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Hydrogeomorphological investigation of the main streams feeding into and out of Loweswater

Client

Lancaster University, The National Trust

Authors

Dr N Haycock

Date

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Version

final

rivers soils hydrology landscapes

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Introduction

Haycock Associates were commissioned by Lancaster University and The National Trust to undertake a hydro-geomorphological investigation of the streams into and out of Loweswater. Loweswater has been the subject of detailed hydrological and hydro-chemical investigation for a period of years, with this work being undetake by Lancaster University and the Centre of Ecology and Hydrology (CEH). In the following report, we summaries the detailed field walk that was undertaken in October 2009 and subsequent analysis of the site in November 2009.

The main aims of the report are to explore the current stream dynamics and how they interact with Loweswater. From this assessment a series of channel and floodplain restoration options are explored. The report also reviews the interaction of the lake level on the geomorphology of the Becks that discharge into the Loweswater.

In the recommendations section, we present some channel restoration options that seek to enhance the freshwater habitats of the lake and channel network.

Loweswater Catchment

Loweswater catchment is illustrated in figure 1 (below). The total calculated area of the catchment, based on OS digital terrain data held by the National Trust, is 14.0 km-sq. For the purposes of this report, we have assumed that the catchment consists of Dub Beck (NW basin), Holme Beck (SW basin and discharged into the mid point of loweswater), Highnook Beck (SSW basin and discharges downstream of lake, but debris fan aquifer is assumed to feed Loweswater), Whiteoak Beck (S

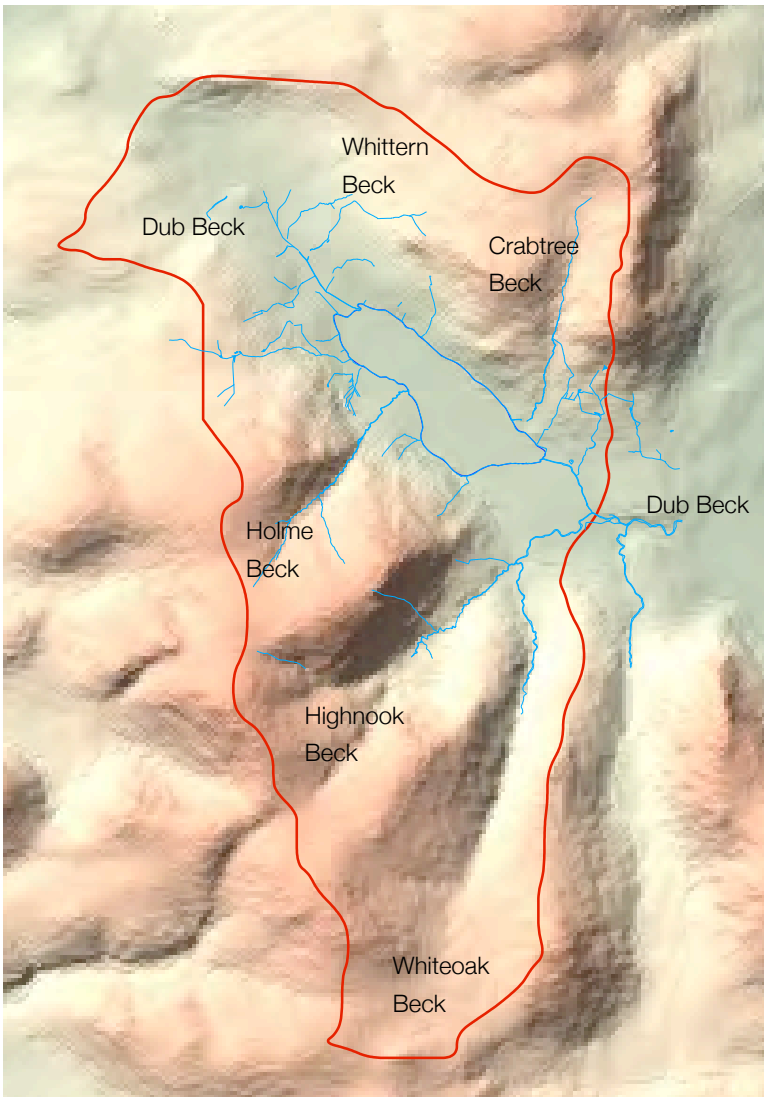


Figure 1: Loweswater Catchment Boundary

basin) and Crabtree Beck (NE basin). These catchments supply runoff and water to Loweswaters 61.4 hectares of open water.

Loweswater Channel / Becks

Of the main channels that enter Loweswater, the lower section of Dub Beck is heavily modified through channelisation and culverting of the channel. Efforts to drain the fields locally to where Dub Beck enters Loweswater seem to have occurred over a period of years, with central drains being excavated into the main floodplain, while the Beck is leated to the north of the floodplain (figure 2). Likewise, Dub Beck on leaving Loweswater (125m AOD) is heavily modified through channelisation from the lake to Maggie's Bridge. From Maggie's Bridge Dub beck flows into Crummock Water (96-98m AOD).

In the comments below, a key tributary of Dub Beck named Whittern Gill (flowing near Graythwaite, figure 1) is of key interest. The lower section of this Beck flows over an active debris fan and the elevation of this channel and the state of the confluence of this Beck with Dub Beck is of concern (figure 2).

Holme Beck, which drains Burnbank Fell, represents a semi natural channel form, especially above Holme Force. Below Holme force the channel has small levels of channel intervention works (revetment) but the main feature is that the channel flows over a large debris fan associated with the erosion of the high level morraine material in Holme Beck valley above the Force (waterfalls, figure 2).

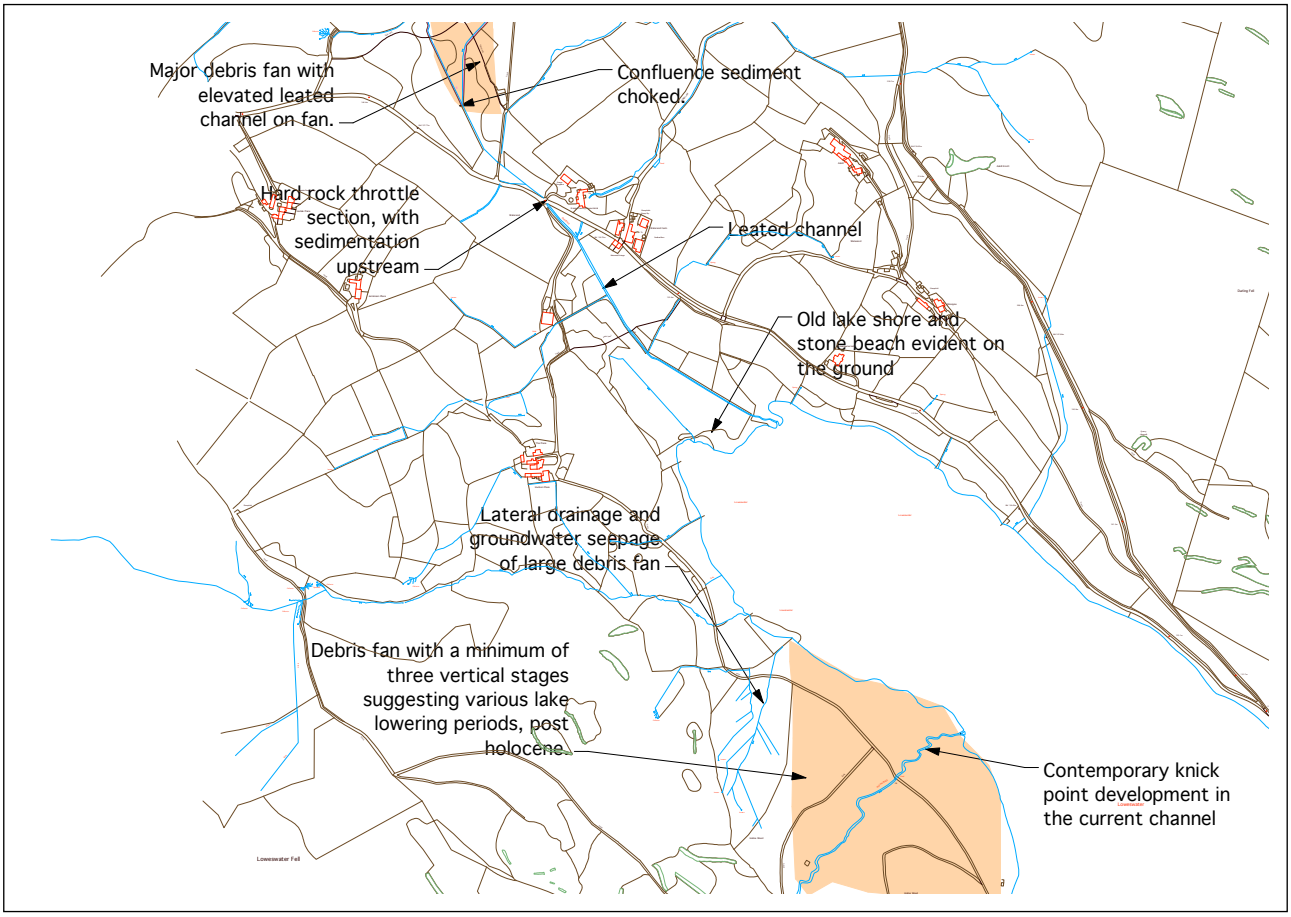


Figure 2: Annotations on Main Geomorphological Features - Dub Beck

The final 50m of Holme Beck, before entering Loweswater, is modified with revetment and also shows stages of vertical erosion into the channel bed. Relative to the 1937-1938 maps of the lake, Holme Beck seems to enter Loweswater further east. To the south of Holme Beck is Highnook Beck.

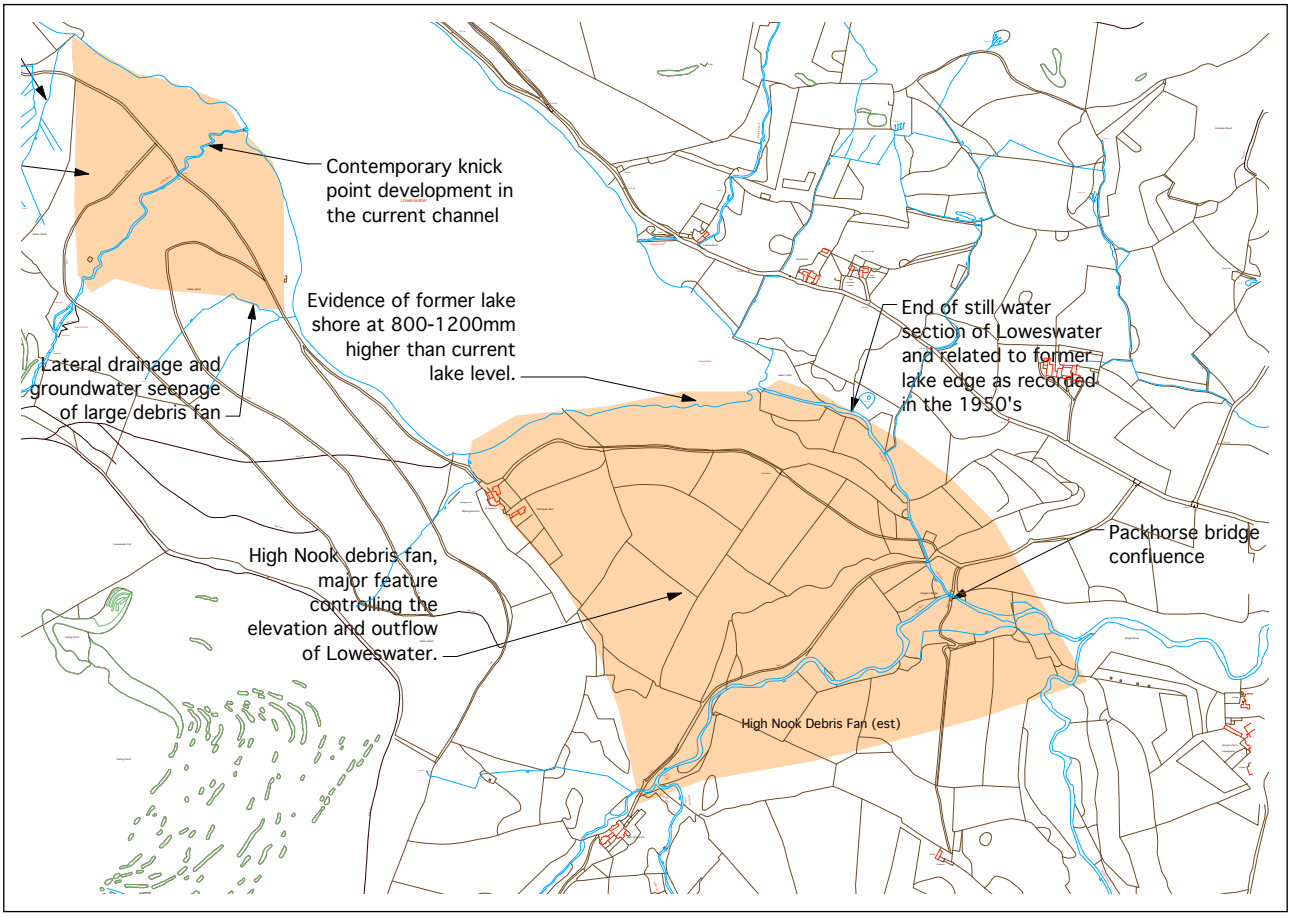


Figure 3: Annotations on Main Geomorphological Features - High Nook

Highnook Beck rises on Lamplugh Fell and flows past High Nook farm building before joining Dub Beck just upstream of Maggie's Bridge. Below High Nook Tarn, the channel enters a deep incised valley associated with erosion of morraine material. This eroded material has formed an extensive debris fan, which start locally to High Nook farm and spreads westwards to Loweswater and eastwards and down to Maggie's Bridge. On the surface of the debris fan are a number of relic channel suggesting that Highnook Beck in the past had a more direct route to Loweswater, but this channel now flows on the eastern side of the debris fan. Joining Highnook Beck is Whiteoak Beck. This valley was not walked in October 2009, but the sediment supply from this valley system appears to have contributed to form the large debris fan that now exists at the southeastern end of Loweswater (figure 3).

Figure 4: Image of Highnook Beck (left) and Dub Beck (right) confluence at Maggie's Bridge, October 2009.

The sediment supply was Highnook Beck seems the largest source of material movement in the valley complexes visited. Figure 4 shows the channel becks of Highnook and Dub's Beck at Maggie's Bridge. Highnook beck seems to be frequently scouring its bed not allowing any algae or benthic vegetation to establish, while Dub Beck (right of image) shows mature benthic algae accumulation on the stream bed.

Further detailed notes on the October 2009 site inspection are to be found in Appendix 1 with corresponding images of key stream sections and floodplain images in Appendix 2.

Loweswater - Contemporary Lake Levels.

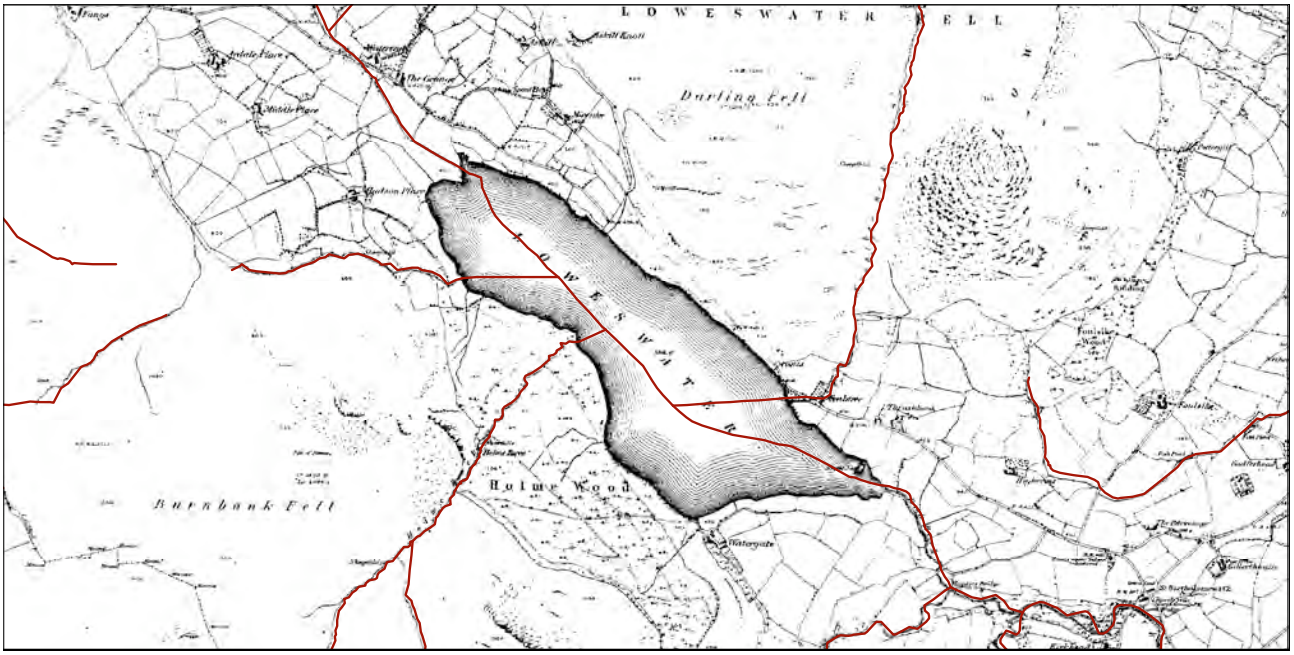


Figure 5: First Series OS map of Loweswater, c. 1860

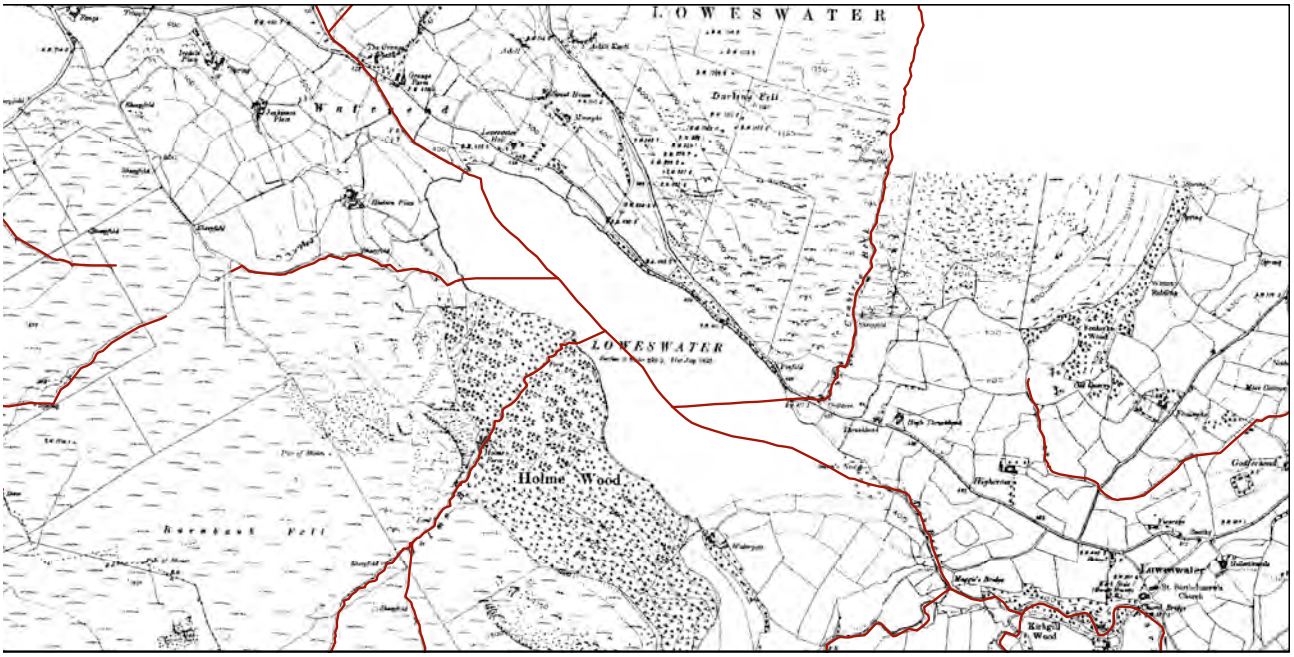


Figure 6: OS map of Loweswater, c. 1930

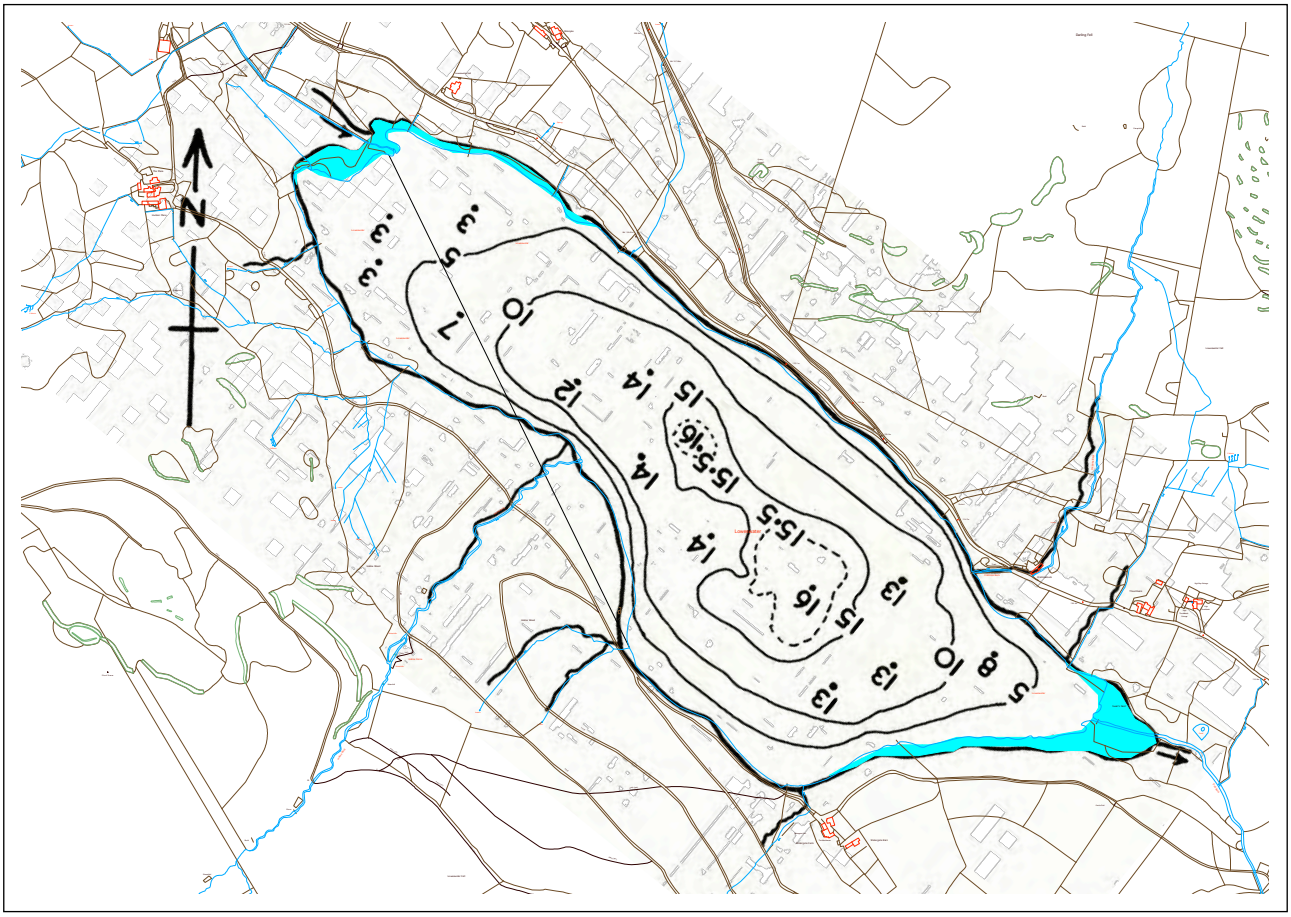


Figure 7: Bathometric Map of Loweswater 1937-1938, Ramsbottom A.E. (1976). Depth charts of the Cumbrian Lakes. Freshwater Biological Association Scientific Publication No. 33. Titus Wilson & Son Ltd. Kendal. Areas in solid light blue show areas where lake shore differs between 1938 and 2009.

In figures 5-7, maps have been collated that seem to suggest that post 1938 the water level in Loweswater was lowered, resulting in the current shoreline being mapped in a different location, especially in the south east and north western shoreline. The bathometic survey of 1937-1938 and also OS maps prior to 1930 suggest that lake levels may have been 0.5-1.0m higher than the current location with the lake area reducing from 64 hectares to 61.3 hectares. This lowering may have reduced the lake volume by 7%, from an estimated 5.4 million cubic metres to 5.02 million cubic metres.

Discussions with Lancaster University and the community forum have not identified a date when this possible lake lowering occurred. It is speculated that the channelisation of Dub Beck either through the WWII years of prior to 1960's would have been a period when drainage may have occurred.

Loweswater - Hydrogeomorphology Initial Field Observation

Following the field walk in October 2009, additional digital terrain model information was secured from the National Trust and Lancaster University. This data plus additional meetings with Lancaster University, National Trust and key land owners of Loweswater has lead to the following observations.

1. The lake level of Loweswater is critically influence, in storm periods, by the flow and water level of Highnook Beck at Maggie's Bridge.

2. National Trust staff have observed water flowing from Highnook Beck into Loweswater, when a major flood is passing though this Beck and when flows from Dub Beck and Holme Beck have not surcharged Loweswater.

3. The possible lowering of Loweswater and the channelisation of Dub Beck along the perimeter of Highnook Debris fan (figure 8) further supports the dominant role that Highnook plays in the flows from Loweswater. If high sediment loads from Highnook block the channel at Maggie's Bridge, then water levels in Loweswater is rise.

4. The possible lowering of Loweswater appears to be represented in the creation of erosion knick points within Holme Beck, with further evidence of a higher shoreline represented in the tree line of this shore. Main trees are all present >600mm from current lake water levels.

5. At the north western end of Loweswater, Dub Beck has been extensively channelised, but evidence of a former shoreline is present in the current sedge mire (figure 9).

6. Dub Beck is not a major course sediment supply channel for Loweswater, the presence of valley mires and smaller debris fans upstream of the Grange Hotel effectively adsorb this material, with evidence of channel blockages witnessed in October 2009.

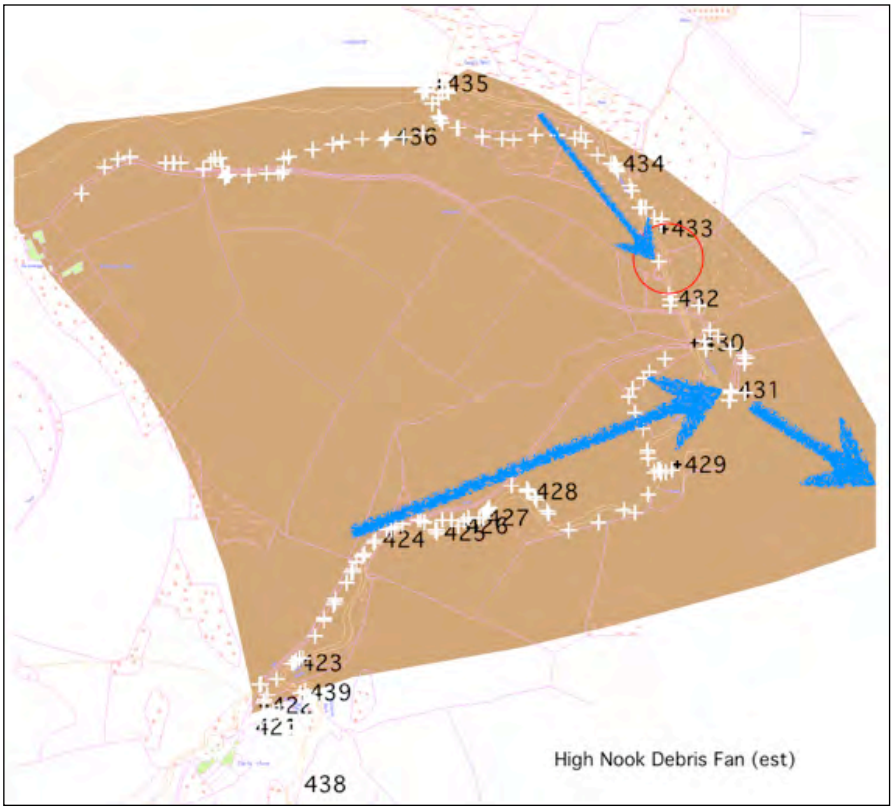


Figure 8: Annotated map of Highnook Beck and its dominance of Dub Beck, discharging from Loweswater at the norther perimeter of Highnook Debris Fan (shaded in tan).

Figure 9: Image of former shoreline at Dub Beck floodplain in the north western section of Loweswater.

Loweswater - Channel modification and restoration options

Dub and Whittern Beck Confluence

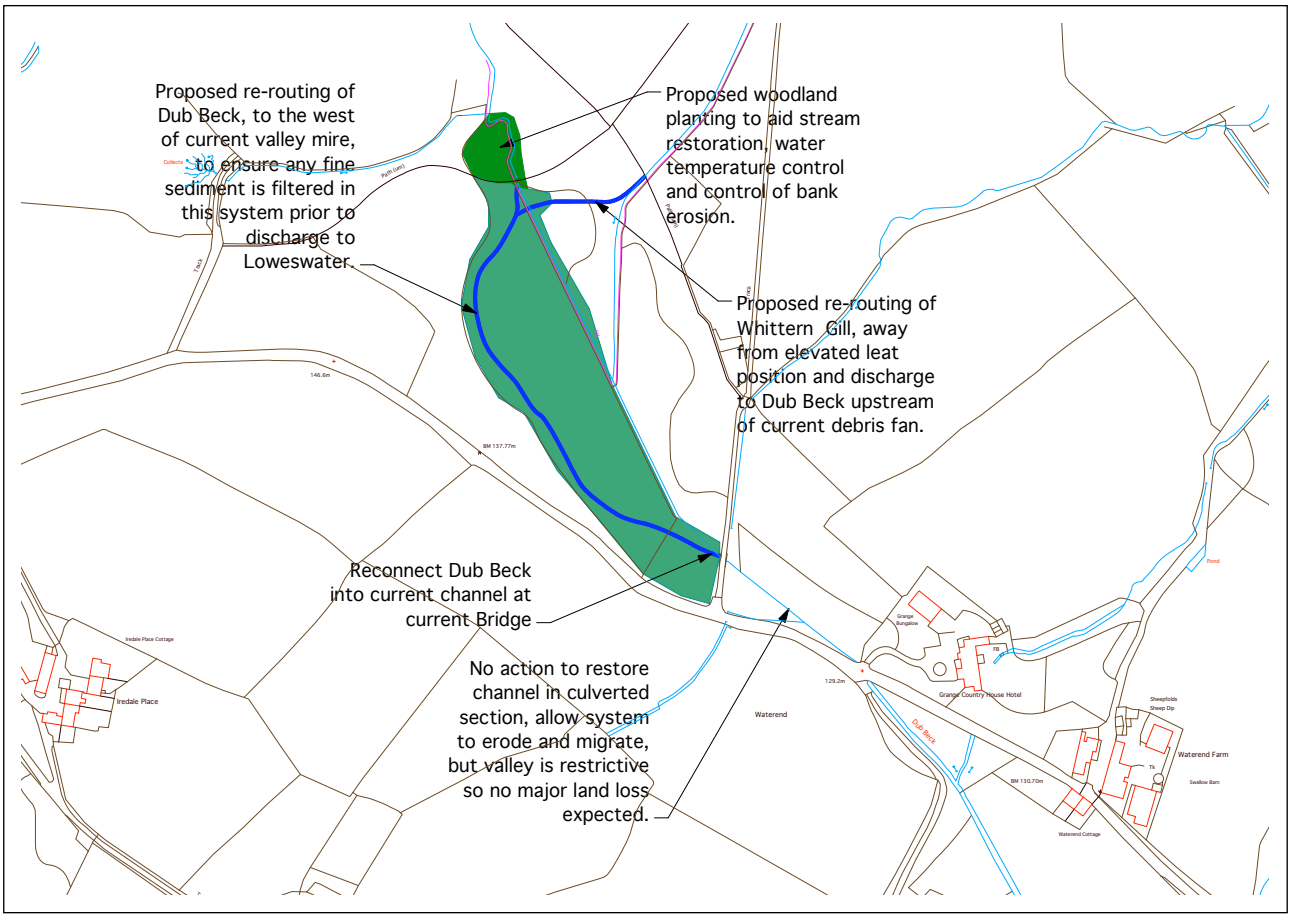


Figure 10: Annotation of options to re direct Dub Beck and Whittern Beck confluence.

The option for Dub and Whittern Beck confluence is to seek to utilise the existing valley mire (figure 10), to the west of the current channel, and in doing so allow this area to become the key wetland within this section of the valley. In re directing Dub beck to the west, the confluence of Dub with Whittern should be moved, since the high sediment supply of Whittern Beck needs to be accommodated and currently this sediment is accumulating in the channel and resulting in poor drainage of three fields. The new pathway would allow additional sediment storage in the floodplain and improve habitat dynamics for the wetland mire, which would be consistently hydrated.

Dub Beck at the inflow to Loweswater

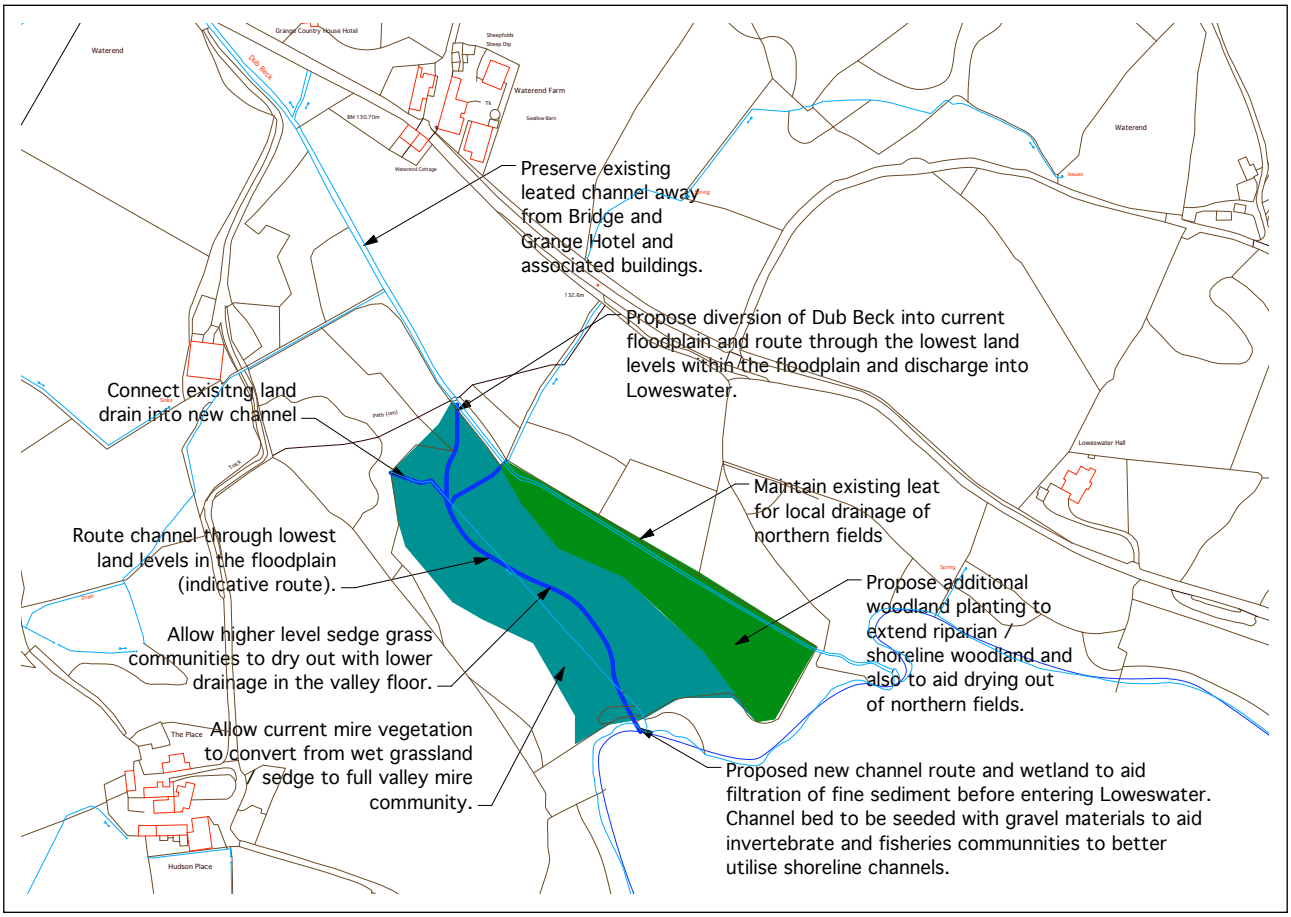


Figure 11: Annotation of options to re direct Dub Beck into Loweswater.

The option for Dub Beck, prior to flowing into Loweswater, is to create a restored channel and floodplain. The current channel is leated to the north of the floodplain and is resulting in poor drainage of non floodplain land, but also depriving the current floodplain of water and sediment. The proposal is therefore to re define the channel in the lowest portion of the floodplain, the channel to be small and thereby allow excessive flood water to discharge over the floodplain, thus allowing water to filter through the floodplain before entering Loweswater (figure 11). The current leat would be kept to allow normal drainage of the northern fields. This option would not be impacted excessively if Loweswater lake level was raised.

Dub Beck at the outflow to Loweswater

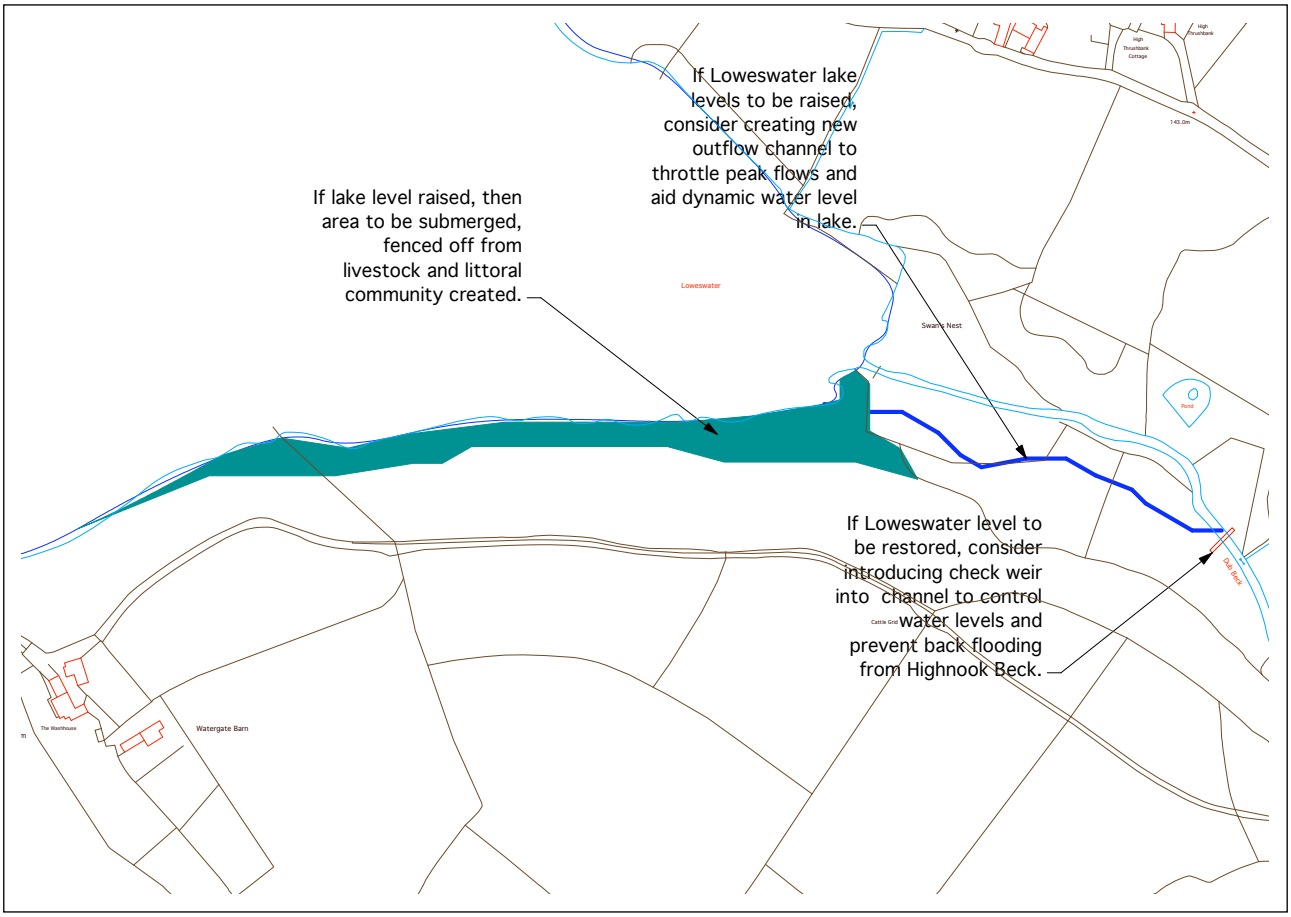


Figure 12: Annotation of options to re direct Dub Beck out flowing from Loweswater.

If there was an intension to raise the water level of Loweswater to the estimated levels prior to 1938, then it is recommended to undertake this through the use of a small check weir (or series of weirs with <200mm steps, figure 12). This weir would be served by a new smaller outflow channel, which would throttle the flow of water from Loweswater thereby allowing a more natural water level regime to be introduced into the lake.

Dub Beck at the outflow to Loweswater

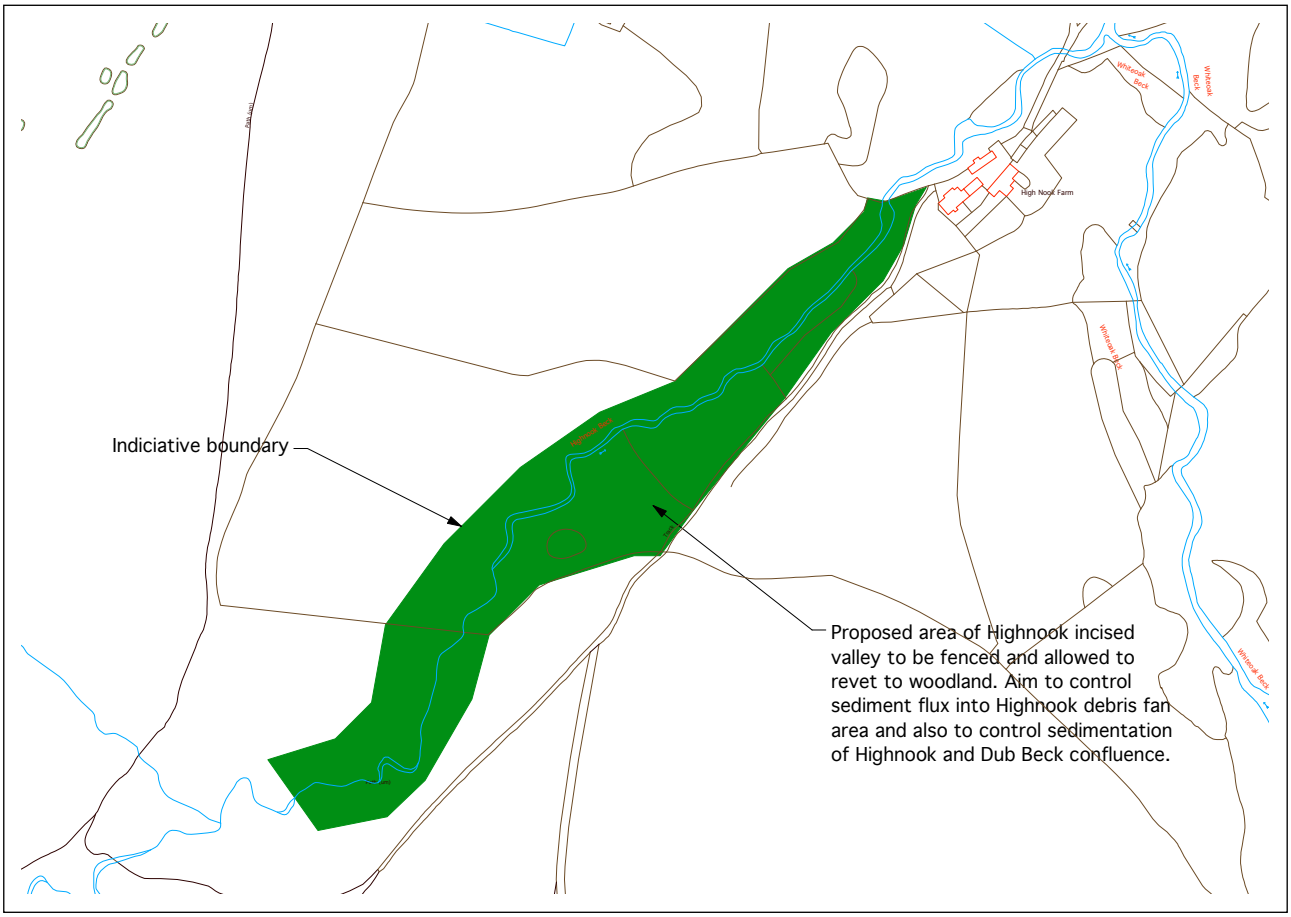


Figure 13: Annotation of options to reduce sediment supply from Highnook Beck.

The sediment supply and incised valley erosion in High Nook Beck needs to be controlled as the rate of sediment supply seems excessive, with stream bed erosion downstream accelerating. The current valley is used to herd sheep to Highnook farm, and the fencing of the valley needs to be associated with creating an effective livestock route to the farm and associated holding areas. The fencing of these features, as undertaken in Wharfedale (Yorkshire Dales) by the National Trust resulted in 80% of the sediment supply to the main river being reduced. Therefore we would recommend this option to the National Trust.

Summary

1. The field inspection of the channels of Loweswater has revealed some contemporary erosion dynamics which we believe to be associated with the lowering to the water surface of Loweswater post 1938. This has resulted in vertical incision of the channel in Holme Beck and also some limited channel erosion on Dub Beck before it flows into Loweswater.

2. Channelisation and revetment of Dub Beck as it flows out of Loweswater, and for a small section of Holme Beck seem to be associated with drainage works post 1938. Drainage works on Dub Beck and Whittern appear to be more historical, with the culverting of Dub Beck at the Grange Hotel from a much earlier era.

3. There appear to be some options to create additional floodplain wetlands, especially on Dub Beck and Whittern Beck, which may result in the reduction of fine sediment entering Loweswater from these catchments.

4. There are not recommended options for Holme Beck, apart from allowing the current geomorphological processes to continue. The current rate of bed and back erosion may reduce locally to the shoreline if Loweswater lake level was restored.

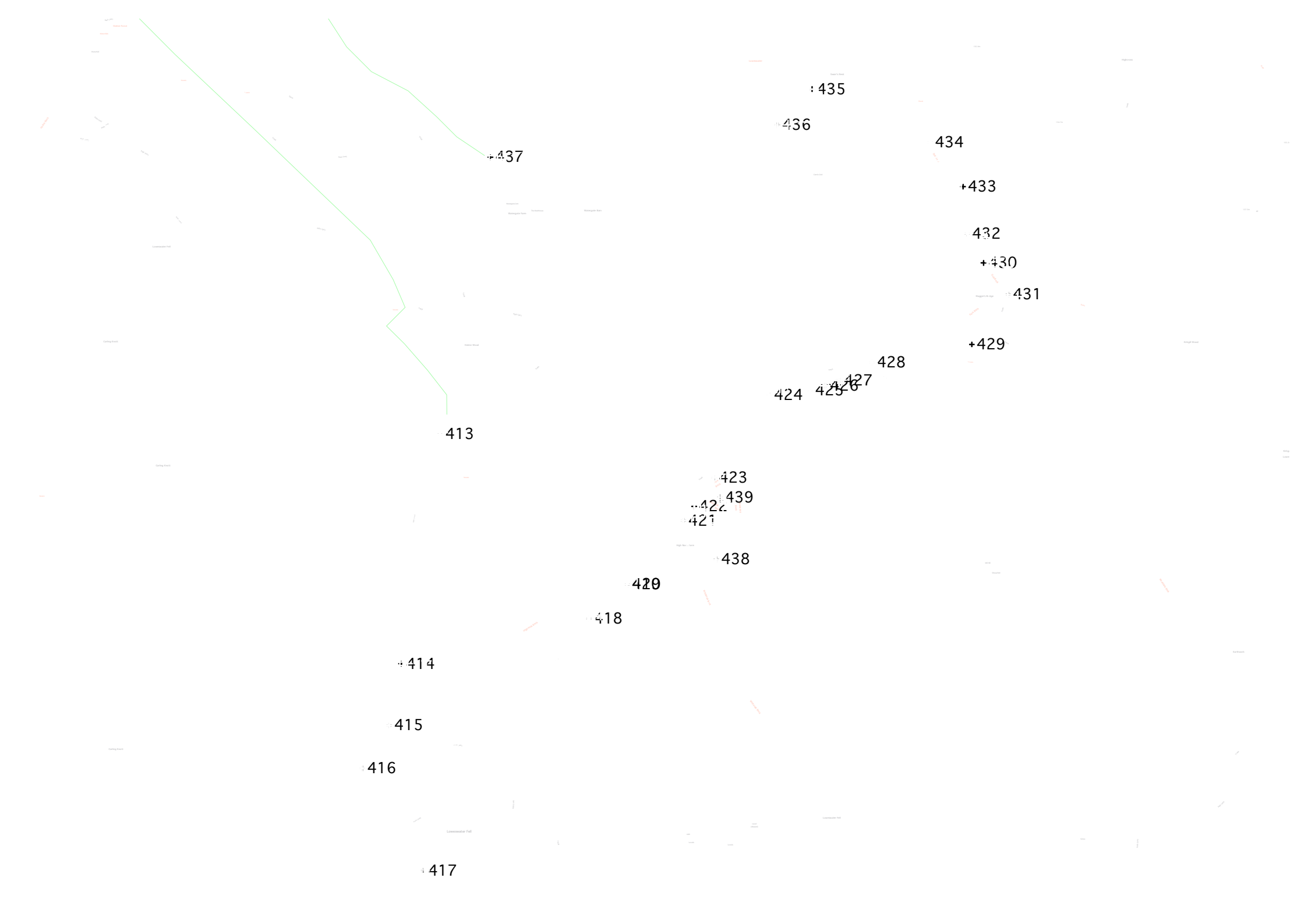
5. Options to restore the lake level of Loweswater need to be considered relative to the dynamics of the lakes ecology and hydro-chemistry. Land owners views needs to be sought and the detailed impact of such a measure needs to be considered.

6. The fencing of the incised Highnook Beck valley needs to be strongly considered, in order to reduce sediment supply to the lower sections of the channel, before Maggie's bridge.

Appendix 1: Field Annotation notes with GPS coordinates (OS GB)

ID	OS_X	OS_Y	OS_Z	Map_ID	Notes	Photo				
1	311726	522404	0	367	leated channel, left floodplain	IMG_1310				
2	311710	522352	0	368	floodplain ditch, dry, iron stains	IMG_1309				
3	311790	522360	0	369	leated channel, 1m base width, 20cm flow depth, wrack left and right	IMG_1312				
4	311853	522321	0	370	leated levee, woodland floodplain left	IMG_1314				
5	311869	522312	0	371	water scum, leat	IMG_1315				
6	311889	522296	0	372	flow into woodland and delta	IMG_1316	IMG_1317			
7	311925	522286	0	373	end of delta, base width 2m, course silt	IMG_1318	IMG_1319			
8	311862	522278	0	374	high level lake shore, 20m inland	IMG_1320				
9	311784	522276	0	375	floodplain ditch, mid point, no flow	IMG_1321				
10	311768	522264	0	376	boundary wall ?	-				
11	311721	522268	0	377	right floodplain, looking us., sedge dominated, tree planting, under story grazed	IMG_1322				
12	311673	522393	0	378	drain start, two piped land drains	IMG_1323				
13	311703	522417	0	379	left bank revetment, right break out point to floodplain	IMG_1324				
14	311697	522423	0	380	right break out point, top of old delta on left floodplain	IMG_1325				
15	311682	522442	0	381	foot bridge section of floodplain	IMG_1326	IMG_1327			
16	311668	522464	0	382	floodplain sediment with red silt bank, course drop zone from old delta	IMG_1328				
17	311656	522498	0	383	right floodplain saturated, confluence upstream	-				
18	311609	522583	0	384	leat channel, 3m wide, glide, channel left floodplain, tree right bank	IMG_1329				
19	311602	522598	0	385	right floodplain, woodland at confluence, chennel glide, no sedimentation, sedge line right bank	IMG_1330	IMG_1331			
20	311631	522539	0	386	right bank, old levee with trees, confluence inflow					
21	311645	522514	0	387	pipe inflow, left bank from house					
22	311551	522485	0	388	right confluence, 1m wide, through levee					
23	311597	522623	0	389	sillage bales within 5m of confluence, barn used for hay, but was cattle	IMG_1332				
24	311565	522639	0	390	confluence left bank, confined valley, left and right steep bank					
25	311542	522671	0	391	bed large boulders and slabs	IMG_1333				
26	311512	522690	0	392	first bridge, 2m base width	IMG_1334				
27	311456	522737	0	393	small floodplain with stone culvert drain near grange hotel	IMG_1335				
28	311458	522771	0	394	bridge 2, box drain, left and right floodplain, looking downstream	IMG_1336				
29	311408	522958	0	395	high sediment load drain, almost blind	IMG_1337				
30	311391	522995	0	396	leat, elevated tributary on left floodplain, bed 2m above floodplain, stile footpath	IMG_1338	IMG_1339			
31	311331	522959	0	397	old track to farm house, raised form	IMG_1340	IMG_1341			
32	311333	522990	0	398	channelised floodplain, confined floodplain, footbridge					
33	311321	523031	0	399	first section of semi natural channel, meander and point bar, pool and riffle with 10cm fall	IMG_1342	IMG_1343			
34	311291	522935	0	400	broad channel with cattle access	IMG_1344				
35	311164	522956	0	401	right floodplain with channel in the tree line, 50m wide					
36	311906	523010	0	402	high level plateaux mire around knoll	IMG_1345				
37	311972	523040	0	403	large cross slow interception drain / rill, 3m deep	IMG_1346				
38	312197	522717	0	404	photo of valley wall and evidence of mining, upper catchment larch and fir plantation	IMG_1347	IMG_1348	IMG_1349		
39	312404	522468	0	405	delta area into lowerwater, image 1353 note large delta into the lake	IMG_1350	IMG_1351	IMG_1352	IMG_1353	
40	312487	522238	0	406	delta on south west shore, deep incut into colluvial material, water fall	IMG_1354				
41	311812	522486	0	407	view back to delta	IMG_1355				
42	311821	522019	0	408	end on phase 1 walk					
43	311830	521935	0	409	SW lake shore, phalaris stand in the lake	IMG_1356				
44	311838	521883	0	410	large tributary, more flow than main valley	IMG_1357	IMG_1358			
45	312264	521754	0	411	enter woodland, GPS off					
					sw delta stream tributary, upstream of footbridge	IMG_1359				
					debris field	IMG_1360				
					sedimentation and local down cutting, knick point in channel	IMG_1361				
					delta into lake, revetment and down cutting, knick point local to bridge	IMG_1362	IMG_1363			
46	312025	521517	0	412	delta of sw catchment into lake, debris field, clean stream section	IMG_1364				
					upstream of 2nd footbridge, incised section, deposition ds. Of footbridge	IMG_1365				
					large boulder field section	IMG_1366				
47	312519	520710	0	413	upper old debris fan, with secondary down cutting, 150m upstream of footbridge, water fall	IMG_1367	IMG_1368	IMG_1369	IMG_1370	IMG_1371
48	312452	520319	0	414	out of woods and into High Nook	IMG_1372	IMG_1373			
49	312432	520214	0	415	ds. Into high nook, down cutting into the morraine	IMG_1374	IMG_1375			
50	312386	520141	0	416	us. Into morraine floor and carrie	IMG_1376				
51	312490	519966	0	417	downcut morraine, local to footbridge in high nook	IMG_1377				

52	312772	520396	0	418	corrie, mire images	IMG_1378	IMG_1379	
53	312837	520454	0	419	high nook incised channel into morraine	IMG_1380		
54	312837	520454	0	420	cliff in morraine, valley confluence on right	IMG_1381		
55	312933	520563	0	421	break in colluvial slope form, suggest delta edge form			
56	312951	520587	0	422	break in colluvial slope	IMG_1382		
57	312985	520636	0	423	confluence on right bank, down cutting old delta form / debris fan, cross check elevation wit SW	IMG_1383	IMG_1384	
58	313079	520777	0	424	nook channel elevation relation to right floodplain, left debris field higher than channel	IMG_1385		
59	313149	520785	0	425	channel through debris fan	IMG_1387		
60	313174	520793	0	426	leat revetted on right bank	IMG_1386		
61	313198	520802	0	427	end of revet section			
62	313254	520832	0	428	channel migrating right of debris fan, revetment issues			
63	313424	520863	0	429	leat and old gill channel merge, junction of large valley debris fan	IMG_1388	IMG_1389	
64	313444	521002	0	430	loweswater bridge, us. Of confluence	IMG_1390		
65	313486	520948	0	431	packhorse bridge, see stream bed colour, high nook scour bed, non scour from loweswater	IMG_1391	IMG_1392	
66	313416	521052	0	432	stable stream bed, algae and vegeatation, fine sediment stored	IMG_1393		
67	313409	521132	0	433	still water section, evidence of higher relic channel, lake lowered ?, no sediment from high nook	IMG_1394		
68	313353	521207	0	434	channel blockage with phalaris and reed			
69	313152	521298	0	435	outflow from loweswater, channelised outflow ds. Of lake, little or no littoral edege, sad lake	IMG_1395	IMG_1396	IMG_1397
70	313093	521237	0	436	edge grazing	IMG_1398		
71	312604	521182	0	437				
72	312989	520497	0	438				
73	312995	520602	0	439				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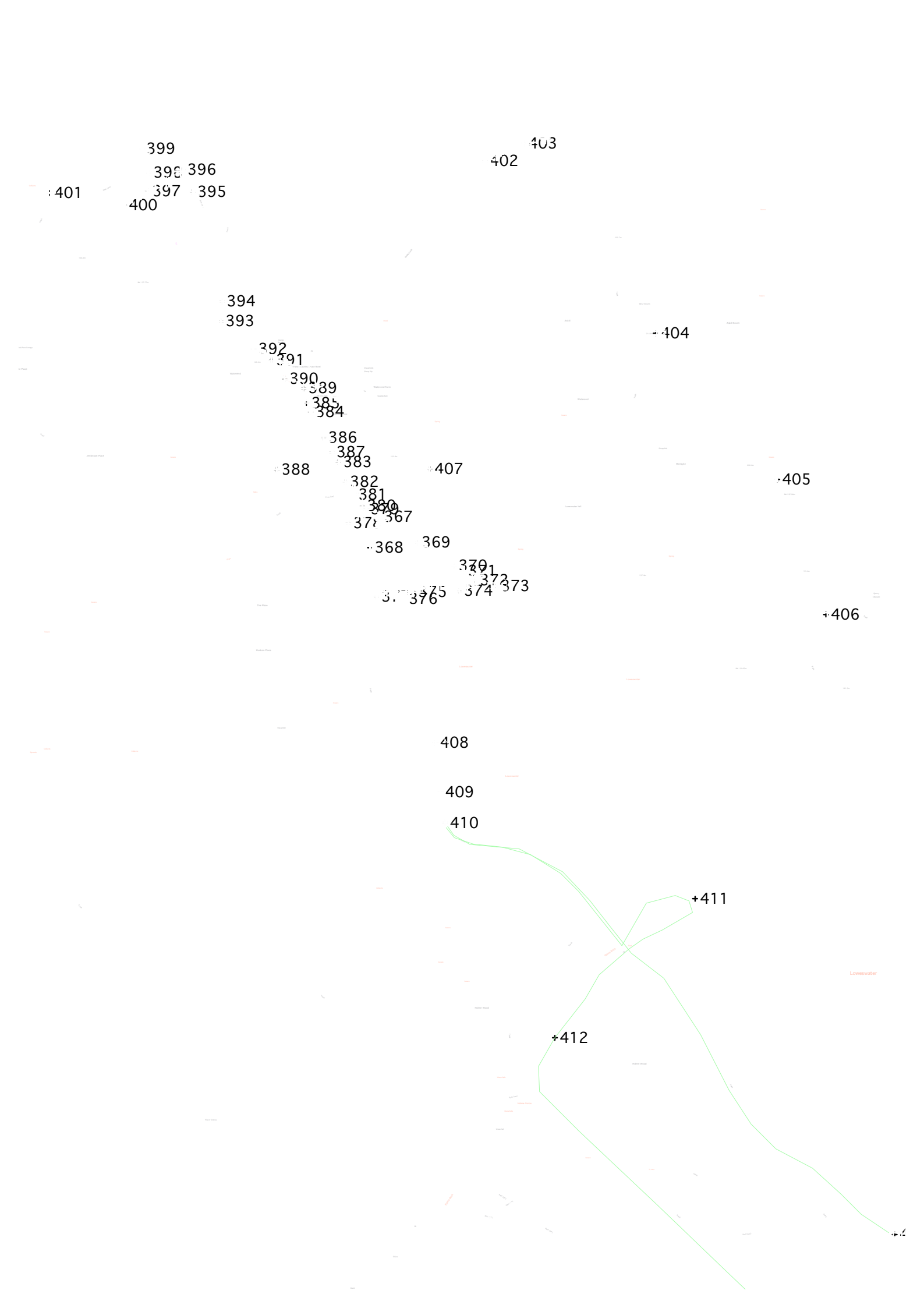
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Appendix 2: Photograph thumbnail images of the October 2009 site walk.

For locations and coordinates of images see Appendix 1

IMG_1309

IMG_1310

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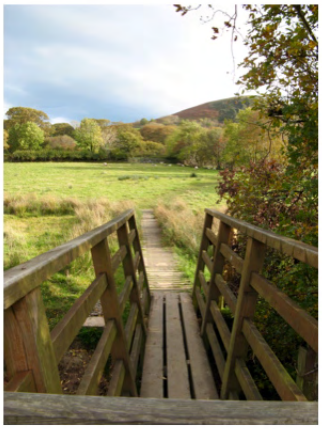

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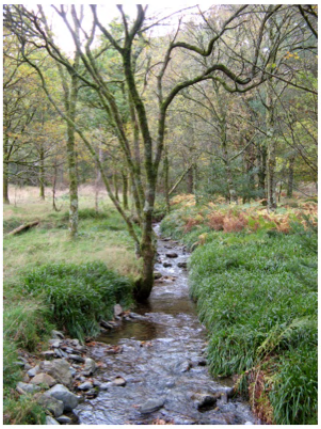

IMG_1358

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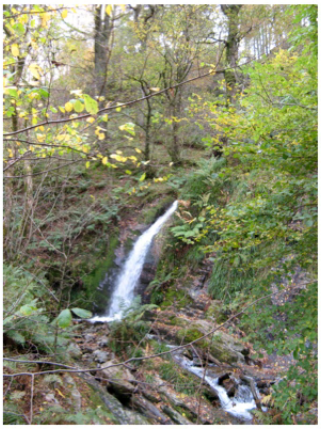
IMG_1366

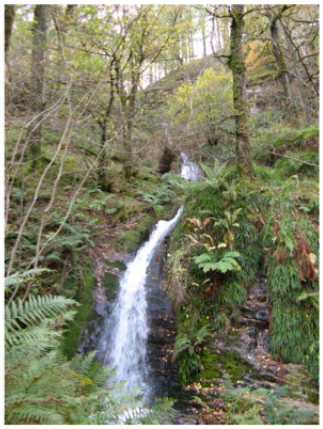
IMG_1367

IMG_1368

IMG_1369



IMG_1370



IMG_1371

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IMG_1398

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IMG_1401

IMG_1402

IMG_1403

IMG_1404

IMG_1405

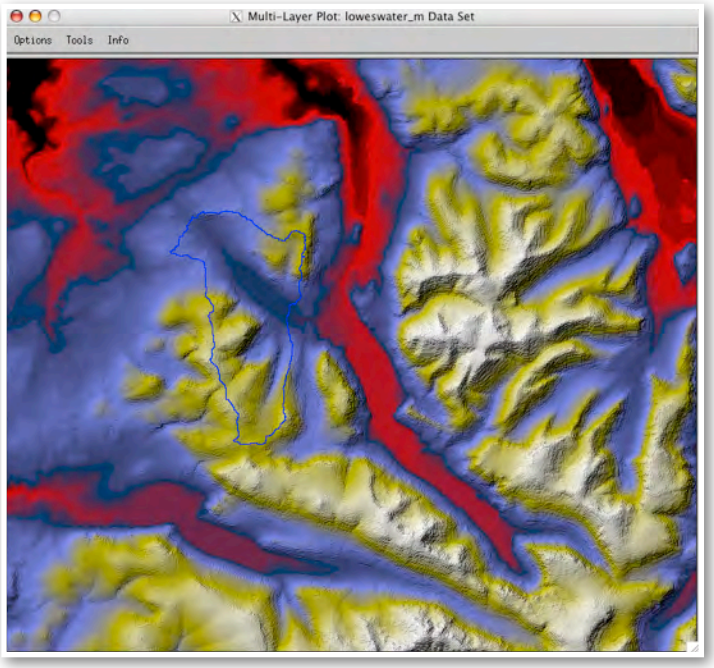
Appendix 3: Catchment Area Statistics.

Attributes of the loweswater_lake Basin

Outlet x-coordinate: 313277.00
Outlet y-coordinate: 521068.00
Outlet pixel ID: 219359
Outlet parent pix. ID: 219360
Outlet elevation: 128.700 (m)

Basin area: 13.968110 (km^2)
Basin relief: 0.43600000 (km)

Pruning method: Area
Pruning threshold: 0.000625000
Strahler order: 7
Network magnitude: 6720
Network diameter: 159
Longest channel length: 5.5612702 (km)
Total channel length: 653.50745 (km)
Drainage density: 46.785675 (km^-1)
Source density: 481.09586 (km^-2)



Note: The last set of attributes depend on
the user-selected pruning method.
