BORD NA MÓNA - CAVEMOUNT BOG

Drainage Management Plan

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EXECUTIVE SUMMARY

Cavemount Bog is located in Co. Offaly, approximately 3km north east of the village of Daingean and 2km south west of the village of Rhode. The bog lies adjacent to the south side of the Grand Canal. The Esker River flows south through the centre of the bog, acting as a dividing boundary between the eastern and western sections. The Tobardaly River flows southwards around the eastern bog boundary before joining the Esker River south of the site. The Esker River then joins the Philipstown River approximately 4.5km south east of Cavemount Bog. The bog is linked by rail to Mount Lucas to the south, Esker Bog to the east and Ballybeg Bog to the north

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 and re-profiling. 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 Cavemount 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 gravity drainage routes retained it is assumed that groundwater levels will reach the surface of the re-profiled peat fields. Standing water may occur in wetland areas which form depressions within the bog landscape. In both scenarios adjacent lands which are at a lower level than the bog could potentially be impacted and the vulnerable area has been defined through a zone of influence approach.

Each of the land parcels has been assessed based on its vulnerability to increased groundwater levels within the bog. In all 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 they will prevent any groundwater impacts on adjacent lands due to the hydrogeological break / cut-off they provide.

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 Cavemount Bog it is appropriate in most cases that the DMP measures involve survey, monitoring and continued retention of the boundary drainage network. A suite of measures is 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.

1 INTRODUCTION

Cavemount Bog is part of the Allen-Clonsast Bog Group. Bord na Móna operated peat extraction within the Allen-Clonsast Bog Group under IPC Licence (Ref. P0503-01) issued and administered by the EPA. Condition 10.2 of this licence requires the preparation of a Rehabilitation Plan for permanent rehabilitation of the bog lands 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 of 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 Cavemount 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

Cavemount Bog is located in Co. Offaly, approximately 3km north east of the village of Daingean and 2km south west of the village of Rhode. The bog lies adjacent to the south side of the Grand Canal. The surrounding landscape is a mosaic 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.

The Esker River flows south through the centre of the bog, acting as a dividing boundary between the eastern and western sections. The Toberdaly River flows southwards around the eastern bog boundary before joining

the Esker River south of the site. The Esker River then joins the Daingean River approximately 4.5km south east of Cavemount Bog.

The site is linked by rail to Mount Lucas to the south, Esker Bog to the east and Ballybeg Bog to the north

Cavemount Bog was originally developed for peat production in the 1970's. Industrial peat production completely ceased at Cavemount Bog in 2015. The peat was harvested for use in Edenderry Power Station and Derrinlough Briquette Factory, Offaly.

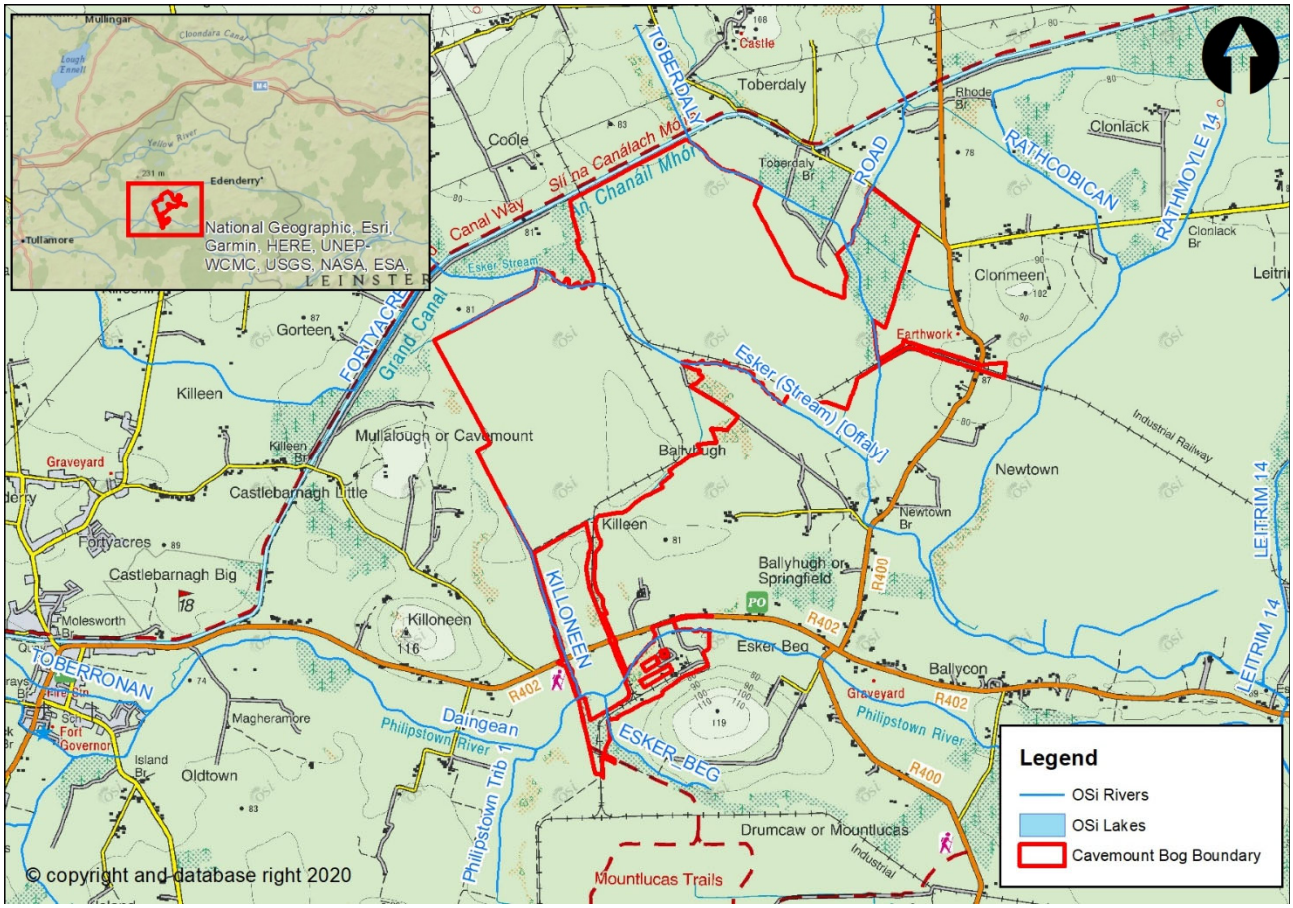

Figure 1.1 Location of Cavemount Bog

2 BASELINE ASSESSMENT

Through cessation of peat extraction and implementation of the Cavemount 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. The drainage under the influence of Cavemount Bog discharges directly into the Esker River or the Tobardaly River at various locations. In addition to these discharge points there are five inflow locations where the adjacent agricultural land drains into Cavemount Bog. 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.

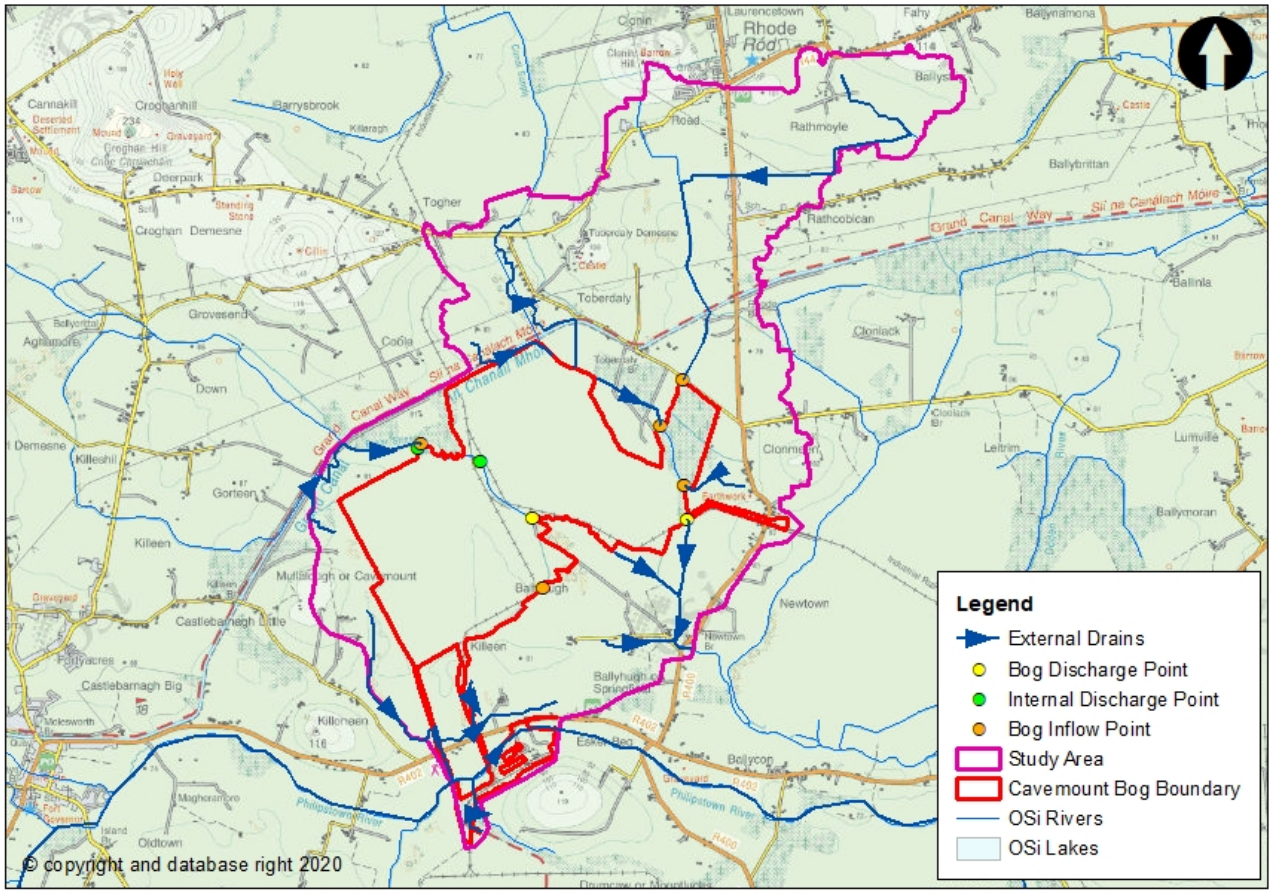

Figure 2.1 Study Area for Cavemount Bog

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.

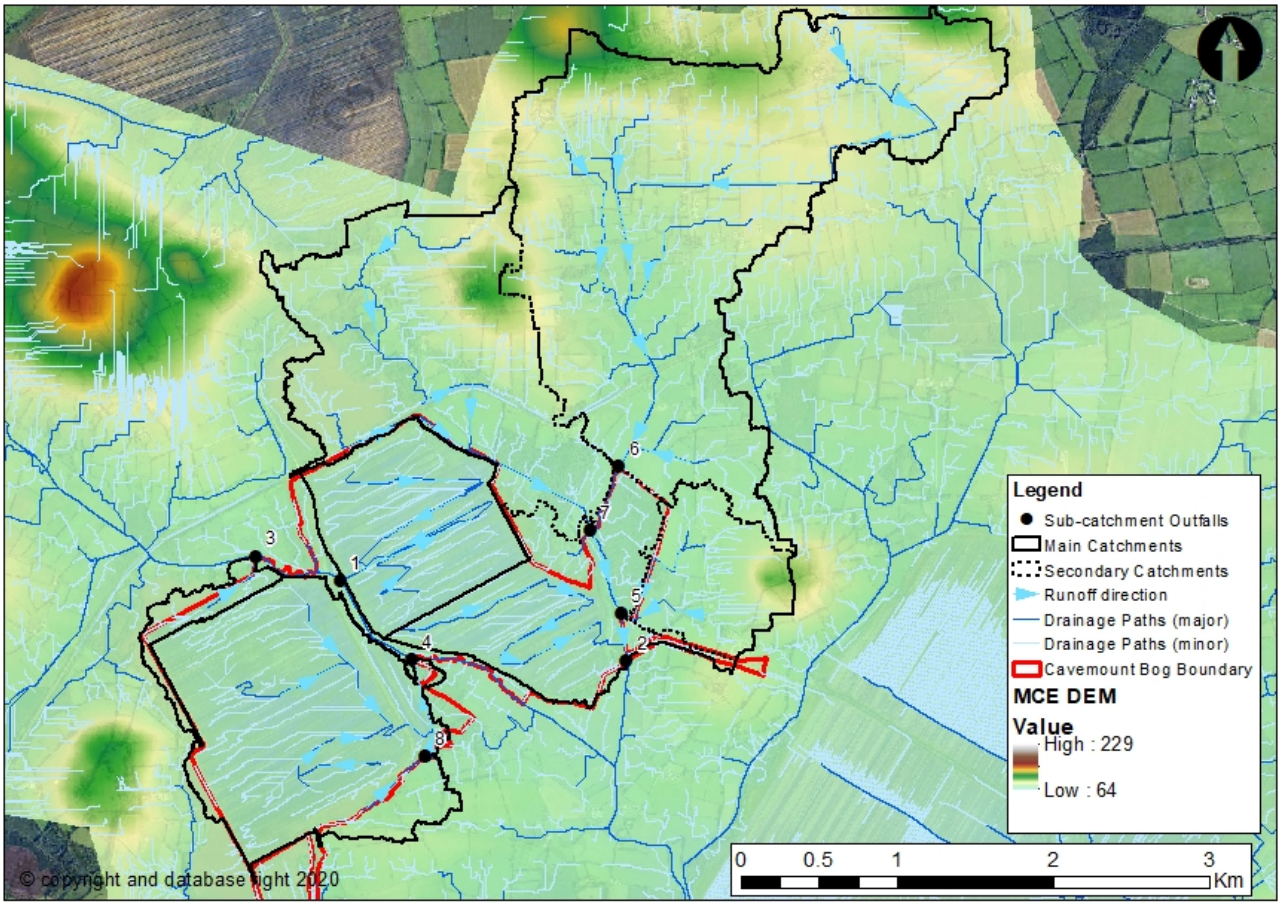

Figure 2.2 Drainage Networks and Sub-Catchments Draining Cavemount Bog

There are four main sub-catchments (points 1 – 4 in Figure 2.2) and four secondary sub-catchments (points 5-8 in Figure 2.2) draining Cavemount Bog and adjacent lands ranging in area from 0.21 km^2 to 9.86 km^2. The catchments are all subject to moderate / low amounts of annual average rainfall. The Baseflow Index for all of the catchments ranges from 0.6 to 0.64 representing a 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 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	1.22	859.19	0.627	1	1.000	100.0	0.334	0.154	**0.267**
2	9.86	861.34	0.638	1	0.508	50.8	1.837	**1.618**	1.394
3	0.21	859.42	0.600	1	1.000	100.0	5.391	**0.065**	0.062
4	2.35	859.23	0.644	1	0.962	96.2	0.578	0.317	**0.459**

2.3 Hydrogeological and Soil Characterisation

According to GSI data there are three different geological bands form the underlying bedrock layers at Cavemount Bog. The major bedrock groups are Dark Limestone and Shale, Thick Limestone and Oolitic Limestone. These bedrock types represent locally important aquifer that is moderately productive in places and karstified in places. Geological Survey of Ireland (GSI) tracing of karst features has identified one spring in close proximity to the bog. The bedrock underlying Cavemount has potential to facilitate relatively high rates of baseflow / groundwater transfer.

The dominant soil type and sub-soils present at Cavemount are classed as 'Raised Bog Cutover Peat'. The main residual peat type exposed on this site is fen peat with some grey/brown Podzolics and surface/groundwater gleys outside the extent of the bog. These soils would be considered to be moderately impermeable restricting transfer of surface water to groundwater. Parts of the site are underlain with limestone tills, as these sub-soils are exposed around the margins of the site. The sub-soils along the southern margin are limestone-based sands and gravels deposited by the river. Shell marl is exposed along some drains in the cutaway area through the eastern basin. These soils would range from moderately to highly permeable facilitating high rates of transfer from surface to groundwater.

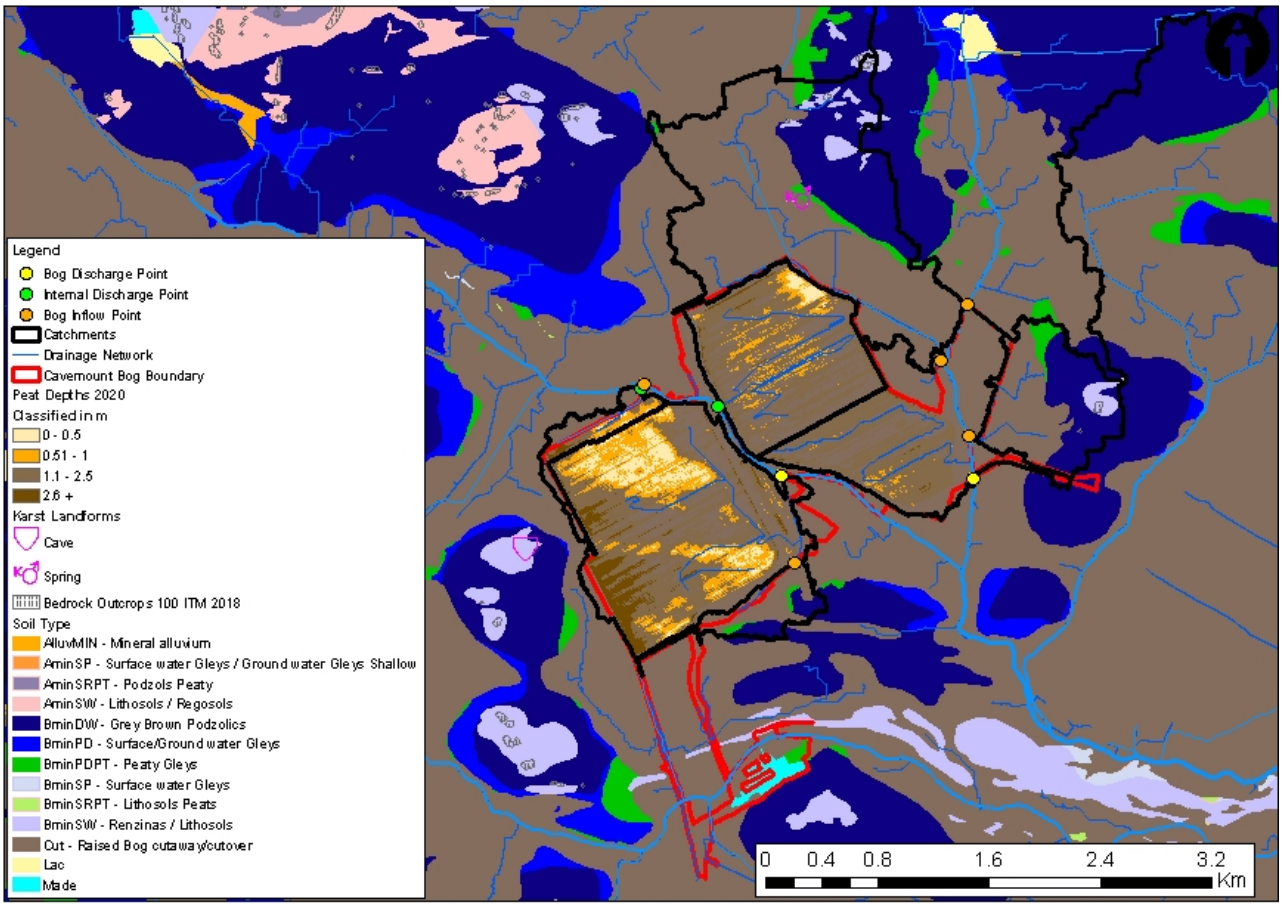

Figure 2.3 Hydrogeological and Soil Characteristics of Cavemount Bog

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 and rivers 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, woodlands and disturbed peat in the surrounding lands there are existing potential sediment sources that could enter the external drains. Given the presence of culverts, channel widening, sharp bends and inflows along the external drains there would be a potential of sediment settling and deposition occurring. The potential for Cavemount bog being a sediment source to the external drains is considered low due to the presence of silt ponds at all discharge points that drain previously active peat fields 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. Most discharge points have a silt pond located upstream which will reduce the amount of peat leaving the bog as water is drained. 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 these drain's capacity has the potential to impact on the agricultural land that drain into the bog.

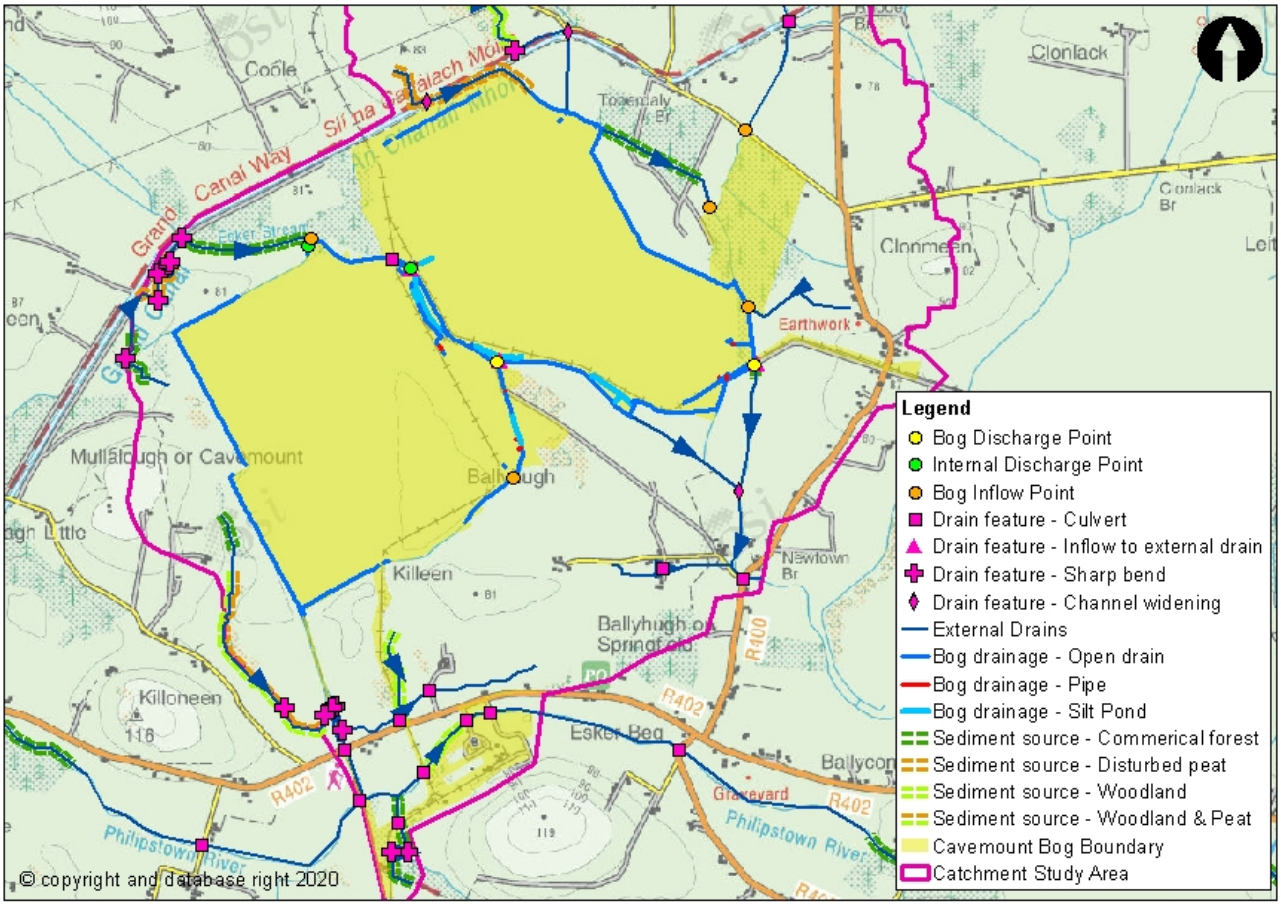

Figure 2.4 Morphological and Hydraulic Characteristics of Cavemount Bog and environs

2.5 Land Use Character

The majority of the land within the study area is peat bog and pasture. The remaining areas of the study area consist of less productive agricultural land with natural vegetation and mixed 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 additional commercial forests and woodland areas are located in the study areas. 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 commercial forests provide for timber production. The majority of the peat bog outside the Bord na Móna bog shows evidence of being

harvested for domestic fuel production, or privately milled peat production. Other areas of peat bog are undisturbed which contribute to carbon storage and biodiversity. The woodland 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, the village of Rhode to the north and provide access to the pastures, forests and peat bogs.

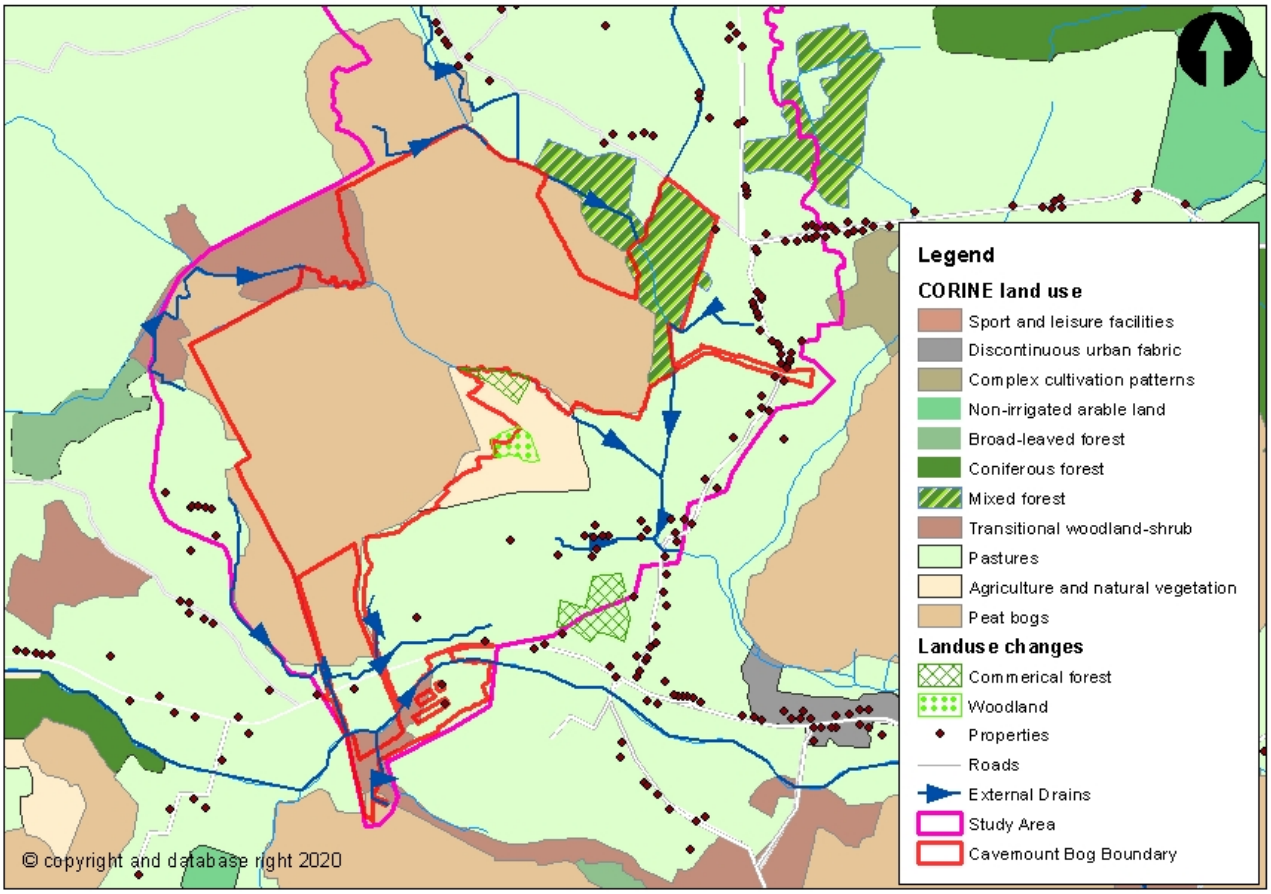

Figure 2.5 Land Use Characteristics of Cavemount Bog and environs

2.6 Flood Risk

A number of sources of flood risk information are available, both predicted and simulated, in proximity to Cavemount 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 groundwater flood maps for high, medium and low probability events
- Mapped flood extents for the 2015 flood event from GSI
- Anecdotal evidence from Bord na Móna

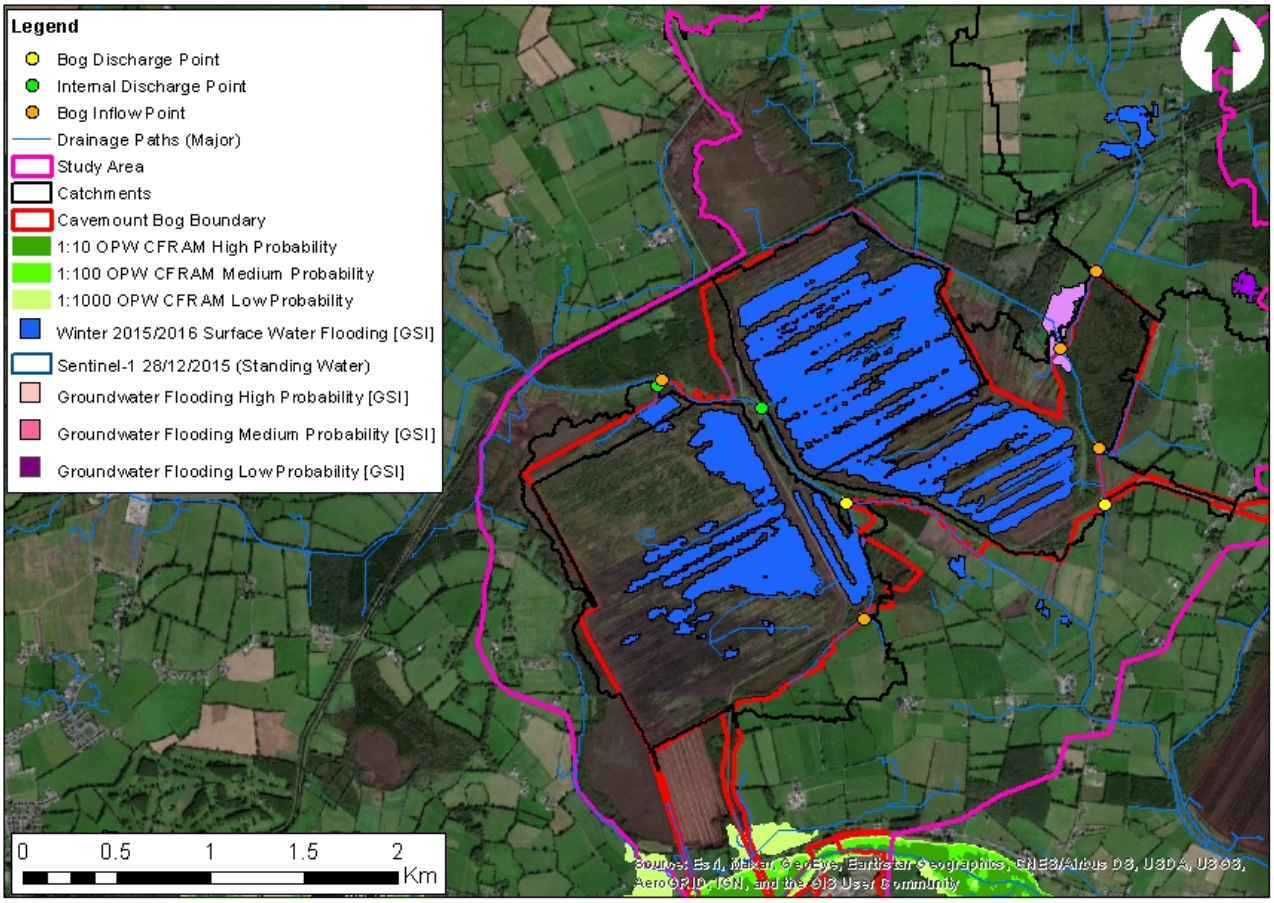

Figure 2.6 Flood Risk at Cavemount Bog

Aside from access routes into Cavemount bog there is no significant fluvial flood risk to the bog from the Philipstown River. It should be noted this analysis did not consider the fluvial flood risk from the smaller watercourses which drain to the Philipstown River through Cavemount Bog. Data from the 2015/16 flood event and observations from Bord na Móna indicate widespread flooding within bog which is consistent with what has been observed by Bord na Móna.

Two reports of flooding from the OPW's historic archive[1] of flood events indicate extensive flooding at Cavemount on 19th August 2008 following a heavy and prolonged rainfall event. The reports are made up of aerial photographs taken by Offaly County Council and show extensive flooding to the peat fields and around the drainage network of the bog.

[1] Report ID-10594 and ID-10595 found at www.floodinfo.ie accessed on 05/02/21

Figure 2.7 Aerial Photograph showing extensive flooding at Cavemount Bog 19th August 2008

One localised area of groundwater flooding is indicated from the GSI datasets. This flooding is estimated to have a high probability of occurrence and is located in adjacent land to the bog, not far from where karst features have been identified and mapped (Figure 2.3).

2.7 Summary

The drainage network sub-catchments within Cavemount Bog and its environs were used to delineate the study area for the Cavemount 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. The assessment showed that the bog discharges to the Esker River which flows through the bog and also discharges to the Tobardaly River.

The catchment area is considered to be relatively small, flat and fairly permeable with a low to moderate annual rainfall. Peak flood flows range from around 0.16 – 0.30 m^3/s per square kilometre (1.6 – 3 l/s per hectare) for the Q_{med} event to 0.46 – 0.86 m^3/s per square kilometre (4.6 – 8.6 l/s per hectare) for the Q_{100} year plus climate change event.

The bedrock within the catchment is limestone. Geological Survey of Ireland (GSI) tracing of karst features has identified one spring in close proximity to the bog 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. There are

some areas of more permeable soils around the margins of the bog where sand and gravels have been deposited or marl exposed through peat extraction.

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. Woodlands, commercial forest 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. Pasture land makes up a significant proportion of the study area also. The remaining land is made up of mixed forest and woodland. 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 private domestic turf is still being extracted from other bogs adjacent to Cavemount Bog conditions should not be made worse.
Roads	Constraint	Minor roads are located in the study area providing access to properties, a village, agricultural land and peat bogs. Access to these roads should be maintained.
River	Constraint	The Philipstown River and tributaries are located within, adjacent or close to the bog. No activity should adversely impact this area.
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. Cavemount 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 Cavemount Bog rehabilitation plan[2] consists of the following measures as summarised in Table 3.1 and presented in Figure 3.1.

Table 3.1 Cavemount Bog rehabilitation measures

Restoration	Description of measures
Deep peat restoration	Berms and field re-profiling (45m x 60m cell) + blocking outfalls and managing overflows + drainage channels for excess water + Sphagnum inoculation
Dry cutaway restoration	Blocking outfalls and managing water levels with overflow pipes
	Regular drain blocking (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 + Targeted blocking of outfalls within a site
	Turn off or reduce pumping to re-wet cutaway + blocking outfalls and managing water levels with overflow pipes + Targeted blocking of outfalls within a site + constructing larger berms to re-wet cutaway + transplanting Reeds and other rhizomes
	More intensive drain blocking (7/100 m), + blocking outfalls and managing overflows + transplanting Reeds and other rhizomes
Other	Maintain silt ponds

[2] For further details see Cavemount Bog Cutaway Bog Decommissioning and Rehabilitation Plan 2020 report

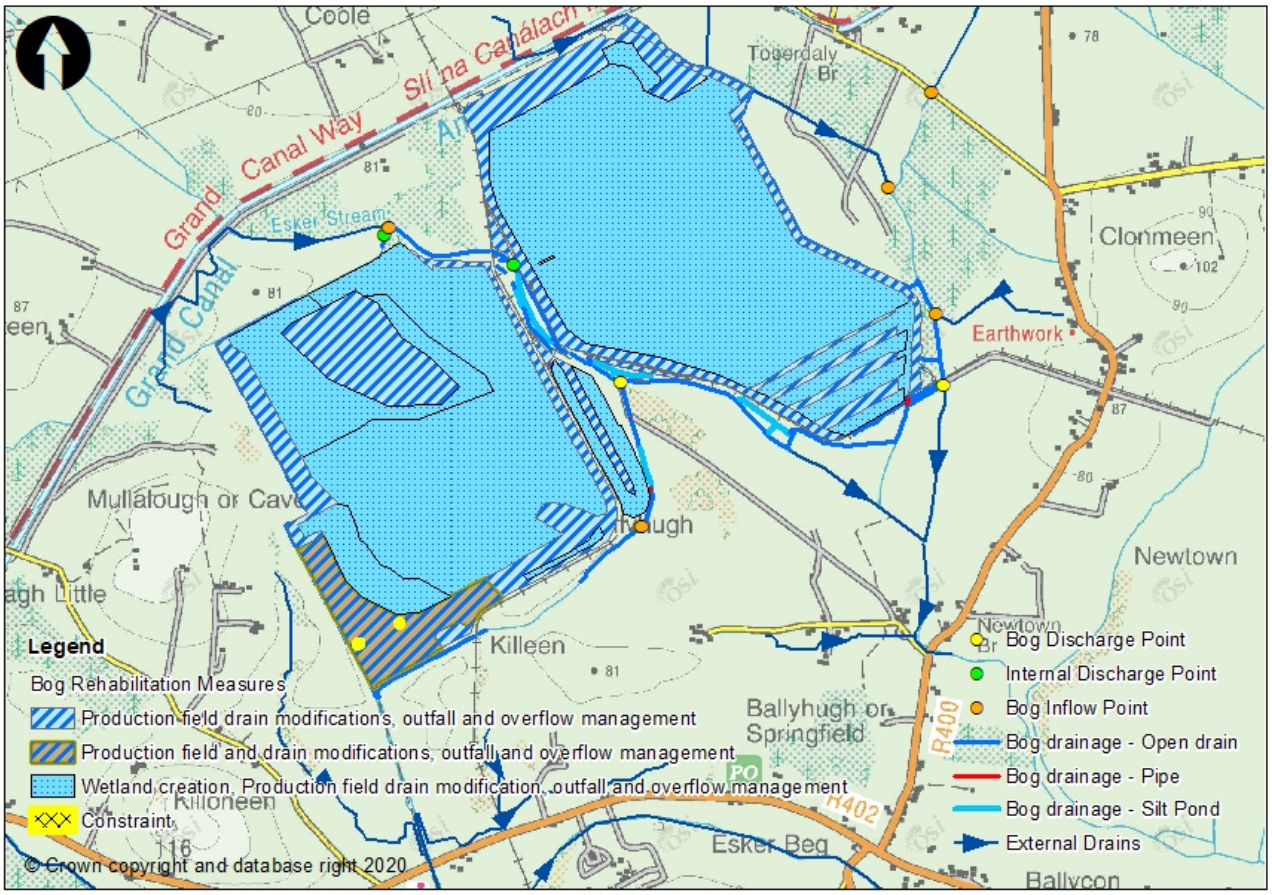

Figure 3.1 Cavemount Bog Rehabilitation Plan

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 Cavemount Bog and their potential impact to adjacent land.

Table 3.2 BRP measures proposed at Cavemount Bog

Bord na Móna rehabilitation measure	Description	Potential Impact	Potential Impact Description
Drain blocking, berm and field re-profiling	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	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

	reduce conveyance or removed altogether by infilling. Surface water runoff through the bog will be slowed allowing the bog to store more water		upstream if conveyance channels through the bog are blocked.
Blocking outfalls	Most production field drain systems drain into a headland 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 ditch 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 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).
Drainage channel for excess water	This measure will work in conjunction with the overflow features. Where suitable drainage channels do not exist or are of insufficient capacity along the bog boundary, a new or upgraded drainage channel will be provided. These drainage channels will convey all flows from the bog to suitable watercourses.	Positive	Drainage channels of sufficient capacity will ensure any overtopping water from the bog does not enter adjacent land. Drainage channels will also act as a hydraulic break in groundwater limiting the impact of bog measures to the groundwater in adjacent lands.
Sphagnum moss inoculation	This measure will propagate sphagnum moss within the bog. Sphagnum moss will cause bog regeneration as it grows and layers.	Positive	Sphagnum moss can hold up to 10 times its weight in water. As such this measure will store 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 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. Land 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.

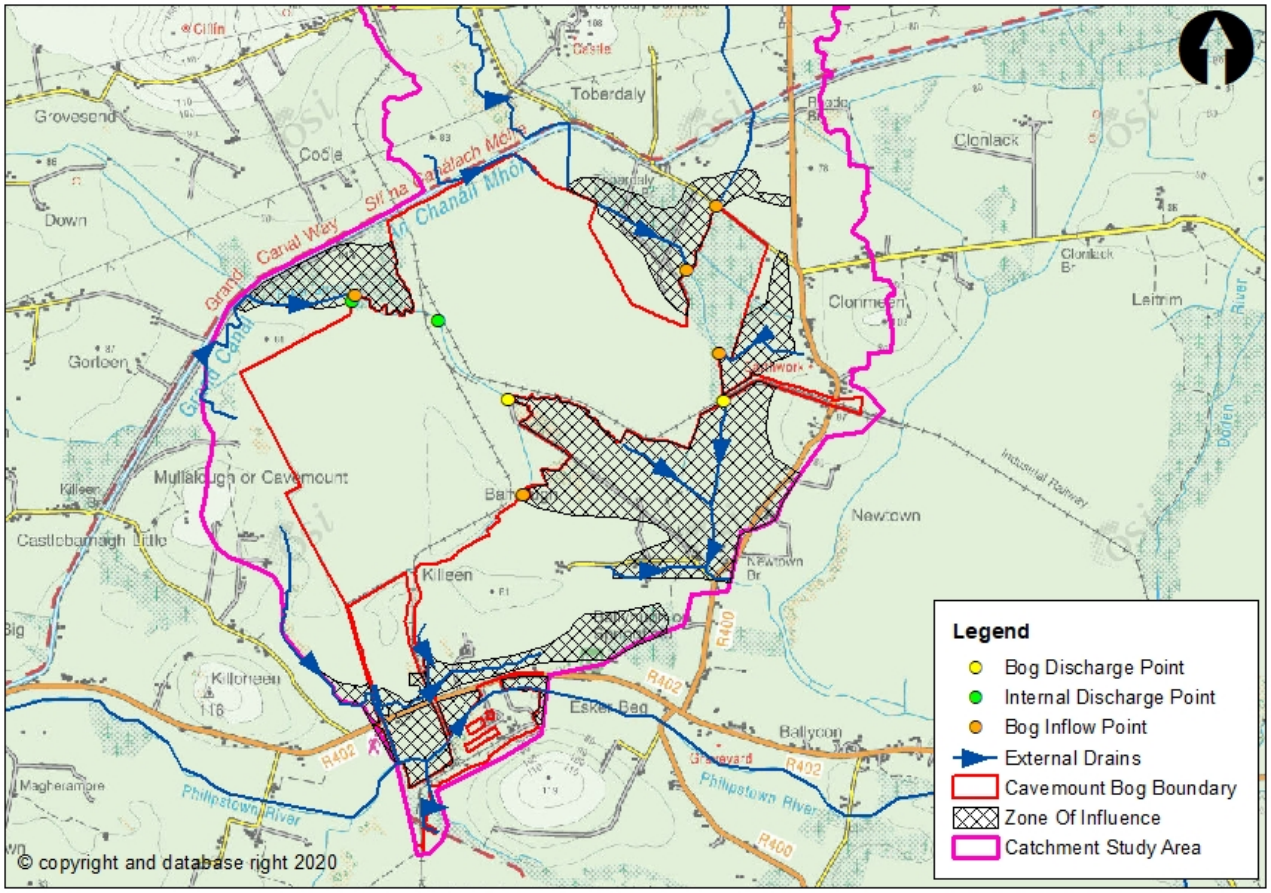

Figure 3.2 Cavemount Bog Rehabilitation Plan – Zone of influence

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 can also 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 Cavemount Bog was assessed firstly by estimating the potential rise in groundwater within the bog. The drainage system in the bog is, on average, 1.5m deep. It can be expected that groundwater would rise by 1.5m to bring it to the surface in non-wetland areas. 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 (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.

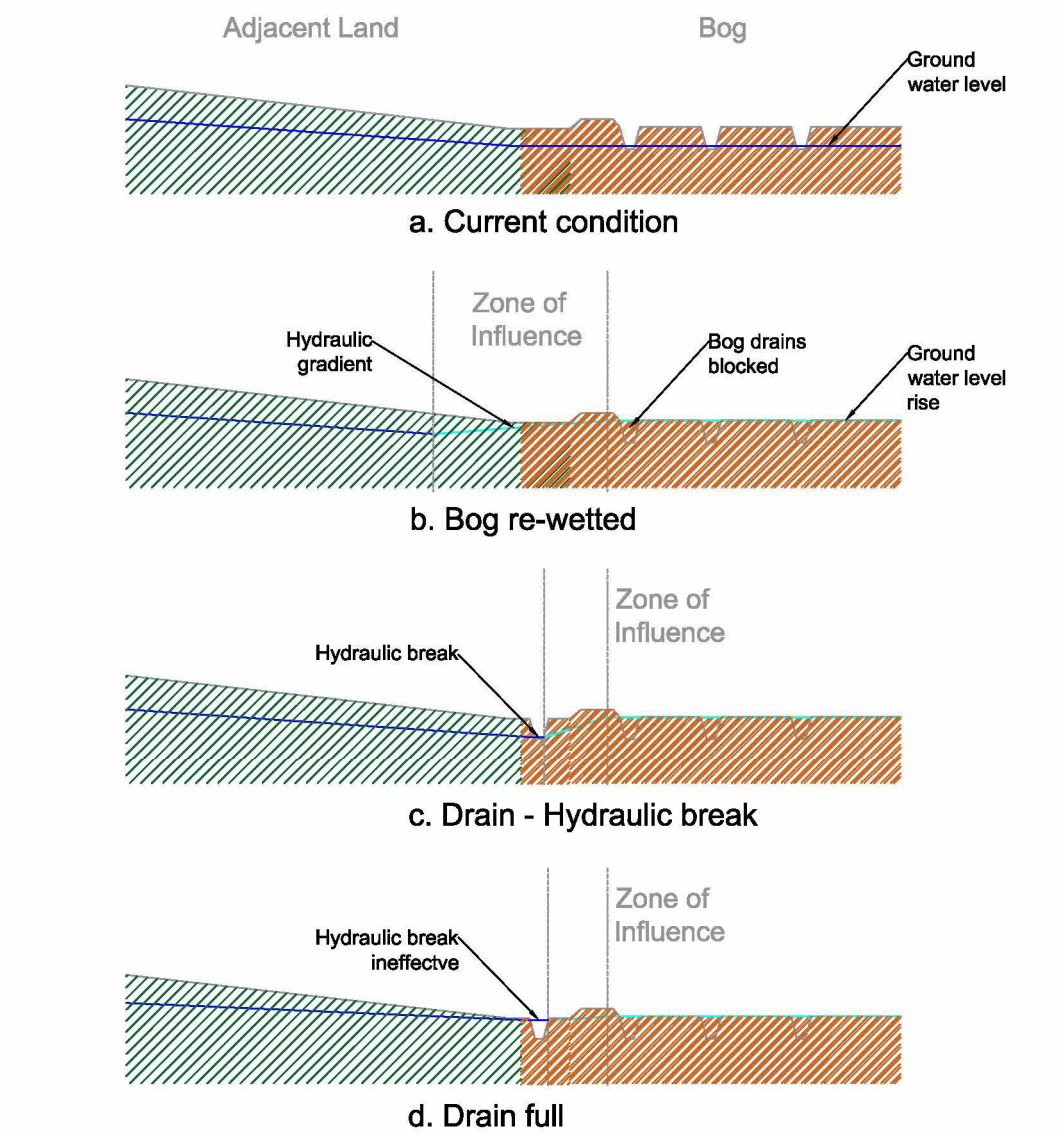

Figure 3.3 Conditions affecting groundwater

A complete survey of the boundary and external drains which provide the groundwater cut-off function to agricultural lands was not available for Cavemount 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 Cavemount 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 western section of the bog discharges to the Esker River and the eastern section discharges to the Tobardaly River. 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 five inflow location to Cavemount Bog (Figure 3.2) which connect to the Esker River or Tobardaly River which flow south through the bog. Should the function and capacity of these drains 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).

3.2.3 Increased Runoff

Evidence from bogs that have previously been the subject of restoration measures demonstrates that the measures proposed at Cavemount, 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 Cavemount Bog is low. All rehabilitation measures being proposed will reduce 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 Cavemount 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 following assets have been identified as being at potential risk from flooding or wetter conditions as described in Table 3.1.

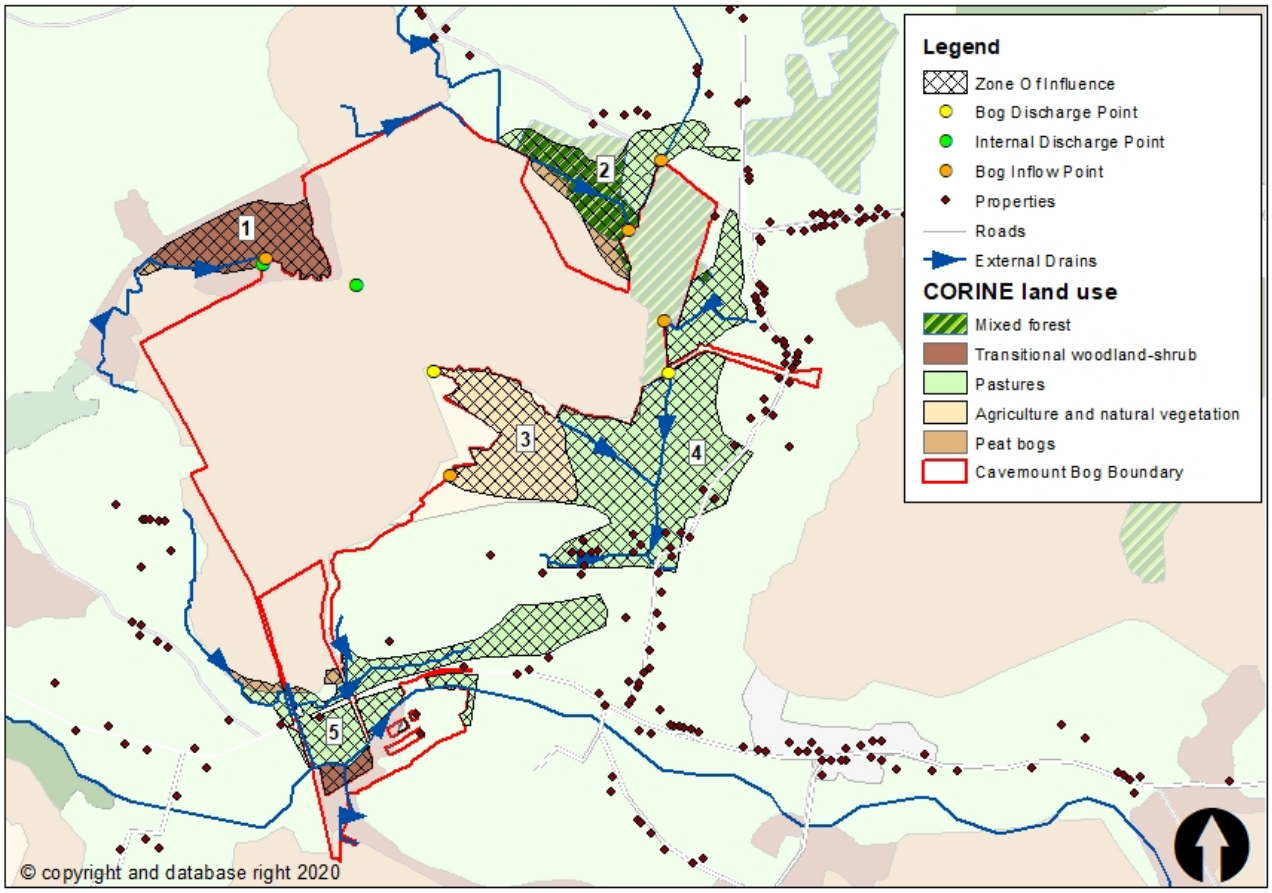

Figure 3.4 Cavemount Bog Rehabilitation Plan – Assets at risk

The assets at risk are set out in **Error! Reference source not found.** along with the vulnerability, based on the current landuse, 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	Woodland	Low vulnerability. Land is mainly woodland which could tolerate wetter conditions.
2	Peat, woodland, and Agricultural land	Low Vulnerability. Land adjacent to bog is peat bog and woodland which can tolerate wetter conditions. Woodland and peat act as a buffer between Cavemount bog and agricultural land dampening any potential groundwater rise.
3	Agricultural land and natural vegetation	High Vulnerability. Agricultural land would become less productive should it be made wetter.
4	Agricultural land	High Vulnerability. Land would become less productive should it be made wetter.
5	Peat, Agricultural land, and woodland	Moderate Vulnerability. Land adjacent to bog is peat bog which can tolerate wetter conditions. Peat acts as a buffer between Cavemount bog and agricultural land dampening any potential groundwater rise.
6	Roads	Low vulnerability. Road level slightly higher than surrounding land. Risk of flooding is low.
7	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 Cavemount Drainage Management Plan is to facilitate the rehabilitation of bog through management of potential adverse impacts to adjacent land and waterbodies. SMART[3] 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 Cavemount bog during and after rehabilitation measures.
2. To retain the current drainage capacity of the agricultural land flowing into Cavemount 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 the watercourses during and after rehabilitation, these measures are to ensure compliance with current discharge limits in IPC Licence.

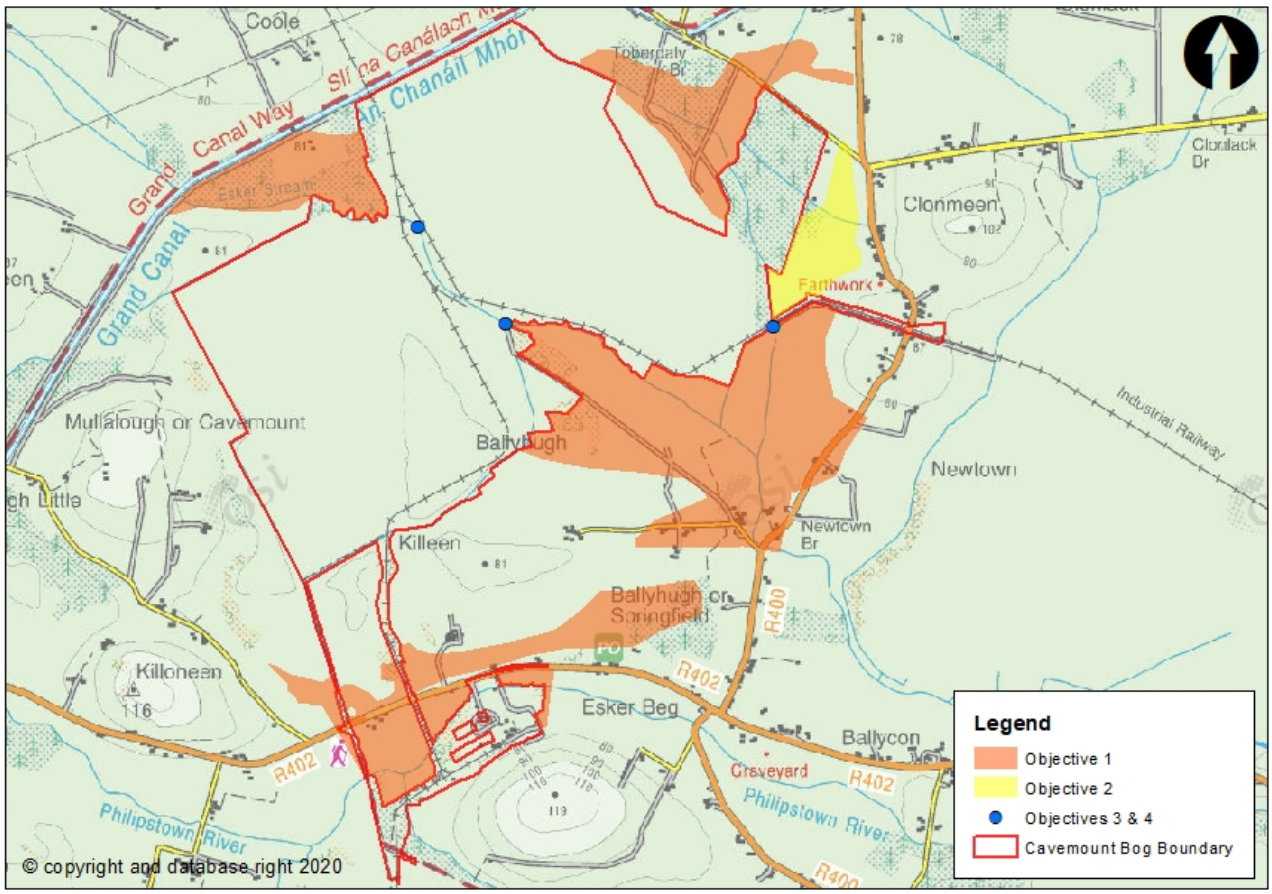

Figure 4.1 Cavemount Bog DMP objectives

[3] 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. Objective 1 considers the potential impact to adjacent land from groundwater rise. Objective 2 considers the existing drainage network flowing into and through the bog. Objectives 3 and 4 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.

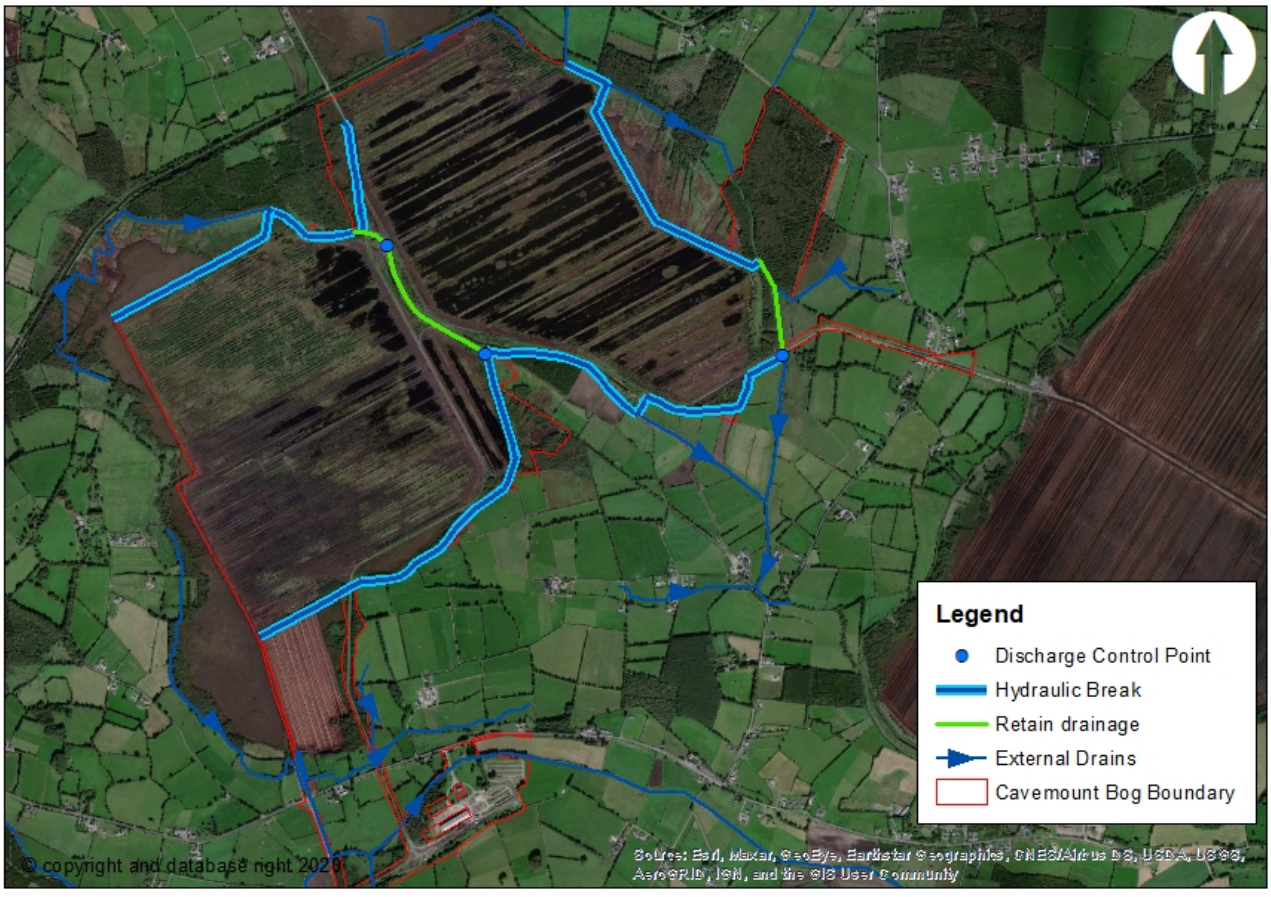

Figure 5.1 Key drainage features for Cavemount Bog

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 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 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 Cavemount 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 the Cavemount 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.

5.1.4 Maintenance of silt ponds

Existing silt ponds are located upstream 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).

5.1.5 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. 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 larger 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 growth curve representing the bog catchment characteristics has been used, whereby growth factors between 2.3 to 2.4 have been used to scale up the Qmed peak flow to determine the Q100 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	Q_{100} / 1% AEP MRFS
1	0.267	0.631	0.757
2	1.618	3.771	4.525
3	0.065	0.153	0.183
4	0.459	1.075	1.290

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.

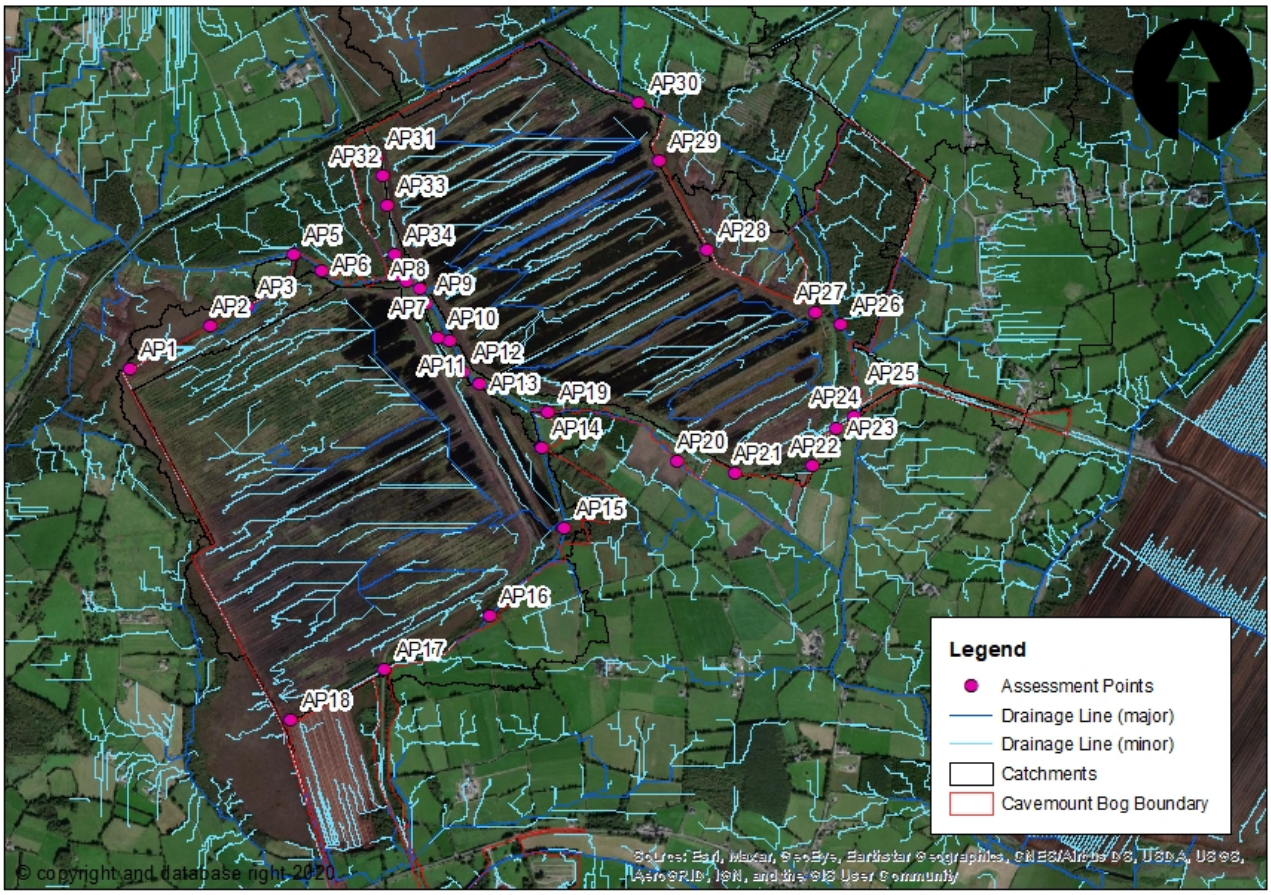

Figure 5.2 Assessment Points at Cavemount Bog

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 APs upstream which is not captured in this point by point capacity check.

Table 5.2 AP Capacity

Ref.	Sub-catch.	Feature Type	Flood Flow Range (m^3/s)	Capacity & Recommendations
AP_1	3	Boundary Drain	0.020 - 0.057	Likely capacity to convey all flood flows.
AP_2	3	Boundary Drain	0.077 - 0.217	Capacity to convey QMED. Out of bank flooding for more extreme events.

Ref.	Sub-catch.	Feature Type	Flood Flow Range (m^3/s)	Capacity & Recommendations
AP_3	3	Boundary Drain	0.107 - 0.304	Capacity to convey QMED. Out of bank flooding for more extreme events.
AP_4	3	Pipe	0.158 - 0.447	**Check pipe capacity to open drain when conditions allow.**
AP_5	3	Boundary Drain	4.716 - 13.356	Likely to flood out of bank.
AP_6	3	Boundary Drain	4.720 - 13.366	Capacity to convey QMED. Out of bank flooding for more extreme events.
AP_7	1	Boundary Drain	3.487 - 9.876	Capacity to convey QMED. Out of bank flooding for more extreme events.
AP_8	1	Pipe	3.489 - 9.880	Likely constriction to flood flows
AP_9	1	Pipe	3.492 - 9.889	No pipe present at this location. Not necessary for drainage management.
AP_10	1	Silt Pond	3.513 - 9.949	Likely to flood out of bank.
AP_11	4	Boundary Drain	3.116 - 8.749	Likely to flood out of bank.
AP_12	4	Pipe	3.128 - 8.784	Likely constriction to flood flows.
AP_13	4	Pipe	3.138 - 8.811	Likely capacity to convey all flood flows
AP_14	4	Pipe	0.264 - 0.743	**Check pipe capacity when conditions allow.**
AP_15	4	Boundary Drain	0.165 - 0.463	Likely capacity to convey flood flows.
AP_16	4	Boundary Drain	0.114 - 0.319	Likely capacity to convey all flood flows.
AP_17	4	Pipe	0.078 - 0.220	**Check pipe capacity when conditions allow.**
AP_18	4	Boundary Drain	0.024 - 0.067	Likely capacity to convey all flood flows.
AP_19	4	Boundary Drain	3.419 - 9.600	Likely to flood out of bank.
AP_20	2	Boundary Drain	2.900 - 8.108	Likely to flood out of bank.
AP_21	2	Boundary Drain	0.025 - 0.069	Likely capacity to convey all flood flows.
AP_22	2	Boundary Drain	0.015 - 0.041	Likely capacity to convey all flood flows.
AP_23	2	Boundary Drain	0.023 - 0.064	Likely capacity to convey all flood flows.
AP_24	2	Pipe	0.025 - 0.070	Likely capacity to convey all flood flows.
AP_25	2	Boundary Drain	1.535 - 4.292	Likely capacity to convey flood flows.
AP_26	2	Boundary Drain	1.387 - 3.879	Likely to flood out of bank.
AP_27	2	Pipe	0.099 - 0.277	**Check pipe capacity when conditions allow.**
AP_28	1	Boundary drain	0.089 - 0.251	Likely capacity to convey all flood flows.
AP_29	1	Boundary Drain	0.034 - 0.096	Likely capacity to convey all flood flows.
AP_30	1	Boundary drain	0.043 - 0.121	Likely capacity to convey all flood flows.
AP_31	1	Boundary Drain	0.015 - 0.044	**Drain and pipe require cleaning to ensure flood flow capacity.**
AP_32	1	Boundary Drain	0.025 - 0.072	Likely capacity to convey all flood flows.
AP_33	1	Boundary Drain	0.046 - 0.131	Likely capacity to convey all flood flows.
AP_34	1	Pipe	0.073 - 0.206	**Drain and pipe require cleaning to ensure flood flow capacity.**

Ref.	Sub-catch.	Feature Type	Flood Flow Range (m^3/s)	Capacity & Recommendations
AP_35	1	Pipe	0.086 - 0.243	**Check pipe capacity when conditions allow.**

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 maintained with their current estimated carrying capacity. Section 2.6 indicates how all boundary drains appear to be functioning sufficiently with no known drainage issues identified along the drain or in adjacent land. Although there is no survey data for some reaches the 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. Table 5.3 and Figure 5.3 details the level of intervention required along each reach of drainage network.

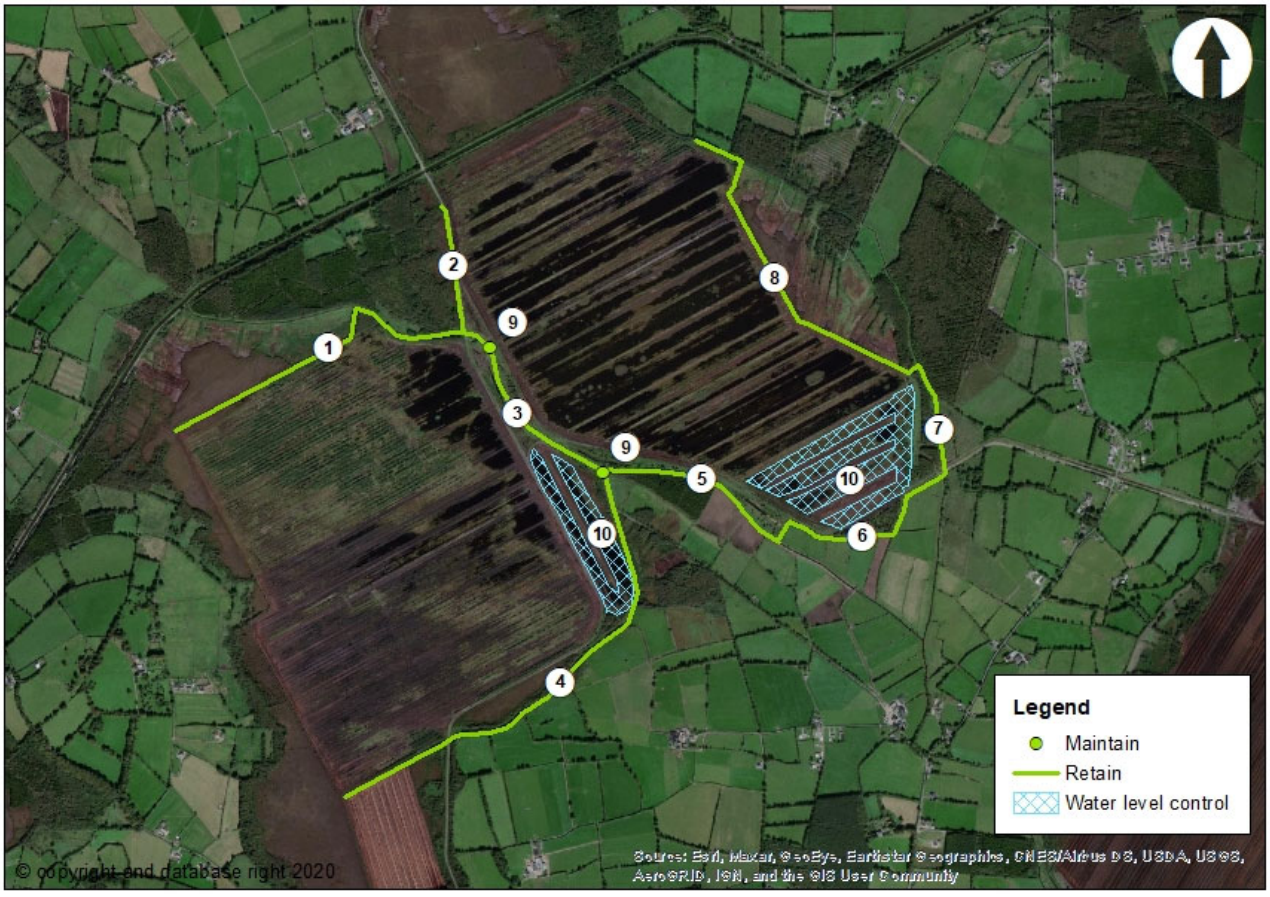

Figure 5.3 DMP measures for Cavemount Bog

DMP measures 3 and 7 refer to the Esker River and Toberdaly River which act as internal drains within the bog. The current capacity of these rivers is adequate to allow the bog to continue to drain, to act as a hydraulic break and to allow the free drainage of other drains acting as hydraulic breaks. There are some reaches of

the Esker and Toberdaly Rivers which have been identified as likely to flood out of bank. During these times the rivers will not function as efficiently as hydraulic breaks. However, given that adjacent lands within the zone of influence will be flooded from both rivers, independently from any influence from the bog rehabilitation measures, the impact from any ground water flow from the bog to the adjacent land will be minimal. During normal flow regime in the Esker and Toberdaly Rivers the hydraulic break function will be provided.

DMP measure 9 identifies all discharge points with an existing silt ponds that should be maintained.

DMP measure 10 identifies proposed wetlands within the rehabilitation plan that 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 drains bypass the wetlands.

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

Table 5.3 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	Boundary drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
3	Esker River	Internal drainage	**Retain river**	Upgrade river	-	Create new drain
4	Internal drain	Drainage of adjacent land	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
5	Esker River	Hydraulic break and internal drainage	**Retain river**	Upgrade river	Maintain outside bog field	Create new drain
6	Boundary drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
7	Toberdaly River	Hydraulic break	**Retain river**	Upgrade river	Maintain outside bog field	Create new drain
8	Boundary drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
9	Silt ponds	Silt and flow control	**Maintain pond**	Upgrade pond	-	-
10	Wetlands	Flow/silt control	-	-	**Rehabilitation adaptation**	Create new silt pond

5.4 Interaction with monitoring plan

As part of the bog rehabilitation plan groundwater level monitors will be installed at Cavemount 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.

Downstream of the site at Clonbullogue on the Figile River is a long term, flood flow gauging station. Although the gauged catchment (247 km^2) is large, much of it represents Bord na Móna lands which will be subject to rehabilitation. The Cavemount site represents approximately 4.0 km^2 of potentially rehabilitated catchment and when taken in combination with the other rehabilitated sites within the catchment it would be expected that changes in run-off and flood peaks would be discernible in the gauging station record after a number of years. This represents an opportunity to determine the impact of rehabilitation measures within an existing, robust flood flow record post rehabilitation.

5.5 Residual Risk & Limitations

The level of flood risk to the bog is considered high due to surface water ponding. Fluvial flood risk from rivers to the bog and the surrounding lands has been shown to be low (Section 2.6). 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. During flood events no increase in flood risk is envisaged as a result of the rehabilitation measures. During normal flow regime there is a fair degree of uncertainty 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[4]. 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 Cavemount 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 BRP measures in mitigating these climate change impacts.

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

6 SUMMARY OF DRAINAGE MANAGEMENT PLAN

The Drainage Management Plan for Cavemount consists of a series of measures to be implemented at different stages of the rehabilitation. 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. These 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 are generally all low intervention and consist of monitoring, retention of existing features and updating the rehabilitation plan. 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 land was included in the plan. The monitoring will observe adjacent bog, agricultural land 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 of internal and boundary drains (see section 5.1.1)	-	-
Monitoring external drains	IF REQUIRED – Consideration of need for higher intervention measures	-
-	Rehabilitation 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