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List of Abbreviations

GDSDS	Greater Dublin Strategic Drainage Study
I/I	Inflow/Infiltration
GIS	Geographical Information System
WC	Water Closet
SUDS	Sustainable Urban Drainage System
CSO	Combined Sewer Overflow
AFD	Anti-flooding Device
PS	Pumping Station

EXECUTIVE REPORT

Background

The Greater Dublin Strategic Drainage Study (GDSDS) requires the development of policies appropriate to the region. These policies would assist the local authorities to comply with their legal responsibilities, their planning and development objectives and would in so far as practicable, conform to good international practice. A particular requirement from the study is that policies adopted across the region should facilitate a uniform and consistent approach to urban infrastructure planning, design, construction and operation.

This section of the policies is entitled "Basements". Many older properties in the study area have basements with connections from basement level to old sewers and culverts. These can be prone to flooding at times of high flow and sewer surcharge. New developments or modifications to the existing drainage networks could result in existing basements being exposed to a higher risk of flooding. Basement flooding incidents could increase due to the impacts of climate change where both increased rainfall intensities and sea level rise are predicted

A policy in relation to basements is required to allow the local authorities decide

- if further development should be restricted because of the effect on the drainage system
- if anti-flooding protection devices should be retrofitted to the existing basement drainage
- how the policy should be financed

The objectives are to establish the locality and extent of basements in the study area, review the causes and risks of basement flooding, review national and international practice including the use of anti-flooding protection devices and to assess the options for financing and the legal and public relations implications to the authorities.

The policy for basements will require implementation at various levels including development plans, designs, planning studies, construction and operation and maintenance.

New Policies – Implications

1. **The adoption of new policies for basements will require systematic implementation through the Planning, Design, Construction and Operation/Maintenance aspects of drainage infrastructure.**

Basement Types

There are a number of different basement types in the study area. These include basements in old properties and basements in new or redeveloped properties. The impact of flooding is dependent on the use of the basement. In old properties basements originally intended as storage areas have been developed into living accommodation with the installation of fully fitted sanitary and utility appliances. In new and redeveloped properties they have been designed as residential or commercial properties and for car parking. These developments unlike the older properties are generally designed to current building codes and standards and are subject to the requirements of planning legislation.

Why Basements Flood

When flows to the sewer exceed the capacity of the system flows are released at the first opportunity. As basement drains are frequently constructed below the maximum level of effluent in the public sewer, sewage will often discharge into basements before overflowing at manholes. Basement flooding can be caused by a variety or combination of problems on the external sewer system or on private drains where there are localised deterioration problems or poorly designed and constructed drainage.

Basement Locations

There is no asset database showing the location and use of basements throughout the Dublin Region. Dublin City Council have prepared a database of properties with basements in the city centre area between the canals. Bord Gais have a database of basements limited to streets that were serviced by old cast iron gas mains.

Using this information the number of basements identified in the study area is 16,200. Given the limited data available the total number of basements is expected to greatly exceed this figure.

Without knowledge on the location and drainage of the basements the risk of flooding cannot be fully assessed when designing modifications to the drainage system or approving the planning of upstream developments.

Issues Governing Policy Options

There are a variety of issues that provide constraints on the policy options adopted. The local authorities are responsible under the Local Government (Sanitary Services) Acts for the provision, operation and maintenance of sewers in their jurisdiction.

In the case of storm and combined sewers it is not usually possible or economic to provide sufficient flow capacity to deal with extreme storm events. There is therefore a point beyond which it would be considered unreasonable to provide protection against basement flooding.

Basements are often constructed below the hydraulic gradient of the sewer and, especially in older areas of the catchments where the sewers are subject to frequent surcharging, the risk of flooding is high.

Where properties suffer repeated flooding from sewer surcharge owners and occupiers may have to pay higher insurance premiums or in some instances may not be able to obtain cover.

When considering planning applications under the Planning and Development Act 2000 the local authority has the opportunity to specify methods of preventing basement flooding as part of the process. However, conversions of existing basements are in many cases not subject to the planning act.

The Irish Building Regulations, 1997 Part H does not specifically cover basement drainage.

The prevention of basement flooding can often be economically achieved through the installation of anti-flooding devices or pumping systems on private drains. This requires the consent of owners. The issue of which party is responsible for the capital and operating and maintenance costs needs to be resolved.

Review of National and International Practice

While some local authorities implement a policy at planning control stage in relation to basement drainage there is no written Irish National policy on this issue.

Internationally there are a variety of policies and recommended practices relating to basement flooding. In Sweden sewers are required to have a capacity such that flooding will not occur more often than 1 in 10 years. CIRIA in the UK consider designs for return storms of 1 in 25 years as “acceptable”. In Germany all inhabited basements are required to be drained using a pumped system thus isolating the basement from the risk of flooding.

In the UK when the sewerage undertaker proposes to install anti-flooding devices or pumping stations on private drains agreement is reached with the property owner. No legally prepared documents are used and the liability for mechanical failure lies with the undertaker. In Canada subsidy schemes have been

introduced to cover the cost of installation. On such schemes responsibility for maintenance and operation remains with the owner/occupier.

Risk of Flooding

Basements are at risk of flooding in the future from increased flows due to upstream developments, increased inflow and infiltration due to deterioration of the drainage system, more frequent high intensity storms and sea level rise predictions associated with climate change, increased groundwater levels and the change of use of basements from storage areas to living space.

Asset Database

To assess the extent of basement flooding it is necessary for the local authorities to establish and maintain a database of basements. This database in GIS format would include information on the location, floor level and use of the basement. Any information on flooding history and the cause of flooding would also be included.

Use of Hydraulic Models

Where numerical models of the sewerage system have been constructed they should be used in association with the asset database, to establish the existing risk of basement flooding and future risks due to additional development and alterations to the existing drainage infrastructure.

Management of Basements - Summary

2. **Establish Database of Basements and Flooding Incidents.**
3. **Use Database and Hydraulic Models to establish a register of at risk properties.**
4. **Use Planning and Development Act to protect basements from flooding.**
5. **Incorporate basement drainage requirements into the Building Regulations.**

Methodology for Preventing Flooding

There are three general methods of preventing flooding of basements through external improvements to the sewerage system. ***Transport and Treat*** requires the construction of sewers, treatment works and other infrastructure large enough for peak wet weather flows without surcharge. ***Detention*** requires the construction of storage tanks to balance flows in the system and control peak flows and therefore reduce surcharge levels. ***Source Removal*** requires the identification and removal of infiltration and inflow into the system to reduce peak flows. These solutions incur high capital costs and take a long time to implement.

Surcharge Management uses local sub-catchment drainage schemes or modifications to private drainage to isolate basements from the effect of sewer surcharge levels. This can include the installation of anti-flooding devices, pumping stations, vacuum sewerage systems or by-pass sewers. These solutions incur lower capital cost and can be implemented within a short-term horizon.

Criteria on Flooding Frequency

As any level of sewer surcharge could potentially cause basement flooding it is difficult to adopt a general criteria on flooding frequency. The design and construction of sewers to prevent surcharge in a 1 in 25 year design storm could prove difficult and expensive to implement. Alternatively a situation where a sewer surcharge frequency of 1 in 2 years causes basement flooding is clearly an unacceptable situation. The adoption of a holistic approach to drainage planning when selecting methods for prevention of basement flooding is favoured. However, the implementation of surcharge management policies can provide a low cost solution to localised basement flooding and can protect against long return period storms.

Surcharge Management

Flooding of basements is typically caused by backflow through the low level drainage connection between the basement and the pubic sewer. Options for dealing with this problem include:

- installation of anti-flooding devices to prevent backflow
- pumping drainage flows from the basement to the public sewer
- pro-active maintenance where flooding is due to deposits or blockages in the public sewer
- purchase of the basement in situations where no other options are feasible and the flooding is clearly the responsibility of the local authority

Anti-flooding devices (AFDs) Type 2 and Type 3 in accordance with the draft European product standard should be considered when the following criteria are satisfied:

- sewer flooding occurs below ground level due to surcharge from a public sewer
- the AFD services one property and is not installed on combined drains
- the surface water contributions are excluded or diverted
- the AFD does not transfer the problem to another property
- access is available for routine, six monthly, inspection and maintenance

Pumping systems should be designed and installed in accordance with current and draft European Standards. Pumping options which discharge above sewer surcharge levels provide additional security on mechanical failure when compared with AFDs as damage will be limited to flows from within the property.

Selection of the most appropriate option should take account of technical, environmental and economic factors.

Protection of Basements - Summary

6. **Select prevention options based on flooding frequency, technical and economic benefits.**
7. **Install pumps in preference to AFDs.**
8. **When fitting AFDs use Type 2 or Type 3 complying with European Standards.**

Financing of Basement Policy

Basement flooding protection requires infrastructure improvements, which require financing.

Protection of developments, which are subject to the Planning and Development Act 2000, can be conditioned as part of the planning process. Capital, ongoing operating costs and overall maintenance responsibility remains with the owner.

In the situation where upstream development increases flows in the sewer and increases the risk of flooding, the planning authority can refuse planning permission, condition or implement drainage infrastructure improvements and recoup costs from the developer in the form of development charges.

Existing basement locations are at risk from a number of factors including changes to the infrastructure, deterioration of the system with age, climate change and change of use.

Many owners are unaware of the risks of basement flooding, the adequacy of their basements drainage and the increased risk due to changes in use of the basement. Where an AFD or pumping station is installed the owner is responsible for the long term repair and maintenance.

The local authorities should introduce a public awareness campaign to explain to homeowners the causes of and methods of protection of basement flooding. The campaign should provide technical advice on the installation of pumping stations and AFDs. The insurance industry should be approached to assist with this campaign.

Financing - Summary

9. Use Planning and Development Act to condition and finance infrastructure improvements.

10. Use a public awareness campaign to inform homeowners of the causes of flooding and methods of prevention.

1. INTRODUCTION

1.1 Background to the GDSDS

The Greater Dublin Strategic Drainage Study requires the development of policies appropriate to the provision of future drainage services in the region. These policies would assist Local Authorities to comply with their legal responsibilities, their planning and development objectives and would, in so far as practicable, conform to good international practice. A particular requirement from the study is that policies adopted across the region should facilitate a uniform and consistent approach to urban drainage infrastructure planning, design, construction and operations. This policy deals with the issue of basements.

1.2 Background Investigations

Many older properties in the study area have basements with existing drainage connections from basement level to old sewers and culverts. These can be prone to flooding at times of high flows or during sewer surcharge conditions. Even where there is no history of flooding new developments contributing increased flows to the existing sewers or modifications to the drainage infrastructure that change the system hydraulics can cause flooding. A policy in relation to basements is required to allow the local authorities decide:

- If further development of older properties or areas upstream of them should be restricted because of the effect on the hydraulic loads in the drainage system.
- If anti-flooding protection devices should be retrofitted to the existing basement drainage.
- On how the recommendations of the policy should be financed.

The policy on basements should be integrated with the other regional policies being prepared under the GDSDS.

1.3 Report Objectives

The objectives of this technical document are to establish the locality and extent of basements within the study area, review the known causes and risks of basement flooding, review national or international practice in relation to basement drainage including the use of anti-flooding protection devices and their operation and maintenance and to assess the options for financing and the legal and public relation implications to the Local Authorities. Based on this review the document will provide conclusions, recommendations and policies in relation to basements.

1.4 Report Format

An executive summary is included at the front of the main document. This summary provides an appreciation of the issues surrounding the requirements for policies in relation to basements and highlights the main policy recommendations included in the main document.

The technical document is divided into six chapters as follows:

Chapter 1 provides an introduction outlining background, policy requirements and report objectives.

Chapter 2 assesses the management of basements, describes the type, extent and use of basements, explains why basements flood, details the risk to basements of flooding, reviews national and international practice and the external constraints relating to flooding of basements.

Chapter 3 examines the methods of controlling flooding to basements, a review of criteria for flooding frequency, a review of basement drainage construction and protection strategies and their operation and maintenance.

Chapter 4 reviews the options for financing drainage improvements and the public information campaign necessary to implement a strategy to retrofit drainage improvements on private properties.

Chapter 5 summarises the study conclusions and sets out the policy recommendations.

Chapter 6 includes a list of references used in research for this policy.

2. MANAGEMENT OF BASEMENTS

2.1 Basement Type

There are a number of different basement types in the study area. These include basements in old properties and basements in new or redeveloped properties.

Basements in the older properties can be broadly sub-divided into two categories.

Full Basements - With full depth of construction below ground level. In some locations, for example, the old commercial centres of towns and suburban villages, the basements can extend under the footpath or roadway. An example of full basement construction is shown on Figure 2.1. In some instances full basements are not evident from an inspection of the exterior of the property. No windows or streetlights are evident and on sloping sites basement windows can be at the rear of the property.

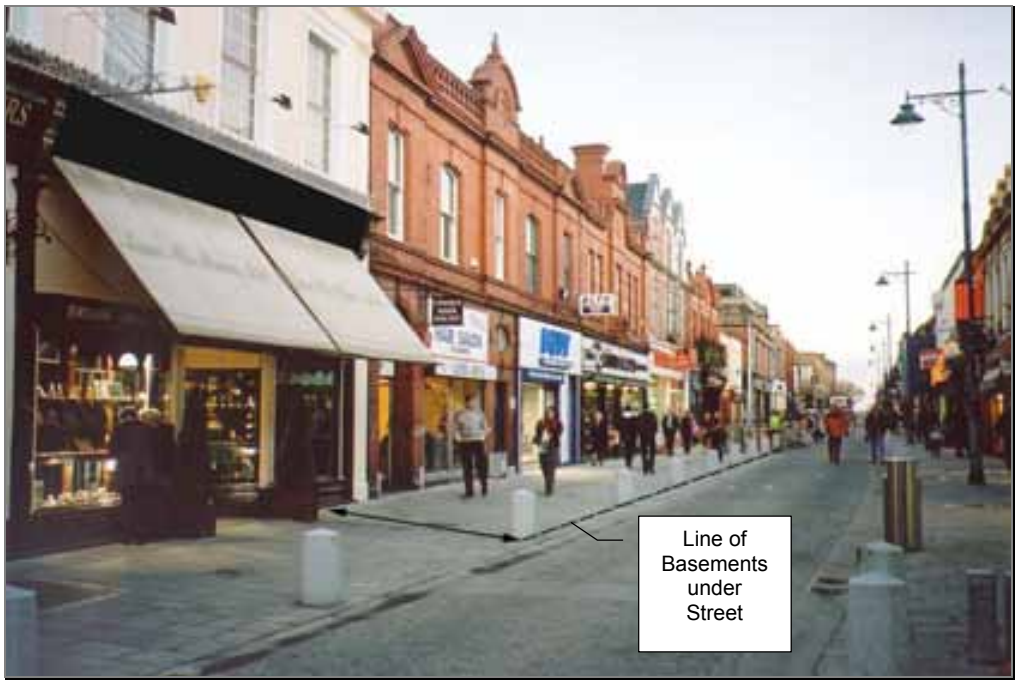

Figure 2.1 Full Basement in Commercial Area

Half Basements - Constructed part above ground and part below. They are normally evident from an inspection of the exterior of the property. An example of half basement construction is shown on Figure 2.2.

Figure 2.2 Half Basement in Residential Area

The impact of flooding, with its associated damages, inconveniences and health risks is dependent on the use of the basements. Basements in old properties were typically intended to be used for storage. Some have been fitted with sanitary and utility appliances and others have been developed into living accommodation. This situation is continually changing with the number of conversions of available basements to living space increasing. This change of use has traditionally been implemented without full knowledge of the flooding risks involved.

In newly constructed or redeveloped properties basements have been designed as residential or commercial properties and for car parking. Unlike the older properties, where conversions have not been subject to the requirements of planning legislation, these are generally designed to current building codes and standards.

2.2 Why Basements Flood

When the flows in the sewer exceed the capacity of the sewerage system, flows will be released at the first opportunity. Where overflows are not available sewer pipes will surcharge and hold sewage until it reaches a level greater that the lowest point of relief. As basement drains are frequently constructed below the hydraulic gradient sewage will often discharge into basements before overflowing at manholes.

Basement flooding can be caused by any or combinations of the following problems on the external sewer system:

- high intensity storms on stormwater and combined sewer systems
- excessive infiltration/inflow in the system
- combinations of wet weather and tidal influence
- sewer blockages or breaks
- mechanical failure of pumping plant
- operator errors

Common routes of entry into basements include:

- backflows through the drainage system due to surcharge
- increased groundwater levels causing ingress through cracks in the walls
- overland flooding entering through air vents or other apertures at ground level

Individual properties which experience more frequent backups or flooding than those adjacent are often found to have localised deterioration problems or poorly designed and constructed drainage systems.

A new development upstream of a basement can not only increase the amount of wastewater entering the sewers but also add to the inflow/infiltration (I/I) entering the system from private sources. Studies in Michigan and elsewhere in the USA have demonstrated that it is not unusual for 50 to 90 per cent of I/I to originate in private properties. These developments can increase the volume and frequency of flooding to basements if not properly planned and controlled. In some locations a number of local authorities share a common interceptor or trunk sewer and backups and flooding in the system can occur within one local authority area even though the additional flows originated within another authorities jurisdiction.

Many new developments in the Dublin region incorporate underground or basement car parks. Flooding at road level can cause ingress of stormwater into the car park. Pumps are often inadequate to drain the basements in such situations and the power supply if inappropriately located in a basement may also be affected by floodwaters resulting in no power being available for pumping. It is good design practice to ensure that entrance levels to car parks are above road level and that pump sumps are located in positions accessible by the emergency services.

2.3 Basement Locations

There is no asset database available that shows the location and use of basements throughout the Dublin Region. Dublin City Council has a database in GIS format showing the outline of buildings with basements in the city centre area between the canals. This database, which was prepared for property rating purposes, includes information on basement usage. No level information or information on the drainage system inside the building is provided.

A further database of basements was produced by Bord Gais around 1993. The survey did not locate individual basements. Each street was divided into 100m segments and the presence or absence of basements recorded. The survey was limited to those streets that were serviced by old cast iron gas mains. No level information or information on usage of basements was included in the survey.

Using the available data, maps have been prepared for the Dublin City Council, South Dublin County Council, Fingal County Council, Dun Laoghaire-Rathdown County Council and Bray Urban District Council areas. No information was available on basements within the other local authority areas.

It is known that basements are also located outside the identified areas. The number of basements identified in the study area is circa 16,200. However, given the limited nature of the data available the total number is expected to greatly exceed that figure.

2.4 Issues Governing Policy Options

In accordance with the Local Government (Sanitary Services) Acts 1878 to 1964 the local authorities are responsible for the provision, operation and maintenance of sewers in their jurisdiction. The definition of sewers under their control is defined under the Acts.

A combined drain is defined as a single private drain used for the drainage of two or more separate premises. The definition is included in Section 10 of the Local Government (Sanitary Services) Act (No. 3 of 1948).

Both drains and combined drains are private drains, for which responsibility is not vested in the local authority.

Whatever may be the cause of flooding, owners and occupiers of properties that experience basement flooding from sewers are unlikely to consider that it represents an acceptable level of service from the local authority. The problems can vary in severity from temporary inconvenience such as the inability to flush WCs for short periods to serious flooding damage and distress to the occupiers. When basement flooding is widespread it tends to receive prominent attention in the media and can adversely impact on the public's perception of the local authority.

In the case of storm and combined sewers it is not usually feasible or economic to provide sufficient flow capacity to deal with extreme storm events. There is therefore a point beyond which it would be considered unreasonable to expect local authorities to provide assurances against basement flooding.

Basements are frequently located below the hydraulic gradient of the sewer. As the drainage systems in older areas of the catchments, where the basements are most common, were designed for duration storm events of 1 in 5 years or less, frequent surcharging of these sewers will occur and the risk of flooding of basements in these areas will be high.

If individual properties or localised areas have suffered repeated flooding from sewers, owners and occupiers may be required to pay higher insurance premiums and in certain instances may not be able to obtain adequate cover. In such cases those affected could expect the local authority to deal with the cause of the damage and the costs involved providing the owners have installed and maintained pumping stations or anti-flooding devices.

It is worth noting that many basement flooding incidents may go unreported. The owner or occupier of the property may consider the problem to be minor or may wish not to publicise the issue for fear of reducing the market value of the property or making it more difficult to rent.

New buildings and the renovation of buildings that affect change of use or modifications to the elevations of the property require planning permission. These are governed by the "Planning and Development Act 2000". When considering the application the local authority has the opportunity to consider drainage issues and can specify methods of preventing basement flooding as part of the planning approval.

Conversions of existing basements into habitable accommodation would not normally be considered a development under the Planning and Development Act and drainage from conversions of basements are, in most instances, unlikely to be notified to or identified by the local authorities.

Drainage is covered by the Irish Building Regulations, 1997 Part H. These regulations apply to new build situations and in the case of material alterations or changes of use. While the regulations include requirements, general guidelines and codes, standards and technical specifications they do not specifically cover basement drainage.

The prevention of basement flooding, due to problems in the external sewerage system, can often be economically achieved by isolating the private drain from the local authority sewer through the installation of anti-flooding devices or small pumping installations. Should the local authority retrofit these to existing basements it would require the consent of the owner and occupier.

2.5 Review of National and International Practice

Some local authorities, including those within the GDSDS area, have standard planning conditions that apply to basements in new developments. These conditions include a requirement for all drainage to discharge at ground level before falling by gravity to public sewers. In applications including basement car parks the requirement to include light liquid separators is also conditioned. However, there is no written Irish national policy on basement drainage practice.

Internationally there are a variety of policies and recommended practices related to basement flooding and its prevention.

In Sweden the policy in relation to basement flooding states that pipework should have a capacity such that flooding will not occur more than once in ten years. While this may be accepted for basements that are unoccupied it is unlikely to be an acceptable standard for basements that are occupied.

In the UK CIRIA, in their publication “Low Cost Options for Prevention of Flooding from Sewers”, 1998, considers that an appropriate level of performance that might be considered “acceptable” is a sewerage system that can handle storms with return periods up to about 25 years without flooding.

In Germany national regulations require that all inhabited basements, below the expected flood level, be drained using a pumped system. This isolates basements from the risk of flooding from sewer surcharge under all storm conditions.

In the UK, when the sewerage undertaker proposes to install anti-flooding devices in private drains or pumping stations, a form of agreement is reached with the property owner concerning the cost of the installation. Current practice varies between the different undertakers. Some have standard forms of agreement while others rely on ad-hoc agreements. Legally prepared documents are not normally used for installations made by the undertaker on private property. The liability, if the device fails to operate, correctly lies with the sewerage undertaker, thus exposing them to liability for the full cost of any damage that would occur. In the agreements the responsibility for maintaining the anti-flooding devices may lie with either the owner or the undertaker. Unless regular maintenance is carried out the full benefit from the investment made in installing devices, will not be obtained.

In Canada, the City of Toronto introduced a flooding protection subsidy scheme for the installation of approved anti-flooding devices and pumping stations. The scheme incorporated a requirement to disconnect rainwater outlet downpipes to provide stormwater separation and hence reduce flows to the city sewers. The scheme was backed up by a strong public information campaign.

2.6 Risks of Basement Flooding

Basements are at future risks of flooding due to:

Upstream Developments – increased flows or I/I into the upstream sewers can increase the levels and frequency of surcharge in the downstream sewers.

Inflow and Infiltration – the deterioration of the system with the age and the uncontrolled additions of surface water connections can increase I/I to the system and the level and frequency of surcharging.

Climate Change – more frequent high intensity storms and increases in sea levels affecting downstream sewer hydraulics could increase the level and frequency of surcharging. Overland flooding in high intensity storms can enter through air bricks or other apertures at ground level.

Increasing Groundwater Levels – an increase in existing groundwater levels due to the implementation of poorly designed SUDS schemes could cause basement flooding through increased water pressures causing ingress through cracks in walls.

Change of Use of Basements – the change of use of basements and the installation of sanitary fittings and utility appliances not previously connected to the existing drainage system.

2.7 Asset Database

To identify the extent of basements at risk of flooding it is first necessary for the local authorities to establish the location, level and use of basements in their jurisdiction. An asset database of all basements in each local authority area should be developed and maintained. The database should be populated with address point data, basement usage description, floor level of basement, drainage details and flooding history. In establishing the flooding history it is necessary to make the best use of available information. This includes information from maintenance personnel and from occupiers of properties.

The maintenance crews, that are called out to deal with sewer problems, normally provide most of the information concerning flooding incidents and it is important to make the best use of this information. Forms recording data and database templates should be practically based and unambiguous. Sketches and plans can add clarity to the information. In many incidents the maintenance teams find it difficult to determine the cause of flooding. In such cases, a drainage engineer should carry out a follow up investigation immediately after the incident to identify the cause and enable a complete record of the incident to be made.

Initial reports on flooding incidents are usually made by occupiers of the properties who have been directly affected or inconvenienced by the flooding incident. They therefore provide the primary information to the maintenance crews and to the follow up investigations. This information should be recorded at the time it is received and not later away from the site.

2.8 Use of Hydraulic Models

Where numerical hydraulic models have been constructed they should be used in association with the asset database to establish the:

- existing risk of basement flooding
- future risks of basement flooding due to:
    * future development
    * alterations to the drainage infrastructure

The model should be used to check the relationship between floor levels from the asset database with hydraulic grade levels within the sewer outside the property. If the floor level is below the predicted hydraulic gradient then flooding will most likely occur.

With new developments upstream or modifications to the drainage infrastructure the models should be used to establish the effects of these changes on surcharge levels in the downstream sewers and their impact on basement flooding.

From the database basement levels can be mapped and compared with sewer surcharge levels and predictions.

Caution should be taken in such model predictions and an allowance for tolerances in levels made in the assessment of basements liable to flooding.

The model should also be used to analyse flooding incidents and develop solutions to these and other operational problems on a catchment-wide basis.

Where hydraulic models are not available the assumption is normally made in the assessment of basement flooding that the sewers can potentially surcharge to ground level.

3. PROTECTION OF BASEMENTS

3.1 Methodology for Preventing Flooding

There are four methods of preventing basement flooding from surcharging that can be adopted on public sewerage systems, namely:

3.1.1 Transport and Treat

Transport and treat requires the construction of sewers, storm overflows, pumping stations and treatment works large enough to accommodate peak flows. By designing conveyance facilities large enough for wet weather peak flows the wastewater will be transported away and will not cause surcharge and flooding unless storms exceed design capacity.

Advantages:
- Little disruption to private properties.

Disadvantages:
- Design and implementation will take many years to complete.
- Capital costs will be high.
- Must be designed for the given storm intensity and risk of sewer surcharge remains with higher storm intensity.
- Construction causes disruption on public roads.

3.1.2 Detention

Detention requires the construction of storage facilities on public lands that will fill when the flow exceeds the capacity of the existing system. The provision of storage can maintain the hydraulic gradient below basement floor level and therefore control basement flooding. This technique normally requires the construction of pumping stations to lift wastewater from the storage system into the sewer after the peak flow event has passed.

Advantages:
- Little disruption to private properties.
- Reduces peak flows so they have a minimal impact on CSOs and treatment works.

Disadvantages:
- Design and implementation will take many years to complete.
- Land for construction of storage will prove expensive and difficult to obtain in urban areas.
- Capital costs will be high.
- Maintenance costs will be high.
- Must be designed for a given storm intensity and risk of sewer surcharge remains with higher storm intensities.
- Construction causes localised public disruption.

3.1.3 Source Removal

Source removal consists of identifying the sources of infiltration/inflow (I/I) into the system and methods of reducing it in the sewer system. This option involves a detailed study to locate the sources of I/I and requires construction works to remove I/I, provide separate stormwater systems or divert flows using additional combined sewer overflows (CSO). As a large proportion of I/I is likely to originate on private properties this method requires the co-operation of the property owners.

Advantages:
- Reduces infiltration and stormwater inflows.
- Reduces flows to treatments with the associated cost benefits.

Disadvantages:
- Requires long-term commitment to sewer rehabilitation.
- Design and implementation will take long time to implement.
- Capital costs will be high.
- The benefits of source removal can be offset by a loss of environmental benefits from the introduction of CSOs.
- Disruption to both public and private property.
- Requires ongoing monitoring to maintain benefits.

3.1.4 Surcharge Management

Surcharge management uses local sub-catchment drainage schemes or modifications to the existing private drainage systems to isolate basements from sewer surcharge levels. This can include the installation of anti-flooding devices, pumping stations, vacuum sewerage systems and by-pass sewers.

Advantages:
- Design and implementation can be completed within short-term horizons.
- Protects properties from high intensity storms.
- Low capital cost.

Disadvantages:
- If not properly designed it can move the problem of surcharge to other locations.
- Does not control surcharge levels or reduce I/I in sewers.
- Requires agreement with property owners.
- Mechanical devices require high degree of maintenance and may fail if not properly maintained.
- May cause structural damage to property if not adequately designed and installed.

The first three methods of preventing flooding transport and treat, detection and source removal can be categorised as prevention of surcharge through improvements to the drainage system. The fourth method is management of surcharge using isolation systems.

OFWAT, the regulator in the UK, has advised the sewerage undertakers that the introduction of anti-flooding devices (AFDs) is not an acceptable means of removing properties from the register of properties assessed to be at risk because of hydraulic overloading of sewers. This is partly because AFDs do not ensure a permanent drainage connection between properties and the public sewer, resulting in the residual risk of the property flooding from its own discharges. The use of AFDs does not lead to an improvement in the public sewerage system which is one of the objectives of the increased expenditure approved by Ofwat to some undertakers. However, this ruling has not prevented the sewerage undertakers installing AFDs where they consider them appropriate.

In Canada and the USA the use of anti-flooding devices as a method of preventing basement flooding is widespread and has been supported by subsidy schemes to finance their installation.

The introduction of surcharge management systems provides a low cost solution to single or localised basement flooding that can be implemented within a short time frame.

Improvements to the drainage system are more appropriate where basement flooding extends over a large area and the problems can be resolved as part of overall drainage area planning.

The selection of an appropriate methodology to reduce the risk of basement flooding can only be taken following a detailed assessment of the problem and the completion of a cost benefit analysis of the possible solutions.

3.2 Review of Criteria on Flooding Frequency

Basements are at risk of flooding from surcharging of sewers through backflows through the drainage system and, in incidences where surcharge levels exceed the ground level at the sewer manholes, from overland flows.

The Swedish VAV Publication July 1995 “Basement Flooding” makes it policy for all local authority sewers to have sufficient capacity such that flooding will not occur more frequently than once every ten years.

CIRIA, in their publication “Low Cost Options for Prevention of Flooding from Sewers”, considers that what constitutes an “acceptable” level of performance is not usually precisely defined because it will vary with circumstances. However as a guide a sewerage system that can handle storms with return periods up to about 25 years without flooding might be considered as being “acceptable” in items of flow capacity.

The WRC, in their Sewer Rehabilitation Manual, give guidelines in relation to surcharge and its effect on the structural sewer conditions and suggests that on new build sewers surcharge should not exceed a frequency of 1 in 2 years. In Dublin there are a large number of existing sewers that are subject to frequent surcharge due to tidal conditions. In general it is not practical that these sewers be re-laid or isolated from the influence of the tide to meet with this surcharge criteria.

As any level of sewer surcharge could potentially cause basement flooding it is difficult to adopt a general criteria on flooding frequency. The design and construction of sewers to prevent surcharge under a 1 in 25 year design storm solely to protect existing basements could prove difficult and expensive to implement. Alternatively a situation where a sewer surcharge frequency of 1 in 2 years or less causes basement flooding is clearly an “unacceptable” situation.

The adoption of a holistic approach to drainage planning when selecting methods for prevention of basement flooding is favoured. The implementation of surcharge management policies as set out in Section 3.1.4 provides a low cost solution to localised basement flooding and can protect against long return period storms.

3.3 Surcharge Management

Flooding of basements is typically caused by backflow through the low level drainage connection between the basement and the public sewer. The remaining property above ground level is not subject to flooding and in this case it is assumed that other adjacent properties are not suffering similar problems.

Situations where this case is relevant include:

- conversion of cellars into occupied basements
- underground car parks and storage areas

An example of this situation is shown on Figure 3.1.

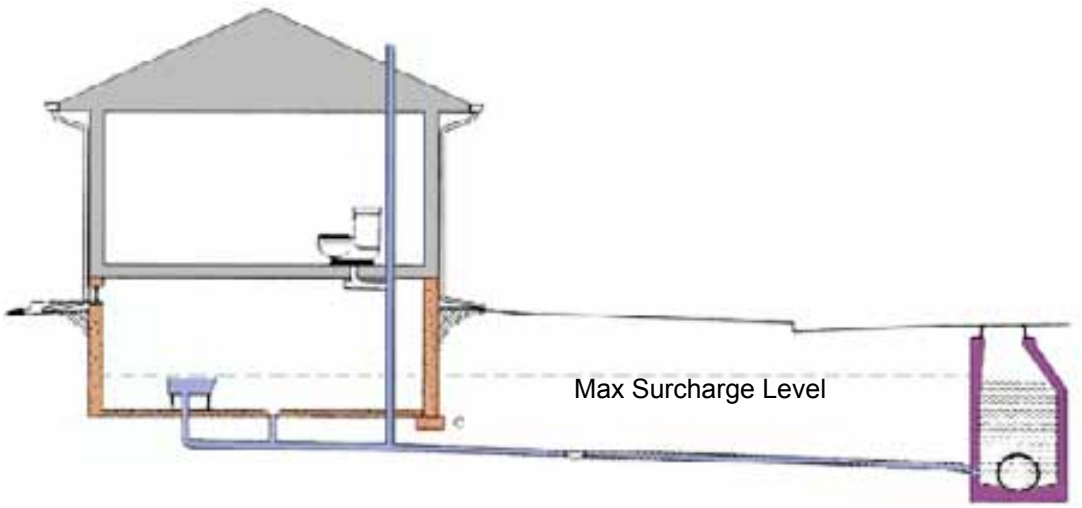

Figure 3.1 Backflow under Surcharge conditions

Five methods for alleviating flooding have been identified These include the use of communal systems which are often not favoured by the Sanitary Authority:

Anti Flooding Devices (AFDs) – to prevent backflow from the public sewer.

An AFD may have an automatic closure device (eg a hinged flap that closes when the flow direction is reversed or a powered closure device linked to a sensor and/or an alarm).

The AFD may be fitted to individual property drainage. In situations where flooding of multiple basements is occurring the drain connection of the affected properties may be disconnected and reconnected to a new gravity rider sewer. This rider sewer would then discharge to the public sewer via an AFD, as illustrated on Figure 3.2. This arrangement does not require pumping but additional flow storage may be necessary to prevent flooding from sources within the property. The volume required will depend on the duration of surcharge in the public sewer.

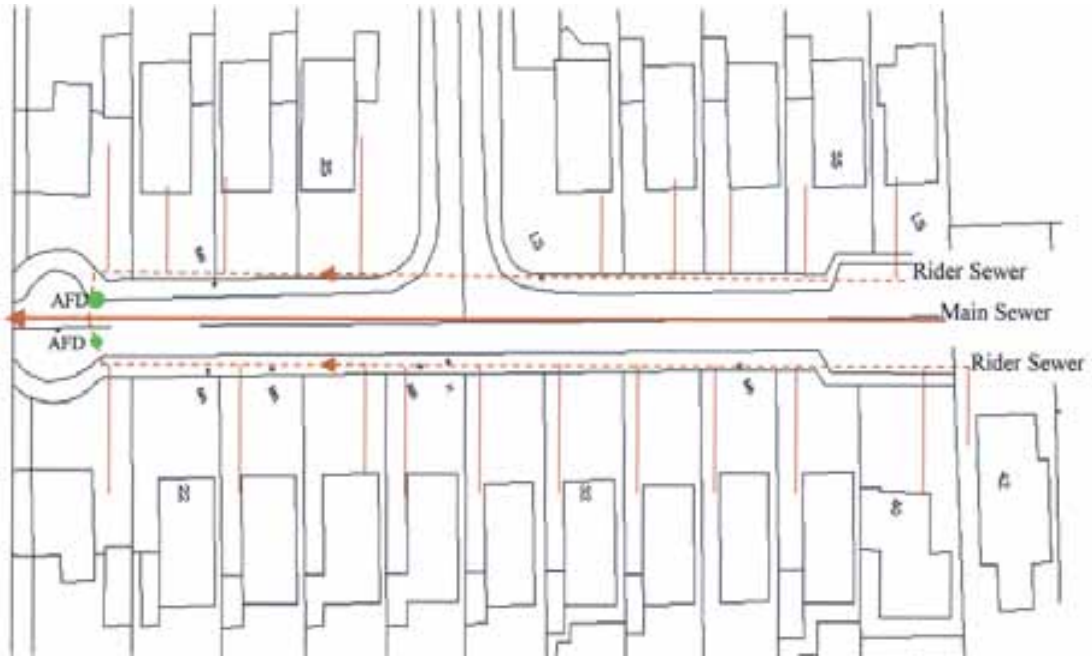

Figure 3.2 Anti Flooding Devices (AFD) with a Rider Sewer

Pumping – to pump drainage flows from the basement to the public sewers using one or more small macerating pump.

The pumps are installed in collection tanks and use small bore pipework which should be taken above ground level in order that flows can be discharged to the public sewer under all conditions of surcharge. Individual sanitary and utility appliances can be fitted with individual pumps or alternatively a single larger unit as illustrated on Figure 3.3 may be installed below the floor to deal with all drainage flows from the basement.

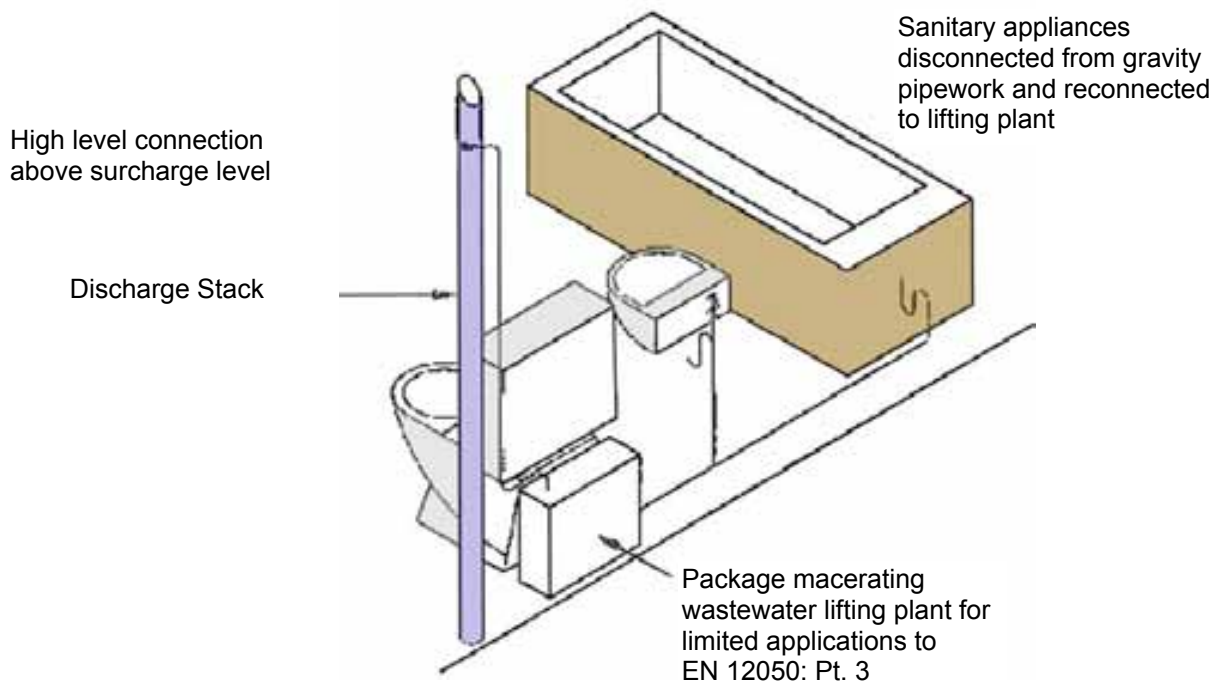

Figure 3.3 Use of Pump

The pumping stations may be installed for individual properties or in the situation where flooding of multiple basements is occurring the drains from connections of the affected properties may be disconnected and reconnected to a new gravity rider sewer. This rider sewer would then connect to a single pumping station (SPS) where flows would be lifted into the public sewer above the maximum surcharge level. A central pumping station facilitates the use of standard equipment with proven reliability. The system is illustrated on Figure 3.4. A suitable site with public access is required for this installation.

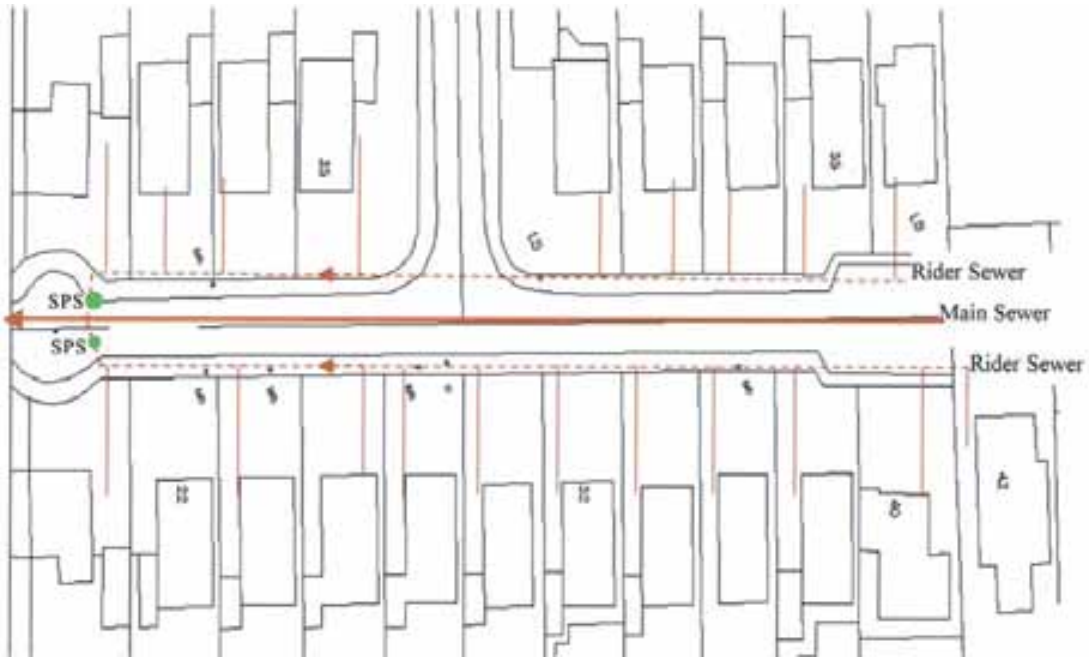

Figure 3.4 Pumping Station (PS) with Rider Sewers

Vacuum Systems - in cases where the disconnection of private drains from the public sewer necessitates the construction of deep rider sewers or multiple pumping stations consideration could be given to the installation of a vacuum sewerage system to transfer flows from individual properties to a central collector station from where they can be pumped to the public sewer above surcharge level. A suitable site with public access is required for this installation.

Additional care must be taken in designing the capacity of pumping and vacuum systems in areas where stormwater contributes to the private drains.

Pro-active Maintenance – where flooding is due to build up of deposits or blockages in the public sewer causing surcharge routine maintenance should be adopted as the primary measure to prevent flooding.

Purchase of the Basement – in situations where no other options are feasible and where the flooding of the basement is clearly the responsibility of the local authority purchase of the basement or alternatively purchase of the property can be a solution. The basement can then be filled, sealed up and the property resold.

3.4 Anti Flooding Devices

An anti-flooding device (AFD) is an in-line device designed for installation in a gravity sewer or drain to prevent backflow. In order to operate effectively it needs to cause a minimum of extra head loss when open and be resistant to blockages. The AFD may contain one or more closure devices which can include flap gates, gate valves or ball valves. The majority of AFDs commercially available use flap gate technology.

Other types of backflow preventors include tide flaps and check valves. These are not normally suitable for use in gravity systems either because of the high head loss produced or their unreliability to seal when rags, grit and faecal solids are in the flow. They are not recommended for consideration as AFDs.

A draft European product standard covering anti-flooding devices has been prepared by the CEN Technical Committee TC 165/WE 4/A HG 5 and awaits approval by European national votes.

Part 1 of the standard defines technical requirements for the following classes of anti-flooding devices:

- **Type 1** for use in horizontal pipes having an automatic closure device and an emergency closure device that can be locked shut. The two devices may be separate or combined into one.

- **Type 2** is similar to Type 1 but has two automatic closure devices and an emergency closure device which may be combined with one of the automatic devices.

- **Type 3** for use in horizontal pipes with an automatic closure device actuated by external energy and a separate closure device.

- **Type 4** is similar to Type 1 but for use with waste fittings or floor gulleys.

- **Type 5** is similar to Type 2 but for use with waste fittings or floor gulleys.

The standard does not specify what form the automatic and emergency closure devices within an AFD should take. The most common available are circular flat plates (sometimes float assisted), ball valves, vertical slide gates and sections of flexible pipe that can be compressed or rotated to prevent flow.

Anti-flooding devices Types 1, 2 and 3 are commonly used on basement drainage systems. Details of typical AFDs using flat plates are shown on Fig. 3.5.

Part 2 of the Standard specifies test methods to be used for checking that the material properties of the AFDs are satisfactory and that they can resist blockage by debris in the flow. The flow tests use a liquid mixture of water and a variety of solid particles to simulate sewage. A separate test is required to simulate blockage by rags trapped in the AFD. Limits on the amount of backflow that can be allowed in the tests due to leakage past the closure devices are specified in the Standard.

AFDs are typically between 0.5m and 1.0m in length and the EN Types 1, 2 and 3 are usually mounted in-line inside an inspection chamber to allow access for maintenance.

AFDs corresponding to Type 4 and 5 in the EN are commonly manufactured as integral parts to floor gullies or waste fittings.

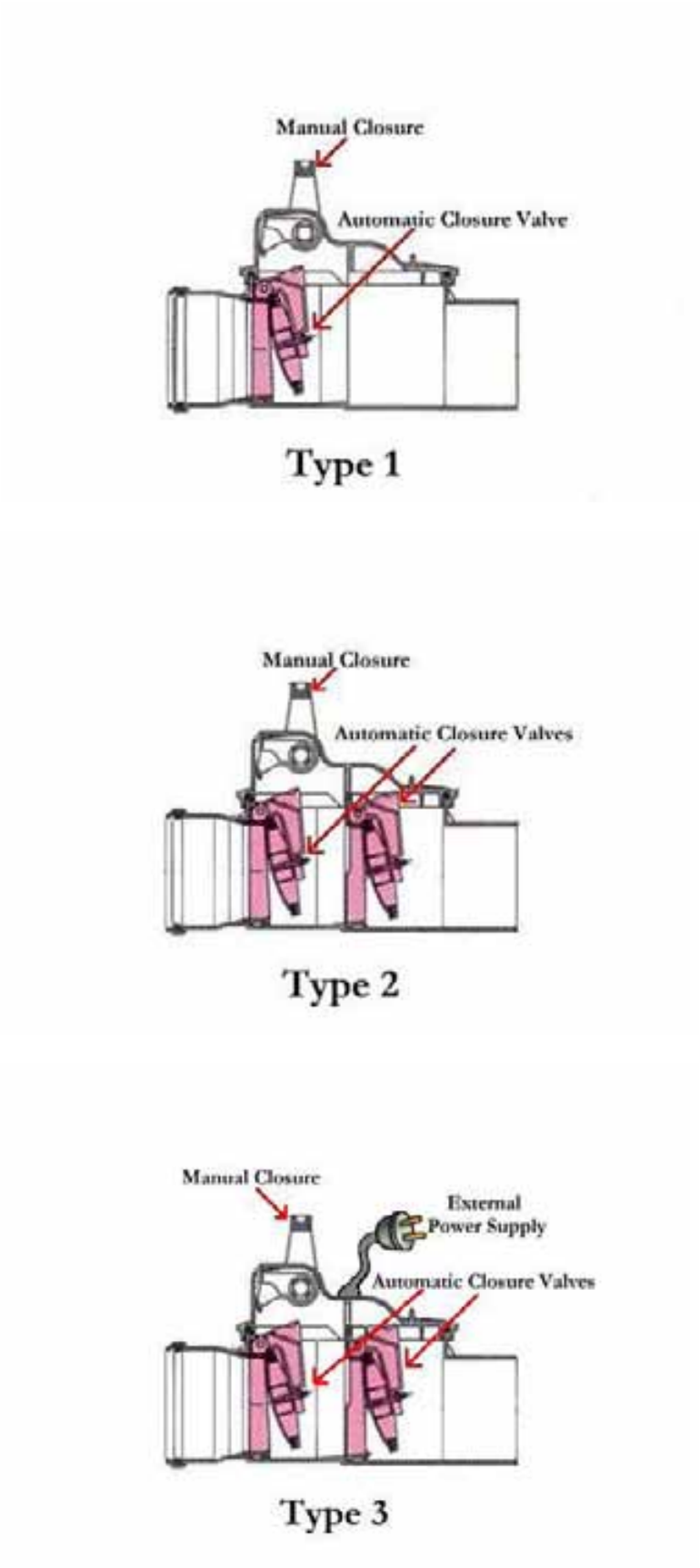

Figure 3.5 Details of Typical AFDs Using Flat Plates

When an anti-flooding device closes due to backflow it temporarily disconnects the property from the public sewerage system. If appliances within the property continue to be used the basement is at risk of flooding from its own discharges. A method of reducing this risk is to use a Type 3 device that is operated from an external energy source and that incorporates an alarm to warn the householder that the sewer is surcharged and not to use the basement appliances.

In evaluating solutions for property flooding the use of AFDs should only be considered when the following criteria are satisfied:

- sewer flooding occurs below ground level on the public sewer.
- the AFD services only one property and is not installed on combined drains.
- the surface water flows from roofs and paved areas entering the drain upstream of the AFD are excluded or diverted.
- the AFD should not simply transfer the problem to another property.
- access is available for routine inspection and maintenance. An inspection frequency of once every six months is recommended.

Type 2 and Type 3 AFDs provide additional levels of security over Type 1 AFDs and Type 3 AFDs can incorporate an alarm system to warn occupiers that the sewer is surcharged and to turn off appliances.

3.5 Pumping Systems

There are a large variety of pumps and installation options available. This section deals with those types installed within premises and those specifically used in schemes to prevent flooding. Three categories are considered:

Packaged Systems - consist of pumps and storage chambers that can take gravity flows from a variety of properties and pump flows into the public sewer above hydraulic gradient level.

Intermediate Systems - are installed within inspection chambers that can discharge flows from a single basement into the public sewer above hydraulic gradient level.

Macerating Pumps - small macerating pumps contained in a collection tank installed in the basement can discharge under pressure through small bore pipework to the public sewer above hydraulic gradient level.

Common types of pumps are submersible centrifugal pumps with vortex impellers with good solids handling or macerating/grinder pumps that cut solids into small pieces that can be pumped through small bore (40mm nominal diameter) pipework without blockage. Macerating/grinder pumps are suitable for pumping rates up to about 5 l/s.

Pneumatic ejectors were in the past one of the most commonly used methods of wastewater pumping within buildings. While extremely reliable they are now seldom used because of their high costs. They are noisy compared with the modern alternatives.

A draft European Standard pr EN 12 056 Part 4 has been prepared by Technical Committee TC 165/WG 21/TG 4 covering the layout and hydraulic design of effluent pumping systems installed inside buildings. The standard awaits approval by European national votes.

European Standard EN 1761 and EN 752 Part 6 covers wastewater pumping outside buildings.

European Standard EN 1671 covers “Pressure Sewerage Systems Outside Buildings”.

Current German national regulations require that all inhabited basements below the expected flood level in the public sewer (usually interpreted as ground level at the point of connection) be drained using pumped systems.

Ofwat in the UK accepts that the installation of suitable packaged systems can provide a permanent solution to sewer flooding problems.

The draft European Standard pr EN 12056 Part 4 requires sanitary appliances located below the expected flood level to be protected against backflow by the installation of a pump with discharge pipework lifting flows above the flood level before discharge. However it also permits sanitary appliances in little used rooms to be protected from backflow by the introduction of AFDs conforming to the current draft European Standard.

Pumping options which discharge above sewer surcharge levels provide additional security on mechanical failure when compared with AFDs as damage will be limited to flows from within the property.

When a pumping station is installed in existing or renovated premises the existing gravity sewer should be sealed by plugging with concrete or the sewer should be grubbed out. Capping the existing pipe is not satisfactory as the cap can dislodge once the drain becomes surcharged.

3.6 Selection of Options

In situations where flooding of existing basements is occurring consideration should be given to the variety of surcharge management options available as analysed in Section 3.3 based on the:

- extent and frequency of the basement flooding
- the technical options available based on the location, ie. ease of retrofitting pumping stations and anti flooding devices on private properties
- cost benefit analysis of the available options

The best technical, environmental and economic options should be selected. All options should incorporate the removal of rainwater before it enters the basement.

4. FINANCING OF BASEMENTS POLICY

4.1 Introduction

In order to prevent basement flooding drainage infrastructure improvements are required and these need to be financed. Viable financing mechanisms are considered in this section.

4.2 Developments Subject to the Planning and Development Act

In new build and renovation situations, subject to the Planning and Development Act 2000, the on-site construction of drainage infrastructure to prevent basement flooding, such as pumping stations, can be conditioned by the local authority during the planning phase. In such situations the capital cost and ongoing operation and maintenance costs remain the responsibility of the property owner.

In developments where increased flows to the sewers can put basements downstream of the development at risk of flooding, the local authority has the opportunity to:

- refuse planning permission
- implement improvements to the existing drainage infrastructure to reduce the risk of flooding
- levy the developer for the cost of the infrastructure improvements
- condition that the developer implement the drainage infrastructure improvements at his own expense

The long-term operation and maintenance becomes the legal and financial responsibility of the local authority. Financing policy should include for cost of long-term operation and maintenance of the system. This could be a once-off payment to cover operation and maintenance over a 25 to 30 year period.

The required drainage improvements should be in place prior to connection of the new development to the public sewer.

4.3 Existing Basement Locations

The financing of policy relating to existing basements is more complex than those for new developments.

Existing basements connected directly to the local authority sewers are at risk of flooding due to changes in system hydraulics following modifications to the infrastructure, deterioration of the system with age causing increased I/I and the impact of climate change.

Many owners are unaware of how their basements are drained and the inherent risks of flooding associated with the development and change of use of their basements. These developments have historically proceeded without the need for planning permission. The use of AFDs or pumping stations is not usually considered.

There are three options available relating to existing basement drainage. These are described below:

Do Nothing

This option would not require any financing mechanism. However, frequent flooding of basements may expose the Sanitary Authority to claims from property owners. In most cases a variety of factors contribute to basement flooding some inside and others outside the control of the Sanitary Authority. This can lead to lengthy and expensive litigation to resolve. Owner/occupiers may be required to pay higher insurance premiums and in some instances may be unable to obtain cover. This will put political pressure on the local authority to compensate for the damage caused and implement drainage improvements.

Local Authority Takes Responsibility

Should the local authorities wish to reduce the risk of basement flooding by the installation of AFDs or pumping stations on private drains they would have to finance the installation and carry out routine six monthly inspections and maintenance unless this responsibility is handed over to the owner through a signed and written agreement.

Joint Participation

Property owners should be made aware of the risks of flooding to basements which can become a health and safety concern as well as causing material damage.

Insurance companies should see the benefits of home owners implementing basement flooding protection options and should be encouraged to consider reductions in policy premiums to those homeowners implementing approved protection options.

The local authorities would gain benefits in having basements protected from flooding. The existing drainage assets could be optimised and additional development connected to the sewers without risking basement flooding.

The local authorities should embark on the process of identifying the extent of the problem and on an extensive and focussed public information campaign to inform homeowners of the causes of flooding and the methods of protections.

The campaign should provide technical advice on the installation of pumping stations and AFDs. The insurance industry should be approached to assist with the campaign.

5. CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1 General Background

Information on the location, use and floor levels of basements in the Greater Dublin area is limited. Some 16,200 basements within the study area have been identified and the total number is expected to greatly exceed this amount. A register containing information on basement location, use, floor level and drainage infrastructure should be prepared. It should include records of flooding history. Flooding reports should be prepared by the local authorities maintenance crews. In incidences where they find it difficult to determine the cause of flooding follow up inspections by a drainage specialist should be carried out.

Register of Basements & Flooding Incidents

11. Prepare a database of all basements.

12. Include details on location, use, floor level and drainage infrastructure.

13. Include records of flooding history.

14. Ensure flooding reports are prepared by the local authorities.

Basements connected directly to the sewerage system are at risk of flooding from a variety of sources including, high intensity storms, increases in I/I, combinations of storms and high tides, sewer blockages and breaks, mechanical plant failures and operator errors. Where hydraulic models are available they should be used to analyse the risks of basement flooding and establish a register of at risk properties.

The local authorities are responsible under the Local Authority Acts 1878 – 1964 for the provision, operation and maintenance of sewers in their jurisdiction. As basements are generally below the maximum hydraulic gradient and the majority located in older areas of the catchment, where frequent surcharging occurs, the risks of flooding of these basements is high.

Basement flooding from sewers is normally considered a “natural hazard” and insurers will reimburse the cost of damage. In situations where the problem is considered due to negligence or a clear lack of maintenance the insurance companies may seek to recover costs from the local authority. Increases in the frequency and extent of flooding of basements will expose the authorities to the risk of increased litigation. Widespread flooding makes the local newspapers and has an adverse impact on the public’s perception of the local authority.

The risks of basement flooding can be increased by:

- the granting of planning permissions which increase flows to the sewers.
- renovations to the drainage system which change the system hydraulics or groundwater levels.
- the deterioration of the existing system and the associated increases in I/I.

All these risks are within the control of the local authorities and can be managed.

Climate change predictions indicate more frequent high intensity storms and a rise in sea level. This is likely to increase the frequency and extent of basement flooding.

Use of Hydraulic Models

15. **Use hydraulic models in association with the basement database to establish the extent of basement flooding.**

16. **Use models to consider the impact of upstream developments with respect to flooding risk on downstream basements.**

17. **Use climate change predictions in the assessment of flooding risk.**

The ongoing change of use of basements from storage areas to accommodation with the installation of sanitary appliances and utility fittings introduces new properties to the risk of flood damage. These developments are not usually subject to the Planning and Development Act 2000 and the basement drainage is not specifically governed by the Building Regulations 1997. The technical requirements relating to basement drainage should be included in the next draft of the Building Regulations.

Building Regulation

18. **Incorporate basement drainage requirements into the Building Regulations.**

5.2 Return Storm Frequencies

It is not normally possible or economic to provide sufficient flow capacity to deal with extreme storm events. In Sweden a storm intensity of 1 in 10 years is considered sufficient protection for basement drainage.

In the UK CIRIA consider a possible “acceptable” level of performance is for the system to handle storms up to 1 in 25 years without flooding.

Many of the basements in the study area are connected to sewers, which are designed for return periods much less than those recommended above. In Germany the regulations require that all drainage from inhabited basements be pumped to the sewers above maximum surcharge level. This isolates the basement from the effects of surcharge in the sewer even if the pump fails.

Isolation of Basements

19. **Install pumping stations on all new basement drainage.**

5.3 Prevention Strategies

Four strategies have been identified to resolve the problems of basement flooding. These include transportation, detention, source removal and surcharge management.

With the exception of surcharge management these strategies require external improvements to the sewerage infrastructure. Capital costs are high and a long period (several years) is required to design and construct improvements. These improvements are best carried out by the local authorities following preparation of detailed drainage area plans, which provide a holistic approach to catchment management.

Surcharge management involves the construction of small sub-catchment drainage schemes or modifications to the private drains to isolate basements from sewer surcharge. This option provides a low cost solution that can be implemented within a short time frame.

Surcharge management includes the introduction of anti flooding devices (AFDs), the installation of pumping stations and the introduction of pro-active maintenance. In situations where no other option is available purchase of the basement should be considered.

Prevention Options

20. Select option based on flooding frequency, technical and economic benefits.

5.4 Prevention Devices

An AFD is an on-line device to prevent backflow from the surcharged sewer to the basement. A draft European product standard covering four types of AFDs has been prepared and awaits approval.

There are a large variety of pumps and installation options available. A draft European product standard pr EN 12056 Part 4 has been prepared to cover pumps located inside buildings and this awaits approval. IS/EN 1761, IS/EN 752 and IS/EN 1671 cover installations outside buildings.

Both AFDs and pumping installations require a routine (six monthly) inspection and maintenance. If the units are not maintained flooding can occur.

Pumping options which discharge above sewer surcharge level provide additional security on mechanical failure as damage will be limited to flows from within the property. Pumps should be installed in preference to AFDs on all new build situations. In the case of existing basements AFDs should only be fitted where pumps cannot be physically retrofitted to the existing system.

Prevention Devices

21. Install pumps in preference to AFDs.

22. When fitting AFDs use Type 2 or 3 complying with European Standards.

5.5 Financing

Basement flooding protection requires infrastructure improvements that require financing.

Protection of developments which are subject to the Planning and Development Act 2000 can be conditioned as part of the planning process. Capital, ongoing operating costs and overall maintenance responsibility remains with the owner.

In the situation where upstream development increases flows in the sewer and increases the risk of flooding, the planning authority can refuse planning permission, condition or implement drainage infrastructure improvements and recoup costs from the developer in the form of development charges.

Developments Subject to Planning and Development Act

23. Condition on site protection measures. The following standard conditions should be included in all planning permissions.

"All drainage from basement level shall be discharged to ground level before falling by gravity to the Public sewer. Pumping stations shall include both duty and standby pumps and adequate sump storage shall be provided."

24. Where downstream basements are affected condition improvements or refuse planning permission.

Existing basements are at risk of flooding from a number of factors including changes to the infrastructure, deterioration of the system with age, climate change, and change of use. Should the local authority finance and install AFDs or pumping stations on private properties they will, in most instances, become responsible for their cost and long term maintenance.

Many owners are unaware of the risks of basement flooding, the adequacy of their basements drainage and the increased risk of flooding due to changes in use of the basement.

The local authorities should embark on identifying the extent of the problem and on an extensive and focussed public information campaign to inform homeowners of the causes of flooding and the methods of protection.

The campaign should provide technical advice on the installation of pumping stations and AFDs. The insurance industry should be approached to assist with the campaign.

Developments Not Subject to Planning and Development Act

25. Embark on a public awareness scheme to inform homeowners of causes of flooding and methods of protection.

26. Provide technical advice on the installation of pumping stations and AFDs.

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