2020 Annual Aquatic Environment Monitoring Program (AEMP) Report
Orange Raw Water Supply System
ANNUAL AQUATIC ENVIRONMENT MONITORING PROGRAM (AEMP) REPORT

RAW WATER SUPPLY

1 JULY 2019 TO 30 JUNE 2020

September 2020
## Revision History

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### ABBREVIATIONS

<table>
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<tr>
<th>Abbreviation</th>
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</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>Degrees Celsius</td>
</tr>
<tr>
<td>AEMP</td>
<td>Aquatic Environmental Monitoring Program</td>
</tr>
<tr>
<td>AHR</td>
<td>Annual Hydrology Report</td>
</tr>
<tr>
<td>AR</td>
<td>Annual Review</td>
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<tr>
<td>BSCSHS</td>
<td>Blackmans Swamp Creek stormwater harvesting scheme</td>
</tr>
<tr>
<td>CFU</td>
<td>Colony-forming unit</td>
</tr>
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<td>CoA</td>
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</tr>
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<td>COD</td>
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</tr>
<tr>
<td>DP&amp;E</td>
<td>Department of Planning and Environment</td>
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<tr>
<td>DPI – BCD</td>
<td>Department of Planning, Industry and Environment’s Biodiversity Conservation Division</td>
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<tr>
<td>DST</td>
<td>Decision Support Tool</td>
</tr>
<tr>
<td>EC</td>
<td>Electrical Conductivity</td>
</tr>
<tr>
<td>kL</td>
<td>Kilolitre (1,000 litres)</td>
</tr>
<tr>
<td>L</td>
<td>Litre (1,000 millilitres)</td>
</tr>
<tr>
<td>LOR</td>
<td>Limit of reporting</td>
</tr>
<tr>
<td>L/s</td>
<td>Litres per second</td>
</tr>
<tr>
<td>mg/L</td>
<td>Milligrams per litre</td>
</tr>
<tr>
<td>mL</td>
<td>Millilitre</td>
</tr>
<tr>
<td>ML</td>
<td>Megalitre (1 million litres or 1,000 kilolitres)</td>
</tr>
<tr>
<td>ML/day</td>
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</tr>
<tr>
<td>MOP</td>
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<td>Nephelometric Turbidity Units</td>
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<tr>
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<tr>
<td>μg/L</td>
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</tr>
<tr>
<td>μS/cm</td>
<td>Micro Siemens per centimetre</td>
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</tbody>
</table>
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>REVISION HISTORY</td>
<td>2</td>
</tr>
<tr>
<td>ABBREVIATIONS</td>
<td>3</td>
</tr>
<tr>
<td>BACKGROUND</td>
<td>7</td>
</tr>
<tr>
<td>1.1 INTRODUCTION</td>
<td>7</td>
</tr>
<tr>
<td>1.2 SCOPE</td>
<td>8</td>
</tr>
<tr>
<td>1.3 OBJECTIVES</td>
<td>8</td>
</tr>
<tr>
<td>1.4 STRUCTURE</td>
<td>8</td>
</tr>
<tr>
<td>AEMP MONITORING &amp; REPORTING</td>
<td>9</td>
</tr>
<tr>
<td>2.1 WATER YEAR</td>
<td>9</td>
</tr>
<tr>
<td>2.2 CHANGES TO CONDITIONS, APPROVAL OR LICENCES</td>
<td>9</td>
</tr>
<tr>
<td>2.2.1 MACQUARIE RIVER TO ORANGE PIPELINE</td>
<td>9</td>
</tr>
<tr>
<td>2.2.2 SUMA PARK DAM ENVIRONMENTAL FLOW RULES</td>
<td>9</td>
</tr>
<tr>
<td>2.2.3 BULK WATER TRANSFER</td>
<td>11</td>
</tr>
<tr>
<td>2.3 WATER QUALITY MONITORING</td>
<td>11</td>
</tr>
<tr>
<td>2.3.1 AIMS</td>
<td>11</td>
</tr>
<tr>
<td>2.3.2 MONITORING REQUIREMENTS AND ACTIVITIES</td>
<td>12</td>
</tr>
<tr>
<td>2.3.3 MONITORING DATA SUMMARY</td>
<td>14</td>
</tr>
<tr>
<td>2.3.4 SCOUR WATER</td>
<td>33</td>
</tr>
<tr>
<td>2.4 AQUATIC ECOLOGY MONITORING</td>
<td>33</td>
</tr>
<tr>
<td>2.5 HYDROLOGY</td>
<td>35</td>
</tr>
<tr>
<td>2.5.1 EXTRACTION</td>
<td>35</td>
</tr>
<tr>
<td>2.5.2 EXTERNAL WATER SOURCES</td>
<td>35</td>
</tr>
<tr>
<td>2.5.3 SUMA PARK DAM SPILL</td>
<td>35</td>
</tr>
<tr>
<td>2.5.4 ENVIRONMENTAL FLOW RULES</td>
<td>35</td>
</tr>
<tr>
<td>2.5.5 SUMMARY</td>
<td>36</td>
</tr>
<tr>
<td>2.6 SPECIAL STUDIES</td>
<td>36</td>
</tr>
<tr>
<td>2.6.1 CRITICAL NEEDS MONITORING</td>
<td>36</td>
</tr>
<tr>
<td>2.6.2 SUMMER HILL CREEK RIFFLES</td>
<td>38</td>
</tr>
<tr>
<td>2.6.3 MACQUARIE RIVER HYDRAULICS</td>
<td>38</td>
</tr>
<tr>
<td>2.6.4 FISH ENTRAINMENT</td>
<td>38</td>
</tr>
<tr>
<td>2.7 CONSIDERATION OF AEMP OBJECTIVES</td>
<td>40</td>
</tr>
<tr>
<td>SUMMARY</td>
<td>40</td>
</tr>
<tr>
<td>3.1 ENVIRONMENTAL PERFORMANCE</td>
<td>41</td>
</tr>
<tr>
<td>3.2 NON-COMPLIANCE SUMMARY AND IMPROVEMENT MEASURES</td>
<td>42</td>
</tr>
<tr>
<td>3.2.1 NON-COMPLIANCES</td>
<td>42</td>
</tr>
<tr>
<td>3.2.2 IMPROVEMENT MEASURES</td>
<td>42</td>
</tr>
</tbody>
</table>
APPENDICES

APPENDIX A
2019-20 Aquatic Environment Monitoring Program – Summer Hill Creek and the Macquarie River (DPM Envirosiences)

APPENDIX B
Summary of DPI Fisheries Monitoring 2014-2020

APPENDIX C
Critical Needs Monitoring Interim Report

TABLES
Table 1.1 – Report Structure .................................................................................................. 8
Table 2.1 – Statement of Approval 80CA722752 .................................................................................. 11
Table 2.2 – Water Quality Monitoring Summary .................................................................................. 12
Table 2.3 – Releases to satisfy flow conditions ...................................................................................... 36
Table 2.4 – Impingement and entrainment percentages for larval Murray cod and juvenile Murray cod and golden perch under experimental approach velocities .................................................................................................... 39
Table 2.5 – Consideration of AEMP Objectives .................................................................................. 40
Table 3.1 – Environmental Performance Compared to Water Quality and Aquatic Ecology Predictions ................................................................................................................. 41
Table 3.1 – Non-Compliance Summary ............................................................................................. 42
Table 3.2 – Improvement Measure Summary ........................................................................................ 42

FIGURES
Figure 1: Site 15 – Suma Park Reservoir Offtake – pH ............................................................................. 14
Figure 2: Site 15 – Suma Park Reservoir Offtake – Electrical Conductivity .............................................. 15
Figure 3: Site 15 – Suma Park Reservoir Offtake – Temperature .................................................................... 15
Figure 4: Site 15 – Suma Park Reservoir Offtake – Turbidity ........................................................................ 16
Figure 5: Site 15 – Suma Park Reservoir Offtake – Dissolved Oxygen ...................................................... 16
Figure 6: Site 15 – Suma Park Reservoir Offtake – Dissolved Oxygen Saturation ...................................... 17
Figure 7: Site 45 – Bulgas Road Suma Park Reservoir (Station 421196) – Temperature (Source: WaterNSW) ..................................................................................................................... 17
Figure 8: Site 45 – Bulgas Road Suma Park Reservoir (Station 421196) – Dissolved Oxygen (Source: WaterNSW) ..................................................................................................................... 18
Figure 9: Site 45 – Bulgas Road Suma Park Reservoir (Station 421196) – Dissolved Oxygen Saturation (Source: WaterNSW) ................................................................................................................. 18
Figure 10: Site 42 – Macquarie River Pump Station Offtake 1 at Cobbs Hut Hole – Turbidity (Source: OCC) .......................................................................................................................... 19
Figure 11: Site 42 – Macquarie River Pump Station Offtake 1 at Cobbs Hut Hole – pH (Source: OCC) .... 19
Figure 12: Sites 42, 45, 46 & 47 - pH .......................................................................................................... 21
Figure 13: Sites 42, 45, 46 & 47 – Electrical Conductivity ............................................................................. 22
Figure 14: Sites 42, 45, 46 & 47 - Temperature .......................................................................................... 22
Figure 15: Sites 42, 45, 46 & 47 - Turbidity ................................................................................................ 23
Figure 16: Sites 42, 45, 46 & 47 - Dissolved Oxygen .................................................................................. 23
Figure 17: Sites 42, 45, 46 & 47 - Dissolved Oxygen Saturation ................................................................. 24
Figure 18: Sites 42, 45, 46 & 47 - Electrical Conductivity ........................................................................... 24
Figure 19: Sites 42, 45, 46 & 47 - Total Dissolved Solids .......................................................................... 25
Figure 20: Sites 42, 45, 46 & 47 - Total Suspended Solids ........................................................................... 25
Figure 21: Sites 42, 45, 46 & 47 - Aluminium ............................................................................................. 26
Figure 22: Sites 42, 45, 46 & 47 - Copper .................................................................................................. 26
Figure 23: Sites 42, 45, 46 & 47 - Nickel................................................................. 27
Figure 24: Sites 42, 45, 46 & 47 - Zinc ................................................................. 27
Figure 25: Sites 42, 45, 46 & 47 - Chromium .................................................. 28
Figure 26: Figure 27: Sites 42, 45, 46 & 47 - Total Nitrogen.......................... 29
Figure 27: Figure 28: Sites 42, 45, 46 & 47 - Total Phosphorus................... 29
Figure 29: Sites 42, 45, 46 & 47 - Faecal Coliforms ....................................... 30
Figure 30: Sites 42, 45, 46 & 47 - Chlorophyll-a ............................................ 30
Figure 31: Sites 42, 45, 46 & 47 - Blue-Green Algae Cell Count ................. 31
Figure 32: Sites 42, 45, 46 & 47 - Blue-Green Algae Biovolume ................. 31
Figure 33: Sites 42, 45, 46 & 47 - Chemical Oxygen Demand ..................... 32
Figure 34: Sites 42, 45, 46 & 47 – Total Alkalinity .............................................. 32
Figure 35: Site 42 – Bromide ............................................................................ 33
Background

1.1 INTRODUCTION

The Orange Raw Water Supply System is the name used for managing the sources of untreated 'raw' water for the community of Orange. It includes:

- Spring Creek Dam and Suma Park Dam
- The Blackmans Swamp Creek stormwater harvesting scheme (BSCSHS)
- The Ploughmans Creek stormwater harvesting scheme (PCSHS)
- Water supply bores
- The Macquarie River to Orange pipeline (MOP)

An Operation Environmental Management Plan (OEMP) has been developed to ensure that the environmental requirements and commitments made during the approvals process for the Macquarie River to Orange pipeline, as well as other relevant licensing conditions, are implemented, monitored and reviewed as Orange's Raw Water Supply System is operated. The OEMP was approved by NSW Department of Planning and Environment (DP&E) on 7 September 2016.

The OEMP includes an Aquatic Environment Monitoring Program sub-plan (Appendix D of the OEMP). A requirement of that sub-plan is to prepare the Aquatic Environment Monitoring Program (AEMP) Annual Report.

As required by Condition of Approval (CoA) C5 of the Macquarie River to Orange pipeline Project Approval (PA), this AEMP Annual Report is required to support the Annual Review.

1.2 SCOPE

The AEMP Annual Report is required to provide the following:

- an overview of monitoring activities for the reporting year;
- a summary of monitoring results including a comparison with all historical results and interpretation for the current year;
- identification of any trends in the monitoring data;
- identification of any non-compliance with the AEMP and what actions were (or are being) taken to ensure compliance;
- identification of any discrepancies between the predicted and actual impacts of the Macquarie River to Orange pipeline operation and analyse the potential cause of any significant discrepancies;
- specific comment against the objectives of the AEMP (see Section 1.3);
• identification of any monitoring parameters and/or frequency that should be changed; and
• identification of any measures that could be implemented to improve the environmental performance of the Macquarie River to Orange pipeline operation or environmental flow releases. Justification for any decision to not implement those measures.

This AEMP Annual Report has been prepared for the 2019-20 water year.

1.3 OBJECTIVES

The objectives of the AEMP include the following:

1. To identify any changes in hydrology and aquatic ecology (including fish and aquatic and riparian vegetation) in the Macquarie River as a result of the operation of the Macquarie River to Orange pipeline project.

2. To determine the efficiency of the Macquarie River to Orange pipeline offtake design and screens to limit impingement, entrainment and minimise impacts to eggs, larvae or changes to recruitment of threatened aquatic species.

3. To identify any changes in hydrology and aquatic ecology (including fish and aquatic and riparian vegetation) in Summer Hill Creek as a result of increased flow volumes and spills from Suma Park Dam.

4. To determine if the environmental flow releases maintain or enhance the key values of water quality, aquatic biodiversity, river health and general ecological condition of Summer Hill Creek.

5. To identify if environmental flow Rule 2 maintains 4% riffle habitat at four (4) riffles on Summer Hill Creek between the confluence of Emu Swamp Creek and the confluence of Blackmans Swamp Creek.

1.4 STRUCTURE

Report structure is outlined in Table 1.1.

Table 1.1 – Report Structure

<table>
<thead>
<tr>
<th>Section</th>
<th>Content</th>
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<tr>
<td>Section 1 – Background</td>
<td>Provides an introduction, scope, objectives and structure of the report.</td>
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<tr>
<td>Section 2 – AEMP Monitoring &amp; Reporting</td>
<td>Provides an overview of water quality monitoring data and aquatic ecology monitoring to meet the requirements of the AEMP forming part of the OEMP.</td>
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<tr>
<td>Section 3 – Summary</td>
<td>Provides a summary of non-compliances and actions and a review of the environmental performance against the relevant water quality and aquatic ecology predictions made in the various environmental assessments.</td>
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</table>
AEMP Monitoring & Reporting

2.1 WATER YEAR

The water year being reported is 1 July 2019 to 30 June 2020.

2.2 CHANGES TO CONDITIONS, APPROVAL OR LICENCES

2.2.1 MACQUARIE RIVER TO ORANGE PIPELINE

2.2.1.1 Margin of Error

Orange City Council received confirmation from the Department of Planning Industry and Environment on 30 September 2019 that it had satisfied the requirement to remove the margin of error applied to the Macquarie River pumping trigger under Condition B6 of Approval MP10_0235.

As such, the 10% margin of error was removed from the pump control on 1 October 2019.

The adopted pumping trigger from 1 October 2019 is 108 ML/day.

2.2.1.2 Pumping Trigger

Orange City Council received authorisation under section 8 of the Water Supply (Critical Needs) Act 2019 (the Act) by the Minister for Water, Property and Housing (Melinda Pavey MP) on 14 January 2020 to operate the Macquarie River to Orange pipeline at a reduced river flow rate trigger of greater than 38 ML/day.

Conditions stipulate that the Critical Needs Authorisation is for a period of 12 months, or if the combined storage in Suma Park Dam and Spring Creek Dam exceeds 50%, or if the provisions of the Act expire. In the case that the latter two do not occur, Council can seek to extend the authorisation, initially for a period of six months.

Conditions attached to this authorisation required that a program be developed to identify and monitor impacts to aquatic ecology (including platypus, water rat / rakali and freshwater turtles), hydrology and water quality resulting from the amended pumping trigger.

2.2.2 SUMA PARK DAM ENVIRONMENTAL FLOW RULES

Water Access Licence 36161 and its associated Approval 80CA722752, permits the operation of Spring Creek Dam and Suma Park Dam and the extraction of water for town water supply purposes from the Summer Hill Creek water source. Approval 80CA722752 contains a range of conditions relating to, among other things, environmental flow releases from Suma Park Dam.
Orange City Council applied to the Natural Resource Access Regulator (NRAR) in July 2019 seeking to amend a number of conditions on Approval 80CA722752.

NRAR completed a review of the proposed amendments and advised Council by letter dated 25 October 2019 that it intended to amend the existing conditions under section 95 of the Water Management Act 2000.

The revised Statement of Approval applied from 25 October 2019. A summary of the amendments is provided below.

**Condition DK6565-00001**

- Removed the reference to the monitoring and reporting requirement based on 4% riffle habitat.

**Condition DK6568-00001**

- Added new conditions (A) and (B) which would apply until the combined storage capacity of Suma Park Dam and Spring Creek Dam first exceeds 40% after 1 October 2019. The new conditions require a visible flow at the Third Crossing gauge (rather than a flow of 1.75 ML/day). Other elements are:
  - A gauge level equating to a visible flow needed to be determined.
  - The requirement to maintain a visible flow would cease if the combined storage measures less than 25% (which it did on 15 December 2019).
  - The requirement to maintain a visible flow must recommence when the combined storage exceed 30% (which did not occur in the 2019-20 water year).
- Amended the monitoring requirement for the 1.75 ML/day flow requirement at the Third Crossing gauge from a 3-day rolling average to a 5-day rolling average.
- Removed the reference to Gosling Creek Reservoir in determining the combined storage capacity.
- Amended the requirement for environmental flow releases during a bulk water transfer. This condition was amended by way of letter to OCC dated 30 September 2019 to allow transfer of water from Spring Creek Dam to Suma Park Dam prior to issue of the amended Statement of Approval.

The amended Statement of Approval caused re-numbering of licence conditions and therefore referencing in the OEMP, particularly when referencing environmental flow rules. Table 2.1 identifies the changes. The OEMP and its relevant sub plans will need to be updated to reflect these changes.
Table 2.1 – Statement of Approval 80CA722752

<table>
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<th>Environmental Flow Rule Condition DK6568-00001</th>
<th>Old Approval</th>
<th>Amended Approval in force from 25/10/19</th>
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<tr>
<td>Determination of visible flow</td>
<td>NA</td>
<td>A</td>
</tr>
<tr>
<td>Maintain visible flow</td>
<td>NA</td>
<td>B</td>
</tr>
<tr>
<td>Flow through Suma Park Dam</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>Maintenance of flow at Third Crossing</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>Freshes from Suma Park Dam</td>
<td>C</td>
<td>E</td>
</tr>
<tr>
<td>Rule suspension</td>
<td>D</td>
<td>F</td>
</tr>
</tbody>
</table>

This AEMP Annual Report adopts the conditions as documented in the amended Statement of Approval which came into force on 25 October 2019.

2.2.3 BULK WATER TRANSFER

OCC received advice from NRAR on 30 September 2019 that bulk water transfer from Spring Creek Dam to Suma Park Dam would not trigger the need for environmental flow release and that OCC could commence bulk water transfer in accordance with the intent of the advice.

A condition reflecting the intent of this advice was subsequently added to the amended Statement of Approval that came into force on 25 October 2019.

2.3 WATER QUALITY MONITORING

2.3.1 AIMS

As identified in Section 2.4.1 of the AEMP, the aims of the water quality monitoring program are to inform the aquatic monitoring program, specifically:

- provide data for the development of site-specific water quality triggers as described by the ARMCANZ/ANZECC (2000) national guidelines;
- provide a water quality database for the identification of trends and comparison with predictions; and
- assist management of environmental flow releases from Suma Park Reservoir.
### 2.3.2 MONITORING REQUIREMENTS AND ACTIVITIES

Table 2.2 outlines the monitoring requirements and summarises activities completed during the reporting period.

<table>
<thead>
<tr>
<th>Site</th>
<th>Requirement</th>
<th>Monitoring Frequency</th>
<th>Completion Status</th>
</tr>
</thead>
</table>
| Site 15 – Suma Park Reservoir Offtake | Water column profiling for:  
- pH  
- electrical conductivity (μS/cm)  
- temperature (°C)  
- turbidity (NTU)  
- dissolved oxygen (mg/L and % saturation)  
Profiles to include 5, 10 and 20 metre depths. | Monthly | Monitoring was completed for each month for surface, 5m and 10m profiles excluding June 2020 due to COVID-19 resourcing constraints.  
- 20m profiles were not taken during the water year due to the low storage level.  
- Dissolved oxygen saturation was not recorded in April 2020 due to operator error. |
| Site 45 – Bulgas Road Suma Park Reservoir (Reach 1) | dissolved oxygen (mg/L and % saturation)  
- temperature (°C) | During environmental flow release and/or spill (continuous logging) | Continuous logging data for temperature and dissolved oxygen is available for the reporting period. |
| Site 46 – Third Crossing (Reach 2) | Field measurements for:  
- pH  
- electrical conductivity (μS/cm)  
- temperature (°C)  
- turbidity (NTU)  
- dissolved oxygen (mg/L and % saturation) | Monthly | Monthly field measurements were taken for Sites 45-47 and 42, except for sites where no flow occurred.  
- Site 46 was not sampled in October 2019 and the field probe was unable to record turbidity on several occasions.  
- EC was also not recorded for site 46 in September 2019. |
### Site 45 – Bulgas Road Suma Park Reservoir (Reach 1)
- **Grab sampling** and laboratory analysis for:
  - electrical conductivity (EC) (μS/cm)
  - total dissolved solids (TDS) (mg/L)
  - total suspended solids (TSS) (mg/L)
  - dissolved metals (mg/L)
    - Aluminium (Al)
    - Cadmium (Cd)
    - Chromium (Cr)
    - Copper (Cu)
    - Lead (Pb)
    - Mercury (Hg)
    - Nickel (Ni)
    - Zinc (Zn)
  - nutrients (nitrogen and phosphorous, mg/L)
  - faecal coliforms (cfu/100mL)
  - Chlorophyll-a (μg/L)
  - Blue-green algae (cell count and biovolume)
  - chemical oxygen demand (COD, mg/L)
  - Alkalinity (mg/L)
  - Bromide (mg/L) (Site 42 only)

### Site 46 – Third Crossing (Reach 2)

### Site 47 – Ophir Reserve (Reach 3)

### Site 42 – Macquarie River Pump Station Offtake 1 at Cobbs Hut Hole
- **pH**
- **Turbidity (NTU)**

### Monthly

The following is noted with respect to monthly samples/analysis during the water year:
- Site 45 was not flowing in February and March 2020.
- EC was reported for all sites where water was flowing.
- TDS was reported for all sites each month where water was flowing.
- TSS was reported for all sites each month where water was flowing.
- Dissolved metals were reported at all sites each month where water was flowing.
- Total N was reported for all sites each month where water was flowing.
- Total P was reported for all sites each month where water was flowing.
- Faecal coliforms were reported for all sites each month where water was flowing.
- Chlorophyll-a was reported for all sites each month where water was flowing.
- Blue-green algae (cell count and biovolume) was reported for all sites each month where water was flowing.
- COD was reported for all sites each month where water was flowing.
- Alkalinity was reported for all sites each month where water was flowing.
- Bromide was reported for all months at Site 42.

### Monthly

During operation of Pump Station 1 (continuous logging)

Logging of pH and turbidity was not continuous during all operations of Pump Station 1 as the sample pump was damaged during the water year and could not be replaced due to high river levels.
2.3.3 MONITORING DATA SUMMARY

2.3.3.1 Site 15 – Suma Park Reservoir Offtake

Water column profile monitoring results at Suma Park Reservoir Offtake (Site 15) are provided in the following graphs for pH, electrical conductivity, temperature, turbidity, and dissolved oxygen. Dissolved oxygen saturation was not recorded for any of the profiles in April 2020. Sampling in June 2020 did not take place due to COVID-19 staffing constraints.

The MOP was operating for the majority of February 2020 through to June 2020, and no obvious changes to water quality in Suma Park Dam can be observed through the monitoring data due to the MOP operation.

![Figure 1: Site 15 – Suma Park Reservoir Offtake – pH](image)

pH of all profiles remains generally consistent between 7 and 9 pH units.

Electrical conductivity in all profiles for the dam shows a gradual increasing trend over the three years of data collation. This may be due to:

- declining water levels due to drought conditions;
- inflow from the Fredericks Valley Creek system which has higher salinity than the Spring Creek system, noting that any inflows to Suma Park Dam in the past few years have been from the Fredericks Valley Creek system; and/or
- input from the Macquarie River whilst dam levels were low.

Salinity data will be reviewed in the 2020-21 water year to observe changes as the storage level increases.
Seasonal variations in temperature are apparent and predicted.

Turbidity sampling shows reasonable consistency throughout all profiles, with some small peaks which may be due to mixing effects as the dam levels drop.
Dissolved oxygen concentration and dissolved oxygen saturation show a generally consistent seasonal pattern across all profile depths. The warmer months show a drop in dissolved oxygen concentration in the lower sections of the reservoir as deep aeration becomes less effective. Conditions in the storage return to typical operating levels within a month, and this is generally consistent each year. The seasonal dissolved oxygen reduction in the 10 m profile was not evident in the 2019-20 water year, which may indicate more effective aeration with decreased storage level.
2.3.3.2 Site 45 – Bulgas Road Suma Park Reservoir (Continuous Log Data)

Temperature, dissolved oxygen, and dissolved oxygen saturation results during environmental flow are provided in the following graphs. As there were limited environmental flow releases during the water year, very limited data is available for comparison to previous years. However, results for the few occasions releases occurred are generally consistent with previous years’ data.
Figure 8: Site 45 – Bulgas Road Suma Park Reservoir (Station 421196) – Dissolved Oxygen (Source: WaterNSW)

Figure 9: Site 45 – Bulgas Road Suma Park Reservoir (Station 421196) – Dissolved Oxygen Saturation (Source: WaterNSW)
2.3.3.3 Site 42 – Macquarie River Pump Station Offtake 1 at Cobbs Hut Hole (Continuous Log Data)

Turbidity and pH results are provided in the following graphs. The sample pump was damaged in early March 2020 which prevented logging of turbidity and pH through to the end of the water year. Council intend to replace the sample pump when the level in the river is lower.

Figure 10: Site 42 – Macquarie River Pump Station Offtake 1 at Cobbs Hut Hole – Turbidity (Source: OCC)

Figure 11: Site 42 – Macquarie River Pump Station Offtake 1 at Cobbs Hut Hole – pH (Source: OCC)
2.3.3.4 Sites 42, 45, 46 and 47

Monthly water quality results from sites 42 (Macquarie River Pump Station Offtake 1 at Cobbs Hut Hole), 45 (Bulgas Road Suma Park Reservoir - Reach 1), 46 (Third Crossing – Reach 2) and 47 (Ophir Reserve – Reach 3) are provided in the following sections for the parameters that include:

Field measurements for:
- pH
- Electrical conductivity (EC) (μS/cm)
- Temperature (°C)
- Turbidity (NTU)
- Dissolved oxygen (mg/L and % saturation)

Grab sampling and laboratory analysis for:
- Electrical conductivity (μS/cm)
- Total dissolved solids (TDS) (mg/L)
- Total suspended solids (TSS) (mg/L)
- Dissolved metals (mg/L):
  - Aluminium
  - Cadmium
  - Chromium
  - Copper
  - Lead
  - Mercury
  - Nickel
  - Zinc
- Nutrients (nitrogen and phosphorous, mg/L)
- Faecal coliforms (cfu/100mL)
- Chlorophyll-a (μg/L)
- Blue-green algae (cell count and biovolume)
- Chemical oxygen demand (COD) (mg/L)
- Alkalinity (mg/L)
- Bromide (mg/L) (Site 42 only)

Where the result reported is below the limit of reporting (LOR) (i.e. <5), half the LOR is reported (i.e. 2.5).
Field and lab measurements were not taken at Site 45 in February and March 2020 or Site 47 in December 2019 due to zero flow.

Several measurements at the sites during January (e.g. nutrients, coliforms, TSS) show considerable peaks in concentration due high flows. Site 45 experienced no flow for majority of the water year due to nil or very minor releases from Suma Park Dam from May 2019 through to end of June 2020. As observed in the following sections, peaks in nutrient and algae concentrations occurred at Site 45 following extended no flow periods due to the extreme drought conditions.

Seasonal and monthly variations can be observed from the three years of data collation shown in graphs below. However, no significant or adverse trends in any parameters are apparent at the four sites.

*Field Measurement – pH*

Figure 12: Sites 42, 45, 46 & 47 - pH

pH samples show reasonable consistency across all sites, with majority of values sitting between 7 and 9 pH units.
**Field Measurement – Electrical Conductivity**

![Graph of Electrical Conductivity](image)

Figure 13: Sites 42, 45, 46 & 47 – Electrical Conductivity

Electrical conductivity ranges from 100 μS/cm to just over 800 μS/cm at the four sites and shows variation at and between sites.

**Field Measurement – Temperature**

![Graph of Temperature](image)

Figure 14: Sites 42, 45, 46 & 47 - Temperature

Temperature at the four sites ranges seasonally with larger fluctuations observed in the Macquarie River.
Field Measurement – Turbidity

Turbidity readings range from 0 to around 160 NTU. This can vary due to increased inflows, especially after dry periods and catchment impacts.

Field Measurement – Dissolved Oxygen

Figure 15: Sites 42, 45, 46 & 47 - Turbidity

Figure 16: Sites 42, 45, 46 & 47 - Dissolved Oxygen
Dissolved oxygen concentration and saturation is reasonably consistent across all sites. Dissolved oxygen ranges from 0.42 mg/L at Site 45 in March 2017 to 15.65 mg/L at Site 46 in May 2018.

Electrical conductivity fluctuates across all sites, ranging between 100 and 700 μS/cm.
Grab Sample – Total Dissolved Solids

Figure 19: Sites 42, 45, 46 & 47 - Total Dissolved Solids

Total dissolved solids range consistently between approximately 100 and 400 mg/L, with the exclusion of Site 45 in April 2020 at just under 600 mg/L.

Grab Sample – Total Suspended Solids

Figure 20: Sites 42, 45, 46 & 47 - Total Suspended Solids

Total suspended solids remain reasonably low at Site 45-47, except for Site 45 in January 2020. Macquarie River has a greater change in suspended solids, probably due to varying rainfall intensity during extended dry periods.
**Grab Samples – Dissolved Metals**

**Aluminium**

Concentrations of aluminium at the four sites are observed to fluctuate between 0 mg/L and 0.3 mg/L.

**Copper**

Copper concentrations ranged from below the LOR to 0.015 mg/L.
Nickel

Nickel ranged from below the LOR to 0.1 mg/L at Site 45 in April 2020.

Zinc

Zinc concentrations ranged from below the LOR to 0.03 mg/L at Site 47 in June 2017.
Cadmium

Results for Sites 42 and 45 - 47 were below the LOR of 0.0001 mg/L for all months sampled except July 2019, which recorded a level of 1.0 mg/L, before returning to <0.0001 mg/L.

Chromium

Chromium concentrations have remained low, with most below the LOR. Levels appear to have increased very slightly in the most recent water year.

Lead

All Lead results from the four sites were recorded below 0.002 mg/L, with majority of these below the LOR of 0.001 mg/L, except for Site 42 in April 2019, with a recording of 0.002 mg/L.
Grab Sample – Nutrients (Nitrogen and Phosphorous)

Total nitrogen at the four sites has ranged between 0.1 mg/L and 7 mg/L. Fluctuations are observed with no obvious trends.

Figure 27: Sites 42, 45, 46 & 47 - Total Nitrogen

Total phosphorus has remained reasonably low between 0.01 mg/L and 0.4 mg/L, except for Site 42 in January 2019 at 0.58 mg/L and Site 45 in January 2020 at a max of 1.31 mg/L which were associated with an increase in suspended solids.

Figure 29: Sites 42, 45, 46 & 47 - Total Phosphorus
Grab Sample – Faecal Coliforms

Faecal coliforms remain below 200 CFU/100mL for majority of the sampling rounds, with some spikes.

Figure 30: Sites 42, 45, 46 & 47 - Faecal Coliforms

Grab Sample – Chlorophyll-a

Figure 31: Sites 42, 45, 46 & 47 - Chlorophyll-a
Chlorophyll-a results have remained consistently low, except for the increases observed during early 2020 at Site 45 which was most likely due to algae accumulating due to less frequent environmental releases from Suma Park Dam.

**Grab Sample – Blue-Green Algae (Cell Count)**

![Figure 32: Sites 42, 45, 46 & 47 - Blue-Green Algae Cell Count](image)

**Grab Sample – Blue-Green Algae (Biovolume)**

![Figure 33: Sites 42, 45, 46 & 47 - Blue-Green Algae Biovolume](image)
The spike in blue green algae in the Macquarie River was following the first major flow after prolonged dry conditions.

**Grab Sample – Chemical Oxygen Demand**

![Chemical Oxygen Demand Graph]

Figure 34: Sites 42, 45, 46 & 47 - Chemical Oxygen Demand

Chemical oxygen demand samples ranged from below the LOR to a maximum of 246 mg/L at Site 45 in January 2020 linked to an increase in TSS and algae.

**Grab Sample – Alkalinity**

![Total Alkalinity Graph]

Figure 35: Sites 42, 45, 46 & 47 – Total Alkalinity
Alkalinity concentrations ranged from 6 mg/L at Site 45 in April 2020 to 236 mg/L at Site 47 in February 2020.

### Bromide – Site 42

Bromide concentrations at Site 42 range from below the limit of reporting to a maximum of 0.165 mg/L. Most recent samples are lower relative to previous sampling rounds.

#### 2.3.4 SCOUR WATER

There was no scour water released from Macquarie River to Orange pipeline for maintenance or emergency activities during the 2019-20 water year. Therefore, the Scour Water Management Plan was not implemented during the water year.

#### 2.4 AQUATIC ECOLOGY MONITORING

Aquatic ecology monitoring required as part of the AEMP was undertaken by DPM Envirosciences (refer – Appendix A).

Aquatic ecological monitoring was undertaken in spring (September) 2019 and autumn (April) 2020, and by Fisheries NSW from 17 March to 24 June 2020. The autumn 2020 monitoring of the Macquarie River satisfies the AEMP stream health monitoring requirements for the Orange Raw Water Supply System. The spring 2019 and autumn 2020 monitoring of Summer Hill Creek satisfies the AEMP requirements pertaining to environmental flow releases from Suma Park Dam.

The AEMP monitoring program includes four sites on Summer Hill Creek downstream of Suma Park Dam, five sites upstream of the pump offtake on the Macquarie River, and four sites on the Macquarie River downstream of the pump offtake.
The AEMP requires that all sites be sampled in autumn, but that only the four Summer Hill Creek sites need be sampled in spring.

The most notable impacts on aquatic habitat in the Macquarie River during the autumn 2020 monitoring round relate to recent evidence of high flows and fine sediment deposits on stream banks and edge habitats. High flows in February and early April 2020 resulted in water levels at the Macquarie River monitoring sites in the order of 1.5 m above normal water levels. These high flow events followed prolonged drought conditions in the catchment that has affected vegetative cover and soil retention abilities, resulting in catchment erosion and deposition of fine sediments in the river, particularly in areas of reduced flow velocity.

Assessment of OCC’s environmental flow releases on the health of Summer Hill Creek is complicated by the absence of a baseline (pre environmental flow) dataset or suitable reference sites from which to draw comparisons. Habitat complexity increases with distance from source and, unlike the Macquarie River sites that are more closely aligned to one another, the physical habitat attributes of the Summer Hill Creek monitoring sites are naturally very dissimilar. The monitoring site immediately downstream of Suma Park Dam is most affected by flow regulation, being positioned at the base of the dam and receiving no other inflows. The site upstream of the Third Crossing likely benefits from flows released from the Orange STP and stormwater holding pond in the absence of other inflows but is also impacted by the presumably higher nutrient content of this water (STP discharge) and urban runoff. Sites further downstream receive flow contributions from other sources and are less impacted by releases.

The results of the 2020 AEMP indicate that the drought affected catchments of both Summer Hill Creek and the Macquarie River continue to impact stream health to varying degrees. However, comparison of upstream to downstream biological indicators has provided no evidence to suggest that the Orange Raw Water Supply System has impacted stream health in the Macquarie River or the lower reaches of Summer Hill Creek. Upstream reaches of Summer Hill Creek appear to be affected by flow regulation from Suma Park Dam and the higher nutrient content of water released from the Orange STP and stormwater holding pond.

Based on the outcomes of the 2020 AEMP, DPM Envirosciences made the following recommendation:

1) Continue to implement the AEMP in order to demonstrate to project stakeholders that the Orange Raw Water Supply System continues to operate without detrimentally impacting the health of the Macquarie River and the lower reaches of Summer Hill Creek.
2.5 HYDROLOGY

The Annual Hydrology Report (AHR) for the 2019-20 water year provides a summary of the system hydrology.

2.5.1 EXTRACTION

Raw water for town water supply purposes was extracted from:

- the existing surface water storage system;
- groundwater bores (not included in the AEMP);
- Macquarie River;
- Blackmans Swamp Creek; and
- Ploughmans Creek (not included in the AEMP).

The 2019-20 AHR describes how these schemes were operated and summarises the hydrological monitoring data.

2.5.2 EXTERNAL WATER SOURCES

External input to Suma Park Reservoir totalled 1,884 ML for the 2019-20 water year and the storage did not spill. The input from the external sources was:

- Macquarie River 1,106 ML
- Stormwater harvesting 646 ML (479 ML from BSCSHS)
- Bores 131 ML

2.5.3 SUMA PARK DAM SPILL

There was no spill from Suma Park Dam in the 2019-20 water year.

2.5.4 ENVIRONMENTAL FLOW RULES

As noted in Section 2.2.2, the identification of environmental flow rules changed during the water year with the issue of an amended Statement of Approval 80CA722752. Table 2.1 summarises the naming changes. This AEMP Annual Report adopts the conditions as documented in the amended Statement of Approval which came into force on 25 October 2019.

The AHR identified no non-compliances with Environmental Flow Rule A and B while these rules were in force during the 2019-20 water year (from 25 October 2019).

The AHR identified no non-compliances with Environmental Flow Rule C, and one non-compliance with Environmental Flow Rule D while these rules (or predecessors) were in force during the 2019-20 water year (up to 15 December 2015).
A bulk water transfer from Spring Creek Dam to Suma Park Dam commenced on 30 September 2019 and ran through until 30 October 2019. Some flow from this transfer continued to be recorded at Station 421185 until 9 November 2019. The amended Environmental Flow Rule C states that environmental flow releases are not required during periods of bulk water transfer.

Environmental Flow Rule E(i) was not implemented as there was no flow recorded at Station 421185 while this rule was in force during the 2019-20 water year (up to 15 December 2015).

Environmental Flow Rule F was implemented on 15 December 2019 when the combined storage measured less than 25%. This rule suspends all environmental flow rules until such time that the combined storage exceeds 30%, which did not occur before 30 June 2020.

Releases made by OCC over the 2019-20 water year from the Orange STP, stormwater holding pond and Suma Park Dam to satisfy Environmental Flow Rule B and D are summarised in Table 2.3. Releases made up 17% of the total flow recorded at the Third Crossing gauge (Station 421197).

<table>
<thead>
<tr>
<th>Total (ML)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange STP Releases</td>
</tr>
<tr>
<td>Holding Pond Releases</td>
</tr>
<tr>
<td>Suma Park Dam Releases</td>
</tr>
<tr>
<td>Total Releases</td>
</tr>
<tr>
<td>Third Crossing Gauge Annual Flow</td>
</tr>
<tr>
<td>Releases as % of Flow</td>
</tr>
</tbody>
</table>

2.5.5 SUMMARY

In summary, and of relevance to the AEMP:

- Extractions from the Macquarie River and Blackmans Swamp Creek were consistent with predictions made in the relevant environmental assessment documents (refer to Section 3 of the AHR) in terms of CoA, licence conditions and impacts on flow regimes; and
- Environmental flow rules were followed with one non-compliance with Environmental Flow Rule D when the flow target at the Third Crossing was based on a 3-day rolling average.

2.6 SPECIAL STUDIES

2.6.1 CRITICAL NEEDS MONITORING

2.6.1.1 Background

Orange City Council received authorisation under section 8 of the Water Supply (Critical Needs) Act 2019 (the Act) by the Minister for Water, Property and Housing (Melinda Pavey MP) on 14 January 2020 to operate the Macquarie River to Orange pipeline at a reduced river flow rate trigger of greater than 38 ML/day.
Conditions attached to the above authorisation required that a program be developed to identify and monitor impacts to aquatic ecology (including platypus [*Ornithorhynchus anatinus*], water rat / rakali [*Hydromys chrysogaster*] and turtles), hydrology and water quality resulting from the amended pumping trigger. The monitoring requirements are outlined in the Critical Needs Aquatic Environment Monitoring Program Version 3 (Critical Needs AEMP) dated 2 April 2020.

The Critical Needs AEMP has been incorporated into the existing Orange City Council Operation Environmental Management Plan for the Orange Raw Water Supply System (OEMP) for a limited time. Once the Critical Needs Authorisation is expended, the Critical Needs AEMP shall be removed from the OEMP following updates in the next scheduled OEMP Annual Report. Conditions stipulate that the Critical Needs Authorisation is for a period of 12 months, or if the combined storage in Suma Park Dam and Spring Creek Dam exceeds 50%, or if the provisions of the Act expire. In the case that the latter two do not occur, Council can seek to extend the authorisation, initially for a period of six months.

### 2.6.1.2 Progress

The first round of sampling was undertaken during 25 to 28 April 2020. River level sensor and loggers and digital cameras were also installed at that time.

An interim report was submitted to the NSW Department of Planning, Industry and Environment’s Biodiversity Conservation Division (DPIE – BCD). This report provided a brief description of the critical needs monitoring program establishment and a summary of data available from the April 2020 monitoring round conducted by Premise Australia and DPM Envirosiences on behalf of Orange City Council.

The interim report is included as Appendix C.

### 2.6.1.3 2020-21 Water Year

The flow in the Macquarie River at the time of the first round was at around the maximum for the integrity of the Critical Needs AEMP in terms of net placement in the riffle zones and platypus habitat. The river level recorded at PS1 (Station 421192) at the time of the first round was 1.33 to 1.37 m (around 130 ML/day).

The second round of sampling under the Critical Needs AEMP was scheduled initially for July 2020 which was then postponed to August 2020 in consultation with DPIE – BCD due to high river levels. Continued high river levels prevented conduct of the second round planned for August 2020.

Given the flow conditions were not favourable for the August 2020 monitoring, plans for the upcoming water year include:

- Review the requirements for the Critical Needs AEMP monitoring in consultation with DPIE – BCD as the combined storage is likely to exceed 50% in the first quarter of the 2020-21 water year.
- If required, undertake the delayed monitoring round at a suitable time after flow in the Macquarie River recedes to a level less than 130 ML/day.
2.6.2 SUMMER HILL CREEK RIFFLES

Field work relating to measurement of riffle habitat under low flow conditions in Summer Hill Creek was completed in February 2017 and was assessed and reported in the 2017-18 water year.

2.6.3 MACQUARIE RIVER HYDRAULICS

This study aims to verify water level changes in pools and riffles in the Macquarie River as a result of the operation of the Macquarie River to Orange Pipeline.

Operation of the Macquarie River to Orange Pipeline was intermittent and did not coincide with the flows targeted for this study. Methodology for the study was altered to allow for its completion and a draft report has been prepared for review.

2.6.4 FISH ENTRAINMENT

Objective 2 of the AEMP is to determine the efficiency of the Macquarie River to Orange pipeline offtake design and screens to limit impingement, entrainment and minimise impacts to eggs, larvae or changes to recruitment of threatened aquatic species.

The initial project contracted to NSW DPI Fisheries in 2014-2017 intended to use field trials to determine efficiency of the offtake design and screens to limit impingement, entrainment and minimise impacts to eggs and larvae of native fish. Due to operational restrictions of the OCC pump by August of 2016 water extraction through the Orange Pipeline had yet to commence and so the scheduled field experiments for offtake efficiency could not be conducted. It was agreed between OCC and DPI Fisheries to conduct controlled tank trials in 2016 and 2017 to examine the efficiency of the offtake design and screen to limit impingement and entrainment of larval and juvenile fish.

Trials were conducted on larval and juvenile Murray cod and juvenile golden perch obtained from the Narrandera Fisheries Centre Hatchery. These two species are known to occur in the upper Macquarie river. These species were also selected as they have similar life histories (spawning seasons, egg and early life history characteristics) to threatened species recorded in the area, golden perch are representative of silver perch and Murray cod for Trout cod.

The tank trials involved the use of an artificial off-take flume that simulated a diversion screen of the same material (2 mm wedge-wire) as is fitted to the OCC pump, and similar, and higher, approach velocities of the OCC pump (between 0.05 and 0.3 m/s). The reason for examining higher velocities was to investigate what may happen if the screen became partially blocked by debris, or otherwise has ‘hotspots’ of higher velocity on the screen due to uneven distribution of flow across the entire screen face.

The laboratory trials showed that having the screen in place reduced entrainment and therefore fish mortality. Higher velocities up to 0.3 m/s led to increases in impingement rates.
therefore any blocking of the screen (through debris) will increase approach velocities and increase impacts to fish.

For golden perch when screen impingement did occur at an approach velocity of 0.15 m/s for a duration of 1 minute, it did not result in mortality. Impingement duration trials were conducted at 0.15 m/s for a duration of only 1 minute. Prolonged impingement at higher approach velocities did result in mortality.

Impingement rates of juvenile golden perch were approximately 65% at an approach velocity of 0.15 m/s (Table 2.4).

Impingement rates of juvenile Murray Cod were approximately 10 and 30% at approach velocities of 0.10 and 0.20 m/s respectively (Table 2.4). Mortality rates for golden perch increased with increased impingement duration at the 0.3 m/s approach velocity trials (1 minute impingement = 1% mortality; 10 minute impingement = 10% mortality; 20 minute impingement = 24% mortality; 40 minute impingement = 42% mortality).

Table 2.4 – Impingement and entrainment percentages for larval Murray cod and juvenile Murray cod and golden perch under experimental approach velocities.

<table>
<thead>
<tr>
<th>Approach velocity (m.s⁻¹)</th>
<th>0.05</th>
<th>0.075</th>
<th>0.1</th>
<th>0.125</th>
<th>0.15</th>
<th>0.2</th>
<th>0.25</th>
<th>0.3</th>
<th>0.35</th>
<th>0.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juvenile Golden Perch (17.5mm SL) Impingement (%)</td>
<td>6</td>
<td>-</td>
<td>41</td>
<td>-</td>
<td>62</td>
<td>78</td>
<td>96</td>
<td>100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Larval Murray Cod (10.6mm SL) entrainment (%)</td>
<td>9</td>
<td>28</td>
<td>58</td>
<td>71</td>
<td>90</td>
<td>95</td>
<td>-</td>
<td>100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Juvenile Murray Cod (26.6mm SL) Impingement (%)</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>30</td>
<td>-</td>
<td>68</td>
<td>83</td>
<td>95</td>
</tr>
</tbody>
</table>

Theoretically, if the screens have been designed to create a 0.15 m/s approach velocity with a 2 mm wedge-wire screen, the screen should meet current fisheries recommended guidelines.

Although the screen has an airburst cleaning system, it is important that it is operated frequently enough to ensure the screen face is kept clean. A seasonal maintenance program of checking the screen for fouling would be beneficial.

Higher approach velocities may also be experienced on sections of the screen if internal baffling does not adequately spread the velocity across the entire screen face, or if the screen has ‘hotspots’ of higher velocity on the screen due to uneven distribution of flow across the entire screen face.

The full summary document of the study is provided in Appendix B.

Council will remain committed to ongoing consultation with NSW DPI Fisheries through the 2020-21 water year to translate the laboratory findings to the field. This will include assessment of the site, pump intake and pump operations to confirm the trial assumptions.

Further studies and/or investigations may be recommended to fully address the requirements of the AEMP and CoA B1.
2.7 CONSIDERATION OF AEMP OBJECTIVES

Consideration of AEMP objectives is provided in Table 2.5.

<table>
<thead>
<tr>
<th>AEMP Objective</th>
<th>Comments</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To identify any changes in hydrology and aquatic ecology (including fish and aquatic and riparian vegetation) in the Macquarie River as a result of the operation of the Macquarie River to Orange pipeline project.</td>
<td>The MOP operated for 138 days over the 2019-20 water year and extracted 1,106 ML. The change in flow regime was consistent with predictions. There were no observed changes in hydrology that are outside of the predictions made in the relevant environmental assessment documents.</td>
<td>2.4</td>
</tr>
<tr>
<td>2. To determine the efficiency of the Macquarie River to Orange pipeline offtake design and screens to limit impingement, entrainment and minimise impacts to eggs, larvae or changes to recruitment of threatened aquatic species.</td>
<td>NSW DPI (Fisheries) completed simulation studies and a research paper. Ongoing consultation with NSW DPI Fisheries is proposed to fully satisfy this condition. Outcomes will be reported on in the 2020-21 water year.</td>
<td>2.6.4</td>
</tr>
<tr>
<td>3. To identify any changes in hydrology and aquatic ecology (including fish and aquatic and riparian vegetation) in Summer Hill Creek as a result of increased flow volumes and spills from Suma Park Dam.</td>
<td>The link is that using external water sources will keep the existing surface water storages fuller leading to more spills (frequency and volume). External input to Suma Park Reservoir totalled 1,884 ML for the 2019-20 water year and the storage did not spill. As such, there can be no assessment of any changes in hydrology resulting from increased flow volumes and spills.</td>
<td>2.5.3</td>
</tr>
<tr>
<td>4. To determine if the environmental flow releases maintain or enhance the key values of water quality, aquatic biodiversity, river health and general ecological condition of Summer Hill Creek.</td>
<td>OCC generally complied with the environmental flow release rules for Suma Park Reservoir. There is insufficient data available to determine if the environmental flow releases maintain or enhance the key values of water quality, aquatic biodiversity, river health and general ecological condition of Summer Hill Creek. Monitoring over the long term will be used to identify trends.</td>
<td>2.6.2</td>
</tr>
<tr>
<td>5. To identify if environmental flow Rule 2 maintains 4% riffle habitat at four (4) riffles on Summer Hill Creek between the confluence of Emu Swamp Creek and the confluence of Blackmans Swamp Creek.</td>
<td>It is noted in Section 2.8.1 of the OEMP that: “The AEMP annual report will not include results of the low riffle monitoring...This shall be reported separately”. This report has been provided to Crown Lands and Water.</td>
<td>2.6.2</td>
</tr>
</tbody>
</table>
Summary

3.1 ENVIRONMENTAL PERFORMANCE

A review of the environmental performance of the raw water supply system against the relevant water quality and aquatic ecology predictions made in the various environmental assessments is provided in Table 3.1.

Table 3.1 – Environmental Performance Compared to Water Quality and Aquatic Ecology Predictions

<table>
<thead>
<tr>
<th>Assessment Document</th>
<th>Prediction</th>
<th>2018-19 Water Year</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macquarie River to Orange Pipeline Environmental Assessment (GHD, 2012) and Macquarie River to Orange Pipeline Preferred Project Report (GHD, 2013)</td>
<td><strong>Water quality in Suma Park Reservoir</strong> Modelling indicates mixing Macquarie River water with stored water should not impact on raw water quality. Review of the water quality monitoring at the Suma Park Reservoir offtake shows no significant changes in water quality during periods when the MOP was operating.</td>
<td>Consistent with predictions.</td>
<td>Section 2.3.3.1</td>
</tr>
<tr>
<td></td>
<td><strong>Water quality impacts from scour water</strong> A scour water management plan would be developed to manage the release of scour water during operation.</td>
<td>The OEMP includes a scour water management plan (Attachment F). There was no scour water released from Macquarie River to Orange pipeline for maintenance or emergency activities during in the 2019-20 water year.</td>
<td>Consistent with predictions.</td>
</tr>
<tr>
<td></td>
<td><strong>Fish entrainment</strong> Intake design and screens would minimise impacts on aquatic biotas.</td>
<td>NSW DPI (Fisheries) completed simulation studies and a research paper. This has been published and results are consistent with predictions. Further investigation is required to come to conclusions on the impact of extraction on fish larvae and a variety of other native juvenile fish species.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Aquatic ecology</strong> Unlikely to have a significant impact on any threatened aquatic flora and fauna and their habitat.</td>
<td>Aquatic monitoring provides no evidence to suggest that OCC’s raw water extraction from the Macquarie River has affected stream health.</td>
<td>Consistent with predictions.</td>
</tr>
<tr>
<td></td>
<td><strong>Increased Spill from Suma Park Dam</strong> Modelling predicted increased spills from Suma Park Dam.</td>
<td>No spill from Suma Park Dam in the 2019-20 water year.</td>
<td></td>
</tr>
</tbody>
</table>
3.2 NON-COMPLIANCE SUMMARY AND IMPROVEMENT MEASURES

3.2.1 NON-COMPLIANCES

A summary of non-compliances and actions taken (or proposed) are provided in Table 3.2.

It is noted that non-compliances with environmental flow rules are not included in the table below as they are addressed in the Annual Hydrology Report.

Table 3.2 – Non-Compliance Summary

<table>
<thead>
<tr>
<th>Non-Compliance</th>
<th>Section</th>
<th>Risk Level</th>
<th>Action Taken or Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data capture – lab data</td>
<td>Section 2.3.2.32</td>
<td>Administrative non-compliance</td>
<td>Ensure this data is correctly recorded in future monitoring.</td>
</tr>
<tr>
<td>Data capture – field data</td>
<td>Section 2.3.2</td>
<td>Administrative non-compliance</td>
<td>Field probe is being replaced by Council to prevent irregular recordings in the field.</td>
</tr>
<tr>
<td>Data capture – Suma Park Dam profiles</td>
<td>Section 2.3.2</td>
<td>Administrative non-compliance</td>
<td>June 2020 not undertaken due to COVID-19 staffing restrictions. 20m depth profile not recorded - noted only as due to low water level in Suma Park Dam.</td>
</tr>
<tr>
<td>Data capture – continuous pH and turbidity</td>
<td>Section 2.3.2</td>
<td>Administrative non-compliance</td>
<td>Council intend to replace the pump when the river level reduces, and they can safely access the site.</td>
</tr>
</tbody>
</table>

3.2.2 IMPROVEMENT MEASURES

Improvement measures have been identified from minor operational issues noted during the water year. These issues are not a non-compliance with environmental requirements or approval/licensing conditions but have been identified to improve future management of the raw water supply system. The improvement measures are outlined in Table 3.3.

Table 3.3 – Improvement Measure Summary

<table>
<thead>
<tr>
<th>Issue</th>
<th>Section</th>
<th>Proposed Improvement Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amendment to Statement of Approval 80CA722752</td>
<td>Section 2.2</td>
<td>An update to Attachment D: AEMP of the Orange Raw Water Supply System OEMP to describe the current approval conditions.</td>
</tr>
</tbody>
</table>