Department of Agriculture, Food and the Marine

An Roinn Talmhaíochta, Bia agus Mara

T27/2A

AQUACULTURE LICENCE

AQUACULTURE LAND BASED FINFISH (FRESHWATER)

Goatsbridge Trout Farm Ltd

Thomastown

Co Kilkenny

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T27/2A

AQUACULTURE LICENCE NO. 797

GRANTED UNDER THE FISHERIES (AMENDMENT) ACT, 1997 (NO. 23 of 1997)

The Minister for Agriculture, Food and the Marine (hereinafter referred to as the "Minister"), in exercise of the powers conferred on him by the Fisheries (Amendment) Act, 1997 (No. 23 of 1997) (hereinafter referred to as the "Act"), grants an Aquaculture Licence to:

Goatsbridge Trout Farm Ltd

Thomastown

Co Kilkenny

(hereinafter referred to as the "Licensee") for the cultivation of Rainbow Trout on a site at Jerpoint, Thomastown, Co. Kilkenny as specified in Schedule 1 attached, subject to the Act and Regulations made under the Act and to the terms and conditions set out in the attached pages.

This Aquaculture Licence shall remain in force for a maximum period of ten years commencing on 10 September 2014, and only so long as the fish farm complies with the Local Government (Water Pollution) Acts licence to discharge effluent granted by Kilkenny County Council on 11th May 2012(ref ENV/W/44) (or a further such licence granted by the said Council or by the Environmental Protection Agency).

A person authorised under Section 15(1) of the Ministers and Secretaries Act 1924 to authenticate the Seal of the Minister for Agriculture, Food and the Marine.

TERMS AND CONDITIONS APPLYING TO THIS AQUACULTURE LICENCE

1. **Licensed Area**

1.1. The area specified in ***Schedule 1*** attached.

2. **Species, Cultivation and Method Licensed**

2.1. Species to be farmed: Rainbow Trout and no fish other than Rainbow Trout shall be bred and handled at this site.

2.2. Method: Land Based subject to the stocking limits as specified in ***Schedule 2*** attached and in accordance with all other consents issued.

2.3. The introduction of fish/ova/fry to the site shall comply with the legislation relating to fish health.

3. **Infrastructure and Site Management**

Indemnity

3.1. The Licensee shall indemnify and keep indemnified the State, the Minister, his officers, servants or agents against all actions, loss, damage, costs, expenses and any demands or claims howsoever arising in connection with the construction, maintenance or use of any structures, apparatus, equipment or any other thing used in connection with the licensed operation in the licensed area or in the exercise of the rights granted under the licence and the Licensee shall take such steps as the Minister may specify in order to ensure compliance with this condition.

3.2. The duty of maintenance and responsibility for the upkeep and safety of the site rests with the Licensee.

Design, Arrangement and Maintenance of Structures

3.3. The Licensee shall ensure that the equipment is placed within the licensed area only. Storage or placement of equipment or stock outside the licensed area is not permitted under any circumstances.

3.4. The Licensee shall at all times for the duration of the licence keep all equipment used for the purposes of the licensed operations in a good and proper state of repair and condition to the satisfaction of the Minister or other competent State authority.

Operational Conduct

3.5. The Licensee shall conduct its operations in a safe manner and with regard for other persons in the area and the environment and shall ensure that the operations are not injurious to adjacent lands or the public interest (including the environment) and do not interfere with lawful activity in the vicinity of the licensed area, and shall comply with any lawful directions issued by the Minister and any other competent State authority in that regard.

3.6. The Licensee shall ensure that any aquaculture or other activity conducted under this licence does not adversely affect the integrity of the Natura 2000 network (if applicable) through the deterioration of natural habitats and the habitats of species and/or through disturbance of the species for which the area has been designated in so far as such a disturbance may be significant in relation to the stated conservation objectives of the site concerned.

Waste Management

3.7. The Licensee shall ensure that the licensed and adjoining area shall be kept clear of all redundant structures (including apparatus, equipment), waste products and operational litter or debris and shall make provision for the prompt removal and proper disposal of such material. If the Licensee refuses or fails to do so, the Minister may cause the said structures, apparatus, equipment or other thing to be removed and the licensed area restored and shall be entitled to recover from the Licensee as a simple contract debt in any court of competent jurisdiction all costs and expenses incurred by him in connection with the removal and restoration.

Inspection

3.8. The licensed area and any equipment, structure, thing, or premises wherever situated used in connection with operations carried out in the licensed area shall be open for inspection at any time by an authorised person (within the meaning of Section 292 of the Fisheries (Consolidation) Act 1959) (No. 14 of 1959) (as amended by Fisheries Act 1980) (No. 1 of 1980), a Sea Fisheries Protection Officer (within the meaning of Sea Fisheries and Maritime Jurisdiction Act 2006) (No. 8 of 2006) or any other person appointed in that regard by the Minister or other competent State authority.

3.9. The Licensee shall give all reasonable assistance to an authorised officer or a Sea Fisheries Protection Officer or any person duly appointed by any competent State authority to enable the person or officer enter, inspect, examine, measure and test the licensed area and any equipment, structure, thing or premises used in connection with the operations carried out in the licensed area and to take whatever samples may be deemed appropriate by that person or officer.

3.10. The Licensee shall keep and maintain in the State for inspection on demand by the Minister or a competent State authority, at all times, records of all operations including compliance monitoring and any required follow up action. These records shall be produced by the Licensee on demand by the Minister or other competent State authority and in any event not later than 24 hours from the making of that demand.

3.11. The Licensee shall furnish to the Minister or other competent State authority in the form and at the intervals determined by the Minister or other competent State authority, such information relating to the licensed area as may be required to determine compliance by the Licensee with the terms of this licence and applicable legislation.

4. **Containment of Stock**

4.1. The Licensee shall take all steps necessary to prevent the escape of fish from its land based site and shall notify the Department of Agriculture, Food and the Marine, Clogheen, Clonakilty, Co. Cork, the Department's Regional Engineering Division, the Marine Institute (Salmon Management Services Division), Oranmore, Co. Galway, and Inland Fisheries Ireland within twenty four hours of any escapes of fish from the licensed area and shall keep records of the fish escaped, including numbers, types, origin and year classes and shall make these records available to the Department, the Marine Institute and Inland Fisheries Ireland.

4.2. The Licensee shall provide and maintain such gratings or other devices at the point of water abstraction from the river into the fish farm, and also at a point as near as possible to the discharge of water, as will prevent the admission of wild fish into the fish farm, and shall make all necessary provisions to prevent the escape of fish from the fish farm.

5. **Environmental Monitoring**

Monitoring

5.1. The Licensee shall undertake and/or partake in monitoring, in particular environmental monitoring, as directed by the Minister or other competent State authority.

5.2. Electronic flow meters with recording capabilities must be installed on the site.

6. **Fish Health / Mortality Management / Movement of Fish**

Fish Health Regulations

6.1. Before the site is stocked the Licensee shall ensure that a Fish Health Authorisation under statutory provisions giving effect to Council Directive No. 2006/88/EC, as amended, or any other legislative act that replaces that Directive on animal health requirements for aquaculture animals and their products, and on the prevention and control of certain diseases in aquatic animals, is in place.

Disposal of Mortalities

6.2. The Licensee shall dispose of dead fish in accordance with the applicable statutory provisions and requirements.

Movement of Fish

6.3. The Licensee shall comply with any regulations in force governing the movement of fish.

7. **Animal Remedies and Dangerous Substances**

Authorised Remedies

7.1. The Licensee shall only use those animal remedies approved by the Department or other competent State authority for the purpose of maintaining the health of the fish stocked. The Licensee shall only use those chemicals and animal remedies in the

licensed area in accordance with instructions issued by the Minister, the Marine Institute or other competent State authority from time to time and in accordance with the prescribing instructions set by the veterinarian.

Authorised Substances

7.2. The Licensee shall not use a "Priority Hazardous Substance" as may be defined from time to time in legislation concerning water quality.

7.3. The Licensee shall not use any substance or thing or do anything, which has a deleterious effect on the environment of the licensed area and shall make adequate arrangements for the hygienic and disease free operation of the licensed area and shall comply with any directions issued by the Minister, the Marine Institute or other competent State authority from time to time in that regard.

Records of Use and Withdrawal Periods

7.4. The Licensee shall keep full records, at the place of business, of all chemicals and animal remedies with which the fish have been treated, including quantities and times of use. All chemical and animal remedies used in the licensed area shall be used in accordance with instructions issued by the Minister, the Marine Institute or other competent State authority from time to time.

7.5. The Licensee shall maintain the following:-

7.5.1. Records of a receipt of a dangerous substance.

7.5.2. Each prescription issued in respect of an animal remedy which consists of or contains a dangerous substance.

7.5.3. Records of storage of a dangerous substance,

7.5.4. Records of use of a dangerous substance, and

7.5.5. Such other record as the Minister may specify.

Storage Requirements

7.6. The Licensee shall ensure that all dangerous substances within the meaning of List II of Annex I to Directive 2006/11/EC on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community are stored in a manner so as to prevent any discharge, accidental or otherwise.

8. **Emergency Plans**

8.1 The Licensee shall regularly maintain and update its Comprehensive Emergency Plan, providing in particular for an appropriate response to, unexplained mortalities significantly above the level of what is considered to be normal for the farm area in question under prevailing conditions, fish escapes, fish disease, chemical spills and other significant matters arising in the course of its aquaculture operations.

9. **Duration, Cessation, Review, Revocation, Amendment, Assignment**

Duration, Cessation

9.1. This Licence shall remain in force until 09 September 2024 and only so long as the fish farm complies with the Local Government (Water Pollution) Acts licence to discharge effluent granted by Kilkenny County Council on 11th May 2012(ref ENV/W/44) (or a further such licence granted by the said Council or by the Environmental Protection Agency).

Review

9.2. The Licensee may apply for a review of the licence at any time after the expiration of three years since the granting of the licence or its last renewal in accordance with section 70 of the Act.

Revocation, Amendment

9.3. Subject to the Act, the Minister may revoke or amend the licence if:-

(a) he considers that it is in the public interest to do so,
(b) he is satisfied that there has been a breach of any condition specified in the licence,
(c) the licensed area to which the licence relates is not being properly maintained,
(d) water quality results or general performance in the licensed area do not meet the standards set by the Minister or the competent State authority.

Assignment

9.4. This Licence shall not be assigned without the prior written consent of the Minister and may not be assigned during the period of three years, dating from the commencement or renewal of this licence, unless the Minister determines that it may be assigned under condition 9(5) or the condition set out in 9(6) applies.

9.5. A Licensee, who considers that there are exceptional reasons for the assignment of the Licence during the first three years, may apply to the Minister, giving those reasons, for a determination that the Licence may be assigned. The Minister may, at his discretion, having considered the reasons given by the Licensee, determine whether or not the Licence may be assigned. The determination of the Minister in this regard is final.

9.6. Where the Licensee is a company (within the meaning of the Companies Acts) and goes into Liquidation (within the meaning of the Companies Acts) in the first three years dating from the commencement of the licence, the Liquidator shall, with the consent of the Minister, be entitled to assign the licence to enable him to discharge any debts of the liquidated company.

9.7. This licence is issued subject to any order that the High Court may make under section 218 of the Companies Act 1963 or otherwise with regard to the assignment of this licence.

Upgrade of the site

9.8. The licensee must upgrade the site to the satisfaction of the Marine Engineering Division, Department of Agriculture, Food and the Marine, within 5 years of the commencement of the licence. Any upgrade works will be subject to planning permission from Kilkenny County Council and will be in line with the Draft Report of 29th January 2013 and drawings prepared by the applicant as specified in Schedule 3 attached.

10. **Fees**

10.1. The Licensee shall pay to the Minister an annual aquaculture licence fee in accordance with the Aquaculture (Licence Application and Licence Fees) Regulations 1998 (S.I. No. 270 of 1998) as amended by the Aquaculture (Licence Fees) Regulations 2000 (S.I. No. 282 of 2000) or an amount payable under Regulations made under section 64 of the Act. .

10.2. The Minister may revoke the licence where the Licensee fails to pay the aquaculture licence fees on demand.

11. **General Terms and Conditions**

11.1. The Licensee shall at all times comply with all laws and Departmental Protocols applicable to aquaculture operations.

11.2. Any reference to a statute or an act of an institution of the European Union (whether specifically named or not) includes any amendments or re-enactments in force and all statutory instruments, orders, notices, regulations, directions, bye-laws, certificates, permissions and plans made, issued or given effect under such legislation shall remain valid.

11.3. If any condition or part of a condition in this licence is held to be illegal or unenforceable in whole or in part, such condition shall be deemed not to form part of this licence but the enforceability of the remainder of this licence is not affected.

11.4. The Licensee shall at all times hold all necessary licences, consents, permissions, permits or authorisations associated with any activities of the Licensee in connection with the licensed area.

Notification

11.5. Without prejudice to any other remedy under the licence or in law, if the Minister is of the view that the Licensee is in breach of any obligation under this licence, the Minister may, by notice in writing, require that the Licensee rectifies such breach, within such time as is specified by the Minister. The Licensee shall comply with any direction of the Minister within the time specified in the notice.

11.6. Any notice to be given by the Minister may be transmitted through the Post Office addressed to the Licensee at the last known address of the Licensee.

11.7. The Licensee shall notify the Minister within 7 days of any change in the Licensee's address, telephone, e-mail or facsimile number.

Tax Clearance Certificate

11.8. During the term of this licence the Licensee shall provide to the Minister on demand a current tax clearance certificate.

Companies and Co-operatives

11.9. In the event of the licence being granted to a company (within the meaning of the Companies Acts), control of the licensee company shall not change in any respect from the control of the company as existed on the date that the licence was granted so long as this licence shall remain in force save with the prior written permission of the Minister.

11.10. In the event of a licence being granted to a company that has been incorporated outside this State, the licensee company shall register with the Companies Registration Office within one month of the establishment of a place of business in the State or alternatively, within one month of the establishment of a branch of the said company in the State and the licensee company shall submit proof to the Department within 14 days of the end of that month that it has been so registered.

11.11. Where the licensee is a company within the meaning of the Companies Acts, the licensee company shall ensure that it does not become dissolved within the meaning of the Companies Acts for so long as this licence shall remain in force.

11.12. In the event of the licence being granted to a society (within the meaning of section 2 of the Industrial and Provident Societies (Amendment) Act 1978 (No.23 of 1978) the following conditions shall apply:-

11.12.1. The rules relating to membership of the society shall enable any resident of the State to become a member of it where the resident fulfils all the conditions laid down by the society for membership of it and the rules shall not lay down different conditions for different classes of people;

11.12.2. The rules relating to the society as submitted to the Minister before the grant of this licence shall not be amended subsequently other than with the written permission of the Minister; and

11.12.3. The Minister may, if he considers it necessary in the interests of good management of the licensed area, direct that an amendment may be made to the rules of the society, and the Licensee shall amend the rules in accordance with that direction.

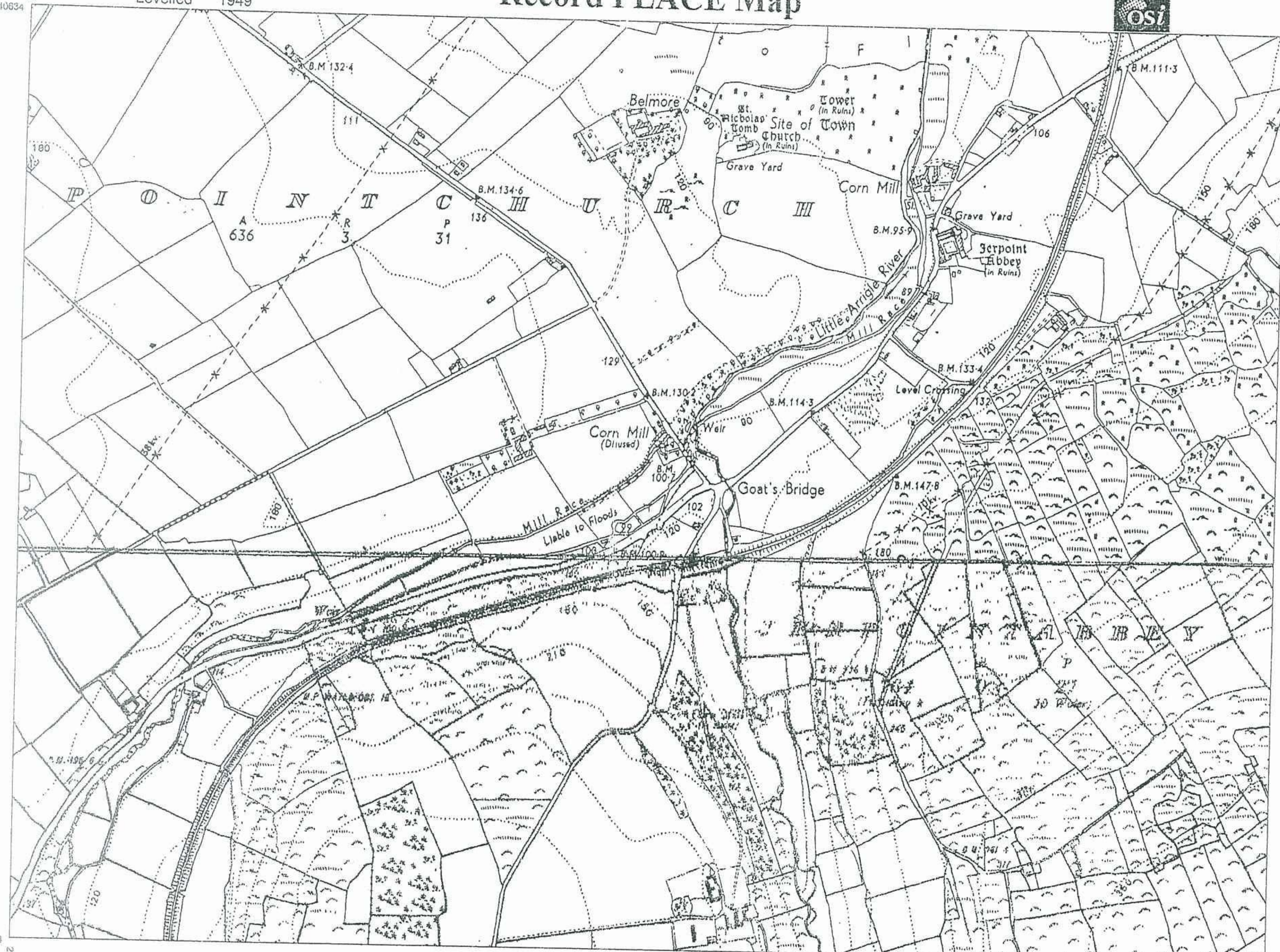
SCHEDULE 1

Schedule 1 contains:

- **maps of the licensed site**

Surveyed 1839
Revised 1901-1949
Levelled 1949

Record PLACE Map



Scale:- 1:10,560
Scála:- 1:10,560

0 200 400 600 800 1,000 Metres
0 500 1,000 1,500 2,000 2,500 Feet

Plot Ref. No. 1066904_1
Plot Date 07-DEC-2005

ITM CENTRE PT COORDS
6?6581,639773

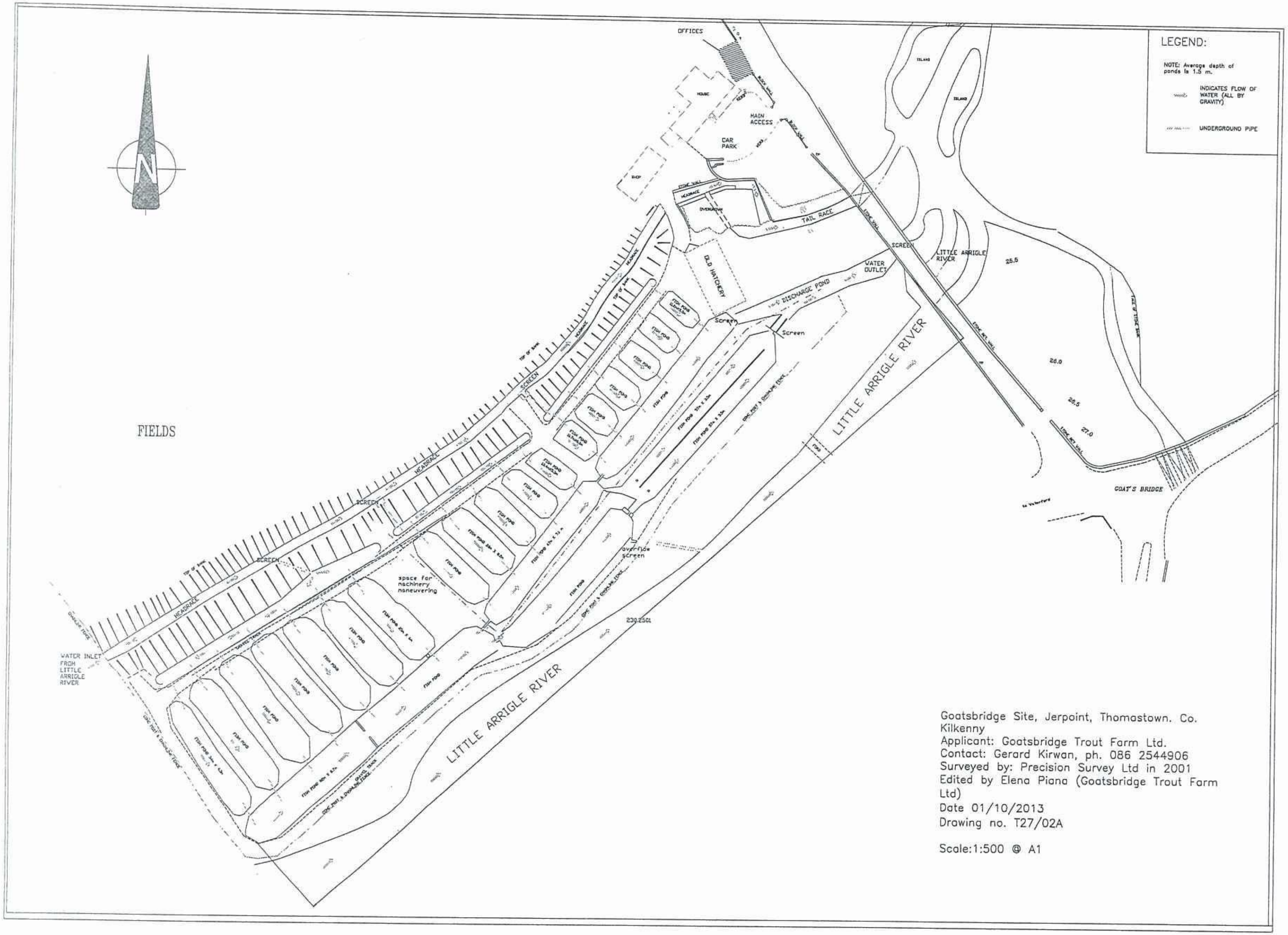
DESCRIPTION

MAP SHEETS

6 inch
KK028 KK032

Produced by The Map Shop,
54 Upr John Street, Kilkenny City
On behalf of Ordnance Survey Ireland,
Phoenix Park, Dublin 8.

N



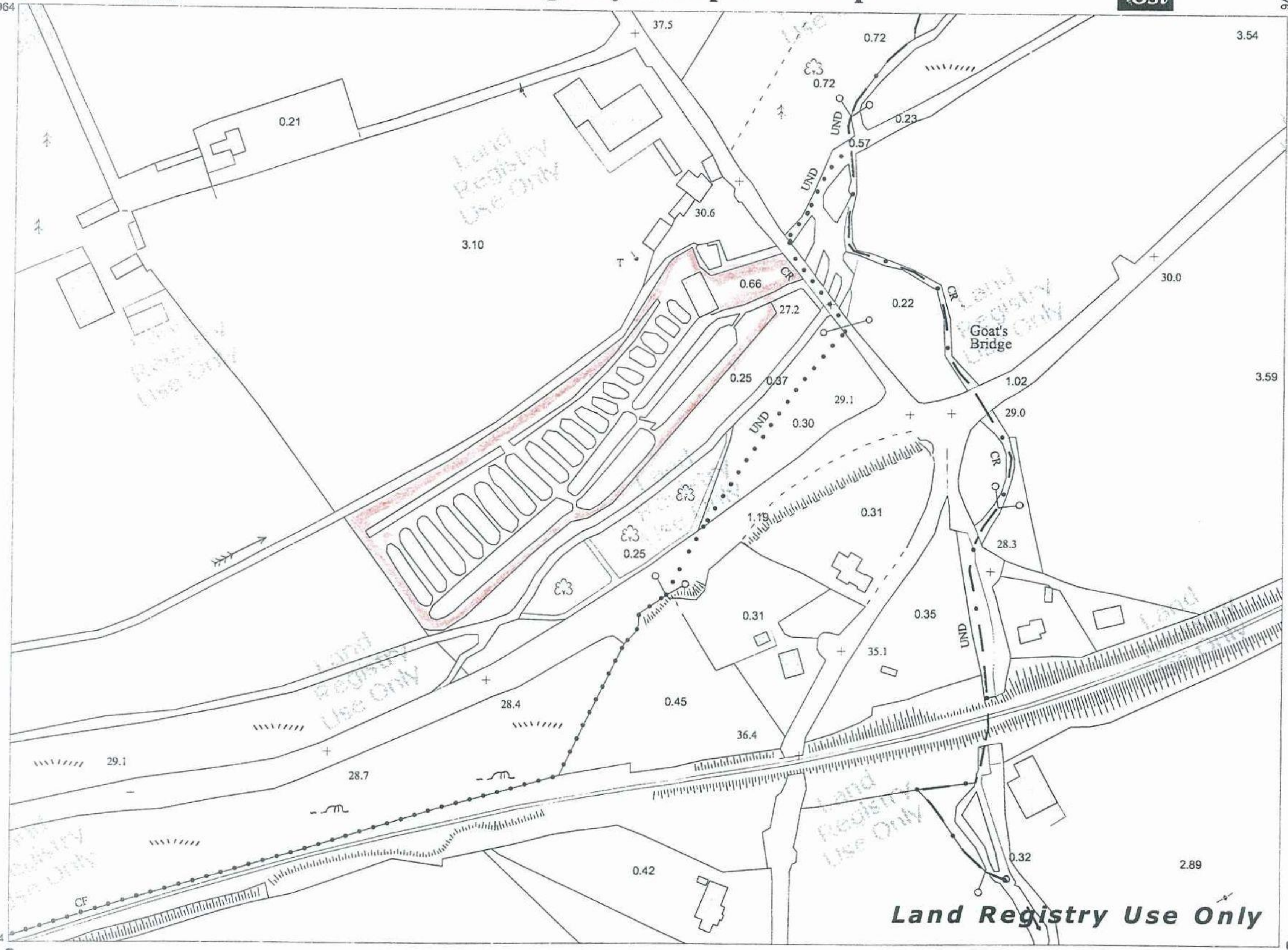
Goatsbridge Site, Jerpoint, Thomastown. Co. Kilkenny
Applicant: Goatsbridge Trout Farm Ltd.
Contact: Gerard Kirwan, ph. 086 2544906
Surveyed by: Precision Survey Ltd in 2001
Edited by Elena Piana (Goatsbridge Trout Farm Ltd)
Date 01/10/2013
Drawing no. T27/02A

Scale:1:500 @ A1

Surveyed 1998
Revised 2012
Levelled

GOATSBRIDGE SITE

Land Registry Compliant Map



ITM CENTRE PT. COORDS.

656585,639749

DESCRIPTION

MAP SHEETS

1:2500
5073-C

Authorised Internet Map

Arna thiomsú agus arna fhoilsiú ag Suirbhéireacht Ordanáis Éireann, Páirc an Fhionnuisce, Baile Átha Cliath 8, Éire.
Compiled and published by Ordnance Survey Ireland, Phoenix Park, Dublin 8, Ireland.

Ní hionann bóthar, bealach nó cosán a bheith ar an léarscáil seo agus fianaise ar chead slí. The representation on this map of a road, track or footpath is not evidence of the existence of a right of way.

Ní thaispeánann léarscáil de chuid Ordanáis Shuirbhéireacht na hÉireann teorann phointí dleathúil de mhaoin riamh, ná úinéireacht de ghnéithe fhisiciúla.
Ordnance Survey maps never show legal property boundaries, nor do they show ownership of physical features.

N

Scale:- 1:2,500
Scála:- 1:2,500

0 50 100 150 200 250 Metres
0 100 200 300 400 500 Feet

Plot Ref. No. 19620730_2_1
Plot Date 10-MAY-2012

SCHEDULE 2 – Stocking Biomass

The maximum standing stock on site during the low flow months of July/August/September shall not exceed 25 tonnes and shall not exceed 50 tonnes at all other times.

SCHEDULE 3 – Upgrade of site

Schedule 3 contains:

- **a copy of draft report of 29th January 2013**
- **drawings prepared by the applicant**

An Overview of Current Limiting Factors to Production and Investigation of Options and Proposal of Future Culture Systems for Goatsbridge Trout Farm Ltd

Date: 29th January 2013

Report Compiled by
Alan Sullivan NDip BSc MIFM
Fisheries and Environmental Consultant

Elena Piana BSc MSc MIEM
Fish Scientist Goatsbridge Trout Farm Ltd

Reference: GBTF/2013/R1

Report for: Goatsbridge Trout Farm LTD in conjunction with BIM

Main Contributors: Alan Sullivan and Elena Piana (Fish Scientist GBTF)

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Disclaimer

This report has been prepared in a working document form and has not been finalised as per instructions from GBTF or BIM; as such it should be taken as an indication only of the material and conclusions that will form the final report. Any calculations or findings presented here may be changed or altered and should not be taken to reflect Alan Sullivan's opinions or conclusions until a finalised report has been issued.

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Document Revisions: None

Contents

Executive Summary

The scope of this study was to evaluate current limiting factors to production on the Goatsbridge Farm (GB) site and investigate a range of potential options for securing trout production at competitive cost for future years.

It is clear that the current physical infrastructure of the GB site has inherent problems that have had negative constraints on the efficacy of production resulting in a production cost of approximately €3/kg making the business unsustainable. It is not simply a case of an antiquated culture system, but our analysis has shown that this is the primary limitation and impacts all other production practices and outcomes on the farm.

The analysis of resources available on site (water quality and quantity) clearly suggests that the site does have the potential to produce around of 300 tonnes per annum in a financially and environmentally sustainable manner.

When evaluating the options, consideration was given to present and future market demands and the need to provide a culture system that has a certain degree of future proofing as both a capital investment and one that could be effectively managed with minimal staffing levels. It was a condition of process to provide a system that was not overly reliant on complicated and expensive machinery that would require a high degree of technical expertise and excessive running costs. The options investigated were intensively researched, discussed both with the management of GBTF and other fish farm operators in Ireland and the UK.

Five options have here been analysed: The option of 'Do Nothing' has been discussed and serves to reflect the operating conditions of the farm in 2012 and the rationale as to why this study is being undertaken. Secondly, it was established that a RAS/PRAS system was not a viable option for this site based on consultation and research and equally the option to install a system of round tanks was deemed not suitable to the GB site. The fourth option 'Upgrade Existing Earth Pond System' shows that the level of investment required to provide ease of management and structural security of the site does not result in an acceptable reduction in production costs, mainly due to the low efficiency of oxygen diffusion within the ponds and consequently the low food conversion efficiency. Option five looks at the construction of a raceway system able to hold 100 tonne standing stock and with a potential annual production of 250-300 tonnes. This is suggested as the most suitable option for GBT. Early analysis of running costs suggests that the system could achieve production costs between 1.7 and 2 euro/kg. Further investigation from Mark and Svend will enable to accurately estimate initial investment, running costs and therefore breakeven time.

Background

Goatsbridge Trout Farm Ltd (GBTF[1]) has established itself as a leading brand in the processing of a range of trout related food products both in Ireland and internationally. They have also been engaged in the intensive culture of rainbow trout since the 1960's and though they have repeatedly produced high quality trout, the fish production element of their business is not meeting the expansion and demand from their processing department. In essence, the physical culture and production systems for the intensive farming of trout at GBTF have become antiquated and when assessed as a standalone business, do not produce sufficient tonnage of trout at an acceptable cost per unit of fish, rendering the operation financially unviable. The owners of GBTF Mr Gerard Kirwan and Mrs Margaret Kirwan recognise the current problems associated with the production of fish on both their Goatsbridge and Ballyduff sites and realise that problems exist in both the physical context of the culture systems and the production methodologies that have been employed. They have taken action to counteract a proportion of the problems identified by employing an aquaculture scientist to assist in assessing and making changes to production management but acknowledge that their production potential is not being fully utilised due to physical/management constraints. They accept; if they attempt to meet future production demands with the current infrastructures in place, sustainable production will be severely limited by a range of financial, environmental and operating constraints.

Aims and Objectives

The aims of this study is to review the current operating (trout production) and physical culture systems of GBTF, and on the basis of the review, delineate a set of proposals that will introduce a culture system and production model that will enhance productivity for the company. The rationale is to find a 'best fit' solution; in formulating this proposal we have reviewed a range of variables; they included:

- The positive attributes of the physical environment of the farm and water supply
- Production planning based on sound scientific principals and influenced by best practice in respect of both commercial and environmental constraints in the trout culture industry
- Cost effectiveness in both design, construction and operation/production systems
- Compliance with environmental legislation now and in the future
- The current and historical ethos of the company

[1] Goatsbridge Trout Farm Ltd will be referred to GBTF throughout remainder of document

In formulating a proposal it was necessary to find a balance between conflicting objectives to:

- Maximise fish quality and health
- Minimise capital cost
- Minimise operating cost
- Minimise risk
- Maximise production

And endeavour to limit the "Total Cost" which includes:
Single expenditure capital costs
Recurring operating costs
Risk related costs

Limiting Factor Analysis (Physical Fish Culture Environment and Current Production Protocols)

Introduction

The primary objective of this section is the identification and the rationale of how current limiting factors to production on both the Goatsbridge (GB) and Ballyduff (BD)[2] are having a negative impact on the financial efficacy of GBTF. It is clear to the managers and owners of GBTF that both the physical culture systems and production models are not attaining anywhere near the maximum efficiencies required to make the business profitable. This chapter is not an exercise in nit picking; it is necessary in some instances to point out the obvious but the key reason is to understand why there is a need to change both the physical fish culture structures of both GB and BD and adopt a science based production model based on the latest aquaculture research. It is imperative that the specifics of an aquaculture production model are directly linked to and in fact governed by the sales and marketing strategy produced by GBTF processing.

Goatsbridge Trout Farm Site

Current Fish Culture System (Earth Ponds)

The establishment of the fish farm in the 1960's and its general layout are well documented and it is understood that the existing design and layout of the farm are a product of the knowledge base at that time. Through consultations and regular site visits, it is clearly apparent that the many physical limiting factors of the site are having a highly negative impact on all aspects of production.

There are a number of key problems associated with the ponds at the GB site:

1. The ponds do not drain, therefore even basic management tasks such as cleaning, harvesting, grading, disease control/prevention and basic maintenance results in every action being either time consuming, impractical, dangerous to operators/stock or not possible.

[2] GB and BD refer to Goatsbridge and Ballyduff sites throughout remainder of document

2. The ponds have experienced high erosion rates this has resulted in collapse of retaining banks at the outflows, elevated erosion in specific areas of the inflow, reduced bank margins between ponds and undercutting of banks. The banks are dangerous to staff and the probability of structural failure is high. Banks have previously given way causing mixing of different age classes and grades, causing loss of revenue through time spent regrading, temporary shoring of banks etc.
3. The design layout of the ponds does not facilitate ease of movement of staff or vehicles for harvesting, grading or the use of automatic feeders if required.
4. Ponds of various size dimensions are not receiving water relative to their dimensions; in some cases the large ponds are receiving the same or less water than smaller ponds within the same site.
5. The hydrodynamics of the ponds is poor and this has led to high rates of deposition of both organic detritus coming in from the headrace and faecal/waste food being heavily deposited in areas of low flow.
6. Oxygen depletion due to organic matter in the ponds. Depending on which source material is used; this figure can range from 30 to 50% of the available oxygen for fish production.

Water Quality, Quantity and Management

Introduction:
The Little Arrigle River is a lowland tributary of the River Nore and its characteristics can be described as consisting of relatively undeveloped, sub-catchment/catchment conditions. Habitat features include dense riparian zones with mix of mature native species, frequent pools, high-quality spawning areas, cool summer water temperatures and reliable flow rates due to a high proportion of the residual flow coming from aquifer sources. The river has a complex in-channel habitat, and a channel floodplain relatively intact. Land use and human interaction has led to light enrichment though there is a high likelihood of minimal future human development.

Possible Future Threats
It is important to note that it is in the interests of GBTF to assist in the protection of the water resource from any environmental damage whether it is upstream of the farm or from the farm itself. The legal environmental protection afforded to the river is both European (Special Area of Conservation and Designated Salmonid River) and national (Freshwater Fisheries Act 1959 and amendments and Wildlife Act 1976 and amendments). One of the major threats to the farm in the future, could be the abstraction of water from the local aquifer; as even the cumulative loss of 100l/s of water from the aquifer by a number of small abstractions could have a highly detrimental impact on the long term financial validity of the farm.

In summation, the Little Arrigle River provides a high quality source of water for trout aquaculture at the GB site; the minor limiting factors in respect of the water resource for aquaculture are the cool water temperatures in the summer

and the relatively high PH in respect of the toxicity of ammonia. A major limiting factor in relation to production could be quantity of water and this will be discussed in detail later in this chapter.

Water Quantity

Disclaimer:

Due to the fact that there is limited reliable information on flow data, this section of the report is unfortunately based on 'best guess' and the author accepts no responsibility for the accuracy of the information in relation to all matters concerned with historical flow rates contained within this report. The dearth of concise information in relation to water quantity has been a limiting factor in the effective management of GBTF.

The core element of this section is to assess current and future production based on worst-case scenarios in respect of the allowable abstraction of water under low flow conditions from the Little Arrigle River. The basis of the production models outlined for the Goatsbridge site will review the sites' current limitations in respect of this primary parameter and how it will impact future decision making in respect of optimising production.

It has to be clearly stated that the figures portrayed in the following EPA duration curve for the Goatsbridge site are not absolute and that GBTF Ltd have installed a number of staff gauges to build a more accurate hydrometric record of flow rates within the headrace (before and after intakes to the farm), and within the natural river channel of the Little Arrigle. Unfortunately a number of years of record keeping will be required to provide an accurate hydrometric record, and therefore all calculations will be based on the EPA upper 95% confidence limits as it has been assessed that the influence of the aquifers on the Little Arrigle River flow rates have not been adequately addressed within the calculations portrayed in the flow duration curve.

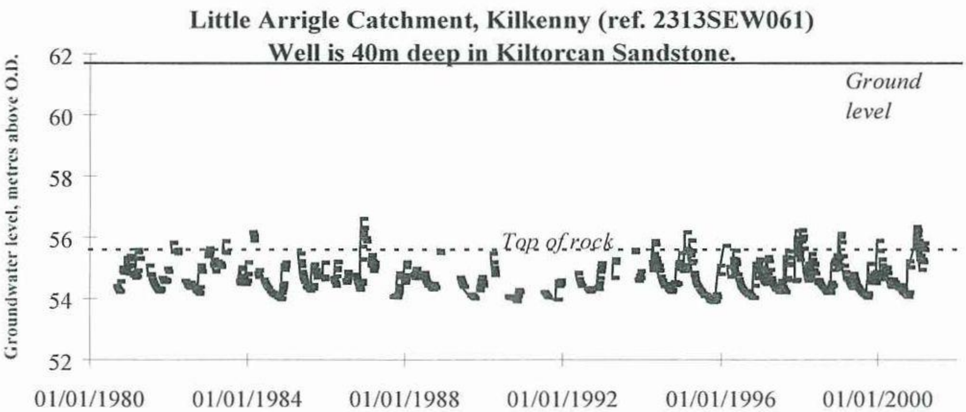
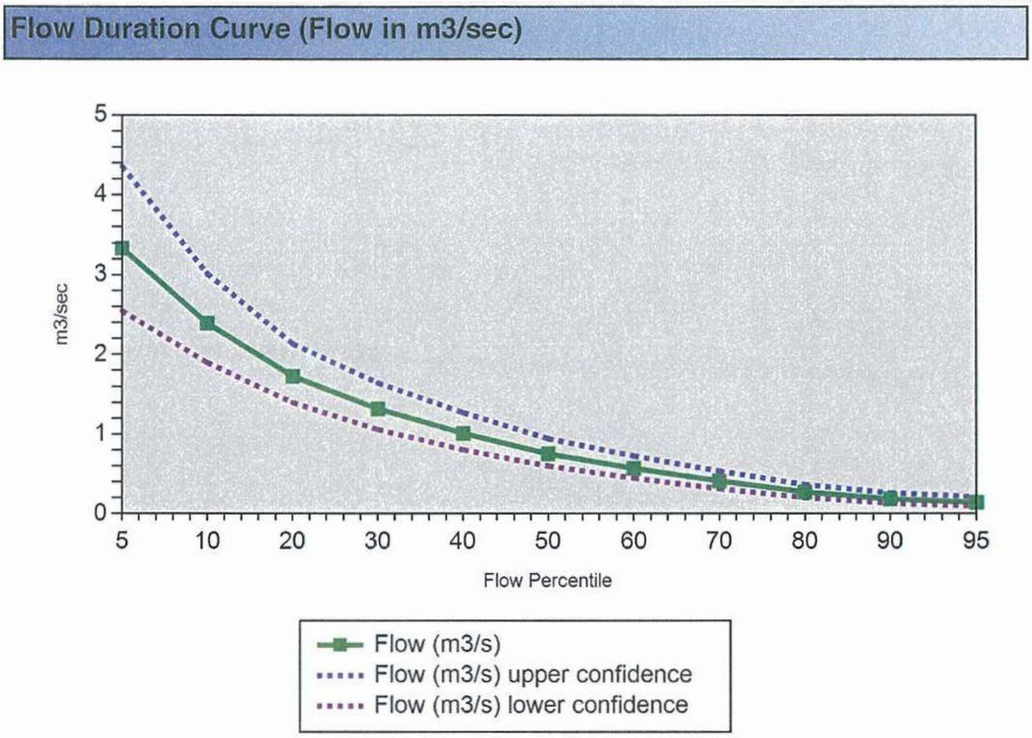


Fig: 1 There is numerous small springs and streams across most of the area where the aquifer occurs close to the surface. In this region, Daly (1985) suggests that recharge is actively occurring, that groundwater flow paths are typically in the order of a few hundred meters, and that most discharge occurs into small streams and springs. Zones of more concentrated discharge occur into the Nore River near Thomastown and the Little Arrigle River near Ballyhale; both zones lying just upslope of the area where the aquifer becomes confined by lower permeability shaley limestones.



%ile	flow(m3/sec)	upper 95% confidence limit m3/sec	lower 95% confidence limit m3/sec
5	3.332	4.358	2.547
10	2.391	3.013	1.898
20	1.724	2.131	1.395
30	1.317	1.641	1.057
40	1.01	1.269	0.803
50	0.753	0.944	0.601
60	0.572	0.728	0.449
70	0.412	0.538	0.315
80	0.274	0.366	0.205
90	0.184	0.26	0.131
95	0.141	0.212	0.094

Fig 2: EPA Flow duration curve and estimated discharge %iles

It has been established that the 95%ile flow at the Goatsbridge site is 212 l/s and the aquaculture licence currently permits a maximum abstraction of two thirds of this flow rate. Therefore under the terms of the aquaculture licence the minimum residual flow to be left in the depleted reach of the Little Arrigle River is 75l/s.

It can therefore be established with certain constraints that the absolute minimum flow likely to be experienced in the Goatsbridge site is in the order of 150l/s.

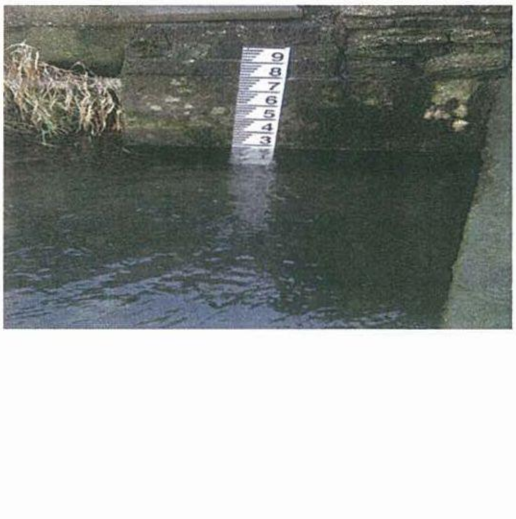
Water Quality

Water quality refers the extent to which water is biologically, chemically and physically suitable to specific purpose. Knowledge of water quality is one of the essential parameters for environmentally sustainable aquaculture. The purpose of understanding water quality in aquaculture is management of water to optimise fish production without impairing environment. To a great extent water quality determines the success or failure of an aquaculture operation.

The analysis of water quality parameters both before entering the farm and at the outflow can be viewed in Appendix @@@. It is clear that the quality of the water in the Little Arrigle River is excellent, key parameters such as

It is absolutely essential for the effective management of both GB and BD farms and their licencing agreements that water quality parameters are measured routinely and records analysed and filed. Basic water quality parameters such as water temperature, dissolved oxygen; pH and rate of flow of water should be studied routinely throughout the year. Though there are many criteria to be considered for trout production, DO, pH, temperature and rates of flow should be taken as the basic parameters. In conjunction with the four main parameters, carbon dioxide, total hardness, alkalinity, ammonium nitrogen, nitrate +nitrite (NO2+NO3), reactive phosphorus, and total phosphorus should be analysed.

The processes of monitoring have been discussed by GBTF and a range of sampling sites have been agreed from four places inside and outside of the fish farm. Water samples should be collected from four sampling stations at least once a month. The sampling stations included station 1 (main source of water from headrace), station 2 (water at inlet of ponds), station 3 (outlet of ponds) and station 4 (main outlet to Little Arrigle River). There is currently a monitoring station on loan to GBTF from BIM that will be incorporated to log data on a range of parameters and a recent purchase of four wireless DO and temperature gauges that are portable will be used within the farm environs. It is highly recommended that a full suite of monitoring equipment and appropriate alarm systems are set up on the farm even if no option to upgrade the culture units is taken.



Water Control Mechanisms

Effective control of water is one of the primary management tools on a fish farm in respect of the efficiency and ergonomics of production. The issue of water control within the GB site has been identified as one of the primary limiting factors to production and day-to-day management activities. Currently there are no effective mechanisms to regulate, measure and accurately distribute water throughout the farm.

Poor control over water dictates that no matter how good the physical culture system or production model is, if the mechanisms for controlling the water from abstraction through to discharge are not effective, then the system will have severe limitations.

For example, currently (Jan 2013) fresh water (300 l/s) that would reduce the amount of time the aerators are being used is currently flowing through the millrace and back into the Little Arrigle River unused; this is due primarily to a highly ineffectual and non-regulated supply throughout the farm.

Primary Identified Problems are:

1. Flood Water Control Mechanisms

Goatsbridge Weir has no easy mechanism for sending large volumes of unwanted floodwater from the headrace back into the main channel of the Little Arrigle River. Currently a member of staff has to go up to the weir and remove boards during a rising flood, which is both cumbersome and highly dangerous. This practice is also time consuming and may involve staff having to go out in the middle of the night to remove boards, the boards have to be stored safely and correctly and then put back in place when the flood has subsided. It is also critical that the boards are returned promptly; particularly after flood events in the summer as river flow can drop quickly.

Recent Mitigation (partial): During September 2012, the weir was cleaned, stabilised and all leaks were fixed. This work has resulted in guaranteeing a minimum supply of 150 l/s in low flow conditions with little or leakage affecting supply at the diversion point. The work however does not mitigate the problems associated with high river flows although the deposits of soil on the weir apron that were raising bank elevations on the weir top have been reduced allowing more flood water to be diverted into the main channel of the Little Arrigle River. It is also apparent from anecdotal information that during flood conditions the majority of trees and large branches that come down the river do go over the weir and into the main channel of the river.

Fig 3: A new rock ramp fish pass and the elimination of piping in the weir have secured both the integrity of fish passage and the water supply to the farm in low flows. The removal of up to 400mm of alluvial deposits and vegetation on the weir crest over a 40m section has also permitted greater conveyance of floodwater back into the main channel of the Little Arrigle River.

Proposed Mitigation: Should the owners of GBTF decide to invest in a new culture system it would be advisable to have a large overspill or by-wash facility on the headrace at the entrance to the farm. It is proposed within the raceway design to incorporate extra conveyance capacity within the inlet channel that will take excess water during flood events and discharge it back into the river channel. In conjunction with the current flow through facility on the headrace, these two channels will have sufficient capacity to cope with all but the very largest (50 - 100 year events).

2. Limited Water Control from Headrace to Distribution Channel

There are currently four abstraction points from the headrace to the distribution channel for the earth ponds with a hydraulic drop of approximately 3.5 to 4m. The hydraulic drop (head) from headrace to ponds has distinct benefits if suitably exploited, but the current abstraction mechanisms have little control over the water. They are prone to blockages and care is required when cleaning in high flows as the flow is managed by the detritus on the screens...remove too much and an excess of water enters the distribution channel and overflows the road causing erosion. The flow in the headrace is turbulent and ideally it should be laminar (slow moving, smooth and not turbulent).

Fig 4: Screening and water distribution from headrace to lower distribution channel. The system works but is limited by lack of control and propensity for blockage and low flows or too much water and erosion of lower banks.

Mitigation:

Currently no mitigation has been undertaken to alleviate the described problems. The primary mechanism to provide control and a laminar flow at the abstraction points would be the installation of a penstock sluice at the bottom end of the headrace. This will back the water up in the headrace, slowing the flow and permit a more even distribution of water. It is proposed under option 5 (Raceway system) that two penstock sluice systems are installed to provide a regulated laminar flow to the raceway system and to the remaining earth ponds. (Refer to plans and report under option 5)

3. Screening:

Screening plays a vital role in providing a mechanism to prevent fish escaping between ponds and out of the farm and preventing detritus, trash and leaves from entering the farm and ponds and wild fish from entering the farm. The screening mechanisms employed at GB are antiquated and require a large number of man-hours each year in cleaning.

The primary problems with the screens at GB are:

- The screen surface area is too small, the bars are aligned vertically when they should be aligned horizontally and the surface area needs to be extensively expanded.
- The screens are being used to regulate the height/depth of water in the ponds. This is fundamentally wrong as anything from leaves, detritus, dead fish etc can cause the screen to block and the pond to overtop causing erosion of banks and loss/mixing of fish. This has and will continue to cause financial losses to GBTF.

Other Risks/limiting Factors

In relation to risk currently within the physical context of GB trout farm; we assessed the likelihood of one of the many mature Scots Pine (Pinus sylvestris) that are planted directly on the embankment of the headrace, and the perceived risk of being uprooted during a storm. The trees are in an elevated exposed position to the prevailing winds from the west/south west, the probability of one these trees falling has been estimated as 'likely'. This has been assessed due to their age, position on the embankment and the material from which the bank is formed. It is highly probable that one or more of these trees could fall which will tear a large hole in the headrace bank resulting in a large discharge of unregulated water flowing into the farm environment. This will result in a near total loss of water to all ponds, destruction of roadway, large loss of fish into the Little Arrigle River and it highly likely that this singular event could have a devastating impact on the financial viability of GBTF. This event could occur at any given time in the future of GB trout farm.

Fig 5: It is clearly apparent that should any one of at least 60 trees fall on this embankment, a major/catastrophic impact on the business will occur.

Mitigation in this instance is relatively straightforward as the trees have a commercial value, and it is recommended that the trees are evaluated by a forester and are cut and harvested immediately by a professional forestry contractor. This should also have the added value of generating some income for the farm as the trees are of timber grade quality.

It is highly probable that some short term logistical problems will have to be overcome in relation to site access and interruption but the key point of the exercise is to acknowledge the gravitas of having a constant threat to the financial efficacy of the farm constantly looming and knowing that there is a mechanism that will extinguish the threat.

Options Review (Goatsbridge only)

Introduction:

Based on the limiting factor analysis on the physical aspects of GB farm, it is strongly recommended that should GBTF wish to, at a minimum, continue to produce an annual tonnage in the range of 150 to 200 tonne cost effectively, they will require a suite of works to upgrade existing facilities in conjunction with more effective management of water and strict production protocols in line with identified market demands.

It is important to acknowledge that the types of system and level of investment proposed by this study has to both be compliant with the financial capabilities of GBTF and compliment the sales/product demand, marketing and associated management and workforce structures.

There are four basic types of fish culture systems open to evaluation for GBTF: open-ponds, round tanks, raceways, and PRAS and RAS systems. Each system has advantages and disadvantages in culture performance, water quality, ease of management, and economic returns.

In response to the terms of reference of this report, we investigated five (5) potential options, though it is important to note that options 3 and 4 have not been reported on in detail as early indications of their unsuitability from discussions with GBTF and information generated by consultant's reports have rendered these options predominantly invalid.

1. Do Nothing

2. Upgrade existing earth ponds and install water control mechanisms

3. Install a raceway system

4. Install a system of round tanks

5. Install a RAS or PRAS system (including model farm)

Option 1 Do Nothing

The option of doing nothing is the consideration by which all other options are measured and is a true reflection of the current status of GB farm. Three primary factors can be discussed:

1. The physical culture system
2. Water quantity, quality and control within the culture system
3. Production protocols and management

The current physical layout and design of the culture system has many problems that have been described within the limiting factors section of this report. It is sufficient to state that irrespective of all options with the exception of closing the farm down; the current culture system is antiquated and in need of investment. If it was considered to do nothing, the current problems associated with day-to-day management, bank erosion, ergonomics, health and safety, disease control and prevention etc, would continue to deteriorate and the frequency of problems will continue to escalate.

Water control and to a lesser extent quality and quantity have been discussed in depth also. It is clear that the failure to have adequate control and distribution of water within the farm environment seriously limits all aspects of efficient production. If there was no further investment in water control structures then it is apparent that limitations imposed within this scenario limit both production and increase the likelihood of large-scale fish kills.

Production should be based on the demand of the processing plant and their identified markets. When these markets have been clearly delineated then a production plan for the farm can be formulated and put into action. The capacity of the farm to currently meet these production requirements is severely restricted due to the plethora of problems described and should no change occur within the production environment, it is strongly recommended that production be scaled down.

In summation, if no investment is made into the GB site in respect of the three areas described above, the deterioration of the farm in both the physical and financial contexts, will accelerate. This is particularly the case if GBTF continue to increase the carrying capacity to meet the demands of the processing plant. The probability of a catastrophic loss of fish is increasing exponentially on a daily basis with the increase in biomass and it should be seriously considered as a potential threat to the entire production company at GBTF.

If the option to do nothing is taken, then it is recommended that the production within the farm (as it is) be capped at an annual production of no more than 70 to 100 tonnes. It is still difficult to imagine how even this low tonnage will be produced cost effectively as all the limitations as delineated will still exist and three to four personnel will still be required to undertake basic management tasks such as harvesting and grading.

Option 2 Upgrade Existing Earth Ponds and Water Control Mechanisms

When evaluating the range of production options available, it has been critical to understand the position of GBTF in relation to their processing and sales and the potential markets available. There is confusion when trying to gauge the future direction of production at GB farm, as there does not appear to be a clearly delineated strategy in relation to matching production plans to predictive sales and the question of the size of fish (and their tonnage) to produce has not been adequately answered.

To reiterate, the physical condition of the ponds and water control mechanism in use at GB have limitations that seriously affect efficient production of trout. The only rationale for upgrading the existing facilities would be to produce the same or more fish in a cost effective manner; that is the default position of this option. There is little point in upgrading the existing facilities to produce the same tonnage of trout in a manner that has a return on investment that may take many years to recuperate.

The work that would be required to upgrade the existing facilities at GB consist primarily of certain construction options investigated in detail under the 'Raceway Option" and these figures will be applied to this option where appropriate. The following list (not exhaustive) outlines the primary works:

1. Restructuring and Stabilisation of the Earth Ponds

Fig: Erosion of pond banks. The majority of ponds have erosion issues that are causing problems in relation to access, health and safety, management, mixing of fish and disease risks. Poor access between ponds limits the use of graders and harvesting.

A basic structural audit of the ponds reveals a plethora of problems as described in the limitations section. The question of how to remediate these problems is not a simple question to answer.

It is our opinion that on a macro scale, the layout of the earth pond system does not conform to best practice on a flow through earth pond system. The site as a whole is difficult to navigate and the use of water and associated resources has not been optimised.

Physical Restructuring of Site and Ponds

- Pond shape and sizes to be adjusted for ergonomics and management (a roadway for vehicular access is required through the middle of the farm).
- Ponds should be redesigned to drain and compliment required hydrodynamics for ease of cleaning, harvesting and grading.
- Banks require reprofiling and stabilisation; this will also involve widening access points between ponds and at the inlet and outlet
- Screens and outlets mechanisms on all ponds will all have to be changed
- Physical structure of pond inlets should all be replaced (see also water control mechanisms)
- A primary settlement pond will be required

Approximate Expenditure on Physical Restructuring Works **€68,000**

Fig: Restructuring, profiling and plugging of holes in earth ponds at Ballyduff 2012

Installation and Upgrading Water Control Mechanisms

- A minimum of one large penstock sluice gate will be required on the headrace
- Control mechanisms to be installed on the headrace discharging water to the lower distribution channel. These will either be in the form of large gate valves or small sluice systems
- A new concrete distribution channel (lower channel) with effective water control mechanisms distributing water throughout the ponds when and where required. This will require gate valves or similar control mechanism to provide controlled water to all the ponds that are directly online to the incoming water.
- Individual water control mechanisms on the inlets and outlets of each of the secondary and third use ponds.
- Screening, both for large trash and leaves/detritus will have to be installed. Large trash does not appear to be a major problem on the GB site but leaves and detritus have to be separated effectively from the inlet supply.
- A reliable mechanism for dealing with excess flood water will have to be installed at the inlet to the farm, in the form of an auxiliary overflow channel, increased conveyance capabilities in the head race or an effective overflow mechanism installed at the weir.

Approximate Expenditure on Water Control Mechanisms **€54000**

Water recirculation and Oxygenation

The current recirculation pump only provides oxygenated water to one distribution channel and does not distribute the oxygenated water evenly along the ponds that should be receiving it. It will be necessary to install a system that has the capacity to deliver a minimum of 150 l/s preferably degassed and oxygenated water to exactly where it is needed. This will require a complete review of the distribution of the recirculated oxygenated water within the farm environment and needs to take into account efficiencies of water delivery, cost associated with electricity and liquid oxygen and ergonomics of design and function.

Approximate Expenditure on Refit **€12,000**

Waste Management

No settlement pond/chambers or any form of treatment of wastewater is currently undertaken. If production was to rise or parameters in the discharge consent to get tighter, the farm will have a problem meeting its discharge consent. It will be necessary to construct or put aside a proportion of the production area to accommodate a wastewater treatment facility. This may be in the form of a primary settlement area and/or drum filter, though current discharge data would suggest that if a drum filter were used the level of filtration would not be more than 300 microns.
Approximate Expenditure **€12 – €20000**

Conclusion:
It is estimated that a suite of upgrade works on the GB site to increase the efficiencies, productivity and the ease of management to produce between 200 and 250 tonne is estimated at between €146 and €156,000. These works will produce a viable functioning farm that will be more cost effective to run and operate than is currently the case but that will not dramatically decrease the production cost per kg of trout, therefore making the investment unsatisfactory.

Option 3 Install a Raceway System

Why a raceway system?

It is very apparent that within the aquaculture business managers, designers and owners all have their specific likes and dislikes of particular operating or culture systems for fish.

During site visits to trout farms in the Republic of Ireland, Northern Ireland and the UK we have had many conversations with people involved in the design and operation of trout aquaculture units. Invariably we heard a range of ideas and saw equipment that reflected the individual's view of how their operation should be run. In most instances we saw an array of unused/discarded equipment and types of experimental systems that were either mistakes or no longer required after management adjustments were made over the years. The basic principals of trout culture do adhere to fundamental biological and physical laws but how aquaculturists interpret these into design of culture units is varied in the extreme.

It is not by default that countries such as Denmark have been forced into developing systems such as the 'model' farm or countries/areas that have very limited supplies of fresh clean water developing various types of RAS, PRAS and other systems that reduce both water use and waste discharge levels. They have had to do this to meet both the constraints of water usage and strict environmental legislation.

It is the belief of the author in this instance that the GB/BD sites has both the quantity and the quality of water to run a serial reuse raceway system (GB only) for the culture of 300 tonne of trout per annum and does not need to invest heavily in complicated and expensive systems such as the Danish model farm or a factory style RAS system. The initial high capital investment, the operating costs and complexities of management for RAS and PRAS systems are not warranted for GBTF Ltd. We feel that both the financial and operating risks associated with these systems are too high. It is important to note that the current aquaculture licence held by GBTF for the GB site does allow for a generous abstraction rate of water and as this licence has a historical precedent it would be difficult to change its conditions.

It is also noted that the discharge licence issued by KCC has been modified with the changes in environmental legislation (primarily WFD and Habitats Directive) and it may be that even more stringent conditions may be set on discharge licences in the future.

One comment that many experienced fish farmers quoted on our visits was the principal of 'keep it simple'; in most cases many of these farmers had tried various schemes and ideas that relied on complicated systems of water delivery/recirculation, oxygenation/aeration, waste removal/management with an over reliance on mechanisation that invariably at some point failed or was

complicated and required regular servicing, expensive to install and run or just simply that it wasn't as good an idea as they thought at the time.

Our proposal is for a robust, simple, tried and tested design that will meet the future production and management requirements for GBTF Ltd. It is understood that like all aquaculture rearing systems, raceways have inherent design and management problems that have to be addressed and are not perfect. The problems associated with the proposed raceway design have been detailed in the report, both generic and site specific and mitigation for these problems has been included in design nomenclature.

Another example of the variation in advice can be seen in the number of consultancy reports in recent years that GBTF have commissioned to try and find a template for both the design and management of a culture unit that will provide them with sustainable financial and ergonomically future options for the culture of trout. Whilst it is appreciated that all the designs met the required scientific principals of intensive aquaculture systems, and in some cases would increase the standing capacity of both the GB and BD sites, the common denominator was a consultant preferring a particular system based on their own experience and not particularly taking into account all the site specific variables particular to GBTF Ltd. These variables may be described as:

- The current and future conditions of their discharge licence (with particular reference to quantity and quality of water).
- No insight on the business structure/financial model
- The philosophy of the business
- No analysis of the natural resources available and their exploitation
- No analysis of the management structure at GBTF

Basic Parameters of a Raceway System

- Need large quantities of good quality water
- Functions as a mechanical system rather than biological
- Inflowing water provides O2 and metabolic wastes are carried out by effluent
- Water quality gradient goes down along axis of raceway
- Production is relatively high per unit space
- Overall management of fish easier
- Commercial viability requires gravity flow
- Large volume of dilute effluent needs treatment
- Discharge is regulated

Disadvantages of a raceway system

1. Most raceway operators believe they have more control over their fish production, and they see this as the major benefit of raceway culture. This control is achieved only if flow rate and water quality are relatively stable over time.
2. Stocking densities for raceways are usually higher than for other culture systems. Densities of 50 to 90 kg per cubic meter are not unusual for raceway systems. These high densities can have distinct disadvantages including: more rapid disease spread, less reaction time when problems occur, and large volumes of effluent with dilute fish wastes.
3. In general, water cannot be economically pumped through raceways; it must flow through them by gravity. The need for large volumes of good quality water is the principal reason raceways have been limited to sites with large springs. Most raceway culture is with coldwater species such as trout and is based around locations with high volume, cold springs and/or rivers, similar to the Goatsbridge site.

4. As a result of the 'plug flow' hydraulics experienced in raceways, the best water quality is found at the head of the raceway where the water first enters and then it deteriorates steadily towards the raceway outlet. Because of the low velocities through the raceway (2-4 cm/s), removal efficiency of settled solids is very poor, and can result in frequent cleaning and maintenance tasks. This is due to the hydraulic design being based on oxygen design requirements, rather than cleaning requirements, that result in the much lower velocities. In practical terms, raceways are incapable of producing the optimum water velocities recommended for fish health, muscle tone, and respiration. Even using lower exchange rates and lower velocities, a raceway system can be limited due to low summer flows, increased concern on environmental impacts on receiving waters, and the difficulty in treating the large flows producing a large effluent discharge.

It is important to address all the limiting factors associated with raceway design and function as it will be necessary within the design phase (should this option be chosen) to mitigate (as is practical) all the identified problems of raceway design and function.

General Information:

Type of Construction:

Concrete Raceway either poured concrete and shuttering, pre-cast sections or block construction (the example in the cost estimate has been based on a poured concrete unit).

Type of Culture System:

Serial reuse of water (3 uses) with option for partial recirculation during low flow events

General Layout and Dimensions of Site (see drawings):

Two sets of three raceways and one set of two (8 raceway series, 3 tanks per series and 24 tanks in total)

Dimensions of Raceway Tanks:

Physical construction dimensions: Length 30m; Width 3m; Depth1.1m
Useable length for fish culture: 27m
Quiescent zone for waste removal: 3m
Depth of water: 0.8m
Surface Area of raceway tank (total): 90m^2
Cross-sectional area of raceway tank: 2.4m^2
Volume of individual raceway tank: 72m^3
Useable volume of individual raceway for fish culture: 64.8m^3
Hydraulic drop between raceway tanks: 0.6m
Design gradient in each raceway tank: 0.15 m per 30 m (0.5 per 100 ft) The raceway outlet will control the water surface grade.
Freeboard: The minimum freeboard is 0.3m with an operating depth of water of 0.8m

Total volume of 24 raceways tanks 1728m^3
Useable volume for fish culture of 24 raceway tanks 1555.2m^3

Water Management and Flow

Design Flow Rates

If the volume of an individual tank is 72m^3 (useable 64.8m^3) and the design specification allows for three turnovers of water per tank per hour, each raceway unit will require 216m^3/hour/tank, this equates to 60l/s. The hydraulic description of the flow type is 'plug' flow, where the water enters at one end and travels in a direct line, at uniform velocity, to outflow at the other end.

The flow rate into each of the eight primary raceway tanks will be 60l/s each. There are eight primary (first) raceways tanks in the set of 24. Each one of these tanks receiving 60l/s of water equates to a total required flow for optimum fish culture of 480l/s with 3 serial reuses of water.

Design Flow Velocity
The design flow of the GB raceway tanks is calculated as:
V = Lm*R/36

Where V is velocity in cm/s, Lm is raceway length in meters and R the exchange rate as water turnover rates per hour.

V = 30*3/36
Therefore the design velocity in each raceway tank is V = 2.5cm/s

The velocity of the water within each raceway unit is a critical component of design and generally raceway design will not produce sufficient flow velocity to facilitate self-cleaning nor create optimal velocities for the effective intensive culture of fish. Raceways create a distinct gradient in water quality from inflow to outflow. Dissolved oxygen (DO) levels decrease downstream, while metabolic by-products, such as ammonia and carbon dioxide, increase. Faeces and excess feed settle quickly and accumulate on the bottom.
This is a distinct disadvantage since fish activity re-suspends these materials, breaking them into finer fractions, which take longer to settle out.

How will the water be delivered to the raceway units?
It is proposed to install two sluice devices in the headrace that will be responsible for controlling the water distribution to both the raceway system and earth ponds at the 'upstream end' of the site and the earth ponds that will be operating at downstream end of the site. It will be important to reduce turbulence within the headrace section delivering water to the raceway system and the lower earth ponds, its is proposed that the penstock sluice that will traverse the headrace, will back up the water and create a 'near' laminar flow within the headrace that will permit greater control of the discharge of water to all the culture systems. Presently the flow in the raceway is fast and quite turbulent (water velocity in some sections exceeds 1m/s).

Fig Possible location (just upstream of wires) for sluice across headrace

Control Mechanisms for Floodwater and Screening for Trash/Leaves

To mitigate against floodwater, the weir crest elevation has been reduced by approximately 300mm of unwanted soil/alluvial depositions over a linear section of approximately 50m (September 2012). This has resulted in considerably less water in flood events coming down the headrace as the excess river water overtops the weir and returns into the main channel of the Little Arrigle. Anecdotally there have not been many instances where large trees, branches and debris have caused major problems for the culture of fish at the GB site. Despite the fact that GB has had few historical problems in relation to large trash, it will however be prudent to install a 'large' trash screen at a location above the two penstock sluices on the headrace.

In respect of leaf and detritus screening, there are a number of options available to investigate. A quote on a mechanised screen can be obtained from Mark Farquhar (Sutherlands and Sterner) as design details and draft drawings will be sent to both Mark and Svend for comment on aeration and degassing.

Another option is a design seen in operation in both Mark McAllister's farm in NI and Ben Hanson's Roadwater Farm in Somerset. The utilised a large surface area mesh screen in conjunction with aeration based agitator on the front of the screen which appeared to work satisfactorily.

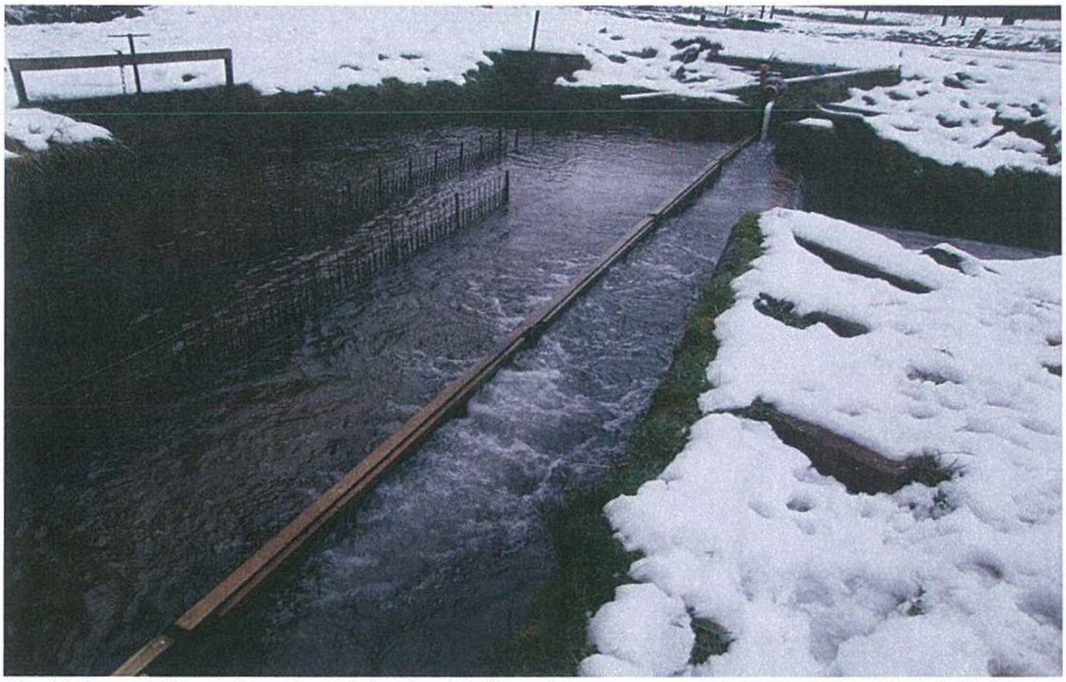


Fig Air is sent through a pipe at the foundation of the screen and the agitation of the air in combination with the large surface area of the screen, works effectively. However, the running and installation costs of all screens have to be examined in more detail.

Design Proposals for Floodwater Alleviation

In conjunction with the works at the weir it is also proposed that the concrete distribution channel that will supply water to the raceway system and upper earth ponds or a by-pass system running parallel to the distribution channel will be designed with sufficient capacity to convey flood water. It should also be remembered that the original headrace channel would also be utilised to convey water during flood events. The 5%ile flow for the Little Arrigle (upper confidence limit) has been established as $4.358m^3/s$ and it is calculated that a large flood event on the Little Arrigle would be in the order of $10m^3/s$. The headrace, currently in use, will comfortably convey $2m^3/s$ and it is proposed to design the inlet (distribution channel) to the Raceway system to convey a further $2m^3/s$ and act as a supplementary flood relief channel when required. It has been assumed that more than 60% of the floodwater will overtop the weir during a flood event and therefore the capacity of $4m^3/s$ in the two channels will be sufficient to deal with all but the very largest flood events.

Managing the system in low flow events

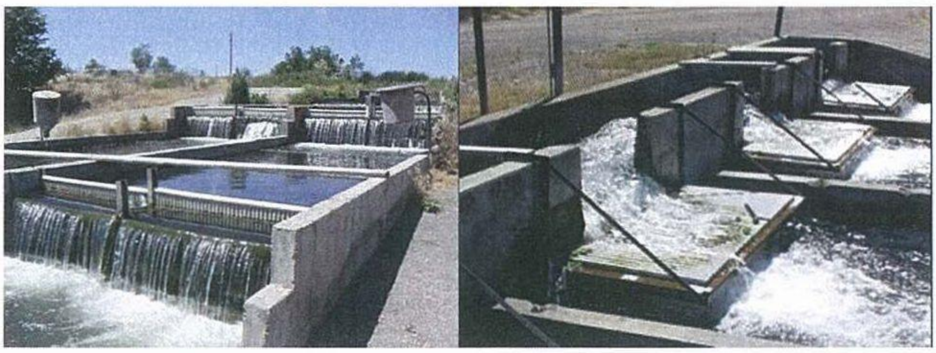
We have estimated that the lowest flows recorded on the GB site are approximately 150l/s and that the recirculation pump currently onsite is capable of recirculating up to 150l/s. It is feasible that we can still run the raceway system at near capacity with 300l/s of water with supplemental oxygen at 140% saturation or possibly greater. We may employ the use of low head oxygenators (LHO's) throughout the normal running of the unit and these will also be utilised during low flow events. The exact nature of supplemental oxygenation and degassing has yet to be defined and further research is required. (Please comment Mark and Svend)

Aeration and Oxygenation

Introduction:
The calculations undertaken in the design phase of the raceway system have looked primarily at passive aeration. It is clearly understood by the designer that in low flow events of 300 l/s or less, the raceway system will require the recirculation of up to 200 l/s of water with supplemental oxygenation and degassing to achieve the stocking densities delineated within the production models (please refer to page @@@) . There will also be a requirement to supply oxygenated water to the earth ponds within the GB site. Determining whether oxygenation or aeration is more appropriate for a given production system will depend on production targets, site dynamics, DO requirements, and costs. Increasing carrying capacity via oxygen supplementation may influence concentrations of carbon dioxide, unionized ammonia, pH, and solids.

Further investigation into this element of design is required and is being assisted by Mark Farquhar (Sutherlands and Sterner) and Svend Christensen (Lykkegaard AS). Within this further review we can explore the options available for supplementary oxygenation and its effect on carrying capacity and production modelling.

Passive Aeration



The proposed vertical (hydraulic) drop from each raceway tank is 600 mm; it is possible that this could be increased up to 900mm (this has to be reviewed during the design stage). It is necessary (as previously stated) to review the options for aeration/oxygenation closely.

With passive aeration, splashboards or similar type devices can be used to partially recharge the water with oxygen between raceway tanks. We have undertaken a simple example within this report (please see page 35) of modelling the raceway system with passive aeration only. This is simply to give a default position in respect of the proposed carrying capacity of the system relative to optimum flow rates.

The physical design parameters of the raceways will incorporate a bulkhead (end of raceway tank), which shall be fitted with a weir overfall. Flashboards in the opening or throat section of the bulkhead may be used for this purpose. The width of the weir or weirs should be equal to the bottom width of the raceway where flashboards are used to establish the desired water level. Two or more weirs separated by rigid center sections shall be installed as the raceway width exceeds 2.5m. To increase aeration, a splashboard or series of boards arranged to create successive splashes shall be considered in design. The minimum distance from the weir crest to the water level below will be no less than 600mm.

Waste Management

Settling basins are commonly used to remove solids and solids-bound nutrients prior to discharge into receiving waters. Sedimentation is undoubtedly the most widely applicable and inexpensive method for removing solids from flow-through trout farms. Gravitational settling can provide a simple, low-maintenance, and only moderately expensive method of removing a high percentage of the solids and accompanying nutrients from raceway effluents, but requires a larger flat area and must be properly designed. Within the raceway production system design, three types of settling basins are used to settle solids: 1) a quiescent zone, 2) a full-flow settling basin, and 3) an off-line settling basin. A quiescent zone will function in conjunction with sludge-cones in an area downstream of the rearing area of each tank for initial separation of settleable solids from the water. A screen will prohibit fish from entering the quiescent zone allowing the solids to settle undisturbed. As has been mentioned previously, a common misconception is that the water velocity within raceway systems serves to 'flush' solids from the tanks. In fact, water velocities in this raceway system are well below the 3.7 cm/s, suggested as the minimum flow required for self-cleaning (2.5cm/s for proposed system). Faecal solids and waste feeds will accumulate nearly anywhere in the system that fish are not present.

Quiescent zones will serve as the pre-treatment system for solids, which are then either pumped or transported by gravity flow to off-line settling basins. The off-line settling basins will receive the concentrated solids removed from quiescent zones, but not the full flow of the water from the facility. The combination of quiescent zones and off-line settling basins is the most commonly used system of treatment with concrete raceways in the U. S. to capture and remove solids. The remaining flow of the facility will discharge into a primary-flow settling basin before discharge into the Little Arrigle River. However, the parameters set by the discharge licence relative to any increase in production would indicate there may be a requirement for further treatment (if required) prior to discharge in this area in the form of a drum filter, biofilter or supplementary aeration of water. Indications in the form of ammonia modelling for the raceway system would predicate the need for some form of treatment of un-ionised ammonia prior to discharge into the Little Arrigle River.

Primary Waste Removal (Sludge cones and sludge basins)

The purpose of sludge traps/cones (Fig) in the rear bottom of each section of the raceways is to remove particulate matter. Sludge traps quickly remove larger particles (faeces, excess feed, etc.),

Fig: Sludge cones are mounted at the downstream end of each raceway section across the full width of the raceway and in line with the raceway bottom.

It is the experience of fish farmers that the management of sludge cones indicates the importance of emptying them regularly (at least twice per week or more and before they are filled). This optimises the retention of nutrients and organic matter and to reduce leakage of dissolved nutrients and organic matter and re-suspension of fine particles. It is envisaged the emptying process should be very short to reduce the amount of water following the sludge to the sludge basins. Plans have not been fully ratified on how the sludge will be delivered to the offline settlement basin; it might be performed automatically (via an electronic control mechanism) at certain intervals with a fixed, short time period or it could be triggered manually or by a fixed degree of filling of the sludge cones. Efficient removal of organic matter is essential to both the operating protocols of production and adhering to waste discharge consents.

The sludge will be pumped to the sludge basins/tanks for sedimentation/storage of sediments and to clear the remaining sludge water (Figure). High retention time in the sludge basins allows for more efficient settling of particles, which reduces the amount of nutrient and organic matter that is discharged with "cleared sludge water" from the sludge basins.

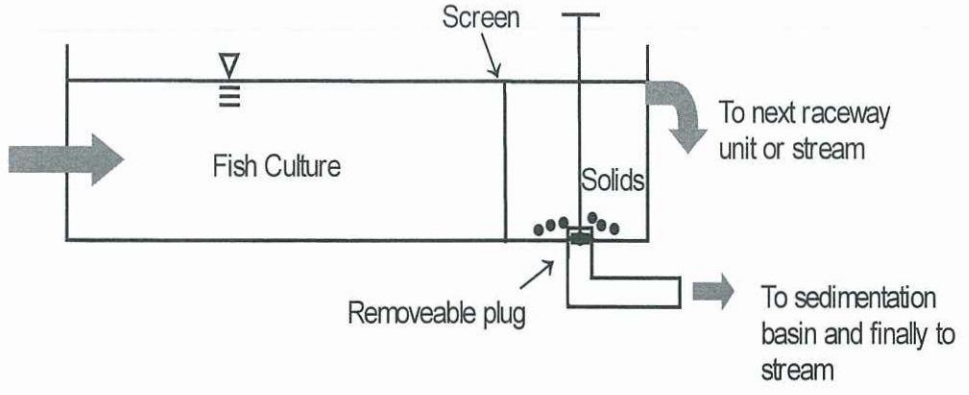
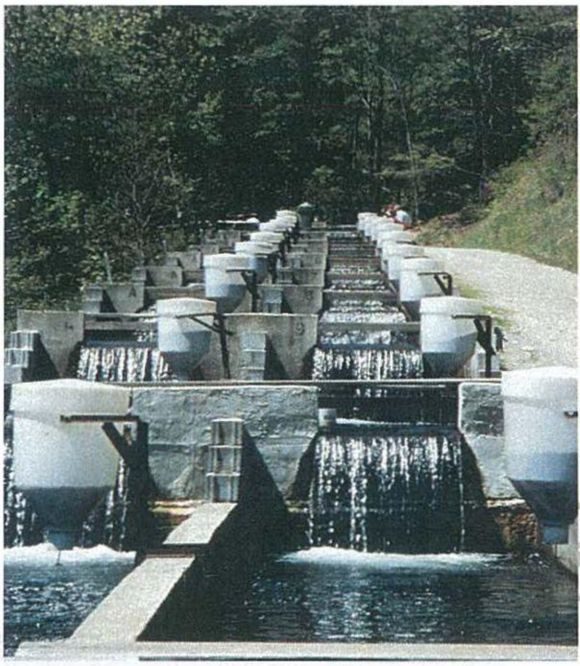


Fig: Possible location for primary flow settlement prior to discharge. The offline settlement basin will be adjacent to the end of the raceway system so sludge has the minimum length to travel and can be easily accessed by a slurry tanker and pump.

Feeders

Demand feeders (pendulum) are commonly used to deliver feed, advantages include:

- Reduced labour
- Access for all fish
- Spreads oxygen demand throughout the day



Other options will be reviewed prior to any decision being made, though research and consultations with other raceway farmers would indicate that pendulum demand feeders are the best cost effective mechanism for use on raceway systems. We have viewed automated feeding systems based on the piggery sector in use in a raceway system in Northern Ireland and despite the ease of both operation and effectiveness at distribution of feed, we feel that the initial investment of the system is not warranted at this time and may be reviewed in the future. Hand feeding may still be viewed as a viable option.

Baffles

This would appear to be a controversial topic as the arguments for and against are equally valid.

Baffles are panels installed in raceways, which make ponds completely, or nearly self-cleaning. Water flowing through the pond is forced along the bottom, which carries the wastes to the outlet. If installed correctly wastes roll gently to a point below the last baffle without breaking up significantly where they can be removed by vacuuming or brushing. Baffles require little maintenance and ponds are continually cleaned without disturbing the fish. Relatively high flows are required to enable them to function efficiently however and they can be costly to fabricate and install depending on materials and methods chosen.

Baffles, for instance, can be placed in rectangular, flow-through rearing units to provide effective and continuous cleaning action. Such baffles are usually spaced at distances approximately equal to the width of the tank or pond. The gap between baffles and the bottom of the unit varies from 3-8 cm. The objective is to create enough velocity along the bottom to move solids to the foot (clean-out section) of the raceway. A velocity of 20-40 cm/sec directly behind a baffle is recommended. To determine the velocity, the following formula can be used:

V = L x R where V equals velocity in meters per second (m/sec), R is the hourly water exchange rate, L is the length of the rearing unit in meters, and 3600 is the number of seconds in one hour. This equation gives the velocity of the water through the rearing unit.

To determine the velocity behind the baffles, this equation is used: $VB = D^1 \times V$, where VB is the velocity in m/sec behind the D_2 baffle, and D^1 is the baffle gap (this ratio can be expressed in either cm or m). If D_2, is the unknown, we have: $D_2 = V^1/VB \times V$

Note:

This section of the report requires a more detailed review during the design process as the costs associated with fabricating and installing Baffles may be as high as €10,000. There are going to be a number of factors, including carrying capacity, stocking densities, production modelling etc that will have a determining influence on this element and until the appropriate research is undertaken, no further action is required.

Carrying Capacity and Production Modelling

Multiple-Pass Systems **Without** Supplemental Aeration

Raceway ponds, arranged for serial passage of water can have serious constraints to successful fish health management if not managed properly. In the proposed system utilising 3 serial water uses, the status of health in succeeding populations often gets progressively worse.

This condition is influenced by at least three major factors within the system:
1. The size of fish;
2. The successive depletion of dissolved oxygen;
3.The successive accumulation of waste products (faecal material and ammonia).

Thus, any successful production in situations such as this must take these three constraints into account.

1. Considering at initial stocking size at 15 gr and a final harvesting size at 550 gr, average fish size for calculations purposes has been set at 300 gr.
2. Definition of oxygen depletion: the system to be modelled is a series of three raceways (3m wide, 30m long, 0.8m water depth) at an elevation of approximately 25m AOD. Between each raceway in the series is a 0.6m fall, which serves to recharge the water with dissolved oxygen. The water inflow to the first-use pond is 60l/s. The average water temperature has been calculated from data taken at GB as 10°C. The minima and maxima range of water temperatures in 2012 was 7°C and 13°C.
   The dissolved oxygen content of the water (10°C) at an elevation of 25m AoD and 95% saturation is 10.72 mg/1 (Appendix I: Table 2). Thus, there is a total of 216,000 l/hr. entering each raceway unit per hour, this equates to 2,315,520 mg dissolved oxygen entering the raceway per hour.
   There should not be more than a 30% depletion of total dissolved oxygen in the first use. Thus, the water exiting the first-use tank should be 70% of saturation (7.5 mg/1). With the fall from the first-use tank into the second-use tank, there will be an oxygen recharge to 80.70% of saturation (8.65 mg/1) (Appendix I: Table 8). The water leaving the second-use pond should have a partial pressure of oxygen (POD of not less than 90 mm Hg or 59.75% of saturation (5.8 mg/l) (Appendix 1: Table 3). With the fall between the second-use and the third-use, the oxygen saturation of the water entering the third-use pond will be 76.2% (8.16 mg/1). Again, as with the second-use pond, the water exiting the third-use pond should not be less than 59.75% of oxygen saturation. This equates to:

Tank	mg/L	mg/hour	mg/day
First	3.22	695,520	16,692,480
Second	2.56	552,960	13,271,040
Third	2.1	453,600	10,886,400

Based on oxygen availability, stocking densities can be calculated:

First Tank (695,520mg/hr./02)
40.5mg of oxy/hr./300g fish = 17173 fish at 300g = 5152kg
Stocking density tank 1 = 79.5kg/m3

Second Tank (552960mg/hr./02)
40.5mg of oxy/hr./300g fish = 13,753 fish at 300g = 4096kg
Stocking density tank 2 = 63.2kg/m3

Third Tank (453,600mg/hr./02)
40.5mg of oxy/hr./300g fish = 11,200 fish at 300g = 3360kg
Stocking density tank 3 = 51.9kg/m3

Total standing stock in each raceway series 12,608kg

Total Standing Stock of Raceway system 100,864kg.

3. Accumulation of waste products (see solids and waste remova)

Ammonia

In salmonids culture, Maximum Allowable un-ionized Ammonia (AUA) has been set at 0.025 mg/L (assuming that pH does not exceed 8).
To estimate the maximum loading levels based o un-ionised ammonia, the following factors need to be considered:

- One Kg of feed requires 250 g of Oxygen for metabolism (OF)
- One Kg of feed generated 30 gr of total ammonia nitrogen (TANF)
- **The AUA is 0.025 mg/l**

Calculation of total ammonia can be based on the following equation:
TAN= (Available Oxygen/OF) * (TANF/1.44)
Where 1.44 equals to *total* TAN (g) for 1mg/l TAN per 24 hours day (1440 minutes). The first part of the equation represents kg feed that can be fed per litre per minute of flow.
The table below shows the calculation for TAN based on available oxygen:

	first tank (g)	**Second (g)**	**Third(g)**
AO	16692	13271	10886
OF	250	250	250

TANF	30	30	30
TAN (g)	1391	1106	907

Total ammonia produced per day: **3,404 g/day**.
Calculations of **percentage of toxic un-ionised ammonia (%UA):** this is a function of water temperature and pH. Considering the worst-case scenario (during summer), temperature will be 13 C and pH 8. Percentage of unionized ammonia will therefore be: 1.8%
(http://www.svl.net/resources/calculators/unionized-amonia-calculator)
Total UA per day: 3,404 gr* 1.8%= 61 g/day

Total UA at outlet: 61 g/ 5,184,000 l·day = 0.012 mg/l

When inlet water does not need recirculation, un-ionised ammonia will not become a limiting factor. In fact, considering that inlet unionised ammonia ranges between 0.01 and < 0.01, the total ammonia at the end of the third use will never be > 0.024 g/l, which is within recommended limits for salmonids culture.
But as the available water at inlet drops and part of the outlet water will need to be re-used, then an ammonia stripping system may need to be considered. (This requires input from Svend and Mark)

Carbon Dioxide
This parameter can be reviewed after input from Svend and Mark, though we believe that due to the pH and alkalinity of the water source, it wont pose a risk to the fish in the context of our prescribed production model. However, it may be critical to degas during low flow events when the water is being recirculated and if it is decided to increase the stocking densities in the system with an oxygen injection system then it will potentially pose a problem to production.

Solids
It is important when water is reused in a serial reuse system that the waste is not passed on to the following tanks in the system. Approximately 300g of waste per kilogram of food and it is estimated when the raceway production system is at full capacity, there will be an average of 50kg of food per day fed to each of the 24 tanks. This equates to an average of 15kg of waste produced in each tank per day and 360 kg per day in the whole system. A large proportion of this waste will have to be transported to the offline settlement basin to prevent water quality degradation in the rearing unit and prevent pollution of the receiving Little Arrigle River. Further settlement will be achieved in the online settlement area prior to discharge.

Outline of Engineering Plans and Proposed Drawings

It has been necessary when evaluating the different types of aquaculture rearing units suitable for the GB site, to understand the potential for unsatisfactory performance of a range of culture systems and the advantages and disadvantages of a number of design options to minimise the risks associated with such a capital outlay. The decision (in reference to this report) of a raceway system for GB was made after a range of variables were assessed and based on these assessments the decision was a 'best fit'.

It is not the remit of this report to produce full design drawings and budgets for the construction of the proposed raceway. However, the production models have been run on the most accurate information we have on water quality and quantity and all the values in respect of raceway dimensions, flow rates, aeration/oxygenation, proposed site layout etc have been accurately calculated.

There will be a requirement should this project move to the design phase, of utilising a suitably qualified civil engineer and quantities surveyor (QS). It is essential that an engineer is engaged as part of the team to design the raceway system and that he/she prepares detailed engineering drawings. The QS will be essential in sourcing and budgeting materials, giving an accurate figure on construction costs and ensuring that the project remains within budgetary allowances. Experience has proved that significant savings on construction, operating costs and improved environmental management will be achieved by utilising professional advice on:

- Earthworks Staging
- Materials Budgets (block work, concreting, piping, drainage, sluices etc)
- Optimising the Performance of the Farm (ergonomics, water flow, ease of management)
- Construction Standards for Contracting Purposes

The engineering report will include:

- A description and evaluation of proposed works giving due consideration to site constraints
- Detailed drawings and designs of the proposed works
- Specifications of the proposed works that indicate the properties of the materials to be used in the construction of the raceway systems and the standards to be met during the construction stage.

It is feasible to give a ballpark figure on design and construction costs though this may be misleading to the client. It is advised that this brief overview of estimates is simply what it states and could range + or – 20% of the value reported.

Estimate of Quantities (This will be undertaken in full by QS though most figure quoted have come direct from suppliers and a QS)

Concrete Volume Estimates on Raceway and Associated Works

Total volume of concrete in walls in raceway system:
33 walls at 30m long (990m*1.1m*.2) = **218m3**

Total volume of concrete in floors in raceway system:
Each series of three is 90m*10m = 900m2 * 2 is 1800m2 plus the series of two (90m*7m = 630m2) total area is 2430m2*.150m = **364.5m3**

Total volume of concrete in walls in inlet:
Inlet walls 48m*2 = 96m*.2*.7 = **13.44m3** (15m3 with adjustments)

Total volume of concrete in floors in inlet:
Inlet floor 48m*1.5m*.150 = **10.8m3**

Total volume of concrete in inlet: **24.24m3**

Total volume of concrete in outlet: **25m3**

Offline Settling Basin: **25m3**

Approximate total volume of concrete is: **682m3**

Approximate Estimations on Raceway Project

Estimation on Design and Construction:

There has been no estimation made in respect of County Council planning fees or any delay in relation to a planning application or changes to aquaculture licencing or discharge consents that may affect the proposed scheme. It should be also noted that any interruptions to current production during the construction phase have not been factored in:
Please note design fees will also include logistics planning, timing of works, order of works, etc.

Planning, design and associated consultancy **€15,000**
This includes all reporting, bill of quantities, detailed design and site drawings, site investigation/topographical reports, logistic planning etc.

Project Management **€15,000**
This will involve all aspects of contract management, tendering processes, hiring of suitable contractors/subcontractors, quality assurance, onsite construction supervision and associated consultancy.

Construction

Site Clearance and Preparation

Site clearance will include mobilisation and demobilisation, excavations, material taken off site where required, buying and haulage of stone, stone foundation 350mm deep (2310 tonne of 4" down), levelling and site preparation, roads where required.

Total Site Clearance and Prep **€42,000**

Concrete Construction Costs

Value of concrete to buy is €70*682m3 = €47,740 (€50,000) inc of VAT

Construction Works Associated with Concrete Works
There is an estimated cost of €72/m3 and with a total estimated volume of 260m3 of concrete, this equates to €18700 inc of VAT

Floor
There is an estimated cost of €19/m3 and with a total estimated volume of 422m3 of concrete, this equates to €8018 inc of vat

Steel Mesh for floor: cost per sheet €48 we will require 217 sheets = € 10,000
Steel for walls: rebar and fixings for wall = €8,500

Cost for walls and floor **€45,218** (works and steel) + **€47,740** (concrete)

Total Concreting Works Raceways and Inlet, Outlet and Offline Settlement: **€92,958** inc VAT

Sluice Systems
A minimum of two penstock sluice systems on the headrace, each sluice system will cost approximately €7,500 each to buy and install. €15,000

Two wooden flashboard sluice systems on headrace and outlet @ €2500 each €5000

Total **€20000**

Piping, Gate Valves and Associated Works

Piping will include all waste delivery systems to offline settling basins, gate valve controls on inlets to raceway (8) and mechanisms for draining/isolating each tank individually.

Water control in raceways
Gate valves
Sixteen (16) 9" gate valves @ €700 = €6300
Eight (8) 12" gate valves @ €1000 = €8000

Piping
65m 12" wavin = €1625
120m 9" wavin = €1800

Waste water control
250m of 6" wavin = €1250
6 90degree bends = €120
25 T joints = €750
Associated Works (connection and fitting foundation works) €5000

6" sludge pump €4000 (optional)

Total Cost of Piping and associated works **€24,845** inc vat (pump optional)

Electrical Circuitry, Recirc Pump, Feeders, Flashboards, Aeration/oxygenation, Lighting, Monitoring Controls, Screens, Baffles

Oxygen generator??
Low head oxygenators LHO??
Degassing and oxygen injection????
(These areas will be discussed within the report from Sutherlands and Sterner, a nominal fee of €20,000 have been given to this section for representative purposes only and requires ratification)

Monitoring and Alarm Systems €10000
48 Feeders (minimum) €10000
24 Screens (Quiescent Zone) €3500
24 sets of flash boards €2000
Recirc Pump €0 currently in situ (may need replacing)

144 Baffles €7000 (again this figure and the requirement is not verified, it may be a requirement to place baffles only from the middle to the end of the raceway, this will save money and reduce time and labour costs during management operations, will require further research)

Screening on inlet (leaves and detritus) not automated €3000

Very approximate cost (not verified) **€55,500**

It should be reiterated that this section is just an overview of expected expenditure on the construction of the raceway system and associated works only. It makes no reference to any upgrading works required on the remaining earth ponds. The figure produced below gives a reasonably accurate figure associated with the raceway proposal.

Net Total €233,747

Grand Total €265,303 inc vat @13.5% (€31,556)

Running and Production Costs

This is currently under review as we are waiting on clarification of issues relating to pumping, oxygenation, and degassing and waste treatment. Sean Fleming GBTF accountant has generated a financial model for the farm and we envisage using this model to generate accurate running costs for the Raceway proposal.

Option 4 Install a RAS or PRAS system (including model farm)

There have been a number of consultant reports commissioned by GBTF in recent years and site visits by representatives of firms that design and build RAS systems. The following conclusions in this option have been based on the views of GBTF management during personal discussions. It should also be noted that we feel the intrinsic value of a high quality water source in combination with relatively high flow rates negates the substantial investment in a complex rearing facility that is more suited to a site with greater limitations than the GB site.

A RAS system is not an appropriate venture for the future development of GBTF Ltd. We arrived at this conclusion due to a number of limiting constraints, in summary, we believe that the necessary training and technical understanding required to run a RAS/PRAS system effectively is currently not in place. The level of investment relative to the perceived risk of failure is too high and does not stand scrutiny under a cost benefit analysis.
A Danish style 'model farm' has at this point fallen into the inappropriate bracket. The primary reasons why we feel this option does not suit are: Increased energy consumption; increased CO_2 discharge; risk of accumulation of NH_3, NO_2, CO_2; increased requirements to monitoring and management; increased technical know how needed; increased need of back-up systems electricity, emergency oxygen, pumps etc.and a large investment in infrastructure.

Option 5 Install a system of round tanks

There are, like many aspects of aquaculture rearing units, ranges of opinions on what the best type of culture systems are for trout. Depending on the consultant, their background, or what they are promoting, it can be confusing to understand what is the right culture system to employ. There are many positive attributes to circular tanks and they are all well documented, from construction advantages through to water use, hydrodynamics, stock observance and conditioning, disease control etc. We believe that to optimise the effectiveness of round tanks on the site, they would have to be large (10m +) to be economically viable.

Our rationale in discounting this option was based on a number of factors:

- The topography and shape of the GB site:

The most obvious drawback to round tanks is they are space intensive. A round tank in a rectangular site means there is going to be a lot of wasted space in the area in the corners that the tank does not cover. Space is at a premium in the GB site and we cannot rationalise the loss of space associated with a raceway system of round tanks.

Other problems associated with large circular tanks include:

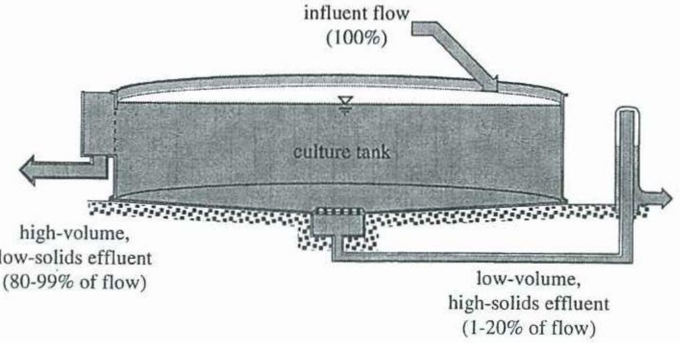
- Distributing flow to obtain uniform mixing and rapid solids removal;

- Grading and harvesting fish;
- Removing mortalities;
- Isolating the biofilter (if required) while treating the fish with a chemotherapeutant;
- Risk of larger economic loss per tank failure due to mechanical or biological reasons.

Another draw back is the fact that a round tank has no difference in length or width, therefore water circulation can only occur in a circular motion. Many designers would explain that this circular motion was the most effective way to remove solids, because the vortex in the center acts like the vortex in a toilet. Unfortunately, in a round tank different dynamic effects cause two vortexes. In a round tank the circular motion may resemble a toilet vortex, but instead of being caused by gravity and a partial vacuum, it is being caused by water flow from a pump. This water flow is greater on the outer edge of the tank then in the center; therefore a certain amount of the solid waste in the tank will travel towards the center. However, the problem is, waste deposited along the outer edge of the tank may have to orbit the tank hundreds of times before it finally makes its way to the center. In the mean time it is being churned and homogenised the entire time and can cause water quality problems as it slowly dissolves.

In a rectangular raceway tank the water flow is generally in a straight line from one end to the other. This would mean that a solid deposited in one end of a 30m long tank can only travel 30m, and in one direction, before it hits the bottom solids trap. In good system designs the time required for the trip may only be a matter of 10-15 minutes. Therefore the solid is removed in its entirety before it has a chance to dissolve in the water column and cause water quality problems.

It is understood that round tank design has been modified to cater for waste management and it is acknowledged that there are certain benefits of round tanks that cannot be achieved with rectangular raceway tanks, particularly water velocities for both the conditioning and effective distribution and use of DO.



Appendix 1 Charts Used in Report Calculations

DISSOLVED OXYGEN (MG/L) CONTENT AT 100% SATURATION
(Compensated for Temperature (°C) and Elevation (ft.))

Water Temp	Elevation (feet)									
(0C)	0	500	1000	1500	2000	2500	3000	3500	4000	4500
0	14.60	14.34	14.09	13.84	13.59	13.35	13.11	12.88	12.65	12.43
1	14.20	13.95	13.70	13.46	13.22	12.98	12.75	12.53	12.30	12.08
2	13.81	13.57	13.33	13.09	12.86	12.63	12.41	12.19	11.97	11.76
3	13.45	13.21	12.97	12.74	12.52	12.29	12.07	11.86	11.65	11.44
4	13.09	12.86	12.63	12.41	12.19	11.97	11.76	11.55	11.34	11.14
5	12.76	12.53	12.31	12.09	11.87	11.66	11.46	11.25	11.05	10.85
6	12.44	12.21	12.00	11.78	11.57	11.37	11.17	10.97	10.77	10.58
7	12.13	11.91	11.70	11.49	11.29	11.09	10.89	10.69	10.50	10.32
8	11.83	11.62	11.41	11.21	11.01	10.81	10.62	10.43	10.25	10.06
9	11.55	11.34	11.14	10.94	10.75	10.55	10.37	10.18	10.00	9.82
10	11.28	11.08	10.88	10.68	10.49	10.31	10.12	9.94	9.76	9.59
11	11.02	10.82	10.63	10.44	10.25	10.07	9.89	9.71	9.54	9.37
12	10.77	10.57	10.38	10.20	10.02	9.84	9.66	9.49	9.32	9.15
13	10.53	10.34	10.15	9.97	9.79	9.62	9.44	9.27	9.11	8.95
14	10.29	10.11	9.93	9.75	9.58	9.40	9.24	9.07	8.91	8.75
15	10.07	9.89	9.71	9.54	9.37	9.20	9.02	8.87	8.71	8.56
16	9.86	9.68	9.51	9.34	9.17	9.00	8.84	8.68	8.53	8.37
17	9.65	9.48	9.31	9.14	8.98	8.81	8.66	8.50	8.35	8.20
18	9.45	9.28	9.12	8.95	8.79	8.63	8.48	8.32	8.17	8.03
19	9.26	9.09	8.93	8.77	8.61	8.46	8.30	8.15	8.01	7.86
20	9.08	8.91	8.75	8.59	8.44	8.29	8.14	7.99	7.84	7.70
21	8.90	8.74	8.58	8.42	8.27	8.12	7.98	7.83	7.69	7.55
22	8.73	8.57	8.41	8.26	8.11	7.96	7.82	7.68	7.54	7.40
23	8.56	8.40	8.25	8.10	7.96	7.81	7.67	7.53	7.39	7.26
24	8.40	8.25	8.10	7.95	7.81	7.66	7.52	7.39	7.25	7.12
25	8.24	8.09	7.95	7.80	7.64	7.52	7.38	7.25	7.12	6.99
26	8.09	7.95	7.80	7.66	7.52	7.38	7.25	7.11	6.98	6.86
27	7.95	7.80	7.66	7.52	7.38	7.25	7.11	6.98	6.86	6.73
28	7.81	7.66	7.52	7.39	7.25	7.12	6.99	6.86	6.73	6.61
29	7.67	7.53	7.39	7.26	7.12	6.99	6.86	6.74	6.61	6.49
30	7.54	7.40	7.26	7.13	7.00	6.87	6.74	6.62	6.50	6.38

DISSOLVED OXYGEN CONTENT (% SATURATION AT A pO_2 OF 90 MM Hg)
(Compensated for temperature and elevation)

Water temp °C	Elevation (in feet above msl) 0	1000	2000	3000	4000	5000
0	0.5687	0.5909	0.6140	0.6380	0.6619	0.6876
1	0.5692	0.5917	0.6150	0.6388	0.6628	0.6882
2	0.5694	0.5915	0.6151	0.6391	0.6627	0.6888
3	0.5691	0.5915	0.6148	0.6387	0.6626	0.6882
4	0.5698	0.5924	0.6153	0.6396	0.6634	0.6891
5	0.5701	0.5924	0.6159	0.6397	0.6636	0.6900
6	0.5703	0.5927	0.6163	0.6402	0.6642	0.6900
7	0.5705	0.5930	0.6162	0.6407	0.6647	0.6906
8	0.5709	0.5935	0.6168	0.6408	0.6654	0.6912
9	0.5714	0.5941	0.6174	0.6414	0.6660	0.6918
10	0.5718	0.5945	0.6178	0.6418	0.6663	0.6921
11	0.5726	0.5953	0.6186	0.6432	0.6670	0.6934
12	0.5729	0.5956	0.6189	0.6434	0.6677	0.6940
13	0.5736	0.5962	0.6201	0.6446	0.6689	0.6951
14	0.5743	0.5970	0.6208	0.6452	0.6693	0.6961
15	0.5748	0.5975	0.6212	0.6462	0.6907	0.6968
16	0.5751	0.5981	0.6217	0.6465	0.6710	0.6974
17	0.5762	0.5991	0.6226	0.6473	0.6723	0.6985
18	0.5772	0.6000	0.6240	0.6485	0.6732	0.7000
19	0.5771	0.6004	0.6243	0.6485	0.6238	0.7003
20	0.5782	0.6014	0.6250	0.6506	0.6748	0.7019

OXYGEN RE-CHARGE ($\%X10^{-2}$) OF WATER FALLING FROM VARIOUS HEIGHTS

Percent Saturation at Outfall of Upper Reuse Pond	Height of fall (ft.)							
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
32	.45549	.50337	.53724	.56399	.58627	.60543	.62227	.63729
33	.46350	.51067	.54404	.57040	.59235	.61123	.67782	.64263
34	.47151	.51798	.55085	.57681	.59844	.61704	.63338	.64796
35	.47951	.52528	.55765	.58322	.60452	.62284	.63893	.63330
36	.48752	.53528	.56445	.58963	.61060	.62864	.64449	.65863
37	.49553	.53989	.57126	.59605	.61669	.63444	.65004	.66396
38	.50354	.54719	.57807	.60246	.62277	.64025	.65560	.66930
39	.51154	.55449	.58487	.60887	.62886	.64605	.66115	.67463
40	.51955	.56180	.59168	.61528	.63494	.65185	.66671	.67997
41	.52756	.56910	.59848	.62169	.64103	.65665	.67226	.68530
42	.53557	.57640	.60529	.62810	.64711	.66346	.67782	.69063
43	.54357	.58371	.61210	.63452	.64319	.66926	.68337	.69597
44	.55185	.59101	.61890	.64093	.65928	.67506	.68893	.70130
45	.55959	.59832	.62571	.64734	.66536	.68086	.69448	.70663
46	.56760	.60562	.63251	.64375	.67145	.68667	.70004	.71197
47	.57560	.61292	.63932	.66016	.67753	.69247	.70559	.71730
48	.58361	.62023	.64612	.66658	.68362	.69827	.71115	.72264
49	.59162	.62753	.65293	.67229	.68790	.70407	.71670	.72797
50	.59963	.63483	.65973	.67940	.67940	.70988	.72226	.73330
51	.60763	.64214	.66654	.68581	.70187	.71568	.72781	.73864
52	.61564	.64944	.67334	.69222	.70795	.72148	.73337	.74397
53	.62365	.65674	.68015	.69864	.71404	.72728	.73982	.74931
54	.63166	.66405	.68695	.70505	.72012	.73309	.74448	.75464
55	.63966	.67135	.69376	.71146	.72621	.73889	.75003	.75997
56	.64767	.67865	.70056	.71787	.73229	.74469	.75559	.76531
57	.65568	.68596	.70737	.72428	.73838	.75049	.76114	.77064
58	.66369	.69326	.71418	.73070	.74446	.75630	.76669	.77598
59	.67169	.70056	.72098	.73711	.75054	.76210	.77225	.78131
60	.67970	.70787	.72779	.74352	.75663	.76790	.77780	.78664
61	.68771	.71517	.73459	.74993	.76271	.77370	.78336	.79198
62	.69572	.72247	.74140	.75634	.76880	.77951	.78891	.79731
63	.70372	.72978	.74820	.76276	.77488	.78531	.79447	.80365
64	.71173	.73708	.75501	.76917	.78097	.79111	.80002	.80798
65	.71974	.74438	.76181	.77558	.78705	.79691	.80558	.81331
66	.72775	.75169	.76862	.78199	.79313	.80272	.81113	.81865
67	.73575	.75899	.77542	.78840	.79922	.80852	.81669	.82398
68	.74376	.76629	.78223	.79482	.80530	.81432	.82224	.82931
69	.75177	.77360	.78903	.80123	.81139	.82012	.82780	.83456
70	.75978	.78090	.79584	.80764	.81747	.82583	.83335	.82998

Percent Saturation at Outfall of Upper Reuse Pond	Height of fall (ft.)							
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
71	.76778	.78820	.80264	.81405	.82356	.83173	.83891	.84532
72	.77579	.79551	.80945	.82046	.92964	.83753	.84446	.85065
73	.78380	.80281	.81626	.82688	.83572	.84333	.85002	.85598
74	.79181	.81011	.82306	.83329	.84181	.84914	.85557	.86132
75	.79981	.81742	.82987	.83970	.84789	.85494	.86113	.86665
76	.80782	.82472	.83667	.84611	.85398	.86074	.86668	.87199
77	.81583	.83202	.84348	.85252	.86006	.86654	.87224	.87732
78	.82384	.83933	.85028	.85894	.86615	.87235	.87779	.88265
79	.83184	.84663	.85709	.86535	.87223	.87815	.88335	.88799
80	.83985	.85939	.86389	.87176	.87831	.88395	.88890	.89332
81	.84786	.86124	.87070	.87817	.88440	.88975	.89446	.89866
82	.85587	.86854	.87750	.88458	.89048	.89556	.90001	.90399
83	.86837	.87584	.88431	.89100	.89657	.90136	.90557	.90932
84	.87188	.88315	.89111	.89741	.90265	.90716	.91112	.91466
85	.87989	.89045	.89792	.90382	.90874	.91296	.91668	.91999
86	.88790	.89775	.90473	.91023	.91482	.91877	.92223	.92533
87	.89590	.90506	.91153	.91664	.92090	.92457	.92779	.93066
88	.90391	.91236	.91834	.92306	.92699	.93037	.93334	.93599
89	.91192	.91966	.92514	.92947	.93307	.93617	.93890	.94133
90	.91993	.92697	.93195	.93588	.93916	.94198	.94445	.94666
91	.92793	.93427	.93875	.94229	.94524	.94778	.95001	.95199
92	.93594	.94157	.94556	.94870	.95133	.95358	.95556	.95733
93	.94395	.94888	.95236	.95512	.95741	.95938	.96112	.96266
94	.95196	.95618	.95917	.96153	.96349	.96519	.96667	.96800
95	.95996	.96348	.96597	.96794	.96958	.97099	.97223	.97333
96	.96797	.97079	.97278	.97435	.97566	.97679	.97778	.97886
97	.97598	.97809	.97958	.98076	.08175	.98259	.98334	.98400
98	.98399	.98539	.98639	.98718	.98783	.98840	.98889	.98933

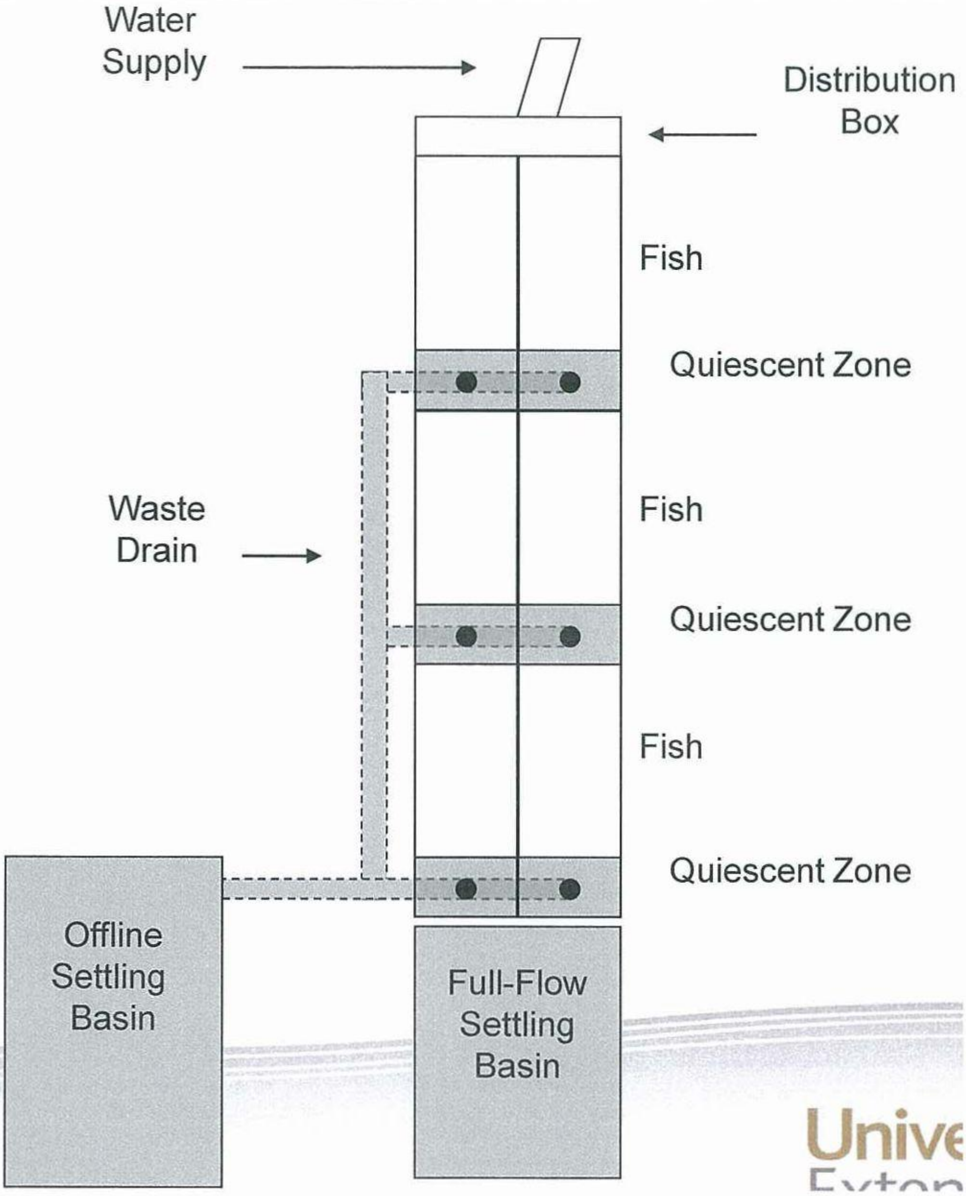
STANDARD METABOLIC RATE (MG OZ CONSUMED PER HOUR)
FOR RAINBOW TROUT
(Compensated for Fish Size and Water Temperature)

Fish Weight (G)	Water Temperature (°C) 1	3	5	7	9	11	13
5	0.6010	0.7138	0.8477	1.0067	1.1955	1.4197	1.6861
10	2.0780	1.2802	1.5203	1.8055	2.1442	2.5464	3.0240
15	1.5171	1.8017	2.1397	2.5410	3.0177	3.5837	4.2559
20	1.9334	2.2961	2.7268	3.1382	3.8457	4.5670	5.4237
25	2.3335	2.7712	3.2910	3.9083	4.6414	5.5120	6.5459
30	2.7211	3.2315	3.8376	4.5575	5.4123	6.4276	7.6442
35	3.0986	3.6798	4.3700	5.1897	6.1632	7.3193	8.6922
40	3.4766	4.1181	4.8906	5.8079	6.8074	8.1912	9.7276
45	3.8296	4.5479	5.4010	6.4141	7.6172	9.0460	10.7428
50	4.1852	4.9702	5.9025	7.0097	8.3246	9.8861	11.7404
55	4.5353	5.3860	6.3962	7.5960	9.0209	10.7130	12.7224
60	4.8803	5.7958	6.8829	8.1740	9.7072	11.5281	13.6904
65	5.2209	6.2003	7.3633	8.7445	10.3847	12.3326	14.6459
70	5.5574	6.5999	7.8378	9.3080	11.0540	13.1257	15.5899
75	5.8902	6.9950	8.3071	9.8654	11.7159	13.9135	16.5233
80	6.2194	7.3860	8.7715	10.4168	12.3708	14.6912	17.4469
85	6.5455	7.7732	9.2313	10.9629	13.0193	15.4614	18.3616
90	6.8685	8.1569	9.6869	11.5039	13.6618	16.2244	19.2677
95	7.1887	8.5372	10.1385	12.0403	14.2988	16.9809	20.1661
100	7.5063	8.9143	10.5865	12.5722	14.9305	17.7311	21.0570
105	7.8214	9.2886	11.0309	13.1000	15.5572	18.4754	21.9409
110	8.1342	9.6600	11.4719	13.6238	16.1793	19.2142	22.8113
115	8.4447	10.0287	11.9099	14.1439	16.7970	19.9477	23.6894
120	8.7531	10.3950	12.3448	14.6604	17.4104	20.6761	24.5545
125	9.0595	10.7589	12.7769	15.1736	18.0198	21.3999	25.4140
130	9.3640	11.1205	13.2064	15.6836	18.6255	22.1192	26.2682
135	9.6666	11.4798	13.6332	16.1904	19.2274	22.8340	27.1171
140	9.9675	11.8372	14.0575	16.6944	19.8259	23.5447	27.9612
145	10.2667	12.1925	14.4795	17.1955	20.4210	24.2515	28.8005
150	10.5643	12.5459	14.8992	17.6939	21.0129	24.9545	29.6353
155	10.8603	12.8974	15.3167	18.1897	21.6017	25.6537	30.4657
160	11.1548	13.2472	15.7320	18.6830	22.1875	26.3493	31.2919
165	11.4479	13.5952	16.1454	19.1739	22.7704	27.0416	32.1140
170	11.7396	13.9416	16.5567	19.6624	23.3506	27.7306	32.9323
175	12.0299	14.2865	16.9662	20.1487	23.9281	28.4165	33.7468

Fish Weight (G)	Water Temperature (°C) 1	3	5	7	9	11	13
180	12.3190	14.6297	17.3739	20.6328	24.5031	29.0992	34.5576
185	12.6068	14.9715	17.7798	21.1149	25.0755	29.7791	35.3650
190	12.8933	15.3118	18.1839	21.5948	25.6455	30.4559	36.1688
195	13.1787	15.6507	18.5864	22.0728	26.2131	31.1300	36.9693
200	13.4629	15.9882	18.9872	22.5488	26.7784	31.8014	37.7666
205	13.7460	16.3245	19.3866	23.0230	27.3416	32.4702	38.5609
210	14.0281	16.6594	19.7843	23.4954	27.9026	33.1364	39.3521
215	14.3091	16.9931	20.1806	23.9960	28.4615	33.8001	40.1403
220	14.5890	17.3256	20.5754	24.4349	29.0183	34.4614	40.9257
225	14.8680	17.6568	20.9688	24.9021	29.5732	35.1204	41.7082
230	15.1460	17.9870	21.3609	25.3677	30.1261	35.7770	42.4880
235	15.4230	18.3159	21.7515	25.8317	30.6770	36.4313	43.2650
240	15.6991	18.6438	22.1410	26.2941	31.2263	37.0836	44.0369
245	15.9743	18.9707	22.5291	26.7551	31.7737	37.7337	44.8117
250	16.2486	19.2965	22.9160	27.2146	32.3193	38.3817	45.5812
255	16.5221	19.6212	23.3017	27.6726	32.8633	39.0277	46.3484
260	16.7947	19.9450	23.6862	28.1292	33.4056	39.6716	47.1132
265	17.0665	20.2677	24.0695	28.5844	33.9461	40.3136	47.8755
270	17.3375	20.5896	24.4517	29.0383	34.4851	40.9537	48.6357
275	17.6077	20.9105	24.8328	29.4909	35.0226	41.5920	49.3938
280	17.8772	21.2305	25.2128	29.9422	35.5586	42.2285	50.1496
285	18.1458	21.5495	25.5917	30.3922	36.0930	42.8631	50.9033
290	18.4138	21.8677	25.9696	30.8409	36.6259	43.4960	51.6549
295	18.6810	22.1851	26.3456	31.2885	37.1575	44.1273	52.4047
300	18.9475	22.5016	26.7223	31.7348	37.6875	44.7568	53.1522
305	19.2133	22.8172	27.0972	32.1800	38.2162	45.3846	53.8978
310	19.4784	23.1321	27.4711	32.6241	38.7436	46.0109	54.6416
315	19.7429	23.4461	27.8441	33.0670	39.2696	46.6356	55.3814
320	20.0067	23.7594	28.2161	33.5089	39.7943	47.2588	56.1235
325	20.2698	24.0719	28.5872	33.9496	40.3177	47.8803	56.8616
330	20.5323	24.3837	28.9575	34.3893	40.8398	48.5004	57.5980
335	20.7942	24.6947	29.3268	34.8279	41.3608	49.1190	58.3327
340	21.0555	25.0050	29.6953	35.2655	41.8804	49.7362	59.0656
345	21.3161	25.3145	30.7021	35.7021	42.3989	50.3519	59.7968
350	21.5762	25.6234	30.4297	36.1376	42.9162	50.9662	60.5263
355	21.8357	25.9316	30.7957	36.5723	43.4324	51.5792	61.2544
360	22.0946	26.2391	31.1609	37.0060	43.9474	52.1908	61.9807
365	22.3530	26.5459	31.5252	37.4387	44.4612	52.8011	62.7054
370	22.6108	26.8520	31.8888	37.8705	44.9740	53.4100	63.4286
375	22.8680	27.1575	32.2516	38.3013	45.4857	54.0177	64.1503

Fish Weight (G)	Water Temperature (°C) 1	3	5	7	9	11	13
380	23.1248	27.4624	32.6137	38.7313	45.9964	54.6242	64.8705
385	23.3810	27.7666	32.9750	39.1604	46.5059	55.2293	65.5891
390	23.6366	28.0702	33.3355	39.5885	47.0144	55.8311	66.3062
395	23.8917	28.3732	33.6953	40.0158	47.5218	56.4358	67.0219
400	24.1464	28.6756	34.0545	40.4423	48.0283	57.0373	67.7362
405	24.4006	28.9775	34.4130	40.8681	48.5340	57.6377	68.4493
410	24.6542	29.2787	34.7707	41.2929	49.0384	58.2368	69.1608
415	24.9073	29.5793	35.1277	41.7169	49.5419	58.8348	69.8709
420	25.1600	29.8794	35.4841	42.1401	50.0446	59.4317	70.5798
425	25.4122	30.1789	35.8398	42.5625	50.5462	60.0275	71.2873
430	25.6640	30.4779	36.1948	42.9842	51.0469	60.6221	71.9935
435	25.9152	30.7763	36.5492	43.4050	51.5467	61.2156	72.6983
440	26.1661	31.0742	36.9030	43.8252	52.0457	61.8082	73.4021
445	26.4164	31.3715	37.2560	44.2444	52.5436	62.3995	74.1043
450	26.6664	31.6684	37.6086	44.6611	53.0408	62.9900	74.8055

Appendix 2 Overview of Raceway System Design



Appendix 3 Reviews and Notes

Major problems encountered during normal routine works.

1. Pond water level changes rapidly in the same day.
2. No control of inlet water.
3. Inlet pipes in ponds are of different radii and flow is omnidirectional
4. Pond banks eroded and falling, maintenance difficult and short-term only
5. Heavy silt deposition in inlet channels
6. Many debris (leaves) in inlet water
7. No easy method for draining ponds
8. Some ponds are impossible to drain.
9. Lack of sludge pond /sedimentation pond
10. Some ponds are too large and have bad water flow resulting in areas in heavy sediment mentation (usually in corners of ponds). See pond G 2 out and G 3out.
11. Oxygen level not controlled
12. Oxygenation system inefficient. Supersaturated water at 15 mg/l O_2 feeds only a few ponds and sometimes also when is not needed, wasting energy and oxygen.
13. Lack of emergency oxygen supply for most of site
14. Water level control system missing both at inlet water and outlet
15. Water turnover different in every pond
16. Difficulty in grading due to lack of dedicated and planned spaces.
17. Outlet screens block easily and have no water control mechanisms
18. Bad use of spaces. i.e. ponds are small so a same batch needs to be split in several ponds (usually split in 1.1 to 1.6) and then they all need to be moved in bigger spaces.

Elena Piana
20/8/2012

ALAN SULLIVAN
PROPOSAL FOR FEASABILTY STUDY IN GOASTBRIDGE TROUT FARM LTD.
29TH NOVEMBER 2012

Introduction:
Recent financial analysis has highlighted high production costs, which will not be sustainable in the long term. It has been asked to propose structural changes, which could help improving production output or vice versa decreasing running costs.
The aim of this report is to explain the need of an in-depth review and assessment of current limiting factors and related production planning in Goatsbridge Trout farm.
The report will propose an analysis process, which will aim at providing a range of **management and capital investment options** for trout production at Goatsbridge Trout Farm LTD.
Should this proposal be accepted, a draft copy would be generated by the end of January 2013 and delivered to an appointed management group. A process of consultation would be undertaken to produce a **one final and defined option report.** Upon its completion, a detailed project management plan will be drawn.
Within the current production scenario at Goatsbridge it is understood that within the terms of reference set out in this report it will be difficult and in some cases impossible to accurately assess said variables due to a dearth of production information relative to the farm's management information archives. It is also been incorporated as essential, with or without the further advancement of this proposal, that key short, medium and long-term monitoring and record keeping should be introduced immediately for both the Goatsbridge and Ballyduff sites.
Historical Background and reasons for this report:
A number of factors have been limiting current production efficiency and expansion of Goatsbridge trout farm Ltd. Owners and management have identified these factors as belonging to **four** main groups:
i) Planning/production management;
ii) Structural and physical parameters;
iii) Water, chemical and environmental;
iv) Sales/product development/diversification;

In order to be able to propose a logical and economically viable range of options, all these 4 areas need to be assessed and defined first. Here is the proposed analysis process:

Analysis process

a) Define current bio-planning strategy and define production achievable:

Bio planning consists in defining and agreeing the ratio of the 3 fish sizes for processing (gutted 350-400g, fillet550-700g and large 1000g+) to be produced at Goatsbridge. This will allow planning and reliably costing: -plan eggs purchase (number and timing); annual production (planning use of pond space well in advance and total annual tonnage) and it will ultimately enable to draw a clear financial model (see table below)

b) Draw different production planning targets. Within this point, it is proposed to look at the following options:

1. Cease production at both farms

2. Do not change current set up and practices substantially

3. Produce between 50 and 100 tonnes

4. Produce between 150 and 200 tonnes
5. Produce between 250 and 300 tonnes
6. Produce 300+ tonnes

Each of these 6 scenarios needs to be assessed by accurately analysing the 4 main groups previously mentioned. Each of this group includes several factors:
i) Planning/management: strategic analysis of carrying capacity and related bio planning (stock rotation and production planning). This will result in: efficient purchase of eggs and timing of fingerling stocking, right amount of fish for harvest at any given time, record keeping of batch in/out resulting in the ability of planning ahead based on performance of previous batch.
ii) Structural and physical parameters: Ponds structure makes harvest long and inefficient. Screen size at outlet of ponds is too small. Impossibility of draining ponds makes cleaning and disinfection a very difficult operation. Impossibility of isolating ponds makes treatments, i.e. formalin, inefficient and Disease risk is high and impossible to control.
iii) Water and chemical and environmental: daily and seasonal fluctuations of water at inlet make planning very difficult and increase the risk of losing stock in some ponds. Factors such as water temperature and rain (turbid water) have a high effect on fish growth, therefore making growth projections difficult. Long-term and accurate recording of feeding percentages, FCR and growth rate will help future production planning. Further to this, pH and ammonia levels need to be considered for stocking planning.
iv) Sales/product development:
There are three main harvest sizes: Gutted (350 gr), Fillet (550 gr) and large (1 Kg plus). Planning of sales of different fish sizes needs to be accurately estimated and assessed. Growing all large will give a very different return from growing 50% large and 50% fillet size and so on. Further to this, considerations for alternative products development strategies, e.g. organic fish, blue trout.... can be looked at.

Appendix 4 Water Quality Test Reports (Samples)

IAS LABORATORIES

Independent Analytical Supplies

Test Report

Lab Report Number:	5924F01	Analysis Number:	99A/60997
Customer ID:	GOAT.T1	Analysis Type:	Misc. Tests (99A)
Contact Name:	ELENA PIANA	Delivery By:	Customer
Company Name:	GOATSBRIDGE TROUT FARM	Sample Card Number:	15OCT/4
Address:	THOMASTOWN KILKENNY	Sample Condition:	Acceptable
Sample Type:	Water	Date Sample Received:	15/10/2012
Sample Reference:	WATER SAMPLES	Date Analysis Commenced:	15/10/2012
Sample Description:	GOATSBRIDGE INLET	Date Certificate Issued:	22/10/2012

Parameter	Method	Result	Unit
Biochemical Oxygen Demand	Oxygen Meter SOP 2006	3	mg/l
Ammonia	Colourimetry SOP 2013	0.12	mg/l NH3
Orthophosphate*	Konelab Aquakem SOP 2061	<0.05	mg/l
pH	Electrometry SOP 2004	7.9	pH units
Total Suspended Solids	Gravimetric/Dry @ 105°C SOP 2016	18	mg/l
Free Ammonia*	Colourimetry SOP 2013	<0.01	mg/l

Signed: W McCall Date: 22/10/12

Wendy McCall - Laboratory Manager

* = not INAB Accredited ^ = Subcontracted

ISO 17025 INAB ACCREDITED TESTING DETAILED IN SCOPE REG NO.275T

IAS LABORATORIES

Independent Analytical Supplies

Test Report

Lab Report Number:	5924F02	Analysis Number:	99A/60998

Customer ID:	GOAT.T1	**Analysis Type:**	Misc. Tests (99A)
Contact Name:	ELENA PIANA	**Delivery By:**	Customer
Company Name:	GOATSBRIDGE TROUT FARM	**Sample Card Number:**	15OCT/4
Address:	THOMASTOWN KILKENNY	**Sample Condition:**	Acceptable
Sample Type:	Water	**Date Sample Received:**	15/10/2012
Sample Reference:	WATER SAMPLES	**Date Analysis Commenced:**	15/10/2012
Sample Description:	GOATSBRIDGE OUTLET	**Date Certificate Issued:**	22/10/2012

Parameter	Method	Result	Unit
Biochemical Oxygen Demand	Oxygen Meter SOP 2006	4	mg/l
Ammonia	Colourimetry SOP 2013	0.01	mg/l NH3
Orthophosphate*	Konelab Aquakem SOP 2061	<0.05	mg/l
pH	Electrometry SOP 2004	7.7	pH units
Total Suspended Solids	Gravimetric/Dry @ 105°C SOP 2016	123	mg/l
Free Ammonia*	Colourimetry SOP 2013	<0.01	mg/l

Signed: W McCall Date: 22/10/12

Wendy McCall - Laboratory Manager

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INAB ISO 17025 ACCREDITED TESTING DETAILED IN SCOPE REG NO.275T

IAS LABORATORIES

Independent Analytical Supplies

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pH	Electrometry SOP 2004	7.9	pH units
Total Suspended Solids	Gravimetric/Dry @ 105°C SOP 2016	18	mg/l
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Signed: W McCall Date: 22/10/12

Wendy McCall - Laboratory Manager

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ISO 17025 INAB ACCREDITED TESTING DETAILED IN SCOPE REG NO.275T

IAS LABORATORIES, Unit 4 Bagenalstown Bus. Park, Bagenalstown, Co. Carlow,
Phone: 00353 59 9721022 Fax: 00353 59 9721897 Email: ias@iaslabs.ie Web: www.iaslabs.ie

Independent Analytical Supplies

IAS LABORATORIES

Test Report

Lab Report Number:	5924F02	Analysis Number:	99A/60998

Customer ID:	GOAT.T1	**Analysis Type:**	Misc. Tests (99A)
Contact Name:	ELENA PIANA	**Delivery By:**	Customer
Company Name:	GOATSBRIDGE TROUT FARM	**Sample Card Number:**	15OCT/4
Address:	THOMASTOWN KILKENNY	**Sample Condition:**	Acceptable
Sample Type:	Water	**Date Sample Received:**	15/10/2012
Sample Reference:	WATER SAMPLES	**Date Analysis Commenced:**	15/10/2012
Sample Description:	GOATSBRIDGE OUTLET	**Date Certificate Issued:**	22/10/2012

Parameter	Method	Result	Unit
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Signed: W McCall Date: 22/10/12

Wendy McCall - Laboratory Manager

*** = not INAB Accredited ^ = Subcontracted**

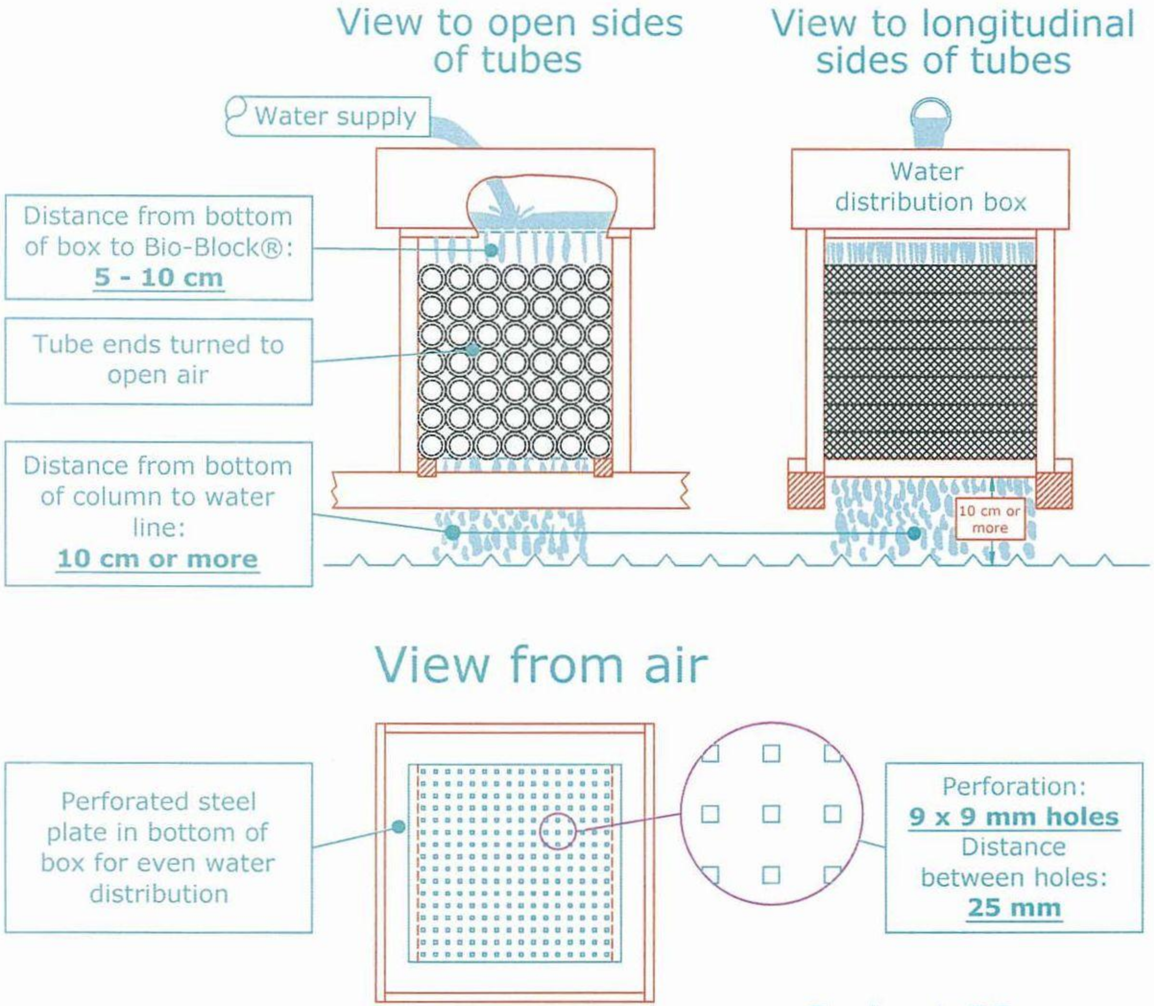
ISO 17025 INAB ACCREDITED TESTING DETAILED IN SCOPE REG NO.275T

IAS LABORATORIES, Unit 4 Bagenalstown Bus. Park, Bagenalstown, Co. Carlow,
Phone: 00353 59 9721022 Fax: 00353 59 9721897 Email: ias@iaslabs.ie Web: www.iaslabs.ie

Appendix 5 Maps and Site Outline

These have been sent separately and will be included in finalised report.

Aeration Column with Bio-Block®



Capacity of column: 15 litres per second

The column is open on all 4 sides in order to:

1. Allow air to come into the tubes

2. Allow gases to escape

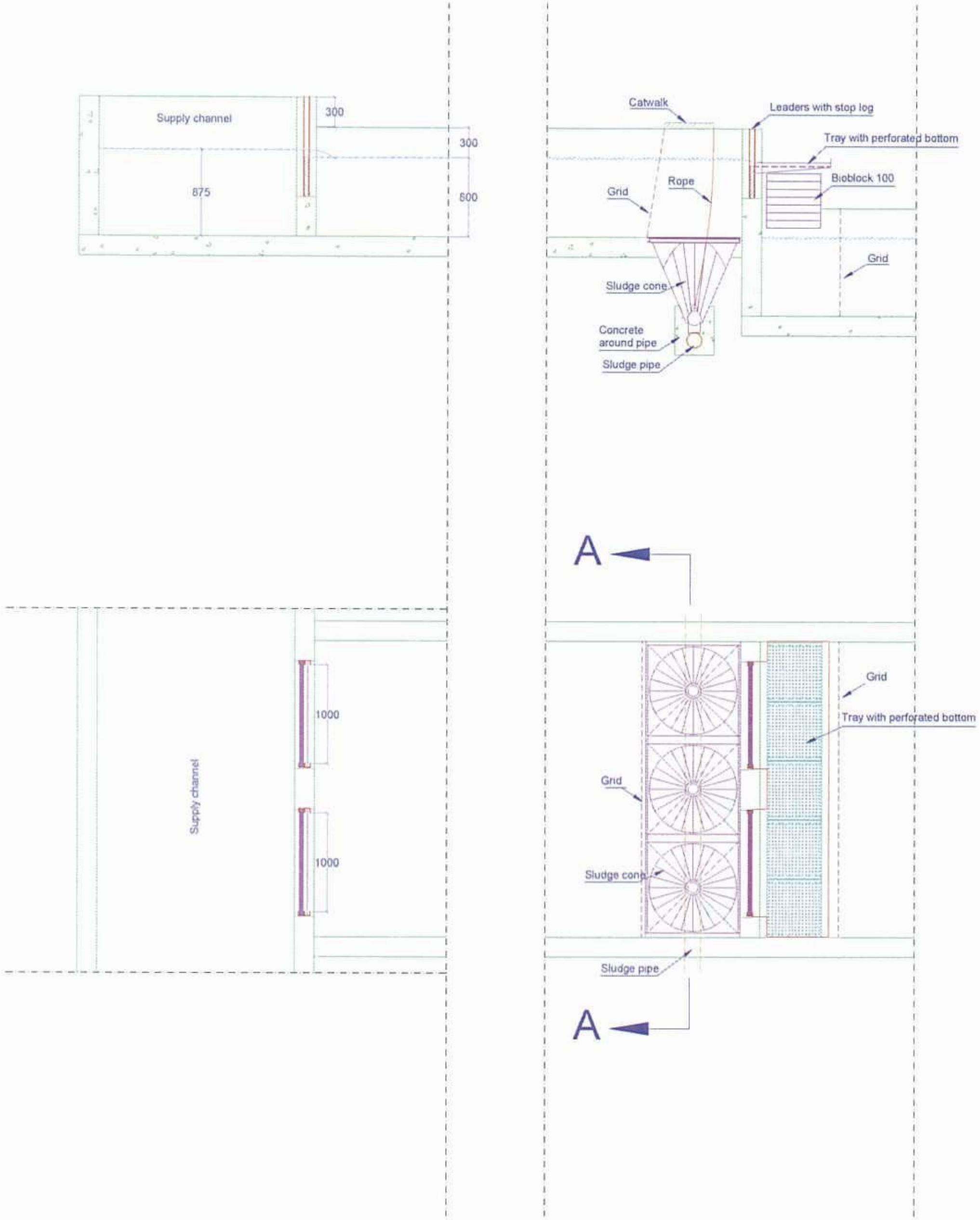
3. Make it possible to pull out the *Bio-Block®* for cleaning

The capacity of one *Bio-Block® 100* is equivalent to 15 litres per second.

The aerator column is **not** suited for water containing much suspended solids or floating weeds.

(The recommended type is *Bio-Block® 100*)

Preben Ikkala - 12/01-2000



Drawing No. 3

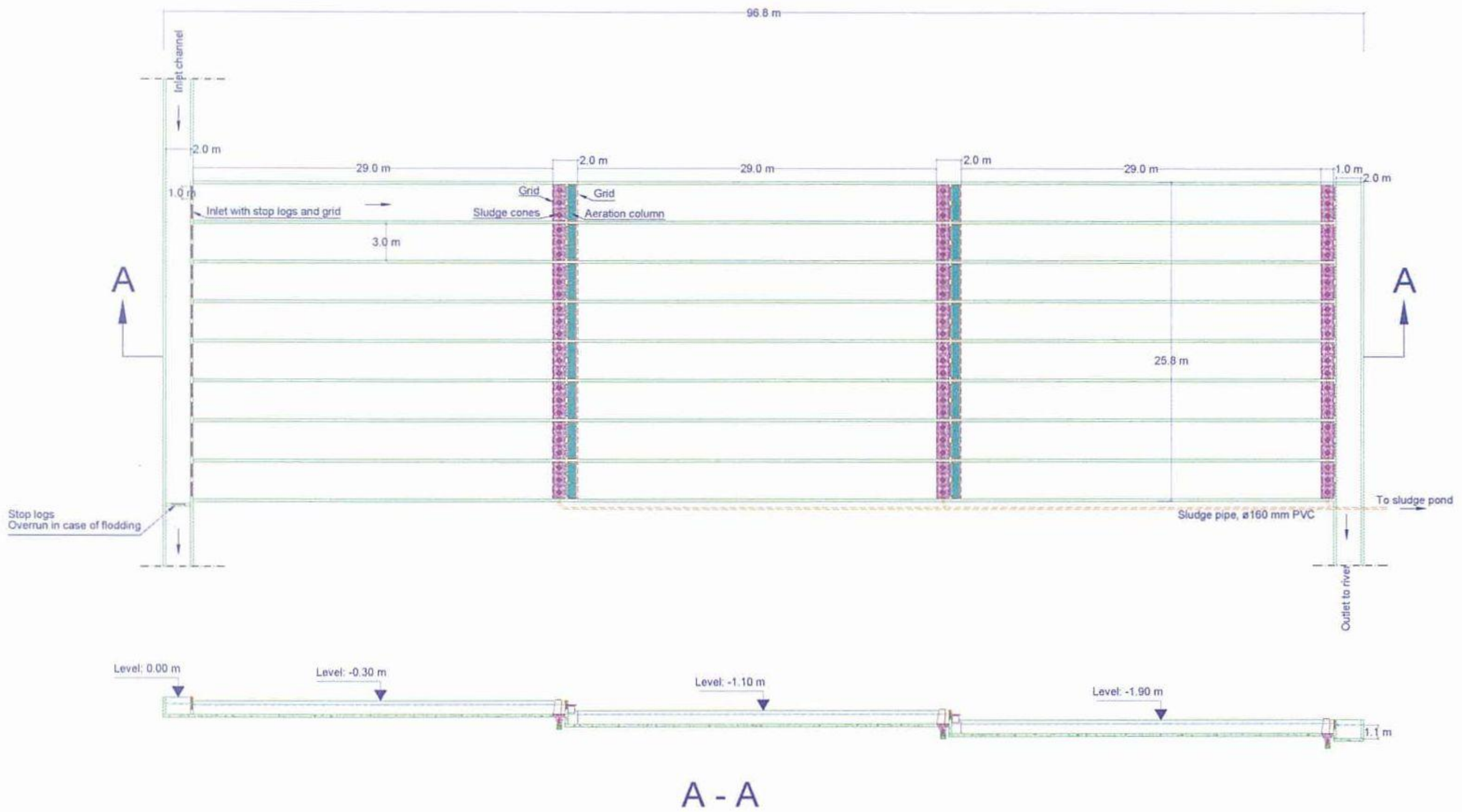
Drawing
Preben Ikkala

Baekvej 8, Farre
DK-7323 Give
Denmark

Project for
Goatbridge Trout Farm

Trout ponds with sludge cones and aeration columns
Details

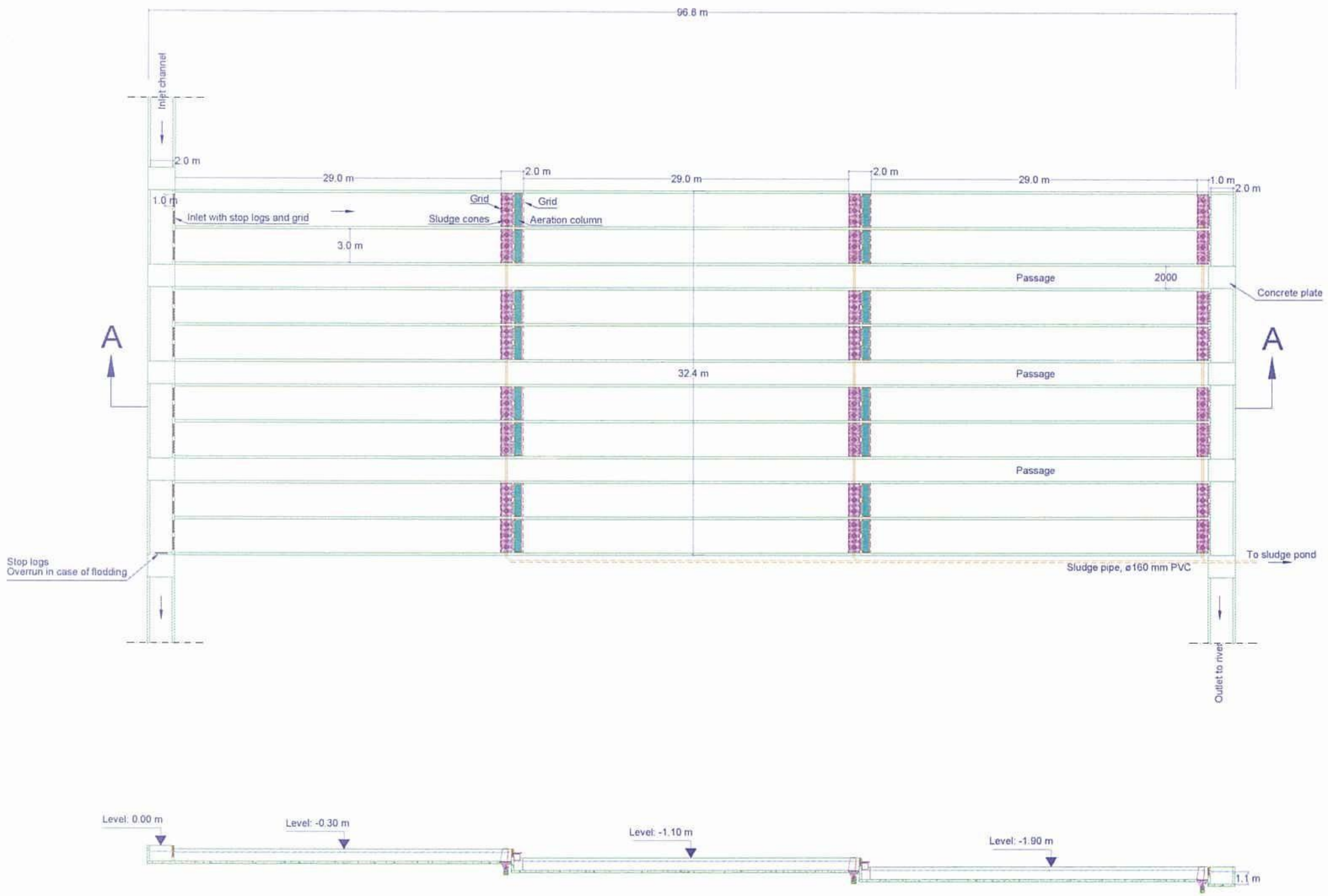
01/04/13



Option with no passage between ponds

Drawing No. 1

Drawing Preben Ikkala	Project for Goatbridge Trout Farm
Baekvej 8, Farre DK-7323 Give Denmark	Trout ponds with sludge cones and aeration columns 01/04/13



Option with passage between ponds

Drawing No. 2

Drawing: Preben Ikkala	Project for Goatbridge Trout Farm
Baekvej 8, Farre DK-7323 Give Denmark	Trout ponds with sludge cones and aeration columns
	01/04/13

TOP OF BANK
GRAVEL TRACK
FISH POND
CHAINLINK FENCE
CONC POST & CHAINLINK FENCE
TOP PIPE 27.64
TOP PIPE 27.06
TOP PIPE 26.95
BED 29.74
BED 29.16
BED 29.27
BED 24.75
BED 25.70
600.000N
750.000N
600.000E
650.000E
700.000E
750.000E

TOP OF BANK
GRAVEL TRACK
FISH POND
CHAINLINK FENCE
CONC POST & CHAINLINK FENCE
800.000N
750.000N
600.000E
650.000E
700.000E
750.000E

FILE COPY

T27/2

AQUACULTURE LICENCE NO.315

GRANTED UNDER THE FISHERIES (AMENDMENT) ACT, 1997 (NO. 23)

AGREEMENT made on 13 March, 2001, between the Minister for the Marine and Natural Resources (hereinafter referred to as the " Minister "), of the one part, and

GOATSBRIDGE TROUT FARMS
GOATSBRIDGE
THOMASTOWN
CO KILKENNY

(hereinafter referred to as the "Licensee") of the other part, whereby the Minister in exercise of the powers conferred on him by the Fisheries (Amendment) Act, 1997 (No. 23) grants an Aquaculture Licence for the culture of Rainbow Trout at a site at Jerpoint Church,(Goatsbridge), Co Kilkenny in accordance with plans approved of by the Minister, subject to the provisions of the Act referred to and to the terms and conditions set out in the Schedule attached.

Subject as aforesaid, this Aquaculture Licence shall remain in force for a maximum of 10 years from 13 March, 2001.

GOATSBRIDGE

SCHEDULE

TERMS AND CONDITIONS TO APPLY TO 10-YEAR AQUACULTURE LICENCE FOR THE CULTURE OF RAINBOW TROUT BY GOATSBRIDGE TROUT FARMS AT JERPOINT CHURCH IN THE BARONY OF KNOCKTOPHER, CO KILKENNY

General

1. Subject to the provisions of the Fisheries (Amendment) Act, 1997 this Licence shall remain in force for a *maximum of ten years* from the date of grant.

2. This Licence is valid only so long as
(a) the layout of the fish farm conforms to the plans submitted to and approved of by the Minister for the Marine and Natural Resources (hereinafter referred to as "the Minister") and

(b) the effluent is discharged in accordance with a Licence granted by Kilkenny County Council or by the Environmental Protection Agency.

3. The Licensee shall comply with such directions in writing as the Minister may issue from time to time for the proper management and control of all fish culture activities at the fish farm, including in particular directions issued in relation to any of the matters referred to in the following paragraphs

4. The Licensee shall indemnify and keep indemnified the State, the Minister, their officers, servants or agents against all actions, loss, claims, damages, costs, expenses or demands arising in any manner whatsoever in connection with the construction, maintenance or use of any structures, apparatus equipment or other thing used in the exercise of the rights granted under this Licence and the Licensee shall take all steps specified in order to ensure compliance with this condition.

5. In the event of neglect or abandonment of the fish farm, the Minister shall take such action as he thinks fit (including disposal of the fish and/or revocation of the Licence) and the Licensee shall be liable to reimburse the Minister the expenses involved in so doing.

6. This Licence is not to be construed as authorising the Licensee in any way to interfere with or infringe the rights of any other person.

7. The Minister shall be at liberty at any time to revoke or amend the Licence if he considers that it is in the public interest to do so, or if he is

satisfied that there has been a breach of any condition specified in the Licence, or in the event of water quality results or general performance at the fish farm not meeting the standards set by the Department of the Marine and Natural Resources. Any such revocation or amendment shall be subject to the provisions of the Fisheries (Amendment) Act, 1997, or any amendment thereto.

Stocking etc., restrictions

8. No fish other than rainbow trout shall be bred and handled at the said fish farm.

9. The maximum standing stock on site during the low flow months of July/August/September shall not exceed 25 tonnes and shall not exceed 50 tonnes at all other times. In the event of extreme low flow these biomass limits may be reduced as directed by the Minister from time to time to ensure that Condition 19 (b) regarding residual flow is adhered to.

10. Such precautions shall be taken as the Minister may specify from time to time, in relation to the introduction of rainbow trout and the ova, fry, and fingerlings thereof for stocking the farm, including disease free certification, and any alteration of methods of operation or type of installation.

11. Live rainbow trout and the ova, fry, or fingerlings thereof shall not be sold or disposed of to any person or in any way transferred outside the said fish farm (except in any case to which Condition 15 refers) save in accordance with the prior written permission of the Minister.

Hygiene and Fish Health

12. The Licensee shall make adequate arrangements for the hygienic operation of the said fish farm (including selection and preparation of food, treatment and disposal of effluent).

13(a) The Licensee shall carry out such water quality monitoring and provide such data relating to such monitoring as may be requested from time to time by the Department of the Marine and Natural Resources.

(b) The Licensee shall comply with the requirements of the current Licence under the Local Government (Water Pollution) Acts issued by Kilkenny County Council dated 27/10/89 or with any subsequent revised Licence pertaining to this fish farm.

(c) Unionised ammonia in the water discharge from the fish farm to Little Arrigle River shall not exceed 0.02mg/l.

14. The Licensee shall comply with any directions which may be issued by the Minister from time to time regarding the fitting of anti-predator netting on fish farm structures so as to prevent predation and the possible introduction of disease by predators.

15. The Licensee shall notify the Department of the Marine and Natural Resources (Coastal Zone Administration Division), Leeson Lane, Dublin 2 and the Fish Pathology Unit, Marine Institute, Abbotstown, Castleknock, Dublin 15, within twenty-four hours of the appearance or suspected appearance of any disease at the said fish farm or abnormal losses or mortalities and shall send samples to the Fish Pathology Unit at the above address in a prescribed manner as and when requested to do so and shall comply with any directions issued by the Department of the Marine and Natural Resources including the treatment, disposal or destruction of stocks of fish at the said fish farm in the interests of safeguarding the stocks of fish in the State.

16. The Licensee shall notify the Department of the Marine and Natural Resources (Coastal Zone Administration Division) and the Fish Pathology Unit, at the above address, within twenty-four hours of any escapes of fish from the fish farm and shall keep records of fish escaped, including numbers, origin, types and year classes and shall make these records available to the Department of the Marine and Natural Resources and Fish Pathology Unit on request.

<u>Special requirements on Fish By-Pass/Water Abstraction</u>

17. The Licensee shall provide and maintain such gratings or other devices at a point as near as possible to the confluence of the fish farm waste channel and the Little Arrigle River as will effectually prevent the admission of migratory fish into the fish farm waste water channels and ponds of the fish farm, and shall make adequate arrangements to ensure the safe passage past the fish farm of migratory fish, and shall make all necessary provisions to prevent the escape of fish from the ponds and water courses of the fish farm.

18. Suitable arrangements shall be adopted by the Licensee to prevent any fish migration into the outlet pipe network from the fish farm.

19(a) A smolt and kelt by-pass arrangement approved by the Department of the Marine and Natural Resources shall be installed and maintained and operated at all times. In the event that the by-pass arrangement does not operate to the satisfaction of the Minister, gratings shall be provided and maintained at the point of water abstraction from the river as will effectually prevent the admission of migratory fish into the fish farm feed channels.

(b) Not more than two thirds of the Little Arrigle River flow shall be abstracted at any time by the Licensee subject, however, to a residual flow of 0.075 m^3/sec being maintained in the Little Arrigle River at all times.

(c) The Licensee shall install, and maintain in proper working order at all times:
(i) a device to measure the flow of water abstracted from the Little Arrigle River into the fish farm, and
(ii) a method to control the flow of water abstracted by the fish farm from the Little Arrigle River, and
(iii) a device to measure the flow of water in the Little Arrigle River adjacent to the fish farm,

as approved by the Department of the Marine and Natural Resources from time to time.

20. The Licensee shall carry out works in the river as directed from time to time by the Minister, to ensure the free and timely passage of fish up the main river channel.

21. The Licensee shall adopt a Fish Farm Management Plan such that the requirements of Condition 13 are met at all times. This Management Plan shall be agreed with the Department of the Marine and Natural Resources and shall be inclusive of the following control options:
    (a) Increased stocking out/cropping out of fish
    (b) Re-aeration
    (c) Re-circulation (subject to suitable water quality standard)
    (d) Reduced feeding
    (e) Improved solid removal facilities at the outfall

22. The Licensee shall make arrangements for the disposal of dead fish in a manner approved of by the Minister and Kilkenny County Council.

Special requirements on chemical usage

23. All animal remedies and chemicals used in the fish farm shall be in accordance with instructions issued by the Minister and/or the Veterinary Surgeon to the fish farm. The Licensee shall keep records of all chemicals and animal remedies used on the fish farm including quantities and times of use. Such information shall be made available on request to the Minister and the Fish Pathology Unit of the Marine Institute.

Inspections, records and returns

24. The Licensee shall keep records of all drugs (including antibiotics), chemicals and disinfectants with which the fish have been treated, including quantities and times of use.

25 (i) The said fish farm and any equipment, structure, thing or premises used in connection with operations carried on at the said fish farm and any smolt and kelt by-pass arrangement approved by the Department of the Marine and Natural Resources and installed by the Licensee* shall be open to inspection at any time by any authorised officer (within the meaning of the Fisheries Acts), or any other person appointed by the Minister.

(ii) The Licensee shall give all reasonable assistance to any such authorised officer or other person appointed by the Minister to enable the officer or person to inspect the said fish farm and any equipment, structure, thing or premises used in connection with operations carried on at the said fish farm and any smolt and kelt by-pass arrangement approved by the Department of Marine and Natural Resources and installed by the Licensee*.

26. Records shall be kept by the Licensee at the said fish farm of all fish stripped, bred, held and handled at the said fish farm and of all sales of fish from it and such records shall be available for inspection at all reasonable times by any inspector appointed for any purpose of the Fisheries Acts.

27. The Licensee shall furnish to the Department of the Marine and Natural Resources (Coastal Zone Administration Division) Leeson Lane, Dublin 2 such returns from the records kept at the said fish farm as may be required from time to time.

*Clause 19 (a) refers.

PRESENT when the Seal of Office of the MINISTER FOR THE MARINE AND NATURAL RESOURCES was affixed and was authenticated by the Signature of:

THOMAS J. TOBIN

A person so authorised under Section 15(1) of the Ministers and Secretaries Act, 1924 to authenticate the seal of the Minister.

WITNESS: Lorraine Hughes

ADDRESS: Dept. Marine & Natural Resources, Leeson Lane, Dublin 2

OCCUPATION: CIVIL SERVANT

SIGNED on behalf of Licensees

Gerard Kirwan

GOATSBRIDGE TROUT FARM

in the presence of:

WITNESS: Mairead Coogan

ADDRESS: Coolmore Knocktopher Co. Kilkenny

OCCUPATION: Secretary