



**WYG** Ireland

part of the **WYG** group



## OFFICE OF PUBLIC WORKS

### Bandon Flood Relief Scheme

### Report on Flood Risk Management Options

**April 2012**

**C008065**

**creative minds** safe hands

## DOCUMENT CONTROL

Document: Report on Flood Risk Management Options

Client: Office of Public Works

Project Name: Bandon Flood Relief Scheme

Project Number: C008065

File Origin: \\CORK10\Projects\C00\C008065\P-03 Execution\02 WA\01 Reports\Report on Flood Risk Management Options\Report on Flood Risk Management Options v2.doc

WYG Office: WYG Engineering (Ireland) Limited,  
Unit 2 University Technology Centre,  
Curraheen Road,  
Cork  
Tel.: +353 (0)21 493 3200  
Fax.: +353 (0)21 493 3250

JBA Office: JBA Consulting,  
24 Grove Island,  
Corbally,  
Limerick  
Tel.: +353 (0)61 345463  
Fax.: +353 (0)61 280146

Issue No.	Date	Prepared by:	Checked by:	Approved by:
1 (Draft)	14-10-2011	Kieran Thornton	Pat Murphy	Kieran Thornton
2	17-02-2012	<i>Kieran Thornton</i>	<i>Pat Murphy</i>	<i>Kieran Thornton</i>

## TABLE OF CONTENTS

<b>1.0</b>	<b>INTRODUCTION .....</b>	<b>1</b>
1.1	BACKGROUND .....	1
1.2	SCOPE .....	1
1.3	METHODOLOGY.....	1
1.4	CURRENT SITUATION.....	2
1.4	DESIGN STANDARD .....	2
<b>2.0</b>	<b>SCREENING OF FLOOD RISK MANAGEMENT OPTIONS .....</b>	<b>3</b>
2.1	POSSIBLE FLOOD RISK MANAGEMENT METHODS.....	3
2.2	CRITERIA.....	4
2.3	SCREENING .....	4
2.4	SUMMARY OF SCREENING.....	15
<b>3.0</b>	<b>DEVELOPMENT OF POTENTIAL OPTIONS .....</b>	<b>17</b>
3.1	INCREASE IN CONVEYANCE .....	17
3.2	NEW FLOOD DEFENCES .....	20
3.3	REHABILITATION/IMPROVEMENT OF EXISTING DEFENCES.....	21
3.4	COMBINATIONS OF DREDGING AND DEFENCES .....	21
3.5	FREEBOARD .....	22
<b>4.0</b>	<b>APPRAISAL OF POTENTIAL OPTIONS .....</b>	<b>23</b>
4.1	INCREASE IN CONVEYANCE .....	23
4.2	NEW FLOOD DEFENCES .....	24
4.3	REHABILITATION/IMPROVEMENT OF EXISTING DEFENCES.....	24
4.4	COMBINATIONS OF DREDGING AND DEFENCES .....	24
4.6	OPTIONS APPRAISAL.....	24
<b>5.0</b>	<b>SELECTION OF PREFERRED OPTION .....</b>	<b>26</b>
5.1	SUMMARY OF APPRAISAL .....	26
5.2	OTHER WORKS .....	26
5.3	NON-STRUCTURAL METHODS.....	26

APPENDIX A	-	FLOOD RISK MANAGEMENT OBJECTIVES AND WEIGHTINGS
APPENDIX B	-	FLOOD RISK RECEPTOR GROUPS
APPENDIX C	-	ASSESSMENT OF MODEL OUTPUT
APPENDIX D	-	MULTI-CRITERIA ANALYSIS MATRIX
APPENDIX E	-	FIGURES

## 1.0 INTRODUCTION

### 1.1 BACKGROUND

This Report follows on the work carried out to-date by the Engineering and Environmental Consultants for the Bandon Flood Relief Scheme which includes:

- Screening for Appropriate Assessment;
- Defence Asset Condition Survey;
- Property Threshold Survey ;
- Constraints Study;
- Hydrology Report,
- Hydraulics Analysis and Report; and
- Site Investigation Survey and Report.

This Report covers the next steps in the development of the flood risk management options and identification of a preferred option.

### 1.2 SCOPE

The Report covers the methodology used for and assessment of activities relating to:

- Screening of possible flood risk management options;
- Developing potential options;
- Appraising potential options
- Selecting a preferred option.

Public and stakeholder consultation is ongoing and will continue for the duration of the project in various forms. A public information day took place on 21<sup>st</sup> October 2011 in Bandon.

### 1.3 METHODOLOGY

The possible flood risk management (FRM) methods were initially screened to identify those that would be applicable and viable considering the risks to society, the environment, cultural heritage and the economy and the objectives of the flood risk management plan for the Project. The Flood Risk Management Objectives and their associated global and local weightings are included in Appendix A. Global and local weightings were agreed with the OPW to ensure consistency in the assessment of flood risk management objectives nationally.

The potentially viable options were developed so that they could be evaluated in more detail. This involved hydraulic modelling of options where flood levels and extents had to be

considered. The options were assessed against the flood risk management objectives with the use of local weightings. The preferred option was then identified following discussion with the OPW and the Steering Group.

## 1.4 CURRENT SITUATION

Bandon Town has a long history of serious flooding. Flooding is primarily due to heavy rainfall in the catchment of the Bandon River and of its tributary, the Bridewell River which joins the Bandon River immediately downstream of Bandon Bridge. It can be exasperated by high tides in the Bandon River estuary, approximately 6km to the east of the town. Since the previous highest recorded flood in 1975, serious flooding has occurred in the town in 1978, 1982, 1986, 1988 and November 2009. Minor flooding in the past decade has occurred in 2004, 2005, 2006 and January 2011.

The management of flood risk at present consists of a Flood Early Warning System which was installed in early 2011 and an associated Flood Emergency Response Plan. The Flood Early Warning System operates by monitoring river levels at three gauging stations located at Longbridge, Bealaboy and Bandon and issuing text alerts to designated people depending on the level of the river and the associated colour of the alert – yellow (low), yellow (high), orange and red. The level of the alert will determine the resulting actions by the people contacted, ultimately resulting in the implementation of the Flood Emergency Response Plan.

## 1.4 DESIGN STANDARD

The design standard to be adopted for the scheme, as instructed by the Steering Group, is the 1% AEP flood level with provision for adaptability to the Medium Range Future Scenario (MRFS). The 1% AEP flood event has been used in this assessment of options.

## 2.0 SCREENING OF FLOOD RISK MANAGEMENT OPTIONS

### 2.1 POSSIBLE FLOOD RISK MANAGEMENT METHODS

The possible flood risk management methods which could be utilised in a flood relief scheme include:

1. Do nothing i.e. implement no new flood risk management measures and abandon any existing practices;
2. Continue existing regime (Flood Early Warning System and Flood Emergency Response Plan)
3. Do minimum i.e. implement additional minimal measures to reduce the flood risk in specific problem areas without introducing a comprehensive strategy;
4. Non-structural Measure:-
  - a. Implement Planning and development control measures;
  - b. Enact building regulations relating to floor levels, flood-proofing, flood-resilience, sustainable drainage systems, prevention of reconstruction or redevelopment in flood-risk areas, etc.;
  - c. Enact regulations for sustainable urban drainage systems;
  - d. Carry out targeted public awareness and preparedness campaign;
  - e. Individual property flood resistance;
  - f. Land use management, including creation of wetlands, riparian buffer zones, etc.
5. Structural measures (potential future risk where necessary floodplain development may occur;
6. Structural measures (existing risk)
  - a. Upstream flood water storage;
  - b. Upstream restriction on river flows;
  - c. Flow diversion;
  - d. Increase conveyance;
  - e. Construct flood defences (walls, embankments, demountable defences, etc.)
  - f. Rehabilitate and improve existing defences including localised protection works (e.g., minor raising of existing defences / levels, infilling gaps in defences, etc.)
  - g. Relocation of properties
7. Channel or flood defence maintenance works / programme

## 2.2 CRITERIA

The criteria used for the initial screening are:

1. Applicability to area;
2. Social;
3. Environmental;
4. Cultural;
5. Economic;

A description of the indicators of flood risk for criteria 2 to 5 is provided in Appendix B.

## 2.3 SCREENING

### 2.3.1 Do Nothing

In this situation, the existing Flood Early Warning System (FEWS) and associated Flood Emergency Response Plan (FERP) would not be utilised. The summary of the assessment of flood risk to the receptor groups is shown below.

Criteria	Assessment
Applicability to area	-
Social	i) 151 residential properties at risk. ii) Housing for elderly at risk iii) Garda station at risk. iv) Park on Glasslinn Road at risk
Environmental	i) Pollution risk from petrol stations and WWTP.
Cultural	i) Protected structures at risk including Bandon Bridge, old Town Walls and many buildings in South Main Street.
Economic	i) 151 residential properties and 201 commercial properties at risk. ii) Density of economic risk = €1,075/1000m <sup>2</sup> . iii) Risk to N71 NPR (Cork-Clonakilty-West Cork) and R586 RR (Cork-Dunmanway-West Cork) transport routes. iv) Risk to telecom exchange.

The existing risk would be increased if the FEWS and associated FERP were not utilised. Overall, this option is not considered acceptable due to excessively high level of risk and it is not considered further.

## 2.3.2 Existing Regime

In this situation, the existing Flood Early Warning System (FEWS) and associated Flood Emergency Response Plan (FERP) would be utilised. The summary of the assessment of flood risk to the receptor groups is shown below.

Criteria	Assessment
Applicability to area	This is applicable to the area.
Social	<ul style="list-style-type: none"> <li>i) 151 residential properties at risk.</li> <li>ii) Housing for elderly at risk</li> <li>iii) Garda station at risk.</li> <li>iv) Park on Glasslinn Road at risk</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>i) Pollution risk from petrol stations and WWTP.</li> </ul>
Cultural	<ul style="list-style-type: none"> <li>i) Protected structures at risk including Bandon Bridge, old Town Walls and many buildings in South Main Street.</li> </ul>
Economic	<ul style="list-style-type: none"> <li>i) 151 residential properties and 201 commercial properties at risk.</li> <li>ii) Density of economic risk = €1,075/1000m<sup>2</sup>.</li> <li>iii) Risk to N71 NPR (Cork-Clonakilty-West Cork) and R586 RR (Cork-Dunmanway-West Cork) transport routes.</li> <li>iv) Risk to telecom exchange.</li> </ul>

The existing risk remains but can be managed to some extent with the implementation of the FEWS and the FERP. Overall, this option is not considered acceptable on its own due to the excessively high level of risk and it is not considered further on its own. It would be appropriate to use with other methods.



## 2.3.3 Minimal Measures

Minimal measure could include annual local dredging of the Bandon River around Bandon Bridge and local trimming of vegetation along the riverbank. The summary of the assessment of flood risk to the receptor groups is shown below.

Criteria	Assessment
Applicability to area	This is applicable to the area.
Social	<ul style="list-style-type: none"> <li>i) 151 residential properties at risk.</li> <li>ii) Housing for elderly at risk</li> <li>iii) Garda station at risk.</li> <li>iv) Park on Glasslinn Road at risk</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>i) Pollution risk from petrol stations and WWTP.</li> <li>ii) Potential direct risk to NHA habitats.</li> <li>iii) Direct risk to legally protected species through damage to habitat, disturbance and potential water quality deterioration during construction</li> <li>iv) Potential indirect risk to Bandon River cSAC upstream.</li> </ul>
Cultural	<ul style="list-style-type: none"> <li>i) Protected structures at risk including Bandon Bridge, old Town Walls and many buildings in South Main Street.</li> </ul>
Economic	<ul style="list-style-type: none"> <li>i) 151 residential properties and 201 commercial properties at risk.</li> <li>ii) Density of economic risk = €1,075/1000m<sup>2</sup>.</li> <li>iii) Risk to N71 NPR (Cork-Clonakilty-West Cork) and R586 RR (Cork-Dunmanway-West Cork) transport routes.</li> <li>iv) Risk to telecom exchange.</li> </ul>

The reduction in risk would be negligible from current situation. The risk can be managed to some extent with the implementation of the FEWS and the FERP. Overall, this option is not considered acceptable on its own due to the excessively high level of residual risk and it is not considered further.

## 2.3.4 Non-structural Measures

The FEWS and FERP are non-structural measures that are currently in place. Other non-structural measures include planning and control measures, building regulations regarding flood-proofing of buildings, public awareness and preparedness campaigns, individual flood protection of buildings and land use management plans. The summary of the assessment of flood risk to the receptor groups is shown below.

Criteria	Assessment
Applicability to area	This is applicable to the area.
Social	<ul style="list-style-type: none"> <li>i) 151 residential properties at risk.</li> <li>ii) Housing for elderly at risk</li> <li>iii) Garda station at risk.</li> <li>iv) Park on Glasslinn Road at risk</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>i) Pollution risk from petrol stations and WWTP.</li> </ul>
Cultural	<ul style="list-style-type: none"> <li>i) Protected structures at risk including Bandon Bridge, old town Walls and many building in South Main Street.</li> </ul>
Economic	<ul style="list-style-type: none"> <li>i) 151 residential properties and 230 commercial properties at risk.</li> <li>ii) Density of economic risk = €1,075/1000m<sup>2</sup>.</li> <li>iii) Risk to N71 NPR (Cork-Clonakilty-West Cork) and R586 RR (Cork-Dunmanway-West Cork) transport routes.</li> <li>iv) Risk to telecom exchange.</li> </ul>

The use of non-structural methods on their own would only provide a limited reduction in risk over the current risk. The measures would take time to implement, possibly in excess of 10-20 years. Overall, this option is not considered acceptable on its own due to excessively high level of residual risk and the time required to implement the methods. It is not considered further on its own. It would be appropriate to use with other methods due to its low cost and to raise general public awareness.

## 2.3.5 Structural Measures for Potential Future Risk

These methods are of relevance where development in the flood plain may occur through necessity e.g. through its location in the town centre. They would include ensuring any development was appropriate for its location, ensuring it was set at an appropriate level relative to flood levels and that there was no increase in flood risk to existing development. The summary of the assessment of flood risk to the receptor groups is shown below.

Criteria	Assessment
Applicability to area	Only applicable if allowed by Authorities.
Social	<ul style="list-style-type: none"> <li>i) 151 residential properties at risk.</li> <li>ii) Housing for elderly at risk</li> <li>iii) Garda station at risk.</li> <li>iv) Park on Glasslinn Road at risk</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>i) Pollution risk from petrol stations and WWTP.</li> </ul>
Cultural	<ul style="list-style-type: none"> <li>i) Protected structures at risk including Bandon Bridge, old town Walls and many building in South Main Street.</li> </ul>
Economic	<ul style="list-style-type: none"> <li>i) 151 residential properties and 230 commercial properties at risk.</li> <li>ii) Density of economic risk = €1,075/1000m<sup>2</sup>.</li> <li>iii) Risk to N71 NPR (Cork-Clonakilty-West Cork) and R586 RR (Cork-Dunmanway-West Cork) transport routes.</li> <li>iv) Risk to telecom exchange.</li> </ul>

The use of structural methods for future potential risk on their own would not reduce the current level of risk. Overall, this option is not considered acceptable on its own due to the excessively high level of existing risk and it is not considered further on its own. It would be appropriate to use with other methods for future developments.

## 2.3.6 Structural Measures for Existing Risk

These methods cover a wide range of options which are discussed separately below.

### a) Upstream Flood Water Storage

This option considers the storage of flood water in the Bandon River catchment upstream of Bandon Town. This option was modelled to assess the storage requirements. In order to avoid damage to property in Bandon, it is estimated that it would be necessary to restrict the flood flow through Bandon to less than the 10% AEP flood flow. In this situation, up to 13,000,000m<sup>3</sup> of storage would be required which would cover an area of approximately 650ha. The summary of the assessment of flood risk to the receptor groups is shown below.

Criteria	Assessment
Applicability to area	No.
Social	i) 151 residential properties protected. ii) Housing for elderly protected iii) Garda station protected. iv) Park on Glasslinn Road protected
Environmental	i) No pollution risk from petrol stations and WWTP. ii) Loss of wetland habitat. iii) Creation of new aquatic habitat.
Cultural	i) Protected structures not at risk except for those within proposed flood storage areas.
Economic	i) 151 residential properties and 201 commercial properties protected ii) Density of economic risk = €1,075/1000m <sup>2</sup> . iii) No risk to N71 NPR (Cork-Clonakilty-West Cork) and R586 RR (Cork-Dunmanway-West Cork) transport routes. iv) No risk to telecom exchange.

This method would reduce the risk to an acceptable level. However, an examination of the catchment upstream of Bandon did not locate any suitable storage areas to provide the required volume of storage. The level of protection is also dependent on the duration of the

flood event. For longer flood events, the storage could be fully utilised before the flood has passed thereby increasing the flood risk.

Overall, this option is not considered acceptable due to the very significant technical difficulties of providing the required storage and because of the residual risk.

## b) Upstream Flood Water Restriction

This option considers the restriction of flows in the river by the creation of partial dam-type structures across the river flood plain. This would have the effect of restricting flows to a manageable level through Bandon. This option is similar to the flood water storage option discussed above. Similar to the flood storage option, it is considered that it would be necessary to restrict the flood flow through Bandon to less than the 10% AEP flood flow and up to 13,000,000m<sup>3</sup> of storage would be required which would cover an area of approximately 650ha. The summary of the assessment of flood risk to the receptor groups is shown below.

Criteria	Assessment
Applicability to area	No.
Social	v) 151 residential properties protected. vi) Housing for elderly protected vii) Garda station protected. viii) Park on Glasslinn Road protected
Environmental	iv) No pollution risk from petrol stations and WWTP. v) Loss of wetland habitat. vi) Creation of new aquatic habitat.
Cultural	ii) Protected structures not at risk except for those within proposed flood storage areas.
Economic	v) 151 residential properties and 201 commercial properties protected vi) Density of economic risk = €1,075/1000m <sup>2</sup> . vii) No risk to N71 NPR (Cork-Clonakilty-West Cork) and R586 RR (Cork-Dunmanway-West Cork) transport routes. viii) No risk to telecom exchange.

This method would reduce the risk to an acceptable level. However, an examination of the catchment upstream of Bandon did not locate any suitable storage areas to provide the required volume of storage. The level of protection is also dependent on the duration of the flood event. For longer flood events, the storage could be fully utilised before the flood has passed thereby increasing the flood risk.

Overall, this option is not considered acceptable due to the very significant technical difficulties of providing the required storage and because of the residual risk.

## c) Flow Diversion

Flow diversion was not considered in detail as the topography of the area does not lend itself to providing an alternative route for flood water without the requirement for very significant volumes of pumping. The difference between the estimated 1% AEP and 10% AEP flows is 145m<sup>3</sup>/s. This option would require a conveyance channel with a minimum cross-section of 50m<sup>2</sup> through which to convey the pumped flows. A secure power supply would be required for the pumps. There would also be a residual risk of pump failure.

Overall, this option is not considered acceptable due to the very significant technical difficulties, the significant costs, the environmental and cultural risk when constructing the bypass channel and the significant residual risk.

## d) Increased Conveyance

Increased conveyance would include deepening the existing channel, widening the existing channel and removal of local constraints to flood flows. All have the ability to reduce the 1% AEP flood level to sufficiently low levels. The summary of the assessment of flood risk to the receptor groups is shown below.

Criteria	Assessment
Applicability to area	Yes.
Social	i) 151 residential properties protected. ii) Housing for elderly protected iii) Garda station protected. iv) Park on Glasslinn Road protected.

Criteria	Assessment
Environmental	<ul style="list-style-type: none"> <li>i) No pollution risk from petrol stations and WWTP.</li> <li>ii) Potential direct risk to pNHA habitats.</li> <li>iii) Direct risk to legally protected species through loss of habitat, disturbance and water quality deterioration during construction.</li> <li>iv) Potential indirect risk to upstream Bandon River cSAC.</li> <li>v) Direct risk to other aquatic species and habitats through loss of habitat, disturbance and water quality deterioration during construction.</li> <li>vi) Visual risk to river landscape.</li> </ul>
Cultural	<ul style="list-style-type: none"> <li>i) Protected structures not at risk except for those that may lie within river.</li> </ul>
Economic	<ul style="list-style-type: none"> <li>i) 151 residential properties and 201 commercial properties protected</li> <li>ii) Density of economic risk = €1,075/1000m<sup>2</sup>.</li> <li>iii) No risk to N71 NPR (Cork-Clonakilty-West Cork) and R586 RR (Cork-Dunmanway-West Cork) transport routes.</li> <li>iv) No risk to telecom exchange.</li> </ul>

The use of increased conveyance has considerable potential to achieve the FRM objectives. The existing overall bed slope from the weir in Bandon to the access bridge over the Bandon River to Woodlands at Curranure is approximately 1:670 which is considered a good gradient for conveyance of river flows. Overall, this method is considered to be viable, either on its own or in conjunction with other methods and is carried forward for consideration as a potential option.

## e) Flood Defences

Flood defences can include walls, embankments and demountable defences. The construction of flood defences has the ability to protect the Area of Potential Significant Risk (APSR) from the 1% AEP flood event. However, there would be a significant residual risk due to the potential of the defences overtopping and more seriously, in the event of failure of a defence. The summary of the assessment of flood risk to the receptor groups is shown below.

Criteria	Assessment
Applicability to area	Yes.
Social	<ul style="list-style-type: none"> <li>i) 151 residential properties protected.</li> <li>ii) Housing for elderly protected</li> <li>iii) Garda station protected.</li> <li>iv) Park on Glasslinn Road protected</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>i) No pollution risk from petrol stations and WWTP.</li> <li>ii) Potential risk to pNHA.</li> <li>iii) Loss of riparian habitat.</li> <li>iv) Significant visual risk to town landscape.</li> </ul>
Cultural	<ul style="list-style-type: none"> <li>i) Protected structures not at risk except for those within river.</li> </ul>
Economic	<ul style="list-style-type: none"> <li>i) 151 residential properties and 201 commercial properties protected</li> <li>ii) Density of economic risk = €1,075/1000m<sup>2</sup>.</li> <li>iii) No risk to N71 NPR (Cork-Clonakilty-West Cork) and R586 RR (Cork-Dunmanway-West Cork) transport routes.</li> <li>iv) No risk to telecom exchange.</li> </ul>

The construction of flood defences has considerable potential to achieve the FRM objectives either on its own or with other methods. Overall, this option is considered to be viable and is carried forward for consideration as a potential option.

## f) Rehabilitate/Improve Existing Defences

There are existing structures which have been constructed as flood defences or can act as flood defences in Bandon. These include the embankment by the Bandon River at the Riverview Shopping Centre and Lidl supermarket, the walls by the Bandon River along McSweeney Quay, and the walls by the Bridewell River along St Finbarr's Place, Market Quay and New Road. These structures could be improved to give some level of protection. The degree of protection would depend on the design flood height which would be determined by



the other flood protection methods adopted. The summary of the assessment of flood risk to the receptor groups is shown below.

Criteria	Assessment
Applicability to area	Yes.
Social	<ul style="list-style-type: none"> <li>i) 151 residential properties at risk.</li> <li>ii) Housing for elderly at risk.</li> <li>iii) Garda station at risk.</li> <li>iv) Park on Glasslinn Road at risk.</li> </ul>
Environmental	i) Pollution risk from petrol stations and WWTP.
Cultural	i) Protected structures at risk.
Economic	<ul style="list-style-type: none"> <li>i) 151 residential properties and 201 commercial properties at risk.</li> <li>ii) Density of economic risk = €1,075/1000m<sup>2</sup>.</li> <li>iii) Risk to N71 NPR (Cork-Clonakilty-West Cork) and R586 RR (Cork-Dunmanway-West Cork) transport routes.</li> <li>iv) Risk to telecom exchange.</li> </ul>

Rehabilitation / improvement of existing flood defences on its own would not provide sufficient protection to Bandon but has potential to achieve the FRM objectives when used with other methods. Overall, this option is considered to be viable when considered with other methods and is carried forward for consideration as a potential option.

## g) Relocation of Properties

It is physically possible to relocate all of the properties, both residential and commercial, out of the flood risk area. This would require 257 properties to be reconstructed or accommodated at a suitable location outside of the 0.1% AEP flood envelope calculated for the MRFS. New infrastructure including transport, electricity, gas, telecommunications, water supply and sewerage would be required. The abandoned properties could be utilised in an appropriate manner suited to their location in a flood plain. It would effectively mean that the commercial centre of Bandon Town would be lost. Ideally, the centre should be rebuilt at one

location rather than be spread around the suburbs of Bandon. The summary of the assessment of flood risk to the receptor groups is shown below.

Criteria	Assessment
Applicability to area	Yes.
Social	i) 151 residential properties no longer occupied. ii) Housing for elderly protected no longer occupied. iii) Garda station no longer occupied. iv) Park on Glasslinn Road remains at risk.
Environmental	i) No pollution risk from petrol stations; risk remains for WWTP.
Cultural	i) Protected structures remain at risk.
Economic	i) 151 residential properties and 201 commercial properties no longer occupied. ii) Density of economic risk = €1,075/1000m <sup>2</sup> . iii) Risk to N71 NPR (Cork-Clonakilty-West Cork) and R586 RR (Cork-Dunmanway-West Cork) transport routes. iv) Risk to telecom exchange.

Relocation of properties would ensure sufficient protection for Bandon. However, the cost of relocation would be excessive. In addition, there would be a very significant impact on society and on commercial activity in Bandon. Very minor relocation could be considered where the cost of protecting an individual property is considered to be excessive. Overall, this option is not considered to be viable and is not considered further.

## 2.4 SUMMARY OF SCREENING

The options considered to be viable and which are considered further, based on the initial screening above, are:

1. Increased conveyance;
2. New flood defences;
3. Rehabilitation/improvement of existing defences when used with other methods.

In addition, the following options, which would not manage the existing risk to an acceptable level on their own, should be incorporated into the flood risk management plan.

4. Implementation of Flood Early Warning System and a Flood Emergency Response Plan when used with other methods.
5. Use of non-structural measures (planning and control measures to ensure that potential risk for future developments is properly managed).
6. Use of structural measures for future risk (to ensure that future development is appropriate for its location and set at an appropriate level relative to flood levels and that there would be no increase in flood risk to existing development)

## 3.0 DEVELOPMENT OF POTENTIAL OPTIONS

### 3.1 INCREASE IN CONVEYANCE

#### 3.1.1 Description

An increase in river flow conveyance can be achieved by

- i) increasing the width of the channel over the full channel depth;
- ii) increasing the width of the channel over the part of the channel depth (compound channel);
- iii) increasing the depth of the channel;
- iv) removal of local channel constrictions e.g. bridge piers, weirs, local narrow points,
- v) any combination of the above.

The works could be carried out locally or over long lengths of the river. The hydraulic computer model created for the Bandon FRS was used to simulate various improved conveyance options. The results of the assessment of the model are included in Appendix C.

#### 3.1.2 Increase in Channel Width

Increasing the channel width was considered initially. There is little opportunity to widen the river channel in the initial 2km below Bandon Weir due to the existing infrastructure and development close to the river bank. Where infrastructure and development is absent, steep topography makes channel widening difficult. This is the situation along the left bank by the waste water treatment plant. Only a small number of locations are available for channel widening.

The option of removing the walkway along the right bank downstream of Bandon Bridge was assessed within the computer model by widening the main channel for the appropriate section. Modelling results show a minor reduction in water levels along this section - in the order of 4 cm.

#### 3.1.3 Increase in Channel Depth

Four dredging options to increase the river channel depth were examined. These are summarised below with details of the dredged bed e.g. the proposed bed level downstream of Bandon Weir, the extent of dredging, the proposed bed slope and the resulting change in

flood levels. The existing and resulting 1% AEP flood levels at various locations through Bandon are also shown in the table below.

**Table 3.1 – 1% AEP Flood Levels for Dredging Options**

	Existing Situation	Dredging Works			
<b>Bed Level DS of Weir (mOD)</b>	11.10	10.00	9.50	9.00	8.00
<b>Gradient</b>	NA	1:1,000	1:1,000	1:1,000	1:1,000
<b>Extent of Dredging (m)</b>	0	3,000	3,600	4,000	5,200
<b>Dredged Volume (m<sup>3</sup>)</b>	0	110,000	153,000	195,000	432,000
Location	Existing Flood Level (mOD)	Flood Levels Resulting from Dredging (mOD)			
<b>Lidl Carpark</b>	17.52	17.42	17.42	17.42	17.42
<b>US of Weir</b>	17.42	17.12	17.12	17.12	17.12
<b>DS of Weir</b>	16.65	15.37	15.00	14.63	13.73
<b>US of Bandon Bridge</b>	16.24	15.02	14.68	14.43	13.42
<b>DS of Bandon Bridge</b>	15.43	14.85	14.48	14.15	13.24
<b>Gauge Station</b>	14.98	14.57	14.19	13.83	12.94
<b>Bypass Roundabout</b>	14.22	13.97	13.62	13.31	12.47
<b>WWTP</b>	13.49	13.40	12.82	12.48	11.81

The resulting 1% AEP flood levels were considering in relation to local ground levels and property threshold levels. There is little difference to flood levels upstream of the weir as the weir is not removed in these options and controls upstream flood levels.

There is a significant reduction in flood levels between the weir and Bandon Bridge for all dredge only options. Flood levels would be below bank level on the right bank for all options. However, it would be necessary to dredge to at least 9.0mOD (2.1m below existing bed level below the Weir) to bring flood levels below the vast majority of property thresholds in South Main Street, Bridge Street, Pearse Street and North Main Street.

There is also a significant but smaller reduction in flood levels between Bandon Bridge and the Bypass Roundabout. It would be necessary to dredge to at least 9.0mOD to bring flood levels below bank levels and property threshold levels in this area.

The benefits of reduced flood levels diminishes downstream of The Bypass Roundabout with reductions at the waste water treatment plant (WWTP) of only 90mm from existing flood

levels for the 10mOD dredge option (increasing to 1,010mm for the 9.0mOD option and 1,680mm for the 8.0mOD option).

All dredge options would need ongoing maintenance dredging due to the transfer and deposition of sediment.

### 3.1.4 Removal of Local Restrictions

Local restrictions to flood flows are apparent at a number of locations in Bandon. These include:

- Bandon Weir;
- Pedestrian Footbridge
- Bandon Bridge
- Confluence with Bridewell River.

Removal of the Weir resulted in a significant reduction in flood levels upstream of its location but made little difference to flood levels downstream of its location. The right bank upstream of the Weir is substantially protected by an existing embankment. This is expected to be improved shortly to provide full protection for the 1% AEP flood event. There is one property at risk on the left bank and removal of the Weir would eliminate this risk. However, it could also be protected locally. The Weir is currently used for hydroelectric power generation. It is also listed as a cultural heritage site. Therefore the benefit of removing it would be outweighed by the benefit of retaining it.

The pedestrian footbridge causes a significant afflux for the current 1% AEP flood flow. This is largely due to the effect of the bridge deck and the handrailing. This afflux is largely eliminated if the river bed is reduced by dredging. In the absence of dredging in the preferred solution, replacement of the bridge with either a clear span or a reduced number of spans and at a higher level could be considered.

Bandon Bridge causes a very significant afflux for the current 1% AEP flood flow. This is due to the effect of the abutments and parapet. This afflux is reduced significantly if the river bed is reduced by dredging. Replacement of the bridge with a clear span bridge or a bridge with fewer and slimmer piers is unlikely to be an option due to its cultural heritage value.

The confluence of the Bridewell River with the Bandon River was examined to determine if it was a significant contributing factor to the flooding at Bandon Town. This option was assessed in the computer model as part of the sensitivity testing by combining the 1% AEP

flow from the Bridewell River with the 50% AEP flow from the Bandon River. Findings show that the Bridewell River on its own does not result in flooding during the 1% AEP event and it is the Bandon River that controls water level along the downstream reach of the Bridewell River. Also, the additional inflow from the Bridewell River to the Bandon River is less than 5% of the total river flow and does not significantly influence flood levels. Although, the precautionary approach was taken to coincide the timing of the flood peak for the Bridewell and the Bandon River, in reality this is very unlikely to occur due to the difference in critical duration.

As a result it can be concluded that improving the confluence of the Bridewell River with the Bandon River would not influence flood levels significantly.

## 3.2 NEW FLOOD DEFENCES

The option of using flood defences was examined by modelling defences along both banks of the Bandon and Bridewell Rivers. The assessment of the model results are included in Appendix C and are summarised below in Table 3.2.

**Table 3.2 – Flood levels for Fully Defended Option**

Location	Existing Flood Level (mOD)	Flood Level with Defences (mOD)
<b>Lidl Carpark</b>	17.52	17.77
<b>US of Weir</b>	17.42	17.41
<b>DS of Weir</b>	16.65	17.19
<b>US of Bandon Bridge</b>	16.24	16.67
<b>DS of Bandon Bridge</b>	15.43	15.59
<b>Gauge Station</b>	14.98	15.04
<b>Bypass Roundabout</b>	14.22	14.37
<b>WWTP</b>	13.49	13.52

This option would effectively protect all properties. It would result in an increase in the 1% AEP flood event level by up to 540m upstream of Bandon Bridge but only marginally downstream of the Bridge. It would require defences of up to 2.33m height along McSweeney Quay and up to 4.83m height on the left bank of the river upstream of Bandon Bridge. It should be noted that a freeboard allowance for defences upstream of Bandon Bridge are significantly greater for the defence only option due to the very significant restriction on flow caused by Bandon Bridge (see section 3.5 below).

There would be a significant visual impact from the heights of the defences, especially along McSweeney Quay in the centre of town. There would also be a significant residual risk due to the potential of the defences overtopping and more seriously, in the event of failure of a defence.

### 3.3 REHABILITATION/IMPROVEMENT OF EXISTING DEFENCES

The option of improving existing flood defences was examined in a similar way to new flood defences but only in the locations where there were existing defences along the Bandon and Bridewell Rivers. This option was effective only along the right hand bank from Lidl supermarket to Bandon Bridge and along the Bridewell River. It would leave large areas of Bandon undefended if used on its own.

### 3.4 COMBINATIONS OF DREDGING AND DEFENCES

Four combined options using dredging and flood defences were examined. These varied from very minor dredging up to reducing the bed depth by 1.6m just downstream of the weir. The assessment of the model results are included in Appendix C and are summarised in Table 3.3 below.

**Table 3.3 – 1% AEP Flood Levels for Combined Dredging / Defences Options**

	Existing Situation	Dredging with Defences				
<b>Bed Level DS of Weir (mOD)</b>	11.10	11.00	10.50	10.50	10.00	9.50
<b>Gradient</b>	NA	Uniform	Uniform	Uniform	Uniform	Uniform
<b>Extent of Dredging (m)</b>	0	500	600	1,400	3,000	3,600
<b>Dredged Volume (m<sup>3</sup>)</b>	0	15,300	28,000	46,000	110,000	153,000
Location	Existing Flood Level (mOD)	Flood Levels Resulting from Dredging with Defences (mOD)				
<b>Lidl Carpark</b>	17.52	17.42	17.42	17.42	17.42	17.42
<b>US of Weir</b>	17.42	17.12	17.12	17.12	17.12	17.10
<b>DS of Weir</b>	16.65	16.51	16.08	15.95	15.45	15.17
<b>US of Bandon Bridge</b>	16.24	16.17	15.73	15.72	15.22	14.92
<b>DS of Bandon Bridge</b>	15.43	15.59	15.38	15.32	14.95	14.60
<b>Gauge Station</b>	14.98	14.88	14.92	14.84	14.47	14.18
<b>Bypass Roundabout</b>	14.22	14.33	14.34	14.20	14.08	13.62
<b>WWTP</b>	13.49	13.49	13.49	13.53	13.53	12.82



The assessment of these options showed that it would be necessary to dredge to 9.5mOD (1.6m below existing bed level downstream of the Weir) to be able to avoid the need for defences upstream of Bandon Bridge on the right bank with local defences only required on the left bank. Defences would be required downstream of Bandon bridge on both banks of the river and along the Bridewell River. Options with lesser amounts of dredging would require flood defences in all areas therefore negating a large benefit of dredging i.e. avoiding construction of defences.

### 3.5 FREEBOARD

Freeboard is an allowance made in the calculation of the heights required for flood defences. This allowance covers uncertainties due to roughness factors used in the modelling, the afflux through bridges and the hydrological bounds. It varies over different stretches of the Bandon River. For the existing situation, it is greatest for the section between the weir and Bandon Bridge due to the significant afflux through the bridge. An additional allowance of 200mm is made for soft defences e.g. embankments.

The calculated freeboards for Bandon for the defended only option and a combined dredged/defended option are shown in table 3.4 below.

**Table 3.4 – Freeboard Allowance for Bandon**

Location	Defended Only Option		Combined Dredged / Defended Option	
	Hard Defence (m)	Embankment (m)	Hard Defence (m)	Embankment (m)
Upstream of Weir	0.59	0.79	0.34	0.54
Between Weir and Bandon Bridge	0.98	1.18	0.59	0.79
Downstream of Bandon Bridge	0.30	0.50	0.50	0.70

## 4.0 APPRAISAL OF POTENTIAL OPTIONS

### 4.1 INCREASE IN CONVEYANCE

Removal of local restrictions and local increase in channel width would provide very limited reduction in flood levels.

Removal or lowering of the Weir would reduce the risk to properties upstream of the Weir. However, when the existing embankment is improved to the correct level, properties upstream on the right bank would be fully protected for the 1% AEP flood event but with some residual risk. Only one property on the left bank would remain at risk.

Dredging to 8.0mOD downstream of the Weir would provide effective protection for all of Bandon but would reduce bed levels between Bandon Bridge and the Weir by up to 3.2m. The volume of dredged material would be significant at 432,000m<sup>3</sup>. This option would result in a significant environmental impact with dredging extending over 5.2km of the Bandon River.

Dredging to a bed level of 9.0mOD downstream of the Weir would provide effective protection for most of the properties in Bandon but would reduce bed levels between Bandon Bridge and the Weir by up to 2.2m. The volume of dredged material would amount to 195,000m<sup>3</sup>. This would still result in a significant environmental impact with dredging extending over 4.0km of the Bandon River

Dredging to a bed level of 9.5mOD downstream of the Weir would require the use of flood defences to provide full protection. However, the environmental impact would be significantly less with the volume of dredged material reducing to 153,000m<sup>3</sup> and the extent of dredging reducing to 3.6km of the Bandon River.

Dredging would result in significant quantities of excavated material. Site investigations have determined that the river bed material is uncontaminated and suitable for re-use. Interest has been expressed by quarry companies in reusing any excavated rock and gravel.

The dredging option was considered favourably by the public in Bandon during the public information day held in Bandon.

## 4.2 NEW FLOOD DEFENCES

The use of this method on its own would require defences of up to 2.33m along McSweeney Quay and up to 4.83m on the left bank of the river upstream of Bandon Bridge. This height of defence may not be acceptable to the public. It would also require significant construction in and about the centre of Bandon. More importantly, there would be a very significant residual risk in the event of the flood defence being overtopped or more seriously, in the event of failure of a flood defence.

## 4.3 REHABILITATION/IMPROVEMENT OF EXISTING DEFENCES

This option would only be effective only along the right hand bank from Lidl supermarket to Bandon Bridge and along the Bridewell River. It would leave large areas of Bandon undefended is used on its own. It could be considered in combination with other options.

## 4.4 COMBINATIONS OF DREDGING AND DEFENCES

The preferred combination of dredging and defences includes the minimum amount of dredging to avoid the need for flood defences on the right bank (McSweeney Quay) and requires local defences only on the left bank upstream of Bandon Bridge. Lesser amounts of dredging would require the provision of flood defences upstream of Bandon Bridge and result in significant extra cost.

## 4.6 OPTIONS APPRAISAL

The three potential options identified as being feasible in terms of cost and effectiveness in providing protection against the 1%AEP flood event were appraised against the objectives included in Appendix A in the form of a multi-criteria analysis. The appraisal involved scoring each of the options against each objective in relation to specified minimum requirements (i.e., requirements for that objective that the option should meet to be acceptable) and aspirational targets (i.e., targets that options should seek to achieve to be assigned a maximum score for that objective), making use of defined indicators for each objective.

In the appraisal, appropriate scores were determined for each option against each objective based on an assessment of benefits and impacts. The basis for the assignment of scores was quantitative where possible, but otherwise qualitative, with the assignment of a score based on a description or category. In assigning scores for each option with respect to each objective, a Global Weighting and a Local Weighting were applied to reflect the importance of that objective for the APSR (areas of potential significant risk) in Bandon.

The indicators, minimum requirements and aspirational targets, along with the Global Weightings and Local Weightings were agreed with the OPW for each objective to ensure consistency with the appraisal of options in other schemes nationally.

The results of the appraisal are included in Appendix D. The summary of the appraisal is shown in table 4.1 below.

**Table 4.1 – Summary of Multi-Criteria Analysis Matrix**

CRITERIA	Factored Weighted Score		
	Dredging Only	Defences Only	Combined Dredging And Defences
1. Technical	12	4.5	9
2. Social	243	54	162
3. Environmental	6	21	85.5
4. Economic	153	94.5	166.5
TOTAL SCORE	414	174	423

The results from the multi-criteria analysis show that the **combined dredging and defences** option is slightly preferable to the **dredging only** option and that both of these are strongly preferable to the **defences only** option.

## 5.0 SELECTION OF PREFERRED OPTION

### 5.1 SUMMARY OF APPRAISAL

It is considered that the option of dredging on its own would result in too great an environmental impact both in terms of the depth of dredging and the extent along the river (5.2km). The option of flood defences on their own would require significant heights of defences resulting in an unacceptable visual impact. A very significant residual risk would remain.

The benefits of local improvements and the improvement of existing flood defences would not provide the required level of protection.

The preferred option therefore is to use flood defences in combination with dredging. The dredged depth would be to 9.5mOD downstream of the Weir and extend for 3.6km. The extent of dredging is shown in Figure 1 in Appendix E. New flood defences would be required downstream of Bandon Bridge and locally on the left bank upstream of Bandon Bridge. Existing flood defences would be improved as needed on the right bank upstream of the Weir and along the Bridewell River. The proposed locations of new and improved defences are shown in Figure 2 in Appendix D.

### 5.2 OTHER WORKS

In addition to dredging and flood defences, other minor works would be required. This would include local drainage with pumping stations to protect low lying properties in Bank Place, Bridge Street/Pearse Street and Brady's lane/Oliver Plunkett Street.

### 5.3 STRUCTURAL MEASURES FOR FUTURE RISK

It is recommended that structural measures for future risk be adopted for future developments that may occur through necessity in the flood extent area behind flood defences. This would include works at the waste water treatment plant site.

## 5.4 NON-STRUCTURAL METHODS

The FEWS and FERP are non-structural measures that are currently in place. Other non-structural measures include planning and control measures, building regulations regarding flood-proofing of buildings, public awareness and preparedness campaigns, individual flood protection of buildings and land use management plans. It is recommended that these methods be adopted along with the recommended structural measures.



## APPENDIX A

### FLOOD RISK MANAGEMENT OBJECTIVES AND WEIGHTING

## FLOOD RISK MANAGEMENT OBJECTIVES AND WEIGHTING

### GLOBAL WEIGHTINGS

Criterion	Objective	Global Weighting
Technical	Operationally Robust	5
Technical	Health & Safety Risk	5
Technical	Adaptability	5
Social	Risk to Human Health	30
Social	Community Risk	10
Social	Risk to Social Amenity	5
Environmental	Ecological Status	5
Environmental	Pollution Sources	15
Environmental	Habitats	10
Environmental	Fisheries	5
Environmental	Landscape Character	5
Environmental	Cultural Heritage	5
Economic	Economic Risk	25
Economic	Transport Infrastructure	10
Economic	Utility Infrastructure	10
Economic	Agriculture	5

### LOCAL WEIGHTINGS

Local Weighting	Description of Importance
5	Major / International Importance
4	Significant / National Importance
3	Medium / Regional Importance
2	Minor / Local Importance
1	Negligible Importance
0	Objective Not Relevant within Area or for Individual Risk Receptor

Note: Global and local weightings provided by the OPW to ensure national consistency in assessment of flood risk management objectives.



## CRITERIA 1 - TECHNICAL

Objective		Sub-Objective		Indicator	Global Weighting	Local Weighting
a	Ensure flood risk management options are operationally robust	i)	Ensure flood risk management options are operationally robust	Level of operational risk of option i.e. mechanical or human intervention required (e.g. lengths/numbers of demountables, pumps etc	5	3
b	Minimise health and safety risk of flood risk management options	i)	Reduce and where possible eliminate health and safety risks associated with the construction and operation of flood risk management options	Health and safety risk to construction workers of Flood Risk Management (FRM) options	5	3
c	Ensure flood risk managed effectively and sustainably into the future	i)	Ensure flood risk management options are adaptable to future flood risk	Level of adaptability of FRM option to future flood	5	3
		ii)	Ensure future maintenance requirements are manageable and sustainable	Level of future maintenance requirements		

## CRITERIA 2 - SOCIAL

Objective		Sub-Objective		Indicator	Global Weighting	Local Weighting
a	Minimise risk to human health and life	i)	Minimise risk to human health and life of residents	Number of residential properties at risk from flooding (0.1% AEP Event)	30	3
		ii)	Minimise risk to high vulnerability properties	Number of high vulnerability properties at risk from flooding (0.1% AEP Event)		
b	Minimise risk to community	i)	Minimise risk to social infrastructure	Number of high-value social infrastructural assets at risk from flooding (0.1% AEP Event)	10	3
		ii)	Minimise risk to local employment	Number of non-residential properties at risk from flooding (0.1% AEP Event)		
c	Minimise risk to social amenity	i)	Minimise risk to flood-sensitive social amenity sites	Number of amenity sites at risk from flooding (0.1% AEP Event)	5	3

## CRITERIA 3 - ENVIRONMENTAL

Objective		Sub-Objective		Indicator	Global Weighting	Local Weighting
a	Support the objectives of the WFD	i)	Prevent deterioration, and where possible raise, ecological status / potential of water-bodies	Ecological status of water-bodies	5	3
		ii)	Prevent deterioration, and where possible raise, chemical status / potential of water-bodies	Chemical status of water-bodies		
b	Minimise the risk of environmental pollution	i)	Minimise risk to potential sources of pollution	Number of potential pollution sources at risk from flooding (including those licensed under Directives 96/61/EC and 92/271/EC)	15	3
c	Avoid or where necessary mitigate against damage to, and where possible enhance, the flora and fauna of the catchment	i)	Avoid or where necessary mitigate against damage to, and where possible enhance, internationally and nationally designated sites of nature conservation importance	Reported conservation status of designated sites relating to flood risk management	10	5
		ii)	Avoid or where necessary mitigate against damage to or loss of habitats supporting legally protected species and other known species of conservation concern and where possible enhance	Presence and/or extent of suitable habitat supporting legally protected species and other known species of conservation concern ('target species')		
		iii)	Avoid or where necessary mitigate against damage to or loss of existing riverine, wetland and coastal habitats (including those for Freshwater Pearl Mussel), and where possible create new habitat, to maintain a naturally functioning system	Area of riverine, wetland and coastal habitat protected or created / restored as a result of flood risk management measures		

Objective		Sub-Objective		Indicator	Global Weighting	Local Weighting
d	Avoid or where necessary mitigate against damage to, and where possible enhance, fisheries within the catchment	i)	Maintain, or where necessary mitigate against damage to, existing, and where possible create new, habitat supporting fisheries and maintain upstream access	Area of suitable habitat supporting salmonid and other fisheries and number of upstream barriers	5	3
		ii)	Ensure no adverse effects on, or where necessary mitigate against damage to, commercial shellfisheries	Classification of shellfish waters		
e	Protect, and where possible enhance, landscape character and visual amenity within the catchment	i)	Protect, and where possible enhance, landscape character within the catchment	Compliance with landscape character objectives relevant to flood risk management measures	5	2
		ii)	Protect, and where possible enhance, the character of designated Landscape Protection Zones within the catchment	Character of lengths of waterway corridor qualifying as Landscape Protection Zones within urban areas relating to flood risk management measures		
f	Avoid or where necessary mitigate against damage to or loss of features of cultural heritage importance, their setting and heritage value within the catchment	i)	Avoid or where necessary mitigate against damage to or loss of known buildings, structures, archaeological features and areas of cultural heritage importance, including their setting and heritage value, within the catchment	Numbers and types of internationally, nationally and locally designated areas and structures at risk from flooding	5	5

## CRITERIA 4 - ECONOMIC

Objective		Sub-Objective		Indicator	Global Weighting	Local Weighting
a	Minimise economic risk	i)	Minimise economic risk	Annual Average Damage (€)	25	3
b	Minimise risk to transport infrastructure	ii)	Minimise risk to transport infrastructure	Number of transport routes (road, rail, navigation) at risk from flooding (0.1% AEP Event)	15	2
c	Minimise risk to utility infrastructure	iii)	Minimise risk to utility infrastructure	Number of utility infrastructure assets (power stations, WWTWs, WTWs, telecom exchanges etc) at risk from flooding (0.1% AEP Event)	15	2
d	Manage Risk to Agricultural Land	i)	Manage Risk to Agricultural Land	Area of agricultural land at risk from flooding (based on CORINE data or other)	5	0



## APPENDIX B

### FLOOD RISK RECEPTOR GROUPS

## FLOOD RISK RECEPTOR GROUPS

### 1. Risk to Society

The indicator sets for the social flood risk are:

- i) the location and number of residential properties
- ii) the location, type, an indicator of vulnerability and number of potentially high-vulnerability sites, such as residential homes for children, the elderly or disabled, etc.
- iii) the location, type, an indicator of vulnerability and number of valuable social infrastructural assets, such as fire stations, Garda stations, ambulance stations, hospitals, government and council buildings, etc.
- iv) the location, type, an indicator of vulnerability and number of social amenity sites, such as parks, leisure facilities, etc.

### 2. Risk to the Environment

The indicator sets for the flood risk to the environment are:

- i) The location, type, an indicator of vulnerability and number of installations referred to in Annex I to EU Directive 96/61/EC (1996) concerning integrated pollution prevention and control and other significant potential sources of pollution. (NOTE: Information on IPPC Licenses are available on the Environmental Protection Agency Website ([www.epa.ie](http://www.epa.ie)) and information on Section 4 and Section 16 licenses under the Water Pollution Act are available from the Water Pollution Control Section of the relevant Local Authorities)
- ii) The location, extent, nature and an indicator of vulnerability of areas identified in Annex IV(1)(i), (iii) and (v) to the Water Framework Directive (EU Directive 2000/60/EC)
- iii) The nature, location, an indicator of vulnerability and areas of other environmentally-valuable sites, such as SACs

### 3. Risk to Cultural Heritage

The flood risk indicator set for cultural heritage is:

- i) The location, type, an indicator of vulnerability and number of sites or assets of cultural value

## 4. Risk to the Economy

The indicator sets for the flood risk to the economy are:

- i) The location, type (residential and classifications of non-residential) and numbers of properties, with associated frequency-depth-damage information based on property type
- ii) The density of economic risk expressed as annual average damage (euro/year) per unit area (e.g., per 100m or 500m square)
- iii) The location, type, an indicator of vulnerability and number (and / or lengths) of transport infrastructural assets, such as airports, ports, motorways, national and regional roads, rail, etc.
- iv) The location, type, an indicator of vulnerability and number of utility infrastructural assets, such as electricity generation and sub-stations, water supply and treatment works, natural gas and oil facilities, important telecom interchanges, data repositories, etc.





## APPENDIX C

### MODEL OUTPUT

Option No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	<b>Proposed Works</b>													
	Existing	Defences Only	<b>Dredging Only</b>							<b>Dredging with Defences</b>				
Bed Level DS of Weir (mOD)	11.10	11.10	10.00	10.0	9.5	9.5	9.0	9.00	8.00	11.00	10.50	10.50	10.00	9.50
Gradient	NA	NA	1:1,000	1:1,000	1:1,000	1:1,000	1:1,000	1:1,000	1:1,000	Uniform	Uniform	Uniform	Uniform	Uniform
Extent of Dredging (m)	0	0	3,000	3,000	3,600	3,600	4,000	4,000	5,200	500	600	1,400	3,000	3,600
Weir lowered to	NA	NA	NA	Removed	12.7	NA	12.7	NA	NA	NA	NA	NA	NA	NA
Dredged Volume (m <sup>3</sup> )	0	0	111,000	115,000	157,000	153,000	197,000	195,000	432,000	15,300	28,000	46,000	110,000	155,000

Section No.	Chainage	Location	Bed Level	FLOOD LEVELS											
23300B	13,344.4	Lidl carpark	13.12	17.52	17.77	17.42	15.61	16.50	17.42	16.50	17.42	17.42	17.42	17.42	17.42
23200B	13,296.1		13.05	17.51	17.72	17.41	15.59	16.45		16.45					
23100B	13,230.9		12.67	17.50	17.71	17.40	15.50	16.37	17.50	16.37	17.50	17.50	17.38	17.38	17.38
23000B	13,135.8		12.52	17.46	17.65	17.33	15.43	16.23		16.23					17.31
22900B	13,051.5		12.61	17.43	17.55	17.18	15.39	16.01	17.43	16.01	17.43	17.43	17.17	17.17	17.17
22830B	12,997.1	US of Weir	12.47	17.42	17.41	17.12	15.39	15.94	17.12	15.94	17.12	17.12	17.12	17.12	17.10
22810B	12,969.2	Weir	14.09	16.72	17.22	16.74	15.38	15.85		15.85					
22801B	12,962.5	Weir	13.77												
22800B	12,962.3	Weir	11.62												
22770B	12,927.1	DS of Weir	11.22	16.65	17.19	15.37	15.41	15.09	15.00	14.72	14.63	13.73	16.51	16.08	15.95
22705B	12,861.2	Pedestrian Bridge	11.43	16.60	17.14	15.30	15.35	15.02		14.66					15.12
22700B	12,859.5		11.27	16.39	16.88	15.25	15.29	14.94		14.58					15.06
22600B	12,741.1		11.23	16.25											14.93
22530B	12,655.0	US of Bandon Bridge	11.47	16.24	16.67	15.02	15.06	14.72	14.68	14.37	14.33	13.42	16.17	15.73	15.64
22505B	12,633.9	Bandon Bridge - US Face	10.88	15.55	15.78	14.98	15.01	14.71		14.37					14.72
22500B	12,623.9	Bandon Bridge - DS Face	10.86	15.62	15.78										
22470B	12,595.1	DS of Bandon Bridge	10.98	15.43	15.59	14.85	14.88	14.50	14.48	14.17	14.15	13.24	15.59	15.38	15.32
22400B	12,518.9		10.48	15.40	15.57	14.80	14.83	14.52		14.18					14.59
22300B	12,422.0		10.66	15.10	15.27	14.69	14.72	14.41		14.09					14.51
22200B	12,346.7	Gauge Station	10.45	14.98	15.04	14.57	14.61	14.28	14.19	13.96	13.83	12.94	14.88	14.92	14.84
22100B	12,227.5		9.81	14.76	14.77	14.33	14.37	14.04		13.74					14.12
22000B	12,101.6		9.74	14.42	14.58	14.11	14.15	13.81		13.53					13.87
21900B	12,010.6		10.04	14.27	14.43	14.02	14.05	13.69		13.40					13.73
21800B	11,894.7	Roundabout on Ring Road	9.91	14.22	14.37	13.97	14.00	13.62	13.62	13.31	13.31	12.47	14.33	14.34	14.20
21700B	11,833.0		10.00	14.16	14.32	13.91	13.94	13.55		13.22					13.56
21600B	11,706.3		10.13	14.01	14.19	13.83	13.87	13.46		13.13					13.41
21500B	11,617.4		9.87	13.91	14.11	13.74	13.77	13.30		12.94					13.22
21400B	11,511.1		9.54	13.85	14.08	13.71	13.75	13.26		12.85					13.17
21300B	11,314.5	WWTP	8.59	13.49	13.52	13.40	13.44	12.82	12.82	12.44	12.48	11.81	13.49	13.49	13.53
21100B	11,134.6		8.67	13.18	13.07	13.13	13.17	12.42		12.04					12.42
20900B	10,971.3		8.74	12.97	12.98	13.03	13.06	12.28		11.85					12.28

None: Where cells are blank, flood levels were not available from the model run.



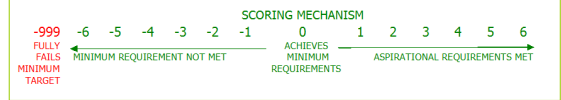
## APPENDIX D

### MULTI-CRITERIA ANALYSIS MATRIX



**BANDON FLOOD RELIEF SCHEME**  
**Appraisal of Potential Options**  
**Multi-criteria Analysis Matrix**

Multi-criteria Analysis Matrix									DREDGING ONLY				DEFENCES ONLY				COMBINED DREDGING AND DEFENCES						
CRITERIA	OBJECTIVE	SUB-OBJECTIVE		INDICATOR	MINIMUM REQUIREMENT	ASPIRATIONAL REQUIREMENT	GLOBAL WEIGHTING	LOCAL WEIGHTING	SCORING COMMENT	SCORE	WEIGHTED SCORE	FACTORED WEIGHTED SCORE	SCORING COMMENT	SCORE	WEIGHTED SCORE	FACTORED WEIGHTED SCORE	SCORING COMMENT	SCORE	WEIGHTED SCORE	FACTORED WEIGHTED SCORE			
1. Technical	a Ensure flood risk management options are operationally robust	i)	Ensure flood risk management options are operationally robust	Level of operational risk of option i.e. mechanical or human intervention required (e.g. lengths/numbers of demountables, pumps etc	Manageable level of mechanical of human intervention	No mechanical or human intervention	5	3	No actions required in flood event	6	90	12	Actions required at flood gates/barriers. Close monitoring of defences required.	0	0	4.5	Small action required at flood gates/barriers.	3	45	9			
	b Minimise health and safety risk of flood risk management options	i)	Reduce and where possible eliminate health and safety risks associated with the construction and operation of flood risk management options	Health and safety risk to construction workers of Flood Risk Management (FRM) options	Manageable level of health and safety risk	No health and safety risk	5	3	H&S risk at construction stage. Manageable.	2	30		H&S risk at construction stage and at O&M stage. Manageable.	0	0		H&S risk at construction stage. Small risk at O&M stage. Manageable.	1	15				
	c Ensure flood risk managed effectively and sustainably into the future	i)	Ensure flood risk management options are adaptable to future flood risk	Level of adaptability of FRM option to future flood	Option to be adaptable to the MRFS	Option to be adaptable to the HEFS at negligible cost	5	3	Either additional dredging or flood defences required for HEFS	0	0		Augmentation of flood defences required for HEFS	3	45		Augmentation of flood defences and additional defences required for HEFS	2	30				
		ii)	Ensure future maintenance requirements are manageable and sustainable	Level of future maintenance requirements																			
2. Social	a Minimise risk to human health and life	i)	Minimise risk to human health and life of residents	Number of residential properties at risk from flooding (0.1% AEP Event)	No increase in number of properties at risk	No. of properties at risk reduced to zero	30	3	No properties at risk	6	540	243	No properties at risk; significant residual risk.	2	180	54	No properties at risk; small residual risk.	4	360	162			
		ii)	Minimise risk to high vulnerability properties	Number of high vulnerability properties at risk from flooding (0.1% AEP Event)	No increase in number of vulnerable properties at risk	No. of vulnerable properties at risk reduced to zero			No high vulnerability properties at risk				No high vulnerability properties at risk; significant residual risk.				No high vulnerability properties at risk; small residual risk.						
	b Minimise risk to community	i)	Minimise risk to social infrastructure	Number of high-value social infrastructural assets at risk from flooding (0.1% AEP Event)	No increase in number of assets ar risk from flooding (0.1% AEP Event)	Number of assets at risk from flooding (0.1% AEP Event) reduced to zero	10	3	No high-value social infrastructural properties at risk	6	180		No high-value social infrastructural properties at risk; significant residual risk.	0	0		No high-value social infrastructural properties at risk; very small residual risk	4	120				
		ii)	Minimise risk to local employment	Number of non-residential properties at risk from flooding (0.1% AEP Event)	No increase in number of non-residential properties at risk from flooding (0.1% AEP Event)	Number of non-residential properties at risk from flooding (0.1% AEP Event) reduced to zero			No non-residential properties at risk				No non-residential properties at risk; significant residual risk.				No non-residential properties at risk; small residual risk						
	c Minimise risk to social amenity	i)	Minimise risk to flood-sensitive social amenity sites	Number of amenity sites at risk from flooding (0.1% AEP Event)	No increase in number of amenity sites at risk from flooding (0.1% AEP Event)	Number of amenity sites at risk from flooding (0.1% AEP Event) reduced to zero	5	3	No amenity sites at risk	6	90		No increase of amenity sites at risk;	0	0		Reduced risk to amenity site.	4	60				
3. Environmental	a Support the objectives of the WFD	i)	Prevent deterioration, and where possible raise, ecological status / potential of water-bodies	Ecological status of water-bodies	Provide no constraint associated with flood management measures to the achievement of good ecological status/potential by 2015	Significant contribution of flood risk management measures to the achievement of good ecological status/potential by 2015	5	3	Very significant impact on ecological status in short term	-6	-90	6	Possible small impact on water bodies in short term.	0	0	21	Significant impact on ecological status in short term	-2	-30	85.5			
		ii)	Prevent deterioration, and where possible raise, chemical status / potential of water-bodies	Chemical status of water-bodies																			
	b Minimise the risk of environmental pollution	i)	Minimise risk to potential sources of pollution	Number of potential pollution sources at risk from flooding (including those licensed under Directives 96/61/EC and 92/271/EC)	No increase in risk to licensed sites as a result of flood risk management measures	Number of licensed sites at risk as a result of flood risk management measures reduced to zero	15	3	Number of sites reduced to zero	6	270		Number of sites reduced to zero; residual risk.	4	180		Number of sites reduced to zero; very small residual risk.	6	270				
		c Avoid or where necessary mitigate against damage to, and where possible enhance, the flora and fauna of the catchment	i)	Avoid or where necessary mitigate against damage to, and where possible enhance, internationally and nationally designated sites of nature conservation importance	Reported conservation status of designated sites relating to flood risk management	No deterioration in the conservation status of designated sites as a result of flood risk management measures	Improvement in the conservation status of designated sites as a result of flood risk management measures	10	5	Short term very significant impact, long term positive impact through improved passage to upstream cSAC.	-2		-100	No work in or effecting designated sites	0		0	Short term significant impact, long term positive impact through improved passage to upstream cSAC.	1		50		
	ii)		Avoid or where necessary mitigate against damage to or loss of habitats supporting legally protected species and other known species of conservation concern and where possible enhance	Presence and/or extent of suitable habitat supporting legally protected species and other known species of conservation concern (target species)	No net decrease in population size of and/or loss of extent of suitable habitat supporting target species	Increase in population size of and/or extent of suitable habitat supporting target species as a result of flood risk management measures																	
	iii)		Avoid or where necessary mitigate against damage to or loss of existing riverine, wetland and coastal habitats (including those for Freshwater Pearl Mussel), and where possible create new habitat, to maintain a naturally functioning system	Area of riverine, wetland and coastal habitat protected or created / restored as a result of flood risk management measures	No net loss or permanent damage to existing riverine, wetland or coastal habitats as a result of flood risk management measures	Increase in extent of riverine, wetland and coastal habitats as a result of flood risk management measures																	
	d Avoid or where necessary mitigate against damage to, and where possible enhance, fisheries within the catchment	i)	Maintain, or where necessary mitigate against damage to, existing, and where possible create new, habitat supporting fisheries and maintain upstream access	Area of suitable habitat supporting salmonid and other fisheries and number of upstream barriers	No net loss of suitable habitat for fisheries and provide no new upstream barriers	Increase extent of suitable habitat for fisheries and improve existing upstream access	5	3	Short term very significant impact, long term positive impact through improved passage for fish and managed fishery improvements.	-2	-30		No change to fisheries.	0	0		Short term significant impact, long term very positive impact through improved passage for fish and managed fishery improvements.	2	30				
		iii)	Ensure no adverse effects on, or where necessary mitigate against damage to, commercial shellfisheries	Classification of shellfish waters	No deterioration in existing classification	Improve existing classification																	
	e Protect, and where possible enhance, landscape character and visual amenity within the catchment	i)	Protect, and where possible enhance, landscape character within the catchment	Compliance with landscape character objectives relevant to flood risk management measures	No adverse impacts on landscape character as a result of flood risk management measures	Improvement to landscape character as a result of flood risk management measures	5	2	Dredging will impact on river landscape in short term over 5.2km.	-3	-30		Flood defences will impact on river and town landscape permanently	-6	-60		Flood defences will not impact on river or town landscape; dredging will impact on river landscape in short term over 3.6km.	-1	-10				
		ii)	Protect, and where possible enhance, the character of designated Landscape Protection Zones within the catchment	Character of lengths of waterway corridor qualifying as Landscape Protection Zones within urban areas relating to flood risk management measures	No adverse changes in character of length of waterway corridor qualifying as a Landscape Protection Zone with urban areas as a result of flood risk management measures	Contribute to the development of existing or new areas of attractive, vibrant, accessible and safe waterway corridors, and Landscape Protection Zones within urban areas																	
f Avoid or where necessary mitigate against damage to or loss of features of cultural heritage importance, their setting and heritage value within the catchment	i)	Avoid or where necessary mitigate against damage to or loss of known buildings, structures, archaeological features and areas of cultural heritage importance, including their setting and heritage value, within the catchment	Numbers of internationally, nationally and locally designated areas and structures at risk from flooding	No damage to or loss of buildings and structures listed on the RMP or RPS or within ACAs/ASCs, including their setting and heritage value, as a result of the flood risk management measures; and/or no increase in flood risk for features sensitive to the impacts of flooding	Enhance the physical context and structure of water based heritage features; and/or reduction in flood risk for features sensitive to the impacts of flooding; and/or contribute to the understanding of the context of water based features listed on the RMP.	5	5	Possible impact on underwater archaeology	0	0	Possible impact on archaeology in town; impact on Bandon Town wall.	-2	-50	Possible impact on archaeology in town; impact on Bandon Town wall.	-1	-25							
4. Economic	a Minimise economic risk	i)	Minimise economic risk	Annual Average Damage (€)	No increase in economic risk	Economic risk reduced to zero.	25	3	Most expensive option; damages reduced to zero for 1% AEP.	2	150	153	Least expensive option; damages reduced to zero for 1% AEP; significant residual risk.	1	75	94.5	Intermediate cost option; damages reduced to zero for 1% AEP; very small residual risk.	3	225	166.5			
	b Minimise risk to transport infrastructure	ii)	Minimise risk to transport infrastructure	Number of transport routes (road, rail, navigation) at risk from flooding (0.1% AEP Event)	No increase in the number of transport routes at risk	Number of transport routes at risk reduced to zero	15	2	Risk reduced to zero	6	180		Risk reduced to zero; residual risk.	4	120		Risk reduced to zero.	6	180				
	c Minimise risk to utility infrastructure	iii)	Minimise risk to utility infrastructure	Number of utility infrastructure assets (power stations, WWTWs, WTWs, telecom exchanges etc) at risk from flooding (0.1% AEP Event)	No increase in the number of utility infrastructure assets at risk	Number of utility infrastructure assets at risk reduced to zero	15	2	Risk reduced to zero	6	180		Risk reduced to zero; residual risk.	4	120		Risk reduced to zero.	5	150				
	d Manage Risk to Agricultural Land	i)	Manage Risk to Agricultural Land	Area of agricultural land at risk from flooding (based on CORINE data or other)	Not applicable	Risk to agricultural land reduced to zero	5	0	Not applicable	0	0		Not applicable	0	0		Not applicable	0	0				
SCORING MECHANISM									TOTAL SCORE: 414				TOTAL SCORE: 174				TOTAL SCORE: 423						

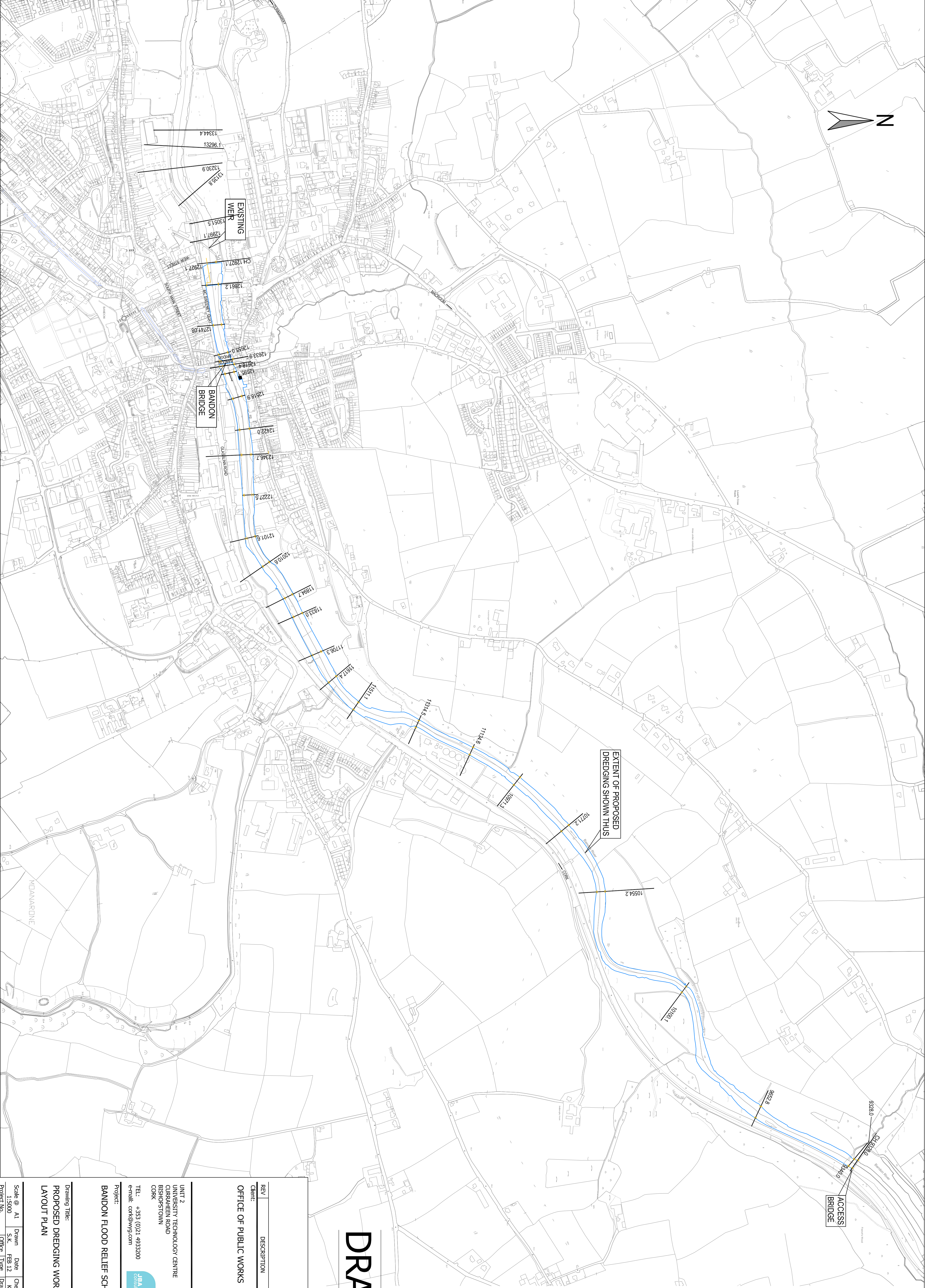




## APPENDIX E

## FIGURES





DRAFT

REV	DESCRIPTION	BY	CHK	APP	DATE
Client:	OFFICE OF PUBLIC WORKS				



UNIT 2  
UNIVERSITY TECHNOLOGY CENTRE  
CURRAHEEN ROAD  
BISHOPSTOWN  
CORK  
TEL: +353 (0)21 4933200  
e-mail: [orp@wys.com](mailto:orp@wys.com)

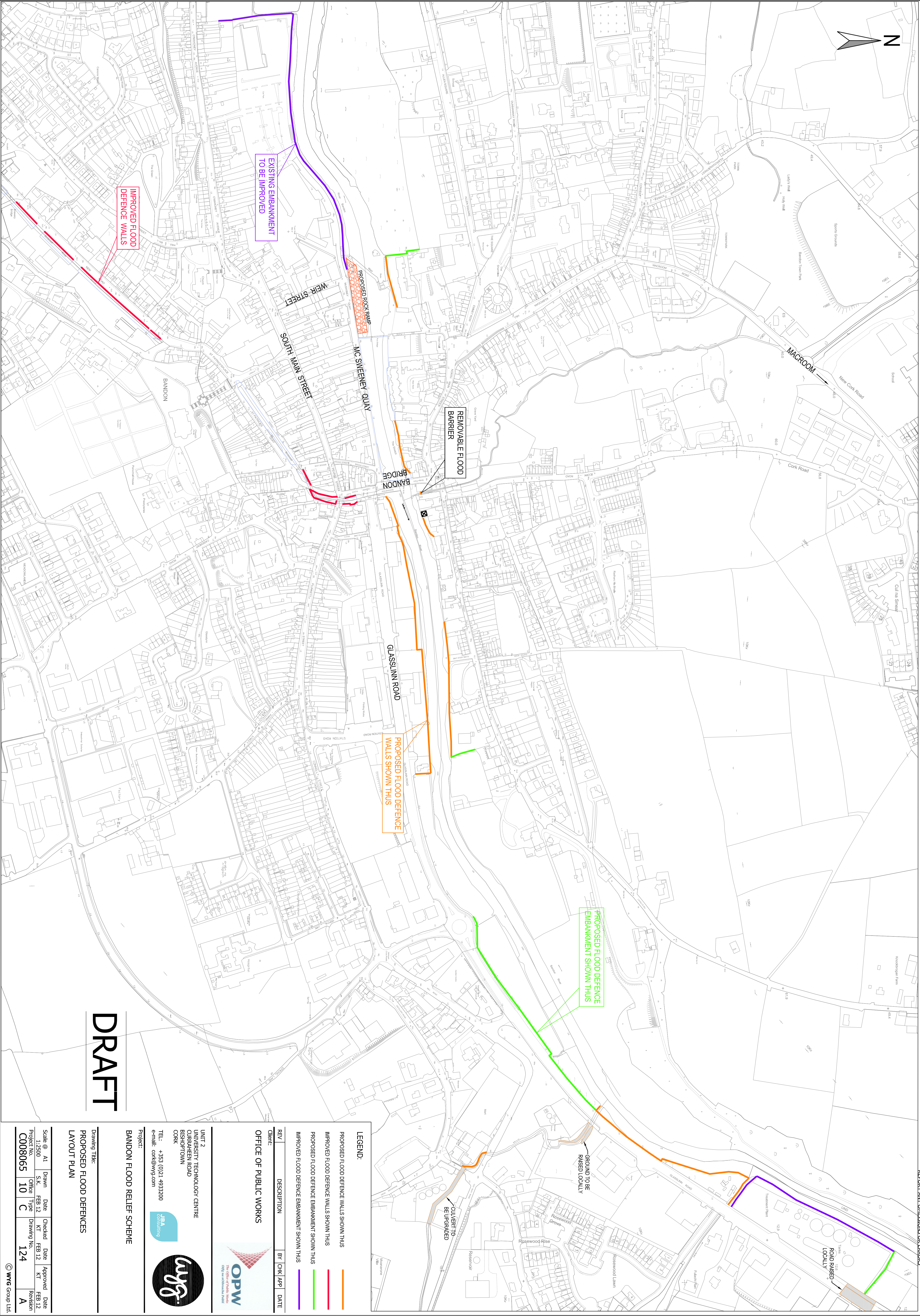


Project: BANDON FLOOD RELIEF SCHEME

Drawing Title:  
PROPOSED DREDGING WORKS  
LAYOUT PLAN

Scale @	A1	Drawn	Date	Checked	Date	Approved	Date
Project No.	1:3000	S.K.	FEB 12	K.T.	FEB 12	K.T.	FEB 12
Office Type	C008065	10	C				
Drawing No.				123			
Revision						A	





DO NOT SCALE. CONTRACTOR TO CHECK ALL DIMENSIONS AND REPORT ANY OMISSIONS OR ERRORS.

DRAFT

**LEGEND:**

- PROPOSED FLOOD DEFENCE WALLS SHOWN THUS
- IMPROVED FLOOD DEFENCE WALLS SHOWN THUS
- PROPOSED FLOOD DEFENCE EMBANKMENT SHOWN THUS
- IMPROVED FLOOD DEFENCE EMBANKMENT SHOWN THUS

**REV**

REV	DESCRIPTION	BY	CHK	APP	DATE
-----	-------------	----	-----	-----	------

**Client:**  
**OFFICE OF PUBLIC WORKS**

**UNIT 2**  
UNIVERSITY TECHNOLOGY CENTRE  
CURRAHREEN ROAD  
BISHOPTOWN  
CORK

**TEL:** +353 (0)21 4933200  
**e-mail:** cork@wv6.com

**Project:**  
**BANDON FLOOD RELIEF SCHEME**

**Drawing Title:**  
**PROPOSED FLOOD DEFENCES LAYOUT PLAN**

Scale @ A1  
1:2500

Drawn	Checked	Date	Approved	Date
S.K.	K.T.	FEB 12	K.T.	FEB 12

Project No. C008065  
Office Type C  
Drawing No. 124  
Revision A

**WV6 Group Ltd.**

**OPW**  
Office of Public Works

**J&A**  
consulting

**wyg.**