

BORD NA MÓNA –DERRYAROGUE BOG

Drainage Management Plan



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Contents

Executive Summary.....	1
1 INTRODUCTION	5
2 BASELINE ASSESSMENT	7
2.1 Drainage Characterisation	7
2.2 Morphological and Hydraulic Characterisation	10
2.3 Flood Risk	11
2.4 Constraints and opportunities	12
3 BOG REHABILITATION PLAN	14
3.1 Impact Screening	15
3.2 Impact Assessment.....	17
3.2.1 Water Table Impact	17
3.2.2 Increased Runoff	20
3.2.3 Low Flow Assessment	21
3.3 Potential Risk Areas	23
4 OBJECTIVES.....	25
5 DRAINAGE MANAGEMENT MEASURES.....	26
5.1 Key Drainage Features	26
5.1.1 Boundary Drains	27
5.1.2 Bog Rehabilitation Modification	27
5.1.3 Maintenance of Discharge Points.....	28
5.1.4 Monitoring	28
5.2 Identification of Measures	28
5.3 Interaction with Monitoring Plan	32
5.4 Residual Risk & Limitations.....	32
5.5 Climate Change Adaptability	32
6 SUMMARY OF DRAINAGE MANAGEMENT PLAN	34

Tables

Table 2-1 Physical Catchment Descriptors of Sub-Catchments Draining the Bog	10
Table 2-3 Potential Opportunities / Constraints	12
Table 3-1 BRP measures proposed at Derryarogue Bog	15
Table 3-2 Parameters of Catchment Low Flow Risk.....	22
Table 3-3 Assets at Risk.....	23
Table 5-1 Selection of DMP Measures.....	31
Table 6-1 Drainage Management Plan	34

Figures

Figure 1-1 Location of Derryarogue Bog	6
Figure 2-1 Derryarogue Bog Drainage Network and Sub-Catchments.....	8
Figure 2-2- Production Field Drainage	9
Figure 2-3 Flood Risk at Derryarogue Bog.....	11
Figure 3-1- Derryarogue Bog production type	14
Figure 3-2 Derryarogue Bog Rehabilitation Plan- Zone of Influence	17
Figure 3-3 The effect of water table rise due to bog rehabilitation	18
Figure 3-4 Conditions affecting water table- Cross-section of Derryarogue Bog.....	19

REPORT

Figure 3-5 Overall Catchment Risk	22
Figure 3-6 Derryarogue Bog Rehabilitation Plan- Assets at risk	23
Figure 4-1 Derryarogue Bog DMP objectives	25
Figure 5-1 Key drainage features for Derryarogue Bog	26
Figure 5-2 DMP measures for Derryarogue Bog.....	30

EXECUTIVE SUMMARY

Derryarogue Bog is located 1km north-east of Lanesborough in Co. Longford. Derryarogue Bog discharges via adjacent drains to the north and east to the Shannon (Upper) River.

There are 8 different sub-catchments that drain water from Derryarogue Bog and one inflow sub-catchment which drains water from the south section of derryarogue bog through the north section. Catchments 1, 6, 7 and 8 were all previously assisted by pumps which were used to lower groundwater levels; however, this is no longer in operation and all future drainage will be under gravity.

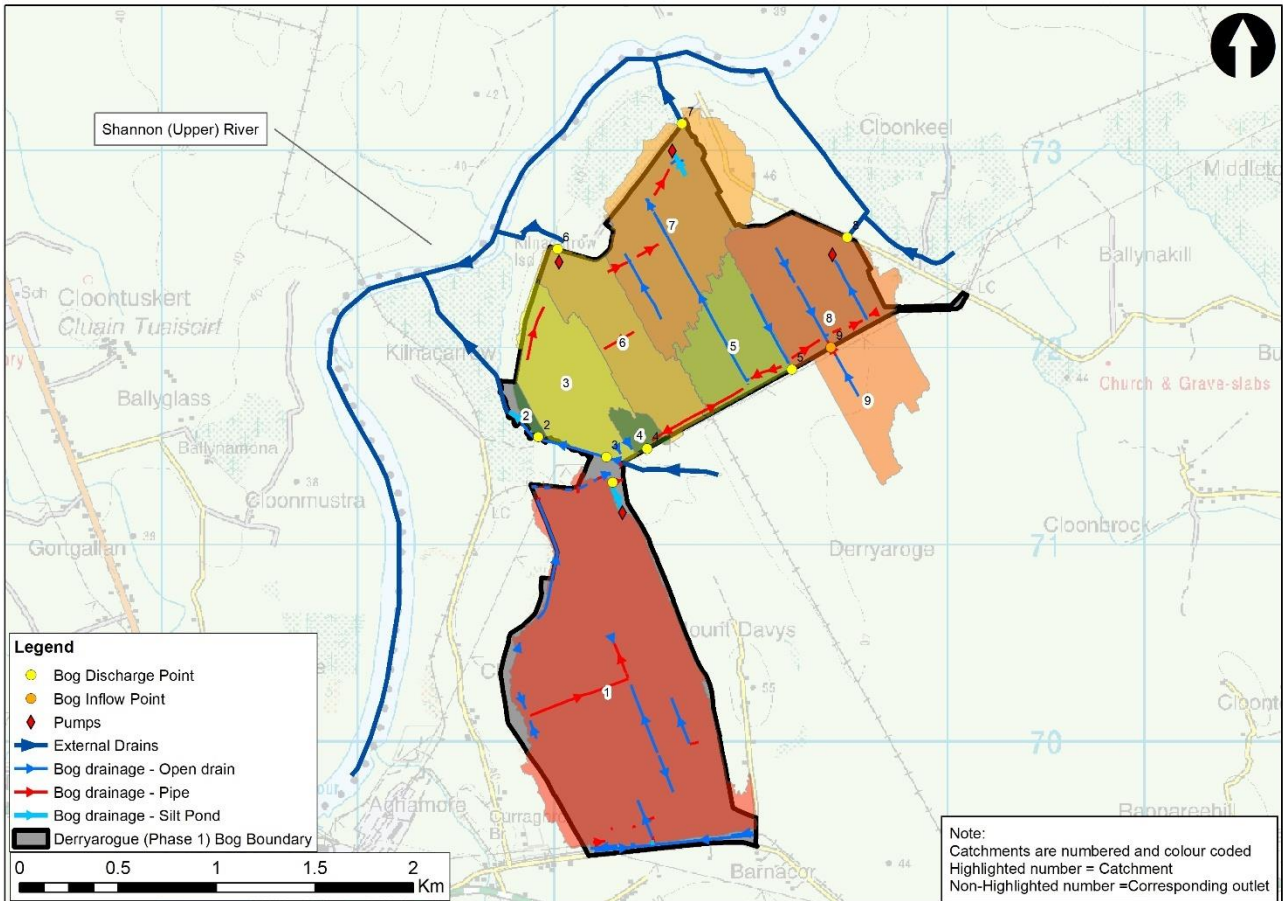


Figure E- 1: Derryarogue Bog drainage catchments

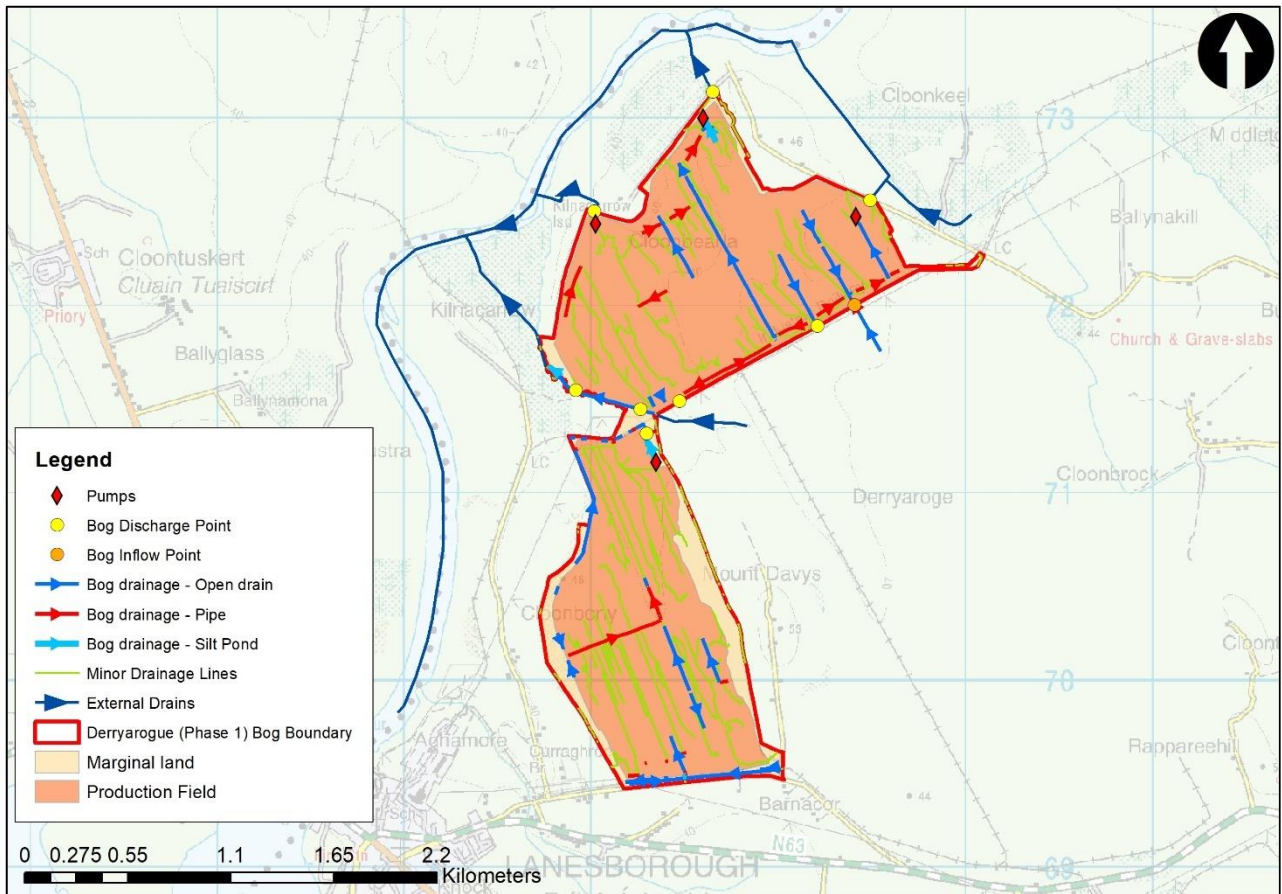


Figure E- 2: : Derryarogue Bog production field drainage

Peat extraction at Derryarogue Bog has stopped and the bog has been selected by Bord na Móna for rehabilitation through the Peatlands Climate Action Scheme (PCAS). The measures proposed to achieve this include blocking the drainage network, deep peat cell bunding and creating wetland areas. These measures will result in raising the water table within the bog and reducing the rate that water drains out of the bog.

It is important to avoid impacting neighbouring lands from the bog rehabilitation measures. Derryarogue Bog Drainage Management Plan (DMP) considers the potential impacts on neighbouring lands and identifies the mitigation measures required. This is a key function of the DMP.

The DMP identified water table raising as having the potential to make neighbouring lands wetter by raising their water table. The lands where this could occur were identified as being within the bog's zone of influence. DMP measures were identified which would prevent the water table impacting adversely on neighbouring lands.

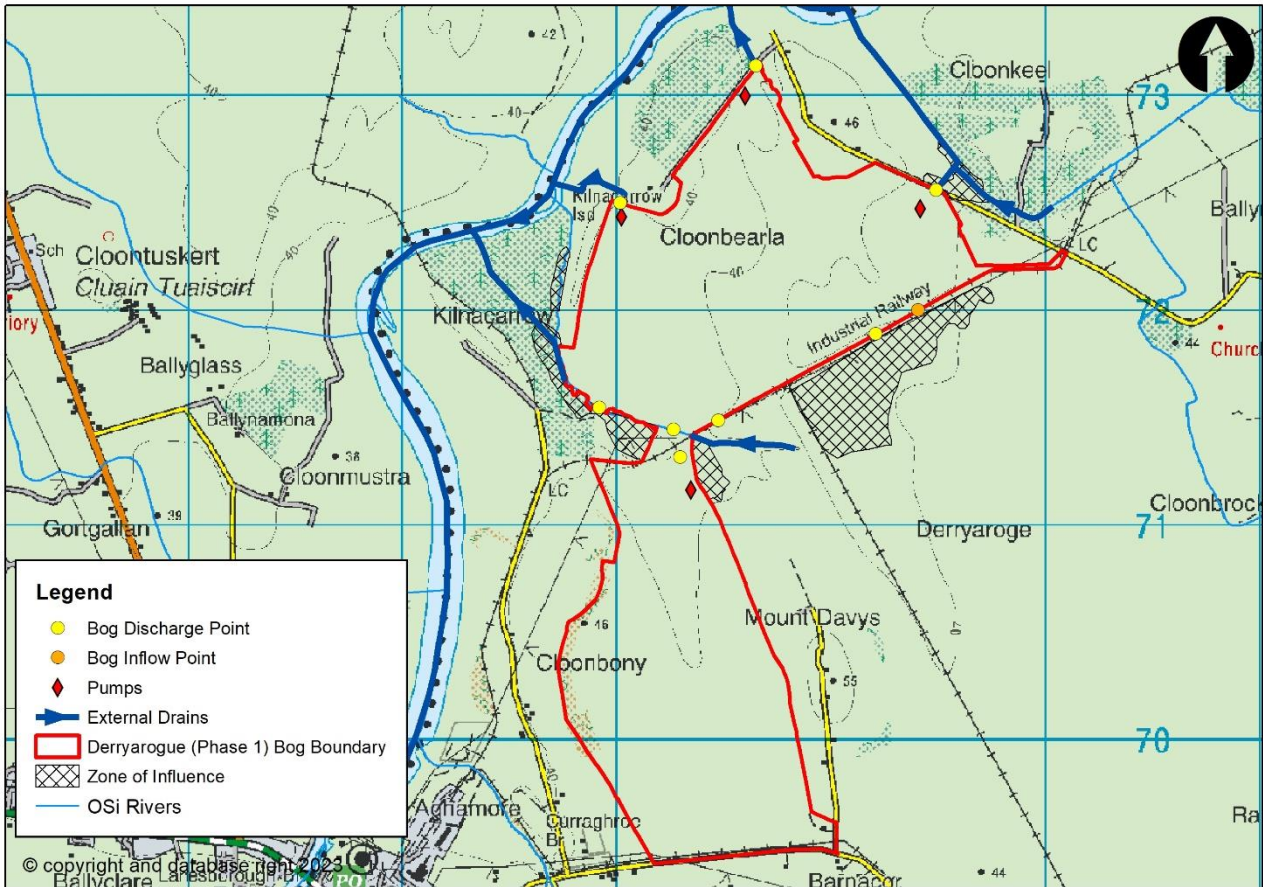


Figure E- 3: Derryarogue Bog Zone of influence

Existing drains along the boundary of the bog and neighbouring lands were assessed. The boundary drains that are in good condition were selected to act as hydraulic breaks to a rise in the water table. The raised water table in the bog would be forced to drop to the water level in the drain mitigating the impact on neighbouring lands.

DMP Measures were identified to control water levels in wetland areas. By ensuring water levels remain below a predetermined level, the risk of water flow across the bog into adjacent land and subsequent water table rise is mitigated.

In addition to these DMP measures, the retention and maintenance of the silt ponds at the existing discharge locations will continue to provide silt control. An additional silt control point at DMP 3 has been recommended as discharge has the potential to be re-routed post rehabilitation. The rehabilitation will, in time, promote the establishment of bog vegetation and will lead to a further reduction in sources of silt.

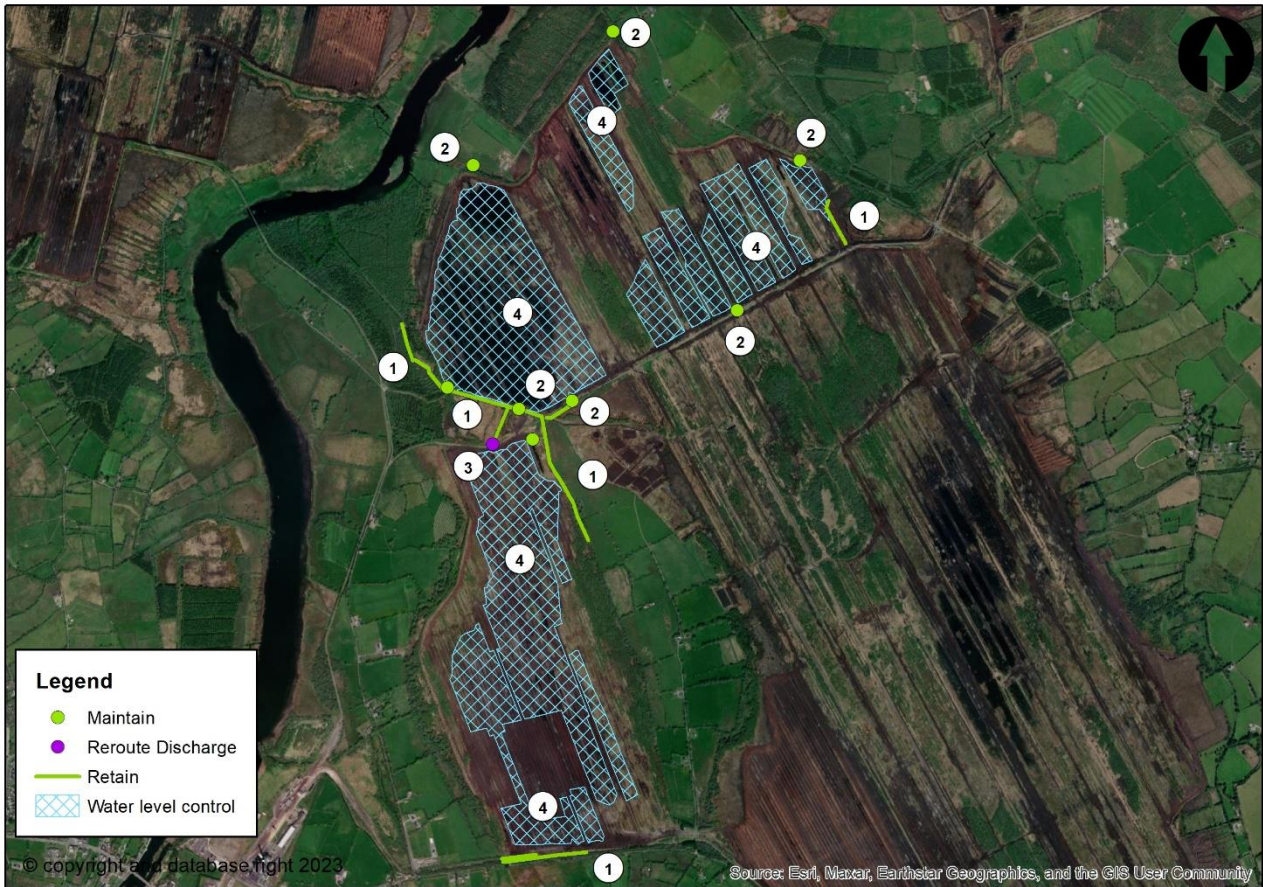


Figure E- 4: DMP measures for Derryarogue Bog (1-Retain drains, 2-Maintain outlets, 3-re-route discharge, 4- Water level control)

1 INTRODUCTION

Derryarogue Bog is located 1km north-east of Lanesborough in Co. Longford. Further site details are described in the Derryarogue Bog Site Characterisation Report 2023, hereafter referred to as the Characterisation Report. Derryarogue Bog is part of the Mountdillon Bog Group. Bord na Móna operated peat extraction within the Mountdillon Bog Group under IPC Licence (Ref. P0504-01) issued and administered by the EPA. Condition 10.2 of this licence requires the preparation of Derryarogue Bog-Cutaway decommissioning and rehabilitation plan 2023¹, hereafter referred to as the 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 Scheme goes significantly beyond what is required to meet rehabilitation and decommissioning obligations under existing EPA IPC licence conditions. Improvements supported by the Scheme ensures that environmental stabilisation is achieved and significant additional benefits, particularly relating to climate action and other ecosystem services, are delivered.

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

This Drainage Management Plan (DMP) for the Derryarogue Bog FY24 PCAS extent 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 or avoid impacts. 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 longer 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.

2 BASELINE ASSESSMENT

Through cessation of peat extraction and implementation of the Rehabilitation Plan there is the potential to hydrologically 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.

Full details of the land use, hydrogeological and soil characterisation can be found in the Derryarogue Bog-site characterisation report 2023. Land use in the surrounding landscape is primarily agricultural land, transitional woodland and cutaway peatland, at-risk land is considered further in section 3.3.

2.1 Drainage Characterisation

Derryarogue Bog discharges via adjacent drains to the north and east to the Shannon (Upper) River. Hydrological analysis was carried out to delineate the drains within and around the bog along with their associated hydrological catchment area. A recent survey of drainage was carried out by Bord na Móna and this was reviewed, and the bog sub-catchments confirmed. Sub-catchments 1,6,7 and 8 were previously pumped and any alteration to the pumping regime would alter how the bog drains. Sub-catchments of the external drains were identified using ArcGIS Hydrology tools. Figure 2.1 presents the catchments areas either draining into the bog or from the bog. Figure 2.2 presents the internal drainage network of Derryarogue Bog.

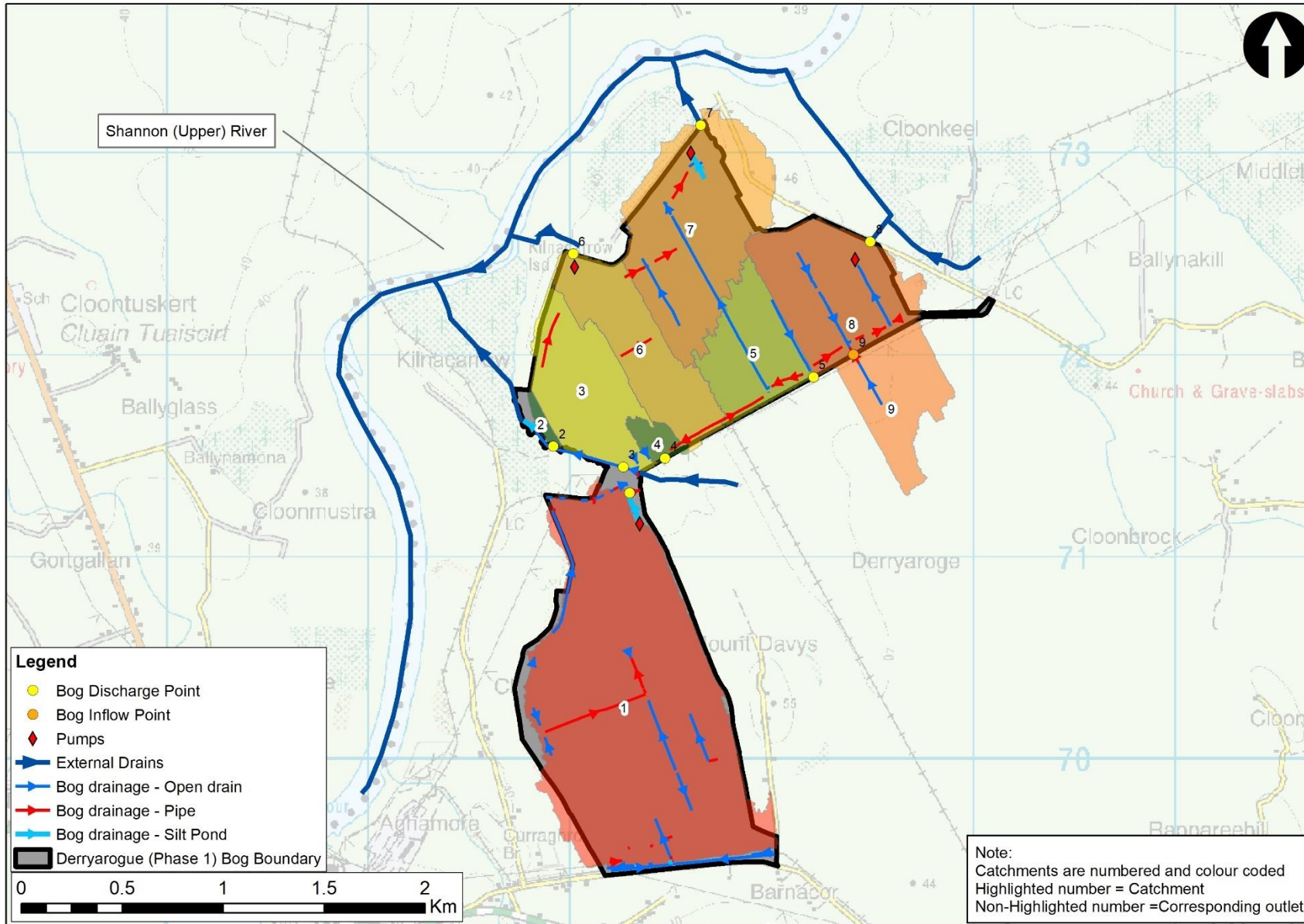


Figure 2-1 Derryarogue Bog Drainage Network and Sub-Catchments

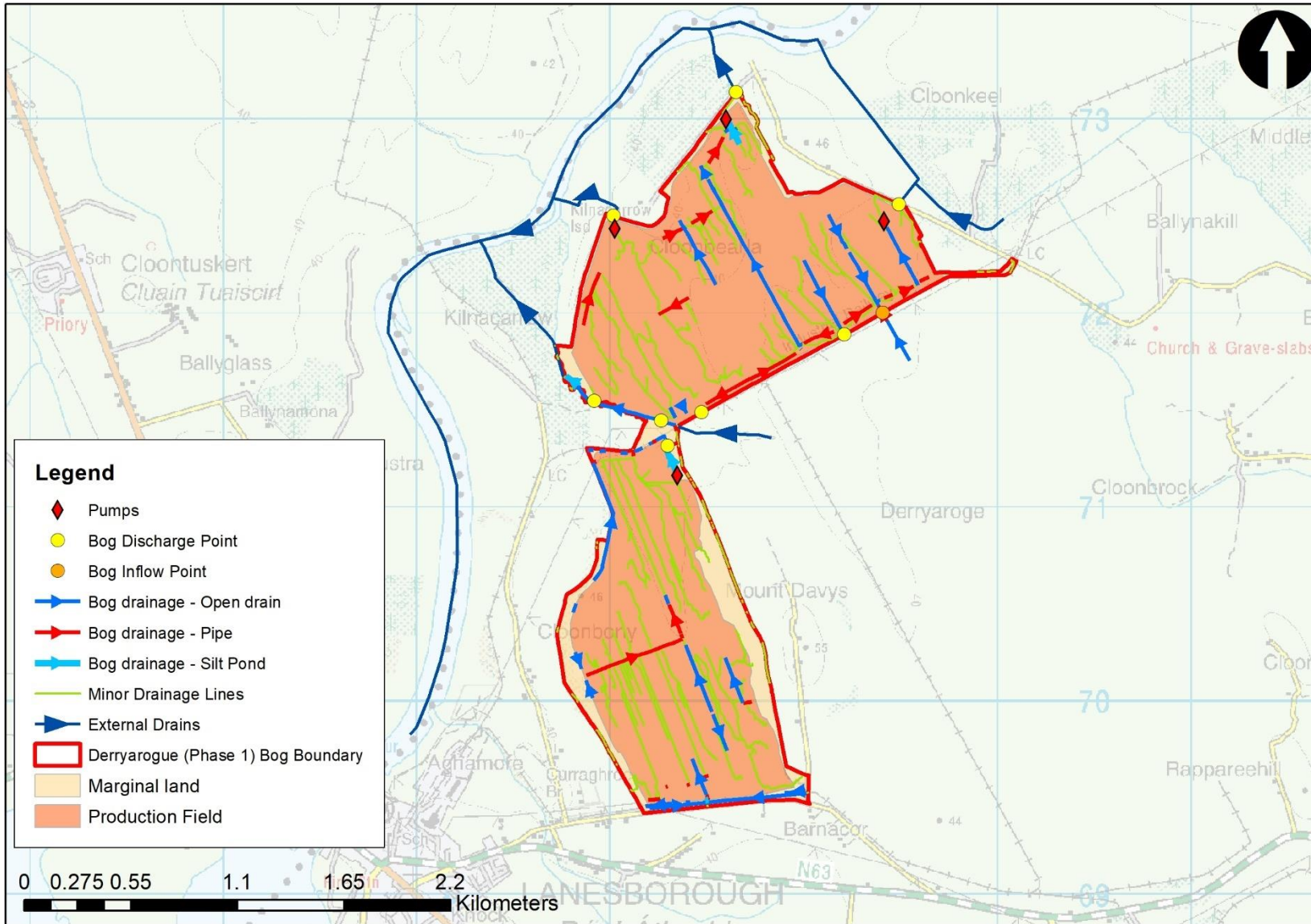


Figure 2-2- Production Field Drainage

The Flood Studies Update (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 2.1

There are 8 sub-catchments draining Derryarogue Bog, and one inflow sub-catchment from the southern section of Derryarogue bog, ranging in area from 0.015km² to 1.458km². The catchments are subject to an average precipitation of 1140mm/year. The Baseflow Index for the catchments between 0.4-0.671, representing a low to moderate catchment permeability. The catchments within the bog are generally quite flat (<3% slope), while catchments that drain areas outside of the bog boundary are typically steeper. This information is based on wider catchment characteristics, and it is acknowledged that these will vary within the bog.

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 (i.e., drained).

Table 2-1 Physical Catchment Descriptors of Sub-Catchments Draining the 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	1.458	1140.1	0.671	0.731	0.093	99.8	1.635	0.177	0.191
2	0.015	1140.1	0.671	0.731	0.093	100.0	1.204	0.002	0.003
3	0.313	1140.1	0.671	0.731	0.093	100.0	0.708	0.035	0.049
4	0.038	1140.5	0.671	0.731	0.093	100.0	0.515	0.005	0.008
5	0.253	1140.1	0.671	0.731	0.093	100.0	0.919	0.030	0.041
6	0.314	1140.6	0.671	0.731	0.093	100.0	2.345	0.047	0.050
7	0.596	1140	0.4	1	0.000	100.0	1.959	0.267	0.266
8	0.653	1140	0.671	0.731	0.093	100.0	0.532	0.064	0.094
9*	0.244	1140	0.671	0.731	0.093	100.0	7.150	0.049	0.040

* Catchments have a significant upper catchment in the adjacent land that drains through the bog

2.2 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 external 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 e.g., woodlands, commercial forest, and peat and where there is potential head loss in the channel due to instream features e.g., culverts, sharp bends, channel widening and inflows. The potential for Derryarogue Bog being a sediment source to the external drains is considered low as silt ponds upstream of the discharge points from production fields mitigate this potential and where deemed necessary additional silt control measures will be provided. A reduction in the mobilisation of silt will be a function of the rehabilitation measures after works are completed.

A review of the bog drains was carried out. The Bord na Móna drainage survey details the open drains, settlement silt ponds and discharge points. Some catchments have pumps to help with the drainage of the bog and removing these will change the drainage characteristics of the bog. The drains in the bog have very gentle

bed slopes before discharging from the bog. It is anticipated that the bog drainage network would be sensitive to drain and pipe alterations.

2.3 Flood Risk

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

- CFRAM Study maps setting out the predicted fluvial 10%, 1% and 0.1% Annual Exceedance Probability (AEP) fluvial flood scenarios
- GSI predicted water table flood maps for high, medium and low probability events
- Mapped fluvial flood extents for the 2009 River Shannon 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

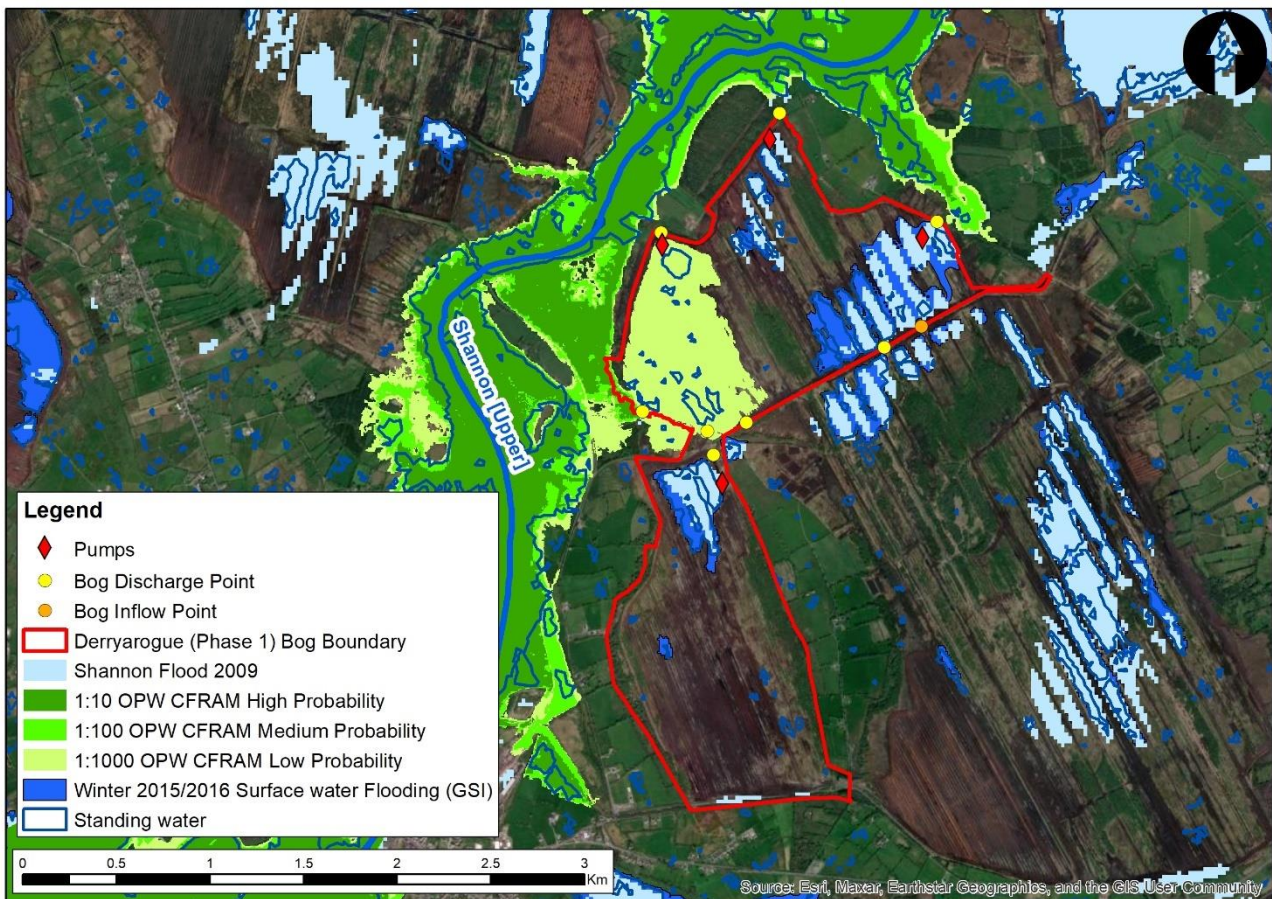


Figure 2-3 Flood Risk at Derryarogue Bog

The CFRAM maps show that there is low to medium risk of Derryarogue Bog flooding from the Shannon (Upper) River and the surrounding areas of the bog have a high probability of flooding. It should be noted this analysis did not consider the fluvial flood risk from the smaller watercourses which drain the land adjacent to Derryarogue Bog. The 2015/2016 surface water flooding data and the 2009 Shannon flood data also indicates

flooding has occurred within the bog boundary in the past. This is consistent with the local knowledge from Bord na Móna operatives familiar with Derryarogue Bog.

Historical anecdotal evidence was reviewed to ascertain if there are any known flooding or drainage issues from these smaller watercourses to the bog or adjacent land. No drainage issues have been identified along the Derryarogue Bog boundary drains.

There is no predicted groundwater flooding to the bog indicated on the GSI datasets.

2.4 Constraints and opportunities

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	The adjacent peatland is in the possession of BnM. A windfarm is proposed for the adjacent Derryadd Bog. The impact from Derryarogue Bog should be considered.
Roads	Constraint	Minor roads providing access to dwellings, agricultural land and peat bogs are located in the study area. Access to these roads should be maintained.
Rivers	Constraint	The Shannon (Upper) River, the Ballynakill 26 Stream and the Kilnacarrow stream flow adjacent to and downstream of Derryarogue Bog. No activity should adversely impact these watercourses.
External drains	Risk	The potential for Derryarogue Bog being a sediment source to the external drains is considered low as silt ponds upstream of the discharge points from production fields in some sub-catchments mitigate this potential and where deemed necessary additional silt control measures will be provided.
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. Derryarogue Bog 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.

REPORT

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 measures identified for the bog rehabilitation plan are detailed in the Rehabilitation Plan 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.

Figure 3.1 shows the areas of the areas where peat extraction took place and production fields were formed, and the areas of marginal land within Derryarogue Bog. Production field areas will have been most intensively drained during the time of peat extraction and the water table lowered more significantly than the marginal land. The bog rehabilitation measures in the production field areas are therefore expected to increase the water table to a greater extent than in the marginal land and have a greater reduction in rate of discharge from these areas.

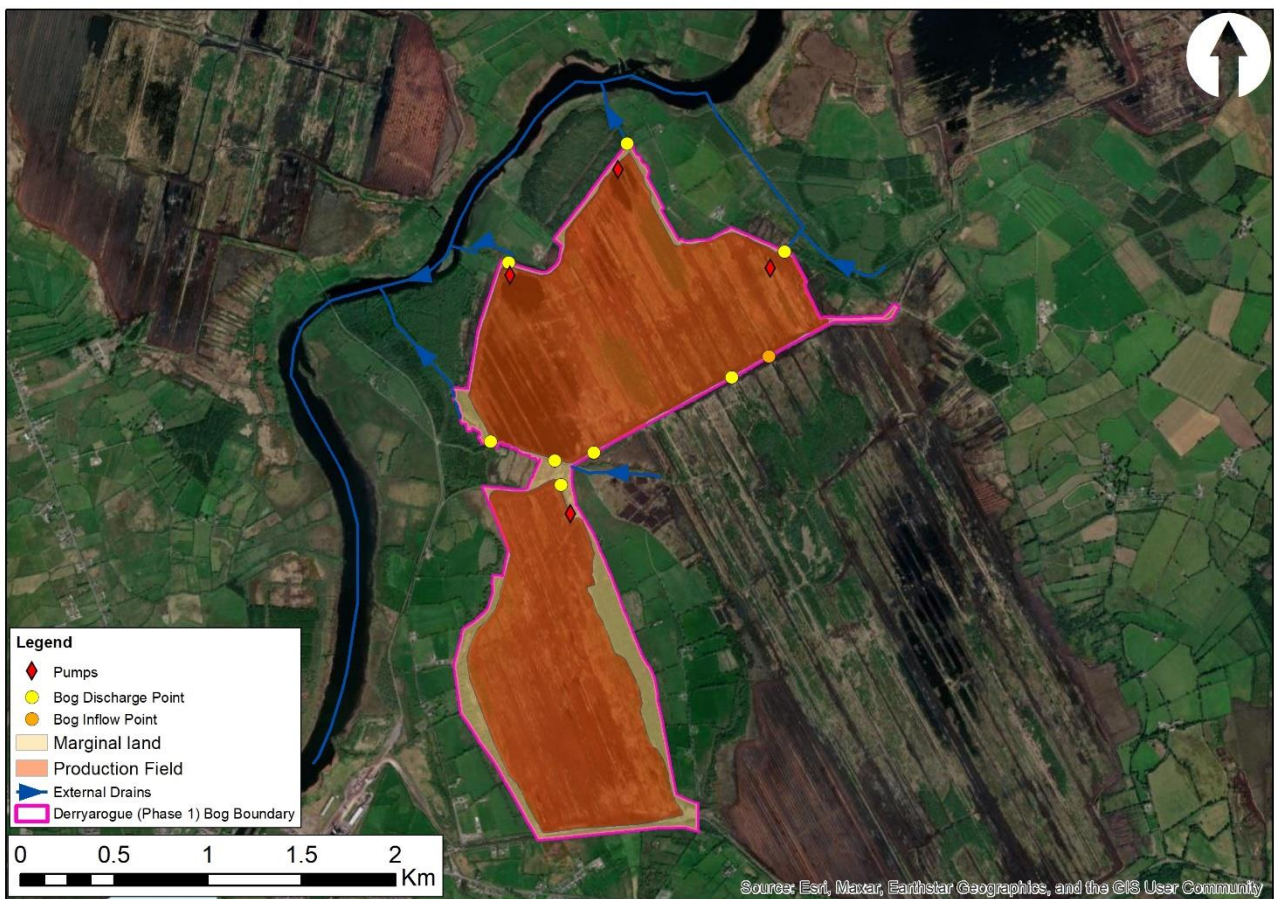


Figure 3-1- Derryarogue Bog production type

3.1 Impact Screening

Table 3.1 summarises the rehabilitation measures proposed for the Derryarogue Bog and their potential impact to adjacent land.

Table 3-1 BRP measures proposed at Derryarogue Bog

BnM rehabilitation measure	Description	Potential Impact	Potential Impact Description
Drain blocking, berm.	<p>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.</p> <p>Surface water runoff through the bog will be slowed allowing the bog to store more water</p>	Positive and negative	<p>Reduced runoff from the bog discharge points resulting in less flow in the external drains located downstream.</p> <p>Reduced conveyance at bog inflow point resulting in increased water volume in external drain located upstream if conveyance channels through the bog are blocked.</p>
Blocking outfalls	<p>Most production field drain systems drain into a headland pipe running perpendicular to the peat field. This intersection is known as an outfall.</p> <p>By blocking the outfalls each production field drain will be prevented from operating resulting in the ditch storing water and raising the water table level in the bog. This will allow the bog to store more water and bring the water table level to the surface.</p>	Positive and negative	<p>Reduced runoff from the bog discharge points resulting in less flow in the external drains located downstream.</p> <p>Raised water table levels to the bog surface will create a hydraulic gradient across the bog into the adjacent land. Water table levels in lands within this hydraulic gradient will potentially rise. The effect will be greatest immediately beside the bog. However, mitigation measures in the form of hydraulic breaks will be implemented, see Section 5.</p>
Managing overflows with overflow pipes	<p>This measure is usually combined with blocking outfalls which cause water table 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 this occurs and where the overtopping water is discharged to.</p>	Neutral	<p>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.</p> <p>Overall, the volume of water discharging from the bog will be reduced but will contribute to raised water table levels within the bog and potentially within the zone of influence (subject to mitigation).</p>
Sphagnum moss inoculation	<p>This measure will propagate sphagnum moss within the bog.</p>	Positive	<p>Sphagnum moss can hold up to 10 times its weight in water. As such this measure will store</p>

REPORT

Sphagnum moss will cause bog regeneration as it grows and layers.

water reducing the runoff from the bog into the exterior drains. This will help retain the external drainage efficiency which adjacent land relies on.

This measure may also contribute to runoff reduction and wider catchment FRM goals but in a piecemeal way.

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 bog into the external drains or river.

Wetland creation

Areas prone to flooding and depressions on shallow peat are designated for wetland creation. Shallow 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.

3.2 Impact Assessment

Three potential impact sources were identified; water table rise, increased runoff from the bog and low flow risk. These impact sources have the potential to make the adjacent land wetter and drain less efficiently or reduce water supply in adjacent drains. 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.

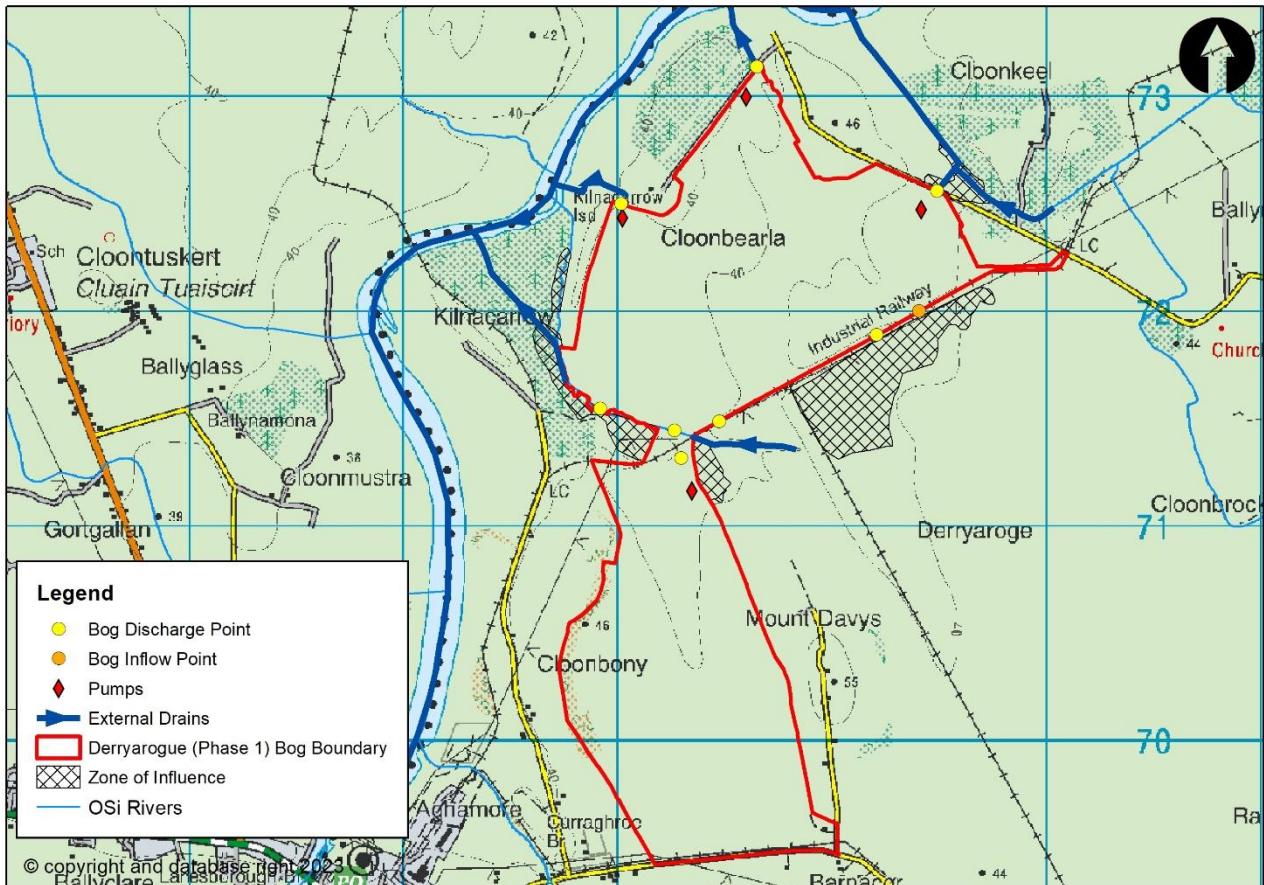


Figure 3-2 Derryarogue Bog Rehabilitation Plan- Zone of Influence

3.2.1 Water Table Impact

The impact of rehabilitation measures on water table levels within and adjacent to the bog is difficult to assess quantitatively in the absence of long term monitoring data and detailed hydrogeological models of the bog. Nevertheless, it can be assumed that water table 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 can also be assumed that the maximum level which the water table 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 large portions of the bog are not dependent on a pumping regime to drain surface water. For areas zoned as wetland or areas no longer to be pumped, the maximum water level will be at or above surface level as shallow water ponding is promoted through rehabilitation measures.

The surface of the bog may lie higher or lower than the adjacent land. This relationship between the bog and adjacent land needs to be considered when assessing potential water table rise. Figure 3.2 show these two relationship scenarios in a simplified schematic. Where the bog is lower than the adjacent land it would be expected that the water table would remain lower on the bog side even when the water table is raised to the bog surface. If wetland areas are created and the water level is raised above the surface it may result in higher levels than the water table in adjacent lands. In this case the presence of a boundary drain can act as a hydraulic break bringing the water table down to its original level and preventing a rise in the water table in the adjacent land. Where the surface level of the bog is higher than the adjacent land the risk of raising the water table in the adjacent land is greater. However, in this scenario the presence of an effective boundary drain will collect runoff from the bog and act as a hydraulic break bringing the water table back down and preventing a rise in the water table in the adjacent land.

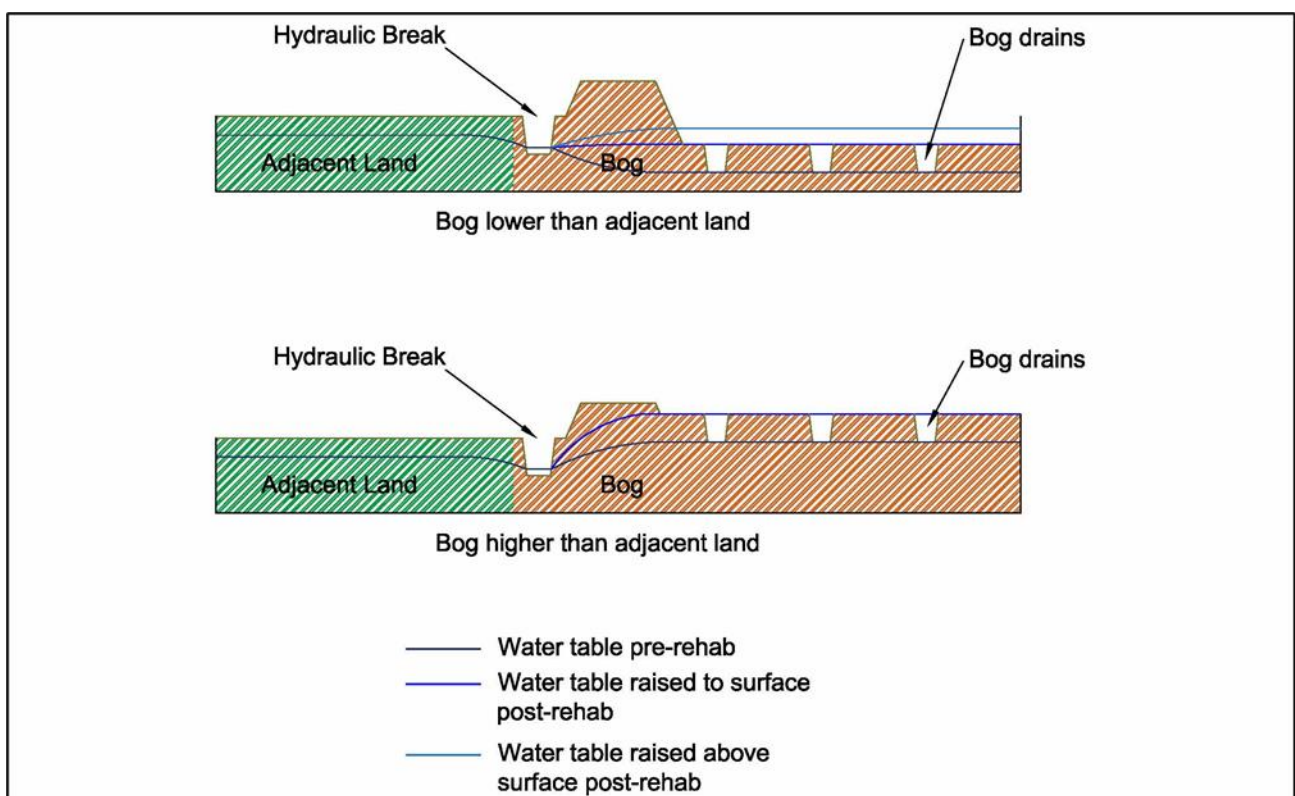


Figure 3-3 The effect of water table rise due to bog rehabilitation

For Derryarogue Bog the adjacent land lies lower than the bog in some locations, identified in Figure 3.1 as the Zone of Influence, and higher in other locations. Water table rise in lands adjacent to Derryarogue Bog was assessed firstly by estimating the potential rise in water table within the bog. The production field drainage system of Derryarogue bog is typically 0.6m deep. It can be expected that the water table would rise by 0.6m to bring it to the surface. A cross section was surveyed, as shown in Figure 3.3, to assess the potential impact of a water table rise.

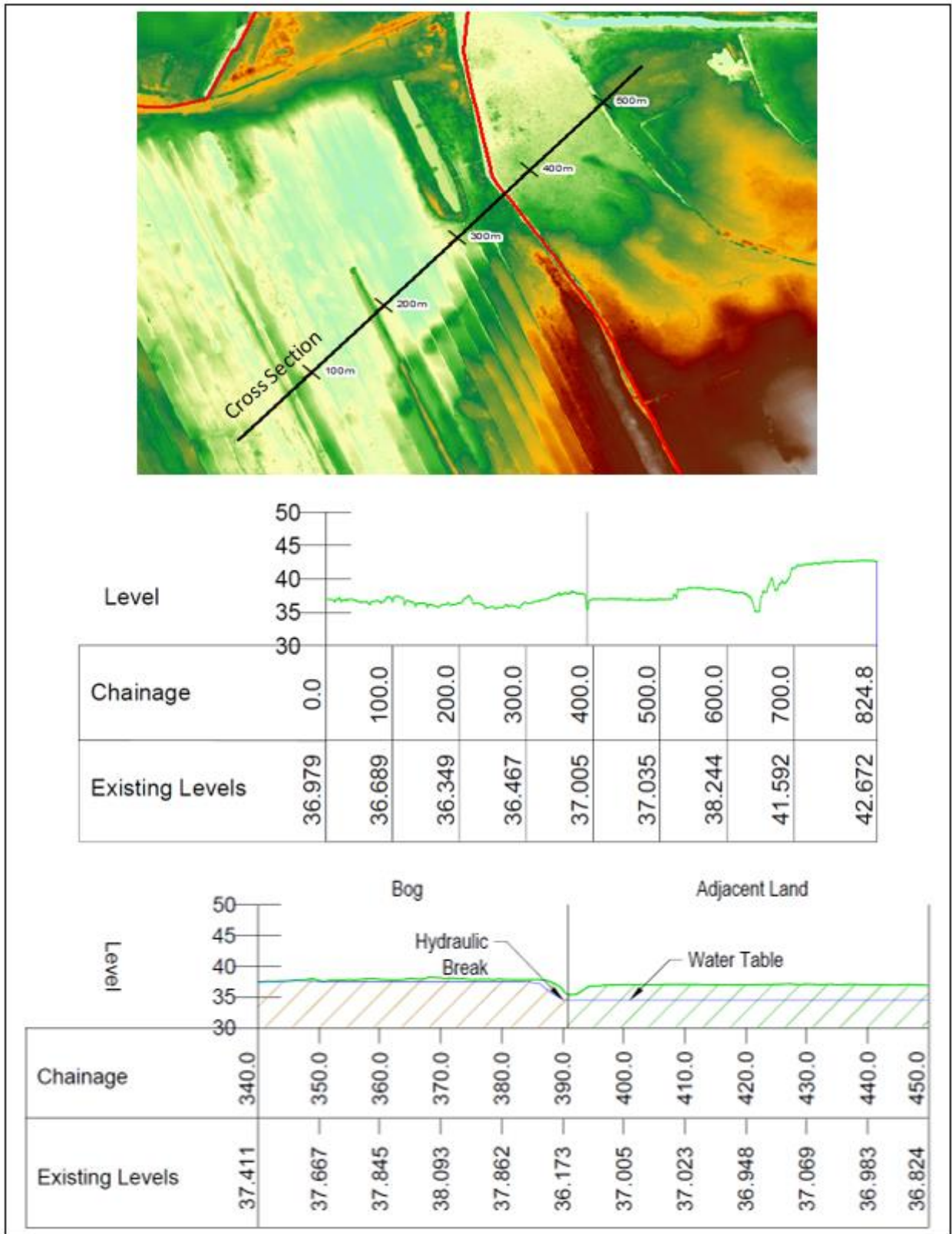


Figure 3-4 Conditions affecting water table- Cross-section of Derryarogue Bog

The cross section shows that a rising head in the bog would create a hydraulic gradient across into the adjacent land with the potential for a raised water table in the adjacent land also. This action determines the zone of influence and the areas of potentially wetter ground. The presence of boundary drains however will act as a hydraulic break controlling the hydraulic gradient and reducing the zone of influence. As these boundary drains lie lower than the adjacent land it is expected that they will function as a hydraulic break. This however is dependent on the drain's ability to adequately convey flow.

Drains that are inefficient with high water levels (independent from the bog rehabilitation measures) will also raise the water table in the bog and potentially in the adjacent lands to the bog would be wet. The avoidance of the drain full condition is dependent on the retention of a positive gravity drainage function of the boundary drains the adequate functioning of which is retained.

Boundary drains were identified by aerial imagery and LiDAR for Derryarogue Bog, which provide the water table cut-off function to agricultural lands. 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 Derryarogue 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.

Caution should be exercised during any alterations of boundary drains around Derryarogue Bog. It is important to avoid the creation of new flow paths into the bedrock which has the potential of increasing water table flood risk elsewhere or altering the hydrogeological conditions for peat formation. If deepening of drains is undertaken it should therefore be undertaken with care so as not to deepen the drain beyond the base of the peat. Full details of the land use, hydrogeological and soil characterisation can be found in the Derryarogue Bog– site characterisation report 2023.

There is also a risk that as the bog fills with water and wants to discharge, and 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. Derryarogue Bog discharges via adjacent drains to the north and east to the Shannon (Upper) River. There is little risk to adjacent lands from increased flows from the bog owing to elevated water table levels. As previously set out this is dependent on existing boundary drainage network isolating the bog from lower-level adjacent lands and providing a positive gravity drainage function. 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 Increased Runoff

Evidence from bogs that have previously been the subject of restoration measures demonstrates that the measures proposed at Derryarogue Bog, 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 designated raised bogs such as Clara Bog, 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 as a result of following rehabilitation measures and monitoring has shown reduced runoff from the moorland as a result of increased storage in the peat.

The risk of increased runoff from Derryarogue Bog is low. All rehabilitation measures being proposed will reduce rate of runoff. However, there is a potential that if bog re-profiling is carried out as part of the bog rehabilitation measures that the bog sub-catchments will be modified. 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 Derryarogue Bog as the re-profiling of the bog, if carried out, will generally result in the same topographical flow paths, catchment watersheds and discharge locations as in the pre-rehabilitation state. Similarly, the effect of reducing or turning off the pumps at discharge points could result in raised water levels and a transfer of water across sub-catchments leading to increased runoff through other discharge points. This would be a low risk provided the alteration to the pumped discharge points allow for continued discharge and for ponding within the bog if necessary, to store the runoff. In the absence of a full pre and post rehabilitation runoff model and a precautionary approach has been adopted to ensure that all drainage infrastructure from the bog is retained and is fit for purpose.

3.2.3 Low Flow Assessment

A low flow risk assessment was completed to identify whether any discharge locations from the bog are at high risk of low flow during periods of low rainfall and high evapotranspiration. While it is anticipated that rehabilitation will generally lead to dampening of peak flows and support sustained flows during dry periods, there is a potential risk that during prolonged dry periods that the rehabilitation measures may lead to downstream watercourses drying out as a result of increased infiltration, increased rates of evapotranspiration along with the additional storage capacity created within the bog.

A high level risk assessment was carried out to identify the particular discharge locations where this may be a risk. The following are considered the key factors that are most likely to influence the risk of drains previously unaffected experiencing low flow:

1. The contributing catchment area to each discharge location (as this is one of the main factors that will influence the range of flow rates);
2. The intensity of the rehabilitation works within the catchment (both in terms of measures proposed and proportion of the catchment undergoing rehabilitation)

The larger the contributing catchment area it is considered less likely that a drain will reduce flow, while the more intensive the rehabilitation works the more likely a drain will be to low flow. In order to simplify the risk assessment process three risk categories (High, Moderate and Low) were identified for catchment area and restoration intensity based on experiences from other bogs where this issue has occurred. For rehabilitation intensity the proportion of the catchment area undergoing rehabilitation was used as an indicator of risk. The overall risk category assigned is determined based on Catchment area risk multiplied by Rehabilitation intensity risk as summarised below:

Table 3-2 Parameters of Catchment Low Flow Risk

Risk category	Catchment area (ha)	Rehabilitation intensity (% of catchment area)	Overall risk category
Low (1)	>20	<30%	Low (1-3)
Moderate (2)	5-20	30-60%	Moderate (4-6)
High (3)	<5	>60%*	High (7-9)

*Note: Rehabilitation intensity (% of catchment area) capped at Moderate for where the rehabilitation measure only involves drain blocking on vegetated high bog (MLT2)

Where any discharge locations are identified as high risk, it is recommended that Bord na Móna undertake a review of the drainage channel downstream of the bog to identify the potential impact to the landowners.

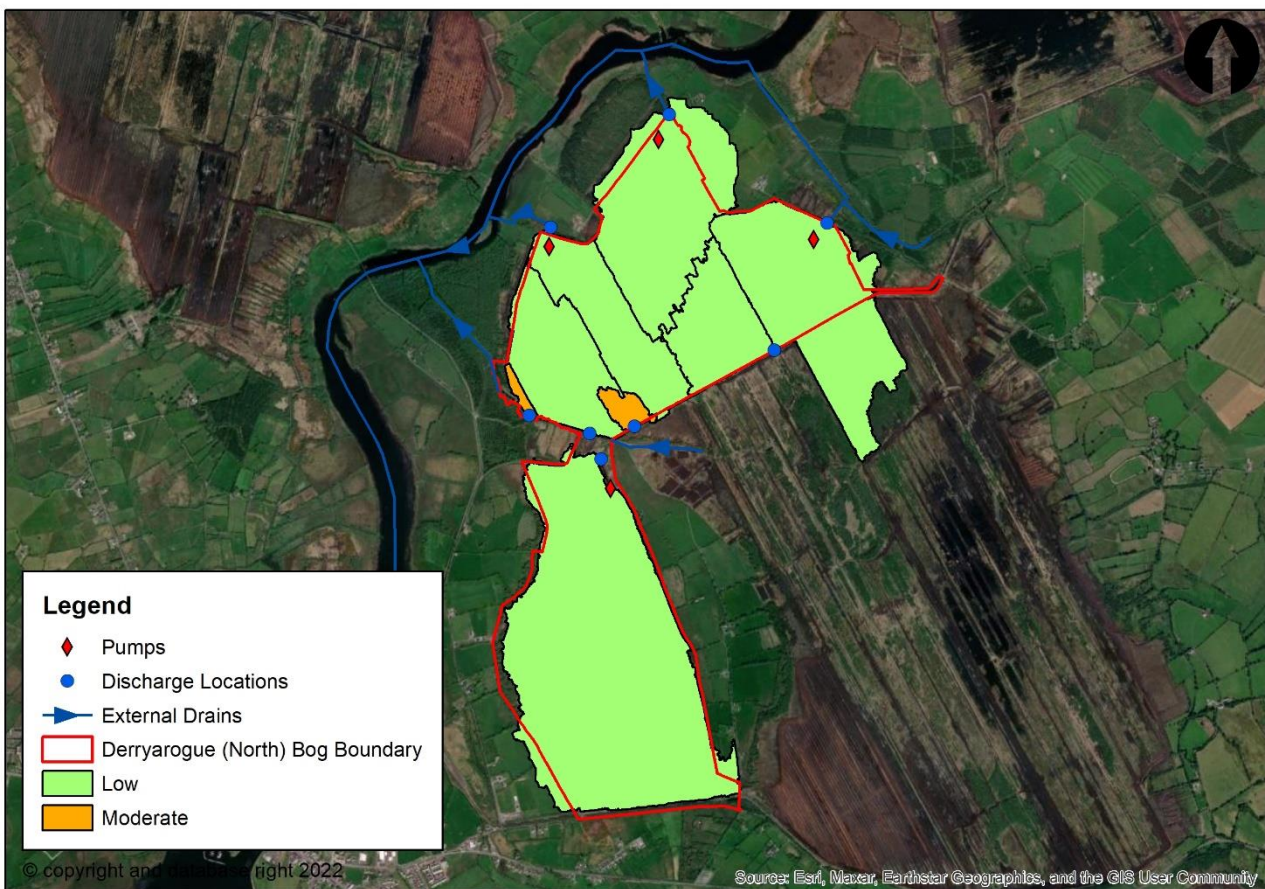


Figure 3-5 Overall Catchment Risk

Through assessing the catchment areas and rehabilitation intensity, most catchments were classified as low risk. Two moderate risk catchment was identified however this moderate risk catchments flow directly into external streams that have an upstream catchment and therefore there would be no risk to low flows. No high risk catchments were identified that would require further survey and assessment.

3.3 Potential Risk Areas

The following assets have been identified as being at potential risk from flooding or wetter conditions as a result of measures described in Table 3.1 being implemented.

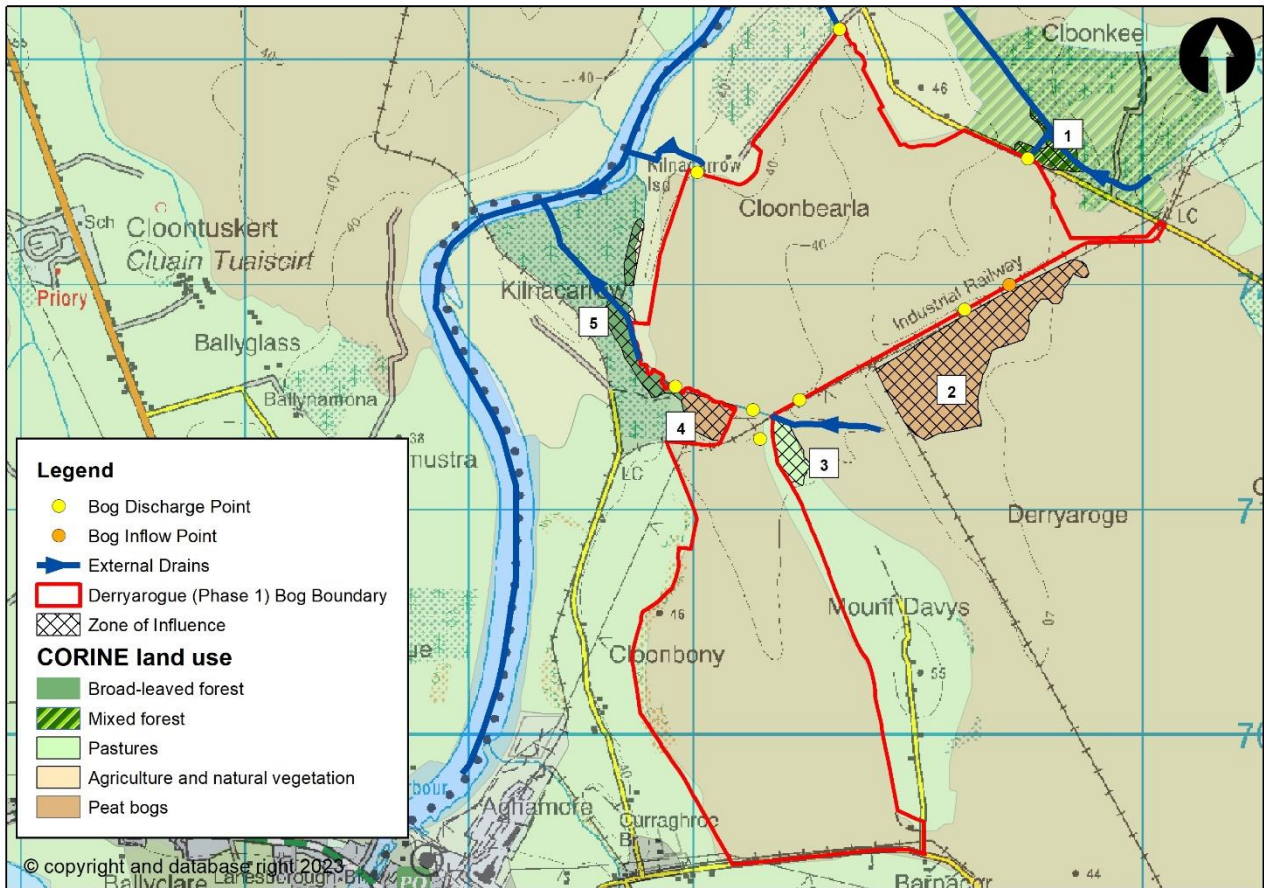


Figure 3-6 Derryarogue Bog Rehabilitation Plan- Assets at risk

The assets at risk are set out in Table 3.3 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 considers 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	Mixed Forest	Low Vulnerability. Forest can tolerate wetter conditions.
2	Peat	Moderate Vulnerability. Peat can tolerate wetter conditions. There is potential for future amenity track to be located along the existing rail line.

REPORT

3	Agricultural Land	High Vulnerability. Land would become less productive should it be made wetter.
4	Peat	Low Vulnerability. Peat can tolerate wetter conditions.
5	Forest	Low Vulnerability. Forest can tolerate wetter conditions.
6	Roads	Low vulnerability. Road level slightly higher than surrounding land. Risk of flooding is low.

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 Derryarogue Bog Drainage Management Plan is to facilitate the rehabilitation of bog through management of potential adverse impacts to adjacent land and waterbodies. SMART² 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 water table impacts between adjacent land and Derryarogue Bog during and after rehabilitation measures.
2. To maintain or reduce flow rate from the bog at the discharge locations.
3. To manage sediment entering the River Shannon during and after rehabilitation, these measures are to ensure compliance with current discharge limits in IPC Licence.

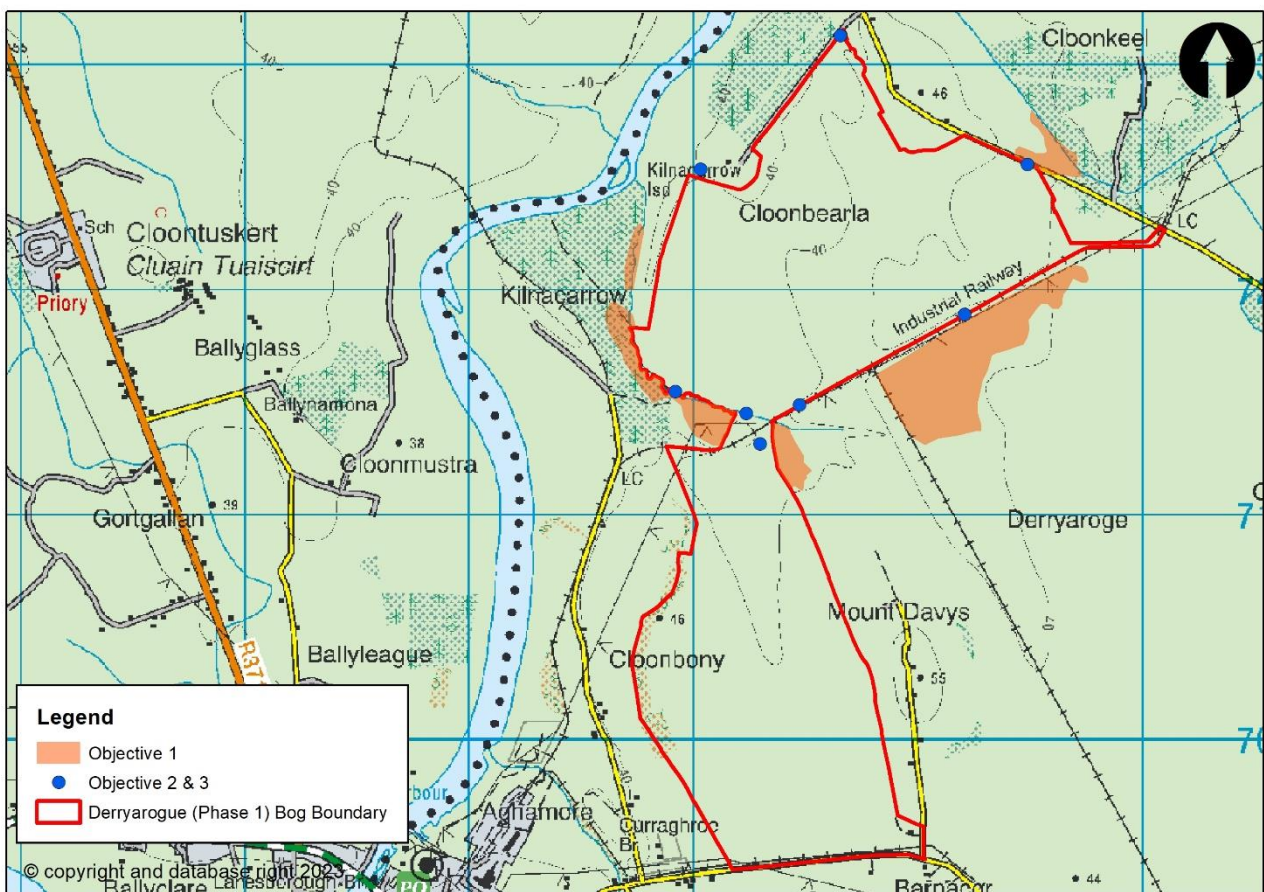


Figure 4-1 Derryarogue Bog DMP objectives

² SMART – Specific, Measurable, 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. Objective 1 considers the potential impact to adjacent land from water table rise. Objectives 2 and 3 consider the control mechanisms to flow discharging from the bog.

An assessment was carried out to identify the existing key drainage features available to meet the objectives set. Figure 5.1 presents the key drainage features identified. It can be seen in the figure that for water table level rise to be managed between the bog and adjacent land that a hydraulic break will be required where available. To ensure that the flow and sediment discharging from the bog is managed the silt ponds at the discharge control points will need to be maintained.

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 mitigate the risk of sediment deposition arising from rehabilitation. Post-rehabilitation there will be in general a reduction in risk of sediment/silt escape once the bog reaches environmental stabilisation. It is noted that sediment deposition in the external drains could impede the drainage of the bog and adversely impact adjacent lands.

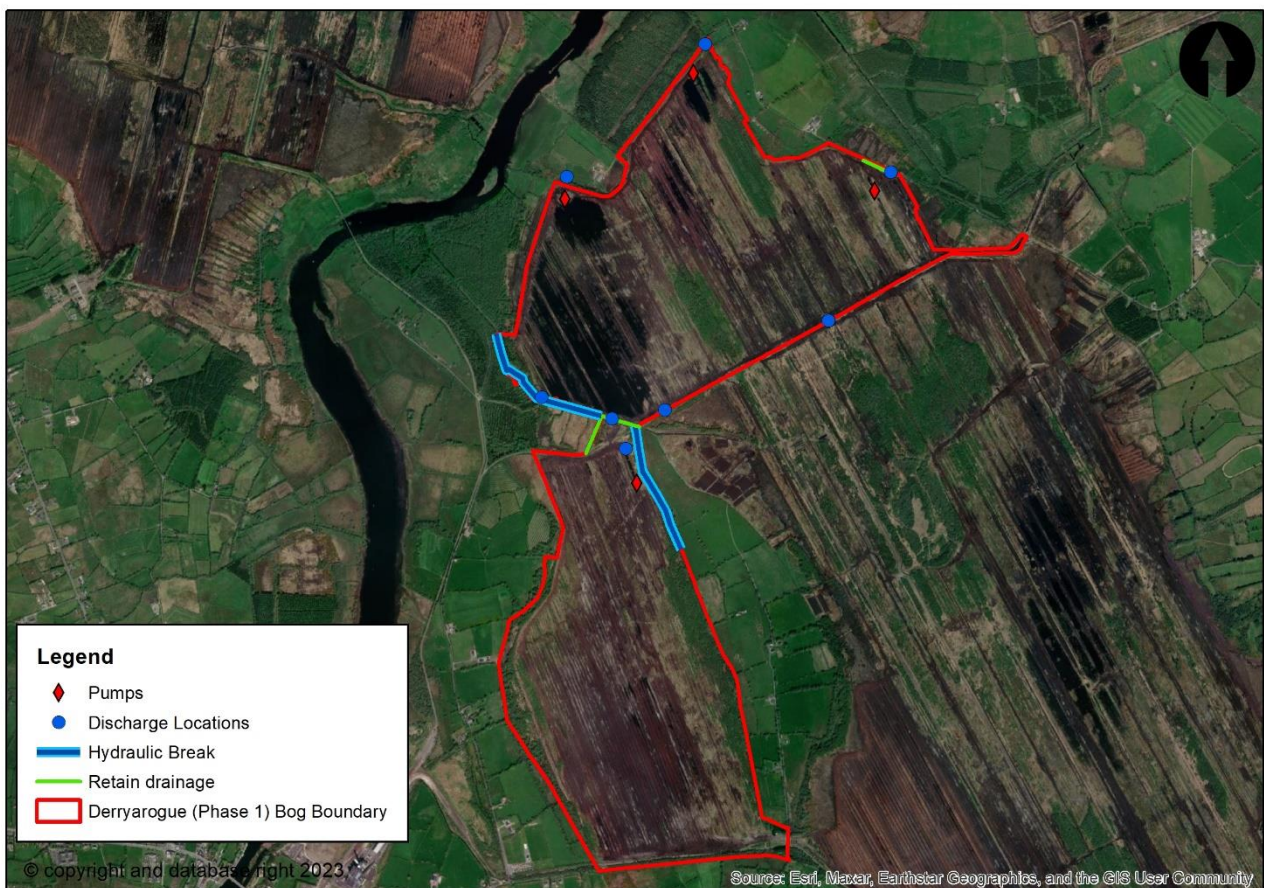


Figure 5-1 Key drainage features for Derryarogue Bog

When identifying measures to provide the key drainage features a review was carried out of the drains. LiDAR, topographical surveys and local knowledge from Bord na Móna operatives were used in this review. While the review gave a good indication of the key drainage features' performance it is acknowledged that gaps in information or changes to features post survey could change the expected performance. Derryarogue Bog Drainage Management Plan therefore outlines a suite of responsive measures taking into account such factors as robustness and ongoing on-site observations. The Drainage Management Plan 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 Derryarogue Bog Drainage Management Plan.

5.1.1 Boundary Drains

Boundary drains can provide hydraulic break between the bog and adjacent land, see Figure 5.1. In most areas of the Derryarogue Bog where hydraulic break would be required there are existing boundary drains. Available information indicates 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. Boundary drains which are currently considered a shared asset between BnM and the adjacent landowner will fall under the responsibility of BnM to retain this asset. Where there is no boundary drain present an alternative measure may be required. This might include a new drain in order to create the hydraulic break required, in these cases a channel of specified dimensions and slope will be required and where possible will not extend into the mineral soils (See section 3.2.1).

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, or equivalent rehabilitation area, closest to the adjacent land where an existing field drain could provide the hydraulic break function. The field's drainage network would be retained keeping the water table to current conditions and providing a water table cut-off in relation to the adjacent land.

In areas zoned as wetland within the rehabilitation plan control of the water levels may be required. Where there is a potential backwater into adjacent lands or where raised water levels could potentially raise water levels on adjacent lands setting a maximum control water level may be required. This control level will allow water to drain freely from the wetland area although water levels may rise higher than the control level during flood conditions.

5.1.3 Maintenance of Discharge Points

Existing silt ponds are located upstream of the bog discharge points. They help regulate the flow and ensure that suspended solids are settled in the pond, maintaining compliance with the emission limit values regulated by the EPA. Bord na Móna have legal responsibility to maintain these silt ponds and ensure their proper functioning capacity under the existing IPC Licence (Ref. P0504-01).

If alterations occur where no silt point exists upstream of a discharge point and no subsequent silt pond will be utilised before flow would leave the bog alternative silt control measures may be required. This can include blocking and or diverting the discharge point so that the relevant sub-catchment of the bog drains to a different discharge point with a silt pond. The rehabilitation plan can be adapted where required to allow proposed wetlands to act as a silt control measure.

5.1.4 Monitoring

As mentioned above DMP measures were selected based on level of certainty and on-site observations. The most appropriate measure was selected from a suite of measures representing varying levels of intervention. Monitoring of the measure 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 or an alternate measure will be undertaken that will satisfy the functional requirement of a hydraulic break. Otherwise, monitoring should continue until environmental stabilisation has taken place.

5.2 Identification of Measures

The following section along with Figure 5.2 and Table 5.1 lists and describes the DMP measures for Derryarogue Bog.

- DMP 1. The boundary drains identified in Section 5.1 as key drains are proposed to act as hydraulic breaks. The boundary drains' ability to carry out this function is dependent on their condition and being free draining. Section 5.1 indicates how all boundary drains appear to be functioning sufficiently with no known drainage issues identified along the drains or in adjacent lands. Topographical surveys, LiDAR and anecdotal evidence 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. If issues are identified during walkover surveys, a higher level of intervention, drain upgrade, can be applied in these locations.
- DMP 2. Existing silt ponds would be required to be maintained.
- DMP 3. DMP 3 refers to silt control. This can be achieved through careful sequencing of drain blocks relative to discharge points, re-routing during the construction or adapting rehabilitation measures to provide silt control.

DMP 4. DMP measures were identified to control water levels in the wetland areas. By ensuring water levels remain below set levels the risk of water flow across the bog into adjacent areas of the bog which are constrained out and subsequent water table rise would remain low.

A review was carried out to ascertain where water would first spill from any proposed wetland area into adjacent land. The ground level at this location, minus 500mm to allow a freeboard, was used to determine a Water Control Level (WCL) in the wetland areas. Standing water would be allowed to pond up to the WCL before free discharge from the wetland would occur.

The ground level in wetland area DMP 4 does not allow for a 500mm freeboard to the adjacent land. Generally, the area is a depression making it suitable for wetland however, several spill points were identified to the adjacent land. At DMP 4 the water level should be controlled to surface level in normal non flood conditions or where ponding already exists aim to keep levels as they are currently.

DMP 4 should be carried out in conjunction with DMP 1, the retention of boundary drains. The WCL is not prescribed as a target water level. It has been derived from the principle that under normal free draining conditions, which will generally align with summer time, the water level of the rewetted bog will not adversely impact adjoining lands. The optimal water depths for rehabilitation and the functioning of the drainage are designed, under normal free draining conditions, so that the WCLs are not exceeded controlling the potential water table level rise in adjacent lands.

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. A review of the internal drains would be required to ensure no drain bypass the wetlands.

The remaining measures are of low intervention consisting of maintaining the existing features or monitoring lands and features

Table 5.1 list the DMP measures identified for Derryarogue Bog and where they sit within the suite of possible measures that could be taken.

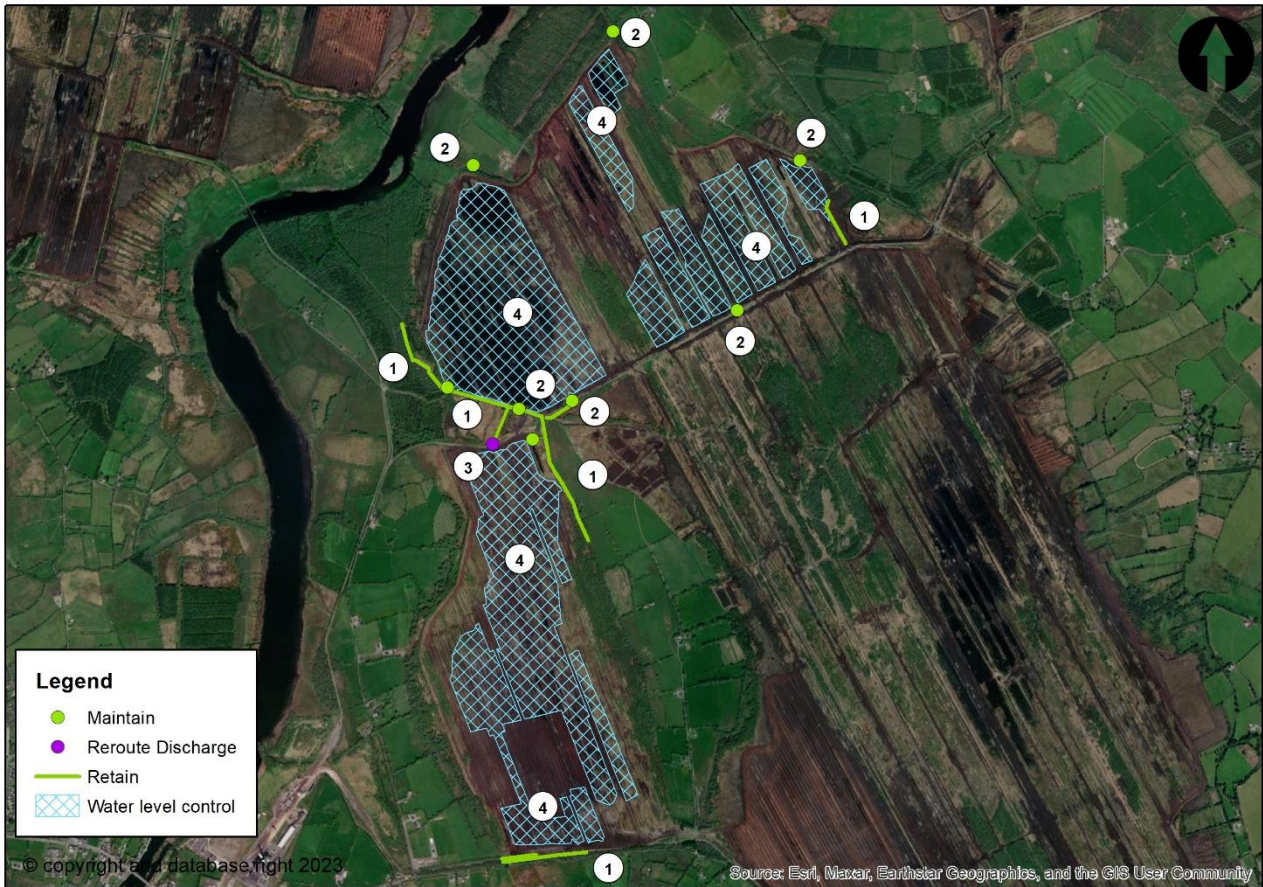


Figure 5-2 DMP measures for Derryarogue Bog

Table 5-1 Selection of DMP Measures

Measures Item	Feature	Function required	Suite of measures Level of intervention			
			Low			High
1	Boundary drain	Hydraulic break	Retain drain	Upgrade drain	Maintain outside bog field	Create new drain
2	Silt ponds	Silt and flow control	Maintain pond	Upgrade pond	-	-
3	Silt ponds	Silt and flow control	Maintain pond	Upgrade pond	-	-
4	Wetland	Water level control	-	Upgrade pond	Update rehabilitation plan	-

5.3 Interaction with Monitoring Plan

As part of the bog rehabilitation plan groundwater level monitoring equipment has been installed at Derryarogue Bog. These record water table and groundwater levels over the coming months. It will therefore be possible to ascertain if the water table 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 water table levels are known to be rising within the bog, monitoring of the adjacent land (as described in Section 5.1.4) should take place on a more regular basis to ascertain if impacts to lands outside the bog are observed.

5.4 Residual Risk & Limitations

The level of flood risk to the bog and the surrounding lands has been shown to be low (Section 2.3) generally but with small areas 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 water table levels and surface water flooding in the bog itself. During flood events no increase in flood risk is envisaged as a result of the rehabilitation measures. During normal flow regime 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 in neighbouring lands. 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 and a suite of measures in any given location has been provided. This will facilitate a reactive approach to be taken if required. In the event that a measure is found to not be operating efficiently, a higher intervention measure can and will be implemented. This will allow Bord na Móna to identify the most appropriate measure while proceeding with drainage function uncertainties.

5.5 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 Plan³. 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

³ Accessed on 10/12/2020 at

<https://www.gov.ie/pdf/?file=https://assets.gov.ie/46534/3575554721374f7ab6840ee11b8b066a.pdf#page=1>

increases in runoff are realised over the timeframe of establishment of rehabilitation measures this could lead to a perception that bog rehabilitation measures at Derryarogue Bog are the cause of increased flood risk.

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 Derryarogue Bog consist of a series of measures to be implemented at different stages of the rehabilitation process. Drains along the boundary were identified as 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 5.1 and deemed suitable 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. 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 Mona and will continue at all existing silt ponds.

Monitoring of adjacent land is included in the plan. The monitoring will observe agricultural land, adjacent bog, and woodland for adverse impacts from the bog rehabilitation. In the event that adverse impacts are confirmed, higher intervention measures can and will 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 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)
Monitoring boundary drains (section 5.1.4)	IF REQUIRED – Consideration of need for higher intervention measures	-
Maintenance of discharge points (see section 5.1.3)	Maintenance of silt ponds (see section 5.1.3)	Maintenance of silt ponds (see section 5.1.3)
Monitoring of adjacent land (see section 5.1.4)	Monitoring of adjacent land (see section 5.1.4)	Monitoring of adjacent land (see section 5.1.4)
-	-	IF REQUIRED – boundary drain upgrades (see section 5.1.1)

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Retention of key drains and pipes
