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ater supply, distribution and management are critical to the operation of all mines. Water monitoring and tracking assists in water use optimization. Water (balance) modeling is a valuable tool for documenting the operation of mine water systems and for tracking water supplies, use, and consumption. Once developed, water models can be used to evaluate water related advantages/disadvantages associated with proposed operational changes, expansions, permitting, and mine closure studies. **HydroGeoLogica** specializes in mine water models for:

- Pre-feasibility
- Feasibility
- Operations
- Expansion studies
- Facility (tailings impoundments, leach pad) studies
- Site-wide water management
- Pit lake modeling (see associated SOQ)
- Permitting
- Closure

Water model construction involves the development of a conceptual model of operational conditions. Operational changes are continual during the active phase of mine life. It is therefore important to maintain operational water balance models regularly so that they represent current conditions.
The conceptual model is used to develop a numerical model in GoldSim.
'Dashboard' controls can be built into GoldSim water models and customized to allow users to evaluate 'what if?' scenarios.

Measured and calculated flow rates from the water model can be displayed on a flow diagram in Excel for ease of use.
Summaries of Selected Projects:

**Zonia Mine, Arizona – Redstone Resources Corporation**
Facility specific water balances were developed in GoldSim to evaluate operational conditions associated with a proposed pit and proposed heap leach pad. These water balances were then used as the foundation for closure water balances of these facilities.

**Standardized Water (Balance) Modeling for Multiple Mine Sites - Freeport-McMorRan Copper and Gold**
Standardized water (balance) modeling techniques were developed and documented. Freeport McMorRan was then able to direct a number of consulting companies to develop water models using these guidelines so that the models would be of a similar format, and would be customized to meet the needs of the parent company. This standardized approach to mine water modeling allows easy comparison of water use data between mine sites, and is helpful for larger, multi-site and international mining companies.

**Bagdad and Safford Mines, Arizona - Freeport-McMorRan Copper and Gold**
Development and maintenance of stochastic dynamic systems models representing operational mine water management using GoldSim. The models are used to evaluate climate related water supply issues and mine water management and facility development alternatives. Training of site staff for operation and maintenance of the models was also provided.

**Martabe Mine feasibility study, Indonesia - Oxiana**
A stochastic dynamic systems model of site-wide mine water management was developed in GoldSim for a gold mine feasibility study. The model includes a synthetic precipitation generator, power and equipment failure frequencies, and 14 site facilities including two fresh water dams, four containment dams, two ore stockpiles, an ore processing facility, a pit, and a water treatment plant. The proposed mine is located in the headwaters of a river which is heavily used downstream as a water supply. The site design was developed in order that the mine would be compliant with the U.S. Cyanide Code, so the output was used to demonstrate the likelihood, frequency and magnitude of any possible releases of untreated water from the site. The model was used to evaluate mine water management alternatives and to predict water storage in various facilities. Calculated inflows and outflows from the various facilities were used as input parameters to hydrochemical modeling (in Phreeq) based on the quality of each influent water type. Supporting chemical mass balance calculations were successfully performed within GoldSim for certain parameters. Changes in water quality at the various water storage facilities throughout the mine life were predicted.

**Tenke Mine, Democratic Republic of Congo (DRC) - Freeport-McMorRan Copper and Gold**
Conceptual model development and dynamic systems modeling was performed in support of water use accounting and optimization for the mine tailings operations. The model was designed to be used for deterministic or stochastic predictions of water demand based on climate scenarios. A ‘player’ version of the model was provided to allow mine staff to operate the model (to evaluate user-defined scenarios and view results without direct knowledge of GoldSim). Goldsim and site-specific-model training were also provided, together with documentation and ongoing model support.

**Mt. Todd Project, Northern Territory (NT), Australia - Vista Gold Australia**
Conceptual model development and dynamic systems modeling was performed in support of evaluating the water balance for the proposed mine expansion and redevelopment project, in support of pre-feasibility analysis. The life of mine model included all aspects of mine water usage from pre-development through the operational period; the model included pit dewatering, tailings facility water balance, heap leach facility and ponds, waste
A separate model was developed to evaluate closure scenarios, including water treatment, and develop the most practical and efficient closure plan; the closure model was evaluated using a stochastic climate generator to evaluate the effects of long-term climate variation.

**Haile Mine Pre-Feasibility Study, South Carolina - Romarco**
A stochastic dynamic systems model was developed using GoldSim to evaluate water management alternatives for a proposed multi-pit gold mine. The model includes several pits, water transfer facilities, water storage facilities and other mine facilities together with intermittent power and equipment failures. Power failures were correlated to extreme weather events. The model was used to verify availability of water on site to operate the mill, to estimate required water treatment rates, and to ensure that the mine design was compliant with U.S. Cyanide Code. Waters of different qualities were tracked across the site so they could be managed separately. Intermittent power and equipment failures were simulated and were correlated to extreme weather events.

**Johnson Camp, copper mine, Arizona - Nord Resources Corporation**
A dynamic systems model was developed in GoldSim to simulate flows within several leach circuits at the mine. 16 site facilities are simulated. The model is designed to allow users to evaluate leach pad loading alternatives and irrigation plans, and optimize solution management during operations. Input data are stored in spreadsheets and results are exported to spreadsheets to allow mine staff to operate the model and view results without direct knowledge of GoldSim.

**Marlin Mine, gold mine, Guatemala - Goldcorp**
A dynamic systems model of mine water and tailings management was developed in GoldSim to predict water and tailings storage needs for changing ore production rates. The model was calibrated to existing site data and then used for predictive purposes. On-site GoldSim training for mine personnel was provided so that the model calibration could be updated and water management procedures within the model modified as necessary.

**Gaby Mine feasibility study, Ecuador - Codelco**
The project consisted of development of a dynamic systems model using GoldSim to evaluate potential mine designs. Model predicted operational and closure issues for various mine design alternatives to ensure the mine operated as a zero discharge facility. Water storage and treatment requirements were optimized.

**Kori Chaca Mine, Bolivia - Inti Raymi (controlled by Newmont)**
A stochastic dynamic systems model (water balance) was developed using GoldSim to evaluate pit filling options for mine closure including timing and water quality issues. The possibility of encapsulating mine waste in highly saline water at the bottom of the pit was evaluated. The water balance included mass-balance water quality calculations to evaluate the likely salinity of the pit lake and the stability of pit lake stratification and continued waste encapsulation into the future.

**Boddington Gold Mine, Australia - Newmont**
A stochastic dynamic systems model (water balance) was developed using GoldSim to evaluate options for mine water disposal and management at closure. The mine includes two pits, two tailings storage facilities, a number of waste rock storage facilities and several water storage dams. Operational changes throughout the closure period, such as the installation of cover systems on closed facilities (TSFs and waste dumps), operation and closure of treatment plants, decommissioning of dams etc are simulated in the model. Mass balance chemistry was also developed within the GoldSim model to calculate and track changes in the concentrations of chloride and sulfate at various locations in the system.