Stantec **Memo**

To:	Andrew Mason Wagga Wagga City Council	From:	Manoj Shrestha Stantec
File:	300203869	Date:	August 30, 2024

Re: Wagga Wagga Pump Levee Augmentation Project – Annual Average Damage Assessment

1. INTRODUCTION

1.1 BACKGROUND

In 2024, Stantec completed an assessment of the effectiveness of different pump station duty flow rates in reducing existing flooding risks at four (4) existing floodgates known as floodgate 8, 10, 17 and 25 as shown in **Figure 1**. Refer to the '*Flood Modelling Assessment of Levee Pump Duty Flow Rates – Wagga Wagga Levee Pump Augmentation Project'* report (Stantec, *February* 2024) for details of this assessment. Following completion of this assessment, Wagga Wagga City Council (*Council)* requested Stantec to complete a cost benefit analysis of different mitigation pump options at two critical floodgate catchments, these being floodgate 8 and 25.

1.1 PURPOSE

The purpose of this Memo is to:

- detail our methodology and findings of the annual average damage (AAD) assessment and cost benefit analysis of three (3) pumping scenarios for two catchments – floodgate 8 and floodgate 25 within the city model domain of Council;
- inform Council of the flood risks and flood damages associated with the pumping scenarios developed by Stantec; and
- inform decision making relating to flood mitigation measures are appropriate to managing flood risks within floodgate 8 and 25 catchments including decisions relating to optimum pump sizing for floodgate 8 and 25.

1.2 SITE CONTEXT

The Wagga Wagga City Levee is approximately 9.6km long starting from the Kooringal Road along the Marshal Creek in the east and ending to the Olympic Highway in the west following the southern bank of Murrumbidgee River. Refer to **Figure 1** below for a 'Locality Map' showing the location of the Wagga Wagga City Levee, waterways, major infrastructure and the catchment areas for floodgate 8, 10, 17 and 25.

Reference: Wagga Wagga Pump Levee – Annual Average Damage Assessment

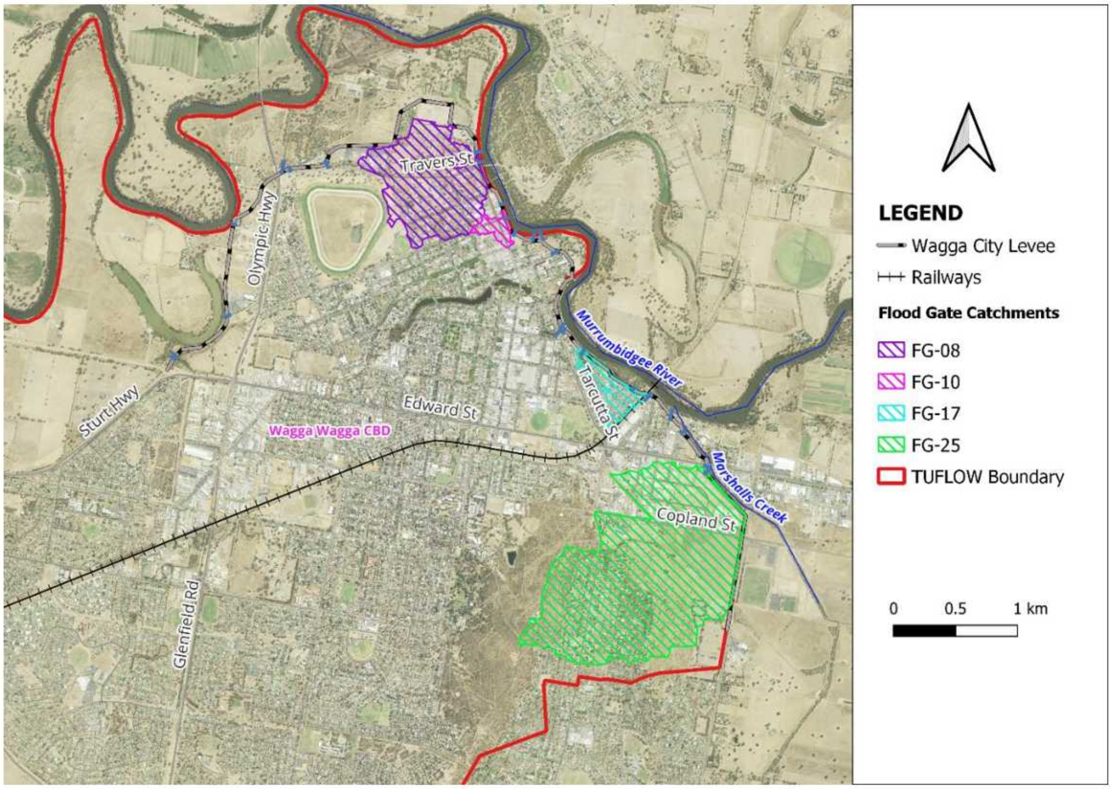

Figure 1 Locality Map

2. PUMP OPTIONS

Three (3) pump options with various pump duty flow rates – 300L/s, 600 L/s and 900 L/s for both floodgate 8 and Floodgate 25 were investigated as part of this study.

Assumptions associated with the pump options assessed were:

- The floodgates under the levee will be closed during the higher riverine flooding conditions; and
- When the flood gates are closed, these pumps will be operational to remove the water trapped behind the levee.

3. FLOOD DAMAGES ASESSMENT

As detailed within the '*NSW Department of Planning and Environment, Flood Risk Management Guideline MM01 (2023)'* flood damages assessments provide a basis for understanding the scale of benefits and disbenefits of flood risk management measures have on flood damages and supports decision-making on Flood Risk Management options

Flood damages are generally categorised as either tangible (direct and indirect) or intangible damage types and are summarised in **Table 1**.

Table 1: Types of Flood Damages

Type	Description
Direct	Property (public and private) including structure, contents and external damages Infrastructure Agricultural Vehicle
Indirect	Clean-up Disruption to public services, businesses and households Alternative accommodation Infrastructure disruptions and associated costs (e.g transport infrastructure)
Intangible	Loss of life (mortality) Injury and other health-related flood impacts, including stress and mental health Social and cultural values Environmental values Loss of memorabilia Inconvenience

The direct damage costs, as indicated in **Table 1,** are just one component of the entire cost of a flood event. There are also indirect costs. Together, direct, and indirect costs are referred to as tangible costs. In addition to tangible costs, there are intangible costs such as social distress and risks to life.

3.1 INPUT DATA

Various input data is required to estimate the flood damages as described below:

Building Footprints:

The primary flood damage calculation relates to building damages, being structural, contents, relocation, and clean-up costs. Therefore, building damages have been calculated for each individual building footprint, based on the building footprint layer provided by Council.

Building Types:

The adopted damages assessment approach allows for unique classification of flood damages based on the type of building that were able to be determined for each building across the study area. Building types for each building footprint were derived from aerial imagery and Google Streetview observations. For example, all 1% AEP flood affected residential classed properties were inspected from Google Streetview to confirm if they were single or double storey. The building types were classified as follows:

- Residential building types:
  - Single storey:
  - Double storey,
  - Multi-unit,

- Townhouse.

> Non-residential building types:

- Low to medium being restaurants, cafes, offices, surgeries, retail outlets, service stations, hardware stores,
- Default average,
- Medium to high being chemists, electrical goods, bottle shops, electronics.

> Public buildings:

- School
- Hospital
- Other

Note that all secondary buildings such as garden sheds and garages in residential properties were excluded from damages calculations

Floor Levels:

Floor levels for all building footprints have been adopted in the damage calculation through one of two methods:

- Floor level survey data was supplied by Council covering a small number of buildings located along Incarnie Crescent and Jones Street;
- From limited floor level survey data provided by Council, of buildings located along Incarnie Crescent and Jones Street, the data indicated an average floor level of 0.15m above ground level.
- For non-surveyed buildings, the following floor level estimation process was applied:
  - Ground levels were assumed based on LiDAR data;
  - Finished floor levels were assumed via a validation process utilising Google Street View as follows:
  - Finished floor levels were estimated at 0.15 metres for buildings with slab-on-ground type construction;
  - 0.3 metres for normal construction approximately two steps above ground level;
  - 0.45 metres for approximately three steps above ground level; and
  - 0.6 metres for approximately four steps or above.
- The estimated floor level was calculated from average ground floor of the building footprint plus the approximate floor height above ground.

Hydraulic Model Results:

Four modelling scenarios were run as below:

- Basecase – Flood Gate Shut Scenario

- Option 1 – 300 L/s pump capacity with flood gate shut
- Option 2 – 600 L/s pump capacity with flood gate shut
- Option 3 – 900 L/s pump capacity with flood gate shut

To inform the flood damages calculation, following were extracted from three design flood events - 20%, 5% and 1% AEP events for each of the modelling scenarios:

- Maximum water levels for footprints were determined for each design event;
- Maximum depth results for footprints were determined for each design event; and
- Maximum H1-H6 hazard category within the footprint were determined for each design event.

3.2 FLOOD DAMAGES ASSESSMENT METHODOLOGY

The flood damages for this study included assessment for base case model and three pumping options (300L/s, 600L/s and 900L/s) based on modelling results for 1% AEP, 5% AEP and 20% AEP for the two floodgate catchments.

For the purposes of this project, the recently released 2024 Flood Damages Tool (DT01) prepared by NSW Department of Planning and Environment as part of the FRM Manual (2023) has been adopted for calculation of tangible and intangibles flood damages. The intangibles flood damage consists of risks to life and social well-being based on the H1-H6 hazard categorisation of the building. The tool estimates the total damage and average annual damage (AAD) cost of flooding. In addition, a cost benefit analysis can be performed within the tool.

Average Annual Damages (AAD) are calculated using a probability approach based on the flood damages calculated for each design event. These damage curves attempt to define the damage experienced on a property for varying depths of flooding. The total damage for a design event is determined by adding all the individual property damages for that event. AAD attempts to quantify the flood damage that a floodplain would receive on average during a single year. It does this using a probability approach. In addition, to accommodate the coincident occurrence of riverine flooding and the local flooding, the design AEP event of the local catchment was multiplied by a factor of 0.2, which is the corresponding design AEP event for the Murrumbidgee River level that triggers shutting off of all levee flood gates within the Wagga Wagga CBD. For example, the probability of 1% AEP event is multiplied by 0.2 which will reduce the probability of occurrence of the 1% AEP event comparable to 0.2% AEP event.

For the most frequent event, the 20% AEP event, a lower bound flood damages estimate is required for the next most frequent event. In the DT01 tool it has been assumed that the total damages in the 50% AEP event will be $0 creating the lower bound of the AAD curve.

Various parameters used in the tool are discussed briefly below.

Consumer Price Index:

The baseline dollar values were provided for calendar year 2022 with a Consumer Price Index (CPI) value of 130.9 for quarter 4 in the damages tool DT01. An inflation rate of 5.19% was calculated based on the most recent data for CPI for March 2024 (137.7) from the Australian Bureau of Statistics at the time of the assessment.

Consequently, all ordinates on the damage curves were increased by 5.19% compared to the curves presented in the flood damages tool DT01.

In addition, the structure values ($/m^2) specific to Council have been updated.

Damage Curves for Overfloor Flooding Depths:

Residential and non-residential flood damages are generally assessed based on assessments of structural damage, damage to contents, external damage, relocation costs and clean-up costs. In limited cases, the additional damage costs related to structural integrity due to building failure may also warrant consideration.

The adopted flood damages curves for residential single and double storey buildings for the various building sizes are shown in **Figure 2** and **Figure 3** respectively. Non-residential flood damage curves including commercial / industrial and public buildings are shown in **Figure 4**.

Further details about the formulation of the residential and non-residential damage curves adopted in the flood damages tool DT01 are included in Section 3.1 and 3.2 of Flood Risk Management Guide MM01.

Reference: Wagga Wagga Pump Levee – Annual Average Damage Assessment

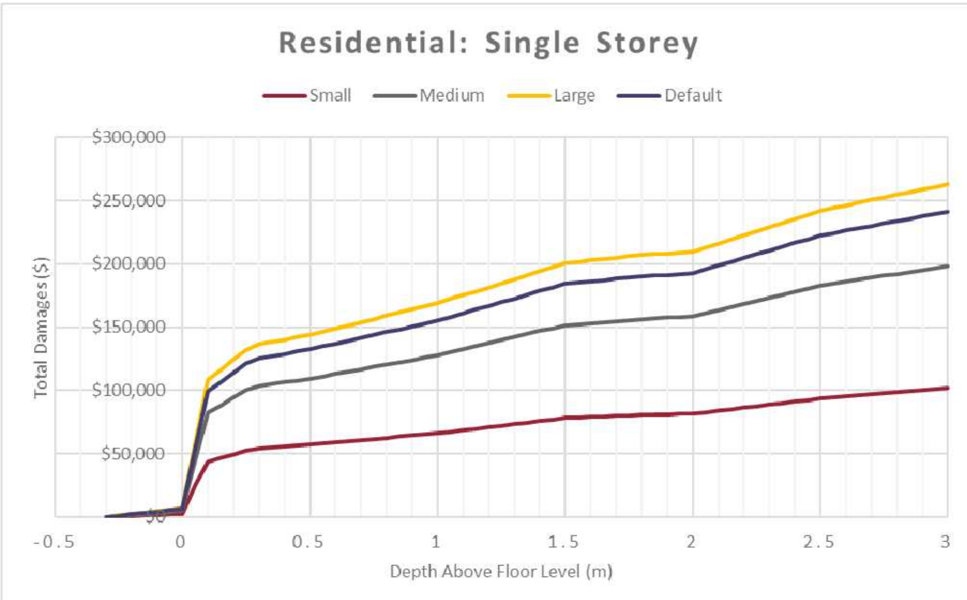

Figure 2: Adopted Damage Curves for Residential Single Storey (Source: DT01 Damages Tool)

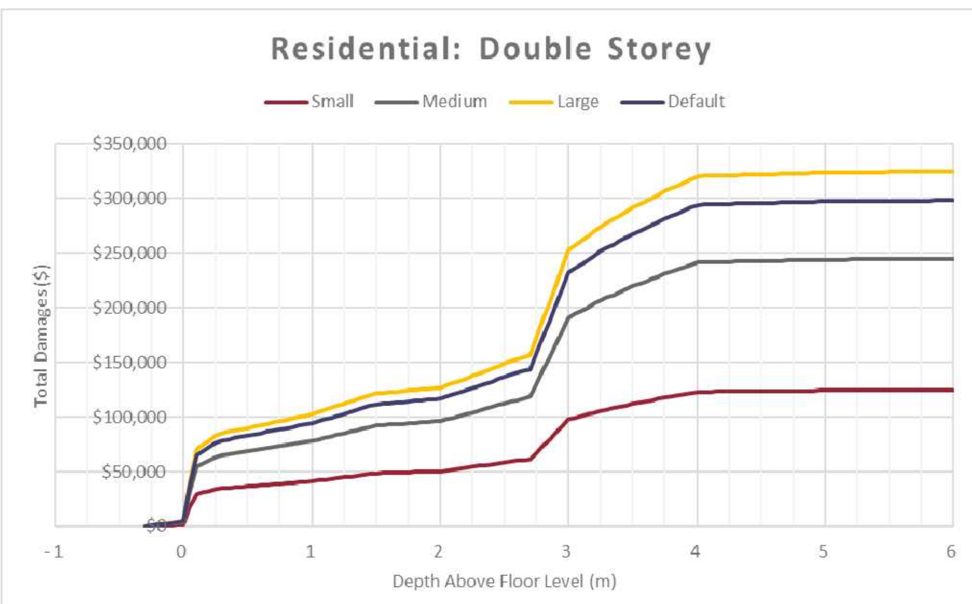

Figure 3: Adopted Damage Curves for Residential Double Storey (Source: DT01 Damages Tool)

Reference: Wagga Wagga Pump Levee – Annual Average Damage Assessment

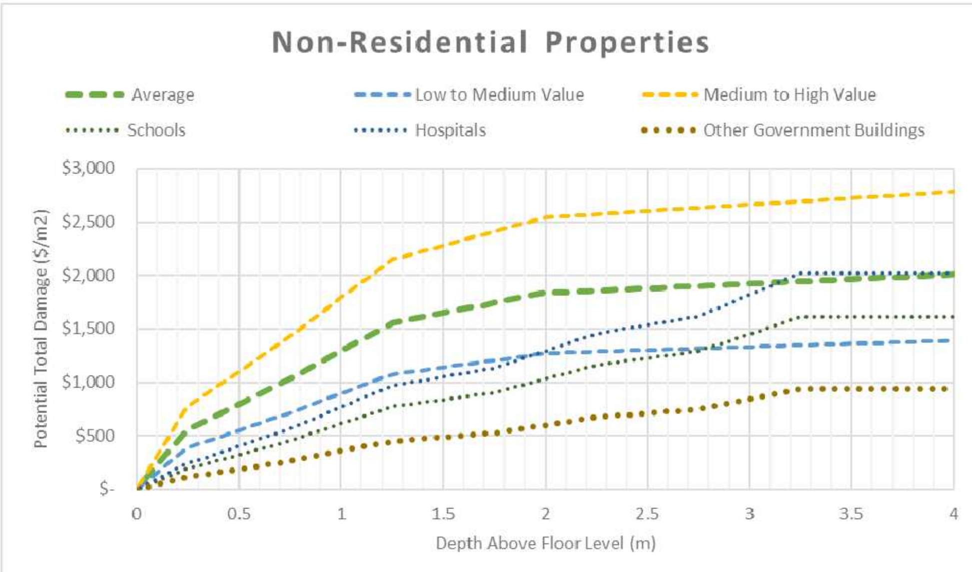

Figure 4: Adopted Damage Curves for Commercial Properties (Source: DT01 Damages Tool)

External Damages Calculation

A fixed external damage of $17,883 in 2024 dollars ($17,000 in 2022 dollars) has been used for each dwelling site and for each site that contains multi-unit dwellings. This is used when flood depths above the ground level adjacent to the building are at least 0.3 metres or are above the habitable floor level of the house. No external damage has been applied to properties without a building.

Other Input Parameters

The flood damages tool DT01 provides numerous input parameters to tailor the flood damages analysis. The tool and associated guide provide advice with respect to default values. The input parameters for this flood damages assessment are as follows:

- Actual to potential ratio = 0.9 (default)
- Regional uplift factor = 1.00 (default for Albury and Wagga Wagga)
- Infrastructure damages uplift = 10% of residential damages (default)
- Damages downscale for townhouses and units = 30% (default)
- Internal / contents rate = $249 / m^2 (Wagga Wagga average)
- Residential clean-up costs = $4,500 / property (default)
- Non-residential indirect costs = 30% of direct actual damages, clean-up costs and loss of trading (default),

The risk to life damages calculations and equations adopted within the flood damages tool DT01 are summarised below in **Figure 5**.

$$Injuries = 2 \cdot N_z \times \frac{HR \cdot AV}{100} \cdot PV$$

$$Fatalities = 2 \cdot N(I) \times \frac{HR}{100}$$

$$Hazard\ Rating\ [HR] = d \times (v + 0.5)$$

Where,

N_z	Population living in the floodplain
HR	Hazard Rating (Table 12-6)
AV	Area Vulnerability (Table 12-7)
PV	People Vulnerability = {% residents suffering any long-term illness, % aged 75+}
N(I)	Number of injuries
d	Depth of flooding (m)
v	Velocity of floodwaters (m/s)

Figure 5: Flood Risk to Life Damages Calculations (Source: NSW DPE, 2023)

4. RESULTS AND DISCUSSIONS

The tool provides the total damages and average annual damage cost for each AEP for each option. These are presented for each floodgate catchments.

4.1 CATCHMENT 8 – AAD RESULTS

The AAD calculation for floodgate catchment 8 has been summarised in **Table 2** for each of the modelling scenarios as described in Section 3.1. The table shows that the AADs for Option 3 is least with an approximate value of $ 128,000. The tool provides $0 damage to non-residential properties and hence the total damage for this catchment is attributed to residential properties only.

The results demonstrate that AADs reduce as pump duty flow rates increase with Option 3 having the least AADs.

Table 2: Catchment 8 AAD Summary

Scenario	AEP	No. of Properties Affected	Total Damages	AAD Contribution	AAD Contribution %
Basecase	20%	62	$967,979	$225,912	81%
	5%	85	$1,410,290	$35,848	13%
	1%	119	$2,914,064	$17,297	6%
			Total AAD	**$279,057**	
Option 1 (300 L/s)	20%	48	$462,653	$107,815	74%
	5%	78	$1,167,942	$24,806	17%
	1%	108	$2,002,456	$12,682	9%
			Total AAD	**$145,302**	
Option 2 (600 L/s)	20%	40	$438,263	$102,205	76%
	5%	68	$926,254	$20,757	16%
	1%	105	$1,845,565	$11,087	8%
			Total AAD	**$134,049**	
Option 3 (900L/s)	20%	40	$437,089	$101,935	80%
	5%	65	$677,144	$16,829	13%
	1%	99	$1,570,349	$8,990	7%
	Total AAD			**$127,754**	

Reference: **Wagga Wagga Pump Levee – Annual Average Damage Assessment**

4.2 CATCHMENT 25 – AAD RESULTS

Floodgate catchment 25 comprises of both residential and non-residential areas. The total damages for combined landuse, and individual residential and non-residential damage estimates are summarised in **Table 3**, **Table 4** and **Table 5** respectively. The calculated AADs shows that 93% of AADs are attributed to the residential areas.

The results demonstrate that there are limited to no benefits to residential areas and minor benefits to non-residential areas, thereby meaning there are residual risks to be managed based on all scenarios assessed. Based on the results, it is advisable that Council should consider other mitigation measures including non-structural mitigation measures to manage current and future risks associated with catchment 25.

Table 3 Combined AAD Summary for Catchment 25

Scenario	AEP	No. of Properties Affected	Total Damages	AAD Contribution	AAD Contribution %
Basecase	20%	165	$25,940,851	$6,039,422	85
	5%	178	$29,136,508	$827,028	12
	1%	178	$30,829,363	$239,863	3
			Total AAD	**$7,106,313**	
Option 1	20%	165	$25,937,994	$6,038,765	85
	5%	178	$29,136,508	$826,985	12
	1%	178	$30,779,434	$239,664	3
			Total AAD	**$7,105,414**	
Option 2	20%	165	$25,940,851	$6,039,422	85
	5%	178	$28,734,568	$820,999	12
	1%	178	$30,742,779	$237,909	3
			Total AAD	**$7,098,330**	
Option 3	20%	164	$25,940,851	$6,039,422	85
	5%	178	$28,701,940	$820,510	12
	1%	178	$30,247,932	$235,799	3
	Total AAD			**$7,095,731**	

Reference: **Wagga Wagga Pump Levee – Annual Average Damage Assessment**

Table 4: Catchment 25 Residential AAD Summary

Scenario	AEP	No. of Properties Affected	Total Damages	AAD Contribution	AAD Contribution %
Basecase	20%	165	$24,329,859	$5,668,894	85
	5%	178	$26,918,894	$769,599	12
	1%	178	$27,308,986	$216,912	3
			Total AAD	**$6,655,405**	
Option 1	20%	165	$24,327,003	$5,668,237	85
	5%	178	$26,918,894	$769,556	12
	1%	178	$27,300,582	$216,878	3
			Total AAD	**$6,654,671**	
Option 2	20%	165	$24,329,859	$5,668,894	85
	5%	178	$26,918,894	$769,599	12
	1%	178	$27,300,582	$216,878	3
			Total AAD	**$6,655,371**	
Option 3	20%	164	$24,329,859	$5,668,894	85
	5%	178	$26,886,266	$769,110	12
	1%	178	$27,300,582	$216,747	3
	Total AAD			**$6,654,751**	

Reference: **Wagga Wagga Pump Levee – Annual Average Damage Assessment**

Table 5: Catchment 25 Non-Residential AAD Summary

Scenario	AEP	No. of Properties Affected	Total Damages	AAD Contribution	AAD Contribution %
Basecase	20%	13	$1,610,991	$370,528	82
	5%	27	$2,217,614	$57,429	13
	1%	35	$3,520,378	$22,952	5
			Total AAD	**$450,909**	
Option 1	20%	12	$1,610,991	$370,528	82
	5%	26	$2,217,614	$57,429	13
	1%	34	$3,478,852	$22,786	5
			Total AAD	**$450,743**	
Option 2	20%	12	$1,610,991	$370,528	84
	5%	22	$1,815,674	$51,400	12
	1%	34	$3,442,197	$21,031	4
			Total AAD	**$442,959**	
Option 3	20%	12	$1,610,991	$370,528	84
	5%	18	$1,815,674	$51,400	12
	1%	32	$2,947,350	$19,052	4
	Total AAD			**$440,980**	

4.3 COST BENEFIT ANALYSIS

A cost benefit analysis (CBA) was performed for each option for floodgate catchments 8 and 25. For comparison purpose of the costs of different pump options, a desktop estimate of the capital cost and operating cost of each pump options and assumptions are provided in Appendix. The following input parameters and design assumptions were used for the CBA:

- Design Life = 50 years
- Assessment period = 50 years
- Discount rate = 5%
- Contingency to cost estimate = 50%

The CBA for catchment 8 and Catchment 25 for various pump options are provided in **Table 6** and **Table 7** respectively. Catchment 8 has a benefit to cost ratio of greater than 1, which suggests the benefit outweighs the cost.

Table 6: CBA for Catchment 8

Metric	Option 1	Option 2	Option 3
Present Value of Costs	**$893,686**	**$989,337**	**$1,064,814**
Present Value of Benefits	**$2,325,544**	**$2,521,195**	**$2,630,648**
Net Present Value	**$1,431,858**	**$1,531,857**	**$1,565,833**
Benefit Cost Ratio	**2.60**	**2.55**	**2.47**

Table 7: CBA for Catchment 25

Metric	Option 1	Option 2	Option 3
Present Value of Costs	**$893,686**	**$989,337**	**$1,064,814**
Present Value of Benefits	**$15,639**	**$138,800**	**$183,994**
Net Present Value	**-$878,047**	**-$850,537**	**-$880,821**
Benefit Cost Ratio	**0.02**	**0.14**	**0.17**

However, for catchment 25 the BCR is below 1, which indicates the economic costs of the pump options outweigh the benefits. The reason economic benefits are not achieved is because most of the industrial buildings' finished floor level are above the flood water level and hence the total potential damage cost does not change much with slight reduction in peak flood water level. While pumps with very high capacity (greater than 2500 L/s) can reduce the peak water level to the desired level, the cost increases significantly and can still have a low BCR of less than 1. Therefore, based on the CBA results, all options assessed for catchment 25 are not recommended.

5. RECOMMENDATIONS & CONCLUSIONS

To support delivery of the *Wagga Wagga Levee Pump Augmentation project'* Stantec have completed a flood damages assessment and cost benefit analysis of three (3) pump options at each critical floodgate catchments of floodgate 8 and floodgate 25. This targeted assessment follows completion of Stantec's assessment of the effectiveness of different pump station duty flow rates in reducing existing flooding risks at four (4) existing floodgates known as floodgate 8, 10, 17 and 25. Refer to the '*Flood Modelling Assessment of Levee Pump Duty Flow Rates – Wagga Wagga Levee Pump Augmentation Project'* report (Stantec, *February* 2024) for details of this assessment.

This flood damages assessment and cost benefit analysis has been undertaken to inform *Council* of the flood risks and flood damages associated with the pumping scenarios undertaken and inform Council decision making relating to what flood mitigation measures are appropriate to manage flood risks within floodgate 8 and 25 catchments.

Key findings and results from this assessment undertaken include:

- The total average annual flood damages for base case are mainly attributed to the residential areas for both Catchment 8 and Catchment 25.
- For Catchment 8, all three pumps show BCR greater than 1 suggesting greater benefits compared to cost. Of the three (3) options assessed, Option 1 inclusive of a 300L/s pump has the highest BCR ratio.
- The average annual flood damages reduction for different pump options compared to base case was very low for Catchment 25, which suggest the tested pump options are not effective. Furthermore, the CBA analysis for this catchment shows that benefit to cost ratio (BCR) is less than 1 for all three pumps. This suggests the cost of implementing the pump options outweigh the benefits in terms of flood reduction.
- For all scenarios assessed, significant residual flooding issues remain in the industrial area upstream of the floodgate 25. In the 5% AEP event assuming a flood gate shut scenario with no pumps, roads are inundated with flood depths ranging between 200 mm to 900mm limiting access to the buildings for more than 20 hrs.

Key recommendations from this assessment undertaken are:

1. Council undertake a flood mitigation options assessment study within the upstream catchment associated with floodgate catchment 25 to identify options and opportunities to mitigate residual flood risks within this catchment. One of the mitigation options that should be explored as part of this study includes a detention basin within the vacant land that borders Copland St to the north, Kooringal Road to the east and the railway line along the southern border of the vacant land.

2. Incorporate the findings from this study including for catchment 8 into the next phases of the Flood Levee Augmentation Review project, which includes informing the sizing and design of the pumps.

Reference: Wagga Wagga Pump Levee – Annual Average Damage Assessment

6. REFERENCES

Australian Bureau of Statistics, 2024. Accessed online on April, 2024 via https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/monthly-consumer-price-index-indicator/latest-release

NSW Department of Planning and Environment, 2023. Flood Risk Management Manual.

NSW Department of Planning and Environment, 2023. Flood Risk Management Measures.

NSW Department of Planning and Environment, 2024.Flood Damages Tool DT01.

Stantec, 2024. Flood Modelling Assessment of Levee Pump Duty Flow Rates – Wagga Wagga Levee Pump Augmentation Project

Wagga Wagga City Council, 2024. Floor Level Survey data covering properties within Incarnie Street and Jones Street supplied by Wagga Wagga City Council

Stantec Australia Pty Ltd

Manoj Shrestha
Senior Flood Engineer
Manoj.Shrestha@stantec.com

Andy Sheehan
Market Leader – Water Resources, Australia
Andy.Sheehan@stantec.com
Direct: +61 3 9070 6780 | 0447 370 566

Joshua Williams
Mechanical Engineer
Joshua.Williams@stantec.com

Stantec
Level 28, Bourke Street
Melbourne, VIC 3000
Direct : +61 3 8554 7000

Attachments: Appendix Cost Estimates

Cost Estimates of 3 Pump Options

Options	300L/s	600L/s	900L/s
CAPEX	$572,700	$633,700	$680,700
50% CAPEX Contingency	$286,350	$316,850	$340,350
CAPEX Total	$859,050	$950,550	$1,021,050
Average annual operating cost($)	$1,900	$2,100	$2,400

Assumptions

Axial flow flood lift pumps

Wet well installation with building/shed enclosure above to secure motor/SWB etc. (Similar to Gate 15A). Assumed same across each option

Assume old wet well demolished and new constructed in same place

Duty only i.e. 1x pump only

50% Contingency

5% NPV discounting rate (typical range is 4-7%)

No changes to existing inlet and outlet pipes to existing MHs, assume single inlet and outlet pipe

Pump operation on/off by manual operation only, no automation

Assume wet well depth of 5m

Pump operation: once every 5 years for 6 days @ 24h/day i.e. 144h every 5 years (advised by WWCC)

Power supply rate: 0.286 $/kWh (current rate advised by WWCC)

Disclaimers

Stantec warrants only that they will exercise the reasonable skill, care and diligence of a Consulting Engineer in the preparation of their professional opinion of those costs. WWCC acknowledges that Stantec has no control over costs of labour, materials, competitive bidding environments and procedures, unidentified field conditions, financial and/or market conditions, or other factors likely to affect the probable cost of the works, all of which are and will unavoidably remain in a state of change. WWCC agrees that Stantec cannot and does not make any warranty, promise, guarantee, or representation, either express or implied, that proposals, bids, project construction costs, or cost of operation or maintenance will not vary substantially from its good faith cost estimate.