Osbornes Drain Ecology

Assessment of the ecological values of Osbornes Drain
Prepared for Te Rūnanga o Ngāi Tahu

2 July 2015

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Cover photograph: Osbornes Drain at the pump house © Boffa Miskell, 2015

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1.0 Executive summary

Te Rūnanga o Ngāi Tahu, and a working party (Department of Conservation, Environment Canterbury and Selwyn District Council), commissioned this work to provide independent advice on Selwyn District Council's proposal to obtain a new consent to discharge land drainage and stormwater from Osbornes Drain into Te Waihora / Lake Ellesmere. This ecological assessment was one of three parcels of expert technical advice for this work, conducted by Boffa Miskell Ltd, Lowe Environmental Impact, and GHD New Zealand. The overall objectives for this collection of work were to provide a more specific basis for the development of acceptable water quality standards for the discharge from Osbornes Drain into Te Waihora / Lake Ellesmere, and to better understand the effectiveness of water quality improvements resulting from a range of proposed mitigation options suggested in the 2013 Pattle Delamore Partners 2013 report.

The main objectives of the ecological assessment presented in this report were to describe the existing condition of Osbornes Drain and the wetlands in the downstream areas (downstream of the pump house) and discuss any likely ecological benefits of the potential mitigation options recommended by Lowe Environmental Impact and GHD New Zealand. In a parallel project, commissioned by the Selwyn District Council, Boffa Miskell ecologists assisted the Council in relocating fish prior to, and during, dewatering and sediment removal works in Osbornes Drain. While the results of this fish relocation work were not the focus of this study, they are summarised in this report.

The habitat within Osbornes Drain was generally poor. The water had virtually no flow at the time of surveying, and there was a thick layer of very soft, anoxic sediments covering the bed along much of the waterway. Although there was no shading over the channel, macrophytes (aquatic plants) did provide some localised shade and cover. Long, green filamentous algae and macrophytes were very abundant throughout the study area, most likely due to the high nutrients and low shading conditions in the drain.

The macroinvertebrate community found in Osbornes Drain was typical of that found in modified, enriched, and slow-flowing or standing waterbodies. The fish community of Osbornes Drain was similarly depauperate, with only five species recorded between the pump house and Gammacks Road. While shortfin eel dominated the fish catch, two threatened species (longfin eel and inanga) were found within the waterway (albeit in low numbers). This confirmed findings of previous work that the ecological health of Osbornes Drain was very poor.

The mitigation options discussed in the LEI and GHD reports, including on-farm management tools and in-drain treatment options, while primarily designed to improve the water quality of Osbornes Drain, may also assist in improving the ecology of the Osbornes Drain area.

2.0 Introduction

The Osbornes Drainage and Pumping Scheme, an approximately 9 km drainage network, was constructed in 1967-68 to drain land and create over 1620 ha of farmland on the perimeter of Te Waihora / Lake Ellesmere.

Concerns have been raised by Te Rūnanga o Taumutu, Te Rūnanga o Ngāi Tahu, local community groups, and local government agencies (the Department of Conservation, Environment Canterbury) regarding the water quality of Osbornes Drain, particularly, with respect to the discharges into Te Waihora.

A draft report produced by Pattle Delamore Partners (PDP 2013) recommended various mitigation options to the Selwyn District Council to improve the water quality of Osbornes Drain, but more information was required to fully implement these and address the effects on Te Waihora.

Te Rūnanga o Ngāi Tahu (Ngāi Tahu), and a working party of the Department of Conservation (DOC), Environment Canterbury (ECan) and Selwyn District Council (SDC), commissioned this current work to provide independent advice on Selwyn District Council's proposal to obtain a new consent to discharge land drainage and stormwater from Osbornes Drain into Te Waihora.

The overall objectives of this work were to provide a more specific (and scientifically robust) basis for:

a) The development of acceptable water quality standards for the discharge from Osbornes Drain into Te Waihora; and
b) Understanding the effectiveness of the water quality improvements suggested in the 2013 PDP Report (or any alternative measures) for achieving acceptable water quality standards for the discharge from Osbornes Drain and, thereby, ecological and cultural benefits for the downstream wetlands and lake.

To achieve this, the following three parcels of expert technical (scientific) advice were undertaken:

a) Mitigation Measures Assessment, Lowe Environmental Impact (LEI), addressing the agricultural / soil aspects of the existing land use practices, in order to provide recommendations of viable on-farm mitigation measures and give Ngāi Tahu a better understanding regarding the effectiveness of the proposed (or alternative) measures for reducing nutrient and sediment losses into ground and / or surface waters;
b) Hydrology and Water Quality Assessment, GHD Limited, addressing groundwater and surface water quality, in particular evaluating the potential effectiveness of in-drain mitigation measures and the on-farm mitigation strategies recommended by LEI.
c) Ecology Assessment, Boffa Miskell Limited, assessing the ecological condition of Osbornes Drain, the downstream wetland area and the immediate margins of Te Waihora; the likely effects of the discharges from Osbornes Drain on the values of these areas; and recommendations regarding the potential ecological impact of mitigation measures.

3.0 Scope

Ngāi Tahu commissioned Boffa Miskell to conduct the ecological assessment of Osbornes Drain.

The objectives of the ecology assessment study were to:

- Review the PDP report and mitigation measures proposed within the report;
- Describe the existing ecological condition of Osbornes Drain, from Gammacks Road to downstream of the pump house;
- Describe the existing condition of the wetlands in the downstream areas of Osbornes Drain; and
- Discuss any likely ecological benefits of the potential mitigation options recommended by LEI and GHD.

In a separately commissioned piece of work, Boffa Miskell ecologists assisted the SDC in relocating fish prior to and during recent dewatering and sediment removal works in Osbornes Drain. This sediment excavation work was limited to the length of Osbornes Drain between the pump house and Gammacks Road (approx. 2.5 km), and under the ECan Resource Consents CRC155497 and CRC155498. While the results of this fish relocation work were not the focus of this study, they are summarised in this report.

4.0 Methodology

4.1 Osbornes Drain ecology

Assessments of the riparian and in-stream habitat conditions, and the macroinvertebrate and fish communities were conducted at five sites along Osbornes Drain, on 26 and 27 March 2015, during base-flow conditions and following fine weather.

The sites were located along approximately 2.5 km of Osbornes Drain, from downstream of the pump house up to Gammacks Road (Figure 1). Note, these sites are not identical to those surveyed in the PDP (2013) and ECan (2013) reports, but were instead selected to be representative of the habitat types found along the waterway within the survey area.

- Site 1: downstream of the pump house
- Site 2: pump house
- Site 3: downstream of the cattle crossing
- Site 4: cattle crossing
- Site 5: Gammacks Road (downstream of the road)

Figure 1. Location of the five sites surveyed during the aquatic ecology study in March 2015, and Osbornes bird survey as defined by O'Donnell (1985) (yellow dashed line).

4.1.1 Riparian and in-stream habitat

Riparian and in-stream physical habitat was qualitatively assessed using the Physical Habitat Assessment (PHA) protocols modified from Storey et al. (2011) and Meredith et al. (2003).

The following riparian and in-stream habitat parameters were estimated at each site:

- Surrounding land use
- Water level
- Macrophyte (aquatic plants) cover
- Periphyton (aquatic algae) cover
- Channel shading
- Water odour
- Water surface oils
- Sediment / substrate appearance
- Turbidity
- Aquatic habitat abundance
- Aquatic habitat diversity
- Hydrologic heterogeneity
- Channel alteration
- Bank stability – measured for both left and right banks
- Riparian vegetation type (within 10 m of the stream) – measured for both left and right banks
- Riparian zone width (within 20 m of the stream) – measured for both left and right banks

In addition, the channel width (wetted width, m) was measured at one location at each site, with the exception of at the pump house (site 2) where the water depth was too great to fully access the site. Water depth (cm) and soft sediment depth (cm) was also measured across the channel at sites 1 and 3-5. Soft sediment depth was determined by gently pushing a metal rod (10 mm diameter) into the soft substrate until it hit harder substrates (usually firmly packed fine sediments) of the drain bed.

4.1.2 Macroinvertebrate community

Macroinvertebrates (e.g. insects, snails and worms that live on the stream bed) can be extremely abundant in streams and are an important part of aquatic food webs and stream functioning. Macroinvertebrates vary widely in their tolerances to both physical and chemical conditions, and are therefore used regularly in biomonitoring, providing a long-term picture of the health of a waterway.

The macroinvertebrate community at each site was surveyed using Protocol C2 described in Stark *et al.* (2001).

In brief, macroinvertebrates were collected from the waterway using a sweep net, where habitat (i.e. bank vegetation) was agitated and any dislodged macroinvertebrates were collected in the net (0.5 mm mesh). The full range of microhabitats present at each site was sampled so as to maximise the likelihood of collecting all macroinvertebrate taxa present at a site, including rare and habitat-specific taxa.

Macroinvertebrate samples were preserved, separately, in 70% ethanol prior to sending to an external laboratory (Ryder Consulting, Dunedin) for identification and counting.

Assessment of Ecological Health

To provide an indication of ecological health, the following macroinvertebrate metrics and biotic indices were calculated from the sweep-net sample collected from each site:

- **Total abundance** – the total number of individuals collected from the sweep-net sample collected at each site. Total abundance can be a good indicator of stream health, or ecological condition, because abundance tends to increase in the presence of organic enrichment, particularly for pollution-tolerant taxa (e.g. chironomid midge larvae and oligochaete worms).
- **Taxonomic richness** – the total number of macroinvertebrate taxa recorded from the sweep-net sample collected at each site. Waterways supporting high numbers of macroinvertebrate taxa (taxonomic richness) generally indicate healthy communities, however, the pollution sensitivity / tolerance of each taxon needs to also be considered.
- **EPT taxonomic richness** – the total number of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) from the sweep-net sample collected at each site. These three insect orders (EPT) are generally sensitive to pollution and habitat degradation and therefore richness of these insects provides a useful indicator of degradation. High EPT richness suggests high water quality, while low richness indicates low water or habitat quality.
- **EPT taxonomic richness excl. hydroptilids** – the total number of EPT taxa excluding members for the caddisfly family Hydroptilidae. The algal piercing hydroptilid caddisflies are generally considered more tolerant of degraded conditions than other EPT taxa.
- **%EPT abundance** – the total abundance of macroinvertebrates that belong to the pollution-sensitive EPT orders, relative to the total abundance of all macroinvertebrates found in the sweep-net collected at each site. High %EPT abundance suggests high water quality.
- **%EPT abundance (excl. hydroptilids)** – the percentage abundance of EPT taxa at each transect, excluding the more pollution-tolerant hydroptilid caddisflies.
- **Macroinvertebrate Community Index (MCI-sb)** – the MCI-sb is a biotic index calculated to provide an indication of stream health. It is a community-based index, and accounts for the variety of pollution-sensitivities, namely organic enrichment, of all macroinvertebrate taxa found at a site. The tolerance scores for macroinvertebrate taxa range between 1 and 10, where a tolerance score of 1 indicates a taxon highly tolerant of organic enrichment / pollution, and 10 indicates a highly pollution-sensitive taxon. For example, EPT taxa (i.e. Ephemeroptera: mayflies; Plecoptera: stoneflies; and Trichoptera: caddisflies) are generally considered the most pollution-sensitive macroinvertebrates and usually have higher tolerance scores, compared to tolerant taxa such as non-biting midge (chironomid) and mosquito larvae.

  The MCI score is essentially an average of the tolerance scores of all macroinvertebrate taxa found at a site, multiplied by 20 to give MCI values of 0-200. Table 1 provides a summary of how MCI-sb and QMCI-sb scores were used to evaluate stream health.
- **Quantitative Macroinvertebrate Community Index (QMCI-sb)** – this is a variant of the MCI-sb, which instead uses abundance data. The QMCI-sb provides information about the dominance of pollution-sensitive species in a sample from soft-bottomed streams.

Table 1. Interpretation of MCI-sb and QMCI-sb scores for soft- bottomed streams (Stark & Maxted 2007).

Stream health	Water quality descriptions	MCI	QMCI
Excellent	Clean water	>119	>5.99
Good	Doubtful quality or possible mild enrichment	100-119	5.00-5.90
Fair	Probable moderate enrichment	80-99	4.00-4.99
Poor	Probable severe enrichment	<80	<4.00

4.1.3 Fish community

The fish community was surveyed at each site, using baited fyke nets and baited Gee Minnow traps (GMT). Fyke nets were baited with tinned cat food, while Marmite was used as bait in the GMTs. Three fyke nets and 6 GMTs were set at each site and left overnight. The following morning, all fish captured were identified and measured (fork length, mm).

As the SDC was proposing to excavate sediment from Osbornes Drain, between the pump house and Gammacks Road, immediately after this ecological survey (CRC155497 and CRC155498), fish captured during this survey were relocated to the Huritini / Halswell River (canal)[1]. However, fish captured at site 1, downstream of the pump house, were returned alive to the survey site, as site 1 was outside of SDC's sediment excavation area. Furthermore, any fish species listed as pest species were humanely destroyed and not returned to the waterway[2].

Fish relocation prior to dewatering and sediment removal works

The fish relocation work involved setting of baited (15) GMTs and (10) fyke nets along Osbornes Drain, from the pump house to Gammacks Road. These traps and nets were set in the afternoon of 30 March, the day before the dewatering and sediment removal works commenced. The following morning, all fish captured were retrieved from the nets and traps, identified and relocated to the Huritini / Halswell River. During dewatering and sediment removal works (31 March – 2 April; and 7 – 10 April) any eels and other fish found in the sediment, or stranded in pools in Osbornes Drain, were removed and relocated to the Huritini / Halswell River.

Due to time constraints, eels were allocated to one of four size categories: <200, 200-500, 500-1000, >1000 mm; other fish were recorded, but not measured.

[1] Fish were relocated from Osbornes Drain to the Huritini / Halswell River (canal) in accordance with Boffa Miskell's authorisation from Ministry for Primary Industries and pursuant to Section 26ZM(2) of the Conservation Act 1987.

[2] The humane euthanization of recognised pest fish species is in accordance with Boffa Miskell's approvals and permits from the Department of Conservation (Conservation Act 1987, Freshwater Fisheries Regulations 1983) and the Ministry for Primary Industries (Fisheries Act 1996).

4.2 Historical extent of wetlands in the Osbornes Drain area

Historical maps, topographical and digital information available on publically accessible spatial databases (e.g. Canterbury Maps, S-Maps) and ArcGIS were used to approximate the historical extent of wetlands in the area of Osbornes Drain.

4.3 Existing wetlands and birds

Existing information was used to describe the wetland vegetation communities and bird values of Osbornes Drain and the wetlands downstream of the pump house.

Environment Canterbury mapped the wetland vegetation communities in the vicinity of Osbornes Drain as part of a Coastal Mapping survey (Grove et al 2012); this information provides sufficient detail for this report.

The birds in the vicinity of Osbornes Drain were described in a Wildlife Service Report (O'Donnell 1985) as part of a lake-wide survey (Figure 1). The vicinity of Osbornes Drain was one of 15 defined areas in this survey. In 2013-2015, further bird surveys were co-ordinated by the Waihora Ellesmere Trust (WET), involving DOC, ECan, Christchurch City Council, and Lincoln University staff with bird expertise, as well as members of the Ornithological Society of New Zealand (WET 2013-2015). These annual surveys (WET 2013-2015) included the sections as defined by O'Donnell (1985). Boffa Miskell staff were involved in the WET (2013-2015) surveys, including within the Osbornes Drain area in 2014.

Data from both the 1985 (O'Donnell 1985) and the 2013-2015 (WET 2013-2015) surveys have been used to describe the birds in the vicinity of Osbornes Drain in this report.

5.0 Existing condition of Osbornes Drain

The following information is a summary of the findings from the survey conducted at the five sites in March 2015.

5.1 Aquatic survey site descriptions

A brief description of the five sites surveyed is provided below. Further details on riparian and in-stream habitat conditions can be found in Section 5.2.

5.1.1 Site 1: downstream of the pump house

Site 1 was located in Osbornes Drain approximately halfway between the pump house and the shores of Te Waihora, around 400 m downstream of the pump house. This was an area of open water, with thick raupō (*Typha orientalis*) beds immediately up- and downstream of the site (Figure 2).

The channel was approximately 6.65 m wide at site 1, with a riparian margin of raupō, saltmarsh ribbonwood (*Plagianthus divaricatus*) and *Carex* extending out into the wetland area of Te Waihora. This wetland area is often grazed by sheep. Further descriptions of the vegetation and bird communities found in this area are provided in Section7. The floating native macrophytes karerarera (*Azolla rubra*) and common duckweed (*Lemna minor*) (the green and red macrophytes seen floating on the water's surface in Figure 2) were very abundant downstream of the pump house.

Figure 2. Site 1; downstream of the pump house, looking upstream towards the pump house (left) and downstream towards Te Waihora (right).

5.1.2 Site 2: Pump house

Site 2 was located at the pump house, and included the storage pond area at the pump house, the outlet of the lateral drain entering on the true right (west) side of Osbornes Drain and the stone weir at the upstream end of the pump house storage pool (Figure 3). The wetted width of the channel upstream of the pump house pond was approximately 6.5 m with a margin of Caldwells clubrush – TBC - (*Bolboschoenus caldwellii*). The pond area at the pump house was wider than the channel (approximately 15 m). The banks were devoid of riparian vegetation except for some macrophytes (aquatic plants) at the edges of the pond. Common duckweed (Figure 3), frequently found in slow-flowing and nutrient rich ponds and drains, was very abundant at this site, and throughout Osbornes Drain.

Figure 3. Site 2; the pump house on Osbornes Drain, looking upstream (left) and immediately downstream of the pump house (right). Note, the area immediately downstream of the pump house, shown in the image on the right, was not included in the survey area.

5.1.3 Site 3: Downstream of the cattle crossing

Site 3 was located approximately 600 m downstream of the cattle crossing / farm bridge (Figure 4). The channel was approximately 3.5 m wide (wetted width) with areas of Caldwells clubrush, macrophyte beds of floating sweetgrass (*Glyceria fluitans*), and bachelor's button (*Cotula coronopifolia*)) and the floating macrophyte common duckweed, interspersed with areas of open water.

Figure 4. Site 3; downstream of the cattle crossing, looking upstream (left) and downstream with Gee minnow traps in view (right).

5.1.4 Site 4: Cattle crossing

Site 4 was located immediately downstream of the cattle crossing, or farm bridge (Figure 5). The channel was approximately 3.5 m wide (wetted width) and, similar to much of the waterway within the survey area, had areas thick with floating sweetgrass, patches of other macrophytes, lots of common duckweed, and areas of open water. In places, almost the entire width of the channel was covered with floating sweetgrass.

Figure 5. Site 4; located immediately downstream of the cattle crossing, looking upstream (left) and downstream (right).

5.1.5 Site 5: Gammacks Road

Site 5, upstream at Gammacks Road (immediately downstream of the road culvert) was very similar to downstream at site 4 (Figure 6). Floating sweetgrass and other macrophytes were abundant, while common duckweed was very abundant, covering almost all of the width of the channel in areas.

Figure 6. Site 5; Gammacks Road downstream of the road culvert, looking upstream (left) and downstream with one of the Gee minnow traps in view (right).

5.2 Riparian and in-stream habitat

Table 2 provides a summary of the riparian and in-stream habitat values of the five sites surveyed in March 2015.

The channel was relatively uniform in width from the pump house to Gammacks Road, but slightly wider downstream of the pump house. Although the waterway is perennial, it had limited / virtually no flow at the time of surveying. The water depth was variable along the waterway, and although not measured, the pond at the pump house appeared particularly deep. The water depth of Osbornes Drain is maintained by the pump house.

There was no shading over the channel, however, macrophytes did provide some cover. There was also a thick layer (> 70 cm in places) of very soft, anoxic sediments covering the streambed along the channel. These were removed from the site during the sediment removal works conducted by the SDC after the conclusion of this ecological survey.

Macrophyte cover was variable along the waterway, with floating sweetgrass being particularly abundant in some areas. Long, green filamentous algae was prolific in places. Macrophytes and algae cover are most likely to be responding to high nutrients and low shade throughout the waterway.

Macrophyte cover was estimated to exceed Canterbury's proposed Land and Water Regional Plan (pLWRP, Decisions Version 18 January 2014) guideline of 30% total cover for macrophytes in 'spring-fed – lower basin' waterways[3].

Taking these parameters, and a range of others, such as diversity of in-stream habitat and flow conditions available for aquatic fauna, it was determined that the habitat within Osbornes Drain was generally poor and expected to only support fauna tolerant of degraded conditions.

Table 2: Riparian and in-stream habitat conditions estimated at the five survey sites along Osbornes Drain.

Parameter	Site 1: downstream of pump house	Site 2: pump house	Site 3: downstream of cattle crossing	Site 4: cattle crossing	Site 5: Gammacks Road
Surrounding land use	Rural; sheep and beef grazing	Rural; sheep and beef grazing	Rural; sheep and beef grazing	Rural; sheep and beef grazing	Rural; sheep and beef grazing with dairy upstream
Water level	Perennial; but virtually no flow	Perennial; but virtually no flow	Perennial; but virtually no flow	Perennial; but virtually no flow	Perennial; but virtually no flow
Channel shading	5% shading, margins only	0%	0%	0%	0%
Wetted width (m)	6.65	-	3.35	3.50	4.10
Average water depth (cm)	35.8	-	16.2	31.4	33.6
Composition of stream bed substrate	100% silt / mud	100% silt / mud	100% silt / mud	100% silt / mud	100% silt / mud
Average soft sediment depth (cm)	59	-	>70	>70	>70
Aquatic Macrophytes	**Total cover: >60%** Raupō (*Typha orientalis*, 5%); *Azolla rubra* (40%,	**Total cover: 80%** *Lemna disperma* (80%, floating);	**Total cover: 60%** *Glyceria fluitans* (50%, emergent); *Cotula*	**Total cover: 65%** *Glyceria fluitans* (50%, emergent); *Cotula*	**Total cover: 80%** *Glyceria fluitans* (70%, emergent); *Cotula*

[3] While these guidelines are relevant for lowland spring-fed systems, Osbornes Drain was previously a wetland system. The development of guidelines for slower-flowing wetland systems, compared to higher-flow, spring-fed systems, may be justified for the Osbornes Drain system.

Parameter	Site 1: downstream of pump house	Site 2: pump house	Site 3: downstream of cattle crossing	Site 4: cattle crossing	Site 5: Gammacks Road
	floating); *Lemna disperma* (20%, floating); *Potamogeton crispus* (80%, submerged); *Elodea canadensis* (10%, submerged)	Caldwells clubrush (5%, margins), *Glyceria fluitans* (5%, emergent)	*coronopifolia* (20%, emergent); *Lemna disperma* (20%, floating); Caldwells clubrush (10%, margins)	*coronopifolia* (10%, emergent); *Lemna disperma* (40%, floating)	*coronopifolia* (10%, emergent); *Lemna disperma* (20%, floating)
Periphyton cover	Long, green filamentous algae very abundant (80%)	Long, green filamentous algae very abundant (80%)	Long, green filamentous algae abundant (60%)	Long, green filamentous algae common (30%)	Long, green filamentous algae sparse (10%)
Water odour	Normal / none	Normal / none	Normal / none	Normal / none	Normal / none
Water surface oils	Water surface oils present / slick visible	Water surface oils present / slick visible	Water surface oils present / slick visible	Water surface oils present / slick visible	Water surface oils present / slick visible
Turbidity	Opaque	Opaque	Opaque	Opaque	Opaque
Sediment / substrate appearance	Anaerobic sediments with strong smell when disturbed; black sediments present	Anaerobic sediments with strong smell when disturbed; black sediments present	Anaerobic sediments with strong smell when disturbed; black sediments present	Anaerobic sediments with strong smell when disturbed; black sediments present	Anaerobic sediments with strong smell when disturbed; black sediments present
Aquatic habitat abundance	Poor <10% of channel contains stable habitat	Poor <10% of channel contains stable habitat	Poor <10% of channel contains stable habitat	Poor <10% of channel contains stable habitat	Poor <10% of channel contains stable habitat
Aquatic habitat diversity	Poor Stable in-stream habitats lacking	Poor Stable in-stream habitats lacking	Poor Stable in-stream habitats lacking	Poor Stable in-stream habitats lacking	Poor Stable in-stream habitats lacking
Hydrological Heterogeneity	Poor Uniform hydrologic conditions; uniform depth and velocity; pools absent	Poor Uniform hydrologic conditions; uniform depth and velocity; pools absent	Poor Uniform hydrologic conditions; uniform depth and velocity; pools absent	Poor Uniform hydrologic conditions; uniform depth and velocity; pools absent	Poor Uniform hydrologic conditions; uniform depth and velocity; pools absent
Channel alteration	Poor Extensive channel alteration; >50% channelized or culverted	Poor Extensive channel alteration; >50% channelized or culverted	Poor Extensive channel alteration; >50% channelized or culverted	Poor Extensive channel alteration; >50% channelized or culverted	Poor Extensive channel alteration; >50% channelized or culverted
Bank stability	Suboptimal Moderately stable 5-30% affected; areas of erosion mostly healed over; some potential for future problems	Suboptimal Moderately stable 5-30% affected; areas of erosion mostly healed over; some potential for future problems	Suboptimal Moderately stable 5-30% affected; areas of erosion mostly healed over; some potential for future problems	Suboptimal Moderately stable 5-30% affected; areas of erosion mostly healed over; some potential for future problems	Suboptimal Moderately stable 5-30% affected; areas of erosion mostly healed over; some potential for future problems
Riparian vegetation	Suboptimal Predominant type is mixed shrubland (*Carex*, browntop, raupō, and saltmarsh ribbonwood)	Poor Predominant type is grassland with farmland immediately adjacent	Poor Predominant type is grassland with farmland immediately adjacent	Poor Predominant type is grassland with farmland immediately adjacent	Poor Predominant type is grassland with farmland immediately adjacent
Riparian zone width	Suboptimal - marginal Width of undisturbed zone 5 – 15 m; human activity visible	Poor Width of undisturbed riparian zone is <5 m; little or no undisturbed vegetation	Poor Width of undisturbed riparian zone is <5 m; little or no undisturbed vegetation	Poor Width of undisturbed riparian zone is <5 m; little or no undisturbed vegetation	Poor Width of undisturbed riparian zone is <5 m; little or no undisturbed vegetation

5.3 Macroinvertebrate community

5.3.1 Overview

A total of 9,808 macroinvertebrates were collected from the five Osbornes Drain sites (Appendix 1). Total abundance ranged from 556 to 3,352 individuals collected at sites 4 and 2, respectively (Table 4). Macroinvertebrate taxonomic richness was relatively consistent along Osbornes Drain and showed a similar trend to total abundance, with the greatest richness of 17 taxa at site 1 (downstream of the pump house) and the lowest richness (8 taxa) at site 4 (cattle crossing) (Table 4).

As is often found in degraded or modified freshwaters, the macroinvertebrate community was dominated by a few, highly abundant, macroinvertebrate taxa (i.e. low diversity, but high total abundance) (Table 4).

Table 3: Summary of macroinvertebrate taxa found at the 13 sites surveyed in February 2015.

Parameter	Site 1: downstream of pump house	Site 2: pump house	Site 3: downstream of cattle crossing	Site 4: cattle crossing	Site 5: Gammacks Road
Total abundance	3162	3352	1361	556	1377
Taxonomic richness	17	12	13	8	10
EPT richness	2	0	1	0	0
EPT abundance (%)	0.5	0	0.5	0	0
MCI	52.2	47.8	41.7	42.2	50.8
QMCI	2.5	2.0	2.0	2.0	2.0

5.3.2 Community composition

The macroinvertebrate community found in Osbornes Drain was typical of that found in modified, enriched standing waterbodies, such as slow-flowing streams and wetland areas.

True flies (or two-winged flies, Diptera) and snails and bivalves (Mollusca) were the dominant macroinvertebrate groups. These groups also numerically dominated the macroinvertebrate community, with molluscs making up over 70% of all macroinvertebrates collected at some sites (Figure 7). True flies were an important component of the macroinvertebrate community downstream of the pump house (Figure 7). Aquatic worms (Oligochaeta), freshwater leeches (Hirudinea), crustaceans, and a few groups of generally pollution-tolerant aquatic insects (Hemiptera, true bugs; Odonata, dragonflies and damselflies; Coleoptera, aquatic beetles; and Trichoptera, caddisflies) were also present throughout the waterway.

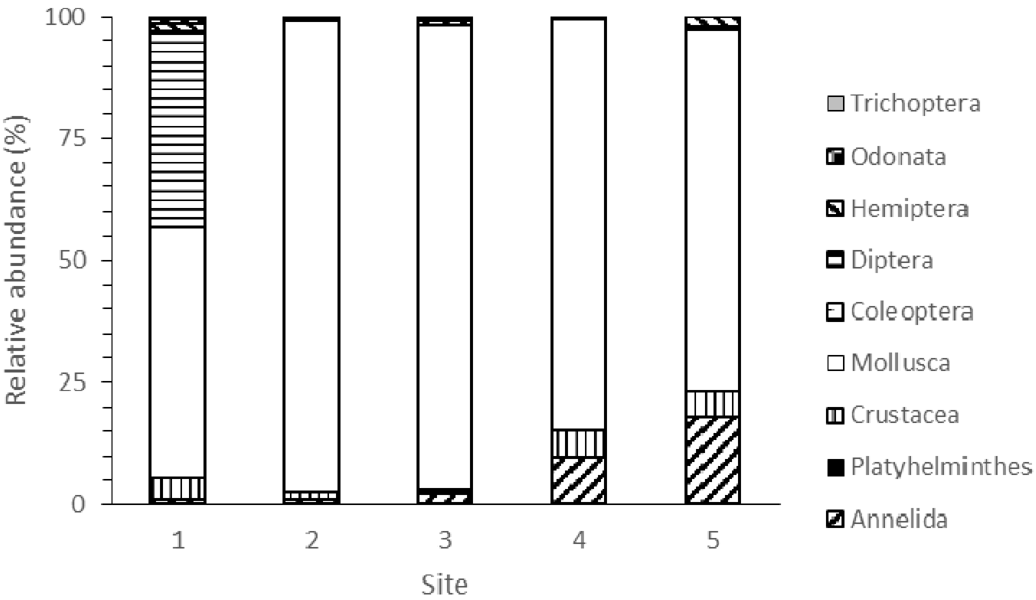

Figure 7. Relative abundances (%) of the major taxonomic groups of macroinvertebrates found in Osbornes Drain.

By far the single most abundant macroinvertebrate taxon in Osbornes Drain was the ubiquitous native mud snail *Potamopyrgus antipodarium* (accounting for, on average, 68% and up to 90% of all macroinvertebrates collected from Osbornes Drain). Other snails (*Gyraulus* and *Physella*) and the freshwater clam (Sphaeriidae) were also present along the waterway, but were not as abundant as *Potamopyrgus*. *Potamopyrgus antipodarium* occurs in a variety of freshwater habitats, and like other snails, feeds on fine algae and diatoms that grow in freshwaters. Snails and bivalves are considered to be generally tolerant of nutrient enrichment and soft sediments, and are often found in high abundances in degraded waterways, but also in naturally slow-flowing or standing waters.

The tiny seed shrimp (Ostracoda) was also found throughout the waterway, albeit in lower abundances than the snails and bivalves. Ostracods are small crustaceans, found in a variety of aquatic habitats, and are considered to be generally tolerant of pollution and organic enrichment.

The damselflies (Odonata) *Austrolesthes* and *Xanthocnemis* were collected from downstream of the pump house (site 1) and downstream of the cattle crossing (site 3), and a single dragonfly nymph (*Procordulia*) was collected from the pump house (site 2). Diving beetles (Dytiscidae) were found at the pump house (site 2) and the cattle crossing (site 4). Damselflies, dragonflies and dytiscid diving beetles are predatory insects, and can be common in slow-flowing or standing waters. These aquatic insects are considered moderately tolerant of pollution and enrichment.

5.3.3 EPT taxa richness

EPT taxa accounted for only a very small proportion of the macroinvertebrate community found in Osbornes Drain (Table 4). The EPT orders (Ephemeroptera, mayflies; Plecoptera, stoneflies; and Trichoptera, caddisfies), which are generally sensitive to pollution and habitat degradation, are useful indicators of stream health. High EPT richness suggests high water and habitat quality, while low EPT richness suggests low water and habitat quality, and degraded stream health.

Only two caddisfly (Trichoptera) taxa were found in Osbornes Drain, and only at two sites in relatively low abundances. The stick caddis, *Triplectides*, was found in Osbornes Drain, but in very low numbers and only at sites 1 and 3 (downstream of the pump house and downstream of the cattle crossing). *Triplectides* larvae build their cases out of wood and leaf fragments, and are often found in slow-flowing or standing waters. The algal-piercing caddisfly, *Paroxyethira*, was only found in very low numbers at site 1, downstream of the pump house. Although caddis taxa are considered ‘clean-water taxa’, both *Paroxyethira* and *Triplectides* are considered generally tolerant of pollution and habitat degradation, compared to other caddis taxa.

5.3.4 Waterway health

The Macroinvertebrate Community Index (MCI) is a biotic index commonly used to provide an indication of waterway health. It is a community-based index, which accounts for the variety of pollution-sensitivities (especially organic enrichment) of all macroinvertebrate taxa found at a site, or in a waterway.

Both the MCI and its quantitative variant (QMCI) indicated that Osbornes Drain had poor ecological health (based on the water quality categories of Stark and Maxted 2007), with 'probable severe enrichment' (Figure 8).

Furthermore, QMCI scores were well below the recommended guideline of 3.5 (p LWRP).

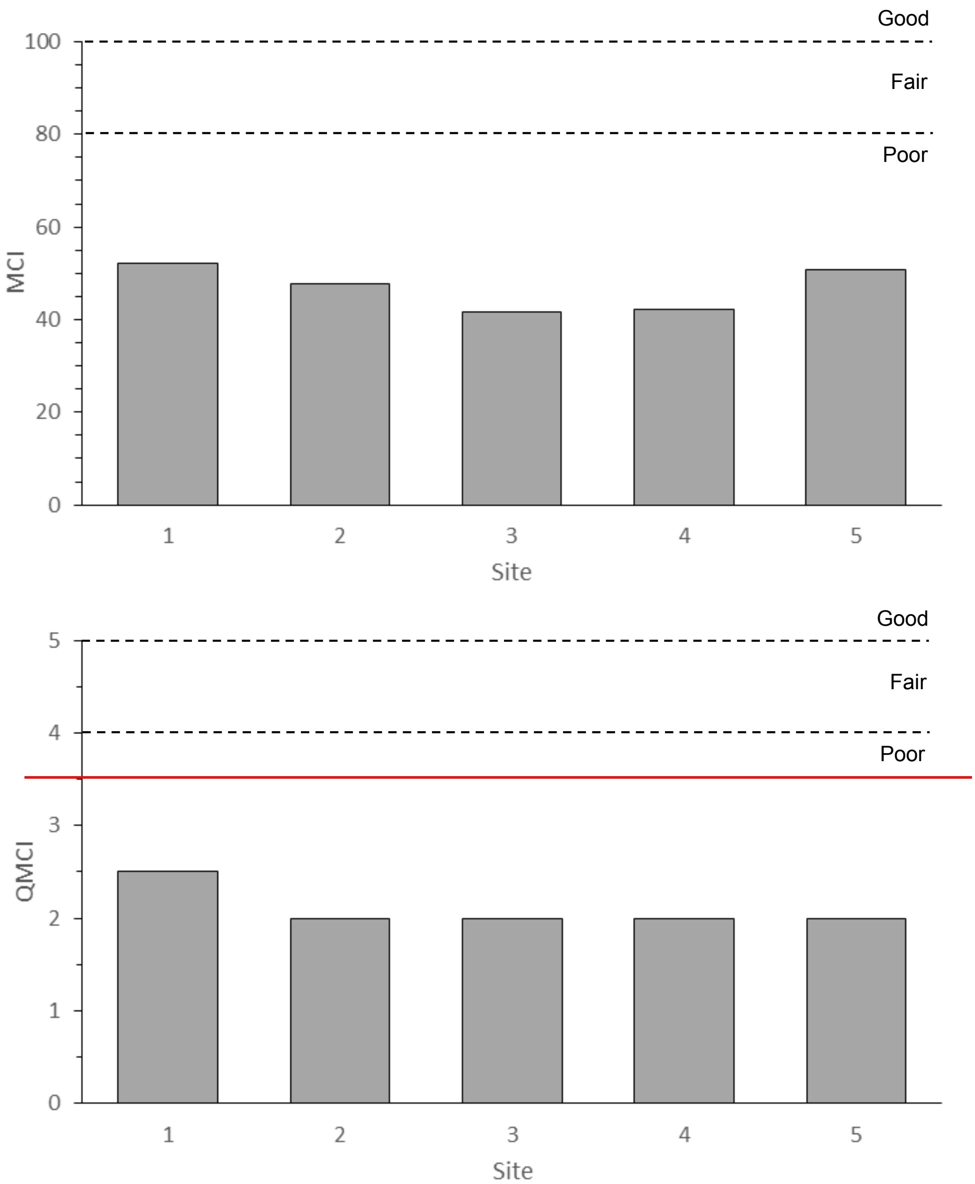

Figure 8. MCI (top) and QMCI (bottom) scores for the five sites surveyed along Osbornes Drain in March 2015. Solid red line represents the 3.5 QMCI guideline for 'spring-fed, lowland' waterways (proposed LWRP).

5.4 Fish Community

A total of 183 fish, belonging to six species, were captured from the five sites along Osbornes Drain. The six species, in descending order of total abundance, were shortfin eel (*Anguilla australis*), upland bully (*Gobiomorphus breviceps*), common bully (*G. cotidianus*), longfin eel (*A. dieffenbachii*), goldfish (*Carassius auratus*), and inanga (*Galaxias maculatus*). Shortfin and longfin eels, common bully, and inanga are all migratory species, which generally require access to the sea to complete their lifecycle. Upland bully is a non-migratory species, spending all of its lifecycle in freshwater.

Longfin eels and inanga are listed as 'at risk, declining', while common bullies, upland bullies, and shortfin eels are 'not threatened' (Goodman et al. 2013). Goldfish is an introduced species that has now become naturalised in the wild and is recognised as pest fish in many Regional Pest Strategies across New Zealand.

Species richness declined upstream along Osbornes Drain, with five species found at sites 1 and 2, but just two species found at sites 3 – 5 (Table 5).

Table 4: Freshwater fish captured at the five sites surveyed in March 2015. Size ranges (mm) are given in parentheses.

Species	**Site 1: downstream of pump house**	**Site 2: pump house**	**Site 3: downstream cattle crossing**	**Site 4: cattle crossing**	**Site 5: Gammacks Road**
Shortfin eel (*Anguilla australis*)	48	12	6	13	6
Longfin eel (*A. dieffenbachii*)	3	4	0	1	3
Common bully (*Gobiomorphius cotidianus*)	2	29	0	0	0
Upland bully (*G. breviceps*)	0	40	1	0	0
Inanga (*Galaxias maculatus*)	1	1	0	0	0
Goldfish (*Carassius auratus*)	13	0	0	0	0
Species richness	5	5	2	2	2
Number of fish / trap / night	7.4	9.6	0.8	1.6	1.0

5.4.1 Fish relocated from sediment and during dewatering

A total of 1,199 fish, belonging to four species (shortfin and longfin eel, upland bully, and inanga), were relocated from Osbornes Drain to the Huritini / Halswell River (canal) during the dewatering and sediment removal works.

Table 6 provides a summary of the number, species and size of fish relocated prior to and during this work.

Table 5. Summary of the fish species relocated from Osbornes Drain, between the pump house and Gammacks Road, prior to and during dewatering and sediment removal works in March and April 2015. Size categories are given for eels; other fish were not measured.

Species	**Size category**	**Fyke nets**	**Gee minnow traps**	**Sediment removal (1.5 km)**	**Total**
Shortfin eel (*Anguilla australis*)	<200 mm	1	0	402	1,028
	200-500 mm	1	0	61	
	500-1000 mm	5	0	390	
	>1000 mm	8	0	160	
Longfin eel (*A. dieffenbachii*)	<200 mm	0	0	0	3
	200-500 mm	1	0	1	
	500-1000 mm	1	0	0	
	>1000 mm	0	0	0	
Upland bully (*G. breviceps*)	NA	43	59	35	137
Inanga (*Galaxias maculatus*)	NA	26	3	2	31

A total of 1,315 fish, captured during the ecological survey and the in-drain maintenance works, were relocated from Osbornes Drain, between the pump house and Gammacks Road. This consisted of 1,065 shortfin eels, 8 longfin eels, 29 common bullies, 178 upland bullies, and 32 inanga.

6.0 Historical extent of wetlands in the Osbornes Drain area

The Osbornes Drainage and Pumping Scheme, constructed in 1967-1968, reclaimed low-lying land that was historically submerged by Te Waihora during times of high lake levels. Much of the farmland surrounding Osbornes Drain and along the shores of Te Waihora would have once been coastal salt marsh wetlands, where the underlying soils were wet and brackish (Figure 9). This past vegetation would have been dominated by plants able to tolerate these salty and wet soils. For example, shrubs such as mikimiki (*Coprosma propinqua*), mānuka (*Leptospermum scoparium*), pōhuehue (*Muehlenbeckia complexa*), and mākaka / saltmarsh ribbonwood would have been common, with toetoe (*Cortaderia richardii*), and wīwī / sea rush (*Juncus kraussii*).

The elevated ground with coastal sand dune along Ridge Road, to the north-east of Osbornes Drain, would have been covered in drought-resistant shrubs, tussocks, and flaxes. This area separated the tōtara / mataī podocarp forests found on moister soils to the north-east from the coastal salt marsh wetlands of the Osbornes Drain area (Figure 9).

Williams (2005) provides a summary of the plant species / vegetation communities that would have occurred on the various soil types around Te Waihora. This information is also a useful guide to the plant species that could be used in restoration projects in the area.

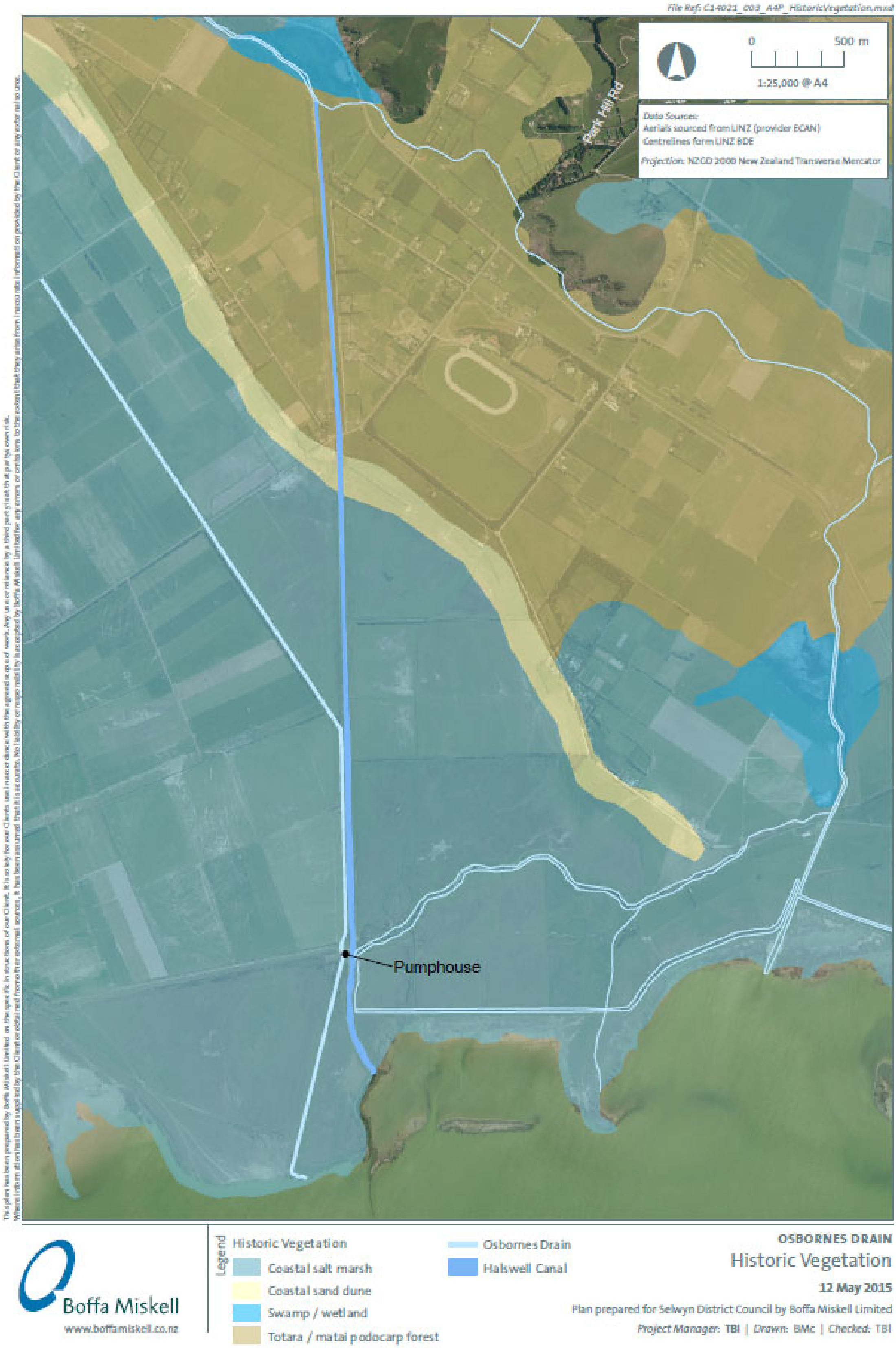

Figure 9. Much of the area surrounding Osbornes Drain would have been dominated by coastal salt marsh wetlands, prior to establishment of the drain in 1967-1968.

7.0 Existing wetlands and birds

7.1 Wetland vegetation communities

Figure 10 shows the current wetland vegetation communities downstream of the pump house (Grove *et al* 2012). The vegetation patterns and composition appear to be driven by Osbornes Drain, the smaller, mainly parallel, drains, and the high groundwater levels due to the close proximity to Te Waihora. While indigenous plant species still dominate in wetter areas, exotic grass and herb species dominate much of the drier land.

In the drain itself, there are several stands of raupō covering, or at the edges of, open water particularly near the pump house. A small area of three square (*Schoenoplectus pungens*) extends south west from Osbornes Drain to an area with high groundwater. The majority of the vegetation either side of the waterway, down to the lake edge, is salt marsh ribbonwood and exotic grass herbfield, dominated by exotic grasses.

Brackish tolerant species occur more frequently and closer to the lake, including native musk (*Thyridia repens*), bachelor's button, and glasswort (*Sarcocornia quinqueflora*).

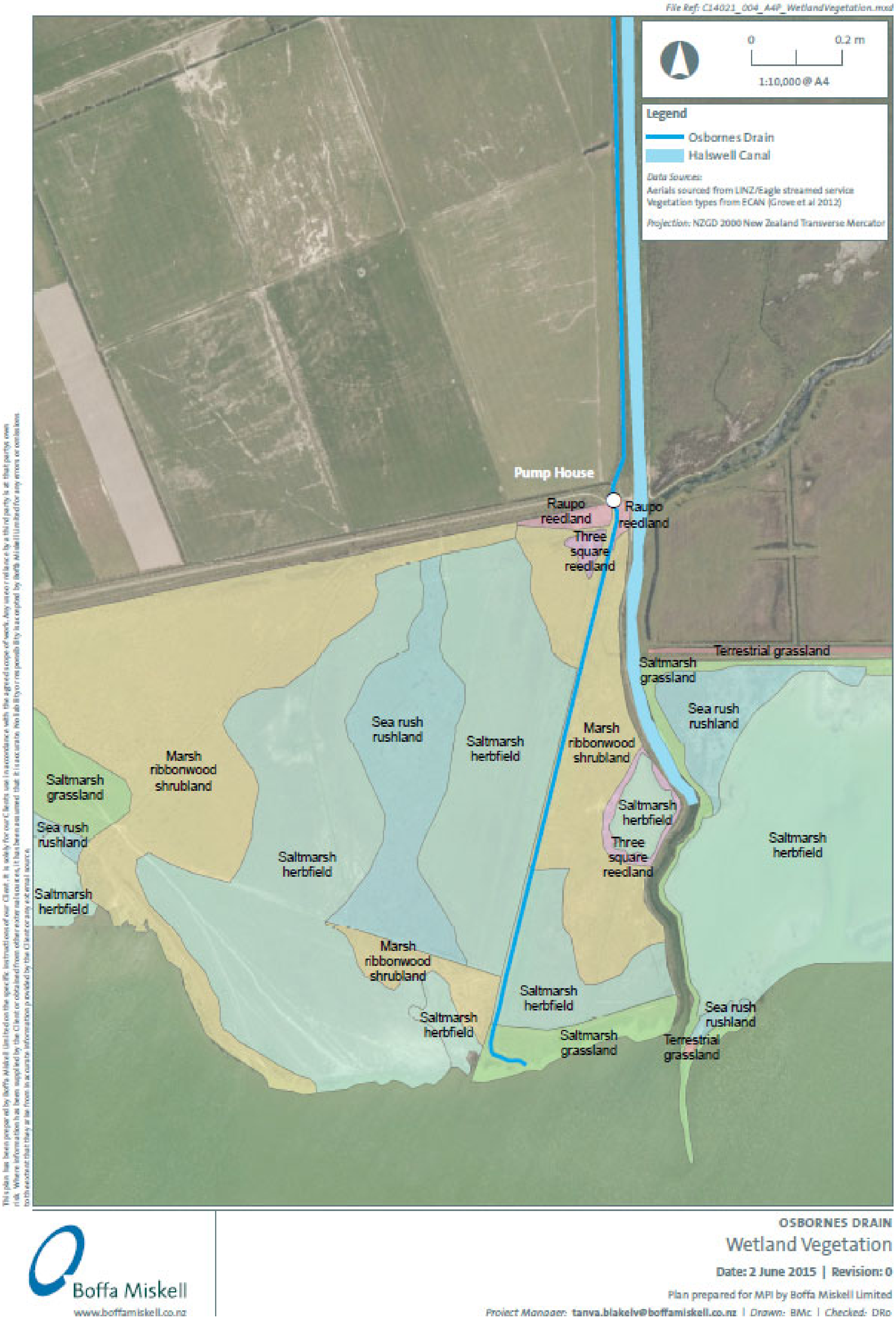

Figure 10. Wetland vegetation communities in the vicinity of Osbornes Drain, downstream of the pump house.

7.2 Wetland birds

Te Waihora is widely regarded as a wildlife habitat of national and international importance with the highest recorded bird diversity of any location in New Zealand (Hughey and O'Donnell 2008). O'Donnell (1985) notes that the Osbornes area previously had bird habitat more similar to the eastern end of the Greenpark Sands (Figure 1), a completely flat area of salt marsh vegetation and mud, which is frequently flooded by fluctuating lake levels. Greenpark Sands generally has high values for migratory wader species. The Osbornes area is higher than Greenpark Sands, and with the addition of stopbanks along the lake shore, and drainage channels throughout the area, it no longer floods with fluctuating lake levels to the same extent as it did historically. However, shallow brackish pools often form after rain or when lake levels are high. The Osbornes area has, therefore, become more vegetated, with fewer muddy or bare areas than previously, thereby reducing available feeding habitat for wader bird species.

In the last three annual surveys (WET 2013-2015) of the migratory waders recorded at Te Waihora, only pied stilt (every year) and banded dotterel (in one year) were recorded in the Osbornes area. Both of these species are more numerous in the neighbouring Greenpark Sands where other New Zealand and international migrant wader species were also consistently recorded.

The black and little shags, white-faced heron, royal spoonbill, a range of waterfowl (black swan, Canada goose, paradise shelduck, mallard and New Zealand scaup), gulls (black-backed, black-billed and red-billed), and Caspian tern were recorded in the WET surveys, but mainly in the lake adjacent to the Osbornes area.

One bittern was also recorded in the 2013-15 surveys. O'Donnell (1985) noted that the swamps around the Huritini / Halswell River were especially important for bitterns, marsh crakes and flocks of pūkeko. This is likely to include the swamp areas, with raupō and associated species, by Osbornes Drain and below the pump house.

In summary, the highest values for birds in the Osbornes area are the swamp areas in and close to the waterway, which provide habitat for bittern and pūkeko, and potentially marsh crake.

8.0 Discussion

8.1 Existing ecological values

The ecological health of Osbornes Drain can be considered to be very poor, often with low dissolved oxygen levels, generally poor to very poor water quality (as described by ECan 2013), highly anaerobic sediments, slow-flowing and sometime stagnant water, and little riparian and in-stream habitat availability. This was reflected by the depauperate and pollution-tolerant macroinvertebrate and fish communities, and the very low MCI and QMCI values, indicating ‘poor’ water quality with probable severe enrichment.

The macroinvertebrate community was found to be dominated by snails and bivalves, chironomid midge larvae and oligochaete worms. All of these taxa are tolerant of high sediment levels, low flows, and organic enrichment. It must be noted, however, that although the fish community consisted of just five species (longfin eel, shortfin eel, upland bully, common bully, and inanga) above the pump house, both longfin eel and inanga are listed as ‘declining’ (Goodman et al. 2013). However, neither of these species were ever particularly abundant. In fact, more than 80% of the fish captured in Osbornes Drain were shortfin eels. The distribution of upland bully appeared to be quite patchy, with some areas supporting relatively high numbers of this species. Shortfin eels were found throughout the waterway. The migratory shortfin eel is thought to be the most tolerant of indigenous fish species, and is currently listed as not threatened (Goodman et al. 2013).

These findings are in-line with that of the report by Pattle Delamore Partners (PDP 2013), which reviewed water quality data collected by ECan in 2011-2012. PDP (2013) identified the drain network, based on its Water Quality Index, as a degraded system, with poor to very poor water quality.

Similarly, the wetland areas surrounding Osbornes Drain have been modified, through the installation of stopbanks and drainage channels, reducing the quantity and quality of habitat available for wetland plant and bird species. A diverse range of wetland plant communities still occur however, and the swamp areas close the waterway, and around nearby Eastern Greenpark, support the highest wetland bird values in the area.

8.2 Ecological benefits of the potential mitigation options

Potential mitigation options to address the poor water quality discharging from Osbornes Drain into Te Waihora were initially recommended in the PDP (2013) report. The reports by GHD New Zealand (GHD 2015) and Lowe Environmental Impact (LEI 2015) further expand on these mitigation options, including more detailed on-farm management and potential in-drain treatment to improve the water quality of Osbornes Drain.

GHD (2015) and LEI (2015) identified that nitrogen (organic nitrogen) and phosphorus (dissolved reactive phosphorus) were the main contaminants of concern, entering Osbornes Drain via runoff (overland and through lateral drains during rainfall events) and through direct inputs of stock effluent into the waterway. These nutrients then cause excessive macrophyte growth in the channel, which then traps sediments and generally reduce the quality of habitat for the aquatic fauna.

As a consequence of the high sediment loads in systems, such as within Osbornes Drain, the SDC conducts regular drain maintenance to improve the drainage capacity during rainfall events. This dredging, or removal of sediments, is not only costly (e.g. recent activities in Osbornes Drain required a number of contractors, including those commissioned to remove the sediment, and freshwater ecologists to recover fish stranded in the channel and removed with the sediments), but is also likely to have a long-lasting negative effect on the ecology of the waterway. Despite the poor ecological condition of Osbornes Drain, based on the depauperate community dominated by tolerant macroinvertebrate and fish species present, the waterway does have some ecological value (e.g. indigenous species are present, including 'threatened' species such as longfin eel and inanga). This is worth considering when evaluating potential mitigation options. For example, LEI (2015) recommend farm management plans be put in place to keep livestock out of the waterway and reduce the sediment load entering the waterway via direct runoff overland and through lateral farm drains. This, in turn, is likely to reduce the need for drain maintenance, over time. Reducing the disturbance associated with this drain maintenance would also benefit the ecological condition of Osbornes Drain.

It is recommended that on-farm management tools (as discussed in LEI 2015) be implemented as the first mitigation option. Secondary mitigation options recommended include in-drain treatment (GHD 2015), such as installing concrete weirs and pools to trap sediment, creating wetland areas within and alongside the waterway to clean the water before being discharged via the pump house to Te Waihora. As with the on-farm management tools, in-drain treatment options are primarily recommended for improving the water quality of Osbornes Drain being discharged to Te Waihora. Nevertheless, if done correctly, these in-drain treatments could also benefit the ecology of Osbornes Drain. Osbornes Drain is currently a slow-flowing system with almost no variety in flows. The introduction of weirs and pools would create some variety, which could improve the quantity and quality of habitat available for aquatic fauna. The existing ecology could not only be maintained but potentially improved, with improved water quality and habitat conditions.

When considering the ecology within Osbornes Drain, it will be essential to take into account the migratory nature of the fish species that currently occur in the waterway. Both species of eel, inanga, and common bully are all migratory species (upland bully is non-migratory), and need access to the sea to complete their lifecycles. It is assumed that these fish currently enter, and possibly exit, Osbornes Drain via the leaky flap valve at the pump house. Fish are also likely to be able to navigate through, or over if water levels allow, the existing stone weirs established throughout Osbornes Drain, and may move between waterways during times of flooding and high lake levels. If the maintenance on the pump house and installation of concrete weirs is undertaken, as recommended by GHD (2015), future fish passage may also need to be considered.

Finally, the establishment of wetlands within and alongside Osbornes Drain, primarily for 'polishing' of water before it reaches the pump house and is discharged to Te Waihora (GHD 2015), could also have benefits for the local ecology. As discussed in Sections 5 and 6 above, the area around Osbornes Drain was once an extensive wetland. It would have supported a variety of wetland plant and bird species, as well as a more diverse aquatic fauna. The re-establishment of wetland areas for water treatment would provide a greater quality and quantity of habitat for these communities, adding to the local biodiversity and ecological value of the area.

9.0 References

GHD New Zealand (2015). Osbornes Drain hydrology and water quality. Report prepared for Boffa Miskell Ltd.

Goodman JM, Dunn NR, Ravenscroft PJ, Allibone RM, Boubee JAT, David BO, Griffiths M, Ling N, Hitchmough RA and Rolfe JR (2013) *Conservation status of New Zealand freshwater fish, 2013.* New Zealand Threat Classification Series 7. Department of Conservation, Wellington. 12p.

Grove, P., Pompei. M. and Parker. M. 2012. Coastal wetland vegetation in Canterbury, 2004-2011. Environment Canterbury Technical Report No. R12/24. 57 pp.

Hughey, K.F.D and O'Donnell, C.F.J 2008. Birdlife of the Lake, Chapter 7 in: Hughey, K.F.D. and Taylor K.J.W. (eds). 2009*. Te Waihora/Lake Ellesmere: State of the Lake and Future Management*. EOS Ecology, Christchurch. 150pp

Lowe Environmental Impact (2015). Osbornes Drain – mitigation measures assessment. Report prepared for Boffa Miskell Ltd.

Meredith AS, Cottham D, Anthony M and Lavender R (2003). Ecosystem health of Canterbury Rivers: development and implementation of biotic and habitat assessment methods 1999/2000. Environment Canterbury Report No. R03/3 ISBN 1-86937-477-0.

O'Donnell, C.F.J. 1985. Lake Ellesmere – A wildlife habitat of international importance. Fauna *Survey Unit Report No. 40*, New Zealand Wildlife Service.

Storey RG, Neale MW, Rowe DK, Collier KJ, Hatton C, Joy MK, Maxted JR, Moore S, Parkyn SM, Phillips N and Quinn JM (2011). Stream ecological valuation (SEV): a method for assessing the ecological function of Auckland streams. Auckland Council Technical Report 2011/009.

Waihora Ellesmere Trust (2013-2015). Te Waihora / Lake Ellesmere wetland bird counts 2013, 2014 and 2015. http://www.wet.org.nz/projects/2015-te-waihoralake-ellesmere-bird-count/ .

Williams K. (2005). Native plant communities of the Canterbury Plains. Department of Conservation report.

Appendix 1: List of all macroinvertebrate taxa found in Osbornes Drain in March 2015.

Macroinvertebrate taxon		1	2	3	4	5
ANNELIDA	HIRUDINEA	1	6	1	3	-
	OLIGOCHAETA	32	29	29	52	246
PLATYHELMINTHES	PLATYHELMINTHES	-	-	4	-	1
CRUSTACEA	Ostracoda	146	50	8	29	75
	Paracalliope	-	1	-	-	-
MOLLUSCA	*Gyraulus*	21	25	2	-	4
	Physella	243	200	98	61	344
	Potamopyrgus	1352	2985	1192	407	669
	Sphaeriidae	-	30	1	-	1
Diptera	*Chironomus*	887	2	-	-	-
	Ephydridae	2	-	-	-	-
	Orthocladiinae	359	-	-	1	1
	Stratiomyidae	-	-	-	1	5
	Tanytarsini	26	-	-	-	-
Hemiptera	*Anisops*	4	-	3	-	-
	Microvelia	2	-	-	-	31
Coleoptera	Dytiscidae	-	1	-	2	-
	Sigara	39	22	10	-	-
Odonata	*Austrolesthes*	16	-	2	-	-
	Procordulia	-	1	-	-	-
	Xanthocnemis	15	-	4	-	-
Trichoptera	*Paroxyethira*	2	-	-	-	-
	Triplectides	15	-	7	-	-