APPENDIX 3
CPW CASE STUDY OPEN CHANNEL OPTION

Contents

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1.0 Introduction

1.1 Background

The piped irrigation distribution network for the case study of the Central Plains Water (CPW) sub-area is described in Appendix 2. Design criteria in terms of peak rate and seasonal volumes at delivery points for the piped and open channel options are the same and are not repeated here. The essential difference from the piped option is that water is delivered at the farm offtake point at ground level. The design issues are therefore related to the layout of the open channel network, the hydraulic capacity of the system along reaches of canal, protection of the canal prism, and structures need for operational control. This appendix describes the basis for the quantification of these issues.

The designs of the CPW canal area were completed on case study sub-area of 36,000 ha located between the Rakaia and Selwyn River below the proposed CPW headrace to the Main South Road.

The open channel network utilised the CPW layout developed by URS, consultants to Central Plains Water Ltd. . The URS network was designed 'on grade' and high velocities in the canal occur requiring armouring of the invert. This option was selected by URS to avoid drop structure costs and excessive cuts and fill embankments required on sloping ground to create flat grade canal systems[1].

URS provided a plan showing the basic layout of the scheme which was expanded as shown on Figure 1, to include pipe sub areas to service all farms to the same level of service as a piped scheme. The following details of the CPW canal scheme (refer to Figure 1):

- Location of CPW headrace
- Boundary of the total proposed irrigated area (relevant to this study)
- Property boundaries and property area
- Contour details (10 m contours)
- Proposed open channel layout

[1] The NZ experience of designing a large open channel system on-grade with prism protection is limited, but has been adopted in this study as it is preferred at this stage by CPW consultants. It is likely that costs of the open channel option would be higher if a more conventional cut and fill long section was adopted with drop structures.

- Water at the intake has already been diverted to a primary canal between the Rakaia and Waimakariri Rivers. Significant intake work, fish screens or river training are therefore not accounted for.
- The topography is generally flat with maximum land slopes ranging from 1 in 100 at higher elevations to 0.7 in 100 towards the lower limits. Canal gradients are generally less than maximum land slopes. The open channel layout does not involve complicated plan or elevation changes which can significantly affect costs.
- Groundwater into the canal excavation is not considered significant.
- The land is primarily cleared farmland.
- Not all farms are bounded by the canal network as occur with the pipe network. This is in areas of smaller farm sizes or lifestyle blocks typically on the eastern fringes of the network. To provide the same level of service small pipe networks were utilised to supply these properties in stead of a tertiary canal system.

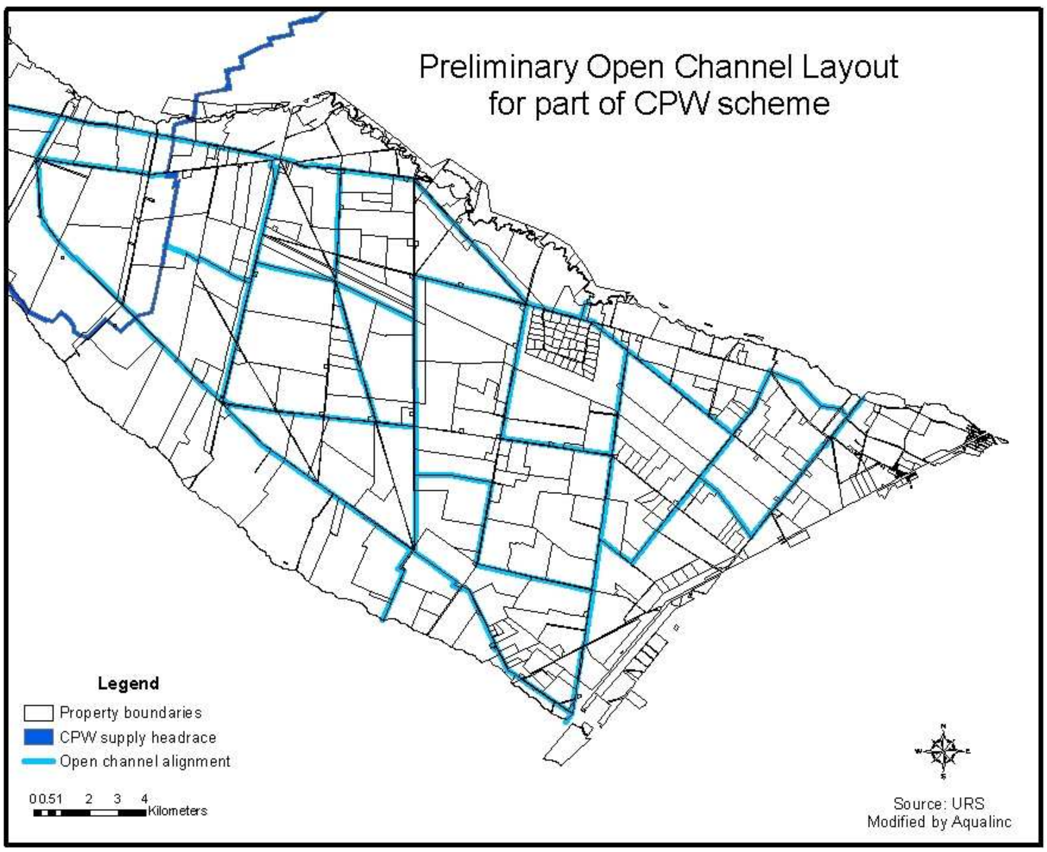


Figure 1: Preliminary open channel layout for part of CPW scheme

A summary of the method for designing the piped distribution network for the CPW case study is provided below.

2.0 Design Details

Water is to be abstracted from the CPW headrace, and will be delivered to the proposed irrigable area via a primary and secondary open channel developed by URS as a result of landholder and current consent discussions. The water will be delivered to each property using an off-take pond point (turnout) suitable for a pipe pumped offtake. Small areas of the scheme are to be irrigated by a small pipe network to avoid the need for a tertiary canal network.

2.1 Irrigated Area

The total area to be irrigated is approximately 36,000 ha. Within this area, there are 305 properties to deliver water to each property. Some turnouts will deliver water to more than one property. There are 133 properties with turnout flow requirements of less than 1 l/s. These turnouts account for less than 1% of the total flow and are not included within the irrigated area.

2.2 System Capacity

The system capacity has been based on a delivering a flow of 0.6 l/s/ha to each property. The total flow to supply an area of 36,000 ha is approximately 21.6 m^3/s.

The design is to be capable of supplying water to each property ‘on demand’ at all times.

2.3 Water Source

The water source is from the CPW headrace and includes three primary offtake points. The intakes considered involve large open ‘U’ shapes structures with gates built into the side of the main canal embankment.

2.4 Elevations

The highest elevation at the CPW headrace is at 240 m amsl and the lowest elevation is at the Main South Road at 63 m amsl.

The contour information as supplied by URS has been used. It is considered appropriate to use 10 m contours as interpolation between these contours gives a reasonable estimation of the lie of the land between the contours.

2.5 On Farm Delivery Pressures

The elevation change over the length of the canal network provides no pressure supply within the main scheme, which means that properties must be fully pumped.

2.6 Canal and Pipe Layout and Sizing

The canal layout was not optimised to minimize capital costs – the information supplied by URS was adopted.

2.7 Turnouts

Turnouts from the scheme distribution system will contain some or all of the following basic components:

- Weir to divert flow from canal
- Culvert
- On farm pond
- Screen
- Pump

One hundred properties comprise small pipe distribution system and will contain some or all of the following basic components:

- Pressure reducing valve and pressure relief valves to control excess pressures
- Flow control
- Flow meter

2.8 On Farm Pumping

Water is to be supplied to each turnout under with no pressure except for the small sub area of pipe scheme.

To aid in the assessment of on-farm pumping requirements, land use projections and monthly and seasonal irrigation demand estimates were scaled from irrigation demand modelling undertaken in the Ashburton region. This was the basis for the criteria used for determining the change in irrigation demand through the irrigation season and the operational costs for on-farm pumping.

Due the variation in pumping pressure and flow required throughout the season, pumps fitted with variable speed drives have been assumed.

2.8.1 Irrigation Demand

A water demand scenario for the Ashburton region was modelled in the Canterbury Strategic Water Study (2002), to determine average and peak monthly irrigation demand. A daily time series of potential irrigation demand was calculated in the Ashburton region using daily rainfall and climate data from June 1972 to May 2000 based on the land-use assumptions summarised in Table 1. Both the monthly peak flow demand and average monthly flow demand were calculated.

Table 1: Assumed land-use for potentially irrigable land

Region	Dairying	Intensive Livestock and Dairy Support	Arable
Ashburton	52 %	30 %	18 %

To estimate the potential irrigation demand for the Rakaia/Selwyn scheme, the data from the Ashburton region has been scaled based on the peak flow difference between the Ashburton and CPW, thus enabling the monthly flow demand to be calculated. The average flow demand as a percentage of the peak flow for each month is shown in Figure 2.

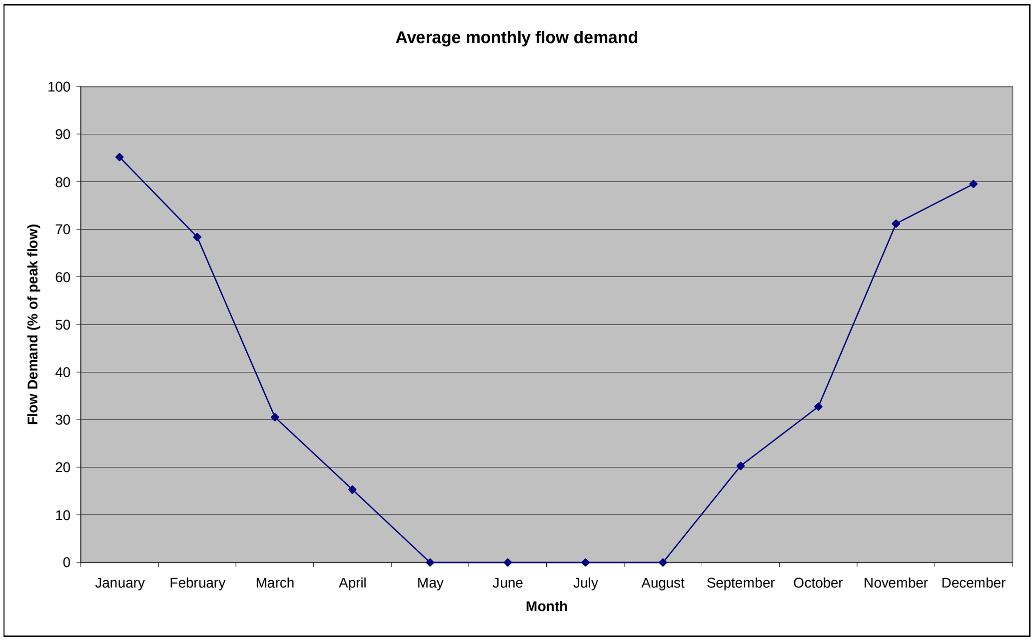


Figure 2: Average monthly flow demand

3.0 Canal Design

3.1 Canal Layout

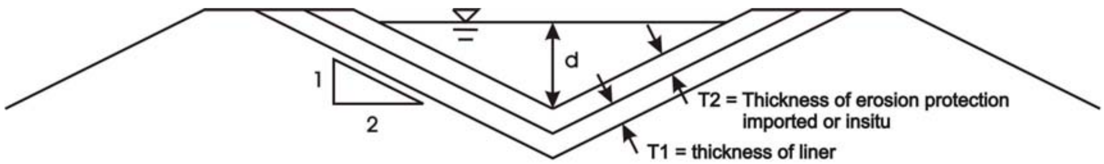
The canal physical layout and flow in each section were developed by URS as shown in Figure 1. This layout does not supply water to all delivery points, so small sections of piped extensions were incorporated to ensure that the delivery ability was similar to the fully piped option. The following steps were then completed to develop the design to price:

- Code each canal section
- Determine canal section sizing based on canal gradients as assessed from 1:50,000 contour plans.
- Calculate erosion liner requirements based on canal velocities
- At each distribution point determine gate requirements
- Determine culverts for road crossings
- Develop a bill of quantities.

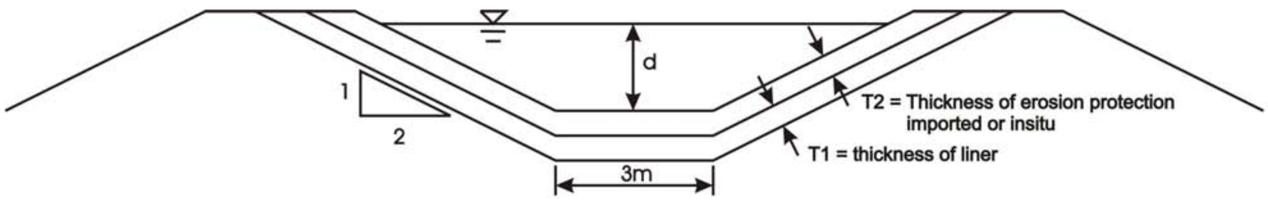
3.2 Canal Design Cross Sections

Two different cross sections were designed to suit the required maximum flow rate of each canal section as shown on Figure 3 below. A triangular cross section was used for lengths of canal with flow rates of less than 2 m^3/s. A trapezoidal profile was used for sections with canals with flow rates in excess of 2 m^3/s. These two options were chosen from a construction perspective allowing for digger or grader excavation of small canals, and for larger canals flow design sizings to allow economical construction by earth moving equipment commonly used by earthworks contractors.

Figure 3 – Design canal cross sections utilised



Triangular cross section for flows less than 2 m^3/s



Trapezoidal cross section for flows greater than 2 m^3/s

3.3 Canal Geology and Design Impacts

No site-specific testing or investigation of the soil grading curves for design purposes was completed. The erodibility of the canal material was estimated using a typical grading for similar alluvial gravels from the Ashburton area. It was found that the local materials would likely erode at the URS proposed canal gradients and flow rates, and that specific gravel or cobble erosion protection measures would be required for all canal sections.

For low gradients along the canal route (i.e. flatter than 1:400) it was assumed that the lining and armour material could be sourced on site. For steeper gradients the armour material would need to be imported or screened from on-site materials.

Based on the above, a table of estimated per metre costs of earthworks and erosion protection was created for each canal flow and gradient.

3.4 Liner Material

The URS design incorporates no liner material for seepage control. The case study design has assessed that a liner material is required. The thickness of both the liner and erosion protection was assumed to be 0.5 m.

3.5 Road Crossing and Culverts

The number of road crossings was estimated from existing maps and a plan of the proposed scheme extensions. Preliminary culvert diameters were calculated based on the required maximum flow at each road crossing, and are shown on Table 1 below.

3.6 Distribution Control Gates

Control gates are required at nodes where flow goes in more than one direction. The number of nodes was obtained from the proposed scheme extension plan as shown on Figure 1.

3.7 Sub Area Pipe Scheme

As shown in Figure 1 small areas of pipe scheme were included to avoid tertiary canal systems where land or land owner permission for canals was deemed unavailable. The full details of the analysis for the pipe area were the same as for the full pipe scheme option as described in Appendix 2.

Limited design iterations were completed. All 100 properties were deemed to need supply to be provided the same level of service as the piped scheme option. Layout of the pipe was optimised so all properties were connected to the networks.

3.8 Quantities and Estimated Costs

A full description of the general basis for the estimation of unit rates and costs is given in Appendix 5.