Lake Moodemere – Water Savings Assessment

Internal Report For DEPI Water Resources Division

January 2014 – Prepared by DEPI Hume Region and Sunday Creek Irrigators Syndicate

Department of Environment and Primary Industries
State Government Victoria

Contents

Introduction

This report has been prepared by the Department of Environment and Primary Industries (DEPI) Hume Region and the Sunday Creek Irrigators Syndicate (SCIS) on behalf of Parks Victoria and the SCIS as joint proponents for a proposed water savings program for Lake Moodemere.

Objectives

The objective of this report is to explain how proposed modifications to irrigation supply practices may impact on the hydrological regime in Lake Moodemere and Sunday Creek, and the water savings resulting from these changes.

Water savings estimates through the proposed modifications have been calculated using a spreadsheet model developed by the DEPI Hume region in collaboration with SCIS, and tested with key stakeholders.

This report will detail:

- current and proposed water management operations
- data constraints
- the source of all data used in the calculation of water savings estimates
- the spreadsheet model and how the model operates
- the projected water savings
- key assumptions made within the assessment process
- a comparison with previous water savings assessments by consultants modelling at Lake Moodemere/Sunday Creek

Background

Currently SCIS manage water levels in Lake Moodemere to ensure there are sufficient inflows to Sunday Creek where their offtake pumps are located (Figure 1). They propose to change the delivery system for irrigation water directly into Sunday Creek as they believe it will be a more reliable and manageable arrangement although pumping costs are acknowledged to likely increase on average. They are also concerned that the current regulator to Lake Moodemere which controls inflows and outflows will fail in the near future. The SCIS claims there will be water savings as a result of changing the water delivery arrangements.

There is an extensive area of wetland marshes to the north of Lake Moodemere, and their health relies on wetting and drying cycles. The current regime however results in sustained annual flooding, and so from a land management perspective any change in the flooding regime which allows periodic drying would be an improved outcome.

Lake Moodemere is also the venue for an annual rowing regatta which is held around mid-January each year, and has been going for nearly 150 years. A minimum water level is required to successfully hold the regatta, which attracts a large number of competitors and is considered to have a significant socio-economic benefit to the local community.

As such, in developing the operational arrangements to achieve the estimated water savings, consideration was given to the environmental requirements of Lake Moodemere and the surrounding wetlands and the socio-economic benefits of recreational use of Lake Moodemere.

These savings are contingent on a range of new works, which the proponents consider could be funded in part or whole through trading. The works required include a new regulating structure to control inflows into Lake Moodemere, a new pump facility and pipeline for direct supply to Sunday Creek and raising the sill between Lake Moodemere and Sunday Creek.

DEPI has been providing assistance to the SCIS to:

- ensure methods applied to quantify water savings using limited data meets the necessary technical requirements;
- understand practical operational viability of the proposed option;
- facilitate engagement with stakeholders; and
- coordinate the necessary planning, licencing and land consent approvals.

Once agreement has been reached on the quantum of water savings based on selected option(s), the next step will be to further investigate the practicality of the option, estimate capital and operational costs, develop clear operating rules (incl. reporting), negotiate any cost sharing arrangement and commission the necessary works. It is proposed that this be jointly managed by Parks Victoria, the land manager for Lake Moodemere, and SCI. The proponents would then apply for an entitlement and arrange sale of the water savings.

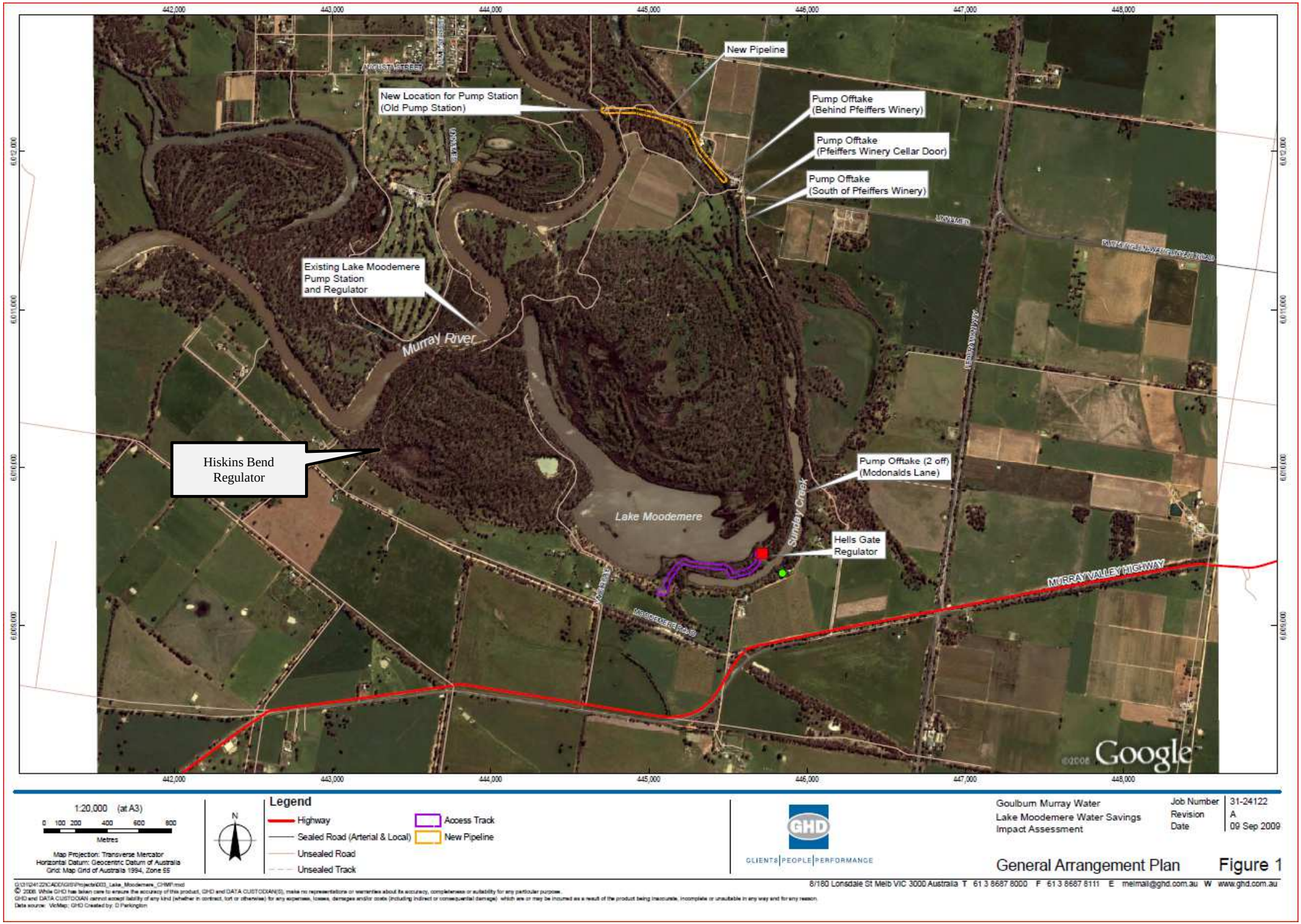

Figure 1 - Site Overview

Water Management Operations

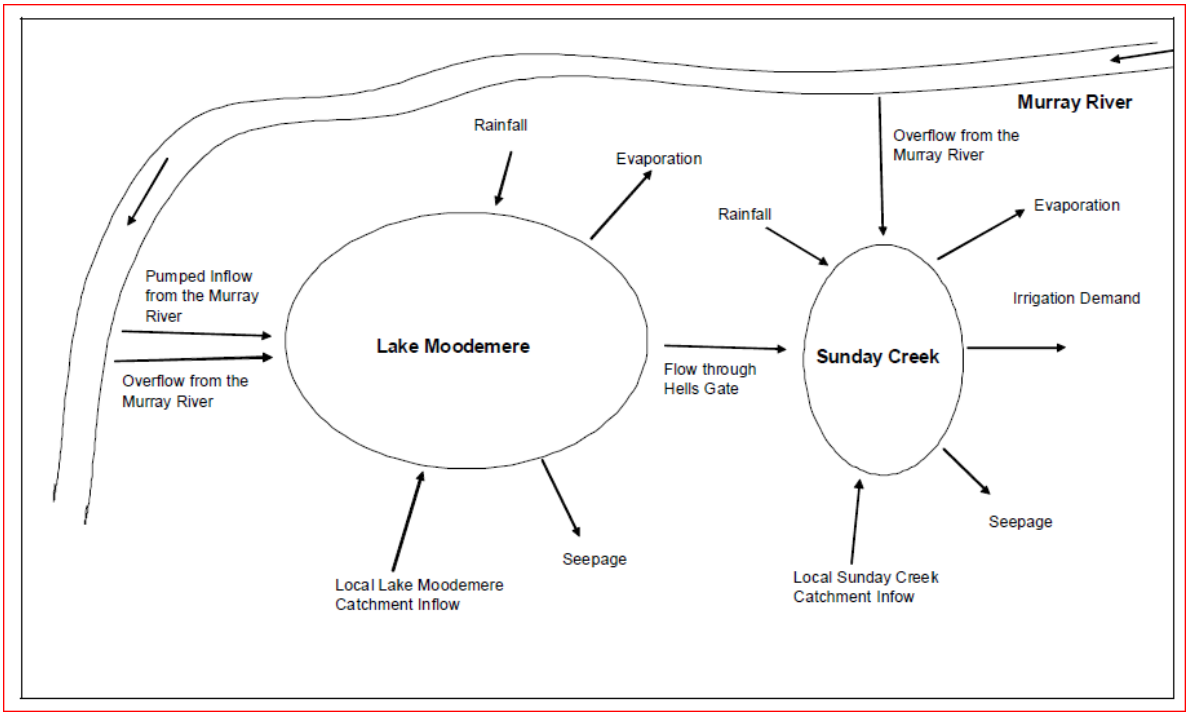

Figure 2 - Water Balance Schematic (GHD, 2010)

Hydrologic control and natural features

The hydrologic regime of Lake Moodemere is controlled by both natural and more importantly anthropogenic features. The current management relies upon the following system modifications:

- Hells Gate is an artificially excavated channel between Lake Moodemere and Sunday Creek. Recent surveys indicate that the invert level and cross section are relatively level throughout the length of Hells Gate. Hells Gate has been in operation since at least 1941 (using aerial photography). The invert elevation of Hells Gate was surveyed at 128.55m AHD.
- The Lake Moodemere regulator on the Murray River on the north western end of Lake Moodemere consists of 2 x 600mm diameter culverts through the bank of the Murray River and a concrete structure with 3 x 610mm wide and 470mm high gated outlets. The invert of the regulator was surveyed at 128.31m AHD. A diesel powered pump used by the SCIS is located adjacent to the regulator on the banks of the river. The regulator was constructed in 1979. The regulator allows inflows up to 130m AHD after which inundation of the lake and surrounding marshes occurs naturally along numerous locations of the Murray River. The Lake Moodemere regulator is a one way structure letting water into the lake from the river however water cannot flow through the regulator back into the river.
- A 150m long excavated channel links the Lake Moodemere regulator to Lake Moodemere.
- An older pump station is located in the vicinity of Hyde Rd. This was used to pump water directly into Sunday Creek prior to the construction of the current Lake Moodemere regulator. This is the site of the proposed new pump location.
- The Hiskens Bend regulator, constructed in 2008, was commissioned to control flows from the Murray River to Forest Swamp, immediately downstream of Lake Moodemere. The regulator is now inoperable and has no impact on Lake Moodemere water levels.

Information on control and operating levels commonly uses a local relative level compared to a gauge at “Chambers Pump” on Sunday Creek. The Chambers Gauge zero datum level has been surveyed at127.1m AHD. Important levels are listed below in both the local level and in meters AHD.

SITE	Level (Chambers m)	Level (m AHD)	Source
Murray culverts to regulator – Murray side	0.74	127.84	survey
Murray culverts to regulator – Regulator side	0.84	127.94	survey
Chambers Gauge	0	127.1	survey
Invert level of Hells Gate	1.45	128.55	survey
Invert level of Lake Moodemere Regulator	1.21	128.31	survey
Minimum level for rowing regatta	1.6	128.7	stakeholder consultation
Northern marshes commence inundation	1.6	128.7	SCIS
SCIS min operating range Sunday Crk	1.6	128.7	SCIS (proposed)
SCIS max operating range Sunday Crk	1.8	128.9	SCIS (proposed)
SCIS average operating level Sunday Crk	1.7	128.8	SCIS (proposed)
Proposed height of new Hells Gate regulator/invert	1.9	129.0	SCIS
Murray overbank flow - flood plain/Moodemere inundation	2.9	130.0	GHD

Table 1 - Level information

Current Operation

Overview

The current operating practice between September to April maintains an artificially high water level in Lake Moodemere through the use of a gravity fed regulator from the Murray River and a pump station that sources water from the river in times of low flow (this pump has been metered since 05/06). Lake Moodemere, once above 128.55m AHD flows under gravity into Sunday Creek via the Hells Gate channel. From Sunday Creek the SCIS have 6 separate licensed offtakes which are all metered.

Official operating guidelines

The former Department of Conservation and Natural Resources produced an ‘Integrated Watering Strategy’ for Lake Moodemere in 1996 (Robley, 1996). This strategy provided operating guidelines for the regulating structure at Lake Moodemere, as follows:

“The regulator gates should be closed in December each year, allowing the lake level to be drawn down to 1.9 m through irrigation and evaporative demands. If the lake falls to a level which creates irrigation supply difficulties, the regulating structure should be operated to restore a maximum level of 1.9 m. The regulator gates should be open between May 1st and August 31st each year to allow for variation in Lake level.”

Although the maximum level was set at 1.9 this was revised down to1.6m. The structures installed on the Lake Moodemere regulator in 1996 did not function well and were subsequently removed, thus the operation of the Lake has been consistent since 1978/79.

The Robley guidelines have been acted upon when practical, i.e. if Lake level falls below 1.6 m any time during the irrigation season, the regulator gates would be opened to allow gravity flows into the Lake if possible. The regulator gates are generally open during the recommended months, however flooding during these months has not occurred very often. (SKM, 2008).

Under current operating conditions, water levels in Sunday Creek between September and April are maintained between 128.7 and 128.95m AHD by SCIS through inflows from Lake Moodemere. To artificially maintain Lake Moodemere at these levels requires between 1 Ha and 31.2 Ha of marsh adjacent and north of Lake Moodemere to be flooded. The lower lying areas of the marsh land are dominated by Giant Rush (*Juncus ingens)* which is a large clump forming indigenous plant capable of growing to 5m.

Proposed Operation

Operating Environment

The SCIS have proposed modification to the infrastructure used to supply water to Sunday Creek for subsequent irrigation extraction. This proposal seeks to provide for more efficient delivery of water to Sunday Creek by construction of a pump station to deliver water directly from the Murray River to Sunday Creek at Hyde Road. The proposal also includes raising the sill at Hells Gate, the current connection between Lake Moodemere and Sunday Creek. Construction of the raised sill will enable water levels in Sunday Creek to be maintained at a level independent of the level in Lake Moodemere (WaterTech, 2011). The existing Lake Moodemere regulator will also be replaced as part of this proposal. Cost estimates are detailed below for each of these works.

During the irrigation season in-between September and April each year, Sunday Creek will be kept at an average level of 128.8m AHD. Maximum and minimum operating levels of Sunday creek will be 128.7m and 128.9m AHD respectively. These levels will be maintained via the new pump station and pipeline to be constructed. The proposed pump facility is planned to have a capacity of 1.4ML per hour operating 7 hours per day on off peak power with an automatic cut-off when the level in Sunday Creek reaches 128.9m AHD. Sunday Creek, between 128.7m and 128.9m AHD, holds approximately 10.1ML of water (GHD, 2010) which acts as a supply buffer to each of the irrigators in the syndicate. More water could be supplied if the proposed pump was run during peak power periods.

The proposed HellsGate sill, restricting flow between Sunday Creek and Lake Moodemere, will be constructed to an elevation of 129 m AHD. The 128.8m proposed operating level for Sunday Creek is on average lower than the historic management levels, thus creating 49ML of average annual evaporation savings, Figure 6 plots a comparison between historic Sunday Creek and proposed Sunday Creek operating levels.

The existing Lake Moodemere regulator, originally built in 1979, will be demolished and replaced with a new regulating structure capable of moderating gravity flows into Lake Moodemere when the Murray is flowing between 128.31 and 130m AHD. The replacement and effective operation of the Lake Moodemere regulator is critical to controlling water levels in Lake Moodemere and to achieving the savings presented in this report. The ability to control the water level in Lake Moodemere when the Murray River flows below 130m AHD is well supported in previous reporting by both GHD and SKM where both state that overbank flows from the river into the flood plain commence at 130m AHD (2.9m Chambers Gauge), prior to this there is no connection between the Murray River and Lake Moodemere.

To ensure there is enough water in Lake Moodemere to run the annual rowing regatta, and for other recreation purposes, water levels in Lake Moodemere will be maintained up to a maximum of 128.7m AHD between September and the end of January via the new Lake Moodemere Regulator. Outside of these times the regulator will remain closed with no controlled inflow or outflow.

The proposed operating regime described above correlates with ‘Option 3a’ in the water savings modelling spreadsheet developed by the DEPI Hume region and SCIS. This report details no other options presented in the spreadsheet.

Under this proposed operating regime no marsh area will be inundated due to water supply into Sunday Creek for the SCIS. It is this reduction in marsh area inundation that leads to the majority of proposed water savings through decreased evapotranspiration and seepage.

Estimated cost of upgrades

Pump station, pipeline and automation – $ 606,900 (SKM estimate, August 2008)

Lake Moodemere regulator repair and upgrade & Hells Gate sill construction – $200,000 (Alluvium consulting estimate, February 2014) -

Required Entitlement and Sunday Creek Operating Losses

Currently the SCIS have a combined total licensed annual allocation of 2322.5 ML, all of which is high reliability share. The total licensed allocation will not be changing under this proposal. Currently, Sunday Creek losses form part of the Murray River loss being shared equally between NSW and VIC and is outside of the MDBA cap. However, under the proposed arrangement Sunday Creek losses will become part of the Victorian River Murray diversion and within the MDBA cap. This, in theory, will reduce the amount of water available to Victorian Murray users, however as the volume is a very modest amount (average proposed Sunday creek losses are 75Ml/year) the impact on the system overall will be insignificant.

Sunday creek losses under the proposed arrangement are modelled to vary from a maximum of 187Ml per year (81/82) to a minimum of 43ML per year (numerous years). On average there is a 2ML net loss in Sunday Creek over the non-irrigation season (May – Aug) however there is often overbank flows to offset this. Modelling the proposed operating regime using climate data and river levels from1979 – 2006, there were only two years (02/03 & 05/06) where the modelled level in Sunday Creek, at the commencement of the irrigation season, was below the 1.7m average operating level however both instances were above the 1.6m minimum operating level. Thus theoretically minimal Victorian diversion water should be required to restore Sunday Creek levels at the commencement of the irrigation season however the volume allocated will need to be conservative to allow for extreme dry years and model uncertainty.

Further details on the exact volume that will be included in the Victorian cap to account for Sunday Creek operating losses will be incorporated into the Lake Moodemere/Sunday Creek operating guidelines that will be developed prior to the sale of any water savings.

Stakeholder Consultation

The DEPI Hume region and the Sunday Creek Irrigators Syndicate have developed this proposed operating environment in close consultation with the North East Catchment Management Authority, Goulburn Murray Water, Parks Victoria, and the Lake Moodemere Rowing Regatta. Over the previous 4 years each of these organisations have contributed to numerous Lake Moodemere stakeholder meetings which have assisted the passage of the proposed management change through numerous permits and application processes within local and state government. Most recently the Lake Moodemere stakeholder group met on February 12th 2013 where the group agreed on the operating environment as proposed in this report.

Data Inputs

Rainfall

Rainfall data is sourced from the SILO datadrill climate product. This interpolated information is available across Australia on a 0.05 degree grid (approximately every five kilometres) extending back to 1889. The location used for this project is from approximately 500m east of Lake Moodemere (-36.0500 latitude 146.4000 longitude). SILO datadrill is an interpolated daily climate data product developed by the Queensland Department of Science, Technology, Innovation and the Arts. The SILO datadrill product uses nearby recorded climate station data and modifies it based on kriging and splinning techniques to create a more accurate climate record where no recorded data is available. SILO datasets are widely used across Australia as the main supplier of interpolated climate data to major Government clients. This data was considered more accurate than the nearest climate recording station at the Rutherglen Research Institute, 12.5km to the south (http://www.longpaddock.qld.gov.au/silo/). Average monthly rainfall values are calculated over the modelling time period of 1979 – 2006.

Evaporation

Evaporation data is likewise sourced from the SILO datadrill product. The SILO datadrill product contains seven different options for evaporation and transpiration calculations:

- FAO56
- Mortons actual
- Mortons potential

- Mortons lake and
- Mortons wet
- Class A Pan
- Synthetic Pan

The DSE 'Technical manual for the quantification of water savings' (DSE, 2012) states that evaporation for open water surfaces can be calculated using recorded pan evaporation estimates multiplied by an pan evaporation factor (PEF) of 0.83. The document also suggests an alternative and more accurate method using weather station data to calculate theoretical evaporation which should be used where the data is available. Although the document doesn't mention a particular methodology there are two common methods used across the world for the calculation of evaporation from a shallow water body, the Penmon-Monteith and Mortons Lake estimates. Both are widely used and both have been used in recent water savings projects within the Murray Darling Basin. The Mortons calculation was used by the Bureau of Meteorology to create evapotranspiration layers for the National Climatic Atlas (Bureau of Meteorology, 2001). There is in fact little difference between all three approaches with an annual summary shown below for Lake Moodemere using the SILO Datadrill product. Average monthly evaporation values are calculated over the modelling time period of 1979 – 2006.

Month	Net Evaporation		
	0.83 pan (mm)	FAO56 (mm)	Mortons Lake (mm)
May	-6.1	-1.4	-4.4
June	-26.0	-22.8	-26.1
July	-26.8	-23.8	-25.4
August	-10.8	-7.3	-2.7
September	17.5	21.6	34.6
October	51.9	55.5	74.7
November	106.8	104.1	121.3
December	155.7	141.8	153.9
January	178.0	159.1	168.8
February	133.6	121.4	128.1
March	101.0	95.0	98.4
April	40.3	42.6	43.2
IRRIGATION SEASON (Sep – Apr)	**784.9**	**741.1**	**823.1**
TOTAL ANNUAL	**715.1**	**685.9**	**764.6**

Table 2 - Average net evaporation comparison figures

A simplified estimate of evaporation rates from Lake Moodemere was made using a water balance approach for recent years to assess the accuracy of the various evaporation estimates (table 3). Using this data for justification the Morton Lake methodology was decided to be the most accurate representation of evaporation and thus was adopted as the data used for open water evaporation estimates within the spreadsheet model. Lake Moodemere and Sunday Creek were modelled as 'open water' whilst the marsh areas, which are are dominated by Giant Rush, were assumed to be vegetated and thus need an evapotranspiration estimate, see the following section.

	06/07		07/08		09/10		
	ML	MM	ML	MM	ML	MM	
PUMP IN	2420	2420	1877	1877	1708	1708	
PUMP OUT	1070	1070	497	497	508	508	
RAIN IN	157	157	244	244	435	435	
SEEPAGE OUT	242	242	242	242	242	242	
RUNOFF IN					0	0	
ET OUT	**1265**	**1265**	**1381**	**1381**	**1393**	**1393**	(by water balance deduction)
RUTHERGLEN RESEARCH SILO DATA Evap	1,654	1,654	1,416	1,416	1,329	1,329	Class A Pan Evaporation Measured
FAO56	**1,222**	**1,222**	**1,147**	**1,147**	**1,093**	**1,093**	**Penmon Monteith ET calculation**
Mlake	1,244	1,244	1,192	1,192	1,166	1,166	Morton evaporation over shallow lakes
Mpot	1,781	1,781	1,665	1,665	1,524	1,524	Morton potential evapotranspiration over land
Mact	661	661	673	673	767	767	Morton actual evapotranspiration over land
Mwet	1,219	1,219	1,169	1,169	1,146	1,146	Morton wet environment areal evapotranspiration over land

Table 3 - evaporation water balance

Evapotranspiration

The marsh areas north of Lake Moodemere commence inundation once the water level of Lake Moodemere exceeds 128.7m AHD. As mentioned previously the marsh area is dominated by Giant Rush plants which transpire, thus evapotranspiration estimates need to be developed for this area for an accurate water savings assessment. The Food and Agriculture Organisation of the United Nations (FAO) report titled *'Crop evapotranspiration - Guidelines for computing crop water requirements'* (FAO, 1998), is a global standard when estimating crop factors for evapotranspiration. Using *'TABLE 12. Single (time-averaged) crop coefficients, K_c, and mean maximum plant heights'* from this report we adopted values for a temperate wetland rush with a mid-season crop factor (Kc) of 1.2 for a plant with a maximum crop height of 2m. As the Giant Bullrush can exceed this height can grow to 5m this is a conservative crop factor suggestion. Average monthly evapotranspiration values are calculated over the modelling time period of 1979 – 2006.

To calculate evapotranspiration, the Mortons Lake evaporation rate is multiplied by Kc, in this case 1.2.

Gauged lake levels

Gauged levels in Lake Moodemere used in the spreadsheet model are those as recorded by SCIS and used in both SKM and GHD water balance modelling.

Change in area of inundation with change in stage height

Stage heights and resultant area of inundation relationships are the same as those developed and used in (GHD, 2010).

Groundwater Flux

An average daily groundwater seepage rate of 0.61mm was implemented in the spreadsheet model. This number sits between the SKM estimate of 0.5mm/day and the GHD estimate of 1mm/day.

0.61mm/day was calculated as the average daily groundwater seepage rate using a simple water balance assessment of Lake Moodemere water levels during the winter months when there was no pumping and no overbank flows.

DEPI depth to water table data, DEPI Modflow groundwater modelling results and DEPI bore monitoring sites11339/3890 suggest a depth to water table of approximately 3-5m below surface suggesting that there will be seepage.

Additional Modelling Data Information

- The period for calculating annual water savings is September to April, which is when water levels in Lake Moodemere are actively managed by the Sunday Creek Irrigators.

- The modelled period is 27 years, from 1979/80 to 2005/06. The Chambers Gauge, which records the stage heights of Lake Moodemere, ceased recording in 2006. Goulburn Murray Water contracted Peter Chambers to read the gauge weekly. In 2006 Goulburn Murray Water took over the responsibility of reading the gauge however ceased soon afterwards due to OH&S concerns associated with accessing the gauge, thus the modelling period only extends to those years for which there is recorded data on the levels of Lake Moodemere.
- Historical monthly lake water levels have been adopted at the Chambers pump gauge.
- The current Lake Moodemere regulator allows inflows up to RL 130m AHD (2.9m local level) after which inundation of the lake and surrounding marshes naturally occurs from a number of locations along the Murray River and the regulator has no influence on the lake. When this occurs during the period September to April no water savings (both evaporation and seepage) were calculated for that irrigation season. (7 out of 27 years)
- Once the water level exceeds 1.6m local gauge height in Lake Moodemere the surrounding marshes start to be inundated, with the area of the lake and the marshes being 247.57Ha at 2.9m local level (as per (GHD, 2010)).

Water Savings Modelling

How are the current losses calculated

The modelling is based on a range of data including historical monthly water levels provided by SCIS, evaporation, evapotranspiration and seepage estimates as outlined above, and area of inundation sourced from Appendix A (GHD, 2010). Based on this data the current estimated losses are 1,407 ML/year.

The key assumption are:

- At heights above 130m AHD (2.9m) both evaporation and evapotranspiration losses are deemed to be part of the operation of the river and so not included in the savings calculations (regulator no longer controlling inflows or outflows).
- Inundation of the northern marshes commences at 1.6 m.

How are the new operating losses calculated

As for the estimate of current losses, the modelling is based on a range of data including historical monthly water levels provided by SCIS, evaporation, evapotranspiration and seepage estimates as outlined above, and area of inundation sourced from Appendix A (GHD, 2010). Based on this data the estimated proposed losses would 813 ML/year .

The key assumption are:

- At heights above 130m AHD (2.9m) both evaporation and evapotranspiration losses are deemed to be part of the operation of the river and so not calculated (regulator no longer controlling inflows or outflows).
- Inundation of the northern marshes commences at 1.6 m.
- Regulator to Lake Moodemere allows inflows up to a maximum of 1.6 m Sep to Jan as per the proposed operational level arrangements.
- Regulator to Lake Moodemere closed at the end of January (no inflow or outflow).
- Sunday Creek maintained at an average level of 1.7 m.
- Assume structure at Hells Gate allows no inflow into Lake Moodemere from Sunday Creek unless overtopped (top of invert set at 1.9 m so will not occur).
- Assume structure at Hells Gate allows no inflow into Sunday Creek from Lake Moodemere unless exceeds new sill height of 1.9 m.

Loss (ML LTCE)	Current Operation	Proposed Operation (3a)	Saving
Lake Evaporation	485	465	20
Sunday Creek Evaporation	123	75	49
Marsh Evapotranspiration	705	246	459
Marsh Seepage	94	28	66
TOTAL LOSS	**1407**	**813**	**594**

Table 4 - Modelled water savings (ML)

Regulated and Non-Regulated Flows

To proportion the water savings between regulated and non-regulated periods the Murray Simulation Model (MSM) was used to designate months when Lake Victoria was spilling (both internally, Victoria to NSW and externally) and not spilling. Based on this data, individual monthly water savings were allocated to regulated or non-regulated resulting in 462ML (78%) of savings from regulated flows and 132ML (22%) of savings from unregulated flows (from the total proposed saving of 594ML).

Comparison between previous modelling and SCIS water modelling results

(GHD, 2010) documents three options for potential water savings scenarios at Lake Moodemere, none of which proposed raising the sill between Lake Moodemere and Sunday Creek thus all three options were only able to offer average annual modelled savings varying from 32 to 79 ML per year. Each of the three GHD scenarios model extensive inundation of the northern marshes which is in comparison to this proposal which significantly reduces inundation of the marsh area. Figures 3 and 4 on the following page show time varying water levels in Lake Moodemere for both the DEPI/SCIS modelling and the GHD modelling. Considering that the northern marsh areas commence inundation at 128.7 m AHD (1.6m), from these figures it can been seen where the differences are between the GHD water savings estimate and the DEPI/SCIS estimates (excluding overbank years where the marsh areas flood regardless)

GHD released a supplementary option (GHD, 2010a), named option 5. This option was similar to the previous GHD option 2 however it installed a regulating structure at Hells Gate, controlling flow between Lake Moodemere and Sunday Creek and maintained Lake Moodemere at 128.7m AHD whenever possible. This resulted in a much larger water saving estimate of 448ML per year. Further savings could be realised, in option 5, if the levels in Lake Moodemere were only held at 128.7m AHD until the end of January, as proposed by the SCIS option 3a, which would see very similar results.

(SKM, 2008) proposed two water savings options. Option 1 was most similar to the SCIS option 4, whereby a regulating structure is installed at Hells Gate and a new pump and pipeline installed to supply water directly to Sunday Creek with no water supplied to Lake Moodemere outside of overbank flows. SKM option 1 calculated a saving of 661ML per year and SCIS option 4 calculated a saving of 684ML per year. SCIS option 3a, as presented in this report, maintains a water level of 128.8m AHD in Lake Moodemere between September and January hence a reduced savings estimate of 594 ML per year. SKM option 2 was a direct pipeline to all SCIS properties, removing the need for supply to Sunday Creek at all. Although this option offered the greatest savings (780ML per year) it was considered unviable due to project cost.

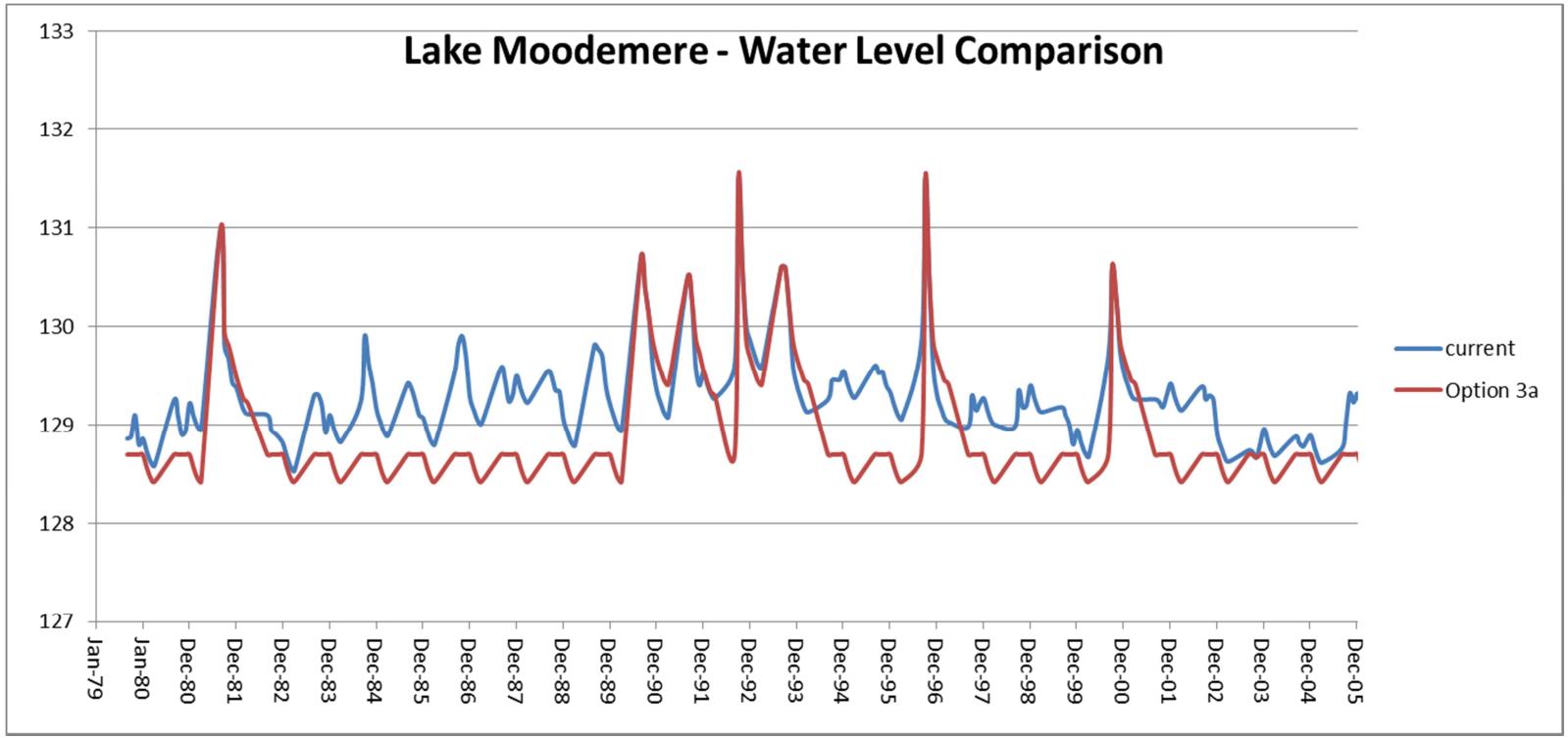

Figure 3 - Lake Moodemere Level Comparison SCIS

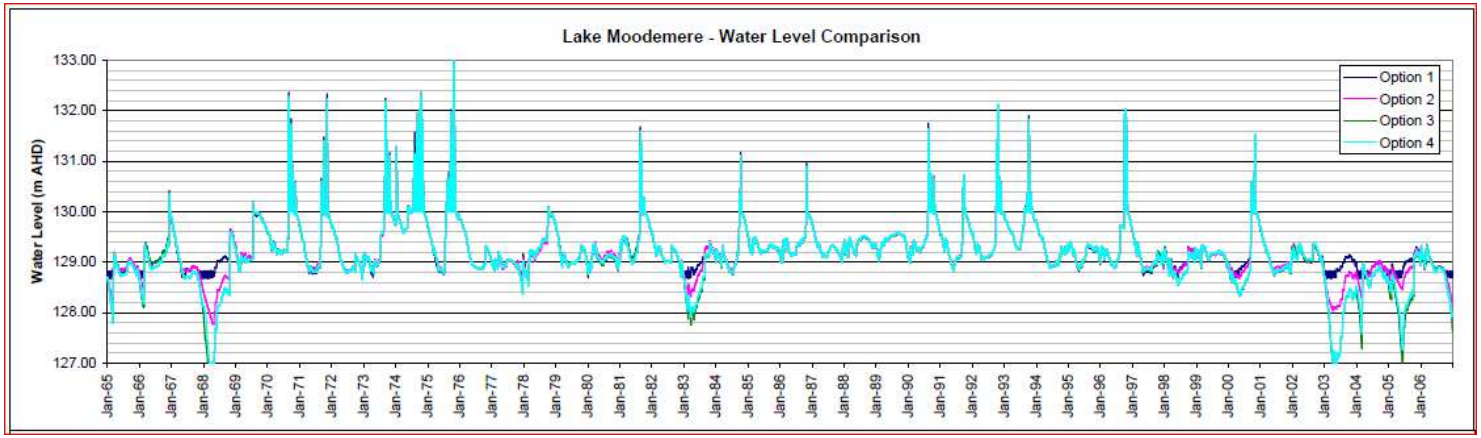

Figure 4 - Lake Moodemere Level Comparison GHD

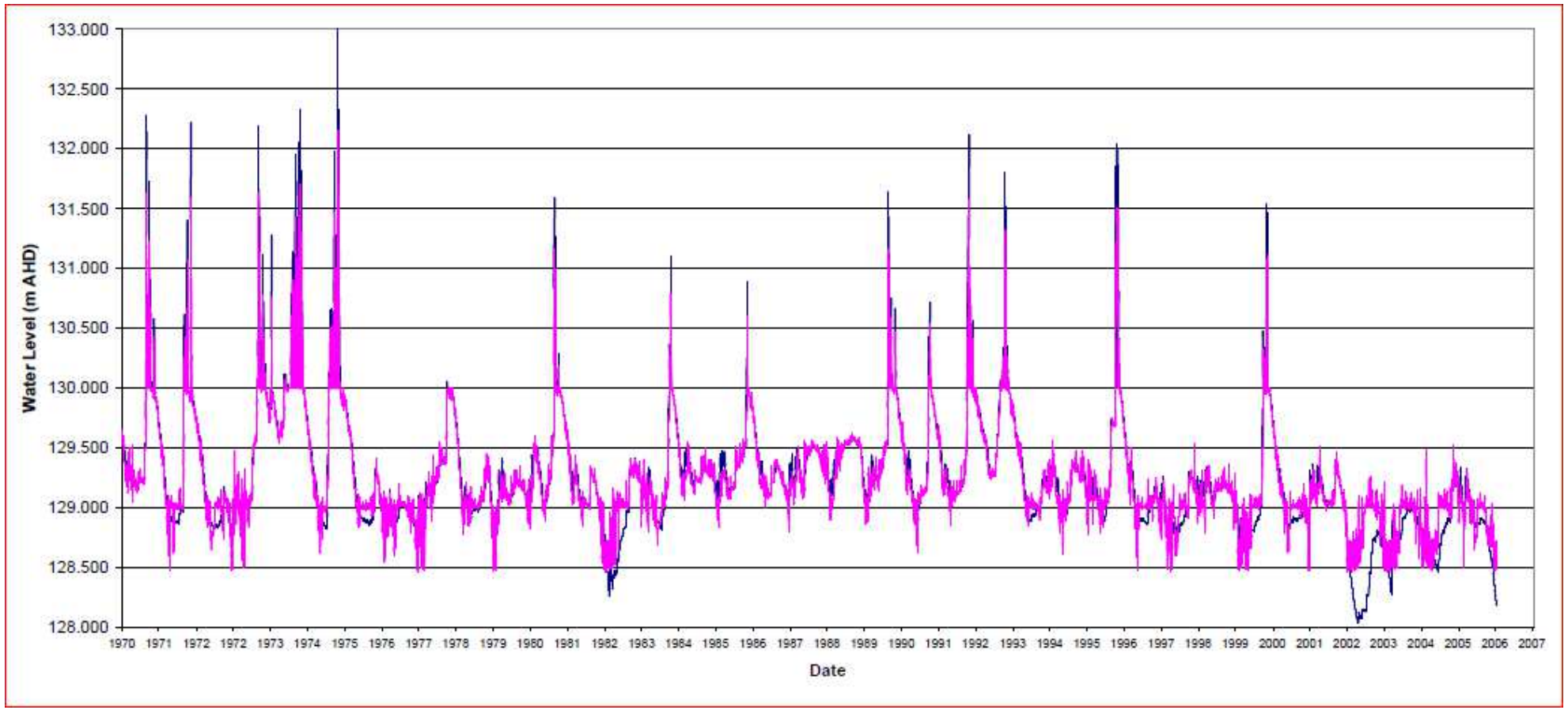

Figure 5 - GHD water level option 2

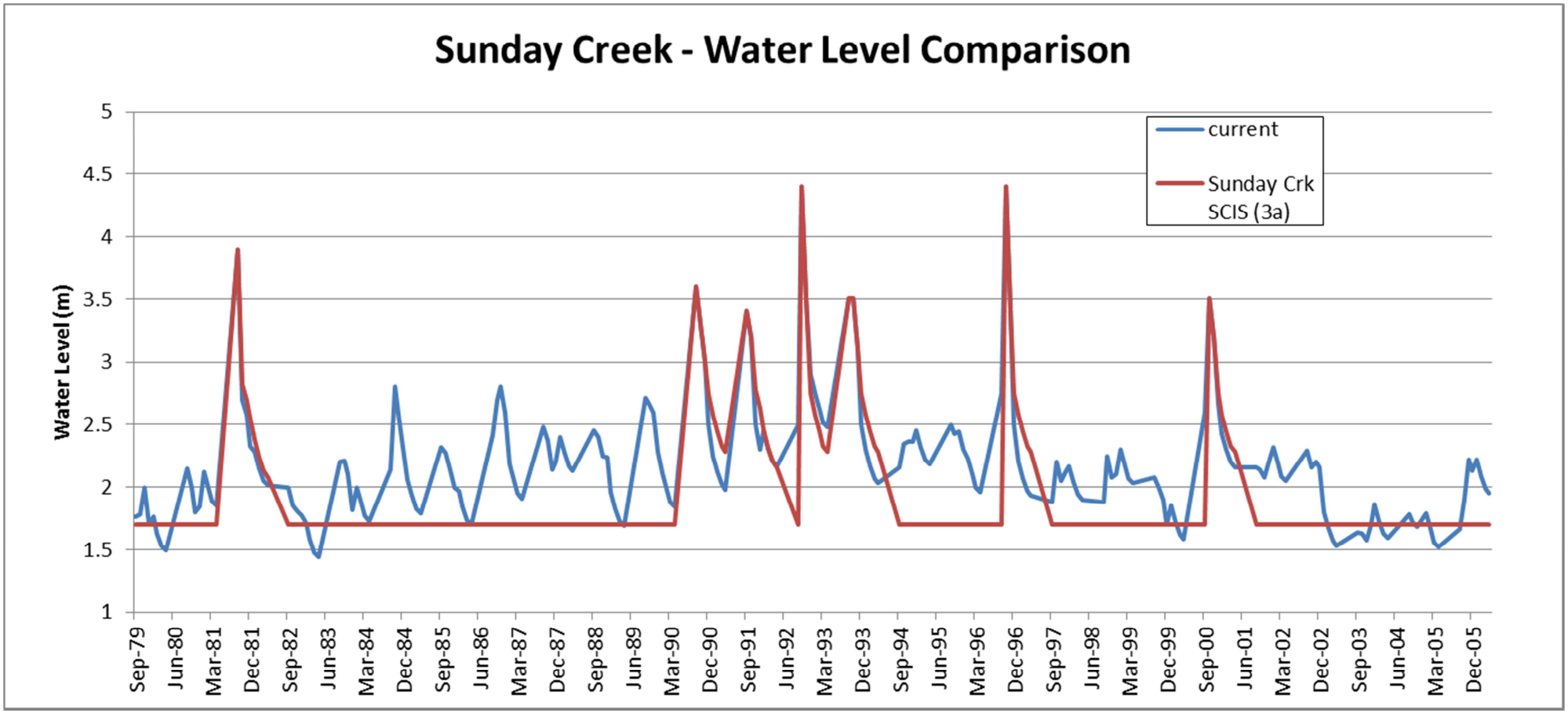

Figure 6 - Sunday Creek Level Comparison (over irrigation season months only)

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