Guidelines for the Design, Construction, Maintenance and Safety of Small Flood Detention Dams

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Foreword

The information contained in this document is intended as a guideline for Environment Bay of Plenty staff when assessing the level of technical input needed to design, construct, maintain and monitor the safety of small flood detention dams. If uncertainty exists as to the suitability of the dam site, design, construction, maintenance or safety further detail will be requested or an external review commissioned. If the dam owner/builder does not have sufficient experience with dams then he should seek professional advice from a Chartered Civil Engineer who does. Obtaining and implementing relevant technical input at all stages of a dam project will help reduce the risk of a dam failure. A geotechnical engineer in particular can help identify potential pitfalls in proposed earth embankment structures and their foundations.

Cover Photo: Detention dam under construction, topsoil being spread prior to sowing grass seed

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Chapter 1: Definitions

A small dam is one less than four metres in height, i.e. from the base of its foundation with the natural ground to its crest. A small dam is also defined as one that retains not more than three metres of water depth and not more than 20,000 cubic metres of water (New Zealand Dam Safety Guidelines, NZSOLD, November 2000).

Small flood detention dams are generally used for the control of high intensity, short duration rainstorms in catchments prone to erosion. As such, they are full only once or twice a year and only for a period of 24 hours or so. They are usually used in conjunction with other methods of soil conservation e.g. land retirement, re-vegetation.

In the event of failure, detention dams would cause only minor incremental damage over-and-above the imminent failure flow to the stream channel downstream. They do not threaten buildings, prime agricultural land or people's lives.

Chapter 2: Design Standards

Detention dams are usually designed to detain the runoff volume from a 10-year event plus freeboard to the emergency spillway crest level. Runoff in excess of this passes over the emergency spillway that is usually designed for the 100-year event plus freeboard to the dam crest level. Freeboard allows for uncertainty in hydrological and hydraulic conditions. It also allows for settlement of the earth embankment itself. Figure 1 shows a typical section through a small flood detention dam.

Detentions dams are generally located on productive agricultural land on which stock regularly grazes or in isolated bush areas. Maintenance then is constrained by these factors.

Their economic value demands only minimal maintenance by the landowner and/or Environment Bay of Plenty's soil conservators.

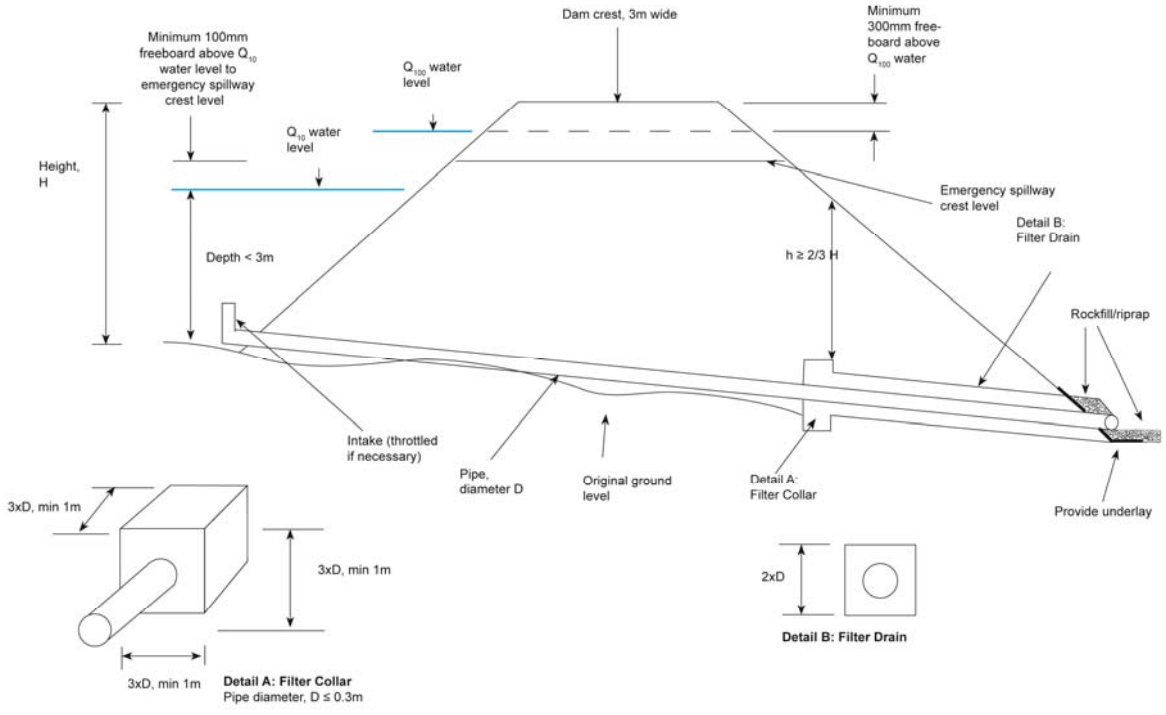

Figure 1 Typical cross section of a small flood detention dam

Chapter 3: Investigations

3.1 Site

Look for landforms upstream of the catchment of concern that affords natural storage with minimal earthworks. This may require more than one dam to give desired protection. Undertake site topographic survey and look for signs of permeable soils e.g. sands, tomos. Environment Bay of Plenty recommends that dam owners/builders seek professional advice to assist them identify suitable dam sites and construction fill material.

Undertake foundation investigations using auger and/or small excavator to log upper soil layers looking primarily for continuous horizontal permeable layers. Undertake simple pour-in test looking for potential seepage paths through foundation. Take soil samples for soil classification, moisture content and Atterburg limits.

If doubtful, undertake scala penetration test to confirm foundation suitability for construction loads.

At the same time look for suitable fill material (clayey or silty gravel, clayey or silty sand, clay or silt). Take soil samples for soil classification, moisture content and Atterburg limits.

3.2 Hydrological

Determine 10-year and 100-year peak flow and total volume using standard hydrological techniques.

Route the storm flow for various storm durations to determine the peak flow and peak storage volume.

In the absence of any flood routing the storage volume shall be of sufficient size to store the 10 year, 24 hour duration term inflow (excluding the discharge capacity of the service outlet pipe).

Routing must be carried out if the detention dam catchment is larger than 10 square kilometres.

Chapter 4: Design and Construction

Design with batter slopes of 4H: 1V and crest width of 3 metres. For dams not subject to stock traffic batter slopes may be increased to 3H: 1V but some other form of vegetation control must be implemented.

Design service outlet pipe and level to allow storage of 10-year event plus minimum 300mm freeboard to the emergency spillway crest level.

Maximise use of readily available fill materials. Do not use earth materials susceptible to "piping" Environment Bay of Plenty recommends that dam owners/builders seek professional advice if any doubt arises as to whether construction fill material is suitable for placement.

Clean off foundation footprint to remove all organic material, topsoil, sands and other permeable material.

Place well mixed fill to create homogeneous fill with no continuous horizontal permeable layers. Place in 200 mm (loose) thick layers and compact to achieve 95% maximum dry density, testing in three locations every 500mm of rise. Take extra care at foundations and abutments. Spread fill in longitudinal direction along crest.

For service outlet pipe, cut trench in natural ground under the dam wherever possible. Scarify[1] bedding, re-compact, place pipe, fill in 200 lifts and compact with whacker. Use strong pipe (e.g. HDPE, thick wall uPVC, concrete), that will withstand construction loads and early settlement loads. Minimum size 200mm with throttle plate[2] at inlet only if reduced flow required. Install wingwalls at inlet and outlet. Construct filter collars and filer drains around the outlet pipe as shown in Figure 1.

Fertilise and sow grass at optimum time of year for strike and keep stock off until grass well established. First graze with sheep or use mower to encourage grass thickening.

Design dam crest level and spillway crest level and width to allow discharge of 100-year event plus minimum 300 mm freeboard to dam crest. Construct spillway approach and discharge channels in natural ground with slopes of 10H: 1V with no abrupt changes in direction or elevation. Keep discharge well clear of dam toe. Sow grass and maintain until well established.

[1] Scarify means to rip with rippers on the back of tractor or by use of a mechanical rotovator. Aerates soil to depth of say 200mm, breaks up clods and allows uniform strength after re-compaction

[2] Thottle plate. A device at the inlet of the bottom outlet to control outflows. Can be a gate valve or an orifice plate.

Chapter 5: Maintenance

- Keep stock off until the fill is well consolidated.
- Keep stock off in wet weather to avoid pugging and consequential surface erosion.
- Keep dam and spillway free of large vegetation that will either obstruct flow, prevent visual inspections or encourage burrowing animals.
- Fill rills and gullies and resow.
- Fertilise and resow as required.
- Remove debris from within storage area and if feasible from within catchment.

5.1 Inspections

Use checklist in Appendix 1. Document and maintain log of inspections.

Inspection schedule:

- Immediately after, and preferably during, first filling.
- Immediately after the design event and lesser events of significant rain.
- Annually, including review of upstream watershed and catchment characteristics.
- Annually, confirm no modifications have been made to the detention dam.
- Annually, confirm the potential impact downstream of a dam failure remains the same i.e. no increase in risk to life or damage to property outside of dam owners.

Chapter 6: Dam Safety

If the catchments, dam, or downstream land use changes then the dam owner should report this to Environment Bay of Plenty. Changes such as these can increase the potential hazard posed by the detention dam and as such may require the owner to carry out a more comprehensive dam safety review and undertake a surveillance monitoring programme. According to Building Act 2004 and NZSOLD guidelines small detention dams are classed as 'very low potential impact dams'. This means that the potential incremental consequences of a dam failure are expected to comprise minimal damages beyond the owner's property and no fatalities. However if over time the potential impact to life and property increases then the owner is responsible for reducing, mitigating or avoiding the increase in detrimental consequences. The potential impact could increase for a number of reasons including:

- Increase in dam inflow resulting from changes in the catchments (e.g. higher catchment run-off).
- Increase in dam size resulting from increased dam height and storage capacity.
- Land use change downstream of dam resulting in an increase of risk to life and property.

Chapter 7: References

F R Barnett 1969, “Water Storage on the Farm – Volume 2 Part 1 Soils, Structural and Seepage Aspects”, Water Research Foundation of Australia, Bulletin No.9, March 1969.

USBR 1965, “Design of Small Dams”, US Department of the Interior.

“Maintaining Small Dams”, Agribusiness Worldwide, March 2001 1993 v 15 n2 21.

NZSOLD 1997, “Guidelines on Inspecting Small Dams”, NZ Society of Large Dams, 1997.

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Damwatch, 2006, “Review of the use of Seepage Collars in Small Dams”, Wellington

Appendices

Appendix 1 Inspection Checklist

Appendix 1 – Inspection Checklist

Dam:	
Location:	
Grid Ref:	

Inspected by		
Inspection date		
Construction date		
Engineered by		
Catchment	size : ha	100-year flow : cumecs
Dam size & material	height to spillway crest : m	height to dam crest : m
	crest width : m	crest length : m
	material :	capacity : m^3
	u/s slope : H to 1V	d/s slope : H to 1V
	comments :	
Outlet Pipe Material and Diameter		
Emergency Spillway	flow depth H : m	crest length b : m
	capacity : cumecs	type :
	comments :	
Downstream hazard		
Recommendations		
	Inspection Comments (e.g. problems identified)	Recommendations
Structure		
Upstream Face		
Crest		
Downstream fact		
Spillway		
Outlet pipe		
Abutments		