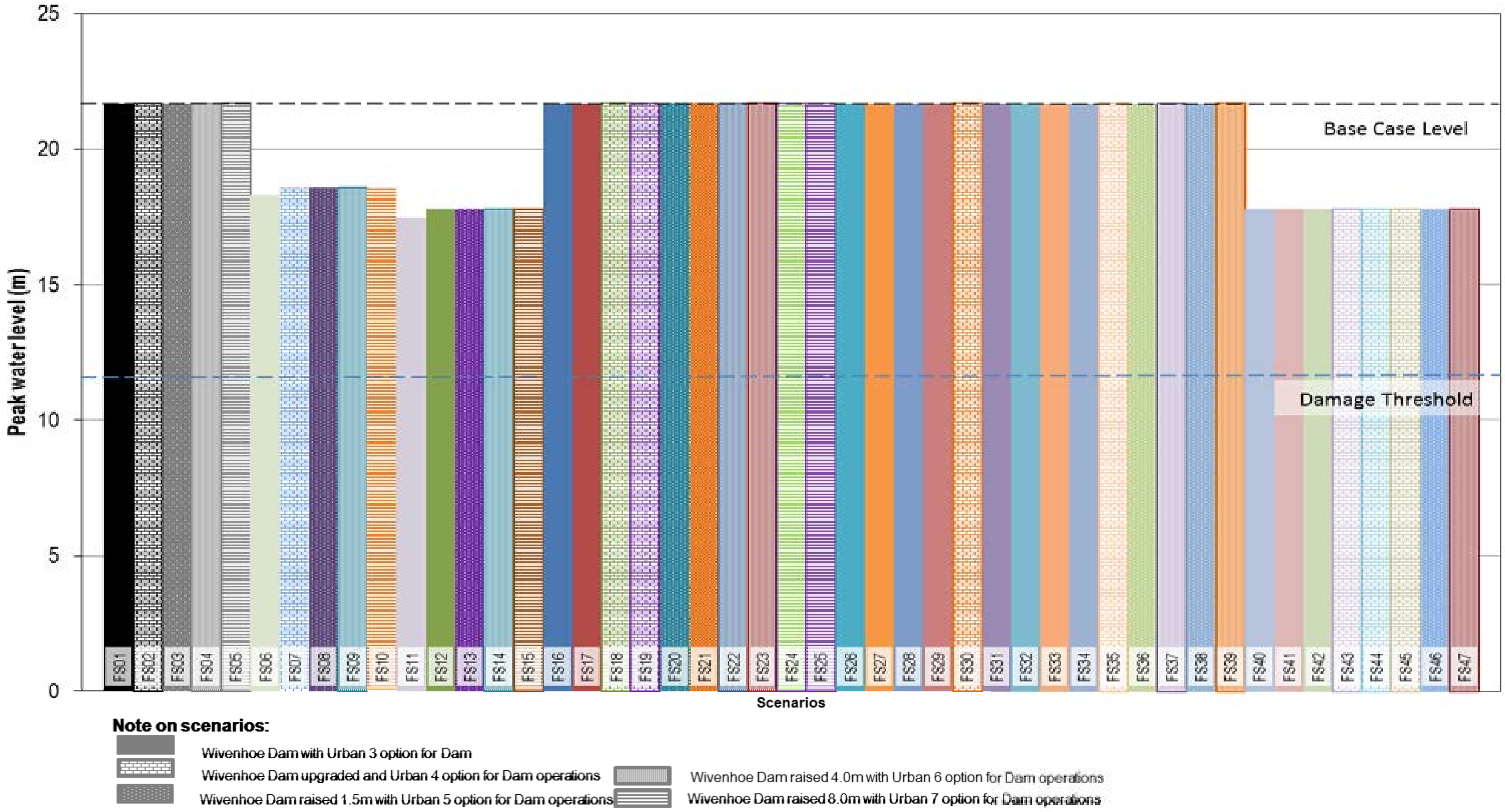
**Figure 9.9 February 1893 (first flood) comparison of peak level at Ipswich**




Notes:

1. Simulated peak levels.
2. Damage threshold as defined in Seqwater 2014b.

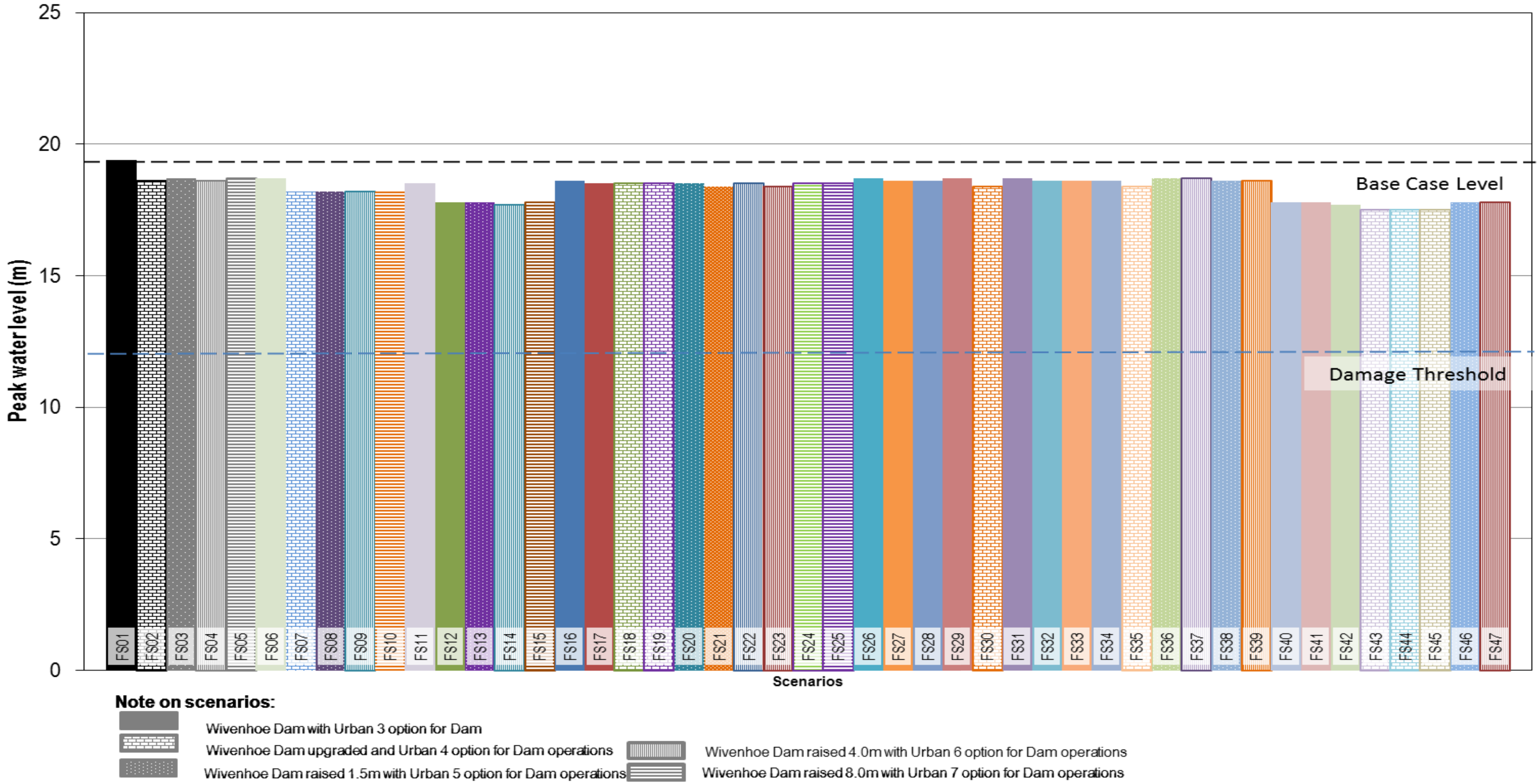
**Figure 9.10 February 1893 (third flood) comparison of peak level at Ipswich**




Notes:

1. Simulated peak levels.
2. Damage threshold as defined in Seqwater 2014b.

**Figure 9.11 January 1974 flood comparison of peak level at Ipswich**




Notes:

1. Simulated peak levels.
2. Damage threshold as defined in Seqwater 2014b.

**Figure 9.12 January 2011 flood comparison of peak level at Ipswich**

### 9.3.2 Limitations

A number of assumptions and limitations should be noted regarding the hydrological assessments undertaken for the PIFMSI:

- Seqwater used the existing WSDOS FOSM for this assessment, with only minor modifications to the model configuration to simulate the raised Wivenhoe Dam options. The main adjustments to model inputs were the Wivenhoe Dam operation assumptions, the Wivenhoe Dam configuration, and inflow hydrographs at key catchment locations.
- The limitations of the FOSM as described by Seqwater (2014b) for the WSDOS investigations hold true for this assessment.
- The operating options for the raised Wivenhoe Dam options were assumed 'as a way to potentially operate' with increased flood storage and are not optimised. Significant further investigation would be necessary to identify optimal operations of Wivenhoe Dam with increased flood storage capacity.
- All of the results for the hydrological assessments prepared by Seqwater (2014a) are sensitive to the accuracy of elevation-storage relationship data for the potential dams.

### 9.3.3 Conclusion

While the hydrological assessments have provided some indication of which scenarios offer potential flood mitigation benefits for the historical floods, this information is not sufficient to base decisions as to the most suitable scenario for further investigation. As expected, the most beneficial scenarios in terms of flood mitigation are those involving combinations of all infrastructure options, which would likely incur the greatest cost.

Summarising the figures and tables in this chapter is difficult and could result in potentially misleading conclusions without further analysis; however these results generally show that (for the key locations of Savages Crossing, Moggill and Ipswich):

- scenarios incorporating either a 4 m raising of Wivenhoe Dam or a water supply offset dam at Brisbane River AMTD 282.3 km offer similar flood attenuation benefits
- scenarios including a lower Warrill Creek AMTD 13.9 km/14.6 km storage would appear to have the most benefit for flood levels in Ipswich with flows from the Bremer River catchment of similar magnitude to 1974.

Beyond these points, it was not considered possible to determine which scenarios should be excluded from economic analysis based on the results of the hydrological assessments alone. This was because a wide range of attenuation across different floods was evident for scenarios with a wide range of potential costs. As a result of this spread of potential benefits and costs, it was determined that cost benefit analysis would be required for all 47 scenarios - as reported in Chapter 10.

# Chapter 10 Scenario evaluation

This chapter presents an evaluation of the scenarios identified (and hydrologically modelled) in Chapter 9. It describes the adopted methodology, assumptions and limitations, and the results of assessments of tangible (i.e. monetised) flood damages and impacts to provide an indicative net present value (NPV) and benefit/cost ratio (BCR) for each scenario compared with the base case.

This chapter brings together the results of:

- Chapter 7 – Engineering assessments
- Chapter 8 – Seqwater dams
- Chapter 9 – Flood infrastructure development scenarios

DEWS engaged Aurecon to estimate flood damages and impacts whilst the Department of State Development, Infrastructure and Planning (DSDIP) undertook the economic analysis.

## 10.1 Methodology

The overall study was at a prefeasibility stage, hence evaluation was directed toward narrowing (principally via an economic evaluation incorporating key costs and benefits) the number of scenarios to be further investigated and assessed. Economic evaluation (i.e. cost-benefit analysis) lends itself well to flood mitigation options appraisal in order to identify the options that maximise the net economic worth to the community. Cost-benefit analysis is a way of systematically identifying and quantifying the costs and benefits of a project in order to assist decision-makers

Benefit/cost evaluation for each scenario requires consideration of the capital and ongoing operation and maintenance costs for the relevant:

- new infrastructure options
- Wivenhoe Dam raising/augmentation options

and benefits as a result of reductions in tangible costs of:

- flood damages
- flood impacts (based mostly on traffic/transport delay costs)

This is consistent with common national practice for the evaluation of flood mitigation projects.

A traditional economic evaluation, as indicated schematically in Figure 10.1, was carried out based on estimates of the costs of flood damages and impacts for each scenario to derive a NPV and BCR for each potential development scenario. Sensitivity assessments were carried out for a number of different assumptions and discount rates.

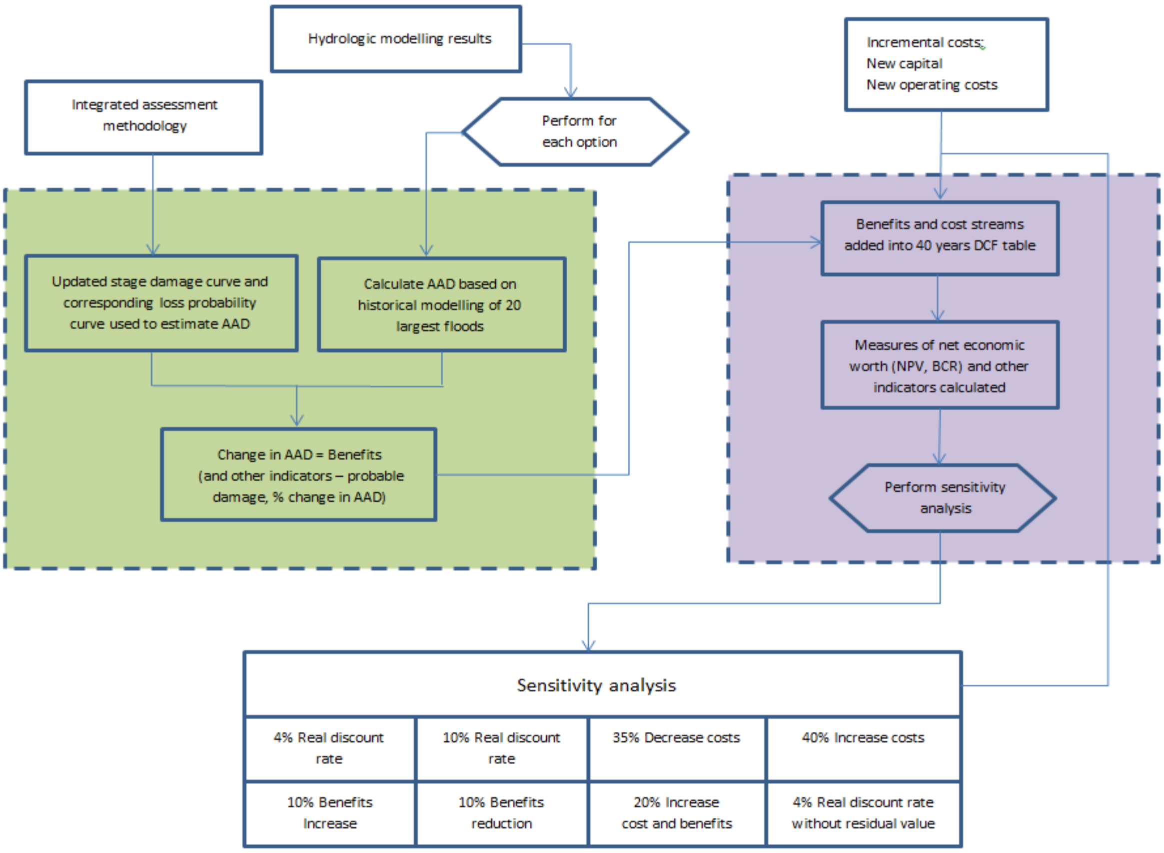



**Figure 10.1 An overview of the economic evaluation methodology**

Scenario FS01 (from Table 9.3) represents the existing dams (including necessary dam safety upgrades) with the Urban 3 operating option from the WSDOS study (proposed inclusion in the Flood Manual for Revision 12). It also represents the optimised operation of existing infrastructure. In this economic analysis, FS01 is the base case or business-as-usual scenario against which the estimated costs and benefits of each of the options are assessed.

## 10.2 Infrastructure costs (capital and operational)

Table 10.1 presents the estimated capital and operating costs of each of the individual infrastructure options (including the Wivenhoe Dam raising/augmentation options) considered in formulating the scenarios modelled in Phase 4 (refer Table 9.1 and Table 9.2).

**Table 10.1 Estimated capital and operational costs of infrastructure options**

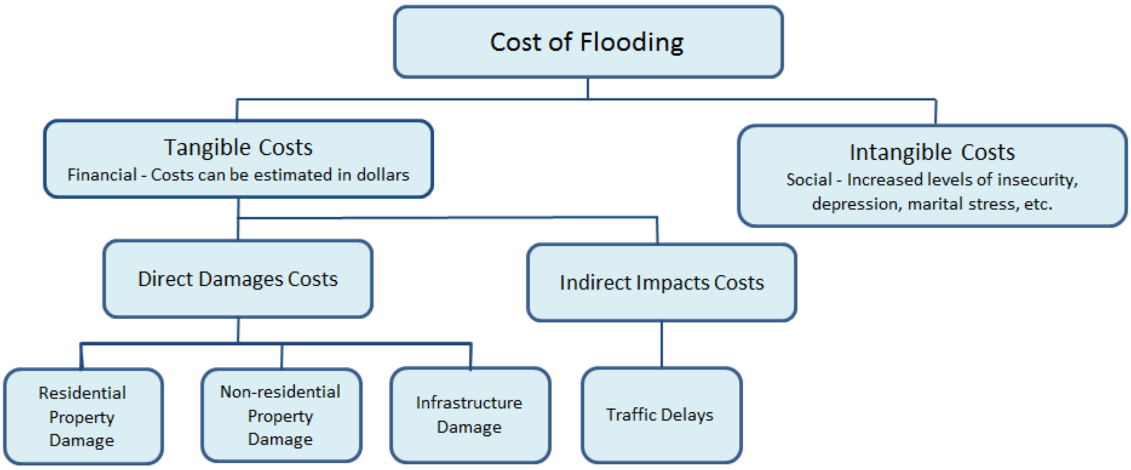
| Infrastructure option | Storage Volume: Up to spillway crest[1,2] (ML) | Storage Volume: Maximum[3] (ML) | Estimated Capital Cost (2014-15 $m) | Operation & Maintenance Cost ($m/yr) | Comments |
|---|---|---|---|---|---|
| Brisbane River AMTD 282.3 km (near Linville) | 240,000 (water supply) | 672,100 | 401 | 3.6 | Combined water supply (allows reduction of the FSV in Wivenhoe Dam) and flood mitigation dam |
| Brisbane River AMTD 282.3 km (near Linville) | 510,000 (water supply) | 1,096,000 | 544 | 3.6 | Combined water supply (allows reduction of the FSV in Wivenhoe Dam) and flood mitigation dam |
| Brisbane River AMTD 282.3 km (near Linville) | 570,000 (water supply) | 1,172,400 | 575 | 3.6 | Combined water supply (allows reduction of the FSV in Wivenhoe Dam) and flood mitigation dam |
| Brisbane River AMTD 282.3 km (near Linville) | 348,000 (flood mitigation) | 766,800 | 429 | 1.7 | Flood detention only dam (i.e. 'dry' dam) |
| Emu Creek AMTD 10.8 km (near Harlin) | 107,000 (flood mitigation) | 191,000 | 293 | 0.4 | Flood detention only dam (i.e. 'dry' dam) |
| Lower Warrill Creek AMTD 14.6 km (near Willowbank) | 125,000 (flood mitigation) | 207,300 | 522 [4] | 0.5 | Combined flood detention dam (i.e. 'dry' dam) and railway embankment for the proposed Southern Freight Railway |
| Bremer AMTD 70.0 km River (near Mt Walker) | 40,000 (flood mitigation) | 65,000 | 138 | 0.5 | Flood detention only dam (i.e. 'dry' dam) |
| Wivenhoe Dam 1a | 1,165,000 (water supply) | 3,131,000 | 325 | 0.05 | Combined water supply and flood mitigation dam |
| Wivenhoe Dam 1b | 1,165,000 (water supply) | 3,131,000 | 399 | 0.05 | Combined water supply and flood mitigation dam |
| Wivenhoe Dam 2 | 1,165,000 (water supply) | 3,465,000 | 535 | 0.05 | Combined water supply and flood mitigation dam |
| Wivenhoe Dam 3 | 1,165,000 (water supply) | 4,049,000 | 881 | 0.05 | Combined water supply and flood mitigation dam |
| Wivenhoe Dam 4 | 1,165,000 (water supply) | 5,120,000 | 1,373 | 0.05 | Combined water supply and flood mitigation dam |

Notes:

1. Volume for potential flood mitigation storages sized on mitigating historic floods
2. Full supply volume for Wivenhoe Dam and for Brisbane River AMTD 282.3 km dam options.
3. Volume up to embankment crest level (less free board); based on safely passing PMF.
4. Includes an amount of $61m for the railway embankment alone and $141m for infrastructure relocations.

## 10.3 Cost of flooding

The costs due to flooding are typically described either as tangible (i.e. those that can be valued) or intangible (i.e. those that cannot readily be valued). Tangible costs are further classified as direct damages (i.e. damage to houses and property) or indirect impacts (impacts such as traffic delays associated with the flooding of crossings and bridges and economic impacts) – refer Figure 10.2.




Source: DEWS 2014, Figure 15.2

**Figure 10.2 Traditional cost breakdown in assessing flood damage and impacts**

Tangible indirect costs other than traffic delays such as the cost of lost productivity (e.g. lost worker days, inability to trade, etc.) are likely to be significant but are very difficult to estimate[1] and have not been included in this evaluation. Similarly intangible costs of flooding (aspects that are not easily valued in monetary terms), such as environmental and social impacts, were not assessed for this evaluation but could also be significant. Thus the total benefits for each scenario are likely to be under estimated and this needs to be taken into account when reviewing the benefit cost assessments presented in this chapter.

The problem of capturing intangible costs is an issue and was noted by the World Bank (2011) as a potential cause of underestimation of damages, in particular for major flooding events.

The methodology for determining tangible flood damage and impact costs for this study is the same as was applied in the Wivenhoe and Somerset Dams Optimisation Study (WSDOS) - (refer Aurecon 2013; DEWS 2014).

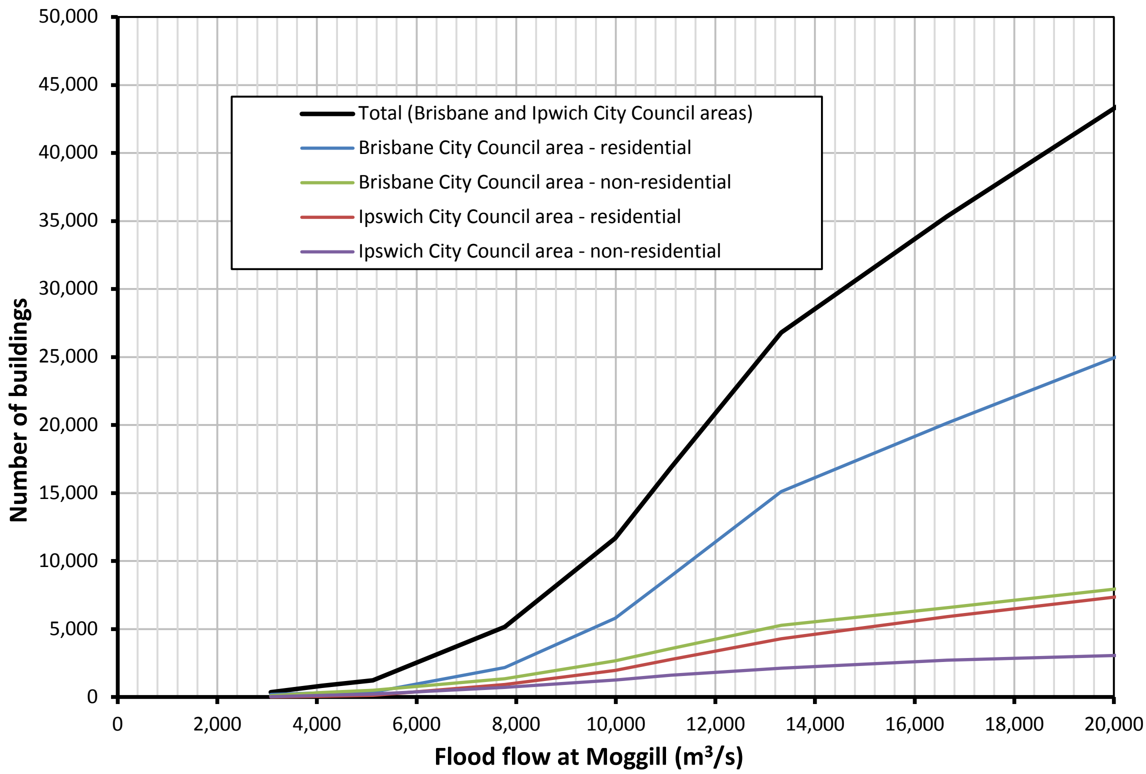
### 10.3.1 Direct damage costs

Direct flood damages to residential and non-residential properties were based on building numbers and building type derived from data obtained from councils.

Figure 10.3 depicts the number of residential, non-residential and total number of buildings estimated to be impacted in Brisbane City Council (BCC) and Ipswich City Council (ICC) areas by flooding in the Brisbane River. The buildings impacted in Somerset Regional

[1] The economic impact of the 2011 flooding event in Queensland was estimated to have decreased the Gross State Product (GSP) by almost 2 percentage points in 2010-11 (a fall in GSP by $5.1 billion driven by significant damages in SEQ). This took into account damage to infrastructure, output losses, business disruptions and resulting productivity losses.(DSDIP 2011)

Council (SRC) and Lockyer Valley Regional Council (LVRC) areas are not indicated in Figure 10.3 as the number is relatively low.




Note: Assessment of the number of buildings impacted is based on flooding above habitable floor level for residential buildings and above floor level for non-residential buildings

Source: DEWS 2014, Figure 14.3

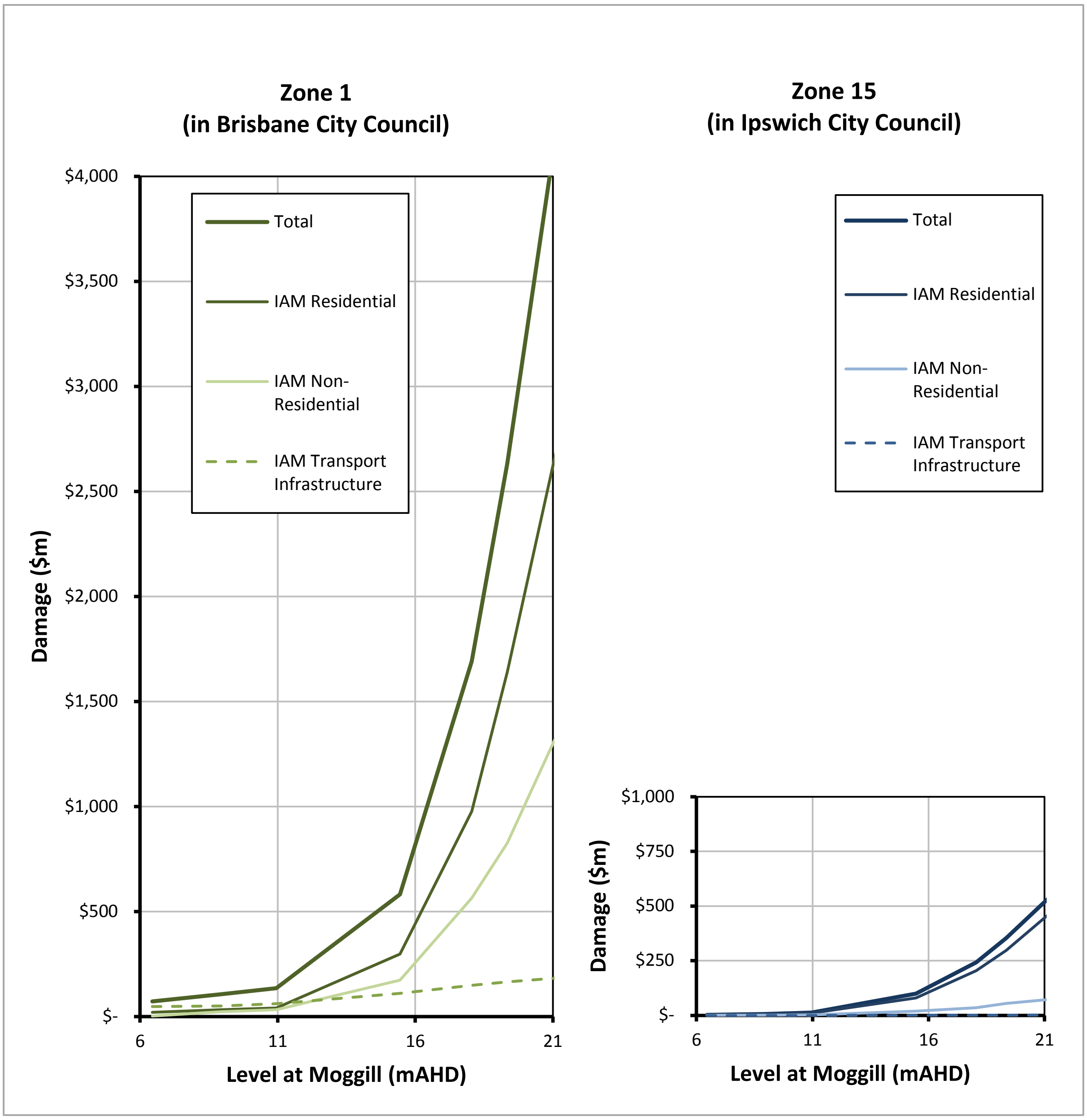
**Figure 10.3 Buildings impacted in BCC and ICC areas**

For the purpose of determining flood damages, the Brisbane River floodplain (downstream of Wivenhoe Dam) was sub-divided into 16 individual zones according to regions of hydraulic influence (based on BCC (2009) flood surfaces) and local government areas. Flood damage rating curves (damage as a function of flow rate or level) were developed for each of the zones to allow estimation of direct flood damages for any particular event (see sections 14.1 and 15.2.5, WSDOS report; DEWS 2014).

The flood damage rating curves for the zones (for flood damage calculation purposes) have been related to key reference locations (hydraulic influence locations) downstream of Wivenhoe Dam, i.e.:

- Brisbane River at Savages Crossing (AMTD 130.8 km)
- Brisbane River at Mt Crosby Weir (AMTD 90.2 km)
- Brisbane River at Moggill (AMTD 73.0 km)
- Bremer River at Ipswich (David Trumpy Bridge – AMTD 16.8 km).

Examples of damage rating curves calculated for two Moggill referenced zones (one in Brisbane and one in Ipswich) using the aforementioned methodology are shown in Figure 10.4




Source: DEWS 2014, Figure 15.4 (based on Aurecon 2014)

**Figure 10.4 Flood damage ratings curves for BCC and ICC areas**

The damage ratings developed for WSDOS have generally been used for the current study without change, with the exception of Zone 16, covering areas of Ipswich affected by the Bremer River. Flood behaviour in this zone is complicated as it depends on Bremer River flows and backwater flooding from the Brisbane River. The damages ratings for Zone 16 were updated to relate to a flood level at the Ipswich flood gauge (David Trumpy Bridge) - which was calculated by Seqwater (Phase 4 Hydrologic modelling) based on both flow in the Bremer River and the Brisbane River level at Moggill.

Flood damages were assessed for historical floods (refer section 4.2.3) by converting flow rates and levels determined from Seqwater's Phase 4 hydrologic assessments (refer section 9.3) to flood damage costs for each zone using the applicable flood surface[2] (from BCC 2009) and flood damage rating curve.

The average annual damage (AAD) cost of flooding (expressed as $/year) is a common measure of the level of potential flood damages. It expresses the tangible costs of floods as a uniform annual amount based on the potential damages across the full range of flood magnitudes (and probabilities).

For this study, AAD costs for each of the development scenarios were approximated based on the estimated costs for the historical floods modelled and the length of the historical record (i.e. 1887–2014 - 127 years). Estimated values are shown in Figure 10.5 and Table 10.2.

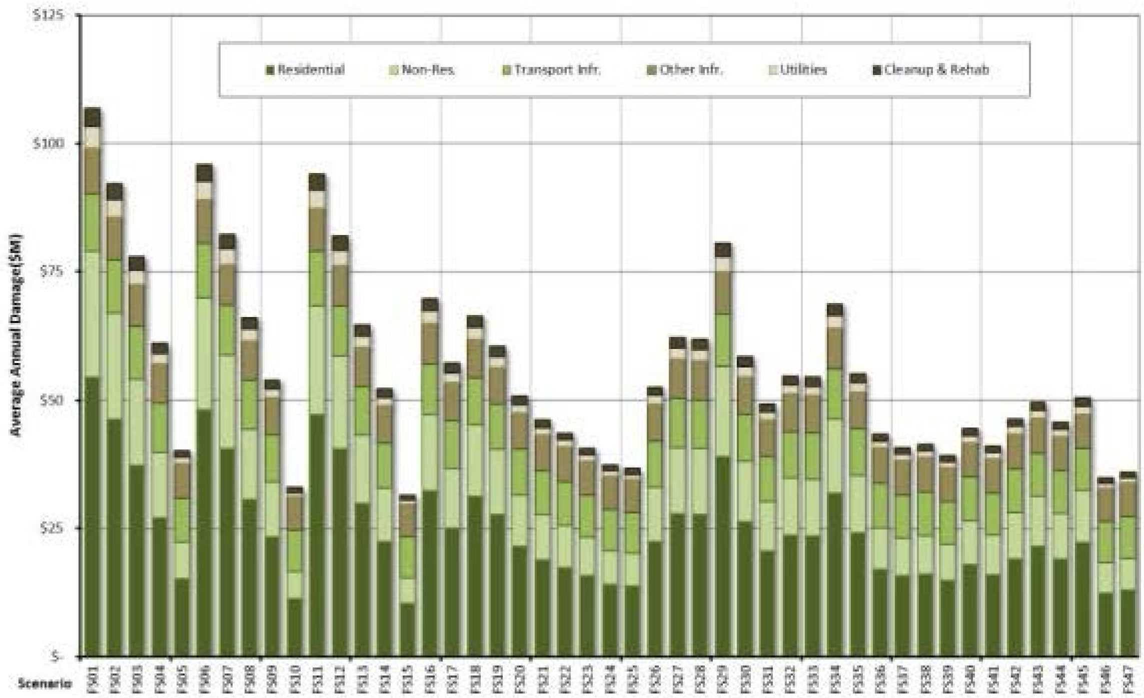



**Figure 10.5 Average annual flood damage costs (AAD)**

It should be noted that basing the estimates on a relatively small number of historical floods may under-estimate the likely damages costs, as damages from both smaller (more frequent) floods and larger (rare but statistically possible) floods are not included. Analysis of scenarios in the WSDOS study indicated that flood costs might be under-estimated by as much as 50%.

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[2] Whilst the update of the flood damage rating of Zone 16 as a function of the flood level at Ipswich (David Trumpy Bridge) introduces a method of selecting a flood surface based on a flood level that varies with flows in either the Bremer or Brisbane rivers, the selected flood surface is still based on the original BCC 2009 modelled flow combination, and therefore may become increasingly inappropriate away from the Ipswich gauge location.

### 10.3.2 Flood impact costs

For this study, flood impacts are impacts associated with loss or disruption of a service due to a flood event. Impacts assessed include:

- flood impacts due to closure of bridges across the Brisbane River
- interruption of ferry services
- repair of the Wivenhoe Dam fuse-plugs.

Bridge impacts were assessed for five bridges (Fernvale Bridge, Mt Crosby Weir, Burtons Bridge, Colleges Crossing and Kholo Bridge) with relatively low flood immunity along the mid Brisbane River. Impacts were assessed in terms of flood closure time (dependant on duration of inundation) and a cleaning and/or repair time (dependent on peak flow rate).

It should be noted that the use of only historical floods tends to significantly underestimate the total impact costs, particularly for the lower bridges, as it omits the minor events which cause frequent closure and the extreme events that cause prolonged closure. However it gives the relative impact costs and effects of the different scenarios.

A limited assessment of fuse-plug repair costs has been undertaken for this study based on operating modes.

Fuse-plug impact costs are also likely to be underestimated due to the lack of extreme flood events within the analysis. However these costs are typically minor compared to ferry and bridge impacts due to the relatively low frequency of fuse-plug triggering.

Cumulative flood impact costs for each scenario are presented in Figure 10.6.

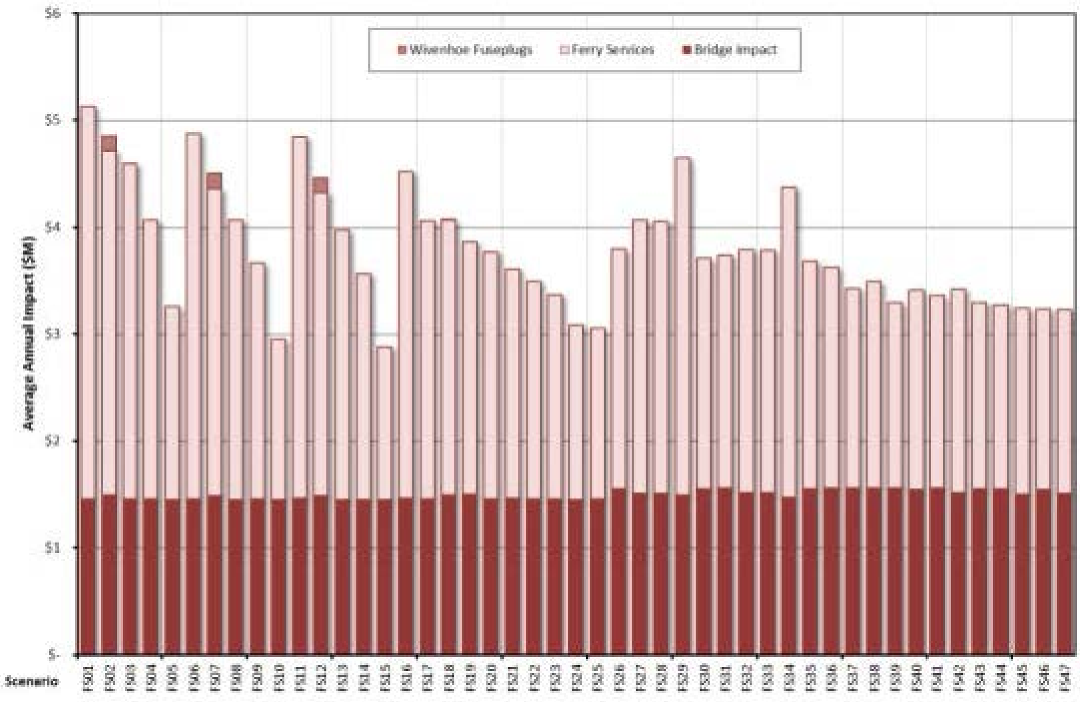



**Figure 10.6 Average annual flood impact costs (AAI)**

## 10.3.3 Total costs

Total AAD and AAI cost estimates for each scenario, based on the modelled historic flood events, are shown in Figure 10.7 and are detailed in Table 10.2, along with the reduction in total costs compared with the base case (FS01).

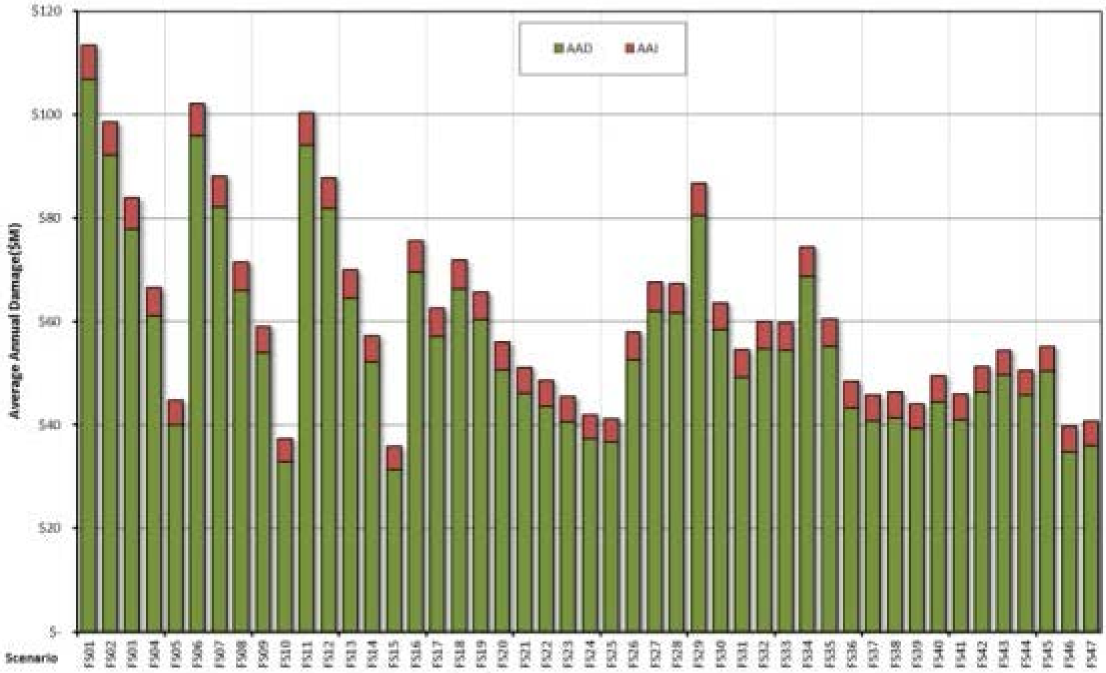



**Figure 10.7 Average annual flood damage and impact costs using historic events**

## 10.3.4 Limitations and assumptions of damages and impacts assessment

The assessment of flood damages/impacts has significant uncertainties due to limitations of the methodology and available data. Although the methodology used was developed using best currently available data, a number of shortcomings were identified. Specific limitations associated with the WSDOS Integrated Assessment Methodology are considered to also apply to the PIFSMI and are documented in Section 8.5 of *'WSDOS/NPDOS Integrated Assessment – WSDOS Assessment Results'* (Aurecon 2014). Additionally, the following limitations should be highlighted:

- Assessment has been limited to a sample of historic events only, which do not necessarily have a complete or statistically balanced distribution of flood frequency or spatial and temporal patterns across the catchment.
- Assessments in Ipswich area are uncertain due to the hydraulic complexities of the Bremer River and Brisbane River interactions during floods which are not able to be adequately reflected in hydrologic modelling.

**Table 10.2 AAD and AAI costs for each development scenario**

| Group | Development Scenario | Scenario No [1] | Infrastructure included [2] | Wivenhoe FSV (%) | Average Annual Damages ($m) | Average Annual Impacts ($m) | Total ($m) | Reduction ($m) |
|---|---|---|---|---|---|---|---|---|
| Existing Wivenhoe Dam | Wivenhoe-1a - Base case | FS01 | Wivenhoe-1a | 100 | $106.888 | $5.131 | $112.020 | |
| | Wivenhoe-1b | FS02 | Wivenhoe-1b | 100 | $92.196 | $4.856 | $97.052 | $14.97 |
| Existing Wivenhoe Dam and Bremer catchment flood mitigation dam(s) | Lower Warrill Creek (Willowbank) AMTD 13.9/14.6 km (flood mitigation dam) | FS06 | Wivenhoe-1a + lower Warrill Ck AMTD 13.9/14.6 km (flood mitigation dam) | 100 | $95.873 | $4.876 | $100.748 | $11.27 |
| | | FS07 | Wivenhoe-1b + lower Warrill Ck AMTD 13.9/14.6 km (flood mitigation dam) | 100 | $82.208 | $4.507 | $86.715 | $25.31 |
| | Multiple storages in Bremer R sub-catchment (flood mitigation) | FS11 | Wivenhoe-1a + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 100 | $94.117 | $4.848 | $98.965 | $13.06 |
| | | FS12 | Wivenhoe-1b + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 100 | $81.944 | $4.467 | $86.411 | $25.61 |
| Existing Wivenhoe Dam and Upper Brisbane catchment flood mitigation dam(s) | Brisbane River (Linville) AMTD 282.3 km – 348,000 ML (flood mitigation dam) | FS16 | Wivenhoe-1a + Brisbane R AMTD 282.3 km (flood mitigation dam) | 100 | $69.674 | $4.526 | $74.200 | $37.82 |
| | | FS18 | Wivenhoe-1b + Brisbane R AMTD 282.3 km (flood mitigation dam) | 100 | $66.357 | $4.079 | $70.436 | $41.58 |
| | Multiple storages u/s of Wivenhoe Dam (flood mitigation) | FS17 | Wivenhoe-1a + Brisbane R AMTD 282.3 km + Emu Ck AMTD 10.8 km (flood mitigation dams) | 100 | $57.140 | $4.068 | $61.208 | $50.81 |
| | | FS19 | Wivenhoe-1b + Brisbane R AMTD 282.3 km + Emu Ck AMTD 10.8 km (flood mitigation dams) | 100 | $60.457 | $3.872 | $64.329 | $47.69 |
| Wivenhoe Dam raising only | Wivenhoe Dam raising – 1.5 m raising | FS03 | Wivenhoe-2. | 100 | $77.942 | $4.599 | $82.541 | $29.48 |
| | Wivenhoe Dam raising – 4 m raising | FS04 | Wivenhoe-3 | 100 | $61.106 | $4.072 | $65.178 | $46.84 |
| | Wivenhoe Dam raising – 8 m raising | FS05 | Wivenhoe-4 | 100 | $40.124 | $3.261 | $43.385 | $68.64 |
| Wivenhoe Dam raising (100% FSV) with additional flood mitigation dam(s) | Wivenhoe Dam raisings with a single storage in the Bremer R sub-catchment (flood mitigation) | FS08 | Wivenhoe-2 + lower Warrill Ck AMTD 13.9/14.6 km (flood mitigation dam) | 100 | $66.067 | $4.073 | $70.141 | $41.88 |
| | | FS09 | Wivenhoe-3 + lower Warrill Ck AMTD 13.9/14.6 km (flood mitigation dam) | 100 | $54.022 | $3.668 | $57.689 | $54.33 |
| | | FS10 | Wivenhoe-4 + lower Warrill Ck AMTD 13.9/14.6 km (flood mitigation dam) | 100 | $32.991 | $2.952 | $35.943 | $76.08 |
| | Wivenhoe Dam raisings with multiple storages in Bremer R sub-catchment (flood mitigation) | FS13 | Wivenhoe-2 + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 100 | $64.573 | $3.976 | $68.549 | $43.47 |
| | | FS14 | Wivenhoe-3 + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 100 | $52.292 | $3.570 | $55.861 | $56.16 |
| | | FS15 | Wivenhoe-4 + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 100 | $31.486 | $2.884 | $34.370 | $77.65 |

| Group | Development Scenario | Scenario No [1] | Infrastructure included [2] | Wivenhoe FSV (%) | Average Annual Damages ($m) | Average Annual Impacts ($m) | Total ($m) | Reduction ($m) |
|---|---|---|---|---|---|---|---|---|
| | Wivenhoe Dam raisings with Brisbane River (Linville) AMTD 282.3 km (flood mitigation) | FS20 | Wivenhoe-2 + Brisbane R AMTD 282.3 km (flood mitigation dam) | 100 | $50.801 | $3.775 | $54.576 | $57.44 |
| | | FS22 | Wivenhoe-3 + Brisbane R AMTD 282.3 km (flood mitigation dam) | 100 | $43.650 | $3.499 | $47.149 | $64.87 |
| | | FS24 | Wivenhoe-4 + Brisbane R AMTD 282.3 km (flood mitigation dam) | 100 | $37.447 | $3.090 | $40.537 | $71.48 |
| | Wivenhoe Dam raisings with multiple storages u/s of Wivenhoe Dam (flood mitigation) | FS21 | Wivenhoe-2 + Brisbane R AMTD 282.3 km + Emu Ck AMTD 10.8 km (flood mitigation dams) | 100 | $46.148 | $3.615 | $49.762 | $62.26 |
| | | FS23 | Wivenhoe-3 + Brisbane R AMTD 282.3 km + Emu Ck AMTD 10.8 km (flood mitigation dams) | 100 | $40.650 | $3.373 | $44.023 | $68.00 |
| | | FS25 | Wivenhoe-4 + Brisbane R AMTD 282.3 km + Emu Ck AMTD 10.8 km (flood mitigation dams) | 100 | $36.721 | $3.059 | $39.780 | $72.24 |
| Wivenhoe Dam raising (lowered FSVs) with additional flood mitigation and water supply dam(s) | Wivenhoe Dam raisings with Brisbane River AMTD 282.3 km (water supply dam) | FS36 | Wivenhoe-2 + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) | 60 | $43.364 | $3.626 | $46.990 | $65.03 |
| | | FS37 | Wivenhoe-3 + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) | 60 | $40.788 | $3.433 | $44.221 | $67.80 |
| | Wivenhoe Dam raisings with Brisbane River AMTD 282.3 km (water supply dam) and Emu Creek AMTD 10.8 km (flood mitigation) | FS38 | Wivenhoe-2 + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) + Emu Ck AMTD 10.8 km (flood mitigation) | 60 | $41.403 | $3.494 | $44.898 | $67.12 |
| | | FS39 | Wivenhoe-3 + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) + Emu Ck AMTD 10.8 km (flood mitigation) | 60 | $39.251 | $3.298 | $42.549 | $69.47 |
| | Wivenhoe Dam raisings with Brisbane River AMTD 282.3 km (water supply dam), lower Warrill Creek AMTD 13.9/14.6 km and Bremer River AMTD 70 km (flood mitigation dams) | FS46 | Wivenhoe-2 + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 60 | $34.905 | $3.240 | $38.145 | $73.88 |
| | | FS47 | Wivenhoe-3 + Brisbane R AMTD 282.3 km (water supply dam FSV 510,000 ML) + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 6075 | $36.014 | $3.234 | $39.248 | $72.77 |
| Existing Wivenhoe Dam with additional water supply dam | Brisbane River AMTD 282.3 km - (water supply dam) – 240,000 ML | FS29 | Wivenhoe-1a + Brisbane R AMTD 282.3 km (water supply dam FSV 240,000 ML) | 85 | $80.648 | $4.648 | $85.296 | $26.72 |
| | Brisbane River AMTD 282.3 km - (water supply dam) – 510,000 ML | FS27 | Wivenhoe-1a + Brisbane R AMTD 282.3 km (water supply dam FSV 510,000 ML) | 75 | $62.082 | $4.072 | $66.155 | $45.87 |
| | Brisbane River AMTD 282.3 km - (water supply dam) – 570,000 ML | FS28 | Wivenhoe-1a + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) | 75 | $61.776 | $4.061 | $65.837 | $46.18 |
| | Brisbane River AMTD 282.3 km - (water supply dam) – 570,000 ML | FS26 | Wivenhoe-1a + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) | 60 | $52.628 | $3.801 | $56.429 | $55.59 |

| Group | Development Scenario | Scenario No [1] | Infrastructure included [2] | Wivenhoe FSV (%) | Average Annual Damages ($m) | Average Annual Impacts ($m) | Total ($m) | Reduction ($m) |
|---|---|---|---|---|---|---|---|---|
| | Brisbane River AMTD 282.3 km - (water supply dam) – 570,000 ML | FS30 | Wivenhoe-1b + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) | 60 | $58.439 | $3.713 | $62.152 | $49.87 |
| Existing Wivenhoe Dam (lowered FSVs) with additional flood Mitigation and Water Supply Offset dams | Combined Brisbane River AMTD 282.3 km - (water supply dam) and Emu Creek AMTD 10.8 km (flood mitigation dam) | FS34 | Wivenhoe-1a + Brisbane R AMTD 282.3 km (water supply dam FSV 240,000 ML) + Emu Ck AMTD 10.8 km (flood mitigation dam) | 85 | $68.723 | $4.378 | $73.101 | $38.92 |
| | | FS32 | Wivenhoe-1a + Brisbane R AMTD 282.3 km (water supply dam FSV 510,000 ML) + Emu Ck AMTD 10.8 km (flood mitigation dam) | 75 | $54.783 | $3.795 | $58.578 | $53.44 |
| | | FS33 | Wivenhoe-1a + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) + Emu Ck AMTD 10.8 km (flood mitigation dam) | 75 | $54.517 | $3.791 | $58.307 | $53.71 |
| | | FS31 | Wivenhoe-1a + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) + Emu Ck AMTD 10.8 km (flood mitigation dam) | 60 | $49.308 | $3.744 | $53.052 | $58.97 |
| | | FS35 | Wivenhoe-1b + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) + Emu Ck AMTD 10.8 km (flood mitigation dam) | 60 | $55.261 | $3.689 | $58.949 | $53.07 |
| | Combined Brisbane River AMTD 282.3 km - (water supply dam) and multiple storages in the Bremer R sub-catchment (flood mitigation dams) | FS40 | Wivenhoe-1a + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 60 | $44.530 | $3.419 | $47.949 | $64.07 |
| | | FS43 | Wivenhoe-1b + Brisbane R AMTD 282.3 km (water supply dam FSV 570,000 ML) + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 60 | $49.663 | $3.300 | $52.962 | $59.06 |
| | Combined Linville (water supply dam) with multiple storages in the Bremer R sub-catchment and u/s of Wivenhoe Dam (flood mitigation dams) | FS42 | Wivenhoe-1a + Brisbane R AMTD 282.3 km (water supply dam FSV 510,000 ML) + Emu Ck AMTD 10.8 km + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 75 | $46.385 | $3.426 | $49.811 | $62.21 |
| | | FS45 | Wivenhoe-1b + Brisbane R AMTD 282.3 km (water supply dam FSV 510,000 ML) + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 75 | $50.525 | $3.246 | $53.770 | $58.25 |
| | Combined Linville (water supply dam) with multiple storages in the Bremer R sub-catchment and u/s of Wivenhoe Dam (flood mitigation dams) | FS41 | Wivenhoe-1a + Brisbane R AMTD 282.3 km (water supply dam FSV 510,000 ML) + Emu Ck AMTD 10.8 km + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 60 | $41.124 | $3.366 | $44.490 | $67.53 |
| | | FS44 | Wivenhoe-1b + Brisbane R AMTD 282.3 km (water supply dam FSV 510,000 ML) + Emu Ck AMTD 10.8 km + lower Warrill Ck AMTD 13.9/14.6 km + Bremer R AMTD 70 km (flood mitigation dams) | 60 | $45.776 | $3.276 | $49.052 | $62.97 |

Notes:

1. Refer to Table 9.2
2. Wivenhoe Dam raisings/upgrade options as follows:
   Wivenhoe-1a – Wivenhoe Dam with Urban 3 dam operations (DEWS 2014) and dam safety upgrades
   Wivenhoe-1b - Wivenhoe Dam with Urban 4 dam operations (DEWS 2014) and associated fuse plug upgrade and dam safety upgrades
   Wivenhoe-2 – Wivenhoe Dam raised 1.5 m incorporating dam safety upgrades and new dam operations.
   Wivenhoe-3 – Wivenhoe Dam raised 4 m incorporating dam safety upgrades and new dam operations.
   Wivenhoe-4 – Wivenhoe Dam raised 8 m incorporating dam safety upgrades and new dam operations.

1. NPC flood savings refers to the NPC of the reduction in flood damages and impacts for the scenario compared to the base case of FS01. and are based on a 40 year operating horizon and 7% p.a. discount rate.

## 10.4 Economic evaluation of scenarios

DSDIP (2014) conducted an economic evaluation of the 47 flood mitigation scenarios. This aimed to narrow the infrastructure options for flood mitigation in Brisbane and Ipswich by determining the most promising options in terms of economic viability.

Costs comprise the capital and operating costs associated with each infrastructure option whilst benefits are the avoided costs of floods as a result of improvement in mitigation. In this (and most) studies, these avoided costs are typically measured in terms of the tangible (mostly direct) damages.

### 10.4.1 Cost benefit analysis

The main costs in this study are the estimated capital and operating costs associated with each proposed infrastructure option as described in Chapter 7 (for new infrastructure options) and Chapter 8 (for Wivenhoe upgrade options) and summarised in Table 10.1. Estimates for Wivenhoe Dam upgrades are considered to have a -30%/+50% level of accuracy, while costings for new mitigation infrastructure have a -30%/+60% level of accuracy.

The benefits are the avoided costs of improved flood mitigation, based on the reduction of average annual damages and impacts costs of each scenario compared with the base case FS01 (see Table 10.2).

### 10.4.2 Discount rate and timeframe of analysis

The cost-benefit analysis for this study used a real discount rate of 7 per cent (central estimate) over the 2014-15 to 2060-61 period, which includes a design and approval phase, construction phase and 40 year operational phase. The discount rate was sensitivity-tested using 4 and 10 per cent discount rates. The selection of the central discount rate and appropriate rates for sensitivity testing is in line with Infrastructure Australia (2013) guidelines for infrastructure project appraisal.

### 10.4.3 Limitations of economic evaluation

The intangible costs and some tangible indirect costs of flooding (refer to section 10.3) were not assessed for this evaluation but would likely be significant. Thus the total benefits for each scenario are likely to be under estimated and this needs to be taken into account when reviewing the benefit cost assessments presented in this chapter.

The study has excluded several potential externalities such as environmental impacts, impact on urban density, housing market and insurance, as well as potential impacts (if any) on bulk water prices. These externalities, although important, are not deemed to be critical at this point in the initial process of shortlisting scenarios.

### 10.4.4 Results of economic evaluation

A detailed breakdown of results, coupled with scenario ranking based on NPV and also BCRs, is presented in Table 10.3 (those cells shaded in green have a positive NPV at a 7% real discount rate).

Note that the relative ranking of each scenario in Table 10.3 is based on NPV. Ranking would vary slightly (i.e. first and second ranked options swap places) if ranked on BCR.

**Table 10.3 Economic analysis results, NPV (7% real discount rate)**

| Scenario No | Total present costs[1] (infrastructure + AAD + AAI) ($m) | Ratio of total present costs[2] (FS01 over Scenario) | Present value of benefits[3] (AAD + AAI avoided) ($m) | Present value of costs[4] (incremental) ($m) | NPV[5] (PV of benefits less PV of costs) ($m) | NPV Rank[6] | BCR for scenarios[7] (PV benefits over PV costs) |
|---|---|---|---|---|---|---|---|
| FS01 | 1,823.8 | | | | | | |
| FS02 | 1,758.2 | 1.04 | 106.8 | 41.1 | 65.7 | 2 | 2.60 |
| FS03 | 1,758.1 | 1.04 | 261.9 | 196.1 | 65.8 | 1 | 1.34 |
| FS04 | 1,863.6 | 0.98 | 386.9 | 426.7 | -39.7 | 8 | 0.91 |
| FS05 | 2,047.8 | 0.89 | 527.0 | 751.0 | -224.0 | 21 | 0.70 |
| FS06 | 2,088.2 | 0.87 | 107.6 | 372.1 | -264.4 | 25 | 0.29 |
| FS07 | 2,074.0 | 0.88 | 241.7 | 491.9 | -250.2 | 23 | 0.49 |
| FS08 | 2,006.9 | 0.91 | 372.0 | 555.1 | -183.0 | 16 | 0.67 |
| FS09 | 2,160.1 | 0.84 | 448.8 | 785.1 | -336.3 | 29 | 0.57 |
| FS10 | 2,348.6 | 0.78 | 584.2 | 1,108.9 | -524.7 | 39 | 0.53 |
| FS11 | 2,183.5 | 0.84 | 124.7 | 484.3 | -359.7 | 31 | 0.26 |
| FS12 | 2,184.6 | 0.83 | 244.6 | 605.4 | -360.8 | 32 | 0.40 |
| FS13 | 2,099.5 | 0.87 | 386.2 | 661.9 | -275.7 | 26 | 0.58 |
| FS14 | 2,251.5 | 0.81 | 463.9 | 891.5 | -427.6 | 34 | 0.52 |
| FS15 | 2,442.6 | 0.75 | 596.2 | 1,215.0 | -618.7 | 42 | 0.49 |
| FS16 | 1,806.6 | 1.01 | 361.2 | 343.9 | 17.2 | 4 | 1.05 |
| FS17 | 1,912.1 | 0.95 | 485.2 | 573.5 | -88.3 | 11 | 0.85 |
| FS18 | 1,889.2 | 0.97 | 397.1 | 462.5 | -65.4 | 10 | 0.86 |
| FS19 | 2,060.5 | 0.89 | 455.4 | 692.1 | -236.7 | 22 | 0.66 |
| FS20 | 1,832.4 | 1.00 | 510.3 | 518.9 | -8.6 | 6 | 0.98 |
| FS21 | 2,004.8 | 0.91 | 553.1 | 734.0 | -181.0 | 15 | 0.75 |
| FS22 | 2,036.1 | 0.90 | 535.9 | 748.2 | -212.3 | 20 | 0.72 |
| FS23 | 2,225.1 | 0.82 | 561.7 | 963.0 | -401.3 | 33 | 0.58 |
| FS24 | 2,346.2 | 0.78 | 548.9 | 1,071.3 | -522.4 | 38 | 0.51 |
| FS25 | 2,554.9 | 0.71 | 554.7 | 1,285.7 | -731.0 | 45 | 0.43 |
| FS26 | 1,759.9 | 1.04 | 530.9 | 467.0 | 63.9 | 3 | 1.14 |
| FS27 | 1,829.9 | 1.00 | 438.0 | 444.1 | -6.1 | 5 | 0.99 |
| FS28 | 1,849.8 | 0.99 | 441.0 | 467.0 | -25.9 | 7 | 0.94 |
| FS29 | 1,927.7 | 0.95 | 237.4 | 341.3 | -103.9 | 12 | 0.70 |
| FS30 | 1,933.2 | 0.94 | 476.2 | 585.6 | -109.3 | 13 | 0.81 |
| FS31 | 1,957.3 | 0.93 | 563.1 | 696.6 | -133.4 | 14 | 0.81 |
| FS32 | 2,022.8 | 0.90 | 474.7 | 673.7 | -198.9 | 18 | 0.70 |
| FS33 | 2,007.4 | 0.91 | 512.9 | 696.6 | -183.6 | 17 | 0.74 |
| FS34 | 2,023.1 | 0.90 | 371.7 | 570.9 | -199.2 | 19 | 0.65 |
| FS35 | 2,132.2 | 0.86 | 506.8 | 815.2 | -308.3 | 28 | 0.62 |

| Scenario No | Total present costs[1] (infrastructure + AAD + AAI) ($m) | Ratio of total present costs[2] (FS01 over Scenario) | Present value of benefits[3] (AAD + AAI avoided) ($m) | Present value of costs[4] (incremental) ($m) | NPV[5] (PV of benefits less PV of costs) ($m) | NPV Rank [6] | BCR for scenarios[7] (PV benefits over PV costs) |
|---|---|---|---|---|---|---|---|
| FS36 | 1,880.0 | 0.97 | 577.7 | 633.9 | -56.2 | 9 | 0.91 |
| FS37 | 2,125.7 | 0.86 | 560.1 | 862.0 | -301.9 | 27 | 0.65 |
| FS38 | 2,076.6 | 0.88 | 596.3 | 849.1 | -252.8 | 24 | 0.70 |
| FS39 | 2,326.7 | 0.78 | 573.9 | 1,076.8 | -502.9 | 36 | 0.53 |
| FS40 | 2,165.1 | 0.84 | 611.9 | 953.2 | -341.3 | 30 | 0.64 |
| FS41 | 2,361.7 | 0.77 | 644.9 | 1,182.7 | -537.8 | 40 | 0.55 |
| FS42 | 2,412.5 | 0.76 | 594.1 | 1,182.7 | -588.7 | 41 | 0.50 |
| FS43 | 2,331.6 | 0.78 | 564.0 | 1,071.8 | -507.8 | 37 | 0.53 |
| FS44 | 2,523.8 | 0.72 | 601.3 | 1,301.3 | -700.0 | 43 | 0.46 |
| FS45 | 2,568.9 | 0.71 | 556.3 | 1,301.3 | -745.1 | 46 | 0.43 |
| FS46 | 2,267.2 | 0.80 | 656.3 | 1,099.6 | -443.4 | 35 | 0.60 |
| FS47 | 2,528.1 | 0.72 | 601.1 | 1,305.4 | -704.3 | 44 | 0.46 |

Notes:

1. Total present cost of base case and scenarios. It includes capital, operating and maintenance expenditures, plus AAD and indirect flood damage costs over 2015-16 to 2060-61 (to include 40 years of operational phase) at 7% real discount rate.
2. Ratio of total present costs for base case (FS01) over total present costs for respective scenarios.
3. Present value of benefits, reflected as avoided costs in AAD and AAI relative to base case. Based on 40 years operation of flood mitigation infrastructure.
4. Reflects capital and operational and maintenance costs for the flood mitigation infrastructure. It is presented in an incremental sense, relative to the base case capital expenditure of $325.1 million and $0.05 million operation and maintenance costs.
5. Reflects the difference between present value of benefits and present value of costs (these are relative to base case FS01, at 7% real discount rate).
6. Reflects the NPV ranking from largest to smallest.
7. BCR calculated as a ratio of present value of benefits (relative to the base case) over present value of costs (relative to the base case) for respective scenarios.

## 10.5 Summary of economic assessment

The following conclusions can be drawn for the flood damages assessment and economic analyses:

### 10.5.1 Costs of flooding

- Total average annual flood damage and impact costs assessed using historical flood events indicate an average annual cost for the base case of around $112m (refer Table 10.2)
- Annual reductions in flood damage and impact costs for the 47 flood mitigation scenarios assessed range from approximately $10m–$80m; with most reducing costs by at least $40m per year (or 36%).
- While the use of historic events underestimates flood impact costs (and to a lesser degree, flood damage costs) these figures provide an indication of the relative costs of flooding and the effect of different scenarios in reducing those costs.
- The method used also only estimates direct and limited indirect tangible flood costs (i.e. it does not include intangible costs nor all indirect tangible costs - section 10.3)

and hence is generally acknowledged to under-estimate total flood costs (and hence likely underestimated savings/benefits).

### 10.5.2 Capital Costs

- The capital costs of new flood storage infrastructure options range from $138m for a flood mitigation storage on the Bremer River AMTD 70 km to $575m for a water supply offset dam at Brisbane River AMTD 282.3 km that would allow the flood storage compartment in Wivenhoe Dam to be significantly increased
- The capital costs for upgrades to Wivenhoe Dam range from $325m for the base case (to address dam safety requirements) to $1,373m for an 8 m raising (including addressing dam safety requirements)

### 10.5.3 Economic Analysis

- Economic analysis by DSDIP provided NPVs and BCRs for all scenarios. Figure 10.8 summarises the economic analysis results.
- The results of the scenario assessment should be treated with caution, as both the costs and benefits have only been determined at a prefeasibility level of accuracy.

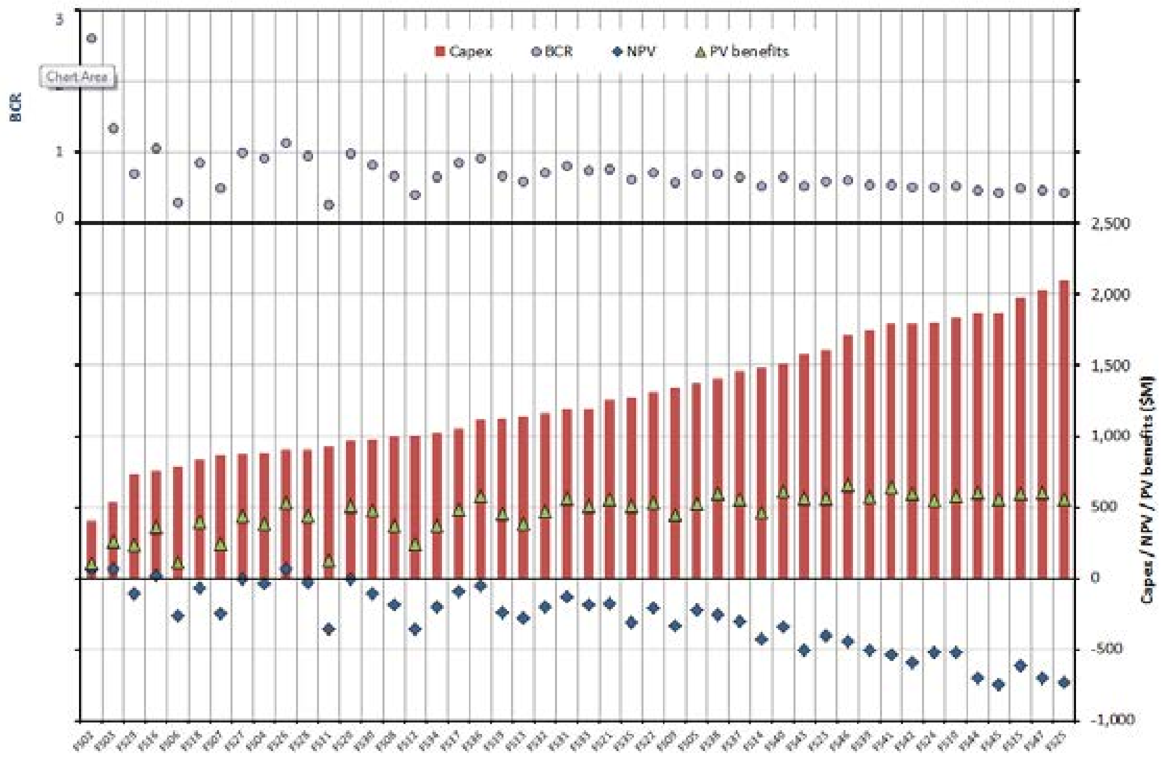



**Figure 10.8 Capex, BCR, NPV and PV of benefits for each scenario**

These results show that:

- Using a real discount rate of 7%, four scenarios have an NPV greater than zero and a BCR > 1.0 (i.e. are estimated to provide net economic benefits) - FS02, FS03, FS16 and FS26.
- The above scenarios involve potential infrastructure investments at only two locations:
  - the existing Wivenhoe Dam
  - the Brisbane River AMTD 282.3 km dam site (near Linville)
- The two top-ranking scenarios (FS03 and FS02) have a significantly lower estimated capital expenditure than other scenarios examined in this study ($534.8m and $399.0m respectively or an incremental increase in capital expenditure of $209.7m and $73.9m over the base case respectively).
- FS16 and FS26 have an estimated capital expenditure of around $750m–$900m ($428.9m and $575m respectively greater than the base case, FS01) but have higher benefits than FS02 and FS03.
- Scenarios that have been assessed as having an only marginally negative NPV are FS04, FS20, FS27, FS28 and FS36 which, combined with the above, provide the top-9 ranked scenarios in terms of NPV (refer Table 10.4). All of these scenarios have an estimated capital expenditure of less than $1 billion (except FS36, which is slightly higher at an estimated $1.1 billion). Also, they all have a benefit-cost ratio of 0.91 or higher, but less than 1. Given the prefeasibility nature of the analysis, these particular projects could also be given further consideration.
- Conversely, there are a number of scenarios which appear to be economically non-viable, generating a large negative NPV and lower benefit-cost ratio. The 10 economically weakest scenarios are FS25, FS47, FS45, FS44, FS15, FS42, FS41, FS10, FS24 and FS39. All of these scenarios had an NPV of less than negative $500m (and BCR's less than 0.6); and capital expenditure higher than $1.7 billion.
- Scenarios which include 8 m raising of the Wivenhoe Dam generally appear to be economically non-viable (best NPV and BCR are for FS05 and are -$224m and 0.7 respectively).
- Scenario FS18 ranked tenth in the economic analysis but given the substantial concerns regarding scenarios involving WSDOS Urban 4 operations of Wivenhoe Dam (refer Chapter 8 and ES2) it has been excluded from further consideration. It is not included in Table 10.4. FS02 is included as it ranked highest – however it is not proposed to be considered further either due to the concerns over the operation of Wivenhoe Dam under WSDOS Urban 4.
- The analysis indicates a relatively low present value of benefits ($107.6m) and relatively high present value of costs ($372.1m) for a storage at the lower Warrill Creek AMTD 14.6 km site (near Willowbank) resulting in a poor BCR (0.29); even though it gives a NPV that is in the mid-range of all results (-$264m). BCR and NPV results are obviously sensitive to capital costs and the capital cost of a lower Warrill Creek AMTD 14.6 km storage is highly dependent on:
  - Alignment - co-location with the proposed Southern Freight Railway creates a significantly longer structure without sufficient savings through cost sharing to compensate for the extra cost. The shorter separate alignment (located approximately 700 m downstream) would give a net saving of around $20m
  - Construction standard – costs for the lower Warrill Creek structure have been based on meeting full water retaining dam safety standards
  - Infrastructure relocation - accounts for approximately $141m of the estimated capital costs (of which the relocations of high voltage power transmission lines are significant costs).

### 10.5.4 Sensitivity analyses

A range of sensitivity analyses were applied to the analysis, including higher and lower costs and benefits as well as higher and lower discount rates (including without the residual value). The results for the top nine ranked scenarios are shown in Table 10.5.

The results are highly sensitive to the discount rate. When using a 4% real discount rate, 30 of the 47 scenarios analysed have a positive NPV.

The sensitivity analysis allowing for a 20% rise in all costs and a 20% higher benefit, shows all ten top scenarios (ranked by NPV) achieve a positive NPV.

Figure 10.9 shows the peak flood flow mitigation that should be achievable with each of the top nine scenarios relative to the base case (FS01); along with the peak flow contribution from the catchment contributing downstream of Wivenhoe Dam.

The figure indicates that for many of the historical floods the top nine scenarios are approaching the maximum mitigation that can be achieved by options based on Wivenhoe Dam with or without a dam at Brisbane River AMTD 282.3 km (i.e. that mitigate flood flows from upstream of Wivenhoe Dam only).

In a number of the historical floods it would be necessary to consider options in the catchments downstream of Wivenhoe Dam (such as in the Lockyer or Bremer catchments) to achieve any significantly greater levels of mitigation.

Table 10.6 gives the estimated reduction in peak flood flows and the number of buildings inundated compared with current[13] operations for a recurrence of the largest 6 historical floods

[13] i.e. FS01 – existing dams and WSDOS Urban 3 operations

**Table 10.4 Top nine ranked scenarios plus the 8 m Wivenhoe Dam raising and lower Warrill Creek flood storage scenarios**

| Scenario Number | Description (Top 9 ranked scenarios plus 8 m Wivenhoe Dam raising and lower Warrill Creek flood storage scenarios) | Number of properties impacted by acquisitions | Estimated Capital Cost [1] $m | Reduced damages and impacts cost (over 40 years @ 7% real discount rate) [2] $m | Present value of cost [3] $m | Net Present Value (7% real discount rate) [4] $m | Benefit Cost Ratio |
|---|---|---|---|---|---|---|---|
| FS02 [5] | Alternative Urban 4 Operations<br>– infrastructure improvements to existing emergency spillway<br>– install a second emergency spillway | 214 | $399 | $107 | $41 | $65.7 | 2.60 |
| FS03 | Raise Wivenhoe Dam by 1.5 m<br>– install a second emergency spillway<br>– optimise flood operations | 214 | $535 | $262 | $196 | $65.8 | 1.34 |
| FS04 | Raise Wivenhoe Dam by 4.0 m<br>– install a second emergency spillway<br>– optimise flood operations | 235 | $881 | $387 | $427 | -$40 | 0.91 |
| FS05 [5] | Raise Wivenhoe Dam by 8.0 m | 297 | $1,373 | $527 | $751 | -$224 | 0.70 |
| FS06 | 125,000 ML lower Warrill Creek Dam near Willowbank<br>– lower Warrill Creek Dam constructed to be a dry flood mitigation dam.<br>– existing Wivenhoe Dam operations | 110 (15 houses) | $461 [6] | $108 | $372 | -$264 | 0.29 |
| FS16 | Existing Wivenhoe Dam plus new 350,000 ML dam near Linville<br>– dam near Linville constructed to be a dry flood mitigation dam<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville | 49 (14 houses) | $754 | $361 | $344 | $17 | 1.05 |
| FS 20 | Raise Wivenhoe Dam by 1.5 m plus new 350,000ML dam near Linville<br>– dam near Linville constructed to be a dry flood mitigation dam<br>– raise existing emergency spillway by 1 metre<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville | 263 (14 houses) | $964 | $510 | $519 | -$9 | 0.98 |
| FS26 | Existing Wivenhoe Dam plus new 570,000 ML dam near Linville<br>– dam near Linville constructed to be a water supply storage<br>– lower Wivenhoe Dam to 60 per cent full supply volume<br>– install a second emergency spillway on Wivenhoe Dam<br>– no net loss to South East Queensland Water Supply Security | 49 (25 houses) | $900 | $531 | $467 | $64 | 1.14 |
| FS27 | Existing Wivenhoe Dam plus new 510,000 ML dam near Linville<br>– dam near Linville constructed to be a water supply storage<br>– lower Wivenhoe Dam to 75 per cent full supply volume<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville<br>– no net loss to South East Queensland Water Supply Security | 49 (24 houses) | $870 | $438 | $444 | -$6 | 0.99 |
| FS28 | Existing Wivenhoe Dam plus new 570,000 ML dam near Linville<br>– dam near Linville constructed to be a water supply storage<br>– lower Wivenhoe Dam to 75 per cent full supply volume<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville | 49 (25 houses) | $900 | $441 | $467 | -$26 | 0.94 |
| FS36 | Raise Wivenhoe Dam by 1.5 m plus new 570,000 ML dam near Linville<br>– dam near Linville constructed to be water supply dam<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville<br>– Wivenhoe Dam lowered to 60% full supply volume | 263 (min 25 houses) | $1,110 | $577 | $634 | -$56 | 0.91 |

Notes:

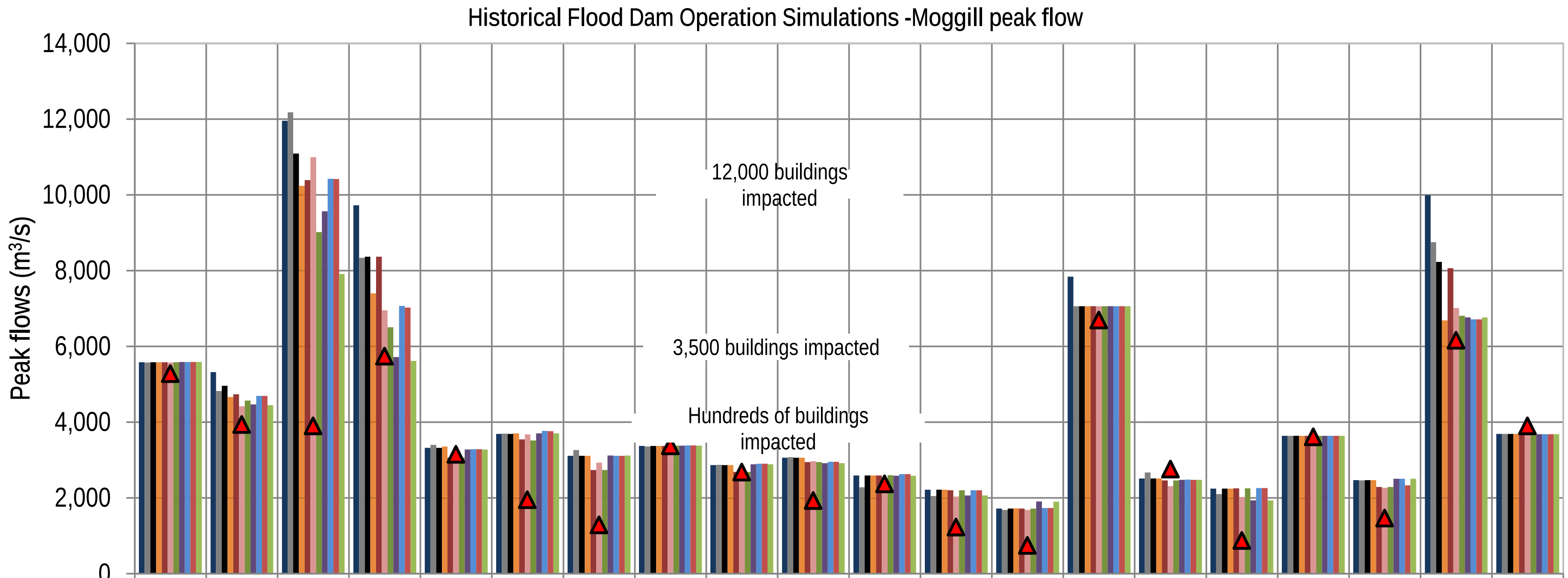
1. Estimated capital cost includes the cost of necessary dam safety upgrades for Wivenhoe Dam with the exception of catchment scenario no. FS06 (refer Note 6).
2. Compared to the Base Case (FS01).
3. Includes capital and operating and maintenance costs and residual value (60 years of remaining useful life added back as partial offset to initial capital cost).
4. Reflects NPV at real discount rate for 40 years operational phase.
5. Table includes FS02 however it is not proposed to be considered further due to concerns over operation of Wivenhoe Dam under WSDOS Urban 4. FS05 included for comparison purposes only.
6. Cost for lower Warrill Creek dam only.

**Table 10.5 Results of sensitivity assessments for top nine scenarios**

| Scenario No. | NPV rank | Description | Capital Costs increment[1] ($m) | Present value of benefits (i.e. reduced damage costs)[2] ($m) | Present value of costs [3] ($m) | Benefit cost ratio | NPV at 7%[4] ($m) | NPV at 4%[4] ($m) | NPV at 10%[4] ($m) | NPV at 4% without residual value[5] ($m) | NPV with 40% higher capital costs[6] ($m) | NPV with all costs and benefits 20% higher[7] ($m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FS03 | 1 | Wivenhoe Dam raised 1.5 m with Urban 5 strategy | $209.7 | $261.9 | $196.1 | 1.34 | $65.8 | $272.5 | -$28.4 | $253.4 | $3.6 | $225.6 |
| FS02 | 2 | Wivenhoe dam 100% FSV, Urban 4 strategy | $73.9 | $106.8 | $41.1 | 2.60 | $65.7 | $154.8 | $27.5 | $147.2 | $59.9 | $217.3 |
| FS26 | 3 | Wivenhoe Dam with Urban 3,60% FSV, Linville as a water supply dam (570GL &160 m spillway) | $575.0 | $530.9 | $467.0 | 1.14 | $63.9 | $411.4 | -$83.7 | $357.7 | -$92.6 | $184.5 |
| FS16 | 4 | Wivenhoe 100% FSV, URBAN 3 strategy, and Linville dam as a dry flood mitigation storage | $428.9 | $361.2 | $343.9 | 1.05 | $17.2 | $259.5 | -$84.8 | $219.9 | -$99.2 | $162.4 |
| FS27 | 5 | Wivenhoe Dam with Urban 3,60% FSV, Linville as a water supply dam (570GL &160 m spillway) | $544.4 | $438.0 | $444.1 | 0.99 | -$6.1 | $275 | -$121.7 | $224.2 | -$154.1 | $119.0 |
| FS20 | 6 | Wivenhoe Dam raised 1.5 m with Urban, dam near Linville in place as flood mitigation storage | $638.6 | $510.3 | $518.9 | 0.98 | -$8.6 | $364.7 | -$163.6 | $303.3 | -$179.1 | $86.7 |
| FS28 | 7 | Wivenhoe Dam with Urban 3,75% FSV , 570 GL dam near Linville (water supply and flood mitigation dam) | $575.0 | $441 | $467 | 0.94 | -$25.9 | $256.8 | -$140.9 | $203.1 | -$182.5 | $94.6 |
| FS04 | 8 | Wivenhoe Dam raised 4.0 m with Urban 6 | $556.3 | $386.9 | $426.7 | 0.91 | -$39.7 | $264.6 | -$161.8 | $209.8 | -$176.5 | $60 |
| FS36 | 9 | Wivenhoe Dam raised 1.5 m with Urban 5, 60% FSV, Linville dam as a water supply and flood mitigation (570GL storage) | $784.7 | $577.7 | $633.9 | 0.91 | -$56.2 | $349.5 | -$219.4 | $273.6 | -$264.2 | $16 |

Notes:

1. Capital costs including relevant dam safety upgrades less $325 million for business-as-usual (FS01) in 2014-15 dollars.
2. Present value of benefits, reflected as avoided costs in AAD and AAI relative to business-as-usual at 7% real discount rate.
3. Includes capital and operating and maintenance costs and residual value (60 years of remaining useful life added back as partial offset to initial capital cost).
4. Reflects NPV at real discount rate for 40 years operational phase.
5. NPV at 4% real discount rate without the residual value.
6. Reflects increase in design and construction costs by 40 per cent.
7. Reflects a 20% increase of all capital, operating and maintenance costs, as well as 20% higher avoided costs (i.e. benefit) in terms of AADs and flood impact damage. Comparative hydrologic performance of top nine scenarios




| | 1887.01 | 1890.03 | 1893.01 | 1893.02 | 1893.06 | 1898.01 | 1898.03 | 1908.03 | 1931.01 | 1955.03 | 1959.11 | 1971.02 | 1973.07 | 1974.01 | 1983.06 | 1989.04 | 1996.04 | 1999.02 | 2011.01 | 2013.01 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FS01 | 5582 | 5326 | 11959 | 9727 | 3320 | 3692 | 3111 | 3374 | 2866 | 3064 | 2593 | 2215 | 1721 | 7845 | 2516 | 2247 | 3638 | 2470 | 9995 | 3688 |
| FS02 | 5574 | 4823 | 12180 | 8338 | 3401 | 3699 | 3263 | 3357 | 2875 | 3079 | 2286 | 2052 | 1681 | 7065 | 2673 | 2105 | 3638 | 2466 | 8752 | 3690 |
| FS03 | 5582 | 4962 | 11092 | 8370 | 3320 | 3692 | 3113 | 3374 | 2866 | 3064 | 2593 | 2215 | 1721 | 7065 | 2516 | 2247 | 3638 | 2468 | 8233 | 3688 |
| FS04 | 5582 | 4665 | 10241 | 7399 | 3359 | 3707 | 3116 | 3374 | 2870 | 3064 | 2593 | 2215 | 1721 | 7065 | 2516 | 2247 | 3638 | 2470 | 6687 | 3688 |
| FS16 | 5582 | 4738 | 10394 | 8368 | 3062 | 3546 | 2735 | 3377 | 2687 | 2945 | 2595 | 2203 | 1721 | 7065 | 2461 | 2253 | 3638 | 2290 | 8069 | 3685 |
| FS18 | 5573 | 4419 | 11001 | 6957 | 3087 | 3680 | 2935 | 3359 | 2687 | 2966 | 2286 | 2041 | 1682 | 7065 | 2315 | 2021 | 3638 | 2267 | 7010 | 3686 |
| FS20 | 5582 | 4571 | 9017 | 6506 | 3062 | 3518 | 2736 | 3380 | 2687 | 2945 | 2599 | 2203 | 1721 | 7065 | 2461 | 2253 | 3638 | 2290 | 6808 | 3685 |
| FS26 | 5589 | 4468 | 9570 | 5718 | 3283 | 3709 | 3118 | 3383 | 2893 | 2918 | 2588 | 2069 | 1905 | 7065 | 2481 | 1938 | 3639 | 2510 | 6767 | 3686 |
| FS27 | 5587 | 4697 | 10427 | 7068 | 3285 | 3769 | 3112 | 3387 | 2904 | 2958 | 2631 | 2202 | 1732 | 7065 | 2485 | 2260 | 3639 | 2508 | 6714 | 3685 |
| FS28 | 5587 | 4692 | 10418 | 7028 | 3284 | 3765 | 3111 | 3387 | 2904 | 2958 | 2631 | 2203 | 1732 | 7065 | 2481 | 2260 | 3639 | 2335 | 6717 | 3685 |
| FS36 | 5589 | 4452 | 7915 | 5616 | 3283 | 3709 | 3118 | 3383 | 2893 | 2918 | 2588 | 2069 | 1900 | 7065 | 2481 | 1938 | 3639 | 2510 | 6767 | 3686 |
| Downstream Catchment | 5276 | 3934 | 3897 | 5741 | 3146 | 1944 | 1286 | 3372 | 2680 | 1929 | 2368 | 1222 | 745 | 6688 | 2756 | 874 | 3609 | 1466 | 6154 | 3900 |

Historical Events

**Figure 10.9 Comparative hydrologic performance of top nine scenarios against the base case (FS01)**

**Table 10.6 Modelled reduction in peak flood flow at Moggill and estimated reduction in number of buildings inundated compared to current operations of existing infrastructure (i.e. FS01) - 6 largest historical floods**

| Scenario Number | Description (Top 9 ranked scenarios plus 8 m Wivenhoe Dam raising and lower Warrill Creek flood storage scenarios) | Estimated Capital Cost [1] $m | Flood event and percentage reduction in peak flow (and in number of buildings inundated) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | January 1887 [2] | February 1893 [3] | February 1893 [4] | January 1974 [2] | January 2011 | January 2013 [2] |
| FS02 | Alternative Urban 4 Operations<br>– infrastructure improvements to existing emergency spillway<br>– install a second emergency spillway | $399 | 0.1%<br>(10) | -1.8%<br>(-990) | 14.3%<br>(3,560) | 9.9%<br>(1,270) | 12.4%<br>(3,660) | -0.1%<br>(0) |
| FS03 | Raise Wivenhoe Dam by 1.5 m<br>– install a second emergency spillway<br>– optimise flood operations | $535 | 0.0%<br>(0) | 7.2%<br>(3,890) | 14%<br>(3,460) | 9.9%<br>(1,270) | 17.6%<br>(5,440) | 0%<br>(0) |
| FS04 | Raise Wivenhoe Dam by 4.0 m<br>– install a second emergency spillway<br>– optimise flood operations | $881 | 0.0%<br>(0) | 14.4%<br>(7,810) | 23.9%<br>(5,780) | 9.9%<br>(1,270) | 33.1%<br>(8,150) | 0%<br>(0) |
| FS05 | Raise Wivenhoe Dam by 8.0 m | $1,373 | -0.1% | 45.9% | 42.2% | 9.9% | 32.3% | 0% |
| FS06 | 125,000 ML lower Warrill Creek Dam near Willowbank<br>– lower Warrill Creek Dam constructed to be a dry flood mitigation dam.<br>– existing Wivenhoe Dam operations | $461 [5] | 21.2%<br>(970) | -0.1%<br>(-40) | 5.0%<br>(910) | 4.2%<br>(970) | 4.2%<br>(1200) | 17.1%<br>(280) |
| FS16 | Existing Wivenhoe Dam plus new 350,000 ML dam near Linville<br>– dam near Linville constructed to be a dry flood mitigation dam<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville | $754 | 0.0%<br>(0) | 13.1%<br>(7,110) | 14.0%<br>(3,470) | 9.9%<br>(1,270) | 19.3%<br>(5,660) | 0.1%<br>(0) |
| FS 20 | Raise Wivenhoe Dam by 1.5 m plus new 350,000ML dam near Linville<br>– dam near Linville constructed to be a dry flood mitigation dam<br>– raise existing emergency spillway by 1 metre<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville | $964 | 0.0%<br>(0) | 24.6%<br>(11,850) | 33.1%<br>(7,110) | 9.9%<br>(1,270) | 31.9%<br>(7,970) | 0.1%<br>(0) |
| FS26 | Existing Wivenhoe Dam plus new 570,000 ML dam near Linville<br>– dam near Linville constructed to be a water supply storage<br>– lower Wivenhoe Dam to 60 per cent full supply volume<br>– install a second emergency spillway on Wivenhoe Dam<br>– no net loss to South East Queensland Water Supply Security | $900 | -0.1%<br>(-10) | 20.0%<br>(10,220) | 41.2%<br>(8,280) | 9.9%<br>(1,270) | 32.3%<br>(8,030) | 0.1%<br>(0) |
| FS27 | Existing Wivenhoe Dam plus new 510,000 ML dam near Linville<br>– dam near Linville constructed to be a water supply storage<br>– lower Wivenhoe Dam to 75 per cent full supply volume<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville<br>– no net loss to South East Queensland Water Supply Security | $870 | -0.1%<br>(-10) | 12.8%<br>(6980) | 27.3%<br>(6,270) | 9.9%<br>(1,270) | 32.8%<br>(8,110) | 0.1%<br>(0) |
| FS28 | Existing Wivenhoe Dam plus new 570,000 ML dam near Linville<br>– dam near Linville constructed to be a water supply storage<br>– lower Wivenhoe Dam to 75 per cent full supply volume<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville | $900 | -0.1%<br>(-10) | 12.9%<br>(7,020) | 27.7%<br>(6,270) | 9.9%<br>(1,270) | 32.8%<br>(8,100) | 0.1%<br>(0) |
| FS36 | Raise Wivenhoe Dam by 1.5 m plus new 570,000 ML dam near Linville<br>– dam near Linville constructed to be water supply dam<br>– install a second emergency spillway on Wivenhoe Dam<br>– optimised flood operations between Wivenhoe Dam and dam near Linville<br>– Wivenhoe Dam lowered to 60% full supply volume | $1,110 | -0.1%<br>(-10) | 33.8%<br>(15,100) | 42.3%<br>(8,430) | 9.9%<br>(1,270) | 32.3%<br>(8,030) | 0.1%<br>(0) |

Notes:

1. Estimated capital cost includes the cost of necessary dam safety upgrades for Wivenhoe Dam with the exception of catchment scenario no. FS06 (refer Note 5).
2. 1887, 1974 and 2013 floods were dominated by Bremer River flows and the floods in which in the Lower Warrill Creek Dam has the most flood mitigation benefit to Ipswich.
3. First flood in February 1893 that peaked on the 5 February 1893 (BoM 2014c).
4. Third flood in February 1893 that peaked on 19 February 1893 (BoM 2014c).
5. Cost for lower Warrill Creek dam only.

# Chapter 11 Study Findings and Next Steps

The Prefeasibility Investigation into Flood Mitigation Storage Infrastructure (PIFMSI) was undertaken with a view to determining whether:

- flood storage infrastructure development could provide further significant flood mitigation benefits downstream of Wivenhoe Dam in the major population centres in the Brisbane River floodplain
- further investigations are warranted on one or more preferred development scenarios.

## 11.1 Investigation findings

The PIFMSI has identified that the following scenarios warrant further investigation because of the potential net benefits over costs for the community:

- a potential raising of Wivenhoe by up to 4 m
- construction of a new dam on the Brisbane River near Linville as a water supply offset dam combined with a lowering of the full supply volume of Wivenhoe Dam with either the current dam crest level maintained or the crest level being increased by around 1.5 m
- construction of a new dam on the Brisbane River near Linville as a dry flood mitigation dam.

The assessments outlined in Chapters 9 and 10 demonstrate that such infrastructure significantly mitigates the downstream impacts of historical floods emanating from upstream of Wivenhoe Dam.

More detailed analysis may prove that certain development scenarios investigated may ultimately not be feasible or desirable, or have additional costs imposed such that its benefit-cost ranking is altered either up or down considerably. For this reason, optimisation work will be necessary.

For Wivenhoe and Somerset Dams and the dam near Linville, it is proposed that optimisation be undertaken as part of the proposed next stage feasibility assessment work. Such work would need close collaboration with government agencies such as Department of Transport and Main Roads (DTMR) and Somerset Regional Council with particular regard to highway relocation matters and public safety.

The PIFMSI also identified that a lower Warrill Creek flood storage near Willowbank and a flood storage on the Bremer River near Mt Walker can reduce flood levels in Ipswich, however the estimated costs exceed the assessed benefits for the options investigated. The lower Warrill Creek site is particularly promising from a hydrologic perspective but is confounded by complications associated with co-location with the proposed Southern Freight Railway and the potential costly relocation of high voltage power transmission lines. There may also be potential to reduce construction standards given that the dam would only store water intermittently. There was insufficient time available to fully investigate the issues at the lower Warrill Creek site.

## 11.2 Further assessments

This study was based primarily on a desktop review of existing information (Chapters 7 and 8). No detailed field investigations or collection of primary data were completed. In particular, for the Brisbane River near Linville and the lower Warrill Creek near Willowbank sites more detailed design optimisation and 'ground-truthing' of information will be required.

Further feasibility assessment to complete value engineering assessments and better quantify the costs, benefits and risks would be necessary before a preferred scenario could be confirmed.

Matters requiring more detailed assessment in subsequent investigations to optimise flood storage infrastructure development are:

1. Flood Hydrology
   - Re-assess the flood mitigation performance using the stochastic flood data and hydrologic and hydraulic models available via the Brisbane River Catchment Flood Study (BRCFS). This is likely to improve assessments of flood mitigation benefits above that available through the use of the limited selection of historical events adopted.
   - Refine estimates of elevation-storage volume relationships and elevation-outflow rating relationships for the potential new dams from better topographic elevation data (which may need to be purpose gathered for this work) and further development of the structure design/s.
   - Similarly for options involving Wivenhoe Dam and in particular a raising of the dam and incorporating modified gate ratings, identify potential operational constraints, and refine assessment of increased flood mitigation storage capacity.
   - Optimise the operations of Wivenhoe Dam and Somerset Dam for options that increase the flood mitigation storage capacity of these dams or for other new dam options that result in changes to the operation of Wivenhoe and Somerset Dam.
2. Engineering and costs
   - Review engineering and cost estimates for short-listed scenarios (including Wivenhoe).
   - Conduct appropriate geotechnical field investigations (e.g. site drilling to determine foundation conditions etc.).
   - Obtain better elevation/survey data (may need to be purpose-generated for project).
   - Undertake more detailed dam designs (including outlet and spillway configurations) to optimise structures and feed back into flood hydrology.
3. Impact assessments (property, infrastructure and environment)
   - Undertake more detailed assessment of property acquisitions and costs
   - Undertake more detailed assessment of infrastructure impact costs
   - Undertake more rigorous environmental and social impact assessment (this work may be able to be deferred to the business case development stage for a preferred flood storage infrastructure development scenario.)
   - for Wivenhoe raising scenarios, further investigate the risks of river bank 'wet flow' failures (bank slumping) due to increased flow rate and volume in the drain down phase associated with large floods (this may require investment to improve resilience of river banks such as revegetation initiatives and hence add to costs).

4. Damages, impacts and economics
    - Re-run damages and impacts assessment with the outcomes of the revised flood hydrology (and use BRCFS outputs).
    - Re-run economics (to the appropriate level of detail) with revised damages and impacts results and revised cost estimates.
    - Investigate how capital and operating costs might be financed.
5. Water supply offset
    - Undertake further modelling to determine the optimum combination of water supply offset storage and flood storage between Wivenhoe Dam and a potential new storage upstream of Wivenhoe Dam.
6. Risk Assessments
    - Assess the dam and public safety risks resulting from Wivenhoe Dam being located immediately upstream of Fernvale and Lowood. (In particular, Wivenhoe Dam options that include Saddle Dam No. 2 fuse plugs pose a very significant hazard to Fernvale and Lowood in extreme flood events. Further studies to better define these risks are required before adopting one of these options.)
    - Assess cascade dam failure risk:
        - for upgraded existing dams
        - with a dam near Linville
7. Strategic optimisation of Wivenhoe and Somerset Dams
    - Prepare a strategic overview of Wivenhoe and Somerset Dam upgrade alternatives in order to address some of the above issues including dam and community safety risks, structural design issues, ease of operation and ability to accommodate potential future increases in PMF.
    - Investigate increasing the maximum safe level of Somerset Dam beyond EL 112 mAHD. This provides an opportunity to optimise the operating rules for Somerset Dam to make use of the increased flood storage and improve overall flood mitigation benefits.
8. Further investigation of lower Warrill Creek dam site
    - Given its potential, undertake further assessments with a view to lowering costs (particularly) and improving the NPV/BCR. It would involve reconsideration of the alignment of the dam and cost sharing with the proposed railway line (Southern Freight Railway) for options involving co-location. Such work would involve consideration of alternative technologies particularly for protection or stabilisation of the long embankment at the site. Construction at the lower Warrill Creek site could be timed to occur concurrently with the railway to lower overall costs. This would require further collaboration with DTMR and Department of State Development, Infrastructure and Planning (DSDIP). Emergency Management and Land Planning.
    - Given the proximity of Fernvale and Lowood, emergency management and land planning needs to appropriately respond to the outcomes of the risk assessments completed above.

## 11.3 Timelines

It is estimated that:

**Feasibility level planning**

1. At least 2 years of feasibility level planning would be necessary to optimise the design of flood storage infrastructure development scenarios. This phase would involve the strategic optimisation activities outlined above, resolution of the higher level engineering complexities, firming up on the costs and benefits, completion of the risk assessments and consequential emergency management and land management requirements, and the development of a preliminary business case for the preferred development scenario for consideration by the government.

**Detailed planning and design**

2. Given the scale and complexity of the Wivenhoe Dam upgrade options, it estimated that at least 3 years of planning and design including full environmental impact assessment and final business case development would be required before the construction of the Wivenhoe Dam upgrade could be commenced.
3. At least 2 years of planning and design including full environmental impact assessment and final business case development would be required before the construction of the Somerset Dam upgrade could commence.
4. At least 2 years of planning and design including full environmental impact assessment and final business case development would be required before the construction of a dam on the Brisbane River near Linville could commence.

**Construction**

5. The construction of the Wivenhoe Dam upgrade would require 3 to 5 years to deliver to allow for the staging necessary to safely manage flood risk during delivery. (This estimate is based on the recent Hinze Dam Stage 3 project which was a similar scale to the Wivenhoe Dam upgrade options. Alternative project delivery methods may allow this program to be compressed).
6. The construction of the Somerset Dam upgrade would require 2 to 3 years to deliver to allow for the staging necessary to safely manage flood risk during delivery. (This is based upon a linear program where design is completed, approvals obtained and construction commenced after completion of the design and approvals process). Alternative project delivery methods may allow this program to be compressed.
7. The construction of a dam near Linville would also require 2 to 3 years to deliver.

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- No. 003 – Phase 2 preliminary routing for indicative size of flood mitigation storage compartment for potential Bremer River and Warrill Creek dams.
- No. 004 - Phase 2 preliminary routing for indicative size of flood mitigation storage compartment for potential Lockyer Creek dams.
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## Legislation

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*Nature Conservation Act 1992* (Qld)

Water Regulation 2002 (Qld)

Water Resource (Moreton) Plan 2007 (QLD

# Appendix A

**Table A1 Initial list of potential flood storage locations considered in the Brisbane River catchment URBS model [1]**

| ID No | Stream Name | AMTD (km) | Sub-Catchment | Seqwater URBS model ID name |
|---|---|---|---|---|
| 1 | Brisbane River (near Linville) | 282.3 [2] | Upper Brisbane River | Upper_1 |
| 2 | Cooyar Creek | 12.4 | Upper Brisbane River | Upper_2 |
| 3 | Emu Creek (near Harlin) | 10.8 | Upper Brisbane River | Upper_3 |
| 4 | Cressbrook Creek | 40.1 | Upper Brisbane River | Upper_4 |
| 5 | Ivory Ck | 12.2 | Upper Brisbane River | Upper_5 |
| 6 | Cressbrook Creek | 33.0 | Upper Brisbane River | Upper_6 |
| 7 | Maronghi Creek | 10.7 | Upper Brisbane River | Upper_7 |
| 8 | Middle Creek | 5.3 | Upper Brisbane River | Upper_8 |
| 9 | Northbrook Creek | 14.2 | Upper Brisbane River | Upper_9 |
| 10 | Reedy Creek | 7.1 | Upper Brisbane River | Upper_10 |
| 11 | Reedy Creek | 9.9 | Upper Brisbane River | Upper_11 |
| 12 | Brisbane River (Wivenhoe raising) | 150.2 | Upper Brisbane River | Upper_12 |
| 13 | Sheep Station Creek | 9.9 | Stanley River | Stanley_1 |
| 14 | Sandy Creek | 19.7 | Stanley River | Stanley_2 |
| 15 | Kilcoy Creek | 16.9 | Stanley River | Stanley_3 |
| 16 | Stanley River (near Peachester) | 86.2 | Stanley River | Stanley_4 |
| 17 | Tenthill Creek (near Caffey) | 29.8 | Lockyer Creek | Lockyer_1 |
| 18 | Lockyer Creek (near Murphys Creek) | 109.9 | Lockyer Creek | Lockyer_2 |
| 19 | Black Duck Creek | 4.0 | Lockyer Creek | Lockyer_3 |
| 20 | Blackfellow Creek | 16.3 | Lockyer Creek | Lockyer_4 |
| 21 | Laidley Creek | 50.5 | Lockyer Creek | Lockyer_5 |
| 22 | Laidley Creek (near Thornton) | 41.0 | Lockyer Creek | Lockyer_6 |
| 23 | Ma Ma Creek | 21.2 | Lockyer Creek | Lockyer_7 |
| 24 | Bremer River | 67.7 | Bremer River | Bremer_1 |
| 25 | Bremer River (near Mt Walker) | 70.0 | Bremer River | Bremer_2 |
| 26 | Bremer River | 88.1 | Bremer River | Bremer_3 |
| 27 | Western Creek (near Grandchester) | 8.0 | Bremer River | Bremer_4 |
| 28 | Franklin Vale Creek | 11.6 | Bremer River | Bremer_5 |
| 29 | Gehrke Creek | 7.8 | Bremer River | Bremer_6 |
| 30 | Western Creek | 21.8 | Bremer River | Bremer_7 |
| 31 | Upper Warrill Creek (near Aratula) | 64.4 | Bremer River | Warrill_1 |
| 32 | Lower Warrill Creek (near Willowbank) | 13.9 | Bremer River | Warrill_2 |
| 33 | Reynolds Creek (Moogerah Dam) | 15.3 | Bremer River | Warrill_3 |
| 34 | Reynolds Creek | 23.0 | Bremer River | Warrill_4 |
| 35 | Coulson Creek | 4.3 | Bremer River | Warrill_5 |
| 36 | Purga Creek | 31.3 | Bremer River | Purga_1 |
| 37 | England Creek [3] | 1.3 | Lower Brisbane River | Lower_1 |
| 38 | England Creek | 2.4 | Lower Brisbane River | Lower_2 |
| 39 | Brisbane River | 110.1 | Lower Brisbane River | Lower_3 |

Notes:

1. Potential locations identified from previous reports, topographic maps and other DEWS data.
2. Hydrology based on Brisbane River AMTD 282.1 km site.
3. Flood storage considered at England Creek at AMTD 1.3 km included a related storage on the adjacent stream (Pryde Creek at AMTD 3.1 km).

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