CIRIA C648 London, 2006

Control of water pollution from linear construction projects

Technical guidance

E Murnane HyderConsulting

A Heap HyderConsulting

A Swain Edmund Nuttall

CIRIA *sharing knowledge ▪ building best practice*

Classic House, 174–180 Old Street, London EC1V 9BP, UK
TEL: +44 (0)20 7549 3300 FAX +44 (0)20 7253 0523
EMAIL enquiries@ciria.org
WEBSITE www.ciria.org

Summary

This publication provides guidance to clients, consultant, designers, contractors and regulators on how to plan and manage water pollution from road, railway, pipeline, waterway and other linear construction projects. It is divided into three sections:

- **Part A Characteristics of linear projects and understanding water pollution** provides an introduction to water pollution and looks at the types and characteristics of water environments.
- **Part B Planning and design** is concerned with the design, planning and programming of a project and the measures that can be taken at these critical stages to minimise water pollution during construction.
- **Part C Construction** provides guidance on the construction phase of a project and covers the management and control of water onsite and pollution prevention measures for key construction activities.

This guidance is fully cross-referenced and illustrated and is intended to be a user-friendly reference guide to support previous CIRIA publications on the subject.

Control of water pollution from linear construction projects. Technical guidance

Murnane, E; Heap, A; Swain, A

CIRIA

CIRIA C648 RP708

ISBN-13: 978-0-86017-648-0

ISBN-10: 0-86017-648-7

British Library Cataloguing in Publication Data

A catalogue record is available for this book from the British Library.

Keywords

Construction management, environmental good practice, pollution prevention, rivers and waterways, site management, water quality

Reader interest	Classification	
Pollution prevention, linear construction, surface water, groundwater, construction cycle, pollution migration	AVAILABILITY	Unrestricted
	CONTENT	Advice/guidance
	STATUS	Committee-guided
	USER	Construction professionals and managers

Published by CIRIA, Classic House, 174–180 Old Street, London EC1V 9BP, UK.

Acknowledgements

This publication was produced as a result of CIRIA Research Project 708, "Control of water pollution from linear construction projects" and was written by Ms Emma Murnane and Mr Andy Heap of Hyder Consulting Ltd and Mr Andrew Swain of Edmund Nuttall Ltd. Additional contributors were Mr Luke Stalley, Mr Bob Sargent, Dr Amy Davis, Mr Simon Witney, Ms Abigail Frost, Ms Sarah Hammond and Mr Daniel Palmer of Hyder Consulting, and Ms Maria Jarosz of Edmund Nuttall Ltd.

Authors

Emma Murnane specialises in environmental management and co-ordination of construction projects including major road and pipeline schemes in urban and rural settings, as well as advising on sustainable construction. She is also author of CIRIA SP156 *Control of water pollution from construction sites – guide to good practice*.

Andy Heap is a project manager for major civil engineering projects (road, rail, transmission lines and pipelines) and specialises in environmental impact assessments and construction environmental management. He is also author of CIRIA C532 *Control of water pollution from construction sites. Guidance for consultants and contractors*, and managed the preparation of CIRIA SP156 *Control of water pollution from construction sites – guide to good practice*.

Andrew Swain is environment manager for Edmund Nuttall Ltd; he specialises in providing in-house environmental advice and technical support to project teams involved in a wide variety of major civil engineering schemes, including linear construction projects.

Steering group

Following CIRIA's tradition of collaboration, the study was guided by a steering group of individuals involved in, or with an interest in the control of water pollution from linear construction sites and related risk mitigation. CIRIA would like to express its thanks and appreciation to all members of the project steering group for their commitment and valued comments throughout the project.

Chairman	Dr Nick O'Riordan	Arup
Attending members	Dr Paul Beckwith	British Waterways
	Mr Barry Beecroft	The BOC Foundation
	Mr Martin Brock	Balfour Beatty
	Mr Phil Chatfield	Environment Agency
	Mr Ian Clarke	Morgan Est
	Dr Mike de Silva	Transport for London
	Mr Peter Fisher	Costain Ltd
	Mr Dave Gibson	Alfred McAlpine
	Mr Sam Hall	Carillion
	Ms Sarah Hides	Defra
	Mr Gareth Jones	MJ Gleeson Group plc
	Mr Howell Jones	Amec Group Ltd.
	Ms Liz McDonnell	Defra
	Mr Peter Martin	Black & Veatch
	Mr Grahame Newman	British Waterways

	Mr Simon Price	Highways Agency
	Mr Stan Redfearn	The BOC Foundation
	Mr Will Rogers	URS Corporation
	Mr S Santhalingam	Highways Agency
	Dr Steve Yeoman	National Grid Transco
Corresponding members	Mr John Lonergan	Balfour Beatty
	Mr Alistair McNeill	Scottish Environment Protection Agency
	Ms Elizabeth Morrison	Scottish Executive

CIRIA project management

The project was initially developed by Ms **Marianne Scott** and subsequently managed by Dr **Das Mootanah** and Ms **Victoria Cole**.

Funders

The project was funded by The BOC Foundation, the Highways Agency, Defra, the Environment Agency and the Scottish Executive.

In addition to the steering group members, CIRIA is grateful to the following organisations for providing photographs, supporting information, case studies and feedback on this study:

ADAS
Amstar
Black & Veatch Costain
Crane Consultants
Dr Peter Howsam, Cranfield University
DTI
Dwr Cymru Welsh Water
Entrepose UK
Ewan Associates Ltd
Faithful & Gould
Morrison Construction
Mowlem Civil Engineering
Network Rail
WJ Groundwater Ltd.

This guidance provides best practice advice and is intended to supplement, rather than replace, any contractual requirements, consultation with regulators or company procedures.

Scope

In this guidance, the following types of linear projects are considered:

- roads – including new motorways, dual carriageways, bypasses, road widening, tunnels, bridges
- railways – including all new railway lines and on-line infrastructure track upgrades, tunnels, bridges, light rail systems, tramways
- pipelines – including new and replacement water, sewerage, oil, gas and chemical pipelines
- cables – including high- and low-voltage electricity supplies below ground or overhead, telecommunications cables
- watercourses – including canals, flood defences, river diversions.

This guidance is specifically aimed at linear projects, although much of the guidance is applicable to any development project. It addresses the control of water pollution throughout the whole project cycle, from the design of a scheme through to construction and commissioning.

Small urban projects such as minor utility and road works, pathways and urban electric cables are not included, although the guidance would be of relevance and interest. Excluded from the scope are coastal and offshore works. CIRIA has published other guidance on managing environmental issues in construction that may be of use to these types of project (see "Other CIRIA guidance", below).

Also excluded from the scope is the maintenance and operational phase of projects (except insofar as any permanent works may be used for temporary works during construction) and decommissioning. The guidance does, however, address issues encountered on upgrades and on-line replacement.

The guidance sets out generic best practice and procedures for controlling water pollution from construction sites in England, Wales, Scotland and Northern Ireland. The reader should note that there are regional legislative and regulatory variations; attention is drawn to these where relevant. However, anyone intending to implement the practices and procedures set out in this guidance should ensure the work complies with the relevant regional variations.

The term "the environmental regulator" refers to:

- Environment Agency (EA) with jurisdiction in England and Wales
- Scottish Environment Protection Agency (SEPA) with jurisdiction in Scotland
- Environment and Heritage Service (EHS) with jurisdiction in Northern Ireland.

The term "the conservation bodies" refers to:

- Natural England (formerly English Nature, the Countryside Agency and the Rural Development Service) with jurisdiction in England
- Countryside Council for Wales (CCW) with jurisdiction in Wales
- Scottish Natural Heritage (SNH) with jurisdiction in Scotland
- Environment and Heritage Service (EHS) with jurisdiction in Northern Ireland.

Target readership

All personnel involved in the promotion, design, construction and maintenance of infrastructure developments have to be aware of their environmental obligations and the benefits that best practice will bring to all stages of a construction project. Decisions taken at the planning and design stage of a project can have a significant impact on the control of water pollution once the project reaches the construction stage. This guidance is of particular relevance to those working on linear projects (roads, railways, pipelines etc), although it can also be applied to most construction sites. The reader should also refer to "Other CIRIA guidance", below for publications about other types of construction site (eg coastal).

This guidance is written for a wide range of readers including:

- clients/promoters
- designers
- environmental consultants
- construction project managers
- senior site engineers and site agents
- site environmental managers
- regulators.

This book is of relevance to all construction personnel. It is supplemented by a *Site guide* (CIRIA publication C649), which is aimed particularly at the following:

- site engineers and construction managers
- site foremen and site supervisors.

How to use this book

This book is arranged in three parts to allow easy reference at different stages of a project:

Part A – Characteristics of linear projects and understanding water pollution

Part B – Planning and design

Part C – Construction.

Part A provides an introduction to the unique characteristics of linear projects, explains what is meant by "water pollution" and provides information on the types and characteristics of water environments. Chapter 2 in particular provides useful information to help understand the water environment (surface water and groundwater).

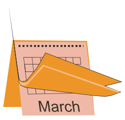
Reducing the risk of water pollution from a construction site starts well before the construction stage. Part B is concerned with the design, planning and programming of a project. At this stage critical decisions are made in terms of route selection and scheme design, which can help to minimise the risk of water pollution throughout the project.

Part C provides guidance on the construction phase of a project. It applies to projects for which any necessary planning approval has been obtained, to contractors requiring guidance at tender or any later stage of the construction phase and to clients and regulators in supervising construction works. This section covers the management and control of water on site and pollution prevention measures for key construction activities.

Developing a project is an iterative process, and although this guidance is divided into planning/design and construction phases, those working in each phase need to be aware of the issues in the subsequent or preceding phase.

This document is accompanied by a *Site guide* (CIRIA C649), which provides key guidance for use on site and can also be read as a standalone document.

Throughout this *Technical guide* and the *Site guide*, the following symbols are used to identify the types of information being provided:



Plan ahead

Take note

Checklist

Information

The law

Case study

Key guidance

Other CIRIA guidance

This document is one of three published by CIRIA that provide key guidance on controlling water pollution from construction:

- C532 *Control of water pollution from construction sites: guidance for consultants and contractors* (Masters-Williams *et al*, 2001)
- SP156 *Control of water pollution from construction sites – guide to good practice* (Murnane *et al*, 2002), comprising training presentation, site inspection checklists, best practice guidance sheets, toolbox talks and a poster.

Previously published guidance on environmental issues in construction from CIRIA includes:

- C533 *Environmental management in construction* (Uren and Griffiths, 2000)
- C584 *Coastal and marine environmental site guide* (Budd *et al*, 2003)
- C587 *Working with wildlife. A resource and training pack for the construction industry* (Newton *et al*, 2004a)
- C613 *Working with wildlife pocket book* (Newton *et al*, 2004b)
- C650 *Environmental good practice on site (second edition)* (Chant-Hall *et al*, 2005a)
- C651 *Environmental good practice on site – pocket book* (Chant-Hall *et al*, 2005b)
- SP120 *A client's guide to greener construction* (CIRIA, 1995)
- SP141V *Building a cleaner future* (CIRIA, 1996), joint CIRIA and Environment Agency training pack, including video, booklet and poster.

Other related CIRIA guidance:

- C643 *The potential for water pollution from railways* (Osborne and Montague, 2005)
- SP125 *Control of risk – a guide to the systematic management of risk from construction* (Godfrey, 1996).

Contents

Figures

Tables

1 Introduction

There are more water pollution incidents from construction sites than from any other industrial sector in the UK, with 180 incidents from construction and demolition sites recorded for England and Wales in 2004 (<www.environment-agency.gov.uk>). At every stage of the construction process there is potential for water pollution problems to arise. Linear construction sites potentially pose a greater risk to the water environment because of the variety of environments they may affect, their cumulative impacts and the distances that require management.

1.1 CHARACTERISTICS OF LINEAR PROJECTS

In this guidance, the following types of linear projects are considered:

- roads – including new motorways, dual carriageways, bypasses, road widening, tunnels, bridges
- railways – including all new railway lines and on-line infrstructure track upgrades, tunnels, bridges, light rail systems, tramways
- pipelines – including new and replacement water, sewerage, oil, gas and chemical pipelines
- cables – including high- and low-voltage electricity supplies below ground or overhead, telecommunications cables
- watercourses – including canals, flood defences, river diversions.

By their nature, linear projects – roads, railways, pipelines, cables and watercourses – are usually large-scale schemes, often predominantly rural in nature. Linear construction projects differ from other construction projects in that they have dynamic site boundaries and cover large areas exhibiting varied physical characteristics. The number of watercourse crossings, discharge points, site compounds and haul roads are inevitably greater than on a static site. The route may cross varied environments, topography, soil types, geology and habitats etc, each requiring differing water management techniques.

Characteristics that distinguish linear projects from other construction sites include:

- a dynamic “corridor” of activity
- varying environmental and aquatic protection requirements in different areas
- numerous access points and haul routes
- cumulative impacts likely on a single watercourse or catchment
- greater variety of ground conditions and soil types
- restricted land take
- jurisdiction of differing regulatory authorities and trans-boundary issues
- longevity of schemes.

2 Water environments

Understanding surface water and groundwater environments is critical to:

- route selection
- scheme design
- planning construction working methods
- identifying mitigation measures to minimise the risk of water pollution.

Surface water and groundwater form two essential components of the water environment which, together with precipitation and evaporation form the hydrologic cycle (see Figure 2.1). Groundwater includes all water stored in permeable underground strata (or aquifers) and surface water includes watercourses, water bodies and runoff. The majority of these water bodies are legally termed "controlled waters" in England, Scotland and Wales, and "waterways" in Northern Ireland. In addition, some surface watercourses are designated as "main rivers", because of their importance in flood risk management. These are shown on statutory main river maps produced by the environmental regulators and government. It should be noted that the environmental regulators are responsible for all surface watercourses, including main rivers and smaller features.

A best practice holistic approach should be taken to consider and manage surface water and groundwater regimes as an integrated system – where surface water provides important recharge to groundwater and groundwater provides essential baseflow to rivers and wetland areas.

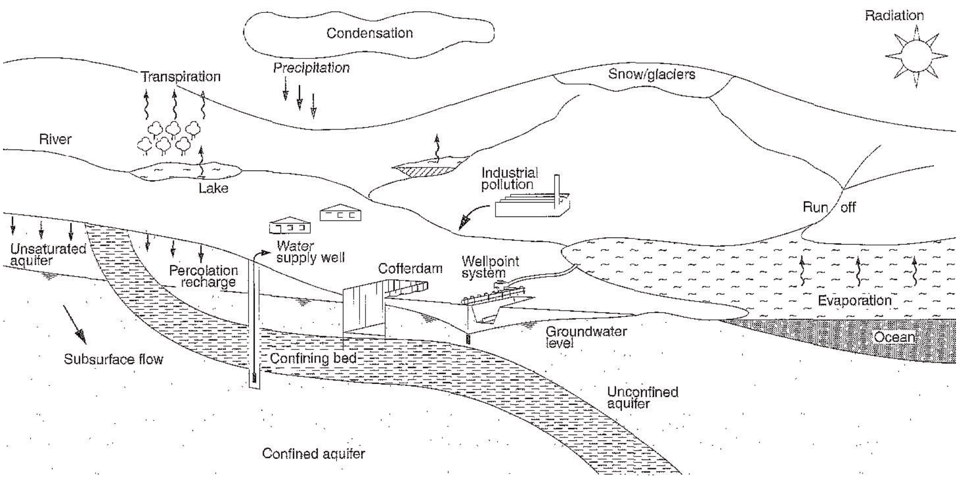


Figure 2.1 *The hydrologic cycle (Preene* et al*, 2000)*

Surface water and groundwater bodies are both highly vulnerable to pollution and impact by construction activities, especially in linear projects where there is high potential for the scheme to have multiple and cumulative impacts on the same water body or regime. Activities on construction sites located away from significant surface water bodies can still result in serious water pollution incidents, both by affecting adjacent small streams, ditches and drains that discharge to larger surface water bodies and by directly affecting the underlying groundwater regime. The effects of water pollution are costly and severe, often resulting in damage to water users and the natural environment some distance away from the polluting activity. Construction activities must not adversely affect surface water or groundwater features. Pollution incidents are often readily visible, are usually traceable to their source and are therefore likely to result in prosecution.

2.1 SURFACE WATER

The surface water environment includes:

- watercourses – natural and artificial, open and covered, including rivers, streams, storm drains, ephemeral ditches and canals
- water bodies – natural and artificial, for example wetlands, lakes and reservoirs
- runoff – controlled and uncontrolled.

Surface watercourses and bodies provide important water resources (for potable and other supply), general amenity and aesthetic value, recreational facilities (eg boating and fishing), conservation and ecological environments (see Chapter 24). Surface water can also provide recharge to groundwater systems.

All surface water bodies are vulnerable to pollution. Surface water pollution is usually readily visible and may reduce water quality, significantly change flow characteristics (level and volume), or significantly modify or destroy physical habitats (see Table 2.1).

Surface water pollution may result in prosecution and is likely to result in ecological damage, fish kill and loss of water supply, amenity value, and recreational use.

Table 2.1 *Construction activities that pose a high risk of surface water impact*

Pollution risk	Hazards
1 Activities that provide a pollution source	❖ Uncontrolled sediment erosion and contaminated silty runoff ❖ refuelling facilities, chemical and waste storage or handling areas ❖ polluted drainage and discharges from site ❖ contaminated groundwater from dewatering of contaminated sites
2 Activities that cause significant variations in natural flow	❖ Unregulated and poorly considered abstractions and discharges eg dewatering ❖ changes to the existing drainage network including interception and redirection of natural and artificial watercourses (eg field drains) ❖ discharge of groundwater to surface water ❖ increased runoff from cleared and capped areas (relative to greenfield values)
3 Activities that significantly modify or destroy physical habitats	❖ Watercourse crossings ❖ works within water ❖ outfall points

Large-scale linear construction projects are likely to encounter numerous natural and artificial water features and transect several watersheds or catchments. The water features encountered may be variable in:

- size, physical character and use
- flow/discharge characteristics and groundwater baseflow component
- conservation and ecological sensitivity
- catchment size, physical character and land use.

It is important to identify and characterise **all** surface watercourses and bodies at and near the corridor of the route, including rivers and streams, ephemeral ditches and field drains, foul and surface water drains and outfalls, canals and leats, lakes, ponds, reservoirs and wetlands and areas prone to flooding. It is also important to be aware that surface water flow (level and volume) is likely to vary with season and may show a flashy response to heavy rainfall. Surface watercourses that are dry or have very low flows during dry conditions may flow or even flood during winter and spring months or following heavy rainfall. In addition, surface water flows may vary as a result of adjacent abstractions and discharges. Understanding the potential variation in natural flows is important because:

- dry weather low flows will determine acceptable discharge quality standards and abstraction volumes – as natural dilution potential and sustainable abstraction quantities are lowest during periods of dry weather flows
- wet weather peak flows will determine the sizing of temporary culverts and structures, and acceptable discharge volumes – as the natural capacity for additional volume loading is lowest during peak flow events.

Key guidance

Further information on river flows (and groundwater levels) throughout the UK can be found in the National Water Archive, which is maintained by Centre for Ecology and Hydrology (CEH) at Wallingford (<www.nerc-wallingford.ac.uk/ih/nrfa/index.htm>).

Understanding the surface water environment is critical to minimising the risk of pollution by identifying vulnerable surface water features, likely impacts and developing sound mitigation measures. For example:

- physical characteristics of each watercourse will reflect the ground conditions and determine the natural form of the drainage channel and the need for appropriate mitigation measures (eg bank erosion control)
- watercourse depth and flow will affect the available dilution of discharges
- catchment size and potential runoff volumes will influence the size and location of balancing ponds (see Chapter 18)
- flooding potential will influence the location of site compounds and the programming and phasing of construction activities see Chapter 18).

2.2 GROUNDWATER

Groundwater occurs in permeable strata within the sub-surface. Groundwater is contained and flows within the pore spaces and fissure spaces of soils and rocks. Below the water table, the pore and fissure spaces are saturated; above the water table, within the unsaturated zone, the pore and fissure spaces contain a mixture of air and water. The permeability or hydraulic conductivity of a sub-surface unit is dependent on the size and connectivity of the pore spaces in granular units (eg gravels and sands) and the fissures in fractured units (eg granites and limestones). Units with high natural permeabilities are termed aquifers (eg chalk, sands and gravels) – classified as major and minor aquifers depending on their hydraulic properties, water resource potential and usage. In contrast, units with very low natural permeabilities that act as barriers to groundwater flow or are only capable of transmitting small amounts include very fine-grained units (eg clays and mudstones).

Groundwater is generally in constant motion and naturally flows along a hydraulic gradient from high points (where surface water, runoff and precipitation infiltrates the ground) to low points (where groundwater typically discharges and provides important baseflow to rivers and wetland areas). In addition, a proportion of groundwater is held in aquifer units deep within the sub-surface that have no natural discharge points. In an unconfined or water table aquifer the upper surface of the aquifer is exposed to the air and infiltration of water pollution. In a confined aquifer the upper surface of the saturated zone is sealed by a low-permeability unit that holds the groundwater at increased pressures within the aquifer. Therefore extreme care must be taken when drilling or piling through confining layers because rising, artesian, groundwater levels will rapidly be encountered, and a new pathway to the aquifer will be generated.

Groundwater is an important resource, providing more than one-third of the potable water supply in the British Isles. In addition, it provides essential baseflow to rivers and wetland areas, often supporting important ecological systems. However, groundwater is vulnerable to pollution – especially because it is generally less apparent than surface water and the potential impacts on groundwater are rarely observed and so tend to receive little consideration. Groundwater pollution is problematic because aquifer pollution persists for long periods and is often very difficult and costly to remediate: groundwater pollution prevention measures cost 10–20 times less than groundwater clean-up and aquifer remediation programmes. Groundwater quality is endangered by construction activities that provide a pollution source or pathway or that significantly vary natural groundwater levels (see Table 2.2). In contrast to surface water, groundwater is generally more vulnerable to pollution by chemicals, metals, hydrocarbons and salts than by sediments, because particulate pollutants are naturally filtered during infiltration and recharge. Pollution of groundwater is likely to result in the loss of potable or other water supplies, the degradation of receiving river or wetland waters and habitats, and, for offenders, prosecution.

Dewatering activities present a significant risk to groundwater through the following mechanisms:

- excessive dewatering in coastal and estuarine areas may induce saline intrusions
- dewatering may draw on to the site contaminated groundwater from off site and thereby generate a contaminated discharge
- dewatering may compromise the yield of nearby water abstractions.

In addition, artificial aquifer augmentation programmes may cause natural groundwater levels to rise, in turn causing remobilisation of contaminants within the unsaturated zone.

Table 2.2 *Construction activities that pose a high risk of groundwater impact*

Pollution risk	Hazards
1 Activities that provide a pollution source	❖ Fuel and chemical use and storage ❖ waste handling, storage and disposal ❖ accidental spillages ❖ use of concrete, bentonite and grout ❖ uncontrolled discharges ❖ works in contaminated land
2 Activities that provide a pollution pathway	❖ Tunnelling ❖ piling ❖ boreholes ❖ excavations
3 Activities that cause significant variations in groundwater levels	❖ Dewatering activities during excavations, earthworks, and tunnelling ❖ artificial recharge activities

Groundwater is likely to be present at depth along all routes, but the degree of vulnerability of different groundwater regimes to pollution may vary widely along a route and will be dependent on aquifer characteristics and the depth of the water table.

In general, groundwater is highly vulnerable to pollution in areas where:

- classified aquifer (major and minor) units are at outcrop with little (< 2 m) protective (silty/clayey) overburden deposits
- the water table is shallow
- there are known direct recharge pathways (eg limestone karst swallow holes).

Groundwater is also at a high risk of pollution in areas where it is directly encountered – ie when working at or below the water table in deep excavations, earthworks, tunnelling and piling. In these situations, a direct pathway to the aquifer exists with little or no natural protection.

Groundwater levels are likely to vary with season and may show a flashy response to heavy rainfall. Excavations that are dry in summer may require dewatering during winter and spring or following heavy rainfall.

The scheme may encounter numerous groundwater abstractions from boreholes, wells and springs. These sources may be operated by water companies for public supply or by private abstractors for domestic, industrial, agricultural or other use. Groundwater sources are most vulnerable to impact by construction activities within the catchment or recharge zone of the supply. The environmental regulators have defined source protection zones (SPZs) to protect groundwater sources that are used for public drinking supply. The SPZ framework is a risk-based classification that delineates sensitive areas where potentially polluting activities and/or accidental pollutant releases will have a detrimental effect on the quality or yield of a groundwater source. In general, the risk increases with increasing proximity of the polluting activity to the groundwater source. Construction activities must not affect the reliable yield or quality of any groundwater abstraction or receiving environment, and the acceptability of high-risk construction activities may be restricted within SPZs and high-sensitivity areas.