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**Legend**

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|-------------|--------------------------|------------------------|
| Survey Area | <b>Surface Hydrology</b> | <b>Sampling Method</b> |
| State Road  | Minor                    | Opportunistic Record   |
|             | Major                    | Quadrat                |
|             |                          | Traverse               |

Scale: 1:2,000

Coordinate System: GDA2020 MGA Zone 50  
 Projection: Transverse Mercator  
 Datum: GDA2020 Created 23/11/2022



**MAIN ROADS WA**  
**Great Eastern Highway Bypass Interchanges Project: Targeted Carter's Freshwater Mussel Survey**  
**Figure 3.2: Carter's freshwater mussel sample sites and traverses**

### 3.2.2 Water quality

Water quality in the Helena River at the time of the August 2022 survey was characterised by fresh<sup>1</sup> waters, with pH ranging from slightly acidic to circum-neutral (Table 3.2). Electrical conductivity (EC) fell between 915  $\mu\text{S}/\text{cm}$  (Q1) and 998  $\mu\text{S}/\text{cm}$  (Q12), and demonstrated a longitudinal gradient, with lower EC recorded upstream and greater EC downstream (Table 3.2). The salinity was considered suitable for Carter's freshwater mussel as the highest measurement (0.65 ppt at Q8) was well below the upper tolerance range of Carter's freshwater mussel (~1.6 ppt) (Klunzinger *et al.*, 2015). Although EC from all spot measurements of the Helena River exceeded the ANZG (2018) DGV, all still represented fresh waters and were not considered sufficient to cause ecological stress or impede the presence of mussels. Redox was positive at nearly all spot locations, indicating oxidative conditions (Table 3.2). While dissolved oxygen (DO) fell below the lower DGV, saturation was still considered adequate to support aquatic fauna, including freshwater mussels.

**Table 3.2: Summary of in situ water quality results.**

Site	Quadrat no.	Water quality parameter and units						
		Water temp. °C	pH	EC $\mu\text{S}/\text{cm}$	Salinity ppt	DO mg/L	DO %	Redox mV
Helena River	Q1	12.5	7.96	915	0.60	6.27	58.6	-4.6
	Q4	12.8	6.89	930	0.61	4.45	41.3	38.2
	Q6	13.0	6.61	954	0.62	5.21	47.4	123.2
	Q8	13.0	6.06	997	0.65	5.34	50.1	57.3
	Q12	13.6	7.59	998	0.64	6.64	60.8	43.0
Wetland West	Q1	15.0	6.49	549	0.33	6.26	62.6	93.7
	Q3	16.5	4.07	517	0.30	6.15	62.7	246.9
	Q4	16.7	5.10	619	0.30	6.60	67.6	219.8
	Q11	16.4	3.94	517	0.30	6.96	70.7	255.7
Wetland East	Q1	14.4	7.43	558	0.34	5.84	56.9	32.0
	Q2	14.4	5.83	555	0.34	6.34	61.8	106.5
	Q4	14.3	6.38	554	0.34	6.66	63.6	90.6

NB: Highlighting indicates exceedances of the ANZG (2018) DGVs for lowland rivers (Helena River), and wetlands (Wetland East and Wetland West).

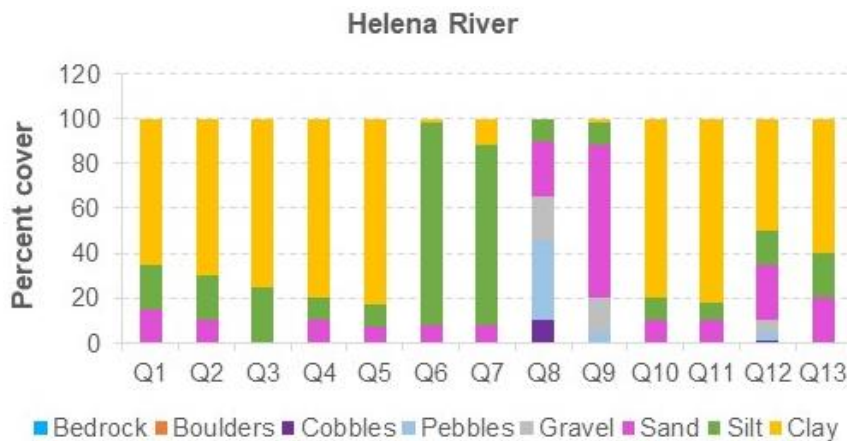
The wetlands were also fresh at the time of survey, with EC being generally lower in the wetlands than the Helena River (Table 3.2). Spot measurements of pH ranged from acidic (3.94, in Wetland West) to circum-neutral, with nearly all measurements falling below the lower pH DGV for wetlands in the south-

<sup>1</sup> Salinity categories are based on the Department of Water and Regulation (DWER) classification system for freshwater rivers, where fresh/marginal < 1,000 mg/L (~1,500  $\mu\text{S}/\text{cm}$ ), brackish = 1,000 mg/L – 2,000 mg/L (~1,500  $\mu\text{S}/\text{cm}$  to 3,000  $\mu\text{S}/\text{cm}$ ), saline = 2,000 mg/L – 10,000 mg/L (~ 3,000  $\mu\text{S}/\text{cm}$  – 15,000  $\mu\text{S}/\text{cm}$ ), and hypersaline > 10,000 mg/L (> 15,000  $\mu\text{S}/\text{cm}$ ) (Mayer *et al.*, 2005).

west (Table 3.2). Although no specific tolerance studies have been undertaken on Carter's freshwater mussel in relation to pH, freshwater mussels in general are considered to be sensitive to low pH (Strayer, 2008). Klunzinger *et al.* (2015) reported records of Carter's mussels from habitats ranging from pH 4.24 to 9.7, suggesting mussels can survive within this range. DO also fell below the lower DGV in both wetlands, but was considered adequate to support aquatic fauna, including freshwater mussels.

### 3.2.3 Habitat assessment

Sediment composition was assessed within each quadrat for habitat suitability. The Helena River Survey Area was dominated by clay, with some silt (Figure 3.3). Quadrats 6 and 7, located just upstream of Roe Highway, were comprised almost exclusively of soft silt. Quadrat 8, located directly underneath the Roe Highway bridge, comprised a heterogenous mix of substrates, including cobbles, pebbles, gravel, sand, and silt. Quadrat 9 was dominated by sand, with some gravel, silt, pebbles, and clay. Sand was present throughout the Helena River, though in relatively low proportions.



**Figure 3.3: Substrate composition within quadrats taken from the Helena River.**

Wetland West was relatively homogenous by comparison, being dominated by clay, with some sand and a small proportion of silt also present (Figure 3.4). The northern section of the wetland was covered in a soft, anoxic organic layer. Bedrock, boulders, cobbles, and gravel were present in very low amounts in some quadrats. At Wetland East, sediment substrates comprised clay and sand, with low amounts of silt (Figure 3.5). Bedrock was present within Quadrats 9 and 10, located towards the north-east side of the wetland.



Figure 3.4: Substrate composition within quadrats taken from Wetland West.

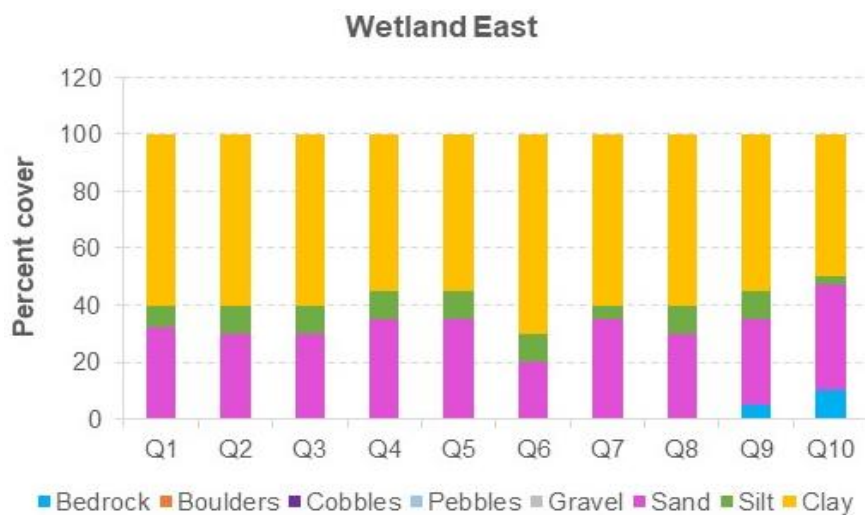




Figure 3.5: Substrate composition within quadrats taken from Wetland East.


Locations sampled within the Survey Area are further described in Table 3.3.

### 3.2.4 Suitable habitat

From the water quality results and habitat assessments, suitable habitat was identified within each location (see Figure 3.6). However, when persistence was considered, the Helena River within the Survey Area became unsuitable for Carter's freshwater mussel because no permanent pools exist in this reach.

**Table 3.3: Habitat summary for all sites sampled in the Survey Area, including site photos.**

Site	Description	Site Photo
<p><b>Helena River</b></p>	<p>A ~500 m section of the Helena River covering the area beneath the Roe Highway bridge and ~200 m upstream and downstream of the NVCP application area. Water was fresh, with pH ranging from slightly acidic to circum-neutral. DO was below the ANZ (2018) DGV, but still considered suitable for supporting aquatic fauna. Sediment was generally dominated by clay, with some sections high in silt, while other sections comprised sand and gravel. Introduced grasses such as couch grass were observed throughout the stretch of river surveyed, particularly in the more upstream section. High amounts of large woody debris (LWD) were observed throughout. Water depth was highly variable throughout, ranging from 0.1 m up to &gt; 2 m.</p> <p>Although the water quality and sections of substrate were suitable for Carter's freshwater mussel, the fact that the reach does not hold permanent water indicates that overall, this section of the Helena River does not support suitable habitat.</p>	
<p><b>Wetland West</b></p>	<p>A large, deep (estimated over 3 m deep) permanent wetland located west of Roe Highway. Water quality was fresh, with acidic pH, moderate DO, and generally clear waters. Sediments were dominated by clay, with some sand and silt. A thick layer of soft organics was present on the northern section of the wetland. Sedges and <i>Melaleuca</i> surrounded the wetland.</p> <p>The majority of the surveyed area of Wetland West supported suitable habitat for Carter's freshwater mussel, with the exception of a north-eastern portion where the substrate was too soft and anoxic, and</p>	

Site	Description	Site Photo
	<p>a north-western portion where the low, acidic pH was recorded.</p>	
<p><b>Wetland East</b></p>	<p>A large, deep (estimated over 2 m) permanent wetland located east of Roe highway. Spot measurements of water quality indicated slightly acidic to circum-neutral waters, which were fresh and clear. DO was below the ANZ (2018) DGVs. Sediments predominately comprised clay and sand, with some silt and bedrock also present. Sedges and submerged macrophytes were common throughout the wetland, along with LWD.</p> <p>The vast majority of Wetland East exhibited habitat suitable for Carter's freshwater mussel, with the exception of the western edge where substrates were too soft and anoxic.</p>	

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**Legend**

- Survey Area
- State Road


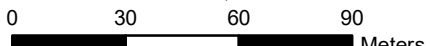
**Surface Hydrology**

- Minor
- Major

**Habitat**

- Potentially unsuitable habitat - low pH
- Suitable habitat available
- Habitat not suitable - soft/anoxic substrate

- Habitat not suitable - not perennial
- Habitat not suitable - hard substrate
- Habitat not assessed

  
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**Figure 3.6: Habitat assessment of the Survey Area**