KNOCKHARLEY LANDFILL LTD.

ENVIRONMENTAL IMPACT ASSESSMENT REPORT (EIAR) FOR THE PROPOSED DEVELOPMENT AT KNOCKHARLEY LANDFILL

VOLUME 2 – MAIN EIAR

CHAPTER 12 – HYDROLOGY & SURFACE WATER QUALITY

NOVEMBER 2018

Knockharley Landfill Ltd.
Kentstown, Navan,Co.Meath

FEHILY TIMONEY & COMPANY

TABLE OF CONTENTS

Page

12 HYDROLOGY & SURFACE WATER QUALITY 1

12.1 Introduction 1
12.1.1 Study Area 1
12.2 Methodology 3
12.2.1 Relevant Guidance 3
12.2.2 Consultation 6
12.2.3 Other Sources 6
12.2.4 Desk Study 6
12.2.5 Field Assessment 7
12.2.6 Evaluation Criteria 7
12.3 Existing Environment 12
12.3.1 Site in Context 12
12.3.2 General Description of the Catchment 14
12.3.3 Existing Flooding in the Area 14
12.3.4 Existing Water Quality 20
12.3.5 Internal Site Drainage 30
12.3.6 Existing Facilities On-site 31
12.4 Proposed Development 33
12.4.1 Screening Berms and Temporary Stock Pile Areas 33
12.4.2 Southern Catchment 36
12.4.3 Northern Catchment 36
12.4.4 Stream Diversion 41
12.4.5 Flood Culvert and Stream Crossing 42
12.4.6 Wetland Outfall 42
12.4.7 Emergency Overflow Weir Storm Water Attenuation Lagoon 42
12.4.8 Temporary Crossing 43
12.5 Flood Risk Identification and Assessment 43
12.5.1 Overview of Storm Water Management Infrastructure. 43
12.5.2 Offset Flood Provision 46
12.5.3 Conclusion of Flood Risk Identification and Assessment 47
12.6 Potential Impacts 47
12.6.1 Do Nothing Impact 48
12.6.2 Potential Impacts during Construction 48
12.6.3 Potential Impacts During Operation and Maintenance 54
12.6.4 Potential Impacts Post Decommissioning 56
12.6.5 Potential Impacts of Flooding 56
12.6.6 Cumulative Impacts 56
12.6.7 Summary of Unmitigated Impacts on Hydrology and Surface Water Quality from the Proposed Development on Sensitive Receptors 56
12.7 Mitigation Measures 59
12.7.1 Proposed Mitigation Measures for the Construction Stage of the Proposed Development 59

TABLE OF CONTENTS - Cont'd...

Page

12.7.2 Proposed Mitigation Measures for the Operation Stage of the Proposed Development 61
12.7.3 Proposed Mitigation Measures for Decommissioning of the Development 62
12.8 Residual Impacts 62
12.9 Conclusion 66
12.10 References 66

LIST OF APPENDICES

Appendix 12-1: Southern Attenuation Pond LW14-821 Calc Set02
Appendix 12-2: Surface Water Management Plan
Appendix 12.3: Licence Compliance Surface Water Quality Results
Appendix 12.4: Northern Storm Water Management
Appendix 12.5: Flood Risk Assessment
Appendix 12-6: Hydrology Report

LIST OF TABLES

Page

TABLE 12-1: WFD STATUS AND EPA Q VALUES 5
TABLE 12-2: DESCRIPTION OF EFFECTS (2) 8
TABLE 12-3: CRITERIA ASSOCIATED WITH SIGNIFICANCE OF EFFECTS 10
TABLE 12-4: EPA MEASURED Q VALUES 21
TABLE 12-5: WFD MONITORING RESULTS 2009-2016 23
TABLE 12-6: IE LICENCE SURFACE WATER MONITORING LOCATIONS 26
TABLE 12-7: BASELINE SURFACE WATER QUALITY 26
TABLE 12-8: AVERAGES OF SURFACE WATER MONITORING RESULTS AT SW2 & SW6 2013- Q3 2018 28
TABLE 12-9: SUMMARY OF KEY HYDRAULIC DESIGN PARAMETERS 40
TABLE 12-10: SUMMARY OF PRELIMINARY CULVERT SIZING 40
TABLE 12-11: SUMMARY OF ESTIMATED INCREASE IN SURFACE WATER RUN-OFF VOLUMES 49
TABLE 12-12: OVERVIEW OF RUNOFF IMPACTS (EXISTING, CONSTRUCTION, OPERATION AND POST DECOMMISSIONING) 50
TABLE 12-13: SUMMARY OF POTENTIAL HYDROLOGICAL AND SURFACE WATER QUALITY IMPACT SIGNIFICANCE ON SENSITIVE RECEPTORS 57
TABLE 12-14: RESIDUAL HYDROLOGICAL AND WATER QUALITY IMPACT SIGNIFICANCE FOR SENSITIVE RECEPTORS 64

LIST OF FIGURES

FIGURE 12-1: WATERBODY CATCHMENT MAP 13
FIGURE 12-2: HYDROLOGICAL FEATURES MAP 18
FIGURE 12-3: OPW FLOOD DATA MAP (1:100 AND 1:1000) 19
FIGURE 12-4: WATER QUALITY MONITORING LOCATIONS 25
FIGURE 12-5: OPW MAINTAINABLE CHANNELS 32
FIGURE 12-6: PROPOSED DRAINAGE LAYOUT 35
FIGURE 12-7: SITE SPECIFIC FLOOD RISK ASSESSMENT – EXISTING SCENARIO AND PROPOSED SCENARIO FLOOD ZONES 44
FIGURE 12-8: CATCHMENT UPSTREAM OF PROPOSED FLOOD COMPENSATION CULVERT 45
FIGURE 12-9: ARTIST IMPRESSION OF NORTHERN STORM WATER MANAGEMENT AND FLOOD AREA 46

LIST OF PLATES

PLATE 12-1: CHART SHOWING TYPICAL CLASSIFICATION OF THE SIGNIFICANCE OF IMPACTS (2) 11

12 HYDROLOGY & SURFACE WATER QUALITY

12.1 Introduction

This chapter describes and assesses the potential impacts of the proposed development at Knockharley Landfill on the surrounding hydrological environment and the water quality within the study area. The receiving environment and the characteristics of the proposed development for construction and operation are described. The potential impacts of the proposed development during the construction and operation phases are evaluated, and the mitigation measures for these potential impacts are presented. The chapter concludes with the predicted residual impacts of the proposed development.

12.1.1 Study Area

The proposed development comprises:

- The acceptance of up to 435,000 tonnes per annum of non-hazardous wastes, which will comprise up to 150,000 tonnes of incinerator bottom ash (IBA), as well as household, commercial and industrial wastes including residual fines, non-hazardous contaminated soils, construction and demolition (C&D) wastes and baled recyclables. In addition, the acceptance of up to 5,000 tonnes per annum of stable non-reactive hazardous waste is proposed.
- The acceptance and placement within the existing permitted landfill footprint of incoming wastes for recovery or disposal as appropriate; the increase in height of the landfill body from the current permitted post settlement final contour height of 74 mOD to a post settlement contour height of 85 mOD – the proposed height increase will apply from the active landfill phase at the time of permission grant. Permission is sought for the acceptance of waste until the cells are full.
- The construction and operation of a dedicated IBA facility. Permission is sought to store IBA until recovery outlets are identified. Permission is sought for trials to prepare IBA for recovery and removal off site. The IBA facility will consist of 5 no. cells which will be constructed in accordance with the requirements of the Landfill Directive 99/31/EC for non-hazardous wastes. A final post settlement contour height of 85 mOD is proposed. Permission is sought for operation of the IBA facility until the cells are full and subsequent aftercare activities as may be required are complete. The development includes additional perimeter (haul) roads and screening berms.

  The IBA facility will comprise 1 no. portal frame building 76 m x 76 m x 15.5 m to facilitate:
  - weathering
  - metals recovery trials
  - crushing and washing to facilitate recovery trials and processing

- The construction and operation of a building for:
  - The extraction and biological treatment of the organic fraction of MSW (otherwise known as MSW 'fines' material) and;
  - contingency storage of baled recyclables
  - contingency storage of baled MSW

  This facility shall comprise:
  - a processing building of 108 m in length, 50 m in width and up to 17 m in height, of portal frame construction with 13 no. vehicle roller shutter doors and 7 or more pedestrian access doors (subject to fire certification requirements)
  - internal storage bays as required
  - 12 no. concrete composting tunnels located within the processing building of c. 6 m in width, 25m in length and 5 m in height
  - a covered bio-filtration unit within the overall processing building footprint, with a stack of height of 20 m
  - access from the internal site road with a marshalling yard area with egress from the existing site road to the landfill gas compound

- all other ancillary and associated works, including leachate storage in a below ground tank, bio-treatment system for sanitary wastewater drainage and fencing.

Permission is sought for the continued use of this building post filling of the landfill cells onsite.

- The construction and operation of a leachate management facility comprising:
  - 3 no. additional floating cover leachate storage lagoons (L2, L3 and L4) of c. 5,000 m^2 each
  - 2 no. bunded above ground tanks for raw leachate from IBA cells (S1 and S2) approximately 25 m diameter 6.0 m high.
  - 3 no. bunded above ground tanks:
    - 1 no. tank (S3) for treated leachate from landfill leachate approximately 22m diameter 6.0m high.
    - 1 no, tank for treated leachate from IBA approximately 25 m diameter 6.0 m high (S4).
    - 1 no. tank for leachate concentrate 16 m diameter by 6.0 m high (S5).
  - Modular - typically containerised plant units (C1 through C6), on concrete slab of c. 1,000 m^2 and 1 no. elevated tank 5 m diameter 10 m high (T1) with provision for 2 no. additional low level (<5.0 m high) bunded storage tanks for dosing and other compounds (T2 and T3).
  - Loading area for 2 no. 25 tonne articulated tankers.

  Permission is sought for the continued operation of this plant post filling of the landfill cells to facilitate continued leachate management.

- Construction of screening berms along the western planning boundary to a maximum of 10 m in height, on the eastern boundary to a maximum height of 10 m and on the northern boundary, to a maximum height of 6 m, with a total berm footprint of c. 11.3 ha. Haul roads for construction will be in or immediately adjacent to berm footprint.
- Construction of surface management infrastructure, with discharge to the adjacent Knockharley Stream to the northern end of the landfilling footprint and the proposed IBA cell development. Key elements will comprise:
  - holding pond for surface water runoff
  - storm water attenuation lagoon to maintain green field surface water discharges to Knockharley stream and to facilitate suspended solids management
  - wetland
  - flood compensation culvert to provide equivalent 1:1000-year flood plain storage
  - permitted stream diversion around permitted development

- Felling of c. 12.5 ha of the existing commercial broadleaf/conifer mix plantations to facilitate:
  - construction of the screening berms along the western boundary and to the north of the proposed IBA area, and
  - development of Phase 7 Cells 27 and 26 and the new northern surface water attenuation pond.

  Replanting and new planting totalling (c.16.8 ha) will off-set loss of commercial forestry in the proposed development footprint at the following locations:
  - replanting over screening berms
  - new planting on the cap over cells 25, 26, 27 and 28 in what is currently the permitted development

- Relocation of an existing 20 kVa overhead ESB powerline that provides power to the existing landfill facility administration buildings, that will be impacted by the development of the screening berm to the east of the proposed IBA cell area.
- Construction of an additional ESB sub-station and new overhead ESB supply to the north-western corner of the currently permitted landfill footprint to facilitate power provision for pumps and other infrastructure.

- Construction of a new ESB sub-station adjacent to the proposed building for biological waste treatment and storage with ESB connection to adjacent 20 kVA power lines.
- Extension of existing below ground infrastructure (permitted development) and provision of additional below ground infrastructure. (Power, water, telemetry, leachate rising mains, drainage). Extension of the existing car park for the administration area.

The proposed development is described in greater detail in Chapter 2 of Volume 2 of this EIAR.

Knockharley Landfill is located 1.5 km to the north of Kentstown village in County Meath.

The site ownership boundary encloses an area of 135 ha. The permitted landfill footprint is located in the centre of this land holding and occupies 25 ha. The layout of the existing development and the layout of the proposed development is shown in Drawing No. LW14-821-01-P-0000-002 Existing Site Layout and Drawing No. LW14-821-01-P-0000-003 Proposed Site Layout in Volume 4 of this EIAR.

12.2 Methodology

The following sources of information were considered in this assessment:

- the design layout of the proposed development
- published literature
- a desk-based assessment of the surface water hydrology and water quality in the catchments relevant to the proposed development, including an assessment of the watercourses which will be intercepted by the layout of the proposed development and those which will receive surface water run-off from the proposed development
- a field assessment of the existing hydrological environment, to both verify desk-based assessment and record all significant hydrological features
- a study of existing water quality sampling to determine the existing water quality

12.2.1 Relevant Guidance

The EIAR has been prepared in accordance with Schedule 6 of the Planning and Development Regulations 2001, as amended, and Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment were also considered (the 2014 EIA Directive).

The following guidelines were considered in the development of this chapter to identify relevant objectives relating to hydrology and surface water quality:

- Guidance Environmental Impact Assessment of Projects Guidance on the preparation of the Environmental Impact Assessment Report, 2018 (1)
- Guidelines on the information to be contained in Environmental Impact Assessment Reports, Draft 2017 (2)

Other reference documents used in the preparation of this section include the following:

- Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes, 2009 (3)
- Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Watercourses, 2016 (4)
- The Planning System and Flood Risk Management Guidelines for Planning Authorities, 2009 (5)

In addition to considering the relevant documents above the methodology for the baseline assessment has been devised with due consideration of the following:

- Meath County Development Plan 2013-2019 (6)
- Strategic Flood Risk Assessment, Variation 3 of Meath CDP 2013-2019, (7)
- Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a Framework for Community Action in the Field of Water Policy (8)
- Flood Mapping Website http://www.floodmaps.ie (9)
- OPW preliminary flood risk assessment (PFRA) indicative mapping website www.cfram.ie (10)
    - Fingal East Meath Flood Risk Assessment and Management Study http://fem.cfram.com/floodmaps.html
- Greater Dublin Strategic Drainage Study (GDSDS): Technical Documents of Regional Drainage Policies, March 2005 (11)
- Environmental Good Practice on Site - Construction Industry Research and Information Association (UK) (12)
- Best Practice Guide BPGCS005 Oil Storage Guidelines (13)
- Control of Water Pollution from Linear Construction Sites (C648) - Construction Industry Research and Information Association (UK) (14)
- Control of Water Pollution from Construction Sites. Guidance for Consultants and Contractors (C532) 2006 (UK) (15)
- Sustainable Construction Procurement. A Guide to Delivering Environmentally Responsible Projects (C571) 2001 (UK) (16)
- UK Pollution Prevention Guidelines (PPG):
    - PPG1: Understanding your environmental responsibilities – good environmental practice, 2013 (17)
    - GPPG: Above ground oil storage tanks, 2011 (18)
    - PPG3: Pollution Prevention Guidelines, 2006 (19)
    - GP4: Treatment and disposal of wastewater where is no connection to the public foul sewer, 2017 (20)
    - PPG5: Works and maintenance in or near water, 2017 (21)
    - PPG6: Working at construction and demolition sites, 2012 (22)
    - PPG7: The safe operation of refuelling facilities,2011 (23)
    - GPP8: Safe storage and disposal of used oils, 2017 (24)
    - GPP21: Pollution incident response plans, 2017 (25)
    - PPG22: Dealing with Spills, 2011 (26)
    - PPG26: Drums and intermediate bulk containers, 2011 (27)
- River Basin Management Plan for Ireland 2018-2021, 2017 (28)
- www.catchments.ie (29)
- Biological River Water Quality Data (30)
- Code of Best Forest Practice – Ireland, 2000 (31)
- Forestry and Water Quality Guidelines, 2000 (32)
- Forestry and Archaeological Guidelines, 2000 (33)
- Forest Harvesting and Environmental Guidelines, 2000 (34)

Water Framework Directive

The Water Framework Directive (WFD) (2000/60/EC) was adopted by the (then entitled) European Community in 2000. This Directive was transposed into Irish law from December 2003 by, *inter alia*, the European Communities (Water Policy) Regulations 2003, (S.I. No 722 of 2003) and subsequent amendments. The first cycle ran from 2009-2015. The Directive runs in 6-year cycles (2016-2021). A draft second cycle River Basin Management Plan was published for public consultation in August 2017 and the finalised second cycle River Basin Management Plan for Ireland 2018-2021 is in place.

The overriding purpose of the WFD is to achieve at least "good status" in all European waters and ensure that no further deterioration occurs in these waters. European waters are classified as groundwaters, rivers, lakes, transitional and coastal waters. The first cycle of river basin management planning, which covered the period 2009-2015, developed plans and associated programmes of measures on the basis of eight River Basin Districts (RBDs) within the island of Ireland. These plans set ambitious targets that envisaged that most water bodies would achieve good status by 2015.

This second cycle plan aims to build on the positive aspects of the first cycle and learn from those aspects which did not progress as well as expected which are summarised as three key learnings.

Firstly, it has been concluded that a single River Basin structure rather than eight River Basin districts will facilitate efficient use of resources and ensure a coherent national approach to similar issues.

Secondly, the implementation structures have been amended in the 2018-2021 plan to ensure better governance and delivery.

Thirdly, the targets in the first cycle were not realistic, the 2018-2021 plan sets targets that are based on sound evidence and are ambitious yet achievable. Where evidence does not exist, it shall be further developed over the course of the second cycle.

Water Framework Directive Waterbody Status

The European Communities Environmental Objectives (Surface Water) Regulations 2009 (S.I. No. 272 of 2009), as amended in 2009, 2012, 2015 (S.I. No. 296 of 2009, S.I. No. 327 of 2012, S.I. No. 386 of 2015) give effect to the criteria and standards to be used for classifying surface waters in accordance with the WFD. There are five categories of surface water status: 'High', 'Good', 'Moderate', 'Poor' and 'Bad'. The status is used to determine the degree of impact by human activities on water resources.

A surface water body must achieve both good ecological status and good chemical status before it can be considered to be of good status. The chemical status of a water body is assessed based on certain chemical pollutants. The ecological status is assessed based on Biotic Indices or Quality (Q) Values. The EPA scheme of Q Values and its relationship to WFD status is set out in Table 12.1.

Table 12-1: WFD Status and EPA Q Values

Q Value	WFD Status
Q5	High
Q4-5	High
Q4	Good
Q3-4	Moderate
Q3	Poor
Q2-3	Poor
Q2	Bad
Q1-2	Bad
Q1	Bad

In accordance with the regulations, waters classified as 'High' or 'Good' must not be allowed to deteriorate. Waters classified as less than good must be restored to at least good status within a prescribed timeframe.

The regulations also state that, for the purpose of classification, a status of less than good is assigned in the case of a water body where the environmental objectives for an associated protected area requiring special protection by virtue of obligations arising from specific national legislation for the protection of water, or for the conservation of habitats and species directly dependent on water, are not met.

Water Framework Directive Risk

A baseline risk assessment was completed of the water bodies within each River Basin District in 2005. This assessment involved using information on water pollution indicators, point and diffuse pollution sources, water abstraction and existing commercial activities. The risk assessment indicated whether the water body would meet the criteria for "good status" or would be considered "at risk" of not meeting the standards by 2015. This assessment provided the baseline information to prepare the first cycle River Basin Management Plan and Programme of Measures necessary to comply with the WFD standards. Following the completion of the first cycle, the status information shows that 55% of river water bodies achieved good or high status. The river basin characterisation process for the second cycle goes beyond the classification of status and assesses whether a water body is at risk of not meeting its objectives based on the review of such information such as water quality trends, catchment pressures and expert local knowledge. There are three categories of risk, 'not at risk', 'at risk' and review. Not at risk requires maintenance of the existing measures in place to maintain the satisfactory status. At risk waterbodies need new and often more targeted mitigation measures. Review waterbodies need more monitoring and assessment.

The following evidence-based prioritisation is proposed for this river basin planning cycle:

- Ensure full compliance with relevant EU legislation
- Prevent deterioration
- Meeting the objectives for designated protected areas
- Protect high status waters
- Implement targeted actions and pilot schemes in focus sub-catchments aimed at (i) targeting water bodies close to meeting their objective and (ii) addressing more complex issues which will build knowledge for the third cycle.

12.2.2 Consultation

The scope for this assessment has been informed by pre-application consultation with An Bord Pleanála, Meath County Council, prescribed bodies and other interested parties as summarised in Chapter 5 of Volume 2 of the EIAR.

This chapter considers the responses, regarding concerns relating to hydrology and surface water quality.

The comments expressed in particular by the Health Service Executive (HSE), Inland Fisheries Ireland (IFI), Irish Water, Office of Public Works (OPW) and An Taisce in written consultations received from them as part of the EIA process were considered in the preparation of this chapter.

12.2.3 Other Sources

Reference is also made to Chapter 2 Proposed Development, Chapter 10 Biodiversity and Chapter 11 Soils, Geology and Hydrogeology in Volume 2 of this EIAR. The drawings referenced in this chapter are included in Volume 4 of this EIAR.

12.2.4 Desk Study

The desk top study involved an examination of the hydrological aspects and water quality aspects of the following sources of information:

- current and historic ordnance survey Ireland mapping, and ortho-photography
- OPW indicative flood maps
- catchment flood risk assessment and management (CFRAM) studies maps
- study of existing surface water/drainage features in the
- review of the water framework directive online mapping and data (cycle 1 and cycle 2)[1]

[1] http://watermaps.wfdireland.ie/NsShare_Web/Viewer.aspx?Site=NsShare&ReloadKey=True and https://www.catchments.ie/maps/ and https://www.catchments.ie/data/#/?_k=7f514q

- review of the EPA online mapping[2]
- study of the proposed layout of the development
- liaison with geotechnical specialists for details on soil conditions on the site
- review of designated sites within 15km of the site
- study of planning documents for adjacent developments
- history of flooding and status of drainage in the neighbourhood
- review of consultation with interested bodies
- study of development plans
- review of baseline surface water monitoring results (2001-2003) and licence compliance monitoring results (2012-2017)

12.2.5 Field Assessment

Site walkover surveys took place on 27 July 2016 and 5 August 2016 to confirm the pattern of existing drainage on the site and to record any significant hydrological features. The site walkovers involved an initial review of available information gathered in the desk study phase followed by a site visit, findings of which are discussed in Section 12.3.5.

A permitted watercourse diversion to the north-western corner of the permitted development was deemed to be necessary to facilitate the construction of the permitted cells to ensure that the watercourse will run sufficiently clear of the construction works thus avoiding any impact on water quality in the stream.

There is an existing low point in the middle of 1:1000-year flood plain storage at the proposed location of the northern surface water attenuation pond. This area is covered in rushes but was dry at the time of the site visit. It is proposed to construct the surface water attenuation pond in the natural low-lying area, for both the permitted and proposed developments. This low-lying area provides flood plain storage during a 1:1000-year storm event. The flood plain footprint and proposed surface water attenuation pond is shown on Figure 12-6.

It is proposed to offset the lost storage by creating compensatory storage upstream of an existing and adjacent culvert within the Knockharley stream.

Water sampling is ongoing at the site in accordance with the existing licence and the sample results were examined to establish the existing water quality conditions.

The monitoring results are compared to the baseline results for the site, pre-development.

12.2.6 Evaluation Criteria

During each phase (construction, operation, maintenance and decommissioning[3]) of the proposed development, several activities will take place on site, some of which will have the potential to cause impacts on the hydrological regime at the site and the quality of surface water draining the site.

Assessment of Significance of Impact on the Receiving Environment

An impact rating has been developed for each of the phases of development. The sensitivity of the receiving environment was first identified. The sensitivity us understood as the sensitivity if the environmental receptor to change, including its capacity to accommodate the changes the project may bring about (1) Then the magnitude of the potential impact was estimated. The magnitude considers the characteristics of the change (timing, scale, size and duration of the impact) which would probably affect the target receptor as a result of the proposed project (1). The sensitivity rating, together with the magnitude of the potential impact, provides an overall rating of the significance of the impact prior to application of mitigation measures.

[2] http://gis.epa.ie/Envision

[3] There is a restoration and aftercare plan place in accordance with the licence and a fund has been established to accommodate aftercare costs including works and costs associated with decommissioning. The restoration and aftercare plan will be updated in accordance with the updated licence for the proposed development.

Sensitivity of Receptors

The sensitivity of an environmental receptor is based on its ability to absorb an impact without perceptible change. The hydrological environment is considered to be of low sensitivity due to the distance of the proposed development from the nearest environmentally designated sites, Laytown Dunes/Nanny Estuary proposed Natural Heritage Area (pNHA), Site Code 000554 and River Nanny Estuary and Shore Special Protection Area (SPA), Site Code 004158, which lie approximately 21 km by hydrological links to the west of the boundary of the proposed development at Knockharley Landfill site, at its nearest point. The WFD risk status of the receiving Flemingstown waterbody is "Review" (29), i.e. needing further investigation to assign the WFD risk status. The Flemingstown waterbody discharges to the Nanny Meath. The WFD risk status is "At Risk" (29) of deteriorating or being at less than good status in the future. The sensitivity of the water quality is considered to be low.

Assessment of Magnitude and Significance of Hydrological and Water Quality Impact

The assessment of the hydrological and water quality impacts examines the quality, significance, extent and context, probability and duration/frequency. A description of possible hydrological effects is presented in Table 12-2.

Table 12-3 gives examples of the criteria used to evaluate the significance if impacts.

Table 12-4 summarises the significant of the criteria.

Table 12-2: Description of Effects (2)

Quality of Effects	**Positive Effect** A change which improves the quality of the environment (for example, by increasing species diversity; or the improving reproductive capacity of an ecosystem or be removing nuisances or improving amenities). **Neutral Effects** No effects or effects that are imperceptible, within normal bounds of variation or within the margin of forecasting error. **Negative/Adverse Effects** A change which reduces the quality of the environment (for example, lessening species diversity or diminishing the reproductive capacity of an ecosystem; or damaging health or property or by causing a nuisance.
Describing the Significance of Effects	**Imperceptible** An effect capable of measurement but without significant consequences. **Not Significant** An effect which causes noticeable changes in the character of the environment but without significant consequences. **Slight Effects** An effect which causes noticeable changes in the character of the environment without affecting its sensitivities. **Moderate Effects** An effect that alters the character of the environment in a manner that is consistent with existing and emerging baseline trends. **Significant Effects** An effect which, by its character, magnitude, duration or intensity significantly alters a sensitive aspect of the environment.

	Very Significant Effects An effect which, by its character, magnitude, duration or intensity significantly alters most of a sensitive aspect of the environment. **Profound Effects** An effect which obliterates sensitive characteristics.
Describing the Extent and Context of Effects	**Extent** Describe the size of the area, the number of sites, and the proportion of a population affected by an effect. **Context** Describe whether the extent, duration, or frequency will conform or contrast with established (baseline) conditions.
Describing the Probability of Effects	**Likely Effects** The effects that can reasonably be expected to occur because of the planned project if all mitigation measures are properly implemented. **Unlikely Effects** The effects that can reasonably be expected not to occur because of the planned project if all mitigation measures are properly implemented.
Describing the Duration and Frequency of Effects	**Momentary Effects** Effects lasting from seconds to minutes. **Brief Effects** Effects lasting less than a day. **Temporary Effects** Effects lasting less than a year. **Short-term Effects** Effects lasting one to seven years. **Medium-term Effects** Effects lasting seven to fifteen years. **Long-term Effects** Effects lasting fifteen to sixty years. **Permanent Effects** Effects lasting over sixty years. **Reversible Effects** Effects that can be undone, for example through remediation or restoration. **Frequency of Effects** Describe how often the effect will occur (once, rarely, occasionally, frequently, constantly – or hourly, daily, weekly, monthly, annually).

Table 12-3: Criteria Associated with Significance of Effects

Significance	Criterion	Description and Example
Imperceptible	An effect capable of measurement but without significant consequences.	Temporary site works removed from watercourse carried out using appropriate surface water management practices.
Not Significant	An effect which causes noticeable changes on attribute but without significant consequences	No perceptible changes to the hydrology and water quality discharges to watercourse but no loss in quality, fishery productivity or biodiversity. No increase in flood risk. Example - change in surface runoff input to stream from diffuse source to point source or minor realignment of water course, maintenance works
Slight effect	An effect which causes noticeable changes in the character of the environment without affecting its sensitivities.	Detectable but non-material and transitory changes to the hydrology and water quality - measurable change in attribute, but of limited size and/or proportion. Example - remedial works to a watercourse requiring works within the channel carried out using appropriate surface water management practices.
Moderate effect	An effect that alters the character of the environment in a manner that is consistent with existing and emerging baseline trends.	Short to medium term changes to the hydrology and water quality loss in productivity of a fishery. Contribution of significant sediment and nutrient quantities in the receiving water, but insufficient to change its water quality status. Example – Earthworks carried out adjacent to or within a watercourse in the absence of appropriate working practices
Significant	An effect which, by its character, magnitude, duration or intensity significantly alters a sensitive aspect of the environment.	Long term changes to the hydrology and water quality Examples - change in water quality status of river reach, loss of flood storage/increased flood risk, pollution of potable source of abstraction.
Very Significant	An effect which, by its character, magnitude, duration or intensity significantly alters most of a sensitive aspect of the environment.	Long term changes to the hydrology and water quality Examples - change in water quality status of river reach, loss of flood storage/increased flood risk, pollution of potable source of abstraction. The extent of impact is greater than 'Significant impact'
Profound	An effect which obliterates sensitive characteristics.	Long term and irreversible change to the hydrology or water quality. Results in loss or extensive change to a water body or habitat.

Potential impacts are assessed as being of profound, very significant, significant, moderate, slight, not significant or imperceptible. Plate 12.1 is a typical classification of the significance of impacts.

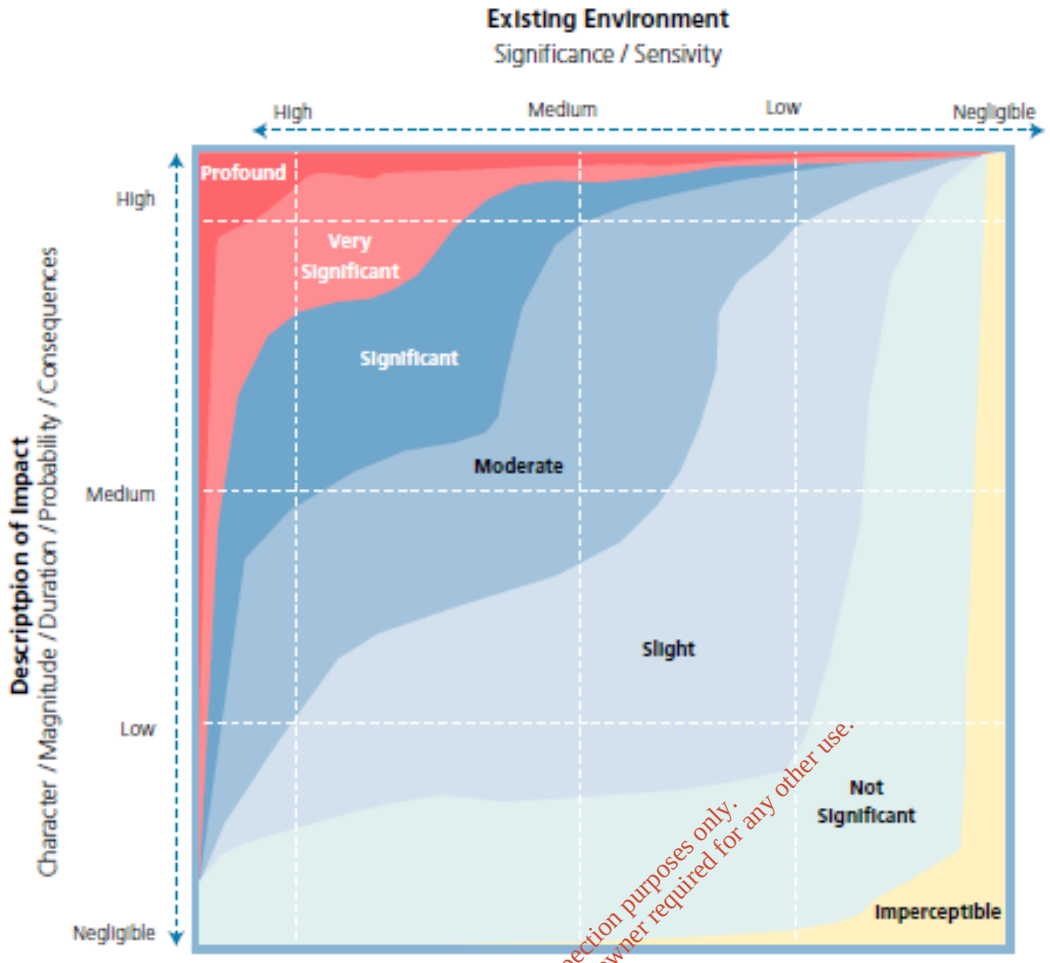


Plate 12-1: Chart showing typical classification of the significance of impacts (2)

A summary of unmitigated potential impacts and the associated significance rating due to the proposed development is provided in Table 12.11 in Section 12.6.6. The residual impacts following mitigation and the associated significance rating are provided in Table 12.14 in Section 12.7.

As part of the evaluation of the site for the proposed development, a flood risk identification and assessment was carried out as discussed in Section 12.5. Landfill development is considered 'Highly Vulnerable' development, as described in Table 3.1 of the guidelines produced by the Department of Environment, Heritage and Local Government (5). This type of development is not appropriate in a Flood Zone A or a Flood Zone B area (where there is a risk of flooding in a 1 in 100-year return period flood or a 1 in 1000-year return period flood) unless it passes a Justification Test (See Appendix 12.5 In Volume 3 of this EIAR). Any potential increase in surface water run-off due to the development in areas deemed to be already at risk of flooding will be examined as part of the impact evaluation in this chapter and mitigation measures will be proposed where required.

In all cases where required, a cumulative flood risk assessment will be undertaken.

12.3 Existing Environment

12.3.1 Site in Context

Prior to development as a landfill, the land was used for agriculture and a network of field drains were installed to improve the land.

A detailed description of the existing surface water regime is included in Appendix 12.6 Hydrological Study of Volume 3 of this EIAR.

The capacity of the existing surface water attenuation pond is described in Appendix 12.1 of Volume 3 of this EIAR.

Figure 12-1 shows the water body catchment map. The Knockharley or Flemingstown stream entering the site from the western boundary at Knockharley is a 1st order tributary of the River Nanny. The stream is not salmonid. It flows from the west in an easterly direction. The stream emerges from a 1.0 m diameter circular concrete culvert at the western boundary. The stream flows into an open channel just upstream of the location of a permitted culvert through a screening berm. The stream continues in an easterly direction and then runs along part of the eastern boundary of the site, continuing southwards to meet the River Nanny via the Knockharley or Flemingstown Stream, 2.89 km south of the site boundary. The existing surface water pond discharges to the Knockharley or Flemingstown Stream south of the wetland. A second tributary, the Kentstown Stream flows east along the southern licensed boundary before turning south and joining the Veldonstown Stream, just upstream of its confluence with the Knockharley or Flemingstown Stream.

The site is sloped with elevations ranging from 70 mOD in the north west to 55 mOD in the south east of the site. The site is a mix of, constructed landfill and associated facilities with some woodland and wet grassland.

The site has a water shed running east to west with natural outfalls to the south and north, this is shown in Figure 12-2.

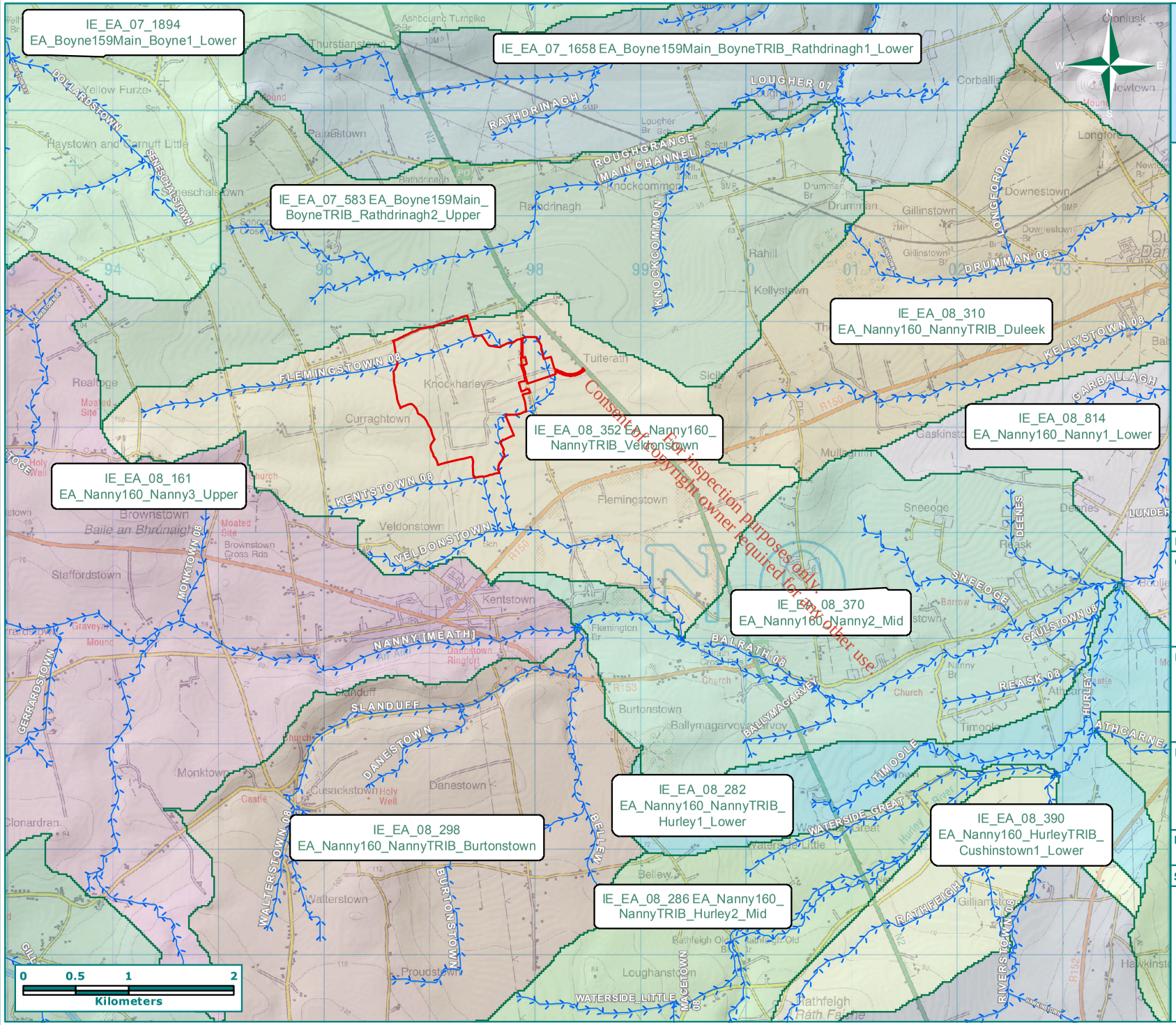
The Geological Survey of Ireland (GSI) website (www.gsi.ie) provides information on subsoils and the underlying aquifer for the site. The overburden soil at the Knockharley Landfill site is mainly Shale and Sandstone Till with some Limestone Till to the south of the site. There is evidence of alluvium along the line of the existing stream to the north of the site and along the line of an old stream which was rerouted to facilitate the original landfill development to the south, as shown in Figure 11.1 in Chapter 11 Soils, Geology and Hydrogeology in Volume 2 of this EIAR. Alluvium can be an indicator of historic flooding.

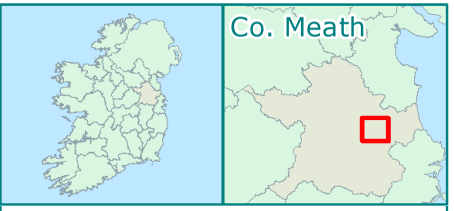
The aquifer is classed as *Low Vulnerability*, as shown in Figure 11.5 in Chapter 11 Soils, Geology and Hydrogeology of Volume 2 of this EIAR and is therefore at a low risk of contamination from activities taking place at the ground surface. Chapter 11 of Volume 2 of this EIAR advises the groundwater is most susceptible to contamination during excavation of cells. However, given that significant overburden will remain in place this risk was considered to be low.

As discussed in Section 12.2.5, the drainage from the proposed development is at a distance of approximately 21 km by hydrological links to any environmentally protected areas. These environmentally designated areas are discussed further in Chapter 10 Biodiversity of Volume 2 of this EIAR.

There are no other sites which are designated for environmental protection within 15 km downstream which would be categorised as sensitive receptors with hydrological links to the proposed development site.

The hydrological features within the site are shown in Figure 12.2 and described in Section 12.3.6.





Legend

- Site Boundary
- Water Framework Directive (Cycle 1) River Sub-basins
- Rivers

Date	18/05/2018
Client Name	Knockharley Landfill Ltd.
Project Title	Proposed Development at Knockharley Landfill
Figure Title	Waterbody Catchment Map
Figure No.	12.1
Rev.	A
Scale	1:50,000 @ A4

FEHILY TIMONEY & COMPANY
CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES
Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464
Unit 16J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501
W: www.fehilytimoney.ie E: info@ftco.ie

12.3.2 General Description of the Catchment

The average annual rainfall (1981 – 2010) in the area of the proposed development is 929 mm[1].

The proposed development site lies within Hydrometric Area HA 08 known as the Catchment of Nanny-Delvin of the Irish River Network and is under the new single River Basin Management Plan for Ireland which is the responsibility of the Water Policy Advisory Committee. The Midlands and Eastern Water and Environment Committee will have responsibility for regional delivery and implementation. The site is situated within the waterbody catchment as defined by the EU Water Framework Directive (WFD - 2000/60/EC) (8), and as shown in Figure 12.1. Waterbody Catchment Map[4]. The risk status and water quality of riverbodies are taken from www,catchments.ie.

Under cycle 2, the relevant:

- Catchment is Nanny-Delvin IE_EA_08_352
- Sub catchment is Nanny Meath SC 010,
- Riverbody is Flemingstown 08_010

Under cycle 1, the relevant:

- River Waterbody is Veldonstown IE_EA_08_352EA_Nanny160_NannyTRIB_Veldonstown.

The river body associated with the proposed development is described in more detail below.

The WFD risk status of the Flemingstown riverbody is "review". The water quality is high.

The northern boundary of the landholding within the site boundary is on the boundary of a second waterbody catchment:

- under Cycle 2 the Boyne SC_10 and the riverbody Roughgrange (Main Channel) 010, and
- under Cycle 1, the river body IE_EA_07_583EA_Boyne159Main_BoyneTRIB_Rathdrinagh2_Upper.

The WFD risk status of the Roughgrange riverbody is "review" and the risk score is subject to review (meaning further investigation is required to assign status as "at risk" or "not at risk". The river water quality status is unassigned.

Veldonstown IE_EA_08_352 Waterbody (cycle 1)

The Knockharley or Flemingstown stream entering the site from the western boundary at Knockharley is a 1st order tributary of the River Nanny. The River Nanny rises to the east of Navan in County Meath and flows in an easterly direction to the Nanny Estuary (status unassigned) at Laytown.

The entire area of the site drains to the tributary of the River Nanny as illustrated in Figure 12.1. The surface water run-off within this catchment drains generally in a south easterly direction to this tributary.

The Veldonstown sub-catchment of the River Nanny has an area of 10.75 km^2 up to where it joins the River Nanny in Balrath.

12.3.3 Existing Flooding in the Area

The national flood hazard mapping website, www.floodmaps.ie (9), indicates a number of historical flooding events in the vicinity of the site as can be seen on Figure 12.3 OPW Flood Maps.

[4] Cycle 1 mapping is used from www.watermaps.wfd.ie as it provides more information on stream order than cycle 2 mapping from catchments.ie.

A copy of the flood map report which summarises all flood events within 2.5 km of the Knockharley site is available in Appendix 12.4 Attenuation Pond Design of Volume 3 of this EIAR. Of the five flood incidents listed, none of these occurred on the Knockharley Stream up to its confluence with the River Nanny. One of the flood incidents occurred approximately 0.75 km downstream of the confluence at Balrath Cross Roads, with events recorded in 2007 and 2009. Photographs are provided on the website for both incidents showing flooded lands adjacent to the River Nanny from Balrath downstream to Duleek.

Minutes of the Area Engineer's meeting in 2005 listed flood events including at Balrath Cross Roads on N2/R153 as follows– *Some of the arches of the Nanny Road Bridge are blocked and bridge does not have the capacity for volume of water. N2 flood January 2005. Flood occurs 1 to 2 times a year* (Flood Id = 696).

There are no areas defined as 'benefitting lands'[5] in the OPW flood hazard mapping website indicated at the Knockharley site or on lands adjacent to the stream up to its confluence with the River Nanny.

Although there are no recorded flood events along the route of the Knockharley Stream, there is evidence of alluvium along the banks of the stream as discussed in Section 12.3.1. which would suggest that the stream may have overtopped its banks historically.

The OPW has produced indicative flood mapping to assist in a preliminary flood risk assessment (PFRA) on its website www.cframs.ie (10). These maps were produced by the OPW from several sources. The indicative flood mapping indicates Flood Zone A areas i.e. an area with a probability of flooding in a 1 in 100-year flood, as shown in Figure 12.3. OPW Flood Data Map, outside the site boundary coinciding with the stream to the north east of the site and downstream of the site to the south of the wetland area along the course of the stream.

An area with a 1 in 1000 probability of a flood event occurring, or a 0.1% annual exceedance probability (AEP), i.e. a Flood Zone B area, is also shown in Figure 12.3 of this EIAR in the footprint where further development is proposed. However, the surface water from lands draining towards this area has been diverted as part of earlier planning applications. A hydrological study prepared by FT (see Volume 2 Chapter 12 Surface Water Appendix 12-6 of this EIAR) found:

- The current course of the Knockharley Stream can cater for a 1 in 100-year flood event without overtopping the river bank.
- The 1 in 1000-year flood will exceed the Knockharley stream banks in the vicinity of the proposed development area.
- The current footprint of the landfill development avoids flood Zone A areas.
- The proposed development provides compensatory flood zone storage in the event of a 1 in 1000-year flood event.

The site-specific areas where possible pluvial flooding has been identified are presented in Figures 12.3 and 12.7. The process for developing the pluvial flood extent maps was based on 'dropping' various depths and intensities of rainfall over a range of durations and modelling how that rainfall would flow over the land and, pond in low-lying areas. The areas are either:

- part of the existing development on site
- coincide with the location of the proposed surface water attenuation pond and holding pond at the low point of the site.

Therefore, this proposed development will not be affected by a pluvial flood risk.

More detailed mapping is available from the Fingal East Meath Flood Risk and Management Study (FEMFRAMS) which indicates a Flood Zone B area i.e. an area with a probability of flooding in a 1 in 1,000-year flood. This area is indicated in and adjacent to the permitted landfill area, where further development is proposed, however, the surface water from lands draining towards this area has been diverted as part of earlier planning applications.

[5] A dataset prepared by the Office of Public Works identifying land that might benefit from the implementation of Arterial (Major) Drainage Schemes (under the Arterial Drainage Act 1945) and indicating areas of land subject to flooding or poor drainage.

A hydrological study was prepared for the Knockharley site by FT in 2011 and it was found that the current course of the Knockharley Stream can cater for a 1 in 100-year extreme event without overbank flooding and that the current footprint of the landfill development avoids flood risk areas for that event.

In the flood risk assessment prepared for this proposed development, a HECRAS river model (See Appendix 12.6 Hydrological Study of Volume 3 of this EIAR) was run to determine the flood level for the 1 in 1,000-year extreme event and thus estimate the potential storage lost in the indicative area shown to be a Flood Zone B area in the Flood Risk Assessment (FEMFRAMS) study, (see Appendix 12.5 Flood Risk Assessment of Volume 3 of this EIAR).

The Meath County Development Plan (CDP) 2013 - 2019 (6) sets out the county's policies and objectives with regard to flooding as outlined below. The policies and objectives relating to water quality are referenced in Section 12.3.4.

It is the policy of Meath County Council:

WS POL 29 *To have regard to the "Planning System and Flood Risk Management – Guidelines for Planning Authorities" (DoEHLG/OPW, 2009) through the use of the sequential approach and application of the Justification Tests for Development Management and Development Plans, during the period of this Plan.*

WS POL 30 *To have regard to the findings and recommendations of the current Strategic Flood Risk Assessment prepared as part of the County Development Plan review. See Appendix 6.*

WS POL 31 *To ensure that all developments have regard to the surface water management policies in the Greater Dublin Strategic Drainage Study (GDSDS). Compliance with the recommendations contained in Technical Guidance Document, Volume 2, Chapter 4 of the Greater Dublin Strategic Drainage Study shall be required in all instances.*

WS POL 32 *To ensure that a flood risk assessment is carried out for any development proposal, where flood risk may be an issue in accordance with the "Planning System and Flood Risk Management – Guidelines for Planning Authorities" (DoECLG/OPW, 2009). This assessment shall be appropriate to the scale and nature of risk to the potential development.*

WS POL 33 *To consult with the Office of Public Works in relation to proposed developments in the vicinity of drainage channels and rivers for which the OPW are responsible, and the Council will, retain a strip of 10 metres on either side of such channel where required, to facilitate access thereto.*

WS POL 34 *To consult, where necessary, with Inland Fisheries Ireland, the National Parks and Wildlife Service and other relevant agencies in the construction of flood alleviation measures in County Meath.*

WS POL 35 *To ensure that flood risk management is incorporated into the preparation of Local Area Plans and Town Development Plans in accordance with 'The Planning System and Flood Risk Management - Guidelines for Planning Authorities (2009)'.*

WS POL 36 *To have regard to the recommendations of the Fingal East Meath Flood Risk Assessment and Management Study, the Eastern, North West and Neagh Bann Catchment Flood Risk Assessment and Management Study when finalised and approved.*

It is an objective of Meath County Council:

WS OBJ 11 *To undertake a review of the 'Strategic Flood Risk Assessment for County Meath' following the publication of the flood mapping which is being produced as part of the Catchment Flood Risk Assessment and Management (CFRAM) Studies.*

WS OBJ 12 *To design flood relief measures to ensure appropriate protection for alluvial woodland (i.e. a qualifying interest) along the Boyne.*

WS OBJ 13 *To design flood relief measures to protect the conservation objectives of Natura 2000 sites and to avoid indirect impacts of conflict with other qualifying interests or Natura 2000 sites.*

WS OBJ 14 *To promote positive flood relief measures that can enhance habitats in the Boyne floodplain such as swales, constructed wetland basins etc.*

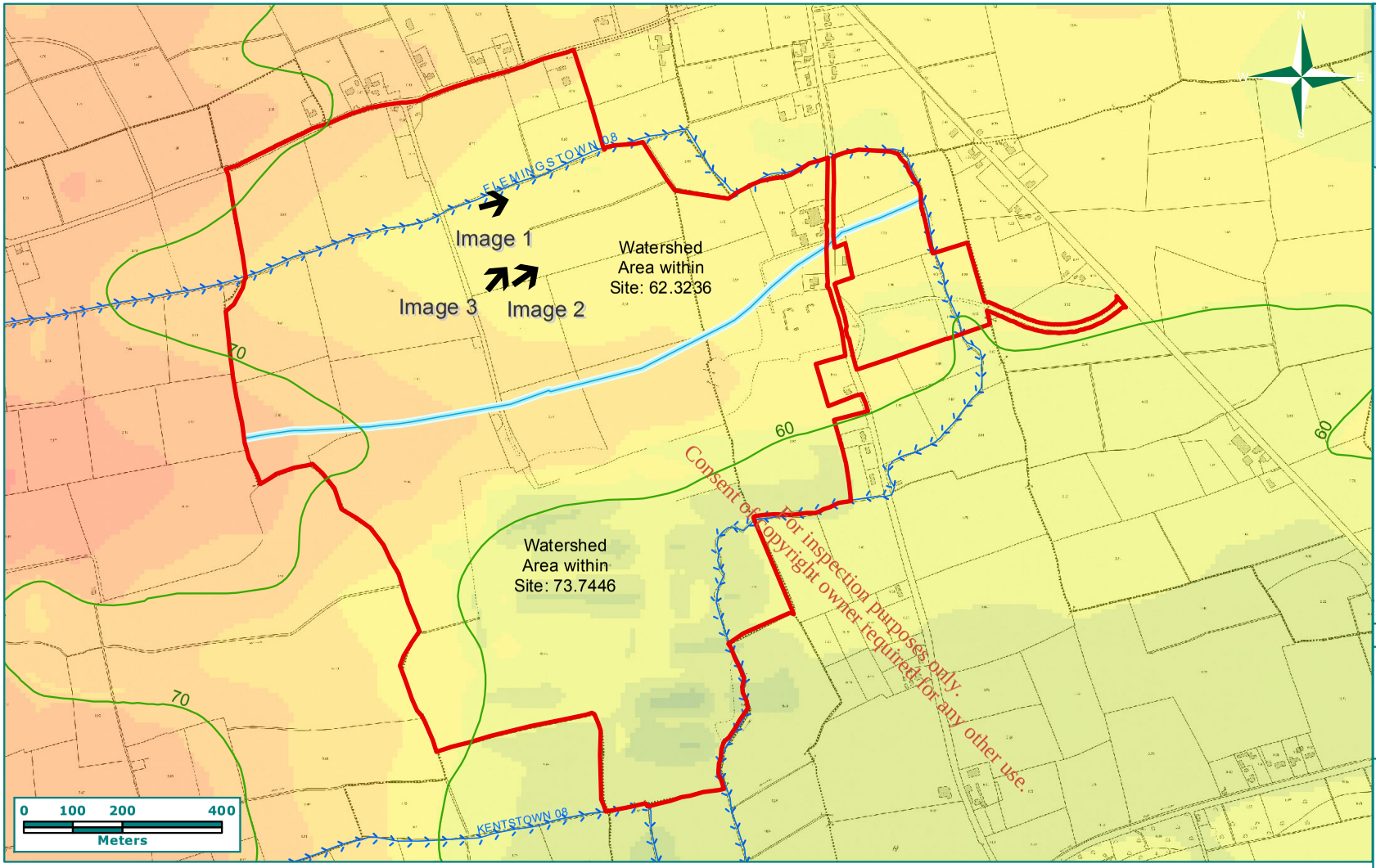
WS OBJ 15 *To seek to ensure that construction works are designed so as not to result in surface water runoff into cSAC or SPAs either directly or indirectly via a watercourse.*

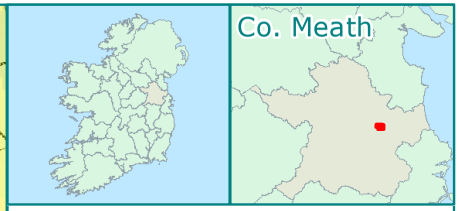
A Strategic Flood Risk Assessment (SFRA) was prepared for County Meath for the Meath CDP 2013-2019. Flood Zone mapping was prepared as part of this SFRA, indicating Flood Zones A (1% Annual exceedance probability, (AEP)) and Flood Zones B (0.1% AEP) in the vicinity of the urban settlements in County Meath.

The SFRA concludes that Flood Risk Management policies should be implemented from the CDP. The flood forecasting and warning system was recommended for the Nanny River and Delvin River.

A study of the Flood Zones indicated in the SFRA, shows the proposed development site is outside the scope of the settlements assessed as part of this SFRA and as such will not be part of the proposed flood forecasting and warning system.

Even if included at a later stage, the proposed development has provision for attenuation to ensure runoff does not exceed green field runoff flow rates and the proposed development will reduce flood storage volumes in or immediately adjacent to the proposed development.



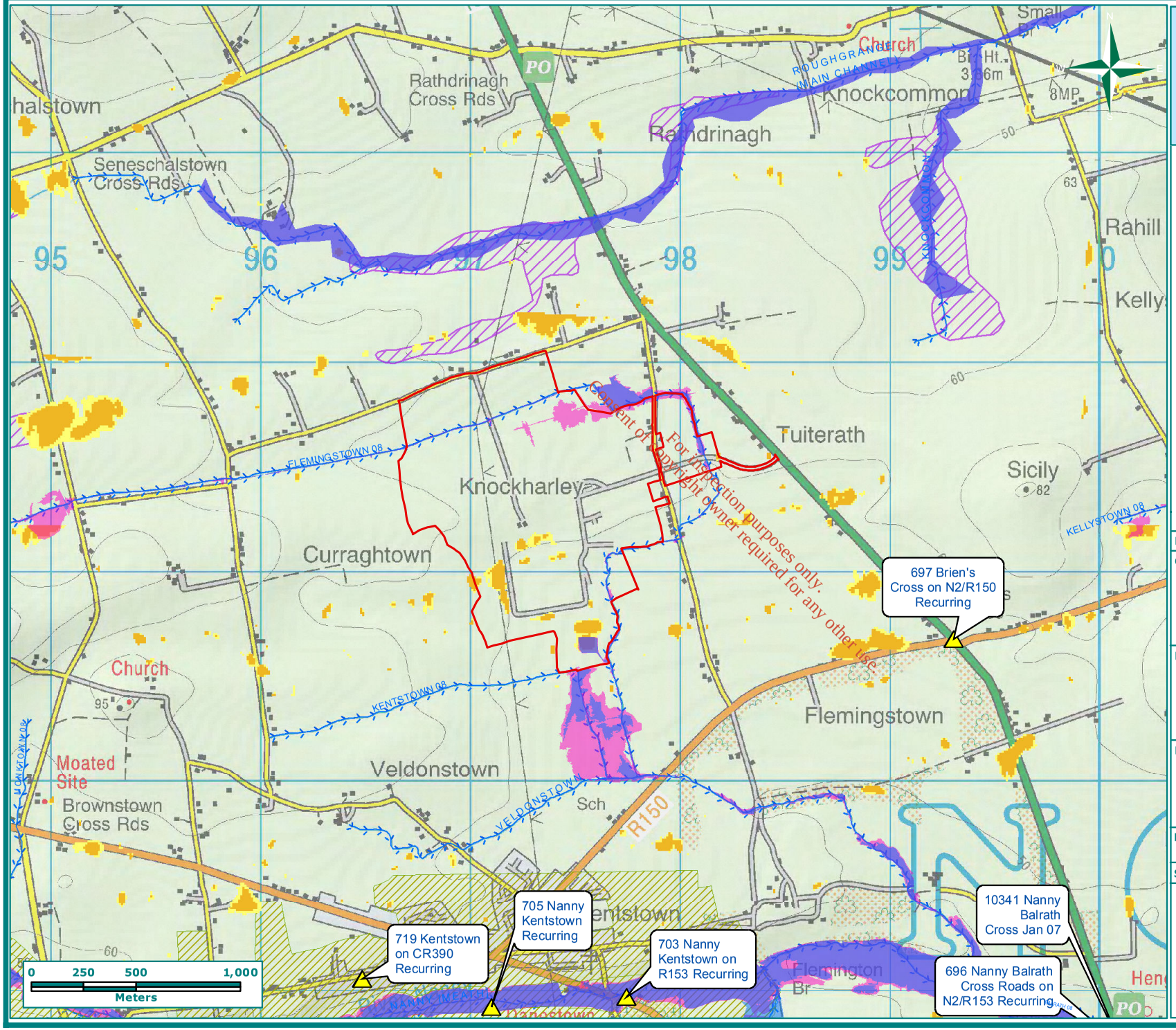


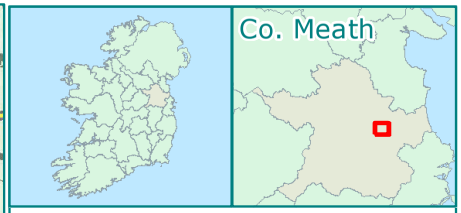
Legend

- Site Boundary
- Rivers
- 10m Contours
- Indicative Watershed Boundary within Site
- Field Survey Photograph Locations

Date	18/05/2018
Client Name	Knockharley Landfill Ltd.
Project Title	Proposed Development at Knockharley Landfill
Figure Title	Hydrological Features Map
Figure No.	12.2
Rev.	A
Scale	1:12,500 @ A4

FEHILY TIMONEY & COMPANY
CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES
Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464
Unit 16J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501
W: www.fehilytimoney.ie E: info@ftco.ie





Legend

- Site Boundary
- *Preliminary Flood Risk Assessment/Catchment Flood Risk Assessment and Management Studies*
- Flood Zone A (PFRA/CFRAMS: 1% AEP Fluvial Flood Extent)
- Flood Zone B (PFRA/CFRAMS: 0.1% AEP Fluvial Flood Extent)
- PFRA/CFRAMS: 1% AEP Pluvial Flood
- PFRA/CFRAMS: 0.1% AEP Pluvial Flood
- Drainage Districts
- Benefiting Lands
- Rivers
- OPW Historic Flood Points

NOTE: The maps on Preliminary Flood Risk Assessme (PFRA) provide only an indication of areas that may be prone to flooding. They are not necessarily locally accurate, and should not be used as the sole basis for defining the flood zones nor for making decisions on planning applications.

Date	18/05/2018
Client Name	Knockharley Landfill Ltd.
Project Title	Proposed Development at Knockharley Landfill
Figure Title	OPW Flood Information Map
Figure No.	12.3
Rev.	A
Scale	1:25,000 @ A4

FEHILY TIMONEY & COMPANY
CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES
Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464
Unit 16J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501
W: www.fehilytimoney.ie E: info@ftco.ie

12.3.4 Existing Water Quality

County Development Plans

Knockharley Landfill is located County Meath. A review of the Meath County Development Plan 2013 – 2019 was carried out to determine their specific objectives in relation to water quality. The policies and objectives relating to flooding are referenced in Section 12.3.4.

Meath County Development Plan 2013 -2019

The Meath County Development Plan 2013-2019 lays down specific policies in relation to water quality as follows:

WS POL 2 To protect and develop, in a sustainable manner, the existing groundwater sources and aquifers in the county and to control development in a manner consistent with the proper management of these resources.

WS POL 17 To ensure that all new developments have access to or are provided with satisfactory drainage systems in the interests of public health and to avoid the pollution of ground and surface waters.

WS POL 19 To protect groundwater resources having regard to the County Meath Groundwater Protection Plan.

WS POL 20 To ensure through the implementation of the River Basin Management Plans[6] and their associated programmes of measures, and any other associated legislation, the protection and improvement of all drinking water, surface water and ground waters throughout the county.

WS POL 21 To work, in co-operation with relevant organisations and major stakeholders to ensure a co-ordinated approach to the protection and improvement of the county's water resources.

WS POL 22 To continue efforts to improve water quality under the Local Government (Water Pollution) Act 1977, as amended and by implementing the measures outlined under the Nitrates Directive (91/676/EEC) and complying with the requirements of the Surface Water Legislation Environment Objectives (Surface Waters) Regulations 2009 and other relevant regulations.

WS POL 23 To promote public awareness of water quality issues and the measures required to protect both surface water and ground water bodies.

WS POL 24 To manage groundwater resources particularly having regard to the abstraction and recharge rates of ground-waterbodies.

WS POL 25 To protect, maintain and improve the natural character of the watercourses and rivers in the county Meath.

WS POL 26 To seek the continued improvement of water quality, bathing facilities and other recreational opportunities in the coastal, estuarine and surface waters in the County.

WS POL 27 To ensure that proposed septic tanks and proprietary treatment systems, or other waste water treatment and storage systems, and associated percolation areas where required as part of a development, comply with the recommendations of the Environmental Protection Agency and that they are employed only where site conditions are appropriate.

NH POL 21 To protect the recreational, educational and amenity potential of navigational and non-navigational waterways within the County, towpaths and adjacent wetlands.

The Meath County Development Plan 2013-2019 lays down specific objectives in relation to surface water run-off as follows:

WS OBJ 9 To promote compliance with environmental standards and objectives established for bodies of surface water, by the European Communities (Surface Waters) Regulations 2009.

WS OBJ 10 To develop groundwater protection schemes in line with the recommendations contained within the DoEHLG/GSI/EPA publication 'Groundwater Protection Schemes, 1999' or any revised or replacement publication.

[6] The draft River Basin Management Plan for Ireland 2018 to 2021 replaces the eight separate RBD Plans.

WS OBJ 16 To incorporate and promote the use of Sustainable Urban Drainage Systems within County Council Developments and other infrastructural projects as required in the Greater Dublin Regional Code of Practice for Drainage Works.

WS OBJ 17 To require the use of Sustainable Urban Drainage Systems in accordance with the Greater Dublin Regional Code of Practice for Drainage Works for new developments (including extensions).

WS OBJ 18 To ensure that all new developments comply with Section 3.12 of the Greater Dublin Regional Code of Practice for Drainage Works V6 which sets out the requirements for new developments to allow for Climate Change.

WFD Status and Risk Assessment

As discussed in Section 12.2.1.1 there is a status and risk for river waterbodies. The information is available on catchments.ie. The status and risk for waterbody (IE_EA_08_352) draining the site are discussed below.

Water Framework Directive Monitoring Data

A water quality monitoring programme was established by the Environmental Protection Agency (EPA) under the WFD to determine the status of the waterbodies, as discussed above. Chemical and biological/ecological quality of surface waters is monitored at numerous locations throughout the country. The monitoring stations near the site are shown on Figure 12.4.

There is one monitoring point downstream of the landfill on the River Nanny, east of Balrath and a second point which is upstream of the confluence of the tributaries draining the site with the River Nanny. The results of the monitoring at this location is included in Table 12.4 and they are discussed below.

Biological Water Quality

The EPA scheme of Biotic Indices or Quality (Q) values was developed to determine the status of organic pollution in Irish rivers by assessing the occurrence of macroinvertebrate taxa of varying sensitivity to pollution.

The Q values measured most recently (3) at the monitoring stations near the site are outlined below. The locations of theses monitoring locations with respect to the landfill facility are shown in Figure 12.4.

Table 12-4: EPA Measured Q Values

Station No.	Station Name	River Sub Basin	Co-ordinates (X,Y) IG	2005	2008	2010	2014
RS 08N010110	East Br Kentstown	NANNY (MEATH)_010 EA_08N010110	N 264966.67 E 297681.67	2-3	2-3	3	3
RS 08N010280	Br d/s Nanny Br	NANNY (MEATH)_010 EA_08N010280_	N 265150.87 E 302748.86	4	4	3-4	3

A Q value of 3 or 2-3 represents 'Poor' water quality status under the WFD. It also indicates that the waterbody is "moderately polluted" and in an "unsatisfactory condition[7]"

A Q value of 3 represents 'Poor' water quality status under the water framework directive. It also indicates that the waterbody is "moderately polluted" and in an "unsatisfactory condition".

A Q value rating of 3-4 represents 'Moderate' water quality status under the water framework directive. It also indicates that the waterbody is "slightly polluted" and in an "unsatisfactory condition".

A Q value rating of 4 represents 'Good' water quality status under the water framework directive. It also indicates that the waterbody is "unpolluted" and in a "satisfactory condition".

The Q values since 2010 have been the same both up and downstream of the confluence of the Knockharley or Flemingstown Stream with the River Nanny. Whilst the most recent results in 2014, represent 'Poor' water quality status under the water framework directive, because the upstream and downstream observations are similar, poor quality status arises from influences external to and upstream of the existing and proposed development.

Chemical Water Quality

Various parameters are analysed from the water samples taken as part of the WFD monitoring programme. The parameters measured at the monitoring stations near the site are outlined below and shown in Table 12.5.

The table shows the mean values recorded during a monitoring programme (2009-2016) (35) for the following locations. The count indicates the number of samples taken over the period for each parameter.

- 08N01-0110 East Br Kentstown
- 08N01-0280 Br d/s Nanny Br

The monitoring results are compared to the environmental quality standards as set out in the European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended in 2012, 2015 (S.I. No. 272 of 2009, S.I. No. 327 of 2012, S.I. No. 386 of 2015).

[7] "Condition" refers to the likelihood of interference with beneficial or potential beneficial uses. EPA website.

Table 12-5: WFD Monitoring Results 2009-2016

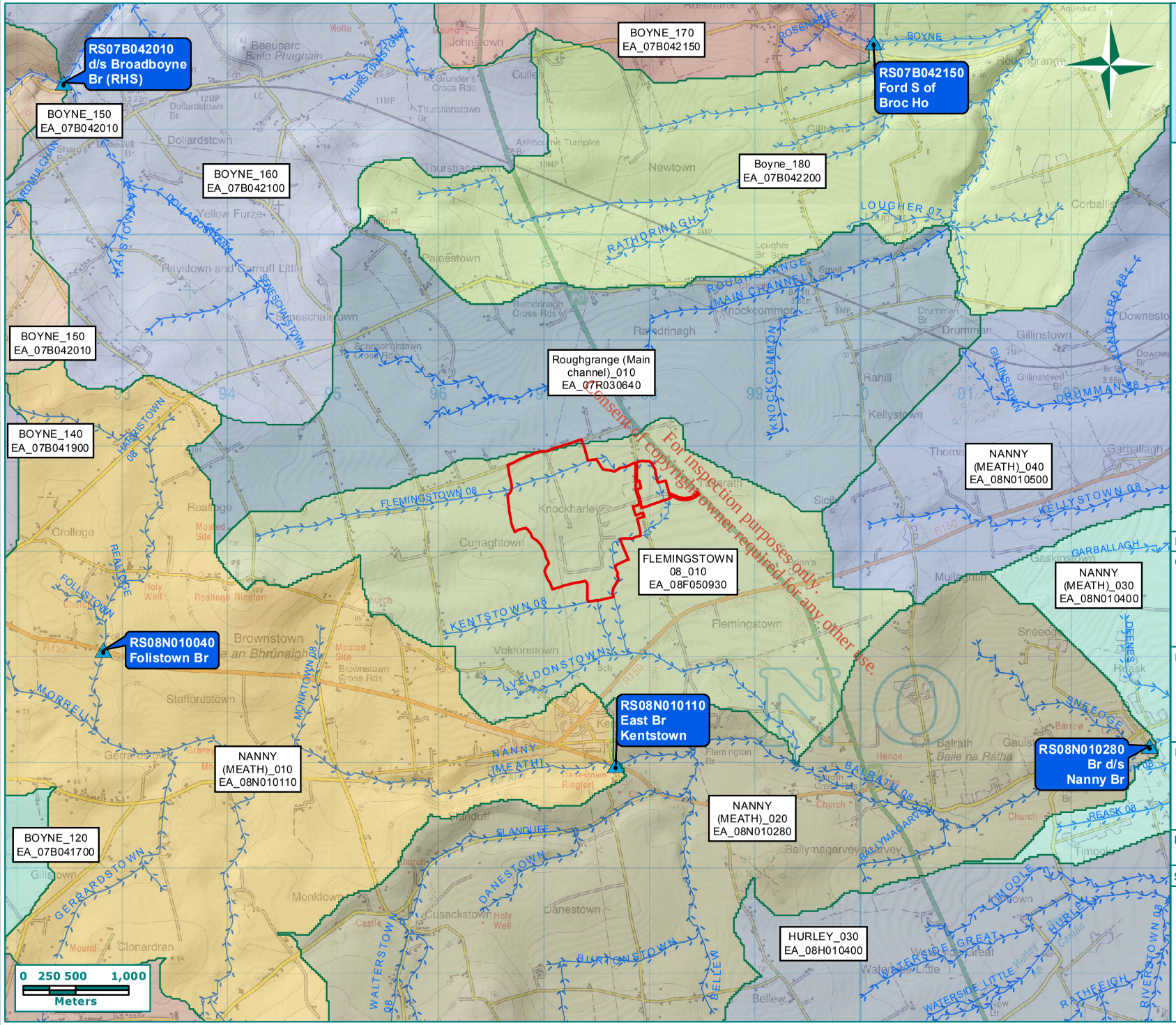
Row Labels	Unit	Count	Minimum	Average	Maximum	Environmental Quality Standard
08N01-0110						
Alkalinity-total (as CaCO3)	mg/l	28	224	318.61	370	
Ammonia-Total (as N)	mg/l	43	0.03	0.30	1.416	0.14 (95%ile good status)
BOD - 5 days (Total)	mg/l	47	0.50	2.25	7.8	2.6 (95%ile good status)
Chloride	mg/l	28	20	25.71	44.3	
Conductivity @20°C	µS/cm	4	569.84	616.42	684.71	
Conductivity @25°C	µS/cm	30	521	720.90	787	
Dissolved Oxygen	mg/l	90	6.66	48.71	104	
Dissolved Oxygen %	%	4	64.50	84.20	93.6	
Nitrite (as N)	mg/l	29	0.01	0.05	0.124	
ortho-Phosphate (as P) - unspecified	mg/l	43	0.01	0.12	0.301	0.075 (95%ile good status)
pH	pH units	42	7.77	8.09	8.6	>6<9
Temperature	°C	33	3.30	9.88	14.9	
Total Hardness (as CaCO3)	mg/l	28	244	369.70	456	
Total Nitrogen	mg/l	4	2.53	3.10	3.46	
Total Oxidised Nitrogen (as N)	mg/l	28	1.76	3	4.62	
True Colour	PtCo Units	25	6.00	19	66	
08N01-0280						
Alkalinity-total (as CaCO3)	mg/l	27	224	321.07	370	
Ammonia-Total (as N)	mg/l	29	0.01	0.05	0.114	0.14 (95%ile good status)
BOD - 5 days (Total)	mg/l	33	0.50	1.19	3.09	2.6 (95%ile good status)
Chloride	mg/l	27	18.30	26.76	50.6	
Conductivity @20°C	µS/cm	4	555.36	614.61	672.95	
Conductivity @25°C	µS/cm	29	512	713.62	771	
Dissolved Oxygen	mg/l	62	7.60	50.63	130	
Dissolved Oxygen %	%	4	81.40	89.90	94.8	
Nitrite (as N)	mg/l	28	0.00	0.03	0.078	
ortho-Phosphate (as P) - unspecified	mg/l	29	0.03	0.09	0.155	0.075 (95%ile good status)

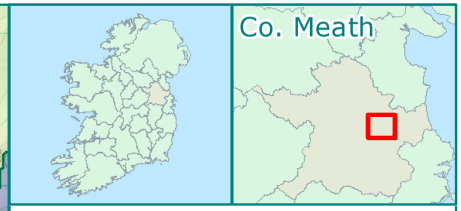
Row Labels	Unit	Count	Minimum	Average	Maximum	Environmental Quality Standard
pH	pH units	29	7.87	8.18	8.49	>6<9
Temperature	°C	32	3.30	10.17	16.6	
Total Hardness (as CaCO3)	mg/l	27	248	374.23	473	
Total Oxidised Nitrogen (as N)	mg/l	28	1.48	2.98	4.56	
True Colour	PtCo Units	24	5.00	18.89	88	

EQS - European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended

The parameters measured, as shown in Table 12.5 are in some instances above the thresholds of the environmental quality standards.

Whilst the most recent results in 2014, represent 'Poor' water quality status under the water framework directive, (see also Figure 12-4 Q Values) because the upstream and downstream observations are similar, poor quality status arises from influences external to and upstream of the existing and proposed development.





Legend

- Site Boundary

EPA Monitoring Stations

- Operational

Water Framework Directive Cycle 2 Revision

- River Sub-basins
- Rivers

Date	18/05/2018
Client Name	Knockharley Landfill Ltd.
Project Title	Proposed Development at Knockharley Landfill
Figure Title	Water Quality Monitoring
Figure No.	12.4
Rev.	A
Scale	1:50,000 @ A4

FEHILY TIMONEY & COMPANY

CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES

Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464

Unit 16J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501

W: www.fehilytimoney.ie E: info@ftco.ie

Licence Compliance Monitoring Data

Surface water quality is currently monitored on a quarterly basis at 8 locations at Knockharley Landfill set out under licence condition D.1 of the existing Industrial Emissions (IE) Licence, W0146-02. The locations are shown in Table 12.6 below and in Drawing No. LW14-821-01-P-050-001 Existing Monitoring Locations in Volume 4 of this EIAR.

Table 12-6: IE Licence Surface Water Monitoring Locations

Monitoring Location	Easting	Northing	Stream	Description
SW1	296706	267600	Knockharley/Flemingstown St.	Upstream
SW2	297464	267862	Knockharley/Flemingstown St.	Upstream
SW3	298087	267634	Knockharley/Flemingstown St.	Upstream
SW5	297764	267116	Knockharley/Flemingstown St.	Upstream
SW6	297663	266562	Knockharley/Flemingstown St.	Downstream
SW7	297510	266525	Kentstown St.	Downstream
SW8	297916	266029	Knockharley/Flemingstown St.	Downstream (and d/s of confluence of Kentstown and Knk/Flem St.)
SW9	297587	266621	Outlet from wetland	Discharge from the surface water wetland (into Knockharley/Flemingstown St.)

The monitoring programme, carried out at the facility since 2001 before waste was accepted, established baseline water quality and identified seasonal variations. The seasonal variation is thought to be associated with local agriculture practices and individual wastewater treatment systems in the area surrounding the facility. Baseline surface water quality results are shown in Table 12.7 for comparative purposes.

Surface water samples are analysed each quarter for a range of parameters as specified in Schedule D of the licence. Surface water results over the last 5-year period were assessed and compared to the baseline and are discussed in following paragraphs.

Table 12-7: Baseline Surface Water Quality

Parameter	Units	SW1	SW2	SW3	SW5	SW6	SW7	SW8
pH	pH Units	7.94-8.20	7.7-8.44	7.75-7.98	7.61-8.07	7.76-8.06	7.42-8.37	7.63-8.02
Electrical Conductivity	mS/cm	0.613-0.730	0.653-0.682	0.593-0.688	0.549-0.726	0.625-0.698	0.590-0.694	0.662-0.720
Ammoniacal Nitrogen	mg/l	<0.2-0.6	<0.2	<0.2-1.1	<0.2-0.5	<0.2-0.5	<0.2-1.7	<0.2-0.4
Dissolved Oxygen	mg/l	5.3-9.4	4.7-8.9	5.1-8.6	4.4-8.4	5.0-8.9	5.0-8.7	4.6-8.5
Chloride	mg/l	21-31	23-56	29-36	29-35	28-33	24-36	30-54

Parameter	Units	SW1	SW2	SW3	SW5	SW6	SW7	SW8
Total Suspended Solids	mg/l	<10-48	<10-46	<10-34	<10	<10-11	<10-10	<10-15
BOD	mg/l	<2-2	<2-12	<2-5	<2-4	<2-3	<2-3	<2-3
COD	mg/l	<15-41	<15-25	<15-46	<15-43	<15-41	<15-29	<15-31
Potassium	mg/l	9	2.6	10.8	11.6	11.8	17.6	2.4
Sodium	mg/l	13.5	8.1	13	14	15	9.8	15
Total Oxidised Nitrogen	mg/l	4.1	7.9	5.4	5.1	5.3	3.7	4.3
Calcium	mg/l	95.44	99.93	77.87	74.7	72.58	99.99	93.66
Cadmium	µg/l	3.5	3.5	3.5	3.5	<0.4	<0.4	<0.4
Chromium	µg/l	4	4	3	4	<1	<1	<1
Copper	µg/l	10	8	8	9	6	6	<5
Iron	µg/l	75	47	112	132	123	38	55
Lead	µg/l	<5	<5	<5	<5	<5	<5	<5
Magnesium	mg/l	6.48	4.44	5.38	5.3	5.23	8.89	6.73
Manganese	µg/l	11	10	10	9	5	6	4
Mercury	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphate	mg/l	25	24	29	29	30	30	29
Zinc	µg/l	<5	<5	<5	<5	<5	<5	<5
Total Alkalinity as CaCo3	mg/l	300	220	200	90	250	270	250
Total Phosphorous	mg/l	0.44	0.09	0.34	0.56	0.54	0.54	0.32

The following is a discussion of surface water quality as monitored in compliance with the licence in the period 2012 to 2017. The results of surface water monitoring at SW2 and S2W6 over the last 5 years are averaged in Table 12.8. The full set of monitoring results for all monitoring locations are presented in Appendix 12.3.

Table 12-8: Averages of Surface Water Monitoring Results at SW2 & SW6 2013- Q3 2018

Parameters	Units	Average SW2	Average SW6
Ammoniacal Nitrogen	mg/l	0.12	0.10
BOD	mg/l	2.09	4.59
Cadmium	µg/l	0.40	0.18
Calcium	mg/l	115.33	119.45
Chloride	mg/l	21.69	19.25
COD	mg/l	14.68	18.91
Dissolved Oxygen	mg/l	9.00	8.40
Electrical Conductivity (lab)	mS/cm	0.60	0.77
Iron	mg/l	0.24	0.18
Lead	µg/l	1.82	2.15
Magnesium	mg/l	8.90	16.95
Manganese	µg/l	97.00	38.50
Mercury	µg/l	0.26	0.26
Orthophosphate	mg/l	1.00	1.00
pH	pH units	7.98	7.47
Sodium	mg/l	15.43	14.18
Sulphate	mg/l	21.65	246.30
Temperature	mg/l	7.73	8.75
TON	mg/l	0.62	0.37
Total Chromium	µg/l	1.01	1.06
Total Phosphorous	mg/l	0.35	0.21
Total Suspended Solids	mg/l	7.00	8.59
Zinc	mg/l	0.01	0.01

In accordance with licence condition 8.8.1, a continuous monitoring programme is in place at the surface water pond (SW pond) and at the discharge point from the wetland (SW9). There is a trigger level of 20 mg/l for Total Organic Carbon (TOC). If this limit is recorded the outlet to the pond is shut. Electrical Conductivity, pH and TOC are measured continuously at the inlet to the pond.

Ammoniacal Nitrogen

The parameter ammoniacal nitrogen is indicative of organic pollution from sources such as leachate, wastewater or agriculture. Ammoniacal Nitrogen levels overall across site have remained relatively stable in the period. There is no baseline for SW9 as it is the outfall from the proposed development. The outfall SW9 from the facility wetland is located upstream and immediately adjacent to SW6 on the Knockharley/Flemingstown Stream (see Drawing No. LW14-821-01-P-050-001 Existing Monitoring Points) in Volume 4 of this EIAR. There has been no exceedance of the baseline level of ammoniacal nitrogen at SW6 in the past 5 years. The level of ammoniacal nitrogen at SW9 the outfall, was recorded once in 2014 above the EQS of ≤0.140 mg/l (95%ile) (S.I. No. 272/2009 - European Communities Environmental Objectives (Surface Waters) Regulations 2009), however at that event, the result for SW6 was similar but was below the baseline. The trendline for ammoniacal N at SW6 and SW9 in the period 2013 to 2018 is flat. These results indicate no impact from the existing development.

Electrical Conductivity

Electrical Conductivity at monitoring locations upstream of the landfill (SW1, SW2, SW3 and SW5) have remained relatively stable but display an upward trend at all locations over the period and the results are generally within the baseline range.

Results for Electrical Conductivity at SW7 and SW8 are broadly stable. Electrical Conductivity results at locations SW6 and SW9 are similar and display a slight upward trend of 0.1 mS/cm in the 5-year period. Electrical Conductivity levels at SW6 were outside the baseline range on occasion in 2015 and in 2016, and on three occasions in 2017 and 2018. The trend in Electrical Conductivity results is upwards at all locations SW1-SW9 over the 5-year period and all locations show results outside the baseline range. The trends displayed at SW6 and SW9 are normal in the context of the upstream results.

Total Suspended Solids

Total suspended solids levels have remained below the surface water discharge limit of 35 mg/l at SW9, as set in the licence with the exception of the Q2 sampling event in 2017 but this was attributed to sampler error due to very low flow.

pH

pH levels are relatively stable across all monitoring locations. Overall trends in pH levels have remained within the baseline range and have been relatively stable over the monitoring period.

Dissolved Oxygen

Dissolved Oxygen levels were broadly similar upstream and downstream of the facility and are within typical ranges for surface waters.

BOD

The levels of BOD recorded at all locations are usually below the laboratory limit of detection and are usually within the baseline level. The results show BOD above the baseline and limit of detection at a number of locations around the site both up and downstream of the facility. The levels of BOD at SW9 were above the EQS on five occasions in the 5-year period but the results are lower than those detected at other locations and the 5 year trend is downwards.

The levels of BOD were above the baseline on two occasions in May 2016 and May 2017 at SW6, however in both instances, the BOD at SW9 was lower than that recorded at SW6 indicating the result was not attributable to the facility.

Chemical Oxygen Demand (COD)

Levels of COD in the past 5 years have generally been recorded within the baseline range. There were 5 no. exceedances of the baseline at upstream locations and one exceedance at SW6 in 2013. Chemical Oxygen Demand exhibits a decreasing trend at all locations in the period.

Chloride

Chloride levels downstream of the facility at SW6 and SW8 have been recorded within the baseline range. The 5-year trend at SW9 and SW6 (discharge to stream) is downwards. At locations upstream, SW1-SW5, the trends are downwards except for SW5. The chloride results are generally within the baseline range, exhibiting higher levels upstream at SW1 and SW3 on two occasions and downstream at SW7 on two occasions.

Given that elevated readings were observed upstream of SW6 and at SW7 which is not influenced by the facility it is likely that external sources are responsible for chloride outside the baseline range.

Annual Parameters

Metals; cadmium, copper, chromium, lead, mercury, zinc have overall remained at low stable levels and have not shown increasing trends in the period. Levels are below the EQS limits and baseline levels.

Iron has been detected at above the baseline range at monitoring locations both upstream and downstream of the landfill. In general, there is no increase in levels of iron at downstream locations than recorded at upstream locations.

Magnesium levels have been recorded above baseline ranges for the period at all monitoring locations.

Levels of Total Phosphorus have been recorded above baseline ranges at a number of monitoring stations periodically throughout 2013-2018 but is within the baseline range at SW6. Levels of Total Phosphorous at SW6 and SW9 have been consistently similar or lower than those upstream.

The results indicate good surface water quality overall at the monitoring locations, with no impact from the landfill development.

The existing groundwater quality is assessed in Chapter 11 Soils, Geology and Hydrogeology in Volume 2 of this EIAR.

12.3.5 Internal Site Drainage

A site walkover survey took place on 27 July 2016 and 5 August 2016, to confirm the pattern of existing drainage on the site and to record any significant hydrological features on the proposed development site.

Whilst site observations showed reeds to be present adjacent to drains and poorly graded pasture which may be subject to localised waterlogging, the ground underfoot was firm and there was no evidence of flooding.

Surface water run-off drains over land and via a network of forestry and man-made drainage ditches to tributary streams of the River Nanny.

Figure 12-2 shows the approximate location of the water shed bisecting the site and also shows photographs taken during the 5th August 2016 survey.

Runoff from the permitted facility developed as of 2017 drains via an operating drainage system from the landfill facility and is directed towards the southern storm water attenuation pond and afterwards to a constructed wetland before it is discharged to the Knockharley/Flemingstown Stream.

A site walkover was conducted in November 2018 to confirm that the pattern of existing features and drainage on the site remained as per the 2016 survey.

12.3.5.1 Existing Surface Water Management

The surface drainage from the (current) permitted development south of the watershed leaves the property via a deep drainage channel located in the extreme south-east corner. An isolating weir facilitates diversion of the site drainage to the storm water pond in the event of a contamination incident. This would allow the polluted water to be retained on the property until the spill event is investigated and remediated. This provision can equally deal with third-party pollution events arising outside the site boundary. The storm water pond has sufficient capacity to dampen storm peaks and to maintain the current discharge characteristics from the landholding. The pond also allows for the settling of fines carried by the drainage waters. This is described in more detail in Section 2.2.8 of Chapter 2 in Volume 2 of this EIAR.

12.3.5.2 Access to OPW Maintainable Channels

There are no OPW maintainable channels within the site boundary. OPW maintainable channels in the vicinity of the site are shown in Figure 12-5.

12.3.6 Existing Facilities On-site

12.3.6.1 Water Supply

There is an existing water supply at the site.

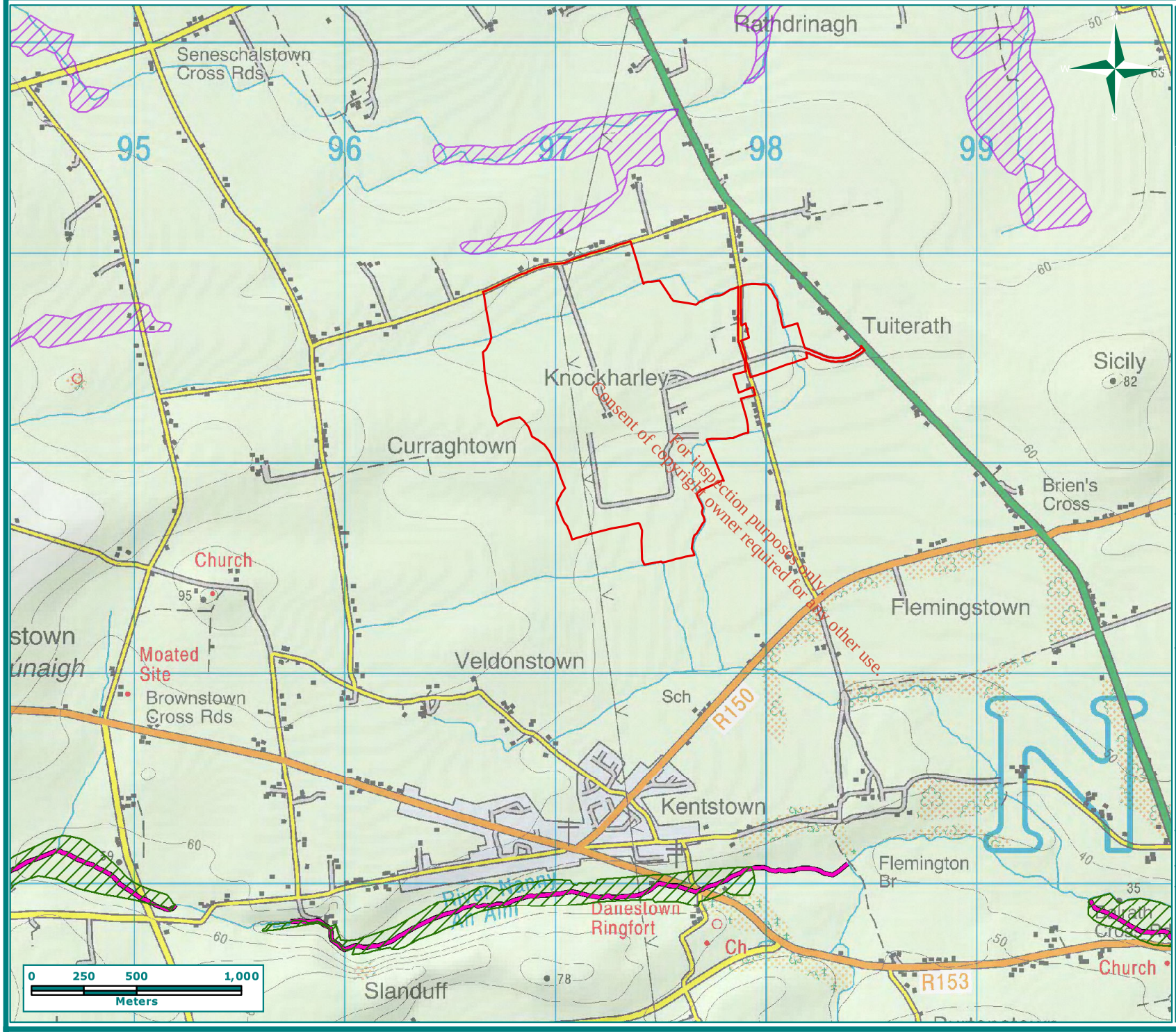
Water is required for the existing wheel wash facility and for dust suppression.

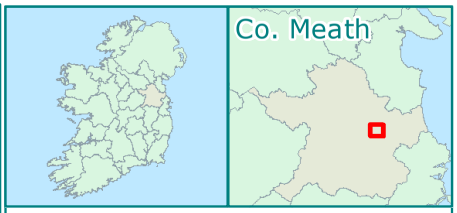
Water will be used during existing and proposed site operations for dust suppression, the additional volumes required will not be significant as it is proposed to reuse water from the attenuation ponds where appropriate.

12.3.6.2 Sanitary Waste Management

There are existing sanitary facilities at the site which will serve to provide for operations personnel. The existing sanitary facilities are located within the administration building and are conveyed to a proprietary wastewater treatment system on site.

Temporary site accommodation will be required during construction works including temporary storage of sanitary waste prior to transfer of sanitary waste off site by a permitted waste collector.





Legend

- Site Boundary
- OPW Benefited Land V3 - Jan 16

Drainage District

- DD - Benefited Land V2 - May 16
- DD - Channels V2 - May 16

Date	18/05/2018
Client Name	Knockharley Landfill Ltd.
Project Title	Proposed Development at Knockharley Landfill
Figure Title	OPW Maintainable Channels Map
Figure No.	12.5
Rev.	A
Scale	1:25,000 @ A4

FEHILY TIMONEY & COMPANY
CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES
Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464
Unit 16J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501
W: www.fehilytimoney.ie E: info@ftco.ie

12.4 Proposed Development

The proposed development is described in detail in Chapter 2 of Volume 2 of this EIAR. The existing landfill, surface water management system and leachate management system were designed in accordance with the Landfill Directive, The Waste Management Act and with EPA guidance. The existing facility is licensed to operate by the EPA and under that licence, all infrastructure design is approved for construction by the EPA under Specified Engineering Works submissions. Following construction, the infrastructure is subject to quality assurance and is validated by the EPA for operation. The preliminary design of proposed IBA facility, biological treatment facility, leachate management facility and ancillary infrastructure is in accordance with the Landfill Directive and associated guidance as per Section 12.2.1. The existing and proposed development has been designed to prevent negative impacts on hydrology and surface water.

The proposed drainage layout is shown in Drawing No. LW14-821-01-P-000-004 through 011 Site Layout Plan in Volume 4 of this EIAR and on Figure 12-6 Proposed Drainage Layout in this chapter.

An existing storm water outfall exists on the southern boundary and it is proposed to develop an additional storm water outfall on the northern boundary.

A four-stage treatment train (swale – holding pond- suspended solids settlement and attenuation – within the northern attenuation pond–wetland) will cater for infrastructure in the northern watershed, that is the permitted landfill area runoff and proposed IBA facility runoff. Drainage from the proposed biological treatment facility and leachate management facility will be directed to the existing southern attenuation pond.

The drainage of the proposed development at Knockharley Landfill will be compliant in the use of SuDS. Swales leading to an attenuation facility are proposed in the drainage of the development. Appendix 12.2 of Volume 3 of this EIAR presents the proposed Surface Water Management Plan (SWMP) and provides further detail on the proposed drainage.

A temporary site compound will be provided by the contractor for future construction works with waste from canteen and sanitary facilities being discharged to a temporary holding tank for removal off site to a waste water facility.

The existing and proposed surface water management outfall were previously described in Chapter 2 of Volume 2 of this EIAR.

12.4.1 Screening Berms and Temporary Stock Pile Areas

During the construction period, excavated material will be used to create the screening bunds as shown Drawing No. LW14-821-01-P-0000-003 Proposed Site Layout Plan in Volume 4 of this EIAR. Surplus materials will be used for the final cap construction. Earthworks associated with berm locations and temporary stockpile areas are presented on Drawing No. LW14-821-01-P-0050-011 Cut/Fill Phasing Plan in Volume 4 of this EIAR.

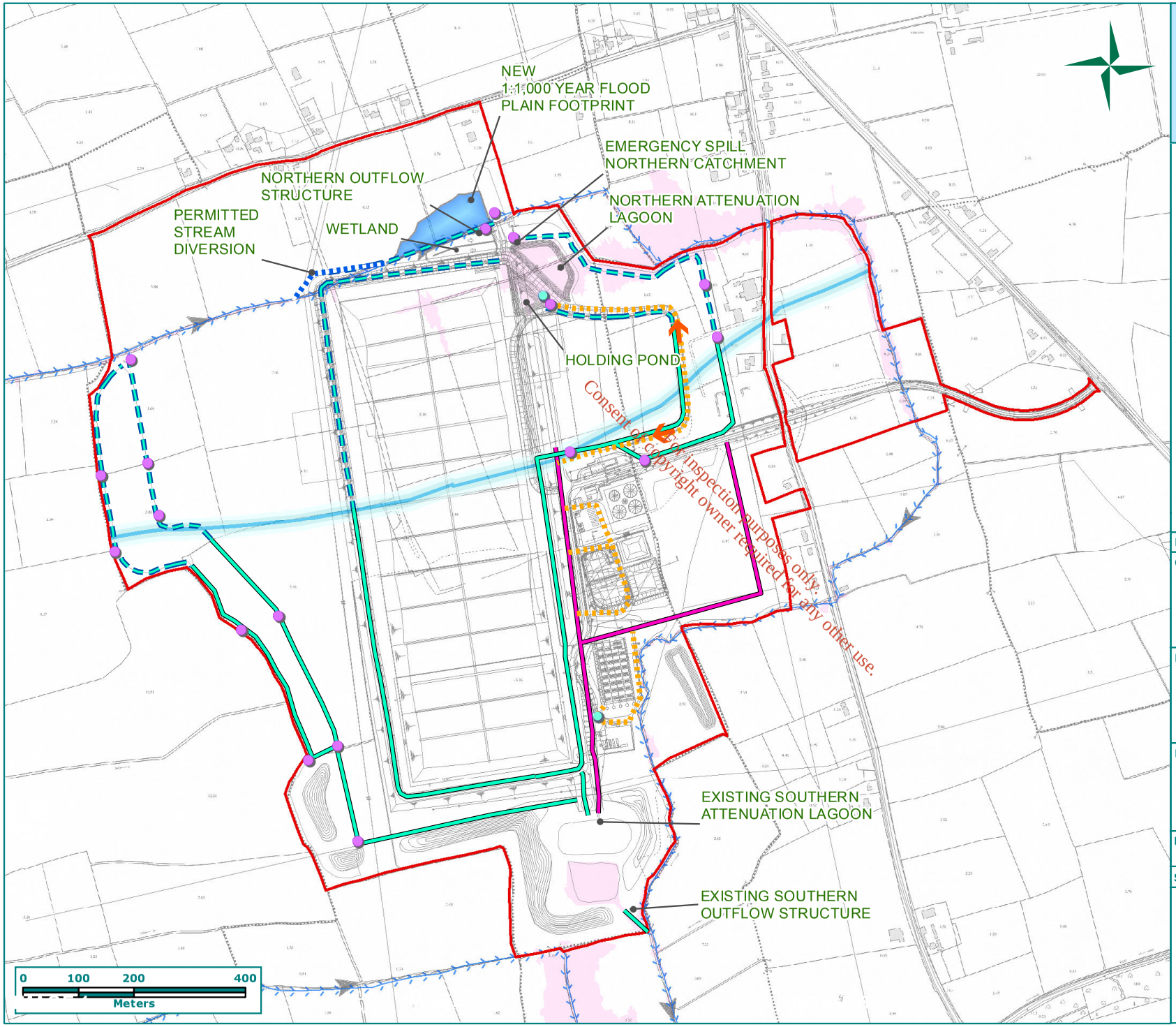
During the construction period, spoil heaps from the excavations will be stored temporarily. All stockpile material will be bunded adequately and protected from heavy rainfall to reduce silt run-off, where necessary. The permanent site drainage system will be put in place prior to excavation, therefore the discharge routes from any temporary stockpiling within that area will be via the site drainage system as detailed in the planning drawings. A minimum buffer of 10 m will be provided between temporary stockpiles and the nearest watercourse. No spoil stockpiles will be left on site after construction is completed.

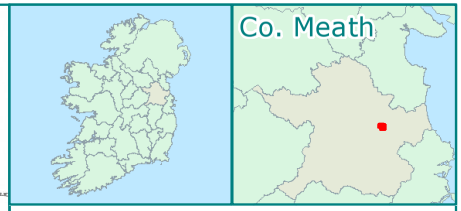
The construction of screening berms will require removal of trees prior to berm placement and reinstatement of trees once berms are constructed.

Prior to removal of trees and installation of haul roads, swales and silt fences will be placed around the perimeter of the proposed works areas to intercept storm water runoff and to pass same to *in situ* drains / watercourses via temporary suspended solids management ponds.

Figure 12-6 shows the proposed primary surface water swale, trunk main layouts and temporary stilling ponds. Construction of cell and cap areas will be subject to prior approval from the Agency in accordance with prevailing IED licence conditions for the facility. Cell, berm and cap construction will be phased.

Swales will be used to drain the reinstated sections to a mixture of temporary and permanent suspended solids management areas. Silt fencing will be erected to further protect streams, where required. The temporary stilling ponds will remain in place until the reinstated areas have attained satisfactory re-vegetation.





Legend

- Site Boundary
- Rivers & Streams
- Indicative Watershed Boundary within Site

Proposed Drainage Layout

- Below Ground Storm - Existing
- Below Ground Storm - Proposed
- Surface Water Swale Northern Outfall - Proposed
- Surface Water Swale Southern Outfall
- Permitted Stream Diversion
- 1:1000 Year Flood Plain Footprint
- New 1:1000 Year Flood Plain Footprint
- Petrol Interceptor
- Suspended Solids Management Ponds

Date	24/07/2018
Client Name	Knockharley Landfill Ltd.
Project Title	Proposed Development at Knockharley Landfill
Figure Title	Proposed Drainage Layout
Figure No.	12.6
Rev.	A
Scale	1:9,500 @ A4

FEHILY TIMONEY & COMPANY
CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES
Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464
Unit 16J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501
W: www.fehilytimoney.ie E: info@ftco.ie

12.4.2 Southern Catchment

This section describes the proposed surface water infrastructure required to accommodate surface water runoff from the catchment areas south of the watershed divide as shown in Figure 12.2. Figures presented below are referenced from Appendix 12.1 of Volume 3 of this EIAR. This southern surface water management outfall has an existing surface water attenuation pond and wetland discharging into the Knockharley stream.

The discharge from the surface water pond is controlled by a slam shut valve that prevents surface water discharging if continuous monitoring of TOC indicates potential contamination of the surface water. The live storage volume of the pond is 4,253 m^3, (theoretical requirement 3,758 m^3). The 1:20 discharge capacity from the existing attenuation pond to the receiving watercourse (via the wetland) is 0.188 m^3/s.

It is proposed to direct additional surface water runoff from the proposed leachate and biological treatment facilities into the southern storm water management system via the in-situ 225 mm to 750 mm trunk main. Surface runoff from these developments will be intercepted by an in-situ petrol interceptor prior to discharge into the existing southern storm water management system.

The development area is 73.74 ha of which buildings and hard standings (from permitted and proposed developments) comprise 16.39 ha.

The greenfield discharge flow rate for the 73.74 ha catchment area is 284.5 l /s and the 1:20 year live attenuation storage[8] requirement is 4,245m^3.

The live attenuation storage of the in-situ constructed southern storm water attenuation pond is 4,253 m^3. The dead storage is 7,197 m^3. On-site in-situ provision therefore exceeds design requirements.

The existing outfall structure between attenuation pond and wetland will require the pipe outfall diameter to be increased from 225 mm to 358 mm to throttle flows to the greenfield discharge flow rates of 284 l/s. At present the discharge rate is lower than the greenfield rate.

Appendix 12.1 Southern Attenuation Pond Calc Set of Volume 3 of this EIAR shows that the existing southern attenuation pond has adequate capacity to accommodate existing increased runoff from the proposed development.

12.4.3 Northern Catchment

Surface water runoff from all roads and hard standings north of the watershed divide including runoff from the proposed IBA facility and permitted landfill will be diverted to the proposed northern surface water management system. The water will drain via landfill perimeter swales and baffled chute inlets into the northern storm water attenuation pond. The drainage pipework will vary from 225 mm diameter up to 750 mm diameter. Water from the IBA facility will drain via a holding pond prior to discharge via a baffled chute inlet to the northern storm water attenuation pond. The pipework will discharge via a Class 1 bypass proprietary oil/water separator into a holding pond and thereafter into the new northern attenuation pond. From there, the surface water will discharge via a wetland to the Knockharley stream on the northern boundary. Figure 12-9 is an artist's impression of the proposed infrastructure. The function of the holding pond will be to provide a containment facility in case contaminated surface water from either the permitted development or proposed IBA facility enters the storm water system. The function of the surface water attenuation pond will be to attenuate discharges from the pond to greenfield discharge rates and to facilitate suspended solids management.

The additional surface water management infrastructure required to accommodate runoff in the northern watershed from the permitted landfill development and proposed IBA facility and will require the construction of:

- A holding pond to isolate, if necessary, contaminated storm runoff with:
    - continuous monitoring of pH, TOC, conductivity and turbidity
    - automated valve set within rectangular weir to isolate flows

[8] A procedure to compute an attenuation pond size based on procedure suggested by Greater Dublin Strategic Drainage Study Regional Policy, Volume 2 Appendix E, Criteria 2, Pages E13-E15

  - pump sump to facilitate pumping of contaminated storm runoff to leachate management facility
  - emergency spill to pass extreme events into the surface water attenuation pond
- a surface water attenuation pond to maintain greenfield runoff rates and to allow settlement of suspended solids:
  - emergency spill and baffled chute to pass water from runoff exceeding 1:100-year extreme events to Knockharley stream
  - floating outlet discharge to wetland to control storm runoff flow rates at or below green field discharge rates
- a wetland to receive attenuated storm flows from the surface water attenuation pond to polish suspended solids to < 35 mg/l and to discharge to Knockharley stream
- a flood compensation culvert across the Knockharley stream sized to facilitate:
  - conveyance of 1:100-year storm events with no impact on upstream water levels
  - compensation storage of flows for 1:1000-year flood event
  - emergency spill in case the compensation culvert becomes blocked
- permitted stream diversion around north-west corner of permitted landfill development
- supporting infrastructure to accommodate monitoring and power.

The sizing of the surface water management infrastructure and detailed of associated structures are presented Appendix 2.4 Northern Storm Water Management of Volume 3 of this EIAR.

The development area is 66.19 ha of which buildings and cells and roads comprise a factored area of 17.45 ha. The greenfield discharge flow rate for the 66.19 ha catchment area is 255 l /s and the 1:20 year live attenuation storage[9] requirement is 3,672 m^3.

The live attenuation storage of the in-situ constructed northern storm water attenuation pond will be 4,698 m^3. The dead storage will be 4,969 m^3. On-site *in situ* provision therefore exceeds design requirements.

During IBA operations potentially contaminated surface runoff will be collected via filter (French) drains with discharges into IBA Facility leachate collection system. The function of the holding pond will be to provide a containment facility in case IBA dust or other contaminants enters the storm water system.

Once IBA cell related operations cease, all runoff will be directed to the Holding Pond and thence to the Storm Water Attenuation pond.

The perimeter swales will have an approximate depth 600 mm with a bottom width of 1,000 mm and side slopes of 1 in 3.

Outflows from the storm water pond will enter the wetland via a floating weir or similar and will be discharged thereafter into the receiving Knockharley stream via a piped outfall with rip rap or similar lining protection. The attenuation pond will also have an emergency spill capable of passing a 1:100-year discharge into the receiving watercourse via a baffled chute.

The pond will be designed to accommodate a suspended solid loading of 2,500 mg/l and deliver an outflow containing less than 25 mg/l (current licence emission limit values require < 35 mg/l). The receiving wetlands will provide additional polishing once wetland vegetation is established.

The proposed storm water management infrastructure is in a 1:1000-year flood plain, accordingly flood compensation provision will be required to offset that lost by placing the proposed northern storm water attenuation management infrastructure in the natural low point of the site.

The operation of the existing pond and the proposed new pond are described in more detail in the Surface Water Management Plan in Appendix 12.2 of Volume 3 of this EIAR.

[9] A procedure to compute an attenuation pond size based on procedure suggested by Greater Dublin Strategic Drainage Study Regional Policy, Volume 2 Appendix E, Criteria 2, Pages E13-E15

Measures following consultation with IFI to protect watercourses and waterbodies on site, are provided under the following:

- A Construction Environmental Management plan in Appendix 2-0 in Volume 3 of the EIAR
- A Surface Water Management Plan IN Appendix 12-2 Volume 3 of the EIAR

Tree-felling will be required to facilitate the proposed new development, albeit that the trees to be felled are commercial forestry and will be harvested in the future. The existing forestry drains will be re-located where required and surface water flows re-diverted as necessary.

12.4.3.1 Proposed Flood Mitigation Measures

The flood risk identification and drainage assessment prepared for this development presented in Appendix 12.5 of Volume 3 of this EIAR, informed the preferred site drainage design for the proposed development.

The establishment of the proposed surface water attenuation pond in the 1:1000-year flood plain required that supplemental flood storage be provided to offset flood storage lost as a result of the works impacting the historic flood plain area.

The recommended action is to place a culvert in the existing water course designed to:

- pass 1:100-year storm runoff flows with no increase in water levels, and
- throttle 1:1000-year storm runoff to provide storage equivalent to the lost 1:1000-year flood plain volume.

The proposed design solution requires construction of a 1500 mm diameter culvert, length approximately 43 m within an embankment across the Knockharley stream at an existing culvert location (see Drawing Nos. LW14-821-01-P-500-001-003 through 005 Surface Water Management Infrastructure details in Volume 4 of this EIAR). Throttling of 1:1000-year storm events will be provided by an eccentric orifice or similar approximate diameter 825 mm (subject to detailed design).

The embankment top level will be approximately 2.15 m above existing ground level and will have an emergency spill to accommodate unforeseen culvert blockages.

The protection works upstream and downstream of the embankment will also accommodate outflows from the northern attenuation storm water pond via the wetland, and emergency spills > 1:100-year storm events from the storm water attenuation pond.

The outline Habitat and Species Management Plan within the CEMP will also define protocols following consultation with the IFI prior to construction in relation to Aquatic Ecology.

The proposed development requiring works within or adjacent to the stream will involve:

- the diversion of a watercourse for c. 171 m to the north of the site. This reach of the watercourse is not fisheries sensitive. (This work is part of permitted development albeit that Section 50 outstanding).
- Construction of a c. 43 m culvert within the Knockharley stream
- Construction of an embankment c. 55 m toe width across the stream with upstream and downstream launching apron protection works to house the culvert and provide access across the stream.
- Inlets to the Knockharley stream from wetland outfall and emergency attenuation pond spill outfall.

The outfall from the emergency spill will be via a baffled chute structure which will dissipate energy prior to discharge onto the embankment launching apron. In the unlikely event of an emergency spill occurring, the baffled chute structure is considered to be the most robust solution in mitigating the potential risk of increased suspended solids loading during an emergency spill. The baffles negating the need for a stilling basin which might get blocked.

The baffles will however be recessed into the stream bed and in the event of larger flows developing, i.e. in excess of design provision, the structure will be designed to accommodate downstream scour erosion up to 1.0 m depth.

The preliminary size of the flood compensation culvert was estimated as part of the flood risk assessment. A summary of the preliminary culvert sizing is provided in Table 12.12. The culvert was sized to convey a 1 in 100-year flood with a 20% allowance for Climate Change and to throttle flows to provide upstream compensation storage for 1:1000-year storm events. Details of supporting documentation is provided under the following:

- Flood Risk Assessment in Appendix 12-5 in Volume 3 of the EIAR
- Hydrology Report in Appendix 12-6 of Volume 3 of the EIAR

A summary of the key hydraulic design parameters is presented in Table 12-9 over and the culvert sizing is presented in Table 12-10.

Table 12-9: Summary of key hydraulic design parameters

Attenuation Ponds

	Southern Pond	Northern Pond	Unit
Development Area	73.74	66.19	ha
Pond live storage requirement for 1 in 20 year flow	4,160	3,672	m^3
Live volume of storage provided	4,253	4,698	m^3
Outflow pipe diameter for 20 year flow	358	300	mm
Outflow pipe discharge for 20 year flow	0	0	l/s
1 in 100 year spill required for 1 in 100 year event or greater	3.66	3.24	m^3/s
Spill design capacity for 1 in 100 year flow or greater	3.71	3.29	m^3/s

Flooding & Culvert Analysis- Northern Catchment

The flood component of the design flow that needs to be accommodated in upstream storage is any flow in excess of the 1:100, 1.83m^3/s flow, and equal to or less than the 1:1000 flood event (i.e. 2.43 m^3/s). This will be achieved by installing an orifice in the conpensation flood culvert which will restrict flows in high flow events, but allow flow to pass unimpeeded for lower flow events (up to the 1 in 100 year event).

	Pre Development	Post Development	Unit
Flood plain storage, 1 in 1000 year	7,677	7,977	m^3
Upstream top water level in 1 in 100 year storm event	59.39	59.41	mOD
Upstream top water level in 1 in 1000 year storm event	59.56	60.5	mOD
Existing Top of bank level	59.62		mOD
Upstream Culvert Invert	-	58.457	mOD
Downstream Culvert Invert	-	58.089	mOD
1 in 100 year flood flow rate	1.83		m^3/s
1 in 1000 year flood flow rate	2.43		m^3/s
Culvert Diameter	-	1.5	m
[1]Orifice provision at entrance to culvert	-	0.825	m
Culvert length	-	43	m
Culvert Slope	-	0.009	or a 1 in 117 gradient
Flow through orifice	-	1.86	m^3/s
Upstream head on culvert in 1 in 100 year event	-	0.108	m
Upstream head on culvert in 1 in 1000 year event	-	0.278	m

1 Orifice shape and design subject to detailed design

Table 12-10: Summary of Preliminary Culvert Sizing

Culvert Reference	Form	Size (m)Pipe diameter	Length (m)	Invert Level U/S (Streambed Level)	Invert Level D/S (Streambed Level)	Culvert Slope (1:X)
Culvert at chainage 4814	Pipe	0.9	68	58.457	58.089	185

Reference	Form	Average Size Width (m) x height (m)	Length (m)	Invert Level U/S (Streambed Level)	Invert Level D/S (Streambed Level)	Slope (1:X)
Stream Diversion	Rectangular Channel	3.1 x 1.5	171	60.55	59.524	167

All natural watercourses which have to be traversed during site development works and/or for access road construction works will be effectively bridged using 600 mm diameter culvert with upstream and downstream stone protection works or similar prior to commencement.

A permanent crossing will be provided across the Flemingstown stream to facilitate an access road and is illustrated in Drawing No. LW14-821-01- P-0500-000 Proposed Storm Water Management Southern Outfall in Volume 4 of this EIAR.

A Section 50 application will be required to obtain the consent of the OPW for:

- stream diversion
- the flood culvert within embankment and stream crossing
- outfall from the wetland
- emergency overflow weir outfall from the northern Surface Water Attenuation Pond
- temporary crossing(s) associated with forestry works and construction works

A description of the works associated with the proposed Section 50 application is presented under respective headings below. The primary risks to receiving waters will be increased suspended solids loadings during construction, during operations and in the aftercare period.

Preliminary design has been informed by consultation with IFI and OPW. However prior to work commencing, detailed design will be reviewed with IFI and OPW to make sure the design criteria adopted accommodate prevailing site conditions.

12.4.4 Stream Diversion

A stream diversion, see Drawing No. LW14-821-01- P-0500-001 Proposed Storm Water Management Southern Outfall in Volume 4 is proposed to facilitate construction of the permitted development. This will require a new stream channel to be constructed. This diversion is permitted under the existing planning permission for the landfill development, but the diversion has not been required to date as the landfill cells have not yet been constructed in that area. The potential impacts and mitigation measures are included in this chapter.

To mitigate the risk of elevated suspended solids occurring, excavation works and connection to the live channels will take place during summer. Whilst there is a risk of elevated suspended solids occurring when water is passed initially through the channel, this risk will be mitigated by allowing the channel to stabilise and to vegetate following excavation prior to letting diverted stream flows enter. Water will be allowed to enter the diversion channel during low flow conditions.

If works are carried out during low flow conditions, the proposed channel is allowed to stabilise with a vegetative cover, and if flows into the channel are initiated during low flow conditions the impact associated with elevated suspended solids will be "not significant".

12.4.5 Flood Culvert and Stream Crossing

The flood culvert is designed to throttle 1:1000-year storm events and to cause localised upstream flooding, see Drawing No. LW14-821-01- P-0500-001 Proposed Storm Water Management Southern Outfall in Volume 4 of this EIAR.

The proposed culvert cross section area is similar to the existing channel section so long-term use will not change velocities outside the normal range and will not increase the risk of suspend solids as flows pass through the proposed culvert. The culvert will also have upstream and downstream protection to allow any eddies initiated by changes section / velocity to be contained within a rip rap stone protection lining.

The primary impact will occur during construction. To mitigate the risk of suspended solids impacting downstream flows construction works will be carried out during low flow periods, excavation in the channel will be kept to a minimum (culvert invert will be coincident with existing channel invert), and downstream settling ponds will be installed to either accept diverted flows or facilitate settlement of suspended solids as may develop during works to the bed and side slopes.

If works are carried out during low flow conditions; the culvert invert is the same as the channel invert; and diversions and or through flows are directed into an on-stream stilling basin as proposed; the risk of elevated suspended solids will be 'not significant.'

The culvert will also have a spill to:

- accommodate storm events exceeding 1:1000-year storm events, and
- accommodate blockages as pay occur in the culvert.

In the event of a spill occurring to pass flows > 1:1000-year events there will be an imperceptible impact on downstream suspended solids as the embankment will be flooded both upstream and downstream such that the downstream channel will act as a stilling basin and it will dissipate any energy developing as flows overtop the spill.

In the event that a spill occurs owing to the culvert becoming blocked, the spill will have a stilling basin and down-stream protection to dissipate any energy developing as flows overtop the spill.

12.4.6 Wetland Outfall

Storm water flow from the proposed storm water attenuation lagoon is designed to pass at a constant greenfield discharge rate with suspended solids < 25 mg/l (waste license requires < 35 mg/l) into the proposed wetland. The wetland is designed to further polish suspended solids before discharging green field flow rates into the Flemingstown stream, see Drawing No. LW14-821-01- P-0500-001 Proposed Storm Water Management Southern Outfall in Volume 4 of this EIAR.

The wetland outlet structure is designed to discharge flows over a weir and to dissipate energy within a vertical stilling basin prior to discharging outflow to the stream into a rip rap stone protected outfall structure. An emergency spill will also be incorporated within the wetland outfall structure in case the outfall pipe becomes blocked.

The structure is designed to discharge storm flows into the stream with negligible energy so as to negate the need for stilling basins within the watercourse. Rip rap stone protection will be provided at the outfall mitigate the risk of suspended solids being generated owing to localised turbulence.

12.4.7 Emergency Overflow Weir Storm Water Attenuation Lagoon

The storm water attenuation lagoon has been designed to attenuate 1:20-year storm event runoff. The overflow spill capacity is designed to accommodate a 1:100-year storm event, see Drawing No. LW14-821-01- P-0500-001 Proposed Storm Water Management Southern Outfall in Volume 4 of this EIAR.

Energy dissipation will be effected by a baffled chute structure. In the event of a storm event flood causing a spill the water will flow over the weir, pass through a culvert and enter the watercourse via the baffled chute. The chute is designed to facilitate energy dissipation within the chute. In the event that energy remains, a localised stilling basin will be provided within the rip rap stone protection at the base of the chute.

Energy dissipation will mitigate the risk of suspended solids being generated.

12.4.8 Temporary Crossing

Whilst there is an option to access lands to the north of the stream from adjoining lands, a worst-case scenario from a hydrology perspective, has been assumed. A worst case also assumes that existing crossings will not be used in case they are damaged.

To facilitate cutting, removal and replanting of trees in lands to the north of the stream, forestry equipment will need to cross the stream.

Temporary works will require installation of a precast pipe culvert min diameter 600 mm and backfill using washed granular fill and removal of same thereafter. The site access will be placed adjacent to the proposed permanent culvert to facilitate construction of the permanent works.

12.5 Flood Risk Identification and Assessment

Section 12.3.3 discusses the existing flood risk. Sections 12.4.2 and 12.4.3 describe the proposed changes to the surface water management system in the southern catchment and the proposed surface water management in the northern catchment.

12.5.1 Overview of Storm Water Management Infrastructure.

Section 12.3 and 12.4 of this chapter discuss the existing and proposed storm water management infrastructure,

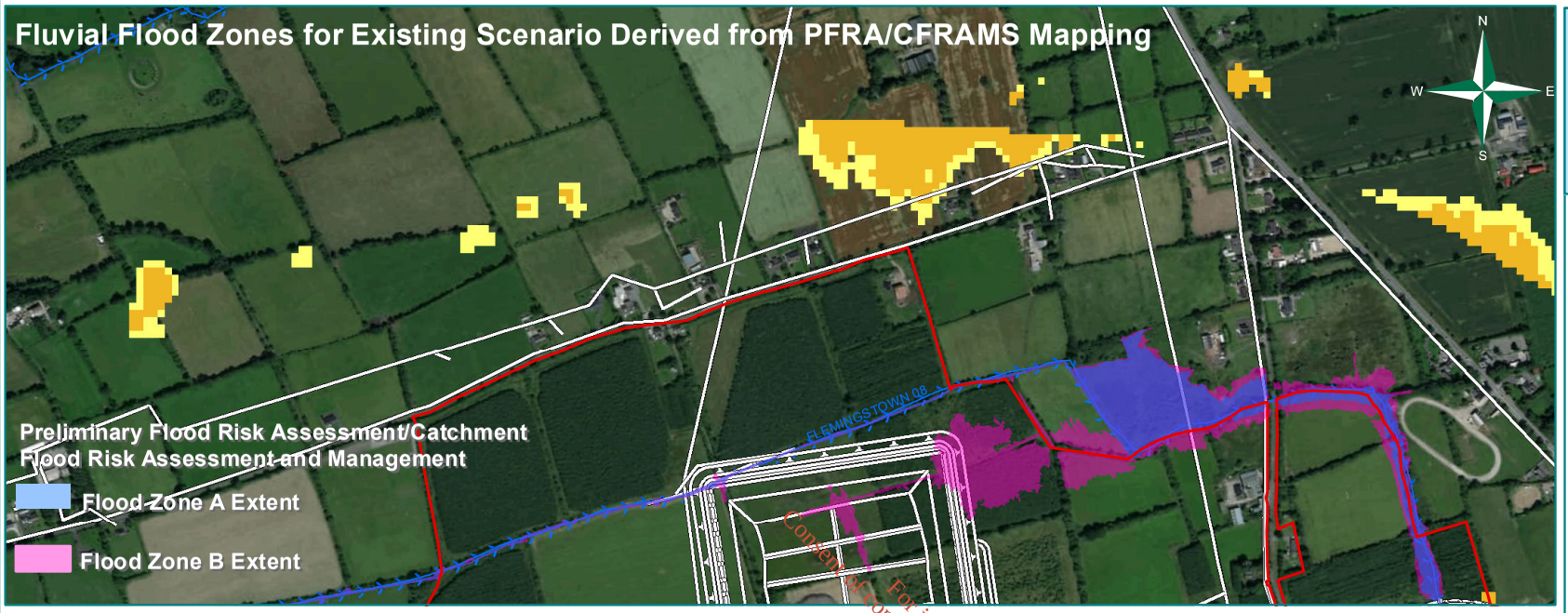
Figure 12.7 shows the 1:1000-year flood plain within the facility boundary and shows the proposed northern storm water attenuation pond will be located over an existing 1000-year flood plain storage.

Figure 12-8 shows the catchment area upstream of the flood plain/proposed flood compensation culvert.

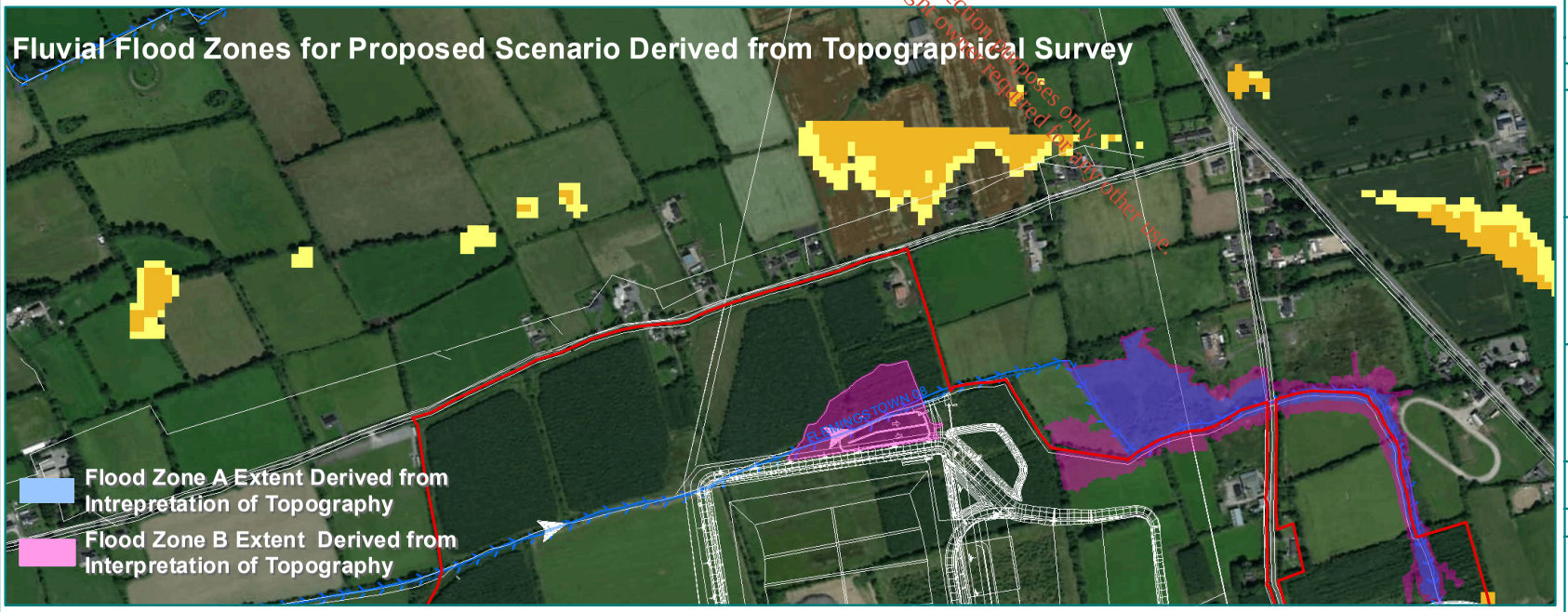
A Justification Test was carried out and is included in Appendix 12.5 of Volume 3 of this EIAR, following which a concept design was developed to provide storage offset that lost by placing a portion of the permitted and proposed developments within a 1000-year flood plain.

Figure 12.9 below illustrates the northern storm water management concept layout and location of compensatory flood provision.

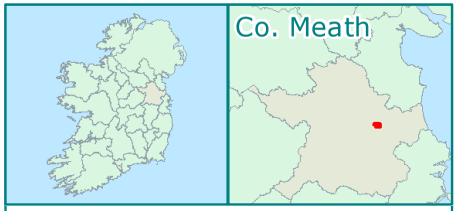
Fluvial Flood Zones for Existing Scenario Derived from PFRA/CFRAMS Mapping



Fluvial Flood Zones for Proposed Scenario Derived from Topographical Survey



0 250 500 1,000
Meters



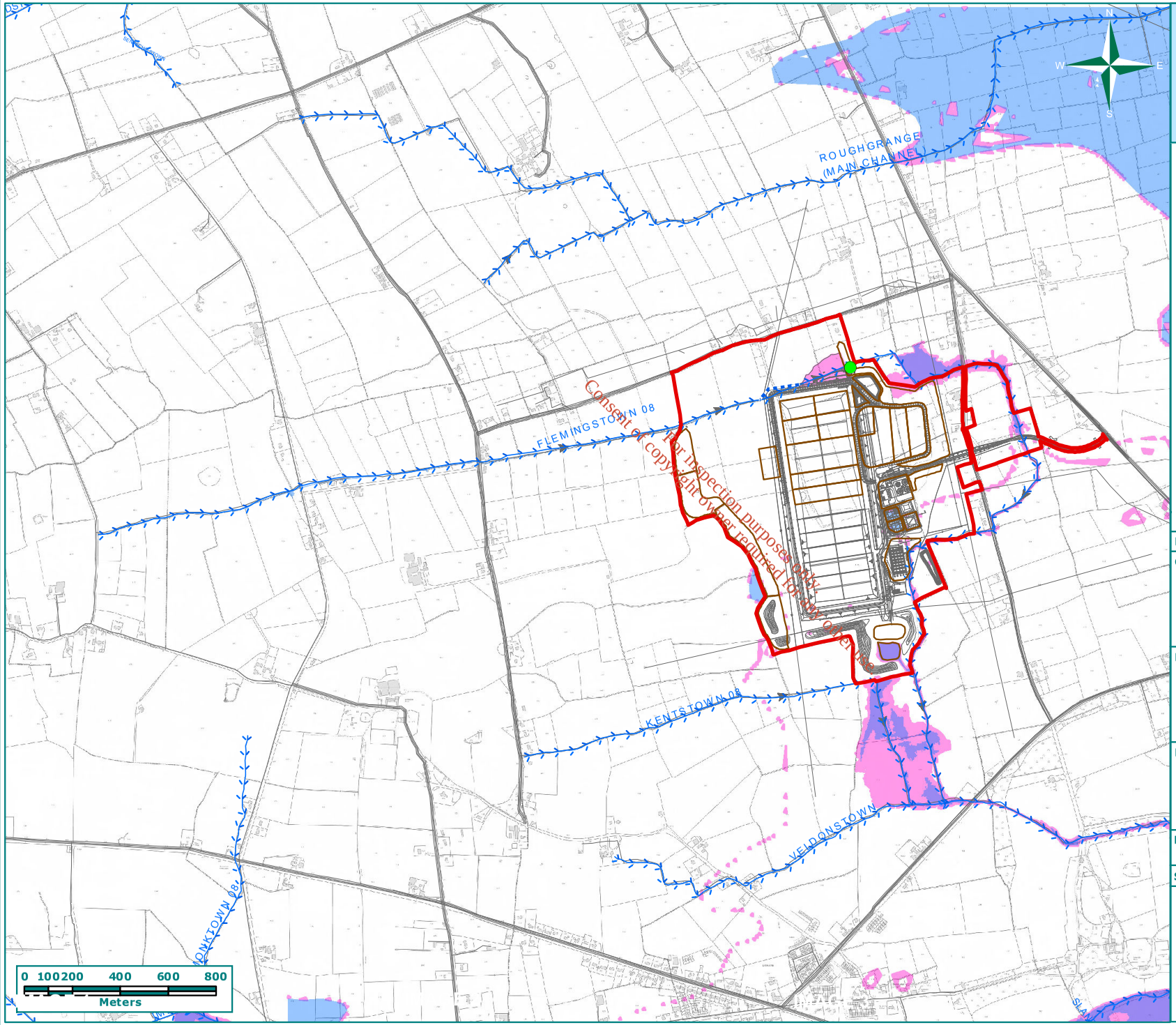
Legend

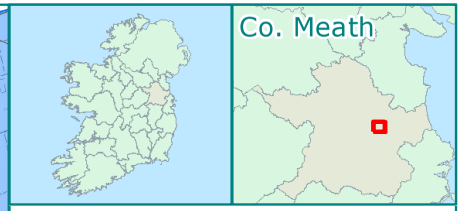
- Site Boundary
- Site Layout
- PFRA/CFRAMS: 1% AEP Pluvial Flood Extent
- PFRA/CFRAMS: 0.1% AEP Pluvial Flood Extent
- Rivers

NOTE: The maps on Preliminary Flood Risk Assessme (PFRA) provide only an indication of areas that may be prone to flooding. They are not necessarily locally accurate, and should not be used as the sole basis for defining the flood zones nor for making decisions on planning applications.

Date	18/05/2018
Client Name	Knockharley Landfill Ltd.
Project Title	Proposed Development at Knockharley Landfill
Figure Title	Site Specific Flood Risk Assessment - Existing Scenarion and Proposed Scenario Flood Zones
Figure No.	12.7
Rev.	A
Scale	1:10,000 @ A4

FEHILY TIMONEY & COMPANY
CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES
Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464
Unit 16J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501
W: www.fehilytimoney.ie E: info@ftco.ie





Legend

- Proposed Flood Compensation Culvert
- Site Boundary
- Flood Zone A Extent Derived from Intrepretation of Topography
- Flood Zone B Extent Derived from Interpretation of Topography
- Rivers

Date	18/05/2018
Client Name	Knockharley Landfill Ltd.
Project Title	Proposed Development at Knockharley Landfill
Figure Title	Catchment Upstream of the Proposed Flood Compensation Culvert
Figure No.	12.8
Rev.	A
Scale	1:22,000 @ A4

FEHILY TIMONEY & COMPANY
CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES
Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464
Unit 16J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501
W: www.fehilytimoney.ie E: info@ftco.ie

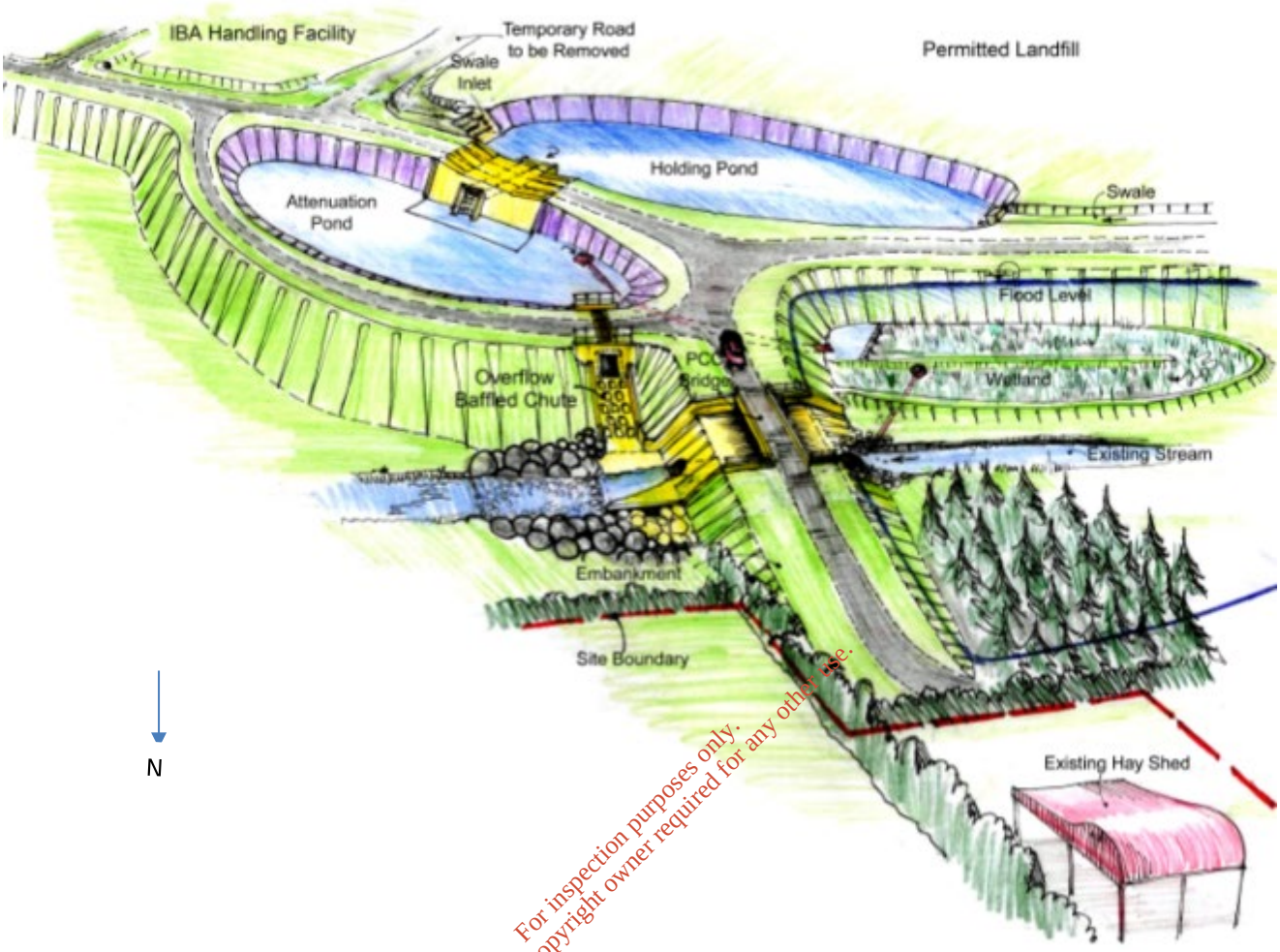


Figure 12-9: Artist Impression of Northern Storm Water Management and Flood Area

12.5.2 Offset Flood Provision

Details of volumes and flow rates quoted in the following sections can be found in Appendices 12.4 and 12.5 of Volume 3 of this EIAR.

As discussed in Section 12.3.3, the indicative flood mapping from the OPW shows an area at the north-east corner of the proposed development to be within a Flood Zone B area i.e. an area at risk of flooding in a 1 in 1000-year return period flood. Overland flows were diverted following construction of the existing permitted development and therefore flows are less likely to collect in this area, however a potential loss in floodplain storage remains.

The 1 in 1000-year flood level area was determined to be 59.56 m OD at the Flood Zone B location of the floodplain identified in the FEMFRAM[10] study. The permitted landfill footprint and proposed storm water management infrastructure will impinge on the Flood Zone B footprint that would otherwise provide *in-situ* storage approximately equal to 7,977 m^3 for 1:1000-year flood events.

It is proposed to provide equivalent compensatory storage by constructing a small culverted embankment which will be designed to throttle 1:1000-year flows and to let 1:100-year flows pass with minimal impact on upstream levels.

[10] http://fem.cfram.com/hydrology.html

A flood risk assessment prepared for the proposed development used a HECRAS river model simulation, referred to in Section 12.3.3, to determine flood levels for the 1 in 1000-year extreme event for alternate culvert diameters and the resulting upstream storage volume was compared to the potential storage lost in the indicative area shown to be a Flood Zone B area in the FEMFRAM study.

The design criteria for the flood compensation area is set out in Appendix 12.4 of Volume 3 of this EIAR.

The perimeter road on the northern boundary will also be higher than the 1:1000-year storm event predicted elevation to protect the landfill facility against flooding.

The proposed compensation culvert will accommodate a 1 in 100-year flood flow with a 20% allowance for Climate Change.

The surface water run-off from the landfill and the IBA facility will be controlled in an attenuation pond, with the outflow limited to greenfield rates before final discharge back into the stream via a wetland.

12.5.3 Conclusion of Flood Risk Identification and Assessment

There are no areas within the proposed development identified by the OPW as 'benefitting lands'[11].

There is no area of the proposed development within the indicative 1 in 100-year floodplain area (Flood Zone A) as identified by the OPW in their CFRAM/PFRA mapping. FEMFRAM Study mapping indicates a Flood Zone B (1 in 1000-year flooding) in both the existing permitted and proposed development areas. A modification to the stream to the north of the proposed development will divert flows over and above the 1 in 100-year return period flows into an offset floodplain area, within the wooded area on the northern boundary of the permitted landfill footprint. A compensation culvert will throttle flows to provide for the lost storage that would otherwise have been provided in the historic flood plain arising from 1 in 1000-year flood event. There is no flood risk to any infrastructure within the proposed or permitted development during a flood event albeit that flooding may occur within the footprint of the site boundary, this will not however compromise the integrity of the proposed or permitted developments.

There will be no appreciable obstruction to flood flows as a result of the proposed development. Any stream crossings will be conveyed in culverts, sized to take the 1 in 100-year flood flow with a 20% allowance for Climate Change.

Because of the proposed development, an overall increase in run-off volume of 4.6% may occur. It will however be attenuated within the Veldonstown catchment and there will be no flood risk due to the development downstream in River Nanny catchment.

The estimated increase in run-off will also reduce over time as vegetation is re-established on the site. The estimated increase is considered to be of 'not significant'. The potential for an increase in flood risk due to the proposed development is therefore of 'imperceptible' due to the small percentage increase in run-off volume contributing to the catchment because of the proposed development.

12.6 Potential Impacts

The potential impacts on the hydrological regime at the site and the surface water quality of waters draining the site are assessed in the following sections for the activities associated with each phase (construction, operation, maintenance and decommissioning) of the proposed development at Knockharley Landfill. The potential impacts are assessed in accordance with the evaluation criteria outlined in Section 12.2.6. The drainage of the proposed development is then considered, taking account of mitigation measures to reduce or eliminate any residual impacts.

[11] A dataset prepared by the Office of Public Works identifying land that might benefit from the implementation of Arterial (Major) Drainage Schemes (under the Arterial Drainage Act 1945) and indicating areas of land subject to flooding or poor drainage.

An impact rating has been developed for each of the phases of development. In Section 12.2.6 the sensitivity of the receiving environment was first identified. Then the magnitude of the potential impact was estimated. The sensitivity rating, together with the magnitude of the potential impact, provides an overall rating of the significance of the impact prior to application of mitigation measures. The assessment of the magnitude of an impact incorporates the timing, scale, size and duration of the potential impact. This is shown in Table 12.13. The residual impacts following mitigation and the associated significance rating is also provided in Table 12.14. The evaluation criteria covered the direct impacts and any indirect, secondary, cumulative, short, medium and long-term, permanent and temporary, positive and negative effects of the project.

The potential impacts in relation to an increase in flooding, cumulative flood risk with neighbouring developments, as well as specific impacts during the various phases of the proposed development are outlined below.

There is an existing landfill with ancillary infrastructure in operation on site with a surface water management system. There has been no significant impact on hydrology or water quality as a result of the existing development. The proposed development has been designed to take account of the risks that it could pose to the environment and mitigation measures have been incorporated into the design.

12.6.1 Do Nothing Impact

If the proposed development does not proceed, it is likely that the land will continue to be used for landfill with areas left as poorly drained pasture and forestry. In areas where conifer forestry plantations are present, deforestation and reforestation will continue to occur into the future. The impact on hydrology and surface water quality would remain largely unaltered as a result.

Modifying the existing landfill facility will avoid the need for a similar development elsewhere on alternative lands where the other constraints and limitations would have to be managed, as opposed to making modifications to the existing site/landfill, where the associated works to accommodate such will be minimal as much of the associated works are in place and functioning efficiently.

12.6.2 Potential Impacts during Construction

In the absence of mitigation measures, the following potential impacts on hydrology and surface water during construction have been identified:

- Increased run-off
- Flooding
- Sediment loading
- Nutrient loading
- Spills

12.6.2.1 Increased Surface Water Run-off

The surface runoff impacts within the southern catchment will be minimal as a surface water attenuation pond is already in place. The proposed development in the northern catchment will also only result in a minor increase in surface runoff volumes prior to and during construction of the northern surface water management infrastructure. It is proposed to construct the surface water management infrastructure prior to other construction works. Once the attenuation pond and supporting infrastructure are constructed with a dedicated outlet to the Knockharley stream, surface water runoff into the receiving waters will revert to green field flow rates.

Increased impermeable surfaces associated with roof, pavements, capped areas and pond areas of the development will however increase surface runoff volumes which will contribute to the increased flow volumes shown in Table 12-11.

The potential impact of an increase in surface water runoff is greater flows in the receiving water bodies. This can cause erosion and scour around water channel structures and siltation in areas where the water velocities reduce, allowing for the waters suspended solid load to be deposited.

Increased surface runoff has the potential to also increase the peak in river water level, which could result in an increased flood risk if the increase is significant.

The percentage increase in surface water runoff volumes presented in Table 12.11 reflects percentage volume increases in the Veldonstown catchment from both the northern and southern catchments areas within the facility footprint during construction and during operations assuming attenuation is provided, and green field discharge rates are maintained.

Table 12-11: Summary of Estimated Increase in Surface Water Run-off Volumes

Catchment	% Increase Construction Note 2	% Increase Operation Note 3
Veldonstown - IE_EA_08_352 catchment Note 1	4.60%	4.69%

Note 1 1:100-year Runoff Flow Rate at Outfall of Veldonstown Catchment is 7.42 m^3/s and this has been used as a datum over a respective period assumes as being required to discharge increased runoff at greenfield discharge rate

Note 2 1:100 volume assume to be 1,106 m^3 taking a period of 54 minutes to be discharged from attenuation pond

Note 3 1:100 volume assumed to be 376 m^3 taking a period of 18 minutes to be discharged from the attenuation pond

Table 12.11 and Table 12.12 show the estimated change in runoff volumes corresponding to a 1-in-100 year, 30-minute duration storm at Knockharley Landfill.

Table 12-12: Overview of Runoff Impacts (Existing, Construction, Operation and Post Decommissioning)

		Run-off [1,3,4]	Change in Runoff Entering Attenuation Ponds	Change in Runoff Entering Downstream Watercourse[6]	Runoff Volume[10]	Change in Runoff Volume	Time to Discharge into Knockharley Stream [8,9,11]	Time to Discharge Veldonstown [7]	Impact
Catchment	**Scenario**	m^3/s	m^3/s	m^3/s	m^3	m^3	mins	mins	
Change in run-off from Entire Development Area[5]	Existing	1.816	0.000	0	3,268	0	0	75	Low[12]
	During Construction	2.025	0.209		3,645	376	18		
	During Operation	2.430	0.614		4,374	1,106	54		
	Decommissioning[2]	1.816	0.000		3,268	0	0		

Notes:

1 Impervious area, factored by runoff coefficient for each surface type.

2 Extent of decommissioning subject to Agency approval. Assumed impervious area not greater than the existing predevelopment area at decommissioning stage.

3 Runoff estimated by the Modified Rational Method, Q = 2.78 x (Rainfall Intensity) x (Contributing Impervious Area).

4 In estimating the runoff, a rainfall intensity for 1 in 100 year return period storm of 30 min. duration supplied by Met Éireann with a factor of 1.1 was applied to allow for climate change in accordance with GDSDS, 30.8mm applied.

5 Catchment Area within site boundary, 139.89 ha.

6 Runoff flows are attenuated in ponds, and discharged at a controlled rate, not exceeding the greenfield runoff rate.

7 Assuming a 1m/s velocity along the modelled 4.5 km reach of stream, gives an approximate time of concentration of 1hr 15m for the Veldonstown stream catchment.

8 The greenfield discharge rate for the "Southern" outfall is $0.351m^3/s$, and $0.329m^3/s$ from the "Northern" outfall.

9 Taking an average discharge of $0.34m^3/s$, the additional runoff volume will be discharged in less time than the TOC.

10 Runoff Volume from 30min storm with return period of 1 in 100 years.

11 Time to discharge additional volume into Knockharley watercourse.

12 Impact is low on the hydrological regime as the time to discharge the additional volume is less that the time of concentration and therefore the discharge of additional volume from the site will have no impact on the peak flow levels in the stream downstream of the Veldonstown catchment.

The estimated increase in run-off will reduce over time as vegetation is re-established on the site. The estimated increases are considered to be not significant.

12.6.2.2 Flooding

The following comprises a list of sources in the absence of mitigation which could result in flooding at the site:

- Small diameter / shallow cross-drains could lead to blockages and consequent flooding and concentration of flows.
- The removal of vegetated material could lead to an increase in the rate of run-off from those areas. This increase in the rate of run-off could lead to a minor increase in flooding downstream.
- Stream flows could be impeded due to inappropriate design of stream crossings and watercourse diversions.
- Flows from the new drainage system could be impeded, should blockages occur in the existing drains.
- Open bodies of water and saturated ground present a risk to the safety of site personnel. Hazards of this type include the stream running through the site and other potentially wet areas following extreme rainfall events (Waterlogged ground was observed during the site walkover. See also Hydrological Features in Figure 12.2).
- The construction of new infrastructure has the potential to obstruct existing overland flow.
- Infrastructure proposed in boggy, poorly drained areas, could lead to an increase in flooding elsewhere.
- The increase in impermeable areas in the proposed new development areas could lead to an increase in flooding downstream.
- The relocation of the 1 in 1,000-year floodplain.

The potential impacts of flooding include, damage to the site's operational infrastructure, a risk to the health, safety and wellbeing of site staff, and a negative impact on the receiving environment, including pollution of watercourse.

Relocating the 1:1000-year floodplain as part of the proposed flood compensation area will have an impact on the flood extent, however, it will have little if any impact on fish, wild life or other as may be present.

12.6.2.3 Sediment & Nutrient Loading

Construction activities on site have the potential to cause soil disturbance. Rain can result in potential run-off of soil particles (sediment) to watercourses causing soil erosion and consequent sediment release into the receiving watercourses.

There is a potential impact on surface water quality from an increase in sediment concentration in watercourses during the construction phase. Sedimentation is the deposition of fine sediment either within the gravel or directly on the substrate surface of an aquatic system. Problems arise when high sedimentation rates smother coarser particles with fine ones. This can reduce oxygen levels either through a decline in through flow rates or, in the case of organic particulates, by their own use of oxygen (36).

The potential sources of sediment to surface water which may arise during tree felling and construction activities in the absence of mitigation measures include:

- Release of sediment during the stream diversion and culverting works.
- Increased sediment loading of streams from personnel and traffic activities.
    - Run-off from access tracks to facilitate forestry works and earthworks during construction

  - Temporary haul roads passing close to watercourses could allow the migration of silt laden run-off into watercourses; crushing of stone in haul roads by heavy vehicles, creates fines and consequent oozing of soluble material in very wet weather out from the roads and into the drainage network.
- Inappropriate site management of excavations could lead to loss of suspended solids to surface waters.
- Spoil heaps from the excavations will be stored temporarily and could lead to an increase in silt-laden run-off draining off site.
- Inappropriate management of berm construction could result in the loss of suspended solids to surface waters.

Other potential sources of nutrients or contaminants in surface water run-off during construction include:

- Wet concrete operations
- Sanitary waste
- Tree felling

As discussed in Section 12.4, the potential for release of sediment and nutrients to surface water during the construction and operation of the development was considered during the preliminary design and will form an integral part of detailed design. The existing and proposed surface water management systems will mitigate the potential release of sediment and nutrients to surface water from the proposed infrastructure (landfill, IBA, biological treatment facility, roads and hardstanding areas). The northern surface water management system will be constructed ahead of other elements of the development. There is potential for sediment and nutrient release in the absence of mitigation measures from areas outside of the northern and southern surface water management systems, i.e. construction of the screening berms, felling activities and during the construction of the northern surface water management infrastructure.

12.6.2.4 Spills

A spillage of diesel or hydraulic fluid during the construction period has the potential to impact on surface water quality in the absence of mitigation measures. These spills have the potential to contaminate surface water which will in-turn impact the water quality and the eco-systems which interact with the catchments surface water.

The potential sources of spills in the absence of mitigation during the construction period include:

- Refuelling activities
- Leak during plant operations
- Leak from storage tanks

12.6.2.5 Potential Cumulative Impacts

The increase in the rate of surface water run-off due to the increase in impermeability in the proposed new development areas within the waterbody catchment, could lead to a low cumulative risk of flooding downstream.

To mitigate the risk of cumulative downstream impacts, programming has been structured such that prior to any bulk earthworks works commencing in the northern sub catchment within the facility boundary, the northern storm water management system will be installed.

There are a number of facilities within the surrounding hinterlands that operate under licences issued by the EPA:

- Kentstown Sow Unit (transferred to Marry Pig Farms Limited) is located approximately 4 km south of the Knockharley Landfill facility in Danestown. It is operated under an IE licence P0456-01 from the EPA. It is a piggery with approximately 4,000 pigs and employs 3 people. Planning permission was granted in January 2015 for the demolition and reconstruction of facility buildings
- There is a poultry farm in Gerrardstown, Garlow Cross, located approximately 3.5 km south west of the facility. The poultry farm produces eggs and currently has capacity for 40,000 layers and is licensed for 117,500 layer spaces. The facility is licensed by the EPA through IE licence P0917-01. The 2015 AER lists one employee.
- A poultry farm in Garballagh, Duleek rears c. 3,000 broilers per annum. It is operated under IE licence P0887-01. It is approximately 4 km west of the facility and employs one person.

  Dunbia operates a meat processing facility in Beauparc under IE licence P0811-02 the operation of slaughterhouses with a carcass production capacity greater than 50 tonnes per day. It has over 70 employees and is 3.5 km north of the facility.
- Cooksgrove Ltd., trading as Euro Farm Foods, operates as cattle slaughterhouse in Cooksgrove, Duleek. It has an IE licence P0822-01 with a throughput of 300 cattle a day. It has over 100 employees. The facility is approximately 8 km west of the Knockharley Landfill facility.
- Nurendale Ltd. trading as Panda Waste Services Ltd. owns and operates a large Materials Recovery Facility at Rathdrinagh Cross Roads, approximately 4 km north east of the facility on the N2 to Slane. It is operated under a licence from the EPA, W0140-04 and is licenced to accept up to 250,000 tonnes per annum of household, commercial and industrial waste, biowaste and biodegradable waste, and construction and demolition waste and the facility employs approximately 160 people. A licence review application for, *inter alia*, the acceptance and processing of incinerator bottom ash is at time of writing under consideration by the Agency.
- Advanced Environmental Solutions (AES) Ltd. owns and operates a waste transfer facility in Navan under IE licence no. W0131-02, approximately 10 km west of Knockharley Landfill. The licensed capacity of the facility is 95,000 tonnes per annum. The facility has approximately 15 employees.
- Perma Pigs Limited, is an operational pig farm located at Littlegrange, Drogheda, County Louth, approximately 9 km north east of Knockharley Landfill. Perma Pigs Limited operates under EPA licence P0431-02. It is a piggery with No. 9,868 stock at the farm according to 2017 AER and is licensed to house 11,490 pigs, ranging from dry sows to weaners. The 2017 AER lists 5 no. employees.
- Irish Cement Limited, located at Platin Works, Platin, Drogheda, County Meath operates a cement production which includes a limestone quarry under the EPA licence register number P0030-05. The facility is approximately 10 km north east of Knockharley Landfill. Irish Cement EPA licence allows for the acceptance of alternative fuel which include meat and bone meal (40,000 tonnes per annum), chipped tyres (30,000 tonnes per annum) and solid recovered fuel (90,000 tonnes per annum). The 2016 AER lists 103 no. employees. Irish Cement Limited has submitted a licence review application to the EPA (P0030-06) to allow for the further replacement of fossil fuels with alternative fuels and the use of alternative raw materials (600,000 tonnes of waste per annum) at their Cement Works in Platin, Co. Meath.
- A poultry farm, located at Dowth, Slane, County Meath, approximately 7 km north east of Knockharley Landfill. The poultry farm produces eggs and currently has capacity for No. 78,000 birds (broilers) at the farm. The facility is licensed by the EPA - IE licence P0951-01. The 2016 AER lists one employee.
- Indaver Ireland Limited operate a waste incineration plant at Carranstown, Duleek, Co. Meath under EPA IE licence no. W0167-03. The plant is approximately 10 km north east of Knockharley Landfill. It is licensed to accept up to 235,000 per annum of household, commercial and industrial waste, sewage and industrial waste, aqueous waste and construction and demolition waste and hazardous waste and the facility employs approximately thirty-nine people.

Each of these facilities is licensed by the EPA and subject to monitoring as part of their licences. The current proposal for construction at the site is not likely to give rise to impacts on the Knockharley Stream following the implementation of best practice construction measures and so cumulative impacts with other projects is not likely to occur.

No future development of scale with the potential to impact on hydrology or surface water quality has been identified in the vicinity of the development location based on an assessment of these information sources and thus no further consideration in this regard is undertaken.

12.6.3 Potential Impacts During Operation and Maintenance

12.6.3.1 Uncontrolled release of leachate

The IBA facility will be designed, constructed and operated in accordance with the Landfill Directive, relevant EPA guidance and the licence. Leachate will be contained within the IBA cell area and pumped via leachate pipework to an appropriately designed leachate management facility. This is described in Chapter 2 of Volume 2 of this EIAR. By virtue of the design standards required, and the operational conditions of the licence, the potential for an uncontrolled release of leachate from the cells or leachate management infrastructure is unlikely.

There is potential for leachate breakouts from the waste body. The facility is, and will continue to be, operated in accordance with the conditions of the licence and regular inspections of the waste body take place. In the unlikely event of a leachate breakout, the leachate will be captured in the surface water management system and directed to the northern holding pond or southern attenuation pond.

12.6.3.2 Increased Surface Water Run-off

Table 12.10 summarises the hydrological impacts on the Veldonstown catchment for the 1:100 30 min duration storm with a 10% allowance for climate change shows:

- There will be no increase in flow rate discharging into the Knockharley stream from the proposed development owing to the proposed storm water attenuation pond maintaining flows at or below green field discharge rates.
- There will be a 4.69 % increase in discharge volumes primarily due to the change in land use resulting in an increase in impermeable ground conditions. This discharge volume is not significant.
- There will be no flood impact at the outfall of the Veldonstown catchment, because the time required to discharge the increased volume is less than the time of concentration associated with developing peak flows in the Veldonstown catchment, i.e. the downstream water body is able to accommodate the increased volume discharges at the greenfield discharge rate.

12.6.3.3 Flooding

During the operation and maintenance phase the attenuation ponds, the wetlands, and the flood compensation will be in place and therefore the risk of flooding at the proposed development or within the catchment is not likely.

12.6.3.4 Sediment & Nutrient Loading

The operation of the facility to date has not had a negative impact on surface water quality. The proposed development will incorporate the same level of mitigation by design and management to prevent uncontrolled releases to watercourses.

The southern and northern surface water management system will direct surface water flows from the site to the attenuation ponds and wetlands prior to discharge to the Knockharley Stream. The pond will attenuate flows and allow suspended solids to settle. The outlet from the pond can be shut to prevent discharge to the watercourse in the event of a suspected contamination incident. Water is discharged from the pond and through a constructed wetland for final polishing before discharge to the receiving watercourse. Therefore, the potential for sediment release to watercourses is low during the operational phase.

To mitigate the risk of IBA dust or hydrocarbons leaks from vehicles on roads surrounding the IBA facility contaminating the storm water, provision has been made in the design to install French drains adjacent to perimeter roads and to direct runoff from same during operations into IBA handling area and thence into the leachate collection system. There will be no risk of contaminated water entering the surface water attenuation lagoon.

During operations, the outfall from this french drainage network will discharge to the leachate collection system. Post capping, the outfall will be redirected to the holding pond via a petrol interceptor into the northern storm water management system.

12.6.3.5 Spills

The licence to operate the facility includes conditions on bunds, pipeline integrity and regular assessments of such. It is unlikely, therefore, that a spill from an on-site storage tank could be released into the environment.

In the absence of mitigation measures, there is potential for contamination of surface water from uncontrolled leaks from operational vehicles or spills during re-fuelling.

There is potential for a spill from a leachate tanker during the transport of leachate off site, both on-site and off-site.

In the unlikely event of a spill on a site road, the spill would be captured in the drainage system with subsequent management. If the spill occurred off-road or outside the facility, the maximum volume of leachate discharged to the environment would be 20 m^3.

12.6.3.6 Emergency

In the event of a fire, there is a potential for an indirect impact on surface water from the contaminated firewater. All contaminated firewater will be directed to the surface water management system and from there can be redirected to leachate storage.

12.6.3.7 Potential Cumulative Impacts

In summary the permitted and proposed developments during operations and following capping/closure (assuming these are considered to be operational activities) will not increase the flow rate of runoff entering the catchment downstream of the facility and whilst the volume of surface water runoff will increase it will not increase the risk of downstream flooding.

The hydrological impacts on the downstream receiving Veldonstown and River Nanny catchments are considered to be not significant because:

- the attenuation capacity provided by the surface water attenuation ponds will maintain flow rates below green field discharge rates (albeit that volumes may increase),
- the suspended solid loadings will most likely be lower than prevailing conditions with no engineering controls, and
- the Veldonstown catchment has sufficient attenuation capacity to negate the impacts of increased volumetric flows arising from the Knockharley permitted and proposed developments.

Given that there are no significant developments within the Veldonstown catchment area, other than farm land and residential properties, the potential cumulative impacts on hydrology and water quality are therefore considered to be imperceptible.

Given that discharges will not increase the flood risk within or downstream of the Veldonstown catchment, it is therefore not expected that other developments as maybe located at significant distances from the proposed development and/or drain into tributaries outside of the catchment of the River Nanny will have any significant potential cumulative hydrological impacts resulting from with the proposed development, i.e. not significant.

12.6.4 Potential Impacts Post Decommissioning

Decommissioning work is defined in the restoration and aftercare plan for the facility, which is a requirement under Condition 4 of IED Waste Licence W0146-02 and which is subject to Agency approval in relation to technical, emission limit values and financial provisions.

Surface water infrastructure associated with the permitted and proposed developments will remain in place. Decommissioning as may be required will be mainly be associated with buildings, paved areas and tanks eventually pumps and landfill gas management infrastructure. These areas will also be connected to the storm water management systems on the northern and southern outfalls. Such emissions as may develop during decommissioning works are likely to be significantly lower than those experienced during operations and installed drainage infrastructure will have sufficient capacity to accommodate suspended solid and other contaminant loadings. In the absence of specific mitigation measures during decommissioning there is potential for impact on surface water where activities take place outside of the permanent surface water management system.

Assuming hard surfaces and buildings will be removed, discharges will be similar to existing conditions which shows a reduction in discharge volumes. Accordingly, the impact on receiving waters is considered to be not significant.

12.6.5 Potential Impacts of Flooding

The flood risk identification, assessment and Justification Test is included in Appendix 12.5 of Volume 3 of this EIAR which discusses the potential impacts from flooding.

12.6.6 Cumulative Impacts

12.6.7 Summary of Unmitigated Impacts on Hydrology and Surface Water Quality from the Proposed Development on Sensitive Receptors

Plat2 12.-1 illustrates the classification approach adopted when determining the significance of impact on the receiving waterbodies.

A summary of unmitigated potential impacts due to the proposed development is provided in Table 12.13. In each case the receptor is the River Nanny.

Table 12-13: Summary of Potential Hydrological and Surface Water Quality Impact Significance on Sensitive Receptors

Activity	Potential Impact	Receptor	Significance Assessment Prior to Mitigation		
			Magnitude of impact	Sensitivity Existing Environment	Determining Significance
Construction Phase					
Hardstanding Areas, IBA facility, screening berms, lagoons and attenuation pond	increase in rate of run-off	River Nanny	negligible	low	Not significant (negative)
Screening berms, excavation and construction of cells, tree felling, stream diversion, culverting, trafficking.	erosion and sedimentation	River Nanny	medium	low	Slight (negative)
Tree felling, concrete works, excavation, wet concrete works, spoil heaps, berms	nutrient loading	River Nanny	low	low	Slight (negative)
Construction of new infrastructure causing blockages of drains, re-location of the 1 in 1000-year floodplain	flooding	River Nanny	negligible	negligible	Not significant (negative)
Section 50 works					
Stream diversion	erosion and sedimentation	River Nanny	low	low	Slight (negative)
Flood culvert and stream crossing	erosion and sedimentation	River Nanny	low	low	Slight (negative)
Wetland outfall	erosion and sedimentation	River Nanny	low	low	Slight (negative)
Emergency overflow weir	erosion and sedimentation	River Nanny	low	low	Slight (negative)
Temporary crossing	erosion and sedimentation	River Nanny	low	low	Slight (negative)
Operation & Maintenance					
Impermeable areas	increase in rate of run-off	River Nanny	low	low	Slight (negative)
Screening berms and IBA facility, trafficking	erosion and sedimentation	River Nanny	low	low	Slight (negative)
IBA facility, leachate management and spoil heaps.	nutrient loading	River Nanny	low	low	Slight (negative)
Heavy rainfall event	flooding	River Nanny	negligible	negligible	not significant (negative)

Activity	Potential Impact	Receptor	Significance Assessment Prior to Mitigation		
			Magnitude of impact	Sensitivity Existing Environment	Determining Significance
Decommissioning					
Trafficking and construction plant	Erosion and sedimentation	River Nanny	low	low	slight (negative)
Demolition works to remove concrete hardstands	Nutrient loading	River Nanny	low	low	slight (negative)

Some activities during the construction, operation, maintenance and decommissioning of the proposed development, if unmitigated, could have a slight negative impact on receiving watercourses.

As discussed, the risk of an increase in flooding is of negligible significance due to maintenance of greenfield discharge rates, the small percentage increase in run-off volumes contributing to the catchment and the attenuation capacity within the catchment to absorb increased flow volumes.

Decommissioning will be subject to prevailing IED Waste Licence W0146-02 Condition 4 Restoration and aftercare which also requires a Final Validation Report to be submitted to the Agency.

12.7 Mitigation Measures

During the iterative design process for the proposed development, cognisance was taken of the locations of existing watercourses and a 10 m buffer was applied to distance the watercourses from proposed infrastructure. A minimum buffer of 10 m from watercourses has been adopted for the proposed works.

The drainage system for the proposed development has been designed to mitigate potential impacts on hydrology and surface water quality and is described in detail in Section 12.4 and the drainage layout is shown in Drawing Nos. LW14-821-01- P-0000-003 through 0011 in Volume 4 and in Appendix 12.2 Surface water Management Plan in Volume 3 of this EIAR. A four-stage treatment train (swale – holding pond- attenuation – wetland will mitigate the potential impacts of increased run-off and sediment loading on watercourses from the proposed development. The residual impacts following mitigation and the associated significance rating is also provided in Table 12.14. Leachate and surface water will continue to be managed in accordance with the IE licence for the facility. The design of the proposed leachate and surface water management infrastructure will be subject to EPA approval prior to construction.

12.7.1 Proposed Mitigation Measures for the Construction Stage of the Proposed Development

Proposed drainage measures to reduce and protect the receiving waters from the potential impacts during the construction of the proposed development are as outlined above in Section 12.6. These include measures to prevent runoff erosion from vulnerable areas and consequent sediment release into the nearby watercourses to which the proposed development site discharges. The mitigation measures proposed to reduce potential direct and indirect impacts are outlined below and they are also included in the:

- Construction Environmental Management plan (Appendix 2-3) in Volume 3 of the EIAR
- Surface Water Management Plan in Appendix 12-2 of Volume 3 of the EIAR

These documents demonstrate the strong commitment that has been provided in the EIAR to ensure suitable measures will be put in place at all times to prevent the release of sediment to drainage waters, associated with construction areas, and subsequent migration to adjacent watercourses.

During the previously permitted stream diversion and proposed culverting, in-stream sedimentation traps will be positioned prior to construction and maintained for the duration. All diverted water /run-off can be sent to the onsite surface water attenuation lagoon to minimise sediment entering the stream, if required. Any in-stream works will be undertaken in consultation with the Planning Authority and Inland Fisheries Ireland (IFI) and subject to Section 50 approval from the OPW. In consideration of fisheries resources downstream, works in watercourses will be carried out during the period July-September unless prior agreement has been reached with IFI.

As discussed, the new attenuation pond will be put in place at the commencement of construction at the site. Site drainage, including silt traps and stilling ponds, will be put in place in parallel with or ahead of construction, such that excavation for new infrastructure will have a functioning drainage system in place.

The existing southern attenuation pond together with the new northern attenuation pond will mitigate any increase in the rate of run-off. Erosion control measures and temporary stilling ponds, including the attenuation ponds will be regularly maintained during the construction phase.

The 4-stage treatment train (swale – holding pond-attenuation pond– wetland/diffuse outflow) will retain and treat the discharges from the new surfaces as a result of the development and reduce any risk of flooding downstream.

Mitigation Measures for Reducing Runoff

- Cognisance has been taken of the findings in Chapter 10 Biodiversity and Chapter 11 Soils, Geology and Hydrogeology in Volume 2 of this EIAR in the location of the drainage system, including the new attenuation pond to ensure that these facilities are located in suitable areas.

- The conceptual site drainage (see section 12.4.3 and Figure 12-6) has been designed to complement existing overland flow.

Mitigation Measures for Flooding

- A modification will be installed across the stream in the form of a dam and culvert arrangement in order to channel extreme overbank flows into a wooded area. This will compensate for any loss in the 1 in 1000-year floodplain. This is described in more detail in Section 12.4.3.
- The proposed compensation flood culvert is designed to provide compensatory storage for the flood plan storage lost through constructing the northern surface water management system and permitted cell development in a 1:1000-year flood plain.
- Construction will not take during extreme weather conditions when channel water levels / flows will be high.

Mitigation Measures for Control of Sediment & Nutrient Loading

The overburden soils have a high clay content and do not readily disperse following rainfall. To mitigate surface water runoff having elevated suspended solids at stockpile, screening berms and stream bank locations where earthworks are proposed, best practices will be employed in the prevention of silt laden run-off from entering watercourses as follows:

- Silt Protection Controls (SPCs) are proposed at the location of watercourse crossings and where access roads pass close to watercourses during construction. Silt fencing will be used to mitigate any contamination of streams with silt at the flowing locations:
    a. All stockpile material will be bunded adequately and/or surrounded by silt fences and protected from heavy rainfall to reduce silt run-off, where necessary.
    b. All open water bodies adjacent to proposed construction areas will be protected by fencing, including the proposed attenuation pond.
    c. along the banks of any streams at the location of the proposed tree felling to provide additional protection to the watercourses in this area.
- Additional silt fencing will be kept on site in case of an emergency break out of silt laden run-off.
- The developer will ensure that erosion control, namely silt-traps, silt fencing, stilling ponds and swales are regularly maintained during the construction phase.
- Standing water, which may arise in excavations, has the potential to contain an increased concentration of suspended solids as a result of the disturbance to soils. The excavations will be pumped into the site drainage system (including attenuation ponds), after which permanent *in situ* dewatering will be implemented during operations. As historically there is little evidence of high inflows, it is anticipated that pumped flows from excavations will be very low. Bio-degradable silt bags (or equivalent approved) will be used during dewatering of excavations.
- The excavated subsoil material will be removed to form the screening berms.
- Swales will be shallow to minimize the disturbance to sub-soils. Temporary silt traps will also be provided at regular intervals in the swales.
- Cross-drainage pipes of 450mm minimum diameter will be provided to prevent a risk of clogging for conveying flows from agricultural drains and forestry drains across the access roads.
- Additional wheel washing facilities will be provided at the exit of the IBA facility. This will supplement the existing wheel wash which will be retained at the entrance to the site. The silt traps will be cleaned on a regular basis.
- Tree felling will be undertaken in accordance the felling licence and the specifications set out in the Forest Service Guidelines (32) and Forest Harvesting and Environmental Guidelines (34), to ensure a tree clearance method that reduces the potential for sediment and nutrient runoff.
- Trees will be felled away from watercourses where possible. Branches, logs or debris will not be allowed to accumulate in watercourses and will be removed as soon as possible.
- The rate of absorption of a felled site is reduced, and therefore rate of run-off is expected to be slightly higher than that of a forested site, however it is proposed to develop berms on the deforested areas as soon as weather conditions allow following felling, followed by replanting.

Thus, no significant increase in the rate of run-off is anticipated as a result of felling or risk of downstream flooding as set out in the flood risk assessment presented in Appendix 12.5, Volume 3.

- There is an existing wheel wash at the entrance to the site which will be used during the construction period.
- A designated concrete wash-down area will be constructed at the temporary compound. Every concrete truck delivering concrete to the site will use this facility prior to leaving the site. A settlement pond will be provided to receive all run-off from the concrete wash down area.
- The outfall from the wetland will have vertical pipe drop energy dissipation structure within the wetland outlet chamber prior to discharge into the adjacent launching apron protection works. This design approach will mitigate the risk of suspended solids developing within the Knockharley stream downstream of the outfall.
- Rock armour will be used to provide bank protection works upstream and downstream of new structures, to ensure no undercutting or destabilisation of either the structure or riparian bank areas occurs.

Mitigation Measures for Spills

- Detail of oil spill protection measures adjacent to a watercourse are outlined in Appendix 2.0 of Volume 3 of this EIAR which details the Proposed CEMP Plan.
- All personnel currently working on site are trained in pollution incident control response and this will be a requirement of the construction contract(s). Emergency Silt Control and Spillage Response Procedures are contained within under Site Drainage Management Plan of the Construction Environmental Management Plan (CEMP).
- Refuelling of plant during construction will only be carried out at the existing designated refuelling station locations. Each station is fully equipped for a spill response and a specially trained and dedicated environmental and emergency spill response team is in place on site. Only emergency breakdown maintenance will be carried out on site and appropriate containment facilities will be provided to ensure that any spills from breakdown maintenance vehicles are contained and removed off site. Drip trays and spill kits will be kept available on site, to ensure that any spills from the vehicle are contained and removed off site.
- Any diesel or fuel oils stored at the temporary site compounds will be bunded. The bund capacity will be sufficient to contain 110% of the tank's maximum capacity.
- Appropriate information will be available on site outlining the spillage response procedure and a contingency plan to contain silt. Adequate security will be provided to prevent spillage as a result of vandalism. A regular review of weather forecasts of heavy rainfall is required, and a contingency plan will be prepared for before and after such events.
- A suitably qualified person will be appointed by the developer to ensure the effective implementation of the CEMP onsite. They will also ensure:
    a. regular monitoring of the drainage system and maintenance as required.
    b. Record keeping of the daily visual examinations of watercourses which receive flows from the proposed development, during and for an agreed period after the construction phase.
    c. Water quality monitoring will continue to be carried out in accordance with the licence. (There will be one new monitoring point, at the discharge point from the new wetland.)
- If excessive suspended solids are noted, construction work will be stopped, and remediation measures will be put in place immediately.
- Discharges from paved roads paved areas will be surrounded by filter drains with petrol interceptors installed at respective outlets upstream of the storm water management attenuation ponds or other.

12.7.2 Proposed Mitigation Measures for the Operation Stage of the Proposed Development

The surface water management system will mitigate any potential impacts on hydrology and surface water quality during the operational phase. Regular visual inspections and monitoring will be required in compliance with the IED licence.

The conceptual drainage has been designed to operate effectively during the operational period. Surface water run-off will discharge to the drainage swales during rain events. During the operation period the swales will have vegetated and will serve to further attenuate flows and reduce the amount of sediment discharging from the site. The attenuation ponds will be permanent features and will continue to be effective in filtering the run-off from the site should any accidental release of silt combine with the surface water run-off during operational activities.

Surface water runoff from the IBA facility perimeter road will be directed to the IBA weathering area leachate collection system to avoid dust contamination of drainage outfalls.

The mitigation measures applicable for spills during the construction phase are applicable during the operational phase. In the event of a leachate spill from a tanker, spill kits are kept on site and site staff are trained in the management of a spill. The haulage contractor will be required to have spill kits and training. There will be regular inspections and maintenance of leachate tankers to mitigate leaks. In the unlikely event of an unforeseen road traffic accident resulting in a leachate spill adjacent to a watercourse, Meath County Council and Inland Fisheries shall be contacted and spill protection measures will be implemented.

Surface water will be visually inspected as part of the operational site walkovers on a weekly basis. There will be continuous monitoring of surface water quality at the outfall from the surface water attenuation ponds to the wetland. Routine surface water sampling is and will continue to be carried out in accordance with the licence which includes the submission of interpretive reports to the EPA for approval. Any incidents shall be notified to the EPA in accordance with the licence.

12.7.3 Proposed Mitigation Measures for Decommissioning of the Development

There will be a period of restoration and aftercare following cessation of waste acceptance activities at the facility. Decommissioning of the development will be subject to Agency approval under prevailing waste licence condition. It is proposed to leave the surface water management system *in situ* and this will mitigate any potential impacts during decommissioning activities and in addition, temporary mitigation will be put in place to protect watercourses in areas outside of the in-situ water management system. These measures will be similar to those proposed during the construction stage such as silt-traps, silt fencing and stilling ponds.

12.8 Residual Impacts

The residual significance of the effects of the proposed development on downstream receptors is expected to be low taking account of the implementation and efficacy of the mitigation measures as outlined in Section 12.6 and 12.7.

Mitigation will be provided to protect the water quality by preventing any silt laden run-off or contaminated storm runoff reaching the downstream watercourses. Table 12.14 shows all Residual Impacts are negligible and therefore will not impact the objectives of the EU Water Framework Directive.

Table 12.14 indicates that, following the implementation of mitigation measures, the residual risk to the receiving watercourses will be negligible during the construction period and negligible during the operation of the proposed development. Implementation and efficacy of the mitigation measures will be monitored throughout the construction and operation phases.

In the unlikely event of a SCADA or other failure impacting the northern attenuation pond continuous monitoring infrastructure, the proposed wetland will further reduce the risk of contamination in the receiving watercourses.

The existing development has not had a negative impact on surface water quality in the environment. The proposed system is very similar to the existing and thus as a result of the surface water management measures to be applied, the proposed development is expected to have a negligible impact on the receiving environment.

The consultation responses received as outlined in Chapter 5 of Volume 2 of this EIAR have been addressed and suitable mitigation has been incorporated into the drainage design for the proposed development at Knockharley Landfill.

The proposed development at Knockharley Landfill is not expected to contribute to any significant, negative cumulative effects with other existing or proposed developments in the immediate vicinity or within downstream waters. The effective implementation and efficacy of mitigation measures will prevent a significant release of silt into the receiving watercourses and/or will avoid spills/ leaks or uncontrolled releases. In these circumstances, any effects on the receiving aquatic environment will be negligible.

Table 12-14: Residual Hydrological and Water Quality Impact Significance for Sensitive Receptors

Activity	Potential Impact	Receptor	Sensitivity Existing Environment	Before Mitigation		After Mitigation	
				Magnitude	Determining Significance	Magnitude	Determining Residual Significance
Construction Works							
Hardstanding Areas, IBA facility, screening berms, lagoons and attenuation pond	increase in rate of run-off	River Nanny	low	negligible	Not significant	negligible	not significant
screening berms, excavation and construction of cells, tree felling, stream diversion, culverting, trafficking.	erosion and sedimentation	River Nanny	low	medium	Slight	negligible	not significant
Tree felling, concrete works, excavation, wet concrete works, spoil heaps, berms	Nutrient loading	River Nanny	low	low	Slight	negligible	not significant
Construction of new infrastructure causing blockages of drains, re-location of the 1 in 1000-year floodplain.	flooding	River Nanny	negligible	negligible	Not significant	negligible	not significant
Section 50 Works							
Stream diversion	erosion and sedimentation	River Nanny	low	low	slight	negligible	not significant
Flood culvert and stream crossing	erosion and sedimentation	River Nanny	low	low	slight	negligible	not significant
Wetland outfall	erosion and sedimentation	River Nanny	low	low	slight	negligible	not significant
Emergency overflow weir	erosion and sedimentation	River Nanny	low	low	slight	negligible	not significant
Temporary crossing	erosion and sedimentation	River Nanny	low	low	slight	negligible	not significant

Activity	Potential Impact	Receptor	Sensitivity	Before Mitigation		After Mitigation	
				Magnitude of impact	Determining Significance	Magnitude of impact	Determining Residual Significance
Operation & Maintenance							
Impermeable areas	increase in rate of run-off	River Nanny	low	low	Slight	negligible	not significant
Screening berms and IBA facility, trafficking	erosion and sedimentation	River Nanny	low	low	Slight	negligible	not significant
IBA facility, leachate management and spoil heaps.	nutrient loading	River Nanny	low	low	slight	negligible	not significant
Heavy rainfall event	flooding	River Nanny	negligible	negligible	not significant	negligible	Imperceptible
Decommissioning							
Trafficking and construction plant	Erosion and sedimentation	River Nanny	low	low	slight	negligible	not significant
Demolition works to remove concrete hardstands	Nutrient loading	River Nanny	low	low	slight	negligible	not significant

12.9 Conclusion

The impact of proposed development at Knockharley Landfill the receiving environment in terms of hydrology and surface water quality will be 'Not Significant' to 'Imperceptible'.

12.10 References

1. **EC.** *Guidance Environmental Impact Assessment of Projects Guidance on the preparation of the Environmental Impact Assessment Report.* 2017.

2. **EPA.** *Guidelines on the information to be contained in Environmental Impact Assessment Reports, Draft August 2017 .* 2017.

3. **(NRA), TII.** *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes.* 2009.

4. **Inland Fisheries Ireland.** *Guidelines on protection of fisheries during construction works in and adjacent to waters.* Dublin: Inland Fisheries Ireland, 2016.

5. **Department of Environment, Heritage and Local Government (IRE) and the Office of Public Works (IRE).** *The Planning System and Flood Risk Management - Guidelines for Planning Authorities.* Dublin: Government Stationary Office, 2009.

6. **Meath County Council.** *Meath County Development Plan 2013-2019.*

7. **Council, Meath County.** *Strategic Flood Risk Assessment, Variation 3 of Meath CDP 2013-2019.* 2015.

8. **European Parliament, Council.** *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.* 2000.

9. **Office of Public Works (IRE).** Flood Maps. [Online] 2013. http://www.floodmaps.ie.

10. —. Interactive Mapping. *Catchment Flood Risk Assessment and Management.* [Online] http://www.cfram.ie.

11. **Dublin Regional Authorities.** *Greater Dublin Strategic Drainage Study (GDSDS): Technical Documents of Regional Drainage Policies.* Dublin : Dublin City Council, 2005.

12. **Charles, P. Connolly, S. (Eds.).** *Environmental good practice on site.* London: Construction Industry research and Information Association, 2005. ISBN 086-17-650-9.

13. **Enterprise Ireland.** Best Practice Guide BPGCS005 Oil Storage Guidelines. *www.envirocentre.ie.* [Online]

14. **Construction Industry Research and Information Association (UK) .** *Control of Water Pollution from Linear Construction Sites: Technical Guidance (C648).* London: Construction Industry Research and Information Association, 2006.

15. **Construction Industry Research and Information Association (UK) .** *Control of Water Pollution from Construction Sites. Guidance for Consultants and Contractors (C532) .* London: Control of Water Pollution from Construction Sites. Guidance for Consultants and Contractors (C532) - Construction Industry Research and Information Association (UK) , 2001.

16. **(UK), Construction Industry Research and Information Association.** *Sustainable Construction Procurement. A Guide to Delivering Environmentally Responsible Projects (C571).* London: Construction Industry Research and Information Association, 2001.

17. **UK Environmental Agency, Northern ireland Environmental Agency and Scottish Environment Protection Agency.** *Pollution Prevention Guidelines - PPG1: Understanding Your Environmental Responsibilites - Good Environmental Practices.* s.l.: Environmental Agency, 2013.

18. **Northern ireland Environmental Agency, Natural Resources Wales and Scottish Environment Protection Agency.** *Pollution Prevention Guidelines - GPPG: Above ground oil storage tanks.* s.l.: NIEA, NRW, SEPA, 2018.

19. **UK Environmental Agency, Environment and heritage Service and Scottish Environment Protection AgencyPollution Prevention Guidelines.** *Pollution Prevention Guidelines - PPG3: Use and design of oil seperators in surface water drainage systems.* s.l.: Environment Agency, 2006.

20. **Northern Ireland Environment Agency, Scottish Environment Protection Agency and Natural Resources Wales.** *Pollution Prevention Guidelines - HPP4: Treatment and disposal of wastewater where there is no connection to the public foul sewervailable.* s.l.: NIEA, SEPA, NRW, 2017.

21. **Northern Ireland Environment Agency, Agency with the Department of Agriculture, Environment and Rural Affairs, Scottish Environment Protection Agency and Natual Resources Wales.** *Pollution Prevention Guidelines - GPP5: Works and maintenance in or near water.* 2017.

22. **UK Environmental Agency, Northern ireland Environmental Agency and Scottish Environment Protection Agency .** *Pollution Prevention Guidelines - PPG6: Working at construction and demolition sites.* s.l.: Environment Agency, 2012.

23. **Northern Ireland Environment Agency, Scottish Environment Protection Agency and Environment Agency.** *The safe operation of refyeliing facilities: PPG7.* s.l.: NIEA, SEPA, EA, 2011.

24. **Northern Ireland Environment Agency, Scottish Environment Protection Agency and Natrual Resources Wales.** *Pollution Prevention Guidelines - PPG8: Safe storage and disposal of used oils.* s.l.: NIEA, SEPA, NRW, 2017.

25. **Northern Ireland Environmental Agency, Scottish Environment Protection Agency and Natural Resources Wales.** *Pollution Prevention Guidelines - GPP21: Pollution Incident Response Plans.* s.l.: NIEA, SEPA, NRW, 2017.

26. **Northern Ireland Environment Agency, Scottich Environment Protection Agency and Environment Agency.** *Dealing with spills: PPG22.* s.l.: NIEA, SEPA, EA, 2011.

27. **UK Environmental Agency, Northern Ireland Environmental Agency and Scottish Environment Protection Agency.** *Pollution Prevention Guidelines - PPG26: Drums and intermediate containers.* s.l. : Environment Agency, 2011.

28. **Department of Housing, Planning and Local Government.** *River Basin Management Plan for Ireland 2018-2021.* 2018.

29. **EPA.** *www.catchments.ie.*

30. **Environmnetal Protection Agency (IRE).** Biological River Water Quality Data. *Data extracted from Aquarius database for Fehily Timoney by Peter Webster 11-07-17 (MonQrecords_11072017.xls).* Cork : Environmental Protection Agency, 2017.

31. **Forest Service (IRE).** *Code of Best Forest Practice – Ireland.* Dublin: Department of Marine and Natural Resources, 2000. ISBN 0-9538874-1-3.

32. **Forest Service.** *Forestry and Water Quality Guidelines .* Dublin: Department of Marine and Natural Resources, 2000.

33. **Department of the Marine and Natural Resources, Forest Service.** *Forestry and Archaeological Guidelines.* s.l.: Forest Service , 2000.

34. —. *Forest Harvesting and Environmental Guidelines.* s.l.: Department of the Marine and Natural Resources, Forest Service, 2000.

35. **www.epa.ie.** *nanny_2016.xls (download).* s.l.: EPA, 2016.

36. **al, Naden et.** *Siltation in Rivers. A Review of Monitoring Techniques. Conserving Natura 2000 Rivers Conservation Techniques Series No. 6. English Nature.* 2003.

37. **National Roads Authority.** *Design Manual for Roads and Bridges.* Dublin: National Roads Authority, 2013.

38. —. *Guidelines for the Crossing of Watercourses During the Construction of National Road Schemes.* Dublin: National Roads Authority, 2005.

39. **Department of Agriculture, Food and the Marine.** *Forest Roads Schemes 2015-2020 .* Dublin: Department of Agriculture, Food and the Marine, 2015.

40. **EPA.** *Advice Notes for Preparing Environmental Impact Statements Draft September 2015 .* 2015.

[1] www.met.ie