Appendix N
Flood Risk Assessment

BUSCONNECTS INFRASTRUCTURE DELIVERY – PROJECT D

FLOOD RISK ASSESSMENT – ROUTE 0304

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1 INTRODUCTION

As part of the preliminary design process (Stage i), TYPSA has carried out a Flood Risk Assessment (FRA) for Route 0304 of Dublin BusConnects Core Bus Corridors Project D: Ballymun / Finglas to City Centre. This report has been prepared to assess the flood risk to the subject site and adjacent lands as a result of the proposed development. This FRA is submitted with the SuDS proposal report.

1.1 Description of study area

The extent of the proposed Route 0304 site area is shown Figure 1 and Figure 2.

Ballymun corridor starts at Ballymun in the north and extends south to the city centre. The area of interest is bounded to the north by Balbutcher Lane and Santry Avenue and to the south by Aran Quay and Inns Quay (by Liffey River). The ground level immediately north of Santry Avenue is approximately +64mOD, this ground level is reduced to +4mOD at the eastern end of Inns Quay. The scheme has a total length of 6.39km from north to south.

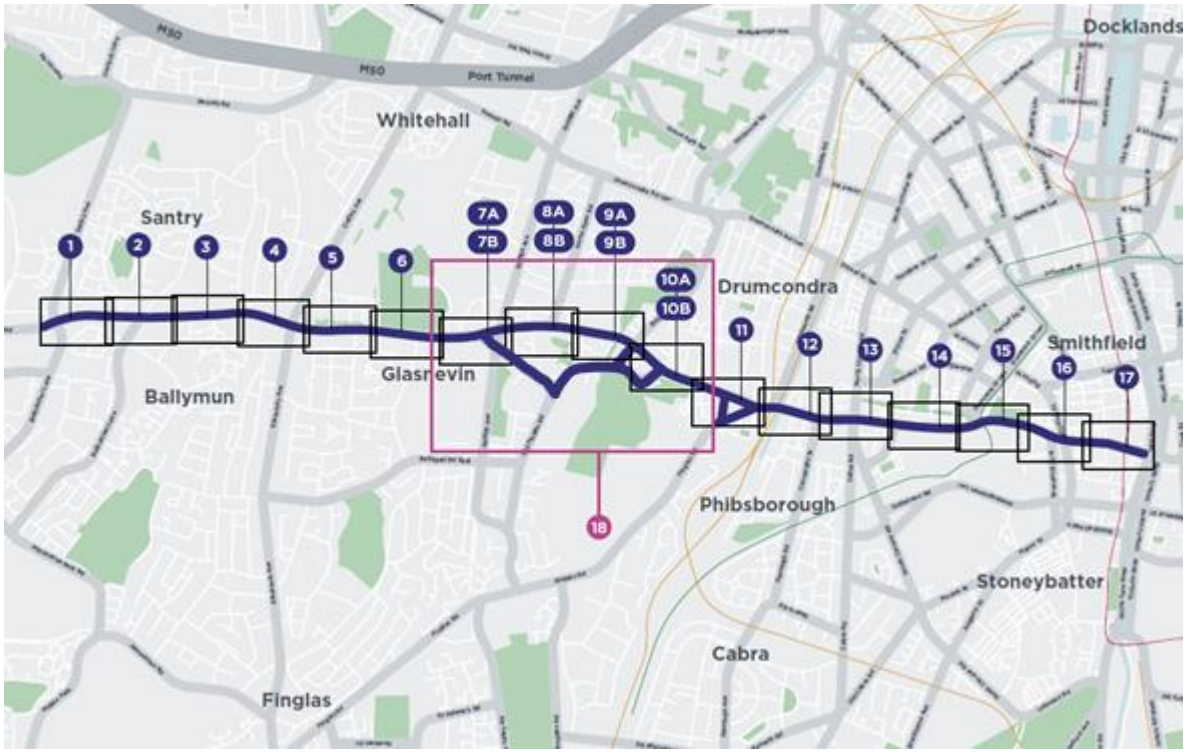

Figure 1. Route 0304: Ballymun Corridor Proposed Development Area

Finglas Corridor starts at Mellowes Park in the north and extends south to Botanic Road, on Finglas Road. The ground level immediately north of Santry Avenue is approximately +64mOD, this ground level is reduced to +26mOD at the eastern end of Inns Quay. The scheme has a total length of 4.18km from north to south.

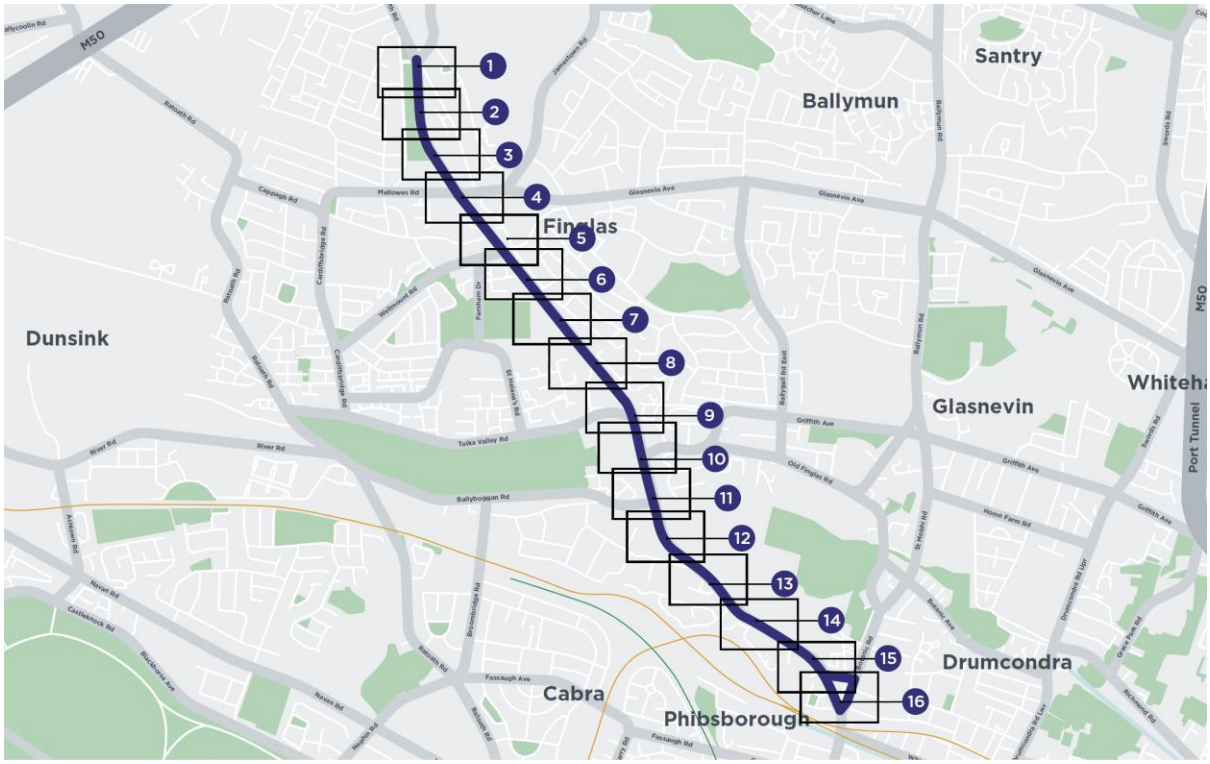

Figure 2. Route 0304: Finglas Corridor Proposed Development Area

1.2 Description of proposed development

This project aims to supply Dublin with a network of Core Bus Corridors, which will improve public transportation services and provide continuous cycle lanes across the city. This Flood Risk Assessment (FRA) is focused on Route 0304 of the future network, from Ballymun all the way to the City Centre and from Finglas to Phibsborough.

The proposal uses the existing roads and infrastructure and aims to improve them to meet the objectives. It does this through the proposal of several types of cross-sections that will be adjusted depending on the geometry of the existing infrastructure. These will include additional bus and cycle lanes and pedestrian access areas.

2 FLOOD RISK

2.1 Introduction

This report has been prepared in accordance with 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' herein referred to as 'The Guidelines' as published by the Office of Public Works (OPW) and Department of Environment, Heritage and Local Government (DoHLG) in 2009.

2.2 Identification of flood risk

Flood risk is a combination of the likelihood of a flood event occurring and the potential consequences arising from that flood event and is then normally expressed in terms of the following relationship:

$$Flood\ risk\ =\ Likelihood\ of\ flooding\ x\ Consequences\ of\ flooding$$

To fully assess flood risk an understanding of where the water comes from (i.e. the source), how and where it flows (i.e. the pathways) and the people and assets affected by it (i.e. the receptors) is required. Figure 2 below shows a source-pathway- receptor model reproduced from 'The Guidelines' (DEHLG-OPW, 2009).

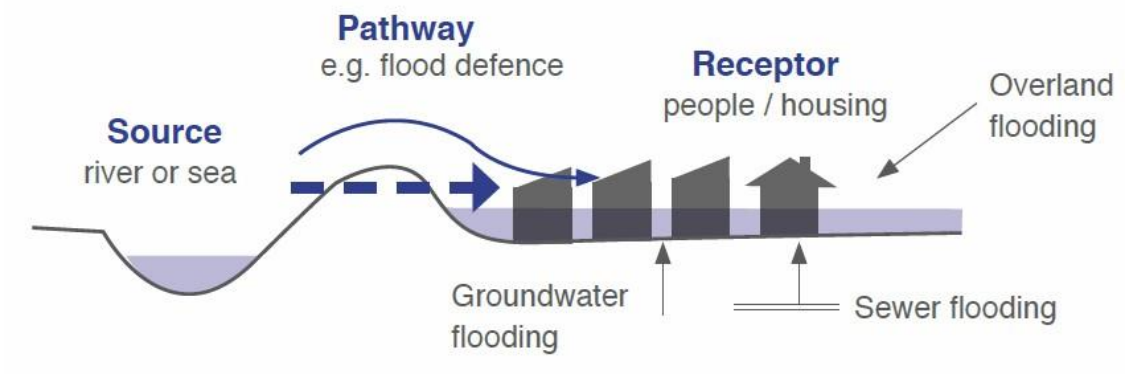

Figure 3. Sources, Pathways and Receptors of Flooding

The principal sources of flooding generally are rainfall or higher than normal sea levels. The principal pathways are rivers, drains, sewers, overland flow and river and coastal floodplains. The receptors can include people, their property and the environment. All three elements as well as the vulnerability and exposure of receptors must be examined to determine the potential consequences.

The Guidelines set out a staged approach to the assessment of flood risk with each stage carried out only as needed. The stages are listed below:
Stage I Flood Risk Identification – to identify whether there may be any flooding or surface water management issues.
Stage II Initial Flood Risk Assessment – to confirm sources of flooding that may affect an area or proposed development, to appraise the adequacy of existing information and to scope the extent of the risk of flooding which may involve preparing indicative flood zone maps.
Stage III Detailed Flood Risk Assessment – to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development or land to be zoned, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures.

2.3 Likelihood of flooding

The Guidelines define the likelihood of flooding as the percentage probability of a flood of a given magnitude or severity occurring or being exceeded in any given year. It is generally expressed as a return period or annual exceedance probability (AEP). A 1% AEP flood indicates a flood event that will be equalled or exceeded on average once every hundred years and has a return period of 1 in 100 years. Annual Exceedance probability is the inverse of return period as shown Table 1 below.

Table 1. Correlation between return period and AEP

Return Period (years)	Annual Exceedance Probability (%)
1	100
10	10
50	2
100	1
200	0.5
1000	0.1

2.4 Definition of flood zones

Flood zones are geographical areas within which the likelihood of flooding is in a particular range. These are split into three categories in The Guidelines:

Flood Zone A

Flood Zone A where the probability of flooding from rivers and the sea is highest (greater than 1% or 1 in 100 for river flooding or 0.5% or 1 in 200 for coastal/tidal flooding).

Flood Zone B

Flood Zone B where the probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 and 1% or 1 in 100 for river flooding and between 0.1% or 1 in 1000 or 0.5% or 1 in 200 for coastal/tidal flooding);

Flood Zone C

Flood Zone C where the probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal/tidal flooding. Flood Zone C covers all plan areas which are not in zones A or B.

It is important to note that when determining flood zones the presence of flood protection structures should be ignored. This is because areas protected by flood defences still carry a residual risk from overtopping or breach of defences and the fact that there is no guarantee that the defences will be maintained in perpetuity.

2.5 Sequential approach and justification test

The Guidelines outline the sequential approach that is to be applied to all levels of the planning process. This approach should also be used in the design and layout of a development and the broad philosophy is shown in **Figure 4** below. In general, development in areas with a high risk of flooding should be avoided as per the sequential approach. However, this is not always possible as many town and city centres are within flood zones and are targeted for development.

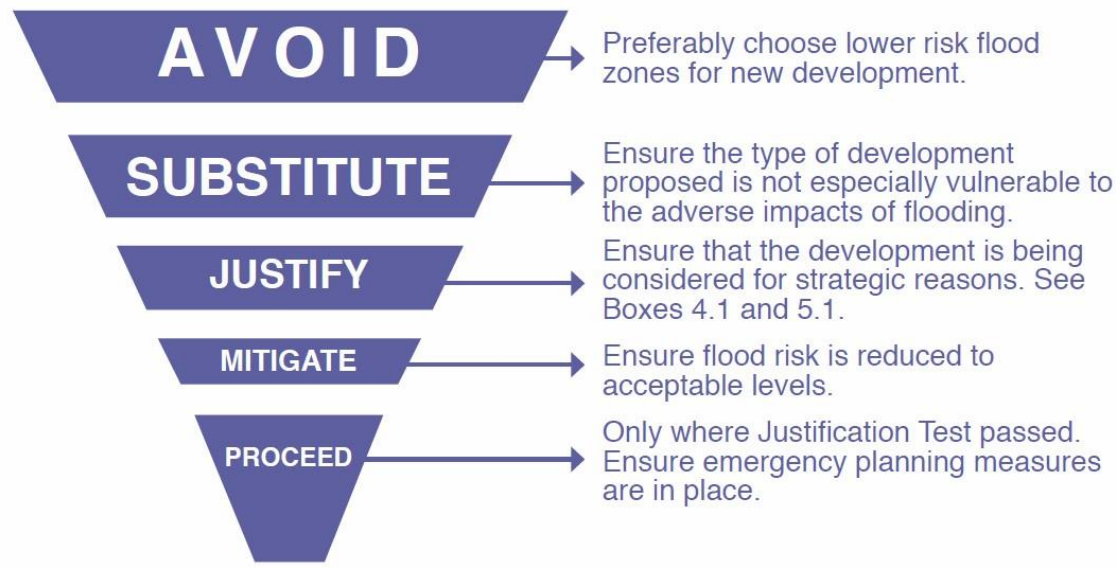

Figure 4. Sequential Approach (Source: The Planning System and Flood Risk Management)

The Justification Test has been designed to rigorously assess the appropriateness, or otherwise, of developments that are being considered in areas of moderate or high flood risk. The test comprises the following two processes.

The first is the Plan-making Justification Test and is used at the plan preparation and adoption stage where it is intended to zone or otherwise designate land which is at moderate or high risk of flooding. The second is the Development Management Justification Test and is used at the planning application stage where it is intended to develop land at moderate or high risk of flooding for uses or development vulnerable to flooding that would generally be inappropriate for that land.

Table 2. Matrix of vulnerability versus flood zone to illustrate appropriate development that is required to meet the justification test (Source: The Planning System and Flood Risk Management)

	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development (including essential infrastructure)	Justification Test	Justification Test	Appropriate
Less vulnerable development	Justification Test	Appropriate	Appropriate
Water-compatible development	Appropriate	Appropriate	Appropriate

3 STAGE 1 – FLOOD RISK IDENTIFICATION

3.1 General

This Stage 1 Flood Risk Identification includes a review of the existing information and the identification of any flooding or surface water management issues in the study area that may warrant further investigation.

3.2 Information sources consulted

The following information sources were consulted as part of the Stage 1 Flood Risk Identification:

Table 3. Information sources consulted

Source	Data Gathered
OPW Preliminary Flood Risk Assessment (PFRA) maps	Fluvial, Pluvial and Coastal flooding examined. Sourced at *http://www.floodinfo.ie/map/floodmaps/*
OPW National Flood Hazard Mapping	Recorded flood events. Sourced at *http://www.floodinfo.ie/map/floodmaps/*
Ground Investigations	Previous ground investigations in the area have been consulted. Sourced at: *https://secure.dccae.gov.ie/goldmine/search.html*
Geological Survey of Ireland (GSI) Spatial Resources	GSI Teagasc subsoils map consulted to identify soil components around the development and to understand its behaviour.
Historical Maps	OSi Flood Maps assessed. Sourced at *http://map.geohive.ie/mapviewer.html*
News Reports	News reports published in newspapers or digital news websites.

3.3 Primary sources of baseline data

Preliminary Flood Risk Assessment

The PFRA is a national screening exercise, based on available and readily- derivable information, to identify areas where there may be a significant risk associated with flooding (referred to as Areas for Further Assessment, or AFA's). As part of the PFRA study, maps of the country were produced showing the indicative fluvial, coastal, pluvial and groundwater flood extents.

The PFRA map throughout the location of Route 0304 indicates several areas of high probability of pluvial flooding, meaning it is located within the 10% AEP (Annual Exceedance Probability) extents. The PFRA mapping does not indicate any fluvial, coastal or groundwater flooding within or in the vicinity of Route 0304.

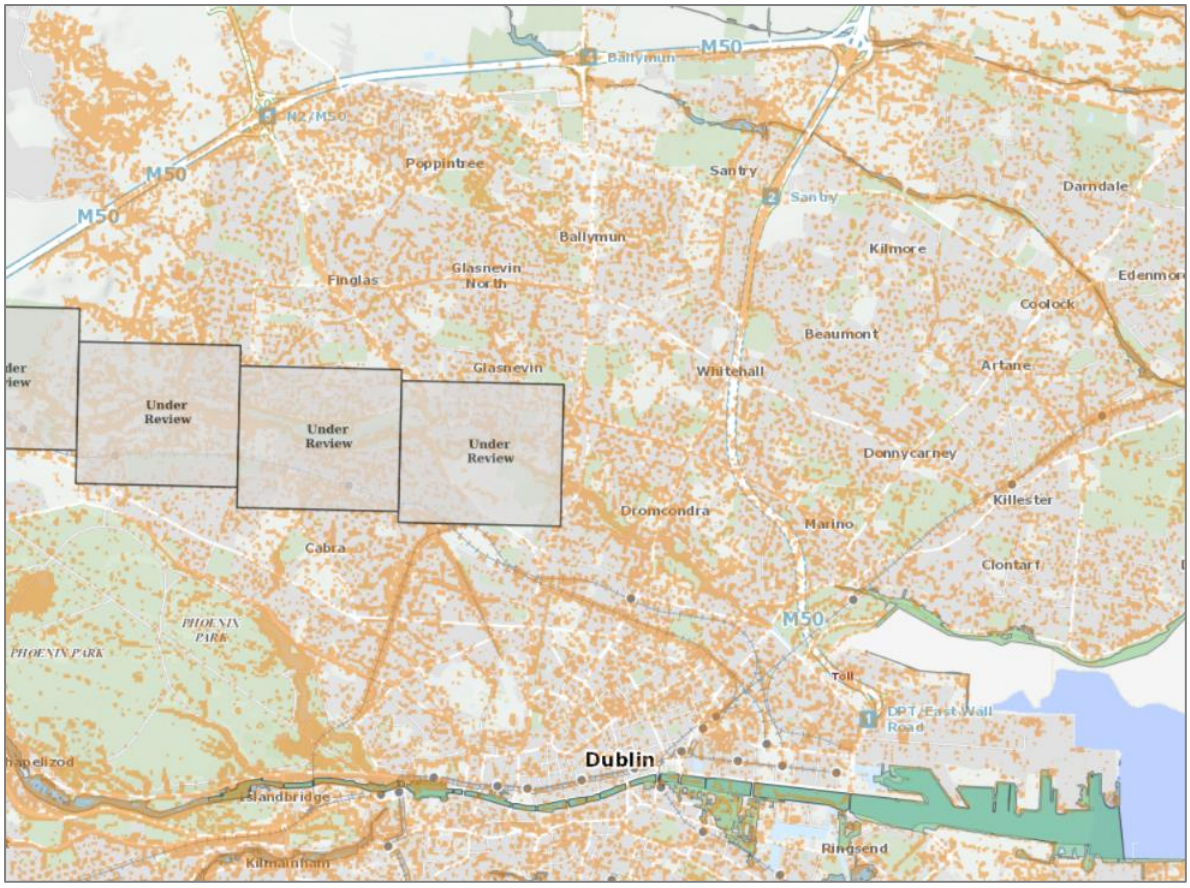

Figure 5. OPW Flood map showing high probability pluvial flooding (in orange)

OPW National Flood Hazard Mapping

The OPW National Flood Hazard Mapping Web Site (www.floodmaps.ie) was examined to identify any recorded flood events within the vicinity of the site. There are two recorded past flood events close to Route 0304: 150-160 Ballymun Road and close to the Tolka River, although as shown in Figure 4 this area is under review.

Ground Investigations

No ground investigations have been undertaken yet. Therefore previous ground investigations have been researched through GOLDMINE service in the Geological Survey website. These studies show the ground on the site to be mostly clay with a low permeability. Moreover, the studies show no presence of groundwater close to the surface. In areas close to the Tolka River and Royal Canal, there might be exceptions to this during high tide periods.

Secondary Sources of Baseline data

The following sources were also examined to identify areas that may be liable to flooding:

Table 4. Secondary sources of baseline data

Source	Data Gathered
GSI Maps	GSI Teagasc subsoils map shows Route 0304 is mainly underlain by made ground with low permeability. In the northern area and central there is some evidence of limestone next to Ballymun Road and to Tolka River. No evidence of Karst features has been identified within the vicinity of the site.
Historical Maps	No areas of the site have been identified as liable to flooding.

Source	Data Gathered
News Reports	An article published on *www.98fm.com* on the 14th November 2014 entitled "Southside Badly Flooded" mentioned flooding in Ballymun. An article published on *www.rte.ie* on the 2nd August 2014 entitled "Dublin City Council assessing flood risk after heavy rain, with more forecast" said 85mm of rain fell in some parts of the city overnight, with Ballymun worst affected. This is to be expected given 2014 was known for its heavy rains. No other news reports regarding flooding in the area have been found.

3.4 Conclusion of stage 1 SFRA

In accordance with Stage 1 of the approach outlined in the Guidelines, the possible sources of flooding associated with this development have been identified. These are summarised in Table 5 (taken from Appendix A of the Guidelines).

Table 5. Possible sources of flooding associated with Route 0304

Source	Pathway	Receptor	Likelihood	Consequence	Risk
Tidal	Overland flow, out of bank	Roads	Low	Medium	Low - Medium
Fluvial	Overland flow, out of bank	Roads	Low	Medium	Low - Medium
Surface Water / Pluvial	Overland flow, drains	Roads	High	Medium	High - Medium
Ground Water	Rising levels	Roads	Low	Medium	Low - Medium

4 STAGE 2 – INITIAL FLOOD RISK ASSESSMENT

4.1 General

A Stage 2 SFRA (initial flood risk assessment) was undertaken to:

- Confirm the sources of flooding that may affect the subject site;
- Appraise the adequacy of existing information as identified by the Stage 1 FRA.

4.2 Sources of flooding

Flooding from Fluvial & Sea Level Rises / Coastal Flooding

Route 0304 is in close proximity to the Liffey and Tolka River. The Liffey River is influenced downstream by the Royal Canal. OPW flood maps show Route 0304 is outside the boundaries of the flood zones and therefore no likelihood of flooding from this source can be expected.

Surface Water Flooding

Surface water flooding occurs when the local drainage system cannot convey stormwater flows from extreme rainfall events. The rainwater does not drain away through the normal drainage pathways or infiltrate into the ground but instead ponds on or flows over the ground instead. Surface water flooding is unpredictable as it depends on a number of factors including ground levels, rainfall and the local drainage network. There is no indication of previous issues with the existing drainage network. The proposed development includes some additional impervious areas; to address possible additional surface water SuDS measures have been studied, please refer to the SuDS proposal report for more information. The proposed site is not considered to require a detailed flood risk assessment with respect to flooding derived from surface water flooding.

Groundwater Flooding

Ground water flooding is a result of upwelling in occurrences where the water table or confined aquifers rises above the ground surface. This tends to occur after long periods of sustained rainfall

and/or very high tides. High volumes of rainfall and subsequent infiltration to ground will result in a rising of the water table. Groundwater flooding tends to occur in low-lying areas, where with additional groundwater flowing towards these areas, the water table can rise to the surface causing groundwater flooding. The sources consulted such as the OPW mapping and GSI records show no indication that Route 0304 is subject to Groundwater derived flooding.

Pluvial Flood Risk

Pluvial flooding results from heavy rainfall that exceeds ground infiltration capacity or more commonly in Ireland where the ground is already saturated from previous rainfall events. This causes ponding and flooding at localised depressions. Pluvial flooding is commonly a result of changes to the natural flow regime such as the implementation of hard surfacing and improper drainage design. OPW flood maps show distributed flooding from this source, SuDS measures have been proposed to mitigate the risk. Pluvial flooding will be considered in the modifications of the drainage system if and when needed.

4.3 Conclusion of stage 2 SFRA

The information provided in this section identifies that there is a risk of surface water flooding due to heavy rainfall and impervious surfaces combined with low permeability soils. This risk has been identified and addressed through the proposal of SuDS that will mitigate the risk. To that effect an additional report has been undertaken. With this flood risk will be mitigated and no Stage 3 Flood Risk Assessment is necessary.

5 RESIDUAL FLOOD RISK

As discussed above, a SuDS proposal has been submitted with this FRA. A thorough study of the area has been undertaken and different SuDS options have been considered depending on the adequacy of them relating to the design of the Core Bus Corridor. SuDS types proposed include: filter drains, bioretention systems, permeable pavement and opportunity spaces. These are expected to be sufficient to manage the increased impermeable areas and residual flood risk.

6 JUSTIFICATION TEST

The OPW Guidelines states that primary infrastructure such as national roads and bridges are classified as “highly vulnerable developments”. As per the sequential approach, a justification test has been undertaken for Route 0304.

Table 6. Justification Test for Development Management

	Justification Test for Development Management
1	**The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines.**
	Route 0304 from the Core Bus Corridors Scheme has been elaborated from an existing road network. To be able to fit the proposed cross sections, modifications to the existing road boundaries may be necessary; this will entail possible land acquisitions.
2	**The proposal has been subject to an appropriate flood risk assessment that demonstrates:**
2-A	**The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;**
	Medium flood risk from pluvial and surface water was identified during Stage 1 and 2 of the FRA. Given there are no known issues from the existing drainage systems and the additional impermeable areas are minimal, SuDS measures will be enough to manage them. Moreover, SuDS may reduce existing flood risk.
2-B	**The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;**

	SuDS measures are proposed to minimise flood risk, this include filter drains, bioretention systems, permeable pavement and other opportunity spaces.
2-C	**The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access;**
	The proposed development does not affect any existing flood defence measures. The proposed development includes measures to minimise overall flood risk as mentioned above.
2-D	**The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.**
	The proposed development will serve existing and future development within Dublin. The proposed project shall reinforce the transportation network, which will assist in achieving strategic planning objectives in the immediate vicinity and Dublin as a whole. The provision of such transport infrastructure can facilitate the organised expansion of towns and villages and have the capacity to cater for pedestrians and cyclists. The proposed development is of a contemporary design in keeping with best urban design practices. Moreover, includes environmentally-friendly and sustainable measures.

7 FLOOD RISK ASSESSMENT CONCLUSIONS

The BusConnects Core Bus Corridors: Route 0304 Ballymun / Fingas to the City Centre Scheme development has been assessed for existing and future sources of flood risk. The primary sources of flood risk identified for the site are from combination of surface water and pluvial sources.

A justification test was completed for the proposed development. The proposed development has been determined to have satisfied all requirements of the justification test. The proposed development is therefore suitable for the associated flood risk as per the OPW Guidelines.

APPENDIX A GLOSSARY OF TERMS

Catchment: The area that is drained by a river or artificial drainage system.
Catchment Flood Risk Assessment and Management Studies (CFRAMS): A catchment- based study involving an assessment of the risk of flooding in a catchment and the development of a strategy for managing that risk in order to reduce adverse effects on people, property and the environment. CFRAMS precede the preparation of Flood Risk Management Plans (see entry for FRMP).
Climate change: Long-term variations in global temperature and weather patterns, which occur both naturally and as a result of human activity, primarily through greenhouse gas emissions.
Core of an urban settlement: The core area of a city, town or village which acts as a centre for a broad range of employment, retail, community, residential and transport functions.
Detailed flood risk assessment: A methodology to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of flood hazard and potential risk to an existing or proposed development, of its potential impact on flood elsewhere and of the effectiveness of any proposed measures.
Estuarial (or tidal) flooding: Flooding from an estuary, where water level may be influenced by both river flows and tidal conditions, with the latter usually being dominant.
Flooding (or inundation): Flooding is the overflowing of water onto land that is normally dry. It may be caused by overtopping or breach of banks or defences, inadequate or slow drainage of rainfall, underlying groundwater levels or blocked drains and sewers. It presents a risk only when people, human assets and ecosystems are present in the areas that flood.
Flood Relief Schemes (FRS): A scheme designed to reduce the risk of flooding at a specific location.
Flood Defence: A man-made structure (e.g. embankment, bund, sluice gate, reservoir or barrier) designed to prevent flooding of areas adjacent to the defence.
Flood Risk Assessment (FRA): FRA can be undertaken at any scale from the national down to the individual site and comprises 3 stages: Flood risk identification, initial flood risk assessment and detailed flood risk assessment.
Flood Risk Identification: A desk- based study to identify whether there may be any flooding or surface water management issues related to a plan area or proposed development site that may warrant further investigation.
Flood Hazard: The features of flooding which have harmful impacts on people, property or the environment (such as the depth of water, speed of flow, rate of onset, duration, water quality, etc.).
Floodplain: A flood plain is any low-lying area of land next to a river or stream, which is susceptible to partial or complete inundation by water during a flood event.
Flood Risk: An expression of the combination of the flood probability, or likelihood and the magnitude of the potential consequences of the flood event.
Flood Storage: The temporary storage of excess run-off, or river flow in ponds, basins, reservoirs or on the flood plain.
Flood Zones: A geographic area for which the probability of flooding from rivers, estuaries or the sea is within a particular range.
Fluvial flooding: Flooding from a river or other watercourse.
Groundwater flooding: Flooding caused by groundwater escaping from the ground when the water table rises to or above ground level.
Initial flood risk assessment: A qualitative or semi-quantitative study to confirm sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information, to provide a qualitative appraisal of the risk of flooding to development, including the scope of possible mitigation measures, and the potential impact of development on flooding elsewhere, and to determine the need for further detailed assessment.
Freeboard: Factor of safety applied for water surfaces. It defines the distance between normal water level and the top of a structure, such as a dam, that impounds or restrains water.
Justification Test: An assessment of whether a development proposal within an area at risk of flooding meets specific criteria for proper planning and sustainable development and demonstrates that it will not be subject to unacceptable risk nor increase flood risk elsewhere. The justification test should be applied only where development is within flood risk areas that would be defined as inappropriate under the screening test of the sequential risk-based approach adopted by this guidance.
Likelihood (probability) of flooding: A general concept relating to the chance of an event occurring. Likelihood is generally expressed as a probability or a frequency of a flood of a given

magnitude or severity occurring or being exceeded in any given year. It is based on the average frequency estimated, measured or extrapolated from records over a large number of years and is usually expressed as the chance of a particular flood level being exceeded in any one year. For example, a 1-in-100 or 1% flood is that which would, on average, be expected to occur once in 100 years, though it could happen at any time.

Ordnance Datum (or OD) Malin: is a vertical datum used by an ordnance survey as the basis for deriving altitudes on maps. A spot height may be expressed as AOD for "above ordnance datum". Usually mean sea level (MSL) is used for the datum. In the Republic of Ireland, OD for the Ordnance Survey of Ireland is Malin Ordnance Datum: the MSL at Portmoor Pier, Malin Head, County Donegal, between 1960 and 1969. Prior to 1970, Poolbeg Ordnance Datum was used: the low water of spring tide at Poolbeg lighthouse, Dublin, on 8 April 1837. Poolbeg OD was about 2.7 metres lower than Malin OD.

Management Train/Treatment Train: the sequence of drainage components that collect, convey, store and treat runoff as it drains through the site.

Mitigation: The term is used to describe an action that helps to lessen the impacts of a process or development on the receiving environment. It is used most often in association with measures that would seek to reduce negative impacts of a process or development.

Pathways: These provide the connection between a particular source (e.g. High River or tide level) and the receptor that may be harmed (e.g. property). In flood risk management, pathways are often 'blocked' by barriers, such as flood defence structures, or otherwise modified to reduce the incidence of flooding.

Pluvial flooding: Usually associated with convective summer thunderstorms or high intensity rainfall cells within longer duration events, pluvial flooding is a result of rainfall- generated overland flows which arise before run-off enters any watercourse or sewer. The intensity of rainfall can be such that the run-off totally overwhelms surface water and underground drainage systems.

Regional Planning Guidelines (RPG): These provide the regional context and priorities for applying national planning strategy to each NUTS III region and encourage greater co- ordination of planning policies at the city/county level. RPGs are an important part of the flood policy hierarchy as they can assist in co-ordinating flood risk management policies at the regional level.

Resilience: Sometimes known as "wet-proofing", resilience relates to how a building is constructed in such a way that, although flood water may enter the building, its impact is minimised, structural integrity is maintained, and repair, drying and cleaning and subsequent reoccupation are facilitated.

Receptors: Things that may be harmed by flooding (e.g. people, houses, buildings or the environment).

Residual risk: The risk which remains after all risk avoidance, substitution and mitigation measures have been implemented, on the basis that such measures can only reduce risk, not eliminate it.

Sequential Approach: The sequential approach is a risk-based method to guide development away from areas that have been identified through a flood risk assessment as being at risk from flooding. Sequential approaches are already established and working effectively in the plan-making and development management processes.

Sustainable Drainage System (SuDS): Drainage systems that are considered to be environmentally beneficial, causing minimal or no long-term detrimental impact.

Site-specific Flood Risk Assessment: An examination of the risks from all sources of flooding of the risks to and potentially arising from development on a specific site, including an examination of the effectiveness and impacts of any control or mitigation measures to be incorporated in that development.

Source: Refers to a source of hazard (e.g. the sea, heavy rainfall).

Strategic Flood Risk Assessment: The assessment of flood risk on a wide geographical area against which to assess development proposed in an area (Region, County, Town).

Vulnerability: The resilience of a particular group of people or types of property or habitats, ecosystems or species to flood risk, and their ability to respond to a hazardous condition and the damage or degree of impact they are likely to suffer in the event of a flood. For example, elderly people may be more likely to suffer injury, and be less able to evacuate, in the event of a rapid flood than younger people.

Source: The definitions above are sourced from the DoEHLG Guidelines for Planning Authorities on 'The Planning System and Flood Risk Management, 2009' and Ciria 753 "the SuDS Manual".