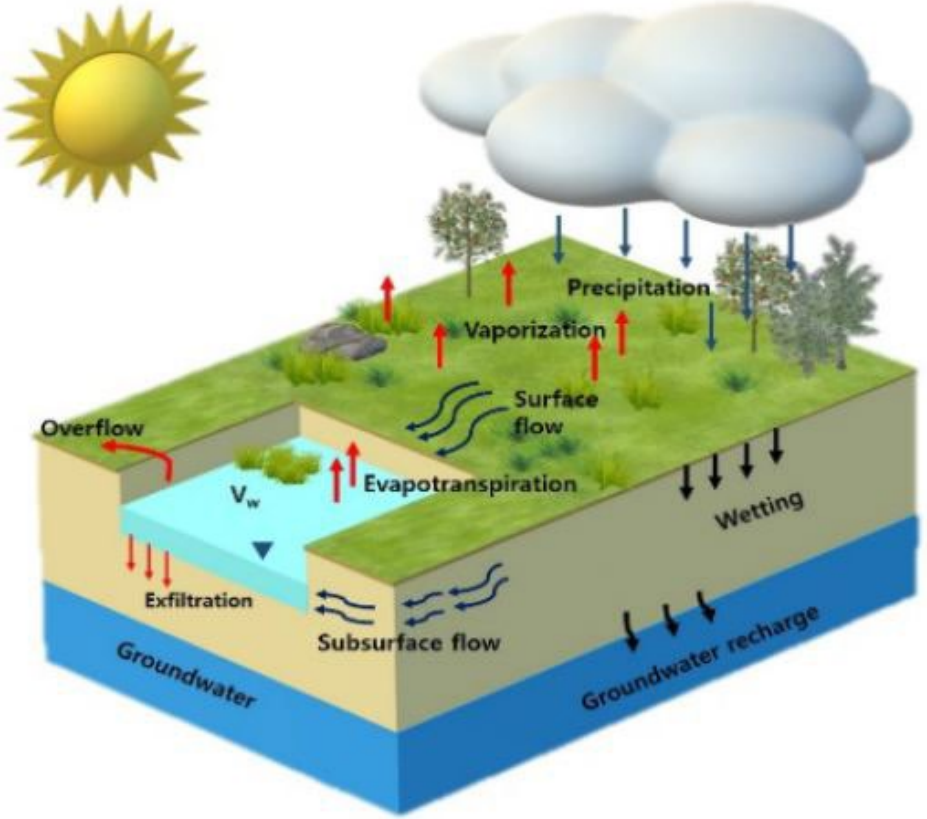
GoldSim

Water Management and Water Quality Modeling Using GoldSim

What is a Water Balance?

- A water balance tracks how water moves through a system: inflows, outflows, storage, losses, reuse, and discharge.
- It builds on the water cycle: rainfall, runoff, infiltration, evaporation, recharge, and discharge; and extends it to managed systems with infrastructure, operations, and demand.
- Water balance models support decisions around supply reliability, containment and discharge, environmental compliance, risk management, and operational optimisation.



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GoldSim

GoldSim Technology Group

- Originally a division of Golder Associates (now WSP)
- Began developing GoldSim in 1990
  - First customers were US Department of Energy and analogous government organizations in Spain and Japan
  - Focused on simulating complex engineering systems associated with radioactive waste management (probabilistic contaminant transport modeling)
- Originally provided software only to clients
- Started marketing software in 2002
  - Rapidly expanded into other related arenas (mining, water resources, business modeling)
- Became independent company in February 2004
- Acquired by Datacor in March 2026

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GoldSim in a Nutshell

"The ability to define what may happen in the future and to choose among alternatives lies at the heart of contemporary societies."

Peter Bernstein, *Against the Gods: The Remarkable Story of Risk*

"Our knowledge of the way things work, in society or in nature, comes trailing clouds of vagueness. Vast ills have followed a belief in certainty."

Kenneth Arrow *(Nobel Laureate, Economics, 1972)*

What were the main drivers behind the development of GoldSim?

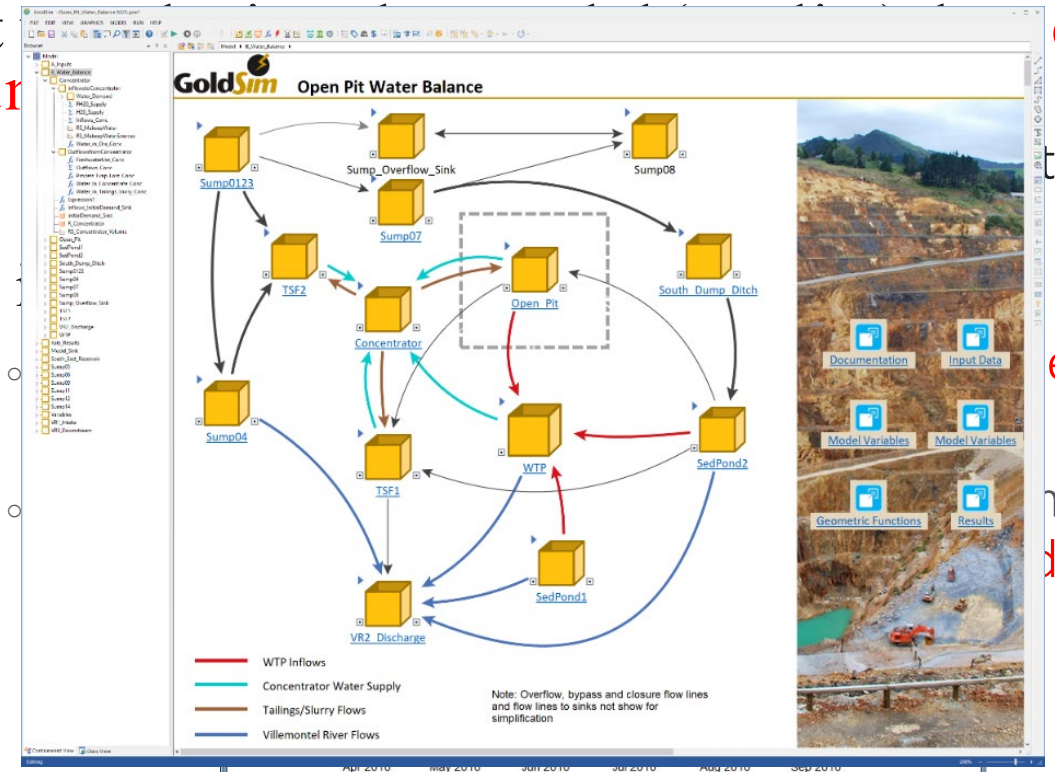
- Many complex engineered systems require predictions of future performance of in order to optimize system design and demonstrate compliance with regulatory requirements.
- These systems often have lots of uncertainty (e.g., due to long time frames or lack of knowledge) and/or involve stochastic processes.
- Analyses are often subject to great public and/or regulatory scrutiny and hence need to be transparent and easy to explain to multiple audiences.
- Projects are often long (years) and complex, requiring frequent (and efficient) updates and iteration of the model as new information was collected and the design evolved.

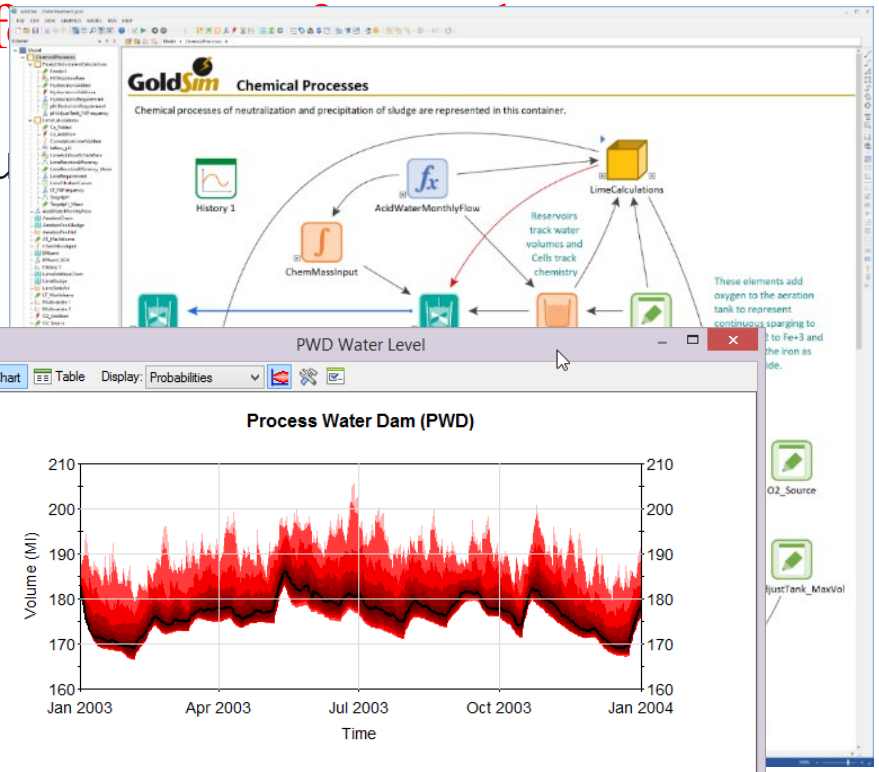
Goal was to create a general-purpose simulation framework that could meet these needs.

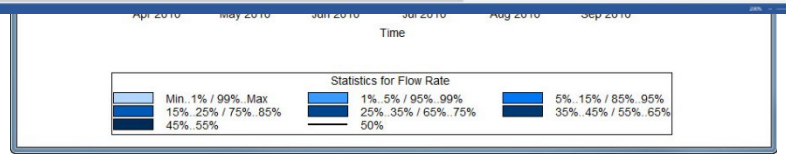
What is GoldSim?

GoldSim is a general purpose dynamic probabilistic simulation framework.

- Models are constructed graphically using a wide variety of modeling objects, each of which carries out a specific mathematical operation.







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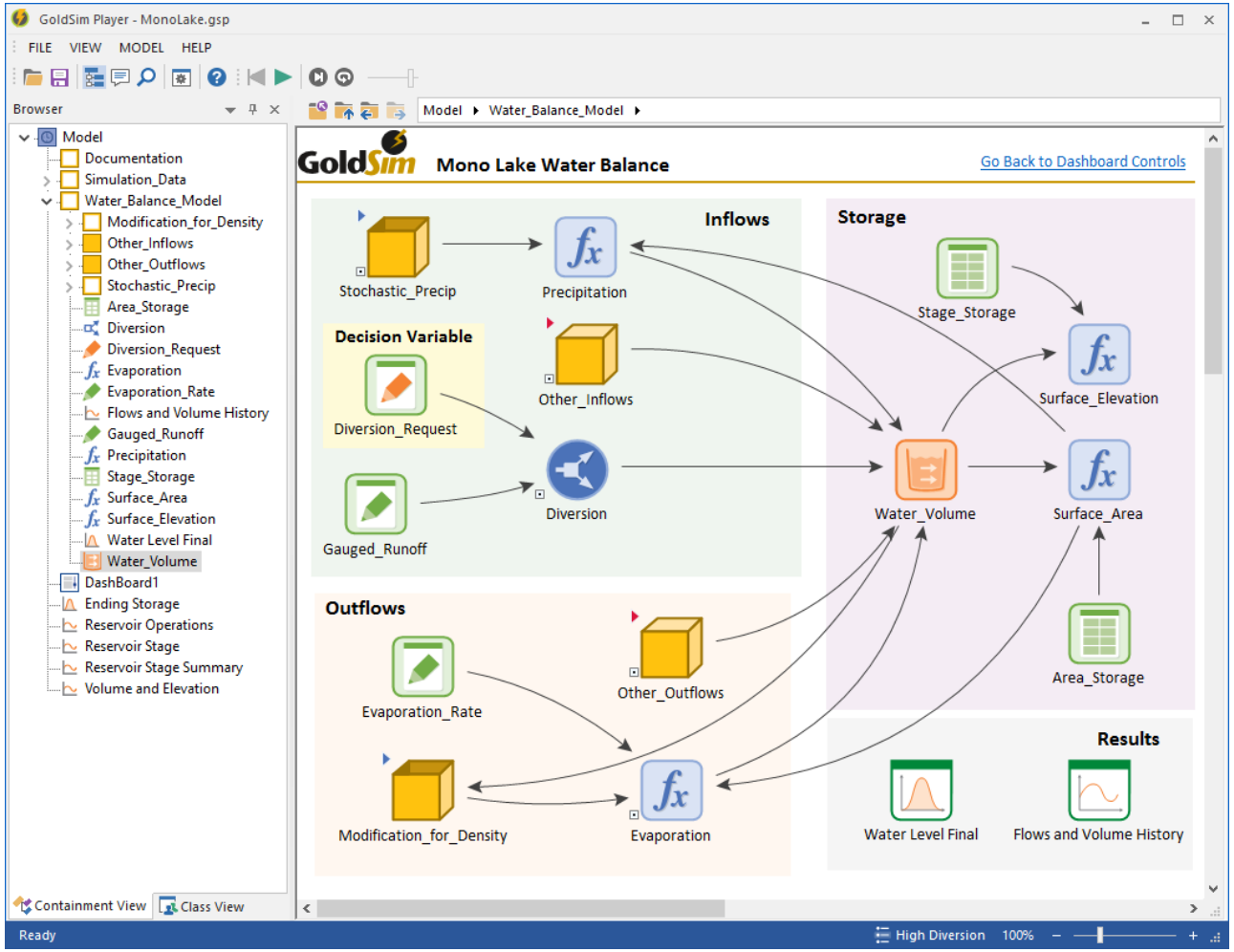
How do you build a GoldSim model?

You manipulate graphical objects (called elements) to draw a schematic or influence diagram of the system being simulated. Models can consist of tens, hundreds and even thousands of elements.



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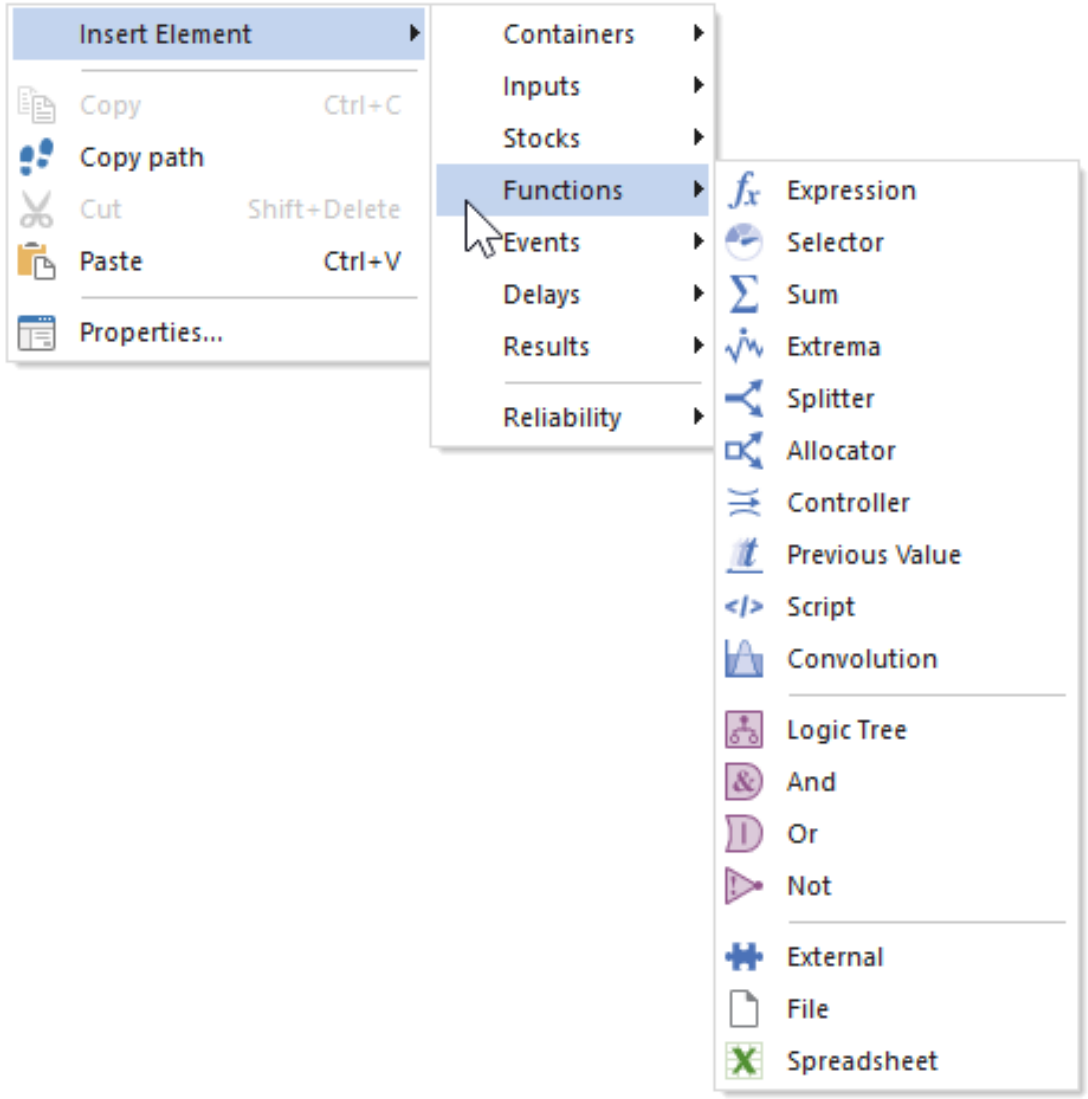
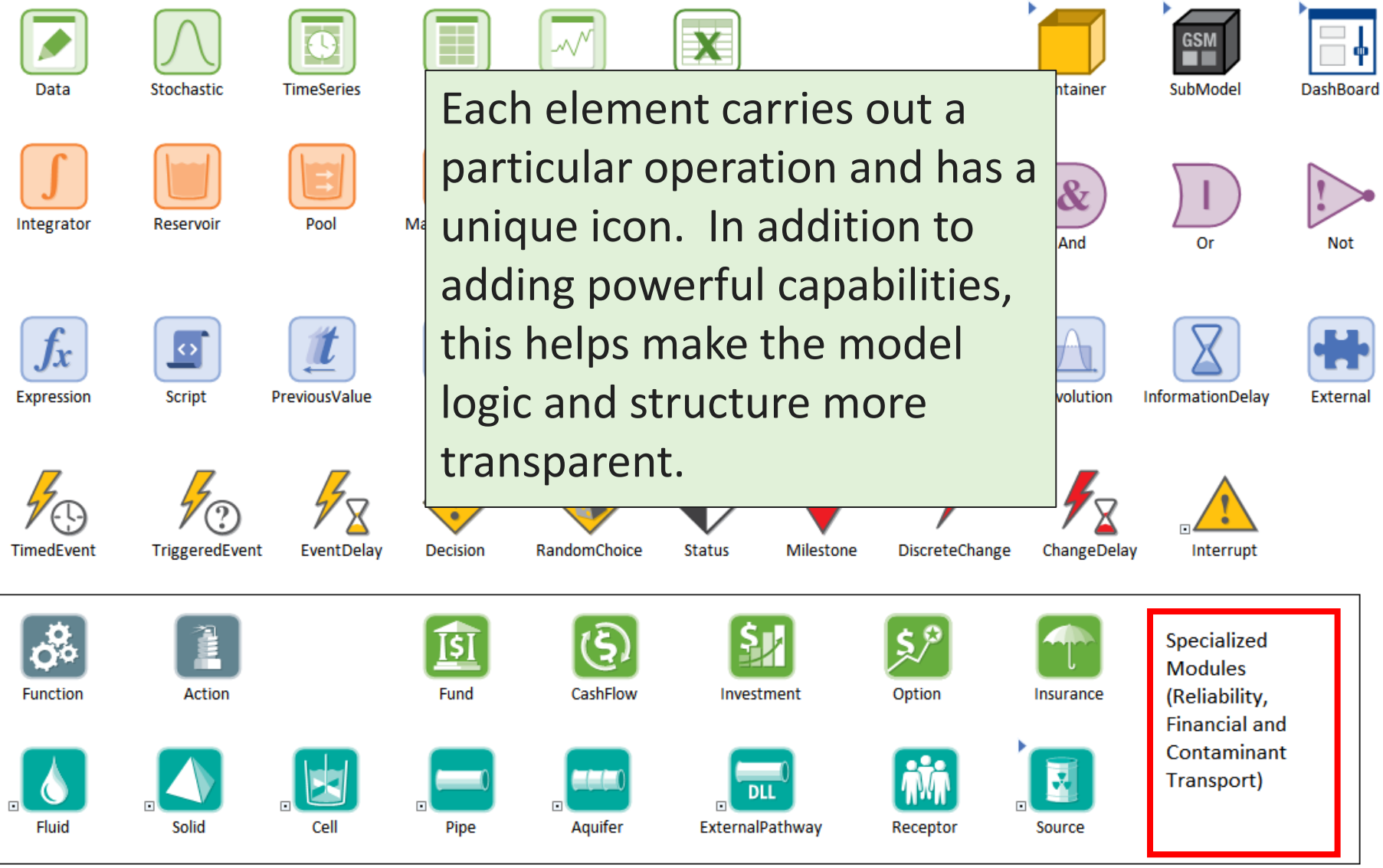
GoldSim provides over 50 element types…





Each element carries out a particular operation and has a unique icon. In addition to adding powerful capabilities, this helps make the model logic and structure more transparent.

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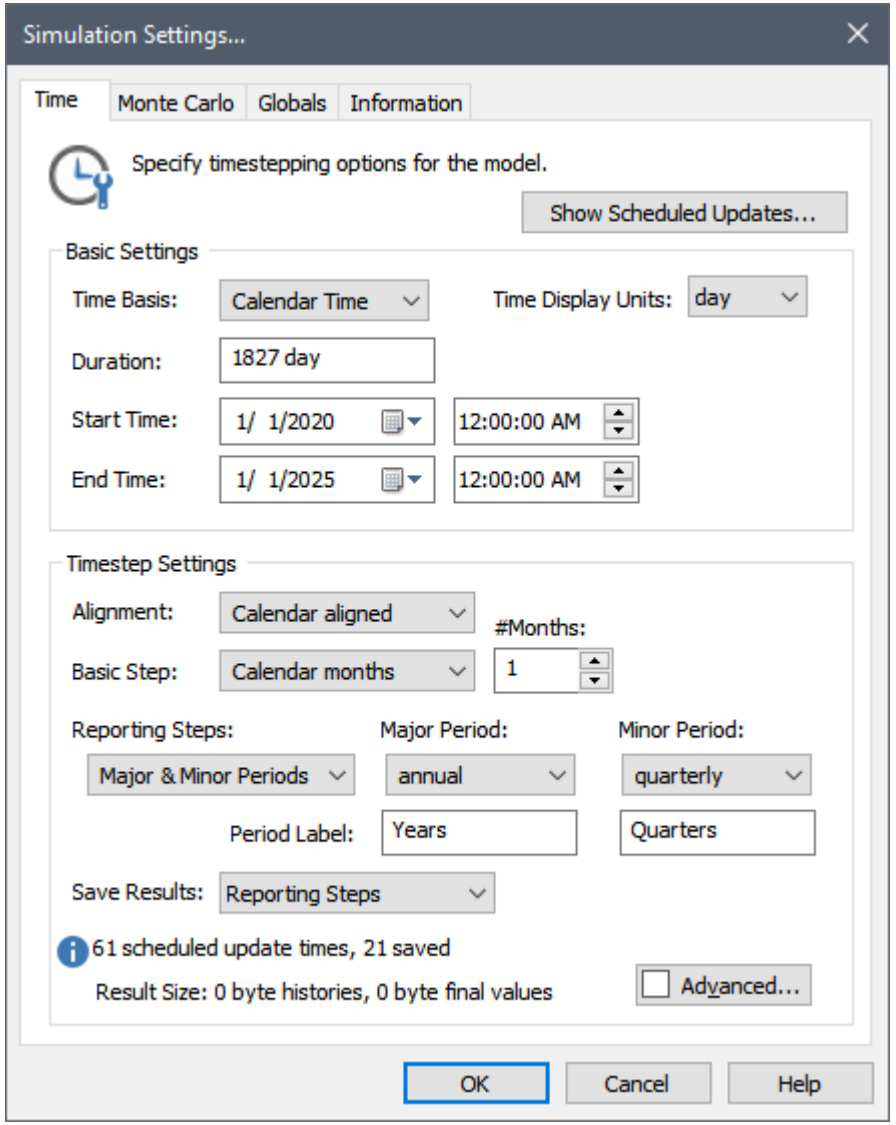
Dynamic Simulation Controls

- Model objects can reference time directly
  - Elapsed Time
  - Elapsed number of hours or days or seconds, etc.
  - Date, month, day of week, day of month, month, hour of day, etc.
- Powerful time stepping options
  - Adjustable, dynamic time steps
  - Telescoping time steps
  - Automatically inserted steps (e.g., in response to discrete events)



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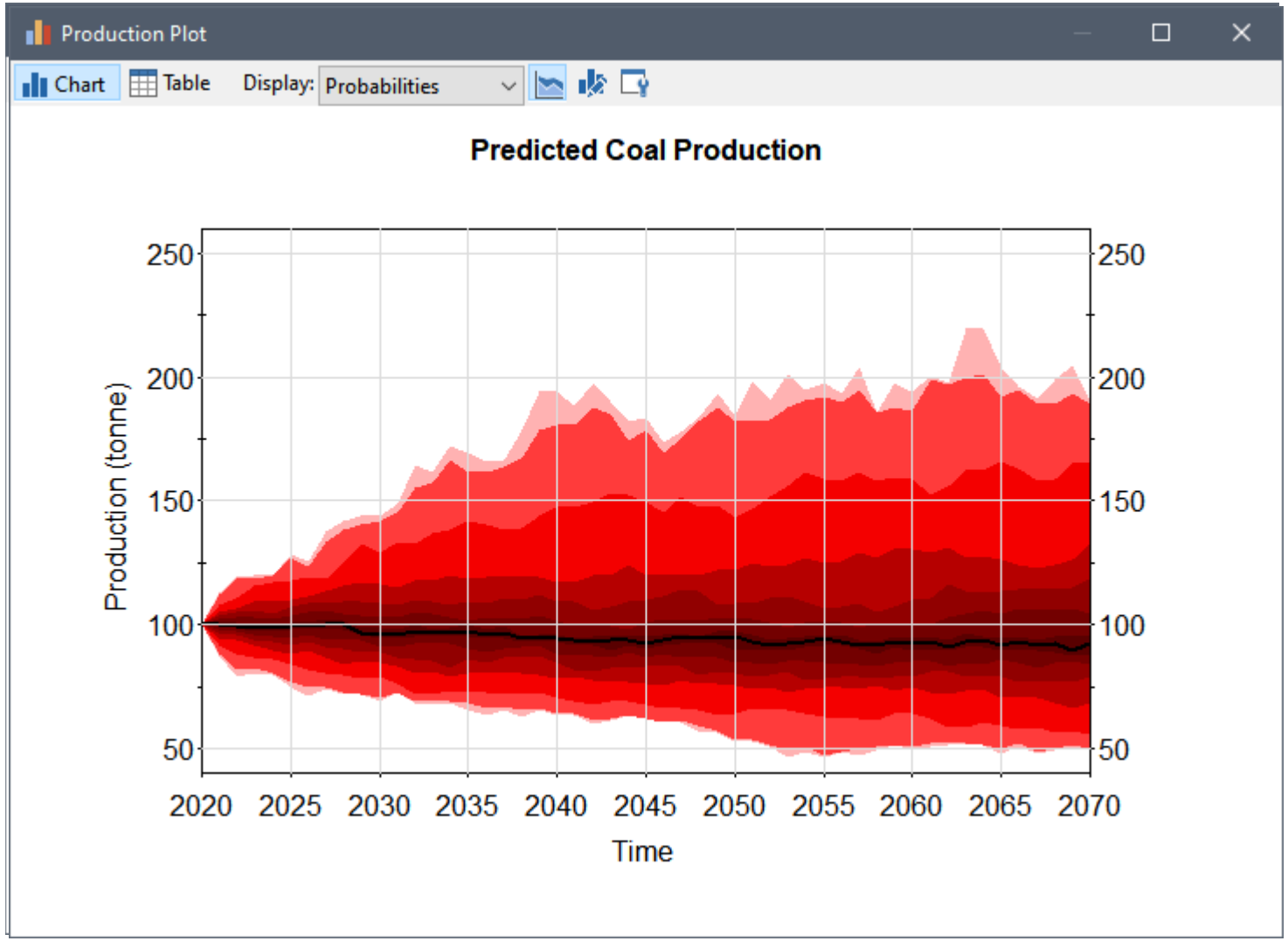
Probabilistic Simulation

- GoldSim puts great emphasis on probabilistic simulation and producing probabilistic predictions of performance
- Was designed from the ground up to be a powerful Monte Carlo simulator
- Designed to represent:
  - Uncertain parameters and processes
  - Stochastic processes and events

Probabilistic Simulation Results



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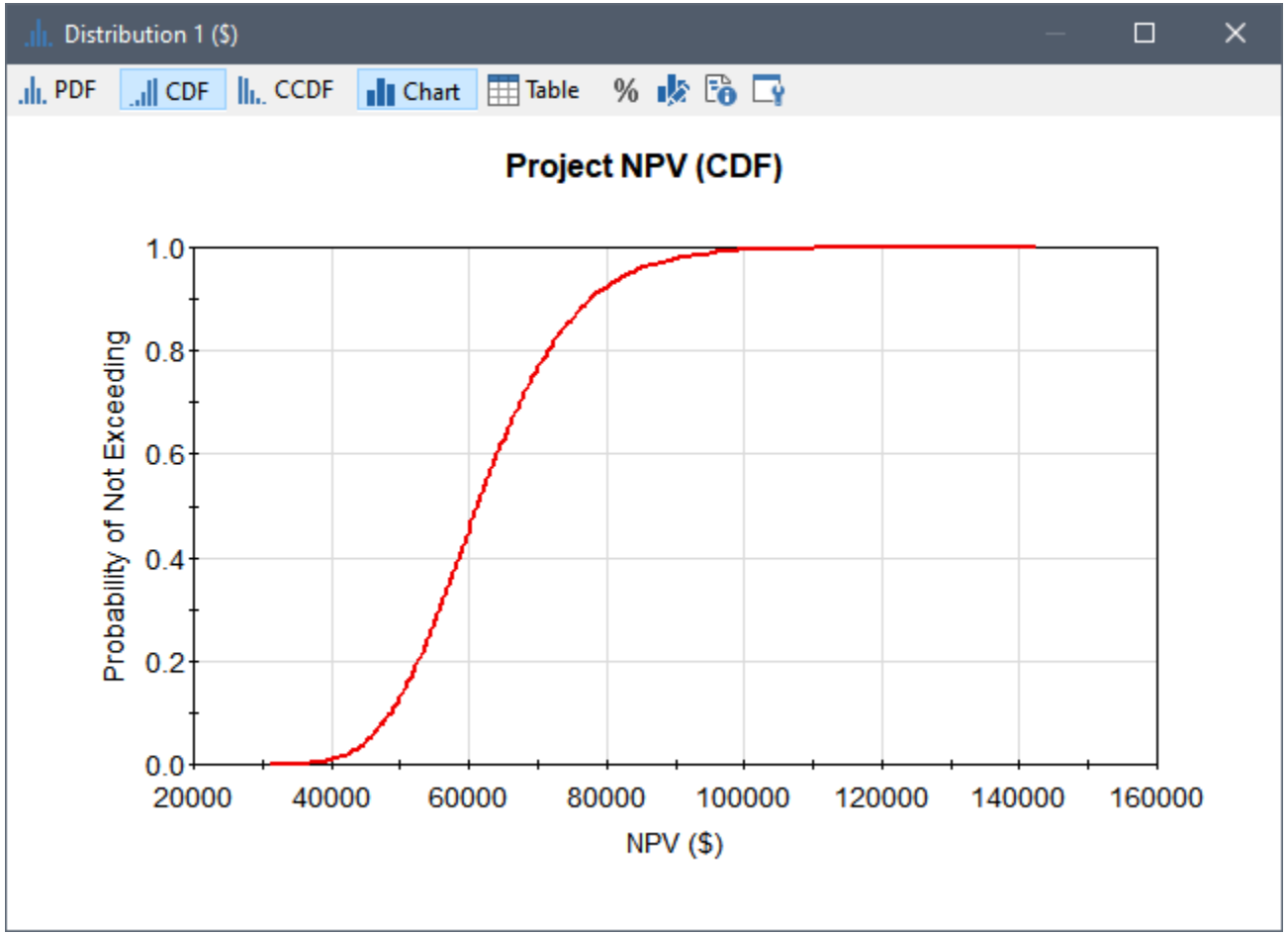
Probabilistic Simulation Results



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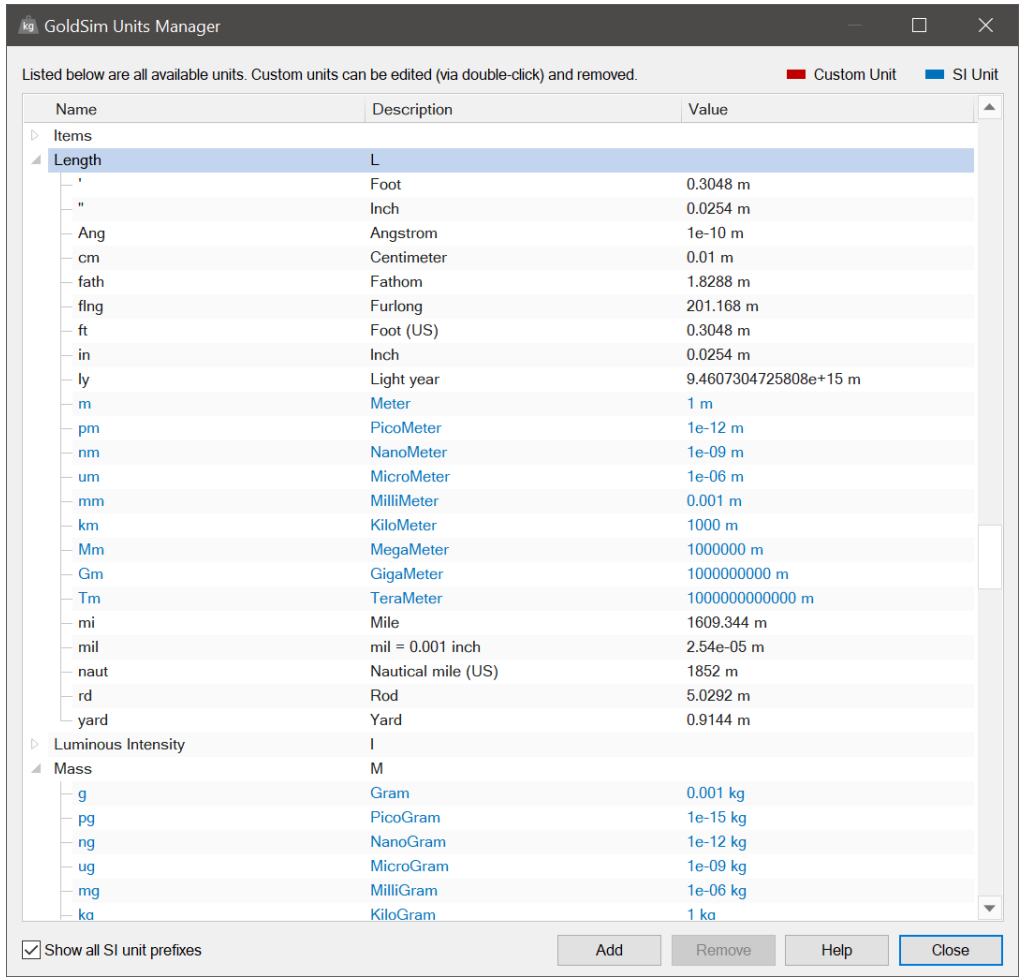
GoldSim Understands Units and Dimensions

When building a model, GoldSim enforces dimensional consistency and does all unit conversions internally



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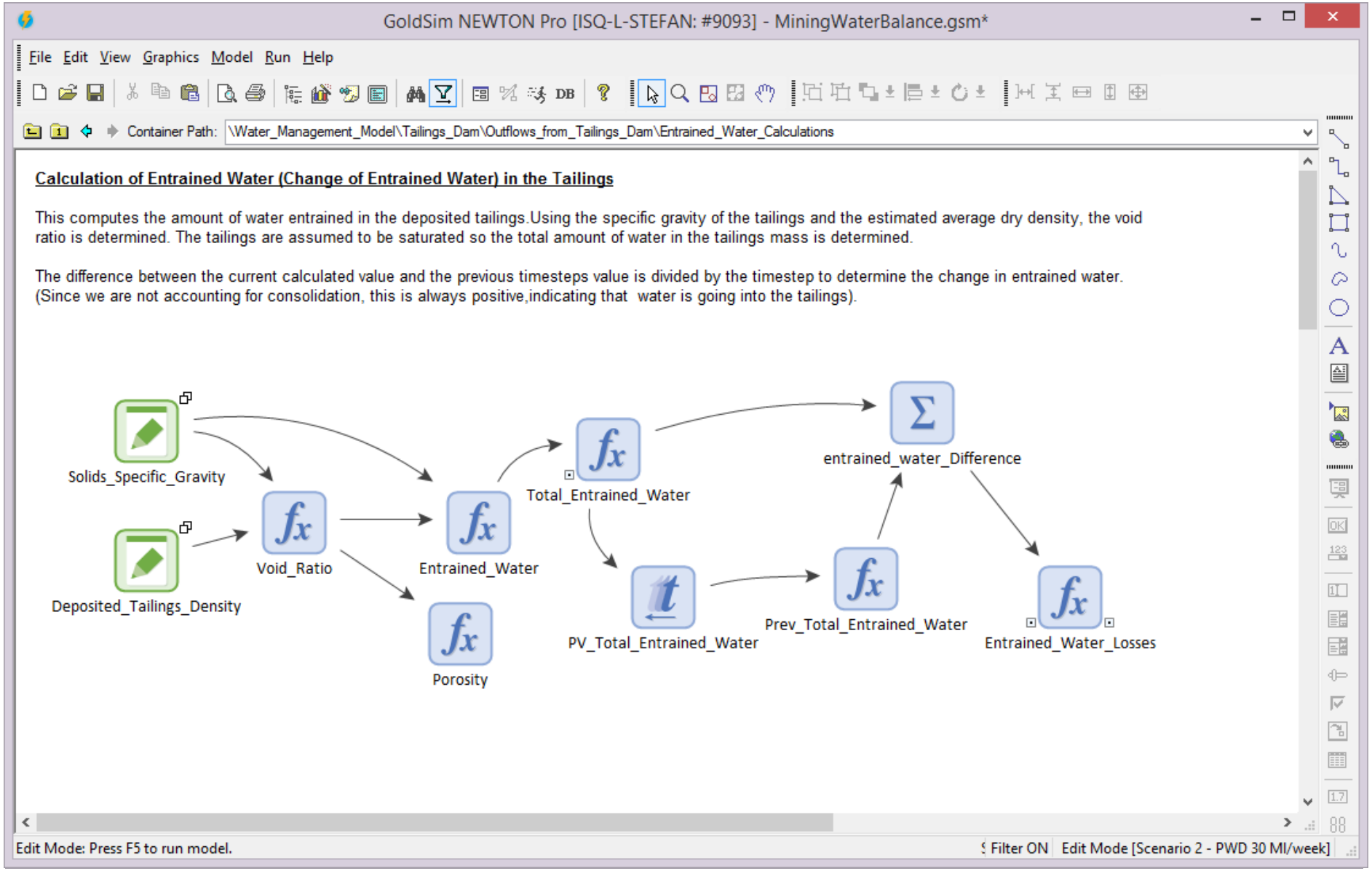
GoldSim models are typically deeply hierarchical

- GoldSim provides:
  - Unlimited nesting of hierarchical models
  - Local variables
- Advantages
  - Easy to understand
  - Reusable components
  - Can support very large models



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Presentation and Documentation

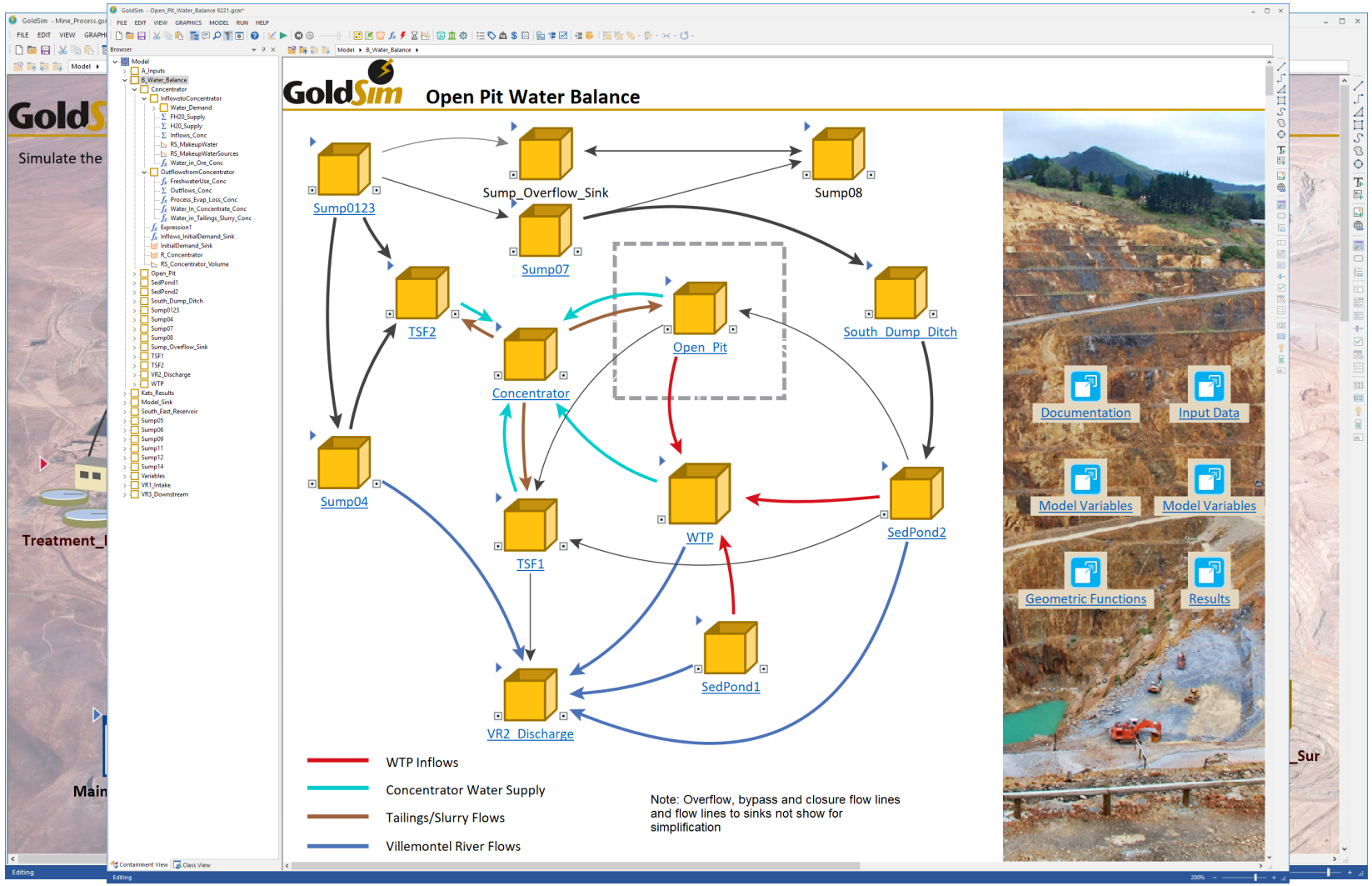
Recall one of the main drivers for development of GoldSim:

- Analyses were subject to great public and/or regulatory scrutiny and hence needed to be transparent and easy to explain to multiple audiences.

As a result, GoldSim provides many tools for documenting and explaining a model

- The goal is the model itself is the documentation and the presentation

Images, Graphics, Text and Hyperlinks



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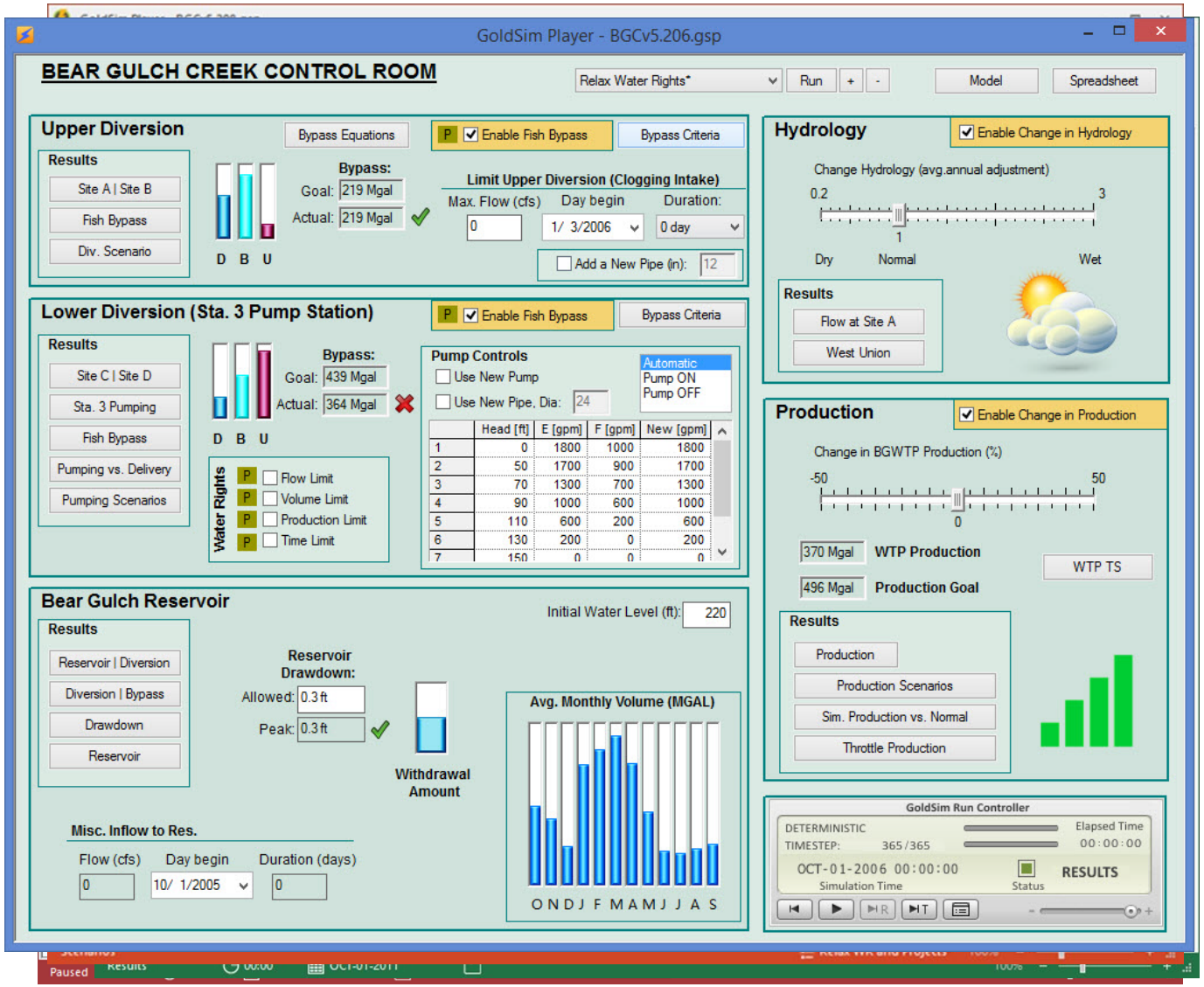
Creating Dashboards

- You can design and construct a "dashboard" interface for models.
  - The interfaces can be designed to look like "control panels", with buttons, gauges, sliders and display panels, instructions, etc.
- A“dashboarded” model can be distributed and then viewed and run using the free GoldSim Player.

Dashboard Examples



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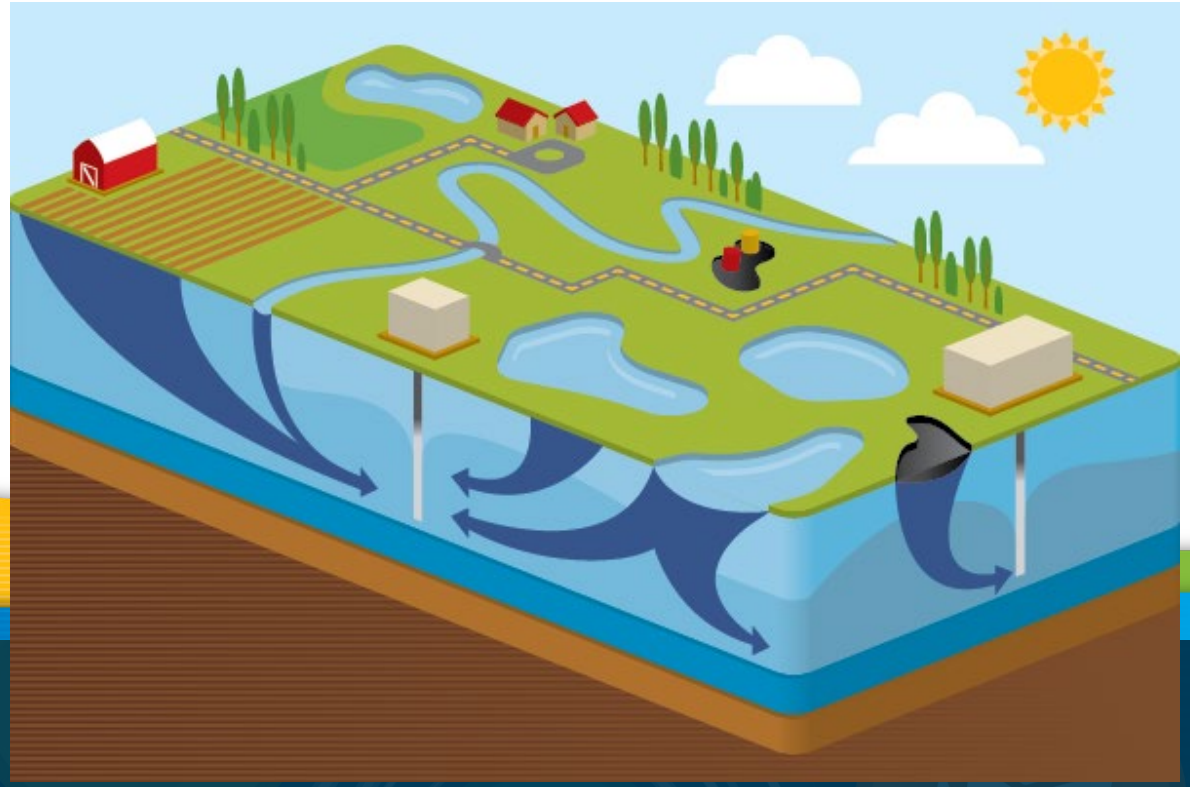
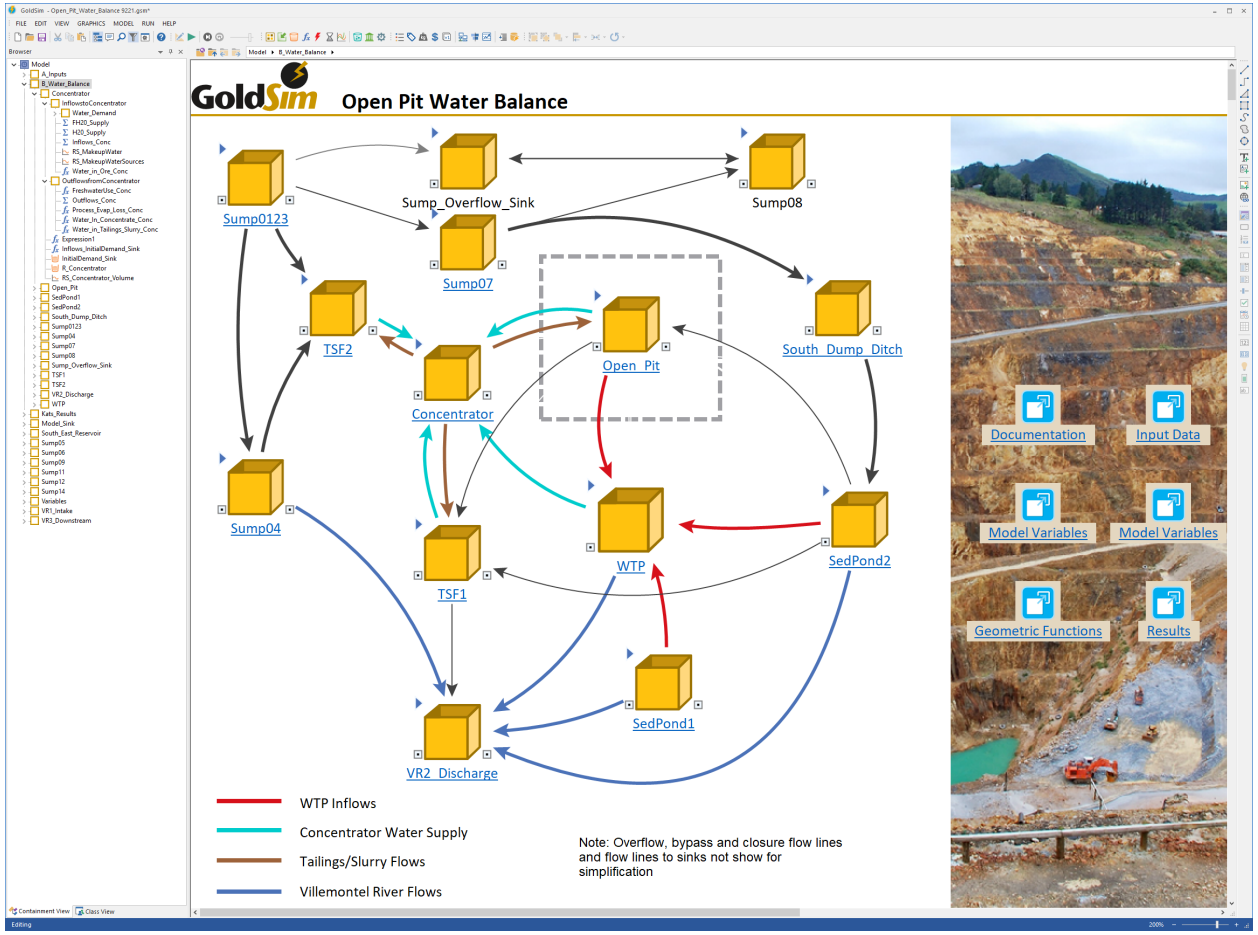
GoldSim Applications



Types of GoldSim Applications

- Solving a very specific problem (e.g., water balance for a mine).
- Using GoldSim as a system integration tool to represent all aspects (e.g., flows, water quality, costs, risks) of a very complex system in a single model.

Site-Wide Water Balance



- Security of Supply
- Environmental compliance
- Operational Efficiency
- Encompass the life of the mine from feasibility to post-closure.
- Time-dependent definition of input data and system rules.

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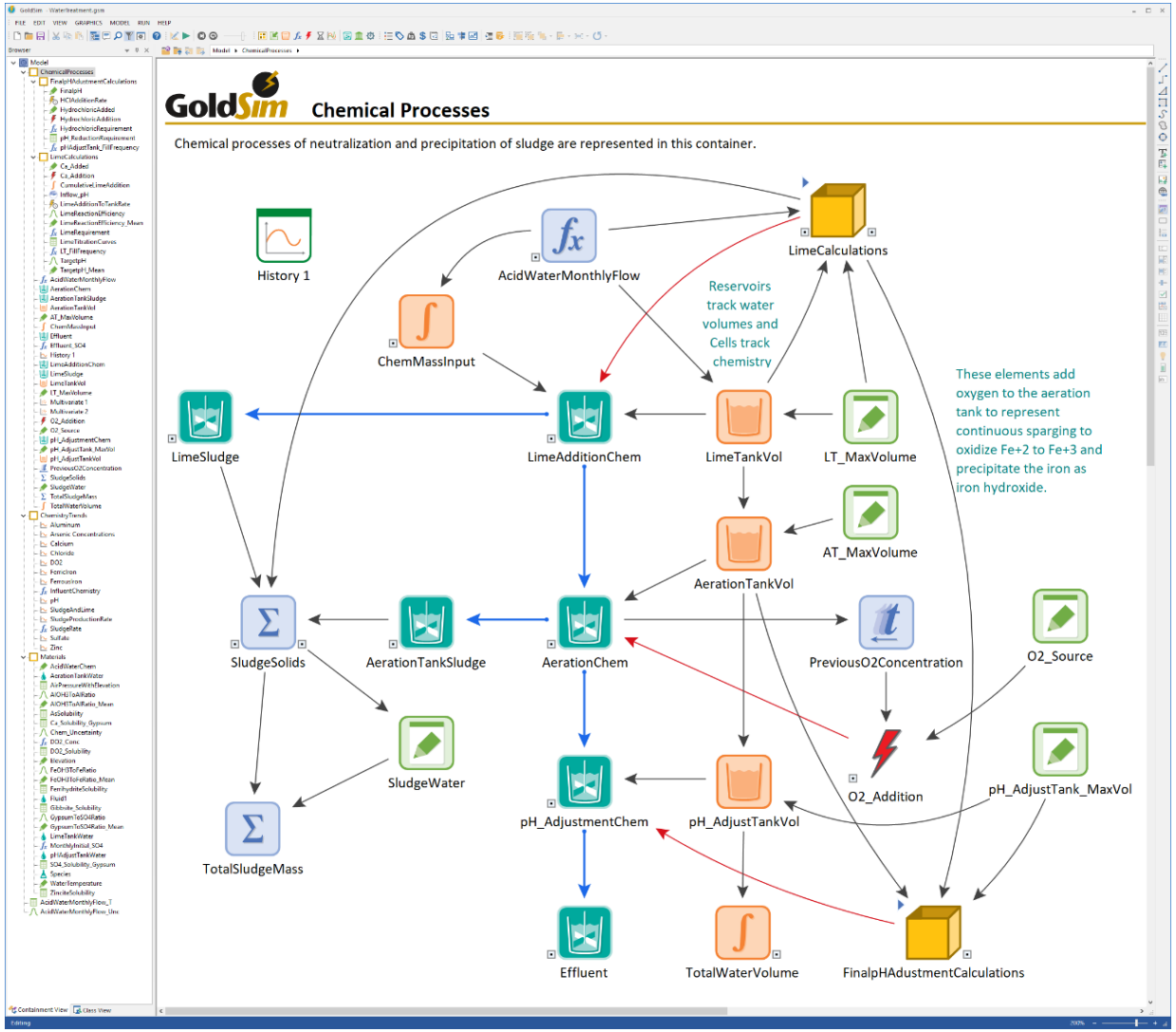
Mine Water Treatment



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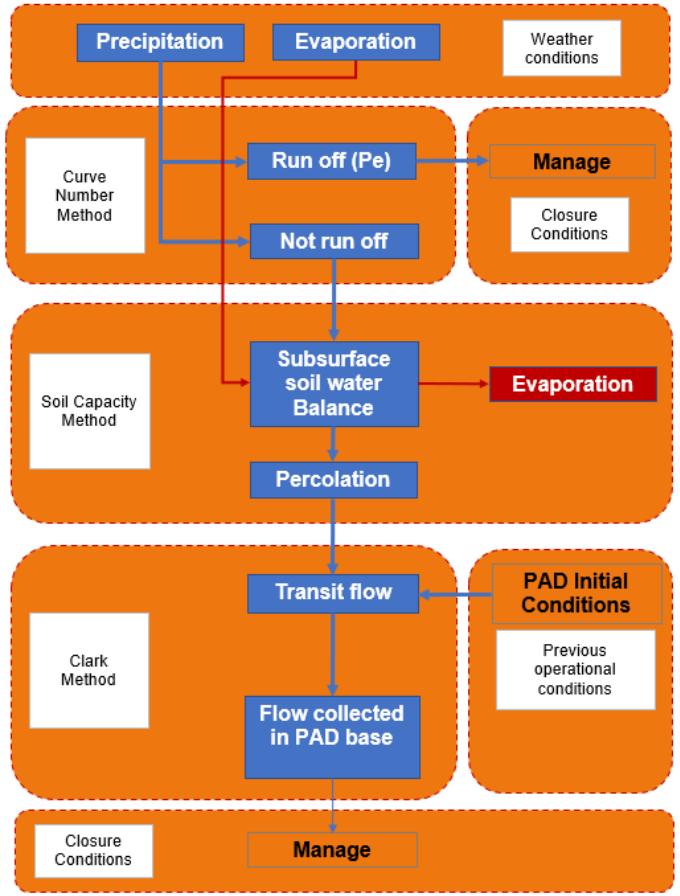
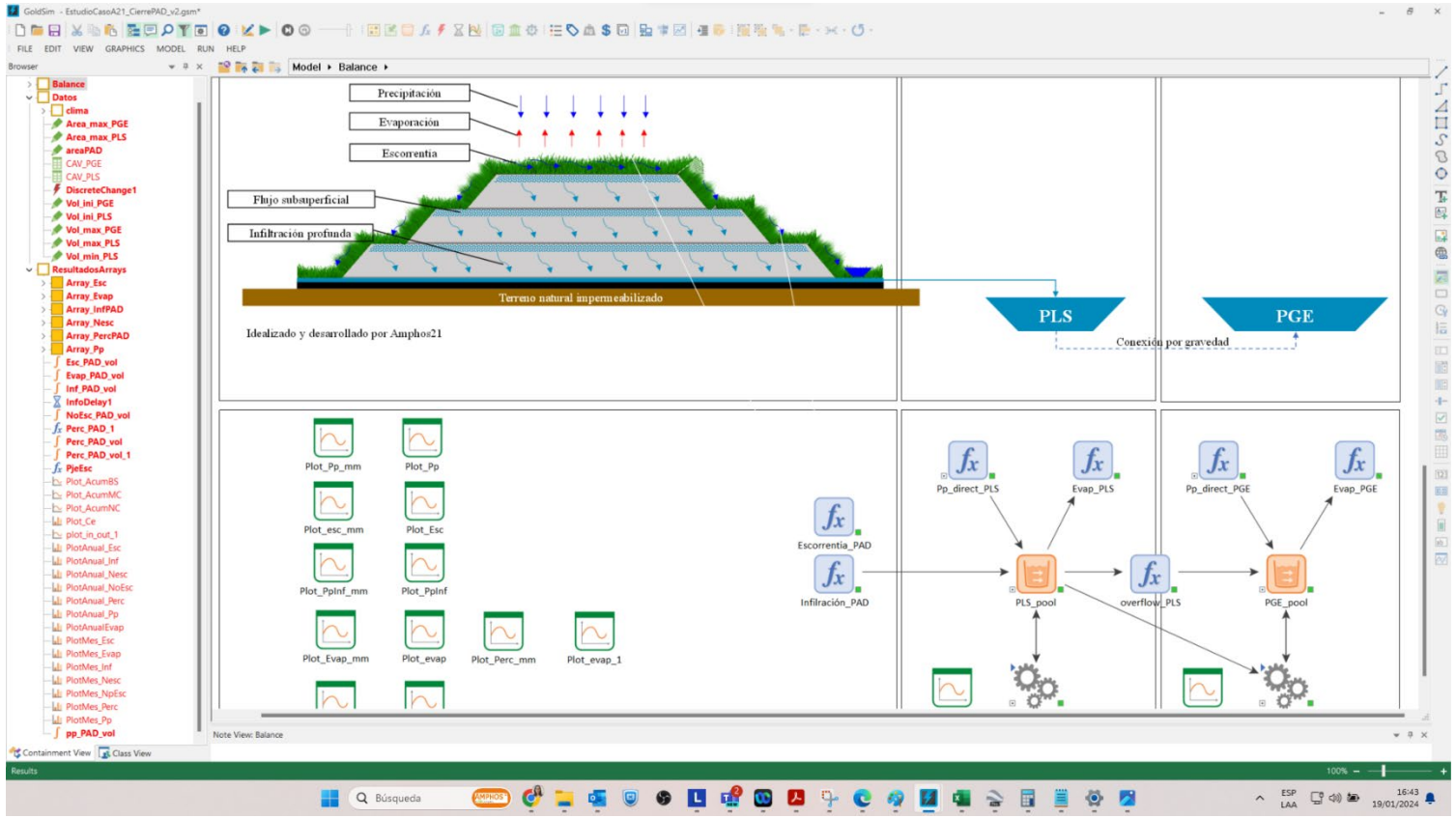
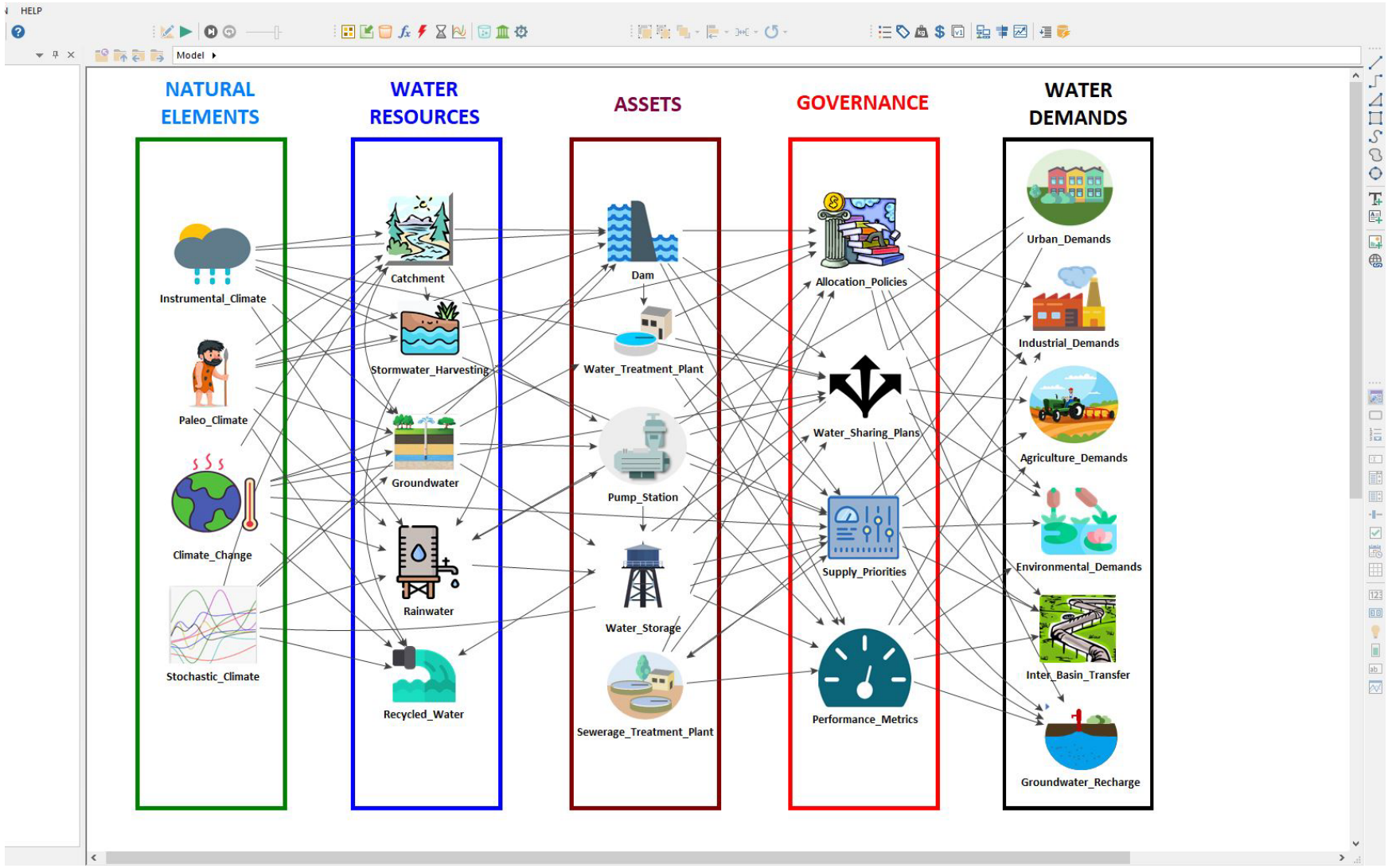
Simulation of Heap Leach Facility





Integrated Water Management



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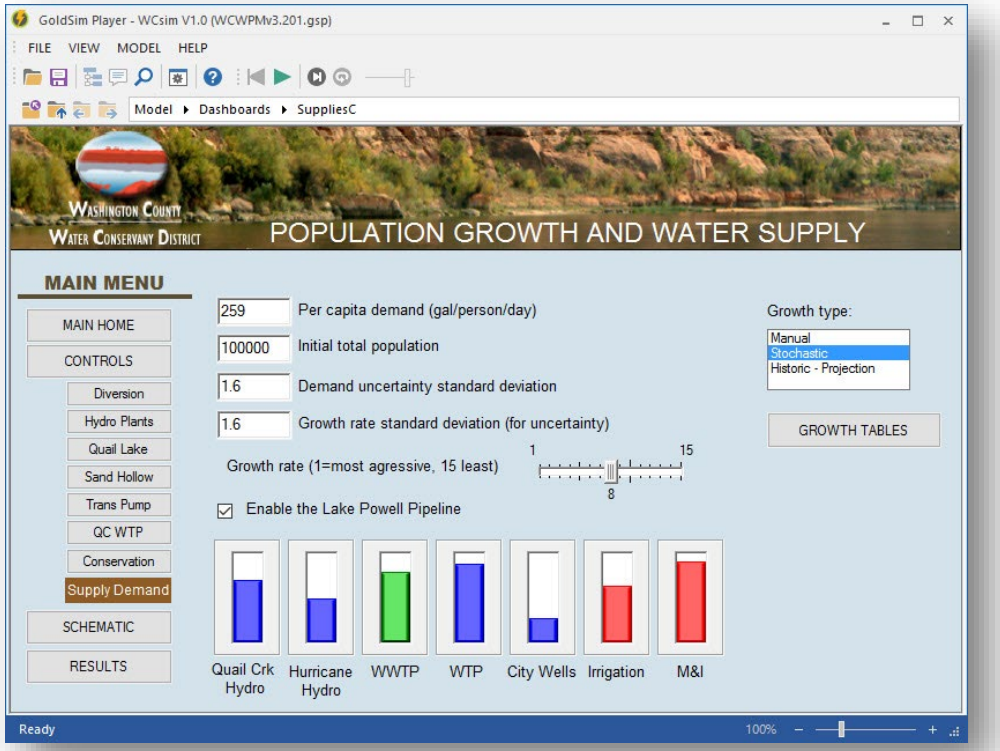
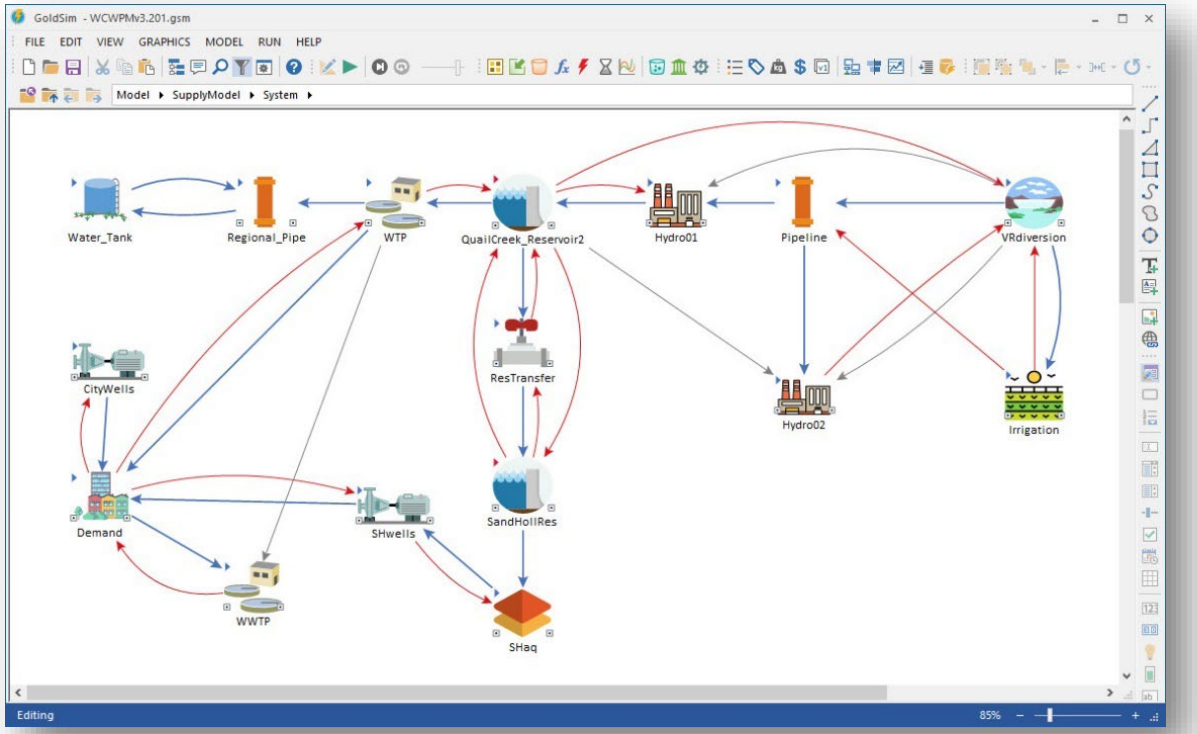
Water Supply Reliability





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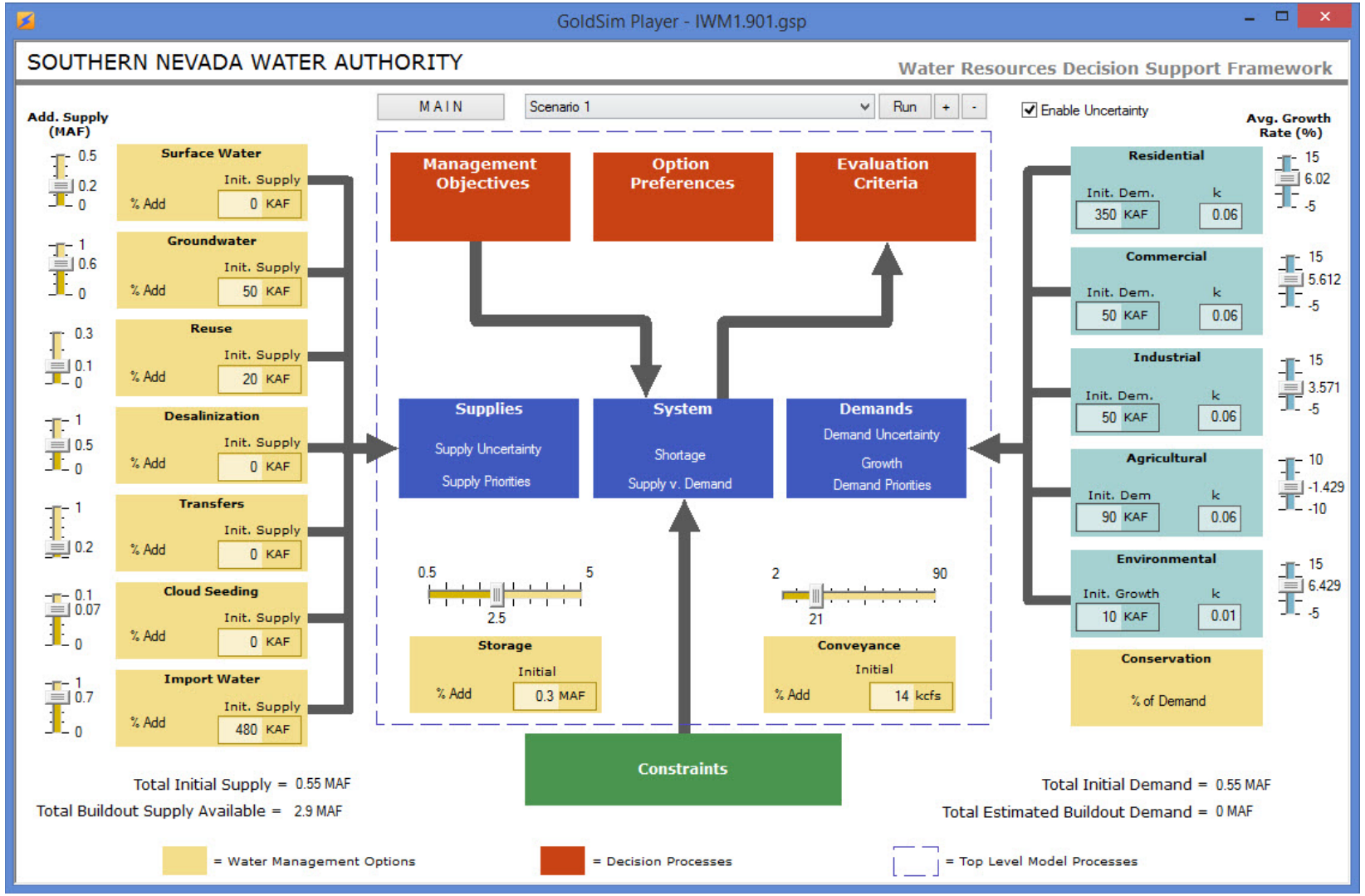
Water Supply Planning



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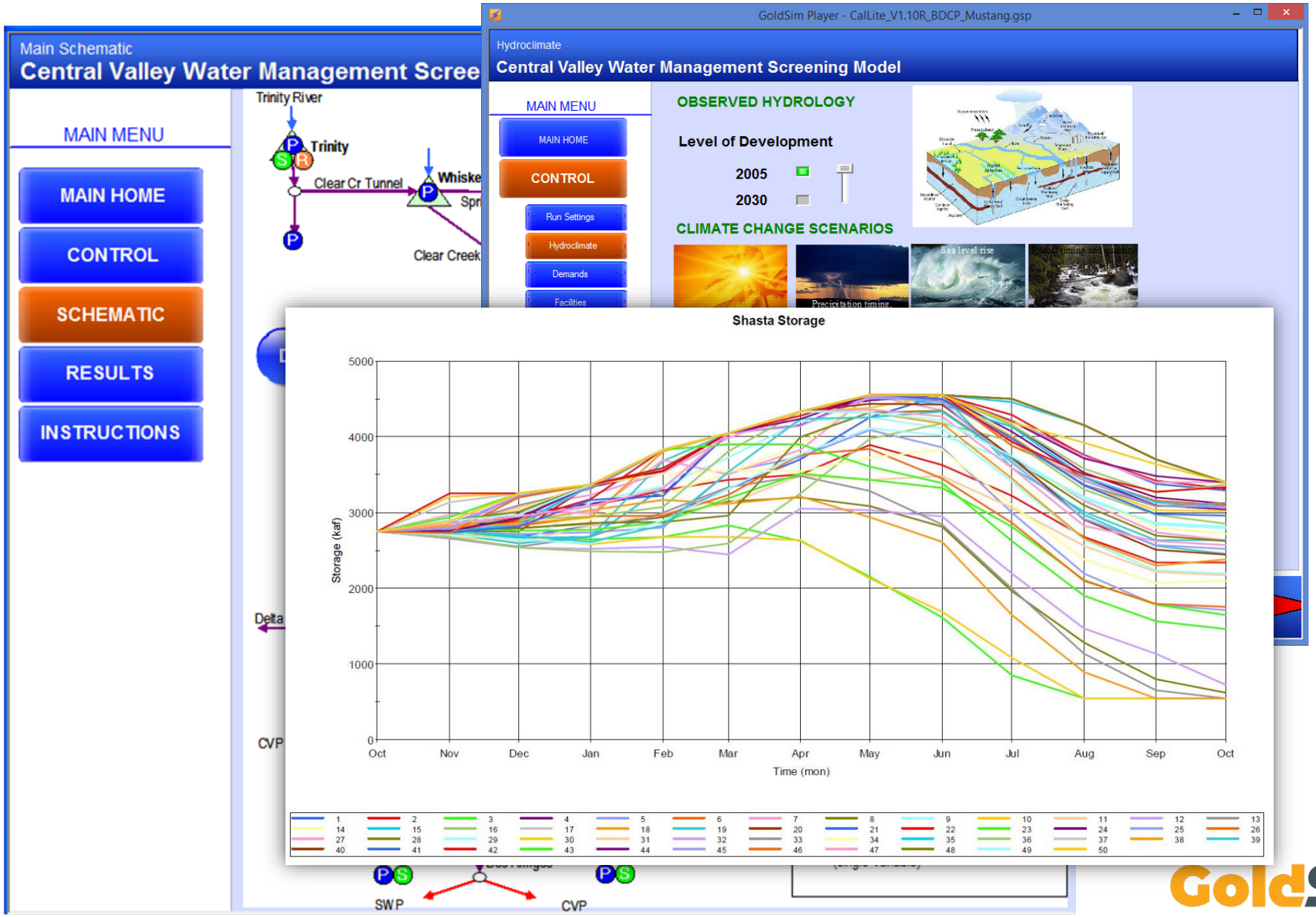
Long-Term Water Planning



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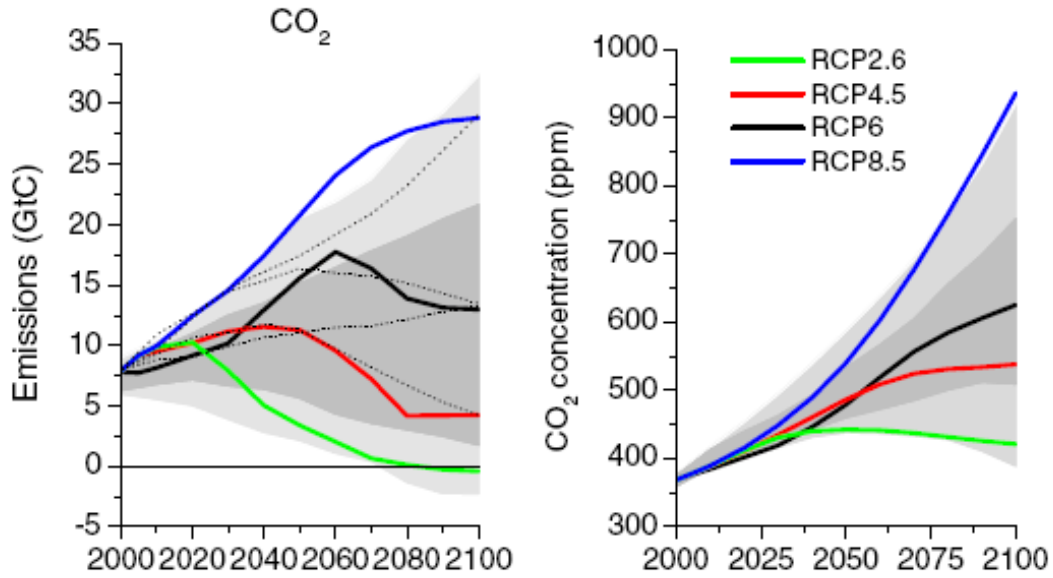
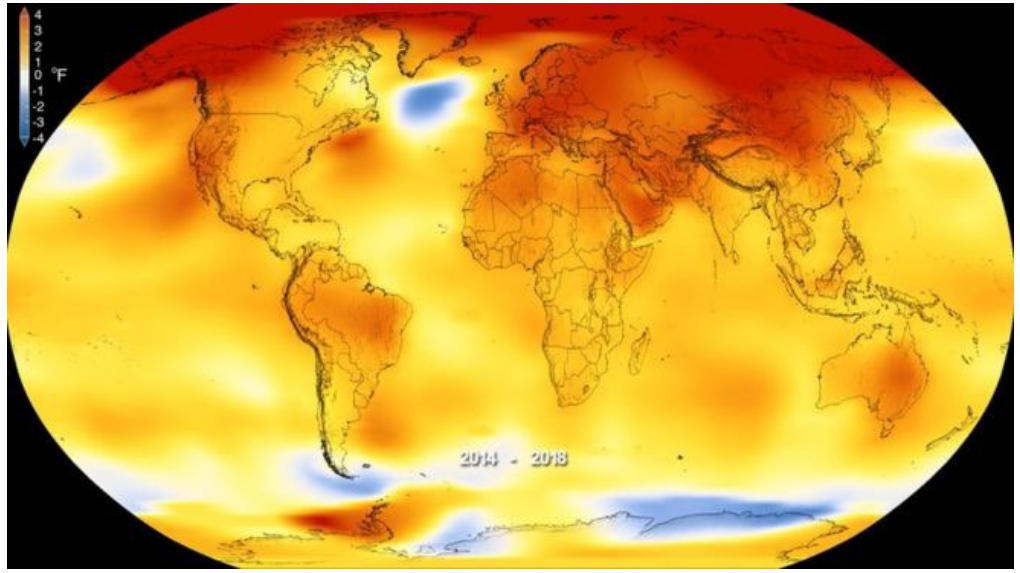
Climate Change and Variability

Assessment of the system performance under projected climate conditions to identify the shortfalls and necessary mitigative measures at future milestones.





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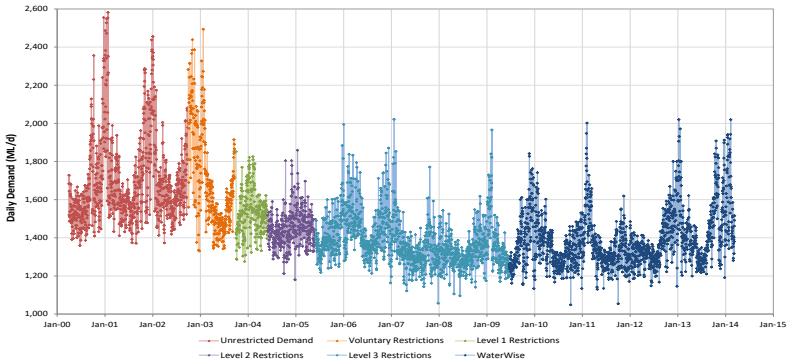
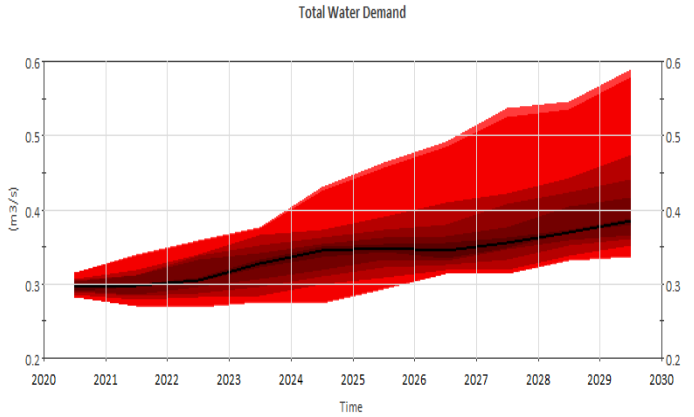
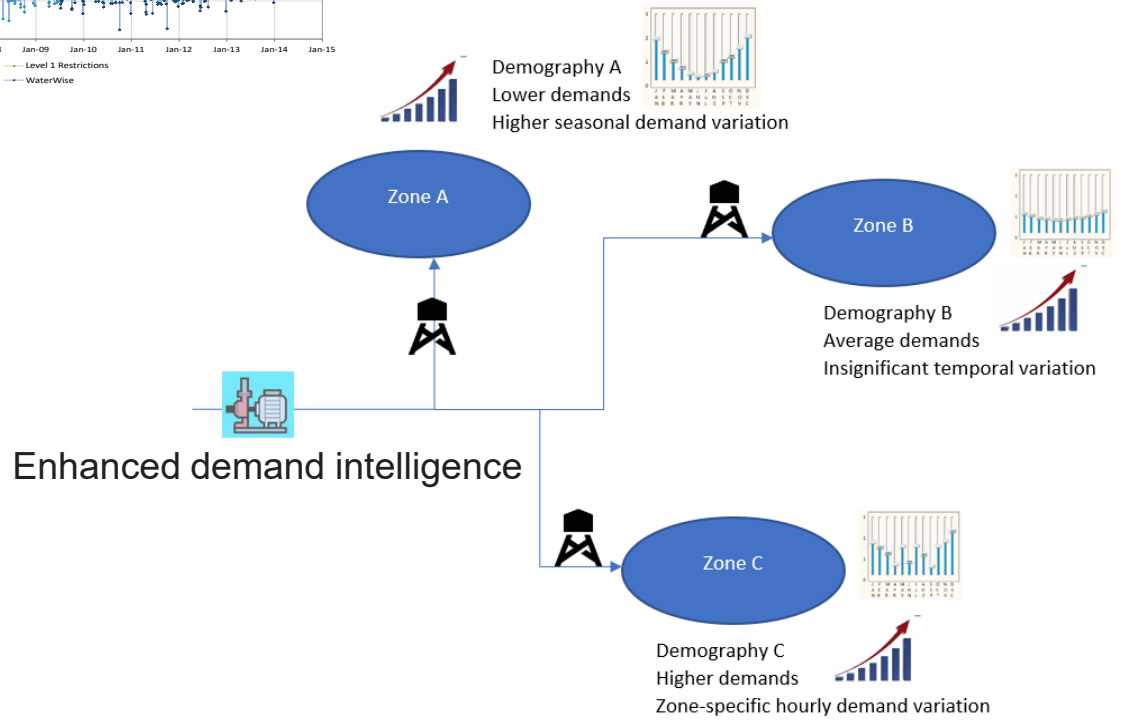
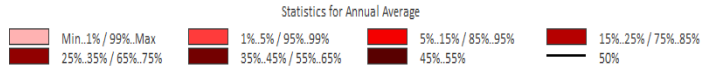
Evidence-based Water Supply Planning



More informed/robust Demand Projections







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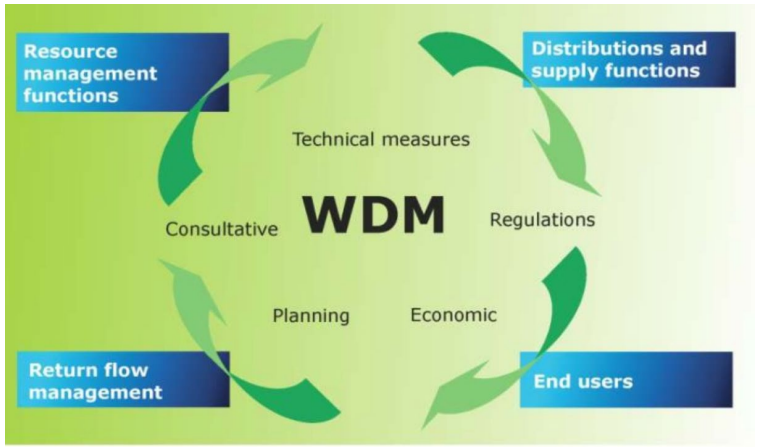
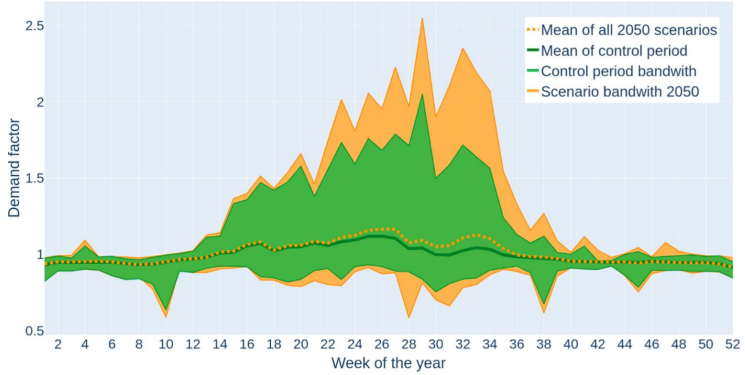
Demand Management Planning

- Probabilistic representation of water demand, daily and seasonal variations and annual trends.
- Actual demand values used rather than “maximum” or “average”.
- System readiness for projected growth in population and water consumption .
- Simulate the effectiveness of demand management measures.





Sources: Estimating Peak Daily Water Demand under Different Climate Change and Vacation Scenarios, Vonk et al. (2019), Water Demand Management, Ali El-Naqa, Hashemite Univ.

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Water Supply Reliability Metrics

Reliability

The probability of non-failure within a fixed period of time

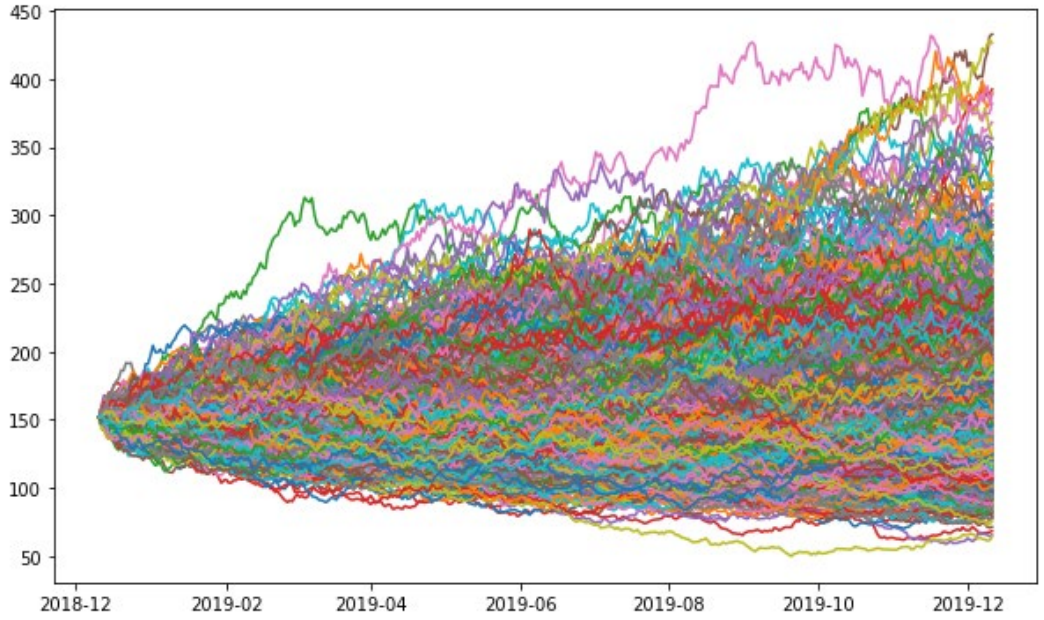
Resilience

The recovery speed of the system from a failure condition

Vulnerability

The severity of a failure's consequence in the system.

RRV: System Performance Metrics (Hashimoto et al., 1982)



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