REVIEW OF THE AQUATIC ECOLOGY OF THE LUNAN WATER SYSTEM: RESAS PESLES PROJECT – CONTRIBUTION TO REPORT D3a, OCTOBER 2017

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Rescobie Loch, Balgavies Loch and the Chapel Mires form part of a series of freshwater bodies in the upper reaches of the Lunan Water (Figure 1), all of which lie within the Rescobie and Balgavies Lochs Site of Special Scientific Interest (SSSI). The two lochs and the Chapel Mires basin fen were formed over depressions and kettleholes left by the last glaciation. The SSSI is located in an area of intensive agriculture, five kilometres east of Forfar in Angus, between Turin Hill to the north and Dunnichen Hill to the south. This area was designated as a SSSI, primarily, because of its basin fen, transition open fen and vascular plant assemblages. Aquatic ecological research in the SSSI, up to now, has primarily focussed on assessing the macrophyte communities of Rescobie and Balgavies Loch as a way of assessing changes in their ecological status.

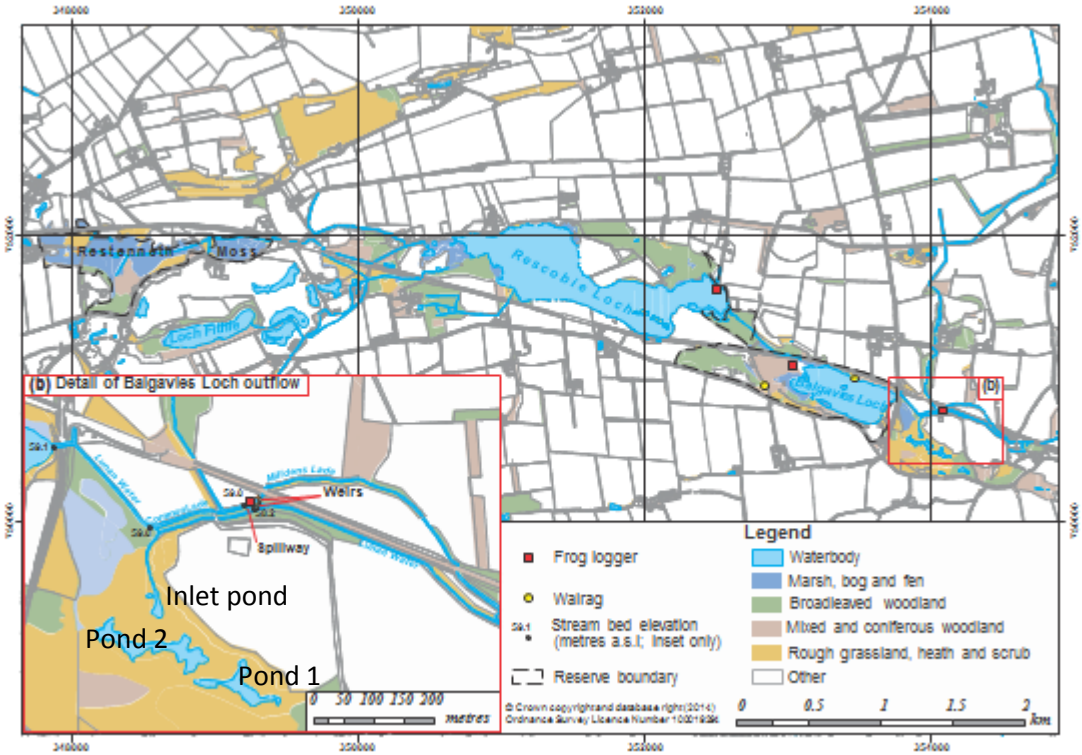

Figure 1. Map of the upper Lunan Water catchment

RESCOBIE LOCH

Rescobie Loch (Figures 2 and 3) occurs at an altitude of 62 m, has a perimeter of 6.0 km, with a mean depth of 3 m and a maximum depth of *c*.7.0 m (UK Lakes Portal). The catchment of 2171 ha comprises *c*.88% of the total catchment area of

Balgavies Loch and has a surface area approximately three times greater, i.e. 59 ha compared to 17.4 ha (UK Lakes Portal).

Figure 2. Rescobie Loch (looking west from eastern end, by outflow)

Figure 3. Rescobie Loch (looking north-west from southern margin)

Rescobie Loch is currently classified as a natural eutrophic standing water. However, historically it may have been more mesotrophic as it formerly contained a rich community of aquatic macrophytes, with a diverse assemblage of 14 *Potamogeton* (Pondweed) species and hybrids recorded before 1947 (Steven, 1988; Table 1). In

1987, a detailed and systematic survey of the aquatic macrophyte vegetation of Rescobie Loch, carried out by the University of Glasgow, found a total of eight submerged and floating-leaved macrophyte species, of which only two were *Potamogeton* with the non-native, *Elodea canadensis,* the dominant submerged species (Murphy and Kendall, 1988; Table 1). This major loss of species richness, compared with pre-war records, was attributed to the deleterious effects of nutrient enrichment resulting from increased levels of nutrients draining into the loch from the surrounding catchment (Murphy and Kendall, 1988; Steven, 1988). Another survey of the submerged aquatic macrophyte community in 1995 indicated a further decline in species diversity and macrophyte coverage with several relatively abundant species recorded in 1987, such as *Callitriche hermaphroditica*, *Potamogeton berchtoldii* and *Zannichellia palustris*, now either absent or rare (ECOS, 1995; Table 1). Even the formerly dominant *Elodea canadensis* was reported to be in 'poor condition', where it was found (ECOS, 1995). However, a 2004 Site Condition Monitoring survey of Rescobie Loch, based on a limited number of shore-based wader and perimeter survey sectors, did record an increased number of submerged and floating-leaved macrophytes, including three *Potamogeton* species (*P. crispus*, *P. pectinatus* and *P. pusillus*), although the vascular plant feature, *Potamogeton filiformis*, was not found (CEH, 2005; Table 1). Nevertheless, the continued dominance of *Elodea canadensis*, the loss of *Potamogeton* species (compared with historical records) and the poor water quality, (as exemplified by a severe algal bloom and very high phosphorus levels (TP of 313.8 µg l^{-1})) resulted in CEH recommending to Scottish Natural Heritage (SNH) that the eutrophic loch feature (of the Rescobie and Balgavies Loch SSSI site) be classified as being in 'Unfavourable Condition'. In August 2014, Peter McPhail, of SNH, carried out a quick survey of the Rescobie Loch submerged macrophyte community, by collecting drag samples from a boat (McPhail, *pers comm.*). This revealed that *Elodea canadensis* continued to be the dominant submerged species with only a few isolated strands of other species, *Chara* sp., *Myriophyllum* sp. (probably *spicatum*) and *Potamogeton* sp. (probably *pectinatus*) recorded (Table 1).

In September 2017, CEH staff made a brief visit to Rescobie Loch, visiting a number of shoreline locations. The primary aim was to assess the loch marginal vegetation that could be affected by changes in the water level regime downstream, as well as to get an impression of the current status of the submerged aquatic macrophyte community, relative to earlier surveys. The shoreline vegetation by the outflow from Rescobie Loch was dominated by dense beds of the emergent *Phragmites australis* with *Eleocharis palustris* abundant on the southern shore. In total, nine submerged and floating-leaved macrophyte species were recorded, either growing or washed up on the shoreline. *Elodea candensis* appeared, to still be, the dominant submerged species although its near relative, the non-native, invasive species *Elodea nuttallii*, was also recorded for the first time (Table 1). All the other recorded submerged macrophyte species, including *Potamogeton pectinatus* and *P. pusillus*, *Myriophyllum spicatum* and *Zanichellia palustris,* had been found in the loch in the last major survey in 2004. It was also noted that the water in the loch and the outflow to the Lunan Water was turbid and green from a cyanobacterium *Microcystis* bloom, indicating that the loch is still subject to ongoing eutrophication pressures (Figure 4).

Figure 4: Lunan Water: outflow from Rescobie Loch

In order to evaluate the changes in trophic status of Rescobie Loch, the available aquatic macrophyte data were assessed using the Plant Lake Ecotype Index (PLEX) scoring system. PLEX arose from a revised classification of British lakes using a comprehensive dataset of aquatic macrophyte survey data, supplemented by environmental data (Duigan *et al.*, 2006; Duigan *et al.*, 2007). The system is based around assigning a score to species based on their affiliation to particular trophic conditions. The scores of qualifying species are summed for a site, and an average score per taxon calculated to give a site PLEX score. Applying this scoring system to the whole Rescobie Loch dataset revealed an increasing trend in PLEX scores from the pre-1947 baseline (characterised by a high diversity of submerged macrophytes, particularly of *Potamogeton* species) to the comprehensive 1987 survey and the, albeit more limited, surveys of 2004 & 2017 (Table 1). Since 1987, overall species diversity has remained relatively low with a species composition typical of standing waters suffering from eutrophication. Based on the 1995, 2004 and 2017 macrophyte survey data, Rescobie Loch classifies as an example of a eutrophic Group I lake, i.e. widespread, mostly moderately large, base-rich lowland lake, with *Chara* spp., *Myriophyllum spicatum* and a diversity of *Potamogeton* species (Duigan *et al.,* 2006). The 1987 macrophyte survey data also classifies Rescobie Loch as a eutrophic lake but more as an example of a Group G lake, i.e. central and eastern, above neutral, lowland lake, with *Lemna minor*, *Elodea canadensis, Potamogeton natans* and *Persicaria amphibia* (Duigan *et al.,* 2006). In contrast, the pre-1947 aquatic macrophyte species dataset classifies Rescobie Loch as an example of a more mesotrophic Group E lake, i.e. northern, often large, low altitude and coastal, above-neutral lake with high diversity of plant species, including *Littorella uniflora, Myriophyllum alterniflorum, Potamogeton perfoliatus* and *Chara* spp. (Duigan *et al.,* 2006).

Species	Pre-* 1947	1947-86	UoG 1987	ECOS 1995	CEH 2004	SNH 2014	CEH 2017
Callitriche brutia var. *hamulata*	+	+	-	-	-	-	-
Callitriche hermaphroditica	+	+	+ (A)	-	+	-	-
Callitriche stagnalis	-	+	-	-	-	-	-
Ceratophyllum demersum	+	-	-	-	-	-	-
Chara sp(p).	-	+	-	-	+	+(R)	-
Elatine hexandra	-	+	-	-	-	-	-
Elodea canadensis	-	+	+(D)	+(D)	+	+(D)	+
Elodea nuttallii	-	-	-	-	-	-	+
Enteromorpha sp.	-	+	-	-	-	-	-
Lemna minor	-	+	-	-	+	-	+
Littorella uniflora	+	+	-	-	-	-	-
Myriophyllum spicatum	+	-	-	-	+	+(R)?	+
Nuphar lutea	+	+	+(F)	-	+	+(LD)	+
Nymphaea alba	+	+	+(R)	-	-	-	-
Persicaria amphibia	-	-	+(F)	-	+	+	+
Potamogeton berchtoldii	-	+	+(F)	-	-	-	-
Potamogeton compressus	+	-	-	-	-	-	-
Potamogeton crispus	+	+	+(R)		+	-	-
Potamogeton filiformis	+	+	-	+(R)?	-	-	-
Potamogeton friesii	+	-	-	-	-	-	-
Potamogeton gramineus	+	-	-	-	-	-	-
Potamogeton lucens	+	+	-	-	-	-	-
Potamogeton natans	+	-	-	-	-	-	-
Potamogeton x *nitens*	+	-	-	-	-	-	-
Potamogeton obtusifolius	+	-	-	-	-	-	-
Potamogeton pectinatus	+	+	-	+(R)	+	+(R)?	+
Potamogeton perfoliatus	+	-	-	-	-	-	-
Potamogeton praelongus	+	-	-	-	-	-	-
Potamogeton pusillus	+	+	-	-	+	-	+
Potamogeton x *salicifolius*	+	-	-	-	-	-	-
Ranunculus circinatus	+	-	-	-	-	-	-
Ranunculus peltatus	+	-	-	-	-	-	-
Sparganium angustifolium	+	-	-	-	-	-	-
Sparganium natans	+	-	-	-	-	-	-
Utricularia vulgaris agg.	+	-	-	-	-	-	-
Zannichellia palustris	+	+	+(F)	+(R)	+	-	+
Species richness	**27**	**18**	**8**	**4**	**11**	**6**	**9**
PLEX score	**6.81**	**N/A**	**7.26**	**N/A**	**8.14**	**N/A**	**8.23**

Table 1. List of aquatic macrophyte species recorded in Rescobie Loch

N.B. Abundance scale: D=Dominant; LD=Locally Dominant; A=Abundant; F=Frequent; R=Rare; + = Present; * Nearly all the pre-1947 species records come from a detailed survey carried out in 1880 by Abram Sturrock, a Perthshire schoolmaster, quoted in Steven (1988)

BALGAVIES LOCH

Balgavies Loch (Figures 5 and 6) is *c*. 0.5 km downstream of Rescobie Loch, connected by the Lunan Water. Balgavies Loch occurs at an altitude of 61 m, has a perimeter of 2 km, with a mean depth of 3.0 m and a maximum depth of *c*.9.4 m in the east basin (Murphy and Kendall, 1988; Murray and Pullar, 1910; UK Lakes Portal).

Figure 5. Balgavies Loch (eastern end)

Figure 6. Balgavies Loch (western end)

Balgavies Loch is currently classified as a natural eutrophic standing water (although historically it may have been more mesotrophic) and formerly contained a rich community of aquatic macrophytes including a diverse assemblage of *Potamogeton* (Pondweed) species and hybrids (Steven, 1988; Table 2). In 1987, a detailed and systematic survey of the aquatic macrophyte vegetation, carried out by the University of Glasgow, found, out of a total of seven submerged and floating-leaved macrophyte species, only three submerged vascular plants, growing in the loch, none of which were *Potamogeton* (Murphy and Kendall, 1988). This major loss of species richness was attributed to the deleterious effects of eutrophication resulting from increased levels of nutrients draining into the loch from the surrounding catchment (Murphy and Kendall, 1988; Steven, 1988). A limnological profile of Balgavies Loch, carried out in 1991, which made special reference to eutrophication and phosphorus, predicted that the annual phosphorus load to it was 0.66 tonnes (i.e., 0.038 t ha^{-1}), a high figure considered indicative of eutrophic conditions (Bailey-Watts *et al*., 1992).

In 2003, the Scottish Wildlife Trust (SWT) commissioned CEH to re-survey the aquatic macrophyte community of Balgavies Loch and list those species present with particular emphasis on recording any *Potamogeton* species found. Gunn and Kirika (2003), unexpectedly, found that the species richness of submerged and floating-leaved macrophytes had increased significantly from a total of only seven species in 1987 to fifteen (Table 2). A finding of particular interest was that four *Potamogeton* species were recorded, including *P. obtusifolius*, which was the predominant submerged plant in the main body of the loch. Although the aquatic macrophyte community was clearly still indicative of a eutrophic loch, the increase in species diversity indicated signs of recovery in the loch's condition. Gunn and Kirika (2003) linked this apparent recovery to water quality improvements in the management of the upper Lunan Water catchment, resulting in reduced nutrient loadings to the loch although there was no loading data available to substantiate this. Gunn and Kirika (2003) also speculated that relatively wet summers may also have helped, by increasing the naturally very high flushing rates ,estimated to be on average 14.4 loch volumes y^{-1}) (Bailey-Watts *et al*. 1992). This would have reduced water residence times in the loch making it a less favourable environment for phytoplankton growth, thereby, preventing the build up of troublesome blooms, which, if given enough time to develop, could shade out submerged macrophytes.

In 2012, CEH were again commissioned by the SWT to re-survey the aquatic macrophyte community of Balgavies Loch, using similar methods to those employed in the August 2003 survey. The 2012 survey found that Balgavies Loch had a very similar aquatic macrophyte community to that found in the 2003 in terms of species composition with, again, fifteen species recorded (the only difference being that *Chara globularis* was found in 2012 while the rare *Ranunculus* sp. was not) (Table 2). Only four *Potamogeton* species (none of which were broad-leaved species) were recorded in 2012, although *P. filiformis* and *P. polygonifolius* had also been

apparently recorded in recent years in the environs of Balgavies Loch. However, even these characteristic eutrophic aquatic macrophyte species that were present, in general, appeared to be

Table 2 List of aquatic macrophyte species recorded in Balgavies Loch

Species	Other Records	UoG 1987	CEH 2003*	CEH 2012*	CEH 2017
Callitriche hermaphrodtica	+	31%	34%	18%	-
Callitriche stagnalis	+ (recorded in 1977)	-	-	-	-
Ceratophyllum demersum	-	-	13%	80%	+
Chara sp(p)	-	4%	-	7%	+
Elodea canadensis	+	44%	38%	34%	+
Enteromorpha sp.	-	23%	35%	27%	+
Lemna minor	+	-	+	2%	+
Lemna trisulca	+	-	30%	17%	+
Myriophyllum spicatum	+	-	58%	20%	+
Nuphar lutea	+	38%	4%	2%	+
Nymphaea alba	+ (recorded in 1977)	-	-	-	-
Persicaria amphibia	-	27%	10%	10%	+
Potamogeton berchtoldii	+ (recorded in 1969)	-	-	-	-
Potamogeton compressus	+ (recorded in 1842)	-	-	-	-
Potamogeton crispus	+	-	6%	1%	-
Potamogeton filiformis	+ (last recorded in 2007)	-	-	-	-
Potamogeton friesii	+ (last recorded in 1962)	-	-	-	-
Potamogeton gramineus	+ (recorded in 1837)	-	-	-	-
Potamogeton lucens	+ (last recorded in 1968)	-	-	-	-
Potamogeton x *nitens*	+ (recorded in 1913)	-	-	-	-
Potamogeton obtusifolius	-	-	23%	4%	-
Potamogeton pectinatus	+	-	1%	3%	+
Potamogeton polygonifolius	+ (recorded in 2005)	-	-	-	-
Potamogeton praelongus	+ (recorded in 1908)	-	-	-	-
Potamogeton pusillus	+	-	16%	3%	-
Potamogeton x *salicifolius*	+ (recorded in 1913)	-	-	-	-
Potamogeton x *zizii*	+ (recorded in 1943)	-	-	-	-
Ranunculus sp.	-	-	1%	-	-
Ranunculus aquatilis	+ (recorded in 1969)	-	-	-	-
Ranunculus trichophyllus	+ (recorded in 1914)	-	-	-	-
Zannichellia palustris	+	23%	16%	4%	-
Species richness	**25**	**7**	**15**	**15**	**10**
PLEX score	**N/A**	**7.99**	**8.21**	**8.17**	**8.36**

*percentages are the frequency of occurrence of macrophyte species in all the survey sector points; + = present

showing signs of decline in their frequency of occurrence in the face of the increasing dominance of the eutrophic indicator *Ceratophyllum demersum,* a species not recorded in 1987 (Murphy and Kendall,1988). In addition, the less invasive, non-native *Elodea canadensis,* occurred at a frequency of occurrence in sample spots greater than then Joint Nature Conservation Committee (JNCC) target of 25%, although the relative frequency of occurrence remained below this threshold. Although the Balgavies Loch aquatic macrophyte community had recovered its species diversity to some degree, compared with the situation in 1987 (when only seven aquatic species were recorded), Gunn and Dudley (2013) concluded, for the reasons outlined above, that Balgavies Loch, was still in an unfavourable condition. Gunn and Dudley (2013) attributed this to the continuing nutrient enrichment of Balgavies Loch (and the upstream Rescobie Loch) from the predominantly agricultural catchment.

In September 2017, CEH staff made a brief visit to Balgavies Loch, visiting the shoreline near the outflow and walking around the perimeter of the loch. The primary aim was to assess the loch marginal vegetation that might be affected by any change in the water level regime downstream, as well as to get an impression of the current status of the submerged aquatic macrophyte community, relative to earlier surveys. Although, CEH carried out only a very cursory survey, it was clear that there was a cyanobacterial bloom and scum of *Microcystis* accumulated by the outflow of Balgavies Loch and that the inflow of the Lunan Water, discharging into north-west corner of Balgavies Loch from Rescobie Loch, was also very green and turbid with what looked like a cyanobacterial bloom (Figure 7).

Figure 7. Lunan Water, upstream of Balgavies Loch

The emergent plant community was dominated by large stands of *Phragmites australis* (NVC S4 community; Rodwell, 1995) with *Carex rostrata, Iris pseudacorus* and *Sparganium erectum* also frequently occurring around the loch's perimeter. The floating-leaved vegetation was dominated by extensive patches of *Nuphar lutea* growing in the shallower water towards the western end of the loch. In total, ten submerged and floating-leaved aquatic species were recorded, all similar species to that found in the 2003 and 2012 surveys. The previously recorded *Chara* sp., found growing on the sandy substrates near the outflow, was identified as *Chara vulgaris*, a species previously unrecorded, as far as the authors are aware, in Balgavies Loch. On the basis of these recent CEH aquatic macrophyte surveys, Balgavies Loch (like Rescobie Loch) currently classifies as an example of a Group I widespread, mostly moderately large, base-rich lowland lakes, with *Chara* spp., *Myriophyllum spicatum* and a diversity of *Potamogeton* species (Duigan *et al.,* 2006).

CHAPEL MIRES

The results of the aquatic macrophyte surveys of three ponds in the Chapel Mires site (Figure 8) carried out September 11-12th 2017 are summarised in Table 3. Ponds 1 (i.e., the easternmost pond) and 2 (i.e., the largest and westernmost pond) were surveyed from an inflatable boat by means of visual assessment supplemented by regular sampling of the submerged macrophyte communities by use of a double-headed rake. The macrophytes in the Inlet Pond (i.e., the northernmost pond) and the Inlet were sampled from the bank using throws of the double-headed rake. There was no previous aquatic macrophyte data available to compare the findings of the 2017 survey findings of the Chapel Mires waterbodies with. Pond 2 (Figures 9-11) was the

Figure 8. Overview of Chapel Mires from west

largest and most diverse water body in the Chapel Mires site with eight aquatic macrophytes species recorded; *Ceratophyllum demersum*, *Elodea canadensis, Lemna minor*, *L. trisulca*, *Nuphar lutea*, *Potamogeton obtusifolius*, *P. pusillus* and

Table 3 List of aquatic and emergent macrophytes recorded in Chapel Mires, September 2017

	Waterbody			
	Pond 1	**Pond 2**	**Inlet Pond**	**Inlet**
Maximum water depth (m)	2.50	1.60	Not measured	Not measured
Secchi Disc depth (m)	2.20	>1.60	Not measured	Not measured
Aquatic species				
Ceratophyllum demersum	D	LD (east)	-	-
Elodea canadensis	R	LD	D	+
Lemna minor	F	LF	O	+
Lemna trisulca	A	A	LA	+
Nuphar lutea	A	LA	-	-
Potamogeton obtusifolius	-	LF	-	-
Potamogeton pusillus	-	O	LA	-
Utricularia vulgaris agg.	A	LF	O	+
Species richness	**6**	**8**	**5**	**4**
PLEX scores	**7.61**	**7.52**	**7.57**	**7.47**
Emergent/marginal species				
Alisma plantago-aquatica	R	R	-	-
Carex rostrata	LF	LF	O	+
Circuta virosa	R	R	O	+
Iris pseudacorus	O	O	O	+
Equisetum fluviatile	-	O	-	-
Lysimachia nummularia	-	-	-	+
Lysimachia thyrsiflora	-	O	-	-
Mentha sp.	-	-	-	+
Menyanthes trifoliata	O	O	-	-
Mimulus sp.	-	-	-	+
Myosotis sp.	-	-	R	-
Phalaris arundinacea	R	-	O	-
Phragmites australis	-	A	A	+
Potentilla palustris	O	R	-	-
Sparganium erectum	LF	O	-	-

N.B. Abundance scale: D=Dominant; LD=Locally Dominant; A=Abundant; LA=Locally Abundant; F=Frequent; LF=Locally Frequent; O=Occasional; R=Rare; + = Present

Utricularia vulgaris agg. (Figures 12-18). The majority were characteristic eutrophic species (all of which have been recorded in Balgavies Loch in recent years) although the presence of *Utricularia vulgaris* agg. (N.B., a species aggregate of *Utricularia australis* and *U. vulgaris* – species that are very difficult to separate based on vegetative features) indicated more nutrient poor conditions (as did the presence of emergents such as *Carex rostrata* and *Menyanthes trifoliata)*. The western half of Pond 2 was dominated by the non-native *Elodea canadensis* while the eastern half was co-dominated by both *Elodea* and *Ceratophyllum demersum.* Pond 1 (Figures

19-21) had a smaller surface area but a greater water depth than Pond 2 but lacked the two *Potamogeton* species and *Elodea canadensis* was rare. However, in the Inlet pond (Figure 22) and the sampled section of the Inlet from the Lunan Water, *Elodea* was the dominant submerged plant species. Unlike Rescobie and Balgavies Lochs, there was no evidence of cyanobacterial blooms in any of the sampled water bodies in the Chapel Mires site and water clarity was excellent with Secchi Disc readings of 2.20 recorded in Pond 1. Evidence of this better water quality was reflected in the lower PLEX scores calculated for Pond 2 and the other sampled waterbodies in the Chapel Mire site, compared with the PLEX scores recorded in the recent surveys of Rescobie and Balgavies Lochs (see Tables 1-3). Ponds 1, 2 and the Inlet Pond all key out, based on their aquatic macrophyte communities, as examples of Group G standing waters, i.e. central and eastern, above neutral, lowland lake, with *Lemna minor*, *Elodea canadensis, Potamogeton natans* and *Persicaria amphibia* (Duigan *et al.,* 2006).

Figure 9. South-western margin of Pond 2, Lysimachia thyrisiflora in foreground

Figure 10. Northern margin of Pond 2 with **Phragmites australis** ***stand***

Figure 11. Southern margin of Pond 2 with **Sparganium erectum** ***stand***

Figure 12. **Ceratophyllum demersum** ***collected from Pond 2***

Figure 13. **Elodea canadensis** ***collected from Pond 2***

Figure 14. **Lemna trisulca** ***collected from Pond 2***

Figure 15. **Nuphar lutea** ***stand in Pond 1***

Figure 16. **Potamogeton obtusifolius** ***collected from Pond 2***

Figure 17. **Potamogeton pusillus** ***collected from Pond 2***

Figure 18. **Utricularia vulgaris** ***agg. collected from Pond 1***

Figure 19. North-eastern margin of Pond 1

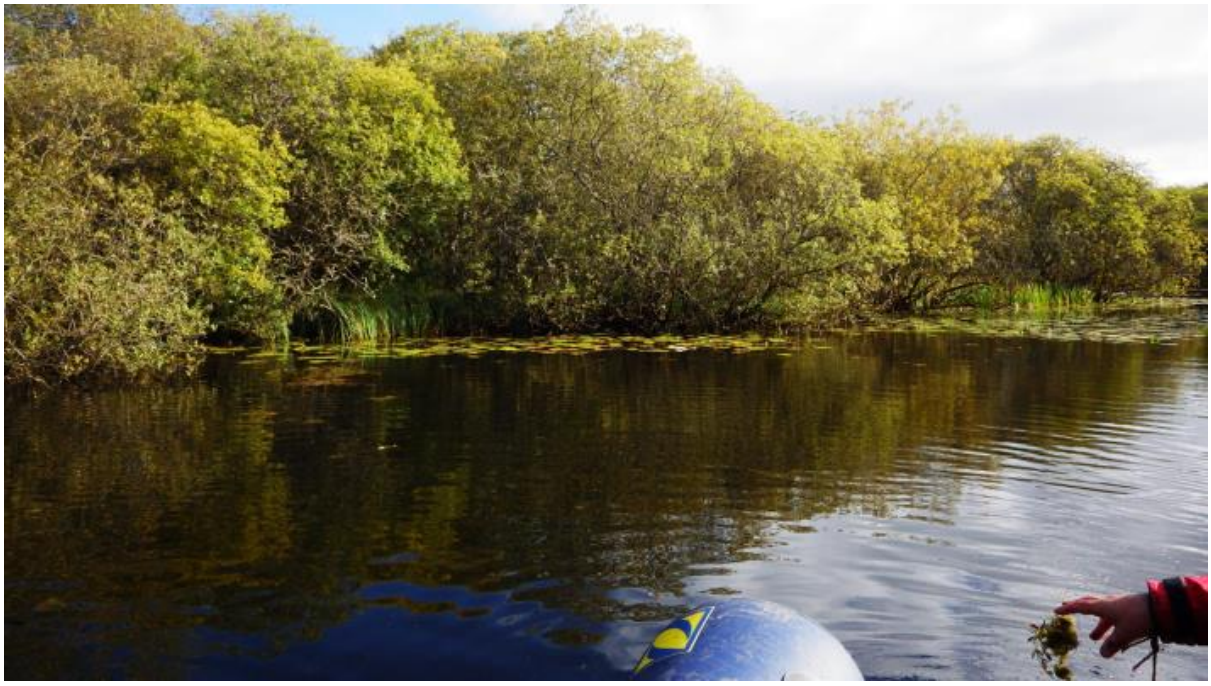

Figure 20. Northern margin of Pond 1

Figure 21. Looking west along Pond 1 from eastern shore

Figure 22. Inlet Pond from eastern shore

LIKELY IMPACT OF PROPOSED CHANGES IN WATER MANAGEMENT ON ECOLOGY OF RESCOBIE LOCH, BALGAVIES LOCH AND CHAPEL MIRES

The current water management plan for the upper reaches of the Lunan Water, proposed by the James Hutton Institute (JHI), envisages installing two hydraulic structures: a flow restrictor at the outlet from Balgavies Loch and a tilting weir on the downstream mill lade (Vinten *et al.*, 2017a and 2017b). The aim of this plan is to allow for more active management of the Lunan Water in order to deliver improvements for flood and low flow mitigation, as well as wetland water quality objectives (Vinten *et al*., 2017a and 2017b). JHI are advocating an increase in the water levels in Balgavies Loch of *c.* 10 - 20 cm in early summer to support low river flows (*Vinten pers comm.)*. Although JHI do not intend to lower the base level of the two lochs, they were also interested in an assessment of the likely impacts of reducing the loch level by, say, 10 cm (Vinten *pers comm*.). SNH and SWT had also expressed concerns over the following aspects of this proposed water management plan: (a) the impacts of any water level change on the ecology of the lochs as a result of changing management; (b) would reducing nutrient inputs into Chapel Mires help alleviate encroachment of sedge rich areas by more aggressive, nutrient loving species, such as *Phalaris arundinacea* and *Sparganium erectum*; and (c) would there be disturbance issues surrounding the installation of the tilting weir. These aspects are discussed below.

Water level changes – Rescobie Loch and Balgavies Loch

Currently, Balgavies Loch water levels fluctuate by *c.* 60 cm per annum (Vinten, *pers comm*.) and exhibits a classic seasonal pattern with the highest levels in winter and the lowest in summer. Based on a recent review, the available information on the effects of water level fluctuations on lake macrophytes, suggests that fluctuations of the magnitude proposed for Balgavies Loch are likely to have relatively minor impacts on aquatic plant communities (Moe *et al*., 2017). The direct effects on the plant community of any water level changes are likely to be limited to those species inhabiting the upper littoral. The majority of aquatic macrophyte species recorded in the lochs are not species of the upper littoral and are, therefore, unlikely to be substantially affected. However, *Potamogeton filiformis* does, normally, inhabit the upper littoral. It was last recorded in 2007 at Balgavies Loch (although the authors of this report are not sure where). Although, *P. filiformis* has not been recorded in CEH's recent surveys of Balgavies Loch (or Rescobie Loch), it is quite possible that it has been overlooked, particularly as it can be notoriously difficult to separate it from its closely related *Potamogeton pectinatus,* a species that certainly does still occur in both lochs. *P. filiformis* is a nationally scarce species (i.e., occurs in 16-100 10-km squares in Britain) and is cited in the original SSSI Rescobie and Balgavies Lochs SSSI designation as a vascular plant feature. Typically, *P. filiformis* is found in water < 1 m deep where vegetation cover has been reduced by fluctuating water levels or by erosion (Preston and Croft, 1997). These conditions exist at the eastern end of Balgavies Loch where areas of, largely, bare, sandy substrate predominate. It is not clear how *P. filiformis* might respond to increased water level fluctuations but Preston and Croft (1997) do indicate that it benefits from the control exerted on other species by disturbance created by level fluctuations. The stonewort, *Chara vulgaris,* was also present in the upper littoral of Balgavies Loch near the outflow, growing in shallow water on the sandy sediments there in September 2017 (also recorded in 2012). It is not a rare species and is sufficiently ruderal to take advantage of changes in water level. The *Phragmites australis* reed beds that dominate the upper littoral margins near the outflow of Rescobie Loch and the western end and northern shores of Balgavies Loch, may also respond to water level changes. Raising the summer water levels may change the area over which suitable conditions exist for these reeds to grow. Alterations in water level management have been associated with changes in reed bed extent in Scandinavia (Hellsten, *pers comm.*). Strong seasonal patterning of water level fluctuations should be carefully considered to avoid leaving plants exposed to frost damage during winter – by reducing water levels at that time.

Water level and nutrient changes to Chapel Mires

The wetland communities present in the Chapel Mires are recorded as a mixture of woodland, swamp, mire and fen communities (Vinten *et al*., 2017a). The swamp and mire assemblages exhibit a wide range of nutrient and water level tolerances (Table 4). This mosaic is possible because of the topography and mixing of different water sources of varying degrees of nutrient enrichment. Any significant changes to water level and nutrients are, therefore, likely to switch the balance in dominance between different communities. Those groups, which characterise transition zones in very shallow water, will be the most sensitive to water level changes. It has been

suggested that *Phalaris arundinacea* is invasive at the site. While it and *Sparganium erectum* are tolerant of more fertile conditions, both species are found in a very wide range of conditions. *P. arundinacea,* in particular, is nearly ubiquitous along British river and lake margins, and is only absent at the most oligotrophic of sites (Preston and Croft, 1997). It should be considered a natural element of the assemblage at Chapel Mires and not thought as an aggressive invasive species. Any reduction in nutrient inputs may disadvantage *S. erectum* but the response from *P. arundinacea* is likely to be more muted. It should be noted that fine sediment builds up around *S. erectum* and is likely to hold nutrients. Therefore, any response to a reduction in nutrient inputs will be tempered by the internal supply from deposited fines.

Disturbance issues surrounding the installation of the tilting weir

From the brief CEH visit to the vicinity of the proposed site of the tilting weir on the Lunan Water September 2017, there would appear to be no vegetation of significant conservation value in the immediate vicinity of the planned installation. Normal general considerations and good practice should be applied with a priority on avoiding significant release of sediments downstream during the installation and care taken when planning any vehicle access to the site.

SUMMARY

For a number of decades the qualifying interests of the Rescobie and Balgavies Lochs SSSI have been compromised by eutrophication. The lochs and fenlands are both affected. There has been no improvement in recent years. There is likely to be little or no negative impact to the qualifying interests from the introduction of a tilting weir and any significant reduction in nutrients to the systems should be considered as potentially beneficial.

Table 4. The relevant characteristics of the wetland plant communities in Chapel Mires. Ellenberg F scores indicate plant moisture preferences: 8 = intermediate between damp and wet sites; 9 = wet-site indicator, often on water-saturated, badly aerated soils; 10 = indicator of shallow-water sites that may lack standing water for extensive periods. Ellenberg N scores indicates nutrient preferences: 2 = infertile; 5 = intermediate fertility; 7-9 = richly fertile. Notes are from the community descriptions given in Rodwell (1991 and 1995).

Rodwell classification codes	**Dominant species**	**Tolerant to permanent flooding**	**Ellenberg F score of dominant species**	**Ellenberg N score of dominant species**	**Notes**
S2	*Cladium mariscus*	yes	10	4	Grows best when the water table is between 15 cm below ground and 40 cm above. Limited to situations too dry for reed and too wet for bushes
S3	*Carex paniculata*	-	9	6	Edges of low water transitions. Benefits from water level fairly stable above substrate surface
S9	*Carex rostrata*	yes	10	2	Shallow to deep mesotrophic waters – roots in organic substrate
S14	*Sparganium erectum*	yes	10	7	Intolerant to drying out of substrate below 10 cm
S27	*Carex rostrata / Potentilla palustris*	-	10 / 9	2 / 3	Open water transitions with diffuse lateral flow near in/outflows.
S28	*Phalaris arundinacea*	no	9	7	Marks upper limit of water level fluctuations
M9	*Calliergon cuspidatum/giganteum*	-	-	-	Indicative of wet and calcareous conditions
M27	*Filipendula ulmaria/ Angelica sylvestris*	no	8 / 8	5 / 5	Rich, moist soils protected from grazing. Common
M28	*Iris pseudacorus/ Filipendlula ulmaria*	no	9 / 8	6 / 5	Moist, rich soils, of mild climate near coasts

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