Sure Partners Limited

ARKLOW BANK WIND PARK
PHASE 2
ONSHORE GRID INFRASTRUCTURE

VOLUME III
Chapter 9 APPENDICES

Appendix 9.1h GI Reports - GII Avoca River Park
Phase 1 Environmental Assessment

Appendix 9.1h

Phase 1 Environmental Assessment

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Ground Investigations Ireland

Avoca River Park

FT Squared

Phase I Environmental Assessment

January 2020

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Ground Investigations Ireland Limited | Registered in Ireland Company Regsitration No.: 405726

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DOCUMENT CONTROL SHEET

Project Title	Avoca River Park
Client	FT Squared
Project No	9230-11-19
Document Title	Phase I Environmental Assessment

Rev.	Status	Author(s)	Reviewed By	Approved By	Office of Origin	Issue Date
A	Final	B Sexton	E O'Connor	E O'Connor	Dublin	10th February 2020

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CONTENTS

APPENDICES

1.0 Executive Summary

Following a review of the available data and a site inspection GII present the following risk summary for the subject site. These findings should be considered within the context of the full unabridged report. The findings have been presented in a colour coded system for ease of reference. The colour coding key is as follows:

Colour Key	Definition
🟥	Critical Issues – Resolution or clarification required prior to a legal commitment to transact
🟨	Important Issues – To be considered within or following the proposed transaction and addressed when appropriate
🟩	No Current Issues – No further action is presently considered necessary within the transaction

Colour Key	Phase 1 Summary Status	Risk Status
Environmental Risk	Based on the sites previous historical use as a fertiliser factory, the presence of several closed landfills adjacent to the site and historical groundwater contamination the site is considered as high risk in terms of potential environmental liabilities. Further assessments in terms of subsoil and groundwater quality are recommended.	🟥
Environmental Permitting	The site was previously located within the bounds of an EPA IPPC Licence. The licence boundary was amended in 2012 and the site was removed from the licenced area.	🟨
Site Setting	The site is considered to be located within an area of moderate to high sensitivity with respect to groundwater resources and surface water resources. The site overlies a gravel aquifer which may be vulnerable to impacts from historical site uses and historical groundwater contamination on site.	🟨
Flood Risk	Following a review of the OPW flood databases and previous flood studies compete as part of an Environmental Impact Assessment the site is considered low risk from flooding. This is based on the presence of earth berm flood barrier. An assessment of the construction and stability of the berm is recommended to assess its effectiveness to future high river flow events.	🟨

Radon Risk	The site is located in an area where between 1% and 5% of residential properties are above the reference level of 200 Bq/m3 for radon set by the Radiological Protection Institute of Ireland (RPII); however, no radon protection measures are likely to be required within residential or commercial premises.	🟩

2.0 Preamble

On the instructions of FT Squared, Ground Investigations Ireland Limited (GII) completed a Phase I Environmental Site Assessment (ESA) and general compliance review of a site at Avoca River Park Industrial Estate, Arklow, County Wicklow. The Phase I ESA was conducted consistent with the American Society for Testing and Materials (ASTM) Practice E 1527-05. In addition, this assessment included information that was reasonably available regarding the presence of protected areas, flooding and radon concerns. This ESA did not include an assessment of non-scope considerations, as listed in ASTM designation E 1527-05, such as lead-based paint, mould, biological agents, industrial hygiene, indoor air quality unrelated to releases of hazardous substances or petroleum products into the environment or lead in drinking water.

3.0 Purpose and Scope

The purpose of the ESA was to identify “recognised environmental conditions” associated with the property as defined in ASTM guidance E 1527-05. Recognised environmental conditions include the presence or likely presence of hazardous substances or petroleum products on a property under the conditions of an existing release, past release or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater, or surface water of the property. Recognised environmental conditions also include hazardous substances, even under conditions which are in compliance with environmental laws. The term is not intended to include de-minimis conditions that generally do not present a material risk of harm to public health or the environment and that generally would not be the subject of an enforcement action if brought to the attention of appropriate governmental agencies.

The principal objectives of the assessment were to:

- Assess the operating environmental compliance status of the site and to identify material environmental compliance risks associated with existing and reasonably foreseeable environmental legislation coming into force 12 months from December 2019;
- Assess the site’s status with regard to Best Management Practices (BMP);
- Characterise the environmental setting, surrounding land use, historical land use and related issues concerning the environmental context; and
- Evaluate current and past activities and related practices at the site to establish known or potential sources, impacting material soil, groundwater and/or surface water.

4.0 Methodology

Where practicable the assessment included the four components specified in the ASTM guidance:

1. Records Review;

2. Site Reconnaissance;
3. Interviews; and
4. Report.

Records Review: The assessment comprised a review of all readily available databases to compile all relevant background information on the geological, hydrogeological, hydrological and general environmental conditions. The data sources included the Environmental Protection Agency (EPA), the Geological Survey of Ireland (GSI), Ordnance Survey of Ireland (OSI), National Parks and Wildlife Service (NPWS), the Water Framework Directive (WFD) 'Water Matters' database, the Wicklow County Council On-Line Planning Database, the OPW Flood Maps Viewer, where applicable relevant licencing and monitoring data held by the EPA was also reviewed. Online historical environmental risk assessment and Environmental Impact reports were also reviewed.

Site Reconnaissance: A site assessment/walkover was completed on the 14th November 2019 to assess any potential sources of contamination on site, both current and historic. The assessment was also carried out to identify any off-site potential sources of contamination.

Interviews: GII attempted to identify previous site owners or operatives in order to conduct interviews which might outline:

- Past site uses as well and general housekeeping;
- Handling and storage of hazardous substances;
- Details relating to any spills of hazardous substances on site; and
- Details of environmental incidents on site;

Report: A report below outlines the findings, opinions and conclusions in the Phase I Environmental Site Assessment along with any relevant supporting documentation.

4.1. Limitations, Exceptions and Exclusions of the Assessment

Specific to this Phase I ESA, lack of evidence of the presence of hazardous materials following completion of the tasks of a reasonable and mutually agreed-upon scope of work does not guarantee the absence of such materials; rather, it only indicates that none were found as a result of the services provided. A warranty or guarantee regarding the presence or absence of hazardous materials that could potentially affect the property is not provided. GII has provided reasonable professional judgment of possible hazardous materials issues and has performed the agreed-upon services in accordance with standardised guidelines for conducting Phase I ESAs.

This report is not definitive and should not be assumed to be a complete or specific definition of the conditions above or below grade. Information in this report is not intended to be used as a construction document and should not be used for demolition, renovation, or other construction purposes. GII makes no representation or warranty that the past or current operations at the site are or have been in compliance with all applicable federal, state and local laws, regulations and codes.

This report summarises all results of the Phase I ESA following ASTM E 1527-05 as far as information was supplied or accessible during the due diligence procedure. Regardless of the findings stated in this report, GII is not responsible for consequences or conditions arising from facts that were concealed, withheld or not fully disclosed at the time the evaluation was conducted.

GII has prepared this report for the sole use of FT Squared. No other warranty, express or implied, is made as to the professional advice included in this report or other services provided by GII.

It was not possible to interview former site owners or operatives and as such it was not possible to definitively establish any use for the site not indicated on the historical maps, aerial photograph, the local authority planning record or the below refenced third party reports.

4.2. User Reliance

This document was prepared for the sole use of FT Squared. No other party should rely on the information contained herein without prior written consent of GII and Richmond Homes.

This Phase I Environmental Due Diligence cannot wholly eliminate uncertainty regarding the potential for recognised environmental conditions associated with the property. Performance of the ESA is intended to significantly reduce, but not eliminate, uncertainty regarding the potential for such conditions.

This report does not constitute an appraisal of value or legal opinion, and GII makes no representations or warranties of the fitness of the property for any specific use or value. GII assumes no responsibility for the client's, or a third party's misinterpretation or improper use of this report.

5.0 Site Description

5.1. Site Location & Layout

The site, which is the subject of the Phase I ESA, is located at the Avoca River Park Industrial Estate, approximately 2.5km to the north west of Aughrim, County Wicklow (Figure 1 – Appendix 1). The area of the site is approximately 13.7 hectares. The site is divided by the "Shelton Abbey Canal" which runs from north west to south east across the site.

The northern section of the site is comprised of a large open asphalt paved area. There is a fenced off ESB compound located in the western section of this area. The compound houses various electrical supply infrastructure.

The southern section of the site is comprised of an open asphalt paved area with several industrial buildings located in its western section. The industrial units are in use by Harmony Timber Solutions. Harmony Timber Solutions manufacture various timber products for the construction industry including joists and roof trusses.

The yard surrounding the industrial units, at the time of the inspection, was being used for the storage of various timber products.

The lands to the east of the site are made up of grassed fields which are closed landfills. The site is bounded to the south by an earth embankment/berm with the Avoca River immediately to the south of the embankment.

There was no visual evidence of waste deposited on site or the storage of any hazardous substances. There was no evidence of discoloration of any of the surface material at the time of inspection.

5.2. Site History

GII carried out a review of the on-line database of historical maps held by the (OSI). These included the 6-inch maps that were produced between 1829 and 1842, the 25-inch maps that were produced between 1888 and 1913 and the 6-inch Cassini Maps that were produced between the 1830's and 1930's (Figures 2 to 4). The site is farmland on all historical maps. The Shelton Abbey Canal is present on all historical maps viewed.

GII reviewed the aerial photograph record between 1995 and present day (OSI and Google Imagery). The aerial photographs show the site in industrial use on all available aerial images. The site appears to have been paved in asphalt or concrete since at least 1995. The Harmony Timber buildings are present all aerial images. There are a number of tanks located in the eastern and southern section of the site which appear to have been demolished and removed between 1995 and the present day.

GII also reviewed a 2011 Risk Assessment Report (Appendix 2) for the below summary of the site's history. [1] The site had previously been in the ownership of Irish Fertilizer Industries (IFI). IFI was a joint venture company formed by the state company Nitrigin Eireann Teoranta (NET) and ICI plc, which operated three manufacturing facilities in Cork, Belfast and Arklow. The main products manufactured at Arklow were Calcium Ammonium Nitrate (CAN) and blends. Other nutrients, which complemented the range of fertiliser products were imported and blended as required. Nitric acid was produced mainly as an intermediate, although there was a minor acid sales business. Facility operations required a typical range of services, including water treatment system generation, laboratory activities and storage of raw materials, intermediates, products and ancillary materials.

IFI was granted an IPC license in January 1997. A revised license was issued in March 2000 which approved significant process changes. In 2002 fertiliser manufacturing stopped and in 2005 following the purchase of the site the license was transferred to Holfeld Plastics. Following acquisition by Holfeld the final decommissioning of the fertiliser manufacturing area and general clean up was completed. The former bulk

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[1] OCM, Environmental Risk Assessment, Holfeld Plastics, Former Irish Fertilizer Industries Site, Arklow, County Wicklow, June 2011.

storage sheds were refurbished. Environmental liabilities identified by IFI resulted in the following remedial actions being undertaken.

- Decommissioning and removal of production plant;
- Hazardous waste disposal;
- Refurbishment of bulk storage sheds;
- Removal of asbestos roofing;
- Excavation and removal of diesel oil contaminated soils;
- Excavation and removal of PCB contaminated soils; and
- General clean up, reinstatement and landscaping of the site.

In October 2011 an application was made to the EPA to amend the extent of the licence boundary area. At that stage the boundary was amended to remove the study site from the licenced area. The application was approved by the EPA in 2012 (Appendix 3).

As part of the application process an assessment was completed on the natural attenuation of the groundwater contamination which had been associated with the former production processes on site. The risk assessment concluded that “the environmental risk associate with the Production Area is insignificant”.[2]

Based on a review of the 2011 AER for the Holfeld Plastics site (Appendix 4) the lands immediately to the south east of the site are comprised of closed landfills. Historical landfill operations at the site can be separated into three main categories as follows:

1. Disposal of phosphogypsum wastes from the production of phosphoric acid;
2. Disposal of carbon from the ammonia plant; and
3. Disposal of general plant wastes.

A summary of the waste despotised at these landfills is summarised as follows:[3]

Phosphogypsum Wastes

Phosphogypsum wastes were produced during the manufacture of phosphoric acid. The phosphogypsum pond was constructed by the use of soil bunds around the perimeter of the pond and the natural alluvial clay and peat deposits formed the base of the pond. The phosphogypsum slurry was pumped to the pond where the phosphogypsum was allowed to settle with the water being drained from the pond by a series of drainage pipes through the bund and discharging into the drainage canal running through the landfill area.

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[2] OCM, Environmental Risk Assessment, Holfeld Plastics, Former Irish Fertilizer Industries Site, Arklow, County Wicklow, June 2011 - page 34.

[3] 2011 Annual Environmental Report, Holfeld Plastics Limited, P0031-02.

The gypsum pond was used for approximately 6 years (1967 - 1973) until the capacity was exhausted. At this time phosphogypsum wastes were diverted to the carbon pond which had been constructed by similar means immediately to the south of the phosphogypsum pond. The pond was covered with up to 0.6 metres of shale and topsoil and grassed.

Carbon Wastes

Carbon wastes, produced during the manufacture of ammonia, were diverted in slurry form to the carbon pond that had been constructed in the south-western corner of the landfill area. The carbon pond was constructed in a similar fashion to the phosphogypsum pond with soil embankments and the surface water was disposed of by drainage to the canal and by seepage into the ground. When exhausted the carbon pond was covered with up to 0.6 metres of shale and topsoil and grassed. Additional material made available during construction of the Arklow by-pass has been added bringing the total depth of cover material to 1 to 2 metres.

General Site Wastes

General solid wastes from the Site have been disposed of in two landfill areas immediately to the east of the phosphogypsum and carbon ponds, the Eastern Landfill, North and South. Wastes disposed of in these areas have historically included excavated clay, plastic bags, insulating materials, concrete blocks, bricks, canteen wastes, dredgings from the drainage canals and effluent lagoon. The Northern Section also includes quantities of iron oxide cinder arising from the manufacture of sulphuric acid from local iron pyrite from the Avoca mines during the period 1972 to 1980. The Eastern Landfill areas were constructed with either clay or shale embankments around the perimeters and the base being provided by the natural alluvial clay and peat deposits. The Northern Section was closed and capped with shale and topsoil in 1984, after which time waste disposal activities started in the Southern Section. The western half of the Southern Section was completed in 1994/95 to allow construction of the Arklow by-pass with the Eastern Section in use until May 2001 for disposal of inert Site wastes. Capping work on the Eastern Section was completed in September 2002.

A summary of the volumes of waste deposited at each of the landfill sections are: [4]

1. Phosphogypsum Pond - 55,847 m^3 of gypsum
2. Carbon/Phosphogypsum Pond - 137,801 m^3 of gypsum and approximately 19,080 m3 of carbon black
3. Northern Landfill - approximately 130,000 m^3 of waste
4. Southern Landfill – approximately 59,588 m^3
5. Western Landfill (Phase1) – approximately 2501 m^3

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[4] 2011 Annual Environmental Report, Holfeld Plastics Limited, P0031-02.

5.3. Geology & Hydrogeology

GII obtained information relating to the local and regional geology and hydrogeology as part of the desk study phase. GII reviewed the Geological Survey of Ireland (GSI) geology databases and the Eastern River Basin District (SRBD) Management Plan.

The local subsoil distribution is shown on Figure 5. The site is described in the GSI Quaternary mapping as being Alluvium (A). Based on previous site investigations and subsequent reports the alluvium is underlain by Gravels to a depth of up to 24m.[5] The bedrock underlying the site is the Kilmacrea Formation (Figure 6). The Kilmacrea Formation is comprised of dark grey slate with minor pale sandstone.

The GSI has developed a classification system for aquifers based on the value of the resource and their hydrogeological characteristics. The site is underlain by the Arklow Gravel Aquifer which is classified as a locally important gravel aquifer (Lg). The bedrock aquifer beneath the site (the Kilmacrea Formation) is classified as a Locally Important Bedrock Aquifer (Figure 7) which is moderately productive only in local zones (Ll).

The GSI have developed a system that ranks an aquifer is terms of the intrinsic geological and hydrogeological characteristics that determine the ease with which that aquifer may be contaminated by human activities. The GSI have through this system assigned a “vulnerability” category to each aquifer nationwide. The vulnerability of groundwater depends on:

- The time of travel of infiltrating water (and contaminants);
- The relative quantity of contaminants that can reach the groundwater; and
- The contaminant attenuation capacity of the geological materials through which the water and contaminants infiltrate.

The depth of subsoil and the subsoil type overlying the aquifer are directly linked to the vulnerability. The GSI vulnerability map indicates that aquifer vulnerability at the site is moderate (Figure 8).

The Eastern River Basin District (ERBD) Management Plan identifies that the groundwater body (GWB) beneath the site is part of the Dublin Urban Groundwater Body (IE_EA_10_1611). The GWB Report, which is in Appendix 2, indicates the status of the water body is ‘Good’.
A review of the GSI groundwater well database found no record of any public water supply or drinking water protection zones within 1km of the site. There are no recorded wells located downgradient of the site.

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[5] OCM, Environmental Risk Assessment, Holfeld Plastics, Former Irish Fertilizer Industries Site, Arklow, County Wicklow, June 2011 – page 10.

5.4. Hydrology

The closest surface water feature to the site is the Avoca River which is located adjacent to the southern site boundary. The Shelton Abbey Canal runs though the central section of the site towards the south east and the Avoca River. Surface water runoff from the site enters the canal.

The site lies within the Avoca Lower surface water body (SWB) catchment area (IE_EA_10_1611). The WFD SWB Report is in Appendix 2. The overall status of this waterbody is ‘Good”. The River Body section directly upstream of the site is the Upper Avoca River (IE_EA_10_1477). The GWB report for this section indicates that the status of the water body is Bad. This s related to the closed Avoca Mines acid mines discharge to the River.

5.5. Ecologically Sensitive/Designated Areas

GII completed a review of the National Parks and Wildlife Services (NPWS) databases. A summary of the surrounding protected areas is presented in Table 1 and Figures 9 & 10. There are no protected areas within 5km of the site.

Table 1 Protected Area Summary

Site ID	Type	Site Code	Distance (m)
Wicklow Head	Special Protection Area	004016	20km north east
Cahore Marshes	Special Protection Area	004006	28km south east
Buckroney-Brittas Dunes and Fen	Special Area of Conservation	000729	5.2km north east
Kilpatrick Sandhills	Special Area of Conservation	001742	8.2km south east

5.6. Radon

A review of the EPA national radon map was carried out. The radon map is broken into 10km^2 grids. Each grid is ranked based on the percentage of dwellings within that grid where radon is present at levels greater than 200 Becquerel per metre cubed (Bq/m^3). The radon map has five categories: less than 1 %, 1 to 5 %, 5 to 10 %, 10 to 20 % and greater than 20 %. The subject site is located within a grid where 1 to 5% of the residences will have radon levels greater than 200Bq/m^3, making it relatively low risk for radon (Figure 11).

5.7. Planning Data

GII carried out a review of the Wicklow County Council online planning system. There have been several planning applications and permissions recorded between 1989 and 2019. The most recent application was for the demolition of the existing buildings and construction of three data centre buildings. The planning applications recorded on the Council database are summarised in Table 2. GII reviewed a 2018 EIAR which was prepared by AECOM as part of the 2019 application for a data centre.

Table 2 Planning Applications

Applicant Name	Proposed Works or Change of Use	Decision Date	Decision
Irish Fertilizer Ind Ltd	Welfare facilities building and septic tank	21/07/1989	Decision not listed on records
Irish Fertilizer Ind Ltd	extension to switch and control room	17/12/1991	Decision not listed on records
Power & Energy Holdings (ROI) Ltd	The development of a Simple Cycle Gas Turbine peaking power station on a site of approx 4.25 hectares at the former Irish Fertilisers Industries Ltd site at the Avoca River Park, in the townland of Shelton, Arklow, Co. Wicklow.	09/11/2008	Granted with conditions
Crosbie Transcar Ltd	palisade fencing to site boundaries and the retention of 3 no buildings (port cabins) together with all associated site works	25/03/2009	Granted with conditions
Restwing Trading Ltd	change of use of existing industrial unit to plastic waste recycling facility	30/06/2015	Granted with conditions
Edmund Holfeld	extend the appropriate period of a permission - 08/468 - Simple Cycle Gas Turbine peaking power station on a site of approx 4.25 hectares at the former Irish Fertilisers Industries Ltd site at the Avoca River Park, in the townland of Shelton, Arklow, Co.	18/07/2018	Extension Granted
Crag Digital Avoca Ltd	demolition of buildings & structures on site & construction of Data Storage Facility comprising 3 data storage buildings & all associated site infrastructure: data storage facility 1 (6 Pod Data Centre) located to north of site served by 1 gas generator compo	20/02/2019	Granted with conditions

5.8. Flood Risk

The Office of Public Works (OPW) has produced flood risk maps that identify areas that may be susceptible to flooding during extreme events. The draft flood maps are predictive flood maps, as they provide predicted flood extent and other information for a design flood event that has an estimated probability of occurrence rather than information of floods that have occurred in the past. The maps identify the risk from fluvial and coastal flooding. The OPW rates risk in terms of %. These percentages are linked to return events or chance of occurrence in any given year:

- 10% - 1 in 10 chance in any given year;
- 1% - 1 in 100 chance in any given year; and
- 0.1% - 1 in 1,000 chance in any given year.

They are also commonly referred to in terms of a return period (e.g., the 100-year flood event), although it should be understood that this does not mean the length of time that will elapse between two such events occurring, as, although unlikely, two or more very severe events may occur within a very short space of time. GII reviewed these maps and it appears from the maps that the site is not at risk from flooding, this is likely due to the presence of a berm between the site and the Avoca River. The lands to the south east of the site which are comprised of the landfill sections appear to lie within an area at risk from both fluvial and coastal flooding.

The 2018 Aecom EIAR included a site-specific flood risk assessment. The report concluded that “the site is protected from flooding by the existing flood defense embankment up to an including the 0.1AEP event (1,000 year)”.[6]

The report as part of flood mitigation recommends a that the embankment is regularly inspected and maintained. The report does not include an assessment of the current condition or structural integrity of the embankment. GII did not encounter documentation in relation to the construction of the berm which is acting as a flood barrier for the site. GII did not encounter any report in relation to the stability of the berm.

5.9. Phosphogypsum Wastes

Landfilling of phosphogypsum waste occurred on the wider fertilizer site between 1967 and 1973 in the gypsum ponds until the pond’s capacity was exhausted. Further landfilling of the phosphogypsum waste was continued at the carbon pond. The cessation date for landfilling of phosphogypsum waste is not known. In this case the phosphogypsum was a by-product of the manufacture of phosphoric acid. Phosphogypsum contains naturally occurring radioactive material (NORM) in the form of uranium and thorium and their associated daughter products. GII have not found any record of any radioactivity survey completed at the site or any assessment of the potentially radioactivity of the material landfilled on site. The areas of landfilling are not located within the study site but is located within the lands immediately adjacent and to

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[6] Avoca River Park, Environmental Impact Assessment Report, Volume 1: Non-technical Summary, August 2018.

the east of the site. The areas where the phosphogypsum material has been landfilled are presented in Figure 13.[7]

6.0 Risk Assessment

This assessment has been undertaken using a risk-based approach, with the potential environmental risk assessed qualitatively using the ‘source-pathway-receptor’ scenario. In consideration of the information gathered an overall risk rating has been provided for the site based on the following definitions:

Low Risk

The site is considered suitable for the ongoing commercial use and environmental setting. It is unlikely that any issues will arise as a liability/cost for the freehold owner of the site and/or impact the value or future saleability of the asset.

Medium Risk

The site may not be suitable for present/proposed use and environmental setting. Contaminants may be present and could have an unacceptable impact on the identified receptors. It is possible that the issue(s) could arise as a liability/cost for the freehold owner of the site. Further work is usually required to clarify the risk.

High Risk

The site is not suitable for the ongoing commercial use and environmental setting. Contaminants are probably or certainly present and are very likely to have an unacceptable impact on the identified receptors. It is likely that the issue(s) will arise as a liability/cost for the freehold owner of the site. Further work is urgently needed.

6.1. Environmental Risk

The phase 1 assessment has indicated that in terms of the transaction there is high environmental liability risk associated with the sites previous historical use as a fertiliser factory and the presence of several closed landfills adjacent to the site. This is due to the potential for subsoil and groundwater contamination. The site has been the subject of a natural attenuation remediation process to deal with groundwater contamination.

There is a risk associated with the fact that site was previously within the boundary of the EPA IPPC licence. The licence boundary was amended in 2012 and the site was removed from the licenced area.

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[7] As adopted from the Byrne Looby Report PH McCarthy Report - Irish Water & Wicklow County Council Arklow Wastewater Treatment Plant Site Assessment Report – Phase 2, May 2015

The site is considered to be located within an area of moderate to high sensitivity with respect to groundwater resources and surface water resources. The site overlies a gravel aquifer which may be vulnerable to impacts from historical site uses and historical groundwater contamination on site.

There is a risk of radioactive material buried on site associated with Phosphogypsum waste which was produced as part of the historical use of the site. It is unknown if any of this waste was buried within the site boundary.

Following a review of the OPW flood databases the site is considered low risk from flooding. This is based on the presence of earth berm flood barrier. An assessment of the construction and stability of the berm is recommended to assess its effectiveness to future high river flow events.

6.1. Recommendations

It is recommended that an intrusive site investigation be undertaken to assess and quantify any future environmental liabilities associated with the site.

The investigation should include an assessment of subsoils quality, the potential presence of buried waste, groundwater quality and surface water quality of the canal.

A geotechnical assessment should be completed on the berm which is acting as a flood barrier between the site and the Avoca River. The assessment should address the construction and stability of the berm in terms of past and projected flood events.

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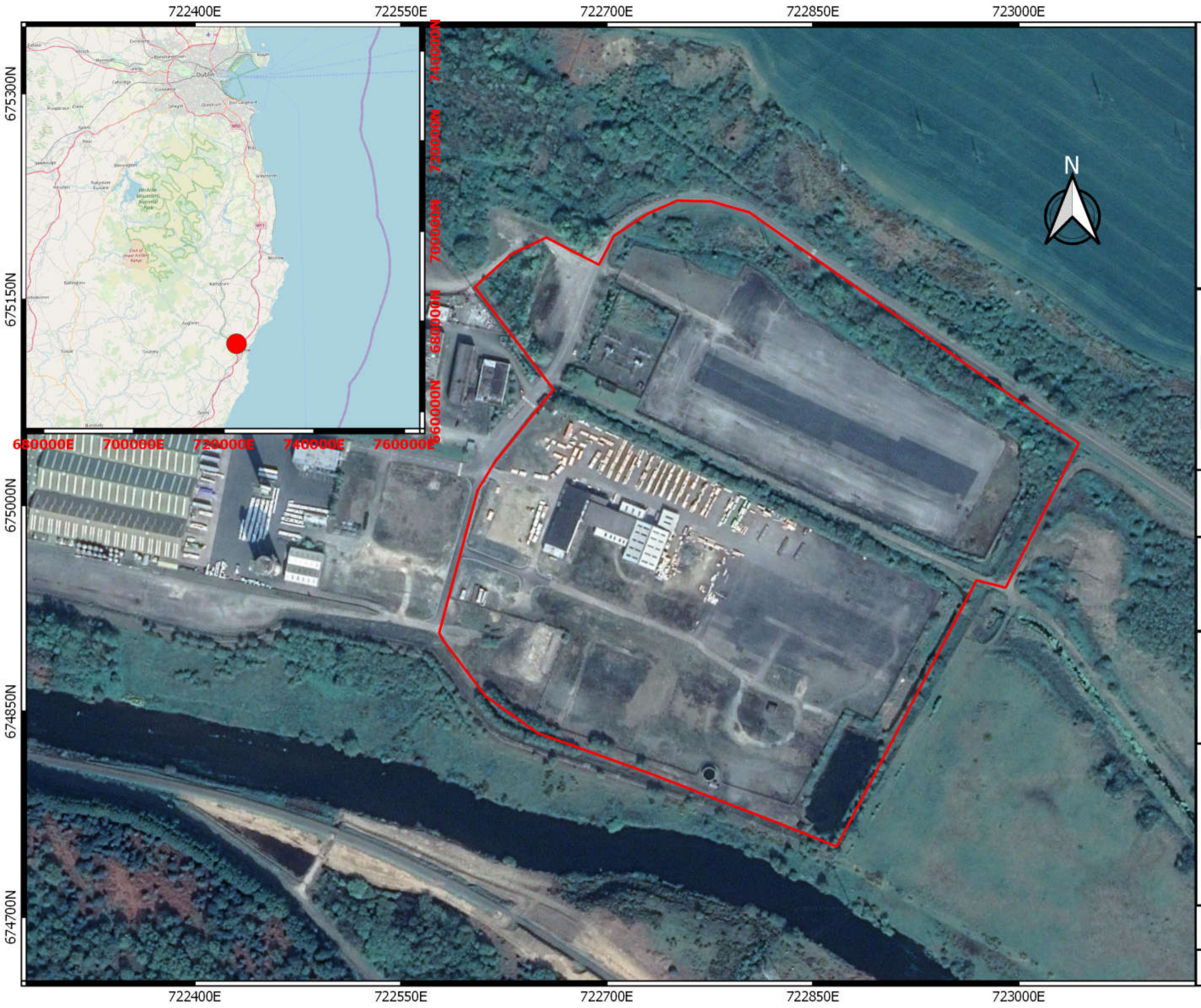
APPENDIX 1 –Figures



● Site Location

▭ Indicative Site Boundary

Client:

FTSQUARED

FT2

Project Code:

9230-11-19

Project Title:

Avoca River Park

Drawing Title:

Figure 1 Site Location

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0 30 60 90 120 150 m

Drawn By:	Date:
BS	20/11/2019

● Site Location

Client:

FTSQUARED
FT2

Project Code:

9230-11-19

Project Title:

Avoca River Park

Drawing Title:

Figure 2 OSI 6-Inch Map

GROUND INVESTIGATIONS IRELAND
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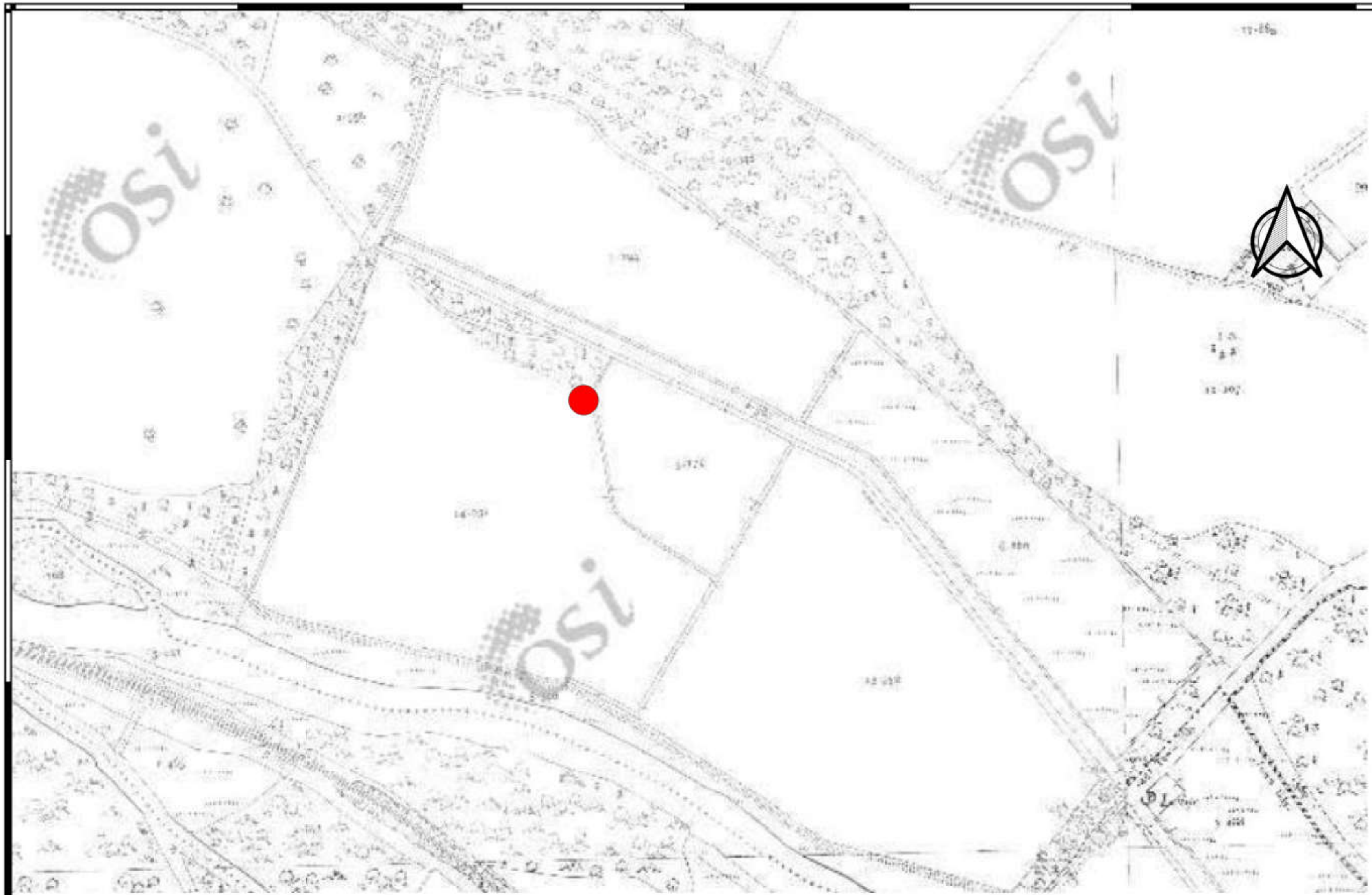
Drawn By: BS	Date: 23-01-2020



● Site Location

Client:

FTSQUARED

Project Code:

9230-11-19

Project Title:

Avoca River Park

Drawing Title:

Figure 3 OSI 25-Inch Map

GROUND INVESTIGATIONS IRELAND
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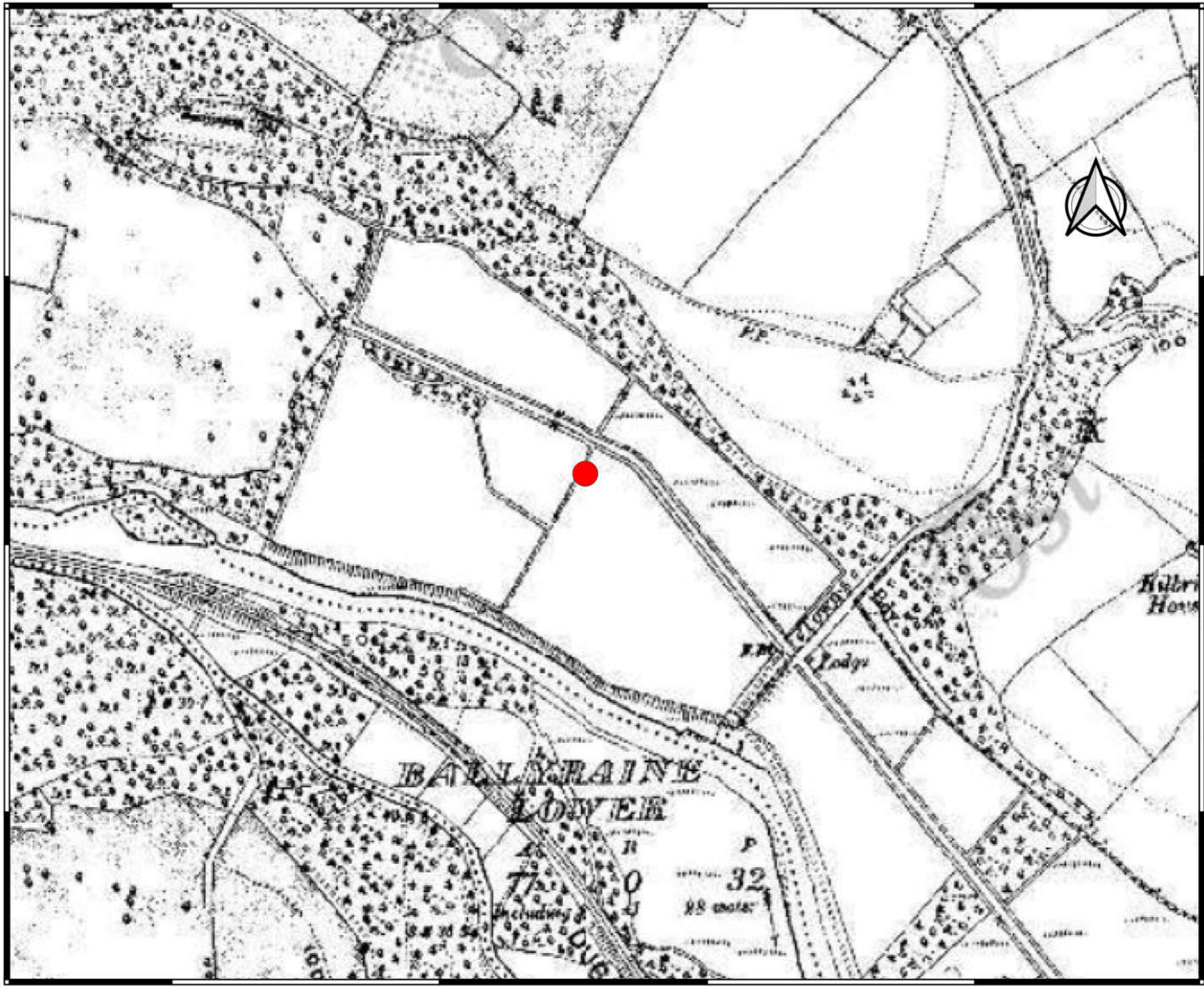
Drawn By:	Date:
BS	23-01-2020



● Site Location

Client:

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Project Code:

9230-11-19

Project Title:

Avoca River Park

Drawing Title:

Figure 4 OSI Cassini Map

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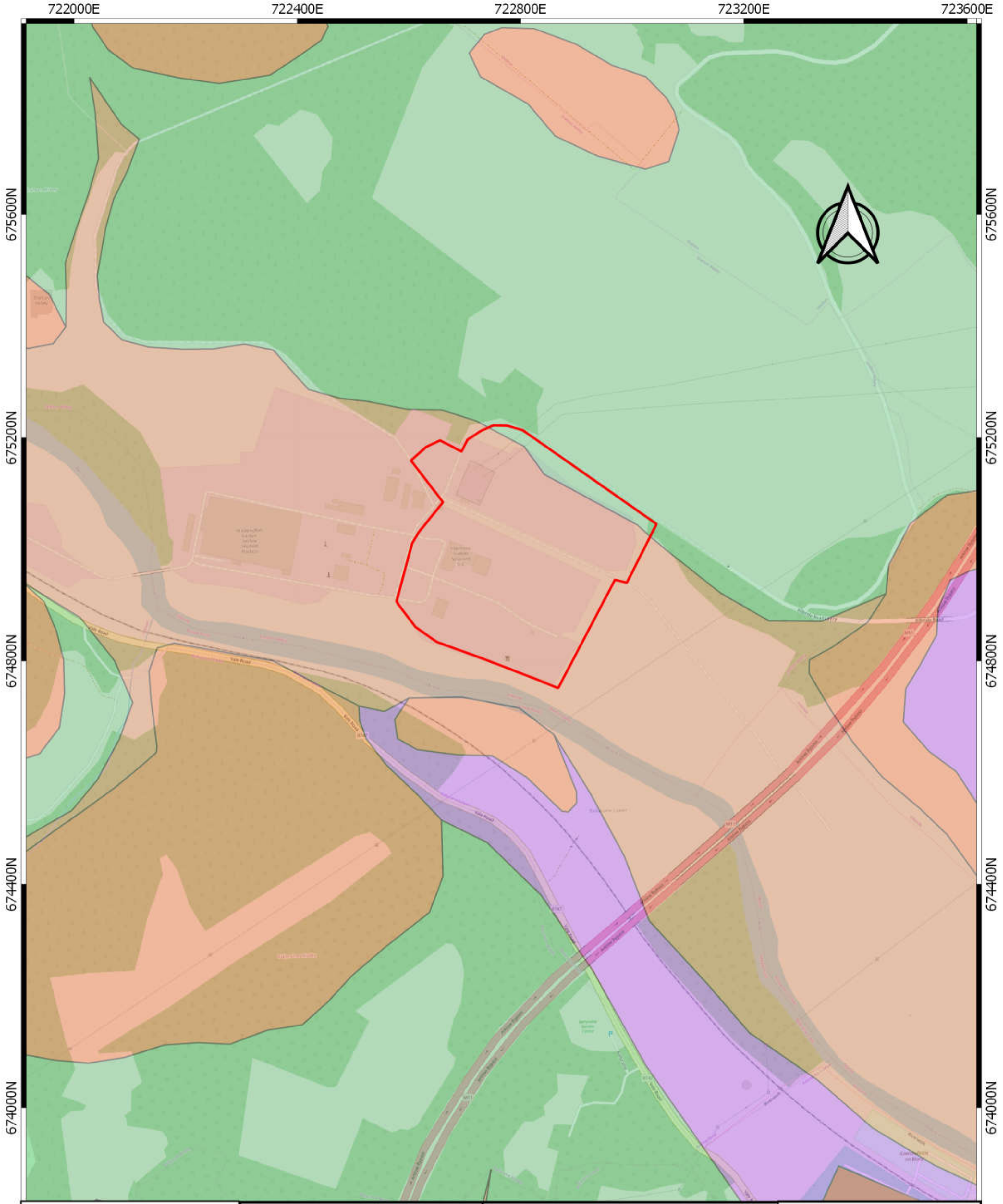

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0 100 200 300 m

Project Title:
Avoca River Park

Drawing Title:
Figure 5 Quaternary Geology

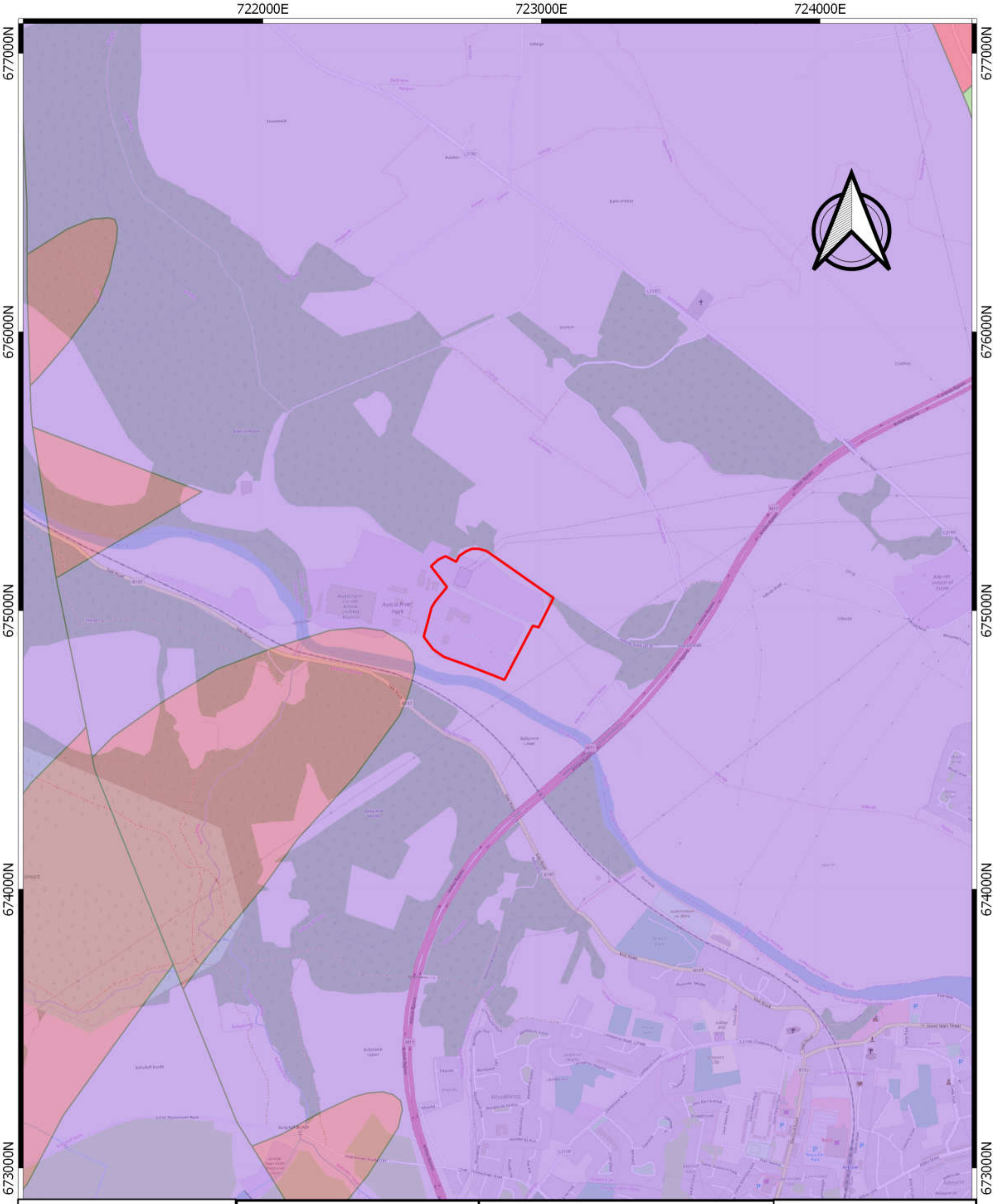
GII Project Reference:
9230-11-19

Drawn By:
BS

Date:
20/11/2019

▭ Site Boundary

Subsoil Type
🟫 A
🟪 IrSTLPSsS
🟧 Rck
🟩 TLPSsS
🟥 Urban



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FT2

0 200 400 600 m

Project Title:
Avoca River Park

Drawing Title:
Figure 6 Bedrock Geology

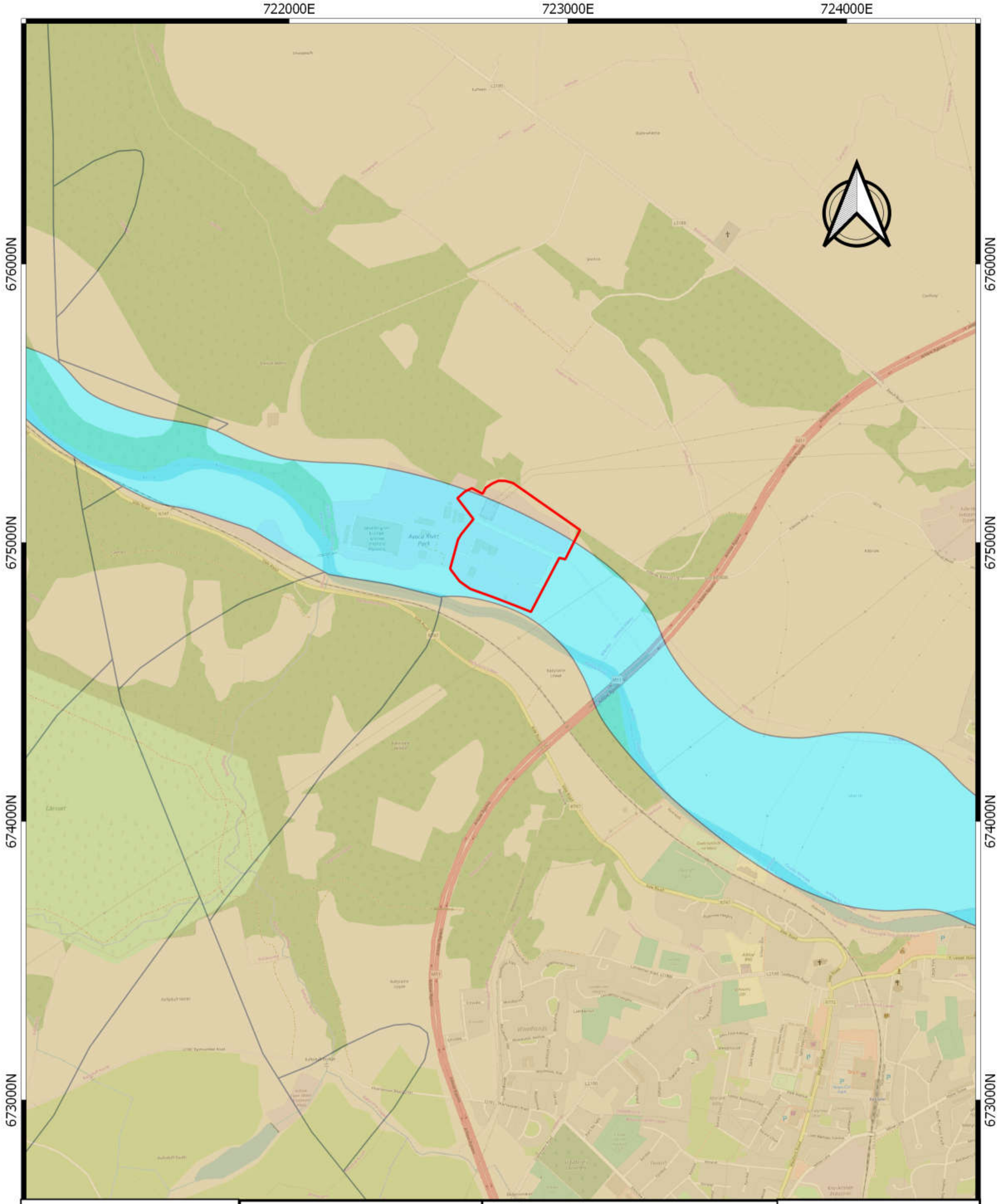
GII Project Reference:
9230-11-19

Drawn By:
BS

Date:
21/11/2019

☐ Site Boundary

Bedrock Geology
- 🟥 Ballymoyle Fm
- 🟩 in Ballymoyle Fm
- 🟪 Kilmacrea Fm
- 🟪 Oaklands Fm



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FT2

0 200 400 600 m

Project Title:
Avoca River Park

Drawing Title:
Figure 7 Aquifer Category

GII Project Reference:
9230-11-19

Drawn By:
BS

Date:
21/11/2019

▭ Site Boundary

Bedrock Aquifer
🟫 LI

Sand/Gravel Aquifer
🟦 Lg

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Client:

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FT2

0 200 400 600 m

Project Title:
Avoca River Park

Drawing Title:
Figure 8 Aquifer Vulnerability

GII Project Reference:
9230-11-19

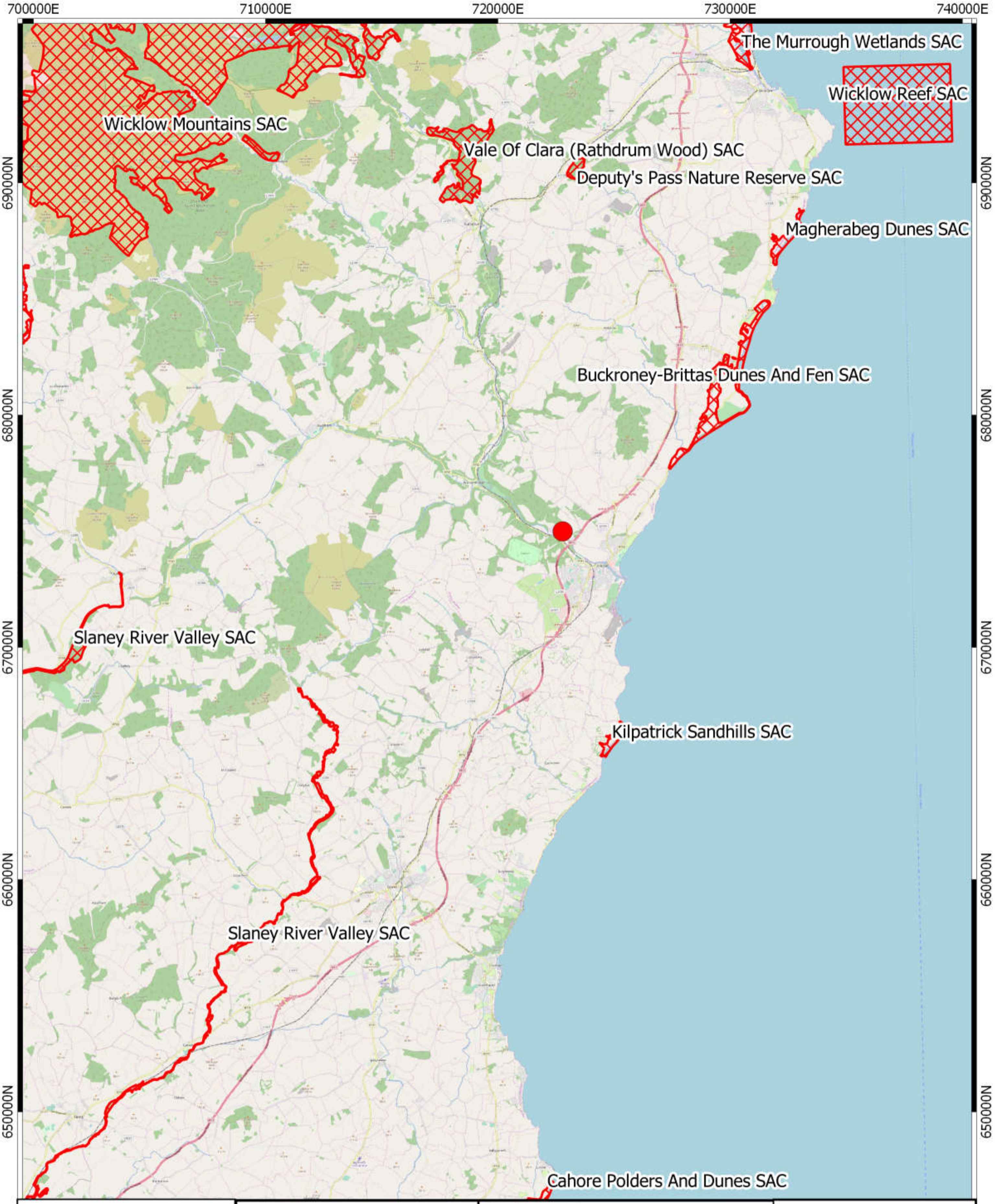
Drawn By:
BS

Date:
21/11/2019

☐ Indicative Site Boundary

Vulnerability

🟥	E
🟧	H
🟩	L
🟨	M
🟥	X



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Client:

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0 2.5 5 7.5 km

Project Title:
Avoca River Park

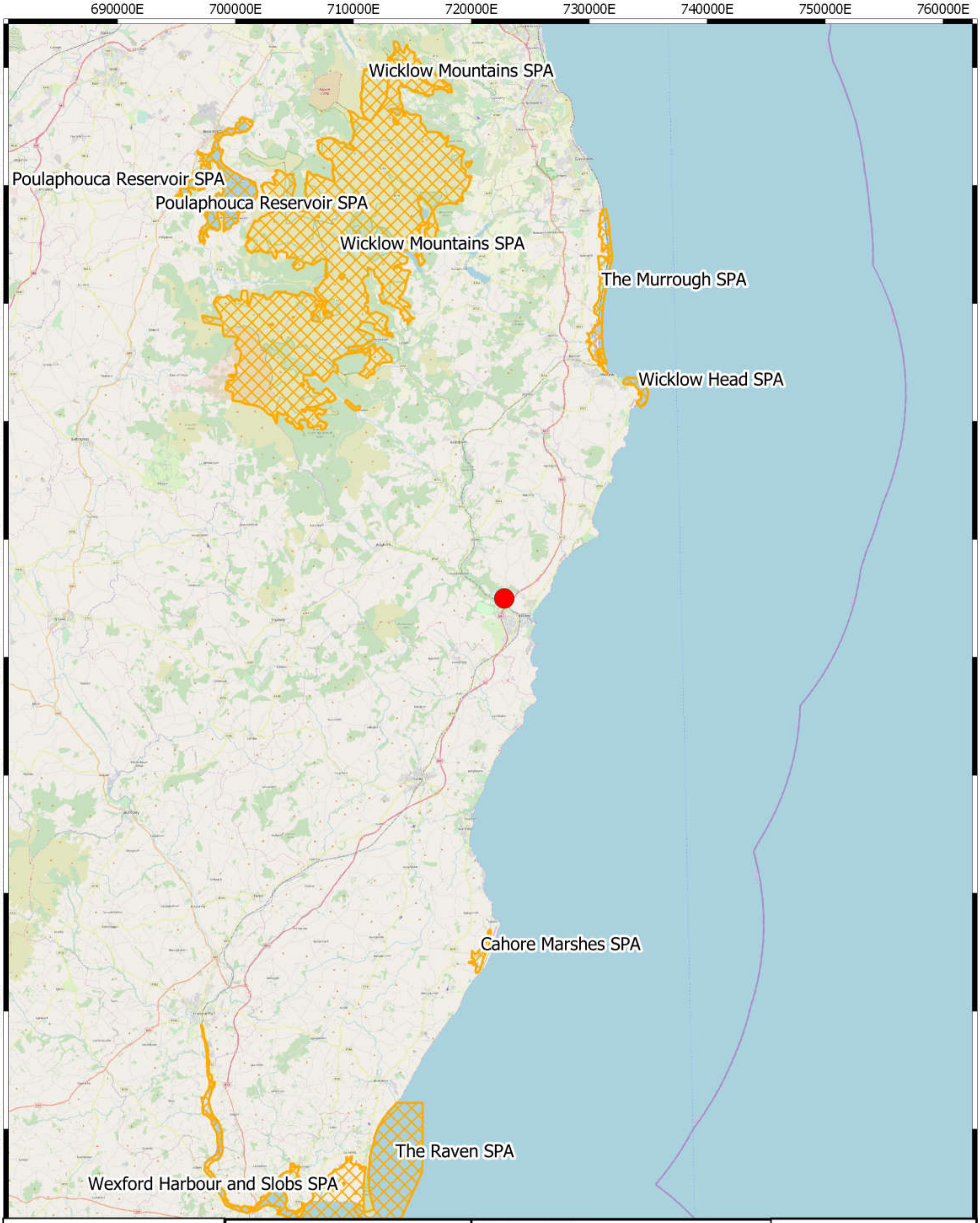
Drawing Title:
Figure 9 Special Area of Conservation

GII Project Reference:
9230-11-19

Drawn By:
BS

Date:
21/11/2019

● Site Location
▨ SAC



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Client:

FTSQUARED
FT²

0 1000 2000 3000 4000 m

Project Title:
Avoca River Park

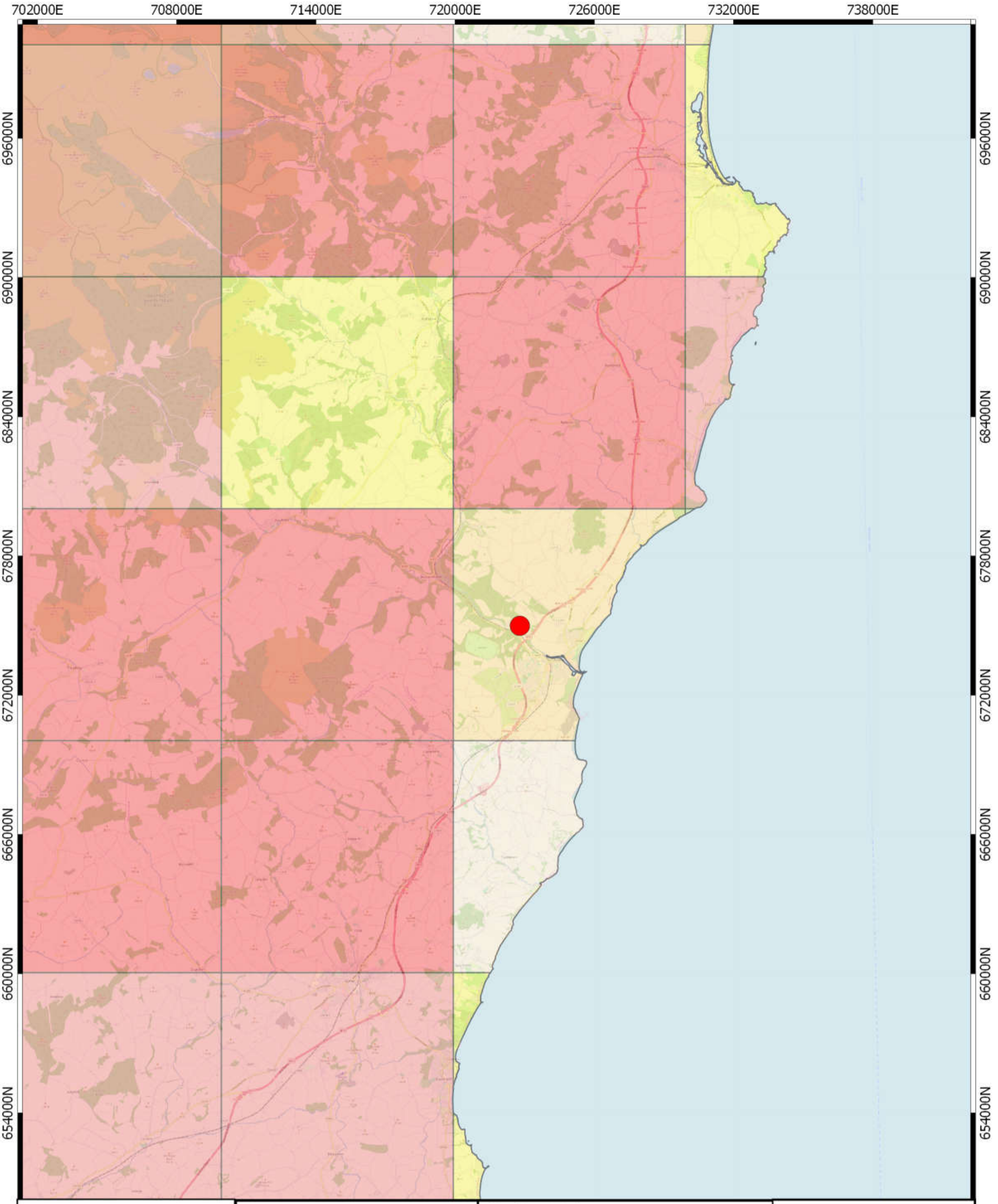
Drawing Title:
Figure 10 Special Protected

GII Project Reference:
9230-11-19

Drawn By:
BS

Date:
21/11/2019

● Site Location
▨ SPA



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0 2.5 5 7.5 km

Project Title:
Avoca River Park

Drawing Title:
Figure 11 Radon

GII Project Reference:
9230-11-19

Drawn By:
BS

Date:
21/11/2019

● Site Location

Radon

- ⬜ <1%
- 🟧 1% - 5%
- 🟨 5% - 10%
- 🟪 10% - 20%
- 🟥 >20%

🟥 Indicative Site Boundary

▭ EPA Licence Boundary

Client:

FTSQUARED

FT2

Project Code:

9230-11-19

Project Title:

Avoca River Park

Drawing Title:

Figure 12 EPA Licence Boundary

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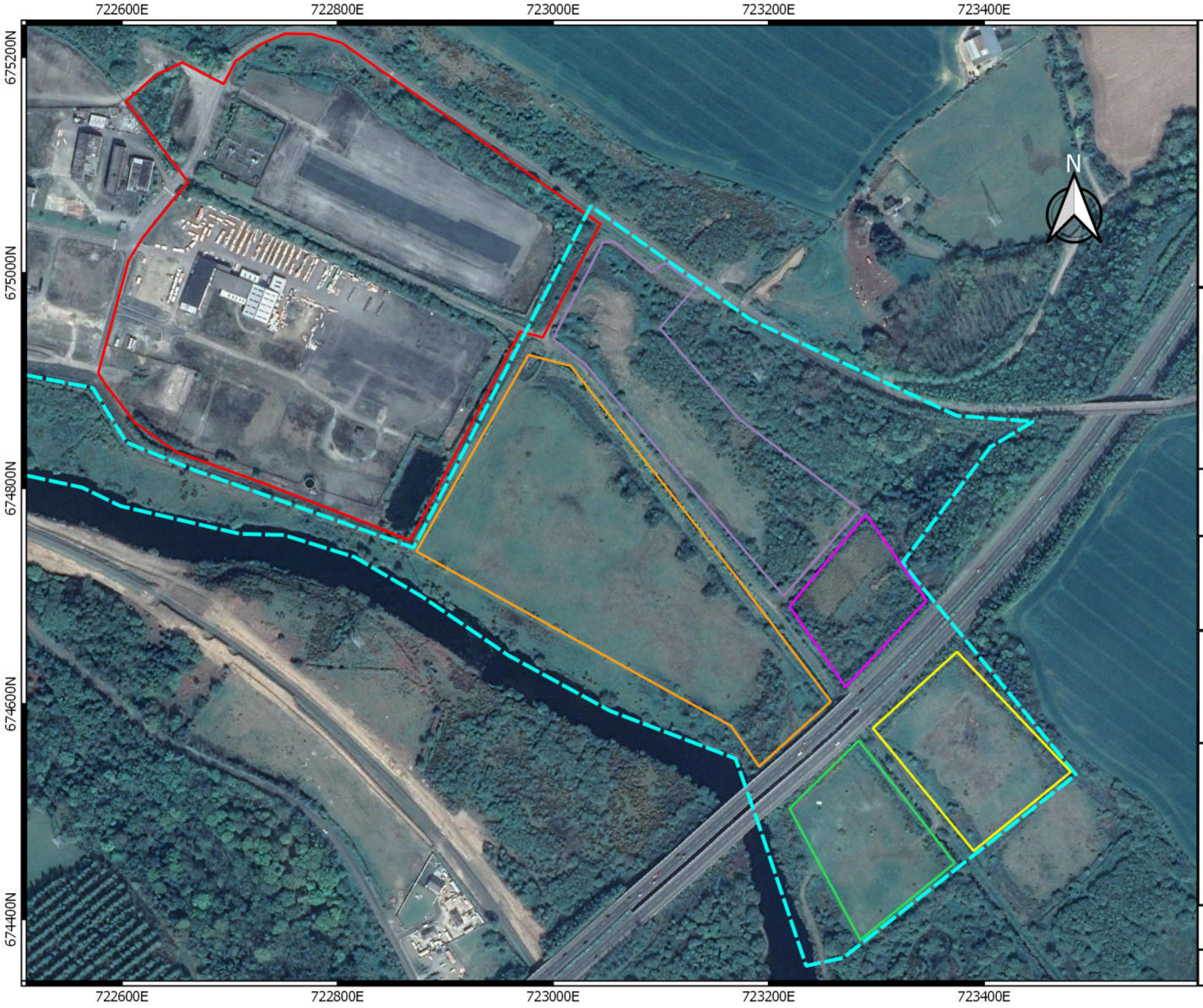
Drawn By:	Date:
BS	20/11/2019



🟥 Indicative Site Boundary

🟦 EPA Licence Boundary

🟪 Phosphogypsum Pond

🟧 Carbon Black Phosphogypsum Pond

🟨 Eastern Landfill North

🟩 Eastern Landfill South

🟪 Western Landfill

Client:

FTSQUARED

FT2

Project Code:

9230-11-19

Project Title:

Avoca River Park
Ground Investigation

Drawing Title:

Figure13 Historical Landfill Cells

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0 50 100 150 m

Drawn By:
BS

Date:
19-01-2020

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D22 YD52

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APPENDIX 2 – Previous Environmental Risk Assessment

PM
GROUP

ATTACHMENT 2

OMC ENVIRONMENTAL RISK ASSESSMENT

Granary House
Rutland Street
Cork

environmental management for business

Tel. (021) 4321521
Fax. (021) 4321522

ENVIRONMENTAL RISK ASSESSMENT

HOLFELD PLASTICS LIMITED

FORMER IRISH FERTILIZER INDUSTRIES SITE

ARKLOW

COUNTY WICKLOW

Prepared For: -

PM Group
Killakee House,
Belgard Square,
Tallaght,
Dublin 24

Prepared By: -

O' Callaghan Moran & Associates,
Granary House,
Rutland Street,
Cork

June 2011

email. info@ocallaghanmoran.com Website: www.ocallaghanmoran.com

O'Callaghan Moran & Associates. Registration No. 8272844U

TABLE OF CONTENTS

PAGE

1. INTRODUCTION

Irish Fertilisers Industries (IFI) operated its fertiliser manufacturing facility in Arklow County Wicklow under an Integrated Pollution and Control (IPC) License (Register No. 31) by the Environmental Protection Agency (Agency). In 2002, fertiliser manufacture stopped and in October 2005 the Licence was transferred to Holfeld Plastics Ltd (Holfeld).

Although fertiliser production ended in 2002, the environmental monitoring programme at the former fertiliser Production Area and adjacent Landfill Areas continued due to the presence of groundwater contamination beneath both areas. This was initially identified during site investigations undertaken in 1994 and subsequent investigations in 1997.

In 2004, Project Management Group (PM) completed an Environmental Risk Assessment that included groundwater modelling to predict long term levels of contaminants in groundwater beneath the former production area. An updated assessment was prepared in 2007, which tracked the progress of the monitored natural attenuation that had occurred.

Based on the reduction in the contaminant levels in the groundwater beneath the production area in line with the predictions of the groundwater modelling completed in 2004 and 2007, Holfeld intends to apply to the Agency to amend the IPPC Licence area to exclude the Production Area. The revised Licence area is shown on Figure 1.1

The Agency has indicated that an application for the revision of the License should include an assessment by an experienced hydrogeologist of the monitored natural attenuation programme from 2007 to date, which should be based on the updated groundwater model (2007) and the Water Framework Directive. The objective is to demonstrate that the groundwater beneath the former production area does not present an environmental or health risk.

PM requested O'Callaghan Moran & Associates (OCM) to undertake the environmental assessment and this report presents the findings. It is based on information on the site history and operations provide by Holfeld Plastics, a review of the reports on the previous site investigations and risk assessments and a site inspection carried out on the 23rd of May 2011.

1.1. Report Contents

Section 2 describes the site layout, site history and the geology and hydrogeology. Section 3 presents a Conceptual Site Model. Section 4 presents an updated risk assessment based on a the groundwater data collected between 2007 and 2011 and surface water monitoring data from the Avoca River collected by OCM in 2011. Section 5 sets out the conclusions and recommendations.

NOTES

LEGEND

▬ · ▬ REVISED BOUNDARY OF HOLFELD PLASTICS LTD

A	FOR INFORMATION					
ISSUE	DESCRIPTION	DRN	CHKD	AUTH	APP	DATE

CLIENT HOLFELD PLASTICS LTD

PM GROUP

PROJECT EPA SUBMISSION

TITLE REVISED IPPC SITE BOUNDARY FOR
HOLFELD PLASTIC LTD.

0 20m 100m

CLIENT REF 11-131-01 CLIENT DWG No Figure 1.1
PROJECT No [illegible]
SCALE [illegible] PM DWG No 01258-22-SK-0004

2. SITE DESCRIPTION

2.1. Site Location & Layout

The site is located on the northern bank of the Avoca River approximately 2.5km to the northwest of Arklow (Figure 2.1). The site layout is shown on Figure 2.2. It covers an area of approximately 50 hectares (c.123 acres), of which the Production Area covers approximately 36.5 hectares. Holfeld Plastics occupies the southwest corner of the Production Area.

2.2. Site Activities

Holfeld manufactures rigid plastics packaging, supplying bespoke formings as well as an extensive range of standard trays and containers to customers throughout Europe in both food and non food sectors. The manufacturing activities do not belong to any of the prescribed processes that are subject to IPPC licensing.

2.3. Site History

IFI was a joint venture company formed by state company Nitrigin Eireann Teoranta (NET) and ICI plc, which operated three manufacturing facilities in Cork, Belfast and Arklow. The main products manufactured at Arklow were Calcium Ammonium Nitrate (CAN) and blends. Other nutrients, which complemented the range of fertiliser products were imported and blended as required. Nitric acid was produced mainly as an intermediate, although there was a minor acid sales business.

Facility operations required a typical range of services, including water treatment, steam generation, laboratory activities and storage of raw materials, intermediates, products and ancillary materials. .

IFI was granted the IPC Licence in January 1997. A revised Licence (Register No. 495) was issued in March 2000, which approved significant process changes. In 2002, fertiliser manufacturing stopped and in 2005, following the purchase of the site, the Licence was transferred to Holfeld.

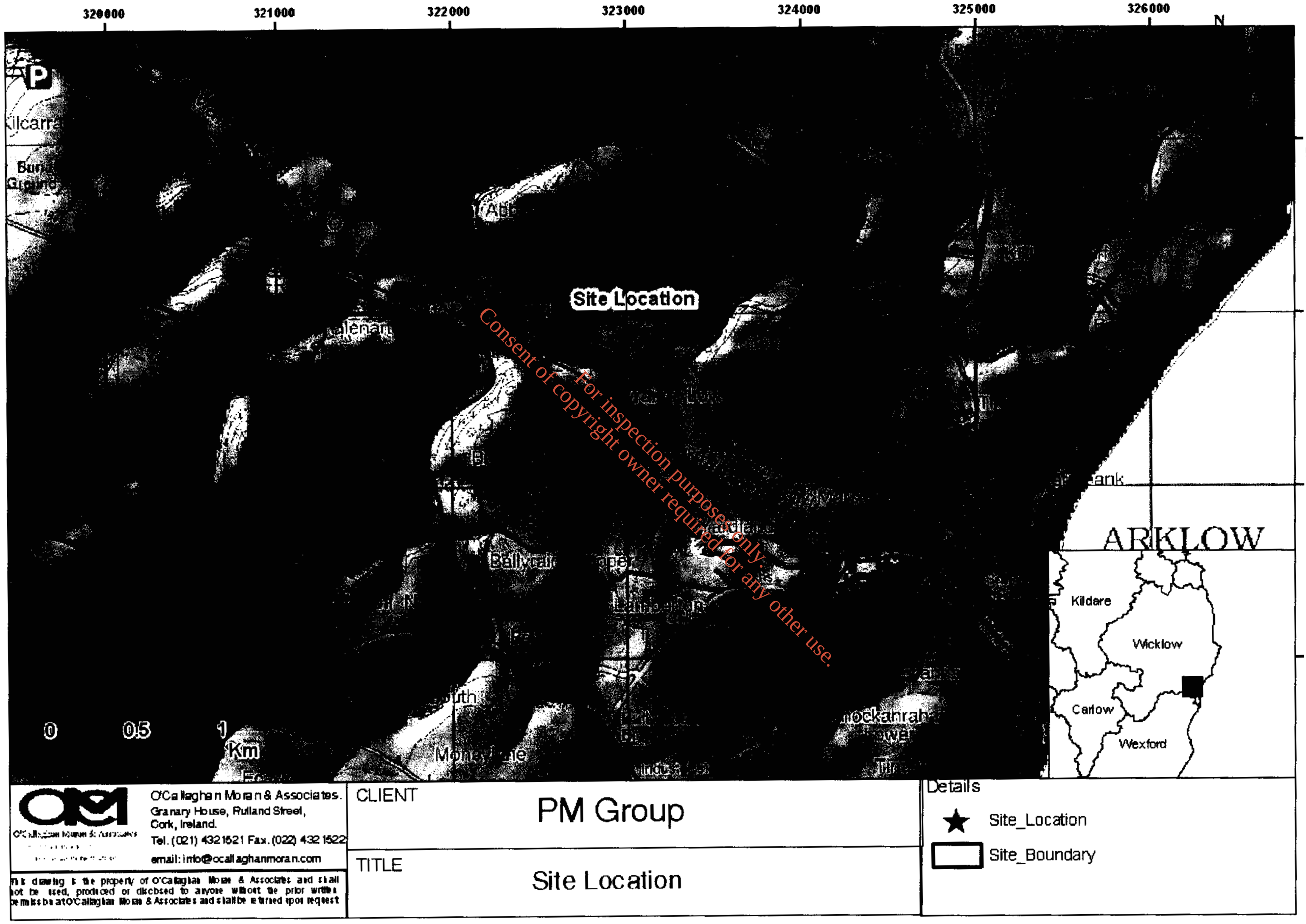
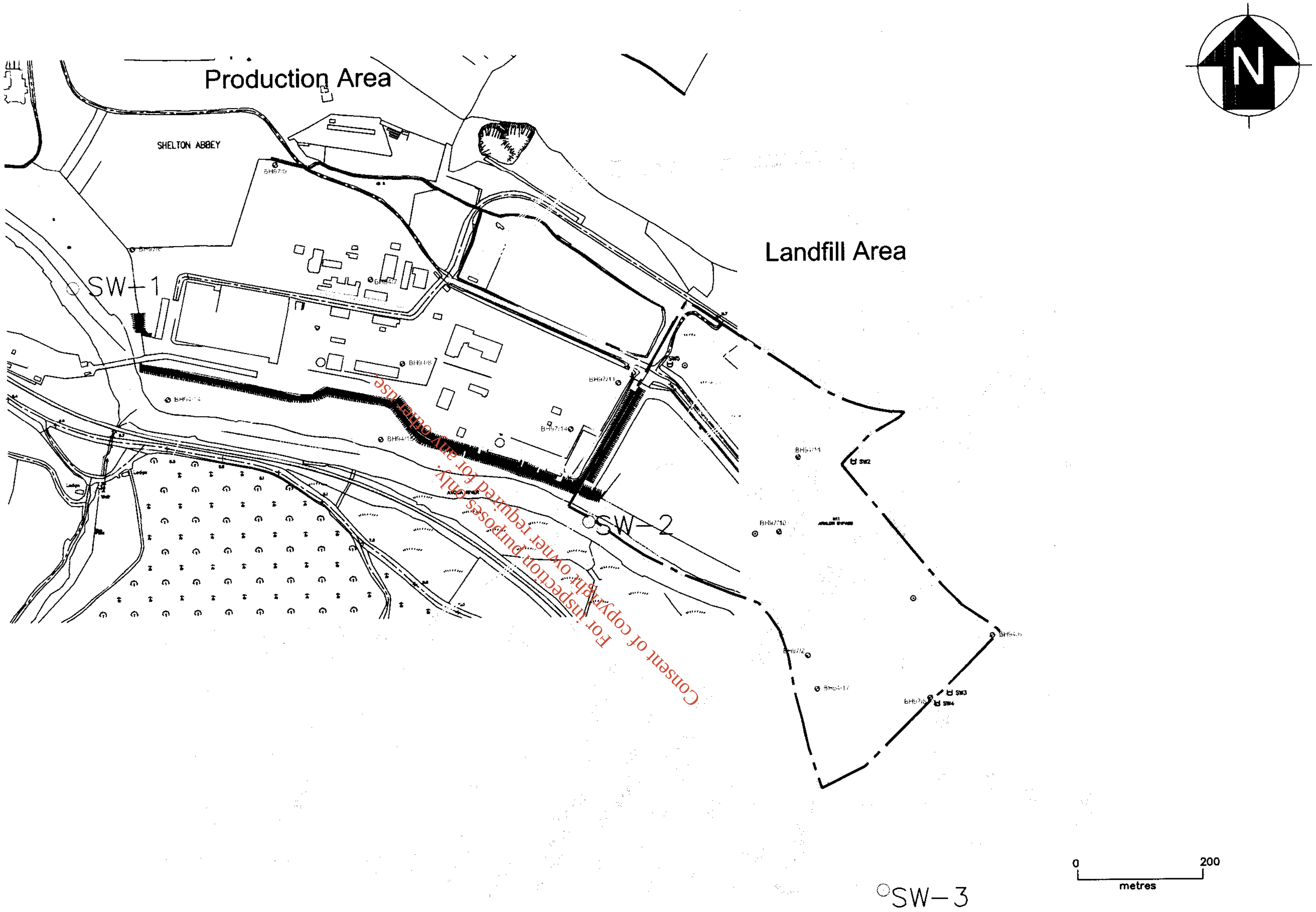


Figure 2.1 Site Location



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Tel. (021) 4321521 Fax. (021) 4321522
email : info@ocallaghanmoran.com

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CLIENT
PM Group

TITLE
Site Layout

DRAWING No.
2.2

SCALE
1:6500
A3

REV.
A

NOTES
▬ ▬ Revised Boundary of Holfield Plastics
○SW-1 Surface Water Monitoring Locations

DOS Filename : *********

Since Holfeld acquired the facility, the final decommissioning of the fertiliser manufacturing area and general site clean-up has been completed. The former bulk storage sheds have been fully refurbished and are now used for plastic product manufacturing.

Earlier studies by IFI had identified known liabilities that have resulted in multiple clean-up projects, these included;

- Decommissioning and removal of production plant
- Hazardous waste disposal
- Refurbishments of bulk storage sheds
- Removal and disposal of asbestos roofing
- Excavation and removal of diesel oil contaminated soils
- Excavation and removal of PCB oil contaminated soils
- General clean-up, reinstatement and landscaping of the site

All remediation projects have been completed and serve to remove all known liabilities from the former production and storage areas.

Table 2.1: Materials Used for Activities at the IFI Site

Material	**Activities**	**Location**	**By-Products/Wastes**
Amine and coating oils	Coating of calcium ammonium nitrate	Main production area	
Ammonia	Manufacture of ammonia	Main production area	Hydrogen sulphide, carbon, carbon dioxide
	Ammonia recovery	Fertilizer production area	
	Manufacture of ammonium sulphate	Fertilizer production area	Ammonium sulphate wastes
	Manufacture of fertilizers	Fertilizer production area	Process condensate containing ammonium nitrate and ammonia
Carbon black	Manufacture of carbon black	Carbon black plant	
Carbon dioxide	Manufacture of carbon dioxide	Ammonia production plant	
	Manufacture of dry ice	Ammonia production plant	
China clay	Coating of fertilizers	Fertilizer production area	China clay
Heavy fuel oil	Manufacture of ammonia, heating	Main production area, Boilers	
Iron pyrites	Manufacture of sulphuric acid	Acid production plant	Iron oxide cinder

Material	Activities	Location	By-Products/Wastes
Limestone /Dolomite	Manufacture of calcium ammonium nitrate	CAN1 granulating and CAN2 prilling plant	Limestone, dolomite
Oils (diesel, engine and hydraulic, transformer, compressor)	Various uses	Stored at western end of process area, garage and engineering workshops	PCB wastes, waste oils
Phosphate rock (crushed)	Manufacture of phosphoric acid	Phosphoric acid plant	Phosphogypsum
Phosphoric acid	Manufacture of phosphoric acid	Phosphoric acid plant	Phosphogypsum
	Manufacture of compound fertilizers	Fertilizer production area	
Potash	Manufacture of compound fertilizers	Fertilizer production area	
Nitric acid	Manufacture of fertilizers	Acid production area	Spent catalysts, filter elements
Solvents and cleaning chemicals	Maintenance and cleaning	All areas	Liquid wastes
Sulphur	Manufacture of sulphuric acid	Acid production area	
Sulphuric acid	Manufacture of ammonium sulphate		
	Manufacture of phosphoric acid	Phosphoric acid plant	Phosphogypsum
	Manufacture of calcium ammonium nitrate	Fertilizer production area	

2.4. Site Investigations

The first site investigations were undertaken in 1994 by ESB International as part of the application for the IPC license. The investigations identified the presence of elevated levels of ammonia, nitrate and sulphate in the subsoil and groundwater.

In 1995 Bord-na-Mona completed a review of the findings of the ESBI investigations, following which more detailed investigations were undertaken by Conestoga-Rovers and Associates (CRA) in 1997. This identified the presence of groundwater contamination (ammonia, sulphate and nitrate) plume and included an assessment of the impacts on the Avoca River.

In addition to the elevated inorganic parameters, localised hydrocarbon contamination was identified around oil storage areas and polychlorinated biphenyls (PCB) were detected in the subsoils at transformer stations. The hydrocarbons and PCB contaminated soils were removed in the 2006. The report on the 1994, 1995 and 1997 investigations are in the CD in Appendix 1

In 2004, PM completed an Environmental Risk Assessment incorporating a quantitative risk assessment using the Modflow groundwater modelling programme. The modelling predicted rates of attenuation of the nitrate and ammonia plume over a 10 year period. In 2007, the assessment was reviewed and revised to include an assessment of the nitrogen loadings to the Avoca River. Copies of the PM reports are included in Appendix 2

Since 2004, PM has conducted annual groundwater monitoring at the facility, with the results reported to the Agency in the Annual Environmental Report (AER). A copy of the 2010 AER is included in Appendix 2. This AER includes groundwater monitoring data from July 1997 to February 2011.

2.5. Hydrology

The site is on the floodplain of the Avoca River. Surface run-off from the high ground to the north drains to the floodplain and into the river. The poorly draining lands at the margins of the flood plain have been drained to improve the lands locally up and downstream of the site. The Shelton Abbey Canal runs through the site, parallel to the river and enters the Avoca River down stream in Arklow.

2.6. Geology and Hydrogeology

OCM established the site geology and hydrogeology from a review of databases maintained by Geological Survey of Ireland (GSI), Teagasc and the reports on the previous site investigations

2.6.1. Subsoils

According to the Teagasc soil maps (Figure 2.3), the majority of the site is covered by made ground. Closer to the river, the subsoils comprise alluvium as would be expected given the location of the site in the floodplain of the river.

The site investigation confirmed the presence of between 1 to 3m of fill comprising topsoil, coarse gravels and cobbles. . Beneath this is a clay layer containing sandy silt with intermittent peat ranging in thickness from 3-7m. The peat is thicker toward the southeastern end of the Production Area and increases in thickness moving further southeast under the Landfill Area.

The clay and peat is underlain by fine to coarse gravels with occasional large cobbles and bolder, probably indicating the presence of ancient river channels. The gravels range in thickness from 15- 18m and extend in depth to 24m below ground level and comprise an upper, middle and lower zone, separated by thin lenses of poorly permeable clays and silts. The total subsoil thickness ranges from at least 22m beneath the Production Area, to greater than 24m beneath the Landfill Area.

2.6.2. *Bedrock*

The bedrock beneath the majority of the site comprises Ordovician metasediments primarily dark, grey slate, with minor pale sandstone from the Kilmacrea Formation (Figure 2.4). A small portion of the Production Area is underlain by green, red-purple, buff slate, siltstone from the Oaklands Formation. The bedrock outcrops in the high ground to the north of the site and the bedrock surface slopes from the north to south beneath the river valley.

The bedrock is classified as a Locally Important Aquifer that is productive only in Local Zones (**Ll**) (Figure 2.5). These types of aquifers are generally described as poor aquifer that are only capable of supplying water to individual dwellings or farm holdings and typically are poorly yielding in drier periods of the year.

The GSI Vulnerability Map for Wicklow (Figure 2.6) indicates that the vulnerability of the bedrock aquifer is Low (**L**). However, it is considers that the gravel deposits overlying the bedrock are water bearing and provide bank storage for the Avoca River.

2.6.3. *Groundwater Flow Direction*

The groundwater flow direction beneath the Production Area was calculated using water levels data from the on-site monitoring wells (BH-97/10, 94/15, 94/14, 97/2, 94/11, 97/9, 97/6, 94/6, 97/14, 94/7 and 94/8) recorded on June 11th 2010 and the ordnance levels provided in the CRA 1997 Report.

In three of the wells (94/7, 94/14 and 94/15), the groundwater level is much higher (c. 0.4-1.2m) than in the other wells. Two of these wells (94/14 and 94/15) are located along the southern site boundary close to the river with the third well toward the centre of the site further north. The construction logs for these wells indicate the presence of much thicker sequences of silt and clay compared to the other wells. It is considered that high water levels in these wells is a result of increased pressure head levels backing up the groundwater due to more poorly permeable subsoils inhibiting discharge to the river.

The direction of flow, which is shown on Figure 2.7, is generally from north to south, with a possible localised slightly southeast component toward the Avoca River.

2.6.4. Nearby Wells

A search of GSI records did not identify any wells within 500m of the site. The closest known wells are at Shelton Abbey and are 750 northwest and up hydraulic gradient of the site.

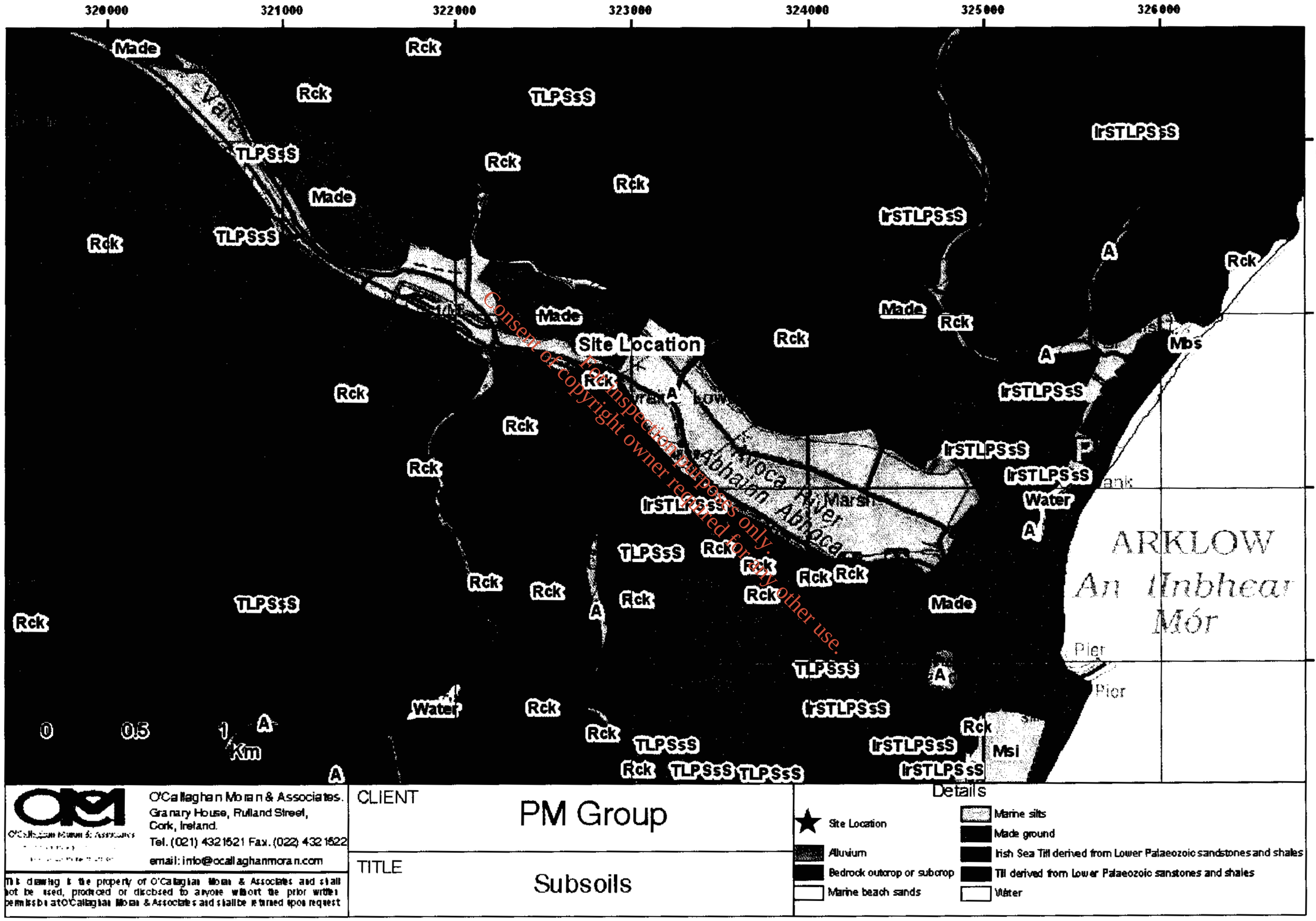


Figure 2.3 Subsoils

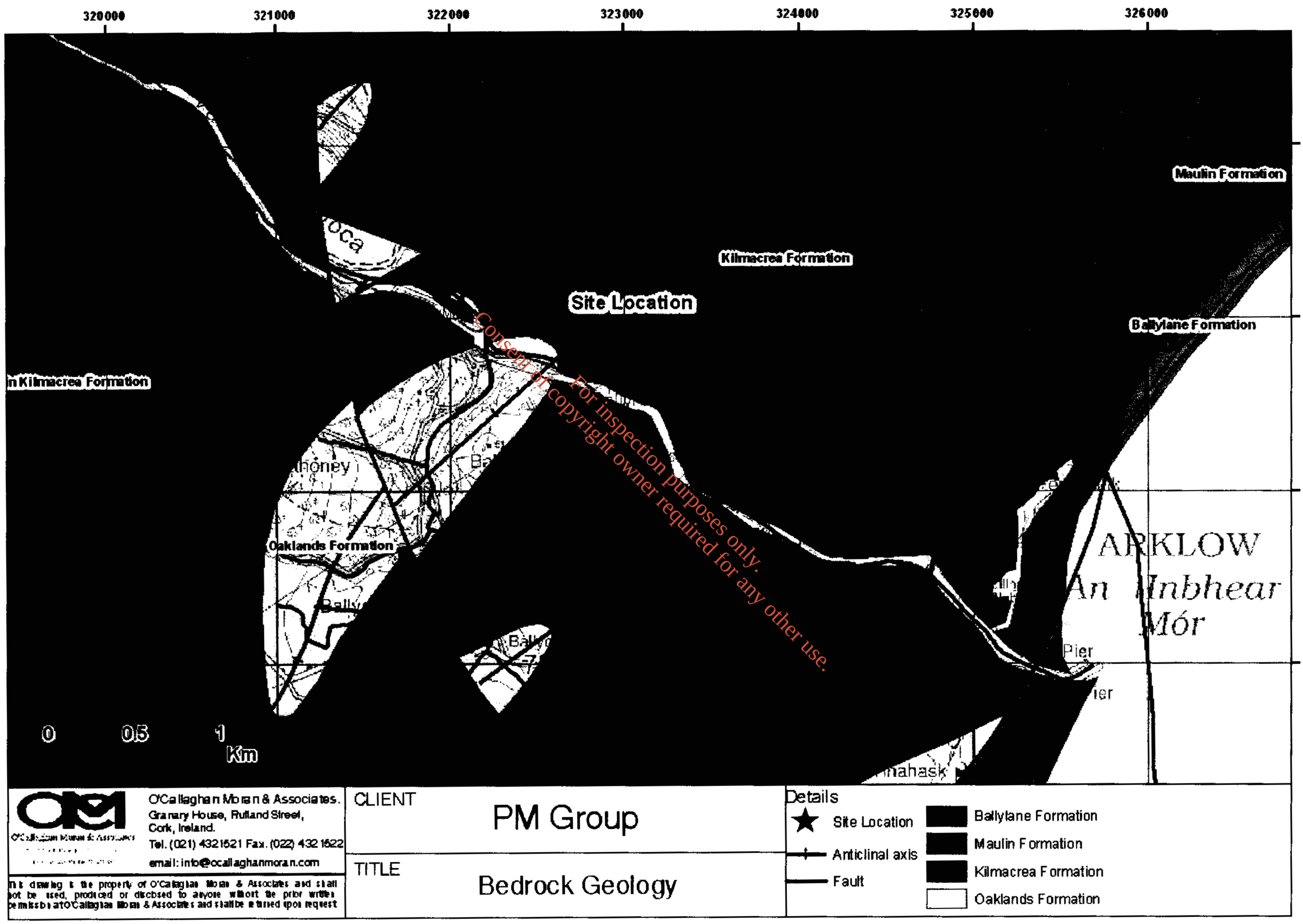


Figure 2.4 Bedrock Geology

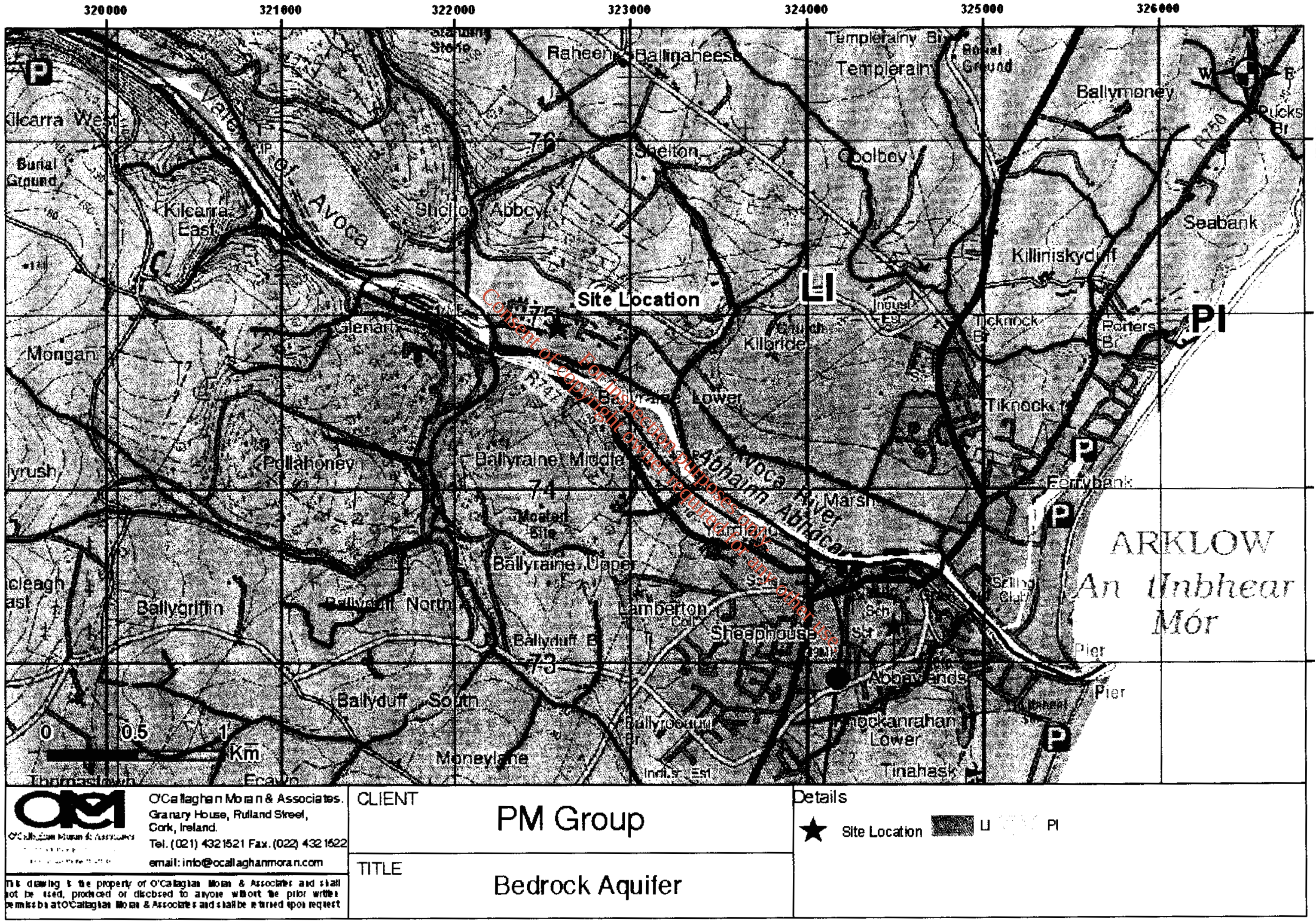
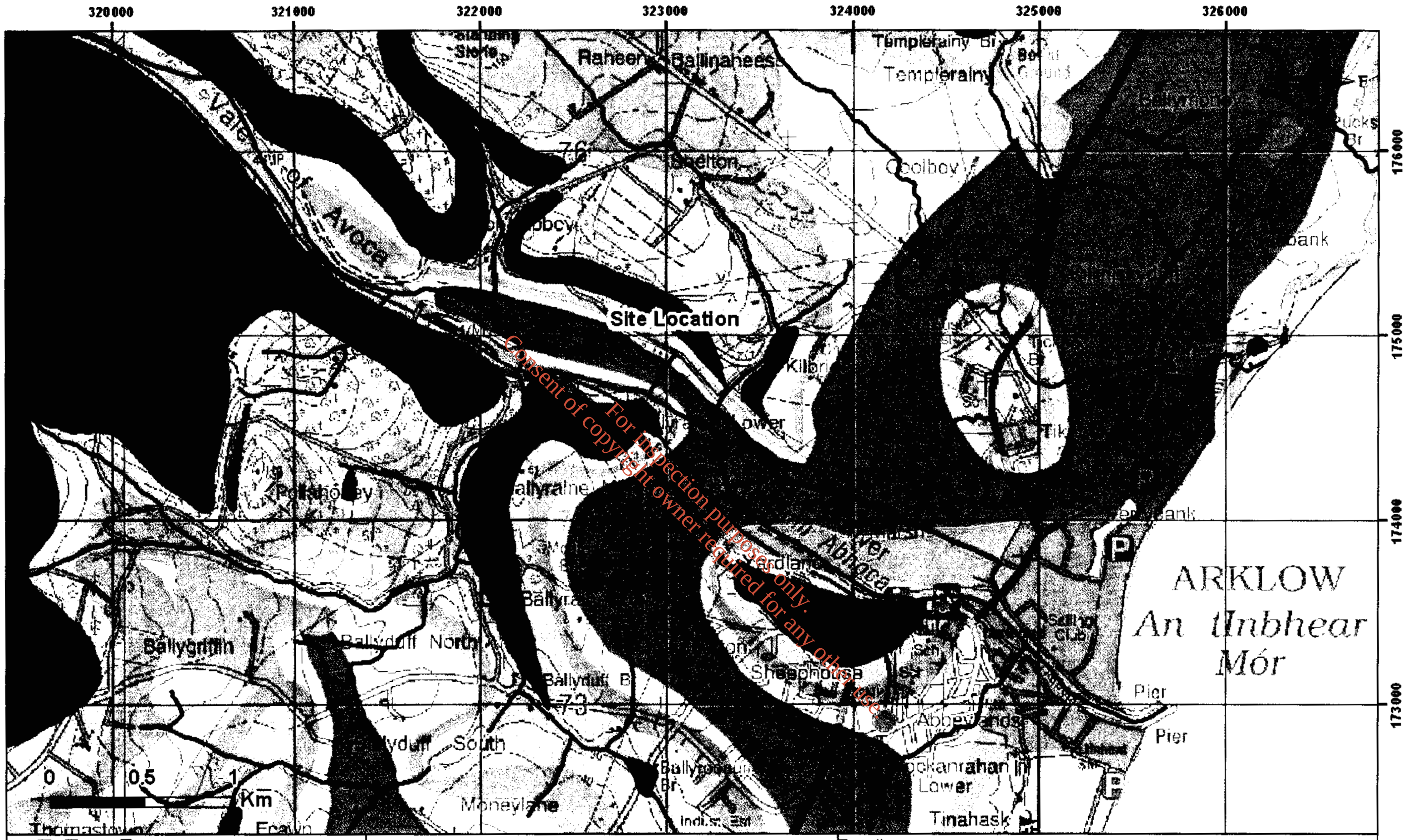


Figure 2.5 Bedrock Aquifer



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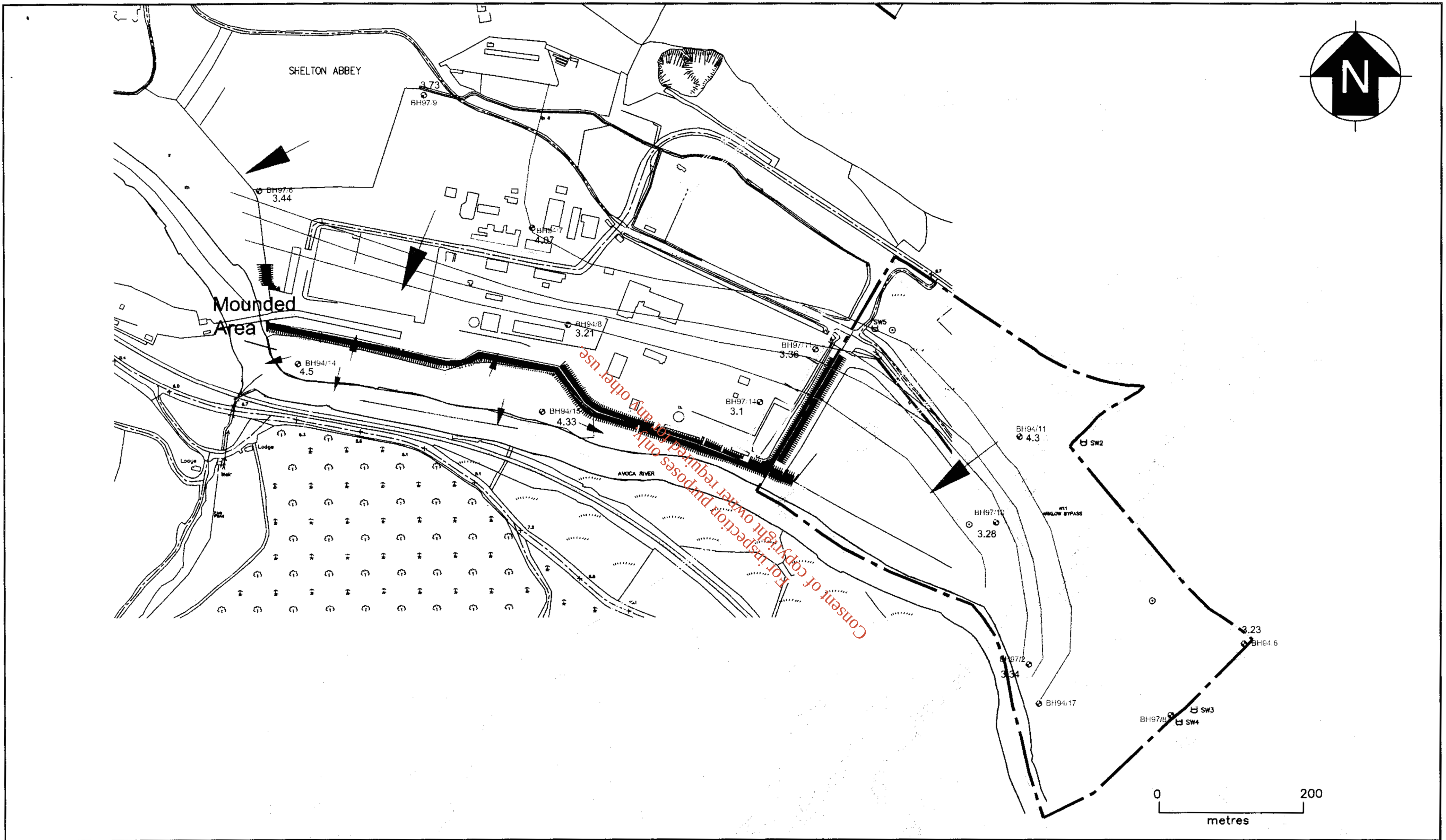
CLIENT
PM Group

TITLE
Groundwater Vulnerability

Details

★	Site Location	▇	H
■	X		M
░	E	■	L

Figure 2.6 Aquifer Vulnerability



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TITLE
Groundwater Flow Direction

DRAWING No.
2.7

SCALE
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A3

REV.
A

NOTES

◄┈	Groundwater Flow Direction
⌒	Groundwater Contour
︿	River Channel
▬ ▪ ▬	Revised Boundary of Holfield Plastics

DOS Filename : *********

3. CONCEPTUAL SITE MODEL

A Conceptual Site Model (CSM) was developed based on the findings of the various site investigations undertaken at the site between 1994 and 1997 and the site inspection undertaken by OCM in May 2011. This is shown on Figure 3.1.

This is based primarily on a long section, running west to east across the Production Area and was updated to reflect OCMs interpretation of the site hydrogeological information.

Most of the Production Area is covered by either, buildings, roads, tarmacadam, gravel hard core or asphalt paved former fertiliser storage areas. A small portion of the site along the river is landscaped with coniferous forestry and grassland.

The upper 1-3m of subsoils comprises topsoil, coarse gravels and cobbles. Beneath the fill, is a layer of silt/clay with peat along the southeast section, which increases in lateral and vertical thickness beneath the landfill area. The silt/clay layer ranges in thickness from 4 to 7 m moving from northwest to south east, but the layer is interspersed with gravel lenses toward the middle of the site. The silt/clay layer is underlain by a sequence of gravels with interspersed clay lenses which are up to 15m thick.

CSA delineated an upper, middle and lower gravel zone separated by thin extensive but discontinuous lenses of clay. Because these clay lenses are not continuous, there is some hydraulic connectivity between the gravel layers. Within the gravel layers, grain sizes range from fine to coarse, with occasionally very large cobbles and boulders. The underlying bedrock is classified as a Poor Aquifer with limited vertical groundwater movement.

Direct infiltration to the subsoils is limited to the small hard core covered or landscaped areas. It is possible the original construction of the fertiliser plant involved either piling through the silt/clay layers or excavation of the clay down to the gravels to foundation formation levels. This could have opened pathways from the ground surface through the silt/clay and into the gravels

The monitoring wells are exclusively screened in the gravel zones. The water levels recorded in June 2010 are all above the top of the gravel on average between 1.5 and 3m below ground level and c. 3-4.5m above the top of the upper gravel zone. The water levels indicate that the silt/clay layer is acting a confining layer above the gravel zone

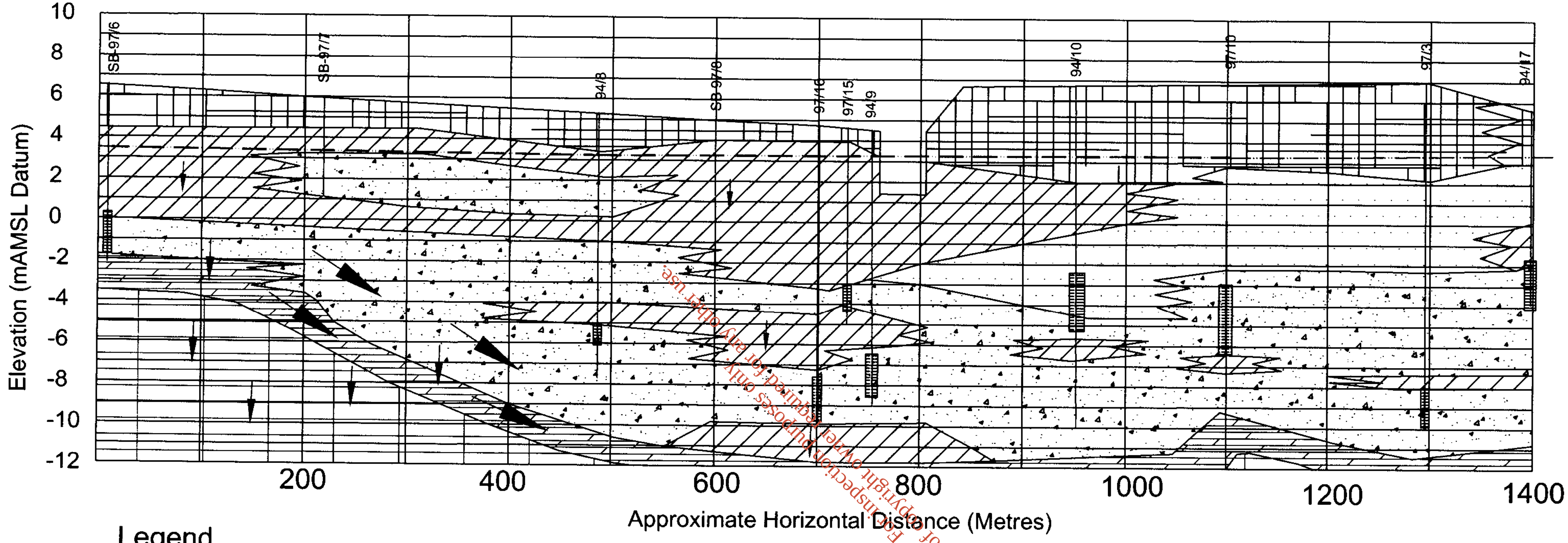
The ground water in the gravels is semi-confined, with some leakage between the upper, middle and lower gravel zones. This is based on CRA report of higher concentrations of contamination in the upper gravel zone with decreasing amounts in the lower gravel zones.

Much of the groundwater throughput originates in the high ground to the north of the site. In 1997, CSA considered that groundwater movement beneath the Production Area was to the west, south and southeast from a high point beneath the Production Area. They indicated a hydraulic gradient ranging form 0.05 -0.5% beneath the Production area, with a much shallower gradient beneath the Landfill Area.

The average hydraulic conductivity for the gravels was estimated at 35m/day, with an aquifer flow velocity of between 0.09 and 0.9m assuming a porosity of 20%. They also concluded that the fastest flow velocities occurred in the northwest of the Production Area, while the slowest flow velocities occur in the east.

The 2010 groundwater level data also indicates mounding or increased hydraulic head in the central and southern part of the Production Area with a gradient indicating flow to the east and west from the this mound area. Over the remainder of the site, the flow is from the northwest to the southeast toward the river.

Conceptual Site Model



Legend

- ▦ Fill Material
- ▨ Clays and Silt
- ░ Peat and Organic-Rich Sediments
- ⁘ Gravel and Sand
- ▤ Weathered Bedrock
- ▤ Bedrock
- — Groundwater Piezometric Surface on 11 June 2011
- ↘ Assumed Direction of Groundwater Flow

97/16 Well Designation

SB-97/7 Boring Designation

Boring or Monitoring Well Screened Interval

O' Callaghan Moran & Associates.
Granary House, Rutland Street,
Cork, Ireland.
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environmental management for business

CLIENT PM Group	DRAWING No. 3.1		NOTES
TITLE Conceptual Site Model	SCALE 1: A3	REV. A	

DOS Filename : *********

4. ENVIRONMENTAL RISK ASSESSMENT

This assessment focuses on the groundwater quality beneath the Production Area and the surface water quality in the Avoca River, which is the closest sensitive off-site receptor for groundwater movement from the site.

4.1. Contaminant Sources

The primary contaminant sources included the handling and storage of the compounds used in the fertiliser manufacture (anhydrite, ammonia, dolomite and gypsum); oil storage, and PCB containing electrical equipment. The oil and PCB contaminated subsoils were removed from the site in 2006, which eliminated this source. All fertiliser manufacturing compounds and finished product were removed from the site during the decommissioning process, thereby eliminating this primary source.

4.2. PM 2004/2007 Risk assessment

The assessment modelled the decline in the concentrations of ammonia and nitrate in the groundwater due to natural attenuation over a 10 year period. PM also completed an assessment of the nitrogen and ammonia loading to the Avoca River and the potential risk posed to the aquatic resources downstream.

4.2.1. Groundwater Model Inputs

The predictive model used to calculate the predicted concentrations of ammonia and nitrate over time was the United States Geological Survey modelling Engine MODFLOW. This model requires a range of hydrological, hydrogeological and meteorological input criteria. Some of the criteria applied were site specific, based on data obtained from the site investigations, while others where based on desk study information. These are summarised in Table 4.1

***Table 4.1:** Initial Model Inputs*

Parameter	Value*	Range (from texts)
SS (specific storage)	1 × 10^{-5} m^{-1}	N/A
Sy (specific yield)	0.2	0.12 to 0.35
Total Porosity	0.3	0.25 to 0.4
Effective Porosity	0.15	0.13 to 0.2
Recharge	1000 mm/yr	N/A
Evapotranspiration	No data available	N/A
K (layer 1)	K=0.0001 m/s (from ESB/CRA reports)	N/A
K (layer 2)	K=0.00042 m/s (from ESB/CRA reports)	0.01 to 0.0001

* Values used were based on model defaults, unless otherwise stated.

No value was entered for evapotranspiration, presumably as most of the Production Area is covered by paving and evapotranspiration is not significant.

The hydraulic conductivity (K) was assigned for the upper fill zone and the lower gravel zone. While the gravels comprise three units separated by partially confining silt and clay layers, the layers are not continuous and the assumption of treating them as a single unit is conservative. This may however affect the model predictions in those parts of the site underlain by greater thicknesses of peat or clay, for example the southern/south eastern section of the Production Area.

A Recharge Value of 1000mm/yr was applied. The main parameters involved in recharge rate estimation are annual rainfall, annual evapotranspiration and annual run-off. Since it was decided that evapotranspiration was negligible, the total potential recharge is assumed to infiltrate to the groundwater system.

This is an over estimate of the amount of recharge. Best practice guidance was developed by the Irish Groundwater Working Group (2005), as part of the implementation of the Water Framework Directive 2000 to assess the level of recharge through a range of different soil types in Ireland, indicates that for gravels the maximum amount of recharge that would occur is 90% of the Potential Recharge.

The inputs are considered to be within acceptable ranges and are generally conservative.

4.2.2. Predicted Ammonia Levels

Table 4.2 is from the 2007 PM Report and shows the maximum predicted concentration of ammonia in the groundwater beneath the site over a 10 year period, starting in 2007.

Table 4.2 Maximum Ammonia Concentrations 2007 - 2017

Time Period	Maximum Predicted Concentration (mg/l)*	Cumulative Reduction (%)
Today (Day 1)	467	
6 Months	286	38.8
1 Year	239	48.8
2 Years	133	71.5
3 Years	92	80.3
5 Years	19	95.9
7 Years	6	98.7
10 Years	1	99.8

*These values have been extrapolated from contour plots

The model predicts that by 2010, the concentration of ammonia in any of the on-site groundwater wells should not exceed 92mg/l.

4.2.3. Predicted Nitrate Levels

Table 4.3 shows the maximum predicted concentration of ammonia in the groundwater beneath the site over a 10 year period, starting in 2007.

Table 4.3 Maximum Nitrate Concentrations 2007 – 2017

Time Period	Maximum Predicted Concentration (mg/l)	Cumulative Reduction (%)
Today (Day 1)	1181	
6 Months	718	39.2
1 Year	571	51.7
2 Years	369	68.8
3 Years	231	80.4
5 Years	105	91.1
7 Years	50	95.8
10 Years	14	98.8

The model predicted that the concentration of nitrate in any of the groundwater wells on site by 2010 should not exceed 231mg/l.

4.2.4. Real Time Data

The ammonia and nitrate levels recorded in the annual groundwater monitoring conducted in the 12 on-site monitoring wells are presented in Tables 4.4 and 4.5, which includes data from July 1997 to February 2011. It was not possible to collect a sample from well 94/14 in 2010 as it was blocked during the monitoring event. OCM unblocked and sampled this well in June 2011.

With the exception of monitoring wells 94/14 (272mg/l) and 94/15 (220mg/l) located in the southwest and south east sections of the Production Area respectively, just before the Avoca River, all ammonia levels were below the predicted model outputs.

In the case of nitrate, with the exception of monitoring well 94/15, the levels in all wells in the Production Area show nitrate levels below the predicted model values.

Table 4.4
Groundwater Analytical results for **Ammoniacal Nitrogen** (mg/l) Results
July 97 to February 2011

Borehole Number	Jul-97	Jan-98	Aug-98	Mar-99	Sep-99	Apr-00	Sep-00	Mar-01	Sep-01	Feb-02	Sep-02	Mar-03	Sep-03	Feb-04	Sep-04	Jun-06	Mar-07	Nov-07	EPA Mar 08	Nov-08	EPA Jun - 09	Oct-09	Jun-10	Aug-10	Feb-11	Jun-11
97/2	6.0	0.8	4.4	4.4	2.8	4.7	4.8	13.2	11	10	8.9	18	27	26	7	<0.1	20	90	2.4	21	28	50	39	26	24	
97/6	0.7	1.4	1.0	2.6	1.2	0.4	0.1	4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.09	0.1		0		<0.1	<0.1		0.12	
97/9	0.2						<0.1	<0.1					<0.1		<0.09	<0.1	0.6	0.1		0		<0.1	<0.1		<0.1	
97/10	116.0	44.8	34.0	41.7	33.5	30.7	29.8	38.5	37	39	26	37	25	17	18	8	16	9.5		10		11	9.3		8.7	
97/11	0.4						0.9						0.1					0.16		0.3		0.57	0.39		0.37	
97/14	507.0						328						487			55	237	7.2		4.3		5.6	5.6		4.7	
94/6	1.9	1.7	1.7	0.9	1.7	1.6	<0.1	1.6	1.3	1.8	0.8	1	3.5	1	9	1	1.4	1.2		1.4		1.2	1.5		1.4	
94/7	321.0						140						73			22	58	49		42		50	33		44	
94/8	437.0						156						262			3.7				79		102	91		89	
94/11	1.9						<0.1						0.2							/						
94/14	824.0	620.0	154.0	2.1	589	561	580	497	632	438	571	335	0.1	59	249	283	365	0.1	324	278	339	186				272
94/15	4230.0	3210.0	4600.0	4209.0	3420	3274	2544	2690	3140	639	516	42	2280	96	418	218	391	320	310	285	295	304	242	234	220	

Figures in Red represent EPA monitoring carried out

NR =	No Result
mg/l =	Milligrams per litre

Table 4.5
Groundwater Analytical Results for **Nitrate** (mg/l)
July 97 to February 2011

Borehole Number	Jul-97	Jan-98	Aug-98	Mar-99	Sep-99	Apr-00	Sep-00	Mar-01	Sep-01	Feb-02	Sep-02	Mar-03	Sep-03	Feb-04	Sep-04	Jun-06	Mar-07	Nov-07	EPA Mar 08	Nov-08	EPA Jun 09	Oct-09	Jun-10	Aug-10	Feb-11	Jun-11
97/2	43	44	48	183	69	87	84	74	82	61	85	75	61	55	29	3	17	0.8	25	17	25	1	0.6	28	19	
97/6	6	25	23	17	<1	7	2	12	9	6.5	12	6	12	9	22	28	2	11		11		2	9		4	
97/9	99						59	81					60		48	35	39	35		31		33	33		32	
97/10	1	<5	<1	<1	36	2.4	1	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	0.68	<0.5	0.5	0.5		0.5		1	<0.5		<0.5	
97/11	14						<0.5						0.6					0.5		0.5		1	<0.5		<0.5	
97/14	86						96						101			108	41	88		73		77	50		62	
94/6	<1	<5	<1	7	<1	2.9	6	1	<0.5	<0.5	<0.5	0.8	0.6	<0.5	0.69	<0.5	0.5	0.5		0.5		1	0.6		<0.5	
94/7	929						312						242			101	186	196		133		66	46		22	
94/8	1281						403						298			47				140		88	85		54	
94/11	2						4						5													
94/14	1803	1004	1700	1270	1470	625	1815	1137	836	1244	1016	1033	0.6	236	660	258	597	319	416	270	338	104				85.6
94/15	/	7830	13120	9675	4685	7035	6348	5733	6049	1428	1739	123	3606	3033	1529	556	816	612	576	506	530	524	455	386	349	

Figures in Red represent EPA monitoring carried out

NR =	No Result
mg/l =	Milligrams per litre

4.2.5. OCM Assessment

The PM model predicts that within 10 years i.e. by 2017 there will have been a 99.8% reduction in ammonia and a 98.8% reduction in nitrate in the groundwater beneath the site as a result of natural attenuation.

The monitoring has confirmed that, in general, the decline predicted by the model has occurred. The actual concentrations of ammonia recorded in February 2011 are lower than predicted values for this year in all but two wells (94/14 and 94/15) and for nitrate the predicted level is only exceeded in one well (94/15).

There are up to 6m of clays and silts above the gravels at monitoring wells 94/14 and 94/15. Figure 4.1 shows a north south cross section compiled by CRA in 1997 across the production area indicating the presence of very thick clays in the vicinity of 94/15 just north of the river.

The 2010 groundwater level data shows that the water level in 94/14 and 94/15 is c.1-1.2m higher than the wells immediately to the north (97/6, 94/6, 97/11). This indicates that the water table in the vicinity of these wells is at least partially confined and that there is limited hydraulic connection with the Avoca River in this area.

The reduction of ammonia levels in groundwater is a primarily linked to the oxygen concentration, which controls the rate of transformation to nitrate. It is likely that the oxygen levels in the groundwater at wells 94/14 and 94/15 are lower than elsewhere across the site due to the presence of larger amounts of clay/silt and the reduction in flow rates to the river. Dissolved oxygen levels in 94/14 measured in June 2011 were only 5mg/l.

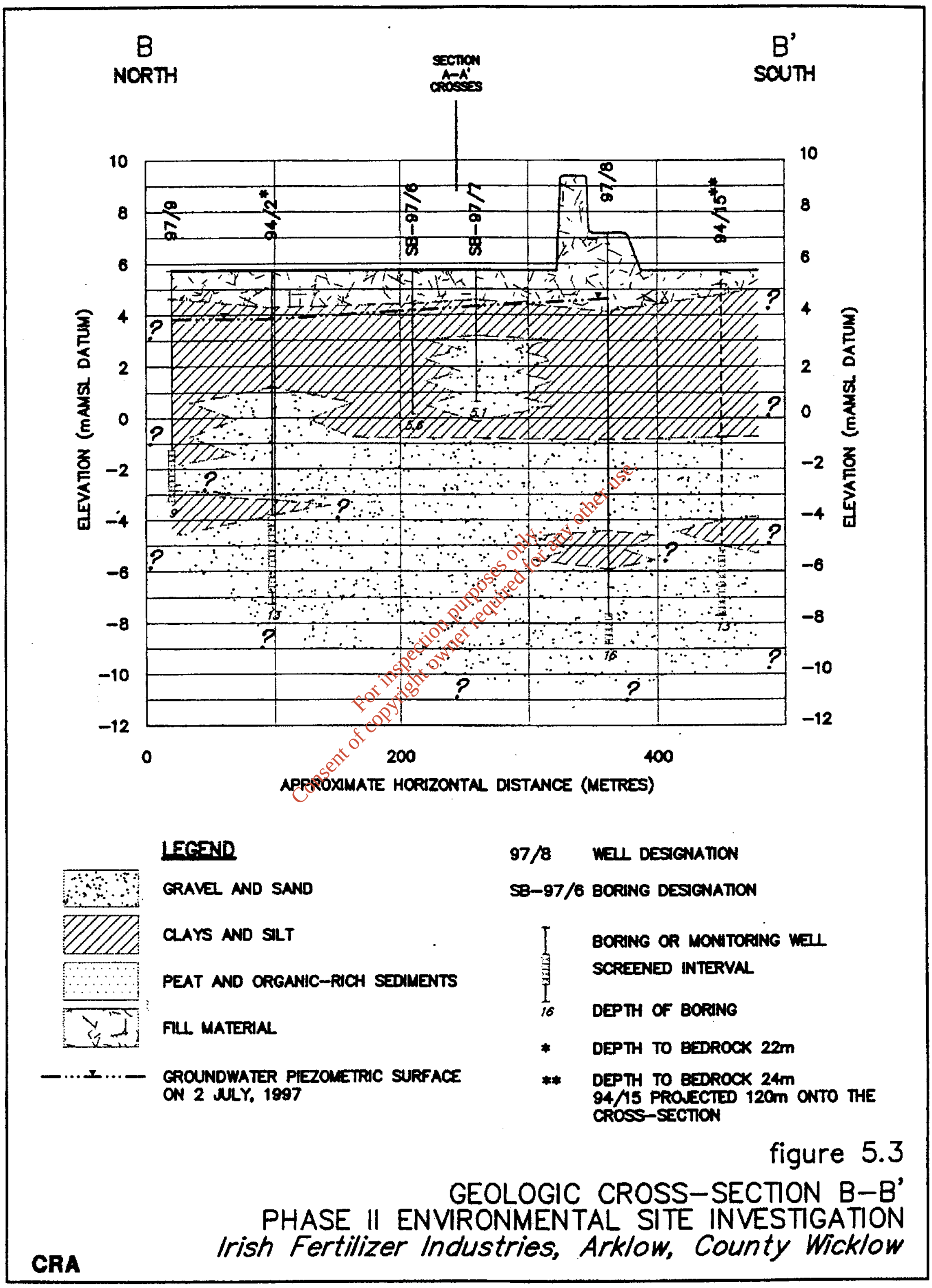
Such conditions will affect the rate of the natural attenuation of the ammonia, by conversion to nitrate, with consequent affects on the reduction of the nitrate level. The reduction of ammonia is primarily a function of dilution as generally it is not susceptible to significant transformation by chemical or biochemical reactions.

Therefore, it is considered that the elevated levels of ammonia in wells 94/14 and 94/15 and nitrate in well 94/25 is a function of the nature of the subsoils at these locations and, as such, are not inconsistent with the model predictions

It is noted that the model predicts a maximum nitrate concentration of 14mg/l after 10 years. While values lower than this have already been recorded in some of the monitoring wells, it is possible nitrate values will not decline to this level across the entire site, if the nitrate levels in the groundwater entering the site from up hydraulic off-site source areas are high. This is particularly relevant where farming activities are likely to be the predominant activity in the catchments up hydraulic gradient of the site to the north.

However, in general terms the monitoring results do show a trend of declining ammonia and nitrate concentrations over time even in monitoring wells 94/14 and 94/15 which indicates that natural attenuation is occurring across the site.

Figure 4.1 North to South Cross Section through the Production Area



4.3. Nitrogen Loading Study and Risk Assessment

In the revised 2007 Report, PM assessed the ammonia and nitrogen loading to the river associate with groundwater discharge. This was done using a groundwater and contaminant flux model to calculate the volume of groundwater reaching the river and the associated ammonia and nitrate load (kg/day) and contaminant flux (m^3/day).

The flux equation used was:

$$Contaminant\ Flux = K \times \frac{gwl_1 - gwl_2}{d} \times ws \times at \times conc$$

This is a standard equation applied for the calculation of contaminant flux and the following data obtained from the 1997 investigations were used:

The hydraulic conductivity value (k) was from the test results for the well closest to the river which was the highest value in the range of testing deemed reliable. This a conservative approach and most likely overestimates the contaminant flux, as it ignores the lower conductivity in areas where the subsoils comprises, silts, clays and gravels.

Aquifer Thickness (at) is the thickness of the entire gravel sequence, excluding silt and clay layers. It does not take into consideration groundwater flow in the weathered parts of the top of the bedrock aquifer. It was also assumed that the concentration of the contaminants in the aquifer unit was constant throughout, whereas the 1997 study indicated that the highest levels occur in the upper gravel zone, with very little contamination at depth. This again is a conservative and more than likely overestimates the contaminant flux to the river.

The hydraulic Gradient (gwl1-gwl2/d) is the gradient between the river and the nearest well used to provide the hydraulic conductivity and was more than 1 metre. This indicated a gradient of almost 0.05%, which PM did not consider realistic because the water in the gravels, particularly along the river, is semi-confined by a clay/silt layer. It is also possible that alluvium in the river bed restricts the flow of groundwater from the gravels to the river.

A gradient of 0.05 would over estimate the groundwater flux to the river. As an alternative, PM calculated the gradient based on the average groundwater gradient of the wells in the gravels across the site calculated at 0.001. This is on the basis that the groundwater flow in the aquifer will be equal to the groundwater discharge to the river when in equilibrium. This assumption does not take account of lower permeability conditions for example due to thick clays along the river at 94/14 and 94/15. But given the very flat topography of the site and the location of the site in the floodplain, the gradient used by PM reflects the actual position. Because of the above assumptions OCM considers that the flux model as applied is generally conservative.

4.3.1. Risk Assessment for Ammonia Toxicity

The ammonia loading to the river from the groundwater was estimated at 118kg/day based on the use of groundwater concentrations monitored in 2007. Applying the relevant dilution factors gave a total ammonia (as N) concentration ranging from 1.38 – 0.09mg/l at low and average flows in the river.

However as indicated in the PM Risk Assessment, it is un-ionised ammonia and not total ammonia that is toxic to aquatic species. Assuming a pH of 7.4 and a temperature of 25C, it was estimated that only 1.4% of the total ammonia is un-ionised, which equates to between 0.019 and 0.001mg/l at the low and average flow rates.

The risk assessment indicated that acute toxicity (48 hour or less exposure duration) to invertebrates occurs at between 0.53 to 22.8mg/l of un-ionised ammonia. It was concluded that aquatic species and in particular fish, which are most sensitive to ammonia toxicity, were not at risk from the groundwater discharge'

4.3.2. Risk Assessment for Oxygen Depletion from Ammonia

The first element of risk assessed by PM was oxygen depletion in the Avoca River. Because ammonia is oxidised to nitrate in the presence of oxygen, it has the potential to reduce the dissolved oxygen level in the river. PM concluded that the risk of oxygen depletion associated with ammonia in the groundwater was insignificant.

The concentrations of ammonia and associated Nitrous Biochemical Oxygen Demand (NBOD) predicted by PM are shown on Table 4.6.

Table 4.6

River Flow	Total Ammonia Concentrations (mg/l)	NBOD Concentrations (mg/l of O_2)
Low	1.38	6.31
95%ile	0.70	3.20
Average	0.09	0.41

4.3.3. OCM Surface Water Monitoring Programme 2011-06-30

OCM monitored surface water quality in the Avoca River at three locations in June 2011 to identify any impact on the water quality and to support the PM Risk Assessment findings.

The monitoring locations are illustrated on Figure 2.2. SW-1 is upstream of the entire site. SW-2 is downstream of the Production Area, while SW-3 is downstream of the entire site.

Prior to the collection of the samples, field parameters, including pH, electrical conductivity and temperature were taken. The field monitoring results are shown on Table 4.7.

Table 4.7 Surface Water Field Parameters

Location	Date	pH	Electrical Conductivity	Temperature
SW-1 Upstream	20/06/2011	8.57	92	14.2
SW-2 Mid stream	20/06/2011	8.61	102	14.4
SW-3 Downstream	20/06/2011	8.47	79	14.4

The samples were collected in accordance with OCM Surface Water Sampling Protocol, a copy of which is included in Appendix 3. All the samples were placed in laboratory prepared containers and stored in coolers to maintain sample temperature at approximately 4°C. Chain of custody (COC) documentation was completed and accompanied the samples to the Jones Environmental Forensics Ltd, a UKAS accredited laboratory for the analysed parameters. The laboratory method detection limits were below the comparative standards used for the assessment of the sediments and water samples.

The monitoring results are presented in Table 4.8, which includes for comparative purposes, the 2009 Surface Water Environmental Quality Standards (EQS) specified by the EPA. The full laboratory results are included in Appendix 4.

Table 4.8 Surface Water Quality Results

Parameter	**SW-1**	**SW-2**	**SW-3**	**EQS**
Sulphate $^{mg/l}$	7.90	8.21	8.24	[redacted]
Nitrate as NO_3 $^{mg/l}$	3.1	2.8	2.6	[redacted]
Total Ammonia as NH_3 mg/l & NH_4	[redacted]	[redacted]	[redacted]	[redacted]
UN-Ionised Ammonia (calculated)	0.0011	0.0025	0.0025	[redacted]
COD mg/l	12	12	13	[redacted]
Dissolved Oxygen mg/l	10	10	10	[redacted]

NAC denotes No Abnormal Change

* denotes mean threshold level for good status river water body

The nitrate and sulphate levels are significantly lower than the EQS, with no significant difference between the sample locations. The dissolved oxygen and COD are indicative of good water quality.

The ammonia (NH_3) concentrations are elevated upstream and downstream of the facility and exceed the EQS at all three sample locations. However there is a slight increase in levels downstream of the Production Area. The ammonia in the groundwater appears to be contributing to the increase in levels in the river downstream of the site.

Following consultation with the analytical laboratory an assessment of the proportion of the ammonia that is un-ionised was made based on the following conversation data provided by the laboratory.

Jones Analytical Laboratory indicate that the ammonium ion is largely predominant at neutral or slightly basic pH: the ratio of the ammonium to the ammonia concentration is equal to 100:1 at a pH of 7.4 and a temperature of 20°C.

Based on the likely percentage of un-ionised ammonia as indicated on Table 4.7 it is unlikely that the un-ionised ammonia concentrations downstream of the Production Area are affecting the river ecosystems.

4.3.4. Risk of Impact from Nitrate on Aquatic Biota

Because the most sensitive aquatic species are fish, the PM assessment was based on nitrate levels that are toxic to fish. The nitrate flux loading calculation it was estimated that the daily nitrate loading as N from groundwater was 59kg/day.

Allowing for dilution, the concentration of nitrate (as N) was calculated as 0.69mg/l for low flow and 0.04mg/l for the 95%ile flow. Toxic effects on fish are not noted until nitrate concentrations exceed 1000mg/l. Therefore it was assumed that the risk posed by nitrate to aquatic species sensitive to nitrate was low. The recent surface water monitoring results confirm the low levels of nitrate in the river downstream of the Production Area.

4.3.4.1. Risk of Eutrophication

PM deemed the risk of eutrophication, as low as the primary driver for this process is excess phosphorous and not nitrate. For this reason the risk posed was considered to be insignificant.

4.3.4.2. *Risk to Shelton Abbey Groundwater Wells*

There was and remains no risk of impact on these wells given their location 750m up hydraulic gradient of the facility.

4.3.5. OCM Assessment

The over all conclusion on the 2007 nitrogen loading risk assessment was that the ammonia and nitrate levels in the groundwater were not having a significant impact on the Avoca River. OCM concurs with this conclusion. It is acknowledged that the river was already impacted upstream by mine drainage, but this primarily related to pH and heavy metals. Based on the surface water sampling programme undertaken in June 2011, ammonia (as NH_3) concentrations while elevated upstream, do increase slightly downstream of the Production Area. However, the increase in unionised ammonia is considered to be low.

5. CONCLUSIONS & RECOMMENDATIONS

The primary sources of the groundwater contaminants of concern (ammonia and nitrate) have been removed. While elevated ammonia and nitrates are present in the groundwater, there has been a significant reduction in levels since 2007.

At 10 of the 12 groundwater monitoring wells the ammonia and nitrate levels are already below the concentrations predicted in the groundwater modelling completed in 2007, which demonstrates that natural attenuation is proving effective.

The attenuation rate has been slower than predicted by the model in the southern part of the Production area. OCM considers this is associated with the presence of very thick silt/clay subsoils in this area, which restricts the rate of groundwater through put to the river resulting in low oxygen levels and slowing down the rate of ammonia degradation in this area. .

The latest surface water monitoring results indicate that there is no significant difference in nitrate, sulphate or COD between the monitoring locations up and downstream of the Production Area. The ammonia concentrations do increase slightly downstream of the Production Area and may be associated with groundwater recharge, however the increases are not significant.

OCM considers therefore that the environmental risk associated with the Production Area is insignificant.

APPENDIX 1

1994, 1995 and 1997 Investigations Reports (CD)

Draft For Discussion Purposes Only

APPENDIX 2

PM AER

PM 2007 Risk Assessment

APPENDIX 3

OCM Surface Water Sampling Protocol

environmental management for business

STANDARD OPERATING PROCEDURE

SURFACE WATER SAMPLING

The primary objective of surface water sampling is to evaluate the chemical quality of a water body. The purpose of this procedure is to ensure that representative samples of surface water are collected and documented using consistent methods to ensure sample integrity. Surface water grab samples may be collected from rivers, streams, lakes and wetlands. In cases where the depth of the surface water body prevents sampling from the banks of the water body, sampling from, a boat may be required.

1.0 SAMPLING PROCEDURES

1) 1.1 Equipment Needed

- Personal protective clothing and equipment as required in the site-specific risk assessment.
- Decontamination equipment and supplies if known contaminated site.
- Temperature probe EC meter, pH meter, dissolved oxygen meter.
- Appropriate sample containers (some will be pre-preserved), labels and chain of custody documentation.
- Field logbook.
- Hard plastic cooler with ice pack.

1.2 Field Parameter Measurement

Measurements of field parameters of pH, temperature and electrical conductivity are made during sampling. Note visual (colour, turbidity) and odour (e.g hydrocarbon, hydrogen sulphide) characteristics in the field logbook.

1.3 Collection of Water Samples

All samples for chemical analysis will be placed in laboratory prepared bottles. The types of sample containers and preservative required for each type of analysis are described in the workplan. If required, preservatives will be placed in the sample containers prior to collecting the samples.

The following procedure will be used -

1) Slowly submerge unpreserved one-liter amber glass or plastic-capped bottles completely into the water. Open and fill bottle from below the water surface. If wading is required, approach the sample site from downstream and do not enter the actual sample area. Do not disturb bottom sediments. Open-end of the bottle should be pointed at approximately 90° to the upstream direction, in undisturbed gently flowing water. This procedure will be performed to minimize the effects due to high turbulence and aeration, or if surface scum is prevalent.

2) Collect a sufficient volume of water to fill all sample containers.

3) For VOC analysis. Pour the samples slowly into the laboratory prepared 40 ml glass vial. Overfill each vial slightly to eliminate air bubbles, a convex meniscus should be present at the top of the vial. Ensure that the Teflon liner of the septum cap is facing inward and that no bubbles are entrapped. After capping securely, turn bottle upside-down, tap it against your other hand, and observe sample water for bubbles. If bubbles are observed, remove the cap, overfill the vial and reseal. Repeat this step for each vial until the samples with no bubbles are obtained.

4) Obtain the semi-volatile compound/pesticides/PCBs sample(s) by transferring the water to a laboratory prepared 1000 ml amber glass bottle with Teflon-lined cap. Fill the bottle to the bottom of the neck and follow steps 4, 5 and 6 above.

5) Dissolved metals (if necessary) may require filtering the sample water through a .45 micron filter. The water is collected in a 1 litre, unpreserved, plastic or glass bottle with HNO_3 preservative. Filtering must be done within 15 minutes of sample collection.

6) Obtain the total metals sample by directly transferring the water into a laboratory prepared 1000 ml plastic or glass bottle with HNO_3 preservative. Ensure the pH of the metals sampled is less than 2 by pouring off an aliquot in a clean jar and testing for pH using litmus paper.

7) Collect and prepare Field QA/QC samples in accordance with separate SOP.

8) Place a label on the container and enter the following information: -

   Client/Site Name
   Date Collected
   Time Collected
   Analysis

Preservative
Sample Identification Number

9) Place custody seals on the container caps. As soon as possible, place sample containers in a cooler with ice and maintain at 4°C. Surround the bottles with packaging.

10) Record pertinent information in the field logbook and on the Field Data Sheet for Sampling Location. Complete chain-of-custody form, place in cooler and seal and label the cooler.

11) Be sure to record all data required on the Field Data Sheet or Sampling Location and appropriate entries into the field logbook.

12) Decontaminate all sampling equipment according to procedure.

END.

APPENDIX 4

Laboratory Results

Jones Environmental Laboratory

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O'Callaghan Moran & Associates
Granary House
Rutland Street
Cork
Ireland

[redacted]

No.4225

Attention :	Barry Sexton
Date :	27th June, 2011
Your reference :	IF1
Our reference :	Test Report 11/4807 Batch 1
Location :	HOLFELD PLASTICS ARKLOW
Date samples received :	21st June, 2011
Status :	Final report
Issue :	1

Four samples were received for analysis on 21st June, 2011 which was completed on 27th June, 2011 Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

J W Farrell- Jones CChem FRSC
Chartered Chemist

Jones Environmental Laboratory

Client Name:	O'Callaghan Moran & Associates	**Report : Liquid**	
Reference:	IF1		
Location:	HOLFELD PLASTICS,ARKLOW		
Contact:	Barry Sexton	**Liquids/products:** V=40ml vial, G=glass bottle, P=plastic bottle	
JE Job No.:	11/4807	$H=H_2SO_4$, Z=ZnAc, N=NaOH, HN=HNO_3	

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-5	6-10	11-15	16-20									
Sample ID	SW-1	SW-2	SW-3	BH94/14									
Depth													
COC No / misc													
Containers	VHPG	VHPG	VHPG	VHPG									
Sample Date	20/06/2011	20/06/2011	20/06/2011	20/06/2011									
Sample Type	Surface Water	Surface Water	Surface Water	Ground Water									
Batch Number	1	1	1	1									
Date of Receipt	21/06/2011	21/06/2011	21/06/2011	21/06/2011							**LOD**	**Units**	**Method No.**
Sulphate $^{\#}$	7.90	8.21	8.24	1116.75							<0.05	mg/l	TM38/PM0
Nitrate as NO3 $^{\#}$	3.1	2.8	2.6	85.6							<0.2	mg/l	TM38/PM0
Ammoniacal Nitrogen as NH3 $^{\#}$	0.11	0.25	0.25	272.45							<0.03	mg/l	TM38/PM0
COD	12	12	13	<7							<7	mg/l	TM57/PM0
Dissolved Oxygen	10	10	10	5							<1	mg/l	TM59/PM0

Jones Environmental Laboratory

Client Name:	O'Callaghan Moran & Associates	**VOC Report :**	**Liquid**
Reference:	IF1		
Location:	HOLFELD PLASTICS,ARKLOW		
Contact:	Barry Sexton		
JE Job No.:	11/4807		

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-5	6-10	11-15	16-20									
Sample ID	SW-1	SW-2	SW-3	BH94/14									
Depth													
COC No / misc													
Containers	V H P G	V H P G	V H P G	V H P G									
Sample Date	20/06/2011	20/06/2011	20/06/2011	20/06/2011									
Sample Type	Surface Water	Surface Water	Surface Water	Ground Water									
Batch Number	1	1	1	1									
Date of Receipt	21/06/2011	21/06/2011	21/06/2011	21/06/2011							**LOD**	**Units**	**Method No.**
VOC MS													
Dichlorodifluoromethane	<2	<2	<2	<2							<2	ug/l	TM15/PM10
Methyl Tertiary Butyl Ether #	<1	<1	<1	<1							<1	ug/l	TM15/PM10
Chloromethane #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
Vinyl Chloride	<2	<2	<2	<2							<2	ug/l	TM15/PM10
Bromomethane	<1	<1	<1	<1							<1	ug/l	TM15/PM10
Chloroethane #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
Trichlorofluoromethane #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
1,1-Dichloroethene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
Dichloromethane #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
trans-1-2-Dichloroethene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
1,1-Dichloroethane #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
cis-1-2-Dichloroethene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
2,2-Dichloropropane	<1	<1	<1	<1							<1	ug/l	TM15/PM10
Bromochloromethane #	$<2^{+}$	$<2^{+}$	$<2^{+}$	$<2^{+}$							<2	ug/l	TM15/PM10
Chloroform #	$<2^{+}$	$<2^{+}$	$<2^{+}$	$<2^{+}$							<2	ug/l	TM15/PM10
1,1,1-Trichloroethane #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
1,1-Dichloropropene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
Carbon tetrachloride #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
1,2-Dichloroethane #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
Benzene #	<1	<1	<1	<1							<1	ug/l	TM15/PM10
Trichloroethene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
1,2-Dichloropropane #	$<2^{+}$	$<2^{+}$	$<2^{+}$	$<2^{+}$							<2	ug/l	TM15/PM10
Dibromomethane #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
Bromodichloromethane #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
cis-1-3-Dichloropropene	<2	<2	<2	<2							<2	ug/l	TM15/PM10
Toluene #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
trans-1-3-Dichloropropene	<2	<2	<2	<2							<2	ug/l	TM15/PM10
1,1,2-Trichloroethane #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
Tetrachloroethene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
1,3-Dichloropropane #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
Dibromochloromethane #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
1,2-Dibromoethane #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
Chlorobenzene #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
1,1,1,2-Tetrachloroethane #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
Ethylbenzene #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
p/m-Xylene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
o-Xylene #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
Styrene #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
Bromoform #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
Isopropylbenzene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
1,1,2,2-Tetrachloroethane	*<4*	*<4*	*<4*	*<4*							*<4*	*ug/l*	*TM15/PM10*
Bromobenzene #	<2	<2	<2	<2							<2	ug/l	TM15/PM10
1,2,3-Trichloropropane #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
Propylbenzene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
2-Chlorotoluene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
1,3,5-Trimethylbenzene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
4-Chlorotoluene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
tert-Butylbenzene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
1,2,4-Trimethylbenzene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
sec-Butylbenzene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
4-Isopropyltoluene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
1,3-Dichlorobenzene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
1,4-Dichlorobenzene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
n-Butylbenzene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
1,2-Dichlorobenzene #	<3	<3	<3	<3							<3	ug/l	TM15/PM10
1,2-Dibromo-3-chloropropane	<2	<2	<2	<2							<2	ug/l	TM15/PM10
1,2,4-Trichlorobenzene	<3	<3	<3	<3							<3	ug/l	TM15/PM10
Hexachlorobutadiene	<3	<3	<3	<3							<3	ug/l	TM15/PM10
Naphthalene	<2	<2	<2	<2							<2	ug/l	TM15/PM10
1,2,3-Trichlorobenzene	<3	<3	<3	<3							<3	ug/l	TM15/PM10

Please include all sections of this report if it is reproduced
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NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

SOILS

Please note we are only MCERTS accredited for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary. If we are instructed to keep samples, a storage charge of £1 (1.5 Euros) per sample per month will be applied until we are asked to dispose of them.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C

Asbestos screens where requested will be undertaken by a UKAS accredited laboratory.

WATERS

Please note we are not a Drinking Water Inspectorate (DWI) Approved Laboratory . It is important that detection limits are carefully considered when requesting water analysis.

UKAS accreditation applies to surface water and groundwater and one other matrix which is analysis specific, any other liquids are outside our scope of accreditation

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples. All samples are treated as groundwaters and analysis performed on settled samples unless we are instructed otherwise.

DEVIATING SAMPLES

Samples must be received in a condition appropriate to the requested analyses. All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. If this is not the case you will be informed and any analysis that may be compromised highlighted on your schedule/ report by the use of a symbol.

The use of any of the following symbols indicates that the sample was deviating and the test result may be unreliable:

$	Sample temperature on receipt considered inappropriate for analysis requested.
^	Samples exceeding recommended holding times.
&	Samples received in inappropriate containers (e.g. volatile samples not submitted in VOC jars/vials).
~	No sampling date given, unable to confirm if samples are with acceptable holding times.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130%. Results are not surrogate corrected.

AQCs

Where AQC's fall outside UKAS/MCERTS criteria analysis is repeated if possible.

NOTE

Data is only accredited when all the requirements of our Quality System have been met. In certain circumstances where the requirements have not been met, the laboratory may issue the data in its final report if it believes that the validity of the data has not been conpromised but will remove the accreditation. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

ABBREVIATIONS and ACRONYMS USED

#	UKAS accredited.
M	MCERTS accredited.
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
SS	Calibrated against a single substance.
*	Analysis subcontracted to a Jones Environmental approved laboratory.
W	Results expressed on as received basis.
+	Accreditation has been removed from this result see 'Note' on previous page.
++	Result outside calibration range, results should be considered as indicative only and are not accredited.
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
DR	Dilution required.

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Test Method No.	Description	Prep Method No. (if appropriate)	Description	UKAS	MCERTS (soils only)	Analysis done on As Received (AR) or Air Dried (AD)	Solid Results expressed on Dry/Wet basis
TM15	VOC - Target by GC-MS, modified USEPA 8260	PM10	VOC GC-MS				
TM15	VOC - Target by GC-MS, modified USEPA 8260	PM10	VOC GC-MS	Yes			
TM38	SO4,Cl,NO3,NO2,F,PO4, Amm N2,ThioCN by Aquakem	PM0	No Preparation	Yes			
TM57	COD by Colourimetric measurement	PM0	No Preparation				
TM59	Dissolved oxygen using DO meter	PM0	No Preparation				

BORDNAMONA
ENVIRONMENTAL PRODUCTS

An evaluation of the nature and extent of groundwater contamination at the IFI Industrial facility at Arklow, Co. Wicklow including an assessment of the natural protection afforded the various water bearing strata beneath the site.

CONFIDENTIAL

Report No.: ELS W825

Attention:
Ms. Niamh Healy
Process Engineer
IFI
Arklow
Co. Wicklow

Prepared by:
Dr. Hubert Henry
Head: Water and Wastewater Section

Date: 27 October 1994

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3.0 SITE INVESTIGATIONS AT THE IFI FACILITY

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3.2 Hydrology/Hydrogeology

3.3 Chemical Analysis of Soil and Groundwater Samples

4.0 GROUNDWATER VULNERABILITY AT THE SITE

5.0 CONCLUSIONS

1.0 INTRODUCTION

The IFI industrial site is located in the Avoca river valley about two miles upstream of Arklow town. Production at the facility has continued since 1965 although major changes in the nature and volumes of products manufactured at the plant have occurred over the years, particularly in the 1980's.

The site is situated on an alluvium flood plain which is bounded on the north and south by steep tree lined slopes and is protected from flooding of the River Avoca by a series of earthen embankments. The site, which occupies an area of 50 hectares, is divided into two separate parts, the plant or production area (approximately 2 - 3m O.D.) to the west and the mainly disused landfill area (approximately 4m O.D.) to the east of the site.

As part of an ongoing environmental monitoring and control strategy at the plant and in response to a request by the local authority, the management of IFI commissioned a comprehensive hydrological/hydrogeological investigation at the site. The study, which was carried out by ESB International (in conjunction with IGSL and Bord na Móna Environmental Products) was completed in June 1994 and focused on the nature and degree of groundwater contamination in a series of shallow and deep monitoring boreholes across the entire site (plant and landfill areas). The findings of the investigation are presented in a detailed report "Irish Fertilizer Industries, Arklow Environmental Site Investigation" submitted to IFI in July 1994 (No. PA 514-R1).

In order to establish the present and predict the future state of the groundwaters at the site Bord na Móna Environmental Products have been requested to examine and interpret the ESBI report with a view to:

(i) Assessing the nature, extent and volumes of groundwater contamination beneath the IFI site, at the site boundaries and beyond the boundaries along a hydraulic gradient.

(ii) Describing the natural barrier which is afforded the middle and lower gravel aquifers against the subsurface migration of contaminants specific to the IFI industrial activity.

This report presents the results of the report interpretation and presents the discussion in the context of existing EC legislation. A short literature review on the fate and transport of contaminants (specific to the IFI site) in subsurface and groundwater systems is also presented.

2.0 THE FATE AND TRANSPORT OF CONTAMINANTS IN THE SUBSURFACE

When assessing the potential of groundwater contamination from an industrial process and associated landfill activity the fate and transport of the different contaminated leachate constituents must be considered. The characteristics of the leachates from the IFI plant and landfill areas are such that several components must be removed by soil/subsurface renovation or attenuation if groundwater pollution is to be avoided. These components include:

(i) Organic components yielding BOD and COD loads.

(ii) Compounds consisting of nitrogen, phosphorous and salts of varying solubilities.

(iii) Organic solvents and hydrocarbons.

(iv) Heavy metals.

The depth within a soil/subsurface profile at which removal or renovation of various contaminants is complete varies with the size of particles, the soil texture and the rate of water movement e.g. contaminants will move greater distances in coarse soils where inputs or application rates are high. It is well accepted that the most important factors which govern the removal efficiency in subsurface materials are:

(i) The presence of clays or other materials with a high specific surface area and ion exchange capacity.

(ii) The thickness of the unsaturated zone.

The properties of the subsurface media at the IFI site are such that a number of mechanisms are available to act on the waste components generated on the site, thereby, effecting at least some degree of attenuation. These mechanisms include filtration, sorption, preciption, chemical alteration and oxidation/biological transformations.

2.1 Migration of Specific Contaminants Beneath the IFI Site

2.1.1 Nitrogen

The two forms of nitrogen which are of most concern are ammonium ions (NH_4^+) and nitrates (NO_3^-). Movement of ammonium ions in the subsurface can be retarded by adsorption, cation exchange, incorporation into microbial biomass or released to the atmosphere in gaseous form. Adsorption mechanisms are generally considered to be the most effective and is directly related to the specific area of the subsurface material. Adsorption of NH_4^+ onto soil clay colloids has been shown to the a very effective attenuation process. However, adsorption is a finite process and once the adsorptive capacity of a soil or subsurface material is exceeded then, the NH_4^+ ion will migrate greater distances to "unoccupied" clay colloids.

Retardation of ammonium migration can also occur by ion exchange processes, however, this is also a finite process and, where a migrating leachate contains large amounts of NH_4^+, saturation of subsurface materials can quickly occur. The efficiency of the ion exchange process is directly related to the cation exchange capacity of the subsurface material i.e. the higher the CEC the greater the ion exchange attenuation process. Clayey/silty materials, for example, will have a CEC greater than 10 times that of a sand or gravel material (i.e. 100 meq/100g and 10 meq/100g respectively) therefore, the restriction of NH_4^+ movement in subsurface layers will be significantly more marked in clay materials.

Nitrate-Nitrogen may enter the subsurface directly from the IFI plant area and landfills or may be generated in the unsaturated zone beneath the site by the nitrification of NH_4^+ ions contained in the migrating leachate. Because nitrate is a negatively charged ion it is not attracted to negatively charged soil colloids and as such is more mobile than the ammonium. Nitrate is referred to as a "conservative" contaminant and, because of its mobility, is a good indication of the outer extremities of a migrating pollution plume. Nitrate may, however, be removed by denitrification in the saturated reducing zones of subsurface materials but this requires a ready source of carbon as the denitrification process requires a considerable energy supply.

2.1.2 Phosphorus

Phosphorus is very effectively restricted from moving in the subsurface by a combination of adsorption and precipitation processes. It is generally accepted that phosphate is not a significant cause for concern with respect to subsurface contamination because of the efficiency of the retardation reactions in soils. It is again the case that high clay content soils are more effective barriers to phosphate migration whereas highly permeable sand and gravel materials may result in the transport of PO_4-P over considerably greater distances. Because of the presence of alluvial clays and subsurface laminated clays at the IFI site phosphate migration is not considered to be a significant problem.

2.1.3 Heavy Metals

Migration of heavy metals constituents in the subsurface is largely restricted by the adsorption and ion exchange reactions. The efficiency of the attenuation process is governed by the valency of the metal and the cation exchange capacity (and specific surface area) of the subsurface material. Preferential removal of certain metals have been consistently demonstrated in previous studies. Migration of heavy metal constituents in the saturated zone is generally along a local hydraulic gradient with attenuation in the saturated zone reduced due to a decrease in the ionic strength of the subsurface materials.

2.1.4 Organic Solvents and Hydrocarbons

Migration of organic contaminants in the unsaturated zone is governed by a number of factors relating to the nature of the organic compound itself (density, solubility, biodegradability etc.) and the subsoil through which it passes. The dominant restriction processes are absorption, adsorption and biological transformation.

Organic contaminants can reach the saturated zone either dissolved in water or as an immiscible organic liquid phase. The subsurface transport of these contaminants differ significantly and their ultimate hydrogeological migration patterns are governed by many different factors.

(i) Dissolved Organics

The migration of dissolved organics in groundwater systems is controlled by:

- Advection
- Dispersion
- Sorption (retardation)
- Chemical/biological transformations

Advection is the dominant factor controlling migration in a gravel aquifer such as that existing at the IFI site. Advection is the process by which solvents are transported by the bulk motion of flowing groundwater. Hydraulic gradient is the term used to describe the magnitude of this driving force. The gradient existing at the IFI site is generally low and complicated by many factors (tidal influences, alluvial and impermeable clay deposits, etc.), however, it is considered that migration along the northwest to southeast hydraulic gradient would be the general migration pattern for dissolved organic contaminants.

The influence of the other factors such as dispersion, sorption and chemical/biological transformations are difficult to estimate. However, it is likely that all these factors are involved to a greater or lesser degree. For example the gravel strata do not offer a significant opportunity of contaminant retardation due to adsorption since there is a low level of solid organic matter content in the aquifer. However restriction in the clay layers is likely to be much more significant.

(ii) Immiscible Organics

Organic compounds differ widely in their solubility from infinitely immiscible polar compounds such as methanol to extremely low solubility compounds such as Toluene. The migration of the immiscible organic liquids in the subsurface is governed by its:

- Density
- Viscosity

Density differences of about 1% are known to influence fluid movements significantly. With few exceptions, the densities of organic liquids differ from that of water by more than 10%.

In general it is usual to consider immiscible organic liquids as belonging to one of two groups:

- Those that have density greater than that of water (dense, non-aqueous - phase liquids or DNAPL's) and;

- Those which have a density less than that of water (light non-aqueous - phase liquids or LNAPL's).

NAPL's which are released into the subsurface will generally not migrate in the same pattern as other leachate constituents. There is evidence to suggest that the materials (e.g. toluene) may in fact migrate against a hydraulic gradient. Substances which are only slightly soluble may phase separate at the top (LNAPL) or the bottom (DNAPL) of a water bearing strata e.g. the upper gravels at the IFI site and slowly release soluble contaminants into the aqueous phase which may then migrate along the dominant hydraulic gradient.

3.0 SITE INVESTIGATIONS

3.1 Subsurface Strata

The geology of the site is made up of a complex mixture of older Ordoviaan sedimentary rocks comprising of shales and mudstones in association with younger Carboniferous limestones and Tertiary chalks. The younger rock formations have been removed by erosion forces (river and glacial) to expose the Ordoviaan shales at numerous locations around the 50 hectare site. The area has also been subjected to intense glacial activity which together with the hardrock geology has combined to give a complex subsurface succession of Alluvium, peaty, gravel and low permeability clays overlying mudstone and shale bedrock.

Investigations at the site have demonstrated that a number of discrete subsurface strata occur beneath most of the site. This section describes each of these separate layers with respect to the expected contaminant restriction or attenuation properties which they possess. A total of seven separate strata were identified beneath the site. The nature of each of these layers i.e. nominal pore size, cation exchange capacity, specific surface areas, permeabilities, and thickness or depth are such that they will permit or restrict contaminant migration to greatly varying degrees. The following table presents the seven separate water bearing layers identified at the site and details the nature of the materials contained therein. The assumed pollution restriction or attenuation properties of the various materials are based on descriptions and analytical results presented in the ESBI report.

Table 1: The nature of the subsurface material present beneath the IFI facility including details of the nominal pollution restriction properties of the industrial strata.

Strata	Constituent	Average thickness m	Comment on attenuation properties
1 Man made fill material	Landfill: Gypsum and carbon slurries rubble plastic and fill. Plant area: Hardcore fill comprising of rubble/shale mix	3.1	Poor attenuation by ion exchange or adsorption with rapid migration of contaminants along zones or "preferred pathways" due to the heterogenous nature of the material and the large nominal pore size.
2 Alluvium	Silty clay, peaty material	3.0 3.1	Very good contaminant restriction properties. The high surface area of the clay and peaty materials (up to $.5m^2/g$) can facilitate sorption processes. The cation exchange properties of both materials are very high : Clay silt (USDA classification) - 60 - 80 meq/100g Peaty material (Von post >5) - >100 meq/100g
3 Upper gravels	Dense medium to coarse gravels with some cobbles and boulders	2.5	Generally poor in contaminant restriction. The dense nature of the material may result in some contamination attenuation by filtration, however, the adsorption and ion exchange properties of this material would be very low.
4 Upper laminated clays	Stiff grey/brown laminated clay	1.3	Although the clay layer is generally very thin (1m or less in places) the nature of the material is such that it constitutes an excellent barrier to the migration of all the contaminants from the leachate plume. The high clay content provides an abundance of sites for ion exchange and sorptions processes to occur and the tight nature of the matrix (permeability 1.24×10^{-10}m/s) provides an efficient physical barrier.
5 Middle gravels	Dense coarse angular gravel	3.2	As for the upper gravel layer.
6 Lower glacial clays	Brown stiff clay/silt with some gravel	2.1	The presence of this layer cannot be fully substantiated throughout the site. However, as with the upper clay layer its presence is extremely important in that it constitutes an effective hydraulic division between the middle and lower water bearing gravels. From the limited information available it is suggested that the thickness of this layer is greater than that existing in the upper clay layer. It is, therefore, considered that the lower gravel layer is very well protected by this strata.
7 Lower gravels/bedrock	Same as middle gravels (also evidence of silty material)	5.8	Poor attenuation within gravels but the water bearing strata is well protected by layers above.

3.2 Hydrology/Hydrogeology

The surface water hydrology of the IFI site is dominated by the presence of the Avoca River. Surface water from the 50 hectare site is diverted into an array of on-site drains and canals which eventually drain to the Avoca River via the effluent settling pond. Assuming an average annual rainfall of 1000mm and a nominal evaporation rate of 40% it is estimated that the average yearly effective rainfall on the IFI site is in the region of 30 x 10^3 m^3 yr^{-1} (with over twice the monthly rainfall in December compared to June). When the average flow rate of the Shelton Abbey Canal and the drain flowing north south from the plant access road is considered then the quantities of rain water which directly recharge the groundwater bodies beneath the site in minimal.

Examination of the results presented in the site investigation (ref. geological cross sections A-A to F-F) present a complicated picture of the hydrogeological conditions beneath the site. There is insufficient evidence to establish conclusively that each of the identified strata are operating as separate or distinct hydrological entities. It is possible that there are interactions between the upper and middle gravels at locations where the dividing clays are at a minimum. However, direct hydrological links between the upper and lower gravels is significantly less likely due to a combination of the upper and lower clay boundaries. It is likely that the upper and possibly the middle gravel aquifers are recharged by diffuse flow from adjoining gravel areas to the north and west of the site. However, given the permeability readings recorded for these gravel layers (3.5 - 8.1 x 10^{-5} ms^{-1}) and the extremely low hydraulic gradients observed (0.001 - 0.002) it is likely that groundwater movement is very slow or static and consequently any contamination of these water bearing strata is likely to remain there for a considerable time. The relatively low permeabilities recorded in the gravels indicate that the area is very poor yielding and as such constitutes a groundwater resource of minor importance. A combined advantage of the low permeability and hydraulic gradients observed in the investigation is that contaminated groundwater is unlikely to "reach and contaminate other aquatic systems or eco-systems" (Article 4 of EU directive 80/68/EEC). A notable exception to this is that there is a distinct possibility of a hydrogeological connection between the upper gravel aquifer and the River Avoca at the western end of the site in the vicinity of borehole 94/14. Therefore, the possibility of surface water contamination from migrating contaminants cannot be discounted and may require further investigation.

It is highly probable that the presence of the low permeability clay/silt layers between the upper, middle, and lower gravel aquifers restrict or even eliminate any hydrological links between them. The extremely low permeability of the upper laminated clays (1.2 x 10^{-10} ms^{-1}) is put in perspective when it is considered that the recorded value is significantly less than that considered suitable in the substratum materials beneath a hazardous waste landfill (1.0 x 10^{-9} ms^{-1}) (Amended proposal for a council directive on the landfill of waste COM (93) 275). Apart from the upper, middle and lower gravels none of the other water bearing strata identified are considered to have any groundwater yielding potential.

3.3 Chemical Analysis of the Subsoil and Groundwater Samples

3.3.1 Soil and Subsurface Material Analysis

Surface soil, sediment and subsoil samples from various locations around the site were analysed for a range of contaminants in accordance with recognised standard methods. The results of the findings are presented in section 6.3 (Tables 6.1 - 6.3) of the ESBI report. The results presented are referenced to the Dutch contaminated land standards (which are likely to become the European standards within the next 12 - 18 months). The results generated show that attenuation of the heavy metals (Table 6.1) is largely complete in the man made fill material and underlying Alluvium layers (where elevated Zn, Cu, Pb, and Ni concentrations were recorded). The Dutch "C" values were not exceeded in any of the samples analysed. Elevated sulphur levels and decreased pH values were, however, recorded in many of the samples analysed although the significance of this can not be solely attributed to contamination from the site activities. Analysis of the subsurface materials for organic compounds and hydrocarbons (Table 6.3) again suggests that contaminant levels are minimal and largely restricted to the upper alluvium areas where it would appear that attenuation is largely complete.

3.3.2 Groundwater Analysis

A series of groundwater samples were collected from an array of monitoring boreholes around the site. The results of the analysis are presented in section 6.4 (Tables 6.4 - 6.8) of the ESBI report.

An important consideration in any groundwater monitoring investigation involving separate water bearing strata is the effective sealing of the separate layers during borehole advancement. This must be carefully controlled to ensure that no unnecessary hydrogeological link is inadvertently made from a contaminated upper layer to pristine lower aquifers. It is not clear from the information to hand if such precautions were taken during this investigation. Therefore, the following discussion is made on the assumption that all the necessary action to prevent this vertical short circuiting of contaminants was taken.

In summary, the results obtained demonstrate that the waters in the upper gravel aquifer beneath the production plant area and the landfills region is considerably contaminated by elevated conductivity values, heavy metals, nitrogen compounds (NH_3 and NO_3) and total hydrocarbon contents. This result is significant when the possible link with the River Avoca described in section 3.2 is considered and highlights the requirements for additional investigative work at the site. The apparent contamination of the middle gravel aquifer is cause for more concern. Elevated ammonia and nitrate levels in addition to phosphate, sulphate, chloride and conductivity values considerably above background values were recorded in the groundwater samples in the middle gravel layer at both the plant and landfill sampling locations. This may suggest that the adsorptive or contaminant restriction capacity of the upper laminated clay layer has been exceeded especially for the ammonium ion where values of up to 2800mgl^{-1} NH_3-N were recorded in sample 94/15A.

The ammonia values recorded beneath the landfill are were considerably lower in the upper gravels (up to 678mgl^{-1}) and barely above background levels in the middle gravel aquifer. High and variable nitrate values were recorded in the upper and middle gravels this is attributed to the "conservative" nature of the nitrate ion which is largely unimpeded in its migration in the saturated zone. It is also highly significant that elevated nitrate levels were recorded in one sample from the lower gravel/bedrock aquifer i.e. 52.1mgl^{-1} from 94/15B.

Therefore, a definite contamination link has been established between the upper gravels and the lower gravel/bedrock aquifer despite the presence of the clay protection strata detailed in 3.1 and 3.2. It is strongly recommended that IFI technical staff undertake an ongoing monitoring programme which will monitor the conservative indicator parameters in the various gravel aquifers and, thereby, track or predict the migration of the outer extremities of the contaminant plume. This could be accomplished with minimum cost and effort by including only the conservative parameters (i.e. NO_3-N, Cl^-, and Conductivity) in the monitoring programme.

Elevated Cu, Zn, Ni, and As levels recorded in the lower gravel aquifer may indicate a metal contaminant plume input from disused tailings or metal rich strata associated with the former Avoca mines.

4.0 GROUNDWATER VULNERABILITY AT THE IFI INDUSTRIAL SITE

There is insufficient information presented in the site investigation report to calculate the volumes of contaminated groundwater at or beyond the IFI boundaries. However, the survey has highlighted a number of factors which indicate that the nature and extent of the contamination recorded in the groundwaters beneath the site is largely restricted to the upper water bearing strata. Furthermore, and possibly of more importance, it would appear that the hydrological and hydrogeological conditions at the site are such that migration of a contamination plume either horizontally or vertically through the saturated zone is minimised due to:

(a) The presence of an upper and lower low permeability clay lens which act as effective hydraulic barriers and;

(b) The low hydraulic gradients recorded together with the medium - low permeability values (for both gravel and bedrock aquifers) would indicate that groundwater movement to adjacent water bodies is minimal. It is, therefore, considered that the general requirements of Article 4 in the EU groundwater protection directive (80/68/EEC) are been satisfied at the site.

On a less optimistic note there is evidence of contamination in the middle aquifer beneath the laminated clay layer. This may indicate that this protective layer is not continuous across the entire site and that a distinct hydraulic link exists between the upper and middle gravel layers. Alternatively, it may suggest that the attenuation capacity of the clay colloids have been exceeded and that migration of certain contaminants, particularly the conservative parameters, to the deeper hydrogeological strata is now occurring. It is recommended that this possible migration of contaminants is routinely monitored in the future by examining the NO_3-N, Cl^- and Conductivity levels in the existing array of monitoring wells. In addition, it is considered necessary to introduce a management plan at the site in order to reduce the infiltration of excess waters through the contaminated sections of the landfill and plant area. This management plan, which may consist of the installation of an effective array of surface drains in addition to appropriate surface slope management, will have an ultimate aim of reducing contaminant inputs to the saturated zone.

5.0 CONCLUSIONS

Hydrological movements at the IFI site occur in a complex series of subsurface strata. The three distinct gravel aquifers are the most significant water bearing bodies present. There is no concrete evidence of any direct hydrogeological link between the separate strata. The possibility that the upper, middle and lower gravels are operating as separate hydrological entities cannot, therefore, be discounted.

The presence of a number of low permeability alluvium and clay strata in the subsurface beneath the IFI site provides an effective barrier to the vertical migration of contaminants from the upper to the middle and lower gravel aquifers.

The possible hydraulic link between the contaminated upper gravels and the River Avoca is cause for concern and may warrant further investigations.

Groundwater analysis has demonstrated that middle gravel aquifer is contaminated to some degree by elevated Nitrogen (NO_3 and NH_3), phosphate, sulphate and chloride levels as well as increased specific conductivity values. It is possible that this is due to an exhaustion of the adsorptive or chemical attenuation capacities of the protective clay strata. The migration of the contaminant plume in the subsurface must therefore be routinely monitored by the IFI technical staff by measuring the "conservative" elements of the contaminant plume (i.e. NO_3 Cl^- conductivity).

It is considered that the vertical or lateral migration of contaminants in the subsurface to adjacent water bodies (surface water or groundwater) beyond the site boundaries is minimal. This is due to a combination of the low permeabilities of the various water bearing strata, the low hydraulic gradient observed and the attenuation properties of the alluvium and upper/lower clay layers. Therefore, the general requirements of the EU groundwater protection directive 80/68/EEC (Article 4) would appear to be satisfied at the site although further evaluation of the site boreholes would have to be undertaken in order to conclusively demonstrate with all aspects of the document.

Further investigative studies on the existing array of monitoring boreholes at the site should be initiated to validate some of the observations made in the previous surveys.

BORD NA MÓNA

ENVIRONMENTAL DIVISION

An Environmental Assessment of the Chemical and Biological Quality of the Avoca River Upstream and Downstream of the IFI Industrial Facility at Arklow, Co. Wicklow.

- An Interim Report -

Project Nos.:	ELSW987/ELSWB25
Attention:	Ms. Niamh Healy IFI Arklow Co. Wicklow
Prepared by:	Dr. Hubert Henry Head of Water and Wastewater Section Dr. Michael Henry Environmental Consultant
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CONTENTS

1.0 INTRODUCTION

The IFI fertiliser production plant is located in the Avoca river valley about two miles upstream from Arklow town. This factory has been in operation since 1965 and at the present time it is considered to be one of the largest fertiliser producing facilities in Ireland. However, over the last 10-15 years, major changes have occured in relation to the nature and volume of products manufactured at the plant.

The site occupies a total area of approximately 50 hectares and is divided into two separate parts, the IFI production/plant area to the west and a landfill area to the east. The site forms a flat flood plain in a rather steep valley bounded to the north and south by tree covered slopes and is protected from flooding of the River Avoca by a series of earthen embankments. The Avoca river runs parallel to the site in a south easterly direction.

As part of the local government water licence requirements, IFI Ltd. were requested to carry out a comprehensive study of the river water and sediment quality in the Avoca river upstream and downstream of the factory site. Bord na Mona, Environmental Division were commissioned by IFI Ltd. to undertake and complete this investigation. It was agreed with IFI to carry out a full assessment of the site on three separate occasions over a 12 month period: February 1995, June 1995 and December 1995/January 1996. In addition, two sampling events examining the general chemical quality of the river water and sediment were arranged for March/April 1995 and September 1995.

This report presents a preliminary account of the sampling events which took place on 8/2/95 and 4/4/95. This interim report preceeds a comprehensive final report which will be submitted on completion of a 12 month monitoring programme. The results of the chemical/biological river water and sediment analysis undertaken at the site are described in addition to a detailed discussion of the implications of such findings.

2.0 METHODOLOGY

2.1 Sampling

The site was visited by 2 technical staff from Bord na Mona Environmental Division on 8/2/95 and 4/4/95 and both investigations were undertaken with the assistance of Ms. Niamh Healy, Process Engineer, Irish Fertilisers Industries. Appendix 1 describes the general location of the IFI site.

In order to give a representative picture of the overall river water and sediment biological/chemical quality, a total of 13 stations at a range of locations were sampled upstream and downstream of the IFI facility. The sampling locations were chosen to help establish the upstream quality of the river and its tributaries as well as the mixing zone downstream of the factory discharge pipe. Table 3.1.1 and Appendix 2 demonstrate the approximate locations of the stations.

An 18 ft boat was used to gain access to the sampling stations. During the initial sampling event (8/2/95), a total of 2 water samples were collected at each location. The first sample was collected in a clean 2.5 l polypropylene plastic container and was used for chemical analysis. The second sample was collected in a presterilised 300ml sterilin plastic container and used for microbiological determinations. In addition, sediment samples were taken at each sampling station using a specialised piece of equipment called an Ekman grab and transferred directly to polythene sampling bags. During the second sampling occasion, which took place on 4/4/95, samples were collected to determine only the chemical quality of the river water and final effluent. In both cases, sampling was in strict accordance with recognised standard procedures.

2.2 Contaminant Plume Dispersion (Mixing Zone)

A number of electrical conductivity measurements were taken both laterally and vertically through the water column downstream of the discharge point to help assess the dilution plume at the factory outfall. In addition, a number of stations were sampled upstream of the factory in order to assess the direct effect of inputs from streams, river tributaries and the disused mine tailings pond adjacent to the River bank.

Three separate lateral transects, 5m from the North bank, the middle of the river and 5m from the South bank were established. Readings were taken equidistant along the transect upstream and downstream of the outfall using a portable WTW conductivity meter (calibrated on site using CRM standards). The results of the investigations were graphically represented in order to demonstrate the migration of the plume. While it is accepted that the containment plume from the IFI facility is multicomponent it is nonetheless considered that the total ion concentration (as measured by electrical conductivity) will yield an acceptable estimation of contaminant movement, dispersion and attenuation.

2.3 Analysis

All samples were returned to the laboratory for analysis. Subsequent analysis was carried out in strict accordance with recognised standard methods as detailed in Table 2.1.

TABLE 2.1: PROPOSED CHEMICAL AND BIOLOGICAL ANALYSIS OF WATER AND SEDIMENT SAMPLES

Parameter	Method of analysis
BOD	APHA 5210 B
pH	APHA 4500 H^+B
Suspended Solids	APHA 2540D
Conductivity	APHA 2510 B
Ammonia	APHA 4500 NH_3F
Nitrates	APHA 4500 NO_3
Total Kjeldahl Nitrogen	Automated Kjeldahl Method
Chlorophyll	Documented in house Method based on APHA 10200 H
Lead	ASTM D 3559-90
Copper	ASTM D 1688-90
Zinc	ASTM D 1691-90
Iron	ASTM D 1068-90
Biological indicators	FBA Identification System

2.4 Quality Control

The Environmental Products Laboratory complex is at present actively pursuing an ILAB accreditation status. When achieved, the Environmental Products Laboratories will have a wider accredited scope than any other laboratory in the country ranging from wet chemistry to analytical chemistry to microbiology. A stringent six point quality control approach is at present implemented in the laboratories.

(i) Controlled chain of custody.

(ii) Operator competence - all analysts must be suitably qualified to carry out required analysis.

(iii) Certified Reference Materials (CRM). The accuracy of a series of determinations is checked against known standards.

(iv) Duplicate - 10% duplication is normal.

(v) Quality Control Charts.

(vi) Inter Laboratory Testing - The Environmental Products Laboratories are members of the W.R.C. Aquacheck scheme.

3.0 RESULTS OF SAMPLING EVENT - 8/2/95

The results of the investigations carried out by Bord na Mona on 8/2/95 are presented as follows:

Table 3.1	Sample identification and locations.
Table 3.2	Results of general chemical analysis of river water and effluent samples.
Table 3.3	Results of metal analysis of water samples.
Table 3.4	Results of general chemical analysis of sediment samples.
Table 3.5	Summary list of macroinvertebrate species identified during the survey.
Table 3.6	Results of biological analysis of river water samples.

TABLE 3.1 LOCATION OF SAMPLING STATIONS		
Our reference	Your reference	Location
W987-1	S1	Aughrim River
W987-4	S2	Avoca River
W987-7	S3	Confluence of Avoca and Aughrim Rivers
W987-10	S4	Adjacent to start of tailings pond
W987-13	S5	Adjacent to middle of tailings pond
W987-16	S6	Adjacent to end of tailings pond
W987-19	S7	Downstream of IFI bridge
W987-22	S8	Adjacent to middle of site (opposite tower)
W987-25	S9	Adjacent to end of site (IFI outfall)
W987-28	S10	Downstream of rapid section after IFI outfall
W987-31	S11	Adjacent to start of IFI landfill
W987-34	S12	Upstream of Iropharm outfall
W987-37	S13	Stream entering Avoca River downstream from IFI bridge
W987-38	S14	IFI final effluent 8/2/95
W987-39	S15	IFI final effluent 9/2/95

TABLE 3.2 RESULTS OF CHEMICAL ANALYSIS OF RIVER WATER AND EFFLUENT SAMPLES

Sample	BOD mgl^{-1}	Conductivity µScm^{-1}	Suspended Solids mgl^{-1}	pH pH units	NH_3-N mgl^{-1}	NO_3-N mgl^{-1}	TKN mgl^{-1}	Chlorophyll mgm^{-3}
S1	<1	114	9	7.4	<0.05	3.2	2.8	<0.1
S2	<1	117	16	6.2	<0.05	1.9	2.0	<0.1
S3	<1	120	13	6.6	<0.05	2.7	2.9	<0.1
S4	<1	118	10	7.7	<0.05	2.7	2.0	<0.1
S5	<1	120	8	7.0	<0.05	2.6	1.6	<0.1
S6	<1	135	37	7.0	1.7	3.2	4.2	<0.1
S7	<1	132	5.5	7.1	1.2	3.1	3.3	<0.1
S8	<1	370	4	9.6	48	24.9	49.3	<0.1
S9	<1	1893	9	9.7	-	186	393	<0.1
S10	<1	253	5	9.5	26	14.3	28.3	<0.1
S11	<1	171	3	8.3	66	7.9	81	<0.1
S12	<1	115	10	7.2	<0.05	2.6	3.7	<0.1
S13	2	259	19	7.8	0.13	9.4	2.6	<0.1
S14	<2	3790	18	10.2	1650	259	1850	<0.1
S15	<2	2930	14	10.6	3375	272	3495	<0.1

TABLE 3.3 RESULTS OF METAL ANALYSIS OF RIVER WATER AND EFFLUENT SAMPLES

Sample	Pb mgl^{-1}	Cu mgl^{-1}	Zn mgl^{-1}	Fe mgl^{-1}
S1	<0.01	<0.02	<0.02	0.06
S2	<0.01	0.02	0.37	<0.05
S3	<0.01	<0.02	0.23	<0.05
S4	<0.01	<0.02	0.22	0.09
S5	<0.01	<0.02	0.21	0.14
S6	<0.01	<0.02	0.17	0.38
S7	<0.01	<0.02	0.20	0.40
S8	<0.01	0.03	0.09	0.26
S9	<0.01	0.03	0.15	0.55
S10	<0.01	<0.02	0.16	0.54
S11	<0.01	0.02	0.15	0.51
S12	<0.01	<0.02	0.20	0.16
S13	<0.01	<0.02	<0.02	0.13
S14	<0.01	0.03	0.13	<0.05
S15	<0.01	<0.02	0.06	<0.05

TABLE 3.4 RESULTS OF CHEMICAL ANALYSIS OF RIVER SEDIMENT SAMPLES

Sample	pH pH units	Pb µg/g	Cu µg/g	Zn µg/g	Fe µg/g
S1	7.4	15.6	25.5	85.7	30403
S2	6.2	82.6	78.2	99.8	30823
S3	4.9	63.9	97.0	88.9	34624
S4	4.7	52.5	80.5	113	37727
S6	8.8	53.3	56.8	119	28154
S7	4.2	566	973	292	51016
S8	7.6	109	112	219	33251
S9	6.1	30.2	89.1	269	36663
S10	5.7	42.5	44.5	60.6	16167
S11	4.9	207	189	185	41313
S12	6.6	50.8	76.0	106	23041

TABLE 3.5 SUMMARY LIST OF MACROINVERTEBRATE SPECIES IDENTIFIED DURING THE SURVEY

List of Macroinvertebratees Recorded

Phylum Uniramia

- Order Plecoptera
    - Family Perlodidae
    - Family Nemouridae
        - *Amphinemura*

- Order Diptera
    - Family Chironomidae
        - *Chironmous*

- Order Coleoptera
    - Family Chrysomelidae
    - Family Elminthidae
        - *Elmis aenia*
    - Family Dytiscidae
        - *Dytiscus*

- Order Trichoptera
    - Family Sericostomatidae
    - Family Psychomyidae
    - Family Rhyacophilidae
        - *Rhyacophila*

- Order Ephemerotera
    - Family Ecdyonurus
        - *Ecdonurus*

Phylum Annelida

- Class Clitellata
    - Subclass Oligochaeta
    - Family Tubificdae

TABLE 3.6 RESULTS OF BIOLOGICAL QUALITY OF RIVER SAMPLES

Organism	Sampling Stations											
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Perlodidae	-	-	-	-	1	-	-	-	-	-	-	-
Amphinemura	-	-	-	-	1	-	-	-	-	-	-	-
Chironomus	-	-	-	-	1	-	8	-	-	-	1	-
Tubificidae	-	-	-	-	3	-	-	-	-	-	-	-
Elmis aenea	-	-	-	-	-	1	1	-	-	-	-	-
Chrysomelidae	-	-	-	-	-	1	-	-	-	-	-	-
Sericostomatidae	-	-	-	-	-	1	-	-	-	-	4	-
Dytiscus	-	-	-	-	-	-	1	-	-	-	-	-
Psychomyidae	-	-	-	-	-	-	1	-	-	-	-	-
Ecolyonurus	-	-	-	-	-	-	-	-	-	-	1	-
Rhyacophila	-	-	-	-	-	-	-	-	-	-	2	-

3.1 DESCRIPTION OF RESULTS

3.1.1 Chemical analysis of river water, effluent and sediment samples

The location of the various sampling stations are described in Appendix 2 and Table 3.1. The results of the chemical analysis of the river water, effluent and sediment samples taken upstream and downstream of the IFI site are presented in Tables 3.2, 3.3 and 3.4.

The chemical quality of the river water samples taken upstream of the factory site (S1-S7, S13) was generally good. These samples exhibited low levels of organic (BOD) content, nitrogen (NO_3-N, NH_3-N and TKN) content and suspended solids levels. No chlorophyll was detected in any of the samples analysed. The levels of lead and copper in the river water samples S1-S7 were low. However, significant quantities of zinc and iron were present in all samples. The results of this study highlight elevated levels of conductivity and NO_3-N in the sample taken from the water course entering the Avoca river downstream of the IFI bridge (S13). The elevated levels in this sample is significant in that they indicate nitrogen inputs to the river from sources other than the IFI facility. This may be from diffuse agricultural run-offs or onsite sewage disposal facilities adjacent to the stream. In particular, sample S8, taken from the river water course adjacent to the middle of the factory site, showed a marked increase in pH, conductivity, NO_3-N and TKN with respect to the upstream samples. This is a somewhat surprising result and may indicate the migration of the nitrogen plume against the river flow, possibly due to tidal action. Results of metal analysis of sample S8 was, however, similar to the levels of metals recorded in river water samples S1-S7 and S13.

Elevated levels of pH, conductivity, NO_3-N, NH_3-N, and TKN were recorded in the River water sample taken adjacent to the effluent discharge pipe (S9). The elevated nitrogen levels highlight the significance of the discharge from the IFI site.

The degree and extent of organic and inorganic contamination of the river water downstream of the factory effluent discharge pipe was also investigated (samples S10, S11 and S12). Sample S10, taken from the water course downstream of the rapid section of the river (Appendix 2) contained significant levels of nitrogen contamination and similarly high pH and conductivity values. The degree of contamination in the sample of river water taken adjacent to the landfill site (S11) was marginally lower than the corresponding values of sample S10. However, NH_3-N levels were higher than that observed in sample S10. The pH, conductivity, suspended solids, nitrogen and metal content of sample S12 were similiar to the levels recorded in the samples taken upstream of the factory discharge pipe. This indicates that the contaminat plume is adequately dispersed at this location (S12) and generally agrees with the results of the conductivity measurements (Appendices 3 and 4).

Two samples of effluent were also analysed prior to the discharge to the Avoca river (S14, S15). The pH and conductivity values recorded in samples S14 and S15 were extremely high. Elevated NH_3-N, NO_3-N, and TKN levels were also recorded. From our estimations on flow data for the Aughrim river and Avonmore river (January to March, 1990-1995) and assuming a typical average daily effluent flow of $4450m^3/d$, a 1:177 dilution factor is available in the water course adjacent to the IFI site. This is an extremely conservative estimation and the above calculation was made excluding the flow data for the Avonbeg river (no data available). Based on the concentration (Table 3.2) and volume ($4,450m^3/d$) of effluent being discharged the estimated loadings to the river are 11,182 $KgNH_3$-N/d (of which approximately 20% is in the unionised form) and 1,181 $KgNO_3$-N/d.

The contaminant plume is demonstrated to remain intact as a single entity at the North bank of the river at a lateral distance of approximately 250 m downstream of the discharge pipe (Appendices 3 and 4). The presence of a turbulent stretch (rapid section) immediately downstream of the discharge does not appear to facilitate good mixing. The horizontal migration of the plume across the river profile occurs at the first river meander adjacent to the landfill site.

Chemical analysis of river water sediment samples in the vicinity of the IFI site was also undertaken by Bord na Móna Environmental Division. Metal analysis of the sediment samples were shown to be extremely variable, with all samples displaying extremely high levels of iron. In particular, sample S7 showed a marked increase in iron content with respect to other sediment samples taken upstream and downstream of the site. The lead contents of the various samples were extremely variable ranging from 15.6µg/g (S1) to a maximum of 566.2µg/g for the sample taken downstream of the IFI bridge (S7). Sample S7 also exhibited markedly highly levels of copper and zinc than the corresponding values of other samples taken. In general, no pattern in the degree or extent of metal contamination was noted. The elevated copper and zinc recorded may be attributed to contamination from the adjacent disused Avoca mining site.

3.2.2 Biological analysis of river water samples

The results presented in Tables 3.5 and 3.6 summarise the main group of macroinvertebrates identified during the survey. A total of two taxonomic phyla were represented, namely, Phylum Uniramia and Phylum Annelida.

Macroinvertebrate species were only found at four of the twelve sampling stations. Sample S5 contained species from Family Perlodidae, Chironomidae and Tubificdae while representatives of Family Chrysomelidae, Elminthidae and Sericostomatidae were present in sample S6, taken adjacent to the end of the mine tailings pond. The sample taken downstream of the IFI bridge (sample S7) was shown to contain mainly *Chrionmous* species. Species from Family Sericostomatidae were predominant in sample S8 and members of Family Chironomidae, Ecdyonurus and Rhyacophilidae were also present.

The results demonstrate an extremely low score using species diversity indices (Trent Biotic Index, Simpsons Index). There is no evidence of biological difference in samples upstream and downstream of IFI outfall. It is, therefore, concluded that the poor biological quality of the river sediment may be due to toxic inputs from historic mining activity along the valley and in addition to possible on going leachates from the associated tailing ponds (both upstream and downstream of the IFI industrial site). The results of the biological survey suggest that the river is, at present, incapable of supporting any significant fish life (Salmonid or Cyprinid) due to the absence of a sustainable food source and the possible toxic of the river sediments.

4.0 RESULTS OF ANALYSIS OF SUB-SAMPLING EVENT (4/4/95)

As described earlier, a sub-sampling event was also undertaken by Bord na Móna Environmental Division on 4/4/95. The location of the various samples are similiar to those described in Appendix 2 and Table 3.1. However, in this case the final effluent samples were sampled on 4/4/95 (S14) and 5/4/95 (S15). The results of the investigations are presented as follows:

Table 4.1	Results of general chemical analysis of river and effluent samples.
Table 4.2	Results of metal analysis of water samples.

TABLE 4.1 RESULTS OF CHEMICAL ANALYSIS OF RIVER WATER AND EFFLUENT SAMPLES

Sample	BOD mgl^{-1}	Conductivity μScm^{-1}	Suspended Solids mgl^{-1}	pH pH units	NH$_3$-N mgl^{-1}	NO$_3$-N mgl^{-1}	TKN mgl^{-1}	Chlorophyll mgm^{-3}
S1	<1	113	2	7.4	0.1	2.8	0.1	1.3
S2	<1	114	9	6.0	0.1	1.8	0.9	1.0
S3	<1	112	9	6.4	0.1	2.1	2.2	2.0
S4	<1	112	9	7.0	0.1	2.1	0.5	1.5
S5	<1	112	8	6.6	0.1	2.2	1.8	2.5
S7	<1	-	8	6.5	0.1	2.2	2.7	3.8
S8	<1	134	5	7.3	3.8	13.4	5.3	3.4
S9	<1	345	4	9.7	83.4	20.9	110	3.3
S10	<1	125	9	7.1	1.2	2.6	2.2	2.5
S11	<1	126	9	7.4	0.9	2.7	2.7	1.9
S12	<1	124	6	6.7	0.8	2.5	1.8	2.3
S13	<1	240	10	7.7	<0.05	6.3	1.8	6.0
S14	10	3750	14	9.9	1076	323	1360	-
S15	<2	3660	18	9.9	1036	358	1340	-

TABLE 4.2 RESULTS OF METAL ANALYSIS OF RIVER WATER AND EFFLUENT SAMPLES

Sample	Pb mgl^{-1}	Cu mgl^{-1}	Zn mgl^{-1}	Fe mgl^{-1}
S1	<0.01	<0.02	<0.02	0.08
S2	<0.01	0.04	0.43	0.24
S3	<0.01	<0.02	0.28	0.05
S4	<0.01	<0.02	0.27	0.06
S5	<0.01	<0.02	0.26	0.08
S7	<0.01	<0.02	0.25	<0.04
S8	<0.01	<0.02	0.24	0.21
S9	<0.01	<0.02	0.13	0.27
S10	<0.01	<0.02	0.21	0.05
S11	<0.01	<0.02	0.22	<0.04
S12	<0.01	<0.02	0.21	<0.04
S13	<0.01	<0.02	<0.02	0.07
S14	<0.01	0.07	0.06	0.14
S15	<0.01	0.03	0.06	0.14

4.1 DESCRIPTION OF RESULTS

4.1.1 Chemical analysis of river water and effluent samples

The results of the chemical analysis of the river water and effluent samples taken upstream and downstream of the IFI site are presented in Tables 4.1 and 4.2.

Analysis of the river water samples taken upstream of the IFI facility (S1-S7, S13) highlighted the generally good chemical quality of the river water at these sampling stations. The levels of BOD, NO_3-N, NH_3-N, TKN and suspended solids were low. Samples S1-S7 exhibited low levels of lead and copper while zinc and iron were present in markedly higher quantities in these samples. Like the previous sampling occasion (8/2/95), the results also highlight elevated conductivity and NO_3-N levels in the sample from the stream entering the Avoca River downstream of the IFI bridge (S13). Sample S8, which was taken adjacent to the middle of the IFI site, exhibited increased levels of conductivity, NH_3-N, NO_3-N, and TKN. These results were similar to those recorded on the previous sampling occasion in that the NO_3-N (and on this occasion the NH_3-N and TKN levels) were significantly above the levels recorded at other sampling stations located upstream of the discharge pipe. This may again be attributed to tidal movements or currents in the vicinity of the outfall. The increased mobility of the nitrate ion is also demonstrated here.

The elevated levels of pH, conductivity and nitrogen (NO_3-N, NH_3-N, and TKN) in sample S9 highlights the signifigance of the discharge from the IFI facility. However, the results recorded in this sample are considerably lower than those recorded on the previous sampling occasion (8/2/95) despite the reduced dilution available in the river. This may be attributed to the decreased strength of the effluent on this sampling event or may be due to difficulty in obtaining similarly representative samples.

The chemical quality of the Avoca river downstream of the IFI discharge point was also examined (S10, S11, S12). The levels of conductivity and nitrogen (NO_3-N, NH_3-N, and TKN) were similar in samples S10, S11 and S12. However, the results of the inorganic analysis of these samples indicate that, while there was significant reductions in the contaminant levels recorded at sampling stations S10, S11 and S12, mixing was not quite complete (e.g. conductivity and NH_3-N levels remain slightly elevated).

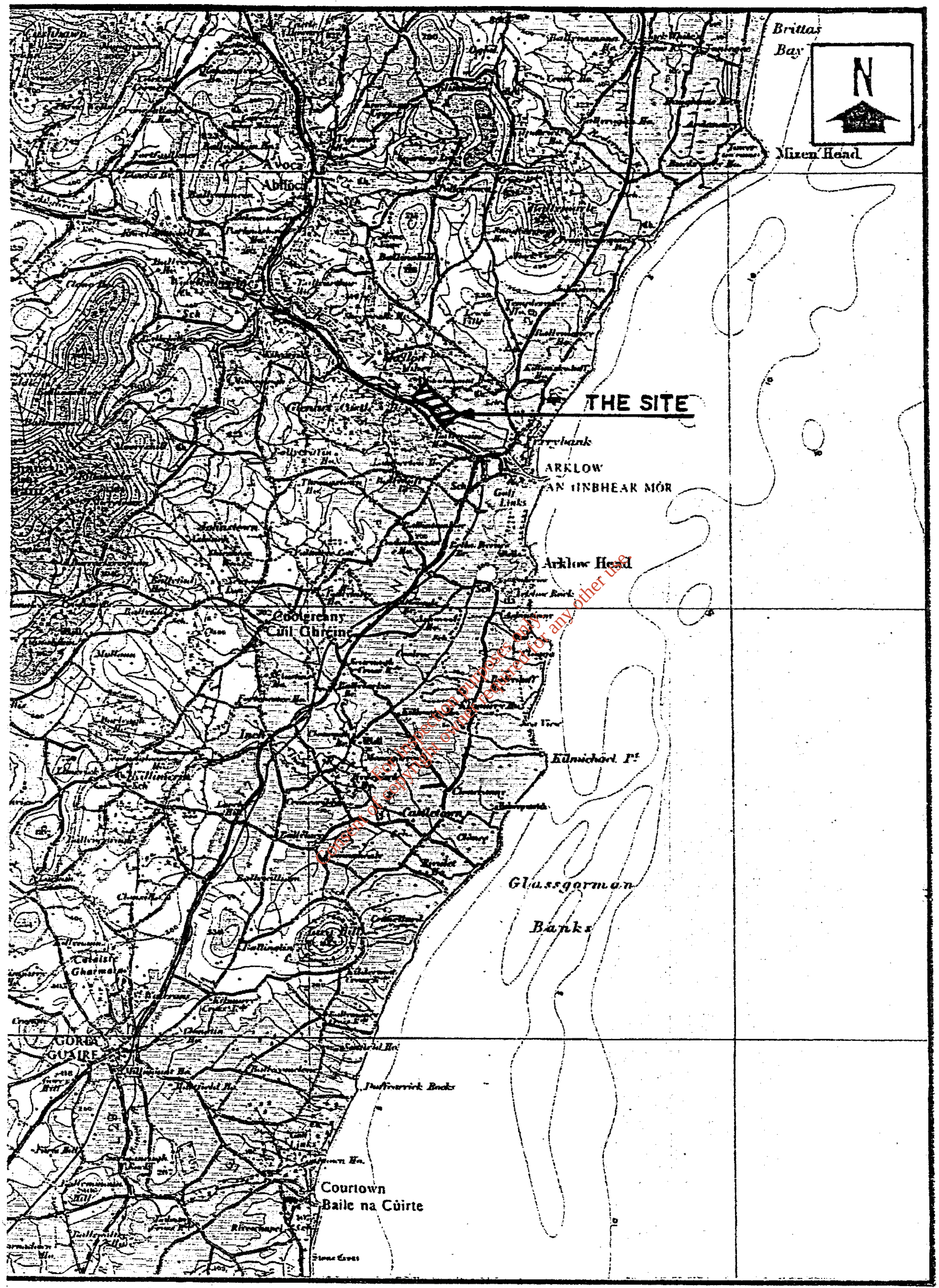
Samples S14 and S15 are representative of the IFI effluent prior to discharge to the nearby water course. The levels of pH, conductivity and nitrogen (NO_3-N, NH_3-N, and TKN) in both samples were extremely high and once again highlight the quality of the discharge.

The dilution available at the discharge, based on flow data for the Aughrim river and Avonmore river (April to June, 1990-1995) and assuming a typical average daily effluent flow of 4450m^3/d is 1:110. Once again, like the previous sampling occasion (8/2/95) this is an extremely conservative estimation and was made excluding the flow data for the Avonbeg river (no data available). The NH_3-N and NO_3-N loadings to the river on this sampling occasion were 4,699 kg/d (of which approximately 20% is in the unionised form) and 1,515 kg/d respectively. The contaminant plume is demonstrated in Appendix 4 and follows a similar pattern as in the previous sampling event. Migration of the plume occurs along the North bank and once again the presence of the rapid section downstream of the discharge point does not appear to facilitate good mixing. The final report will highlight in greater detail the mixing zone and assimilative capacity of the river.

It should be emphasised that the two sampling events described in previous sections indicate the initial situation at the site prior to the planned process upgradings at the factory. It is considered that the remaining evaluations (June, 1995, September 1995 and December 1995/January 1996) will demonstrate a significant improvement in the quality of the effluent and consequently the receiving water downstream of the discharge. An improvement in the biological status of the river is less likely.

APPENDIX 1

Location of site

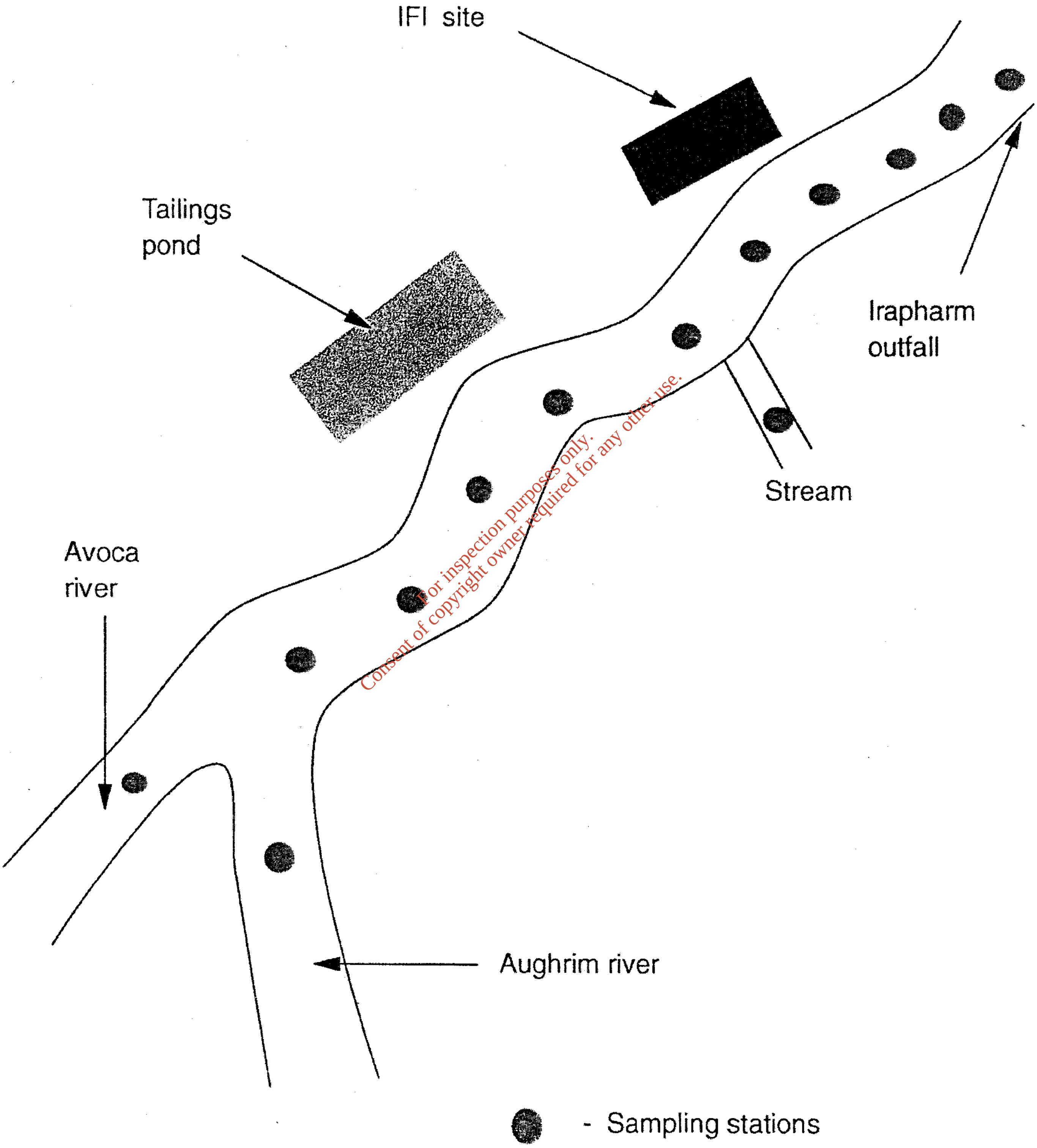


THE PERMISSION OF THE ORDNANCE SURVEY TO REPRODUCE MAPS IS ACKNOWLEDGED.

SCALE÷1:126, 720 (1/2" TO 1 MILE)

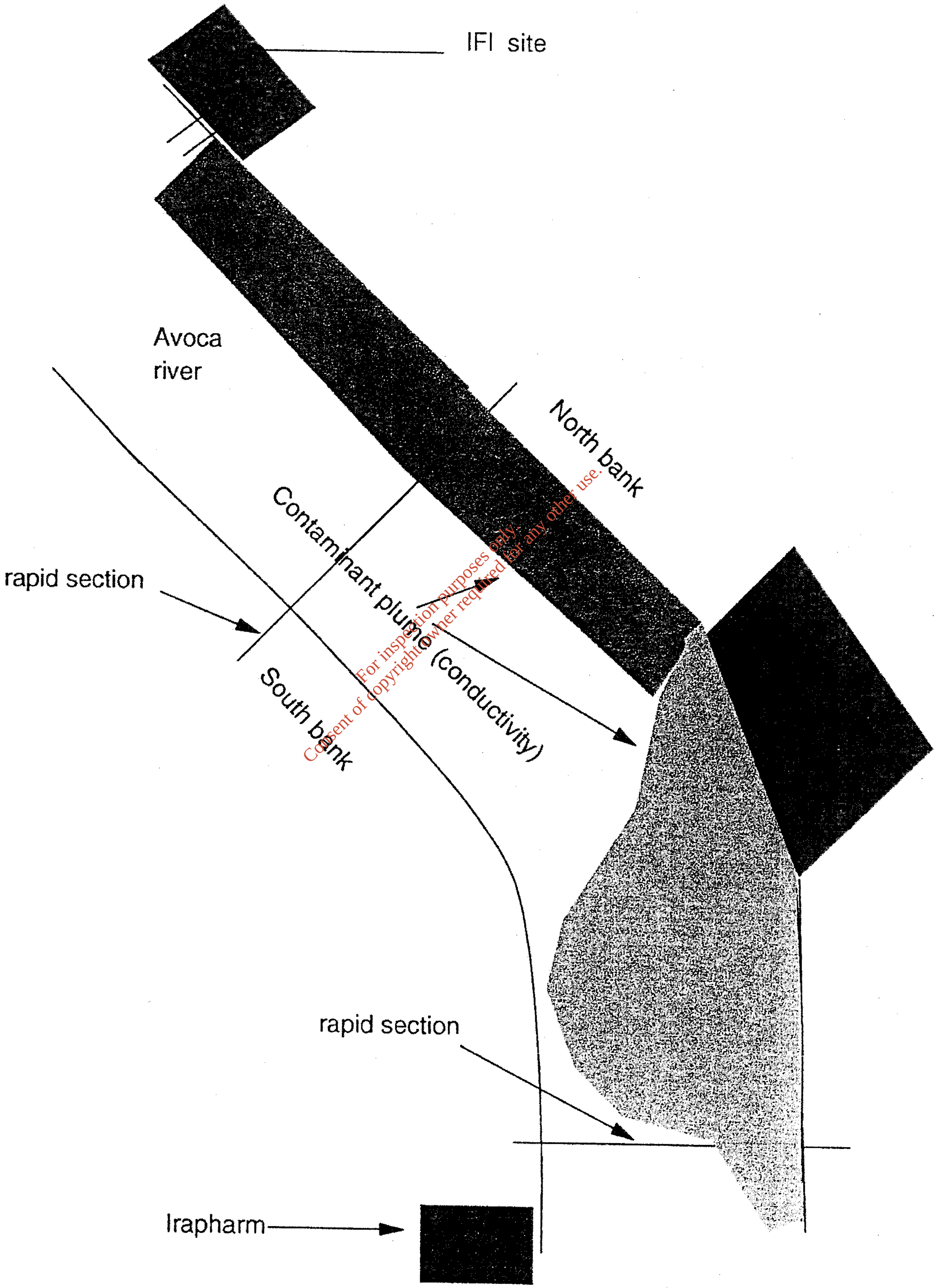
APPENDIX 2

Location of sampling stations


IFI site
Tailings pond
Irapharm outfall
Stream
Avoca river
Aughrim river
● - Sampling stations

APPENDIX 3

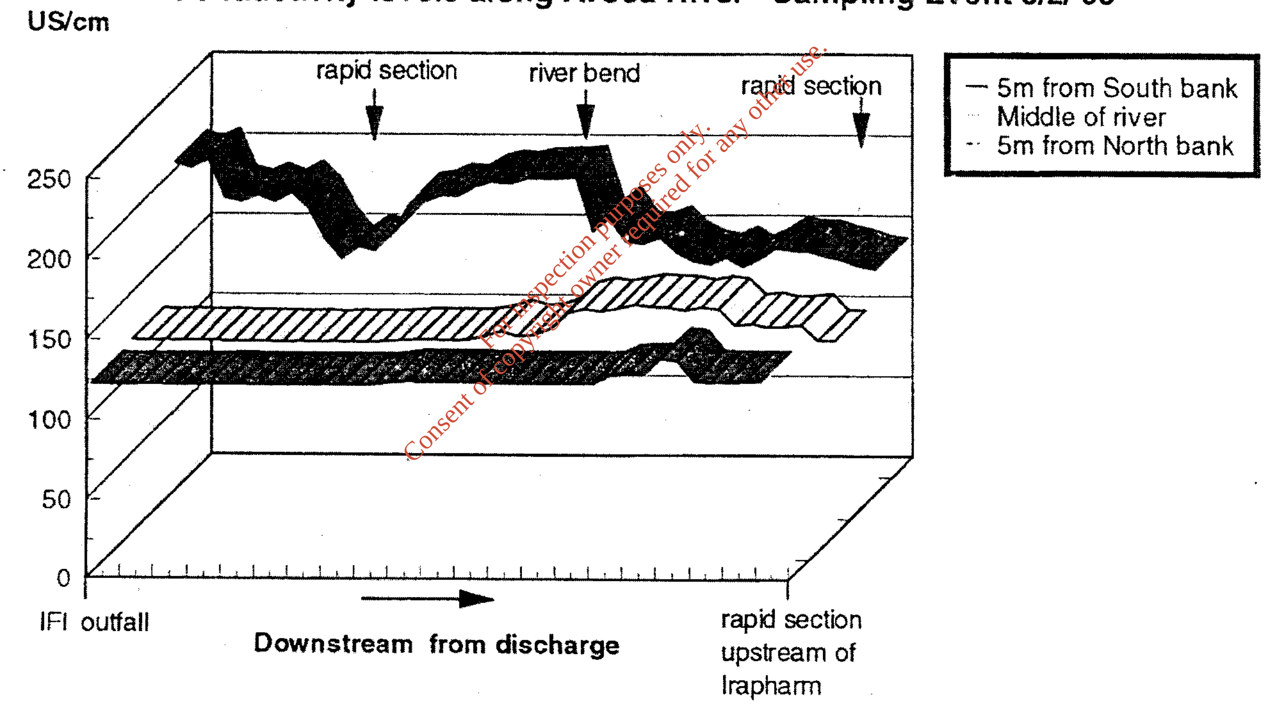
Schematic representation of conductivity plume along Avoca river


IFI site
Avoca
river
North bank
Contaminant plume (conductivity)
rapid section
South bank
rapid section
Irapharm

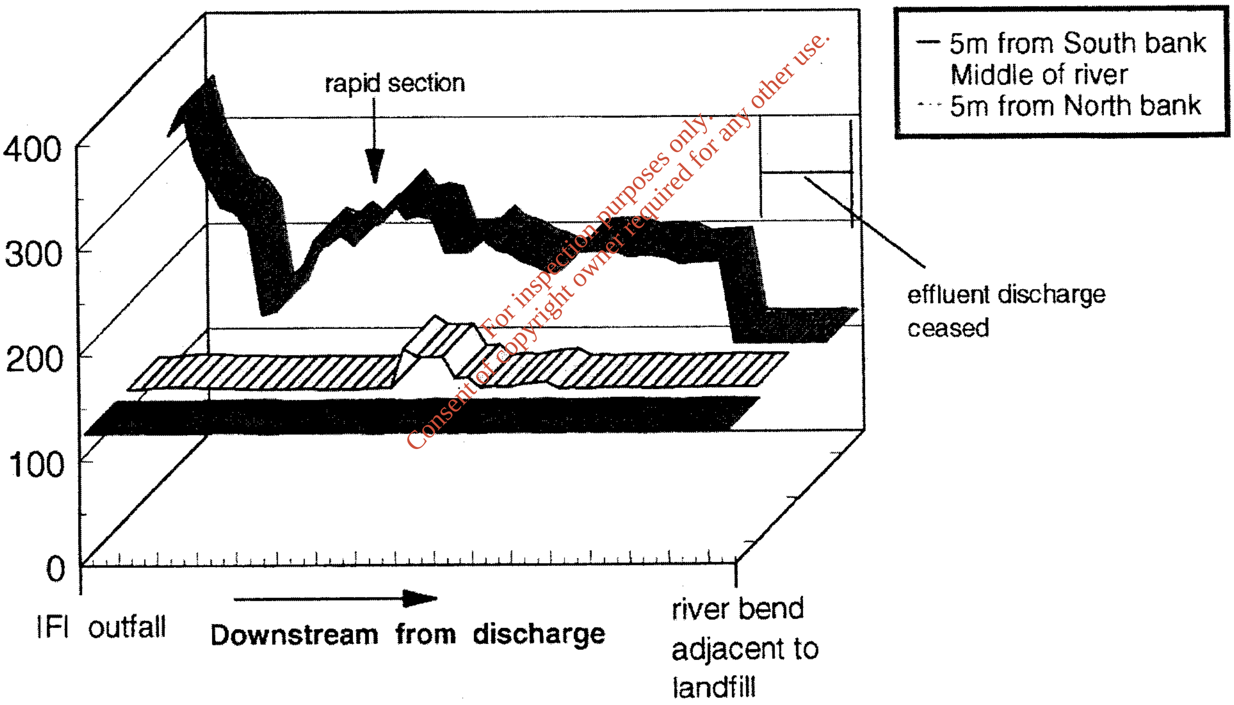
APPENDIX 4

Schematic representation of conductivity levels along Avoca River

Conductivity levels along Avoca River - Sampling Event 8/2/'95



Conductivity levels along Avoca River - Sampling Event 4/4/95



GROUND INVESTIGATIONS IRELAND
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APPENDIX 3 – EPA Licence Technical Amendment Data

PM
GROUP

File: 011258.04.160
EPA Ref: P0031-02/gc37ma.docx

Killakee House
Belgard Square
Tallaght
Dublin 24
Ireland

T +353 1 404 0700
F +353 1 459 9785
E dublin@pmgroup-global.com
www.pmgroup-global.com

17 January 2012

Environmental Licensing Programme (ELP),
Environmental Protection Agency (EPA),
P.O. Box 3000,
Johnstown Castle Estate,
Co. Wexford

Re: Technical Amendment (Section 96(1) of the EPA Acts) Request – IPPC Licence Register No. P0031-02

To Whom It May Concern:

In relation to our previous letter regarding a technical amendment request dated 12 October 2011, and subsequent to a discussion with Dr Magnus Amajirionwu, Inspector of the Office of Environmental Enforcement on 03 January 2012, we would like to submit an amended drawing for the redrawing of the IPPC licensed site boundary. This request concerns a proposed change to the IPPC licence boundary at the facility in Avoca River Park near Arklow, Co. Wicklow. The proposed IPPC site boundary is outlined in Drawing No. 011258-22-SK-0004 Issue B.

Please do not hesitate to contact me at 01 4040797 or by email at mags.dalton@pmgroup-global.com if you have any questions on the above or you wish to request additional information regarding. Alternatively we would be happy to meet to discuss, if required.

Yours sincerely,

Mags Dalton

EHS Manager

On behalf of Holfeld Plastics Limited

Cc Mr Edmund Holfeld (Holfeld Plastics Ltd.)
Mr Brian Kealy (Holfeld Plastics Ltd

ENVIRONMENTAL PROTECTION
AGENCY
18 JAN 2012

NOTES

LEGEND

- REVISED BOUNDARY OF HOLFELD PLASTICS LTD.

ENVIRONMENTAL PROTECTION AGENCY
18 JAN 2012

ISSUE	DESCRIPTION	DRN	ORIG	AUTH CHK	APP	DAT
B	REISSUED FOF INFORMATION	BD	FO'N	RO'D	FO'N	18/01/
A	FOR INFORMATION	BD	FO'N	RO'D	FO'N	08/08/

CLIENT HOLFELD PLASTICS LTD

PM GROUP

PROJECT EPA SUBMISSION

TITLE REVISED IPPC SITE BOUNDARY FOR HOLFELD PLASTIC LTD.

CLIENT REF.

CLIENT DRG No.

Headquarters
P.O. Box 3000
Johnstown Castle Estate
County Wexford
Ireland

TECHNICAL AMENDMENT B TO INTEGRATED POLLUTION PREVENTION & CONTROL LICENCE

Licence Register Number:	P0031-02
Licensee:	Holfeld Plastics Limited
Location of Installation:	Arklow County Wicklow

Reasons for the Decision

The Environmental Protection Agency is satisfied, on the basis of the information available, that subject to compliance with the conditions of Integrated Pollution Prevention and Control (IPPC) licence Reg. No. P0031-02 granted on the 10th March 2000, (and amended on 31st December 2008) as well as any amendments noted herein, any emissions from the activity will comply with and not contravene any of the requirements of Section 83(5) of the Environmental Protection Agency Acts, 1992 to 2011.

Technical Amendment

In pursuance of the powers conferred on it by Section 96(1)(c) of the Environmental Protection Agency Acts, 1992 to 2011, the Agency amends the licence, granted to Holfeld Plastics Limited, Avoca River Park, Arklow, County Wicklow.

Henceforth, the licence shall be read in conjunction with Amendment A issued on 31st December 2008, and the amendment set out below.

This technical amendment is limited to the following:

Amendments

Amend Condition 1.4 of the licence, to read as follows:

1.4 For the purposes of this licence, the installation authorised by this licence is the area of land outlined in broken red line on Drawing No. 011258-22-SK-0004 (Revision B) *'Revised IPPC Site Boundary for Holfeld Plastic Ltd.'*, received by the Agency on 18th January 2012.

Any reference in this licence to "installation" shall mean the area thus outlined in broken red line. The licensed activities shall be carried on only within the area outlined.

This technical amendment shall be cited as Amendment B to the licence.

Sealed by the Seal of the Agency on this the 18th day of May, 2012.

PRESENT when the seal of the Agency was affixed hereto

Mary Turner, Authorised Person

GROUND INVESTIGATIONS IRELAND
Geotechnical & Environmental

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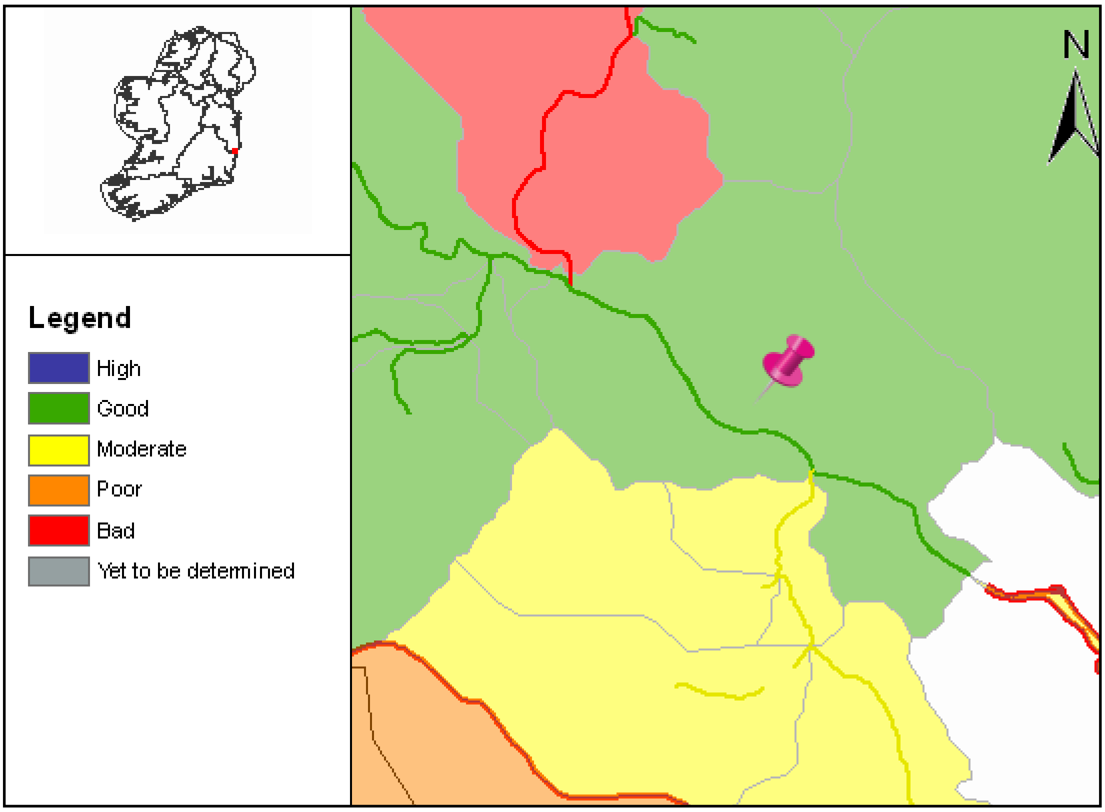
Email: info@gii.ie
Web: www.gii.ie

APPENDIX 4 – 2011 Holfeld Plastics AER

Full Report for Waterbody Avoca Lower



River Basin Management Plans (RBMPs) have been published for all River Basin Districts in Ireland in accordance with the requirements of the Water Framework Directive. The WaterMaps viewer is an integral part of the River Basin Management Plan and provides access to information at individual waterbody level and at Water Management Unit level for all the River Basin Districts in Ireland.

The following report provides summary plan information about the selected waterbody (indicated by the pin in the map above) relating to its status, risks, objectives, and measures proposed to retain status where this is adequate, or improve it where necessary. Waterbodies can relate to surface waters (these include rivers, lakes, estuaries [transitional waters], and coastal waters), or to groundwaters. Other relevant information not included in this report can be viewed using the WaterMaps viewer, including areas listed in the Register of Protected Areas.

You will find brief notes at the bottom of some of the individual report sheets that will help you in interpreting the information presented. More detailed information can be obtained in relation to all aspects of the RBMPs at www.wfdireland.ie.

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

water matters
'Our Plan'

Summary Information:

Water Management Unit:	IE_EA_Avoca
WaterBody Category:	River Waterbody
WaterBody Name:	Avoca Lower
WaterBody Code:	IE_EA_10_1611
Overall Status:	Good
Overall Objective:	Protect
Overall Risk:	1a At Risk
Heavily Modified:	No

Report data based upon final RBMP, 2009-2015.

The information provided above is a summary of the principal findings related to the selected waterbody. Further details and explanation of individual elements of the report are outlined in the following pages.

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

Status Report

Water Management Unit: IE_EA_Avoca

WaterBody Category: River Waterbody

WaterBody Name: Avoca Lower

WaterBody Code: IE_EA_10_1611

Overall Status Result: Good

Heavily Modified: No

	Status Element Description	Result
	Status information	
Q	Macroinvertebrate status	N/A
PC	General physico-chemical status	Good
FPQ	Freshwater Pearl Mussel / Macroinvertebrate status	N/A
DIA	Diatoms status	N/A
HYM	Hydromorphology status	N/A
FIS	Fish status	N/A
SP	Specific Pollutants status (SP)	N/A
ES	Overall ecological status	Good
CS	Overall chemical status (PAS)	n/a
EXT	Extrapolated status	N/A
MON	Monitored water body	YES
DON	Donor water bodies	N/A

n/a - not assessed

Status
By 'Status' we mean the condition of the water in the waterbody. It is defined by its chemical status and its ecological status, whichever is worse. Waters are ranked in one of 5 status classes: High, Good, Moderate, Poor, Bad. However, not all waterbodies have been monitored, and in such cases the status of a similar nearby waterbody has been used (extrapolated) to assign status. If this has been done the first line of the status report shows the code of the waterbody used to extrapolate.

You can read more about status and how it is measured in our RBMP Document Library at www.wfdireland.ie (Directory 15 Status).

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

Risk Report

Water Management Unit: IE_EA_Avoca

WaterBody Category: River Waterbody

WaterBody Name: Avoca Lower

WaterBody Code: IE_EA_10_1611

Overall Risk Result: 1a At Risk

Heavily Modified: No

	Risk Test Description		**Risk**
	Diffuse Risk Sources		
RD1	EPA diffuse model (2008)	2a	Probably Not At Risk
RD2a	Road Wash - Soluble Copper	2b	Not At Risk
RD2b	Road Wash - Total Zinc	2b	Not At Risk
RD2c	Road Wash - Total Hydrocarbons	2b	Not At Risk
RD3	Railways	2b	Not At Risk
RD4a	Forestry - Acidification (2008)	2b	Not At Risk
RD4b	Forestry - Suspended Solids (2008)	2b	Not At Risk
RD4c	Forestry - Eutrophication (2008)	2a	Probably Not At Risk
RD5	Overall Unsewered (2008)	2b	Not At Risk
RD5a	Unsewered Areas - Pathogens (2008)	2a	Probably Not At Risk
RD5b	Unsewered Phosphorus (2008)	2b	Not At Risk
RD6a	Arable	2a	Probably Not At Risk
RD6b	Sheep Dip	2b	Not At Risk
RD6c	Forestry - Dangerous Substances	2b	Not At Risk
RDO	Diffuse Overall -Worst Case (2008)	2a	Probably Not At Risk
	Hydrology		
RHY1	Water balance - Abstraction	2b	Not At Risk
	Morphological Risk Sources		
RM1	Channelisation (2008)	2b	Not At Risk
RM2	Embankments (2008)	2b	Not At Risk
RM3	Impoundments	2b	Not At Risk
RM4	Water Regulation	2b	Not At Risk
RM5	Intensive Landuse		N/A
RMO	Morphology Overall - Worst Case (2008)	2b	Not At Risk
	Overall Risk		
RA	Rivers Overall - Worst Case (2008)	1a	At Risk

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

	Point Risk Sources		
RP1	WWTPs (2008)	2b	Not At Risk
RP2	CSOs	2b	Not At Risk
RP3	IPPCs (2008)	2b	Not At Risk
RP4	Section 4s (2008)	2b	Not At Risk
RP5	WTPs/Mines/Quarries/Landfills		N/A
RPO	Overall Risk from Point Sources - Worst Case (2008)	2b	Not At Risk
	Q Value		
Q	EPA Q rating and Margaritifera Assessment		N/A
	Q/RDI or Point/Diffuse		
QPD	Q class/EPA Diffuse Model or worst case of Point and Diffuse (2008)	1a	At Risk
	Rivers Direct Impacts		
RDI1	Rivers Direct Impacts - Dangerous Substances		N/A

Risk
By 'risk' we mean the risk that a waterbody will not achieve good ecological or good chemical status/potential at least by 2015. To examine risk the various pressures acting on the waterbody were identified along with any evidence of impact on water status. Depending on the extent of the pressure and its potential for impact, and the amount of information available, the risk to the water body was placed in one of four categories: 1a at risk; 1b probably at risk; 2a probably not at risk; 2b not at risk. Note that '2008' after the risk category means that the risk assessment was revised in 2008. All other risks were determined as part of an earlier risk assessment in 2005.

You can read more about risk assessment in our 'WFD Risk Assessment Update' document in the RBMP document library, and other documents at www.wfdireland.ie (Directory 31 Risk Assessments).

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

Objectives Report

Water Management Unit:	IE_EA_Avoca
WaterBody Category:	River Waterbody
WaterBody Name:	Avoca Lower
WaterBody Code:	IE_EA_10_1611
Overall Objective:	Protect
Heavily Modified:	No

	Objectives Description	Result
	Objectives information	
OB1	Prevent deterioration objective	No Status
OB2	Restore at least good status objective	No Status
OB3	Reduce chemical pollution objective	No Status
OB4	Protected areas objective	Protect
OB5	Northern Ireland Environment Agency objective	No Status
OBO	Overall objectives	Protect

Extended timescales
Extended timescales have been set for certain waters due to technical, economic, environmental or recovery constraints. Extended timescales are usually of one planning cycle (6 years, to 2021) but in some cases are two planning cycles (to 2027).

Objectives
In general, we are required to ensure that our waters achieve at least good status/potential by 2015, and that their status does not deteriorate. Having identified the status of waters (this is given earlier in this report), the next stage is to set objectives for waters. Objectives consider waters that require protection from deterioration as well as waters that require restoration and the timescales needed for recovery. Four default objectives have been set initially:-

Prevent Deterioration
Restore Good Status
Reduce Chemical Pollution
Achieve Protected Areas Objectives

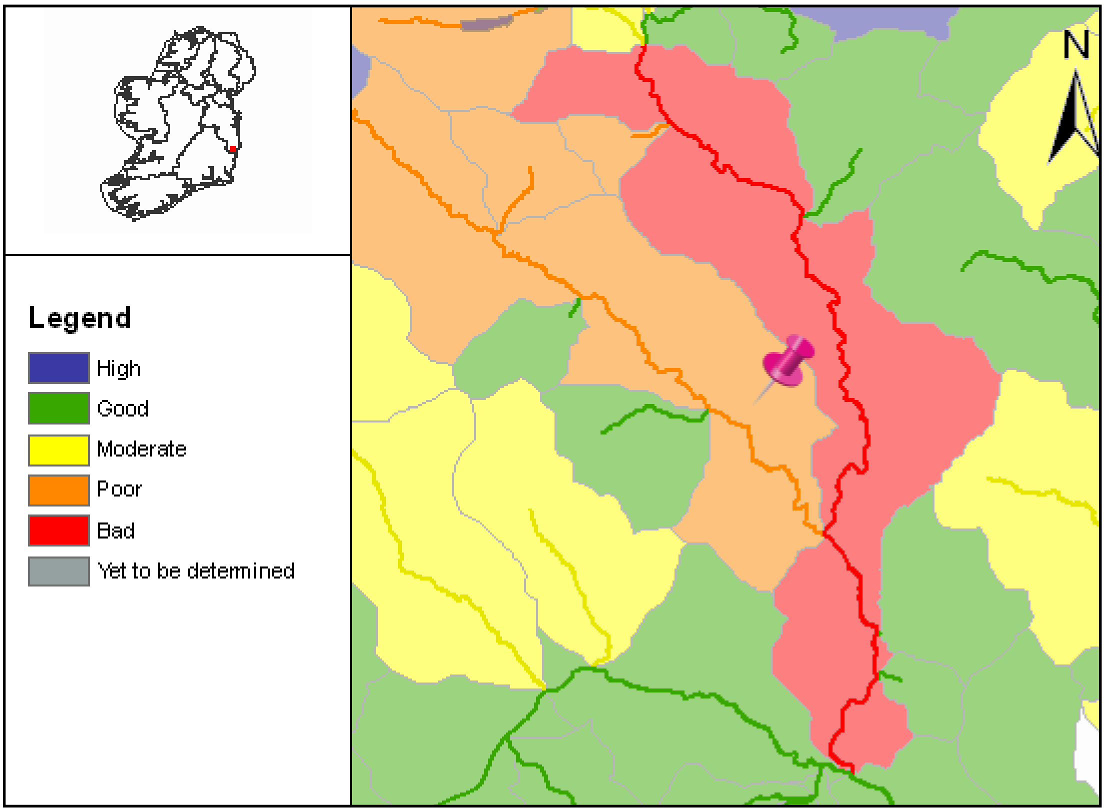
These objectives have been refined based on the measures available to achieve them, the latter's likely effectiveness, and consideration of cost-effective combinations of measures. Where it is considered necessary extended deadlines have been set for achieving objectives in 2021 or 2027.

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

water matters
'Our Plan'

Full Report for Waterbody Avoca Upper



River Basin Management Plans (RBMPs) have been published for all River Basin Districts in Ireland in accordance with the requirements of the Water Framework Directive. The WaterMaps viewer is an integral part of the River Basin Management Plan and provides access to information at individual waterbody level and at Water Management Unit level for all the River Basin Districts in Ireland.

The following report provides summary plan information about the selected waterbody (indicated by the pin in the map above) relating to its status, risks, objectives, and measures proposed to retain status where this is adequate, or improve it where necessary. Waterbodies can relate to surface waters (these include rivers, lakes, estuaries [transitional waters], and coastal waters), or to groundwaters. Other relevant information not included in this report can be viewed using the WaterMaps viewer, including areas listed in the Register of Protected Areas.

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Date Reported to Europe:July 2010

Date Report Created 21/11/2019

Summary Information:

Water Management Unit:	IE_EA_Avoca
WaterBody Category:	River Waterbody
WaterBody Name:	Avoca Upper
WaterBody Code:	IE_EA_10_1477
Overall Status:	Bad
Overall Objective:	Restore_2027
Overall Risk:	1a At Risk
Heavily Modified:	No

Report data based upon final RBMP, 2009-2015.

The information provided above is a summary of the principal findings related to the selected waterbody. Further details and explanation of individual elements of the report are outlined in the following pages.

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

Status Report

Water Management Unit:	IE_EA_Avoca
WaterBody Category:	River Waterbody
WaterBody Name:	Avoca Upper
WaterBody Code:	IE_EA_10_1477
Overall Status Result:	Bad
Heavily Modified:	No

	Status Element Description	**Result**
	Status information	
Q	Macroinvertebrate status	Bad
PC	General physico-chemical status	Good
FPQ	Freshwater Pearl Mussel / Macroinvertebrate status	N/A
DIA	Diatoms status	N/A
HYM	Hydromorphology status	N/A
FIS	Fish status	N/A
SP	Specific Pollutants status (SP)	N/A
ES	Overall ecological status	Bad
CS	Overall chemical status (PAS)	n/a
EXT	Extrapolated status	N/A
MON	Monitored water body	YES
DON	Donor water bodies	N/A

n/a - not assessed

Status
By 'Status' we mean the condition of the water in the waterbody. It is defined by its chemical status and its ecological status, whichever is worse. Waters are ranked in one of 5 status classes: High, Good, Moderate, Poor, Bad. However, not all waterbodies have been monitored, and in such cases the status of a similar nearby waterbody has been used (extrapolated) to assign status. If this has been done the first line of the status report shows the code of the waterbody used to extrapolate.

You can read more about status and how it is measured in our RBMP Document Library at www.wfdireland.ie (Directory 15 Status).

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

water matters
'Our Plan'

Risk Report

Water Management Unit: IE_EA_Avoca

WaterBody Category: River Waterbody

WaterBody Name: Avoca Upper

WaterBody Code: IE_EA_10_1477

Overall Risk Result: 1a At Risk

Heavily Modified: No

	Risk Test Description		**Risk**
	Diffuse Risk Sources		
RD1	EPA diffuse model (2008)	2a	Probably Not At Risk
RD2a	Road Wash - Soluble Copper	2b	Not At Risk
RD2b	Road Wash - Total Zinc	2b	Not At Risk
RD2c	Road Wash - Total Hydrocarbons	2b	Not At Risk
RD3	Railways	2b	Not At Risk
RD4a	Forestry - Acidification (2008)	2b	Not At Risk
RD4b	Forestry - Suspended Solids (2008)	2b	Not At Risk
RD4c	Forestry - Eutrophication (2008)	2a	Probably Not At Risk
RD5	Overall Unsewered (2008)	2b	Not At Risk
RD5a	Unsewered Areas - Pathogens (2008)	2a	Probably Not At Risk
RD5b	Unsewered Phosphorus (2008)	2b	Not At Risk
RD6a	Arable	2a	Probably Not At Risk
RD6b	Sheep Dip	2b	Not At Risk
RD6c	Forestry - Dangerous Substances	2b	Not At Risk
RDO	Diffuse Overall -Worst Case (2008)	2a	Probably Not At Risk
	Hydrology		
RHY1	Water balance - Abstraction	2b	Not At Risk
	Morphological Risk Sources		
RM1	Channelisation (2008)	2b	Not At Risk
RM2	Embankments (2008)	2b	Not At Risk
RM3	Impoundments	2b	Not At Risk
RM4	Water Regulation	2b	Not At Risk
RM5	Intensive Landuse		N/A
RMO	Morphology Overall - Worst Case (2008)	2b	Not At Risk
	Overall Risk		
RA	Rivers Overall - Worst Case (2008)	1a	At Risk

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

	Point Risk Sources		
RP1	WWTPs (2008)	1a	At Risk
RP2	CSOs	2b	Not At Risk
RP3	IPPCs (2008)	2b	Not At Risk
RP4	Section 4s (2008)	2b	Not At Risk
RP5	WTPs/Mines/Quarries/Landfills		N/A
RPO	Overall Risk from Point Sources - Worst Case (2008)	1a	At Risk
	Q Value		
Q	EPA Q rating and Margaritifera Assessment		N/A
	Q/RDI or Point/Diffuse		
QPD	Q class/EPA Diffuse Model or worst case of Point and Diffuse (2008)	1a	At Risk
	Rivers Direct Impacts		
RDI1	Rivers Direct Impacts - Dangerous Substances		N/A

Risk
By 'risk' we mean the risk that a waterbody will not achieve good ecological or good chemical status/potential at least by 2015. To examine risk the various pressures acting on the waterbody were identified along with any evidence of impact on water status. Depending on the extent of the pressure and its potential for impact, and the amount of information available, the risk to the water body was placed in one of four categories: 1a at risk; 1b probably at risk; 2a probably not at risk; 2b not at risk. Note that '2008' after the risk category means that the risk assessment was revised in 2008. All other risks were determined as part of an earlier risk assessment in 2005.

You can read more about risk assessment in our 'WFD Risk Assessment Update' document in the RBMP document library, and other documents at www.wfdireland.ie (Directory 31 Risk Assessments).

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

Objectives Report

Water Management Unit: IE_EA_Avoca

WaterBody Category: River Waterbody

WaterBody Name: Avoca Upper

WaterBody Code: IE_EA_10_1477

Overall Objective: Restore_2027

Heavily Modified: No

	Objectives Description	**Result**
	Objectives information	
OB1	Prevent deterioration objective	No Status
OB2	Restore at least good status objective	No Status
OB3	Reduce chemical pollution objective	No Status
OB4	Protected areas objective	Restore_2027
OB5	Northern Ireland Environment Agency objective	No Status
OBO	Overall objectives	Restore_2027

Extended timescales
Extended timescales have been set for certain waters due to technical, economic, environmental or recovery constraints. Extended timescales are usually of one planning cycle (6 years, to 2021) but in some cases are two planning cycles (to 2027).

Objectives
In general, we are required to ensure that our waters achieve at least good status/potential by 2015, and that their status does not deteriorate. Having identified the status of waters (this is given earlier in this report), the next stage is to set objectives for waters. Objectives consider waters that require protection from deterioration as well as waters that require restoration and the timescales needed for recovery. Four default objectives have been set initially:-

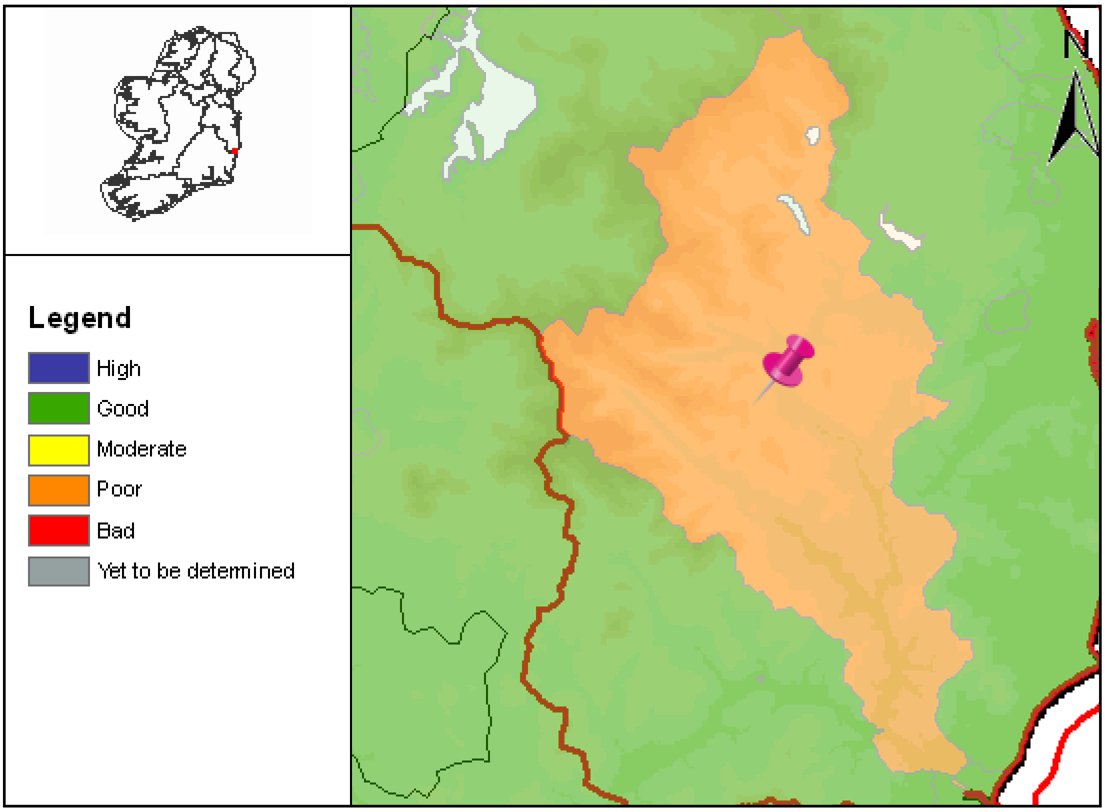
Prevent Deterioration
Restore Good Status
Reduce Chemical Pollution
Achieve Protected Areas Objectives

These objectives have been refined based on the measures available to achieve them, the latter's likely effectiveness, and consideration of cost-effective combinations of measures. Where it is considered necessary extended deadlines have been set for achieving objectives in 2021 or 2027.

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

Full Report for Waterbody Wicklow Central (Avoca Mine)



River Basin Management Plans (RBMPs) have been published for all River Basin Districts in Ireland in accordance with the requirements of the Water Framework Directive. The WaterMaps viewer is an integral part of the River Basin Management Plan and provides access to information at individual waterbody level and at Water Management Unit level for all the River Basin Districts in Ireland.

The following report provides summary plan information about the selected waterbody (indicated by the pin in the map above) relating to its status, risks, objectives, and measures proposed to retain status where this is adequate, or improve it where necessary. Waterbodies can relate to surface waters (these include rivers, lakes, estuaries [transitional waters], and coastal waters), or to groundwaters. Other relevant information not included in this report can be viewed using the WaterMaps viewer, including areas listed in the Register of Protected Areas.

You will find brief notes at the bottom of some of the individual report sheets that will help you in interpreting the information presented. More detailed information can be obtained in relation to all aspects of the RBMPs at www.wfdireland.ie.

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

Summary Information:

Water Management Unit: N/A

WaterBody Category: Groundwater Waterbody

WaterBody Name: Wicklow Central (Avoca Mine)

WaterBody Code: IE_EA_G_007

Overall Status: Poor

Overall Objective: LSO

Overall Risk: 1a At Risk

Heavily Modified: No

Report data based upon final RBMP, 2009-2015.

The information provided above is a summary of the principal findings related to the selected waterbody. Further details and explanation of individual elements of the report are outlined in the following pages.

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

Chemical and Quantitative Status Report

Water Management Unit:	N/A
WaterBody Category:	Groundwater Waterbody
WaterBody Name:	Wicklow Central (Avoca Mine)
WaterBody Code:	IE_EA_G_007
Overall Status Result:	Poor
Heavily Modified:	No

	Status Element Description	**Result**
	Status information	
INS	Status associated with saline intrusion into groundwater	N/A
DWS	Status associated with exceedances of water quality above specific standards	N/A
DS	Chemical status of groundwater due to pressure from diffuse sources of pollution	N/A
CLS	Chemical status of groundwater due to pressure from contaminated soil or land.	N/A
MS	Chemical status of groundwater due to pressure from mine sites (active or closed).	N/A
UAS	Chemical status of groundwater due to pressures from urban areas	N/A
GWS	General groundwater quality status	N/A
RPS	Status associated with MRP loading to rivers	N/A
TNS	Status associated with nitrate loading to transitional and coastal waters	N/A
SWS	Overall status associated with nutrient loadings to rivers and transitional and coastal waters	N/A
SQS	Status associated with dependant surface water quantitative status	N/A
GDS	Groundwater dependant terrestrial ecosystems status	N/A
QSO	Quantitative status overall	Good
CSO	Chemical status overall	Poor
OS	Overall status	Poor

GS -HC : Good status High Confidence
GS- LC : Good status Low Confidence
n/a - not assessed

Status
By 'Status' we mean the condition of the water in the waterbody. It is defined by its chemical status and quantitative status, whichever is worse. Groundwaters are ranked in one of 2 status classes: Good or Poor.

You can read more about status and how it is measured in our RBMP Document Library at www.wfdireland.ie (Directory 15 Status).

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

Risk Report

Water Management Unit:	N/A
WaterBody Category:	Groundwater Waterbody
WaterBody Name:	Wicklow Central (Avoca Mine)
WaterBody Code:	IE_EA_G_007
Overall Risk Result:	1a At Risk
Heavily Modified:	No

	Risk Test Description	**Risk**
	Groundwater Dependent Terrestrial Ecosystems	
TE	GWDTE Risk	N/A
	Groundwater Quality	
DIF	Diffuse Elements (General) Risk	N/A
DW	Drinking Waters Risk	N/A
INT	Intrusions Risk	N/A
WB	Water Balance Risk	N/A
	Groundwater Quality (General)	
GQ	General Groundwater Quality Risk	N/A
	Groundwater Quality (Point Risk)	
CL	Contaminated Land Risk	N/A
LF	Landfill Risk	N/A
MI	Mine Risk	N/A
QY	Quarry Risk	N/A
UR	Urban Risk	N/A
UW	UWWT Risk	N/A
	GW Diffuse Risk Sources	
WB3	Mobile Nutrients (NO3)	N/A
WB4	Mobile Chemicals	N/A
WB5	Clustered OSWTSs and leaking urban sewerage systems	N/A
	GW Hydrology	
WB1	Water balance - Abstraction	N/A
WB2	Abstraction - Intrusion	N/A

Date Reported to Europe:July 2010

Date Report Created 21/11/2019

	GW Point Risk Sources		
WB10	Risk from Point sources of pollution - Contaminated Land		N/A
WB11	Risk from Point sources of pollution - Trade Effluent Discharges		N/A
WB12	Risk from Point sources of pollution - Urban Wastewater Discharges		N/A
WB6	Risk from Point sources of pollution - Mines		N/A
WB7	Risk from Point sources of pollution - Quarries		N/A
WB8	Risk from Point sources of pollution - Landfills		N/A
WB9	Risk from Point sources of pollution - Oil Industry Infrastructure		N/A
	Overall Risk		
RA	Groundwater Overall - Worst Case		N/A
	Risk information		
CLR	Contaminated land risk	2a	Probably Not At Risk
DR	Risk of groundwater due to pressure from diffuse sources of pollution	2a	Probably Not At Risk
DWR	Risk associated with exceedances of water quality above specific standards	2b	Not At Risk
GDR	Groundwater dependant terrestrial ecosystems risk	2b	Not At Risk
GWR	General groundwater quality risk	1a	At Risk
INR	Risk associated with saline intrusion into groundwater	2b	Not At Risk
LR	Risk due to landfills sites/old closed dump sites	2b	Not At Risk
MR	Mines risk	1a	At Risk
NULL	Diffuse nitrates from agriculture risk		N/A
QR	Risk due to quarries	2b	Not At Risk
RA	Revised risk assessment	1a	At Risk
RPR	Risk associated with MRP loading to rivers	2a	Probably Not At Risk
SQR	Risk associated with dependant surface water quantitative status	2b	Not At Risk
SWR	Overall risk associated with nutrient loadings to rivers and transitional and coastal waters	2a	Probably Not At Risk
TNR	Risk associated with nitrate loading to transitional and coastal waters	2b	Not At Risk
UAR	Risk of groundwater due to pressures from urban areas	2b	Not At Risk
UWR	Risk due to direct discharges of urban wastewater	2b	Not At Risk

Risk
By 'risk' we mean the risk that a waterbody will not achieve good ecological or good chemical status/potential at least by 2015. To examine risk the various pressures acting on the waterbody were identified along with any evidence of impact on water status. Depending on the extent of the pressure and its potential for impact, and the amount of information available, the risk to the water body was placed in one of four categories: 1a at risk; 1b probably at risk; 2a probably not at risk; 2b not at risk. Note that '2008' after the risk category means that the risk assessment was revised in 2008. All other risks were determined as part of an earlier risk assessment in 2005.

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Date Reported to Europe:July 2010

Date Report Created 21/11/2019

Objectives Report

Water Management Unit: N/A

WaterBody Category: Groundwater Waterbody

WaterBody Name: Wicklow Central (Avoca Mine)

WaterBody Code: IE_EA_G_007

Overall Objective: LSO

Heavily Modified: No

	Objectives Description	Result
	Objectives information	
OB1	Prevent deterioration objective	No Status
OB2	Restore at least good status objective	LSO
OB3	Reduce chemical pollution objective	No Status
OB4	Protected areas objective	No Status
OBO	Overall objectives - objective	LSO

Extended timescales
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Objectives
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Date Reported to Europe:July 2010

Date Report Created 21/11/2019

GROUND INVESTIGATIONS IRELAND
Geotechnical & Environmental

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Newcastle,
Co. Dublin.
D22 YD52

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Email: info@gii.ie
Web: www.gii.ie

APPENDIX 5 – WFD Water Body Reports

GROUND INVESTIGATIONS IRELAND
Geotechnical & Environmental

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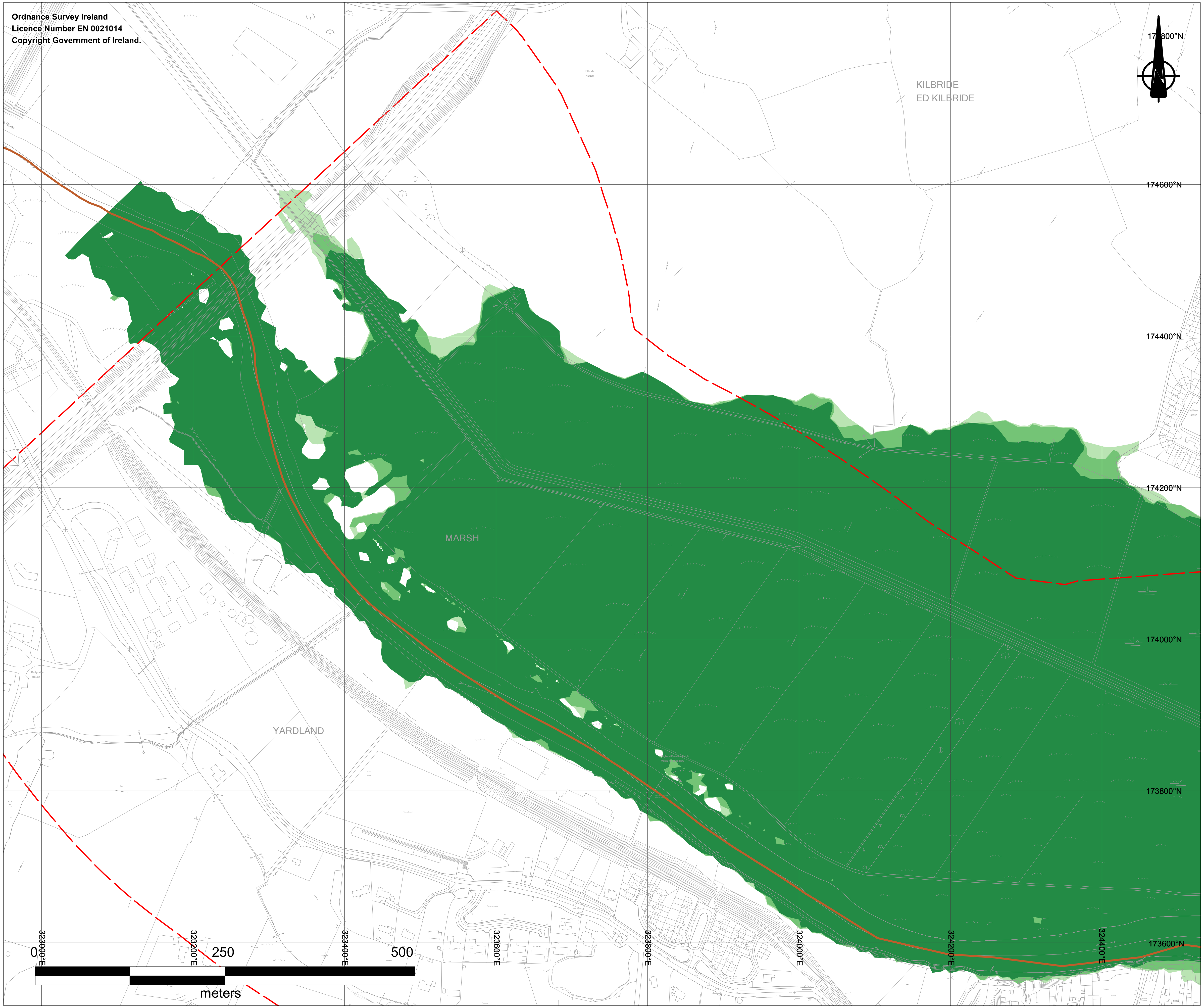
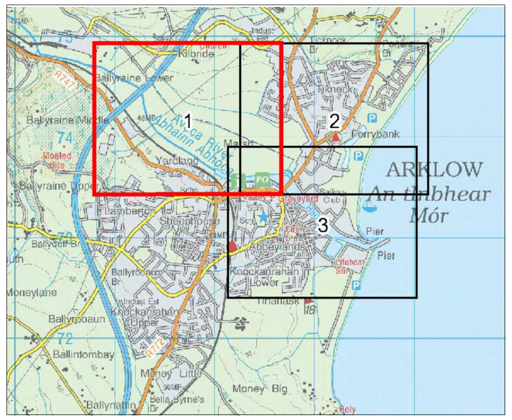
APPENDIX 6 – Flood Maps





Legend

- 🟩 10% AEP Tidal Extent
- 🟩 0.5% AEP Tidal Extent
- 🟩 0.1% AEP Tidal Extent
- — Modelled River Centreline
- ▭ AFA Boundary

IMPORTANT USER NOTE:-
THE VIEWER OF THIS MAP SHOULD REFER TO THE DISCLAIMER, GUIDANCE NOTES AND CONDITIONS OF USE THAT ACCOMPANY THIS MAP.

AVOCA RIVER (ARKLOW) FLOOD RELIEF SCHEME

BYRNELOOBY PHMcCARTHY

OPW
Oifig na nOibreacha Poiblí
The Office of Public Works

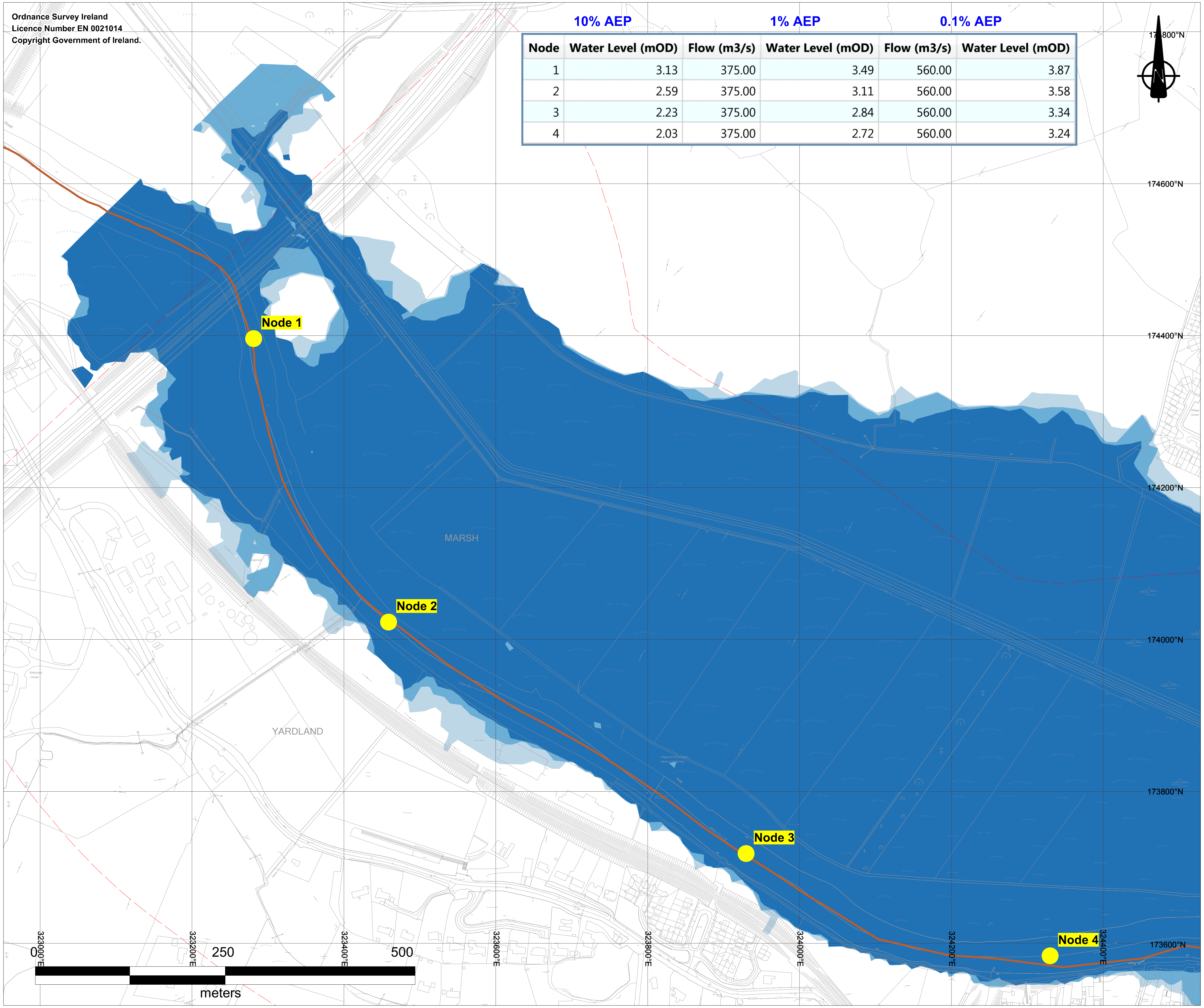
Map Title: ARKLOW COASTAL FLOOD EXTENT MAP

Type: EXTENT

Source: COASTAL

Scenario: CURRENT

Drawn NOB	Scale 1:5,000 @ A3	Map Number E10999_EXCCD_F0_01	Rev. F0
Chkd. SH	Date 29/07/16		
Apprd. KT	Status FINAL		



Ordnance Survey Ireland
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Copyright Government of Ireland.

	10% AEP		1% AEP		0.1% AEP
Node	Water Level (mOD)	Flow (m3/s)	Water Level (mOD)	Flow (m3/s)	Water Level (mOD)
1	3.13	375.00	3.49	560.00	3.87
2	2.59	375.00	3.11	560.00	3.58
3	2.23	375.00	2.84	560.00	3.34
4	2.03	375.00	2.72	560.00	3.24

Legend

▇	10% AEP Fluvial Extent
▇	1% AEP Fluvial Extent
▇	0.1% AEP Fluvial Extent
●	Node Point
—	Modelled River Centreline
▭	AFA Boundary

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AVOCA RIVER (ARKLOW) FLOOD RELIEF SCHEME

BYRNELOOBY PHMcCARTHY

OPW
Oifig na nOibreacha Poiblí
The Office of Public Works

Map Title ARKLOW FLUVIAL FLOOD EXTENT MAP
Type: EXTENT
Source: FLUVIAL
Scenario: CURRENT

Drawn NOB	Scale 1:5,000 @ A3	Map Number E10999_EXFCD_F0_01	Rev. F0
Chkd. SH	Date 27/07/16		
Apprd. KT	Status FINAL		