Modelling code (mode type)	GoldSim (Water Balance Model)	Geochemists Workbench (Mixing Model)	MODFLOW (Groundwater Model)		FEFLOW (Groundwater Model)
			2021	2022	
Model Use	• Prediction of Fountain Head pit dewatering requirement and pit water level drawdown. • Site water balance modelling. • Water quality modelling for single source term parameter (arsenic) for which acts independently from pH. The water quality modelling has been undertaken by a non-reactive solute balance paired with water balance model.	• Prediction of Fountain Head pit lake water quality for source term constituents (acidity, arsenic, cobalt and copper).	• Prediction of steady state (current) regional groundwater elevation. • Understand the extent and scale of the groundwater drawdown in response to mine-related water affecting activities with regard to the location of identified environmental values reliant to some extent on groundwater. • Inform groundwater drawdown triggers.	• As per 2021 model • Provide predictions of groundwater flow to determine the degree of potential impact on downstream environmental receptors. • Benchmark the groundwater fluxes predicted by the Goldsim water balance model to provide increased certainty improved confidence of the dewatering requirements. • Reducing and describing in greater detail the model uncertainty.	• Inform mounding triggers from potential seepage from the evaporation pond. • Determine whether seepage would 'daylight' and present as surface expressions outside of the evaporation pond area.
Description	A multi-functional model that predicts pit dewatering requirements, pit level drawdown and recovery, movement and distribution of water around the Fountain Head site and water quality associated with these movements of water. Modelling is completed via two approaches: 1. A deterministic approach (i.e. outcomes are the result of unique set of parameters). 2. A probabilistic approach (Monte Carlo analysis) (i.e. attempts to account for uncertainty of input parameters by presenting results as likelihood of an outcome).	A spreadsheet-based model designed for geochemical analysis. The function of the model is to allow for reactive mixing predictions of different waters in the Fountain Head pit lake. Results are static in that each prediction is calculated based on a set volume of water at a given solute concentration.	A conservative groundwater flow model developed to interface with the Goldsim water balance model that predicts the steady state groundwater elevations regionally, groundwater drawdown as a result of pit dewatering, the extent of the drawdown regionally (across the model domain) and the regional groundwater recovery post mining. Informs impact of drawdown on the surrounding environment and associated triggers.	A stochastic groundwater flow model updated (based on the 2021 version) with additional calibration targets (additional monitoring bores and transient water level data) to improve the calibration performance, predict groundwater flow to downstream receptors, benchmark groundwater fluxes of the Goldsim water balance model and describe in greater detail the model uncertainty.	A highly conservative single-use model developed to inform mounding triggers that were set to (i) assess whether seepage from the evaporation pond would report as surface expressions from the evaporation pond structure and/or ground to the surrounding environment, and (ii) to serve as a validation of groundwater modelling. Mounding triggers were requested as part of comments received on the Draft EIS in late 2021.

Calibration	**Transient calibration** - Calibrated based on recorded pit water levels to derive estimates of the groundwater and surface water inflow components. - A good fit to the observations was achieved using an internal runoff coefficient of 0.6 (60% of rainfall becomes runoff while 40% is lost to evaporation or infiltration). - Bulk aquifer hydraulic conductivity of 0.2 m/d. - Groundwater inflows are simulated using the Dupuit-Forcheimer equation.	Not calibrated	**Steady state calibration** • Calibrated against 13 groundwater level observations from July 2019 and three observations with earlier unknown dates. • RMS error of 1.9m equating to SRMS of ~30% **Transient calibration** • Calibrated against estimates of groundwater flux to the pit from the water balance model (which in turn was calibrated to the pit water levels). • 1 flux target for each transient stress period totalling 76 flux targets. • Combined steady-state and transient data was calibrated using PEST. • RMS error of 0.2 ML/d equating to SRMS of 12%	**Transient calibration** • Calibrated against 22 transient groundwater level observations with 245 time series records and 75 time series groundwater flux targets. • 'Steady state' period representing current conditions measured from July 2021 groundwater levels. • Calibrated using PEST • SRMS of 5-6%.	Not calibrated

Model Parameters	Key model parameters: • Hydraulic conductivity - 0.2m/d (constrained by historical pit water level recovery). • Water table elevation near pit - 95m AHD. • Initial pit lake volume – 2,064 ML. • Soil thickness - 3m. • Kv soil - 0.0034m/d. • 0.15 Mt PAF material • Total area of pit walls at 55,563m^2 • Density of 2.7t/m^3 • Cumulative scaling factor 0.4 • Water volumes variable	Key model parameters: • 0.15 Mt PAF material • Total area of pit walls at 55,563m^2 • Rainfall of 1250mm/y • Density of 2.7t/m^3 • Cumulative scaling factor 0.4 • Runoff volume of 116 ML/y • Rainfall volume of 92 ML/y • Groundwater volumes varying from 500 to 7,500 ML	• Hydraulic conductivity - 0.053m/d • Rainfall recharge - 31 mm/y • Specific yield - 0.0083	Geomean parameters • Hydraulic conductivity - 0.4m/d • Rainfall recharge – 9% • Specific yield – 0.005 • Specific storage – 0.000032 • Vertical anisotropy ratio (kh/kv) – 11.8	• Hydraulic Conductivity - 0.01 m/d • Specific yield - 0.05 m/d In-transfer rate - 0.001 m (based on adopted soil conductance values used in goldsim water balance)

Assumptions	**Fountain Head pit** • Transition of pit from existing dimensions to final mined dimension assumed to occur instantaneously. Considered conservative since the groundwater inflow rates will increase rapidly in following this transition and pit development will be slower in reality. • Assumes two scenarios for recovery of pit water levels: 1. Unaided recovery (UR) – through groundwater inflow and rainfall sources. 2. Aided recovery (AR) – by adding the volume of water remaining in the Evaporation Pond directly back to the pit void, in addition to groundwater inflow and rainfall sources. • Assumes a 20% outflow flux (i.e. throughflow) from Fountain Head pit (2070 onwards) when pit lake level is >90m AHD. • A factor of 0.75 was applied to pan evaporation rates to account for water saturation (i.e. where relative humidity is 100% and no evaporation can occur) **Evaporation pond** • Balances the inflows (direct rainfall, runoff and contribution from the Fountain Head Pit dewatering) and outflows (evaporation, both natural and mechanically forced by evaporators, and groundwater infiltration / seepage). • Residual pond water body assumed to be permanent and not accounted for in storage capacity.	• All PAF is stored within the pit during and post mining. • Contact water concentrations for S1, S2 are combined with groundwater over five mixing scenarios (i.e. different groundwater volume contributions). • Solute loading rates from stored PAF material remain in steady state. • Source term constituents are derived from three sources, S1 (PAF material in pit) and S2 (PAF rock in pit walls) and groundwater. Contributions of arsenic from other sources have not been considered. • Solute loading rates from PAF material in exposed pit walls remain constant which is thought to be occurring at present. • The mean 52-week	• HSUs in study area simplified to be homogeneous and isotropic. • Model domain approx. 10km x 10km and centred on Fountain Head pit. • Model surface sourced from high resolution survey data and 25 x 25m digital elevation model (ELVIS) outside high resolution survey area. • Model base set to -80m AHD (approx. 50m below base of pit post mining). • Model grid is 50 x 50m and 25 x 25m within vicinity of the pit and 4 model layers. • Constant head boundaries are applied around the perimeter of the model, with head values derived from correlation between topography and measured groundwater elevations. • Margaret River is simulated as a drain boundary with the head elevation specified as the surface elevation. • Rainfall recharge is applied to the uppermost active cells of the whole domain using the MODFLOW Recharge (RCH) package, with the	• HSUs in study area simplified as a singular unit, with variable hydraulic properties governed by 7,866 pilot points with nominal separation distance of around 250m. • Model domain approx. 10km x 10km and centred on Fountain Head pit. • Model surface sourced from high resolution survey data and 25 x 25m digital elevation model (ELVIS) outside high resolution survey area. • Model base set to -80m AHD (approx. 50m below base of pit post mining). • Model grid is 50 x 50m and 25 x 25m within vicinity of the pit and 4 model layers. • Constant head boundaries are applied around the perimeter of the model, with head values derived from correlation between topography and measured groundwater elevations. • Margaret River is simulated as a drain boundary with the head elevation specified as the surface elevation. • Evapotranspiration is simulated using the EVT package, with the potential rate set to 6.5 mm/d based on the Douglas River Research Farm weather station (14901) and the extinction depth set to the standard value of 2 m. • The HSUs are simplified as a singular unit with variable (heterogeneous) hydraulic	• Considered to operate at a full level of 98 mAHD for three years covering the initial dewatering phase and two years of mining operations. This is conservative as during operations, the evaporation pond will not likely remain at full capacity. • Post-operation, the residual evaporation pond lake is assumed to stabilise at 95 mAHD. This assumption is conservative as this level is higher than the current observed water level within the evaporation pond and around 20% higher than the level simulated using the Goldsim model. • Evaporation is not represented in the model.

	• Residual pond considered separate to the base of the evaporation pond. - Total additional capacity 1074ML for a dam wall height of 98.8m AHD. - Minimum operating level set at 93m AHD and maximum operating level set at 97.4m AHD allowing for a 1.2m freeboard. • Operating volume defined by these thresholds amounts to 660ML. • Upper threshold aims at keeping sufficient storage capacity in the evaporation pond to prevent a 1% AEP 72-hr rainfall event from reaching the spillway. • Pit dewatering to evaporation pond assumes 9ML/d until pit is empty after which lower pumping rates will be required to maintain dry pit conditions Evaporators will be moved to evaporation pond and have a maximum capacity of 135m3/hr each typically equating to a daily removal of 2 - 2.45ML/d. • Assumed evaporators will not interfere with natural evaporation from the pond. • Groundwater infiltrations assumed to increase with increase in wetted area and water level in the pond. **Fountain Head Lake** • Sed dams W2, W3 and E3 will discharge directly in the fountain head lake catchment and included in the model. • Accounts for water inflows from direct rainfall and from runoff, as well as losses of water to evaporation and through downstream overflow to the north.	extrapolated value from the kinetic test data has been used to derive source term loading rates. • All PAF material is of the equivalent geochemical make up as the PAF sample used in the column leach test and has the same reaction with water. • A cumulative scaling factor of 0.4 has been applied to the predictions to account for the overestimation of kinetic test results. • Leachate generation assumed to occur only when open to atmosphere and progressively reduces with recovering pit water levels and submersion of PAF material occurs.	recharge rate adjusted during model calibration. • Evapotranspiration is simulated using the EVT package, with the potential rate set to 6.5 mm/d based on the Douglas River Research Farm weather station (14901) and the extinction depth set to the standard value of 2 m. • The HSUs are assumed to be isotropic and homogeneous, with hydraulic conductivity and specific yield of the bedrock aquifer estimated during model calibration. Storage coefficient is set to 7x10-5. • The open pit is represented by a parameter zone with a high hydraulic conductivity of 100 m/d and specific yield of 1. • The pit water level is represented using a constant head boundary. The constant head values are based on the water balance model outputs and change over time due to dewatering activities. • **When assessing the effect of the Evaporation Pond, the RCH package is used to simulate seepage from the Evaporation**	properties to enable greater model calibration over the model domain such as hydraulic conductivity, specific yield, rainfall etc. • The pit water level is represented using a constant head boundary. The constant head values are based on the water balance model outputs and change over time due to dewatering activities. • **When assessing the effect of the Evaporation Pond, the RCH package is used to simulate seepage from the Evaporation Pond at a rate predicted by the water balance model.** • A 'no flow' boundary is applied across the bottom of the model domain. • Prediction period is from 2008 to 50 years following mining commencement (i.e. 2072)	

	• Lake surface level assumed to approximate the water table elevation based on nearby groundwater levels and sate little imagery showing frequent presence of water in the lake. • Losses from the lake to groundwater during high water levels and potential groundwater flow during low water levels have been neglected from the modelling. **Water quality modelling** • All PAF is stored within the pit during and post mining. • Full quantity of PAF material is available (un-earthed) from beginning of mining which is considered conservative. • Leachate from the PAF material is applied as a solute load (kg/d) which mixes with the inflow water types each with unique water chemistry. • Solute loading rates from stored PAF material remain in steady state from 52 weeks post mining start until submerged. • Arsenic is derived from three sources, S1 (PAF material in pit) and S2 (PAF rock in pit walls) and groundwater. Contributions of arsenic from other sources have not been considered. • Solute loading rates from PAF material in exposed pit walls remain constant which is thought to be occurring at present. • The 52-week extrapolated value from the kinetic test data has been used to derive loading rates for arsenic.		**Pond at a rate predicted by the water balance model.** • A ‘no flow’ boundary is applied across the bottom of the model domain. • Prediction period continues for approx. 50 years.		

	• All PAF material stored within Pod 3 post mining. This is conservative as a portion of this material may be stored lower within the pit and would therefore be submerged by the recovering pit water levels earlier. • All PAF material is of the equivalent geochemical make up as the PAF sample used in the column leach test and has the same reaction with water. • A cumulative scaling factor of 0.4 has been applied to the predictions to account for the overestimation of kinetic test results. • Leachate generation assumed to occur only when open to atmosphere and progressively reduces with recovering pit water levels and submersion of PAF material occurs.				

Limitations	• Excludes seasonal groundwater recharge, seepage from the integrated waste landform or soil stockpiles, and return from processed or other water used on site sourced from the Fountain Head pit. • The inflow for the mining pit at a depth of -34 m AHD assumes the same uniform aquifer hydraulic properties and therefore doesn't account for a likely reduction of hydraulic conductivity with depth that is commonly observed in fractured aquifers. • Assumes uniform mixing of water storages (i.e. evaporation pond and pit lake). • Leachate generation derived from kinetic test data collected over 24 weeks and measured every four weeks (i.e. 7 data points) and use of the 52 week linear extrapolated value as a loading rate to the model. • Does not consider the colloidal behaviour of solutes or portioning to sediment over time. • Models solutes in terms of mass balance, therefore, only parameters which show an independent relationship to other parameters can be predicted with reasonable accuracy.	• Assumes uniform mixing of water storages (i.e. evaporation pond and pit lake). • Leachate generation derived from kinetic test data collected over 24 weeks and measured every four weeks (i.e. 7 data points) and use of the mean 52 week linear extrapolated value as a loading rate to the model. • Does not consider the colloidal behaviour of solutes or portioning to sediment over time. • Static model which does not allow for prediction of results that factor in variability of water volumes. To account for this limitation, five model mixing scenarios have been completed.	• The influence of faults or fault zones have not been considered in this assessment. • Given the nature of fractured rock aquifers and the homogenous model domain, the model is unlikely to capture all the local scale heterogeneities, some of which may have considerable control on local groundwater flow dynamics as they may act as recharge or discharge boundaries. • The model has not directly considered the influence of the unsaturated zone on recharge timing or other spatial variability. • The sensitivity analysis suggests groundwater inflow to the pit is highly sensitive to the value of specific yield. • The numerical groundwater model calibration is based on the outputs (i.e. pit water level, groundwater inflow and infiltration from the Evaporation Pond) of the GoldSim water balance model and spatial distributions of groundwater level data. • Seepage from the CIP or other site infrastructure not	• The influence of faults or fault zones have not been considered in this assessment. • Given the nature of fractured rock aquifers and the nominal pilot point separation distance of 250, the model is unlikely to capture all the local scale heterogeneities, some of which may have considerable control on local groundwater flow dynamics as they may act as recharge or discharge boundaries. • The model has not directly considered the influence of the unsaturated zone on recharge timing or other spatial variability. • The sensitivity analysis suggests groundwater inflow to the pit is highly sensitive to hydraulic conductivity. • The numerical groundwater model calibration is based on the outputs (i.e. pit water level, groundwater inflow and infiltration from the Evaporation Pond) of the GoldSim water balance model and spatial distributions of groundwater level data. • Seepage from the CIP or other site infrastructure not specified above is not included in the model. • Besides the Margaret River and Evaporation Pond, other surface water features (including Fountain Head Lake) are not explicitly represented in the model.	• The transition through the unsaturated zone is not represented. The evaporation pond seepage reports directly to the water table and flow through delays from unsaturated zone (which should be about 5 m thick at the beginning of operations) are ignored. • Does not account for the drawdown generated by the Fountain Head pit dewatering. This assumption is also conservative as the actual water table elevation will result from the superposition of mounding generated by the evaporation pond and drawdown generated by the pit dewatering.

			specified above is not included in the model. • Besides the Margaret River and Evaporation Pond, other surface water features (including Fountain Head Lake) are not explicitly represented in the model.		