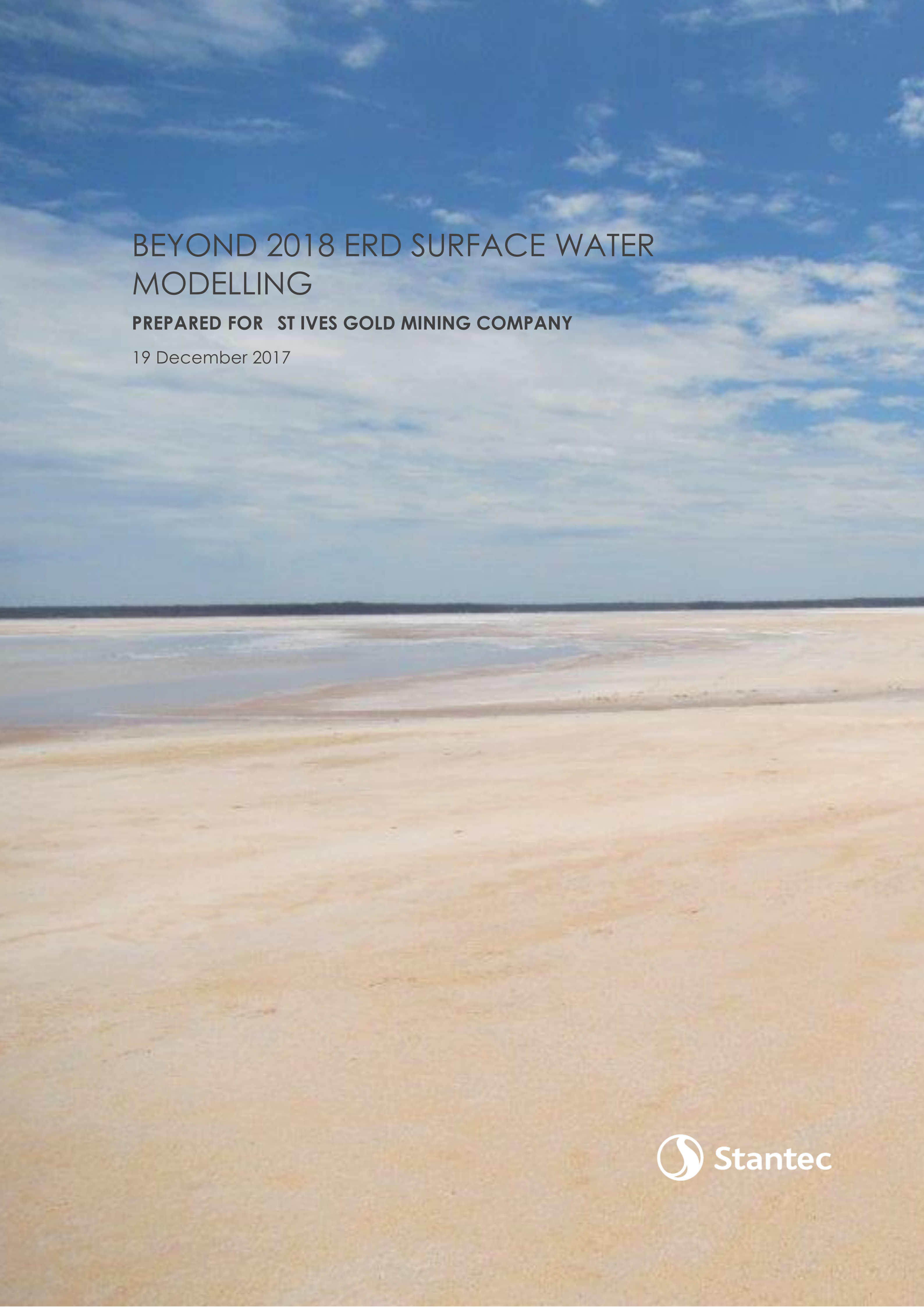
APPENDIX L: SURFACE WATER MODELLING - B2018 PROJECT (STANTEC)

BEYOND 2018 ERD SURFACE WATER MODELLING

PREPARED FOR ST IVES GOLD MINING COMPANY

19 December 2017



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REVISION SCHEDULE

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Executive Summary

St Ives Gold Mining Company Pty Limited (SIGMC) currently operates the St Ives Gold Mine (St Ives) at Lake Lefroy, located approximately 20 kilometres (km) south-east of Kambalda. The St Ives Gold Mine involves both open cut and underground gold mining activities on the lake-surface and adjacent land. SIGMC requires an additional expansion of the current area of disturbance approved under Ministerial Statement 879, which covers the current lake-based mining operations only. The revised proposal is for development of new lake-based and land-based gold mining areas for a ten-year period (i.e. 2019 – 2028), referred to as the Beyond 2018 (B2018) Project.

SIGMC commissioned Stantec to undertake surface water modelling to support the Beyond 2018 Environmental Review Document (ERD) submission and to assess the various groundwater and surface water management impacts from the Beyond 2018 mining campaigns.

The B2018 project considers expansion of current and / or development of new lake-based and land-based areas. Only indicative footprints and locations of potential future developments were available for consideration in this assessment. Given the long history of mining at the site, pre-mining baseline lake bathymetry and salinity information was not available. The B2016 information (lake bathymetry, salt loads, etc) was therefore assumed as the starting condition for B2018 modelling scenarios and impact assessment. Note that although assessments were undertaken for B2010 and the original project in 2000, the baseline for B2018 is assumed to be B2016 as the B2010 and 2000 projects were assessed as separate projects.

Lake Lefroy is assumed to overlay a clayey lacustrine mixture of sediments, highly heterogeneous in its properties. Due to its clayey nature and the presence of precipitated salt crust, the interaction between groundwater and occasionally available surface water in the lake is limited, driven by low permeability of this layer (Stantec 2017). Limited surface water groundwater interaction is expected within Lake Lefroy.

The hydraulic modelling presented in this report supports the conclusion that the differences between dewatering scenarios do not contribute to significant differences in water surface elevation across Lake Lefroy or inundation levels of vegetation along the fringes of Lake Lefroy.

Very large differences in inundated area are apparent between the alternatives assessed in this report; however, the depth differences associated with these are generally relatively small. Most of the differences lie within the flat lake bed area. Along the lake fringe where vegetation is present, the primary differences between scenarios arise from sheet flow that enters the lake rather than ponded water from the lake itself. There is insignificant change in predicted lake water levels based on the B2018 dewatering discharge scenarios.

The north-south causeway culverts are currently blocked. Opening these culverts or introducing new culverts would allow the water surface to balance more closely across the causeway. Some of the water surface elevations become ponded behind the existing and proposed B2018 causeways as indicated by the water surface elevation profiles presented in this report. This can result in substantial differences in water surface elevations contained by the causeways and the larger lake surface area. The introduction of culverts in these causeways will increase the flow connection to the larger lake areas. Further assessment and optimisation may be required to support detailed design of causeway culverts.

Limited information is available on the salt crust present on Lake Lefroy. Due to limited baseline data it is difficult to determine the extent of the impact to the salt crust formation that is related to dewatering discharge. The thickness of the salt crust has been estimated to range from 1-2 cm in areas remote to the discharge locations, increasing to up to 10 cm in areas closer to discharge locations (Clarke 1994). Recent measurements and estimates indicate that thickness of the salt crust has increased to around 50 cm in areas closer to the main north-south causeway, while reducing over time in the northern and southern extremities of the lake (URS 2010, MWH 2017a). The focus of the dewatering impact assessment is mainly on discharge locations and the immediate surrounding areas, which are located closer to the main north-south causeway and edge of Lake Lefroy, resulting in limited salt crust information across the remainder of the playa surface.

The presence of causeways to support the B2018 operations can have impacts on local water surface elevations and salinity, intercepting fresher (lower salinity runoff) from the external catchments. The use of culverts can be considered for the purpose of balancing surface water across the lake and allowing fresher catchment runoff to reach the larger Lake Lefroy surface areas.

Mine dewatering discharge volumes generate most of the salt load on the lake. While the external catchments are important for supplying fresher surface water inflows to the lake and supporting the lake hydrology, the lake salt load is largely generated from the existing hyper saline salt crust and dewatering discharge of hyper saline water.

The B2018 land-based operations are expected to have an insignificant impact on the Lake Lefroy surface water regime. The proposed B2018 land-based operations will impact a catchment area of approximately (230 km²), which is approximately 8.7% of the western extent of the Lake Lefroy extent catchment area (of 2,630 km²), or 5% of the Lake Lefroy total catchment area of approximately 4,350 km². Considering that surface water management measures such as flow diversion will be implemented during operations, most of the runoff volume will still reach Lake Lefroy, albeit with some flow attenuation.

The modelling results presented in this report can be used to inform management decisions in support of the B2018 project.

A summary of potential impacts and recommended management strategies is outlined in **Table E-1**.

Table E-1: Potential impacts and opportunities associated with B2018 project

	Potential impact	Description	Management strategy
1	Dewatering discharge onto Lake Lefroy	Due to the hypersaline character of dewatering discharge to be disposed onto the lake surface, further salt encrustation has the potential to develop on the already salt encrusted playa. A potential rate of approximately 200,000 tonnes per month is estimated to be deposited onto the lake footprint. Due to the large size of the lake this is estimated to raise the encrustation level of the lake by several millimetres over the B2018 lifespan.	Undertake further characterisation program during hypersaline disposal to understand and document the formation of encrusted mound. Continue aquatic life monitoring. Regularly monitor discharge salinity and quality. Consider modelling of spatial encrustation distribution when numerical tools are available. No numerical tools are currently available to model the spatial encrustation distribution with confidence.
2	Dewatering discharge onto Lake Lefroy	Continued dewatering discharge will likely result in an increase in salt crust extent on Lake Lefroy. Limited information is available on the spatial and temporal development of the salt crust extent over time. The focus of the dewatering impact assessment has mainly been on discharge locations and the immediate surrounding areas, which are generally located closer to the main north-south causeway and edge of Lake Lefroy.	Assess the extent of the salt crust on Lake Lefroy. A preliminary desktop assessment of historical aerial imagery was undertaken. No clear trends or correlation between salt coverage and dewatering discharge onto Lake Lefroy were evident. Rainfall and dilution of the salt crust following rainfall events impact the visible salt crust. Further assessment of temporal development of salt crust extent based on historical aerial imagery could be considered.

	Potential impact	Description	Management strategy
			Several new mapping techniques (involving aerial imaging) may be available to assess the surface extent and depth of salt loads on the lake. The application of these techniques to the Lake Lefroy environment should be assessed. The results of salt mapping and subsequent salt modelling (if deemed appropriate) may be used to gain a better understanding of the associated risk to aquatic biota and riparian vegetation. This may need to be undertaken on an annual basis. Expand monitoring area to be more representative of the wider playa surface extent.
3	Causeways and haul roads impact lake balancing capacity	A number of additional causeways and haul roads are proposed on Lake Lefroy to provide access to operational areas. These causeways / haul roads will isolate parts of the playa surface and impact balancing capacity within the isolated areas and the lake, resulting in both elevated water levels and elevated salt loads in places.	Consider inclusion of culverts in the various causeways and haul roads to improve balancing capacity. Consider different disposal strategies, water management controls and location of dewatering discharge points.
4	Land-based operations	Land-based operations have the potential to impact surface water regimes where mining pits and operational infrastructure intersect or impact flow paths and drainage lines discharging surface water flows to Lake Lefroy.	Develop surface water management measures for implementation during operations to minimise impacts on landforms, hydrological regime and receiving environment, including Lake Lefroy. Where possible, locate operational areas away from key drainage lines.
5	Dewatering discharge onto Lake Lefroy	Ongoing discharge of hypersaline water have the potential to result in further salt encrustation, impacting bathymetry of the playa surface. Accurate lake bathymetry data will improve confidence in future surface water modelling efforts and be useful to understand nature and location of lake bathymetry changes over time.	Consider annual aerial surveys of the playa surface.

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1. Introduction

1.1 Background

St Ives Gold Mining Company Pty Limited (SIGMC) currently operates the St Ives Gold Mine (St Ives) at Lake Lefroy, located approximately 20 kilometres (km) south-east of Kambalda (Figure 1-1). The St Ives Project involves both open cut and underground gold mining activities on the lake-surface and adjacent land.

In 2009, SIGMC referred the Beyond 2010 project to the Environmental Protection Authority (EPA), which involved an increase of the mining area by 440 hectares (ha) to a total of 1,713 ha of disturbance, and an increase in discharge from 20 gigalitres (GL) to 30 GL of dewater into Lake Lefroy. To date there have been two modifications under section 45C of the Environmental Protection Act (EP Act) to the proposal approved under Ministerial Statement 879 (MS 879). The first change was for an increase of 348 ha to develop the Invincible Mine, resulting in a total disturbance area of 2,061 ha, with this change approved in March 2014. The second change – referred to as the Beyond 2016 Project – included an increase to the proposal Development Envelope, realignment of the layout of the approved disturbance area (with no increase in disturbance clearing), and additional dewatering points. This change was approved in December 2016.

SIGMC requires an additional expansion of the current area of disturbance approved under MS 879; which covers the current lake-based mining operations only. The revised proposal is for development of new lake-based and land-based gold mining areas for a ten year period (i.e. 2019 – 2028), referred to as the Beyond 2018 (B2018) Project.

The B2018 Project was referred to EPA pursuant to Section 38 of EP Act on 15 December 2016. On 15 February 2017, the EPA set the level of the assessment to "Environmental Review – 6 week public review". On 5 July 2017, SIGMC provided its complete application for a Change to Proposal via section 43A of the EP Act. The proposed change was an alteration of the Development Envelope (with no increased impacts), and for an increase in dewatering discharge from 30 gigalitres per annum (GL/a) to 40 GL/a. The EPA approved the section 43A Change to Proposal on 21 July 2017. It should be noted that only indicative footprints and locations of potential lake-based and land-based developments were available for consideration in this assessment. On 6 October 2017, EPA released the final Environmental Scoping Document (ESD) for the Project which outlined the range of studies expected to be completed by the EPA.

SIGMC commissioned Stantec to undertake surface water numerical modelling to support the Beyond 2018 Environmental Review Document (ERD) submission and to assess the various groundwater and surface water management impacts from the Beyond 2018 Project. In addition, requirements set in the ESD to support the Beyond 2018 Environmental Review Document (ERD) submission were addressed where possible.

1.2 Report scope and objectives

The objectives of the surface water assessment are to:

- simulate the potential impact to the Lake Lefroy riparian vegetation due to the proposed B2018 dewatering discharge by comparing water levels and vegetation inundation depths; and
- undertake a qualitative assessment of potential long-term salinity impacts due to ongoing dewatering discharge to the lake.

A staged approach has been implemented to develop a hydraulic model to enable an impact assessment of future mining campaigns.

The surface water assessment is undertaken in accordance with the relevant guidance documentation listed in the St Ives Gold Mine – Beyond 2018 Project Environmental Scoping Document (October 2017), including:

- Environmental Factor Guideline – Hydrological Processes (EPA 2016);
- Department of Water and Department of Environment and Conservation - Wetland, Waterways and Estuary Agreement (June, 2008);
- Operational policy No. 1.02 - Policy on water conservation/efficiency plans (Department of Water, 2009);
- Western Australian water in mining guidelines (Department of Water, 2013);
- WA Environmental Offsets Guidelines (Government of Western Australia, 2014).
- Supporting policies and guidelines from Department of Water, Department of Environment and Conservation.

This report should be read in conjunction with the "Beyond 2018 ERD: Hydrogeological Assessment" (Stantec, 2017).

Findings presented in this report, including water surface levels, confidence levels, and contingencies, are intended only for the purpose of comparing potential impacts associated with B2018 scenarios.

1.3 Methodology and data sources

The hydrology assessments presented are based on the following existing reports data provided by SIGMC, Talis Consultants (Talis) and additional information sources. A number of additional reports were available, however, only the reports most relevant to the surface water aspects are listed below.

Reports:

- Beyond 2018 PER: Hydrogeological Assessment (Stantec, 2017 – being developed in conjunction with this surface water report)
- Annual Environmental Program, Lake Lefroy, 2016 (MWH 2017a)
- Closure of Lake-Based Dewatering Discharge Outfalls: Desktop assessment (MWH 2016)
- St Ives Gold Mine 2016 Mine Closure Plan (MWH 2016)
- St Ives Surface Water Assessment for Min Closure (MWH 2016)
- Lake Modelling Verification (Palaris 2014)
- Invincible Mine Change Assessment on Lake Lefroy Hydrology (URS, 2013)
- Lake Lefroy Surface Water Impact Study (URS, 2010)
- Extension of Lake Lefroy Hydrological Program (CSIRO, 2003)
- The Hydrology of Lake Lefroy (CSIRO 2001).

Design rainfall information:

- Bureau of Meteorology (BOM) Intensity Frequency Duration (IFD) data: http://www.bom.gov.au/water/designRainfalls/ifd/, accessed November 2016.

Geospatial data:

- digital elevation model (DEM) "StIves_2m.img" provided by SIGMC, based on LiDAR data surveyed in 2016
- high-resolution aerial photography for Lake Lefroy: "StIves_RGB.ecw"

- B2018 development footprint - “Proposed_Disturbance_Areas_B2018_AMENDED_20161102.shp”
- riparian vegetation layer - Base_VegMapping_0a.shp”
- B2018 potential culvert locations – “culvert_locations.pdf”.

The following software applications were used in the development and presentation of hydrological and hydraulic models in this assessment:

- TUFLOW Build 2016-01-AC-iDP-w64
- WaterRide Version 7.00 2015-05-01
- ArcGIS Spatial Analyst and 3D Analyst V10.4

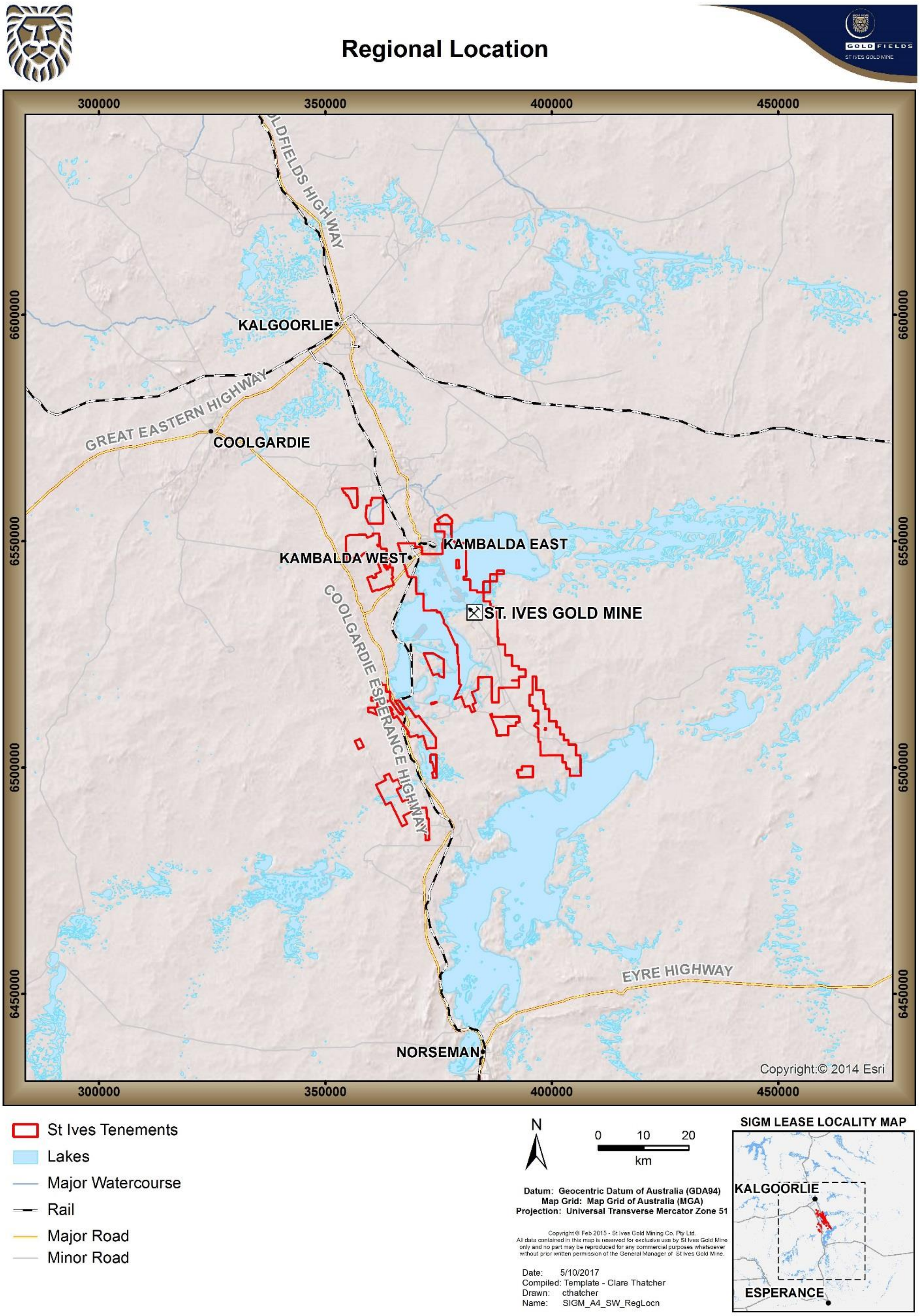

Figure 1-1: Regional location

1.4 Previous modelling

A number of modelling projects have previously been undertaken for Lake Lefroy or individual landforms or operations. Some of these were locally focussed and would therefore not reflect potential interaction between different operations and Lake Lefroy. These projects have been driven by the purpose for which they were developed.

Examples of other modelling tools, previously developed for SIGMC operations include:

- URS (2010) developed a Mike 21 two-dimensional (2D) hydraulic model of Lake Lefroy based on terrain data developed from survey data. Catchment rainfall-runoff excess was modelled using XP RAFTS rainfall-runoff model in order to simulate hydrographs as input to the hydraulic model. The hydraulic model was developed for Lake Lefroy and the immediate surrounds only. Modelling focussed on the 1:20 year 72 hour and 1:100 year 72 hour duration design rainfall events and the potential impacts of the Beyond 2010 dewatering discharge on Lake Lefroy water levels and inundation of fringe vegetation communities.

  B2010 key outcomes related to impacts to the fringe vegetation communities include:

  - Under baseline 100 year conditions 177 surveyed riparian vegetation locations were inundated (all located in the southern half of the lake);
  - The number of surveyed locations remained the same for the B2010 scenarios, with some marginal increases in flood depths at the fringe of the lake;
  - The hydroperiod could increase as a result of the B2010 scenarios, however, the increase in hydroperiod was unlikely to impact on the riparian zone when compared to baseline conditions as the riparian zone would be significantly impacted in baseline conditions.

- URS (2013) updated the hydraulic model of Lake Lefroy with higher resolution topographic data, changed from the Mike 21 (2010 model) to TUFLOW and verified the model using the Cyclone Vance (1999) event. The model was updated to rain-on-grid to model the regional catchment and estimate inflows to Lake Lefroy (local model). Modelling focussed on the 1:20 year 72 hour and 1:100 year 72 hour duration design rainfall events and the potential impacts of the Invincible Mine dewatering discharge on Lake Lefroy water levels and inundation of fringe vegetation communities.

  Key outcomes related to impacts to the fringe vegetation communities include:

  - There was insignificant difference in predicted water levels with the addition of the Invincible project compared to B2010 levels;
  - The 2013 study confirmed the results of the B2010 study;
  - Dewatering discharge was not expected to significantly change the salinity and salt crust built up of Lake Lefroy compared to the B2010 model results.

- MWH (2016a) undertook surface water assessments for six precincts in support of the mine closure plan. The focus was on surface water management at closure, with conceptual surface water management measures developed. Five of the precincts modelled are land-based, with the Mars Open Pit the only lake-based precinct considered. Land-based precincts included:

  - Cave Rocks waste rock landform and pit;
  - Junction waste rock landform and pit;
  - Leviathan waste rock landform and pit;
  - Tailings storage facility (TSF) 4;
  - TSF 1-3.

2. Existing Environment

2.1 Biogeographical context

The Project tenements are predominantly located in the Eastern Goldfields subregion (COO 3), within the Coolgardie bioregion, in WA (**Figure 2-1**), as defined by the Interim Biogeographical Regionalisation for Australia (IBRA) classification system (Thackway and Cresswall 1995). The subregion lies within the Yilgarn Craton, a granite basement characterised by Archaean Greenstone intrusions in parallel belts. The relief is subdued and comprises of gently undulating plains interrupted in the west with low hills and ridges of Archaean greenstones and in the east by a horst of Proterozoic basic granulite. Basement rocks have been eroded into a flat plane covered with recent sediments leaving remnant outcrops of bedrock (MWH 2016b).

Lake Lefroy lies within the Kalgoorlie Botanical Province, correlating with the majority of the Coolgardie botanical district (Beard 1990) and Coolgardie bioregion (Thackway and Cresswall 1995). The Eastern Goldfields subregion is a transitional vegetation zone where mulga and spinifex country is beginning to be replaced by eucalypt woodland (Bastin and ACRIS Management Committee 2008). The broad vegetation type comprises Mallee, Acacia thicket and shrubheath on sandplain, with a diverse Eucalyptus woodland around salt lakes, on ranges, and in valleys (Cowan 2001). The area is also rich in endemic Acacia species. Dwarf samphire shrubland (Tecticornia) dominates the fringing vegetation of salt lake systems. Flora and fauna records from the subregion list more than 30 threatened mammal, bird and plant species (Cowan 2001), at risk in part by the proliferation of feral and introduced animals including goats, foxes, rabbits, camels, cats and dogs.

2.2 Land use

The Eastern Goldfields subregion totals 5,055,624 ha, with approximately 11.4% freehold (576,435 ha) and 88.4% Crown land. The primary land uses comprise Unallocated Crown Land (UCL) (42.1%, 2,128,895 ha), other Crown Reserves (4.8%, 243,186 ha), Conservation and Natural Environments (62.5% 3,159,828 ha), Production from Native Environments (37.4%, 1,893,206 ha), and Production from Dryland Agriculture and Plantations (0.04%, 1,899 ha) (IBRA, 2016). Note the values for these 'land uses' do not add up as some of the categories overlap, for example some areas that are classified as UCL are also classified as Conservation and Natural Environments.

An overview of the land use surrounding the Project is presented in **Figure 2-2**. Past and present land use in the vicinity of the Project is summarised as follows:

- extensive gold and nickel prospecting, exploration and mining activities since 1897;
- salt mining was conducted at the southern end of Lake Lefroy near Widgiemooltha during the 1940s, and Lake Lefroy Salt Mining Pty Ltd harvested salt from evaporation ponds at the northern end of the Lefroy Peninsula between 1968 and 1982;
- sand mining was conducted periodically at the northern end of the Lake Lefroy Peninsula;
- pastoral land is located throughout the region and is the main land use other than mining in the vicinity, with the Project located within or adjacent to the Woolibar, Madoonia Downs and Mt Monger Pastoral Stations (**Figure 2-2**). Sheep grazing is also noted to occur in UCL and other Crown Reserves in the area;
- Conservation, comprising the following:
    - C Class Kambalda Timber Reserve. The Caves Rocks development lies within this reserve; and
    - C Class Kambalda Nature Reserve. The Caves Haul Road lies within this reserve.
- Recreational activities are associated with the lake, including wildlife photography, camping, walking and hiking, motorbike riding, and land yacht sailing.

Figure 2-1: Location of the Project within the within the Coolgardie bioregion and Eastern Goldfields subregion

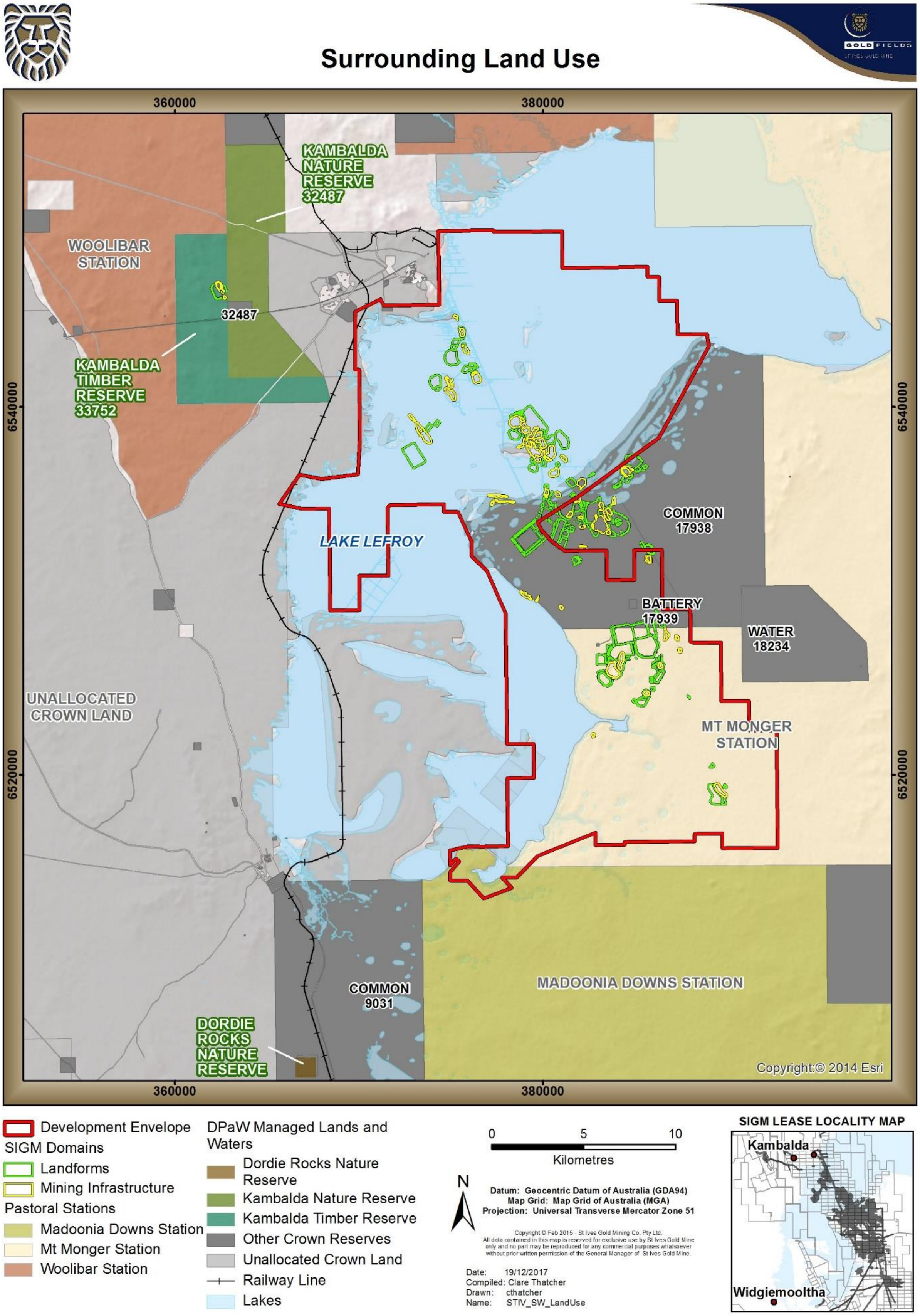

Figure 2-2: Land use surrounding the Project

2.3 Climate

The climate of the Lake Lefroy and surrounding area is classified as semi-arid to arid warm Mediterranean, characterised by hot, dry summers and cool winters and 250 to 300 millimetres (mm) of rainfall per annum. The Project is located approximately 60 km south of Kalgoorlie, near the towns of Kambalda East and Kambalda West. Climate data used for this report was based on climate statistics from the Bureau of Meteorology (BOM) station at Kalgoorlie – Boulder Airport (station 12038) (BOM 2016a), located approximately 60 km north of the project area. Weather data is available at this station from 1939 to present.

Annual rainfall at Kalgoorlie-Boulder airport is shown in **Figure 2-4**. Regional rainfall is highly variable with a large degree of intra-annual (within-year) and inter-annual variation. Mean annual rainfall is around 268 mm per annum, with minimum and maximum annual rainfall of 109 mm (1940) and 526 mm (1992), respectively. Mean monthly rainfall ranges from 14 mm (September) to 30 mm (February) (**Figure 2-5**). The area has an average of 64 wet days per year and most of the rain falls between March and August, during the passage of cold fronts. Summer rainfall occurs periodically as a result of tropical cyclones or thunderstorm activity.

During the summer months the winds are predominantly from the east in the mornings tending southwest in the afternoon. During the winter months the wind direction is from the northeast in the morning tending mildly west in the afternoon. The morning wind speed ranges from 12 km per hour (km/hr) in June to 17 km/hr in November. The afternoon wind speed ranges from 14 km/hr in April / May to 18 km/hr in September (BOM 2016a). **Figure 2-3** shows the Kalgoorlie-Boulder Airport wind rose, based on a record period 1939 to date.

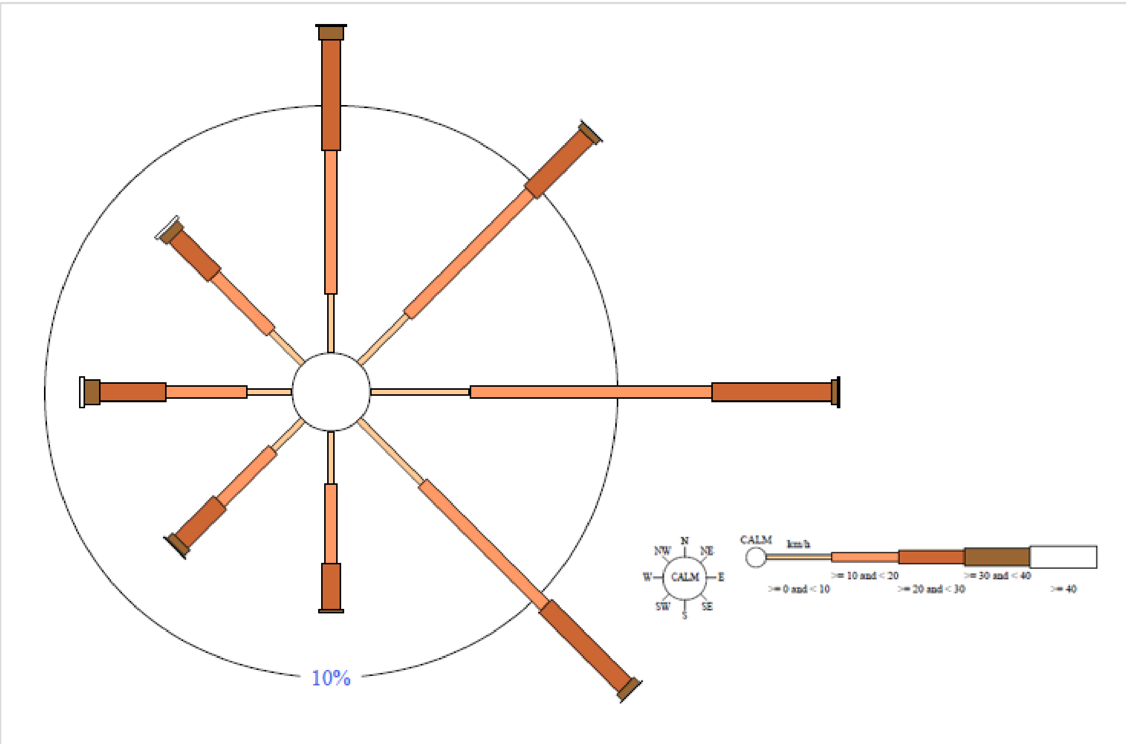

Figure 2-3: Kalgoorlie-Boulder Airport wind rose

In March 1999 ex-cyclones Elaine and Vance deposited significant rainfall in the region (197 mm of rainfall was recorded during March 1999 at Kalgoorlie-Boulder Airport). A secondary peak occurs in June, which is generally associated with the passage of cold fronts.

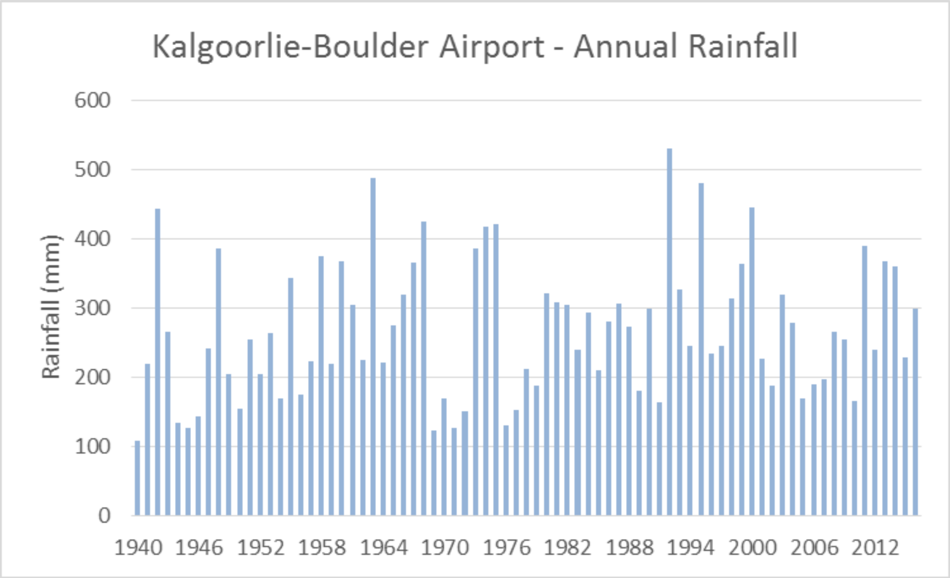

Figure 2-4: Kalgoorlie-Boulder Airport annual rainfall

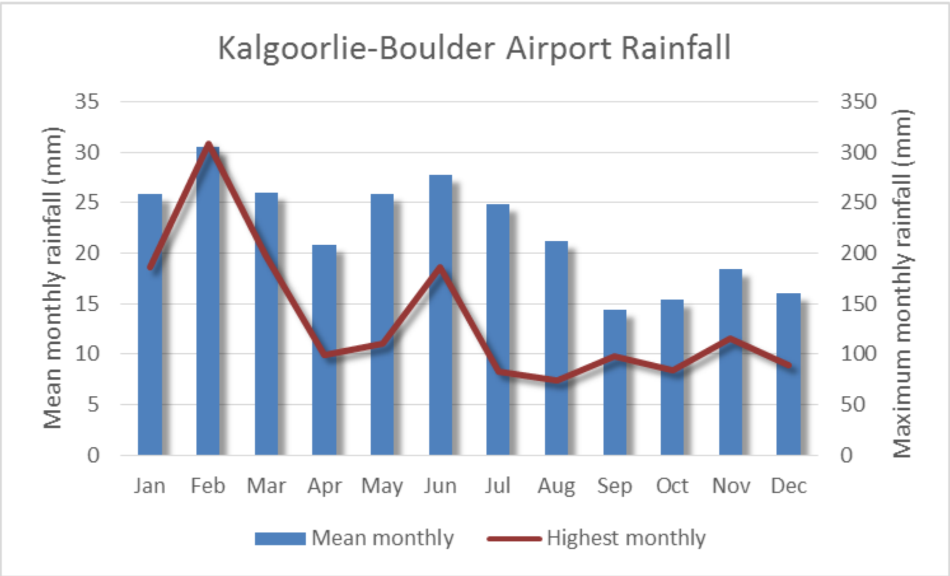

Figure 2-5: Kalgoorlie-Boulder Airport monthly rainfall

Based on climate statistics from the Kalgoorlie-Boulder airport BoM weather station (station 12038), mean maximum temperatures in the summer months from December to February exceed 32°C. The winter season occurs from June to August with mean daily maximum and minimum temperatures of approximately 17°C and 6°C, respectively (**Figure 2-6**).

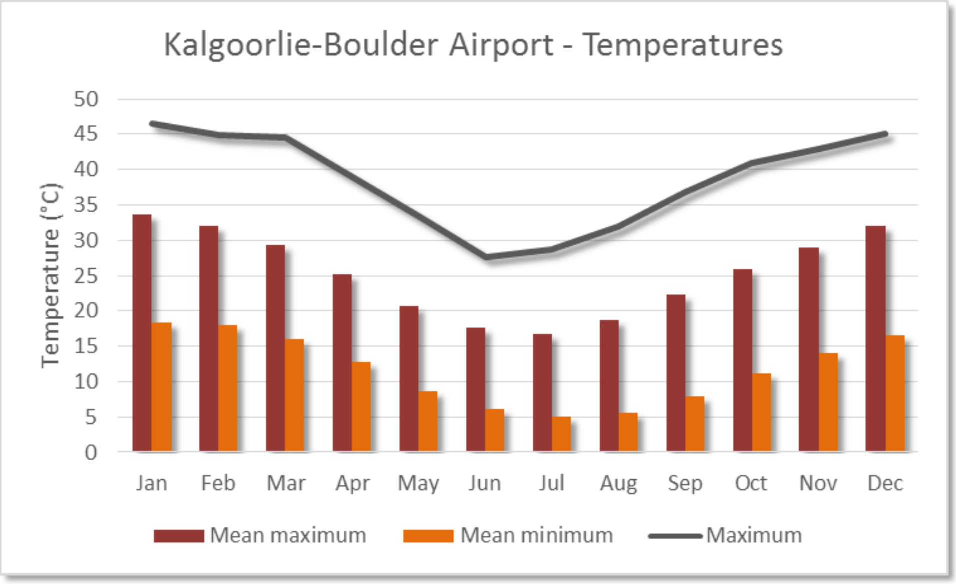

Figure 2-6: Kalgoorlie-Boulder Airport temperatures

Average annual pan evaporation (based on Kalgoorlie-Boulder Airport evaporation data) is 2,640 mm/year, which is an order of magnitude higher than the average annual rainfall. Mean monthly evaporation ranges from 78 mm in June to 388 mm in January (**Figure 2-7**). Evaporation is greatest during the summer months of January and February and lowest during the winter months of June and July.

Potential evaporation on the playa of Lake Lefroy is approximately 1,350 mm per year. The evaporation rate varies with the salinity and size of the lake (URS 2010).

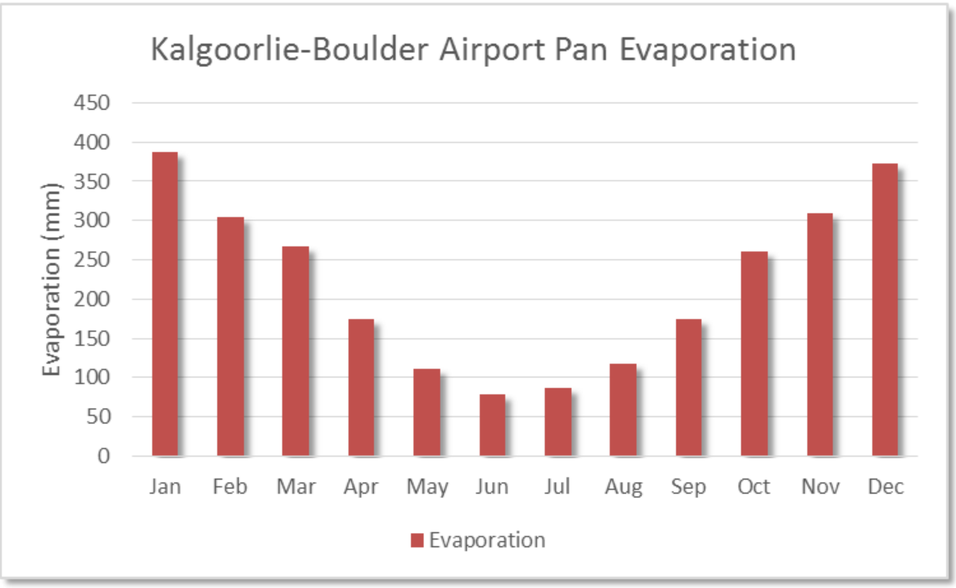

Figure 2-7: Kalgoorlie-Boulder pan evaporation

2.4 Topography and drainage

Lake Lefroy is a playa lake which has developed within the Roe paleodrainage system and is located within the Lake Lefroy catchment (**Figure 2-8**), which is approximately 3,950 km^2 in size (Clarke 1991). Lake Lefroy is the main surface water body and receptor in the catchment and covers an estimated area of 544 km^2.

The regional topography is low to gently undulating, with plains rising from around 286 m AHD at Lake Lefroy to in excess of 410 mAHD at the catchment divide surrounding the lake. The surrounding catchments drain via ephemeral gullies and drainage lines, trending towards Lake Lefroy. Channels are generally poorly defined, with runoff largely occurring as sheet flow. Surface runoff is only generated in response to significant rainfall. Rainfall typically generates minimal lake surface flows, with runoff tending to infiltrate terrestrial soils, prior to entering the playa (MWH 2016a, Handley 1991). The high infiltration capacity of the lake sediments, coupled with high evaporation rates, also generally contributes to the limited residency time of surface waters (URS 2010).

Catchments and sub-catchments draining towards Lake Lefroy were delineated using GIS software (ARC-Hydro) and a 1-arc-second (approximately 30-m) digital elevation model (DEM) (Geoscience Australia 2011). Catchment areas range from less than 10 km^2 (local catchments) to in excess of 1,700 km^2 (regional catchments draining areas to the west and south-west of Lake Lefroy) (**Figure 2-9**).

The lake appears to be a system in transition between an ephemeral lake and a salt pan, with increased build-up of salts occurring via natural processes (Clarke 1994), as well as dewatering discharge. While the surface of Lake Lefroy varies in bathymetry over a large area, the playa is generally of low relief, at approximately 286 m above sea level. There are two shallow-water accumulation areas in the northeast and central southern areas. The northern half of the lake has slightly higher elevations than the southern half.

Given the long history of mining at the site, pre-mining baseline information related to the lake bathymetry is not available. The most recent aerial survey and lake bathymetry was therefore assumed as a starting condition for B2018 impact assessment discussed in this report.

2.5 Surface water groundwater interaction

Lake Lefroy is assumed to overlay a clayey lacustrine mixture of sediments, highly heterogeneous in its properties. Due to its clayey nature and the presence of precipitated salt crust, the interaction between groundwater and occasionally available surface water in the lake is limited, driven by low permeability of this layer (Stantec 2017).

Groundwater recharge mechanisms vary from direct rainfall infiltration to enhanced creek (or drainage) line infiltration. Regional values of recharge rates typical for this region do not exceed more than 1 to 3% of annual rainfall. Presence of clays in the saprolite-weathering zone in area where Archaean basement is close to the surface may locally prevent or delay infiltration of rainfall to the underlying fractured bedrock (Stantec 2017).

Based on the above limited surface water groundwater interaction is expected within Lake Lefroy. The surface water modelling therefore assumed no surface water groundwater interaction.

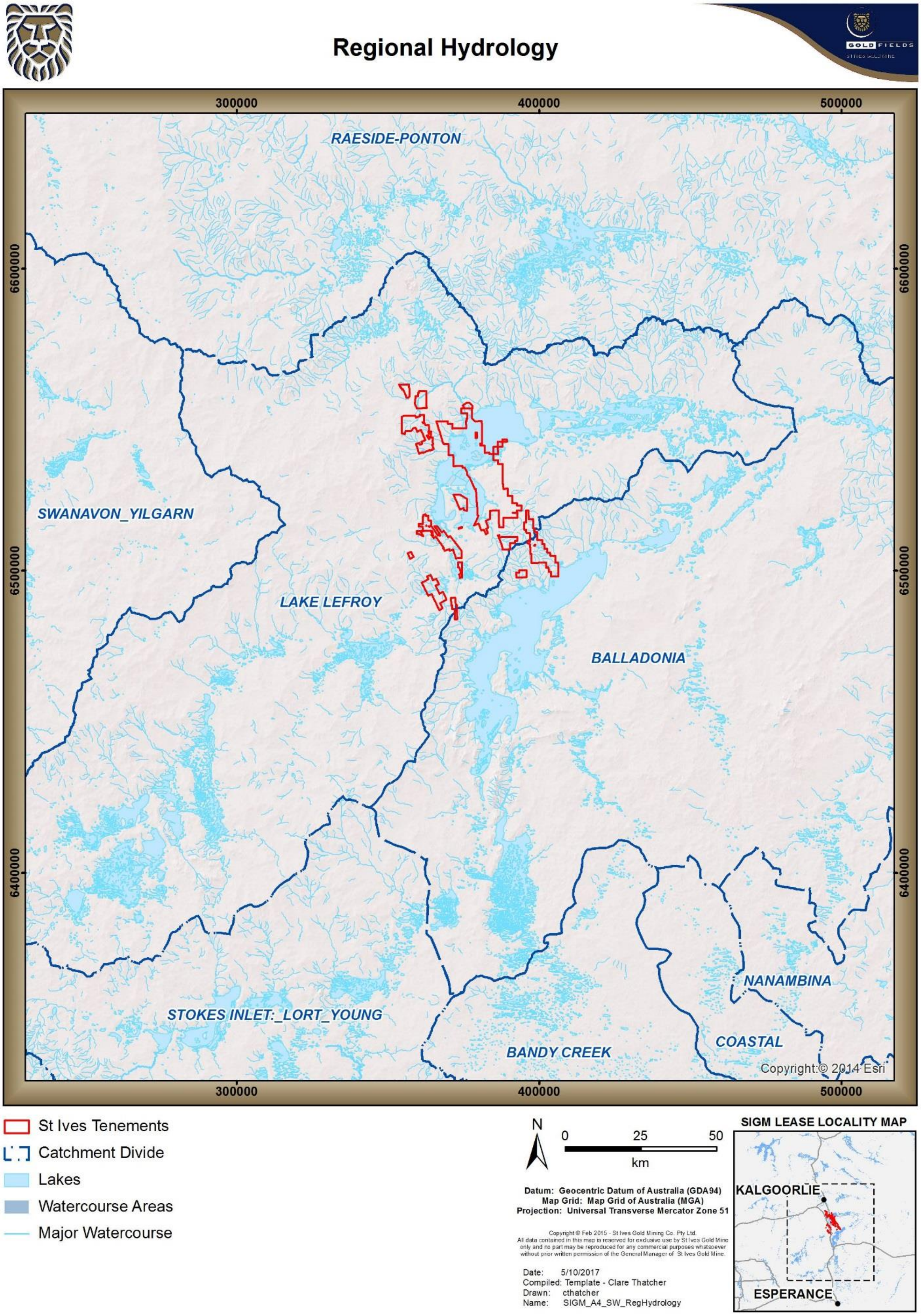

Figure 2-8: Lake Lefroy regional hydrology

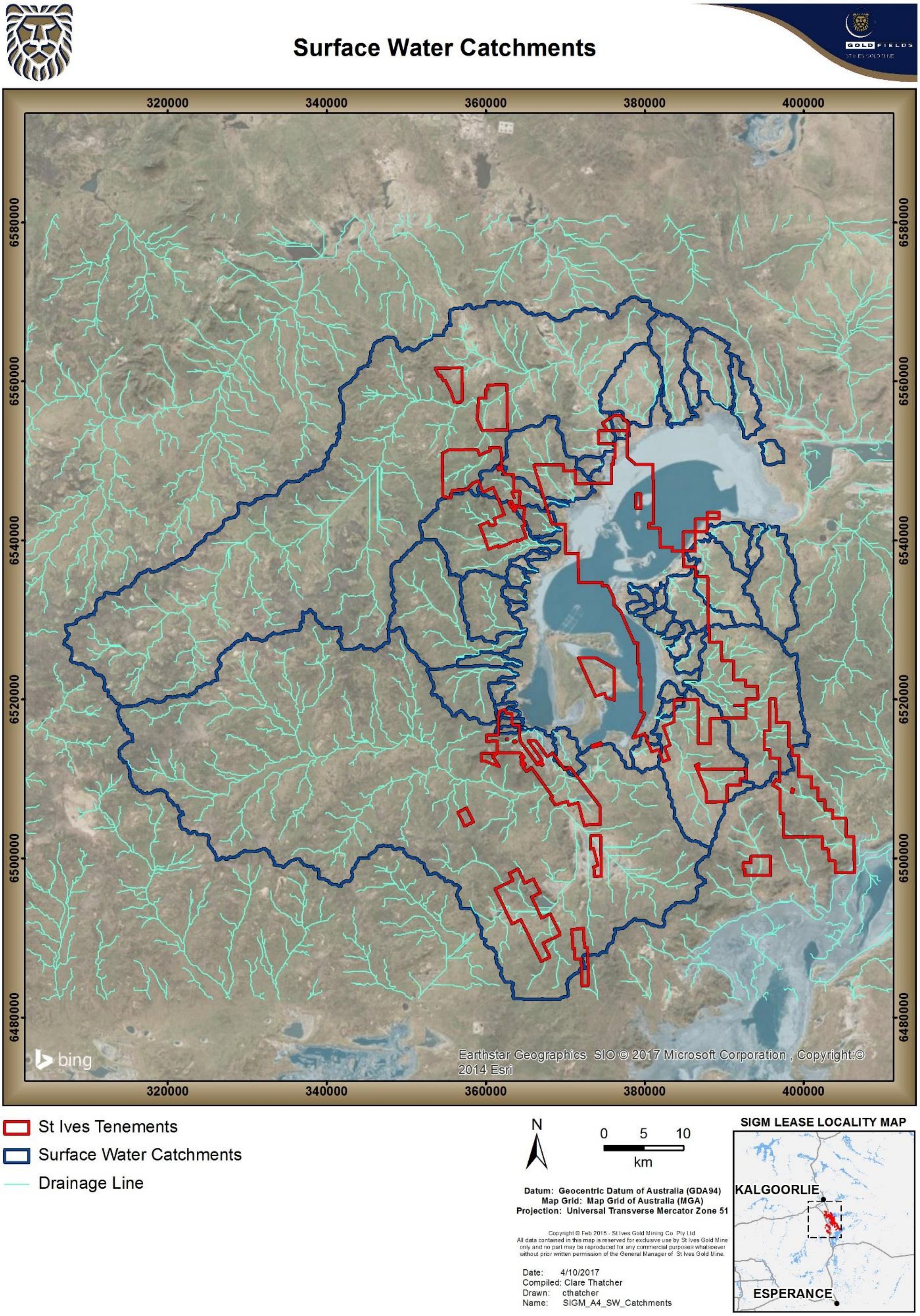

Figure 2-9: Lake Lefroy local catchments

While rare, Lake Lefroy is subject to major flood events, and due to its large size, the playa can accommodate major inflows, often attributed to ex-tropical cyclones causing heavy rainfall during summer (**Figure 2-10**). Note that although the colours in the **Figure 2-10** are quite different, the picture on the right shows a significant portion of Lake Lefroy flooded following major surface water inflows. In these instances, flooding occurs rapidly, and surface waters may remain in the lake for long periods (CSIRO Land and Water 2003). This was demonstrated after ex-tropical cyclones Vance in March 1999 and Steve in February and March 2000, which led to the persistence of surface waters in the lake for approximately nine months (MWH 2016). The last significant flooding of Lake Lefroy occurred in 2014, following more than 150 mm of rain, received over a three day period in late January (BoM 2015), as a result of local isolated storm activity.

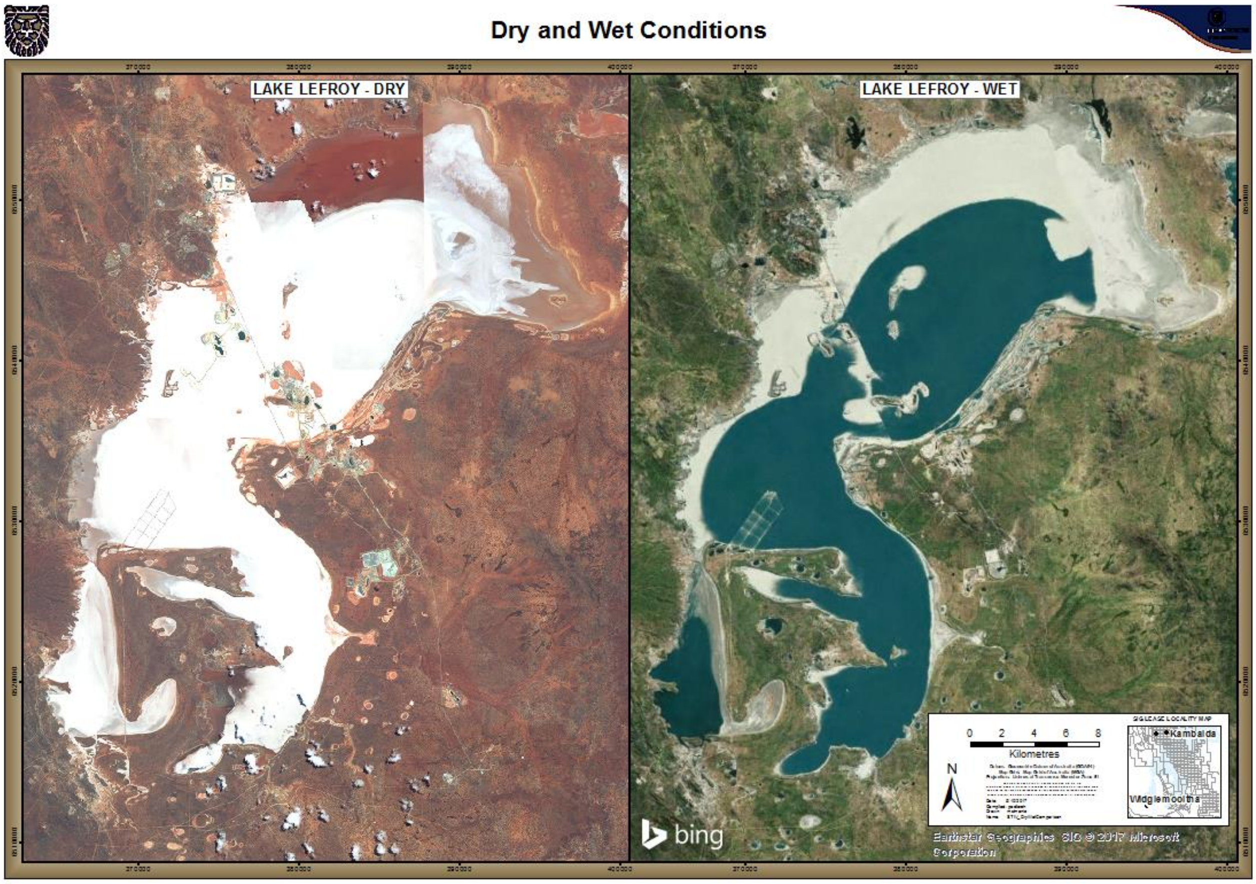

Figure 2-10: Dry and wet conditions in Lake Lefroy

2.6 Salinity

Surface waters on the lake are generally hyper saline unless the lake has been recently inundated by surface runoff (URS 2010, CSIRO 2001). Water discharged from the mining operations is also hyper saline. The occurrence of freshwater in the landscape is highly infrequent, with the salinity of surface water on the lake ranging from 260,000 to 435,000 milligrams per litre (mg/L) (TDS) (URS 2010). It is also unlikely that large freshwater influxes, due to tropical low pressure systems, would significantly reduce the salinity of surface water on Lake Lefroy, due to the thick salt crust on the playa surface. The lake does not appear to support a low salinity phase, even after large influxes of freshwater (Phoenix Environmental Sciences 2014). This is largely attributed to the presence of an extensive salt crust, which covers a significant portion of the lake. The salt crust is estimated to be up to 60cm thick in places closer to the main causeway (MWH 2017a), and propagating to the east and west of the causeway on an increasingly lower gradient. The high salinity of the lake also promotes settling of sediments mantled with salts, hardening to form a halite crust (URS 2013), which tends to be thicker closer to the discharge sites (MWH 2017a).

While the bathymetry of the lake is generally flat, there are two shallow water accumulation areas in the northeast and central southerly areas of the lake. The lake dries to a salt pan annually, while confined areas may maintain some surface water pools. Inundation of the lake has occurred through direct rainfall on the lake surface and from external flow from the surrounding catchment. Rainfall events of greater than 30 mm in total, with an average greater than 5 mm per day, are likely to produce partial to complete inundation of Lake Lefroy, with two events of at least such magnitude likely to occur each year (URS 2010).

Lake Lefroy is bisected by a north-south running causeway. The causeway contains thirty 900mm pipe culverts to provide east-to-west flow connection. The pipe culverts are mostly blocked due to salt accumulation, effectively dividing the lake into two sections. Monitoring of flow through the culverts (CSIRO 2003) indicated that there was no significant drainage of the lake from one side of the causeway to the other after significant rainfall events.

2.7 Water quality

MWH (2017) completed the annual program of environmental monitoring to ensure compliance with regulatory conditions. The conditions were primarily established to assess impacts associated with dewatering discharge from the St Ives Gold Mine (SIGM) to the receiving environment of Lake Lefroy. The annual program covers the reporting period from 1st January to 31st December 2016 (2016 reporting period) and summarises the results of the annual program, for inclusion into the EPA's Compliance Assessment Report (CAR) and the Department of Water and Environment Regulation (DWER), formerly known as DER, Annual Environmental Report (AER).

During the October 2016 annual program, at aquatic sites where surface water was present, basic water quality parameters were measured to record pH, salinity, electrical conductivity, temperature and redox. Samples were collected for the analysis of dissolved metals and trace, as well as a range of total petroleum hydrocarbons, total recoverable hydrocarbons and BTEXN2 components/surrogates.

Sediment samples were collected at each of the 17 aquatic sites sampled during the October 2016 annual program (MWH 2017a), with sediments taken from the top 2 cm of lake sediment and analysed for a range of total petroleum hydrocarbons, total recoverable hydrocarbons and BTEXN3 components/surrogates. Key water quality and sediment quality findings included:

- Surface water quality during the October 2016 annual program was generally circumneutral and hypersaline.
- Salinity concentrations were well below the SIGMC upper reference range, with a maximum of 255,000 mg/L, dominated by sodium and chloride ions; however, salinity had increased in comparison to 2015.
- Concentrations of total nitrogen and total phosphorus were variable in surface water, with the maxima of both nutrients recorded at the discharge sites. However, while nitrogen was elevated, concentrations were lower than 2015, in contrast to total phosphorus, which had increased. High nitrogen levels are often a feature of salt lakes in the Goldfields subject to dewatering discharge, while changes in phosphorus dynamics can be attributed to microbial activity over the course of the hydroperiod.
- The majority of metals in surface water were below analytical detection levels. However, copper, lead and zinc substantially exceeded their upper reference ranges and / or ANZECC & ARMCANZ (Australian and New Zealand Guidelines for Fresh and Marine Water Quality) trigger values at more than half of the discharge sites. In particular, zinc was more than 130 times higher than the corresponding ANZECC & ARMCANZ trigger value. These results are consistent with past trends, with elevated concentrations of some metals considered a characteristic of the dewatering discharge.

- Sediment quality during the October 2016 annual program indicated that the pH ranged from strongly acidic to moderately alkaline throughout the lake.
- Nutrients typically displayed a similar range across the discharge and reference sites, with total nitrogen concentrations exceeding total phosphorus concentrations.
- However, salinity was found to be significantly higher in the sediment of the discharge sites, in comparison to the reference sites, with the salt crust being thicker in the central parts of the lake, and appearing to migrate further towards the outer periphery in 2016.
- Metal concentrations in the sediment were generally no more than twice the SIGMC upper "high' reference ranges or the ANZECC & ARMCANZ ISQG-High triggers, with the exception of copper, which was more than three times the SIGMC upper "high" reference ranges; however, remained below the ANZECC & ARMCANZ ISQG-High trigger. This was a similar trend to 2015; however, cobalt and manganese have regularly exceeded the SIGMC upper "high" reference ranges at discharge sites, prior to 2015, related to the influence of the dewatering discharge.

3. Hydraulic assessment

Proposed lake-based and land-based mining developments have the potential to impact the surface water regime of Lake Lefroy. A key objective of the surface water assessment is to assess the potential impact of the proposed B2018 development and dewatering discharge to the Lake Lefroy surface water elevations and riparian vegetation. It should be noted that only indicative footprints and locations of potential lake-based and land-based developments were available for consideration in this assessment; the detail will be finalised with development of individual operations.

A hydraulic modelling approach has been used to characterise the lake hydrology and assess potential impacts. This chapter describes the modelling approach and input parameters used in the hydraulic model.

3.1 Model approach

Previous hydraulic models developed by URS in 2010 and 2013 were compiled, and selected runs were tested to confirm prior results with updated versions of the 2-dimensional TUFLOW model (WBM 2016). The previous models were used as a basis for developing new models of the Lake Lefroy catchment.

An updated regional model was developed to apply direct precipitation over the entire Lake Lefroy catchment using a "rain-on-grid" approach. The resulting flow hydrographs were extracted at selected, concentrated inflow locations to the lake. In order to reduce excessive computational times, a smaller, internal model of Lake Lefroy was then developed using the results of the rain-on-grid model as time-varying inflow hydrographs.

Figure 2-9 shows the external catchments draining to Lake Lefroy. These catchments formed the basis of the regional rain-on-grid hydraulic model.

3.2 Model inputs

3.2.1 Terrain data and model domain

The underlying terrain for the hydraulic model is based on a 2-metre x 2-metre digital elevation model (DEM) provided by SIGMC under file name "StIves_2m.img", with elevations based on a 2016 LiDAR survey. The regional model domain covers the entire Lake Lefroy catchment while the localised model covers the immediate area around and including Lake Lefroy itself. Pits and landforms were removed from the model domain.

3.2.2 Inflow and outflow

Seasonal precipitation rates were described in the previous chapter. 20-year and 100-year average recurrence interval (ARI) 72-hour duration precipitation events were introduced into the hydraulic model as direct rainfall. **Figure 3-1** shows the 72-hour hyetographs applied to the regional direct rainfall model. 20-year and 100-year ARI rainfall depths of 129 mm and 200 mm, respectively, were used (BOM 2016b).

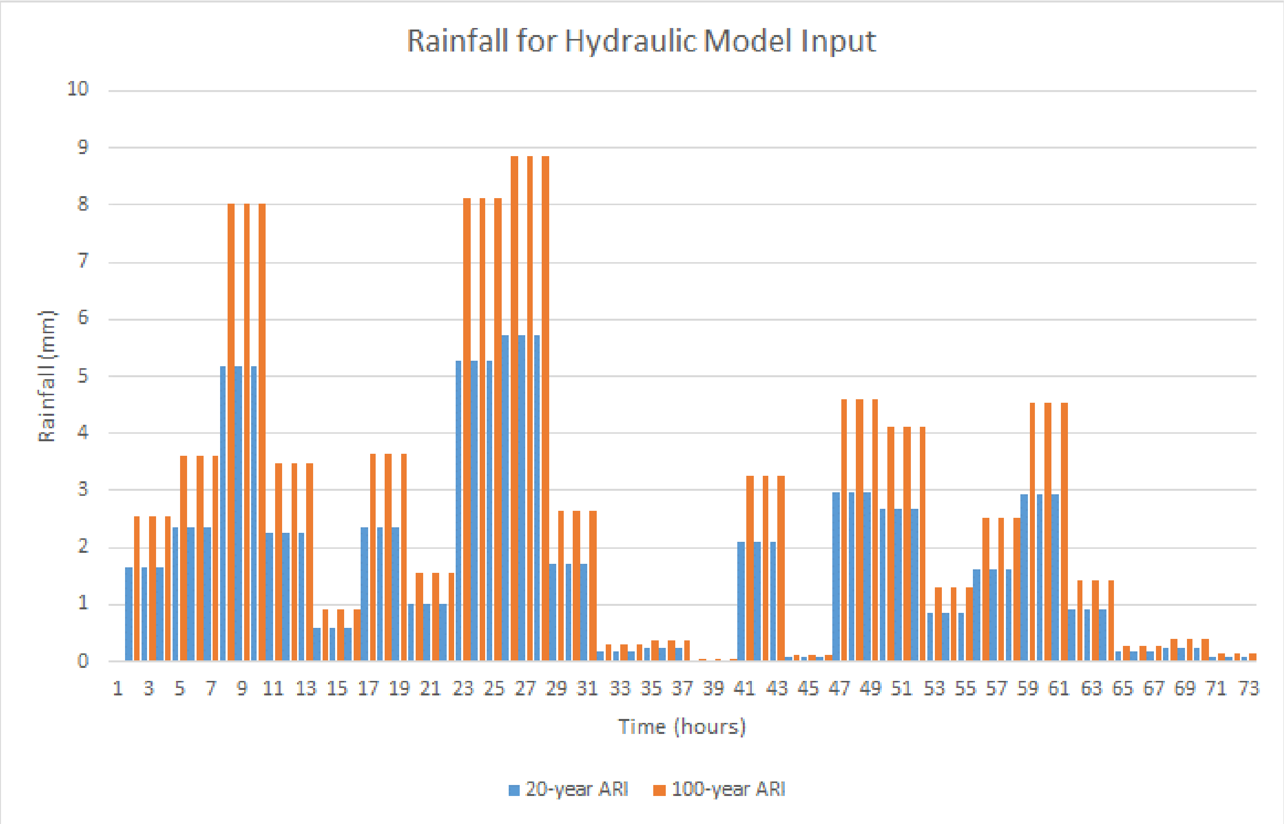

Figure 3-1: Rainfall depths used as input into regional direct rainfall hydraulic model

Time series flow hydrographs were extracted from the regional model at concentrated flow locations using PO lines in TUFLOW. The discharges were entered as time-varying flow hydrograph (QT) boundary conditions for the localised model. **Figure 3-2** shows the inflow locations for the localised Lake Lefroy model. Selected sub-catchment locations corresponding to these inflow points are shown in **Figure 3-2**.

Summer and winter flow hydrographs are shown for the 20-year and 100-year ARI models in **Appendix A**.

3.2.3 Computational grid size

Computational grid sizes ranging from 30 metres to 100 metres were applied as a sensitivity analysis in order to optimise run times against model performance. The 100-metre computational grid size resulted in instabilities and excessive oscillations in the results. Volumetric differences between the 30-metre and 60-metre results were not found to be significant. Because the computational run times for the 30-metre runs were excessive, the final runs adopt a computational grid size of 60 metres. **Figure 3-3** illustrates the grid size sensitivity for 30-metre, 60-metre, and 100-metre grids.

Figure 3-2: Inflow locations for localised model

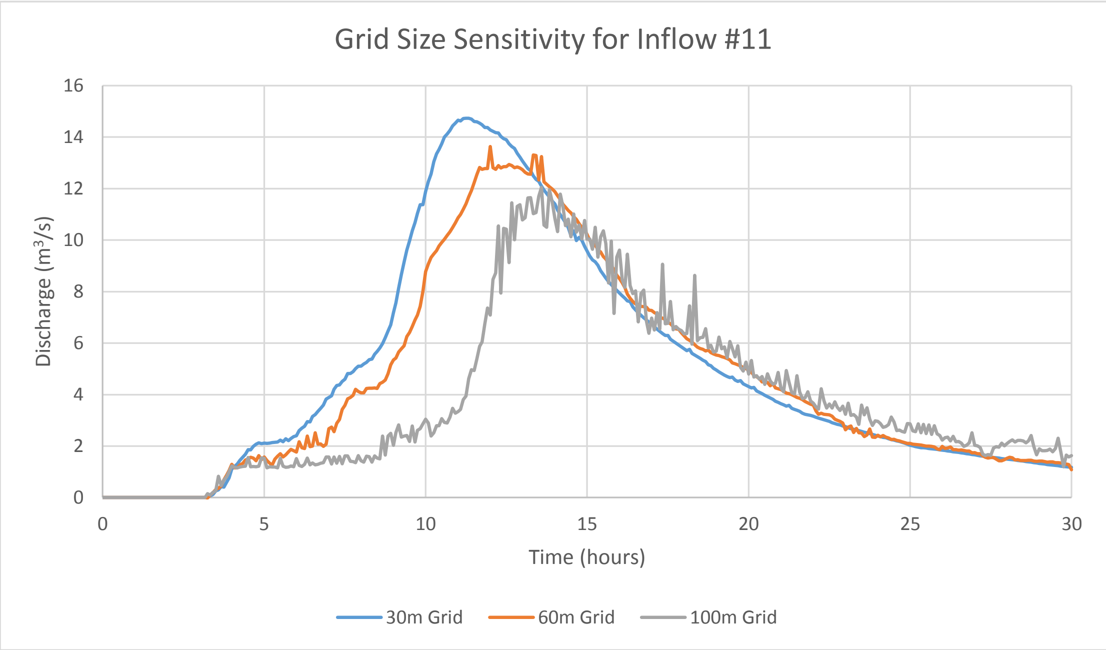

Figure 3-3: Computational grid sensitivity

3.2.4 Time step and duration

The TUFLOW manual (WBM 2016) recommends a computational time step in seconds equal to half the grid size in metres. This criterion complies with recommended Courant Number values in Australian Rainfall and Runoff (ARR) 2016 (Ball et al 2016) 2D modelling guidance for systems with energy velocities less than 2 m/s. The Lake Lefroy system meets these velocity criteria, and a sensitivity analysis confirmed that the results converge with a 30-second time step. For 1-dimensional elements, a time step of half the 2-D time step is recommended; culvert routines in the model thus use a 15-second time step. The total modelled duration is 180 hours for winter runs and 250 hours for selected summer runs.

3.2.5 Manning's roughness and wet-dry coefficients

Aerial and ground photographs of the modelled area show substantial differences in vegetation cover and substrate material between Lake Lefroy and the surrounding catchment area. No vegetation is present within the lake area. The roughness values presented in the 2010 and 2013 models were reviewed and applied to the current model. A comparison of aerial photographs (as shown in StIves_RGB.ecw) and site photographs (provided by SIGMC) to published values indicates that the applied roughness coefficients are representative. Lake roughness varies from 0.013 to 0.022, and the surrounding catchment uses a roughness ranging from 0.05 to 0.06. The models use a wet-dry depth of 0.2 mm.

3.2.6 Infiltration and Evaporation

An initial infiltration loss of 38 mm and 20 mm was applied to the model for the 20-year and 100-year ARI respectively, with a continuing loss of 3 mm. As presented in the previous chapter, an evaporation rate of 0.315 mm/hr is used in the model for summer runs, and a rate of 0.065 mm/hr is used for winter runs.

3.2.7 Initial Water Level

Based on the gauge data collected before Cyclone Vance in 1999, the initial water level for the northern portion of Lake Lefroy is 287.7 m AHD in the winter runs, and the initial level for the southern portion of Lake Lefroy is 287.8 m AHD. Summer runs begin dry.

3.3 Model verification

A verification run was modelled based on Cyclone Vance, 1999. The model uses a rain-on-grid approach and covers the entire Lake Lefroy catchment.

3.3.1 Model setup

Based on the recorded data, the recorded initial water level was applied, and the model was run for more than 11 days, beginning on 19 March 1999. The initial water level reported by CSIRO (2003) before the actual event was 287.7 m AHD for the Eastern side of the lake (East side of the Causeway) and 287.8 m AHD for the Western side of the lake (West side of the Causeway). The total recorded rainfall of 164.4 mm was used as net rainfall above the regional model grid (covering entire Lake Lefroy catchment).

The calibration model was run for 550 hours to allow water level recovery after the peak, ensuring that the model results capture the maximum water levels. The Causeway was modelled without any culverts. Although it is known that there are some culverts, they have been reported as blocked due to salt encrustation (CSIRO, 2003). Model losses were based on 20-year ARI loss values developed by ARR87 (38 mm initial and 3 mm/hr continuous loss, standard AR&R values, Engineers Australia 1987). Evaporation for this event is 0.315 mm/hr. Pits and landforms are not in the model domain, in order to increase the modelling speed. The impacts of the pits and landforms are likely to have insignificant impacts on modelling results given the small area of the pits and landforms compared to the surrounding lake surface area.

3.3.2 Verification results

Simulation of the March 1999 event demonstrated a model response that matches the recorded values relatively closely. Simulated water levels were within the gauged range based on recorded surface water elevations (CSIRO 2003). Recorded surface water elevations east of the main causeway varied between 287.90 and 288.50 mAHD, and 288.30 to 288.50 mAHD west of the causeway. It is important to note that the model did not incorporate any circulation of water across the Causeway and did not account for any effect from the wind.

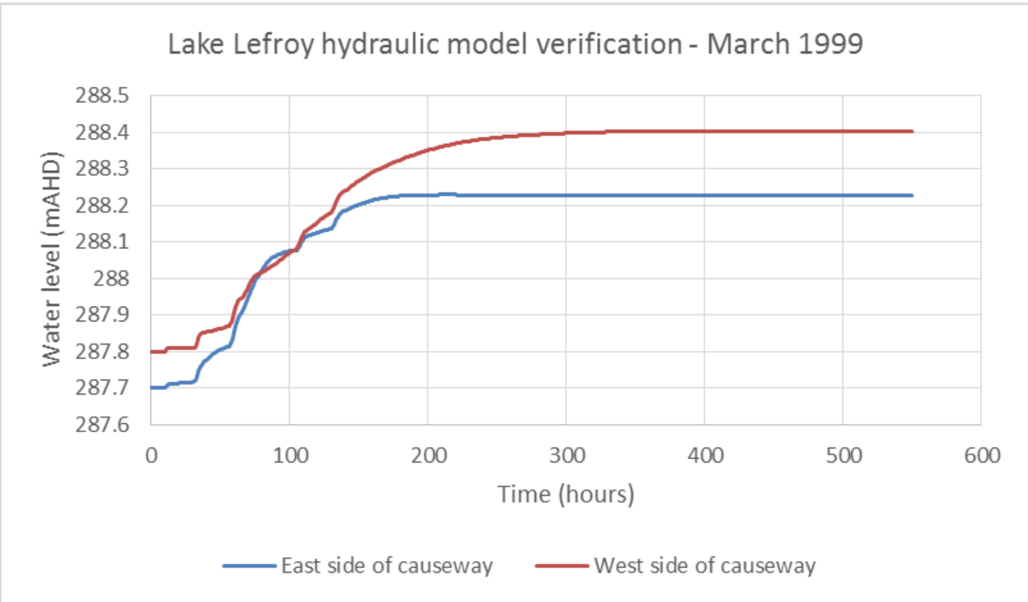

Figure 3-4: Model verification

3.4 Modelled scenarios

3.4.1 Present day and maximum discharge scenarios

The St Ives Gold Mine involves both open cut and underground gold mining activities on the lake-surface (lake-based operation) and adjacent land (land-based). Existing infrastructure (including mine pits, waste rock landforms, causeways, etc.) have been captured in the 2016 DEM provided by SIGMC and are reflected in the underlying terrain data. Given the long history of mining at the site, pre-mining baseline lake bathymetry was not available. The 2016 DEM was therefore assumed as the starting condition for B2018 modelling scenarios and impact assessment.

For the purposes of this assessment the present day scenario was assumed to be 6.8 GL/year, based on the mine dewatering discharge from the following operations:

- A5 - 0.39 GL/year
- Beta Hunt - 0.26 GL/year
- Grinder/Aga/Revenge - 2.68 GL/year
- Thunderer - 3.50 GL/year

For reference purposes the present day scenario is hereinafter referred to as B2016. The surface water assessment focused on surface water impacts related to a potential increase in water elevations in Lake Lefroy as a result of B2018 project dewatering discharge, and any associated impacts to fringe vegetation communities. Ecological values of Lake Lefroy and potential impacts are not discussed in detail in this report; refer to "BY 2018 Project: Ecological Assessment of Lake Lefroy's Peripheral Wetland" (MWH 2017b).

Sensitivity analyses included a no-dewatering scenario, as well as a theoretical maximum dewatering discharge of 60 GL/year. The maximum discharge scenario was also used to assess potential impact on modelled water levels east and west of the causeway of introducing a number of culverts to allow east-to-west flow connection.

The locations for all discharge points were in accordance with the DWER EP Act License L8485/2010/2.

3.4.2 Beyond 2018 project

The B2018 project considers expansion of current and / or development of new lake-based and land-based areas (**Figure 3-5**). As indicated, only indicative footprints and locations of potential future developments were available for consideration in this assessment. If considered necessary, hydraulic models could be updated in future to reflect actual location and size of project area footprints.

Different project areas will have different operational periods, ranging from a single year (or less) to multiple years (e.g. Invincible underground mine operational period of 12 years). The estimated dewatering discharge volumes for the proposed operations are summarised in **Table 3-1** (note that these are interim volumes pending the results of the numerical groundwater model (Stantec 2017)).

The discharge volume shown in **Table 3-1** is the maximum annual discharge for each individual operation. The total annual maximum discharge of 15.1 GL/year is estimated to occur in 2019, while 2028 was used to be the maximum for the purposes of this assessment (dewatering discharge of 12.3 GL, but with the maximum causeways that will present the maximum potential impact on the lake surface water). Both current and B2018 lake-based operations require causeways to provide access to the various lake-based operational areas. Proposed causeway locations associated with the B2018 operations are shown in **Figure 3-5**.

The main north-south causeway contains existing culverts intended to allow surface water flow between the two sides of the lake. These culverts have been blocked over time due to salt accumulation within the culverts and semi-permanent raised access roads on the west side, preventing surface water flow between the two sides of the lake.

It was assumed for modelling purposes that the proposed B2018 causeways would remain in place once mining operations terminate. This would result in the lake to be discretised in a number of segments, with some areas likely to be fully contained by the causeways. A sensitivity analysis was undertaken to assess the impact on water levels within these areas and the wider lake with the introduction of culverts in the respective causeways.

For modelling purposes discharge locations were, apart from one location, assumed to be within the wider lake extents, i.e. not in smaller areas contained by the proposed causeways. Discharge locations used for modelling purposes are shown on **Figure 3-5**.

Table 3-1: B2018 maximum annual dewatering discharge volumes to Lake Lefroy

Pit	Lake or land-based	Discharge (GL/year)
East of main causeway		
Playa_Neptune	Lake	1.51
Eastern Causeway	Lake	2.96
Boulder Lefroy	Lake	5.95
Playa	Lake	1.01
Rialto	Lake	0.57
UG 1	Lake	2.87
UG 5	Lake	3.52
West of main causeway		
2024	Land	11.37
2026	Land	10.55
Implacable	Lake	2.58
Speedway	Lake	2.65
Pilbailey	Lake	2.07
Gibraltar	Lake	6.45
APN	Lake	2.37
SW Dome	Lake	1.08
Piston Club	Lake	1.47
LUT	Lake	1.56

3.4.3 Summary of scenarios

Table 3-2 summarises the modelled scenarios. Changes to water salinity in the lake has been highlighted as a potential risk to the ecology of Lake Lefroy and especially fringe vegetation communities around the lake. To assess potential impacts of dewatering discharge to Lake Lefroy water levels and compare results of the various scenarios, modelled water levels were compared at selected vegetation locations around Lake Lefroy (**Figure 3-6**). Seasonal variation and impacts were assessed by undertaking B2018 summer (20 year) and winter (100 year) runs with winter and summer starting conditions, respectively.

Scenario 21 (**Table 3-2**) is representative of a closure scenario, where all infrastructure remain in place and culverts were added to all causeways to encourage surface water flow connection between the project areas and wider Lake Lefroy extents.

As indicated in **Section 2.5** limited surface water groundwater interaction is expected within Lake Lefroy. Potential surface water groundwater interaction impacts were therefore not considered in the surface water modelling.

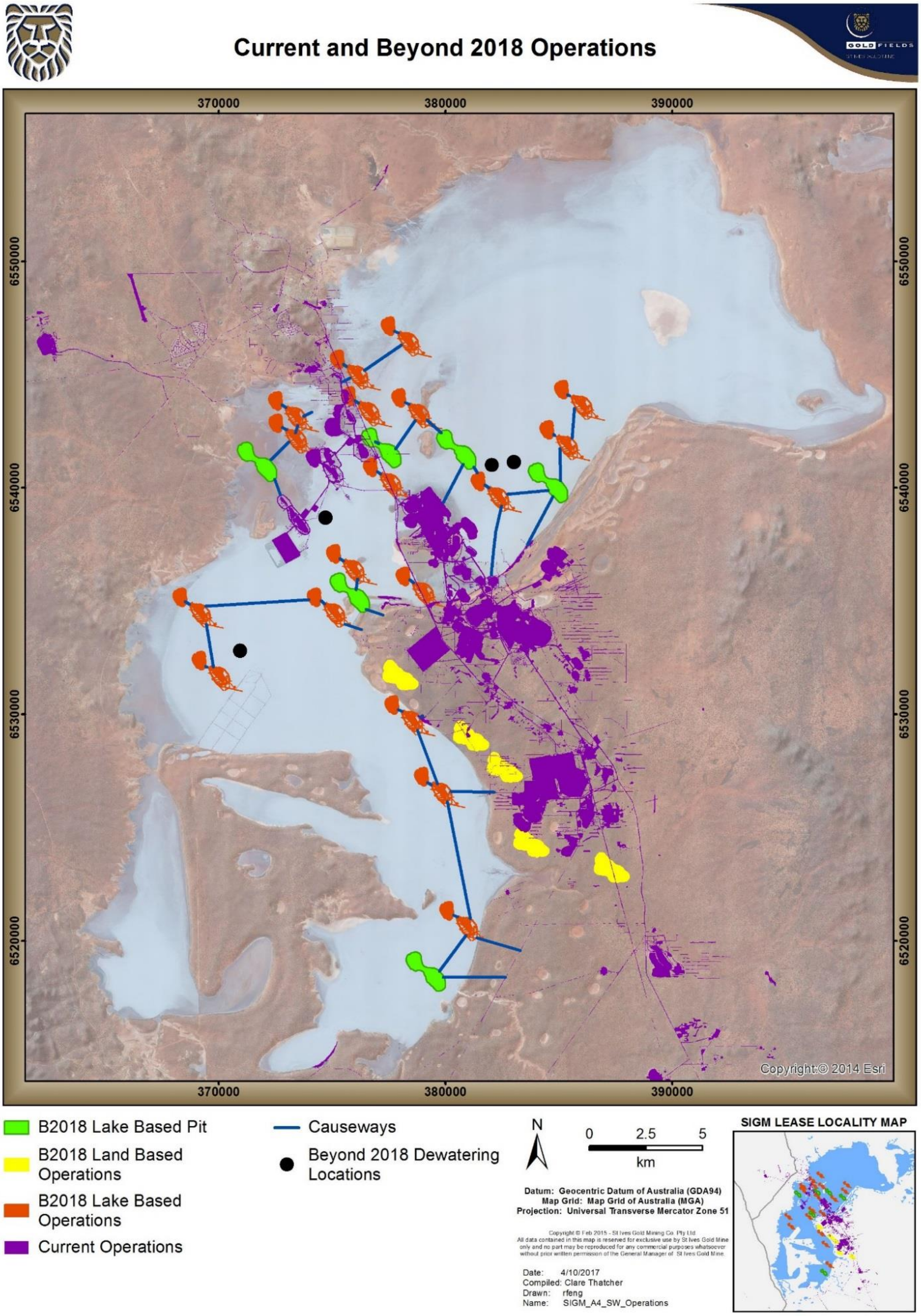

Figure 3-5: Current and Beyond 2018 operations

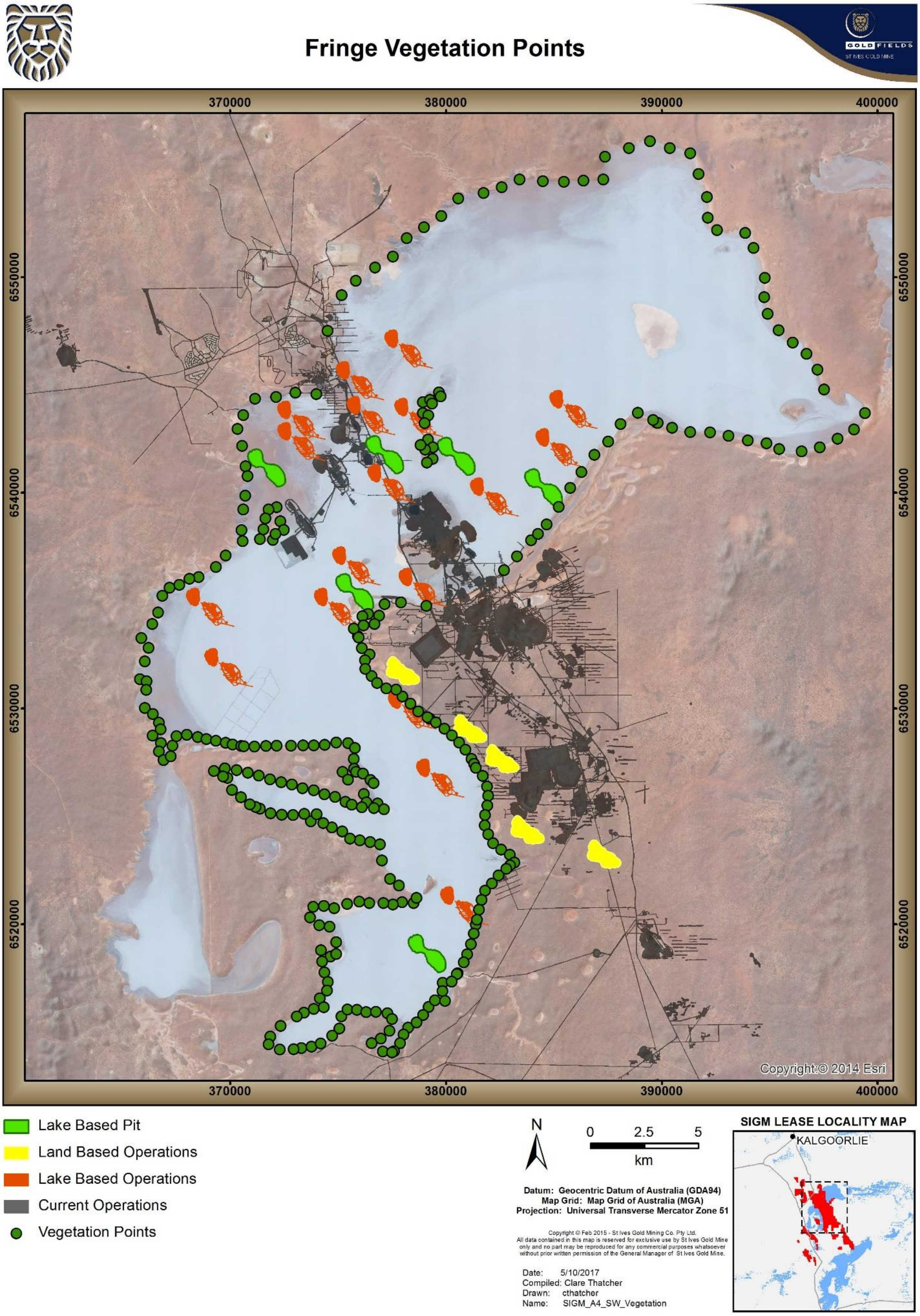

Figure 3-6: Lake Lefroy fringe vegetation points

Table 3-2: Summary of modelled scenarios (results included in this report are shown with **bold** scenario numbers)

Scenario number	Description	Discharge volume (GL/year)	Causeway	Design rainfall event	Season	Evaporation (mm/hr)	Initial water level		Causeway culverts
							East	West	
1	Present day	6.8	North-south only	100 yr	Summer	0.315	Dry	Dry	No
2				20 yr	Summer	0.315	Dry	Dry	No
3				100 yr	Winter	0.065	287.55	288.55	No
4				20 yr	Winter	0.065	287.55	288.55	No
5				100 yr	Winter	0.065	287.7	287.8	No
6				20 yr	Winter	0.065	287.7	287.8	No
7	Maximum sensitivity	60	North-south only	100 yr	Winter	0.065	287.55	288.55	No
8				20 yr	Winter	0.065	287.55	288.55	No
9				100 yr	Winter	0.065	287.7	287.8	No
10				20 yr	Winter	0.065	287.7	287.8	No
11				100 yr	Summer	0.315	Dry	Dry	No
12				20 yr	Summer	0.315	Dry	Dry	No
13				100 yr	Summer	0.315	Dry	Dry	Yes
14				100 yr	Winter	0.065	287.7	287.8	Yes
15	B2018	12.8	North-south + B2018	100 yr	Summer	0.315	Dry	Dry	No
16				20 yr	Summer	0.315	Dry	Dry	No
17				100 yr	Winter	0.065	287.7	287.8	No
18				20 yr	Winter	0.065	287.7	287.8	No
19				20 yr	Summer	0.315	Dry	Dry	Yes
20				100 yr	Winter	0.065	287.7	287.8	Yes (main causeway only)
21				100 yr	Winter	0.065	287.7	287.8	Yes, main causeway and proposed B2018 causeways
22				100 yr	Winter	0.065	Dry	Dry	No
23				20 yr	Summer	0.315	287.7	287.8	No
24	No dewater	0	North-south only	100 yr	Summer	0.315	Dry	Dry	No

4. Hydraulic modelling results

This chapter summarises the results of the selected hydraulic modelling scenarios.

4.1 Inundation of fringe vegetation points

Table 4-1 compares the hydraulic model results in terms of potential inundation of the number of vegetation points. The following key points are noted:

- The 20-year summer present day scenario results in the inundation of 15 vegetation points (western extent of the lake), increasing to 51 during the 100-year summer present day scenario. A sensitivity analysis assuming no present day dewatering discharge (of 6.8 GL) did not result in a change in the number of inundated points.
- The 100-year winter present day scenario results in the inundation of 89 vegetation points, 83 west of the north-south causeway and 6 to the east.
- Compared to the 100-year winter present day, only one additional vegetation point is inundated during the 100-year winter maximum dewatering scenario, i.e. the increase in dewatering volume from 6.8 GL/year to 60 GL/year had insignificant impact on the water levels in Lake Lefroy. Note this scenario assumed that the north-south causeway culverts were blocked; hence, there was no east-to-west flow connection on the lake.
- The maximum scenarios (100-year winter) for present day, maximum dewatering discharge and B2018 resulted in inundation of a similar number of vegetation points.
- Seasonal variation impacts are insignificant, i.e. the number of vegetation inundated during the B2018 summer 20 year event increased from 12 to 17 when using winter starting conditions. A similar reduction is seen when starting the B2018 winter 100 year scenario with summer (i.e. dry) lake conditions.
- The largest impact on water levels and inundation of vegetation points is associated with the introduction of culverts in the north-south causeway for the 100-year winter maximum dewatering scenario. Allowing east-to-west flow connection through the causeway culverts resulted in a reduction in water levels to the east of the causeway, but an increase to the west and increase in the number of inundated vegetation points as water levels reach an equilibrium on both sides of the causeway.
- Similar increases were noted for the B2018 scenarios when causeway culverts were introduced. The impacts were locally evident as the main north-south causeway was assumed to be blocked for the B2018 scenarios. Adding a culvert in the main north-south causeway, in addition to culverts in all B2018 causeways, had insignificant impact, with the total number of wet points increasing from 88 to 93.

The modelling does not consider the impacts of wind on water levels. CSIRO (2003) reported that the shallow water in Lake Lefroy is blown around the lake bed by prevailing winds, with relatively large fluctuations of up to 0.6 m (0.3 m amplitude) detected in short periods. These non-periodic short term water level fluctuations are caused predominantly by variations in wind speed and direction. The largest fluctuations were noted against the causeway. The wind effects would only be temporary given the relatively inconsistent nature of wind direction at Lake Lefroy.

The prevailing winds are mainly from the east, south-east and north-east (Kalgoorlie-Boulder Airport wind rose show in **Figure 2-3**) and would support findings by CSIRO (2003) that the largest water level fluctuations due to wind were noted against the causeway. Based on prevailing wind directions riparian vegetation along the western and southern fringe of the southern half of the lake could likely be most impacted. Further monitoring is however required to validate this.

4.2 Inundation extents and depths

Figure 4-1 shows a plan view of the inundation depths and flood extents for 20-year ARI summer conditions with present day dewatering discharge (6.8 GL/year). **Figure 4-2** shows the same data for winter conditions (100-year ARI) with maximum dewatering discharge (60 GL/year). The dots represent the vegetation points around the lake; green and blue dots show dry and wet vegetation points, respectively. **Figure 4-3** compares inundation extents associated with the 20-year summer and 100-year winter conditions.

The comparison plan shows the maximum difference between all of the scenarios by comparing the wettest and driest scenarios. As shown in **Figure 4-3**, the total inundated area varies quite significantly. The minimum scenario results in a total of 15 wet points, all west of the north-south causeway. The maximum scenario results in a total of 90 wet points, 6 and 84 east and west of the causeway, respectively.

The depths near the fringes are generally very shallow, however, and interpretation of the results should consider the depth differences as well, as indicated by the profiles and stage hydrographs described below. Results of selected scenarios are summarised in Appendix E, showing depths and estimated inundation durations.

The relatively small impacts on modelled depths should be considered within the context of the Lake Lefroy storage capacity. With a total lake surface area of 544 km^2 and an assumed average depth of water across the lake of 0.5 m, the lake may have a capacity of approximately 270 GL. The total B2018 dewatering discharge volume is estimated to be approximately 107 GL. Assuming the total B2018 dewatering volume is discharged within a single year (which will not be the case) and no evaporation / infiltration losses or external catchment inflows, the lake water elevations will increase by less than 0.2m. Indicative inundation durations are discussed in Section 4.4.

4.3 Water surface profiles

Figure 4-5 shows the alignment of a long section profile line used to extract water surface elevations from the hydraulic model results. The numbered lines in the profiles refer to the eight control points numbered in **Figure 4-5**. **Appendix B** includes individual charts for comparison between scenarios, with water surface profiles highlighted for each scenario.

Figure 4-6 shows water surface profiles along the selected profile line for the scenarios that are based on 2016 terrain conditions. **Figure 4-7** shows water surface elevation profiles for the B2018 scenarios. Profiles are shown at a time step of 170 hours (approximately one week of modelled time).

As shown in the figures, with the exception of the perched area represented by Point #8, the maximum variation in water surface between scenarios is generally less than 1 metre under current (B2016) model conditions. For the B2018 model with additional causeways in place, the total variation climbs to just more than 1 metre (including Point #8). Modelled elevations are generally higher to the east of the north-south causeway.

The impact of introducing culverts in the proposed B2018 causeways is shown in **Figure 4-7** (100-yr winter B2018 elevations – without and with culverts are highlighted in thicker blue and red dotted lines). Assuming the B2018 causeways will have no culverts will result in elevated water levels in areas contained by the causeways. The impact of introducing culverts is clearly shown in **Figure 4-7** at comparison Point #2, where the water elevation drops by almost 1.0 m when adding the culverts.

Note that the with-culverts scenarios were based on a nominal number of 1-m high by 5-m wide box culverts and are intended only to show potential impacts associated with the culverts.

4.4 Time series

Figure 4-5 shows eight selected control points for extracting time series stage hydrographs from the hydraulic model.

Figure 4-8 shows the extracted stage hydrographs for each of the control points under 100-year ARI conditions for the maximum dewatering scenario. **Figure 4-9** shows time series stage hydrographs for control point #5, located just west of the causeway, under the ten selected scenarios. As shown in the hydrographs, the summer event water levels begin to drop over time more prominently than the winter events. Time series plots are shown for all control points and all scenarios in **Appendix C**.

Inundation times have been estimated by only applying evaporation losses to the lake recovery curve, and assuming no infiltration losses. Maximum summer recovery periods were less than six (6) months, hence only summer evaporation rates were used. Maximum winter recovery periods were longer than six months. Winter evaporation rates were used for the first six months, and summer evaporation for the next six months in order to accommodate the higher summer evaporation rates in the recovery curve estimation. The estimated inundation durations for the vegetation points are summarised in **Appendix E**. Key findings include:

- 20 year summer present day and B2018 inundation durations are reasonably similar, with a small reduction in average (30 to 23 days) and maximum (59 to 50 days) inundation durations associated with the B2018 scenario;
- 100 year winter present day and B2018 inundation durations are reasonably similar, with a small reduction in average inundation durations associated with the B2018 scenario (reduced from 149 to 147 days), but an increase in maximum duration form 250 to 257 days;
- The small reduction in inundation durations for the B2018 scenario is a result of the proposed causeways preventing, in some areas, natural catchment runoff to reach the wider lake extents;
- As shown in **Figure 4-4**, the proposed B2018 footprint blocks the low flow connection north-to-south along the eastern edge of the lake. This impacts the inundation and recovery periods in the southern (and south-east) sections of the lake.

URS (2010) reported that there is a significant difference between mean summer (74 days) and mean winter (265 days) baseline hydroperiods. An increase in hydroperiods as a result of B2010 (with an equivalent dewatering discharge of 31 GL/year, which is double the 15.1 GL/year associated with the B2018 project) of 27% to 31% were expected. The increase in hydroperiods due to B2010 were not expected to significantly impact riparian vegetation health, as vegetation health would also be impacted under baseline hydroperiod conditions (URS 2010).

The total modelled durations used in this project is 180 hours for winter runs and 250 hours for selected summer runs, which is too short to develop a full understanding of the lake hydroperiods. An increase in hydroperiods as a result of the B2018 project, compared to baseline conditions, would be expected. Impacts on hydroperiods due to B2018 will however likely be less than that associated with the B2010 project, given the B2018 estimated dewatering discharge is approximately 50% of B2010 estimated discharge volumes. Additional modelling, with model duration runs in excess of 3,000 hours, would be required to assess impacts on hydroperiods. Indicative present day hydroperiod estimates, based on the current model and a number of selected points east and west of the main causeway, were in the order of 100 days for summer and 270 days for winter, which are reasonably similar to the B2010 results (URS)

Table 4-1: Hydraulic model results

Scenario number	Description	Discharge volume (GL/year)	Causeway	Design rainfall event	Season	Causeway culverts	Initial water level		Wet points	
							East	West	East	West
1	Present day	6.8	North-south only	100 yr	Summer	No	Dry	Dry	5	46
2				20 yr	Summer	No	Dry	Dry	0	15
5				100 yr	Winter	No	287.70	287.80	6	83
9	Maximum sensitivity	60	North-south only	100 yr	Winter	No	287.70	287.80	6	84
10				20 yr	Winter	No	287.70	287.80	0	23
14				100 yr	Winter	Yes	287.70	287.80	1	118
15	B2018	12.8	North-south + B2018	100 yr	Summer	No	Dry	Dry	3	33
16				20 yr	Summer	No	Dry	Dry	0	12
17				100 yr	Winter	No	287.7	287.8	4	79
18				20 yr	Winter	No	287.7	287.8	1	22
20				100 yr	Winter	Yes[1]	287.7	287.8	6	82
21				100 yr	Winter	Yes[2]	287.7	287.8	6	87
22				100 yr	Winter	No	Dry	Dry	4	55
23				20 yr	Summer	No	287.7	287.8	0	17
24	No dewater	0	North-south only	100 yr	Summer	No	Dry	Dry	5	46

Notes: 1. Culverts in the proposed B2018 causeways only

2. Culverts in main north-south causeway and proposed B2018 causeways

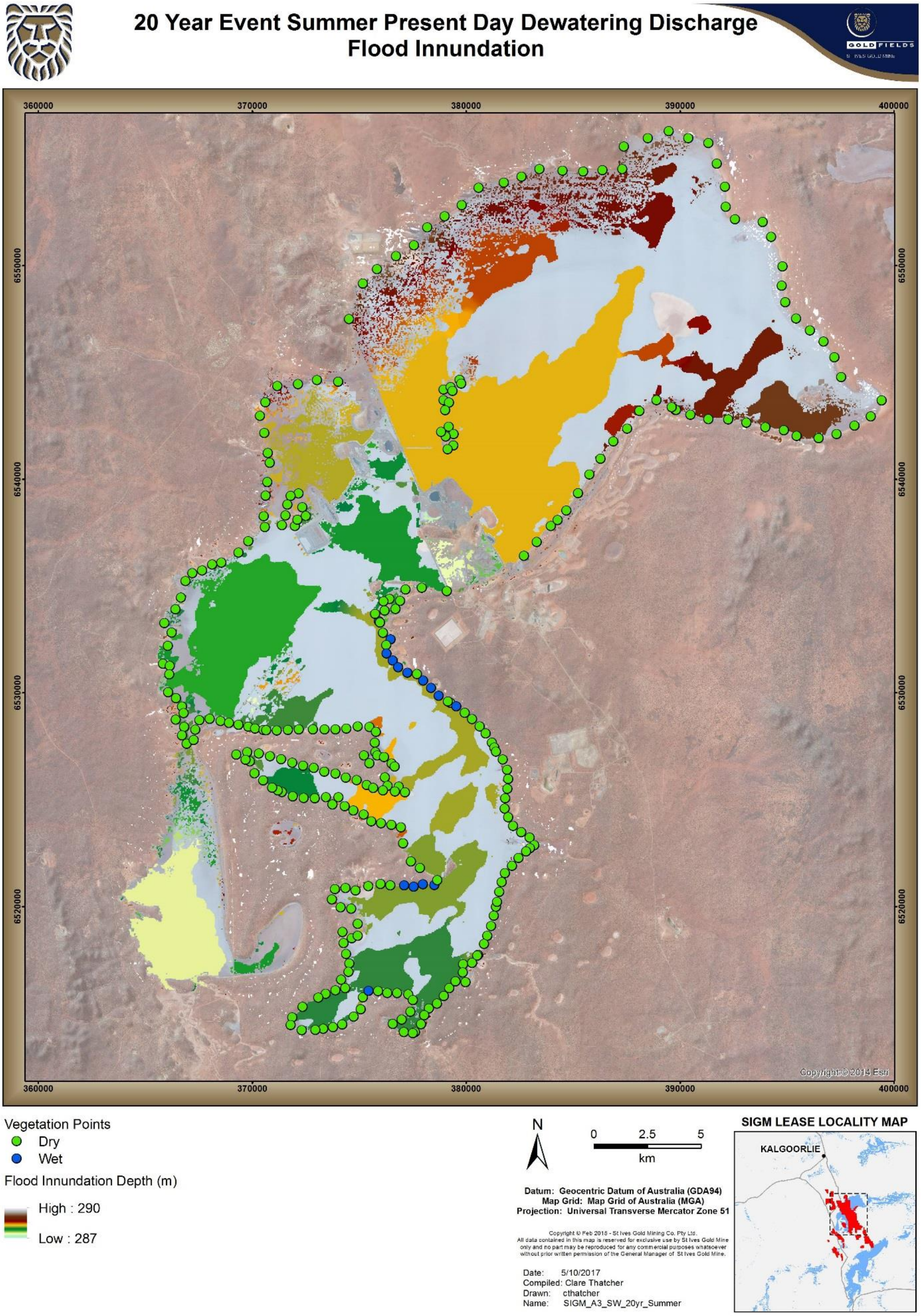

Figure 4-1: Summer inundation map for present day 20 year summer scenario

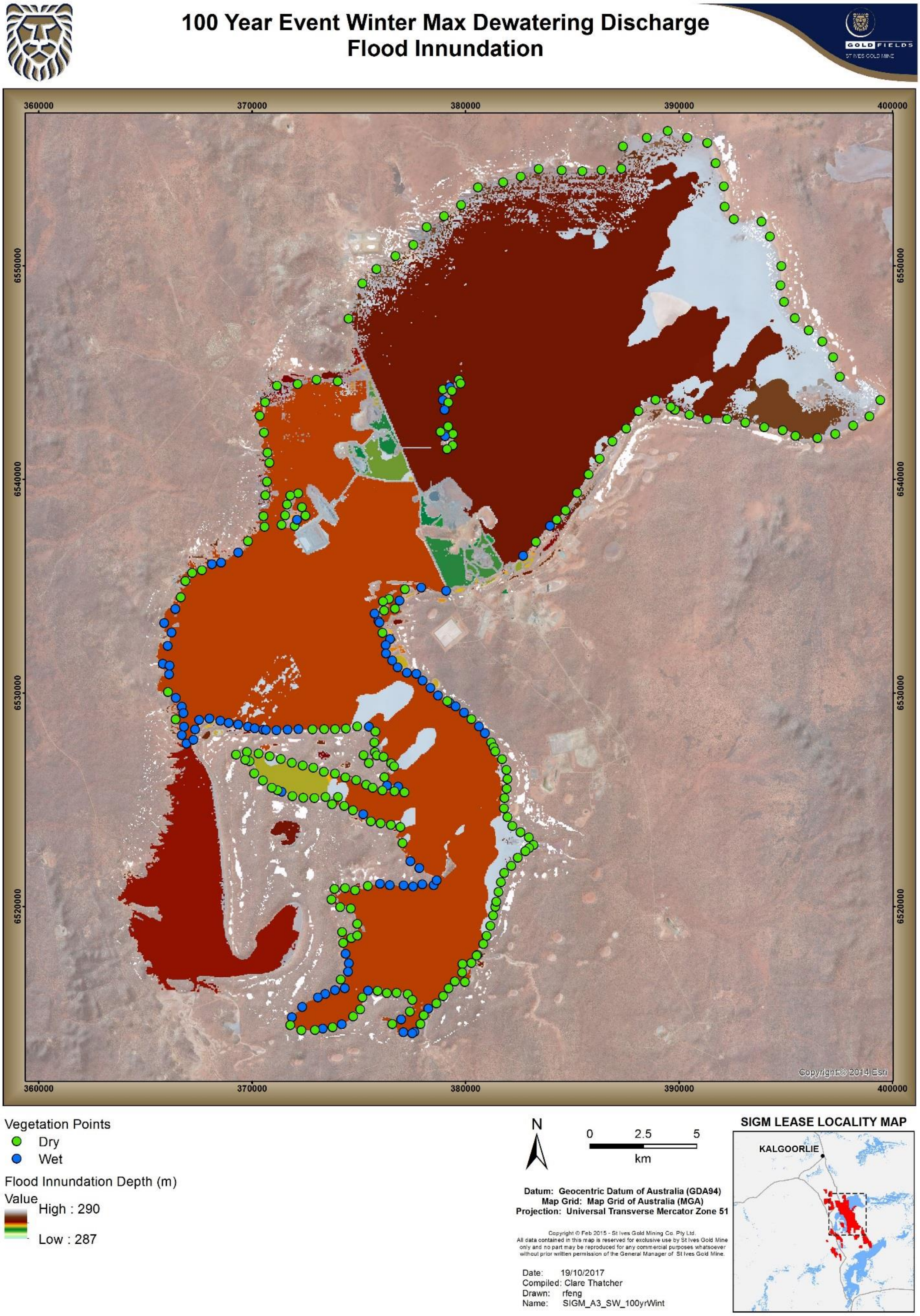

Figure 4-2: Winter inundation map for maximum dewatering scenario

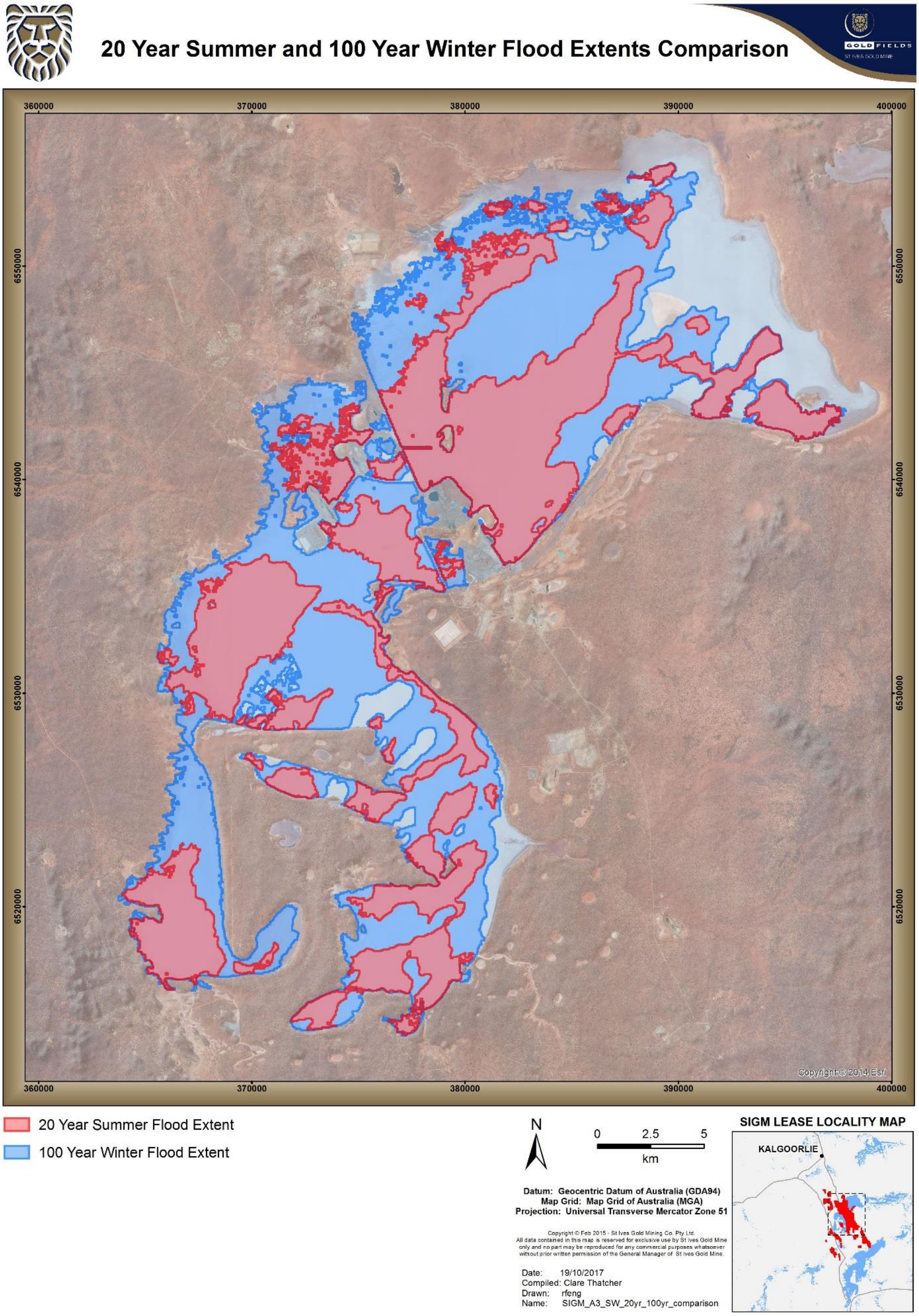

Figure 4-3: Comparison of summer and winter inundation extents

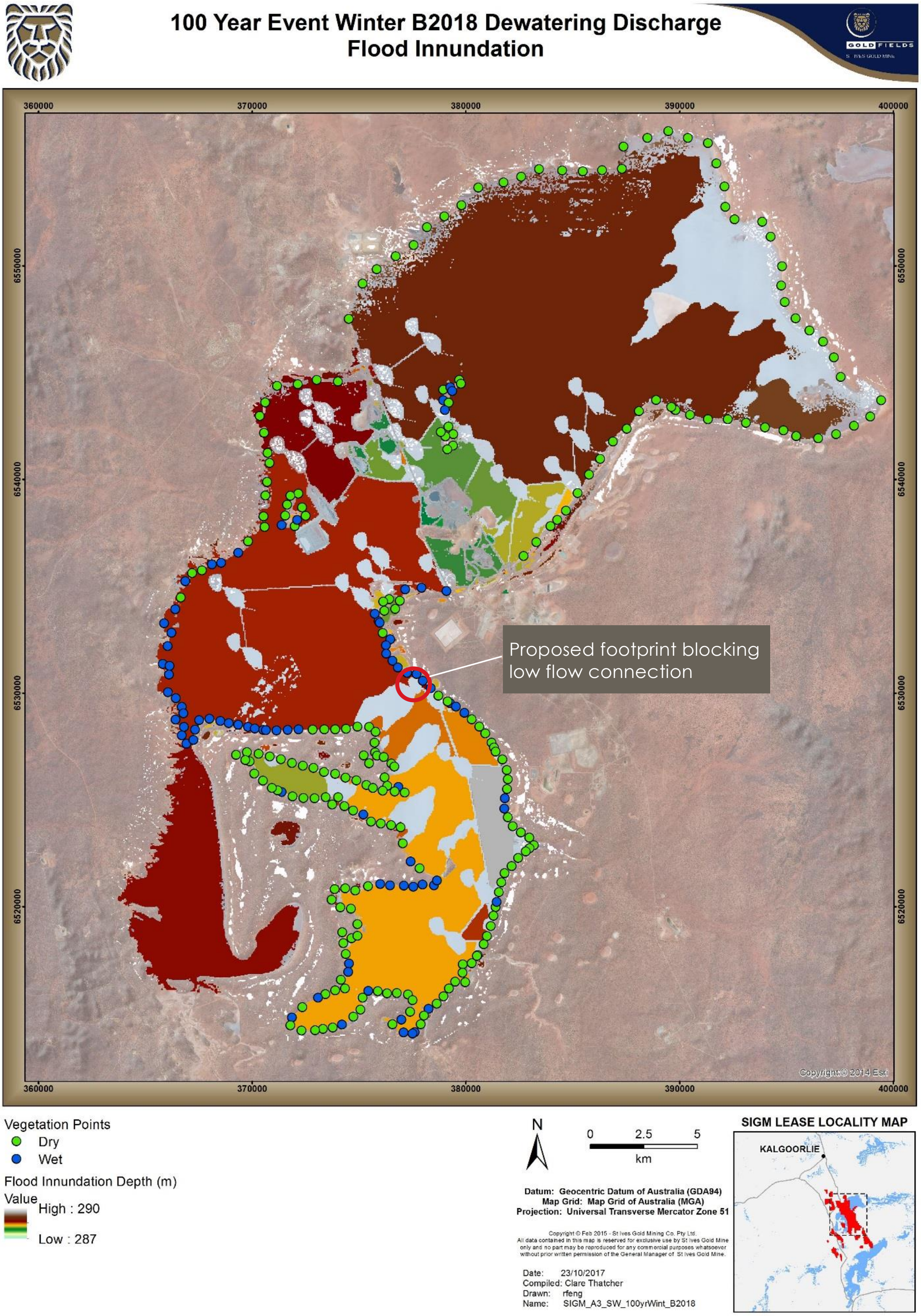

Figure 4-4: 100 year winter B2018 winter inundation map

Figure 4-5: Index points and long section alignment

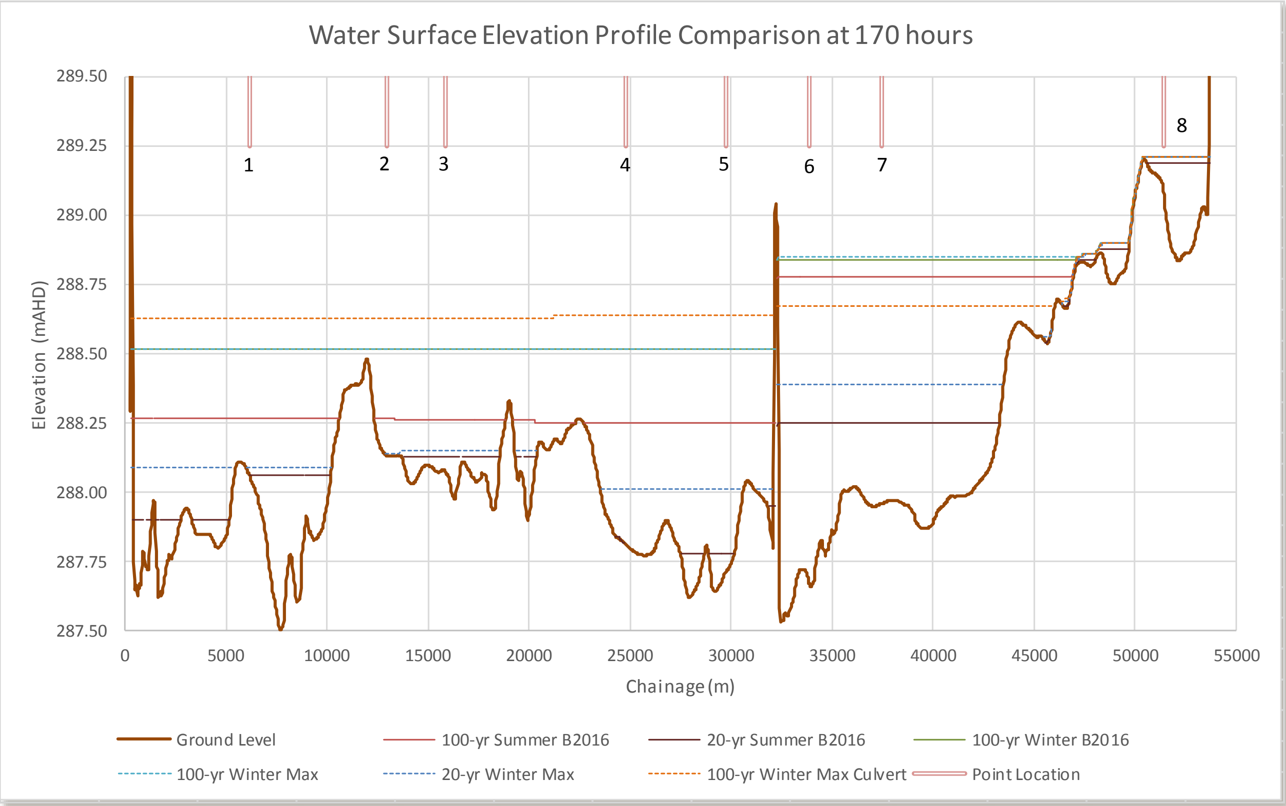

Figure 4-6: Water surface profiles for 2016 conditions

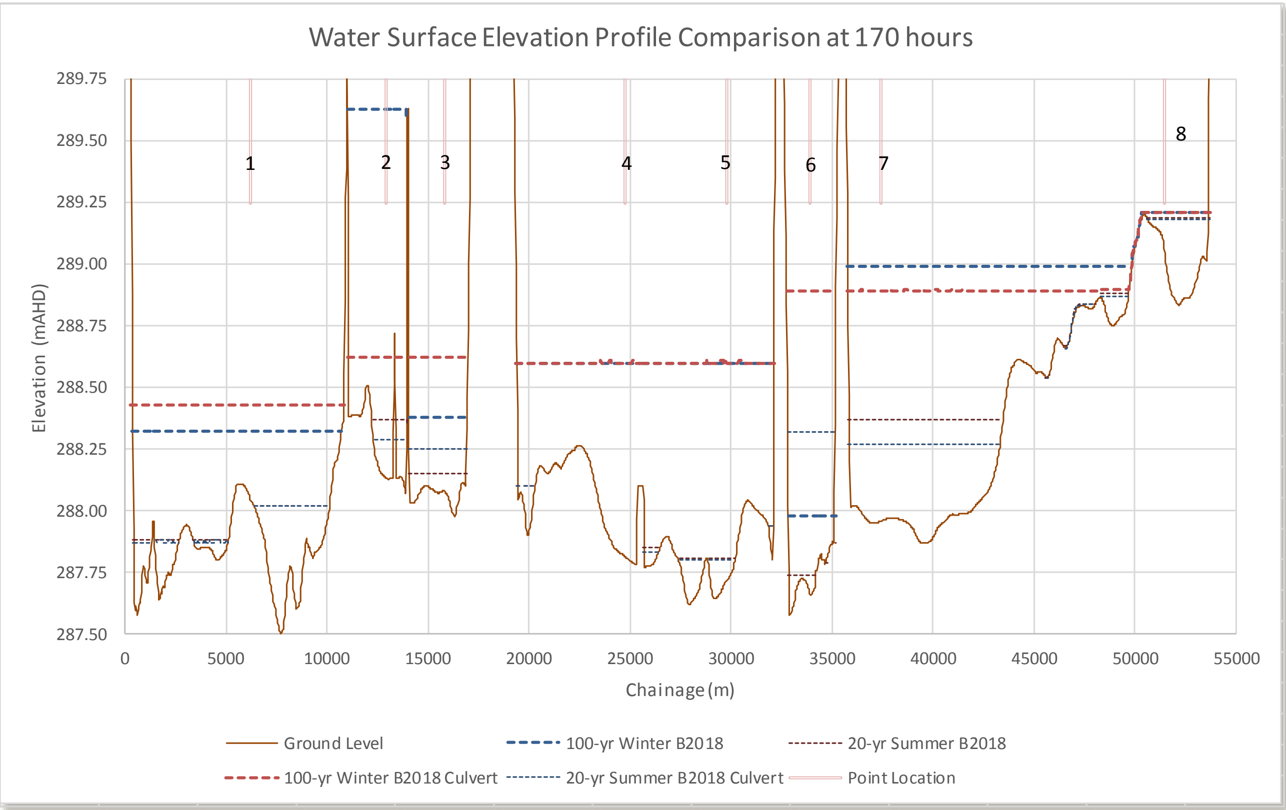

Figure 4-7: Water surface profiles for Beyond 2018 conditions

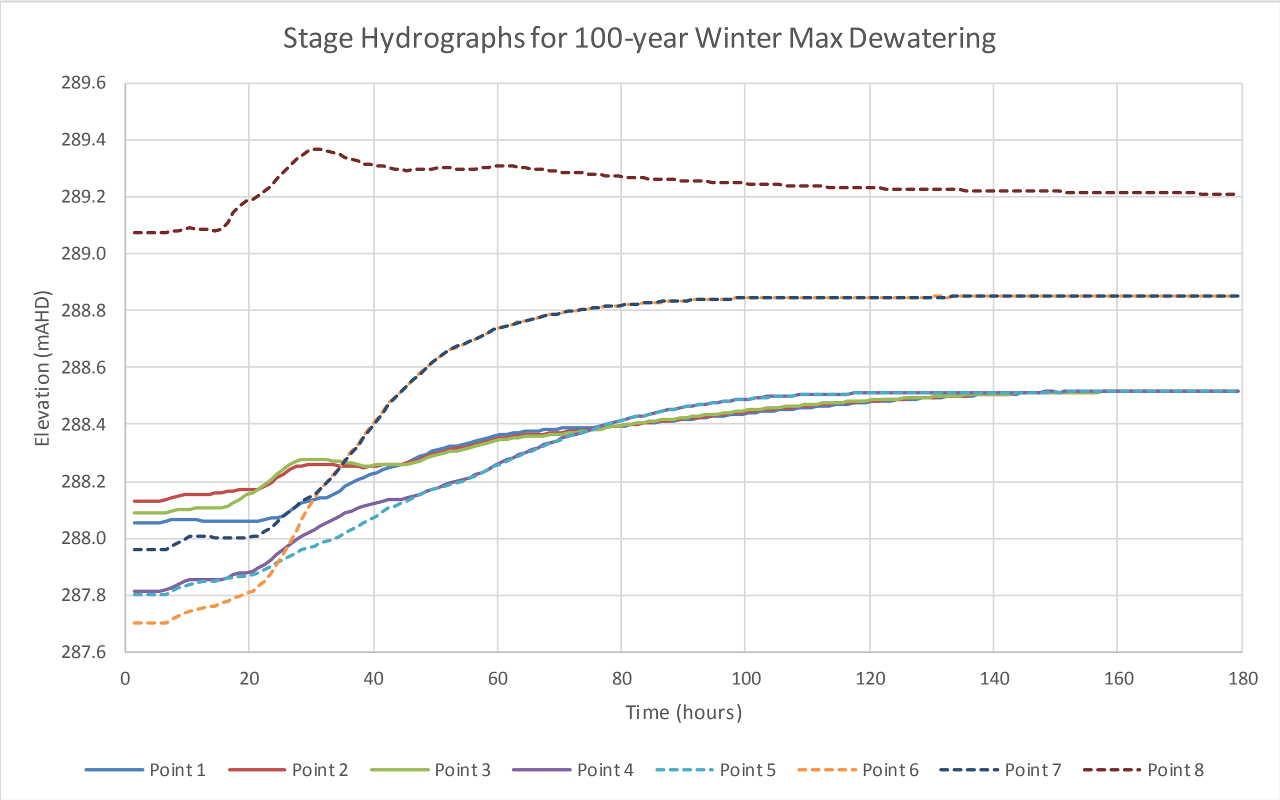

Figure 4-8: Stage hydrographs for all control points for 100-year winter model with maximum dewatering

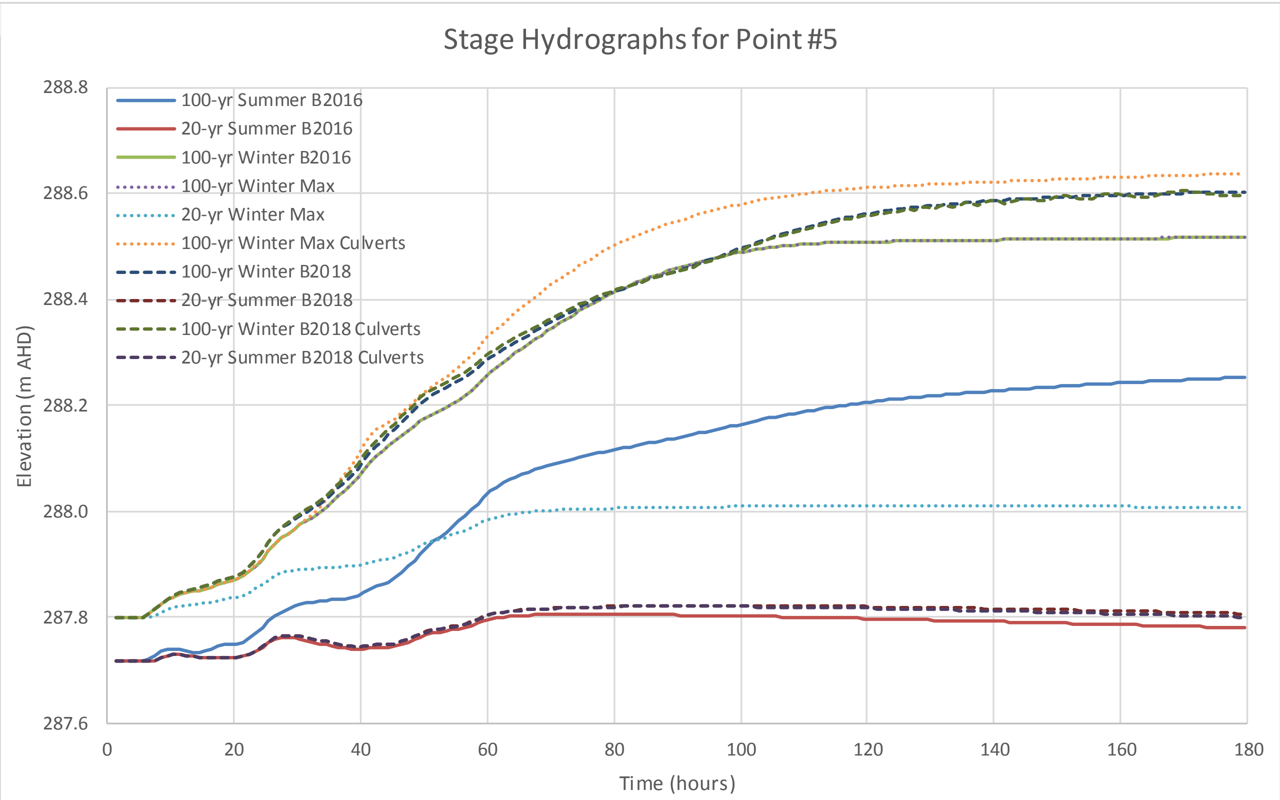

Figure 4-9: Stage hydrograph for ten selected scenarios at control point #5 (just west of causeway)

The main north-south causeway culverts have been blocked over time due to salt accumulation within the culverts and semi-permanent raised access roads on the west side, preventing surface water flow between the two sides of the lake. The blocked culverts result in different water elevations east and west of the causeway, as shown in **Figure 4-2** and **Figure 4-6**. Water surface elevations for the winter maximum dewatering scenario vary by 0.38 m, with elevations of 288.79 mAHD and 288.41 mAHD east and west of the causeway, respectively.

The potential impact of opening the culverts to allow east-to-west flow connection was assessed by including 20 x 1-m high by 5-m wide culverts in the causeway. **Figure 4-10** shows the extracted stage hydrographs for the maximum discharge scenario with these culverts. Water elevations balanced after approximately 220 hours model time, with flow through the culverts from east to west.

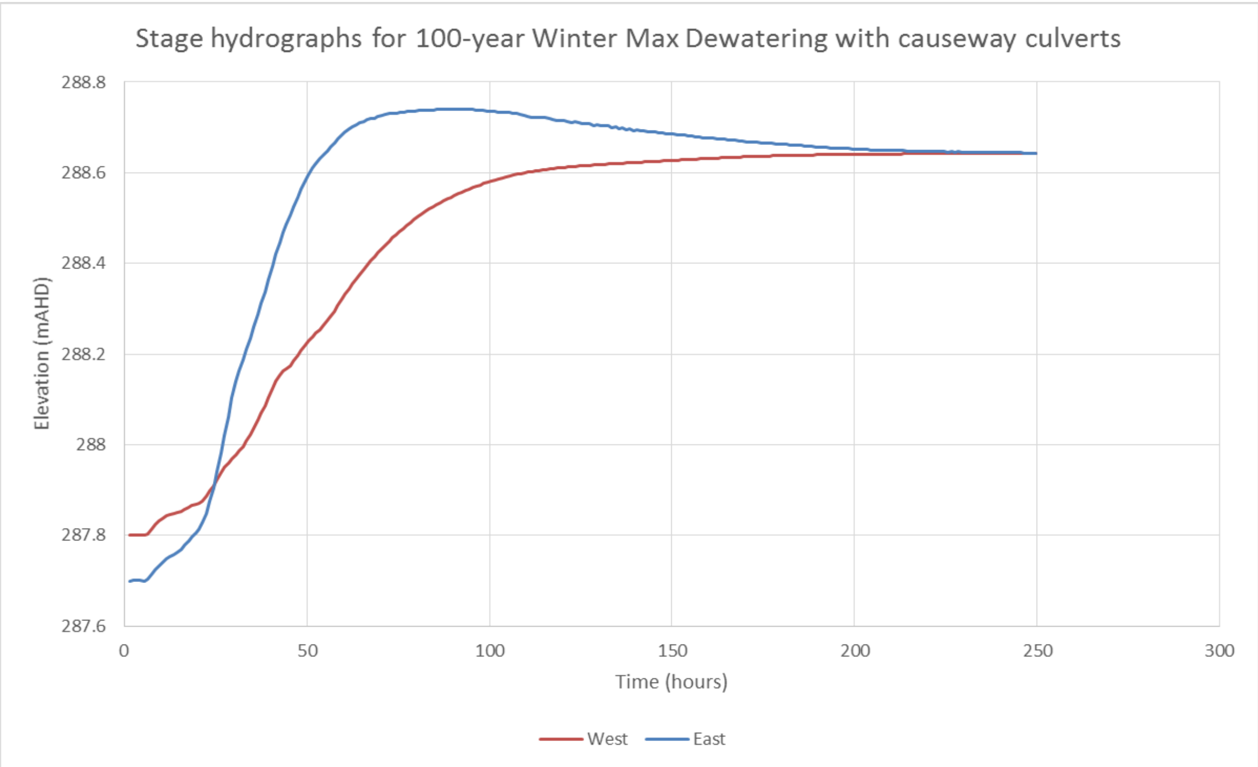

Figure 4-10: Stage hydrograph for maximum discharge scenario (60 GL) with causeway culverts

5. B2018 Land-based operations

B2018 operations will include land-based mining options. Land-based operations have the potential to impact surface water regimes where mining pits and operational infrastructure intersect or impact flow paths and drainage lines discharging surface water flows to Lake Lefroy. Detailed information related to extents and locations of pits, waste landforms, tailings storage facilities, etc., is yet to be developed.

Indicative locations of the B2018 land-based operations and potentially impacted surface water catchments are shown in **Figure 5-1**. Based on proposed disturbance areas and footprints the total impacted area is approximately 230 km² (this area includes upstream catchments). Note that the larger southern sub-catchment (**Figure 5-1**) is only partially impacted by the proposed footprints.

To gain an understanding of the potential impacts that operations may have on the Lake Lefroy surface water regime, it is important to establish the percentage disturbance within the regional catchment. The impacted catchment (230 km²) results in a relative disturbance within the Lake Lefroy western extent catchment area of approximately 8.7%. The small percentage of disturbance within the regional catchment infers that any alteration to the surface water regime will likely be insignificant on the Lake Lefroy surface water regime.

The actual impact, however, is likely to be significantly less than the 8.7%, as surface water management measures such as flow diversion will be implemented during operations. While flow diversion measures may attenuate flood peaks, it is expected that most of the runoff volume will still reach Lake Lefroy, therefore reducing the potential impact on Lake Lefroy surface water.

Management of surface water drainage in and around the various pits and landforms is important for long-term stability, erosion control and water quality, both during operations and post-closure. Concept surface water management measures were developed for a number of land-based operations as part of the St Ives Mince Closure Plan (MWH 2016a). The focus was on diversion and flow collection systems to incorporate strategically placed flow control structures, channels, and controlled discharge points to minimise potential impacts on landforms and receiving environments. A similar approach should be applied to the B2018 land-based operations, however, this can only be done when locations and extents of land-based operations have been agreed.

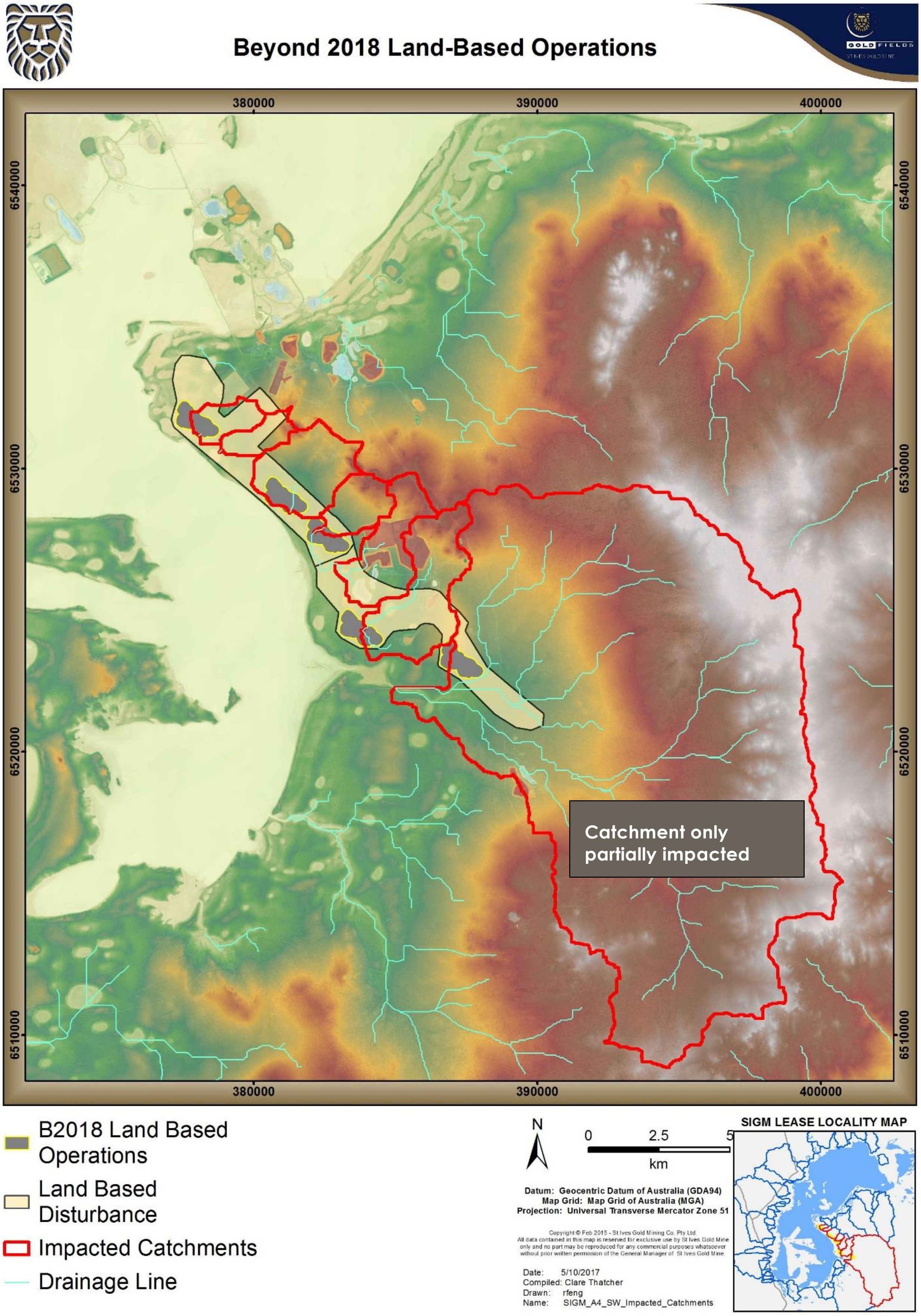

Figure 5-1: B2018 land-based operations and impacted catchments

6. Surface water salinity

6.1 Background

Saline groundwater has been discharged to Lake Lefroy since 1965, prior to the establishment of St Ives. Dewatering discharge from St Ives to the lake is believed to have commenced between 1980 and 1981, during initial development of the Victory-Leviathan gold deposits by Western Mining Corporation Resources Limited (WMC). Historical and ongoing active dewatering discharge from other operations have occurred (MWH 2016). Currently, dewatering of several SIGMC open pits and underground operations is required to maintain safe and dry operating conditions. Prior to discharge to the lake, pre-treatment takes the form of sediment settlement (using in-pit or underground sumps) and hydrocarbon capture.

While there may be minor contributions to salt loads from natural groundwater, the key sources of salt inputs into Lake Lefroy include:

- Salt contained in sediments load and catchment runoff following runoff generating rainfalls;
- Precipitation of salt from rainfall over the lake surface; and
- Dewatering discharge from mine pits (current and historical).

Lake Lefroy surface water quality is largely determined by the inundation of freshwater from direct rainfall onto the lake surface, and from inflows into the lake from the surrounding catchment. Salts, which accumulate due to evaporation following rainfall and runoff, are distributed over the surface of the lake during wet conditions, when dissolved salts distribute across the lake through natural flow direction on the lake surface when the Lake is inundated and between smaller, shallow pools through windschief effects.

The salinity of the lake's surface waters range from 260,000 to 435,000 mg/L of total dissolved solids (TDS) (URS, 2010); this is consistent with the 255,000 mg/L reported by MWH (2017). The lake does not appear to maintain a low salinity phase, even after large influxes of freshwater (Phoenix Environmental Sciences, 2014). This is largely attributed to the presence of an extensive salt crust covering a significant portion of the lake surface area.

URS (2010) reported that surface water flows on Lake Lefroy are largely governed by lake bed bathymetry and that mine dewatering discharged onto the lake surface has caused an altered lake bed bathymetry due to the deposition of the predominantly gypsiferous salt. It is likely that a portion of the deposited salt would have been redistributed across the lake during large rainfall events, however, less soluble deposits, including gypsum and mine sediment, might have remained close to the discharge locations, resulting in changes in lakebed bathymetry over time in these areas. It is also likely that interruptions to flow paths from mine infrastructure have probably affected the normal depositional processes on the lake bed, with some areas along the main causeway showing evidence of salt and sediment build-up (URS 2010).

URS (2010) undertook field studies at discharge locations and along the causeway to determine the changes in lake bed bathymetry that could have resulted from mining operations. Field studies included holes being drilled to a depth of 450 mm at each discharge location and depth of discharge estimated by examining the trends in the sediment characteristics moving away from the discharge point.

Results of the field studies (URS 2010) indicated that gypsum deposited from dewatering discharge altered the vertical lake bed bathymetry by causing maximum mound heights of between 100 to 200 mm at each site. The mounds propagated laterally over small areas and were often constrained by infrastructure. Mounding occurred over areas less than 500 m², except for Belleisle and Argo, where the mounding and radial influence was up to 1 km. The causeway was found to be a more significant factor than the dewatering discharge. The causeway resulted in a build-up of sediment up to 450 mm in height and extending some 2 to 3 km to the east of the causeway, with the depth of sediment build-up the greatest adjacent to the causeway and propagating eastwards on an increasingly lower gradient (URS 2010). Indicative salt crust extents based on the field data are shown in **Figure 6-2**.

MWH (2017) prepared the St Ives annual environmental monitoring program to ensure compliance with regulatory conditions, including the DWER Environmental Protection Act 1986 (EP Act) Licence L8485/2010/2. The annual monitoring program considered 14 DWER, approved St Ives operated lake based dewatering discharge outfalls on Lake Lefroy during the 2016 reporting period, and which are permitted to discharge excess mine water onto the playa. Current, historic and planned outfall locations are summarised in **Table 6-1** and locations shown in **Figure 6-1**.

Table 6-1: List of approved and historic dewatering discharge outfall locations and their operational status (as at March 2017) (MWH 2017a)

Discharge outfall	Discharge infrastructure	Operational Status	Last Discharged To	Salt crust
Apollo Pit	In-pit	Active	(current)	-
Cave Rocks	Turkeys Nest	Active	(current)	Speckled
Revenge (GRA)	Turkeys Nest	Active	(current)	Intact (20cm)
Leviathan (new)	Turkeys Nest	Active	(current)	Speckled
Invincible (a)	Turkeys Nest	Active	(current)	Intact (30cm)
Temeraire Pit	In-pit	Active	(current)	-
Argo Pit	In-pit	Inactive	TBA	-
Intrepide Pit	In-pit	Inactive	TBA	-
Revenge Pit	In-pit	Inactive	TBA	-
Belleisle	Turkeys Nest	Inactive	Jul-14	Intact (60cm)
Leviathan (old)	Lake via channels	Inactive	TBA (~mid 2000s)	-
Thunderer	Turkeys Nest	Inactive	Sep-10	-
Africa Pit	In-pit	Inactive	Dec-12	-
Argo Hydroslide	Turkeys Nest	Inactive	Apr-14	Speckled
Santa Ana	Turkeys Nest	Inactive	Sep-15	Intact (20cm)
Bahama-Santa Ana	Turkeys Nest	Inactive	Jun-15	-
Revenge (b)	Turkeys Nest	Inactive	TBA	-
Foster (historic)	Lake	Inactive (historic)	1990s	Intact (8cm)
GRA	Turkeys Nest	Inactive (historic)	TBA	Intact (40cm)
Junction	Creekline	Inactive (historic)	Late 1990s	Intact (20cm)
Intrepide A	Turkeys Nest	TBC	Planned	
Intrepide B	TBD	TBC	Planned	
Foster (new)	Lake	TBC	Planned	
Pistol Club	TBD	TBC	Planned	
Grinder	TBD	TBC	Planned	
Invincible (b)	Turkeys Nest	TBC	Planned	
Incredible	TBD	TBC	Planned	

Though variable in thickness, the salt crust is between 50 to 60 cm in areas closer to the centre of the lake and the main north-south causeway, reducing to a speckled cover in areas to the north and south extremities (**Table 6-1**). While the most obvious impact is the presence of a thick salt crust on the lake's surface, it is difficult to determine the extent of the impact that is related to dewatering discharge, due to limited baseline data (MWH 2016c). The high salinity of the lake also promotes settling of sediments mantled with salts, hardening to form a halite crust (URS 2013), which tends to be thicker closer to the discharge sites (MWH 2017a). The focus of the dewatering impact assessment is on discharge locations, which are located closer to the main north-south causeway and edge of Lake Lefroy (**Figure 6-1**), resulting in limited salt crust information across the remainder of the playa surface. Indicative salt crust extents and depth contours, developed from the information summarised in **Table 6-1**, are shown in **Figure 6-2**.

The dominant winds tend to range between south-easterly to northerly (**Figure 2-3**), which could have contributed to settlement of sediments and increased salt crust to the east of the causeway. It should be noted that the extents were developed based on field observations. These results do not suggest that the salt crust is limited to these extents; further field validation is required to validate the full extent of the salt crust.

Surface water is diluted by direct rainfall events and/or surface water runoff of fresher water from the surrounding catchment area (URS 2010). CSIRO (1999) measured average total dissolved solids (TDS) in the lake following ex-cyclones Elaine and Vance in March 1999 and found a significant reduction in TDS compared to average to drier conditions. Salinity measurements taken across the lake surface shows surface water salinity to be highly variable, with TDS varying by more than 300,000 mg/L in dry conditions (URS 2010).

Changes to water salinity in the lake have been highlighted as a potential risk to the ecology of Lake Lefroy and especially to fringe vegetation communities around the lake. Some of these communities are characterised as being fragile and susceptible to damage from changes to their local environment, including an increase to salinity (Datson, 2004; Outback Ecology, 2004).

The B2018 mining projects will include ongoing discharge of hypersaline mine dewatering volumes to the surface of Lake Lefroy, adding to the already hyper saline environment. The B2018 proposed causeways will segment the Lake Lefroy surface into a number of discrete areas. Dewatering discharge points will, in general, be on the lake surface outside areas contained by the causeways. The potential implication is that areas contained by the network of causeways receiving natural runoff from external catchments, may in the medium to long term have a different salt balance to areas on the lake receiving dewatering discharge volumes.

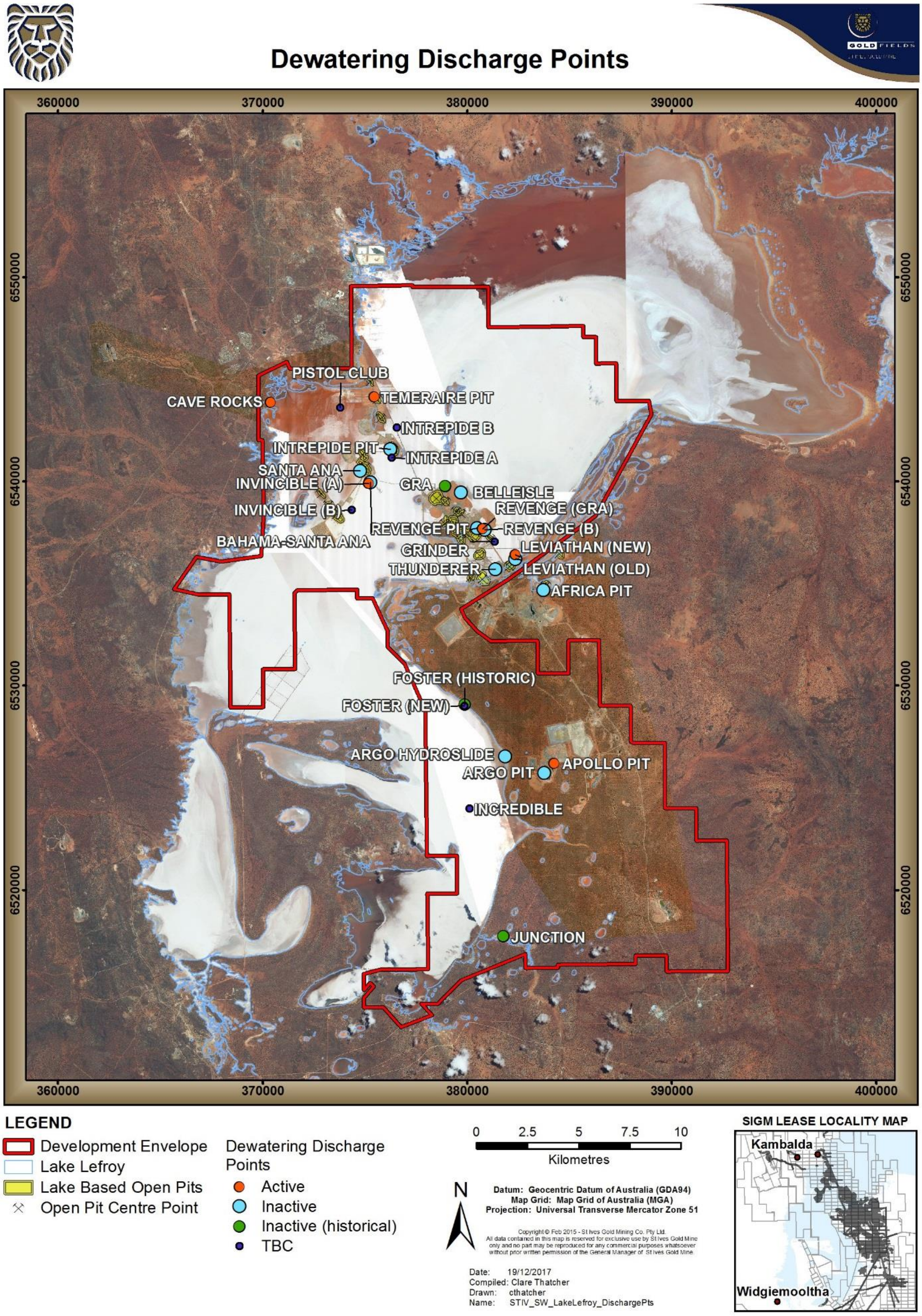

Figure 6-1: Location and status of dewatering discharge outfalls at SIGM

Figure 6-2: Indicative salt crust extents

6.2 Surface water salinity methodology

In order to qualitatively assess potential impacts of dewatering discharge and causeways on the salt balance of Lake Lefroy, a spreadsheet-based monthly water-and-salt balance model was developed, with calculations based on water quantity, salt loads and salinity assumptions.

The water-and-salt balance is based on the various lake segments impacted by the proposed B2018 operations. Inputs to the water-and-salt balance for each lake segment include:

- direct rainfall and assumed salinity concentration;
- surface water runoff from external catchment draining to each segment and assumed salinity concentration;
- dewatering discharge (from mining) and assumed salinity concentration; and
- evaporation losses.

Given the high level assessment, the focus of the water-and-salt balance is on potential change over time, providing a means of comparing potential impacts rather than absolute results.

Lake Lefroy was divided into 10 discrete segments based on the proposed B2018 footprints and causeways, as shown in **Figure 6-4**. Also shown in **Figure 6-4** are the external catchments draining to each of the lake segments.

Assumptions made to inform the water-and-salt balance assessment are summarised in **Table 6-2**.

Table 6-2: Inputs to water-and-salt balance

Component	Unit	Value
Lake segment areas	km^2	6 to 228
Catchment areas	km^2	0 to 2172
Surface water runoff salinity concentration	mg/L	200
Rainfall salinity concentration	mg/L	30
Dewatering discharge concentration[1]	mg/L	260,000
Initial lake salinity concentration	mg/L	260,000
Evaporation factor	%	40
Salt crust density	kg/m^3	2,500

1. dewatering discharge concentration based on hydrogeological modelling (Stantec 2017)

The following additional assumptions were made:

- Indicative starting water levels of 0.1 m in all lake segments in order to set initial salt loads.
- Causeways contained no culverts to allow surface water flow between segments, i.e. both runoff and dewatering discharge volumes would be contained within the respective segments.
- A numerical groundwater model (Stantec 2017) was developed to estimate potential volumes of discharge for the B2018 development period of 2017 to 2028. Historical monthly rainfall for the period 2004 to 2015 was used as proxy for the future rainfall. Rainfall from the same period was used for the balance calculations.

- The groundwater model was used to predict dewatering discharge volumes associated with the B2018 project and discharged onto the lake. These monthly volumes were used in the balance calculations (**Figure 6-3**).
- Dewatering discharge locations were assumed to be in the larger lake segments (segments A, E and J in **Figure 6-4**). Final discharge locations are yet to be decided.
- The loss of salt due to windschief and aeolian transportation, as well as infiltration / leakage of surface water to the underlying aquifers, is minimal.
- The loss of water and salt to the subsurface is minimal or negligible due to the limited available storage (the groundwater level is close to the ground surface in the lake area).
- Change in salt load and concentration will be evenly spread throughout the various lake segments, i.e. results are averaged over the segment area and not limited to the extent of likely diffusion around the dewatering discharge location.
- Depth of the salt crust varies throughout the lake. Limited information is available on the distribution of salt crust depths across the lake. This assessment focussed on potential increase in salt crust as a result of B2018 dewatering discharge volumes.

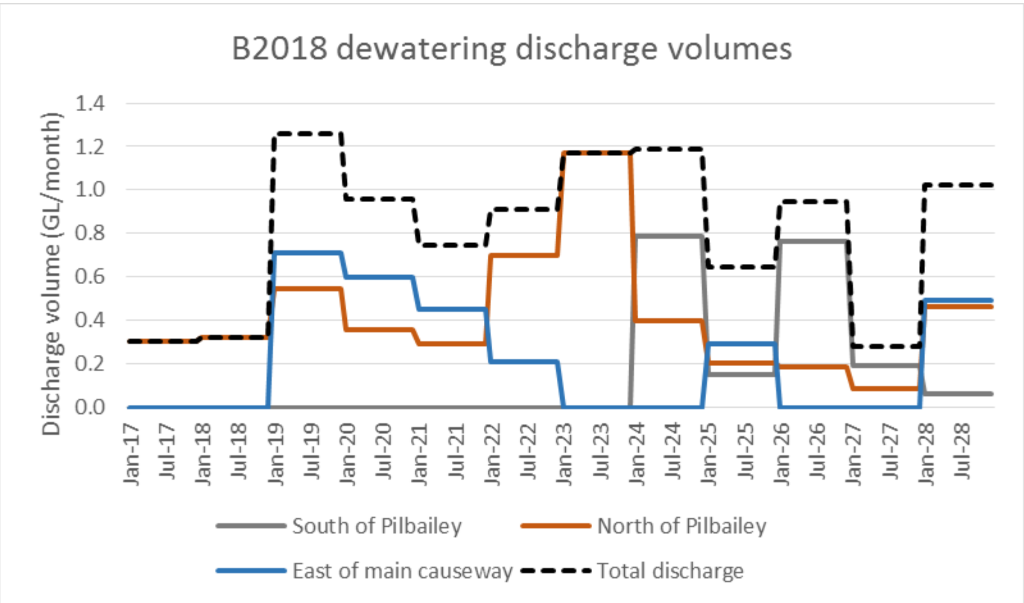

Figure 6-3: Predicted B2018 monthly dewatering discharge volumes

Salt load calculations were based on standard non-dynamic mass balance formulas. These formulas use volumetric inputs, such as rainfall, runoff and lake volumes, along with concentration of solute, such as TDS. The mass balance calculation for the salt load in Lake Lefroy is as follows:

M_{salt} (total) = M_{salt} (current) + M_{salt} (rainfall) + M_{salt} (runoff) + M_{salt} (groundwater discharge)

where M_{salt} = mass of salt calculated as (volume of solution x TDS concentration).

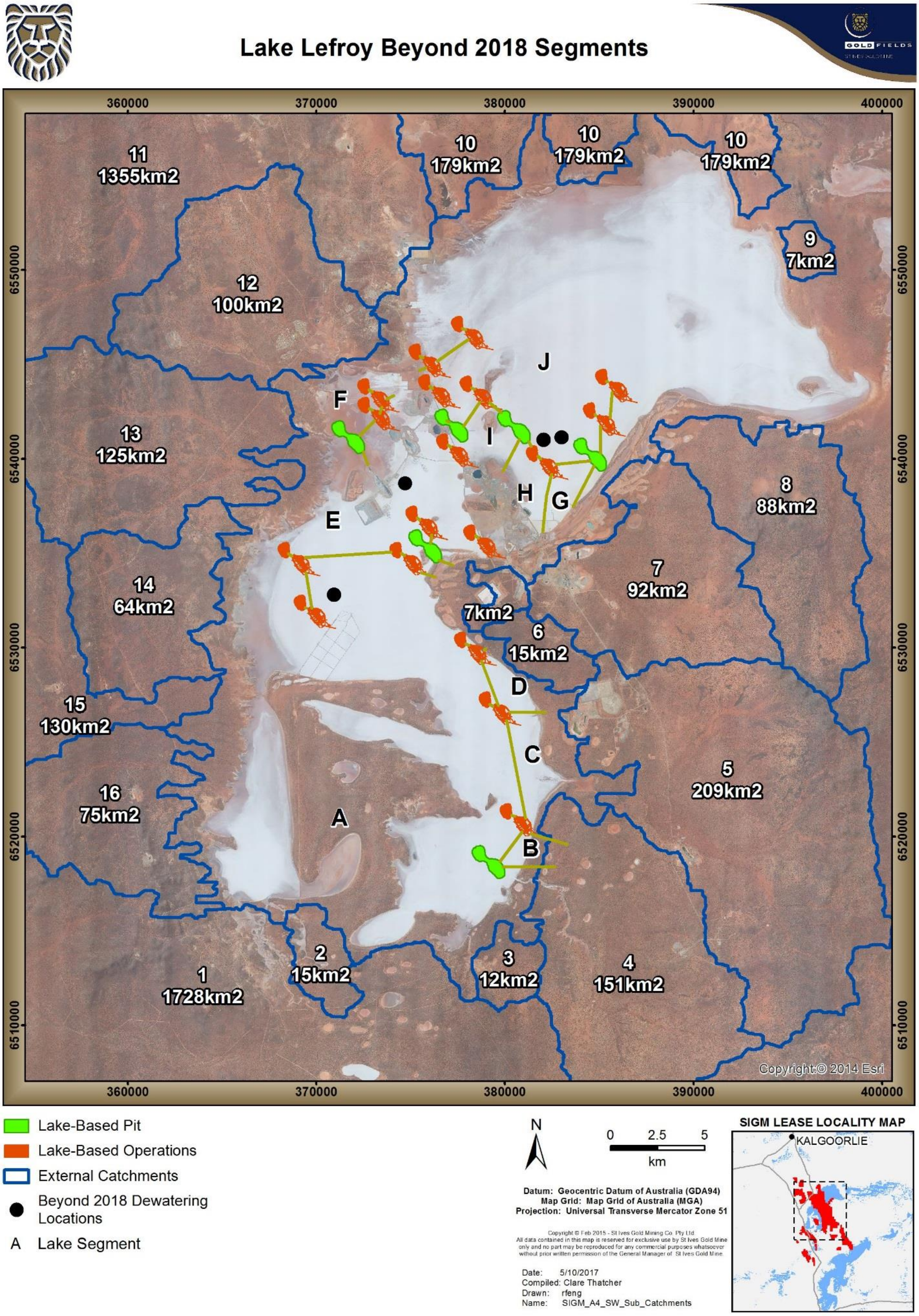

Figure 6-4: Lake Lefroy discretised segments based on B2018 developments

6.3 Results

The impact of dewatering discharge on salt loads is demonstrated in **Figure 6-5**. The largest volume of discharge per segment occurs in the period January to September 2023 (**Figure 6-4**) in the area contained by the main north-south causeway and east-west causeway at Pilbailey (**Figure 6-5** segment E). The dewatering discharge results in an additional load of 305,000 T/month in 2023. Similarly high loads are added to segments A and J during periods of high dewatering discharge.

Salt loads in the segments that do not receive any dewatering discharge are significantly lower; i.e., the maximum salt load in these segments occurs in segment C; however, the salt load of 1,200 T/month (in January 2027 due to the larger surface water catchment contribution) is orders of magnitude smaller than the salt loads in segments A, E and J.

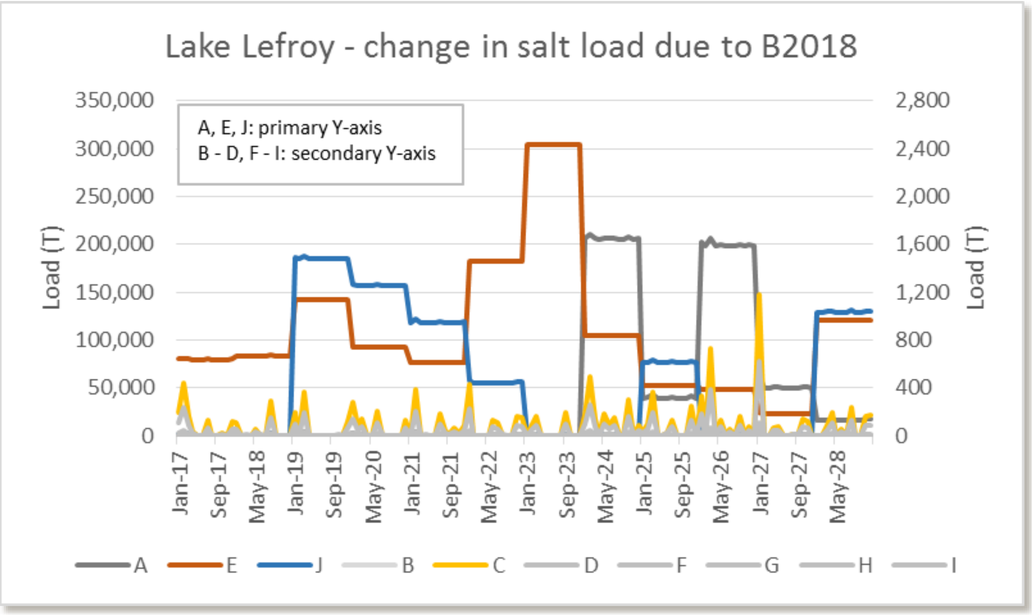

Figure 6-5: Change in salt load within Lake Lefroy segments

The predicted cumulative salt load as a result of B2018 dewatering discharge is estimated to be in the order of 31 Mt (**Figure 6-6**) over the 12 year period, or an average annual load of 2.6 Mt/year. Assuming that the causeways will not contain any culverts, the salt load will be contained to the larger lake segment (A, E and J as shown in **Figure 6-4**).

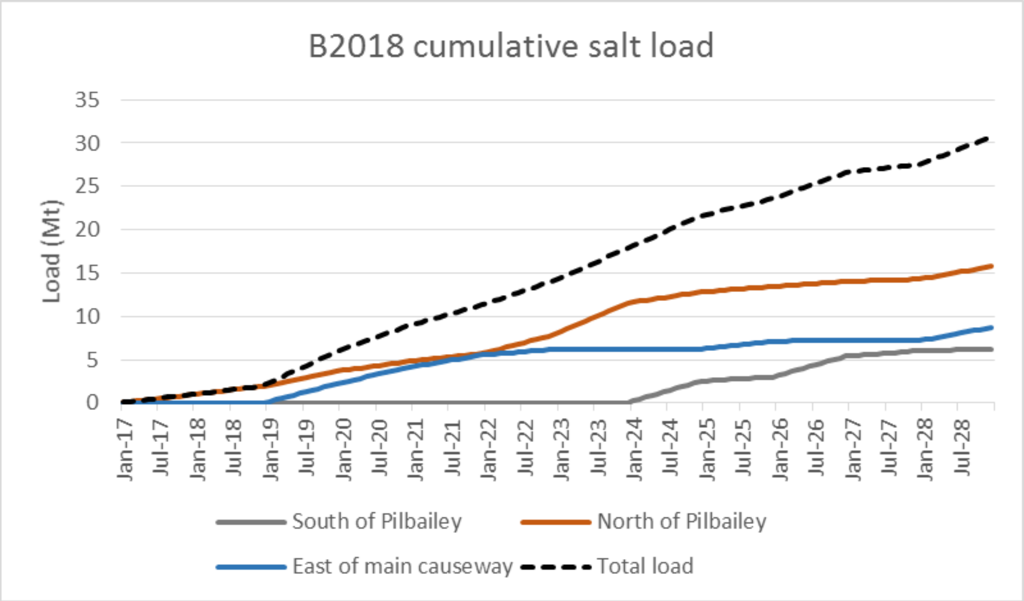

Figure 6-6: B2018 estimated cumulative salt load

The average annual salt load of 2.6 Mt/year due to B2018 dewatering discharge and based on a salinity concentration of 260,000 mg/L is approximately 40% of the 6.86 Mt associated with the B2010 scenario (URS 2010). The B2010 discharge volume was assume to be 30 GL/year, with average TDS salinities ranging between 282,000 and 386,000 mg/L.

The impact of dewatering discharge on salt loads to the various lake segments is further illustrated by comparing the salt load on a kg/m² basis. As shown in **Figure 6-7**, the maximum load into segment E over the simulated period is around 7.6 kg/m² which is significantly higher than the maximum for any of the other areas (compared to approximately 1 kg/m² for segment A and J). Segment E high load is the result of large dewatering discharge volumes onto a relatively small portion of the lake area (40 km² compared to 166 km² and 228 km² for segments A and J, respectively).

As expected, salt loads into segments not receiving any dewatering discharge are orders of magnitude smaller in comparison, with a maximum of approximately 0.1 kg/m² (segment C) over the simulated period.

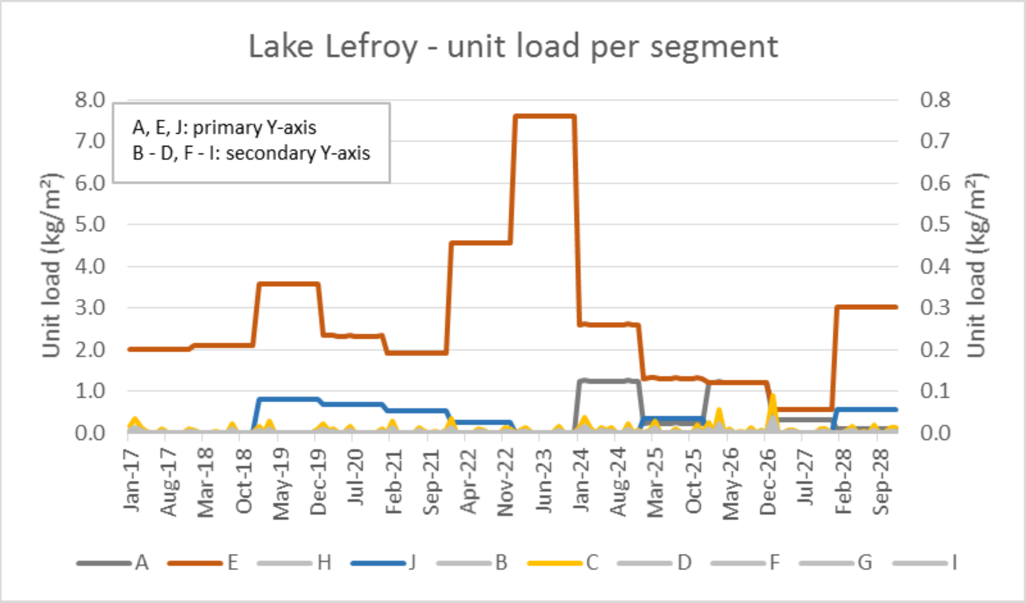

Figure 6-7: Unit load (kg/m²) comparisons

Figure 6-8 shows the contribution to Lake Lefroy salt load of the groundwater discharge, direct rainfall over the lake and inflow from external catchments, with dewatering discharge contributing 99.1% of the salt load entering the lake. Rainfall and catchment inflows contribute 0.1 and 0.7%, respectively.

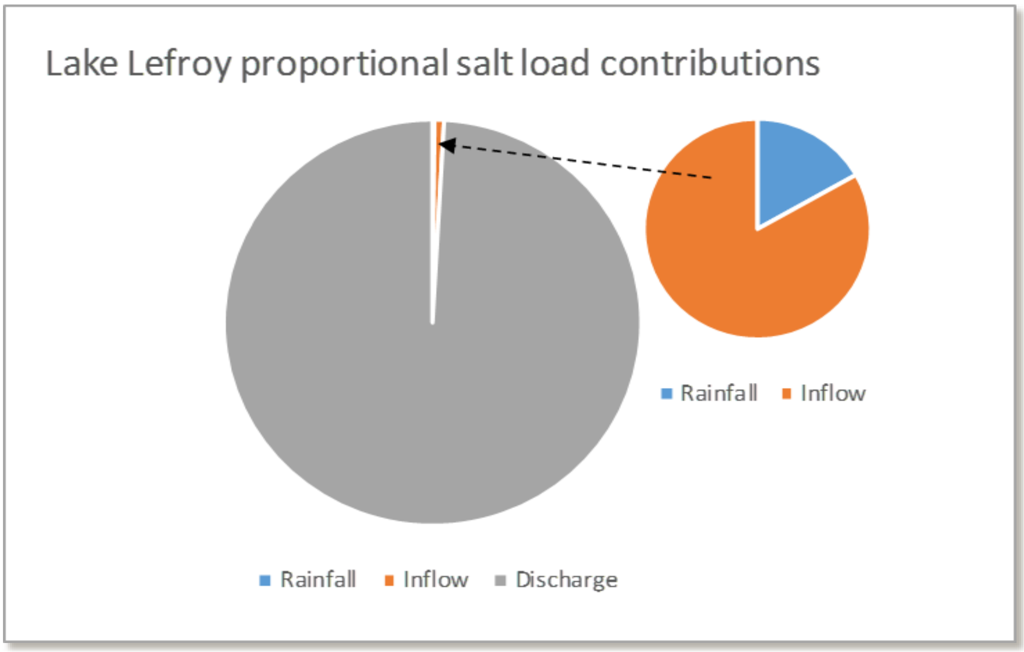

Figure 6-8: Proportional salt load contribution

Limited information is available on the salt crust present on Lake Lefroy, based mainly on sampling related to historical discharge and reference sites during flooded conditions. The most obvious impact of mine dewatering discharge is the presence of a thick salt crust on the lake's surface; however, due to limited baseline data it is difficult to determine the extent of the impact that is directly related to dewatering discharge (MWH 2016).

The thickness of the salt crust has been estimated to range from 1-2 cm in areas remote to the discharge locations, increasing to up to 10 cm in areas closer to discharge locations (Clarke 1994). Recent measurements and estimates indicate that the thickness of the salt crust has increased to around 50 – 60 cm in areas closer to the main north-south causeway, while reducing in the northern and southern extremities (MWH 2017a).

Change in salt crust thickness associated with the predicted B2018 dewatering discharge was estimated based on an assumed salt crust density of 2,500 kg/m³. The increase in salt crust thickness over the simulated period is estimated to be less than 20 mm for the larger lake segments, increasing to approximately 160 mm for the areas contained by the Pilbailey and north-south causeway (**Figure 6-9**).

It should be noted that these are averages assumed to be spread evenly across the respective segments. In reality, the crust thickness will likely increase in the deeper (central) parts of the lake and closer to the discharge locations, and decrease towards the lake shoreline.

The mass balance calculations do not take into account other potential losses such as limited infiltration of lake water to the subsurface or transport of salts from the lake surface by wind – both are considered to be minor compared to dewatering discharge and the occasional surface runoff.

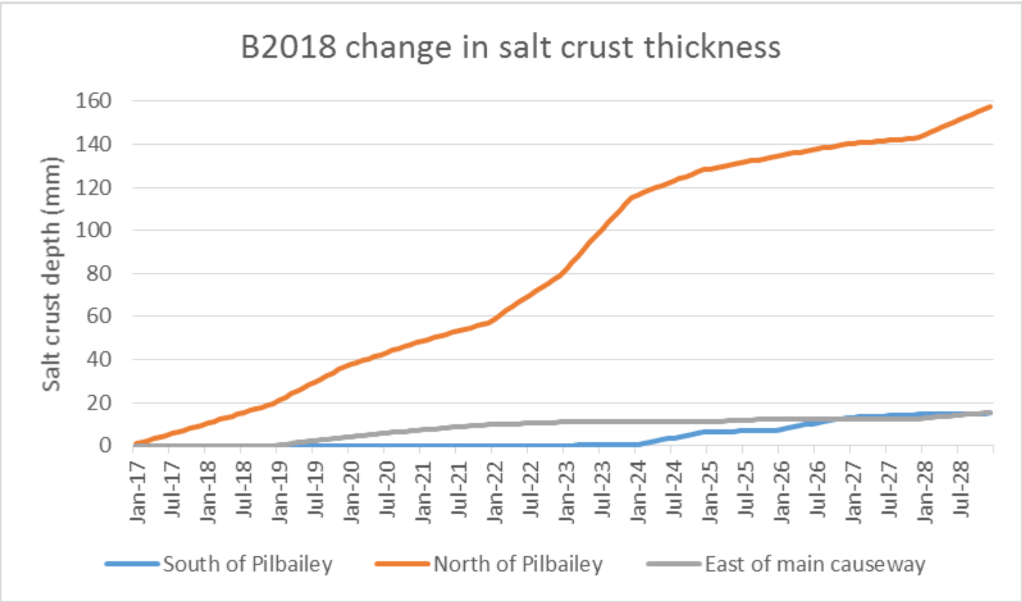

Figure 6-9: Change in salt crust thickness

The above results assumed a dewatering discharge concentration of 260,000 mg/L. Changes in the concentration and volume of the dewatering discharge, as well as location of discharge will impact changes in the salt crust thickness over time. Introduction of culverts in the causeways to allow connection between lake segments should result in the more even spread of salt loads across the lake and hence salt crust thickness. Additional monitoring is required to fully understand the full extent and depth of the existing salt crust.

Field observations (URS 2010, MWH 2017a) have found that the build-up of salt/sediment is the greatest closest to the causeway, and propagating away to the east and west from the causeway. The impacts on surface water levels in the lake are expected to be small, and similarly on the fringe vegetation communities.

7. Summary

7.1 Conclusions

The primary purpose of the results presented in this report is to inform management decisions regarding future operations and closure.

The B2018 project considers expansion of current and / or development of new lake-based and land-based areas. Only indicative footprints and locations of potential future developments were available for consideration in this assessment. If considered necessary, hydraulic models could be updated in future to reflect actual location and size of project area footprints.

Given the long history of mining at the site, pre-mining baseline information was not available. The B2016 information (lake bathymetry, salt loads, etc) was therefore assumed as the starting condition for B2018 modelling scenarios and impact assessment. Note that although assessments were undertaken for B2010 and the original project in 2000, the baseline for B2018 is assumed to be B2016 as the B2010 and 2000 projects were assessed as separate projects.

Lake Lefroy is assumed to overlay a clayey lacustrine mixture of sediments, highly heterogeneous in its properties. Due to its clayey nature and the presence of precipitated salt crust, the interaction between groundwater and occasionally available surface water in the lake is limited, driven by low permeability of this layer (Stantec 2017). Limited surface water groundwater interaction is therefore expected within Lake Lefroy.

The hydraulic modelling presented in this report supports the conclusion that the differences between dewatering scenarios do not contribute to significant differences in water surface elevation across Lake Lefroy or inundation levels of vegetation along the fringes of Lake Lefroy.

Very large differences in inundated area are apparent between the alternatives assessed in this report; however, the depth differences associated with these are generally relatively small. Most of the differences lie within the flat lake bed area. Along the lake fringe where vegetation is present, the primary differences between scenarios arise from sheet flow that enters the lake rather than ponded water from the lake itself. There is insignificant change in predicted lake water levels based on the B2018 dewatering discharge scenarios.

The north-south causeway culverts are currently blocked. Opening these culverts or introducing new culverts would allow the water surface to balance more closely across the causeway. Some of the water surface elevations become ponded behind the existing and proposed B2018 causeways as indicated by the water surface elevation profiles presented in this report. This can result in substantial differences in water surface elevations contained by the causeways and the larger lake surface area. The introduction of culverts in these causeways will increase the flow connection to the larger lake areas. Further assessment and optimisation may be required to support detailed design of causeway culverts.

Limited information is available on the salt crust present on Lake Lefroy. Due to limited baseline data it is difficult to determine the extent of the impact that is related to dewatering discharge. The thickness of the salt crust has been estimated to range from 1-2 cm in areas remote to the discharge locations, increasing to up to 10 cm in areas closer to discharge locations (Clarke 1994). Recent measurements (URS 2010, MWH 2017a) and estimates indicate that thickness of the salt crust has increased to around 50 – 60 cm in areas closer to the main north-south causeway, while reducing in the northern and southern extremities of the lake. The focus of the dewatering impact assessment is mainly on discharge locations and the immediate surrounding areas, which are located closer to the main north-south causeway and edge of Lake Lefroy, resulting in limited salt crust information across the remainder of the playa surface.

The presence of causeways to support the B2018 operations can have impacts on local water surface elevations and salinity, intercepting fresher (lower salinity runoff) from the external catchments. The use of culverts can be considered for the purpose of balancing surface water across the lake and allowing fresher catchment runoff to reach the larger Lake Lefroy surface areas.

Mine dewatering discharge volumes generate most of the salt load on the lake. While the external catchments are important for supplying fresher surface water inflows to the lake and supporting the lake hydrology, the lake salt load is largely generated from the existing hyper saline salt crust and dewatering discharge of hyper saline water.

The B2018 land-based operations are expected to have an insignificant impact on the Lake Lefroy surface water regime. The proposed B2018 land-based operations will impact a catchment area of approximately (230 km²), which is approximately 8.7% of the western extent of the Lake Lefroy extent catchment area (of 2630 km²), or 5% of the Lake Lefroy total catchment area of approximately 4350 km². Considering that surface water management measures such as flow diversion will be implemented during operations, most of the runoff volume will still reach Lake Lefroy, albeit with some flow attenuation.

The modelling results presented in this report can be used to inform management decisions in support of the B2018 project.

7.2 Assessment of potential impacts/opportunities and management strategies

A summary of potential impacts and recommended management strategies is outlined in **Table 7-1**.

Table 7-1: Potential impacts and opportunities associated with B2018 project

	Potential impact	Description	Management strategy
1	Dewatering discharge onto Lake Lefroy	Due to the hypersaline character of dewatering discharge to be disposed onto the lake surface, further salt encrustation has the potential to develop on the already salt encrusted playa. A potential rate of approximately 200,000 tonnes per month is estimated to be deposited onto the lake footprint. Due to the large size of the lake this is estimated to raise the encrustation level of the lake by several millimetres over the B2018 lifespan.	Undertake further characterisation program during hypersaline disposal to understand and document the formation of encrusted mound. Continue aquatic life monitoring. Regularly monitor discharge salinity and quality. Consider modelling of spatial encrustation distribution when numerical tools are available. No numerical tools are currently available to model the spatial encrustation distribution with confidence.
2	Dewatering discharge onto Lake Lefroy	Continued dewatering discharge will likely result in an increase in salt crust extent on Lake Lefroy. Limited information is available on the spatial and temporal development of the salt crust extent over time. The focus of the dewatering impact assessment has mainly been on discharge locations and the immediate surrounding areas, which are generally located closer to the main north-south causeway and edge of Lake Lefroy.	A preliminary desktop assessment of historical aerial imagery was undertaken. No clear trends or correlation between salt coverage and dewatering discharge onto Lake Lefroy were evident. Rainfall and dilution of the salt crust following rainfall events impact the visible salt crust. Further assessment of temporal development of salt crust extent based on historical aerial imagery could be considered.

	Potential impact	Description	Management strategy
			Several new mapping techniques (involving aerial imaging) may be available to assess the surface extent and depth of salt loads on the lake. The application of these techniques to the Lake Lefroy environment should be assessed. The results of salt mapping and subsequent salt modelling (if deemed appropriate) may be used to gain a better understanding of the associated risk to aquatic biota and riparian vegetation. This may need to be undertaken on an annual basis. Expand monitoring area to be more representative of the wider playa surface extent.
3	Causeways and haul roads impact lake balancing capacity	A number of additional causeways and haul roads are proposed on Lake Lefroy to provide access to operational areas. These causeways / haul roads will isolate parts of the playa surface and impact balancing capacity within the isolated areas and the lake, resulting in both elevated water levels and elevated salt loads in places.	Consider inclusion of culverts in the various causeways and haul roads to improve balancing capacity. Consider different disposal strategies, water management controls and location of dewatering discharge points.
4	Land-based operations	Land-based operations have the potential to impact surface water regimes where mining pits and operational infrastructure intersect or impact flow paths and drainage lines discharging surface water flows to Lake Lefroy.	Develop surface water management measures for implementation during operations to minimise impacts on landforms, hydrological regime and receiving environment, including Lake Lefroy. Where possible, locate operational areas away from key drainage lines.
5	Dewatering discharge onto Lake Lefroy	Ongoing discharge of hypersaline water have the potential to result in further salt encrustation, impacting bathymetry of the playa surface. Accurate lake bathymetry data will improve confidence in future surface water modelling efforts and be useful to understand nature and location of lake bathymetry changes over time.	Consider annual aerial surveys of the playa surface.

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Appendices

Appendix A Inflow Hydrographs

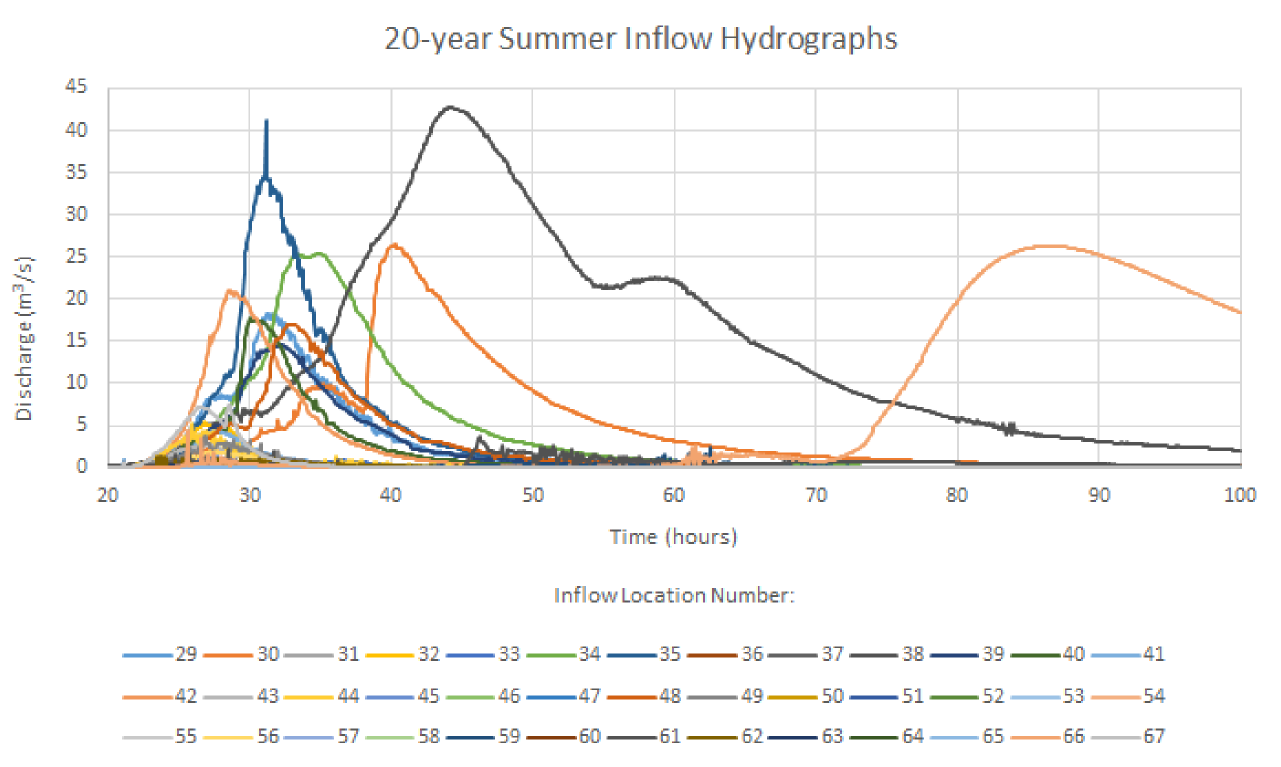

Figure A-1: 20-year summer inflow hydrographs

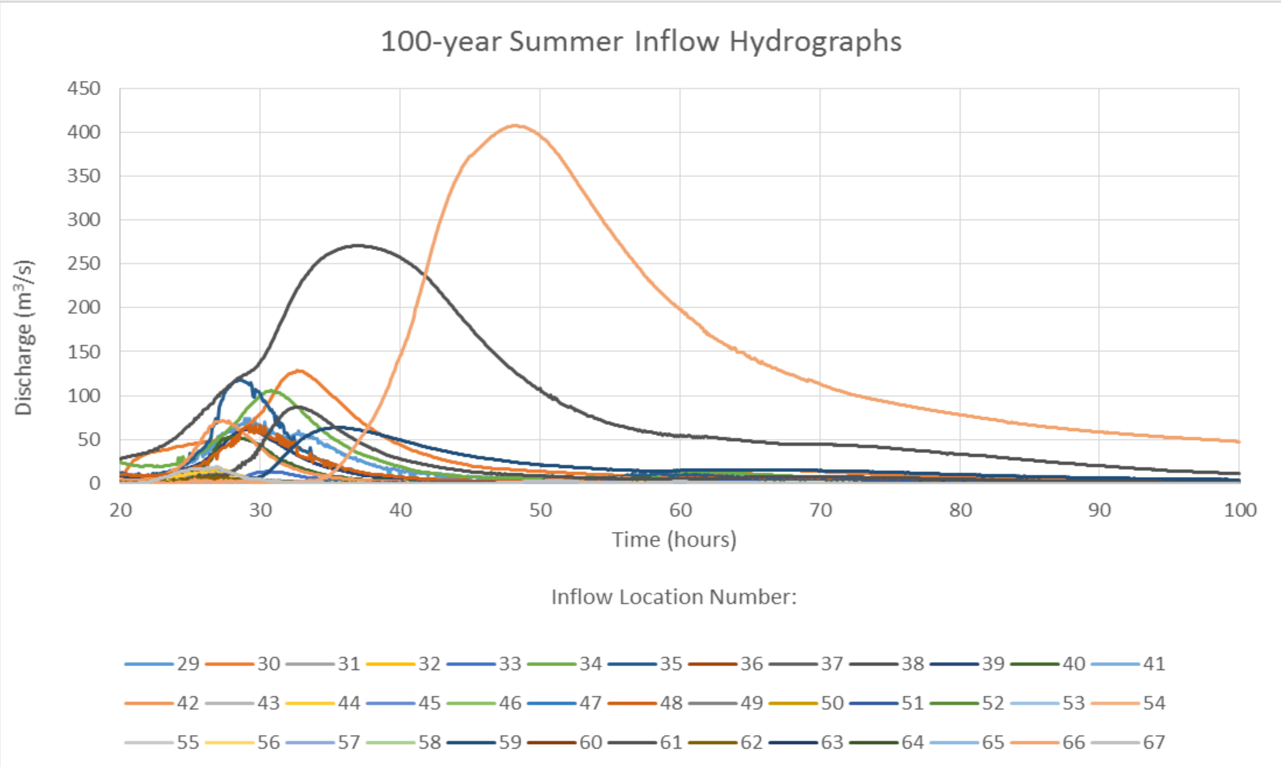

Figure A-2: 100-year summer inflow hydrographs

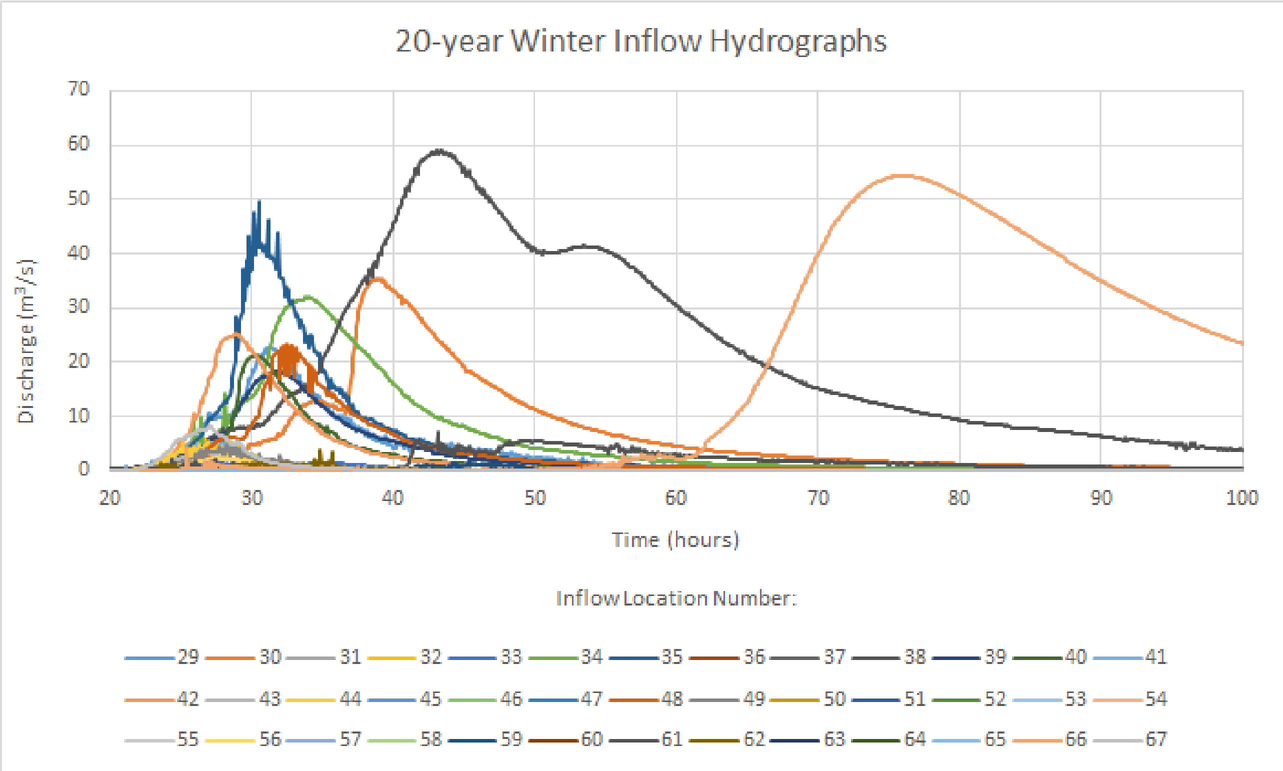

Figure A-3: 20-year winter inflow hydrographs

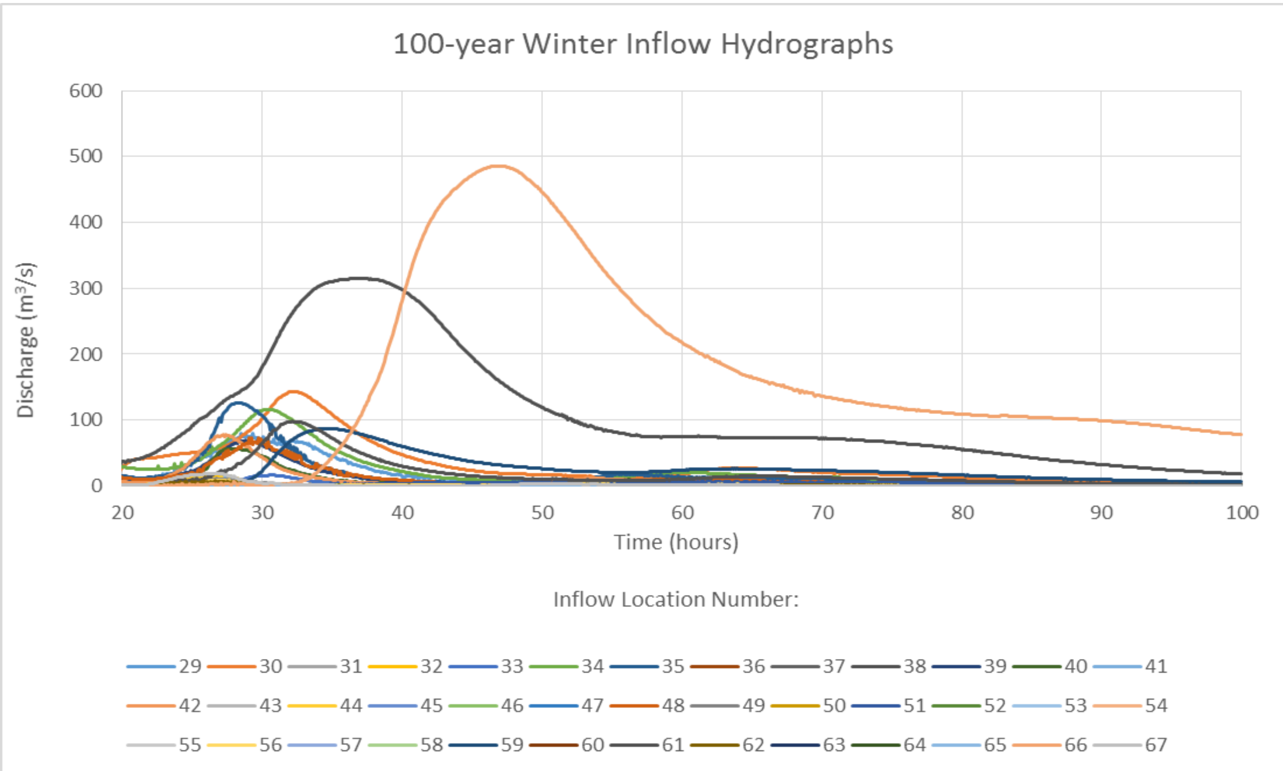

Figure A-4: 100-year winter inflow hydrographs

Appendix B Water surface profiles

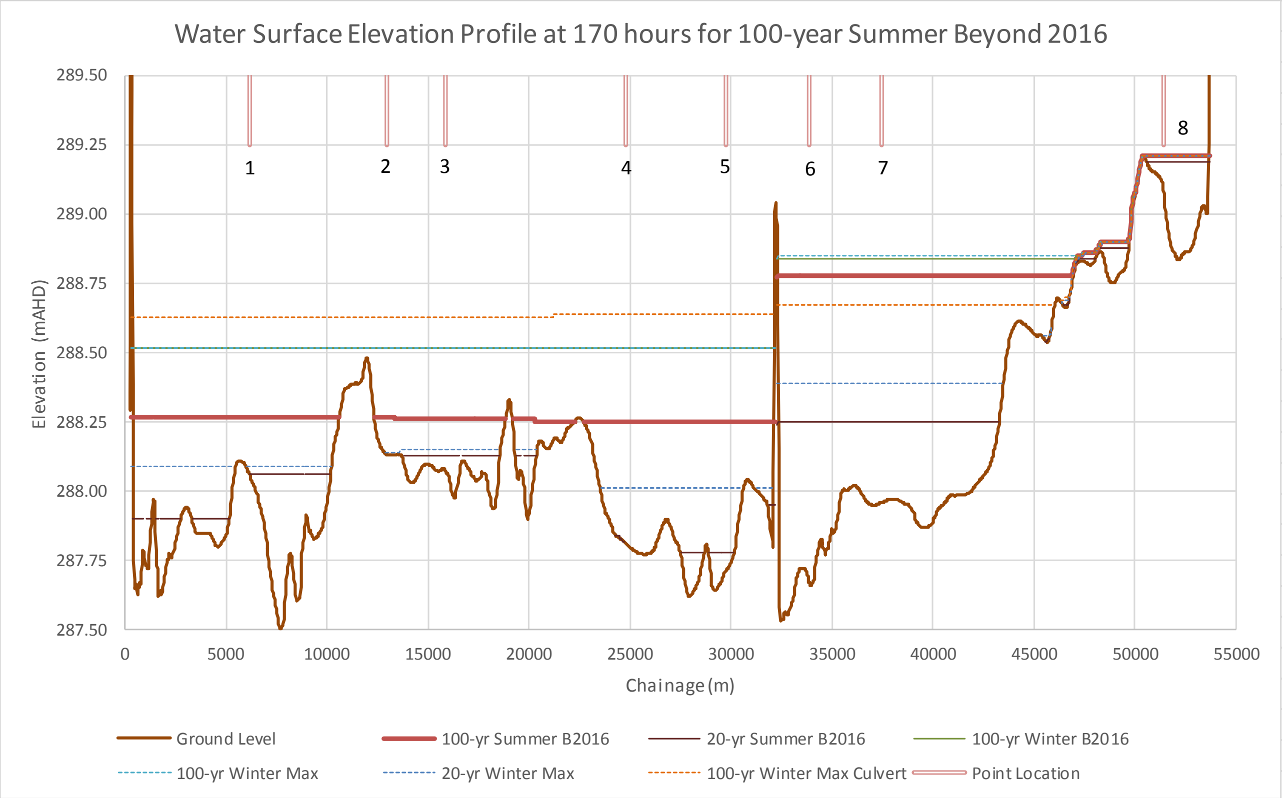

Figure B-1: Water surface profile for 100-year summer Beyond 2016

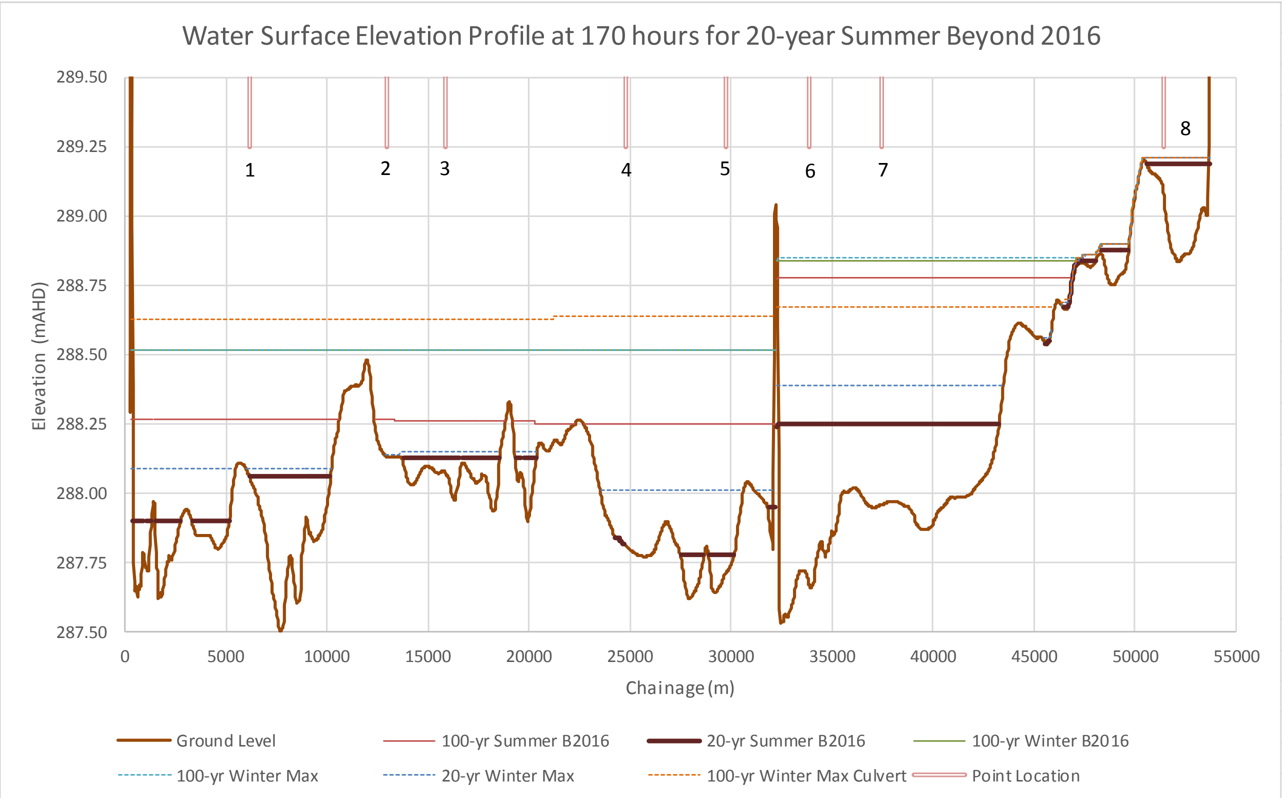

Figure B-2: Water surface profile for 20-year summer Beyond 2016

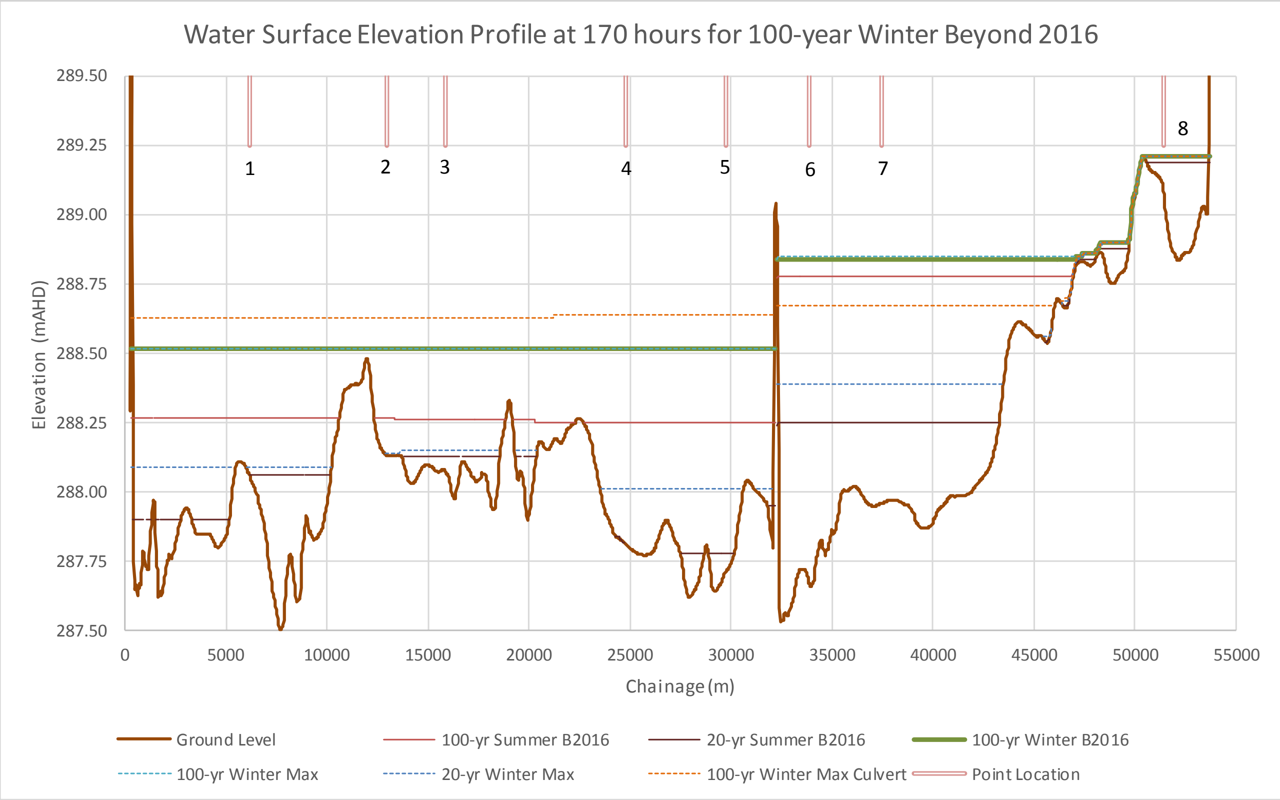

Figure B-3: Water surface profile for 100-year winter Beyond 2016

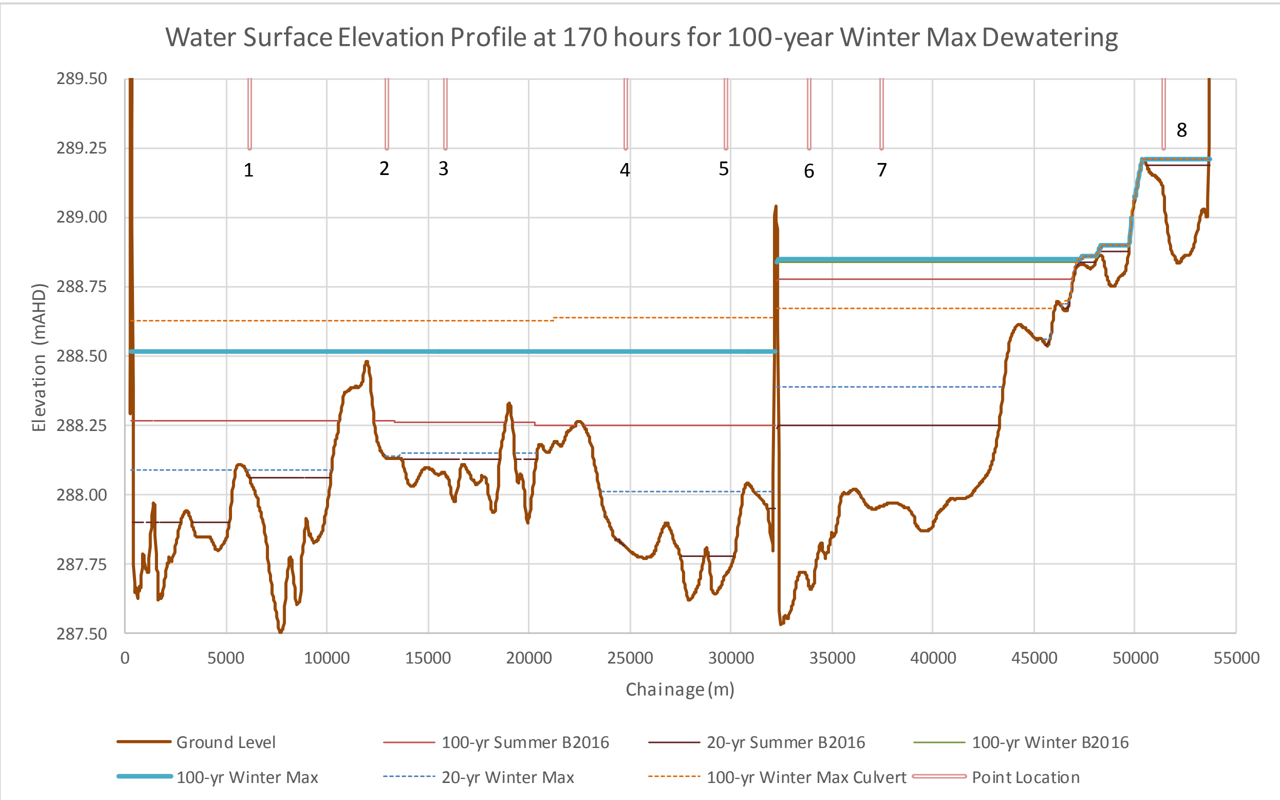

Figure B-4: Water surface profile for 100-year winter maximum dewatering with culvert

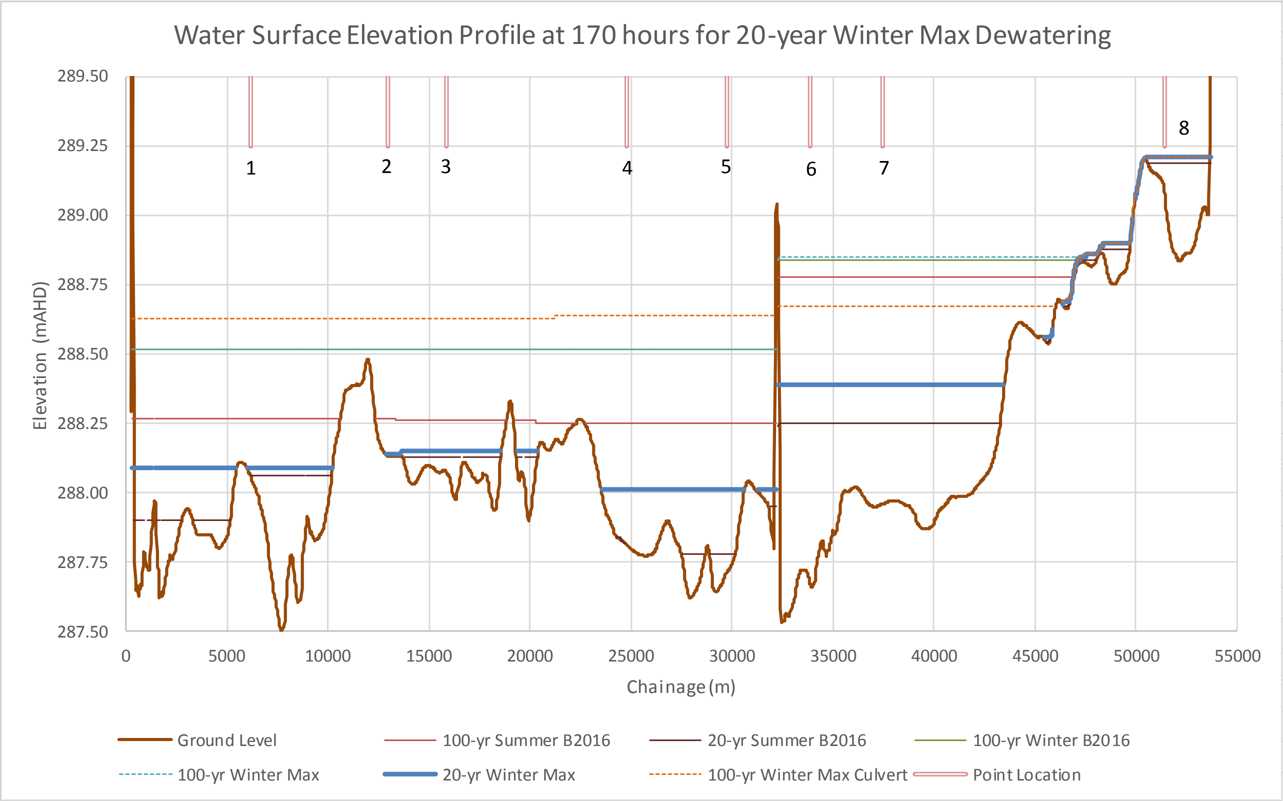

Figure B-5: Water surface profile for 20-year winter maximum dewatering with culvert

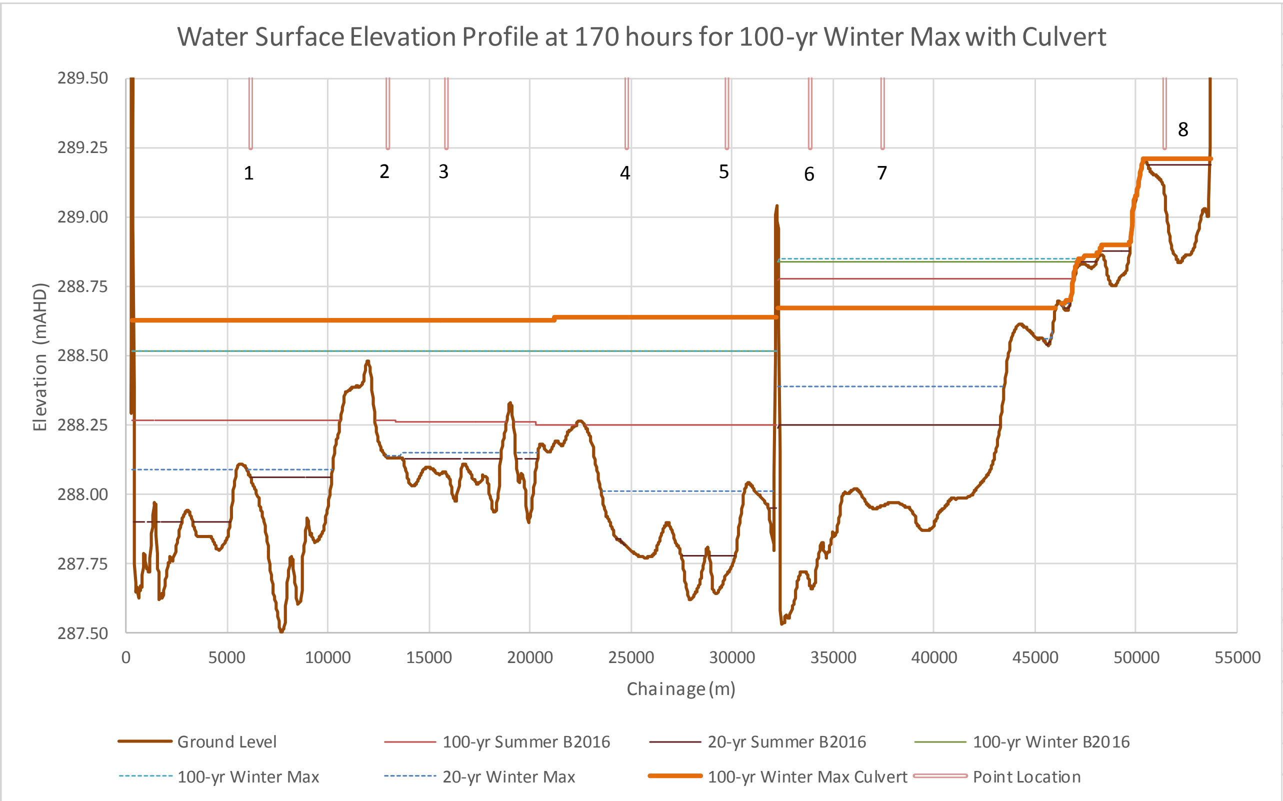

Figure B-6: Water surface profile for 100-year winter maximum dewatering with culvert

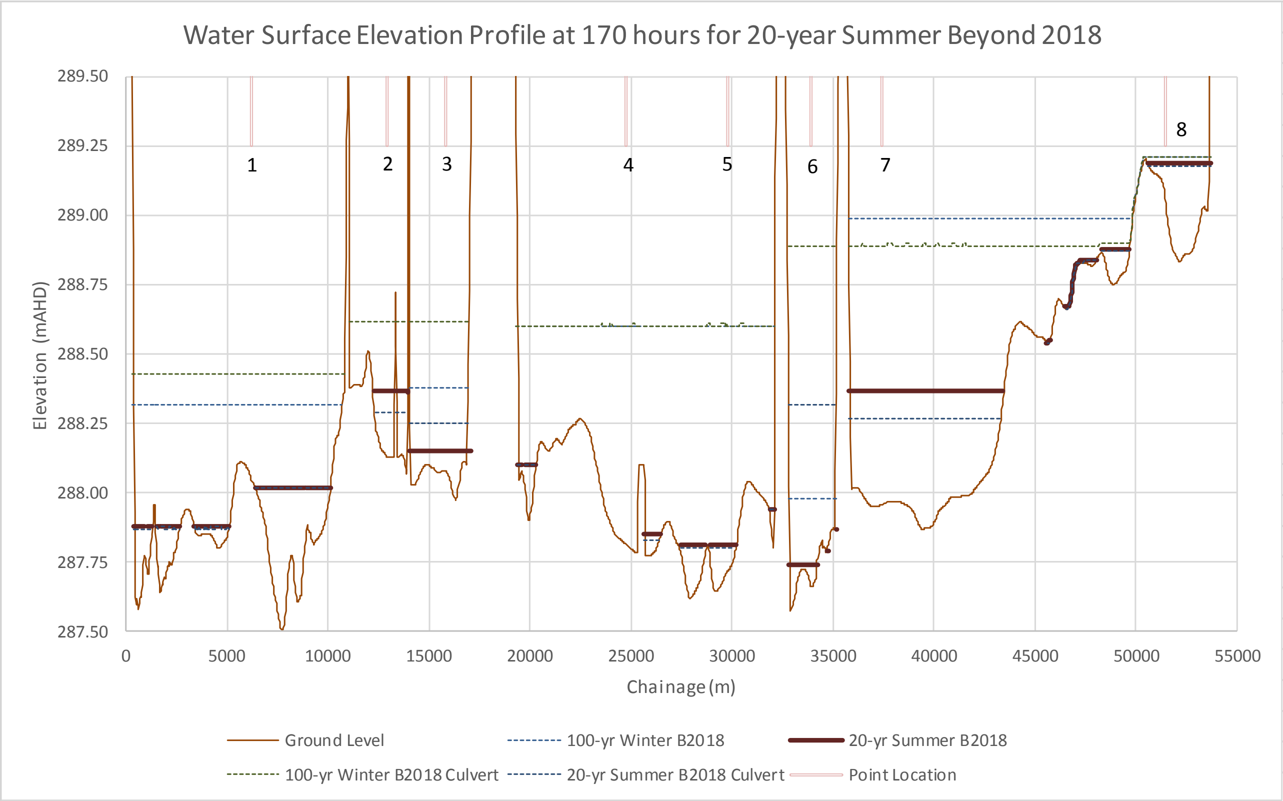

Figure B-7: Water surface profile for 20-year summer Beyond 2018

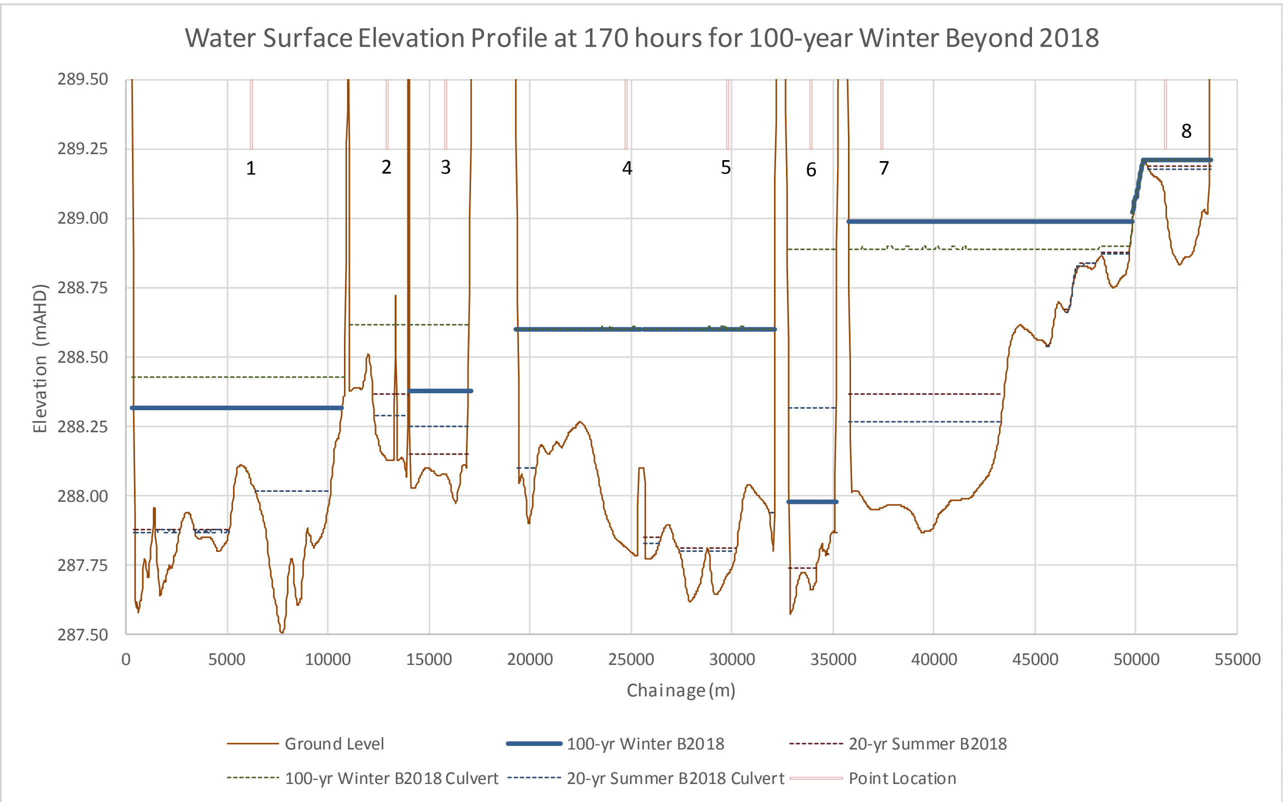

Figure B-8: Water surface profile for 100-year winter Beyond 2018

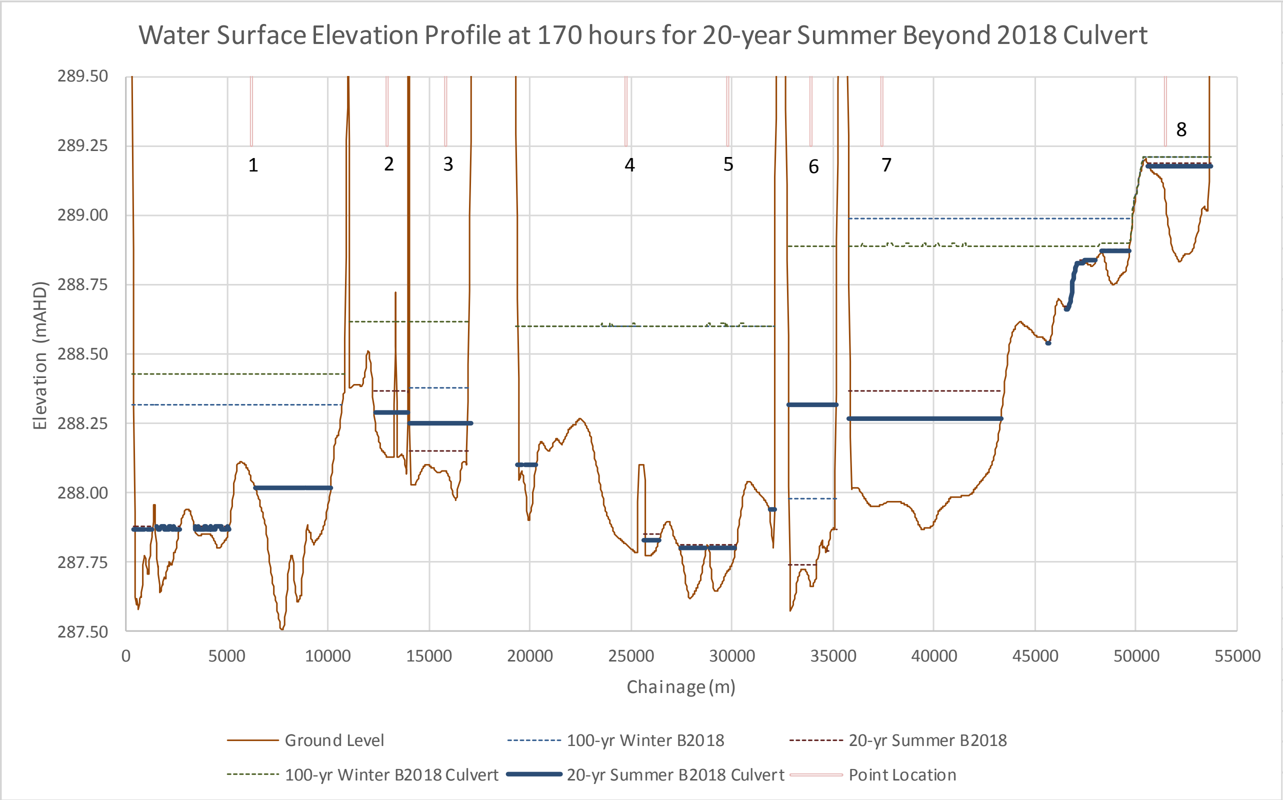

Figure B-9: Water surface profile for 20-year summer Beyond 2018 with culverts

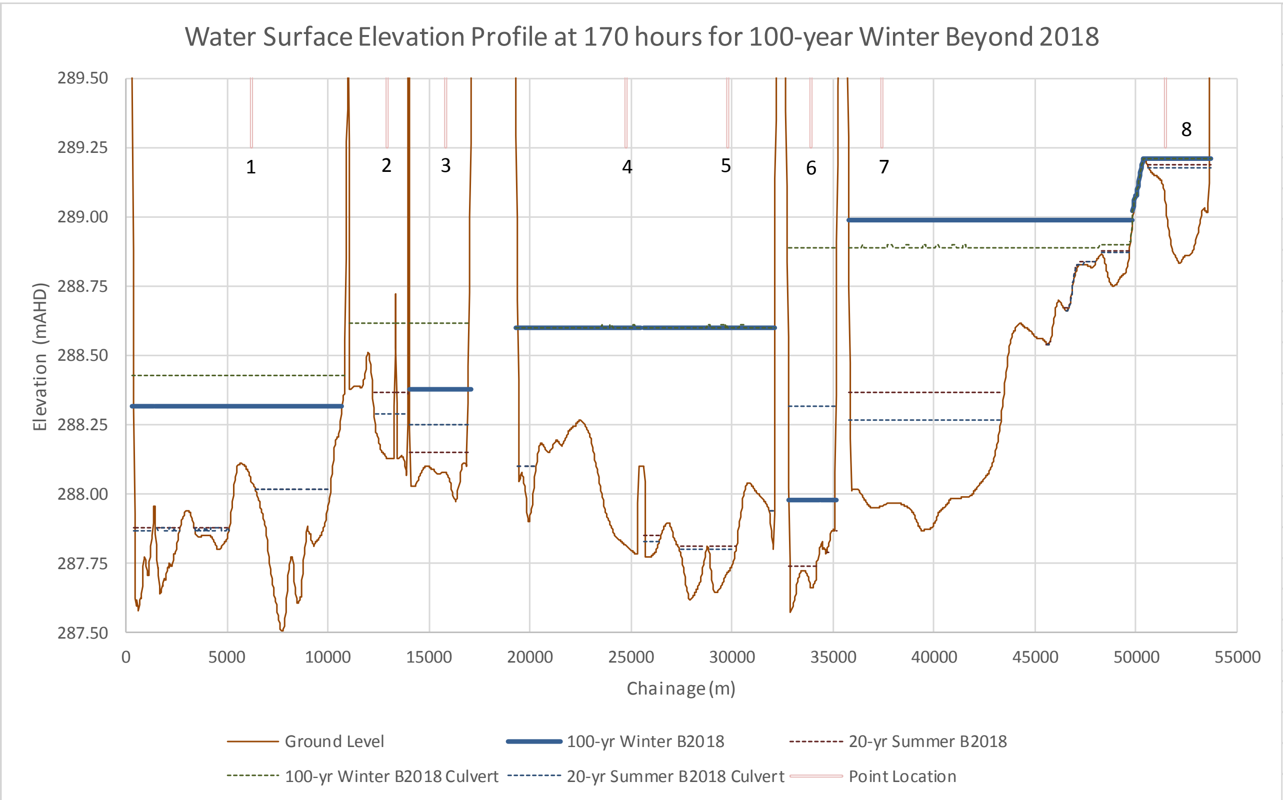

Figure B-10: Water surface profile for 100-year winter Beyond 2018 with culverts

Appendix C Time series stage hydrographs

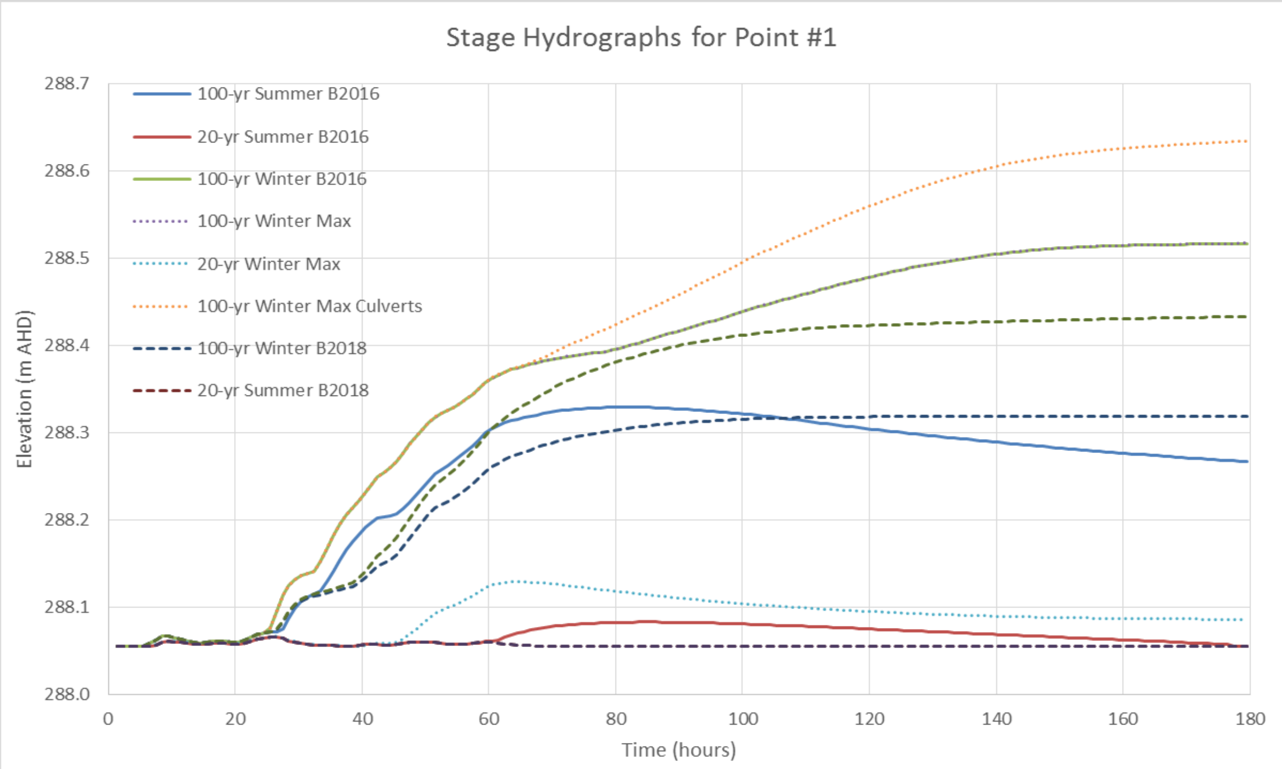

Figure C-1: Stage hydrographs for Point #1

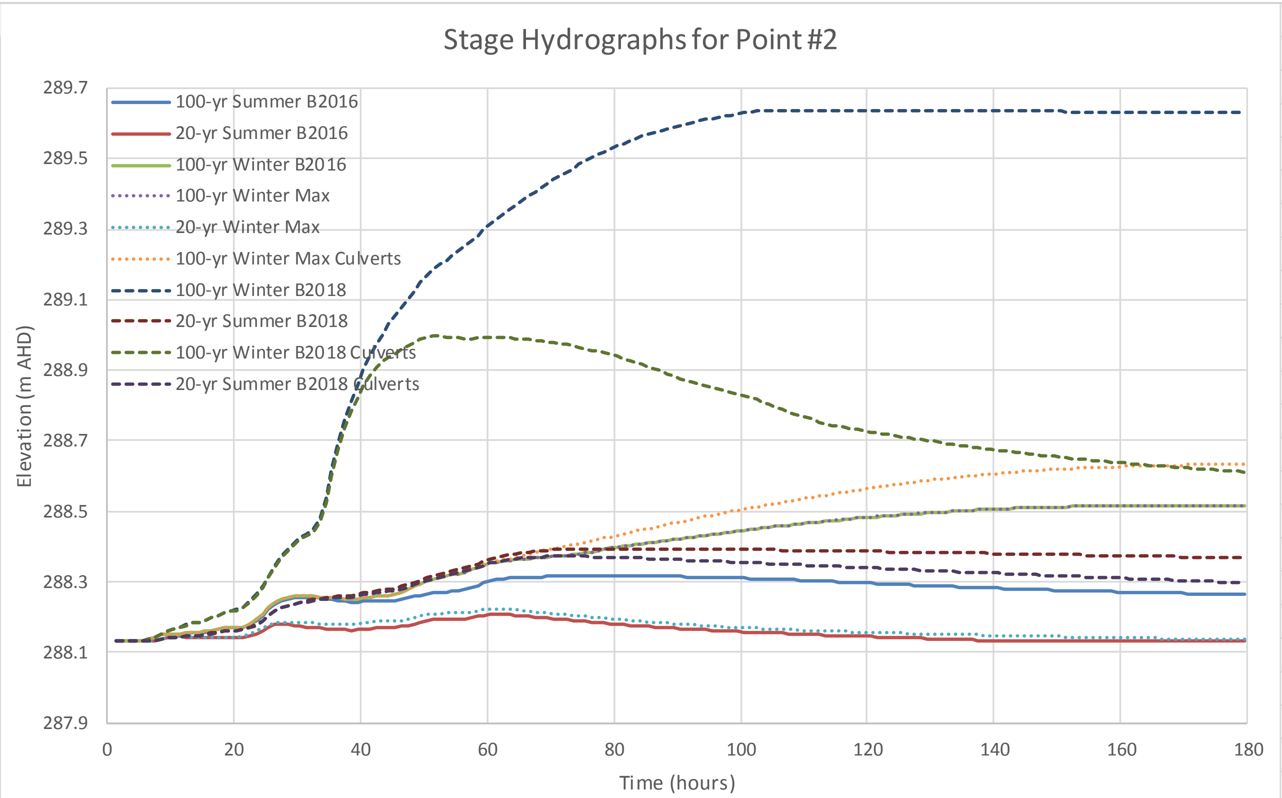

Figure C-2: Stage hydrographs for Point #2

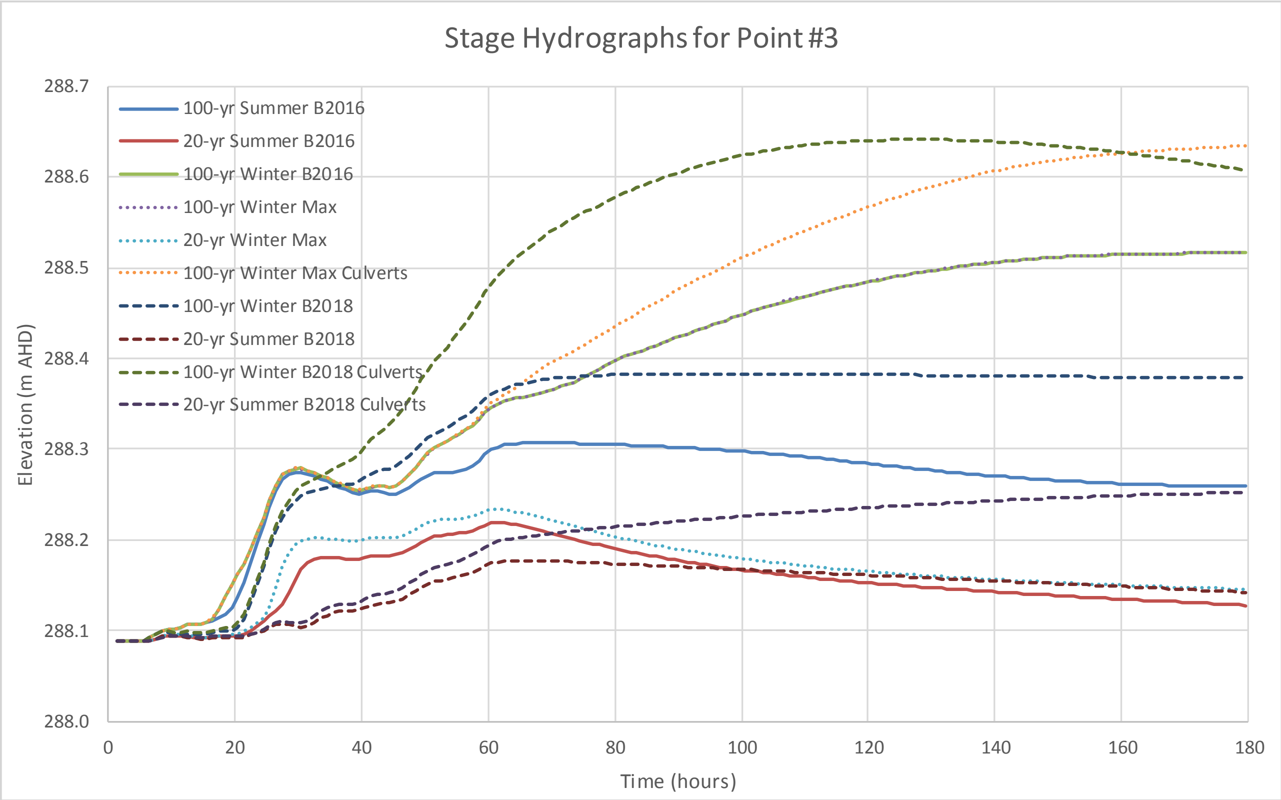

Figure C-3: Stage hydrographs for Point #3

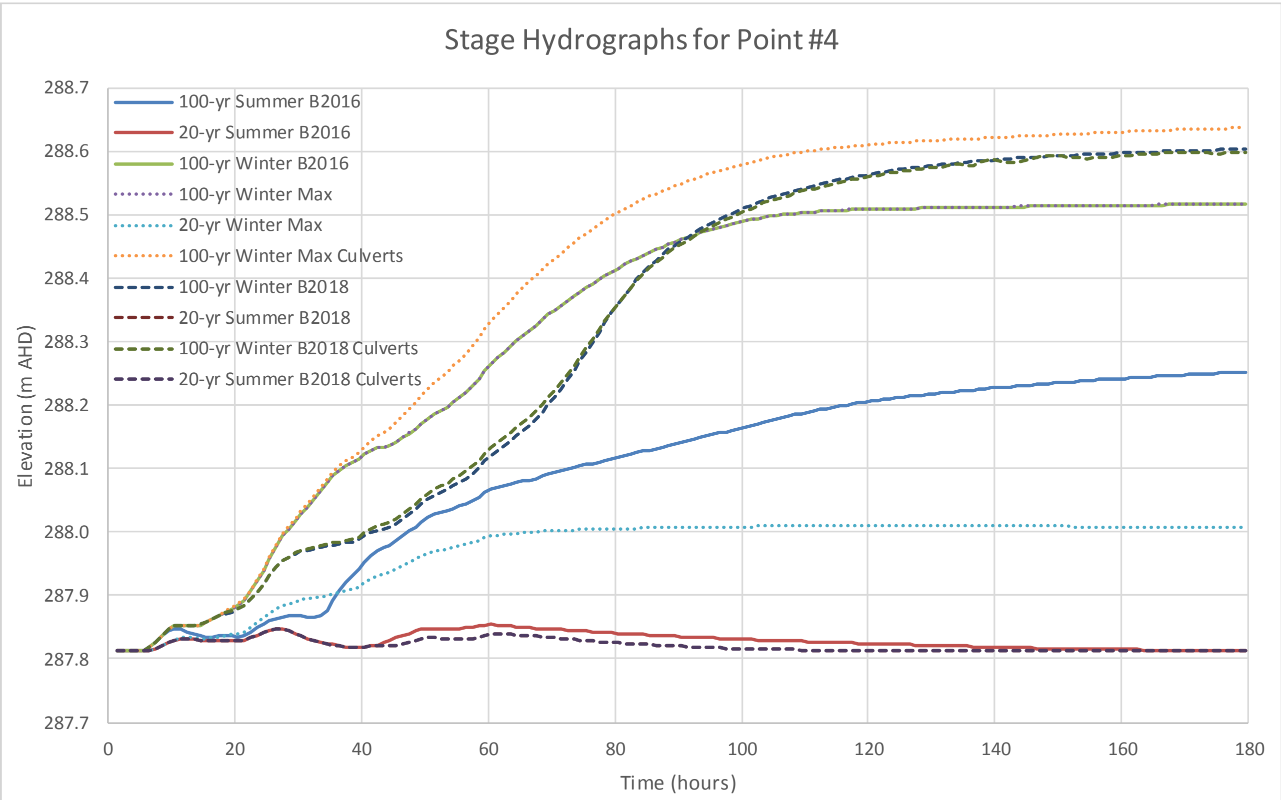

Figure C-4: Stage hydrographs for Point #4

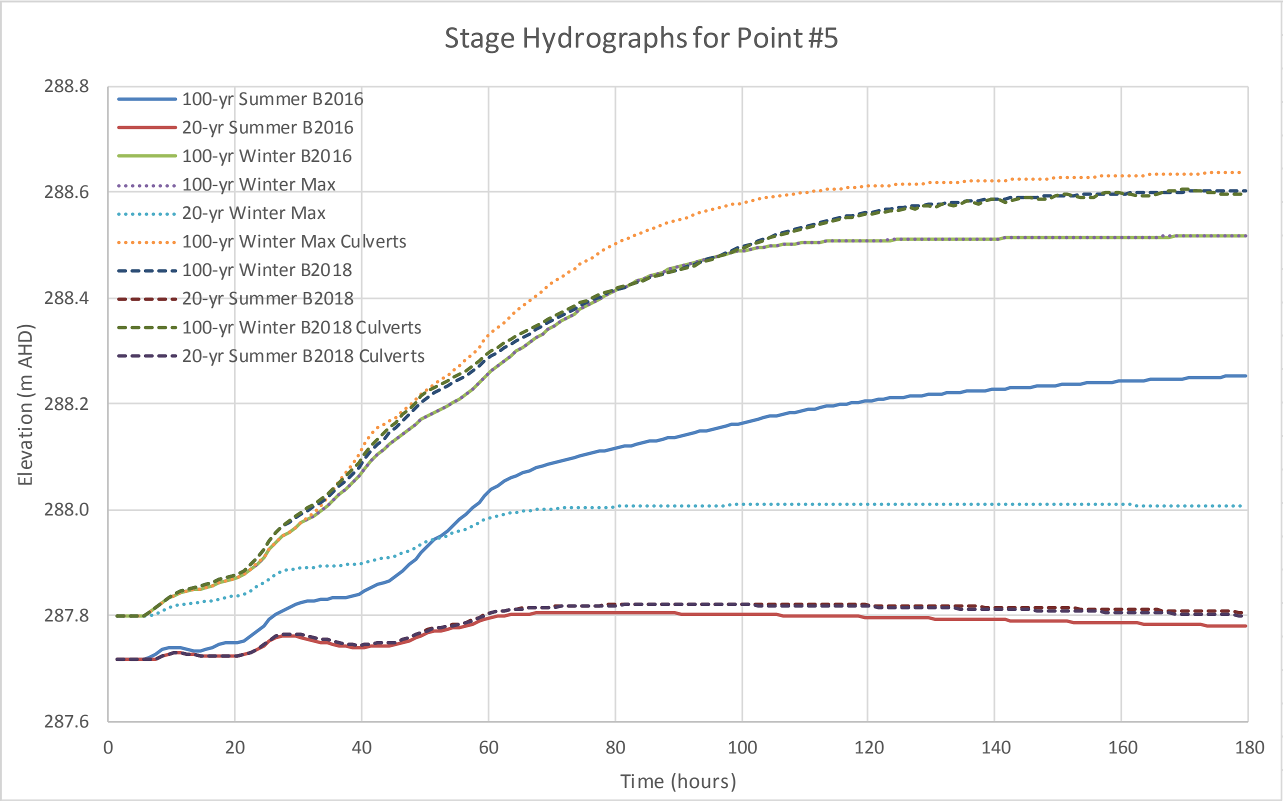

Figure C-5: Stage hydrographs for Point #5

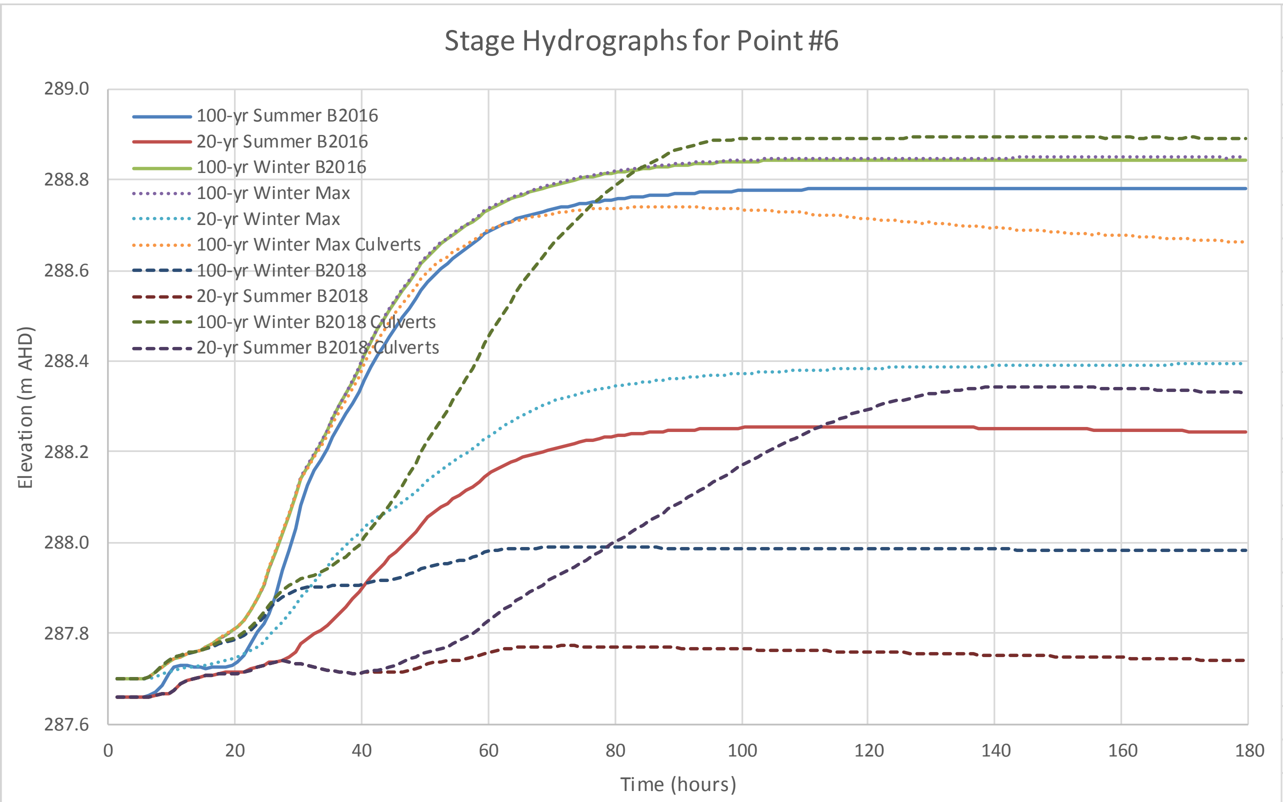

Figure C-6: Stage hydrographs for Point #6

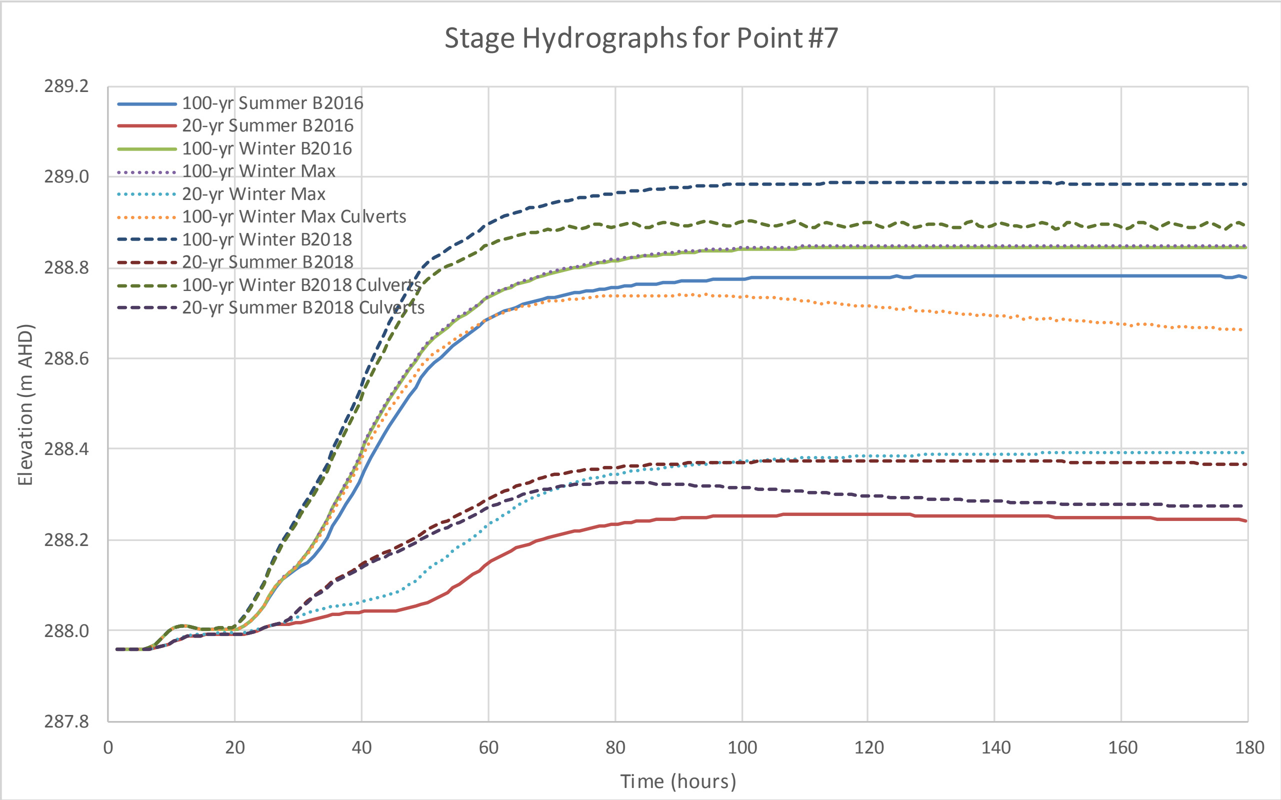

Figure C-7: Stage hydrographs for Point #7

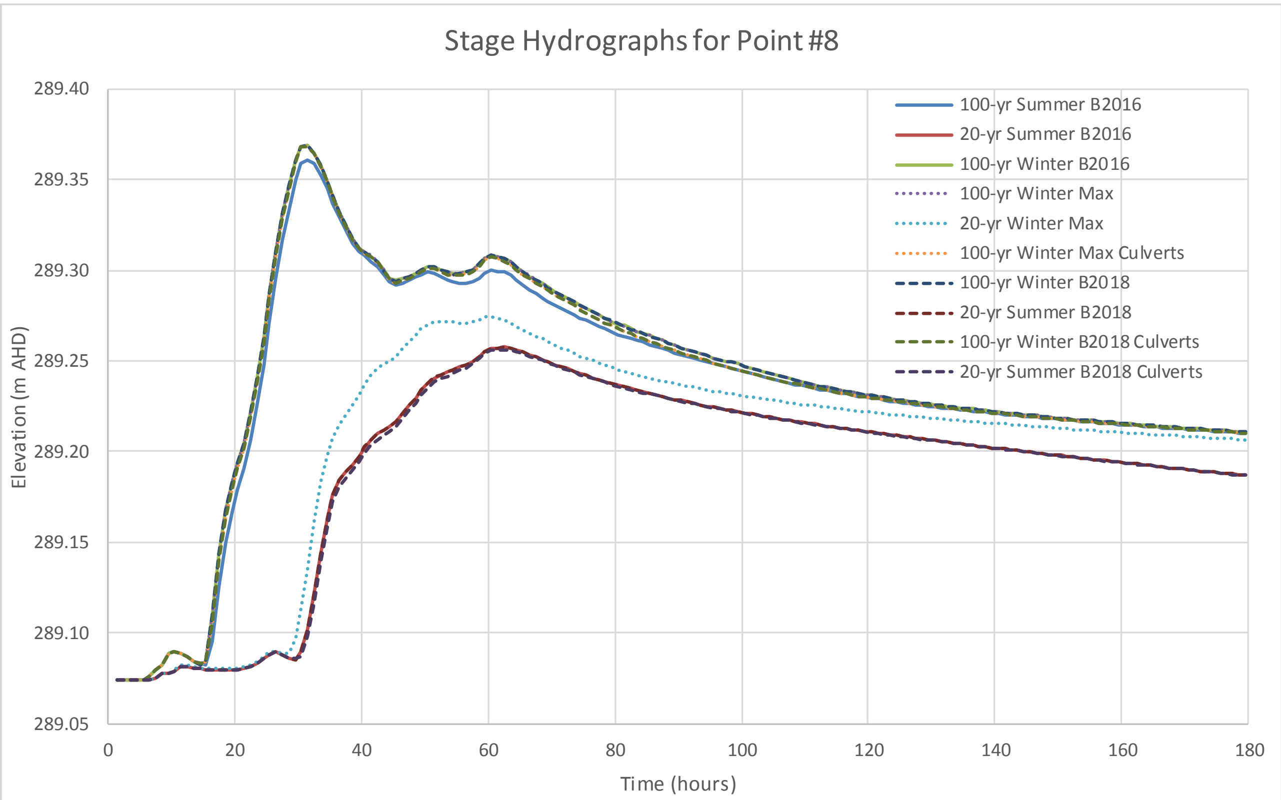

Figure C-8: Stage hydrographs for Point #8

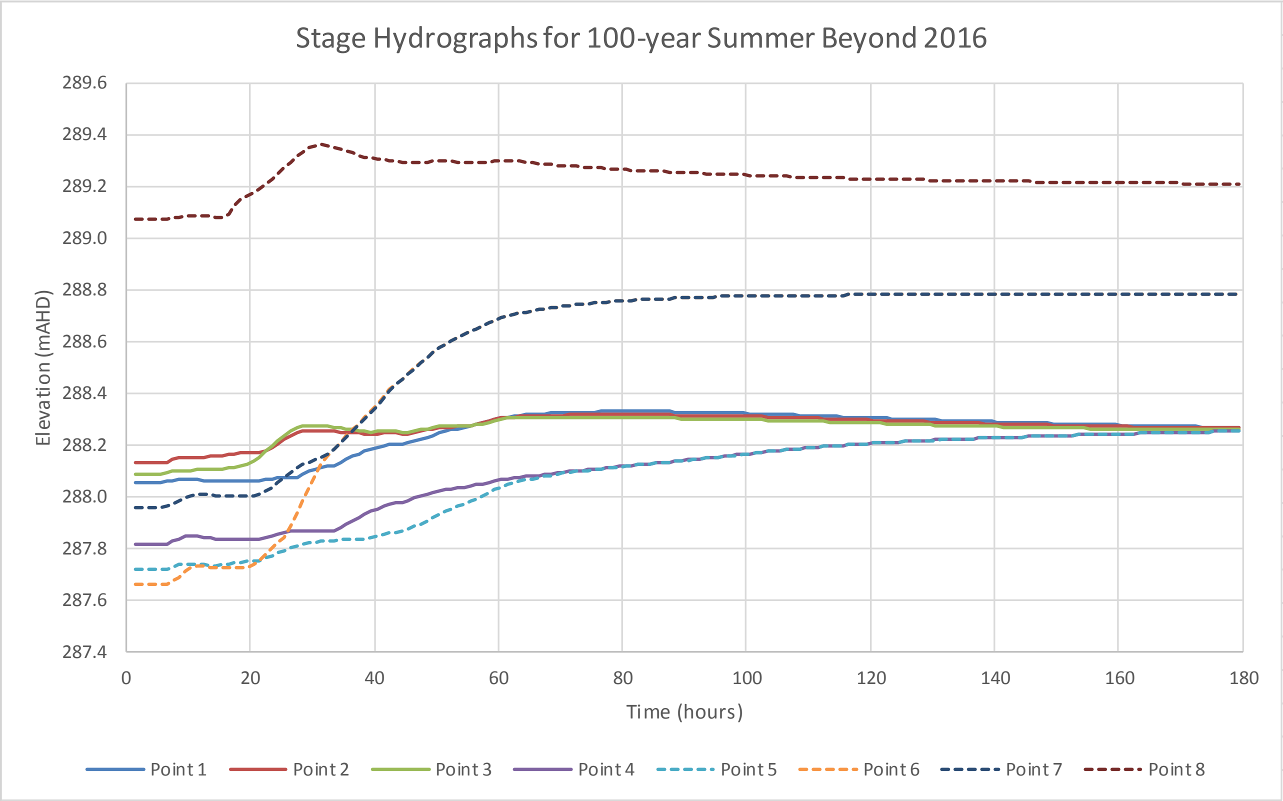

Figure C-9: Stage hydrographs for 100-year Summer Beyond 2016

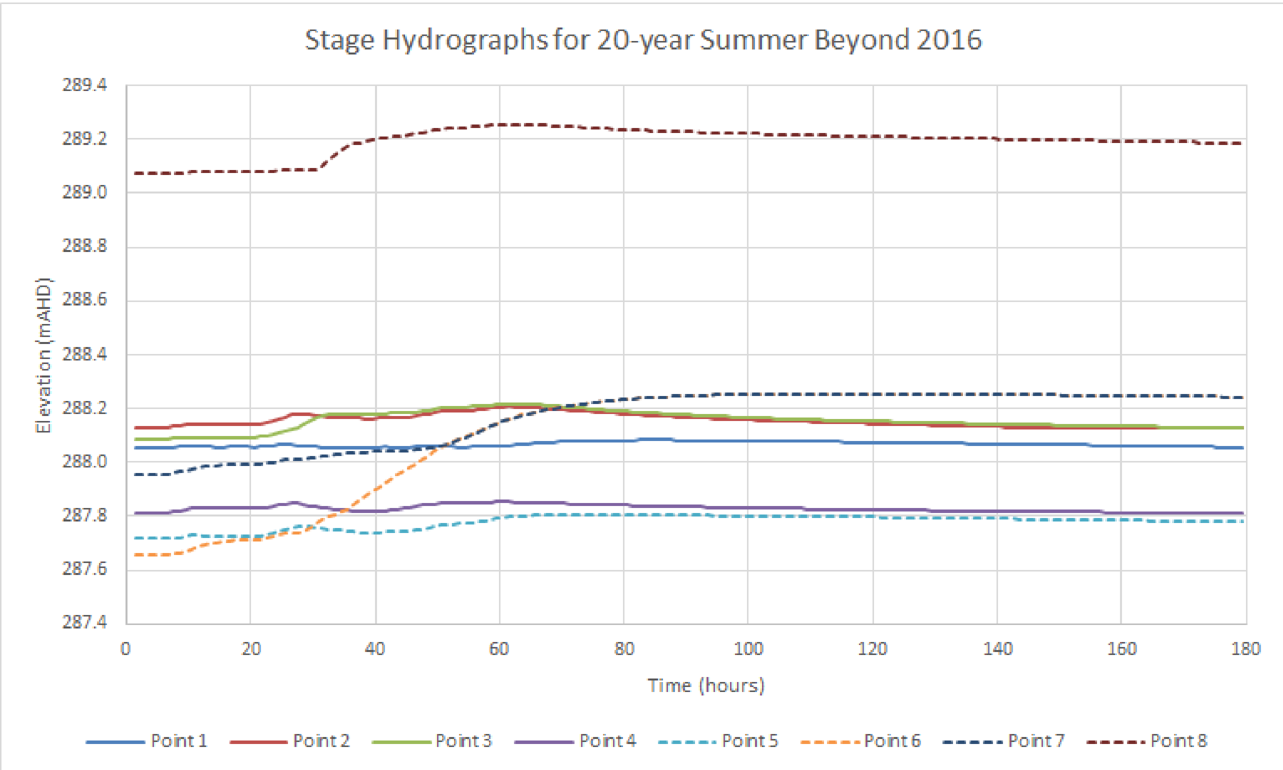

Figure C-10: Stage hydrographs for 20-year Summer Beyond 2016

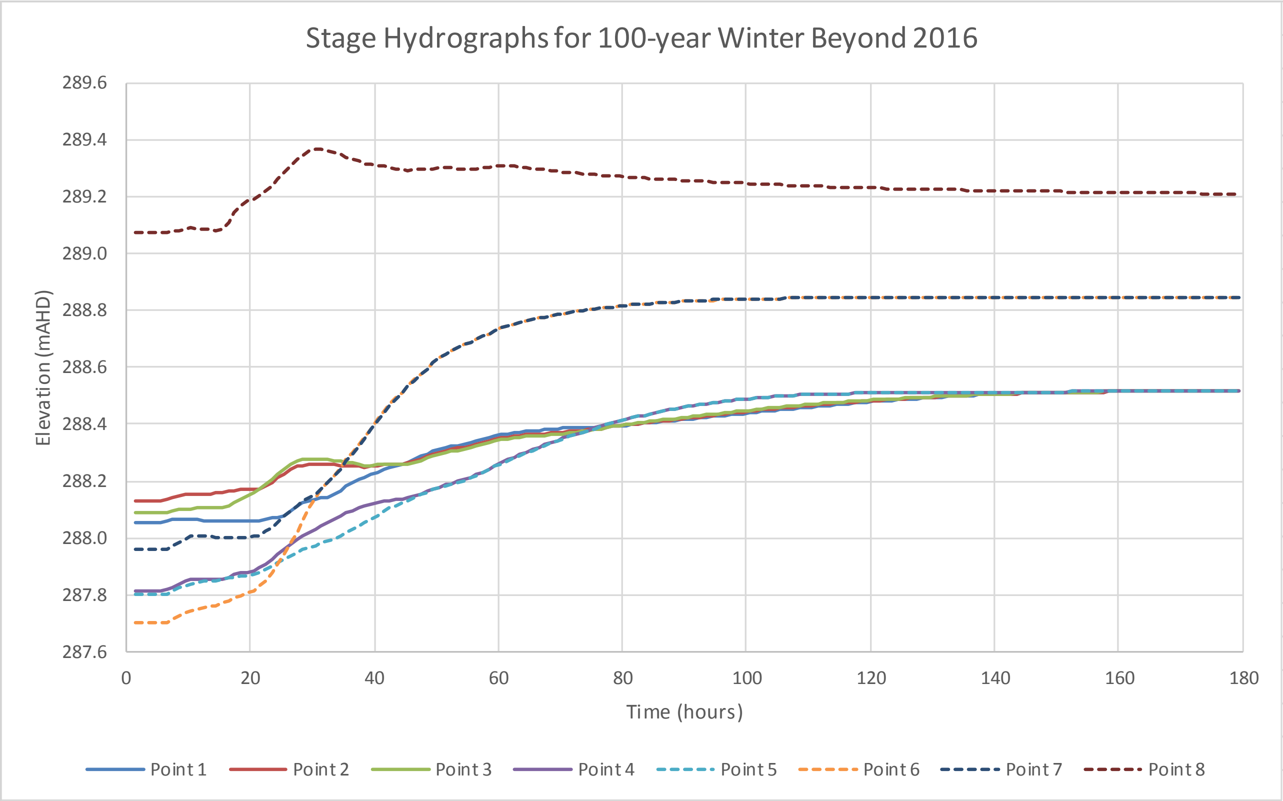

Figure C-11: Stage hydrographs for 100-year Winter Beyond 2016

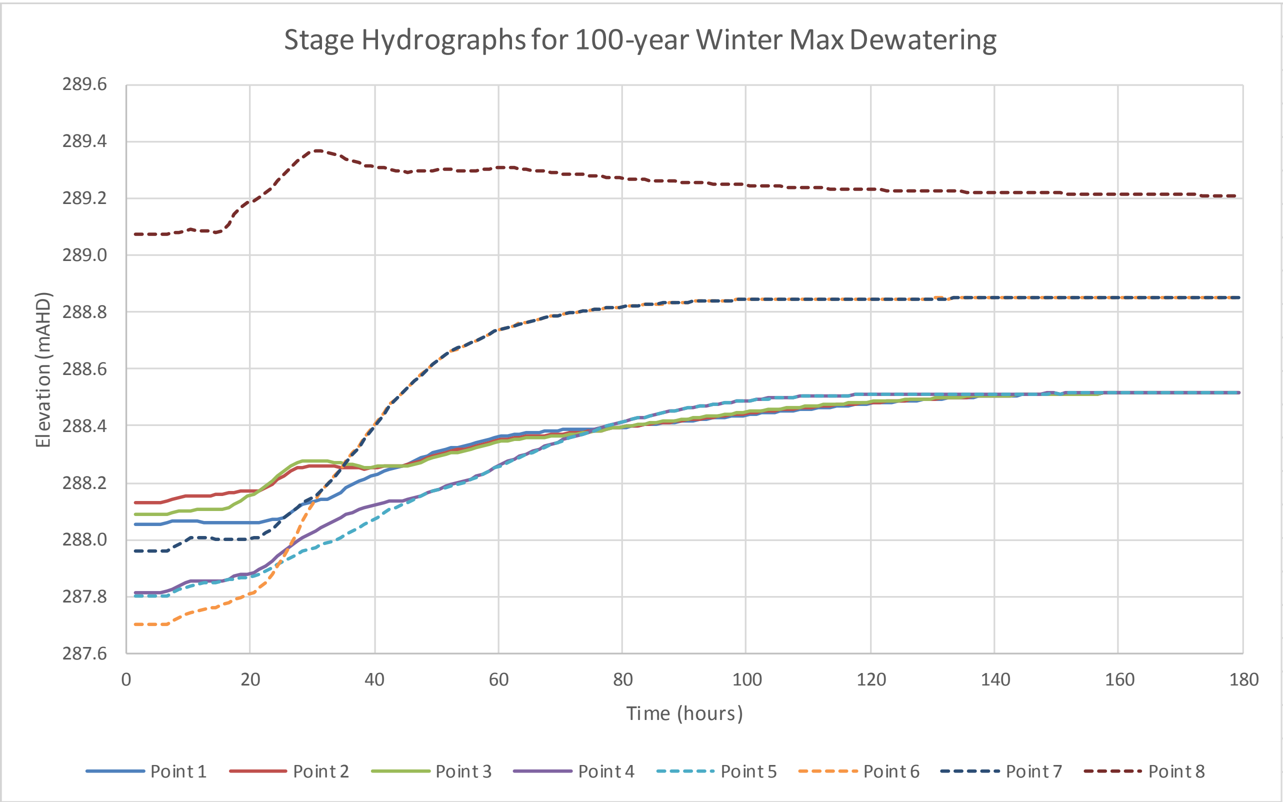

Figure C-12: Stage hydrographs for 100-year Winter max dewatering

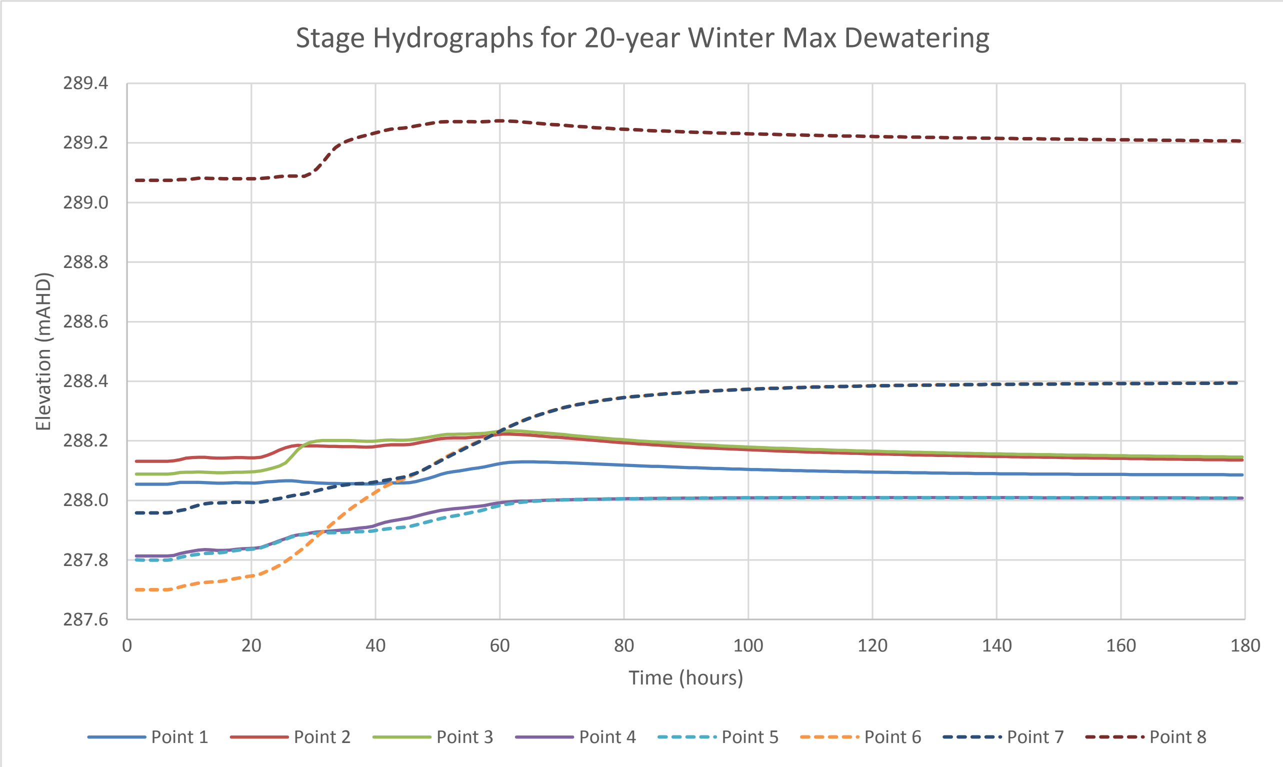

Figure C-13: Stage hydrographs for 20-year Winter max dewatering

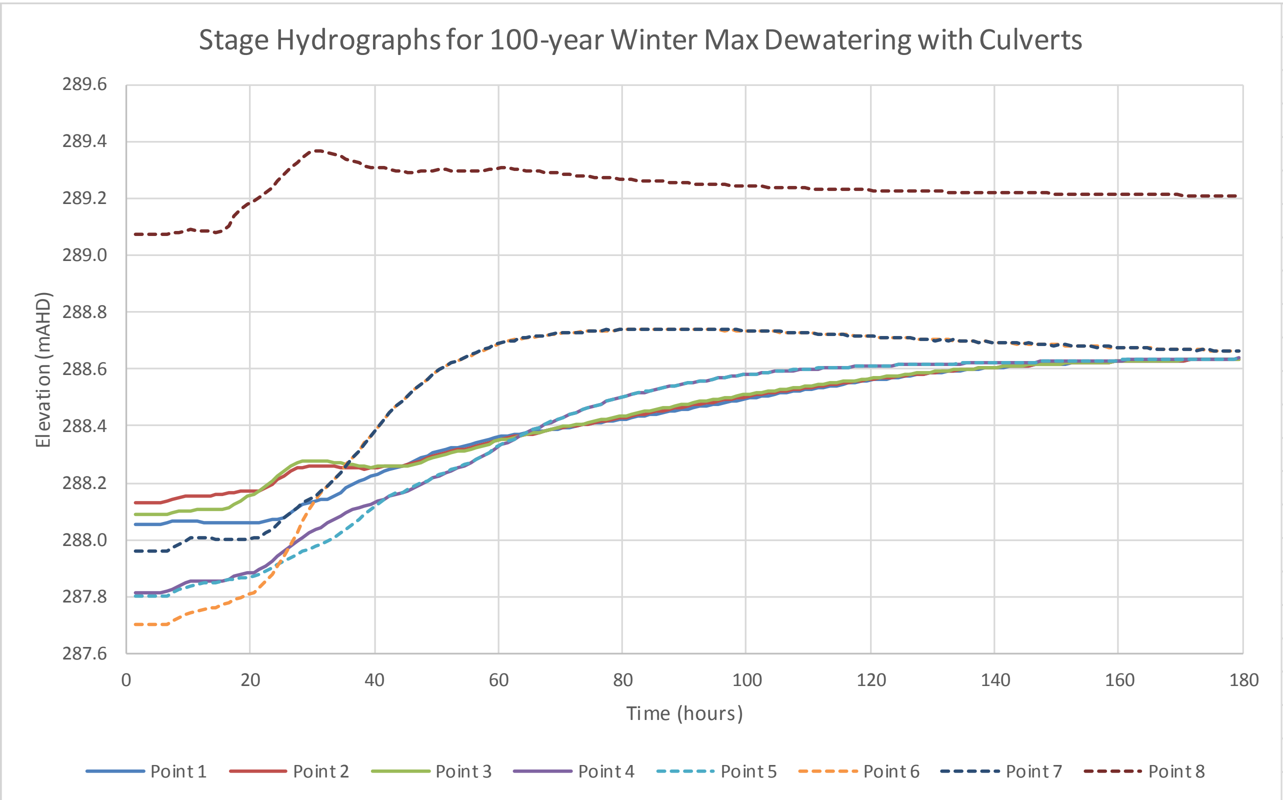

Figure C-14: Stage hydrographs for 100-year Winter max dewatering with culverts

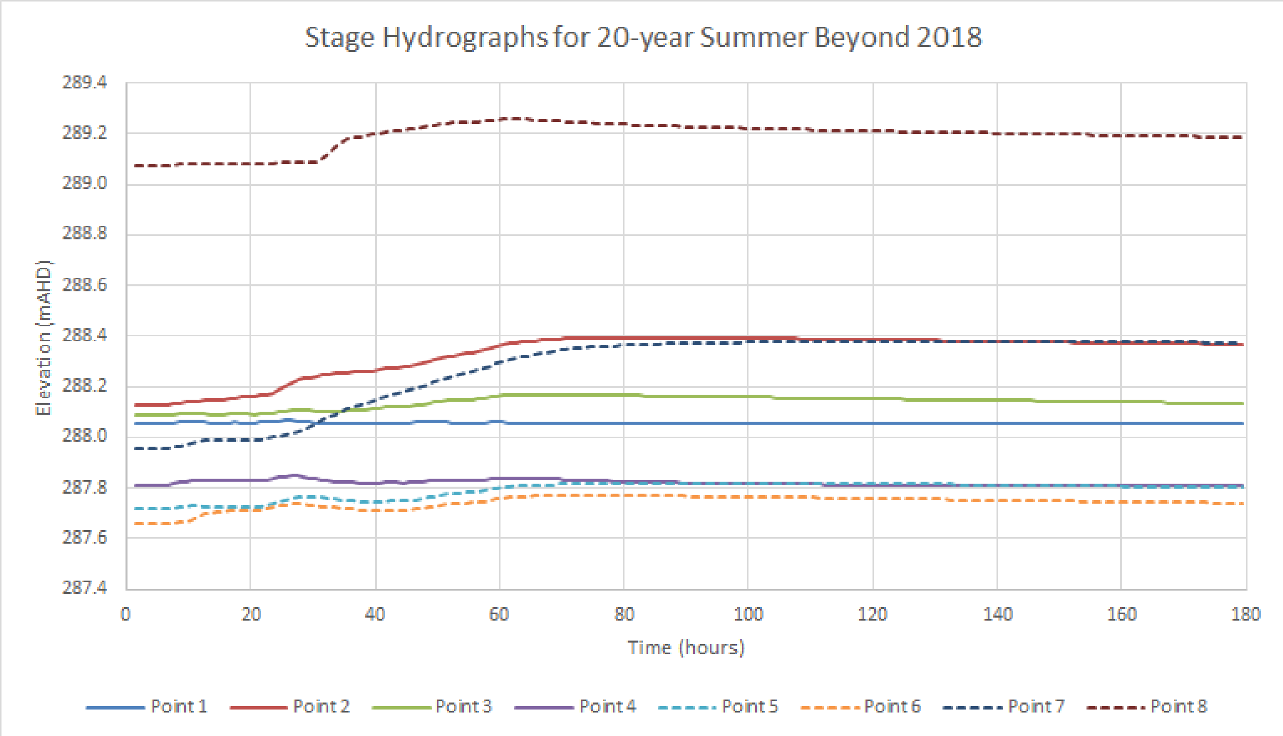

Figure C-15: Stage hydrographs for 20-year Summer Beyond 2018

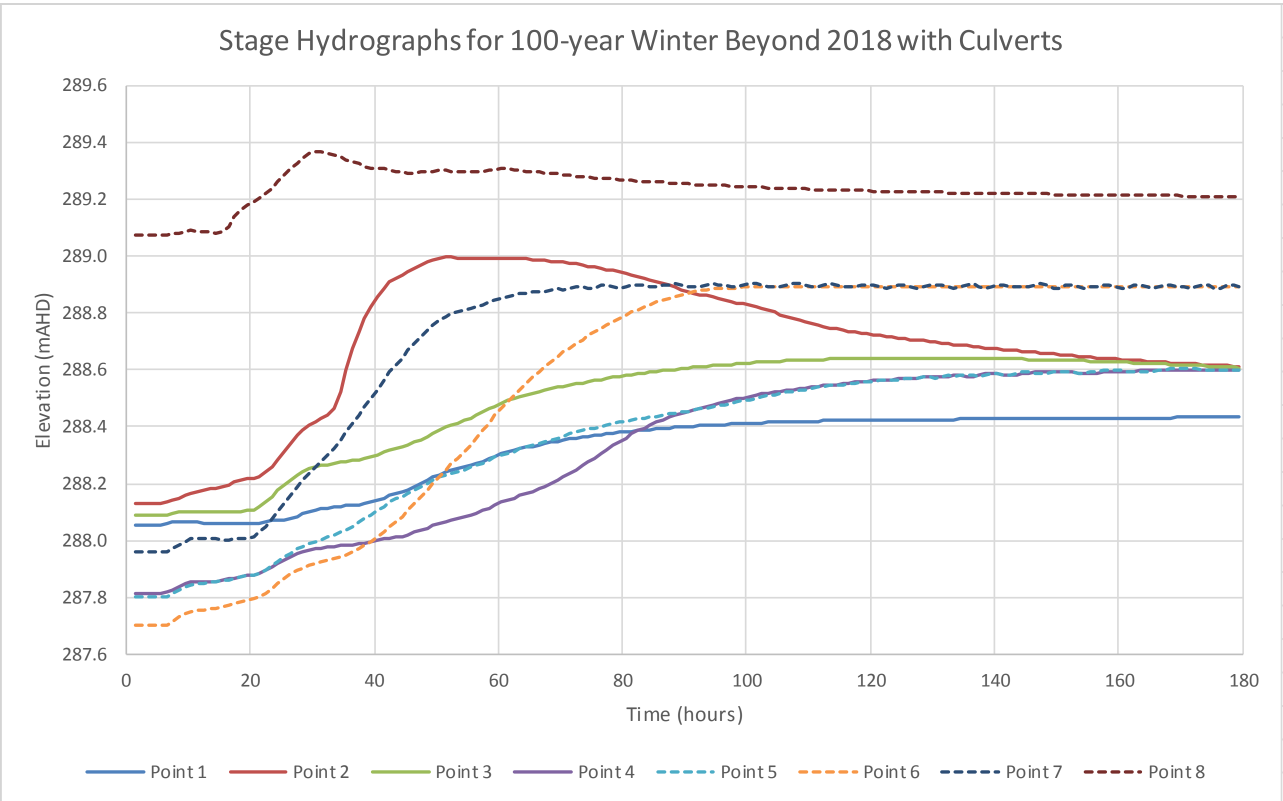

Figure C-16: Stage hydrographs for 100-year Winter Beyond 2018 with culverts

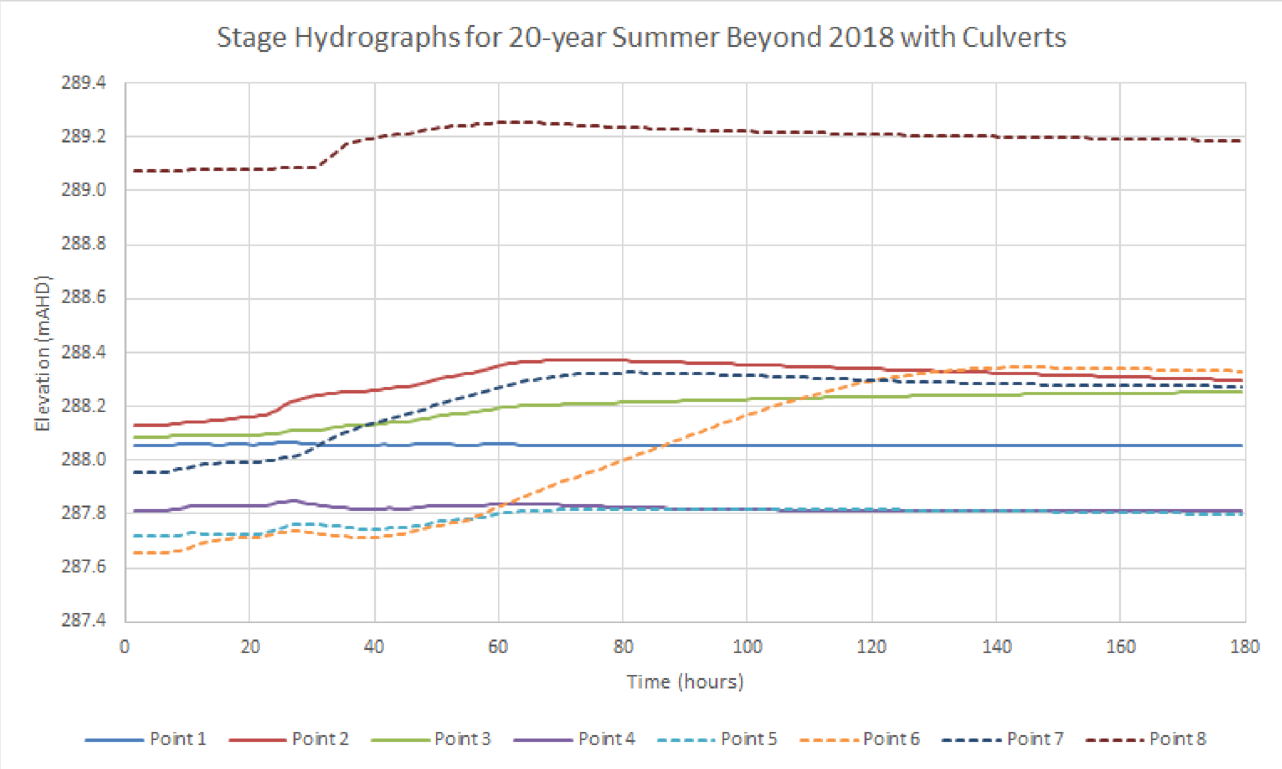

Figure C-17: Stage hydrographs for 20-year Summer Beyond 2018 with culverts

Appendix D Flood inundation extents

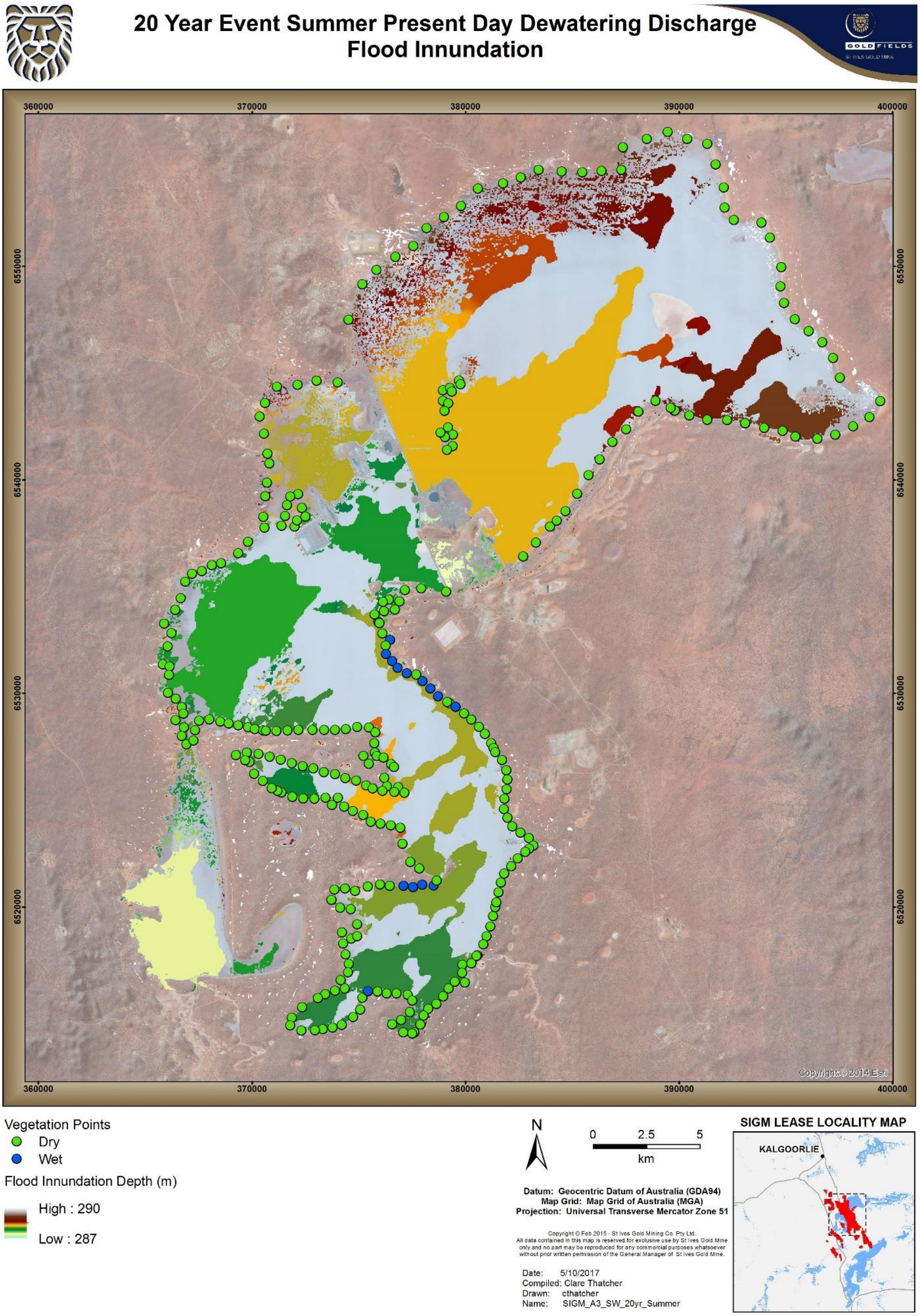

Figure D-1: 20-year summer present day dewatering discharge flood inundation

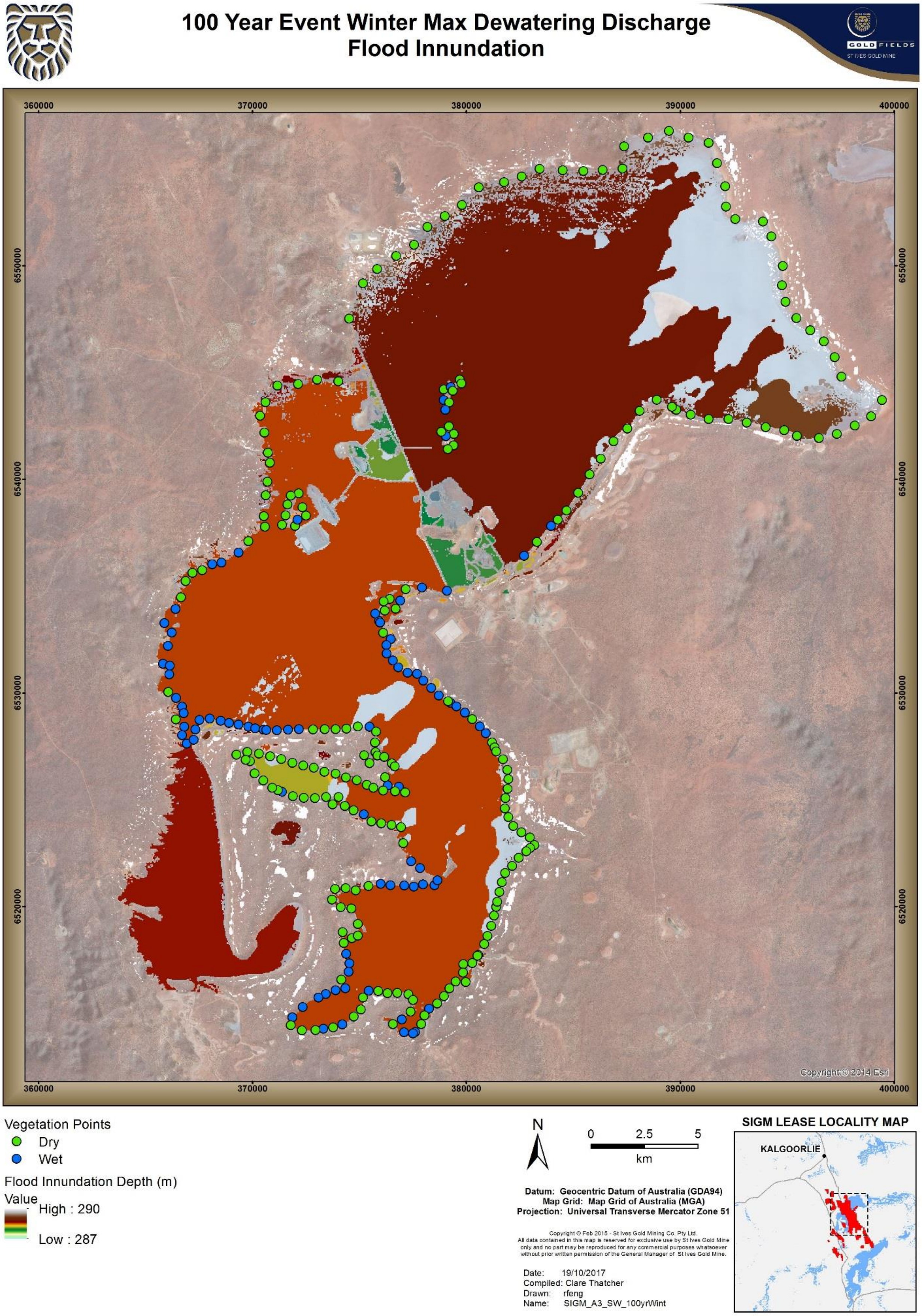

Figure D-2: 100-year winter maximum dewatering discharge flood inundation

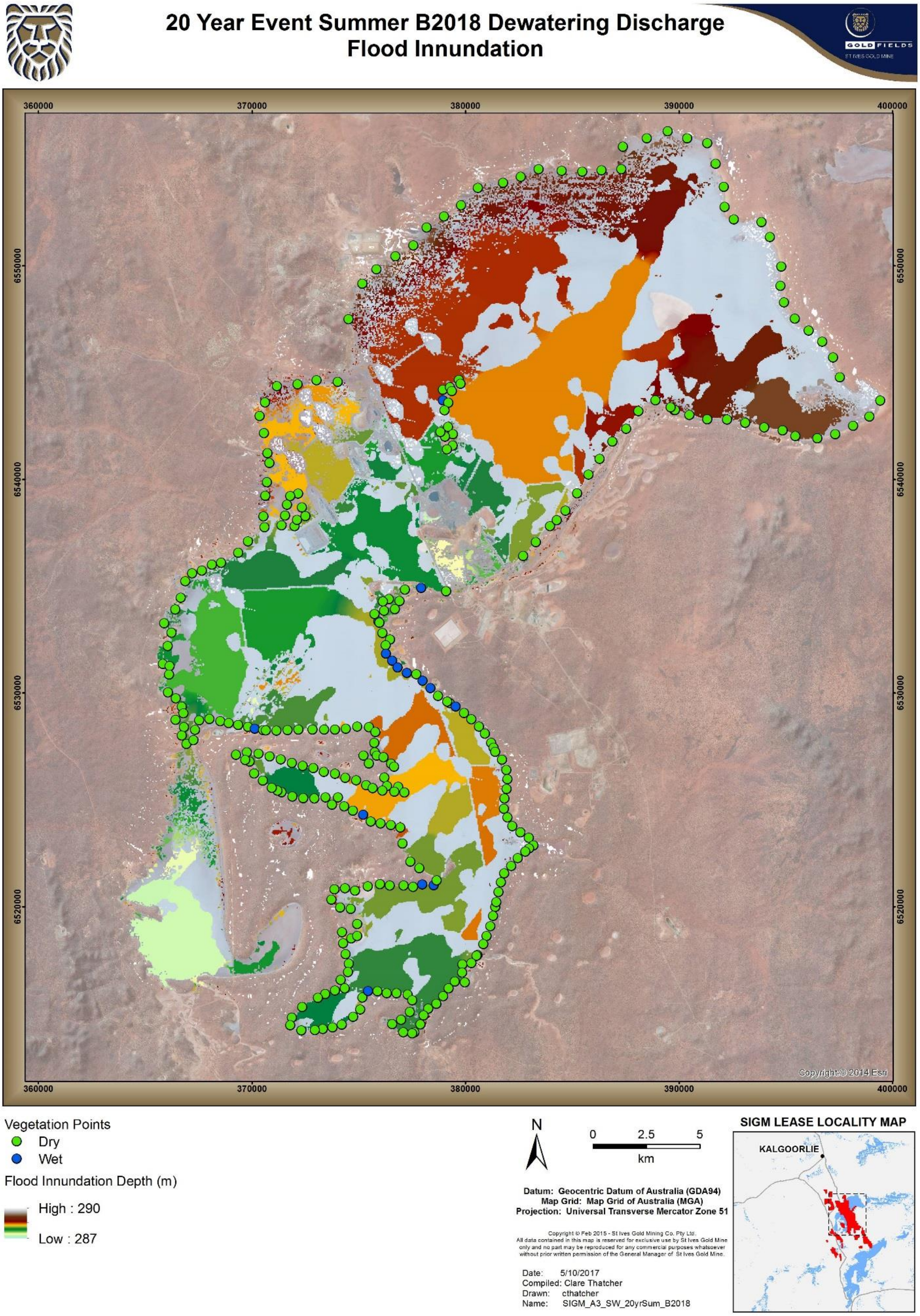

Figure D-3: 20-year summer B2108 dewatering discharge flood inundation

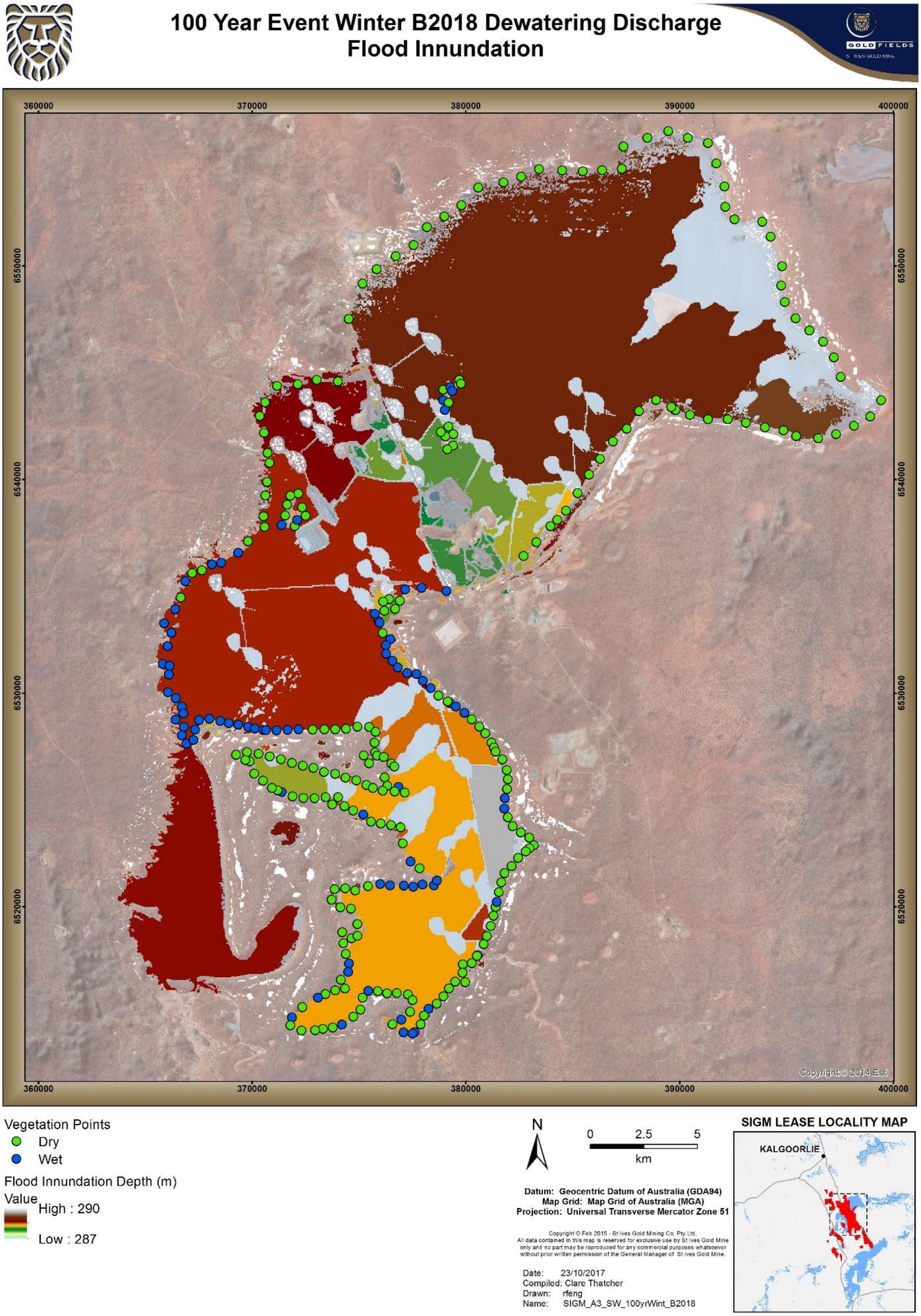

Figure D-4: 100-year winter B2108 dewatering discharge flood inundation

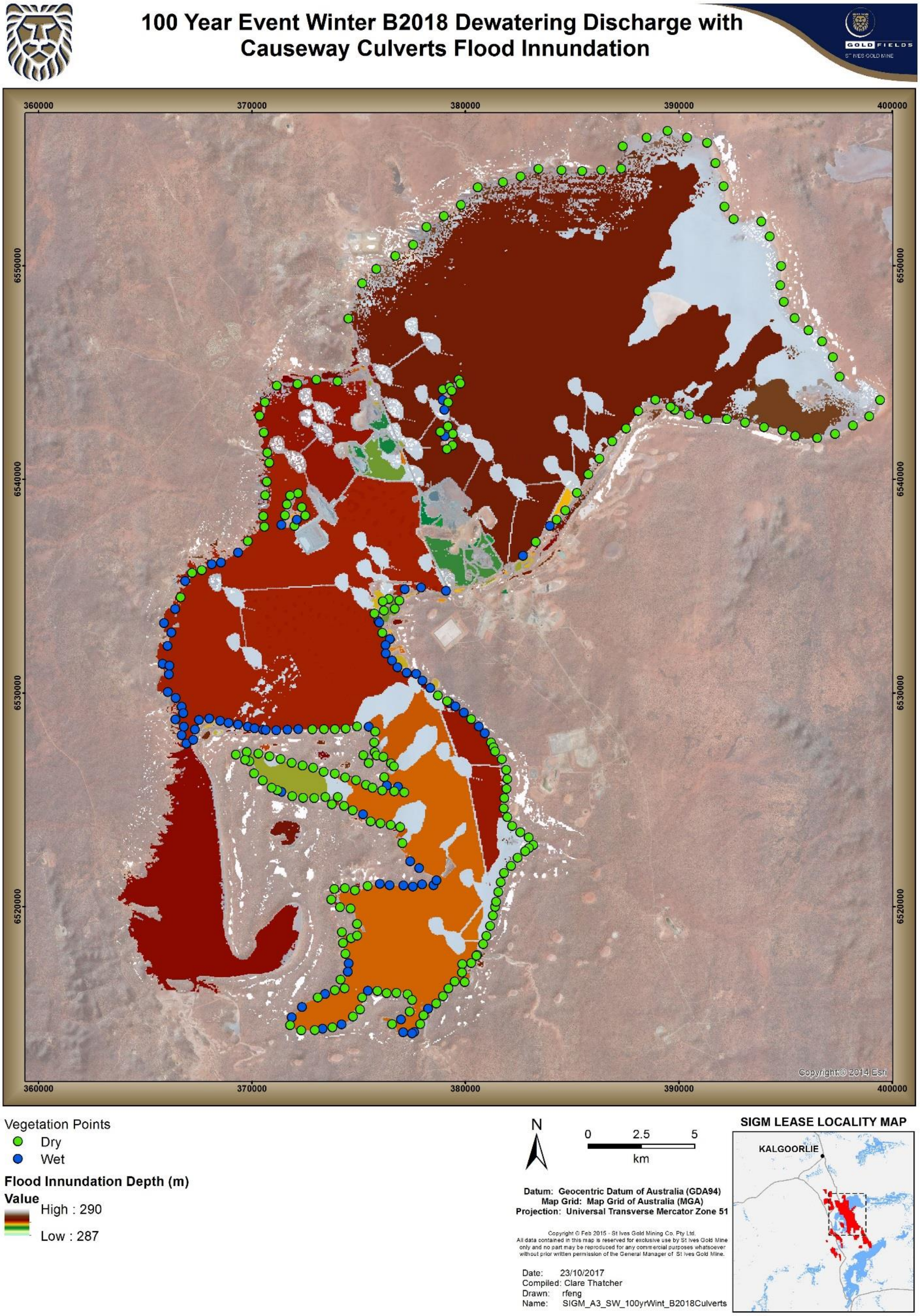

Figure D-5: 100-year summer B2108 dewatering discharge with floodway culverts flood inundation

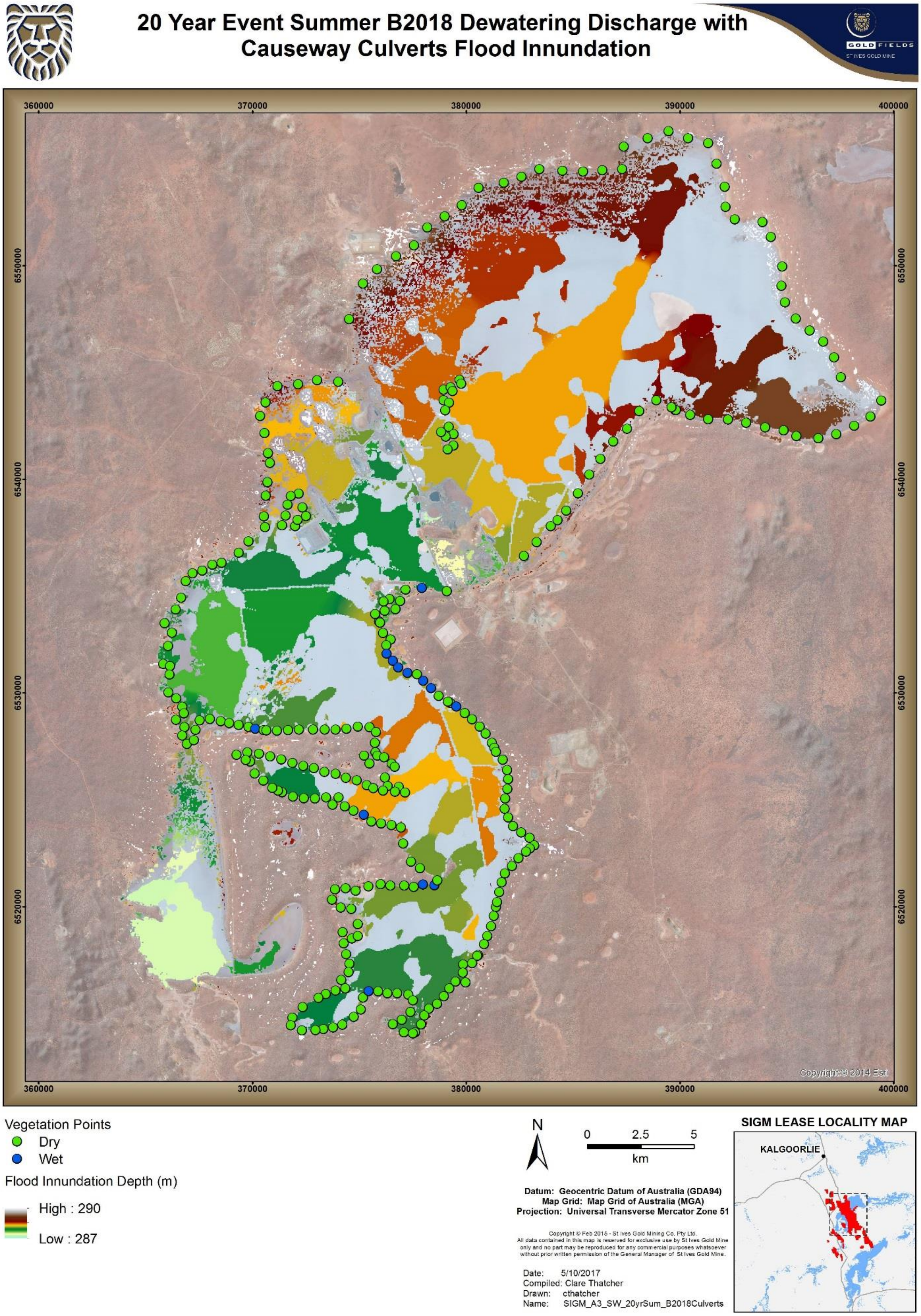

Figure D-6: 20-year winter B2108 dewatering discharge with floodway culverts flood inundation

Appendix E Flood inundation results – Depth and Period

Vegetation Location	Riparian Vegetation Elevation (mAHD)	Present day 6.8 GL dewater Discharge						2028 12.8 GL dewater Discharge								
		20 year Summer			100 year Winter			20 year Summer			100 year Summer			100 year Winter		
		Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)
1	289.49	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
2	289.80	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
3	292.05	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
4	290.38	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
5	289.95	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
6	290.64	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
7	290.05	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
8	289.50	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
9	290.27	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
10	290.26	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
11	290.06	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
12	289.63	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
13	289.96	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
13	289.96	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
14	289.30	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
15	291.19	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
16	289.33	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
17	291.19	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
18	289.86	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
19	290.06	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
20	290.37	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
21	291.49	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
22	290.74	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
23	290.57	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
24	291.24	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
25	290.44	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
26	291.56	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
27	291.19	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
28	291.79	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
29	291.57	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
30	291.58	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
31	291.27	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
32	291.61	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
33	291.93	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
34	292.26	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
35	291.32	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
36	291.70	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
37	291.78	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
38	292.34	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
39	291.78	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
40	290.06	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
41	289.16	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
42	289.71	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
43	290.20	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
44	289.96	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
45	289.10	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
46	291.37	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
47	289.27	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
48	289.36	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
49	289.21	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
50	289.40	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
51	289.09	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
52	289.60	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
53	289.25	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
54	289.76	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
55	291.06	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
56	290.41	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
57	288.93	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.22	0.00	0	288.27	0.00	0
58	289.10	288.25	0.00	0	288.85	0.00	0	287.74	0.00	0	288.22	0.00	0	288.27	0.00	0
59	289.06	288.25	0.00	0	288.85	0.00	115	287.74	0.00	0	288.22	0.00	0	288.27	0.00	0
60	288.68	288.25	0.00	0	288.85	0.17	0	287.74	0.00	0	288.22	0.00	0	288.27	0.00	0
61	288.97	288.25	0.00	0	288.85	0.00	33	288.04	0.00	0	288.13	0.00	0	288.16	0.00	0
62	288.80	288.25	0.00	0	288.85	0.05	129	288.04	0.00	0	288.13	0.00	0	288.16	0.00	0
63	288.33	287.75	0.00	0	288.52	0.19	241	287.81	0.00	0	288.17	0.00	0	288.6	0.27	180.03
64	287.79	287.75	0.00	0	288.52	0.73	0	287.81	0.02	5	288.17	0.38	57	288.6	0.81	257.30
65	288.58	287.75	0.00	0	288.52	0.00	22	287.96	0.00	0	288.14	0.00	0	288.6	0.02	13
66	288.49	287.75	0.00	0	288.52	0.03	0	287.68	0.00	0	287.81	0.00	0	288.03	0.00	0
67	288.68	287.75	0.00	0	288.52	0.00	0	287.68	0.00	0	287.81	0.00	0	288.03	0.00	0
68	288.66	287.75	0.00	0	288.52	0.00	0	287.68	0.00	0	287.81	0.00	0	288.03	0.00	0
69	289.56	287.75	0.00	0	288.52	0.00	0	287.68	0.00	0	287.81	0.00	0	288.03	0.00	0
70	288.58	287.75	0.00	0	288.52	0.00	22	287.89	0.00	0	288.06	0.00	0	288.22	0.00	0
71	288.49	287.75	0.00	0	288.52	0.03	226	288.1	0.00	0	288.11	0.00	0	288.6	0.11	72.97
72	287.90	288.22	0.32	49	288.52	0.62	101	288.1	0.20	33	288.11	0.21	34	288.6	0.70	242.35
73	288.37	288.22	0.00	0	288.52	0.15	0	288.1	0.00	0	288.11	0.00	0	288.6	0.23	151.61
74	292.24	288.22	0.00	0	288.52	0.00	195	288.1	0.00	0	288.11	0.00	0	288.6	0.00	0
75	288.13	288.22	0.09	17	288.52	0.39	34	288.1	0.00	0	288.11	0.00	0	288.6	0.47	210.77
76	288.47	288.22	0.00	0	288.52	0.05	205	288.1	0.00	0	288.11	0.00	0	288.6	0.13	85.77
77	288.06	288.22	0.16	27	288.52	0.46	217	288.1	0.04	11	288.11	0.05	13	288.6	0.54	220.81
78	287.97	288.22	0.25	39	288.52	0.55	233	288.1	0.13	23	288.11	0.14	25	288.6	0.63	233.27
79	287.85	288.22	0.37	55	288.52	0.67	204	288.1	0.25	39	288.11	0.26	41	288.6	0.75	248.98
80	288.07	288.22	0.15	26	288.52	0.45	180	288.1	0.03	10	288.11	0.04	12	288.6	0.53	220.06
81	288.25	288.22	0.00	0	288.52	0.27	206	288.1	0.00	0	288.11	0.00	0	288.6	0.35	194.17

Vegetation Location	Riparian Vegetation Elevation (mAHD)	Present day 6.8 GL dewater Discharge						2028 12.8 GL dewater Discharge								
		20 year Summer			100 year Winter			20 year Summer			100 year Summer			100 year Winter		
		Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)
82	288.05	288.22	0.17	29	288.52	0.47	196	288.12	0.07	15	288.51	0.46	67	288.7	0.65	235.77
83	288.13	288.22	0.09	18	288.52	0.39	196	288.12	0.00	0	288.51	0.38	57	288.7	0.57	225.61
84	288.13	288.22	0.09	18	288.52	0.39	0	0	0.00	0	0	0.00	0	0	0.00	0
85	290.35	288.22	0.00	0	288.52	0.00	168	288.15	0.00	0	288.3	0.00	0	288.38	0.00	0
86	288.27	288.22	0.00	0	288.52	0.25	236	288.15	0.00	0	288.3	0.03	11	288.38	0.11	77
87	287.82	288.22	0.40	59	288.52	0.70	114	288.15	0.33	50	288.3	0.48	69	288.38	0.56	221
88	288.35	288.22	0.00	0	288.52	0.17	0	288.15	0.00	0	288.3	0.00	0	288.38	0.03	23
89	288.63	288.22	0.00	0	288.52	0.00	82	288.15	0.00	0	288.3	0.00	0	288.38	0.00	0
90	288.40	288.22	0.00	0	288.52	0.12	14	288.15	0.00	0	288.3	0.00	0	288.38	0.00	0
91	288.50	288.22	0.00	0	288.52	0.02	0	288.15	0.00	0	288.3	0.00	0	288.38	0.00	0
92	289.29	288.22	0.00	0	288.52	0.00	0	288.15	0.00	0	288.3	0.00	0	288.38	0.00	0
93	289.51	288.22	0.00	0	288.52	0.00	0	288.15	0.00	0	288.3	0.00	0	288.38	0.00	0
94	288.84	288.22	0.00	0	288.52	0.00	0	288.15	0.00	0	288.3	0.00	0	288.38	0.00	0
95	290.20	288.22	0.00	0	288.52	0.00	0	288.15	0.00	0	288.3	0.00	0	288.38	0.00	0
96	290.10	288.22	0.00	0	288.52	0.00	0	288.37	0.00	0	289.3	0.00	0	289.63	0.00	0
97	290.37	288.22	0.00	0	288.52	0.00	0	288.37	0.00	0	289.3	0.00	0	289.63	0.00	0
98	289.65	288.22	0.00	0	288.52	0.00	0	288.37	0.00	0	289.3	0.00	0	289.63	0.00	0
99	289.26	288.22	0.00	0	288.52	0.00	0	288.37	0.00	0	289.3	0.04	5	289.63	0.37	196
100	289.36	288.08	0.00	0	288.52	0.00	0	288.37	0.00	0	289.3	0.00	0	289.63	0.27	178
101	290.40	288.08	0.00	0	288.52	0.00	0	288.37	0.00	0	289.3	0.00	0	289.63	0.00	0
102	290.04	288.08	0.00	0	288.52	0.00	0	0	0.00	0	289.3	0.00	0	289.63	0.00	0
103	291.54	288.08	0.00	0	288.52	0.00	0	0	0.00	0	289.3	0.00	0	289.63	0.00	0
104	292.37	288.08	0.00	0	288.52	0.00	0	0	0.00	0	289.3	0.00	0	289.63	0.00	0
105	290.81	288.08	0.00	0	288.52	0.00	0	0	0.00	0	289.3	0.00	0	289.63	0.00	0
106	291.68	288.08	0.00	0	288.52	0.00	0	0	0.00	0	289.3	0.00	0	289.63	0.00	0
107	291.93	288.08	0.00	0	288.52	0.00	0	0	0.00	0	289.3	0.00	0	289.63	0.00	0
108	290.95	288.08	0.00	0	288.52	0.00	0	0	0.00	0	289.3	0.00	0	289.63	0.00	0
109	291.26	288.08	0.00	0	288.52	0.00	0	0	0.00	0	289.3	0.00	0	289.63	0.00	0
110	289.90	288.08	0.00	0	288.52	0.00	0	0	0.00	0	289.3	0.00	0	289.63	0.00	0
111	289.65	288.08	0.00	0	288.52	0.00	0	0	0.00	0	289.3	0.00	0	289.63	0.00	0
112	289.97	288.08	0.00	0	288.52	0.00	0	0	0.00	0	0	0.00	0	289.63	0.00	0
113	289.05	288.08	0.00	0	288.52	0.00	0	0	0.00	0	0	0.00	0	289.63	0.58	224
114	289.65	288.08	0.00	0	288.52	0.00	0	0	0.00	0	0	0.00	0	289.63	0.00	0
115	289.29	288.08	0.00	0	288.52	0.00	0	0	0.00	0	0	0.00	0	288.55	0.00	0
116	289.15	288.08	0.00	0	288.52	0.00	0	0	0.00	0	0	0.00	0	288.55	0.00	0
117	288.82	288.08	0.00	0	288.52	0.00	0	0	0.00	0	0	0.00	0	288.55	0.00	0
118	291.21	288.08	0.00	0	288.52	0.00	0	0	0.00	0	0	0.00	0	288.55	0.00	0
119	289.03	288.08	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
120	289.79	288.08	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
121	289.86	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
122	289.67	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
123	288.60	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
124	288.80	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
125	289.13	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
126	288.77	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
127	288.57	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
128	288.91	287.94	0.00	0	288.52	0.00	182	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
129	288.24	287.94	0.00	0	288.52	0.28	0	287.88	0.00	0	288.2	0.00	0	288.32	0.08	58
130	288.70	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
131	288.74	287.94	0.00	0	288.52	0.00	150	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
132	288.29	287.94	0.00	0	288.52	0.23	191	287.88	0.00	0	288.2	0.00	0	288.32	0.03	21
133	288.17	287.94	0.00	0	288.52	0.35	184	287.88	0.00	0	288.2	0.03	11	288.32	0.15	104
134	288.22	287.94	0.00	0	288.52	0.30	0	287.88	0.00	0	288.2	0.00	0	288.32	0.10	69
135	288.76	287.94	0.00	0	288.52	0.00	197	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
136	288.12	287.94	0.00	0	288.52	0.40	0	287.88	0.00	0	288.2	0.08	17	288.32	0.20	131
137	289.40	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
138	288.54	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
139	289.38	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
140	288.96	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
141	289.46	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
142	288.80	287.94	0.00	0	288.52	0.00	250	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
143	287.72	287.94	0.22	36	288.52	0.80	0	287.88	0.16	28	288.2	0.48	70	288.32	0.60	227
144	288.91	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
145	289.45	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
146	288.53	287.94	0.00	0	288.52	0.00	181	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
147	288.24	287.94	0.00	0	288.52	0.28	0	287.88	0.00	0	288.2	0.00	0	288.32	0.08	55
148	288.94	287.94	0.00	0	288.52	0.00	96	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
149	288.38	287.94	0.00	0	288.52	0.14	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
150	288.54	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
151	288.60	287.94	0.00	0	288.52	0.00	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
152	289.23	287.94	0.00	0	288.52	0.00	193	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
153	288.15	287.94	0.00	0	288.52	0.37	115	287.88	0.00	0	288.2	0.05	14	288.32	0.17	116
154	288.35	287.94	0.00	0	288.52	0.17	216	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
155	287.98	287.94	0.00	0	288.52	0.54	186	287.88	0.00	0	288.2	0.22	35	288.32	0.34	197
156	288.21	287.94	0.00	0	288.52	0.31	55	287.88	0.00	0	288.2	0.00	0	288.32	0.11	78
157	288.44	287.94	0.00	0	288.52	0.08	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
158	288.50	287.94	0.00	0	288.52	0.02	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
159	289.56	287.94	0.00	0	288.52	0.00	139	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
160	288.31	287.94	0.00	0	288.52	0.21	172	287.88	0.00	0	288.2	0.00	0	288.32	0.01	10
161	288.26	287.94	0.00	0	288.52	0.26	55	287.88	0.00	0	288.2	0.00	0	288.32	0.06	43
162	288.44	287.94	0.00	0	288.52	0.08	0	287.88	0.00	0	288.2	0.00	0	288.32	0.00	0
163	288.91	287.94	0.00	0	288.52	0.00	0	0	0.00	0	288.2	0.00	0	288.32	0.00	0

Vegetation Location	Riparian Vegetation Elevation (mAHD)	Present day 6.8 GL dewater Discharge						2028 12.8 GL dewater Discharge								
		20 year Summer			100 year Winter			20 year Summer			100 year Summer			100 year Winter		
		Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)
164	288.87	287.94	0.00	0	288.52	0.00	0	0	0.00	0	288.2	0.00	0	288.32	0.00	0
165	288.72	287.94	0.00	0	288.52	0.00	0	0	0.00	0	288.2	0.00	0	288.32	0.00	0
166	289.88	287.94	0.00	0	288.52	0.00	0	0	0.00	0	288.2	0.00	0	288.32	0.00	0
167	289.20	288.08	0.00	0	288.52	0.00	0	0	0.00	0	288.2	0.00	0	288.32	0.00	0
168	289.56	288.08	0.00	0	288.52	0.00	0	0	0.00	0	288.2	0.00	0	288.32	0.00	0
169	289.50	288.08	0.00	0	288.52	0.00	0	0	0.00	0	288.2	0.00	0	288.32	0.00	0
170	288.98	288.08	0.00	0	288.52	0.00	0	0	0.00	0	288.2	0.00	0	288.32	0.00	0
171	289.02	288.08	0.00	0	288.52	0.00	0	0	0.00	0	288.2	0.00	0	288.32	0.00	0
172	288.96	288.08	0.00	0	288.52	0.00	0	0	0.00	0	288.2	0.00	0	288.32	0.00	0
173	288.98	288.08	0.00	0	288.52	0.00	0	0	0.00	0	288.2	0.00	0	288.32	0.00	0
174	288.52	288.08	0.00	0	288.52	0.00	157	0	0.00	0	288.2	0.00	0	288.32	0.00	0
175	288.28	288.08	0.00	0	288.52	0.24	175	288.02	0.00	0	288.2	0.00	0	288.32	0.04	29
176	288.25	288.08	0.00	0	288.52	0.27	206	288.02	0.00	0	288.2	0.00	0	288.32	0.07	47
177	288.06	288.08	0.02	8	288.52	0.46	204	288.02	0.00	0	288.2	0.14	26	288.32	0.26	174
178	288.06	288.08	0.02	7	288.52	0.46	218	288.02	0.00	0	288.2	0.14	24	288.32	0.26	168
179	287.96	288.08	0.12	22	288.52	0.56	239	288.02	0.06	13	288.2	0.24	38	288.32	0.36	195
180	287.80	288.08	0.28	43	288.52	0.72	191	288.02	0.22	35	288.2	0.40	59	288.32	0.52	216
181	288.17	288.08	0.00	0	288.52	0.35	102	288.02	0.00	0	288.2	0.03	11	288.32	0.15	103
182	288.37	288.08	0.00	0	288.52	0.15	201	288.02	0.00	0	288.2	0.00	0	288.32	0.00	0
183	288.09	288.08	0.00	0	288.52	0.43	0	288.02	0.00	0	288.2	0.11	21	288.32	0.23	153
184	288.96	288.08	0.00	0	288.52	0.00	0	288.45	0.00	0	288.45	0.00	0	288.32	0.00	0
185	289.36	288.22	0.00	0	288.52	0.00	0	288.45	0.00	0	288.45	0.00	0	288.32	0.00	0
186	288.94	288.22	0.00	0	288.52	0.00	0	288.29	0.00	0	0	0.00	0	288.32	0.00	0
187	288.74	288.22	0.00	0	288.52	0.00	0	288.29	0.00	0	288.31	0.00	0	288.32	0.00	0
188	288.52	288.22	0.00	0	288.52	0.00	145	288.29	0.00	0	288.31	0.00	0	288.32	0.00	0
189	288.30	288.22	0.00	0	288.52	0.22	0	288.29	0.00	0	288.31	0.01	8	288.32	0.02	17
190	289.01	288.22	0.00	0	288.52	0.00	0	288.29	0.00	0	288.31	0.00	0	288.32	0.00	0
191	289.37	288.22	0.00	0	288.52	0.00	0	288.29	0.00	0	288.31	0.00	0	288.32	0.00	0
192	289.06	288.22	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
193	289.39	288.22	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
194	288.69	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
195	288.62	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
196	288.47	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
197	288.26	287.86	0.00	0	288.13	0.00	38	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
198	288.08	287.86	0.00	0	288.13	0.05	0	287.83	0.00	0	287.98	0.00	0	288.11	0.03	24
199	288.30	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
200	288.28	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
201	288.52	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
202	289.17	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
203	288.35	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
204	288.39	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
205	288.95	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
206	288.31	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
207	288.25	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
208	288.39	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
209	288.45	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
210	288.45	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
211	288.18	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
212	288.47	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
213	288.51	287.86	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
214	288.84	288.22	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.11	0.00	0
215	288.57	288.22	0.00	0	288.13	0.00	0	287.83	0.00	0	287.98	0.00	0	288.32	0.00	0
216	288.55	288.22	0.00	0	288.52	0.00	0	288.29	0.00	0	288.31	0.00	0	288.32	0.00	0
217	288.76	288.22	0.00	0	288.52	0.00	0	288.29	0.00	0	288.31	0.00	0	288.32	0.00	0
218	288.56	288.22	0.00	0	288.52	0.00	0	288.29	0.00	0	288.31	0.00	0	288.32	0.00	0
219	289.09	288.22	0.00	0	288.52	0.00	0	288.29	0.00	0	288.31	0.00	0	288.32	0.00	0
220	288.55	288.22	0.00	0	288.52	0.00	0	288.29	0.00	0	288.31	0.00	0	288.32	0.00	0
221	289.44	288.22	0.00	0	288.52	0.00	136	288.27	0.00	0	288.31	0.00	0	288.32	0.00	0
222	288.32	288.22	0.00	0	288.52	0.20	62	288.27	0.00	0	288.28	0.00	0	288.32	0.00	8
223	288.43	288.22	0.00	0	288.52	0.09	0	288.27	0.00	0	288.28	0.00	0	288.32	0.00	0
224	289.18	288.22	0.00	0	288.52	0.00	0	288.27	0.00	0	288.28	0.00	0	288.32	0.00	0
225	290.30	288.22	0.00	0	288.52	0.00	0	288.38	0.00	0	288.4	0.00	0	288.42	0.00	0
226	289.32	288.22	0.00	0	288.52	0.00	0	288.38	0.00	0	288.4	0.00	0	288.42	0.00	0
227	289.35	288.22	0.00	0	288.52	0.00	0	288.38	0.00	0	288.4	0.00	0	288.42	0.00	0
228	289.12	288.22	0.00	0	288.52	0.00	0	0	0.00	0	288.4	0.00	0	288.42	0.00	0
229	288.54	288.22	0.00	0	288.52	0.00	0	0	0.00	0	288.4	0.00	0	288.42	0.00	0
230	289.02	288.22	0.00	0	288.52	0.00	0	0	0.00	0	288.4	0.00	0	288.42	0.00	0
231	289.00	288.22	0.00	0	288.52	0.00	0	0	0.00	0	288.4	0.00	0	288.42	0.00	0
232	288.64	288.22	0.00	0	288.52	0.00	0	288.39	0.00	0	288.4	0.00	0	288.42	0.00	0
233	289.27	288.22	0.00	0	288.52	0.00	33	288.39	0.00	0	288.4	0.00	0	288.42	0.00	0
234	288.47	288.22	0.00	0	288.52	0.05	0	288.41	0.00	0	288.4	0.00	0	288.43	0.00	0
235	289.03	288.22	0.00	0	288.52	0.00	0	0	0.00	0	0	0.00	0	288.6	0.00	0
236	289.07	288.01	0.00	0	288.52	0.00	0	0	0.00	0	0	0.00	0	288.6	0.00	0
237	288.79	288.01	0.00	0	288.52	0.00	0	0	0.00	0	0	0.00	0	288.6	0.00	0
238	288.63	288.01	0.00	0	288.52	0.00	0	287.93	0.00	0	288.1	0.00	0	288.6	0.00	0
239	289.13	288.01	0.00	0	288.52	0.00	111	287.93	0.00	0	288.1	0.00	0	288.6	0.00	0
240	288.35	288.01	0.00	0	288.52	0.17	24	287.93	0.00	0	288.1	0.00	0	288.6	0.25	162
241	288.49	288.01	0.00	0	288.52	0.03	102	287.93	0.00	0	288.1	0.00	0	288.6	0.11	77
242	288.37	288.01	0.00	0	288.52	0.15	104	287.93	0.00	0	288.1	0.00	0	288.6	0.23	154
243	288.36	288.01	0.00	0	288.52	0.16	206	287.93	0.00	0	288.1	0.00	0	288.6	0.24	156
244	288.05	288.01	0.00	0	288.52	0.47	236	287.93	0.00	0	288.1	0.05	13	288.6	0.55	220
245	287.83	287.75	0.00	0	288.52	0.69	189	287.93	0.10	19	288.1	0.27	43	288.6	0.77	250

Vegetation Location	Riparian Vegetation Elevation (mAHD)	Present day 6.8 GL dewater Discharge						2028 12.8 GL dewater Discharge								
		20 year Summer			100 year Winter			20 year Summer			100 year Summer			100 year Winter		
		Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)	Water Level (mAHD)	Innundation Depth (m)	Innundation Duration (day)
246	288.18	287.75	0.00	0	288.52	0.34	149	287.93	0.00	0	288.1	0.00	0	288.6	0.42	203
247	288.29	287.75	0.00	0	288.52	0.23	189	287.93	0.00	0	288.1	0.00	0	288.6	0.31	188
248	288.18	287.75	0.00	0	288.52	0.34	208	287.66	0.00	0	288.17	0.00	0	288.6	0.42	203
249	288.04	287.75	0.00	0	288.52	0.48	190	287.66	0.00	0	288.17	0.13	24	288.6	0.56	222
250	288.17	287.75	0.00	0	288.52	0.35	233	287.66	0.00	0	288.17	0.00	7	288.6	0.43	204
251	287.85	287.75	0.00	0	288.52	0.67	57	287.66	0.00	0	288.17	0.32	49	288.6	0.75	247
252	288.44	287.75	0.00	0	288.52	0.08	130	287.66	0.00	0	288.17	0.00	0	288.6	0.16	110
253	288.32	287.75	0.00	0	288.52	0.20	126	287.66	0.00	0	288.17	0.00	0	288.6	0.28	182
254	288.33	287.75	0.00	0	288.52	0.19	197	287.66	0.00	0	288.17	0.00	0	288.6	0.27	178
255	288.12	287.75	0.00	0	288.52	0.40	78	287.66	0.00	0	288.17	0.05	13	288.6	0.48	211
256	288.40	287.75	0.00	0	288.52	0.12	0	287.66	0.00	0	288.17	0.00	0	288.6	0.20	131
257	288.53	287.75	0.00	0	288.52	0.00	188	287.66	0.00	0	288.17	0.00	0	288.6	0.07	47
258	288.19	287.75	0.00	0	288.52	0.33	201	287.66	0.00	0	288.17	0.00	0	288.6	0.41	202
259	288.09	287.75	0.00	0	288.52	0.43	239	287.66	0.00	0	288.17	0.08	18	288.6	0.51	215
260	287.80	287.75	0.00	0	288.52	0.72	0	287.66	0.00	0	288.17	0.37	55	288.6	0.80	253
261	288.56	287.75	0.00	0	288.52	0.00	180	287.66	0.00	0	288.17	0.00	0	288.6	0.04	28
262	288.24	287.75	0.00	0	288.52	0.28	192	287.66	0.00	0	288.17	0.00	0	288.6	0.36	194
263	288.16	287.75	0.00	0	288.52	0.36	240	287.66	0.00	0	288.17	0.01	8	288.6	0.44	206
264	287.79	287.75	0.00	0	288.52	0.73	185	287.66	0.00	0	288.17	0.38	56	288.6	0.81	254
265	288.21	287.75	0.00	0	288.52	0.31	101	287.66	0.00	0	288.17	0.00	0	288.6	0.39	199
266	288.37	287.75	0.00	0	288.52	0.15	102	287.66	0.00	0	288.17	0.00	0	288.6	0.23	153
267	288.37	287.75	0.00	0	288.52	0.15	144	287.66	0.00	0	288.17	0.00	0	288.6	0.23	154
268	288.30	287.75	0.00	0	288.52	0.22	0	287.66	0.00	0	288.17	0.00	0	288.6	0.30	187
269	288.63	287.75	0.00	0	288.52	0.00	0	287.66	0.00	0	288.17	0.00	0	288.6	0.00	0
270	288.56	287.75	0.00	0	288.52	0.00	0	287.66	0.00	0	288.17	0.00	0	288.6	0.04	31
271	288.72	287.75	0.00	0	288.52	0.00	0	287.66	0.00	0	288.17	0.00	0	288.6	0.00	0
272	288.62	287.75	0.00	0	288.52	0.00	0	287.66	0.00	0	288.17	0.00	0	288.6	0.00	0
273	288.51	287.75	0.00	0	288.52	0.01	62	287.85	0.00	0	288.17	0.00	0	288.6	0.09	60
274	288.43	287.75	0.00	0	288.52	0.09	68	287.85	0.00	0	288.17	0.00	0	288.6	0.17	114
275	288.42	287.75	0.00	0	288.52	0.10	0	287.85	0.00	0	288.17	0.00	0	288.6	0.18	120
276	288.73	287.75	0.00	0	288.52	0.00	0	287.85	0.00	0	288.17	0.00	0	288.6	0.00	0
277	288.86	287.75	0.00	0	288.52	0.00	0	287.85	0.00	0	288.17	0.00	0	288.6	0.00	0
278	289.61	287.75	0.00	0	288.52	0.00	0	288.05	0.00	0	288.17	0.00	0	288.6	0.00	0
279	289.34	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.27	0.00	0	288.6	0.00	0
280	289.15	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.27	0.00	0	288.6	0.00	0
281	288.97	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.27	0.00	0	288.6	0.00	0
282	290.00	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.57	0.00	0	288.6	0.00	0
283	289.14	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.57	0.00	0	288.7	0.00	0
284	289.50	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.57	0.00	0	288.7	0.00	0
285	289.22	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.57	0.00	0	288.7	0.00	0
286	289.50	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.57	0.00	0	288.7	0.00	0
287	289.37	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.57	0.00	0	288.7	0.00	0
288	289.44	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.57	0.00	0	288.7	0.00	0
289	289.77	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.57	0.00	0	288.7	0.00	0
290	289.91	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
291	289.62	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
292	288.91	288.25	0.00	0	288.85	0.00	0	288.37	0.00	0	288.87	0.00	0	288.99	0.08	58
293	291.47	288.25	0.00	0	288.85	0.00	76	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
294	288.74	288.25	0.00	0	288.85	0.11	186	288.37	0.00	0	288.87	0.13	24	288.99	0.25	166
295	288.53	288.25	0.00	0	288.85	0.32	0	288.37	0.00	0	288.87	0.34	51	288.99	0.46	208
296	289.01	288.25	0.00	0	288.85	0.00	101	288.37	0.00	0	288.87	0.00	0	288.99	0.00	0
297	288.70	288.25	0.00	0	288.85	0.15	0	288.37	0.00	0	288.87	0.17	29	288.99	0.29	186
298	289.20	288.25	0.00	0	288.85	0.00	0	287.74	0.00	0	287.87	0.00	0	287.98	0.00	0
299	288.99	288.25	0.00	0	288.85	0.00	0	287.74	0.00	0	287.87	0.00	0	287.98	0.00	0
300	290.55	288.25	0.00	0	288.85	0.00	0	287.74	0.00	0	287.87	0.00	0	287.98	0.00	0
301	289.03	288.25	0.00	0	288.85	0.00	96	287.74	0.00	0	287.87	0.00	0	287.98	0.00	0
302	288.71	288.25	0.00	0	288.85	0.14	0	287.74	0.00	0	287.87	0.00	0	287.98	0.00	0
303	288.91	288.25	0.00	0	288.85	0.00	0	287.74	0.00	0	287.87	0.00	0	287.98	0.00	0
304	289.42	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.27	0.00	0	288.6	0.00	0
305	288.60	288.19	0.00	0	288.52	0.00	0	288.05	0.00	0	288.17	0.00	0	288.6	0.00	0
306	288.93	288.19	0.00	0	288.52	0.00	12	288.05	0.00	0	288.17	0.00	0	288.6	0.00	0
307	288.51	288.19	0.00	0	288.52	0.01	0	288.05	0.00	0	288.17	0.00	0	288.6	0.09	62
308	290.85	288.19	0.00	0	288.52	0.00	0	288.05	0.00	0	288.17	0.00	0	288.6	0.00	0
309	288.57	288.19	0.00	0	288.52	0.00	0	288.05	0.00	0	288.17	0.00	0	288.6	0.03	21
310	288.91	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	288.17	0.00	0	288.6	0.00	0
311	288.88	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	0	0.00	0	288.6	0.00	0
312	289.51	288.19	0.00	0	288.52	0.00	0	288.26	0.00	0	0	0.00	0	288.6	0.00	0

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