Appendix B – Flood Risk Assessment & Management Report – Shelton Abbey (IFI Site)

Irish Water & Wicklow County Council

Arklow Wastewater Treatment Works

Flood Risk Assessment and Management Report – IFI Site (Shelton Abbey)

Report No. W3111-R002

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UISCE ÉIREANN : IRISH WATER

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1.0 Introduction

1.1 Background

Irish Water (IW) intends to develop the Arklow Wastewater Treatment Plant (WwTP) Project to eliminate untreated wastewater discharge to the Avoca River near Arklow Town, County Wicklow. The project will entail the construction of a new wastewater treatment plant to treat 36,000 PE (population equivalent) with a new sea or river outfall.

Following a non-statutory public consolation process, held by Irish Water between 15th October 2014 and 12th December 2014, the former Irish Fertiliser Industries (IFI) site at Shelton Abbey was established as a favourable site for the WwTP by the public, subject to its environmental suitability and flood resilience. Details of the consultation are presented in the *Phase 1 Consultation Report*. A high level *Site Assessment Report* has also been produced and revised in early 2015 which outlines the need to assess the flood risk to the IFI site.

1.2 Project Brief

Byrne Looby PH McCarthy have been appointed to assess the flood risk to the IFI site in accordance with *The planning Systems and Flood Risk Management – Guidelines for Planning Authorities*, hereafter referred to as 'the Guidelines'. At this stage, a detailed design of the treatment plant has not been undertaken and the aim of this report is to assess the suitability of the IFI site (or part thereof) for use for a WwTP in relation to flood risk.

1.3 Avoca Catchment & IFI Site Location

The Avoca catchment is outlined below in Figure 1.1 with the extent of the site shown in Figure 1.2. The site is located to the north west of Arklow town and is bounded to the south by the Avoca River and is crossed by the Sheepswalk steam.

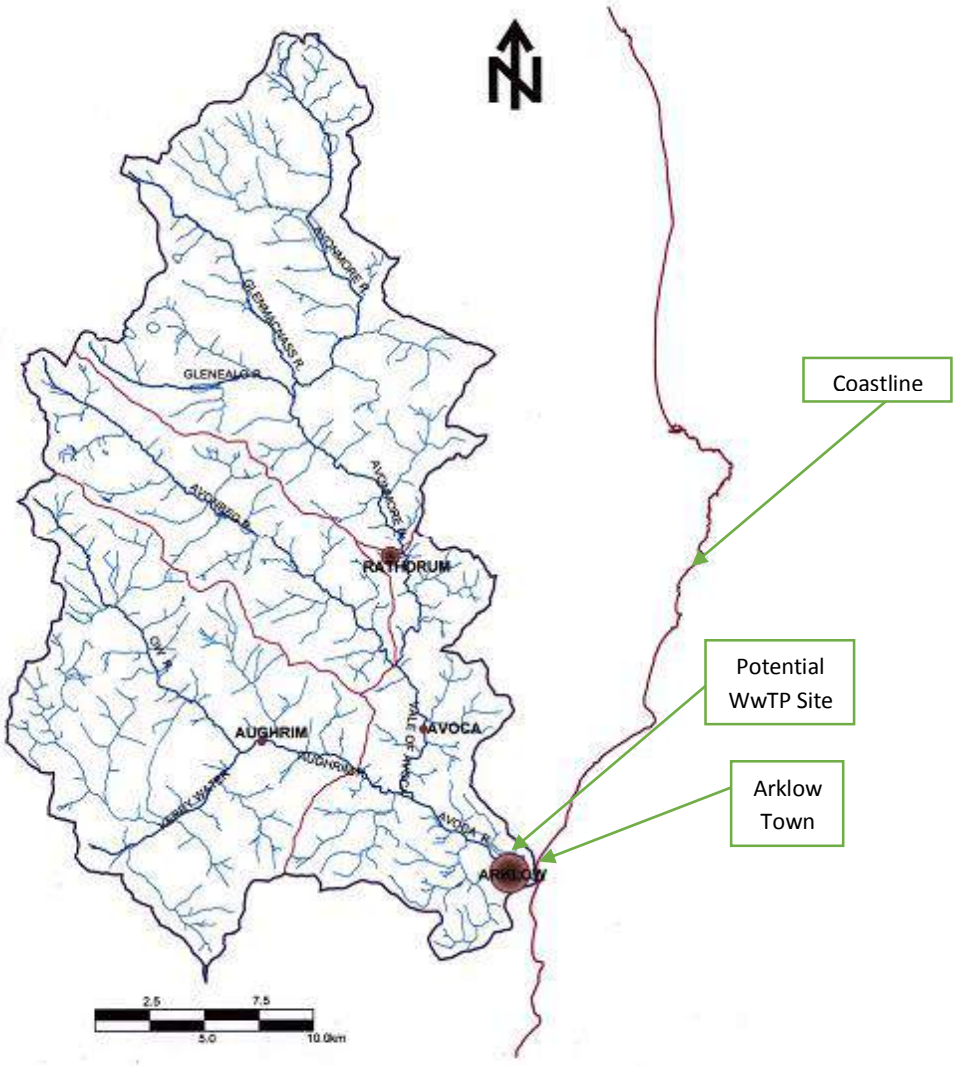


Figure 1.1 Avoca catchment

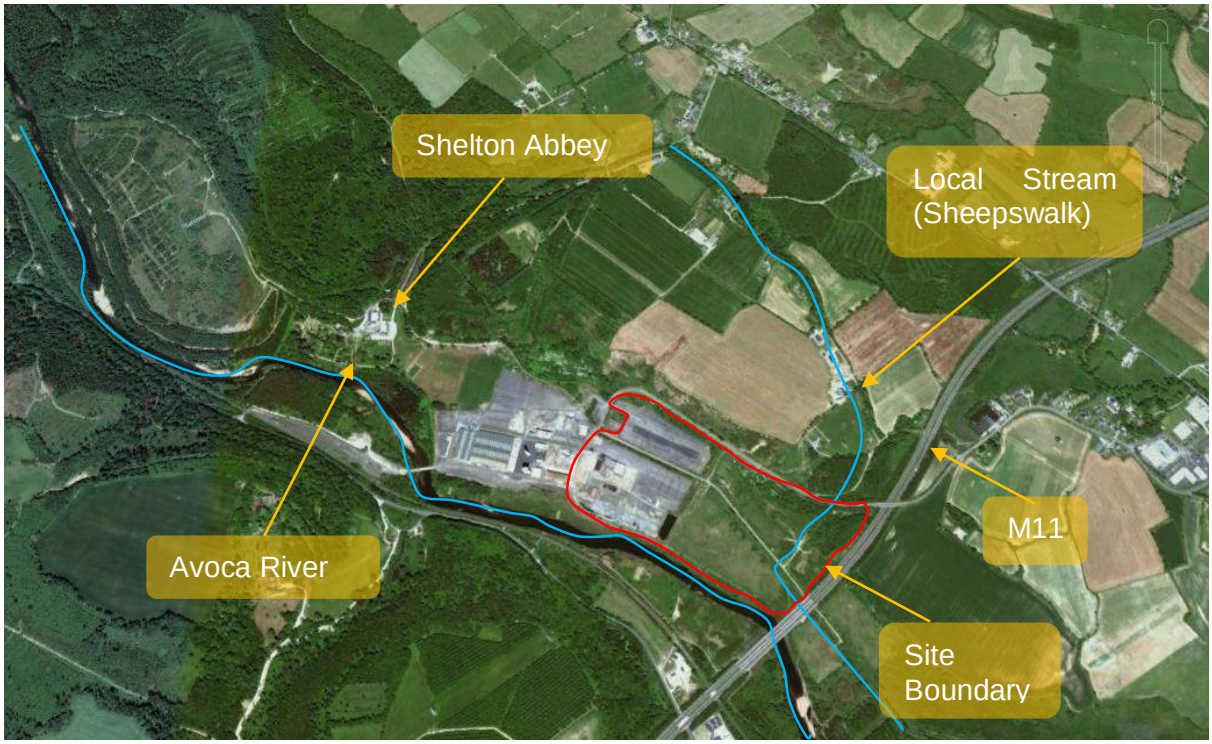


Figure 1.2 Site Location Plan

1.4 Report Objectives

The objective of the report are to:

- Establish flood zonings for the site in accordance with *The planning Systems and Flood Risk Management – Guidelines for Planning Authorities;*
- Establish the flood risk to the site;
- Determine what portions of the site (if any) are suitable for development of a WwTP in relation to flood risk.

It should be noted that only flood risk suitability is being assessed within this scope and other criteria are being assessed separately.

2.0 Data Collection

2.1 Historic Floods Data

The OPW operate and manage a database of historical flooding incidents which can be accessed at www.floodmaps.ie. An examination of this database shows that there is no record of previous flooding at the site.

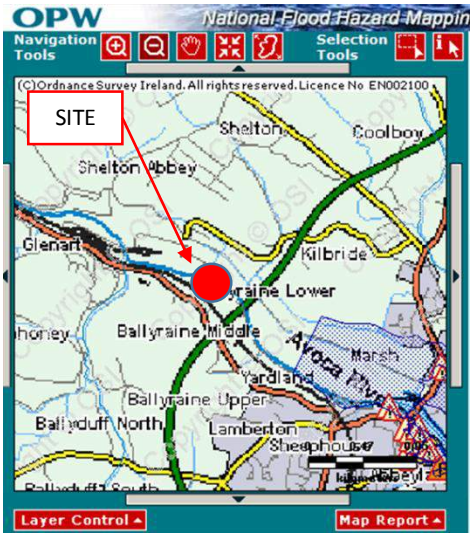


Figure 2.1 Flood history of IFI site on OPW National; Flood Hazard Mapping website

2.2 National Preliminary Flood Risk Assessment

The national Preliminary Flood Risk Assessment (PFRA) was completed in 2011 by the OPW to identify areas where there may be a significant risk associated with flooding. The objective of the PFRA is to identify areas where the risks associated with flooding might be significant, although 'significant' is not defined in the Floods Directive (2007/60/EC), the primary legislative driver behind the PRFA.

The PRFA considers flooding from natural (coastal, fluvial, pluvial and groundwater sources) but not infrastructural (drainage systems, reservoirs, water supply) sources. The OPW commissioned *Planning Systems and Flood Risk Management – Guidelines for Planning Authorities* defines each of these flood risk sources.

Draft mapping to outline the preliminary flood risk is available for all areas of Ireland. The relevant map for the Arklow environs is presented in Appendix A, and indicates that both coastal and fluvial flood risks may be present at the IFI site.

The PRFA designates Arklow as a probable AFA (Area for further Assessment) and the ESB substation at the IFI site as a possible AFA. These were further assessed under the Eastern CFRAM programme which is discussed below.

2.3 Eastern CFRAM Study

The Eastern Catchment Flood Risk Assessment and Management (CFRAM) study commenced in June 2011 and will run until the end of 2016. The district covers a land area of 6,300 km^2, including parts of counties Cavan, Dublin, Kildare, Louth, Meath, Offaly, Westmeath, Wexford and Wicklow.

Flood Risk Management Plans (FRMPs) are due to be prepared by 2016 and will include measures in relation to flood prevention, protection and preparedness. Emergency response to flooding, recovery from flooding and incorporating lessons learned will be an important element of the FRMPs along with issues such as climate change, land use practices and future development.

As of the most recent update in August 2014, the status is as follows:

- All survey work, to gather data on the elevation and shape of river channels and floodplains to feed into the computer models, is complete;
- The development of computer models to predict flood extents and flood risk is complete;
- Flood mapping is being developed;
- Flood Risk Management Measures to deal with the identified flood risk are being developed;
- Flood Risk Management Plans, including measures to deal with flood risk, are due to be published in 2016.

A Flood Risk Review (FRR) was completed under the CFRAM programme in late 2011 with Arklow being confirmed as an area for further assessment (AFA). BLP have separately been appointed by the OPW/WCC to progress the Arklow Flood Relief Scheme to address the Flood Risk to Arklow Town.

Following assessment under the FRR report, the ESB sub-station at Shelton Abbey identified as a possible AFA in the PFRA, was determined under the CFRAM programme not to be an AFA on the basis that it appeared to be within a defended site and was an individual receptor.

2.4 Arklow Flood Relief Scheme

The Hydrology and Hydraulics Report, Avoca River (Arklow) Flood Relief Study (Cawley, 2007) was prepared in 2007 on behalf of OPW. It presented flood flows for use in the optioneering of the Arklow Flood Relief Scheme. The report also notes the flood information recorded during Hurricane Charlie in 1986 where the ESB noted peak flood levels and a flood profile adjacent to the former IFI site of 4.51m OD observed at the downstream end of the IFI factory flood embankment. This event was estimated to

be a 0.66% AEP event (1:150 year) by a PH McCarthy Report (1989) with an associated flow rate of 695 m^3/s (excluding climate change).

In 2012, 2D hydraulic modelling of the Avoca River at Arklow (Cawley, 2012) was undertaken on behalf of the OPW to support the preliminary design of the Arklow Flood Relief Scheme, with particular emphasis on modelling the impact of Arklow Bridge of flood levels.

The *Avoca River Flood Relief Feasibility Study – Preliminary Report* (BLP, 2013) is the final report and collates the information from previous hydrological studies and presents the proposed design flows for the scheme which are presented in Section 4.1 below.

2.5 Arklow Town and Environs Development Plan 2011-2017

Arklow Town and Environs Development Plan 2011-2017 outlined flood zones for the town area only (not the surrounding environs) in accordance with OPW guidelines for Flood Risk Management. The proposed site is not within the town boundary and is therefore not mapped although it is within the surrounding environs.

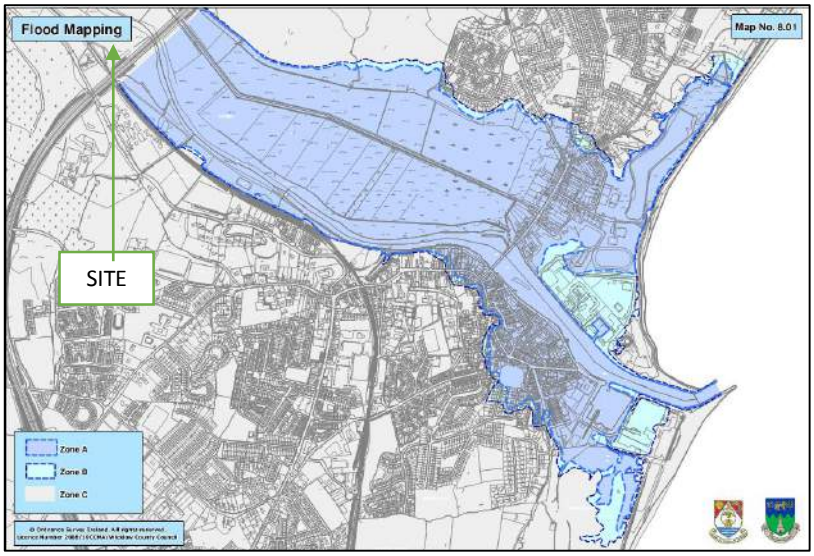


Figure 2.2 Flood Zones for Arklow

2.6 Topographical Survey

A topographical survey of the entire site was undertaken as part of this assessment. Details of the survey are included in Figure 001 included in Appendix B. The site is described below.

2.7 Site Walkover

A site walkover and recognisance survey was undertaken on the 18th February 2015. Selected photographs from the site visit are included in Appendix C along with a photograph location map.

The extent of the c. 24 hectare site under consideration is shown below in Figure 2.3 along with other relevant features. The site consists mainly of existing agricultural, wooded and industrial brownfield areas. There are live commercial activities ongoing on the IFI site to the west of the proposed site. For the purposes of describing the site, it has been sub-divided into three plots (A, B and C) as indicated in Figure 2.3 as these areas have their own individual characteristics. Access to the site is via the minor road connecting the R747 and Beech Road which runs alongside the northern boundary of the site. A canal runs through the site between plots A and B and discharges into the Avoca River immediate upstream of Arklow Bridge. It construction is believed to be associated with the former Shelton Abbey estate but little information is available on its construction or purpose.

Plot A of the site consists of relatively level made ground including a number of disused industrial buildings. It is bounded to the north by the access road and to the south by the Avoca River. Access is achieved via the local road serving the IFI site. There is an existing access track through the middle of the plot, running in an NE-SW direction, with a drainage channel on the south side of the access track. The plot is afforded flood protection by the flood defence embankment which surrounds the entire IFI site and run-off is collected in local drains and attenuated in a pond in the south east corner of plot A. There is an ESB sub-station (presumably providing power to the IFI site) located at the western extent of plot A. It is noted that the current landowner has reported that the site has not suffered from flooding in recent years.

Plot B is natural ground consisting of pasture and woodlands. The plot is at a higher elevation than plot A but lower than plot C. It is bounded to the north by the access road and to the south by the access track which runs along the north side of the canal. Current access to plot B is via the access track, but access from the local road serving the IFI site is also possible. The plot is likely to be afforded some level of flood protection by the higher ground to the south, but is at risk of flooding from backwatering via the canal during extreme flood events in the Avoca River. The plot drains naturally to the south into the canal.

Plot C is mainly set out in grass which slopes gently to the north. The plot has been artificially raised by the construction of an impoundment which was subsequently used as a waste pond for gypsum and carbon by-products from the fertiliser production process at the IFI site. The pond has subsequently been capped and set in grass. It is bounded to the north by the canal and to the south by the Avoca River. Access is available along the access track, where an existing entrance crosses the canal. At the time of the site visit, it was not possible to see any continuity (other than pumping) between the portion of canal between plots B and C and the portion in plot A. Plot C is afforded flood protection due to its increased elevation, which matches that of the flood embankment surrounding the IFI site. Notwithstanding any artificial drainage of the

underlying strata, the surface water drains naturally to the north of the site towards the canal.

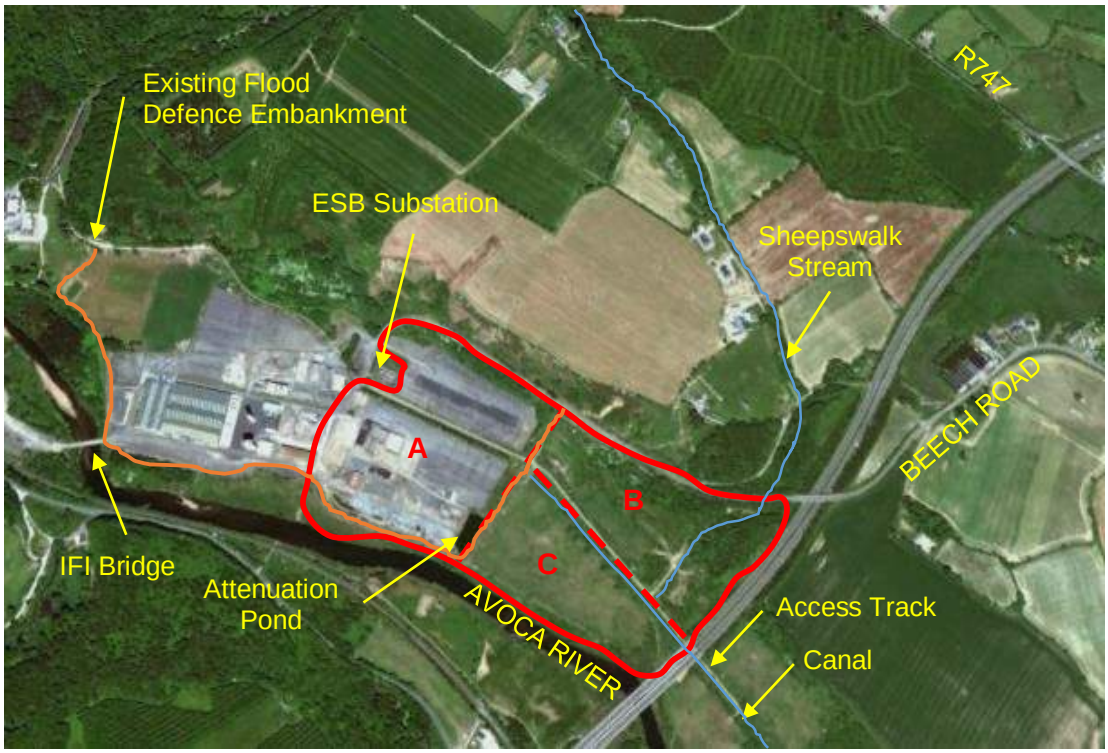


Figure 2.3 Outline of site and plots A, B and C.

3.0 Proposed Development

3.1 Description of Development

The proposed development is a wastewater treatment plant to serve a PE of 36,000. Detailed plans for the layout of the plant will not be known until the site is selected and an indicative design completed, however, it is anticipated that a site area of c. 2 hectares will suffice. Such a site area will provide flexibility in selecting the final treatment process to be used allowing for any necessary screening while also providing for future expansion.

3.2 Sources of Flood Risk

3.2.1 Pluvial

Pluvial flooding should typically not be a major issue for sites located next to or very near to river channels. It is noted that the PRFA has not indicated that the site is prone to pluvial flooding. However, surface water run-off on the site has been significantly modified by the presence of the canal and the flood defence embankment. The result is that natural run-off from the site to the Avoca River is not possible for plot A. Pumping arrangements were noted at a number of locations on the site during the site visit which are shown in Figure 3.1 below to assist in the drainage of plot A. Details of the maintenance and performance of the pumps have not been assessed. Plots B and C drain naturally to the canal.

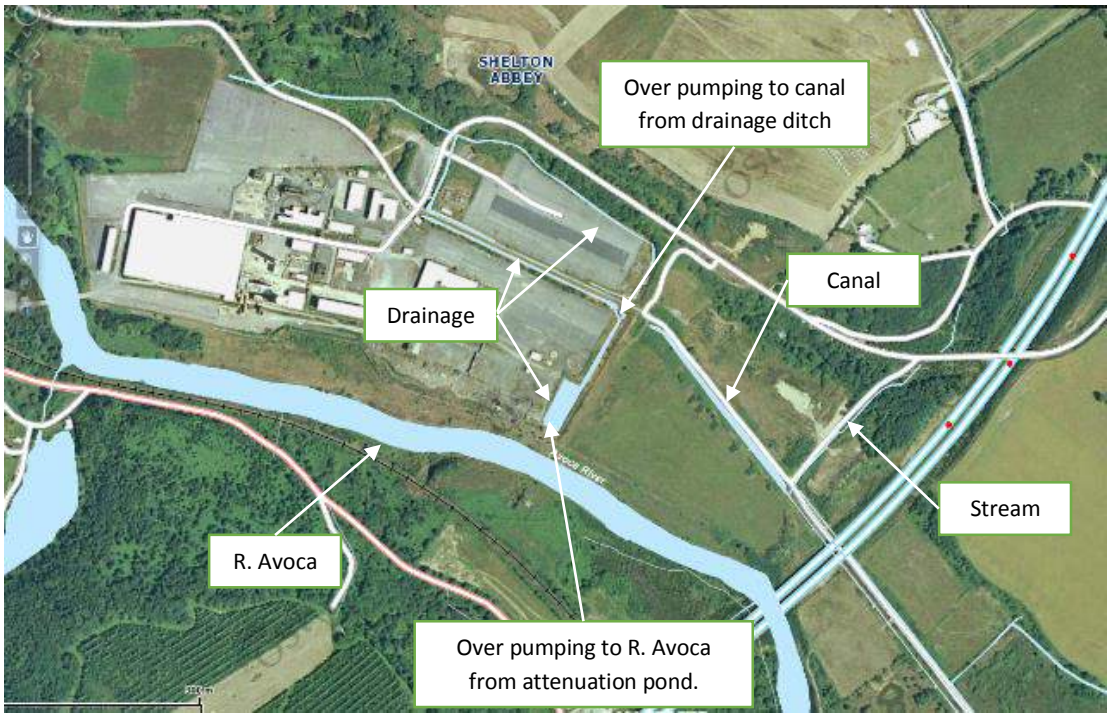


Figure 3.1 Drainage at the IFI Site

3.2.2 Fluvial

Historic 25" and 6" maps do not indicate that the site is liable to flooding, although much of the surrounding sites, and a portion of the proposed site are shown on the maps as being wet or marshy ground.

However, the fluvial flood risk to the IFI site is well established evidenced by the existing flood defence embankment that has been constructed around the site. Anecdotal evidence suggests that the embankment has been successful in defending against floods and flood events have not been recorded on the site in recent times.

The main risk to the site therefore arises from failure of the flood defence and overtopping. Of these, failure is the greater risk and the consequences would be severe if such an event was realised.

3.2.3 Coastal

The Irish Coastal Protection Strategy Study Phase 2 - South East Coast Work Packages 2, 3 & 4A - Technical Report IBE0104/June 2010 also outlines the flood risk to coastal areas. These boundaries were subsequently incorporated into the PFRA maps.

The maps show that the IFI site is generally outside the limit of coastal risk, also the canal and the River Avoca represent flood paths to the site. The maps indicate that the flood extent is restricted to the canal and river channel for coastal flooding and the plots would therefore not be at risk.

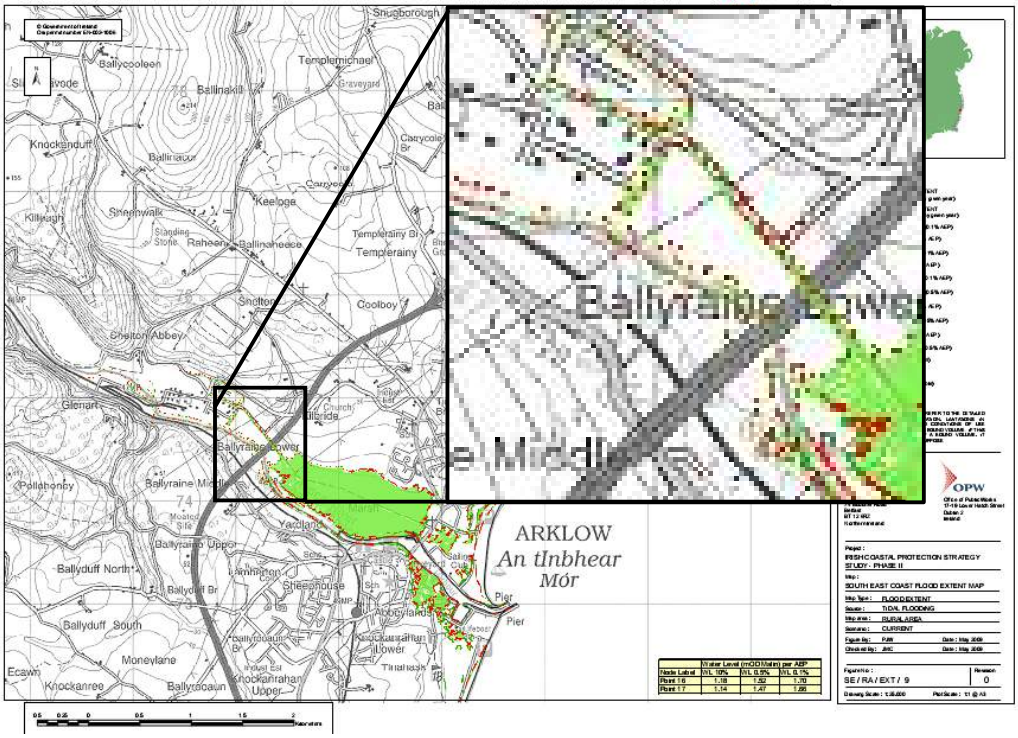


Figure 3.2 Irish Coastal Protection Strategy Mapping – Arklow

3.2.4 Groundwater

There are no mapped karst features within the site or the surrounding district which would allow the rapid passage of groundwater. The underlying bedrock geology is the Kilmacrea Formation with some Oaklands Formation in the south west portion of the site. The sub-soil consists of alluvium till with sandstone and shale tills located north and south of the alluvium band under the river.

The PFRA does not indicate significant flooding of the site from groundwater and consequently, it is anticipated that any risk of flooding at the site due to groundwater flow is minimal.

(Note: not considered here is the risk arising from seepage under the flood defence embankments which may manifest as 'groundwater' but which would be caused by high flood levels in the river).

3.2.5 Summary of Risk

Table 3.1 below summarises the flood risk to each plot on the site. In addition to the risks highlight below, there is the possibility of combined events (i.e. fluvial and coastal) where a flood risk would be exasperated by another flood risk.

The fluvial risk to the site represents the most significant risk and is discussed further in the following sections.

Table 3.1 Summary of Flood Risks

Plot / Source of Flood RIsk	Pluvial	Fluvial	Coastal	Groundwater
Plot A	✓	✓	×	×
Plot B	×	✓	×	×
Plot C	×	✓	×	×

4.0 Hydrology

4.1 Avoca catchment

The OPW have approved the use of the Flood Study Report (FSR) (NERC, 1975) catchment characteristic method for estimation of the mean annual flood (Q_{BAR}) with the design flows then estimated based on a pooled growth curve using a number of catchments and other studies. On this basis the OPW FSU portal was not used to estimate flood flows and instead, the flow rates used for the design of the OPW FRS as described above are used for input to the hydraulic model.

The flow estimation point for the Arklow FRS hydraulic model is approximately 200m upstream of the M11 Bridge, which is approximately 450m downstream of the most western part of the site. It is noted that the flow rates are considered to be conservative in the Feasibility Study and consequently the flows rate are deemed to be appropriate for use for the site. The adopted design flows are presented in Table 4.1 below. An allowance of 20% has been included for climate change in the figures below for the midrange future scenario (MFRS).

Table 4.1 Design Flow Rates

Event	Flow Rate (m^3/s)	Flood Level immediately Downstream of the M11 Bridge
Q100	560	3.49
Q1000	745	3.87
Q100 MRFS	672	3.74
Q1000 MRFS	894	4.13*
*Estimated from other design flow rates		

4.2 Local Stream catchment (Sheepswalk Stream)

The initial desk study identified a minor stream to the north of the site as a potential source of flooding. Subsequently, based on site recognisance and the results of the topographical and hydrometric surveys, it was deemed that that the stream did not represent a significant flood risk to the proposed site.

Specifically, flow rates in the stream are limited and restricted to the capacity of a culvert which has been constructed under the access road to the north of the site. The pipe is a 1.2m diameter corrugated iron pipe laid at a gradient of 3.5% with a resulting capacity of approximately $8m^3/s$. which will not result in a significant risk to the site from the Sheepswalk Stream. Assuming a 1.6m wide channel with vertical banks, a flow depth of approximately 0.6m would be required to convey the flow in the culvert, which is generally available in the channel. The flood risk to plot B from the Sheepswalk stream is therefore very low and there is no flood risk to plots A or C from the stream.

5.0 Hydraulic Modelling

5.1 Model Construction

A 1D hydraulic model was generated from survey data and analysed using HEC-RAS 5.0 beta version to estimate the water surface profile in the Avoca for a range of flood event probabilities as outlined in Table 4.1.

The model consisted of a single river reach extending from the M11 Bridge over the Avoca River upstream for approximately 1,800 meters and includes 24 river cross sections, 2 structures (bridges) and a levee (flood defence embankment).

A Manning's roughness coefficient of 0.04 was used for the main channel, which assumes a clean winding reach with some pools and shoals. For the flood plains, a Manning's roughness coefficient of 0.07 was used due to the medium brush and trees observed during the site visit. Ineffective flow areas were included in the model where the floodplain was deemed to be ineffective in conveying flood flows (for example where wooded areas or very dense scrub were identified).

The model was run using steady state flow analysis which typically results a conservative estimate of flood levels.

5.2 Model Calibration & Verification

As there are no flood records available or no record of flooding having occurred at the location of the site, a direct calibration of the model was not possible. Calibration was therefore carried out against the Avoca River Flood Relief Scheme, which overlaps with the model at the M11 Bridge for approximately 200m. The downstream boundary condition of the model was set to match the approved flood levels from the Arklow FRS.

As a check, the boundary condition was removed and the downstream boundary set to be such that critical flow conditions prevailed. This resulted in a slight lowering of flood levels at the downstream end of the reach in the order of 100-200mm. This can be expected given that the Arklow FRS flood levels are based on a more refine 2D model which includes the downstream Arklow Bridge which is a known restriction on flood flows causing a significant backwater effect upstream. In addition, the 1D model above would not take into account tidal influences. On this basis the model was deemed to be acceptable for use for the flood risk assessment purposes.

5.3 Results

The results from the various model runs are presented in Appendix D and the flood profile to the site is presented in Figure 5.1. Table 5.1 summaries the flood levels at chainage 779m in the model, which is the nearest upstream section to the proposed site, and are therefore the maximum flood levels for the site. Lower flood levels are estimated downstream of this location as presented in Appendix D.

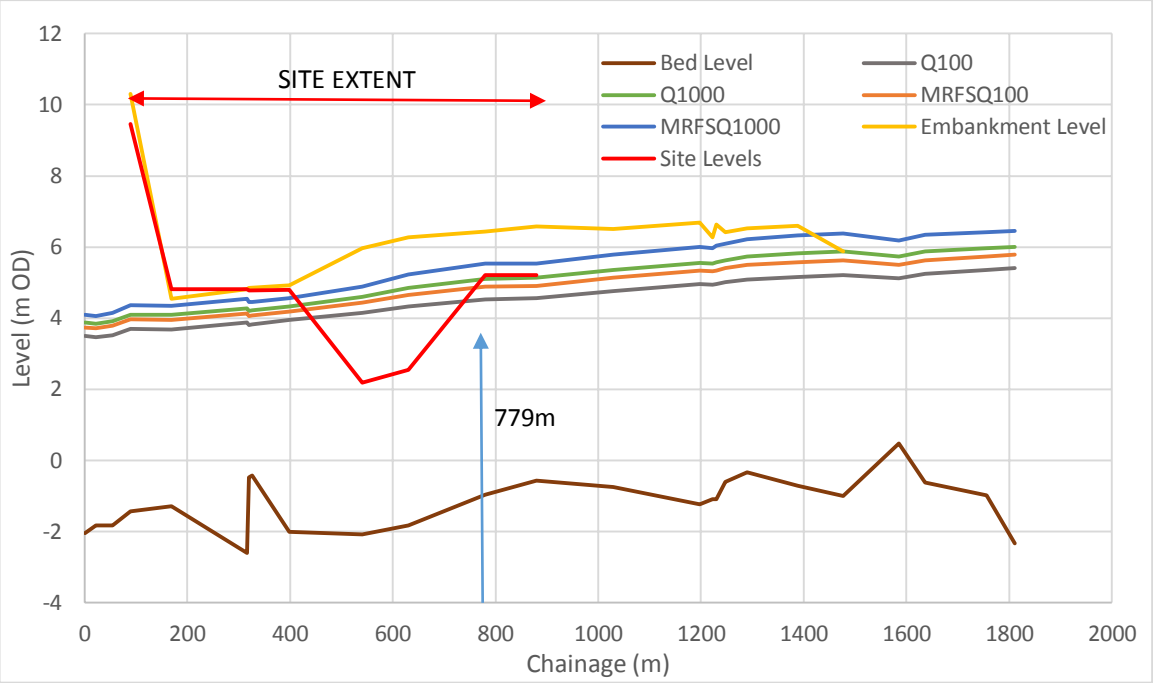


Figure 5.1 Flood Profiles for Avoca River at FIF Site

Table 5.1 Flood levels at chainage 779m (most upstream chainage of the proposed site)

Event	Event % AEP	Flow rate (m^3/s)	Flood level (m OD)
Q100	1%	560	4.52
Q1000	0.1%	745	5.1
Q100 MRFS	1%	672	4.88
Q1000 MRFS	0.1%	894	5.53
MRFS – Mid Range Future Scenario (includes for climate change)			

5.4 Flood Extents & Flood Routes

5.4.1 Flood Extents

In accordance with *The Planning Systems and Flood Risk Management – Guidelines for Planning Authorities* flood zones have been established for the site by BLP. In line with the guidelines, the development of the zones assumes that the existing flood

defence embankment does not exist. The resulting flood extent maps for the site for the current scenario are presented in Figure 002 in Appendix B.

The map confirms that plot A is within flood zone A and B, plot B is partially within flood zone A and B while plot C is largely outside of flood zones A and B.

5.4.2 Flood Routes

In the event that there was no flood defence embankment, inundation of the site would occur directly from the River Avoca via overbank flow. This would affect plots A, B and C, with flooding of plot A arising directly from the Avoca and flooding of plots B and C via the canal.

However, plots A is well protected from flooding by the flood defence embankment although overtopping of the embankment to the north represents a possible flood route to plot A. Inundation would not be expected to be rapid or significant as the low lying areas of the sports field and surrounding areas would flood initially before the water makes its way to the proposed site.

The estimated flood level for the 0.1% AEP event immediately upstream of the embankment overtopping location is 5.73m OD (Appendix D, chainage 1584m) while top of embankment where it has been surveyed is 5.80m OD. Lidar data indicates that the embankment may be lower than 5.8m OD in some areas. The likely flood route for the 0.1% AEP event immediately upstream at Shelton Abbey is shown in Figure 5.2 below.

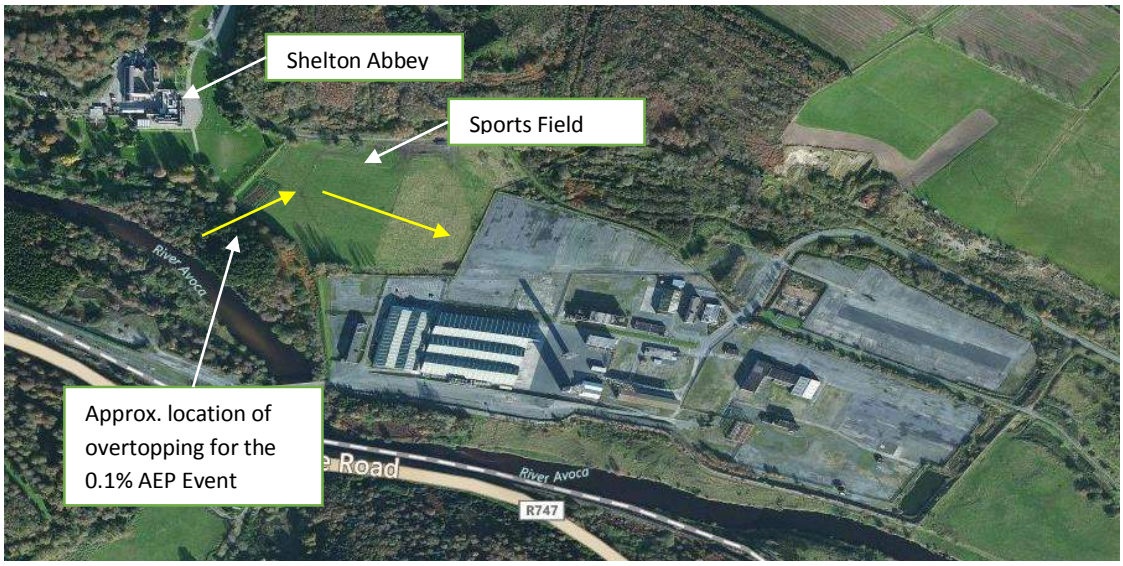


Figure 5.2 Flood Route to IFI Site

A second flood route is presented by the River Avoca backing up into the canal downstream of the site and then flowing back up the canal. This represents a significant risk to Plot B. This has been considered in the flood extent maps by conservatively

assuming that the flood level in the canal is the same as the level in the River Avoca for a given chainage.

5.4.3 Flood Route and Extents for embankment overtopping

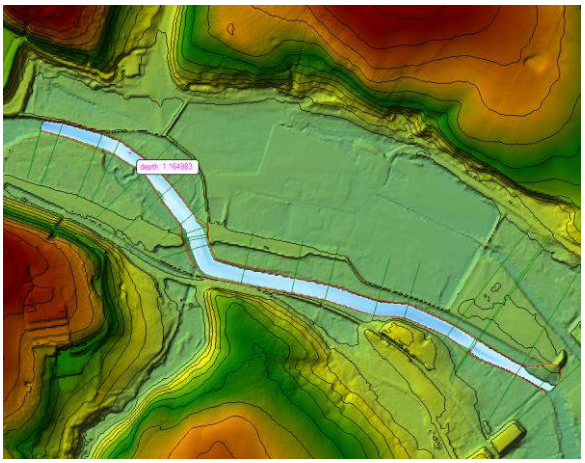
To establish the risk to plot A from the overtopping of the flood defence embankment west of the site a, linked 1D-2D model was created in HEC-RAS. Overtopping only occurs for the 0.1% AEP event, and thus this event was modelled in the hydraulic model using unsteady flow. The hydrographs for the event were adapted from the 2012 Arklow Hydrology & Hydraulics Report (Cawley, 2012)

Unsteady flow was then modelled in 1D in the river channel which was linked to a 2D flood flow area inside the protected area using a levee. This allowed a simulation of the volume, route and extent of flooding for the 0.1% AEP event. Figure 5.3 presents the sequence of flooding, the flood route and the areas at risk. The resulting flood extents map for the defended scenario is presented in Figure 003 in Appendix B.

Upon overtopping the embankment, the water flows in a north eastern direction to low lying ground where an existing drainage channel is located. From here, it flows in an eastern direction along the northern extent of the IFI site before reaching plot A, where it splits in two. One flow path continues along the north side of plot A, while the other runs along the western boundary finding its way into the canal.

The northern portion of the existing ESB sub-station site is affected by ponding initially, but the operational part of the site remains above the flood level.

Generally, maximum flood depths on plot A are located adjacent to the drains where ground levels are lowest and flood depths are generally no more than 350mm.



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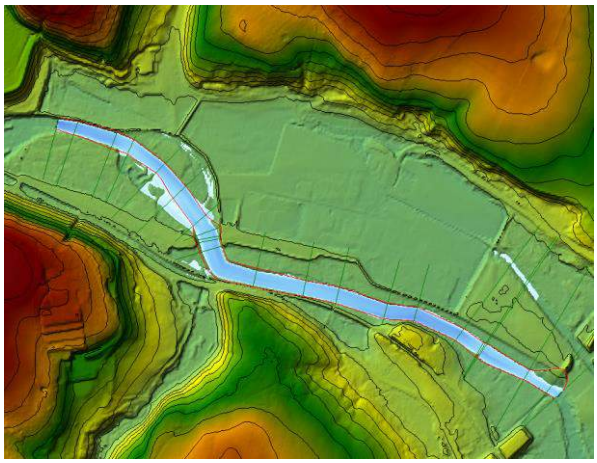

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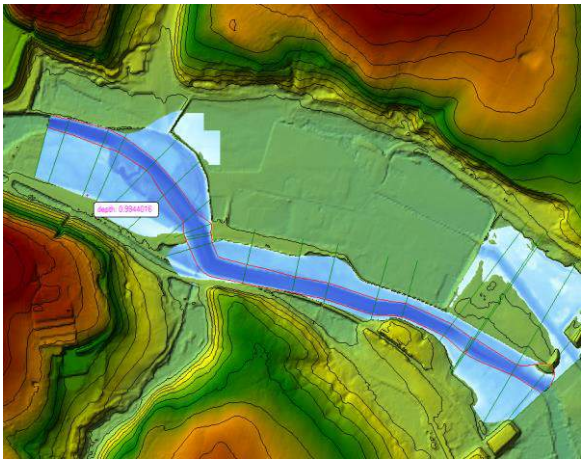

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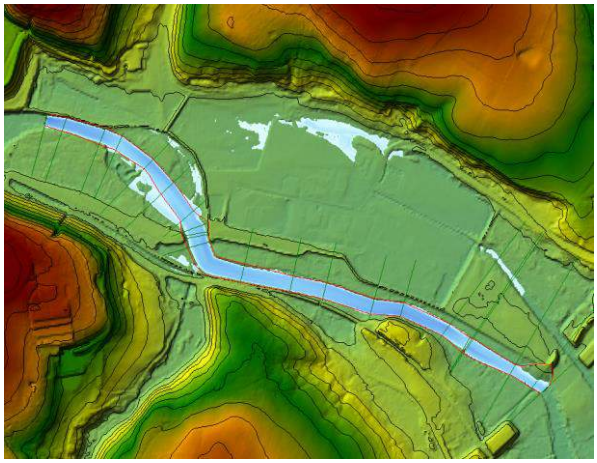

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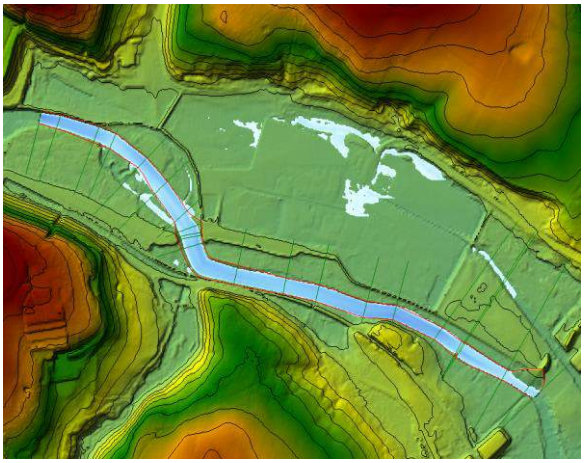

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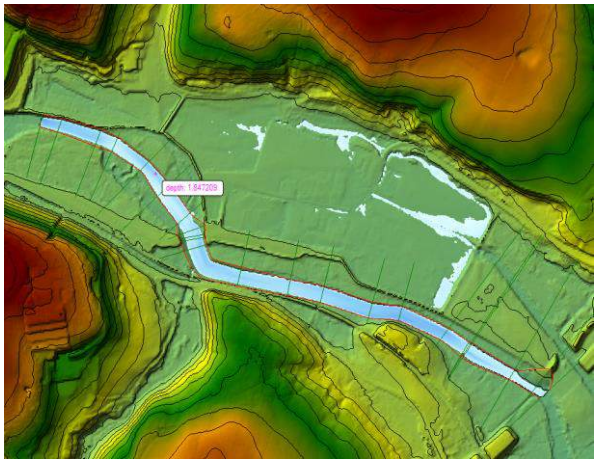


0048 hours (Q = 20m^3/s)

Figure 5.3 – Sequence of inundation of plot A

6.0 Proposed Mitigation Measures

6.1 Recommended Measures

The site is almost entirely defended from the 0.1% AEP event with the exception of the possible flood route upstream of the site. Given the high vulnerability of the development it would be advisable to ensure full flood protection and to consider additional mitigation measures to minimise the risk to the development, particularly given the policy outlined in Circular L8/08 where the Department of the Environment, Heritage and Local Government advocate not building treatment plants in active or former floodplains.

The proposed WwTP should be located outside the 0.1% AEP flood extent as shown in Figure 003 in Appendix B. In the event of overtopping for the embankment for the 0.1% AEP event, the WwTP would then be located outside the flood extent.

Alternatively protection up to the 0.1% AEP event could be achieved for the entire area behind the flood defence embankment by raising the embankment locally where low areas are identified (See Figure 5.2). Permission from the embankment owner would be required to undertaken the works and compensatory storage would need to be provided elsewhere should this option be undertaken.

Typically, the floor levels of building and tanks etc. are set so that they are above the level of the 1% AEP event including climate change (Q100MFRS) with further allowance for freeboard. Freeboard is typically taken as 300mm and takes account of the hydrological and hydraulic uncertainties associated with the flood level estimates.

Locating the WwTP site in Zone C will ensure that levels are above this level as the Q1000 flood levels are higher than the Q100MRFS flood levels. However, if the WwTP is developed in plot A it should be constructed so that the floor and tank levels are above the Q100MRFS to mitigate against the risk of embankment failure. The appropriate development level for plots A, B and C are presented in Table 6.1 below.

Table 6.1 Minimum Design Development Levels for the WwTP

Event	Q100 MFRS Flood Level (m OD)	Allowance for Freeboard (m)	Design level (m OD)
Plot A	4.88	0.3	5.18
Plots B & C	4.18	0.3	4.48

6.2 Impacts of Development on Flood Risk

The impacts on flood risk elsewhere, should the site be developed are discussed in this section. Detailed plans for the plant are not available, and it is therefore assumed that the proposed development will not alter the existing topography of the site. The primary impact that the development will have of flood risk elsewhere will depend on the final location chosen for the WwTP.

Plot A - Development on plot A would not impact flood risk elsewhere significantly as the site is already protected. A minor loss of existing flood plain storage would occur if the embankment was raised upstream of the site to protect against the 0.1% AEP event. However, the volume is a tiny fraction of the overall flow rate (peak overspill flows are less than $1m^3/s$ compared to the $894m^3/s$ peak flow rate and as a result raising the embankment would not significantly impact flood levels downstream.

Plot B - Development on plot B is possible in Flood Zone C without impacting flood risk elsewhere.

Plot C - Development on plot C, which is generally within Zone C, would not result in adverse impact on flood risk elsewhere. A new access arrangement may be required to ensure access is maintained during flood event, but this would not impact on flood risk elsewhere if positioned along the western boundary.

7.0 Residual Flood Risk Management Measures

7.1 Introduction

Portions of the site are within flood zones A and B and as a WwTP is considered to be highly vulnerable development, would not normally be considered. However, the site benefits from an existing flood defence embankment, which hydraulic modelling has shown offers a very high level of protection, almost to the 0.1% AEP event, for the current scenario. Additional residual flood risk management measured that should be included if the development proceeds are outlined below.

7.2 Measures for Flood Defence Failure

Failure of the flood defence embankment could occur in a number of ways with varying degrees of severity and therefore risk to the site. Seepage through or under the embankment would not be catastrophic and while flooding of the site may occur, it is possible that the onsite drainage combined with the available attenuation and pumping arrangements would prevent significant flooding of buildings. This cannot be confirmed however, and it would be prudent, should the WwTP be located in plot A, that appropriate arrangements for discharging surface water are provided.

A local breach in the embankment would be more severe and with increased flow rates and velocities could potentially lead to significant loss of protection to the site by means of embankment failure. The site would become rapidly inundated and pose a significant risk to life as well as imposing large economic losses, and may affect the operation of the WwTP. This risk is mitigated against by setting the development levels (floor levels, tank levels etc.) above the design flood level with an allowance for climate change and freeboard as discussed above.

Additionally, a routine inspection and maintenance programme to ensure that the embankment is in good order should be implemented and permission to undertake such works and repairs should form part of any sale agreement and should extend for the entire embankment length.

7.3 Measures for Flood Defence Overtopping

There is a residual risk to the site arising from the overtopping of the existing embankment. This is somewhat mitigated against by the mitigation measures presented above for flood defence failure, but cannot be eliminated. Flood resilient construction should also be incorporated into the design and in the event of a flood greater in magnitude than the 0.1% AEP event, a level of mitigation would be provided to the proposed plant.

7.4 Access/Egress

Access to development for emergency service is critical, even during flood events when people may need assistance either because they have been injured or for evacuation purposes. It is generally accepted that emergency vehicles can traverse up to 300mm depth of standing water.

Access would generally be possible to plots B and C if the WwTP was located within Zone C on these sites. Emergency access would also generally be achievable to plot A, unless one of the residual risks (i.e defence failure) was realised.

7.5 Emergency Response Planning

There are a number of flood warning systems in place in Ireland varying from national to local level. These are typically operated by Met Éireann (severe weather warnings) and local authorities (severe weather and flooding alerts).

Should the development proceed on the site, a Flood Emergency Repose Plan should need to be developed which would be triggered when necessary by the above mentioned warnings.

8.0 Justification Test

8.1 Introduction

In accordance with Table 3.1 of the FRM Guidelines, WwTPs are deemed to be "Highly Vulnerable Development". Table 3.2 of the FRM Guidelines states that developments deemed as being "highly vulnerable" that are within Flood Zones A and B require a justification test.

The following section details the justification test of the proposed development in accordance with Box 5.1 of the FRM Guidelines.

8.2 Justification Test Criteria

The following section includes each of the criteria from Box 5.1 of the FRM Guidelines, along with an explanation on how each of the criteria are satisfied:

1. *'The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines'*.

   Response:

   The current site is within the area zoned for employment in the 2011-2017 Arklow Local Area Plan which a small portion of plot B with the agricultural zone. While portions of the site are under pasture or woodlands, the entire site has a single zoning objective and forms part of a larger industrial semi brownfield site. The use of the site for the provision of wastewater treatment facilities should be reviewed with the Planning Authority.

2. *'The proposal has been subject to an appropriate flood risk assessment that demonstrates':*

   (i) 'The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk'

   Response:

   The flood risk to the site has been assessed and it has been demonstrated that in the site adequate lands are available within Flood Zone C. Further lands are available in Zone A and B, which are currently defended by a flood defence embankment and are outside the actual flood extent for the 1% AEP event. It is possible therefore to construct the development without affecting flood risk elsewhere.

(ii) The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;

Response:

Ideally, the WwTP would be located on higher ground which is not within Zones A or B. However, the lower parts of the site are well protected by the existing flood defence embankment and the risk to people, the economy and property is significantly reduced. The development proposals also include setting the building level above the design flood level plus an allowance for climate change and freeboard.

(iii) The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access:

Response:

Measures including implementing a Flood Emergency Response Plan, flood resilient construction techniques and setting the floor levels of buildings above the anticipated flood levels are proposed which mitigate against the residual risk.

(iv) The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.

Response:

The existing industrial use for the site is well established and development of a WwTP is compatible and appropriate with the zoning.

9.0 Summary and Conclusions

Following IW public consultation the former IFI site west of Arklow was identified as a potential site for the Arklow WwTP. An assessment of the flood risk to the site has been undertaken and it has been shown that an adequate area of land is available within the assessment site for the provision of Arklow WwTP which is outside the 0.1% AEP flood extent. Portions of the suitable land are within flood Zones A or B but are well protected by an existing flood defence embankment.

The key points are:

- Adequate lands are available outside the 0.1% AEP flood extent:
- Development in Zone C is the preferred option, but development in Zone A or B where it is defended by the flood defence embankment is also possible;
- A justification test has been undertaken that demonstrates that an adequate area within the assessment site is suitable for development in terms of flood risk;
- No other criteria have been assessed other than flood risk;
- Site investigations to assess the strength and condition of the existing flood defence embankment, as well as the potential for seepage should be conducted if development in plot A is proposed.
- The development levels (floor and tank) shall be as presented in Table 6.1.

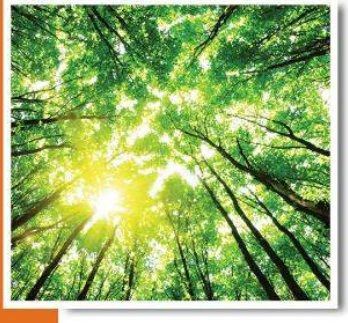
References

BLP, 2013, *Avoca River (Arklow) Flood Relief Feasibility Study,* Byrne Looby Partners, Dublin 12,

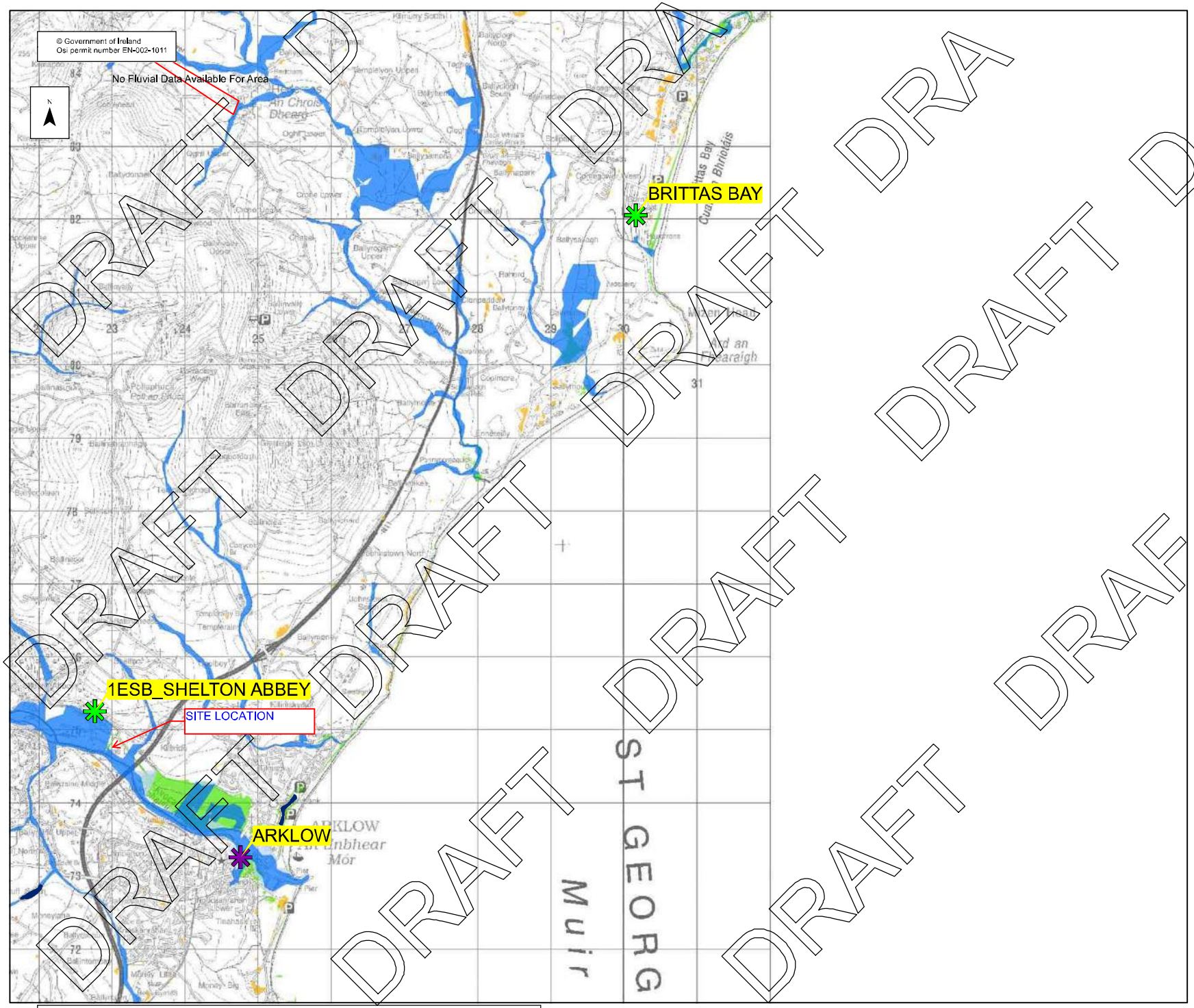
Cawley, A., 2012, *Avoca River (Arklow) Flood Relief Feasibility Study, Hydrology and Hydraulics Report*, Arklow Flood Relief Scheme, PHMcCarthy Consulting Engineers, Dublin 14.

Cawley, A., 2012, *Hydraulic Report II - Two-Dimensional Hydraulic Modelling Of the Avoca River at Arklow*, Arklow Flood Relief Scheme Preliminary Engineering Design, Report No. HEL092501 v1.1, WYG, Dublin, Ireland.

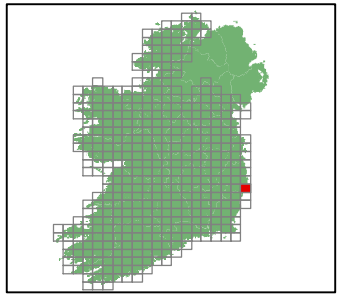
Flood Studies Report (1975), Natural Environment Research Council, 5 Volumes, 1198 pages and twelve maps (available from Institute of Hydrology, Wallingford, Oxfordshire)



Appendix A – Preliminary Flood Risk Assessment Map for Arklow



Location Plan :



Legend:

Flood Extents

- Fluvial - Indicative 1% AEP (100-yr) Event
- Fluvial - Extreme Event
- Coastal - Indicative 0.5% AEP (200-yr) Event
- Coastal - Extreme Event
- Pluvial - Indicative 1% AEP (100-yr) Event
- Pluvial - Extreme Event
- Groundwater Flood Extents
- Lakes / Turloughs

PFRA Outcomes

- Probable Area for Further Assesment
- Possible Area for Further Assesment

Important User Note:

The flood extents shown on these maps are based on broad-scale simple analysis and may not be accurate for a specific location. Information on the purpose, development and limitations of these maps is available in the relevant reports (see www.cfram.ie). Users should seek professional advice if they intend to rely on the maps in any way.

If you believe that the maps are inaccurate in some way please forward full details by contacting the OPW (refer to PFRA Information leaflets or 'Have Your Say' on www.cfram.ie).

Office of Public Works
Jonathon Swift Street
Trim
Co Meath
Ireland

Project :
PRELIMINARY FLOOD RISK ASSESMENT (PFRA)

Map :
PFRA Indicative extents and outcomes
- Draft for Consultation

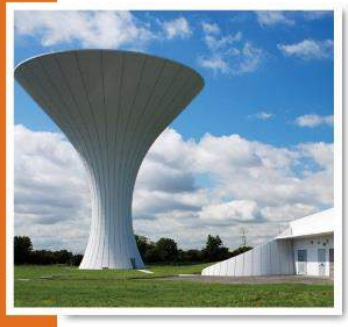
Figure By : PJW Date : July2011

Checked By : MA Date : July 2011

Figure No. : 2019 / MAP / 173 / A

Revision 0

Drawing Scale : 1:50,000 Plot Scale : 1:1 @ A3



Appendix B – Report Figures

001 – Topographic Survey

002 – Flood Zone Map

003 – Flood Extent Map

A3

Chainage (m)	Section ID
1810.893	01AVOC0210
1755.831	01AVOC0200
1636.97	01AVOC0190
1584.917	01AVOC0180
1476.919	01AVOC0170
1387.915	01AVOC0160
1290.073	01AVOC0150
1247.829	01AVOC0140
1230.031	01AVOC0130
1197.199	01AVOC0120
1029.347	01AVOC0110
879.89	01AVOC0100
779.8	01AVOC0090
630.124	01AVOC0080
540.847	01AVOC0070
397.996	01AVOC0060
325.88	01AVOC0055
320.23	01AVOC0050
316.041	01AVOC0045
168.647	01AVOC0040
89.131	01AVOC0030
54.533	01AVOC0020

N
W E
S

GENERAL NOTES

LEGEND:

ASSESSMENT SITE BOUNDARY

ORDNANCE SURVEY IRELAND
LICENCE No. EN 0064809

Rev	Date	Description	By	Chk	App
F1	07/04/15	FOR INFORMATION	NM	SH	KT

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CLIENT
IRISH WATER

PROJECT
ARKLOW SS FRA

DRAWING TITLE
SITE TOPOGRAPHICAL SURVEY

STATUS
FOR INFORMATION

Date: 25/03/15	Scale: AS SHOWN	Drawn: NM	Chk: SH	App: KT
Project No: W3111	Drg. No: W3111-FG001			Rev: F1

A3

PLOT A

PLOT B

PLOT C

Tk

Avoca River

N

W E

S

REFER TO OPW FLOOD EXTENT MAPS FOR DETAILS OF THE FLOOD RISK DOWNSTREAM OF THE SITE

GENERAL NOTES

LEGEND:

ASSESSMENT SITE BOUNDARY

ZONE A

ZONE B

ZONE C

ORDNANCE SURVEY IRELAND
LICENCE No. EN 0064809

Rev	Date	Description	By	Chk	App
F1	07/04/15	FOR INFORMATION	NM	SH	K

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CLIENT
IRISH WATER

PROJECT
ARKLOW SS FRA

DRAWING TITLE
FLOOD ZONES FOR THE POTENTIAL WWTP AT THE IFI SITE, ARKLOW

STATUS
FOR INFORMATION

Date: 25/03/15	Scale: 1:2500	Drawn: NM	Chk: SH	App: K

Project No:	Drg. No:	Rev:
W3111	W3111-FG002	F1

A3

PLOT A

PLOT B

PLOT C

Avoca River

Tk

N

W E

S

REFER TO OPW FLOOD EXTENT MAPS FOR DETAILS OF THE FLOOD RISK DOWNSTREAM OF THE SITE

GENERAL NOTES

LEGEND:

ASSESSMENT SITE BOUNDARY

1% AEP FLOOD EXTENT

0.1% AEP FLOOD EXTENT

ORDNANCE SURVEY IRELAND
LICENCE No. EN 0064809

Rev	Date	Description	By	Chk	App
F1	07/04/15	FOR INFORMATION	NM	SH	K

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CLIENT
IRISH WATER

PROJECT
ARKLOW SS FRA

DRAWING TITLE
EXISTING DEFENDED FLOOD EXTENTS MAP

STATUS
FOR INFORMATION

Date: 25/03/15	Scale: 1:2500	Drawn: NM	Chk: SH	App: K

Project No:	Drg. No:	Rev:
W3111	W3111-FG003	F1

Appendix C – Site Photographs

Figure C.1 Locations of photographs

1. Upstream view from IFI Bridge

2. Downstream face of IFI bridge

3. Upstream view of the Avoca River

4. Upstream view of the Avoca River

5. Weir structure on the Avoca RIver

6. Downstream view to the M11 Roadbridge

7. Site condition near IFI bridge

8. Downstream view of the IFI embankment

9. Upstream view of the IFI embankment from SW corner of Plot A

10. View from the SW corner of plot A in NE direction

11. Downstream view of the embankment adjoining plot A

12. Attenuation pond at SE corner of plot A with pumped discharge arrangement

	
13. View from the SW corner of plot C in eastern direction	14. View from the SW corner of plot C in northern direction
	
15. View of plot C in western direction	16. Upstream view of the canal from NE comers of plot C
	
17. Downstream view of canal from NW corner of plot C	18. View from east of plot A in north western direction

19. Upstream view of lower section of Sheepswalks Stream

20. Upstream view of Sheepswalks Stream

21. Upstream view of culvert on the Sheepswalks Stream

22. View of plot A on right and plot C on the left from wayleave

23. View from east of plot B in western direction

Appendix D – Hydraulic Modelling Outputs

Profile Output Table - Standard
HEC-RAS Plan: Plan 09 River: Avoca 1 Profile: Q100

Rivers 1
Hydraulic Reaches 1
River Station 28
Plans 1
Profiles 1

Date: 03/04/2015
By: SH

Reach	River Station	Profile	Q Total (m3/s)	Bed Level (mOD)	W.S. Elev (mOD)	Crit W.S. (mOD)	E.G. Elev (mOD)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Avoca 1	1810.893	Q100	560	-2.34	5.4		5.82	0.001577	2.88	196.36	183.21	0.39
Avoca 1	1755.831	Q100	560	-0.98	5.36		5.72	0.001385	2.67	210.24	194.08	0.38
Avoca 1	1636.97	Q100	560	-0.62	5.24	2.71	5.53	0.001397	2.42	243.22	208.44	0.37
Avoca 1	1584.917	Q100	560	0.48	5.11	3.44	5.45	0.001782	2.67	229.46	205.35	0.42
Avoca 1	1500		Lat Struct									
Avoca 1	1476.919	Q100	560	-1	5.2	3.02	5.28	0.000482	1.56	532.37	273.13	0.22
Avoca 1	1387.915	Q100	560	-0.71	5.16	2.75	5.24	0.000459	1.47	524.12	227.95	0.22
Avoca 1	1290.073	Q100	560	-0.34	5.08	2.41	5.19	0.000552	1.66	463.69	134.27	0.24
Avoca 1	1247.829	Q100	560	-0.6	5.01	2.3	5.16	0.000803	1.72	325.65	83.16	0.28
Avoca 1	1230.031	Q100	560	-1.1	4.96	2.28	5.14	0.000876	1.86	301.05	72.21	0.29
Avoca 1	1222.931		Bridge									
Avoca 1	1222.431	Q100	560	-1.1	4.94		5.12	0.000893	1.87	299.16	72.14	0.29
Avoca 1	1197.199	Q100	560	-1.24	4.95	1.99	5.08	0.0006	1.68	376.75	180.18	0.25
Avoca 1	1029.347	Q100	560	-0.75	4.75	2.36	4.96	0.001125	2.13	320.63	107.21	0.33
Avoca 1	879.89	Q100	560	-0.58	4.56	2.53	4.78	0.001238	2.27	313.46	104.3	0.34
Avoca 1	779.8	Q100	560	-0.97	4.52	2.14	4.66	0.000754	1.86	374.6	133.78	0.27
Avoca 1	630.124	Q100	560	-1.83	4.32	1.56	4.53	0.000905	2.13	315.1	94.35	0.3
Avoca 1	540.847	Q100	560	-2.08	4.15	1.37	4.43	0.001084	2.42	260.42	66.06	0.33
Avoca 1	397.996	Q100	560	-2.02	3.94	1.84	4.25	0.001459	2.57	258.72	83.31	0.38
Avoca 1	325.88	Q100	560	-0.43	3.83	2.75	4.12	0.002209	2.61	279.86	128.21	0.45
Avoca 1	320.23	Q100	560	-0.49	3.8	2.82	4.11	0.002902	2.87	286	138.68	0.48
Avoca 1	316.041	Q100	560	-2.6	3.88	1.56	4.06	0.000971	2.02	361.15	140.75	0.31
Avoca 1	168.647	Q100	560	-1.3	3.68	2.8	3.89	0.001418	2.43	385.19	221.5	0.36
Avoca 1	89.131	Q100	560	-1.43	3.69		3.78	0.000634	1.51	528.08	223.82	0.25
Avoca 1	54.533	Q100	560	-1.84	3.52	1.73	3.74	0.001247	2.34	373.26	262.51	0.35
Avoca 1	54.033		Bridge									
Avoca 1	21.733	Q100	560	-1.84	3.46	1.64	3.69	0.001341	2.36	359.3	268.55	0.36
Avoca 1	1	Q100	560	-2.04	3.49	1.53	3.64	0.000935	2.04	452.21	269.4	0.31

Profile Output Table - Standard
HEC-RAS Plan: Plan 09 River: Avoca 1 Profile: Q1000

Rivers 1
Hydraulic Reaches 1
River Station 28
Plans 1
Profiles 1

Date: 03/04/2015
By: SH

Reach	River Sta	Profile	Q Total (m3/s)	Bed Level (m OD)	W.S. Elev (m OD)	Crit W.S. (m OD)	E.G. Elev (m OD)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Avoca 1	1810.893	Q1000	745	-2.34	6.01		6.61	0.001986	3.44	219.13	185.38	0.45
Avoca 1	1755.831	Q1000	745	-0.98	5.97		6.48	0.001678	3.17	236.27	195.43	0.42
Avoca 1	1636.97	Q1000	745	-0.62	5.87	3.32	6.25	0.001541	2.78	285.56	209.78	0.39
Avoca 1	1584.917	Q1000	745	0.48	5.73	3.97	6.16	0.001929	3.04	268.27	208.88	0.44
Avoca 1	1500		Lat Struct									
Avoca 1	1476.919	Q1000	745	-1	5.87	3.34	5.97	0.000477	1.69	647.58	312.86	0.23
Avoca 1	1387.915	Q1000	745	-0.71	5.83	3.02	5.92	0.000479	1.64	622.42	285.53	0.23
Avoca 1	1290.073	Q1000	745	-0.34	5.73	3.02	5.86	0.000607	1.89	553.03	145.62	0.26
Avoca 1	1247.829	Q1000	745	-0.6	5.63	2.73	5.83	0.000919	1.96	379.67	87.89	0.3
Avoca 1	1230.031	Q1000	745	-1.1	5.57	2.73	5.81	0.001019	2.16	345.42	74.04	0.32
Avoca 1	1222.931		Bridge									
Avoca 1	1222.431	Q1000	745	-1.1	5.54		5.78	0.001042	2.17	342.91	73.92	0.32
Avoca 1	1197.199	Q1000	745	-1.24	5.56	2.49	5.74	0.000672	1.93	443.55	182.41	0.27
Avoca 1	1029.347	Q1000	745	-0.75	5.35	3.15	5.6	0.001215	2.38	385.07	109.17	0.35
Avoca 1	879.89	Q1000	745	-0.58	5.13	3.29	5.4	0.001362	2.56	373.57	105.56	0.36
Avoca 1	779.8	Q1000	745	-0.97	5.1	3.19	5.27	0.000772	2.04	453.54	135.3	0.28
Avoca 1	630.124	Q1000	745	-1.83	4.85	2.16	5.12	0.001082	2.49	365.11	96.13	0.33
Avoca 1	540.847	Q1000	745	-2.08	4.59	2	5	0.001441	2.94	289.49	67.6	0.39
Avoca 1	397.996	Q1000	745	-2.02	4.32	2.57	4.76	0.001911	3.1	290.19	84.68	0.44
Avoca 1	325.88	Q1000	745	-0.43	4.21	3.19	4.58	0.002544	2.99	328.93	129.76	0.49
Avoca 1	320.23	Q1000	745	-0.49	4.2	3.34	4.57	0.003195	3.22	342.21	144.88	0.51
Avoca 1	316.041	Q1000	745	-2.6	4.28	2.19	4.52	0.001199	2.38	417.86	145.89	0.34
Avoca 1	168.647	Q1000	745	-1.3	4.09	3.22	4.32	0.001484	2.63	477.74	225.17	0.38
Avoca 1	89.131	Q1000	745	-1.43	4.1		4.2	0.000734	1.71	619.89	228.63	0.27
Avoca 1	54.533	Q1000	745	-1.84	3.91	2.64	4.16	0.001388	2.6	466.01	263.7	0.37
Avoca 1	54.033		Bridge									
Avoca 1	21.733	Q1000	745	-1.84	3.84	2.84	4.09	0.001511	2.64	448.46	269.96	0.39
Avoca 1	1	Q1000	745	-2.04	3.87	2.52	4.04	0.001048	2.26	554.88	270.89	0.33

Profile Output Table - Standard
HEC-RAS Plan: Plan 09 River: Avoca 1 Profile: Q100MRFS

Rivers 1
Hydraulic Reaches 1
River Station 28
Plans 1
Profiles 1

Date: 03/04/2015
By: SH

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m OD)	W.S. Elev (m OD)	Crit W.S. (m OD)	E.G. Elev (m OD)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Avoca 1	1810.893	MRFSQ100	672	-2.34	5.78		6.31	0.001838	3.23	210.41	185.38	0.43
Avoca 1	1755.831	MRFSQ100	672	-0.98	5.74		6.19	0.001567	2.98	226.33	195.43	0.41
Avoca 1	1636.97	MRFSQ100	672	-0.62	5.63	3.08	5.98	0.001488	2.64	269.55	209.78	0.38
Avoca 1	1584.917	MRFSQ100	672	0.48	5.49	3.79	5.89	0.001874	2.9	253.62	208.88	0.43
Avoca 1	1500		Lat Struct									
Avoca 1	1476.919	MRFSQ100	672	-1	5.62	3.21	5.71	0.000478	1.64	603.66	310.03	0.23
Avoca 1	1387.915	MRFSQ100	672	-0.71	5.57	2.97	5.66	0.000472	1.57	585.16	283.21	0.22
Avoca 1	1290.073	MRFSQ100	672	-0.34	5.49	2.91	5.61	0.000576	1.78	518.75	137.85	0.25
Avoca 1	1247.829	MRFSQ100	672	-0.6	5.4	2.56	5.57	0.000886	1.87	359.04	86.96	0.29
Avoca 1	1230.031	MRFSQ100	672	-1.1	5.34	2.56	5.55	0.000964	2.05	328.6	73.28	0.31
Avoca 1	1222.931		Bridge									
Avoca 1	1222.431	MRFSQ100	672	-1.1	5.31		5.53	0.000985	2.06	326.35	73.18	0.31
Avoca 1	1197.199	MRFSQ100	672	-1.24	5.33	2.3	5.49	0.000645	1.84	418.26	181.58	0.26
Avoca 1	1029.347	MRFSQ100	672	-0.75	5.13	2.8	5.36	0.001182	2.29	360.67	108.43	0.34
Avoca 1	879.89	MRFSQ100	672	-0.58	4.91	2.8	5.17	0.001316	2.45	350.85	105.09	0.35
Avoca 1	779.8	MRFSQ100	672	-0.97	4.88	2.56	5.04	0.000765	1.97	423.69	134.82	0.28
Avoca 1	630.124	MRFSQ100	672	-1.83	4.65	1.93	4.9	0.001016	2.35	346.21	95.47	0.32
Avoca 1	540.847	MRFSQ100	672	-2.08	4.43	1.77	4.79	0.0013	2.74	278.71	67.03	0.37
Avoca 1	397.996	MRFSQ100	672	-2.02	4.18	2.3	4.57	0.001729	2.89	278.72	84.17	0.42
Avoca 1	325.88	MRFSQ100	672	-0.43	4.07	3.01	4.41	0.002407	2.84	311	129.24	0.47
Avoca 1	320.23	MRFSQ100	672	-0.49	4.05	3.23	4.4	0.003074	3.09	321.51	143.04	0.5
Avoca 1	316.041	MRFSQ100	672	-2.6	4.13	1.97	4.35	0.001108	2.24	397.01	143.78	0.33
Avoca 1	168.647	MRFSQ100	672	-1.3	3.94	3.1	4.16	0.001445	2.55	444.88	224.09	0.37
Avoca 1	89.131	MRFSQ100	672	-1.43	3.96		4.05	0.00069	1.63	587.21	226.93	0.26
Avoca 1	54.533	MRFSQ100	672	-1.84	3.78	2.14	4.01	0.001322	2.5	433.74	263.29	0.36
Avoca 1	54.033		Bridge									
Avoca 1	21.733	MRFSQ100	672	-1.84	3.71	2.07	3.95	0.001429	2.52	418.02	269.48	0.38
Avoca 1	1	MRFSQ100	672	-2.04	3.74	1.91	3.9	0.000993	2.17	519.66	270.34	0.32

Profile Output Table - Standard
HEC-RAS Plan: Plan 09 River: Avoca 1 Profile: Q1000MRFS

Rivers 1
Hydraulic Reaches 1
River Station 28
Plans 1
Profiles 1

Date: 03/04/2015
By: SH

Reach	River Station	Profile	Q Total (m3/s)	Min Ch El (m OD)	W.S. Elev (m OD)	Crit W.S. (m OD)	E.G. Elev (m OD)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Avoca 1	1810.893	MRFSQ1000	894	-2.34	6.45		7.2	0.00226	3.85	235.98	185.38	0.48
Avoca 1	1755.831	MRFSQ1000	894	-0.98	6.42		7.05	0.001876	3.52	255.59	195.43	0.45
Avoca 1	1636.97	MRFSQ1000	894	-0.62	6.34	3.88	6.79	0.001617	3.02	317.2	209.78	0.41
Avoca 1	1584.917	MRFSQ1000	894	0.48	6.18	4.32	6.69	0.002002	3.29	297.34	208.88	0.46
Avoca 1	1500		Lat Struct									
Avoca 1	1476.919	MRFSQ1000	894	-1	6.38	3.55	6.48	0.000468	1.77	735.55	312.86	0.23
Avoca 1	1387.915	MRFSQ1000	894	-0.71	6.32	3.39	6.43	0.000487	1.75	696.73	286.5	0.23
Avoca 1	1290.073	MRFSQ1000	894	-0.34	6.22	3.32	6.37	0.000643	2.06	629.86	168.15	0.27
Avoca 1	1247.829	MRFSQ1000	894	-0.6	6.1	3.05	6.33	0.00095	2.12	421.93	91.17	0.31
Avoca 1	1230.031	MRFSQ1000	894	-1.1	6.03	3.08	6.31	0.001099	2.35	379.71	75.55	0.33
Avoca 1	1222.931		Bridge									
Avoca 1	1222.431	MRFSQ1000	894	-1.1	5.96		6.25	0.001145	2.39	374.79	75.33	0.34
Avoca 1	1197.199	MRFSQ1000	894	-1.24	6	2.96	6.21	0.00072	2.11	492.2	183.89	0.28
Avoca 1	1029.347	MRFSQ1000	894	-0.75	5.78	3.64	6.06	0.001274	2.56	432.18	110.7	0.36
Avoca 1	879.89	MRFSQ1000	894	-0.58	5.54	3.65	5.86	0.001442	2.75	417.33	106.46	0.38
Avoca 1	779.8	MRFSQ1000	894	-0.97	5.53	3.49	5.71	0.000782	2.16	510.97	135.96	0.29
Avoca 1	630.124	MRFSQ1000	894	-1.83	5.22	2.8	5.55	0.001202	2.74	401.65	97.38	0.35
Avoca 1	540.847	MRFSQ1000	894	-2.08	4.88	2.53	5.41	0.001728	3.33	309.67	68.74	0.43
Avoca 1	397.996	MRFSQ1000	894	-2.02	4.56	3.02	5.12	0.002287	3.5	311.07	85.68	0.49
Avoca 1	325.88	MRFSQ1000	894	-0.43	4.46	3.48	4.9	0.002827	3.29	361.84	131.42	0.52
Avoca 1	320.23	MRFSQ1000	894	-0.49	4.46	3.63	4.88	0.003447	3.49	380.55	147.98	0.53
Avoca 1	316.041	MRFSQ1000	894	-2.6	4.54	2.69	4.83	0.00138	2.64	456.58	148.53	0.37
Avoca 1	168.647	MRFSQ1000	894	-1.3	4.35	3.44	4.61	0.001574	2.81	537.01	226.68	0.39
Avoca 1	89.131	MRFSQ1000	894	-1.43	4.36		4.48	0.000825	1.86	679.17	231.59	0.29
Avoca 1	54.533	MRFSQ1000	894	-1.84	4.15	3.01	4.43	0.001531	2.82	523.2	264.57	0.39
Avoca 1	54.033		Bridge									
Avoca 1	21.733	MRFSQ1000	894	-1.84	4.06	3.15	4.35	0.001687	2.87	502.08	270.85	0.41
Avoca 1	1	MRFSQ1000	894	-2.04	4.1	2.82	4.3	0.001168	2.45	617.26	271.99	0.35