GLAMORGAN SPRING BAY COUNCIL

TWAMLEY DAM TRANSMISSION LOSS ASSESSMENT

VERSION 2.0

MARCH 2017

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Project Twamley Dam Transmission loss assessment	**Project Number** **117003**
Client Glamorgan Spring Bay Council	**Client's Representative** David Metcalf
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Date 8 March 2017	**Verified by**

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2	FINAL	Glamorgan Spring Bay Council, Bill Shackcloth	08 Mar 2017
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EXECUTIVE SUMMARY

Glamorgan Spring Bay Council is investigating the development of Twamley Dam on Tea Tree Rivulet, to be located on the Twamley property. The proposed dam would be part of would be part of the Prosser Plains Raw Water Scheme which aims to deliver water to users who will extract it from the river system at Lower Prosser dam. To deliver the water to Lower Prosser Dam, the proponents aim to transfer water via the natural watercourses which run between the storages.

This desktop study of the reach transmission losses has been carried out to support an application for a Water Course Authority to transmit water between Twamley Dam and Lower Prosser Dam.

The scheme aims to deliver water to Lower Prosser Dam at a continuous daily rate in the order of 1 – 5 ML/day, with a monthly profile. During Summer an average loss of 2 ML/day is estimated, rising to 2.9ML/day during periods of low natural flows. During Winter an average loss of 0.4 ML/day is estimated, rising to 1.5ML/day during periods of low natural flows. DPIPWE have indicated that "*the Low flow loss rate should be adopted for summer period – we are reasonably comfortable using the average for winter period*." (Bill Shackcloth, pers.comm., 28 Feb 2017). Based on this advice, to deliver a target volume at Lower Prosser Dam, an additional 2.9ML/day is required to be released from Twamley Dam in Summer, and 0.4ML/day in Winter. For example if 3ML/day is required at Lower Prosser in Summer then 5.9ML should be released from Twamley Dam, if 1.5ML/day is required at Lower Prosser in Winter then 1.9ML/day should be released from Twamley Dam.

At the time of writing the intent was to release water at a continuous daily rate, with a monthly profile, from Twamley Dam to Lower Prosser Dam. If a stop-start release profile is employed then an initial loss, when transfers are started, is also applicable in addition to the ongoing daily loss. The worst case scenario will occur under dry conditions when there are no naturally occurring flows. Under these conditions the instream pools, watercourse banks and bed will need to be recharged by released water before flows can be transferred. Under dry conditions it is anticipated that losses will continue at a rate similar to the low flow losses presented, for a period of time until the watercourse dries out. This water would need to be recharged before water transfer can be restarted. For example, if Tea Tree Rivulet was experiencing dry conditions, and water transfer was stopped for 5 days, then the initial loss would be estimated at 5 times the total daily low flow loss for this reach, equating to 9.5ML.

These transmission loss estimates have been calculated using a conceptual model which considered the various components which makeup the total transmission loss. The results could be refined through the implementation of an appropriate gauging programme either using natural flows prior to construction or during the first period of operation using controlled releases from the new Twamley dam.

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1. INTRODUCTION

Glamorgan Spring Bay Council is investigating the development of Twamley Dam on Tea Tree Rivulet, to be located on the Twamley property. The proposed dam would be part of would be part of the Prosser Plains Raw Water Scheme which aims to deliver water to users who will extract it from the river system at Lower Prosser Dam. To deliver the water to Lower Prosser Dam, the proponents aim to transfer water via the natural watercourses, Tea Tree Rivulet and the Prosser River, which run between the storages. The scheme aims to deliver water to Lower Prosser Dam at a continuous daily rate in the order of 1 – 5 ML/day, with a monthly profile. A copy of the demand profile as it stood at the time of writing is included in Appendix B.

This assessment of the reach transmission losses has been carried out to support an application for a Water Course Authority to transmit water between Twamley Dam and Lower Prosser Dam.

2. LITERATURE REVIEW

There is limited literature available on modelling approaches for estimating stream transmission losses. A review of available literature was carried out which revealed a number of studies which have been carried out in the USA and Australia. These studies highlighted that the assessment of transmission loss is generally carried out through data driven methods rather than physical or conceptual modelling. The studies found that transmission losses vary enormously. For example, Boughton (2015) assessed 99 ephemeral stream sites in Australia and found losses of up to 0.2mm/day. This equates to approximately 0.022%/km in Tea Tree rivulet, assuming a flow of 5ML/day. A summary of published reports on transmission losses in ephemeral streams in the USA found losses up to 11% per km (Cataldo et al. 2004).

As flow data is not available in the study reach to carry out a data driven assessment of losses, efforts were made to obtain reports covering similar reaches in Tasmania. Tasmanian Irrigation have published loss rates for the Midlands Water Scheme (Tasmanian Irrigation 2014). While the full report is not available, the reaches are reasonably comparable to the study site and it is understood the loss rates have to some extent been validated with field measurements. The loss rates adopted in these schemes range from 0.4%/km (+/- 0.2%) to 1%/km (+/- 0.5%) for summer, in winter they range from 0.2%/km (+/- 0.1%) to 0.7%/km (+/- 0.4%/km).

Transmission losses are comprised of 4 components, (Boughton & Stewart 1983):

- **Water-hole storage** – “Along any stream channel there are both natural and man-made water-holes which required filling after a low rainfall period. Water from a release may be lost due to the filling of such water-holes. Not only will water be used to fill them but it will also be lost through evaporation from the water-hole surface and infiltration through the water hole bed.”
- **Infiltration –** “Infiltration is the seepage of water through the stream channel, banks and flood plains. Some of this infiltration finds its way into the ground-water storage and some may flow back into the stream at a later time.”
- **Evaporation and Evapotranspiration** – “Direct evaporation may take place from the stream channel or from water-holes.” … “Vegetation in the creek bed or on the banks and flood plain has been suggested as a significant remover of quantities of transmission loss water. Water which has infiltrated into the streambed or banks may be drawn up by the roots of the trees and other plants and lost from the system.”
- **Bank Storage –** “During a release or flood events water may infiltrate into the banks or flood plains. This water may be temporarily stored in the subsurface strata and seep back into the stream once the events has passed or during the recession of the events. This results in an attenuation of the flood peak as well as providing the opportunity for losses through evapotranspiration.”

3. METHOD

Given the lack of data to implement alternate methods a conceptual modelling approach has been taken to consider the contributions of the four transmission loss components; the key steps to the adopted method are outlined below:

- GIS datasets of the reach Topography, Geology, Soil and Watercourse were collated and reviewed to identify characteristics which could have a significant impact on transmission losses in the study reach.
- The extent of the watercourse and riparian area where evaporation and evapotranspiration losses are likely to be recharged from channel flows was identified.
- Evaporation data observed at the Bureau of Meteorology's station located in Tunnack was analysed to derive Summer and Winter evaporation rates.
- Flow duration curves for significant locations along the reach were calculated utilising daily streamflow data from the DPIPWE's TasCatch model for the period 1970-2007. Copies of the flow duration curves have been provided in Appendix A.
- A field trip was conducted to ground truth the desktop analysis of the reach, to gain an understanding of the channel characteristics, and to inspect the reach for any significant losses that may be occurring.
- The results of the field trip and GIS analysis were collated and the study reach characterised into zones of distinct transmission loss rates. The characteristics of each zone, significant to transmission loss have been described, and an assessment of the likely losses from each transmission loss component made.
- A conceptual model was developed to quantify losses based on the data collated. Infiltration, bank storage, evaporation and evapotranspiration losses were explicitly accounted for in the model. The model assumed that losses to the transferred water were negligible during periods where the natural flow was double the water to be transferred, and for low flows all losses were assumed to be supplied by the transmitted water.
- The conceptual model was used to quantify the loss rates for each zone, the results for each section were then collated into an overall loss rate for the study reach.

4. REACH CHARACTERISATION

The study reach runs from the proposed Twamley Dam for 9.13km down Tea Tree Rivulet before joining the Prosser River, where it runs for another 7.42km before reaching Lower Prosser Dam. The catchment area upstream of the proposed storage is 50.6km^2, extending to 83.4km^2 upstream of the confluence to the Prosser, 644.3km^2 at the confluence, and 675.2km^2 at Lower Prosser Dam. The river system is anecdotally recognised as being ephemeral. This is backed up by flows observed at DPIPWE gauge site PROSSER RIVER UPSTREAM LOWER DAM (Station: 2202) which shows flows dropping to zero or close to zero in most years of record.

A field trip was undertaken on the 19th January to visually inspect the river at accessible points. The field trip was carried out 16 days after the last inflow event observed at the DPIPWE stream gauge site PROSSER RIVER UPSTREAM LOWER DAM (Site ID: 2202), which had peaked at 98ML/day. The river system was in gentle recession with 1.7ML/day being observed at the site 2202. It is therefore felt that the conditions under which the reach was observed are typical of the summer period.

The reach has been broken into three transmission loss zones as highlighted in Figure 1. The characteristics of each zone are described in the following section.

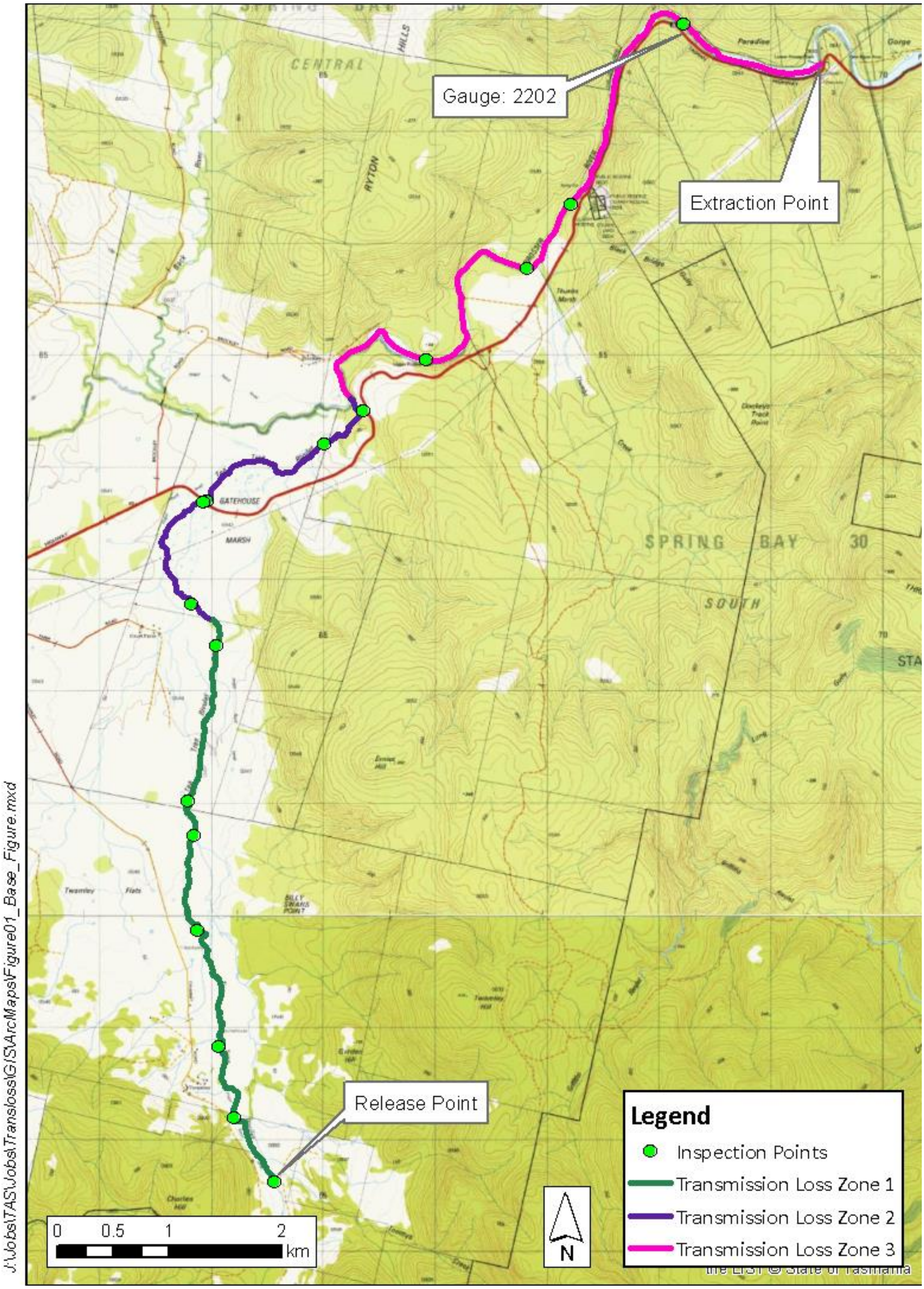

Figure 1 Map of study area.

4.1. Zone 1 – Twamley Dam to Upstream of Gatehouse March

Reach Characteristic	Description
Length (km)	5.69
Slope (%)	0.5
Geomorphology	The geology has been mapped as "sand gravel and mud of alluvial, lacustrine and littoral origin" (DPIWE 2000; Mineral Resources Tasmania 2017). This was evidenced on the field trip with channel bed and banks being made up of heavy clays along the extent of the reach. In the mid section of the reach armouring of the channel was evident which would have the effect of lowering infiltration losses over this area.
Riparian Vegetation	The upper and lower sections of this reach are characterised by dense riparian vegetation which would have the effect of lowering evaporative losses through shadowing the channel - this is likely to be countered by the evapotranspiration caused by their roots in the channel. In mid sections the channel contains no vegetation and the riparian area is characterised by open grassland.
Channel geometry and flows	The channel is characterised by deep (>0.5m) standing pools interspersed by free flowing sections. It is generally well formed and during low flow periods such as those observed during the field trip, the addition of the released water will not significantly increase the water surface area. During the field trip comparable flows were observed at all inspection points along this reach, and these flows did not appear to be being recharged from tributary flows. Natural flows are more than double the targeted volume to be transmitted 10% of the time in Summer and 55% of the time in Winter (derived from (DPIPWE 2017b)).
Other significant features likely to impact losses	None.

The following photos capture the nature of the channel in this zone.	
	

Assessed loss rate due to each transmission loss component:

Water-hole storage

- **LOW** - As the release is to be continuous throughout the year it has been assessed there will be no significant loss rate to fill water holes.

Evaporation and evapotranspiration

- **MODERATE** - Due to the contained nature of the channel the loss rates to transferred flows will negligible during times of high flow. There are however significant periods of time when the natural flows are small compared to the transferred flow and during these periods more, or all, of these losses will need to be supplied by released water.

Bank storage

- **LOW –** As the release is continuous there will be minimal losses to bank storage as the banks will remain saturated, losses via the banks are most likely to occur in the form of evapotranspiration which has been accounted for above.

Infiltration

- **LOW –** These losses are likely to be low due to the well-established nature of the channel and the armouring visible in the central section of the reach. The relatively wide channel width and slope of the reach mean that there will be only minimal increase in the hydraulic head to force more infiltration to occur.

4.2. Zone 2 – Gatehouse Marsh to Prosser Confluence

Reach Characteristic	Description
Length (km)	3.44
Slope (%)	0.3
Geomorphology	The geology has been mapped as "sand gravel and mud of alluvial, lacustrine and littoral origin" (DPIWE 2000; Mineral Resources Tasmania 2017). This was evidenced on the field trip with channel bed and banks being made up of heavy clays along the extent of the reach.
Riparian Vegetation	The dominant feature of this zone that will affect transmission losses is Gatehouse Marsh which has a mapped area of 0.43km^2 (DPIPWE 2017a). The extent of this area which remains saturated during low flows is unclear however it is likely to be recharged through seepage from the main channel in addition to overflow from high flow events, increasing the rivulets effective evaporative area.
Channel geometry and flows	Throughout this section the main channel remains well defined though some braiding is evident from ortho-photography. It is characterised by deep (>0.5m), wide (>4m) standing pools. The addition of the released water will not significantly increase the water surface area or depth and there are unlikely to be losses due to overbank flows during low flow periods when transmission losses will be highest. Losses in the order of 1-2ML/day through Gatehouse Marsh were observed in the field trip. Natural flows are more than double the targeted volume to be transmitted 15% of the time in Summer and 65% of the time in Winter.
Other significant features likely to impact losses	None.

The following photos capture the nature of the channel in this zone.

Assessed loss rate due to each transmission loss component:

Water-hole storage

- **LOW** - As the release is to be continuous throughout the year it has been assessed there will be no significant loss rate to fill water holes.

Evaporation and evapotranspiration

- **VERY HIGH** - Due to the contained nature of the channel the loss rates to transferred flows will negligible during times of high flow, there are however significant periods of time when the natural flows are small compared to the transferred flow, during these periods more, or all, of these losses will need to be supplied by released water. Due to the large surface area of Gatehouse Marsh the high observed losses during the field trip are anticipated to occur during all low flow periods.

Bank storage

- **LOW –** As the release is continuous there will be minimal losses to bank storage as the banks will remain saturated. While losses are likely to via the banks to the Gatehouse Marsh they will ultimately lost to the system via evaporation and evapotranspiration and are accounted for there.

Infiltration

- **LOW** –The relatively wide channel width and slope of the reach mean that there will be minimal increase in the hydraulic head to force more infiltration to occur.

4.3. Zone 3 – Prosser Confluence to Lower Prosser

Reach Characteristic	Description
Length (km)	7.42
Slope (%)	0.3
Geomorphology	The geology has been mapped as "Dolerite with locally developed granophyre" (DPIWE 2000; Mineral Resources Tasmania 2017). This was evidenced on the field trip with channel bed made up of either heavy dolerite clays, pebbly dolerite cobbles or bedrock. A number of fault lines intersect the watercourse which increases the likelihood of losses to groundwater however there was no evidence of this at the time of inspection.
Aquatic and Riparian Vegetation	The waterway along this reach is bordered by dense riparian vegetation, with some aquatic vegetation evident in standing pools.
Channel geometry and flows	Throughout this section the main channel remains well defined. It is characterised by deep (>0.5m), wide (10-20m) standing pools interspersed by free flowing sections. The addition of the released water will not significantly increase the water surface area or depth and there are unlikely to be losses due to overbank flows during low flow periods when transmission losses will be highest. Tea Tree Rivulet joins the Prosser River at the top of this zone, as a result there is a significant increase in the natural flows when compared with Zone 2. Natural flows are more than double the targeted volume to be transmitted 60% of the time in Summer and 95% of the time in Winter. At the time of field trip flows appeared consistent along the reach, these flows did not appear to be being recharged from tributary flows.
Other significant features likely to impact losses	Upper Prosser Dam, operated by TasWater, is located in the upper section of this reach. It has been assumed that an agreement will be put in place to pass flows through this

<table>
<tr><td></td><td>storage. The storage has an open channel spillway so during times of spill, flows can be transferred without any management of the storage. It is worthy of note that an outlet valve to the storage could not be observed during the field trip, so mechanical works may need to be undertaken to allow the passing of flows should the storage be drawn below spill for any reason.</td></tr>
<tr><td colspan="2">The following photos capture the nature of the channel in this zone.</td></tr>
<tr><td></td><td></td></tr>
</table>

Assessed loss rate due to each transmission loss component:

Water-hole storage

- **LOW** - As the release is to be continuous throughout the year it has been assessed there will be no significant loss rate to fill water holes.

Evaporation and evapotranspiration

- **HIGH** – The reach contains numerous waterholes and two storages meaning there is a relatively large surface area available for evaporation to occur from. Dense riparian vegetation extends beyond the inundated extent. Due to the contained nature of the channel the loss rates to transferred flows will be negligible during times of high flow, there are however significant periods of time when the natural flows are small compared to the transferred flow, during these periods more, or all, of these losses will need to be supplied by released water.

Bank storage

- **LOW –** As the release is continuous there will be minimal losses to bank storage as the banks will remain saturated.

Infiltration

- **LOW –** The watercourse is contained in a gorge formed in the dolerite bedrock with shallow soils providing limited opportunity for infiltration to occur. In addition, the relatively wide channel width and slope of the reach mean that there will be minimal increase in the hydraulic head to force more infiltration to occur.

5. RESULTS

A conceptual model was developed to make a quantitative estimation of the transmission losses based on the data collated and the reach characterisation presented in Section 4. The results for each zone are presented below. The average losses are the estimated average daily loss for the season. Losses are expected to be higher on days of low natural flows and these are also presented.

Table 1 Estimated transmission losses.

	Zone 1	Zone 2	Zone 3	Total
Summer				
Low Flow Losses (ML/day)	0.2	1.7	0.9	2.9
Average Losses (ML/day)	0.2	1.5	0.4	2.0
Winter				
Low Flow Losses (ML/day)	0.1	0.9	0.5	1.5
Average Losses (ML/day)	0.1	0.3	0.0	0.4

The scheme aims to deliver water to Lower Prosser Dam at a continuous daily rate in the order of 1 – 5 ML/day, with a monthly profile. During Summer an average loss of 2 ML/day is estimated, rising to 2.9ML/day during periods of low natural flows. During Winter an average loss of 0.4 ML/day is estimated, rising to 1.5ML/day during periods of low natural flows. DPIPWE have indicated that "*the Low flow loss rate should be adopted for summer period – we are reasonably comfortable using the average for winter period*." (Bill Shackcloth, pers.comm., 28 Feb 2017). Based on this advice, to deliver a target volume at Lower Prosser Dam, an additional 2.9ML/day is required to be released from Twamley Dam in Summer, and 0.4ML/day in Winter. For example if 3ML/day is required at Lower Prosser in Summer then 5.9ML should be released from Twamley Dam, if 1.5ML/day is required at Lower Prosser in Winter then 1.9ML/day should be released from Twamley Dam.

At the time of writing the intent was to release water at a continuous daily rate, with a monthly profile, from Twamley Dam to Lower Prosser Dam. If a stop-start release profile is employed then an initial loss is also applicable in addition to the ongoing daily loss when transfers are started. The worst case scenario will occur under dry conditions when there are no naturally occurring flows, under these conditions the instream pools, watercourse banks and bed will need to be recharged by released water before flows can be transferred. Under dry conditions it is anticipated that losses will continue at a rate similar to the low flow losses presented in Table 2 for a period of time until the watercourse dries out. This water would need to be recharged before water transfer can be restarted. For example if Tea Tree Rivulet (Zone 1 and Zone 2) was experiencing dry conditions, and water transfer was stopped for 5 days, then the initial loss is estimated at 5 times the total daily low flow loss for those reaches (0.2ML/d + 1.7ML/d), equating to 9.5ML.

These transmission loss estimates have been calculated using a conceptual model which considered the various components which makeup the total transmission loss. The results could be refined through the implementation of an appropriate gauging programme either using natural flows prior to construction or during the first period of operation using controlled releases from the new Twamley dam. Stop-start releases will also be affected by transmission time, and some options for understanding the impact of this include hydraulic modelling and/or an appropriate flow monitoring program.

6. REFERENCES

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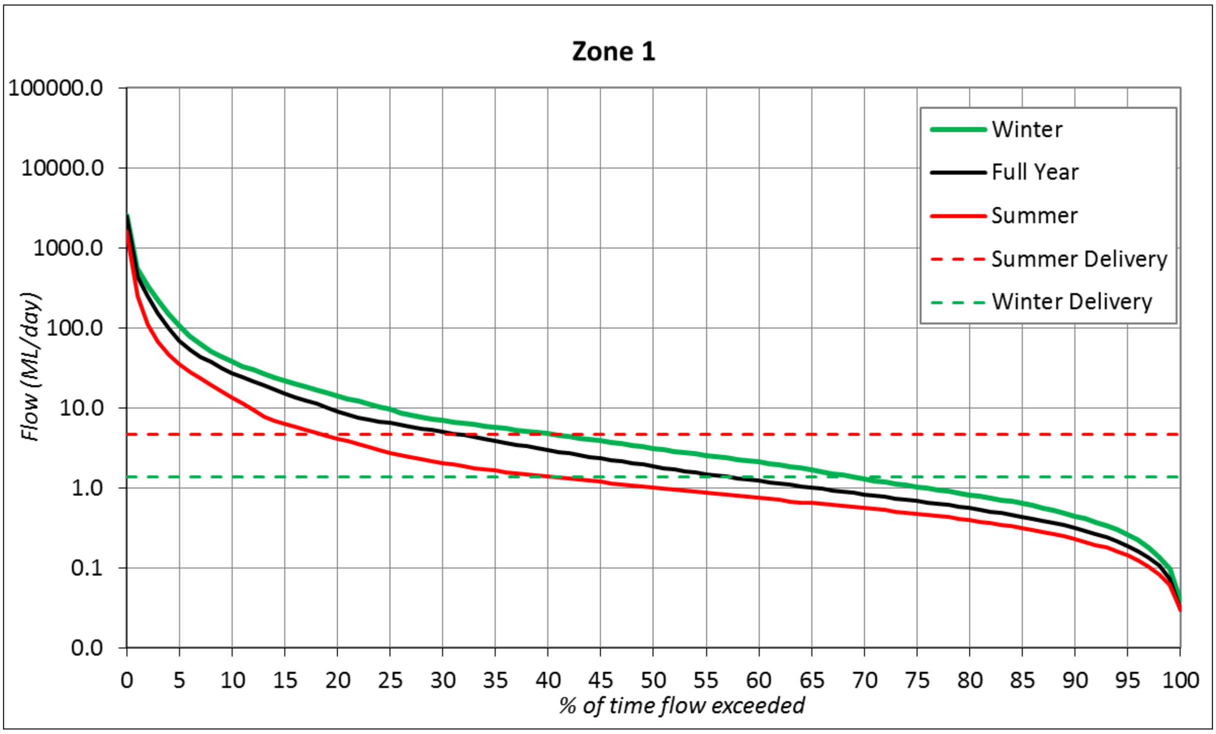
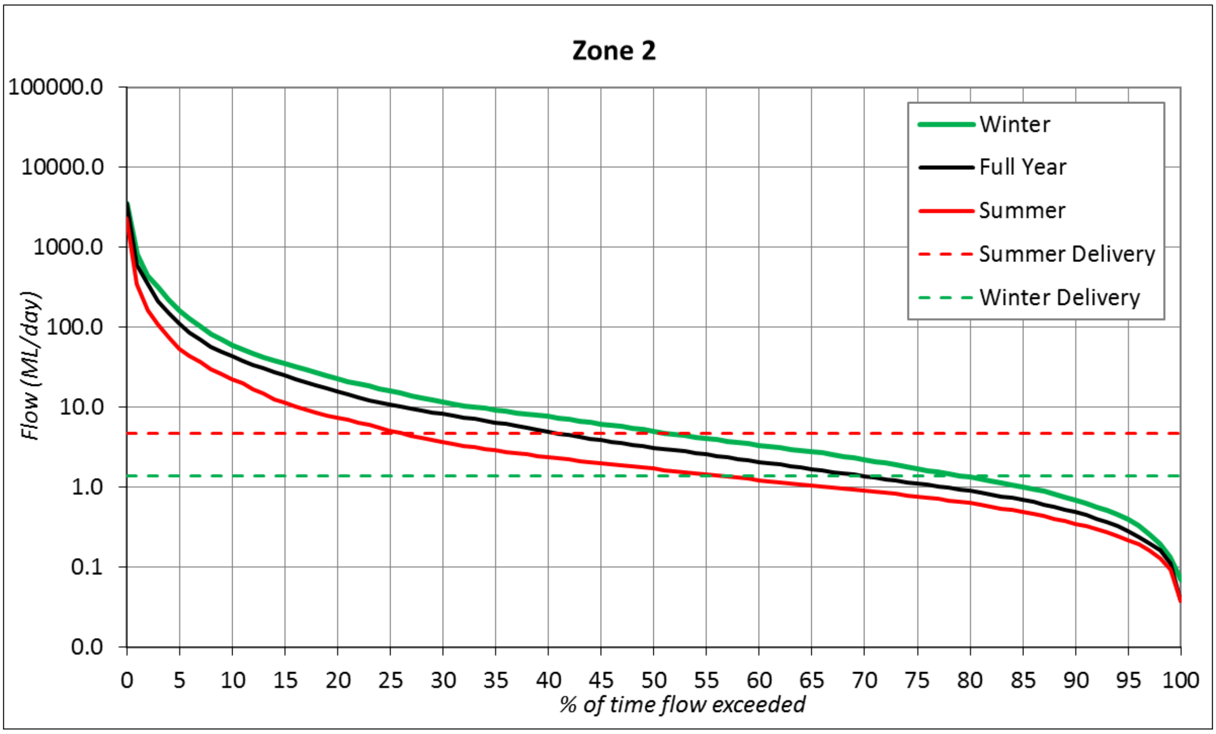
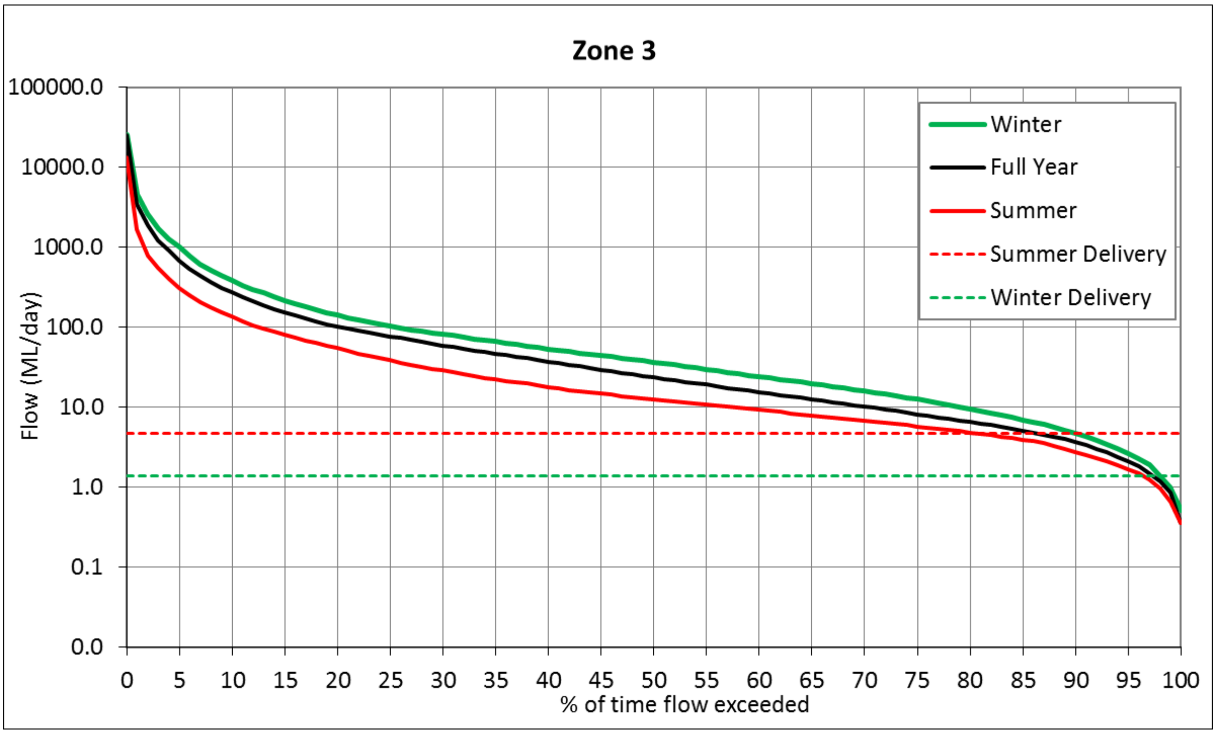
APPENDIX A. Flow Duration Curves

The following flow duration curves were calculated from daily flows obtained from DPIPWE's TasCatch model of the catchment, period 1970 - 2007.






Zone 3
100000.0
10000.0
1000.0
100.0
10.0
1.0
0.1
0.0
Flow (ML/day)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
% of time flow exceeded
Winter
Full Year
Summer
Summer Delivery
Winter Delivery

APPENDIX B. Pumped Water Demand Profile

Project: Prosser Plains Raw Water Scheme (PPRWS) **Approvals Phase**

Basis of Design (BoD): **Pumped Water Demand Profile** **Rev** **1** **Allocation**

ML pa

1 Tassal Demand Descriptive: **500**

Salmon bathing frequency is driven by seawater temperatures and confirmed by a pen's samles fish gill amoeba counts

Bath volume: **3** ML delivered overnight (15+ hours) and minimum bath volume of 2ML

Bathing activity 8 to 10 hours during dayshift

No. of Pens 28 Maximum **Baths/day** **ML/d** Peak ML/wk

Summer higher water temperature period - November to March inclusi **1** 3 21 Maximum Flowrate design point

Shoulder periods - April & May, September & October **0.5** 1.5

Winter period - June, July & August **0.25** 0.75 ie 1 bath in 4 days

2 Golf Course Demand Descriptive **300**

TBC by developer but expectation is more even application during first two years of grass establishment

On site dam storage is estimated at 80ML - decouples pumped demand, assume topped up during daytime (opposite to Tassal)

Summer irrigation season - November to March uses typically at least twice the winter demand, shoulder demand varys with rain

3 Other Customers (Not pumped)

TasWater - reserves 200ML for summer peak demand surety via their WTP at Lower Prosser Weir **200**

Run-of-River Delivery Total ex Twamley Dam **1000**

Twamley Farm 150

EOI by others (Volumes T.B.C. at lower surety levels, post yield calculations in Stage 2 hydrology reports) 0

Twamley Dam Net Delivery for yield calculations 1150

	Customer			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
			Days/month	31	28	31	30	31	30	31	31	30	31	30	31	365
1	Tassal	Adjusted to Allocation limit		80	80	80	45	20	15	10	10	10	20	60	70	500
2	Golf Club	Estimated per farming practice		40	40	40	25	20	10	10	10	10	15	40	40	300
			Totals	120	120	120	70	40	25	20	20	20	35	100	110	800