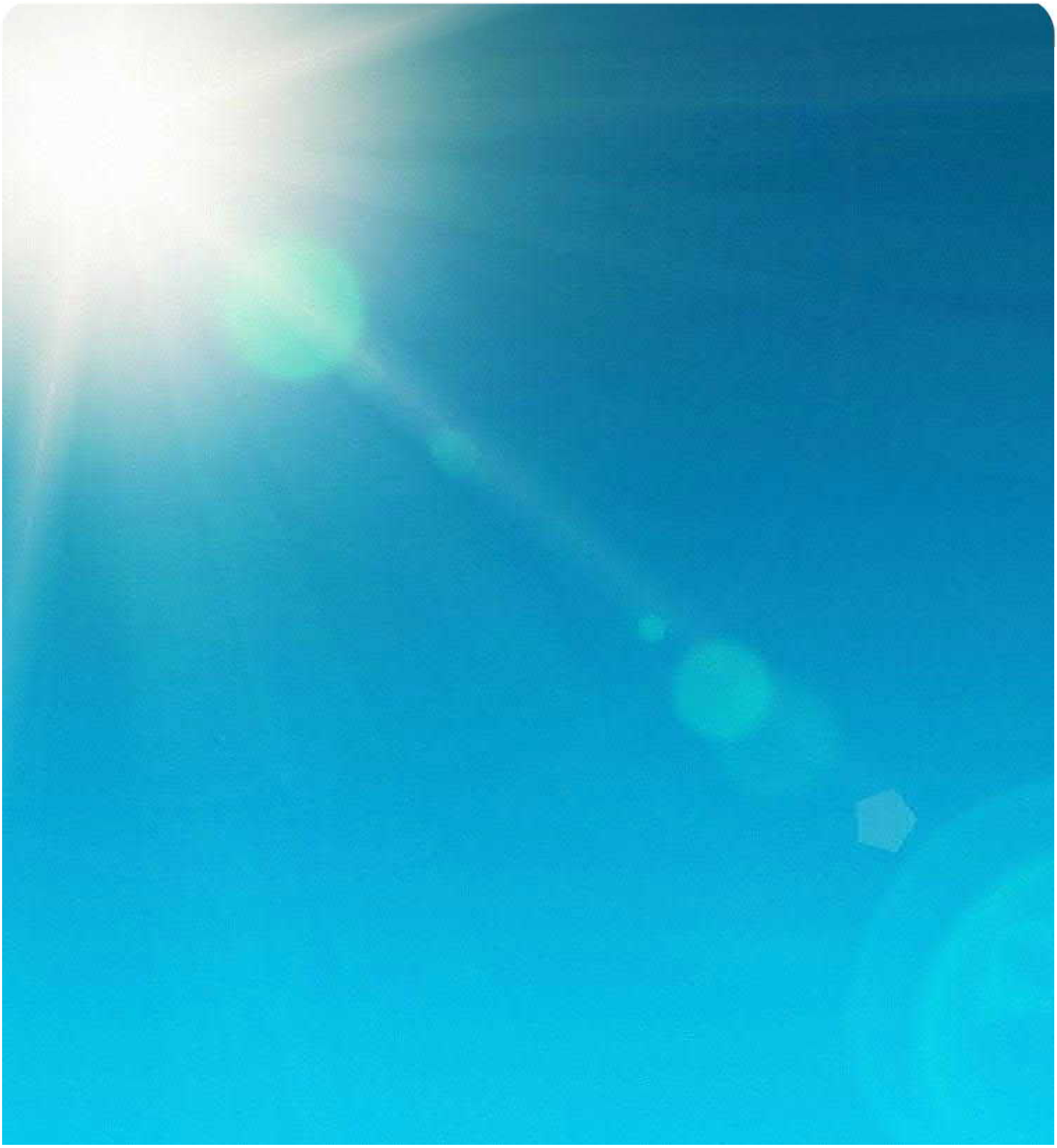
suncable.sg

SUN CABLE

March 2022

Appendix N – Flood Modelling Report

Australia-Asia PowerLink Environmental Impact Statement



Surface Water Hydrology Investigation and Static Flood Study

Sun Cable Site 4, Lake Woods, Northern Territory.

VERSION 02 – 22 FEBRUARY 2022

SURFACE WATER HYDROLOGY INVESTIGATION AND STATIC FLOOD STUDY

SUN CABLE SITE 4, LAKE WOODS, NORTHERN TERRITORY.

VERSION 2 – 22 FEBRUARY 2022

Frontispiece www.abc.net.aunewsrural2016-01-11newcastle-waters-station-flood-cpc7080094

Executive Summary

Sun Cable is proposing solar power infrastructure installation on their sites on the western shore of Lake Woods near Elliott in the Northern Territory. Lake Woods is a terminating, losing system. The main losses are from open water evaporation and infiltration to groundwater.

Newcastle and Ross Creeks enter the lake through Newcastle Waters from the north. The Lake Woods catchment, including Newcastle Creek and Newcastle Waters has a total catchment area of 35,978 km^2. Stage height data are available in Lake Woods from 1973 to 1977. These data were used to calibrate a HEC-HMS hydrologic model that, combined with GIS static modelling, was used to assess flood levels in Lake Woods.

24-hour rainfall data were used as input and the HEC-HMS basin models were configured using an 8 x 8 m digital elevation model.

The HEC-HMS model comprises 3 sub-catchments: Lake Woods, Newcastle Creek, and Newcastle Waters. Newcastle Creek and Newcastle Waters have a confluence to the north of Lake Woods and debouches into Lake Woods from the north.

Newcastle Creek forms the northeastern portion of the catchment. It lies to the east of the Stuart Highway and has an area of 18,826 km^2 at gauging station G0280009 on the Stuart Highway. The catchment is characterised by wide sandy river reaches up to 19 km wide. Flow data have been recorded at G0280009 since 1967. There are no rain gauges in the catchment. In Newcastle Creek, the 1967, 1974, 1975, 2001 and 2004 water-years were used to calibrate/validate the HEC-HMS model at G0280009. Prior to 1990 there was a causeway on the Stuart Highway. In about 1990 (based on the lack of flow data collected during 1990) the road was upgraded, and 3 bridges were constructed at this crossing.

At gauging station G0280125, Newcastle Waters, the upstream catchment area is 26,497km^2 including Newcastle Creek. Stream flow data have been collected since 1993. These data were used to calibrate the Newcastle Waters catchment to G0280125 using flow at G0280009 as input. Water levels at G0280125 are driven by Newcastle Creek and there is little difference in hydrograph shape between G0280125 and G0280009. The Ross Creek catchment upstream of G0280125 to the west of the Stuart Highway has many surface depressions based on DEM analysis.

Aerial imagery interpretation indicates that the southern catchments in Lake Woods comprise a rocky desert landscape. There are no flow or rainfall data available to calibrate/validate flow into Lake Woods.

To assess changing lake levels, continuous simulations are required, therefore, an Initial Deficit (ID) and Constant Rate (CR) model was developed for all catchments. This approach enabled derivation of a single set of monthly evaporation rates. The ID/CR HEC-HMS model for Lake Woods was calibrated and validated and used to simulate >100 years of water levels in the lake. A Log Pearson 3 distribution was derived for the annual maximum surface water elevation (SWE) in the lake based on the 121-year simulated record. The distribution was used to determine the 1% AEP, 0.5% AEP, 0.2% AEP, and 0.1% AEP SWE for the lake.

The surface area of site 4 is only 0.35% of the Lake Woods catchment area. Therefore, any water retention on the site resulting from direct rainfall within the area of impoundment is likely to have a negligible effect on environmental flows or changes in water levels in the lake.

TABLE OF CONTENTS

FIGURES

TABLES

1. Introduction

The proposed Sun Cable solar precinct is located 70 km southwest of Elliot in the Northern Territory (NT). The preferred site is referred to as 'Site 4' and is located near 331782m East, 7986913m North, GDA94/MGA52, between the Alice Springs-Darwin Railway line and the western shore of Lake Woods (Figure 1-1).

A long-term record of water level data in Lake Woods will be estimated using a fitted HEC-HMS hydrology model. The simulated record will be used to determine the 1%, 0.5%, 0.2%, and 0.1% annual exceedance probability (AEP) surface water levels in the lake. These static water levels will be plotted on a map to assess the extent of inundation of lake floodwaters onto Site 4.

This assessment is divided into the following parts:

- Desktop analysis of aerial images and digital elevation models (DEM) to determine catchment configurations.
- Collation of existing hydrological data.
- Development of a GIS for terrain analysis and static hydrologic modelling.
- Development and calibration of an HEC-HMS catchment hydrologic model to pre-1990 water level data in Lake Woods.
- Development and calibration of hydrologic models post-1990 to determine lake inflows and surface water elevations; and
- Plot static flood levels based on frequency analysis of a 120-year simulated water level data in Lake Woods.

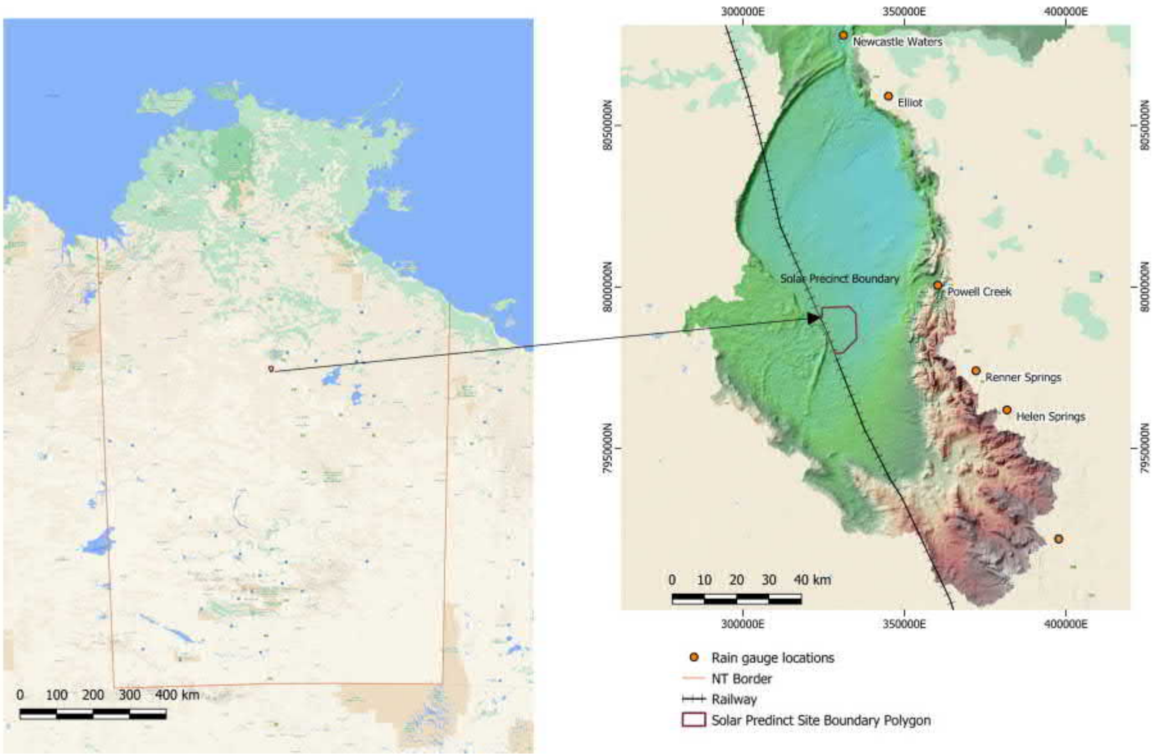


Figure 1-1 Location of the proposed Sun Cable preferred project Site 4 and alternative sites 1-3. The centroid of site 4 is at 331485mE and 7987264mN. Map grid of Australia zone 53.

2. SITE DESCRIPTION

Desk-top analysis of aerial imagery and 1' Shuttle Radar Topography Mission (SRTM) data provided an understanding of the stream catchments in the area and the general channel network.

2.1 Climate

The Lake Woods region is dominated by a wet season from October to May with the occurrence of monsoonal rains. The approximate water-year average is 500mm based on data recorded at the BOM rain gauge at Newcastle Waters where records commenced in 1889. The maximum annual water-year rainfall at Newcastle Waters is 1380.5mm recorded in 1974.

Annual open water evaporation is 2180mm (http://www.bom.gov.au/water/landscape) but based on high radiation levels Bowler et al (1998) reported a potential annual evaporation of near 3200mm.

The site is in the arid climate zone.

2.2 Stream Catchments

Lake Woods is in the Wiso River basin (Appendix A.1) extending from north of Alice Springs in the south, north to near Daly Waters, east to near Broadmere and west to Tanami near the NT-WA border.

There are three sub-catchments which affect flood levels in the lake: 1) Lake Woods itself through direct rainfall and runoff; 2) the Newcastle Waters (Ross Creek) catchment upstream of the Northern Territory Government's (NTG) gauging station G0280125; and 3) the Newcastle Creek catchment upstream of G0280009. The combination of these 3 catchments makes a very large and complex watershed covering ≈2.6% of the Northern Territory's area.

Sub-catchments were delineated using Northern Territory Government (NTG) stream sub-catchments from NR Maps (https://nrmaps.nt.gov.au/nrmaps.html), Hydrosheds catchment data (https://www.hydroshed.org), and detailed digitising of catchment boundaries based on contours extracted from the Australian Government's 30 x 30m DEM of the region to confirm boundaries from NR Maps and Hydrosheds.

2.2.1 Newcastle Creek Catchment

The most upstream catchment is Newcastle Creek. The catchment lies to the east of the Stuart Highway and has an area of 18,826 km^2 at gauging station G0280009 on the Stuart Highway. With well over half the total Lake Woods catchment area, this catchment has the greatest influence on water levels in Lake Woods. The catchment is referred to as Newcastle Creek in this study. The Newcastle Creek catchment may receive rainfall from tropical rain depressions moving west from the Gulf of Carpentaria and south from the north coast of the NT and WA.

Changed Hydraulic Conditions

Newcastle Creek crosses the Stuart Highway immediately downstream of G0280009. Prior to 1990 there was a floodway crossing at this location. During 1990 there is no recorded flow data at G0280009, and it is thought that this is when the Stuart Highway was upgraded. The upgrade raised the road surface at G0280009 from a floodway at level 208.3m AHD to road surface of 211.8m AHD. In addition, 3 x 6-span bridges were constructed at intervals across the Newcastle Creek stream channel and flood plain.

Enquiries with the Northern Territory Government could not confirm the date of the upgrades.

Changed hydraulic conditions caused by the three bridges and raised road surface will be considered in HEC-HMS model post-1990 for Newcastle Creek.

The rainfall runoff properties in the Lake Woods catchment, referred to as Lake Woods, are not affected by the changed conditions as that model receives flow regardless of the upstream conditions.

The pre-1990 model at Newcastle Creek, with the original floodway, was used to calibrate the Lake Woods catchment model to 1973–1977 water level data from G0280011 on the eastern shore of the lake prior to road construction.

The post-1990 model, incorporating the 3 bridges, was used to simulate present day conditions for static flood level assessment.

2.2.2 Newcastle Waters Catchment

The Newcastle Waters/Ross Creek catchment receives inflow from Newcastle Creek at about 7km upstream of G0280125, which then flows into Lake Woods. It has a catchment area, not including Newcastle Creek, of ≈7,671 km². The catchment is referred to as Newcastle Waters in this report.

2.2.3 Lake Woods Catchment

Lake Woods is in an impoundment and is a terminating lake receiving flow from Newcastle Creek and Ross Creek through Newcastle Waters. From south of Newcastle Waters at G0280125, Lake Woods has a catchment area of ≈9,841 km². It is a losing water system with the main losses being open water evaporation and groundwater seepage. Its total drainage area, including Ross Creek and Newcastle Creek, is ≈35,978 km². The Lake Woods catchment downstream of G0280125 is referred to as Lake Woods in this report. The drainage system acts as a groundwater recharge zone (Bowler, et al. 1998).

3. Data Availability

3.1 Digital Elevation Data

The 1' SRTM data, provided as a 30 x 30 m digital elevation model (DEM), were downloaded from the GeoScience Australia website. These data are hydrologically corrected by Geoscience Australia.

Sun Cable obtained an 8 x 8m DEM for Lake Woods to the 208 m contour in Lake Woods. The 30 m and 8 m DEM were mosaiced with a 1000 m blending distance to obtain 8 x 8 m coverage downstream of G0280125.

3.2 Stream Flow Data

Northern Territory gauging station data were available from:

- G0280009 – Newcastle Creek, and
- G0280125 – Newcastle Waters.

Details on the stations are provided in Table 3-1. Flow records at these sites were at irregular intervals so flow data were extracted for 24h intervals and average 24h discharges calculated.

A flood frequency analysis (FFA) was conducted using the observed flow record at G0280009 (Figure 3-1) and G0280125 (Figure 3-2). The Newcastle Creek FFA is more reliable because there is a longer observed record of stream flow.

SURFACE WATER & EROSION SOLUTIONS

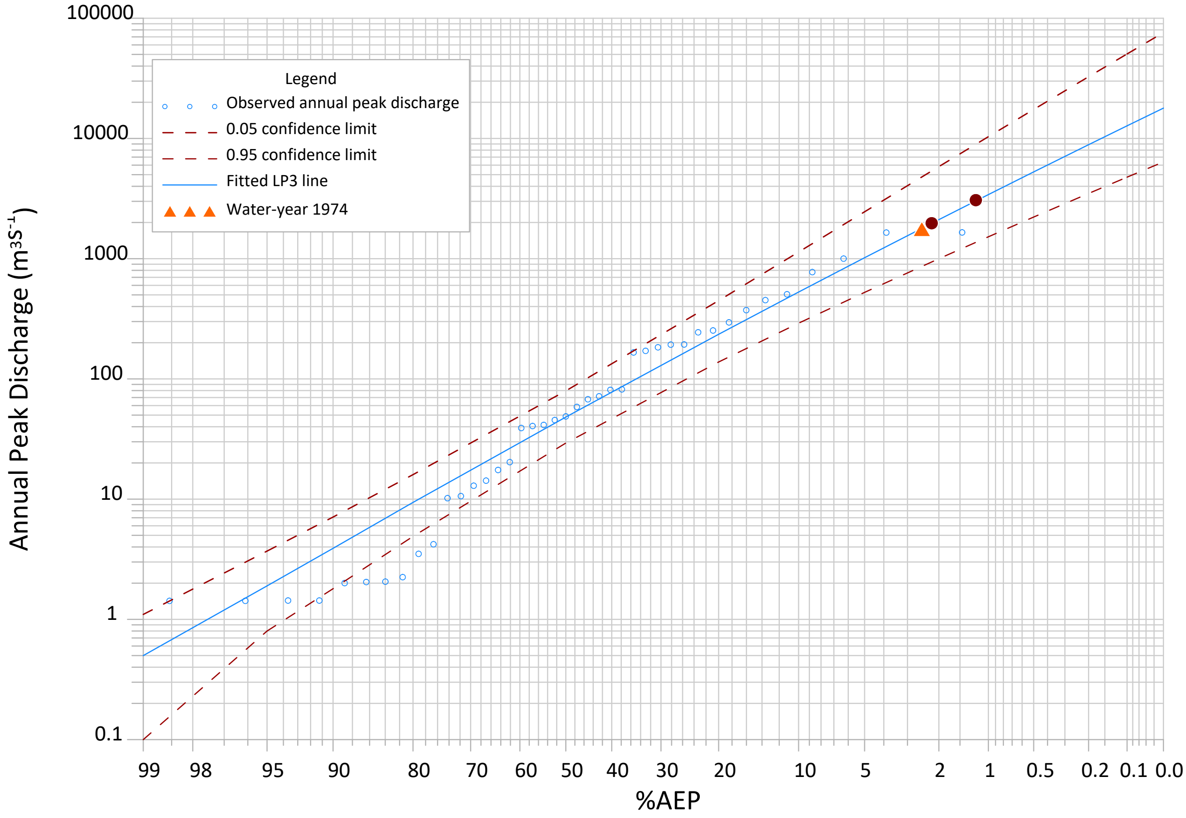


Figure 3-1 FFA at G0280009 using a Log Pearson 3 (LP3) distribution.

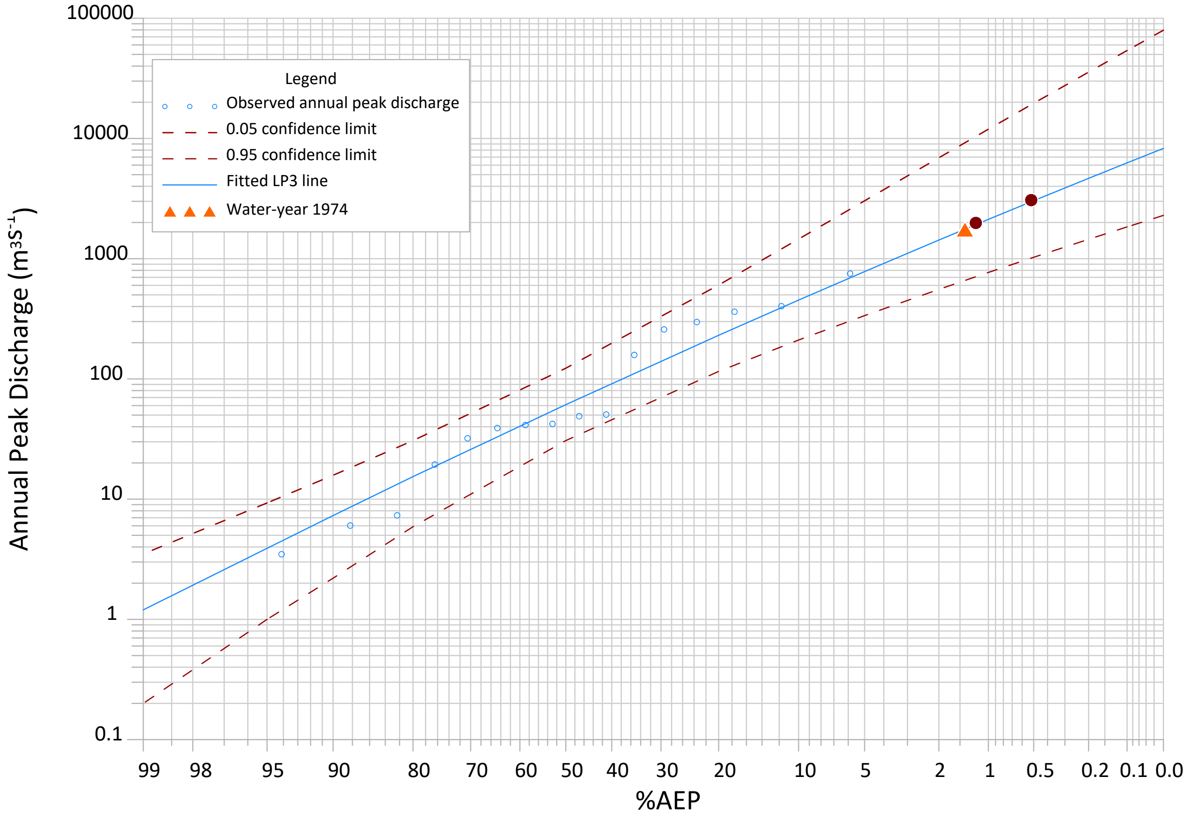


Figure 3-2 FFA at G0280125 using a Log Pearson 3 (LP3 distribution).

3.3 Water Level Data

Water level data are available in Lake Woods at G0280011 for a period from 1973 to 1977 (Table 3-1).

Table 3-1 NTG flow and stage gauging stations. G0280009 and G0280125 are flow gauges and G0280011 is a stage height recorder

Station Name	Station Number	Drainage Area (km²)	Location		Period of Record Used
			Easting (m)	Northing (m)	
Newcastle Creek – Stuart Hwy	G0280009	18,826	335718	8090920	21/2/1967-19/11/2008
Newcastle Creek – Newcastle Waters	G0280125	Upstream – 26,497 Downstream – 9,841	331328	8078683	1/1/1993-3/10/2017
Lakes Woods – Lawson Creek Bore	G0280011	-	349945	8035222	1/9/1974-31/7/1977

4. Rainfall Data

A combination of BOM and SILO rainfall data were used for the model simulations. The use of SILO data provides a better coverage of the entire catchment area than just BOM gauges alone, particularly over the more arid parts of the catchment in the south.

When selecting point data from SILO, a search is conducted for a BOM gauge location. If a BOM gauge is within the SILO database, the SILO rainfall record for that location incorporates the observed BOM data and shows the BOM gauge details. If a BOM gauge is not within the SILO database, the SILO rainfall record for that location is a fully interpolated daily record based on observed data collected at surrounding gauges.

Rainfall records from 1900 to 2021 were obtained for the BOM/SILO data points. The Lake Woods Southwest point is a complete infill by SILO (i.e., there are no observed BOM data at this location).

The site locations are given in Table 4-1. The variation in monthly rainfalls at the sites across the region are shown in Figure 4-1. The spatial distribution of the network was determined using the Voronoi Polygon algorithm in QGIS (QGIS.org, 2020) (Figure 4-1).

Table 4-1 BOM/SILO rainfall input stations used in this study.

Station Name	Station Number	Location		BOM Period of Record Used
		Easting (m)	Northing (m)	
Banka Banka	15067	397746	7921908	1/1/1949–27/12/2014
Broadmere	14716	521352	8183489	1/1/1971–3/10/2017
Daly Water Airstrip	104626	326880	8201620	1/5/1039–present
Dunmarra Roadhouse	14611	330453	8155170	1/1/1963–30/4/2014
Elliott	15131	345458	8058432	1/1/1949–present
Helen Springs	15015	381446	7961474	1/1/1945–30/4/2014
Hidden Valley	14636	275901	8169056	1/1/1965–31/7/2015
Lake Woods Southwest	-	296623	7967316	-
Newcastle Water	15086	331082	8077706	1/1/1889–present
Powell Creek	15083	360314	8000462	1/1/1885–28/2/1987
Renner Springs	15082	372132	7973986	1/1/1953–31/5/2014
Walhallow	15147	569957	8034033	1/8/1919–31/1/1924 1/1/1977–30/4/2019

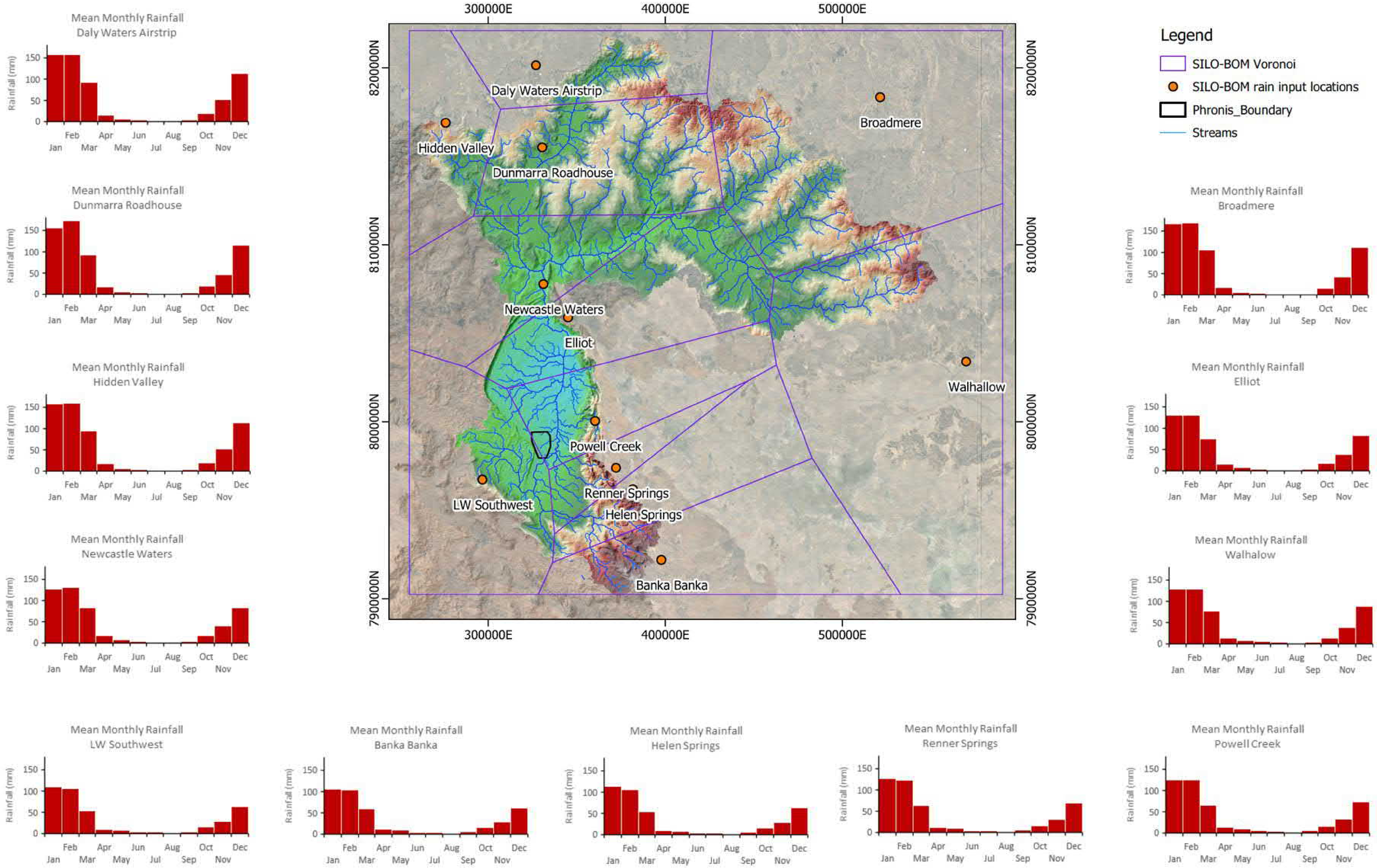


Figure 4-1. Average monthly rainfalls for each SILO-BOM rainfall site and their area of influence on Lake Woods determined using Voronoi polygon analysis shown in purple.

5. HEC-HMS Hydrologic Model Setup

A hydrologic model was developed for each of the catchments described above (Appendix A.1).

Each HEC-HMS model comprises a basin model, meteorological model, control specification, time series data (rainfall, discharge, stage) and paired data (cross sections, volume/elevation curves, area/elevation curves).

5.1 Basin Models

The GIS tool embedded in HEC-HMS was used to identify the drainage channels, delineate the sub-basins and reaches, and insert junctions. The physical characteristics: area, slope, reach length and channel cross sections were derived, and used to determine transform and routing parameter values in the models. These properties were determined for each sub-basin and reach.

5.2 Meteorological Models

The BOM infilled with SILO daily data were extracted for the network of sites (Appendix A.1) relevant to the Lake Woods Catchment. The rainfall sites are treated as the specified hyetographs required for the catchment model. The meteorological model relates the sub-basins within Voronoi polygons to the relative rain gauge location. Time windows of data were extracted for the simulated water-years. Monthly evapotranspiration data were extracted from SILO for the period 1900 to 2021 for the same locations as the rainfall and were applied to the relevant catchments for an Initial Deficit/Constant Rate model.

5.3 Control Specifications

These are the time windows for a simulation period and link the time windows in the rainfall, discharge, stage, and paired data time windows.

5.4 Time Series Data

These data are time windows of the BOM daily rainfall, NTG stream flow data and the NTG stage height data, where available. The flow data and stage data are used for calibration and validation of the model and are the benchmarks for fitting parameter values.

5.5 Paired Data

Paired data are the relationships between water elevation and surface area, as well as water elevation and volume, which are required to fit changes in water elevation in a water body.

Cross sections using lake and bridge outlets are also input in this area.

6. HEC-HMS MODEL PARAMETERS

The aim of modelling is to run long-term simulations to obtain a frequency distribution of water levels in Lake Woods that can be used to plot inundation levels in Lake Woods for AEP levels. Therefore, parameter values suitable for continuous simulations alternating between Wet and Dry Seasons are required.

6.1 Canopy Method

A canopy method was used for continuous simulations in this study with the Deficit and Constant Loss method discussed below. A simple canopy method was used.

Figure 6-1 shows the vegetation distribution for Lake Woods. Storage capacities range from 2.3 mm, open woodland, which is the main vegetation in the Newcastle Creek catchment north of Newcastle Waters, to 1.3 mm for tussock grassland, the main vegetation south of Newcastle waters.

6.2 Rainfall Loss method

The deficit and constant loss method was used. This method allows for continuous simulation. It was used in combination with a canopy method that extracts water from the soil in response to potential evapotranspiration computed in the meteorologic model.

This method is suitable for continuous simulations.

Initial Deficit (ID)

This is the deficit at the start of a simulation and is the amount of rain loss required to fill the soil layer storage.

Maximum Deficit (MD)

This is total amount of water that a soil can hold. In this study it was considered equal to the ID value.

Constant Rate (CR)

The constant rate defines the infiltration and percolation rates when the soil layer is saturated.

6.3 Transform Method

The transform method was used to calculate runoff from rainfall. The parameter value, lag time (min), was determined from catchment properties of storage (w_s), mean basin slope (S_b), basin length (L) (m), α is a constant controlling time and peakiness of the hydrograph. The lag time (t_{BL}) equation, is:

$$T_L = \alpha L^{0.8}(S_b + 1)^{0.7}(579.12w_s)^{-0.5} \quad (1)$$

$$w_s = 1000/CN - 10 \quad (2)$$

where CN = curve number. For the Lake Woods region CN = 63 for a hydrologic soil group D in fair condition.

6.4 Routing Parameters

Channel lag routing was determine using Equation (3). The parameter value, lag time (min), was determined from catchment properties of mean channel slope (S_c) and stream length (L) (m). β is a fitted parameter controlling time and peakiness of the hydrograph. The lag time (t_{CL}) equation, derived for NT conditions by Moliere, Boggs, Evans et al (2002), is:

$$T_{CL} = \beta 0.57 L^{0.983} S_c^{-0.187} \quad (3).$$

6.5 Baseflow

The largest recorded rainfall runoff events were used for calibration and validation. Baseflow is generally a minor component of very rare/extreme flood events and was not used here (Babister, et al. 2019).

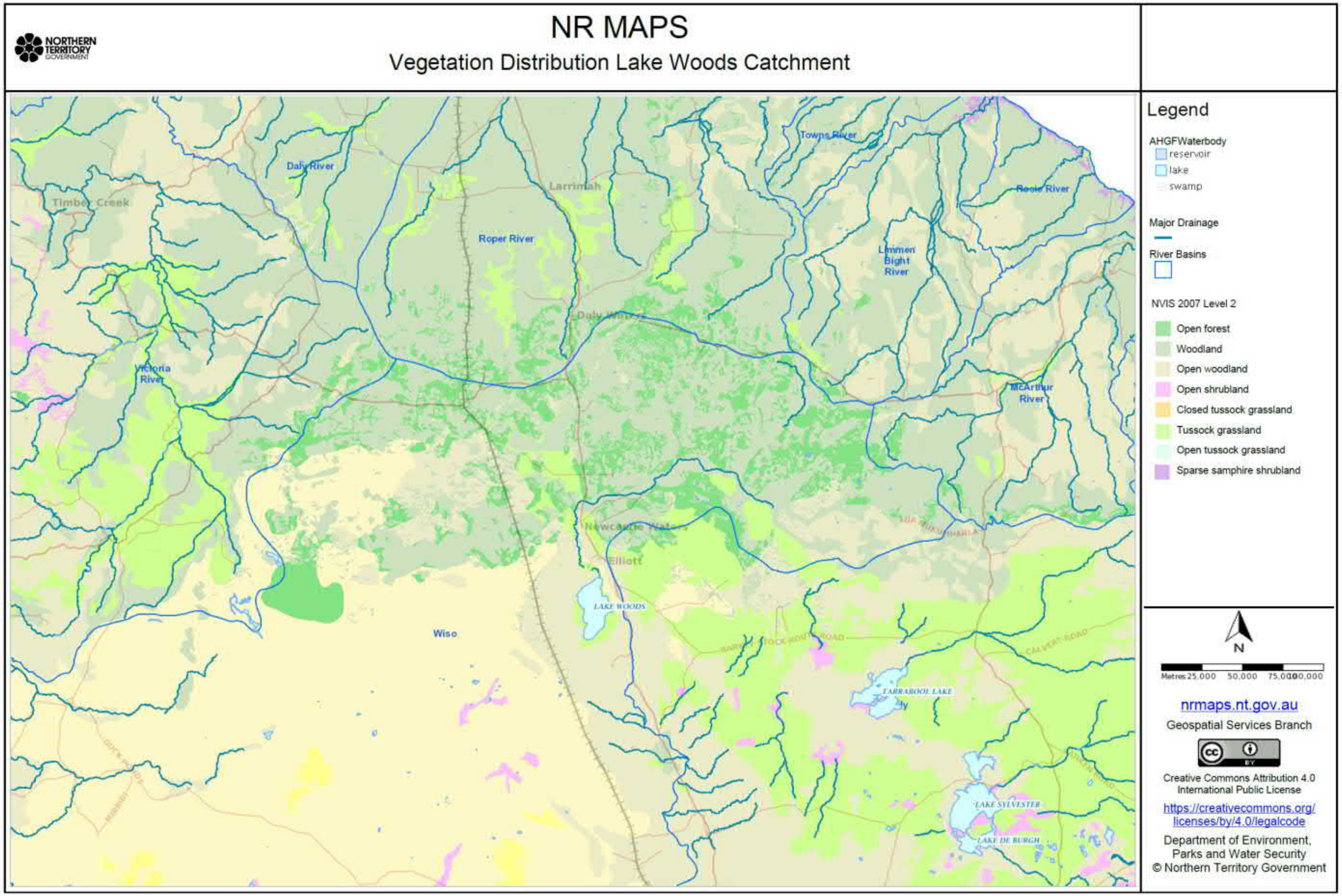


Figure 6-1 Vegetation communities and major streamlines in the Lake Woods region NT

7. CALIBRATION AND VALIDATION OF THE HEC-HMS MODEL.

7.1 Introduction

This model was established to simulate a continuous period and determine the optimum parameter values that could be used under all model simulation scenarios.

7.2 Calibration and Validation of Best-Fit Model Parameters for Lake Woods

The parameter values fitted were canopy loss (Section 5.1) and initial deficit and constant loss (Section 5.2.2). Parameter values were calibrated/validated for the Newcastle Creek model and a combined Newcastle Waters and DS-0280125 model with observed flow at G0280009 used as input.

7.2.1 Initial Deficit and Constant Deficit

The ID (mm) and MD (mm) were variable and the total of 15 days rain prior to the commencement of runoff (Minty and Meighen 1999) was used to determine a starting point for their value. Because simulations start at the end of the Dry Season, it was considered that the soil storage was completely empty (i.e., ID = MD). The CR was iteratively fitted.

7.2.2 Lag Parameters

The initial sub-basin transform and routing lag parameters were calculated using Equation 1, 2 and 3 and then adjusted through iterative fitting of the constants, α and β.

7.2.3 Calibration/Validation

Newcastle Creek Upstream of G0280009

For calibration, the 1974 water-year was used, and the 1975 water-year was used for validation. Several smaller water years were also fitted. The catchment model used is the Newcastle Creek model (Appendix B.1). The graphical results are presented in Appendix B.1 and B.2 and summarised in Table 7-1.

Table 7-1 Calibration/validation results for G0280009 initial deficit (ID) and constant rate (CR) model. ID is variable.

Water - year	CR (mmh^{-1})	α	β	Computed Volume (GL)	Observed Volume (GL)	Computed Q_p (m^3s^{-1})	Observed Q_p (m^3s^{-1})	NSE
1967	1.71	0.5	0.5	2191	1501	986.5	990.0	0.55
1974	1.39	1.32	0.5	3829	3833	1633.8	1637.9	0.68
1975	0.95	1.32	1	2600	2612	642.1	1581.9	0.34
2001	1.63	0.5	0.5	2149	2191	544	768.5	0.86
2004	2.5	0.42	2	832	833	292.3	292.2	0.81
Average	1.64							

Validation is not strong as no single set of parameter values could be applied to multiple events. Computed and observed total volumes match well, but there is a difference in CR. Using the 1975 CR will result in higher lake volume than if the 1974 CR value was used. An average CR value, 1.64 mmh^{-1} was used for long-term simulations. CR can vary with storm intensity and duration as shown in Table 7-1.

Newcastle Waters Upstream of G0280125

This gauge recorded data between 1993 and 2010. For calibration of the Newcastle Waters catchment, the 2001 water-year was used, and the 2004 water-year was used for validation. The catchment model used is the Newcastle Waters/Ross Creek model (Appendix C.1). The results are presented in Appendix C.1 and are summarised in Table 7-2.

Table 7-2 Calibration (2001) and validation (2004) results for G0280125 initial deficit (ID) and constant loss (CD) model. ID is variable.

Water - year	CR (mmh^{-1})	α	β	Computed Volume (GL)	Observed Volume (GL)	Computed Q_p (m^3s^{-1})	Observed Q_p (m^3s^{-1})	NSE
2001	3.4	0.33	0.5	2280	2090	765	750	0.98
2004	3	0.33	0.5	932	932	293	361	0.94
Lake Woods				Maximum computed water level (m)	Maximum observed water level (m)			
1974-1975	1.4	0.33		204.2	203.9			
1976-1977	2.5	0.33		200.7	200.7			
Average	2.58							

Computed and observed total volumes match well but there is a difference in CR. The observed peak discharge is underpredicted for the 2004 water year simulation. However, there is little confidence in the values as the discharges at G0280125 are driven by discharge from the large Newcastle Creek catchment at G0280009.

Lake Woods

For this analysis, the Newcastle Waters catchment, upstream of G0280125 and the Newcastle Creek upstream of G0280009 were combined and simulations conducted for the period where water level data were collected. The observed stream flow data at G0280009 were unput to G0280125 and these flows were input to Lake Woods downstream of G0280125 as upstream flow to the lake.

A continuous simulation was conducted for the period 1 July 1972 to 31 December 1977 using the ID/CR model. This was the period that level data were collected at G0280011 in Lake Woods.

Evaporation rates (increased to include groundwater losses) and CR were adjusted for the northern blacksoil Lake Woods regulary-inundated area and the parameter values for the southern rocky and aeolian sand catchments were fitted.

There was difficulty in fitting this time span. Good fits could be obtained for the 1973 to 1975 water years (Table 7-3), which contained the largest events but could not fit the 1976 to 1978 water years. By adjusting the parameters to average values, the 1976 to 1978 water years (Table 7-3) could be fitted but not the 1973 to 1975 water years. Therefore, 1973–1975 was fitted separately from 1976–1978 water years. The results are presented in Appendix D.1 and Table 7-3. The results show that the high SWEs are well fitted in the 1974 water-year and the lower SWEs during September–December in the 1977 and 1978 water-years are reasonably well predicted.

Table 7-3 Calibration for the 1973-1978 water years in Lake Woods.

Water - year		ID (mm)	CR (mmh^{-1})	α	β	Computed water level (m)	Observed water level (m)
1974-1975	Blacksoil	54	0.6	0.166	0.0.25	204.2	203.9
	Sandy/Rocky	83	2.2				
1976-1978	Blacksoil	54	2	0.166	0.25	200.6	200.7
	Sandy/Rocky	83	9				

8. Surface Water Elevation Annual Exceedance Probabilities

A simulation from 1990 to 2021 was conducted for the catchment upstream of G0280009, Newcastle Creek (Appendix B.1). The mean CR value, 1.64 mm/hr (Table 7-1) was used. It is considered closer to long-term values compared with the CR = 1.39 mm/hr fitted for the highest observation in 1974. By using the lower value, CR of 1.39 mm/hr, to fit the 1974 peak, the simulations will produce more water flow into the lake and higher surface water levels because of reduced rainfall losses. This will skew the results to high SWEs, which is not representative of the system.

The simulated discharge at the outlet was substituted with observed flow at G0280009 where available, from 1966 to 2008. The combination of simulated and observed discharge was then input to the Newcastle Waters for the 1900–2021 simulation period (Appendix E.1) and flow at G0280125 was obtained for input to the Lake Woods catchment downstream of G0280125.

The distributed SILO/BOM daily rainfall record (Figure 4-1) from 1900 to 2021 was used as input and the peak annual SWEs determined. An LP3 distribution was fitted to the annual maximum SWE with a Cunnane plotting position allowing the 1%, 0.5%, 0.2%, and 0.1% AEP levels to be determined (Appendix E.1).

8.1 Frequency Based Peak SWE Results

The derived peak SWE values using the 1900–2021 simulation are given in Table 8-1. The highest recorded level of 203.9 in 1974 is equivalent to a 0.8% AEP event. It would not have reached the solar precinct.

Flood inundation levels were mapped using a combination of static methods and the hydrologic model developed in this study. Static methods based on hydrologic modelling, using a GIS, are fit to inform strategic flood management decisions and provide some insight into where water may rise when flooding occurs in Lake Woods. These methods are not to a level of detail to facilitate detailed design of infrastructure. Detailed design requires high resolution DEMs and hydrodynamic modelling.

Static flood levels for the SWE frequency method using the long-term simulation (Table 8-1) were mapped and are presented in Appendices E.2 and E.3. There is no impact on site from the 1% AEP (1in100) flood event, which is typically used for development assessment purposes. It is not until the 0.1% AEP (1in1000) flood event does the Lake begin to impact the site, with some minor inundation along the northeast boundary of the site. This inundation represents less than 4.25% of the site and would be standing water less than 200mm in depth.

Figure 8-1 is a cross section through the site showing the extent of inundation. This only occurs through very low frequency extreme events. The long-term simulations indicate that Lake Woods may not have inundated the site for the last 120 y and the 0.1% AEP level of 204.6m is an extrapolation (Appendix E.1).

Table 8-1. The highest observe SWE in Lake Woods and derived peak SWE levels in Lake Woods using water-year simulated SWE frequency.

% AEP	Historic Water Year 1974	Simulated SWE LP3 distribution 1902-2021	Highest simulated SWE	Simulated SWE LP3 distribution 1902-2021
	Peak SWE (mAHD)	Peak SWE (mAHD)	(m AHD)	Peak SWE (mAHD)
1		202.8		204.3
0.7			203.2	
0.5		203.4		204.9
0.3	203.9			
0.2	-	204.1		205.6
0.1	-	204.6		206.1

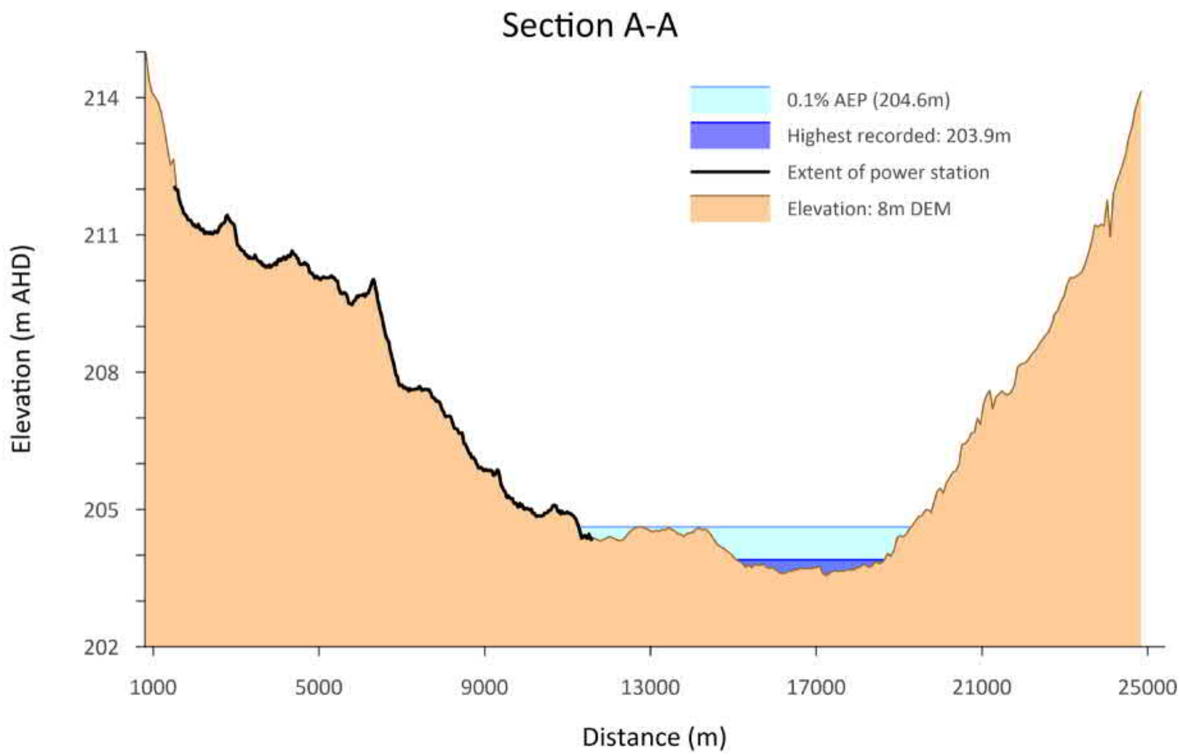


Figure 8-1 Section A-A, Appendix E.2, shows minor inundation of the site by the 0.1% AEP SWE.

9. Climate Change Assessment

The Representative. Concentration Pathway (RCP) is a greenhouse gas concentration trajectory adopted by the International Panel on Climate Change of which, there are 7. The ARR 2019 recommend using the midpoint of the percentage rainfall increase of the RCP 4.5 and RCP 8.5 models. The percentage increase for both models for the Lake Woods area is supplied on the ARR Data Hub.

For this simulation the the rainfall record from 1/1/1900 to to 31/12/2020 was redated from 1/1/2020 to 31/12/2140 and the SILO rainfall from 1900 to 2020 was increased relative to the climate change model in accordance with the percentages provided by the ARR Data hub (Babister, Trim, Testoni, & Retallic, 2016).

The results are given in Table 8-1 and Appendix F.1.

As expected, there is a consistent increase in lake SWE (Appendix F.2) and an increase in flow entering the Lake Woods. The LP3 distribution (Appendix F.1) estimates that all AEP levels increase by 1.5 mAHD by 2140. So, by 2140 it is estimated that the 1% AEP (1in100) flood event could increase to a SWE of 204.3mAHD, which is shown in Appendix F.2. Even at this level the site would remain immune to inundation from Lake Woods from this design event.

A point of interest is that the peak lake SWE in the climate change scenario was 204 mAHD. This occurred in April 2094 (the 1974 observed level of 203.9 mAHD). At the same time there was outflow from the lake of 250 GL (Appendix F.1).

The reason this occurs is that a “non-level outflow” state occurs at an invert level of 203.5 mAHD (Appendix D) at Newcastle Waters. At this point the level of flood waters in Lake Woods equals the level of the catchment above Newcastle Waters. As the Lake continues to fill above this invert level, incoming flows from Newcastle creek would begin to back up and ultimately flows can reverse direction with Newcastle creek becoming an outflow from the Lake. As such, it is likely that overflow prevents lake SWEs greatly exceeding 204 mAHD. Detailed modelling of the different 'head' levels between the catchments and the Lake during a range of rainfall events would be required to analyse this outcome.

Given that the 1% AEP SWE produced in this climate change assessment does not impact the site, the expense of this further detailed analysis is not justified for this report and predicted rises in SWE for rarer events with a lower AEP can be considered conservative.

10. CONCLUSIONS

Static flood levels derived from long-term simulations of water levels in Lake Woods showed only minor inundation of a small part of the site in extreme or rare events. (0.1% AEP or a 1in1000 event or greater)

Climate change modelling showed potential increases in water levels with flood inundation from Lake Woods impacting parts of the site from rare to extreme events. However, these are unlikely to be as high as the levels extrapolated in the analysis due to outflows from Lake Woods that occur when flood levels go above the 'non flow' inversion level at Newcastle Waters.

Most importantly the predicted 1% AEP (standard 1in100 design event) by the year 2140 still has no impact on the site.

11. REFERENCES

Aminuddin, AB Ghani, Azazi Zakaria Nor, Chun kIAT Chang, Ariffin Junaidah, Abu Hasan Zorkeflee, and Bakri Abdul Ahmad. 2007. "Revised equations for Manning's coefficient for sand-bed rivers." *Intl J River Basin Management* 5 (4): 329-346.

Babister, M, r Nathan, Weeks B, E Weinmann, M Retallick, and I Testoni. 2019. *Estimation of very rare events to extreme floods, Book 8 in Australian Rainfall and Runoff - A Guide to Flood Estimation, .* Engineers Australia, Commonwealth of Australia, (Geoscience Australia).

Ball, J, M Babister, R Nathan, W Weeks, E Weinmann, M Retallick, and I Testoni. 2019. *Australian Rainfall and Runoff: A Guide to Flood Estimation.* Commonwealth of Australia (Geoscience Australia).

Beck, Hylke E, Albert I van Dijk, Diego G Miralles, Richard A de Jeu, L A Bruijnzeel, T R McVicar, and Jaap Schellekens. 2013. "Global patterns in base flow index and recession based on streamflow." *Water Resources Research* 49: 7843-7863. doi:10.1002/2013WR013918,2013.

Bowler, JM, GAT Duller, N Perret, JR Prescott, and K-H Wyrwoll. 1998. "Hydrologic Changes in Monsoonal Climates of the Last Glacial Cycle: Stratigraphy and Liminescence Dating of Lake Woods, NT, AUstralia." *Palaeoclimates* 179-207.

Coombes, P, and S Roso. 2019. *Rianfall Estimation, Book 2 in Australian Rainfall and Runoff - A Guide to Flood Estimation.* Commonwealth of Australia (Geoscience Australia).

Cunnane, C. 1978. "Unbiased plotting Positions - A review." *Journal of Hydrology* 37: 205-255.

Fisher, K, and H Dawson. 2003. *Roughness Review.* London: DEFRA. Accessed November 17, 2020. http://www.river-conveyance.net/ces/documents/RoughnessReviewFinal_July07.pdf.

Hill, P, Z Graszkiewicz, M Taylor, and R Nathan. 2014. *Phase 4 Analysis of loss values for rural catchments across Australia. Australian Rainfall and Runoff, Revision Project 6: Loss Models for catchments simulation.* Barton ACT: Engineers Australia.

Hutley, A P, A P O'Grady, and D Eamus. 2000. "Evapotranspiration from Eucalypt open-forest savanna of Northern Australia." *Functional Ecology* 14: 183-194.

Minty, L J, and j Meighen. 1999. *Rainfall Antecedent to large and extreme rainfall bursts over southeat Australia. HRS Report No. 6.* Hydrology Report Series, Hydrometeorology Advisory Service, Melbourne: Bureau of Meteorology, Australia, 61. Accessed January 20, 2021.

Moliere, DR, GS Boggs, KG Evans, MJ Saynor, and WD Erskine. 2002. *Baseline hydrology characteristics of the Ngarrradj catchment, Northern Territory.* Supervising Scientist Report, Darwin: Supervising Scientist.

QGIS.org. 2020. "QGIS Geographic Information System. Gepspatial Foundation Project." *http://qgis.org.*

Svensson, C, and D A Jones. 2010. "Review of rainfall frequency estimation methods." *Journal of Flood Risk Management* 3: 296-313.

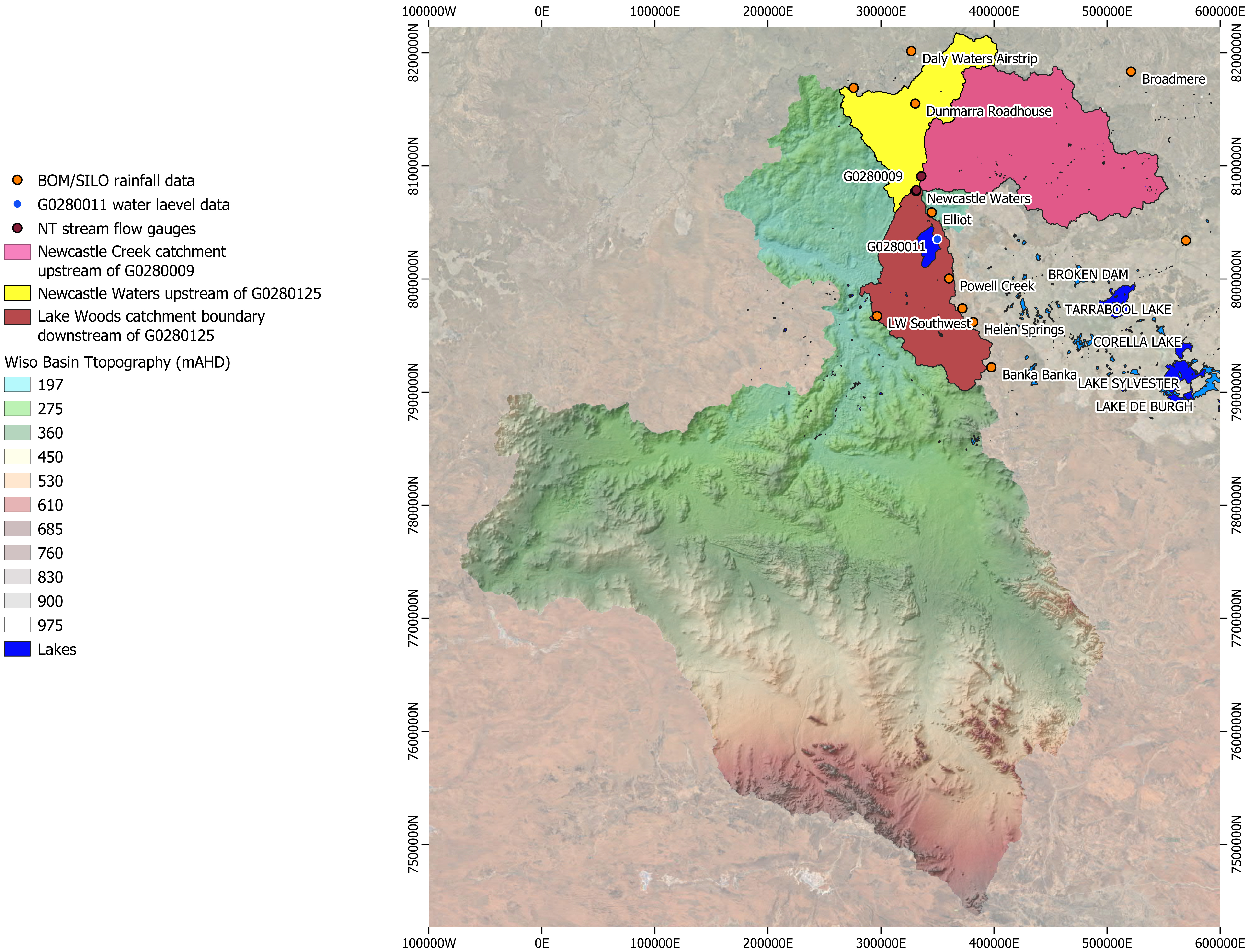
SWES. 2021. *Hydrologic Modelling Study. Suncable Sites, Lake Woods, Northern Territory. Version 5 - 05 February 2021.* Darwin. NT: Surface Water & Erosion Solutions.

US Army Corps of Engineers. 2020. *Hydrologic Model system. HEC-HMS User's Mannual Version 4.6.* US Army Corps of Engineers.

APPENDICES

Appendix A

Study Catchments

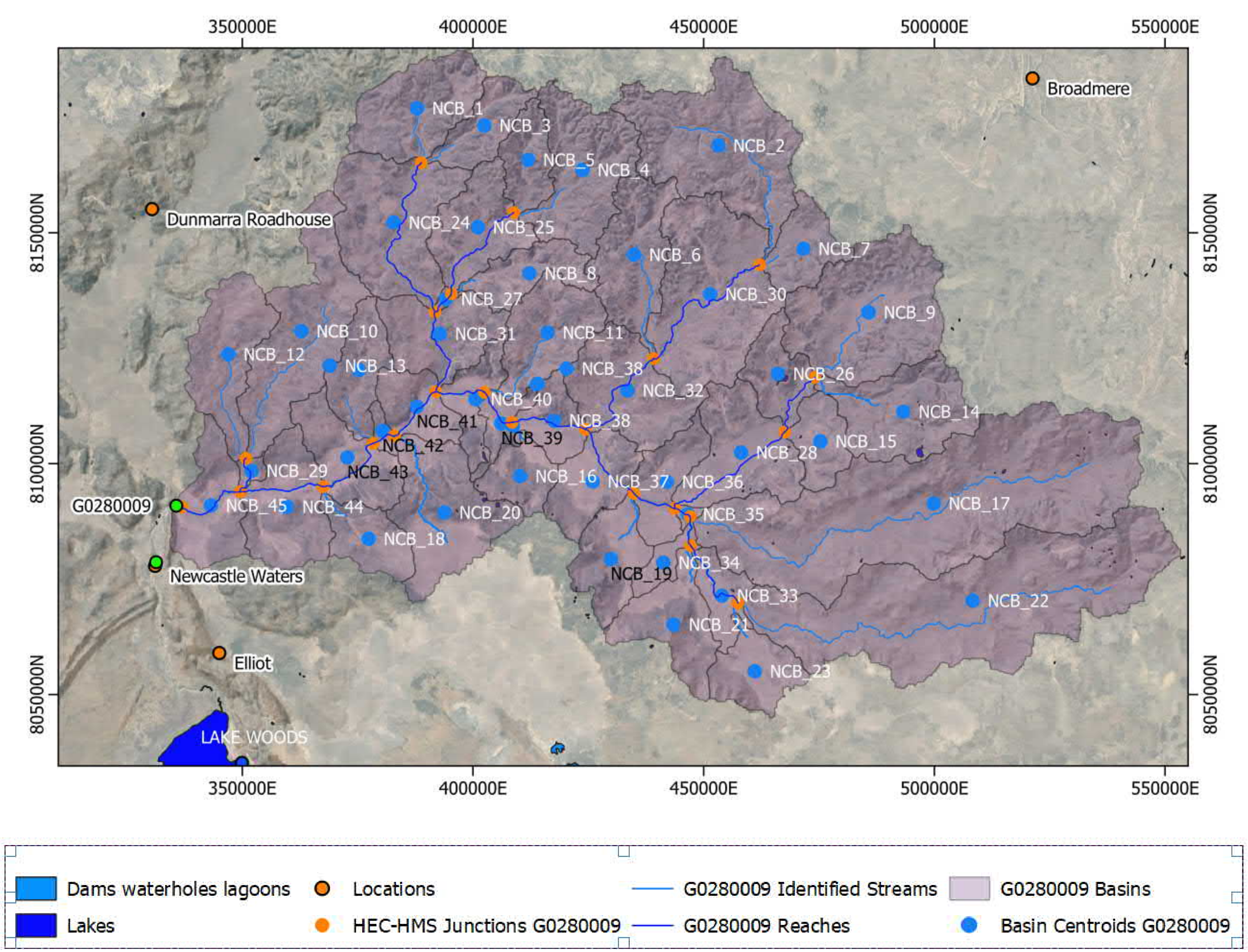


Appendix A.1 Study Catchments and Bureau of Meteorology and Northern Territory Government monitoring stations.

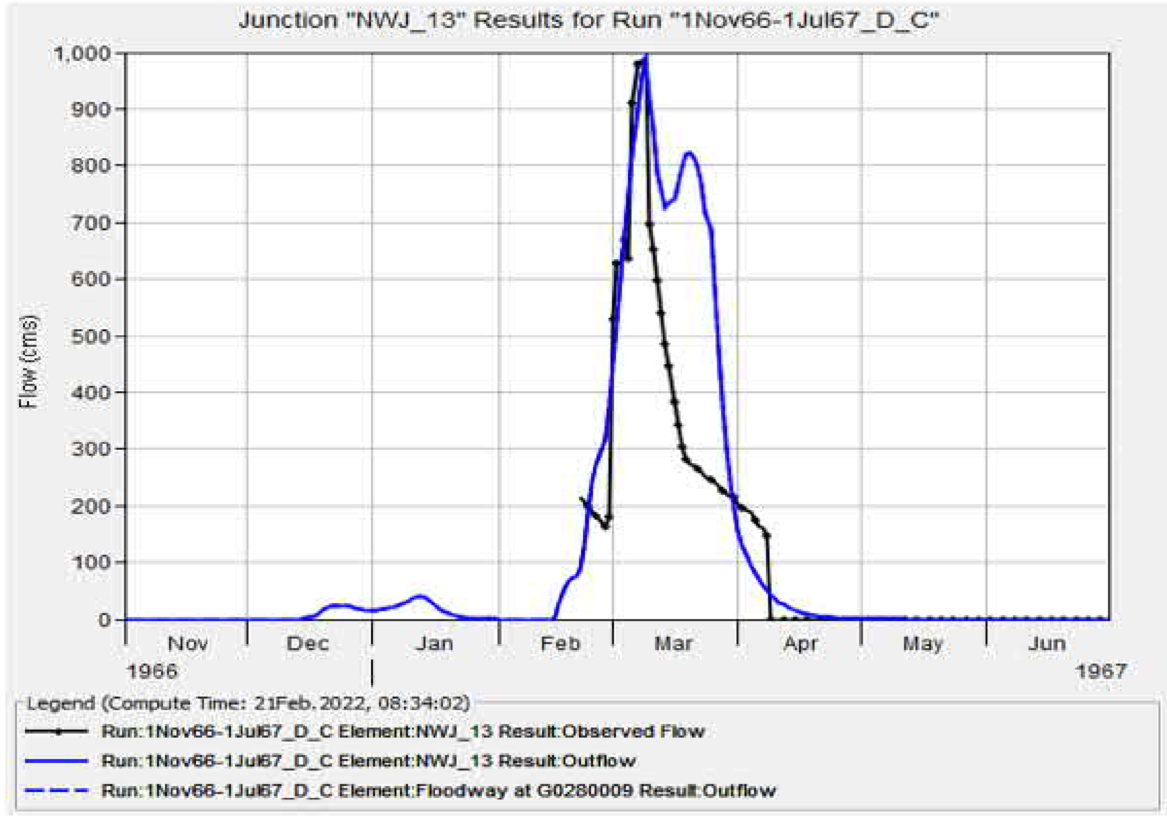
Surface Water & Erosion Solutions

Appendix B.1 and B.2

Upstream G0280009 Model & Calibration



Above: The HEC-HMS model for the Newcastle Creek catchment upstream of gauging station G0280009. There is a paucity of data for hydrologic analysis and modelling. No rain gauges are located within the model area and there is only 1 stream gauge at the outlet of the catchment.



Project: LW_30m_DEM_SILO_rain Simulation Run: 1Nov66-1Jul67_D_C
Junction: NWJ_13

Start of Run:	01Nov.1966, 00:00	Basin Model:	All_pre-1990_D_C _1966-67
End of Run:	01Jul.1967, 00:00	Meteorologic Model:	Silo_Rainfall-All_monthly_ET
Compute Time:	01Apr.2022, 15:32:28	Control Specifications:	1Nov1966-1Jul1967

Volume Units: ◯ MM ◉ 1000 M3

Computed Results

Peak Discharge:	986.46 (M3/S)	Date/Time of Peak Discharge:	09Mar.1967, 00:00
Volume:	2190998.7 (1000 M3)		

Observed Flow Gage G0280009_1973-74_adjusted

Peak Discharge:	990.00 (M3/S)	Date/Time of Peak Discharge:	09Mar.1967, 00:00
Volume:	1505660.0 (1000 M3)		
RMSE Std Dev:	0.67	Nash-Sutcliffe:	0.550
Percent Bias:	38.46 %		

Above: 1967 water year was used for validation. Computed and observed peak discharges at the outlet of the Newcastle Creek model compare well. Volume was a poor fit with NSE = 0.55 due to missing observed data. The fitted CR = 1.71 mmh^{-1}. which may under predict the true volume if compared to a complete observed hydrograph. Transform lag was adjusted by a factor of 0.57 and routing lag was adjusted by a factor of 0.5.

Project: LW_30m_DEM_SILO_rain   Simulation Run: 1Nov73-1Jul74_D_C
Junction: NWJ_13

Start of Run:	01Nov.1973, 00:00	Basin Model:	All_pre-1990_D_C _1973-74
End of Run:	01Jul.1974, 00:00	Meteorologic Model:	Silo_Rainfall-All_monthly_ET
Compute Time:	01Apr.2022, 15:09:05	Control Specifications:	1Nov1973-1Jul974

Volume Units: ◯ MM ◉ 1000 M3

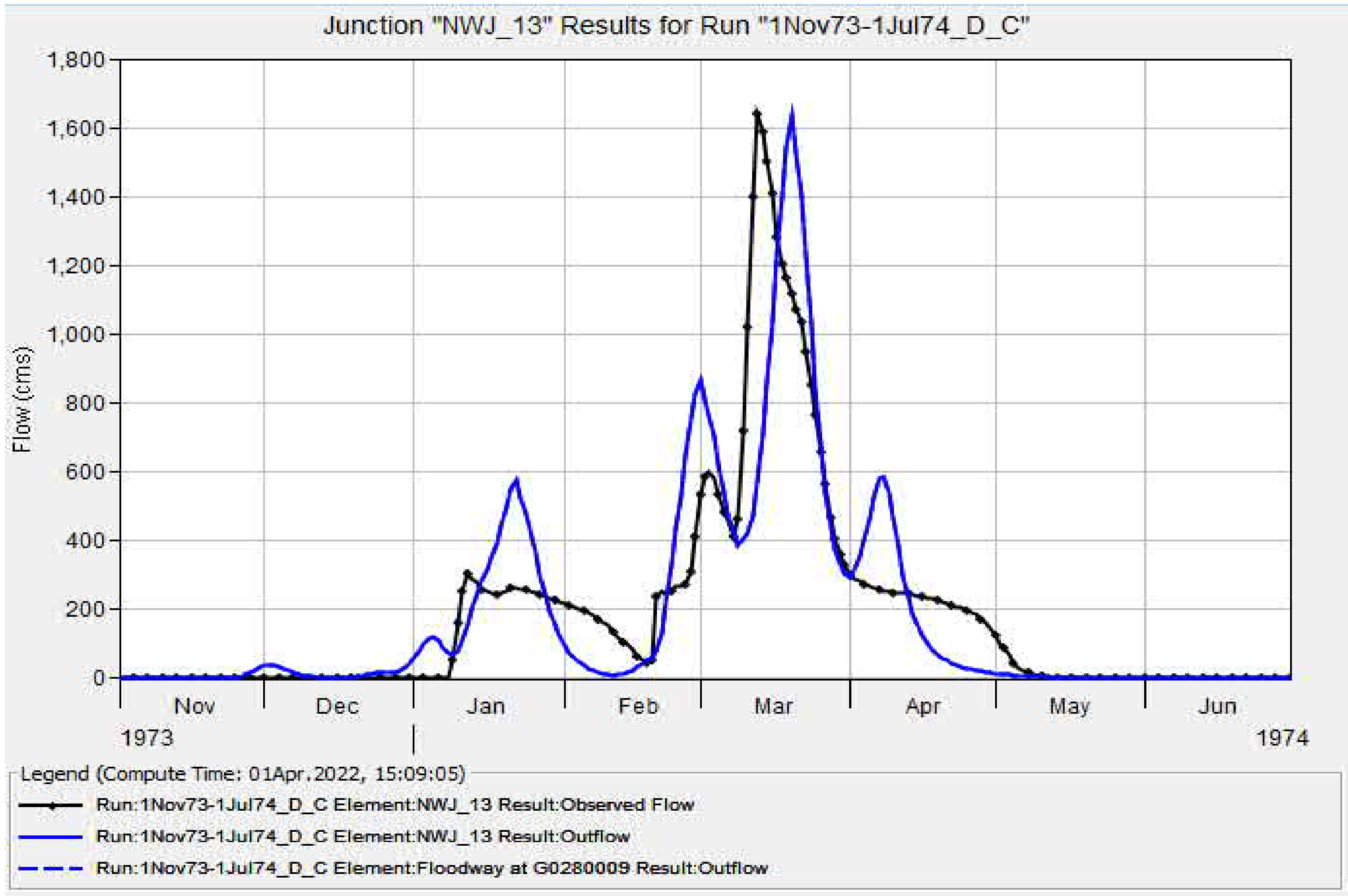
Computed Results

Peak Discharge:	1635.22 (M3/S)	Date/Time of Peak Discharge:	20Mar.1974, 00:00
Volume:	3826728.8 (1000 M3)		

Observed Flow Gage G0280009_1973-74_adjusted

Peak Discharge:	1637.90 (M3/S)	Date/Time of Peak Discharge:	13Mar.1974, 00:00
Volume:	3832928.7 (1000 M3)		
RMSE Std Dev:	0.57	Nash-Sutcliffe:	0.680
Percent Bias:	-0.16 %		

Above and Right: 1974 water year computed and observed results at the outlet of of the Newcastle Creek model (G0280009) for variable ID and CR = 1.39 mmh^{-1}. This model incorporates the pre-1990 causeway with a level of 208.3 mAHD. The computed and observed volumes and peak discharges compare well, giving a conservative result with NSE = 0.68. Usually only the loss parameters are fitted however, transform lag and and routing lag were also adjusts by a factor of 0.57 and 0.5 respectively, to improve the timing and peakiness of the hydrograph. This is the largest observed event and is well calibrated.



Project: LW_30m_DEM_SILO_rain   Simulation Run: 1Nov74_1Jul75_D_C
Junction: NWJ_13

Start of Run:	01Nov.1974, 00:00	Basin Model:	All_pre-1990_D_C _1974-75
End of Run:	01Jul.1975, 00:00	Meteorologic Model:	Silo_Rainfall-All_monthly_ET
Compute Time:	01Apr.2022, 15:14:50	Control Specifications:	1Nov1974-1Jul975

Volume Units: ◉ MM ◯ 1000 M3

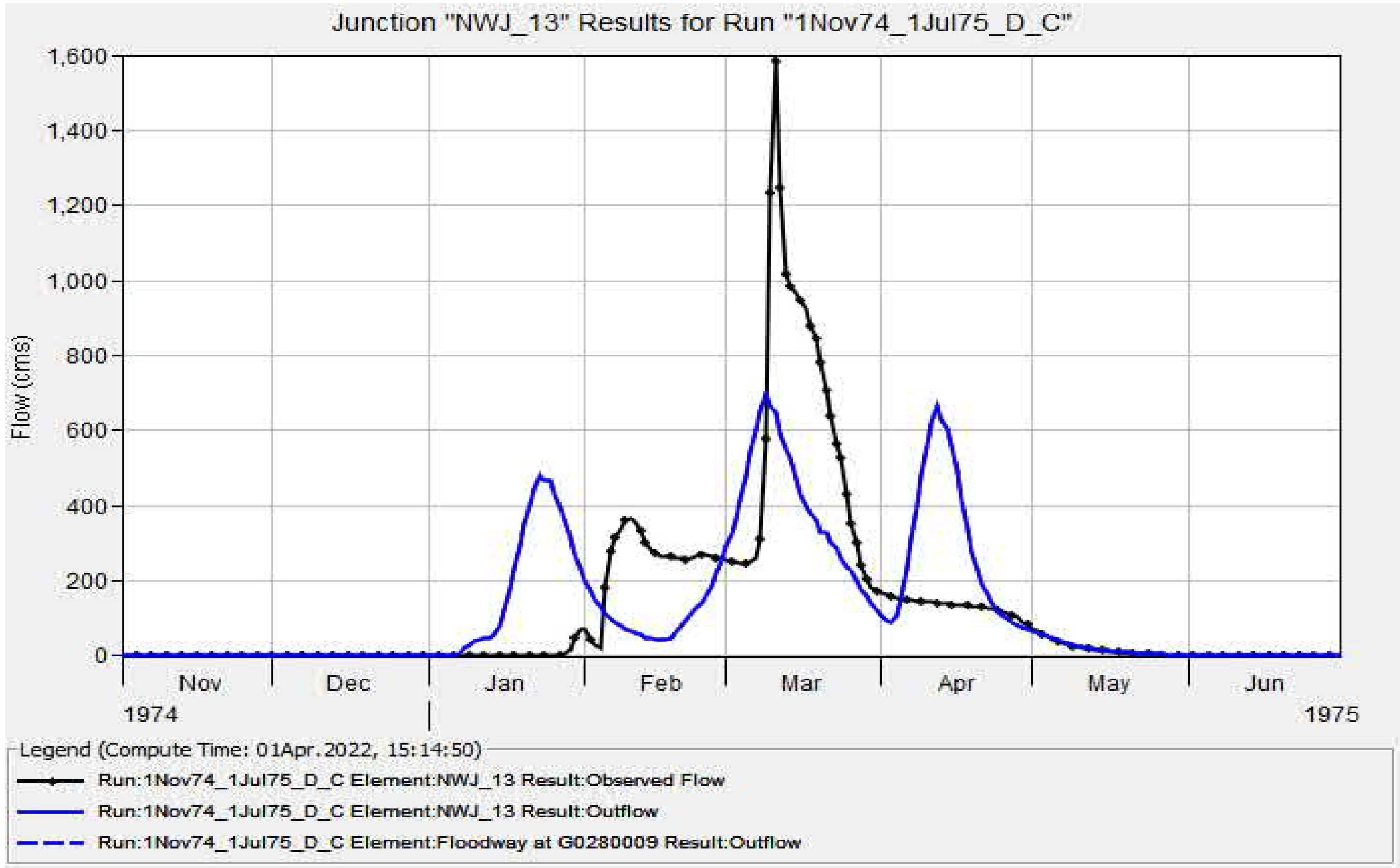
Computed Results

Peak Discharge:	698.00 (M3/S)	Date/Time of Peak Discharge:	09Mar.1975, 00:00
Volume:	140.76 (MM)		

Observed Flow Gage G0280009_1973-74_adjusted

Peak Discharge:	1581.90 (M3/S)	Date/Time of Peak Discharge:	11Mar.1975, 00:00
Volume:	140.74 (MM)		
RMSE Std Dev:	0.81	Nash-Sutcliffe:	0.343
Percent Bias:	0.01 %		

Above and Right: 1975 water year was used for validation. Although computed and observed volume at the outlet of the Newcastle Creek model compare well, the peak discharge was a poor fit with NSE = 0.35. The fitted CR = 1 mmh^{-1}. Transform lag was adjusted by a factor of 0.57 and routing lag was adjusted by a factor of 0.5.



Appendix B.2 Newcastle Creek HEC-HMS model calibration and validation for the 1974 and 1975 water years.

Project: LW_30m_DEM_SILO_rain Simulation Run: 1Nov2000-1Jul2001
Junction: NWJ_13

Start of Run:	01Nov.2000, 00:00	Basin Model:	All_post-1990_D_C _2000-2001
End of Run:	30Jun.2001, 00:00	Meteorologic Model:	Silo_Rainfall-All_monthly_ET
Compute Time:	03Mar.2022, 19:59:17	Control Specifications:	US_G0009_2000-2001

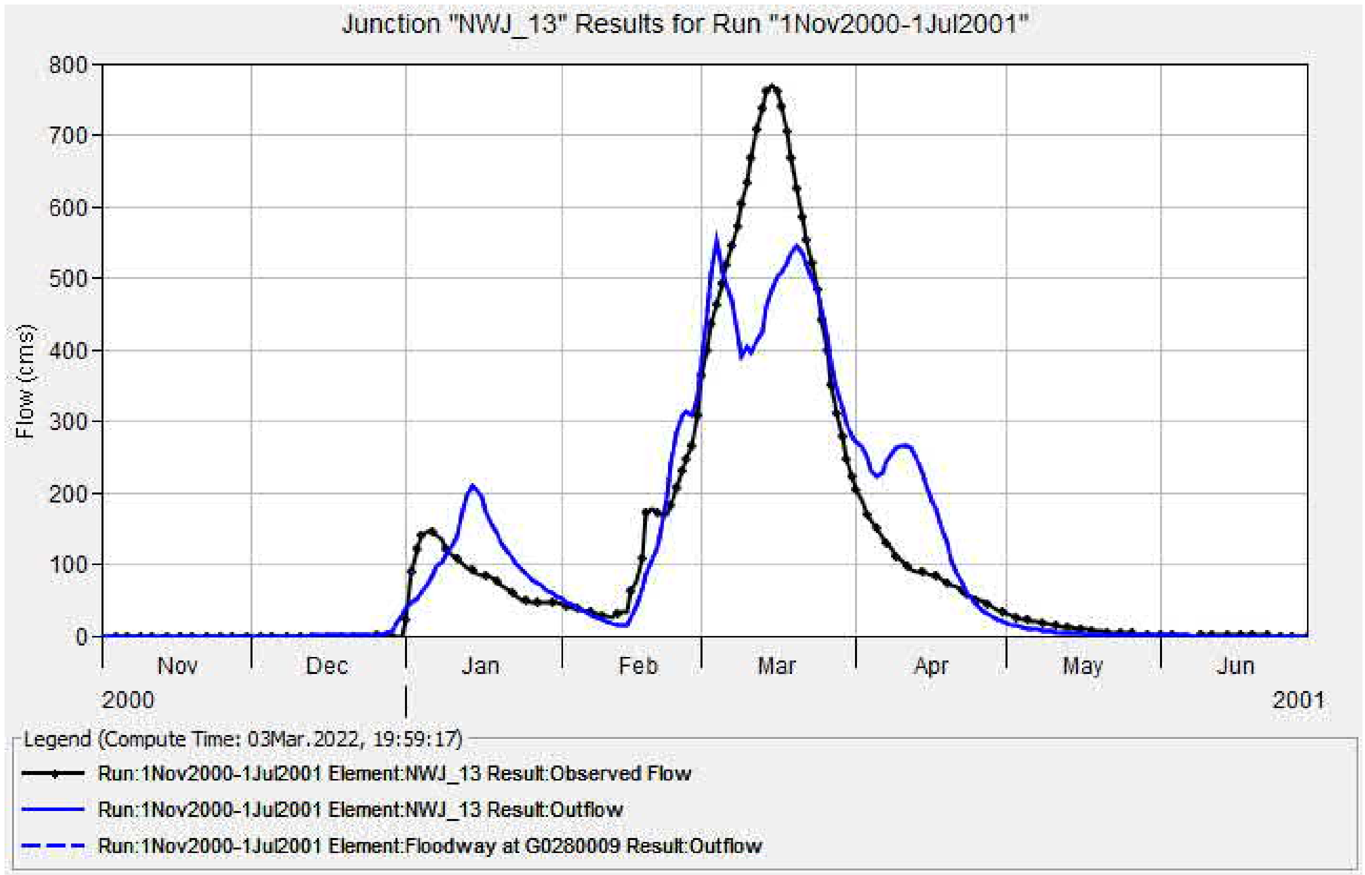
Volume Units: (•) MM ( ) 1000 M3

Computed Results

Peak Discharge:	553.1 (M3/S)	Date/Time of Peak Discharge:	04Mar.2001, 00:00
Volume:	118.38 (MM)		

Observed Flow Gage G0280009_1973-74_adjusted

Peak Discharge:	768.5 (M3/S)	Date/Time of Peak Discharge:	15Mar.2001, 00:00
Volume:	118.09 (MM)		
RMSE Std Dev:	0.4	Nash-Sutcliffe:	0.853
Percent Bias:	0.25 %		



Right and Above: 2001 water year computed and observed results at the outlet of Newcastle Creek model (G0280009) for variable ID and CR = 1.63 mmh^{-1}. This model incorporates the post-1990 3 bridges. The computed and observed volumes compare well. The peaks to not compare well. NSE = 0.85 indicating a good fit.

Project: LW_30m_DEM_SILO_rain Simulation Run: 1Nov2003-1Jul2004
Junction: NWJ_13

Start of Run:	01Nov.2003, 00:00	Basin Model:	All_post-1990_D_C _2003-2004
End of Run:	01Jul.2004, 00:00	Meteorologic Model:	Silo_Rainfall-All_monthly_ET
Compute Time:	03Mar.2022, 20:09:56	Control Specifications:	1Nov2003-1Jul2004

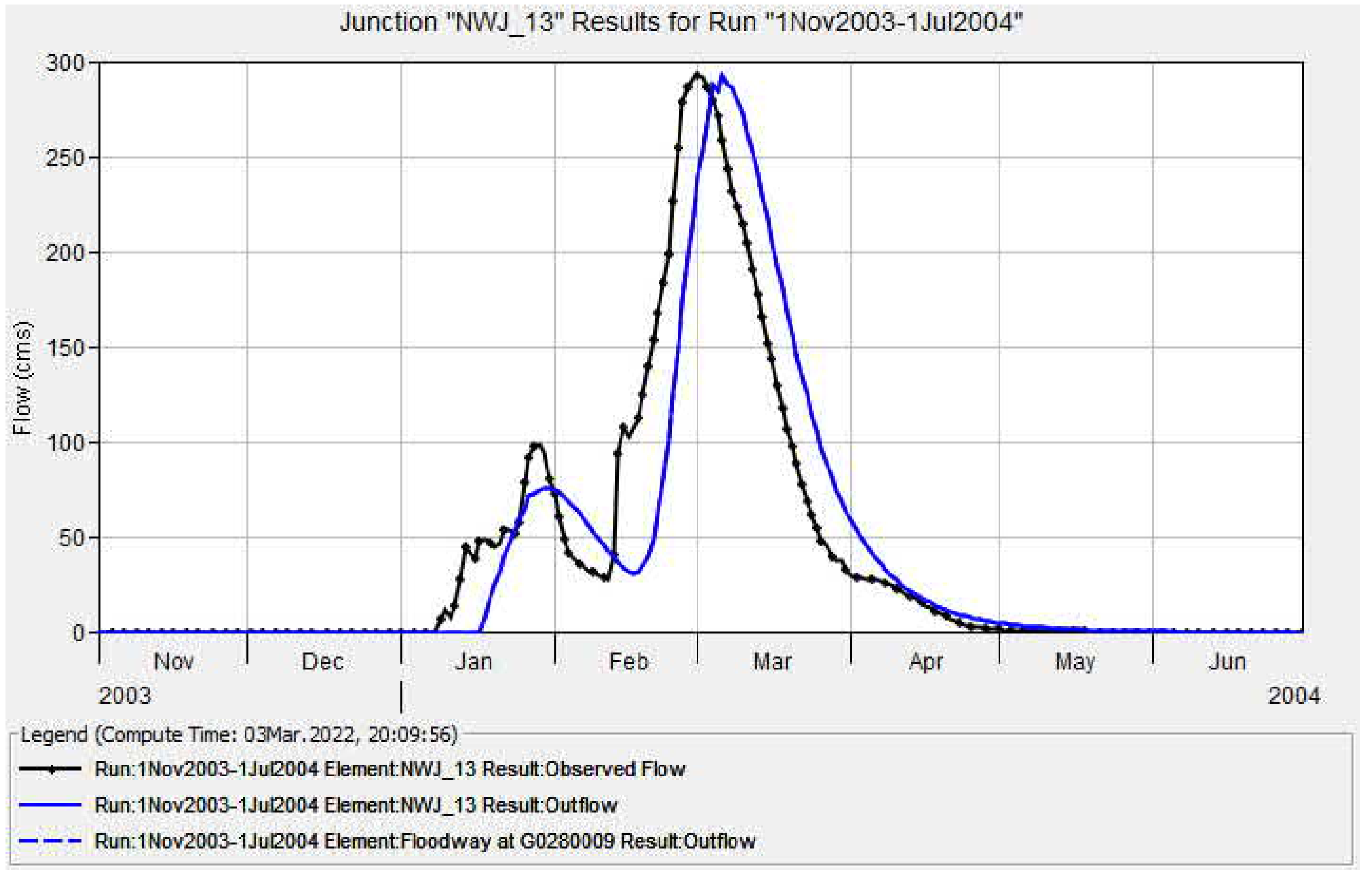
Volume Units: (•) MM ( ) 1000 M3

Computed Results

Peak Discharge:	292.3 (M3/S)	Date/Time of Peak Discharge:	06Mar.2004, 00:00
Volume:	44.37 (MM)		

Observed Flow Gage G0280009_1973-74_adjusted

Peak Discharge:	292.2 (M3/S)	Date/Time of Peak Discharge:	01Mar.2004, 00:00
Volume:	44.90 (MM)		
RMSE Std Dev:	0.6	Nash-Sutcliffe:	0.680
Percent Bias:	-0.16 %		

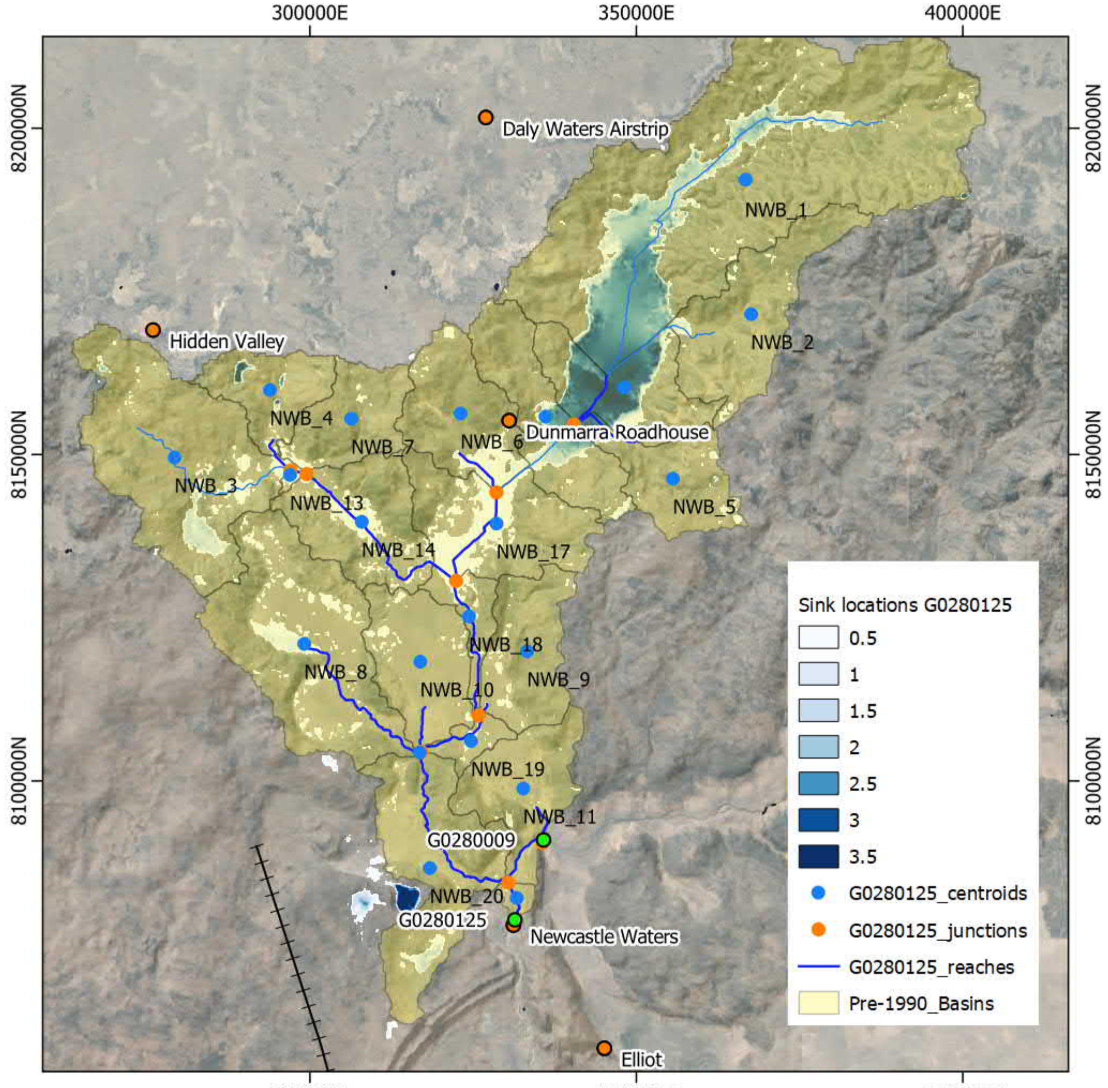


Right and Above: 2004 water year computed and observed results at the outlet of Newcastle Creek model (G0280009) for variable ID and CR = 2.5 mmh^{-1}. This model incorporates the post-1990 3 bridges. The computed and observed volumes and peak discharges compare well. NSE = 0.68.

Appendix B.3: Newcastle Creek HEC-HMS model calibration and validation for the 2001 and 2004 water years post-bridges at Newcastle Creek..

Appendix C

Upstream G0280125 Model & Calibration



Above: Newcastle Waters US-G0280125 HEC-HMS model.

Junction: WJ_1

Start of Run: 01Nov.2000, 00:00 Basin Model: LW_2000-2001_D_C
End of Run: 30Jun.2001, 00:00 Meteorologic Model: Silo_Rainfall-All
Compute Time: 22Feb.2022, 07:48:21 Control Specifications: US_G0009_2000-2001

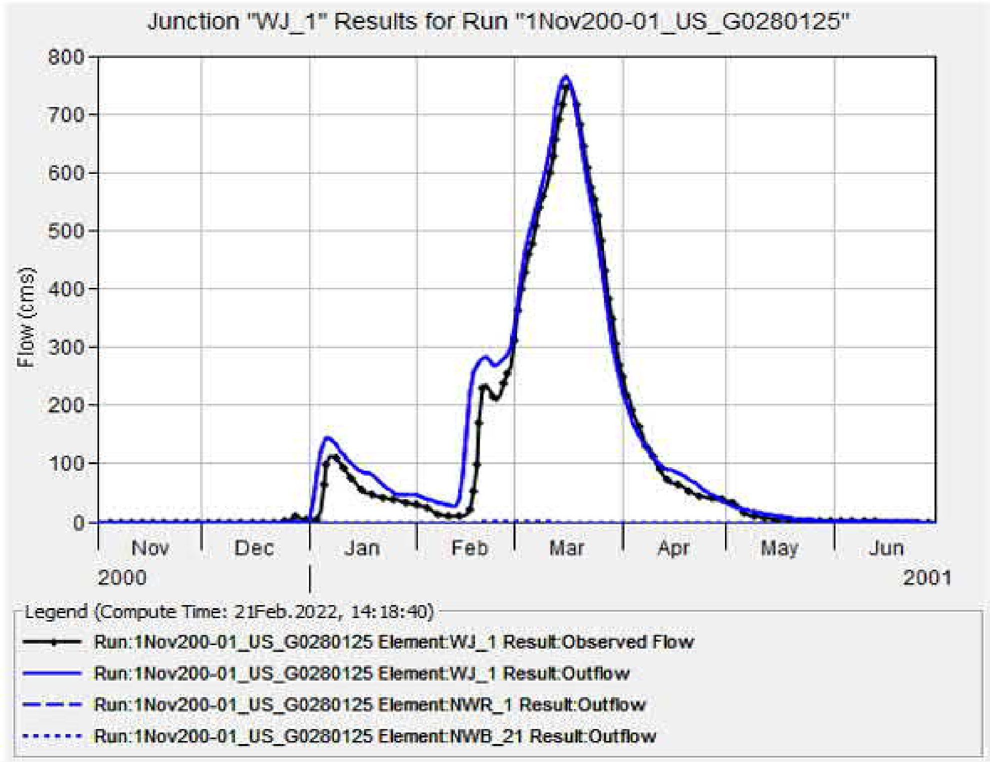
Volume Units: MM 1000 M3

Computed Results

Peak Discharge: 764.7 (M3/S) Date/Time of Peak Discharge: 16Mar.2001, 00:00
Volume: 2280883.4 (1000 M3)

Observed Flow Gage G0280215

Peak Discharge: 750.1 (M3/S) Date/Time of Peak Discharge: 17Mar.2001, 00:00
Volume: 2090099.8 (1000 M3)
RMSE Std Dev: 0.1 Nash-Sutcliffe: 0.979
Percent Bias: 9.13 %



Above and Right: Computed and observed volume and at the outlet of the Newcastle Creek model at G0280125 for the 2001 water year. There are high levels of storage in this catchment (upper and lower Left) and the outflow hydrograph is mostly driven by inflow from the large Newcastle Creek catchment. There are considerable losses in the catchment due to storage in lakes and sinks. It is unknown how the catchment would respond to a rare or extreme rainfall event as there are no flow data available. CR = 3.4 mm/hr and ID is variable.

Project: LW_30m_DEM_SILO_rain Simulation Run: 1Nov2003-1Jul2004_US_G028012
Junction: WJ_1

Start of Run: 01Nov.2003, 00:00 Basin Model: LW_2003-04_D_C
End of Run: 01Jul.2004, 00:00 Meteorologic Model: Silo_Rainfall-All
Compute Time: 21Feb.2022, 14:05:12 Control Specifications: 1Nov2003-1Jul2004

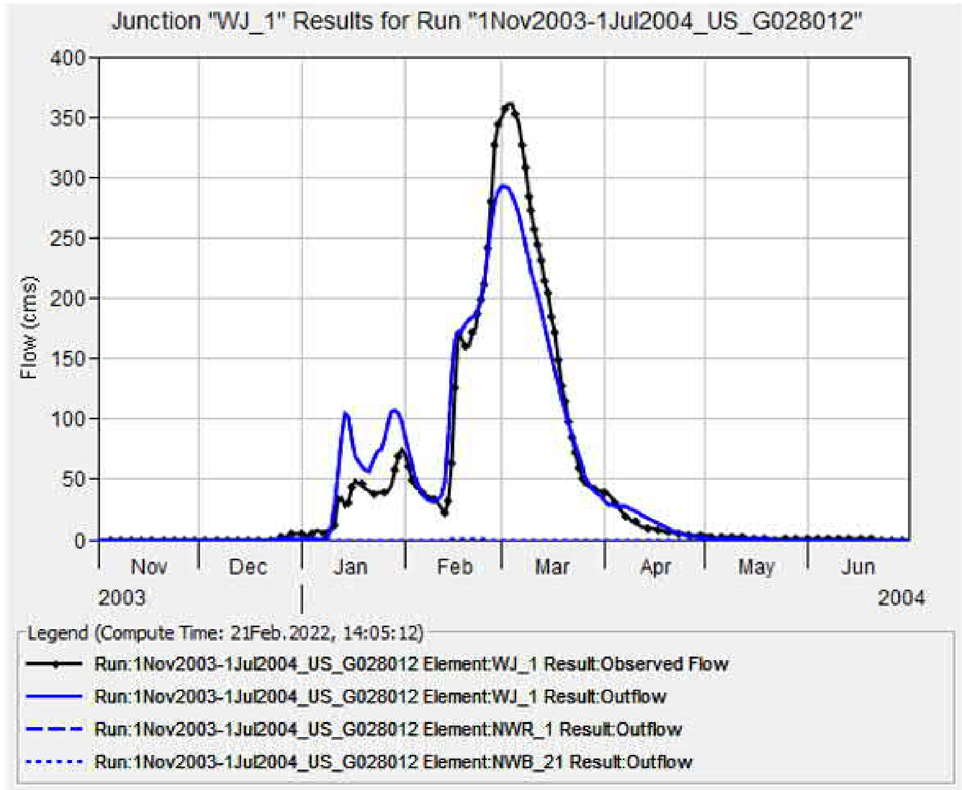
Volume Units: MM 1000 M3

Computed Results

Peak Discharge: 293.0 (M3/S) Date/Time of Peak Discharge: 02Mar.2004, 00:00
Volume: 931745.4 (1000 M3)

Observed Flow Gage G0280215

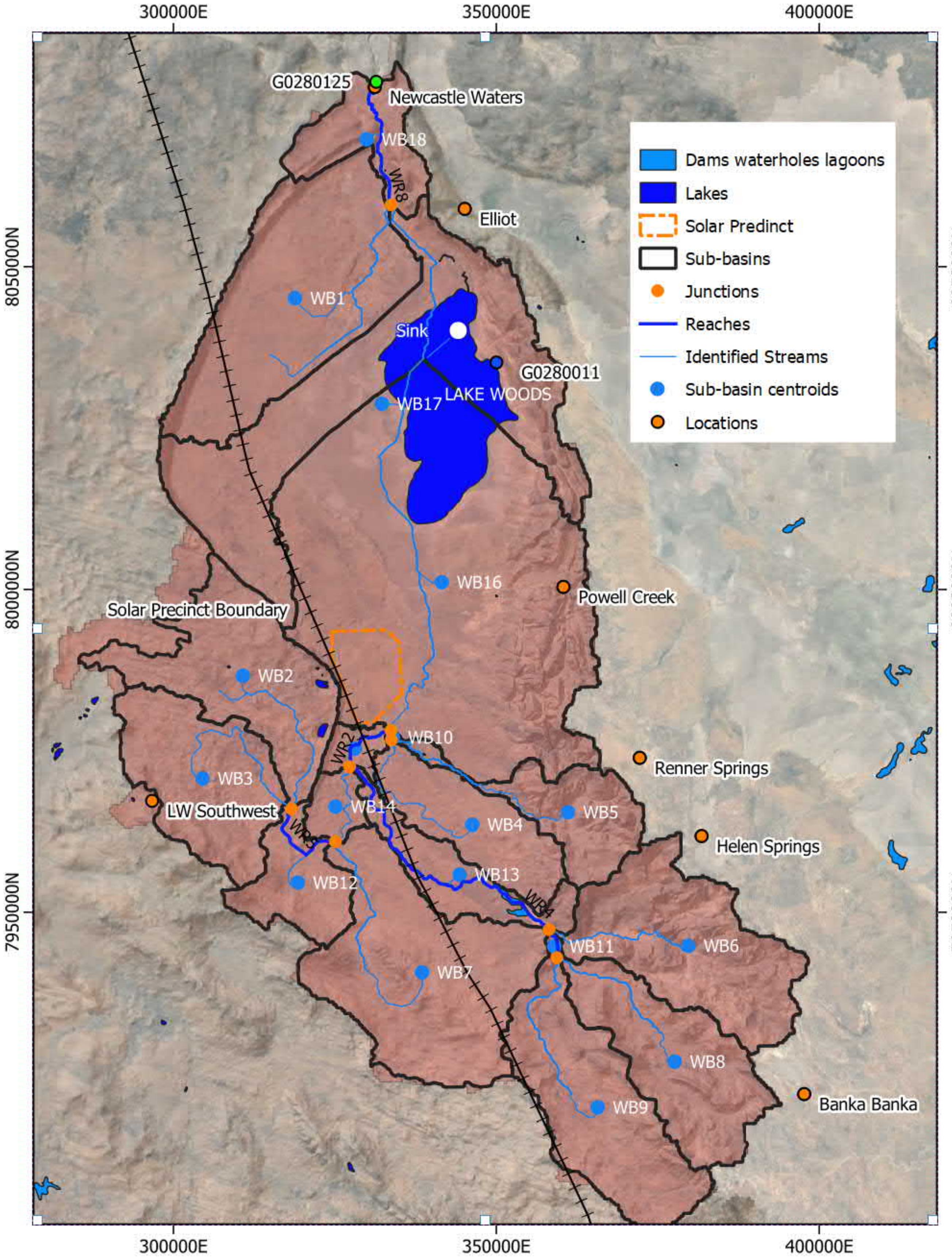
Peak Discharge: 361.2 (M3/S) Date/Time of Peak Discharge: 03Mar.2004, 00:00
Volume: 931970.9 (1000 M3)
RMSE Std Dev: 0.2 Nash-Sutcliffe: 0.940
Percent Bias: -0.02 %



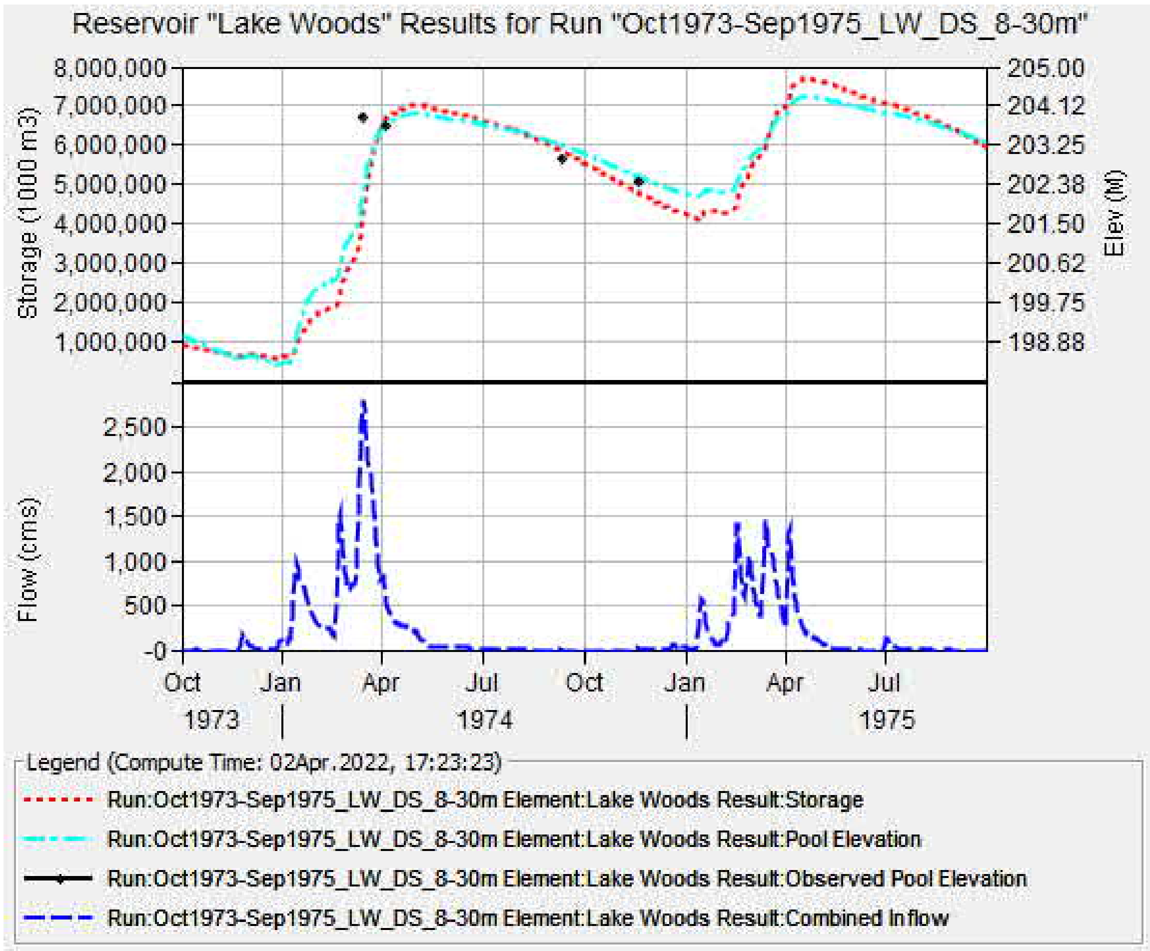
Above and Right: Computed and observed volume and at the outlet of the Newcastle Creek model at G0280125 for the 2004 water year. There are high levels of storage in this catchment (upper and lower Left) and the outflow hydrograph is mostly driven by inflow from the large Newcastle Creek catchment. There are considerable losses in the catchment due to storage in lakes and sinks. It is unknown how the catchment would respond to a rare or extreme rainfall event as there are no flow data available. CR = 3 mm/hr and ID is variable.

Appendix D

Downstream G0280125 Model & Calibration – Lake Woods.



Above: Components for HEC-HMS model DS G0280125



Above: Simulation for 1973 to 1975 water years. This is a good fit using CR = 2.2 mm/hr in the southern rocky catchments and 0.6mm/hr in the lake, giving a simulated peak elevation of 203.9 m (below). **See Appendix D.2 for 1975-1978 simulation**.

Project: LW_30m_DEM_SILO_rain   Simulation Run: Oct1973-Sep1975_LW_DS_8-30m
Reservoir: Lake Woods

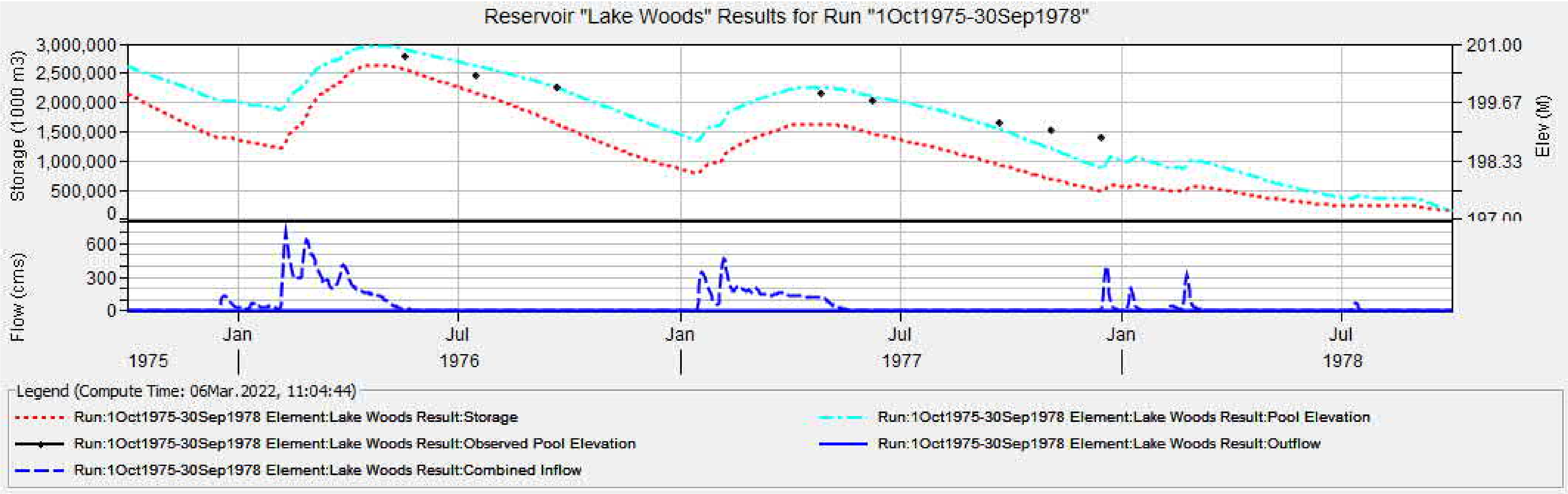
Start of Run:	01Oct.1973, 00:00	Basin Model:	Ortho8m-30m-low_CL
End of Run:	30Sep.1975, 00:00	Meteorologic Model:	Silo_LW_DS_G0280125
Compute Time:	02Apr.2022, 17:23:23	Control Specifications:	Oct73-Sep75

Volume Units: (•) MM ( ) 1000 M3

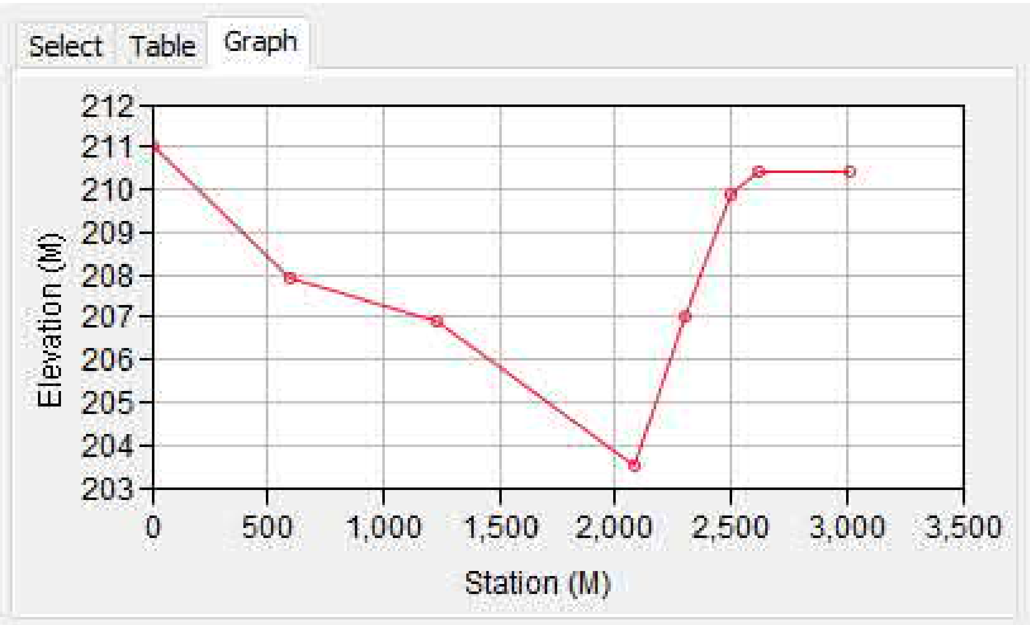
Computed Results

Peak Inflow:	2796.0 (M3/S)	Date/Time of Peak Inflow:	15Mar.1974, 00:00
Peak Discharge:	25.1 (M3/S)	Date/Time of Peak Discharge:	20Apr.1975, 00:00
Inflow Volume:	370.09 (MM)	Peak Storage:	7692834.2 (1000 M3)
Discharge Volume:	2.08 (MM)	Peak Elevation:	204.3 (M)

Appendix D.1	SUN CABLE SURFACE WATER & EROSION SOLUTIONS	Project: Sun Cable Lake Woods Surface Hydrology Study	Title: Simulations for 1973-1975 when water levels were recorded in Lake Woods.	Designed	Drawn	Checked	Sheet size	Date	Sheet No.	Sheet of



Above: The simulation from1976-1978 water years for the period when water level data (black dots in top view) were collected in Lakes Woods at G0280011. The model uses observed flow input at G0280009. There is good visual agreement between observed and predicted surface water elevation using CR = 2 mm/hr for the black soil areas of the lakes and 9 mm/hr for the southern and northern rocky catchments. The maximum predicted water surface level in Lake Woods was 201.0 m (see right).



Above: The stream cross section at Newcastle Waters which acts as a non-level overflow for Lake Woods towards Newcastle Waters. The invert is 203.5m AHD. It had to be raised to 204 mAHD to fit the 1974 observed peak but was returned to 203.5m for the longterm simulations.

Project: LW_30m_DEM_SILO_rain   Simulation Run: 1Oct1975-30Sep1978
Reservoir: Lake Woods

Start of Run:	01Oct.1975, 00:00	Basin Model:	Ortho8m-30m-High_CL
End of Run:	30Sep.1978, 00:00	Meteorologic Model:	Silo_LW_DS_G0280125
Compute Time:	06Mar.2022, 11:04:44	Control Specifications:	1Oct1975-30Sep1978

Volume Units: ○ MM ◉ 1000 M3

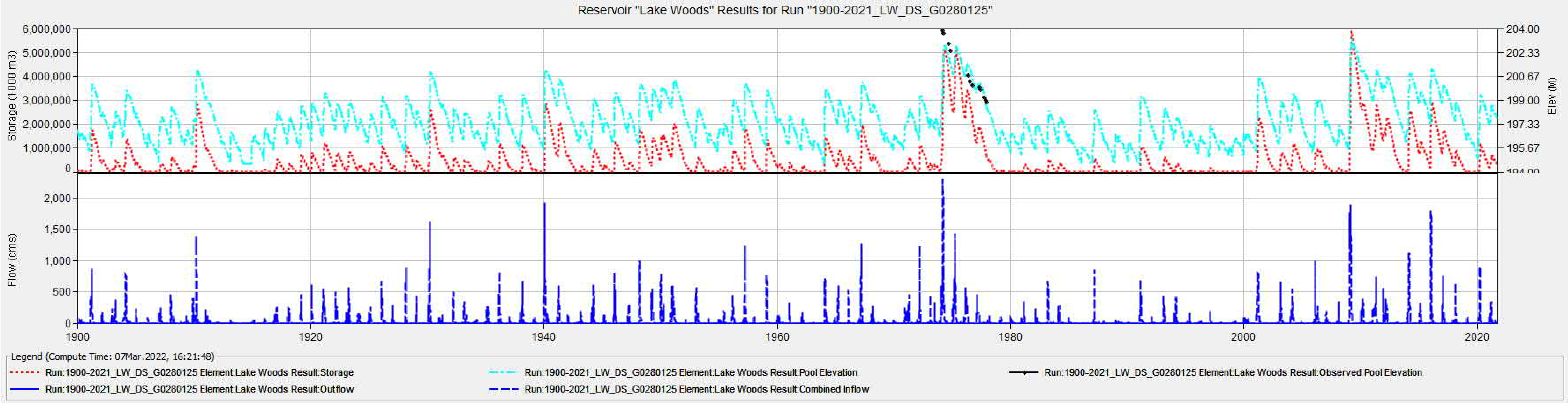
Computed Results

Peak Inflow:	698.7 (M3/S)	Date/Time of Peak Inflow:	09Feb.1976, 00:00
Peak Discharge:	0.0 (M3/S)	Date/Time of Peak Discharge:	01Oct.1975, 00:00
Inflow Volume:	4672570.6 (1000 M3)	Peak Storage:	2639632.9 (1000 M3)
Discharge Volume:	0.0 (1000 M3)	Peak Elevation:	201.0 (M)

Appendix D.2	SUN CABLE / SURFACE WATER & EROSION SOLUTIONS	Project: Sun Cable Lake Woods Surface Hydrology Study	Title: Simulations for 1975-1978 when water levels were recorded in Lake Woods.	Designed	Drawn	Checked	Sheet size
				Date		Sheet No.	
						Sheet of	

Appendix E

Long term simulation 1900-2021 and flood inundation extents on Lake Woods

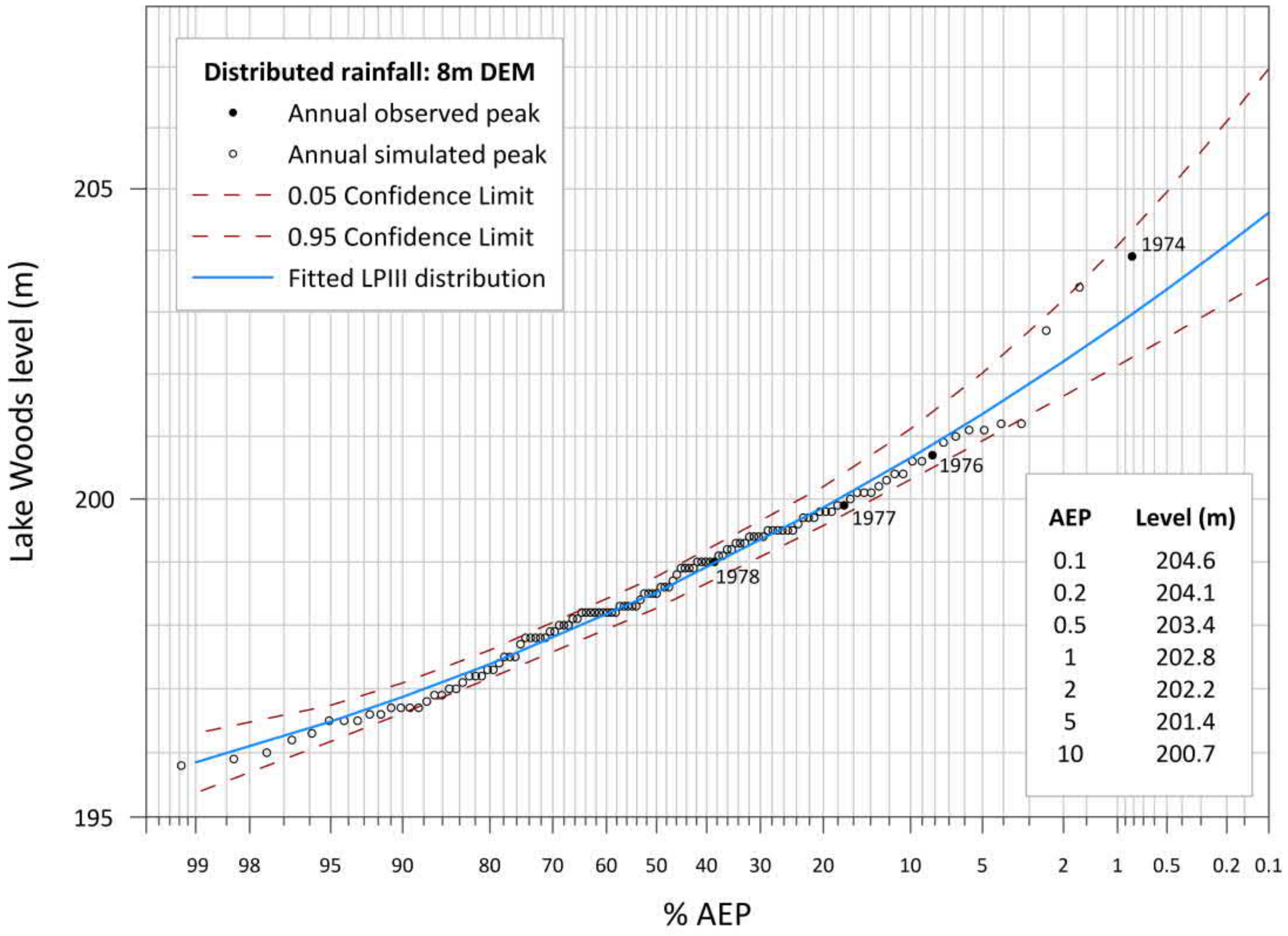


Above: A long-term simulation 1900 to 2021 of water surface elevations (SWE) in Lake Woods using the BOM/SILO rainfall network.

Loss parameter values derived for Lake Woods for the lower rainfall years where water surface elevations were available, 1976 to 1978 (Appendix D.1) were used in the simulations as low rainfall years occur more often than the high rainfall years as reflected above in the dark blue inflow trace in the lower panel.

The simulated discharges at G0280009 with observed discharges inserted were used. This simulation used an average CR = 1.64 mm/hr for US G0280009. For the lake DS of G0280125, CR = 2 mm/hr was used for the black-soil areas of the lake (**left**) and for the rocky ridges and aeolian sands in the southern catchment, CR = 9 mm/hr reflecting the value of 10 mm/hr provided by the ARR Data Hub (https://data.arr-software.org/) for this location.

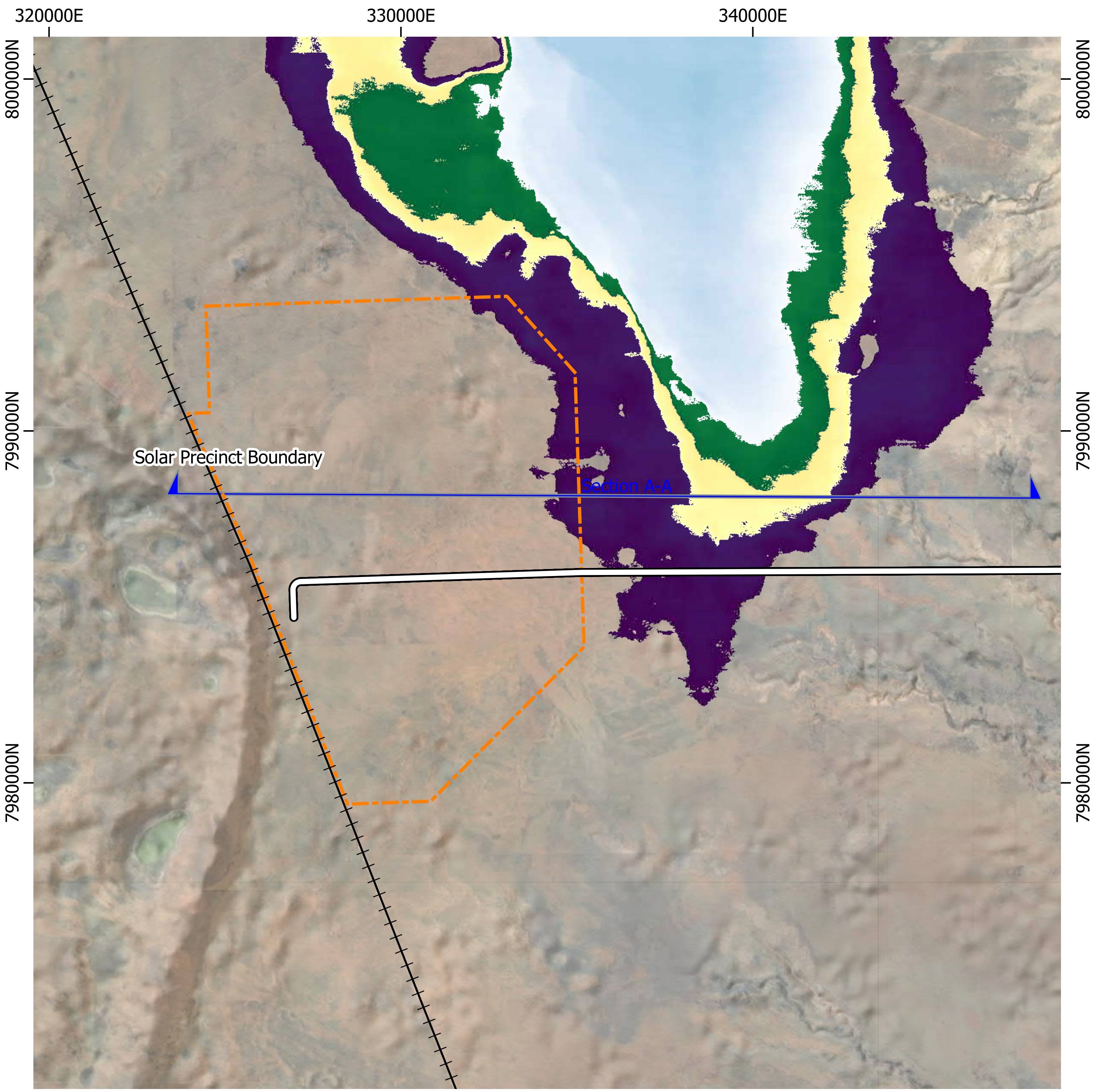
The simulated lake levels, light blue dotted trace top panel, do not fit the black dotted observed levels. However, the observed historic levels replaced the simulated levels in the LP3 analysis (left).

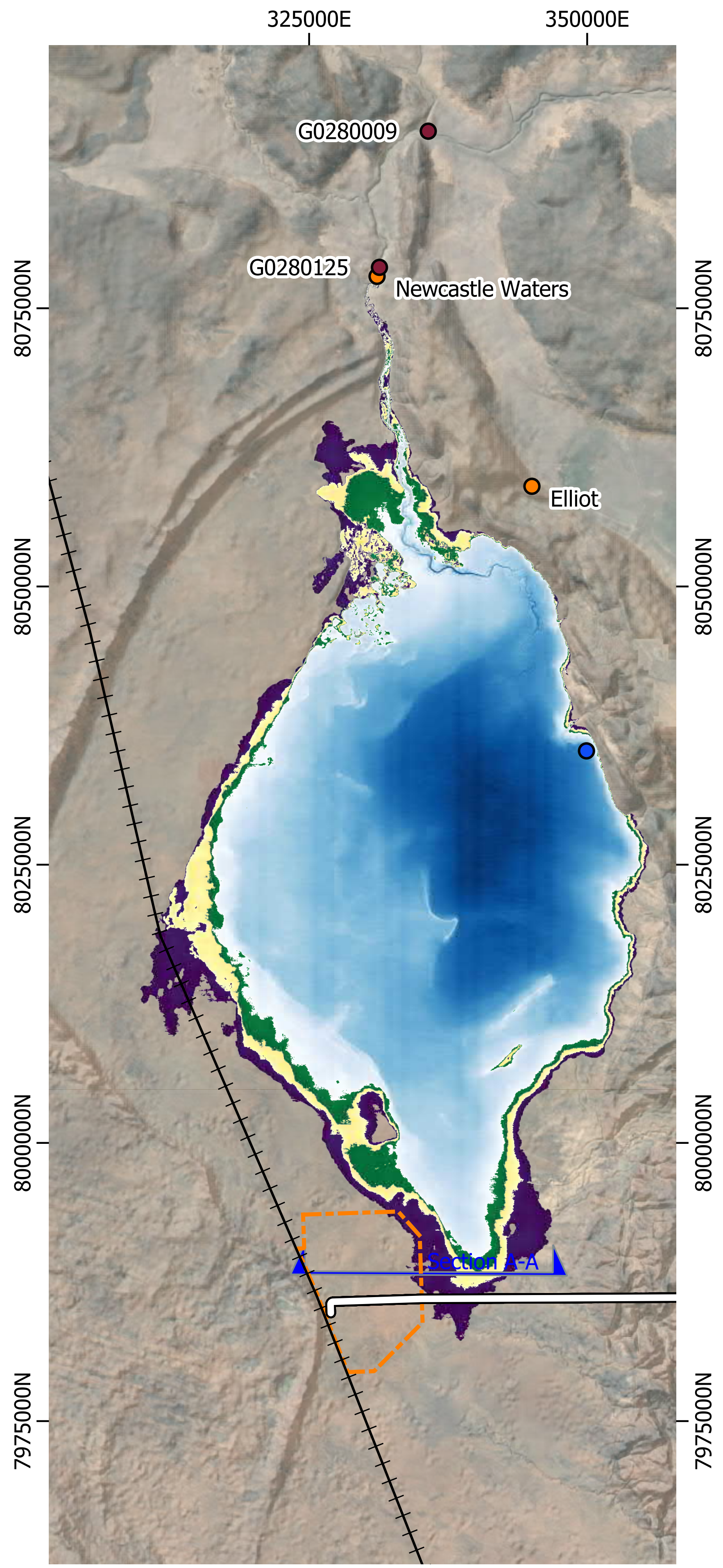


AEP	Level (m)
0.1	204.6
0.2	204.1
0.5	203.4
1	202.8
2	202.2
5	201.4
10	200.7

Left: Annual maxima of the 1900-2021 simulated WSEs were extracted and the historic observed maxima 1974, 1976, 1977, 1978 replaced the simulated values. The maxima were used to fit an LP3 distribution using the Bulletin 17B method in HEC-SSP. This analysis was used to plot Annual Exceedence Probablity floods (Appendices E.2 and E.3)

Appendix E.1	SUN CABLE SURFACE WATER & EROSION SOLUTIONS	Project Sun Cable Lake Woods Surface Hydrology Study	Title Longterm simulation - 1900 to 2021 and WSE LP3 distribution.	Designed	Drawn	Checked	Sheet size
				Date		Sheet No.	
						Sheet of	





Railway
Solar Predinct Site Boundary Polygon
Main Access Road

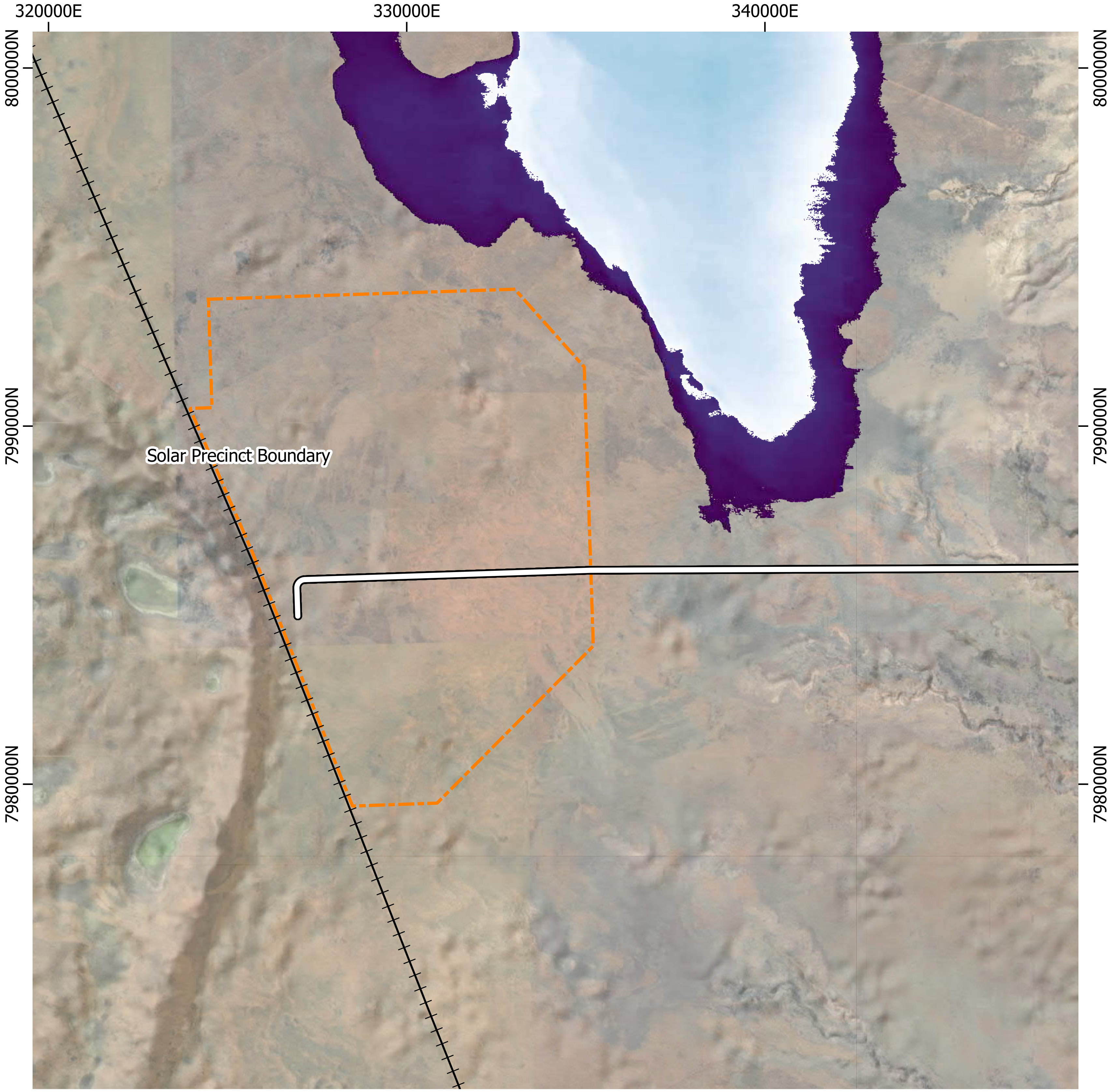
0.1% AEP flood peak
204.6 mAHD

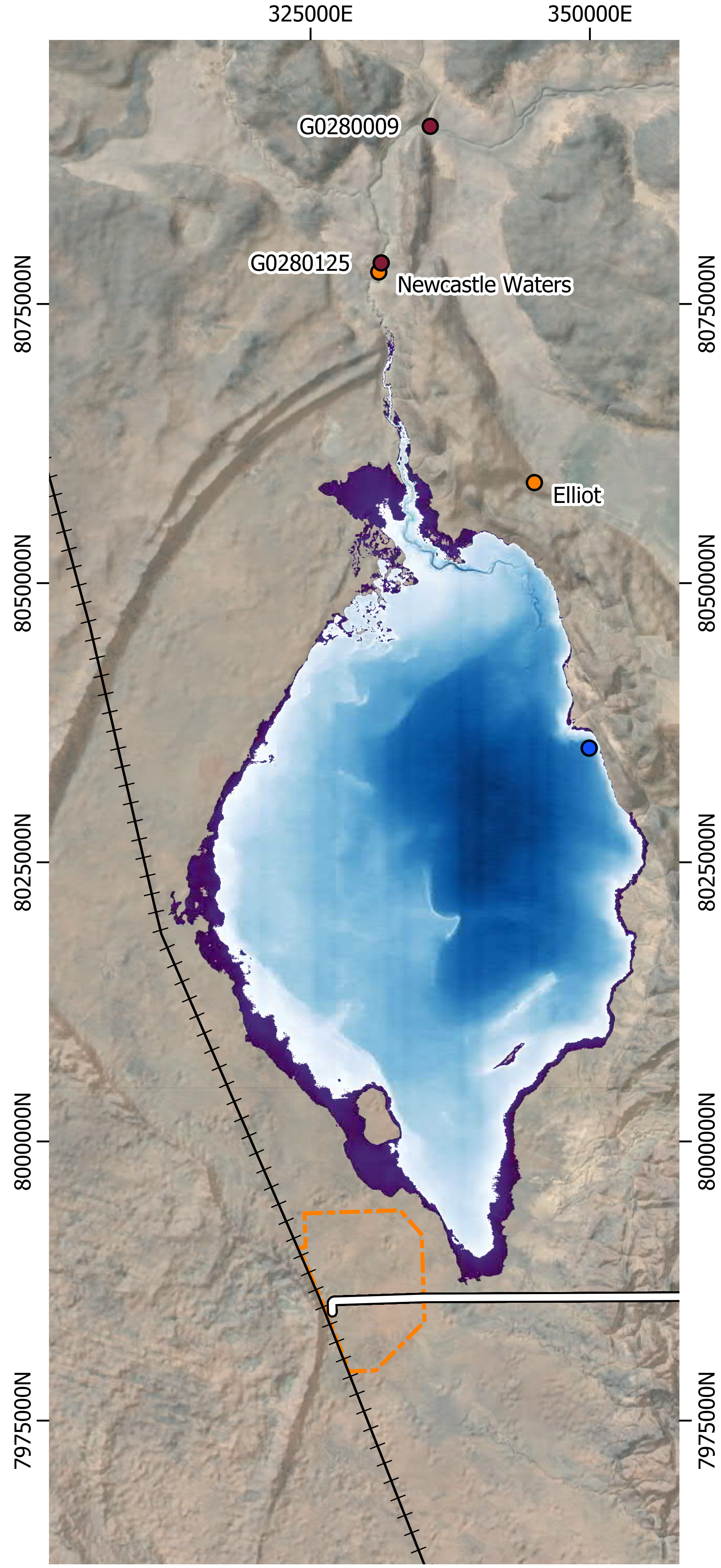
0.2% AEP
204.1 mAHD

0.5% AEP
203.4 mAHD

1% AEP - 202.8m AHD
1% AEP Bathymetry
0.01 m
6.81 m

Appendix E.2	SUN CABLE SURFACE WATER & EROSION SOLUTIONS	Project Sun Cable Lake Woods Surface Hydrology Study	Title 1%, 0.5%, 0.2%, 0.1% AEP Flood Inundation Levels	Designed	Drawn	Checked	Sheet size
				Date		Sheet No.	
						Sheet of	





Railway
Solar Predinct Site Boundary Polygon
Main Access Road

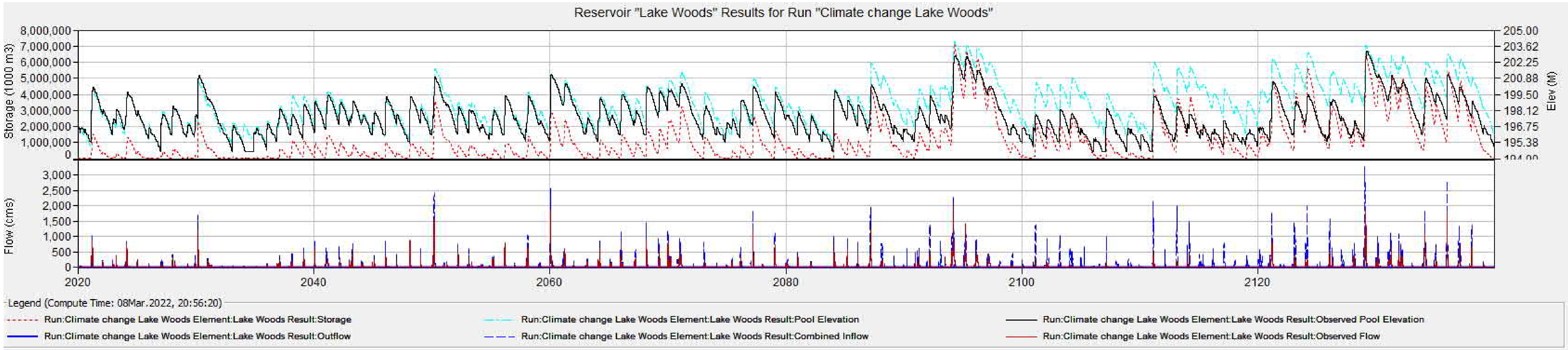
1% AEP - 202.8 m AHD
1% AEP Bathymetry
0.01 m
6.81 m

0.3% AEP observed level, 1974, 203.9 m AHD

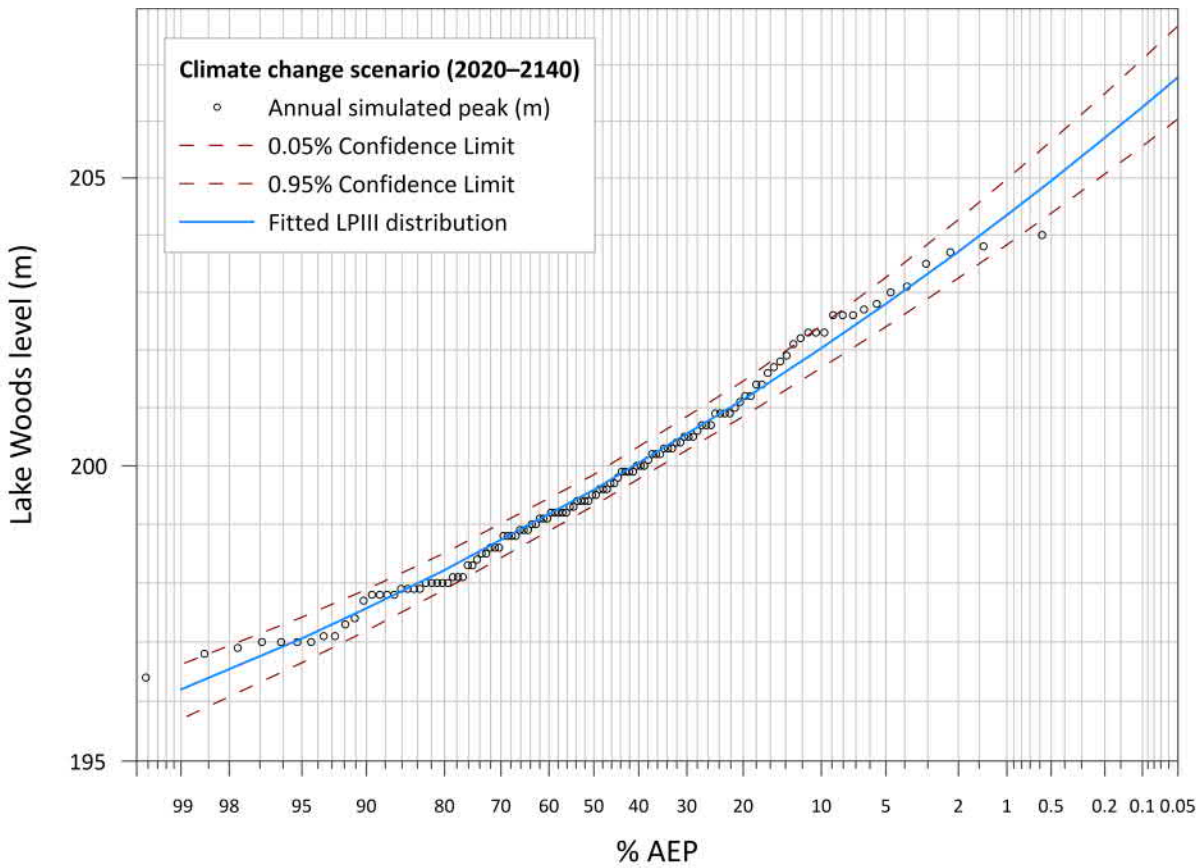
Appendix E.3	SUN CABLE / SURFACE WATER & EROSION SOLUTIONS	Project: Sun Cable Lake Woods Surface Hydrology Study	Title: 1%, AEP and Highest Observed Level	Designed	Drawn	Checked	Sheet size
				Date		Sheet No.	Sheet of

Appendix F

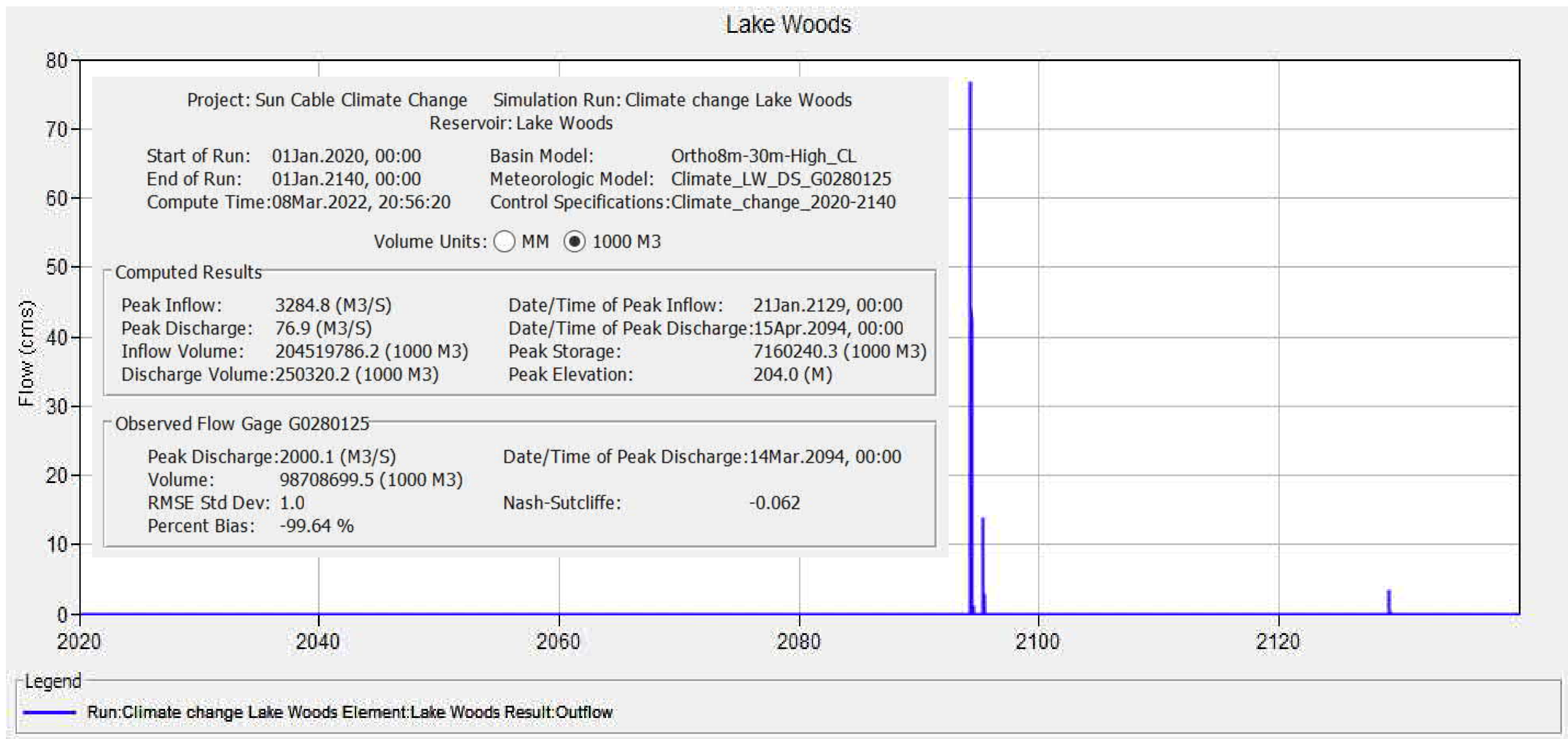
Climate Change Assessment



Above: A long-term climate change simulation based on the mid-point of the RCP 4.5 and RCP 8.5 models. The black trace above represents the simulated WSE from 1900 to 2020 referred to as observed pool elevation. This rainfall record was then used for the 2020 to 2140 simulation with the percentage increase in rain applied. The light blue trace in the top panel above represents the 2020 to 2140 scenario. The red trace in the lower panel above is the inflow which occurred for the 1900 to 2020 simulatons. The dark blue trace is the climate change impact inflows which are clearly higher than the pre-2020 flows.

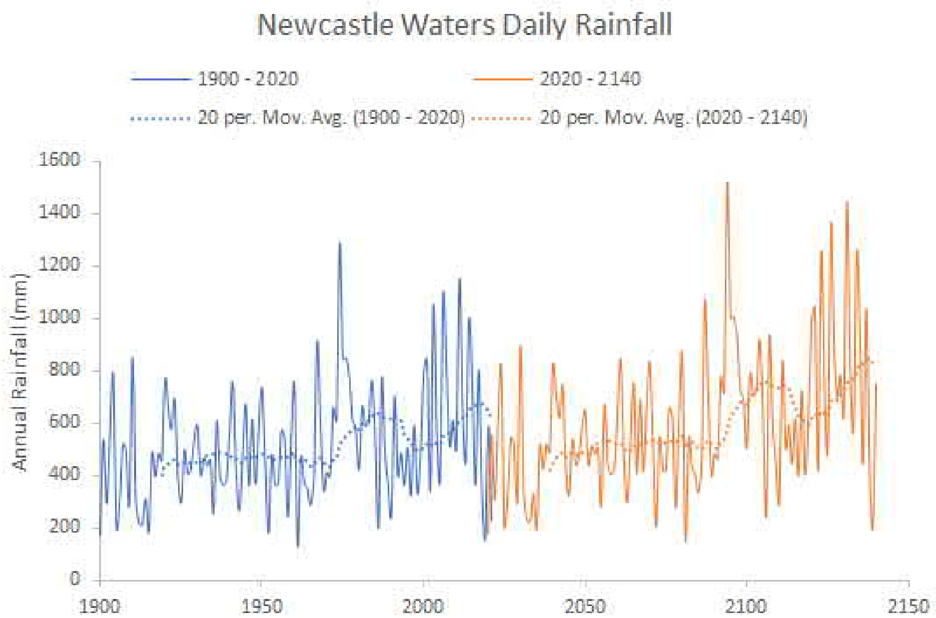


Above: LP3 distribution for the 120 y climate change simulation. Simulated WSEs don't exceed 204 mAHD.

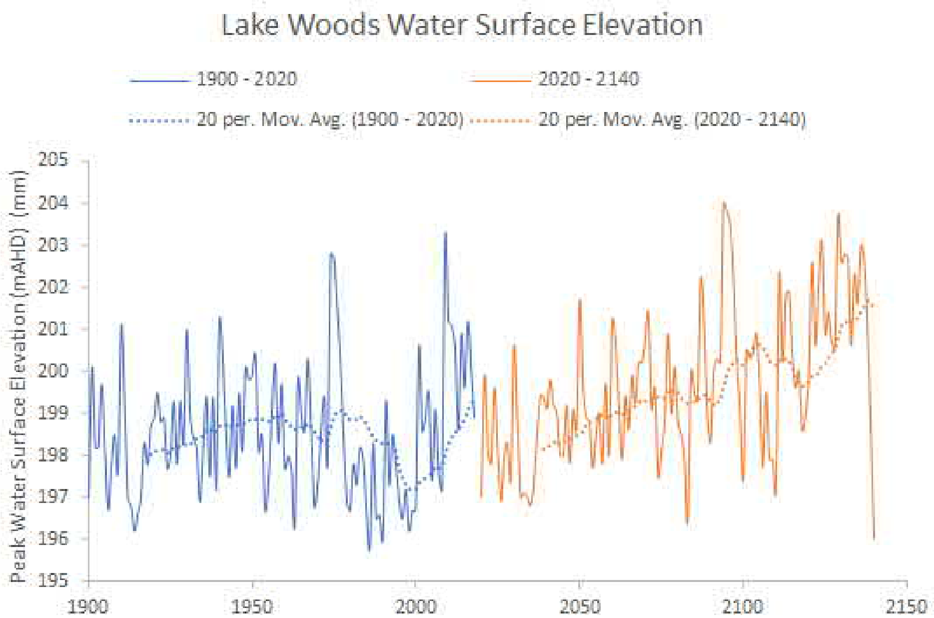


Above: The outflow from the lake during high water levels. There was a discharge of 250 GL which is assumed to have occurred through the non-level outflow at Newcastle Waters (See Appendix D.1)

Appendix F.1	SUN CABLE SURFACE WATER & EROSION SOLUTIONS	Project Sun Cable Lake Woods Surface Hydrology Study	Title Climate Change Simulation 2020 to 2140	Designed	Drawn	Checked	Sheet size
				Date		Sheet No.	
						Sheet of	



Above: Newcastle Waters observed BOM data from 1900 to 2020 showing a trend of increasing annual rainfall (blue). Newcastle Waters rainfall with climate change rainfall percentage increase applied (orange).



Above: Lake Woods simulated annual peak water surface elevation from 1900 to 2020 (blue). Lake Woods annual peak surface water simulated with climate change adjusted rainfall from 2020 to 2140 (orange).

Railway

Solar Predinct Site Boundary

Polygon Main Access Road

1% AEP - 202.8 m AHD 1% AEP Bathymetry

0.01 m

6.81 m

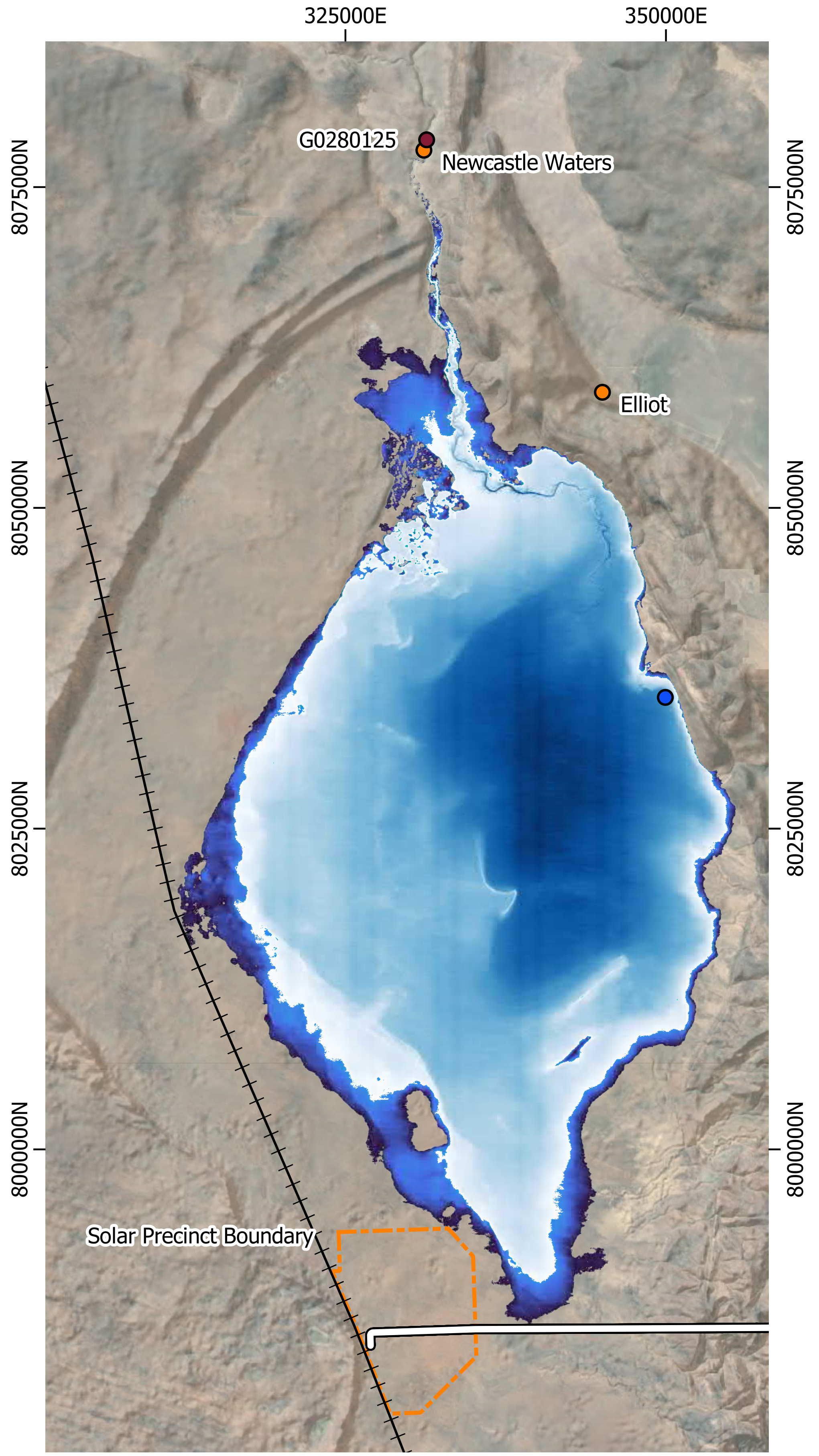
1% AEP climate change - 204.3 m 1% AEP climate change bathymetry

0.01 m

1.08 m

Right: Lake Woods inundation area for the 1% AEP surface water level for 1900 to 2020 peaks.

Lake Woods inundation area for the 1% AEP climate change scenarios from 2020 to 2140.



Appendix F.2	SUN CABLE SURFACE WATER & EROSION SOLUTIONS	Project Sun Cable Lake Woods Surface Hydrology Study	Title Lake Woods simulations 1900 to 2020 and 2020 to 2140 climate change projections	Designed	Drawn	Checked	Sheet size
				Date		Sheet No.	
						Sheet of	