

Dike Operation and Maintenance Manual

TEMPLATE

(for Dikes and Associated Flood Protection Works)



Public Safety Section
Water Management Branch

Province of British Columbia
Ministry of Environment, Lands & Parks

January 2001



BRITISH
COLUMBIA

Ministry of Environment, Lands and Parks

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Dike Operation and Maintenance Manual Template

(for Dikes and Associated Flood Protection Works)

This document has been prepared to assist Diking Authorities and flood protection professionals in fulfilling dike safety requirements as legislated under the British Columbia *Dike Maintenance Act*.

Standard management includes a range of activities aimed at ensuring flood protection works are repaired and well maintained, and that advance preparations are made to protect public safety during flood events. In brief, this means implementation by a local diking authority of a continuing funded program including provision for periodic inspection, performance monitoring, operation, repairs and maintenance, contingency emergency planning, and flood patrol and response all in accordance with the system Operation and Maintenance Manual.

The purpose of this document is to provide advice and information to assist diking authorities in preparing new, or in updating existing, Operation and Maintenance Manuals. The document takes the form of a template which, with system specific data and expert advice, may be adapted for local use.

P.J. Woods, P.Eng.
Inspector of Dikes

January 2001

Forward

The purpose of this document is to provide a template so that communities in areas protected by flood protection works may easily create an Operation & Maintenance (O & M) manual for their flood protection system. Large flood protection facilities, with many dikes and sophisticated equipment, will require additional operation and maintenance procedures not covered by this template.

The intent of this guide is NOT to replace existing O & M Manuals, but rather to ease difficulties encountered by numerous communities where extensive, and expensive, manuals are not required. This guide is also NOT intended to fully identify the requirements applicable to new or proposed works. Such proposals will require design, construction, and documentation acceptable to Ministry of Environment, Lands & Parks..

Instructions for Using the Template to Create the O & M Manual

The template is embedded within this document so that when the Fundamental Information (Chapter 2) has been completed, the template *becomes* the O & M Manual. To create a basic O & M Manual, the local diking community association or the Diking Authority simply needs to fill in the tables in Chapter 2, Fundamental Information. These tables are printed on the blue pages. Data specific to the flood protection works should be filled in and any inappropriate items crossed out. Once the fundamental tables are completed and the new title filled in, the basic O & M Manual is complete.

Chapter 3 (yellow pages) includes information that is supplementary. Some information is already filled in as reference material. The site-specific information in the tables should be filled in over time, and technical information (including drawings, manufacturer information, etc) should be inserted directly in the binder or into a ‘data pocket’.

As information is added to Chapter 3, a check mark should be placed in the appropriate box on the Table of Contents and in the relevant section in Chapter 3. This will assist users of the manual to identify the information that is included.

The Emergency Response Plan for the local area may be inserted into Chapter 3.

Layout of the Manual

The manual is divided into four Chapters. Chapters 1, 2, and 3 include increasing detail of information on the flood protection works and Chapter 4 includes the references.

The information in the first three chapters is presented in the following order:

- *Administrative* information including location, ownership, management, taxes;
- *Physical* description of the flood protection works;
- Information identifying the predictable *flood hazard* including high water seasons, flood history, and hydrometric data;
- *Inspection* requirements for the flood protection works;
- *Maintenance* requirements;
- *Emergency repair work* information and problem identification;

Emergency Response Plan (insertion is optional).

Operation and Maintenance Manual

FOR

(Dike Name)

Of The

(Diking District)

(Dike Owner)

Table of Contents

1. Background Information.....	i
1.1 Administration.....	1
1.2 Physical Works.....	1
1.3 Flood Hazard.....	1
1.4 Inspection.....	2
1.5 Maintenance.....	2
1.6 Emergency Work.....	3
Emergency Warning.....	3
Emergency Repairs.....	3
1.7 Emergency Response Plan.....	3
2. Fundamental Information.....	5
Table 1. Administrative Information for the Flood Protection System.....	5
Table 2. Regional and Local Contact Names and Agencies.....	6
Table 3. Summary of Legislation Applicable to Flood Protection Works.....	7
Table 4. Summary of Relevant Available Guides.....	8
Table 5. Overview of the Flood Protection Works.....	9
Table 6. Physical Description of the Works.....	10
Table 7. Sensitive Months for Flood Concern and Hydrometric Considerations.....	11
Table 8. Annual Inspection Activities.....	12
Table 9. Special Inspections.....	14
Table 10. Routine Surveillance Check List (Whenever you visit the site.).....	15
Table 11 Inspection and Maintenance Schedule.....	16
Table 12 Routine Maintenance Activity Summary.....	17
Table 13. Troubleshooting Guide (An Example).....	18
Table 14. Summary of Emergency Conditions and Repair.....	19
3. Supplementary Information.....	21
3.1 Administration.....	21
<input type="checkbox"/> Additional administrative information is included:.....	21
<input type="checkbox"/> Table 15. Stakeholders.....	22
<input type="checkbox"/> Table 16. Property Owners within the Flood Protection Area.....	23
<input type="checkbox"/> Table 17. Local Contractors & Suppliers.....	24
3.2 Physical Works.....	25
<input type="checkbox"/> Additional Physical Works information is included:.....	25
<input type="checkbox"/> Table 18 Design Criteria.....	26
3.3 Flood Hazard.....	27
<input type="checkbox"/> Additional flood hazard information is included:.....	27
<input type="checkbox"/> Table 19. Past Flooding Events Record.....	28
<input type="checkbox"/> Table 20. Hydrometric Records and Streamflow Gauges.....	29
3.4 Inspection.....	30
<input type="checkbox"/> Additional inspection information is included:.....	30

3.5	Maintenance of Flood Protection Works	31
	✓ Additional information is included:	31
	Dike Maintenance	32
	✓ Table 21 Summary of Supplementary Dike Maintenance Considerations	33
	Slope & Bank Erosion Protection	34
	✓ Table 22 Summary of Supplementary Slope & Bank Protection Maintenance Considerations.....	34
	Floodbox	35
	✓ Table 23 Summary of Supplementary Floodbox Maintenance Considerations	35
	Pump Station.....	36
	✓ Table 24. Typical Pump Station Surveillance Checklist	37
3.6	Emergency Repair Work	38
	✓ Additional information is included:	38
	Active Boiling.....	38
	Excessive Slope Seepage.....	39
	Riverside Erosion.....	39
	Wavewash.....	39
	Local Overtopping	40
	Internal Drainage	40
3.7	Emergency Response Plan inserted	40
4.	References	41

1. Background Information

This chapter provides background information applicable to all flood protection systems. Site specific information is included in the following chapters.

An O & M Manual is the most important reference for management of the flood protection system. It is the place to turn whenever there are questions or concerns about flood protection in a community, from how to maintain vegetation, to where to turn in a flood emergency. Regular inspection and maintenance of works is necessary to maintain the dependability of the system.

The O & M Manual is intended to be a comprehensive and up-to-date document into which new information will be added over time and as experience is gained. Future operators and residents can then benefit from and build on previous experience.

1.1 Administration

Administration information is important as it clarifies the ownership and management issues specific to the flood protection system.

Fundamental administration information is identified in Chapter 2, and includes the following:

- areas and facilities that could be affected by flooding,
- local government and association,
- diking organization and taxation arrangements,
- management arrangements for inspection and maintenance,
- regional contacts including PEP, governments and authorities
- local contacts such as local committee or ratepayers association members,
- landowners and stakeholders affected by flooding or involved in management of the system,

- provincial and federal legislation applicable to works on and around the flood protection system,
- relevant local legislation and bylaws.

1.2 Physical Works

The flood protection works are described in this section. Areas with restricted access need to be identified, as access to the dike system is very important during emergency events. There should be no obstacles that prevent access by authorized vehicles. **Access to dikes should be restricted to authorized vehicles only and access routes must be kept accessible at all times.**

Fundamental descriptive information is identified in Chapter 2, and includes:

- An overview including identification of the watercourse, location, year of construction and upgrades, and a list of structures and associated appurtenances
- A description of the structures and appurtenances associated with the works including location, lengths, sizes, etc.
- Access difficulties and considerations.

1.3 Flood Hazard

The flood hazard, for which the flood protection works have been constructed, is identified in this section. Certain conditions and times of the year can be established as 'sensitive' to flooding. **Unexpected conditions, including rain, temperatures, storms, and debris jams, can create flood conditions at any time of the year.**

Fundamental information on the predictable flood hazard is identified in Chapter 2, including the sensitive months and the types of activities to be performed during, before, or after each period. Issues that create sensitive months include the identifiable high and low water periods and the usual wet season. Other important information includes the ‘fisheries construction window’ – the time period each year, for the specific watercourse, during which permits for construction MAY be obtained (through MELP). The availability of hydrometric data is also identified.

Information regarding how to obtain data for this chapter can be obtained from MELP.

1.4 Inspection

Frequent periodic inspection is essential for identification of areas requiring maintenance before major problems develop. Both inspection and maintenance are required to maintain the dependability of the flood protection system.

Information in this section includes a description of the items to be covered in routine annual inspections and in special inspections. Annual inspections should be completed prior to the *flood hazard* ‘sensitive month’ of the high flow season (see above) and early enough to allow adequate time for any required work to be completed prior to possible flood events. Special inspections are conducted during high and low water events, after an occurrence of a flood or earthquake, and as needed to react to particular situations such as storms, stream channel sedimentation or degradation, ice or debris jamming events, etc.

In addition to annual inspections, the appurtenances of the flood protection system (such as pump station and floodbox) may require more frequent checks to verify that the system is operational. These surveillance visits provide an opportunity for frequent surveillance to check for any obvious problems with the system.

All inspections should be scheduled, conducted and documented according to the “*Flood Protection Works, Inspection Guide*” (3).

1.5 Maintenance

The flood protection works must be maintained to assure serviceability of the structures in time of flood. Failure to maintain works properly may render the flood protective system inoperative during periods when protection is needed. As well, neglect of maintenance will mean significant capital expenditures in the future to rehabilitate a deteriorated structure.

Maintenance should correct all problems and concerns identified in inspections, and should include the control of development and construction on, through or in, the vicinity of flood control works, to ensure that the standard of protection provided by the works is maintained.

Access to the dike crest, slopes and adjacent bank protection must be maintained to permit inspection and repair of the dike, bank protection, and adjacent flood protection works.

Vegetation control is an important aspect of maintenance as excessive growth can obscure problems and tree roots can threaten the stability of the dike itself. Vegetation on the dike slope should ideally consist of closely trimmed grass. Tree and brush growth should be removed for the following reasons:

- Vegetation attract burrowing animals whose burrows are detrimental to dike stability.
- Tall vegetation obscures signs of seepage or damage to the dike which thus may go undetected and eventually cause dike failure.
- Tree roots, when they decompose, can encourage the development of pipes and consequent dike failure.
- Large trees pose an additional threat to dike stability, especially during flood events when the dike structure becomes saturated. High winds and overbank erosion during floods can cause trees to fall resulting in the displacement of dike fill material and possible failure of the dike as well as debris problems downstream. In coastal regions especially, these conditions may occur simultaneously.

Vegetation control should be in accordance with *Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment* (5).

Fundamental maintenance information is identified in Chapter 3, and includes a schedule, based on the *flood hazard* ‘sensitive months’ (see above), for surveillance checks, inspections, and routine maintenance activities. Maintenance may be required more frequently than identified in the schedule when safety, security, and operational issues warrant. A ‘typical’ troubleshooting guide is included as a reference and this table can be modified as necessary for specific facilities.

1.6 Emergency Work

If there is a threat to the safety of the dike, the Local Diking Authority may carry out any work that is essential to prevent the dike or bank protection from failing, when site conditions provide a safe working environment. Further information is available in the *Flood Planning & Response Guide* (7).

The local diking authority is responsible to ensure there is adequate personnel, equipment and materials available to respond to emergency conditions. As the river rises to critical levels, crews should be prepared to undertake emergency repairs as discussed below. Environmental agencies should be consulted for advice as to good environmental practise.

Emergency Warning

An emergency warning is necessary when the possibility of uncontrollable dike failure is identified. Such failure could occur due to an identified potential overtopping or a breach.

If a potential failure is identified, the local Emergency Response Plan should be implemented.

The Local Authority and community group(s) should confine their efforts to preventing flooding while ensuring the safety of the workers.

Emergency Repairs

If there is a threat of failure to the dike system, repair work that is essential to prevent the dike or bank protection from such failure should be undertaken immediately, as long as working conditions remain safe. An emergency warning (see above) should be issued if there is concern of an imminent dike failure. If high water levels are sustained for some time, and the dikes become thoroughly saturated, it may become necessary to restrict traffic on the dike crest road and in low-lying areas near the dike.

A summary of emergency conditions and repairs is included in Chapter 2, **Table 14**, and supplementary information on failure modes and repair is identified in Chapter 3.

1.7 Emergency Response Plan

An emergency response plan is important to provide for the safety of the public and is required by provincial legislation. Emergency plans are intended to prevent loss of life, and to minimize damage to and loss of property resulting from flooding. For detailed information, see the *Flood Planning and Response Guide* (7).

A copy of the local Emergency Response Plan can be inserted in section 3.7.



Pump disassembled for maintenance.

2. Fundamental Information

Table 1. Administrative Information for the Flood Protection System

Item	Description
<p>Areas that could be Affected by Flooding and Areas Protected by Facilities <i>(towns, communities, districts, public facilities, etc.)</i></p>	<p><input type="checkbox"/> Towns, communities, districts: _____ _____</p> <p><input type="checkbox"/> Homes, residential complexes <input type="checkbox"/> Agricultural lands, farms, etc <input type="checkbox"/> Airport _____ <input type="checkbox"/> Highways, railroads _____ <input type="checkbox"/> Schools _____ <input type="checkbox"/> Utilities, _____ <input type="checkbox"/> Public facilities _____</p>
<p>Local Government <i>(municipality / regional district)</i></p>	<p>Address: Phone: Fax:</p>
<p>Local Association <i>(residents' association, rate payers' association, etc.)</i></p>	
<p>Diking Taxes : Paid by local residents? <input type="checkbox"/> yes <input type="checkbox"/> no</p>	<p>If yes, Diking taxes paid to: <i>(local government, district, association, Inspector of Dikes, etc.)</i> Diking taxes provided to: <i>(rate payers association, etc)</i> By: <i>(direct taxation / grant from district)</i></p>
<p>Dike Right-of-Way or Easement</p>	<p>ROW: registered <input type="checkbox"/> yes <input type="checkbox"/> no Easement: registered <input type="checkbox"/> yes <input type="checkbox"/> no</p>
<p>Management of System</p>	<p>Diking Authority (under the Dike Maintenance Act):</p>
<p>Dike Inspections</p>	<p>Group responsible to conduct dike <i>inspections</i> <i>(Local Diking Authority, Inspector of Dikes, etc.)</i></p> <p>Is there a special agreement in place for inspections? <input type="checkbox"/> yes <input type="checkbox"/> no</p>
<p>Dike Maintenance</p>	<p>Group(s) responsible to undertake maintenance activities:</p> <p>Is there a special agreement in place for inspections? <input type="checkbox"/> yes <input type="checkbox"/> no</p>

Table 2. Regional and Local Contact Names and Agencies

Organization	Office Address & Phone	Representatives & Phone Numbers	After-hours Phone Numbers
Provincial Emergency Program (PEP)	1-800-663-3456		
Local Government			
Diking Authority			
MELP	Water Management Branch, Victoria	(250) 387-1531	
MELP Regional Office			
RCMP or Police (local detachment)			
Local Committee or Association			
Local Committee Members			
Stakeholders and Landowners			

Table 3. Summary of Legislation Applicable to Flood Protection Works

Legislation	Type of Work Proposed	Contact Authority* (for information & direction)
Written approval from the Office of the Inspector of Dikes (MELP) is required, as per the Dike Maintenance Act, prior to the start of any construction work on or near flood protection works. Approvals from other government offices may also be required.		
Dike Maintenance Act	<ul style="list-style-type: none"> ▪ Proposed work at or near existing flood protection works ▪ Proposed new flood protection works. 	<ul style="list-style-type: none"> ▪ MELP
Water Act	<ul style="list-style-type: none"> ▪ Any work proposed in and about watercourses. ▪ Any instream work or crossings. ▪ Proposed gravel or sediment removal or excavation. 	<ul style="list-style-type: none"> ▪ MELP
Canada Fisheries Act	<ul style="list-style-type: none"> ▪ Any proposed work or vegetation removal in or adjacent to waters frequented by fish or containing fish habitat (marine or fresh water). 	<ul style="list-style-type: none"> ▪ MELP. ▪ DFO.
Land Act	<ul style="list-style-type: none"> ▪ Proposed gravel removal / borrowing 	<ul style="list-style-type: none"> ▪ BCAL (where the stream-bed is on Crown Land).
Forest Act	<ul style="list-style-type: none"> ▪ Removal of merchantable trees and wood from Crown land including streambeds and banks. 	<ul style="list-style-type: none"> ▪ MOF.
Navigable Waters Protection Act	<ul style="list-style-type: none"> ▪ All proposed work within, above or under the wetted perimeter of a navigable water (defined in the Act). 	<ul style="list-style-type: none"> ▪ MOT.
BC Environmental Assessment Act	<ul style="list-style-type: none"> ▪ Major projects. (Legislation under development.) 	<ul style="list-style-type: none"> ▪ MELP.
Local Government Act	<ul style="list-style-type: none"> ▪ Provides for formation of bylaws and Improvement Districts. ▪ Authorizes new Diking Authorities. ▪ Provides authority for local government to regulate diking works. 	<ul style="list-style-type: none"> ▪ Local Government. ▪ PEP.
Emergency Program Act	<ul style="list-style-type: none"> ▪ Requires a local government to establish and maintain and emergency management plan. ▪ Provides local government authority to declare a state of emergency. 	<ul style="list-style-type: none"> ▪ Local Government.
Other Legislation (local bylaws, etc)		

MELP: BC Ministry Of Environment, Lands & Parks.

MOF: BC Ministry of Forests.

DFO: Department of Fisheries and Oceans (Government of Canada)

BCAL: BC Assets & Land Corporation

MOT: Minister of Transport (Government of Canada)

PEP: Provincial Emergency Program

For further information on legislation relevant to flood protection works, see *Guidelines for Management of Flood Protection Works in British Columbia* (1), and www.qp.gov.bc.ca/bcstats/.

Table 4. Summary of Relevant Available Guides

Information covered	Guide	Date of publication
<ul style="list-style-type: none"> ▪ Summary of legislation & regulation relevant to flood protection works. ▪ Approvals & controls under the Dike Maintenance Act. ▪ Responsibilities for flood management. ▪ Overview of operation, maintenance, & emergency measures. ▪ Checklists. 	Guidelines for Management of Flood Protection Works in British Columbia (1)	March 1999
<ul style="list-style-type: none"> ▪ Responsibility of local government for flood hazard management and development in flood prone areas: <ul style="list-style-type: none"> ▪ Authority and regulation, ▪ Implementation of controls, ▪ Official Community Plans, ▪ Floodplain bylaws. ▪ Steps in preparation of a floodplain bylaw (including a sample bylaw). 	Regulatory Tools for Flood Hazard Management A Guide for Local Government (2)	March 2000
<ul style="list-style-type: none"> ▪ A complete guide to inspection of flood protection works including dikes and appurtenances. ▪ Inspection scheduling, preparation, record keeping, report forms, patrol logs, etc. ▪ Field guides to identifying problems. ▪ Explanation of typical issues affecting flood protection works. 	Flood Protection Works Inspection Guide (3)	March 2000
<ul style="list-style-type: none"> ▪ Guide to design and placement of riprap for bank and slope protection. ▪ Design considerations. ▪ Construction practices and placement. ▪ Emergency repair. ▪ Maintenance. ▪ Technical appendix. 	Riprap Design and Construction Guide (4)	March 2000
<ul style="list-style-type: none"> ▪ Minimum standards for vegetation management on flood control structures. ▪ Environmentally sensitive approach to vegetation control. ▪ Consideration of fish habitat and dike maintenance activities. 	Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment (5)	March 1999
<ul style="list-style-type: none"> ▪ Responsibilities under the Emergency Preparedness Act (EPA). ▪ Flood response activities. ▪ BC Flood Plan 	Water Related Hazards Emergency Response Plan and Procedures (6)	February 1998
<ul style="list-style-type: none"> ▪ Emergency planning and preparedness in B.C. 	See web site: www.pep.bc.ca	
Local Guides (eg. <i>Gravel removal guide in Chilliwack</i>)		

Table 5. Overview of the Flood Protection Works

Item	Description
Watercourse <i>(river, lake, inlet, ocean)</i>	
General Location <i>(town, region, local name)</i>	
Specific Location <i>(right/left/both banks when looking downstream)</i>	
Year of Original Construction	
Year(s) of Upgrades / Rebuilds	
Dike(s)	✓ yes Number:
Bank / Slope Protection	<input type="checkbox"/> yes <input type="checkbox"/> no Number of locations:
Floodbox(es)	<input type="checkbox"/> yes <input type="checkbox"/> no Number of locations:
Pipe / Storm Sewer(s)	<input type="checkbox"/> yes <input type="checkbox"/> no Number of locations:
Pump Station(s)	<input type="checkbox"/> yes <input type="checkbox"/> no Number:
Trash Rack(s)	<input type="checkbox"/> yes <input type="checkbox"/> no Number of locations:
Water Level Gauge(s)	<input type="checkbox"/> yes <input type="checkbox"/> no Number:
Other:	<input type="checkbox"/> yes <input type="checkbox"/> no Number:
Access Route <i>(direction, road, etc.)</i>	
Access restricted <i>(locked gate / private property ,etc.)</i> <input type="checkbox"/> yes <input type="checkbox"/> no	Access / keys available through:

Table 6. Physical Description of the Works

Item	Location	Description
Dike	<i>(left/right bank)</i>	<i>(length)</i>
Bank / Slope Protection	<i>(left/right bank)</i>	<i>(type of protection (e.g. riprap))</i>
Floodbox		<i>(number, size, material at each location)</i>
Pipe / Storm Sewer		<i>(number, size, material at each location)</i>
Pump Station		<i>(number and type of pumps, etc.)</i>
Trash Rack	<i>(location, purpose)</i>	<i>(size, type, etc.)</i>
Water Level Gauge	<i>(location)</i>	Datum: _____ m GSC

Note: Systems with more than one of any item above (protection works) should include additional information. Extra pages or multiple rows below first entry may be used as necessary.

Table 7. Sensitive Months for Flood Concern and Hydrometric Considerations

Item	Sensitive Months	Importance and Activities
<p>Usual High Water Period (Usual flood season)</p>		<ul style="list-style-type: none"> ■ Usual or predicted flood threat season(s).* ■ Annual inspection and necessary maintenance should be completed prior to usual flood season. ■ Water level gauges should be read during the high water period. ■ High water inspections and watches may be needed.
<p>Usual Wet Season (heavy rainfall)</p>		<ul style="list-style-type: none"> ■ High water inspections and watches may be needed. ■ Read water level gauges.
<p>Usual Low Water Period</p>		<ul style="list-style-type: none"> ■ Low-water inspections to be completed. ■ Repairs to areas exposed during low water should be completed. ■ Annual maintenance should be done in months prior to onset of usual flood season.
<p>Fisheries Construction Window</p>		<ul style="list-style-type: none"> ■ Period when work in the specified watercourse is allowed. (Approval through MELP required.)

* Note: Unexpected conditions, including rain, temperatures, storms, and ice and debris jams, etc., can create flood conditions *at any time of the year*.

Table 8. Annual Inspection Activities

Component	Inspection Items ¹	Operational Duties
Safety	<ul style="list-style-type: none"> ▪ Take safety seriously and take precautions. 	<ul style="list-style-type: none"> ▪ Review safety requirements and take precautions.
Reporting	<ul style="list-style-type: none"> ▪ <i>Flood Protection Works Basic Inspection Checklist¹</i> 	<ul style="list-style-type: none"> ▪ Fill in inspection checklist. Identify required maintenance work. ▪ File inspection report in O & M Manual.
Access	<ul style="list-style-type: none"> ▪ Check for security; safety, vandalism; signage, operation. ▪ Check condition of crest road. ▪ Check for obstructions to access, conditions of fences, gates, etc., availability of keys. 	<ul style="list-style-type: none"> ▪ Initiate repair or correct access and safety issues as soon as possible.
Dike	<ul style="list-style-type: none"> ▪ Check crest, slopes, and toe for <ul style="list-style-type: none"> ▪ settlement, depressions, sinkholes ▪ cracking, slides, sloughing, ▪ erosion, ▪ seepage, piping, boils, ▪ loss of freeboard, low spots. ▪ Look for unauthorized activity (construction, excavation, etc). ▪ Check for areas where vegetation hampers inspection and/or may weaken the dike. ▪ Look for rodent activity – paths and burrows. (Beavers can cause serious sinkholes.) One or more inspections annually to be done at low water to include toe.) ▪ Check for unauthorized excavation or construction on or adjacent to dike. ▪ Check river flow pattern for changes, deposition, scour, debris jams, etc. ▪ Check condition of scour or erosion around bridges or other structures in the vicinity. 	<ul style="list-style-type: none"> ▪ Identify needed repairs. ▪ Report unauthorized activity. ▪ Complete Basic Inspection Checklist¹ and Flood Protection Inspection Report¹ during annual inspection. Insert copy of report into O & M Manual and provide copy to DIOD.
Bank / Slope Protection	<ul style="list-style-type: none"> ▪ Check bank protection along river for signs of erosion, damage to existing protection, including: <ul style="list-style-type: none"> ▪ Loss, disturbance, weathering, or abrasion of protective material, ▪ Sloughing or cracking on slope, ▪ Scour at the toe (Toe to be done at low water), ▪ Erosion or scour of upstream or downstream ends (outflanking), ▪ Animal burrows and activity, ▪ Vegetation growth through bank protection material. 	<ul style="list-style-type: none"> ▪ identify needed repairs.

Component	Inspection Items ¹	Operational Duties
Floodbox	<ul style="list-style-type: none"> ▪ Check condition of flap gates and operation to open and close freely providing a watertight seal. ▪ Check inlet and outlet for debris, structural conditions, etc. ▪ Check for leaks: look & listen for trickling or flow in inlet channel. ▪ Check outlet at low water for leaks and operation of gates. ▪ Check exposed outlets in the vicinity of the sea for corrosion. 	<ul style="list-style-type: none"> ▪ Identify needed repairs. ▪ Monitor identified minor leaks.
Pipe or Storm Sewer	<ul style="list-style-type: none"> ▪ Check structural integrity of inlet/outlet structures. ▪ Check for clear flow path; debris blockage. ▪ Check for erosion or sedimentation at inlet and outlet. 	<ul style="list-style-type: none"> ▪ Identify needed repairs.
Pump Station	<ul style="list-style-type: none"> ▪ Check security; vandalism, signage outside and inside station. ▪ Check access structures and railings for safety, security. ▪ Check for debris, sedimentation, or other problems at inlet or outlet. ▪ Check structural condition and functional operation of pumps. ▪ Check outlet for free and effective flow. ▪ Check maintenance records. ▪ Check condition of pump power source (lines, control switches, breakers, etc.) ▪ Check for areas where vegetation hampers inspection. ▪ Check for beaver activity. 	<ul style="list-style-type: none"> ▪ Make entries into logbook: pump hours, deficiencies. ▪ Run pump and motor to check for smooth operation and discharge. (See Troubleshooting Guide in Section 5 as necessary.) ▪ Check and tighten grease cup at motor. ▪ Identify needed repairs.
Trash Rack	<ul style="list-style-type: none"> ▪ Check structural condition. ▪ Check for debris or sediment blockage hampering flow. 	<ul style="list-style-type: none"> ▪ Identify needed repairs.
Water Level Gauge	<ul style="list-style-type: none"> ▪ Check for damage, proper operation. ▪ Check reference level, visibility of gauges, monitoring equipment. 	<ul style="list-style-type: none"> ▪ Read and record water level. ▪ Ensure gauge is maintained at correct datum. Identify repair or re-leveling required.
Low water inspections	<ul style="list-style-type: none"> ▪ Check toe for rodent activity, seepage, settlement, condition of bank protection etc. ▪ Check all outlets for leaks, gate operation, debris, etc. 	<ul style="list-style-type: none"> ▪ Identify needed repairs.

¹ For more information, see *Flood Protection Works, Inspection Guide* (3).

Table 9. Special Inspections

Type of Inspection¹	Inspection Items¹	Operation Duties¹
Low water inspections	<ul style="list-style-type: none"> ■ Conducted at least once annually (see Table 11). 	<ul style="list-style-type: none"> ■ See Table 8 Annual Inspection Activities.
High water patrol inspections	<ul style="list-style-type: none"> ■ Conducted during floods and high water events. ■ Monitor the performance of the flood control works. ■ Monitor land side slope and toe for excessive seepage and possible piping problems. 	<ul style="list-style-type: none"> ■ Organize dike patrols, if required in flood years. ■ Initiate or take corrective action as required.
Post Flood	<ul style="list-style-type: none"> ■ Conducted after a flood event. 	<ul style="list-style-type: none"> ■ Develop high water profile. ■ Inspect and assess condition of works.
Post Earthquake	<ul style="list-style-type: none"> ■ Integrate with emergency plan. 	<ul style="list-style-type: none"> ■ Conduct a rapid overall assessment of remaining level of protection. ■ Identify immediate danger of secondary damage.
Other	<ul style="list-style-type: none"> ■ As needed at other times of the year to react to particular situations including: <ul style="list-style-type: none"> ■ Storms, earthquakes. ■ Stream channel sedimentation. ■ Debris or ice jamming. 	<ul style="list-style-type: none"> ■ Organize dike patrols, if required. ■ Initiate or take corrective action as required. ■ Other duties as needed

¹ For more information, see *Flood Protection Works, Inspection Guide* (3).

Table 10. Routine Surveillance Check List (Whenever you visit the site.)

Component	Inspection Items¹	Operational Duties
Safety	<ul style="list-style-type: none"> ▪ Take safety seriously and take precautions. 	<ul style="list-style-type: none"> ▪ Review safety requirements and take precautions.
Access	<ul style="list-style-type: none"> ▪ Check for security; safety, vandalism; signage, operation. 	<ul style="list-style-type: none"> ▪ Initiate repair of access and safety issues as soon as possible.
Dike (crest, slopes, toe)	<ul style="list-style-type: none"> ▪ Check for obvious problems & damage (erosion, rodent burrows, sinkholes, etc.) 	<ul style="list-style-type: none"> ▪ Initiate repair immediately or with annual maintenance work as needed.
Bank / Slope Protection	<ul style="list-style-type: none"> ▪ Check for obvious problems & damage (erosion, loss of material, scour, etc.) 	<ul style="list-style-type: none"> ▪ Initiate repair immediately or with annual maintenance work as needed.
Floodbox	<ul style="list-style-type: none"> ▪ Check for obvious leaks, debris blockage, gate closure problems. 	<ul style="list-style-type: none"> ▪ Initiate repair immediately or with annual maintenance work as needed. ▪ Monitor identified minor leaks.
Pipe / Storm Sewer	<ul style="list-style-type: none"> ▪ Check inlet and outlet for obvious problems of erosion, deposition, debris, etc. 	<ul style="list-style-type: none"> ▪ Initiate repair immediately or with annual maintenance work as needed.
Pump Station	<ul style="list-style-type: none"> ▪ Check security, signage, etc. ▪ Check safe access bridges, railings, etc. ▪ Check for obvious debris blockages at inlet and outlet. ▪ Check pump operation. ▪ Check outlet for effective flow. 	<ul style="list-style-type: none"> ▪ Make entries into logbook: pump hours, deficiencies. ▪ Check pump and motor for smooth operation and discharge. (If problems are encountered, see Table 12, Troubleshooting Guide.) ▪ Check and tighten grease cup at motor. ▪ Initiate repair immediately or with annual maintenance work as needed.
Trash Rack	<ul style="list-style-type: none"> ▪ Check for obvious damage & blockage problems. 	<ul style="list-style-type: none"> ▪ Initiate repair immediately or with annual maintenance work as needed.
Water Level Gauges	<ul style="list-style-type: none"> ▪ Check for obvious problems and damage. 	<ul style="list-style-type: none"> ▪ Read & record water levels. ▪ Initiate repair immediately or with annual maintenance work as needed.
	<ul style="list-style-type: none"> ▪ 	<ul style="list-style-type: none"> ▪
	<ul style="list-style-type: none"> ▪ 	<ul style="list-style-type: none"> ▪
	<ul style="list-style-type: none"> ▪ 	<ul style="list-style-type: none"> ▪

¹ For details on inspections see *Flood Protection Works, Inspection Guide* (3).

Table 11. Inspection and Maintenance Schedule

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Routine Surveillance¹												
Annual Inspection^{1,2}												
High Water Inspection²	During high water events.											
Low Water Inspection²	At least once annually.											
Routine Maintenance	At least once annually.											
Vegetation Control³												

¹ Once monthly during low water months (✓); twice monthly during high water and wet months (✓✓); more often during periods of heavy rain.

² For more information see *Flood Protection Works, Inspection Guide*. Public Safety Section, Water Management Branch, Ministry of Environment, Lands & Parks; March 2000.

³ Vegetation control should be at least once or twice annually, depending on growth. For more information see *Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment*. BC Ministry of Environment, Lands & Parks and Department of Fisheries and Oceans Canada; March 1999.

Table 12. Routine Maintenance Activity Summary

Component	Maintenance Items	Schedule	Action
Gates, locks, access	<ul style="list-style-type: none"> ▪ Operation of security, safety, and access systems. ▪ Clear access needed at all times. 	<ul style="list-style-type: none"> ▪ Annually or more often if needed. ▪ Safety issues immediately. 	<ul style="list-style-type: none"> ▪ Lubricate locks, hinges, etc. ▪ Correct sign and access issues.
Dike	<ul style="list-style-type: none"> ▪ Integrity of slope and bank erosion protection. ▪ Settlement, sinkholes, loss of material in dike crest and cross section, and other dike damage. ▪ Beaver or other animal activity causing damage to dike. 	<ul style="list-style-type: none"> ▪ Annually or more often if needed for operation. ▪ Safety issues immediately. 	<ul style="list-style-type: none"> ▪ Repair damage and settlement to maintain design elevation and section. ▪ Repair erosion protection. ▪ Carefully explore and expose all rodent holes and tunnels. Excavate and fill with suitable compacted material. ▪ Control animal population as necessary.
Floodbox	<ul style="list-style-type: none"> ▪ Gate operation. ▪ Prevention of backflow through floodbox. 	<ul style="list-style-type: none"> ▪ Annually or more often if needed for operation. ▪ Safety issues immediately. 	<ul style="list-style-type: none"> ▪ Lubricate hinges and locks. ▪ Investigate cause and location of suspected leaks. ▪ Clear debris.
Pump Station	<ul style="list-style-type: none"> ▪ Pump and motor operation. ▪ Pump discharge as per operational requirements. ▪ Controls, electrical, switching. 	<ul style="list-style-type: none"> ▪ Annually or more often if needed for operation. ▪ Safety issues immediately. 	<ul style="list-style-type: none"> ▪ Perform maintenance and repairs to pump and motor. ▪ Re-fill grease cup and lubricate equipment. ▪ Clear debris at inlet and outlet.
Vegetation Control	<ul style="list-style-type: none"> ▪ Mowing / trimming grass and weeds on dike crest and slopes including toe. 	<ul style="list-style-type: none"> ▪ At least once or twice annually. 	<ul style="list-style-type: none"> ▪ Mow dike from crest to toe of slope. ▪ Remove trees as needed.
Water Level Gauges	<ul style="list-style-type: none"> ▪ Operation and visibility of gauge. ▪ Datum level. 	<ul style="list-style-type: none"> ▪ Annually or as necessary. 	<ul style="list-style-type: none"> ▪ Repair & re-level as necessary. ▪ Ensure gauge can be observed from dike. ▪ Maintain correct datum.
Critical Dike Damage	<ul style="list-style-type: none"> ▪ Major leak or settlement. ▪ Structural damage to any part of system. ▪ Stability of dike threatened 	<ul style="list-style-type: none"> ▪ Immediately. 	<ul style="list-style-type: none"> ▪ Repair immediately. ▪ Inform DIOD. ▪ Invoke Emergency Plan if necessary. ▪ Advise landowners as necessary.
Special Maintenance Items	<ul style="list-style-type: none"> ▪ Creek bed erosion ▪ Sedimentation 	<ul style="list-style-type: none"> ▪ As necessary and determined by established procedures. 	<ul style="list-style-type: none"> ▪ Establish procedure for sediment/debris removal ▪ Establish design allowances.

Table 13. Troubleshooting Guide (An Example)

Problem	Details	Action
Beaver holes	<ul style="list-style-type: none"> ▪ Sinkholes or dike damage. 	<ul style="list-style-type: none"> ▪ Carefully explore and expose all tunnels leading to/from main hole. ▪ Excavate holes & tunnels and fill with suitable compacted material.
Motor doesn't start	<ul style="list-style-type: none"> ▪ Power is on but motor/pump doesn't start. 	<ol style="list-style-type: none"> 1. Check connections and plug-ins. 2. Set on MANUAL. 3. Press re-set button. Try to start motor. 4. Check power in building. Lights could be on but one phase off will prevent pump operation. 5. Check main breaker and fuse boxes in station. 6. If power is on and pump still won't start, arrange for repair, contact DIOD. 7. Advise Landowner Contact if pump will be inoperative for a time.
No Power	<ul style="list-style-type: none"> ▪ No power in building. 	<ol style="list-style-type: none"> 1. Check Hydro fuse breakers near pump house and on power poles. 2. Check for downed wires. 3. Check manual power cut-out (if existing). 4. Contact BCHydro. 5. Advise Landowner Contact if pump will be inoperative for a time. Contact DIOD (MELP Regional Office).
Pump runs rough	<ul style="list-style-type: none"> ▪ Rough running with vibration or loud banging noise. 	<ol style="list-style-type: none"> 1. Check for debris inside sump and remove object if visible. (Pump and main breaker must be off.) 2. Observe discharge flow at outlet for fluctuation (i.e. suction at impeller is impeded). 3. Check for cavitation within screened sump (air suction displayed by vortex). 4. Stop and re-start pump to clear debris. 5. Shut down pump if vibration is severe or loud 'banging' noise persists. 6. Arrange for repair as necessary; contact DIOD. 7. Advise Landowner Contact if pump will be inoperative for a time.
Backflow through Floodbox	<ul style="list-style-type: none"> ▪ Leaking suspected by eye or ear. ▪ Gate not properly sealed. 	<ul style="list-style-type: none"> ▪ Monitor minor backflow concern (some minor leaking occurs occasionally when small debris stuck in gate – may correct itself at next high water.) ▪ Check hinge operation at low water. Lubricate or arrange for repair as necessary. ▪ Look for obvious blockage at gates – logs, submerged objects or rocks blocking free swing of gate doors. Arrange for debris removal as necessary.

Table 14. Summary of Emergency Conditions and Repair

Emergency Condition	Definition	Problem	Repair
Active boil	Stream of seepage water carrying silt and sediment and rising as a spring in a depression – on landside of dike	Sudden failure due to undermined dike foundation.	Construction of an impervious ring around boil to stop transportation of solid material.
	Contact emergency organization if (1) active boils extensive, (2) inactive boils and water levels rising. IMPLEMENT EMERGENCY RESPONSE PLAN IF DIKE FAILURE IS POSSIBLE.		
Slope Seepage (excessive)	Percolation of water through or under the dike foundation – usually visible in landside toe ditch.	Sloughing of landside toe, threatening dike stability.	Add free draining fill berms where landside slope soggy.
	Obtain expert advice on slope stability where time permits. IMPLEMENT EMERGENCY RESPONSE PLAN IF DIKE FAILURE IS POSSIBLE.		
Riverside Erosion	Scour of riverside slope of dike, berm, or bank.	Removal of dike material under the water surface resulting in dike failure.	Additional bank protection (such as large riprap). End dumping acceptable in emergency situation only.
	Obtain expert advice on bank protection and stability where time permits. IMPLEMENT EMERGENCY RESPONSE PLAN IF DIKE BREACH IS POSSIBLE.		
Wavewash	Erosion of the dike slope by wave action (high wind and wave conditions).	Removal of exposed materials causing breach.	Placement of protective material or filled sacks. Patrol identified areas and monitor closely.
	Obtain expert advice on likely locations of wavewash prior to high water..		
Local Overtopping	Flow of water over the dike crest.	Breach of dike due to wash out of crest material once overtopping occurs.	Sandbags for raising short sections of the dike. Other methods of adding material for longer dike sections.
	IMPLEMENT EMERGENCY RESPONSE PLAN IF OVERTOPPING OR BREACH IS POSSIBLE. No heavy equipment on dike when water level is high.		
Internal Drainage	Local runoff and drainage from areas inside dike which is trapped due to high water on the receiving watercourse.	Saturation of landside of dike. Possible flooding of areas internal to dike.	Temporary pumping or upstream diversion of inflow from higher elevations.
	Maintain a list of potential pump and generator suppliers.		

3. Supplementary Information

3.1 Administration

The O & M Manual can serve as the place to document all information regarding the flood control works, and a list of local contractors and experts can be very useful when work is required on the works. Table 15 is an example table that can be copied and filled in with information relevant to the local area and works, as suggested in the list below. Additional information and suggested tables are included in the “*Flood Planning and Response Guide*” (7).

Additional administrative information is included:

Information	Located:
<input type="checkbox"/> Copies of Relevant Documents & Drawings <ul style="list-style-type: none"> <input type="checkbox"/> Maps, plans, drawings, including benefit area <input type="checkbox"/> Agreements <input type="checkbox"/> Government Acts <input type="checkbox"/> Right-of-way information <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 	
<input type="checkbox"/> Stakeholders <ul style="list-style-type: none"> ▪ Agencies and individuals concerned with flooding issues. 	Table 15
<input type="checkbox"/> Property Owners	Table 16
<input type="checkbox"/> Local Contractors and Suppliers <ul style="list-style-type: none"> ▪ Local or experienced professionals ▪ (such as engineering firms and construction firms). ▪ Local contractors and equipment. ▪ Locally available rental equipment (such as pumps and generators). ▪ Local sources and available materials (such as gravel pits, sources for riprap and fill material). ▪ ▪ ▪ 	Table 17
<input type="checkbox"/> Local Authority supplies available: <ul style="list-style-type: none"> ▪ Stores, services, equipment, ▪ Radios and cellular telephone numbers, ▪ Employees with first aid certification. ▪ ▪ 	
<input type="checkbox"/> Drawings and Maps <ul style="list-style-type: none"> ▪ Plan or map of protected (benefit) area. ▪ Aerial photos. 	

Table 15. Stakeholders

Corporation	Contact Person	Phone	Involvement
			Community Action Group
			Environmental Group

Table 16. Property Owners within the Flood Protection Area

Landowner Name	Property Identification (address, legal description)	Phone Number

Table 17. Local Contractors & Suppliers

Corporation	Contact Person	Phone	Expertise
			Consulting Engineer
			Construction Contractor
			Equipment Rental
			Gravel Supplier

3.2 *Physical Works*

Additional Physical Works information is included:

Information

Located:

- Design Criteria
- Key plan or schematic
- Design drawings
- As-constructed drawings
- Design report
-
-
-
-

Table 18

Table 18. Design Criteria

Item	Object	Criteria
Designated Flood Event		<input type="checkbox"/> 1 in 200 year event <input type="checkbox"/> 1894 flood of record <input type="checkbox"/> 1 in 20 year event <input type="checkbox"/>
Dike design	<ul style="list-style-type: none"> ▪ Crest elevation ▪ Freeboard ▪ ▪ 	<ul style="list-style-type: none"> ▪ ▪

3.3 Flood Hazard

Additional flood hazard information is included:

Information

Located:

- Record of past flooding events
- Record of Hydrometric Records and Gauges
- Records of historical flood events
- (newspaper articles, interviews, etc.)
- Photographs of flood events and damage.
- Floodplain mapping.
- Annual peak flow and stage (water level)
- Mean monthly and annual flow data
- Rainfall records
-
-
-

Table 19

Table 20

Table 19. Past Flooding Events Record

Date (month, year):	Flood Severity <i>(return period, severity)</i>	Flooded Area <i>(general description)</i>

Table 20. Hydrometric Records and Streamflow Gauges

Information		Additional data
Geodetic Survey of Canada bench markers	Location:	
River levels at Gauge: Location:	Source: Environment Canada	<input type="checkbox"/> annual peak flow and stage (water level) <input type="checkbox"/> mean monthly and annual data <input type="checkbox"/> <input type="checkbox"/>
River flood levels Location:	Report prepared by (dated _____)	<input type="checkbox"/> included in:
		<input type="checkbox"/> included in:

3.4 Inspection

Additional inspection information is included:

Information

Located:

Inspection reports

3.5 Maintenance of Flood Protection Works

The information presented below is supplementary to the summary presented in Chapter 2 and provides additional detail to the maintenance activities identified in that table.

✓ **Additional information is included:**

Information	Located:
✓ Summary of Supplementary Dike Maintenance Considerations	Table 21
✓ Summary of Supplementary Slope & Bank Protection Maintenance Considerations	Table 22
✓ Summary of Supplementary Floodbox Maintenance Considerations	Table 23
✓ Typical Pump Station Surveillance Checklist	Table 24
<input type="checkbox"/> Manufacturer's and other specialized documentation	
<input type="checkbox"/> Pump	
<input type="checkbox"/> Motor	
<input type="checkbox"/> Maintenance records	
<input type="checkbox"/> Inspections and tests	
<input type="checkbox"/> List of potential pump and generator suppliers	
<input type="checkbox"/>	
<input type="checkbox"/>	
<input type="checkbox"/>	

Dike Maintenance

Access, Fences, and Gates

Access should be restricted to authorized vehicles only, wherever possible. Access should always be free of obstacles since an emergency can occur at any time and access may be needed for fire fighting, rescue, etc. Gates and locks should be kept in good working order, with keys readily available. (The location of the key is included in Chapter 2, Table 5.)

Dike Crest, Cross-section, and Embankment

To provide the intended flood protection, the crest elevation and dike cross-section must be maintained. The crest elevation protects against the water levels predicted for the design flood event and the cross-section provides dike stability at those water levels. Dike crowns should be graded for good drainage, and vegetation controlled appropriately.

Every three to ten years the dike crest profile should be surveyed and compared to the design profile. Any low areas should be raised by the addition of crushed gravel surfacing, prior to grading of the whole dyke crest as required to maintain a smooth riding surface.

A significant part of maintenance of the dike itself is the early identification of problems. Identification and repair of problems is discussed further in *Guidelines for Management of Flood Protection Works in British Columbia* (1), and *Flood Protection Works, Inspection Guide* (3).

Vegetation Control

Vegetation is the most effective means of protecting the dike from surface erosion due to rain, currents, and wave wash. The root systems of larger trees and shrubs can threaten the stability of the dike system by providing routes for piping. Piping removes fill material and can result in structural failure of the dike. Thus, from a flood protection perspective, vegetation on dike slopes should consist of closely trimmed grass.

Large trees pose an additional threat to dike stability, especially during flood events when the dike structure

becomes saturated. High winds and overbank erosion can cause trees to fall resulting in the displacement of dike fill material and possible failure of the dike. In coastal regions especially, flood and storm conditions can occur simultaneously. (9)

Trimming of vegetation is important to:

- allow proper inspection of the surface and slopes for seepage and erosion,
- prevent piping, which can lead to dike failure, due to tree and brush root systems,
- discourage burrowing animals whose burrows are detrimental to dike stability,
- prevent large trees, and thus prevent potential piping routes along root systems, from establishing on the dike.

In recognition of environmental and recreational opportunities, and of the cost of mowing, longer grasses and small bushes are acceptable on dike slopes under controlled conditions. Vegetation should be well trimmed just prior to the high water season so that proper inspections can be made as water levels rise. Trees should not be permitted to attain a diameter greater than about two inches. Larger trees, and their root systems, should be removed and the excavation properly backfilled. This work is best carried out after the predicted flood season has passed.

The document *Environmental Guidelines for Vegetation Management* (5) presents effective techniques for vegetative maintenance which balance the environmental benefits of vegetation with the operation of the dike for flood protection.

Animal Burrows

Animal burrows can threaten the stability of the dike and embankment as well as cause significant settlement and erosion. If animal holes or burrows are discovered during inspection, the holes and tunnels should be completely excavated and backfilled with suitable compacted material.

Trapping of the animals may be advisable in such areas after consultation with local Fish and Wildlife authorities.

Internal Drainage

Internal drainage systems are installed to prevent excess flow through the dike fill which can convey material out of the dike resulting in a piping failure of the foundation and ultimately the embankment. Inspection of the dike system should identify potentially serious seepage problems.

Serious seepage problems, particularly where seepage waters are observed to be muddy indicating that material is being lost from the dike, the responsible individuals should be notified without delay so that corrective action can be taken immediately if necessary.

Table 21 summarizes the dike maintenance considerations.

✓ **Table 21. Summary of Supplementary Dike Maintenance Considerations**

Component	Important Considerations	Maintenance Activity
Access, Fences, & Gates	<ul style="list-style-type: none"> ▪ Maintain clear access at all times. ▪ Fences & gates reduce vandalism, provide safety, reduce liability. ▪ Restrict access to authorized vehicles only. 	<ul style="list-style-type: none"> ▪ Maintain roadways, fences, gates, etc. ▪ Ensure locks are in good order and keys are readily available. ▪ Keep access clear at all times.
Dike Crest, Cross Section, & Embankment	<ul style="list-style-type: none"> ▪ Crest elevation protects against water levels. ▪ Cross section and embankment (slope) provide dike stability at high water. 	<ul style="list-style-type: none"> ▪ Repair damage and settlement with appropriate fill materials and compaction¹. ▪ Grade crown for drainage. ▪ Maintain crest road. ▪ Control vegetation. ▪ Repair seepage problems¹. ▪ For erosion protection see below. ▪ Occasional survey to verify crest profile.
Vegetation Control²	<ul style="list-style-type: none"> ▪ Trimmed grass protects from surface erosion. ▪ Large vegetation and roots interfere with inspection, threaten stability of dike by providing a piping route, and can displace dike materials and create debris during flood event. 	<ul style="list-style-type: none"> ▪ Trimming, mowing and weed control. ▪ Remove large trees and shrubs.
Animal Burrows	<ul style="list-style-type: none"> ▪ Burrows threaten stability of dike and embankment. 	<ul style="list-style-type: none"> ▪ Excavate burrows and tunnels and fill with suitable compacted material¹. ▪ Discourage animals¹.
Internal Drainage	<ul style="list-style-type: none"> ▪ Prevents excess flow through dike fill. ▪ Piping can result in dike or foundation failure due to lost material. 	<ul style="list-style-type: none"> ▪ Repair drainage system¹. ▪ Install additional drainage systems.

¹ Obtain expert advice as needed. Contact MELP for assistance.

Slope & Bank Erosion Protection

Bank erosion protection is installed on steep slopes adjacent to the watercourse to prevent erosion from degrading the material comprising the dike embankment. The protection is comprised of angular pieces of blasted rock, or riprap, which protects the fine materials in the embankment from degradation due to swiftly moving waters of the main watercourse. The gradation and size of the rock is determined by the stream velocity and/or wave strength and the slope of the bank.

Bank protection requires varying degrees of maintenance depending upon the degree and frequency of exposure to stream flow or wave action. The protection should be maintained to design grade and thickness. Riprap surfaces should be kept clean of all trees and brush as the root system of a toppled tree

can displace riprap to expose finer materials subjecting the embankment to severe erosion attack.

Damage to dike slopes should be repaired by the addition and compaction of appropriate earth fill materials to restore the slope to original conditions, and by the addition of suitable graded rock riprap. Approval must be obtained from MELP before commencing repair work within the wetted perimeter of the dike system. Where severe erosion has or is occurring at points of concentrated attack, redesign of protection may be needed before repairs are effected. Technical advice can be obtained from MELP.

Table 22 summarizes the erosion protection considerations. For more information see *Riprap Design and Construction Guide* (4).

✓ **Table 22. Summary of Supplementary Slope & Bank Protection Maintenance Considerations**

Component	Important Considerations	Maintenance Activity
Riprap or Rock Slopes²	<ul style="list-style-type: none"> ▪ Angular pieces of rock provide protection against erosion due to high water velocities and waves. 	<ul style="list-style-type: none"> ▪ Maintain design grade, elevation, and thickness by addition of suitable rock¹. ▪ Repair slides, settlements, washes, and material loss. ▪ Prevent undercutting at ends of protection.
Vegetation Control³	<ul style="list-style-type: none"> ▪ Vegetation and roots threaten the integrity of the erosion protection. 	<ul style="list-style-type: none"> ▪ Remove vegetation from protected areas.
Animal Burrows	<ul style="list-style-type: none"> ▪ Burrows displace protective materials and threaten slope stability. 	<ul style="list-style-type: none"> ▪ Excavate burrows and tunnels completely and fill with suitable compacted material¹. ▪ Discourage animals¹.
Debris & Drift	<ul style="list-style-type: none"> ▪ Debris can cause rock materials to be dislodged. 	<ul style="list-style-type: none"> ▪ Remove debris, drift, refuse, etc. washed onto the slope.

¹ Obtain expert advice as needed. Contact MELP for assistance.

² For further information see *Riprap Design and Construction Guide* (4).

³ For further information see *Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment* (5).

Floodbox

The purpose of the floodbox is to allow the gravity discharge of the internal drainage water from behind the dike into the main watercourse during times when the external water level is lower than the level behind the dike. The system consists of culverts through the dike with gates at the outlet to prevent backflow from the watercourse when water levels are high. Trash racks may be fitted at the inlet and/or the outlet.

Maintenance of a floodbox consists of cleaning the inlet and outlet of any accumulated debris and sediment to ensure water can flow freely through the culvert, and cleaning and lubricating the closure gate to ensure that it swings freely and closes properly with

a good seal. The dike slopes adjacent to the floodbox should be kept clear of trees and brush to allow unimpeded inspection of the inlet and outlet and to restrict the amount of debris accumulating in the channel.

The floodbox should be checked regularly in areas where beavers are present since these animals can plug culverts or construct dams very quickly. Unusually high water levels are a good indication of beaver activity. Culverts should be cleared immediately, before the situation becomes more difficult to rectify.

Table 23 summarizes the floodbox considerations.

✓ **Table 23. Summary of Supplementary Floodbox Maintenance Considerations**

Component :	Important Considerations	Maintenance Activity
Floodbox (Pipes and Culverts)	<ul style="list-style-type: none"> ■ Provides drainage for areas behind the dike from which surface runoff would otherwise be trapped. 	<ul style="list-style-type: none"> ■ Keep pipes clear of trash and debris. ■ Inspect frequently where beavers exist.
Inlet and Outlet Channels & Headwalls	<ul style="list-style-type: none"> ■ Channels direct flow into culvert(s). ■ Headwalls provide structural and hydraulic control. 	<ul style="list-style-type: none"> ■ Clear any debris or blockage. ■ Identify, evaluate and repair structural problems¹.
Gates, Valves, Operating Mechanisms, Emergency Closures	<ul style="list-style-type: none"> ■ Control mechanisms allow the pipes to be closed in times of high water (on the watercourse) to prevent reverse flow or for repair purposes. 	<ul style="list-style-type: none"> ■ Lubricate and test operate gates regularly. ■ Maintain in good operating condition. ■ Clear debris and blockage.
Trash Racks	<ul style="list-style-type: none"> ■ Trash racks keep large debris from entering the pipe where it could become lodged against a wall causing a blockage inside the pipe. 	<ul style="list-style-type: none"> ■ Clear trash and debris. ■ Maintain in good operating condition and repair damage, corrosion, etc.
Riprap	<ul style="list-style-type: none"> ■ Riprap provides erosion protection to the surfaces of the structures that are in the watercourse. 	<ul style="list-style-type: none"> ■ See previous section on Slope & Bank Erosion Protection.

¹ Obtain expert advice as needed. Contact MELP for assistance if necessary.

Pump Station

Pump stations provide for discharge of drainage water from within the diked area during times of high water in the main watercourse when the floodboxes are closed. Proper maintenance is necessary since failure of the station will likely result in flooding inside the diked area.

Skilled electricians and mechanics should complete specialized tests and repairs when necessary. Manufacturers recommendations should be followed for maintenance and removal / installation work.

Any equipment removed from the station for repair or replacement should be returned or replaced as soon as

practicable and should be trial operated after reinstallation. Repairs requiring removal of equipment from the plant should be made during off-flood seasons as far as practicable.

Checklists provide an easy way to check a facility thoroughly. An example checklist is included in Table 24, below. This table can be modified to fit the specific pump station. The Troubleshooting Guide, in Chapter 2, also provides some insights into inspection and maintenance checks for a typical pump station.

✓ **Table 24. Typical Pump Station Surveillance Checklist**

Component	Item	Activity
Structural	<ul style="list-style-type: none"> ▪ Outside conditions & grounds. 	<ul style="list-style-type: none"> ▪ Check safety and cleanliness.
	<ul style="list-style-type: none"> ▪ Outside lights. 	<ul style="list-style-type: none"> ▪ Replace bulbs, etc.
	<ul style="list-style-type: none"> ▪ Building and locks secure. 	<ul style="list-style-type: none"> ▪ Check and lubricate locks, doors, gates, etc.
	<ul style="list-style-type: none"> ▪ Inside of building. 	<ul style="list-style-type: none"> ▪ Check conditions. ▪ Clean and re-paint painted equipment and surfaces as needed.
	<ul style="list-style-type: none"> ▪ Inside lights. 	<ul style="list-style-type: none"> ▪ Replace bulbs, etc.
	<ul style="list-style-type: none"> ▪ First aid kit, flashlights, etc. 	<ul style="list-style-type: none"> ▪ Check first aid kit is complete. ▪ Check flashlights work and other tools are available as nec.
	<ul style="list-style-type: none"> ▪ Fire extinguisher. 	<ul style="list-style-type: none"> ▪ Check extinguisher is up to date and readily accessible.
	<ul style="list-style-type: none"> ▪ Air quality, odours. 	<ul style="list-style-type: none"> ▪ Check for gas leaks and unusual odours in building.
	<ul style="list-style-type: none"> ▪ Log book. 	<ul style="list-style-type: none"> ▪ Record entry in logbook. ▪ Record any faults, concerns, or work in progress.;
Electrical	<ul style="list-style-type: none"> ▪ Breakers, switches, etc. 	<ul style="list-style-type: none"> ▪ Check are in ON position as appropriate.
	<ul style="list-style-type: none"> ▪ Power source; BC Hydro lines, breakers, etc. 	<ul style="list-style-type: none"> ▪ Verify intact, on, etc.
	<ul style="list-style-type: none"> ▪ Emergency lighting, telephone, automatic equipment, etc. 	<ul style="list-style-type: none"> ▪ Test and service equipment and insulated wiring as needed.
Mechanical	<ul style="list-style-type: none"> ▪ Pump and motor bearings, seals, oil levels. 	<ul style="list-style-type: none"> ▪ Check levels, fill oil reservoirs and lubricate as necessary.
	<ul style="list-style-type: none"> ▪ Pump(s) & motors. 	<ul style="list-style-type: none"> ▪ Run pumps and motors. ▪ Check for proper operation, temperature, vibration, noise, leaks. ▪ Check outlet for proper discharge and performance.
	<ul style="list-style-type: none"> ▪ Gates, valves, etc. 	<ul style="list-style-type: none"> ▪ Operate, lubricate, maintain as necessary for proper operation.
	<ul style="list-style-type: none"> ▪ Fuel supplies. 	<ul style="list-style-type: none"> ▪ Check and replenish as necessary.
	<ul style="list-style-type: none"> ▪ Generator. 	<ul style="list-style-type: none"> ▪ Check switches, power, etc.

3.6 Emergency Repair Work

✓ **Additional information is included:**

Information

Located:

- ✓ Summary of dike emergency problems
- ✓ Descriptive paragraphs of supplementary explanation of explanation of these problems and their repair

Table 14
(Ch 2)

below

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Active Boiling

A *boil* is a definite stream of seepage water issuing from the earth, usually near the landside toe of the dike or appearing as a spring in a ditch or depression on the landside. An *active boil* is a boil that is actively upwelling sandy or silty water. Recognition of a boil is discussed in the document “*Flood Protection Works Inspection Guide*” (3).

Water that flows from a boil carries with it material from beneath the dike itself and may gradually undermine the dike and result in a failure by causing sudden subsidence of the dike foundation. Due to the difficulty in evaluating the seriousness of a boil, all boils should be marked, uniquely named, and watched closely for changes.

A boil that discharges **clear** water in a steady flow is an *inactive boil* and is usually not a serious threat to the safety of the dike. The only action necessary in this case is to make careful and frequent observation of the boil and to drain excess water off to prevent its impoundment near the dike. If the flow increases and carries a material load of sand or silt, corrective action, as for an active boil, should be taken immediately. (7). All flowing inactive boils should be flagged and uniquely numbered and closely monitored throughout the flood period in case they start to transport solids.

The dike emergency organization should be notified if (1) the area of active boils is extensive, or (2) the area of inactive boils is extensive and the river level is expected to rise.

Repair:

The simplest and most effective method of treating an active boil (one that is carrying sand and silt) is to construct an impervious ring around it of a sufficient height to stop the transportation of solid material. It should not be built to a height which stops the flow of clear water because of the probability of building up an excessive local pressure head, which could cause dike failure or additional boils nearby. Sandbag rings are the most generally accepted method of repair, but concrete well rings, short pieces of large diameter pipe, earth berms, sheet steel pilings, etc., can all be used.

The recommended method of building a sandbag ring is:

- **Scarify the base**
for the ring (internal diameter of which should be at least 1.5 times the contemplated height) to provide a watertight bond between the natural ground and the sack ring (**a very important step**).

- **Lay sacks in a ring**
around the boil and surrounding weak ground starting at the outer edge and working towards the centre. Joints should be staggered and loose earth used as a mortar.
- **When proper height**
is reached (when clear water only is being discharged) a ‘V’-shaped drain constructed of wood or sheet metal should be inserted near the top of the ring to carry off water in a controlled manner and in the desired direction.
- **An alternative method**
of controlling an active boil is by placing a blanket of pea gravel or other free-draining gravel over it. The thickness of the gravel blanket must be increased until the seepage water runs clean. **Note:** When soil conditions are such that boils occur, it will probably be impossible or imprudent to bring loaded dump trucks into the area. First consideration should be given to methods that do not impose heavy loads on the ground adjacent to boils.

Excessive Slope Seepage

Seepage is the percolation of water through the dike or under the foundation. Although not dangerous in itself, it may threaten the stability of the dike by saturating the soil and causing sloughing of the landside slope. Seepage is usually first visible in the seep ditch at the landside toe of the dike. As the water rises against the dike, the seepage flow increases. As long as the wetted area is relatively small on the landside slope, and no movement of soil at the base is observed, no action other than keeping the water drainage away from the dike will be necessary. (7)

Repair

Where seepage on the dike’s landside slope leads to soggy unstable conditions, free draining fill berms may be added. Where time permits, expert advice regarding slope stability should be obtained before taking corrective action.

Riverside Erosion

Riverside erosion is *scour* of the riverside slope of the dike, berm, and/or adjacent banks by abnormally high water velocities. Scours are particularly dangerous due to the treacherous manner in which they develop and the difficulty of detection until almost irreparable damage has been done. The danger is that the scour will work into the dike slope. This type of scour resembles the caving bank of a river in that it erodes under water and has a vertical caving face. When the water is near the top of the dike, and by the time the vertical caving face appears above the water surface, a large portion of the dike is gone. (7)

Repair

Where river currents are eroding the face of the dike or nearby overbank, additional large rock riprap should be placed with an excavator or end-dumped if the site is accessible to heavy equipment and safe for operation. If time permits, expert advice should be obtained.

Under emergency conditions, maintenance of bank protection by end-dumping quarry-run rock into the bank is acceptable. Fines should naturally settle against the embankment face, and the coarser stones will work to the outside. However, under normal maintenance, placement by hydraulic excavator or clamshell is preferred. Specification of riprap placement is further discussed in the *Riprap Design and Construction Guide* (4).

If overtopping or creation of a breach is possible, an Emergency Warning should be issued (see above).

Wavewash

Wavewash is the erosion of the slope of a dike by wave action. The wave action may be caused by passing boats, on-shore winds, or storms. In any case, wave action may cause serious damage to a dike if the water surface is near the dike crown or if the dike has fine materials exposed.

Expert advice can often predict the locations where wavewash is likely to occur, and in that case filled sacks and other materials should be kept available for

an emergency. During periods of high wind and waves, patrols should closely monitor the identified areas. Under water washouts can occur under high wind and wave conditions, and wavewash can lead to formation of a breach in the dike due to progressive loss of dike material.

The necessity for wavewash protection cannot be foreseen in all cases, and observation must be continuous under high water conditions, as described in the “*Flood Protection Works Inspection Guide*” (3).

Repair

The type of wavewash protection to be constructed depends on local conditions. The result of excessive erosion due to wavewash is likely to be a breach, and if a breach is possible, an Emergency Warning should be issued (see above).

Local Overtopping

Local overtopping is the flowing of water over the dike crown. Overtopping may occur over a small local area, at a depression in the crown, but presents a significant danger. Once water flows over the dike crest, fill is usually washed away from the crest and landside slope creating a breach. Such a breach is virtually impossible to close until the water levels equalize on both sides of the dike. Equalization of the water levels occurs either due to subsiding water levels or due to uncontrolled flooding of the landside area.

Although dike crowns are constructed to the design elevation plus freeboard, local settling can occur over the years to reduce the crown elevation. As well, the design event can be exceeded. Either situation can

result in overtopping during a flood. As the prediction of flood profiles is uncertain, and because dikes often have varying freeboard, patrols should **pay close attention to lower than average freeboard.**

Repair

Sandbags are usually considered for raising low sections of dike. However, progress is slow and an excessive amount of labour is required. Sandbags should normally only be considered for raising short sections of dike. As an alternative to sandbags, reinforced plastic sheeting can be used to contain loose granular or other fill. Heavy equipment and trucks can be used to raise a dike **provided this work is done well in advance of high river levels.** No heavy equipment should be allowed on the dike when the water level is near the top of the dike as the vibration might cause a failure.

If overtopping or creation of a breach is possible, an Emergency Warning should be issued (see above).

Internal Drainage

Internal drainage is the local runoff and drainage from the areas behind the dike on the landside that drain to the main watercourse through the floodbox of pump station.

Local drainage will not escape in diked areas that lack adequate permanent pumping facilities. Temporary pumping of local drainage, or interception and diversion of inflow from higher elevations, may be necessary to alleviate this condition.

3.7 Emergency Response Plan inserted

4. References

1. *Guidelines for Management of Flood Protection Works in British Columbia*. Public Safety Section, Water Management Branch, Ministry of Environment, Lands & Parks; March 1999.
2. *Regulatory Tools for Flood Hazard Management A Guide for Local Government*. Public Safety Section, Water Management Branch, Ministry of Environment, Lands & Parks; March 2000.
3. *Flood Protection Works, Inspection Guide*. Public Safety Section, Water Management Branch, Ministry of Environment, Lands & Parks; March 2000.
4. *Riprap Design and Construction Guide*. Public Safety Section, Water Management Branch, Ministry of Environment, Lands & Parks; March 2000.
5. *Environmental Guidelines for Vegetation Management on Flood Protection Works to Protect Public Safety and the Environment*. Ministry of Environment, Lands & Parks, Department of Fisheries and Oceans Canada. March 1999.
6. *Water Related Hazards. Emergency Response Plan and Procedures*. Water Management Branch, Ministry of Environment, Lands & Parks; February 1998.
7. *Flood Planning & Response Guide for British Columbia*. Water Management Branch, Ministry of Environment, Lands & Parks; and Provincial Emergency Program, Ministry of Attorney General. March 1999.
8. *Flood Fight Manual, A Manual of High—Water Practices and Construction*. US Army Corps of Engineers, Portland District. October 1993.
9. *Operation and Maintenance Manual, Local Flood Protection Works*. US Army Corps of Engineers, Portland District. 1990.