

Australian aquatic veterinary emergency plan (AQUAVETPLAN) for decontamination

Version 2.0, 2022



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AQUAVETPLAN

AQUAVETPLAN is a series of manuals that outline Australia's approach to national disease preparedness and proposes the technical response and control strategies to be activated in a national aquatic animal disease emergency.

This strategy will be reviewed regularly. Forward suggestions and recommendations for amendments to:

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Being a guide only, outbreaks or suspected outbreaks must be assessed case by case and expert advice should be obtained to determine the most appropriate management plan in response to the risk.

NOTE: Important regulatory information for infectious salmon anaemia is contained in the World Organisation for Animal Health [Aquatic Animal Health Code](https://www.oie.int/animal-health-codes/), which is updated annually.

Disease watch hotline 1 800 675 888

The Disease Watch Hotline is a toll-free telephone number that connects callers to the relevant state or territory officer to report concerns about any potential emergency animal disease situation. Anyone suspecting an emergency disease outbreak should use this number to get immediate advice and assistance.

Preface

This operational procedures manual outlines decontamination procedures for use in aquatic animal disease emergencies. It forms part of the Australian **Aquatic Animal Disease Emergency Plan**, or [AQUAVETPLAN](#). The primary reason for decontamination of infected premises or equipment is to prevent the spread of disease.

AQUAVETPLAN disease strategy manuals are response manuals and do not include information about preventing the introduction of disease.

The Department of Agriculture, Fisheries and Forestry provides quarantine inspection for international passengers, cargo, mail, animals, plants and animal or plant products arriving in Australia, and inspection and certification for a range of agricultural products exported from Australia. Quarantine controls at Australia's borders minimise the risk of entry of exotic pests and diseases, thereby protecting Australia's favourable human, animal and plant health status. Information on current import conditions can be found at the Department of Agriculture, Fisheries and Forestry [Biosecurity Import Conditions System](#) (BICON) website).

This manual is aimed at both government and industry personnel who may be involved in emergency disease preparedness and response. It is designed to provide decision makers with access to sufficient information on decontamination procedures to enable informed decisions. The manual does not replace state, territory, industry or farm emergency plans, which may have a more specific operational focus. Instead, it is designed to complement such plans and documents. This manual was scientifically reviewed by the Sub-Committee for Aquatic Animal Health of the Animal Health Committee, before being endorsed by the Aquatic Animal Health Committee of the National Biosecurity Committee in March 2020; and the National Biosecurity Committee in June 2022.

To facilitate access to relevant information, certain sections or tables have been modified from other documents, in particular those contained within the [AUSVETPLAN](#) and AQUAVETPLAN series of manuals.

Terminology used in this manual parallels that in the AQUAVETPLAN [Enterprise Manual](#) by dividing aquaculture into four types of systems, based on the ability to control the water and stock in each system. Several factors need to be considered in the design and implementation of any decontamination program. These include the type of pathogen, the type of system (open, semi-open, semi-closed or closed), the degree of organic soilage, the quality of water supply and avenues for safe disposal of waste.

All decontamination procedures must be conducted in accordance with relevant state, territory and Commonwealth legislation governing the use of chemicals, occupational health and safety and environmental impact. Agricultural and veterinary chemical guidelines and environmental legislation may vary between states and territories. Detailed instructions for the field implementation of AQUAVETPLAN are contained in the disease strategies, operational procedures manuals and management manuals. Industry-specific information is given in the enterprise manual.

The full list of [AQUAVETPLAN manuals](#) that may need to be accessed in an emergency are:

- disease strategies
 - individual strategies for each disease
- operational procedures manuals
 - disposal
 - destruction
 - decontamination
- enterprise manual, including sections on
 - open systems
 - semi-open systems
 - semi-closed systems
- management manuals
 - control centre manual.

[Aquatic Animal Diseases Significant to Australia: Identification Field Guide](#) (Department of Agriculture 2012) is a source of information about the aetiology, diagnosis and epidemiology of infection with infectious salmon anaemia and should be read in conjunction with this strategy.

This edition of the manual was prepared by Dr Ben Diggles. It revises the earlier document (version 1.0) that was developed by Kevin Ellard, (Tasmanian Department of Primary Industries and Water) with assistance from Dr Frances Stephens and Dr Joanne Sadler in consultation with a wide range of stakeholders from aquaculture, recreational fishing and government sectors throughout Australia. The text of the current edition was amended at various stages of the consultation and endorsement process, and the policies expressed in this version do not necessarily reflect the views of the original authors. Contributions made by others not mentioned here are also gratefully acknowledged.

The format of this manual was adapted from similar manuals in AUSVETPLAN (the Australian veterinary emergency plan for terrestrial animal diseases) and from the AQUAVETPLAN enterprise manual. The format and content have been kept as similar as possible to these documents, so animal health professionals trained in AUSVETPLAN procedures can work efficiently with this document in the event of an aquatic veterinary emergency. The work of the AUSVETPLAN writing teams and the permission to use the original AUSVETPLAN documents are gratefully acknowledged.

The revised manual has been reviewed and approved by representatives of government and industry.

Government

- CSIRO Australian Animal Health Laboratory
- Department of Primary Industries, New South Wales
- Department of Primary Industry and Resources, Northern Territory
- Department of Agriculture and Fisheries, Queensland

- Department of Primary Industries, Parks, Water and Environment, Tasmania
- Department of Primary Industries and Regional Development, Western Australia
- Department of Economic Development, Jobs, Transport and Resources, Victoria
- Department of Primary Industries and Regions, South Australia
- Biosecurity Animal Division, Department of Agriculture, Fisheries and Forestry, Australian Government

Industry

- National Aquaculture Council

The complete series of [AQUAVETPLAN documents](#) is available on the Department of Agriculture, Fisheries and Forestry website.

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Contents

Preface.....	iv
About this manual.....	10
Part A: General principles	10
Part B: Recommendations for specific procedures	11
1 The decontamination process	11
1.1 Stages in the decontamination process	11
1.2 Risks and pitfalls	14
2 Planning.....	15
2.1 Nature of the pathogen.....	15
2.2 Type of enterprise	16
2.3 Type of material requiring decontamination	16
2.4 Available water supply.....	17
2.5 Choice of disinfection process.....	18
2.6 Assessment of decontamination	19
2.7 Workplace safety	20
2.8 Environmental considerations	20
2.9 Relevant legislation.....	21
3 Cleaning before disinfection	23
3.1 Gross soiling.....	24
3.2 Increasing water efficiency	25
3.3 Cleaning compounds.....	27
3.4 Equipment requirements	29
4 Disinfection.....	34
4.1 Nature of the target pathogen	34
4.2 Choice of disinfecting agents	39
5 General recommendations	55
5.1 Chemical use considerations	55
5.2 Environmental considerations	55
5.3 Safety considerations.....	55
6 Recommendations for enterprise types	58
6.1 Open systems.....	58
6.2 Semi-open systems.....	59
6.3 Semi-closed systems.....	60
6.4 Closed systems	62

7	Recommendations for specific disinfecting agents	64
7.1	Hypochlorite solutions	64
7.2	Chloramine-T	66
7.3	Stabilised chlorine dioxide solutions	67
7.4	Iodophors	69
7.5	Alkaline compounds	71
7.6	Peroxygen compounds	73
7.7	Aldehydes	74
7.8	Calculation of concentration and quantities required	84
7.9	Use of thiosulfate to inactivate oxidising disinfectants	84
8	Decontamination of site infrastructure	86
8.1	Decontamination of earthen ponds	86
8.2	Decontamination of tanks	87
8.3	Decontamination of cages, nets, pots and marine equipment	88
8.4	Decontamination of pipework	90
8.5	Decontamination of fish transport containers	92
8.6	Decontamination of boats	93
8.7	Decontamination of divers and dive equipment	95
8.8	Decontamination of vehicles	96
8.9	Footbaths	98
8.10	Treatment of slurries	99
9	Procedures for personnel	102
9.1	Personnel decontamination site	102
9.2	Personal decontamination procedures from infected premises	102
9.3	Decontamination procedures for diagnostic team personnel	104
	Glossary	107
	Abbreviations	110
	References	111
	Index	122

Tables

Table 1	Ten points to remember when planning and undertaking a decontamination program	14
Table 2	Relative susceptibility of pathogen types to disinfection	16
Table 3	Recommended temperatures for cleaning procedures.....	26
Table 4	Characteristics of common cleaning and wetting compounds.....	31
Table 5	Disinfection categories of viral disease agents of aquatic animals listed as reportable in Australia	35
Table 6	Bacterial disease agents of aquatic animals listed as reportable in Australia	36
Table 7	Protozoal and protozoal-like disease agents of aquatic animals listed as reportable in Australia	38
Table 8	Summary of some published literature relating to decontamination of diseases listed as notifiable in Australia (minimum 3 log (99.9%) reduction).	43
Table 9	Common types of chlorine-liberating compounds	45
Table 10	Corrosive qualities of some commonly used chemical disinfectants	50
Table 11	Relative susceptibility of viruses, fungi and protozoa to disinfecting agents.....	51
Table 12	Relative susceptibility of bacteria to disinfecting agents	51
Table 13	Working characteristics of main chemical disinfectant groups.....	52
Table 14	Major advantages and disadvantages of main chemical disinfectant groups.....	53
Table 15	Safety considerations for specific chemical disinfectants	57
Table 16	Comparison of the relative activity of alkali compounds	73
Table 17	Characteristics of common aldehydes.....	75
Table 18	Disinfectant applications and recommended doses. See Table 8 for information for specific pathogens.	79
Table 19	Recommendations for disinfection of earthen pond bases.....	87

Figures

Figure 1	The decontamination process	12
Figure 2	Stages of decontamination	13

About this manual

This manual provides specific information about the control of disease agents during an aquatic animal disease emergency response. It is primarily concerned with decontamination of the production environment following disease incursion, rather than routine hygiene procedures necessary for the production of healthy stock.

It is assumed that, during the initial stages of an emergency disease event, stock will be either culled or emergency harvested and disposed of according to the directions of regulatory authorities. Consequently, the procedures outlined in this manual do not consider the safety of aquatic animal stock held on infected premises.

For the purposes of this document, 'decontamination' refers to the complex process involving cleaning, destruction of the infective agent and disposal of contaminated materials.

The manual should also be regarded as a potential training resource. Significant emphasis has been placed on the processes involved in decontamination, rather than simple recommendations for disinfectants and concentrations. The document is divided into two parts. Part A provides information on the basic principles and planning of a decontamination program. Part B gives specific recommendations for a range of common tasks. Caution notes in the manual highlight particular items of significance that may significantly affect the efficiency of the procedure or safety of the operator. They commonly relate to important occupational, health and safety points, but can also include other areas considered to be important.

Part A: General principles

Part A describes basic principles relating to decontamination procedures for aquaculture establishments. It is strongly recommended that this section be consulted during preparations for emergency disease response, training of personnel or the planning stage of any decontamination program.

[Part A](#) has three major sections:

Planning — describes aspects that must be taken into consideration when designing and planning decontamination programs.

Cleaning before disinfection — describes key aspects of the cleaning process.

Disinfection — describes key aspects of the disinfection process and lists common disinfection agents, together with their advantages and disadvantages. For the purposes of this document, 'disinfection' refers to the process of inactivating specific pathogens that may cause disease in susceptible livestock. The disinfection process may be physical, chemical or biological in nature.

Part B: Recommendations for specific procedures

[Part B](#) contains a series of tables and job sheets summarising procedures and providing recommendations for specific enterprise types and tasks. These have been divided into the following sections:

Recommendations for enterprise types — provides an overview of recommendations, including restrictions and limitations, for decontamination for each of the major enterprise types (as described in the AQUAVETPLAN [Enterprise Manual](#)).

Recommendations for specific disinfecting agents — provides technical information on common agents used for disinfection.

Decontamination of site infrastructure — outlines procedures that should be considered for decontamination of equipment or material commonly found on aquaculture or fishing enterprises.

Procedures for personnel — outlines decontamination procedures for personnel moving between facilities when working on decontamination programs.

Since the effectiveness of any decontamination process depends on the conditions under which it is used, persons using recommendations from Part B should also take into account factors outlined in Part A.

Part A

General principles

1 The decontamination process

Decontamination involves a combination of physical and chemical procedures that are used to remove soiling¹ and inactivate the target disease organism (OIE 2018b). The process should also take into account appropriate disposal of waste products.

An effective decontamination program is vital during all stages of any emergency disease response. Appropriate procedures are required to allow personnel, machinery and equipment to move safely between premises during the surveillance, destocking or clean-up stages of the operation. Decontamination will also reduce the period between initial destocking and the re-introduction of healthy fish² stocks to a previously contaminated site.

The decontamination process comprises a number of stages. These are:

- planning: identification and assessment of risks, design of efficient and effective procedures, and training of personnel;
- implementation: cleaning, disinfection, and waste treatment and disposal; and
- testing for effectiveness.

In the case of aquatic animal disease, implementation of effective decontamination procedures presents unique challenges. These usually include containing and disinfecting large quantities of water and disposing of waste material. There may also be specific difficulties associated with decontaminating large equipment, such as biofilter towers and marine vessels.

Although this manual is primarily designed for use during an aquatic animal disease emergency, appropriate sanitation procedures should also form part of routine husbandry practices for any aquaculture or processing establishment. Decontamination strategies used during an emergency disease response differ from those used as part of normal sanitary operating procedures only in terms of the selection, application and allocation of specific resources. The general principles of decontamination are the same and are summarised in Figure 1.

1.1 Stages in the decontamination process

To be effective, the decontamination process should be broken down into a series of specific tasks that address identified risks (e.g. decontamination of dive equipment or the treatment of discharge water). Figure 2 illustrates how this series of tasks then combines to form the final decontamination program.

¹ Refer to [Section 3.1](#) and the Glossary for a definition of 'soil/soiling'.

² Fish is defined here as any aquatic animal, including finfish, molluscs and crustaceans.

Figure 1 The decontamination process

Source: Adapted from Le Breton (2001a)

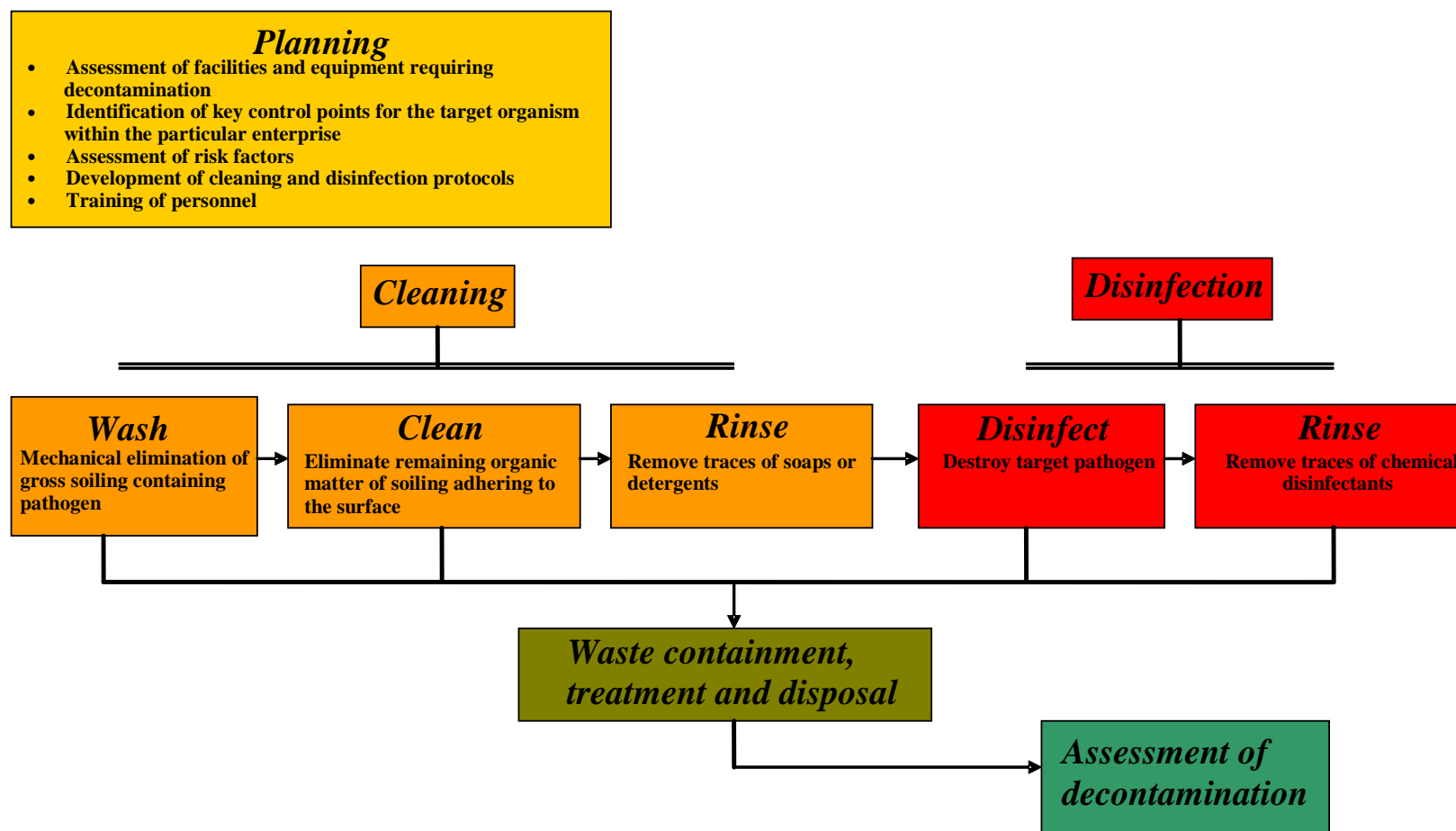
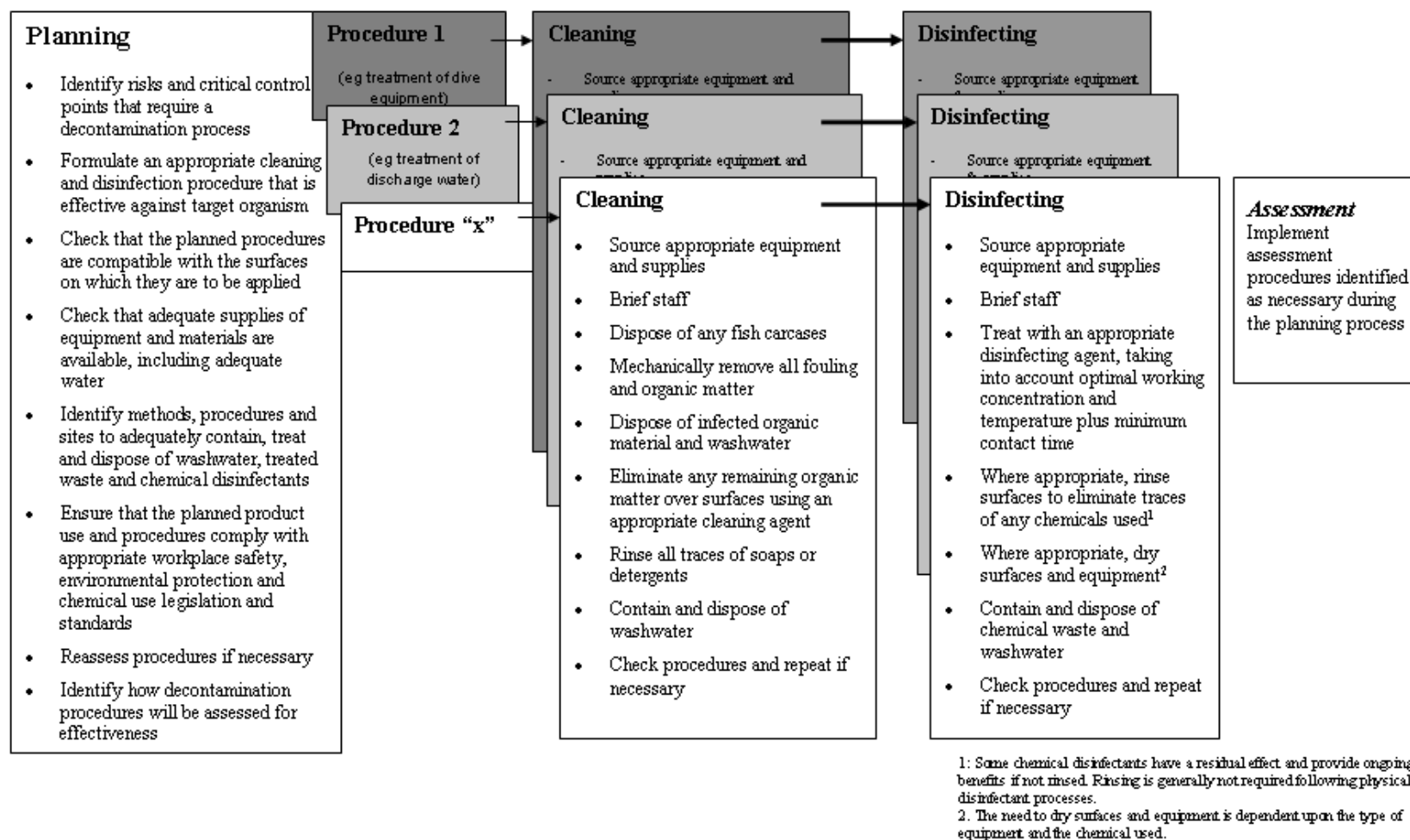


Figure 2 Stages of decontamination

1.2 Risks and pitfalls

It is a surprisingly common misconception that decontamination requires only cursory application of chemical disinfectants to be effective. Unfortunately, this belief can result in practices that are ineffective and provide a false sense of security, allowing contaminated personnel, machinery or equipment to travel between sites. The points listed in Table 1 are important when decontamination programs are being designed and implemented.

Ineffective decontamination usually:

- fails to include adequate cleaning as part of the process;
- uses inappropriate disinfecting agents; or
- does not allow adequate contact time with the disinfecting agent.

For example, footbaths that are replenished infrequently or have staff walking through them without pausing to clean footwear are of limited value. Divers working on farms removing mortalities from cages may reassure themselves with a cursory application of sanitising solution that is insufficient to deal with the accumulation of fish slime or oils that can rapidly build up on suits, decks and equipment. In such circumstances, these chemical disinfectants merely treat the surface of accumulations, leaving the infective agent protected within an envelope of organic matter.

Decontamination procedures, whether being used during an emergency response or as part of routine management, must be effective in order to be worthwhile. However, they should also be straightforward. Overly cumbersome or complex procedures tend to be ignored or done in a cursory fashion.

Table 1 Ten points to remember when planning and undertaking a decontamination program

- | |
|---|
| <ol style="list-style-type: none"> 1. Effective cleaning is responsible for more than 90% of the success of a decontamination program. 2. Accumulations of soil, dirt or organic matter provide an effective barrier, protecting pathogens from disinfecting agents. 3. Organic matter rapidly inactivates a number of chemical disinfectants. 4. Some cleaning agents are incompatible with specific types of chemical disinfectants. 5. The effectiveness of certain cleaning compounds and disinfectants depends on the quality and hardness of the water used. 6. The effectiveness of chemical disinfectants depends on the concentration used, as well as the contact time. 7. The effectiveness of many chemical disinfectants depends on temperature and pH. 8. Many disinfectants are corrosive to equipment, and most are irritant to people and toxic to aquatic life. 9. Washwater may still contain viable pathogenic organisms or polluting chemicals that must be disposed of appropriately, and 10. Many disinfectants are not effective against spores, and some are only mildly effective against mycobacteria and non-enveloped viruses. |
|---|

2 Planning

During any aquatic animal disease emergency event, the objectives of decontamination are to:

- allow staff and equipment used for inspection duties to move safely between sites;
- allow staff and equipment located on known infected premises to move safely off the site without spreading infection;
- reduce the level of pathogen loading on the infected premises; and
- allow the property to be released from quarantine.

Key issues to be considered during the planning stage include the following:

- What is the pathogen of concern and how is it most effectively inactivated?
- What type of enterprise is involved?
- What types of material or equipment require decontamination?
- Is the available water supply of sufficient quality and quantity?
- What options are available for disinfection?
- What are the risks to the safety of personnel?
- Are there environmental pollution risks?
- What relevant legislation must be complied with?

2.1 Nature of the pathogen

The first step in any disinfection program is to understand the properties of the target pathogen and the disinfection processes that are likely to be effective. Infective pathogens vary greatly in their susceptibility to various disinfection processes. Table 2 summarises the relative susceptibility of various pathogen types to chemical disinfectants and ultraviolet (UV) radiation. [Section 4.2](#) provides further detail on the susceptibility of different types of organisms to specific disinfecting agents.

Information on the epidemiology of specific pathogens is contained in the relevant [AQUAVETPLAN disease strategy manual](#). This information is necessary to identify critical disease control points for each enterprise.

Table 2 **Relative susceptibility of pathogen types to disinfection**

Susceptibility to chemical disinfectants and UV radiation	Microorganism
Highly susceptible	Mycoplasmas, rickettsias
Susceptible	Gram-positive bacteria
	Enveloped viruses
	Gram-negative bacteria
	Fungal spores
Resistant	Non-enveloped viruses
	Mycobacteria
Highly resistant	Bacterial endospores
	Protozoal oocysts Protozoal-like spores
Extremely resistant	Prions

Source: Adapted from Quinn and Markey (2001)

2.2 Type of enterprise

As outlined in the [AQUAVETPLAN Enterprise Manual](#), aquaculture enterprises and industries may be classified as one of four types:

- Open systems — systems where there is no control of either host movement or water flow (e.g. wild-caught fisheries).
- Semi-open systems — systems where there is control of host movement but no control of water flow (e.g. net-pen culture).
- Semi-closed systems — systems where there is control of host movement and some control of water flow (e.g. pond culture, race culture).
- Closed systems — systems where there is good control of both host movement and water flow (e.g. aquaria, recirculation facilities).

The ability to control host movement and water flow from infected premises is a major factor in the success of any decontamination program. The specific characteristics of each enterprise type affect the type of program that may be undertaken. [Section 6](#) contains further details on enterprise types and how they influence decontamination programs.

2.3 Type of material requiring decontamination

The planning stage should assess the physical characteristics of material and equipment requiring decontamination. An inventory of all equipment requiring decontamination should be formulated, including detail on the materials used in construction, surface porosity, access to areas requiring decontamination, and resistance of materials and equipment to damage.

The level of cleaning of equipment that is required before disinfection should also be assessed. If heavy soiling is present, extra attention will need to be given to the cleaning process and the tools required. The type of cleaning product used during these initial stages should either be

compatible with the disinfectant chosen or thoroughly rinsed off surfaces before disinfectants are applied.

The type of material requiring decontamination plays a significant role in the effectiveness of decontamination. Hard, nonporous materials, such as polished metal surfaces, plastics or painted concrete, are relatively easy to clean and disinfect because there is little opportunity for infective material to lodge in crevices. Decontamination is more difficult when the surface is corroded or pitted, or paint is flaking. Absorbent materials such as rope, wood or uncoated concrete are also more difficult to treat. For these materials, the cleaning stage must be more rigorous and the disinfection contact times considerably longer. In many cases, it may be safer and more cost effective to dispose of such items, rather than attempting to disinfect them for reuse.

Machinery and equipment used in aquaculture are often bulky and require specialised equipment for safe handling. Tanks, biofilters and pipework can also have limited access, making work difficult and potentially hazardous. The facility manager or equipment manufacturer should be consulted during the planning stage about safe handling of heavy equipment, including access to enclosed spaces or the process of dismantling. Such specialised tasks should always be left to suitably qualified personnel.

Depending on the enterprise type, significant volumes of water may require decontamination. It is practical to contain and disinfect contaminated water only under limited situations. It will not be possible for open-water systems, but can be achieved in closed systems and may be possible in flow-through systems (semi-open or semi-closed) if the water flow can be diverted.

On most sites, significant quantities of fish carcasses and organic waste are likely to require disposal as part of the decontamination process. Such material generally carries a very high infective load and is difficult to disinfect. The safe disposal of all organic material should form a major part of the planning process. Further details on the safe disposal of biological material may be found in [Section 8.10](#) of this document, and in the [AQUAVETPLAN Operational Procedures Manual — Disposal](#).

2.4 Available water supply

Adequate supplies of water are necessary for all washing, cleaning, disinfection and rinsing steps of the decontamination process. Where possible, water should be clean (low in suspended solids), soft (low in mineral solutes) and of sufficient volume to complete the task required.

The quality of the water supply has significant impact on the efficacy of both disinfection processes and cleaning compounds. Water that contains high organic loads quickly inactivates chemicals such as chlorine and iodine, and hard waters containing high levels of dissolved ions can reduce the activity of some detergents and disinfectants (see [Sections 3.2](#) and [3.3](#) for further details).

Due to its potential to reduce the effectiveness of chemical detergents and disinfectants, wherever possible, seawater should not be used as a diluent for chemical agents. However, it may be used for initial removal of gross fouling or some rinsing procedures. Where adequate supplies of clean, fresh water are not available on site, consideration should be given to shipping in supplies for critical cleaning and disinfection tasks.

The selection of appropriate water handling facilities should also form part of the planning stage. This includes the supply of pumps, hoses, pressure cleaners and storage facilities. Planning should also include containment, temporary storage and possible treatment of water used during decontamination procedures.

2.5 Choice of disinfection process

When the disinfection process is first considered, it is common to limit planning to chemical disinfectants. However, disinfection may also use physical and, in some cases, biological processes. The most practical physical processes for use during an aquatic animal disease emergency event include the use of desiccation, dry heat, wet heat, UV radiation and sedimentation/filtration.

Potential biological disinfection processes include burial, ensilage or composting. The complex biological processes that occur during decomposition result in enzymatic degradation as well as changes in oxygen content, moisture content, pH and temperature. All of these processes can inactivate pathogens in infected material.

The range of chemical disinfectants currently on the market is daunting, and anyone investigating this issue for the first time is likely to be overwhelmed by the numerous brands and combinations available. Many of the commercial preparations are a combination of chemicals, which can include more than one disinfectant, as well as stabilising agents, buffers, wetting and cleaning agents, and compounds that assist penetration. Properties of different types of disinfecting agents are summarised in [Section 4](#).

Some disinfectants are especially corrosive to metals, rubber or fabrics, and may considerably shorten the life span of equipment. Oxidising chemicals, alkaline compounds, acids and even extremes of heat are all corrosive. Table 9 in Section 4 summarises the corrosive characteristics of a number of the more common chemicals used during decontamination. Where there is any doubt, a small section of material should be tested first. In many cases, the corrosive action of chemicals can be minimised by thorough rinsing after cleaning or disinfection.

The concentration or intensity of the disinfectant and the time of exposure needed vary with the type of pathogen, the level of contamination, the nature of the items to be disinfected and the process being used. It is therefore imperative that the characteristics and limitations of each product or active ingredient are understood before a disinfection program is implemented. Use of an inappropriate disinfectant could have serious consequences for disease control, as well as being expensive in terms of labour and materials.

The following checklist should be considered when selecting a disinfection process:

- Are the agent and procedure effective against the pathogen in question?
- Does the procedure meet the appropriate safety standards?
- Are the agent and procedure safe for equipment?
- Is the agent environmentally acceptable? If release of the agent into the environment is not acceptable, can it be contained and neutralised?

- Can the agent be used with the available water supply (i.e. fresh water, hard water or seawater)?
- If cost is a consideration, are the agent and procedure cost effective?
- Are the agent and equipment available in sufficient quantities?
- Is formal authority needed to use the agent or perform the procedure?
- What are the available alternatives?

2.6 Assessment of decontamination

Although specific disinfection procedures can be tested under controlled laboratory conditions, the high number of variables experienced under field conditions makes it difficult to predict the effectiveness of any decontamination program with a high degree of certainty. It is therefore important to assess the effectiveness of a decontamination program before facilities are fully restocked or movement restrictions are lifted.

Methods for testing effectiveness of decontamination may be divided into three basic types.

1. Testing for the pathogen within the environment. This process uses swabs or samples collected from suitable locations in the facility to test for presence of the viable pathogen.

Samples should be taken from areas where a high loading of the pathogen would be expected before decontamination, such as effluent pits, pipe biofilms, sumps, biofilters, pond floors or anywhere organic material is likely to accumulate.

This method is more commonly used for bacterial pathogens of terrestrial species, where surfaces can be swabbed using a variety of quantitative or semi-quantitative methods. These include use of direct swabbing, agar cylinders or agar-impregnated linen (Tamasi 1995).

Testing for the specific pathogen is only useful where there is a reliable test available for the viable pathogen and the degree of test sensitivity is known.

The process has limited application as the primary assessment procedure for aquatic pathogens; however, some tests (e.g. polymerase chain reaction) may be useful as adjunct test methods.

2. Testing for an indicator species. This process uses ubiquitous microbial organisms as indicators of efficacy of the decontamination process. It assumes that the indicator species is of similar susceptibility to the target pathogen.

This method is generally used where appropriate test methodology is not available or practical for the target pathogen, but is available for the indicator species.

The process has the advantage of being able to provide quantitative results, if known quantities of the indicator species are used. It has specific applications for testing treated effluent water being released from infected facilities.

3. Use of sentinel livestock. Use of sentinel stock is likely to be the most commonly used method of assessing effectiveness of decontamination programs, particularly for aquaculture facilities.

The process uses livestock susceptible to the target pathogen housed within the treated premises and purposely exposed to high-risk areas (i.e. areas where the pathogen is most likely to remain). This stock is closely monitored and tested for disease following a prescribed period of time.

The period required for sentinel stock to be housed within a facility before it may be considered clear depends on the disease of concern. As a general rule, a minimum of three times the incubation period for a disease is required before testing of sentinel stock. Other factors such as possible intermediate hosts, potential for pathogen dormancy and viability within the environment must be taken into account when determining the surveillance period required before the facility is considered safe.

2.7 Workplace safety

It is beyond the scope of this document to provide detailed information on the requirements for workplace safety. All those involved in undertaking or supervising decontamination procedures are responsible for ensuring that all reasonable measures are undertaken to maintain a safe working environment.

Hazardous operations that may occur during the decontamination process include:

- handling of corrosive or irritant chemicals;
- use of steam or hot-water cleaners;
- use of high-pressure water cleaners (refer to [Section 3.4.5](#));
- lifting of heavy equipment during cleaning and disinfection operations;
- working in confined spaces;
- diving operations; and
- working on or around water wearing heavy protective clothing.

The planning stage should include a risk assessment of all activities to be undertaken. Where risks are considered to be unacceptable, procedures must be put in place to reduce risks to appropriate levels, or an alternative process must be implemented.

Material safety data sheets should be readily available for all chemical agents used on site. Appropriately trained first aid officers and medical equipment should be available, as well as a safety officer responsible for ensuring that appropriate standards are met.

Further details on safety considerations are in [Section 5.3](#).

2.8 Environmental considerations

Disinfectants used in disease control programs are potentially noxious substances and may have adverse effects on the environment. Although the disinfection method will be selected primarily on the basis of its effectiveness against the target organism, the potential environmental impact should also be considered during the planning process. This includes assessing whether methods for containment or neutralisation of chemicals are viable and acceptable. State or

territory authorities responsible for environmental management should always be consulted at this stage.

The volumes of water requiring disposal will need to be considered during planning. In some cases, water may be able to be released into waterways if treated to inactivate chemical disinfectants (e.g. treatment of oxidising disinfectants with thiosulfate) or following a prescribed period of time that allows chemicals to dissipate to acceptable levels (e.g. hypochlorite and chlorine dioxide). Other options could include discharge onto approved wasteland sites. Approval from relevant authorities should always be sought before disposing of treated material.

Other options to reduce the impact of decontamination activities on the environment include thorough cleaning before disinfection, the use of temporary drains to trap and divert waste, and the use of lined ponds or tanks for temporary storage.

2.9 Relevant legislation

Legislation relating to decontamination procedures falls largely within three categories.

1. Legislation relating to the control of the use of agricultural and veterinary chemicals

Australia has a national system for the registration of agricultural and veterinary chemicals, including disinfectants. This system is overseen by the [Australian Pesticides and Veterinary Medicines Authority \(APVMA\)](#). The APVMA maintains the Public Chemical Registration Information System (PUBCRIS), a database containing details of agriculture and veterinary chemicals that are registered for use in Australia, including the product name, active constituents and details of the registering company.

In addition to this national registration system, use of any chemical directly or indirectly for the control of an animal disease is governed by relevant 'control of use' legislation in each state and territory. Such legislation requires that chemicals be used for the purpose for which they are registered, and that appropriate instructions are given on the label for their safe use.

During emergency disease response situations, chemicals may need to be used for 'off-label' purposes. In such situations, the relevant state or territory authority and/or the APVMA should be consulted for advice before use of the chemical.

2. Legislation relating to the control of discharge of pollutants into waterways

In all states and territories, legislation requires that activities should not have significant detrimental impact on the natural environment. The discharge of chemicals, silt, organic matter or carcasses into natural waterways or other environments may be deemed an offence. It is essential that authorities are consulted when the decontamination process is being designed and that waste materials are disposed of appropriately.

3. Regulations relating to workplace safety

Legislation relating to workplace safety requires that persons involved with decontamination procedures receive appropriate training in the use of equipment, chemicals and procedures. It

also requires that appropriate protective equipment and resources be provided to ensure that such activities are performed safely.

3 Cleaning before disinfection

Effective cleaning must always precede disinfection. If completed correctly, this step may remove more than 90% of the pathogen loading (Lewis 1980, Fotheringham 1995a).

Cleaning is designed to:

- remove the organic matter that reduces the activity of many chemical disinfectants;
- remove gross contamination that may shield the action of disinfectants; and
- remove traces of chemical residues.

The basic steps to be followed during cleaning operations will vary according to the enterprise type but should generally be as follows:

- 1) Tanks and ponds should be drained and the contaminated water treated in an appropriate manner before discharge or disposal. Refer to Part B for further details on the treatment of infected water.
- 2) Carcasses should be removed and disposed of in an appropriate manner (refer to the [AQUAVETPLAN Operational Procedures Manual — Disposal](#) for further details). Appropriate disposal methods may include deep burial, ensilage, composting or rendering.
- 3) Organic material in the form of faeces, uneaten feed and sediments at the base of ponds or tanks should be collected and disposed of in a similar fashion to carcasses. Treatment and disposal of slurry are discussed in [Section 8.10](#).
- 4) Effluent, including solid wastes and infected water, must be contained and treated in an appropriate manner.
- 5) Residual stocks of feed should be disposed of.
- 6) Any material that cannot be thoroughly disinfected (e.g. wooden planks or other highly porous materials) should be removed for incineration or burial.
- 7) Before cleaning starts, suitably qualified personnel should disconnect electrical supplies to all equipment requiring cleaning. Cables carrying electrical power to washing equipment should also be fitted with residual current devices.
- 8) Equipment that can be removed should be rinsed to remove dust and soaked in detergent before disinfection.
- 9) Pipework, biofilters, net pens and other structures should be dismantled for cleaning and disinfection.
- 10) Interior surfaces of tanks, pipework, filters, buildings and cages must be thoroughly cleaned using appropriate physical abrasion, heat or strong detergents.
- 11) After cleaning, detergents should be rinsed off all surfaces and equipment. Washwater should be contained for later disposal because it may still contain viable pathogens.
- 12) All machinery and tools used in the removal of soiling must also be washed and disinfected.

3.1 Gross soiling

Soil is defined here as any material — mineral or organic — that accumulates on equipment, personnel or within facilities. For the purposes of this document, the types of soil or soiling are classified into five basic types.

Type 1: Oily buildups and protein accumulations

This type of soiling is common in facilities and equipment used for processing or handling of fish or fish material. Oils and fats form highly resistant layers that are difficult to remove and provide an environment that enhances survival of the pathogen.

Locations where this type of soiling may occur include:

- decks of boats or jetties used in handling fish or fish feed;
- equipment in processing facilities;
- diving suits (when mortalities from cages are being removed); and
- containers used to transport fish and fish products.

Type 2: Sediment accumulations

This soil type is usually associated with the buildup of particulate matter on equipment. Water containing high loads of sediment in suspension also falls into this category.

Situations where this type of soiling commonly occurs include:

- earth accumulations on earthmoving equipment;
- mud accumulations on the underside of vehicles;
- sediments at the base of ponds or tanks;
- suspended solids in water; and
- dust accumulation over the surface of machinery and equipment.

Type 3: Biofilms

A biofilm is defined as a collection of bacteria or fungi that exist as a community within an exopolysaccharide matrix adhered to the surface of equipment (Morck et al. 2001). In aquaculture, biofilms accumulate over the internal surfaces of tanks and associated pipework, in biofilters and on nets. The extracellular matrix creates a protective environment that resists the action of disinfectants and provides a nidus or reservoir for potential reinfection.

This type of soiling is of particular importance in closed or semi-closed aquaculture establishments where complex pipework provides a suitable environment for the establishment of biofilms and presents significant difficulties in cleaning. The buildup of biofilms within hatcheries has been postulated as the cause of increased disease events over time, especially in establishments that do not dry out their systems each year.

Type 4: Organic fouling

This category refers to the growth of organisms, such as algae and invertebrate animals, over the surface of tanks, cages or equipment. These growths and the associated debris may provide a protective barrier to the pathogen. In specific cases, fouling organisms may also act as an intermediate host or reservoir for pathogens.

Organic fouling commonly occurs:

- on boat hulls;
- on net pens and associated structures;
- in pumps and pipework on boats or marine sites;
- over the internal surfaces of tanks;
- on pond furniture and fixtures; and
- as cohabitants of pond systems.

Type 5: Mineral accumulations

Mineral deposits are generally due to calcium or salts in water precipitating onto surfaces. Although such deposits are generally benign, they do provide a physical barrier to disinfectants. Mineral accumulations occur as a buildup on the inside of pipes, tanks or biological filters and over the surface of equipment used in marine environments.

3.2 Increasing water efficiency

Water will be required to rinse chemicals and soil from surfaces and to act as a diluent for detergents and disinfectants. It may also be used as an abrasive during pressure cleaning and as a medium to apply heat to surfaces.

Ideally, water should be clean and free from pathogens or chemical contaminants and have a low level of dissolved ions. In reality this is rarely the case but, wherever possible, clean, fresh water should be used in preference to seawater or fresh water with a high organic or mineral loading.

Factors that affect water quality for cleaning and disinfection operations are outlined below.

3.2.1 Water temperature

The cleaning efficiency of water may be improved by increasing water temperature and the mechanical force with which it is applied. The effects of chemical cleaning and disinfecting agents also tend to increase with temperature; effects approximately double for every 10°C rise in temperature (Holah 1995b).

Table 3 gives recommendations for optimum water temperatures during various stages of cleaning. Methods for increasing the mechanical cleaning force of water are discussed further in [Section 3.4](#).

Table 3 Recommended temperatures for cleaning procedures

Type of cleaning	Ideal water temperature	Comments
Preliminary rinsing	38–46°C	Generally done with low water pressure.
Cleaning	49–77°C	Some detergents — in particular, alkaline cleaners — are unstable at higher temperatures (outside this range).
Rinsing	7–13°C	Colder waters assist rinsing by reducing the formation of foams.

Source: Adapted from Salvat and Colin (1995)

3.2.2 Water hardness

Water hardness is most commonly caused by the presence of calcium and magnesium compounds, as either bicarbonates or chlorides (Bitton 1994). Hardness is responsible for increased consumption of anionic detergents and bicarbonate-based cleaners (Lewis 1980). It reduces the efficacy of a number of disinfectants, leads to the formation of scale (type 5 soiling) and makes it difficult to rinse residues of some detergents.

Hard water may be softened by:

- adding sequestering agents (e.g. sodium tripolyphosphate);
- adding ion-exchange resins (also known as the zeolite process); or
- the more complicated lime-soda process (Bitton 1980).

Water softening using the lime-soda process results in high water pH, and this must be taken into account when choosing chemical disinfectants. This method has the advantage of reducing microbial loading through inactivation (via high pH) and precipitation (Bitton 1994).

For convenience and availability, the use of sequestering agents or ion-exchange resins is preferable to the lime-soda process.

3.2.3 pH

Extremely acid or alkaline waters can affect the action of chemical disinfectants. As a general rule, seawater tends to be buffered by dissolved salts to around pH 8, but fresh water may have a much wider pH range. Waters associated with acid sulfate soils will tend to be highly acidic, whereas fresh water in limestone areas or from bores is often alkaline.

It is useful to test water if using chemical disinfectants that may be affected by extremes in pH. Test kits for determining water pH and hardness are readily available from laboratory suppliers, swimming pool supply shops and pet stores specialising in aquarium fish.

3.2.4 Turbidity

Water turbidity plays a key role in the inactivation of microorganisms by ultraviolet (UV) irradiation, including that produced by solar radiation. If UV disinfection is to be used, special

consideration needs to be given to ensuring that water clarity is as high as possible, usually through filtration. UV radiation requires at least a six-fold greater intensity in unfiltered water than in filtered water when used to control vibrio and aeromonad bacterial pathogens (Bullock and Stucky 1977, Torgersen and Hastein 1995).

In some cases, water with a high colloidal load caused by minerals, clay particles and organic matter may be treated with a flocculant, which causes small particles to join together until they are large enough to settle out of the water column. As well as improving water clarity, flocculants have the benefit of removing significant numbers of pathogens, especially viruses, which adhere to colloidal particles. Bitton (1994) states that up to 99% of viruses and 90% of bacteria are removed from water treated with flocculants under laboratory conditions. Flocculants act by transferring pathogenic microorganisms from the water suspension to a bottom layer of sludge, which must be disposed of properly. This method may also be used to pretreat waste water from infected properties before secondary treatment or release into the environment. Common flocculants are alum, ferric chloride and ferric sulfate.

Solar radiation plays a key role in the decline of pathogenic organisms in water (Torreterra et al. 1994). Dark or turbid waters that are often found in freshwater or estuarine ecosystems can protect pathogens from the effects of solar radiation, particularly if these systems are static or stratified. Environmental viability of pathogens is greatly reduced in clear marine ecosystems, which tend to have much greater penetration of solar radiation. This factor should be taken into consideration when determining the appropriate period before restocking, especially in open systems.

3.3 Cleaning compounds

The purpose of cleaning compounds is to reduce the surface tension of water and allow lifting and flushing away of soils.

Cleaning compounds generally act by:

- wetting;
- reacting with both the soil and the cleaning surface to emulsify fats, peptonise proteins, dissolve minerals or organic material, and disperse solids; and
- helping to prevent redeposition of soils onto cleaned surfaces.

The choice of an appropriate cleaning agent (detergent) can be confusing because they are rarely sold as single compounds. Instead, they are complex mixtures of surfactants (surface wetting agents), dispersants, solvents, and sequestering or chelating agents (Myers 1992).

For the purpose of this document, the base components of cleaning agents can be classified into three major groups: alkaline detergents, acidic cleaning compounds and surface wetting agents. The relevant characteristics of each group, and of sequestering agents, are outlined below. Characteristics of the common cleaning and wetting compounds are summarised in Table 3.

3.3.1 Alkaline detergents

Alkaline detergents have good saponifying qualities and are able to dissolve many organic solids,

but their alkaline nature means that they corrode some metals and can also be irritating to skin and mucous membranes. Alkaline detergents are used for heavy-duty cleaning. They include products containing sodium hydroxide, sodium carbonate and sodium silicates.

Detergents containing sodium hydroxide are commonly used in the food processing industry. These detergents are relatively cheap and very effective in removing protein and fat residues (Troller 1983). They are suitable for initial cleaning of most hard surfaces and can be used on steel, most plastics, glass, ceramics and concrete. Alkaline detergents are generally not suitable for cleaning wood, galvanised iron, aluminium or delicate fabrics. For these applications, neutral detergents or weakly alkaline or acidic surface active agents can be used.

In some cases, adding chlorine to alkaline detergents aids in removing protein deposits. This can be done by adding chlorine-liberating disinfectant compounds (see [Section 4.2.1](#)). Although these disinfectants lose much of their biocidal action above pH 7.5, including when they are mixed with alkaline detergents (Holah 1995a), the chlorine can enhance the product's cleaning action.

Alkaline cleaning compounds have a tendency to precipitate ions from hard water, resulting in a surface scum that can be difficult to rinse off equipment. This may be overcome by restricting the temperature at which alkaline cleaners are used to less than 65°C, or by using an acid rinse following cleaning procedures (Cancellotti 1995).

3.3.2 Acidic cleaning compounds

Acidic detergents are particularly useful in removing mineral deposits caused by hard-water and marine environments. They are also useful in removing heavy buildups of proteinaceous material and can be used with salt water. Acids also assist in water penetration and softening when combined with other compatible agents. They are easily rinsed from surfaces and have some residual biocidal capacity.

The organic acids are generally less corrosive and irritant than inorganic acid or alkaline cleaners. Acids should generally be used with cold water to avoid the production of fumes and to reduce corrosive effects.

3.3.3 Surface wetting agents (surfactants)

Surfactants act by emulsifying fat deposits, but also have dispersion and wetting properties. They are generally noncorrosive and nonirritating. Surfactants are key components of most cleaning agents and are often included in acid or alkali preparations.

There are four types of surfactants (Myers 1992):

- **Anionic surfactants.** These are salts of complex organic acids and are by far the most commonly used.
- **Nonionic surfactants.** These are polar molecules but have no electrical charge. They exist as organic compounds rather than salts and are useful in hard-water or marine environments.
- **Cationic surfactants.** These are relatively poor cleaners but have sanitising properties (i.e. they reduce the overall microflora load). Cationic surfactants occur as salts of organic bases.

Surfactants within this group are better known for their disinfecting capabilities and generally do not have the capacity for the heavy-duty cleaning required in aquaculture facilities or processing plants. Quaternary ammonium compounds are commonly used cationic surfactants.

- **Amphoteric surfactants.** These alkaline amino acids enhance water penetration, are good emulsifiers and are compatible with anionic, ionic or cationic surfactants.

3.3.4 Sequestering (chelating) agents

Sequestering agents are important in ensuring that cleaning efficiency is maintained in hard water that contains calcium (Ca^{++}) or magnesium (Mg^{++}) ions. They are an important component of any detergent that is exposed to, or used with, seawater or very hard, fresh water. Examples of sequestering agents are sodium tripolyphosphate and ethylenediaminetetraacetic acid (Lewis 1980, Morris 1994).

3.3.5 Other cleaning agents

Other cleaning agents that may be of use under specific circumstances include amphoteric compounds (used to loosen charred residues from surfaces), proteolytic enzymes (digest proteins and other complex organic soils) and abrasive compounds (Lewis 1980).

3.4 Equipment requirements

Equipment used to remove gross soiling may be as simple as scrapers or brushes, but may also include a wide range of specialist equipment such as transportable vehicle wash systems. Commonly used equipment is briefly described below.

3.4.1 Brushes and scrapers

Although the use of brushes and scrapers requires little explanation, the importance of this basic equipment should not be overlooked. Any decontamination program must have adequate supplies of good quality scrubbers, brushes and scrapers to removed thick deposits of soil.

Scrapers are useful to mechanically lift and dislodge heavy accumulations, particularly type 1 and type 4 soiling. Equipment used to clean hulls (available from boat chandlerys) is often most suitable for this purpose.

3.4.2 Boot cleaners

Boot cleaners, used in conjunction with footbaths to remove gross soiling before chemical disinfection, are also highly recommended. A range of specialised units are available that are designed to remove soil from boots using a series of floor-mounted brushes. These units allow staff to clean boots easily before entering the footbath, and reduce the amount of soil contaminating the chemical solution.

3.4.3 Misters and low-pressure sprayers

Hand or backpack sprayers can be used to apply detergents and disinfectants to surfaces. These

units operate at very low pressures and are not effective at dislodging soils. They must therefore be accompanied by mechanical action (brushing or high-pressure water) for effective cleaning. Such units are probably most useful for applying disinfectants over surfaces after cleaning.

Mechanically-driven misters are commonly used to apply chemicals in horticulture and broadscale agriculture. Because they produce a mist that disperses to all surfaces, they can be used in decontamination programs where areas and equipment are difficult to access or have complex structures. Misters are available in a range of sizes, from small petrol-driven models to large tractor-mounted units.

3.4.4 Pumps

High-volume pumps, such as those used in firefighting units, are useful for removing loose accumulations associated with type 2 soiling, but have limited value for other soiling types. Their main value is during the rinsing stages of the operation because of their ability to thoroughly wet equipment. These pumps are also essential for transferring water between storage facilities or for removing waste water. High-volume pumps are readily available from most agricultural or irrigation equipment suppliers. Specialised sludge or diaphragm pumps may be required to transfer and agitate liquids containing high levels of solids — for example, faecal waste slurries.

Table 4 **Characteristics of common cleaning and wetting compounds**

Cleaning compound	Applications*	Advantages	Disadvantages	Common examples
Mild alkaline detergents	Primarily type 2 soiling, but also useful for type 1 soiling	Useful as a general detergent May have chlorine added to enhance protein breakdown capability Produces pH of 8.4	High concentrations can be irritant Mildly corrosive May be difficult to rinse	Sodium carbonate Sodium sesquicarbonate
Strong alkaline detergents	Excellent for type 1 and type 3 soiling Also useful for type 2 soiling	Provide good saponification Have good foaming characteristics, which may be used to prolong contact time on vertical surfaces High pH aids soil removal and has some biocidal characteristics May have chlorine added to enhance protein breakdown	Corrosive to some metals, in particular soft alloys and aluminium Irritant to skin and mucous membranes Interact with calcium and magnesium ions in hard waters to produce soap scums that may be difficult to rinse Inefficient at deflocculation and emulsification	Sodium hydroxide Sodium orthosilicate Sodium sesquisilicate
Organic acid compounds	Type 5 soiling and for other inorganic acid-soluble substances	Remove inorganic precipitates and other acid-soluble substances Less corrosive than alkalis Easily rinsed from surfaces	Mildly corrosive Inhibited by various organic nitrogen compounds	Acetic acid Citric acid Oxalic acid
Inorganic acid compounds	Type 5 soiling	Highly efficient at removing mineral deposits produced by marine or hard waters Some biocidal effect through low pH Effective at softening water Can be combined with other agents to enhance penetrating ability Easily rinsed from surfaces	Corrosive to metals Irritant to eyes, skin and mucous membranes	Phosphoric acid Sulfamic acid Nitric acid
Nonionic surfactants	Excellent detergents for oils; therefore effective on some type 1 soils Useful for type 2 soils	Compatible with most other cleaning compounds Very good wetting characteristics Good dispersing and detergent action	May be sensitive to acids	Polyethen-oxyethers
Cationic surfactants	Some wetting effect, but not recommended for general cleaning purposes	Good biocidal characteristics	Relatively poor penetration capability Must not be used with anionic compounds	Quaternary ammonium compounds
Anionic surfactants	Some type 1 soils; effective against oils, fats and waxes Also useful on absorbent or pitted material	Can be used under acid or alkaline conditions Good penetration characteristics Compatible with acid or alkaline cleaners and may have a synergistic effect	Some types foam excessively Must not be used with cationic compounds	Soaps Sulfated alcohols Sulfated hydrocarbons

Source: Table compiled from information in Lewis (1980), Fotheringham (1995b), Holah (1995a), Salvat and Colin (1995)

*Type 1 soiling = oily build-ups and protein accumulations
Type 3 soiling = biofilms
Type 5 soiling = mineral accumulations

Type 2 soiling = sediment accumulations
Type 4 soiling = organic fouling

3.4.5 High-pressure water cleaners

High-pressure water cleaners (HPWCs) are a key piece of equipment for all stages of cleaning and disinfection. They are highly efficient at dislodging most types of gross soiling.

Water pressure output from HPWCs may be fixed or variable. These units may be used to apply detergents and disinfecting chemicals via a chemical injection facility that is available on most units when used at low pressure (refer to Caution note A5, p33). Although HPWCs are commonly electrically powered, petrol-driven units suitable for use in isolated locations are also available.

Several types of HPWC are readily available on the market:

- Pressure water cleaners use a high-pressure water jet to dislodge soiling. Smaller units generally have a working water pressure below 125 bar (1800 psi), and larger units can apply water up to 240 bar (3500 psi). Most also have the capacity to use preheated water (usually <60°C) to enhance cleaning. See Caution notes A1 and A3, p33.
- Heated pressure water cleaners have a mechanism within the unit to increase water temperatures (to 60–90°C) and apply this heated water to the site at pressure. Pressure capacities vary according to the model chosen but are generally similar to those of the nonheated units described above. Although more expensive than nonheated HPWCs, they have significantly greater cleaning efficiency, especially when dealing with type 1 soiling. Refer to Table 3 for optimum cleaning temperatures and see Caution notes A2, A3 and A4, p33.
- Steam cleaners heat water within the unit to produce a jet of very hot water and steam (up to 140°C). These cleaners are extremely efficient at loosening fat and oil deposits (type 1 soiling) during the initial stage of cleaning, but combining their use with chemical cleaners is generally not possible or recommended. Due to the high temperatures produced, steam cleaners can also be used for disinfection purposes on some surfaces. See Caution notes A2 and A4, p33.

3.4.6 Net washers

Nets from aquaculture pens present particular challenges for effective cleaning. They are generally bulky and difficult to handle, and are made of absorbent material that is usually heavily fouled with type 3 and type 4 soiling.

Nets may be cleaned using two basic methods: spreading out on a slab, then using HPWCs to blast off gross soiling (see Caution note A3, p33); or using specialised net washers.

Net washers work in a similar fashion to the domestic washing machine. They have a large rotating drum in which the net is agitated while being rinsed with clean water. Although this mechanical action is highly efficient at dislodging soil, net washers are unlikely to be available during emergency events unless they are already installed as part of the farm infrastructure.

Where net washers are used, consideration must be given to diverting the washwater for appropriate disposal away from nearby surface water bodies.

3.4.7 Foam projectile pipe cleaning systems

Foam projectile pipe cleaning systems, also referred to as 'pigging systems', are routinely used by the oil industry and by food or beverage manufacturers to remove buildups on the inside of pipes without the need for dismantling. They are considered to be highly effective in removing biofilms. The system can also be used to remove residual chemicals and dry the inside of pipelines following disinfection.

These systems use a range of foam projectiles that are forced through the pipelines using compressed air. The projectiles come in a range of sizes, densities and abrasive surface textures that can be used to either scour, wipe or dry the internal surface of pipelines.

For decontamination purposes, pigging systems are most useful in facilities such as hatcheries where complex pipe systems occur. These cleaning systems have already gained some acceptance in abalone hatcheries and 'grow-out' facilities in Australia as part of normal maintenance procedures.

The cost of these systems depends on the size of the piping requiring cleaning, but they are relatively cost effective when savings in time required for dismantling equipment are taken into account. They also have significant benefits in cleaning and disinfecting piping that is difficult to access. Such piping may harbour pathogens, resulting in reinfection when the facility is restocked.

Caution notes:

- A1** Care should be taken to ensure that pressure applied by HPWC units does not damage the surface of equipment and tanks. It is advisable to test a small area first. Concrete tanks are particularly susceptible to pitting and erosion by HPWCs. This problem may be overcome by choosing a wider spray pattern rather than a concentrated jet, by holding the jet further away from the surface, or by lowering the pressure output.
- A2** Although cleaning agents are often more effective when used hot, temperatures should not exceed 65°C. The emulsions formed with the detergent are destroyed at high temperatures (Cancellotti 1995). This temperature restriction also applies to some alkaline detergents when used with hard water. Acidic cleaners are normally used cold.
- A3** Pressure water cleaners have a tendency to spread dirt and water over an area surrounding the immediate work site. Operators should wear appropriate protective clothing and ensure that they are not contaminating other equipment with the spray.
- A4** HPWCs have the potential to cause injury or burns. Operators should be supplied with appropriate protective equipment, including face shields, gumboots and waterproof clothing.
- A5** When using HPWCs to apply chemicals for disinfection purposes, the water/chemical mix may vary depending on viscosity and venturi pressure. Where a prescribed disinfection concentration is required, simple calculations are necessary to determine the application rate.

4 Disinfection

A key element of disinfection is the choice of a suitable disinfecting agent. Disinfecting agents are selected according to the following criteria:

- nature of the target pathogen(s) (see [Section 2.1](#) and Table 2);
- nature of the items to be disinfected (see [Section 2.3](#));
- toxicity and other dangers involved in using the disinfectant (see [Section 2.7](#));
- persistence and environmental impact of disinfectant residues (see [Section 2.8](#));
- solubility, stability, corrosiveness and penetration of the disinfectant; and
- price, handling characteristics and availability.

Characteristics of different types of disinfectants are described in [Section 4.2](#).

4.1 Nature of the target pathogen

4.1.1 Viruses

Viruses vary in their susceptibility to inactivation by disinfecting agents. For disinfection purposes, viruses fall into three basic groups:

- **Category A:** These viruses contain a lipid envelope and are of intermediate to large size. Category A viruses are the easiest group of viruses to inactivate since the lipid envelope is sensitive to many lipophilic compounds such as soaps and detergents.
- **Category B:** These viruses are the most difficult to inactivate. They include small, nonlipid-containing viruses and those protected within a protein matrix (occlusion). Baculoviruses are included in this group because they are embedded in an occlusion that provides protection to the viral particle (Spann et al. 1993).
- **Category C:** These viruses are intermediate in their ease of inactivation by chemical agents. They do not contain lipid but are usually larger than the viruses in category B.

Table 5 Disinfection categories of viral disease agents of aquatic animals listed as reportable in Australia lists the viral agents of aquatic animals that are currently reportable in Australia and their disinfection categories.

Table 5 Disinfection categories of viral disease agents of aquatic animals listed as reportable in Australia

Disease or infective agent	Viral group	Disinfection category
Finfish		
Channel catfish virus disease	<i>Herpesviridae</i>	A
European catfish virus/ European sheatfish virus	<i>Iridoviridae</i>	C
Epizootic haematopoietic necrosis	<i>Iridoviridae</i>	C
Grouper iridoviral disease	<i>Iridoviridae</i>	C
Infectious haematopoietic necrosis	<i>Rhabdoviridae</i>	A
Infectious pancreatic necrosis	<i>Birnaviridae</i>	C
Infection with HPR-deleted or HPR0 infectious salmon anaemia virus	<i>Orthomyxoviridae</i>	A
Infection with salmonid alphavirus	<i>Togaviridae</i>	A
Koi herpesvirus disease	<i>Herpesviridae</i>	A
Megalocytiviruses (ISKNV-like viruses, Red Sea Bream Iridovirus)	<i>Iridoviridae</i>	C
Spring viraemia of carp	<i>Rhabdoviridae</i>	A
Viral encephalopathy and retinopathy	<i>Nodaviridae</i>	B
Viral haemorrhagic septicaemia	<i>Rhabdoviridae</i>	A
Molluscs		
Abalone viral ganglioneuritis (AVG)	<i>Herpesviridae</i>	A
Iridovirose	<i>Iridoviridae</i>	C
Ostreid herpesvirus 1 μ Var (POMS, AVNV)	<i>Herpesviridae</i>	A
Crustaceans		
Gill-associated virus	<i>Roniviridae</i>	A
Infectious hypodermal and haematopoietic necrosis virus	<i>Parvoviridae</i>	B
Infectious myonecrosis virus	<i>Totiviridae</i>	B
Spherical baculovirosis (<i>Penaeus monodon</i> -type baculovirus)	<i>Baculoviridae</i>	B
Infection with Taura syndrome virus	<i>Dicistroviridae</i>	B
Infection with White spot syndrome virus	<i>Nimaviridae</i>	A
Macrobrachium rosenbergii nodavirus	<i>Nodaviridae</i>	B
Infection with Yellow head virus genotype 1	<i>Roniviridae</i>	A
Amphibians		
Infection with ranaviruses	<i>Iridoviridae</i>	C

A = most susceptible, B = most resistant, C = intermediate

Source: Information obtained from Spann et al. (1993), Bondad-Reantaso et al. (2001), Hatori et al. (2003), OIE (2018a) and ICTV (2017).

4.1.2 Bacteria

Bacterial pathogens can also be classified according to their susceptibility to disinfecting agents (Russel 2001, Table 2).

- Mycoplasmas, rickettsias and gram-positive vegetative bacteria tend to be most susceptible to disinfection, especially chemical disinfectants.
- Gram-negative bacilli are less susceptible to disinfecting agents than gram-negative cocci (Russel 2001).
- Mycobacteria are relatively resistant and tend to occupy an intermediate place between vegetative bacteria and bacterial spores.
- Bacterial spores are the most resistant to the action of disinfectants (Table 2).

Table 6 lists bacterial pathogens of aquatic species that are reportable within Australia, including their gram reaction and structure. None of the bacteria species listed are spore forming. These characteristics can be used to indicate susceptibility to disinfection.

Among fish bacterial pathogens, Torgersen and Hastein (1995) report that *Aeromonas salmonicida* and a number of the vibrio species are able to produce respiring nonculturable cells that can survive for several months in free water or sediments. *Renibacterium salmoninarum*, the cause of bacterial kidney disease, has been shown to be comparatively resistant to inactivation by heat (Humphries et al. 1991).

Table 6 Bacterial disease agents of aquatic animals listed as reportable in Australia

Disease (bacterial agent)	Gram reaction	Structure	Disinfection rating
Finfish			
<i>Aeromonas salmonicida</i> — atypical strains	Gram-negative	Bacilli	less susceptible
Bacterial kidney disease (<i>Renibacterium salmoninarum</i>)	Gram-positive	Bacilli	susceptible
Enteric redmouth disease (<i>Yersinia ruckeri</i> — Hagerman strain)	Gram-negative	Bacilli	less susceptible
Enteric septicaemia of catfish (<i>Edwardsiella ictaluri</i>)	Gram-negative	Bacilli	less susceptible
Furunculosis (<i>Aeromonas salmonicida</i> subsp. <i>Salmonicida</i>)	Gram-negative	Bacilli	less susceptible
Piscirickettsiosis (<i>Piscirickettsia salmonis</i>)	Gram-negative <i>Rickettsia</i> -like	Pleomorphic/ coccoid	highly susceptible
Molluscs			
Infection with <i>Candidatus Xenohaliotis californiensis</i>	Gram-negative <i>Rickettsia</i> -like	Pleomorphic/ coccoid	highly susceptible
Crustaceans			
Acute Hepatopancreatic Necrosis Disease (AHPND) (<i>Vibrio parahaemolyticus</i> , <i>VpAHPND</i>)	Gram-negative	Bacilli	less susceptible
Infection with <i>Candidatus Hepatobacter penaei</i>	Gram-negative <i>Rickettsia</i> -like	Pleomorphic/ rods or helical	highly susceptible

Source: Information adapted from Inglis et. al. (1993), J Carson (Principal microbiologist, Tasmanian Department of Primary Industries and Water, pers comm, 2005), and Nunan et al. (2013).

4.1.3 Protozoal and protozoal-like parasites

The complete life cycle should be considered for any pathogen within this group before any decontamination procedure is undertaken. Since reservoir populations may lead to reinfection, the presence of intermediate hosts or resistant spores is an important factor to consider during decontamination.

Most of the protozoan parasites listed as reportable in Australia are microcell parasites of molluscs. The life cycles of many of these are poorly understood. For this reason, few control programs have been attempted to limit their spread (Bondad-Reantaso et al. 2001), but see [Ministry for Primary Industries NZ \(2018\)](#). A number of these organisms are also considered to have resistant spore stages within the life cycle (see Table 7 for summary information), and research on the efficacy of various disinfectants against these types of spores is limited.

Wesche et al. (1999) found that spores produced by *Marteilia sydneyi* were largely inactivated using 200 ppm (ppm = mg/L) chlorine for 2 hours, with complete inactivation after 4 hours (Table 8). Bushek et al. (1997a) reported that 400 ppm chlorine, with a contact time of 4 hours, was required to kill *Perkinsus marinus* parasites in culture medium, with 300 ppm chlorine for 30 minutes inactivating all *P. marinus* stages in seawater (Bushek et al. 1997a, 1997b). These high residual chlorine levels and long contact times suggest that, in the absence of specific information to the contrary, protistan spores should be regarded as highly resistant to disinfection techniques.

The [AQUAVETPLAN Disease Strategy Manual — Whirling disease](#) states that, within the life cycle of the parasitic cnidarian *Myxobolus cerebralis* (the causative agent), the myxospore stage is the most resistant to disinfectant strategies. Water entering freshwater habitats has the potential to contain viable myxospores if it is not adequately disinfected. Recommended methods for inactivation of myxospores include calcium hydroxide (0.5% for 24 hours), calcium oxide (0.25% for 24 hours), chlorine (1600 mg/L (ppm) for 24 hours, 5000 ppm for 10 minutes, or 500 ppm for 15 minutes for myxospores (Hedrick et al. 2008), and heating to more than 90°C for at least 10 minutes (DAWR 2016, Table 8**Error! Reference source not found.**). Other protists, such as ciliates and flagellates, are comparatively easy to inactivate using a variety of disinfectant products.

Table 7 Protozoal and protozoal-like disease agents of aquatic animals listed as reportable in Australia

Notifiable disease (protozoal/protozoal-like agent)	Formation of resistant spores	Life cycle
Finfish		
Whirling disease (<i>Myxobolus cerebralis</i>)	Spores extremely long lived in pond sediments	Indirect with oligochaete intermediate host ^a
Crustaceans		
Infection with <i>Enterocytozoon hepatopenaei</i>	Spore forming ^f	Direct transmission demonstrated
Molluscs		
Infection with <i>Bonamia</i> species, including <i>B. ostreae</i> and <i>B. exitiosa</i>	No spores demonstrated ^b , except for <i>Bonamia perspora</i> ^g	Direct life cycle suspected, no known intermediate host
Infection with <i>Mikrocytos mackini</i>	Unknown	Direct life cycle suspected, no known intermediate host
Infection with <i>Marteilia refringens</i>	Spore forming ^c	Indirect with crustacean intermediate host ^h Complete life cycle unknown
Infection with <i>Marteilia sydneyi</i>	Spore forming, survive up to 35 days outside host ^d	Indirect with polychaete intermediate host ⁱ Complete life cycle unknown
Infection with <i>Marteilioides chungmuensis</i>	spore forming ^j	Complete life cycle unknown Intermediate host strongly suspected
Infection with <i>Perkinsus</i> species	Spore forming ^{e, k}	Direct transmission demonstrated Host range for some species may be broad

^a DAWR (2016)^b Engelsma et al. (2014)^c Berthe et al. (1998),^d Wesche et al. (1999)^e Bondad-Reantaso et al. (2001)^f Tourtip et al. (2009)^g Carnegie et al. (2006)^h Audemard et al. (2002)ⁱ Adlard and Nolan (2015)^j Itoh et al. (2004)^k Delany et al. (2003)

4.1.4 Fungi

The fungal diseases of aquatic organisms listed as notifiable within Australia are epizootic ulcerative syndrome (causative agent *Aphanomyces invadans*) in finfish, and crayfish plague (causative agent *A. astaci*).

The fungi are primarily pathogens of freshwater or estuarine systems, but infection of marine species can also occur. This group produces motile zoospores that, apart from a brief period of encystment, are relatively susceptible to most disinfectants. It should be noted, however, that microsporidia are now considered to be derived fungi rather than protozoans (Vossbrinck and Debrunner-Vossbrinck 2005, Didier et al. 2014), hence infection with *Enterocytozoon hepatopenaei* in prawns (see [Section 4.1.3](#)) can also be considered a fungal disease.

The [AQUAVETPLAN Disease Strategy Manual — Crayfish plague](#) recommends iodophors, peracid solutions or sodium hypochlorite as the most appropriate chemical disinfectants for this group. Lilly and Inglis (1997) reported that *A. invadans* was susceptible to 100 ppm available iodine with a contact time of at least 1 minute, whereas sodium hypochlorite and a commercial peracid solution required 20 minutes contact time to produce inactivation at 100 ppm. The manual also recommends the use of heat (>50°C for a minimum of 12 hours) and desiccation (drying) for 48 hours as alternatives for the inactivation of *A. invadans* (see DAFF 2005).

4.2 Choice of disinfecting agents

Types of disinfecting agents that might be used during an outbreak of disease in aquatic animals include the following:

- oxidising agents;
- ozone
- pH modifiers (alkalis and acids);
- aldehydes;
- biguanides;
- quaternary ammonium compounds (QACs);
- ultraviolet (UV) irradiation;
- heat;
- drying; and
- high temperatures.

It is beyond the scope of this manual to discuss all possible types and combinations of disinfectants. Those most likely to be used during an emergency disease event are discussed below. Table 8 provides a summary of some of the published literature relating to decontamination of diseases listed as notifiable in Australia. Table 9 provides information on chlorine compounds while Table 10 provides information on the corrosive qualities of common disinfecting agents. Table 11 and Table 12 indicate the relative efficacy of common disinfecting agents against different types of microorganisms, and Table 13 and Table 14 summarise the working characteristics of common chemical agents. Further details on the practical applications of each type of agent are contained in Part B of this manual.

More than one effective disinfecting agent may be used during the decontamination program. For example, more expensive products are often used for critical tasks or the disinfection of personnel, but it may be more appropriate to disinfect large volumes of water using cheaper compounds that are also available in sufficient quantities or consider physical options such as UV or heat.

The shortcomings of chemical disinfectants can often be improved by adjusting working concentrations and modifying physical parameters of the water used. For example, the antimicrobial effect of iodophors, carboxylic acids and chlorine may be improved by lowering the pH of the solution. With the exception of iodophors and alcohols, increasing concentration

generally improves antimicrobial efficacy. Similarly, increased temperature (within a defined range) and contact time also increase the effectiveness of disinfecting agents.

4.2.1 Oxidising agents

The majority of oxidising agents are relatively fast acting and very effective disinfectants for a large range of microorganisms when they are used under appropriate conditions, at a suitable concentration and with acceptable contact times.

Most oxidising agents — apart from iodophor compounds — are corrosive to soft metals such as aluminium, brass and copper, and can damage rubber items such as gumboots and vehicle tyres. Oxidising agents can be neutralised using a reducing agent such as sodium thiosulfate (see [Section 7.1](#) for further details).

Chlorine-liberating compounds

Chlorine-liberating compounds are the most widely used chemicals for disinfection purposes. As indicated in Table 9, chlorine compounds considered most suitable for use during decontamination programs fall into three basic categories: hypochlorite compounds, organic chloramines and chlorine dioxide liberators.

Hypochlorite solutions release chlorine in the form of hypochlorite ions and hypochlorous acid, which are the active disinfecting agents. Hypochlorite ions have much weaker biocidal action than hypochlorous acid.

Hypochlorous acid and hypochlorite ions occur in equilibrium in solution, with the relative concentration of each determined by either temperature or pH. The concentration of hypochlorite ions increases with either increasing pH or increasing temperature. It is therefore optimal to maintain water pH at or below 7 (a pH range of 6–8.5 for working solutions is recommended) in order to maximise the effectiveness of these disinfecting solutions. In hot environments (>25°C), the increase in hypochlorite ions may need to be compensated for by use of higher hypochlorite concentrations. [Section 7.1](#) contains further details on the properties and uses of hypochlorite solutions.

Chloramine-T is the most commonly used organic chloramine. It is used as a veterinary disinfectant and therapeutic in both terrestrial and aquatic livestock.

The chemical action of chloramine-T is the subject of some debate, but it is generally accepted that, like the hypochlorites, chloramine-T decomposes in water into hypochlorite ions and hypochlorous acid. The organic anion in chloramine-T degrades at a much slower rate than hypochlorites, and this slow degradation makes solutions more stable, less corrosive and less irritant. Chloramine-T is also less affected by the presence of organic matter. [Section 7.2](#) contains further details on the properties and uses of chloramine-T.

Chlorine dioxide has been used to treat drinking water for many years. It is normally a highly reactive gas at room temperature, requiring complex infrastructure for its generation. However, products have recently been introduced onto the market that allow chlorine dioxide to be used for a range of small-scale disinfection applications. These products commonly use sodium chlorite (also referred to as ‘stabilised chlorine dioxide’) solutions that are treated with an acid

‘activator solution’ to generate chlorine dioxide in solution. Chlorine dioxide does not ionise to form hypochlorite or hypochlorous acid and thus is not subject to the constraints of temperature or pH described above.

Chlorine dioxide has a number of significant advantages over other chlorine-based solutions. It is less affected by the presence of organic matter and more tolerant of changes in pH. Chlorine dioxide is also reported by some authors to have greater antimicrobial activity than sodium hypochlorite, particularly against spores (Dychdala 2001). [Section 7.3](#) contains further details on the properties and uses of chlorine dioxide.

Peroxygen agents

Peroxygens include compounds such as hydrogen peroxide, peracid solutions and monosulfates of either sodium or potassium. Peroxygen disinfecting agents are very active, and are not affected by organic matter, but some products may be corrosive to alloys, aluminium and plain steel.

Peracid solutions are a mixture of peracetic acid, hydrogen peroxide and acetic acid. The two latter compounds have a synergistic effect with peracetic acid. They are extremely effective biocides and have no toxic residuals (Block 2001), but their acidic pH makes them corrosive to some materials when used at high concentrations. Peracids are active against all types of microorganisms, including spores, and retain activity in the presence of organic matter (Jeffrey 1995). Although biocidal activity is effective over a wide pH range, peracids tend to be more effective as weak acid solutions.

Powdered forms of peroxygens occur as sodium or potassium monosulfates (e.g. potassium peroxomonosulfate triple salt). Throughout this document, they will be referred to as monosulfates to differentiate them from other peroxygen agents. Monosulfates produce chlorine when dissolved into solution, and peroxide under acid conditions. They therefore have two actions depending on water pH. One common member of this group has achieved wide acceptance as a general disinfectant in the veterinary industry and is commonly used during emergency livestock disease events.

[Section 7.6](#) contains further details on the properties and uses of peroxygen compounds.

Iodophors

Iodine is a potent disinfecting agent that is effective against a wide range of bacteria, fungi and viruses. The older inorganic aqueous and alcohol solutions of iodine disinfectants are generally toxic and corrosive, making them unsuitable for decontamination programs. These problems have largely been overcome in the group referred to as the iodophors, which are effective and widely used disinfectants.

Iodophors are a complex of iodine and an organic carrier molecule. This increases solubility and allows a sustained release of iodine over time in aqueous solution. These solutions have lower toxicity or irritant effects and are less affected by organic matter (3×) than chlorine disinfection compounds (Gottardi 2001).

A readily available iodophor is povidone iodine, which uses a particular type of carrier molecule. Povidone iodine is nontoxic and noncorrosive. It is commonly used as a general disinfectant in

veterinary medicine and is suitable as a disinfectant for skin or delicate equipment. It has gained wide acceptance in aquaculture for disinfection of fish eggs and the control of viruses such as infectious pancreatic necrosis virus (Table 8).

Other iodophor solutions commonly used for disinfection on farms are acidified solutions, as this enhances their biocidal activity and penetrating ability. These solutions are commonly used in dairies to disinfect milking equipment and remove milk deposits. Such preparations would also have applications in cleaning and disinfection of aquaculture recirculation systems. Due to their low pH, acidified iodophor solutions may be corrosive to some materials. Iodophors have the unique characteristic of producing higher levels of free molecular iodine (the disinfecting agent) when diluted. The concentration of free molecular iodine rises 10-fold with a 1:100 dilution of 10% povidone iodine solution; further dilution reduces the biocidal effect (Gottardi 2001). The optimum working solution, for maximum free molecular iodine, is therefore 0.1% povidone iodine.

Because free iodine gives iodophor solutions their brown colour and solutions lose colour as iodine is consumed, colour may be used as an indicator of exhaustion of the iodine in the solution.

[Section 7.4](#) contains further details on the properties and uses of iodophors.

Table 8 Summary of some published literature relating to decontamination of diseases listed as notifiable in Australia (minimum 3 log (99.9%) reduction).

Finfish Diseases	Drying out	Heat	UV mj/cm ²	Ozone mg/L/min	Chlorine (mg/L)	Ethanol	Iodine (mg/L)	Formalin	Benzalkonium chloride (mg/L)	Sodium hydroxide	Virkon S®	References
<i>Aeromonas salmonicida</i> – atypical	✓	>50°C 2min	>6	0.5	2/ 1min		2.6/ 5min		300/ 2min	>5min pH >12	0.5%/10 min	1-9, 15
Bacterial kidney disease	✓	>65°C 15min	>20		10/ 1min		25/ 5min			>6 hr pH >12	1%/ 10 min	4, 9, 10
Channel catfish virus disease	>2 days	>60°C 1 hr	>0.2		540/ 30min		250/ 30min			>6 hr pH >12		4, 5, 8,11,15
Enteric redmouth disease	✓	>75°C 1min	>5	0.7	250/ 2 hrs		25/ 15sec			>5 hr pH>12	1%/ 10 min	2,4,7,8,9,12,15
Enteric septicaemia of catfish***	✓	>60°C 1 hr	>5		50/ 1min	30%/1min	50/ 1min			>6 hr pH >12	1% / 1 min	13
Epizootic haematopoietic necrosis	>200d	>60°C 15min			200 /2hrs	70%/ 2hr				>2 hr pH>12		10, 14
European catfish virus /European sheatfish virus	✓	>60°C 1 hr								>24 hr pH >12		15
Furunculosis	✓	>60°C 1 hr	>6	0.5	2/ 1min		2.6/ 5min		300/ 2min	10min pH>12	0.5%/10 min	1-9
Grouper iridoviral disease	✓				200/ 2 hrs	70%/ 2hr					1%/ 1 min	9, 14
Gyrodactylus (Infection with <i>Gyrodactylus salaris</i>)	✓	>40°C 1min						0.002%/18hr			susceptible	8, 16
Infection with <i>Aphanomyces invadans</i> (EUS)***	✓		>210		100/ 20min		100/5min					8,17,18
Infection with HPR-deleted or HPR0 ISA virus	✓	>56°C 5min	>8	0.3	100/15min		100/5min	0.5%/16hrs		>24hr pH>12	0.5%/10 min	8,9,10,15,19,20
Infection with salmonid alphavirus	✓	>60°C 1 hr					400/5min				0.5%/5min	8,21
Infectious haematopoietic necrosis	✓	>45°C 10min	>4	0.5	0.5 /10min		100/ 5min			>24hr pH>12	0.1%/15 min	5,8,10,11,22,23
Infectious pancreatic necrosis	✓	>80°C 10min	>250	0.5	50/ 30min		10/ 2.5min	2%/ 5min		20min pH>12	1%/ 10 min	1,2,9,10,15,19
Megalocytiviruses (ISKNV-like)	✓	>50°C 30min 65°C 20 min	>5		200/ 30min			0.2%/15 min		30min pH>11		5,24,25, 75
Koi herpesvirus disease	✓	>50°C 1min	>4		200/20 min	40%/ 30sec	200/30sec		60/ 30sec			8, 26
Piscirickettsiosis	✓	>30°C	>10		5/indefinite				10% /30 min			10,27,28
Red Sea Bream Iridovirus disease	✓	>56°C 30min	>5		200/ 30min					30min pH>11		5,25
Spring viraemia of carp	✓	>56°C 30min			540/ 20min		250/ 30min	3%/5min	100 /20 min	10min pH>12	0.1%/15 min	29
Viral encephalopathy and retinopathy	>7 days	>60°C 30min	>200	0.5	100/ 5min		100/ 30min	0.2%/ 6hrs	50/ 10min	>24 h pH>12		8,10,20,30,
Viral haemorrhagic septicaemia	>10 d	>50°C 10min	>10		50/ 1min	40%/2min	100/ 10min		125/ 5min	>2hr pH>12.2	0.1%/15min	4, 9, 10,19,31
Whirling disease	>1 day	>90°C 10min	>40		500/ 15min		5000/60min		1500 /10 min		1%/ 5 min	8,24,32,33,34
Crustacean Diseases												
AHPND (<i>VpAHPND</i>)	✓	>60°C 1min	>5	1.9	250/ 30 min		25/ 2 min				1% /10 min	1,2,4,8,9,12,35,36
Crayfish plague (infection with <i>Aphanomyces astaci</i>)	>2 days	>50°C 12 hrs			100/20min		100/ 1min				0.3%/15 min	18,37
IHHN	✓	>100°C>2 hr										38
Infection with <i>Enterocytozoon hepatopenaei</i>	✓	60°C >10min 100°C >3min		0.5	25/ 10 min	70%/10min						39-49 for similar parasites

Table 8 (con't)	Drying out	Heat	UV mj/cm ²	Ozone mg/L/min	Chlorine (mg/L)	Ethanol	Iodine (mg/L)	Formalin	Benzalkonium chloride (mg/L)	Sodium hydroxide	Virkon S®	References
Infection with <i>Candidatus</i> Hepatobacter penaei	✓	>60°C 5min	>10					3.5%/20min				23,50,68 for similar bacteria
Infectious Myonecrosis	✓	100°C >1min										51, 52
Monodon slow growth syndrome	✓	100°C >1min										51, 52
Taura Syndrome	✓	100°C >1min										51, 52
White Spot Disease	>3 hrs	>70°C 5 min	>250	5	200/ 10 min	30%/1min	200/10 min		75/ 10 min	25min pH>12		53-56
White tail disease	✓	>50°C 5 min	>132				100/ 10min			10min pH>8.5		57
Yellowhead Virus (YHV1) / GAV	✓	>60°C 15min		0.5	30/ 60 min							58
Mollusc Diseases												
Abalone viral ganglioneuritis	✓				2/ 15 min		1/20 min		500/20 min			59
Infection with <i>Bonamia ostreae</i> , <i>Bonamia</i> spp.*	✓	>60°C 15min										60, 61, 62
Infection with <i>Marteilia refringens</i>	✓				200/4 hrs							63 for similar parasites
Infection with <i>Marteilia sydneyi</i>	✓				200/4 hrs							63
Infection with <i>Marteilioides chungmuensis</i>	✓											no information
Infection with <i>Mikrocytos mackini</i> *	✓	>60°C 15min										60, 61, 62 for similar parasites
Infection with OsHV-1µVar (POMS/AVNV)	>7 days	>50°C 5min	600				1000/5min	10%/30min	800/ 10 min	20g/L 10min	1% /15 min	64
Infection with <i>Perkinsus marinus</i> **	>7 days	>50°C 1 hr	28		300/30 min							65,66, 67, 68
Infection with <i>Perkinsus olseni</i>	>7 days	>50°C 1 hr	240		300/30 min							65,66,69, 70
Infection with <i>Xenohaliotis californiensis</i>	✓	>60°C 5min			>10		1%/ 1 hour					71,+ 23,50,72 for similar bacteria
Iridoviruses	✓											no information
Amphibian Diseases												
Infection with <i>Batrachochytrium dendrobatidis</i> ***	>3 hrs	>37°C 4 hr >60°C 5 min			0.01%/10min	70%/ 20 sec		0.1%/10min	1000/ 20sec		0.1%/20 sec	73
Infection with ranavirus	✓				3% /1min						1% / 1 min	74

✓ = likely to be effective, but duration not recorded, * = also 10-50 mg/L (0.001-0.005%) acetic acid (vinegar), ** = also freshwater for 30 min, *** = also >3-5 ppt salt.

References: 1 Torgersen and Hastein 1995, 2 Liltved et al. 1995, 3 Liltved and Landfald 1995, 4 Hine and MacDiarmid 1996, 5 Kasai et al. 2002, 6 Summerfelt and Vinci 2003, 7 Chevretils et al. 2006, 8 Skall and Olesen 2011, 9 Antec International, undated, 10 Bovo et al. 2005, 11 Yoshimizu et al. 2005, 12 Jacobsen et al. 1989, 13 Mainous et al. 2010, 14 Langdon 1989, 15 Dixon et al. 2012, 16 Schelkle et al. 2009, 17 Kimura et al. 1980, 18 Lilley and Inglis 1997, 19 Oye and Rimstad 2001, 20 Liltved et al. 2006, 21 Graham et al. 2007, 22 Wedemeyer et al. 1978, 23 Yoshimizu 2009, 24 Yanong and Erlacher-Reid 2012, 25 Yanong and Waltzek 2016, 26 Kasai et al. 2005, 27 Lannan and Fryer 1994, 28 Muniesa et al. 2018, 29 OIE 2018c, 30 Arimoto et al. 1996, 31 Dorson and Michel 1987, 32 Wagner et al. 2003, 33 Hedrick et al. 2007, 34 Hedrick et al. 2008, 35 Brown and Russo 1979, 36 Sugita et al. 1992, 37 Jussila et al. 2014, 38 Haung et al. undated, 39 Lom and Dykova 1992, 40 Shaw et al. 1999, 41 Koudela et al. 1999, 42 Jacangelo et al. 2002, 43 Johnson et al. 2003a, 44 John et al. 2005, 45 Xunde and Fayer 2006, 46 Ferguson et al. 2007, 47 Kent et al. 2009, 48 Murray et al. 2011, 49 Leiro et al. 2012, 50 Frickmann and Dobler 2013, 51 Biosecurity Australia 2009, 52 Diggles 2017, 53 Chang et al. 1998, 54 Nakano et al. 1998, 55 Osekeo et al. 2006, 56 Balasubramanian et al. 2006, 57 Ravi and Sahul Hameed 2016, 58 OIE 2018d, 59 Corbeil et al. 2012, 60 Grizel 1985, 61 OIE 2018e, 62 Morga et al. 2009, 63 Wesche et al. 1999, 64 Hick et al. 2016, 65 Bushek et al. 1997a, 66 Bushek et al. 1997b, 67 Bushek and Howell 2000, 68 Ford et al. 2001, 69 Goggin et al. 1990, 70 Lester and Hayward 2005, 71 OIE 2018f, 72 Hijnen et al. 2006, 73 Johnson et al. 2003b, 74 Bryan et al. 2009, 75 Becker et al. 2016.

Table 9 Common types of chlorine-liberating compounds

Chemical group	Common examples	Physical state (concentrate)	Available chlorine (concentrate)
Hypochlorite compounds	Sodium hypochlorite	Liquid	1–15%
	Potassium hypochlorite	Liquid	12–14%
	Calcium hypochlorite	Powder	65–70%
	Lithium hypochlorite	Powder	30–35%
	Chlorinated trisodium phosphate	Powder	3.25% + detergent action
Organic chloramines	Chloramine-T	Powder	24–26%
Chlorine dioxide liberators	Sodium chlorite + acid	Liquid	17%

Source: Adapted from Dychdala (2001)

4.2.2 pH modifiers

Alkalies

Alkalies, which act by raising the ambient pH to very high levels, are effective against a wide range of pathogens. Compounds such as sodium hydroxide and sodium carbonate are commonly included in the formulation of cleaning compounds. When used at high concentrations, they also have significant antimicrobial properties. Strong alkalies, at pH 12 or more, have excellent activity against all categories of viruses but are very slow acting compared with oxidising agents.

Alkalies retain their effectiveness in the presence of heavy burdens of organic matter, assist the penetration of soiling through their saponifying action on fats, and are effective in loosening organic matter. They are particularly useful for decontaminating ponds, drains, effluent waste pits and carcase disposal pits. Unlike acids, they may also be used on concrete surfaces.

Alkalies are corrosive to some metal alloys, and care should be taken when treating metal or painted surfaces. They are also irritant to skin and mucous membranes, and staff must be supplied with appropriate safety equipment.

[Section 7.5](#) contains further details on the properties and uses of alkalies.

Acids

The antimicrobial activity of acids depends on the concentration of hydrogen ions, which destroy cell amino-acids and precipitate proteins (Maris 1995, Quinn and Markey 2001). Acids act slowly and, although they have specific benefits as disinfectants, their use on their own is limited. They are more likely to be used as adjuncts to other compatible disinfecting agents, such as iodophors, where they produce optimal pH and enhance penetration or rinsing qualities. They are commonly used in heated water for disinfection of pipework in dairies, a process that may also have some application in the disinfection of hatchery pipework.

Many organic acids (e.g. formic and citric acid) are used in disinfection formulations to enhance fungicidal and virucidal properties. They may also be mixed with anionic detergents to enhance sanitising capabilities.

As with alkalies, all acid solutions (with the exception of peracid solutions) are slow acting.

4.2.3 Aldehydes

Aldehydes act by denaturing protein. Two aldehyde compounds that may be used during decontamination of aquaculture facilities are formaldehyde and glutaraldehyde. They are highly effective against a wide range of organisms, but are also relatively slow in action. Aldehydes maintain their activity in the presence of organic matter and are only mildly corrosive. Their main disadvantages are the irritating fumes produced, their expense and their carcinogenic properties.

Formalin is a 40% aqueous solution of formaldehyde gas. Formalin diluted to 8% (dilution factor of 12) is considered effective against most viral groups ([AUSVETPLAN Decontamination Manual](#)). Glutaraldehyde is approximately three times more active than formalin and is commonly used at a concentration of 1–2%.

Formaldehyde gas is sometimes used to fumigate equipment and premises. For gaseous formaldehyde to be effective, the gas concentration, gas distributions, temperature, humidity and contact time must be carefully controlled. In order to be effective, it requires high relative humidity, temperatures above 13°C and contact times of at least 12 hours. Formaldehyde gas is extremely toxic and, given the conditions required for it to be an effective disinfectant, its use is limited to specific situations. It might be considered, if appropriate under the jurisdiction's legislation, for sealed spaces that are otherwise difficult to disinfect (such as cool rooms, boat holds and complex pipework), or in tropical hatcheries where ambient conditions (temperature and humidity) are suitable.

[Section 7.7](#) contains further details on the properties and uses of aldehydes.

4.2.4 Biguanides

Of the many biguanides available, chlorhexidine is probably one of the most commonly used. Chlorhexidine preparations do not irritate tissues and are commonly used as skin disinfectants. However, they are not effective in hard or alkaline water and are less active against most types of pathogens than many other disinfectants.

The use of chlorhexidine during emergency disease events would generally be restricted to use as a skin cleansing agent or disinfectant for delicate materials.

4.2.5 Quaternary ammonium compounds

The biocidal efficacy of QACs is variable and selective. They are effective against some vegetative bacteria and some fungi, but not all viruses (Treeves-Brown 2000, Ritcher and Cords 2001). QACs are most active against gram-positive bacteria; action against gram-negative bacteria is slow, with some strains showing resistance. These compounds are not effective against spores.

The advantages of QACs are that they are odourless, noncorrosive and nonirritant, and have wetting properties and low toxicity to mammals. They also retain activity over a wide pH range (pH 3–10.5), are stable at higher temperatures, are not generally affected by organic matter and maintain a residual effect on treated surfaces. Hard water and anionic detergents inhibit QACs, reducing their effectiveness in saltwater, however they remain useful for decontamination of

some sensitive category A viruses with lipid envelopes, such as WSSV which causes white spot disease in prawns (Chang et al. 1998, Table 8).

As with chlorhexidine, QACs are more commonly used for sanitation rather than disinfection. Since they are also cleaning agents, they may be used to combine the cleaning and disinfection stages, where appropriate.

4.2.6 Ultraviolet irradiation

UV irradiation is a viable option for the treatment of water entering and/or leaving aquaculture facilities where there is some control over water flows (e.g. semi-closed systems such as hatcheries or shore-based abalone farms, and closed systems such as recirculation facilities) and where other chemical or heat treatments are not viable options. Inactivation of the target microorganisms occurs due to denaturing of their DNA (Summerfelt 2003).

UV disinfection systems use low-pressure mercury lamps enclosed in quartz tubes, which allow passage of UV radiation at a wavelength of approximately 260 nm (Bitton 1994). The tubes are immersed in flowing water channels.

Some units also use a titanium dioxide catalyst that, when irradiated with UV light, produces superoxide ions and hydroxy radicals that increase the disinfection capability. These systems are lightweight and function over a range of temperatures, pressures and pH (McDonnell and Pretzer 2001). Similar units have recently been used to control fungal infections in finfish hatcheries.

The efficacy of UV disinfection depends on the type of microorganism, the clarity of the water, the intensity of light and the exposure time. Variables such as suspended solids, water flow rates and water clarity affect the efficacy of UV irradiation and thus the practical disinfecting capability. Total microbicidal UV dosage is calculated in mJ/cm^2 based on the relationship of $1 \text{ mJ}/\text{cm}^2 = 10 \text{ J}/\text{m}^2 = 1,000 \text{ }\mu\text{W}/\text{cm}^2$ per second, i.e.:

$$\text{total dose in mJ}/\text{cm}^2 = \frac{\text{intensity } (\mu\text{W}/\text{cm}^2) \times \text{duration of exposure (sec)}}{1000}$$

In general, resistance to UV follows a similar pattern to that described in Table 2 (Bitton 1994). The major disadvantage of UV irradiation in emergency disease events is its effectiveness against a number of fish pathogens, particularly viruses, may be limited. Although Torgersen (1998) demonstrated that infectious salmon anaemia (ISA) virus was inactivated by moderate levels of UV, the infectious pancreatic necrosis (IPN) virus is UV resistant. Very high doses are also required for shrimp baculoviruses (Chang et al. 1998). Vegetative bacteria and enveloped viruses may require only $10 \text{ mJ}/\text{cm}^2$ of UV irradiation, but non-enveloped viruses (category B and C) may need over $200 \text{ mJ}/\text{cm}^2$ (Bitton 1994, Table 8). UV disinfection is not a suitable primary method of treatment for waters during emergency disease events involving category B viruses.

For UV to be effective, water must be pretreated to remove contaminants that could inhibit light penetration. Flocculation and filtration of waste water before irradiation significantly improve the disinfecting effect and reliability of UV radiation units (Summerfelt 2003). Water filtration and UV units must also be matched to maximum water flow rates to ensure that the output is

capable of treating peak water flows. Filtration to 50 µm or below before UV irradiation is recommended for most situations.

Although it is unlikely that UV radiation would be used during initial stages of an emergency response, commercial units are now available in a range of sizes that can be added to existing production and processing facilities. These should be considered if environmental contamination by chemical disinfectants is a significant concern, or it is anticipated that a disinfection process for water leaving infected premises will be required for some time. UV irradiation may also be used to treat inlet water to safeguard facilities from reinfection.

4.2.7 Ozone

As with UV irradiation, ozone treatment would not normally be available during the early phase of an aquatic animal disease emergency event. However, ozone is highly efficient at disinfecting water and, where available, has an important role in the ongoing treatment of water entering or leaving facilities (Summerfelt 2003).

Ozone is normally generated on site by passing dry air and oxygen between electrodes separated by a glass or ceramic plate. The ozone is then injected into water in a specialised ozone contact vessel designed to provide adequate control over residual ozone concentration and water contact time.

As with other oxidative disinfectants, organic matter consumes ozone, and the initial ozone concentration tends to drop rapidly in treated water, making reliable dosing levels difficult to predict. In practice, it is important that the initial ozone dose is high enough to account for oxidation demands, thereby establishing sufficient residual concentration for the required contact time. Ozone dose trials in river water indicated that an initial dosing level up to 4 mg/L was required to maintain a residual level of 0.2 mg/L for 10 minutes (Summerfelt and Hochheimer 1997).

Although the relative susceptibility of pathogens to ozone is similar to that described for UV radiation, ozone has been shown to be effective against a wide range of fish viruses, including category B viruses (). Residual levels of 0.2 mg/L have been shown to inactivate IPN virus (a category B virus) after 1 minute (Wedemeyer et al. 1979).

Residual ozone levels of at least 0.5 mg/L applied for a minimum of 10 minutes (total dose = 5 mg/L/min) or 1 mg/L for at least 1 minute (dose = 1 mg/L/min) are recommended to treat water during emergency disease events.

4.2.8 Heat

Where circumstances permit, heat may be used as a disinfecting agent. The effect of heat is completely dependent on time and temperature, and these will vary depending on the type of organism being treated. Unless heat is used under controlled conditions, such as autoclaves, it is difficult to maintain these variables for practical disinfection purposes. However, if combined with other forms of treatment, heat processes are excellent supplementary methods for decontaminating equipment such as transport bins, tanks or machinery.

Under most conditions, moist heat is more effective than dry heat as a disinfecting agent. The use of steam or hot water pressure cleaners to apply wet heat to surfaces is likely to be the most common form of heat process during an emergency disease response. These types of steam/heat pressure cleaners are readily available (see [Section 3.4.5](#)). Although their primary purpose is to loosen buildups of soil, the heat applied can also have some disinfecting properties; however, it is important to note that there may be significant loss of temperature between the unit and the treatment area. It has been demonstrated that a steam jet of 1300°C applied 15 cm from the surface results in no more than 800°C. This effect is further exacerbated where the treatment surface is metal, thus allowing heat to be conducted away. In this case, depending on how long the jet is applied, temperatures may reach no more than 350°C (Salvat and Colin 1995).

Heat is also an important tool for disinfecting small volumes of contaminated water. This process is used in some laboratories to treat aquarium waste water before its release.

The use of 'flame guns' has been promoted in some literature as an effective method for applying dry heat to large areas, such as buildings, concrete tanks or other nonflammable structures. However, flame guns are difficult to source and are associated with major workplace safety risks. Although they would be suitable for treating large concrete ponds, in practice their use is unlikely.

4.2.9 Desiccation

For many pathogens, desiccation (drying out) is an effective disinfecting process and should not be underestimated as a final stage to the decontamination process. Practical applications for dry heat include the use of heat rooms for diving equipment to ensure that suits and other delicate equipment are thoroughly dried at the end of each day.

In Australia, the hot, dry climate is an important disinfecting tool that is often overlooked. Leaving equipment to dry in areas exposed to sunlight is an extremely effective adjunct to other disinfection processes.

4.2.10 Biological disinfection

Processes involved in the biological breakdown of organic matter should not be overlooked as viable options for inactivating pathogens. Biological processes result in enzymatic degradation, as well as changes in oxygen content, moisture content, pH and temperature. All of these processes can act to inactivate pathogens in infected material.

Potential biological disinfection processes include deep burial, composting, soil injection and reticulation. The first three methods are viable options for the safe disposal of solid biological material and should be considered for carcasses, faecal matter and other organic solids.

Whereas deep burial relies on anaerobic decomposition, composting utilises aerobic decomposition to generate heat (up to 70°C) and convert soft tissue and bone to humus over a 40–60-day period (Kube 2002). With the exception of category B viruses and spore-forming pathogens, the majority of fish pathogens can be inactivated by the temperature profile of well-managed compost heaps. For more information on composting see the [AQUAVETPLAN Operational Procedures Manual - Disposal](#).

Soil injection, or the maceration and incorporation of wastes into surface soils through cultivation, may be used for both solid and liquid wastes. It relies on bacterial degradation of soil bacteria.

Reticulation may only be used for contaminated water. It uses bacterial degradation, desiccation and UV irradiation as the mechanisms for disinfection.

Soil run-off and drainage should be taken into consideration when choosing disposal sites for the methods described above.

Table 10 Corrosive qualities of some commonly used chemical disinfectants

Disinfectant	Common examples	Corrosive against	Relative corrosive strength
Oxidising agents	Chlorine	Metal alloys Rubber compounds	Moderate/high
	Chlorine dioxide	Metal alloys	Moderate/high
	Iodophors ^{a, b}	Metal alloys	Low/moderate
Strong alkalis	Sodium hydroxide ^c	Metal alloys Aluminium	High
	Calcium hydroxide	Metal alloys Aluminium	High
Acids	Acidified iodophors	Concrete Metal alloys	Moderate
	Peracids ^d	Concrete Rubber Metal alloys	Low
	Organic acids	Concrete	Low

a Corrosive only at higher temperatures (>40°C)

b Dependent on pH of specific formulations

c Highly corrosive to aluminium

d Corrosive to steel and copper

Source: Compiled from Bruins and Dyer (1995), Quinn and Markey (2001) and Ritcher and Cords (2001)

Table 11 Relative susceptibility of viruses, fungi and protozoa to disinfecting agents

Disinfecting agent	Virus category A	Virus category B	Virus category C	Fungi	Spore-forming protozoa
Strong alkalis	++	+	++	++	+
Aldehydes	++	+	++	++	+
Peracetic acid	++	++	++	++	+
Chlorine	++	+	++	++	+/- ^a
Chlorine dioxide	++	++	++	++	+
Iodophors	++	+/-	++	++	+/- ^a
Ozone	++	+	++	+	+/-
Ultraviolet	+	+/-	+	+	?
QACs	+/-	-	-	+	-
Acids	+	-	+/-	-	-
Biguanides	+	-	-	-	-

QAC = quaternary ammonium compound

a High concentrations required to be effective

Key:

++: Highly effective

+: Effective

+/-: Limited activity

-: Not recommended

?: Limited information, refer to Table 8 for more information

Table 12 Relative susceptibility of bacteria to disinfecting agents

Disinfecting agent	Gram-negative	Gram-positive	Mycobacteria	Rickettsia-like	Bacterial spores
Strong alkalis ^a	++	++	+	++	+
Aldehydes ^b	++	++	+	+	+
Peracetic acid	++	++	++	++	+
Chlorine dioxide	++	++	++	++	+
Chlorine	++	++	++	++	+
Iodophors ^b	++	++	++	++	+
Ozone	++	++	++	++	+
Ultraviolet	++	++	+	++	?
QACs	+/-	+	-	+	-
Acids ^b	+	+	+/-	+	+/-
Biguanides	+	+	-	+	-

QAC = quaternary ammonium compound

a High concentrations required to be effective

b Prolonged contact times required in some circumstances; in particular, for spores

Key:

++: Highly effective

+: Effective

+/-: Limited activity

-: not recommended

?: Limited information, refer to Table 8 for more information

Table 13 Working characteristics of main chemical disinfectant groups

Chemical disinfectant group	Effective pH working range	Relative chemical hazard to user (concentrate)	Relative chemical hazard to user (working solution)	Relative chemical hazard to environment	Comparative corrosion characteristics	Stability of working solution
Alkaline compounds	Alkaline conditions	10.0	7.0	8.0	10.0	>7 days
Acids	Narrow pH 2–3	8.0	5.0	2.0	3.0	>7 days
Hypochlorite compounds	Moderate	8.0	4.0	3.0	8.0	1 day
Chloramine-T	Moderate	8.0	3.0	3.0	6.0	2 days
Iodine (iodophors)	Moderate pH 2–6	6.0	2.5	6.0	6.0	5 days
Peracid solutions	Wide	7.0	0.5	0.5	4.0	1 day
Monosulfates	Wide	6.0	2.5	3.0	8.0	5 days
Chlorine dioxide solutions	Wide	8.0	7.0	1.0	8.0	<1 day
Aldehydes	Wide	10.0	8.0	6.0	1.0	>7 days ^a
Quaternary ammonium compound	Wide pH 3–10.5	1.0	0.5	4.0	0.5	>7 days

^a In sealed containers

Key:

	Poor working characteristics		Acceptable working characteristics		Good working characteristics
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Source: Adapted from summary information provided in Bruins and Dyer (1995) and Ritcher and Cords (2001)

Table 14 Major advantages and disadvantages of main chemical disinfectant groups

Chemical disinfectant group	Inactivation by organic matter	Wetting ability	Temperature tolerance	Effect of hard water	Effectiveness against mineral deposits	Residual activity	Foaming characteristics	Inhibitors
Acids	Stable	Good	Wide; some loss at very low temperatures	Low	Effective	Slight residual bacteriostatic activity	Low	Cationic surfactants Very low temperatures
Chlorine compounds	Loses activity rapidly	None	Wide	None unless alkaline	None	Limited	Nil	Organic matter High pH
Iodophores	Moderate to high loss of activity	Moderate to good, depending on formulation	5–40°C Loses activity below 50°C, and gives off gases above 120°C	Moderate	Limited, dependent on pH of formulation	Some	Moderate, dependent on formulation	Hard water Organic matter Temperature extremes High pH
Peracid solutions	Low to moderate loss of activity	Dependent on product formulation	Wide	None	Limited effect due to acid nature	Some	Low, unless combined with a surfactant	Copper, iron, manganese and chloride ions
Chlorine dioxide	Low to moderate loss of activity	None	Wide	None	None	Some	Nil	
Aldehydes	Stable	None	Moderate; gives off fumes at higher temperatures	None	None	Some	Nil	
Quaternary ammonium compounds	Moderate to stable	Good	Stable	Inactivated by hard water	None	Some	High	Very low temperatures Anionic detergents or wetting agents

Key:

	Poor working characteristics		Acceptable working characteristics		Good working characteristics
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Part B

Procedures and recommendations

5 General recommendations

5.1 Chemical use considerations

Information on the legislation relating to the use of agricultural and veterinary chemicals in Australia is provided in [Section 2.9](#). Advice on the legal use of these chemicals should be sought from the relevant state or territory authority (in most cases, this is the veterinary registrar within the relevant department of primary industries or agriculture) and/or the Australian Pesticides and Veterinary Medicines Authority (APVMA) before commencing a decontamination process.

5.2 Environmental considerations

Environmental considerations in the planning of a decontamination process are outlined in [Section 2.8](#). Each state and territory has its own environment protection legislation. It is essential that authorities are consulted before a decontamination process begins so that waste materials (including chemicals and waste water) are disposed of appropriately.

5.3 Safety considerations

Workplace safety considerations are outlined in [Section 2.7](#). The following general safety warnings and safety instructions may prove useful during a decontamination process.

5.3.1 General safety warnings

- Ensure that all personnel have been adequately briefed on duties and are aware of potential health risks.
- Ensure that appropriate risk assessments have been done and documented for each procedure.
- Ensure that all personnel are issued with appropriate safety equipment, are competent in its use and adhere to safety procedures.
- Ensure that all personnel are familiar with safety precautions when handling chemicals and equipment. The use of chemicals or equipment should conform to the manufacturers' instructions and safety standards.
- Ensure that all personnel operating machinery — for example, boats, forklifts, front-end loaders, excavators, hoists and diving equipment — are appropriately qualified.
- Ensure that only appropriately qualified personnel perform duties requiring a licensed operator or technician; for example, connection and disconnection of electricity or repair of equipment.
- Ensure that suitable first aid kits and appropriately trained first aid officers are available at every work site. The kits should be equipped to treat injuries caused by irritant chemicals.

- Allocate a safety officer for each work site.
- Ensure that all accidents, however small, are logged, and any treatment documented. These should be reported to the site supervisor and the local disease control centre.
- Ensure that the use of electrical equipment is strictly controlled, and leads are protected from moisture and cannot fall into water.

5.3.2 Safety instructions for handling chemicals

- Read all instructions, product information and safety advice on the labels of chemicals used. Ensure that material safety data sheets are available at all sites for all chemicals used.
- When mixing disinfectants, wear protective boots, overalls, goggles or face shields, and head coverings.
- When diluting concentrate forms of chemicals, ALWAYS add the concentrate to water, NEVER water to concentrate (or powder).
- Do not mix acid and alkaline disinfectants.
- Do not combine chlorine compounds with other chemical compounds. Never mix chlorine compounds with acids.
- Do not allow strong oxidising agents such as chlorine-liberating compounds to come into contact with acids or combustible materials such as paper, sawdust or kerosene.
- Contact with acid or alkaline concentrates can cause chemical burns. If chemical burns occur, douse the affected area well with fresh water and seek medical advice. Refer the person to hospital if necessary.
- If chemical contact with eyes occurs, immediately irrigate the eye thoroughly with eyewash solutions and refer the person to hospital.
- Store containers of concentrate in a secure area, under cover, away from sunlight, in a well ventilated area and away from the main work area. Check containers each day for rupture or spillage.
- If spills occur, douse the affected area liberally with water.

Table 15 Safety considerations for specific chemical disinfectants

Chemical agent	Health aspects	Contraindications
Hypochlorites	Irritant to eyes and skin	Strong oxidising agent
Peroxygen compounds	Reasonable care necessary	
Sodium hydroxide	Highly irritant to eyes and skin	
Sodium carbonate	Irritant to eyes and skin	Avoid contact with strong acids
Acids	Irritant to eyes, skin and respiratory tract	Avoid contact with strong alkalis
Glutaraldehyde	Avoid eye and skin contact	
Formalin solution	Avoid eye and skin contact Releases toxic gas, irritant to respiratory tract and mucous membranes	May emit toxic fumes if involved in fires
Formaldehyde gas	Very toxic to mucous membranes at concentrations down to 2 ppm	Cannot be used in the presence of water or chlorine; cannot be released into atmosphere
Chlorine dioxide	Concentrate extremely alkaline; gives off toxic fumes when first activated	Strong oxidising agent
Chloramine-T	Concentrate can be irritant to eyes, mucous membranes and respiratory tract	Strong oxidising agent

Source: Adapted from the [AUSVETPLAN Decontamination Manual](#)

6 Recommendations for enterprise types

Aquatic animal industries are highly variable, as are the range of disease agents and hosts that may be involved in the emergency disease situation. In many cases, information on the pathogen and disease epidemiology may be limited; therefore, a control strategy may need to be quickly developed using first principles. Decontamination procedures must be appropriate for the aquaculture system involved.

For the purposes of [AQUAVETPLAN](#), aquaculture systems have been categorised into four basic types: open, semi-open, semi-closed and closed. A single industry might use more than one system in different phases of production. For example, salmon production in Tasmania often uses closed systems during egg incubation and larvae growth, semi-closed systems for the production of smolt, and semi-open systems for final grow-out.

The structure and operation of enterprise types is explained in detail in the [AQUAVETPLAN Enterprise Manual](#).

6.1 Open systems

6.1.1 General characteristics

- Usually large infected area.
- Limited or no control over water movements.
- Limited or no control over stock movements.
- Limited or no control over nontarget fish movements.
- Limited or no ability to decontaminate the system.
- Decontamination restricted to movement of personnel and equipment in and out of the infected area.
- Very wide group of stakeholders.

6.1.2 Common examples

- Native fish stocks in natural waterways, dams, rivers or bays.
- Recreation fishing stocks in dams, lakes or rivers.
- Stock used in reseedling or restocking programs.

Open systems, such as wild-caught fisheries or sea ranching, are waterways where there is no control of either movement of aquatic animal stock or water flow. Aquatic animal disease emergencies occurring in open waterways will invariably be difficult to manage due to the lack of control of animal and water movements and the very large areas involved. If implemented, decontamination procedures may have a significant impact on the environment, and a wide group of stakeholders might be affected by control measures.

Eradication and control programs in open systems require significant long-term planning. They will generally involve the control of susceptible species and measures to limit spread of the pathogen. Decontamination programs will tend to be limited to decontamination of personnel, vehicles and equipment moving out of the infected area.

As the infected area will usually be associated with a water catchment or large water body, there are likely to be multiple access points that are difficult to control. Control measures will rely on simple measures undertaken by multiple users, as well as effective public education campaigns.

The potential for litigation resulting from recommendations made to the general public or action taken by authorities is extremely high. Under such circumstances, decontamination procedures must be simple, safe and noncorrosive. Decontamination procedures recommended to the general public should rely primarily on good cleaning procedures, using products that would normally be available for such purposes. The use of more corrosive or irritant chemicals, such as sodium hydroxide or formalin, should be avoided by people other than trained officers.

Decontamination control measures that may be applied include:

- installation of wheel baths at strategic points around the control area;
- production of technical literature explaining how the general public may undertake simple cleaning or disinfection procedures;
- establishment of signage and wash-down bays at boat ramps;
- for commercial operators working within the infected area, establishment of logbook systems that document when decontamination procedures are undertaken; and
- training workshops for those frequently entering or leaving infected areas.

6.2 Semi-open systems

6.2.1 General characteristics

- Limited or no control over water movement.
- Control over stock movements.
- Limited or no control over nontarget fish species.
- Limited or no ability to decontaminate the environment.
- Decontamination tends to be restricted to personnel or equipment moving out of infected areas and the safe disposal of infected material.

6.2.2 Common examples

- Finfish marine farms (salmon, ocean trout, tuna, yellowtail kingfish).
- Oyster or mussel leases.
- Open-water abalone farms.
- Finfish cages within freshwater systems.

In semi-open systems, there is control of movement of aquatic animal stock, but no control of water flow. Infected areas are likely to involve whole water bodies such as estuaries, lakes or bays. Under such circumstances, the disinfection of water and animal wastes may not be practical. Decontamination operations in semi-open systems should concentrate on controlling spread of disease through appropriate destruction and disposal of susceptible stock, together with decontamination of personnel, equipment, machinery and vessels leaving the infected area.

Although wild fish stocks or water currents may carry pathogens out of the area, there is usually a significant dilution factor. The risk of transfer of disease is often greater from anthropogenic movement of equipment used to contain fish stocks or waste material leaving the area without appropriate disinfection. Personnel and equipment that come into contact with infected material should be thoroughly cleaned and disinfected. Equipment, nets and cages left on site should also be decontaminated, as these may act as reservoirs of infection and thus compromise ongoing decontamination operations or allow reinfection once stock are reintroduced to the site.

Semi-open systems are often some distance from shore, and the availability of suitable water supplies for cleaning and disinfection operations may be a problem. Disposal of waste water from decontamination operations will present problems and may rely primarily on adequate dilution before release into the aquatic environment. Chemical agents that have low environmental impact should be chosen, and appropriate authorisation obtained from relevant state or territory authorities.

The use of plastic liners within polar circles is a common method of transporting fresh water for the treatment of parasitic disease in the Tasmanian salmonid industry. Such liners are also useful for holding large quantities of water for cleaning and disinfection operations. Liners may also be used to store waste water containing disinfecting agents before it is transported to an appropriate disposal site, or — in the case of chlorine-based disinfectants — until chemicals have decomposed to levels considered safe for discharge into natural waterways (see [Section 7.1](#)).

If required, various stages of cleaning and disinfection may be undertaken at separate locations. Initial cleaning of equipment, personnel and vessels may occur at the farm site before they are moved to a shore-based location for final disinfection. This separation of operations allows the removal of gross fouling at the farm, retaining the majority of infected material at the site and reducing the amount of waste material that must be disposed of on shore. This type of approach may require additional work teams, but has the advantage of breaking the decontamination program down into manageable sections, especially where water-based facilities are limited.

6.3 Semi-closed systems

6.3.1 General characteristics

- Some ability to control water movements.
- Ability to control stock movements.
- Ability to exclude nontarget fish species.
- Ability to decontaminate the infected premises.

- Disinfection of large volumes of water may be required.

6.3.2 Common examples

- Finfish hatcheries using river water.
- Land-based freshwater finfish farms
- Prawn farms.
- Land-based abalone grow-out sites (nonrecirculation).
- Land-based mollusc hatcheries (nonrecirculation).
- Laboratories using flow-through systems.
- Marron or yabby farms based on river systems.

Semi-closed systems, such as pond culture and raceway culture, allow control of aquatic animal movement and some control of water flow. In these systems, finfish, crustaceans or molluscs are contained so that the animals, water and other associated materials are not in direct contact with natural waterways. Water is usually taken from an adjacent natural source and discharged from the enterprise further downstream. Release of this water may be a continuous or intermittent flow.

Under such circumstances, it is possible that an infected area may be restricted to one or more premises rather than a complete water catchment, and therefore decontamination of individual premises is a viable option. In addition to decontamination of personnel, equipment and vehicles leaving the infected premises, decontamination in semi-closed systems is likely to include tanks, pond systems, intakes and drains, large machinery, buildings, pipework and large volumes of water.

Before the decontamination program begins, inlet water into the facility will need to be diverted and/or any inlet pumping ceased, and the discharge of infected material or chemical wastes strictly controlled. Apart from water drained from tanks and ponds, there is no need to repeatedly disinfect large volumes of water while inlet water is diverted.

Water in tanks, ponds, intakes, drains, pipelines and biofilters may be treated with chemical disinfectants before release or disposal. Due to the large volumes involved and the relatively low organic loading, chlorine-based disinfectants (hypochlorites or chlorine dioxide), will most likely be used. If a high level of organic matter is present, chlorine dioxide solutions, alkaline compounds or peracid solutions may be considered as alternatives to hypochlorite. The use of flocculating agents (as a pretreatment), other oxidising disinfectants and ultraviolet (UV) irradiation are alternatives that could be considered.

Decontamination of water entering or exiting semi-closed systems will be a major challenge. Attempts to disinfect large volumes of water will depend on whether infection is localised to the specific enterprise, or whether the waterway from which it feeds is also infected.

If infection is localised to a specific site, discharge of infected wastes downstream should be prohibited until the infective agents have been inactivated, after which discharge of disinfected wastewater can be strictly controlled to meet relevant environmental regulations. This is especially important in the case of outbreaks of exotic diseases, however, disinfecting water that

will exit a facility into a known infected open system is less critical in the case of outbreaks of endemic diseases. Under the latter circumstances, disinfection of water entering the enterprise after the site has been decontaminated becomes more important.

Oxidising agents such as hypochlorite or iodophores may be inactivated with thiosulfate before release of the treated water into waterways. Alternatively, water treated using chlorine-based disinfectants may be held until chlorine levels dissipate to acceptable levels, or discharged at controlled rates to achieve adequate dilution. Given sufficient sunlight, chlorine will usually dissipate over one or two days depending on levels of organic matter and the chlorine concentration used. Aeration in combination with sunlight will increase the dissipation rate.

Discharge onto waste ground or irrigation over pastures are also potential options in some circumstances. Irrigation onto pasture has the benefit of achieving additional pathogen reduction through the actions of sunlight and desiccation.

After decontamination of the facility, there may be a need for decontamination of discharge water during a monitoring period and/or ongoing disinfection of inlet water. Advice from state or territory environmental management authorities should be sought regarding appropriate maximum levels of chemicals in discharge water. Where there is any doubt about the levels of chemicals in the discharge water, levels should be tested before release.

6.4 Closed systems

6.4.1 General characteristics

- Good control of water movements.
- Good control of stock movements.
- Ability to restrict nontarget fish species.
- Ability to disinfect infected premises.
- Disinfection of large volumes of water may be required.
- Generally associated with water recirculation facilities.

6.4.2 Common examples

- Closed aquarium facilities.
- Pet stores.
- Laboratories using water recirculation.
- Finfish, crustaceans or molluscs held in recirculation facilities.

Within a closed water system, both the stock and the water are closely controlled, usually in tanks with attached filtration systems. Decontamination programs in closed systems have the greatest chance of being successful in the long term, since infection tends to be confined to the facility. Following disinfection, external water supplies can be treated before they enter the facility.

Decontamination within closed systems will almost certainly require the decontamination of biofiltration systems and complex pipework. If the facility is small and uses multiple biofilters, it is safer and often more cost effective to dispose of gravels, plastic tubing, biofilter substrates and filter components, rather than attempting to disinfect them. Such porous material will be difficult to clean and disinfect and, as a result, may provide a nidus or reservoir for future infection.

Larger closed systems will have complex systems of pipework and large biofilter towers. The complexity of these structures and limited access to them makes them difficult to disinfect without complete or partial dismantling. As with smaller closed systems, attempts to salvage porous material may turn out to be false economy.

Biofilter towers should have substrates removed for disinfection or replacement. All filter canisters or sand (in the case of sand filters) should be replaced. Pipework should be cleaned via a pigging system (see [Sections 3.4.7](#) and [8.4.2](#) for further information on pigging systems) or completely dismantled. Following cleaning and disinfection, the whole system should be allowed to dry completely for a significant period of time.

Closed systems lend themselves to the use of heat, UV, ozone or chemical treatment of both intake and discharge water because the water can be held in batches and treated before entry into the system or release into the environment

7 Recommendations for specific disinfecting agents

7.1 Hypochlorite solutions

Hypochlorites are among the most commonly used disinfectant solutions. They are fast acting, inexpensive and readily available, and have a wide spectrum of activity. Their major disadvantages are that organic matter readily inactivates them and working solutions tend to decompose quickly, especially in direct sunlight (the latter is, however, an advantage for disposal of hypochlorite solutions). However, to ensure rapid neutralisation and disposal, it is important to use formulations containing only Sodium hypochlorite, Potassium hypochlorite or Calcium hypochlorite as the active ingredient, and to avoid products with stabilised formulations of chlorine, such as Sodium Dichloroisocyanurate or stabilisers such as cyanuric acid).

The concentrated liquid solutions of sodium hypochlorite and potassium hypochlorite also degrade over time; open containers lose up to 50% of their original concentration within one month (Quinn and Markey 2001). Powder formulations, although significantly more stable, can react with moisture if open to the air.

As shown in Table 9, the available chlorine levels produced by different chlorine disinfectants vary significantly. Sodium hypochlorite is commonly supplied in a solution containing 14% (wt/vol) active chlorine (but this may vary from 1% to 15%). Calcium hypochlorite is generally 65% active chlorine. Using these products, either 1 litre of sodium hypochlorite (at 14% available chlorine) or 216 grams of calcium hypochlorite mixed with 140 litres of fresh water produces a solution containing 1000 mg/L available chlorine.

The chlorine concentration in the initial dose and residual levels of chlorine (see [Section 7.8.2](#) for an explanation of initial dose and residual levels) should both be confirmed. Chlorine test kits are readily available from pool supply or aquarium stores.

Table 11 to Table 14 contain further details on hypochlorite disinfectants. The recommended doses for various disinfectant applications are shown in Table 8 and Table 18.

7.1.1 Advantages

- Wide spectrum of activity — effective against bacteria, fungi, viruses, protozoa and spores.
- Rapid disinfecting action.
- Nonfoaming action and easily rinsed from surfaces.
- Not affected by cold temperatures.
- Not affected by hard water unless pH is high (>8.5).
- Low toxicity at dilute concentrations.
- Ease of use.
- Readily available.

- Relatively low cost.

7.1.2 Disadvantages

- Working solutions degrade rapidly.
- Concentrate solutions tend to degrade over time.
- Readily inactivated by organic matter.
- Disinfecting ability significantly affected by pH, with loss of activity above pH 8.5.
- No wetting capability.

7.1.3 Availability

Hypochlorite disinfectants are readily available, in a range of concentrations, from commercial cleaning supply wholesalers, swimming pool supply stores and chemical wholesalers. Supplies required to decontaminate large quantities of water (such as multiple hectare ponds on prawn farms treated to a minimum 30 mg/L for >24 hr to decontaminate for WSSV), will most likely have to be sourced directly from major industrial chemical suppliers.

7.1.4 Environmental and workplace safety considerations

- Adhere to recommendations and safety advice from the manufacturer and in the material safety data sheet.
- Hypochlorites are toxic to fish, but they are rapidly neutralised by sunlight and organic matter, and therefore any effects are short lived. To maximise disinfection effectiveness and peak available chlorine concentrations in large ponds or water bodies, chlorine should be applied in the early evening or after sunset.
- Hypochlorites are inactivated by thiosulfate.
- Hypochlorites are powerful oxidising agents, and some compounds may cause fire or explosion or produce severe burns. Concentrate preparations should not come into contact with other chemicals (especially acids) or with combustible material such as paper, fabric, sawdust or kerosene.
- Concentrate preparations should be stored in dry, well-ventilated areas away from sunlight. Large quantities of concentrated chlorine need to be stored in suitable bunded dangerous goods stores. Hence, best practice management of large quantities of chlorine requires its purchase (usually in liquid solution as dissolving large quantities of granular chlorine can be difficult and time consuming.) directly from suppliers, who can transport the chlorine directly to the infected area in large bulk liquid tanker trucks or semi trailers designed for transport of dangerous goods. This negates the need for storage on site as the chlorine solutions can be distributed directly from the truck into the water body being disinfected.
- If road access to the site being treated does not allow direct access for large chlorine trucks, consideration should be given to using pumps and hoses or other mechanical delivery systems to avoid any need for people to manually handle large quantities of chlorine solutions.
- Hypochlorites should not be mixed with other chemicals or with different types of chlorinating chemicals.

- Concentrate preparations can irritate eyes, nose, throat and skin. Avoid contact with skin, eyes, and clothing. Avoid breathing dust or vapour.
- Hypochlorites liberate chlorine gas at low pH and therefore should not be mixed with acids.

7.1.5 Applications

- As a basic disinfecting agent for most applications (taking into account the points listed above).
- On clean surfaces.
- Disinfection of water.
- Disinfection of previously cleaned buildings, equipment, vehicles, tanks and pipework.
- Not recommended for disinfection of slurries, manures, carcasses, uncleaned surfaces or other situations with high levels of organic matter.

7.2 Chloramine-T

Chloramine-T (sodium p-toluene) has a slower disinfecting action than the hypochlorites. It is most suited to applications where greater contact times are possible and a more stable or less corrosive solution is required.

As with hypochlorites, disinfecting capability is affected by water pH. The biocidal activity of chloramine-T is greatest under acidic conditions and reduced by high pH, high organic loading and excessive water hardness.

Chloramine-T is a white crystalline powder, which may cause respiratory irritation. Preparations generally supply 25% available chlorine; thus 4 grams dissolved in 1 litre produces 1000 mg/L available chlorine. Experience has shown that the coarser crystalline formulations are significantly less irritant to eyes and respiratory membranes than the fine powder preparations.

[Section 4.2.2](#) and Table 11 to Table 14 contain further details on organic chlorine solutions. The recommended doses for various disinfectant applications are shown in Table 8 and Table 18.

7.2.1 Advantages

- Less affected by organic matter than hypochlorite solutions.
- Less corrosive and irritant than hypochlorite solutions.
- Effective against a wide range of organisms, although data on specific fish pathogens is limited.
- Concentrate powder is very stable.
- More stable in solution than other chlorine-liberating agents.
- Effective against biofilms.

7.2.2 Disadvantages

- More expensive than hypochlorite, but comparable in price to iodophors.

- Slower disinfecting activity than hypochlorites; therefore requires longer contact times.
- Limited specific data on effects on fish pathogens.
- Some preparations are fine powders that are highly irritant to respiratory tracts.
- Activity reduced by high pH.
- Activity reduced by hard water.

7.2.3 Environmental and workplace safety considerations

- Adhere to recommendations and safety advice from the manufacturer and in the material safety data sheet.
- Chloramine-T is reported to have the lowest acute oral toxicity of 12 chlorine-liberating compounds tested, including hypochlorites and chlorine dioxide (Dychdala 2001).
- The concentrate powder is a strong oxidising agent, which may irritate skin, eyes, respiratory tract and mucous membranes. However, solutions are considered relatively safe.
- It is inactivated by thiosulfate.
- Chloramine-T is an oxidising agent that may cause fire or explosion, or produce severe burns. Powder preparations should not come into contact with other chemicals (especially acids) or with combustible material such as paper, fabric, sawdust or kerosene.
- Chloramine-T liberates chlorine at low pH and therefore should not be mixed with acids.

7.2.4 Availability

Chloramine-T is available through veterinary wholesalers or distributors as registered veterinary products. Generic compounds are available through chemical wholesalers.

7.2.5 Applications

- Where chlorine disinfection is required and long contact time is possible, but the presence of organic matter, possible corrosion and the need for a relatively stable working solution preclude the use of hypochlorites.
- As a general disinfectant where longer contact times are possible or the solution is left to dry on treated surfaces.
- Disinfection of water, dive equipment, pipework, nets, ropes and instruments.
- In footbaths.

7.3 Stabilised chlorine dioxide solutions

These products commonly use sodium chlorite ('stabilised chlorine dioxide') solutions that are treated with an acid 'activator solution' to generate chlorine dioxide in solution.

Compared with other chlorine-based solutions, chlorine dioxide is less affected by the presence of organic matter and is unaffected by changes in pH between 6 and 10 (Dychdala 2001). Manufacturers claim that commercial products remain effective between pH 3 and pH 10.

Chlorine dioxide is also reported to have significantly greater antimicrobial activity than sodium hypochlorite, particularly against spores (Dychdala 2001).

The most significant problems associated with chlorine dioxide are its tendency to give off fumes when first activated and the short working life of activated solutions.

When making up disinfectant solutions, the stabilised chlorine dioxide solution is first diluted with water and then an activator acid solution is added (or as per the manufacturer's instructions). At this point, care must be taken to avoid any fumes given off during the reaction. The activated stock solution is generally left to stand for 20 minutes. It is then diluted to the appropriate working concentration of the final disinfecting solution (see Table 18).

Activated solutions are unstable if exposed to sunlight or high temperature, and manufacturers recommend making up solutions immediately before use. Stability of activated solutions is enhanced by storage in sealed, dark containers at cooler temperatures. Advice on the working life of solutions should always be sought from the manufacturer. Chlorine dioxide test kits are available and should be used to measure the residual concentration of working solutions.

Some manufacturers also recommend the application of unactivated stabilised chlorine dioxide solution to liquids. Under these conditions, the agent is reported to degrade slowly and produce low levels of chlorine dioxide for prolonged periods, usually 2–3 days.

There is little information in the literature on the effectiveness of chlorine dioxide against pathogens of aquatic species. Given that its disinfecting activity is considered to be greater than that of hypochlorite solutions, it is reasonable to use recommendations for hypochlorite as a conservative guide (Table 8). However, the advice of the manufacturer should always be sought before use.

[Section 4.2.2](#) and Table 11 to Table 14 contain further detail on chlorine dioxide solutions.

7.3.1 Advantages

- Highly effective disinfectant, with activity greater than hypochlorite solutions.
- Not affected by high levels of organic matter to the same extent as other chlorine-liberating compounds
- Effective over a wide pH range (up to pH 10).
- Reported to be effective against biofilms.
- Unactivated solutions are relatively stable.

7.3.2 Disadvantages

- Gives off toxic fumes when first activated.
- Strong oxidising potential means that chlorine dioxide has similar corrosive characteristics to hypochlorite solutions.
- Working solutions are unstable, especially in the presence of sunlight and elevated temperature.

7.3.3 Environmental and workplace safety considerations

- Adhere to recommendations and safety advice from the manufacturer and in the material safety data sheet.
- Chlorine dioxide is considered to have relatively low environmental impact.
- Manufacturers recommend that solutions should have residual levels of less than 10 ppm chlorine dioxide before release into the environment.
- The stock solution is highly alkaline, therefore harmful if ingested, corrosive to eyes, and causes burns to skin.

Caution note:

B1 Stabilised chlorine dioxide produces irritant vapours when first activated. The solution must be allowed to stand in a well-ventilated area for a period before use. Inhalation of vapours, mists or aerosols may result in respiratory irritation.

7.3.4 Availability

Stabilised chlorine dioxide solutions are available through cleaning and disinfection manufacturers or wholesalers, in a range of brands.

7.3.5 Applications

- On hard surfaces where fast action is required.
- Disinfection of pipework and boat holds.
- Treatment of water containing higher levels of organic matter.
- Treatment of containers or facilities used to contain or manufacture food for human consumption.

7.4 Iodophors

7.4.1 General characteristics

Iodophors generally have low toxicity and low irritant characteristics when compared to other disinfecting compounds. Gottardi (2001) reports that iodine reacts with proteins at least three times more slowly than chlorine, thus making iodophors more stable than hypochlorites in the presence of organic loading. However, iodophors are more adversely affected by water hardness and alkaline conditions.

With the exception of povidone-iodine, which tends to be neutral, iodophors form mild acid solutions and are most active at low pH. As a result, they are somewhat corrosive to metal and fabrics. Iodophors have optimum biocidal activity between pH 2 and pH 5, but retain effectiveness up to pH 7. Some iodophor solutions are formulated with phosphoric acid to provide an optimal pH (pH 3) for biocidal activity.

Available free iodine, the active component of iodophors, can be measured to assess the viability of working solutions, but it is more common to use colour as an indication of solution

exhaustion. Once solutions have lost their brown colour to become colourless, they are no longer active.

Iodophors must be properly diluted to achieve full antimicrobial activity. Dilution causes more iodine to be available in solution and thus enhances antimicrobial activity. In the case of povidone-iodine, the optimum working solution, for maximum free molecular iodine, is 0.1% (Gottardi 2001).

[Section 4.2.1](#) and Table 10 to Table 13 contains further details. The recommended doses for various disinfectant applications are shown in Table 8 and Table 18.

Caution note:

B2 The bactericidal agent in iodophor solutions is free molecular iodine rather than total iodine or iodophor. There is considerable variation in how the iodine content is reported between different brands of iodophors. Manufacturers should be consulted for recommended dilution rates if there is any doubt.

7.4.1 Advantages

- Excellent broad-spectrum antimicrobial activity, with good activity against bacteria, fungi, viruses and protozoa, as well as bacterial and fungal spores (Table 8). Treatment of spores and non-enveloped viruses will require longer contact times.
- Less affected by organic material than chlorine compounds. Remains active in the presence of organic matter, provided pH does not rise above 4.
- More stable than chlorine solutions.
- Lower corrosive qualities and less irritant than chlorine, alkaline or peroxygen compounds. Acidified iodophors have some corrosive qualities.
- Working solutions easy to monitor, as brown colour disappears when iodine is exhausted.
- Mild acidic nature prevents film formation and makes it easy to rinse off.
- Works equally well at both low and high temperatures (10–40°C).

7.4.2 Disadvantages

- Acidic solutions may be corrosive and are not recommended for concrete surfaces.
- Biocidal activity is reduced when diluted with highly alkaline water.
- Can cause staining under some circumstances.
- Can produce iodine gas if used at temperatures above 50°C (Ritcher and Cords 2001).
- Activity is reduced by hard water and very high levels of organic matter, particularly under alkaline conditions.
- Comparatively expensive.

7.4.3 Environmental and workplace safety considerations

- Adhere to recommendations and safety advice from the manufacturer and in the material safety data sheet.

- Iodophors are highly toxic to aquatic life; they are toxic to fish at concentrations as low as 50 ppm (Treeves-Brown 2000).
- Waste solutions may be discharged into sewers (subject to approval by the appropriate authority), where they will gradually be inactivated by proteins.
- Iodophores can be neutralised by sodium thiosulfate.

7.4.4 Availability

Povidone-iodine solutions are readily available in a range of brands from veterinary or medical wholesalers. Most products are sold as 10% (wt/vol) povidone-iodine solution, providing 1% available iodine.

Acidified iodophors, which are used by the dairy industry for cleaning and disinfection purposes, are generally available through agricultural supply companies.

7.4.5 Applications

- In footbaths.
- Disinfection of hands.
- Disinfection of smooth surfaces, including fibreglass or plastic tanks.
- Disinfection of diving equipment (povidone-iodine).
- Disinfection of personnel (povidone-iodine).
- Water treatment.

7.5 Alkaline compounds

7.5.1 General characteristics

These compounds are effective against a wide range of pathogens. Strong alkalis, at pH 12 or more, have excellent activity against all categories of viruses.

Alkalis retain their effectiveness in the presence of heavy burdens of organic matter and assist the penetration of soiling. They are particularly useful for decontaminating ponds, drains, effluent waste pits and carcase disposal pits. They may be used on concrete surfaces.

Alkalis are corrosive to some metal alloys and irritant to skin and mucous membranes. Care should be taken when treating metal or painted surfaces. Staff must be supplied with appropriate safety equipment.

The activity of alkalis is relatively slow compared with other disinfectants such as hypochlorites, peracid solutions and chlorine dioxide. Raising water temperatures and increasing concentration can enhance the effect of most alkali compounds, but this should be done with extreme caution because of risks to workplace safety and the risk of corrosion.

Alkalis can form complexes with ions in hard water when used at high temperatures, and these precipitates can be difficult to rinse off equipment. An acid rinse to remove residues may be required.

[Section 7.5](#) and Table 11 to Table 14 contain further details on alkali disinfectants. Table 16 compares the disinfection activity of various alkalis. The recommended doses for various disinfectant applications are shown in Table 8 and Table 18.

7.5.2 Advantages

- Effective against a wide range of pathogens, especially viruses.
- Not affected by the presence of organic matter; therefore useful in the disinfection of pond bases.
- Useful for the decontamination of carcasses and organic matter in burial pits.
- Relatively cheap and available in bulk.

7.5.3 Disadvantages

- Corrosive on metallic structures, especially aluminium and soft metal alloys.
- Irritant to skin and mucous membranes. Sodium hydroxide and calcium oxide are highly corrosive and irritant.
- Use requires experience and appropriate personal protective equipment.
- Run-off into waterways should be avoided.
- May be corrosive to painted surfaces.

7.5.4 Environmental and workplace safety considerations

- Adhere to recommendations and safety advice from the manufacturer and in the material safety data sheet.
- Alkalis may affect the pH of surface waters, especially fresh water, if large amounts of run-off occur, affecting aquatic life in localised regions.

Caution notes:

- | | |
|----|--|
| B3 | Sodium hydroxide is highly irritant and should be used with care. Appropriate safety equipment, including waterproof clothing, hats, boots and eye protection, should be worn. |
| B4 | Sodium hydroxide is corrosive to some surfaces. |
| B5 | Under some circumstances, sodium hydroxide may make surfaces slippery. Care should be taken to ensure its use does not result in a slipping hazard. |

7.5.5 Availability

Sodium hydroxide (caustic soda), calcium hydroxide (slaked lime), calcium oxide (quicklime or burnt lime) and sodium carbonate (anhydrous or hydrated forms — soda ash or washing soda) are available from chemical wholesalers. Calcium carbonate is readily available from agricultural suppliers as crushed limestone.

Table 16 Comparison of the relative activity of alkali compounds

Chemical	Disinfection activity	Comments
CaO (quicklime)	High	Produces heat in contact with water Often used to disinfect carcasses
Ca(OH) ₂ (slaked lime)	Very high	Stains surfaces
NaOH (caustic soda)	High	Produces heat when reacting with water
Na ₂ CO ₃ (washing soda or soda ash)	Moderate	Anhydrous form is more active
CaCO ₃ (limestone)	Poor	Particles need to be small (<0.24 mm)

7.5.6 Applications: sodium hydroxide

- Against a wide range of bacteria and viruses, including spores and mycobacteria (using high concentrations that produce pH 12 or more).
- Disinfecting earthen ponds when mixed in a solution with a wetting agent ('Teepol') and lime.
- Disinfecting concrete structures and plastic structures (including tanks).
- Disinfecting footpaths.
- In footbaths.

7.5.7 Applications: calcium oxide

- Disinfecting earthen ponds, particularly for cases of whirling disease (infection with *Myxobolus cerebralis*).
- Disinfecting carcasses and organic material at the time of burial.

7.6 Peroxygen compounds

7.6.1 General characteristics

Peroxygens include peracid solutions and monosulfate compounds. They are very active against a wide range of microorganisms (including spores), are not affected by organic matter and do not leave toxic residues, but they may be corrosive to alloys, aluminium and carbon steel. [Section 4.4.2](#) and Table 11 to Table 14 contain further details on peracid solutions and monosulfates. The recommended doses for various disinfectant applications are shown in Table 18.

7.6.2 Advantages

- Wide spectrum of activity.
- Remain effective at low temperatures.
- Fast acting.
- Effective sporicides.

- Effective in the presence of organic matter.
- Effective over a wide pH range, but most effective in weak acid solutions.
- Relatively nontoxic.

7.6.3 Disadvantages

- Concentrated peracid solutions are relatively unstable; Block (2001) reported a loss of 1 – 2% activity per month. Powdered preparations (monosulfates) are stable if kept dry.
- Working solutions must be replaced every 2–3 days.
- Corrosive to metals, including steel, if left in contact for prolonged periods.
- Relatively high cost.

7.6.4 Environmental and workplace safety considerations

- Adhere to recommendations and safety advice from the manufacturer and in the material safety data sheet.
- Concentrated peracid solutions tend to be corrosive and will cause chemical burns if ingested or spilt onto skin or mucous membranes.
- Appropriate protective equipment should be worn when mixing solutions.
- Working solutions tend to be low irritant and low toxicity.

7.6.5 Availability

Peracid disinfectants are available in solution from manufacturers or wholesalers of chemical disinfectants.

Monosulfates are available as powder concentrates from veterinary wholesalers or direct from Australian distributors.

7.6.6 Applications

- As a general disinfectant for personnel and equipment.
- As a fogging agent for decontamination of buildings.
- Disinfection of pipework.
- Disinfection of machinery.
- In footbaths.
- Some monosulfates have added detergents and may be used as a one-stage cleaning and disinfection compound for light soiling.

7.7 Aldehydes

7.7.1 General characteristics

Although several aldehydes are available, only formaldehyde and glutaraldehyde are routinely

used as disinfectants. Both compounds have a wide spectrum of activity and are highly effective disinfecting agents, but their toxicity, irritant qualities and potential as carcinogens limit their use to specific applications (Quinn and Markey 2001). Both agents act slowly, but their biocidal activity may be increased with increased temperature (which also increases the irritant vapours) and alkaline pH.

Glutaraldehyde is only minimally affected by organic matter and is generally noncorrosive (Quinn and Markey 2001). It is generally used as a 2% solution for disinfection, and is more active in neutral or alkaline preparations. Due to cost and difficulties of supply, use of glutaraldehyde in large-scale disinfection operations is unlikely. It is best retained for disinfection of smaller items that require a highly effective, but noncorrosive, solution.

Formaldehyde may be used as a disinfecting solution and as a fumigant. Although still active in the presence of organic matter, it is more affected by very high levels of organic matter than glutaraldehyde. Formaldehyde produces highly irritant vapours, and considerable care should be taken in its use.

Table 10—12 contain further details on aldehydes; Table 17 shows the characteristics of common aldehyde disinfectants. The recommended doses for various disinfectant applications are shown in Table 8 and Table 18.

Table 17 Characteristics of common aldehydes

Aldehyde	Presentation	Use concentrations	Comments
Formalin	40% formaldehyde in solution, diluted 1:12 for use	8% (vol/vol)	Cheap, but may not be suitable for small, non-enveloped viruses Toxic, flammable and explosive
Formaldehyde gas	Special generation required	As per instructions given below 24 hours	Most effective at 70% humidity and 14°C
Glutaraldehyde	Concentrate solution	2% (wt/vol) for 10–30 minutes	Expensive

7.7.2 Advantages

- Wide spectrum of activity.
- Generally noncorrosive.
- Generally not affected by organic matter.
- Formalin is relatively cheap.

7.7.3 Disadvantages

- Significant workplace safety concerns, depending on use and presentation; produce vapours that are irritant to skin, eyes, respiratory tracts and mucous membranes. Formaldehyde gas is highly irritant and potentially deadly.
- Glutaraldehyde is expensive.

7.7.4 Environmental and workplace safety considerations

- Glutaraldehyde and formaldehyde are potential carcinogens.
- All aldehydes are irritant to mucous membranes and skin. Contact with skin and eyes should be avoided, as should working with, and breathing in, spray mist.
- Formaldehyde gas is extremely toxic and must only be used under appropriate conditions. Fumes may be explosive and react with chlorines to produce carcinogenic compounds. Advice from an appropriate authority should be sought before formaldehyde gas is vented into the environment.
- People handling solutions should wear protective clothing made of resistant material, eye protection, boots and gloves.
- Adequate ventilation should be available. Formaldehyde should not be used in confined spaces (this recommendation does not apply to the use of formaldehyde gas).
- Exposed parts of the body should be washed after use and before eating or smoking.
- Toxic fumes may be emitted if aldehyde material is involved in a fire.
- If poisoning occurs, medical advice should be sought, the affected person should be removed from the area, contaminated clothing should be removed and affected skin areas should be washed thoroughly.
- If spills occur, ventilation should be increased, and the liquid contained with soil and diluted with water (>4:1).

Caution notes:

- B6 Formaldehyde gas is highly irritant and potentially deadly. Its use is not recommended during decontamination operations unless no viable alternative is available and disinfection of the affected space is essential.
- B7 Formaldehyde gas fumigation should only be used in sealed spaces.
- B8 Approval from an appropriate authority is required before releasing formaldehyde gas into the environment.
- B9 Personnel must be equipped with appropriate safety equipment, and all relevant safety procedures must be followed.

7.7.5 Applications: glutaraldehyde

- Disinfection of smaller items subject to corrosion.

7.7.6 Applications: formalin

- In footbaths (only in well-ventilated, outside areas).
- Disinfection of nets.
- Disinfection of surfaces in well-ventilated areas.
- Disinfection of pipework.
- Disinfection of water.

7.7.7 Applications: formaldehyde gas

- Disinfection in tropical hatcheries.
- Disinfection of sealed spaces where no viable alternative is available.

7.7.8 Procedure for use of gaseous formaldehyde

Gaseous formaldehyde can be used to decontaminate the inside of sealed spaces and equipment that must be kept dry (e.g. areas containing electrical equipment). For gaseous formaldehyde to be effective, the conditions must be carefully controlled, including gas concentration, gas distribution, ambient temperature, ambient humidity and contact time. It requires a relative humidity of more than 70%, an air temperature of more than 13°C and a contact time of at least 12 hours.

Spaces to be decontaminated must be completely sealed to prevent gas escape. Under emergency decontamination circumstances, it is unlikely that suitable conditions will be available for the use of formaldehyde gas, but it may be suitable for the disinfection of cool-rooms, fish holds on fishing vessels, areas within and around complex pipework in hatcheries, and buildings containing electrical equipment.

Although an elevated relative humidity is necessary for optimal activity, water cannot be present in liquid form as it will dissolve the gas and reduce its effective concentration in the gaseous phase.

An evenly controlled temperature is also essential for effective decontamination. If the temperature of surfaces falls during decontamination, the formaldehyde will form a powdery residue of paraformaldehyde, which reduces the effectiveness of the operation and creates problems of residual toxicity.

Outlined below is the recommended method for generation of formaldehyde gas for fumigation (Fotheringham 1995b, Torgersen and Hastein 1995). A description of formaldehyde gas generation is also contained in the [AUSVETPLAN Decontamination Manual](#).

- 1) Rigorously clean the area to be disinfected.
- 2) Arrange all appropriate safety procedures and authorisations before commencing disinfection operations.
- 3) Brief staff and issue them with appropriate safety equipment (including gloves, and eye and face protection). Ensure that trained personnel, equipped with breathing apparatus, are available in case of emergency.
- 4) Use 1 litre of commercial grade formalin (30–40% formaldehyde), mixed with 300 grams of potassium permanganate (KMnO₄) for every 20 cubic metres of space to be disinfected.
- 5) Place 1–2 litres of formalin in buckets made of metal or heat-stable plastic. Buckets should be at least 25-litre capacity.
- 6) Position the necessary number of buckets on the floor. Beside each bucket, place an appropriate amount of potassium permanganate.

- 7) Beginning as far away from the exit as possible, pour the potassium permanganate into the buckets, moving quickly from each. The formaldehyde gas develops in a few minutes.
- 8) Completely seal the area for 24 hours and erect warning signs.
- 9) Ventilate treated areas well before allowing personnel to re-enter.

7.7.9 Availability

Formalin is available as a 40% formaldehyde solution from chemical wholesalers and laboratory suppliers. Formalin is also registered as a treatment for footrot in sheep, and some products may be available through veterinary wholesalers and rural supply stores.

Glutaraldehyde is generally only available through chemical wholesalers or laboratory suppliers.

Table 18 Disinfectant applications and recommended doses. See Table 8 for information for specific pathogens.

Disinfecting agent	Application	Pathogens	Recommended dose	Comments	Reference
Hypochlorite solutions (calcium hypochlorite or sodium hypochlorite)	Treatment of clean, hard surfaces	All pathogens	Minimum 30 mg/L available chlorine	Use as a general disinfecting solution	A, B
	Treatment of water (assuming low organic loading)	All pathogens	Minimum 30 mg/L available chlorine Maintain a minimum of 5 mg/L of residual chlorine	Hold for a minimum of 24 hours to inactivate Test chlorine level before discharge or neutralise with thiosulfate Less active in the presence of high levels of organic matter Re-dose if necessary	B
	Treatment of net pens	All pathogens	Initial dose of 1000 mg/L available chlorine Maintain a minimum of 5 mg/L of residual chlorine	Thoroughly mix to ensure even distribution Immerse for a minimum of 6 hours	G
	Dip treatment of absorbent material such as dip nets, clothing, ropes or absorbent surfaces	All pathogens	Solution of >200 mg/L available chlorine	Allow time to completely saturate plus a further 2 minutes (minimum) Rinse items in fresh water or neutralise with thiosulfate	B, F
	Treatment of tanks, floors and walls in culture facilities	All pathogens	Spray with a solution >1500 mg/L available chlorine	Leave solution for 2 hours, then rinse to free any remaining soils Tanks should be filled with freshwater and dosed with 200 mg/L available chlorine Leave for 24 hours in the case of whirling disease	H
Chloramine-T	Treatment of water	Bacteria, viruses, fungi	20 mg/L of chloramine-T (or as per manufacturer's instructions)	Hold for a minimum of 24 hours Test chlorine level before discharge or neutralise with thiosulfate Concentrations and doses vary between products	

	Treatment of previously cleaned hard surfaces	Bacteria, viruses, fungi	20 g/L of chloramine-T (or as per manufacturer's instructions)	Leave to dry on suitable surfaces, or for a minimum of 30 minutes before rinsing Concentrations and doses vary between products	
	Footbaths	Bacteria, viruses, fungi	50 g/L of chloramine-T (or as per manufacturer's instructions)	Brush boots clean before immersion Leave to dry on boots Concentrations and doses vary between products	
	Treatment of hard surfaces	All pathogens	1% solution for >60 minutes (or as per manufacturer's instructions)	Concentrations and doses vary between products	
Peracetic acid	Treatment of porous surfaces	All pathogens	2% solution for >60 minutes (or as per manufacturer's instructions)	Concentrations and doses vary between products	
	Treatment of waste slurries (high organic matter)	All pathogens	40 L concentrate solution per 1000 L	Contact time >1 hour May cause excessive foaming and tank overflow in presence of high levels of protein	I
Monosulfate compounds	Treatment of hard surfaces	All pathogens	10 g/L (or as per manufacturer's instructions)	Application rate of 400 mL/m ² for >10 minutes Concentrations and doses vary between products	C
	Treatment of porous surfaces	All pathogens	20 g/L (or as per manufacturer's instructions)	Application rate of 400 mL/m ² for >10 minutes Concentrations and doses vary between products	C
	Footbaths	All pathogens	50 g/L (or as per manufacturer's instructions)	Remove all organic matter on footwear before immersion Immersion time >1 minute Replace solution daily in areas of heavy use; every 4 days in areas of light use Concentrations and doses vary between products	C

Chlorine dioxide	Treatment of hard and porous surfaces Treatment of water	All pathogens	As per manufacturer's instructions	Can produce volatile fumes when first activated	
Iodophors	Treatment of hard surfaces	Bacteria, fungi, viruses	>200 mg/L available iodine	Apply to surface 1–2 minutes	A, B, D
	Spray disinfection of equipment	Bacteria, fungi, viruses	100 mg/L available iodine	Apply to previously cleaned and dried equipment.	F
	Footbaths	Bacteria, fungi, viruses	>200 mg/L available iodine	Clean boots before disinfection. Replace daily in high-use areas, or when solution has lost colour.	
	Use as a hand or skin wash, or on angling or other delicate equipment	Bacteria, fungi, viruses	> 200 mg/L available iodine	Povidone-iodine solution only, do not use acidified iodine solutions.	A
	Treatment of water	Bacteria, fungi, viruses	30 mg/L available iodine, left for 12 hours	Treat with thiosulfate before release.	E
Calcium oxide	Earthen-based ponds	All pathogens	0.5 kg/m ² for 1 month	Repeat dose on at least two occasions in wet areas or in event of flooding.	A
Sodium hydroxide	Treatment of concrete or cracked surfaces of appropriate materials	All pathogens	Applied as a mixture with CaOH and Teepol	NaOH generally sold as pellets. Repeat dose on at least two occasions in wet areas or in event of flooding. May also be used as a 0.2% solution as a cleaning agent for equipment. Teepol (wetting agent) enhances penetration through soil and into concrete.	A, C, F, J
	Treatment of appropriate surfaces where high organic loading may be a problem	Viral pathogens on suitable surfaces	Applied as a solution of 20 g/L NaOH for >10 minutes		
	Treatment of waste water	All pathogens	At a rate to achieve pH >12 for 24 hours		
	Treatment of waste slurries (high organic matter)	All pathogens	50% (wt/vol) solution at a rate of 30 L/1000 L of slurry	Dose should achieve a pH of >12. Treat for >4 days.	I

Calcium hydroxide	Treatment of waste slurries (high organic matter)	All pathogens	40% (wt/vol) solution at a rate of 60 L/1000 L of slurry	Dose should achieve a pH of >12. Treat for > 4 days.	I
Glutaraldehyde	Treatment of small items or those subject to corrosion	All pathogens	2% (wt/vol) for 30 minutes	Available as concentrate solution	C
Formalin solution	Treatment of hard or porous surfaces Foot baths	All pathogens	8% (vol/vol) for 30 minutes	Available as 40% solution Dilute 1:12 for use Use only in well-ventilated areas	C
	Treatment of waste slurries (high organic matter)	All pathogens	40 L formalin solution per 1000 L (40%)	Must be distributed evenly	I
	Treatment of pipelines or sewage channels (in situ)	All pathogens	300 mL of commercial-grade formalin solution per 10 L of water	Completely fill pipeline with disinfecting solution and leave for 24 hours	A
Quaternary ammonium compounds	Use on skin or delicate items	Some bacteria, some viruses	1 mg/L for >1 minute	Limited range of efficacy	A
	Use on hard surfaces	Some bacteria, some viruses	2 mg/L for >15 minutes	Limited range of efficacy	A
Heat	Treatment of waste water	Most pathogens Category A viruses and some bacteria may be resistant	60°C for 10 minutes 70°C for 6 minutes 75°C for 5 minutes 80°C for 4 minutes		A, B
	Treatment of hard surfaces and equipment	Most pathogens Category A viruses and some bacteria may be resistant	Steam cleaning at 115–130°C for 5 minutes	Difficult to regulate, best used as an adjunct to other disinfection methods Especially suitable for treatment of transport tanks	F
Desiccation and light	Earthen tanks	Most pathogens	Dry for >3 months at an average temperature of >18°C	Drying period can be reduced if combined with an appropriate chemical disinfectant Use drying and sunlight as a general adjunct to all disinfection if possible	F
UV light	Treatment of waste water	Viruses, bacteria, fungi	>25 mJ/cm ²	Requires pretreatment with chemical precipitation or filtration	A

	Treatment of water	Myxosporidean species spores	>35 mJ/cm ²		A
Ozone	Water treatment	All pathogens	1 mg/L for >1minute (= 1 mg/L/min)		A

Note: Levels recommended in this table come from a number of sources and have been provided here as a general guide. Since the disinfecting capability of disinfecting agents will vary depending on the conditions, concentrations and contact times given should be viewed as minimum acceptable levels for decontamination purposes. See Table 8 for more details.

A: Torgersen and Hastein (1995)

B: OIE (2018a, 2018b)

C: AUSVETPLAN Decontamination Manual

D: Finlay (1978)

E: Hegde et al. (1996)

F: Hnath (1983)

G: Fisheries Research Services (1999)

H: Bell and Lightner (1992)

I: Haas et al. (1995)

J: Hastein and Torgensen (1999)

7.8 Calculation of concentration and quantities required

7.8.1 Dose calculation

Chemical disinfectants come in a range of concentrations and presentations. In this manual, wherever possible, the dose recommendations are based on the concentration of the active disinfecting agent. For example, chlorine-based disinfectants can range from 1% to 70% available chlorine (see Table 9). The available 'active' for each unit of concentrate should always be checked before the working solution is prepared.

7.8.2 Initial dose and residual levels

Some disinfectants (e.g. hypochlorites, chlorine dioxide and other oxidising agents) begin degrading as soon as they are mixed. In such cases, two recommended levels may be provided for the disinfectant solution — an initial dose level and a residual level.

Initial dose refers to the concentration of chemical disinfectant in the solution at the start of the disinfection process. In many cases, the initial dose is calculated to achieve a minimum residual level, taking into account consumption of the chemical agent over time.

Residual level refers to the level of active remaining in the solution at completion of the prescribed contact period. This level is normally reported as a minimum (e.g. >5 mg residual chlorine). Redosing may be necessary if working solutions fall below the required residual level. Residual levels are best monitored using commonly available chemical test kits.

7.8.3 Volume required

The amount of chemical disinfecting solution required for specific tasks varies, depending on the surface type and degree of soiling. For a hard, nonporous surface, the [AUSVETPLAN Decontamination Manual](#) recommends 100 mL of disinfecting solution per square metre if specific product recommendations are not available. For porous surfaces such as concrete or wood, the volume required is at least three times that required for hard surfaces. Other authors recommend a minimum of 400 mL disinfecting solution per square metre for porous surfaces.

7.8.4 Combining chemicals

It is unwise to mix different chemicals unless specific technical advice has been sought from the manufacturer. Most commercial products have been formulated to achieve maximum activity for a specific purpose, and there is little to be gained from mixing such products with other chemicals.

7.9 Use of thiosulfate to inactivate oxidising disinfectants

Chlorine-based and iodine-based disinfecting agents are toxic to aquatic life and in some circumstances must be inactivated before they are released into the environment. A 1% solution of thiosulfate may be used to inactivate both compounds. The required volume of 1% thiosulfate (in mL) can be calculated as follows:

Chlorine - $28.5 \times (\text{litres of disinfecting solution} \times \text{concentration in mg/L})/100$

Iodine - $7.8 \times (\text{litres of disinfecting solution} \times \text{concentration in mg/L})/100$

8 Decontamination of site infrastructure

8.1 Decontamination of earthen ponds

8.1.1 Applications

Decontamination of earthen-based facilities used to hold diseased stock, including ponds, channels, dams and settlement areas.

8.1.2 Procedures

- 1) All ponds, including intake channels and settlement ponds, should have fish³ stocks removed and disposed of in an appropriate manner. The [AQUAVETPLAN Operational Procedures Manual — Disposal](#) contains details on disposal. However, if a leave in-situ (destroy and let lie) method of destruction and disposal has been utilised (e.g. in the case of small, easily decomposable species such as prawns), the ponds may still contain remains of fish during the early stages of the decontamination process. If non-disease carrier species occur in ponds (e.g. finfish in prawn ponds during an outbreak of WSD), they should be removed immediately once deceased prior to leaving the target species in-situ for the prescribed time period.
- 2) All ponds and channels should be drained or pumped out. Consideration needs to be given to whether it is appropriate to discharge untreated water into natural waterways, treat water with disinfectants before discharge, or dispose of water at a separate location. If a leave in-situ (destroy and let lie) method of destruction and disposal has been utilised, the remains of undecomposed target species (i.e. carapaces, skeletons) will need to be removed with the pond sludge and disposed of appropriately (see the [AQUAVETPLAN Operational Procedures Manual — Disposal](#)).
- 3) As ponds empty, there is a greater chance that sediment and organic matter containing high pathogen loads close to the bottom will be discharged. Precautions should therefore be taken to control sediment discharge into waterways. This is best undertaken through controls at the settlement pond, if one is present.
- 4) Sediments, organic matter and the top 10–15 cm of silt should be removed using excavators and disposed of by burial or treatment with alkaline compounds. Excavation should begin at the uppermost section of the pond system, gradually working downstream.
- 5) Recommendations for the treatment of ponds are summarised in Table 19. Areas treated should be kept dry for at least 2 months. Where ponds have reflooded after cleaning or it is impossible for them to be completely dried out, wet areas should be pumped out and

³ Fish is defined here as any aquatic animal and may include finfish, molluscs or crustaceans.

retreated on at least two additional occasions. In hot, dry conditions (>10°C minimum temperature), the dry-out period may be reduced to 1 month.

- 6) Where possible, the chemicals should be incorporated into the top 5 cm of the clean, moist pond base.
- 7) Following treatment, all ponds should remain dry until the total clean-up has been completed for the entire farm facility.
- 8) Care should be taken when refilling treated pond systems to ensure that the water does not contain unacceptable levels of chemicals that may be toxic to fish. Torgersen and Hastein (1995) recommend that the pH of water discharged into natural waterways be less than 8.5, but acceptable levels should be confirmed with appropriate state or territory authorities.

Table 19 Recommendations for disinfection of earthen pond bases

Disinfecting agent	Application rate	Minimum dry-out period	Comments
Calcium oxide	0.5 kg/m ² or 5 tonne/ha of dried ponds Retreatment of wet areas at a rate of 1 kg/m ² on two subsequent occasions	1 month	Recommended for <i>Myxobolus cerebralis</i>
Calcium hydroxide and sodium hydroxide mix	A mixture containing 500 g CaO ₂ , 100 g NaOH and 10 g Teepol and diluted with 10 L of fresh water Final solution applied at a rate of 2 L/m ²	14 days	Mixture assists in penetration of porous surfaces Recommended for hard, dry ponds, or unpainted concrete ponds
Calcium hydroxide	1.5 tonne/ha applied evenly across the base of ponds	1 month, or until deep cracking occurs	Recommended for prawn ponds

Source: Torgersen and Hastein (1995); Bell and Lightner (1992); Hastein and Torgersen (1999); Le Breton (2001b); OIE (2018b)

8.2 Decontamination of tanks

8.2.1 Applications

Disinfection of tanks used for holding infected stock.

8.2.2 Procedures

- 1) All fish stocks, carcasses, faecal matter and uneaten feed should be removed from tanks for disposal. The [AQUAVETPLAN Operational Procedures Manual — Disposal](#) contains details on disposal.
- 2) Tanks and associated pipework or channels should be drained, taking into account the safe disposal of infected water.
- 3) Any ancillary equipment, such as feeders, aerators or lights, should be removed for separate cleaning and disinfection.

- 4) Tank surfaces should be washed using high-pressure water cleaners (HPWCs) to remove gross fouling. Very high-pressure cleaners have the potential to erode the surface of concrete tanks if used incorrectly. This problem may be overcome by moving the nozzle away from the concrete surface, using wider spray nozzles or reducing water pressure.
- 5) Once gross fouling has been removed, alkaline or other powerful detergents should be sprayed onto surfaces using low pressure, then the area should be washed using pressure cleaners or mechanical scrubbing. If possible, heated water should be used to enhance the cleaning process. Refer to Table 3 and Caution notes A1–A5.
- 6) Acidic detergents may be used to assist removal of mineral deposits. Acidic detergents should not be used on concrete surfaces. If waters are very hard (marine water, or fresh water with high calcium levels), nonionic or acidic detergents should be used.
- 7) Each cleaning stage should always start from the top and proceed downwards. Excess water should be allowed to drain away before application of disinfection solutions.
- 8) An appropriate disinfectant should be sprayed over the entire surface of the tank at a rate of >400 mL/m² (Torgersen and Hastein 1995, Quinn and Markey 2001), and left for the recommended time. The application of disinfectants should start from the base of the tank and proceed upwards.
- 9) Unpainted and cracked concrete surfaces are best disinfected using alkaline disinfectants (OIE 2018b). Torgersen and Hastein (1995) recommend the use of a sodium hydroxide/calcium hydroxide/Teepol mix, sprayed onto concrete surfaces at a rate of 0.1 L/m² and left for 48 hours.
- 10) Plastic and fibreglass tanks can be disinfected with any chemical agent suitable for hard surfaces — for example, hypochlorites, peracid solutions, iodophors, chlorine dioxide or chloramine-T. Refer to Table 18 for further details.
- 11) When applying disinfectants to vertical surfaces, care must be taken to ensure that adequate contact time is maintained before the disinfectant drains away. Hypochlorites, chlorine dioxide solutions or peracid solutions are recommended if short contact times are required on previously cleaned vertical surfaces.
- 12) Following disinfection, tanks should be rinsed and allowed to dry completely. This may require the removal of grids or dismantling of pipes to ensure that all water is drained and does not lie in pools at the base of tanks or drains. All tanks should remain dry until the site has been cleared for restocking.

8.3 Decontamination of cages, nets, pots and marine equipment

8.3.1 Applications

Disinfection of fishing equipment and infrastructure used on marine farm sites, including nets, polar circles, rigid farm systems and pontoons.

8.3.2 Procedures

Nets and soft crab/lobster pots

- 1) All nets and pots should be removed from floats and brought to shore for treatment.
- 2) Net materials should be thoroughly cleaned using net washers or laid out on a hard surface and cleaned with HPWCs. Refer to Section 3.4.6 for further details.
- 3) Where possible, the disinfecting agents used should be unaffected by organic matter, suitable for porous surfaces and unlikely to damage netting. Possible options include chlorine dioxide, formaldehyde solutions, iodophors (povidone iodine) and in cases where they are suitable for inactivation of particular disease agents (e.g. WSSV), quarternary ammonium compounds. Hypochlorite solutions may also be used if the nets are cleaned and rinsed thoroughly.
- 4) Disinfectant solutions should be thoroughly mixed, and the netting materials should be spread out as much as possible to ensure even application of disinfectant over all surfaces.
- 5) Recommendations for the control of infectious salmon anaemia in Scotland were made by a joint government/industry working group (FRS Marine Laboratory Aberdeen 2000). These recommendations include immersion of nets in fresh water dosed with sodium hypochlorite at a rate of 1000 mg/L for a minimum of 6 hours. Where netting materials cannot be adequately cleaned and are heavily fouled, a minimum residual chlorine level of 5 mg/L available chlorine should be maintained. Alternative treatments included the immersion of netting materials in water at a temperature of 55–70°C for a minimum of 5 minutes. Preferably, cleaned netting materials should be placed into disinfecting solutions while still wet, since this assists penetration of net fibres by the disinfectant solution.
- 6) McCarthy (1975) found that it was possible to disinfect both wet and dried nets contaminated with *Aeromonas salmonicida* using acriflavine (1:4000) and 0.1% Teepol in 1% NaOH, but 1% hypochlorite alone disinfected only wet cage nets.
- 7) Following disinfection, nets and pots should be rinsed of residual chemicals and completely dried. Nets should not be rolled up for storage until they have been disinfected and dried.
- 8) Where appropriate treatment of nets and pots cannot be achieved, they should be destroyed by incineration or disposed of in approved landfill sites.

Marine infrastructure and hard crab/lobster pots

- 1) Where possible, floating installations should be dismantled and brought on shore for cleaning.
- 2) Water should be drained from all equipment by opening drains and inspection ports. Where there may be water in inaccessible areas, drainage holes may need to be installed. It is important that these are placed in positions that are easily repaired following decontamination.
- 3) All surfaces should be thoroughly cleaned using HPWCs, scrapers and mechanical brushing to remove fouling organisms and gross soiling. On suitable surfaces, these treatments can be combined with a nonionic or acidic detergent to remove soil buildup. If fresh water is used, strong alkaline detergents may be used to remove heavy soiling, but their use should be avoided on soft metals or galvanised surfaces.

- 4) The use of wet heat, in the form of steam cleaners, is also a viable option for cleaning and disinfecting marine infrastructure if adequate supplies of fresh water are available. This has the advantage of not producing chemical wastes requiring containment and disposal.
- 5) Surfaces should be disinfected using chemical agents suitable for hard surfaces. Options include hypochlorite solutions, chlorine dioxide solutions, chloramine-T or iodophors.
- 6) Drainage of chemicals into the surrounding environment should be taken into consideration during disinfection on floating facilities. Washwater containing detergents and disinfectants should be contained for later disposal.
- 7) In many cases, it is difficult and time consuming to dismantle floating installations for cleaning and disinfection on shore. Where installations cannot be dismantled, the underwater section can be cleaned by divers using mechanical scrubbers routinely used for cleaning the hulls of commercial vessels. Underwater high pressure cleaners are also available and may be used by commercial divers to clean equipment (including nets) in situ.
- 8) Torgersen and Hastein (1995) report that marine facilities in Norway have been effectively disinfected by wrapping the underwater section in tarpaulins, pumping the internal section dry and refilling it with fresh water containing an appropriate disinfectant. This may not be practical on larger facilities, and safe disposal of the disinfectant solution is difficult. Sodium hypochlorite at a rate of 1000 mg/L, with the tarpaulin held in place for 24 hours, has been used for this purpose. Chlorine dioxide, peracid solutions or formaldehyde would also be suitable and would have lower environmental impacts than chlorine.
- 9) Wherever possible, structures or equipment should always be removed from the water for cleaning and disinfection.

8.4 Decontamination of pipework

Complex pipework systems in hatcheries, recirculation facilities or boats present significant challenges for disinfection due to limited access and the formation of biofilms.

8.4.1 Applications

Decontamination of pipework, pumps and filters used to circulate water through fish holding facilities, including recirculation facilities, biofilter towers, seawater inlets or outlets, and pipework on transport barges and fishing vessels.

8.4.2 Procedures

- 1) The pipework should be drained and any external fouling removed.
- 2) Any ancillary equipment should be removed and electrical equipment made safe by qualified technicians.

If using foam projectile pipe cleaning systems (pigging systems)

If pigging systems are available and the pipework design is suitable for their use, they may reduce the amount of dismantling required. Refer to [Section 3.4.7](#) for further details on pigging systems.

- 3) Pipework should be divided into sections that foam projectiles may be forced through easily.
- 4) Appropriate plates or valves should be removed from the end of each section to allow access.
- 5) Pipework should first be cleaned using an abrasive projectile to remove biofilms and internal buildups. Multiple passes of the projectile may be required to remove as much internal fouling as possible.
- 6) If required, the system may be flushed with a strong alkaline detergent to loosen residual fouling. If calcium deposits are a problem, flushing with an acidic detergent will be necessary.
- 7) A drying projectile may be used to force out any remaining detergent solution. The pipework should then be flushed with fresh water and allowed to drain.
- 8) Pipework should be filled with an appropriate disinfection solution. Hypochlorite, chloramine-T, monosulfate, chlorine dioxide, formaldehyde or iodophor solutions are suitable for this purpose, subject to potential corrosion effects.
- 9) If there is any doubt about the effectiveness of cleaning, disinfectants that retain activity against biofilms should be used (e.g. monosulfate, chlorine dioxide, formaldehyde or chloramine-T solutions). If residual mineral deposits are present, acidified iodophor solutions are most suitable.
- 10) In choosing appropriate chemical disinfectants, the corrosive properties of the agent against soft metal alloys or rubber seals present in the system should be considered. Thorough flushing after disinfection should alleviate most corrosion problems.
- 11) Following disinfection, clean fresh water should be flushed through the system and a second drying projectile forced through.
- 12) Pipework should be left to dry thoroughly, with access plates removed to allow circulation of air. The system should remain dry until the whole facility is cleared of disease and ready for restocking.

If not using pigging systems

- 3) All access plates and valves should be removed. Any blind-end pipes, where water circulates, should be either opened or removed.
- 4) Where possible, internal fouling should be removed using high-pressure water sprayers, scrapers or brushes. Reverse flushing with water may also assist in loosening deposits.
- 5) All pipework should be filled with strong detergents, which are thoroughly circulated through the system. If calcium deposits are a problem, flushing with an acidic detergent will be required. The system should then be flushed thoroughly with fresh water and allowed to drain.
- 6) Pipework should be refilled with an appropriate disinfectant and left for the prescribed period of time. Hypochlorite, chloramine-T, monosulfate, chlorine dioxide, iodophore or formaldehyde solutions are most suitable for this purpose.

If there is any doubt about the effectiveness of cleaning, disinfectants that retain activity in the presence of biofilms should be used (e.g. monosulfate, chlorine dioxide, formaldehyde

or chloramine-T solutions). If there are residual mineral deposits, acidified iodophor solutions are most suitable.

In choosing appropriate chemical disinfectants, the corrosive properties of the agent against any soft metals or rubber seals present in the system should be considered. Thorough flushing after disinfection should alleviate most corrosion problems.

- 7) The pipework should be drained and again flushed with fresh water.
- 8) All pipework should be left to dry thoroughly, with access plates removed to allow circulation of air. The system should remain dry until the whole facility is cleared of disease and ready for restocking.

8.5 Decontamination of fish transport containers

8.5.1 Applications

Decontamination of transport containers used to carry live fish, including tanker trucks, removable transport bins, containers used for air transport and fish transport trailers.

Decontamination of accompanying fixtures and equipment, such as air lines, pumps, pipework and gas diffusers/air stones.

[Section 8.8](#) describes the procedures for decontamination of vehicles, including livestock transport vehicles.

8.5.2 Procedures

- 1) All water should be drained from transport tanks. Any fish, faecal matter or other soil should be cleaned from tanks by flushing with clean water. All pipes and associated pumps should also be inspected and flushed to ensure that carcasses or organic material trapped within are removed.
- 2) Equipment such as gas diffusers, electrical monitoring equipment and other delicate or porous items should be removed for individual cleaning, disinfection or replacement.
- 3) The complete exterior of the truck and/or transport containers should be thoroughly washed using HPWCs, beginning at the top and working down to the wheels. The underneath of the truck and tanks should also be washed (see [Section 8.8](#)).
- 4) The interior of transport containers should be washed using HPWCs and mechanical scrubbing. Cleaning should start from the top of the internal surface and move downward.
- 5) Surfaces should be thoroughly rinsed if detergents have been used. All surfaces should then be allowed to drain.
- 6) Internal surfaces of tanks should be disinfected using wet heat (on suitable surfaces) or chemical disinfectants. Suitable chemical disinfectants include hypochlorite solutions, chlorine dioxide solutions, chloramine-T or iodophors. Refer to Table 18 and Table 19 for appropriate times and concentrations.

Disinfection should start from the lowest level of the tanks and gradually work upwards.

Caution notes:

- B10 Many chemical disinfectants give off vapours that may affect personnel when used in confined spaces such as transport tanks. Personnel undertaking disinfection of transport tanks should follow appropriate safety procedures and should be monitored at all times.
- B11 Many chemical agents, particularly iodophors, are toxic to fish at low levels. If the tanks are to be used for transport of live fish in the future, special care must be taken to completely rinse all traces of chemicals from tanks, hoses and pumps.

- 7) Following disinfection, the transport tanks should be drained, thoroughly rinsed with fresh water and allowed to dry in direct sunlight. All valves, inspection ports and pipes should be left open or disconnected to allow free circulation of air.

8.5.3 Alternative method

For routine disinfection of transportation equipment, Amend and Conte (1982) recommend the use of calcium hypochlorite mixed into solution and circulated through the tanks. This procedure requires the complete filling of containers with disinfecting solutions and therefore can only be used where sufficient quantities of fresh water are readily available and facilities allow the dumping of used disinfectant solutions. The procedure is recommended as an alternative when tanks cannot be entered for manual cleaning and disinfection.

Procedure

- 1) The tank or container is filled with the desired amount of water.
- 2) If the pH of the water is below 6, glacial acetic acid is added at a rate of 40 mL per 500 L of water.
- 3) Calcium hypochlorite is added to the buffered water at a rate of 16 g per 100 L, and the water is thoroughly mixed (refer to Caution note B12).
- 4) Pumps are used to circulate the disinfecting solution throughout the tanks and pipework for 30 minutes.
- 5) Tanks and pumps should be thoroughly flushed.
- 6) The vehicle and tanks are allowed to dry completely in direct sunlight. All valves, pipes and inspection ports should be left open to allow free circulation of air.

Caution note:

- B12 DO NOT ADD acetic acid to dry calcium hypochlorite or lower the pH below 5. Mixing concentrate chlorine compounds and acids produces toxic chlorine gas.

8.6 Decontamination of boats**8.6.1 Applications**

Decontamination of any vessels that operate in marine farms and can be slipped locally.

- Vessels operating between nonsuspect sites within surveillance zones must be decontaminated between sites down to and including the water line.
- Vessels operating within confirmed infected sites must be slipped and decontaminated before entering areas of lower risk. The route to the slip must be chosen to minimise contact with other fish farms.

8.6.2 Procedures

On the water

- 1) All gross fouling and organic matter should be removed by scraping or brushing or using HPWCs (see point 9 for disposal of waste and waste water).
- 2) A suitable detergent solution should be applied over all surfaces on the inside of the hull. Suitable detergents include nonionic detergents for marine situations and acidic detergents where there are fat, protein or mineral buildups.
- 3) All deck, equipment and superstructure surfaces should be cleaned by scrubbing or using high-pressure sprayers, starting on the upper surfaces and working down to and including decks. If available, heated water or steam cleaners will assist this process, but they can only be used on suitable surfaces.
- 4) All pipework and pumps, particularly those used to transfer water for fish holding facilities, should be rinsed with disinfecting solutions.
- 5) Steps 2 and 3 should be repeated for gunwales and top sides (outside of the hull).
- 6) All external areas should be rinsed with fresh water.
- 7) A suitable disinfecting solution should be applied to all areas. Foaming solutions may be required for vertical surfaces.
- 8) All equipment (mooring lines, life jackets, wet-weather clothing and fenders) should be cleaned and soaked in disinfectant.
- 9) Waste and waste water should be left in the craft until ashore or, if approved, released out in the main channel well away from the lease. Containment of disinfecting solutions may require temporary blocking of scuppers or drainage into the bilge. For safety reasons, scuppers should be reopened immediately following rinsing, and bilges emptied as soon as possible. Bilges may require additional dosing with disinfecting solution to achieve acceptable residual levels.
- 10) All internal cabin areas should be thoroughly vacuumed to remove any accumulations of mud or soil. All surfaces, including floors, benchtops and seats, should be wiped with a disinfecting solution.
- 11) Rubbish, clothing and equipment should be bagged in heavy-duty plastic bags before they are transported to shore. The outside of all plastic bags and containers should then be sprayed with disinfectant.
- 12) If not already done, the bilges should be pumped and the whole vessel thoroughly ventilated.

On shore (trailable boats)

- 1) A site where contamination will not enter waterways should be chosen, and all bilges and decks should be drained.
- 2) All rubbish or contaminated items should be placed in plastic bags for later disposal or decontamination. The outside of bags should be sprayed with a disinfecting solution before the bags are removed from the vessel.
- 3) All external surfaces should be cleaned with a HPWC unit. In the absence of a high-pressure cleaning unit, surfaces must be scrubbed with a detergent and then rinsed with fresh water.
- 4) A suitable disinfectant should be applied to all external surfaces and left in contact for the prescribed time.
- 5) All equipment (mooring lines, life jackets, wet-weather clothing and fenders) should be cleaned and soaked in disinfectant.
- 6) All surfaces, including bilges, should be rinsed with fresh water. The vessel should be allowed to dry in direct sunlight, with bilges, hatches and windows open.

Nontrailable boats and vessels

Steps 1 through 8 of 'On the water' procedures should be followed.

- 7) Upon return to shore, bilges should be drained. The vessel should be slipped, the hull cleaned and fresh antifoul paint applied.
- 8) For vessels that cannot be slipped, the hull should be tarped and soaked with a disinfecting solution as outlined in [Section 8.3](#).

8.7 Decontamination of divers and dive equipment

8.7.1 Applications

Decontamination of equipment used for commercial diving activities on fish farms, including dive suits, regulators, hoses and control panels.

8.7.2 Points to consider

- Certain high-risk tasks, such as mortality removal, expose divers to very high levels of infected material. Under such conditions, frequent rinsing of dive suits and equipment throughout the day will reduce buildup of organic matter and make the final decontamination procedures easier and more efficient.
- Where possible, the equipment chosen should be nonabsorbent and easy to clean. For diving suits, membrane drysuits should be used in preference to neoprene wetsuits.
- Many disinfectant chemicals are corrosive, but adverse effects can be minimised by thoroughly cleaning diving equipment before the disinfection stage, not leaving equipment soaking in disinfection solutions longer than necessary, and rinsing well in fresh water.

- Equipment (e.g. wetsuits) should be examined to ensure that the whole surface is exposed to the chemical agent while ensuring that the agent does not enter delicate internal workings (e.g. regulators, electrical equipment).
- Dive equipment must be allowed to dry thoroughly by storing it in a well-ventilated area. As well as reducing any corrosive effects of chemicals, the drying process significantly aids in the disinfection of equipment and ensures that moist microenvironments that may harbour pathogens are avoided. This is particularly important when dealing with wetsuits, ropes and bags, or containers used to hold fish carcasses.

8.7.3 Procedures

- 1) Gross contamination with organic material should be removed by rinsing divers, equipment and decks throughout diving operations. Deck hoses and pressure sprayers may be used for this purpose, but divers' eyes must be protected.
- 2) At the end of diving, all equipment should be rinsed in fresh water to remove salt water.
- 3) All equipment should be washed in a cleaning solution to remove traces of organic matter. If on-site showers are available, thoroughly rinsing wetsuits while showering is acceptable practice and has the advantage of using warm water to clean the suit. Divers must ensure that all areas of the suit are cleaned, including the internal surface. Other equipment is best washed in large plastic bins. At this stage, any nonalkaline detergent is satisfactory, provided that it is safe for staff and equipment and appropriate for the cleaning task.
- 4) Equipment should be thoroughly rinsed in fresh water.
- 5) All equipment should be dipped in a bath of disinfectant solution for the prescribed time. Suggested disinfectants include:
 - povidone iodine solutions at 100 mg/L available iodine for 10 minutes (avoid acidified iodophors);
 - chloramine-T solution at 2% by weight for 10 minutes; or
 - monosulfate solutions (Virkon-S®) at 0.5% by weight for 10 minutes.

Alternatively, gear may be heat treated using hot water maintained at more than 55°C for at least 5 minutes.

- 6) Equipment should then be rinsed in fresh water and dried in a well-ventilated area.

8.8 Decontamination of vehicles

Most vehicles should remain off infected or dangerous contact premises. If the number of vehicles warrants it, a local area with a hard standing, drainage and good water supply should be designated as a local vehicle disinfection station.

A carwash facility is ideal for decontamination of surveillance vehicles if one is conveniently located.

The following procedures are adapted from the [AUSVETPLAN Decontamination Manual](#).

8.8.1 Applications

Vehicles can be divided into four broad categories according to contact history with diseased stock or infected premises:

- those that do not need cleaning and disinfection;
- those that need only the wheels cleaned and disinfected;
- those that need only the outside cleaned and disinfected; and
- those that need both outside and inside cleaned and disinfected.

8.8.2 Procedures

Cars

The wheels, wheel arches and undercarriages of cars should be sprayed with a noncorrosive detergent, and the dirt thoroughly rinsed away. Areas of bodywork covered with dirt or mud should also be cleaned with noncorrosive detergents. As an alternative, wheels, wheel arches and undercarriages can be cleaned using high-pressure cleaners (preferably using heated water) or steam cleaners, but care should be taken not to damage paintwork.

- 1) Once cleaned, these areas should be thoroughly rinsed. The wheels and wheel arches should then be sprayed with a disinfecting solution.
- 2) Any rubber floor mats should be removed for scrubbing with disinfectant. The dashboard, steering wheel, handbrake, gearstick and driver's seat should be wiped liberally with appropriate disinfectant.
- 3) If the rear compartment is considered contaminated, the contents must be removed and the interior of the boot wiped with disinfectant. The contents of the rear compartment should be treated similarly before being replaced.
- 4) Heavily contaminated vehicles should be cleaned only on the infected premises, as most cleaning processes, including HPWCs, have the potential to spread infectious agents via aerosols and water run-off. Brushing with disinfectant or soap and water to dislodge encrusted dirt and organic matter is preferable to washing with strong water streams.
- 5) Where possible, cars should be parked in direct sunlight to dry.

Transport trucks

- 1) All solid debris should be removed from trailers, transport tanks and harvest bins. Any residual fish mucus, blood and faecal matter must also be removed.
- 2) If the outside of the vehicle has been decontaminated, the tanks and bins should be lifted free from the trailer. The undersides of the tanks and bins, and where the tanks and bins were sited on the trailer, can then be decontaminated.
- 3) All fixtures and fittings must be dismantled to ensure that infected material is removed. Some trailers may carry extra equipment under the body, and this must be treated. It is common practice for specialised live transport vehicles to be self-contained with water and

oxygen supplies for fish. All water, aeration equipment, pipework and pumps in live transport tanks must be disinfected (see [Section 8.5](#) for further details).

- 4) Any wood surfaces must be cleaned and disinfected or, where appropriate, valued before removal for destruction.
- 5) The outside dual wheels and spare wheels must be removed to ensure adequate decontamination of wheel hubs and allow inspection of the spare wheel hangers, which can be of hollow construction and therefore could hold contaminated material.
- 6) The wheels, wheel arches, bodywork and undercarriage must be cleaned and disinfected.
- 7) The external surface of the vehicle is then soaked in a detergent and scrubbed down thoroughly.
- 8) The vehicle is thoroughly rinsed and a disinfecting solution applied.
- 9) The driver's cabin and, where fitted, the sleeping compartment must be thoroughly cleaned. All water, foodstuff and litter carried in vehicles must be burnt or buried.
- 10) The driver should identify the clothing and boots he/she was wearing when in contact with suspect fish stock. These articles must be decontaminated. Arrangements should be made for dry cleaning, where applicable.
- 11) If the vehicle is known to have carried diseased or suspect stock that were removed before departmental officers identified the vehicle as being contaminated, every effort should be made to identify the location of disposal of these animals. Once identified, these materials must be disinfected and disposed of by burial or burning.
- 12) Where possible, the truck should be parked in direct sunlight to dry.

8.9 Footbaths

8.9.1 Applications

Footbaths are a valuable tool to restrict the transport of pathogens on footwear. Footbaths also serve the secondary purpose of continually emphasising to personnel the need for biosecurity procedures.

In order to be effective, footbaths must:

- be of sufficient size;
- utilise appropriate contact times;
- use a disinfectant solution that is resistant to organic matter;
- incorporate a cleaning procedure to remove accumulations of mud or soil; and
- be regularly emptied and refreshed.

Footbaths should be placed at points of entry into and exit from quarantine areas or facilities undergoing decontamination. They should be used to aid in reducing tracking of contamination

from within or between infected areas where a complete change of footwear is not possible or practical.

8.9.2 Additional precautions

Wherever possible, additional procedures should be used to reduce contamination of the disinfecting solution in the footbath and the potential for carriage of soil.

Such procedures include:

- a complete change of footwear at the point of entry;
- all personnel being supplied with waterproof footwear; and
- complete scrubbing of footwear to thoroughly remove all remnants of soil.

8.9.3 Procedures

- 1) Appropriate locations should be identified for footbaths, including at the boundary of the infected site (e.g. at the entry of buildings) and within the site.
- 2) Footbaths should be placed in a well-ventilated area out of direct sunlight, and protected from rain or flooding.
- 3) Footbaths should be placed on hard, well-drained surfaces. Alternatively, small tarpaulins (3 m × 3 m) can be used to prevent the area becoming waterlogged and muddy.
- 4) Footbath stations should incorporate a method of cleaning footwear before it is immersed in the disinfecting solution. This may include a separate bath of detergent next to the footbath, stiff brushes to remove mud, or specially designed boot scrubbers.
- 5) Footbaths should be large enough to allow the person to stand with both feet in the solution, and deep enough to cover the tops of the feet. Recommended dimensions for footbaths are a minimum of 50 cm × 50 cm in area and 25 cm in height. Disinfectant solutions should be at least 15 cm deep.
- 6) Disinfectant in footbaths should be drained and refreshed daily, or more frequently if required during instances of heavy foot traffic. A log should be kept of changes of the disinfection solution.
- 7) Disinfectant solutions that may be suitable for use in footbaths include Virkon-S® or other monosulfate compounds, iodophors and chloramine-T. Formalin may also be used in well-ventilated areas.
- 8) Clear instructions, outlining procedures and minimum contact times, should be posted at each footbath station.

8.10 Treatment of slurries

8.10.1 Applications

The treatment of any material containing high levels of organic matter in a liquid slurry. Examples of such materials include solids (residual feed, faeces or carcase materials) drained

from tanks and ponds, benthic material removed from ponds and channels, materials in settlement ponds or tanks, and washings from cleaning processes.

8.10.2 Procedures

Chemical treatment

- The most practical chemical agents of most practical importance in the treatment of slurries are formaldehyde and those that modify pH.
- To be effective, chemical disinfecting agents must be thoroughly dissolved and evenly distributed throughout the slurry. General recommendations for the chemical treatment of slurries (as outlined in Haas et al. 1995) suggest that slurries must be continuously agitated before, during, and for at least 6 hours after, the addition of chemical disinfectants.

This requirement causes significant practical difficulties, since most pumps are not suitable for pumping thick slurries, and suitable mechanical mixers are not readily available. In addition, some of the chemicals used (e.g. sodium hydroxide) will be corrosive to pumps and mixing equipment.

The use of centrifugal impeller pumps to recirculate the slurry material is possible where the slurry is a liquid. Where slurries are thicker, diaphragm pumps will be required. Vigorous aeration of the slurry using compressed air may also aid the mixing effect.

- Alkalis are an economical and effective means to treat slurries. Sodium hydroxide and calcium hydroxide are the most commonly used (Haas et al. 1995). Treatments should aim to raise the slurry pH above 12.

Recommendations include the use of:

- Ca(OH)_2 in a 40% solution at a rate of 60 L/m³ for at least 4 days
- NaOH in a 50% solution at a rate of 30 L/m³ for at least 4 days
- formalin (40% solution) at a rate of 40 L/m³ for more than 4 days; formalin has reduced effect below 20°C and should not be used below 10°C
- peracetic acid at a rate of 40 L/m³ for more than 1 hour; the use of acids may cause excessive formation of foams that may spill out of holding containers.

8.10.3 Spread over pastures

If the pathogen is readily inactivated by sunlight and desiccation, or previous chemical treatment has been undertaken, distribution of slurries over suitable pastures is a practical means of disposal and further disinfection.

- This process requires the use of sewage transport trucks to pump out temporary storage facilities on the infected property and a practical means of spreading the slurry over a wide area (e.g. the use of liquid manure spreaders). All vehicles and operators should be subject to the decontamination procedure and not permitted to resume normal duties until they have been thoroughly disinfected.

- Areas chosen for disposal of slurries should be away from waterways. There should be a low risk of heavy rainfall and flooding soon after application. This process is best suited to hot, dry environments where adequate dry periods can be guaranteed.
- Wherever possible, the slurry should be incorporated into the soil for tillage crops following a period of desiccation and exposure to sunlight.

8.10.4 Composting

Where commercial composting operations are available, infected slurries may be injected into compost windrows. The aerobic composting process ensures that windrow temperatures will remain above 55°C for a number of weeks (generally 12 weeks). This long-term elevation of temperature will inactivate most pathogens, with the possible exception of some category B viruses.

- The final use of compost materials should be controlled to ensure that they not used in high-risk locations.
- This process requires the use of sewage transport vehicles dedicated to the transport of slurry.
- Checks should be made to ensure that any pretreatment with chemical disinfectants does not adversely affect beneficial saprophytic organisms required within the composting windrows.
- This process is most suitable where large volumes of infected slurries require disposal, and commercial composting operations are within reasonable distances.

For more information on composting, see the [AQUAVETPLAN Operational Procedures Manual — Disposal](#).

Heat treatment (pasteurisation)

Heat treatment of slurries to between 70°C and 100°C for a minimum of 30 minutes is recommended for small amounts of material (Haas et al. 1995).

Pasteurisation may not be completely effective against highly resistant organisms, such as category B viruses (see [Section 4.1](#)) and some bacteria. Humphries et al. (1991) found that the infectious pancreas necrosis virus and *Renibacterium salmoninarum* could survive at 70°C for more than 30 minutes. These findings were also supported by Whipple and Rohovec (1994).

9 Procedures for personnel

9.1 Personnel decontamination site

A site designated for decontamination of personnel should be arranged near the exit point from any infected premises. This should allow staff to leave the infected premises without becoming recontaminated.

The personnel decontamination site should be placed at the limit of the contaminated area, and in an area that is easily and safely decontaminated. Where infected areas require the use of boats to transfer personnel from marine farms to shore, a personnel disinfection site is best located at the site where the boat docks or at the entrance to shore facilities. Alternatively, a boat or barge may be designated as the personnel decontamination site, provided that it can be easily disinfected and has adequate facilities on board to cater for disinfection procedures.

Ideally, the personnel decontamination site should be a building with power, water and drainage. If there is no suitable site, then caravans, transportable toilet blocks, temporary barriers and plastic ground covers can be used. Wherever possible, the personnel decontamination site should include showers (even if they are cold) and changing rooms.

Once a location has been identified, the personnel decontamination site should be cleaned and sprayed with an appropriate disinfectant.

Each person should have a clean change of clothes kept in plastic containers at the outermost point of the personnel decontamination site. Spare overalls and boots should also be kept in case of mishaps.

Run-off water from the personnel decontamination site must be controlled and must not be allowed to flow into clean areas. If adequate drainage is not available, channels should be dug to contain washwater and divert it into pits or tanks within the infected area for later treatment and disposal.

9.2 Personal decontamination procedures from infected premises

The following is adapted from the [AUSVETPLAN Decontamination Manual](#).

The aim of personal decontamination is to safely remove any contamination from the body or clothing. The process minimises the risk of cross-contamination, so that people can confidently move away from a contaminated environment with minimal risk of transferring disease.

Heaviest contamination of personnel will occur:

- when infected animals are inspected and diagnostic samples are collected;
- at the sites of carcase slaughter, removal or disposal; and

- when faecal or organic matter and residues are removed from ponds, tanks or pens during the clean-up phase.

9.2.1 Procedures

- 1) It is important that appropriate clothing is chosen before work activities are undertaken, because this will significantly reduce the amount of contamination. Wherever possible, waterproof protective clothing and disposable clothing items (e.g. disposable overalls) should be worn.
- 2) Protective clothing is first cleaned using a sponge or low-pressure pump while it is still being worn. The protective clothing should be washed from top to toe to remove gross material, paying particular attention to the back, under the collar, zips and other fastenings, and the inside of pockets. It is then rinsed with water before being removed and placed in disinfectant solution to soak for the required period.
- 3) Overalls are treated similarly, paying attention to the crotch, pockets and the inside of the bottom of trouser legs.
- 4) Disinfected items are then hung to dry (if they remain on site) or placed in a plastic bag for removal.
- 5) Rubber boots should be thoroughly scrubbed down, paying particular attention to the soles, then soaked completely in disinfecting solution. They should be hung upside down to drain or bagged for removal. Industrial hard hats, or other protective items used on site, must also be scrubbed and bagged.
- 6) Equipment used on a daily basis should be left on site rather than being disinfected and taken out of the infected area. If practical, disposable items and those that are difficult to disinfect should also be left on site for appropriate disposal.
- 7) Any items that require specialised techniques for disinfection (e.g. irradiation or gas fumigation) should be cleaned as thoroughly as possible and placed in sealed plastic bags before they are removed from the site.
- 8) All items removed from the infected site should always be double bagged. The bags should be sprayed with disinfecting solutions and carried in solid containers in case of puncture.
- 9) After removing contaminated clothing, the person should walk across the area, wash their feet in a footbath, change into clean overalls and street shoes, and leave directly without re-exposure to contaminated areas.
- 10) Wherever possible, staff leaving infected premises should shower out through the personal decontamination site. Used towels should be treated as used clothing. Showering with soap, shampoo and hot water is the most effective, safe and practical method for decontamination of staff. Where shower facilities are not available, warm, soapy water should be used for washing face, hair and exposed areas of skin. Few chemical disinfectants are both approved for use on human skin and effective against a wide range of pathogens. Most disinfecting hand washes use either quaternary ammonium compounds, chlorhexidine or povidone-iodine as the disinfecting agent and are mixed with suitable nonirritant detergents. Of these, povidone-iodine has the widest range of biocidal activity.
- 11) Minimum underclothing should be worn and clean spares should be carried. If it is cold, two sets of overalls can be worn.

- 12) Plastic bags containing used overalls and other articles are sealed, given a second wash-down in disinfectant and then placed at the outer limit of the area for collection. They are then taken for cleaning. These garments should be autoclaved or treated as contaminated clothing in a hospital laundry. A sufficient daily supply of clean overalls should be supplied to each work site.
- 13) On returning to home or lodgings, the person should have a long bath or shower. If people are leaving infected premises for other duties, they must avoid susceptible stock for a period of time as directed. This period will be dependent on the pathogen involved and its ability to survive outside of the host.

9.3 Decontamination procedures for diagnostic team personnel

The personal decontamination procedures outlined in [Section 9.2.1](#) relate to all personnel. However, since resources available during the initial stages of the event will vary significantly, some personnel (e.g. diagnostic or surveillance teams) must ensure that they carry sufficient resources to enable personal decontamination.

9.3.1 Equipment and resources for personal decontamination

- PVC protective clothing
- rubber boots
- disposable overalls
- spare overalls
- disposable gloves
- disposable latex/nitrile gloves
- disposable face masks
- alcohol wipes
- safety glasses
- personal soap and towels
- nail brushes
- long-sleeved, heavy-duty gloves
- suitable quantities of disinfectant solutions with powdered formulations preferable to liquids; more than one disinfecting type may be required (eg monosulfates, chloramine-T and povidone-iodine)
- low-pressure sprayer for applying disinfectant solution
- general-purpose detergent
- sufficient quantities of fresh water
- plastic sheets (2@ 3 m × 3 m)

- 10-L buckets
- large (approximately 50 L) plastic bins with lids
- long-handled scrubbing brushes
- large, heavy-duty plastic garbage bags
- quantity of 'zip-loc' plastic bags of varying sizes
- biohazard waste bags
- pen, pencils and paper (preferably waterproof)
- facial tissues.

Full-length overalls, eye protection and gloves should be worn when preparing cleaning and disinfecting solutions.

9.3.2 Procedures

On entering the site

- 1) The site manager should arrange to meet the diagnostic team where there is minimal chance of contamination occurring to their vehicle. If possible, the vehicle should be left outside the contaminated area.
- 2) All jewellery, including watches, should be removed.
- 3) Mobile phones should have the correct time displayed and fully-charged batteries. Phones are placed inside a sealed plastic bag of suitable size.
- 4) Groundsheets should be spread between the vehicle boot and the farm entrance or 'threshold' so that the line demarcating the 'clean' area from the 'dirty' area runs down the middle of the sheets.
- 5) The 10-L sprayer should be filled with disinfectant solution and placed on the groundsheet.
- 6) Diagnostic team personnel should put on two pairs of disposable overalls and rubber boots. The hood of one pair of the overalls must be drawn up over the head, and the legs of the outside pair of overalls worn outside the boots. If the work situation is likely to damage the disposable overalls or weather conditions dictate, plastic waterproofs can substitute for the outer disposable overalls. Street shoes are placed within easy reach in the vehicle boot.
- 7) The minimum of equipment required should be taken onto the site.
- 8) Two buckets should be prepared, one with wash solution and one with disinfecting solution suitable for personal disinfection (e.g. povidone-iodine). Another two plastic bins — one with detergent solution and one with disinfectant — should be prepared for decontaminating equipment.

On leaving the site

- 9) As much dirt and organic material as possible should be removed, preferably via sponging and vigorous hosing.
- 10) Used needles and scalpel blades are placed in a sharps container. The sharps container, disposable syringes and their packaging are placed directly into the biohazard waste bag.

- 11) All paperwork, unexposed equipment, mobile phone, car keys, pens, pencils etc. and samples (in their respective plastic bags or waterproof containers) are cleaned and rinsed in the disinfecting solution and passed over to the 'clean' area.
- 12) Any visible dirt is removed from waterproofs (if applicable), rubber boots and other equipment, paying particular attention to the boot soles, inside the trouser cuffs and equipment that came in direct contact with susceptible animals.
- 13) While standing on the 'dirty side', the person should remove waterproofs and boots and soak them in the disinfecting solution. These items are then placed in a garbage bag (double bag) for disinfection on return to base.
- 14) Disposable overalls and any other disposable items are placed in biohazard waste bags. The biohazard waste and garbage bags (double bag) are sprayed with disinfecting solution and passed over to the 'clean' side.
- 15) The external surfaces of the car boot, door handles, wing mirror and steering wheel should be wiped with a paper towel soaked in disinfecting solution from the garden sprayer. The paper towel is then placed in the biohazard waste bag.
- 16) The sprayer is used to spray wheels, wheel arches, buckets, plastic bins and cover sheet. The cover sheet is then bagged and placed in the empty plastic bin.
- 17) Personnel should thoroughly wash all exposed skin with soap and water, scrub fingernails, blow their noses and clean their ears. Paper towel used for drying and any remaining waste items are placed in the biohazard waste bag, which is sealed. Bags may be left on the site for burning, but if there is any doubt that the bag will be disposed of properly, it should be disinfected again and taken back to base for incineration.

On returning to base

- 18) All equipment should be removed from the vehicle for disposal or disinfection.
- 19) The vehicle should be taken through a car wash.
- 20) Personnel should have a long, hot shower and wash their hair.
- 21) Clothes should be changed again and washed on a hot cycle.

Glossary

Aquaculture establishment	An establishment used for the culture and production of fish species. Establishments may be classified as open, semi-open, semi-closed or closed systems. Refer to the AQUAVETPLAN Enterprise Manual for further details.
AQUAVETPLAN	<i>Australian Aquatic Veterinary Emergency Plan.</i> A series of technical response plans that describe the proposed Australian approach to an emergency aquatic animal disease incident. <i>See also</i> AUSVETPLAN
AUSVETPLAN	<i>Australian Veterinary Emergency Plan.</i> A series of technical response plans that describe the proposed Australian approach to an animal disease emergency incident. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency-management plans.
Biofilter	A structure through which water is circulated and containing a large surface area substrate on which bacteria suitable for the conversion of ammonia to nitrate are grown. Biofilters may be small compact units, as in small aquaria, or large towers, as seen in commercial hatcheries.
Cleaning	The process of removing 'soil' from equipment, personnel and infrastructure.
Composting	The aerobic breakdown of organic material by biological processes.
Control area	A buffer between the restricted area and areas free from disease. Restrictions on this area will reduce the likelihood of the disease spreading further afield. As the extent of the outbreak is confirmed, the control area may reduce in size. The shape of the area may be modified according to circumstances, such as water flows, catchment limits, etc. In most cases, permits will be required to move animals and specified product out of the control area into the free area.
Critical disease control point	Any point within a process or area identified as being critical in limiting the spread of disease.
Dangerous contact premises or area	That which has had a direct, and possibly infectious, contact with an infected premises or area. The type of contact will depend on the agent involved in the outbreak but, for example, may involve animal movements or net/equipment movements.
Decontamination	A combination of physical and chemical procedures that are used to remove soiling and inactivate the target disease organism.
Destocking	The process of removing some or all livestock from an aquaculture facility.

Destruction	The killing by humane means (euthanasia) of infected fish and/or fish exposed to infection.
Diluent	A neutral substance used to reduce the concentration of an active substance.
Disease agent	A general term for a transmissible organism or other factor that causes an infectious disease.
Disinfectant	A chemical used to destroy disease agents outside a living animal.
Disinfection	The application, after thorough cleaning, of procedures intended to destroy the infectious or parasitic agents of animal diseases, including zoonoses. Applies to premises, vehicles and other objects that may have been directly or indirectly contaminated.
Disposal	Sanitary removal of fish carcasses and things by burial, burning or some other process so as to prevent the spread of disease.
Emergency disease event	The detection of a significant exotic pathogen or outbreak of disease, considered of major significance, requiring immediate response and highest priority of resources.
Ensilage	Anaerobic fermentation of organic waste through the addition of acetic acid resulting in significant lowering of the pH.
Enterprise	<i>See Risk enterprise</i>
Fish	Any aquatic animal, including finfish, molluscs and crustaceans.
Hard water	Water containing high levels of mineral solutes, such as seawater.
Incubation period	The period of time from infection to the first appearance of clinical disease. The period will differ depending on the disease involved.
Infected premises or area	The area in which the disease has been confirmed. Definition of an 'infected area' is more likely to apply to an open system, such as an oceanic lease.
Intermediate host	The host in which a parasite undergoes a stage in its development.
Livestock	Any animal held under controlled conditions, may include fish.
Local disease control centre	An emergency operations centre responsible for the command and control of field operations in a defined area.
Material safety data sheet	A document outlining the characteristics and safety hazards associated with a particular chemical compound or product.
Monitoring	Routine collection of data for assessing the health status of a population. <i>See also Surveillance</i>
Nidus	A point of origin or focus of residual contamination potentially resulting in an outbreak of disease.

Operational procedures	Detailed instructions for carrying out specific disease control activities, such as disposal, destruction, decontamination and valuation.
Pigging	The process of passing plugs or other structures through pipes in order to removed accumulations within pipes.
Polar circle	A floating circular structure used to support net pens in finfish aquaculture production.
Premises or area	A production site, which may range from an aquarium to an aquaculture lease in the open ocean.
Quarantine	Legal restrictions imposed on a place, fish, vehicles, or other things, limiting movement.
Risk enterprise	A defined livestock or related enterprise, which is potentially a major source of infection for many other premises. Includes hatcheries, aquaculture farms, processing plants, packing sheds, fish markets, tourist angling premises, veterinary laboratories, road and rail freight depots, and garbage depots.
Sanitation	A process of reducing the overall microflora load on a structure using washing or mild chemical agents.
Saprophytic	The process describing organisms (ie bacteria or fungi) which live on dead or decaying organic matter.
Sentinal animals	Susceptible animals, including fish, of known health status monitored for the purpose of detecting presence of a specific disease agent.
Slurry	A suspension of solids in liquid, unusually animal manure.
Soil/soiling	Any material — mineral or organic — that accumulates on equipment, personnel or within facilities.
Surveillance	A systematic series of investigations of a given population of fish to detect the occurrence of disease for control purposes, and which may involve testing samples of a population.
Susceptible animal	Animal that can be infected with a particular disease.
Vessel	Any boat or floating structure.

Abbreviations

AHPND	acute hepatopancreatic necrosis disease
APVMA	Australian Pesticides and Veterinary Medicines Authority
AQUAVETPLAN	Australian Aquatic Veterinary Emergency Plan
AUSVETPLAN	Australian Veterinary Emergency Plan
AVG	abalone viral ganglioneuritis
AVNV	acute viral necrosis virus (of scallops)
EUS	epizootic ulcerative syndrome
GAV	gill associated virus (yellowhead virus genotype 2)
HPWC	high-pressure water cleaner
IPN	infectious pancreatic necrosis
ISA	infectious salmon anaemia
ISKNV	infectious spleen and kidney necrosis virus
OsHV-1 μ Var	ostreid herpesvirus 1 microvariant
POMS	Pacific oyster mortality syndrome
ppm	parts per million, 1 ppm = 1 mg/L
QAC	quaternary ammonium compound
UV	ultraviolet
WSD	white spot disease
WSSV	white spot syndrome virus
YHV1	yellowhead virus genotype 1

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Index

- abbreviations, 111
- acidic compounds, for cleaning, 33, 48, 89-90
- agricultural and veterinary chemicals
 - legislation, 27
- aldehydes, 48, 77-81
- alkaline compounds, 74-75
- alkaline detergents, for cleaning, 32-33
- anti-pollution legislation, 27
- AQUAVETPLAN
 - defined, 4
- bacteria, 22, 29, 39-40, 54
- biguanides, 49
- biofilms, 29
- biological disinfection, 52-53
- boats, 93-94
- boot cleaners, 34
- brushes and scrapers, 34
- cages, 88-90
- chelating agents, for cleaning, 33
- chloramine-T, 69-70, 88
- chlorine dioxide solutions, 70-72
- chlorine-liberating compounds, 43-46
- cleaning before disinfection, 28-389
 - cleaning compounds, 32-35
 - equipment requirements, 34-37
 - gross soiling, 29
 - increasing water efficiency, 30-32
- cleaning compounds, 32-34
 - acidic compounds, 33
 - alkaline detergents, 32-33
 - other cleaning agents, 34
 - sequestering (chelating) agents, 33
 - wetting agents (surfactants), 33
- composting, 100
- corrosive qualities of chemical
- disinfectant, 53
- decontamination
 - risks and pitfalls, 20
 - assessment of, 25-26
- decontamination process, 17-19
 - stages, 17-18
- decontamination, general principles, 17-60
- decontamination, procedures and recommendations, 59-106
- decontamination, site infrastructure, 86-101
 - boats, 93-94
 - cages and marine equipment, 88-90
 - divers and dive equipment, 95-96
 - earthen ponds, 86-87
 - fish transport containers, 92-96
 - footbaths, 98-99
 - nets, pots, 88-90
 - pipework, 90-91
 - tanks (fibreglass, concrete, plastic), 87-88
 - treatment of slurries, 99
 - vehicles, 96-97
- desiccation, 52
- diagnostic team personnel, 104-106
- disinfecting agents, 42-85
 - advantages and disadvantages, 55-56
 - aldehydes, 48
 - biguanides, 49
 - biological disinfection, 52-53
 - chlorine-liberating compounds, 43-46
 - corrosive qualities, 53
 - desiccation, 52
 - dose calculation, 85
 - heat, 51-52
 - iodophors, 47-48
 - oxidising agents, 43-47
 - ozone, 50-51
 - peroxygen agents, 47
 - pH modifiers, 48-49
 - quaternary ammonium compounds, 49
 - relative susceptibility of pathogens, 53
 - thiosulfate as an inactivator, 85
 - ultraviolet radiation, 49-50
 - working characteristics, 55
- disinfection, 38-58
 - choice of disinfecting agents, 42-56
 - nature of target pathogen, 38-45
- disinfection process, choice of, 24-25
- divers and dive equipment, 95-96
- earthen ponds, 89-90

- enterprise type
 - relevance to planning, 22-23
 - environmental considerations and choice of procedures, 59
 - and planning, 26-27
- equipment requirements, 34-37
 - boot cleaners, 34
 - brushes and scrapers, 34
 - foam projectile pipe cleaning systems, 37
 - high-pressure water cleaners, 36
 - low-pressure sprayers, 34
 - misters, 34
 - net washers, 34
 - pumps, 34,36
- fish transport containers, 92-96
- foam projectile pipe cleaning systems, 37
- footbaths, 98-99
- fungi, 43, 53
- glossary of terms, 107-109
- heat, 51-52
- high-pressure water cleaners, 36
- hypochlorite solutions, 46, 67-69
- iodophors, 47-48, 72-73
- legislation, 27
- low-pressure sprayers, 34
- marine equipment, 88-93
- mineral accumulations, 30
- misters, 34
- net washers, 36, 88-90
- occupational health and safety, 26-27, 52, 59-61
- oily buildups, 29
- organic fouling, 30
- ozone, 50-51
- pathogen, type
 - relevance to disinfection, 38-42, 44-45
 - relevance to planning, 21-22
- peroxygen compounds, 47, 75-76
- personnel procedures. *See* procedures for personnel
- pH levels, 31
- pH modifiers (acids and alkalis), 48-49
- pipework, 90-91
- planning, 18-27
 - assessment of decontamination, 25-26
 - choice of process, 24-25
 - environmental considerations, 26-27
 - legislation, 27
 - nature of the pathogen, 21-22
 - type of enterprise, 22
 - type of material requiring decontamination, 22-23
 - water supply, 23-24
 - workplace safety, 26
- ponds, earthen, 86-87
- procedures for personnel, 102-106
 - diagnostic team personnel, 104-106
 - personal decontamination procedures, 102-106
- personnel decontamination site, 105-106
- protein accumulations, 29
- protozoal parasites, 40-42, 53
- pumps, 34, 36
- quaternary ammonium compounds, 49
- recommendations, enterprise types, 62-66
 - closed systems, 66
 - open systems, 62-63
 - semi-closed systems, 64-66
 - semi-open systems, 63-64
- recommendations, general, 59-61
 - chemical use considerations, 59
 - environmental considerations, 59
- safety considerations, 59-61
- recommendations, specific disinfecting agents, 67-84
 - aldehydes, 77-80
 - alkaline compounds, 74-75
 - calculation of concentration and quantities, 85
 - chloramine-T, 69-70
 - hypochlorite solutions, 67-69
 - iodophors, 72-73
 - peroxygen compounds, 75-76
 - stabilised chlorine dioxide solutions, 70-72
 - use of thiosulfate to inactivate oxidising disinfectants, 85
- risks in the decontamination process, 20
- sediment accumulations, 29
- sequestering agents, for cleaning, 33-34
- slurries, 99-101
- soiling- gross, 29
- stages in decontamination process, 17-19

surface wetting agents, for cleaning, 33
surfactants, for cleaning, 33
tanks, 87-88
thiosulfate, 85
turbidity, 31-32
ultraviolet radiation, 49-50
vehicles, 96-97
viruses, 38-39, 44-45, 53
water hardness, 31
water supply, 23-24
water temperature, 30-31
workplace safety. *See* occupational health
and safety