Innovation in infrastructure – the construction challenges of delivering low flows at existing private dams

Rowley, Damian

Flows for the Future program, Department for Environment and Water, SA, Email:F4F@sa.gov.au

Key Points

- The Flows for the Future program is a voluntary program, working with landholders in the Eastern Mount Lofty Ranges to deliver environmental flows through infrastructure based solutions.
- Due to its unprecedented nature and the broad program area, a range of construction challenges have been encountered. There is no such thing as a "normal dam".
- The program has needed to be innovative out of necessity and has multiple options for environmental flow delivery.
- Passing of low flows is simplified if implemented during the dam design and construction phase.
- To date, modelled mean additional flows available to the system through program activities are estimated to be 347 ML per year.

Abstract

The Eastern Mount Lofty Ranges (EMLR) and Marne Saunders Water Allocation Plans were adopted in 2013 and 2010 respectively. The low flows policy detailed in the plans were implemented to meet the environmental water requirements of the surface water resources, whilst supporting consumptive use limits (NR SAMDB 2013, NR SAMDB 2010). The Flows for the Future (F4F) program implements the low flows policy through the construction of low flow bypass devices in the EMLR and Marne Saunders Prescribed Water Resource Areas (PWRA). The practical implementation of this policy has necessitated innovation to develop on-ground solutions to suit a diverse range of environmental settings.

Due to the unprecedented nature of the program, extensive research, consultation, and development has occurred to refine environmental flow solutions. The program is adaptable, with key learnings fed into the continual improvement of engineering designs which can be modified to suit a range of dam characteristics. This development has been undertaken in collaboration with industry partners and contractors with a community of practice approach.

The progressive design of low flow infrastructure has resulted in a comprehensive understanding of which low flow delivery options can be practically implemented and, importantly, which options are impractical; formulating important learnings for other states and agencies to consider should they wish to pursue similar environmental low flow deliveries in their local contexts.

Keywords

Infrastructure
Construction
Innovation
Environmental flow delivery
Voluntary

Introduction

The F4F program is a $33 million joint Australian and South Australian funded program to secure low flows to re-establish more natural flow regimes across the EMLR at existing private dams and structures. The program aims to:

- improve the ecological health of the EMLR and Marne Saunders catchments.
- return long term average flows to the River Murray and Lower Lakes at Lake Alexandrina.

The program is voluntary and has worked with the community on a dam-by-dam scale to deliver low flows at over 420 sites. The program has constructed devices on dams with a range of characteristics in unique catchment conditions and continually reviews and improves device designs.

Environmental flow delivery is not a new concept (AMLR NRM et. al 2006). However, implementing an infrastructure-based program on a large scale, across hundreds of existing dams, in a variety of catchments has necessitated innovation to develop on-ground solutions.

Every catchment in the EMLR has its own unique hydro-geological characteristics (NR SAMDB 2013) and every dam has its own distinctive features. Dam construction reflects this, with ingenuity and design a reflection of landholder’s requirement to access a secure water source.

Gravity Low Flow Device

The primary mechanism to deliver low flows is through the construction of a gravity bypass device (Figure 1), which returns the low flow component of dam inflows downstream of the dam, whilst still allowing the dam to fill during larger inflow events. The program’s contemporary design is durable, low maintenance, and has an estimated lifespan of approximately 25 years (and likely more). Staff recently visited a research driven gravity bypass device (Lee 2009), constructed in the Marne Catchment in 2005. The device was audited and was found to be in good condition and still passing the calibrated threshold flow rate.

A gravity low flow device requires the construction of an inlet weir, a trenched bypass pipe, and an outlet discharge structure. As each dam is unique, constructing a durable and effective gravity low flow bypass device needs to consider the following:

- **Watercourse geometry and energy.** The gravity device inlet is modified and engineered to sustain the energy and erosive forces in the watercourse. The device design is modified to suit channel geometry and watercourse energy (watercourse order):
- **Geology.** The bypass pipe is trenched to a consistent stable grade (typically 1%) to maintain flow velocity and minimise risk of pipe blockages. The presence of rock is a common challenge, but sandy soils can also be problematic when trenching the bypass pipe:
- **Native and pest vegetation species.** Watercourses generally sustain thick riparian vegetation which must be carefully considered during the planning phase:
- **Longitudinal slope required for gravity bypass devices.** Construction experience and modifications to the design have enabled the implementation of devices where lack of slope is a technical challenge:
- **Some private dams are large and very long.** This results in the scale of works being greater and necessitates technically challenging trench routes to deliver the target flow rate:
- **Dams which cross property boundaries.** This scenario can be mitigated through engagement with multiple landholders or modifications to the inlet weir and/or the proposal of a different option:
- **Dams with more than one defined inflow (or sheeting inflows).** The program has deployed devices which deliver flows through a modified design, with inlet structures that are linked together. For sheeting inflows, the design is modified to suit site survey:
- **Existing dam infrastructure and site hazards.** This includes pumping infrastructure, power, water, livestock, and snakes:
- **Construction in watercourses.** There are distinct construction windows in catchments across the EMLR. These construction windows are commonly disrupted by rainfall events:

- **Dam condition.** The majority of dams in the EMLR are at least several decades old and have existing maintenance related issues (e.g. erosion, stock damage, subsequent modifications):
- **Construction access.** Machinery access to safely construct in and around watercourses is consistently a challenge, which requires ingenuity to safely overcome:
- **A unique build in a hydrological setting.** The design is technically challenging to implement and requires skilled contractors with construction experience in a hydrological setting.

These construction challenges have resulted in the development of a generic design, which can be adapted to suit a wide variety of dams. The contemporary gravity device design is the result of continuous engineering development, refined through years of constructing in different on ground scenarios.

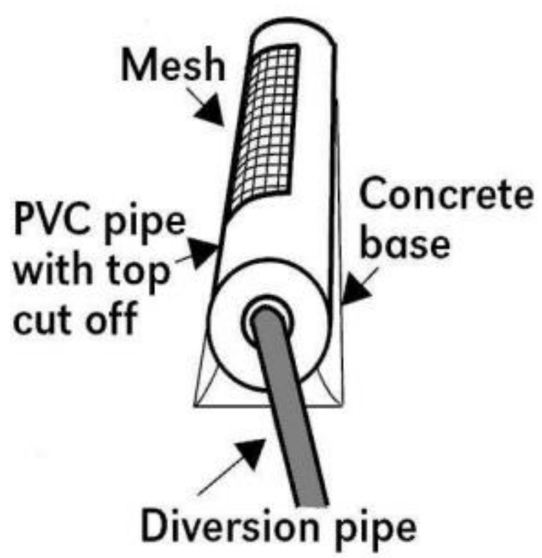

Figure 1. The Initial concept design (left) and a refined, engineered gravity low flow device (right)

Manual Siphons

Where a gravity low flow device is not suitable for a specific site (e.g. extensive rock, native vegetation, access constraints), the program can install a manually operated siphon with an environmental release schedule determining flow rate and operational windows calculated for each participating dam. Significant research and development has gone into the refinement of the design to ensure operation is simple for landholders and target flow rates are delivered.

The environmental release schedule is calculated using the following input criteria:

- Has no greater impact to the security of water supply than the application of threshold flow rates.
- Minimising landholder effort and inconvenience (not requiring excessive visits to valves).
- Creating a schedule which is responsive to dam and catchment characteristics.
- Aiming to achieve approximate environmental equivalence, when compared to the installation of a gravity bypass device.

This method of delivering environmental flows is less preferable to a gravity bypass device, but does have a range of benefits:

- The landholder is proactively engaged and has control of the infrastructure. This also gives the landholder flexibility to lower the dam water level for maintenance activities and mitigate risks associated with erosion and dam safety.
- The system can be implemented at sites which have prohibitive construction challenges for a generic gravity device.
- The design is simple, low cost, and the components are readily available.
- The design is low impact, easy to modify and fast to deploy.
- The design can be constructed by landholders or general skill contractors as the requirements for heavy machinery, graded trenching, and technical construction are removed.
- The design and components can be provided to landholders in a kit form for installation.

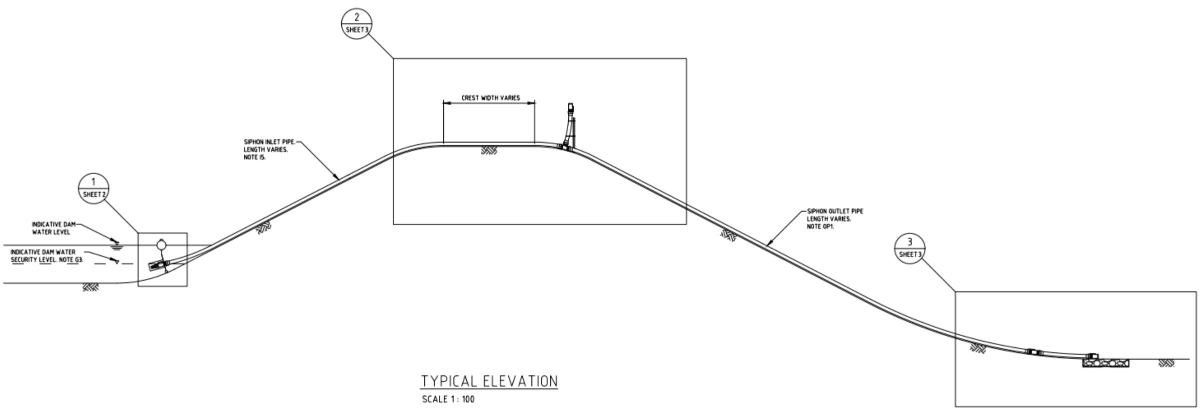

Figure 3. Manual siphon generic design

Figure 3. Utillizing remote controlled bathymetric instrumentation to accurately set the siphon intake level ensuring the siphon breaks at the identified water security level (a hard fail-safe)

Dam Removals

The program has undertaken dam removals across multiple catchments in the water resource areas. While low flow devices only affect the low flow component of the flow regime, dam removals allow all flows to pass. This is a permanent solution and the entire volume associated with the dam is removed from the consumptive limits within the relevant Prescribed Water Resource Area.

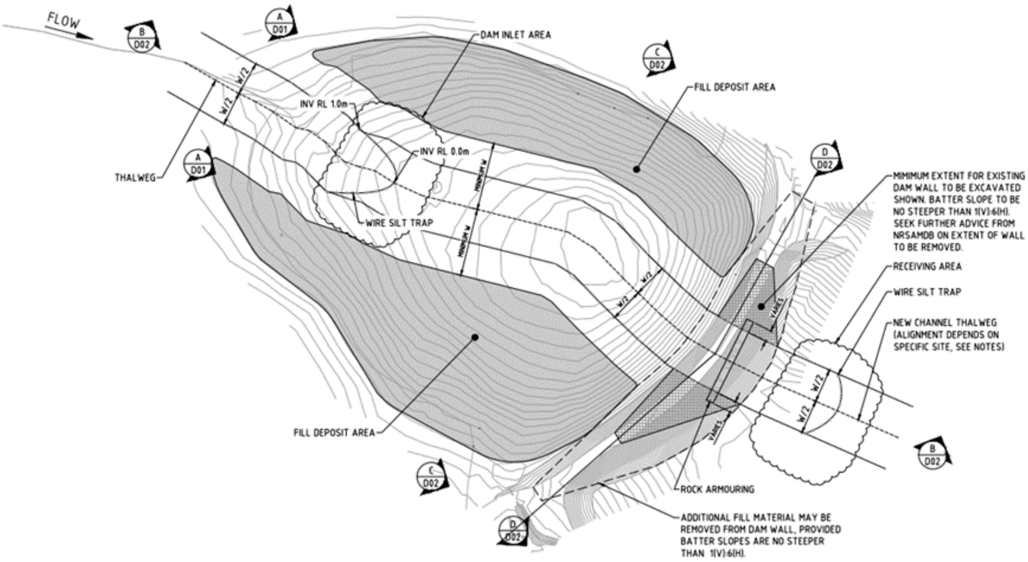

Figure 5. Conceptual Dam removal generic design, requiring adapatation to the dam characteristics.

The program has encountered a range of dam removal scenarios which have required adaptability to undertake the works in an environmentally sensitive method.

Some of the challenges requiring careful planning when removing dams have included:

- **Hydrological setting**. This is relevant when considering the presence of water in the dam and the persistence of inflows. Dams are also commonly built on or immediately below springs, which presents challenges to earthmoving. Dam de-watering is required to safely and efficiently decommission the structure.

- **Sediment presence**. This includes refining volumetric estimations and a risk-based approach to contamination based on upstream catchment characteristics. The sediment within a dam is treated distinctly different to the dam wall itself and represents a potential cost-based risk to dam removals if volumes are not well constrained.

- **Flora and Fauna.** A management plan for every dam is created for both native and pest flora and fauna species.

There are further considerations such as stream energy, erosional forces, longitudinal bed slope and pre-existing infrastructure that required innovative thinking in order to effectively and safely remove the barrier to flow.

Figure 4 Moblizied heavy machinery, in preparation for a Dam removal in the Bremer River Catchment.

Conclusions

South Australia's water resource management framework is unique in the context of the country and has been developed through necessity. It aims to achieve and equitable balance between environmental, social, and economic requirements of the resource (NR SAMDB 2013). The implementation of the low flows policy has resulted in complex challenges due to the broad program area and variable dam configurations. The F4F program has been adaptive and innovative through the delivery of environmental flow delivery projects. This has resulted in an additional modelled mean annual flow of 347 ML available to the catchments for environmental water requirements.

Acknowledgments

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Hills and Fleurieu Landscape Board

Northern and Yorke Landscape Board

Murraylands and Riverland Landscape Board

Participating landholders in the Eastern Mount Lofty Ranges

Industry partners and contractors

F4F program Staff

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