NATIONAL WATER QUALITY MANAGEMENT STRATEGY

Guidelines for Sewerage Systems

Sewerage System Overflows

November 2004

Natural Resource Management Ministerial Council

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Photos on the front cover courtesy of Melbourne Water and Dr Peter Pollard of Griffith University

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Preamble

This document provides national guidelines for use by the community, regulators and sewerage authorities, for management of the human health and environmental impacts of sewerage system overflows.

This document is one of a suite of documents forming the National Water Quality Management Strategy (NWQMS).

The series, *Guidelines for Sewerage Systems,* covers sewerage systems as a whole. Five separate documents deal with particular aspects of sewerage systems as set out in Figure 1. This document provides national guidelines for the management of sewerage system overflows.

It has been developed as a basis for a common approach throughout Australia.

Guidelines for Sewerage Systems				
Acceptance of Trade Waste	Sewerage System Overflows	Reclaimed Water	Effluent Management	Biosolids Management

Figure 1 Diagrammatic Structure of the *Guidelines for Sewerage Systems.*

Further information on the National Water Quality Management Strategy is given in Appendix A.

FIGURES

TABLES

1 INTRODUCTION

Most Australian cities and towns are served by sewerage systems although there are situations where properties are not serviced. In general sewage is conveyed from domestic and commercial users to treatment plants, where it is treated and discharged into receiving environments or re-used. Separated biosolids are either re-used or disposed at landfills.

Historically, the primary environmental management emphasis has been on the appropriate management of discharges from sewage treatment plants. However, sewerage systems have a variety of potential environmental impacts, including sewer odour and gas emissions of a potentially poisonous and explosive nature, noise from pumping stations, and sewage overflows, which must be managed. Management of sewage overflows will be discussed in detail in these guidelines.

1.1 Sewage Overflows

An overflow causes or has the potential to cause environmental or human health harm. The conditions of the receiving environment will dictate the degree of risk of such harm. The scale of the spill depends on the volume and duration of the overflow and receiving environment characteristics. It can be described in the context of the dispersion zone or attenuation distances necessary to disperse, dilute or contain a pollutant that affects the environmental values of that zone but does not go beyond it. The effect on both surface water and groundwater needs to be considered in the assessment of the impact.

Ideally, there should be no overflows from sewerage systems, apart from those caused by exceptional circumstances: extreme wet weather events and/or major sewerage system failures. Accordingly some systems are designed with overflow structures intended to control the location of overflows and reduce environmental or health risk.

Overflows can occur from gullies and other private property points designed to prevent flooding of houses. Overflows can be minimised with emergency response systems, which can include in situ or mobile back-up energy supplies and replacement pumping systems, and in-sewer storages and detention basins. Professional asset management can predict mechanical breakdown, and structural failure of sewerage infrastructure.

The prevention and management of overflows from sewerage systems complements the traditional emphasis placed on managing discharges from sewage treatment plants. It highlights the importance of minimising the overall environmental impacts from the operation of both sewage collection and treatment systems.

1.2 Purpose of these Guidelines

These guidelines have been developed as a basis for a national approach to sewerage system overflow management to minimise overflow occurrence and impacts on human health and the environment.

The purpose of these guidelines is to show how to minimise and manage overflows and their impact through regulation, sewerage system design, and judicious selection of sites for overflow if it does occur, and operation and maintenance of the sewerage systems. These guidelines address overflows throughout a sewerage system, with the exception of those arising from internal plumbing systems within buildings.

Sewerage systems differ widely in both form and operation. In addition, the legislative, regulatory and resource management requirements relating to sewerage system management varies between different regions, states and territories. Large sewerage system operators and other organisations commonly have technical guidelines for the design of sewerage systems. Consequently, these national overflow guidelines are not prescriptive but provide a broad guide to assist sewerage system management, operation and maintenance. They are sufficiently flexible to serve as a framework for developing local management practices and to allow adaptation to local needs and conditions. They are, however, not intended for use as a regulatory instrument and should be used supplementary to existing sewer codes, A/NZ Standards, and guidelines.

The guidelines describe:

- sewer overflows and their potential impacts on human health and the environment;
- sewer overflow abatement planning;
- approaches to minimise overflows through system management, operations and maintenance; and
- structural measures to minimise overflows.

The guidelines are intended for use by:

- sewerage system managers, which include water authorities, local councils and the private sector;
- regulatory authorities, including environmental and human health regulators, as a guideline document on sewerage system management; and
- community groups, to indicate the management approaches that can be expected from sewerage system operators.

This document relates to a number of other NWQMS guidelines within the series Guidelines for Sewerage Systems as mentioned in the preamble. Other documents that are interrelated include:

- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000;*

- *Australian Guidelines for Water Quality Monitoring and Reporting 2000*; and
- *Australian Guidelines for Urban Stormwater Management 2000.*

2 SEWERAGE SYSTEMS

In many countries, stormwater and sewage are conveyed in a common pipe network designed to spill into the receiving environment during large rainfall events. These are known as combined sewers. Most sewerage systems in Australia are different and operated as separate systems that are not designed to transport stormwater. Some combined systems were constructed in Australia in the late 19th and early 20th Century, however, most have since been separated into stormwater and sewerage systems.

2.1 Sewerage System Overflows

The sewerage system delivers raw sewage to treatment plants. The plant provides treatment so that either the treated effluent can be re-used, or disposed of if re-use is not a practical option. The degree and method of treatment varies from plant to plant and within each plant. Some flows receive a lesser degree of treatment when it is necessary to deal with large wet weather flows.

The sewerage system can consist of property sewers/drains, private sewers, sewer pipes (reticulation, branch and trunk), maintenance holes (or access chambers), designed overflow structures, sewage pumping stations, odour scrubbing systems and vent-shafts. With the use of alternative sewerage systems such as vacuum sewerage and grinder pump systems, there are increasingly more varieties of overflow mechanisms. Local councils, major water authorities or private sewerage system operators have ownership of sewerage systems and are responsible for the operation and maintenance of the sewerage system downstream of property sewers/drains connections. Maintenance of property sewer/drains, and in some cases the private sewers, is generally the responsibility of the property owner.

Stormwater can enter existing sewerage systems, including even relatively new systems. An allowance for wet weather flows should be made when designing separate systems.

Sewer overflow structures are built into sewerage systems enabling discharge into detention basins or designated locations in the environment, primarily where the effect on human health is minimised. The objective is to ensure that sewage does not flow back up through the sewers into properties in the event of blockages, mechanical or electrical failures, or when excessive stormwater enters the system.

New systems should be designed to a defined level of system performance and environmental impact. New systems are designed to minimise or stop overflows in dry weather under normal circumstances, however, the performance of older systems is more difficult to characterise. This is due to less rigorously defined original design criteria and changes over time in hydraulic capacity due to local system augmentation and deterioration. Additionally increased flow within sewerage systems can result from urban in-fill.

2.2 Causes of Sewer Overflows

Sewer overflows occasionally occur in sewerage systems. When they do occur the causes need to be documented and considered in work programs for the sewerage system. There is a range of potential causes for dry and wet weather sewer overflows as detailed below.

2.2.1 Sewer Blockages

The most common cause of dry-weather overflows is completely or partly blocked pipes. These are more common in smaller diameter pipes. Sometimes blockages in sewers are due to disturbance in the vicinity of the pipelines such as construction and land subsidence. Typically, blockages develop when displaced pipe joints or cracks in pipes permit the entry of soil or tree roots to form an initial obstruction. It is common for the blockage to become worse as the obstruction in the pipes catches solids from sewage.

2.2.2 Pumping Station Factors

Overflows during dry-weather situations also occur from pumping station malfunctions and rising main bursts or damage. Pumping station failures may be due to factors such as equipment failure or interruptions to the power supply, which are unable to be rectified before the storage volume for a pumping station is exceeded. Rising main damages may be due to failures in maintenance, the age and condition of infrastructure, or in coordinating urban activities such as construction and excessive overburden on mains. Overflows from rising mains are generally of shorter duration and mitigated by planned cut-off pumping which may result in controlled overflow at pumping stations.

2.2.3 Infiltration/Inflow (I/I)

One cause of wet weather overflows is rainfall infiltrating through the ground into leaky sewers. Excess water can also inflow through downpipes illegally connected to sewers and broken or badly connected property sewer/drains. This infiltration/inflow can significantly increase flows in sewers during wet weather far beyond the design storm allowance made for the sewers. Exceeding the capacity of the sewers causes overflows at overflow structure points, maintenance holes and at the sewage treatment plant. The extent of this problem varies within and between systems, depending on factors such as rain intensity soil conditions and infrastructure conditions.

The operation of every sewerage system in Australia is affected to some extent by infiltration/inflow, and/or illegal connections of stormwater. The impact of infiltration/inflow may be significant if the sewers or property sewers/drains are in poor condition. Hydraulic modelling of the systems and understanding the implications of uncontrolled added flows, as well as exfiltration (i.e., escape of sewage out of sewers and drains into the surrounding soil), must form part of the overall system operation. A program of illegal connection control is also essential. Smoke testing of sewers can result in identifying stormwater entry points such as roof gutters.

2.2.4 System Growth

Another potential cause of overflows is sewers and sewage pumping stations that are too small to carry sewage from newly developed subdivisions or commercial areas. This occurs when urban growth is not foreseen and accounted for.

2.2.5 System Conditions

Problems can be caused by a deteriorating sewer system or by failing to account for the impacts of additional growth. When sewers are not properly installed or maintained, widespread problems can develop and result in significant future expenditure. Sewer system problems also have the potential to curtail new development until they are corrected or system capacity is increased.

Maintenance holes can also be a source of infiltration/inflow through defects in maintenance hole walls, displaced joints where pipes enter or leave these holes, displaced maintenance hole cones and surrounds, and cracked or missing maintenance hole covers.

2.2.6 Major Industrial Discharges

Major industries often have large trade waste retention tanks and large quantities of trade waste may be discharged to sewer in short time periods. If sewerage "catchment" has several such industries and if multiple discharges occur simultaneously, sewerage system overflows may occur. To optimally manage these discharges trade waste agreements between the industry and the sewerage authority should include specific details on discharge frequency considering, sewerage system capacity and diurnal flow fluctuations.

3 IMPACTS OF SEWER OVERFLOWS

Sewage overflows exert physical, chemical and biological effects on the receiving environment. This may result in human health, environmental and aesthetic impacts, which can be both acute and cumulative. Such impacts are dependent on the characteristics of the discharge and receiving environment.

3.1 Potential Human Health Impacts

As sewer overflows may contain raw sewage, they can carry pathogens (disease causing organisms). These include bacteria, viruses, protozoa (parasitic organisms), helminths (intestinal worms), and inhaled moulds and fungi. Thermotolerant coliforms and enterococci can be used as indicators of pathogen pollution.

The diseases they may cause range in severity from mild gastroenteritis (causing stomach cramps and diarrhoea) to potentially life-threatening ailments such as cholera, dysentery, infectious hepatitis, and severe gastroenteritis. Human health impacts can be dependent on the duration of exposure to, and the levels of pollutants in the overflow. Humans can be exposed to pathogens through:

- overflows into drinking water sources;
- direct contact with overflows in public areas such as parks, streets, or to swimming or boating waters (For more information on guidelines for recreational water see NWQMS *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* and for information on reclaimed water use see NWQMS *Guidelines for Sewerage System – Use of Reclaimed Water 2000*);
- the consumption of shellfish harvested from areas contaminated by overflows; and
- inhalation and skin absorption.

Overflows can cause or add to organic rich pooling/streams resulting in increased amounts of mosquito breeding. This can result in public pest and potential disease situations (e.g., Arboviruses, Ross River Virus, Murray River Encephalitis).

3.2 Potential Environmental Impacts

Sewer overflows can contain a range of pollutants including:

- sediment and turbidity;
- nutrients, particularly nitrogen and phosphorus;
- toxicants, including metals, pesticides and other chemicals;
- substances creating a biochemical oxygen demand; and
- gross pollutants, including plastic and paper products.

The potential environmental impacts of sewer overflows are noted in Table 1.

Table 1 Potential environmental impacts of sewer overflows

Pollutant:	Potential impacts include:
Suspended solids	Deposited sediment affects aquatic insect habitats
Turbidity	Reduces water clarity, resulting in impact on fish and aquatic plants
Phosphorus and nitrogen	Stimulates growth of algae and undesirable aquatic plants, micro-organisms, and invertebrates (e.g., mosquitoes)
Ammonia, metals and pesticides	Toxic to fish and aquatic insects at high levels
Organic matter/Biochemical oxygen demand	Reduces dissolved oxygen levels, affecting fish, insects, and micro-organisms productivity
Gross pollutants/litter	Visually unattractive

Further information on the impact of pollutants is contained in the NWQMS *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000.*

Managers who have the responsibility for overflow management should consider the long and short-term impacts on the environment, and apply the Precautionary and Ecologically Sustainable Development (ESD) Principles (described in Section 4.2.2). For example, the impact of overflows in dry weather depends on the volume and duration of the overflow. The flow and any tidal conditions of the receiving waterway will also influence the impact of an overflow. Overflow impacts can be localised if the overflow is detected and rectified early. Significant impacts, including fish kills and mosquito productivity, are a possibility if overflow volumes are significant and occur over time.

Pollutants from sewer overflows can also potentially affect groundwater. Fine sediments and organic matter may clog infiltration zones, while toxicants, bacteria and nutrients can affect groundwater quality. Similarly, groundwater and tidal water intrusions into sewers can cause overflows and possibly increased salinity, thus affecting the re-use potential of the treated sewage effluent.

Pollutant concentrations in dry weather sewer overflows are generally higher than those in urban stormwater. In wet weather, though, sewage overflow concentrations are diluted and stormwater pollution levels rise. As stormwater volumes are often higher than sewage overflow volumes, loads of most pollutants in stormwater are frequently higher. A common exception is bacterial pollution, when sewer overflows can be the dominant source in wet weather. Definitive comparisons are difficult due to the variability in pollutant levels for both sources.

3.3 Potential Aesthetic Impact

Sewage overflows can cause unpleasant sights, even if their human health and environmental impacts are successfully managed. They can be perceived as offensive, and undermine the confidence of the community in the effectiveness of sewerage authorities.

4 MANAGEMENT FRAMEWORK FOR SEWER OVERFLOWS

Management of sewer overflows must occur within the context of maintaining or improving environmental (including human) health. The following sections outline overflow management objectives and some of the existing framework of policies and approaches for managing overflows.

4.1 Managing Sewer Overflows and Other Emissions

Contemporary developments in quality assured construction, materials and communication systems allow for the installation of new sewers with minimal emissions of sewage, odour or noise, unless there are exceptional circumstances. It is unlikely, however, that achieving zero emissions will be cost-effective for most existing systems. Therefore a multiple objective approach should be adopted, which considers objectives such as ecosystem health, both aquatic and terrestrial, human health and safety and economic considerations.

These objectives often need to be addressed in two contexts.

1. Minimising overflows from existing sewerage systems. In this context, the likelihood of sewage discharge should be reduced to an expected frequency that is acceptable to the general community, bearing in mind financial costs, best practice technology, and environmental and health benefits, and matching the probability of an overflow to the environmental values of the water; and

2. Minimising the potential for overflows from new sewerage systems. In this context, overflows should not occur except in exceptional circumstances. This has long term importance for sewerage system managers.

Sometimes it is more economical and effective to minimise the potential for overflows than to minimise their future impacts. The applicability of many overflow management techniques will depend on which context is being considered.

A source control or pollution prevention approach should be the focus of sewer overflow management. This equates to appropriate management, operations and maintenance, in addition to structural techniques such as minimising infiltration/inflow and leakage. Downstream techniques, such as amplification and storages, should only be considered for the residual impacts that cannot be cost-effectively mitigated by source controls.

Sewerage systems are to be managed and designed to undertake best practice environmental management (BPEM) and best practice engineering standards (BPES). It should be remembered that sewer overflow management is an integral part of effective sewage management, which includes financial management and meeting customer expectations.

Nuisance odours and other gaseous emissions from sewerage systems should be compliant with relevant State air quality policies and regulations. Nuisance odours should not be detectable outside the control structures. Odour management is largely related to the control of septicity and provision of ventilation. Management options include stack ventilation, ventilation odour treatment canisters, biofilters (filter treatment beds), odour scrubbers and oxygen injection systems.

Noise emissions from sewage pump station activities and other aspects of sewer operation must be minimised. There are four basic considerations in regard to noise management.

1. Minimisation of the generation of sound energy;
2. Minimisation of the objectionable characteristics of the sound;
3. Reduction of sound energy using attenuation measures such as sound absorption; and
4. Deflection of sound energy away from sensitive sites.

More detailed discussion of the management of odour and noise emissions is beyond the scope of this guideline. Further advice is available from technical guides and codes on sewerage infrastructure management.

4.2 Framework of Policies

4.2.1 Integrated Catchment Management

Integrated Catchment Management (ICM) or Total Catchment Management (TCM) recognises the catchment-wide relationships between resource use and management. It also addresses the need for community involvement in identifying issues and management solutions. It has been adopted in a number of States and Territories and embraces:

- a holistic approach to natural resource management within catchments, marine waters and aquifers, with linkages between water resources, vegetation, land use and other recognised natural resources;
- integration of social, economic and environmental issues;
- co-ordination of all the agencies, levels of government and interest groups within the catchment; and
- community consultation and participation.

ICM is increasingly being recognised by government as the key conceptual means to achieving sustainable resource management.

Sewer overflows are one potentially significant impact on water quality. They should be considered in plans that relate to managing sewer systems in order to achieve Ecologically Sustainable Development (ESD) and water quality objectives.

Experience indicates that sewer overflows are unlikely to be the only source of pollution within a catchment. Point sources may exist, in addition to other diffuse sources such as urban or agricultural runoff. A catchment-based approach with the principles of ICM to water quality management should ideally be undertaken to achieve the desired water quality objectives. This approach can be used to achieve a cost-effective balance between managing the various pollutant sources within a catchment.

4.2.2 Ecologically Sustainable Development (ESD)

Ecologically Sustainable Development (ESD) aims to ensure that we can sustain both the economy and the environment, now and in the future.

The core objectives of ESD are:

- to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations;
- to provide for equity within and between generations; and
- to protect biological diversity and maintain essential ecological processes and life-support systems.

The guiding principles of ESD are:

- that decision making processes should effectively integrate both long and short term economic, environmental, social and equity considerations;
- where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation (i.e., the Precautionary Principle);
- the global dimension of environmental impacts of actions and policies should be recognised and considered;
- the need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised;
- the need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised;
- that cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms; and
- that decisions and actions should provide for broad community involvement on issues which affect them.

The National Strategy for ESD states that 'the challenge is to develop and manage in an integrated way, the quality and quantity of surface and groundwater resources and to develop mechanisms for water resource management which aim to maintain ecological systems while meeting economic, social and community needs.' The National Water Quality Management Strategy (NWQMS) is built on the principles of the National Strategy for ESD and provides the framework to protect local water quality.

4.2.3 Water Quality Objectives

The NWQMS provides a framework for water quality management based on principles that apply nationwide. The NWQMS *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* is designed to provide tools for assessing and managing ambient water quality. These guidelines were prepared by the Australian and New Zealand Environment Conservation Council (ANZECC) and the Agricultural Resource Management Council of Australia and New Zealand (ARMCANZ), which have both since been absorbed by the Natural Resource Management Ministerial Council (NRMMC). The guidelines describe a framework for managing water quality and identifying community based environmental values for a waterway.

Ambient water quality objectives, which are numerical values or descriptive statements, have been, or are in the process of being, established in most jurisdictions. These objectives can provide a goal for sewer overflow management. However, this may be complicated by water quality being affected by other pollution factors, such as point sources, agricultural runoff and stormwater runoff. There are difficulties in establishing direct relationships between ambient water quality concentrations and sewage overflows.

The establishment of environmental values and corresponding water quality objectives will assist in prioritising actions for overflow management to protect the environment. Once protocols and actions are implemented progress towards water quality objectives can be used as a measure of success and would be integral to evaluating the performance of a sewage system.

4.3 Approaches for Managing Overflows

4.3.1 Regulatory Approaches

Regulation by ordinances or by-laws is widely used at a State/Territory and at a local level to prohibit stormwater connections to sewerage systems.

The direct regulation of overflows by environment protection agencies (e.g., through licensing) is a relatively new approach which differs from (but is complementary to) encouraging environmental management of sewerage systems or setting receiving water quality objectives. The management process can be based on the Environmental Management System approach outlined in ISO 14001 series of standards.

Under the current system, governments set the standards for overflows (often on the recommendation of the regulator). Resource managers normally monitor the system whilst the regulator ensures adequate and appropriate monitoring is undertaken and audited. Regulators may indirectly influence the sizing and extent of infrastructure works as well as levels of investment in sewer maintenance and performance.

The standards for overflow should be based on potential impacts on the health of humans and the environment as reflected in environmental values and associated water quality objectives for receiving waters. (NWQMS *Australian and New Zealand Guidelines for Fresh & Marine Water Quality 2000).*

A number of approaches could be used for the regulation of overflows. They could be used separately or in combination. Possible approaches to overflow regulation are noted in the sections below. These approaches could also include requirements to:

- record overflows from the sewerage system;
- report overflows to a regulatory authority and/or report significant overflows to the public; and
- follow emergency response procedures in the event of a significant overflow.

The resource manager must comply with the relevant environmental and/or health legislation about overflow management and compliance requirements.

4.3.1.1 Presumption Approach

A regulating authority may presume that an overflow control program meeting any of the following criteria provides an adequate level of control:

- no more than a prescribed number of wet weather overflow events per year that have been determined to have no significant impact on the receiving environment;
- the elimination or capture for treatment of a specified percentage of the volume of the sewage collected from a wet weather overflow; or
- the elimination or removal of no less than the mass load of the pollutants that have a negative impact on water quality objectives of the receiving waters.

This presumptive approach would need to be supplemented by conditions relating to dry weather overflows. There are a number of limitations with this approach. Due to rainfall variability, the number of wet weather overflows per year can vary for an individual sewerage system. Also, compliance with these conditions may require extensive monitoring. Difficulties may also arise in allocating responsibility for exceedances of ambient water quality objectives, given compounding factors such as urban stormwater pollution and other point sources of pollution. A variation on this approach is to determine actions required to meet these criteria based on modelling of the system, with the regulation being based on the implementation of one of these criteria.

4.3.1.2 Demonstration Approach

A regulating authority may require the demonstration of the adequacy of an overflow control program. The control program:

- must not affect environmental values;
- must meet water quality objectives; and
- must allow cost effective expansion or modification of infrastructure if subsequent additional controls prove necessary.

As noted above, there may be difficulties in determining what actions are required to meet ambient water quality objectives. Determining compliance may also be difficult, though through the assessment process the achievement of performance indicator values will be a measure of success for management and infrastructure investment.

4.3.1.3 General Prohibition

A general prohibition on overflows can be adopted, with overflows only permitted during exceptional or unavoidable circumstances. Such circumstances may include incidents beyond the reasonable control of the operator and where there was no feasible alternative to the overflow, but excluding discharges caused by operational errors or inappropriately designed, constructed, operated or maintained systems. The responsibility for demonstrating that the overflow was exceptional should rest with the operator. The regulatory authority should identify criteria that an operator can use for demonstrating that an overflow was unavoidable.

4.3.1.4 Best Practice

The best practice approach can address both operational and sewer rehabilitation issues. The operator should be required to follow an approved sewerage system operations and maintenance plan. To ensure that it represents "best practice" an independent review/audit of the plan is an approach that should be applied. The operator may also be required to implement structural measures to upgrade the sewerage system to reduce overflows.

4.3.2 Asset Management Approach

The aim of asset management is to provide, operate and maintain infrastructure to meet sewerage performance requirements and customer service levels. Asset management is varied, and influenced by factors such as the scale and type of activity. Asset management covers planning, maintenance and asset creation where sub-plans, instructions, procedures and strategies exist to deliver the overall infrastructure objectives. Such structured approaches can be used to clarify the scope of performance and reduce operational and investment costs for establishment and renewal.

Rationalising maintenance and retrofit infrastructure priorities are influenced by cost and risk-based analysis on environmental and human health impacts. The overall performance of the sewerage system may be assessed on specific target overflow frequencies. Achievable targets would depend on the age and condition of the system as well as its design (and maintenance regime).

When determining expenditure to upgrade wet weather sewer overflow systems, the quantification of cost and benefits should be assessed to justify the use of resources. Where significant expenditure is required the assessment of the likelihood and consequence of impacts is also required.

5 SEWER OVERFLOW ABATEMENT PROGRAM

Sewer overflows can be managed through abatement programs, effective operations and maintenance of the system and implementation of structural measures. This is discussed in the next three chapters. Chapter 8 outlines how new sewerage systems can be designed, constructed and inspected to minimise their future overflow potential. It is recommended that local, regional and national overflow abatement initiatives, Australia/New Zealand standards (*e.g., AS/NZS 3500.2.2:1996: National Plumbing and Drainage - Sanitary Plumbing and Drainage – Acceptable Solutions*), and sewerage system codes be considered. The program below may be used to supplement these initiatives.

The authorities responsible for sewerage systems that consider the following program excessive to their needs should consider selecting only those parts of the program pertinent to their requirements.

5.1 Overflow Abatement Program

To minimise or eliminate sewer overflows, sewerage system managers should implement an overflow abatement (or management) program/plan.

Integral with any abatement plan is asset management, which includes an asset register addressing the whole life operation of the infrastructure. The authority should have customer service standards for the operation of the sewerage scheme covering overflows. It should also detail what the authority will do in the case of an overflow and what are the rights of the consumers.

One approach for developing programs for existing systems is to prepare two overflow abatement plans:

1. A short-term plan, which details actions that provide for the best operations of an existing, unmodified system. It provides a short-term reduction in overflows by focusing on management and maintenance issues.
2. A long-term plan that contains actions to upgrade the system over a number of years to further reduce overflows. It focuses largely on structural actions that may take a number of years to identify. It may also include a refinement of a number of the management and maintenance actions identified in the short-term plan. The plan may require approval by a regulator.

The short and long-term plans should be complementary and consistent in methodology. For new systems, a detailed management plan should be initially prepared to ensure that the performance objectives are met.

Infiltration/inflow modelling of the systems and understanding the implications of uncontrolled added flows, as well as exfiltration, should form part of the overall system operation. A program of identifying and controlling illegal connection should be a priority.

A suggested outline of these two plans is described below.

5.2 Short-Term Overflow Abatement Plan

The short-term plan could identify a suite of actions that can be implemented in the short-term at relatively low cost to minimise overflows. They will generally focus on:

- improving the management of the sewerage system;
- formalising and improving operations and maintenance practices;
- implementing recording procedures, i.e., those responsible for management of the sewerage system detail events and causes, for overflows (particularly dry weather overflows) for statistical predictive and management purposes;
- developing reporting procedures for significant overflows;
- encouraging continuous improvement through the reporting procedures on overflows, and
- implementing minor structural works (e.g., relocating overflows).

Possible management and maintenance options are described in Chapter 6, with structural options in Chapter 7.

A short-term plan is usually prepared for implementation within one or two years, depending on the system size.

5.3 Long-Term Overflow Abatement Plan

A long-term overflow abatement plan should follow the customary approach in preparing management plans for many different activities. An example process is illustrated in Figure 2.

This planning process can be tailored to the characteristics of the sewerage system. For example, a system serving a large urban area needs a more detailed plan than a small regional town. This methodology can be applied to a short-term overflow abatement plan, although as a simplified version, and can include assumptions that are to be confirmed in the preparation of a long-term plan.

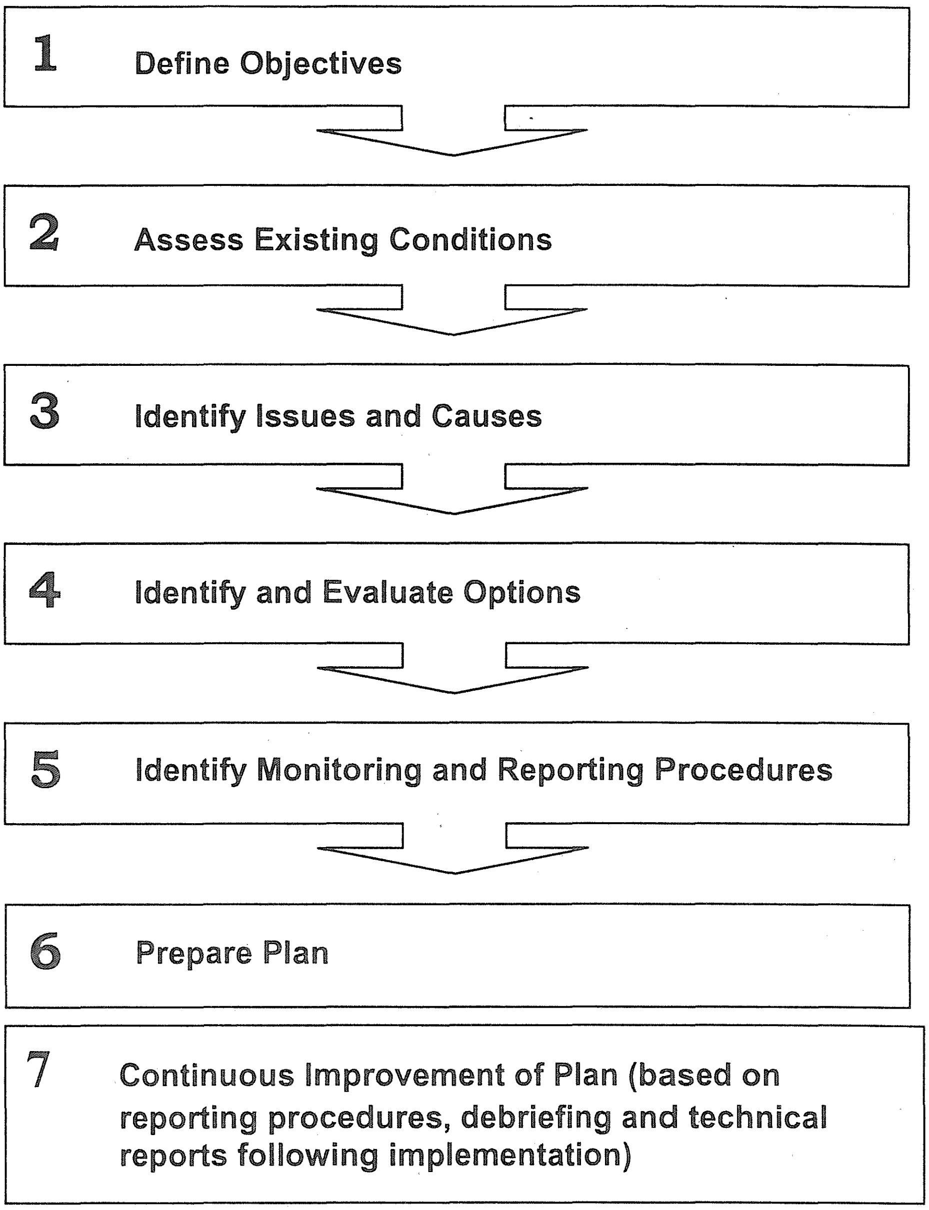

Figure 2 – Steps in Preparing a Sewer Overflow Abatement Plan

The six steps in the process noted in Figure 2 are described in detail below.

1. Define Objectives

The first step of the abatement planning process involves defining the objectives that the plan is intended to meet. Where practical, these should be quantifiable objectives, against which the performance of the plan can be measured. Objectives may include:

- meeting any relevant statutory or regulatory requirements;
- meeting any relevant state/territory government policies, including water quality and human health;
- ensuring that overflows do not compromise water quality objectives;

- reducing dry weather overflows to a specified level (e.g., a limit on the average annual frequency of choke-related overflows);
- reducing overflows (surcharges) into properties to a specified level of customer service;
- ensuring that overflows or exfiltration from sewers do not adversely affect groundwater quality regarding environmental and human health values;
- informing the public of overflows with potential human health impacts; and
- coordinating and optimising major industrial trade waste discharges.

The objectives may also relate to other aspects of overflow management, including odour and noise management.

The regulatory authority or authorities should be consulted during development of the plan's objectives.

2. Assess Existing Conditions

This part of the planning process describes the existing conditions of the sewerage system and its catchment.

Data collected on the sewerage system can include:

- the location of all designed overflow structures and potentially affected areas. These can be presented on a map of the system using Geographical Information System (GIS);
- the characteristics of any sewage pumping stations (e.g., inflow rates, storage volumes, detention times, pump characteristics, alarm characteristics);
- population, land use (e.g., residential/industrial) and sewage flow data (monitored or calculated);
- data on major industrial discharges and trade waste licence conditions;
- conditions relating to external service providers (e.g., power supply reliability, remoteness from supporting services, etc.);
- any modelling of the sewerage system to determine its capacity;
- quality characteristics of sewage, in dry and wet weather;
- data on leakage (or exfiltration) from the sewerage system (possibly calculated using dry weather flow and water consumption data);
- information on the condition of the sewers. At a minimum, this may include the age of the sewers. It could also include any sewer inspection information (e.g., from closed circuit television (CCTV) inspections); and
- records of any dry or wet weather overflows.

Data on the environment affected by the sewerage system can include:

- water quality and aquatic ecosystem information, including the potential for mosquito breeding;
- information on the flow characteristics of receiving water bodies (e.g., flow rates for watercourses, tidal characteristics for estuaries);
- information on urban bushland potentially affected by sewer overflows, including any rare or endangered species;

- aquatic recreational areas (e.g., popular bathing areas);
- land-based recreational areas likely to be affected by overflows (e.g., sporting fields);
- information on other sources of pollution (e.g., point sources, urban stormwater);
- climatic data, particularly rainfall patterns;
- soil characteristics, particularly those that may affect sewerage systems (e.g., expansive clays, sands, land subsidence, groundwater flows, slope stability, flood effects); and
- vegetation characteristics in the vicinity of the sewerage system (again, those likely to affect sewers, particularly in terms of root infestations).

For smaller systems, some of this data may not be readily available. In these circumstances, the plan could be prepared based on the available data, supplemented by scientific and engineering judgement. An action identified in the plan could be to collect important additional data to enable future versions of the plan to be refined. If the data needs are significant, additional investigations could be undertaken before proceeding further with the plan.

3. Identify Issues and Causes

This step involves identifying the issues or problems that may prevent the management objectives from being met. These issues may include:

- exceeding water quality criteria, possibly caused by sewer overflows;
- management and treatment of overflows to prevent potential for mosquito breeding;
- overflows having an impact on urban bushland areas;
- discharges into private properties;
- frequency of dry weather overflows exceeding a specified limit;
- lack of or inadequate recording and reporting procedures for overflows and sewerage systems;
- lack of or inadequate emergency response procedures and actions for overflows;
- power supply reliability;
- inadequate trade waste licence conditions compromising the sewerage system (e.g., not coordinating the release of major industrial discharges or requiring adequate trade waste management practices);
- failure in coordinating urban activities;
- mine subsidence and other geological activities;
- corrosion of sewerage system components;
- erosion of sewerage system components; and
- misunderstanding of sewerage system operation by stakeholders.

These issues can be identified by a combination of:

- a "desk-top" study, involving a review of existing information contained in reports, studies and monitoring programs. This may also include collation of information contained in files, such as complaints about overflows;
- discussion with staff including the sewerage system manager and field staff. Discussions could also be held with the local council, catchment management

bodies, and relevant state/territory government agencies (e.g., human health and environment protection); and

- community consultation. The community may identify the location of overflows during a consultation process, which may also allow greater community 'ownership' of resulting management decisions.

The underlying causes of some of these issues may not be immediately obvious and may require further investigations. Potential causes may include:

- infiltration/inflow into sewers;
- inadequate sewerage system storage volumes and alarm systems for failures at pumping stations, and inadequate response times to alarms;
- insufficient sewer capacity to carry the actual flow which is elevated above the original design flows;
- inadequate operations and maintenance of sewerage systems;
- inappropriate trees planted over sewers;
- poor sewerage system amplification, including not providing for the impact of new connections on the frequency of downstream overflows; and
- poor sewer design standards, sewer construction specifications and inspection procedures for new sewers.

The level of complexity of the investigations to assess the risk of overflows will vary, depending on the system size, the consequence and likelihood of the potential hazard, and the resources available. For example, assessing the consequence of wet weather overflows from a small system could involve a small-scale qualitative exercise with some basic modelling to estimate the magnitude. For large systems, a more rigorous approach with a complex model calibrated with data derived from extensive flow management and sampling may be needed. The likelihood of overflow would need to be examined with the understanding of the characteristics (e.g., hydrology, emergency response, access, resources) of the area of study.

Following identification of these problems, the causes can be identified and their relative contribution to the problem assessed (quantitatively or qualitatively and by using probability). This can enable the development of cost-effective management strategies and assist with allocating priorities for action. A risk-based approach that could be used to identify the critical or the high priority components for priority actions is described in *AS/NZS 4360:1999 Risk Management Standard*. Issues associated with risk assessment are described in Appendix C.

Many Australian systems indicate that a "*Pareto*" effect exists in wet weather overflows, whereby the cause of 80% of the overflows can be attributed to 20% of the system. Targeting of resources towards this 20% is an effective way of minimising overflows. Therefore it is important to investigate fully all options for remedial work in order to select the most economic and effective solution. There is rarely a single source of infiltration/inflow into a system, and in general terms the problems are the result of a multitude of small problems within the system.

4. Identify and Evaluate Options

Both short and longer-term actions should be identified. Generally the shorter-term actions are non-structural and can be implemented at moderate cost. Longer-term approaches generally centre on structural actions, which may need further investigations, including design and environmental impact assessment before they are implemented. These actions may also be more costly than the non-structural actions.

Actions to address sewer overflow issues can be split into two categories:

1. Non-structural management practices (e.g., improved management, operations and maintenance). These are described further in Chapter 6; and
2. Structural actions. These can include rehabilitating degraded sewers, installing additional sewers and upgrading pumping stations. These options are further described in Chapter 7.

The least risk of sewerage system failure is achieved through a combination of hard engineering (assessment and capacity increase) and selective source control. The actual flows in the systems may be vastly different from the original design flows. The use of such tools as flow monitoring and hydraulic modelling should be used to assess the existing system's actual performance and to find the best improvement options.

Where practical and economical, a "source control" approach should be adopted to sewer overflow abatement. This essentially involves targeting problems in the reticulation system prioritising reticulation catchments, based on sewer flow gauging and/or asset failure history. This allows the system operators to better target problem areas, rather than amplifying downstream trunk sewers. This can be achieved by a combination of improved operations and maintenance activities, and rehabilitating degraded reticulation sewers and property sewer/drains.

This approach will minimise dry weather overflows, which primarily occur from the reticulation system. In wet weather, it also reduces the amount of infiltration/inflows into the reticulation systems, reducing downstream overflows.

Potential actions to address overflows can be evaluated by assessing:

- estimated capital cost;
- estimated operations and maintenance costs;
- effectiveness in addressing the issue, including the ability to address multiple issues;
- ability to complement other potential management practices;
- the proportion of the problem/issue addressed by the option;
- any adverse environmental impacts;
- technical and administrative viability;
- whether any legal requirements are satisfied;
- consistency with policies on other related issues (e.g., human health); and
- expected community acceptance.

Cost/performance relationships can be developed to demonstrate the relationships among a set of reasonable control alternatives. An analysis can determine where the incremental pollution reduction achieved diminishes compared to the increased costs.

A ranking system can also be a valuable technique for allocating priorities to management options. Scores can be allocated to the costs and benefits of identified options to determine a priority. Although this is a relatively simplistic and subjective process, it is 'transparent' and avoids unstated assumptions. While this is a potentially valuable tool, judgement will need to be applied when interpreting the results.

5. Identify Monitoring and Reporting Procedures

The overflow abatement plan should include monitoring and reporting procedures addressing progress of the plan's implementation and if objectives are being achieved.

Management procedures, including reporting of 'milestones' can be used to monitor the plan's implementation. Monitoring of the plan's outcomes may include monitoring within the sewerage system (e.g., flows, overflow frequency) and environmental monitoring (e.g., water quality or river health). Environmental monitoring is discussed further in the NWQMS *Australian Guidelines for Water Quality Monitoring and Reporting 2000*. It is generally easier to monitor the performance of the sewerage system than environmental monitoring. This is due to the influence of "natural" environmental variations and sources of pollution within the receiving environment.

Another form of monitoring is an annual review of overflow reports (e.g., frequency of chokes). Feedback from the public (e.g., choke reporting) can also be requested.

Service providers such as power companies can also be included in the review process by providing information on frequency of power outages or surges, and response times to address these power delivery problems. Customer service standards are vital drivers for performance improvements and should be used.

The reporting procedures can provide information about the plan's implementation to the sewerage system's customers. This is particularly important if the customers have been asked to provide additional rating income to fund the plan's implementation, and community support for the plan needs to be maintained. Possible reporting mechanisms include a brochure included with rates notices and a summary in the system manager's annual report. Feedback from the public can also be requested through this process, which can assist in the monitoring and review of the plan.

6. Prepare Plan

Overflow abatement plans should include an implementation schedule (or program) providing a timetable for the implementation of the adopted actions. The schedule should address financial and institutional considerations necessary for avoiding the potential for loss of community support if the recommendations of the plan are not implemented. A program timetable for revising the plan should also be identified.

Public comments can be sought on a draft plan, and this may be particularly useful if additional income is required to implement the plan. It is possible that the long-term plan will be subject to formal agreement with regulators for environment, conservation, human health, and financial management.

5.4 Implementing Sewer Overflow Abatement Plans

Preparation of the Overflow Abatement Plans clearly constitutes only the first step towards the ultimate aim of improved environmental and human health outcomes. It is important for system managers to also focus on the implementation of the plans.

It is important for the Overflow Abatement Plans to be viewed as "live" documents, which are actively consulted, reviewed and revised. System managers should adopt a model of "continuous improvement" in the progressive refinement of the Plan.

System managers should actively monitor the effectiveness of the plan, and report on the findings to the community. Monitoring and reporting is considered to form an integral component of the 'continuous improvement' of the abatement plan.

The preparation of an Overflow Abatement Plan is considered one element of an environmental management process (or system) for a sewerage system. This is illustrated in Figure 3. This management process should be based on Environmental Management System approach outlined in the ISO 14001 series of standards.

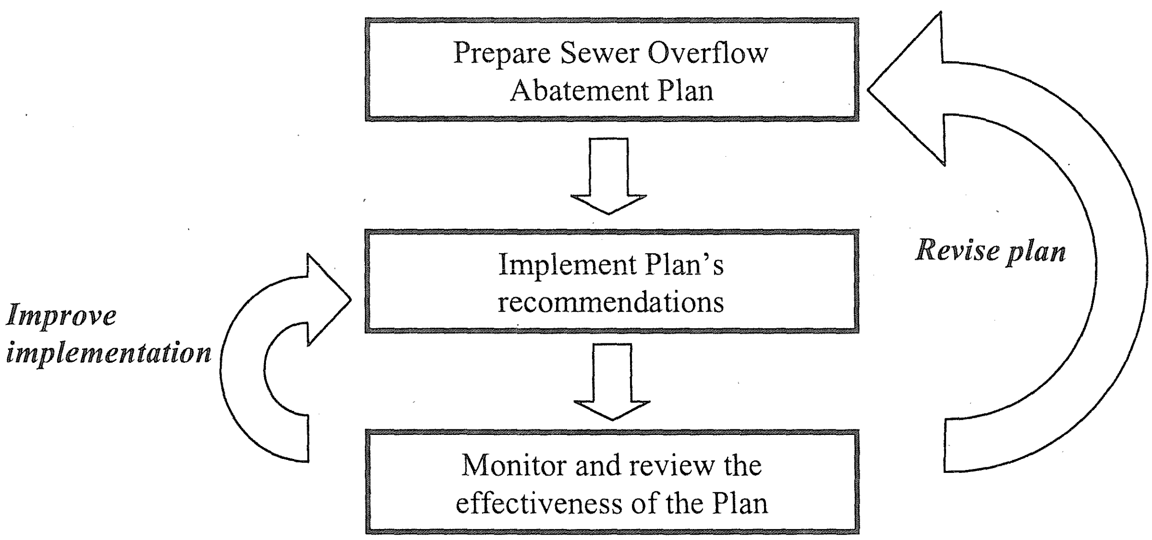

Figure 3 - The Sewer Overflow Abatement Planning Process

It is important to note that preparation of the plan is only one part of overflow management. There should also be a review of the implemented practices leading to ongoing improvements by the sewerage authority.

6 MANAGEMENT, OPERATIONS AND MAINTENANCE OF SEWERAGE SYSTEMS

The minimisation of overflow events and their impacts through the management, planning, monitoring, and emergency response and notification protocols are actions of a non-structural nature.

6.1 Organisational Management

To a certain extent, organisations base their asset management on human resources, customer services, and finance.

It is important that organisations that manage sewerage systems have clearly defined accountabilities relating to managing overflows. These accountabilities relate to:

- sewerage system planning;
- preparation and implementation of an overflow abatement plan;
- system maintenance which may include separate responsibilities for inspection and maintenance;
- maintenance of records relating to overflows; and
- acceptance of new connections to the system.

It is also important that there is a defined chain of communication and responsibilities laid out in the event of a serious overflow. These responsibilities include reporting the overflow to the appropriate authorities, sensitive downstream users, and the public.

Another important aspect for management is the appropriate training to manage overflows. This primarily applies to the staff of the organisation. Training can address appropriate operations and maintenance, system planning and inspection procedures for new connections. It can also highlight the responsibilities of individuals and explain the resources available to assist them in carrying out their roles. Operations and maintenance training can include training of staff in a number of skills, to ensure that the effectiveness of operations and maintenance activities are not compromised in the event of illness or absence. Refresher training could be provided to ensure that skills and knowledge are not lost over time and new techniques and technologies are used to manage overflows.

Training should also be provided to consultants, developers and contractors on the requirements for new systems.

6.2 Sewerage System Planning

Appropriate sewerage system planning is an important component of effective overflow minimisation. Planning involves the designing of the system to convey projected sewage flows and assessing the impact on system capacity of redevelopments in existing areas and extensions to serve new areas. This aspect is discussed further in Chapter 8.

6.3 Managing New Sewerage Connections

To complement suitable system planning for new developments, it is important that the system manager has in place clear requirements for the design, construction, inspection and testing of new systems. This should include a prohibition on stormwater connections to the sewerage system. These requirements could be contained in an ordinance, by-laws or in a standard agreement with developers. It is important that the system manager does not accept new connections that are substandard or overload the sewerage system. The system manager should be expected to minimise future overflows. Further details on minimising overflows from new systems are contained in Chapter 8.

In addition to technical requirements for new connections, the financial implications of new connections will need to be considered. New connections may result in the need to amplify downstream sewers or treatment plants. While a contribution to ongoing costs will be provided by the new ratepayers, consideration must be given to a charging scheme that recovers some or all of the capital costs of any required system augmentation.

6.4 Sewerage System Operations

The sewerage system can be operated in such a way as to maximise the storage available in the system for wet weather flows. This is generally achieved by operating the pumping stations to optimise storage with the sewer pipes and pumping station wet wells. This can minimise or eliminate wet weather overflows or direct wet weather overflows to less sensitive locations. Dynamic hydraulic modelling of the system is generally required to develop appropriate operating rules. Supervisory control and data acquisition (SCADA) systems are generally used for the remote control of pumping stations.

It should be remembered that the ability of the operators to manage the system to maximise wet weather storage is generally limited and may often only be a short-term option.

There is a range of system input (or demand-side) management techniques that can be implemented to minimise overflows and their impacts. These pollution prevention techniques include controlling wastewater inputs, in particular, major trade waste discharges to sewer, customer education, and dry weather flow reduction.

Sewage from industrial areas often has higher levels of pollutants than that from domestic sources. Therefore, overflows from these areas have the potential for a higher environmental impact. Solids, grease and corrosive substances have the potential to cause overflows or cause deterioration in sewers. Trade waste agreements are necessary to ensure that discharges to the system do not have excessive levels of pollutants. This is an integral consideration in determining whether the sewage treatment plant can accommodate these pollutants. Further details on trade waste issues are provided in the NWQMS *Guidelines for Sewerage Systems: Acceptance of Trade Waste (Industrial Waste).*

Education programs can assist in educating the community in overflow management. For example, this program could:

- highlight what to avoid putting in a sewer (grease, oil, sanitary pads, disposable nappies, cotton buds);
- encourage low phosphorous detergents;
- advertise the location of collection facilities for liquid waste for the community; and
- identify the species of trees suitable for planting above sewer pipes etc (to minimise root infestation).

Another aspect of community education is encouraging the inspection and maintenance of property sewers/drains. The length of these sewers is often approximately equal to those owned by the sewerage system manager. A community education campaign could also encourage checking of pipeline locations with the sewerage system manager before doing construction work.

6.5 Sewerage System Maintenance

6.5.1 Maintenance Activities

Sewerage systems are a significant and valuable part of Australia's water infrastructure. Appropriate operations and maintenance to minimise overflows may be relatively expensive. However, this should be weighed against the value of the sewerage system and the higher future costs if the asset is allowed to deteriorate further. Maintenance and rehabilitation add value to the original investment by maintaining the system's capacity and extending its life. Although the costs of sewer rehabilitation can vary between systems, costs are expected to be highest in systems where regular preventative maintenance programs have not been implemented.

Maintenance activities can be placed in three categories.

1. *Preventative maintenance.* These are routine scheduled activities performed before failure of the asset. Obviously, this extends the equipment life, reduces overall maintenance costs and increases system reliability.
2. *Corrective (or reactive) maintenance.* This relates to the use of an asset until it fails and then requires repair and replacement. This approach is generally used for non-critical assets and when corrective maintenance cannot be scheduled.

3. *Emergency maintenance.* This is a form of corrective maintenance that is applied to a critical asset that has failed, resulting in a risk to human health or the environment.

There are a number of elements of appropriate maintenance planning, including:

- an initial operational review;
- scheduling of routine inspections;
- scheduling of routine maintenance;
- emergency maintenance;
- reporting and record keeping;
- formal procedures for maintenance activities; and
- training of maintenance staff.

If a sewerage System Manager does not have a formal maintenance plan in place, an operational review of the system can be undertaken before a plan is prepared. This review can involve assessing existing facilities, operating conditions and maintenance practices.

The System Manager should have maps or a mapping system, such as GIS, of its sewerage system. The map should be based on work-as-executed plans, where available. This will show the location of designed sewer overflow structures and potential extent of pooling/contamination. It should also include streets and other landmarks, so that maintenance crews can locate elements of the system when required.

Overflow Abatement Plans (Chapter 5) can also provide important information for the review. This includes the sensitive areas subject to overflows and information on system characteristics such as sewer condition. It can also include pumping station data.

A schedule for routine inspections of the sewerage system is mandatory. Priorities should also be clearly stated. A risk-based approach is also necessary, considering factors such as the consequences of an overflow, the age of the asset, sewer diameter, the likelihood of the overflow, and the adequacy of the maintenance program.

In order to ensure that the schedule meets its goals, it needs to be periodically reviewed, and the results reviewed by management personnel to see if any further action is necessary. Reactive inspections are necessary to investigate the cause of any public complaints.

Routine or preventative maintenance of the system is also necessary. This is an important component of asset management, as it reduces the rate of deterioration and costly reactive maintenance of the asset. Problems identified during routine inspections should receive the necessary maintenance or repair actions.

Risk-based maintenance scheduling, stating frequency and type, is necessary, and more frequent maintenance on sewers that are likely to overflow to sensitive waters.

This schedule must also be reviewed, possibly based on the results of overflow reports, and revised as necessary.

Reactive or emergency maintenance occurs when a component of the system fails unexpectedly. In order to return it to service as soon as practical, the system manager will have written procedures for reactive maintenance. A record keeping system documenting the maintenance should be included in an Operational and Maintenance Plan. These records, based on inspection reports should include information on when elements of the system were inspected and what, if any, maintenance was performed (including details of the problem, the action taken, whether any further action is required and personnel involved). Significant maintenance issues should be reported to management, and in larger systems, this information could be included in the GIS for the system.

System managers are encouraged to write policies, procedures or protocols for system operations and maintenance, to be used for personnel training and monitoring activities. These, reviewed and revised as necessary, will ensure consistency in maintenance activities, for cost-effectiveness and comparison purposes.

Training of operations and maintenance staff is discussed in Section 6.1. An appropriate blend of formal classroom type training and on-the-job training can be used.

6.5.2 Maintenance of Sewers

Maintenance programs may include a geological stability assessment around the infrastructure, e.g., to account for washing away of sand lenses, which will affect structural stability. Assessment also includes sewer corrosion externally by aggressive groundwater and internally by sulphates producing sulphuric acid. Inspections of sewers can involve closed circuit TV (CCTV) inspection of sewer pipes and visual inspection of large diameter sewers to identify and record blockages, cracks, tree roots and accumulated sediment.

In areas where reports of overflows are unlikely to be reported by the public, e.g., bushland areas, the route of the sewer can be walked to check for any dry weather overflows. Maintenance holes and overflow structures are visually inspected for defects, possibly aided by mirrors on an adjustable pole. The pipes from overflow structures are checked for obstructions and the performance of any gas check valve is also checked.

Sewer maintenance techniques include:

- root cutting using a remotely operated cutting tool inserted at maintenance holes;
- chemical cleaning to reduce root infestation;
- removal of blockages by rodding; and
- sewer flushing to remove accumulated sediment.

Sewer rehabilitation and repair techniques are described in Chapter 7.

6.5.3 Maintenance of Pumping Stations

Sewage pumping station inspection and maintenance techniques include:

- inspection of telemetry and instrumentation;
- checking of valves and penstocks;
- mechanical and electrical inspection;
- pump capacity testing;
- removal of sediment/grit accumulated in wet wells; and
- cleaning of wet wells so that grease and fat build-up does not interfere with level control devices, as this can cause pump failures and overflows.

6.6 Monitoring Of Overflows

The System Manager and the regulator will often use technology, such as open-channel flow monitors, to monitor and report overflows. In some cases the overflow rate may be constant enough to monitor the start and end time of the overflow using using level gauges or switches. Overflow monitors may be connected to telemetry or supervisory control and data acquisition (SCADA) systems to provide alarms back to the system operator if required. If the hydraulic behaviour of the system is studied over time it may be possible to provide an alarm *before* an overflow occurs.

When using hydraulic models of the system, it will need to be calibrated using flow-monitoring data to analyse wet and dry weather, and inflow and infiltration volumes, and to calculate the severity for each defined catchment. This forms a basis for further work such as smoke testing, manhole inspections and CCTV.

Long-term flow monitoring provides information for planning purposes as well as the operation and maintenance of the sewer system. Load changes due to population growth and seasonal variation can be monitored accurately and the data used for future planning to avoid any potential future overflow problems. Long-term monitoring of key locations provides an ongoing check on the calibration of the hydraulic model if one has been built. This will increase confidence in model-generated reports for the whole system. Just as most pumping stations are considered critical points in a sewerage system and connected to SCADA, critical points within the gravity system can be monitored and also connected to the SCADA system.

6.7 Overflow Emergency Response

While the goal of effective sewerage system management is to convey, treat, reuse or dispose of sewage, overflows occasionally do occur. When it does, it is important that there are procedures in place that are followed to minimise the impacts.

An emergency response protocol must be developed and implemented in all sewerage systems. The system manager should ensure that the following are in place:

- adequate training of personnel;
- provision of appropriate equipment (e.g., bypass pumps, generators, bypass pipelines);
- access to operations and maintenance plans and system maps;
- prescribed actions to contain overflow, and prevent overflows during repairs;
- protocols for remedial work and debriefing of staff and others involved;
- reporting procedures to notify management, regulators and stakeholders; and
- community communications processes.

Emergency response teams should have access to all sewer facilities, and appropriate equipment to implement all of the contingencies necessary to deal with the sewer overflows.

These may include:

- process instructions for emergency operation of pumping stations;
- emergency notification phone numbers/contact details;
- inflatable weirs to contain overflows;
- filter socks to remove floatable and coarse solids;
- backup sewage pumps;
- tanker trucks that can pump or vacuum sewage and sludge;
- public warning signs and emergency tape to mark affected areas;
- sampling equipment; and
- occupational health and safety equipment to protect employees.

6.8 Emergency Response and Notification Protocol

Figure 4 presents a generic emergency response and notification protocol, as a guide for sewerage system operators. Variations may be expected, depending on local statutory, regulatory and administrative arrangement. While this protocol is presented as a sequential list of procedures, in reality some of these procedures may need to take place simultaneously. Alternatively, they may take place in a different order due to information collection problems, or other site-specific complications. Further, some of the steps may not be required for small overflows that do not present a significant risk to the environment or human health.

The protocol is also likely to vary depending on whether the overflow occurred in dry or wet weather. Generally, the most urgent response is necessary for a dry weather overflow. In wet weather, dilution by stormwater frequently occurs.

The procedures for the protocol are discussed in detail on the following pages.

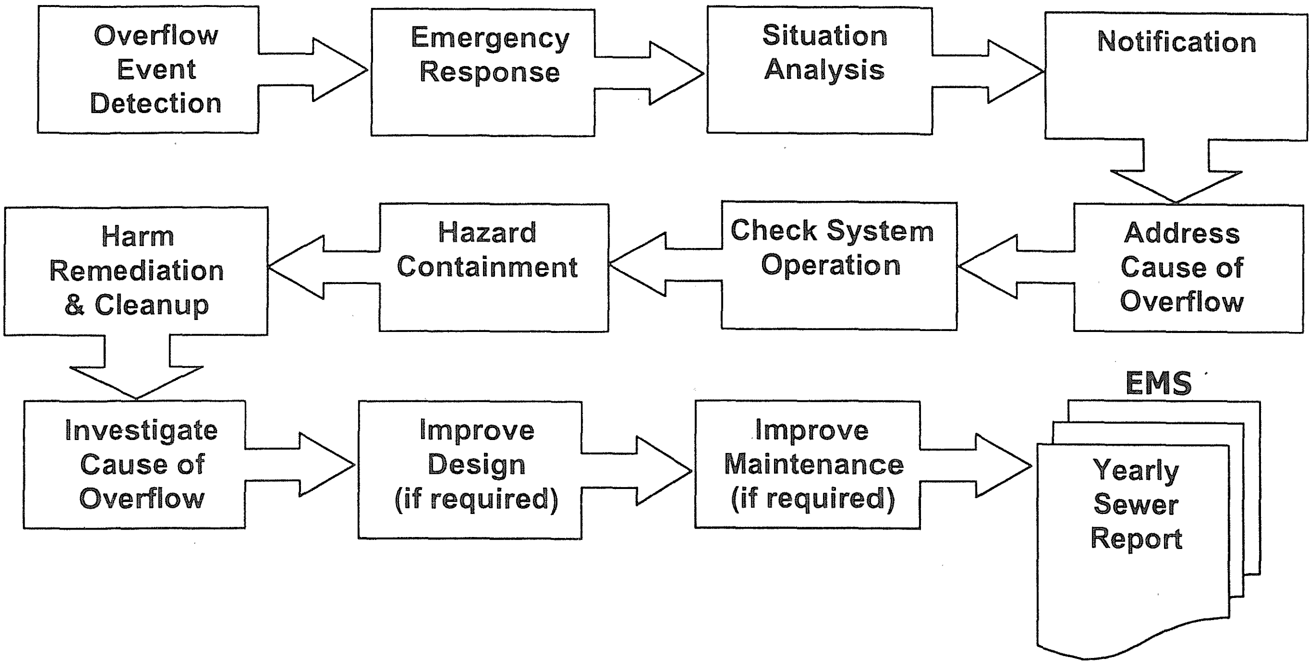

Figure 4 - Emergency Response and Notification Protocol

6.8.1 Overflow Event Detection

Overflow events can be most effectively detected by the automated control system of the sewerage system. These control systems alert operators to overflows from pump stations as well as other monitored points within the sewerage system.

Events that may generate an automatic alarm could be:

- low flow, high water, pump failure, or power failure at a pumping station;
- overflow to detention structures;
- low flow in on-line sewer monitoring; or
- low flow at the sewerage treatment plant.

Overflow events can also be determined by operators based on data correlation (e.g., hydraulic load measurements) and anticipated by statistical predictive techniques. Unusual operating conditions, such as a power drain, may indicate a rising main burst and warrant investigations. Remote pumping stations may rely on visual light or audible alarms that encourage the public to notify the sewerage authorities. Community participation can be is facilitated by local awareness programs on the purpose of the alarms. A 24-hour customer service line would enable the public to report overflows promptly to the sewerage authority.

In isolated regions and in some metropolitan areas, public notification is discouraged, given the reduced cost of automated dial-out alarm systems. These dial-out systems would link into the sewerage authority control system.

6.8.2 Emergency Response

Operators of sewerage systems provide 24-hour emergency response to overflows, to minimise or eliminate overflows.

Emergency response teams must follow the established emergency response protocol.

As noted in Section 6.5.1 the system manager has written procedures for failures that necessitate emergency. Emergency response plans may include restriction of sewer use by customers during exceptional, prolonged events (e.g., major overflow event greater than one or two days).

6.8.3 Situation Analysis

Ideally, key information collected to quantify the risk presented by a particular overflow includes:

- the duration of overflow;
- the capacity of sewer;
- the volume of the overflow;
- any available detention volume, if the alarm has occurred at a pumping station;
- the environmental values of the receiving waters;
- any exposure pathways to the public (e.g., swimming areas, school grounds);
- the ability to restrict public access;
- the overflow types, categorised as sewage, infiltrated sewage and treated effluent in order of potential impact; and
- referenced risk assessment information.

The volume of the overflow can be the most important piece of information used to assess the risks presented to downstream users. This is determined roughly by multiplying the duration of the overflow by the pump capacity, or the peak flow rate of sewage as an upper limit and applying factors for the time of day, wet weather conditions and other environmental factors. The duration of overflows may be accurately determined from on-line monitoring or estimated from pumping station duty hours from electricity supply records.

The initial risk assessment is naturally undertaken by personnel suitably trained in this area.

6.8.4 Notification

As soon as practicable after the overflow has been detected and the level of risk presented by the overflow has been estimated, the sewerage system operator notifies relevant stakeholders. These may include:

- environmental and human health agencies;
- local councils;

- waterway managers;
- downstream users potentially affected by the overflow; and
- the media for public notification of large events.

6.8.5 Address Cause of Overflow and Hazard Containment

It is important that the cause of the overflow be addressed as soon as practical. Addressing the cause may be a two-stage process, involving temporarily stopping the overflow and then undertaking permanent repairs.

Containment of the overflow should be undertaken as soon as practical, to prevent continued risk of pollution to the environment. Containment aims to capture the overflow while it is occurring, so that as much of the sewage as practical is returned to the sewer when operations are restored. Containment has the potential to cause problems at the site or upstream and should be approached with caution.

Possible actions to contain the overflows include:

- temporary weirs or bunds;
- the use of sewage pumping or vacuum trucks (to remove pools of sewage or pump out overflowing pump wells);
- temporary generators for pumping stations if the power supply has failed and temporary pumps if the pump has failed;
- bypass pumping;
- staggered pump station operation; and
- in-sewer storage (if feasible).

It may be possible to disinfect sewage impacted ground or pooled areas, however, this should be limited to localised areas and isolated pools produced by the overflows and the disinfection should not include disinfecting waterways. Care should be taken so that disinfection should not have a significant impact on the environment. Disinfection may be inappropriate in public areas such as parks and riparian zones for environmental reasons.

Flushing streams adversely affected by the spill can be a simple means of reducing the impact of the spill. However, this needs careful consideration so as not to compromise the environmental values downstream.

In emergencies, such as a major overflow event greater than one or two days, sewer use must be restricted. An example of restriction is for trade waste customers to cease discharge to sewer, and domestic customers in the affected sewer area be restricted to essential use, i.e., restrict or stop use of washing machines.

During risk containment and remediation, the risk to human health must be minimised. This can be done by restricting access with temporary emergency fencing and by erecting warning signs. Any residents or members of the public likely to be directly affected by the overflow must be notified. Warning measures must remain in place until there is no potential human health risk (e.g., when an ambient monitoring program indicates that the receiving environment has returned to “normal” or acceptable conditions).

6.8.6 Harm Remediation and Clean-up

Any environmental harm, property damage or other problems caused by an overflow will require remediation by the sewerage system manager. If this is competently managed, all those affected by the overflow, individuals and companies, and environmental, health, water management and municipal authorities, should be satisfied.

Clean up requires the removal to an acceptable level of all pollutants, including sediments and gross solids that may be left by an overflow. Any structures damaged by erosion or other effects of the overflow must also be repaired.

Disinfection of public areas such as parks and riparian zones may be inappropriate for environmental reasons. Disinfection generally is not considered an effective risk management response, as it implies that the health risk is removed, which may not be the case.

Remediation will need to be monitored for effectiveness in reducing the contaminants and secondary effects such as micro-organisms and insect population elevation. This may take some time, considering the possibility of insect infestation issues such as enhanced mosquito production.

Where practicable, an experienced Environmental Officer should be called to the site as an adviser on the potential environmental harm of an overflow.

Clean up should not involve potentially harmful activities, including the hosing down of gross solids and other pollutants into stormwater drains or aquatic environments and over use of disinfectants or use of environmentally damaging disinfectants. Records should also be kept of all actions undertaken to minimise the overflow and remediate any environmental harm.

For major overflows that reach waterways, water quality and river health monitoring must be undertaken after the clean up is complete, and repeated regularly until the waterway has returned to pre-overflow conditions. This monitoring may indicate that additional actions, such as insect control, are required to mitigate the impact of the overflow.

At the end of the clean up, all parties who were first alerted to the spill should be notified to verify that the incident has been addressed and completed and circumstances can return to normal.

6.8.7 Investigate Cause and Implement Improvements

It is important that the cause of the overflow is investigated. The cause may be reasonably obvious (e.g., a choke caused by tree roots), or less obvious (e.g., problems with the controller of a pumping station). When the cause has been determined, reasonable actions should be implemented to prevent a re-occurrence of the event. This principally applies to dry weather overflows. Actions may include modifications to the design, operation and maintenance of the system.

Relevant regulatory authorities may require a report on significant individual overflows or an annual report that summarises all overflows.

Failure analysis is an important aspect of the continual improvement of sewers and sewerage systems. It is important to explore hypothetical situations and response protocols in order to refine management of overflow incidents.

It is an important step to record all reasons for failures, to improve future designs, upgrade existing systems, and to fine-tune the performance of complex sewer systems. Improvements to design should also be fed back into both the Asset Management System and Environmental Management System for the sewerage system.

Regulatory authorities require demonstrated improvement to systems that have failed to satisfy their requirements of best practice environmental management and due diligence. Annual reporting of sewer improvements through Environmental Management Systems or other reporting strategies is an important aspect of sewerage system management. Sewerage system performances are assessed on the basis of the agreed reporting strategy.

7 MANAGING OVERFLOWS BY STRUCTURAL MEASURES

This section describes a range of structural techniques that can be used to minimise the environmental impacts of sewer overflows. A combination of these techniques is likely to be the most appropriate approach. The relevant personnel will usually want to enhance asset structural condition, augment asset capacity, improve the reliability of the sewerage system and monitor the environment of the potentially problematic areas. During the overflow abatement planning process (Chapter 5), when costs and benefits of the techniques are evaluated is the best time to select the appropriate technique. They may also need to do preliminary investigations such as sewer gauging, smoke testing, CCTV inspection, visual inspections and water quality monitoring to select the most appropriate techniques. They could also identify an appropriate combination of options by modelling the sewerage system.

7.1 Infrastructure Rehabilitation

7.1.1 Sewer Pipe

Sewer pipes that are broken or cracked need to be rehabilitated to minimise infiltration/inflow and leakage. The most common techniques involve "trenchless technology", which minimises the costs and disruption compared with open excavation. There are two common approaches:

1. Grouting the sewer to fill cracks and joint defects.
2. Lining sewers with a durable waterproofing liner material or inserting a new pipe (through an approach called pipe bursting).

In some circumstances, such as broken or collapsed sewers, open excavation and replacement may be required. This is also often required at the junctions with property sewer/drains on lined pipes.

7.1.2 Maintenance Hole

Defective maintenance holes can be rehabilitated by:

- spraying the inside of the maintenance hole with a non-porous material;
- installing a durable waterproofing liner or insert; or
- reconstructing part or all of the maintenance hole (e.g., if the cone is offset)

Cracked maintenance hole lids and surrounds can be replaced, and leakage from surface runoff into maintenance holes should be prevented.

7.1.3 Property Sewer/Drain

Property sewer/drains can be rehabilitated by lining or by replacement through open excavation.

It should be noted that although private sewers may contribute significantly to wet weather overflows property sewer/drain rehabilitation is only undertaken with the property owners' approval.

7.2 Sewerage Upgrades

7.2.1 Sewage Pumping Stations

There are a number of approaches to reduce overflows from sewage pumping stations, and these include:

- providing additional storage volume;
- installing additional pumps;
- upgrading the pump or pumps and the rising main;
- providing an additional power supply to the pumping station; and
- upgrading the alarm system, including any telemetry system.

If there is no telemetry system available, installation may occur on a staged basis. Priority should be given to large pumping stations, pumping stations that discharge to sensitive locations, or those that overflow frequently. In these situations Supervisory Control and Data Acquisition (SCADA) systems may be used to continuously monitor the operating status of pumping stations.

7.2.2 Overflow Structures

In some cases overflow structures discharging into sensitive locations can be relocated to less sensitive locations. This is done by relocating the discharge pipe from the overflow structure or by sealing the discharge pipe and relocating the structure to another location in the sewerage system. A similar approach is adopted for overflows discharging from sewage pumping stations.

It may be necessary for treatment facilities to be provided at designed overflow structures. The various levels of treatment range from primary treatment (e.g., screening, grit removal) to secondary treatment with disinfection.

7.2.3 Wet Weather Storages

In some cases underground storages are constructed in-line or off-line within the sewerage system to temporarily store wet weather flows. These storages generally drain back to the sewerage system when flows in the system have reduced. Above ground wet weather storages are also acceptable in most circumstances. These storages are sometimes provided at the treatment plant, however, depending on the size of the system and the extent of the problem wet weather storage can be an expensive option.

7.2.4 Amplify Sewers

Sewer amplification can be used to reduce wet weather overflows. This commonly occurs in the trunk section of the sewerage system. The additional hydraulic capacity can be used to convey the wet weather flows to the treatment plant or to an overflow structure in a less sensitive location.

If the wet weather flows are conveyed to the treatment plant, a degree of treatment of the wet weather flows is likely to occur prior to discharge. It may be necessary to compare the costs and benefits of this sewer amplification approach relative to minimising wet weather flows by sewer rehabilitation. This may include an assessment of the additional sewage treatment costs and maintenance costs for the additional sewer.

If the treatment plant has a primary and secondary outfall, these wet weather enhanced flows are likely initially to be discharged through the secondary outfall. The secondary outfall often discharges to a more sensitive location than the primary outfall. The additional flows may, however, increase the frequency at which lower treatment level discharges occur from the treatment plant. Upgrading of the treatment plant may be required to avoid occurrence of this problem.

7.3 Other Measures

7.3.1 Cross Connection Elimination

Cross connections between the stormwater and sewerage system are usually corrected by physically disconnecting the stormwater pipe from the sewer, and connecting it to the stormwater system. Downpipes from roofs are the most common illegal connection to sewers. Another source of stormwater inflows to sewerage systems can be gully drains under outside taps. To prevent this, gully drains may be constructed with a surround (or bund) to prevent stormwater runoff from flowing into the gully and entering the sewerage system.

8 MINIMISING FUTURE OVERFLOW RISK FROM NEW SEWERAGE SYSTEMS

This chapter discusses how new sewerage systems can be designed, constructed and inspected to minimise their overflow potential. It is not intended to be a design guide for new systems. Large system operators, some regional and state jurisdictions and other organisations, such as Water Services Association of Australia (WSAA) have technical guides or codes for the design of sewerage systems which should be used where applicable.

This chapter also discusses the sizing of sewerage system elements (sewers, sewage pumping stations), the location of overflow structure, and the construction of new sewerage systems.

The level of service required for the sewerage system should be determined by the system operator. Agreement may be required with a regulator, possibly through a licence/permit.

8.1 Sewerage System Sizing

8.1.1 Design flows

Sewerage systems are generally designed to convey dry weather sanitary flows and wet weather flows. The dry weather flows are commonly calculated using a relationship between flow and the population served by the sewer (often expressed as equivalent persons or tenements). The wet weather flows are commonly calculated as a function of the catchment area contributing to the sewer, a multiple of the dry weather flow or as a function of the length of the sewer.

An effective asset management program should be designed to minimise overflows from system failures. The volume of the dry weather overflow can be small and the area affected limited, but the localised impact may be significant. As many dry weather overflows may be an indication of a poorly maintained system or a system suffering from lack of investment, such events are generally viewed in a negative light by regulators. Poorly designed, constructed or maintained systems result in high wet weather flows.

It is important that the design flow account for the more immediate future conditions. The design for dry weather flows may need to accommodate future upstream developments. If this does not occur, the additional flows can cause downstream overflows by reduced capacity to convey flows. The wet weather flows should account for expected deterioration in the sewerage system, resulting in increasing infiltration/inflow.

While it is important to design and construct the sewerage system to minimise overflows, it is unlikely that wet weather overflows can be prevented in older systems. The failure to account for these flows when designing elements of the system such as pipes and pumping stations can result in an increasing frequency of wet weather overflows over time.

8.1.2 Sewers

It is necessary to design sewers to minimise slime growth or siltation, which may reduce capacity, resulting in overflows. They should also be designed to minimise long term erosion, which may lead to a failure and a consequent overflow.

Design charts or tables to convey design flows are effective methods of sizing sewers. In larger systems, it may be appropriate to use hydraulic models of the sewerage system. It is important that the hydraulic sizing of the system accounts for head losses at maintenance holes. To identify unexpected flow restrictions or head losses it may be necessary to use models of structures with complex hydraulic behaviour.

To minimise pipe blockage, pipe diameters for reticulation systems should not decrease in a downstream direction, even if this results in excess hydraulic capacity. However, this situation of decreasing pipe diameter may be acceptable in larger diameter trunk sewers, where blockages rarely occur.

Consideration should be given to the choice of pipe materials, particularly in regard to structural soundness and corrosion resistance. Joints should also be designed to minimise tree root intrusion and infiltration of groundwater. However, as a general principle, pipelines should have minimal joints.

8.1.3 Maintenance holes

Maintenance holes should be designed to minimise the potential for infiltration/inflow and should not collect surface runoff. These factors are minimised by avoiding the location of maintenance holes with conventional covers in drainage paths or flood-prone areas. Sealed or bolt-down covers should also be used under these conditions.

8.1.4 Sewage Pumping Stations

Most sewage pumping station storage volumes have two components: design volume and emergency storage. The first component caters for the design inflow, balancing storage volume and pumping rate. Pumping stations are usually designed to cater for the peak inflow they can reasonably be expected to receive during their life (e.g., peak inflow = 1.5 x average flow for 3 hours duration). Under these circumstances the station should not hydraulically impede the flow in the sewerage system.

In addition, pumping stations normally have an emergency storage capacity in the system so that any pumping station breakdown is less likely to result in overflow. The emergency storage capacity must be sufficient to allow for an effective response time necessary to remedy the overflow cause. The level of additional capacity and backup facilities provided must relate to the potential impact of the pollution that would occur in the event of overflow.

Detention time for the emergency storage in the system is the period between the first pumping station alarm and overflow to the environment. Detention times usually range between two and eight hours at the peak flow. Where the response time is short or the environmental impacts of an overflow are likely to be minor, a shorter detention time could be adopted. Longer detention times are appropriate when response times are long (e.g., access difficulties) or when the environmental impact of the overflow may be significant. The relationship between response time and detention volume is illustrated in Figure 5.

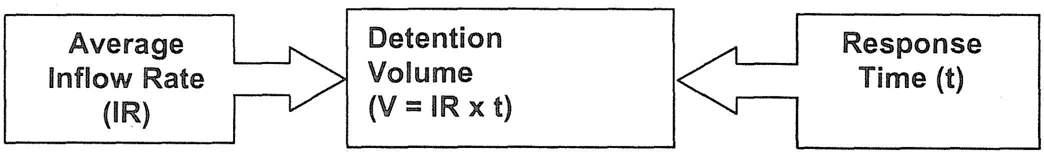

Figure 5 Sewer and Pump Station Design Criteria

(IR = Average inflow rate during the response time over the period of maximum inflow)

In sensitive areas, detention ponds or other above ground storages may also be provided. Flows from pumping stations can be designed to overflow to other sewerage systems in the event of station failure. Large storage volumes are not likely to be cost-effective for larger pumping stations. These cost considerations provide an incentive for developing alternative design and operational considerations to reduce the risk of overflow.

In addition to mechanical and electrical faults within the pumping stations, power failure is another frequent cause of overflow. Dual power supplies or emergency generators are often installed on major or critical stations to reduce the risk of overflows. Alternatively mobile generators are stored at depots and used when necessary at pumping stations.

Pumps installed at pumping stations must permit the passage of solids, i.e. have appropriate impeller and pump characteristics.

For vacuum systems an alternative power source can be provided to operate the pumping station during times of power failure. In addition, an emergency storage volume may be provided at the interface valve pit/maintenance hole on the gravity sewer.

Telemetry and dial-up systems are preferable to audible or visual alarms to minimise the elapsed time between a problem and its solution.

Overflows from the sewerage system due to power or equipment failure are generally considered to be unacceptable. The following actions ensure impacts of failure are mitigated:

- 24 hour emergency response plan;
- telemetry or dial-up systems to provide early advice of failure;
- dual pumps;
- back up controls;
- stand-by/alternative power; and/or
- ensuring that spare parts are readily available.

If power or equipment failure does threaten, contingency plans will be necessary, involving management of mobile pumps and generators, and adequate emergency storage.

8.1.5 Design Phase

The following elements should be included in the design phase:

- overflow structures if required,
- in-system storage capacity if required;
- back up for mechanical, electrical, telemetry, communications or control breakdowns,
- bypass facilities for pumping stations;
- availability and response time of support service; and/or
- asset management and maintenance.

In the event of power failure, it may be necessary to provide on-site power generation, sufficient storage capacity to allow for portable power generation to be connected in the system or an alternative power supply line to a zone distributor.

In the event of plant or equipment failure, stand-by pump/equipment must cut in automatically. Sufficient storage capacity must be installed or brought on line in the system, and the existing plant be repaired, or the station must be manually controlled.

8.2 Location of Overflow Structures and Sewage Pumping Stations

There are a number of factors to consider regarding the:

- selection of overflow structure locations (minimal impacts, access and purposes);
- components of overflow structures (detention, discharge points, services required, access and working space); and
- hazard of overflow structures (safety, flooding, rodents, signage, public exclusion, erosion and overgrowth).

Sewage pumping stations are often designed with an overflow pipe to cater for when the peak design hydraulic capacity is exceeded or a critical malfunction has occurred. The overflow is directed to an appropriate location: a stormwater drain or a watercourse. It is important that any overflow from a pumping station is carefully located to minimise any environmental impacts. If this is not feasible, the location of the pumping stations should be reviewed. Alternatively, a larger storage volume resulting in a longer detention time should be provided with an alarm system.

As large detention basins can, however, be health and environmental hazards, minimum detention volumes, based on a risk assessment taking into account the available emergency response, are recommended.

Storage includes available capacity within the reticulation network. The use of other appropriate approved storages is recommended. Approval from the local planning authority may be necessary for storages outside the boundary of the pumping station.

Large storage volumes are likely to be cost-prohibitive with pumping stations, and these cost considerations provide a further incentive for the development of alternative design and operational considerations to reduce the risk of overflow (e.g., multiple pumps in conjunction with a duplicate power source).

Operational considerations need to be adapted to the circumstances, and an emergency response manual (based on the Emergency Response Plan) should be prepared to guide the operation of the emergency response team. The existence of the manual, and the form and reliability of the response in different situations can be outlined in a fact sheet for easy access. The manual may also describe training arrangements for the emergency response team, and arrangements made to monitor, report and review the effectiveness of the emergency control response (Sections 6.7 and 6.8). Where proposals for alternative design specifications are put forward for approval, justification and technical documentation must be provided.

8.3 Construction and Inspection

Construction specifications for new sewerage systems require the system to be built in order to minimise future overflows. This includes addressing issues such as:

- defects in maintenance holes (e.g., joints in pre-cast maintenance holes);
- settlement of sewers or maintenance holes, possibly resulting in joints opening;
- root ingress through pipe joints;
- appropriate tree planting above sewers;
- sufficient cover above pipes to minimise the risk of breakage (alternatively, the pipe could be encased or bridged); and
- ensuring no cross-connections with stormwater pipes.

This applies to both the reticulation systems operated by the system manager, property sewer/drains, and private sewers.

Management practices must ensure that new systems are constructed in accordance with the design and specifications and in accordance with a quality assurance system.

It is important that new sewerage systems are inspected to detect any defects that may result in future overflows. Inspections must include:

- visual inspection of maintenance holes and sewers to identify any defects and to ensure that maintenance hole covers fit tightly into their surround;
- an assessment of the alignment of sewers, to detect defects such as displaced pipes; and
- a water or air test of gravity sewers.

APPENDIX A: THE NATIONAL WATER QUALITY MANAGEMENT STRATEGY (NWQMS)

In October 2001 the Natural Resource Management Ministerial Council superseded the Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ). The Council will continue the development of the National Water Quality Management Strategy (NWQMS).

The guiding principles for the NWQMS are set out in *Policies and Principles - A Reference Document*, which emphasises the importance of:

- ecologically sustainable development;
- integrated (or total) catchment management;
- best management practices, including the use of acceptable modern technology; and waste minimisation and utilisation; and
- the role of economic measures, including user pays and polluter pays.

The process of implementing the NWQMS involves the community working in concert with government in setting and achieving local 'environmental values', which are designed to maintain good water quality and to progressively improve poor water quality. It involves development of a plan for each catchment and aquifer, which takes account of all existing and proposed activities and developments, and which contains the agreed environmental values and feasible management options.

APPENDIX B NWQMS: GUIDELINES AND DOCUMENTS

No.	Paper Title
Policies and Process for Water Quality Management	
1	Water Quality Management - An Outline of the Policies 1994
2	Policies and Principles - A Reference Document 1994
3	Implementation Guidelines 1998
Water Quality Benchmarks	
4	Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) revised
5	Australian Drinking Water Guidelines – Summary 1996
6	Australian Drinking Water Guidelines 1996 revised
7	Australian Guidelines for Water Quality Monitoring & Reporting 2000
Groundwater Management	
8	Guidelines for Groundwater Protection in Australia 1995
Guidelines for Diffuse and Point Sources	
9	Rural Land Uses and Water Quality - A Community Resource Document 2000
10	Australian Guidelines for Urban Stormwater Management 2000
11	Australian Guidelines for Sewerage Systems - Effluent Management 1997
12	Guidelines for Sewerage Systems - Acceptance of Trade Waste (Industrial Waste) 1994
13	Guidelines for Sewerage Systems - Biosolids Management (2004)
14	Guidelines for Sewerage Systems – Use of Reclaimed Water 1999
15	Guidelines for Sewerage Systems - Sewerage System Overflows (2004)
16a	Effluent Management Guidelines for Dairy Sheds 1999
16b	Effluent Management Guidelines for Dairy Processing Plants 1999
17	Effluent Management Guidelines for Intensive Piggeries 1995
18	Effluent Management Guidelines for Aqueous Wool Scouring and Carbonising 1995
19	Effluent Management Guidelines for Tanning and Related Industries 1995
20	Effluent Management Guidelines for Australian Wineries and Distilleries 1998

The guidelines for diffuse and point sources are national guidelines which aim to ensure high levels of environmental protection that are broadly consistent across Australia. For more information on these guidelines please visit either of these websites: http://www.daff.gov.au/ or http://www.deh.gov.au/

APPENDIX C: ISSUES FOR SEWER OVERFLOW RISK ASSESSMENT

A. References for Risk Assessment

For existing sewerage systems, there are several published methods that are applicable for a risk-based sewer overflow impact assessment. These methods are described in more detail in the *Guidelines for Ecological Risk Assessment,* US EPA, April 1998 and *Combined Sewer Overflows: Guidance for Long Term Control Plan,* US EPA, August 1995.

A risk-based approach that could be used to identify the critical or the high priority components for priority actions is described in *AS/NZS* 4360:1999 *Risk Management Standard.*

The issues suggested below are only a brief summary of the common elements of these methods and include:

- characterisation of the wet weather overflows;
- receiving water characteristics;
- assessment of the probability and consequences of the overflow;
- improvement plan; and
- overflow abatement program (Chapter 5).

The aim is to prioritise existing overflows in terms of their potential environmental and human health impact, and identify any significant system deficiencies. It is not intended for use in designing new sewerage systems.

B. Overflow and Receiving Waters Characteristics

(i) Overflow Quantity

Initially the frequency, duration and volume of overflows can be quantified. In small systems it may be possible to monitor each overflow. In general, however, some kind of model is necessary to understand and predict the performance of the sewerage system. In larger systems a possible approach is to gauge several known significant overflows and to establish a calibrated model of the system's behaviour in wet and dry weather. This may then be used to characterise the overflow performance for a variety of operational scenarios or system enhancements. The model might take the form of a simple spreadsheet or for more complex systems, use available hydraulic modelling software.

(ii) Overflow Quality

Sewage derived from domestic sources may present a lower impact compared with that derived from industries, which could have:

- high environmental risk;

- high volume discharges;
- poor performance history; and
- waste streams containing significant concentrations of toxicants or other pollutants.

Table 2 characterises the quality of domestic raw sewage that may be in an overflow. Note that industrial waste may be substantially different.

Table 2 – Typical Contaminant Levels in Domestic Sewage

Contaminants	Unit	Concentration		
		Weak	Medium	Strong
Biochemical Oxygen Demand	mg/L	110	220	400
Chemical Oxygen Demand	mg/L	250	500	1000
Suspended Solids	mg/L	100	220	350
Settleable Solids	mL/L	5	10	20
Total Dissolved Solids	mg/L	250	500	850
Total Organic Carbon	mg/L	80	160	290
Nitrogen (total as N)	mg/L	20	40	85
Organic Nitrogen	mg/L	8	15	35
Free Ammonia	mg/L	12	25	50
Phosphorus (total as P)	mg/L	4	8	15
Organic P	mg/L	1	3	5
Inorganic P	mg/L	3	5	10
Alkalinity (as $CaCO_3$)	mg/L	50	100	200
Grease	mg/L	50	100	150
Total Coliforms	No./100mL	10^6-10^7	10^7-10^8	10^7-10^9

Source: Wastewater Engineering Treatment Disposal Reuse, Metcalf and Eddy 3rd Edition 1991

(iii) Receiving Waters Characteristics

Physical factors, which influence the rate of dilution and dispersion of overflows include:

- number of tide cycles to flush estuarine/marine systems;
- proportion of flow in riverine system;
- channelled or un-channelled urban waterway or unmodified waterways;
- receiving water catchment area; and
- location in catchment (headwaters, catchment outlet).

(iv) Environmental Values and Water Quality Objectives

If the environmental values and associated water quality objectives for a particular receiving water are known an immediate assessment of the potential issues and the associated environmental risks related to the overflow can be made. The scale of the impact can also be ascertained.

The environmental values as detailed in the NWQMS *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* are for aquatic ecosystem, recreation, primary production, drinking water, industrial waters and cultural and spiritual values. Water quality objectives are numerical concentration limits or descriptive statements recommended to support and maintain designated environmental values in the receiving environment.

The principal parameters (key indicators) of concern for overflows and their associated potential effects are detailed in Table 1 (Section 3.2).

(v) Risk Associated with Overflow

In general terms the following table characterises the potential effects of the overflow.

Table 3 Risk associated with Overflows

Parameters	Low Potential or Risk	High Potential or Risk
Environmental Values	Industrial Waters, Agricultural Waters	Drinking Water, Recreational Water-Primary Contact, Aquatic Ecosystem Protection
Water Quality Objectives	Low degree of compliance	High degree of compliance
Overflow Characteristics	Infrequent, low volume, short duration	Frequent, high volume, long duration
Physical Factors	High dilution and dispersion rate	Low dilution and dispersion rate
Overflow Quality	Domestic source	Industrial source

The ultimate aim of this process is to prioritise overflows in terms of potential impact, identify system deficiencies, and determine acceptable system performance. At this stage there may be some iteration in terms of modelling different system operation or system configuration scenarios to optimise system performance and costs. Consideration may also be given to transfer of overflow impact from a sensitive catchment to an area where the impact is less significant.

After the initial risk assessment is completed, further assessments can be undertaken as part of the overflow abatement planning. Various structural options can be investigated (possibly using modelling) to reduce the priority ranking of high priority overflows. An iterative approach may also be used to investigate different system operation or system configuration scenarios to optimise system performance and costs.

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APPENDIX E: GLOSSARY

Algae
Comparatively simple chlorophyll-bearing plants, most of which are aquatic and microscopic in size.

Alkalinity
The quantitative capacity of aqueous media to react with hydroxyl ions. The equivalent sum of the bases that is titratable with strong acid. Alkalinity is a capacity factor that represents the acid-neutralising capacity of an aqueous system.

Ambient waters
All surrounding waters, generally of a natural occurrence.

Aquatic ecosystems
Any watery environment from small to large, from pond to ocean, in which plants and animals interact with the chemical and physical features of the environment.

Aquifer
An underground layer of permeable rock, sand or gravel that absorbs water and allows it free passage through pore spaces.

Biochemical (or Biological) Oxygen Demand
The decrease in oxygen content in mg/L of a sample of water in the dark at a certain temperature over a certain of period of time which is brought about by the bacterial breakdown of organic matter.

Biosolids
Stabilised organic solids derived from wastewater treatment processes solids which can be managed safely to utilise beneficially their nutrient, soil conditioning, energy, or other value (biosolids does not include untreated raw wastewater sludges, industrial sludges that cannot be used beneficially without further processing or the product produced from the high temperature incineration of sewage sludge).

Branch
Lateral or connection to the sewerage reticulation system.

Concentration
The quantifiable amount of chemical in, say, water, food or sediment.

Contaminant
Biological (e.g., bacterial and viral pathogens) and chemical (see Toxicants) introductions capable of producing an adverse response (effect) in a biological system, seriously injuring structure or function or producing death.

Dry weather flow (DWF)

The flow carried by a sewerage system during dry weather. It consists of flows generated by properties connected to a sewerage system excluding the effects of inflow/infiltration resulting from rain events. Also known as sanitary flow.

Ecologically Sustainable Development
Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends.

Effluent
Treated or untreated wastewater flowing out of a treatment plant or transfer system.

Emergency relief structure
See Overflow structure.

Enterococci
The enterococcus group is a subgroup of faecal streptococci that includes *S. faecalis, S. faecium, S. gallinarum and S. avium*. The enterococci are differentiated from other streptococci by their ability to grow in 6.5% sodium chloride, at pH 9.6 and at 10 °C and 45 °C. The enterococci portion of the faecal streptococcus group is a valuable bacterial indicator for determining the extent of faecal contamination of recreational surface waters.

Environmental values
Particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and that require protection from the effects of pollution, waste discharges and deposits. Several environmental values may be designated for a specific waterbody.

Exfiltration
The escape of sewage to the surrounding soil through faults in sewerage systems.

Groundwater
Subsurface water from which wells or springs are fed; strictly, the term applies only to water below the water table.

Illegal discharge
The deliberate diversion of water or unlicensed dumping of liquid or substances to a sewerage system.

Infiltration
The ingress of groundwater to a sewerage system.

Inflow
The entry of water into the sewer resulting from rainfall events.

Lateral
See Property Sewer/Drain.

Main sewer

A larger diameter sewer, usually not available for direct connection of Property Sewer/Drains.

Nutrients
Compounds required for growth. Nitrogen and phosphorus are the most common nutrients.

Operator
An individual connected to the operation and maintenance, monitoring, or internal regulation or assessment of the performance or management of a sewerage system.

Overflow structure
A structure which is intended to provide relief, in a controlled manner, from potential hydraulic overloading of a sewerage system. Also known as an emergency relief structure (ERS). These structures are designed to discharge sewage during an emergency situation, not during normal operating conditions.

Pathogen
Micro-organisms which can cause disease in humans and animals.

Peak Flow
The maximum flow that occurs in a system.

Pollution
The introduction of unwanted components into waters, air or soil, usually as result of human activity, e.g., sewage into waterways, oil on land.

Potable water
Water suitable, on the basis of both health and aesthetic considerations, for drinking or culinary purposes.

Primary treatment
The process that removes a substantial amount of suspended matter but little or no colloidal and dissolved matter.

Property Sewer/Drain
A portion of the gravity system that links the household to the reticulation sewer.

Reticulation sewer
A small diameter sewer that receives flows from property sewers/drains and feeds main sewers.

Rising Main
A sewer requiring sewage pumping stations to provide the energy to discharge sewage at a higher level. Rising mains are under pressure, and therefore require more controls and design requirements such as alarms on SPS or automatic shutoff functions to reduce flows from a burst pressure main. Also referred to as pressure main.

Risk

A statistical concept defined as the expected likelihood or probability of undesirable effects resulting from a specified exposure to known or potential environmental concentrations of a material. A material is considered safe if the risks associated with its exposure are judged to be acceptable.

Salinity
The presence of soluble salts in or on soils or in water.

Sanitary flow
See dry weather flow.

Secondary treatment
The processes that remove or reduce suspended and dissolved solids and colloidal matter.

Sewage
The used water from domestic, commercial and industrial sanitary appliances containing dissolved and suspended matter. Sewage may also contain approved trade wastes.

Sewerage
A system of pipes, maintenance holes, pumps, treatment facilities and other items for handling sewage.

Sewage Pumping Station
A facility that may be above ground or underground, with pumps and wells that provide the hydraulic lift for pressurised sewage flows in rising mains. Pumping stations must have automated alarm systems, and, if required, detention systems for returning flow to the sewer.

Sewer
Pipes for conveying sewage.

Sewer overflow
The liquid, dissolved and suspended matter (including inflow and infiltration) discharging from a sewerage system to the environment. An overflow is an event that causes or has a potential to cause an environmental or human health harm. The receiving environmental conditions will dictate the degree of risk of such harm.

The scale of the spill depends on the volume and duration of the overflow and receiving environment characteristics. It can be described in the context of the dispersion zone or attenuation distance required to disperse/dilute or contain a pollutant that affects the environmental values of that zone but not beyond it. The effect on both surface water and groundwater would need to be considered in the assessment of the impact.

Surcharge capacity
The maximum flow which can be carried by a gravity sewer without overflow occurring.

Suspended solids
Material that resides in the sewage or water; it is dispersed in a sample upon agitation.
Thermotolerant coliforms

Also known as faecal coliforms. A subset of coliforms found in the intestinal tract of humans and other warm-blooded animals which can ferment lactose at 44 -45°C to produce acid and gas. Normally consists chiefly of *E.coli*. They are used as indicators of faecal pollution.

Toxicant
A chemical capable of producing an adverse response (effect) in a biological system at concentrations that might be encountered in the environment, seriously injuring structure or function or producing death. Examples include pesticides, heavy metals and biotoxins.

Trade waste
Trade waste is the liquid waste generated from any industry, business, trade, or manufacturing process. It does not include domestic wastewater.

Trunk sewer
A very large diameter sewer which carries large flows directly to treatment plants or major pumping installations.

Turbidity
A condition in water or wastewater caused by the presence of suspended matter, resulting the scattering and absorption of light; an analytical quantity usually reported in nephelometric turbidity units (NTU) determined by the scattering of light.

Wastewater
The used water of a community or industry, containing dissolved and suspended matter. (See sewage.)

Water quality objective
A numerical concentration limit or narrative statement that has been established to support and protect the designated uses of water at a specified site. It is based on scientific criteria or water quality guidelines but may be modified by other inputs such as social or political constraints.

Wet weather flow (WWF)
The flow carried by a sewerage system during wet weather. It consists of sanitary flow and the flows resulting from the inflow/infiltration.