EU Interreg IVB FloodResilienCity Project

Final Report – Dublin

Volume Four: Appendix D

Dublin North West Pilot Area

Detailed Modelling, Pluvial Flood Hazard and Risk Mapping for Pilot Areas
# Contents

Volume Four – Appendix D: Dublin North West Pilot Area

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D1 DEtailed modelling approach

D1.1 Modelled Area

A Type 2 detailed hydraulic model has been developed for the Dublin North West Pilot Area (Kippure Park, Finglas South) to simulate pluvial flooding over an area of approximately 1.2 km² centred on Kippure Park.

The modelled area for the Dublin North West Pilot Area is shown on Figure D1.1 along with the combined and storm drainage networks.

D1.2 Available Data Used for Dublin North West Pilot Area Type 2 Model

The datasets used to construct the Type 2 model within the Dublin North West Pilot Area are common to all Type 2 models constructed for this study. These are summarised in Section 2.1 of the Volume Four Main Report.

D1.3 Type 2 Dublin North West Pilot Area Hydraulic Model Schematisation

D1.3.1 2D Grid Schematisation

The Type 2 Dublin North West Pilot Area model grid was populated with ground elevation using filtered LiDAR covering the modelled area. No further modification to the 2D grid using breaklines or 1D elements was required.

D1.3.2 Hydraulic Friction and Ground Infiltration (2D Domain)

The land use regions used to determine the appropriate Manning’s “n” values and ground infiltration losses required for the model grid are shown on Figure D1.2.

D1.3.3 Boundary Conditions in the 2D Domain

Figure D1.2 shows the locations where ‘Inflow’ and ‘Free flow’ boundaries have been applied along the Dublin North West Pilot Area Type 2 model boundary.

\[1\] Refer to Section 2.2.2 of the Volume Four Main Report for the definitions of breaklines and 1D elements.
Figure D1.1: 2D Modelled Area (black outline) and Storm Water Drainage Network (blue lines)
Figure D1.2: Type 2 Dublin North West Pilot Area Model, 2D Domain Schematisation
D1.3.4 Sub-surface Drainage Network Schematisation (1D Domain)

Manhole and pipe data were readily extracted from the existing Infoworks CS model of the Tolka catchment developed for the GDSDS study (2006) and assembled together to form the storm drainage network that includes a total of 393 pipes and 389 manholes.

All the pipes are gravity drained in a general south to north direction with two outfalls into the River Tolka. There are no pumps or rising mains within the system.

Figure D1.3 shows the extent of the storm drainage system included in the Type 2 Dublin North West Pilot Area model. The blue arrow attached to each pipe represents the flow direction under normal conditions.

D1.3.5 1D Boundary Conditions

Boundary types and locations of the stormwater network included into the Type 2 Dublin North West Pilot Area are shown on Figure D1.3.

D1.3.6 Rainfall Runoff Infiltration into the Drainage System (1D/2D link)

Figure D1.3 illustrates the locations of the 1D/2D links which were set up between the 2D domain to calculate the overland flow and the 1D drainage system where pluvial floodwater is conveyed underground.
Figure D1.3: Type 2 Dublin North West Pilot Area Model, 1D Domain Schematisation
D1.4 Type 2 Dublin North West Pilot Area Model Verification

D1.4.1 Model Performance

No significant performance issues were identified for the Type 2 Dublin North West Pilot Area.

D1.4.2 Verification against Historic Flood Events

Figures D1.4 and D1.5 show the maximum flood depths predicted by the Type 2 model and the flood incident locations for both August 2008 and July 2009 events.

The figures illustrate that there is generally reasonable agreement between the flood incident locations which were reported and flood depth extents predicted by the Type 2 Dublin North West Pilot Area model. However, there are also many locations at which pluvial flooding is predicted by the Type 2 model, but do not appear in the flood incident database. This may be attributed to under-reporting.

As noted in Volume Four Main Report, a further significant event occurred on 24 October 2011. However, as flood incident records were still being reviewed at the time of carrying out the Type 2 modelling, it was not possible to use this event for model verification. However, for information purposes, the recorded incidents from this event for the Dublin North West Pilot Area are displayed for the 2% AEP, 3 hour duration modelled event on Figures D3.4B and D3.4C of this Appendix.
Figure D1.4: Comparison between Reported Flood Incidents in August 2008 and Maximum Flood Depths predicted by the Model
Figure D1.5: Comparison between Reported Flood Incidents in July 2009 and Maximum Flood Depths predicted by the Model
D2 BASELINE SCENARIO DETAILED PLUVIAL FLOOD HAZARD AND RISK MAPPING

D2.1 Pluvial Flood Depth and Hazard Rating Mapping

D2.1.1 Examples of Maximum Flood Depth, Flow Velocity and Flood Hazard Rating Outputs

The following section provides examples of the Type 2 Dublin North West Pilot Area model outputs for the Do Minimum (existing conditions) and Do Nothing scenarios. Maximum flood depth, velocity and flood hazard rating (combined depth and velocity)\(^2\) predicted across the modelled area for a 2% AEP (1 in 50 annual chance) event are presented in Figures D2.1 and D2.2 overleaf.

Both scenarios show relatively similar results, however maximum flood depths and flood hazard rating are slightly exacerbated in the case of the Do Nothing scenario. This is expected as the Do Nothing scenario assumes 90% blockage to all inlets to the drainage system.

Areas where flood depths are above 0.5m are within Kippure Park and along Tolka Valley Road. Significant flood hazard rating is also predicted at these locations. Maximum velocity maps show the largest velocities are confined to the road network with the maximum values (>1 m/s) predicted in Kippure Park.

Further detail on the areas at risk of flooding along with the flooding mechanisms is provided in the next section.

\(^2\) Refer to Section 3.1 of Volume Two; City-wide Pluvial Flood Risk Assessment Report for a comprehensive definition of flood hazard.
Figure D2.1: Examples of the Type 2 Pluvial Flood Depth, Velocity and Hazard Rating Mapping in the Existing Situation (Do Minimum scenario)
Figure D2.2: Examples of the Type 2 Pluviial Flood Depth, Velocity and Hazard Rating Mapping (Do Nothing scenario)
D2.1.2 Flooding Mechanisms within Dublin North West Pilot Area

This section discusses the likely flooding mechanisms in the vicinity of the Dublin North West Pilot Area (Kippure Park) which are apparent from the model outputs. Figure D2.3 shows the development of pluvial flooding through the 2% AEP (1 in 50 annual chance) 3 hour duration event under existing (Do Minimum) conditions.

The model output shown in Figure D2.3 comprises three time-steps centred on Kippure Park, as shown in parts A, B and C of Figure D2.3.

Event analysis

The velocity vectors shown in Figure D2.3 indicate that flooding to Kippure Park results from upstream runoff flowing in a generally north to south direction before reaching and flooding low topographic ponding locations in Kippure Park and continuing to the Tolka valley. The existing road network plays a major role in conveying surface flows from the north-east, in particular via St Helena’s Road. Velocity peaks at around 2 hours into the event, with maximum values reaching approximately 1.75 m/s at the west end of St Helen’s Road and within Kippure Park.

Flood depth increases rapidly at Kippure Park as overland flow has difficulty escaping further south, being impounded by an embankment separating the residential properties from the Tolka Valley Road. Flood depth peaks around 2.5 hours into the event, with values ranging from 0.5m to 1.2m across the affected residential properties within Kippure Park.

Immediately south of Kippure Park, Tolka Valley Road is another area where significant flooding is predicted (up to 0.65m deep) by the model due to incoming runoff from the north routed along Cardiffsbright Road and also floodwater overtopping the embankment at Kippure Park.

As a combination of depth and velocity, moderate to significant flood hazard rating is predicted within Kippure Park and on Tolka Valley Road. Although high velocities are predicted in other areas such as St Helena’s road, the flood hazard rating remains low due to very low flood depth being predicted at these locations.

It is difficult to quantify exactly to what extent the drainage system contributes to the flooding at Kippure Park and Tolka Valley Road. However, it is likely to exert an important influence as the local topography causes the surface water runoff to flow toward these areas. This is also the case with the drainage system, for which the local catchment extends as far as Berryfield Road to the north, Deanstown Avenue to the west and St Helena’s Road to the east. Water conveyed through the drainage system converges toward a pinch point at a manhole located on Tolka Valley Road, immediately upstream of the outfall into the Tolka.

Storm drainage pipes run at full capacity in the vicinity of Kippure Park after around 1.5 to 2 hours into the event. This is rapidly followed by signs of manhole surcharging at around 2 hours into the event. Locations where manhole surcharging occurs correspond to the deeply flooded areas (i.e. Kippure Park and Tolka Valley Road) but also along Cardiffsbright Road and St Helena’s Road. Along both of these roads, the underlying drainage system is under pressure from the incoming flow to the drainage system from the upper catchment as well as being subject to backing up from the aforementioned pinch point in the system on Tolka Valley Road.
Figure D2.3A: Time Series Showing Flood Depth, Velocity, Hazard Rating and Status of the Drainage Network during a 2% AEP Three Hour Duration Event at t = 1 hour
Figure D2.3B: Time Series Showing Flood Depth, Velocity, Hazard Rating and Status of the Drainage Network during a 2% AEP Three Hour Duration Event at t = 1.75 hours
Figure D2.3C: Time Series Showing Flood Depth, Velocity, Hazard Rating and Status of the Drainage Network during a 2% AEP Three Hour Duration Event at \( t = 3 \) hours.
D2.2 ‘Existing Situation’ Pluvial Flood Risk Maps

The flood risk maps based on the existing situation are shown in Figures D2.4A and D2.4B. The flood risk map showing Risk to the Environment and Cultural Heritage has not been provided as there are no relevant receptors in the Dublin North West Pilot Area.
D3 CORRECTIVE MITIGATION MEASURES APPRAISAL

D3.1 Overview of Key Problem Areas

As discussed in section D2.1 and as illustrated in Figure D2.3, the key flood mechanisms and characteristics of pluvial flooding and specific ‘Hot Spot’ or ‘problem areas’ within the Dublin North West Pilot Area (Kippure Park) can be summarised as follows:

- Upstream surface water runoff flowing in a generally north to south direction as overland flow before reaching and flooding low topographic ponding locations in Kippure Park and continuing to the Tolka valley.
- The existing road network plays a major role in conveying surface flows from the north-east, in particular via St Helena’s Road.
- Flood depth increases rapidly at Kippure Park as overland flow has difficulty escaping further south, being impounded by an embankment separating the residential properties from the Tolka Valley Road.
- Kippure Park is also flooded due to incoming surface water runoff from the north routed along Cardiff Bridge Road, and floodwater overtopping the embankment at Kippure Park.
- Locations where manhole surcharging occurs correspond to the deeply flooded areas (i.e. Kippure Park and Tolka Valley Road) but also along Cardiff Bridge Road and St Helena’s Road. From the flooded areas mentioned above, backing up occurs within the pipe system resulting in additional surcharged manholes further upstream.

Therefore the mitigation measures considered for the Dublin North West Pilot Area have been specifically tailored to reduce the flooding to these areas, taking into account the key flooding mechanisms, while not increasing flood risk elsewhere in the immediate area or beyond.
D3.2 Options Identification

In addition to the wider generic and good practice measures recommended in Section 4.3 of Volume Four Main Report, the following measures were identified as appropriate for further consideration to address the flood risk specifically in the Dublin North West Pilot Area:

- External Resistance Measures;
- SuDS storage and GreenWaterSpace storage;
- Surface Conveyance (Streets as Streams Roads as Rivers);
- Bio Swales;
- Below Ground Conveyance; and
- Access Protection

The flood risk management options developed based on the appropriate combinations of the above measures for the Dublin North West Pilot Area are as follows:

**Option A:** This option included storage areas where appropriate (Bioswales, SuDs Storage) in the Tolka Valley Park area (between Farnham Drive and Dunsink road) in addition to External Resistance and Access Protection measures.

**Option B:** This option included External Resistance and Access Protection measures (including flood walls and raised kerbing) within the Kippure Park area and Tolka Valley Park area.

**Option C:** Mainly External Resistance Measures and Access Protection measures (including flood walls and raised kerbing) but with redirection of flow by Surface Conveyance and Below Ground Conveyance measures.

D3.3 Appraisal of Options

The total Present Value (PV) ‘Do Nothing’ damages for the Dublin North West Pilot Area is estimated to be €6,214,605.

Table D3.1 summarises the economic benefits for each flood risk management option, along with the estimated benefit / cost ratio.

<table>
<thead>
<tr>
<th>Option</th>
<th>Do Nothing</th>
<th>Do Minimum</th>
<th>Residual</th>
<th>Benefits</th>
<th>Costs</th>
<th>Benefit Cost Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>€6,214,605</td>
<td>€5,389,325</td>
<td>€2,823,985</td>
<td>€3,390,620</td>
<td>€2,724,308</td>
<td>1.2</td>
</tr>
<tr>
<td>B</td>
<td>€6,214,605</td>
<td>€5,389,325</td>
<td>€2,980,590</td>
<td>€3,234,015</td>
<td>€1,663,380</td>
<td>1.9</td>
</tr>
<tr>
<td>C</td>
<td>€6,214,605</td>
<td>€5,389,325</td>
<td>€2,580,533</td>
<td>€3,634,071</td>
<td>€3,018,554</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Table D3.1 indicates that the total cost of each option is less than the benefit in terms of reduction in damages caused from flooding, i.e. the benefit/cost ratio is greater than 1 for all options.
Comparison of Options A, B and C indicated that Option B would have the greatest economic advantage. However model results indicated that the introduction of some elements of Option C could provide further benefit. This option was further evaluated using the model and economic appraisal indicated benefits greater than Option B with a similar benefit/cost ratio (1.8), confirming this as the ‘preferred option’ (refer to Table D3.2). The various measures and elements which comprise the preferred option are discussed in the following section.

Table D3.2 Summary of Economic Assessment for Preferred Option

<table>
<thead>
<tr>
<th>Option</th>
<th>Do Nothing</th>
<th>Do Minimum</th>
<th>Residual</th>
<th>Benefits</th>
<th>Costs</th>
<th>Benefit Cost Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preferred</td>
<td>€6,214,605</td>
<td>€5,389,325</td>
<td>€2,580,533</td>
<td>€3,634,071</td>
<td>€1,984,825</td>
<td>1.8</td>
</tr>
</tbody>
</table>

D3.4 Preferred Mitigation Option

The preferred option comprises the following set of mitigation measures. The main elements as indicated in the Schematic Plan in Figure D3.4A are:

- External Resistance Measures;
- Surface Conveyance (Streets as Streams Roads as Rivers);
- Below Ground Conveyance; and
- Access Protection.

Table D3.3 provides a summary of the total estimated costs of this preferred option, including any uplifts applied compared with those costs estimated for Options A, B and C. Further details with regards the location, scope/extent as well as the estimated construction costs for each measure within the preferred option are outlined in Table D3.4.

Table D3.3 Summary of the Estimated Options Costs

<table>
<thead>
<tr>
<th>Cost Items</th>
<th>Uplift</th>
<th>Summary Costs of each option (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Construction</td>
<td></td>
<td>€1,462,018</td>
</tr>
<tr>
<td>Design &amp; Survey</td>
<td>24%</td>
<td>€350,884</td>
</tr>
<tr>
<td>Planning &amp; Environmental</td>
<td>9%</td>
<td>€64,212</td>
</tr>
<tr>
<td>Land &amp; Legal</td>
<td>2%</td>
<td>€20,211</td>
</tr>
<tr>
<td>PM &amp; Site Supervision</td>
<td>7%</td>
<td>€4,851</td>
</tr>
<tr>
<td><strong>Sub-Total</strong></td>
<td></td>
<td>€1,922,176</td>
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<tr>
<td>Optimism Bias (30%)</td>
<td>30%</td>
<td>€576,653</td>
</tr>
<tr>
<td>PV Future Maintenance</td>
<td></td>
<td>€225,479</td>
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<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td>€2,724,308</td>
</tr>
</tbody>
</table>

This option includes External Resistance Measures (flood walls, raised kerbing and access protection) within the Kippure Park area and Tolka Valley Park area, in addition to the redirection of flow by Surface Conveyance and Below Ground Conveyance measures at Kippure Park.
### Table D3.4 Location, Scope / Extent and Estimated Construction Costs for Each Measure Within the Preferred Option

<table>
<thead>
<tr>
<th>Location</th>
<th>Generic Measure</th>
<th>Community Flood Resilience Measure</th>
<th>Site Specific Measure</th>
<th>Reprofiling Earth Bund</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basement and Ground Level Access Protection</td>
<td>External Resistance Measures</td>
<td>Surface Conveyance (SoS / RaR) including Raised Kerbs</td>
<td>Below Ground Conveyance</td>
</tr>
<tr>
<td>Per m</td>
<td>Per m</td>
<td>Per unit (Property)</td>
<td>Per m</td>
<td>Per m</td>
</tr>
<tr>
<td>Farriham Drive / Sports Ground</td>
<td>253</td>
<td></td>
<td>€50,600</td>
<td></td>
</tr>
<tr>
<td>Gortmore Avenue</td>
<td>20</td>
<td>€100,000</td>
<td>338</td>
<td>€67,600</td>
</tr>
<tr>
<td>O’connor Road</td>
<td>35</td>
<td></td>
<td>€19,600</td>
<td></td>
</tr>
<tr>
<td>Gortmore Drive</td>
<td>15</td>
<td>€75,000</td>
<td>113</td>
<td>€22,600</td>
</tr>
<tr>
<td>Barrack Grove</td>
<td>4</td>
<td>€20,000</td>
<td>45</td>
<td>€9,600</td>
</tr>
<tr>
<td>Bannmore Park</td>
<td>7</td>
<td>€35,000</td>
<td>75</td>
<td>€15,200</td>
</tr>
<tr>
<td>Kilspire Park</td>
<td>55</td>
<td>€4,250</td>
<td>45</td>
<td>€225,000</td>
</tr>
<tr>
<td>St. Helena’s Road</td>
<td>10</td>
<td></td>
<td>501</td>
<td>€105,000</td>
</tr>
<tr>
<td>Toka Valey Park</td>
<td>37</td>
<td>€1,850</td>
<td>274</td>
<td>€54,800</td>
</tr>
<tr>
<td>Preferred Option Construction Cost Total:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figures D3.4B and D3.4C show the Existing Situation (Pre-Scheme) depth mapping and the With Scheme depth mapping for the Preferred Option.
This drawing is not to be used in whole or part other than for the intended purpose and Project as defined on this drawing. Refer to the contract / associated Report for full terms and conditions of use.

Legend

Flood Depth (m)

Legend

Flood Depth (m)
0.1 m to 0.2 m
0.2 m to 0.3 m
0.3 m to 0.5 m
0.5 m to 1.0 m
1.0 m to 2.0 m
> 2.0 m

Reported Flood Incidents (Aug 2008 & July 2009)
Reported Flood Incidents¹ (October 2011)

Type 2 Model Boundary

Notes:
1 - Reported flood incident locations were provided by DCC and are up to date as of 22/06/12.
D3.5 ‘With Scheme’ Pluvial Flood Risk Maps

The ‘With Scheme’ Pluvial Flood Risk Maps are displayed in Figure D3.5 (A and B) and can be compared with the equivalent Existing Situation maps in Section D2.2.

These maps illustrate the effectiveness of the Preferred Option in reducing flood risk to the ‘Hot spot’ areas identified in Section D3.1.

Please note that a ‘With Scheme’ flood risk map is not included for the ‘Environment and Cultural Heritage’ receptor group as there are no relevant receptors in the Dublin North West Pilot Area.
D4 CONCLUSIONS AND RECOMMENDATIONS

D4.1 Conclusions

The modelling approach has highlighted specific problem areas within the Dublin North West Pilot Area and provides an indication of local flood hazard and risk areas, which may be summarised as follows:

- Overland flow across the area flowing in a generally north to south direction leading to flooding at low ponding locations in Kippure Park and continuing to the Tolka valley.

- Flood depth increases rapidly at Kippure Park as overland flow cannot flow further south as it is impounded by an embankment separating the residential properties from the Tolka Valley Road.

- Kippure Park is also flooded due to incoming surface water runoff from the north routed along Cardiffbridge Road, and floodwater overtopping the embankment at Kippure Park.

- Manhole surcharging occurs corresponding to the deeply flooded areas of Kippure Park and Tolka Valley Road, as well as along Cardiffbridge Road and St Helena’s Road. Backing up leads to additional surcharged manholes further upstream.

In general, pluvial flooding in Dublin North West Pilot Area is influenced by the capacity of the drainage system in addition to surface runoff from upstream areas which reaches the low ponding areas within Kippure Park.

The Type 2 Pluvial Flood Risk Assessment and Mapping indicates a high level of pluvial flood risk within Kippure Park with a large proportion of properties contributing potentially significant damages.

The Present Value (PV) damages for the Do Nothing and Do Minimum (Existing Situation) options are €6.21M and €5.39M respectively based on a 50 year time frame and a 4% discount rate (as noted in Section D3.3).

Three options (Options A, B and C) were considered, each comprising a range of specific measures to be implemented in combination. The preferred option from the economic appraisal is based on a combination of Options B and C. This preferred option comprises mainly external resistance measures including flood walls, raised kerbing, access protection and redirection of flow in addition to underground conveyance which is used to reduce flood depths within Kippure Park. This option has estimated PV costs of around €1.9M and estimated PV benefits of €3.6M giving a benefit/cost ratio of approximately 1.8. On this basis further more detailed consideration of this option is justified.

The benefit/cost ratio of the Do Minimum option is 1.15.
D4.2 Recommendations

Recommendations for mitigating pluvial flood risk in the Dublin North West Pilot Area, through the implementation of the Preferred Option, include:

- Reducing risk associated with pluvial flooding in the vicinity of the Tolka Valley Park embankment (Tolka Valley Road) is recommended as this is showing up as a high risk area. In addition Kippure Park and Gortmore Avenue will require local receptor measures to be considered where risk is greatest.

- Within the localised area of Kippure Park, a combination of external property resistance measures and walls, access protection and underground conveyance.

- Designated pathway measures including the localised re-profiling of certain road/embankment sections and kerb raising along designated flow routes, specifically in the Tolka Valley.

As outlined within Section 4.3 of Volume Four Main Report, wider generic and good practice measures are also considered as an integral part of any scheme to reduce and manage pluvial flood risk in the area.

This study has confirmed there are a number of potentially viable flood risk management options for the Dublin North West Pilot Area. It is possible that Dublin City Council could consider progressing a Flood Risk Management Scheme through the standard appraisal process. This would start with a more detailed feasibility, or appraisal, study to investigate the potential flood risk management options in more detail. The outline design of a preferred option, or combination of options, would be the deliverable from such a detailed appraisal study.

In the interim period, prior to any further measures being put in place, it is recommended that the ‘Do Minimum’ option is continued. This represents the existing situation and should include:

- Gulley maintenance/inspections;
- Maintenance of flap valves;
- Check after major storm events for blockages; and
- Clear out through autumn where leaves can be a particular blockage risk.

To support any future detailed appraisal study, the following immediate tasks are recommended:

- A topographic level survey to determine the property thresholds of all properties in the Dublin North West Pilot Area.
- Further public consultation with those who completed the questionnaires made available as part of this project, thanking them for the information supplied, informing them of the project report conclusions and anticipated way forward.
Much of the information collected, and tools developed, for this project could be used for any future detailed appraisal study. However, there are a number of recommendations made in this report that should be taken into consideration. These are as follows:

- A review of the TUFLOW 2D model is carried out to ensure it remains appropriate and fit for the purpose of a detailed appraisal study.
- In addition a more comprehensive costing associated with the recommended mitigation measures to allow for a more accurate evaluation.