BORD NA MÓNA - OUGHTER BOG

Drainage Management Plan

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EXECUTIVE SUMMARY

Oughter Bog is located adjacent to the R357 in Co. Offaly, circa 3km to the west of Blueball. Oughter Bog lies to the south of the River Brosna and is drained by a number of its tributaries. The Grand Canal is located to the north of Oughter. Oughter is linked to the adjacent Turraun Bog

The rehabilitation measures will generally result in reduced runoff and drainage from the existing peat fields through a mixture of techniques including drain blocking, cell bunding, re-profiling and wetland creation. It is assumed that these measures will not significantly alter the existing topographical catchments and that the spine of the drainage networks, those which the upstream catchments drain through, will be retained by Bord na Móna.

Three potential impacts were considered: the potential to reduce the drainage function to upstream lands, the potential for increased flows downstream and the potential for increased groundwater levels impacting adjacent lands. There is no potential for increased flows downstream and the rehabilitation of Oughter Bog, based on evidence from other bogs, will reduce the runoff from the bog by returning the peatlands towards its natural water retention function. The avoidance of reduced drainage function to upstream lands depends on Bord na Móna retaining the drainage routes which traverse the bog upon which drainage of adjacent and upstream lands is dependent.

The potential for increased groundwater levels and to a lesser extent marginal alteration of the topographical catchments has been assessed based on a precautionary approach. With drainage routes retained it is assumed that groundwater levels will reach the surface of the re-profiled peat fields throughout some of the bog. However there are large hollow areas where wetland creation will occur. In these scenarios adjacent lands which are at a lower level than the bog could potentially be impacted and vulnerable areas have been defined through a zone of influence approach.

Each of the land parcels have been assessed based on its vulnerability to increased groundwater levels within the bog. In most cases there exists a boundary drain separating the rehabilitation area from the potentially vulnerable lands. Best evidence has shown that these drains provide a positive gravity drainage function and through retaining them, and in some instances upgrading them, they should prevent any groundwater impacts on adjacent lands due to the hydrogeological break / cut-off they provide. Where no boundary drain exists between the bog and adjacent lands, the retention of a buffer area of bog with functioning internal drains is recommended for retention. For areas where the creation of wetland is proposed as a rehabilitation measure, the maximum allowable water level has been determined such that backwater flooding to lands surrounding the bog does not occur.

There are some limitations with this approach namely the effect of backwater levels and the lack of detailed survey of the boundary drainage network. Given the low level of risk at Oughter it is appropriate in most cases that the DMP measures involve initial survey, monitoring and retention of the boundary drainage network to ensure its ongoing functionality. A suite of measures was identified in order to mitigate any deterioration in the drainage to adjacent lands should monitoring of these lands indicate a groundwater or drainage impact on these lands. The upgrading of boundary drains and the control of water levels in wetland areas are proposed as higher intervention measures to be implemented following valid concerns from stakeholders. Together with

the retention of the boundary drainage network these measures will ensure the rehabilitation measures do not negatively impact the adjacent lands.

1 INTRODUCTION

Oughter Bog is part of the Boora Bog Group. Bord na Móna operated peat extraction within the Boora Bog Group under IPC Licence (Ref. P0500-01) issued and administered by the EPA. Condition 10.2 of this licence requires the preparation of a Rehabilitation Plan for permanent rehabilitation of the boglands within the licensed area.

It is proposed by Government that Bord na Móna carry out enhanced decommissioning, rehabilitation and restoration under the Peatlands Climate Action Scheme on peatlands previously used for energy production. This proposed Scheme will significantly go beyond what is required to meet rehabilitation and decommissioning obligations under existing EPA IPC licence conditions. Improvements supported by the Scheme will ensure that environmental stabilisation is achieved and significant additional benefits, particularly relating to climate action and other ecosystem services, will also be delivered.

A key issue for Bord na Móna is the potential hydrological impact rehabilitation that this bog may have on the bog, surrounding lands and lands downstream which may be hydrologically linked to the bog. Rehabilitation measures generally seek to increase groundwater levels and surface water retention such that they are closer to the surface to encourage peat formation, the associated ecological benefits and carbon sequestration capacity. While in general terms this will reduce the volume of water released from the bog following a rainfall event, the impact on flood run-off is not well understood. Furthermore the increase in the local water table could result in negative impacts to surrounding lands if mitigation measures are not applied (e.g. to agriculture).

This Drainage Management Plan (DMP) for Oughter Bog seeks to establish the baseline hydrological performance of the bog and the surrounding drainage network. The plan sets out the characterisation of the bog and surrounding lands, the existing performance of the drainage network and the level of flood risk. The plan identifies the potential hydrological zone of influence of the bog and the objectives, risks and opportunities associated with the rehabilitation of the bog. The plan assesses the potential impact of the various rehabilitation measures which are proposed on the local drainage network and flood risk. It sets out, where necessary, mitigation measures required to reduce impacts to an acceptable level. The plan sets out the measures which are required to be delivered in advance or in parallel with the rehabilitation plan as well as the long term operation and retention of the drainage network and associated infrastructure. The plan assesses the level of residual risk, the potential impact due to climate change and the adaptability of measures in response to these climate change impacts.

1.1 Bog details

Oughter Bog is located adjacent to the R357 in Co. Offaly, circa 3km to the west of Blue Ball.

The surrounding landscape primarily consists of low-lying agricultural land (pasture) interspersed with other raised bogs, many of which have also been managed by Bord na Móna for peat production with some areas utilised for domestic turf-cutting. Lough Boora Discovery Park is approximately 2km south west of Oughter.

Oughter Bog lies to the south of the River Brosna and is drained by a number of its tributaries. The Grand Canal is located to the north of Oughter. Oughter is linked to the adjacent Turraun Bog (also owned by Bord

na Móna) to the northwest by a railway line and machinery travel path, which provides the main access also to Oughter. Within the bog, the railway line broadly divides Oughter into two main sections.

Oughter Bog has not been used for industrial peat production since 2012. It formerly provided peat for use in the Derrinlough Briquette factory and also as fuel peat for West Offaly Power (WOP) in Shannonbridge, Offaly. The existing east-west rail line through Oughter is still in use however and has been utilised as recently as 2020 to transport peat- from adjacent sites.

A portion of the original site has been taken up with a Native Woodland Scheme and is no longer in the ownership of BORD NA MÓNA – this area is now outside of the Oughter Bog boundary. Part of the southern portion of Oughter Bog has previously been developed as The Midlands National Shooting Centre of Ireland.

There is a small tea centre in the south west of the bog, 200m along an access track from the R357. A telecommunications mast (Vodaphone) is also present 60m from the R357 with access from the same location.

There are several other adjacent BORD NA MÓNA bogs nearby including Pollagh/Cornalaur, Boora, Derries, the aforementioned Turraun and Killaranny. Killaranny, which is due north east of Oughter is connected via a machinery travel path and rail line.

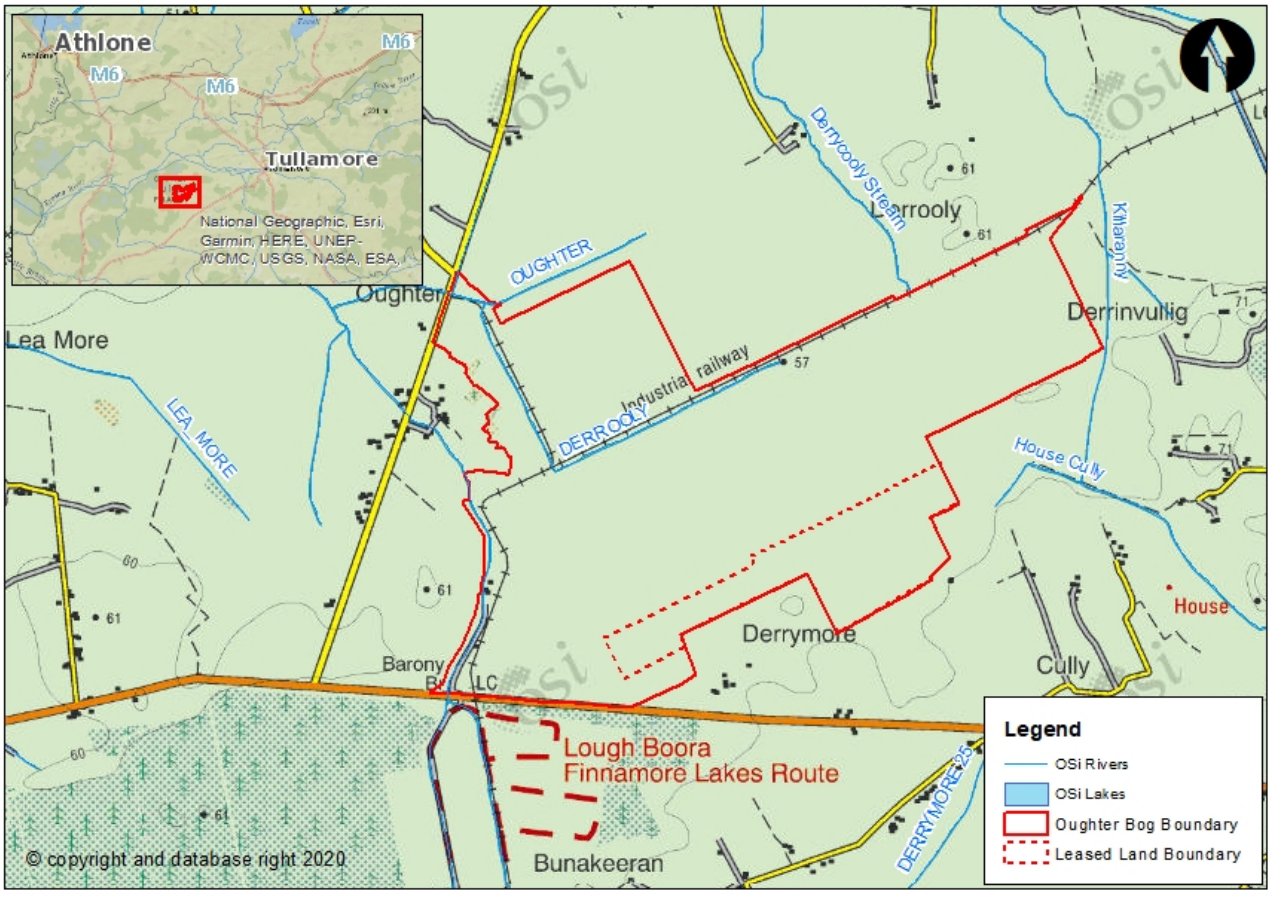

Figure 1.1 Location of Oughter Bog

2 BASELINE ASSESSMENT

Through cessation of peat extraction and implementation of the Oughter Bog rehabilitation plan there is the potential to impact the adjacent land. The extent of the impact will depend on the existing baseline characteristics of the catchments which drain the bog and the adjacent lands.

The purpose of characterising the catchment area is to develop an understanding of how the catchment currently operates and drains. The characterisation also investigates the risks, constraints and opportunities to the operation and drainage.

2.1 Study Area

To characterise the catchments a study area was determined encompassing the total catchment area draining the bog and adjacent lands through the bog. Oughter Bog is located in the Lower River Shannon Catchment. It is mainly drained to the west by the Derrooly Stream (EPA Code 25D91) and the Oughter watercourse (EPA Code 25O12), these converge west of Oughter to form the Pollagh Stream. The eastern extremity of Oughter Bog is drained by both the Derrycooley Stream and the Killaranny Stream, the latter converges with the Derrycooley north of Oughter from where it then flows northwards into the Clodiagh (Tullamore). Onsite gravity drainage directs the former peat extraction area towards the Pollagh Stream. A review was carried out to delineate the external drains around the bog as presented in Figure 2.1 along with their associated hydrological catchment area.

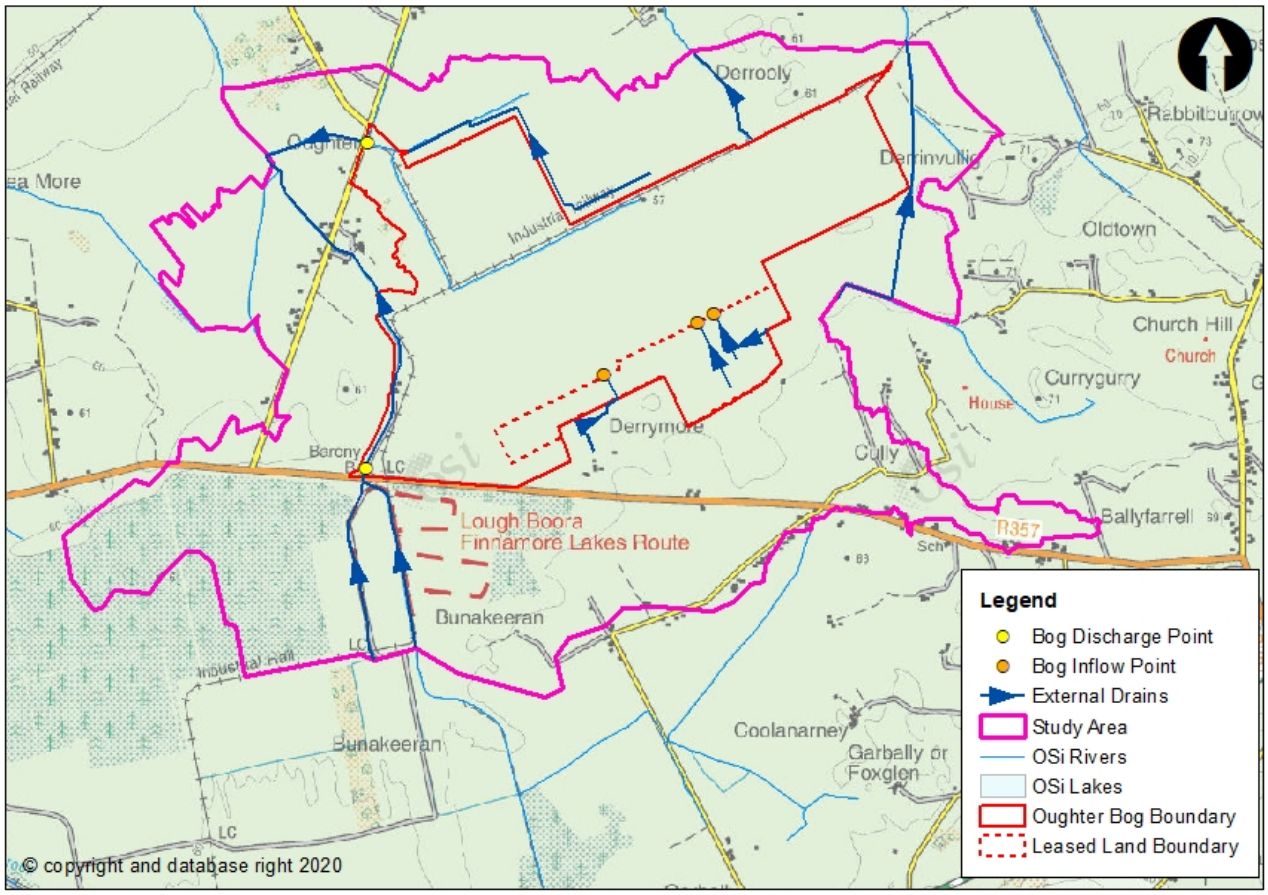

Figure 2.1 Study Area for Oughter Bog

2.2 Catchment Runoff Characterisation

A hydrological analysis was carried out within the study area to delineate the sub catchments of the bog drains and the external drains. The recent Bord na Móna drainage survey was reviewed, and the bog sub-catchments confirmed. Sub-catchments of the external drains were identified using ARC GIS tools. The sub catchments are presented in Figure 2.2.

The FSU catchment characteristics provide an overview of how much rain a catchment receives, how impermeable the catchment is and how quickly the water will runoff the catchment due to topography and drainage. Table 2.1 summarises the FSU catchment descriptors for the sub-catchments identified in Figure 2.2.

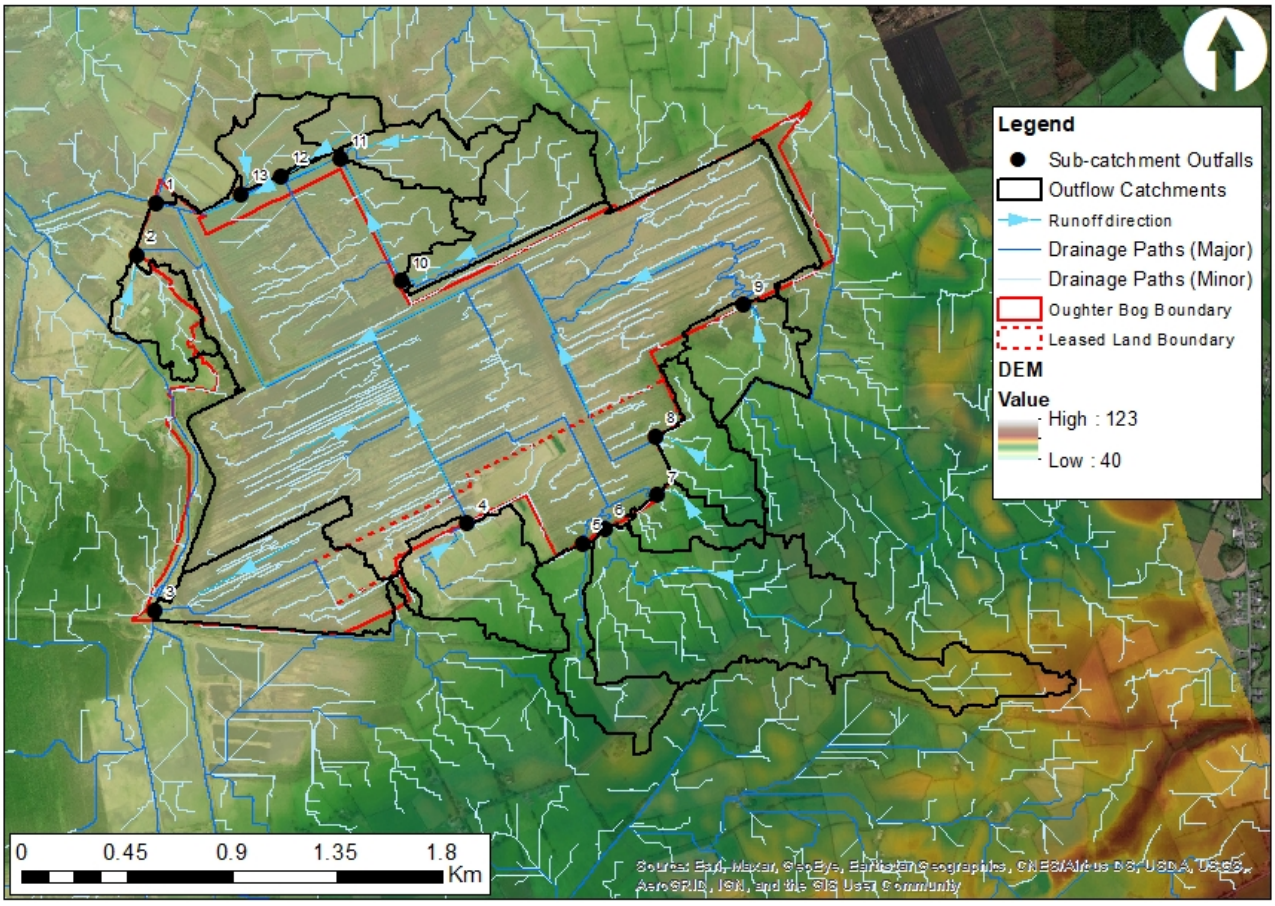

Figure 2.2 Drainage Networks and Sub-Catchments Draining Oughter Bog

There are two major catchments (1 and 3) draining Oughter Bog and adjacent lands ranging in area from 0.35 km^2 to 5.63 km^2. There are a further eleven sub-catchments (2, 4-13) within the two main catchments draining the bog and adjacent lands ranging in area from 0.012 km^2 to 1.04 km^2.

The catchments are all subject to moderately low amounts of annual average rainfall. The Baseflow Index for all of the catchments has been taken as a range from 0.497-0.697 representing a moderately permeable to fairly permeable catchment. The catchments range from very flat to moderately flat.

The Index Flood Flow (Q_{med}) values, which represent the typical peak flood flow which might be anticipated (a 50% chance of being exceeded in any given year), for each of the sub-catchments have been calculated. This is based on two different methods, the Flood Studies Update (FSU) 5 variable equation designed for small and / or urbanised catchments in Ireland, and the RPS derived Peat Q_{med} equation, derived in support of the Drainage Management Plan project for SAC sites on behalf of NPWS. Both methods result in very similar Q_{med} values where the proportion of arterial drainage (ARTDRAIN2) is assumed to match the proportion of the catchment managed by Bord na Móna (drained).

Table 2.1 Physical Catchment Descriptors of Sub-Catchments Draining Oughter Bog

Sub-Catchment Number	Area (km^2)	SAAR (mm)	BFI	FARL	ARTDRAIN2	PEAT (%)	S1085 (m/km)	FSU5 Q_{MED} (m^3/s)	Peat Q_{MED} (m^3/s)
1	5.629	873.87	0.697	1	0.84	83.8	2.49	**0.978**	0.920
2	0.133	872.80	0.695	1	0	72.79	1.81	**0.028**	0.024
3	0.349	867.50	0.497	1	1	100	0.61	0.071	**0.115**
4	0.268	877.36	0.69	1	0	93.23	1.44	**0.052**	0.044
5	0.184	877.36	0.69	1	0	32.22	5.83	**0.052**	0.032
6	0.772	877.36	0.69	1	0	18.95	5.67	**0.194**	0.112
7	0.105	877.36	0.69	1	0	50.72	16.62	**0.040**	0.020
8	0.159	877.36	0.69	1	0	54.05	8.41	**0.050**	0.028
9	0.179	868.09	0.687	1	0	100	3.98	**0.046**	0.031
10	0.276	872.24	0.687	1	0	100	1.96	**0.057**	0.045
11	0.148	872.24	0.687	1	0	100	4.63	**0.040**	0.026
12	0.061	872.24	0.687	1	0	100	1.17	0.012	0.012
13	0.114	872.24	0.687	1	0	100	0.31	0.016	**0.021**

2.3 Hydrogeological & Soil Characterisation

Oughter Bog and the surrounding area are underlain by Visean limestone bedrock which represents a regionally important, karstified aquifer. Geological Survey of Ireland (GSI) tracing of karst features has not identified any significant features such as springs, swallow holes or turloughs in close proximity to the bog. Nevertheless the bedrock underlying Oughter has potential to facilitate relatively high rates of baseflow / groundwater transfer. The soils covering the catchments are primarily peat, with some groundwater / surface water gleys and some grey brown podzols to the south of the bog on higher ground. All of these soils would be considered to be moderately impermeable.

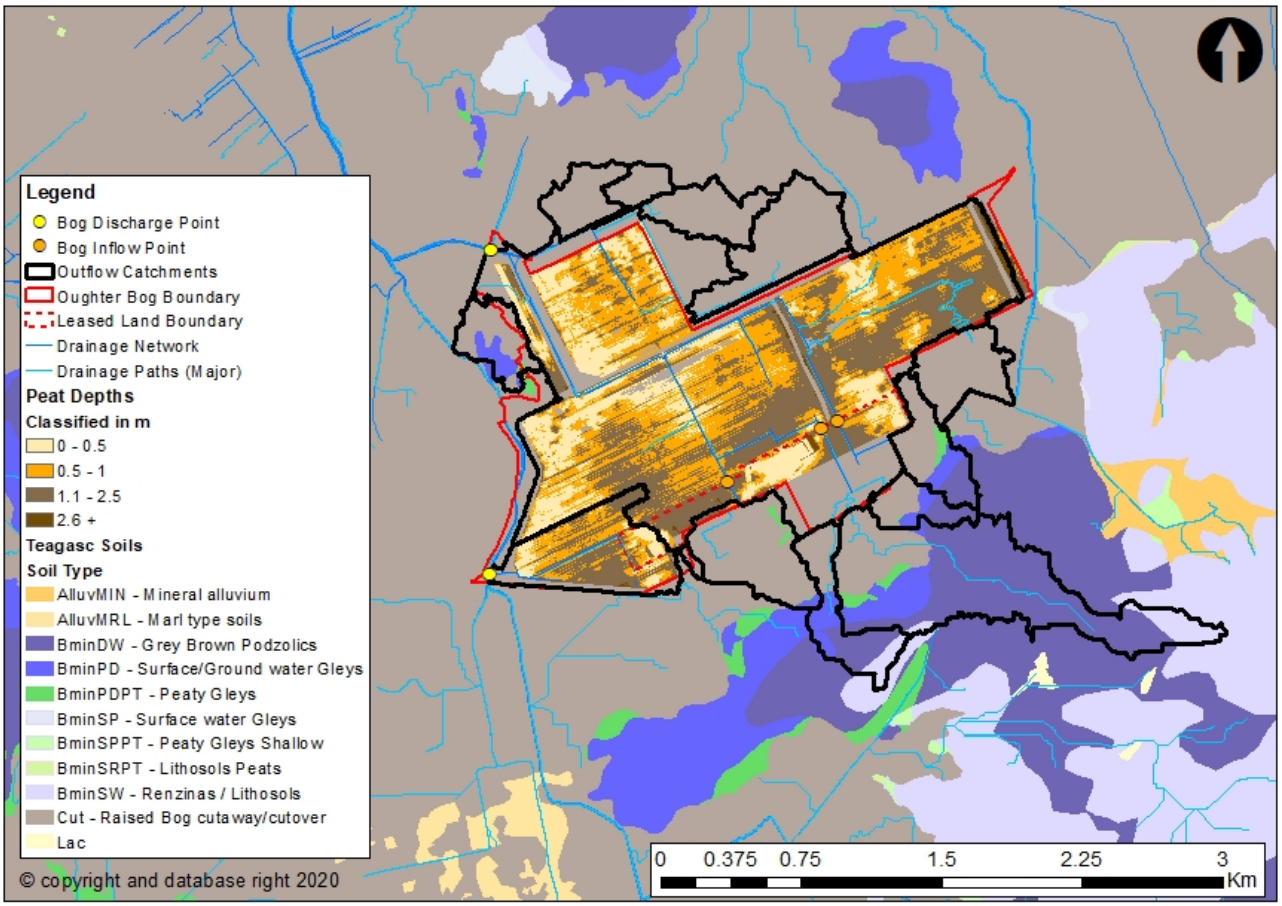

Figure 2.3 Hydrogeological and Soil Characteristics of Oughter Bog

2.4 Morphological and Hydraulic Characterisation

A desk top review was carried out of bog drains and external drains. Morphological and hydraulic features were identified.

The external drains are generally small with gentle bed slopes. Aerial photography shows no signs of erosion or deposition however given that the drains are considered small with gentle bed slopes there would be a risk of deposition, and therefore reduced land drainage efficiency. Risk of deposition would occur where there is potential for an erosion or debris source from the surrounding land and where there is potential head loss in the channel due to instream features. Figure 2.4 details the reaches of the external drains where there are

potential erosion or debris sources and where instream features may facilitate deposition. The figure shows that due to the location of commercial forests and disturbed peat in the surrounding lands there are existing potential sediment sources that could enter the external drains. Given the presence of external features such as; culverts, sharp bends and inflows along the external drains there would be a potential of sediment settling and deposition occurring. The potential for Oughter bog being a sediment source to the external drains is considered low due to the presence of silt ponds and that peat extraction activities have ceased.

A review of the bog drains was carried out. The Bord na Móna drainage survey details the open drains, pipes, silt ponds and discharge points. The discharge point to the majority of the site, at the northern boundary of the bog, has a silt pond located upstream which will reduce the amount of peat leaving the bog as water is drained. The discharge point at the southern boundary would require a silt control measure as part of the rehabilitation works. The drains in the bog have very gentle bed slopes and pass through numerous pipes before discharging from the bog. It would be expected that the bog drainage network would be sensitive to drain and pipe alterations and the drains which receive an inflow from the adjacent land, as shown in Figure 2.4, need careful consideration. A reduction in this drain's capacity has the potential to impact on the agricultural land that drain into the bog.

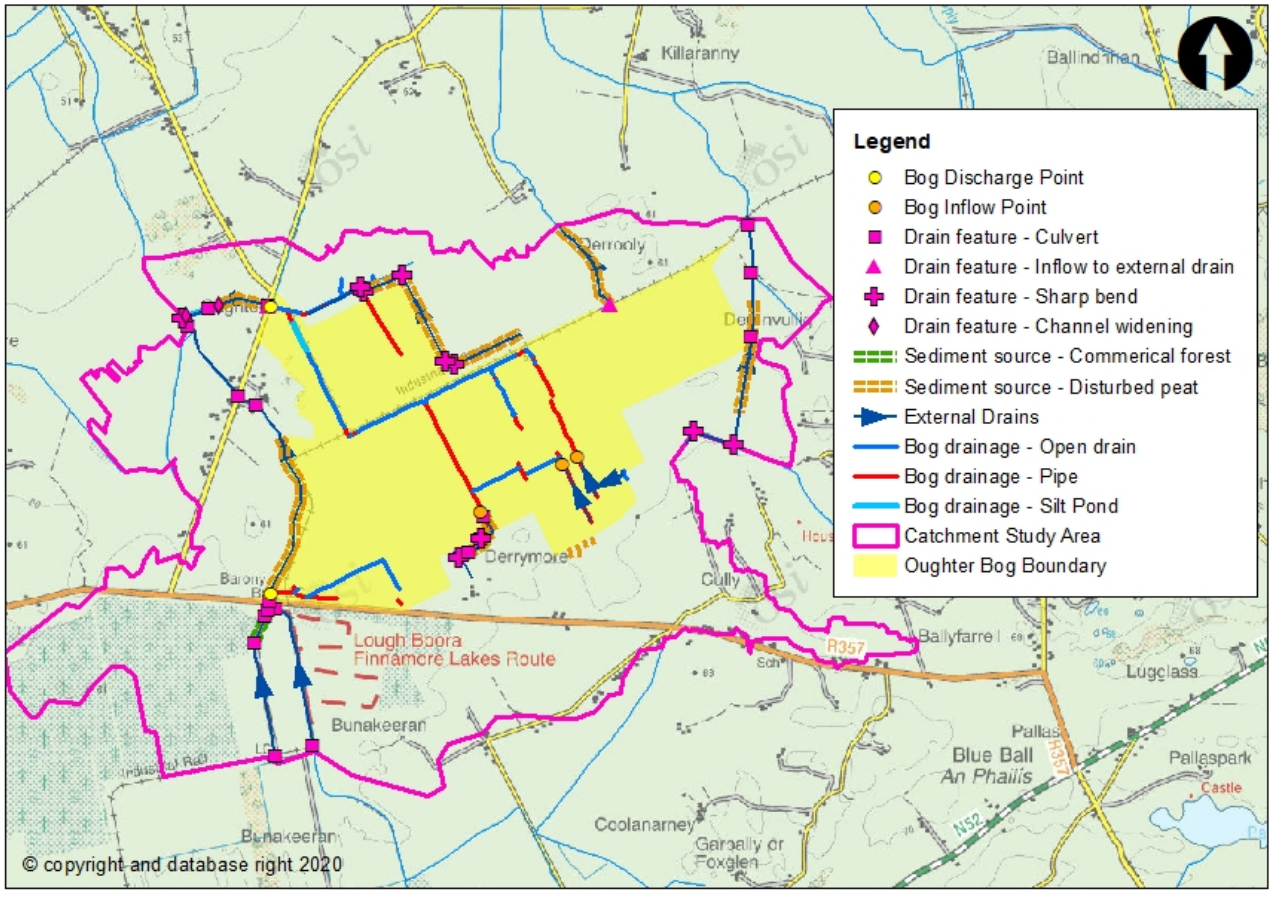

Figure 2.4 Morphological and Hydraulic Characteristics of Oughter Bog and environs

2.5 Land use character

The majority of the land within the study area is peat bog, pasture and transitional woodland scrub. The remaining areas of the study area consist of commercial forest. The CORINE land use dataset was used to identify landuse types. This dataset was then reviewed using aerial photography to establish landuse amendments or land use alterations. The review found that some peat bog have been improved and used as a shooting range and ponding has become established. There are some minor roads and properties located in the study area also.

The pasture land is mainly used for livestock which provides food production. The majority of the peat bog outside the Bord na Móna bog shows evidence of being harvested for domestic fuel production. Other areas of peat bog are undisturbed which contribute to carbon storage, biodiversity and the lakes/wetlands area provides recreational services (angling, walking). The woodland scrub areas are likewise providing carbon storage and biodiversity albeit as a different habitat to the peat bogs. The minor roads within the study areas service properties and provide access to amenities such as the shooting range located on the southern boundary, pastures and peat bogs.

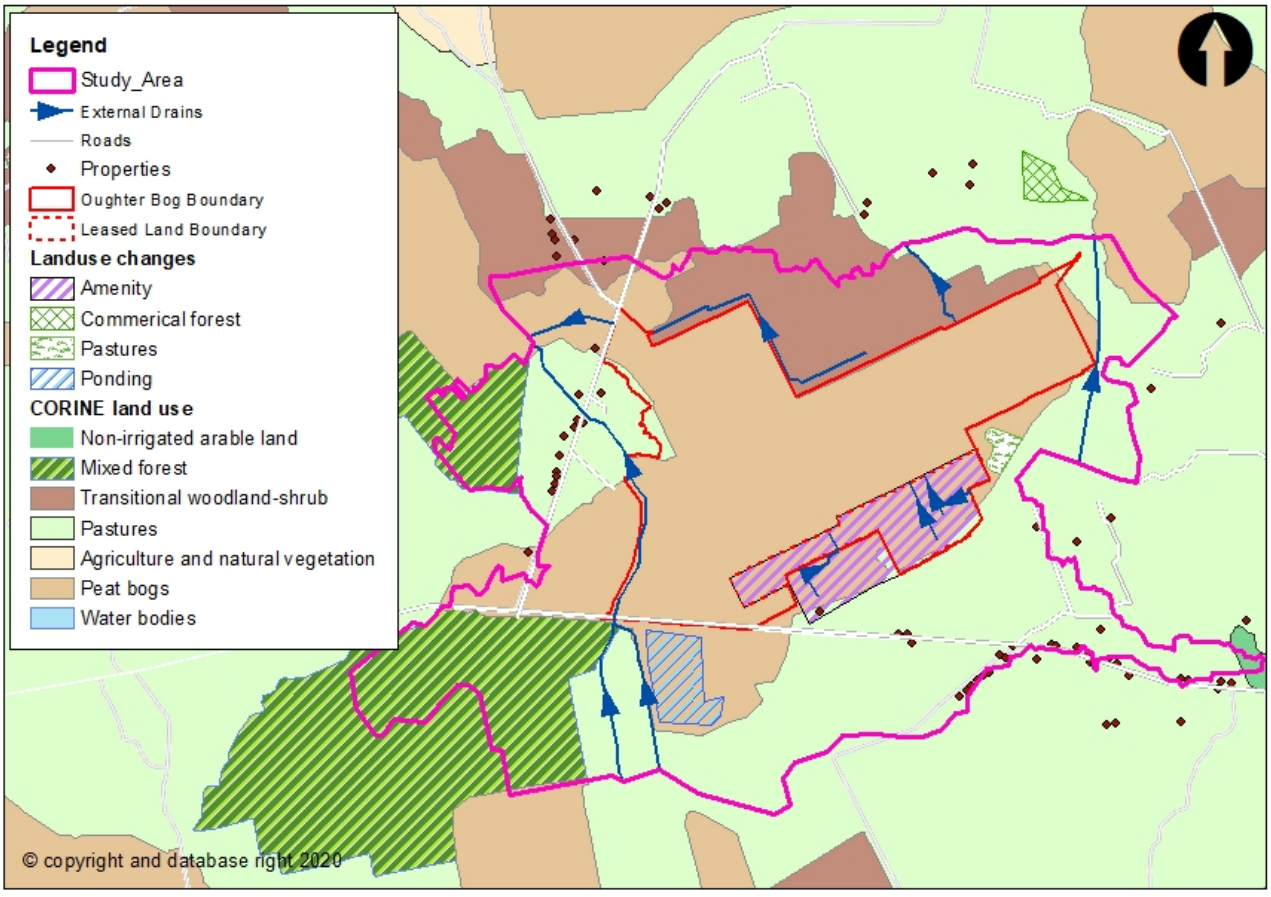

Figure 2.5 Land Use Characteristics of Oughter Bog and environs

2.6 Flood Risk

A number of sources of flood risk information are available, both predicted and simulated, in proximity to Oughter Bog. These include:

- CFRAM Study maps setting out the predicted fluvial 10%, 1% and 0.1% Annual Exceedence Probability (AEP) fluvial flood scenarios for the Brosna River.
- GSI predicted groundwater flood maps for high, medium and low probability events
- Mapped fluvial flood extents for the 2009 flood event
- Mapped flood extents for the 2015 flood event (from Sentinel-1 satellite imagery) and a GSI surface water flooding dataset for the same event
- Anecdotal evidence from Bord na Móna

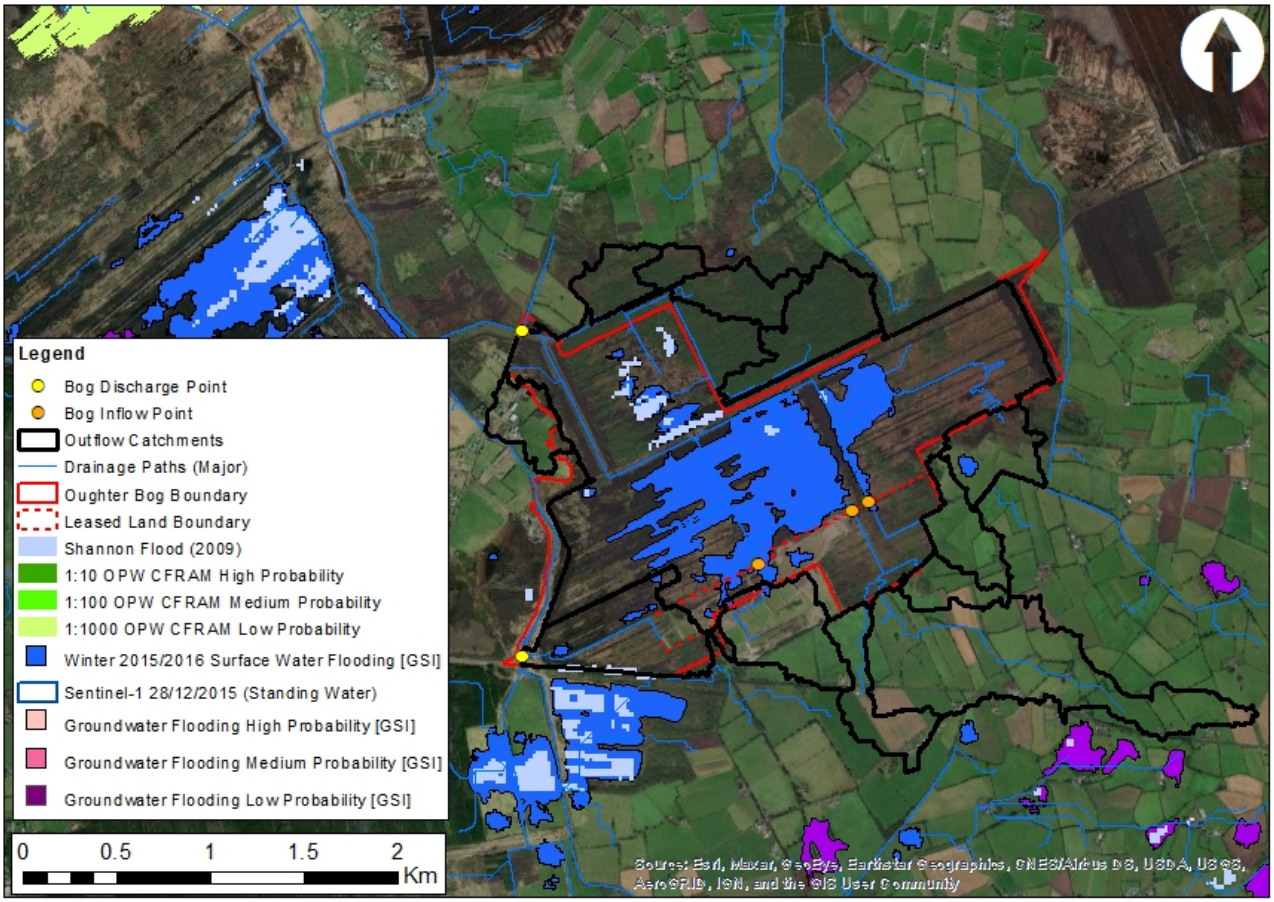

Figure 2.6 Flood Risk at Oughter Bog

Data from the 2015/16 flood event indicate flooding in the centre of the main peat field which is consistent with what has been observed from anecdotal evidence from Bord na Móna. This flooding extended into the leased land also. No other fluvial or pluvial datasets were available in this area to provide further information on flood risk. Historical anecdotal evidence was reviewed to ascertain if there are any known flooding or drainage issues along the bog boundary or adjacent land. No drainage issues have been identified along the Oughter Bog boundary drains.

There is no predicted groundwater flooding to the bog indicated. There is predicted groundwater flooding in areas south and east of the study area as shown on the GSI datasets.

2.7 Summary

The drainage network sub-catchments within Oughter Bog and its environs were used to delineate the study area for the Oughter Drainage Management Plan. The overall catchment area was characterised within the context of hydrology, hydrogeology, morphology, landuse and flood risk.

A detailed drainage network delineation was carried out. Drains within the bog and external drains were identified, including drains along the boundary of the shooting range lease. The assessment showed that the bog discharges to the west towards the Pollagh Stream.

The catchment area is considered to be relatively small, flat, fairly permeable with a low to moderate annual rainfall. Peak flood flows range from around 0.17 – 0.38 m^3/s per square kilometre (1.7 – 3.8 l/s per hectare) for the Q_{med} event to 0.51 – 1.36 m^3/s per square kilometre (5.1 – 13.6 l/s per hectare) for the Q_{100} year plus climate change event.

The bedrock within the catchment is limestone, however no karst features were identified in GSI records which could influence groundwater movement and flooding. The soil on top of the bed rock is mainly peat with some other soils in the higher ground. All soil types are relatively impermeable which would restrict transfer to groundwater although the permeable underlying bedrock represents a regionally important aquifer.

The morphological and hydraulic characteristics of the external drains were assessed. No signs of erosion of deposition could be observed. Areas of deposition risk were identified along each drain. Culverts, bends, inflows, channel widening were identified as potential factors for sediment deposition. Commercial forests and bare peat adjacent to the drains were identified as potential sources of sediment. Given that the drains are relatively flat the risk of deposition in the external drains is considered high.

The land use was assessed within the study area. The majority of land is peat bog, some of which has been drained for agricultural purposes. Transitional woodland makes up a significant proportion of the study area also. The remaining land is made up of commercial forest. The land provides important services such as food production, timber production, domestic turf cutting, carbon storage, biodiversity and habitat creation.

Table 2.2 summarises the constraints, risks and opportunities identified as part of the baseline assessment.

Table 2.2 Potential Opportunities / Constraints

Land Parcel / Feature	Risk or Opportunity?	Details
Agricultural land	Constraint	It is important to maintain the productivity of agricultural land surrounding the bog
Peat bog	Constraint	Where turf is still being extracted for domestic use from other bogs adjacent to Oughter Bog conditions should be not be made worse.

		Some adjacent peat bogs are Bord na Móna owned. While peat is not being extracted from these bogs its general use should be considered to ensure conditions are not made worse.
Roads	Constraint	Minor roads are located in the study area providing access to dwelling houses, agricultural land and peat bogs. Access to these roads should be maintained.
External drains	Risk	Risk of deposition in the drains is considered high due to potential sediment sources in adjacent lands and features within the external drains. External drains may be sensitive to change.
Bog rehabilitation plan	Opportunity	To improve water quality discharging from the bog; stabilisation or improvement in water quality parameters (e.g. suspended solids)
Bog rehabilitation plan	Opportunity	To reduce carbon emissions from the bog and to set bog on a trajectory towards naturally functioning peatlands habitats. Oughter has potential to develop embryonic Sphagnum-rich vegetation that has potential to be a carbon sink.
Bog rehabilitation plan	Opportunity	To improve biodiversity by vegetating bare peat and creating more habitat for flora and fauna.
Bog rehabilitation plan	Opportunity	To reduce runoff and restore a more natural runoff regime, thus contributing to flood risk management.

3 BOG REHABILITATION PLAN

The Oughter Bog rehabilitation plan[1] consists of the following measures as summarised in Table 3.1 and presented in Figure 3.1.

Table 3.1 Oughter Bog rehabilitation measures

Restoration	Description of measures
Dry cutaway restoration	Blocking outfalls and managing water levels with overflow pipes
	Regular drain blocking (max 3/100 m) + blocking outfalls and managing water levels with overflow pipes + targeted fertiliser treatment
Wetland creation	Turn off or reduce pumping to re-wet cutaway + blocking outfalls and managing water levels with overflow pipes
	More intensive drain blocking (max 7/100 m), + blocking outfalls and managing overflows + transplanting Reeds and other rhizomes
Other	Maintain silt ponds

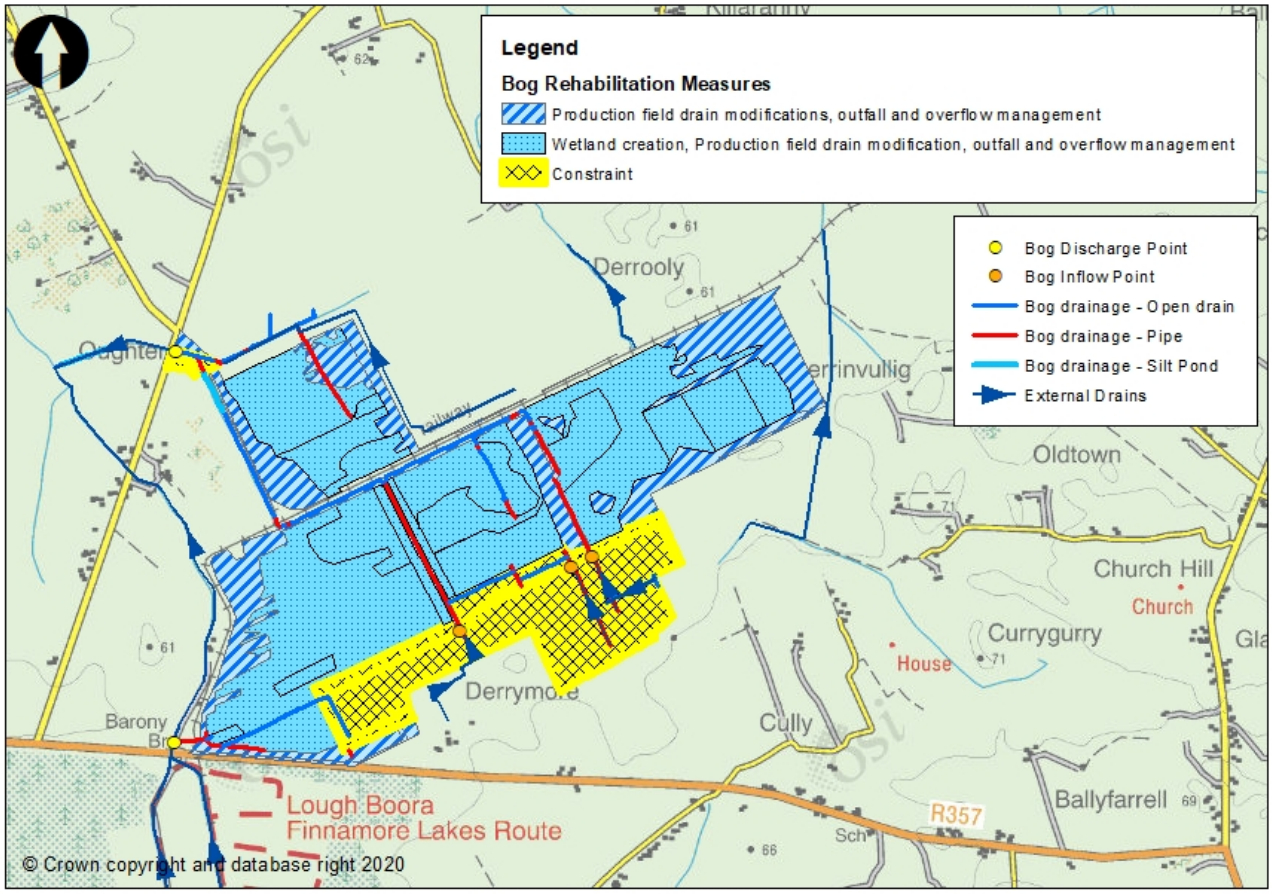

Figure 3.1 Oughter Bog Rehabilitation Plan

[1] For further details see Oughter Bog Cutaway Bog Decommissioning and Rehabilitation Plan 2021 report

Each measure while designed to promote the rehabilitation and re-wetting of the bog will have a potentially positive and/or negative impact on the adjacent land. This section identifies and assesses these potential impacts.

3.1 Impact Screening

Table 3.2 summarises the rehabilitation measures proposed for the Oughter Bog and their potential impact to adjacent land.

Table 3.2 BRP measures proposed at Oughter Bog

Bord na Móna rehabilitation measure	Description	Potential Impact	Potential Impact Description
Drain blocking,	Existing production field drains within the bog areas that convey surface water away from the former peat production fields towards the bog discharge points will be modified to reduce conveyance or removed altogether by infilling. Surface water runoff through the bog will be slowed allowing the bog to store more water	Positive and negative	Reduced runoff from the bog discharge points resulting in less flow in the external drains located downstream. Reduced conveyance at bog inflow point resulting in increased water volume in external drain located upstream if conveyance channels through the bog are blocked.
Blocking outfalls	Most production field drain systems drain into a headland drain or pipe running perpendicular to the peat field. This intersection is known as an outfall. By blocking the outfalls each production field drain will be prevented from operating, resulting in the drain storing water and raising the groundwater level in the bog. This will allow the bog to store more water and bring the groundwater level to the surface.	Positive and negative	Reduced runoff from the bog discharge points resulting in less flow in the external drains located downstream. Raised groundwater levels to the bog surface will create a hydraulic gradient across the bog into the adjacent land. Ground water levels in lands within this hydraulic gradient will potentially rise. The effect will be greatest immediately beside the bog.
Managing overflows with overflow pipes	This measure is usually combined with blocking outfalls which cause groundwater levels to rise. As the bog fills up it will want to overtop at the lowest part of the bog boundary. Overflow pipes control the location where this occurs and where the overtopping water is discharged to.	Neutral	The control features will determine the location of the discharge from the bog. However the flow leaving the bog once it is full will be the same as prior to remedial works. Overall the volume of water discharging from the bog will be reduced but will contribute to raised groundwater levels within the bog

			and potentially within the zone of influence (subject to mitigation).
Silt ponds	Existing silt ponds will be maintained to store runoff water from the bog and allow any suspended peat to settle out of the water before it is discharge to the external drains.	Neutral	Maintained capacity from the bog discharge points to the external drains and river located downstream. Maintained quality of water being discharged from the bogs into the external drains or river.
Wetland creation	Areas prone to flooding are designated for wetland creation. Standing water will be allowed to occur resulting in increased water storage. Establishment of reeds and other rhizomes will form part of the wetland creation.	Positive and negative	Reduced runoff from the bog discharge points resulting in less flow in the external drains and river located downstream. Raised groundwater levels to the bog surface will create a hydraulic gradient across the bog into the adjacent land. Groundwater levels within this hydraulic gradient will potentially rise. The effect will be greatest immediately beside the bog.

3.2 Impact Assessment

Three potential impact sources were identified; groundwater rise, increased runoff from the bog and reduced drainage capacity into the bog. These impact sources have the potential to make the adjacent land wetter and drain less efficiently. An assessment was carried out to delineate the zone of influence resulting from these potential impact sources. Figure 3.2 presents the areas which are at potential risk.

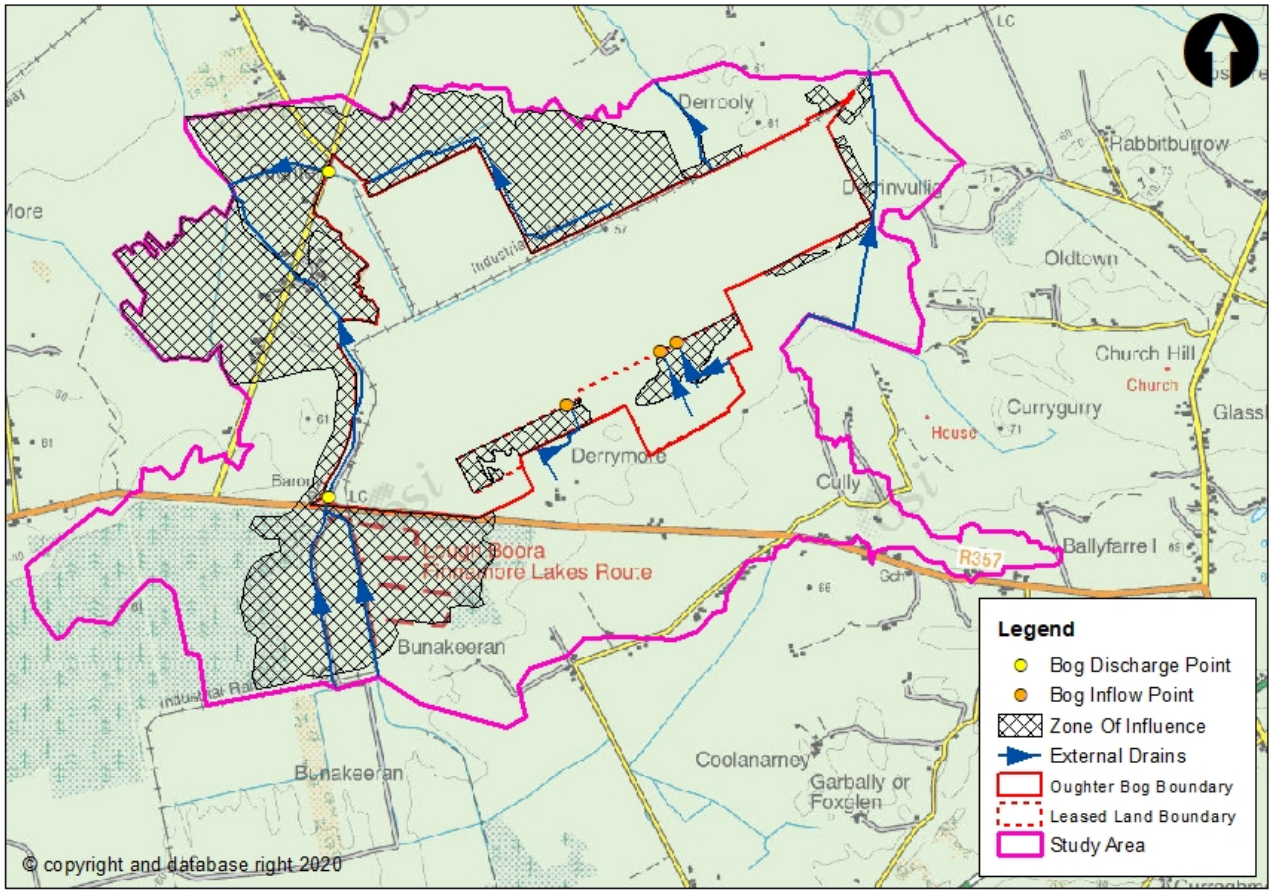

Figure 3.2 Oughter Bog Rehabilitation Plan – Zone of influence

3.2.1 Groundwater Impact

The impact of rehabilitation measures on groundwater levels within and adjacent to the bog is difficult to assess quantitatively in the absence of long term monitoring data and hydro-geological models of the bog. Nevertheless it can be assumed that groundwater levels will rise within the bog itself given that this is an objective of the rehabilitation measures – to restore the hydrological conditions for peat formation. It is to be assumed that the maximum level which groundwater will reach outside areas zoned as wetland is the surface of the peat fields post-rehabilitation. This is because topographical flow paths for surface water out of the bog (by gravity) will be retained and the bog is not dependent on a pumping regime to ensure ponding does not occur. For areas zoned as wetland the maximum water level will be above surface level as water ponding is promoted through rehabilitation measures.

Groundwater rise in lands adjacent to the Oughter Bog was assessed firstly by estimating the potential rise in groundwater within the bog. The drainage system in the bog is, on average, 0.8m deep. It can be expected that groundwater would rise by 0.8m to bring it to the surface in non-wetland area. Water level rise in wetland areas is expected to be greater and will be determined by the higher surrounding bog fields or the construction of a berm and by the outlet control to the wetland area. As the groundwater rises in the bog to ground surface level a head water difference will be created between the bog and adjacent land forming a hydraulic gradient (see Figure 3.3a and 3.3b). Groundwater will flow across the hydraulic gradient. This flow will be dependent on the porosity of the ground it flows through and the head difference. This will determine the extent of the zone of influence and the area of potentially wetter ground. Where external drains are located in the zone of influence they will act as a hydraulic break or groundwater cut-off and reduce the zone of influence (see Figure 3.3c). This however is dependent on the drain's ability to convey water away. Drains that are inefficient with high water levels, caused by insufficient hydraulic gradient or infilling of vegetation (independent from the bog rehabilitation measures) will also raise the groundwater and the adjacent lands to the bog would be wet (see Figure 3.3d). The avoidance of the drain full condition is dependent on maintenance of a positive gravity drainage function of the boundary drains through monitoring and maintenance.

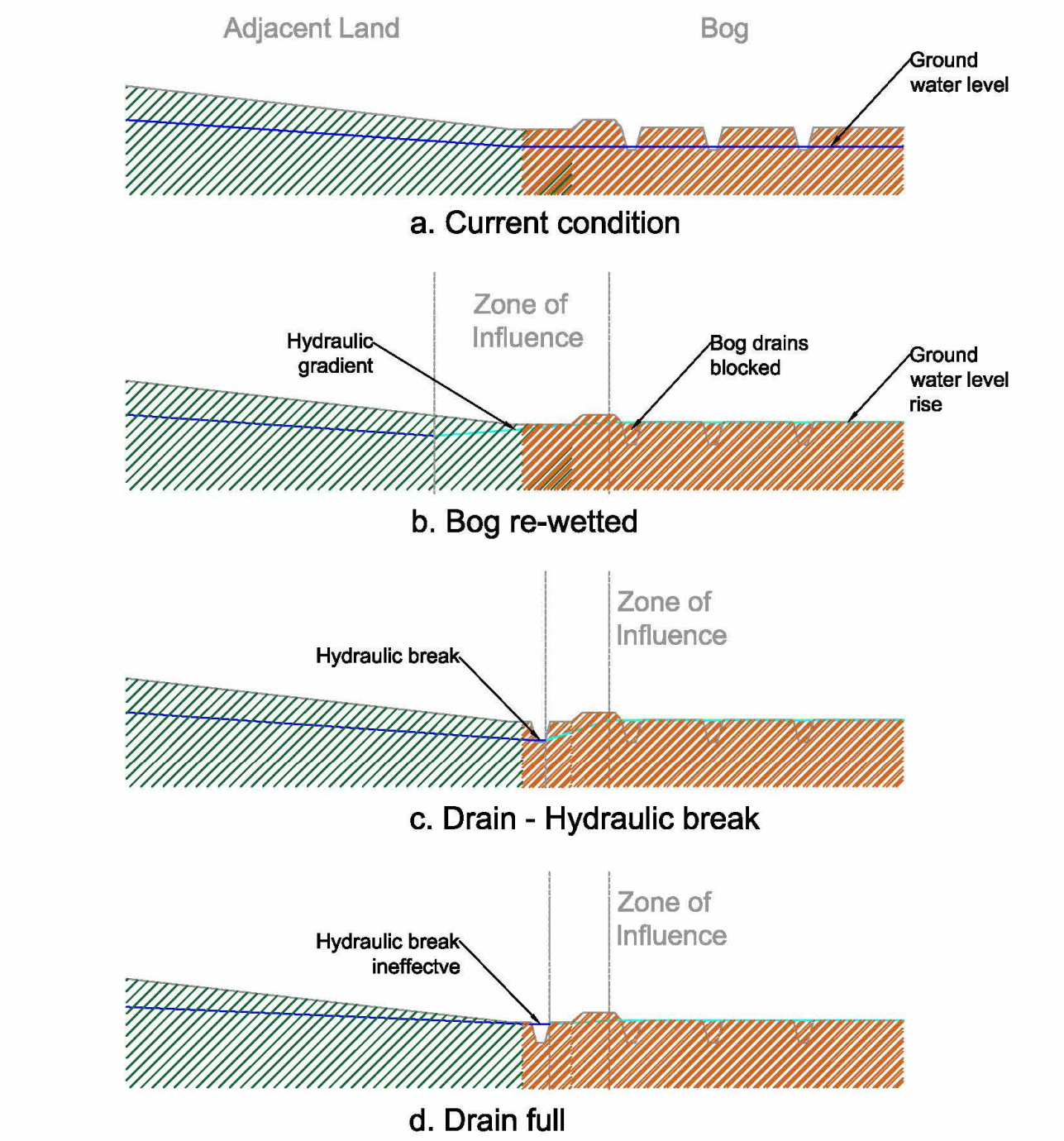

Figure 3.3 Conditions affecting groundwater

A complete survey of the boundary and external drains which provide the groundwater cut-off function to adjoinng lands was not available for Oughter Bog. It is assumed that these drains would be able to convey Q_{med} (2 year return period) flows under non-backwater conditions which would be typical of natural watercourses in Ireland. Therefore under non-flood conditions it is expected that the external drains identified around Oughter Bog will act as a hydraulic break to any hydraulic gradient created by bog re-wetting. However there is a risk that should the flow regime in any external drain be changed post rehabilitation that the land adjacent to the drain would become wetter.

There is also a risk that as the bog fills with water and wants to discharge, that unintended discharge locations would occur. A review of the bog boundary was carried out. No low points were identified that may become an unintended discharge location. The west boundary of the bog discharges toward the Pollagh stream. As such there is little risk to adjacent lands should there be increased flows from the bog owing to elevated groundwater levels. However as previously set out this is based on the ability of the existing boundary drainage network, separating the bog from adjacent lands at a lower level, to provide a positive gravity drainage function in relation to groundwater entering the drain. In other words capacity to convey Q_{med} or 2 year return period flows and a free flow (constantly falling) away from the bog.

3.2.2 Insufficient Drainage

It is a significant concern for adjacent landowners that restoration and rehabilitation measures could lead to localised impacts in terms of reduced drainage leading to flooding of agricultural lands upstream of the bog.

There are three inflow locations to Oughter bog (Figure 3.2) which connect to drains which flow north west through the bog. Should these drains' function and capacity deteriorate, low lying parts of the upstream land may reduce in drainage efficiency. This low lying land was identified and included in the zone of influence (see Figure 3.2).

An assessment of the external drains outside of the Bord na Móna site boundary was carried out in chapter 2. Various features were identified that may reduce the external drains' flow capacity. Culverts, bends, deposition and flooding backwater, located outside the bog boundary, were identified as potential features that could reduce flow capacity. The drains which serve the lands in question flow through the western part of Oughter bog and are currently a mix of open drains with culverted sections. The continued drainage of the lands identified is dependent on the continued performance of these drainage paths and as such positive gravity drainage function must be retained.

3.2.3 Increased Runoff

Evidence from bogs that have previously been the subject of restoration measures demonstrates that the measures proposed at Oughter, which are all aimed at reducing runoff and retaining water within the bog, have the effect of reducing the frequency and magnitude of flood events by restoring a more natural hydrological regime. Restoration / rehabilitation has been successfully applied to numerous Bord na Móna bog sites as well as SAC sites such as Clara Bog (East), Raheenmore Bog, Carrownagappul Bog and Lisnageeragh Bog. Elsewhere, the restoration of peatland catchments in numerous sites across the UK, such as Exmoor National Park in Snowdonia, has demonstrated positive flood alleviation following rehabilitation measures. Monitoring found that this occurred as runoff from the moorland was reduced due to increased storage in the peat.

The risk of increased runoff from Oughter Bog is low. All rehabilitation measures being proposed will reduce runoff. However there is a potential that changes in bog topography caused by the bog rehabilitation measures employed may modify the bog sub-catchments. Changes in sub-catchments could result in certain discharge points draining larger areas. This would result in increased flows that could outweigh the effect of the reduced runoff arising from the rehabilitation. This is a moderately low risk at Oughter as the re-profiling of the bog will generally result in the same topographical flow paths, catchment watersheds and discharge locations as in the

pre-rehabilitation state. However in the absence of a full pre and post rehabilitation runoff model and in line with a precautionary approach it is prudent that all drainage infrastructure from the bog is fit for purpose and retained such that at a minimum capacity to convey high frequency flood events (Q_{med} or 2 year return period) is provided.

3.3 Potential Risk Areas

The assets that have been identified as being at potential risk from flooding or wetter conditions as described in Table 3.1 are shown in Figure 3.4.

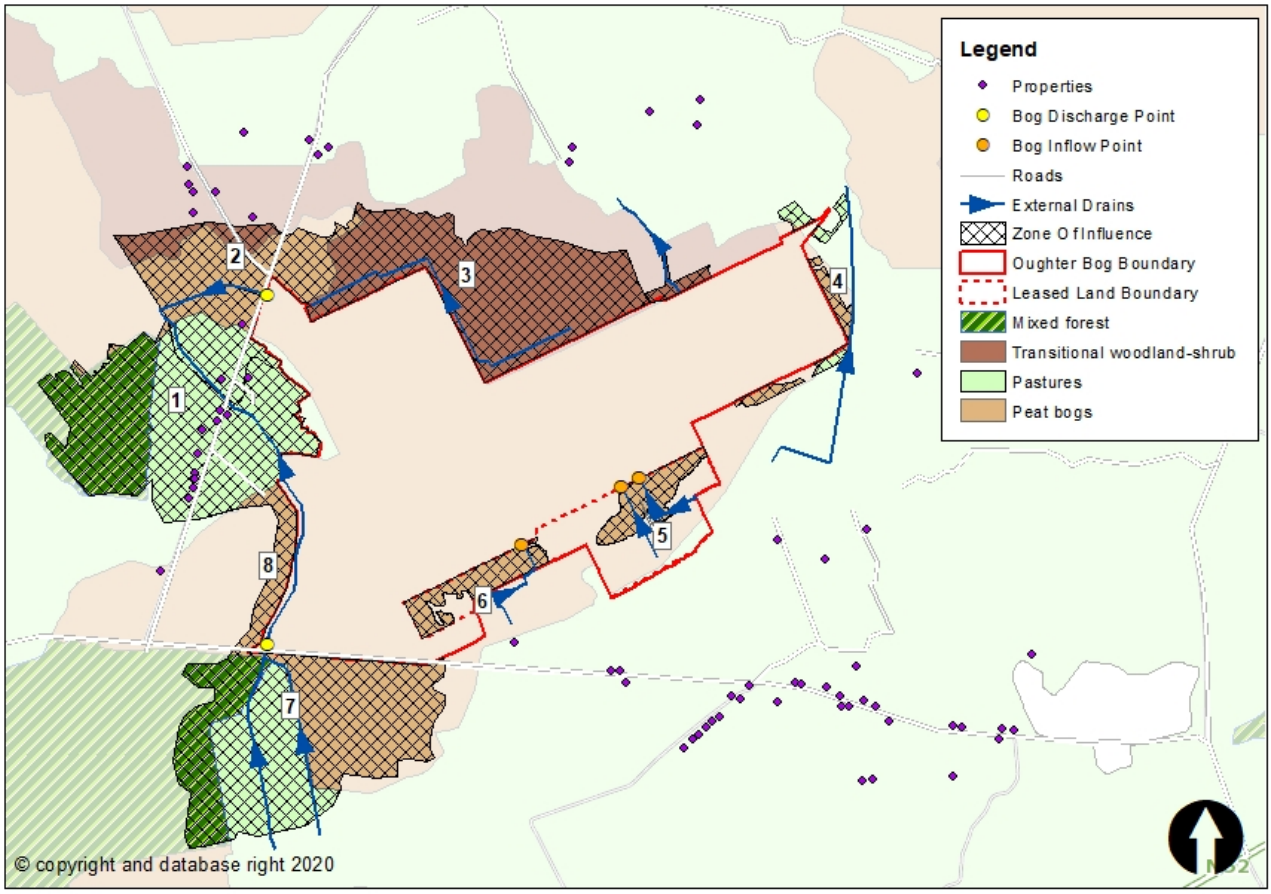

Figure 3.4 Oughter Bog Rehabilitation Plan – Assets at risk

The assets at risk are set out in **Error! Not a valid bookmark self-reference.** along with the vulnerability, based on the current land use, of the asset. It should be noted that the appraisal of the assets at risk is considering the consequences of flooding or wetter conditions, not the likelihood of flooding or wetter conditions occurring.

Table 3.3 Assets at risk

Item	Asset	Vulnerability to flooding and/or wetter conditions
1	Agricultural land and commercial forest.	High Vulnerability. Agricultural land adjacent to the bog would become less productive should it be made wetter. Commercial trees adjacent to bog require good drainage. Should the ground become wetter the growth rate of the trees may be reduced.
2	Peat and woodland	Low vulnerability. Land is mainly bog and woodland which could tolerate wetter conditions
3	Woodland	Low vulnerability. Land is mainly woodland which could tolerate wetter conditions.
4	Peat and agricultural land	Moderate Vulnerability. Land adjacent to bog is peat bog which can tolerate wetter conditions. Bog acts as buffer between Oughter bog and agricultural land dampening any potential ground water rise.
5	Peat and shooting range	High Vulnerability. Wetter conditions may make shooting range harder to operate and use safely.
6	Peat and shooting range	High Vulnerability. Wetter conditions may make shooting range harder to operate and use safely.
7	Peat, Agricultural land and woodland	Moderate Vulnerability. Land adjacent to bog is peat bog which can tolerate wetter conditions. Bog acts as buffer between Oughter bog and agricultural land and woodland dampening any potential ground water rise.
8	Peat	High Vulnerability. Assumed turf cutting. Land would become less productive should it be made wetter.
9	Roads	Low vulnerability. Road level slightly higher than surrounding land. Risk of flooding is low.
10	Properties	Moderate – High Vulnerability. Although the impact of wet ground conditions or flooding to properties would be considered high, the location of these properties is mostly away from the bog at the limit of the zone of influence or the level of the property is at a higher elevation than the surrounding land. Properties at low elevations are considered high risk. A number of the properties are agricultural sheds which would be more resilient to any potential flood risk.

In addition to the above risks there is a general low risk that should degradation of the bog boundary occur surface water could be released into adjacent lands.

4 OBJECTIVES

The overarching objective of the Oughter Drainage Management Plan is to facilitate the rehabilitation of bog through management of potential adverse impacts to adjacent land and waterbodies. SMART[2] objectives were developed for the Drainage Management Plan that provides direction for the overarching objective. These objectives consider constraints, risks and opportunities that were identified in chapters 2 and 3 and are detailed as follows:

1. To manage potential groundwater impacts between adjacent land and Oughter bog during and after rehabilitation measures.
2. To retain the current drainage capacity of the agricultural land flowing into Oughter Bog both during and after the rehabilitation measures.
3. To maintain or reduce flows released from the bog at the discharge locations.
4. To reduce sediment entering water courses during and after rehabilitation, these measures are to ensure compliance with current discharge limits in IPC Licence.

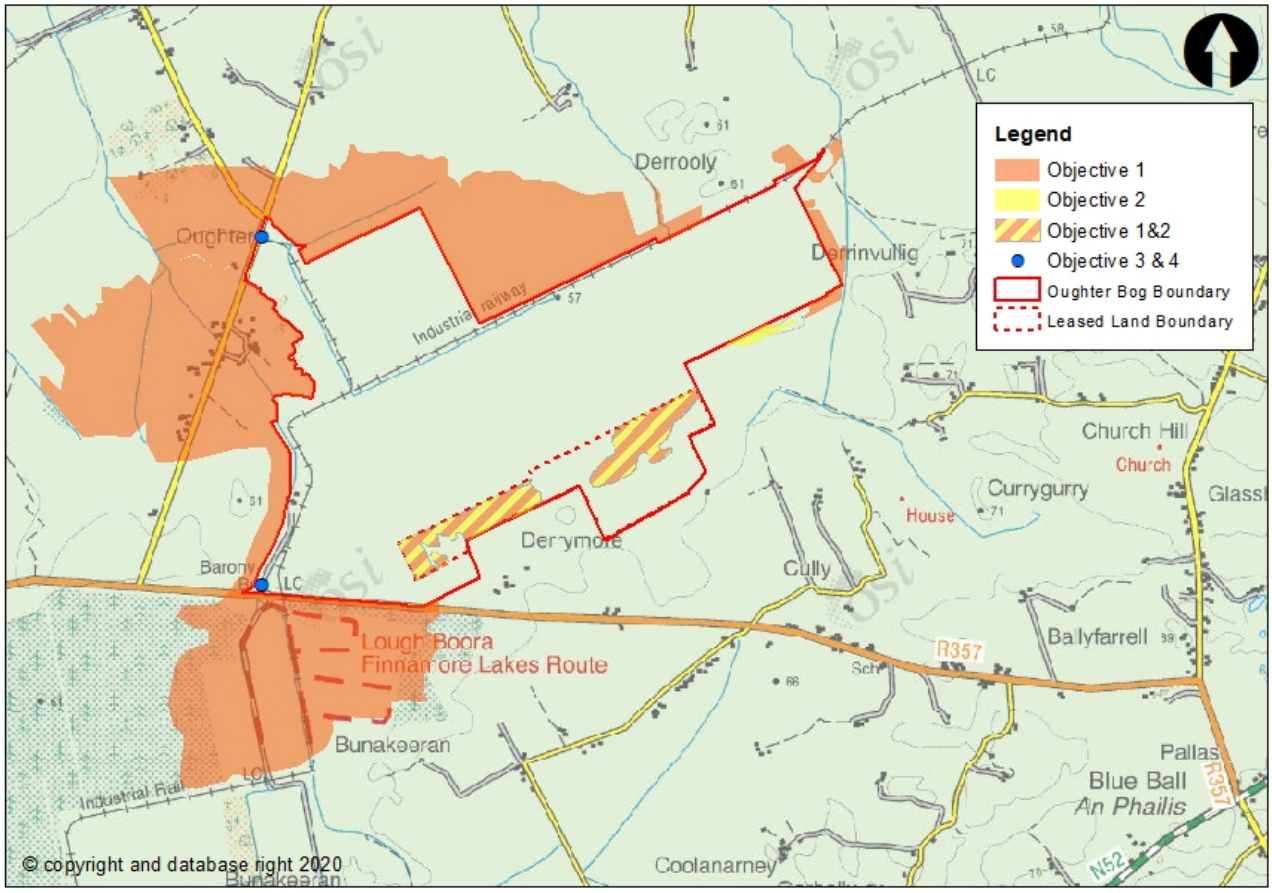

Figure 4.1 Oughter Bog DMP objectives

[2] SMART – Specific, Measureable, Achievable, Relevant, Time bound

5 DRAINAGE MANAGEMENT MEASURES

5.1 Key drainage features

Drainage management measures were identified in relation to the objectives set in chapter 4 and are described below. Objectives 1 and 3 consider the potential impact to adjacent land from groundwater rise. Objective 2 considers the existing drainage network flowing into and through the bog. Objectives 4 and 5 consider the control mechanisms to flow discharging from the bog.

An assessment was carried out to identify the key drainage features required to meet the objectives set. Figure 5.1 presents these features. It can be seen in the figure that for groundwater level rise to be managed between the bog and adjacent land that a hydraulic break will be required. To ensure that the land draining into the bog is not impacted the drainage path through the bog will need to be retained. And to ensure that the flow and sediment discharging from the bog is managed the discharge control points will need to be maintained.

Although outside the Bord na Móna bog boundary key external drains were identified. These drains are hydrologically connected to the bog drainage network. While no drainage issues were identified along these external drains, see section 2.4, a risk of sediment deposition was highlighted from sources outside the bog. The maintenance of the existing silt ponds will ensure that the bog will not contribute to an increased risk of sediment deposition arising from rehabilitation. Should this occur drainage from the bog could be impeded and adjacent land could become wetter.

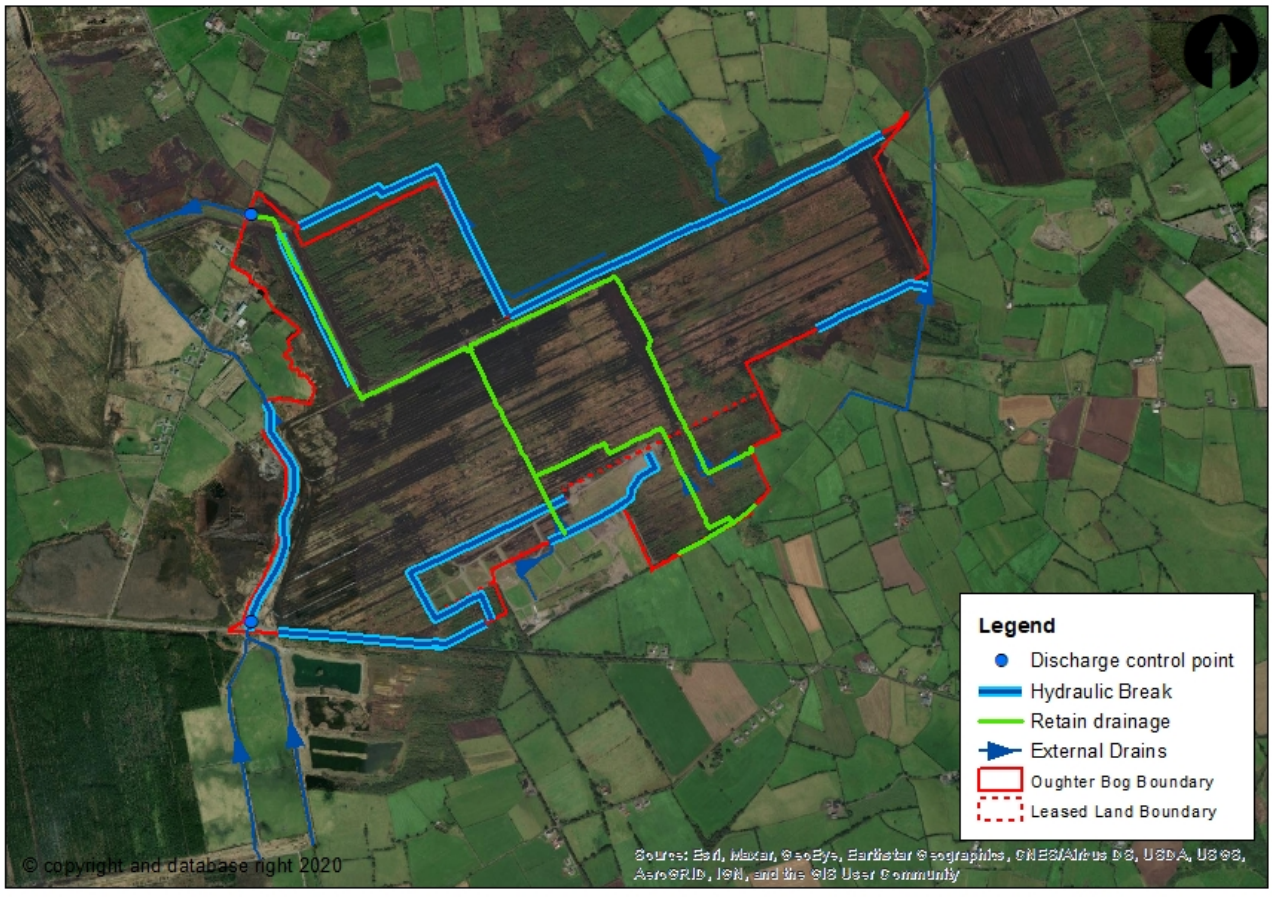

Figure 5.1 Key drainage features for Oughter Bog

When identifying measures to provide the key drainage features a review was carried out of the drains. The review found that there is limited data available on flow capacity and elevations for boundary drains to the bog and external drains within the adjacent land. While data is available for internal drains this was found to be limited in this regard also. It was therefore required to produce a Drainage Management Plan that could offer a suite of measures whereby the most appropriate measures can be selected based on the level of robustness and on-site observations. The DMP would therefore allow the bog to be managed and adapted as the rehabilitation plan progresses and is retained in the future. The following sections describe the suite of measures that can feasibly be implemented for the Oughter Bog Drainage Management Plan.

5.1.1 Boundary drains

Boundary drains can provide hydraulic breaks between the bog and adjacent land, see Figure 3.3. In most areas of Oughter Bog there are existing boundary drains. Available information indicate that these drains are suitable to provide hydraulic breaks and can be designated as such and retained in the future. Observing and recording the suitability of the boundary drains is recommended and where they are found to be not functioning as predicted upgrade works will be required. This would involve modification of the drain to make them larger/deeper/wider/steeper. This may be only in specific locations along the drain or an entire reach may require upgrading. Where there is no boundary drain present a new drain can be excavated in order to create the hydraulic break required. In these cases a channel of specified dimensions and slope will be required.

5.1.2 Bog rehabilitation modification

Where a boundary drain is not suitable to act as a hydraulic break or where none exists it may be possible to review the bog rehabilitation plan to provide the required mitigation measure. This can take the form of sacrificing rehabilitation of the last peat field, closest to the adjacent land where an existing field drain could act to provide the hydraulic break function. The field's drainage network would be retained keeping the groundwater to current conditions and providing a groundwater cut-off in relation to the adjacent land.

5.1.3 Internal drain retention

Drains within the bog that include adjacent land within their sub catchment may need to be designated as key drainage features and retained to ensure that the drainage to the adjacent land does not deteriorate.

In some instances wetland areas have been proposed where key drains have been identified. It may not be possible to retain these drains as a result. Where this situation occurs a positive drainage path must be retained in non flood conditions. This would be achieved by limiting the maximum water level in the wetland area and ensuring a fall between the adjacent land draining into the bog and the wetland area.

5.1.4 Maintenance of silt ponds

Existing silt ponds are located at one of the bog discharge points. They help regulate the flow and level of suspended peat leaving the bog into the external drains and rivers. Bord na Móna have legal responsibility to

maintain these silt ponds and ensure their proper functioning capacity under the existing IPC Licence (Ref.P05020).

One discharge control point was identified requiring silt control to regulate the flow and suspended peat leaving the bog. Where this situation occurs the drainage network can be modified to reroute the discharge through an existing silt pond. Where this is not possible a new silt control measure would be required.

5.1.5 Monitoring

As mentioned above DMP measures were selected based on the level of certainty and on-site observations. The most appropriate measures were selected from a suite of measures representing varying levels of intervention. Monitoring of the measures and adjacent land will be required prior, during and after the rehabilitation measures. A monitoring programme can be implemented to observe the impact from the bog rehabilitation to the adjacent land. Monitoring would be observational where the condition of the asset in question is assessed in relation to present day conditions accounting for seasonal variability. Where negative impacts are observed other measures can be implemented that will establish a hydraulic break. Otherwise monitoring should continue until environmental stabilisation.

5.2 Drainage assessment

A review was carried out of the existing drainage networks falling within the key drainage features as shown in Figure 5.1. These drainage networks were reviewed to the confluence with streams in order to identify potential downstream control features.

The estimated flood flows were compared with the hydraulic capacity of each of the control features which are important to the effective performance of the drainage network.

Two methods have been considered for the derivation of the Index Flood flow (Q_{med}) as set out in Section 2.2. There is a high degree of uncertainty in the estimation of flood flows at the small catchment scale and therefore the largest of the two estimates has been chosen for each sub-catchment in line with a precautionary approach to uncertainty. Flood flows for Q_{med} (50% AEP) and Q_{100} (1% AEP) peak flows for each sub-catchment have been calculated. A generalised growth curve for peat catchments in the midlands has been used, whereby a growth factor of 2.3 has been used to scale up the Q_{med} peak flow to determine the Q_{100} event (100 year return period flood event).

The best projections on the effect of climate change have been applied to determine the Mid-Range Future Scenario (MRFS). This represents a 20% uplift over the present day flood flows.

Table 5.1 Peak Flows in Each Sub-Catchment

Sub Catchment	Q_{med} / 50% AEP	Q_{100} / 1% AEP	Q100 / 1% AEP MRFS
1	0.978	2.250	2.700
2	0.028	0.065	0.078

3	0.115	0.264	0.317
4	0.052	0.119	0.143
5	0.052	0.120	0.143
6	0.194	0.447	0.536
7	0.040	0.093	0.111
8	0.050	0.115	0.137
9	0.046	0.105	0.126
10	0.057	0.132	0.158
11	0.040	0.092	0.110
12	0.012	0.029	0.034
13	0.021	0.047	0.057

5.2.1 Assessment Points

Assessment Points have been assigned at key / critical points within the drainage network identified in Figure 5.1 as providing a key drainage management function. The location of the Assessment Points is provided in Figure 5.2.

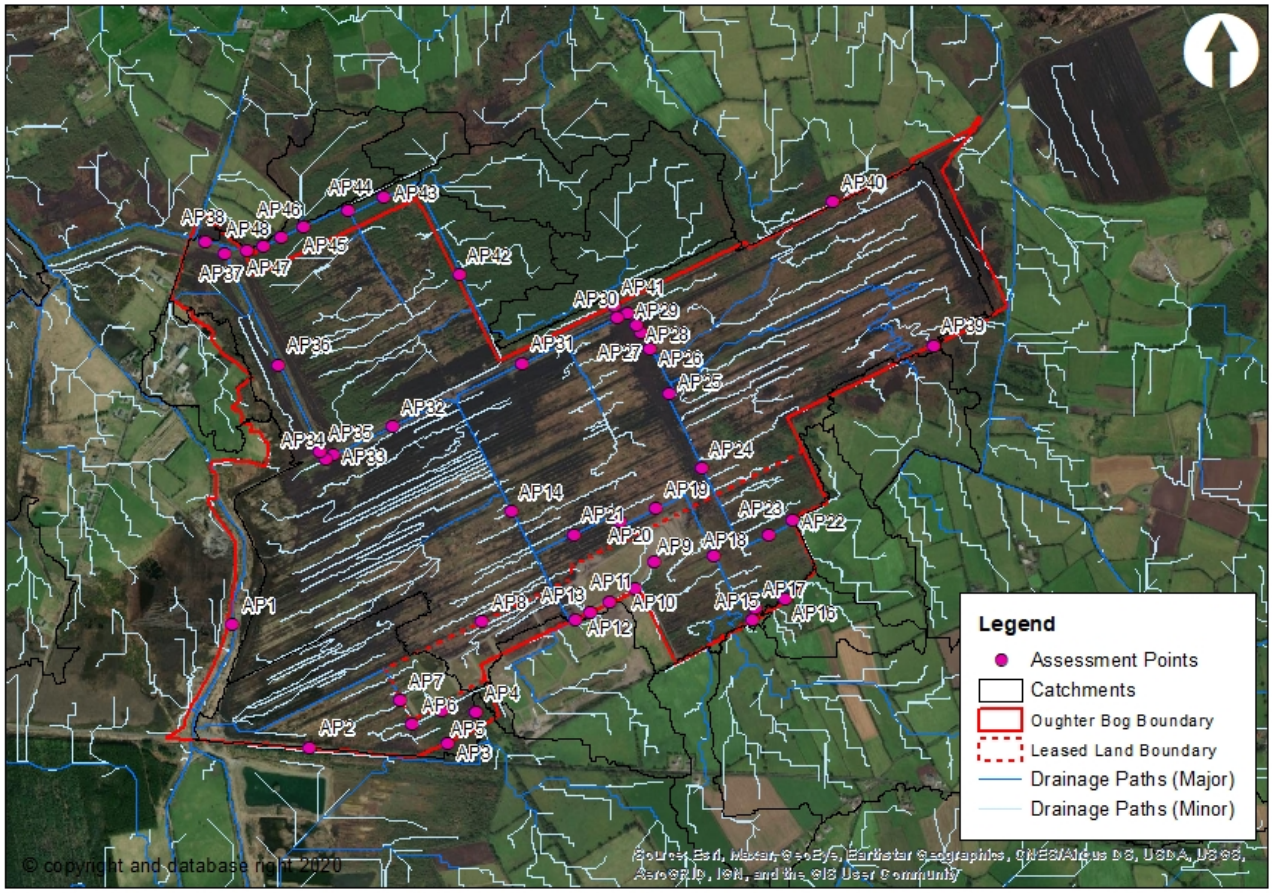

Figure 5.2 Assessment Points at Oughter Bog

5.2.2 Hydraulic Analysis

The peak flows at each Assessment Point (AP) have been compared to the estimated hydraulic capacity of each of the features. A summary of the flood flows that may be generated at each AP along with their likely capacity to convey these flows is summarised below in Table 5.2. Note that capacity issues at an AP may have knock on impacts in terms of flooding for the AP upstream.

Table 5.2 AP Capacity

Assess. Point	Sub-Catch.	Feature Type	Flood Flow Range (m^3/s)	Capacity & Recommendations
AP1	Pollagh	Pollagh Stream	2.713 - 7.488	Likely capacity to convey all flood flows.
AP2	3	Boundary drain	0.050 - 0.139	Very poorly defined drain but larger drain outside of site boundary may act as hydraulic break.
AP3	3	Boundary drain	0.010 - 0.027	No defined drain at this location but adjacent land approx. 2m higher
AP4	3	Internal drain	0.003 - 0.008	No defined drain at this location but no significant contributing catchment.
AP5	3	Internal drain	0.010 - 0.026	Likely capacity to convey all flood flows.
AP6	3	Pipe	0.013 - 0.035	**Check pipe capacity when conditions allow.**
AP7	3	Internal drain	0.024 - 0.066	Capacity at QMED but not above. Very Shallow.
AP8	1	Field drain	0.009 - 0.025	Capacity at QMED but not above. Very Shallow, potential obstructions.
AP9	1	Internal drain	0.012 - 0.033	Capacity at QMED but not above. Very Shallow, potential obstructions. **Check pipe capacity when conditions allow.**
AP10	1	Pipe	0.020 - 0.056	
AP11	1	Boundary drain	0.020 - 0.055	Likely capacity to convey all flood flows.
AP12	1	Pipe	0.024 - 0.066	**Check pipe capacity when conditions allow.**
AP13	1	Boundary drain	0.028 - 0.079	Likely capacity to convey all flood flows.
AP14	1	Pipe	0.320 - 0.882	Likely capacity at QMED. Potential constriction at extreme events. **Replacement with open channel may reduce flooding / maintenance requirements.**
AP15	1	Boundary drain	0.193 - 0.533	Poorly defined drain at this location. **Check drain capacity when conditions allow and re-form drain if necessary.**
AP16	7	Boundary drain	0.042 - 0.116	Capacity at QMED but not above.
AP17	1	Internal drain	0.153 - 0.423	Poorly defined drain, liable to flood depending on final upstream catchment. **Check drain capacity when conditions allow and re-form drain if necessary.**
AP18	1	Pipe	0.196 - 0.541	Likely to flood due to capacity / gradient. **Replacement with open channel may reduce flooding / maintenance requirements.**
AP19	1	Internal drain	0.208 - 0.575	Poorly defined drain, liable to flood depending on final upstream catchment. **Check drain**

Assess. Point	Sub-Catch.	Feature Type	Flood Flow Range (m^3/s)	Capacity & Recommendations
				capacity when conditions allow and re-form drain if necessary.
AP20	1	Pipe	0.212 - 0.586	Likely to flood due to capacity / gradient. **Replacement with open channel may reduce flooding / maintenance requirements.**
AP21	1	Internal drain	0.217 - 0.600	Capacity at QMED but uncertainty above.
AP22	8	Boundary drain	0.055 - 0.152	Likely capacity to convey all flood flows.
AP23	1	Internal drain	0.036 - 0.099	Likely capacity to convey all flood flows.
AP24	1	Pipe	0.061 - 0.168	Likely capacity to convey flood flows although reverse falls upstream. **Replacement with open drain may reduce flooding / maintenance requirements.**
AP25	1	Pipe	0.084 - 0.233	Capacity at QMED but potential constriction of extreme events due to reverse falls in pipe. **Replacement with open drain may reduce flooding / maintenance requirements.**
AP26	1	Pipe	0.104 - 0.288	Capacity at QMED but potential constriction of extreme events due to reverse falls in pipe. **Replacement with open drain may reduce flooding / maintenance requirements.**
AP27	1	Internal drain	0.117 - 0.322	Capacity at QMED but potential flooding at more extreme events. **Check drain capacity when conditions allow and re-form if necessary.**
AP28	1	Pipe	0.124 - 0.343	Likely capacity at QMED but reverse fall in pipe. **Replacement with open channel may reduce flood risk and maintenance requirements.**
AP29	1	Internal drain	0.131 - 0.362	Likely capacity to convey flood flows.
AP30	1	Pipe	0.131 - 0.363	Likely capacity at QMED but reverse fall in pipe. **Replacement with open channel may reduce flood risk and maintenance requirements.**
AP31	1	Internal drain	0.158 - 0.436	Likely capacity to convey flood flows.
AP32	1	Internal drain	0.626 - 1.728	Likely to capacity to convey all flood flows.
AP33	1	Pipe	0.631 - 1.741	**Check pipe capacity when conditions allow.**
AP34	1	Internal drain	0.657 - 1.813	Likely capacity to convey all flood flows.
AP35	1	Pipe	0.657 - 1.814	Likely capacity to convey QMED. **Check pipe outfall capacity when conditions allow.**
AP36	1	Internal drain	0.659 - 1.819	Likely capacity to convey all flood flows.
AP37	1	Pipe	0.689 - 1.901	Constriction to flood flows leading to backup through bog. **Consider replacement with open channel / weir.**
AP38	1	Internal drain	0.898 - 2.477	Likely capacity to convey flood flows.
AP39	1	Boundary drain	0.014 - 0.038	No defined drain at this location but adjacent land approx. 2m higher

Assess. Point	Sub-Catch.	Feature Type	Flood Flow Range (m^3/s)	Capacity & Recommendations
AP40	1	Boundary drain	0.014 - 0.038	Likely capacity to convey all flood flows but poorly defined. **Check drain capacity when conditions allow.**
AP41	1	Boundary drain	0.006 - 0.016	Likely capacity to convey all flood flows but poorly defined. **Check drain capacity when conditions allow.**
AP42	1	Boundary drain	0.075 - 0.206	Likely capacity to convey QMED. **Very flat / potential obstructions. Check drain capacity when conditions allow.**
AP43	1	Boundary drain	0.117 - 0.323	Likely capacity to convey QMED. Very flat / potential obstructions. **Check drain capacity when conditions allow.**
AP44	1	Pipe	0.123 - 0.340	Likely capacity to convey QMED flows. **Check pipe inflow capacity when conditions allow.**
AP45	1	Boundary drain	0.138 - 0.381	Likely capacity to convey all flood flows
AP46	1	Pipe	0.165 - 0.455	Likely capacity to convey flood flows.
AP47	1	Boundary drain	0.166 - 0.459	Likely capacity to convey all flood flows
AP48	1	Pipe	0.207 - 0.572	Likely capacity to convey QMED flows but potential backwatering for more extreme events.

5.3 Identification of measures

The review of drain capacities found that most open drains are likely to have sufficient capacity to convey flow away from the bog. They would therefore be suitable to act as hydraulic breaks provided they are retained with their current estimated carrying capacity. Three reaches of boundary drain have been identified as requiring a higher level of intervention to increase conveyance capacity. Section 2.6 indicates how all boundary drains appear to be functioning sufficiently with no known drainage issues identified along the drains or in adjacent land. Although there is no survey data for some reaches the anecdotal evidence therefore suggests that the boundary drains identified for retention are functional and can be used as drainage management measures. They would therefore be suitable to act as hydraulic breaks provided they are retained with their current estimated carrying capacity.

At DMP 6 the bog boundary has no suitable boundary drain. An area of field bog has therefore been identified for exclusion from the bog rehabilitation plan. The existing drains would need to be retained including their drainage path out of the bog.

DMP 16 & 17 refers to the wetland areas proposed as part of the rehabilitation plan. These wetland areas are located along the drainage path for adjacent lands that flow into the bog. As such it is important that adjacent lands can continue to drain through the bog and that the wetlands will not cause water to back up into the adjacent land. DMP 9 & 10 propose that the maximum water level in the wetland areas is controlled to provide a freeboard of 500mm to the adjacent land draining into the bog. Where it is required to adjust outfalls as part of the rehabilitation measures the invert of the outfall that regulates the maximum water level will not be set

higher than 51.7mOD for DMP9 and 53.0mOD for DMP10. It should be noted that during extreme flood conditions, that are beyond Bord na Móna's control, water levels in the wetland areas may rise above the invert of the outfalls as they regulate the discharge. The proposed wetland areas can be adapted to function as silt control measures before the relevant part of the bog discharges to the Pollagh River. A review of the internal drains would be required to ensure no drain bypass the wetlands.

Existing silt ponds at DMP13 would be required to be maintained. A new sediment control measure would be required at DMP 2. This may be achieved by adapting the proposed wetland to function as a silt control measure before the bog discharges to the Pollagh River. Temporary silt control measures may be required during the initial upgrade of drains in this area.

Table 5.3 and Figure 5.3 details the level of intervention required along each reach of drainage network.

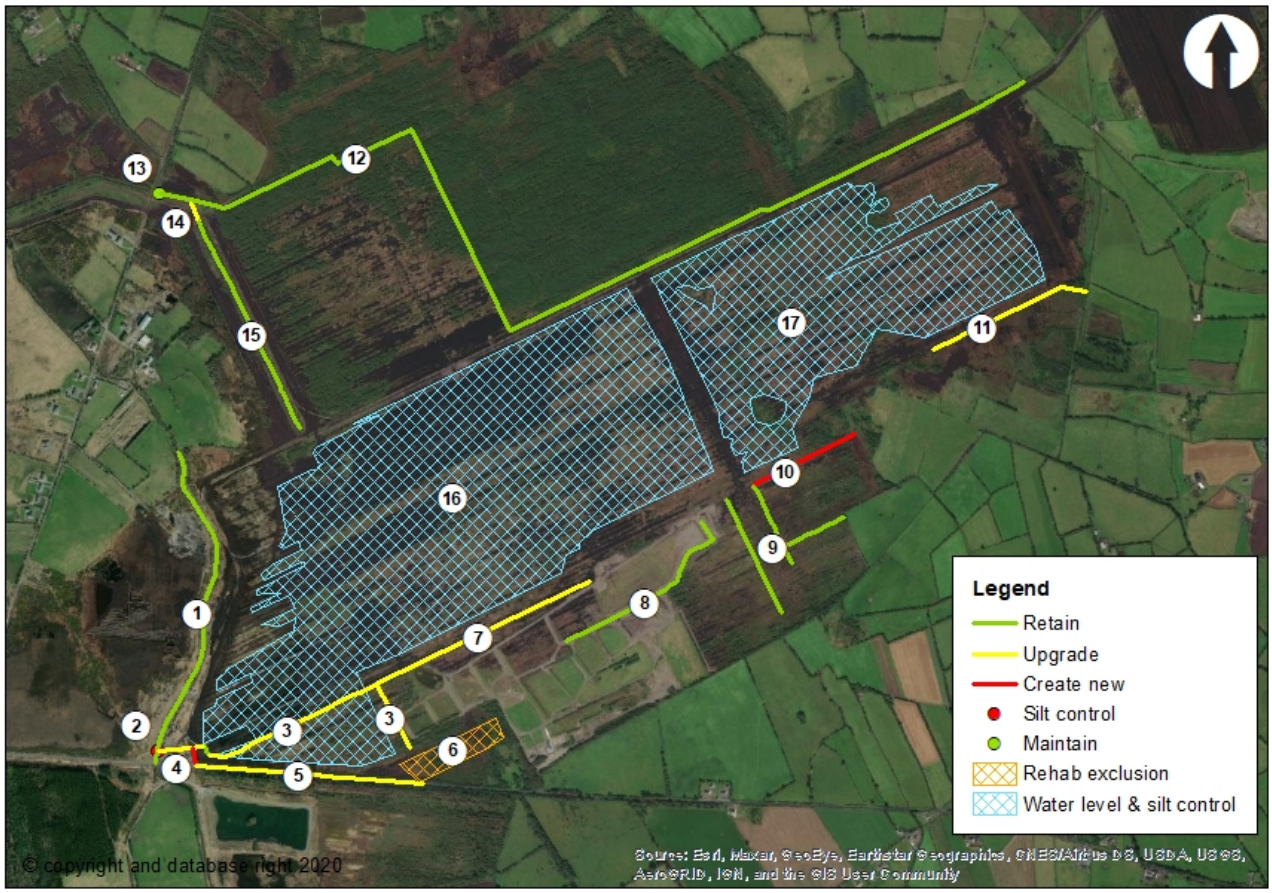

Figure 5.3 DMP measures for Oughter Bog

Table 5.3 Selection of DMP measures

Measures Item	Feature	Function required	Suite of measures Level of intervention			
			Low			High
1	River	Hydraulic break	Retain river	Maintain outside bog field	Modify rehabilitation plan	Upgrade river
2	Silt pond	Flow and silt control	-	-	**Rehabilitation adaptation**	Create new silt control feature
3	Internal drain	Drainage of hydraulic break	Retain drain	**Upgrade drain**	Maintain outside bog field	Create new drain
4	Boundary drain	Hydraulic break	-	-	-	**Create new drain**
5	Boundary drain	Hydraulic break	Retain drain	**Upgrade drain**	Maintain outside bog field	Create new drain
6	Marginal land	Hydraulic break	-	-	**Retain drains in area of bog**	-
7	Boundary drain	Hydraulic break	Retain drain	**Upgrade drain**	Maintain outside bog field	Create new drain
8	Boundary drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
9	Internal drain	Drainage	**Retain drain**	Upgrade drain	-	Create new drain
10	Boundary drain	Hydraulic break	Retain drain	Upgrade drain	Maintain outside bog field	**Create new drain**
11	Boundary drain	Hydraulic break	Retain drain	**Upgrade drain**	Maintain outside bog field	Create new drain

Measures Item	Feature	Function required	Suite of measures Level of intervention			
			Low			High
12	Boundary drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
13	Silt ponds	Flow control	**Maintain pond**	Upgrade pond	-	-
14	Pipe	Hydraulic break	Retain pipe	**Upgrade drain**	-	Remove pipe
15	Boundary drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
16	Wetland	Drainage of adjacent land Flow/silt control	-	-	**Rehabilitation adaptation**	Create new silt control feature
17	Wetland	Drainage of adjacent land Flow/silt control	-	-	**Rehabilitation adaptation**	Create new silt control feature

5.4 Interaction with monitoring plan

As part of the bog rehabilitation plan groundwater level monitors will be installed at Oughter Bog. These monitors will record groundwater levels over the coming months. It will therefore be possible to ascertain if groundwater is rising within the bog following the implementation of the rehabilitation plan.

This data should be considered during the monitoring measures of adjacent land. When groundwater levels are known to be rising within the bog, monitoring of the adjacent land (as described in Section 5.1.5) should take place on a more regular basis to ascertain if impacts to lands outside the bog are observed.

5.5 Residual Risk & Limitations

The level of flood risk to the bog and the surrounding lands has been shown to be low (Section 2.6) generally but with an area in the centre of the bog susceptible to poor drainage and flooding. The impact of the proposed rehabilitation measures will generally be to reduce runoff from the bog but this will lead to increased groundwater levels and surface water flooding in the bog itself. There are unknowns in relation to the post-rehabilitation water levels which will be realised, however the Drainage Management Plan seeks to identify the measures that should provide a hydrological cut off between the bog and the surrounding lands.

As indicated in previous sections there are limitations to the assessments associated with the drainage network both within the bog and outside. Factors such as flow estimations of small catchments, lack of survey data limiting drain capacity estimations and high level definition of soil porosity all contribute to these limitations. Nevertheless the measures recommended represent a pre-cautionary approach based on conservative assumptions.

The DMP measures proposed set a baseline approach however a suite of measures in any given location has been provided. This will allow a reactive approach to be taken if required. Should a measure not be operating efficiently a higher intervention measure can be implemented. This will allow Bord na Móna to identify the most appropriate measure while proceeding with drainage function uncertainties.

5.6 Climate Change Adaptability

There is high uncertainty in relation to the effects of climate change, particularly in how it may manifest in terms of small catchment runoff. Ireland is predicted to have drier summers and wetter winters. The most appropriate guidance in an Irish context can be found in the OPW's Flood Risk Management Climate Change Sectoral Adaptation Plan[3]. For the Mid-Range Future Scenario, representing a central emissions estimate on a 100 year time horizon, it is recommended that allowances for peak flow and rainfall are increased by 20%. If such increases in runoff are realised over the timeframe of establishment of rehabilitation measures this could lead to a perception that bog rehabilitation measures at Oughter are the cause of increased flood risk.

[3] Accessed on 10/12/2020 at https://www.gov.ie/pdf/?file=https://assets.gov.ie/46534/3575554721374f7ab6840ee11b8b066a.pdf#page=1

It is anticipated however that the rehabilitation measures will lead to reduced peak runoff as the water storage function of the bog is increased. This will serve to regulate peak runoff in winter and potentially smooth out the flows in drier periods, essentially acting against the anticipated effects of climate change.

It is therefore anticipated that the bog rehabilitation measures themselves will provide the mitigation of the effects of climate change on runoff and no additional measures will be needed. There are unknowns however in the effectiveness of the rehabilitation measures in this regard and also the severity of climate change impacts. Continued monitoring of the adjacent lands is therefore also crucial to gauge the effectiveness of the bog rehabilitation measures in mitigating these climate change impacts.

6 SUMMARY OF DRAINAGE MANAGEMENT PLAN

The Drainage Management Plan for Oughter Bog consists of a series of measures to be implemented at different stages of the rehabilitation measures. Drains within the bog and along its boundary were identified as being key drainage paths or hydraulic breaks in order to mitigate against any potential impacts from the bog rehabilitation measures. The effectiveness of all drains acting as hydraulic breaks is dependent on their ability to convey flow which have been outlined in Section 5.3 and deemed appropriate subject to the measures recommended. Factors such as channel size and slope will determine this along with any downstream feature which may control water levels. The external drains which these boundary drains discharge into are also key drainage features that will affect the operation of the drainage network. Measures will range from low intervention to high and consist of monitoring, retention of existing features, upgrading features, updating the rehabilitation plan and creating new features. Maintenance of measures are proposed to the silt ponds within the bog to ensure that discharge from the bog and sediment is controlled. This is a legal obligation for Bord na Móna and will continue at all existing silt ponds. Monitoring of adjacent lands was included in the plan. The monitoring will observe adjacent agricultural land, bog and woodland for adverse impacts from the bog rehabilitation. Should these impacts be confirmed, higher intervention measures can be implemented to mitigate the impacts. Monitoring measures will therefore be ongoing during and after the bog rehabilitation measures. Continued retention and maintenance of the key drains and silt ponds will also be required after the bog rehabilitation measures. Throughout the process landowner engagement is recommended to ensure both the rehabilitation plan and Drainage Management Plan are understood and to promote collaborative working to manage impacts as they arise.

Table 6.1 Drainage Management Plan

Measures required PRE bog rehabilitation measures	Measures required DURING bog rehabilitation measures	Measures required POST bog rehabilitation measures
Landowner engagement if required via community liaison	Landowner engagement if required via community liaison	Landowner engagement if required via community liaison
Retention and upgrading of boundary drains (see section 5.1.1)	Retention of boundary drains (see section 5.1.1)	Retention of boundary drains (see section 5.1.1)
-	Wetland water level control (see section 5.1.2)	Wetland water level control (see section 5.1.2)
-	Retain field bog drains (see section 5.1.2	Retain field bog drains (see section 5.1.2
Monitoring external drains	IF REQUIRED – Consideration of need for higher intervention measures	-
-	Rehabilitation exclusion and adaptation (see section 5.1.2)	-
Maintenance of silt ponds (see section 5.1.4)	Maintenance of silt ponds (see section 5.1.4)	Maintenance of silt ponds (see section 5.1.4)

Monitoring of adjacent land (see section 5.1.5)	Monitoring of adjacent land (see section 5.1.5)	Monitoring of adjacent land (see section 5.1.5)
-	-	IF REQUIRED – boundary drain upgrades (see section 5.1.1)
-	-	Retention of key drains and pipes