Department of Environment & Local Government
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Island Seafoods Ltd
Carricknamohill
Killybegs

Construction of Hydro-Electric Power Scheme
At
Carricknamohill
Killybegs

02/221.

LOUGHADEERY HYDRO POWER SCHEME

Nr. Killybegs, County Donegal

ENVIRONMENTAL IMPACT STATEMENT

Shawater Ltd

November 2001

To: ISLAND SEAFOODS LIMITED

ENVIRONMENTAL IMPACT STATEMENT

LOUGHADEERY RIVER HYDRO-POWER SCHEME

near KILLYBEGS , COUNTY DONEGAL

REPORT NO. 340/ES1

FROM: Shawater Ltd

Ston Easton, Bath, BA3 4DN, UK

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In preparing this Environmental Impact Statement, Shawater Ltd has received specialist scientific advice from the following:

The Meteorological Service (rainfall)

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Informal discussions about relevant ecological issues have also been held with the Central and Southern Regional Fisheries Boards, the Environmental Protection Agency and the National Museum. While every attempt has been made to ensure that the view of these organisations and individuals on the specific topics discussed with them are fairly and fully reflected in this Environmental Impact Statement, the observations reported shall be attributed to Shawater Ltd.

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HYDRO POWER: THE PRESENT CONTEXT

Background

It is generally agreed that renewable energy sources rather then fossil-fuels must be used to generate electricity, though not at any price. Costs to consumers and the environmental effects of constructing and operating each power station must be compared on a project-by-project basis.

The Government's position on renewable energy (Ref.1) mirrors the European Union's objectives (Ref.2). The hydro-power station proposed here is judged to meet the Government's technical and economic criteria specified in its Fifth (2001) Round of the Alternative Energy Requirements scheme and accordingly is expected to be awarded a Power Purchase Agreement.

The Draft Development Plan for County Donegal endorses Government policy in respect of small scale hydro schemes (ref Clause 2.2.3 of Ref. 3, reproduced in Annex A). Key statements in the Development Plan (Ref. 3) are that the Council:

Most thermal power stations operate for about 70% of the year; few run more continuously. In just the same way as their outputs are readily combined through the national grid to meet customers' varying needs, so intermittent renewable sources are used efficiently via the grid without storage. For hydro schemes, this means that dams and reservoirs are not now required. Natural storage in catchments allows these 'run-of-river' schemes to operate for about 70% of the year, more continuously in winter when their outputs are most valuable.

By avoiding the need for reservoirs, the capital costs and environmental effects of hydro schemes are much reduced. These advantages are appreciated by the European Union, which has turned against large storage-dependent hydro projects in favour of smaller, dispersed schemes (Ref. 2).

This size of hydro scheme meets the needs of local communities. Much of the electricity required in rural Ireland could be generated by small, distributed schemes of this type. Where they are shown to be compatible with environmental regulations they are supported by the statutory bodies.

The Proposed Scheme

The Loughadeery River Hydro-Power Scheme (Figure 1) is of the 'run-of-river' type, i.e., it will operate according to the flow discharged down the overflow spillway of the Loughadeery Dam at any time. When that flow is sufficient it will pass via a buried pipeline to a conventional water turbine and returned to the river without delay further downstream. The water will not be polluted, and since no storage is needed, no land will be flooded.

The scheme will generate up to 600kW and will be connected to the ESB's power line. A full description of the scheme is given in Chapter 2.

The fact that run-of-river hydro schemes accord quite closely with the power requirements of local communities allows existing electricity distribution networks to receive and distribute that power. Connections to the grid are often short, as is so in the present case. These schemes therefore ensure that existing power lines are used more efficiently and, because the schemes are located near to consumers, they reduce the power losses associated with long-distance transmission lines and hence help to defer the need for grid reinforcement.

Environmental Considerations

Generating power from upland rivers could detract from their natural character. This type of risk is reflected in the national importance of these rivers. A full appreciation of how the construction and operation of any scheme could affect its environment is therefore essential.

Riparian (river-related) environments differ from river to river. They also vary along each according to elevation, river steepness, whether sheltered or exposed, rocky or muddy, acidic or alkaline, and in many other ways. It is not possible to specify the likely effects of any project by simply referring to another. The steps taken to evaluate these and other effects of the proposed scheme, together with the solutions thereby proposed, are set out in Chapters 3-12. The conclusions are drawn together in the water abstraction policy suggested in Chapter 13.

The visibility of power stations, especially those located away from industrial settings, is commonly a key landscape issue in their design and assessment. For hydro schemes of the type and size considered here, the powerhouse is no larger than (and it often resembles) a small single-storey barn. Their locations can usually be adjusted to suit such factors as landscape, visibility, access, existing land uses and ease of grid connection, and their walls, roofs, doors, windows, drainageware and the colours thereof can readily be made to comply with planning policy.

Pipelines are usually buried throughout. The present scheme is no exception. The normal policy of full land reinstatement is adopted so that quite soon following construction there will be no visible indication of the pipeline's existence.

Rivers have many functions. In addition to the various life-forms which they directly and indirectly support, e.g., fish, plants and birds, they have many aesthetic and amenity functions. A full appreciation of these for any river is needed before abstraction rules can be specified. This may, for example, include an added amount determined by the needs of ecosystems at specific times of the year, for example if migratory salmonids are expected.

The economics of run-of-river hydro schemes favours projects based on the higher flows more often available in winter rather than the lower flows more typical of summer. Hence at least 70% of the energy produced annually will usually be generated in the winter six months (October-March inclusive), and most of the remainder occurs during wetter summer periods. In total, generation at either maximum or reduced power occupies about 75% of the year. Much of the non-operating time is in dry periods each of which lasts a few weeks, usually in May, June or July.

Abstraction is therefore closely associated with wet weather and ceases a week or so after heavy rain occurs, i.e., long before drought conditions set in. The aesthetic, ecological and social effects of a hydro scheme on the Loughadeery River operated in this way are considered in this report.

Upland Developments

The land surface is affected by a wide range of developments, some of which like forestry and urbanisation stand out in the landscape. Transport systems create linear features, prominent amongst which are trunk roads and high voltage transmission systems. Whereas upland areas are more affected by forestry and power lines, road and rail routes are few and urban developments mostly small, long-established and accepted.

This infrastructure also commonly includes networks of buried water, gas and other supply pipelines, water treatment and pumping stations, footpaths, telephone and low voltage power lines and field and property boundary walls. Less common are water supply reservoirs and quarries though these tend to occur in upland areas, as in the present case.

All of Ireland's uplands have to some extent been affected by development. Areas of natural woodland have been extensively cleared, low-grade agriculture established and in some cases abandoned, farm buildings and boundary walls erected and often allowed to decay, and water supply and other infrastructure services extensively installed.

Since new run-of-river hydro schemes have few visible features they need not intrude into their landscape settings. However, they may not be economic if ready access to a public road and electrical network is not available. The landscapes of locations suited to their development will therefore usually contain these features.

Suitably designed, the weir will fit into the character of the area and the route of the buried pipeline will not be discernable when land reinstatement measures have taken effect. The powerhouse and its access track will be additions unless suitable services already exist. However, since these are on valley floors they are more likely to lie amongst other developments.

Good design practice including the application of sensitive construction methods minimises the landscape consequences of these schemes. The tasks are conventional and with sensitive design the finished product should merge readily into existing upland environments.

1. INTRODUCTION

1.1 Background

It is proposed to construct a run-of-river hydro-power scheme on the Loughadeery River near Killybegs in County Donegal. The scheme will have a generating capacity of 600kW. Its technical and operational details are described in Chapters 2 and 4 respectively. The physical conditions relevant to constructing and operating it are addressed in Chapters 3 and 4 and its wider environmental effects are set out in Chapters 5-12. Chapter 13 identifies the water abstraction regime which most fully accords with the need to accommodate these factors.

Government policy is to encourage the production of energy from renewable sources (Ref. 1). This is being achieved through the 'Alternative Energy Requirements Scheme'. This commitment applies to energy sources demonstrated to be technically and economically viable and environmentally acceptable. Each project must be designed to suit local conditions.

The Government's favourable view of hydro power is mirrored by the European Union and governments generally (Ref. 2). The planning authorities have also specified the basis on which they will assess hydro schemes. The position adopted by Donegal County Council is reviewed in Section 1.2d and Annex A.

Most worldwide experience with hydro-power relates to projects involving reservoir storage. The trend now, however, is towards 'run-of-river' schemes like the proposed Loughadeery River project which operate according to the river flow prevailing at any time rather than in response to the daily pattern of demand of electricity consumers. In addition to the absence of reservoirs, an important environmental effect of this is that they do not create the unnatural releases of water at specific times each day which are a characteristic of many reservoir-based schemes. This alternative operating method has become viable as electricity networks have grown into national systems. The evidence assembled about the effects of reservoirs and scheduled daily releases, much of which tends to be critical of hydro schemes which include that feature, is therefore of little value to the design, planning and assessment of run-of-river schemes.

Under the provisions of the Environmental Protection Agency Act, 1992 (Ref. 4), planning authorities may require that Environmental Impact Statements (EISs) are submitted for projects deemed likely to have a significant effect on the environment. The present report meets the requirements of that legislation.

1.2 Statutory Bodies

1.2a The Office of Public Works (OPW)

The OPW's responsibility for developments of the type proposed relates to any implications which it may have for land drainage and flooding, and for its implications for cultural heritage. These subjects are addressed in Section 4.7 and Chapter 9, following consideration of the effects of the proposed abstraction regime on flows downstream of the intake weir for the scheme.

Construction issues are set out in Annex B. The possible consequences of the works for existing arterial drainage systems are addressed.

1.2b The Department of the Marine and Natural Resources (DMNR)

The DMNR has responsibility for the Central and Regional Fishery Boards. The proposed scheme lies in the area for which the Northern Regional Fishery Board (NRFB) has jurisdiction. The measures taken during the design phase of the scheme to establish its implications for the fisheries resource of the affected reach of the Loughadeery River are set out in Section 7.1.

1.2c Environment Protection Agency (EPA)

The EPA's responsibility was referred to in Section 1.1 above and is detailed in Ref. 4.

The EPA's policy is to support the use of small-scale hydro schemes to generate electricity other than in cases where such schemes are likely to be significantly detrimental to landscape quality or wildlife.

The 1992 (Rio) Convention on Biological Diversity is being implemented by the Government through action plans for threatened habitats and species (Annex C). The EPA has a central role in carrying out these plans for habitats and species in Ireland (Ref. 5).

Biodiversity is perhaps the most complex of all the issues facing man, namely how to meet the needs of a growing human population without compromising the variety and abundance of plants and animals and their habitats.

The implications of the proposed hydro-power scheme for key biodiversity sites and species are reviewed in Chapters 6 and 7 in the light of the results of the surveys of the area which the scheme could in some way influence. A more general statement on the effects of small hydro schemes on the principles behind biodiversity is given in Annex C.

1.2d Donegal County Council (DCC)

The Loughadeery Hydro-Power Scheme lies in County Donegal so is subject to the particular planning considerations which apply in that County (Ref. 3). A key commitment of DCC is to protect the landscape and natural beauty of its area and make suitable provision for its quiet enjoyment by the public.

The DCC's policy on renewable energy is set out in its County's Draft Development Plan (Ref. 3). A summary of the principal Clauses pertinent to the proposed project is given in Annex A.

1.3 Structure of this Environmental Impact Statement (EIS)

This EIS reports on the pre- and post-construction regimes of both the river and the pipe route where the latter deviates from the river, not only from the points where water enters and leaves the pipeline but also beyond these points. The basic change engendered by the scheme is to aspects of the river regime. It is therefore essential that both the established regime, however 'natural' it may be, and that which could replace it according to the way in which the scheme is designed, constructed and operated are clearly understood.

The scope which exists to vary the design, construction and operation of each part of the scheme emphasises the need to identify the significant issues and how best to achieve each within an overall solution. The procedure used to explain the steps taken to realise this goal in the case of the Loughadeery Scheme is as follows.

1. The necessary elements of a run-of-river scheme are first described (Chapter 2). A preliminary design scheme is set out, making assumptions about water intake arrangements, maximum abstraction rate, pipeline diameter, powerhouse location and outfall geometry;

2. The existing regime of the Loughadeery River is described in Section 4.2, based on the results of a continuous flow monitoring programme. The effects of the preliminary water abstraction procedure proposed in Section 4.1 on the natural sequence of flows and the associated features of the river regime are covered in subsequent Sections of Chapter 4;

3. Chapters 5-12 deal individually with specific environmental subjects, initially by reporting prevailing conditions, followed by the implications of the proposed scheme for those conditions, the consequences thereupon and the measures proposed for limiting any perceived adverse effects;

4. A summary of the various mitigation measures identified on a topic-by-topic basis in Chapters 5-12 is assembled in Chapter 13, where attention is given to how the relevant details of the basic scheme and its effects on river flow identified in Chapters 2 and 4 may be amended to either reduce or remove those features of the scheme deemed to merit improvement. The design changes which make up the revised project are then listed.

2. PROJECT DESCRIPTION

2.1 Main Details of Project

The site for the Loughadeery Hydro-Power Scheme is at Carricknamoghil, about 4km north of Killybegs. Figure 1 shows this area and Figure 1a indicates the locations of the main elements of the projecl. The intake location is from one of the pools of the stepped overflow spillway on Lough Adeery Reservoir (Plates 1&2). The main features of the pipe route are shown in Plates 3-8 and the position preferred and general details of the combined powerhouse and outfall are shown in Plate 9 and Figures 4-7. The Frontispiece shows a similar powerhouse in Donegal.

The area as a whole is open moorland in a laterally flat valley which slopes gently south-eastwards. The Lough Adeery water supply reservoir occupies the site of a former natural lake which has been deepened and extended in area by the construction of a dam. The reservoir intercepts the many streams which fed the former lake. It is also supplied by flow diverted from a nearby river, the residue of which continues down that river's former course to join the Loughadeery River above its confluence with the Strager River. (The Bungosteen River, the main freshwater discharge to Killybegs Harbour, is formed by these two main tributaries.) The catchment of the Loughadeery River attracts few walkers and climbers (Chapters 5 and 10).

No part of the finished scheme will be readily visible. The intake weir will not be discernible, lying within the spillway of Loughadeery Dam, the pipeline will be buried throughout its length, and the powerhouse will be closely associated with the water treatment works associated with Island Seafoods' factory. The scheme has therefore been designed to blend and function in sympathy with its environment.

The principal components of the project are:

a) a low weir across the spillway from where the turbine will be supplied whenever the weir conveying excess flow down the spillway from the reservoir is discharging at a sufficient rate to operate the turbine (Figure 2);

b) a shut-off valve in a chamber at the pipeline intake (Figure 2);

c) a pipeline - buried (Figure 3);

d) anchorages for the pipeline - buried (Figure 3):

e) a powerhouse (Figures 4-6);

f) an outfall, closely related to the powerhouse (Figure 7);

g) a grid connection (task for ESB);

h) a contractor's compound.

All power generating and ESB sub-station equipment will be contained in the poweerhouse..

2.2 Description of Components

2.2a Weir (Figure 2)

The weir arrangement meets abstraction requirements. A low weir built just below the second step down the spillway of the Loughadeery Dam (Plate 1) will determine the water level above that step according to river flow; by slightly raising the associated wall height it will not cause localised flooding. When the spillway flow, i.e., pond level, is sufficient, the turbine will abstract from the pool formed by the weir, a process which will respond as the overflow rate from the reservoir increases until the capacity of the turbine is met. All additional flow will then pass down the spillway.

A permanent screen with 10mm openings will cover the intake to the pipeline to exclude any coarse sediments and river-borne debris carried down the spillway, also any fish washed out of the reservoir.. No special provision for upstream fish passage is proposed because any which should climb the spillway from the river downstream could not, as at present, reach the reservoir.

2.2b Intake to Pipeline (Figure 2)

The intake to the pipeline will be submerged to prevent air from being drawn into the pipeline. A water level sensor in the pool will ensure that the correct flow is fed to the turbine. It will also detect blockage of the screen. This information will pass to the control unit in the powerhouse by cable laid in a duct buried alongside the pipeline.

2.2c Pipeline (Figure 1a & 3)

The diameter of the 1830m long pipeline will be 600mm (about 24 inches). Either PVC or GRP (glass reinforced plastic) pipe could be used. These materials have the benefit of light weight. The pipeline will be secured by buried concrete anchorages.

Much of the route comprises shallow soils over bedrock. The extent and depth of the soils has been established by probing (Section 3.2b). The rock to be moved mainly comprises loose material.

Surface reinstatement following pipe laying, anchoring and buffering to prevent the pipe trench becoming a water pathway will be carried out as described in Annex B. The pipeline and its anchorages will accord with manufacturers' standards. All construction work will be closely supervised by professional staff. Reinstatement of the pipe route will be carried out as each section of the pipeline is backfilled, following the procedures set out in Section 6.3a.

2.2d Powerhouse (Figures 4-6)

The powerhouse will contain the turbine/generator unit and the control and metering equipment. The building will comprise a reinforced concrete base slab (required to secure the generating plant) with rendered block walls and a standard pitched and tiled roof. The external finish including doors, ventilation units and drainageware will comply with the planning requirements of Donegal County Council. The provisions made for ventilating the building will ensure that

external noise levels meet planning conditions (Section 12). The Frontispiece shows a similar powerhouse operating in County Donegal.

Grid connection is the primary responsibility of ESB and will be subject to their statutory procedures.

2.2e Outfall Structure (Figure 7)

The discharge from the powerhouse will return to the river via a structure which releases it at river level without causing scour or adversely affecting fish movement (Section 7.2b). A permanent screen with 10mm openings will exclude fish.

The river bank over the outfall will be reinstated.

2.2f Temporary Track and Contractor's Compound

The whole site is well served by the old road from Killybegs to Ardara, the upper section including the intake via a spur off it south of Carricknamoghil and the main section including the powerhouse and outfall from Island Seafoods' site entrance at Bungosteen Bridge (Figure 1).

It is proposed that an area on Island Seafoods' property adjacent to the public road at Bungosteen Bridge will serve as the contractor's compound. Its base will be protected during the course of the works. All materials will be stored in this area until required for installation. A temporary pipe storage facility will be needed in the upper part of the site.

The pipeline will follow the route shown in Figure 1a. Tracked machine operations will be limited to this route. Vegetation and topsoil will be lifted from a 1.5m wide strip and stored prior to reinstatement. All lengths being actively worked will where necessary be fenced to exclude animals. Such lengths will normally not exceed 50m. A 'Construction Method Statement' is given in Annex B.

2.3 Power Generation

2.3a Generating Equipment (Figure 4)

The powerhouse will contain all components of the power generating system, namely the turbine/generator unit, transformer, switchgear and control equipment. The metering equipment (ESB's responsibility) will also be in the powerhouse. This accords with an important criterion in the Donegal County Draft Development Plan (Ref. 3, Clause 2.2.5 - see Annex A).

The turbine will be of the 'reaction' type suited to medium operating pressures. It will be directly coupled to a synchronous 3-phase generator producing electricity at 415 volts for supply to ESB's network.

A maximum power output of 600kW is intended. In an average rainfall year, the amount of energy generated will be about 2 million units (2 million kWh, or 2GWh). By the way in which electricity networks operate, this energy would be used locally, hence reducing the need to import

from further afield. The scheme would therefore have a community function, supporting local services as advocated by DCC (Ref. 3). About 15% more energy would be generated in a wet year and 15% less when conditions are much drier than average, giving an essential degree of annual consistency. The connection to ESB's network will be subject to statutory procedures.

The way in which the project will operate according to the flow passing down the spillway is set out in Section 4.3. The environmental effects of this abstraction are then considered, including (Chapter 13) details of how it should be modified to make it compatible with specific constraints.

2.3b Project Maintenance and Lifetime

By monitoring the performance of the scheme continuously by telemetry, any faults will be detected immediately. All maintenance and general repairs will be carried out by well-trained locally-based personnel. Special work will be done by the technical representatives of the main suppliers of the equipment.

The generating equipment will either need to be refurbished or replaced after 40 years, when advantage will be taken of new materials and technology to further improve performance.

2.4 Project Regulation

2.4a Water Abstraction

Fisheries and conservation are the principal factors determining abstraction rates and volumes (Section 4.3). For example, project design includes screening the (intake and) outfall to exclude fish, and the discharge design limits the extent to which fish will be attracted to the outfall. Further information on these and related topics is given in Chapters 6-8.

2.4b Building Regulations

The powerhouse is a simple, conventional small single-storey building with rendered walls and a slated pitched roof. The design and construction of the building will comply with statutory building regulations and will satisfy the applicable fire safety requirements. All internal structural work will comply with building standards, and the exterior will be maintained in a colour and to a standard acceptable to DCC. The site will be drained to the outfall from the turbine.

2.4c Pipeline Construction

The pipeline and its bedding and anchorages will accord with relevant standards (Annex B). All construction work will be closely supervised by qualified staff. Standard pressure tests and pipeline inspection will be carried out.

The reinstatement of the route will be carefully supervised, with expert botanical advice to ensure that indigenous vegetation is re-established as quickly as possible. Any re-seeding which needs to be done will be carried out with the prior agreement of DCC.

2.5 Design Alternatives

The basic project has been selected from a number of ways of harnessing the energy potential of the site while ensuring that its implications accord with the constraints set out in Section 2.4.

2.5a Intake Location

The energy potential of a hydro scheme depends on its operating pressure and the water flow available. High pressures offer various economic advantages but to intercept a river high in its catchment has the disadvantages that the area contributing to the flow is less, the pipeline is long and access is often more difficult and visually obtrusive. The present site on the Loughadeery River offers a compromise between pressure and catchment area, and it has the added advantage that the intake may be located on the spillway which has no function other than to convey excess water from the reservoir, thereby saving the need for additional river works. .

2.5b Pipe Route

The selected pipe route is shown in Figure 1a. A primary requirement for an acceptable route is that it should at no point rise higher than the river level of the intake. However, where its elevation remains similar to that of the intake the pressure in it will be small and hence its unit cost (£/metre) will be less than where the pressure is higher. It follows that a steep gradient down to the powerhouse is to be preferred to a steep gradient down from the intake. In the present case the preferred pipe route, chosen for reasons of access and the opportunity to follow an existing former field ditch and bank (Plates 3&4) offers a steady grade throughout (Figure 3).

The short-term landscape implications of the pipe route have been carefully considered in selecting this alignment. Since by the flat nature of the site, work on the open hill face is unavoidable, immediate attention to reinstatement will be given. This applies throughout the route; all of which is visible from a wide though little populated area, but which with the exception of the crossing at Bungosteen Bridge is not readily seen from public roads.

2.5c Powerhouse and Outfall Location

Several possible sites for the powerhouse were compared. The principal factors considered were the visibility of the finished works in its setting, access to it for maintenance and various fishery requirements (Section 7.2). If located on the left (north) bank of the river, the pipeline would have to cross the river and access would then be more difficult. These constraints are avoided by locating it on the right (south) bank, where there are a number of possible sites within the limits of the property of Island Seafoods. The deciding factor was maximisation of the operating pressure (ref. 2.5a above), the additional cost of a longer pipeline being more than offset by extra power generating potential. Moreover, the technically best site at the limit of Island Seafoods' property means that the powerhouse will lie within the complex of structures which comprise the factory's water treatment plant, and its scale will be well within that of the plant. It will not therefore be a landscape feature in the view from either the public road at Bungosteen Bridge or the nearby properties along that road.

The preferred arrangement was the only one which satisfied all of the following considerations:

- fisheries - the results of specially commissioned surveys (Section 7.1c) showed that the lower reaches of the Loughadeery River serve as spawning and feeding grounds for indigenous brown trout but not for salmon. The NRFB's requirement that, wherever possible, abstracted water is returned to the river from which it was taken rather than to another watercourse is satisfied by the proposed arrangement;

- noise (Chapter 12) - the only properties in the immediate vicinity are 250m from the proposed powerhouse location; suitable preventative measures incorporated into the design of the powerhouse will ensure that no noise nuisance is caused;

- grid connection - by locating the powerhouse close the ESB's network where it enters Island Seafoods' treatment plant, a direct connection can be made;

- access - the site is close to the public road (Figure 1a).

3. PHYSICAL CATCHMENT CHARACTERISTICS

3.1 Catchment Area

The 10.5km^2 catchment area which drains (or in the case of the Balbane River is in part diverted) to Lough Adeery Reservoir is shown in Figure 1. An additional area of about 4km^2 (40%) contributes to flow in the river at the outfall from the hydro scheme.

The upland, western edge of the catchment is defined by a ridge whose high points rise to nearly 500mOD (Crocknapeast). The many upland streams which ultimately contribute to the main river fall steadily to an elevation of about 200mOD. The Loughadeery River then becomes meandering watercourse across relatively flat moorland of which a feature is areas of conifer forestry and which contains a number of shallow lake..

The main rivers are only mildly incised over much of their lengths, their gradients being controlled by frequent rock outcrops. Vegetation in the catchment is principally limited to upland grassland characteristic of this range of mountains, also the conifer forestry, part of which is cleared but not replanted (Chapter 6). The lower reach of the river down to the reservoir features effectively unbroken open moorland, a regime which continues downstream of the dam with the exception of one area of conifer forestry to the north of the valley and very limited deciduous woodland in places along river banks and on fence lines (Plates 5, 8&9). .

3.2 Geology (Refs. 6-11)

Reconnaissance investigation and assessment of bedrock and overburden geology was undertaken over the area which the scheme could occupy according to its layout (Figure 8).

The assessment involved a review of published data and a site survey. The survey comprised a study of the bedrock geology and preliminary investigations and observations of the likely nature of ground conditions (overburden) which will be encountered on trenching for pipe laying.

Investigations included estimation of depths of overburden by depth probing using a 15mm diameter steel bar driven to refusal with a sledge hammer. The results obtained from this work are a guide to overburden depths.

3.2a Bedrock

The area surveyed is underlain by a formation of the Dalradian Supergroup of late Pre-Cambrian age, the Termon Formation. The formation consists of semi-pelitic schists interbedded with thin units of dolomitic marble and lenses of psammite.

These highly metamorphosed rocks are believed to represent earlier shelf facies sediments (mudstones and siltstones) interbedded with sandstones.

A major north-east south-west trending fault, the Killbegs fault occurs to the south of the proposed pipeline route.

Outcrop is poorly developed along the proposed route. Despite this, bedrock may be encountered in a number of locations and may cause a problem when excavating for the pipeline. Avoiding breaks in slope will lessen the likelihood of encountering bedrock.

3.2b Overburden (Figure 8)

Descriptions and approximate depths to base of overburden (based on driving a 15mm steel bar to refusal) are shown in Table 1. Approximate locations of probing areas are shown in Figure 8, numbered A to P. For ease of description the proposed route of the pipeline has been divided into six sections numbered 1 to 6 (Figure 8).

Section 1.

Below the intake area (Plate 10), overburden c. 1m thick is exposed in the southern bank of the river (Plate 11). Nearby, bedrock is exposed in the riverbank, with the area A below the intake also being very rocky, with angular/sub-angular boulders been strewn around (Plate 10).

The overburden exposed in the riverbank consists of a thick peaty layer (c.0.3m) draped over 0.3-0.5m of grey marl, which in turn is interbedded with fine-medium silty till, the matrix of which consists of micaceous silty material (which has probably been eroded from the underlying schists). The till also comprises cobbles of schist bedrock.

From the intake the route follows a relatively flat lying area with refusal depths of >1m being encountered at B in a well developed peat. A range of refusal depths of 0.5->1m in peat overlying till were encountered across this part of the section (Plate 12).

From B the route follows a relatively flat lying area to C where it crosses over old worked out turf banks.

A number of probes were driven to refusal depths of between 0.3-1m around C, with c. 0.3m of peat overlying till. From C the route crosses over a bank (Plate 13) just before a bend in the bank and keeps between two parallel banks (old field boundaries) to just before the Island Seafoods' factory.

The overburden thickness thins towards the bend in the bank, from >1m to c.0.3-0.5m.

Keeping away from breaks in slope and humps in the topography will lessen the likelihood of encountering bedrock and/or large boulders when excavating the pipeline (Plate 14).

Bedrock is exposed close to where the route crosses the bank at D. Approximately 0.3m of peat and a medium-coarse till are exposed by a small stream at D (Plate 15).

Section 2

This part of the route is characterised by an undulating topography, with a thin layer of overburden being draped over boulders and/or bedrock (Plate 15). Keeping below a break in slope should lessen the likelihood of encountering bedrock when excavating the pipeline.

Probing at E met with refusal depths of c. 0.3m of peat overlying c. 0.3m of till and a very thin peaty soil (<0.1m) overlying c. 0.3m of rustic coloured overburden on bedrock exposed by a stream at F (Plate 16). Probing between the undulations in the topography along this section met with refusal depths of c. 03-0.7m in a soft peaty overburden.

Section 3

This section is flatter, less undulating with refusal depths indicating a more uniform overburden thickness, especially around G where depths to refusal of >1m in peat (blanket bog) were encountered (Plate 17). A small bank crosses the proposed route at H where boulders are observed at the surface. Here depths of refusal range between 0.3-0.5m.

Immediately south of H, depths in excess of 1m (peat) were encountered. A small stream crosses the proposed route south of H exposing >1m of peat overlying bedrock.

Keeping the pipeline to the eastern field bank (old field boundary) along this part of the route should lessen the likelihood of encountering bedrock.

Towards the end of this section at I, depths to refusal of 0.6->1m in peat overlying boulders (bedrock?) were encountered.

Section 4 (Plate 18)

From south of location I this section becomes more like section 2, with an increased likelihood of encountering large boulders and/or bedrock close to the surface.

Probing at J and K encountered refusal depths of 0.2-0.6m in a thin peaty soil overlying boulders. Close to J, bedrock is likely to be encountered when excavating the pipeline.

Section 5

Between K and L a relatively steep break in slope is encountered, with bedrock (probable) being exposed. A thin layer of soil (c. 0.2-0.3m) was encountered close to a small tree below the break in slope (Plate 19). South of this break in slope the route crosses a small grassy field before crossing a double-bank/lane and another small field where refusal depths of c. 0.4m of peaty soil over a stiff till were recorded.

Variable thicknesses of overburden were encountered between M and N as the route starts to bend around the factory, with 0.3-0.6m of peat over till being encountered at M and >1m of overburden being exposed by a stream at N (Plate 20). The overburden consists of c. 0.3m of well developed medium, brown soil overlying c. 0.4m of soft grey till, itself consisting of a mica rich matrix and small angular clasts 1-2cm in size.

Section 6

The final part of the route to the outfall crosses a small stream at N. Depths to refusal of c. 0.3m were encountered at O (Plate 21).

Cutting through a large earthen bank (at least 3m high) which surrounds the factory and following the bank on its eastern side (within the factory compound) to the road would lessen interference with a nearby dwelling house and also reduce the likelihood of encountering bedrock along this part of the route.

On crossing the road the route follows the bottom of a man-made bank to the outfall (Plate 22). Probing reached depths of c. 0.2-0.4m in a stiff, brown soil/till around P

At the outfall, bedrock is exposed in the riverbed c. 2m below the level of the field.

3.3 Summary (Table 1)

Section 1: Should offer relatively easy digging if undulating topography is avoided. Overburden depths of between c. 0.3 - >1m are likely to be encountered.

Section 2: Rocky, with bedrock close to surface in a number of areas. As with section 1, keeping away from undulating topography should lessen the likelihood of encountering bedrock when excavating for the pipeline. Overburden depths of c.0.3-0.7m are likely to be encountered.

Section 3: Generally underlain by peat (>1m deep) and should offer relatively easy digging. Bedrock may be encountered at H.

Section 4: Similar to section 2, rocky with boulders and/or bedrock likely to be close to surface. Overburden depths of c. 0.2-0.6m are likely to be encountered.

Section 5: A sharp break marks the start of section 5, where bedrock is likely to be encountered. Refusal depths of c. 0.3->1m were recorded. It is recommended that some detailed site investigation work be carried over this section to determine depth to bedrock.

Section 6: Cutting through the earthen bank which runs down the western side of the factory, crossing the road and following the bottom of another bank along the eastern side of a gently sloping field to the outfall should lessen the likelihood of encountering bedrock. Bedrock is exposed in the river below the outfall.

3.4 Land Use

Much of the catchment comprises unimproved upland grassland which supports a limited population of sheep with some conifer forestry. The upper faces of the catchment feature extensive exposures of rock. The wide, open topography of the catchment provides distant views in all directions, the hills to the west forming a prominent component of a largely unspectacular scenery in which the water intake tower at the dam is, as at reservoirs elsewhere, a characteristic and distinctive man-made intrusion amongst few visible artifacts.

TABLE 1	SUMMARY OF OVERBURDEN TYPE FROM PROBING

SECTION No.	PROBE AREA	APPROX. DEPTH TO REFUSAL (m)	OVERBURDEN TYPE	COMMENTS
1	A	1	Peat, marl, till	Bedrock exposed in river
	B	0.5 - >1	Peat over till	Flat lying area
	C	0.3 - 1	Peat over till	Flat lying area
	D	0.3	Peat over medium - coarse till	Bedrock exposed close by
2	E	0.6	Peat over till	Undulating topography
	F	0.4	Thin peaty soil rustic coloured till	Undulating topography
	-	0.3 - 0.7	Peaty	Between undulations in topography
3	G	>1	Peat	Flatter section, blanket bog
	H	0.3 - 0.5 >1	Peat over boulders Peat	Boulders exposed Blanket bog
	I	0.6 - >1	Peat	Overlying boulders/bedrock
4	J	0.2 - 0.6	Thin peaty soil over probably boulders	Bedrock expected close to surface
	K	0.2 - 0.6	Thin peaty soil over probable boulders	Undulating topography
5	L	0.2 - 0.4	Thin peaty soil over stiff till	Below steep slope
	M	0.3 - 0.6	Peat over till	Grassy fields
	N	>1	Brown soil over stiff grey till	Grassy fields
6	O	0.3	Brown soil	Grassy field
	P	0.2 - 0.4	Stiff brown soil - till	Grassy field Bedrock exposed in river close to outfall

(Depths to refusal are an average or a range as a number of probes were driven to refusal at every location lettered)

4. RIVER FLOW REGIME AND CONSTRAINTS ON WATER ABSTRACTION

4.1 Operating Characteristics of Run-of-River Hydro Schemes

The general operating principles of run-of-river schemes were outlined in Section 1.1. These principles are translated in the present Chapter into a **basic** abstraction policy formulated essentially on hydrological considerations, i.e., largely without regard for other considerations. This policy is then used to assess the environmental implications of the scheme if operated in that way and hence how that policy needs amendment to lessen or remove any perceived adverse effects. The **recommended** abstraction policy having regard for all considerations is drawn together and presented in Chapter 13.

Flow rates in upland rivers rise and fall quite quickly due to the combined effects of relatively small and rocky catchments, highly variable rainfall and steep surface gradients. Figure 9 shows examples of such flows in the Loughadeery River. The steep rise and initially steep fall lead to an extended recession when the flow rate declines progressively more slowly. The time interval between storms therefore largely determines the flow rate when the next storm occurs.

Figure 9 suggest that the aggregated time for which any flow is exceeded during, say, a month or year is much less for higher than for lower flows. This 'flow-duration' relationship showing the proportion of a year during which any flow in the Loughadeery River is exceeded is indicated in Figure 10. It shows both the proportion of that period during which, for example, a flow rate chosen as the maximum for power generation is exceeded and the opportunity for energy to be produced at reduced levels.

The **basic** abstraction policy for run-of-river hydro schemes is founded on the assumptions that:

1. If maximum power is produced for say 25% of the year, the period following each storm event for which this output will be maintained will typically be 1½-2½ days, and there will be 40-50 such periods annually;

2. The abstraction rate required for maximum power is only a small proportion of high flows (Figure 10). If a 'high flow' is taken to be that exceeded for an aggregated 5% of an average year, i.e., about 440 hours, each of these 40-50 events will last for about 10 hours (Figure 9).

3. Power output reduces when the flow falls below the peak abstraction rate (the need to maintain a Residual Flow downstream of the intake is considered below). Without further rainfall, each period of reducing power will typically last for about seven days before generation ceases. During that period the associated output is equivalent to about three days at full power. Part-load generation will therefore occur for 45% of the year.

4. No abstraction occurs when the natural flow falls below about 20% of the annual average value, a situation in upland rivers which typically prevails for about 25% of the year.

Average monthly rainfall and evapotranspiration, and hence by subtraction runoff depths, for the Loughadeery catchment estimated from national statistics are shown in Figure 11. Since large percentage variations in monthly rainfall (and hence runoff) commonly occur from year-to-year, particularly in the summer months (April-September), this will be reflected in the year-by-year monthly distribution of power generation. A strong wintertime bias when generation is relatively continuous but with little generation in some summer months is normal, at least 65% of annual output occurring in the winter period.

The Residual Flow (RF) which is released into the river at the foot of the dam independently of flow down the spillway is required for a number of environmental reasons specified in Chapters 6-8. To this will be added flow which passes down the spillway past the intake, i.e., as for other run-of-river hydro schemes the proposed project will create the full range of natural flow conditions, namely:

Since high river flows are many times greater than the maximum abstraction rate, these (and their associated characteristics) will continue downstream with little change;

As the natural flow falls from the peak, the constant abstraction rate initially has little effect on the magnitude of flows passing downstream but this effect progressively increases as the abstraction rate becomes a more significant proportion of the total available. The duration in each peak flow event for which any flow rate is exceeded is therefore reduced more for lower than for higher rates;

When abstraction ceases, the natural flow continues downstream unaltered.

Abstraction will have no effect on flows upstream of the spillway and downstream of the outfall. The substantial additional flow entering the river between intake and outfall from tributaries and groundwater progressively lessen the significance of abstraction along that reach.

Important environmental factors also need to be taken into account in determining policy, for example the requirements of fisheries, riparian plants (those dependent on some feature of the river regime, e.g., level, splash, spray) and the aesthetics of waterfalls. These introduce a range of factors such as the time of year when relevant fisheries issues apply and the times of day and year and the visibility needed for waterfalls to be landscape features. Each is considered according to its relevance to the Loughadeery project in the Chapters which follow. The operating policy set out in Chapter 13 is based on the overall assessment.

4.2 River Regime

The flow regime of the Lough Loughadeery River has been determined from two complementary data sets, namely national records plus gauging made when the reservoir was designed giving average annual and monthly statistics, and measurements in the river to establish its short-term response to rainfall (e.g., Figure 8). Together these comprised:

1. From national statistics, the average annual rainfall for the Loughadeery Reservoir is estimated from Meteorological Service and other data sources to be about 3000mm (Ref. 12). A typical monthly distribution is given in Figure 10. Some water returns to the

atmosphere as evaporation and as transpiration from vegetation (Figure 10). This is estimated to total about 420mm annually, leaving about 1380mm as river flow. Over the 10.5 square kilometre catchment, this is equivalent to an average annual runoff of 0.85 cubic metres per second (cumecs), distributed as in Figure 10.

2. Recording water levels in the river and converting them to flows by the conventional procedure of preparing a rating curve from the simultaneous measurement of flow and level for a number of flows spread over a suitably wide range (Figure 11 and Annex D);

The individual data points shown in Figure 11 are believed to be accurate to within 15%, in which case the accuracy of the interpreted curve will be within 10%. When corrected for rainfall over the 12-month period on which Figure 9 is based compared with long-term annual average rainfall, the average annual flow at the gauging site determined from this record is 1.1cumecs. This value is about 35% more than for the intake (Section 3.1), i.e., the calculated flow at the intake is about 0.81cumecs, allowing for abstraction at the reservoir. This compares with 0.85 cumecs determined from national statistics. The latter is taken here to be the natural resource.

The average annual runoff says nothing about temporal variations, for example the height of peaks and duration of low flows. The proposed scheme will operate according to all the demands on the flow prevailing at any time (Section 4.1). The on-site data measurements demonstrate catchment response to rainfall; their use in this EIS is limited to this purpose.

4.3 Effects of Abstraction Policy on River Regimes and Flow Rates

The environmental constraints on abstraction referred to in Section 4.1 are addressed in Chapters 6-8 and are reviewed collectively in Chapter 13 in order to formulate Abstraction Policy.

4.3a Hydrological Considerations

From hydrological considerations alone the **basic** abstraction policy referred to in Section 4.1 as input to the assembly of environmental information are:

the maximum abstraction rate shall be 0.90cumecs, close to the estimated average annual flow entering the reservoir;

abstraction shall cease when the flow available to the turbine falls below 10% of this value (taken to be 0.10 cumecs)

Although abstraction reduces the flow in the affected reach at any time, the rate which would then have existed will still do so but will occur sooner after the flood peak. Apart from the highest flows, the flow range occurring in each storm event and the form of the natural recession will not be affected. Local hydrological and hydraulic features such as groundwater levels and splashing will therefore still feature. Any change will be greatest close to the intake and will reduce further downstream as groundwater and tributary streams add to the flow. The total catchment area contributing to the river at the outfall increases the flow by about 30% above that approaching the intake. If the flow which would have passed the intake at any instant is reduced by, say, 50%, the corresponding reduction upstream of the outfall would then be about 38%.

This proposed abstraction policy means that high flows will continue to occur as often as they would have done had no abstraction taken place. However, the duration of each period and hence that of the associated submergence and splashing/spray will be reduced, though less so at higher flows because the relative magnitude of the amount then removed is much less.

4.3b Wetting Effects

The relationship between water depth and flow rate in upland channels is largely determined by the control exerted by rock features, particularly when flows are low. Flow rate increases more quickly with increasing depth when rocks are covered. Observations show that since the flow at this threshold is usually well above the maximum abstraction rate, the greater water depths, widths, wetted areas, velocities and sediment transport capacities associated with high flows will be little affected by the proposed abstraction regime.

The data shown in Figure 11 allow changes in depth associated with changes in flow rate to be estimated . The proposed abstraction policy reduces water level by about:

20mm at high flows;

150mm when the flow is just sufficient for full power output to be sustained.

a progressively reducing amount down to about 20mm just before generation ceases;

zero at lower flows (no generation).

The depths and associated flow patterns occurring during abstraction are essentially natural, the only difference being that, had the flow not been reduced, each flow rate (i.e., water level) would have occurred a short time later. Abstraction therefore brings forward the time when flows fall from one level to another.

These changes occur shortly after heavy rain, when both the river flow and surface and near-surface water levels close to the river are high. Hence when river flow is sufficient for abstraction, the water regime close to and in the river will reflect the short time since the recent storm.

If generation is tied absolutely to flow it will occur in response to all storms. Abstraction policy must also consider the ecological significance of wetting due to isolated storms (Section 6.2). The proposed method of turbine operation would limit abstraction from isolated storms which follow extended dry periods. Depending on the size of each storm, abstraction could deprive the river system of the full benefit of that 'flush', or wetting event. Because of the potential ecological importance of that event, it is intended that when there is a period of at least 14 days without sufficient flow to generate, the next start-up will be delayed for 6 hours from the time when it would otherwise have commenced. Figure 8 shows that this is a sufficient period for the natural flow to pass its maximum in response to an isolated storm, hence the full wetting process will then occur.

4.3c Humidity

Upland valleys in areas of high rainfall tend to be relatively humid, especially when they are narrow and have extensive tree cover. Atmospheric moisture derives from a number of sources, principal amongst which is evaporation from groundwater emerging from rock strata comprising valley walls. Compared with river flows, this is a steady source of water which only reduces after many weeks without meaningful rain. It seldom fails.

Transpiration from vegetation can be another substantial local source of atmospheric moisture though lower air temperatures in upland valleys reduce this effect.

The prevailing meteorological regime also has a profound effect on humidity levels. In addition to the presence or absence of rainfall, factors such as wind speed and direction, air temperature and general ambient humidity influence conditions. However, essential differences between the environments created by a standard Stevenson screen at exposed meteorological stations and those existing in sheltered river valleys raise doubts about the use of national data to describe conditions in these localised environments.

In view of the importance of upland valleys for lower plants and the expectation that humidity is a determinand of their regimes, a programme of monitoring in conditions representing those in the more sheltered locations along the open and largely tree-free valley of the Lough Loughadeery River above the proposed intake point was set up. The initial results indicate that the two most important factors determining humidity in that situation are air temperature and the time since significant rainfall last occurred, i.e., the extent of groundwater depletion. River flow does not appear to be an important influence, hence the proposed abstraction pattern is not expected to modify local humidity materially.

4.4 Water Quality

No changes to the overall water quality regime are expected from the proposed abstraction policy. The river flow is naturally fairly acidic (pH less than x). No other contaminants have been identified. There neither is nor has been any mining in the catchment above the intake.

4.5 Water Temperature

River temperature depends in part on that of the ground through which water flows prior to entering the river, i.e., on earlier solar radiation levels and air temperatures, as well as on the air temperature to which the river is exposed. Opposing forces ensure that there is little change in water temperature along rivers. It is not expected that abstraction will affect this parameter.

4.6 Sediments

It is important to limit the mobilisation of sediments during construction work such that these do not enter the watercourse. This could happen at the intake and outfall, the two points at which directly associated river works occur. It could also happen when installing the pipe crossings of the main river and its small tributaries (Figure 1a).

The proposed working procedures having regard for this potentially sensitive issue are set out in Annex B, and reference to the environmental implications of elevated sediment loading in rivers is given in Section 6.2.

4.7 Waterfalls

There is only one small waterfall on the affected reach of the Loughadeery River and this is of no landscape significance. The succession of small falls which follow it also do not constitute landscape features.

4.8 Flooding and Land Drainage

One consequence of altering river levels is that the nearby groundwater regime could be affected, potentially impairing the efficiency of land drainage systems leading to flooding. Permanently raising average river level, e.g., by constructing a weir, may raise flood levels, causing more frequent and extensive inundation of adjacent areas. The proposed project will either have no effect on or will lower existing river levels, though changes will in all cases be small and will not extend more than a few metres out from the watercourse.

The slightly reduced river levels between intake and outfall resulting from abstraction will have an imperceptible effect on local groundwater levels, and none when flows are low.

At the outfall, the total flow which would have been present at any time will be reinstated when the abstracted water is returned. Downstream of the outfall the flooding and drainage regime will not be affected, and the arrangements proposed for discharging from the outfall will ensure that the prevailing risk of local flooding is not accentuated. Since highest river levels will not be altered, the flooding which occasionally occurs would not be affected. (The powerhouse is located well above the known level of flooding.)

The procedures adopted for installing the buried pipeline will ensure that any natural and existing artificial sub-surface drainage paths intercepted will be reinstated (Annex B).

4.9 Summary of Principal Environment-Related Hydrological Changes

The main conclusions reached in Chapter 4 about the potential effects of the project on the hydrological regime of the affected reach of the Loughadeery River are:

1. Each abstraction period follows significant rainfall and in the absence of further rain steadily decreases in amount after about 2 days and ceases after about 7 days;

2. The flow rates which continue down-river past the intake will be like those which would have occurred at a later time in the absence of abstraction, the difference in timing being a few hours when flows are high and a day or so when lower;

3. Whereas individual high flows are of short duration and relatively numerous, low flow periods are few and are necessarily protracted to give time for the flow to fall that low. The bias of rainfall towards the winter means that most high flow

events occur at that time. Conversely, most periods of low flow occur in summer.

4. Hence whereas the collective duration of high flows which together make up 5% of the year (about 18 days) comprise a large number of isolated events, the lowest flow events which aggregate to a similar period are few in number.

5. The river-related stresses affecting dependent plant and animal communities tend to occur during the lower 10% of flows (36 days), partly because the flow is then low but also because of the time without significant rainfall needed for the flow to reach that level. The proposed abstraction specification will ensure that this flow is exceeded during the relatively short generating period following each storm event.

Whereas reference to average annual flow rates is appropriate when designing run-of-river hydro and other water resource projects, it is not instructive in the assessment of issues of conservation importance where shorter duration and especially low flow conditions in summer are more likely to matter. In particular, whereas water resource issues relate principally to water volumes, conservation issues are mainly determined by durations. The fact that the durations of relatively constant hydrological conditions are most when flows are least is therefore particularly significant.

The significance of abstraction on flow rate progressively reduces below the intake. The total catchment area contributing at the outfall is nearly 40% more than that at the intake. The consequences of abstraction on river flows are therefore most immediately downstream of the intake, these progressively diminishing downstream.

5. HUMAN BEINGS

5.1 The Present Situation

5.1a The Local Community

The resident population in the immediate vicinity of the site is about 30 people, almost all of whom live close to the former main road from Killybegs to Ardara (Figure 1). The nearest town is Killybegs some 4km south; Ardara is 10km north and Donegal Town is 25km east. Most of the properties close to the site are of relatively recent construction; few are either active or former farmhouses. The local area creates few land-related jobs. Directly or indirectly, most of the community looks to the major fishing industry based at Killybegs for employment. By virtue of the relative geographical isolation of the port, a full range of engineering and support services is locally available, including transport. Tourism is also a substantial component of the income-producing potential of the area.

However, most visitors have targets in the coastal destinations of the south and west coast of this corner of the County Donegal. Few travel to inland locations, only using the roads over the high ground to reach other coastlines and towns. The well-being of the local community therefore bears substantially on the economic fortunes of the main local towns, most notable Killybegs. Clause 2.1.2 of Ref. 3 (Annex A) sets out the County Council's general intentions in this respect.

5.1b The Proposed Project

The all-up capital cost of the project will be about £0.5million. Much of this investment relates to the purchase of the pipeline and power generating equipment, specialised items likely to be supplied by companies outside the area. These purchases will not therefore have a direct effect on the local economy.

However, by virtue of the relatively small scale of the project, it is expected that the supply of ordinary building materials and standard construction plant will be obtained locally. The necessary construction skills are held by several contractors based within 20km of the site, hence the workforce is also likely to come from local resources.

Employment contracts will extend for up to 6-months. Those employed who are not resident locally (need not be more than two) will require accommodation. The level of commercial activity created by the scheme will be sufficient to be felt by the local economy.

5.2 Implications for People

5.2a During Construction

The scheme will have the following effects on local people:

a) up to twelve local construction workers will be employed during the six month programme (Annex B);

b) the small scale of the scheme means that local suppliers of building materials are likely to be preferred over nationally based companies;

c) local accommodation will be required for supervisory and specialist staff not based in the area;

c) some limited inconvenience to users of the old Killybegs-Ardara road (Figure 1) may occur (most of the work is located well off this road - Chapter 11):

at the start and end of the working day when up to five vehicles associated with the work use the public highway;

when equipment is being delivered, in particular the 150 pipe lengths likely to arrive in batches of about 16, i.e., some 10 loads;

d) over a ten-week period, any walkers using the undesignated track up the site will be guided around on-going pipeline installation work (Annex B);

No social disruption due to construction of the scheme is envisaged because of its location and the absence of residential and other developments in its immediate vicinity.

5.2b During Operation

a) electricity consumers in the area will be supplied from this source;

b) permanent local maintenance staff will be required (Annex B);

c) no noise or other environmental nuisance will result;

d) the scheme could be the forerunner of similar local projects, resulting in continued local employment and the provision of services as set out above.

No social disruption due to the operation of the scheme is envisaged because of its location and the absence of residential and other developments in its immediate vicinity

5.2c Wider Scale

This scheme could encourage the development of other hydro-power sites in the area, in which case much of this employment could be continued, producing a core of expertise whose skills will be in demand for projects of this type. The potential for further schemes is considerable. Experience with the construction and operation should benefit the economics of replication.

5.3 Mitigation Measures

The principal though limited implication of the scheme for most people, whether residents, suppliers or visitors, will be the effects of construction-related traffic on other local road users. This subject is addressed in Chapter 11, where the scale of the issue is put into perspective.

6. FLORA

6.1 Present Regime

The main physical features of the preferred pipeline route were described in Chapter 2 (Figure 1a).

The composition, distribution and abundance of riparian (river-related) plant communities depend on several aspects of the river regime, of which the most important are the time-variations of water flow rate (in particular levels and how these may create spray), substrate, temperature and water chemistry. In order to establish how the **basic** abstraction regime set out in Section 4.3a may affect flora dependent on the river, it is necessary to establish how the relevant features of the flow will be altered and the consequences thereof.

The construction work will mainly affect the pipeline corridor and the zone downstream of it which depends on the sub-surface movement of water across it. The general literature revealed nothing of direct interest about either the riparian (river-related) zone or the adjacent terrestrial area through which the pipeline would pass. Surveys were therefore made of the mosses and liverworts (bryophytes), lichens and higher plants present:

- within both the riparian zone and that immediately above it which may also depend on the presence of the river;

- along possible pipeline routes to establish information relevant to the specific conditions which pipeline work could affect so that the most suitable route, construction procedures and reinstatement measures could be planned.

6.2 Survey Details

Surveys of the streambed, the zone of flooding and a zone immediately above the flooding zone were carried out. A strip of ground extending to 5m either side of the streambed was surveyed.

The proposed pipe route traverses an area of marginal wet heath and blanket bog on hill slopes above the river channel for approximately 500m and then traverses semi-improved rush pasture and disturbed ground in the vicinity of Island Seafoods' factory to the outflow point just below Bungosteen Bridge. The site is not included in any nationally designated area, e.g., Natural Heritage Area or Special Area of Conservation.

6.2a Bryophytes (Figure 13)

The stretch was divided into four sections for detailed survey as follows:

1. The 'artificial' channel, below the reservoir outflow, constructed from natural materials (rock boulders and earth) and some wire netting

2. A waterfall, approximately 3m high, and the incised channel below the waterfall

3. An incised section with scattered trees

4. A tree-lined section adjacent to and below the factory

Also, the corridor was divided into four vertical zones as follows.

Bryophyte Zone 1: Submerged Zone. This is a difficult zone to define and its boundary is arbitrary since water levels fluctuate greatly. Most species of the submerged zone also grow on wet substrates such as seepage sites that are infrequently submerged or are even above the direct influence of the river (Refs. 13-15). Since water levels were relatively low at the time of survey, they were used to defined zone 1.

Bryophyte Zone 2: Lower Inundation Zone. This zone includes the lower rocks and boulders in and along the river and the semi-vegetated vertical or steeply sloping water-cut sections of banks. This zone is submerged during 'bank-full' flow.

Bryophyte Zone 3: Upper Inundation Zone. Bare rock and vegetated areas occur in this zone. It is only submerged during periods of peak flow.

Bryophyte Zone 4: Terrestrial Zone. This zone is never, or only as a result of exceptional storms, inundated. However, localised seepage from adjacent slopes can affect the zone.

In addition to recording the 'ground-based' bryophytes of the above zones, 'tree-based' species were also investigated. The trunks and branches of several of the trees within the corridor were examined up to 2.5m above ground level.

Many species were identified in the field but a number required inspection of microscopic detail for positive identification. All gatherings were kept in self-seal polythene bags and stored in a fridge until they could be identified. Identifications were made using a stereo microscope and a high-power microscope. The identification keys used were those of Smith (Ref. 13) for the mosses and Smith (Ref.14) and Paton (Ref. 15) for the liverworts. A few gatherings that were difficult to name were checked against specimens in the Herbarium of the Plant and Soil Science Department, University of Aberdeen or sent to British Bryological Society Referees.

A number of species require reproductive shoots to be present for them to be reliably identified. In these cases, progress through the identification keys is only possible when appropriate material is being examined (e.g. Jungermannia sp). No attempt was made to distinguish Polytrichum commune from P. formosum. Reliable separation of these two common species can require leaves to be sectioned. This is time-consuming and does not add to the value of the results.

The site status of each species along the surveyed corridor was assessed using the DAFOR (dominant, abundant, frequent, occasional, rare) frequency scale. Although the DAFOR scale is subjective and is sometimes difficult to apply to the less frequently occurring species and those that are difficult to identify, it gives a general indication of frequency that can be useful. The local status of a species, however, does not necessarily correspond to its national status.

There are difficulties in determining the national status of bryophyte species in Ireland. Two main reasons account for this difficulty. Firstly, the bryophyte flora of Ireland is comparatively under-recorded. Good progress has been made over the past few decades but much more information is still needed. Secondly, there is no standard or 'official' system for determining the status of Irish bryophyte species. In Britain, species recorded in 1-15 and 16-100 hectads (10km grid squares) are classed as nationally rare and nationally scarce, respectively. Since the land-area of Ireland is much less than that of Britain, these numbers may not be appropriate. Species known to occur in up to 15 hectads are regarded by the National Botanic Garden as rare (personal communication). However, Neil Lockhart of the Wildlife Service is putting together a draft Red Data Book for Ireland in which species recorded in up to 10 hectads since 1950 are classified as nationally rare Red Data species (personal communication). Both contacts confirmed that criteria have not been set for classing Irish bryophyte species as nationally scarce. Perhaps occurrence in up to 10 hectads is appropriate for classing species as rare in Ireland but occurrence in up to 100 hectads for classifying species as scarce may be too high a number, especially as bryophytes are under recorded in the country.

It could be argued that because of their geographical proximity and climatic similarity, Ireland and Britain should be viewed together for the purpose of assessing the status of bryophytes. However, whether bryologists eventually adopt an Ireland-based or a combined Ireland and Britain approach, some way of indicating the status of species recorded in this and in other river surveys is needed.

With the above points in mind and while acknowledging the somewhat arbitrary nature of such a classification, an indication of the status of bryophytes is given based on the numbers of hectads in which they have been recorded since 1950. The national status of each species was determined using Hill, Paton and Smith (Ref. 16) supplemented with on-line information for British distributions from the National Biodiversity Network. Not all of the categories below will be represented by the bryophytes of any one river, including the Loughaderry.

1. Species recorded in fewer than 10 hectads in Ireland and in 1-15, 16-100 and more than 100 hectads in Britain.

2. Species recorded in 11-100 hectads in Ireland (* denotes 11-15 hectads in Ireland) and in 1-15, 16-100 and more than 100 hectads in Britain.

Species recorded in more than 100 hectads in Ireland were not classified.

Those species with Oceanic and/or Atlantic status were determined using Hill and Preston (Ref. 17) and Ratcliffe (Ref. 18) respectively. Oceanic and Atlantic species have a predominantly western distribution in Ireland and Britain. The terms Oceanic and Atlantic are largely synonymous. The Oceanic classification, however, because it was produced 30 years after the Atlantic classification and is based on many more records, arguably is the more complete of the two. For continuity, both classifications are used in this report.

Nomenclature follows Blockeel and Long (Ref. 19).

6.2b Lichen Survey (Figure 14)

The lichen communities of freshwater habitats have only recently received serious attention through a series of papers and publications by Gilbert (Ref. 20), Gilbert & Giavarini (Refs. 21&22) and Gilbert, Giavarini and Orange (Ref. 23). The zonation scheme adopted for the current survey is based on stream studies carried out by Gilbert (Ref. 20), who identified four overlapping bands of lichen vegetation related to length of submergence. These were named:

1. Submerged (specialised true aquatic species),
2. Fluvial mesic (an amphibious zone often rich in species),
3. Fluvial xeric (a transitional zone combining weakly aquatic species and terrestrial lichens tolerant of submergence)
4. Fluvial terrestrial (streamside terrestrial lichens)

The vertical zonation of freshwater lichens may be viewed as a continuum but boundaries may occasionally become blurred due to local changes in topography or tree cover density. For example, species can move up into another zone where rock is slow drying because of factors such as shade, ground water seepage or in response to a higher than normal bryophyte cover. In gorges where water levels may quickly rise and fall the zonation pattern can become confusing. Otherwise, this zonation is consistent. Because of the specialised nature of the aquatic habitat, it regularly yields lichen species rarely recorded from other ecosystems.

The lichen epiphytes of trees or shrubs occurring 5m to either side of the watercourse involve different communities of species from those on rock or soil and therefore, require an alternative evaluation of their importance. Rose (Ref. 24) originally developed the concept of 'ancient woodland indicator' lichens to assess woodland quality. The standard measure, is the Revised Index of Ecological Continuity (RIEC) (Ref. 24). Based on 30 lichen species, the scale can be applied generally across UK woodland habitats and is an important tool when evaluating sites for biodiversity conservation. Regional indices have also been developed to improve accuracy across the rest of Britain. The New Index of Ecological Continuity (NIEC) based on 70 species, can be used on woodland sites in Ireland other than those in the extreme west where the West of Ireland Index of Ecological Continuity (WIIEC) is most appropriate. Both of these scales were employed. Lichen indicator species have been coded appropriately in the table. It is sufficient to understand that the coded lichen epiphytes indicate where currently, disturbance of habitat is, or has been minimal; high numbers suggest a long continuity of woodland conditions.

The survey involved sampling the full range of lichen habitats along the river corridor up to 5m either side of the riverbank, walking the full extent of accessible river corridor, making species lists, ecological and habitat notes and collecting samples of problematic microlichens for certain determination. It was found most productive to divide the watercourse into manageable sections of between 30-250m and to study them over one to two hours. These sections are shown on the site map.

Time was divided between examining the streambed zones and adjacent rocks and surveying trees and shrubs for epiphytes. After compiling a list from the stream, species were assigned to one of the four zones and given a frequency rating on the DAFOR scale. It is often necessary when working these habitats to collect samples for microscopic identification. This involves using a hammer and chisel or small sheath knife, and carefully wrapping and labelling each specimen in the field, so that it can be later placed into the context of the site. Delicate material of lichens that may easily disintegrate in paper packets, such as that collected from soft bark, soil or overgrowing mosses was wrapped in tissue paper and stored in collecting tins.

Microscopic identification, chemical spot tests, UV scanning, thin-layer chromatography plus reference to floras and taxonomic papers are often required to run-down some species, especially if they are rare, newly described or frequently misidentified.It is difficult to apply the DAFOR scale accurately to certain poorly understood species that require laboratory identification. However, I have attempted a very subjective appraisal of abundance of notable species, but this must be regarded as carrying a 'health warning'.

The points raised in the discussion of the national status of bryophytes (Section 6.2a) can be applied to lichens also. At the time of writing this report it was not possible to access hectad information about lichen distribution in Ireland. However, based on experience and the available information the categories used to describe the status of the bryophytes have been applied in a qualified way to the lichens. Again, the 'health warning' principle applies. The distribution of Irish lichens is given in Ref. 25. Nomenclature follows Purvis (Ref. 26).

6.2c Vascular Plants

The site is divided into the five areas shown on Figure 15 which reflect the broad habitat division along the proposed pipe route.

Nomenclature for vascular plants follows Stace (Ref. 27), nomenclature for bryophytes, mosses follow Smith (Ref. 13) and liverworts follow Smith (Ref. 14).

6.3 Results

6.3a Bryophytes

Table E1 (Annex E) contains a complete listing of the bryophytes recorded along the surveyed stretch, together with site status, zone occurrence, status in Ireland and Great Britain and Oceanic/Atlantic classification, where these are applicable. Figure 13 shows the locations of the main bryophyte survey sections. The least abundant species and those which occur infrequently along the surveyed stretch and have both national and Oceanic/Atlantic designations are listed in Table E1. A total of 92 bryophyte (66 moss and 26 liverwort) taxa were recorded.

None of the bryophytes can be defined as rare or scarce if the definition of these categories is based on the sum of Irish and British records. The moss Didymodon spadiceus and the liverwort Scapania subalpina have been recorded in fewer than 16 hectads and the liverwort Cololejeunea minutissima is scarce in Britain having been recorded in fewer than 101 hectads.

In total 17 species (11 mosses and 6 liverworts) have been recorded in fewer than 101 hectads in Ireland. The 17 species are listed below.

Andreaea rothii	Hypnum andoi*	Blasia pusilla
Anomobryum julaceum	Didymodon spadieceus*	Cololejeunea minutissima
Blindia acuta	Orthotrichum lyelli	Matzgeria fruticulosa
Bryum alpinum	Racomitrium ellipticum*	M. congugata
Entothsodod attenuatus	Ulota hutchinsiae*	Riccardia multifida
Hygrohypnum ochraceum*	Scapania subalpina*	

Asterisks identify species that have been recorded in fewer than 50 hectads in Ireland. This number of hectads cannot be used as a guide for indicating scarce species because of the limitations discussed in Section 3.2a. It is used solely to indicate those species recorded in the surveyed corridor that might be least common.

The following 11 species (7 mosses and 4 liverworts) are classified as Oceanic or Hyperoceanic (extremely Oceanic) by Hill and Preston (Ref. 17) and/or Atlantic by Ratcliffe (Ref. 18).

Breutellia chtysocoma	
Campylopus atrovirens	
Entosthodon attenuata	
Hyocomium amoricum	Cololejeunea minutissima
Ptychomitrium polyphyllum	Frullania teneriffi
Racomitrium ellipticum	Pleurozia purpurea
Ulota phyllantha	Saccrogyna viticulosa

A further 14 mosses and 5 liverworts are classified as Suboceanic and/or Sub-atlantic (Table E1).

Many of the bryophytes occur in more than one zone. This is an indication of ecological tolerance or the effects of fluctuating river levels and lateral seepage.

Within zone 1, the Submerged Zone, just 2 species, the moss Fontinalis antipyretica and the liverwort Scapania undulata, were recorded. Neither species was restricted to the Submerged Zone.

Within zone 2, the Lower Inundation Zone, 39 species (30 mosses and 9 liverworts) were recorded. Of these the following 12 mosses and 3 liverworts were not recorded in other zones.

Atrichum undulatum	Pohlia wahlenbergii
Bryum alpinum	Rhizomnium punctatum
Ceratodon purpureus	Schistidium apocarpum
Cratoneuron filicinum	Ulota hurchinsiae
Fissidens cristatus	
Entosthodon attenuatus	Blasia pusilla
Hygrohypnum ochraceum	Jungermannia sp.
Hyocomium armoricum	Nardia secalaris

Within zone 3, the Upper Inundation Zone, 51 species (36 mosses and 15 liverworts) were recorded. The following 18 (11 mosses and 7 liverworts) were recorded in this zone only.

Aulocomnium palustre	Plagiomnium undulatum	Calypogia fissa
Barbula fallax	Pogonatum nanum	Cephalozia bicuspidata
Breutellia chrysocoma	Rhytidiadelphus loreus	*Lophosia ventricosa*
Campylopus paradoxus	Tortella tortuosa	Riccardia chamedryfolia
Dicranella palustris	R. multifida	
Dicranum scorparium	Saccogyna viticulosa	
Hookeria lucens	Scapania subalpina	

Within zone 4, the Terrestrial Zone, 32 species (24 mosses and 8 liverworts) were recorded of which the following 9 mosses and 3 liverworts were not recorded in other zones.

Didymodon spadiceus	S. papillosum
Scleropodium purum	S. subnitens
Racomitrium heterostichum	
Sphagnum capillifolium	
S. compactum	Calypogia sphagnicola
S. fallax	Kurzia sp
S. inundatum	Plagiochilla porelloides

Trees are a distinctive bryophyte habitat and can be regarded as a fifth zone. Fourteen corticolous (growing on bark) species (8 mosses and 6 liverworts) were recorded. Of these the following 5 mosses and 5 liverworts were recorded only on trees.

Hypnum andoi	*Cololejeunea minutissima*
H. cupressiforme	Frullania ditatata
Orthotrichum lyellii	Metzgeria fruticosa
Ulota crispa	M. furcata
U. phyllantha	Microlejeunea ulicina

6.3b Lichens

Table E2 lists the 124 lichens recorded. The local abundance of each species and zone in which it occurs are noted. Species status designations and inferred national status are also indicated. However, not all the species with a national status designation in Table E2 are shown in Figure 14. The omitted species are considered to be largely overlooked and therefore under-recorded.

Saxicolous lichens are best developed where ledges of bedrock cross the river. Good underhangs and caves are virtually non-existent saxicolous habitats whereas epiphytes make up almost 41% of the total lichen flora.

The submerged zone (true aquatic species)

Three true aquatic species dominate the submerged portion of the river. Hymenelia lacustris and Verrucaria hydrela are present throughout, whereas Verrucaria praetermissa is more localised.

The amphibious zone (fluvial mesic)

This is the zone where the richest freshwater lichen flora is to be found reaching maximum diversity and cover. Here it involves the eight species show below:

Collema glebulentum 2ii	Polyblastia cruenta 2ii	R. lavatum
Ephebe lanata	Pterygiopsis coracodiza 1ii	Verrucaria aethiobola
Porina chlorotica	Rhizocarpon caesium 1i	

Porina chlorotica and Rhizocarpon lavatum require moist surfaces and will grow almost anywhere where there is prolonged dampness, the first species, mostly in shady crevices, the second, where water washes over well-lit rock surfaces. Polyblastia cruenta was frequent at the top of the site near the reservoir where water seeps through gravel and mossy pebbles.

Rhizocarpon caesium is reported new to Ireland. It is currently being described by Dr Alan Fryday of Michigan State University (Ref. 28). As there are less than 15 British km squares for the species it should be regarded as a 1i species. It should also be viewed as data deficient, particularly since non-specialists could easily overlook it. Its scarcity may be strongly linked to its mineral requirement which is for slightly basic rock, provided here by mica-schist.

Terrestrial lichens tolerant of submergence (fluvial xeric)

This, a transitional band between the fluvial and terrestrial zones supported 17 lichens. Characteristic species include:

Massalongia carnosa 2ii	Placopsis lambii	Porina lectissima
Micarea peliocarpa	Polychidium muscicola 2ii	Stereocaulon pileatum

The predominance of thalloid liverworts on soily deposits along the river margins limited the full development of lichen communities occupying this zone.

The terrestrial zone (fluvial terrestrial)

This zone is here very narrow. In the absence of large rock outcrops and prominent boulders it includes mostly species of peat, soily rocks and grassy banks. The more interesting finds were

Peat	**Soily rocks and boulders**	**Grassy banks**
12 Cladonia species	Baeomyces roseus	Peltigera didactyla
Coelocaulon aculeatum	Heterodermia isidiophora 1i	P. lactucifolia
Micarea lignaria	Lepraria lobificans	P. membranacea
Pycnothelia papillaria	Pertusaria albescens	
	Protoparmelia badia	
	Sphaerophorus globosus	

An extremely important discovery is Heterodermia isidiophora. This foliose lichen which forms small rosettes of grey lobes bearing tiny outgrowths (isidia) was discovered growing attached to rock below overhanging mounds of heather near the middle section of the river at GR726813.

Other than this site and one in County Kerry (recorded during the same series of river surveys relating to hydro-power schemes) the species is known in Europe from only two localities on the Lizard Peninsula, Cornwall, England. It is believed that high humidity may be an important factor in maintaining populations. In Britain the lichen is Red Listed as Critically Endangered. In Ireland it should be regarded as a 1i species. Although there is some evidence of scrub encroachment, potential risks here are few.

Epiphytic lichens associated with the river corridor

Of the 124 lichen taxa recorded, 40% of these were epiphytes. The best areas for epiphytes were, a) a narrow band of trees towards the middle of the stretch and, b) trees of alder, oak, ash and hawthorn that lined both side of the river for almost 0.5km along the lowest stretch of the watercourse. The main epiphytes of note recorded from these areas are shown below:

Arthonia cinnabarina
Arthopyrenia nitescens 1ii
A. salicis
Buellia disciformis
Caloplaca ferruginea 2ii
Japewia carrollii 2ii
Loxospora elatinum RIEC/NIEC
Pannaria rubiginosa NIEC
Parmelia crinita RIEC/NIEC
P. reddenda RIEC/NIEC
P. sinuosa NIEC (B)
Parmeliella parvula NIEC
Phaeographis dendritica NIEC

The 1ii and 2ii species indicated above show a markedly western pattern of distribution in the British Isles. Together with quality woodland indicator species with RIEC or NIEC ratings, they demonstrate that trees here are a valuable source of biodiversity.

6.3c Plants along Pipeline Route

Area 1 (Figure 15)

This part of the pipe route comprises areas of wet heath and willow scrub. Most of the natural habitats here have been significantly disturbed in forming the reservoir. Secondary re-growth of wet heath species and patches of willow scrub has occurred over most of the shore area.

The principal species which occur in the wet heath are listed in Table E3. In flushed areas of wet heath, Sharp flowered rush (*Juncus acutifloris*), Soft Rush (*J. Effusus),* Bog Myrtle (*Myrica gale),* Carnation sedge (*Carex panicea),* Star sedge (*c. Echinata)* and occasionally Flea sedge (*C. pulicaris*) Common sedge (*C. nigra*) and Common Yellow sedge (*C. demissa)* occur.

Along the lake shore some flushes support species such as Lesser Spearworth *Ranunculus flammula,* Bulbous Rush (*Juncus bulbosus*), Marsh Pennywort (*Hydrocotyle vulgaris*), Many Stalked Spike Rush *(Eleocharis multicaulis),* Bog Pimpernel (*Anagallis tenella),* Carnation sedge (*Carex panicea)* and Common Yellow sedge (*carex demissa).*

The areas of Willow scrub and associated wet grassland are dominated by *(Salix cinerea),* and Eared Willow (*Salix aurita).* Large scrubby European Gorse (*Ulex europaeus)* also occurs in association with the willows. Wet Grassland species associated with and occurring in the

vicinity of the willow scrub including principally *Anthoxanthum odoratum, Holcus lanatus, Cirsium palustre, Agrostis stolonifera, Agrostis capillaris, A. canina, Festuca ovina.*

Area of exposed gravel, laid as part of the construction of the Loughadeery Dam supports a sparse vegetation cover principally of scattered *Holcus lanatus, Juncus effusus, J. squarrosus, Tussilago farafara, Cirsium palustre, Hypochoeris radicta, Leontodon taraxacoides, L. autumnalis inter alia.*

Area 2 (Figure 15)

The area to the immediate south of the outfall from Lough Adeery has been much modified, graded and planted with Oak, Hawthorn and Willow etc. Disturbed ground in the vicinity of the outfall supports such species as the grass species *(Nardus stricta, Anthoxanthum odoratum, Holcus lanatus, Festuca rubra, F. ovina, Cynosurus cristatus, Molina caerulea, Agrostis capillaris, A. canina.* Forb species which occur in this area include *Cirsium palustre, Prunella vulgaris, Hypochoeris radicata, Leontondon spp. Sonchus asper, Tussilago farafara, Leucanthemum vulgare, Trifolium pratense, Epilobium palustre, E. montanum, Soncuus asper, Potentilla erecta inter alia.* Rush species which occur commonly here include *Juncus effusus, J. acutifloru,* and *J. squarrosus. J. bulbosu,* occurs in areas of more bare ground. Sedge species occurring here include *Carex binervis, C. demissa* and *C. panicea.* Mosses commonly occurring include *Rhytidiadelphus loreus, Pleurozium schreberi* and *Thidium tamariscinum.*

Area 3 (Figure 15)

Common species in this area of acid grassland/wet heat mosaic are *Nardus stricta, Juncus squarrosus, Juncus effusus, Agrostis stolonifera, A. capillaris, A. canina, Carex paniecea, Scirpus cespitosus, Cirsium disectum* and *Luzula multiflora.* Wet heath species *Eriophorum vaginatum, Potentilla erecta, Calluna vulgaris, Ulex gallii* and *Erica tetralix* also occur.

Area 4 (Figure 15)

This area comprises a significant length of the pipe route and a mosaic of habitat types occurs here. Areas of Wet Heath/Shallow Blanket Bog occur on areas of deeper peat, rocky ridges support area of Grass heath and Acid Grassland, and areas of Flushed Wet Heath/Blanket Bog and Soligenous Flushes/Pools occur in depressions and areas of water seepage. Much of the slopes of the upper stretches of the pipe route on the hill above the river support significant areas of Flushed Wet Heath/Blanket Bog. This habitat occurs in areas which have an influence of down-slope water movement. Species which typify it include Purple Moor Grass (*Molinia caerulea*) and Bog Myrtle *(Myrica gale), these* occurring in association with heath species such as Ling Heather (*Calluna vulgaris*), Cross Leaved Heath (*Erica cinerea*) Deer gras (*Scirpus cespitosus*) and Bog Cottons (*Eriophorum vaginatum* and *E. angustifolium*). The bog moss species *Sphagnum palustre, S. auriculatum* and *S. Subnitens* are also associated with the Flushed Wet Heath/Blanket Bog habitat (Table E4).

Bog Mosses also occur abundantly in the Wet Heath/Shallow Blanket Bog Habitat (Table E5).

Areas of rock outcrop and shallow peat support Heath and Acid Grassland communities. Acid Grassland species include *Danthonia decumbens, nardus stricta, Agrostis capillaris, A. canina, A. stolonifera. Fetuca ovina* and *Holcus lanatus inter alia.* Damper areas of Acid Grassland supports higher abundance of the grass species *Holcus lanatus, Anthoxanthum odoratum, Agrostis capillaris* and *A. stolonifera,* often associated with rushes *Juncus effusus, J. acutifloris* and *cirsium palustre.* Heath species include *Ulex gallii, calluna vulgaris, Erica cinerea, Carex binervis* and *Potentilla anserina.*

The most noteworthy plant assemblages in this area are associated with the Soligenous Flush/Pool habitats. The Soligenous Flush habitat supports a diversity of sedge *(Carex)* species listed in Table E6. Of these sedges, the Dioecious sedge *Carex dioica* is the most notable; this sedge is rather rare in Ireland but is of occasional occurrence in the north of the country (Ref. 29). Other species associated with the Soligenous Flush habitat include *Hypericum elodes, Eleocharis multicaulis* and *Anagallis tenella inter alia.*

The Pool habitat supports species such as *Menyanthes trifoliata, Rhynchospora alba, Carex limosa* (very occasional), *Potamogeton polygonifolius, Sphagnum cuspidatum, S. auricultum inter alia.*

Area 5 (Figure 15)

This area is very similar to Area 4 as described above and supports a mosaic of habitat types including areas of Wet Heath/Shallow Blanket Bog occurring on areas of deeper peat, rocky ridges support areas of Grass Heath and Acid Grassland, areas of Flushed Wet Heath/Blanket Bog on slopes. The area differs from Area 4 in that there are few areas of Soligenous Flush/Pool, there are however area of *Juncua acutiflorus-Eriophorum angustifolium-Sphagnum rich* Mire in depressions between rocky outcrops, see photo. Otherwise a mosaic of Acid Grassland, Wet Heath and Heath habitats dominate in this area (Table E7). The other noteworthy difference between this area and Area 4 is that some overgrazing of the Acid Grassland and Heath has occurred; areas of bare peat and soil poaching are evident.

Area 6 (Figure 15)

This area is dominated by Wet Grassland-Rush Pasture. It has been drained in the past to maintain a grass pasture. The species which are abundant here (Table E8) include grass and rush species such as *Anthoxanthum odoratum, Holcus lanatus, Juncus effusus, J. conglomeratus,* and *J. acutifloris.* This area is grazed by cattle and adjoins the Island Seafood factory.

Area 7 (Figure E9)

The pipeline route adjacent to and below the factory site traverses an area of disturbed ground which is dominated by characteristics weeks and grasses which include Grass species *Agrostis capillaris, A. stolonifera, Anthoxanthum odoratum, Cynosurus cristatus, Dactylis glomerata, Holcus lanatus, Poa annua, Poa trivialis,* and forbs such as *Alchemilla xanthochlora, Plantago lanceolata, Ranunculus repens, Rumex acetosa, R. crispus, R. obtusifolius, Senecio vulgaris, Polygonum persicaria, Cirsium palustre, Prunella vulgaris, Hypochoeris radicata, Leontondon* spp. *Sonchus asper, Tussilago farafara, Leucanthemum vulgare, Trifolium pratense, Epilobium*

montanum, Potentilla erecta inter alia. Rush species which occur commonly here includes *Juncus effusus. J. acutiflorus* occurs in areas of more bare ground.

Along the riverbank between the factory site and the proposed powerhouse a mixed deciduous woodland vegetation occurs, the principal species composition of which is given in Table E9.

6.4 Impact of the Project

6.4a Construction Phase

Most of the vegetation along the main length of the pipeline route has been significantly modified by human activities over many years, areas of secondary wet heath and willow scrub vegetation occur in the area of the reservoir (Areas 1, 2 and 3), heavily grazed wet heath and acid grassland occur in Area 5, semi-improved area of wet grassland/rush pasture occur above the factory site (Area 6) and an area of disturbed ground occurs along the pipeline route between the factory site and the proposed powerhouse (Area 7).

The least disturbed area of the pipeline route, where significant areas of natural and semi-natural habitats occur, is found in Area 4. This area supports a mosaic of wet/heath/shallow blanket bog, grass heath/wet acid grassland, flushed wet heath/blanket bog and soligenous flushes/pool habitats. Characteristic species assemblages are associated with these habitats, see species lists given in Tables E4-E7.

Of particular significance in Area 4 are the occurrences of mineral rich flushes on the slopes above the river channel. The water flowing through these flushes are stiff with enrichment of iron and manganese from outcropping bedrock, and support species such as *Hypericum elodes, Carex hostiana, C. pulicaris, C. demissa, C. panicea, C. echinata, Angallis tenella, Juncus bulbosus, Myrica gale inter alia.* Of some botanical interest is the occurrence of the dioecious sedge *carex dioica,* in these flushes. This plant is of somewhat restricted occurrence in Ireland and occurs only occasionally on suitable habitats, flushed peaty ground predominantly in the north of the country (Ref. 29).

The botanical investigation found no plants in the development site which could be considered as nationally important, i.e. no legally protected plant species or Irish Red Data list species were recorded for the site.

6.4b Operating Phase

In order to establish how the proposed **basic** abstraction regime will affect plant species established along the river and pipeline reaches and reported above, it is necessary to refer to the various implications of that regime for the total water environment set out in Chapter 4. Two main issues require consideration:

1. *Changes to features of the flow regime which modify some aspect of patterns of wetting, for example frequencies and durations of submergence, frequencies and magnitudes of spray formations, contribution of free water surface area to humidity* (ref. Section 4.3b)

There is commonly a zonation of species within the riparian zone, though the precise sequence and abundance of species within it varies with such factors as the degree of shade and strength of the current according to flow rate (rocks high in the zonation and exposed to the flow may only ever be inundated by high velocity flows. The position of a particular species in the zonation is largely determined by the frequency of submergence. The fact that durations per event extend to hours and days depending on zonation suggest that this is less an issue than the time between events, a factor reflected in frequency. Abstraction would reduce submergence duration per inundation event, more so for species low in the zonation for which the durations are relatively long. Frequencies of submergence due to higher flows will be little changed by abstraction whereas those caused by small flushes, i.e., at low levels in the zonation, will be reduced (Section 4.1). Species now just submerged by moderate flows may therefore be most affected, possibly leading to a narrowing and lowering of this zone. Species submerged for either a high proportion of the time (low in water column) or rarely would experience little changed conditions.

The transitional (fluvial xeric) zone of the cascade which, for example, supports the rare lichen Heterodermia isidiophora (1i) would therefore be little affected, the preferred north-facing, vertically orientated outcrops which support this species continuing to receive an unchanged sequences of periodic flushing and, because of their orientation, slow drying.

Where the effects of spray reflect the nearby presence of the river, wetting is associated with the incidence of high flows and, in exposed locations, to strong winds. Near-continuous tree along the river give some protection from strong wind action, but spray will still occur as a result of break-up of high flows at the many small falls which are a feature of this length of the watercourse. Abstraction will have little effect on this process, ever less so with increasing flow rate when spray is normally most evident.

The significance of direct wetting by rainfall prior to submergence will not be affected by abstraction. All levels of the zonation wetted by the resulting river flow will therefore experience this shortly in advance, i.e., it constitutes a pre-submergence event which adds to the total duration of wetting. Its significance for species high in the zonation which, because of their location, are inundated less frequently may be more than proportionally important for this choice of habitat, especially in summer when desiccation is a greater risk and the probability of high flows, and hence abstraction, occurring is less than that for rainfall, .i.e., the changes will be less when the risk of dessication is most.

2. *Contribution of the river to humidity*

Humidity levels are important to both riparian and fluvial terrestrial species during periods of exposure. Sources of humidity were reviewed in Section 4.3c, where the reported results of field studies of this parameter in representative upland locations have shown that its main determinands are air temperature and time lapse since rainfall last occurred (the latter factor also reflecting in river flow rate) The notion that humidity levels are controlled by direct evaporation from the river was not supported but, as might reasonably be expected, spray can be a locally controlling influence on this.

From this information it is concluded that the bryological floras associated with the Loughadeery River will be affected as follows:

1. Any changes would probably be long-term and non-seasonal;

2. There might by a down-slope shift in the zonation of species and communities by 10-20mm;

3. It is unlikely that the Atlantic species which grow mainly on steep rocks above normal river level, where submergence is infrequent or lacking but where atmospheric humidity is high as a result of spray, splash and the close proximity of the river, will be affected;

4. There might by an increase in the abundance of some common terrestrial bryophytes on rocks beside the river.

Since seepage zones through rocks and the discharge of sub-surface water from porous media will not be altered by abstraction, it may reasonably be concluded that plant communities which depend on those environments will also not be affected.

In summary, some small changes to the locations and possibly the abundances of the aquatic and semi-aquatic bryophyte species established within the zone from time to time wetted by higher river flows may be induced by the proposed abstraction policy, though whether with the outcome in time of slightly increasing, re-establishing or reducing their coverage is not clear from the evidence currently available. The continued creation of the extensive zone of wetting during higher flows is clearly essential to ensuring that the principal features of the existing bryophyte and lichen regimes are sustained, coupled with the fact that the lower flows which are more likely to occur during the drier summer months of the year and which are thereby responsible for considerable temperature control at plant level will not be changed.

6.5 Mitigation Measures

6.5a Construction Phase

The area of the pipeline route, which has the highest component of natural and semi-natural habitats, Area 4, is the area of the site where the most care must be taken during the construction phase of the hydro-electric scheme. The principal disturbance of habitats at the site in Area 4 will occur as a result of pipe-laying activities. Because the wet heath, shallow blanket bog, heath, grass heath and acid grassland habitats in Area 4 occur on shallow peaty and somewhat mineralized peat substrata the problem of significant disturbance of peat stratigraphy will be minimal. As some mineralisation of much of the peat habitats in this area is in evidence (evidenced by the occurrence of *Myrica gale, Carex echinata*, etc over wide areas) the problems associated with the mineralisation of areas of ombrotophic (non-mineralised peat) peat as a result of digging will also be less than usual for deep peat habitats. It is expected that recovery of the above habitats will occur naturally on re-filling of pipe trench with little other intervention.

However, it must be stressed that due care should be taken in avoiding the sloping flushes. In areas where these flushes occur the pipe route, where possible, should follow the lowest course above the river channel to avoid hydrological damage to the mineral rich flushes which support characteristic species such as the diecious sedge (*Carex dioica*).

Since all seven Areas 1-7 have been previously disturbed by human activities it is not envisaged that construction of the hydro scheme will impact adversely on their present habitats, each of which should recover naturally with little active intervention.

6.5b Operating Phase

Although some modifications to the lower riparian plant regime along the affected reach of the watercourse may result from the proposed abstraction regime, these are likely to be limited to that zone. There is no evidence to suggest that the changed flow regime will cause species to be lost from the present community, though some small redistribution of those sensitive to frequency of inundation could occur.

Maintenance work on the scheme will involve occasional visits to the intake works. This will be done via the public road which passes close to the intake, hence it will not be detrimental to the vegetation along the pipe route and will avoid the nearby Heterodermia isidiophora lichen community.

The possible risk, albeit not demonstrated, that the proposed abstraction regime applied to an isolated flush in an otherwise dry period extending over several weeks would be detrimental to sensitive riparian plants has been taken into account in the modified abstraction policy set out in Section 4.3b and Chapter 13

7. FAUNA

7.1 Fish

The Loughadeery River is a tributary of the Bungosteen River which flows into Killybegs Harbour. It is well established that the Bungosteen River supports migratory salmonids, however no record of this species being present in the Loughadeery River was known to the Northern Regional Fisheries Board. The expected presence of brown trout was reported by the NRFB but no definite evidence of the present position was available.

7.1a Fisheries Survey

In order to establish this information, an electric fishing survey was carried out at the four representative locations shown in Figure 1a. As for other riverine ecosystems, the task was to resolve two basic issues:

- how the flow regime would or could be altered according to the constraints put on abstraction;
- how those alterations could affect the fish regime.

To fulfil this task required that the existing flow and associated fish regimes are understood. It is also necessary to know how the changes made to the flow regime will affect fish. For example, if fish are sensitive to very low flows and it was resolved that the abstraction proposed during those flows should not be permitted, the average annual loss in energy generating potential associated with this constraint could be determined.

The questions relating to fish which need to be answered are:

1. What is the population structure and density of the resident fish stocks?
2. How important are the impacted reaches as non-migratory salmonid spawning and nursery areas?
3. What contribution do the impacted reaches make to the overall recruitment of salmonids in the river catchment?
4. Will the proposed scheme:
   a) Impede upstream migration of adult salmonids?
   b) Impede the downstream migration of juvenile fish?
   c) Cause mortality of juveniles through entrainment, particularly during the dispersal stages of their life cycle?

5. What will be the effect of the operating rules on the flow regime and how will this affect the fisheries with respect to:

   a) Loss of spawning and nursery habitat either on a temporary or permanent basis?

   b) Change in wetted area and available food resources?

6. What will be the loss of amenity value in terms of fisheries and other recreation and conservation aspects?

The upper three of the four survey sites were upstream of the powerhouse outfall and number 4 was below the outfall. The physical characteristics of each site are as follows:

Site A NGR G718817, immediately downstream of spillway
80% stones/cobbles, 20% boulders

Site B NGR G723815, downstream of first waterfall
10% gravel, 80% stones/cobbles, 10% boulders

Site C NGR 728807, riffle 50m downstream of left bank tributary
5% gravel, 15% stones/cobbles, 40% boulders, 40% bedrock

Site D NGR G732804, Bungosteen River downstream of Loughaderry tributary
10% stones/cobbles, 60% boulders, 30% bedrock

7.1b Survey Materials and Methods

The principal survey strategy used was a semi-quantitative assessment using electro-fishing as the method of capture (Ref. 30). This strategy involved three operatives fishing with a single anode electro-fishing apparatus. The gear used varied depending on the accessibility of the water. At remote sites or where the stream was narrow (<4m), backpack electro-fishing gear (24V DC input - 200-400V, 100W, 50Hz pulsed DC output) was used. At accessible sites a 2kVA generator with a 220V 50Hz pulsed DC output was employed.

Representative 30-100m reaches of the river were fished once in the upstream direction. No stop nets were used because fishing was carried out betwen natural obstacles such as low weirs or up to shallow, fast flowing riffles. During the fishing exercise as many salmonids as possible were caught by the operatives who were positioned either side. At the same time a count was taken by the operatives of the number of fish seen but not captured and other species present.

The areas of river fished were determined by measuring its width at 10m intervals along each stretch. Habitat data relating to flow regime at the time of survey, substrate and vegetation cover were also recorded.

Interpretation of the results of these semi-quantitative surveys using data from the successive surveys at each site which make up the 'quantitative' appraisal of fishery resources was not possible on this river because the numbers of fish recorded were too small

7.1c Survey Results

For both electro-fishing methods, fish were identified to species and measured to the nearest mm (fork length). Length-frequency distributions supported by ageing of scales from selected length groups were used to separate 0+ fish from older age groups. Back-calculation of growth history was not undertaken because insufficient fish older than 2+ years of age were caught, and the scales taken from most fish over 120mm had been replaced at some stage, as is frequently found in older salmonids, thus they were not suited to growth analysis.

The density of 0+ and >0+ fish/100m² had, in the absence of quantitative survey data, to be determined from the semi-quantitative survey results by direct proportion between the number of fish caught and the wetted area sampled. These data were used to assess the status of the fish populations according to the standard matrix procedure.

7.1d Discussion of Fisheries Results

The results of the surveys are presented in Table 2. The densities of fish recorded are given in numbers/100m² and Class follows the standard matrix procedure. The measured mean lengths of trout (mean fork length in mm & standard deviation) for each age group are also given.

TABLE 2 Results of Electro-fishing Surveys of Loughadeery River

Site	Width	NGR	Salmon			Trout			Other Species
			0+	1+	Class	0+	1+	Class	
A	5.1m	G718817	0.00	0.00	E	0.36	1.78	D	None
B	3.2m	G723815	0.00	0.00	E	0.89	2.23	D	Eels
C	5.5m	G728807	0.00	0.00	E	2.54	1.09	D	Eels
D	10.2m	G738804	1.74	0.00	D	0.00	0.65	D	None

Mean Fork Lengths (mm) and Standard Deviations

Site	Salmon		Trout			
	0+	1+	0+	1+	2+	3+
A			80.0	114.5±2.1	154.5±4.9	
B			62.0	115.5±3.4		
C			72.5±3.6	116.5±0.7		
D	74.6±6.7			121.0±4.3		

No historic data were available for comparison with the results obtained. Hence it cannot be assumed that the results are representative of the long-term status of the fishery on that reach of the Loughadeery River of interest here. The characteristics of upland trout populations in terms of age composition are known to be extremely variable due to differences in population recruitment between years. What is clear is that without exception there was a generally poor level of salmonid stocks throughout the reach surveyed.

7.1e Discussion of Results

The Loughadeery River is a tributary of the Bungosteen River, the latter being used by migratory salmonids. Flows in the Loughadeery River are determined by releases from the reservoir immediately upstream of site A. The status of the fish populations was poor considering the habitat available, especially at site C. A contributory factor to the more general situation may be the flows arising from the reservoir with possible loss of suitable spawning habitat. No salmon were captured in the Loughadeery River (sites A, B and C), confirming the position reported by the NRFB.

Juvenile salmon were captured at site D which is situated in the main Bungosteen River indicating that this river is an important nursery area for salmon. The survey site D is situated downstream of the outfall from the proposed hydro-power scheme.

The potential impacts of the proposed scheme on fisheries can be minimised or overcome by adopting suitable design and operating rules. These rules will, for example, guarantee appropriate flow regimes in the affected reach of the river in order to:

protect the various life stages of all species of fish from undue stress during high or low discharge levels, and:

ensure all fish species are able to complete their life cycles by maintaining migratory pathways.

Although the relevance of these rules to the very few trout and, with the exception of eels, no other species recorded in the affected length of the Loughadeery River may seem to be of minor significance, provision for possible significant increases in populations should be incorporated into designs to ensure that the scheme does not conflict with and therefore perhaps deny this situation should it otherwise occur at some future time.

7.2 Birds

From the literature there is no likelihood that either golden plover or dunlin are included in any bird breeding populations in the locality of the scheme. These are two of the rare species associated with blanket bog in the northern half of the country. Dippers were observed along the rapid lower section of the river though the turbulent, rocky nature of the channel suggest that there would be few feeding places.

7.3 Mammals

Principal interest in mammals in upland riverine environments centres on otters. The most sensitive requirements of this species relate to their feeding and breeding habits. These respectively hinge on fish/amphibians and dense thickets of any type of vegetation located close to rivers and which are free from human interference.

The steep reaches of rivers like the Loughadeery River which make them physically suited to run-of-river hydro power schemes generally support no more than low densities of salmonids,

as the survey reported in Section 7.1 confirmed. Furthermore, amphibians focus on marshy areas, which are not features of steep hillsides though they often occur extensively between hill-tops.

The dense vegetation sought by otters for breeding occurs in some catchments at the elevations typically suited to run-of-river schemes, though it is more common in lower reaches than on higher ground. The flora of the reach of the Loughadeery River affected by the proposed scheme has these characteristics (Section 6.3c).

The home run or hunting ground of an otter may cover several kilometres, this extending both along an individual river and possibly to those in adjacent valleys. Suitable resting places will be visited regularly, these often comprising cavities within piles of large rocks and around the roots of established trees from which soil has been eroded by strong river flows. These habitats are not common along the mainly open watercourse of the Loughadeery River, though there are some accumulations of large rocks.

7.4 Effects of Project

7.4a Design Considerations

The requirements for the design of intakes from and outfalls to rivers which support fisheries are specified in The Fisheries (Consolidation) Act of 1959 (Ref. 31). These requirements have been assembled from earlier legislation, based in large measure on adverse experiences with a variety of works, including hydro schemes, which have in some cases damaged the indigenous fishery resource.

By virtue of its location, the design of the intake for the proposed project is not an issue in this respect. However, the outfall incorporates the requirements set out in Ref. 31, including those relating to velocities and details of the screens to be provided at these locations. It is intended that the outfall screens shall be permanent rather than only be in place at specific times of the year, as specified in Ref. 31.

7.4b Construction Phase

In addition to the intake structure which is in the spillway, most of the construction is located well away from its banks. Only the powerhouse and the outfall close to it (Figure 7) will also involve working close to the river.

Reference was made in Section 4.6 to the intention to ensure that construction work does not cause unnaturally high loadings of fine sediments in the rivers, which could threaten bryophytes, invertebrates, fish and dependent ecosystems.

Invertebrates and birds breed in spring and early summer, and fish spawning and egg development occur during early winter and spring. To suit these times of the year, it is proposed that construction of the river-related works shall be done in the summer and autumn when the breeding season of birds likely to occupy habitats along those lengths has finished. This will ensure than any birds present are not disturbed once they have nested.

This schedule will also minimise any effects of the work on fish, any sediments mobilised at and close to the intake and at the river crossing and outfall then having least effect on the productivity of in-river faunal communities.

7.4c Operating Phase

Potentially the most significant effect of the scheme on invertebrates will result from the modified pattern of wetting of habitats (sediments and flora) on which the various species depend (Section 4.1). However, the sediment structure is not expected to change because it contains little fine material and is determined by high flows whose velocities, durations per high-flow event and frequency will be little affected by the proposed abstraction regime (Section 4.3).

Evidence from elsewhere regarding the effects of water level changes on invertebrates relates particularly to the consequences of water storage projects, especially where persistent low downstream flows are created. This information is of limited value in the present context because the river regime would not be deprived of its principal flow features and their timing.

These species will therefore experience a marginally more stable water line within essentially the same range of wetting conditions. From the information reported in Ref. 32 any changes caused to the range of invertebrate species and populations are expected to be small and may well be beneficial, for the same reasons as were set out in Section 6.2b for bryophytes.

The change in flow regime which the **basic** abstraction policy (Section 4.3) could cause upstream of the outfall may not have an adverse effect on access to it by migratory species for spawning, though from the survey results (Section 7.1) none do so at present..

The capacity of the river to support river birds, e.g., dippers, will not be significantly affected because the invertebrate population is unlikely to be adversely affected by the changed water regime, and any improvement which may occur due to this effect is expected to be small.

7.3 Mitigation Measures

The location selected for the outfall works and its proposed designs take full account of the statutory requirements on structures of this type to ensure that full protection is given to the interests of local fisheries. The proposed abstraction policy recognises the river flows needed by migratory salmon to gain access upstream of the outfall for spawning.

8. LANDSCAPE

8.1 The Existing Situation

Over the reach of interest, the Loughadeery River flows from ther Lough Adeery Reservoir to its confluence with the Bungosteen River (Figure 1a). Much of this reach, particularly at a lower level, is lightly wooded. Conifer forestry borders part of the north bank of the river. Throughout, the mountain range to the west which forms the headwaters of the catchment provides a prominent backdrop to the mildly sloping plain within which Loughadeery Lake (as it was prior to the raising of its level) occupied a depression.

Apart from the dam and the reservoir which it has created there are few focal points on the west bank of the Bungosteen River. There are very few farmhouses and associated buildings in this area and those which are present do not stand out in the landscape. There are no other man-made features apart than field boundary walls and fences, and limited areas of conifer forestry.

8.2 The Proposed Works

Into this landscape the proposed works and their visibility would appear as follows:

1. The intake will be incorporated into the existing spillway structure and will be fully submerged. The small external modification needed to one length of the walls of the spillway will not be discernable, though the works would be seen from the public road during the construction stage;

2. Apart from walkers crossing the site, the pipeline installation work would only be evident from distant vantage points and then as only a minor activity on the wide open scale of the landscape. Its effects would also cease to be locally evident when this part of the route is reinstated;

3. The powerhouse (Figure 6) will constitute a minor and very conventional structure within the specific features of the effluent processing facility which services the factory.

4. The outfall structure (Figure 7) will also not be seen from the public road because of its low level behind the powerhouse.

5. Arrangements for electricity transmission from the building lie with the ESB. They are not covered by this EIS. If direct connection to the factory's adjacent sub-station at the effluent treatment works is decided, the connection to the powerhouse is expected to be underground.

In summary, the proposed works will only be a landscape feature while they are being carried out. The necessary construction machinery and the associated activity will be clearly visible for the period of about twelve weeks required to construct the pipeline.

Abstraction will reduce the river flow down this length of the Loughadeery River. However it is not a landscape feature even when flows are high.

8.3 Mitigation Measures

The selected layout of the scheme has had full regard for the potential visibility of the proposed works in an impressive landscape setting.

The external detail of the powerhouse, the only above-ground structure, will only be visible from close by.

The works required by the scheme are therefore minor in scale and will not be evident in the landscape.

9 ARCHAEOLOGY

9.1 Present Regime

9.1a Results of Desk Study

A desk-top survey and field search of the archaeological and heritage features located in the area of the proposed scheme was carried out. The full extent of the land area covered by the study included that for the possible pipeline routes referred to in Section 2.3.

The importance and condition of previously recorded and newly reported archaeological features were assessed and areas of archaeological potential evaluated according to their significance within the cultural landscape of the area and as individual items which comprise that landscape. A Bibliography of the literature consulted is given at the end of the References.

Consultations were carried out of the maps, computer records, written records and reference works which make up the Sites and Monuments Record of the Heritage Service. This is the definitive record of all known existing monuments and sites of destroyed monuments.

The topographical Files of the National Museum of Ireland were also consulted. These are files on artifacts in the collection of the National Museum or which are known to the Museum. It is not a complete index to the Museum's collections: such an index has yet to be compiled.

The first edition of the Ordnance Survey Six-Inch maps, surveyed in the 1830s, and the most recent edition, surveyed in the early 1900s, were examined for marked antiquities and anomalies in field boundaries which may indicate the presence of archaeological remains as yet unidentified.

For most of these areas there would not have been any survey at a larger scale than six inches to a mile, and the Six-Inch maps have not been revised since the early years of the present Century, or in one case the 1890s. These maps are therefore the basic cartographic source of archaeological information. 25-inch maps, while offering the potential for reporting more detailed surveys of monuments shown on the Six-Inch maps, tend not to show additional sites.

The Ordnance Survey Letters reveal the correspondence of a number of antiquarian researchers employed by the Ordnance Survey when compiling the first edition of the Six-Inch maps. They include both descriptions of field monument and local folklore concerning them. A modern typescript in bound volumes was consulted in the National Library.

The records would be expected to show quite a low density of monuments or artifacts in this type of terrain because the types of activity which reveal archaeological remains, such as agriculture and building, have only taken place on a limited scale.

The desk study did not reveal the presence of any features of archaeological importance within the area of interest.

9.1b Results of Field Survey

The pipeline commences at the recently built Lough Adeery Reservoir and runs out east and then south-east through the townland of Carricknamoghill. It generally follows the line of the Loughadeery River which forms the boundary between Carricknamoghill and Bungosteen townlands (6" OS sheet no 91). The ground to be crossed by the pipeline is rough, wet, boggy pasture which slopes gently downhill to the south-east (Section 6.2). The route proposed for the pipeline was walked but with one exception no archaeological material was found.

This one item was a small limekiln. This limekiln is set ca. 40m due west of Loughadeery River where it joins a large tributary. It is a small, roughly circular stone built structure set in the ground and into the east-facing slope of the hill. The surrounding ground is fairly flat wet pasture at a curve in the river, where the flat land begins to slope uphill to the west. It survives as a roughly circular dry-stone interior, is overgrown and flooded at the base. The walling of uncut limestone barely rises above the surrounding ground. It is built of random limestone blocks with more flattish stones around the top. The opening into the kiln chamber is only barely visible in interior, the overgrowth hides all but the lintel over the opening. The internal face of the stone walling appears to be fire-reddened.

Max dimensions	N - S 2.7m	E - W 2.6m
Max internal dimensions	N - S 1.32m	E - W 1.25m
Internal height	.95m	
External height	.86m	
Interior lintel of opening max D.	.09m high	
	.42m wide	

The list of recorded monuments for County Donegal notes the presence of crannogs in Lough Adeery DG091-01, it is described in the archaeological survey as 674 Carrickataggart An early report (NMI topographical files) suggests "two crannogs" in Lough Adeery. There are no islands in the lake. The sites were not inspected and further information about these crannogs could be obtained. It is possible that they are submerged (Ref. 33). The relevant topographical file was consulted in the National Museum; there was no field record of these sites.

The only other archaeological site listed in the recorded monuments for the area is a court tomb in Carricknamoghill townland. It is listed as DG091-02 and is described in the archaeological record as: 11. Carricknamoghill 'marked Dermot and Grania's bed' on the OS revision of 1900. The monument is situated on a low ridge in rush pasture and arable land above the valley of the Bungosteen river. The monument is difficult to interpret. Two galleries 8m apart stand in a mound 30m long and 15m wide. The western gallery, at least 7m, long may have been of two chambers. Doubled jams covered by a single lintel mark its eastern end. Several low stones next to these could indicate a court. Several heavy corbels lie in the gallery. The eastern gallery is less well preserved. It was at least 4m long and seems to have a jamb at its western end. It is possible that the tomb may have been of centre-court type. (Ref. 33). This monument is situated 500m SSW of the SE end of the proposed pipeline.

No boundary walls, which could have historic importance, are crossed by the scheme.

9.2 Implications of Project

9.2a Construction Phase

The fact that careful site inspection did not reveal features of archaeological importance within the area of interest does not mean that no such items are present. It is therefore proposed that the site management team (Annex B, Section B.7) shall include the services of an archaeologist.

The potentially most intrusive element of the project is the pipe trench. This will be some 800mm wide and at least 800mm deep. The impact of the scheme on the cultural heritage will be minimised by the correct choice of pipe route and by using the most appropriate method to establish the trench, lay the pipe and reinstate the route. Careful attention to these details will be paid as the site is opened up (Annex B), modifications being made as advised by the archaeologist to be necessary.

The working corridor will be the minimum needed to open up the trench, store vegetation and soil, and reinstate. To offset the impact of construction on any cultural remains, the archaeologist shall be present as potentially sensitive sections of the corridor are opened up. If features of interest are identified, professionally approved recording measures suited to the merits of the find will be employed. Hand working will be adopted in locations in which it is advised that machine operations are likely to cause unacceptable damage to artefacts.

9.2b Operating Phase

The archaeological features reported in Section 9.1a and any others which may be identified during construction of the scheme would not be affected by the operations phase.

That phase should involve no more than occasional visits to the intake structure via the track which also has other uses not associated with the project. Only portable equipment will be needed for routine work at the intake. The pipe route will not require attention. The powerhouse, which will be visited more frequently, lies close to the public road at a location at which no features of archaeological importance have been identified.

9.3 Mitigation Measures

The fact that experienced archaeologists have not identified any features of archaeological importance on the site which the proposed scheme would affect does not justify assuming that none will be revealed during construction.

In order to ensure that any artefacts which may be revealed by the works are properly recorded and preserved according to their importance, a competent archaeologist will be on site to advise the Project Supervisor and through him the Contractor as work proceeds, especially in areas towards the ends of the pipeline where historic activities are most likely to have occurred.

10.. RECREATION AND AMENITY

10.1 The Present Situation

The Loughadeery catchment above the reservoir and location proposed for the hydro scheme attracts few walkers compared with the higher and more spectacular hille which lie to the west and north-west. No other significant recreational activities occur in this isolated area, where the population density is amongst the lowest in County Donegal despite its nearness to main roads.

10.2 Mitigation Measures

The proposed construction procedure will ensure that walkers using tracks up the Loughadeery Valley are assured safe and ready access past any on-going pipeline construction work. When not manned, unfinished works will be clearly marked to warn walkers.

The works are not expected to impose significant extra traffic movements on either the N56, the currest main road between Aradar and Killybegs, of the former link between these important local towns which passes the site (Chapter 11).

The measures taken to ensure that the lower reaches of the Loughadeery River remain as accessible as at present for spawning by migratory salmonids are explained in Section 7.2b.

The proposed scheme will not affect the limited potential of the immediate area for fishing.

The scheme is expected to have a neutral effect on the tourism potential of the area.

11. TRAFFIC

11.1 The Existing Situation

The Contractor's compound and focus for construction work lie close to Bungosteen Bridge (so-named despite the fact that it is on the Loughadeery River above its outfall to the Bungosteen). This bridge is on the former main road between Ardara and Killybegs, now replaced by a bew section and designated the N56. This is generally a good quality two-lane route and does not bear a heavy traffic load. Vehicle movements are mainly limited to private cars, visitor traffic adding modestly to this in the summer months. Farm and commercial vehicles do not constitute a significant proportion of total traffic. Movements seldom exceed 50-100 per hour each way.

11.2 The Effects of the Scheme

11.2a Construction Phase

The main item for delivery to site is the pipeline. Individual pipes may up to 12metres long. About 150 of these would be required. They will be delivered on flat-bed vehicles in loads of about 16 pipes per load, i.e., a total of about 10 deliveries. In addition there will be deliveries of pipe bends, valves, the power generating equipment and building materials, all of which are relatively compact. The anticipated construction programme set out in Annex B, Section B.8, shows that these deliveries will be spread out over much of the duration of the work, the pipeline being needed earlier in the programme than the generating equipment which will not be supplied until the powerhouse is available for occupation.

The full complement of site staff is not expected to exceed twelve, not all of whom will be on site throughout the construction period. It is expected that small vans and/or private cars will be used to transport these staff to and from site, and that most vehicle movements will be southwards from the site towards Killybegs. . Since they will not add materially to traffic loading on either the local road or the N56 towards Donegal Town, no special provisions for them, for example limiting their daily timing, need be made.

11.2b Operations Phase

No noticeable increase in traffic on local roads will result from operation of the scheme. That which does occur will be associated with the periodic maintenance visits which the scheme will require, most of which will be by locally-based personnel trained for the necessary routine tasks.

Specialist visits will normally be required on an annual basis and will only involve the use of portable equipment suited to transport by car or light van.

11.3 Mitigation Measures

The effects of traffic movements associated with the scheme on other vehicles using the N56 and local roads is expected to be marginal. No specific traffic control measures need be implemented at any point on the public highway and no constraints on daily working hours and the delivery of equipment and materials need be made.

12. NOISE, VIBRATION AND AIR QUALITY

12.1 The Present Situation

The only significant source of noise in the Loughadeery Valley is the wind. Close to the river (as for upland rivers in general) the flow is readily audible, even when it is quite low. There is no arable farming or forestry activity in the immediate area, and there is no quarrying in the immediate vicinity.

Air quality in the valley is not subject to any significant polluting influences. Vehicle traffic is minor because movements on the local roads are few and those on the N56 Ardara to Killybegs road at the foot of the valley are well away from the site of interest (Figure 1).

12.2 The Effects of the Project

12.2a Construction Phase

During construction, the main sources of noise will be from occasional vehicles moving to and working on the site and from any rock-breaking which needs to be done to create the pipe trench and the foundation areas required for the intake, powerhouse and outfall structures.

Vehicle movements and rock-breaking will be restricted to daylight hours during weekdays in order to limit disturbance to the few residents of the area who might be affected. Recognised procedures for the suppression of noise will be followed.

12.2b Operations Phase

The only source of noise created by the scheme when operating will come from the power generating equipment located in the buried powerhouse. This concrete structure and its soil overburden will ensure that the audibility of the equipment will be strictly contained.

Turbine noise will be further suppressed by ensuring that the outfall is below river level and is hence submerged. (This can sometimes be the main route by which this source of noise is evident outside the building.)

To establish background noise data on which to base designs of powerhouses of the size and type proposed in the present case, noise measurements have been made at a wide variety of typical near-river locations. This has been done over a range of different weather conditions and river flow rates. A Norsonic real-time octave band analyser type 114 was used for measuring the data. The results confirm that noise spectrum variations more than 100 metres from the powerhouse occur in response to weather conditions and are not related to those (e.g., river flow) at the powerhouse site.

The insertion loss to be incorporated into the provisions made for ventilating the powerhouse to secure a noise level commensurate with river-flow noise in that locality has been determined from this information. This will ensure that the installation is not audible at nearby dwellings.

The scheme will not discharge contaminants to either the atmosphere or river. This is one of the particular merits of renewable energy schemes, as recognised by Governments and the public. It is in sharp contrast with the effects of fossil-fuel burning stations, especially those not fitted with emission control measures. Coal-fired plant typically emits about 700 tonnes of CO_2 and 100 tonnes of SO_2 annually for the same energy output as the proposed scheme, the latter figure depending on the sulphur content of the fuel.

Construction activities will result in vehicle emissions and the release of dust to the atmosphere. However, the number of necessary vehicle journeys and the control which will be exercised during rock-breaking and trenching work will ensure that these have no measurable effect on the high air quality of the local area.

12.3 Mitigation Measures

The provisions made in the design of the project to deal with its potential effects during construction and operation were reported above. All are conventional and are regularly applied to projects of the type proposed.

13. INTERACTION OF FACTORS AND SPECIFIED ABSTRACTION REGIME

13.1 Ecological Conclusions based on Water Abstraction Policy Proposed in Section 4.3

The site for the project is not ecologically outstanding. The river is acidic which, together with its torrential character, limits the diversity of the communities which it supports. The scheme would not affect these features of the river. The results of studies of the ecological regime and consideration of the effects of the project upon it have shown that:

1. A small (50mm) downward redistribution of riparian bryophytes and lichens occupying the zone corresponding to the level of average flows could in time result from lowering this level, though the upper and lower limits of riparian species are not expected to change because higher and lower river levels and the generation and spread of spray in high flows will be unaffected. The proposed abstraction regime should therefore have little effect on these species;

2. The torrential nature of flows in the affected reach of the Loughadeery River and hence its generally coarse substrates suggest from observations made in many similar upland rivers that the invertebrate biomass is low. Since this basic river flow characteristic will remain, the invertebrate community will benefit little by the marginally greater stability of average flows. This reach will therefore continue to offer only limited support for river birds.

3. No salmon were recorded upstream of the position of the proposed outfall from the scheme and trout numbers in the reach of interest were very small. This status will not be adversely affected by either the proposed water abstraction regime or the means by which water is returned to the river. Specimens of the indigenous brown trout population resident upstream of the intake will be no more likely to be carried down through the reach of interest, hence the integrity of that community will not be threatened by the scheme. No changes to the proposed abstraction regime for fishery reasons are therefore deemed to be necessary;

4. Since the few habitats in this area which could be favoured by otters would not be damaged by the scheme, the support which it could give to this species should not be altered.

5. No mature trees need be felled.

13.2 Other Conclusions

6. The effects of construction work for users of the N56 Ardara to Killybegs/Donegal Town road will mainly relate to the delivery of equipment and will comprise a total of about 20 commercial vehicle journeys spread over much of the 6-month construction period. The daily movement of the approximately 12 construction workers will add little to the limited volume of traffic which uses this good quality road.

7. No recorded items of archaeological interest likely to be affected by the construction works are recorded. Possible finds revealed during the course of the works will be safeguarded by a regular site inspection programme.

8. Following reinstatement of the pipeline route, the scheme will not be publicly discernible in the landscape of the Loughadeery Valley;

9. The presence of the scheme will not induce further commercial investment in the area. The single product of the scheme, namely electricity, will be exported to the ESB's network via a connection at Bungosteen Bridge;

10. The scheme is in accord with the energy and environmental requirements of Donegal County Council's Development Plan (Ref. 3);

11. The targets set by the 1992 Rio Convention (United Nations Conference on Environment and Development) and its successors for the reduction of gaseous emissions to the atmosphere can in part be met by run-of-river hydro-power schemes whose ecological effects are as slight as those judged to apply to the proposed Loughadeery project

13.3 Summary of Water Abstraction Regime

Except for the measure specified in Sections 4.3b (wetting during isolated spates), the proposed **basic** abstraction policy set out in Sections 4.3 forms an acceptable foundation for the project. It is therefore designated the **recommended** abstraction policy and shall comprise:

no abstraction until the flow at the intake exceeds 0.10cumecs (100 litres per second);

all flow additional to 0.90cumecs passes downstream, the turbine then continuing to take 0.90cumecs.

This policy ignores the additional approximately 40% of runoff which enters the Loughadeery River between intake and outfall. This addition will be most significant at times of average river flow when it will substantially increase the flow in the river.

A further feature of the **recommended** abstraction policy is that, following at least 14 days of insufficient flow to generate, no abstraction will take place until 6 hours after the time when abstraction would otherwise have commenced. This is to ensure that, in the event that this is an isolated storm event in a dry period, the full benefits of that flush are experienced by downstream river ecosystems.

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ANNEX A

EXTRACTS FROM DRAFT DONEGAL C.C. DEVELOPMENT PLAN (Ref. 3)

The statutory basis for planning in County Donegal is the County's 1988 Development Plan. This is being superceded, a draft of its replacement having been published in December 1998. This draft sets out the County's suggested planning requirements. Since these refer to the current and expected circumstances within the County rather than to those of more than a decade ago, they are used here to illustrate the regime within which it is expected that the proposed scheme will be assessed. The extracts are referenced by their paragraph numbers in the Draft Plan.

2.1.2 (The County's Goal for Urban and Rural Development is).....To provide a focus and support for a living countryside and quality built environment which will support a viable and sustainable local population.

2.1.3 (Objectives) .... To create the highest quality built environment where every part of the physical fabric reflects a pride of place which demands only the best.

2.2.2 (The County's Goal for Natural Resource Development is) ,,, To optimise the contribution of the County's natural resource base to balance local and national development objectives.

2.2.3 (Objectives) .... To observe the conservation objectives for scenic landscapes, scenic roads and views and prospects .....

The County recognises the potential of the County's alternative energy resource .....to contribute to European and national energy and environmental objectives and will seek to balance this with the achievement of local economic and environmental objectives and in particular the creation of local development benefits.

2.2.5 (The County's Guideline for the Development of Hydro Schemes is that they) .....shall be so designed as to ensure the undergrounding of all penstock (pipeline) and power distribution lines, the landscaping of dam walls and ancillary infrastructure and the minimisation of noise emissions.

2.4.1 .....the concept of sustainable development now provides a guiding principle for linking development and the environment and this translates into Agenda 21 and Local Agenda 21. Environmental considerations must form a fundamental part of all policy.

2.5.3 (Objectives) ...To respect the landscape character of the County and the natural and archaeological heritage and to contribute to the erection of the highest quality built environment.

2.6.4 The diversity and complexity of activities and actors in the scenic landscape and heritage areas of Donegal require a more holistic response by the Council rather than a simple land use zoning. The aim and objectives will be met through a strategy of *active management partnership with ..... agencies/partnerships .....*

The core principles underlying the Council's policies for landscape conservation are to give the highest degree of protection to the areas of highest scenic landscape quality and to adopt a positive attitude to development proposals in areas of relatively lower scenic landscape quality.

2.6.5 (e) The development of natural resources like wind and water power, fishery and aquaculture industries will be subject to integration and environmental considerations.

(f) The construction of electricity poles, masts and pylons will be subject to the application of the least visually harmful route principle and will have regard to any other relevant environmental consideration.

The Council will not permit development which would:

- Restrict the view or prospect
- Intrude significantly on the view or prospect
- Materially alter the view or prospect.

ANNEX B

CONSTRUCTION METHOD STATEMENT AND SITE MANAGEMENT PLAN

B.1 The Project

The scheme involves abstracting water from the Loughadeery River in County Donegal (Figure 1). Abstraction will be determined by the natural release of water from Loughadery Reservoir. The water will pass through a pipeline to a water turbine driving a generator connected via protective switchgear to the ESB's electricity transmission network. It will then be returned in full and without delay to the river. The pipeline will be buried throughout its 1830m length. Only the powerhouse one face of the outfall will be visible when the site is reinstated. The civils work will be completed within five months and the scheme will be commissioned in six months.

B.2 Site Access and Contractor's Compound (Figure 1a)

Site access will be from both the old Ardara-Killybegs road at Bungosteen Bridge and via the track alongside the spillway at the southern end of the dam. Throughout the site, access will be via the pipeline corridor. The Contractor's compound will be located close to the site proposed for the powerhouse. Any damage done to the ground in this area will be reinstated following construction.

Movement of construction traffic will be limited to the hours of 0800-1800 from Monday to Friday inclusive, both on site and on the public highway. The case for weekend working will be considered on its merit but will be more the exception than the rule.

Provisions for wheel-washing for vehicles leaving the site shall be made.

B.3 Site Working Arrangements

The Client's Project Engineer working with the Site Supervisor will be responsible for approving site working arrangements. Nationally approved working regulations will apply, and care for public safety and the environment will be of paramount importance.

The detailed pipe route and working procedures will be decided by the Engineer in close association with the Client's archaeological and ecological advisers. Sensitive areas will be given the strict attention recommended by these advisers.

Work is expected to start with the intake (Figure 2). Allowance for the adverse effects of high flows during its construction will be made. A water level (submerged pressure) sensor will be installed at the intake to detect pond level in the chamber from which the pipeline draws its supply. This will show whether the intake arrangement is performing satisfactorily or whether, for example, its screen needs to be cleaned (a hand-operation, with access by foot). A low voltage electrical cable from this sensor will be carried to the powerhouse in a robust conduit laid in the same trench as the pipeline, though separated from it. The cable will include spare cores, and the diameter and alignment of the conduit will allow the cable to be withdrawn and replaced if necessary.

The plant and materials needed to construct the pipeline will be distributed along the site as necessary before vegetation and soil are lifted. Pipelining will proceed downhill to the powerhouse. Much of the route is on a shallow gradient which averages 1 in 20 (Figure 3). Not more than 50m of the route will be worked at any time. Trenched lengths will be protected with warning tapes. Grazing animals will be excluded for up to twelve months from those parts of the route which merit protection until the vegetation has recovered.

Bedrock will be broken out by rockbreaking attachments to tracked excavators. Trenching is not expected to cause any local instability of the ground. Areas with a sufficient depth of soil offer the potential for soil compaction, rutting and possibly erosion due to the movement of vehicles. If it occurs at all, this is expected to be limited to the lower valley floor. Measures to restore the subsoil on completion of the works will be applied if necessary.

Turves lifted from the route will be stored on `terram' (or similar) sheeting and replaced following construction. Stripped soils will also be stored separately on sheeting, in small piles to prevent deterioration. This will not be done in ecologically sensitive areas. Soils from different parts of the route will be kept separate and will be returned to the areas from which they were removed.

Reinstatement will be done as pipe sections are completed. The task of lifting, storing and reinstating surface vegetation will be closely monitored by the ecological adviser.

Anchor (thrust) blocks will be provided at specified locations along the pipeline, dimensions to be determined according to ground conditions. Details of anchorages will be supplied by the Engineer.

Compacted subsoil will be broken up when the pipeline has been backfilled, prior to replacing the topsoil and vegetation previously stripped from each area. Existing walls affected by the construction work will be rebuilt and fences and gates will be reinstated, all to the satisfaction of the Engineer..

Changes in drainage behaviour can significantly alter agricultural potential. Appropriate reinstatement measures for each section of the pipe route will be decided by the Engineer to take account of this. Any tile drains crossing the pipe route will be marked when exposed and replaced at the correct depth and level. Where this may not be possible, a satisfactory alternative acceptable to the Engineer will be applied. Any other field drainage systems affected by the works will also be fully restored.

Drainage in areas where this is naturally impeded must not be improved by bedding or back-filling in the pipe trench. In that situation, water-stops comprising clay or concrete bunds will be installed at specified intervals.

Although the pipeline may be pressure tested in sections it must be tested as a single unit. A Certificate of satisfactory testing will be issued by the body responsible for this work. Construction of the powerhouse will be scheduled to allow the generating plant to be installed and commissioned as soon as possible after the water supply becomes available and connection to the national grid is made by ESB.

B.4 Specification of Materials and Generating Plant

a) Intake (Figure 2)

The weir comprises a reinforced concrete structure. The side walls of the spillway through the bay immediately upstream of the step below which the weir will be constructed have to be raised. The valve chamber outside of the walls of the spillway will also be formed in reinforced concrete..

b) Pipeline (Figures 1a & 3)

The pipeline is 1830m long and 600mm in diameter. PVC/polyethylene and/or GRP spigot and socket pipes with joints sealed by standard O-rings are well suited to this duty. Manufacturers' recommendations for laying and backfilling will be met. All fill material will be provided by the contractor. Excavated subsoil and small stone may be used when approved by the Engineer. No part of the site is expected to experience subsequent heavy wheel loadings nor be subjected to ploughing or other significant surface disturbance. A minimum 300mm cover to the pipeline is therefore specified.

The Contractor must make provision for excess material from trenching to be removed from site to an approved location unless otherwise specified by the Engineer.

c) Powerhouse and Outfall (Figures 4-7)

The powerhouse comprises a reinforced concrete base slab with conventional rendered block walls and a pitched slated timber-framed roof (Frontispiece). The outfall is a separate but adjacent structure connected to the powerhouse by a short length of 800mm duct which conveys the discharge from the turbine to the stilling chamber in the outfall structure from which it is released gently to the river.

The base slab of the powerhouse carries the power generating equipment (Section d below). Anchorages for plant will be accurately built into this slab. Apart from cut-outs for the turbine, the slab has a plain top surface. It includes a key-way foundation anchorage. Details of this key-way will be specified by the Engineer when ground conditions are exposed.

Double doors and two sound-proofed ventilation louvres, all to a style and colour to be approved, will be the only penetrations of the external wall into the powerhouse. A single door and two small louvres provide access to and ventilation of the ESB's switchroom which forms an integral part of the building, in which all power generating and electrical equipment including the transformer is located.

The outfall comprises a diffuser in which the velocity of the water is reduced below 0.3 metres/second, this being regarded by the fisheries authority as acceptable for release to rivers. For this flow to be discharged at river level, the floor level of the outfall chamber is similar to that of the river bed. The top of the outfall is well below the top of the river bank. A screen comprising vertical bars with 10mm openings covers the outfall.

d) Pipeline and Generating Plant

1. Pipeline

Diameter	- 600mm
Pressure Rating	- 10 bar max - ref Figure 3 for pressure profile
Material	- either PVC/polyethylene or GRP according to cost of supply, installation and bedding requirements

2. Turbine

Type	- Reaction (Francis)
Water Capacity	- 0.90 cubic metres per second
Rated Head	- 65 m
Runner Speed	- 1000 rpm

3. Generator

Type	- Synchronous
Shaft Speed	- 1000rpm
Input Power	- 525kW
Output Power	- 510kW
kVA Rating	- 600kVA

5. Water level Sensor

Type	- submerged, depth-sensitive

6. Control Equipment

to meet total requirements of scheme

7. Turbine House Ventilation/Sound-proofing

according to noise levels of selected generating plant and requirements of local Environmental Health Officer

B.5 Summary of Construction Contract

The following tasks are to be carried out:

1. Intake - construct reinforced concrete weir and valve chamber, raise spillway wall, install intake screen;

2. Pipeline - receive approx 160 No. 600mm polyethylene or GRP spigot & socket pipes, plus bends and gaskets and distribute as specified by the Engineer.

3. Pipeline (working on a progressive 50m exposure basis) - install protective fencing, strip off and store surface vegetation and topsoil in specified manner, open up trench for minimum 300mm cover, lay bedding and backfill to pipe manufacturer's specification, break up subsoil compacted during pipe laying, replace topsoil and vegetation.

4. Pipeline - follow procedure to be specified for environmentally sensitive areas, including attention to locally wet zones and any of archaeological interest.

5. Powerhouse - a block and faced non-cavity single-storey walled structure with pitched tiled roof on a reinforced concrete slab with footings and detailing to retain plant.

All to be managed from one compound located close to the powerhouse. Work to be contained within the specified hours, noise criteria to be strictly adhered to, fencing to be maintained around all open works and reinstated areas until removal is approved, and wheel-washing facilities to be used on vehicles leaving site whenever conditions so require.

B.6 Environmental Liaison Officer (ELO)

The Client will appoint an ELO to advise the Engineer on all ecological matters and serve as the contact between on-going site work, the Project Supervisor, the Engineer and the Client.

The location of the scheme requires that its design and construction have particular regard for landscape and other environmental issues. Landscape is important because the Carricknamoghil area has experienced little development, having only been used for sheep farming for a long time.

B.7 Site Management

The Contractor's management tasks set out above will be reproduced in the Contract Documents. To ensure these commitments are fulfilled, the Contractor will be required to retain the necessary expertise, e.g., on site safety.

Responsibility for environmental management will be retained by the client and the contractor will be required under his Contract to respond to the advice given. This procedure will simplify liaison on this subject with the statutory and other bodies. However, for safety and security reasons all site visits must be approved in advance by the Contractor.

The secure this interaction, the site management structure should be as follows:

MANAGEMENT	**Client**	**Statutory Bodies**
PROJECT MANAGEMENT	**Engineer** **Project Manager** **Environmental Liaison Officer** **Archaeologist**	
CONTRACTOR	**Contractor**	

B.8 Construction Programme

Week No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Establish Site	xxx																					
Construct (weather permitting):																						
Intake		xxxxxxxx																				
Pipeline/Signal Cable		xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx																				
Reinstate Pipe Route			xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx																			
Powerhouse									xxxxxxxxxxxxxxxxxxxxxxxxxxxx													
Outfall									xxxxxxxxxxxxxx													
Install Wiring and Plant															xxxxxxxxxxxxxx							
ESB Network Connection																xxxxx						
Commission Scheme																				xxxxxx		
Decommission temporary works																		xxxx				

B.9 Conclusions

The particular environmental effects of constructing the Loughadeery River Hydro-Power Scheme require that care is taken in planning and executing the works. The proposals set out above have regard for the specific nature of the site and the works required to implement the project.

Although geared to this project, the conclusions have wider application. The case for close environmental liaison via the Engineer and Project Supervisor between the Client's appointee to oversee the project, the Contractor's site representatives and the statutory agencies are regarded as both essential and innovative.

B.10 Conditions for Construction

1. The Contractor shall construct and maintain the works to the satisfaction of the Engineer and in accordance with details previously submitted and approved.

2. No structures shall be erected within a distance of 7 metres of the watercourse without the consent of the Engineer.

3. No temporary works shall be constructed in watercourses without the Engineer's consent.

4. The Contractor shall make all necessary arrangements for the continuance of any flow in the watercourse past the site of the works during construction.

5. The Contractor shall at all times permit reasonable access to the watercourse across the site for the continuance of established and approved functions.

6. The Contractor shall indemnify the Client against all actions, proceedings, costs, claims and demands which may be brought or made against the Client in respect of the works.

7. The Contractor shall give the Planning Authority not less than seven days notice of their intention to commence construction of the works.

8. The Contractor shall provide and maintain permanent markers on both banks of the watercourse to indicate the presence of any concealed works.

9. The Contractor shall reinstate the watercourse upon completion of the works to the satisfaction of the Engineer.

10. The Contractor shall at all time maintain the works in a clean and good condition so that no obstruction is offered to the flow of water in the watercourse.

11. The Contractor shall take such steps as the Engineer may require to prevent or remedy any deterioration in the condition of the watercourse resulting from construction of the works.

12. All temporary works shall be removed on completion of operations.

13. It is an offence to discharge any polluting material such as cement, oil, petroleum spirit, sewage, into a watercourse, or underground strata, or coastal waters.

14. The deliberate spillage of such materials near a river bank shall be strictly forbidden.

15. In executing the works the contractor shall take all necessary precautions to secure the complete protection of rivers, streams, waterways, ditches, coastal waters and water in underground strata against silting, erosion or pollution which may contaminate water supplies or cause injury to fish or plant life. If, notwithstanding these precautions such silting, erosion or pollution does take place then the Engineer shall be advised immediately and the Contractor shall take immediate action to minimise the effect on the watercourse.

16. Refuelling of machines shall be strictly controlled and together with the oil storage tanks shall be confined to a location remote from any watercourse or drain etc. All leaking or empty drums shall be immediately removed from the site.

17. The placing of any wet concrete in or close to the watercourse shall be so controlled as to eliminate as far as possible the risk of cement leaking into that watercourse.

18. The washing out of any concrete mixing plant or cleaning of ready mix concrete tankers shall not be carried out close to any watercourse etc. The effluent from such cleaning shall not be allowed to flow into any drain, watercourse, coastal or ground waters.

19. Haul roads on the site and approaches to river crossings must be regularly scraped and maintained free from deposits of slurry.

20. Water pumped from any section of the site shall be contained within a lagoon of previously agreed adequate dimensions to afford effective sedimentation of solids prior to discharge to any watercourse or underground strata or coastal water. Any such discharge must be approved by the Engineer well in advance of its taking place.

21. The Engineer must be given seven (7) days notice in writing of any intention to either temporarily or permanently divert the flow of any watercourse, carry out works within the river channel or commence any operations in the river channel so that suitable arrangements can be made concerning fishery and pollution-control interests.

22. The Contractor shall not carry out work in rivers during the fish spawning season which would be detrimental to spawning or the passage of spawning fish other than within a suitable cofferdam.

23. The Contractor is reminded in particular that any works on or near a foul sewer and especially a trunk sewer pose a major threat of river pollution, and at least seven days notice in writing should be given to the Engineer prior to any such work.

24. Only material known to be free from polluting or toxic substances should be used at locations where drainage from the material can directly or indirectly enter surface, underground or coastal waters.

25. In the event of river flooding in the vicinity of the works, all necessary steps shall be taken by the Contractor to release flood water held up by any temporary works gradually over a period of time, in such a manner that no damage is caused by scour or erosion to the bed or banks of the river, any flood embankments, or the fabric of any structure within such parameters.

26. Due regard shall be given to the local environment, and the requirements of the Engineer, whether notified directly or through the Project Supervisor, shall be adhered to.

27. All works shall be carried out in a manner that protects wildlife habitats.

ANNEX C

BIODIVERSITY

The Convention on Biological Diversity was one of several major initiatives which stemmed from the 'Earth Summit' in Rio do Janeiro in 1992. Together these initiatives form an International Agreement on sustainable development. The Convention reflected worldwide concern that human activities are changing and destroying habitats and natural ecosystems on an increasing scale, with consequential loss of species. Signatories to the Convention agreed "....to develop national strategies, plans and programmes for the conservation and sustainable use of biological diversity".

Biological diversity, or 'biodiversity' for short, covers the intricate network of ecosystems, habitats and species which together provide the support systems which sustain human existence. In the local context, biodiversity has particular importance in giving a distinctive character to an area, whether it be mountain, woodland or estuary. Developing a programme for biodiversity conservation at local level is one of the main functions of Local Agenda 21, another consequence of the Earth Summit.

Action plans on biodiversity must set out the broad strategy and targets for conserving and enhancing wild species and wildlife habitats. For these aims to be met by the proposed hydro-power scheme (and every construction project), it must be designed, planned and implemented with regard for the requirements of the ecosystems which it could affect, whether beneficially or otherwise.

However, the intent of the Convention is not limited to protecting species and habitats at locations proposed for new human activity, though this is an important objective. The thrust of the Convention is that, by its very nature, securing biodiversity can only be successful if it is addressed on a worldwide aim, indeed the signatories endorsed the Convention on that understanding.

The proposed project will supply electricity to the regional network. In so doing it will reduce the need to generate at least an equivalent amount of energy elsewhere. The production of energy is regarded as one of the principal reasons why the Convention was necessary. No significant source of generation lies beyond reproach. All contributors to this essential industry create adverse ecological implications of some sort. All have therefore much to learn, including hydro.

The purpose of the present Environmental Impact Statement is to identify how the opportunities open for upland run-of-river hydro schemes to comply with the aims of biodiversity are best incorporated into the design, construction and operation of the proposed project.

ANNEX D

ON-SITE RIVER FLOW MEASUREMENT

D.1 Results of River Flow Gauging

The flow in the Loughadeery River was monitored by an industry-standard float-operated chart recorder located within the reach of interest (Figure 1a). Figure 9 shows samples of the record of changes in water depths provided by this instrument. By locating the instrument over a pool, near zero flows were recorded as positive water depths, i.e., when flows were small, the operation of the float was not affected by water depth. No build-up of sediment occurred to affect the operation of the recorder.

Water levels were converted to flows by a calibration (Figure 12) prepared by measuring each of a range of flows and noting the simultaneously recorded water levels. Flows were measured by an industry-standard Valeport mini current meter using the procedure set out in ISO 748. The flow range corresponded with that needed for the present purpose, namely from under 10% of the average annual value up to about three times the annual value, i.e., from 0.1 to 3cumecs.

It is not possible to use this record to calculate the average annual flow because the full range of flows was not measured. However, since only about 10% of the full annual volume lies outside the recorded range, the average flow for the period of the record can be estimated with reasonable accuracy by extending the flow-duration curves determined for that range.

The result to two significant figures was determined to be 1.1cumecs. The average annual flow at the location of the recorder is estimated to be about 35% more than at the intake, i.e., the corresponding intake flow is about 0.81cumecs, allowing for abstraction for water supply.

The record also allowed annual distributions of water levels and hence flows to be determined.

The qualifications to be put to the precision of flow measurements suggest an accuracy for the interpreted data of about 10%, sufficient for the purposes for which this information is required.

This result for the average annual flow at the intake is compared in Section 4.2 with that determined from the hydrological data held in various national archives.

ANNEX E

BRYOPHYTE, LICHEN AND VASCULAR PLANT SPECIES LISTS

TABLE E1

Bryophytes recorded along the surveyed corridor of Loughaderry River. Site status is indicated using the DAFOR (dominant, abundant, frequent, occasional, rare) scale. Zones: 1 submerged zone, 2 lower inundation zone, 3 upper inundation zone, 4 terrestrial zone and T trees. Ireland and Great Britain status: 2iii recorded in 11 to 100 hectads in Ireland and in more than 100 hectads in Britain. An * denotes that the species has been recorded in fewer than 16 hectads in Ireland. All other species have been recorded in more than 100 hectads in both countries. Species with Hyperoceanic and Oceanic/Atlantic status are indicated by bold type, whereas those with Suboceanic and Sub-atlantic status are indicated by regular type: HoSt Hyperoceanic Southern-temperate, HoT Hyperoceanic Temperate, MA Mediteranean-Atlantic, OBm Oceanic Boreal-montane, OBt Oceanic Boreo-temperate, OT Oceanic Temperate, OSt Oceanic Southern-temperate, (NA) Northern Atlantic, (WA) Western Atlantic, SmSa Submediteranean-Subatlantic, SoBm Suboceanic Boreal-montane, SoBt Suboceanic Boreo-temperate, SoT Suboceanic Temperate, (Sa) Sub-Atlantic, WB Western British.

Mosses	Site Status (DAFOR)	Zones	Status in Ireland+GB	Oceanic/ Atlantic spp
1 Andreaea rothii	O	2 3	2iii	
2 Anomobryum julaceum	O	2 3	2iii	
3 Atrichum undulatum	O	2		
4 Aulocomnium palustre	R	3		
5 Barbula fallax	R	3		
6 Blindia acuta	O	3 4	2iii	
7 Brachythecium plumulosum	F	2 3 4 T		
8 Brachythecium rutabulum	O	2 T		
9 Breutellia chrysocoma	O	3		HoT/(Sa)
10 Bryum alpinum	R	2	2iii	
11 Bryum pseudotrequetrum	O	2 3		
12 Calliergonella cuspidata	O	3 4		
13 Campylopus atrovirens	O	2 3 4		HoT/(Sa)
15 Campylopus introflexus	O	2 3 4		SoT
16 Campylopus paradoxus	R	3		SoT/(Sa)
17 Ceratodon purpureus	R	2		SmSa
18 Cratoneuron filicinum	R	2		
19 Dicranella palustris	R	3		
20 Dicranum scorparium	R	3		
21 Didymodon spadiceus	R	4	2iii*	
22 Eurhynchium praelongum	O	2 3		
23 Fissidens cristatus	O	2		

24 Fissidens taxifolius	O	2 3		
25 Fontinalis antipyretica	O	1 2		
26 Entosthodon attenuatus	O	2	2iii	**MA/(Sa)**
27 Hookeria lucens	R	3		SoT/(Sa)
28 Hygrohypnum ochraceum	F	2	2iii	
29 Hylocomium splendens	F	3 4		
30 Hyocomium armoricum	O	2		**OT**
31 Hypnum andoi	O	T	2iii	SoT
32 Hypnum cupressiforme	O	T		
33 Hypnum jutlandicum	O	3 4		SoT
34 Isothecium myosuroides	O	2 T		SoBt
35 Leucobryum glacum	O	3 4		
36 Mnium hornum	F	2 3		
37 Orthotrichum lyellii	R	T	2iii	SoT
38 Plagiomnium undulatum	R	3		
39 Pogonatum nanum	O	3		
40 Pogonatum urnigerum	O	2 3 4		
41 Pohlia wahlenbergia	R	2		
42 Polytrichum commune/formosum	O	2 3		
43 Polytrichum piliferum	O	2 3		
44 Pseudoscleropodium purum	R	4		
45 Ptychomitrium polyphyllum	R	2 3		**OSt/(Sa)**
46 Racomitrium aciculare	F	2 3 4		SoBt
47 Racomitrium ellipticum	O	3 4	2iii	**OBm/(Sa)**
48 Racomitrium fasciculare	O	3 4		
49 Racomitrium heterostichum	R	4		SoBt
50 Racomitrium lanuginosum	F	3 4		
51 Rhizomnium punctatum	R	2		
52 Rhytidiadelphus loreus	R	3		SoBt
53 Rhytidiadelphus squarrosus	F	3 4		
54 Schistidium apocarpum	O	2		
55 Sphagnum capillifolium	F	4		
56 Sphagnum compactum	O	4		
57 Sphagnum fallax	F	4		
58 Sphagnum inundatum	F	4		
59 Sphagnum papillosum	F	4		
60 Sphagnum subnitens	F	4		SoBt
61 Thuidium tamariscinum	F	3 4		
62 Tortella tortuosa	R	3		
63 Trichostoium brachydontium	R	2 3		SmSa
64 Ulota crispa	F	T		
65 Ulota phyllantha	F	T		**OBt/(Sa)**
66 U. hutchinsiae	O	2	2iii	SoBm/(WB)

Liverworts

1 Aneura pinguis	F	2 3		
2 Blasia pusilla	R	2	2iii	
3 Calypogia arguta	O	3 4		SmSa/(Sa)
4 Calypogia fissa	R	3		SoT
5 Calypogia sphagnicola	R	4	2iii	
6 Cephalosia bicuspidata	R	3		
7 Cololejeunea minutissima	R	T	2iii	**HoSt/(SA)**
8 Conocephallum conivens	F	2 3 4		
9 Diplophyllum albicans	F	2 3 4		SoBt
10 Frullania dilatata	F	T		
11 Frullania teneriffi	F	3 4 T		**HoSt**
12 Jungermannia sp.	R	2		
13 Kurzia sp.	R	4		
14 Lophosia ventricosa	R	3		
15 Metzgeria fruticulosa	F	T	2iii	(Sa)
16 Metzgeria furcata	F	T		
17 Microlejeunea ulicina	R	T		SoT/(Sa)
18 Nardia secalaris	R	2		
19 Pellia epiphylla	A	2 3 4		
20 Plagioichilla porelloides	O	2 3		
21 Pleurozia purpurea	R	4		**OBm/(NA)**
22 Riccardia chamedryfolia	R	3		
23 Riccardia multifida	R	3	2iii	
24 Saccogyna viticulosa	O	3		**OSt/(WA)**
25 Scapania subalpina	R	3	2iii*	
26 Scapania undulata	F	1 2 3		

TABLE E2

Lichen species recorded along the surveyed corridor of Loughaderry River.
Column 2 SpSt: species with special status, RDB(CR) Red Data Book species in the critically endangered category, RIEC Revised Index of Ecological Continuity species, NIEC New index of Ecological Continuity species. Column 3 status in Ireland and Great Britain: 1i recorded in fewer than 11 hectads in Ireland and fewer than 16 hectads in Britain, 1ii recorded in fewer than 11 hectads in Ireland and in 16 to 100 hectads in Britain, 2ii recorded in 11 to 100 hectads in Ireland and 16 to 100 hectads in Britain. All other species have been recorded in more than 100 hectads in both countries. Column 4 DAFOR scale: D dominant, A abundant, F frequent; O occasional, R rare. Column 5 ZONE: S submerged, FM fluvial mesic, FX fluvial xeric, FT fluvial terrestrial, (ep) epiphyte occurring in that zone.

Species	SpSt	Status in Ir and GB	DAFOR	Zone
1 Acarospora smaragdula			O	FX
2 Anisomeridium biformis			R	FT(ep)
3 Arthonia cinnabarina			R	FT(ep)
4 A. didyma			R	FT(ep)
5 A. punctiformis			F	FT(ep)
6 A. radiata			F	FT(ep)
7 Arthopyrenia lapponina			O	FT(ep)
8 A. nitescens		1ii	O	FT(ep)
9 A. salicis			O	FT(ep)
10 Baeomyces roseus			R	FT
11 B. rufus			F	FX
12 Buellia disciformis			O	FT(ep)
13 Caloplaca ferruginea		2ii	O	FT(ep)
14 C. holocarpa			R	FT(ep)
15 Cladonia chlorophaea			O	FT
16 C. ciliata			O	FT
17 C. coniocraea			R	FT
18 C. diversa			R	FT
19 C fimbriata			O	FT
20 C. floerkeana			O	FT
21 C. furcata			O	FT
22 C. portentosa			O	FT
23 C. pyxidata			O	FT
24 C. subcervicornis			F	FT
25 C. subulata			R	FT
26 C. uncialis subsp. biuncialis			O	FT
27 Coelocaulon aculeatum			R	FT
28 Collema glebulentum		2ii	R	FM
29 Ephebe lanata			D	FM
30 Evernia prunastri			O	FT(ep)
31 Fuscidea cyathoides var cyathoides			O	FT
32 F. lightfootii			O	FT(ep)
33 Graphis elegans			F	FT(ep)
34 G. scripta			R	FT(ep)
35 Herteliana taylorii		2ii	R	FX
36 Heterodermia isidiophora	**RDB(CR)**	1i	R	FT
37 Hymenelia lacustris			D	S
38 Hypogymnia physodes			O	FT(ep)
39 H. tubulosa			O	FT(ep)
40 Japewia carrollii		2ii	O	FT(ep)
41 Lecanora chlarotera			F	FT(ep)
42 L. dispersa			R	FX
43 L. expallens			R	FT(ep)
44 L. intricata			O	FT
45 L. polytropa			O	FT

46 L. symmicata			R	FT(ep)
47 Lecidea lithophila			R	FT
48 Lecidella elaeochroma f. elaeochroma			F	FT(ep)
49 L. elaeochroma f. soralifera			F	FT(ep)
50 L. scabra			F	FX
51 Lepraria lobificans			O	FT
52 L. sp(K+y;P+o)			O	FT
53 Loxospora elatina RIEC			R	FT(ep)
54 Massalongia carnosa		2ii	O	FX
55 Micarea lignaria var lignaria			F	FT
56 M. peliocarpa			O	FX
57 M. prasina			O	FT
58 Mycoblastus caesius			F	FT(ep)
59 Mycoglaena myricae		2ii	R	FT(ep)
60 Normandina pulchella			O	FT(ep)
61 Ochrolechia androgyna			O	FT
62 O. parella			O	FT
63 Opegrapha atra			F	FT(ep)
64 O. gyrocarpa			A	FT
65 O. herbarum			R	FT(ep)
66 Pannaria rubiginosa			R	FT(ep)
67 Parmelia caperata			O	FT(ep)
68 P. crinita	RIEC		R	FT(ep)
69 P. exasperata			O	FT(ep)
70 P. glabratula subsp. glabratula			O	FT
71 P. perlata			O	FT(ep)
72 P. reddenda	RIEC		R	FT(ep)
73 P. revoluta			F	FT(ep)
74 P. saxatilis			O	FT(ep)
75 P. sinuosa			R	FT(ep)
76 P. subaurifera			O	FT(ep)
77 P. sulcata			O	FT(ep)
78 Parmeliella parvula			R	FT(ep)
79 Peltigera didactyla			R	FT
80 P. lactucifolia			O	FT
81 P. membranecea			O	FT
82 Pertusaria albescens var. albescens			O	FT
83 P. albescens var.corallina			R	FT
84 P. leioplaca			O	FT(ep)
85 P. pertusa			R	FT(ep)
86 P. pseudocorallina			F	FT
87 Phaeographis dendritica	NIEC		O	FT(ep)
88 Physcia aipolia			O	FT(ep)
89 P. tenella			O	FT(ep)
90 Placopsis lambii			O	FX
91 Placynthiella icmalea			F	FT
92 Polyblastia cruenta		2ii	O	FM

93 Polychidium muscicola	2ii	R	FX
94 Porina chlorotica		O	FM
95 P. lectissima		F	FX
96 Porpidia crustulata		O	FX
97 P. macrocarpa		O	FX
98 P. tuberculosa		F	FX
99 Protoblastenia rupestris		R	FT
100 Protoparmelia badia		O	FT
101 Pterygiopsis coracodiza	1ii	O	FM
102 Ramalina farinacea		O	FT(ep)
103 R. fastigiata		O	FT(ep)
104 Rhizocarpon caesium Fryday in ed.	1i	O	FM
105 R. lavatum		F	FM
106 R. reductum		O	FT
107 Scoliciosporum chlorococcum		O	FT(ep)
108 S. umbrinum		A	FX
109 Sphaeophorus globosus		R	FT
110 Stereocaulon pileatum		R	FX
111 S. vesuvianum var. vesuvianum		O	FT
112 Tephromela atra		O	FT
113 Trapelia coarctata		O	FX
114 T. involuta		O	FX
115 T. obtegens		R	FX
116 T. placodioides		O	FX
117 Trapeliopsis granulosa		O	FT
118 T. pseudogranulosa		R	FT
119 Usnea cornuta		O	FT(ep)
120 U. subfloridana		O	FT(ep)
121 Verrucaria aethiobola		F	FM
122 V. hydrela		F	S
123 V. praetermissa		O	S
124 Xanthoria parietina		R	FT

TABLE E3

Wet Heath Species

Calluna vulgaris	Ling Heather
Campylopus paradoxus	Moss
Carex echinata	Star sedge
Cladonia uncialis	Cladonia lichen
Drosera rotundifolia	Round Leaved Sundew
Erica tetralix	Cross Leaved Heath
Eriophorum vaginatum	Hare's Tail Bog Cotton
Eriophorum angustifolium	Common Cotton Grass
Hypnum cupressiforme	Moss

Juncus squarrosus	Heath Rush
Molinia caerulea	Purple
Narthecium ossifragum	Bog Asphodel
Odontoschisma sphagni	Liverwort
Pedicularis palustris	Lousewort
Polygala serpyllifolia	Milkwort
Polytrichum commune	Moss
Potentilla erecta	Tormentil
Scirpus cespitosus	Deer Grass
Sphagnum papillosum	Variety of Sphagnum Moss
Sphagnum capillifolium	Variety of Sphagnum Moss
Sphagnum palustre	Variety of Sphagnum Moss
Sphagnum papillosum	Variety of Sphagnum Moss
Sphagnum subnitens	Variety of Sphagnum Moss
Succisa pratensis	Devil's Bit Scabious
Ulex gallii	Western Gorse

TABLE E4

Wet Heath/Shallow Blanket Bog Species

Aulacomium palustre	Moss
Carex echinata	Star sedge
Carex panicea	Carnation sedge
Carex pulicaris	Flea sedge
Cirsium dissectum	Thistle
Myrica gale	Bog Myrtle
Pinguicula vulgaris	Butterwort
Sphagnum auriculatum	Variety of Sphagnum Moss
Sphagnum palustre	Variety of Sphagnum Moss
Sphagnum subnitens	Variety of Sphagnum Moss

TABLE E5

Wet Heath/Blanket Bog

Calluna vulgaris	Ling Heather
Campylopus atrovirens	Moss
Campylopus paradoxus	Moss
Carex echinata	Star sedge
Cladonia uncialis	Cladonia lichen
Dactylorhiza maculata	Orchid
Drosera rotundifolia	Round Leaved Sundew
Erica tetralix	Cross Leaved Heath

Eriophorum vaginatum	Hare's Tail Bog Cotton
Eriophorum angustifolium	Common Cotton Grass
Hypnum cupressiforme	Moss
Juncus squarrosus	Heath Rush
Molinia caerulea	Purple Moor Grass
Narthecium ossifragum	Bog Asphodel
Odontoschisma sphagni	Liverwort
Pedicularis palustris	Lousewort
Polygala serpyllifolia	Milkwort
Polytrichum commune	Moss
Potentilla erecta	Tormentil
Rhynchcospora alba	White Beaked Sedge
Schoenus nigricans (occurs v. occasionally)	Black Bog Rush
Scirpus cespitosus	Deer Grass
Sphagnum papillosum	Variety of Sphagnum Moss
Sphagnum compactum (in eroded areas)	Variety of Sphagnum Moss
Sphagnum capillifolium	Variety of Sphagnum Moss
Sphagnum palustre	Variety of Sphagnum Moss
Sphagnum papillosum	Variety of Sphagnum Moss
Sphagnum subnitens	Variety of Sphagnum Moss
Sphagnum tenellum	Variety of Sphagnum Moss
Succisa pratensis	Devil's Bit Scabious
Ulex gallii	Western Gorse

TABLE E6

Pools and Soligenous Flushes

Agrostis stolonifera	Creeping Bent Grass
Anagallis tenella	Bog Pimpernel
Aulacomium palustre	Moss
Breutilia chrysocoma	Moss
Campylium stellatum	Moss
Carex demissa	Common Yellow Sedge
Carex dioica (in many flushes)	Dioecious Sedge
Carex echinata	Star sedge
Carex hostiana (occasional)	Sedge
Carex limosa (v. occasional in pools)	Mud Sedge
Carex nigra	Sedge
Carex panicea	Carnation sedge
Carex pulicaris	Flea sedge
Eleocharis multicaulis	Many Stalked Spike Rush
Epilobium palustre	Marsh Willowherb
Eriophorum angustifolium	Common Bog Cotton
Hydrocotyle vulgaris	Marsh Pennywort
Hypericum elodes	Marsh St. John's Wort

Juncus acutifloris	Sharp Flowered Rush
Juncus articulatus	Articulated Rush
Juncus bulbosus	Bulbous rush
Menyanthes trifoliata	Bog Bean
Myrica gale	Bog Myrtle
Narthecium ossifragum	Bog Asphodel
Potamogeton polygonifolius	Bog Pondweed
Ranunculus flammula	Lesser Spearwort
Rhynchospora alba	White Beaked Sedge
Sphagnum auriculatum	Sphagnum moss
Sphagnum cuspidatum	Sphagnum moss
Sphagnum palustre	Sphagnum moss
Viola palustris	Marsh Violet

TABLE E7

Acid Grassheath/Acid Grassland

Agrostis canina	Brown Bent Grass
Agrostis capillaris	Common Bent Grass
Agrostis stolonifera	Creeping Bent Grass
Anthoxanthum odoratum	Sweet Vernal Grass
Caliergon cuspidatum	Moss
Calluna vulgaris	Heather
Carex binervis	Green ribbed Sedge
Carex panicea	Carnation Sedge
Cirsium dissectum	Meadow thistle
Cirsium palustre	Marsh Thistle
Dactylorhiza maculata	Marsh Orchid
Danthonia decumbens	Heath Grass
Epilobium palustre	Marsh Willowherb
Galium saxatile	Heath Bedstraw
Erica cinerea	Bell Heather
Festuca ovina	Sheep's Fescue
Festuca rubra	Red Fescue
Holcus lanatus	Yorkshire Fog Grass
Hypnum cupressiforme	Moss
Juncus acutifloris	Sharp Flowered Rush
Juncus effusus	Soft Rush
Juncus squarrosus	Heath Rush
Luzula multiflora	Heath Woodrush
Molinia caerulea	Purple Moor Grass
Nardus stricta	Mat Grass
Narthecium ossifragum	Bog Asphodel
Pleurozium schreberi	Moss
Polygala serpyllifolia	Milkwort

Potentilla erecta	Tormentil
Prunella vulgaris	Self Heal
Pseudoscleropodum purum	Moss
Ranunculus acris	Bulbous Buttercup
Rhytidiadelpus loreus	Moss
Rhytidiadelpus squarrosus	Moss
Rumex acetosa	Sorrel
Scutellaria minor	Lesser Skullcap
Sphagnum capillifolium	Sphagnum moss
Sphagnum palustre	Sphagnum moss
Sphagnum subnitens	Sphagnum moss
Succisa pratensis	Devil's Bit Scabious
Thuidium tamariscinum	Moss
Trifloium repens	White Clover
Ulex gallii	Western Gorse

TABLE E8

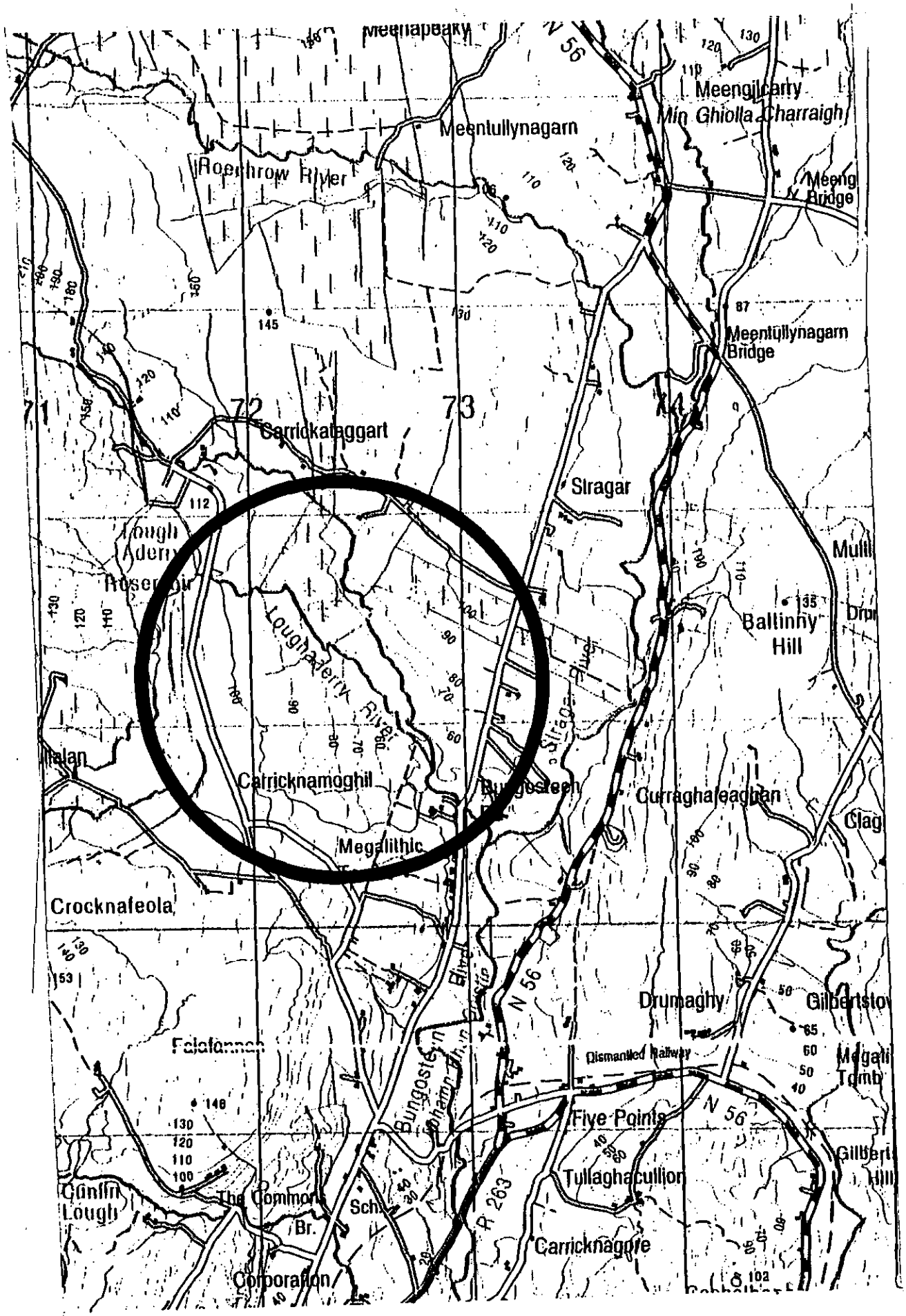
Rush Pasture

Agrostis stolonifera	Creeping Bent Grass
Anthoxanthum odoratum	Sweet Vernal Grass
Cardamine pratensis	Lady's Smock
Cirsium palustre	Marsh Thistle
Festuca arundinacea	Meadow Fescue
Holcus lanatus)	Yorkshire Fog Grass
Hypochaeris radicata	Cat's ear
Juncus acutifloris	Sharp flowered Rush
Juncus conglomeratus	Rush
Juncus effusus	Soft Rush
Leontodon autumnalis	Hawkbit
Lotus uliginosus	Greater Bird's Foot Trefoil
Lythrum salicaria	Purple Loosestrife
Molinia caerulea	Purple Moor grass
Plantago lanceolata	Ribwort Plantain
Prunella vulgaris	Self Heal
Ranunculus acris	Meadow Buttercup
Ranunculus repens	Creeping Buttercup
Rumex acetosa	Sorrel
Rumex acetosella	Sheep's Sorrel
Rumex crispus	Curled Dock
Succisa pratensis	Devil's Bit Scabious
Trifolium pratense	Red Clover
Trifolium repens	White Clover
Pteridium aquilinum	Bracken
Senecio jacobea	Ragwort

TABLE E9

Mixed Deciduous Woodland

Alnus glutinosa	Alder
Betula pubescens	Birch
Blechnum spicant	Hard Fern
Corylus avellana	Hazel
Crataegus monogyna	Hawthorn
Digitalis purpurea	Foxglove
Dryopteris affinis	Fern
Dryopteris dilatata	Fern
Dryopteris felix -mas	Fern
Fraxinus excelsior	Ash
Hedera helix	Holly
Ilex aquifolium	Ivy
Luzula sylvatica	Woodrush
Pteridium aquilinum	Bracken
Quercus petraea	Sessile Oak
Rubus fruticosus agg.	Bramble
Salix aurita	Eared Willow
Salix cinerea	Grey Willow
Sorbus aucuparia	Rowan
Ulex europaeus	European Gorse

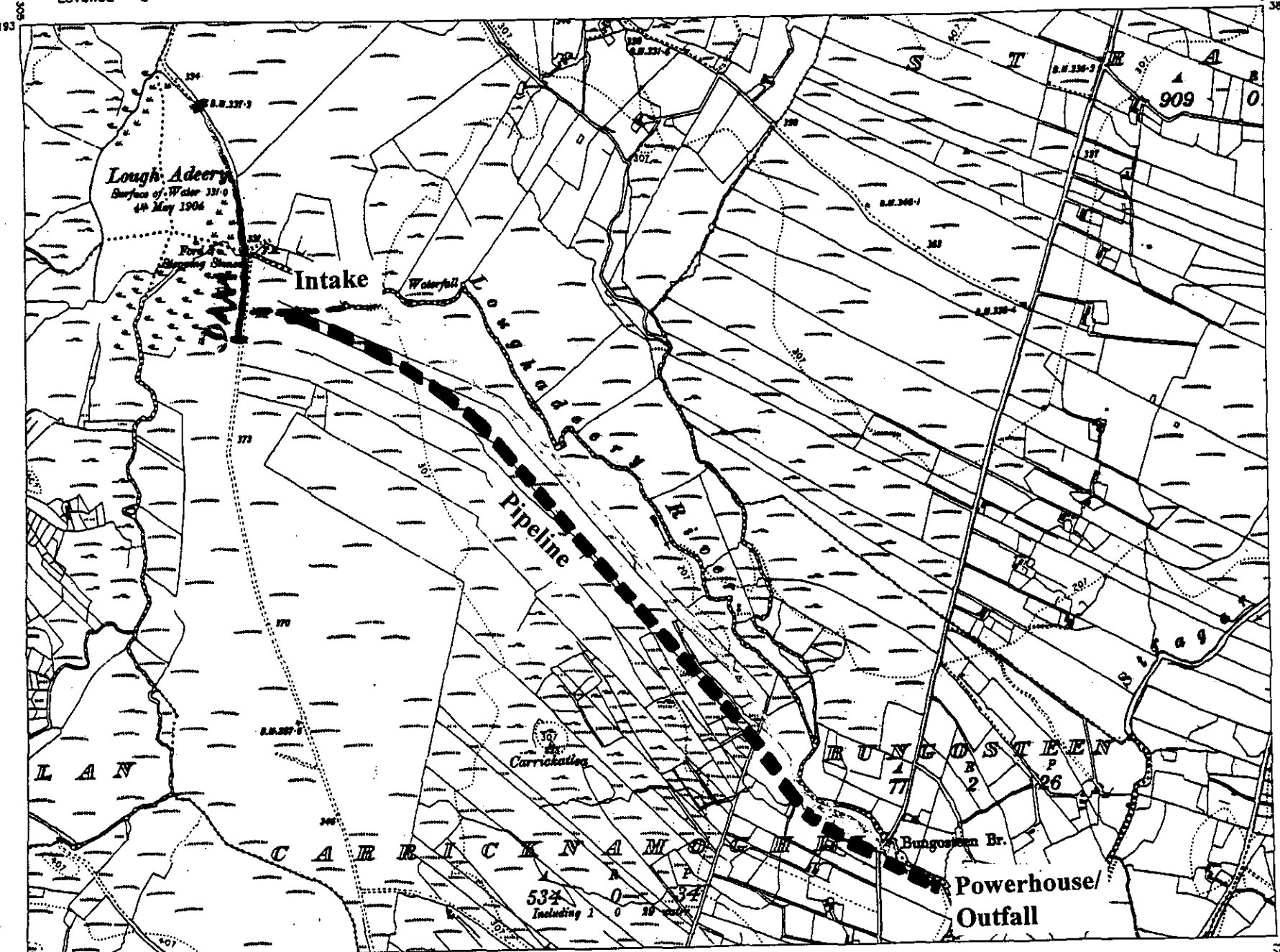


Location of Project

Surveyed 1835
Revised 1904
Levelled 0

Record PLACE Map

Figure 1a



DESCRIPTION

MAP SCALES

6inch
DL091

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Ní hionann bóthar, bealach nó cosán a bheith ar an léarscáil seo agus fianaise ar cheart sli.

The representation on this map of a road, track or footpath is not evidence of the existence of a right of way.

Dlanchosc ar mhacasamhlú an iomlán ná aon chuid de gan cead roimhré ó Stiúrthóir Shuirbhéireacht Ordanáis Éireann.

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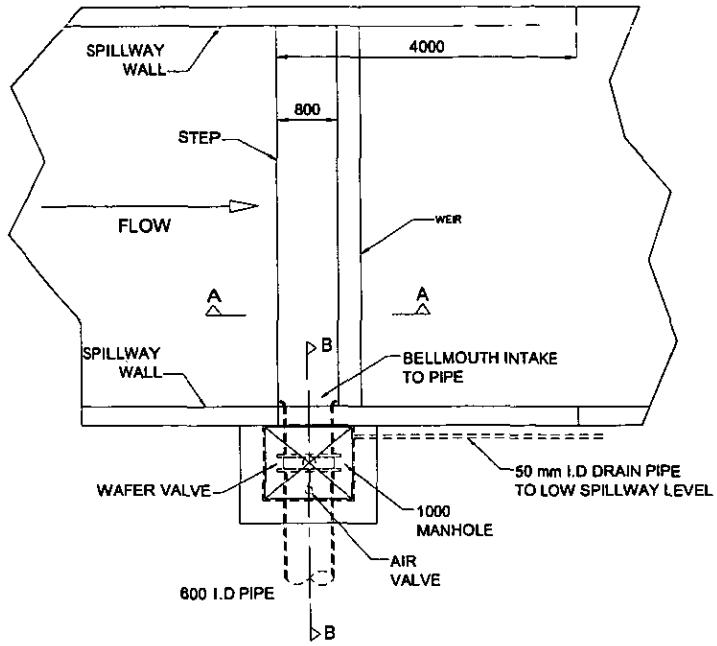
Scale:- 1:10560
Scála:- 1:10560

500 400 300 200 100 0 500 Metres
1000 500 0 1000 Feet

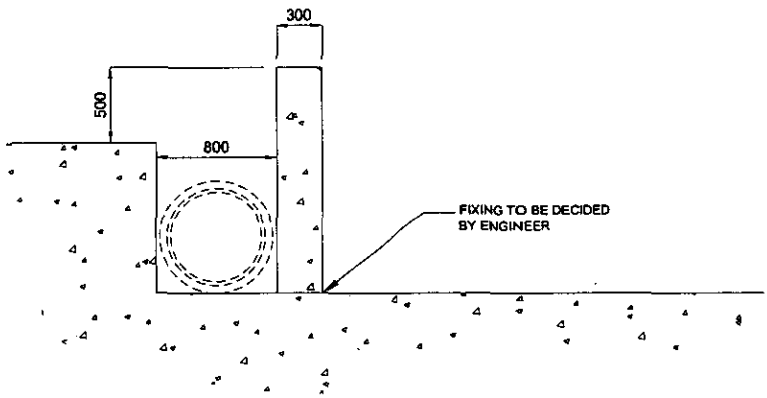
Plot Ref. No. 172967_2
Plot Date 12-JUN-2001

Location Plan Showing Fishery Survey Sites



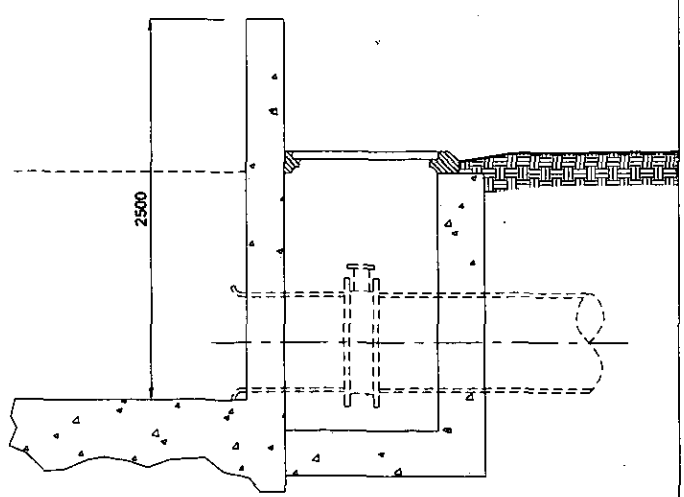
LAYOUT OF INTAKE

(SCALE 1:100)



SECTION A-A

(SCALE 1:50)



SECTION B-B

(SCALE 1:50)

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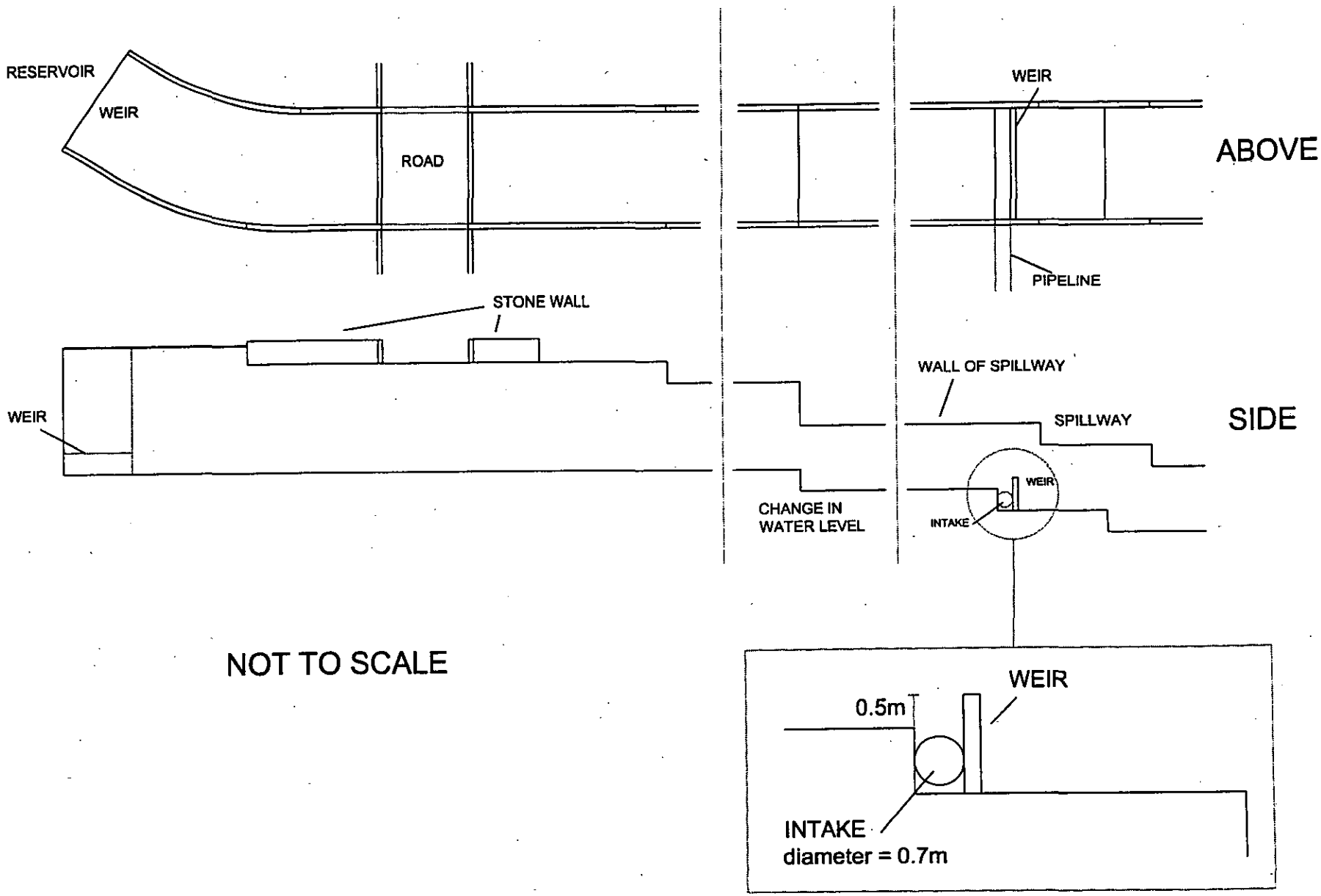
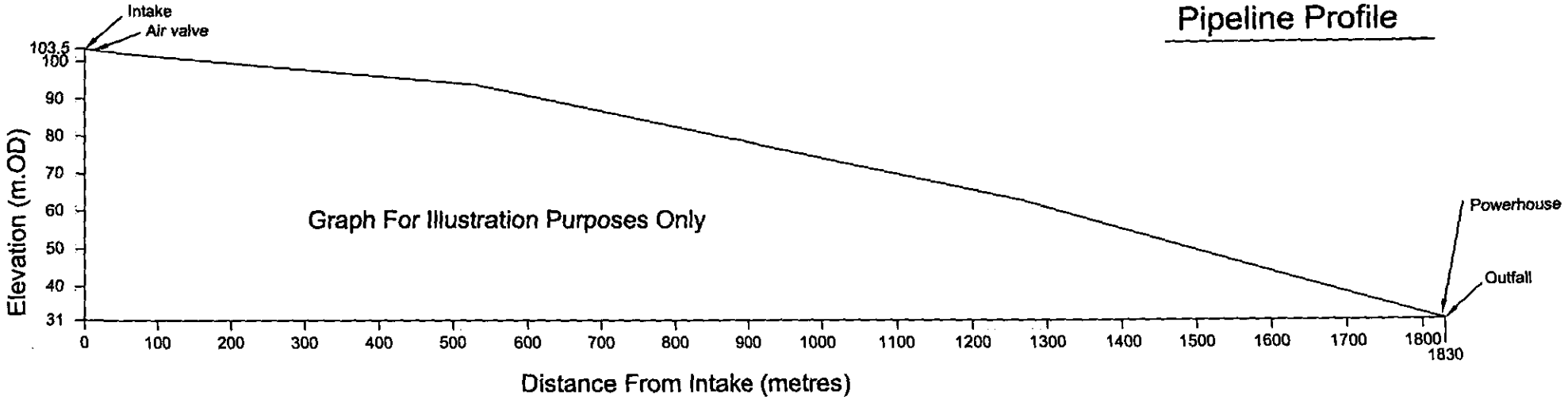
Adeery Hydro-Power Scheme
Detail of Intake Structures and Weirs

Drwg No : 340 / 2	Date : 18/09/01
Scale : 1:50 / 1:100 at A4	Drawn By : SDC

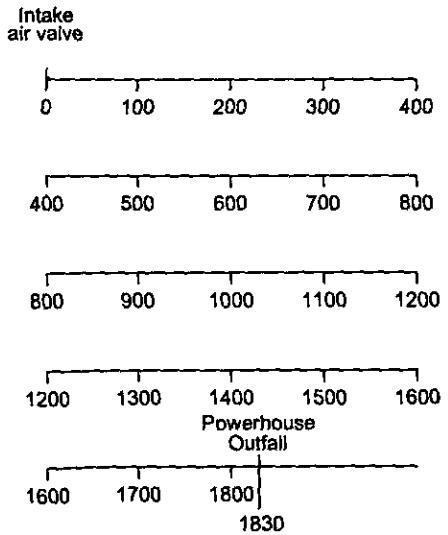


Layout of Upper Part of Spillway on Loughadeery Dam

Pipeline Profile



Pipeline details (m from intake)

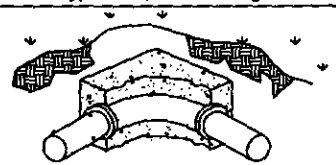


Bends

A = 90°
B = 45°
C = 22.5° (4 no)
D = 11.25° (6 no)

Note :
May be modified during construction

Detail of Typical Pipe Anchorage



1. All bends of more than 11.25' angle shall be supported by mass concrete thrust blocks.
2. The dimensions of each block shall be decided by the engineer when the excavation for each bend is opened up.
3. Each anchorage shall accord with the general specification of the pipeline supplier.
4. Wherever possible, all anchorages shall be located at a depth sufficient for full ground reinstatement to be carried out.

Specification for Pipeline

1. Pipeline to be of GRP and/or polyethylene.
2. Pipe bedding and backfilling to be to manufacturer's specification for prevailing ground conditions.
3. Internal and external surfaces of pipeline, bends, and joints to be protected as per manufacturer's advice to give minimum of 50 years protection against corrosion.
4. Pipeline to be laid with minimum 300 cover, locally increased with added protection as necessary to suit vehicle wheel and any other specified loadings.
5. All protection and trench fill materials to be acceptable to the relevant regulatory authority.
6. Pipe route to be reinstated as found or locally covered as may be specified.

Notes;
To be read in conjunction with Drg Nos.340/2 -340/7
Drg. No. 340/1 shows pipe route drawn on OS 1:50,000 map ref no 10

Drg. No. 340/2 shows detail of intake structure at G 718 816

Drg. No. 340/4 shows detail of the layout of turbine house and equipment

Drg. No. 340/5 shows detail of power house and structural work

Drg. No. 340/7 shows detail of outfall structure at G 731 805

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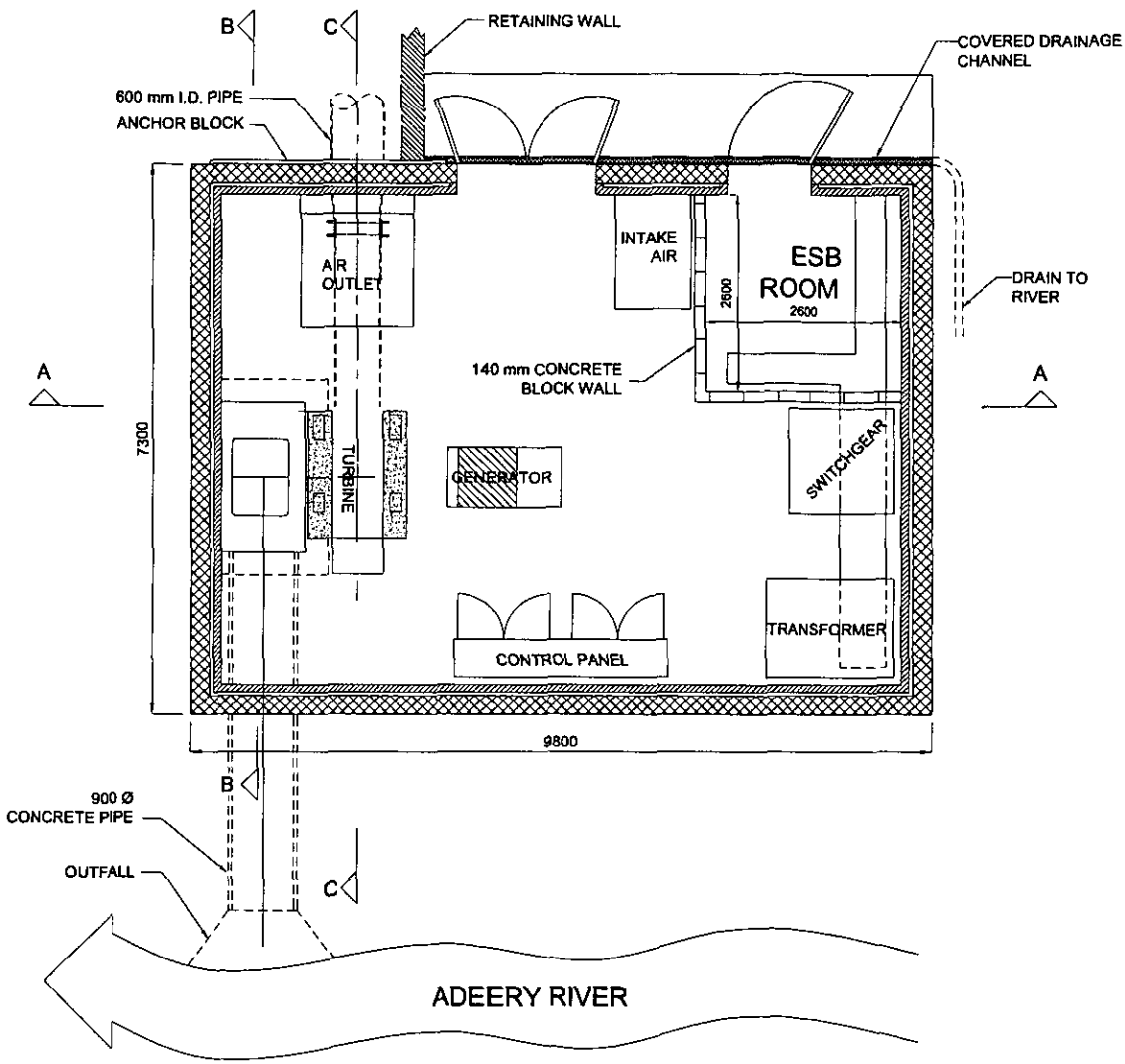
Title
Adeery Hydro- Power Scheme
Details of Pipe Route Including Anchorages

Drwg No.:	340/3	Date:	07/11/01
Scale:	NTS	Drwn By:	S.D.C



POWERHOUSE LAYOUT

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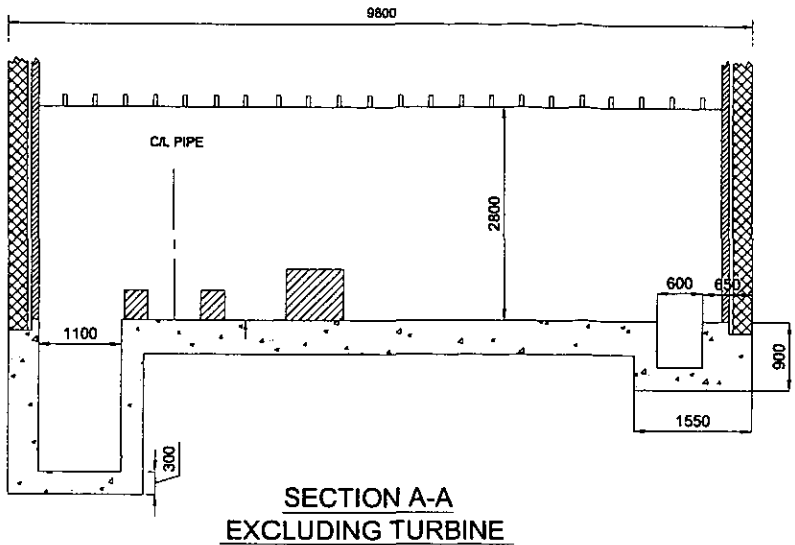
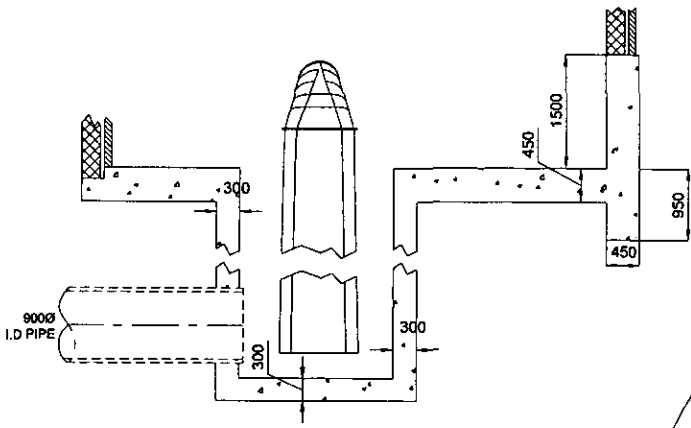
Adeery Hydro-Power Scheme
Powerhouse layout

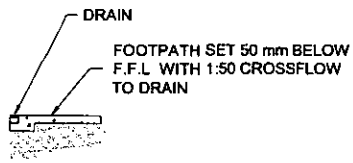
Drwg No :	340/4	Date :	21/11/01
Scale :	1:100 at A4	Drawn By :	SDC



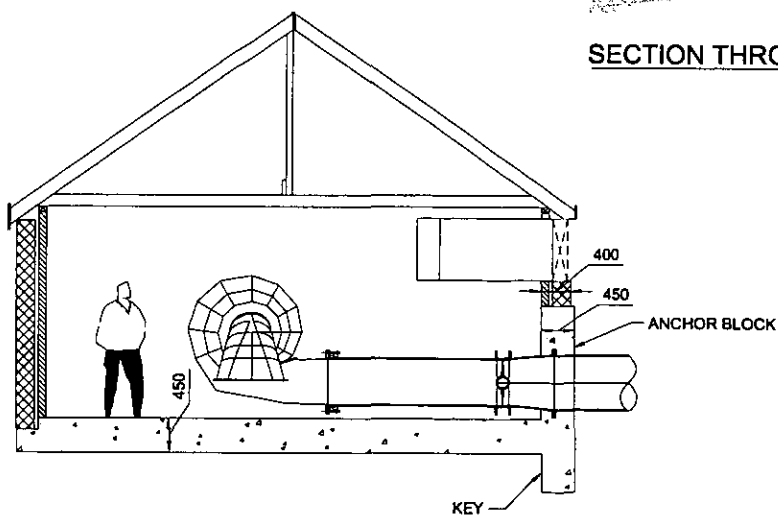
SECTION A-A
EXCLUDING TURBINE



SECTION B-B



SECTION THROUGH PATH



SECTION C-C

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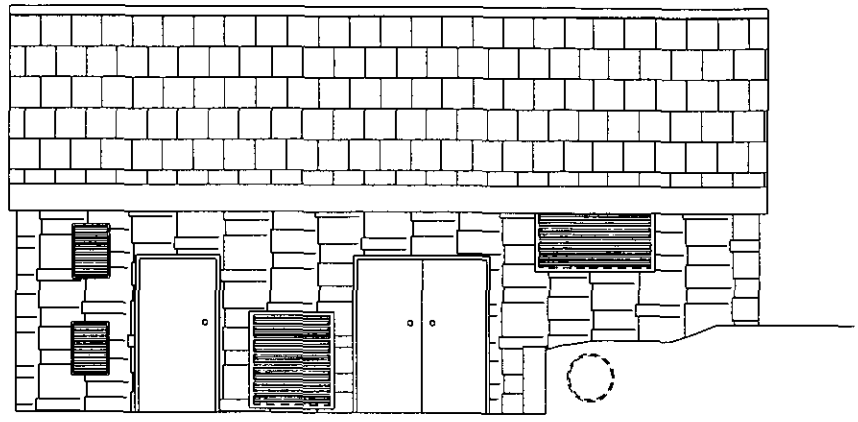
Adeery Hydro-Power Scheme
Powerhouse Sections

Drwg No :	340/5	Date :	21/11/01
Scale :	1:100 at A4	Drawn By :	SDC



FRONT ELEVATION

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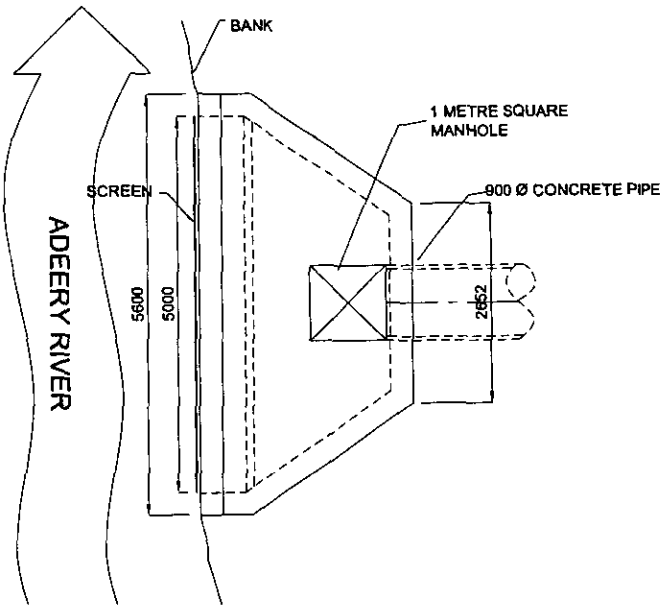
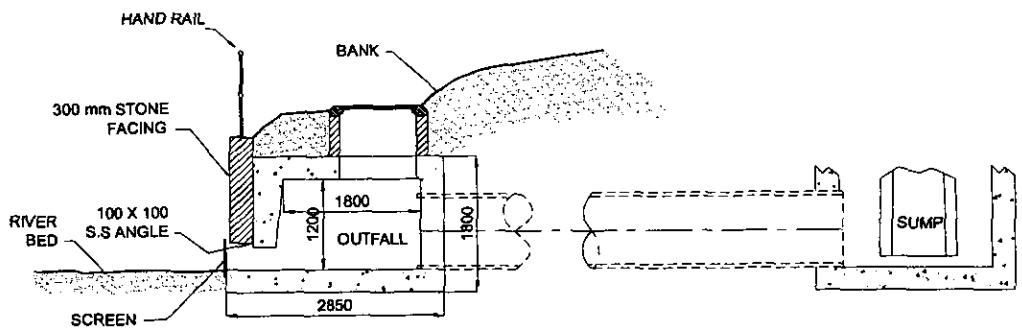
Adeery Hydro-Power Scheme
Powerhouse Front Elevation

Drwg No : 340/6	Date : 21/11/01
Scale : 1:100 at A4	Drawn By : SDC



PLAN ON OUTFALL



SECTION THROUGH OUTFALL/POWERHOUSE

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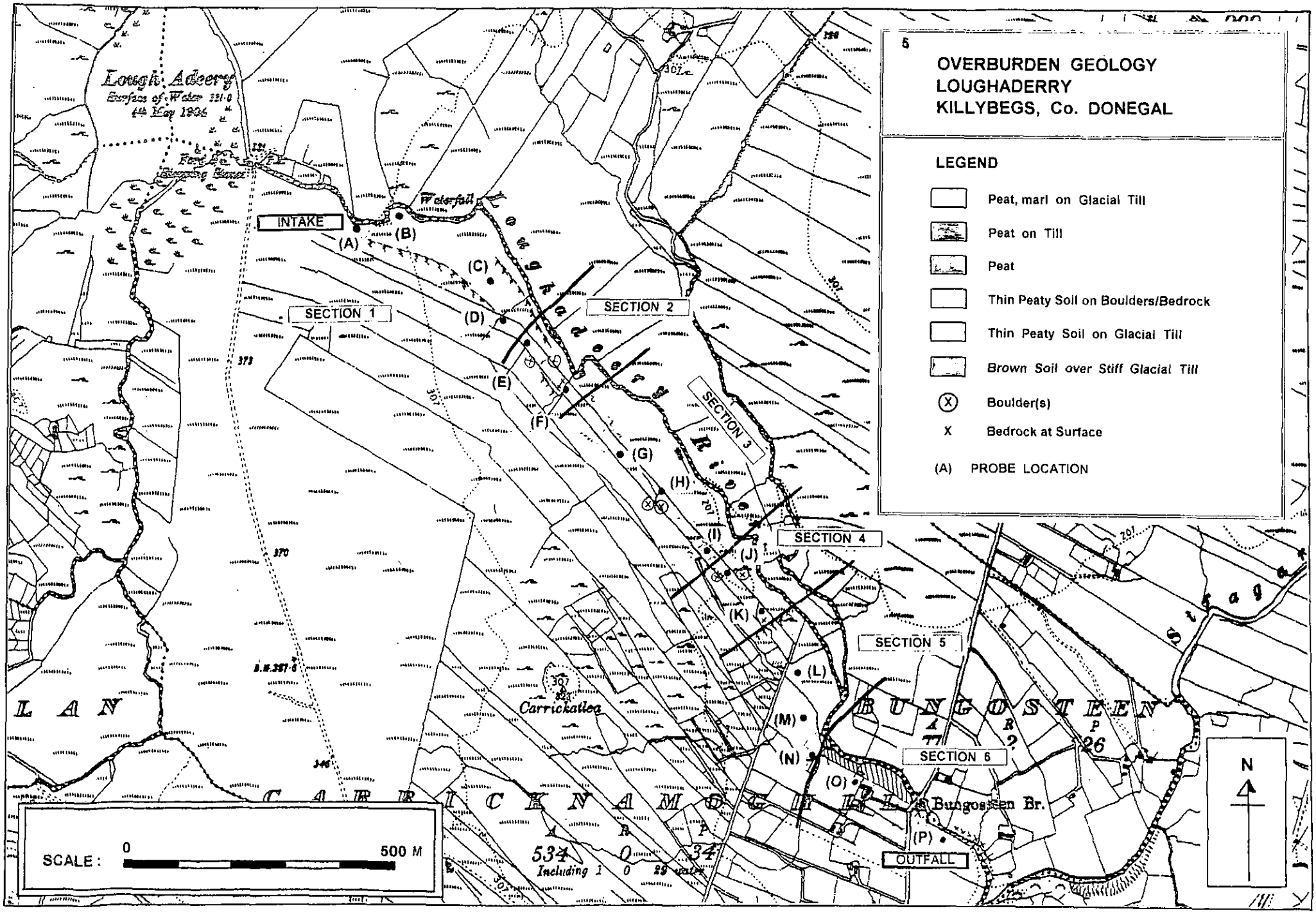
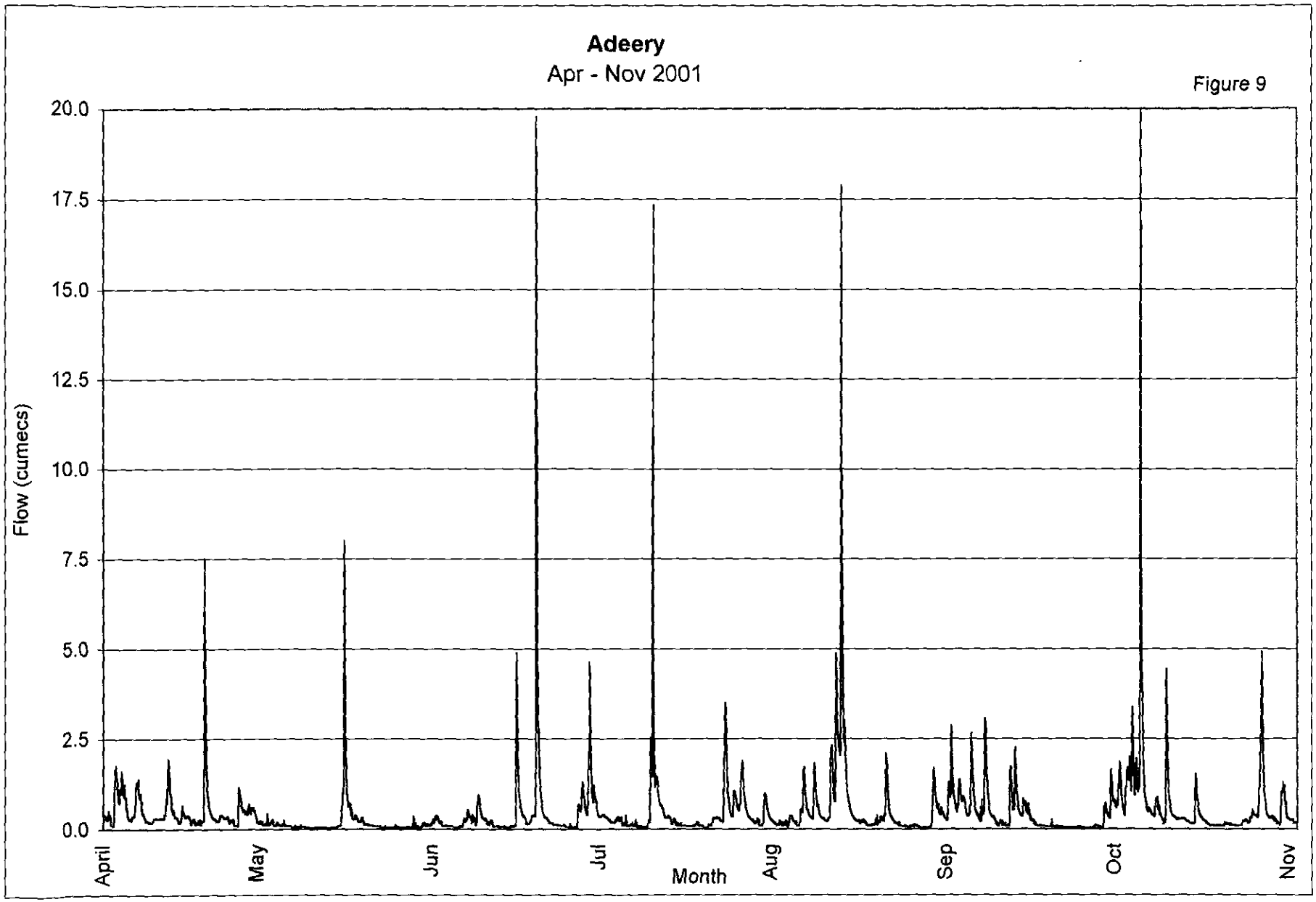
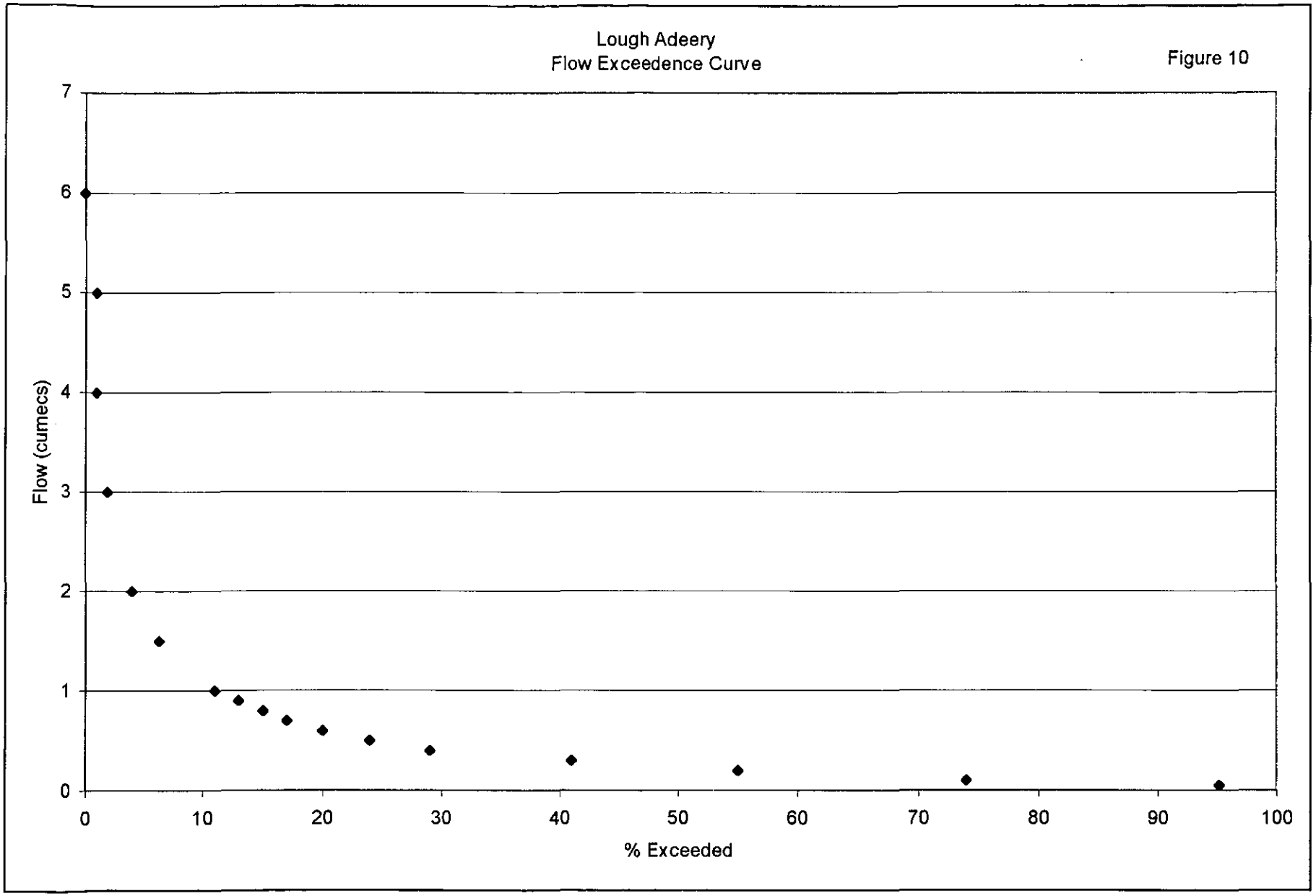
Adeery Hydro-Power Scheme
Detail of Outfall

Drwg No :	340/7	Date :	17/09/01
Scale :	1:100 at A4	Drawn By :	S.D.C


5
OVERBURDEN GEOLOGY
LOUGHADERRY
KILLYBEGS, Co. DONEGAL
LEGEND
Peat, marl on Glacial Till
Peat on Till
Peat
Thin Peaty Soil on Boulders/Bedrock
Thin Peaty Soil on Glacial Till
Brown Soil over Stiff Glacial Till
Boulder(s)
Bedrock at Surface
(A) PROBE LOCATION
Lough Adeery
Surface of Water 331·0
4th May 1936
Waterfall
INTAKE
(A)
(B)
(C)
(D)
(E)
(F)
(G)
(H)
(I)
(J)
(K)
(L)
(M)
(N)
(O)
(P)
SECTION 1
SECTION 2
SECTION 3
SECTION 4
SECTION 5
SECTION 6
OUTFALL
Carrickatlea
Bungosteen Br.
SCALE : 0 500 M
N


Adeery
Apr - Nov 2001
Figure 9
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Flow (cumecs)
April
May
Jun
Jul
Aug
Sep
Oct
Nov
Month


Lough Adeery
Flow Exceedence Curve
Figure 10
Flow (cumecs)
7
6
5
4
3
2
1
0
0
10
20
30
40
50
60
70
80
90
100
% Exceeded

Lough Adeery
Annual Average Meteorological Data

Figure 11

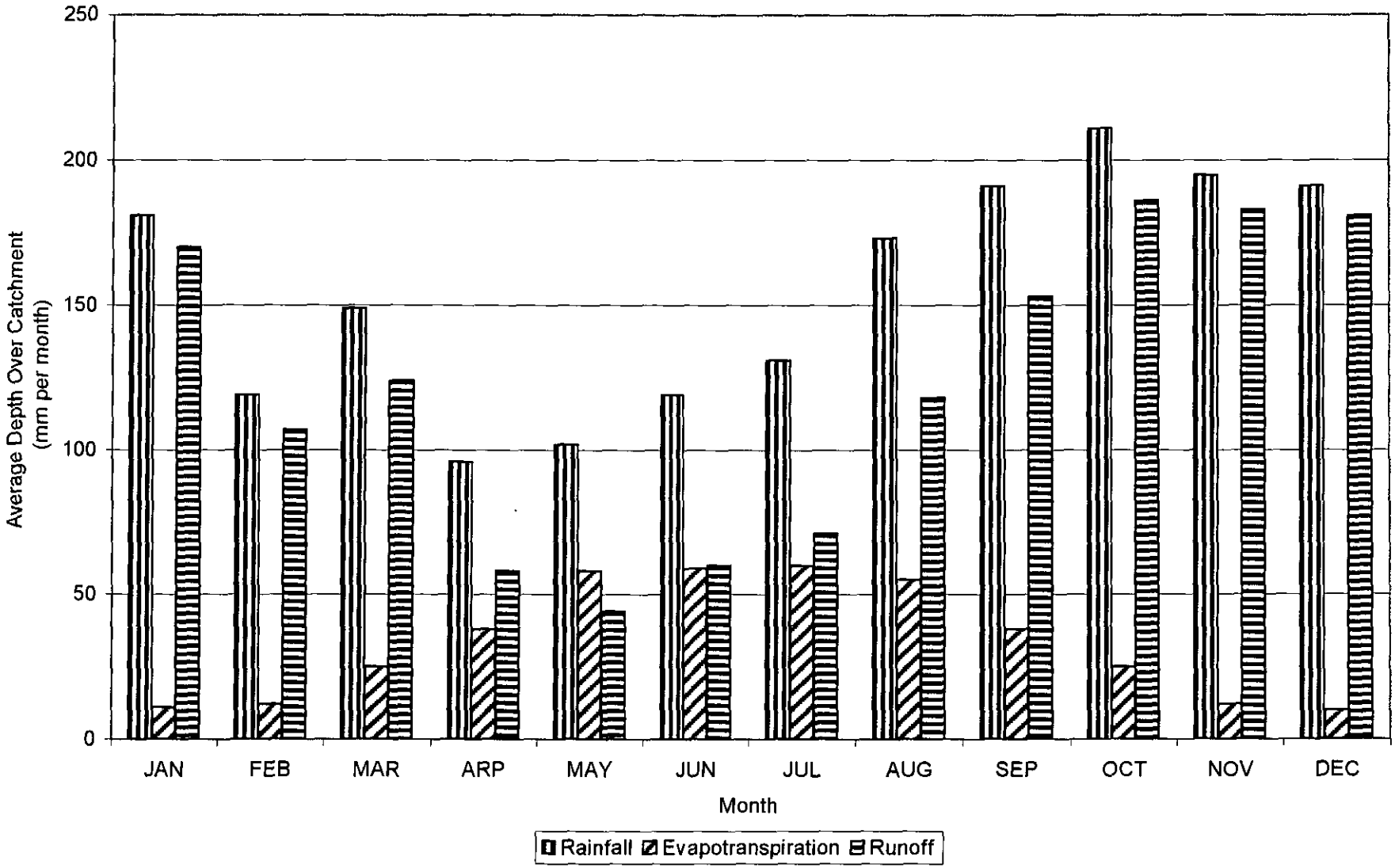
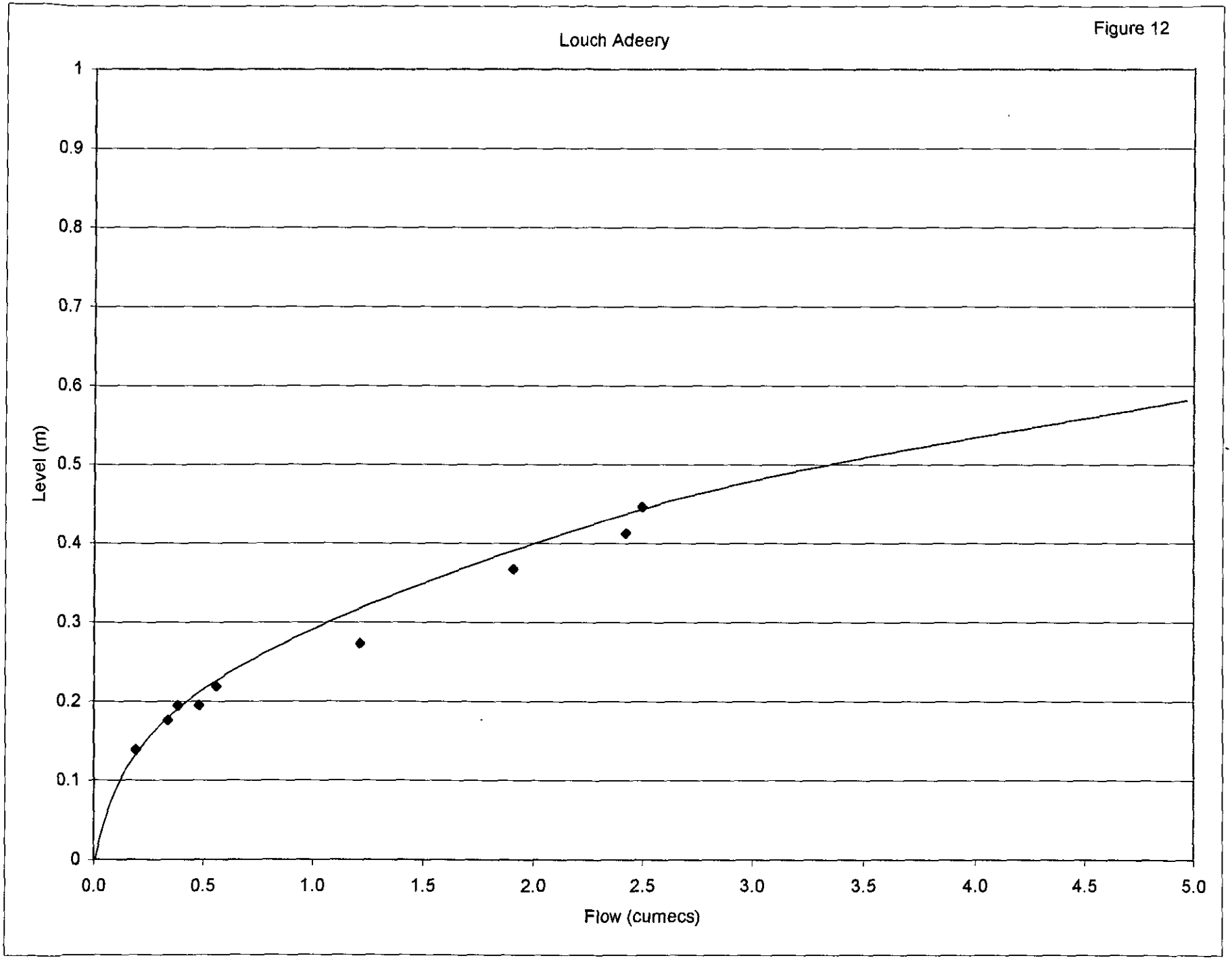
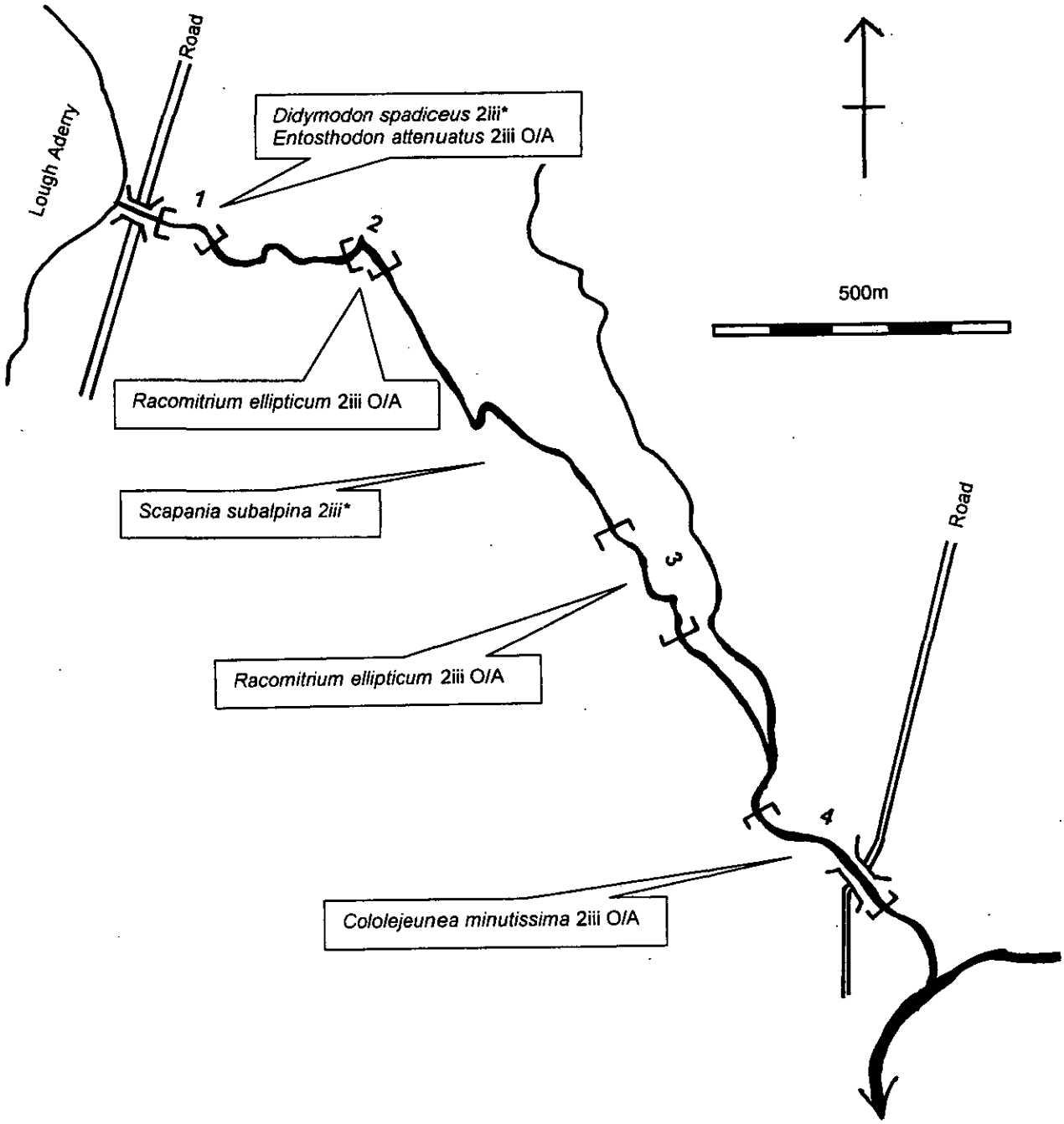


Figure 12

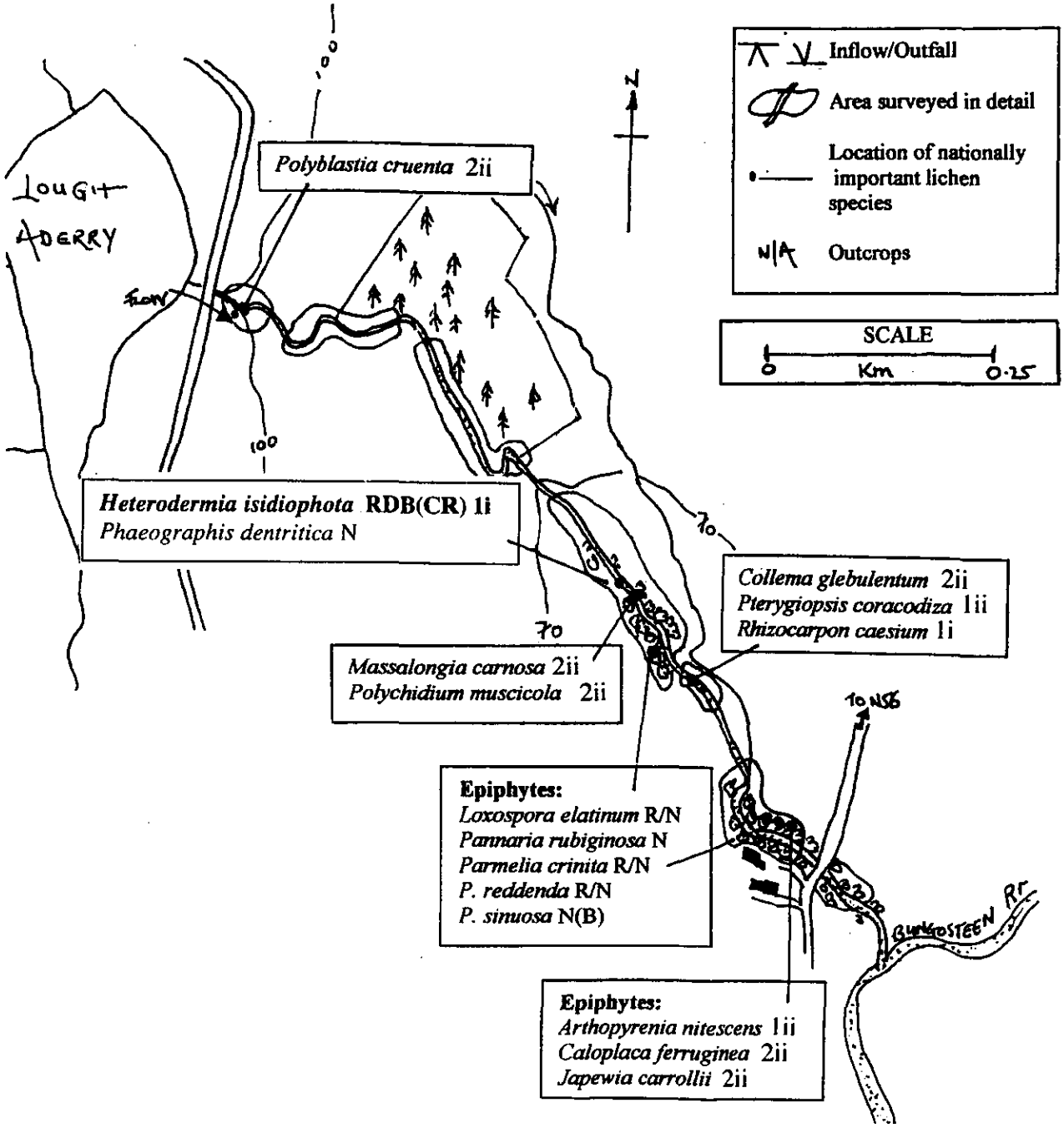

Louch Adeery
Level (m)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Flow (cumecs)

Map of the surveyed stretch of Loughadeery River showing the locations of the main bryophyte survey sites (1 - 4), the species with 2iii* status and Oceanic/Atlantic species with 2iii status (see Table E1 for information about status and Oceanic/Atlantic categories)



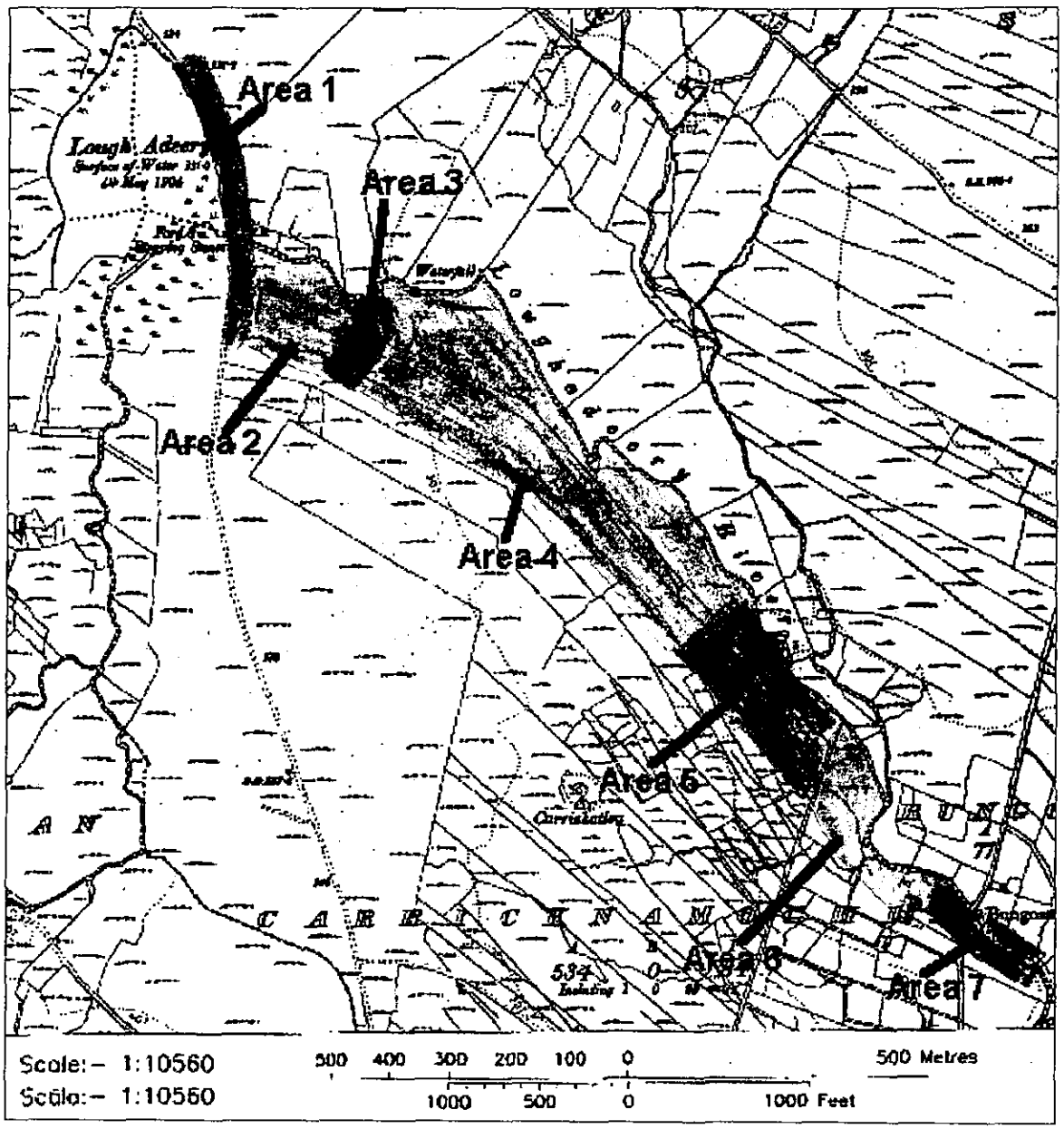
Locations Reported in Assessment of Flora

Map of the surveyed stretch of the Loughadeery River showing the locations of the main lichen survey sites and the species of particular interest. 1i, 1ii and 2ii = status, N = NIEC indicator species, R = RIEC indicator species, (B) = bonus species and RDB(CR) = critically endangered Red Data Book species (see Table E2 for information about status and indicator species)



Locations Reported in Assessment of Flora

Site Habitat Map



Site Habitat Map **See text for description of habitats in Areas 1-7 highlighted on the above map.**

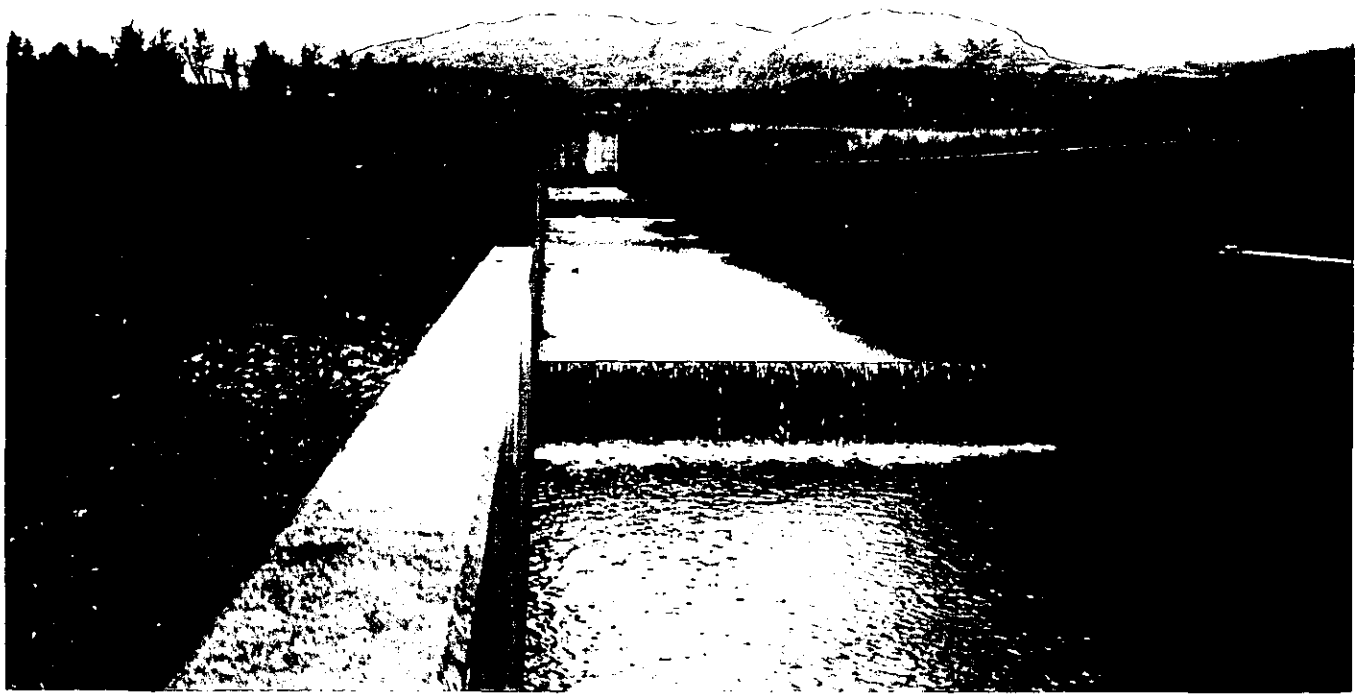


Plate 1 **Location of Intake below Second Step down Spillway**

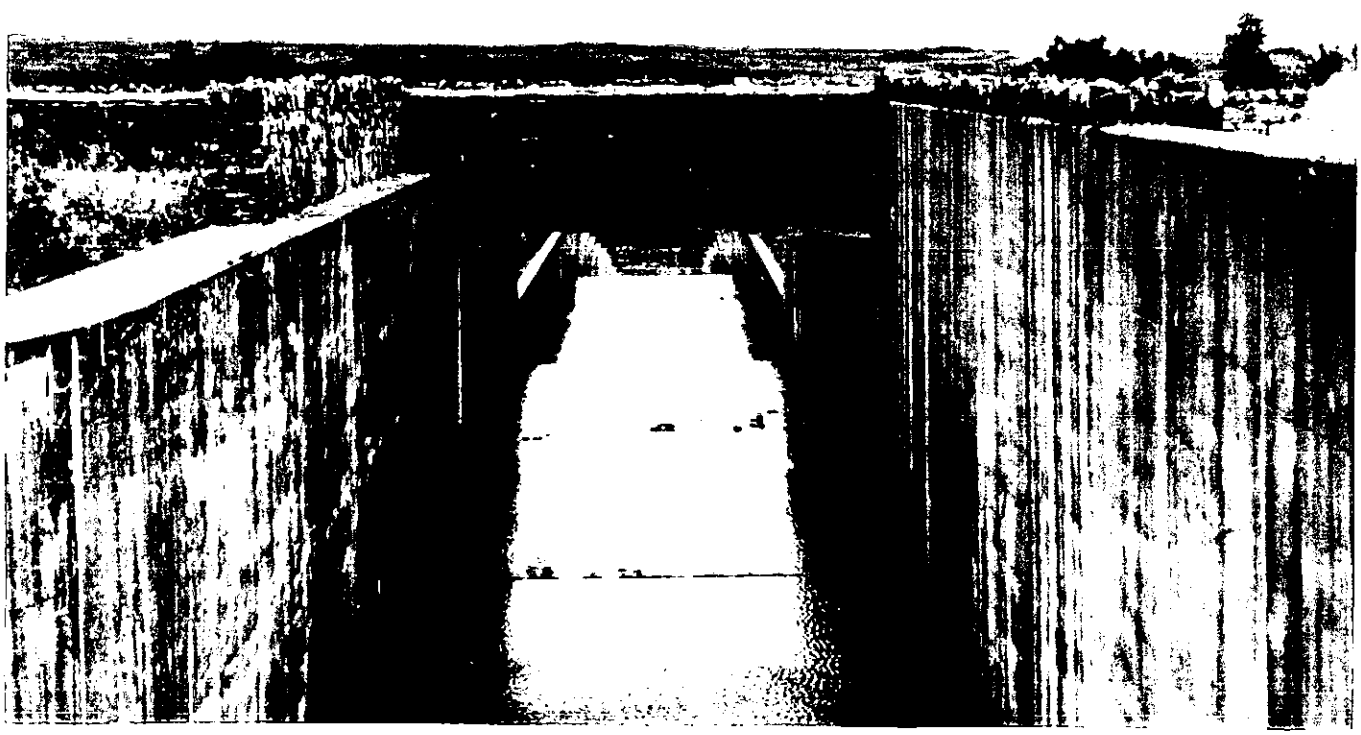


Plate 2. **View Down Spillway (under bridge) to First and Second (Intake) Steps**

Plate 3 **View Uphill in Direction of Spillway**

Plate 4. **View Uphill along Proposed Pipe Route**

Plate 5 View of Pipe Route which passes Down Right Side of Factory

Plate 6. View from Factory along Pipe Route towards Powerhouse

Plate 7 View from near Powerhouse Up Pipe Route towards Powerhouse

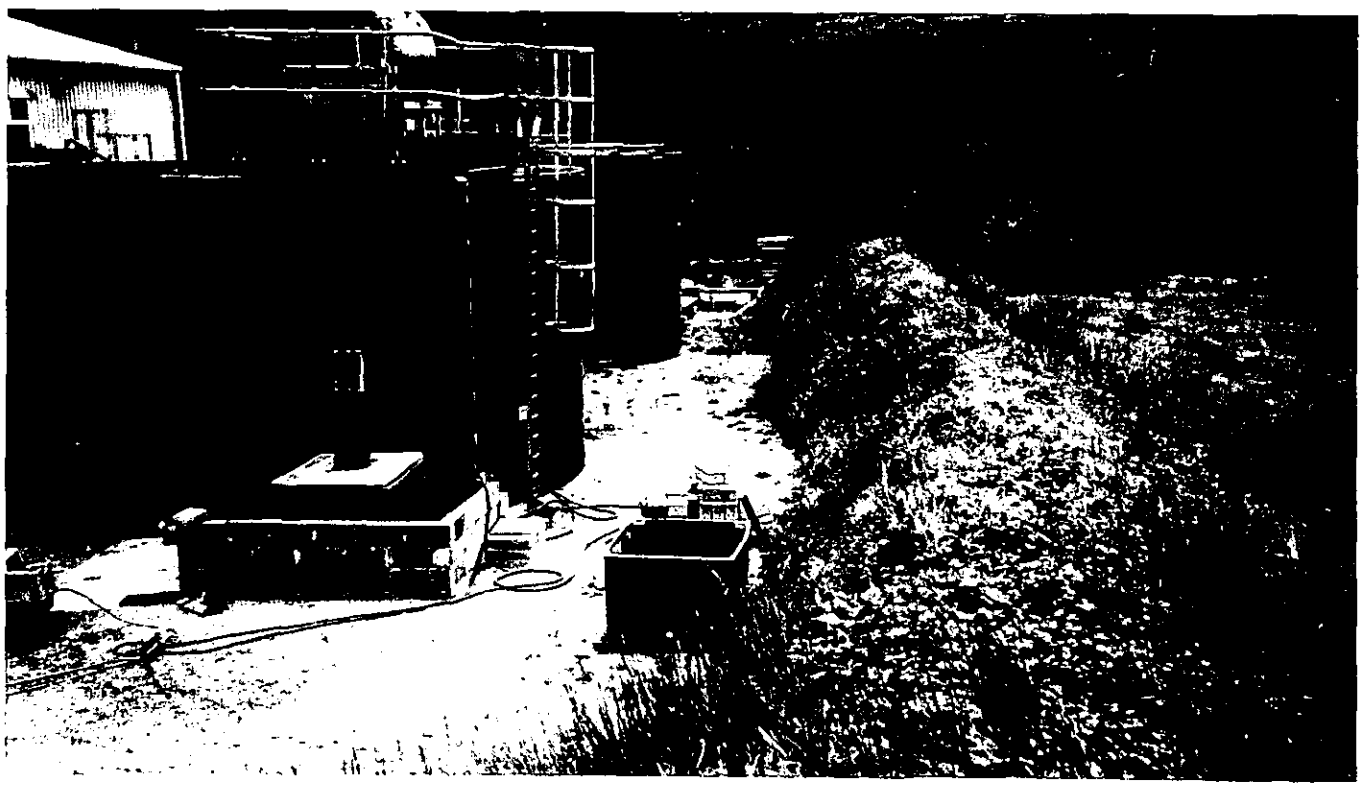


Plate 8. View Past Treatment Plant to Powerhouse Site Below

Plate 9 **Powerhouse Site Immediately Below Treatment Plant**

Plate 10 SECTION I. View westward towards proposed intake area and Loughaderry.

Plate 11 SECTION I. Overburden exposed along riverbank close to proposed intake.

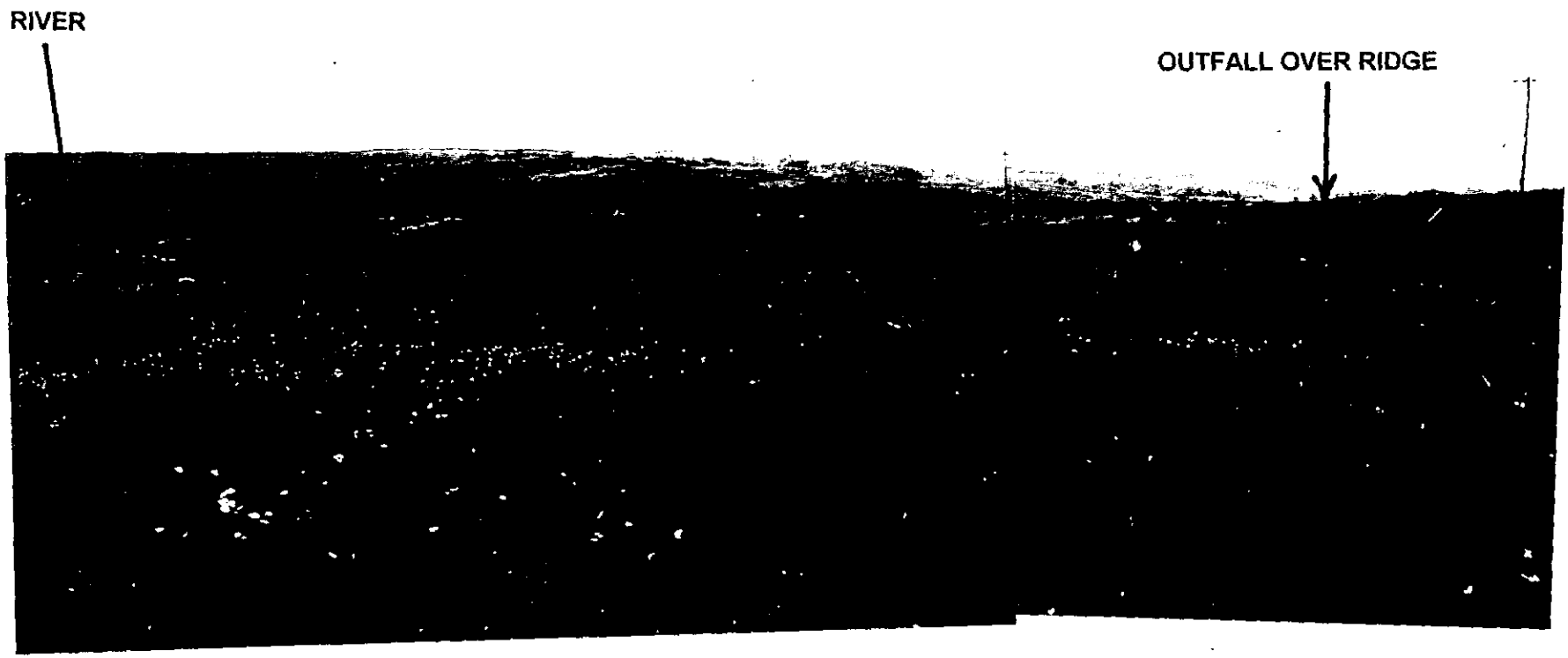


Plate 12 SECTION 1. View looking South along proposed route from (B).

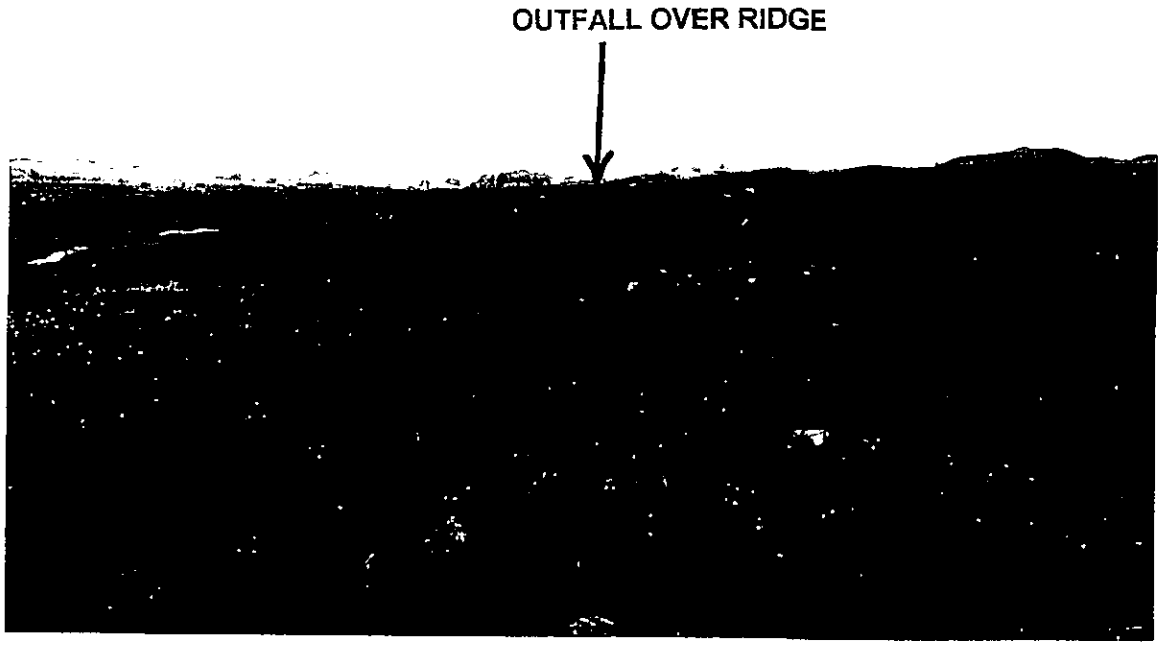


Plate 13 SECTION 1. View of old field boundary at (D).

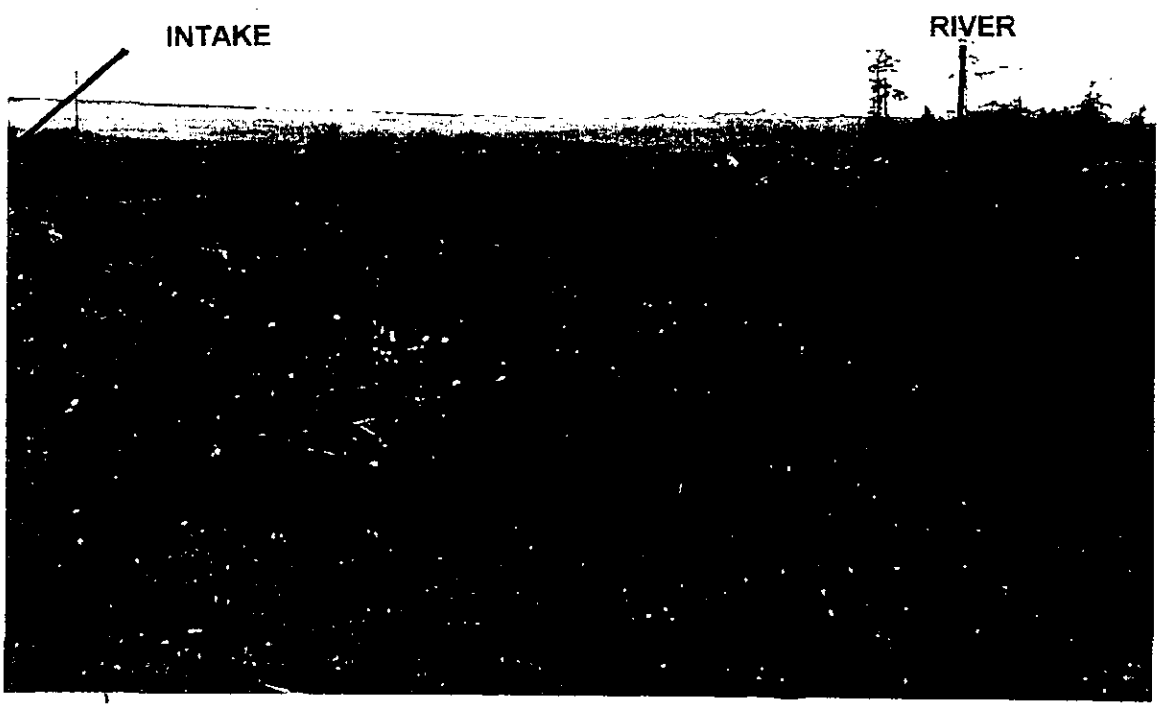


Plate 14 SECTION 1. View looking North over boggy area.

Plate 15 SECTION 1 Overburden and bedrock exposed close to (D)

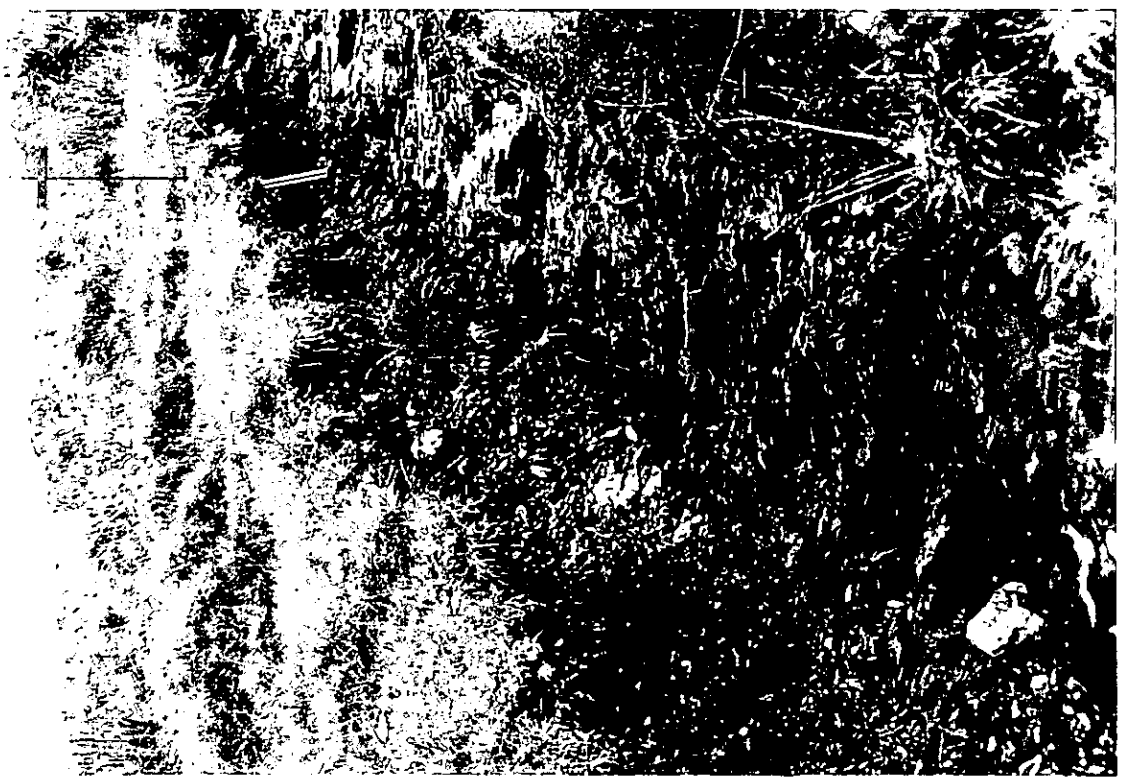


Plate 16 SECTION 2. Overburden exposed at (F).

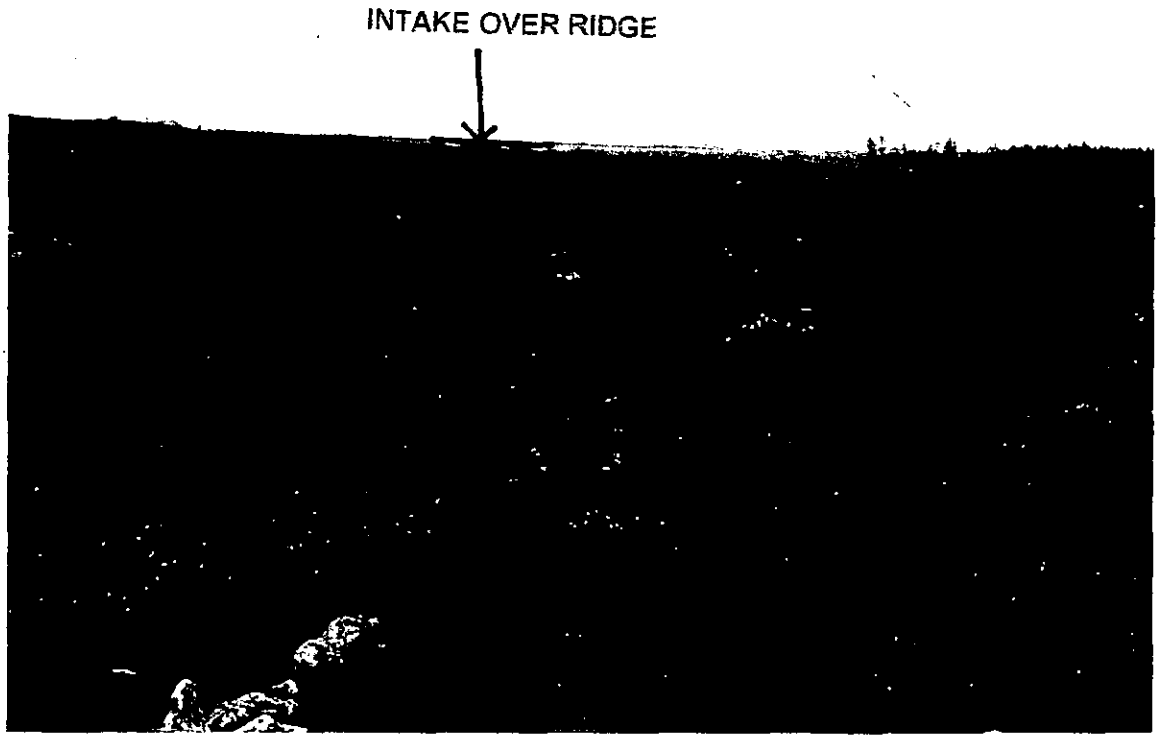


Plate 17 SECTION 3. View looking North over bog from (G).

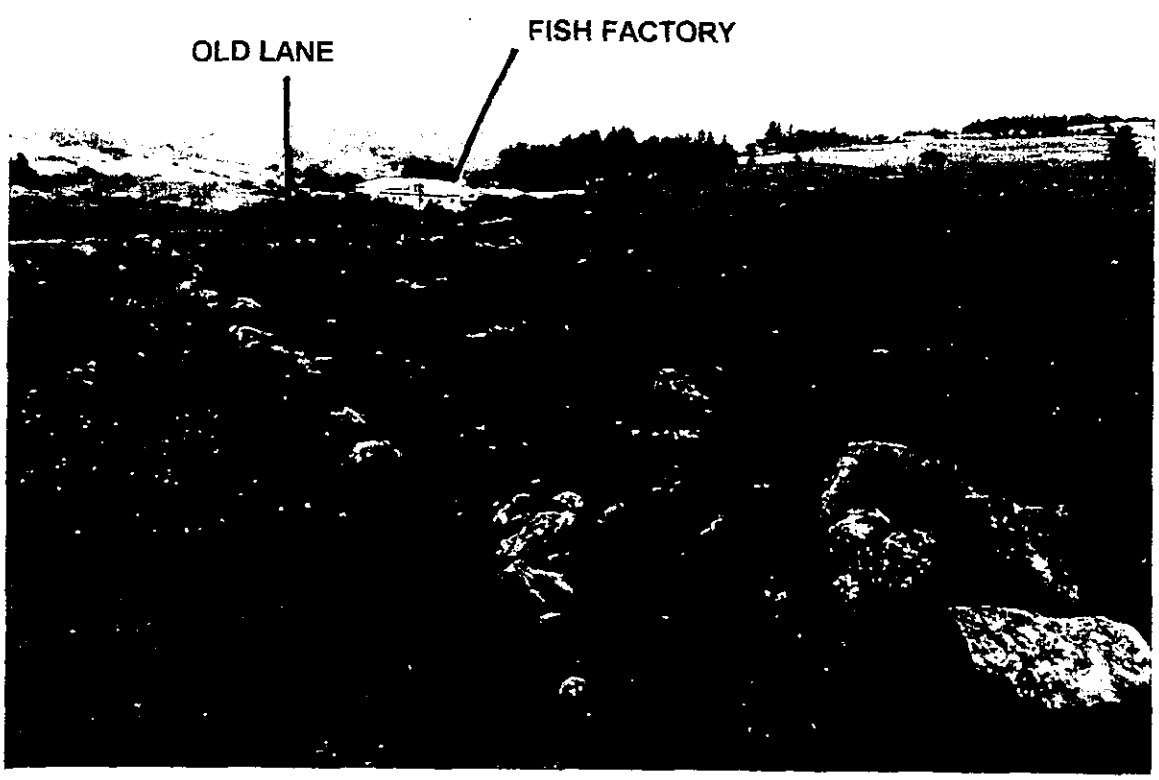


Plate 18 SECTION 4. View looking South. (Note: fish factory in the distance).

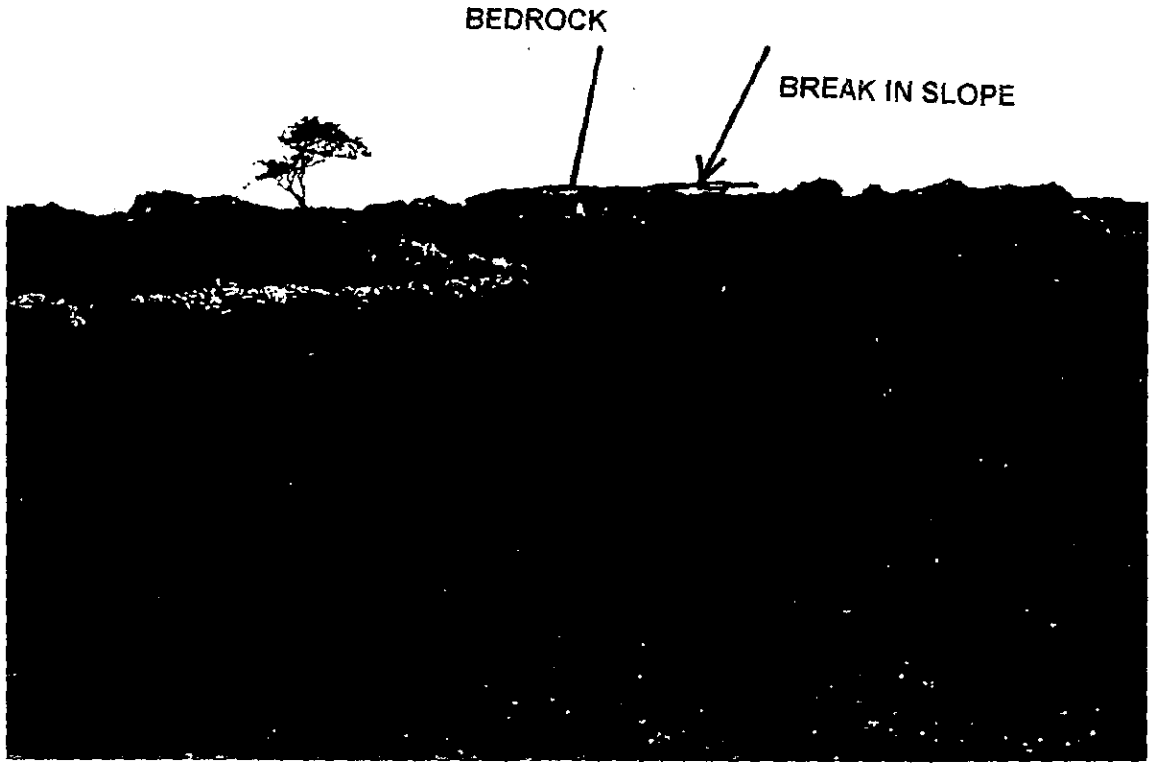


Plate 19 SECTION 5. View looking North towards break in slope.

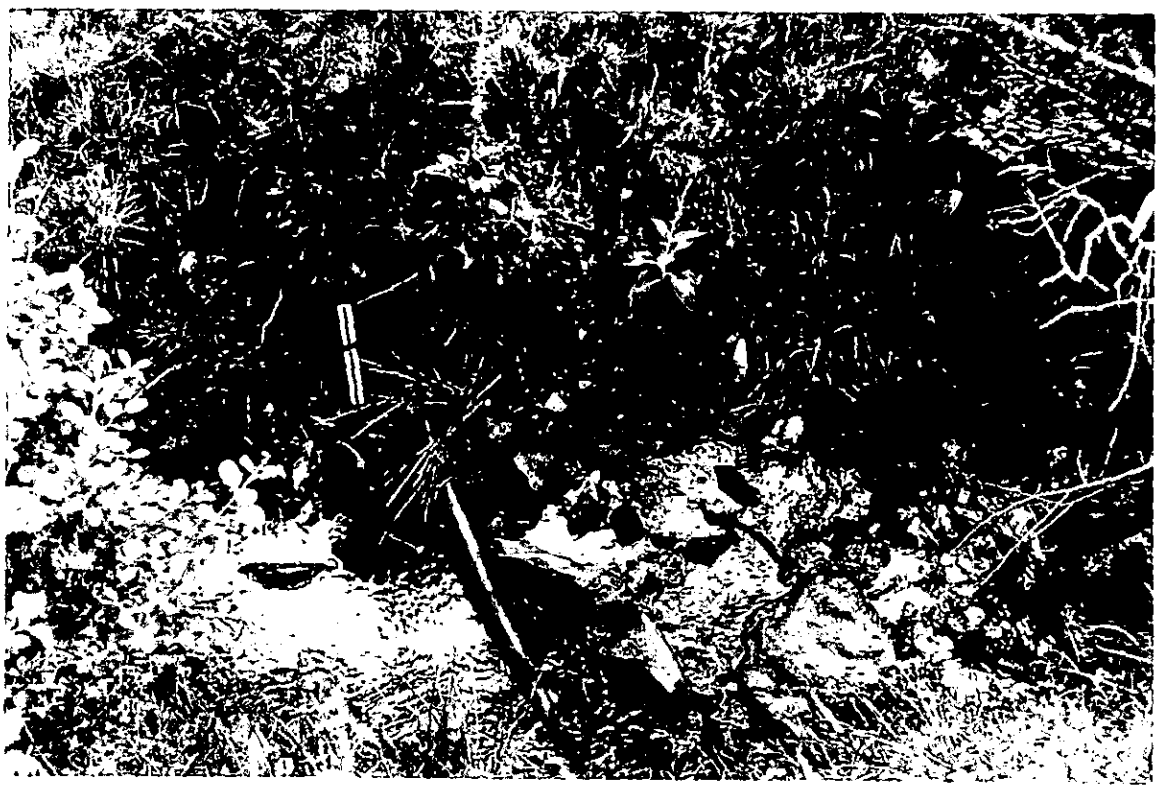


Plate 20 SECTION 5. Overburden exposed in stream at (N).

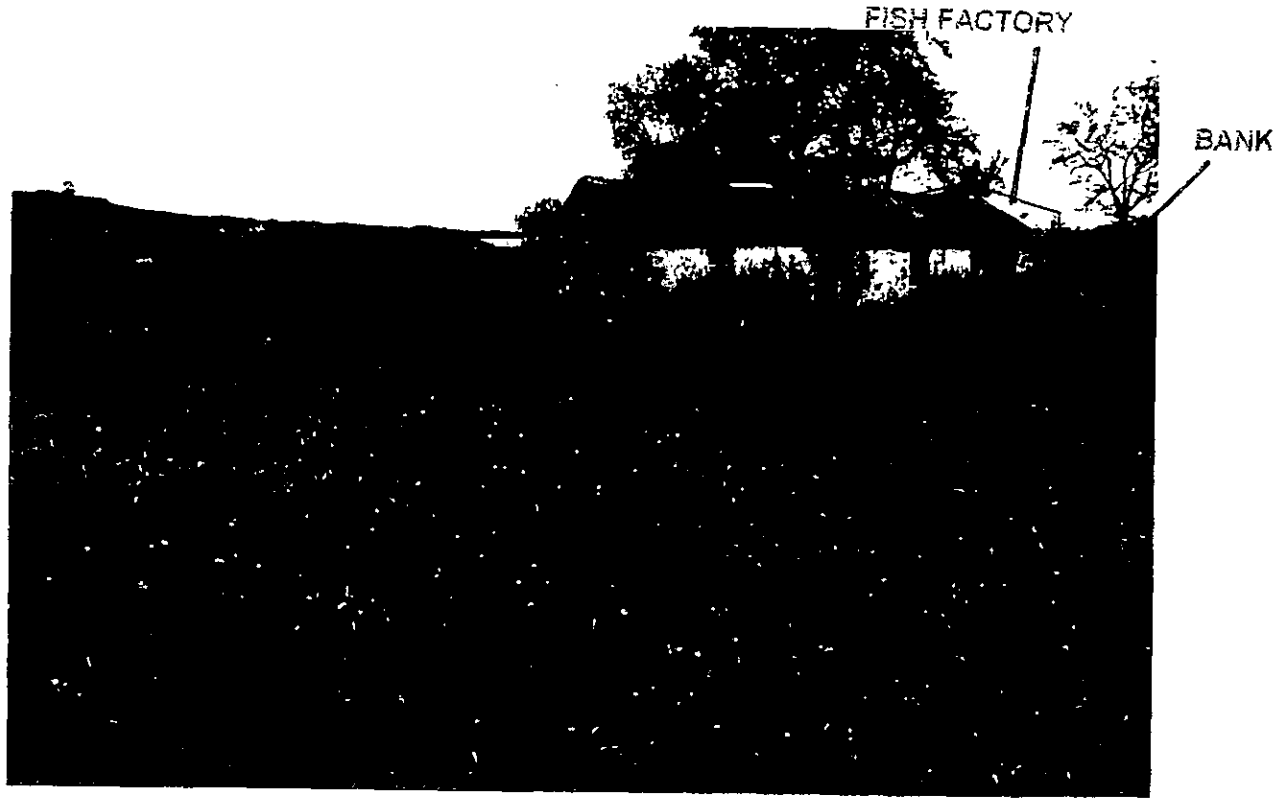


Plate 21 SECTION 6. View of grassy field looking North from (O).

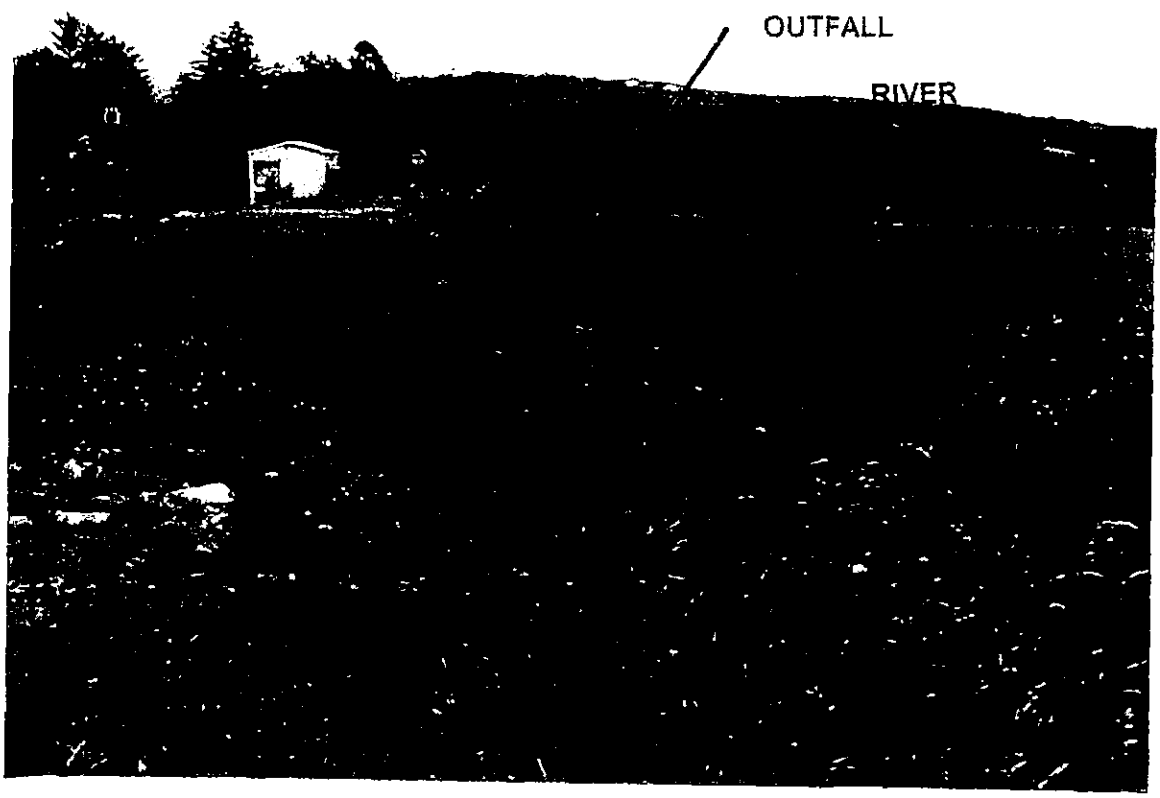


Plate 22 SECTION 6. View looking South towards proposed outfall from road.