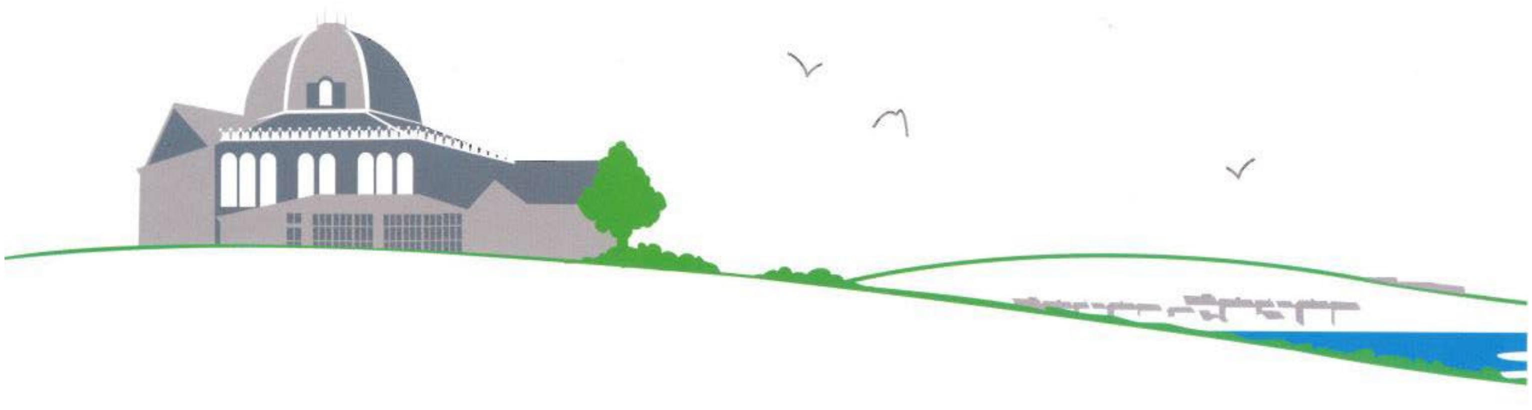
Penny Anderson
Associates Ltd
CONSULTANT ECOLOGISTS

CANAL & RIVER TRUST

MARCH HAIGH PROPOSED ACCESS TRACK

HYDROLOGY ASSESSMENT AND PEAT DEPTH MAPPING



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HYDROLOGY ASSESSMENT AND PEAT DEPTH MAPPING

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December 2021 (updated November 2022)

This project has been undertaken in accordance with PAA policies and procedures on quality assurance.

Signed: Sarah Ross

Penny Anderson Associates Ltd
CONSULTANT ECOLOGISTS

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1. INTRODUCTION

Background

1.1 Penny Anderson Associates Ltd (PAA) was commissioned by Canal & River Trust to undertake a hydrological assessment and peat depth survey of the upland moorland area known as March Haigh Flat, associated with the proposed permanent access track to March Haigh Reservoir (hereafter referred to as the 'site').

1.2 March Haigh Reservoir is located approximately 1.6km north-west of the town of Marsden, in the Metropolitan Borough of Kirklees, West Yorkshire. The proposed track begins at Blake Lea Lane (grid reference SE 0264 1267) and ends close to the reservoir spillway (grid reference SE 0176 1304) and in part crosses the open moorland area of March Haigh Flat, part of the South Pennines.

1.3 The proposed permanent access track would cross an area of moorland that is within the South Pennine Moors SSSI[1], the South Pennine Moors (Phase 2) SPA[2], and the South Pennine Moors SAC[3]. These designations relate to the occurrence of Priority Habitats and the bird interest of the area. The citations for the SSSI, SPA and SAC are presented in the Phase 1 Habitat and NVC Survey Report for the site (PAA 2021).

1.4 In 1999 a temporary track was installed along the same route to aid necessary maintenance and repair works at the reservoir. The track was granted planning permission and a restoration method statement was prepared to cover over and revegetate the route after use.

1.5 To lay this original track, peat was removed from the route to expose the underlying basal material, onto which stone material was laid to form a suitable surface for vehicle movements. The removed peat and turf material was stockpiled nearby. Following completion of works, the stone track was buried using the original excavated peat and the turf re-laid, leaving the stone foundations *in situ*.

1.6 The proposal is to construct a permanent track to March Haigh Reservoir, which would follow the route of a previously installed temporary track. The temporary track was subject to a ground surface restoration scheme agreed with the local authority in 1999 through which it was covered over and revegetated.

Objectives

1.7 The objective of the hydrological survey was to assess the current hydrological conditions on site and assess the potential effect of the proposed permanent track creation.

1.8 The objective of the peat depth mapping is to assist in the assessment of any potential impacts of the proposed permanent track on the peat resource on site, including helping determine where blanket bog occurs, which is partly defined by the depth of peat cover along with the vegetation communities that are present.

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[1] *SSSI – Site of Special Scientific Interest*

[2] *SPA - Special Protection Area*

[3] *SAC - Special Area of Conservation*

1.9 In addition, peat soils are increasingly acknowledged as an important landscape feature due to their role in catchment hydrology and surface water regulation, along with their carbon storage capacity.

2. METHODS

Hydrology Assessment

2.1 A walkover hydrological survey was carried out by Consultant Scientist Gerard Hawley on 8th October 2021 of a proportion of the March Haigh Catchment in the Southern Pennines across which the proposed permanent track would be constructed. The survey area was between March Haigh Reservoir and approximately 2.5km downstream, incorporating a corridor of land known as March Haigh Flat (Figure 1).

2.2 The results of the hydrological field-based survey were combined with a desk review of the underlying geology and hydrogeology of the area to inform the overall hydrology assessment.

Peat Depth Mapping

2.3 Peat depth mapping was undertaken along the route of the proposed permanent track within the main moorland area (largely co-incident with the designations of SSSI/SAC/SPA), covering the line of the track and 50m either side. Measurements were taken at intervals of approximately 10m, 25m and 50m perpendicular to the centre of the former track line to identify in some detail the depth of peat on the previous track and in the adjacent area (Figure 2). A total of 196 peat depth measurements were taken.

2.4 Mapping was completed by a small team of surveyors, Gerard Hawley and Phoebe Gray on 15th October 2021 and Phoebe Gray and Beth Howes on 2nd November 2021. Surveyors used pre-programmed handheld GPS[4] units (Garmin etrex 20) to navigate to each sample point in order to take the measurements.

2.5 Measurements were made using purpose-made calibrated peat depth probes, the probes used were extendable to 4m in length. The probe is inserted into the soil with pressure applied until the basal material is struck by the probe. At this point, the depth is measured to the nearest 1cm. The average of two measurements was recorded at each point and if they were significantly different a third was taken to clarify the results.

2.6 The depth measurements were used to categorise the peat depth into those recording shallow peat (<40cm) and those recording deep peat (≥40cm). The 40cm definition of deep peat is widely used and follows that used by the Soil Survey of England and is more conservative than the 50cm depth category used by the Phase 1 Habitat methodology (PAA 2021).

2.7 The peat depth point measurements were used to generate a model of peat depth across the entire survey site using an advanced statistical method in which values are interpolated using distance weighting, with the weighting dependent on the best fitted statistical model for the dataset.

Assessment Approach

2.8 The above survey and assessment results were used to identify any potential impacts on the hydrological functioning and integrity of the peat soils of the proposed track route and implications the wider area.

2.9 Potential impacts on habitats and other notified features on or nearby the site resulting from predicted changes in the hydrology or peat soils were also identified. Particular emphasis was

[4] *GPS - Global Position System*

placed on those habitats notified under the SSSI/SAC designations for the area, which also help support the bird species listed under the SPA designation.

3. RESULTS AND DISCUSSION

Catchment Geology

3.1 The March Haigh Catchment, below the present-day March Haigh Reservoir (Appendix 1, Photograph 1), is underlain by sedimentary rocks of Namurian age (326Ma to 313Ma), a subdivision of the Carboniferous period.

3.2 The Haigh Clough flows over Upper Kinder Scout Grit described as a medium to very coarse-grained feldspathic sandstone. A thin outcrop of the Hebden Formation is exposed in the steep sides of the Haigh Clough, a fine to course-grained felspathic sandstone interbedded with siltstone and mudstone.

3.3 The north of the catchment consists of the Marsden Formation and other sedimentary rocks that belong to the Millstone Grit Group.

3.4 These sedimentary lithologies were largely formed in a coastal setting and include deltaic, estuarine, fluviatile and palustrine deposits.

3.5 The predominant rock type is gritstone with thinner intervening mudstones and siltstones, and occasional turbidites and thin seams of coal. There are no superficial unconsolidated deposits except for deeper peat, that is confined to the upper reaches of the catchment and interfluves between surrounding upland catchments (British Geological Survey 2021a and 2021b).

Catchment Hydrogeology

3.6 Groundwater flow is controlled by a number of factors, e.g. rock porosity (percentage of void space), permeability (whether and how water can flow through a rock) and hydraulic conductivity (rate of flow). There are three sub-surface flow mechanisms; intergranular flow (water moves between grains), fracture flow (via cracks and fissures) and mixed (a combination of both).

3.7 Millstone Grit forms a multi-layered aquifer system with the intervening thinner shales and mudstones acting as an aquiclude, tending to separate sandstone horizons that effectively act as separate aquifer (Abesser *et al*. 2005; Lewis *et al.* 2006). Sandstones are generally well cemented and water transmission is restricted to joints and fractures. The predominant mechanism for these rocks is fracture flow, which is faster than intergranular flow, suggesting groundwater travels relatively quickly to augment surface flow and the catchment response to rainfall events is swift (Banks 2017). There will also be a contribution from throughflow, i.e. lateral flow of water in the soil zone that either infiltrates to the water table or travels downslope.

3.8 The dense vegetation cover over March Haigh Flat, predominantly of purple moor-grass (*Molinia caerulea*), often obscured the surface conditions. However, it was clear during the survey that there are areas of very wet ground and a number of minor springs. These are likely attributable to the underlying alternating bands of thicker sandstone and inter-bedded thinner shales and mudstones. Where the shales and mudstones meet at the surface exposing the boundaries between these and sandstones, minor springs occur.

Surface Drainage

3.9 The reservoir water level is governed by the set height of an outflow channel (Photograph 2) that feeds into Haigh Clough (refer to Figure 1 for the locations/directions of photographs). Following prolonged dry periods, the water level may be well below this set height. At times of extreme precipitation and high water levels, an adjacent overflow and spillway also diverts water to Haigh Clough (Photograph 3). At the time of the survey the overflow spillway was dry, although it had been active, and a channel below the spillway has been eroded, although the frequency at which this occurs is not known (Photograph 4).

3.10 The moorland area to the north of the proposed trackway, March Haigh Flat, has a small number of south-flowing watercourses that cross the proposed trackway route before joining Haigh Clough, a watercourse that leads eventually to the River Colne (classed as a Main river[5]) in Marsden. Haigh Clough occupies an incised, steep-sided, 'V'-shaped valley of interlocking spurs (Photograph 5). The moorland area south of the proposed track route, including the upper reaches of Haigh Clough, is identified as a Drinking Water Safeguard Zone (Surface Water) (England)[6].

3.11 Two streams flow under the track route, rising to the north and passing beneath bridges. One is unnamed and close to the base of the dam (Photographs 6 and 7) and the other is Hard Haigh Clough Stream at the far eastern boundary of the survey area (Photographs 8 and 9).

3.12 At the time of the survey these streams were at baseflow. The channel widths range between 1 and 2m. They are incised with vertical banks with a steep incline from the surrounding ground height. In both channels the latitudinal gradient descends in a step-like manner as a series of small chutes and falls and an occasional plunge pool (Photographs 10, 11 and 12). This reflects the control exerted by the near-horizontal bedding planes of the underlying gritstone and sandstone on channel morphology. Bedrock is exposed in the banks and channel bed, and platy and slab-shaped boulders line the channels. There is an insignificant sediment load in the streams and little/no sediment deposited on the channel bed. Precipitation is the primary feed mechanism, supplying water to the sub-surface and surface water system.

3.13 There are also two minor channels (Photographs 13 and 14) marked by a depression and change in vegetation mix.

Soils

3.14 The Soil Survey of England and Wales (Avery 1980, Mackney *et al.* 1983, Cranfield University 2021) indicates there are three soil associations within the March Haigh Catchment. The upper areas of the catchment consist of Winter Hill soils that are very acid raw peat soils associated with blanket bog. These are perennially wet and prone to soil erosion if wetness decreases and/or vegetation is lost due to, for example, poor management, over-grazing, pollution or wildfires. On the steeper, higher slopes north of Haigh Clough the soils are classified as the Belmont association and described as coarse loamy very acid upland soils with a peaty surface horizon. March Haigh Flat, which the majority of the track traverses, is classified as Wilcocks II, which is a seasonally waterlogged loam over clay with a peaty surface horizon. Each soil type is affected by high rainfall and a high water table, particularly where the gradient is low, and waterlogged conditions that leads to impeded drainage and the development of peat and organic-rich soils (Avery 1990).

3.15 Where incised streams have exposed soils in profile in the banks (Photograph 9), a weathered layer above the solid bedrock is visible and an organic-rich humic topsoil over loamy and gritty mineral substrate. The edge of the channels experience water table drawdown and tend to be drier than soils more distant from the channel edges. Elsewhere, a peat layer has developed where waterlogged anoxic conditions have led to peat accumulation.

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[5] https://www.arcgis.com/apps/webappviewer/index.html?id=17cd53dfc524433980cc333726a56386

[6] https://magic.defra.gov.uk/MagicMap.aspx

Peat Depth Mapping

3.16 Figure 2 presents the locations and design of the peat depth mapping sample grid in relation to the proposed permanent track alignment. Figure 3 presents the peat depth mapping measurements at each point (data also provided in Appendix 2) while Figure 4 presents a peat depth model to provide an indication of depth of peat across the site based on those data from the site survey.

3.17 The peat depth survey shows variation in peat depth over short distances. To the south of the track the soils are shallow with a thin organic surface horizon over a weathered and clayey substrate. This is particularly the case where the gradient is steep to the south of the track and falling towards Haigh Clough. North of the track the variability is likely the result of there being underlying hummocky terrain, likely the product of periglacial weathering in advance of a warmer climate and the establishment of vegetation and subsequent peat development.

3.18 The majority of the deepest peat depth measurements were taken along the northern edge of the sample area upslope of the proposed track route (Figures 3 and 4). The deepest peat (120 to 140cm) was measured infrequently towards the centre of March Haigh Flat along with one measurement close to the reservoir spillway. Deep peat measuring 100 to 119cm was recorded on the moorland north of the spillway and again along the northern edge of the sample grid. Peat depths 40 to 99cm, still generally considered suitable for supporting blanket bog habitat, dominate the sampling taken within the first 25m north of the proposed track route. Along the route itself, six out of the 28 sample points recorded a depth of 40cm or greater, the maximum being 102m deep. Below the proposed track route shallower peat depth measurements dominate with only 12 out of 84 measurements at 40cm or deeper.

3.19 An investigation of the March Haigh Reservoir catchment (Yeloff *et al*. 2006), instigated primarily as a research project to investigate the reasons for peat erosion and sediment fluxes in the catchment, provides a useful surrogate site. A range of surveys were carried out including taking peat samples for dating, recording the degree of humification, pollen analysis, plant microfossil identification and microscopic charcoal. The conclusion was that, as with other locations in the Southern Pennines, prior to the mid-20th Century degradation of vegetation was caused by pollution, climate change and fire. Following a severe fire in 1959 that removed vegetation, bare peat was maintained through over-grazing that caused widespread soil erosion.

3.20 Rainfall is relatively high in the Southern Pennines compared to many regions of the UK. Climate records are available for the Blackmoorfoot Reservoir that lies approximately 8km to the east of March Haigh Reservoir and at a similar altitude (Yeloff *et al.* 2006). Between 1886 and 2000 the ten-year moving average was 1154mm of rainfall. There has been a gradual trend throughout the period 1886 to 2000 of an increase in rainfall.

3.21 Examination of peat cores as part of the Yeloff investigation found that at most sampling sites peat was well humified and the macrofossil assemblage indicated peats composed of a mixture of grasses, sedges and ericaceous scrub in varying proportions, with small amounts of *Sphagnum*. Small bands of poorly humified peat suggested *Sphagnum* was more abundant before being replaced by grasses, sedges and ericaceous scrub. Peat accumulation records suggested low rates of accumulation between 1840 and 1905 with average accumulation rates 1840 to 2000, ranging from 0.3 to 1.5mm/year. South-facing areas had the higher accumulation rates, suggesting aspect influenced peat accumulation.

3.22 Detailed core examination did not form part of this peat depth survey, but the results above provide a credible description of the nature of the wider peat body present at March Haigh Flat.

4. CONCLUSIONS

Overview

4.1 As with many upland areas in the Pennines and the UK, precipitation is relatively high and annual temperatures are low. This leads to waterlogged conditions that promotes the development of organic-rich soils and peat. Where the gradient at March Haig Flat is steep, particularly on the slopes that lead down to March Haigh Clough, the soils are thin and lie over a gritty mineral substrate, which is typical of a 'shedding site'.

4.2 More immediately adjacent to the proposed track and further to the north, the gradient is relatively low, surface and sub-surface water movement is constrained and the residency time in the soil increased. This has led to peat accumulation, although as stated earlier, the depth is variable. Generally, however, the deepest peats are situated away from, and north of, the proposed track route.

4.3 The variation in peat depth is perhaps to be expected given the underlying topography of the area (with shallow depressions developing localised deeper peat) and the location on the edge of the main March Haigh peatland body where peat accumulation rates vary with natural changes in slope leading to Haigh Clough. The peat depth and topography indicate that this area is likely to support a mosaic of blanket bog, wet heath and dry heath/acid grassland habitats with localised acidic flushes where water accumulates.

4.4 The former track installation can be seen to have affected the local site hydrology and consequently the vegetation along the former track route, as indicated by the colonisation by soft-rush (*Juncus effusus*), and in places *Sphagnum*, along its length.

Summary of Potential Impacts

4.5 There are three structures, including culverts, potentially impacted by the proposed route of the permanent track. The watercourses will be retained along their existing routes with new structures, or culverts, included to accommodate the proposed track whilst minimising impacts on these ecological features.

4.6 A proposed permanent track has the potential to act as a barrier to surface and subsurface flow. It would cut across the slope of March Haigh Flat and is likely to impede flow to some extent, increasing wetness immediately north of the track and reducing water flow to the immediate south of the track.

4.7 A common design is to install a catch drain upslope of the track to divert water to a pipe/culvert that passes beneath the track. However, this causes drying downslope between the pipes and concentrates flow to a few points of discharge where accelerated erosion may be triggered. This can be avoided by using a greater number of smaller dimension pipes installed at frequent intervals rather than larger pipes at less frequent intervals. A permeable granular track footing would also limit the drying effect downslope.

4.8 Therefore, it is important that the design principals seek to minimise impacts on the peat deposits and retain the hydrological connectivity between the peat soils north and south of the proposed track route.

4.9 Given the already modified hydrological conditions along the proposed track route due to the previous temporary track, installing any proposed permanent track along essentially the same route would minimise any further disruption of the local site hydrology and the wet conditions that support the wider vegetation types and maintain the peat deposits.

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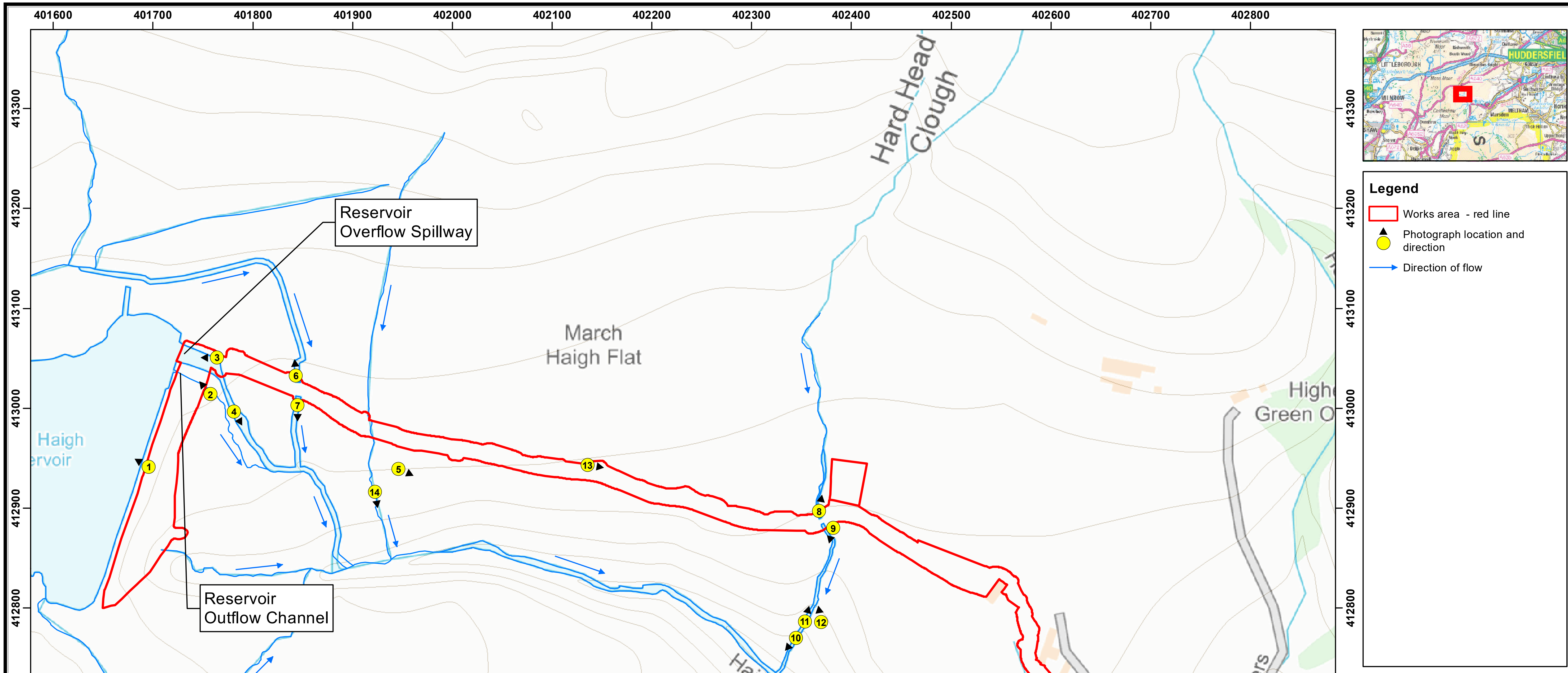
6. ABBREVIATIONS

PAA	Penny Anderson Associates Ltd
SSSI	Site(s) of Special Scientific Interest
SPA	Special Protection Area(s)
SAC	Special Area(s) of Conservation
GPS	Global Position System

FIGURES



Legend

- Works area - red line
- Photograph location and direction
- Direction of flow

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False Northing: -100000.000000
Central Meridian: -2.000000
Scale Factor: 0.999601
Latitude Of Origin: 49.000000

N

ISO A3

0 25 50 100 150 Metres

Canal & River Trust
Making life better by water

Penny Anderson Associates Ltd
Consultant Ecologists

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Telephone 01298 27086

Project Name: March Haigh Reservoir

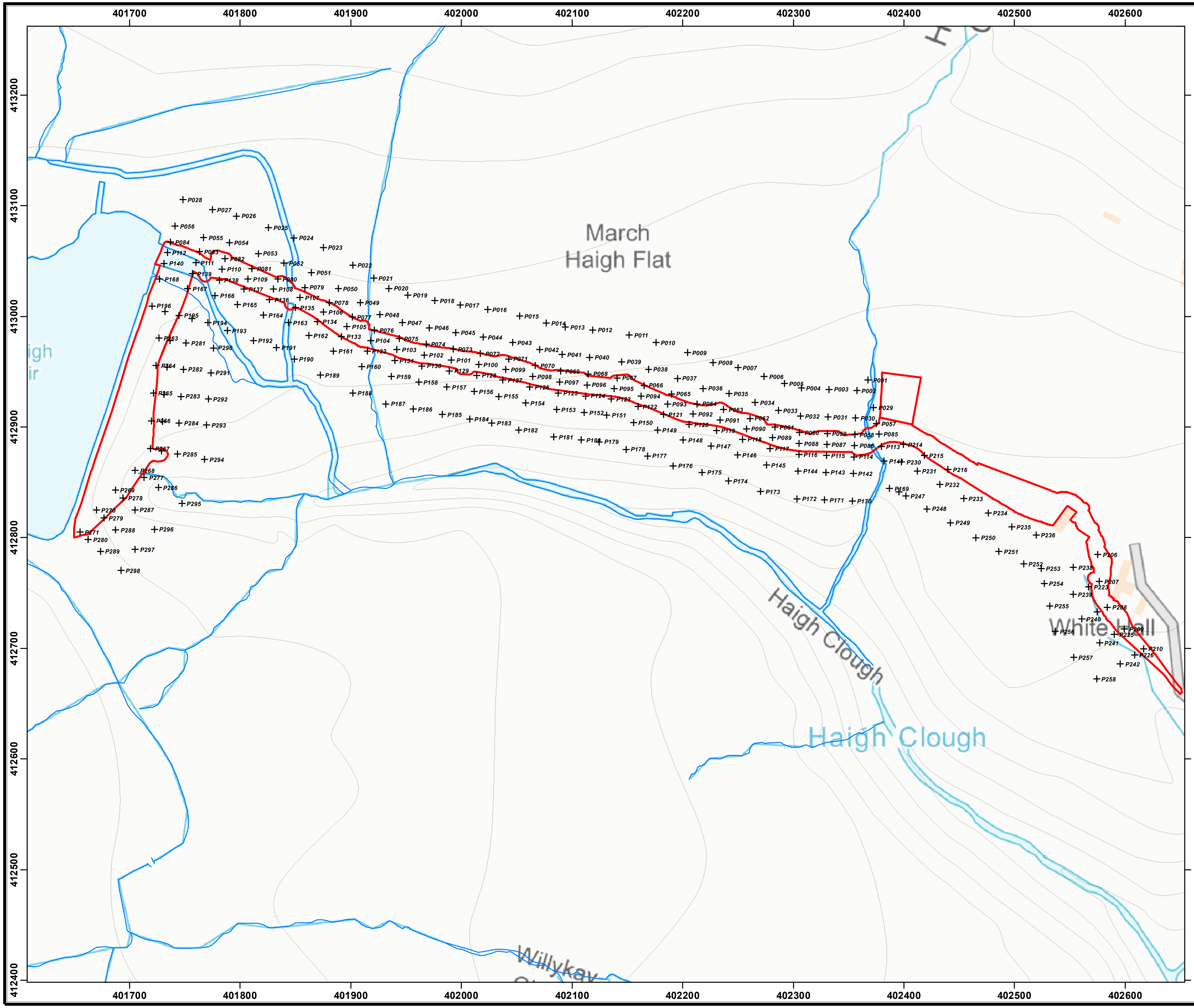
Discipline: Ecology

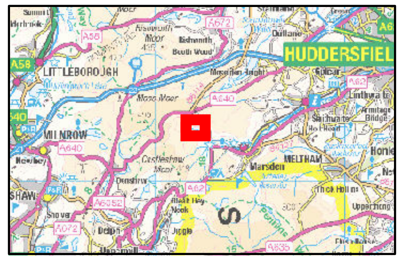
Title:

HYDROLOGY - SURFACE DRAINAGE

Scale 1:4,000		Drawing No. Figure 1	
Drawn By CC	Originator SRS	Date 08/03/2023	
PAA Ref.		Revision 1.0	

Figure 1 - Hydrology - Photo Locations - CART02-1 CC 221012.mxd





Legend

Works area - red line

+ Peat depth survey point

British National Grid
Projection: Transverse Mercator
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False Northing: -100000.000000
Central Meridian: -2.000000
Scale Factor: 0.999601
Latitude Of Origin: 49.000000

N

ISO A3

0 25 50 75 100 Metres

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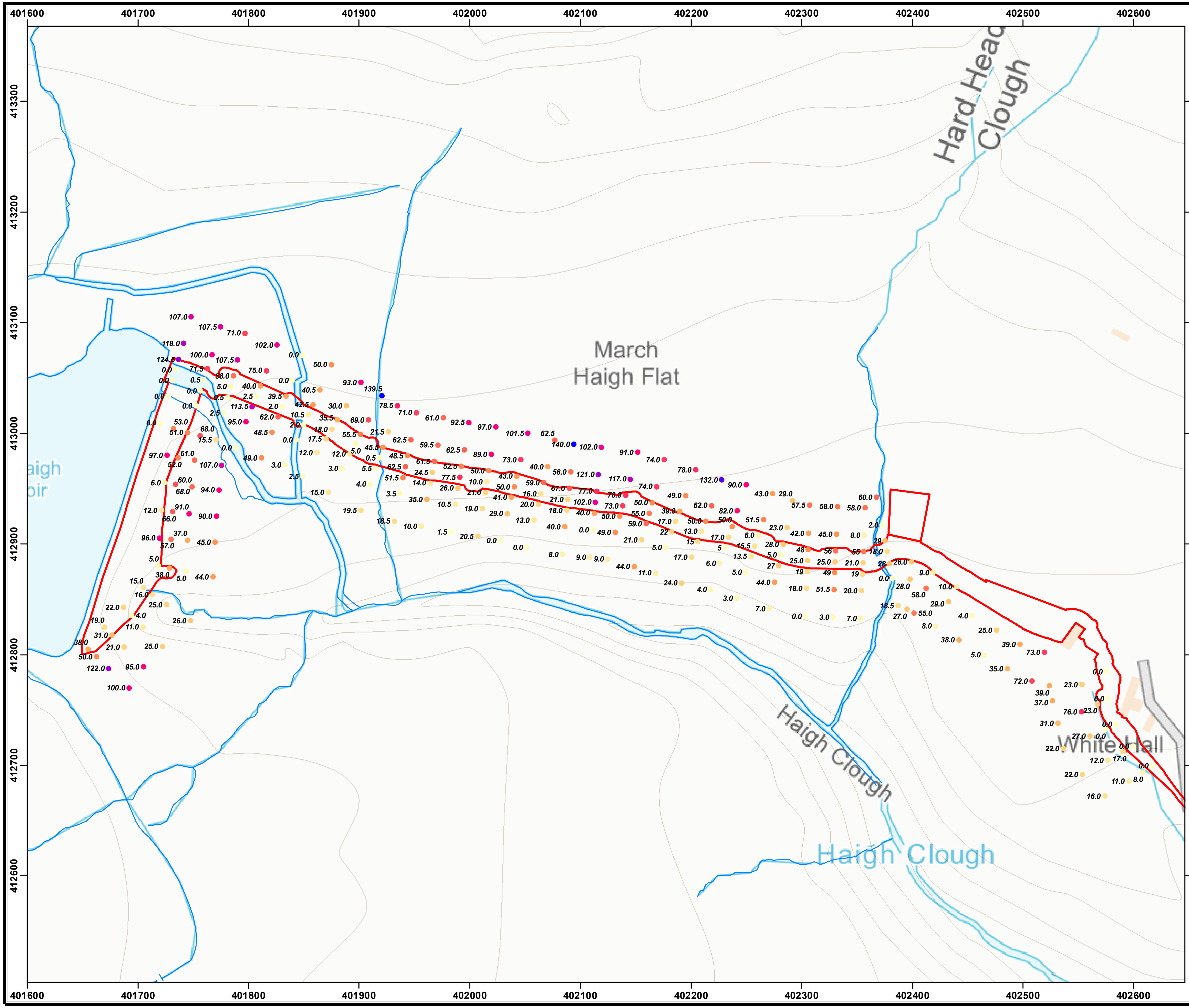
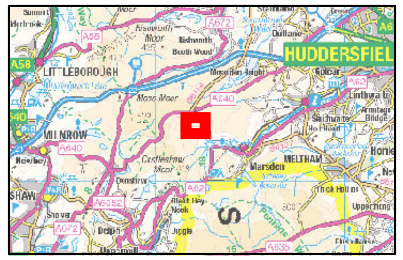
Title:

PEAT DEPTH SURVEY GRID

Scale	1:3,200	Drawing No.	Figure 2		
Drawn By	CC	Originator	SRS	Date	08/03/2023
PAA Ref.				Revision	1.0

Figure 2 - Peat Depth Survey Grid - CART02-1 CC 230308.mxd





Legend

Works area - red line

Measured peat depth

High : 140cm

Low : 0cm

British National Grid
Projection: Transverse Mercator
False Easting: 400000.000000
False Northing: -100000.000000
Central Meridian: -2.000000
Scale Factor: 0.999601
Latitude Of Origin: 49.000000

N

ISO A3

Metres

0 25 50 75 100

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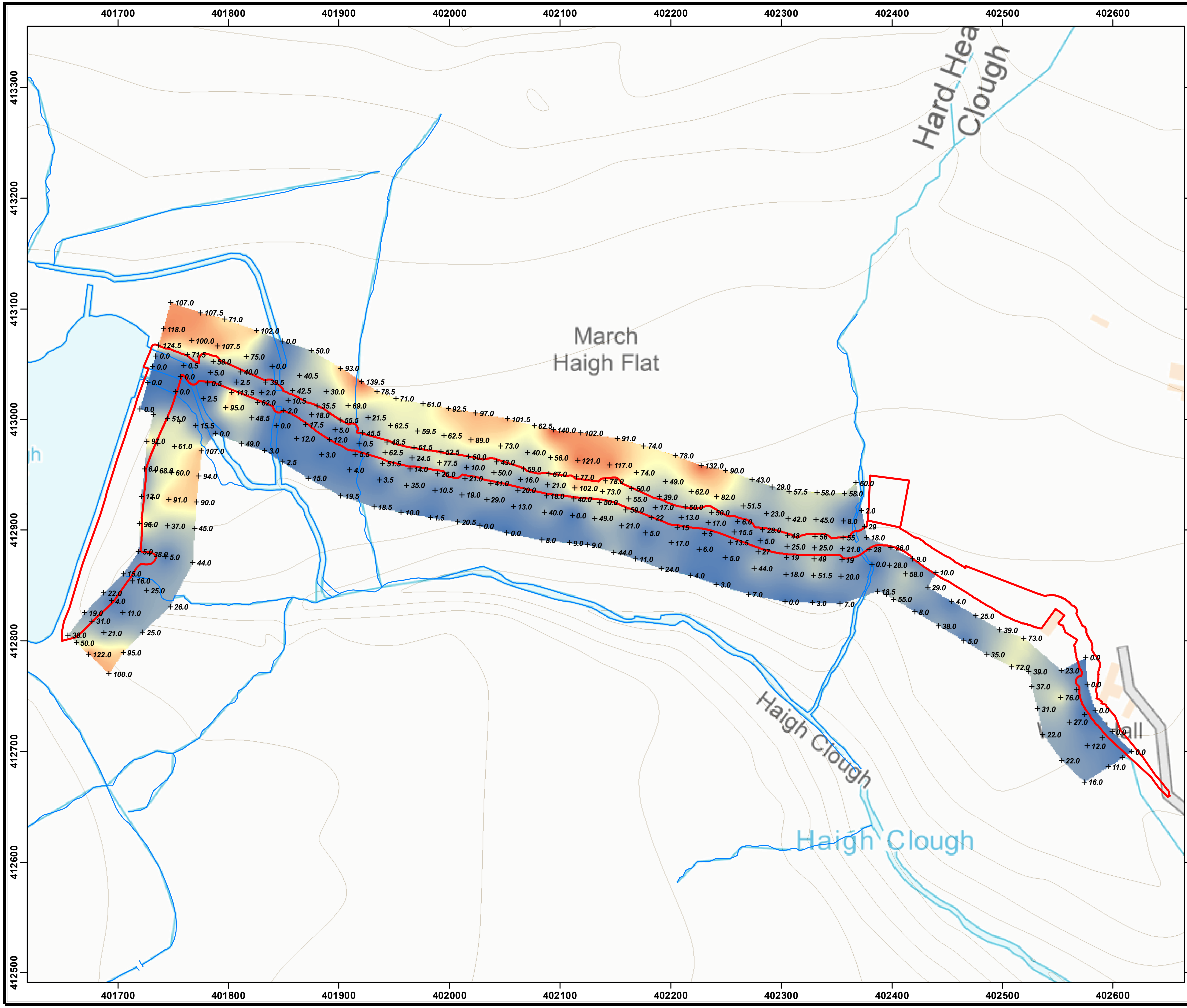
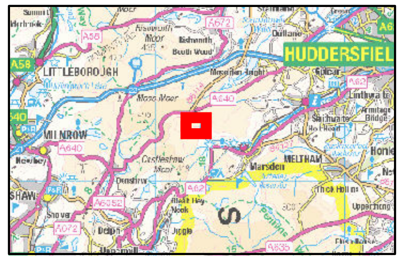
Project Name	March Haigh Reservoir
Discipline	Ecology
Title:	PEAT DEPTH MEASUREMENTS

Scale	1:3,200	Drawing No.	Figure 3		
Drawn By	CC	Originator	SRS	Date	08/03/2023
PAA Ref.				Revision	1.0

Figure 3 - Peat Depth Survey Measurements - CART02-1 CC 230308.mxd





Legend

Works area - red line

+ Peat depth measurements

Modelled peat depth

High : 140

Low : 0

British National Grid
Projection: Transverse Mercator
False Easting: 400000.000000
False Northing: -100000.000000
Central Meridian: -2.000000
Scale Factor: 0.999601
Latitude Of Origin: 49.000000

N

ISO A3

Metres

0 25 50 75 100

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Project Name	March Haigh Reservoir
Discipline	Ecology
Title:	**PEAT DEPTH MODEL**

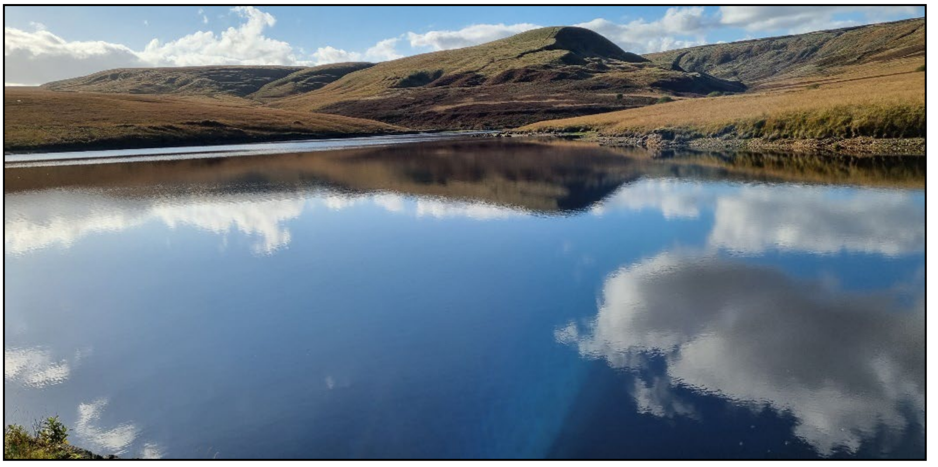
Scale	1:3,200	Drawing No.	Figure 4
Drawn By	CC	Originator	SRS
Date	08/03/2023		
PAA Ref.		Revision	1.0

Figure 4 - Peat Depth Model - CART02-1 CC 230123.mxd

APPENDICES

APPENDIX 1

Photographs



Photograph 1
March Haigh Reservoir

Photograph 2
Outflow channel from March Haigh Reservoir

Photograph 3 Overflow spillway

Photograph 4 Eroded channel below spillway

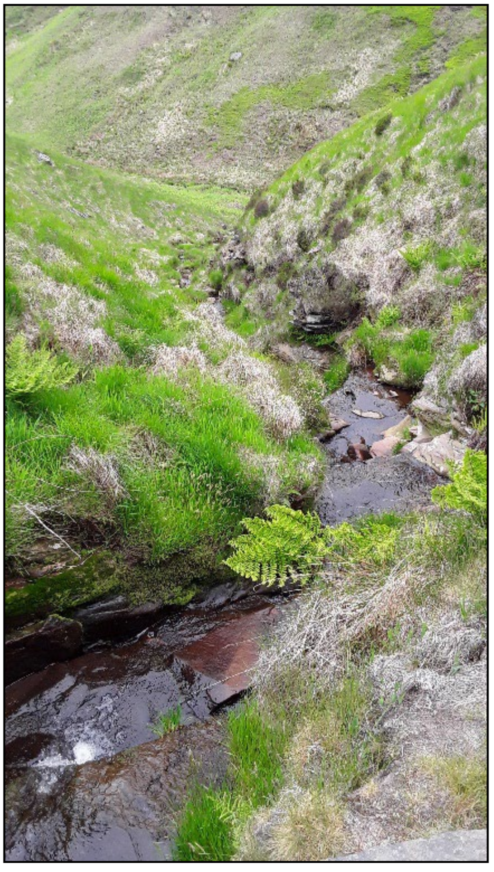
Photograph 5
March Haigh Clough

Photograph 6
Looking upstream from western bridge

Photograph 7
Downstream from western bridge

Photograph 8
Eastern survey boundary looking upstream of Hard Head Clough

Photogrph 9
Downstream from eastern bridge



Photograph 10 Stream descending to Haigh Clough

Photograph 11
Plunge pool

Photograph 12
Stepped channel exposing bedrock

Photograph 13
Minor flow channel obscured by vegetation

Photograph 14
Minor channel

APPENDIX 2

Peat Depth Measurements

Appendix 2 Peat Depth Measurements

POINT NUMBER	PEAT DEPTH TO NEAREST 0.5CM
1	60
2	58
3	58
4	57.5
5	29
6	43
7	90
8	132
9	78
10	74
11	91
12	102
13	140
14	62.5
15	101.5
16	97
17	92.5
18	61
19	71
20	78.5
21	139.5
22	93
23	50
24	0
25	102
26	71
27	107.5
28	107
29	2
30	8
31	45
32	42
33	23
34	51.5
35	82
36	62
37	49
38	74
39	117
40	121
41	56
42	40
43	73
44	89
45	62.5
46	59.5
47	62.5
48	21.5
49	69

POINT NUMBER	PEAT DEPTH TO NEAREST 0.5CM
50	30
51	40.5
52	0
53	75
54	107.5
55	100
56	118
57	29
58	55
59	56
60	48
61	28
62	6
63	50
64	50
65	39
66	50
67	78
68	77
69	67
70	59
71	43
72	50
73	52.5
74	61.5
75	48.5
76	45.5
77	55.5
78	35.5
79	42.5
80	39.5
81	40
82	58
83	71.5
84	124.5
85	18
86	21
87	25
88	25
89	5
90	15.5
91	17
92	13
93	17
94	55
95	73
96	102
97	21
98	16

POINT NUMBER	PEAT DEPTH TO NEAREST 0.5CM
99	50
100	10
101	77.5
102	24.5
103	62.5
104	0.5
105	5
106	18
107	10.5
108	2
109	2.5
110	5
111	0.5
112	0
113	28
114	19
115	49
116	19
117	27
118	13.5
119	5
120	15
121	22
122	59
123	50
124	40
125	18
126	20
127	41
128	21
129	26
130	14
131	51.5
132	5.5
133	12
134	17.5
135	2
136	62
137	113.5
138	0.5
139	0
140	0
141	0
142	20
143	51.5
144	18
145	44
146	5
147	6

POINT NUMBER	PEAT DEPTH TO NEAREST 0.5CM
148	17
149	5
150	21
151	49
152	0
153	40
154	13
155	29
156	19
157	10.5
158	35
159	3.5
160	4
161	3
162	12
163	0
164	48.5
165	95
166	2.5
167	0
168	0
169	18.5
170	7
171	3
172	0
173	7
174	3
175	4
176	24
177	11
178	44
179	9
180	9
181	8
182	0
183	0
184	20.5
185	1.5
186	10
187	18.5
188	19.5
189	15
190	2.5
191	3
192	49
193	0
194	15.5
195	51
196	0

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