Woolgoolga to Ballina Pacific Highway Upgrade

Threatened Fish Monitoring Program Annual Report 2023

Year 3 Operational Phase Report

NSW GOVERNMENT

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Threatened Fish Monitoring Program Annual Report 2023

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Introduction

The following report summarises the methods and results from the third and final year of threatened fish monitoring undertaken during the operational phase of the Woolgoolga to Ballina Pacific Highway upgrade (W2B Upgrade).

1.1 Background

As part of the conditions of approvals required for construction of the W2B Upgrade Transport for NSW (TfNSW) are monitoring a range of environmental factors prior to, during, and after construction, including threatened species. Formal environmental assessments undertaken during the planning phase of the W2B Upgrade revealed that a variety of threatened species listed under state and federal environmental legislation occur, or have the potential to occur, at various locations within or near the construction footprint. One species of threatened fish, Oxleyan Pygmy Perch (OPP) (*Nannoperca oxleyana*), was identified during the project EIS. As a result, a Threatened Fish Management Plan (Roads and Maritime 2015) was prepared to inform monitoring and adaptive management actions for this species during all stages of the project. This report documents the results of the second year of monitoring conducted during the operational phase, with the combined operational phase data being assessed against results from three pre-construction surveys and seven construction phase surveys.

1.2 Objectives

The Threatened Fish Management Plan (Roads and Maritime 2015) states that monitoring will be conducted during construction and operation where known Oxleyan Pygmy Perch populations may be impacted, and for a period until such time as the mitigation measures have been proven to be effective over three consecutive annual monitoring periods.

Monitoring will provide information such that conclusions can be drawn in relation to management of threatened species. The overall monitoring objectives include:

- Evaluate the success of mitigation measures (including erosion and sediment control and pollution control measures).
- Determine the extent of secondary impacts of the project on Oxleyan Pygmy Perch populations and identify any additional mitigation measures that may minimise these impacts such as connectivity, stream mitigation, water quality and restoration of habitat.
- Determine the effectiveness of bridge design and bank rehabilitation in the management of Oxleyan Pygmy Perch.

1.3 Species Profile

1.3.1 Oxleyan Pygmy Perch (OPP)

In NSW OPP are known to occur in Banksia-dominated coastal heath (wallum) ecosystems and coastal lakes as far south as Tick Gate Swamp (just south of Wooli). The systems where they are

usually found are dystrophic, acidic and freshwater (Knight & Arthington 2008) in addition to being shallow, slow flowing and narrow. They are mostly found over sandy and sometimes muddy benthos with high proportions of riparian cover, leaf litter and emergent aquatic plants. Typically, water depths are around 50 cm but OPP have been collected from depths of up to 130 cm. Water velocities are almost always below 0.4 m/sec, limiting occurrence to backwaters and small tributaries (Pusey, Kennard & Arthington 2004).

The predicted natural range of OPP in NSW is from the Queensland border south as far as the Manning River. In recent years, OPP have mostly been collected from the area around Evans Head NSW. OPP are known to be particularly sensitive to capture by nets. In particular, surveys using seine nets have resulted in significant mortality. The methods suggested for OPP surveys are electrofishing and setting unbaited standard fish traps (DSEWPaC 2011). To minimise disturbances to breeding, surveys should be avoided between October and April inclusive.

Table 1.1 Summary of water quality information from NSW sites where OPP have been collected.

Measure	*Range*	*Mean ± SE*
Temp (°C)	10.9 – 28.3	16.1 ± 0.34
DO (mg/L)	2.15 – 10.02	6.42 ± 0.189
pH	3.32 – 6.9	4.47 ± 0.087
Cond (µS/cm)	68 - 2148	186 ± 22.7
Turbidity (NTU)	0 – 80	14 ± 3.6

From Knight & Arthington (2008)

Plate 1.1 OPP captured at site C5 during the May 2023 survey.

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Methods

2.1 Study Area and Monitoring Sites

The study area is located within Sections 6 – 9 of the W2B Upgrade corridor.

The number of sites sampled has varied over time during pre-construction, construction and operational phases. In the first year of construction phase threatened fish monitoring 27 and 28 sites were sampled in May 2017 and September 2017 respectively. In the second year of monitoring a reduced number of sites were sampled due to landholder restrictions upon access to sites 11b, 13e and 26b. In the third year of monitoring 7 sites, previously monitored as part of the Devils Pulpit Pacific Highway upgrade threatened fish monitoring (GeoLINK 2015), were added to the survey, but landholder restrictions upon access have continued to impact monitoring at sites 13e, 26b and OPP4. All sites that are both accessible and were monitored during the construction phase have continued to be monitored during the operational phase.

The waterways monitored include backwaters on flood-prone land, ephemeral swamps, farm drainage lines, natural creeks, dams and excavations. Of the total sites currently monitored eleven are control sites.

The study area and location of sampling sites are displayed in **Illustrations 2.1**, **2.2**, **2.3** and **2.4**. A list of sampling locations is presented in **Table 2.1**.

Due to the potential for construction impacts to extend along waterways, and the location of suitable habitat for the target species, some sites were located outside of the immediate W2B upgrade corridor. In most cases, the maximum distance from the highway corridor of individual impact sites was 200 m. For the same reason control sites were mostly located at a larger distance from the W2B upgrade corridor.

Table 2.1 A brief description of the significant waterways sampled during the survey.

Section	*Waterway*	*Sites*	*Chainage*	*Notes*
DP	Tabbimoble 3 Channel	OPP3, OPP7	110500	Constructed channel that drains floodwaters from the west of the Pacific Highway. Confluence with Tabbimoble 2 Channel 300m downstream of the highway. Permanent **Class 1** stream with intermittent areas and an offstream dam. OPP previously identified. **2 sites**, one upstream and one at the impact. The upstream site (OPP7) frequently dries out.
DP	Tabbimoble 2 Channel	OPP1, OPP2, OPP4, OPP6	110800	Constructed channel that drains floodwaters from the west of the Pacific Highway. Permanent **Class 1** stream with intermittent areas and an offstream dam. OPP previously identified. **4 sites**, two upstream, one at the impact and one reference site far downstream. One of the upstream sites (OPP6) frequently dries out. Another site, OPP 4, can only be accessed across private property and the landholder has denied access during the operational phase.

Section	*Waterway*	*Sites*	*Chainage*	*Notes*
7	Unnamed waterway south of Serendipity Rd	2a, 2b, 2c	114000	Drains from headwaters approximately 1km upstream. Intermittent **Class 1** stream. OPP previously identified. **3 sites**, upstream, impact and downstream. The impact and downstream site frequently dry out.
7	Tabbimoble floodway no. 1	3a	115300	Drains from headwaters approximately 1.5km upstream. Intermittent **Class 1** stream. OPP previously identified. **1 site** at impact.
8	Unnamed waterway south of MacDonalds Ck	10b, 10c	134600	**Class 1** waterway, draining flood prone land connecting with Broadwater NP. OPP previously identified. **2 sites**, impact and downstream. The downstream site frequently dries out. The upstream site has a constructed drought refuge pool.
8	MacDonalds Ck tributary	11b, 11d	135200, 135530, 136450	Manmade drains connecting cane fields and flood prone land in Broadwater NP with a small natural **Class 1** waterway. OPP previously identified. **2 sites**, impact and downstream.
8	MacDonalds Ck	12a	136600	**Class 1** waterway draining flood prone land connecting with Broadwater NP. OPP previously identified. **1 site**, at impact.
8	Various dams south of Broadwater National Park	22b, 22c	136700 - 137900	Two manmade dams and excavations on private property. OPP previously identified. Each individual waterbody sampled at **1 site** only. Both located E (downstream) of impact.
9	Broadwater NP Swampland	16a, 16b, 27b, 27e	139000 - 140500	Series of wetland pools throughout protected wallum country. **Class 1** stream. OPP previously identified. **4 sites** one impact, three to the east.
9	Various dams north of Broadwater National Park	26d	140900 - 142300	Manmade dam/excavation on private property. OPP previously identified. Located E (downstream) of impact.
9	Montis Gully tributary 1	13b, 13c, 13e	141180 141850	Series of **Class 1** waterways and canals draining agricultural land and flood prone land. OPP previously identified. **3 sites**, 1 slightly upstream, 2 at the impact.
N/A	Bundjalung National Park Swampland	OPP5 C13, C14	N/A	Large coastal wetland complex. **Class 1** intermittent wetland area with a variety of natural depressions, natural drainage lines, constructed drainage lines and flooded trails. OPP previously identified. **3 reference sites**, 2 intermittent, 1 permanent.
N/A	Broadwater National Park Swampland	C1, C2, C3, C5, C8, C11, C12	N/A	Large coastal wetland complex. **Class 1** intermittent wetland area with a variety of natural depressions, natural drainage lines, constructed drainage lines and flooded trails. OPP previously identified. **7 reference sites**, 4 intermittent, 3 permanent.

A control site was monitored for each of the locations with a confirmed population of OPP. Control sites were selected according to the methods set out in the *Threatened Fish Management Plan* (Roads and Maritime 2015) for the W2B Upgrade. The locations of all impact and control sites are presented in in **Illustrations 2.1**, **2.2 2.3** and **2.4**.

Access to some sites was restricted in the current monitoring period. Sites 13e, 26b and OPP4 could not be accessed for either survey in 2023 due to landholder restrictions. Other sites

were dry during one or both survey periods. Sites 2c, 10c, C2, C11, C14 and OPP5 were dry during both surveys. Sites OPP6 and OPP7 were dry during the September 2023 survey only.

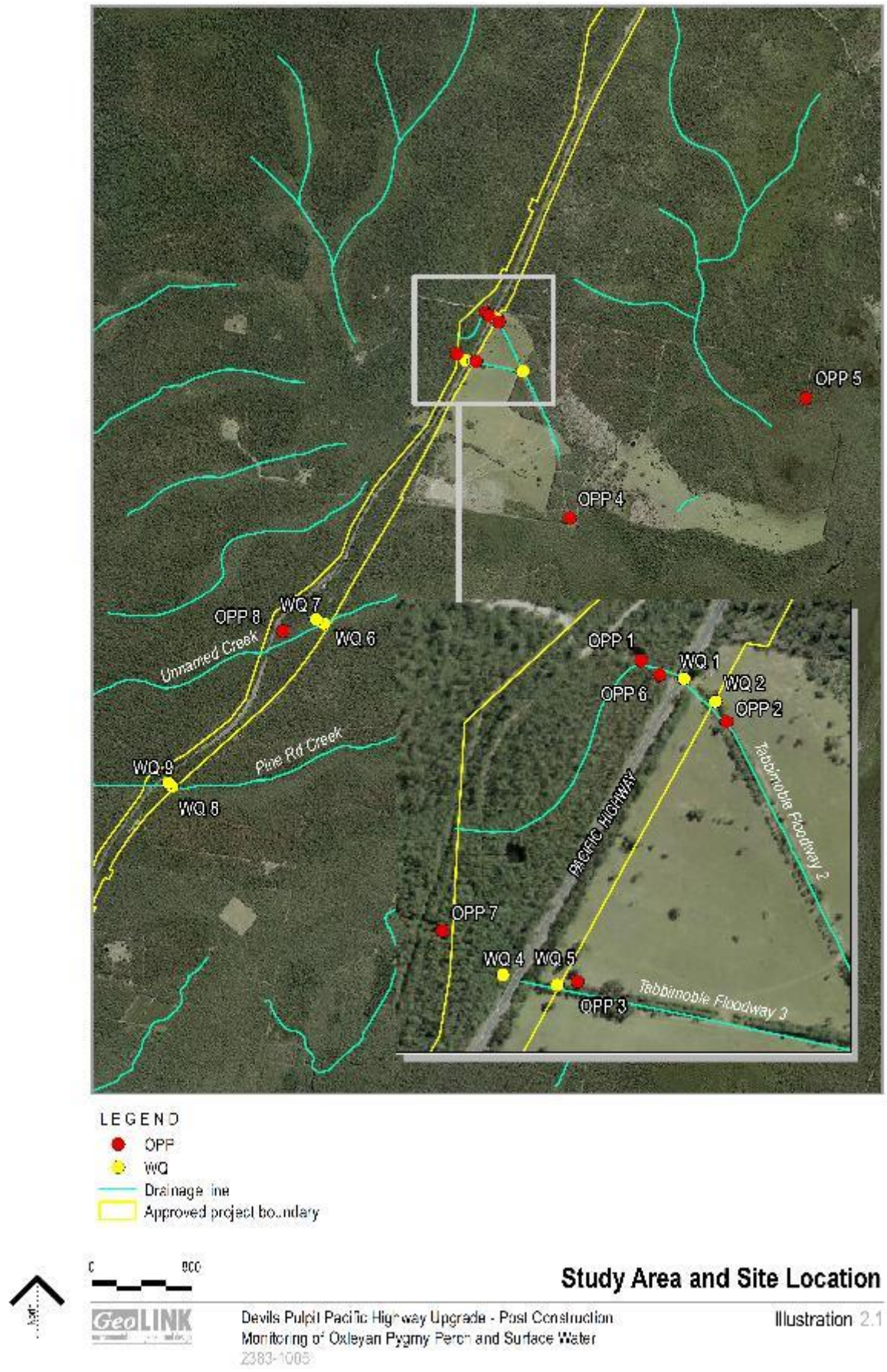


Illustration 2.1 Map of Devils Pulpit (DP) sampling sites (from GeoLINK 2015)

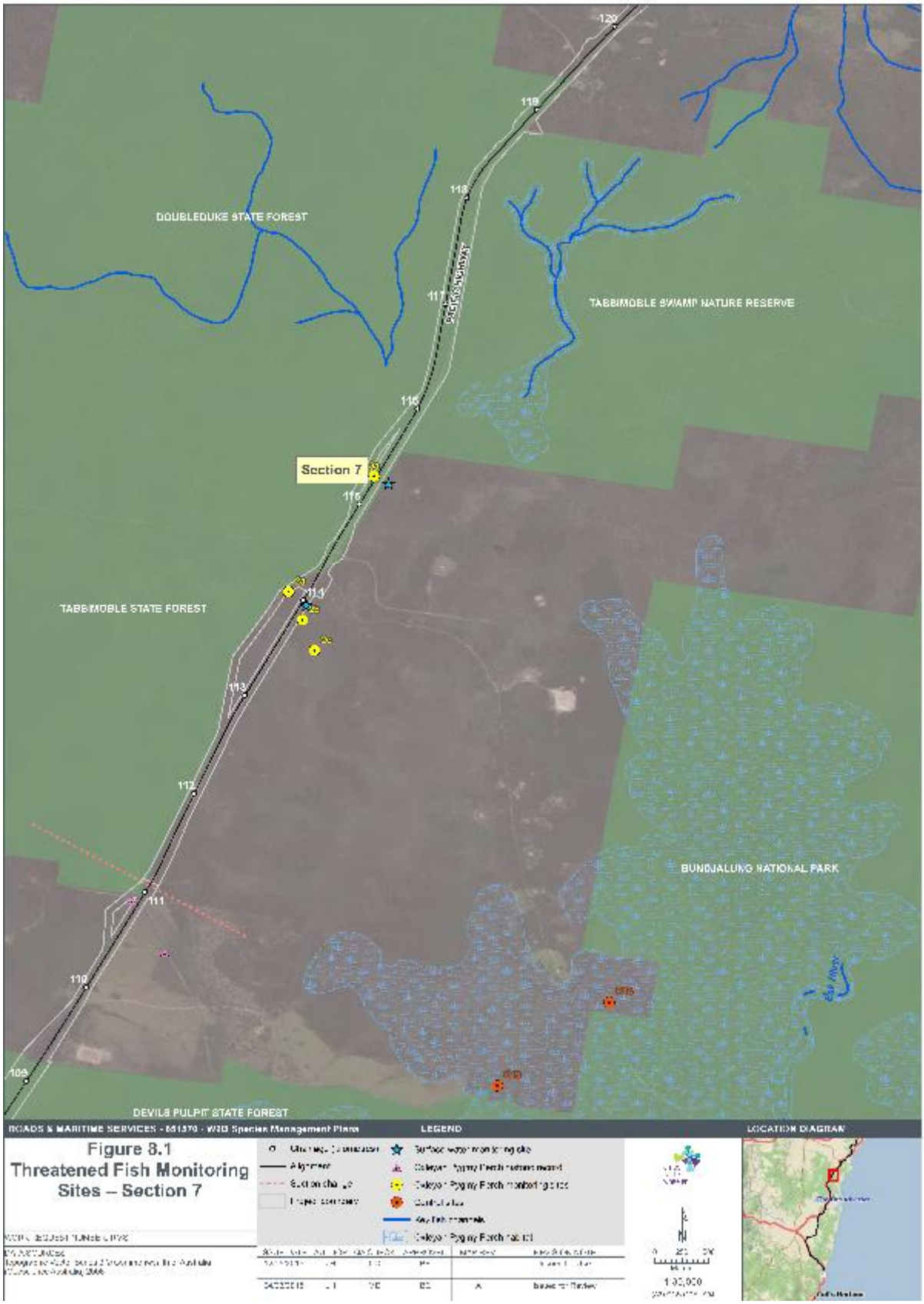


Illustration 2.2 Map of Section 7 sampling sites taken from the TFMP (RMS 2015)

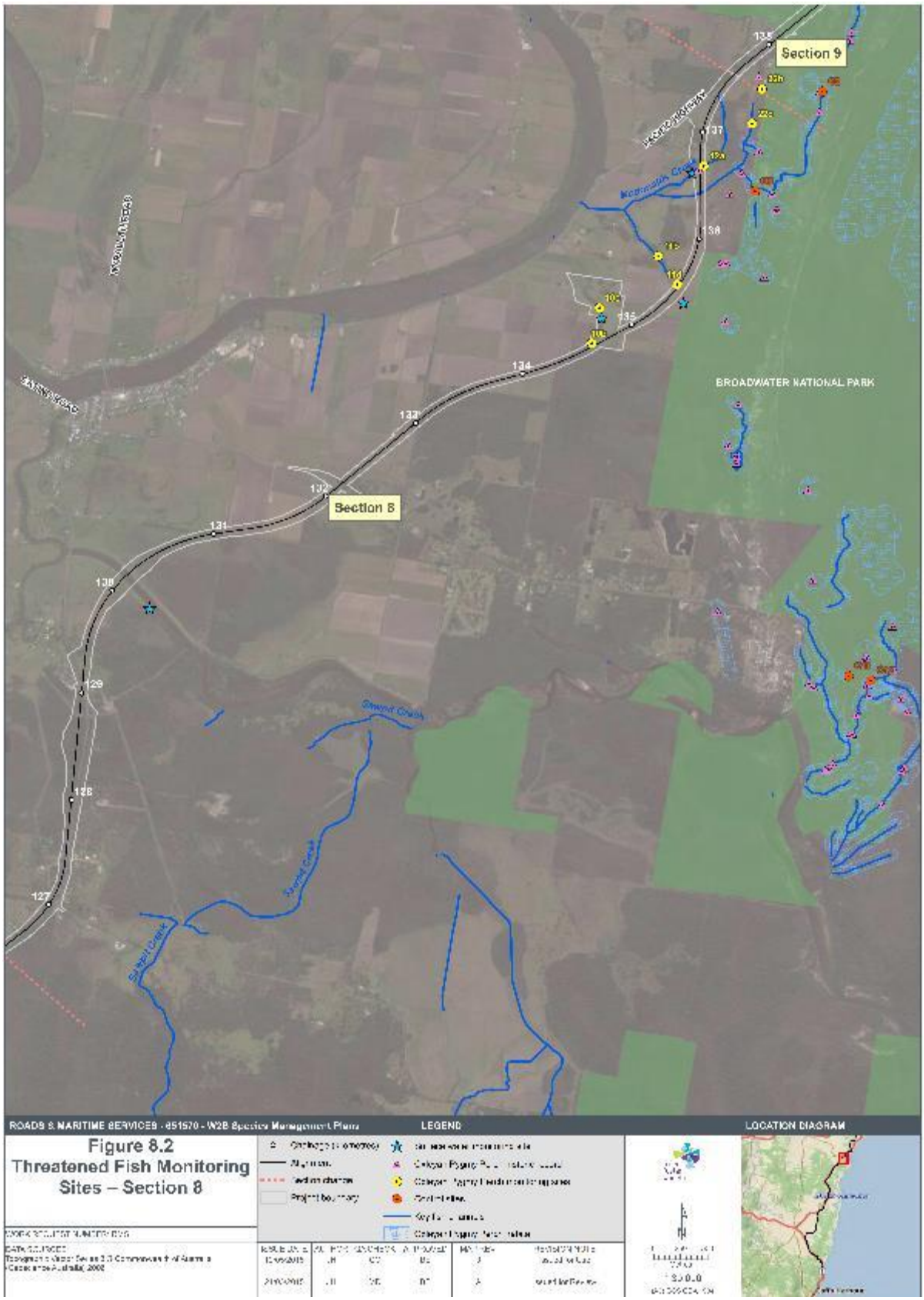


Illustration 2.3 Map of Section 8 sampling sites taken from the TFMP (RMS 2015)

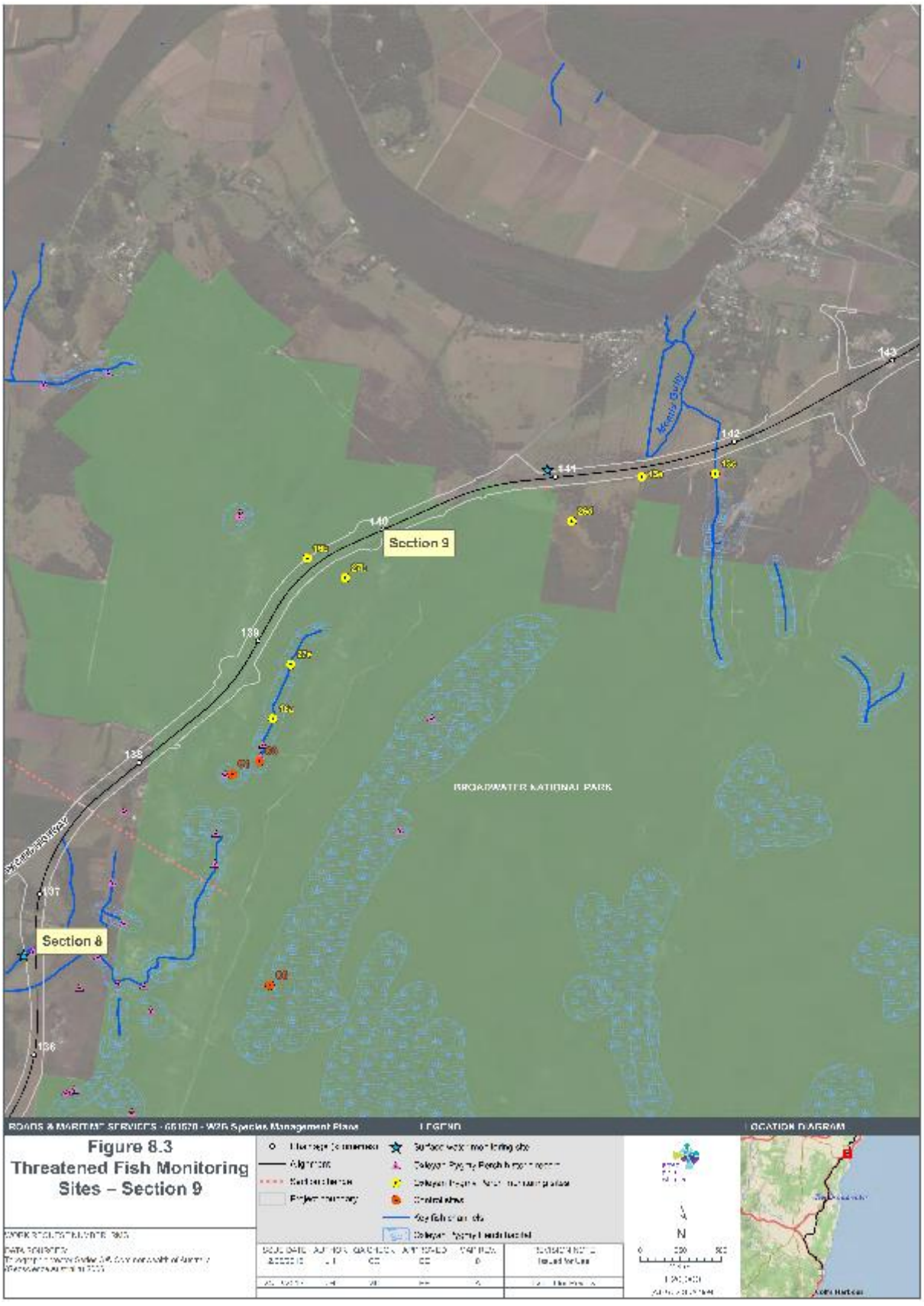


Illustration 2.4 Map of Section 9 sampling sites taken from the TFMP (RMS 2015)

2.2 Timing

Bi-annual targeted threatened fish monitoring is scheduled to occur in May/June and August/September and align with the methods used during the pre-construction survey. During this reporting period the surveys were undertaken in May 2023 and September 2023.

Monitoring was scheduled to avoid the OPP breeding season, which peaks between October and April, and timed to ensure optimum conditions with respect to water levels.

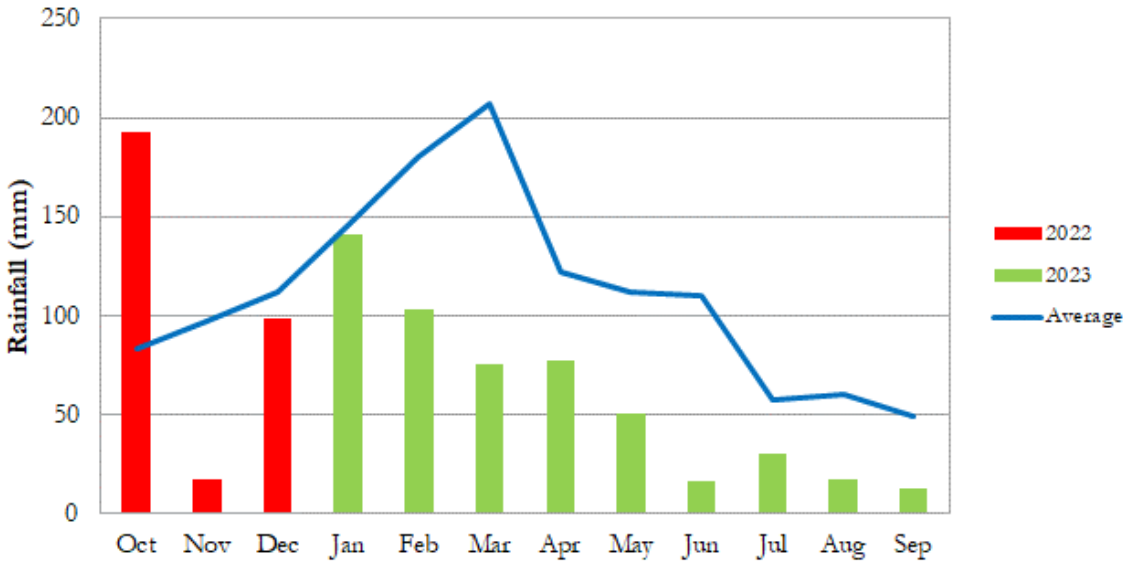


Figure 2.1 Mean monthly rainfall and average monthly rainfall from the New Italy Bureau of Meteorology station for the current reporting period.

The total rainfall for this annual reporting period was 62% of the yearly average. The monthly rainfall from November 2022 until September 2023 was below average. (**Figure 2.1**). At the time of the May 2023 and September 2023 surveys many sites were dry and water levels at many other sites were lower than average. Fluctuating water levels are an important consideration because they significantly change the ability to capture fish, the amount of aquatic terrain available, the ability to deploy fish traps and also heavily impact the habitat measurements collected.

2.3 Fish Survey

Fish sampling was undertaken under a *Fisheries Management Act 1994* Section 37 permit using a combination of back-pack electro-fisher and unbaited box traps, in accordance with procedures for Oxleyan Pygmy Perch outlined in the *Survey guidelines for Australia's Threatened Fish* (DSEWPaC, 2011), and Knight *et al.* (2007). In summary, this involved:

- The deployment of 10 unbaited standard collapsible bait traps at each site for a standard 30-minute period. Traps were redeployed for an additional 30-minute period where no Oxleyan Pygmy Perch were recorded at the sampling station in the first 30-minute period
- Undertaking back-pack electrofishing at each site, where safe to do so. Backpack electrofishing was restricted to shallow areas (e.g., <1 m deep) due to safety issues with use in deeper water. The electrofisher settings were adjusted according to conductivity to ensure that fish were stunned temporarily. Settings were recorded at each site and are

presented in **Table 2.2** and **Table 2.3**. Sampling was undertaken at each site for 600 seconds of pulse time or two passes of all available habitats. Stunned fish were collected using a 5mm dip net (knotless mesh). If 30 individual OPP were captured at one site further efforts were abandoned to minimise processing times and ensure that captured fish were released back into the environment in good condition.

Table 2.2 Details of electrofisher settings and effort at each site in May 2023

Section	*Site*	*Voltage (V)*	*Pulse Freq (Hz)*	*Duty Cycle (%)*	*Passes*	*Seconds Pulsed*
6	OPP1	250	50	12	1	606
6	OPP2	200	50	12	1	600
6	OPP3	250	50	12	1	607
6	OPP4	No Access				
6	OPP5	Site Dry				
6	OPP6	75	50	12	2	104
6	OPP7	100	50	12	2	450
7	2a	175	50	12	1	600
7	2b	275	50	12	2	458
7	2c	Site Dry				
7	3a	250	50	12	1	636
8	10b	250-300	50	12	1	601
8	10c	Site Dry				
8	11b	175	50	12	1	622
8	11d	100	50	12	1	645
8	12a	225	50	12	1	602
9	13b	125	50	12	1	593
9	13c	200	50	12	1	603
9	13e	No Access				
9	16a	125	50	12	1	520
9	16b	150	50	12	1	642
8	22b	250	50	12	1	623
8	22c	250	50	12	2	616
9	26d	No Access				
9	27b	250	50	12	1	607
9	27e	200	50	12	2	428
Control	C1	250	50	12	1	601
Control	C2	Site Dry				
Control	C3	125	50	12	1	602
Control	C5	125	50	12	2	383
Control	C8	200	50	12	1	628
Control	C11	Site Dry				
Control	C12	125	50	12	1	614
Control	C13	250	50	12	1	607
Control	C14	Site Dry				

Table 2.3 Details of electrofisher settings and effort at each site in September 2023

Section	*Site*	*Voltage (V)*	*Pulse Freq (Hz)*	*Duty Cycle (%)*	*Passes*	*Seconds Pulsed*
6	OPP1	225	50	12	1	601
6	OPP2	150	50	12	1	613
6	OPP3	225	50	12	2	601
6	OPP4	No Access				
6	OPP5	Site Dry				
6	OPP6	Site Dry				
6	OPP7	Site Dry				
7	2a	175	50	12	2	290
7	2b	200	50	12	2	770
7	2c	Site Dry				
7	3a	225	50	12	1	618
8	10b	200	50	12	1	617
8	10c	Site Dry				
8	11b	150	50	12	1	625
8	11d	75	50	12	2	392
8	12a	175	50	12	1	607
9	13b	150	50	12	2	488
9	13c	200	50	12	1	620
9	13e	No Access				
9	16a	100	50	12	1	90
9	16b	200	50	12	2	404
8	22b	200	50	12	1	620
8	22c	200	50	12	1.25	603
9	26d	No Access				
9	27b	200	50	12	1	606
9	27e	150	50	12	1	613
Control	C1	200	50	12	1	605
Control	C2	Site Dry				
Control	C3	75	50	12	2	121
Control	C5	100-150	50	12	2	301
Control	C8	200	50	12	1	607
Control	C11	Site Dry				
Control	C12	125-150	50	12	2	503
Control	C13	250	50	12	1	604
Control	C14	Site Dry				

All captured fish were retained in aerated storage buckets until all fishing at the station had been completed to avoid skewing results with recapture. Captured fish were identified, counted and measured for total length. Abnormalities including wounds or deformities were recorded at the time of capture. Exotic species captured were euthanased in accordance with approved animal ethics procedures (Barker *et al.*, 2009).

2.4 Water Quality

At each site physico-chemical water quality parameters were measured in surface water with a HORIBA U52 multimeter to determine the suitability of the site for Oxleyan Pygmy Perch in terms of water quality. The parameters measured were temperature, conductivity, dissolved oxygen, pH and turbidity.

2.5 Habitat Description

A general description of the habitat characteristics of each monitoring site was made, documenting riparian vegetation characteristics and condition, stream substrate composition and profile, areas of bank erosion and sedimentation, and overall aquatic habitat condition. The methods described in Pusey, Kennard & Arthington (2004) formed the basis of habitat descriptions.

At each monitoring site the following in-stream habitat features were recorded as key determinants of habitat suitability for the target fish species:

- average channel depth from 3 points in each site;
- average stream width from 3 points in each site;
- per cent cover of large woody debris (>150 mm stem diameter), small woody debris and leaf litter from 12 points in each site;
- per cent cover of submerged and emergent macrophytes from 12 points in each site. Species of aquatic vegetation were also recorded;
- substrate composition from 12 points in each site in per cent cover of mud, sand, fine gravel (2-16mm), coarse gravel (16-64 mm), cobble (64-128 mm), rock and bedrock;
- per cent of bank classified as undercut (20 cm overhang), or as root masses averaged from 4 transects at each site;
- per cent cover of riparian vegetation averaged from 4 transects at each site; and
- flow rates.

In order to collect this data three transects were positioned perpendicular to stream flow and the substrate composition, debris cover and vegetative cover were estimated in four individual 0.5 m x 0.5 m quadrats randomly positioned along each transect. Wetted width and depth were also measured at each of these transects. Additionally, 4 transects, representing a total of 20 per cent of wetted stream perimeter, were randomly positioned along each bank and longitudinal percentage cover estimates of root masses, bank and vegetation overhangs and riparian cover were made along each transect.

At some sites, the steepness of the banks and depth of the water combined to make it difficult to lay and interpret quadrats. On such occasions, and on others where the wetted width of the stream was less than 2.5 m, the full complement of 12 quadrats was not utilised.

In addition to the above structural habitat descriptions an inventory of aquatic plants at each site was compiled.

Photographs were taken facing upstream and downstream from a standard, central position at each site. The locations of the photographic monitoring point as well as upstream and downstream site boundaries were recorded with a GARMIN GPS map 62 handheld GPS to facilitate repeat sampling. All spatial data were collected and are reported in WGS84.

Results

3.1 Fish Surveys

During the May 2023 survey approximately 218 hours of fish trapping and 14,716 seconds of electrofishing were used. During the September 2023 survey approximately 154 hours of fish trapping and 12,519 seconds of electrofishing were used.

There were some sites where fish capture was not attempted during the two surveys this year due to either changing access permission to private lands or a lack of water at the time of the survey. These sites were:

- Sites OPP4, 13e and 26d, which had access restrictions at the time of the May 2023 and September 2023 surveys.
- Sites 2c, 10c, C2, C11, C14 and OPP5, which were dry at the time of the May 2023 and September 2023 surveys.
- Sites OPP6 and OPP7, which where dry at the time of the September 2023 survey.

In the May 2023 survey a total of 4,946 fish from ten species were captured. Of the total number of fish captured, 2,528 individuals from nine species were captured using the electrofisher and 2418 individuals from eight species were captured using fish traps.

In the September 2023 survey a total of 3,970 fish from eight species were captured. Of the fish captured during the September 2023 survey 2,215 individuals from ten species were captured using the backpack electrofisher and 1,755 individuals from six species were captured using bait traps.

In the May 2023 survey 180 individual OPP were captured. Of these, 123 were captured using the backpack electrofisher and 57 in fish traps. In the May 2023 survey OPP were captured at 5 of the 24 impact sites and at 5 of the 11 control sites.

In the September 2023 survey 128 individual OPP were captured. Of these 83 were captured using the backpack electrofisher and 45 in fish traps. In the September 2023 survey OPP were captured at 5 of the 24 impact sites and at 4 of the 11 control sites.

The most commonly captured species of fish during the May 2023 survey was the Empire Gudgeon (*Hypseleotris compressa*). Individuals of this species accounted for approximately 41 per cent of the total number of fish captured in the May 2023 survey. The most commonly captured species of fish during the September 2023 survey was also the Empire Gudgeon, accounting for approximately 42 per cent of the fish captured. Overall, OPP accounted for approximately 4 per cent of the fish captured in the May 2023 survey and approximately 3 per cent of the fish captured during the September 2023 survey.

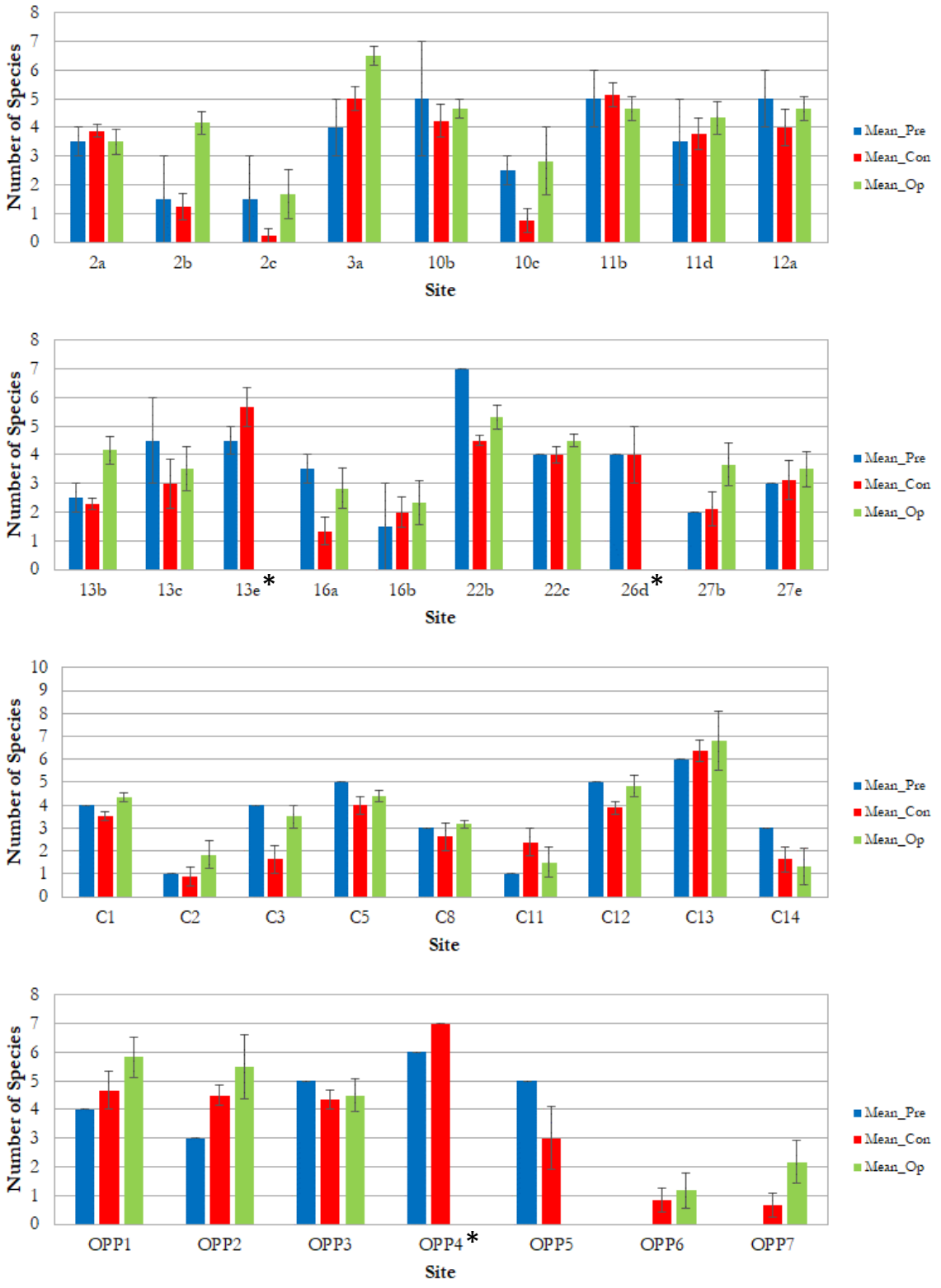


Figure 3.1 Mean ± SE taxonomic richness of captured fish at all sites during the operational phase surveys to date (plotted against Mean ± SE in preconstruction and construction phase surveys)

***** **Site not surveyed during operational phase due to access restrictions**

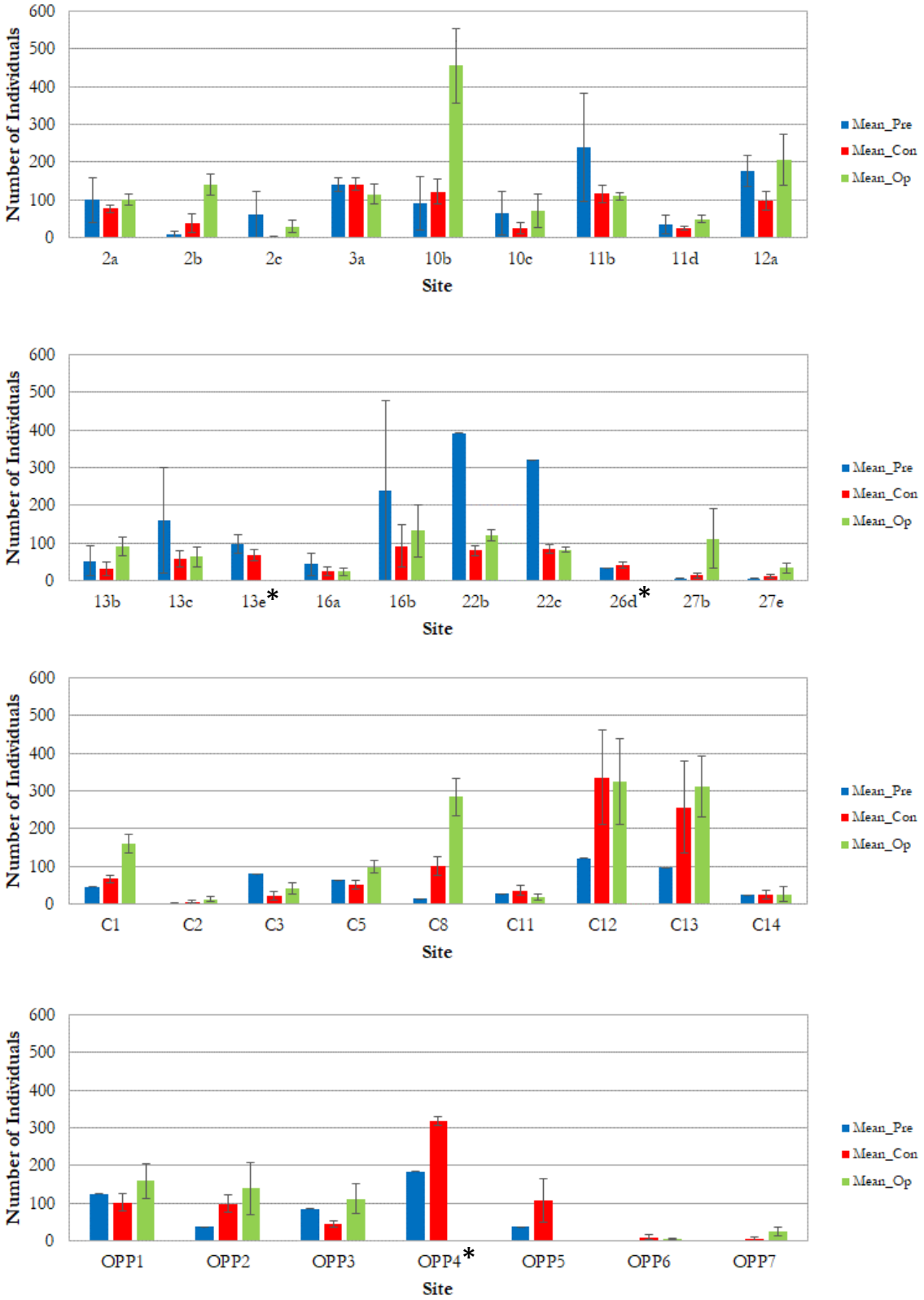


Figure 3.2 Mean ± SE abundance of captured fish at all sites during the operational phase surveys to date (plotted against Mean ± SE in preconstruction and construction phase surveys)

***** **Site not surveyed during operational phase due to access restrictions**

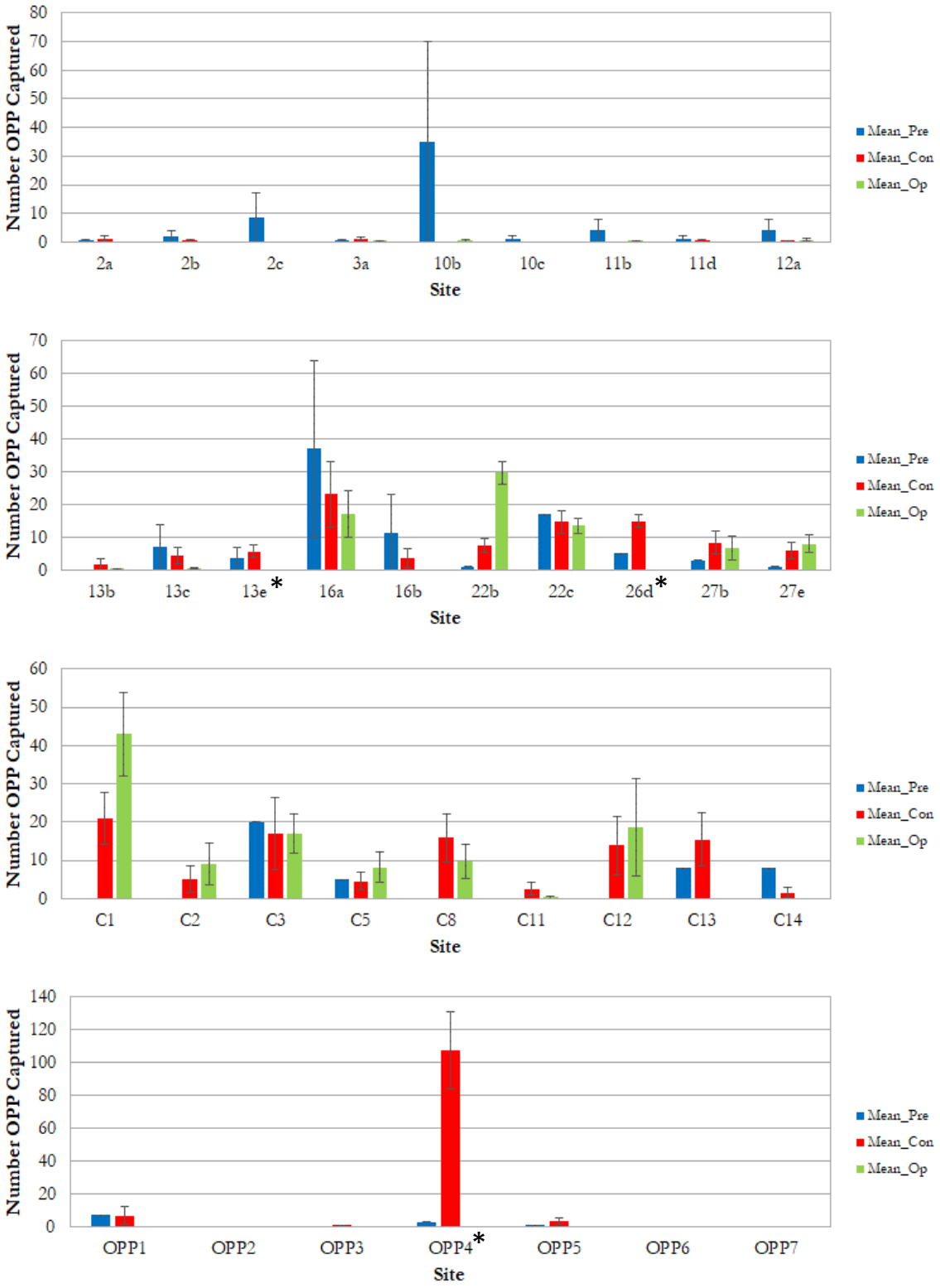


Figure 3.3 Mean ± SE OPP captured at all sites during the operational phase surveys to date (plotted against Mean ± SE in preconstruction and construction phase surveys)

*** Site not surveyed during operational phase due to access restrictions**

The full results of the May 2023 and September 2023 fish surveys are presented in **Appendix B**. Summary results for each site are presented in **Figures 3.1** to **3.3**. The results during operational monitoring to date have been comparable with the results of pre-construction and

construction phase monitoring at most impact and control sites in terms of fish diversity and abundance (**Figures 3.1** and **3.2**). With very few exceptions average diversity and abundance at each site falls within the variability identified during pre-construction and or construction phase sampling. In the 2 surveys this year between one and eight species of fish were captured at each site where surveys were possible. In the May 2023 survey the sites with the highest diversity of captured fish were 3a, 22b, C12 and OPP2 with seven or eight species. In the September 2023 survey the sites with the highest diversity of captured fish were 3a, 10b, 11b, 13b, 22b, 27b, C3, C12 and OPP2 with five or six species.

Between 12 and 787 individual fish were captured at the impact sites during the two surveys this year. The impact sites where the most fish were captured during the May 2023 survey were 10b, 16b and 12a. In the September 2023 survey the impact sites where the most individual fish were captured were 10b, 27b and OPP3.

The total number of individual fishes captured at the control sites varied between 77 and 423, with the largest numbers of fish captured at C8 and C1 in the May 2023 survey and C13 and C8 in the September 2023 survey.

The average numbers of OPP captured at each site during pre-construction, construction and operational phase monitoring are presented in **Figure 3.3**. The total numbers of OPP captured during this reporting period were slightly above average in May 2023 and slightly below average in September 2023. The number of OPP captured at each site varied between the May 2023 and September 2023 surveys, but not to a great degree. OPP were captured at 10 sites in the two surveys this year (compared to 22 sites in 2017, 17 sites in 2018, 5 sites in 2019, 7 sites in 2020, 11 sites in 2021 and 18 sites in 2022). The reduced number of sites where OPP were captured and the reduced numbers of OPP captured, in comparison to the previous year, is reflected in the results of other years of low rainfall (such as 2019 and 2020, when the numbers of OPP captured were even lower). In the context of results from the nineteen surveys undertaken as part of the W2B upgrade monitoring to date, it does not indicate a negative impact upon OPP populations resulting from the operation of the W2B upgrade.

The capture of OPP has varied significantly between sites and over time since monitoring along the W2B upgrade began in 2013. The average capture per survey at each site during pre-construction, construction and operational phase monitoring is presented in **Figure 3.3**. The figures indicate that average pre-construction phase captures were higher than average operational phase captures at several impact sites, including sites 2a, 2b, 2c, 10b, 10c, 11b, 11d, 13c, 16b and 22c although pre-construction phase variability was equal to the average at most of these sites (at sites 2a, 2b, 2c, 10b, 10c, 11b, 11d, 13c and 16b there were no OPP captured in the second pre-construction survey). Average operational phase OPP captures were also higher at some impact sites, including 22b and 27e. Average captures at the control sites during the operational phase monitoring to date have mostly been larger than or equivalent to captures during the pre-construction phase monitoring, the exceptions being sites C3, C13 and C14. However, the control sites were only monitored once during pre-construction phase monitoring and it was after a year of severe drought conditions (2014), when OPP numbers were atypically low.

When the control and impact sites are considered as a group, the pre-construction and construction phase average captures per site show a reduction in the average OPP capture at impact sites in the construction and operational phase monitoring, although variability in the pre-construction phase monitoring was high, and an increase in the average capture at control

sites in the construction and operational phase monitoring, although it was based upon only one pre-construction survey during a drought year (**Figure 3.4**).

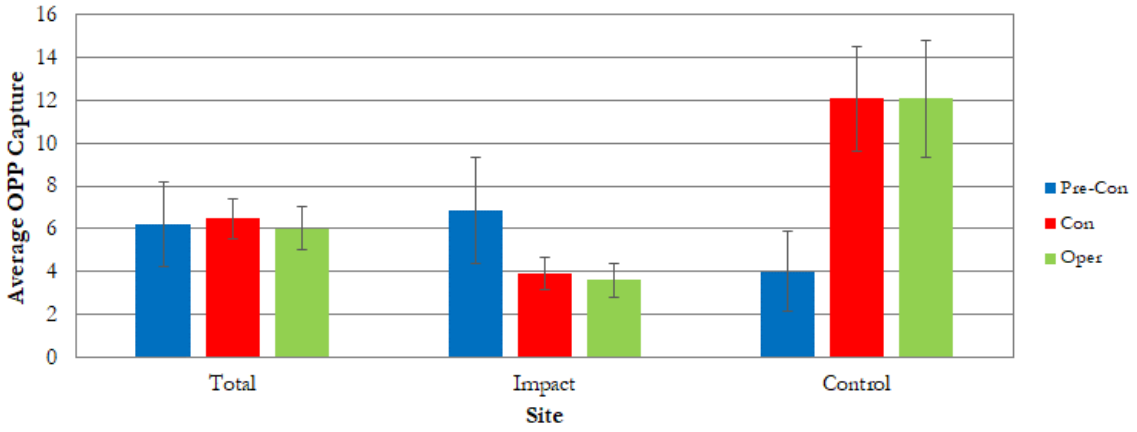


Figure 3.4 Mean ± SE OPP capture at combined control and impact sites in pre-construction, construction and operational phase monitoring to date (pre-construction data from GeoLINK 2014, 2015a & 2015b, Hyder 2012)

3.2 Water Quality

The results of water quality samples are presented in **Tables 3.1** and **3.2**. The results are indicative of the water quality at the time of sampling only and are likely to fluctuate considerably at each site according to weather and seasonal conditions.

Table 3.1 Results of water quality sampling from all sites for the May 2023 survey

Site	*Date*	*Temperature*	*pH*	*Conductivity*	*Turbidity*	*DO*	*DO%*
		°C		*mS/cm*	*NTU*	*mg/L*	*%*
OPP1	11/05/2023	14.34	5.45	0.109	7.1	**1.33**	13.5
OPP2	11/05/2023	16.1	5.67	0.229	6.6	4.7	49.3
OPP3	11/05/2023	18.09	5.69	0.188	5.6	3.28	35.8
OPP4		No Access					
OPP5	11/05/2023	No Water					
OPP6	11/05/2023	15.3	**4.98**	0.229	25.2	3.96	40.8
OPP7	11/05/2023	18.17	5.75	0.19	50.1	**1.96**	21.4
2a	8/05/2023	17.36	6.80	**0.065**	6.4	3.35	36
2b	8/05/2023	19.18	6.90	0.421	23.3	4.31	48.1
2c	8/05/2023	17.2	6.14	0.234	12.5	4.61	49.4
3a	15/05/2023	17.14	5.98	0.161	7.8	4.5	48.2
10b	9/05/2023	16.43	6.75	0.419	9.9	3.86	40.7
10c	9/05/2023	No Water					
11b	15/05/2023	17.08	5.00	0.195	6.6	**2.04**	21.8
11d	9/05/2023	19.38	5.77	0.178	5.4	**0.9**	10
12a	9/05/2023	13.11	6.18	0.334	60	**1.72**	16.9
13b	9/05/2023	13.49	6.22	0.205	44.2	**0.51**	5
13c	15/05/2023	17.04	**3.92**	0.172	16.9	**1.47**	15.7
13e		No Access					
16a	12/05/2023	18.69	**3.77**	0.153	3.3	**1.09**	12

Site	Date	Temperature	pH	Conductivity	Turbidity	DO	DO%
		°C		mS/cm	NTU	mg/L	%
16b	12/05/2023	16.41	5.96	0.308	8.6	**1.71**	18
22b	10/05/2023	15.43	**4.37**	0.119	7.3	2.58	26.7
22c	10/05/2023	13.97	**4.37**	0.114	1.2	**1.79**	17.9
26d		No Access					
27b	12/05/2023	15.49	**4.28**	0.101	6.3	**0.81**	8.4
27e	12/05/2023	17.9	**4.28**	0.098	16	**0.53**	5.8
C1	10/05/2023	16.98	**3.98**	0.092	6.4	5.96	63.6
C2	13/05/2023	No Water					
C3	10/05/2023	17.84	**3.51**	0.192	9.4	6.17	66.9
C5	10/05/2023	12.87	**4.51**	0.098	6.8	**1.88**	18.4
C8	13/05/2023	14.79	**3.61**	0.234	3.1	**2.1**	21.4
C11	13/05/2023	No Water					
C12	13/05/2023	16.72	**3.94**	0.128	9.2	2.18	23.1
C13	8/05/2023	16.16	6.14	0.184	17.3	**1.98**	20.8
C14	8/05/2023	No Water					

Red Text Outside of the known range of OPP
Blue Text Within a range thought to provide OPP with a competitive advantage
Green Text OPP captured at site during this survey

Table 3.2 Results of water quality sampling from all sites for the September 2023 survey

Site	Date	Temperature	pH	Conductivity	Turbidity	DO	DO%
		°C		mS/cm	NTU	mg/L	%
OPP1	8/09/2023	17.33	5.19	0.108	18.3	**1.63**	17.5
OPP2	8/09/2023	17.58	6.24	0.282	4.8	4.39	47.4
OPP3	8/09/2023	18.25	5.49	0.186	24.6	3.86	42.2
OPP4		No Access					
OPP5	8/09/2023	No Water					
OPP6	8/09/2023	No Water					
OPP7	8/09/2023	No Water					
2a	4/09/2023	17.72	6.72	0.077	9.9	3.5	37.9
2b	4/09/2023	18.64	6.9	0.746	24.4	6.34	70
2c	4/09/2023	No Water					
3a	8/09/2023	15.37	5.56	0.075	1.7	7.15	73.8
10b	5/09/2023	17.07	5.7	0.309	24.5	3.03	32.4
10c	5/09/2023	No Water					
11b	7/09/2023	20.74	5.12	0.231	27.6	**1.85**	21.2
11d	5/09/2023	17.17	5.79	0.169	16	2.81	30.1
12a	5/09/2023	17.03	6.4	0.326	56	2.83	30.3
13b	5/09/2023	15.15	6.55	0.355	42.3	3.69	37.9
13c	7/09/2023	17.31	**4.1**	0.152	65	**0.54**	5.8
13e		No Access					
16a	10/09/2023	15.13	**3.78**	0.184	28.7	**2.02**	20.8
16b	7/09/2023	15.36	5.74	0.327	49.6	2.25	23.2
22b	6/09/2023	21.01	**4.26**	0.141	70.7	2.95	33.9
22c	6/09/2023	18.45	**3.85**	0.119	0.2	2.87	31.5
26d		No Access					
27b	7/09/2023	20.7	**3.94**	0.117	1.1	3.98	45.6
27e	10/09/2023	11.65	**4.06**	0.105	20	**1.99**	18.9
C1	10/09/2023	18.08	**3.82**	0.108	9.7	4.23	46.1
C2	6/09/2023	No Water					

Site	Date	Temperature	pH	Conductivity	Turbidity	DO	DO%
		°C		mS/cm	NTU	mg/L	%
C3	10/09/2023	19.43	3.43	0.296	4.1	6.01	67.2
C5	6/09/2023	17.61	3.92	0.085	0	3.02	32.6
C8	6/09/2023	20.61	3.9	0.229	2.2	6.74	77.2
C11	8/09/2023	No Water					
C12	8/09/2023	19.96	3.9	0.15	1.2	2.84	32.1
C13	4/09/2023	17.27	5.78	0.16	4.6	0.62	6.7
C14	4/09/2023	No Water					

Red Text Outside of the known range of OPP
Blue Text Within a range thought to provide OPP with a competitive advantage
Green Text OPP captured at site during this survey

The results of the water quality measurements show that, at the time of sampling, the water quality at most sites was within the known physico-chemical tolerances of OPP (refer to **Table 1.1**). At slightly less than half of the sites the pH values were in the range thought to provide OPP with a competitive advantage. There were some sites where the water quality was outside of the known tolerance ranges of OPP with respect to dissolved oxygen in the 2023 surveys. Notably, at the majority of the sites where OPP were captured during this reporting period the water quality measurements were within the known tolerance ranges of OPP and pH was recorded within the range thought to provide OPP with a competitive advantage.

Although the dissolved oxygen (DO) concentrations at multiple sites were below the levels thought to be ideal for fish survival and function (> 4-5 mg/L), OPP are commonly associated with dystrophic (low DO concentration) waterways and the swamps and streams in the wallum country favoured by OPP are typically low in DO. During the surveys in 2023 OPP were captured from six sites where DO concentrations of less than 2.15 mg/L were measured.

A comparison of threatened fish monitoring pre-construction and construction phase water quality ranges with the water quality results collected during the May 2023 and September 2023 surveys is presented in **Appendix C**. All of the results are within the ranges previously measured in pre-construction and construction phase monitoring.

A program of operational phase water quality monitoring on the W2B upgrade is undertaken at some of the sites where threatened fish monitoring occurs. A brief analysis of the key indicators (DO, pH and turbidity results) captured in that water quality monitoring shows some parameters falling out of the reported water quality ranges for OPP at some sites over the operational phase monitoring period (**Table 3.3**).

Very few individual, and no average, pH and turbidity results were out of the reported water quality ranges for OPP (**Section 1.2**). At some sites a high percentage of individual, and some average, dissolved oxygen concentrations were out of range. However, as discussed, it is relatively common to capture OPP at sites with low DO concentrations. Taken as a collective, the results indicate:

- that water quality has remained suitable for OPP at most sites for the majority of the operational phase.
- that isolated instances of poor water quality can occur at crossing sites. In particular, low DO concentrations are common during dry conditions and high turbidity measurements and high pH measurements are more common during wet conditions.

- that water quality measurements over the operational phase show an improvement in comparison to the water quality measurements over the construction phase.
- that water quality along the Pacific Highway is unlikely to have resulted in significant negative impacts to OPP populations, particularly during the operational phase.

Table 3.3 Summary water quality results for key parameters from W2B operational phase water quality monitoring at OPP sites (from GeoLINK 2023)

Site	*OPP site*		*Parameter*								
			DO			*pH*			*Turbidity*		
			Average	*Count*	*% outside range*	*Average*	*Count*	*% outside range*	*Average*	*Count*	*% outside range*
SW7-02	2a, 2b, 2c	Dry	4.12	4	0.0	5.95	4	0.0	16.43	4	0.0
		Wet	4.74	5	20.0	6.36	5	20.0	50.18	5	20.0
SW7-04	3a	Dry	5.39	9	11.1	6.28	9	22.2	14.91	9	0.0
		Wet	6.44	9	11.1	6.34	9	22.2	23.48	9	0.0
SW8-04	10b, 10c	Dry	**0.36**	4	100.0	5.25	4	0.0	13.75	4	0.0
		Wet	3.09	5	60.0	5.49	5	20.0	31.48	5	0.0
SW8-06	11b, 11d	Dry	4.32	5	0.0	4.74	5	0.0	13.50	5	0.0
		Wet	4.29	9	11.1	5.14	9	0.0	22.14	9	11.1
SW8-08	12a	Dry	2.51	8	62.5	5.23	8	0.0	17.84	8	0.0
		Wet	2.77	9	44.4	5.19	9	0.0	25.66	9	0.0
SW9-01	13c	Dry	**0.77**	10	100.0	4.84	10	0.0	22.40	10	10.0
		Wet	**1.67**	9	66.7	4.76	9	0.0	67.66	9	11.1

3.3 Habitat Description

Habitat availability and condition varied across the study area. A brief description of the general habitat conditions at each location is presented in **Table 3.3**. Summary results from habitat surveys are displayed in graphical form in **Appendix A**. The two approaches, qualitative and quantitative, are intended to be used in conjunction. An inventory of aquatic plants found at each site during this reporting period is presented in **Table 3.4, Table 3.6**, **Table 3.6** and **Table 3.7**.

The flows were low or non-existent at all sites during this reporting period, mostly due to very low rainfall throughout the reporting period. Across the pre-construction, construction and operational phase monitoring periods flows and water levels have been highly variable. At some sites habitat descriptions and measurements have been hampered by the depth and flow velocities at the time of the surveys, and aquatic habitat measurements throughout all monitoring periods have depended largely on flow and water level conditions.

Table 3.4 Brief descriptions of habitat features at all impact sites

Section	*Site*	*Habitat Description*
7	2a	Site 2a is located approximately 200m upstream of the upgrade corridor and consists of two pools located either side of a culvert on a dirt road. The benthic material was dominated by mud but varied across the site and included sand and gravel in some areas. Structural habitat at the site was comprised mostly of leaf litter, undercut banks and root balls, all of which were variable within the site. The riparian zone was well vegetated and continuous with adjacent forest. There was no aquatic vegetation, no flow and very low water levels at the time of both surveys. The site had largely recovered from bushfire impacts at the time of the 2023 surveys.
7	2b	Site 2b is located in a shallow drainage line immediately downstream of a bank of new box culverts under the Pacific Highway. There was very limited structural habitat. The benthic material was mostly mud with a small amount of gravel, sand and scour rock. The riparian zone was cleared for construction and the creek bed altered for asset protection. Due to its proximity to the culverts the habitat at this site changed markedly during and following construction.
7	2c	Site 2c is also located in a shallow drainage line approximately 300m downstream of the existing highway. Site 2 is ephemeral and carries no water in moderately dry conditions. There was no water at the time of either survey in 2023. Most signs of bushfire have disappeared.
7	3a	Site 3a consists of a wide, shallow channel located directly upstream of an existing highway bridge. The benthic material is variable throughout the site, including mud, sand, fine gravel, coarse gravel and rock. There is a variety of structural habitat available, including a number of fallen logs, a moderate cover of woody debris and leaf litter, dense beds of aquatic vegetation and occasional root balls and undercut banks. The aquatic vegetation is dominated by Water Ribbons (*Cycnogeton procerum*) and Maundia (*Maundia triglochinoides*). The banks are mostly steep and undercut in some areas. A bridge has been built over the site and shading has affected the vegetation cover in some areas. There was very little flow at the time of the 2023 surveys.
8	10b	Site 10b is an excavation located within the upgrade corridor at the point where a wide ephemeral wetland of variable depth drains out into open agricultural land. Habitat availability is highly variable depending upon water levels. The benthic material included mud and sand and scour rock. Structural habitat availability varied throughout the site, although there was mostly a high proportional cover of leaf litter and some emergent and submerged vegetation. The stream margins vary between rock, bare sand and grass. There was no flow at the time of sampling in 2023. This site has been substantially modified during construction, including the construction of an upstream refuge pool, a deepened channel under the bridge crossing and installation of rock scour protection on the northern margins of the original excavation.
8	10c	Site 10c consists of a shallow, broad, degraded natural drainage line through agricultural land. It is located downstream of the upgrade corridor. The stream margins were flat and grassed with no significant riparian vegetation. Cattle access to the water has reduced since construction. Vegetative and structural habitat varies across the site from emergent grasses, knotweeds and spikerushes to bare unconsolidated sediments. The benthic material was mud. There was no water at the time of either survey in 2023.

Section	Site	Habitat Description
8	11b	Site 11b consists of a narrow channel, probably modified by excavation, draining agricultural land and cane fields into McDonalds Creek. The benthic material was mud, with a high proportional cover of debris. Other structural habitat included scattered rushes, regular root mass and trailing vegetation. The stream banks were relatively well vegetated with a mixture of trees, rushes and grasses. There was very low flow at the time of both surveys in 2023.
8	11d	Site 11d consists of a narrow, shallow channel, probably modified by excavation, draining sugar cane fields. The benthic material was mud and imported rock, with a moderate proportional cover of leaf litter and a sparse cover of mostly senescing emergent aquatic plants. The stream margins were steep and grassy, with no undercutting, little trailing vegetation and very little root mass. This site had been substantially modified during construction including revegetation and formalising of the channel. Shading effects from the bridge are evident. There was low flow at the time of both surveys in 2023.
8	12a	Site 12a consisted of a narrow channel, possibly modified by excavation, draining agricultural land. The benthic material was mud, with a high proportional cover of leaf litter and dense emergent plants, mostly knotweeds, Grey Rush (*Lepironia articulata*) and Jointed Twig-rush (*Baumea articulata*), in some areas. The degree of riparian cover, undercutting and root mass varies across the site. There was low to no flow at the time of both 2023 surveys. The site has now been significantly modified by a diversion and revegetation. Shading effects from the constructed bridge are evident.
9	13b	Site 13b is located in a very shallow drain on agricultural land. The benthic material was dominated by mud, with a small proportion of sand and some scour rock. There was a high proportion of leaf litter and a moderate cover of emergent plants. The banks at this site vary across the site from grassy to bare scour rock. There was no flow at the time of either 2023 survey. The site has been significantly modified by a bridge construction, diversion, reshaping and revegetation. Shading effects of the bridge are evident.
9	13c	Site 13c is located in a narrow, deep drain on agricultural land approximately 20m upstream of the new highway crossing. The benthic material was dominated by mud, with a small proportion of sand. There was a high proportion of leaf litter and scattered small woody debris. Other structural habitat included dense emergent vegetation in some areas. The banks at this site were grassy and there are scattered rushes. There was limited flow at the time of both 2023 surveys. The site appears relatively unchanged after construction.
9	13e	Site 13e consists of a small billabong located along the path of an agricultural drain. It was approximately 15 m wide at its widest point and 1.2m deep. The margins were gently sloping and grassy. At the time of the last survey in September 2017 most of the structural habitat was formed by submerged and emergent vegetation. The benthic material was dominated by mud with low percentage of sand. There was no flow. Site 13e is located on private property with no access arrangement in place for this monitoring period.

Section	Site	Habitat Description
9	16a	Site 16a consists of a wetland pool in an old sand mining channel located within Broadwater National Park approximately 150 m to the east of the existing highway. The benthic material was mud and sand and the site contained little structural habitat aside from a regular cover of leaf litter, a high proportional cover of submerged vegetation and scattered emergent vegetation. There was no flow at the time of either survey in 2023 and water levels were very low at the time of the September survey. This site is prone to drying out.
9	16b	Site 16b consists of a wide, shallow wetland pool located approximately 50m to the west of the new Woodburn-Broadwater access road. The benthic material was a mixture of sand and mud. Structural habitat availability is strongly dependent upon water levels and varied across the site with a dense cover of emergent aquatic plants in some areas, a moderate cover of leaf litter and small woody debris in some areas and bare sediment in others. This site has been significantly modified during construction of the Woodburn-Broadwater access road by construction of a drought refuge pool, removal of some riparian vegetation and partial infilling of the eastern margin. This is a no-flow waterway that dries out at times.
8	22b	Site 22b is an excavation located approximately 100m E of the upgrade corridor on property acquired by TfNSW. The margins of the excavation varied between gently sloping and steep and were moderately vegetated. Structural habitat was dominated by submerged vegetation with occasional debris. The benthic material was mostly sand. There was no flow during either survey in 2023.
8	22c	Site 22c is a deep excavation located in an agricultural drainage line approximately 250m E of the upgrade corridor on a private property. The margins were well vegetated but marginal habitat availability is strongly dependent upon water levels, which were low during the 2023 surveys. Structural habitat is limited in the middle but around the margins consisted of submerged vegetation and occasional debris. The benthic material was mostly sand. There was no flow during either 2023 survey and flow is unusual at this site.
9	26d	Site 26b is a deep pool in a shallow natural drainage line, possibly enhanced by excavation. At the time of the last survey in September 2017 the margins were very well vegetated and trailing vegetation was a major habitat feature. Other structural habitat included dense submerged vegetation and stands of emergent rushes. The benthic material was mostly sand and there was no flow at the time of sampling. Site 26d is located on private property with no access arrangement in place for this monitoring period.
9	27b	Site 27b is a shallow, natural depression in a paperbark swamp. At the time of sampling, it was continuous with the surrounding wetland forest with no clear margins. As a result, riparian zone measurements were not collected. Structural habitat was formed by a high proportional cover of submerged vegetation and leaf litter, irregular woody debris and scattered but dense stands of emergent rushes, mostly Jointed Twig-rush. The benthic material was mud with no flow evident at the time of the 2023 surveys. Flows are unusual at this site and habitat measurements are strongly dependent upon water levels.

Section	Site	Habitat Description
9	27e	Site 27e is a shallow, natural depression in a paperbark swamp. At the time of sampling, it was continuous with the surrounding wetland forest with no clear margins. As a result, riparian zone measurements were not collected. Structural habitat was formed by a high proportional cover of submerged vegetation and leaf litter, irregular woody debris and scattered but dense stands of emergent rushes, mostly Jointed Twig-rush. The benthic material was mud with no flow evident at the time of the 2023 surveys. Flows are unusual at this site and habitat measurements are strongly dependent upon water levels.
DP	OPP1	Site OPP1 is an excavation located approximately 50m to the north, and offstream of, Tabbimoble Channel 2. The benthic material is mud. Structural habitat was abundant, including fallen trees and a high proportional cover of leaf litter, small woody debris and emergent aquatic plants (mostly *Maundia triglochinoides*, *Eleocharis equisetina* and *Philydrum lanuginosum*. The riparian zone is densely covered with paperbarks and acacia. The site is very rarely subject to flow events. The site was heavily impacted by 2019 bushfires but most signs of bushfire have now disappeared.
DP	OPP2	Site OPP2 is located in Tabbimoble Channel 2 immediately downstream of the upgraded Pacific Highway crossing. The site is relatively uniform in width and depth with the exception of a gravel bar running through the middle of the site and scour rock which may have been transported downstream from under the highway bridge in flood events. At the time of the 2023 surveys water levels and flow were low, particularly so in September 2023. Benthic material is primarily mud with low proportional cover of gravel, sand and rock. Structural habitat availability on the stream margins is highly dependent upon water levels but includes rootballs, overhanging banks and small but dense beds of emergent vegetation including *Maundia triglochinoides* and *Eleocharis equisetina*.
DP	OPP3	Site OPP 3 is located in Tabbimoble Floodway 3 immediately downstream of the upgraded Pacific Highway crossing. The site was relatively uniform in width and depth. Benthic material at this site was dominated by mud, with very little leaf litter and a low proportional cover of small and large woody debris. Structural habitat was limited with no aquatic vegetation recorded and limited overhanging banks and root mass. The riparian margin was continuously but narrowly vegetated. At the time of the May and September 2023 surveys there was little flow and moderately low water levels.
DP	OPP6	Site OPP 6 is immediately upstream (west) of the upgraded Pacific Highway crossing where Tabbimoble Floodway 3 opens out into an area of semi-permanent swampland. The site was heavily impacted by 2019 bushfires, but signs of the bushfires have mostly disappeared. It was dry at the time of the September 2023 surveys. Habitat is dominated by emergent grasses and rushes, mostly *Leersia hexandra* and *Eleocharis equisetina*.
DP	OPP7	Site OPP 7 is immediately upstream (west) of the upgraded Pacific Highway crossing where Tabbimoble Floodway 2 opens out into an area of flood prone land/ephemeral swampland with ill-defined channels. The site was dry at the time of the September 2023 survey. Structural aquatic habitat at this site is very limited. Benthic materials are variable and include mud, sand and fine gravel. The site was heavily impacted by 2019 bushfires, but signs of the bushfires have mostly disappeared.

A number of the sites were heavily impacted by the bushfires of summer 2019 – 2020. This included both impact and control sites. In particular, a number of the sites around Tabbimoble were subject to high intensity bushfires that burnt the surrounding vegetation and, in some cases, the wetland vegetation itself. The proportional cover of charcoal in the

benthic material at these sites (OPP1, OPP5, OPP6, OPP7, 2a, 2c, C13 and C14) has now reduced and vegetation is largely returning to the pre-bushfire conditions. It is likely that any impacts of the bushfires upon water quality have also reduced over time

Aquatic plant diversity has been relatively stable at both control and impact sites over the three phases of monitoring. Although collection of an inventory of aquatic plant species was not designed as a quantitative measure, an assessment of the diversity of species observed at each site has been undertaken for this final report. The results are presented in **Figure 3.5**. They indicate that the diversity of aquatic plants was similar at control and impact sites but that the diversity increased slightly at impact sites in the operational phase. This result indicates that aquatic plant diversity has not been negatively impacted at impact sites over the course of construction and that habitat rehabilitation measures undertaken may have led to an improvement in the diversity of aquatic plant species.

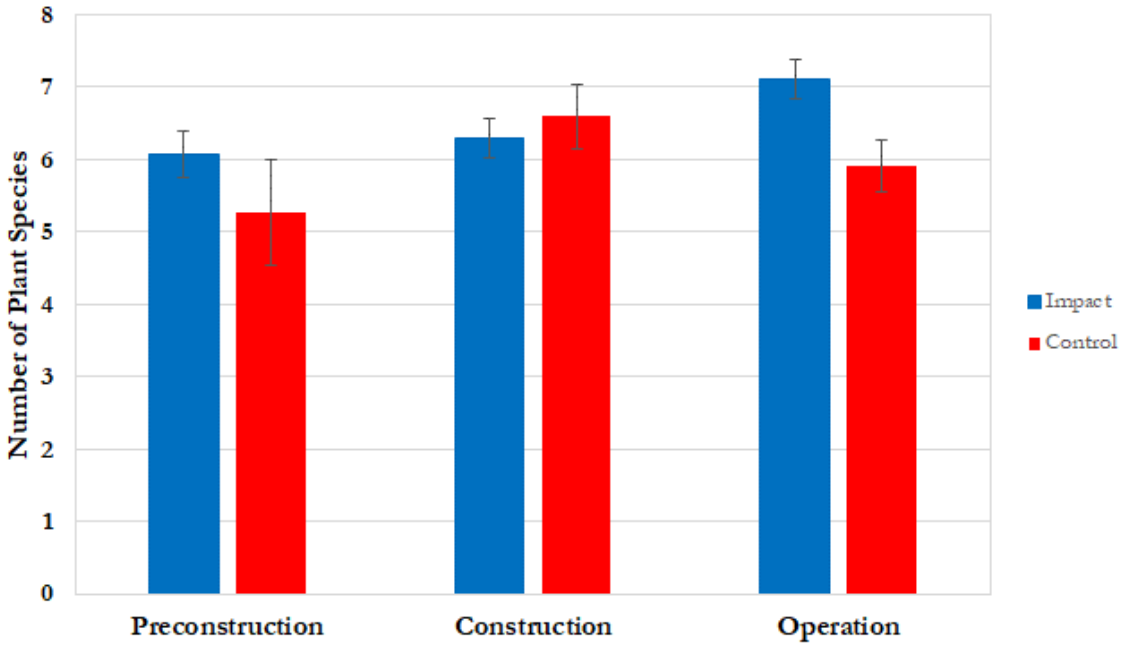


Figure 3.5 Mean ± SE number of aquatic plant species observed at combined control and impact sites in pre-construction, construction and operational phase monitoring to date (pre-construction data from GeoLINK 2014, 2015a & 2015b)

Table 3.5 Aquatic plants identified at impact sites during the May 2023 survey

Species Name	Common Name	2a	2b	2c	3a	10b	10c	11b	11d	12a	13b	13c	13e	16a	16b	22b	22c	26d	27b	27e
Azolla spp.	Azolla									x	x				x					
Baloskion (Restio) pallens	Zigzag Rush													x					x	
Baloskion (Restio) tetraphyllum	Feathery Rush															x	x			
Baumea articulata	Jointed Rush									x	x			x					x	x
Baumea rubiginosa	Baumea													x	x	x			x	x
Blechnum indicum	Fern													x			x		x	x
Carex appressa	Tall Sedge	x								x	x									
Carex fascicularis	Tassel Sedge				x			x												
Ceratophyllum demersum	Hornwort				x															
Chorizandra cymbaria	Heron Bristle-sedge			x													x			
Cygnogeton procerum	Water Ribbons				x															
Cyperus sp.	Sedge														x					
Cyperus difformis	Dirty Dora								x											
Cyperus exaltatus	Giant Sedge							x												
Cyperus haspan	Sheathed Flatsedge		x												x					
Cyperus polystachyos	Bunchy Sedge								x	x	x	x								
Eleocharis acuta	Common Spikerush			x							x									
Eleocharis equisetina	Spike-rush		x								x	x								
Eleocharis pusilla	Small Spike-rush								x											
Gahnia clarkeii	Razor Grass													x		x	x		x	x
Gahnia sieberana	Sawsedge													x	x	x	x			
Isolepis inundata	Swamp Club Rush			x	x					x		x								
Juncus prismatocarpus	Branching Rush		x		x				x	x										
Juncus usitatus	Common Rush			x						x	x	x								
Leersia hexandra	Swamp Ricegrass					x		x	x	x										
Lemna spp.	Duckweed														x					
Lepironia articulata	Grey Rush					x		x		x				x	x					x

Species Name	Common Name	2a	2b	2c	3a	10b	10c	11b	11d	12a	13b	13c	13e	16a	16b	22b	22c	26d	27b	27e
Lomandra hysterix	Creek Mat rush	x		x	x				x	x	x					x				
Ludwigia peploides	Water Primrose*							x			x									
Lycopodiella cernua	Scrambling Clubmoss															x				
Maundia triglochinoides	Maundia				x															
Myriophyllum sp.	Millfoil				x															
*Nymphaea sp.**	Waterlily*					x		x	x		x	x				x				x
Ottelia ovalifolia	Swamp Lily	x			x															
Paspalum distichum	Water Couch										x	x								
Persicaria decipiens	Slender Knotweed								x		x									
Persicaria hydropiper	Water Pepper					x					x									
Persicaria strigosa	Prickly Knotweed					x		x		x	x	x								
Philydrum lanuginosum	Frogsmouth		x	x	x			x	x		x								x	
Sacciolepsis indica	Indian Cup-scale Grass								x	x	x	x								
Schoenoplectus mucronatus	Marsh Clubrush		x					x												
Schoenoplectus validus	River Clubrush																			
Sphagnum sp.	Peat Moss									x	x			x		x	x		x	x
Utricularia sp.	Bladderwort							x						x	x	x	x		x	x
Viola banksii	Native Violet							x												

* Introduced Species

Grey cells indicate site not surveyed.

Table 3.6 Aquatic plants identified at control and Devils Pulpit sites during the May 2023 survey

Species Name	*Common Name*	*C1*	*C2*	*C3*	*C5*	*C8*	*C11*	*C12*	*C13*	*C14*	*OPP1*	*OPP2*	*OPP3*	*OPP4*	*OPP5*	*OPP6*	*OPP7*
Azolla spp.	Azolla								x								
Baloskion (Restio) pallens	Zigzag Rush	x		x		x		x									
Baloskion (Restio) tetraphyllum	Feathery Rush				x	x											
Baumea articulata	Jointed Rush								x								x
Baumea rubiginosa	Baumea			x		x		x									
Blechnum indicum	Fern				x	x			x								x

Species Name	Common Name	C1	C2	C3	C5	C8	C11	C12	C13	C14	OPP1	OPP2	OPP3	OPP4	OPP5	OPP6	OPP7
Carex fascicularis	Tassel Sedge												x				
Cygnogeton procerum	Water Ribbons															x	x
Cyperus sp.	Sedge											x					
Cyperus exaltatus	Giant Sedge								x								x
Eleocharis acuta	Common Spikerush										x						
Eleocharis equisetina	Spike-rush								x		x						x
Gahnia clarkeii	Razor Grass			x	x												
Gahnia sieberana	Sawsedge			x		x											
Isolepis inundata	Swamp Club Rush										x		x			x	
Juncus prismatocarpus	Branching Rush											x					
Leersia hexandra	Swamp Ricegrass								x			x				x	x
Lepironia articulata	Grey Rush	x			x												
Lomandra hysterix	Creek Mat rush											x					
Maundia triglochinoides	Maundia								x		x	x					x
*Nymphaea sp.**	Waterlily*	x							x								
Ottelia ovalifolia	Swamp Lily								x								x
Persicaria strigosa	Prickly Knotweed								x		x	x					
Philydrum lanuginosum	Frogsmouth								x		x	x				x	x
Potomageton octandrus	Pondweed								x								
Sacciolepsis indica	Indian Cup-scale Grass															x	
Schoenoplectus mucronatus	Marsh Clubrush										x	x					
Sphagnum sp.	Peat Moss	x		x	x	x		x								x	
Typha orientalis	Cumbungi								x								
Utricularia sp.	Bladderwort	x				x		x	x		x	x	x				

* Introduced Species

Grey cells indicate site not surveyed.

Table 3.7 Aquatic plants identified at impact sites during the September 2023 survey

Species Name	Common Name	2a	2b	2c	3a	10b	10c	11b	11d	12a	13b	13c	13e	16a	16b	22b	22c	26d	27b	27e
Azolla spp.	Azolla									x	x			x	x					
Bacopa monnieri	Water Hyssop																			
Baloskion (Restio) pallens	Zigzag Rush																		x	
Baloskion (Restio) tetraphyllum	Feathery Rush															x				
Baumea articulata	Jointed Rush									x	x								x	x
Baumea rubiginosa	Baumea																			x
Blechnum indicum	Fern									x							x		x	x
Carex appressa	Tall Sedge	x								x										
Carex fascicularis	Tassel Sedge				x															
Ceratophyllum demersum	Hornwort				x															
Chorizandra cymbaria	Heron Bristle-sedge		x																	
Cygnogeton procerum	Water Ribbons				x															
Cyperus sp.	Sedge													x	x					
Cyperus exaltatus	Giant Sedge							x												
Cyperus polystachyos	Bunchy Sedge								x	x	x	x								
Eleocharis acuta	Common Spikerush										x									
Eleocharis equisetina	Spike-rush		x									x								
Eleocharis pusilla	Small Spike-rush								x											
Gahnia clarkeii	Razor Grass															x	x		x	x
Gahnia sieberana	Sawsedge					x								x	x	x	x			
Isolepis inundata	Swamp Club Rush				x					x	x	x								
Juncus prismatocarpus	Branching Rush		x						x											
Juncus usitatus	Common Rush		x						x	x	x	x								
Leersia hexandra	Swamp Ricegrass					x		x	x	x	x									
Lemna spp.	Duckweed													x	x					
Lepironia articulata	Grey Rush					x		x		x				x	x					x
Lomandra hysterix	Creek Mat rush	x			x	x			x	x	x									
Ludwigia peploides	Water Primrose*							x												
Maundia triglochinoides	Maundia				x															
*Nymphaea sp.**	Waterlily*					x		x	x	x		x				x				x

Species Name	Common Name	2a	2b	2c	3a	10b	10c	11b	11d	12a	13b	13c	13e	16a	16b	22b	22c	26d	27b	27e
Ottelia ovalifolia	Swamp Lily				x									x	x					
Paspalum distichum	Water Couch										x	x								
Persicaria strigosa	Prickly Knotweed					x		x		x	x	x								
Philydrum lanuginosum	Frogsmouth		x					x	x		x									
Sacciolepsis indica	Indian Cup-scale Grass										x	x								
Schoenoplectus mucronatus	Marsh Clubrush		x					x												
Sphagnum sp.	Peat Moss										x			x	x	x	x		x	x
Utricularia sp.	Bladderwort		x					x	x					x	x	x	x		x	x

* Introduced Species

Grey cells indicate site not surveyed.

Table 3.8 Aquatic plants identified at control and Devils Pulpit sites during the September 2023 survey

Species Name	Common Name	C1	C2	C3	C5	C8	C11	C12	C13	C14	OPP1	OPP2	OPP3	OPP4	OPP5	OPP6	OPP7
Azolla spp.	Azolla								x								
Bacopa monnieri	Water Hyssop																
Baloskion (Restio) pallens	Zigzag Rush	x		x		x		x									
Baloskion (Restio) tetraphyllum	Feathery Rush	x			x	x											
Baumea articulata	Jointed Rush								x								
Baumea rubiginosa	Baumea				x	x		x									
Blechnum indicum	Fern				x	x											
Carex fascicularis	Tassel Sedge												x				
Chorizandra cymbaria	Heron Bristle-sedge										x						
Cygnogeton procerum	Water Ribbons								x								
Eleocharis equisetina	Spike-rush										x	x					
Gahnia clarkeii	Razor Grass			x	x	x											
Gahnia sieberana	Sawsedge	x		x		x											
Isolepis inundata	Swamp Club Rush										x		x				
Leersia hexandra	Swamp Ricegrass								x								
Lepironia articulata	Grey Rush	x															
Lomandra hysterix	Creek Mat rush										x						

Species Name	*Common Name*	*C1*	*C2*	*C3*	*C5*	*C8*	*C11*	*C12*	*C13*	*C14*	*OPP1*	*OPP2*	*OPP3*	*OPP4*	*OPP5*	*OPP6*	*OPP7*
Maundia triglochinoides	Maundia								x		x	x					
*Nymphaea sp.**	Waterlily*	x															
Nymphoides indica	Water Snowflake								x								
Ottelia ovalifolia	Swamp Lily								x								
Persicaria strigosa	Prickly Knotweed								x		x	x					
Philydrum lanuginosum	Frogsmouth								x		x	x	x				
Potomageton octandrus	Pondweed								x								
Schoenoplectus mucronatus	Marsh Clubrush										x	x					
Sphagnum sp.	Peat Moss	x		x	x	x											
Typha orientalis	Cumbungi								x								
Utricularia sp.	Bladderwort	x									x	x	x				

* Introduced Species

Grey cells indicate site not surveyed.

4

Discussion and Conclusion

The two fish surveys completed during the third year of the operational phase for the W2B Threatened Fish monitoring were completed in May and September 2023. There were OPP captured at 5 of the 24 impact sites and 5 of the 11 reference locations during this reporting period. Habitat quality and availability varied across the sites sampled, as did water quality. Due to very low rainfall during this reporting period, many sites were dry at the time of the surveys. The lack of rainfall also impacts habitat availability and dispersal opportunities, and this is reflected in the lower numbers of OPP captured and the lower number of sites OPP were captured at.

In comparison with previous results (Hyder 2012, GeoLINK 2014 & 2015, Jacobs 2018, 2019, 2020, 2021), close to average numbers of OPP were captured during the two surveys this year. However, overall the operational phase results indicate a reduction in the average number of OPP captured per site when compared with the average catches from the pre-construction and construction phase monitoring at impact sites and an increase in the same measure at control sites. However, when assessed year by year, for example comparing flood years with drought years) it is evident that environmental conditions unrelated to W2B upgrade construction explain much of the variation observed in the dataset. For example, the number of OPP captured in 2016 and 2017, after excellent conditions for dispersal, were similar to the preconstruction surveys in 2013. With that variation in mind, and the extreme conditions experienced during the monitoring period, it is a positive outcome that OPP were captured at least once at most of the impact sites during the operational phase period.

Fish habitat data collected during this reporting period indicates continued variability among both impact and control sites. Again, much of the variability is explained by environmental conditions unrelated to the W2B upgrade operation with the exception of sites where construction of crossings has necessitated changes to stream morphology, riparian condition and benthic materials. At some of those sites there are positive signs that habitat rehabilitation efforts have been successful. These include improved vegetative cover and structural habitat features such as leaf litter. Water quality measurements collected during this reporting period were also variable within and between sites. Again, much of the observed variability is explained by environmental conditions unrelated to highway operation.

Operational phase monitoring has been undertaken at all of the 24 impact and 11 control sites that were being monitored at the end of the construction phase threatened fish monitoring. During this monitoring period operational phase threatened fish monitoring along the W2B Upgrade was undertaken according to the TFMP, with the exception of monitoring at sites where access was denied by landholders (OPP4, 13e, 26d). There were also several dry sites encountered where no fishing effort could be made but where there were clearly no fish. It is not possible to assess how access restrictions have impacted results but it is notable that all three of the sites where access was denied have some value as drought refuges, making them likely sites for consistent captures of OPP.

The fishing effort for the two surveys this year consisted of 372 individual fish trapping hours and 27,235 seconds of electrofishing. A total of 4,946 fish were captured in May 2023 and 3,970 fish were captured in September 2023. These totals included 180 (4%) OPP and 128 (3%) OPP respectively. The OPP capture rates (as a percentage of total fish captured) in

previous surveys have varied between 1% and 25%. The sites where OPP were captured in 2023 included:

- Five of the eleven control sites. OPP were captured at site C1, C3, C8, and C12 during both surveys and C5 in the May 2023 survey.
- Five of the twenty-four impact sites. OPP were captured at 16a, 22b, 22c, 27b and 27e during both surveys.

During this reporting period there were a number of sites where OPP were not captured, but had been captured in the previous reporting period. Without exception these were sites where captured OPP numbers had been low in the previous reporting period and, in some cases, where the site itself, or nearby reaches, had dried up. The sites where OPP were captured during this reporting period were all sites where OPP were captured with the highest frequency throughout the pre-construction, construction and operational phase monitoring to-date.

There has been a high degree of variability in the numbers of OPP captured at each site since monitoring began in 2013, at both the impact and control sites. Due to the opportunistic life cycle strategies and quick responses to stochastic environmental factors displayed by OPP (Knight *et al.* 2012) it is expected that surveys conducted at different times would yield different results depending upon favourable or unfavourable breeding and dispersal conditions. A comparison of average OPP capture at impact and control sites in the pre-construction, construction and operational (to date) phases of monitoring shows an increase in the average capture at control sites and a decrease in the average capture at impact sites (**Figure 3.5**). However, these unfavourable results are unlikely to be related to the W2B upgrade in any large part. As discussed in the previous annual Threatened Fish Monitoring Report (TfNSW 2022, **Figure 4.3**), trend analysis shows that throughout construction phase monitoring there was a trend towards reduced average per-site capture at both impact and control sites. During the operational phase to date trend analysis points to slightly increasing OPP captures per impact site and slightly decreasing OPP captures per control site, although there is a poor fit to the trend at control sites (**Figure 4.4**). Additionally, the observed increase in average capture at control sites between the pre-construction and construction phase monitoring is likely to be driven by the fact that no control sites were monitored during pre-construction monitoring in September 2013 after breeding and dispersal conditions had been very good. Pre-construction phase monitoring at control sites was only undertaken in September 2014, after a drought that resulted in very poor breeding and dispersal conditions and many dry sites, leading to very low numbers of OPP captures at both control and impact sites. This resulted in particularly low average captures at impact sites for the per-construction phase monitoring, whereas impact sites were monitored during one very good and one poor year of captures over the pre-construction phase, resulting in improved average capture rates for that period.

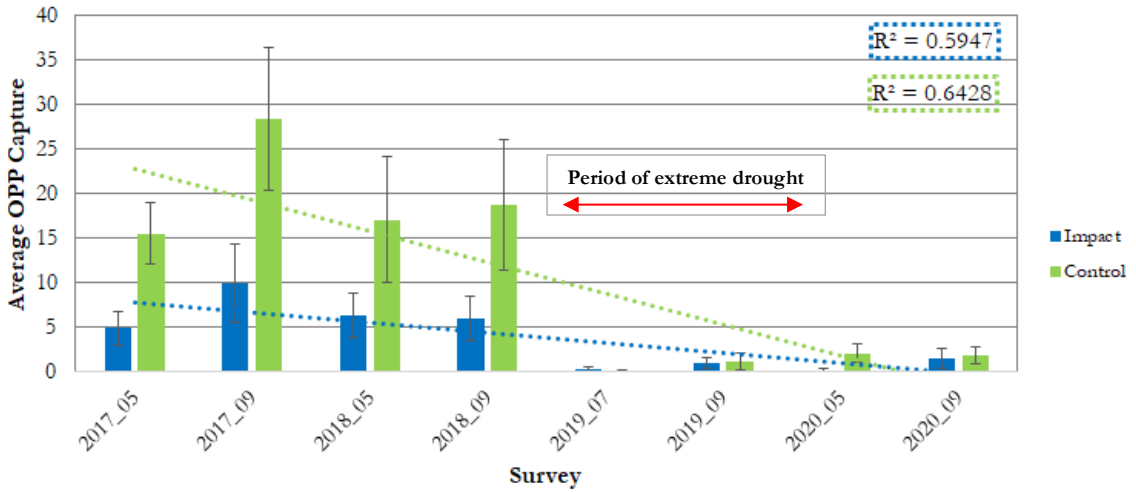


Figure 4.1 Mean ± SE OPP capture per site at impact and control sites during construction phase monitoring.

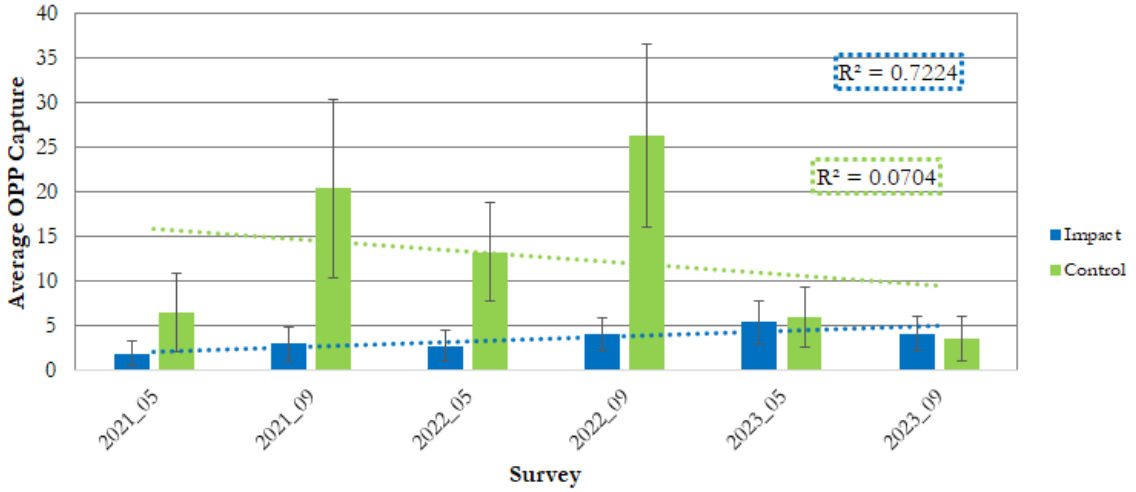


Figure 4.2 Mean ± SE OPP capture per site at impact and control sites during operational phase monitoring to date.

The numbers of Mosquitofish (*Gambusia holbrooki*) encountered at each site are of specific interest as predation by this species is identified as a Key Threatening Process under the *Biodiversity Conservation Act 2016* and they are antagonistic towards OPP. There has been variation in the numbers of Mosquitofish encountered during threatened fish surveys to date. Overall, Mosquitofish captures were reduced during this reporting period in comparison with operational phase monitoring to date. This was particularly so for the September 2023 survey where very low numbers were captured. In comparison with the pre-construction and construction phases, the average catch of Mosquitofish to date in operational phase monitoring has increased slightly, although there are high levels of variation in the dataset (**Figure 4.5**). During the operational phase monitoring to date there has been an increase in the average capture of Mosquitofish at the impact sites, but not at the control sites, when compared with the pre-construction and construction phase monitoring. The increased average capture at impact sites has resulted from very strong increased captures at sites 2b, 10b, 16b, OPP1 and OPP2, particularly during 2022 (**Figure 4.6**). There are also numerous impact sites where average Mosquitofish captures have reduced since pre-construction monitoring.

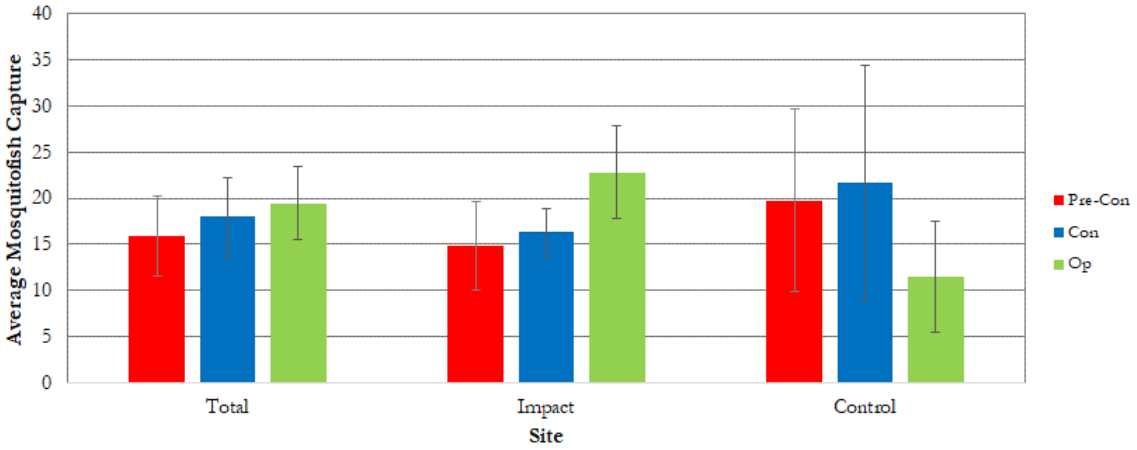


Figure 4.3 Mean ± SE Mosquitofish Capture at all impact and control sites in the pre-construction, construction and operational phase surveys.

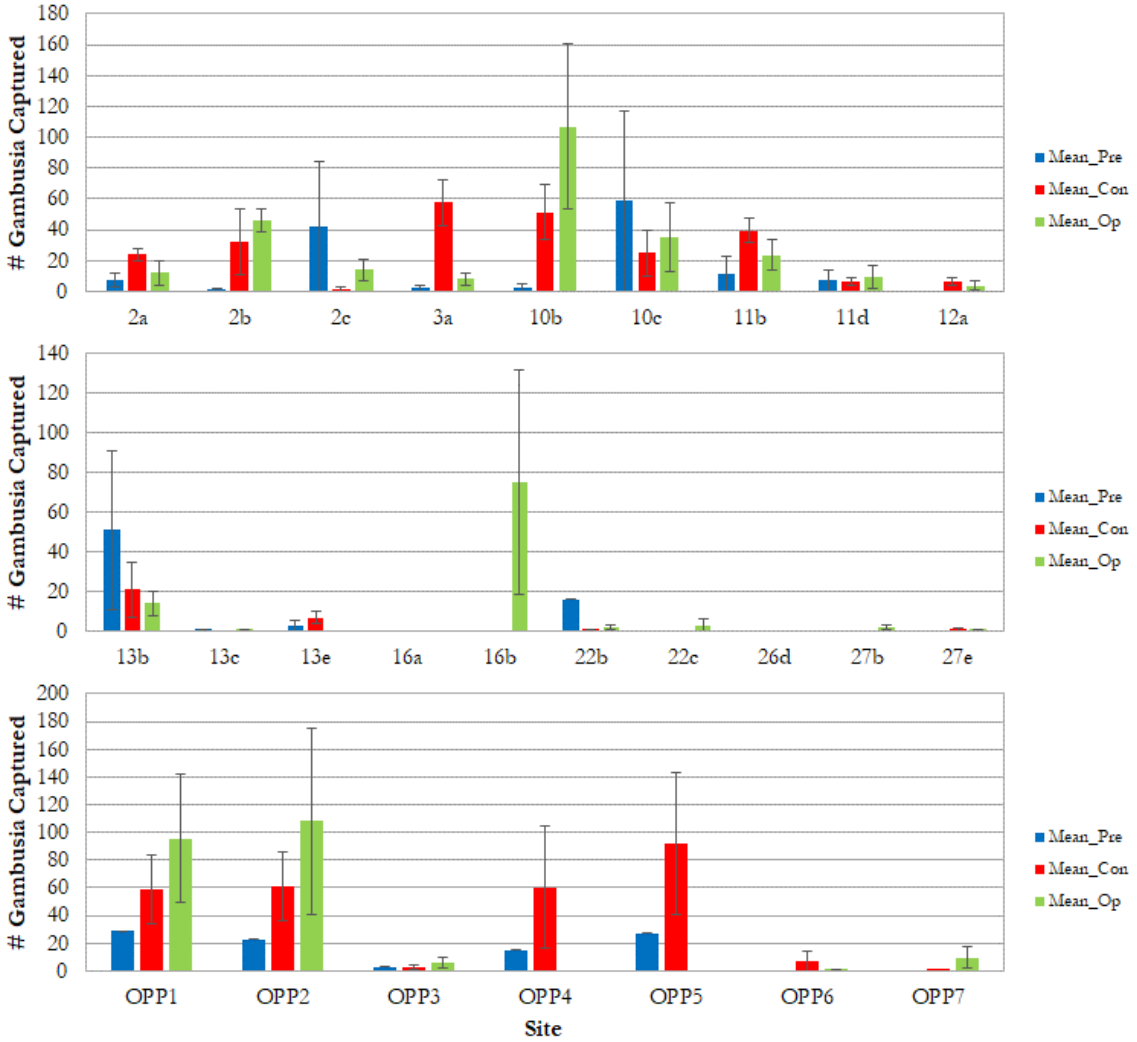


Figure 4.4 Mean ± SE Mosquitofish capture at impact sites during each monitoring phase

This study measured vegetative and physical habitat features including, flow, width, depth, benthic material, aquatic vegetation, debris, riparian cover and stream bank forms. Over the course of the two surveys this year we have collected a large volume of information describing habitat conditions at all sites qualitatively and quantitatively. All of the sites surveyed had at

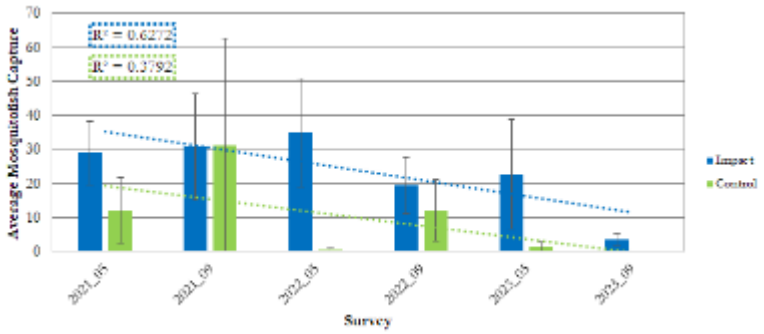
least some habitat features commonly associated with OPP (Knight & Arthington 2008). Variation among habitat features collected during the operational phase surveys to date was similar to previous surveys undertaken as part of pre-construction and construction phase monitoring. A graphical assessment of the habitat data collected in the pre-construction, construction and operational (to date) phases of monitoring is presented in **Appendix A**. The analysis indicates significant differences between data collected in the pre-construction, construction and operational (to date) phases at a relatively low number of sites and for some variables only. In general, the observed differences are evenly spread between the impact and control sites. Many of the differences observed are simply a function of hydrological condition, such as width and depth measurements or, in some cases, aquatic vegetation cover, benthic material, trailing vegetation and stream bank form, which vary at some sites in relation to the water depth and width and, in turn, the flooding and drying regime. Observer bias is also a significant factor, particularly in relation to variables such as riparian cover. Fixed point photographs at each site (presented in the final annual report) are a useful reference for determining actual differences in such cases.

Several disturbances potentially relating to construction impacts were described in the final construction phase monitoring report (TfNSW 2021). Most of these resulted from necessary changes to the shape of waterways associated with crossing designs, clearing of riparian vegetation around bridge abutments and/or material use such as rock utilised as scour protection around bridge abutments. There were also some changes in vegetative cover at crossing sites, for example, where rehabilitation efforts had successfully resulted in increased emergent vegetation cover and/or where shading from bridge crossings resulted in reduced vegetation cover. At the majority of sites and for the majority of measures, the results of habitat monitoring during the operational phase are similar to those of the later years of construction phase monitoring, indicating no significant changes associated with operation of the highway. Where changes in habitat related to highway construction and operation have been measured, the measured changes are unlikely to reduce the suitability of the environment for OPP. Key environmental factors relating to OPP habitat suitability, such as the cover of sand and emergent and submerged vegetation, either changed little at impact sites, were strongly related to changes in water level or improved over the course of construction and operational phase monitoring.

This study also measured physicochemical water quality variables. A brief summary of water quality measures is presented in **Appendix C**. During this reporting period the vast majority of water quality measurements were within the known ranges of waters inhabited by OPP. The exceptions were a small number of low dissolved oxygen concentrations. All pH measurements collected during the 2023 surveys were within the reported ranges of waters known to be inhabited by OPP. Water quality measures collected during the W2B upgrade water quality monitoring program (GeoLINK 2023) also indicate that water quality remains suitable for OPP at most sites most of the time.

The Threatened Fish Management Plan (Roads and Maritime 2015) outlines performance indicators for assessing the impacts of construction on threatened fish populations and habitats. The performance indicators, relevant notes and conclusions are listed in **Table 4.1**. To date, no recommendations with 'on-ground' implications have arisen from threatened fish monitoring. While there are some performance indicators that were not met during this third year of operational phase monitoring, they are generally minor and acceptable in nature and there are no recommended changes to highway operation arising from the data collected for this report.

Table 4.1 Performance indicators for threatened fish management on the W2B upgrade.

Performance Indicator	*Notes*	*Conclusion*
Relative abundance of OPP in impact sites has reduced significantly when compared to control sites over three consecutive monitoring periods	Using number of OPP captured as a measure of relative abundance, the relative abundance of OPP at impact sites increased in comparison to the three previous years (see **Figure 4.2**). Over the same period the relative abundance of OPP captured at reference sites reduced.	Performance indicator met - No significant impact from highway operation
Occurrence of Eastern Gambusia in waterways where they have not previously been recorded	Over the course of operational phase monitoring, Eastern Gambusia were captured at three impact sites where they had not previously been captured; 16b and 22c and 27b. However, they were also captured at one control site, C1 where they had not been observed since May 2017. They had previously been captured in all of the subcatchment areas where these sites are located. Eastern Gambusia have now been captured at some sites during both construction phase and operational phase monitoring where they were not captured during pre-construction phase monitoring. However, these sites have included both control and impact sites. Trend analyses (TfNSW 2021) undertaken with construction phase data indicated that detected increases in the Eastern Gambusia populations were greater at control sites than at impact sites, suggesting that Eastern Gambusia population dynamics were not strongly associated with the construction of the highway. Similar analyses for operational phase data to date indicate that, although capture at impact sites has been greater on average, there are moderate trends towards reduced average Mosquitofish capture at both control and impact sites. 	Performance indicator not met – Highway operation does not appear to be the cause.
Survey of Class 1 and 2 waterways with known or potential OPP habitat identifies additional populations of OPP.	A population of OPP were found in the Montis Gully area during the construction period. As a result, an impact site (13b) was added to the list of sites monitored prior to the September 2017 survey. Monitoring continued at that site throughout construction and operational monitoring.	Performance indicator met during construction phase. No additional populations of OPP observed during operational phase monitoring to date.

Performance Indicator	*Notes*	*Conclusion*
Any change in habitat structure downstream of construction area, i.e., macrophyte and woody snag cover.	Some minor changes to habitat structure around highway crossings were noted during the construction phase monitoring (discussed in TfNSW 2021). At this stage of the operational phase monitoring no new changes to habitat structure related to highway operation have been detected. In general, measured changes to habitat are unlikely to reduce the suitability of the sites for OPP, particularly where the results have indicated improved or stable vegetative cover.	Performance indicator met
Any change in natural stream flow and velocity resulting in threatened fish being trapped in isolated pools.	No significant changes to stream flow and velocity have been noted to date. Flow rates greater than 0.1 m/second have only been detected on a few occasions throughout monitoring. Several sites included in the monitoring program dry out on occasion. All sites subject to drying out were observed drying out in the pre-construction phase (GeoLINK 2014).	Performance indicator met
Any weed incursion into OPP waterways	There were no new introduced species of aquatic plants observed at any of the control or impact sites during the surveys this year.	Performance indicator met
No threatened fish species observed in ponds where fish have been translocated to.	OPP were translocated from construction sites at Montis Gully (Ch 141100 - 141900) and the Woodburn to Broadwater Service Rd (Ch 139000) on several occasions in 2017 into sites 27b and C1 during the course of dewatering and stream diversion activities. OPP, in relatively large numbers, were captured at C1 in all annual reporting periods to date. OPP were also captured at Site 27b in relatively large numbers during surveys this year, and during each of the other two years of operational phase monitoring.	Performance indicator met in operational phase.
Any change in water quality from baseline conditions in the vicinity of, or downstream of the construction works	The water quality results collected as part of the threatened fish monitoring gives some indication that there has been a reduction in the DO concentrations in the vicinity of construction works in comparison with baseline results. However, there was also a reduction in the DO concentrations at some of the control sites in comparison with baseline results. During the construction phase monitoring some of the pH measurements collected during threatened fish monitoring and during construction phase water quality monitoring indicated a potential increase in the pH around construction areas (TfNSW 2021). However, during operational phase threatened fish monitoring pH measurements have tended to be lower at the majority of those sites (**Appendix C**).	Performance indicator met during operational phase.
Any evidence of sediment or erosion being caused by the project	No erosion or sedimentation being caused by the project were noted during the threatened fish surveys during the construction and operational phase monitoring to date.	Performance indicator met.
Disparity in water quality between downstream and upstream monitoring sites observed during operation of the project	Information collected under the operational phase Water Quality Monitoring Program for the W2B upgrade indicates that water quality downstream of the crossings over OPP waterways has remained suitable for OPP at most sites for most of the time. Some poor dissolved oxygen results have been measured at some sites.	Performance indicator partially met.

To summarise, the number of OPP that were captured during this reporting period was close to average in comparison with previous W2B upgrade monitoring undertaken since 2013. Variable OPP captures occurred at impact and control sites alike and is likely to be related to environmental conditions rather than the construction or operation of the W2B upgrade.

Over the course of operational phase monitoring, OPP captures have indicated varying population density and distribution at both impact and control sites. Much of the variability has resulted from environmental conditions, chiefly rainfall. After very low captures during the late construction phase monitoring, the results of the operational phase monitoring included a number of very positive indications for OPP conservation generally:

- OPP were captured at Site 10b in 2022 for the first time since May 2013, a good indication that the habitat rehabilitation measures at that site have been successful and further confirmation of the excellent dispersal conditions associated with heavy flooding. It is hoped that the drought refuge installed at 10b will help maintain the population of OPP at this site.
- OPP were captured at site 3a in 2022 for the first time since May 2018. This was also the first capture of OPP from the Tabbimoble Swamp catchment during W2B threatened species monitoring since bushfire activity in late 2019 and early 2020.
- OPP were captured at site 11b in 2022 for the first time since May 2013, indicating that the connectivity measures implemented upstream of this site have successfully provided the opportunity for OPP to disperse along the unnamed tributary to MacDonalds Creek.
- OPP were captured at site 13b in 2022 for the first time since September 2017, indicating that the habitat restoration measures at that site, which include dense growth of emergent aquatic plants, were successful in restoring OPP habitat.

The lack of OPP captures at some sites during operational phase monitoring could indicate some negative impacts upon OPP populations or habitat arising from operational, and in some cases construction, phase impacts. No OPP were captured at impact sites 2a, 2b, 2c, 10c, 11d, 16b, OPP1, OPP2, OPP3, OPP6 or OPP7 during the operational phase (46% of impact sites). This feature of the dataset is partially reflected by no captures at control sites C13, C14, OPP4 or OPP5 over the same timeframe (36% of control sites). It is also, in the opinion of the author, likely to be a result of environmental conditions throughout the construction and operational phases rather than impacts of highway construction or operation. For example:

- Some of these impact sites, such as 2a, 2b, 2c, 10c, 11d, 16b, OPP6 and OPP7 dried out on more than one occasion during the operational and construction phases and are remote from potential refuge sites that would provide opportunities for recolonisation by OPP during wet years.
- Some of the impact sites, such as 2a, 2b, 2c, OPP6 and OPP7, and control sites such as C13, C14 and OPP5, were impacted directly by bushfires (and the preceding drought) in the summer of 2019 and 2020, during which, fires burnt through intermittently aquatic habitat. No OPP were captured in any of the sites within the Tabbimoble swamp catchment area following the bushfires until 1 was captured at site 3a in May 2022. It may be many years before OPP populations in the Tabbimoble swamp catchment area recover to pre-bushfire levels.

In conclusion, the data captured during the construction phase monitoring period does not indicate that highway operation is negatively impacting OPP populations or habitat in the study area. It indicates that sediment, erosion and pollution control methods have been effective in protecting OPP populations and habitat and that bridge design and bank rehabilitation has been effective in the management of OPP. It does not conclusively indicate any secondary impacts of the project upon OPP populations or habitat. Although average capture at impact sites during operational phase monitoring to date is lower than pre-construction average captures, average OPP capture trended upwards during the operational phase and during operational phase monitoring.

Project Team

- Chris Thomson – Project Director
- Mathew Birch – Aquatic Ecologist: Technical leader and author
- Brenton Hays – Field Team
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- Allie Cooke – Field Team
- Dave Consterdine – Field Team
- Jorja Vernon – Field Team
- Jeremy Benwell – Field Team

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Appendix A

Aquatic Habitat Summaries

Figure A1 Average (±SE) habitat measurements at each site in the pre-construction, construction and operational phases of monitoring

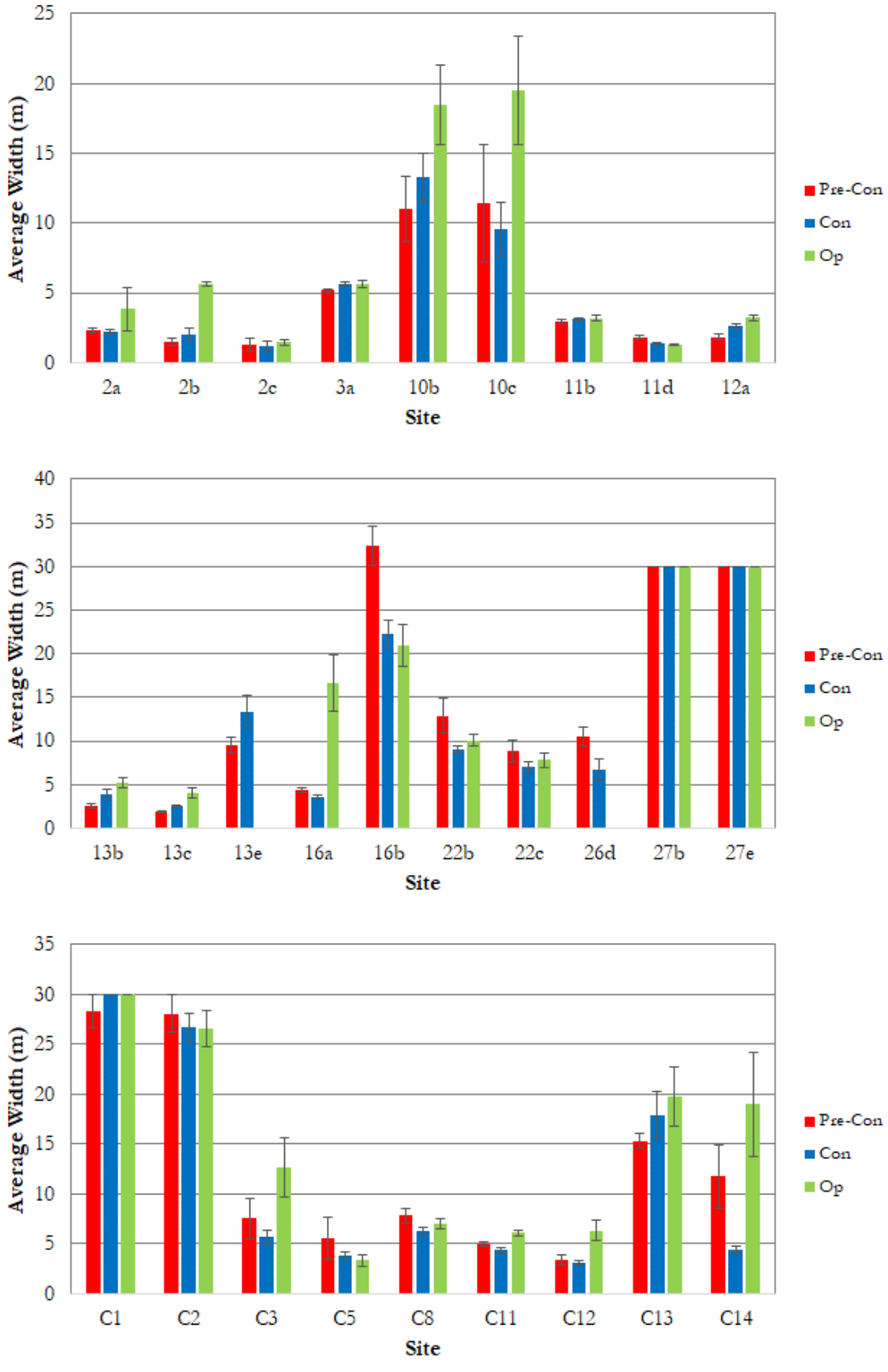
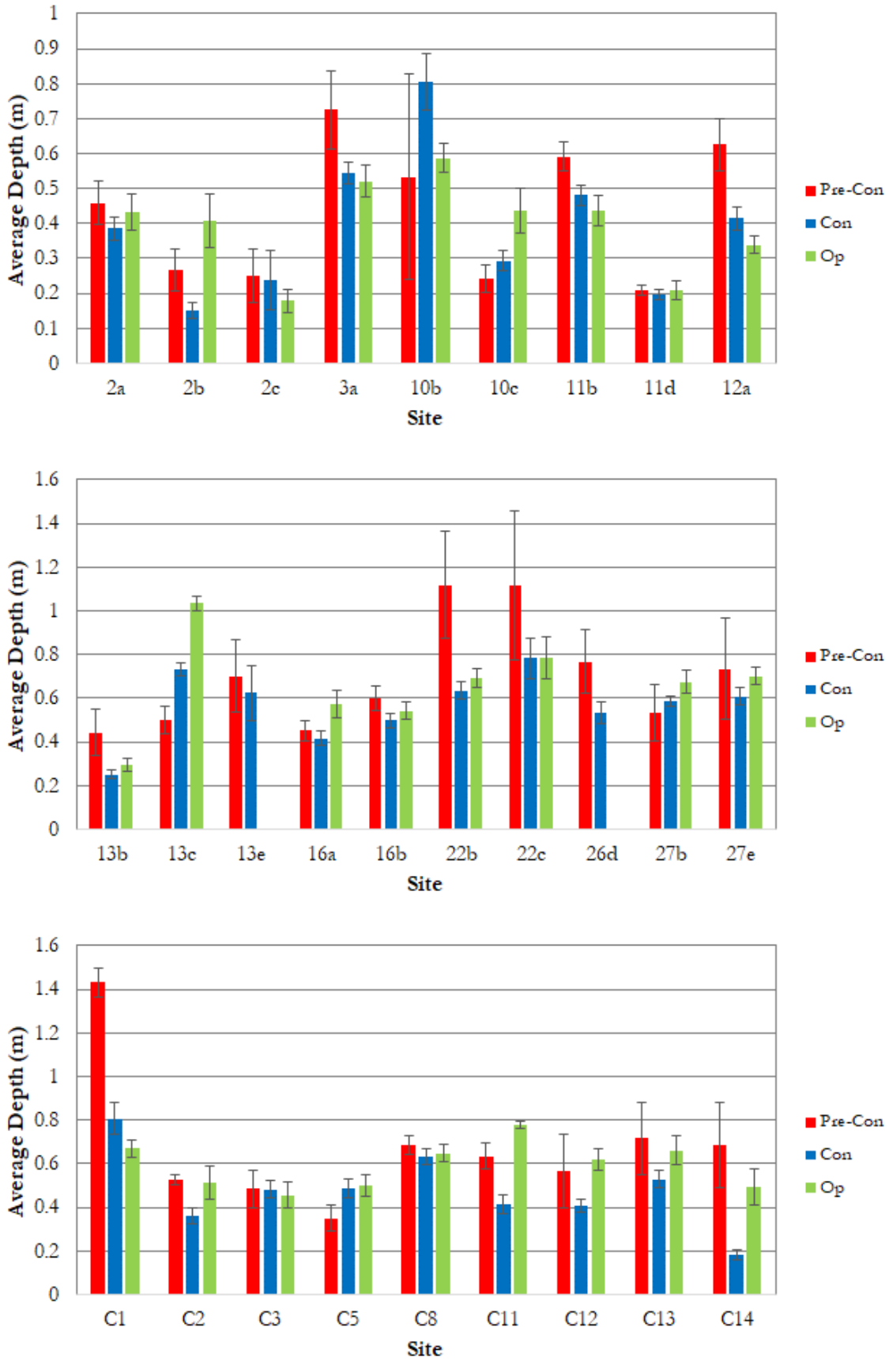


Figure A1 Average (±SE) habitat measurements at each site in the pre-construction, construction and operational phases of monitoring



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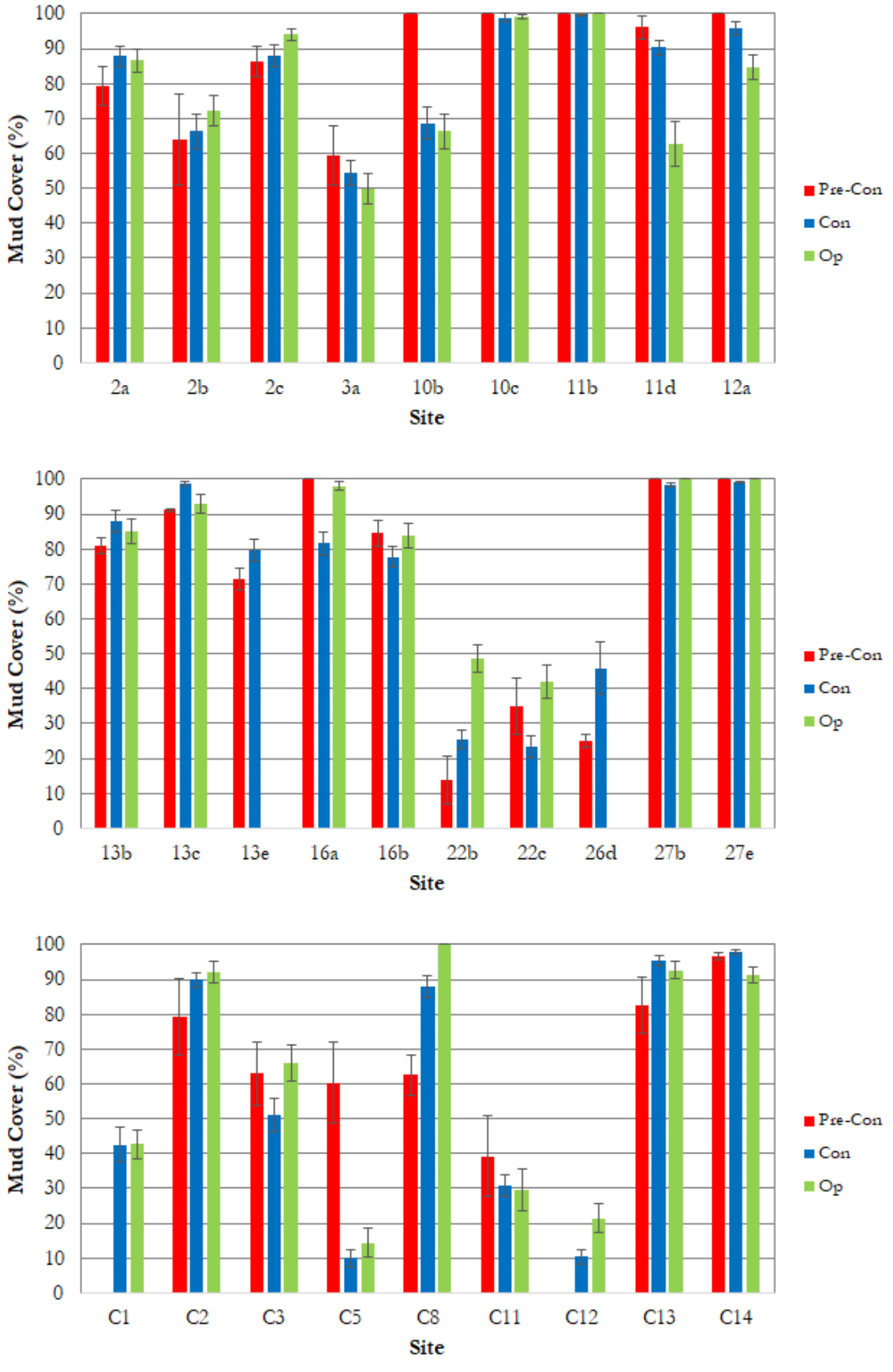

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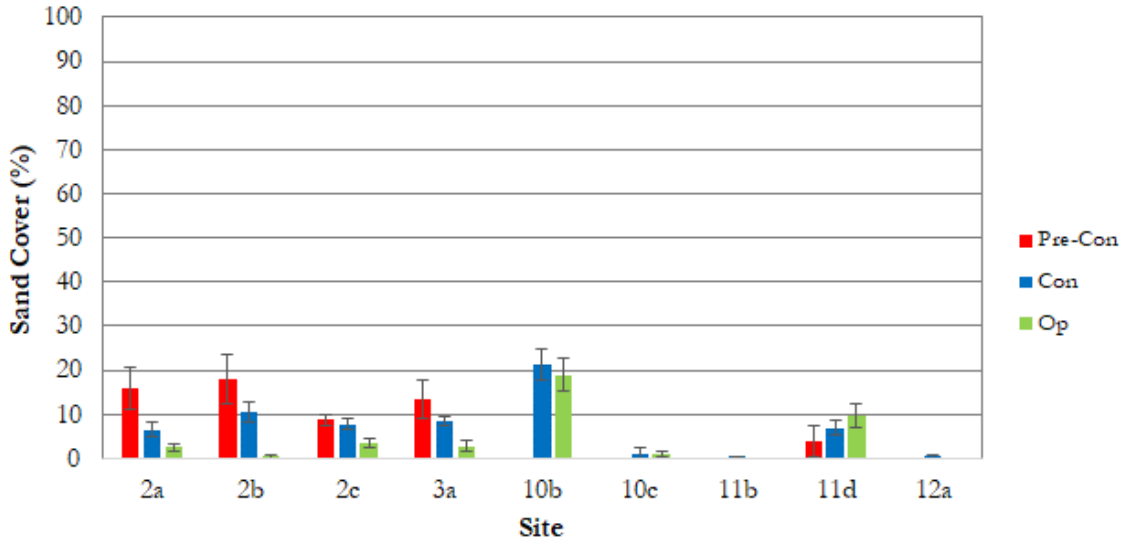

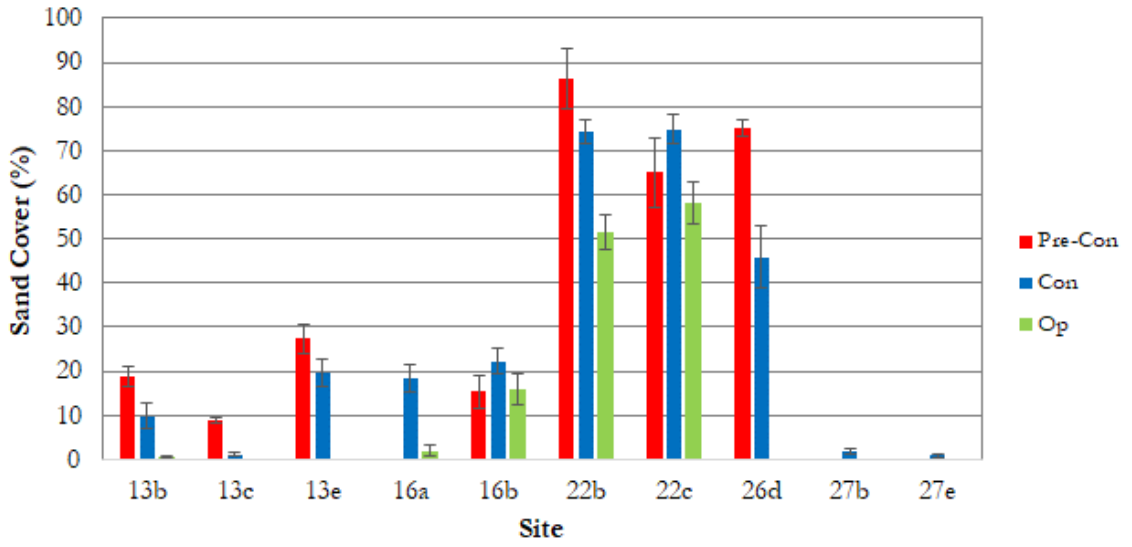

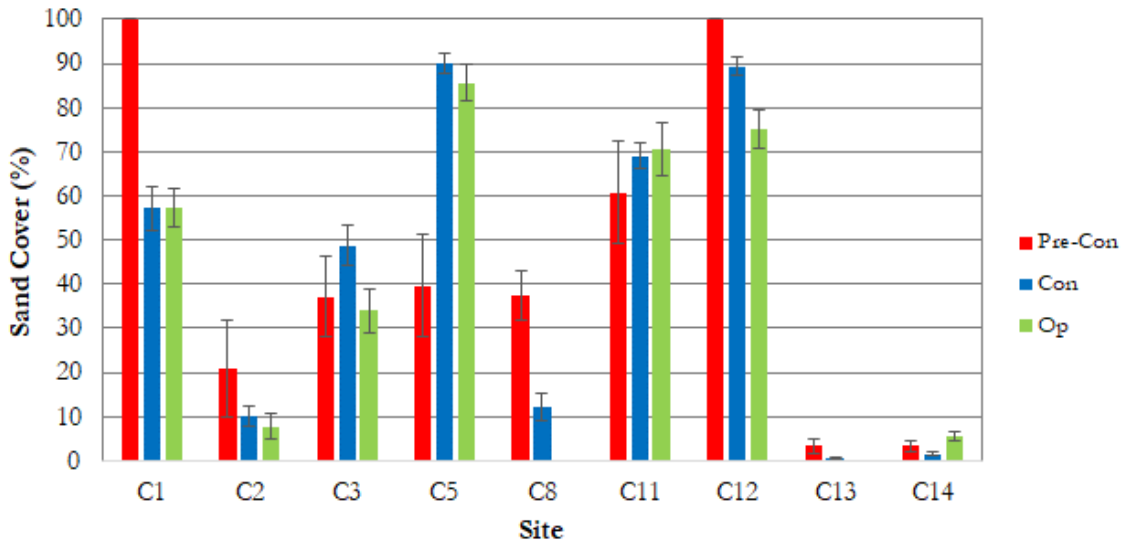

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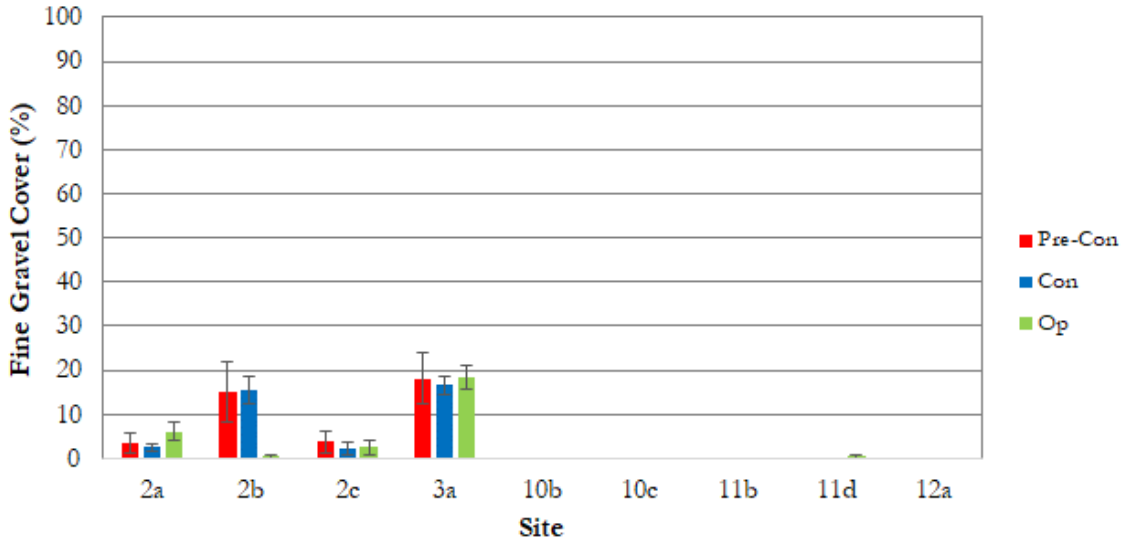

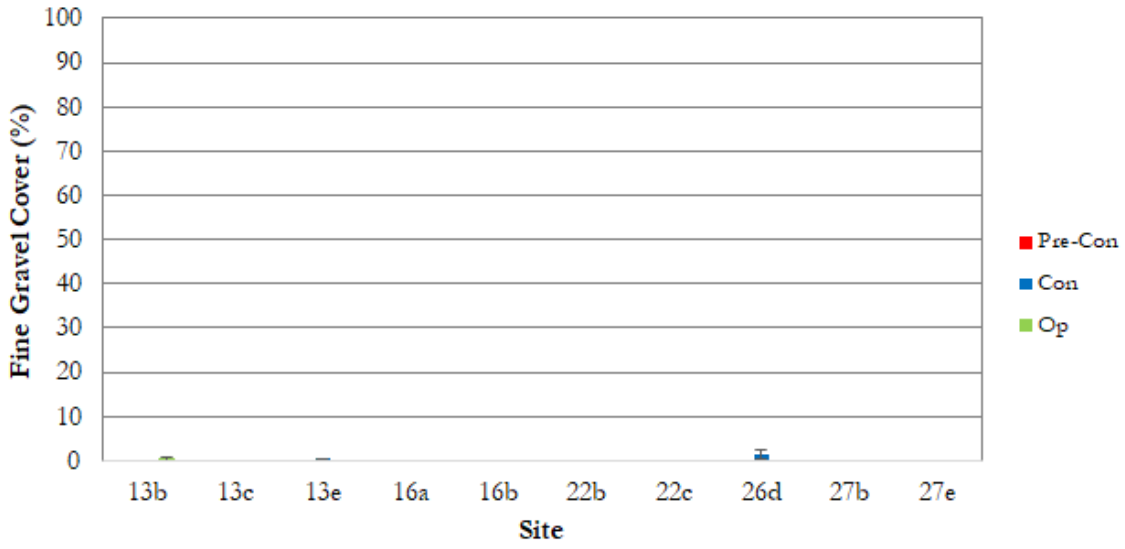

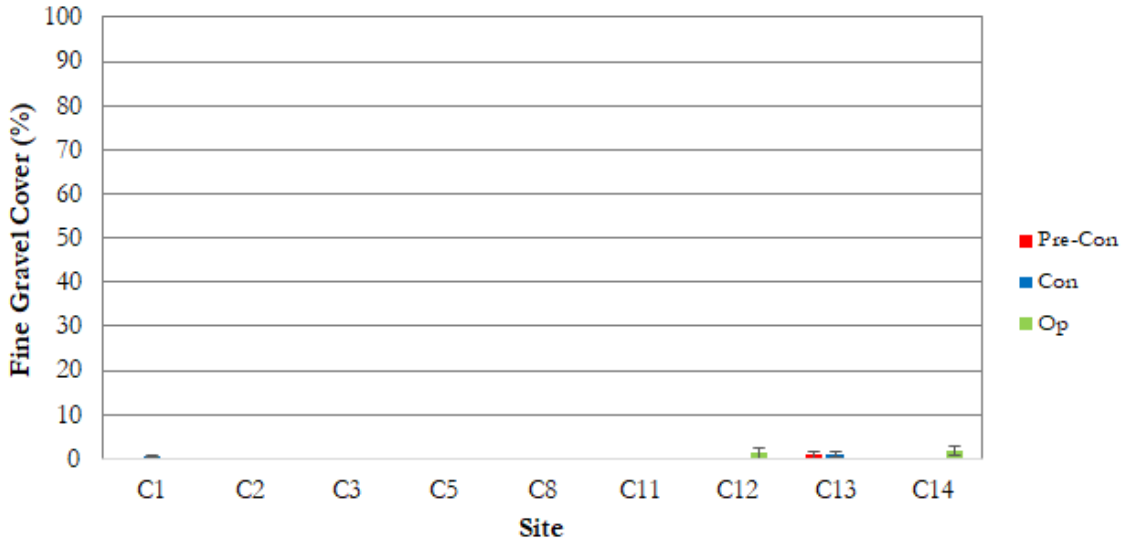

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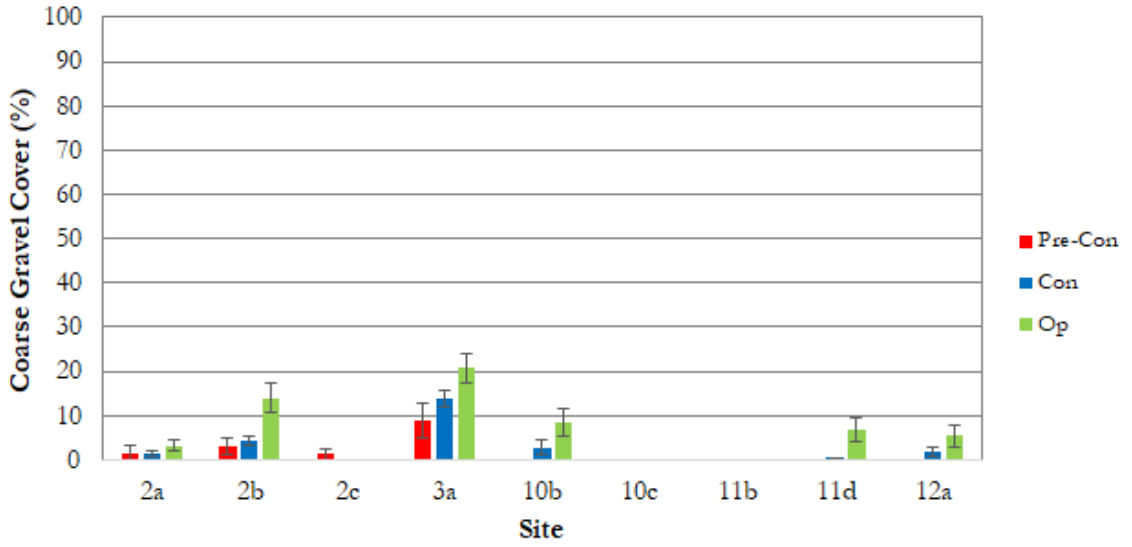

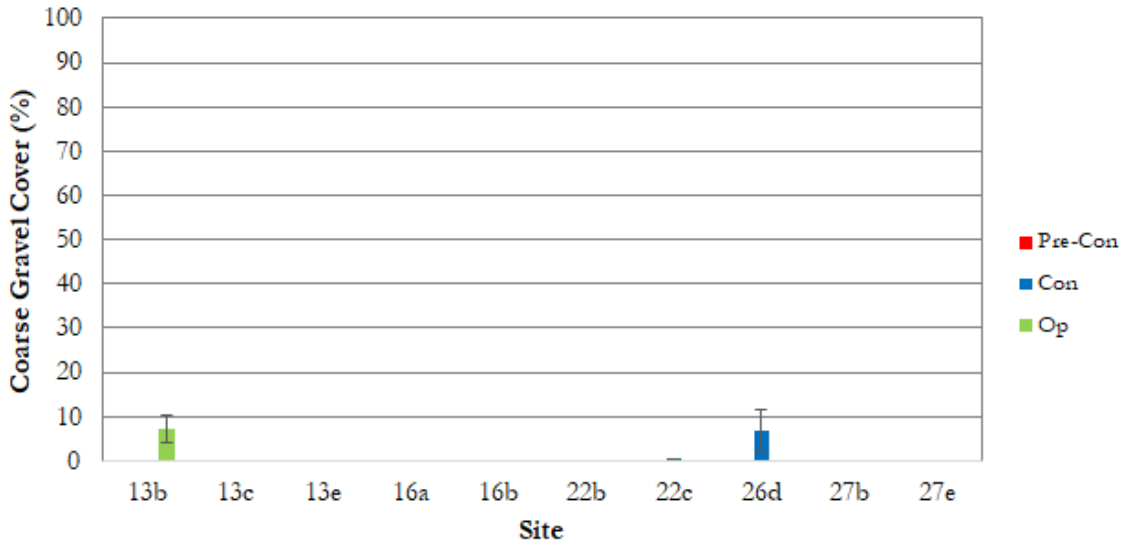

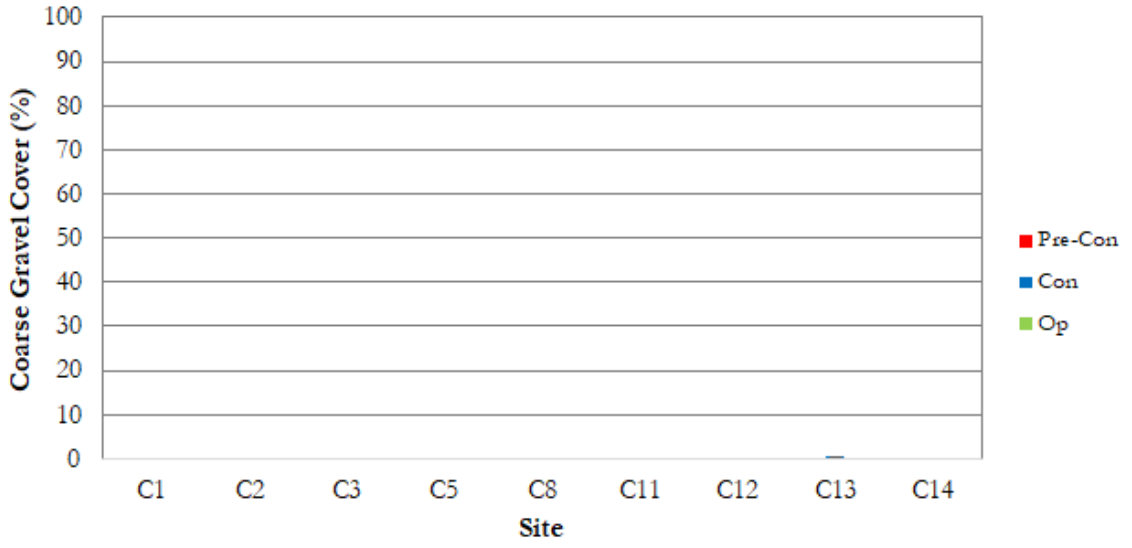

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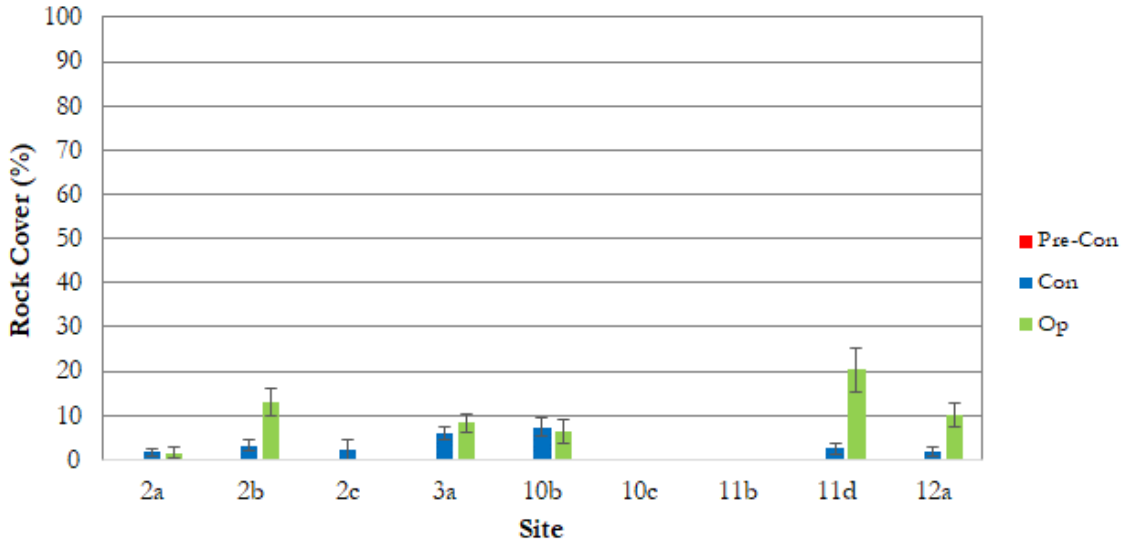

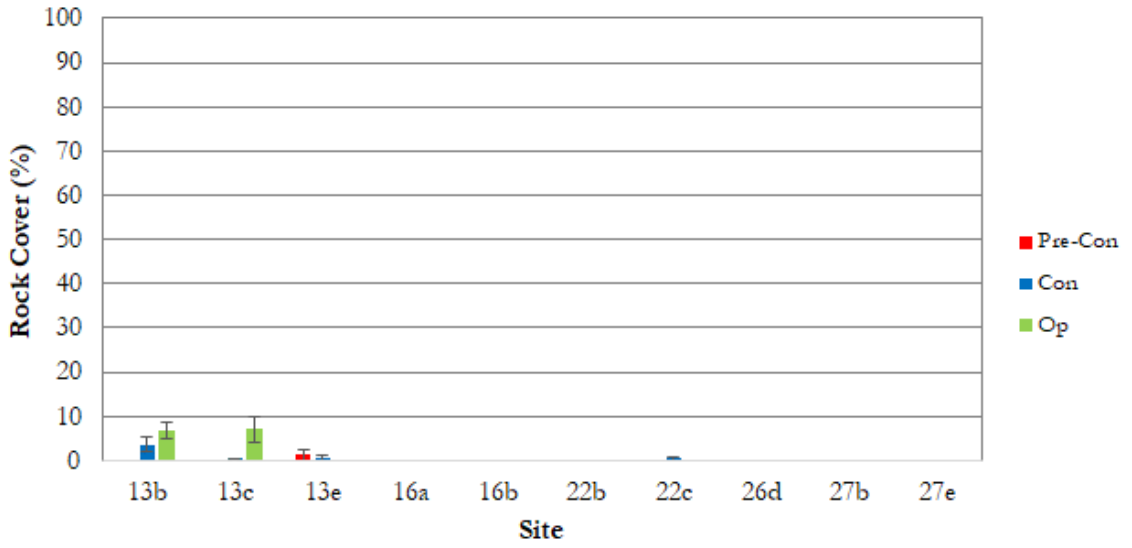

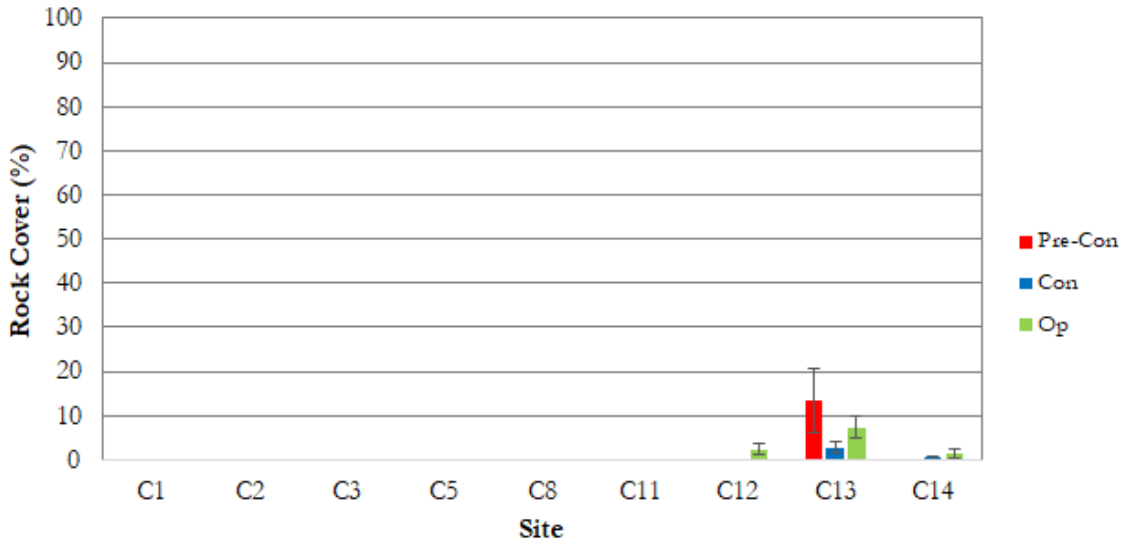

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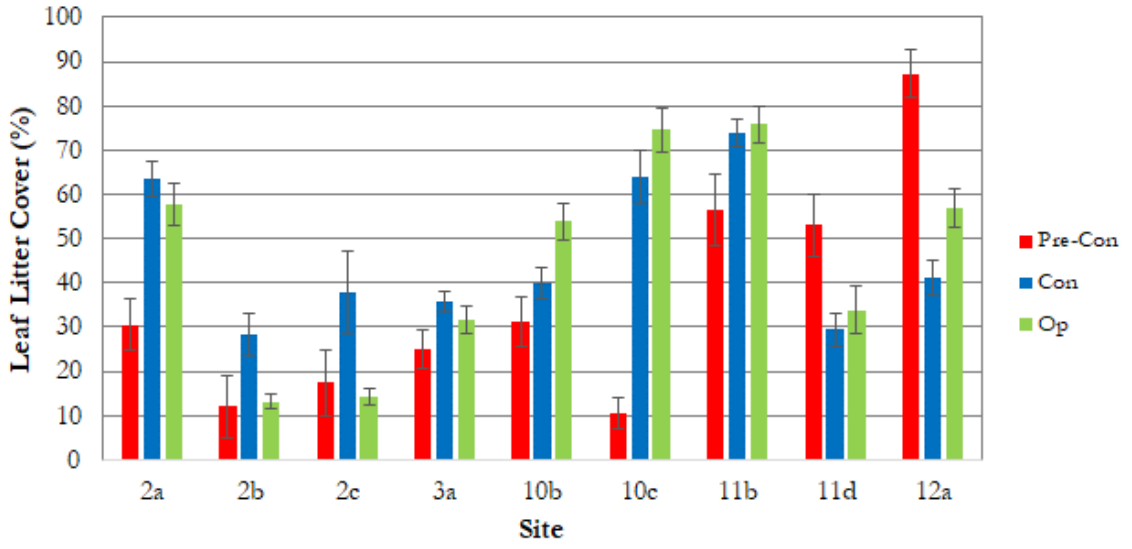

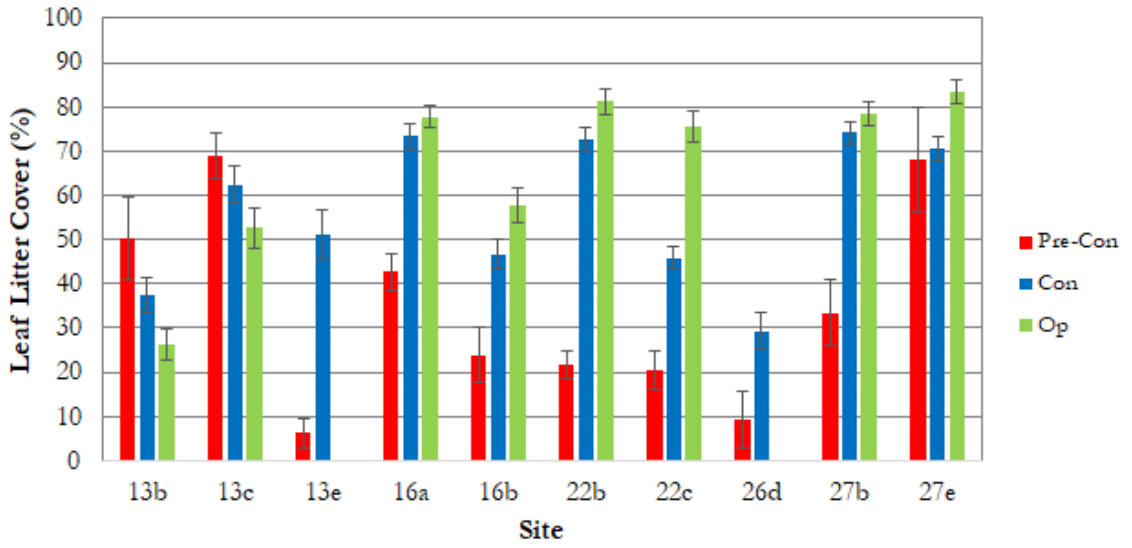

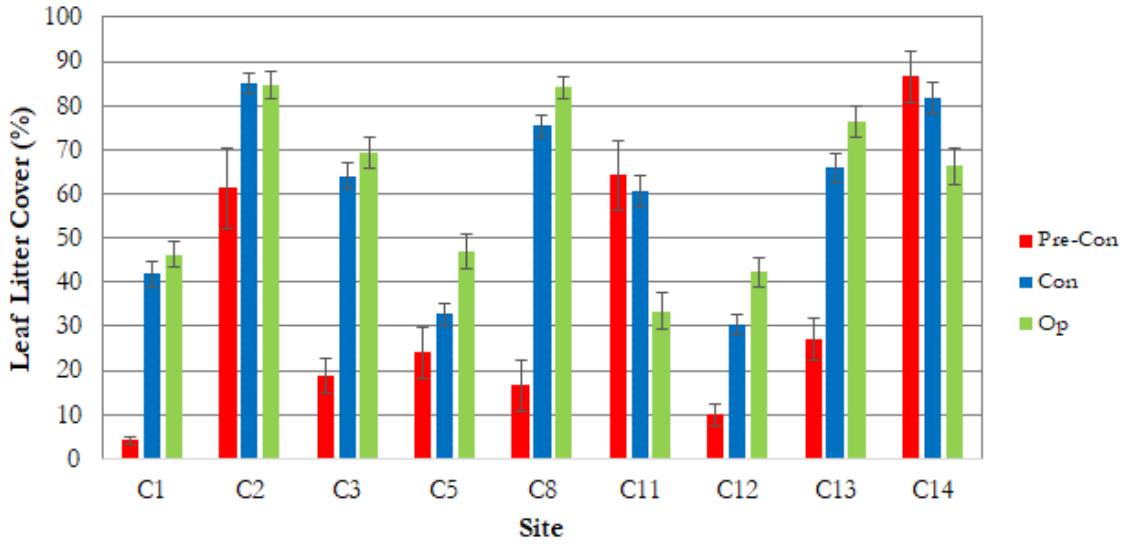

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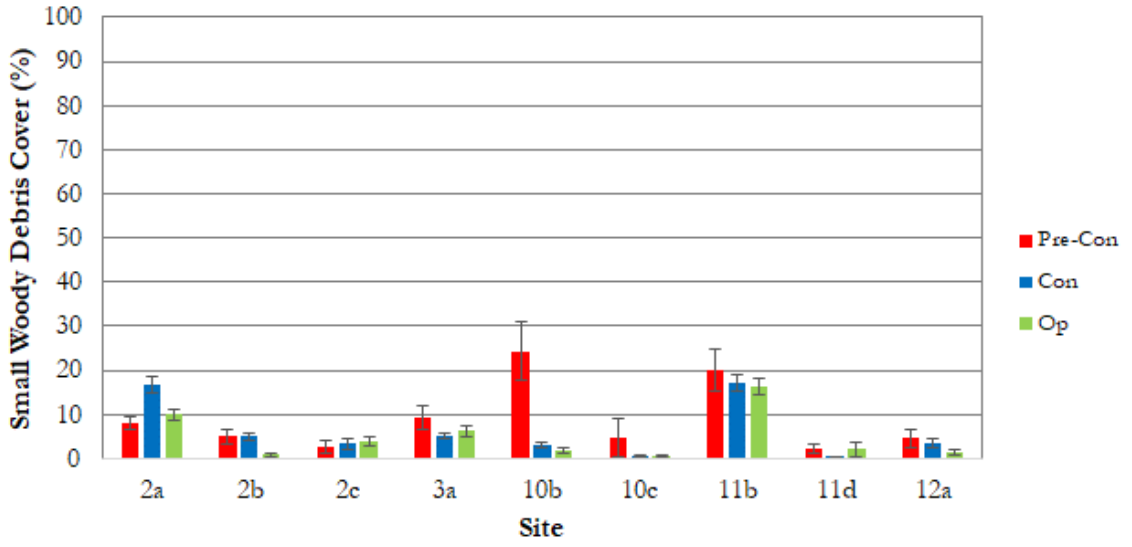

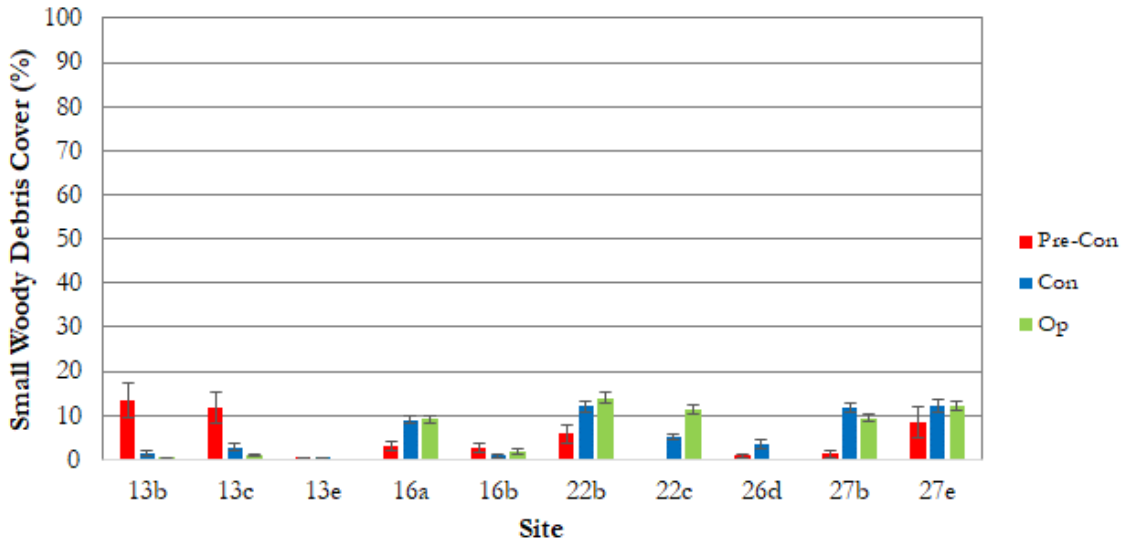

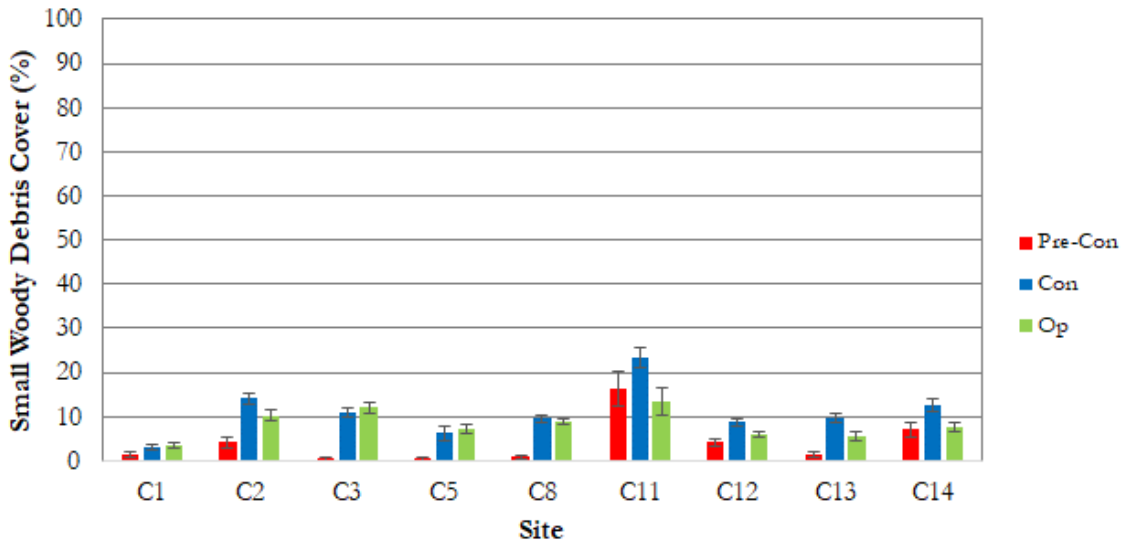

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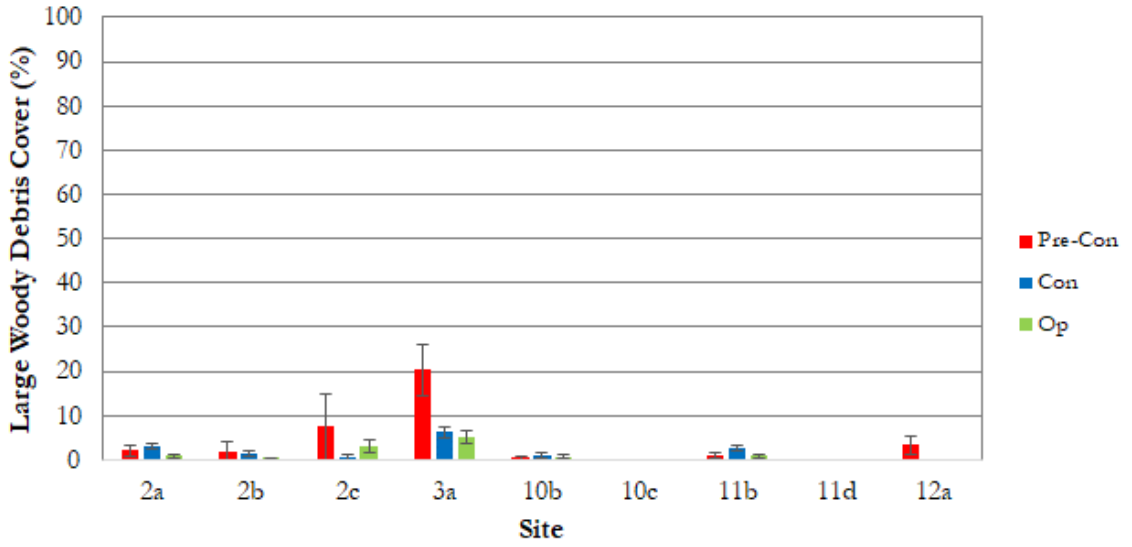

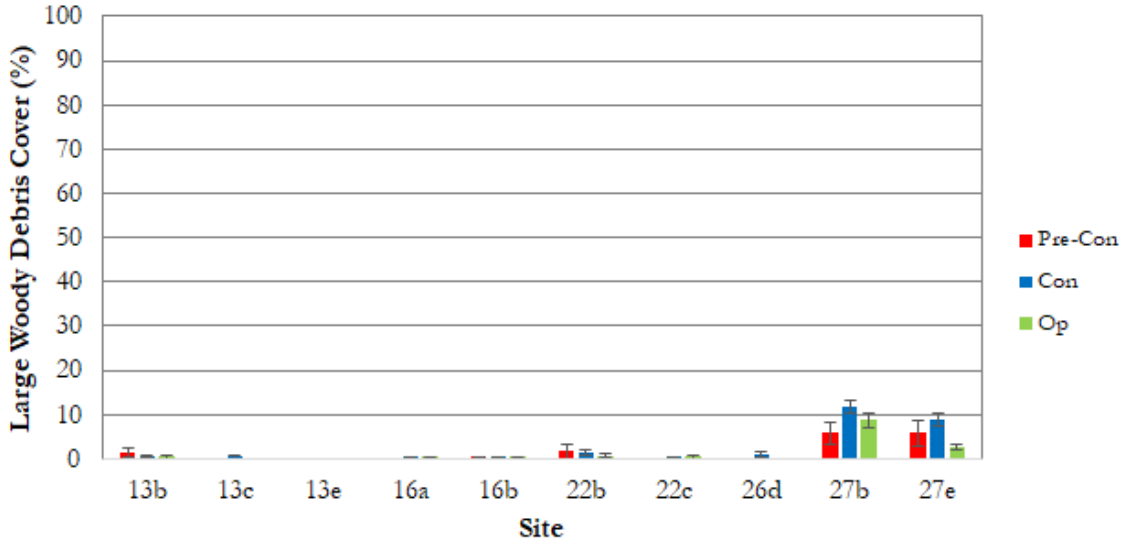

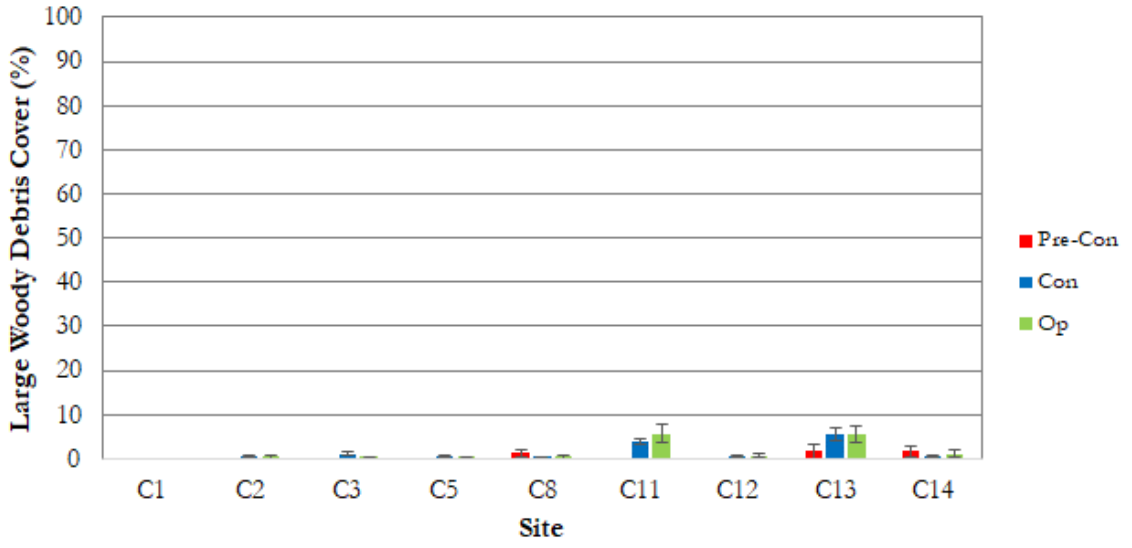

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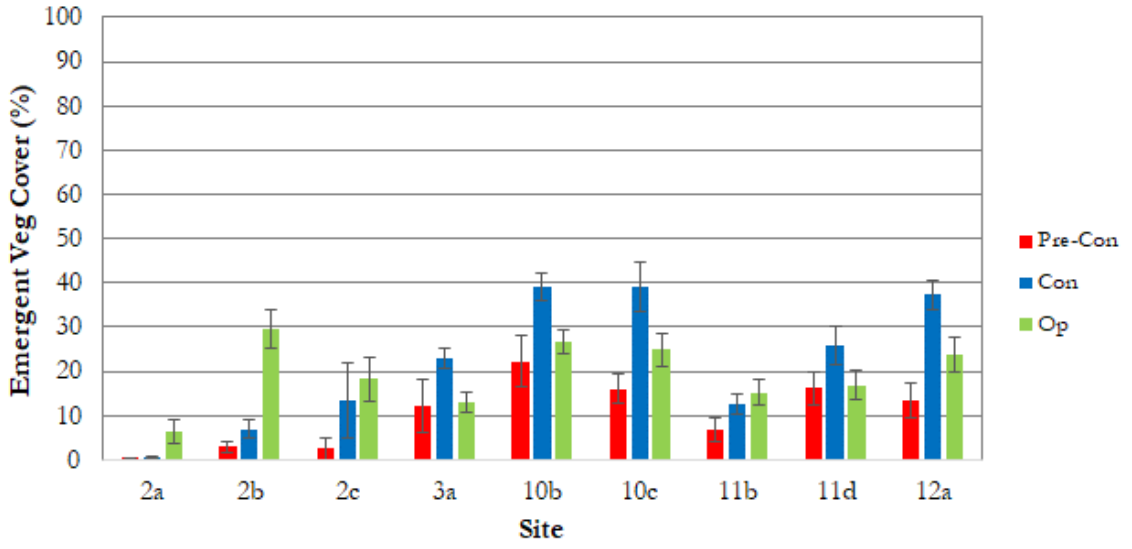

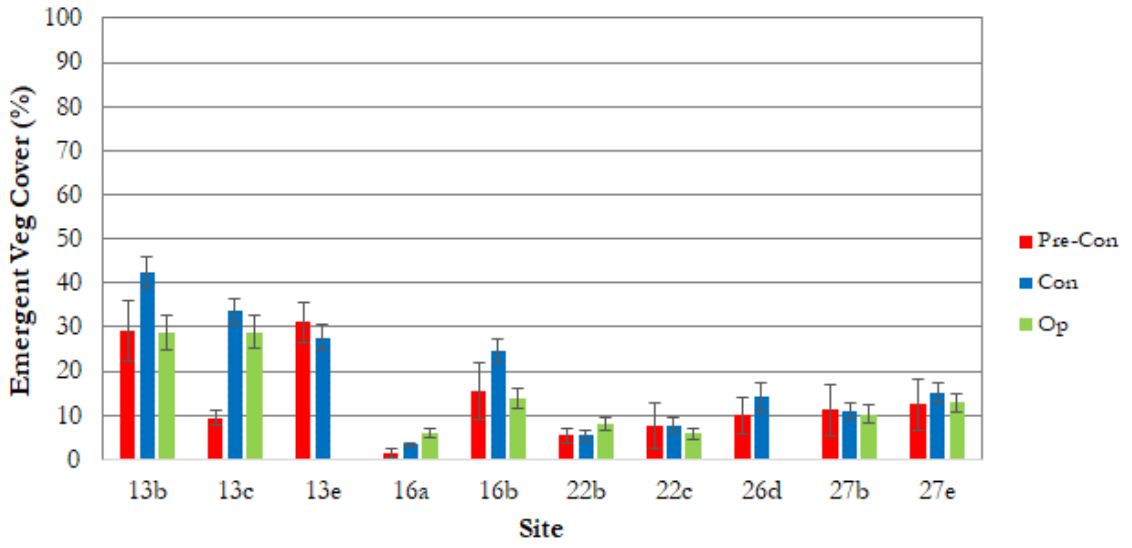

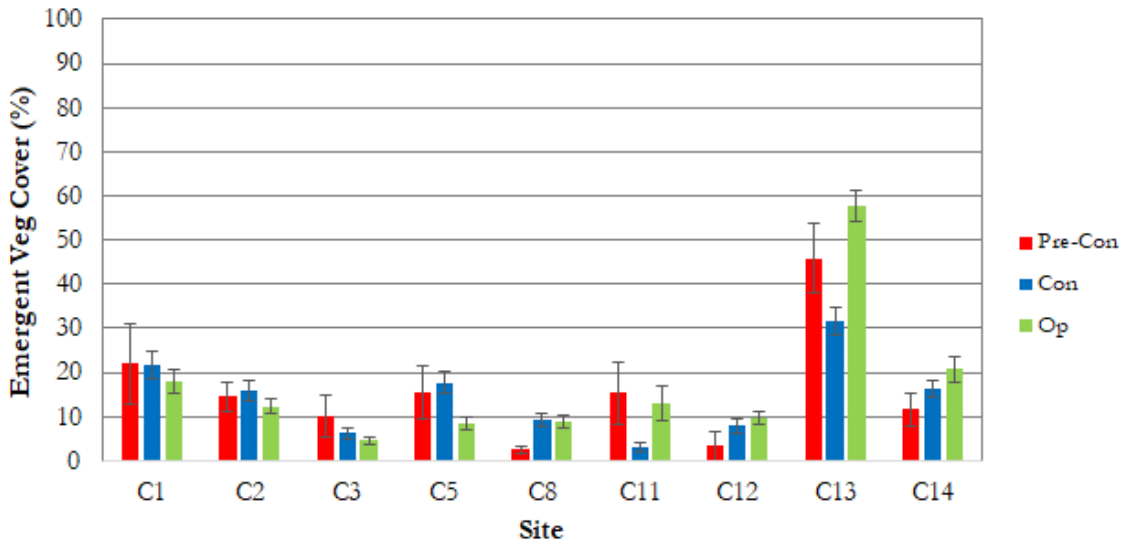

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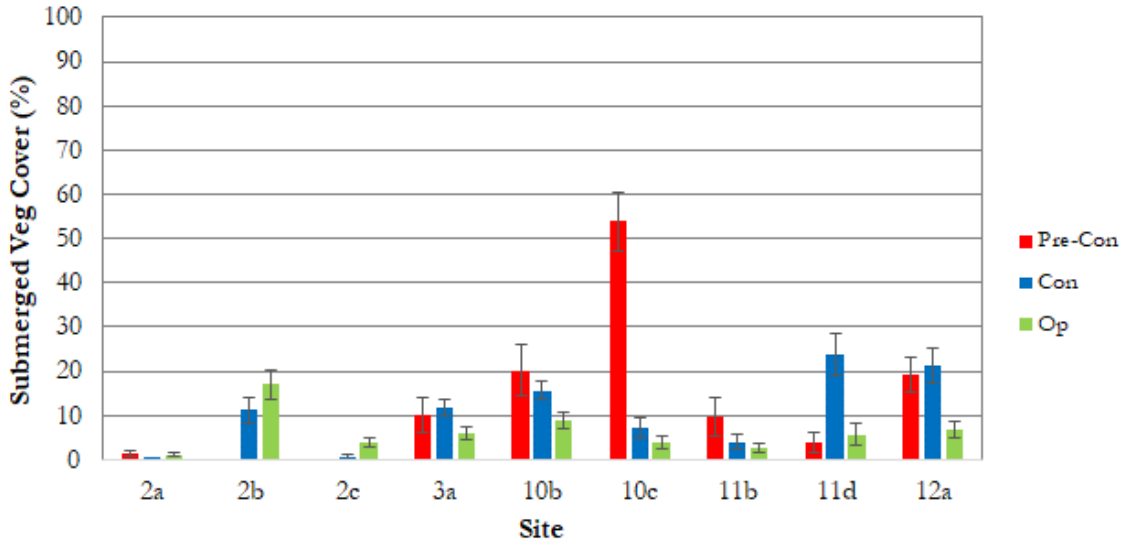

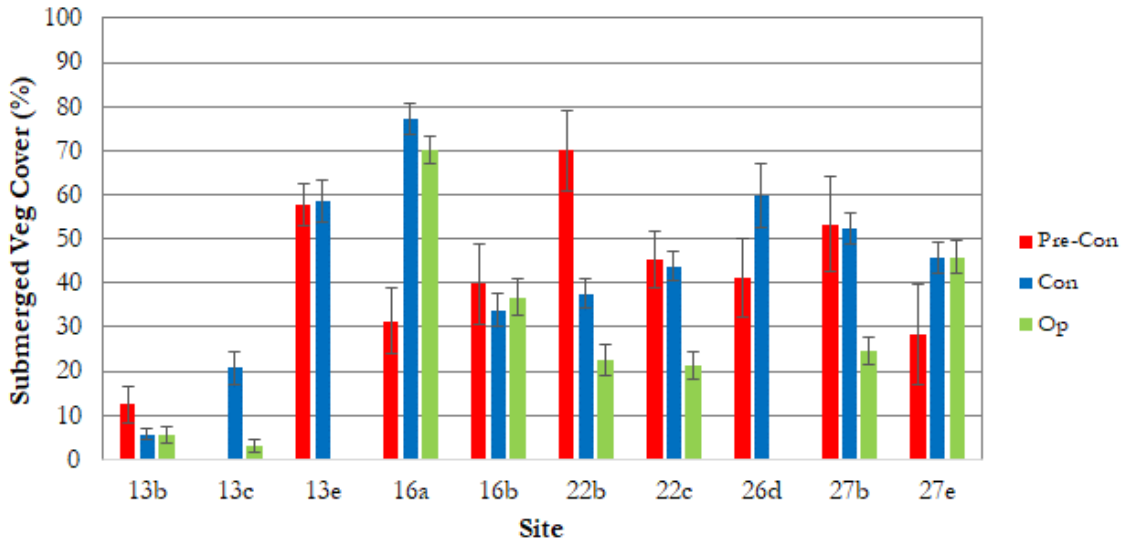

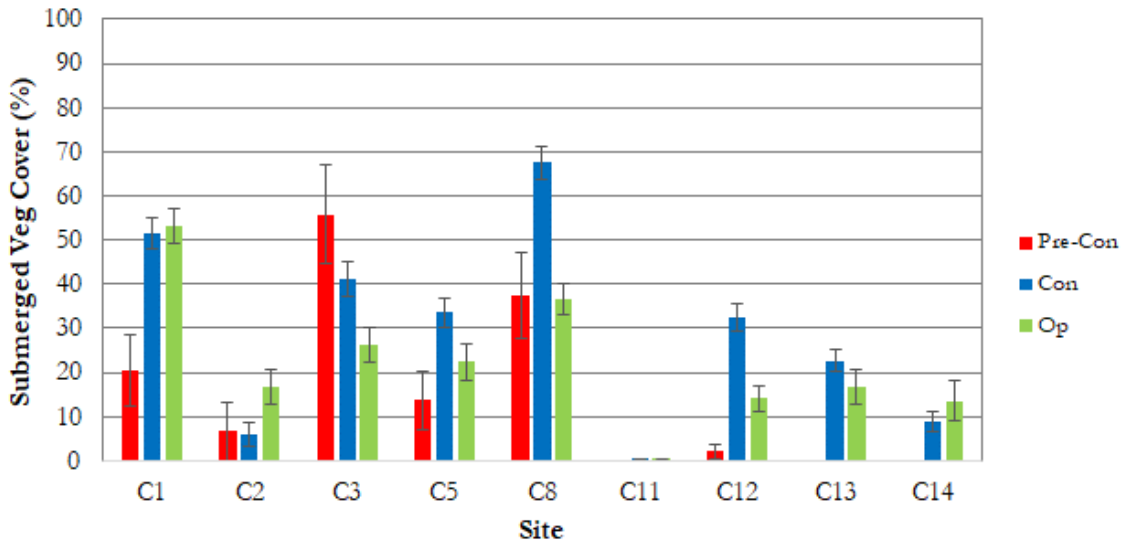

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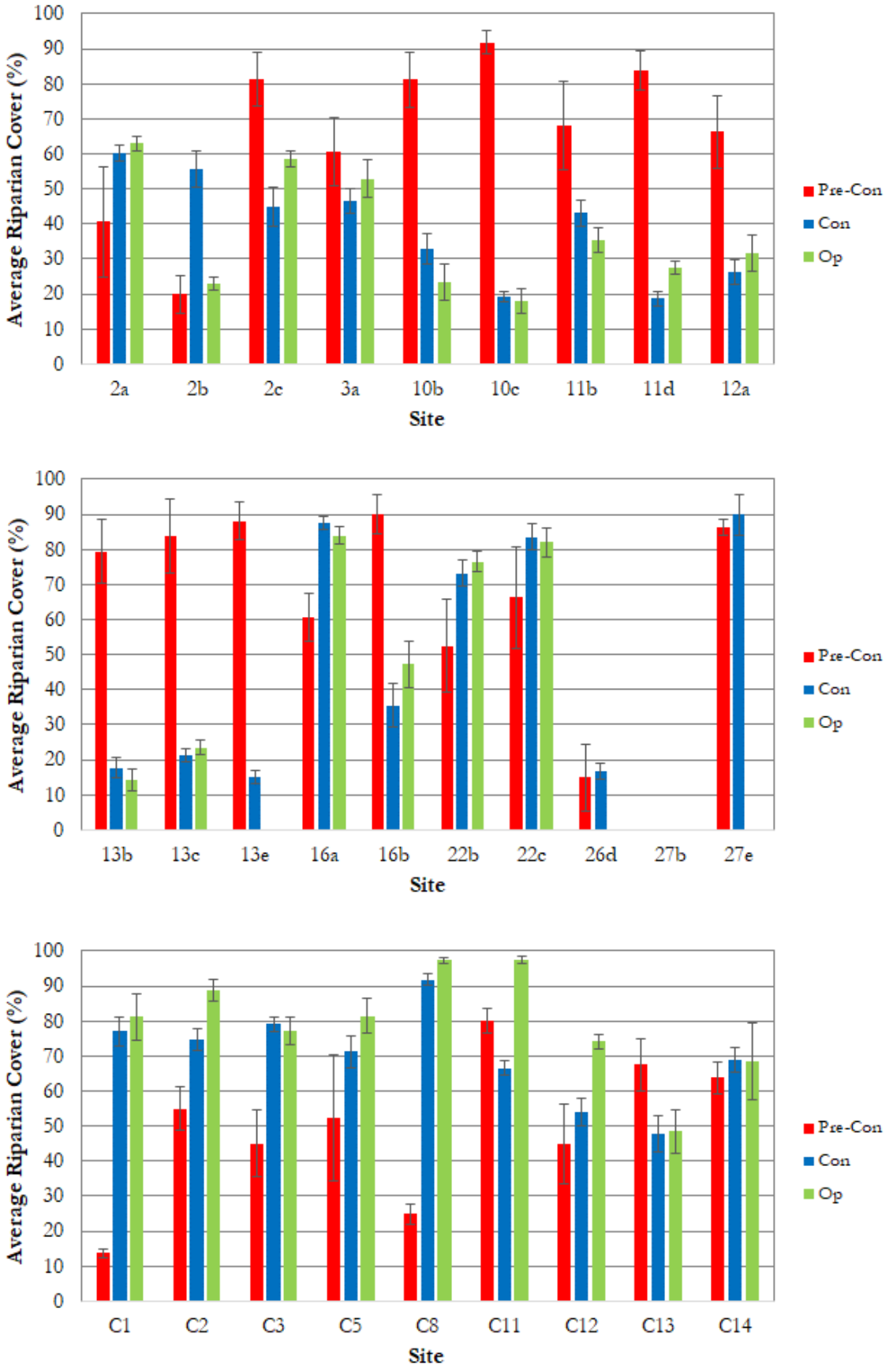

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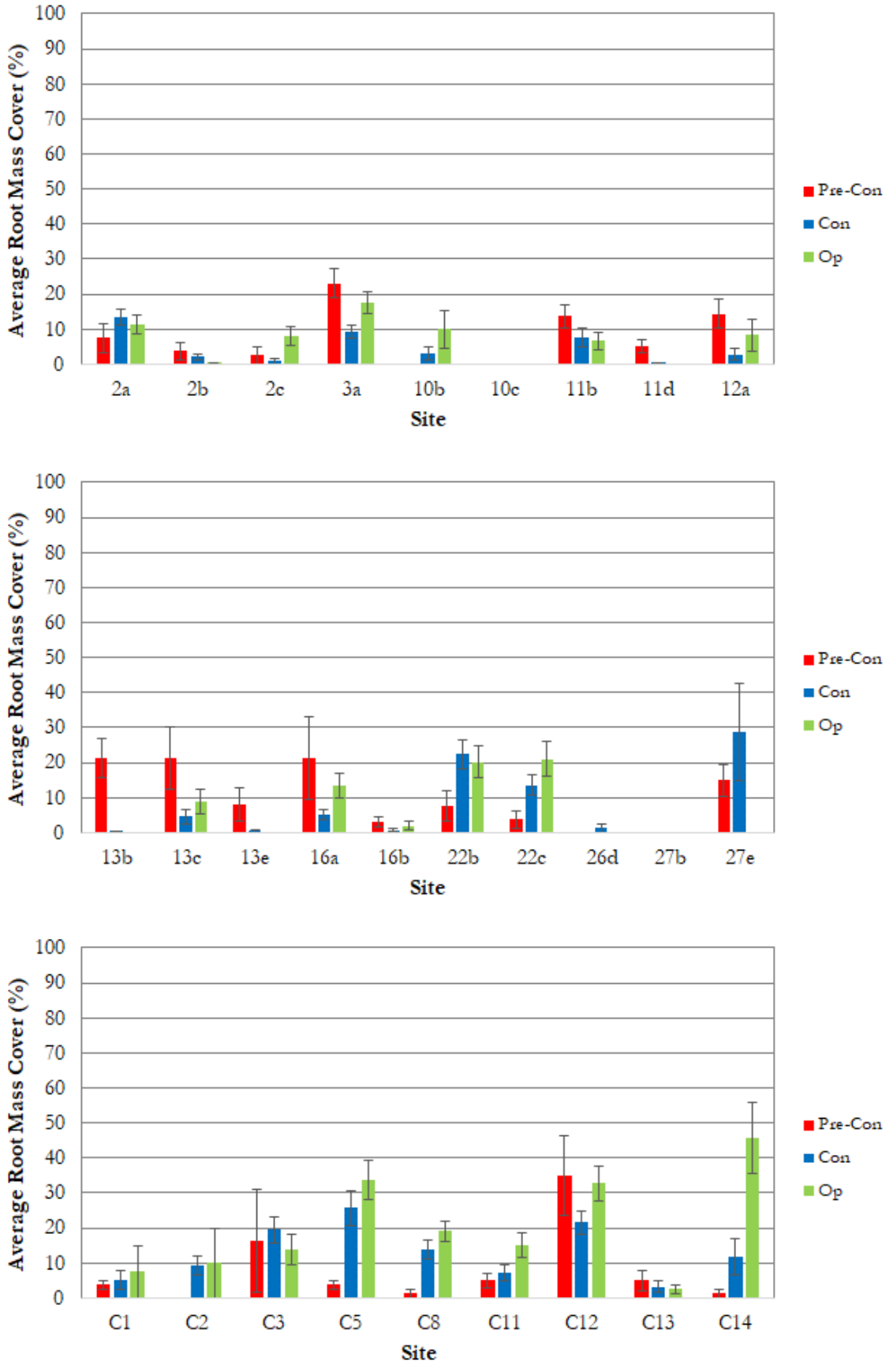

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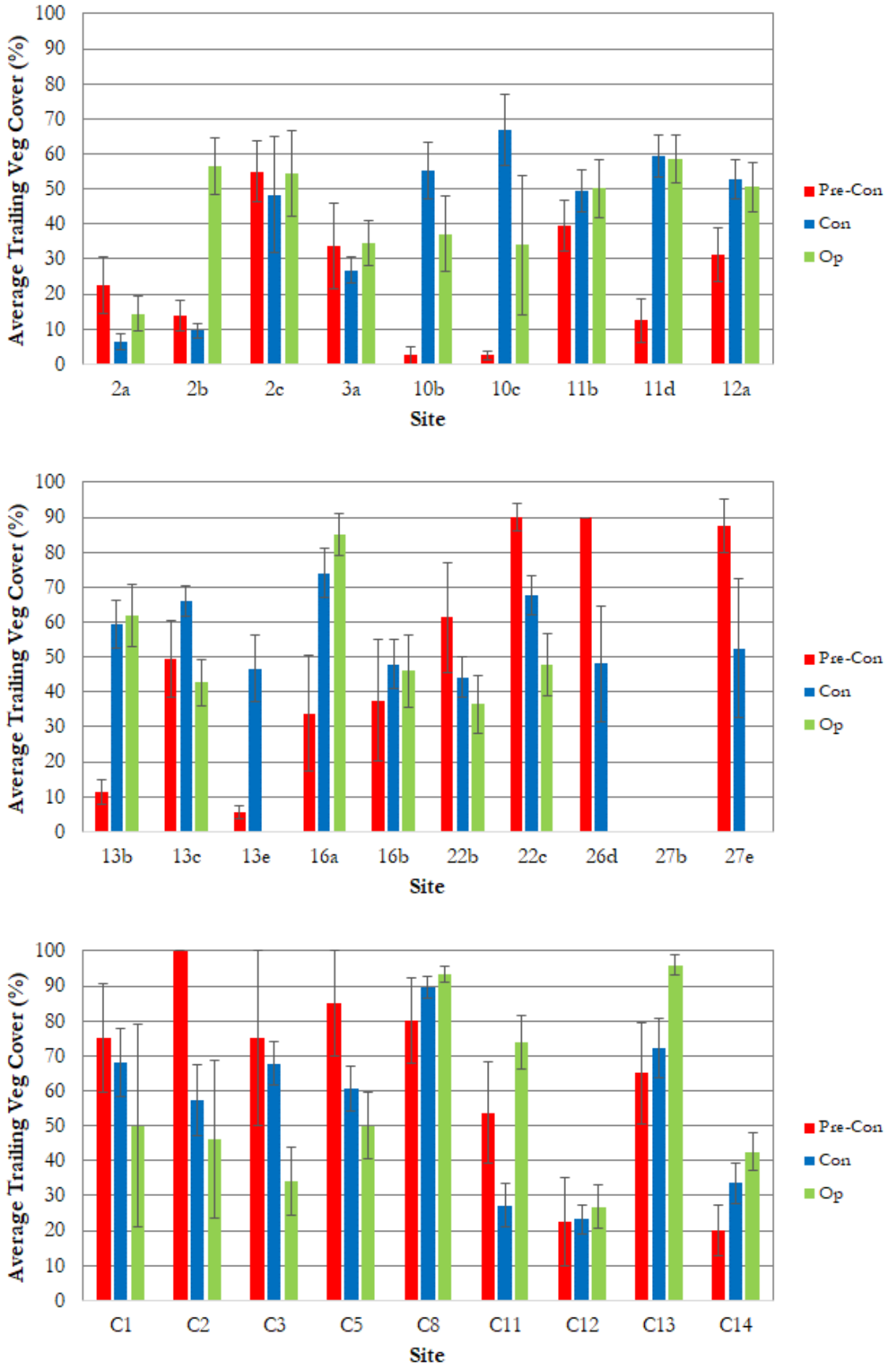

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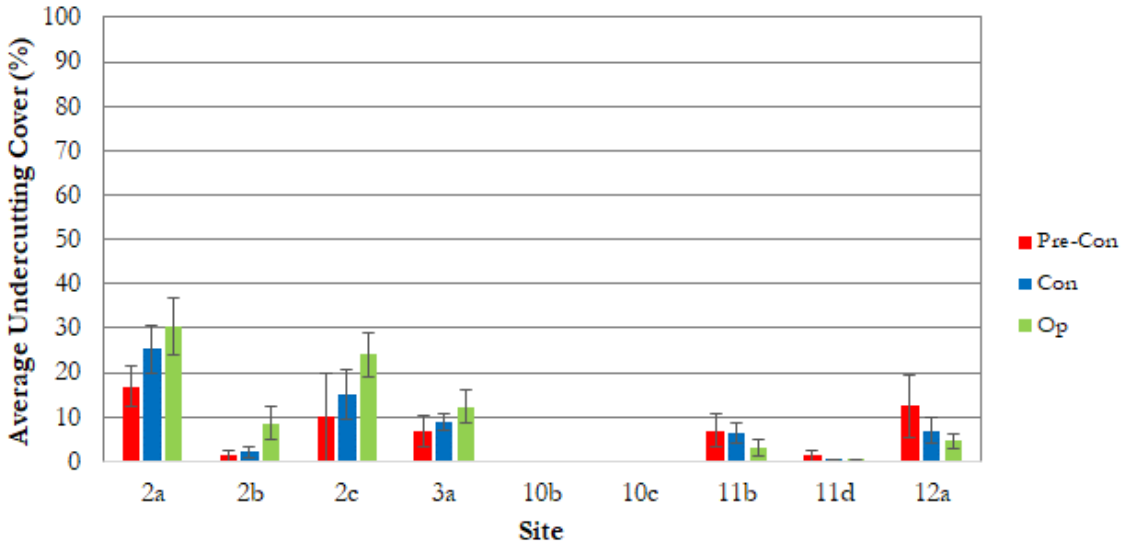

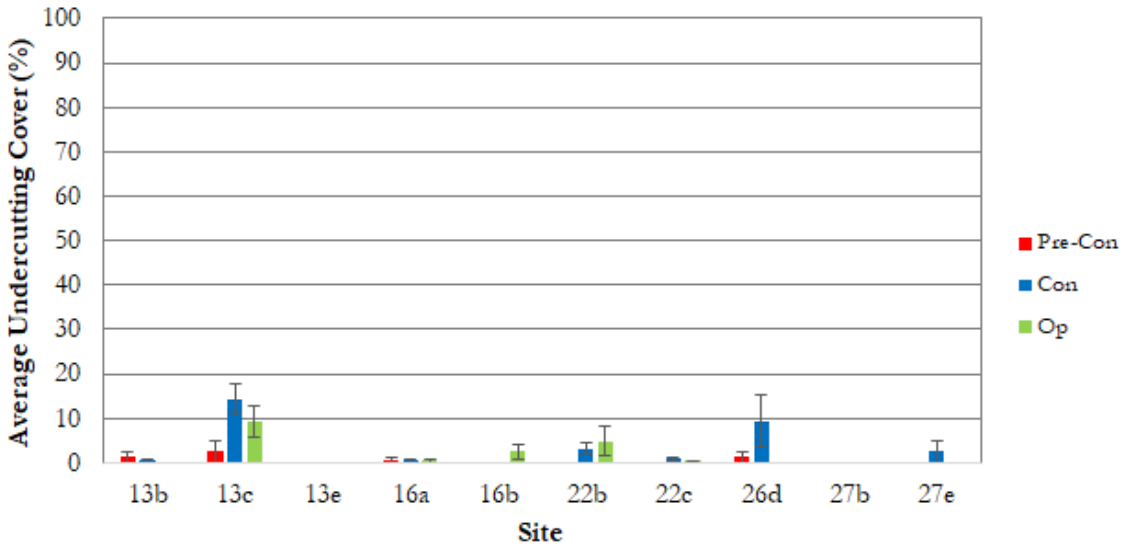

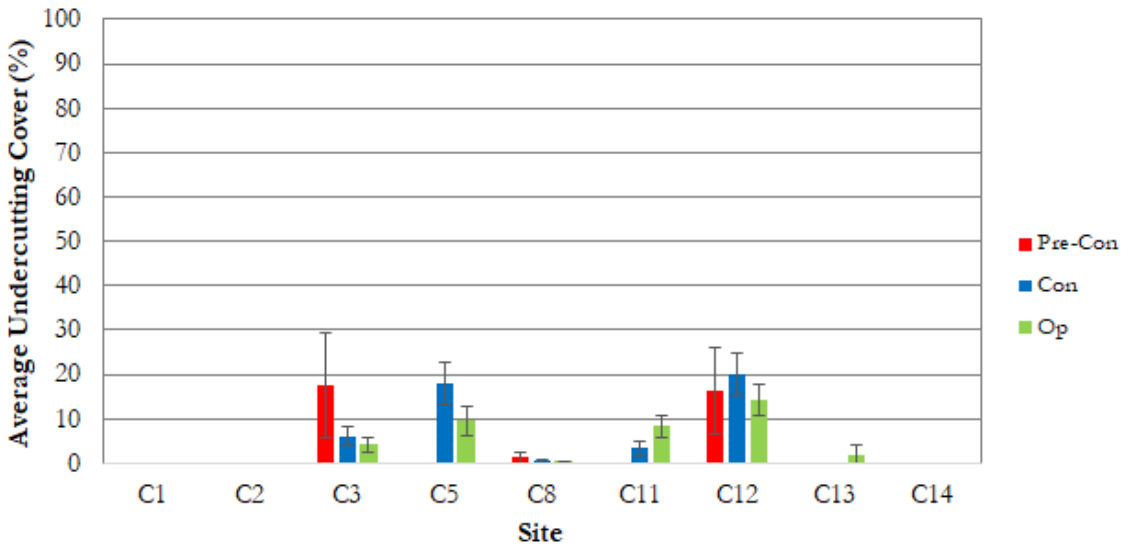

Appendix B

Construction and Operational Phase Fish Monitoring Results

Table B1. Summary of captures for all fishing methods at all impact sites during the May 2017 survey

		Site																	
Scientific Name	***Common Name***	**2a**	**2b**	**2c**	**3a**	**10b**	**10c**	**11b**	**11d**	**12a**	**13b**	**13c**	**13e**	**16a**	**16b**	**22b**	**22c**	**26d**	**27b**	**27e**
Anguilla australis	Shortfin Eel	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	1	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	7	0	0	15	92	0	61	4	60	0	20	5	0	0	13	5	14	0	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	42	0	28	0	67	0	17	1	0	0	0	0	0	1	1
Hypseleotris galii	Firetail Gudgeon	49	1	4	103	45	1	43	3	37	0	3	13	0	4	26	64	0	4	5
Rhadinocentrus ornatus	Ornate Rainbowfish	0	0	0	0	1	0	0	0	18	0	46	3	0	0	3	0	6	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	3	0	4	0	0	0	0	0	0	5	7	6	3	6	34	13	7	1
Gambusia	Mosquito Fish	18	25	14	52	42	28	76	19	0	0	0	8	0	0	0	0	0	0	1

Table B2. Summary of captures for all fishing methods at all control sites during the May 2017 survey

		Site								
Scientific Name	***Common Name***	**C1**	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**
Anguilla australis	Shortfin Eel	0	0	0	1	0	0	1	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	1	0
Gobiomorphus australis	Striped Gudgeon	0	0	0	11	0	0	7	11	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	0	1	0
Hypseleotris galii	Firetail Gudgeon	9	2	8	31	97	39	90	4	0
Rhadinocentrus ornatus	Ornate Rainbowfish	18	17	33	2	30	6	14	9	11
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	28	0	7	10	18	7	96	5	2
Gambusia	Mosquito Fish	1	0	0	0	0	6	0	1	1

Table B3. Summary of captures for all fishing methods at all impact sites during the September 2017 survey

Scientific Name	*Common Name*	*Site*																	
		2a	**2b**	**2c**	**3a**	**10b**	**10c**	**11b**	**11d**	**12a**	**13b**	**13c**	**13e**	**16a**	**16b**	**22b**	**22c**	**26d**	**27b**	**27e**
Anguilla australis	Shortfin Eel	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0
Anguilla reinhardtii	Longfin Eel	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	25	0	0	30	0	0	60	3	0	35	27	11	2	0	23	5	16	0	5
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	1	1	0	0	12	15	0	0	0	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	95	0	0	47	0	0	28	4	0	0	2	47	0	33	49	44	9	5	4
Rhadinocentrus ornatus	Ornate Rainbowfish	0	0	0	0	0	0	0	0	0	0	10	0	4	3	3	0	8	1	2
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	2	0	0	2	0	0	0	0	0	12	4	8	77	2	15	14	17	9	8
Gambusia	Mosquito Fish	15	0	0	15	0	0	28	1	0	10	0	1	0	0	2	0	0	0	0

Table B4. Summary of captures for all fishing methods at all control sites during the September 2017 survey

Scientific Name	*Common Name*	*Site*								
		C1	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**
Anguilla australis	Shortfin Eel	0	0	0	0	1	0	0	2	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	3	0
Gobiomorphus australis	Striped Gudgeon	0	0	0	32	0	0	23	27	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	0	3	0
Hypseleotris galii	Firetail Gudgeon	25	1	16	44	84	35	180	25	0
Rhadinocentrus ornatus	Ornate Rainbowfish	22	1	2	25	19	30	16	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	48	23	75	20	40	13	2	34	0
Gambusia	Mosquito Fish	0	0	0	0	0	12	0	4	0

Table B5. Summary of captures for all fishing methods at all impact sites during the May 2018 survey

Scientific Name	*Common Name*	*Site*																		
		2a	**2b**	**2c**	**3a**	**10b**	**10c**	**11b**	**11d**	**12a**	**13b**	**13c**	**13e***	**16a**	**16b**	**22b**	**22c**	**26d***	**27b**	**27e**
Anguilla australis	Shortfin Eel	1	0	0	0	0	0	0	0	2	2	0	0	0	2	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	25	0	0	20	1	0	41	20	25	26	25	0	0	0	14	4	0	2	1
Hypseleotris compressa	Empire Gudgeon	0	0	0	4	4	0	34	1	52	0	39	0	0	0	0	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	32	0	0	79	1	0	6	0	9	0	0	0	1	67	75	27	0	13	13
Rhadinocentrus ornatus	Ornate Rainbowfish	0	0	0	0	0	0	0	0	0	0	6	0	14	13	14	7	0	2	1
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	0	0	2	0	0	0	4	1	0	4	0	32	2	7	10	0	28	19
Gambusia	Mosquito Fish	33	3	0	114	20	0	44	9	17	103	0	0	0	0	0	0	0	0	4

* No survey - access restrictions.

Table B6. Summary of captures for all fishing methods at all control sites during the May 2018 survey

Scientific Name	*Common Name*	*Site*								
		C1	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**
Anguilla australis	Shortfin Eel	0	0	1	1	1	1	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	2	0	0	7	0	0	5	8	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	0	9	0
Hypseleotris galii	Firetail Gudgeon	26	0	0	11	96	8	96	18	0
Rhadinocentrus ornatus	Ornate Rainbowfish	28	0	9	4	37	0	32	60	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	51	0	5	0	39	0	16	43	0
Gambusia	Mosquito Fish	0	0	0	0	0	18	0	17	23

* No survey - access restrictions.

Table B7. Summary of captures for all fishing methods at all impact sites during the September 2018 survey

Scientific Name	*Common Name*	*Site*																		
		2a	**2b**	**2c**	**3a**	**10b**	**10c**	**11b***	**11d**	**12a**	**13b**	**13c**	**13e***	**16a**	**16b**	**22b**	**22c**	**26d***	**27b**	**27e**
Anguilla australis	Shortfin Eel	1	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	32	0	0	16	10	0	0	22	23	1	78	0	0	0	15	31	0	3	1
Hypseleotris compressa	Empire Gudgeon	0	0	0	8	17	0	0	1	64	0	44	0	0	0	1	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	49	0	0	77	9	0	0	0	3	0	0	0	0	527	82	84	0	5	4
Rhadinocentrus ornatus	Ornate Rainbowfish	0	0	0	0	0	0	0	0	0	0	11	0	2	2	12	0	0	10	3
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	0	0	0	0	0	0	1	0	0	3	0	29	0	7	22	0	21	13
Gambusia	Mosquito Fish	9	0	0	70	72	0	0	4	3	4	0	0	0	0	0	0	0	0	0

* No survey - access restrictions.

Table B8. Summary of captures for all fishing methods at all control sites during the September 2018 survey

Scientific Name	*Common Name*	*Site*								
		C1	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**
Anguilla australis	Shortfin Eel	0	0	1	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	0	0	0	23	0	0	0	12	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	0	10	0
Hypseleotris galii	Firetail Gudgeon	41	0	2	8	136	56	889	35	1
Rhadinocentrus ornatus	Ornate Rainbowfish	21	0	4	0	10	0	79	83	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	25	0	23	2	15	0	65	38	1
Gambusia	Mosquito Fish	0	0	0	0	0	4	0	0	2

* No survey - access restrictions.

Table B9. Summary of captures for all fishing methods at all impact sites during the July 2019 survey

		Site																		
Scientific Name	***Common Name***	**2a**	**2b**	**2c**	**3a**	**10b**	**10c**	**11b**	**11d**	**12a**	**13b**	**13c**	**13e***	**16a**	**16b**	**22b**	**22c**	**26d***	**27b**	**27e**
Anguilla australis	Shortfin Eel	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	31	0	0	9	2	0	14	9	4	3	0	0	0	0	4	10	0	0	1
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	29	0	14	0	6	0	0	0	0	0	0	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	26	0	0	45	5	0	0	0	0	0	0	0	0	5	11	12	0	0	3
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	0	0	0	4	0	0	0	0	0	0	0	0	0	0	18	31	0	0	1
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	0	1
Gambusia	Mosquito Fish	40	0	0	109	57	0	30	0	7	2	0	0	0	0	0	0	0	0	0

* No survey - access restrictions.

Table B10. Summary of captures for all fishing methods at all control and Devils Pulpit sites during the July 2019 survey

		Site															
Scientific Name	***Common Name***	**C1**	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**	**OPP1**	**OPP2**	**OPP3**	**OPP4***	**OPP5**	**OPP6**	**OPP7**
Anguilla australis	Shortfin Eel	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	0	0	0	13	0	0	4	30	0	2	7	30	0	0	0	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	0	2	0	0	0	4	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	12	0	0	3	0	0	8	13	0	3	6	9	0	0	0	0
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	21	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia	Mosquito Fish	0	0	0	0	0	0	0	17	0	45	8	8	0	0	0	0

* No survey - access restrictions.

Table B11. Summary of captures for all fishing methods at all impact sites during the September 2019 survey

		Site																		
Scientific Name	***Common Name***	**2a**	**2b**	**2c**	**3a**	**10b**	**10c**	**11b***	**11d**	**12a**	**13b**	**13c**	**13e***	**16a**	**16b**	**22b**	**22c**	**26d***	**27b**	**27e**
Anguilla australis	Shortfin Eel	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	3	0	0	14	10	0	0	0	5	0	0	0	0	0	9	7	0	0	2
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	75	0	0	0	6	0	0	0	0	0	0	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	8	0	0	86	3	0	0	0	0	0	0	0	0	95	50	65	0	0	6
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	3	0	0	1
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	12	0	0	5
Gambusia	Mosquito Fish	40	0	0	14	54	0	0	0	19	1	0	0	0	0	0	0	0	0	0

* No survey - access restrictions.

Table B12. Summary of captures for all fishing methods at all control and Devils Pulpit sites during the September 2019 survey

		Site															
Scientific Name	***Common Name***	**C1**	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**	**OPP1**	**OPP2**	**OPP3**	**OPP4***	**OPP5**	**OPP6**	**OPP7**
Anguilla australis	Shortfin Eel	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	0	0	0	3	4	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	1	0	0	12	0	0	6	34	0	4	70	31	0	0	0	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	0	25	0	1	0	4	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	30	0	0	13	0	0	238	32	0	46	20	36	0	0	0	0
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	28	0	0	43	0	0	22	1	0	0	1	1	0	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	9	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia	Mosquito Fish	0	0	0	0	0	0	0	5	0	0	5	0	0	0	0	0

* No survey - access restrictions.

Table B13. Summary of captures for all fishing methods at all impact sites during the May – June 2020 survey

Scientific Name	*Common Name*	*Site*																		
		2a	**2b**	**2c***	**3a**	**10b**	**10c**	**11b**	**11d**	**12a**	**13b**	**13c**	**13e***	**16a**	**16b**	**22b**	**22c**	**26d***	**27b**	**27e**
Ambassis agassizii	Olive Perchlet	0	6	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla australis	Shortfin Eel	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	5	0	0	8	12	2	19	36	47	0	0	0	0	0	7	7	0	0	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	1	40	1	1	2	154	0	0	0	0	0	1	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	18	17	0	25	6	0	2	1	8	0	0	0	0	0	20	38	0	0	0
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	0	0	0	0	1	0	0	0	13	0	0	0	0	0	3	4	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	28	192	0	111	34	54	22	4	5	4	0	0	0	0	3	0	0	0	0

* No survey - access restrictions.

Table B14. Summary of captures for all fishing methods at all control and Devils Pulpit sites during the May – June 2020 survey

Scientific Name	*Common Name*	*Site*															
		C1	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**	**OPP1**	**OPP2**	**OPP3**	**OPP4***	**OPP5**	**OPP6**	**OPP7**
Ambassis agassizii	Olive Perchlet	0	0	0	0	0	0	0	66	0	0	0	0	0	4	0	0
Anguilla australis	Shortfin Eel	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	1	0	0	4	0	0	4	13	0	4	9	17	0	0	0	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	0	18	0	1	7	1	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	12	1	0	32	23	12	37	170	31	1	3	1	0	42	0	0
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	11	0	0	8	28	0	22	9	4	0	0	0	0	2	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	10	0	0	6	1	0	6	0	0	0	0	0	0	0	0	0
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Gambusia holbrooki	Mosquito Fish	0	0	0	0	0	1	0	63	40	95	99	2	0	322	44	0

Table B15. Summary of captures for all fishing methods at all impact sites during the September 2020 survey

		Site																		
Scientific Name	***Common Name***	**2a**	**2b**	**2c***	**3a**	**10b**	**10c**	**11b**	**11d**	**12a**	**13b**	**13c**	**13e***	**16a**	**16b**	**22b**	**22c**	**26d***	**27b**	**27e**
Ambassis agassizii	Olive Perchlet	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla australis	Shortfin Eel	2	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	3	1	0	15	30	0	18	34	66	0	2	0	0	0	37	25	0	0	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	2	111	0	33	0	23	0	0	0	0	0	0	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	4	17	0	26	9	0	9	1	5	0	1	0	0	0	74	78	0	0	0
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	0	0	0	0	0	0	2	6	7	0	0	0	0	0	4	7	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	17	0	0	0
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	25	71	0	22	179	118	18	3	3	23	0	0	0	0	0	0	0	0	0

* No survey - access restrictions.

Table B16. Summary of captures for all fishing methods at all control and Devils Pulpit sites during the September 2020 survey

		Site															
Scientific Name	***Common Name***	**C1**	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**	**OPP1**	**OPP2**	**OPP3**	**OPP4***	**OPP5**	**OPP6**	**OPP7**
Ambassis agassizii	Olive Perchlet	0	0	0	0	0	0	0	39	0	0	0	0	0	0	0	0
Anguilla australis	Shortfin Eel	0	0	0	1	1	0	1	0	0	6	2	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	0	0	0	3	0	0	3	75	0	7	12	10	0	0	0	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	0	8	0	1	0	1	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	26	0	0	8	101	18	554	40	3	6	10	15	0	12	0	0
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	21	2	0	20	35	14	164	0	0	0	0	0	0	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	6	0	0	3	2	1	9	0	0	0	0	0	0	0	0	0
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	0	0	0	0	0	2	0	910	86	165	41	2	0	109	0	0

* No survey - access restrictions.

Table B17. Summary of captures for all fishing methods at all impact sites during the May 2021 survey

Scientific Name	*Common Name*	*Site*																		
		2a	**2b**	**2c**	**3a**	**10b**	**10c**	**11b**	**11d**	**12a**	**13b**	**13c**	**13e***	**16a**	**16b**	**22b**	**22c**	**26d***	**27b**	**27e**
Ambassis agassizii	Olive Perchlet	0	9	71	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla australis	Shortfin Eel	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	18	0	1	52	5	6	19	24	24	5	2	0	0	0	26	7	0	2	3
Hypseleotris compressa	Empire Gudgeon	2	0	0	3	34	18	24	0	18	3	9	0	0	0	0	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	24	8	8	84	8	1	10	1	4	2	3	0	0	2	41	25	0	0	0
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	0	0	5	19	0	0	0	4	4	0	0	0	2	0	13	30	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	14	0	0	0
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	49	47	17	21	116	6	40	2	1	39	0	0	0	0	0	0	0	0	0

* No survey - access restrictions.

Table B18. Summary of captures for all fishing methods at all control and Devils Pulpit sites during the May 2021 survey

Scientific Name	*Common Name*	*Site*															
		C1	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**	**OPP1**	**OPP2**	**OPP3**	**OPP4***	**OPP5***	**OPP6**	**OPP7**
Ambassis agassizii	Olive Perchlet	0	0	0	0	0	0	0	14	35	7	2	2	0	0	0	0
Anguilla australis	Shortfin Eel	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	1	0	0	4	0	0	8	12	1	3	3	4	0	0	6	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	0	18	0	21	5	1	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	19	0	2	21	227	16	86	19	68	109	23	35	0	0	3	6
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	20	0	4	0	1	0	0	0	1
Rhadinocentrus ornatus	Ornate Rainbowfish	37	3	2	27	56	14	123	11	2	14	4	75	0	0	3	5
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	41	2	1	6	1	0	8	0	0	0	0	0	0	0	0	0
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	0	0	0	0	0	6	0	97	18	146	126	18	0	0	2	8

* No survey - access restrictions.

Table B19. Summary of captures for all fishing methods at all impact sites during the September 2021 survey

Scientific Name	*Common Name*	*Site*																		
		2a	**2b**	**2c**	**3a**	**10b**	**10c**	**11b**	**11d**	**12a**	**13b**	**13c**	**13e***	**16a**	**16b**	**22b**	**22c**	**26d***	**27b**	**27e**
Ambassis agassizii	Olive Perchlet	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla australis	Shortfin Eel	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1
Anguilla reinhardtii	Longfin Eel	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	20	8	0	31	53	0	43	25	100	18	0	0	0	0	14	27	0	0	3
Hypseleotris compressa	Empire Gudgeon	0	24	0	0	157	0	16	0	52	12	0	0	0	0	1	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	99	97	0	83	2	0	10	27	0	0	1	0	0	0	23	26	0	0	0
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	0	0	0	17	0	0	0	8	2	0	0	0	0	0	0	0	0	2	1
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	0	0	0	0	0	0	0	3	0	0	0	3	0	36	14	0	1	0
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	14	80	0	19	32	5	22	0	2	12	0	0	0	0	0	0	0	0	0

* No survey - access restrictions.

Table B20. Summary of captures for all fishing methods at all control and Devils Pulpit sites during the September 2021 survey

Scientific Name	*Common Name*	*Site*															
		C1	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**	**OPP1**	**OPP2**	**OPP3**	**OPP4***	**OPP5**	**OPP6**	**OPP7**
Ambassis agassizii	Olive Perchlet	0	0	0	0	0	0	0	3	0	3	8	1	0	0	0	0
Anguilla australis	Shortfin Eel	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	3	0	1	2	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	5	0	0	22	0	0	10	36	0	1	32	13	0	0	0	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	0	149	0	4	1	4	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	28	3	4	37	283	0	623	32	0	60	122	91	0	0	0	0
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	17	0	3	1	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	68	9	0	8	5	0	144	60	0	10	6	1	0	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	75	34	1	8	9	0	16	0	0	0	0	0	0	0	0	0
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	3	0	0	2	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	0	0	0	0	0	0	0	313	0	200	291	0	0	0	0	0

* No survey - access restrictions.

Table B21. Summary of captures for all fishing methods at all impact sites during the May 2022 survey

Scientific Name	*Common Name*	*Site*																		
		2a	**2b**	**2c**	**3a**	**10b**	**10c**	**11b**	**11d**	**12a**	**13b**	**13c**	**13e***	**16a**	**16b**	**22b**	**22c**	**26d***	**27b**	**27e**
Ambassis agassizii	Olive Perchlet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla australis	Shortfin Eel	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	9	2	0	27	0	1	28	2	16	9	14	0	5	0	13	3	0	0	1
Hypseleotris compressa	Empire Gudgeon	1	0	0	0	17	28	38	0	16	7	14	0	0	0	27	0	0	1	0
Hypseleotris galii	Firetail Gudgeon	40	18	6	19	16	14	17	2	5	2	5	0	1	2	84	66	0	5	6
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	0	0	0	17	0	0	0	0	3	0	12	0	1	0	5	11	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	0	0	1	2	0	1	0	0	0	2	0	3	0	38	5	0	1	8
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	5	51	37	5	352	64	66	47	18	25	2	0	0	62	7	18	0	4	0

* No survey - access restrictions.

Table B22. Summary of captures for all fishing methods at all control and Devils Pulpit sites during the May 2022 survey

Scientific Name	*Common Name*	*Site*															
		C1	**C2**	**C3**	**C5***	**C8**	**C11**	**C12**	**C13***	**C14**	**OPP1**	**OPP2**	**OPP3**	**OPP4***	**OPP5***	**OPP6**	**OPP7**
Ambassis agassizii	Olive Perchlet	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Anguilla australis	Shortfin Eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	5	0	0	0	0	0	3	0	0	0	0	2	0	0	1	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3
Hypseleotris galii	Firetail Gudgeon	63	3	5	0	69	6	46	0	1	8	7	12	0	0	0	3
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	10	3	7	0	20	34	47	0	0	1	0	5	0	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	41	14	23	0	10	1	4	0	0	0	0	0	0	0	0	0
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	1	0	0	0	0	0	0	0	3	1	2	6	0	0	0	0

* No survey - access restrictions.

Table B23. Summary of captures for all fishing methods at all impact sites during the September 2022 survey

		Site																		
Scientific Name	***Common Name***	**2a**	**2b**	**2c**	**3a**	**10b**	**10c**	**11b**	**11d**	**12a**	**13b**	**13c**	**13e***	**16a**	**16b**	**22b**	**22c**	**26d***	**27b**	**27e**
Ambassis agassizii	Olive Perchlet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla australis	Shortfin Eel	0	0	0	0	4	1	1	2	0	2	0	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	33	3	0	22	7	3	65	27	187	22	3	0	0	0	11	1	0	5	4
Hypseleotris compressa	Empire Gudgeon	0	54	0	1	315	136	24	1	45	49	37	0	0	0	15	16	0	4	12
Hypseleotris galii	Firetail Gudgeon	110	118	1	19	12	9	4	1	1	6	7	0	0	65	44	55	0	1	14
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	0	1	1	1	0	0	0	2	18	0	2	0	4	0	3	5	0	0	1
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	0	0	0	1	0	0	0	2	1	1	0	23	0	31	16	0	3	12
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	3	33	31	1	129	134	0	3	1	4	0	0	0	10	0	0	0	0	0

* No survey - access restrictions.

Table B24. Summary of captures for all fishing methods at all control and Devils Pulpit sites during the September 2022 survey

		Site															
Scientific Name	***Common Name***	**C1**	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**	**OPP1**	**OPP2**	**OPP3**	**OPP4***	**OPP5***	**OPP6**	**OPP7**
Ambassis agassizii	Olive Perchlet	0	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0
Anguilla australis	Shortfin Eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	0	1	0	16	0	0	5	13	0	5	12	5	0	0	6	0
Hypseleotris compressa	Empire Gudgeon	2	0	0	9	0	0	0	68	0	12	0	4	0	0	0	5
Hypseleotris galii	Firetail Gudgeon	56	1	5	9	333	17	268	138	0	37	5	5	0	0	0	33
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Rhadinocentrus ornatus	Ornate Rainbowfish	8	0	6	26	34	16	149	8	0	4	0	1	0	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	72	5	24	23	31	1	81	0	0	0	0	0	0	0	0	0
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	0	0	0	0	0	0	0	79	30	36	13	0	0	0	0	31

* No survey - access restrictions.

Table B25. Summary of captures for all fishing methods at all impact sites during the May 2023 survey

		Site																		
Scientific Name	***Common Name***	**2a**	**2b**	**2c**	**3a**	**10b**	**10c**	**11b**	**11d**	**12a**	**13b**	**13c**	**13e***	**16a**	**16b**	**22b**	**22c**	**26d***	**27b**	**27e**
Ambassis agassizii	Olive Perchlet	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla australis	Shortfin Eel	0	0	0	0	3	0	0	0	1	0	0	0	0	4	1	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	24	48	0	35	52	0	24	37	52	37	14	0	8	5	15	30	0	30	3
Hypseleotris compressa	Empire Gudgeon	0	17	0	15	727	0	82	53	447	143	153	0	4	4	52	7	0	80	35
Hypseleotris galii	Firetail Gudgeon	95	72	0	26	0	0	2	0	0	0	1	0	1	69	14	24	0	23	13
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	0	0	0	2	0	0	0	3	0	0	9	0	5	0	3	0	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	0	0	0	0	0	0	0	0	0	0	0	41	0	30	21	0	13	15
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	0	39	0	2	4	0	3	3	1	2	0	0	0	355	4	0	0	7	2

* No survey - access restrictions.

Table B26. Summary of captures for all fishing methods at all control and Devils Pulpit sites during the May 2023 survey

		Site															
Scientific Name	***Common Name***	**C1**	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**	**OPP1**	**OPP2**	**OPP3**	**OPP4***	**OPP5**	**OPP6**	**OPP7**
Ambassis agassizii	Olive Perchlet	0	0	0	0	0	0	0	0	0	5	1	0	0	0	0	0
Anguilla australis	Shortfin Eel	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	2	2	0	0	1	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	1	0	5	69	1	0	5	9	0	21	56	25	0	0	0	1
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	1	139	0	31	2	14	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	229	0	40	37	409	0	124	9	0	65	19	74	0	0	0	12
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	14	0	20	39	10	0	115	0	0	0	30	1	0	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	23	0	28	4	3	0	2	0	0	0	0	0	0	0	0	0
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	0	0	0	0	0	0	0	14	0	30	3	0	0	0	12	36

* No survey - access restrictions.

Table B27. Summary of captures for all fishing methods at all impact sites during the September 2023 survey

		Site																		
Scientific Name	***Common Name***	**2a**	**2b**	**2c**	**3a**	**10b**	**10c**	**11b**	**11d**	**12a**	**13b**	**13c**	**13e***	**16a**	**16b**	**22b**	**22c**	**26d***	**27b**	**27e**
Ambassis agassizii	Olive Perchlet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla australis	Shortfin Eel	1	0	0	1	4	0	2	1	1	3	0	0	0	0	0	0	0	2	0
Anguilla reinhardtii	Longfin Eel	0	0	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	52	22	0	51	33	0	30	19	34	50	13	0	2	19	22	22	0	75	8
Hypseleotris compressa	Empire Gudgeon	0	20	0	16	639	0	68	1	186	88	84	0	0	12	7	5	0	263	38
Hypseleotris galii	Firetail Gudgeon	15	45	0	38	0	0	5	0	0	1	0	0	3	169	102	37	0	98	16
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	0	1	0	2	0	0	0	0	0	0	0	0	5	0	1	0	0	29	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	0	0	0	0	0	0	0	0	0	0	0	0	32	0	14	11	0	22	13
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	0	28	0	0	8	0	11	0	0	2	0	0	0	25	0	0	0	0	0

* No survey - access restrictions.

Table B28. Summary of captures for all fishing methods at all control and Devils Pulpit sites during the September 2023 survey

		Site															
Scientific Name	***Common Name***	**C1**	**C2**	**C3**	**C5**	**C8**	**C11**	**C12**	**C13**	**C14**	**OPP1**	**OPP2**	**OPP3**	**OPP4***	**OPP5**	**OPP6**	**OPP7**
Ambassis agassizii	Olive Perchlet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla australis	Shortfin Eel	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0
Anguilla reinhardtii	Longfin Eel	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Gobiomorphus australis	Striped Gudgeon	4	0	7	54	0	0	9	33	0	36	40	151	0	0	0	0
Hypseleotris compressa	Empire Gudgeon	0	0	0	0	0	0	0	204	0	27	2	1	0	0	0	0
Hypseleotris galii	Firetail Gudgeon	142	0	33	12	196	0	44	4	0	52	15	123	0	0	0	0
Melanotaenia duboulayi	Crimson-spotted Rainbowfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhadinocentrus ornatus	Ornate Rainbowfish	8	0	11	59	4	0	24	0	0	0	0	0	0	0	0	0
Nannoperca oxleyana	**Oxleyan Pygmy Perch**	6	0	25	0	4	0	1	0	0	0	0	0	0	0	0	0
Tandanus tandanus	Eel-Tailed Catfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carassius auratus	Goldfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia holbrooki	Mosquito Fish	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0

* No survey - access restrictions.

Appendix C

Water Quality Comparisons

Table C1. Comparison of Water Quality Ranges from pre-construction monitoring and construction phase TFMP monitoring

Location	Sites	Parameter	Units	OPP Range	Pre-Con Range	Con Range	2021 Range	2022 Range	2023 Range
Unnamed waterway south of Serendipity Rd Ch. 11400	2a, 2b, 2c	Temp	(°C)	10.9 – 28.3	13.3 – 23.6	**10.76** – 22.01	17.88 – 22.27	16.4 – 21.28	17.2 – 19.18
		DO	(mg/L)	2.15 – 10.02	4.11 - 10	**0** – 5.64	3.12 – 10.57	**1.9** – 8.19	3.35 – 6.34
		pH		3.32 – 6.9	5 – 6.9	4.98 – **7.1**	5.44 – **7.51**	4.88 – 6.78	6.14 – 6.90
		Conductivity	(mS/cm)	0.068 – 2.148	0.009 – 0.368	0.093 - 0.578	0.089 – 0.597	0.079 – 0.431	0.065 – 0.421
		Turbidity	(NTU)	0 - 80	0.9 - 118	0 - **446**	7.9 – 32.5	16.5 - **461**	6.4 – 24.4
Tabbimoble floodway no. 1 Ch. 115300	3a	Temp	(°C)	10.9 – 28.3	12.8 - 24	**10.11** – 19.4	16.93 – 18.38	15.37 – 18.65	17.14 – 18.41
		DO	(mg/L)	2.15 – 10.02	1.3 - 8.07	4.4 - 7.71	5.55 – 5.8	7.15 – 7.4	4.50 – 5.95
		pH		3.32 – 6.9	4.4 – 7.2	5.43 - **7.62**	5.51 – 5.86	5.23 – 5.56	5.46 – 5.98
		Conductivity	(mS/cm)	0.068 – 2.148	0.009 – 0.140	0.089 - 0.331	0.112 – 0.163	**0.054** – 0.075	0.113 – 0.161
		Turbidity	(NTU)	0 - 80	18.9 – 132	0 - 17	11	26.9 – 42.5	1.7 – 7.8
Unnamed waterway south of MacDonalds Ck Ch. 134600	10b, 10c	Temp	(°C)	10.9 – 28.3	16.6 - 29	11.11 – 21.7	17.04 – 23.96	17.07 – 24.38	16.43 – 19.32
		DO	(mg/L)	2.15 – 10.02	3.17 - 10	**0.58** - 6.32	**0.09** – 14.33	2.27 – 10.9	**1.40** – 3.86
		pH		3.32 – 6.9	4 – 9.3	4.7 - **7.06**	4.9 – 6.02	4.95 – 5.7	6.48 – 6.75
		Conductivity	(mS/cm)	0.068 – 2.148	0.102 – 0.537	0.249 - 0.581	0.13 – 0.474	0.095 – 0.309	0.419 – 0.502
		Turbidity	(NTU)	0 - 80	1.3 - 800	3.8 - 28.8	0 – 3.8	24.5 – 202	9.9 – 10.1
MacDonalds Ck Tributary Ch. 135200, 135530 and 136450	11b, 11d, 22b, 22c	Temp	(°C)	10.9 – 28.3	15.4 – 26.7	**10.29** – 24.69	15.36 – 22.03	15.13 – 22.14	13.97 – 21.01
		DO	(mg/L)	2.15 – 10.02	2.27 – 8.9	**0.74** - 9.46	**1.31** – 5.45	**2.04** – 6.52	**0.90** – 2.95
		pH		3.32 – 6.9	3.8 – 8.9	3.44 - 6.44	3.82 – 5.63	3.67 – 5.48	3.85 – 5.79
		Conductivity	(mS/cm)	0.068 – 2.148	0.092 – 0.606	0.131 - 0.237	0.115 – 0.227	0 – 0.153	0.114 – 0.261
		Turbidity	(NTU)	0 - 80	2.4 - 138	0 - **212**	0 – 6.7	5.3 – **399**	0.2 – 70.7
MacDonalds Ck Ch. 136600	12a	Temp	(°C)	10.9 – 28.3	14.9 - 26	12.89 - 19.72	16.26 – 17.76	15.53 – 18.05	13.10 – 17.03
		DO	(mg/L)	2.15 – 10.02	1.7 – 8.1	**0.43** – 2.74	**2.03** – 2.48	**1.74 – 2.49**	**1.72** – 2.83
		pH		3.32 – 6.9	3.6 – 6.3	**2.72** – 6.41	4.48 – 5.58	4.18 – 4.29	6.18 – 6.40
		Conductivity	(mS/cm)	0.068 – 2.148	0.164 – 0.406	0.25 – 0.41	0.148 – 0.331	0.124 – 0.182	0.326 – 0.334
		Turbidity	(NTU)	0 - 80	0 - 14	0 - 41.6	0	5.9 – 93.2	50.6 – 60.0
Broadwater NP Swampland	16a, 16b, 27b, 27e	Temp	(°C)	10.9 – 28.3	18.6 – 21.45	**9.92** - 21.38	14.2 – 21.75	14.07 – 20.86	11.65 – 20.70
		DO	(mg/L)	2.15 – 10.02	1.83 – 5.39	**0.62 - 10.28**	**0.2** – 10.95	0.61 – 6.51	**0.53** – 3.98

Location	Sites	Parameter	Units	OPP Range	Pre-Con Range	Con Range	2021 Range	2022 Range	2023 Range
Ch. 139000		pH		3.32 – 6.9	4.15 – 4.63	3.7 - 5.91	3.71 – 6.24	3.24 – 6.32	3.78 – 5.96
		Conductivity	(mS/cm)	0.068 – 2.148	0.128 – 0.171	0.116 - 0.571	0.098 – 0.412	**0.061** – 0.185	0.098 – 0.327
		Turbidity	(NTU)	0 - 80	0 - 703	0 - 64.2	0 – 18.8	7 – 40.5	1.1 – 49.6
Montis Gully Tributary 1 Ch. 141180 and 141850	13b, 13c, 13e, 26d	Temp	(°C)	10.9 – 28.3	17.23 – 30.9	13.33 - 24.6	13.7 – 24.5	14.63 – 18.27	13.49 – 17.31
		DO	(mg/L)	2.15 – 10.02	2.1 – 9.4	**0.29** - 4.23	**0.04 – 1.1**	**0.74** – 3.3	**0.51** – 3.69
		pH		3.32 – 6.9	3.7 - 7	3.44 – 6.8	3.67 – 6.36	3.69 – 4.95	3.92 – 6.55
		Conductivity	(mS/cm)	0.068 – 2.148	0.026 – 0.209	0.137 - 0.818	0.138 – 0.293	0.09 – 0.162	0.152 – 0.355
		Turbidity	(NTU)	0 - 80	0 - 225	0 - **90**	7.6 – 9.1	4.6 - 207	16.9 – 65.0
W of Bundjalung NP Approximately 4 km east of Ch. 110000	C13, C14	Temp	(°C)	10.9 – 28.3	18.09 – 19.11	11.79 - 17.4	17.65 – 19.5	14.88 – 18.79	16.16 – 17.27
		DO	(mg/L)	2.15 – 10.02	2.24 – 4.38	**1.34** - 10.97	**0.89** – 5.38	2.32 – 3.68	**0.62 – 1.98**
		pH		3.32 – 6.9	4.56 – 5.47	4.84 - 6.92	5.62 – 6.22	5.05 – 6.24	5.78 – 6.14
		Conductivity	(mS/cm)	0.068 – 2.148	0.086 – 0.112	0.063 - 0.155	**0.065** – 0.134	0.099 – 0.122	0.160 – 0.184
		Turbidity	(NTU)	0 - 80	0 – 8.7	0 - 18.9	0 – 0	12.7 – 27.9	4.60 – 17.13
Broadwater NP 6.5 km east of Ch.13000	C11, C12	Temp	(°C)	10.9 – 28.3	15.91 – 18.49	**9.73** – 29.36	17.08 – 17.83	17.36 – 19.39	16.72 – 19.96
		DO	(mg/L)	2.15 – 10.02	2.9 – 5.59	**1.76** - 8.35	2.28 – 4.04	**1.45** – 5.49	2.18 – 2.84
		pH		3.32 – 6.9	3.85 - 4	3.79 - 4.54	4.11 – 4.33	3.49 – 4.05	3.90 – 3.94
		Conductivity	(mS/cm)	0.068 – 2.148	0.124 – 0.149	0.106 - 0.278	0.081 – 0.145	0.088 – 0.138	0.128 – 0.150
		Turbidity	(NTU)	0 - 80	0 – 2.3	0 - 6.8	0 – 0.8	2.3 – 14	1.2 – 9.2
MacDonalds Ck Tributary 0.5 km east of 136600 and 1 km east of 137800	C2, C5	Temp	(°C)	10.9 – 28.3	16.87 – 17.78	**8.15** - 20. 2	13.36 – 23.71	13.21 – 20.01	12.87 – 17.61
		DO	(mg/L)	2.15 – 10.02	4.58 – 4.69	**2.08** - 5.42	**0.96** – 5.5	3.44 – 4.0	**1.88** – 3.02
		pH		3.32 – 6.9	3.7 – 4.22	**3.31** - 4.47	3.83 – 4.39	3.37 – 3.88	3.92 – 4.51
		Conductivity	(mS/cm)	0.068 – 2.148	0.115 – 0.158	0.013 - 0.256	0.089 – 0.254	0.09 – 0.154	0.085 – 0.098
		Turbidity	(NTU)	0 - 80	0 - 0	0 - 37.6	0 – 0	9.2 – 79.9	0.0 – 6.8
Broadwater NP 1 km east of Ch 138000	C1, C3	Temp	(°C)	10.9 – 28.3	17.2 - 18.91	12.33 - 23.66	17.74 – 20.76	14.87 – 20.54	16.98 – 19.43
		DO	(mg/L)	2.15 – 10.02	4.55 - 9.18	**1.35** - 9.65	2.82 – 7.88	2.33 – 8.01	4.23 – 6.17
		pH		3.32 – 6.9	3.97 – 4.49	3.42 - 4.27	3.46 – 4.15	3.63 – 4.08	3.43 – 3.98
		Conductivity	(mS/cm)	0.068 – 2.148	0.089 - 0.176	0.100 - 0.306	0.091 – 0.231	0.068 – 0.109	0.092 – 0.296
		Turbidity	(NTU)	0 - 80	0 – 1.4	0 - 28.5	0 - 3	8.4 – 39.3	4.10 – 9.70

Location	Sites	Parameter	Units	OPP Range	Pre-Con Range	Con Range	2021 Range	2022 Range	2023 Range
Broadwater NP 2 km east of 136400	C8	Temp	(°C)	10.9 – 28.3	17.98	12.18 - 19.02	17.51 – 22.33	14.5 – 18.51	14.97 – 20.61
		DO	(mg/L)	2.15 – 10.02	5.77	2.46 - 9.96	**1.36** – 4.56	**1.56 – 2.02**	**2.10** – 6.74
		pH		3.32 – 6.9	3.95	**3.21 -** 4.07	3.57 – 3.93	3.69 – 3.8	3.61 – 3.90
		Conductivity	(mS/cm)	0.068 – 2.148	0.236	0.269 - 0.458	0.176 – 0.263	0.115 – 0.154	0.229 – 0.234
		Turbidity	(NTU)	0 - 80	12.1	0 - 12.2	0	19.2 – 28.4	2.2 – 3.1
Tabbimoble Channel 2	OPP1, OPP2, OPP4, OPP7	Temp	(°C)	10.9 – 28.3	7.86 – 18.66	8.91 – 16.15	16.04 – 17.54	13.58 – 19.47	14.34 – 18.17
		DO	(mg/L)	2.15 – 10.02	3.17 – 8.74	**1.89** – 5.83	3.72 – 8.2	4.88 – 7.57	1.33 – 4.7
		pH		3.32 – 6.9	4.79 – 6.92	5.06 – 6.8	5.35 – **6.93**	4.58 – 5.12	5.19 – 6.24
		Conductivity	(mS/cm)	0.068 – 2.148	0.081 – 0.194	0.104 – 0.23	**0.039** – 0.215	**0.025** – 0.115	0.108 – 0.282
		Turbidity	(NTU)	0 - 80	1.3 – 44.3	1.8 – 12.1	10.3 – 58.5	31.0 – 45.6	4.8 – 50.1
Tabbimoble Channel 3	OPP3, OPP6	Temp	(°C)	10.9 – 28.3	11.66 – 19.14	11.99 – 18.14	16.59 – 18.46	13.59 – 19.82	15.3 – 18.25
		DO	(mg/L)	2.15 – 10.02	4.64 – 6.53	**0.79** - 5.3	3.89 – 8.61	6.01 – 7.78	3.28 – 3.96
		pH		3.32 – 6.9	4.99 – 6.11	5.87 – 6.56	5.4 – 6.28	4.46 – 5.45	4.98 – 5.69
		Conductivity	(mS/cm)	0.068 – 2.148	0.128 – 0.215	0.171 – 0.185	**0.041** – 0.2	**0.028** – 0.123	0.186 – 0.229
		Turbidity	(NTU)	0 - 80	0 – 6.5	0 - 0	5.3 – 44.7	25.9 – 60.9	5.6 – 25.2

Appendix D

Site Photographs

Table D1. Site photographs from selected surveys since September 2013

		
Site 2a 2013_09	**Site 2a 2014_09**	**Site 2a 2017_09**
		
Site 2a 2020_09	**Site 2a 2022_05**	**Site 2a 2023_09**

		
Site 2b 2013_09	**Site 2b 2014_09**	**Site 2b 2017_09**
		
Site 2b 2020_09	**Site 2b 2022_05**	**Site 2b 2023_09**

		
Site 2c 2013_09	**Site 2c 2014_09**	**Site 2c 2017_09**
		
Site 2c 2020_09	**Site 2c 2022_05**	**Site 2c 2023_09**

		
Site 3a 2013_09	**Site 3a 2014_09**	**Site 3a 2017_09**
		
Site 3a 2020_09	**Site 3a 2022_05**	**Site 3a 2023_09**

		
Site 10b 2013_09	**Site 10b 2014_09**	**Site 10b 2017_09**
		
Site 10b 2020_09	**Site 10b 2022_05**	**Site 10b 2023_09**

		
Site 10c 2013_09	**Site 10c 2014_09**	**Site 10c 2017_09**
		
Site 10c 2020_09	**Site 10c 2022_05**	**Site 10c 2023_09**

		
Site 11b 2013_09	**Site 11b 2014_09**	**Site 11b 2017_09**
		
Site 11b 2020_09	**Site 11b 2022_05**	**Site 11b 2023_09**

		
Site 11d 2013_09	**Site 11d 2014_09**	**Site 11d 2017_09**
		
Site 11d 2020_09	**Site 11d 2022_05**	**Site 11d 2023_09**

		
Site 12a 2013_09	**Site 12a 2014_09**	**Site 12a 2017_09**
		
Site 12a 2020_09	**Site 12a 2022_05**	**Site 12a 2023_09**

		**No Survey**
Site 13b 2013_09	**Site 13b 2014_09**	**Site 13b 2017_09**
		
Site 13b 2020_09	**Site 13b 2022_05**	**Site 13b 2023_09**

		
Site 13c 2013_09	**Site 13c 2014_09**	**Site 13c 2017_09**
		
Site 13c 2020_09	**Site 13c 2022_05**	**Site 13c 2023_09**

		
Site 13e 2013_09	**Site 13e 2014_09**	**Site 13e 2017_09**
No Access	**No Access**	**No Access**
Site 13e 2020_09	**Site 13e 2022_05**	**Site 13e 2023_09**

		
Site 16a 2013_09	**Site 16a 2014_09**	**Site 16a 2017_09**
		
Site 16a 2020_09	**Site 16a 2022_05**	**Site 16a 2023_09**

		
Site 16b 2013_09	**Site 16b 2014_09**	**Site 16b 2017_09**
		
Site 16b 2020_09	**Site 16b 2022_05**	**Site 16b 2023_09**

		
Site 22b 2013_09	**Site 22b 2014_09**	**Site 22b 2017_09**
		
Site 22b 2020_09	**Site 22b 2022_05**	**Site 22b 2023_09**

		
Site 22c 2013_09	**Site 22c 2014_09**	**Site 22c 2017_09**
		
Site 22c 2020_09	**Site 22c 2022_05**	**Site 22c 2023_09**

		
Site 26d 2013_09	**Site 26d 2014_09**	**Site 26d 2017_09**
No Access	**No Access**	**No Access**
Site 26d 2020_09	**Site 26d 2022_05**	**Site 26d 2023_09**

		
Site 27b 2013_09	**Site 27b 2014_09**	**Site 27b 2017_09**
		
Site 27b 2020_09	**Site 27b 2022_05**	**Site 27b 2023_09**

		
Site 27e 2013_09	**Site 27e 2014_09**	**Site 27e 2017_09**
		
Site 27e 2020_09	**Site 27e 2022_05**	**Site 27e 2023_09**

		
Site C1 2013_09	**Site C1 2014_09**	**Site C1 2017_09**
		
Site C1 2020_09	**Site C1 2022_05**	**Site C1 2023_09**

		
Site C2 2013_09	**Site C2 2014_09**	**Site C2 2017_09**
		
Site C2 2020_09	**Site C2 2022_05**	**Site C2 2023_09**

		
Site C3 2013_09	**Site C3 2014_09**	**Site C3 2017_09**
		
Site C3 2020_09	**Site C3 2022_05**	**Site C3 2023_09**

		
Site C5 2013_09	**Site C5 2014_09**	**Site C5 2017_09**
	**No Access**	
Site C5 2020_09	**Site C5 2022_05**	**Site C5 2023_09**

		
Site C8 2013_09	**Site C8 2014_09**	**Site C8 2017_09**
		
Site C8 2020_09	**Site C8 2022_05**	**Site C8 2023_09**

		
Site C11 2013_09	**Site C11 2014_09**	**Site C11 2017_09**
		
Site C11 2020_09	**Site C11 2022_05**	**Site C11 2023_09**

		
Site C12 2013_09	**Site C12 2014_09**	**Site C12 2017_09**
		
Site C12 2020_09	**Site C12 2022_05**	**Site C12 2023_09**

		
Site C13 2013_09	**Site C13 2014_09**	**Site C13 2017_09**
	**No Access**	
Site C13 2020_09	**Site C13 2022_05**	**Site C13 2023_09**

		
Site C14 2013_09	**Site C14 2014_09**	**Site C14 2017_09**
		
Site C14 2020_09	**Site C14 2022_05**	**Site C14 2023_09**

		
Site OPP1 2014_09	**Site OPP1 2015_05**	**Site OPP1 2019_09**
		
Site OPP1 2020_09	**Site OPP1 2022_05**	**Site OPP1 2023_09**

		
Site OPP2 2014_09	**Site OPP2 2015_05**	**Site OPP2 2019_09**
		
Site OPP2 2020_09	**Site OPP2 2022_05**	**Site OPP2 2023_09**

		
Site OPP3 2014_09	**Site OPP3 2015_05**	**Site OPP3 2019_09**
		
Site OPP3 2020_09	**Site OPP3 2022_05**	**Site OPP3 2023_09**

		**No Access**
Site OPP4 2014_09	**Site OPP4 2015_05**	**Site OPP4 2019_09**
No Access	**No Access**	**No Access**
Site OPP4 2020_09	**Site OPP4 2022_05**	**Site OPP4 2023_09**

		
Site OPP5 2014_09	**Site OPP5 2015_05**	**Site OPP5 2019_09**
	**No Access**	
Site OPP5 2020_05	**Site OPP5 2022_05**	**Site OPP5 2023_09**

		
Site OPP6 2014_09	**Site OPP6 2015_05**	**Site OPP6 2019_09**
		
Site OPP6 2020_09	**Site OPP6 2022_05**	**Site OPP6 2023_09**

		
Site OPP7 2014_09	**Site OPP7 2015_05**	**Site OPP7 2019_09**
		
Site OPP7 2020_09	**Site OPP7 2022_05**	**Site OPP7 2023_09**