July 15, 2015

Toro Energy Limited
Level 3
33 Richardson Street
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Mr. Alan Tandy
Environmental Scientist

Dear Mr. Tandy:

Wiluna Uranium Project Extension
Hydrogeological & Hydrological Report Review

1 INTRODUCTION & BACKGROUND

Klohn Crippen Berger Ltd (KCB) was commissioned by Toro Energy Limited (TEL) to undertake a review of previously compiled hydrogeological and hydrological investigation documents on the Wiluna Uranium Project and Lake Maitland Project. The purpose of the external review is to address a requirement specified in the *Extension to the Wiluna Uranium Project (CMS 14025) Assessment No: 2002 Environmental Scoping Document* (TEL, 2014) regarding preliminary key environmental factors associated with *Inland Water Environmental Quality and Hydrological Processes*.

The proposed scope of work provided to TEL comprised the review of the following documents, including:

- West Creek Water Supply Groundwater Modelling (Aquaterra, 2010);
- Groundwater Studies – Lake Maitland Uranium Project (Golder Associates, 2011);
- Lake Maitland Uranium Project – Hydrologic Studies and Site Water Balance (Golder Associates, 2011);
- Wiluna Uranium Project – Surface Hydrology Studies (RPS, 2015);
- Centipede – Millipede Groundwater Impact Assessment (RPS, 2015); and,
- Bore Completion Report Millipede Uranium Project (Pennington Scott, 2015).

Discussions with TEL indicate that additional reports may be available, however, this document is based on the reports provided to KCB, as identified above.

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2 REGULATORY FRAMEWORK

The regulatory framework applicable to the hydrogeological and hydrological processes of the Wiluna Uranium Project Extension is based on Western Australian State policies and guidelines; and, industry adopted guidelines. Specific policy and guidelines comprise:

- Position Statement No. 4: Environmental Protection of Wetlands, Perth, Western Australia (EPA, 2004)
- Position Statement No. 5: Environmental Protection and Ecological Sustainability of the Rangelands in Western Australia, Perth, Western Australia (EPA, 2004)
- Position Statement No. 2: Environmental Protection of Native Vegetation, Perth, Western Australia (EPA, 2000)
- Operational Policy No. 1.02 – Policy on water conservation/efficiency plan, Perth, Western Australia (DoW, 2009)
- Operational Policy No. 5.08 – Use of operating strategies in the water licensing process, Perth, Western Australia (DoW, 2010)
- Operational Policy No. 5.12 – Hydrogeological Reporting Associated with a Groundwater Licence (DoW, 2009)
- Water Resource Allocation and Planning Series Report No. 45 – Groundwater risk-based allocation of planning process, January 2011, Perth, Western Australia (DoW, 2011
- Water Licensing Delivery Series Report No. 12 – Western Australian Water in Mining Guidelines (DoW, 2013)
- Australian and New Zealand guidelines for fresh and marine water quality, Australian and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand, Canberra, Australian Capital Territory (ANZECC / ARMCANZ, 2000)

3 PROJECT DEVELOPMENT – WATER-RELATED COMPONENTS

TEL proposes to develop two projects to the south-southeast of Wiluna in Central Western Australia. These projects comprise the Lake Way and Lake Maitland Uranium Projects.

Proposed mine infrastructure that may potentially impact the groundwater and surface water systems include:

- Open pits;
- Mine waste storage facilities;
- Landfill facilities;
- Process infrastructure;

- Haul roads and access roads;
- Water supply borefields; and,
- Aquifer reinjection borefields.

Potential impacts on the surface water and groundwater systems, and the proposed mine infrastructure, associated with the development of these projects, includes:

- Modification of the surface water flow systems due to project infrastructure implementation, including:
    - increased flood levels as a result of infrastructure flood bunding;
    - increased surface water flow velocities and erosion potential due to project encroachment into flow channels;
    - increase duration of flood inundation; and,
    - over-topping of project water storage facilities.
- Pit dewatering for the Centipede-Millipede Mine Area (Lake Way) and the various deposits associated with the Lake Maitland project; and, associated impacts of discharge water management and extent of drawdown away from the mining areas;
- Contaminant infiltration and transport through the groundwater system; and,
- Water supply borefield for both Lake Way and Lake Maitland Projects – potential impacts due to drawdown of groundwater levels and extent of drawdown.

4 REPORT SUMMARIES

The following sections provide a review summary of the hydrological and hydrogeological reports provided to KCB by TEL. These reviews summarise the following aspects of:

- Investigation objectives;
- Adopted investigation methodology;
- Results and interpretations; and,
- Investigation undertaking in compliance/adherence with appropriate guidelines.

Potential deficiencies and limitations of the reviewed investigation reports are summarised in Section 5.

4.1 West Creek Water Supply Groundwater Modelling (Aquaterra, 2010)

Investigation Objectives:

- Aquaterra were commissioned in 2010 to conduct an assessment of the shallow calcrete aquifer underlying West Creek to potentially provide a long-term sustainable water supply for the Wiluna Uranium Project. The potential for water supply from this aquifer were constrained by groundwater level drawdown triggers for the protection of stygofauna habitat.

Investigation Scope of Work:

- The scope of work for this investigation comprised:
  - the development of a conceptual model of the aquifer system;
  - construction, calibration and predictive simulation of a groundwater numerical model to assess water supply borefield options; and,
  - preliminary design and cost estimate for the preferred borefield location and reticulation to deliver water to the Centipede site.

Background Summary:

- The report provided a summary of the background information (i.e. previous site investigations, public domain regional studies, monitoring records) used for the undertaking of the investigation.
- A general summary of the project setting was provided, including the climate, physiographic setting and aquifer conceptualisation. A summary of the mine water demand was also provided, comprising two options – 1) ore crushing and screening, followed by alkaline heap-leaching with ion exchange (0.8 GL/yr); and, 2) crushing, screening, grinding and agitated alkaline leaching and direct precipitation (2.5 GL/yr).
- Two borefields, West Creek South Borefield and Apex Southern Borefield, have already been established in the West Creek Aquifer. TEL propose to develop and supplement the West Creek South Borefield for the project water supply due to the high salinity of the Apex Southern Borefield. Supplementary water is proposed to be source from upper catchment of the calcrete aquifer.

Conceptual Hydrogeological Model:

- Groundwater system across the West Creek Borefield area comprises thecalcrete aquifer; alluvium aquifer; basal silt and clay; and, fractured bedrock aquifer (Finlayson Member).
  - Calcrete aquifer – extends along full length of West Creek drainage system (~16 km) and ranging in width from 1 km to 4 km. The aquifer ranges in thickness from 5 m to 15 m with thicknesses increasing towards the southeast, towards Lake Way. Groundwater levels are approximately 3 to 7 meters below ground level (mbgl) with flow towards the southeast into Lake Way. Lake Way removes groundwater from the aquifer via evaporation following discharge into the lake.

    Recharge occurs via direct rainfall infiltration in areas of the calcrete outcrop, with recharge ranging from 1 to 5% of rainfall. Rainfall runoff typically occurs for events greater than 50 mm, which also results in recharge to the aquifer.

    Hydraulic conductivity in the aquifer is anticipated to be variable, but is governed by the solution cavities throughout the formation. Aquifer testing conducted on the calcrete aquifer identified transmissivities ranging from 110 m^2/d to 950 m^2/d, while specific yields ranged from 0.001 to 0.27.
  - Alluvium aquifer – is constrained by the calcrete aquifer through the central zone of the project site and by bedrock around the periphery; and is approximately 5 m thick

across the majority of the site. The water level in the aquifer ranges from 4 to 9 mbgl and flows towards Lake Way to discharge.

Recharge to the alluvium aquifer occurs from rainfall infiltration with estimated recharge rates of 0.09 to 1% of rainfall, with higher rates anticipated along the flanks of the alluvium. In areas of shallow groundwater (2-3 mbgl) evapotranspiration from the aquifer occurs.

The average hydraulic conductivity of the aquifer is 2.5 m/d, while the specific yield varies from 0.05 to 0.1.

- Basal clay and silts – underlie the Calcrete aquifer and varies in thickness from 5 m to 10 m. Typically this unit acts as an aquitard.
- Fractured bedrock (Finlayson Member) – underlies the alluvium, calcrete and basal clay and silts units. This unit is relatively “tight” and provides limited contribution to the overall water balance of the groundwater system.

Numerical Groundwater Model:

- A numerical groundwater model was constructed using MODFLOW-Surfact to simulate the hydrogeological system and allow predictive simulation of proposed borefield configurations. The objective of the modelling was to identify a borefield capable of sustaining 0.7 GL/yr over a 10-year duration.
- The groundwater model was constructed as a three layer model, based on the interpreted conceptual model. Fixed heads were applied to the model domain to simulate groundwater flow direction toward Lake Way.
- Calibration
  - Calibration was conducted to steady-state conditions using groundwater levels as calibration targets. Modification of aquifer parameters, recharge and fixed head elevations were undertaken to achieve calibration. Modification of the model inputs were within the bounds of the conceptual model.
  - Initial calibration results provided a scaled root mean squared (SRMS) error of 13.6%, higher than the accepted 10% error for undeveloped catchments and 5% for developed catchments (Murray Darling Basin Commission (MDBC) Groundwater Modelling Guidelines, 2001). The largest difference in predicted and observed groundwater levels were identified in two bores. With these bores removed the SRMS reduced to 8.4%.
  - Transient calibration was conducted over the period of October 1986 to November 2009 based on the operation of the West Creek Borefield bores and the Apex Southern Borefield. Calibration hydrographs for bores in the West Creek Borefield and the Apex Southern Borefield were presented, however, SRMS error results were not presented. Mass balance results for the model were presented, indicating a reasonable correlation between the cumulative influx and outflux of the model and for each model time step.
  - Based on the results of the calibration runs the model was considered acceptable.
- Predictive Simulation

  - Nine predictive simulations were conducted based on various borefield configurations. The criteria for the predictive simulation was to identify a borefield configuration that could provide the proposed water demand while maintaining an aquifer saturated thickness of 75% (3 m drawdown) and 60% (4 m drawdown) to maintain the stygofauna habitat.
  - Based on the required criteria the long-term yield from the borefield configurations ranged from 550 m^3/d to 1,730 m^3/d, which is below the proposed target of 1,917 m^3/d. Drawdown associated with the proposed borefields resulted in a minimum of 0.5 m drawdown across 90% of the project area and over 4 m of drawdown across 10% of the project area.
  - The recommended borefield configuration to approach the proposed demand comprised four existing bores and six additional nominal bores. Cost estimates for the installation of the borefield and associated reticulation infrastructure and installation were provided.

Investigation Limitations:

- Steady-state calibration results exceed acceptable guideline values when the entire monitoring data set was included as the calibration data set. Removal of monitoring records was required to achieve acceptable model calibration.
- Transient calibration results did not include error statistics for the comparison of observed and predicted groundwater levels. Although mass balance results indicated that flow in and out of the model was relatively balanced, the lack of groundwater level calibration statistics indicate possible uncertainty in the calibration.

4.2 Bore Completion Report – Millipede Uranium Project (Pennington Scott, 2015)

Investigation Objectives:

- The objective of this investigation included drilling, bore installation and aquifer hydraulic testing at the Wiluna Uranium Project. Results from this investigation were to be used to support the RPS (2015) numerical groundwater modelling assessment. The deliverable from this investigation was a factual report on the field investigation program.

Investigation Scope of Work:

- The scope of work conducted for this investigation comprised:
  - Installation of three test production bores (MPD_1P1, MPD_2P1, MPD_3P1) and four monitoring bores.
  - Aquifer hydraulic testing of three test bores comprising multi-rate tests (2 to 3 steps of 40 minutes duration for each step) and constant rate tests of 24 to 48 hours duration.
  - Groundwater discharge from the tests occurred 50 m to 80 m away from the pumping bore to limit potential re-circulation of water through infiltration.

Investigation Results:

- MPD_1P1 – hydraulic conductivity estimate of 4.4 m/d (T = 79 m^2/d), based on analysis of constant-rate test drawdown curve
- MPD_2P1 – hydraulic conductivity estimate of 5.0 m/d (T = 105 m^2/d), based on analysis of constant-rate test recovery curve. However, the constant-rate test drawdown curve displayed a boundary condition near the end of test which was not incorporated into analysis or discussed during the interpretation. RPS (2015) applied a different hydraulic conductivity value (35 m/d) in the groundwater model than the analysed result of this investigation.
- MPD_3P1 – hydraulic conductivity estimate of 10 m/d (T = 148 m^2/d), based on analysis of the constant-rate test recovery curve. Variations in drawdown curve near the end of the test duration were not included in the interpretation of the aquifer parameter values. The hydraulic conductivity estimate (40 m/d) applied by RPS (2015) in the groundwater model differed from this investigation.

4.3 Centipede – Millipede Groundwater Impact Assessment (RPS, 2015)

Investigation Objectives:

- The objective of this assessment was to update the Aquaterra (2011) hydrogeological assessment of the Centipede deposit to include the combined Centipede-Millipede deposits. Specific items of assessment associated with this work included:
  - Potential impacts to the groundwater system due to development of the Centipede and Millipede pits (i.e. dewatering requirements, lateral extent of drawdown);
  - Post-closure groundwater level recovery following the cessation of mining activities; and,
  - Potential impacts on other groundwater users within the vicinity of the project site.

Investigation Scope of Work:

- The scope of work for this investigation comprised the update of the existing Centipede mining area groundwater model (Aquaterra, 2011) to include the revised mine plan and additional hydrogeological investigation results/interpretations at Millipede (Pennington Scott, 2015).

Background Summary:

- The report provided a summary of the existing environment including the physical setting (climate and physiography), geological and regional hydrogeology.
- A summary of groundwater users within the vicinity of the project site was provided based on groundwater well licences and allocations (i.e. mining, town supplies and stock and domestic purposes).
- The groundwater quality distribution across the project site was also summarised; indicating hypersaline conditions (TDS = 150,000 mg/L) within the vicinity of the Centipede-Millipede Deposits and lower concentrations of TDS to the west of the deposits.
- A summary of the recent resource definition drilling program and the Pennington Scott (2015) hydrogeological field investigation program at the Millipede Deposit were provided.

RPS conducted a re-analysis of the Pennington Scott (2015) testing pumping results to obtain aquifer hydraulic parameters. These parameters were adopted in the numerical groundwater model and differed from the Pennington Scott (2015) calculations.

Conceptual Hydrogeological Model:

- The conceptual hydrogeological model of the groundwater system within the vicinity of the Centipede and Millipede Deposits was based on the previous Aquaterra (2011) study with the incorporation of resource drilling and the Pennington Scott (2015) hydrogeological investigation at the Millipede Deposit.
- Six hydrogeological units were identified for the conceptual groundwater model:
  - Calcrete aquifer – occurs within the Abercromby palaeochannel and has an average thickness of 8 m. Limited information is available in the western extent of the aquifer, and interpolation/interpretation of the aquifer in this area is required. Groundwater levels are ~2 to 5 mbgl with a flow direction from west to east (along Abercromby Creek), discharging into Lake Way. Lake Way acts as a drain, removing groundwater from the aquifer via evaporation.

    The hydraulic conductivity of the calcrete aquifer is a function of the solution cavities within the unit and varies from 35 m/d to 600 m/d. Specific yield ranges from 0.03 to 0.25. Recharge to the aquifer occurs via episodic rainfall and periodic flow in Abercromby Creek, and has been estimated to be recharging at a rate of 1-5% of rainfall.
  - Alluvium and colluvium aquifer – Cainozoic alluvium occurs as sheetwash and sandplain sediment covering the flat-lying areas adjacent to Abercromby Creek and the calcrete aquifer. The aquifer has an average thickness of 10 m, increasing to 20 m in the southern portion of the study area. A transition zone occurs between the alluvium/colluvium and underlying calcrete. Groundwater levels are between 3 to 7 mbgl and flow towards the east, predominantly draining into Lake Way.

    Recharge to the aquifer occurs via episodic direct rainfall infiltration, with an infiltration rate of 0.09 to 1.2% of rainfall. Hydraulic testing of the aquifer has identified an average hydraulic conductivity of 2.5 m/d and a specific yield range from 0.05 to 0.1.
  - Playa lake sediments – comprise playa and dune deposits in Lake Way, which include evaporates, clay and sand. These sediments have an average thickness of 4 m. The estimated hydraulic conductivity of this unit is 0.1 to 0.5 m/d.
  - Basal clays and silt – underlie the calcrete aquifer and range in thickness from 2 m to 27 m (~11 m average thickness). This unit acts like an aquitard, with a hydraulic conductivity of 0.77 to 6 m/d.
  - Palaeochannel sediments – form part of the "inset-valley" palaeochannel system linking Lake Way through to Lake Maitland. This unit is up to 40 m thick and comprises various mixtures of Cainozoic sediments. The hydraulic conductivity for this unit ranges from 1 to 40 m/d, while the estimated specific yield is 0.2.

- Fracture bedrock – occurs from 1 to 21 mbgl at the project site, comprising predominantly gnessic granit. Hydraulic conductivity of this unit is a function of the secondary porosity, and is estimated to be 0.001 m/d. A storativity of 0.001 is estimated for this unit.

Numerical Groundwater Model:

- The numerical groundwater model was updated from the MODFLOW-Surfact model developed by Aquaterra in 2011. The numerical model was developed to identify the dewatering volumes over the life-of-mine, the groundwater drawdown impact and the post-closure groundwater level recovery.
- The constructed model domain comprised five layers:
  - Layer 1 to layer 3 represented the Calcrete aquifer, calcrete-alluvium transition zone, alluvium/colluvium, Lake Way playa sediments and the fractured bedrock.
  - Layer 4 represented the silty alluvium, Lake Way clay, alluvium/colluvium and the fractured bedrock.
  - Layer 5 represented the palaeochannel sediments and the fracture bedrock.
- Fixed head boundary conditions were located along the western, northern and eastern extent of model domain, with the western and northern boundary conditions used to simulate inflow into model domain (511 mRL and 490 mRL, respectively ; and the northern boundary condition only applied to Layer 5 representing the palaeochannel); while the eastern boundary condition simulated outflow (488 mRL) from the model. These boundary conditions were adopted to simulate the regional groundwater flow direction from west to east, with some contribution from the north via the palaeochannel.
- Recharge and evapotranspiration were applied in the model domain, however, these parameter were modified to support the calibration.
- Calibration
  - Calibration was conducted to steady-state conditions using groundwater levels as the calibration target. A total of 179 measured groundwater levels were used for calibration. Modifications to the aquifer hydraulic conductivity, recharge and evapotranspiration were undertaken during the calibration.
  - The calibration result indicated an SRMS error of 4.4% between the simulated and observed groundwater levels. The majority of groundwater bores within the vicinity of the deposits predicted water levels within 0.5 m of observed levels.
  - The water balance of the steady-state calibration run indicates that the majority of inflow and outflow occurs via recharge and evapotranspiration, respectively; which corresponds with the conceptual understanding of the groundwater system.
  - Based on the calibration results, and considering the adopted parameters are within the range of parameters identified during field investigation, the model was considered adequate for predictive simulation.
- Predictive simulations

  - Dewatering was simulated by incorporating the Centipede-Millipede mine plan into the numerical model. This comprised a total simulation period of 18 years, with 5 years for mining and 13 years of tailings infilling of the pits. The predictive simulation was conservatively modelled without the use of cut-off walls in the pit.

    The MODFLOW Drain package was used to simulate the sump-pumping from within the pit, with the drains activated and deactivated in accordance with the mining panels (5 panels) of 5 m to 15 m depth. The hydraulic conductivity in the model was modified throughout the transient run to simulate the placement of tailings and waste rock in the pit.

    - Results from the dewatering simulation indicate that a peak inflow of 12,400 kL/d is observed during the first year of pit development and reducing to 2,400 kL/d after 5 years at the cessation of active mining. After 18 year (at the cessation of infilling) the inflow rates reduced to 300 kL/d.

      After 18 years 7 m of drawdown was predicted in the mine area, while the 0.2 m drawdown extent was simulated at 3.8 km to the west, 8.6 km to the east, 3.2 km to the north and 5.3 km to the south of the mine.

  - Simulation of the post-closure groundwater level recovery was undertaken by extending the dewatering model duration by an additional 1,000 years and deactivating the Drain cells at the cessation of tailings infilling (after 18 years). Additionally, recharge across the infilled pit area was halved to represent the presence of a cover/cap.

    - Results indicate that groundwater levels would recover to pre-mining conditions approximately 70 years following the cessation of infilling.

  - Sensitivity analyses were conducted on the hydraulic conductivity and it was identified that the model was most sensitive to changes in the hydraulic conductivity. An increase in the hydraulic conductivity of the calcrete aquifer (to 500 m/d), within the range of values identified during field investigations, was applied as a sensitivity run. This resulted in an increase in the peak inflow rate into the pit and an increase in the drawdown lateral extent.

    RPS interpreted that although localised increases in hydraulic conductivity values have been observed for the calcrete aquifer, it is unrealistic for these values to be observed as a bulk aquifer parameter value. Therefore, the results from the base case simulation were considered acceptable.

- A cumulative impact assessment of the pit dewatering and tailings/waste rock placement was undertaken by RPS.

  - Potential cumulative impacts resulting from the drawdown of groundwater levels due to dewatering were not identified. Drawdown extents resulting from mining project or groundwater users within the vicinity of the Centipede and Millipede Deposits are not anticipated to interfere with the drawdown extent of the Centipede and Millipede Pit dewatering activities.

  - RPS referenced solute fate and transport modelling conducted by Aquaterra in 2011. These results indicated that seepage from the tailings infill would be limited to 15 m from the Centipede Deposit after 1,000 years (U concentrations of less than 0.001 mg/L). RPS also indicated that CSIRO are undertaking updated solute fate and transport modelling of the Centipede-Millipede Deposits, and it is anticipated that the results from this work will be similar to the RPS (2011) investigation.

Potential impacts associated with density dependent flow, due to the hypersaline conditions of the groundwater at Centipede and Millipede were not discussed in the report.

Investigation Limitation:

- Limitations to this investigation highlighted within the report include:
  - The developed numerical groundwater level was established for assessing a project at a level of a pre-feasibility study.
  - Aquifer parameters associated with the infill tailings and waste rock material were assumed.
  - Transient calibration of the model domain was not conducted. This results in less confidence in the simulation results for seasonal conditions beyond the average conditions.
- A limitation not highlighted in the report was the lack of discussion associated with the hypersaline groundwater in the vicinity of the Centipede and Millipede deposits. The potential impacts associated with density dependent flow and migration of tailings infill seepage with more saline and dense groundwater was not discussed.
- Justification for the reinterpretation of the Pennington Scott (2015) aquifer parameters were not provided.

4.4 Wiluna Uranium Project – Surface Hydrology Studies (Aquaterra, 2015)

Investigation Objective:

- The objectives for this investigation comprised:
  - Establishing the existing surface water environment for Lake Way and Lake Maitland, particularly within the vicinity of the project sites.
  - Estimate the frequency, magnitude and duration of flooding events which may affect the project areas.
  - Evaluate the potential hydrological impacts of implementing projects on Lake Way and Lake Maitland.
  - Assess potential hydrological impacts from dewatering discharges.
  - Assess mitigation requirements for potential surface water impacts.
  - Characterise the surface water quality.
  - Develop a surface water management strategy to minimise potential contamination of surface water

- Rainfall records for this assessment were adopted from the Bureau of Meteorology (BoM) weather stations at Wiluna and Wonganoo. Evaporation records were obtained from the BoM Meekatharra weather station.
- Design rainfall events used for the assessment of likely impacts of various project components include the 100 year ARI and the PMP (10,000 year ARI). For Lake Way these depths are 1.5 m depth (491.7mRL) and 3.2 m depth (493.4mRL), respectively; while at Lake Maitland the 100 year ARI is approx. 2 m depth increasing to 3 m depth at the perimeter of the pit.
- Based on the proposed mine infrastructure layout relative to calculated flood depths across the project areas to following have been identified:
  - Three deposits are located within the 100 year floodplain of Lake Way and will require bunding for protection; however, under PM P conditions all deposits are located within the floodplain of Lake Way and the local creek flooding, and could be impacted by flooding.
  - Development of project infrastructure on the shore of Lake Way will not measurably impact the lake flood levels.
  - Development of project infrastructure at Lake Maitland will significantly impact flood levels and flow velocities within the lake. An immediate increase in flood levels by 1 m to 1.3 m during a 100 year ARI, and 1.5 m to 2 m during a PMP, upstream of the bunded project area is simulated. Flow velocities are predicted to increase from ~0.6 m/s to 1.5 m/s as a result of the project development.
- Based on the results of the hydrological assessment, the following general strategies have been recommended:
  - Project infrastructure location of the floodplains of contributing creeks, or crossing creeks, will require bunding
  - Encroachment of bunding onto the floodplains or creeks will result in flow restrictions and increase water levels upstream, therefore, bunding within the vicinity of the main channel should be limited and diversion channels for the main channel (for short periods of time) should be considered.
  - The selected southern haul road route crosses several ephemeral drainage lines. Due to the relatively flat topography across the project areas, the structures proposed at the creek crossings include floodways, floodways with culverts or full flow culverts.

Investigation Limitation:

- Rainfall records are based on daily rainfall events. Therefore, the assessment of storm events shorter than 24 hours is unable to be undertaken.

4.5 Groundwater Studies – Lake Maitland Uranium Project (Golder, 2011)

Investigation Objectives:

- The objectives of this investigation comprise:

- Assess the potential impact on the groundwater system as a result of mine development and operation
- Estimate the dewatering requirements from the pits during operation
- Develop a water management strategy for the Lake Maitland project.

Background Summary:

- A summary of the physiographic, geological and general hydrogeological setting was provided. These settings were compiled from previous investigation, historical data and public domain data; and, were used to develop the field investigation program.
- In relation to the site hydrogeology, the proposed development of the Lake Maitland project comprises:
  - Dewatering of groundwater levels by 3.5 m to 4 m to achieve "dry" mining conditions over a duration of 13 year.
  - Backfilling of sections of the pit with tailings throughout the mine life.
  - Sourcing of process water from an upstream tributary of the Lake Maitland catchment (fresh water source).
  - Selected mined-out pits will be used as water storage/management facilities (storage of dewatering discharge, process water, stormwater runoff)

Conceptual Hydrogeological Model:

- The conceptual hydrogeological model within the vicinity of the Lake Maitland project can be broadly categorised by the following units:
  - Surficial aquifer – comprising Tertiary and Quaternary alluvial sediments and calcareous deposits (calcrete), with the majority of groundwater hosted in the solution cavities of the calcrete unit. The calcrete unit is 7 m to 10 m thick with a hydraulic conductivity of 150 m/d to 1,000 m/d (average = 300 m/d) and a specific yield of 6%. The alluvial sediments have a hydraulic conductivity of 0.05 m/d to 10 m/d and a specific yield of 5%.

    Groundwater flow in this aquifer is generally southward along the axis of the palaeodrainage, towards the playas. In the Lake Maitland area, flow is towards the lake in a west to southwest direction following palaeochannels. The average flow gradient in this unit is approximately 0.03%.
  - Lacustrine aquifer – separates the surficial aquifer from the underlying palaeochannel sand and has a relatively low hydraulic conductivity of 0.001 m/d to 0.0001 m/d.
  - Palaeochannel sand aquifer – is approximately 1 km wide and follows the "inset valley" underlying Lake Maitland. The hydraulic conductivity, specific yield and storage coefficient of this unit was estimated at 2.5 m/d, 0.15 and 0.0001, respectively.

    Groundwater flow is generally towards Lake Maitland along palaeodrainage lines, with a flow gradient of approximately 0.008%. Recharge to the aquifer may occur from the surficial aquifer through lacustrine clay unit, particularly when the lacustrine clays are not present.

    - Weathered bedrock aquifer – underlies the sedimentary aquifer units and comprises a granitoid and mafic volcanics. The estimated hydraulic conductivity of this unit is 0.1 m/d.
    - Fresh bedrock aquifer – underlies the weathered bedrock aquifer and has an estimated hydraulic conductivity of 0.05 m/d.
- Groundwater quality – salinity concentrations are variable in the aquifers associated with the Lake Maitland project. These concentrations range from brackish (1,000 mg/L) to hypersaline (250,000 mg/L), with the hypersaline concentrations potentially contributing to density-dependent flows at the project site.

  Salinity concentrations in the surficial aquifer ranges from 340 mg/L to 99,000 mg/L, while the concentration in the calcrete aquifer is approximately 50,000 mg/L. Salinity concentrations decrease up-gradient of Lake Maitland, while hypersaline groundwater is observed in the groundwater of the playa sediments.

Field Investigation Program:

- A detailed field investigation program was undertaken by Golder as part of this investigation. This field program comprised:
    - Installation of 100 bores and 8 vibrating-wire piezometers
    - Physicochemical parameter monitoring for all bores and water level monitoring from all facilities
    - Multiple testing programs for hydraulic parameter assessment:
        - Costean excavation, inflow monitoring program and modelling to assess aquifer hydraulic conductivity – 6 to 5,550 m/d.
        - Slug testing and air-lifting recovery tests to assess aquifer hydraulic conductivity– 0.03 to 9.5 m/d.
        - Trial test pit dewatering was undertaken using barrier trenches and deeper trench sump pumping. Inflows into the trial pits were monitoring and simulated using a numerical model and Seep/W two-dimensional model to assess the hydraulic conductivity. The trial pits were also used to assess the application of pit inflow mitigation infrastructure (e.g. seepage barriers) and groundwater level recovery following the cessation of pit development.
        - Test pumping of the calcrete aquifer to assess aquifer parameters and dewatering requirement of this unit. Discharge water from the test pumping program was re-injected into aquifer at rate of discharge and an assessment of reinjection efficiency was undertaken. Groundwater level mounding of 0.6 m was observed at the injection wells during test, while negligible mounding was observed 20 m from the reinjection site.

Water Supply Assessment:

- The project water supply assessment and associated numerical model was conducted by RPS Aquaterra, however, the results were presented in Golder's report. Key findings include:

  - The proposed water supply borefield is located in the upper alluvium aquifer along a northern tributary of the main Lake Maitland drainage system. Testing of this aquifer indicates a long-term potential yield of up to 11 L/s.
  - Numerical modelling of the proposed borefield (10 bore, 1 km spacing) simulated a supply of 3,600 kL/d over a period of 13 years. The maximum drawdown simulated for the proposed borefield was 6.5 m (25% of aquifer depletion); which correlates to no detrimental impacts on stygofauna habitat.

Regional Groundwater Model:

- A regional model, developed by Golder, was constructed to simulate the potential impacts to the groundwater system due to the proposed mining and processing operations; including the assessment of drawdown extent, volume of water to be managed, post-closure recovery of groundwater levels, the lateral groundwater movement through surficial aquifer and hydraulic connection between the surficial and palaeochannel aquifers.
- Calibration
  - Model was calibration to steady-state conditions to measured groundwater level targets. Aquifer hydraulic conductivities were modified to within an acceptable range (based on results of field investigations) to achieve model calibration. Once acceptable calibration was achieved the model was used for predictive simulation.
- Predictive simulations
  - Dewatering of the Lake Maitland pits were simulated using the MODFLOW Well package, which comprised a series of pumping wells spread over the proposed mining area. Each well was simulated to pump at a fixed pumping rate over the 13 year duration of mine development.
  - At the cessation of mining (after 13 years) the wells were deactivated and the groundwater level was allowed to recover across the mining area.
  - Results from the predictive simulations include:
    - Dewatering impacts – 3.5 m groundwater level drawdown is predicted in the mining area, with 1.5 m drawdown simulated up to 10 km from the pit (towards the west).
    - Post-closure groundwater level recovery in the mining area occurs to 50% of the total drawdown within 2-3 years following the cessation of mining activities; to 80% of the total drawdown at 10 years following the cessation of mining activities; and, to 95% of the total drawdown at 20 years following the cessation of mining activities.
    - Following the cessation of mining activities, once the pit has been backfilled (with low permeability material - 1×10^{-3} m/d), the simulated groundwater flow within the vicinity of the backfilled pit indicates that groundwater flows around the previous pit rather than through or underneath the pit. This is due to the contrast between the lower permeability backfilled pit and the adjacent calcrete and alluvium aquifers.

- Density dependent flow
  - High salinity concentrations within the vicinity of the Lake Maitland site will likely results in density dependent flow in the groundwater system. This was assessed as part of Golder investigation.
  - Generally, the brine in the surficial aquifer would expand laterally by 50 m for every 1 m that it sinks (developed through evapotranspiration over time). While the concentration of the saline plume decreases by 20,000 mg/L over a distance of 1,500 m from the centre of the plume. Brines are typically located below the unvegetated playas.

Numerical Modelling of Density Dependent Flow:

- The numerical modelling of the density dependent flow was conducted using FEFLOW in a two-dimensional model domain. The objective of this modelling exercise is to assess potential contaminant migration within the brine.
- Results from the FEFLOW modelling indicate that shallow brines will be captured by dewatering activities during the operation of the dewatering system, however, deeper brines will not be affected by dewatering. The simulations indicate that these results in continued vertical migration of the brine.

Near Mine Numerical Modelling:

- A near mine numerical groundwater model was developed in MODFLOW to allow assessment of impacts resulting from pit dewatering; and, to identify possible groundwater pit inflow management and stygofauna habitat protection strategies.
- Pit inflow management and stygofauna habitat protection strategies include:
  - hydraulic barrier to limit both pit inflow and drawdown extent migration; and,
  - reinjection wells to maintain groundwater levels in the stygofauna habitat.
- Two predictive scenarios, with and without mitigation measures, were undertaken, with the results indicating:
  - Without mitigation measures (including Kangaroo Line reinjection system) – by year 12 of mining, a drawdown of 0.5 m to 1 m was simulated over a large portion of the calcrete tongue (main body of calcrete aquifer and a stygofauna habitat), with the extent of drawdown 3.2 km to the west of the western mine lease boundary. This drawdown amounts to 25% of the average saturated thickness of the calcrete aquifer. Pit dewatering rates range for this scenario range from 2,000 to 24,000 m^3/d.
  - With mitigation measures – includes the operation of the stygofauna line injection wells and Kangaroo line injection wells. Results of this simulation indicate that the mitigation measures have limited drawdown to less than 0.5 m of original groundwater levels and within the mining lease from the start of the mining operation to year 8. 0.5 m drawdown is predicted up to 800 m beyond the western lease boundary between year 9 and 10; and, from year 10 to year 12 0.5 m drawdown extends beyond the northern boundary, potentially interfering with the drawdown from the water supply borefield. Dewatering rates of for this scenario are from 2,000 to 24,000m^3/d.

Investigation Limitations:

- Calibration of the various numeric al models in this investigation (water supply borefield model, regional model, near-mine model) were conducted to steady-state conditions. Therefore, confidence in the results is based on assumed average conditions of the groundwater system. Uncertainty in the model results may arise when simulation of storm and/or seasonal events are undertaken, as comparison or predictive simulation results against the actual groundwater conditions have not been completed.

4.6 Lake Maitland Uranium Project – Hydrologic Studies & Site Water Balance (Golder, 2011)

Investigation Objectives:

- The objectives of this investigation comprised:
  - Analysis of rainfall data for the estimation of design storm rainfall events (for the project site and up-catchment);
  - Duration and depth of flooding in the mine area under existing conditions and during operations;
  - Assess the site water balance to develop a management plan for impacted surface water for onsite containment and to confirm the borefield demand; and,
  - Assess the potential sediment transport prior, during and following mining.

Background Summary:

- The surface water catchment for the project site covers an area of 15,000 km^2 and ranges in elevation from 595 mRL to 470 mRL. 70% of the catchment area is upstream of Lake Way storage. Topographic gradients in the catchment range from 0.06 to 0.05%.
- Rainfall records are based on the BoM sites Wonganoo and Wiluna (annual average rainfall is 224 mm and 250 mm, respectively), while evaporation records are based on the Meekatharra station (annual average evaporation is 3,559 mm). Class A pan evaporation mapping undertaken by BoM simulate an evaporation rate of 3,200 mm for the project site.
- Design rainfall events for short duration from 5 minutes to 72 hours for ARIs up to 100 years; and, longer durations ARIs from 100 to 1000 years were undertaken. These calculated rainfall events were used to develop intensity-frequency-duration curves. Golder identified limitations to the calculated design rainfall events include:
  - Rainfall records for periods shorter than 24 hours are not available, therefore, short-term duration design events are not validated; and,
  - For ARIs calculated for storm events less than 24 hours BoM assumes these represent more localised events <1000 km^2, while durations of 24 hours and longer represent the entire lower catchment of the project site catchment.

Flood Level and Discharge Assessment:

- A RORB runoff-routing model was used to assess flood level for calculated ARIs. Results from this model were used to support mine infrastructure planning.
- Due to a lack of streamflow monitoring data at the project site, regional relationship with the similar catchments (Wheatbelt and Pilbara region) were applied to construct the model.
- Results of the modelling indicated that critical storm events were 24 hour storm events for ARIs above approximately 10 years, therefore, assessment of 48 hour events were not undertaken. As a result, stormwater management infrastructure for the mine were designed for the 24 hour, 100 year ARI storm event.
- Hydraulic analyses (based on estimated flood discharges) were undertaken to define flood levels in the vicinity of the mine; and, extent and duration of inundation and flow velocities along the playa.
    - A HEC-RAS model was constructed for these hydraulic analyses. Inputs into this model included a DTM, which produced a 0.25 m contour plan across and beyond the project site and cross-sections every 200 m along main channel.
    - The design criteria for flood mitigation infrastructure (bunds) were based on a 24 hour 100 year ARI flood level, plus 0.5 m freeboard. The 100 year ARI was selected based on the level of risk of over-topping during the 12 year mine life, which equates to approximately 11% (i.e. the risk of exceeding the 100 year ARI flood level is 1%, therefore, over a 12 years would result in approximately 11%).
    - Results from the modelling indicates that the flood levels from a 100 year and 500 year ARI events equate to a 1.2 m to 1.3 m increase in water levels, predominantly occurring in the northern portions of the mine area. Correlation of these calculated flood levels with actual comparable storm events (i.e. Cyclone Bobby) indicate that the predictions are approximately 0.5 m higher than the actuals flood level.

      Little to no impact on the flood levels were predicted 2 km upstream of the mine. The increase in flood levels within the vicinity of the mining area is due to the reduced conveyance across the water course caused by bunding for the mine infrastructure. In addition to the increased flood levels, the reduced conveyance areas will also result in increased flow velocities around the bunded areas. Under pre-mining conditions peak flow velocities were estimated at approximately 0.6 m/s, however, during operations maximum flow velocities were estimated to be 1.5 m/s towards the south of the mining area.

      The duration of flood inundation for the 100 year and 500 year ARI storm events are approximately 12 hours at the maximum flood level before declining over a period of 3 to 4 days.

Site Water Balance:

- A water balance was constructed using the GoldSim modelling platform to allow assessment of on-site management and containment of water; and, the allocation of water for on-site usage. The model comprised various compartments representing water management component of the project site; which changes over the duration of the 12 year mine life.

- Model inputs include – rainfall/evaporation, dewatering rates, dust suppression requirements, supernatant return from the TSF, moisture within the ore, runoff factors and catchment areas.
- The model results indicate:
  - Ponds surface areas for the mine should be sized to the following:
    - Process plant surface water runoff pond – 2 ha
    - Sewage pond – 0.01 ha
    - Supernatant pond – 16 ha
  - Salinity concentrations in the ponds were simulated to be 200,00mg/L to 300,000mg/L.
  - Based on the simulated allocation of available water, there is unlikely to be shortfall in dust suppression demands.

Investigation Limitations:

- The limitations identified from this investigation include:
  - Evaporation records were sourced from the BoM Meekatharra weather station, approximately 200 km from the study area. Although the BoM Class A pan evaporation mapping indicated similar evaporation rates between the estimate site location and the Meekatharra station, site specific evaporation rates would increase the confidence in the assessment.
  - Rainfall records were sourced from BoM weather stations with a minimum recording interval of 24 hours. Therefore, calculated rainfall durations less than 24 hours were unable to be validated.

5 REPORT REVIEW SUMMARY MATRIX

A matrix summarising the reviewed reports including the investigation objectives, extent and limitation is provided in Table 5-1.

Table 5-1 Report Review Summary Matrix

Report	Project Location	Project Objectives	Project Limitations
West Creek Water Supply Groundwater Modelling (Aquaterra, 2010)	Wiluna Project	▪ Assess water supply potential from the West Creek Calcrete Aquifer to provide a long-term sustainable supply to the Wiluna Project. ▪ Assess potential environmental impacts associated with groundwater level drawdown resulting from the borefield development.	▪ Steady-state calibration of numerical model exceeded MDBC guideline error trigger for project in a "greenfield" catchment (SRMS < 10%). Two data points were remove to achieve compliant calibration statistics (SRMS = 4.4%) ▪ Calibration statistics for transient calibration were not included in report, only the mass balance of the model fluxes was presented. ▪ Further work on the model calibration is required to increase confidence in the result of the predictive simulation.
Bore Completion Report – Millipede Uranium Project (Pennington Scott, 2015)	Wiluna Project	▪ Factual report on the drilling, installation and testing of production bores and associated monitoring bores across the Millipede Deposit. ▪ Analytical assessment of test pumping results.	▪ Analytical assessment and interpretation of the test pumping results were not appropriately conducted. Boundary conditions observed in the drawdown curves from the test pumping program were not identified by Pennington Scott. Additionally, incorrect sections of the drawdown curve were selected for the analytical assessment. ▪ Aquifer hydraulic parameters calculated by Pennington Scott were not adopted by RPS (2015) in the Centipede-Millipede Deposits groundwater model. The drawdown curves were reinterpreted by RPS prior to inclusion in the groundwater model.
Centipede – Millipede Groundwater Impact Assessment (RPS, 2015)	Wiluna Project	▪ Update the 2011 numerical groundwater model with additional hydrogeological information to assessment potential impacts on the groundwater system due to the mine development; post-closure groundwater level recovery following the cessation of mining; and, potential impacts on other groundwater users within the vicinity of the project site.	▪ Numerical model was developed for assessing a project at a pre-feasibility level. ▪ Aquifer properties of pit infill material were assumed. ▪ Transient model calibration was not conducted; therefore, simulated seasonal variability was not validated. ▪ The potential for density dependent flow as a result of the hypersaline groundwater, particularly the potential to contribute to contaminant migration from the infilled pit, was not discussed in the report.

Report	Project Location	Project Objectives	Project Limitations
Wiluna Uranium Project – Surface Hydrology Studies (RPS, 2015)	Wiluna and Lake Maitland Projects	▪ Assess the hydrological flow and design flood characteristics of the Wiluna and Lake Maitland Deposits catchments. ▪ Develop a surface water management strategy to minimise potential contamination of the surface water system	▪ Rainfall records were sourced from weather stations with a minimum frequency of daily records. Therefore, calculated storm durations less than 24 hours were unable to be validated. ▪ Evaporation records were sourced from the Meekatharra weather station 200 km west of the project site, although Class A pan evaporation mapping for the project site indicate similar values. ▪ Assessment of the inundation duration was not undertaken as part of this assessment.
Groundwater Studies – Lake Maitland Uranium Project (Golder, 2011)	Lake Maitland Project	▪ Assess the potential impact on the groundwater system as a result of mine development and operation ▪ Estimate dewatering requirements ▪ Develop a water management strategy for the Lake Maitland Project	▪ Calibration of the numerical models were conducted to steady-state conditions only. Therefore, confidence in the modelling results is based on the assumed average conditions of the groundwater system. Uncertainty in the simulation results may arise when the simulation of storm and/or seasonal variability rainfall scenarios is undertaken.
Lake Maitland Uranium Project – Hydrologic Studies & Site Water Balance (Golder, 2011)	Lake Maitland Project	▪ Assess the hydrological characteristics of the Lake Maitland surface water catchment, including existing and anticipated flood levels and flow velocities. ▪ Develop a water balance for the project to allow assessment of pond sizing and allocation of available water.	▪ Rainfall records were sourced from weather stations with a minimum frequency of daily records. Therefore, calculated storm durations less than 24 hours were unable to be validated. ▪ Evaporation records were sourced from the Meekatharra weather station 200 km west of the project site, although Class A pan evaporation mapping for the project site indicate similar values.

6 DOCUMENT CLOSURE

KCB is pleased to provide this hydrogeological and hydrological report review of the various investigation reports completed at the Wiluna and Lake Maitland Projects. Should you have any queries regarding this report, please do not hesitate to contact the undersigned on +61 7 3004 0244 or cstrachotta@klohn.com.

Yours truly,

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REFERENCES

Toro Energy Limited, 2014. Extension to the Wiluna Uranium Project (CMS 14025) Assessment No: 2002 Environmental Scoping Document. November 2014.