National Parks and Wildlife Service

Catchment Assessment Report Manual

Introduction

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Manual for the Production of

Catchment Assessment Reports for *M margaritifera* Catchments

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Acknowledgements

The production of this manual would not have been possible without the support and assistance of my colleagues Thady O Brien and Aileen Gallagher and the staff of the NPWS wetlands unit, in particular Jim Ryan and Aine O Connor.

The manual draws heavily on our experiences in assessing the Bundorragha catchment in Co. Mayo and the Dawros and Owenriff catchments in Co. Galway. The consent and co-operation of landowners in all three of these areas was an essential prerequisite to this work and their contribution is one that I am happy to acknowledge.

Executive Summary

Freshwater Pearl Mussel (*Margaritifera margaritifera*) populations are distributed across 96 catchments in Ireland. Of these, 27 populations have been designated within 19 SAC's for the species. The status of the *M margaritifera* populations in these catchments varies considerably. However in most cases the population is aging and display an unhealthy age profile with younger cohorts absent or present only in small numbers. This situation cannot be sustained indefinitely and a continuation of the current trend will inevitably lead to local extinctions.

The principal causes of the decline in *M margaritifera* populations have been identified as;

- Siltation and or nutrient enrichment of juvenile habitat.
- Adult pearl mussel deaths due to siltation and or nutrient enrichment.
- Deaths of adult and juvenile mussels due to toxic pollution.

The causes identified above are intrinsically linked with land use within the catchment. Siltation and nutrient enrichment in particular are catchment wide issues; their negative impacts are cumulative and in many cases are observed at a considerable distance from the source.

The activities that lead to siltation and eutrophication include the following;

- Forestry related operations
- Construction and land development.
- Overgrazing.
- Fertiliser and lime use.
- Use of agri chemicals
- Land drainage
- Recreational pressure
- Waste water disposal

The negative impacts associated with siltation and nutrient enrichment may be observed at existing and historic *M margaritifera* sites. However the causative factors behind them may be distributed throughout the catchment and may have changed over time.

The identification and assessment of these pressures is an essential component of any attempt at reversing declines in *M margaritifera* populations. To address this requires an assessment of individual catchments, the identification of the pressures within those catchments and proposals for remedial action to address these. This will be delivered by means of a Catchment Assessment Report. This document provides guidance on the collation and presentation of Catchment Assessment Reports in a manner that is accessible to stakeholders and will facilitate the conservation of *M margaritifera* populations.

Introduction

The objectives of the catchment assessment process are to;

- Identify the real or potential threats to *M margaritifera* populations within the catchment.
- Identify the processes or drivers that have contributed to the identified threats.
- Assess the scale and apparent trends in respect of each identified threat.
- Propose remedial actions to address identified threats.
- Establish a sustainable stocking rate in respect of each management unit within the catchment
- To facilitate stakeholders by providing clear and concise information on how the catchment could be managed to improve *M margaritifera* habitats.
- To provide a baseline which future researchers and land managers can use to determine progress in addressing threats within the catchment?

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A catchment assessment report is the first part of a process aimed at delivering improvements in *M margaritifera* habitat. The next phase of this process involves implementation at individual farm and management unit level.

Scope.

This manual establishes a protocol for those tasked with producing Catchment Assessment Reports. In particular it will assist them with;

- Planning a catchment assessment.
- The identification and assessment of pressures or threats.
- The identification and assessment of possible remedial measures.
- The consequences for stakeholders of proposed remedial measures.
- The layout and presentation of Catchment Assessment Reports.

It does not include issues arising solely from urban wastewater treatment, the operation of septic tanks or commercial forestry. While these can be significant factors in many catchments they will be dealt with under a separate set of procedures. Commercial activities such as hotels, retail outlets or workshops are not normally dealt with in Catchment Assessment Reports but their presence should be noted and any obvious risks indicated. The principal focus of the Catchment Assessment Reports will be on the impacts arising from agriculture, from recreational use and from lands used for extractive industries for example turf cutting or quarrying.

Structure of a Catchment Assessment Report.

The catchment assessment report or CAR along with its associated GIS layers is the primary mechanism for delivering the data collected and the remedial measures required to stakeholders. To achieve this, the CAR has to allow the reader to easily identify management units within the catchment and to ascertain the issues and proposed remedial measures within each management unit.

The CAR is divided into four main parts;

1) A short introduction and description of the study area.

2) Description of each sub catchment within the study area. These are described under the following headings;

- Site description.
- Land tenure.
- Land use.
- Habitat units.
- Management unit condition
- Trends
- Threats
- Proposed actions
- Planned maximum stocking levels.

3) General issues within the catchment. This will include the ranking of threats, prioritisation of remedial actions and future monitoring requirements.

4) Appendices containing station report cards and other data that was collected and used in the assessment process and that may be of value as a baseline in future monitoring campaigns. Appropriate Assessments for planned interventions in sites with SAC or SPA designations are also included here.

The layout of a Catchment Assessment Report is given in Appendix 1 of this manual.

Production of a Catchment Assessment Report.

The production of a Catchment Assessment Report has six phases;

1) Planning.

A. Collation of materials and existing data.
B. Desk study of relevant publications and other data sources.
C. Reconnaissance visit.
D. Liaison with local NPWS staff.
E. Consultation with landowners.
F. Delineation of sub catchments.
G. Identification of areas of interest.
H. Planning of transects through the study area.

2) Fieldwork.

A. Safety considerations.

i. Clothing and Equipment.
ii. Training and Supervision
iii. Communications
iv. Weather conditions
v. Other Issues.

B. Transect lines.
i. Areas of interest.
ii. Stations.

C. Mapping.
i. Habitat units.
ii. Management units.

D. Photographic standards.

3) Identification and assessment of threats or risks.

4) Identification and assessment of possible remedial measures.

5) GIS.

A. Production of a GIS.
   i. Habitat unit map.
   ii. Management unit maps.
   iii. Active Intervention Area maps.
   iv. Spreadsheet of polygon attributes.

B. Quality control.

6) Writing a Catchment Assessment Report.

A. Writing a draft report.

   i. Structure.
   ii. Calculation of sustainable stocking rates.
   iii. Ranking of threats.
   iv. Prioritisation of actions.

B. Submission of a draft CAR.

C. Final deliverables.

1) Planning a Catchment Assessment Survey.

It is important that those tasked with the production of Catchment Assessment Reports are familiar with ecological requirements of the *M margaritifera*. It is also essential that they acquaint themselves with the characteristics of the catchment by a reconnaissance visit and by a desk study of any available data on the catchment and the *M margaritifera* and Salmonid populations within it.

A. Collation of material and existing data.

The object of this planning phase is to identify areas of interest within the study area and to ensure that planned transects allow for the investigation of these areas. The process begins with the collation of the material required for a desk study of the catchment. A desk study is an essential component of the planning phase of any catchment assessment. It serves to ensure that fieldwork is safe, efficient and effective. NPWS will supply the assessors with maps and ortho-photographs of the study area. The details on other sources of information along with where they can be obtained are given below.

It is important that the Assessors familiarise themselves with the catchment, the land uses within it and with problems or issues that have already been identified by other researchers. To achieve this it is suggested that assessors make use of the following;

I. Sub basin management plans.
II. Commonage Framework Plans and Dept. of Agriculture, Food and the Marine stocking levels for individual commonages.
III. Ortho-photographs.
IV. Discovery Series 1:50,000 maps.
V. Morphological monitoring and catchment walkover risk assessments.
VI. Land Parcel Identification System data.
VII. Property Registration Authority website.
VIII. Consultations with individual land owners in the study area.

I. Sub-basin management plans.

At a general level, the sub basin management plans provide useful information in respect of the ecological quality objectives for *Margaritifera,* the current status of *Margaritifera* populations and their significance in a European context. They also provide useful information on the causes of population decline and

the historical and legislative background to the objective of reversing this process.

On a catchment specific level they provide information on topography, underlying geology and land use within the catchment. The current status of *Margaritifera* populations within the catchment is detailed including known sites and population age profiles (where available this is complimented with historical data) along with data on water quality and the water framework directive status is provided. In addition an assessment is made of the morphological, diffuse and point source pressures that have been identified within the catchment. Sub basin management plans can be obtained from NPWS or on line at www.wfdireland.ie.

II. Commonage Framework Plans.

Large increases in sheep numbers throughout the 1970's and 1980's led to situations where significant damage was caused to peatland and upland habitats throughout Ireland. To address this, the commonage framework planning process was initiated in 1998. During the period 1998- 2005 Commonage Framework Plans were produced for the bulk of commonage land in Ireland. As part of this process each commonage was assessed for damage that could be attributed to overgrazing by domestic livestock. Based on this assessment; the level of destocking that was required in each case was calculated. This was subsequently implemented by the Dept. of Agriculture, Food and that Marine.

The results of this destocking have been monitored at selective sites and in many cases recovery in vegetation quality was apparent.

Areas classed as MS, S or S* in the commonage framework plans should be considered as areas of interest. These sites along with any noted dump sites, quarries, sand pits, turbary areas, stock pens, dipping stations or supplementary feeding sites should be investigated in the course of the field assessment.

While the commonage framework plans are obsolete they can provide useful information on historic incidents of overgrazing. This can be invaluable both in planning fieldwork and in assessing trends within individual management units. Commonage Framework Plans can be obtained on line at www.agriculture.gov.ie.

Data on the maximum and minimum stocking rates permitted on each commonage land parcel can be obtained from the Dept. of Agriculture, Food and the Marine.

III. Ortho-photographs.

The use of ortho-photographs at the planning stage helps ensure that possible areas of interest can be identified and subsequently visited. They can serve to compliment fieldwork during the production of habitat and management unit maps and are undoubtedly a useful tool. The analysis of historical series of ortho-photographs may also help in determining certain trends in landscape development. However it is important to appreciate that there are limits to the value that can be obtained from the analysis of ortho-photographs.

The usefulness of ortho-photos can be affected by shadow, age, seasonal factors and camouflaging of details by the canopy of trees. Shadow effects, particularly in mountain areas can mean that little detail is available for large areas, see plate 1. Shadow effects also contribute to the prominence of features such as turf cutting banks. The age of available ortho photographs

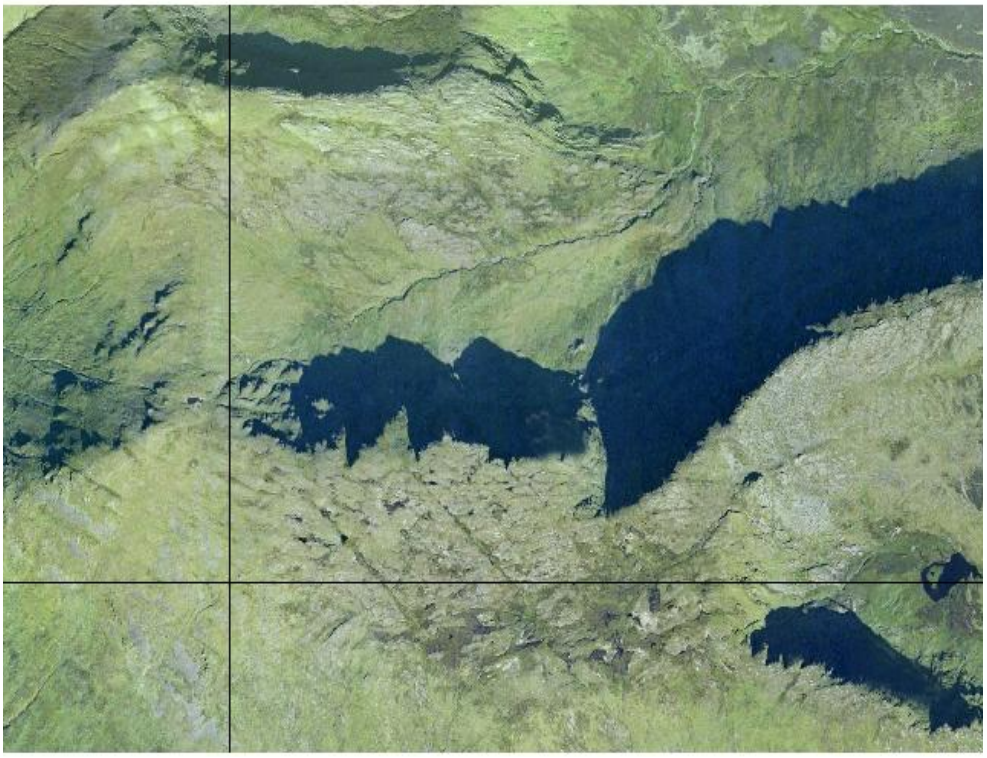


Plate 1: Slopes on the Sheefry Hills obscured by shadow.

may result in recent developments not being apparent. Details of the landscape may be obscured by physical barriers such as a tree canopy or may be obscured by seasonal factors, e.g. the prominence of silage grounds depends on the correlation of harvesting with the date the images are collected.

To deliver its full potential, the examination of ortho-photographs must be methodical. This is best done by overlaying the Irish grid on to the ortho-photograph layer. Each 1 km square is then examined in detail and areas of interest along with their grid reference noted. The assessors should pay particular attention to the following;

- Turbary Areas.
- Vegetation Condition
- Quarries/ Sand Pits
- Road and Track Networks
- Buildings

<u>Turbary areas.</u>

- Banks where turf was cut by hand or using a hopper are readily identified on ortho-photographs. These sites will often include areas where turf cutting is historic and no recent activity has taken place, see plates 2 and 3.
- Areas where turf was cut using a DIFCO cutter or sausage machine can often be identified by oil like smudges that contrast with the relatively uniform shade of adjacent and intact bog surfaces.
- Sites close to roads or tracks that can provide vehicle access should receive particular attention, see plate 3.

Assessors should note that the examination of ortho-photographs has its limits in terms of establishing the status or extent of turbary operations. In particular areas where hand cutting of turf has been abandoned will still show up as banks on the ortho-photographs. A determination as to whether turf cutting is still active will require a field examination.

The effects of shadow at turbary sites should not be under estimated. In many cases it is the shadow created by a turf bank that is most apparent on an ortho-photograph and not the bank itself. The prominence of the workings can thus

be affected by the orientation of the site, the weather conditions at the time the original photograph was taken and by the time of day that the original photograph was taken.

In the case of sausage machine cutting, shadow is rarely significant, what is observed at these locations are primarily changes to vegetation and drainage patterns. The destruction of the original vegetation, in particular on areas where turf is dried can create patches where the shades or colour of the surface differs from that of the surrounding bog. Very often the shape of these areas can be of assistance. Relatively straight boundaries and regular rectangular outlines can be indicative of turbary activity. However sausage machine cutting where turf was dried quickly and removed may have allowed some vegetation to survive, this will make identification from ortho photographs more difficult. Likewise on historic sausage machine cut sites, there may have been a partial recovery of vegetation. While this makes the site less visible on ortho-photographs it does not remove the potential risk of peat instability or erosion. In many cases associated vehicle tracks may be more apparent on the ortho-photograph than the turbary area itself. In some situations this may allow the observer to follow the tracks to the turbary site itself, see plate 2.

Another issue to be considered is the possibility of turbary operations commencing in the period since the original photographs were taken. For these reasons the possibility of active turbary operations on a part of the site cannot be dismissed by examination of ortho-photographs in isolation.

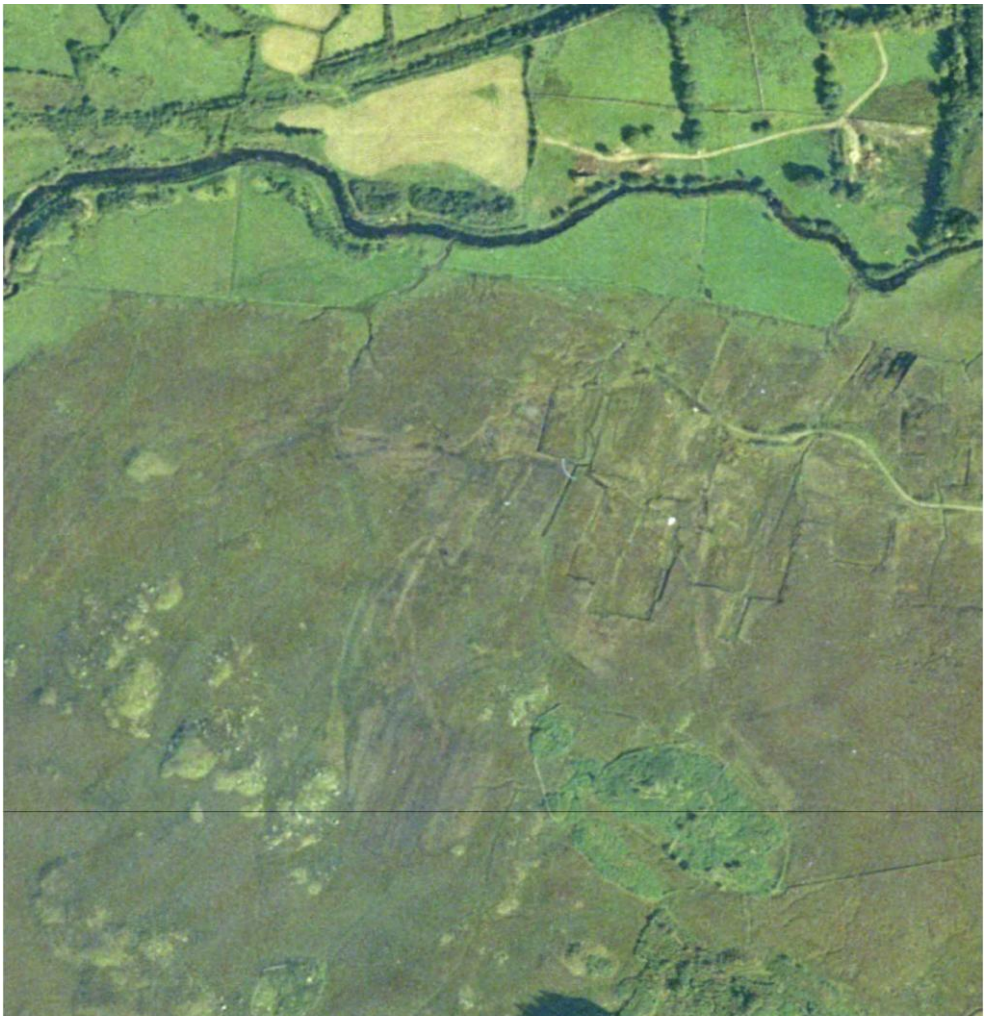


Plate 2: Note 1. Historic turf banks adjacent to the access road (centre right of photograph).

Note 2. Vehicle tracks on Blanket bog leading to sausage machine cut area in the lower part of the photograph.

Plate 3: Note 1. The uniform light brown colour of undamaged blanket bog in the upper left of the photograph.
Note 2. The turbary areas adjacent to the access road in the centre of the photograph.

Vegetation condition.

Shape, shade and texture can be useful indicators of certain habitats or land uses. For example coniferous forestry plantations appear dark green and have a rough texture on ortho-photographs. They often have regular outlines and forestry tracks or roads can sometimes be seen within them. It is often possible to discern different age classes and species mixes, see plate 4 below. Factors that are not so readily determined are the precise tree species involved or the drainage patterns within the block.

Plate 4: Note 1. Conifer plantations surrounded by blanket bog.
Note 2. Clearing and tracks visible within the plantation.

Undamaged blanket bogs can appear a uniform light brown colour on ortho-photographs, see plate 4 above. This is a result of the flat surface, poor plant productivity and modest variations in vegetation height. However to focus exclusively on areas with this uniform appearance can cause the observer to miss other types of blanket bog. An example of this is where water channels are present. These can cause the flat surface to be broken up, thus affecting the texture of the areas on the ortho-photograph and making it appear less uniform. In addition areas adjacent to moving water often support different plant communities and more vigorous vegetative growth. This can change the colour or shade of that part of the ortho-photograph. It should also be noted that the banks of drains or streams often create shadow effects on the ortho-photograph. This shadow effect can be mistakenly identified as being indicative of habitat damage.

Areas used for silage harvesting may be identifiable if the photograph was taken in the aftermath of harvesting, see plate 5. However this is obviously dependent on the correlation between the date of harvesting and the date the ortho-photographs were taken. While the appearance of stubble fields on ortho-photographs can be taken as evidence of silage harvesting and likely

high fertiliser use, the reverse is not true. The absence of such features on ortho photographs does not imply that the activity does not occur.

Plate 5: Note1: Silage stubble on recently cut fields.

Areas damaged by overgrazing will often contrast with adjacent areas with healthier vegetation. Sharp lines on ortho-photographs may correspond with fence lines on the ground and reflect different grazing intensities.

Plate 6: Damaged Area (dark in colour) to the left of the river, note the distinct fence line along the southern and western boundaries of the damaged area.

Quarries/ sand pits.

Areas that are largely devoid of vegetation such as active sandpits are very apparent on ortho photographs. As these are also likely sources of mobilisable silt or sediment, they should in all cases be considered areas of interest and investigated during fieldwork, see plate 7 below.

Plate 7: Active Sand Pit. Note large un-vegetated areas in close proximity to the river channel.

Buildings.

While domestic houses and commercial premises are outside the remit of Catchment Assessment Reports, the presence of possible farm yard complexes should be noted. Potential point sources such dipping stations, animal housing and waste storage facilities are often located in or adjacent to farm complexes. Where these are also in close proximity to a watercourse they warrant close attention, see plate 8.

Plate 8: Note 1. Two large buildings between road and watercourse (the watercourse is covered by a canopy of trees but is immediately below the buildings and roughly parallel to the road). On investigation it was discovered that these were animal housing units.

Road and track networks.

Roads and tracks provide access to lands. Activities that require vehicles to transport materials or equipment will normally be forced to utilise access routes such as these. For this reason turbary operations, supplementary feeding, fertiliser spreading, silage harvesting and drainage are more likely in accessible lands close to a track network, see plates 2, 3, 4, 5, 6 & 7.

IV. Discovery Series 1:50,000 maps.

A map can be defined as a pictorial representation of the situation on the ground. In this way it is very similar to an ortho photograph. It can however provide information not readily discernable from an ortho photograph. An example of this is the case of streams or channels within wooded areas, these are often obscured by the canopy on ortho-photographs but are apparent on 1;50,000 series maps, see plates 9 and 10.

Altitudes and slopes are indicated on the 1:50,000 Discovery series along the eastings and northings used in the Irish grid. Certain land uses such as forestry are indicated along with the names of rivers, lakes, townlands and urban areas.

Maps are irreplaceable as tools in route planning. In particular they can be used for identifying transect routes to incorporate areas of interest identified from other sources, in estimating distances and in the planning of emergency escape routes.

Discovery Series maps can be obtained from Ordnance Survey Ireland or from any good bookshop.

Plate 9. 1:50,000 series map of the lower Dawros River, note the two large river islands to the south west of Dawros Bridge.

Plate 10: Ortho-photograph of lower Dawros River, note river islands are not apparent as channels are obscured by the canopy.

V. Morphological monitoring and catchment walkover risk assessments.

These reports consist of two distinct components. Firstly an assessment of the morphological condition of the river channel and secondly a catchment walkover assessment which seeks to identify the main pressures on the catchment. Their principle value is that they provide the assessor with a brief and concise description of the issues within the catchment.

The morphological assessments make use of a technique known as River Hydro-morphology Assessment Technique. This was developed by the EPA as part of the North South share project in order to classify rivers in terms of their morphology. These assessments classify rivers based on their departure from a natural state. Channels are considered under the following categories;

- Channel morphology and flow types.
- Channel vegetation.
- Substrate diversity and embeddedness.
- Channel flow status.
- Bank and bank top stability.
- Bank and bank top vegetation.
- Riparian land use.
- Floodplain connectivity.

Scores are attributed to each of these attributes based on the deviation from the expected normal condition. This is used to generate a RHAT score. The authors of these reports have noted a correlation between RHAT scores and Q scores used in biological assessment of river channels.

The catchment walkover assessments seek to identify the main pressures on the catchment. These pressures are identified and classed into 8 different categories as shown below;

- Source of erosion.
- Diffuse Nutrient.
- Diffuse Silt.
- Current Riparian Zone.
- Field Drainage.
- Outfalls.
- Abstractions.
- Barriers to Migration.

The focus of these walkover assessments is similar to those in the Catchment Assessment Reports. There are however several key differences between the two systems;

- Walkover assessments are designed to give a general report on the condition of the catchment and to point out key threats at selected locations mainly along the watercourses themselves. This contrasts with Catchment Assessment Reporting which is more intensive and focussed on the catchment as a whole.
- Walkover assessments deal with the river and stream channels along with the riparian zone. Catchment Assessment Reports deal with the entire catchment.
- Walkover assessments identify threats to the catchment. Catchment Assessment Reports seek to identify threats and through the development of a GIS link these threats to the interaction between habitat type and management.
- Walkover Assessments do not incorporate proposals for remedial action to address identified threats. Such Proposals are a central component of a Catchment Assessment Report.

VI. Land Parcel Identification System (LPIS).

The LPIS system is used by the Dept. of Agriculture, Food and the Marine to identify individual land parcels. Each parcel consists of an area of land used for a single purpose, e.g. Permanent Pasture, Buildings, Barley etc. The parcels are identified by a unique alpha numeric code consisting of a letter denoting the county and a series of numbers identifying the individual parcel of land. The letters denoting the county are allocated in alphabetical order, thus Carlow has the letter A and Wicklow has the letter Z. The Land Parcel numbers are used by farmers to declare the lands they are farming in their annual Single Payment Application. In some cases (often due to the division of a parcel) it has been necessary to change the LPIS number of a given parcel. For this reason LPIS No.'s for a plot may vary over time. Both commonage and privately owned lands are allocated LPIS numbers, the key difference being that in the case of commonage it will often be declared by more than one farmer.

The benefit of information on Land Parcels to those involved in the production of Catchment Assessment Reports is in the identification of separate land holdings and management units. This is required for two reasons, firstly to obtain consents for access to lands that are to be assessed and secondly in delineating management unit boundaries when the GIS is being produced.

This data will be supplied to the Assessors by the Dept. of Agriculture, Food and the Marine.

VII. Property Registration Authority website.

The data on land title held by the property registration authority is of value in obtaining consent for access and in delineating management units. It is also of value in determining the title status of land in particular in identifying whether land is privately owned or commonage.

This can be obtained from the Property Registration Authority website www.landregistry.ie.

VIII. Consultations with individual landowners in the study area.

Consultations with individual landowners within the area are essential for two reasons. First they are required in order to obtain consent to enter onto lands for the purpose of assessing possible impacts on the catchment. Secondly they are invaluable for collecting information on local land management, title and activity. For example, knowing that only two individuals of out six shareholders actively utilise a particular commonage and that two other individuals have recently retired from farming could be of significant value in determining trends in the quality of vegetation and erosion risk on the commonage. Likewise information about historic events such as changes to drainage patterns, bog fires, landslides and wind throw events may only be obtainable from local farmers.

While the production of a Catchment Assessment Report is not a public relations exercise it is important that those involved interact with local residents in a respectful and open manner. Assessors should make every effort to explain the purpose of their work to local residents who express an interest and to note any concerns expressed to them by stakeholders.

B. Desk study of relevant publications and other data sources.

It is essential that those involved in the production of catchment assessments are familiar with the habitat requirements of *M margaritifera.* A good summary of these requirements can be found in the *M margaritifera* Sub Basin Management Plans SEA Scoping Document (Dept. of Environment, Heritage and Local Govt. 2009). The literature review for the *M margaritifera* Sub Basin Management Plans (Dept. of Environment, Heritage and Local Govt 2010) provides further detail and references.

On a local level, the catchment specific documents should be considered and their findings incorporated into the planning phase. The objective of the desk study is to identify issues of concern noted by previous researchers and to ensure that the planning of fieldwork is safe, efficient and effective.

C. Reconnaissance Visit.

Following a desk study, the assessors should undertake a reconnaissance visit to the study area. This is an opportunity for them to familiarise themselves with the catchment. Particular attention should be given to the following;

- Transport links. Distances from base, time taken to reach study area, suitability of tracks for vehicle use etc.
- Accommodation if required.
- Access points to lands including emergency escape routes from high ground.
- Mobile phone coverage.
- Stream size and flow.
- Identification of areas of interest.
- Land use patterns.

D. Liaison with local NPWS staff.

Assessors should make full use of the local knowledge of the relevant local Conservation Rangers and District Conservation Officers. They may be able to identify further site specific concerns including those relating to other species of conservation interest and provide assistance in liaison with local landowners.

E. Consultation with Landowners.

The consent of landowners / occupiers to enter onto lands for the purpose of identifying and assessing possible impacts should be obtained wherever possible.

- In the case of commonage lands, it is only required to obtain the consent of a single shareholder.
- In the case of lands where turbary rights exist, consent should be sought from the owners of the land as opposed to those with turbary rights only.
- In the case of rented land the consent of either the tenant or the landowner should be sought.
- Where it is not possible to identify or trace the landowner, the lands should be observed from neighbouring properties or from public roads. Entry onto lands in these circumstances should only be made in exceptional situations such as an emergency descent from high ground. Where it is felt that an adequate assessment of such lands requires access, this requirement should be notified to NPWS.
- In the case of publically owned lands, e.g. Local Authority Property, Coillte lands, NPWS owned lands, consent should be sought in the first instance from the relevant local management.
- Where access is denied by the landowner the matter should be reported to NPWS as soon as is practical.

These involved in the production of Catchment Assessment Reports should be sensitive to agricultural practices and landowner privacy. In particular no entry should be made into the environs of a private dwelling other than for the purpose of consulting with the resident, gates should be left closed, no materials should be left behind and any accidental damage to private property should be notified to the landowner and to NPWS.

F. Delineation of Sub-Catchments.

The first step in the production of a catchment assessment report is to divide the area involved into sub catchments. This is done so that issues identified later in the assessment process can be linked to individual sub catchments. This is a key issue as the impact of any given threat may be affected by its location. For example an issue affecting a tributary that flows into the main channel downstream of key *M margaritifera* sites will be of lesser consequence than a similar issue on a tributary upstream of *M margaritifera* populations.

The sub catchment delineation process is carried out as follows;

- The catchment of each second order stream is considered as a separate sub-catchment.
    - Lakes and any lake islands can be incorporated in their entirety within these sub catchments if the outlet stream is still considered as a first or second order stream.
- In the case of third order and higher streams (excluding the main channel) the area draining into each side of the stream is considered as a separate sub-catchment.
    - Areas that drain directly to the main channel by means of local drainage routes or first order streams are not considered sub catchments in their own right. They are instead incorporated into adjacent sub-catchments.
    - Lakes and any lake islands along third order and higher streams excluding the main channel are divided notionally with each half incorporated into the adjacent sub-catchments.
- Lakes on the main channel and any river or lake islands that may be present along the length of the main channel are considered as part of a separate sub catchment. In addition areas such as reed beds adjacent to the main channel are incorporated into this sub-catchment.

The sub-catchments, as delineated above are named with capital letters. In general this should be done from west to east and from north to south. That is the sub catchment containing the most westerly point of the study area is identified as A. The sub catchment with the next most westerly point (excluding areas within sub catchment A) is identified as B. If the most westerly points of two or more sub catchments are very close, the next available letter will be allocated to the sub catchment with the most northerly point. In all cases the main channel will be allocated the last letter in the sequence. An example of completed catchment delineation is shown on plate 11 below.

Plate 11: Sub-catchment delineation for the Owenriff River, Co. Galway.

This procedure inevitably faces a problem when dealing with large catchments where in excess of 26 sub catchments can be identified. The assessment of large catchments also causes logistical and organisational difficulties and will lead to reports of excessive size and complexity. This risks a loss in quality and consistency of approach and the production of a document that may not be easily accessible to land managers and other involved with *M margaritifera* conservation. To overcome these issues, the size of the area dealt with in a single report should be capped. The maximum area should not exceed 4,000 Ha or 26 sub-catchments whichever is smaller. When dealing with catchments in excess of this size, the catchment will be partitioned into two or more study areas.

G. Identification of Areas of Interest.

Catchment Assessment involves the entire catchment; however certain areas may be identifiable in advance as being of special interest. These could include areas suggested by previous reports or by local NPWS staff or identified in a study of available ortho-photographs.

Issues that would be of particular interest include the following;

- Peatland locations where there appears to be significant damage, this would include areas identified as MS, S or S* on Commonage framework plans as well as sites identified from ortho-photographs or suggested by local Conservation Rangers or others.
- Areas where recent change in land use has occurred, e.g. tree planting, removal of scrub etc.
- Areas where there are pronounced changes in vegetation cover, e.g. along stockproof fences in upland areas. These are of particular significance if they serve to channel the movement of stock on a narrow axis.
- Active turbary areas including bog roads and access points.
- Quarries and sandpits.
- Recreational areas, including popular angling or kayaking sites.
- Farmland used for intensive agriculture.
- Farmyards.
- Supplementary Feeding sites.
- Sheep dipping stations.
- Fording points on rivers.
- Dumps.
- Landslide scars.

In addition to the issues listed above, there may well be other issues that arise at particular locations that require further investigation. The identification of areas of interest during the planning phase ensures these locations are visited in the course of fieldwork. It is however very important that this process does not serve to eliminate other parts of the study area from consideration. The identification of areas of interest serves primarily as a management tool to assist the assessor in planning the allocation of labour resources. For example the assessment of an upland site that contains two separate areas of interest may require the allocation of extra man days. It is also important to note that further issues will arise during fieldwork and other areas of interest that merit close attention and perhaps changes to work schedules are likely to be identified.

H. Planning of transects through the study area.

The planning of transect lines through the study area is required to ensure adequate coverage of the site and to ensure the personal safety of the assessors.

Assessors should take the following into consideration when planning transects:

- They should commence at a suitable access point, ideally where a vehicle can be safely parked.
- Transect lines should be of a length that can be adequately covered in the time available. Pay particular attention to the amount of daylight hours on the date of the survey. As fieldwork is neither safe nor practical after dark, route planning should ensure that personnel can be back on a public road before nightfall.
- Consideration should be given to the value of prepositioning a vehicle at the end of the transect line rather than being forced to plan a circular route.
- Weather conditions and start time on the day of a survey may dictate which transect line should be selected. Long routes over high ground should only commence when weather conditions and day length are suitable. Shorter lower altitude transect lines may be feasible on days which are sub optimal for upland work.
- Steep slopes, cliffs or unstable surfaces should be avoided.
- Upland streams are often subject to large variations in flow. This can be particularly acute in response to rainfall events. No risks should be taken in

crossing streams during or after heavy rainfall. If this means that a planned survey has to be cut short and rescheduled then so be it.

- In the event of an emergency, there should be a pre-planned escape route from all sections of the transect line. This could include one of the following;
    - Continue on the planned route.
    - Return the way the team had come.
    - An emergency escape route. In an emergency, the priority should be to get back to a public road or at least to reduce altitude before darkness. In extreme cases where third party assistance is required the assessors should find a safe and easily locatable refuge.
- Transect lines should work along the terrain, staying where possible at the same altitude. Routes which require giving up altitude that will have to be regained later place undue strain on the team and are likely to reduce output.
- All known areas of interest should be incorporated into the route and adequate time made available for their investigation. If this proves to be inadequate the team must decide if it is realistic to deal with them on that day or whether another visit is necessary. Large deviations from the pre-planned transect lines should be avoided.
- A third party should be aware of the route that is to be undertaken and the expected completion time for this route.

2) Fieldwork and Mapping.

For fieldwork to be safe, effective and efficient it is essential that the personnel involved are trained and equipped for the task in hand. It is also essential that they have a thorough understanding of the projects objectives, the methodologies to be employed and the plan for the fieldwork campaign.

A. Safety considerations.

i. Clothing and Equipment.

Assessors working in the field must be provided with adequate clothing and equipment to ensure the safe performance of the tasks allocated. Suggested clothing and equipment issue include;

- 3 season climbing boots.
- Gaiters.
- Water proof pull-ups.
- Climbing jacket, (Bright colours preferred).
- First aid kit.
- Backpack.
- Compass.
- Waterproof map.
- GPS plus spare batteries in waterproof packaging.
- Mobile phone.
- Torch (LED Headlights with spare batteries).
- Digital camera (ideally one with an incorporated GPS).

ii. Training and Supervision.

All personnel should be experienced in working in upland areas. Personnel without adequate experience should undergo a stage 1 Mountain Safety Course run by a Mountaineering Ireland approved trainer.

No personnel should work unaccompanied in remote locations. All teams working in remote upland locations should inform a third party of their area of operations and expected return time. This person should be notified by the team when work is completed and the team have returned to their vehicle.

iii. Communications.

All personnel should be equipped with a mobile phone. Battery status should be checked before work begins. A mobile phone while a useful aid should never be seen as a substitute for equipment or training.

iv. Weather conditions.

The weather forecast should be checked before work commences. Fieldwork in mountainous areas should not be carried out during inclement weather. It may be possible to work in more accessible low lying areas on days where weather conditions prevent high altitude work.

v. Other Issues.

- Assessors should be aware of the potential safety hazards posed by livestock, in particular bulls, horses and cows with young calves.
- The physical abilities of team members and any underlying medical conditions must always be considered by those responsible for planning fieldwork.

B. Transect lines.

i. Areas of interest.

Transect lines should ensure that all areas previously identified as being of interest are visited.

ii. Stations.

A selection of stations will be assessed for the purpose of providing baseline data for future researchers. The selection of locations for these stations shall focus on sites with identified threats, e.g. overgrazing, turbary etc. No attempt need be made to ensure that stations are representative of the study area as a whole.

C. Mapping.

i. Habitat units.

Each sub catchment will be divided into separate habitat units. Habitat units are areas with similar habitat types, risk profiles and within the same management unit. Each habitat unit is identified first by a letter denoting the relevant sub catchment and secondly a letter denoting the habitat unit, e.g. P-K. The principal habitats within each habitat(s) unit are to be recorded using the appropriate Fossitt codes as described in "A Guide to Habitats in Ireland" (Fossitt J.A. 2000). Micro habitats or areas occupying less than 10% of the unit are not normally recorded. Likewise codes for field boundaries such as hedges or watercourses are not normally listed unless there are specific risk factors applying to those habitats.

ii. Management units.

Management units are identified as areas sharing a common management and bounded by either the external boundaries of the study area or by a natural or artificial barrier which is effectively stockproof. Management units are labelled by the letter denoting the sub catchment and by a numeral, e.g. M-1. Management units can of course cross sub catchment boundaries, where this occurs one of two approaches are taken;

- If the management unit crosses two or three sub catchments it is identified by the respective sub catchment codes and a number, e.g. LMN-2. Issues relating to the management unit are reproduced in each of the sections dealing with the relevant sub catchments.
- Where the management unit crosses four or more sub catchments it is to be identified by a prominent geographical feature within it, e.g. Mweelrea Mountain.

iii Stations.

A number of stations representative of the habitat unit in which they occur will be selected as monitoring stations. Unlike in the commonage framework planning process stations need not be representative of the range of habitats and conditions found in the study area as a whole. In most cases they will be selected from areas where particular problems are known to exist.

Each station will be numbered in sequence, e.g. X1, X2 etc. The location of each station shall be fixed using GPS equipment. The location shall be recorded as a 10 figure reference using the Irish grid system. Station size will be 10m x 10m. A series of photographs will be taken at each location; these will include at least two directional photographs, where the bearing to a landmark visible in the photograph shall also be recorded. In addition to this at least four photographs shall be taken of the vegetation within the station. A station card will be used to record species cover abundance within the station using the DAFOR scale. In the case of blanket bog, wet heath and dry heath habitats this will be supplemented by a station assessment card. The station assessment card will assist in determining the appropriate condition code to be assigned to the station. Examples of these cards can be seen in Appendix 2 of this manual.

D. Photographic Standards.

All photographs are to be taken with a digital camera at a resolution of not less than 6mb. Ideally the cameras to be used would have an integrated GPS. This records the location where the picture was taken onto the properties of the photograph.

It is essential that the assessors are able to group the photographs together with other appropriate data once they have returned to base. One useful technique for doing this is to use a picture of the sky as a break between photographs taken at different locations. Once the photographs have been downloaded the pictures of the sky divide the set into sequential groups which can then be linked with station data, point feature data etc. Notes pertaining to photographs should be taken to assist in their later classification.

Assessors should endeavour to download and classify all photographs after each day of fieldwork. This reduces the data loss that would be caused by a camera being mislaid or damaged to an extent that material could not be retrieved. In addition it makes the classifying of photographs easier as assessor's memory of the site visit will be fresher.

3) Identification and Assessment of Environmental Pressures.

For a population of *M margaritifera* to be sustainable they require an environment that can meet their requirements at all stages of their lifecycle. This requires conditions that support adult mussels, glochidia (and their salmonid hosts) and juvenile mussels. Chronic or once off pollution incidents can negatively impact on any of the life cycle stages although juvenile mussels buried in the river bed substrate appear to be the most vulnerable.

In most cases, the loss of pearl mussel populations occurs from the continuous failure to produce a new generation of adult mussels. An important cause of this is the loss of clean gravel beds due to the infiltration of fine sediment. As juvenile mussels, i.e. during their first five years are buried in the sediment, they are vulnerable to physical and chemical changes within the substrate. One of the most significant of these is the reduction in dissolved oxygen levels. This can occur because of the infiltration of the substrate by fine sediment, reducing the exchange of water and lowering the supply of oxygen to the juvenile mussels. It can also be caused by the decomposition within the substrate of fine or dissolved organic matter. Substrates at sites supporting juvenile recruitment show no detectable differences between the redox potential (Eh) of the open water and the interstitial water at 5 or 10cm depth (Geist and Auerswald, 2007). Excessive siltation can also lead to compaction of the river bed which further reduces the potential for dissolved oxygen to reach the juvenile mussels.

Physical siltation can continue to affect mussels on a long term basis (Killeen et al 1998). Adult mussels can be killed by ingestion of silt or from stress caused by long term clamming up. The negative impact is exacerbated in the summer months if it is associated with high water temperatures. Siltation can also facilitate the establishment of aquatic macrophytes, e.g. *Ranunculus spp* and *Myriophyllum spp* which can cause further silt trapping. The growth of aquatic macrophytes is encouraged by even small increases ortho-phosphate levels. Increases ortho- phosphate can also lead to damaging algal growth. To prevent this and to maintain oligotrophic waters as suitable habitats for *M margaritifera* background levels of ortho phosphate should not exceed 0.005mg/l (Moorkens, 2006a).

Pearl mussel habitats can be destroyed by changes to the morphology of the channel through canalisation, boulder removal, arterial drainage etc (Moorkens

1999, Hastie et al 2000). Flow regulation in particular can cause stress to adult and juvenile mussels (McAllister et al 1999 and Araujo and Ramos 2001) particularly by causing more prolonged low flows. This can result in increased temperatures, reduced dissolved Oxygen levels, concentration of pollutants and increased potential for deposition of sediments. Secondly peak flows can be damaging by disrupting the mussels life cycle and increasing stress.

The management of *M margaritifera* rivers' for angling such as the provision of fishing weirs, dams, fishing platforms, pool dredging and footbridges all threaten pearl mussel populations both during construction and operational phases (Hastie and Young 2003). In addition management for angling often includes the control of river bank vegetation which increases the risk of erosion and may involve the use of hazardous chemicals.

Mussels can be negatively impacted by toxic chemicals in their environment. Both adult and juvenile mussels are benthic suspension feeders. They are exposed to pollutants in surface water, interstitial water and ingestion of filtered particles with sorbed contaminants. Chemicals that are of particular concern include the following;

- Heavy Metals, the early life stages of freshwater mussels have been shown to be particularly sensitive to Copper (Wang et al 2007). The known impact of other metals such zinc, lead, chromium, cadmium, nickel, silver and mercury on other bivalves suggests that *M margaritifera* would also be negatively impacted by exposure to these substances.
- Persistent organic pollutants (POP's) such as DDT and its metabolite DDE and polychlorinated biphenyls (PCB's).
- Compounds containing mercury, e.g. Mercuric nitrate and methyl mercury chloride (Dolmen et al 1995).
- Ammonia, Juvenile freshwater mussels have been found to be chronically sensitive to ammonia (March et al,.2007)
- Fungicides containing chlorothalonil, pyrasclostrobin and propiconazole have been shown to be damaging to glochidia and juvenile mussels (Bringollf et al., 2007a).
- Glyphosate. This chemical is a component of the well known herbicide Roundup. It has been found to be acutely toxic to glochidia and juvenile mussels. Toxicity testing has shown that the surfactants used to allow penetration of waxy leaves may be the most toxic component of the product (Bringollf et al., 2007b). Note this study was based on the effects on the North

American species *Lampsilis siliquoidea* but the conclusions are likely to be valid for *M margaritifera* as well.

- Wood preservation products containing copper or chromium (O Grady., 2006).
- Insecticides such as Rotenone, chlorpyrifos and perithrin may be a risk to juvenile mussels (Bringollf et al,. 2007c).
- Sheep dip containing organo-phosphates and pyrethroides uses in sheep dipping are highly toxic to species that are a lot less sensitive to pollution than the *M margaritifera* (Bringollf et al,. 2007c).

Changes to pH can have negative impacts on *M margaritifera*. In Ireland acidification is often linked to water draining from coniferous forests on soils with a low buffering capacity. It is well documented that acidification is a threat to the Salmonid hosts of the *M margaritifera* (Bowman and Bracken.,1993; Allott et al,.1990; Kelly Quinn et al.,1997). Direct effects on the *M margaritifera* can also occur. These include; the gradual destruction of the mussels calcareous shell, infertility and problems with the regulation of acid-base mantle fluid (Vinogradov et al.,1987). An Increase in pH caused by the liming of agricultural land can result in direct toxic effects and through increased growth rates leading to shortened life expectancy and thus a loss in of reproductive years (Bauer et al,.1991; Skinner et al,.2003).

Assessment of Threats.

The assessment of threats or pressures is based on using an expert-judgement-based risk assessment method, following a standard “source-pathway-receptor” model. Source in this case can be equated with the pressure or threat, the pathway is the route to the pearl mussel habitat, e.g. overland flow- land drain- stream-river and finally the receptor is the pearl mussel and its habitat.

Assessors should consider the DPSIR framework for use in pressure and impact analysis.

Table 1

Term	Definition
Driver	An anthropogenic activity (e.g. agriculture) or natural phenomena (e.g. Geological instability causing rockslides).
Pressure	The direct effect of the driver, e.g. change in water chemistry or alteration to drainage characteristics).
State	The condition of the water body resulting from both natural and anthropogenic factors (i.e. physical, chemical and biological characteristics).
Impact	The environmental effect of the pressure, (e.g. change in trophic status).
Response.	Measures taken to improve the state of the water body by reducing or removing the pressure, interrupting or blocking the pathway or ameliorating the impact on the receptor.

(this is a modified version of that used in the IMPRESS Guidance)

Nine aspects of the pressure should be considered by Assessors, these are;

i. **Characteristics** of pressure or threat.
ii. **Drivers** or causative factors behind the pressure.
iii. **Scale** or magnitude of the pressure/ threat.
iv. **Location** of the site affected.
v. **Pathway**, the characteristics of the pathway between the source and the pearl mussel habitat. In particular any buffering capacity which may ameliorate the pressure.
vi. **Trends** in the nature or scale of the activity.
vii. **Multi-factor pressures**.
viii. **Interaction** with other threats or factors existing or emanating from outside the affected area.
ix. **Temporal factors**.

i. Characteristics

Catchment threats to *M margaritifera* populations include any activity, phenomenon, feature or situation that is causing potentially harmful material to be mobilised and enter the aquatic ecosystem. It also includes activities that could affect the morphology of the river channel or the drainage or runoff characteristics of the catchment. They can be divided into pressures arising from;

- Hydromorphological pressures.
- Point source pressures.
- Diffuse source pressures.

Examples of Hydro-morphological Pressures.

- Obstruction of water flow.
- Water abstraction.
- Increases in peak flows.

Examples of Point Pressures

- Sheep dipping stations where there is potential for chemicals known to be harmful to *M margaritifera* or to fish to escape to the aquatic environment.
- Animal housing, soiled yards and fodder or animal waste storage facilities from which there is a risk of polluting material being lost to a watercourse.
- Quarries or sand pits where there is the potential for sand, silt or soil to be mobilised and lost to the aquatic environment.
- Un-metalled roads, e.g. forestry roads. These can be of a source of sediment and calcareous materials which may affect the pH of receiving waters both during the construction and operational phases, see plate 12. The problems is exacerbated if the road is poorly maintained, on a steep slope, has an inadequate camber and if the surface water discharge points are direct to a receiving watercourse.
- Metalled roads. Roadwash and surface drainage can be a source of oils and sediment. Construction, repair and maintenance works have the potential for providing a severe

siltation risk (Dept. of the Environment, Food and Rural Affairs. 2004.

- Fords where the crossing of a watercourse by people, vehicles or animals is leading to damage to river banks and consequent erosion, physical damage to known *M margaritifera* populations or pollution caused by the deposition of wastes directly into the watercourse.

Plate 12: Construction of unmetalled roadway in blanket bog habitat.

Examples of Diffuse Pressures.

- Lands which are in receipt of chemical fertiliser or organic manures where there is a potential for the loss of plant nutrients to watercourses. The export of plant nutrients from field sources is likely to be linked to intense rainfall events and as such to be periodic in nature. This contrasts with many point sources where the rate of nutrient export may be more constant. A significant proportion of plant nutrients lost from field sources may be in a particulate form.
- Overgrazed areas where peat or soil particles can be mobilised and washed into streams, see plate 13. Erosion is the process by which soil particles are detached and transported by the

actions of wind and/or water. Erosion occurs naturally due to the influence of climatic forces on the earth's surface. Anthropogenic factors, such as removal of or damage to vegetation can accelerate the process of erosion.

- Overgrazed areas where the runoff characteristics of the land have changed to the extent that peak flows may be damaging to *M margaritifera* or their habitat. The reverse also holds true, if the water retention capacity of the catchment has been reduced by erosion and peat compaction, then dry periods may lead to water levels being falling to a level that has negative implications for *M margaritifera*. Low water flows, particularly in the summer months when temperatures are higher can be stressful to *M margaritifera*. While floods and periods of low flow are encountered in all water courses, changes to the drainage characteristics of the catchment may increase the frequency, duration and or scale of these events.

- Active turbary areas. Damage to vegetation caused by turf cutting and associated activities, e.g. drying of sods of turf, storage of turf and vehicle use may lead an increased risk of peat silt being mobilised. Once mobilised peat silt is unlikely to settle permanently unless it passes through a large flat, undamaged and vegetated area. Turbary operations can also lead to slope stability issues and changes to drainage patterns. The cracks created by harvesting turf using a sausage machine can be up to 1m deep, see plate 14. They create a pathway for the ingress of water into the humified catotelm. This can result in a change in the internal water regime of the bog leading to an increased risk of slope failure.

  The drying of turf damages or destroys the natural vegetation on the bogs surface. This can expose the peat surface and lead to the mobilisation of surface peat during intense rainfall events. This can occur even where some relic vegetation cover persists.

  Surface drains cut to facilitate turbary operations create a pathway for mobilised peat to reach watercourses, they lower the water table and alter the runoff characteristics and the internal water regime of the bog.

- Changes to field drainage systems. Long established field drainage systems probably do not represent a serious threat as the catchment has already been modified by their action. However new drainage or extensive changes to existing drainage patterns can have serious negative implications, see plate 15. They can change drainage characteristics and may act as a conduit for mobilised silt or peat, animal wastes or plant nutrients. The changes to drainage characteristics could result in increased peak flows in the receiving watercourse with a consequent risk of undermining or erosion of banks.

- Recreational use. The creation of paths by recreational users can increase the risk of erosion, particularly at stream crossing points, see plate 16.

- Clearance of scrub. Land improvement works such as scrub clearance exposes the soil surface and increases the risk of material being eroded, see plate 17.

- Burning of scrub or bogs exposes the soil surface and increases the risk of post fire erosion. It also increases the risk of fires getting out of control and damaging large areas. Fires may also change the vegetation in a manner that is damaging to bio diversity in general and to the habitat of *M margaritifera* populations in particular. An example of this is the repeated burning of Purple Moor Grass (*Molinia caerula)* litter; this can kill off heather and other plants and lead to increased dominance of the deciduous *M caerula.* This excessive dominance increases the risk of future more intense fires and lowers the bio diversity value of the site. However post fire erosion of peat also has a potential impact on *M margaritifera* populations further down the catchment.

- Removal or excessively frequent or severe coppicing of streamside trees to facilitate angling, see plate 18. This may destabilise banks and make them more vulnerable to erosion or collapse.

- Dominance of invasive species. Certain invasive species may increase the erosion risk within a catchment. Some species

such as *Gunnera spp* are deciduous and when they die back in the winter the soil underneath is exposed and vulnerable to erosion.

- Acidification of runoff from large coniferous forestry plantations.

- Land Slides or peat flows. The implications of land slides or peat flows in a *M margaritifera* catchment are potentially very serious. Large quantities of material can be mobilised and eventually make their way into *M margaritifera* habitats. This impact can be exacerbated if the zone of deposition extends into a significant watercourse. If this were to occur the temporary damming of the watercourse, the inevitable bypassing or collapse of the blockage can create a sudden increase in flow rates with possible impacts on watercourse morphology and *M margaritifera* habitats.

Plate 13: Overgrazed area acting as a source of peat silt and which has altered runoff characteristics.

Plate 14: Cracks in bog created by the use of a sausage machine for harvesting turf.

Plate 15: New drainage as part of land improvement works.

Plate 16: Path created by recreational users of upland area, at this intensity no difficulty is created.

Plate 17: Clearance of Scrub.

Plate 18: Hard coppicing of riverbank trees to facilitate angling.

The examples above are not exhaustive and assessors may well encounter other issues of concern in the course of an assessment. If they are in any doubt they should consult with the wetlands section of the NPWS.

It is important to note that there can be considerable variation in the relative significance or risk attaching to a given threat with time. This can occur over a short time frame such as the linkage of erosion with high rainfall events or over a longer period such as a commercial forestry cycle. In the case of forestry, risks may be associated with major operations, e.g. planting, fertilisation, track construction, thinning and clear felling and may be separated by long relatively stable periods.

ii. The drivers or causative factors for environmental pressures.

Once a pressure or threat has been identified the causative factors behind it should be considered. While agriculture may be identified as a broad category, the driver may in fact be a complex interaction with local and national and even international components. The driver itself may be in a state of flux and the resulting changes in its characteristics may be critical to the impact on the receptor. For example, changes in grazing pressure could be a response to changes in the price for agricultural commodities. Perverse consequences of agricultural regulations or rules could also be a factor. At a more local level the individual goals or aspirations of a particular landowner may also be involved.

An example of this would be in respect of turf cutting. If the scale or location of turbary activity has changed in the recent past, is it possible to attribute this to any local or wider cause, e.g. fuel prices, un-employment rates etc.
In all cases it is useful to also consider the following;

- Are further changes likely in the future?
- Will such changes lead to a reduction or an increase in the characteristics or magnitude of the pressure?

iii. **The scale of the pressure.**

The scale of the threat posed is an issue that must be considered, it is influenced by the nature of the threat, the size and location of the area affected, the presence or absence of any ameliorating or buffering features along with likely future trends. The current condition of the site is a key factor in determining the scale of the pressure and what, if any response is warranted to reduce the threat to *M margaritifera* habitats. The presentation of the current

condition is made using the condition code scale. This assessment on a scale of 1-10 is made at a habitat unit level. The characteristics of each level on this scale are shown on table 2.

Table 2.

Condition Code	Description (note assessment of condition must not discriminate based on cause of damage)
1	Under grazed areas, typically dominated by *M caerula* and or *Juncus* species. Areas with dense bracken or heather may also be included in this category.
2	Undamaged areas with little or no bare peat/ soil.
3	Areas where some damage to vegetation (irrespective of the cause) is evident. However there is little or no risk of erosion and damage to vegetation structure or species composition while present is minimal in extent and or severity.
4	Areas where damage to vegetation structure is significant but bare peat/ soil is less than 3% and erosion risk is considered low.
5	Areas where bare peat/ soil are significant (3-6%) and where erosion risks are present.
6	Bare peat/ soil (6-8%), erosion risks are significant and damage to vegetation structure or species composition is normally very apparent.
7	Bare peat/ soil (8-10%) erosion risks are potentially serious.
8	Bare peat/ soil (10-20%) damage is obvious and erosion is occurring. Sites where there are concerns as to surface stability, e.g. sites with evidence of recurring landslides and cutting of turf using sausage machines should be included here.
9	Bare peat/ soil (20-40%), seriously damaged, active erosion is apparent. Sites where cross cutting of turf using sausage machines has occurred or where the vegetation in cutting or drying areas has been significantly damaged should be scored as 9 or 10.
10	Bare peat/ soil (>40%). Very seriously damaged, erosion is extensive and easily observed. Sites where significant landslides or peat flows have recently occurred or where tension cracks or pipes are evident should be included in this category. Large deposits of unconsolidated material particularly where these include fine mineral particles or peat should be also be included in this category as should sites where the use of hazardous chemicals, e.g. sheep dip, herbicides is occurring without adequate controls or buffering capacity.

Note 1: Lands where there is concern in respect of soil eutrophication should be given a condition code based on the factors described in the above table. This does not preclude planning for these areas to include recommendations on nutrient management planning or buffer zones to be made.

To assess the condition code for stations, a series of station assessment cards have been produced. These can be seen in Appendix 2 of this manual. These are based on a modified version of the system developed by McDonald et al 1998 as reported in Horsfield, D. (2009). This system is based on a assessing a number of different indicators and scoring the site accordingly. While designed initially for stations the same system can be applied to habitat units. In the version used by Horsfield D (2009) these indicators assessed the following;

- Direct impacts on plants, such as the proportion of leaf or shoot removed due to grazing or browsing.
- Amount of bare and trampled ground.
- Frequency of erosion scars.
- Amount of herbivore dung deposited.
- Rates of flowering and fruiting of plant species particularly Heather species and Bog Cottons (*Eriophorum spp*).
- Sward height and cover.
- Growth form of different plant groups.

Trend indicators were used to indicate change in impact over the past year or a few years. These include:

- Persistent grazing- or browsing-induced plant growth forms.
- Relative heights of grasses and dwarf-shrubs.

In Ireland this system was adopted for the production of commonage framework plans. For the purposes of this manual, the system used above has been adapted to provide a better match for the requirements of catchment management for *M margaritifera*. The principal differences arise from the requirement to sub-divide the severely damaged category. From the perspective of assessing the condition of upland vegetation McDonald and later Horsfield asserted that bare peat in excess of 10% constituted severe damage. For our purposes this threshold of 10% is too low to assist in classifying the potential for the mobilisation of peat from sites with bare peat in the 10-100% range. To deal with this issue the condition codes have been changed from U*, U, MU, MM, MS, S to a numerical condition classification from 1-10. As in the commonage framework plan system there are separate station cards for blanket bog/ wet heath and for dry heath.

On the blanket bog/ wet heath assessment card there are three extra parameters relating to the abundance and growth habits of *Nardus stricta, M*

caerula and *Sphagnum spp.* While this places an additional weighting on the condition and abundance of *Sphagnum spp* this is considered as justified on the basis of the importance of these species in the interdiction of mobilised peat and in the protection of the peat surface from driving rain. The evidence for the usefulness of Sphagnum as indicator species was examined by O Reilly C (2008) who noted that the use of Sphagnum species as indicators, if applied critically, is a valid, quick and simple proxy field technique to assess ecological conditions. However evidence of the value of specific species as indicators is limited to the following (O Reilly C, 2008);

Sphagnum capillifolium (where it out competes other *Sphagnum* species) – increases suggest drying out
S. compactum – increases suggest drying or recovery from burning
S. ***cuspidatum*** – decreases suggest drying out
S. ***fallax*** – increases suggest nutrient enrichment and/or recovery from bare ground / erosion / burning.

In addition to the potential use of different species of Sphagni, assessment of the structure and abundance of Sphagnum as an indicator of ecological condition is widely used. In the system described in this manual, a combination of the cover and the structural characteristics of Sphagnum, the number of species present along with the presence/ absence of a single species, i.*e. S cappillifolium* are used as indicators of condition. It is felt that this approach is utilisable by personnel without specialist bryophyte identification skills and is responsive to varying impacts of trampling (associated with grazing or recreational pressure and turbary operations) and to the drying out of the bog surface associated with drainage, turbary operations and the effects of burning.

The other additional parameters used in the Catchment Assessment system are in respect of the abundance of *M caerula* and *N stricta*. They are used here as indicators of grazing pressure. Dominance of *M caerula* is used as an indicator of under grazing or lack of management, particularly in wet heath habitats whereas high cover abundance of *N stricta* on blanket bog and wet heath can be indicative of over grazing.

There is effectively no change to the dry heath assessment card from that used in the commonage framework planning program.

It is important to note that when assessing the overall condition, the questions on the assessment cards are not weighted equally. Due to the primary interest of these assessments in determining the risk of peat silt being lost to the

aquatic environment the issue of bare peat is of primary importance. To ensure this primacy, the condition code attributed on the bare peat question shall be taken as the minimum condition code value for the site. If the answers to the other questions suggest that a higher condition code should be used then the condition code value can be increased. The reverse however does not apply and a number of very low scores for other parameters does not serve to lower the overall score below that attributed to the extent of bare peat.

No assessment cards have been developed for habitats other than blanket bog, wet heath and dry heath. The assessment of damage in these habitats shall be guided by Table 1 above.

The condition code applied to each habitat unit is an essential part of providing a baseline against which future progress in catchment management can be gauged. It is also key to assessing sustainable grazing levels, the ranking of threats and the identification of areas where active intervention is required.

iv. The location of the affected area.

The location of the affected area is very important for two reasons. The first is in relation to the local topography of the area affected. A site that is steeply sloping or in close proximity to a watercourse may be of greater concern because of the easy route by which eroded or polluting material may make their way to the river system. A second concern is in respect of the location of the site with respect to known *M Margaritifera* populations. If the site drains into the catchment downstream of most known populations the consequences may be less than if the drainage route was upstream of the population centres.

v. Available buffering capacity.

The negative impacts arising from certain threats may be ameliorated if adequate buffering capacity is available. Geology, topography, vegetation and management can all influence the extent to which the aquatic ecosystem can be protected against potential threats. For our purposes two principal types of buffering capacity are relevant;

- **Geological buffers.** These can affect the potential for acidification arising from coniferous forestry within the catchment. In this case the pH buffering capacity of the soils on which the trees are grown is a key determinant in whether negative impacts for *M margaritifera* will arise.

- **Topographical buffers.** The topography of the site may serve to interrupt the movement of eroded material from its source to *M margaritifera* habitat. Buffering capacity of this type can be either terrestrial or aquatic.

    - **Terrestrial buffers.** The topography and vegetation cover on the land between the source of mobilised material and the receiving watercourse may create a protective barrier. For example, the presence of a large flat area with undamaged vegetation between the damaged area and the receiving watercourse may provide for the interception of mobilised peat silt. The effectiveness of such a barrier is dependent on size, slope, density of vegetation cover and the absence of drainage channels which could allow mobilised material to bypass the vegetated surface.

    - **Aquatic buffer.** A lake is located downstream of the affected area can moderate extremes in water flows and act as a sink by intercepting suspended solids. The size of the lake and the properties of the suspended material are key issues to be considered in assessing its effectiveness as a buffer. In general a large deep lake will provide more buffering capacity than a small shallow one.

Terrestrial buffering capacity in particular is subject to influence by management. Any activities which increase the velocity of water runoff and hence the velocity of mobilised particles reduces the effectiveness of the buffer zone. Examples of this would include cleaning of drains or removal of or damage to vegetation. It is important to appreciate that management can also improve natural buffering capacity. For example in certain cases this could be achieved by excluding stock and by planting trees along river banks.

While the characteristics of the local environment may serve to protect the watercourse from damage, the effectiveness of these natural buffers should not be overestimated. Assessors should err on the side of caution and appreciate the vulnerability of buffer zones and the factors that impact on their effectiveness.

If as an example we consider a riparian buffer zone from which livestock are excluded and which has been planted with native trees. Upslope from this

zone is a severely damaged wet heath which is a source of mobilised peat. The assessor must decide if the buffering capacity of the riparian zone is adequate to protect the main river channel. The presence of the buffer zone is undoubtedly beneficial, in that the trees help stabilise the river bank; no livestock deposit waste into the river and the absence of grazing prevents damage to vegetation. However if the site is steeply sloping, the route for most of the mobilised peat may be via progressively larger drainage channels and streams. During periods of peak flows the water velocity in these channels is high enough to ensure that peat silt is not intercepted and is carried onward to the river. Thus the riparian zone is bypassed by the minor watercourses and channels through which the mobilised peat is transported. Consequently an assessment of the threat must conclude that the presence of the protected riparian zone does not reduce the threat emanating from the damaged wet heath area.

vi. Trends in the nature or scale of the impact.

Is the impact arising from an identified threat increasing or decreasing? An assessment of the trend is necessary to plan whether intervention to address the threat is warranted. If it is decreasing under current management practices, then perhaps no remedial action is required. An example of this would be peat erosion from areas damaged by historic overgrazing and which are now recovering. If the threat to *M margaritifera* is increasing or is being maintained at a high level then it is likely that some sort of intervention will be required.

vii. Multi- factorial threats.

In many locations it is the interaction between a number of different factors which creates the threat to the habitat of the *M margaritifera*. An example of this can be seen on the Dawros River in Co. Galway. In its lower stretches the Dawros cuts a meandering course through a blanket bog dominated valley floor. Even a casual observation will note that the river bank has been undercut in many places and that this undercutting has contributed to river bank collapses. Visual evidence of this process is commonplace. The cause of this phenomenon has in some quarters been attributed to angling. However this may be an over simplification of a complex situation, the actual causes of the ongoing erosion may include the interaction between a range of different factors. These factors include;

- The natural tendency of meandering rivers to change their course over time. This happens as bank side material is eroded (particularly on the outside of bends) and deposited elsewhere.
- While this stretch of the river has certain lowland features, the system is short and most of the catchment is upland. It is thus a typical spate river in terms of the frequency of flood events
- As the river is an important Salmon fishery, the passage of anglers on the river bank may physically contribute to collapses.
- Management to facilitate angling has removed or weakened trees from the riverbank over much of its length. This has reduced the cohesion of the river bank that had been provided by the tree roots.
- The removal of trees has allowed grass to become the dominant vegetation cover on the river bank; this is more palatable to cattle than the vegetation on the adjacent blanket bog. Consequently cattle in these management units spend a lot of their time on or near the river banks where their weight may be contributing to river bank collapses. In addition cattle entering the river to drink are physically breaking down river banks and changing the morphology of the river channel.
- The spread of Montbretia along the river bank, in particular on its very edge may be excluding other species which might have given the river bank greater cohesion. The root mat of Montbretia while dense does not penetrate very deeply and so does not inhibit the undercutting of the river bank. Examples of clumps of Montbretia overhanging the bank are commonplace along this stretch.

In this example, while the site may be naturally prone to river bank collapses this process is being accelerated by the combination of management for angling, agriculture and the spread of an invasive plant.

viii. Interaction with other pressure or threats emanating from outside the affected area.

In an area that has been identified as posing a particular risk to *M margaritifera* habitats, the possibility that pressure remote from that location is a contributory factor should be considered. An example of this could be changes to drainage patterns upslope from the affected area. This could have several possible impacts;

The diversion of streams or the creation of interception channels that serve to divert overland flow could lead a large increase in water flow within pre-existing receiving channels. These channels are inadequate to cope with the increased flow and this results in an element of constriction of the flow occurring. This can lead to channel erosion, the undercutting of banks and consequent collapses. These collapses create a source of mobilised material and a risk of damage to downstream *M margaritifera* habitats. What is significant here is that the cause (increased peak flow rates) of the observed threat (the collapsing banks of drains) originates at a different location from where the problem is observed, see plate 19. Consequently local action at the site of the collapses may be an inadequate response.

Plate 19: Collapse of the side of a drainage channel.

On a larger scale, overgrazing can result in a reduction in the water holding capacity of the bogs and heaths in the upper catchment; this could result in faster runoff particularly during intense rainfall events. A consequence of this is an increased frequency of flood events and the erosion of river banks further down the system.

ix. Temporal Factors.

It is important to note that there can be considerable variation in the relative importance of an identifiable threat with time. The impacts of pressures within the catchment may be;

- Continuous, e.g. ongoing such as the pressure from agriculture.
- Once off, e.g. Bridge Construction.
- Periodic, this can occur over a short time scale such as the linkage of erosion with high rainfall events. However it can also occur or over a longer period such as that observed in a commercial forestry cycle. Many of the threats from forestry tend to be associated with major operations, e.g. planting, fertilisation, track construction, thinning and clear felling. These may be separated by long relatively stable periods.
- Historic. Erosion of peat from areas damaged by overgrazing in the past but now improving.
- Potential future impacts, e.g. post fire erosion of silt from a *M caerula* dominated heath. A situation like this may not be having any current impact but presents an ongoing risk for the future.

5) Identification of Specific Threats and Appropriate Remedial Measures.

The identification of strategies to reduce the impact of identified threats is a core component of Catchment Assessment Reporting. This process begins with the identification and assessment of threats. It leads on to the ranking of threats in terms of their potential impact on *M margaritifera* populations. Once this has been achieved the identification and assessment of strategies to address these issues can begin. Sites where it is deemed necessary to introduce significant measures, other than sustainable grazing levels are considered as Active Intervention Areas (AIA's). These will consist of one or more habitat units and will be numbered sequentially. A map showing these areas will be produced as one of the deliverables of an assessment project. The boundaries of each AIA may, but are not required to be the same as the management unit in which occur. However where the intervention proposed serves to divide a management unit, e.g. new fencing then this division should be reflected in the sustainable grazing tables.

Intervention in terms of habitat management is not to be recommended for its own sake. If the situation in respect of a given threat is improving under the current regime then intervention may not be required. Assessors should consider the following when considering a potential remedial measure to an identified threat.

- Proposals to alter the management of the site must have the potential to reduce the total risk to *M margaritifera* populations or their habitats. There are many real threats where there are no practical response measures or where the impact of remedial measures may create or exacerbate another threat.
- The impact of proposed strategies on traditional agricultural practices.
- The impact of proposed strategies on other management practices such as turf cutting or recreational use.
- Interventions should be on as small a scale and for as short a duration as is compatible with achieving the desired goal.
- The impact of proposed measures on other species or habitats for which an SAC or SPA has been designated must be considered.

Assessors should consider the same DPSIR model used in the assessment of pressures when selecting suitable remedial measures. Interventions to

address a known pressure can target either the driver and or the pressure itself. Measures to reduce the driver should be addressed in the implementation phase of a *M margaritifera* conservation program. These could include measures such as payments to landowners to refrain from turf cutting or to reduce stock numbers. Active measures directed at the pressure itself intend to reduce the pressure for example by reseeding bare soil or by interrupting the pathway from the pressure to the receptor. An example of this would be the establishment of buffer zone to intercept plant nutrients lost from improved grassland. Compensatory payments may be also be required here if land is taken out of agricultural production.

There are a wide range of possible intervention strategies available; the exact choice of which approach is the most suitable is dependent on the nature of the identified threat and its setting. Assessors must always be aware of the danger of creating a new problem in an attempt to control an existing one. This could happen in a situation where the presence of invasive plant species is identified as a threat, e.g. Rhododendron (*R ponticum*) on wet heath or Japanese Knotweed (*Fallopia japonica*) on river banks. In the case of Rhododendron, the careless use of herbicides or the pulling of established plants could result in disturbance and exposure of the peat surface. At least in the short term this could result in the loss of large quantities of peat silt to the aquatic ecosystem. In the example of Japanese Knotweed on a riverbank, satisfactory control is likely to require the use of herbicides, a process which carries the risk of these chemicals entering the aquatic ecosystem. The assessment of these issues has to weigh the potential benefits against the risks arising from the actions required to achieve these benefits. In many cases the potential benefits will not justify the risks involved. In these cases the assessors will have to consider whether there are any alternative strategies that carry a lower risk exist or if accepting the status quo is the best available option.

The identification and assessment of possible remedial measures should also consider the pathway between the source of the threat and the receiving watercourse. It may in some cases be possible to interrupt this pathway by improving the buffering capacity of the intervening lands.

As the situation will vary from site to site it is not possible for this document to be prescriptive as to what action is required. Assessors will have to use their own judgement in consultation with NPWS and other experts to identify an appropriate strategy. They should also appreciate that large areas of *M margaritifera* catchments have also been designated as SAC's or SPA's for a range of other species. Appropriate Assessment of possible courses of action

in respect of other designated species/ habitats will be required for all planned actions in AIA's with SAC or SPA designation. This should include the following;

Phases in the Appropriate Assessment Process.

Step One – *Information required*, where the conservation objectives of the site are reviewed and the aspects of the proposed plan or project which affect these conservation objectives are identified.

Step Two – *Impact Prediction*, where the likely impacts of a project or plan are examined. These include direct/indirect, short/long term, construction/ operational/ decommissioning, isolated, interactive and cumulative effects.

Step Three – *Conservation Objectives*, where the effects of a project or plan are assessed as to whether they have any adverse effects on the integrity of the site as defined by its conservation objectives.

Step Four – *Mitigation Measures*, where the level of mitigation (top of mitigation hierarchy) is assessed against the adverse effects that the project or plan is likely to cause.

Step Five- *Alternative solutions.*

From Appropriate Assessment for *M margaritifera* Sub-Basin Management Plans and Corresponding Action Programmes 2010.

Examples of Mitigation measures for certain species (taken from Appropriate Assessment for *M margaritifera* Sub-Basin Management Plans and Corresponding Action Programmes 2010.

Table 3.

Implementation of mitigation for Otter							
No.	**Mitigation Measure to be introduced**	**How will mitigation measure avoid impact**	**How measure will reduce adverse effect on integrity of site**	**How will measure be implemented and by who**	**Likely degree of success**	**When will measure be implemented**	**How will mitigation be measured**
1	Use ONLY of standard Agricultural stock-proof fencing along river banks in SACs with presence of Otter.	Will avoid preclusion of otter from river at key stretches where agricultural fencing is necessary	Will allow free passage to water for otter at key sites e.g. otter slides, feeding areas etc	Landowner (who is responsible for appropriate fencing) with NWPS ranger supervision	High	During construction	Otter survey post construction

Table 4.

Implementation of mitigation for Kingfisher.							
No.	**Mitigation Measure to be introduced**	**How will mitigation measure avoid impact**	**How measure will reduce adverse effect on integrity of site**	**How will measure be implemented and by who**	**Likely degree of success**	**When will measure be implemented**	**How will mitigation be measured**
1	Kingfisher survey required prior to plantation & introduction of bank side woodland or riparian zone at bare banks	Will avoid covering all Bank side with vegetation at locations used by kingfisher and key sections of banks will remain in current bare condition	Will identify small but key areas along bank precluded from measure	Landowner in consultation with trained ecologist / NPWS ranger	High	Prior to implementation of measures	Kingfisher survey post construction

Table 5.

Implementation of mitigation for Red-Throated Divers and Golden Plover.							
No.	**Mitigation Measure to be introduced**	**How will mitigation measure avoid impact**	**How measure will reduce adverse effect on integrity of site**	**How will measure be implemented and by who**	**Likely degree of success**	**When will measure be implemented**	**How will mitigation be measured**
1	Survey of Breeding birds (Sensitive spp. such as Red Throated Diver, Golden Plover) required in area proposed for fencing off of lengths of river bank.	Will avoid impeding access of sensitive spp. along key lengths of river used by sensitive species implemented	Will identify key areas along bank where different type of fencing can be used	Landowner in consultation with trained ecologist / NPWS ranger	High	Prior to implementation of measures	Survey of Breeding birds (Sensitive spp. such as Red-Throated Diver, Golden Plover) after measure
2	Ensure fencing type does not impede sensitive spp. access to river and bank side.	Will avoid impeding access of sensitive spp. along key lengths of river used by sensitive species	Will allow sensitive spp. to access river and river banks	Landowner in consultation with trained ecologist / NPWS ranger	High	During construction	Survey of Breeding birds (Sensitive spp. such as Red-Throated Diver, Golden Plover) after measure

Table 6.

Implementation of mitigation for Merlin							
No.	**Mitigation Measure to be introduced**	**How measure will reduce adverse effect on integrity of site**	**How will mitigation measure avoid impact**	**How will measure be implemented and by who**	**Likely degree of success**	**When will measure be implemented**	**How will mitigation be measured**
1	Survey for nesters (e.g. Merlin) required prior to tree felling to identify trees not to be felled	Will avoid key habitats (specific tress) used by nesters (e.g. Merlin) being felled	Will maintain habitat of protected nesting birds such as Merlin	Survey completed by ecologist in conjunction with NPWS	High	Prior to implementation of measures	Survey of sensitive spp.

The Appropriate Assessment for each AIA (within designated areas) should be included as an appendix to the Catchment Assessment Report. A photographic record of each AIA (whether designated or not) should also be provided in an appendix to the Catchment Assessment Report. This will be of value in assessing the progress of interventions as part of any implementation programme.

Pressures emanating from point sources can often be accurately located and an appropriate response planned, the situation with threats from field sources is more complex. Many of the potential diffuse pressures on a catchment have erosion of soil or peat as a key component. To appreciate the origin of these and possible responses requires an appreciation of the erosion process itself.

The erosion and transport of mobilised particles along with their eventual deposition are processes that require energy inputs. In most cases this energy is provided by precipitation and wind. The amount of energy required is dependent on the characteristics of the material being eroded/ transported or deposited, the topography of the site and the level of shielding provided by vegetation cover.

The energy for the initial detachment of particles may come from the direct impact of raindrops or from the flow of water. Once detached the particles may be entrained and then transported by the flow of water Mulqueen et al (2006). The energy available in flowing water is linked to the volume or mass of the water involved, its velocity and the duration of the flow. The velocity of the water is linked to the topography of the site with higher velocities expected on the steeper slopes and moderating on the gentler slopes near a valley floor. However as the volume of water is also a factor and one that can be expected to increase with the size of a streams catchment, the energy available at lower slopes on the valley floor can still be very high in the aftermath of heavy rainfall.

If the energy flow is adequate the flow of water may also serve to transport the mobilised particles. This will continue until the energy available is no longer adequate to keep the particles in suspension, at which point net deposition will commence.

The characteristics of the material being eroded/ transported must also be considered. Initially the erodibility of the material and any protection offered to it by vegetation must be considered. Once mobilised the density of the material will determine at which point the energy balance in a flow of water will no longer be adequate to prevent its deposition.

The erodibility of a substrate is linked to its cohesiveness, for example loose material already detached by earlier events will not have the same cohesiveness as soil in situ Mulqueen et al (2006). In an undamaged blanket bog or heath context, the fibrous peat near the surface, knitted together by a dense mesh of roots is relatively cohesive and resistant to erosion. In addition the peat surface in an undamaged bog is normally shielded from direct impacts by raindrops by a canopy of vegetation. Not only is the potential for particles to be detached relatively low but the ability of the bog to absorb water limits the extent of overland flow and reduces the potential for entrainment and transport of any detached particles. This contrasts with a damaged site where vegetation may not offer an effective shield against raindrop impact. Overgrazing may have resulted in compaction of the peat surface which increases the volume of overland flow, contributes to the formation of rills and gullies and thus provides a pathway for the transport of entrained peat particles.

However even on sites where the vegetation has been severely damaged, the characteristics of the peat itself may affect the rate that particles are detached, entrained and transported. Mulqueen et al (2006) demonstrated that the shearing and remoulding of the peat by animal treading (poaching) and weathering-induced cracking of exposed peat surfaces along sheep tracks and land slips predispose the peat to erosion.

Table 7:

Erosion Types
Splash Erosion: When raindrops strike bare soil directly, the impact on the soil can cause the soil aggregates to break apart. The detached soil particles may then be transported due to the action of the water and/or wind. The role of driving rain in the mobilisation of peat particles was demonstrated by Walsh M (2011). Sheet Erosion: Sheet erosion can be, but is not always, the means by which soil aggregates are detached from the surface of the soil. It is usually the means by which soil particles, detached by rainfall impact, are transported by the action of shallow sheets of water flowing over the soil surface. Rill Erosion: Shallow surface flow of sheet erosion seldom flows in a uniform manner for more than a few metres before becoming concentrated by soil surface irregularities (low spots). The change from shallow sheet flow to condensed flow is accompanied by an increase in velocity and turbulence, which in turn can both break up the soil aggregates and transport the soil particles. Rill erosion occurs when the condensed flow begins to cut well-defined tiny channels (rills), at most a few cm deep, into the soil surface. Gully Erosion: As the condensed flow cuts rills into the soil surface, the flow within the rills transforms into concentrated flow where velocity and turbulence, increase causing greater erosion. Rills become deeper, wider, and/or combine to become well-defined larger channels (gullies) within the soil surface. Large amounts of soil falling away from a gully's headwall can be transported by the concentrated flow, resulting in substantial soil loss. Due to undercutting and the force of gravity, gullies can form in both uphill and downhill directions. A large storm event can transform a rill into a gully in a very short. Once a gully is formed, it can be very difficult and costly to halt or repair. Channel Erosion: Channel erosion can occur on a large or small scale and in both natural and man-made channels. Channel erosion occurs when the equilibrium between the flow of water and the friction of the soil surface in a channel is disrupted causing the soil aggregates to detach and transported away. Channel erosion can result from an increase in the volume, velocity, and/or duration of flow, the constriction of flow, the removal of stream bank vegetation, and/or the creation of an unprotected man-made channel. *Erosion types from "Guidance for temporary soil stabilisation, State of California, Dept. of Transportation, 2003".*

Efforts to address the erosion and transport of soil or peat can be directed at some or all of the following;

1) Preventing the erodibility of the peat/ soil surface from being increased by poaching. Possible methods to achieve this could include;
    a. Fencing to exclude livestock.
    b. No supplementary feeding.
    c. Cessation of turbary operations.
    d. Restriction of access for vehicles or for recreational use.

2) Protecting the peat/ soil surface from direct impact of raindrops. This could include;
    a. Re-establishing/ improving vegetation cover.
    b. Use of geo textilies or mulch (short term value only and on small sites).

3) Increasing the cohesiveness of the peat/ soil surface.
    a. Re-establishing vegetation cover, if necessary this may involve the use of nurse grasses applied with or without a wood pulp or other stabiliser.
    b. Use of geo textilies or mulch (short term value only and on small sites).

4) Reducing the volume of overland flow.
    a. Diverting water flow away from particular vulnerable areas.

5) Reducing the velocity of overland or channel flow.
    a. Dividing the slope into a series of temporary benches with sandbags or fibre rolls. The steeper the slope the closer such barriers should be. Realistically this is only practical on relatively small sites < 1 Ha and even then only as a temporary measure to facilitate the establishment of vegetation.
        i. Slope inclination is 1:4 or flatter, break up the slope length with sediment control at intervals no greater than 6.0 meters.
        ii. If the slope length is between 1:4 and 1:2, break up the slope length with sediment control at intervals no greater than 4.5 meters.
        iii. If the slope inclination is 1:2 or greater, break up the slope length with sediment control at intervals no greater than 3.0 meters.

b. Installing check dams. Check dams are small dams constructed of rock, sand bags, or fibre rolls placed in small natural or man-made open channels or drainage ditches. Check dams reduce scour and channel erosion by reducing flow velocities in turn increasing the settlement of sediment.

c. Sediment traps (for mineral fines only). Sediment traps are temporary basins with a controlled release structure formed by excavating and/or constructing an earthen embankment across a waterway or low drainage area. They provide additional protection to a water body from sediment-laden storm water by reducing the sediment load before it enters a drainage system or water course.

   Sediment traps may be used where the contributing drainage area is less than 2 hectares. They should be placed where sediment-laden storm water enters a drain and/or a water course.

6) Interrupting the pathway for the transport of entrained material.

   a. Drain blocking with spill over into vegetated areas.

Some of these strategies are of short term benefit only, e.g. mulching or the use of fibre rolls to slow the velocity of overland flow, nevertheless they may have local applications, in particular as mechanisms to facilitate the re-establishment of vegetation. In most cases to work effectively the erosion control mechanisms described above will require that site disturbance be minimised. This may require the control of access/ exclusion of livestock, vehicle and or people.

The identification and assessment of possible remedial measures should not be restricted to the damaged area. It should also consider the pathway between the source of the threat and the receiving watercourse. In some cases, it may be possible to interrupt this pathway by improving the buffering capacity of the intervening lands.

A selection of possible remedial measures for a range of different threats is given below. As the situation will vary from site to site it is not possible for this document to be prescriptive as to what action is required. Assessors will have to use their own judgement in consultation with NPWS and other experts to identify an appropriate strategy for each site.

Possible strategies to alleviate pressures from the following threats.

A. Overgrazing damage.
B. Undergrazing.
C. Supplementary Feeding.
D. Animal Housing.
E. Loss of plant nutrients from intensively farmed lands.
F. Re-contouring or improvement of rough grazing pastures.
G. Importation of fill or other materials.
H. Re-seeding of pastures.
I. Access of livestock to watercourses.
J. Sheep dipping, use of pour on or injectible alternatives.
K. Removal of scrub/ woodland.
L. Drainage works.
M. Invasive plant species.
N. Landslides and peat flows.
O. Un-metalled roads.
P. Metalled roads.
Q. Quarries/ sand pits.
R. Dumping.
S. Turf cutting.
T. Recreational pressure.

A. Overgrazing

Overgrazing of pastures leads to a change in the species and structural composition of vegetation, to compaction of soil and in severe cases to the removal of vegetative cover with consequent risks of soil erosion. These effects can also impact on the drainage characteristics of the affected area with consequent impacts on downstream channel morphology. The water retention capacity of the soil can be reduced, soil particles become vulnerable to mobilisation during high rainfall and the response time to rainfall events can be reduced. This can result in an increased frequency and scale of flood events. These events not only transport soil particles from damaged areas but can create additional sources of fine particles by collapsing river banks in receiving channels.

In large management units, the distribution of damaged areas is rarely uniform Walsh M (2011). The degree of damage at a given site is a function of the scale of the grazing pressure, i.e. the stocking rate and species involved, the vulnerability due to slope, depth of peat etc of the habitat and the degree to

which the location is preferentially grazed by livestock. Temporal factors include seasonal patterns of grazing and on a multi annual level, the duration and trend of the period of excessive grazing. There is a complex inter relationship of these factors as grazing patterns are influenced by vegetation types and vice versa. In turn both grazing pressures and vegetation types are influenced by past and current management, geology, topography and climate.

Even within the same management unit stocking levels vary with the intensity of individual farmers' utilisation of the land, this may also be subject to short and long term cycles. Short term variations may reflect seasonal management patterns whereas longer term cycles could be in response to changes in livestock prices, direct payments to agriculture and the circumstances of individual farmers.

Some habitat types appear to be more vulnerable to damage by grazing, e.g. blanket bog, others for example upland grasslands appear to be grazed preferentially by livestock and yet can support more intense grazing without negative effects.

Attempts to manage grazing in a manner that reflects this inherent variability are fraught with difficulty. Simply reducing stock levels from the historically high levels of the early 1990's, as was done in the implementation of the Commonage Framework Plans produced some benefits but does not provide an optimal solution in a *M margaritifera* conservation context. The averaging of required destocking percentages across different habitat types risks a stocking rate that is still excessive on some habitat types and yet is inadequate to utilise or even maintain certain other parts of the management unit.

The objectives of the commonage framework planning process, i.e. to improve the average condition of the vegetation cover differ considerably from the objectives in a *M margaritifera* conservation program. In catchment management for *M margaritifera* there is an additional focus on addressing the more severely damaged areas and local blackspots. This finer focus means that the implementation of sustainable stocking rates while important may not represent an adequate response. Additional measures to protect key sites or to influence grazing patterns may be necessary.

The variations in grazing pressure that exist over the available range have been the subject of a number of studies. In a study at the Teagasc Hill farm in Leenane, Co. Galway sheep grazing patterns were not uniform over the available range and individual animals only occupied 9-20% of the available area Williams B. et al 2009. The spatial preference exhibited by individual

animals may be influenced by availability of grazing but may also be learned from the dam. The authors of that paper noted that when sheep distribution is compared with an assessment of habitat condition, a preference for areas classed as MU (Moderately undamaged, equivalent to condition scale 3 as described in this manual) followed by VS (Very Severely damaged, equivalent to condition scale 8-10) areas is apparent. The utilisation of very severely damaged areas was particularly strong in the growing season. This could be explained by selective grazing for preferred species during the growing season. The authors of that paper refer to a study by Grant et al (1987) who reported high proportions of *Narthecium ossifragum* and *Eriophorum spp* in the diets of Scottish Blackface sheep grazing blanket bog. These species were dominant on areas of exposed peat (i.e. severely damaged areas) in that study. A significant consequence of this is that the passage of grazing sheep through damaged sites can cause puncture damage to bare peat surfaces by sheep hooves can increase the erodibility of the peat Mulqueen et al (2006).

Williams et al (2009) found that there is not necessarily a direct correlation between sheep occupation and habitat condition. This is partly attributable to other factors of erosion that are not grazing related, e.g. driving rain and partly because of the variations in the stock carrying capacities of different plant communities. The authors of the study in Leenane hypothesised that the apparent preference for habitats in the MU category could be explained by a preference for areas of acid grassland, which in many cases is maintained by grazing. They also noted that the preference for very severely damaged areas conforms to the widespread notion that “sheep prefer the bare bite”.

While certain habitats e.g. acid grasslands are grazed preferentially by sheep, damage (caused by livestock) and consequent erosion of peat and soil may be more significant on other more vulnerable habitats. These could be adversely affected by proximity to grazing lawns (acid grassland); to choke points created by fencing or topographical features or along traditional droving routes from enclosed lands and collection points.

The identification of sustainable stocking rates based on habitat type and condition is useful but faces challenges arising from this internal variation. In addition, the presentation of sustainable grazing pressure on a livestock unit basis is not ideal as the different species of domestic herbivores have different requirements from fodder and a different impact on the habitat. These cannot always be accounted for by using a conversion factor.

In small management units, particularly where these are privately owned it may be possible to implement a farming system that addresses these issues appropriately. However on large upland management units, particularly where these are owned in common merely setting a stock number for sustainable grazing is unlikely to be the optimal approach. While attempts to micro manage areas like these are doomed to failure, consideration has to be given to the requirement to address severely damaged areas within larger blocks. Possible strategies for doing this include;

- Fencing to exclude livestock or to control access.
- Grazing at sustainable levels.
- Alteration to grazing patterns.
- Closed season for grazing.

The implementation phase of any *M margaritifera* conservation project will have to engage with farmers both as individuals and in the context of commonages as groups. Such interactions will have to devise mechanisms for addressing the identified threats in a manner that is effective but realistic and that does not cause unnecessary damage to the viability of upland agriculture.

Fencing to exclude livestock or to control access.

Fencing to exclude stock from damaged sites or from areas that may offer buffering potential is a potential response for dealing with areas damaged by livestock. This fencing can serve to totally exclude livestock or to facilitate controlled access of stock either in terms of number, type of livestock or on a seasonal basis. The fencing can be planned to remain in place for a relatively short period to facilitate recovery or can be planned as a semi permanent arrangement. Before taking a decision to exclude stock from a given site the assessors have to be satisfied that the proposed action will not merely divert the problem elsewhere. Both the assessors and those subsequently tasked with the implementation of the planned actions, must appreciate that new fencing requires careful monitoring. This is needed to ensure that new fence lines do not give rise to unforeseen impacts arising from changes to stock behaviour.

The fencing off of certain areas whether to control access or to exclude stock completely will impact on the vegetation type and on the eligibility of the lands to draw down direct payments. Studies of vegetation succession within permanent exclosures, such as that by Walsh M (2008) at the Teagasc Hill Sheep Farm in Leenane have shown that dwarf shrub cover increased significantly in lowland blanket bog following the exclusion of stock, while low-

growing plants such as *Carex spp, Pinguicula spp* and *Juncus spp*. declined. Similar patterns were observed in exclosures on other habitat types.

This succession towards dwarf shrub dominate communities may well have an impact on the eligibility of lands as forage area. The reduction of stocking levels in fenced off lands may result in a vegetation succession towards scrub, dense heather, bracken or rushes that may be ruled ineligible as forage area. If this occurs there may eventually be a consequent impact on direct payments received by farmers from the Dept. of Agriculture, Food and the Marine. In addition where livestock are to be excluded from a site then this area cannot be considered as part of the utilisable agricultural area of a farm and thus will not count as forage area. Such a development would have an immediate impact on the forage area available to the farmer. If this course of action is decided on the implications for individual farmers will have to be considered as part of a farm plan.

As part of any proposal to exclude stock or control their access, an identification of the desired outcome of the intervention should be made. Such identification will impact on the duration of the intervention and on the monitoring required to ensure that adequate progress is occurring.

Issues to consider;

- Is a progression towards scrub or dense swards of *M caerula* desired?
- If not, how will succession be managed?
- Will the fencing be removed or the close season reduced once certain thresholds are reached?

In some cases the exclusion of stock may be required as a long term intervention. An example of this could be in the riparian zone of a stream where there is a risk of undercutting the slope and triggering a landslide. In a situation like this, consideration could also be give to the potential benefits of the planting of native woodland as a means of further stabilising the site. This could accelerate the succession towards the desired climax community.

However at most sites it is likely that exclosures may be used in conjunction with sustainable stocking as a temporary measure to speed up vegetation recovery. Proposals for how recovery in these areas can be assessed and for the removal of redundant fencing once favourable status has been attained should also be made.

Grazing at sustainable levels.

Sustainable grazing is essential for the management of pastures in a manner that minimises impacts on *M margaritifera* habitats. To achieve this, consideration must be given to the carrying capacity of the lands available. Carrying capacity is a function of the present condition of the lands, the area involved and the habitats present.

The calculations as to what constitutes the current sustainable grazing level are included in the Catchment Assessment Report for each management unit. Instructions on how to complete these calculations are given in Section 6 "Writing a Catchment Assessment Report". These calculations give an average stocking rate for each management unit, the reality on the ground may be that individual management units are subject to large seasonal variations in actual stocking rates. In some cases particularly on enclosed lands on hill sheep farms the swings in grazing pressure can be dramatic. An example of this would be on a sheep farm where on the enclosed land stocking rates are high when ewes are brought down for lambing in spring, stocking rates fall in early summer as most of the ewes with single lambs are released back to the hill. They drop further in late summer as ewes with twin lambs are released to the hill and sales of lambs commence. The stocking rate increases to a high level again in November when ewes are brought down for tupping and then falls to near zero as the pasture is rested to get it ready for lambing in April. This pattern is a normal feature of hill farming and has to be respected. In this case rather than focus excessively on the average stocking rate, the assessors should give attention to the peak numbers, the level of supplementary feeding and fertiliser use and the possibilities for buffering any negative impacts.

The objective of introducing sustainable grazing is in all cases where the condition code is 4 or higher to reduce this value by at least two steps on the condition code scale within 5 years. Where the condition code is 1, 2 or 3 the objective is to maintain the site in its current condition[1].

It is important to note that the sustainable grazing level is subject to change over time as the condition of the habitats improves or dis-improves. For this reason the prescribed stocking level must remain subject to review on a cycle of no longer than 5-7 years.

[1]In some cases where the condition code is 1 due to rank *M caerula* and there is concern about post fire erosion, then the objective may be to increase the condition code to 2.

Alteration to grazing patterns.

Individual sheep or sub flocks on upland pastures often display a loyalty to certain parts of the available range. In some situations it may be possible to reduce grazing in certain vulnerable areas without creating the potential for under grazing on the management unit as a whole. Obviously one method of achieving this is by fencing so that access by stock can be controlled. However there are situations where fencing is either prohibitively expensive or is otherwise considered undesirable. In these cases other strategies may be contemplated, these could include the reducing the numbers of animals that graze damaged areas either by selective culling of sub flocks or by ensuring that ewe lambs from these areas are not kept as replacements. Other approaches such as the use of virtual fencing technology, changing the locations of supplementary feeding sites or providing mineral blocks to draw animals away from damaged areas may be viable options and could be considered. Regular shepherding may also be useful in this regard.

These approaches are not going to be feasible everywhere and will require ongoing monitoring to ensure that it is achieving the desired results

Closed season for grazing.

This may be for stock as a whole or for individual species such as cattle and horses. Due to seasonal changes in the availability of fodder species, the grazing habits of sheep and cattle are not constant. Closing of the pasture at certain times of the year will reduce the grazing pressure on those species that would be otherwise be favoured by livestock. In an upland environment the closing of grazing in the winter is likely to favour heather which is selectively grazed during that period. Walsh M (2008) found that dwarf shrubs mainly heather and bog myrtle benefitted from summer only grazing regimes.

The development of a dwarf shrub layer may serve to shield the peat surface from driving rain and thus prevent the erosion of peat silt. If this was considered as a local objective then greatly reducing grazing pressure from November to April is a strategy worth considering. A closed season for stock is one mechanism for achieving this, however attracting stock away by the use of feed blocks, excluding stock completely or very low sustainable grazing levels are other possible options. The final choice of strategy has to be guided ty the practicality of the measures proposed at farm level.

B. Undergrazing,

The issue of under grazing in upland habitats has received considerable attention in recent years. Like overgrazing, prolonged under grazing can lead to excessive dominance by a small number of plant species, e.g. Purple Moor Grass (*M caerula*) in Wet Heath areas, Ling (*Calluna vulgaris)* on dry heaths, Bracken (*Pteridium aquilinum*) on acid grasslands and Rush species (*Juncus spp*) on wet grasslands. The increasing dominance of these species can discourage grazing livestock and displace grazing pressure onto nearby and perhaps more sensitive sites. *C vulgaris* and *M caerula* dominance can also contribute to increased fire risk, particularly in the spring months. Some farmers will be tempted to burn such areas in order to encourage a flush of grass or to ensure continued eligibility as forage area for direct payments, see plate 20. Fire poses a risk to other habitats, to commercial interests, to other conservation objectives and can lead to post fire erosion of peat with negative consequences for *M margaritifera*.

Plate 20: Uncontrolled burning of heath.

Possible strategies for control of these species are suggested below. However before recommending any course of action the assessors must be certain that what they are proposing is necessary and likely to be effective in protecting *M margaritifera* habitats.

Possible strategies to address excessive dominance of *M caerula* include;

- Controlled burning.
- Mechanical cutting.
- The use of herbicides.
- Increased stocking levels.
- Promotion of mixed grazing.
- Seasonal management of grazing.

Controlled burning.

This is unlikely to be viable option due to the risks of post fire erosion. The impact on heather species, bryophyte communities and insects is unlikely to be compatible with an SAC designation. The burning of *M caerula* litter is unlikely to offer effective long term control as *M caerula* will recover rapidly while other competing plants, e.g. *Calluna vulgaris* will be destroyed. While burnt areas may show signs of colonisation by seedlings of other species in the period immediately following a burn they are likely to be outcompeted by the recovering *M caerula*, (Marrs et al, 2004). As a result repeated burning could be counterproductive and lead to even greater dominance by *M caerula*.

Mechanical cutting.

The use of machinery to cut *M caerula* is impractical due to the likely difficulty of access, the risk of soil compaction and the potential damage to drains and minor watercourses caused by heavy vehicles. Cutting with hand held equipment such as a strimmer is likely to be viable on such a small scale as to be inconsequential. One possible exception may be the cutting of vegetation overhanging or shading pools created by the blocking of drains if this were required to increase light penetration and vegetation establishment.

Use of herbicides.

The use of herbicides to control *M caerula* is not compatible with an SAC designation. Even on non designated sites the risk of herbicides making their way into watercourses and the risk of erosion from sites where the vegetation has been killed off is not acceptable.

Increased stocking levels.

This can be considered as an option, but care has to be taken to ensure that the increase in grazing pressure is applied where required. On large management units there is no certainty that increased sheep numbers will result in an increased utilisation of under grazed areas. For example if we consider an area of rank *M caerula* on part of an upland pasture. There is no guarantee that increased grazing pressure will be directed towards the *M caerula* dominated wet heath. It may instead result in increased grazing of more palatable species on other parts of the site with little impact on the *M caerula.* Assessors will also have to consider the practicalities of increasing sheep numbers on large management units. Issues of particular concern include the availability of green land for lambing and the feasibility of safely over wintering the increased numbers.

Promotion of mixed grazing.

The introduction of cattle or horses may be appropriate in some situations. These animals will eat vegetation that is not preferentially grazed by sheep such as *M caerula*. An issue that has to be considered in assessment of the suitability of a site for mixed grazing is the possible impact on drains and watercourses by the transit of heavy livestock. This may be serious and could result in damage to watercourses that would outweigh any benefit accruing from reducing *M caerula* dominance. It should be noted that *M caerula* is a relatively poor fodder species and is unsuitable for young animals or lactating cows or mares. It is particularly unsuitable for horses as their digestive system is less efficient at extracting nutrients compared to cattle. In practice horses in particular are likely to seek better quality grazing and avoid grazing exclusively on *M caerula*, Anderson et al (2006). With both cattle and horses long term grazing on *M caerula* is likely to lead to a loss in condition unless supplemented by concentrates and or mineral licks. These management practices would lead to an importation of nutrients, the consequences of which in terms of vegetation change and or loss to watercourses would have to be considered.

If a decision is made to tackle *M caerula* dominance in this way then dry cows of one of the traditional upland breeds should be used, e.g. Aberdeen Angus, Galloway, Highland or Kerry. Continental breeds have been shown to be just as effective at controlling *M caerula* but their greater size could lead to increased poaching and damage to watercourses. Another factor to consider is that continental breeds may present greater welfare issues in an upland environment. A relatively high stocking rate is required for effective control. Experiments in Great Britain demonstrated effective control of dominant *M*

caerula utilised bovine stocking rates of 0.75 LU/ Ha during the summer months Anderson et al (2006).

This level of stocking is not safe on blanket bogs and may also be unacceptable on some wet heaths, particularly in wet summers. However lower stocking rates may be ineffective, a stocking rate of 0.5 Livestock units / Ha for 2 months has been shown to be ineffective (ADAS workshop report on *M caerula* management (2000)) at controlling *M caerula*. For this reason attempts at control of *M caerula* on deep peat or vulnerable sites using cattle are inadvisable.

Effective *M caerula* control by cattle requires them to be confined to the target area. While experiments in Australia and the USA into the use of virtual fencing are ongoing this option is not yet commercially or agriculturally viable, in practice the use of temporary electric fencing is likely to be the only practical option. The impact of this along with an assessment of supplementary feeding and other management practices required to support these animals would have to be made before any recommendation to pursue this course of action could be considered.

The introduction of cattle or ponies to upland areas is not feasible without the co-operation of the land owners involved. Their own aspirations along with their farming infrastructure and skill set have to be considered before this strategy can be seen as viable.

Seasonal management of grazing.

M caerula is a deciduous grass, the fresh green shoots are palatable to sheep when young but are largely avoided later in the season unless alternative forage is lacking. The movement of ewes to green lands for lambing often coincides with the start of *M caerula* growth in spring. If stock are absent for an extended period the window of opportunity for sheep to control it may have passed before the animals return. One solution that may be practical in some locations (normally smaller management units) is to ensure that some grazing perhaps by older cattle, hoggets or dry ewes continues in the months of April/ May to early June. This approach has the additional benefit of improving the overall carrying capacity of the available range. Mixed grazing by cattle and sheep has been demonstrated to improve the utilisation of *M caerula* dominated swards by sheep, Wright et al (2006).

In enclosed lands this does not present a management difficulty (see plate 21) other than addressing possible mineral deficiencies. This could be addressed by providing a mineral lick. In unenclosed lands it may be possible to attract

stock into *M caerula* dominated areas in the spring by providing molasses sweetened licks such as Rumevite. These have been demonstrated to result in enhanced grazing within 30m of the lick. Such a strategy may be useful in the vicinity of forestry plantations to reduce the risk of fire spreading across *M caerula* dominated swards. Another possible use is in attracting stock away from damaged areas at particular times of the year. It carries a potential risk for localised soil eutrophication and possibly poaching in the vicinity of the mineral blocks. While these could possibly be addressed by moving the locations on a regular basis, the implications of this policy will have to be considered on a cases by case basis by the assessors.

Plate 21: Effective early summer grazing of rank *M caerula* by sheep in a small enclosed area.

Finally addressing areas of rank *M caerula* cannot be allowed to create or exacerbate the risk of erosion within the catchment. Active measures to deal with this issue are likely to be useful on smaller enclosed sites where grazing can be easily controlled. On most large management units accepting the risk of under grazing of *M caerula* may be the best option.

In relation to excessive dominance of *C vulgaris*, concerns have been expressed by the Dept. of Agriculture, Food and the Marine as to whether such areas can be considered as forage areas for the purposes of the dis-advantaged areas scheme and the single payment scheme. It is possible that

this could lead to uncontrolled burning or spraying by individual landowners in an attempt to maintain direct payments. This could occur in a manner that is damaging to *M margaritifera* populations and habitats. Assessors should be aware of the potential risk and consider what if any steps could be taken to mitigate it.

Those involved with implementing any conservation project for *M margaritifera* will have to consider how excessive dominance by *C vulgaris* can be addressed or compensated for. This is likely to also involve an assessment of other conservation interests such as Red Grouse *(Lagopus lagopus).*

Control of excessive growth of rushes and bracken should be by cutting only. Any proposed use of herbicides for this purpose will require consultation with NPWS.

C. Supplementary Feeding.

This practice creates a risk of point source pollution and should not be carried out in the vicinity of watercourses or in areas where a pathway to a watercourse exists. Many of the problems associated with supplementary feeding in upland areas often arise from the limited number of access points where feeding is feasible. In general outdoor supplementary feeding should be minimised. Where there is no alternative, supplementary feeding sites should be;

- Sited away from watercourses (at least 20m).
- They should not be located on deep peat, bare rock on steep slopes or near grass heather interfaces. Ideally they would be located on improved grassland.
- Be moved frequently.
- Feeding with concentrates and small bales of hay may be more flexible and less damaging than using silage.

D. Housing of livestock.

The housing of livestock in the winter months may be an appropriate intervention in many cases. It allows stock numbers to be maintained at a level that can provide appropriate summer grazing pressure without being excessive in the winter. The principal risks associated with this practice arise from ensuring the correct storage and disposal of animal wastes.

Assessors must pay careful attention to the adequacy of existing animal housing and waste storage facilities. As a minimum these must conform to the Dept of Agriculture, Food and the Marine requirements in terms of the safe containment of animal wastes. Where facilities are inadequate, proposals must be made as to how this can be addressed. Such a response could include either an enhancement of existing facilities or changes to the farming system to reduce or remove the dependence on these facilities.

The presence or otherwise of suitable animal housing will affect the range of options open to farmers and assessors in terms of tackling other issues of concern on the farm, e.g. out-wintering of stock. This is an issue of vital significance to the farmer involved. Reaching an effective yet equitable solution may require some modification to the assessor's original proposals in the course of the implementation phase. The acceptance of this should not deter assessors from their role in identifying and quantifying the pressures and suggesting solutions.

E. Loss of plant nutrients from intensively farmed lands.

A nutrient management plan should be put in place for all intensively managed lands. This would include all lands that are cut for silage/ hay or where an annual crop is sown. In addition lands that receive applications of animal slurry, sewage sludge, poultry bedding or large quantities of chemical fertilisers or farmyard manure should have a nutrient management plan prepared. Enclosed lands that are heavily grazed at any time of year irrespective of the average stocking density should also receive attention. This could occur on sheep farms where ewes are brought down for tupping in November and for lambing in April. On a year round basis the stocking density may be relatively modest but at key periods stocking densities could reach very high levels. High stocking rates results in the sward being grazed down and the deposition of large quantities of dung at a time when grass growth and nutrient uptake is poor. This greatly increases the risk of runoff during intense rainfall. On cattle farms, fields that are used for supplementary feeding and outwintering should receive particular attention.

Soil sample areas should be identified based on soil types and management history. Mineral and peat soils should not be mixed in a sample. In all cases soil sample area should not exceed 1 sample to 5 Ha. No samples should be taken within a period of 3 months after the application of chemical or organic fertiliser or lime. All samples should be taken using the methodology outlined in the Nitrates Directive Regulations. Soil tests results should be considered as valid for a period of 5 years.

As a minimum soil analysis should include P, K and pH. The physical composition in terms of mineral/ organic content and the proportions of sand, silt and clay in the sample should also be established. Samples should be sent to a Dept. of Agriculture, Food and the Marine approved Laboratory. A lime requirement will be calculated by the laboratory. In general the application of lime should not be planned for, however where it is absolutely necessary the Molybdenum status of the soil should be checked before recommendations are given to a farmer. This is needed to avoid any risk of a Molybdenum induced Copper deficiency in livestock.

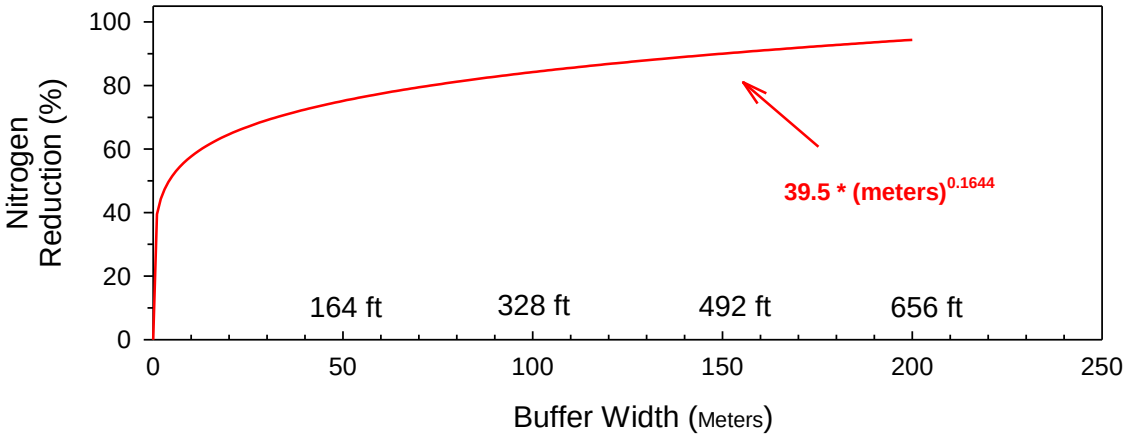
The calculation of maximum nutrient application rates should be based on crop requirements and the risk of excess nutrients being lost to the aquatic environment. The target for soil P should not in any case exceed index 2. On steep slopes or where there is no buffering capacity, a target of index 1 for P may be required. The installation of adequate buffers particularly in riparian

zones down slope from intensively farmed areas should be considered as part of a nutrient management plan. The successful development of such buffers may permit certain agricultural practices to safely continue which would otherwise be considered as potentially dangerous to *M Margaritifera* populations. Assessors should note that intensively farmed fields with open drains or watercourses other than on the field boundaries are difficult to manage safely. The provision of buffer zones that can potentially be bypassed by such drains and streams will be of limited value.

The width of buffers to provide adequate protection for watercourses from intensively managed agricultural land should be at least 15m. In general, wider buffers provide more water quality improvements and habitat value. However the relationship is not linear. Rather, the increased benefits of wider buffers tend to increase at a slower rate once the buffer width exceeds 16m (NC Interagency Review Team (IRT) 2009).

The design of buffer strips should incorporate permanent fencing to control access by stock. These fences should be at least 15m back from the top of the river bank. Where a farm road runs alongside the river it can be incorporated into the buffer zone. If this occurs then the width of the buffer zone should be increased accordingly.

Figure 1. Reduction of nitrate nitrogen as a function of riparian buffer width taken from Anon, (2009) Regulatory Guidance for the Calculation of Stream and Buffer Mitigation Credit for Buffer Widths Different From Standard Minimum Widths.



Ideally buffer zones should develop into a mosaic of woodland, scrub and rough grassland. However the precise objective will vary from site to site. A

completely wooded riparian zone may create difficulties with accessing the river channel for management functions such as the dealing with overhanging trees.

Management of buffer zones should be based on the following;

- Buffer zones must not receive any fertiliser applications (chemical or organic).
- Some summer grazing can be permitted but if grazing of cattle is planned then they should be kept at least 2m back from the top of the bank. A temporary electric fence can be used for this purpose.
- In situations where the adjoining intensively managed land is subject to seasonal variations in use, e.g. land used for lambing the buffer zone should not be grazed in the period of peak usage.
- A conservation cut of the sward in the buffer zone may be feasible in situations where grazing is impractical, however access of machinery for this purpose cannot be permitted if there is any risk of destabilising the river bank .
- Limited tree planting of native broad leaves can be considered.

Consideration should be given to the practicality of exporting wastes to lands outside the catchment. Spreading of Farmyard manure and slurries should not be permitted in situations where there is a high risk of runoff into watercourses. Lands on steep slopes or with open drains other than at field boundaries or lands adjoining permanent watercourses are not suitable for receiving animal slurry. The disposal of small quantities of farmyard manure may be feasible in some of these situations.

These issues will have to be addressed at an individual farm level but cases where assessors observe inadequate facilities or inappropriate practices should be noted.

F. Re-contouring or improvement of rough grazing pastures.

The removal of rocks, walls, hedges, earth banks as part of land improvement works is a very high risk activity. This type of activity is often associated with new drainage systems and the use of fertiliser to aid in the establishment of new pastures. The disturbance of the site exposes soil to erosion; the piling of large amount of unconsolidated material removed from the site also creates a source of mobilisable silt that is likely to remain for many years into the future.

In practice this type of activity should not be permitted. Where it has already occurred, remedial action should concentrate on re-establishing vegetative cover as rapidly as possible. While the landowner may be keen to re-vegetate the cleared area with agricultural grasses, they may not have any clear plans for the areas where material has been stockpiled. These areas will require careful attention and planning to minimise the potential for fine material to be exported. The possibility of water, either from precipitation or from pre-existing watercourses creating ducts through the stockpiles with potentially destabilising effects should be considered. This may require the input of a hydrologist, geologist or civil engineer.

In all cases the revegetating of the site Including spoil heaps) has to be considered as a priority. The installation and maintenance of silt traps, the planting of trees and other vegetation and the management of drainage patterns should all be considered and planned for where appropriate.

G. Importation of fill or other materials.

An examination of the type of material involved is required. Such an examination should consider the presence or absence of hazardous or toxic materials including materials that may alter the ph or other aspects of the water draining through the site. If there is any reason to believe that hazardous materials are involved then the matter must be reported to NPWS as soon as is practical. The advice of the EPA should be sought on how to deal with the situation.

Even where the materials involved are inert this practice creates a layer of unconsolidated material, providing a source of fine material that can be exported to *M margaritifera* habitats. In addition the importation of large quantities of material risks loading a slope and conditioning it for slope failure.

Many of the risks relating to the stockpiling of waste material from land improvement works also apply in this type of situation. Specialist advice from a suitably experienced civil engineer, geologist or hydrologist may be required

H. Re-seeding of pastures.

Reseeding of pastures is a high risk activity, see plate 22. It should not be recommended as part of a Catchment Assessment Report. The issues of concern include;

- Use of herbicides over large areas to kill off existing vegetation.
- The potential for erosion of soil in the period from the destruction of the original sward until the new sward is established.
- The loss of nutrients from fertiliser applied to aid sward establishment.

Plate 22: High risk preparation of land for re-seeding. The location is on the banks of the Owenriff River, a known *M margaritifera* watercourse.

This activity should not be permitted without the consent of the NPWS. Where there are sound reasons for a deviation from this policy, ground preparation, immediately followed by sowing should be carried out in April/ May so as to allow adequate time for sward establishment. Under no circumstances should bare soil be left over the winter. The use of herbicides to burn off vegetation prior to reseeding should not be permitted. The application of fertiliser and or lime on a seed bed should only be permitted if proven to be absolutely necessary by a recent soil test. Re-seeded pastures should be lightly grazed in

the autumn to encourage tillering. Out wintering of stock in the first winter should not be permitted as the soil surface may not be adequately cohesive.

Notwithstanding the above, there can be situations where the seeding of bare soil with grass or other plants is an essential management tool to consolidate the substrate and prevent erosion.

I. Access of livestock to watercourses.

Assessors should be aware of the risk to the riparian environment posed by free access of large herbivores such as cattle and horses, see plate 23. The passage of these animals can contribute to the collapse of river banks, it can inhibit the development of potentially beneficial vegetation in the riparian zone and it can facilitate direct access to the river channel itself. For these reasons cattle and horses should not be generally be allowed free access to watercourses on enclosed lands. On unenclosed lands or on extensive parcels the situation is more complex, if cattle and horses are traditionally grazed then it is important to establish if the existing practices are causing any damage and what steps can be taken to address such damage. Such steps may or may not include fencing of watercourses. In cases where it is proposed to introduce cattle or horses an assessment of the likely impacts on watercourses and drainage channels should be made and the plan adapted to deal with these impacts. This may require fencing of some or all watercourses, the provision of piped drinking water, the use of pasture pumps or other mechanisms for delivering water to stock, seasonal grazing etc.

Where fencing is used to prevent access, it must be set far enough back from the bank to provide adequate protection. In most cases this means at least 2m back from the top of the bank. Fences that are placed too close to the river bank (see plate 24) are ineffective and can be lost if erosion undermines their support.

All fences must be to the S148 standard.

Plate 23: Free access of cattle to watercourses leading to damage to river banks.

Plate 24: Fence undermined by riverbank collapses.

J. Sheep dipping, use of pour on or injectible alternatives.

Sheep dip contains a range of chemicals that are toxic to *M margaritifera*. Its use has been identified as the most likely cause of a number of major mussel kills (Moorkens, 1999; Skinner et al., 2003; Young, 2005; Cosgrove and Young, 1998). The continued use of sheep dip as a parasite control is a high risk practice that must cease in *M margaritifera* catchments.

This course of action creates agricultural and animal welfare issue for farmers in these areas. This creates a requirement for alternative measures to control parasites. For this reason the use of pour on treatments will have to be accepted. Spray on treatments are the preferred option for treating foot infections but foot baths can be permitted if located at a safe location. The risk from foot baths is less than that arising from sheep dipping stations as the volumes of liquid are much lower and the active ingredients less toxic. Nevertheless proposals for locating such facilities will have to be agreed with NPWS on a case by case basis. Advice to individual farmers on how to deal with these issues will have to be made available.

To ensure that sheep dipping will cease it will be necessary to decommission existing sheep dipping stations. This will have to be done in a manner that ensures that they can no longer be used. The suggested method is to fill them with concrete. A statement to this effect should be included in respect of each identified sheep dipping station. In some cases the facility can continue to be used as a pen, for the application of pour on and or injectible treatments and for foot baths.

Note: The use of products containing Copper Sulphate cannot be permitted in foot baths.

K. Removal of Scrub/ Woodland.

The clearance of scrub or woodland disturbs the soil surface and exposes it to erosion. In all cases the assessors should consider the re-establishment of vegetative cover on these sites as a matter of urgency.

The removal of scrub or woodland should not normally be considered as an appropriate strategy in a Catchment Assessment Report. There may be situations where the limited removal of trees to prevent tunnelling of a river channel, to facilitate access is justifiable or where there is a concern that if trees fell they would destabilise the riverbank. Where this is the case, trees should be felled, ring barked or killed by cambium injection of glyphosate rather than be dug up or sprayed with herbicide. Consideration should be given to the

potential for allowing re-growth from the stumps in preference to complete removal. Even where removal is warranted the advice of a forester or arboriculturalist should be sought.

L. Drainage Works.

There are two principal functions of drains that assessors are likely to encounter. The first are drains intended to remove excess water from land, the second are roadside drains designed to protect the road from scouring by surface water. Both of these are important functions but they raise potential threats for *M margaritifera* populations.

Long established drainage patterns through areas with intact vegetative cover generally do not present a significant risk to *M margaritifera* populations or habitats. However where changes are made to drainage patterns a range of potential risk factors can be present.

Among these are the risks of;

- The mobilisation of silt particles during construction, maintenance and cleaning, see plate 25.
- The risk of damage caused by increased water flow undercutting banks and contributing to bank collapses. This can occur downstream of the new drains see plate 26.
- The pathway they create for the transport of damaging materials to streams and rivers.

Plate 25: New Drains.

Plate 26: Channel erosion on land drains.

Where assessors encounter new drains they should identify them as a potential threat and plan to reduce the impact of these drains as quickly as possible. Strategies to do this could include;

- Blocking of drains.
- Fencing of drains to prevent access by livestock.
- The piping of drains underground.
- Spreading or vegetating of spoil heaps.
- Changes to Drain maintenance Regime.

Blocking of drains.

This could be recommended where the new drain is likely to change the drainage characteristics of the area in a manner that could lead to the destabilisation of existing habitats. For example, the drainage of a wet heath could reduce its water holding capacity. This could lead to increased incidents of spate flows due to rapid runoff following heavy rainfall. Blocking of drains may also be required in situations where the new drains are diverting water towards existing drains that may be destabilised by the increased volumes of water flow. Where drains are to be blocked consideration must be given to the effect such a course of action will have on water flow. Ideally the blocking of drains will lead to a restoration of the original drainage patterns. Where this is not possible the blocking of drains should be designed to allow water to overflow at numerous points along the length of the channel and into down slope vegetated areas. Notches to serve as surface water discharge points should be cut into the side of the drain. Ideally the level of the water backing up from each dam should reach the base of the next dam upstream.

Successful blockages will have an impact on the local water table with the level down slope of the drain being raised. This may have an impact on vegetation cover in the vicinity of the drain. Work by Armstrong, Holden and Stevens (2008) showed that areas down slope of blocked drains tended to be dominated by Grasses and Bog Cottons (*Eriophorum spp)* with heather (*Calluna vulgaris*) more prevalent up slope from the blocked drain. No difference was detected in *Sphagnum* cover on either side of the blocked drain. The possible implications of this on land use and eligibility as forage area should be considered.

The assessors must always be aware of the risks posed by poorly planned drain blocking. Inadequate provision for discharge of water and too few

blockages can cause excessive volumes of water to back up. This could potentially lead to plug failure due to the scouring action of overflowing water, the bypassing of the blockage, flow of water underneath the blockage or a sudden burst due to excessive hydraulic loading. To prevent this, a series of blockages which provide for the overflow of water from the drain and down the hill slope is preferable to a single blockage.

The choice of materials for blocking drains should be based on utilising locally available materials that will have minimal impact on water quality. In small drains on blanket bogs or wet heaths a plug of peat may be adequate, if necessary this can be reinforced with a simple plastic or timber dam, see plate 19. This should be three times as long as the width of the drain to be blocked. Bales of heather, rushes or straw can be used but are not as effective as peat. In addition to damming, spoil from the initial excavation may be used to partially fill in the drains. On other sites, a simple plastic dam (see plate 27), may be or locally sourced rocks may be more practical. Rocks have the advantage of allowing some water to pass through thus reducing the risk of a build-up of water pressure causing a blowout or catastrophic failure of the blockage.

Plate 27: Simple plastic dam,
Note the establishment of *Sphagnum spp* upstream of the blockage.

Worrall and Warburton in a study of the blocking of grips (drains) in the northern Pennines found that when assessing the impact on sediment loss there was a significant interaction after blocking and whether the grip (drain) sections were entirely in peat or not. They noted that there is little difference upon blocking when the sections are entirely in peat but a big improvement where the blocking is of sections not entirely in peat. They also noted a significant interaction between the success of blockages and the presence of cotton grass (*Eriophorum spp*) blocking being significantly more effective where cotton grass is present. Although the effect is smaller than the interaction observed for grip sections entirely compared to those not entirely in peat.

At what sites can the use of blockages be most successful?

The Worrall and Warburton study found that drains entirely in peat tended to heal themselves over time and that no significant benefit in terms of reducing the cross sectional area of the drain was achieved by blocking of channels. Their work suggested that drains that were dug below the peat layer and that penetrated in to mineral material showed better responses to blockages. This would suggest that drains in the shallower peats of wet heaths would be better candidates for blocking then those found in blanket bog habitats see plate 28. On this basis and considering the greater risks associated with the use of machinery on blanket bogs it is considered appropriate to refrain from blocking of drains on blanket bogs. Natural recoveries following the cessation of drainage maintenance and in some cases restricting the access of livestock to damaged areas are considered more appropriate strategies in this habitat type.

Plate 28: New drain dug on wet heath, possible candidate for blocking with a series of simple dams or peat plugs.

What factors cause blockages to fail structurally?

Worrall and Warburton found two significant variables in explaining the occurrence of failed blocks. These are the drain slope and the angle between the hill and the drain slope. In both cases the likelihood of failure increased with decreasing drain slope and with decreasing angle between hill slope and drain slope. This would appear to be contradictory, however decreasing drain slope leads to an increased likelihood of ponding. This causes a build up water leading to bypassing which Worrall and Warburton classed as a block failure. However bypassing is not necessarily a catastrophic failure if the block remains intact and sediment continues to accumulate behind it.

For a long term benefit, any proposal to block drains should have an objective of increasing vegetation within the drain. Armstrong et al (2008) identified that the establishment of peat forming species, i.e. *Sphagnum spp* and *Eriophorum spp* were particularly beneficial. The establishment of these species within a grip (drain) was more successful on gentler slopes. Techniques to encourage vegetation within a drain include;

- Ensuring that light penetration is good. In practice this means ensuring the area is shallow and not shaded by overhanging banks or vegetation in particular heather (*Calluna vulgaris*).
- Ensuring that water velocities within the drain are slow. As water velocity will increase on greater slopes site selection becomes critical. Blockages on gentle slopes are likely to be more successful.
- Ensuring that the hydraulic pressure from ponding on a single blockage is reduced by placing a series of blockages along the drain.

The successful blocking of drains and establishing vegetation within them is a long term project which will require ongoing monitoring and maintenance e.g. control of overhanging vegetation and repair of dams or blocks.

The piping of drains underground.

The piping of drains underground is unlikely to be considered as an option in an SAC designated area. However in undesignated parts of the catchment it may be considered if there is no other practical method of preventing bank side material being mobilised and washed downstream.

Spreading or vegetating of spoil heaps.

Where spoil heaps exist from previous drainage works, the assessors should plan a strategy for either removing these materials away from the water course or re vegetating the spoil heaps as rapidly as possible. The danger in this situation is twofold, first that the downward pressure from large piles of spoil adjacent to the bank could lead to a collapse of the sides of the drain. The second is that erosion of soil particles from the spoil heaps could add to the sediment loading in the water flowing through the drainage channel. If removal is considered then this should be done during dry weather in the period April – July. If carried out at this time of year the risk of disturbed material being mobilised is reduced and adequate time to re vegetate the site before winter is available.

Note: This refers to the removal of existing spoil heaps not to cleaning out the drainage channel itself.

Changes to Drain maintenance Regime.

The cleaning of existing drains should be as infrequent as possible. Where there is no alternative cleaning should be restricted to the period in April –

September and should involve one side of the drain only. In all cases proposals to clean drains should be discussed with NPWS in advance. In SAC designated sites cleaning should be restricted to the month of September. This restriction is required to ensure compliance with Fisheries regulations and to minimise the disturbance to wildlife and the potential for disturbed material to be washed away.

M. Landslides and peat flows.

Landslides and peat flows have the potential to mobilise vast quantities of fine material and for this reason pose a significant risk to *M margaritifera* populations. While large events such as occurred at Pollatomish Co. Mayo and at Derrybrien Co. Galway in 2000 are relatively rare, smaller less spectacular incidents are commonplace. The scars from these are readily observable in most upland areas. Planned management of *M margaritifera* catchments in respect of landslide or peat flow risk must consider 3 different factors. These are;

i. Reducing risk.
ii. Interception or deflection of debris flows.
iii. Site remediation post land slide event.

Reducing risk.

Any plan to deal with the risk from landslides must consider the different types of material that may be involved in a landslide. In Ireland, the substrates commonly associated with landslides are;

a. Glacial tills, sands or gravels.
b. Rock slides from unstable cliff faces.
c. Peat.

a. The risks arising from glacial tills, sands and gravels have often been linked with the undercutting of the slope by excavation. The stability risks associated with excavations into this type of material are addressed by installing a herringbone drainage system in excavated slopes. The assessment of the requirement for such an intervention is a task for a suitably experienced civil engineer. Slope failures involving this type of substrate can be triggered by a “toe” failure where a stream has undercut the slope, see plates 29 & 30. This is potentially quite serious as the pathway to the aquatic environment is very direct. Stabilising such banks by excluding stock and where practical, the planting of native trees and shrubs should be a priority.

Plate 29: Small landslides initiated where the steam has undercut the slope.

Plate 30: Small Landslide, potential for further collapses?

b. Rock slides from cliff faces are a common occurrence in many upland areas. It is possible that in some situations these could be initiated by a failure of the peat slope on the plateau and that this may have been influenced by overgrazing. However in most cases, rockfalls of this type seem to be a natural occurrence on unstable slopes. There does not appear to be any realistic mechanism for preventing such occurrences, see plate 31.

   The pathway for debris from such an event is limited by the slope of the land and will not extend as far as may be expected with a peat flow. The greatest risk from such events is that if the debris field reached a major watercourse that the flow of water would be dammed. Such a dam would inevitably be breached, circumvented or overtopped with possible consequences for channel morphology downstream. A secondary impact would be in respect of the presence of large amounts of unconsolidated material and the damage to vegetation in the debris field. Efforts to consolidate and re-vegetate such sites after a significant event could be considered by NPWS. However the details of such a response are outside the remit of a Catchment Assessment Report as they relate to possible future events, the scale and location of which are unknown.

Plate 31: Landslides on the slopes of Mweelrea in Co. Mayo

c. Most peat flows in Ireland have been linked with intense rainfall events. The failure mechanism is often a basal failure surface within the peat or at the interface of the peat with underlying mineral soil. There is a strong inverse correlation between peat depth and slope angle. This means that as the depth of peat increases the slope angle associated with failure events reduces. Most natural landslides have occurred on slopes of $>5^0$, although human interference can reduce this critical slope angle to 2^0. This may be explained by the reduced shear strength of the peat at the interface with mineral soil in deep peats. Increasing depth of peat means an increased humified layer or catotelm. The shear strength of this layer is much less than the surface layer or acrotelm. Highly humified peats can have a shear strength of less than 4 KPa. This contrasts with shear strengths of greater than 20 Kpa that may occur in the more fibrous acrotelm Creighton et al (2006).

   The mechanisms for slope failure include;

   - The ingress of water into this basal peat through cracks in the peat. This water can further reduce the shear strength of the catotelm and it accumulates can provide an uplifting force which may initiate slope failure.
   - Increased loading of the peat by placement of fill, construction of buildings or roads.
   - Undercutting of the slope by excavation, stream erosion, peat cutting or drying.

Nothing can be done about intense rainfall events and the depth of peat and slope angles are fixed. Risk management can however seek to address the other conditioning factors namely cracks in the peat caused by the use of sausage machines undercutting of slopes and the loading of slopes by placement of fill or construction.

The measures that can be employed to address these issues include;

- Turf harvesting using sausage machines should not be permitted. Other methods of turf harvesting should only be permitted on the gentlest of slopes, i.e. $<2^0$.
- No new drainage should be permitted in peatlands.
- Stabilising stream banks that are undercutting a peat slope. The erosion process may be associated with an increase in peak

flows due to changes in the runoff characteristics of the streams catchments. To address may require;

- The exclusion of stock from the riparian zone, possibly accompanied by tree or shrub planting.
- The introduction of a sustainable grazing regime within the sub catchment.
- The blocking or diversion of man- made drains feeding into the stream.

- An assessment by a suitably experienced engineer or geologist of land slide susceptibility before any new excavation or construction project is undertaken on peatlands within *M margaritifera* catchments.

Interception or deflection of debris flows.

The debris flow from a peat flow will be rapidly converted into a liquified slurry. This will tend to flow down slope along natural drainage channels. While small flows outside a natural channel may be deflected by bunds or earth banks, larger flows will breach or overflow such barriers. The construction of bunds to deflect or stop landslides is considered impractical due to;

- The difficulty of predicting the exact location of future flows.
- The difficulty in predicting the size of possible future flows.
- The expense of such a project. It is felt that the resources required would be better employed on measures to reduce the risk of landslides occurring in the first instance.
- The risks associated with construction of suitable berms. Construction of such defences would create risks of fine materials being lost to the aquatic environment.
- The uncertainty associated with the effectiveness of such defences. Even if some debris could be contained or deflected, it would remain unconsolidated and subject to further erosion. In particular, the successful containment of the liquified slurry from a peat flow is considered to be unlikely.

Site remediation post land slide event.

The debris field left after a landslide event or a peat flow is a potential source of further mobilisable material, see plate 32. The material is unconsolidated and has poor cohesiveness. Post event management of this is a priority within *M*

margaritifera catchments. The exact details of such a response are however outside the remit of a Catchment Assessment Report, as it relates to possible future events, the scale and nature of which cannot be ascertained in advance. The scar from where the slid initiated is less of an issue as in most cases virtually all the mobilisable material will have been lost during the land slide or shortly after. However above the scar, tension cracks may be apparent and further (smaller scale) slope failures may be inevitable.

Plate 32: Small landslide, debris field in the foreground.

N. Invasive Plant Species.

The spread of invasive species creates potential erosion risks that may be damaging to *M margaritifera* habitats. This can occur because of the tendency of many of these species to completely dominate a site to the exclusion of other plan species. This dominance creates a new habitat type that may be seasonally or structurally vulnerable to erosion. For example Rhododendron typically suppresses any field layer of herbaceous vegetation underneath its canopy. This creates a risk of fine material being eroded. *Gunnera spp*, Montbretia (*Crocosmia* × *crocosmiflora)*, Japanese Knot weed (*Fallopia japonica*) and Himalayan Balsam (*Impatiens glandulifera)* die back exposing the soil surface during the winter months.

In addition, the presence of these species may attract intervention by landowners or other stakeholders who see them as a threat to their interests in the site. Such attempts at removal of these species create their own risks such as loss of herbicides to watercourses, the disturbance of soil by mechanical extraction and un-controlled burning leading to the erosion of fine material.

Where invasive species are an issue, the Catchment Assessment Report must consider how on a site by site basis the issues should be addressed. Such an assessment will have to consider the following topics;

- Scale of the problem.
- Impact on *M margaritifera* habitats.
- Potential control methods.
- Herbicides use, type of chemicals to be used, method of application, seasonal factors affecting use. Impact on *M margaritifera* population and habitat.
- Physical control. Method and timing of operations, equipment required the potential disturbance to soils and any consequent impact on *M margaritifera* populations and habitats.
- Any requirement for phased removal of exotics from large sites over an extended timeframe.
- Re-vegetating site post removal of exotics.

In many situations, in particular along channel banks the risks attached to removing invasive species may outweigh any potential benefit to *M margaritifera* habitat. Where this is the case no action should be proposed. The impact of such a proposal on landowners and other with legitimate interests in the site is an issue that will have to be considered during the implementation phase of any conservation program.

O. Un- Metalled Roads.

Forestry road Manual; Guidelines for the design, construction and Management of Forest Roads (2004) produced by COFORD should serve as a guide to the design, construction and maintenance of un-metalled roads. Consultation with NPWS before the construction or large scale maintenance on un-metalled roads should be required in all cases. In addition competent professional advice should be sought by the landowner prior to commencing such works.

P. Metalled Roads

The repair and maintenance of metalled roads creates risks of fine materials being mobilised and exported to the aquatic ecosystem. This risk is particularly acute in the vicinity of bridges and culverts. Consultation with NPWS before any repair or modifications to metalled roads or associated bridges or culverts should be required in all cases.

Q. Quarries/ Sand Pits.

Quarries and Sand pits are potentially large sources of fine mineral materials which could be damaging to *M margaritifera* habitats.

The risks attaching to active quarries or sandpits include the following;

- Mobilisation of fine material by blasting or from the removal of protective vegetation and the transporting, grading, washing, crushing and stockpiling of aggregates, see plate 33. This material can potentially be transported to the aquatic environment through either by wind or water.
- Waste material from site operations including oils and other chemicals along with fine material from wheel washes.

Plate 33: Exposed and unstable deposits of fine material at a disused sand pit.

Inactive sites remain a high risk as large amounts of unconsolidated material may remain on site and large areas may remain un-vegetated. Assessors should consider also the route by which materials originating from the site could be transported to the aquatic environment. This could be by surface drainage, drainage to groundwater or by wind erosion. Sites in close proximity to a water course should be considered as particularly high risk due to the lack of any protective buffer.

Any plan to minimise the threat posed by quarrying operations should consider the following;

- Minimisation of the size of the working area of the quarry.
- Diversion of surface water away from working areas.
- Installation of sediment traps to prevent export of fine material.
- Dust control.
- Stabilisation and regarding of worked out parts of the site.
- Vegetating of berms used to screen the site from view or to mitigate noise emanating from the site.

In the case of inactive sites the many of the above issues will still apply although dust and issues related to site operations such as blasting, crushing, and stockpiling may not be applicable. Measures to ensure the stabilisation of the site may still be required. Where appropriate these could include;

- The installation of sediment traps.
- The removal of chemicals or debris.
- The vegetating of bare areas. The establishment of stable vegetative cover over bare areas may require the removal of exotic species, the importation of top soil to facilitate establishment and or the use of fertiliser. When deciding on appropriate species assessors should consider the attributes of the site in question. Many old quarries and sand pits will have little or no topsoil on site. In these circumstances the assessors should consider the natural succession that may be occurring already on the margins of the site, e.g. establishment of gorse or alder scrub. Where this is occurring it should be encouraged, if necessary by appropriate planting. The establishment of vegetation cover may have to be preceded by grading out of the site to create a stable seedbed. This can be followed up by the sowing of nurse grasses or cereals Rye (*Secale cereale*) is capable of growing on unstable sandy sites, a 50:50 mix of Rye and Red Fescue (*Festuca rubra*) by weight applied at a rate of 56 Kg / Ha can be used to reseed the site US Army Corps of Engineers (1997). A once off application of fertiliser to aid establishment is permitted. A decision on the type of fertiliser to be employed and application rates should be based on the results of soil analysis. In some situations the addition of a suitable binder such as coir fibres or wood pulp may be required. On slopes or if the substrate is very loose, hydroseeding may be more suitable than simple broadcasting of seeds. The Rye can be expected to largely disappear within two years, the red fescue will also be steadily displaced by other species. Planting of alder or gorse can follow this initial intervention. Due to the likely presence of unconsolidated material, the site should not be grazed or excessively trafficked for two years after a sward has been established.
- An alternative strategy for small areas is the use of geotextiles, either pre-seeded or with holes cut to allow the planting of suitable vegetation.

- The grading of unstable slopes. Where feasible, grading operations should be planned around optimal seeding dates. If the time of year is not suitable for seeding a permanent cover (perennial species) then a temporary cover crop should be planted. Sowing of annual species Rye (*S cereale*) and Italian Ryegrass (*Lolium mulitiflorum*) is feasible even in late summer/ Autumn to provide protection over the following winter. A more permanent mix incorporating perennial species can be made the following spring.
- When addressing steep slopes it may be more practical to accept that material will be lost from the face of the quarry / sand pit and that intercepting that material by means of sediment traps or by vegetating the quarry floor may be the best approach.

R. Dumping.

Dumping of waste creates a risk of hazardous materials, e.g. metals, oils or toxic chemicals making their way into the aquatic ecosystem. The Catchment Assessment Report should consider the scale of the problem, the type of materials involved and the risks to the aquatic environment. This may require liaison with the local authority and the EPA.

S. Turf Cutting.

The risk to *M margaritifera* populations from turf cutting arises primarily from the export of peat silt from turbary areas. The impact of this is dependent on the scale of turbary operations, the methodology involved and the pathway to *M margaritifera* habitats.

For the purposes of the assessment, turbary areas should be considered as all areas affected by the turf harvesting operations. This includes the actual cutting site, drying areas, stockpiles, drains and access routes.

The different methods employed in turf cutting create different risk profiles for the aquatic environment. For the purposes of this assessment turf harvesting methods can be divided into two principal types.

- These are cutting from a vertical face as is done with traditional hand cutting and when using a hopper, see plate 34.
- Cutting from a horizontal plane either on the surface such as is the case where milled peat is being harvested or sub surface, e.g. using sausage machines, see plate 35.

Plate 34: Cutting from a vertical surface, with vegetation re-establishment on the cut over area.

Plate 35: Cutting from a horizontal plane with turf drying and stockpiling on the cut site.

Cutting from a vertical surface obviously reduces the area involved, cut over areas often re-vegetate naturally and can intercept some of the peat silt mobilised from the vertical faces. Away from the active cutting face, vegetation can be damaged by the drying and stockpiling of turf and on vehicular access routes. The impact from the drying of turf may be exacerbated if the area involved is drained, compacted or rolled as may happen with the use of Lilliput type machines. Practices involving replacing the scraw or vegetated surface layer on to the cutover site may facilitate the re-establishment of a bog like vegetation and are to be encouraged. Nevertheless the remaining high bank will be damaged by the loss of water from the vertical face and by oxidation.

The impact from harvesting that is carried out on a horizontal plane is more serious, as the area affected by cutting operations is larger. There may be a total removal of vegetative cover with harvesting at the surface of the bog, see plate 35 while with the use of sausage machine type harvesters, sub surface ducts are created with consequent destabilising impacts on the entire bog. In addition to these issues the problems associated with the access and the drying and stockpiling of turf are also present.

Sausage machine cutting may also increase the risk of peat flows as the cracks created may allow the direct ingress of water below the acrotelm to the much weaker humified layer beneath. This risk is exacerbated in situations where the same site is repeatedly cut. The acrotelm may be so damaged in these circumstances that the bog surface is destabilised. This is especially the case if second or subsequent harvesting is at an angle to the original cutting.

Possible strategies to minimise the impact from turbary operations include;

- Cessation of turbary operations.
- Diversion of drainage channels to points downstream of *M margaritifera* populations. In practice the options for the application of this strategy are likely to be very limited.
- Change of cutting methodology. A change away from sausage machine cutting to cutting from a bank may allow for turf harvesting to continue at some smaller sites, while still reducing the impact on *M margaritifera* populations and habitats.
- Restoration of cutover areas. In areas affected by sausage machine cutting this will require a cessation of turbary activities and possibly the exclusion of livestock. Where it is planned to exclude livestock, a proposal for fencing is required along with a plan for the removal of such a fence when adequate recovery

has taken place. A definition of what constitutes adequate recovery or indicators of success should be provided.

- The use of silt traps is not considered as an appropriate strategy as peat silt is slow to settle and is unlikely to be retained.
- Reducing the velocity of water draining from cutover sites and the creation of shallow pools may facilitate the recovery of vegetation on these sites. The use of coir rolls staked in place to create small berms can be effective in this regard (no more than 10m apart) Yorkshire Peat Partnership, Technical Guidance Note 3, (2011). This can be accompanied by the use peat plugs plastic dams or coir rolls to block water channels. The intention is to reduce the velocity of water, to create shallow pools and to facilitate the establishment of vegetation. It is not intended to create deep pools. Deep pools (see plate 36) will not serve as sediment traps as the specific density of peat is too low for effective settlement and their depth makes it difficult for plants to get established (due to poor light penetration) at the bottom of the pool.
- The sowing of nursery grass species mix such as 50% *Agrostis cappilaris,* 30%, *Lolium perrenae*, 20% *F rubra* mix at a rate of 40 Kg / Ha should be considered on extensive areas of bare peat such same time as sowing. The planted grasses will stabilise the surface and permit the establishment of other species. They will be as turbary drying areas. A once off harrowing of the surface may be required on compacted sites. An application of fertiliser to aid establishment should be made at sowing time, the exact quantities and composition of this fertiliser should be made following the analysis of a soil sample, (in most cases P and K are likely to be deficient), Yorkshire Peat Partnership, Technical Guidance Note 3, (2011).
- Alternative access routes or improvements to access routes may prevent or reduce the damage caused by vehicular access to turbary areas.

Plate 36: Deep pools in cutover bog, these sites do not facilitate the re-establishment of vegetation.

Some of the measures proposed above may result in a short term increase in the loss of peat. Because of this, natural recovery following the cessation of turf cutting is the preferred approach; fencing to exclude livestock from damaged areas can complement and accelerate natural recovery processes. Where more active measures are deemed necessary they should be staggered over a number of years to avoid large short term increases in the sediment loading to downstream watercourses.

T. Recreational Pressure.

Some recreational pressures such as those arising from angling or kayaking are confined to the riparian zone. Others like hill walking may be spread over large areas of the catchment.

In the case of pressures within the riparian zone, efforts should focus on discouraging practices such as wading at known *M margaritifera* sites. Angling from the river bank is not normally a threat although management practices to facilitate angling like excessively frequent coppicing of bankside trees may be more of a threat. Where angling interests are significant incorporating

provisions required for safe access may be required to reduce the impact on the channels morphology. This could include installation of simple bridges over vulnerable sites, see plate 37. These bridges could be constructed of untreated railway sleepers with appropriate anti slip covering. Management practices to increase the ”fishability” of stretches of river such as removing trees to facilitate fly angling should be assessed to determine their compatibility with maintaining the stability of the riparian zone. In some cases where local bye laws stipulate that fly fishing is the only legal method the issue may have to be referred to the NPWS and Inland Fisheries.

In respect of kayaking, the main concern is at access points. These should be located away from known populations of *M margaritifera.*

Recreational activities outside of the riparian zone have the potential to create local blackspots. In addition developments such as new tracks may create slope stability concerns. Where these pressures are a concern, efforts should be focussed at diverting the activity away from sensitive areas. In some cases the impact at particularly vulnerable locations could be minimised by the provision of appropriate protective infrastructure. However the wider implications of such a course of action would have to be considered.

An example of this would be at crossing points over watercourses where the provision of simple bridges may be of benefit in terms of bank stability. However if the bridge serves to channel walkers towards a single crossing point with consequent damages to vegetation on the approach routes it may be counterproductive. On heavily trafficked areas the development of alternative routes and mechanisms for switching the bulk of pedestrian traffic between them on a rotational basis may be worthy of consideration.

Plate 37: Simple bridges to prevent damage from pedestrian traffic at points where minor watercourses enter the main channel.

5) Geographic Information System.

Production of the GIS Component in the Assessment of *M margaritifera* Catchments.

The GIS and electronic mapping component for a Catchment Assessment Report are been constructed using the following workflow:

a) Create and print (A1 size) of background electronic map for the catchment comprising:

   i. Colour high resolution OSI Ortho-photo tiles geo-referenced to OS75 grid.
   ii. 1/50000 OSI Discovery raster maps geo-referenced to OS75 grid.
   iii. 1/5000 OSI vector mapping on OS75 grid.
   iv. OSI 10m grid ground surface XYZ point data converted to TIN surface and stylised by solid colour banding to show steep slopes.
   v. Catchment boundary.

b) Scanning & geo-referencing of the sub-catchment boundary map and digitising boundaries onto background map. Sub-catchment references are added as polygon labels. Copies of sub-catchment maps are printed for use by field surveyors.

c) Scanning & geo-referencing field assessor's habitat maps and digitising habitat boundaries onto background map. Habitat references are added as polygon labels.

d) Aggregate habitats into management areas according to spreadsheet list from assessors. Management area references are added as polygon labels.

e) Aggregate habitats into Active Intervention Areas. AIA references are added as polygon labels.

f) GPS points are added (including point reference label) from XYZ ASCII file.

g) SAC boundaries are added from NPWS website.

h) Production of A1 maps (paper print and pdf):

i. Sub Catchments: 50,000 OSI discovery map of the surrounding Catchment area with the Sub Catchment boundaries visible at a scale of 1:10,000. Code symbols are also displayed.
ii. Map of Habitat Areas: Habitat boundaries with river and lake features visible at 1:10,000 scale. Point features and code symbols are also displayed.
iii. Map of Habitat and Sub Catchment Areas: same as Map of Habitat Areas with Sub catchment boundaries also displayed.
iv. Map of Active Intervention Areas (AIA's) and Management Zones: AIA and Management Area boundaries are visible at 1:10,000 scale. River and lake features and code symbols are also displayed.

i) Linking habitat attribute data (supplied by assesors as an excel spreadsheet) to habitat polygons (via unique habitat reference labels).

j) Create polygon geometry & attribute files in ESRI ArcGIS shp format:

i. Sub Catchments: Attribute data consists of the Sub catchment, area (m^2) and Letter Code.
ii. Habitats: Attribute data consists of the Area (m^2), Letter Code (prefix identifies sub catchment, suffix identifies individual habitat unit) and Habitat Type (Fossitt code), plus condition code represented by a number in 1-10 range.
iii. Active Intervention areas: Attribute data consists of the AIA Area (m^2) and Numeric Code.
iv. Management areas: Attribute data consists of the Area (m^2) and the alpha numeric code of each management unit.

k) Intersection of habitat and SAC boundaries to find habitats not included in an SAC. Create shp file for same.

l) Production of maps showing the following for inclusion with written report;

i. Habitat Units with designated areas (SAC, SPA etc).
ii. Management Units with Active Intervention Areas.
iii. Any additional maps that may be required to demonstrate particular features of a study area.

m) All mapping and GIS work to be carried out using AutoCAD MAP 3D 2012 or 2013. This allows the use of standard Autocad drawing, editing and plotting commands combined with MAP 3D's enhanced mapping, raster geospatial referencing, GIS tools and import/export from multiple GIS formats. All digitised or aggregated linework are created as single lines with no duplication and only created as a final polygon topology after all editing of boundaries had been completed.

Digitising and labelling are to be carried out by a qualified GIS technician and quality checked by a qualified GIS supervisor and the field assessors. Completeness of the polygon topology and uniqueness of the reference attribution was checked automatically by the software. GIS work should progress in tandem with field assessments and not be left to the end of the period. It is recommended that those involved in the production of the GIS should periodically accompany assessors on so as to familiarise themselves with the context of the work.

6) Writing a Catchment Assessment Report.

A. Writing a draft report.

i. **Structure**.

A catchment assessment report is produced on the template provided in Appendix 1 of this manual. This is done to ensure consistency in structure and to facilitate stakeholders in the management of *M margaritifera* catchments.

The report consists of four distinct parts;

a) An Introduction.
b) Analysis at sub catchment level.
c) Analysis at a catchment level and conclusions.
d) Appendices.

The first section is an introduction to the report and sets out the background to the assessment, a short description of the catchment and the methodology employed.

The analysis at sub catchment level describes the sub catchment, its current condition and management, the threats identified and the proposed actions to address these threats. Tables from the Catchment Assessment Report for the Dawros River in Co. Galway are included in the following section for demonstration purposes. Full details on how to deal with each heading are given

- **Site Description.** A short description of the sub-catchment including its area, altitude range and principal watercourses.

- **Designation.** Any conservation designation, e.g. SAC or SPA that the sub catchment or parts thereof may have.

- **Land Tenure.** The ownership pattern within the sub catchment. This would detail whether the lands are privately owned, are commonage or are in state ownership. It is not required to identify all land owners.

- **Habitats.** The principal habitats within the sub catchment should be named.

- **Habitat, Condition and Erosion Risk.** This is a table which lists each habitat unit within the sub catchment. Each habitat unit is then described in terms of the habitats using the classification developed by Fossitt for the Heritage Council (2000). The condition code that the habitat unit has been assessed as, the erosion risk, its area and the presence/ absence of a monitoring station. The erosion risk is primarily based on the condition code. Habitat units with condition codes of 1-4 are normally considered as low risk, 5-6 represents medium risk and 7-10 constitutes high risk. Sites with a very direct pathway to watercourses may be considered in a higher risk category than would otherwise apply.

Habitat Unit	Code	Condition	Erosion Risk	Area	Stations
F-A	*HH3, PB2, ER1*	*2*	*Low*	*27.77*	*X3*

- **Land Use.** A short description of the principal land uses within the sub catchment, e.g. grazing of sheep/ cattle, dwelling houses, commercial forestry, transport etc.

Management Unit	Description
Diamond Hill	*Part of Connemara National Park. This area is contained within the Deer fence. It is open to other park lands outside of the catchment.*

- **Management Unit Condition.** The management unit condition is described in a table.

Management Unit	Description	Habitat Units
Diamond Hill	*This management unit is Undamaged. Localised problems exist with Rhododendron dominance particularly in habitat unit F-D.*	*F-A, F-B, F-C, F-D, F-F, F-N, F-CB, I-A, I-B, J-A, J-C, N-A, N-B, N-C, N-D, O-A, O-B, R-D, R-E*

- **Trends.** Any trends that may be apparent wither from field observation; previous reports should be described under this heading.

- **Threats.** Any threats to *M margaritifera* habitat that emanate from a given management unit are described in this section.

Management Units	Description.
Diamond Hill	*Occasional Riverbank collapses. Expansion of Rhododendron scrub. Evidence of landslides in habitat unit F-CB.*

- **Proposed Actions.** Any actions proposed to address the threats already identified should be described here. In some cases it may be decided that there is no practical response to the identified threat, if this is the case then this should be state here. If appropriate a consideration of alternative approaches to the dealing with the identified threat should be considered and the reasons for the final choice elucidated.

Management Unit	Description.
Diamond Hill	• *The river bank collapses are considered to be natural phenomena due to an unstable surface. As the adjoining vegetation condition is in good condition, it is considered that no reasonable mechanism exists to address this issue. Consequently no action is recommended. Control of Rhododendron to prioritise areas where the canopy is still open and a herb layer still exists.* • *No pulling or spraying of large Rhododendron plants. Cambium injection of a suitable herbicide is the preferred control technique.* • *Where a Rhododendron canopy has closed over no action is permitted outside of an agreed management plan.* • *The risk of a land slide reaching the Polladirk River is real. Such an event would create a source of unconsolidated material that would be vulnerable to erosion. In a worst case scenario a landslide could result in the river being blocked by debris.* *The area involved has been managed as part of the National Park for many years. The vegetation in habitat unit F-BC is effectively undamaged by livestock and the area is not heavily trafficked by visitors to the park. For these reasons the risk of further landslides is considered to have little anthropogenic component.* *It appears that landslides at this location are a natural*

	phenomena and that there are no realistic options for reducing the scale or impact of further landslides *It is considered that any attempts to initiate remedial action following a landslide blocking the Polladirk river would be non-viable. In a spate river such as the Polladirk, heavy rainfall of a type likely to initiate a landslide would also lead to a rapid increase in flow rates in the river. This enhanced flow could be expected to breach or circumvent a blockage very quickly. The use of heavy equipment to attempt to remove a blockage or mobilisable material in such circumstances would be futile and would be likely to cause additional damage.*

- **Future Grazing Management.** The sustainable stocking rate proposed for each management unit within the sub catchment should be given here.

Management Unit: *Diamond Hill*					
Habitat Units	**Habitat Code**	**Condition**	**Area**	**Stocking Rate ewes/ ha**	**Permitted Stock Numbers Ewe Equivalents**
F-A	*HH3, PB2, ER1*	*2*	*27.77*	*1.25*	*34.71*
F-B	*HH2, HH3, ER1, WS3*	*2*	*61.58*	*0.75*	*46.19*
F-C	*HH3, PB3, WS1, WS3, BL3*	*2*	*29.63*	*0.75*	*22.22*
F-D	*PB3, HH3, WS3*	*2*	*36.75*	*0.75*	*27.56*
F-F	*HH3, PB3, WS3*	*2*	*15.41*	*1.25*	*19.26*
F-N[1]	*HH3, WS1, WS3*	*2*	*4.90*	*0.50*	*2.45*
F-CB[2]	*HH3, ER1*	*2*	*27.54*	*1.35*	*37.18*
I-A	*HH3, PB2*	*2*	*46.88*	*1.25*	*58.60*
I-B	*HH3, PB2*	*2*	*13*	*1.25*	*16.25*
J-A	*HH3, PB2*	*2*	*45.74*	*1.25*	*57.18*
J-C	*HH3, PB2*	*2*	*8.79*	*1.25*	*10.99*
N-A	*HH3, PB2*	*2*	*60.78*	*1.25*	*75.98*
N-B	*HH3, ER1*	*2*	*24.23*	*0.75*	*18.17*
N-C[3]	*HH3, ER1, GS3*	*2*	*31.58*	*3.09*	*97.50*
N-D	*HH3, PB3, WS3*	*2*	*5.37*	*0.83*	*4.48*
O-A	*HH3, ER1*	*2*	*6.57*	*0.75*	*4.93*
O-B	*HH3, PB2, PB3*	*2*	*27.92*	*1.17*	*32.57*
R-D	*HH2, HH3,ER1*	*2*	*26.84*	*1.00*	*26.84*
R-E	*HH3, HH1*	*2*	*42.73*	*1.50*	*64.10*
Sub total			*544.01*		*657.15*
Total(s)			***544.01***		***657***

Note 1: Scrub is being ignored for the purpose of calculating the sustainable stocking level.

Note 2: As the area of bare rock is small in proportion to the overall habitat unit, the sustainable stocking density has been adjusted to 1.35 ewes/ Ha.

Note 3: As the exposed rock makes up c 5% of this habitat unit, the stocking density has been adjusted to 3.09 ewes per Ha.

- **Other Grazing Issues.** Any seasonal restrictions on grazing or on the introduction of new types of livestock or grazing related management issues, e.g. supplementary feeding to particular management units should be dealt with here.

- **Other Management Issues.** Any issues relating to site management issues other than grazing, e.g. turbary or construction should be dealt with on a management unit basis under this heading.

The third section combines the key points identified for each sub catchment. An analysis is made of the key threats identified and the proposed response to each. This is accompanied by a prioritisation of the Active Intervention Areas in terms of where resources should be focussed within the catchment.

The final section contains station data and any other supporting material referred to in the report.

ii. Calculation of sustainable stocking rates.

The calculation of a sustainable stocking level is carried out for each management unit in the study area. This calculation has three principal components, these are;

- Area of the constituent habitat units.
- Habitats present in each habitat unit and standard stocking levels for each habitat type.
- Condition of each habitat unit.

Area of the constituent habitat units.

Habitat units were identified as areas with similar habitat types, risk profile and within the same management unit. The area of each unit is calculated by the GIS system.

Habitats present

The habitats present refers to the principal habitats, it does not normally include habitats that make up less than 10% of the area of the habitat unit, nor does it normally include field boundaries unless there are specific concerns in respect of these. For the purposes of the calculation it is assumed that all listed habitats make up an equal portion of the total area for the habitat unit concerned, if this is not the case then the assessors should describe the actual relativities and insert a note beneath the table explaining their course of action.

Table 8.

Habitat type	**Max sustainable Stocking rate (undamaged)**
Blanket bog and montane heath	1 ewe/ ha.
Wet and dry heath	1.5 ewe/ ha
Wet grassland	0-6.7 ewes/ ha.
Improved grassland	5-11 ewes/ ha.
Other grasslands	5 ewes/ ha.
Ungrazeable areas e.g. scrub dense bracken, extensive water and bare rock.	0 ewes/ ha.

In the case of mosaics of different habitats, an average of the above stocking rates is used. In certain cases where it is apparent that one habitat type is dominant within the habitat unit the stocking rate is adjusted to reflect this. Where necessary a proportionate reduction in the stocking rate has been made to account for the extent of ungrazeable habitats in a habitat unit.

Condition of each habitat unit.

A condition assessment for each habitat unit was made using a modified version of the coding system used for commonage framework plans. As in the commonage framework plan system bare peat/ soil is the most important parameter in the decision on which condition code to apply. A description of the each condition class is given below.

Situations where the condition code allocated to a habitat unit was for a reason that has no relationship to sustainable grazing or where the sustainable stocking rate will change over time should be explained in the text by way of a note under the relevant table or in the proposed actions section.

Table 9

Condition Code	Description (note assessment of condition must not discriminate based on cause of damage)
1	Under grazed areas, typically dominated by *M caerula* and or *Juncus* species. Areas with dense bracken or heather may also be included in this category.
2	Undamaged areas with little or no bare peat/ soil.
3	Areas where some damage to vegetation (irrespective of the cause) is evident. However there is little or no risk of erosion and damage to vegetation structure or species composition while present is minimal in extent and or severity.
4	Areas where damage to vegetation structure is significant but bare peat/ soil is less than 3% and erosion risk is considered low.
5	Areas where bare peat/ soil are significant (3-6%) and where erosion risks are present.
6	Bare peat/ soil (6-8%), erosion risks are significant and damage to vegetation structure or species composition is normally very apparent.
7	Bare peat/ soil (8-10%) erosion risks are potentially serious.
8	Bare peat/ soil (10-20%) damage is obvious and erosion is occurring. Sites where there are concerns as to surface stability, e.g. evidence of recurring landslides or sausage machine cutting of turf should be included here.
9	Bare peat/ soil (20-40%), seriously damaged, active erosion is apparent. Sites where cross cutting of turf or repeated cutting using sausage machine cutters has occurred or where the vegetation in cutting or drying areas has been significantly damaged should be scored as 9 or 10.
10	Bare peat/ soil (>40%). Very seriously damaged, erosion is extensive and easily observed. Sites where significant landslides or bog bursts have recently occurred or where tension cracks or pipes are evident should be included in this category. Large deposits of unconsolidated material particularly where these include fine mineral particles or peat should be also be included in this category as should sites where the use of hazardous chemicals, e.g. sheep dip, herbicides is occurring without adequate controls or buffering capacity.

The condition code is incorporated into the calculation by the use of an appropriate correction factor as shown below. The correction factor to be applied is based on the condition of the habitat unit.

Table 10.

Condition Category	Correction Factor
1	1
2	1
3	0.80
4	0.60
5	0.50
6	0.35
7	0.20
8	0
9	0
10	0

The calculation of planned max stocking levels is made on a management unit level. The basic formula is;

Stocking rate x Area = Sustainable stock numbers.

The stocking rate is itself a function of the standard stocking level for the relevant habitat multiplied by a correction factor based on the condition of the habitat. If the formula is expanded to reflect this we get.

Standard Stocking Level x correction factor for Condition x Area = Sustainable stocking level.

This formula is applied to each of the constituent habitat units in the management unit. The sustainable stock numbers for the management unit is the sum of the product for each habitat unit. The calculations are displayed on a Future Grazing Management table see examples 1 and 2 below.

When preparing the future grazing management table all values are expressed to two decimal places except the total for permitted stock numbers which is rounded off to the nearest whole number.

Example 1:

Management Unit M-1 has an area of 43.22 Ha; it consists of three separate habitat units identified as M-D, M-G and M-H with areas of 21.25 Ha, 10.58 Ha and 11.39 Ha respectively.

Management Unit: M-1					
Habitat Units	**Habitat Code**	**Condition**	**Area**	**Stocking Rate ewes/ ha**	**Permitted Stock Numbers Ewe Equivalents**
M-D	*PB4*	*6*	*21.25*	*0.35*	*7.44*
M-G	*HH3, PB4*	*5*	*10.58*	*0.62*	*6.61*
M-H	*GS4*	*2*	*11.39*	*4*	*45.56*
Sub total			*43.22*		*59.61*
Total(s)			***43.22***		***60***

In this case, the permitted stock numbers for M-D are calculated by the following formula:

Stocking rate for blanket bog, i.e. 1 ewe equivalent per Ha x correction factor for condition code 6, i.e. 0.35. The stocking rate is thus 1 x 0.35 = 0.35 ewes/ Ha

Permitted stock number is **1 x 0.35 x 21.25 = 7.44 ewes.**

In the case of habitat unit M-G, as the habitat unit is considered a mosaic of wet heath and blanket bog, the standard stocking rate used is an average of those for the two habitats involved, i.e. (1 + 1.5)/2 = 1.25 multiplied by the appropriate correction factor for a condition code of 5, i.e. 0.5. Thus the stocking rate is 1.25 x 0.5= 0.62.

Permitted stock number for M-G is **1.25 x 0.5 x 10.58 = 6.61 ewes.**

In the case of habitat unit M-H the habitat is wet grassland, the undamaged carrying capacity has been assessed as 4 ewes/ ha and the site has a condition code of 2. Thus the sustainable stocking rate is 4 x 1 = 4 ewes/ Ha.

Permitted stock number for M-H is **4 x 1 x 11.39 = 45.56 ewes.**

The total permitted sustainable stocking number for management unit M-1 is 7.44+6.61+45.56= 59.61. This is rounded up to 60 ewes.

Example 2

Management Unit PV-1 has an area of 64.30Ha; it consists of two separate habitat units identified as P-D and V-A with areas of 18.36 Ha and 45.94 Ha respectively.

Management Unit: PV-1					
Habitat Units	**Habitat Code**	**Condition**	**Area**	**Stocking Rate ewes/ ha**	**Permitted Stock Numbers Ewe Equivalents**
P-D	*HH3, PB4*	*4*	*18.36*	*1.38*	*15.20*
V-A[1]	*GS4, GA1*	*2*	*45.94*	*5*	*229.70*
Sub total			*64.30*		*244.90*
Total(s)			***64.30***		***245***

Note 1: Wet Heath is the dominant habitat in this management unit, estimated cover is 75%. Stocking rate has been adjusted accordingly.

In this example the stocking rate for habitat unit P-D is not an average of that normally used for two habitats involved, it has been increased to reflect the greater preponderance of wet heath in the habitat unit.

Stocking rate = (stocking rate for blanket bog + (3(stocking rate for wet heath))/4.

Stocking rate = **(1+ (3*1.5))/4 = 1.38**

Permitted stocking rate for habitat unit P-D is **1.38 x 0.6 x 18.36= 15.20.**
A note explaining the departure from the normal practice had been inserted into the table.

Habitat unit V-A is a mosaic of wet grassland and improved grassland. As the ability to carry stock varies considerably on grassland habitats, the standard stocking rates are based on an acceptable range. It is up to the assessor in the field to determine what level is appropriate. In this case the undamaged stocking rate has been assessed as 5 ewes / Ha. The condition code is 2 as the site is considered undamaged.

Permitted stock number for habitat unit V-A is **5 x 1 x 45.94 = 229.70**

The total permitted sustainable stocking number for management unit PV-1 is 255.04 ewes, i.e. 15.20+229.70 = 244.90. This is rounded up to 245 ewes.

The sustainable stocking number should be totalled for each sub catchment.

iii. Ranking of threats. The threats identified for each sub-catchment should be ranked in terms of the potential impact on *M margaritifera* habitats and populations. This process should be based on;

- The type of threat.
- The magnitude of the threat.
- The area affected.
- The location of the threat, relative to downstream *M margaritifera* populations.
- The pathway to *M margaritifera* populations and the presence/ absence of any buffering capacity.
- Any trends in the development of the threat, e.g. a threat that is diminishing under current management may be considered less serious than one of similar scale which is continuing to grow.

Threats should be referred to by the name of the relevant habitat unit. This process is subjective but is an essential prerequisite for the planning or proposed remedial measures.

iv. Prioritisation of Active Intervention Areas.

With the exception of proposed changes to the management of grazing livestock all areas where significant remedial actions are proposed shall be considered active intervention areas or AIA's. These interventions should be prioritised in order of the potential benefit to *M margaritifera* habitats and populations from their successful implementation. This prioritisation does not necessarily reflect the ranking of the threats that it is proposed to address. This is because there are some threats, e.g. certain landslide risks where no effective intervention is feasible. In these cases, even though the risk or threat is deemed to be high the site may not be earmarked as an AIA or is accorded a low priority for intervention.

This prioritisation process is inevitably subjective but assessors should ensure that AIA's that receive a high priority are those where an important threat can be successfully addressed within a reasonable timeframe. AIA's further down

the list could include those where the threat is smaller or where the prospects for a successful intervention are deemed to be lower.
Assessors should be guided by;

- The pathway to *M margaritifera* habitats.
- The proximity to downstream *M margaritifera* populations.
- The viability of the proposed interventions. Viability is linked to likely cost, the time required for a positive response and the likelihood of success.

B. Submission of a draft report.

When ready, a draft Catchment Assessment Report (CAR) should be submitted to NPWS for consideration. It may also be necessary to disclose all or part of the draft to relevant third parties for comment. When consultations following the submission of a draft report are complete, a final report should be prepared incorporating any approved changes or modifications resulting from discussions with the NPWS or others following the consultation period.

C. Final Deliverables.

The final deliverables are;

1. A digital copy of the report in PDF and word format.

2. Maps of the following in a pdf format.
   - Two sub catchment maps, one on a plain background and one layered on a 1:50,000 series O/S map.
   - Map of habitat units with the SAC layer Map of Active Intervention Areas with Management unit layer.
   - Any other maps referred to in the report.

3. The shape files for the GIS.

6) Conclusion.

As *M margaritifera* is one of the most sensitive of aquatic species, the health of its population will be affected by pressures below the thresholds that impact on other more tolerant species. Its conservation is not only a worthy end in its own right but also a guarantee that suitable conditions for other species will remain in place. This in turn, helps ensure that the asset value of water resources, for example water abstraction and recreation are safeguarded.

An effective conservation program for *M margaritifera* has to be holistic in its scope. The aquatic habitat of *M margaritifera* cannot be considered in isolation from its terrestrial hinterland. Events and processes within the catchment are intrinsically linked to the health of the freshwater ecosystem that it depends on. Thus the status of the terrestrial habitats in the catchment, their management and future prospects are vital to the *M margaritifera* populations in the rivers into which these lands drain. This means that efforts to restore the health of *M margaritifera* populations have to be made at a landscape level.

Inevitably this means interaction with landowners and other stakeholders. To be successful this interaction has to ensure that conservation is not seen as a threat to other legitimate land uses but is complimentary to them. Ensuring that this happens will be a major challenge to those tasked with implementing a Catchment Assessment Report.

For those involved with producing the report in the first instance, the priority is to produce a management tool that will be of assistance to all stakeholders in a *M margaritifera* conservation program. They have to be aware of how interdependent the different facets of the catchment are, how geology, topography and climate along with past and present management combine to make the catchment what it is. Assessors have to be aware that the location of a problem may well be remote from its origin. They also have to be conscious of how the actions that they propose may impact on habitats, land uses and stakeholders. However if they approach the task with honesty, imagination and a willingness to consult with others, particularly the local farming community and experts in other disciplines they can make a huge contribution to conserving an ancient species and its habitat.

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Introduction

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Acknowledgements

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Methodology.

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Sub-catchment A.

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Site Description.

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Designation.

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Land Tenure.

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Habitats.

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Habitat Condition and Erosion Risk.

Habitat Unit	Code	Condition	Erosion Risk	Area	Stations

Land Use.

Management Unit	Description

Management Unit Condition.

Management Unit	Description	Habitat Units

Trends.

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Threats.

Management Unit	Description.
All other Management Units	

Proposed Actions.

Management Unit	Description.
All other Management Units	

Future Grazing Management

Management Unit:					
Habitat Units	**Habitat Code**	**Condition**	**Area**	**Stocking Rate ewes/ ha**	**Permitted Stock Numbers Ewe Equivalents**
Sub total					
Total(s)					

Note 1 Stocking rates in these habitat units are adjusted to account for the amount of bare rock.
Note 2 Stocking rate adjusted to take into account bare rock and farm road.

Sustainable Stocking Levels for each sub catchment.

Sub Catchment	Area Terrestrial Habitats	Ewe Equivalents	Livestock Units	Average Stocking Density LU/ Ha
Totals				

Notes:
1)
2)

Analysis of Threats or Pressures.

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Ranking of Threats.

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Prioritisation of Active Intervention Areas (AIA)		
Priority	Location	Action

Recommendations.

1).....
.....
2).....
.....

Conclusions.

1).....
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2).....
.....

General Station Report Card
Upland Habitats

Assessors **Sub catchment**

Station No. **Date**

Assessment Unit/ Station No. (10mx10m recommended)_____

Locational details (*including GPS reading, Irish Grid format only*_____

Photographs taken @ Assessment Unit *(Record / Film No/ Frame Nos. and view direction*

Plates

Soil Type ***Tick*** *use probe*	**Soil Depth** /
Peat	< 15 cm
Peaty podsol	15 - 80 cm
Mineral	> 80cm

Habitat (tick only one)

Blanket Bog	Wet Heath	Dry Heath
Grassland	Other	

Ground Cover of Vegetation *Estimate % Cover*

D = Dominant >50%; A= Abundant 25 - 50%;
F= Frequent 5 - 25%; O = Occasional < 5%.

Ling Heather *(Calluna*) %cover % suppressed % topiary % normal	
Cross-leaved Heath *(Erica tetralix*)	Orchid spp
Bell Heather *(E. cinerea*)	*Rhododendron ponticum*
Tormentil *(Potentilla errecta)*	Gorse (*Ulex spp)*
Galium palustre	Bog Myrtle (*Myrica gale)*
G saxatile	Bilberry (*Vaccinium myrtillus*)
Bog Asphodel *(Narthecium ossifragum)*	Crowberry (*Empetrum nigrum*)
Butterwort (*Pinguicula vulgaris)*	Willows *(Salix spp)*
Bog Pimpernel (*Anagallis tenella*)	Bracken *(Pteridium aquilinum)*
Milkwort (*Polygala serpyllifol*ia)	Fern *(Blechnum sp)*
Lousewort (*Pedicularis sylvatica)*	Bladderwort (*Utricularia spp*)
Devils bit scabious (*Succisa pratensis*)	Thistles *(Cirsium spp)*
Buttercups *(Ranunculus spp)*	*Rhyncospora alba*
Purple Moorgrass (*Molinia caerula)*	Deergrass (*Scirpus caespitosus)*
Black Bog Rush *(Schoenus nigricans)*	Bogbean *(Menyanthes trifoliata)*
Bog Cotton (*Eriophorum vaginatum*)	Other Grasses
Heath rush (*Juncus squarrosus)*	Sedges (*Carex spp)*
Mat Grass (*Nardus stricta*)	Woodrush (*Luzula spp*)
Bog Cotton (*Eriophorum angustifolium*)	Crustose lichens on peat
Other Grasses (Fescues)	*Cladonia portentosa*
Holcos lanatus	*Cladonia unicialis*
Bog Cotton (*Eriophorum vaginatum*)	*Juncus spp*
Racomitrium languinosa	*Pleurozia purpurea*
Polytrichum commune	*Sphagnum cuspidatum*
Campylopus spp	*Sphagnum spp*
Club moss *(Polytrichum commune)*	Other Mosses

Other species which might have an indicative value_____
Upland Habitats Station Report Card - (continued)

% Vegetation % Bare peat % Rock %Litter
Average height Ling **cm** Bell heather **cm** Cross-leaved heath **cm**
Rest of sward cm
Are Terracettes present No
If Terracettes are present, what % vegetation cover is there on the treads?_____

Damage assessment for station:
Drainage pathway: _____

STATION ASSESSMENT CARD - *Upland areas, Margaritifera catchments.*

adapted from Mac Donald et. al. 1998, Scottish Natural Heritage

Sub Catchment: **Station No.** **Date:**

	Trampling and grazing of pool systems and water tracks.		**Trampling of *Sphagnum* moss hummocks and lawns.**
5-10	Edges of pools broken down, neither abrupt vertical sides nor sloping *Sphagnum* covered edges. Wet hollows obviously trampled, hoof prints abundant.	5-10	Most *Sphagnum* moss surfaces broken by hoof prints over most of the bog surface. Loose and bleached portions of *Sphagnum* mosses present.
1-4	No evidence of trampling or grazing around pools, particularly those containing Bog Bean (*Menyanthes trifoliata*) and water tracks. Wet hollows with intact *Sphagnum cuspidatum* cover. No pools present.	3-4	Minority of *Sphagnum* moss surfaces broken by hoof prints, locally distributed of the bog surface. Loose and bleached portions of *Sphagnum* mosses very local.
		1-2	Most *Sphagnum* moss surfaces intact. Evidence of hoof prints found only after extensive searching. Loose + bleached portions of *Sphagnum* mosses absent or very infrequent.
NA		NA	No Sphagnum hummocks or Lawns present.
	Extent of ground cover of mosses and or lichens among + between dwarf-shrub, sedge and grass plants.		**Abundance of bare peat in the transect station.**
7-10	*Sphagnum* mosses and/ or lichens absent or very patchy. "Feather" mosses may be abundant but if so then forming thin (<< 5cm deep) mats.		**<1 % 1-2** ☐ **<3% 3-4** ☐ **3-10% 5-7** ☐ **10-20% 8** ☐
4-6	*Sphagnum* mosses and/ or lichens present but patchy. Feather mosses if present, forming thin to moderately deep mats and low hummocks (< 10 cm deep).		
1-3	*Sphagnum* mosses and/ or lichens extensive and abundant. Feather mosses, if present, forming deep mats and low hummocks (> 10 cm deep).		**20-40% 9** ☐ **40-100 % 10** ☐
NA			
			Amount of *Nardus stricta*
		7-10	Abundant or widespread especially on hummocks
		1-6	Occasional or absent.
	Firmness of ground underfoot.		**Signs of browsing on Cross-leaved heath *(Erica tetralix)* and Crowberry *(Empetrum nigrum).***
5-10	Hard or firm over most of the bog surface. [Note: drainage and frequent burning can have similar effects]	5-10	Some. [Note: *E. tetralix* is very rarely browsed. *E.nigrum* is almost never browsed, although it may be damaged by trampling. If these species show extensive signs of browsing this is a good indication of heavy browsing and grazing in the immediate area]
3-4	Variable or intermediate.		
1-2	Soft to very soft, spongy, over most of the bog surface.		
		1-4	None
		NA	Absent
	Amount of flowering bog cottons *(Eriophorum* spp).		**Evidence of browsed woody material on Bog myrtle *(Myrica gale).***
6-10	Little or none. Inconspicuous.	6-10	Any extensive browsing into old woody material beyond current year's growth
4-5	Abundant or widespread but thinly scattered.	3-5	Browsed shoots easy to find but not immediately conspicuous.
1-3	Widespread and abundant, very conspicuous and may give a colour cast to large areas of the bog.	1-2	Browsed shoots difficult to find or absent
N/A	Out of season or absent.	NA	Absent.
	Abundance of *Molinia caerula*		**Sphagnum hummocks**
6-10	Suppressed < 15cm, evidence of grazing by sheep is apparent.	6-10	*Sphagnum absent* or very sparse.
3-5	May be present but not dominant and not forming tussocks.	4-5	*Sphagnum* restricted to hummocks, may be predominantly *S cappillifolium.*
1-2	Dominant, may be forming tussocks, litter maybe present for most of the year between tussocks.	1-3	More than 2 species of *Sphagnum*, present in pools and or lawns in addition to hummocks.
N/A	Absent.	N/A	No Sphagnum present.

Assessors overall evaluation of the current condition of vegetation in station based on evaluating the above indicators (selected category in bold)

1 2 3 4 5 6 7 8 9 10

STATION ASSESSMENT CARD - *Upland areas, Margaritifera catchments.*

adapted from Mac Donald et. al. 1998, Scottish Natural Heritage

Sub Catchment: **Station No.** **Date:**

5-10 1-4 NA	**Summer browsing of Ling (*Calluna vulgaris*).** Extensive, obvious, easy to find. Very limited, patchy, negligible. Though infrequent may still be obvious due to removal of flowering shoots.	5-10 3-4 1-2 NA	**Type of shoot material removed from Ling (*Calluna vulgaris*) and/ or Frauchan/ Bilberry (*Vaccinium myrtillus*).** Frequent evidence of browsing of woody shoot material older than the most recent year's growth. Little or no browsing of woody shoot material older than most recent year's growth. Mainly shoot tips removed. Only tips of shoots browsed.
7-10 4-6 1-3 NA	**Dwarf-shrub stem breakage as a result of trampling by large herbivores (check for hoof prints).** Conspicuous. > 50m from supplementary feeding locations. Common in immediate vicinity of supplementary feeding locations or other locations where animals become unusually concentrated even when average stock densities are low. Inconspicuous, except < 50m from supplementary feeding locations.	**Amount of bare ground in station.** Estimate actual percentage = % **<1 % 1-2** ☐ **<3 % 3-4** ☐ **3-10 % 5-7** ☐ **10-20 % 8** ☐ **20-40 % 9** ☐ **40-100 % 10** ☐	
5-10 3-4 1-2	. **Amount of trampled, bare ground.** Frequent, especially in recently burnt patches. Little or none except for sporadic sheep scars.	5-10 1-4 NA	**Uprooting of dwarf-shrub seedlings in recently burnt patches.** Conspicuous. Not conspicuous, but possible to find with limited searching. Little or none.
6-10 4-5 1-3 N/A		6-10 3-5 1-2 NA	**Depth of carpet of mosses and liverworts or "bushy" *Cladonia* lichens, under andbetween the dwarf-shrubs**. } Thin <5cm deep, and patchy. } Thick and luxuriant > 10cm deep, extensive. No mosses or lichens or no dwarf shrubs present.

Assessors overall evaluation of the current condition of vegetation in station based on evaluating the above indicators (selected category in bold)

1 2 3 4 5 6 7 8 9 10