SECTION 2 CITY-WIDE PRELIMINARY MAPPING OF FLOWPATHS AND PONDING

2.1 Introduction and Methodology

An initial appraisal of potential pluvial flooding hotspots throughout Dublin was undertaken using GIS screening techniques to produce:

- Surface water flowpaths based on ‘rolling ball’ analysis; and
- Depressions in the topography (ponding areas) based on Contour Polygon Screening.

These GIS techniques identify rainfall runoff flowpaths and potential ponding areas where runoff can accumulate. The ‘rolling ball’ technique is one of four surface water flood risk modelling techniques described in Defra’s Surface Water Management Plan Technical Guidance, March 2010. This is defined as follows:

‘Rolling ball’ methods identify natural flow pathways determined by topography only. The analysis is completed within GIS software and uses terrain data from digital terrain models (DTM). The rolling ball method can be used in conjunction with tools predicting point sources of flooding (e.g. from sewers) to identify likely pathways and receptors. This information can be used to conceptually model 1D channels on the surfaces representing the flow pathway.

2.1.1 Available Data

Dublin City Council provided the majority of data, with supplementary information provided by OSi.

Table 2.1 summarises the datasets used to generate the ‘dry’ maps. They were supplied at a City-wide scale and therefore provided sufficient coverage of the study area (which is defined by the Dublin City Council administrative boundary) as shown in the mapping outputs of this report.

Table 2.1 – Available data for City-wide (Type 1) ‘Dry’ Mapping

<table>
<thead>
<tr>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dublin City Council Boundary Data</td>
<td>Dublin City Council administrative boundary. Used to define the extents of the study area.</td>
</tr>
<tr>
<td>LiDAR</td>
<td>Light Detecting And Ranging (LiDAR). A digital terrain model generated from aerial imagery.</td>
</tr>
<tr>
<td>OSI - NTF</td>
<td>Ordnance Survey Ireland large scale background mapping.</td>
</tr>
<tr>
<td>Historical flood records</td>
<td>Historic flooding datasets available for the August 2008 and July 2009 pluvial flood events. These datasets included information on the location (address) and type/extent of flooding.</td>
</tr>
</tbody>
</table>
Quality checks were undertaken on sample areas prior to the processing of the LiDAR data to ensure the correct format was used to provide the required outputs.

2.1.2 Technique – Surface Water Flowpath Mapping

Derivation of surface water flowpaths using the ‘rolling ball technique’ adopted tools in the ArcHydro Toolbar within ArcGIS v9.3. This uses a staged approach to process the LiDAR to produce a series of grids calculating the surface runoff contributing factors i.e. catchments, flow accumulation and flow direction.

When this LiDAR elevation dataset is collected, points are returned that indicate both the height of the land surface and the height of objects on the land surface, such as buildings and blocks of vegetation. For applications such as the ArcGIS ArcHydro tools used for flood modelling, a digital elevation model (DEM) that only uses points that hit the ground is necessary for showing water flow during an event. This surface, known as a “bare earth surface” or “filtered LiDAR data” (achieved by applying filter algorithms) shows the land surface and interpolates across areas where no bare earth points are found.

By identifying catchments greater than one hectare the technique determines flow direction and linkages to produce a flowpath network. Both the “unfiltered” and “bare earth” LiDAR was used to ensure a more realistic representation of the flowpaths.

These flowpaths were then graded according to gradient and accumulating flow/area. This was achieved by combining the steepness of slope (flowpath gradient) and the cumulative, upstream catchment area (flowpath accumulation; km$^2$). Both the ‘flowpath gradient’ and ‘flowpath accumulation’ have been colour coded to represent the variations in accumulation and gradient; refer to Figure 2.1 for an example.

The flowpaths are typically defined along surface features, such as watercourses or roads, via which flood waters can flow. Flowpaths are mapped with the supporting flow ‘gradient’ and ‘flow accumulation’ information shown to give an indication of the accumulated flows and potentially high velocities (as a result of steep gradients) that may be present. This information is then used to supplement the indicative risk assessments as it allows likely impacts of the presence of flowpaths to be assessed.
A complete set of figures for the entire study area showing the outputs from the surface water flowpath mapping technique is provided in Appendix V2-A.

2.1.3 Technique – Ponding Areas

Potential ponding areas were identified using a Contour Polygon Screening (CPS) technique which has proven highly effective in identifying topographic depressions where surface water is likely to pond.

Using the ‘bare-earth’ LiDAR, the GIS-based CPS technique contours the topographic data to identify areas of closed contours; these are the depressions where surface water could pond. The outermost closed contour is taken as the depression boundary, which is converted to a polygon.

Only polygons with a surface area greater than 100m² are normally considered to represent a significant potential hazard. However, for this Dublin FRC project, this threshold has been reduced to allow the technique to assist identification of basement flats or underground access points (to carparks etc), which are known to be particularly vulnerable to pluvial flooding.

By dividing the volume of the depression by its surface area, the average depth of the depression has been determined. Only those depressions with an average depth greater than 200mm are considered to be a potential hazard on the basis of this preliminary mapping. Therefore for clarity, the shallower ponding areas were not displayed on the map outputs.

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3 The legend shown here is indicative of the mapping outputs provided in Appendix V2-A. The flowpath accumulation areas represent the wider area from which this example was taken.
4 The minimum surface area of polygons shown is 4m²
5 Although the shallower areas were filtered out for display purposes, this data is available and can be displayed if required.
2.1.4 False Depressions and Flowpaths

It should be noted that the GIS processing of the bare-earth LIDAR data does not necessarily ‘see’ culverts, underpasses or bridges through embankment structures. Hence a ponding area may be indicated which in fact may drain through a culvert, bridge or underpass. Similarly, the process does not always recognise large, flat water bodies and therefore false flowpaths may be generated. Nevertheless the identification of such ponding areas and flowpaths are of benefit as drainage pathways can be checked on site and included in the subsequent detailed modelling.

Figure 2.3 and 2.4 identifies examples of these false depressions and flowpaths, in this Type 1 Dry Mapping exercise.
Figure 2.3 – Example of ‘False’ Ponding Area (known culverts exist under canal and rail infrastructure; ponding area identified upstream)

Figure 2.4 – Example of ‘False’ Flowpath (flowpaths shown across the large, flat waterbody – the Liffey River)
2.2 Site Inspections

2.2.1 Purpose of Site Inspections

The overall aim of this initial series of site visits was to better understand pluvial flooding processes and gain an initial overview of significant risk factors specific to Dublin. They have also been used to verify the findings of the Type 1 ‘Dry’ Maps, and thereby identify features which should be incorporated in subsequent ‘wet’ modelling. The locations visited included areas identified as deep depressions and areas where flooding had previously occurred. They covered heavily urbanised areas, as well as parkland areas. Between the 6th and 21st of September 2010, a total of 29 sites were visited across the Dublin City Council administrative area.

During the visits, each site was assessed to confirm the presence of flowpaths and ponding areas and gauge their likely impacts; for example the number of properties likely to be affected, the potential depth of flooding, and the velocity of flows. The locations of the site assessments are presented in Appendix V2-C. The data collected during the site visits has also been used to complete an indicative assessment of pluvial flood risk at these specific locations. This has prioritised areas on the basis of an initial assessment of risk and can be clearly portrayed to identify areas of particularly high pluvial (or surface water) flood risk. The results from the indicative risk assessment are discussed in Section 2.3.

2.2.2 Comments Relevant to the Entire Study Area

The majority of the Dublin City Council study area is flat or gently undulating. The few areas where very high velocity surface water flows are likely to be found appear to be concentrated along the river valleys and are generally outside the city centre area. The flat nature of the terrain in many areas also means that areas can be susceptible to widespread shallow ponding as the surface runoff cannot drain away easily. Buildings with entrance threshold levels at or close to, or even below ground level may be particularly susceptible in these areas.

The study area is also dissected by numerous watercourses (for example the rivers Tolka, Liffey and Dodder) and flood risk in many areas is likely to result from a combination of fluvial flooding and pluvial flooding. For example high watercourse levels can cause backing up of sewerage and drainage systems which can result in or exacerbate surface flooding. Extreme rainfall may exceed design parameters for some culverts – in such cases the ‘exceedance’ flow can flood across the ground surface and combine with pluvial flooding. Tide-locking of drainage outfalls due to high tidal conditions can also exacerbate pluvial flooding. There can thus be complex inter-relationships between different types of flood risk and this includes the potential for sewer flooding during extreme rainfall to add to pluvial flooding on the surface. It can also be the case that any excess capacity in the sewerage or drainage system could alleviate pluvial flooding.

A large proportion of areas assessed appear to have properties with entrance thresholds at or below ground level and there are many basement properties and also entrances to below ground facilities such as car parks or goods receiving areas. This can pose a serious risk of rapid flooding where properties are adjacent to flowpaths or in ponding areas and even in areas of flat terrain which have the potential to cause shallow flooding to very large numbers of properties. Flooding in flat areas is also often exacerbated by sewer flooding due to the flat gradients of the sewer systems. Sections
of rail or road infrastructure in cutting or at dips at bridge crossings can also be particularly vulnerable to pluvial flooding – this was observed as a possible risk at various locations.

2.2.3 Location of Site Inspections

Table 2.2 provides a summary of the locations identified for inspection during the site visits which are shown on the map included in Appendix V2-C.

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Site Name</th>
<th>Summary Reason for Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ballyfermot, Blackditch Road</td>
<td>Flooded during August 2008 event; sample of shallow depression on flowpath</td>
</tr>
<tr>
<td>2</td>
<td>Ballyfermot, Kylemore Road</td>
<td>Deep depression on flowpath near major river</td>
</tr>
<tr>
<td>3</td>
<td>Inchicore, Jamestown Ave</td>
<td>Flooded during July 2009 event near two major depressions</td>
</tr>
<tr>
<td>4</td>
<td>Kilmainham, Carrickfolye Terrace</td>
<td>Potential for small localised ponding due to walls at end of street. False depression (due to bridge). All drains to river. Key issue: High velocity flows - potential for wall and end of road to collapse to river</td>
</tr>
<tr>
<td>5</td>
<td>Islandbridge, South Circular Road</td>
<td>Localised depression at doorway of apartment complex. (rear of Heuston Station)</td>
</tr>
<tr>
<td>6</td>
<td>Cabra, Carnlough Road</td>
<td>Multiple flooding incidents during the August 2008 event. Minor depression.</td>
</tr>
<tr>
<td>7</td>
<td>Ashtown, Glendu Park</td>
<td>Flooded during August 2008 falls within depression</td>
</tr>
<tr>
<td>8</td>
<td>Finglas South, Kippure Park</td>
<td>Minor depression flooded during August 2008 event</td>
</tr>
<tr>
<td>10</td>
<td>Phibsborough, Dalcassin Downs</td>
<td>Elongate depression along flowpath</td>
</tr>
<tr>
<td>11</td>
<td>Cabra North, Circular Road</td>
<td>Small localised depression along flowpath</td>
</tr>
<tr>
<td>12a</td>
<td>Mater Hospital, Eccles Street</td>
<td>Localised deep depression in heavily urbanised area</td>
</tr>
<tr>
<td>12b</td>
<td>Phibsborough Basements, Eccles Street</td>
<td>Localised deep depression in heavily urbanised area</td>
</tr>
<tr>
<td>13</td>
<td>Drumcondra, Whitworth Road</td>
<td>Multiple flooding incidents during the July 2009 event. Minor depression.</td>
</tr>
<tr>
<td>14</td>
<td>Ballybough Road</td>
<td>More than 8 recorded incidents of flooding during both the 2008 and 2009 flood events.</td>
</tr>
<tr>
<td>15</td>
<td>Fairview, Clonliffe Road</td>
<td>Site located on major flowpath in extensive depression &gt;2m deep.</td>
</tr>
<tr>
<td>16</td>
<td>North Strand (Dublin 3), Bessborough Avenue</td>
<td>Topography suggests area is susceptible to flood risk</td>
</tr>
<tr>
<td>17</td>
<td>East Wall, Church Road</td>
<td>Site located on flowpath</td>
</tr>
<tr>
<td>20</td>
<td>Dublin 2, Pearse Square</td>
<td>Two reported flooding incidents during the August 2008 and July 2009 flood events</td>
</tr>
<tr>
<td>22</td>
<td>Ringsend Gordon Street</td>
<td>Large flat depression</td>
</tr>
<tr>
<td>23</td>
<td>Sandymount Bath Avenue Gardens</td>
<td>Large flat depression which reportedly flooded during the 2009 events</td>
</tr>
<tr>
<td>24</td>
<td>Ballsbridge Shelbourne Road</td>
<td>Multiple flooding incidents within depression on flowpath</td>
</tr>
<tr>
<td>25</td>
<td>Proud's Lane</td>
<td>Small localised depression along small flowpath</td>
</tr>
<tr>
<td>26a &amp; 26b</td>
<td>Rathmines Effra Road &amp; Rathmines Effra Road (Convent &amp; School)</td>
<td>Small shallow depression - Reported incident of flooding during August 2008 event &amp; Small shallow depression - Reported incident of flooding during August 2008 event</td>
</tr>
<tr>
<td>30</td>
<td>Fairview Dublin 3 Annesley Bridge Road</td>
<td>Site located within major depression along flowpath</td>
</tr>
<tr>
<td>31</td>
<td>Marino St. Aidans Park &amp; Fairview Avenue Upper</td>
<td>Flooded during August 2008 event along flowpath</td>
</tr>
<tr>
<td>32</td>
<td>Marino Clontarf Road</td>
<td>Flooded during July 2009 event along flowpath</td>
</tr>
<tr>
<td>35</td>
<td>Ballymun/Finglas Sandyhill Gardens</td>
<td>Minor depression near flowpath</td>
</tr>
<tr>
<td>37</td>
<td>Clonsough Clonsagua Walk</td>
<td>Flooded during July 2009 event</td>
</tr>
<tr>
<td>38</td>
<td>Dardnaile Belcamp Crescent</td>
<td>Flooded during August 2008 and July 2009 flood events localised shallow depression</td>
</tr>
</tbody>
</table>
2.2.4 Typical Examples of Generic Site Types Requiring Further Review in the Wet Modelling Process

A number of sites are discussed below that typify the pluvial risks which are characteristic within the study area and apparent from this initial series of site visits.

**Flat Areas and Shallow Depressions**

This type does not represent very steep flowpaths or deep depressions. The shallow depression in such an area does however appear to accumulate a number of gentle – moderate sloping flowpaths which combine at the end of a road.

Properties located within such an accumulation point can have basement floors and/or steep side entrances which lead to rear gardens below ground level. Very intense rainfall in the catchment area is likely to result in flooding of basement levels and rear gardens. This will be further assessed by the ‘Wet’ model. Basements and ‘low level’ properties can also be at risk within other types of risk area.

Photograph 1
Example of a gently sloping road

Photograph 2
Open entrance to basement level of property
The location illustrated below is typical of many residential streets in North Dublin City, with no or limited green space (impermeable areas to facilitate drainage/soak-away) and many basement dwellings. The shallow depression identified in this area is bound by the canal and railway embankments (with bridges).

Flowpaths (illustrated by blue arrows) are minor in this area and the depth of depression identified is not particularly significant or extensive. However, the flat to gently undulating terrain indicates that very intense rainfall is likely to result in widespread shallow ponding and potential risk to life due to basement flooding.
Deep Depressions

Areas located at a defined deep depression can be affected by a number of flowpaths accumulating in the depression. Intense rainfall may not significantly affect residential properties in such an area where they are sufficiently raised above road level and/or flowpaths are directed away from the depression.

Where there are steep slopes in such a depression, very intense rainfall can result in rapid flooding of any basement properties present. The steep slopes and likely associated high velocity flowpaths could also pose a potential risk to life.

Photograph 5
Example of a deep depression >1m at some locations. Potential direction of flowpath illustrated

Photograph 6
Example of potential direction of flowpath towards a deep depression.
Some relatively deep depressions can extend across large areas. For example Photograph 7 below illustrates the start of a large depression which is obvious by the slope of ground at this location - sandbags were also observed at the properties at the bottom (south) of this slope. Although there is a steep slope at this site, flooding in this area is not considered sufficiently deep or rapid to pose a potential risk to life during a pluvial flooding event.

Examples of this type of area can be found in the River Tolka catchment in particular.
In the example illustrated below the car park and construction works are located within a depression approximately 2 metres below the surrounding ground level. The area is not fed by any major flowpaths, but there is a high potential for extensive ponding due to the deep nature of the depression and lack of outlet.

Construction site depression (>2m below road level)

Car park depression (>1m below road level)

Photograph 9
Construction site within a deep depression.
Note: New building includes floors below ground-level

Photograph 10
Car park in depression
Steep Slope

An example of this type of area was observed with steep hard-surfaces and potential flowpaths leading to cul-de-sac areas. During a pluvial event, such areas can include barriers to flow. These barriers can include walls on the banks of rivers. In such an area, the potentially high velocity flows over steep hard-surfaces in the direction of a river could pose a risk to life in a very intense rainfall event.
**Basements Adjacent to Flowpaths**

The example illustrated below is typical of city centre streets with limited/no green space (for storage and flow attenuation) and many basement properties. Although this site is on a relatively minor flowpath, the presence of basement properties and low threshold levels at basement access points along footpaths increases the risk of pluvial flooding in this area (as well as the risk to life).

![Photograph 14](image1.png)  ![Photograph 15](image2.png)

**2.2.5 Summary Comments on Pluvial Risks**

The site inspections undertaken have identified the following key risks:

- A large proportion of residential and commercial areas have low property and/or footpath thresholds, with many at and below ground level and many basement properties which are particularly vulnerable.

- 70% of the sites visited have flat to gentle sloping ground surface conditions. The lack of fall at these locations means that shallow surface water flooding could occur relatively quickly and affect many properties.

- Multiple and inter-related flood hazards exist at many locations - understanding of these flood mechanisms and inter-relationships will underpin the development of mitigation measures appropriate to the specific location.

- Railway lines are constructed on embankments throughout the city and several important flowpath connections through underpasses and bridges have been identified which will be incorporated in subsequent ‘wet’ modelling. However, in areas such as the north city centre these embankments can form a barrier and flowpaths are restricted. Sections of rail or road infrastructure in cuttings or at dips at bridge crossings can also be particularly vulnerable to pluvial flooding and this was observed as a possible risk at various locations.
2.3 City-wide Preliminary Risk Assessment

2.3.1 Dry Mapping Indicative Risk Categorisation

During the Type 1 ‘Dry’ Mapping site inspections, an indicative risk assessment of pluvial flooding at these locations was carried out using a simple scoring system to rate the perceived overall level of flood risk and make an initial assessment of potential risk to life.

The scoring system applied to each ‘Dry’ mapping site visit location, is summarised in Table 2.3.