ALTA Conference 2023

Heathgate Resources Pty Ltd

Accurate Production Prediction Guiding Business Decisions

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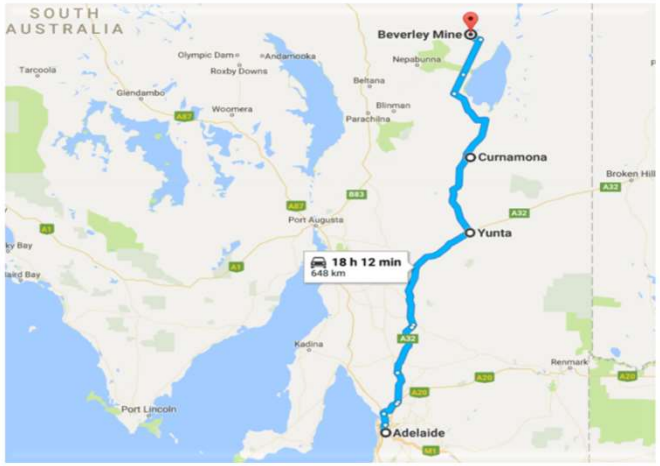
Technical Excellence
Driving Change

Introduction

Heathgate Overview

- Heathgate is a privately owned company
- Producing uranium for 23 years using *In Situ* Recovery (ISR)
- Beverley Mine is roughly 650km North of Adelaide, 1 hour flight
- Main office in Adelaide CBD
- Fly from Adelaide airport to private airstrip at mine
- Has 300 employees
- Plant 1km away from camp

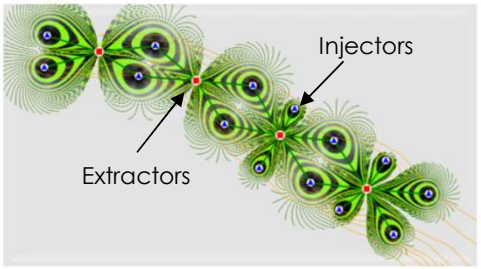


Production Estimation

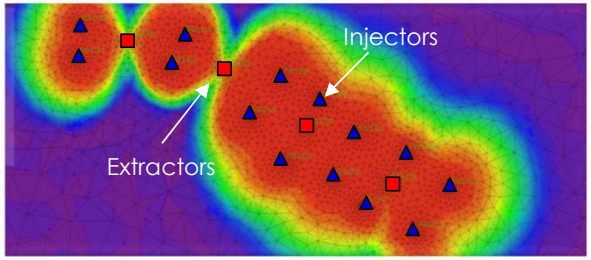
Software (PathCAD™)

- To accurately plan future production in ISR, you need specific software to consider all aspects of mining
- For Uranium ISR mining, the software should be dynamic in all applications, as ISR mining is very much a dynamic environment
- Heathgate is turning on new wellfields every 2 months, this requires rapid analysis and planning
- Heathgate has trialled and uses many software's, but PathCAD is still the primary software for all production modelling
- PathCAD™
  - Founder Craig Bartels, 50 years experience in ISR
  - Originally designed to optimise wellfield patterns
  - Program continually upgraded since 1980
  - **User friendly, quick processing, accurate estimates**
  - Functions cover all aspects of an ISR project development
    - ❖ resource estimation, wellfield design, decline curve design, production assessment, production forecasting and plant optimisation.
  - No other software at the time; still unique for Sandstone Uranium ISR
- Key functions in PathCAD used for accurate production prediction are:
  - Modelling of the Decline Curve (Production Curve)
  - Production Forecast

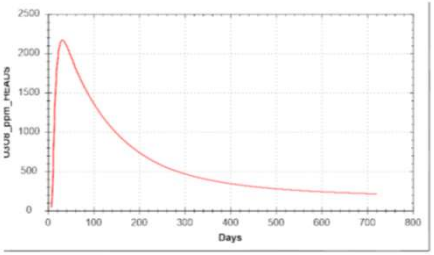
PathCAD™ Icon



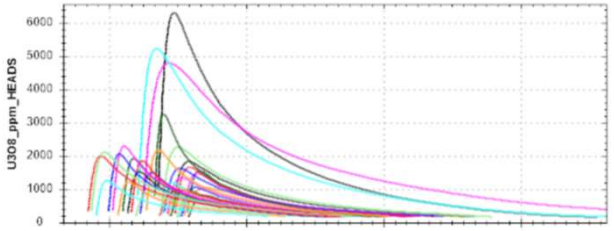
PathCAD Model Of 4 Patterns



FEFLOW Model Of Patterns



PathCAD Decline Curve

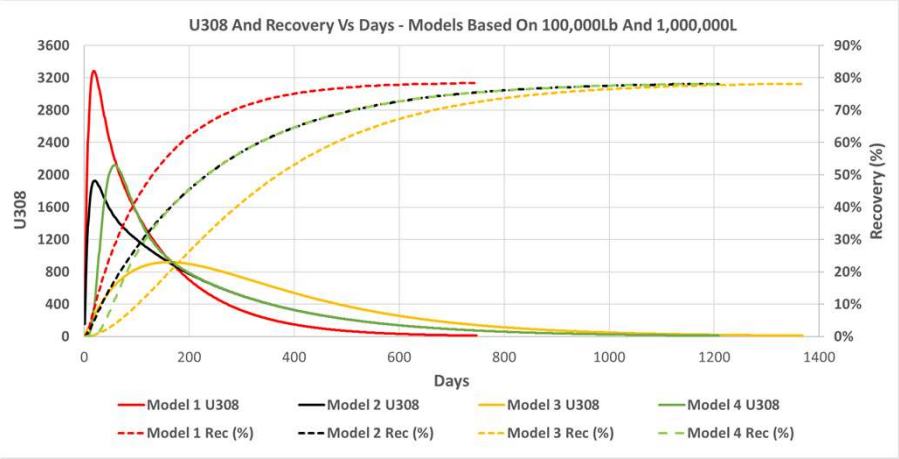


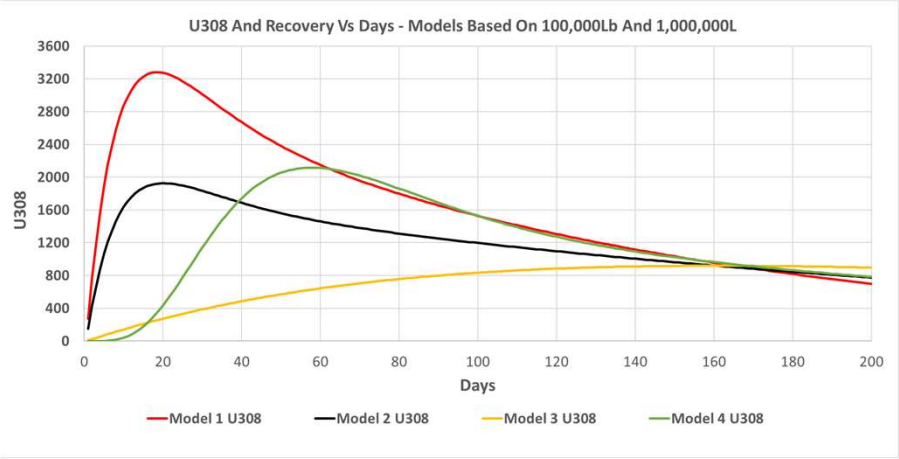
PathCAD Forecast

Production Estimation

What is a "Decline Curve"

- Decline curve is a production curve, comes from the Petroleum Industry
- PathCAD decline curve is an **Exponential Decline Equation**, which uses first order rate kinetics or first principles
- Decline curve design is based on the **relationship** between the inputs
  - Resource, Pore Volume (PV), Kinetics (Reductants, DEF, Reagents, etc), Permeability, Porosity, Zoning, etc.
- Pore Volume (PV) is a standard PathCAD variable, which defines the size of the leaching volume
- All inputs condition the model in the design of decline curve
- Incorrect inputs can generate variety of results
  - Example on right showing 4 models based on same Resource and PV (Liters) but varying conditions
- All inputs have an influence on the design of the curve, some more than others: Data, Mining Zones, Resource Estimation And Kinetics





Production Estimation

Data -Advanced Prompt Fission Neutron (APFN+) tool

- Accurate production prediction starts with accurate data
- APFN tools have been used for the last 10 years
- Developed by UIT in Dresden, Germany
- This tool is used to estimate the following:
  - U grade
  - Disequilibrium
- Tool is regularly calibrated on-site using calibration pits and test holes
- Reliable quantitative estimates
- Provides confidence in resource estimates

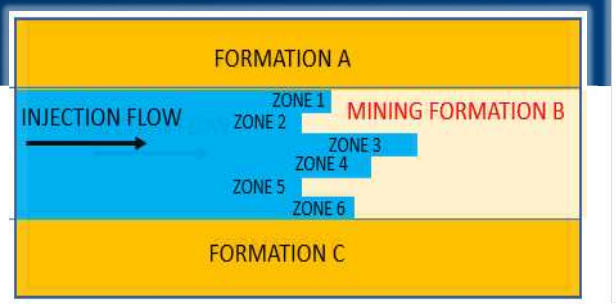
APFN Tool Lowered In To A Drillhole

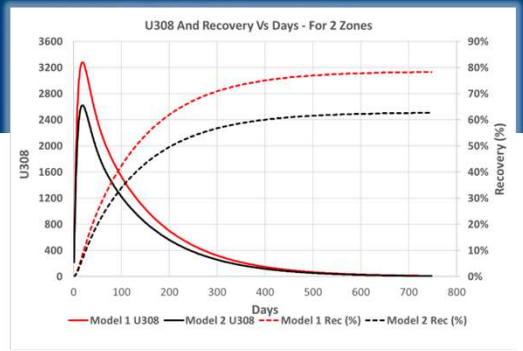
Calibration Pit

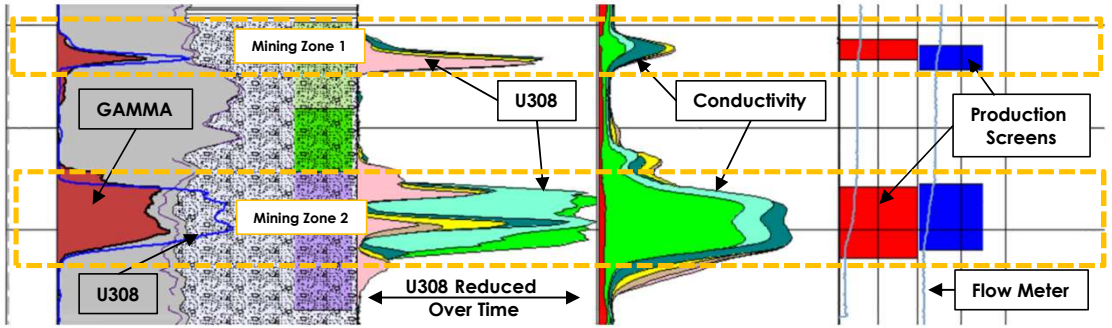
Production Estimation

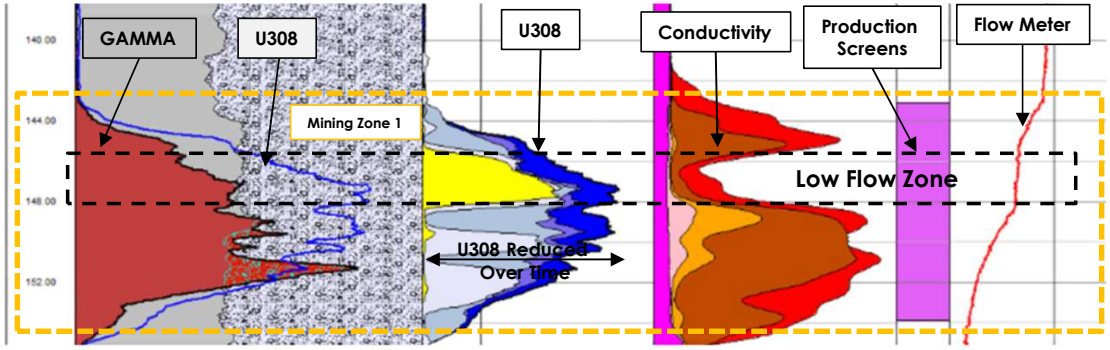
Mining Zones

- Zoning is the most fundamental step when designing a model for estimation of a decline curve
- The number of mining zones should reflect the different characteristics or variability in the formation
- Mining Zones are determined by correlating the geology and mineralisation
  - normally identified by uranium roll-fronts (APFN or GAMMA), geophysics and lithology
  - Resistivity is used to estimate permeability using Petrophysics, good insight towards vertical and horizontal variability
- Selected zones are pump tested for permeability
  - Permeability is later used to estimate flow rate
  - Flow meters are used to define flow across production screens









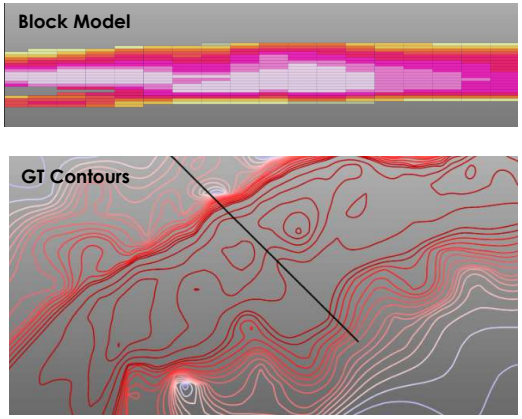
Geophysical Logs In WellCAD

Production Estimation

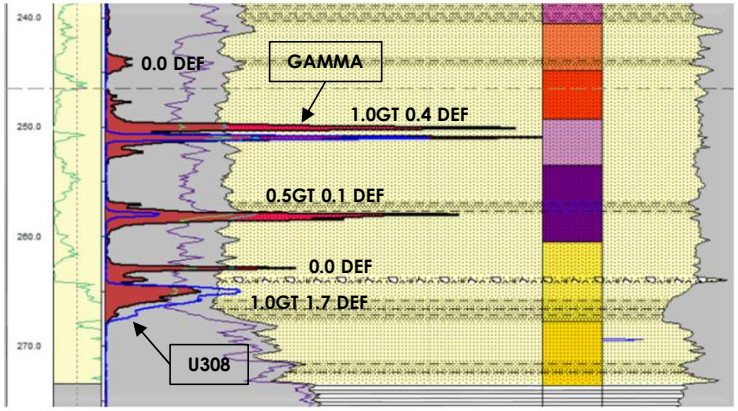
Resource Estimation

Disequilibrium Factor
DEF = U308/GAMMA
Negative <1.0 DEF

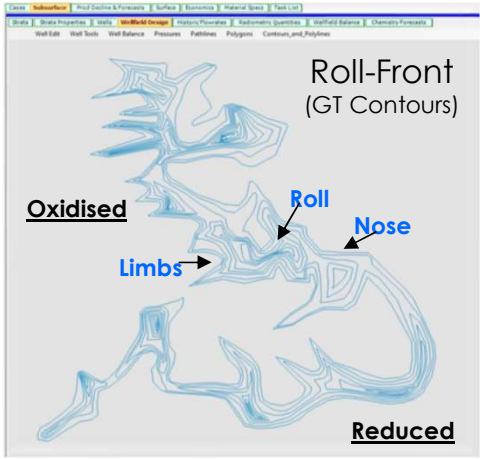
- Resource estimation is done for each zone
- Only minable or leachable resource are used in estimates
- Negative DEF is not used as part of the resource estimation
- PathCADs decline curve estimation is done with input of GT contours (Grade x Thickness)
- GT Contours are generated from block models or drawn by hand
  - Conventional method of roll-front resource estimation
  - Provides a good understanding of the grade or roll-front distribution, especially when the roll-fronts are:
    - very complex in shape
    - Stacked roll-fronts
- This method has worked well at Heathgate in the past years:
  - to justify any of the new projects to be undertaken
  - to design very efficient wellfields for ISR mining
- GT contouring method has been reliable at all levels of estimation (inferred, indicated and measured)



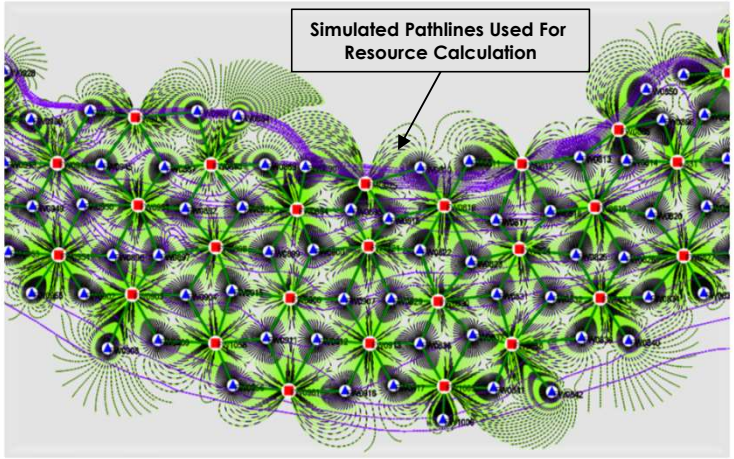
Block Model GT Contours



Log In WellCAD showing GAMMA, U308 And DEF



GT Contours In PathCAD

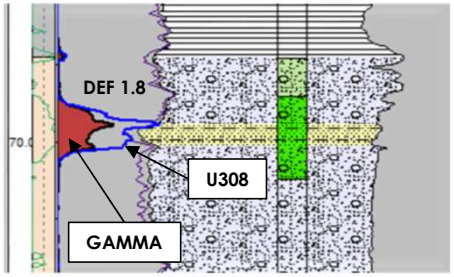


PathCAD Resource Calculation Using Pathline Simulation

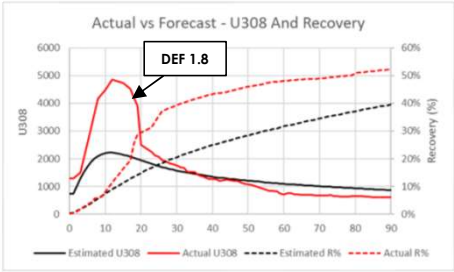
Production Estimation
Kinetics

- To predict recovery, you need to understand recovery rate or kinetics
- Column Leach Test or Beaker Test provide insight to kinetics
  - Tests should be done on all identified mining zones
  - Upscaling of CRT data is complex
- DEF is an excellent guide in kinetic change
- Core drilling is performed in all new deposits
- Typically 1 core hole is drilled per wellfield in a representative location, but in more complex areas (variable permeability, etc.) may require additional holes
- Core drilling is challenging due to the unconsolidated nature of the sediments
- The core is logged and sent away for external analysis
  1. Geochem
  2. Permeability and Porosity
  3. Bulk density
  4. Mineralogy

Column Leach Test

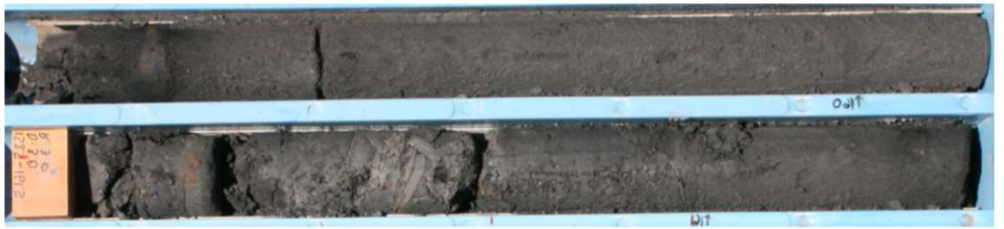


Log Showing GAMMA And U308



Actual vs Estimated

Beaker Test



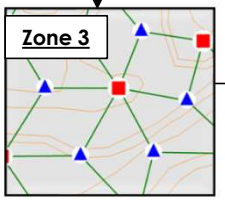
Four Mile West Core

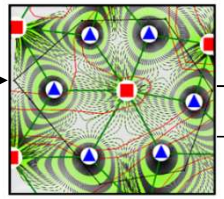
Production Estimation

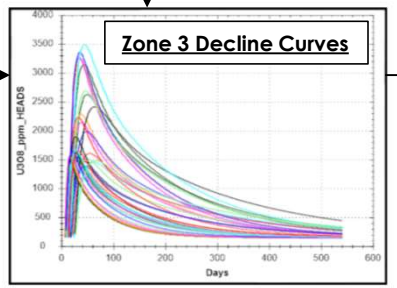
Decline Curve Estimation - "Composite CRT Kinetics" function

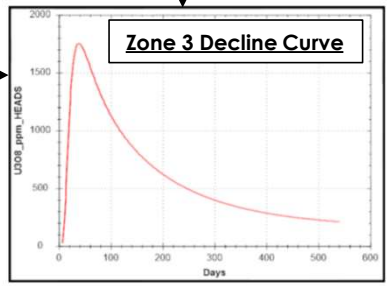
- Planning of patterns over resource
- Opening wells in specific zones for estimation

- Number of pathlines for simulation depends on resource variability
- More variability more pathlines, ranging from 72 to over 1000
- Each zone has different pathlines based on flow and symmetry
- Pathlines are then combined for final zone decline curve

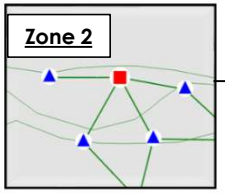


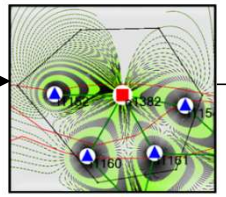


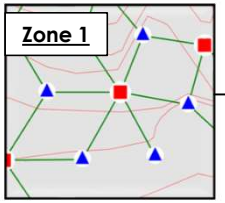


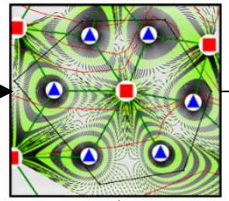


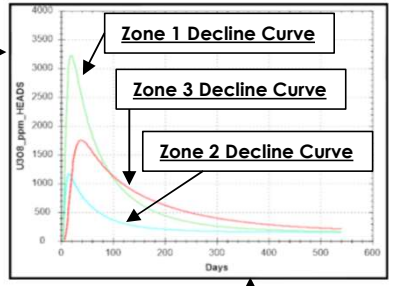
- Final decline curve for forecasting is defined by the exponential decline equation, made up of Resource, PV, Flow, Kinetic Rate
- Equation which accurately describes that decline

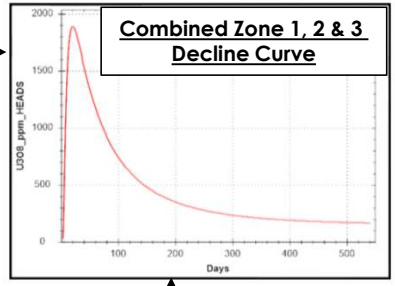


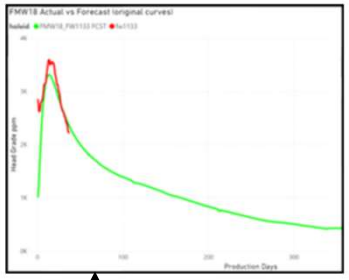












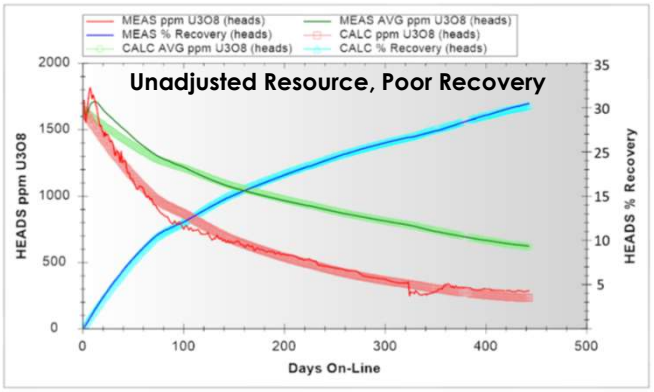
- Simulated pathlines from injectors to extractors based on estimated flow rate
- Each pathline estimates U308 based on assigned kinetics
- Pathline density represents different permeability

- Each zones decline curve is then combined for final extractor decline curve

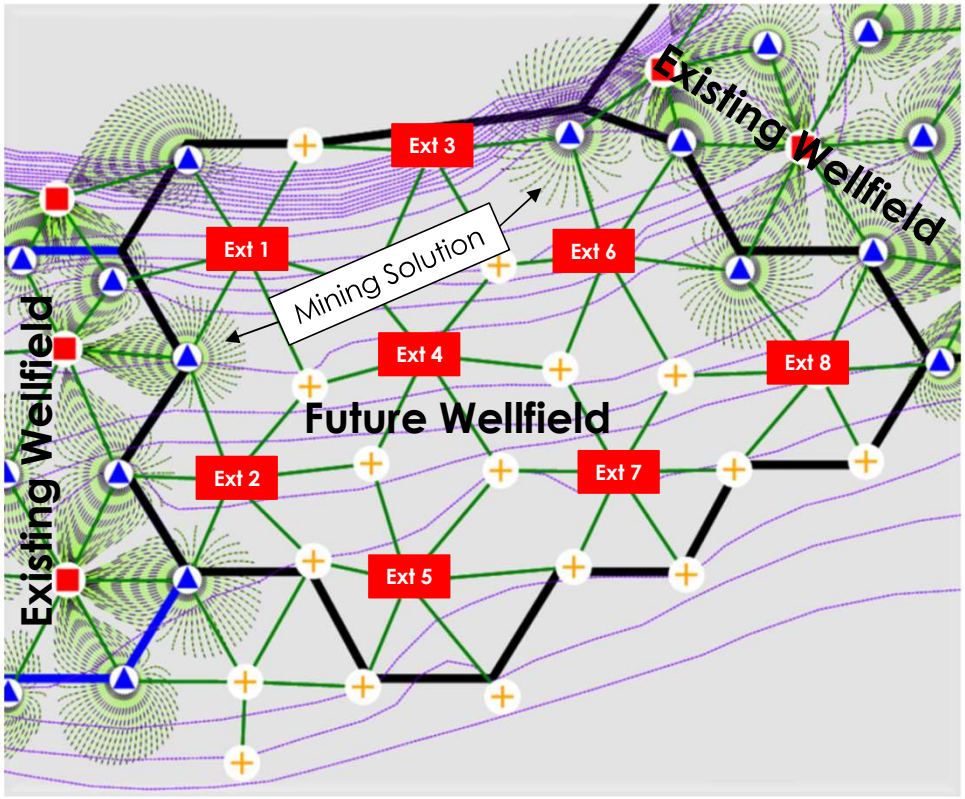
Production Estimation

Decline Curve Resource Adjustment

- Future wellfields or patterns are likely to be next to active patterns
- Existing wellfields which have produced for a while have no doubt robbed adjacent resources
  - High permeability equals large flaring, equals lots of robbing
- Future decline curves if contacted require resource adjustment
  - Review of Mining solution spread over future patterns, chems, geophysics and induction
  - Statistical analysis is used to adjust the resource for the decline curve equation



PathCAD Extractor Modelling

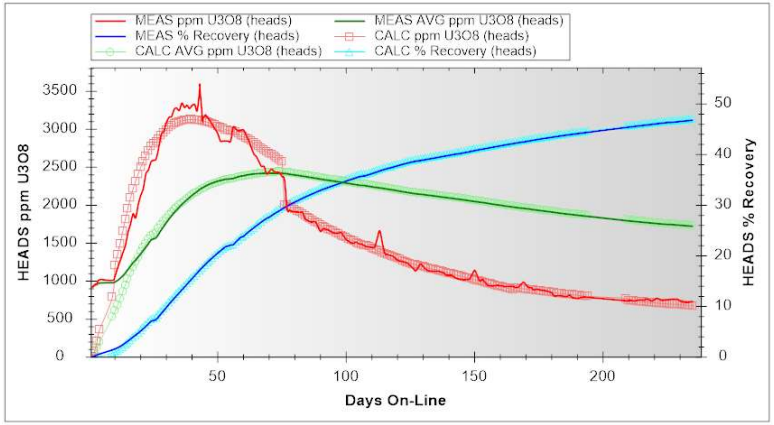


PathCAD model showing flare of mining solution

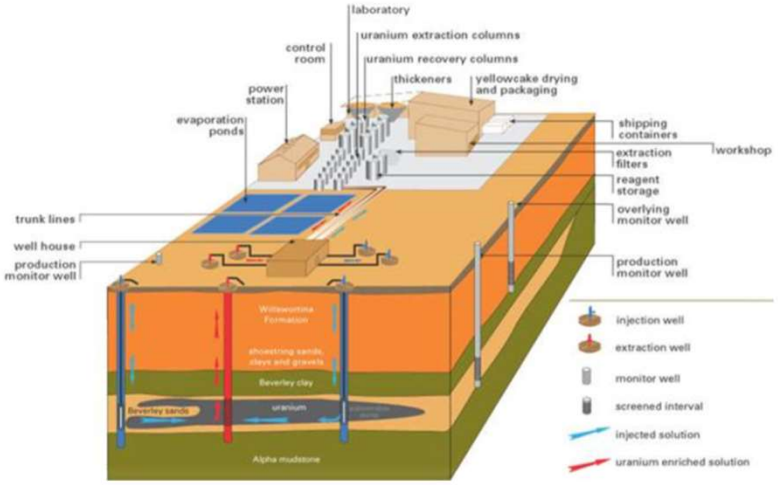
Production Estimation

PathCAD™ – Production Forecast

- Forecast generated monthly or when required
- Generates short term and long term production estimates
- Forecasts are based on all exiting and future decline curve
- Provides information of when new projects/wellfields are starting
- Is calibrated to real time operational events
- Is constrained to actual individual satellite plant and processing plant capacities/capabilities
    - Number of IX Vessels, Number of Elution Trains, Elution Cycle, Resin Loading, IX Tail Re-circulation, etc.
- Estimates production for Years, Months and Days for:
    - ❖ Existing and future wellfields or wells
    - ❖ Number of wells, wellfield costs, Start and Finish date, % Recovery
    - ❖ Max U ppm, Ave U ppm, End U ppm, Months on line
    - ❖ Reagents use (Volume), Cost of reagents per pound
    - ❖ Operational expenditures



PathCAD U308 Decline Modelling

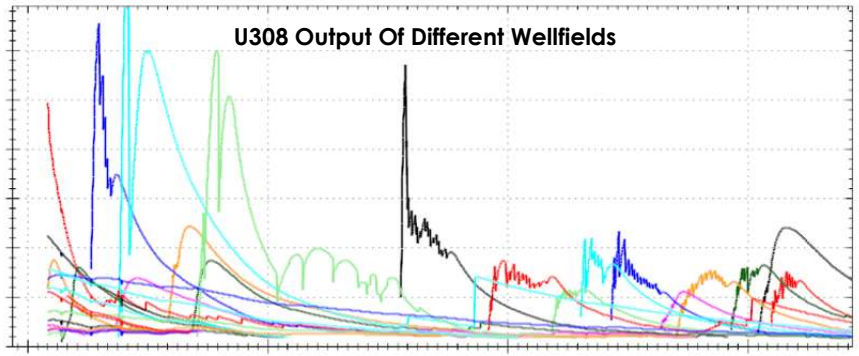


ISR Mine Diagram

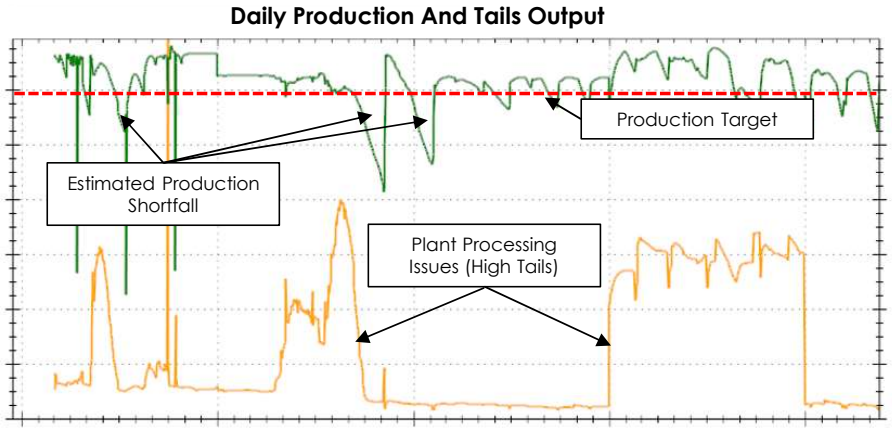
Production Estimation

Forecast Outputs

- The production forecast generates a variety of outputs for review
- Production prediction is reviewed in detail to understand if company is on track to meet production targets
- When predicted shortfalls are identified, new project options are prioritized to get production back on track
- The long-term production forecasting is targeting different deposits with different flow rates, grades and kinetics to make expected production targets
- Plant processing is reviewed to understand efficiency
- Many iteration of scenarios are modelled to best understand future business needs



Forecast Output U308



Forecast Output Daily Production And Tails

Conclusion

- To make any future business decisions, you need to have accurate predictions
- Heathgate has been lucky to have PathCAD as it has guided the business to many key decisions
- PathCAD or any other software to be accurate in predictions require a lot calibration
- Calibration starts with quality in the data and setting up of models
    - Zoning, Resource Estimation and Kinetics
- No quality, no accuracy

END