Case Study: Site-Wide Water Balance of the Pierina Gold Mine, Peru

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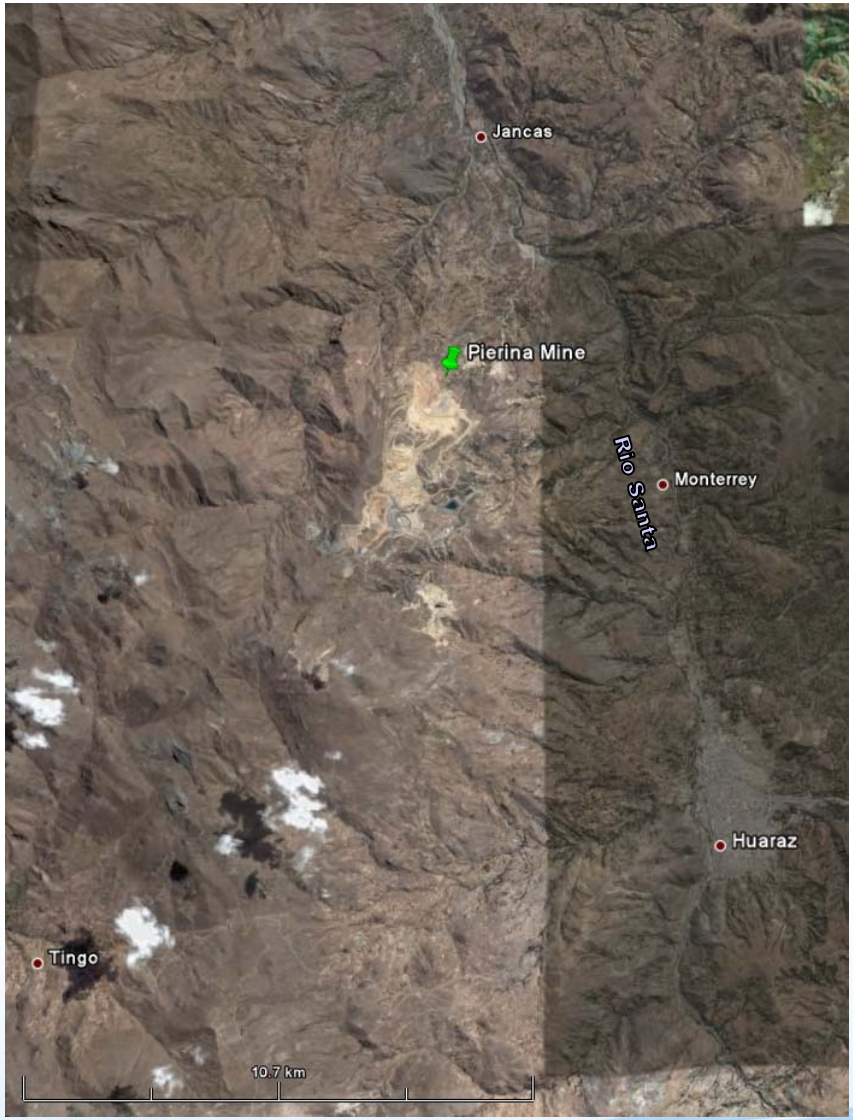

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Introduction

- Produced ~ 45,000 tonnes per day of gold-silver ore in 2007
- Began operations in 1998
- Active mining will continue until 2011
- Mine split between two watersheds:
  - The open pit in Puca Uran watershed
  - Process facilities are in Pacchac watershed
    - Focus of project
    - Process facilities cover an area of about 5.4 km^2
  - Waste dump split between both watersheds

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Scope

- Tool for daily solution management
- Compliance with the International Cyanide Code
- Help prevent unintentional releases:
  - failure of pumping equipment
  - extreme precipitation events
- Account for mine expansion
- Estimate make-up water or excess solution in the leach pad

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Climate

- *Precipitation*
  - Wet season from October to April
  - Dry season from May to September
  - Average annual is approximately **1.16 m**
- *Evaporation*
  - Average annual pan evaporation is approximately 1.11 m
  - Pond (open water) evaporation
    - 0.8*(pan evap) = **0.88 m**
    - Net positive

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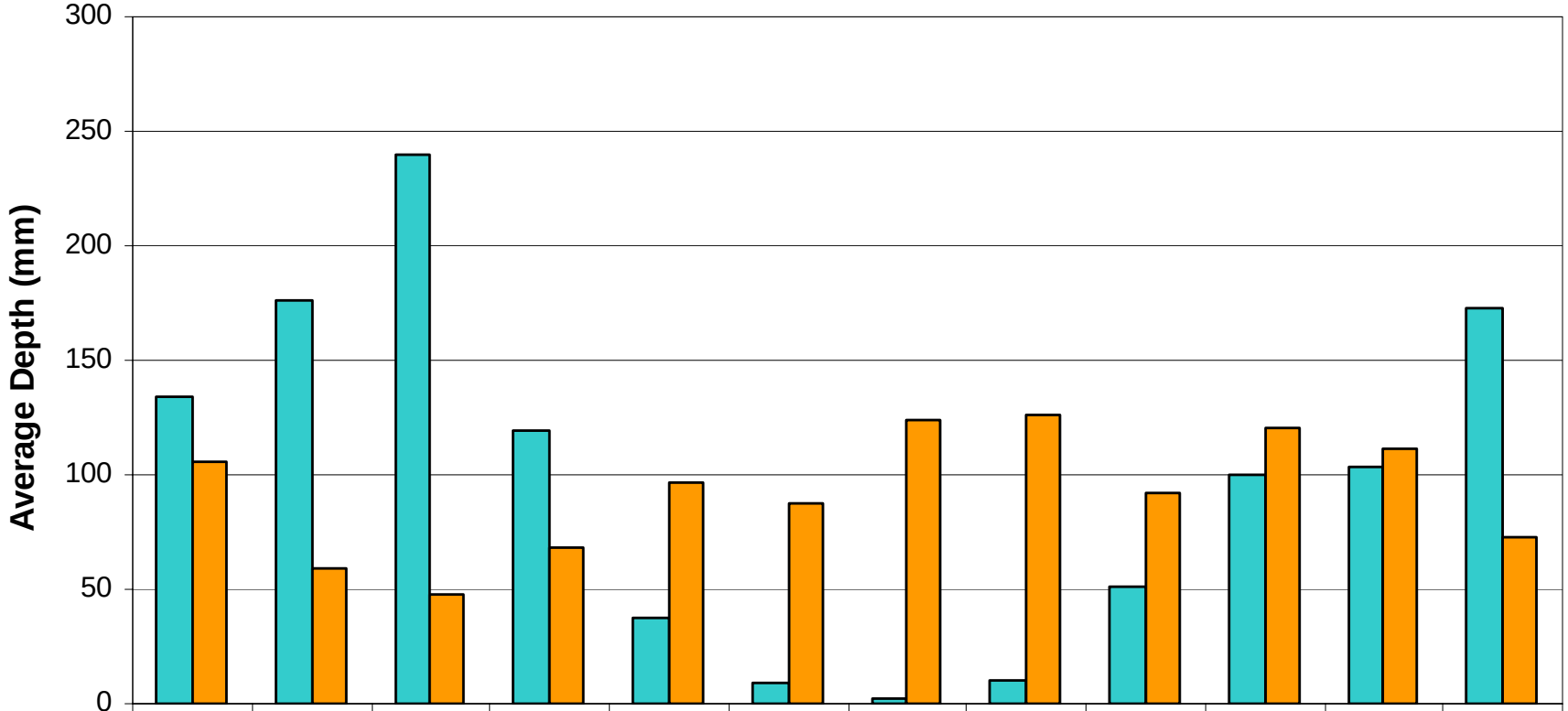
Pacchac Meterological Station Average Monthly Precipitation and Evaporation (mm)



	Janurary	February	March	April	May	June	July	August	September	October	November	December
Precipitation	134.3	176.1	239.7	119.3	37.5	8.8	2.2	10.5	51.5	100.3	103.3	173.1
Evaporation	105.4	59.4	48.3	68.1	96.8	87.0	123.7	126.4	92.5	119.9	111.9	72.8

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Site Facilities

- Six holding ponds
- Leach pad and caisson platform
- Processing plant
- Acid Rock Drainage (ARD) treatment plant
- Two diversion ditches (SDD and NDD)

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Conceptual Model

Site-wide water balance model

- Individual facility water balances integrated into one model
- Includes flows that are not currently in use, but are required for predictive purposes
- Run on a daily time-step
  - For use as a daily solution management tool
- Complex water and solution flow →→

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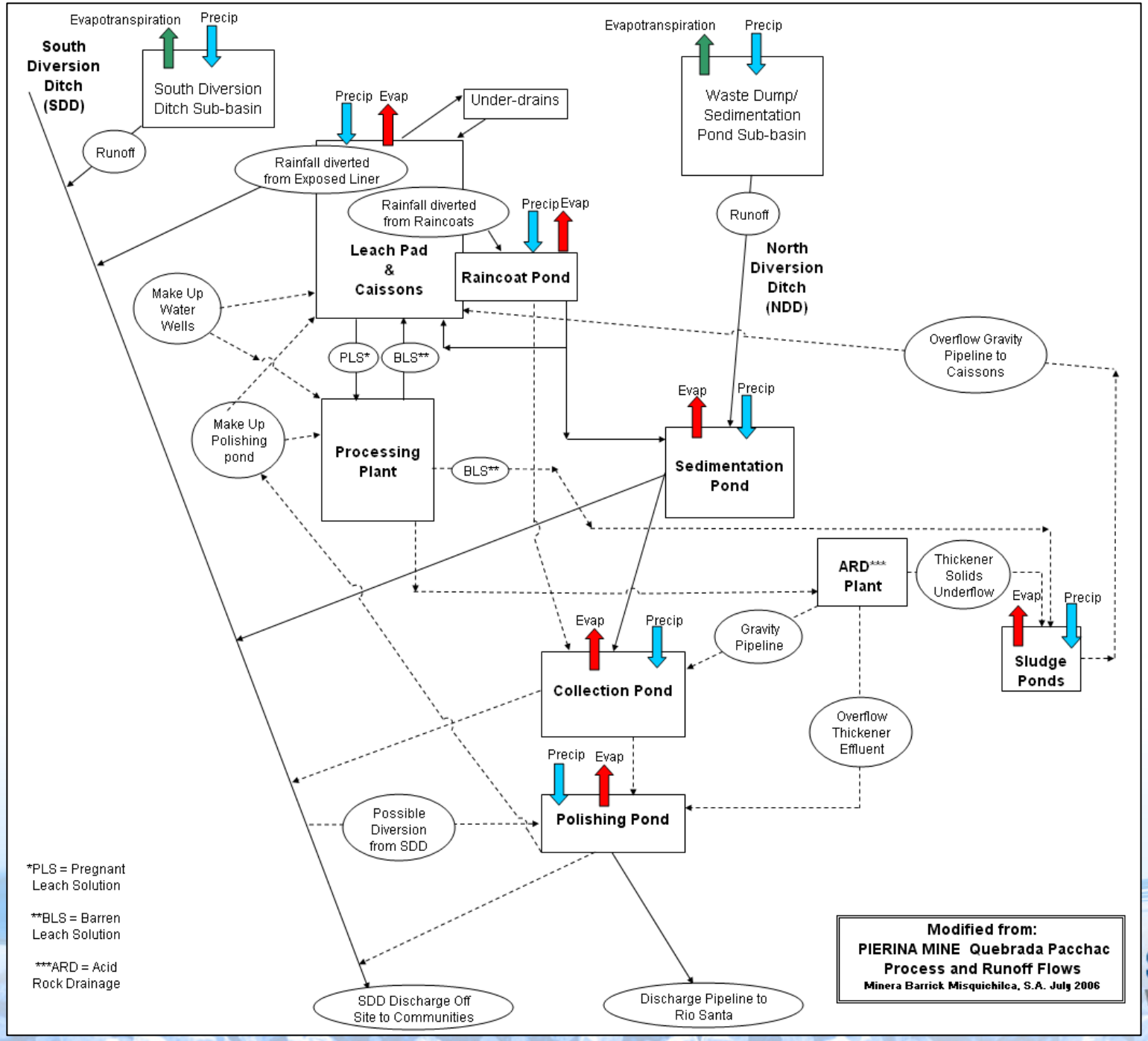

Arrows indicate direction of flow for solution/ water on site.

Main facilities shown in bold.

All flows indicated are represented in the model.

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Climate Management

- Historical climate data were used when available
- Statistics from historic daily data (2000-2006) used for predictive model runs:
  - mean
  - standard deviation
  - precipitation - normal distribution
  - evaporation - log-normal distribution, inversely related to precipitation
  - creates storm events

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Surface Water Management

- *Surface water runoff volumes*
  - NRCS curve number method
- *Antecedent Moisture Conditions*
  - Model looks at the five previous days
  - Higher runoff if previous days are wet

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Process Water Flow Management

- *Flow through the leach pad*
  - Delayed by:
    - pore-space wet-up
    - flow-through
    - and drain-down.
  - Complex leaching schedule based on actual process at mine
- *Piping/diversions*
  - Flows are instantaneous
  - On a daily time-step, this travel time is not a major concern

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Model Calibration

- Match the simulated water elevations to historically recorded elevations in:
  - 4 of the 6 holding ponds
  - No historical data available to calibrate the sedimentation and raincoat ponds
  - Caissons in the PLS solution dike
- January to August, 2006
  - most comprehensive dataset
  - normal operating conditions

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Calibration Approach

- Some process flows were not recorded, or had significant measurement error
  - reasonable adjustments to the historical data
    - based on quality of the data evaluated
    - determined possible error (+/-)
    - removed outliers
  - maximum flows estimated
    - typical pump rates limited to 150 m^3/hr
    - flow limit for most of Pierina's pumps and conveyance systems

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Results

- Caissons, collection and polishing ponds
  - Difference between was typically less than one meter
  - Trends well matched
- Sludge ponds
  - Difference of up to two meters
  - Total volume of the sludge ponds is relatively small when compared to the other storage facilities
  - Trend well matched

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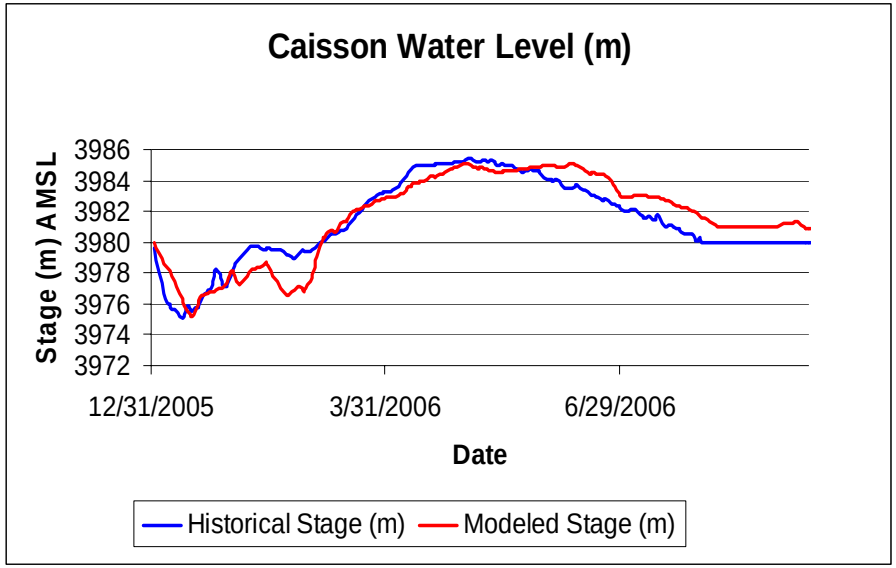

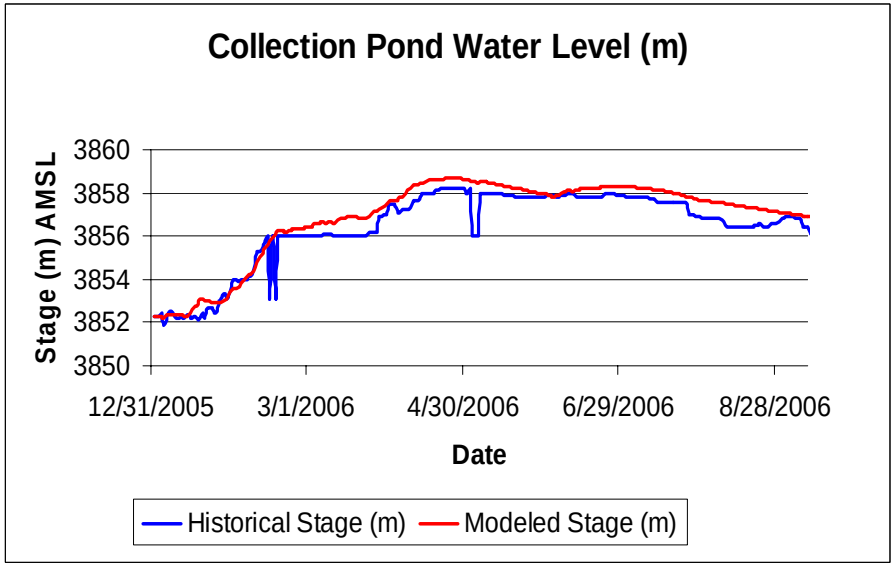

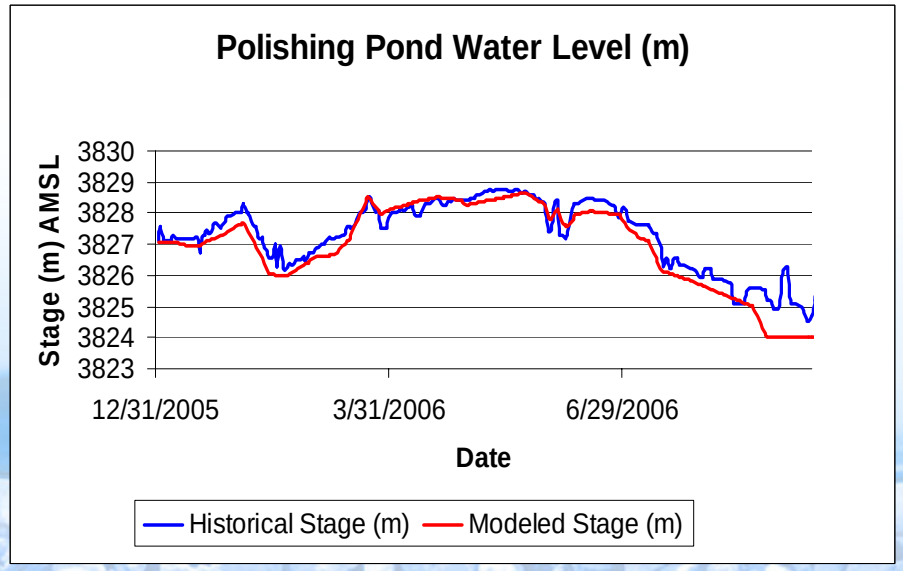

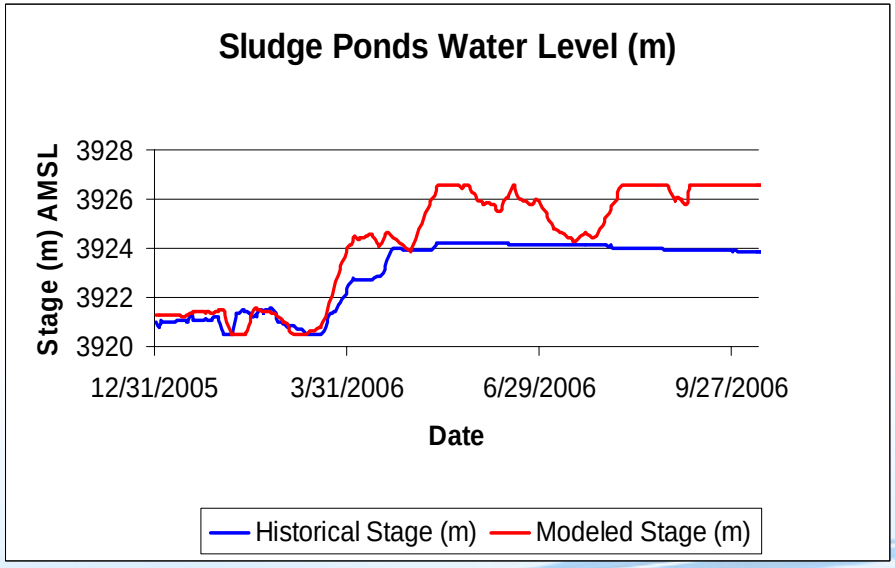

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Predictive Runs

- *Loss of PLS Caisson Pumping Capacity*
  - Goal – dike can not overtop
  - Three scenarios:
    - barren solution application continues as normal
    - barren solution application reduced by 50 percent
    - barren solution application ceases
- *Extreme precipitation event*
  - Goal – no offsite discharge

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Loss of PLS Pumping Capacity

- *Caisson Platform Pumping ceased*
  - Start at high elevation for normal operating conditions
  - available storage volume of ~350,000 m^3
- Results
  - barren solution application continues as normal
    - Overtops in 7 days
    - Not recommended
  - barren solution application reduced by 50 percent
    - Overtops in 12 days
    - Will give operators more time (almost two weeks) for repairs
  - barren solution application ceases
    - Does not overtop within 20 days (max pump shutdown period in model)
    - Should be enough time to make needed repairs to system

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Extreme precipitation event

- Synthetic 100-year, 24-hr storm
  - 98 mm (3.9 inches)
  - during the wet season
  - The starting elevations of water in the ponds based on normal operating levels during the wet season
- Results
  - Sedimentation and raincoat ponds overflow
  - Water not transferred to the SDD
  - Enough storage available in collection pond
  - No off-site discharge necessary

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Conclusions

The Site-Wide Water Balance

- Provides information required to safely manage daily solution transfer and volumes.
- Can be used as a decision-making tool by creating predictive runs.
- Can be used by mine personnel for day-to-day solution management
  - Graphical User Interface (GUI)
  - easy to learn
  - easy to use

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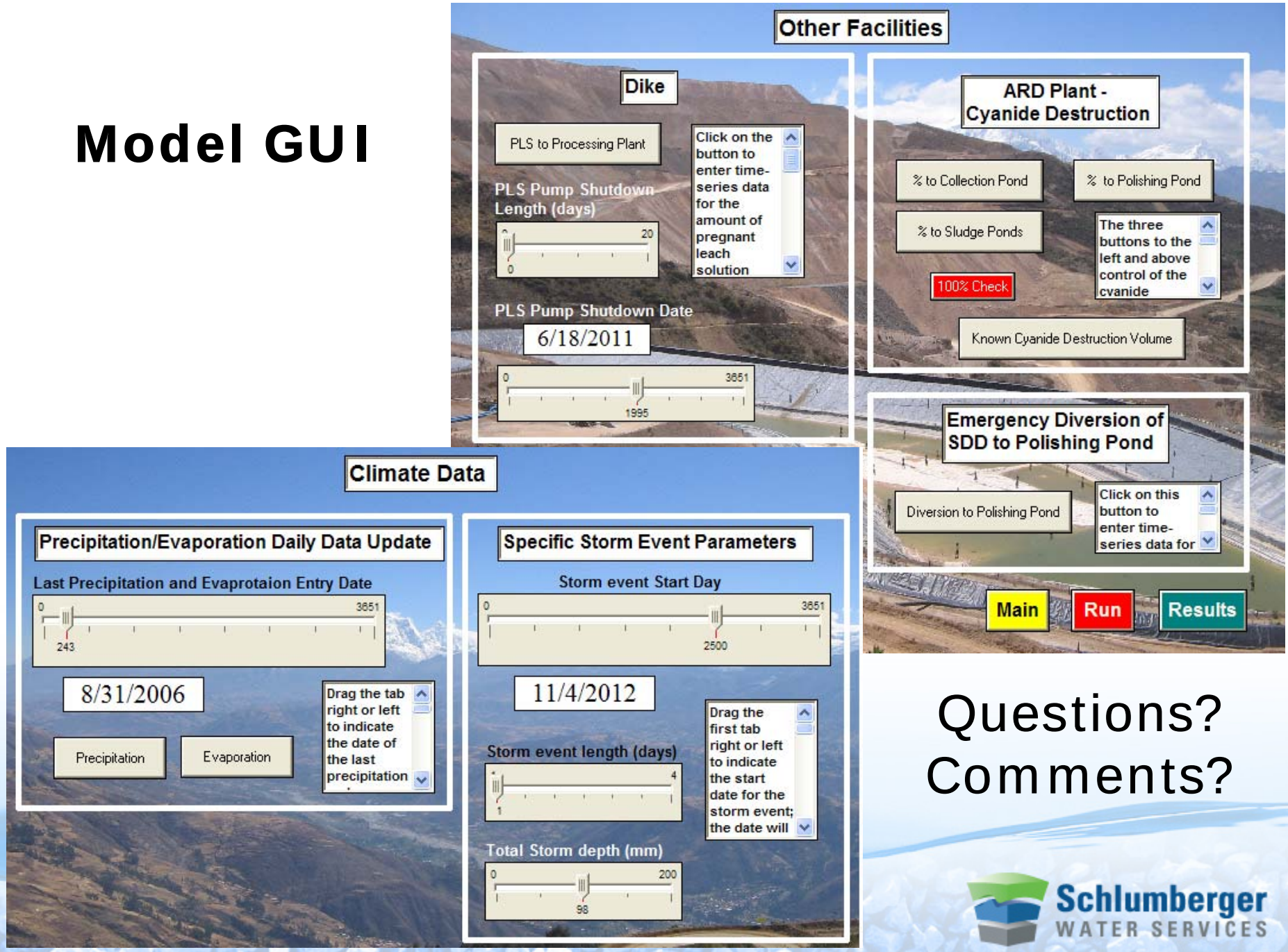
Model GUI



Questions?
Comments?

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