

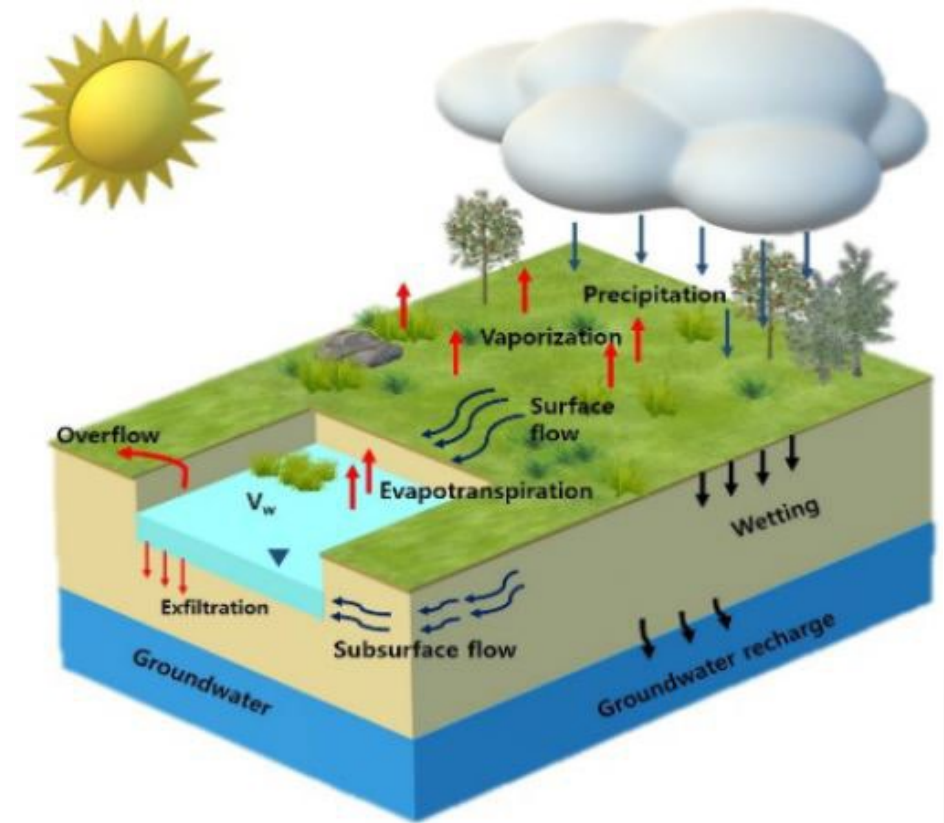
GoldSim

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.



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

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?

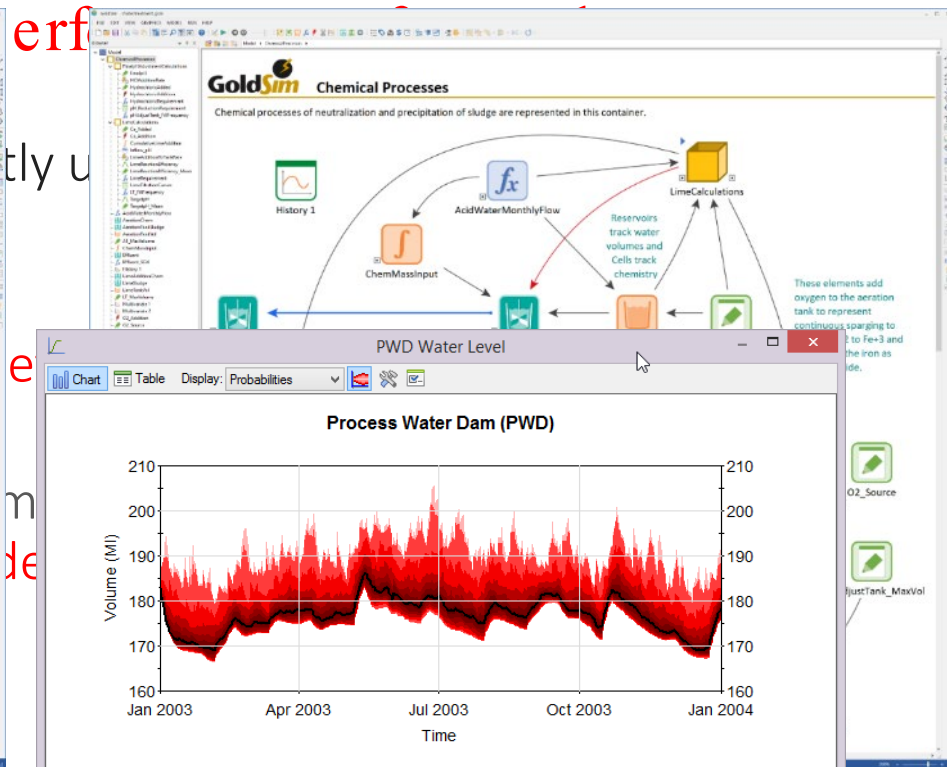
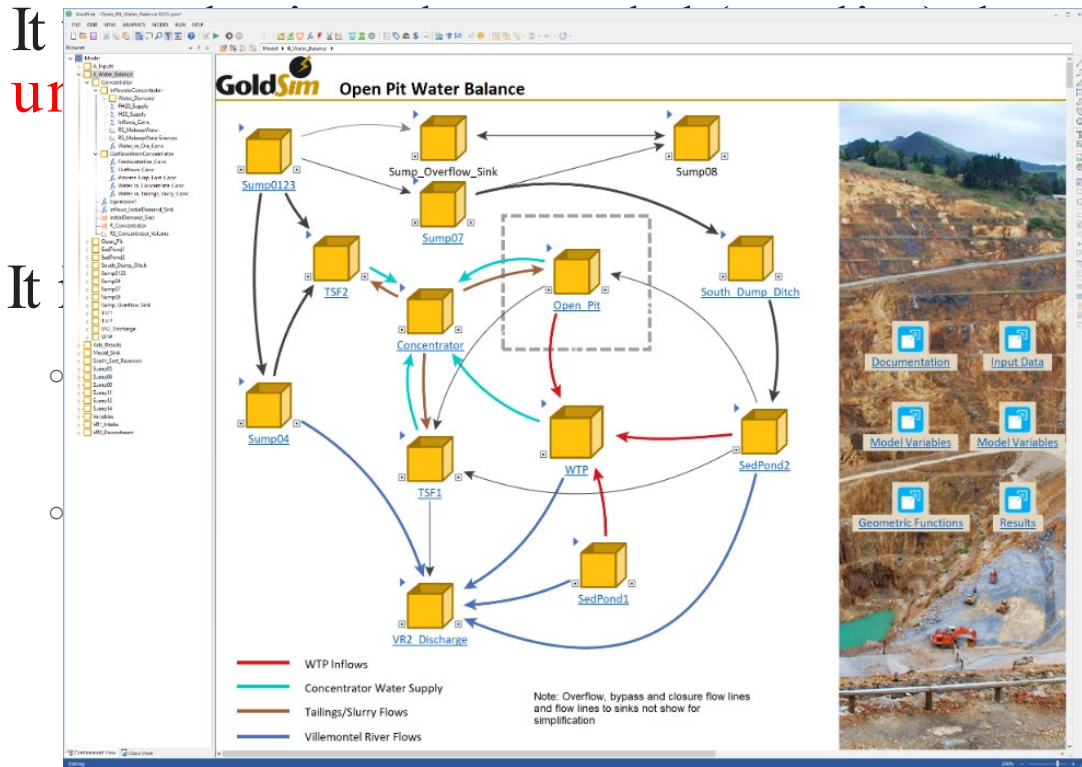
- Many complex engineered systems require **predictions of future performance** of in order to **optimize system design** and **demonstrate compliance with regulatory requirements**.
- These systems often have lots of **uncertainty** (e.g., due to long time frames or lack of knowledge) and/or involve **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?

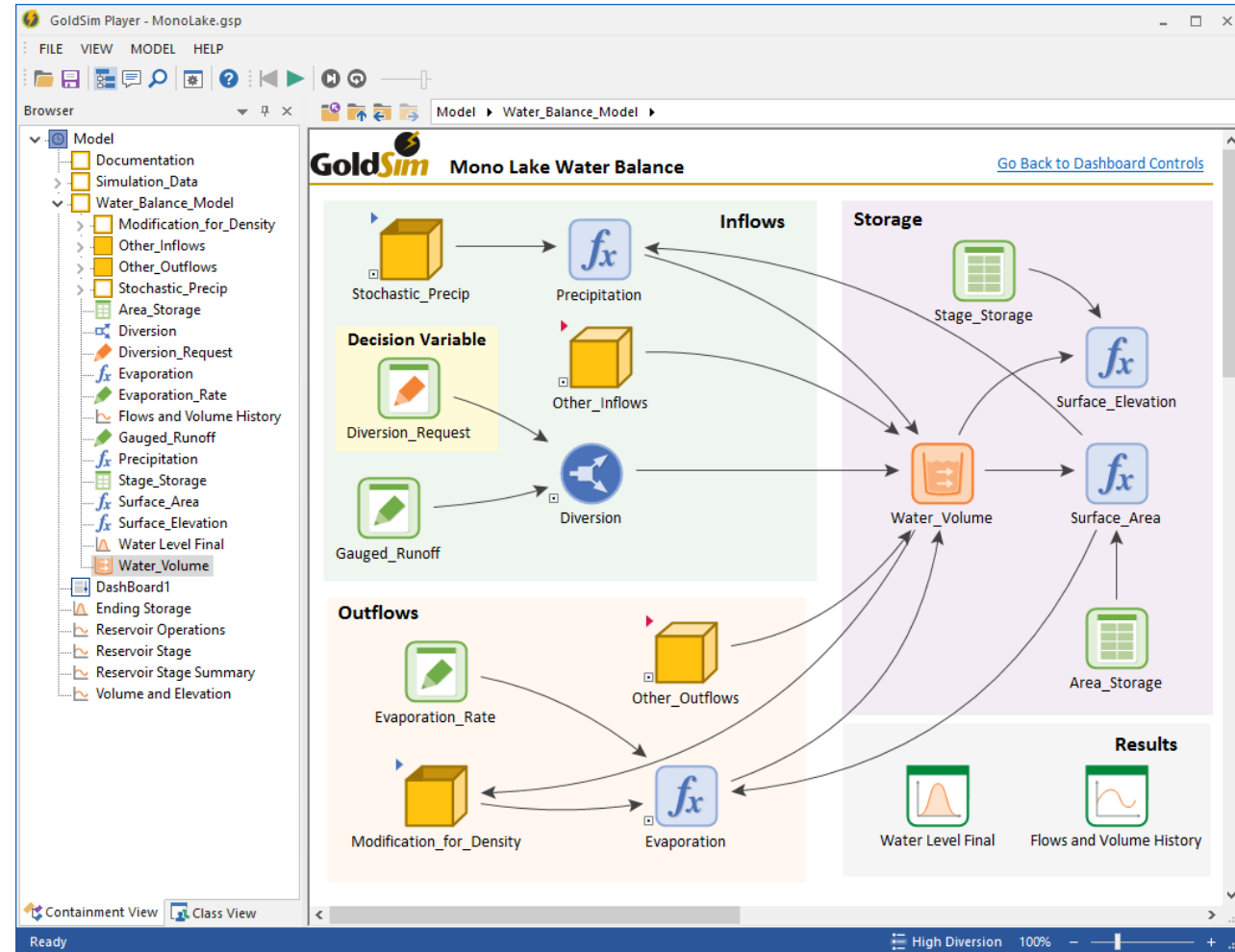
GoldSim is a general purpose dynamic probabilistic simulation framework.

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

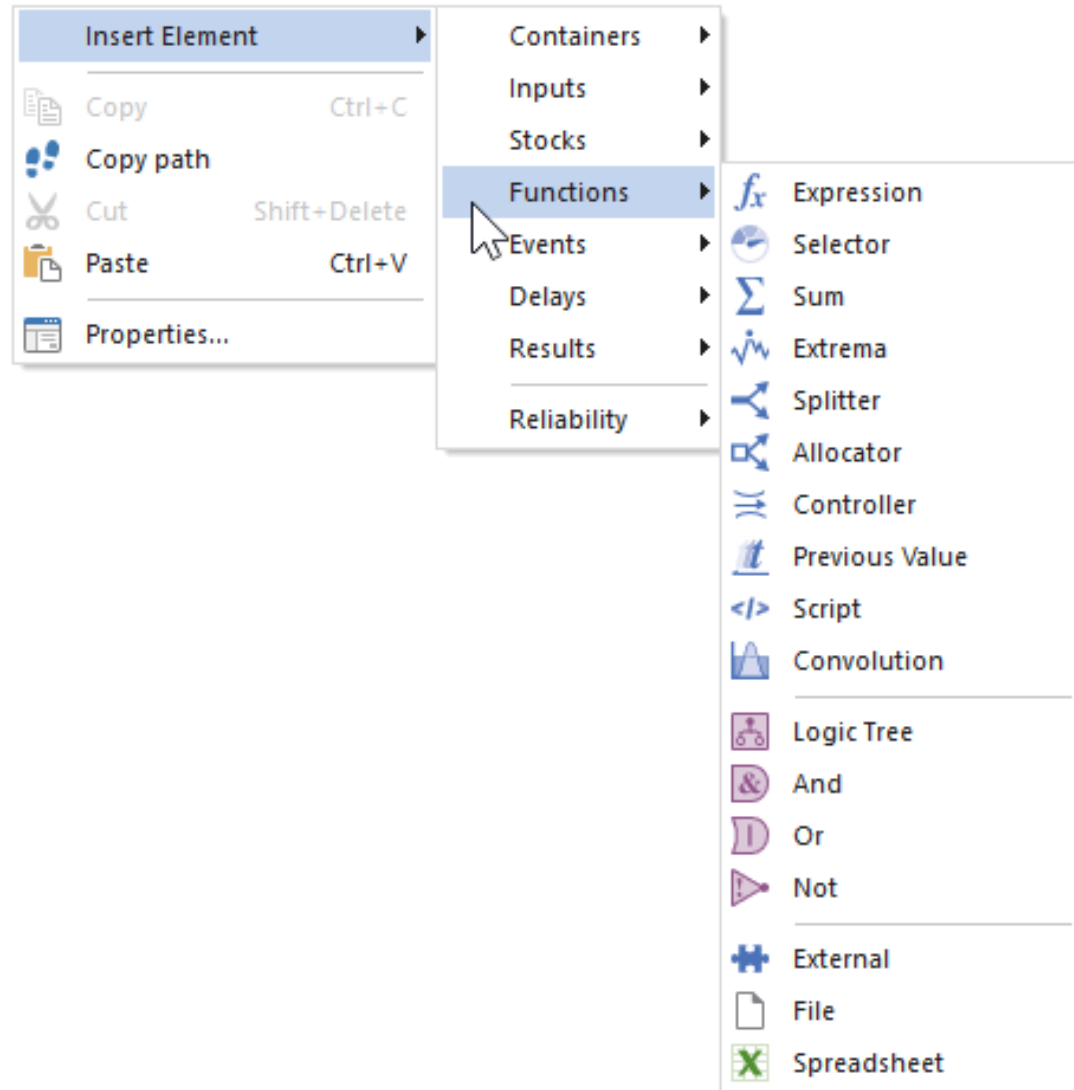


How do you build a GoldSim model?

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.



GoldSim provides over 50 element types ...





Data



Stochastic



TimeSeries



Ma



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.



Container



SubModel



Dashboard



Integrator



Reservoir



Pool



Expression



Script



PreviousValue



TimedEvent



TriggeredEvent



EventDelay



Decision



RandomChoice



Status



Milestone



DiscreteChange



ChangeDelay



Interrupt



Function



Action



Fund



CashFlow



Investment



Option



Insurance



Fluid



Solid



Cell



Pipe



Aquifer



ExternalPathway



Receptor



Source

Specialized Modules (Reliability, Financial and Contaminant Transport)

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)

Simulation Settings...

Time Monte Carlo Globals Information

Specify timestepping options for the model.

Show Scheduled Updates...

Basic Settings

Time Basis: Calendar Time Time Display Units: day

Duration: 1827 day

Start Time: 1/ 1/2020 12:00:00 AM

End Time: 1/ 1/2025 12:00:00 AM

Timestep Settings

Alignment: Calendar aligned #Months:

Basic Step: Calendar months 1

Reporting Steps: Major Period: Minor Period:

Major & Minor Periods annual quarterly

Period Label: Years Quarters

Save Results: Reporting Steps

61 scheduled update times, 21 saved

Result Size: 0 byte histories, 0 byte final values

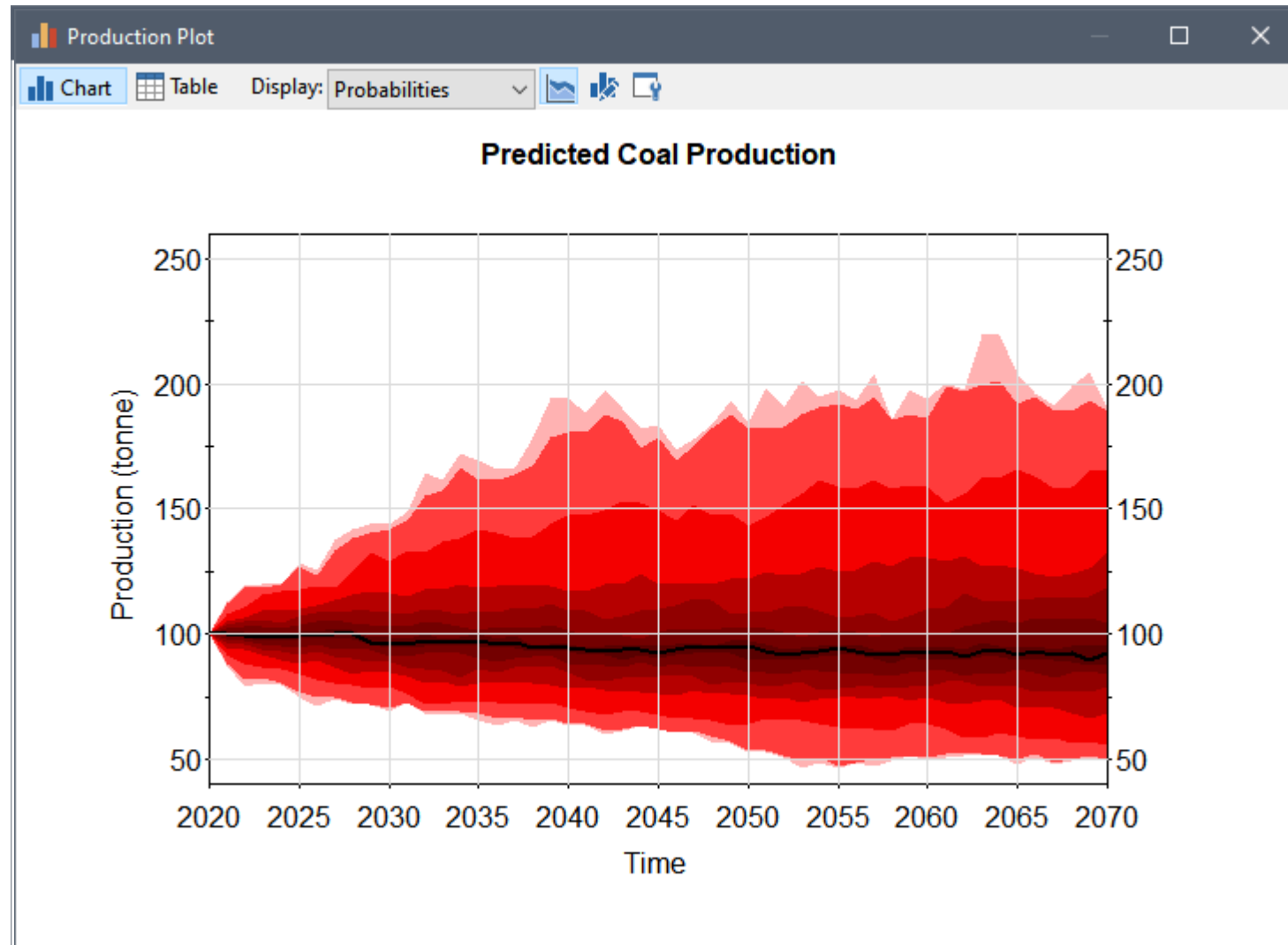
Advanced...

OK Cancel Help

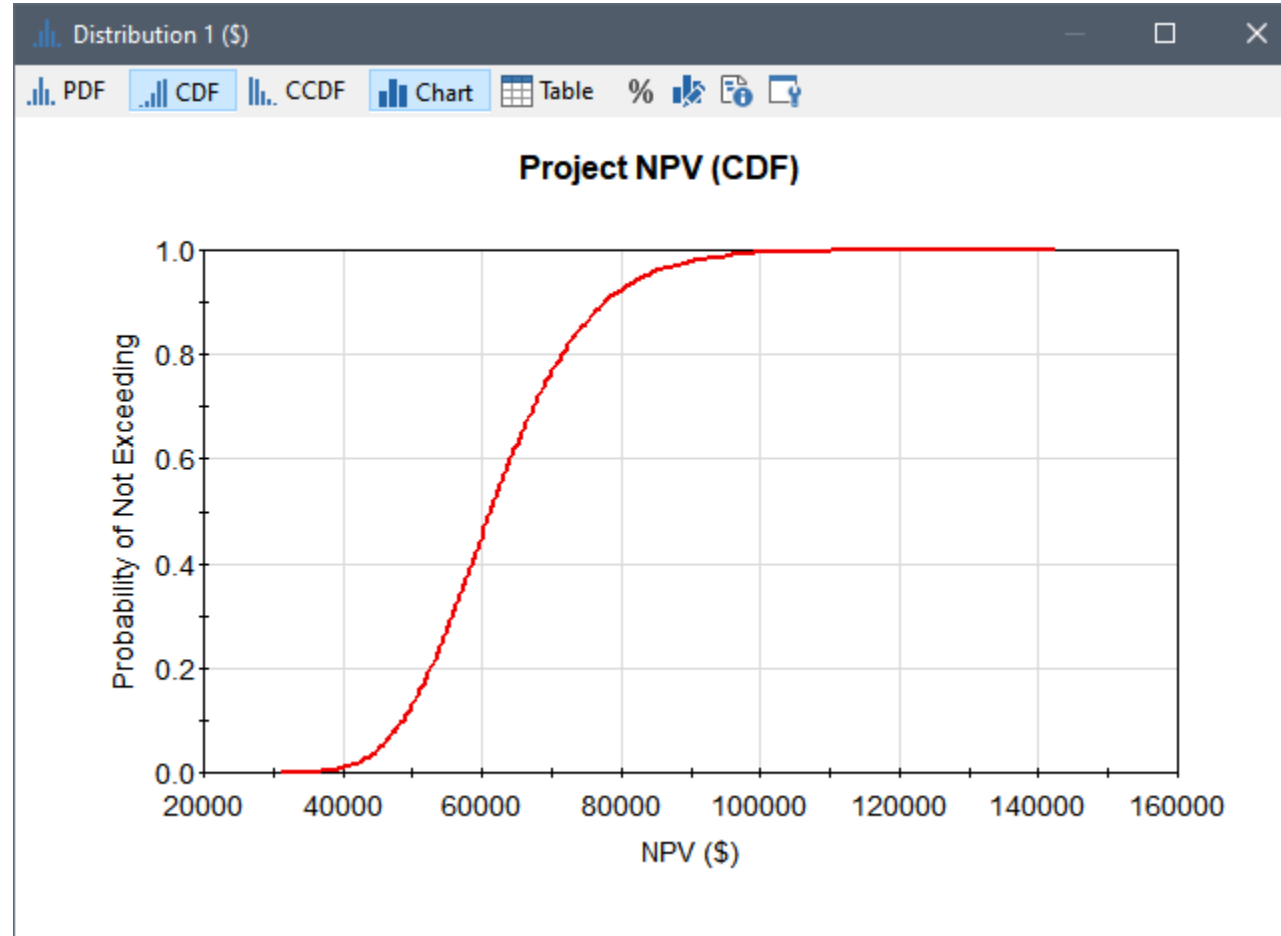
Probabilistic Simulation

- 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

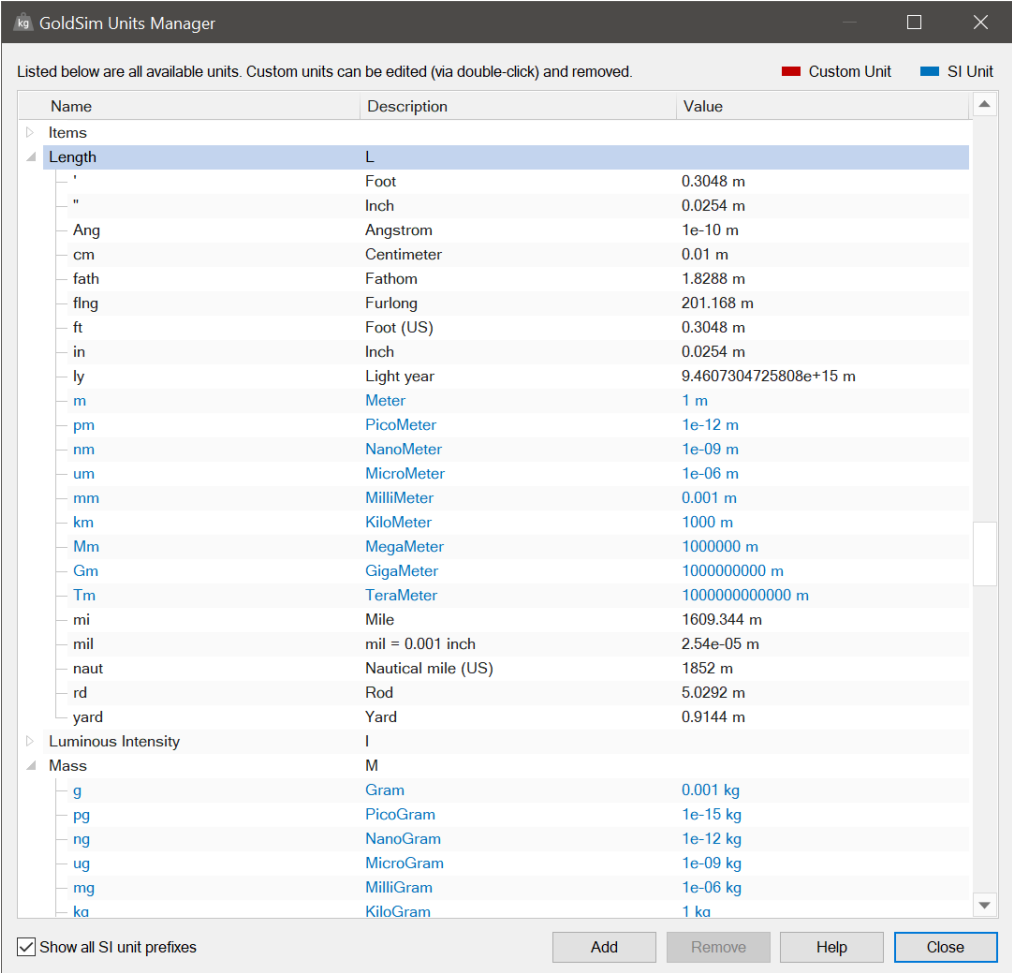


Probabilistic Simulation Results



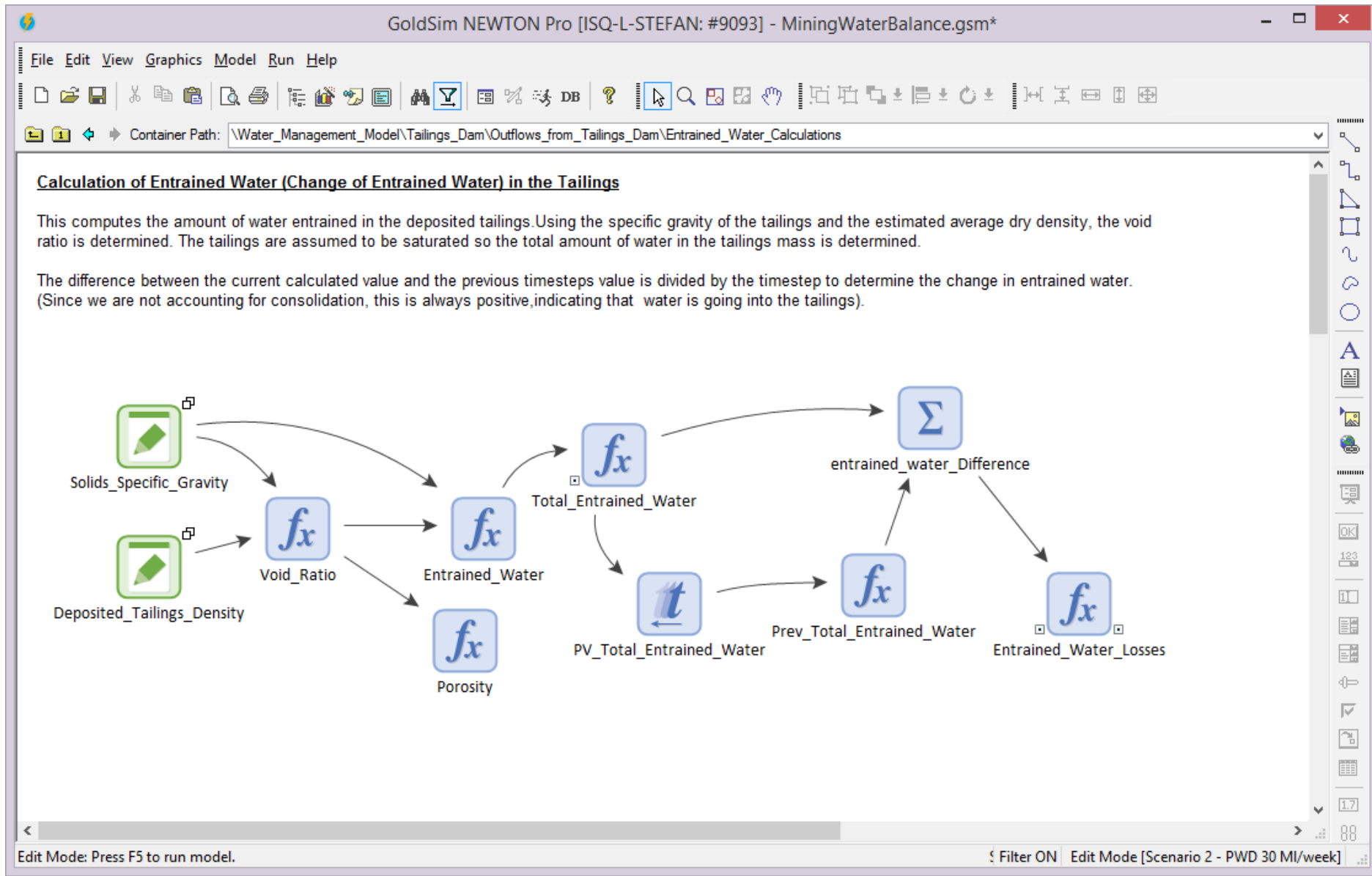
GoldSim Understands Units and Dimensions

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



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





Presentation and Documentation

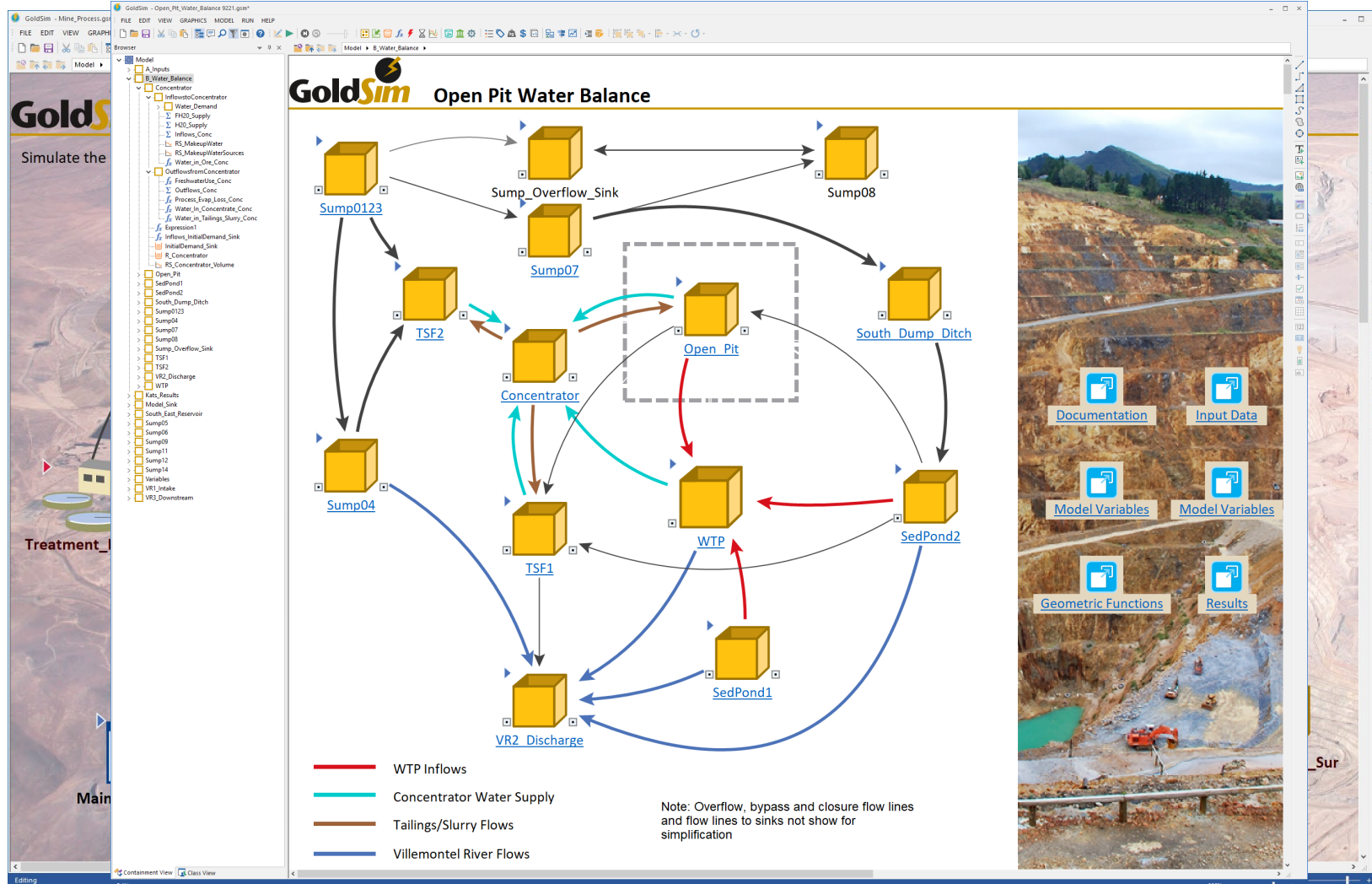
Recall one of the main drivers for development of GoldSim:

- 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



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

GoldSim Player - BGCv5.206.gsp

BEAR GULCH CREEK CONTROL ROOM

Relax Water Rights* Run + - Model Spreadsheet

Upper Diversion

Bypass Equations Enable Fish Bypass Bypass Criteria

Results: Site A | Site B, Fish Bypass, Div. Scenario

Bypass: Goal: 219 Mgal, Actual: 219 Mgal ✓

Limit Upper Diversion (Clogging Intake)
 Max. Flow (cfs): 0, Day begin: 1/ 3/2006, Duration: 0 day
 Add a New Pipe (in): 12

Hydrology

Enable Change in Hydrology

Change Hydrology (avg.annual adjustment)
 0.2 1 3
 Dry Normal Wet

Results: Flow at Site A, West Union

Lower Diversion (Sta. 3 Pump Station)

Enable Fish Bypass Bypass Criteria

Results: Site C | Site D, Sta. 3 Pumping, Fish Bypass, Pumping vs. Delivery, Pumping Scenarios

Bypass: Goal: 439 Mgal, Actual: 364 Mgal ✗

Pump Controls
 Use New Pump, Use New Pipe, Dia: 24
 Automatic Pump ON, Pump OFF

	Head (ft)	E (gpm)	F (gpm)	New (gpm)
1	0	1800	1000	1800
2	50	1700	900	1700
3	70	1300	700	1300
4	90	1000	600	1000
5	110	600	200	600
6	130	200	0	200
7	150	0	0	0

Water Rights: Flow Limit, Volume Limit, Production Limit, Time Limit

Production

Enable Change in Production

Change in BGWTP Production (%)
 -50 0 50

370 Mgal WTP Production, 496 Mgal Production Goal, WTP TS

Results: Production, Production Scenarios, Sim. Production vs. Normal, Throttle Production

Bear Gulch Reservoir

Initial Water Level (ft): 220

Results: Reservoir | Diversion, Diversion | Bypass, Drawdown, Reservoir

Reservoir Drawdown: Allowed: 0.3 ft, Peak: 0.3 ft ✓

Withdrawal Amount

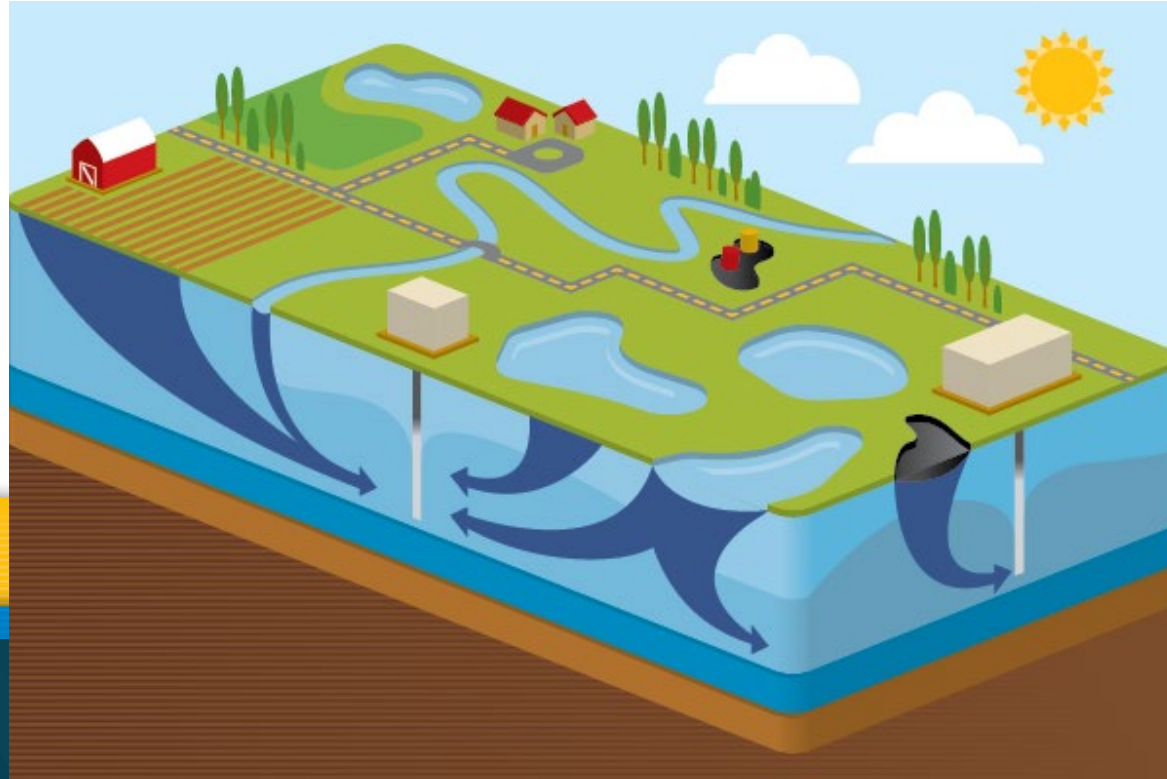
Avg. Monthly Volume (MGAL)
 O N D J F M A M J J A S

Misc. Inflow to Res.
 Flow (cfs): 0, Day begin: 10/ 1/2005, Duration (days): 0

GoldSim Run Controller

DETERMINISTIC, Elapsed Time: 00:00:00
 TIMESTEP: 365/365
 OCT-01-2006 00:00:00
 Simulation Time, Status: RESULTS

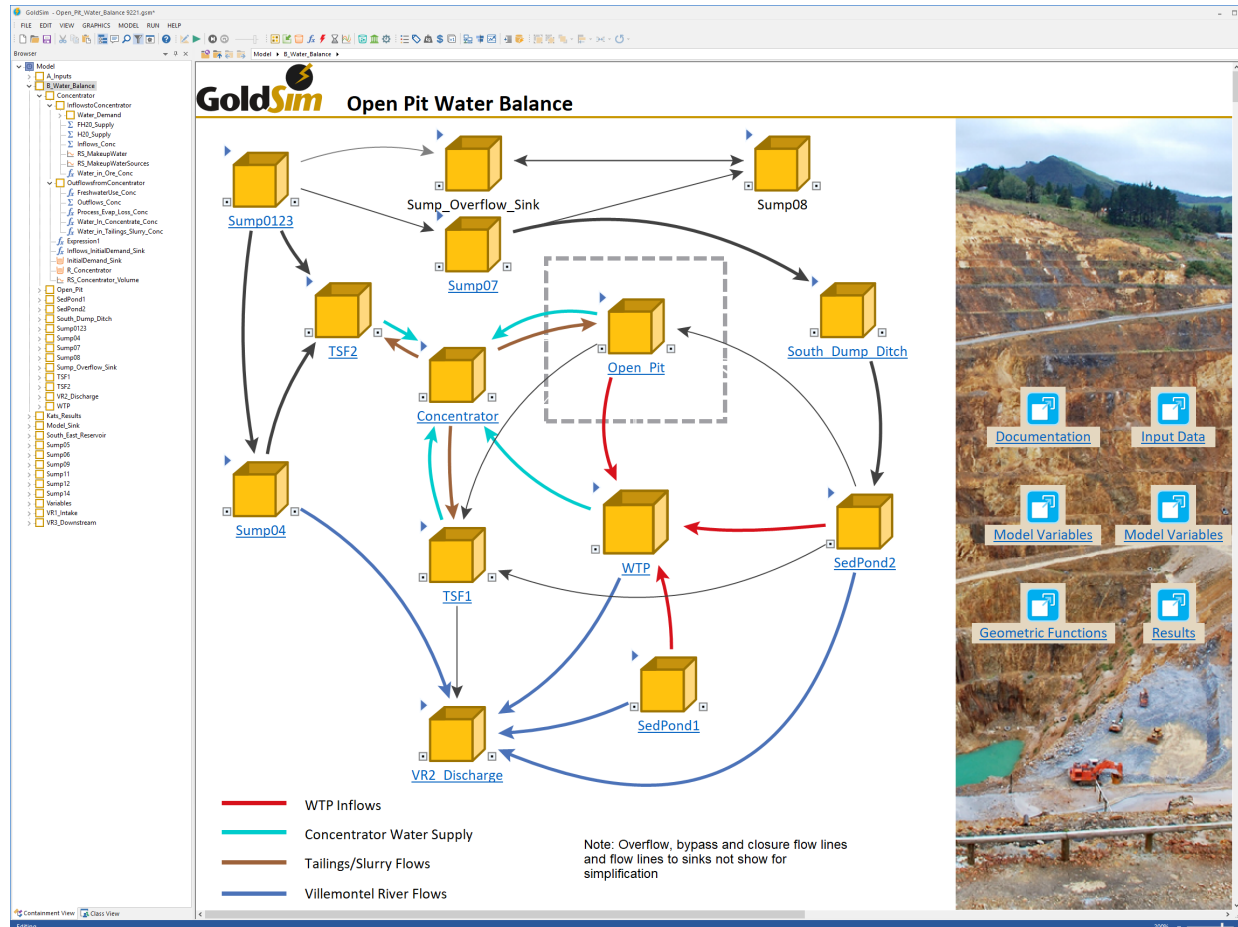
GoldSim Applications



Types of GoldSim Applications

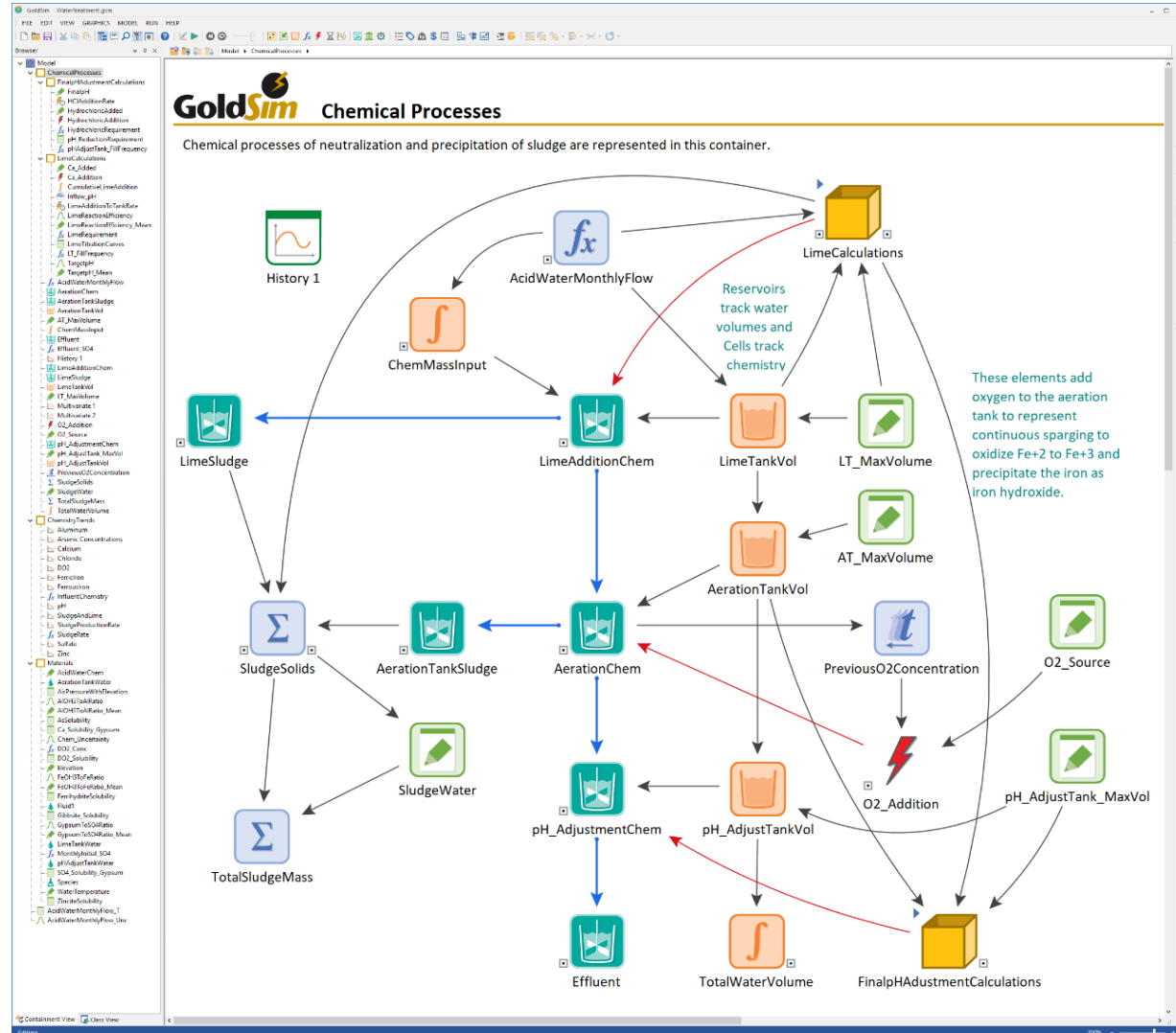
- Solving a very specific problem (e.g., water balance for a mine).
- Using GoldSim as a system integration tool to represent all aspects (e.g., flows, water quality, costs, risks) of a very complex system in a single model.

Site-Wide Water Balance

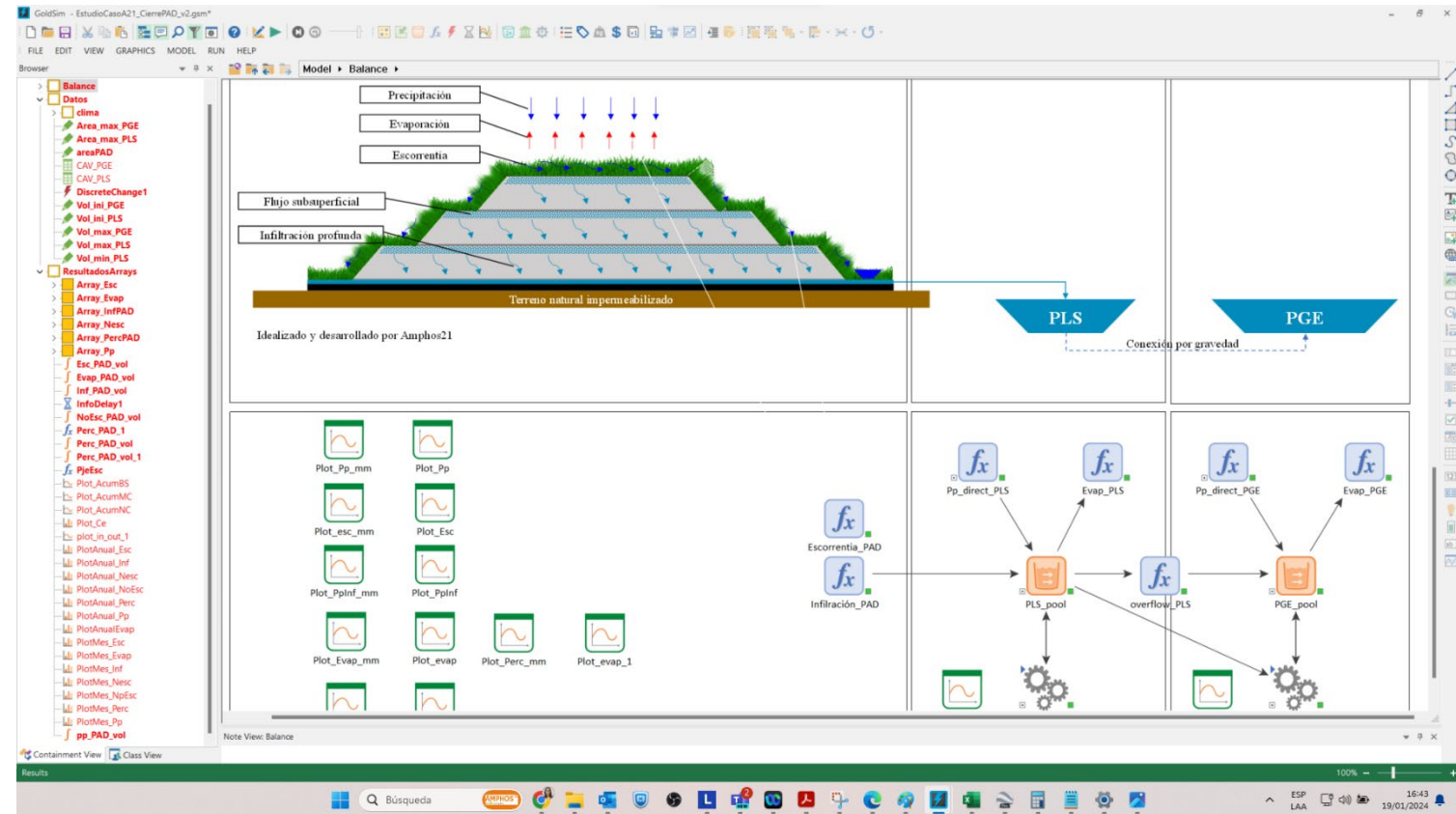
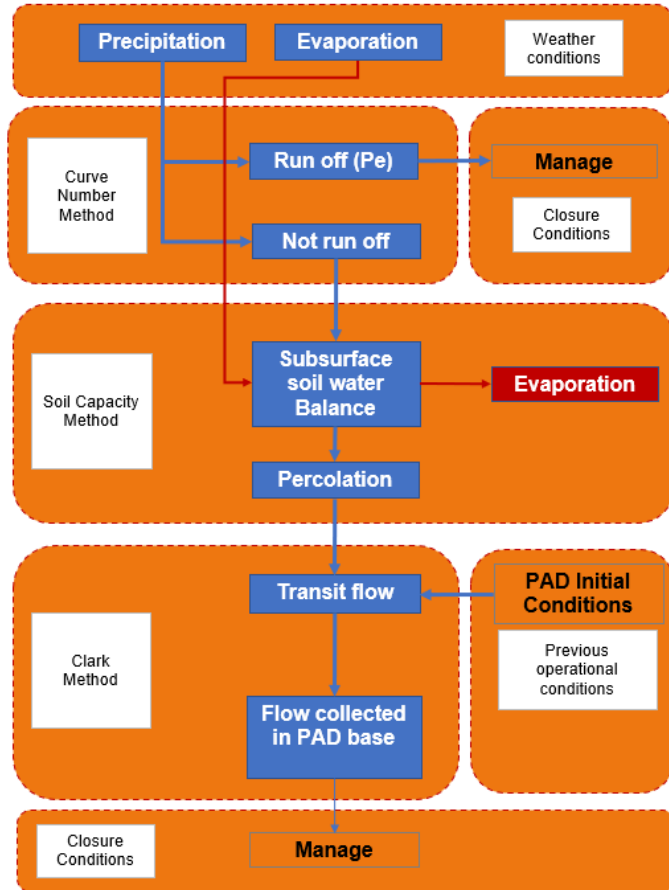


- Security of Supply
- Environmental compliance
- Operational Efficiency
- Encompass the life of the mine from feasibility to post-closure.
- Time-dependent definition of input data and system rules.

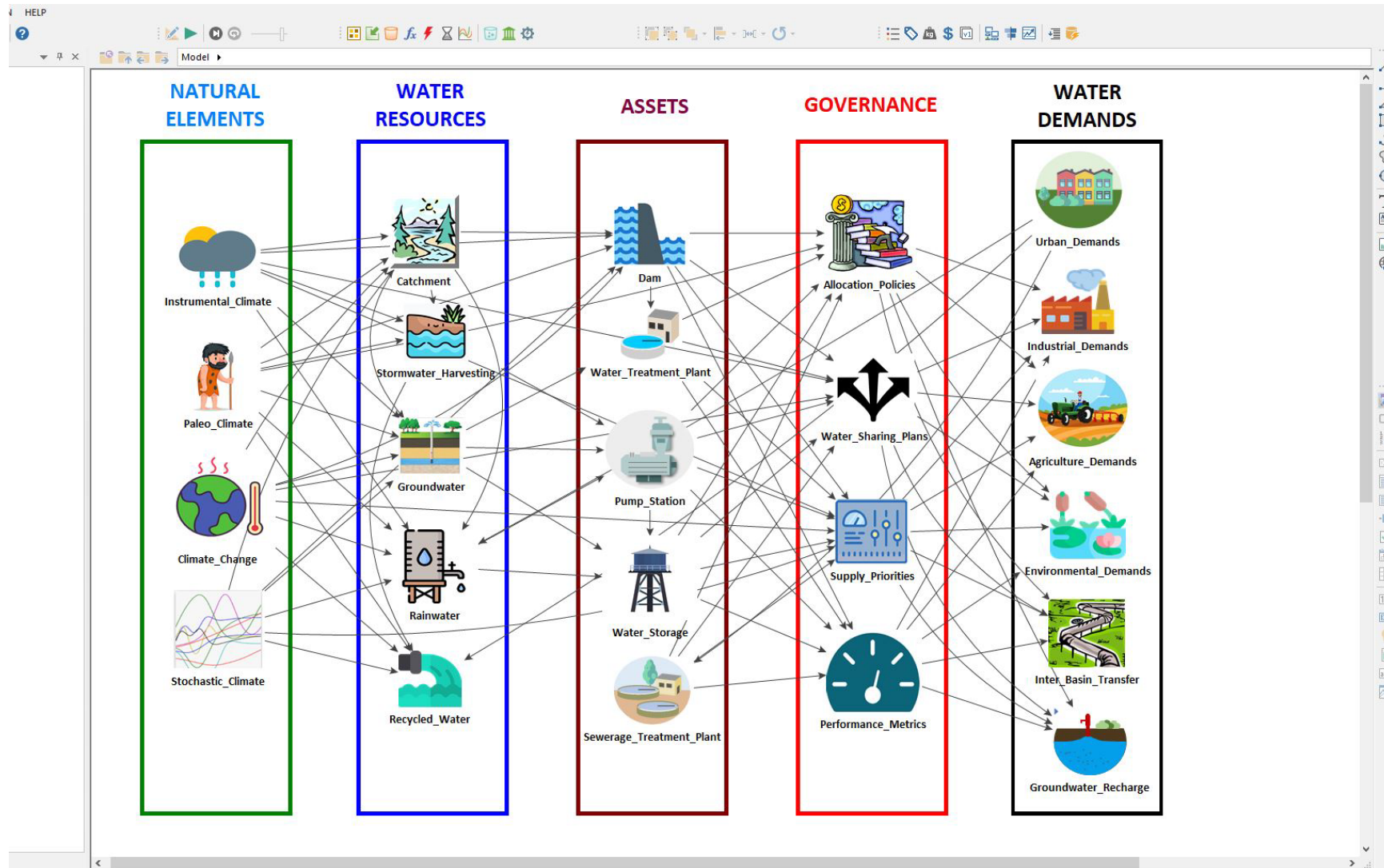
Mine Water Treatment



Simulation of Heap Leach Facility



Integrated Water Management



Water Supply Reliability

GoldSim Player - WCsims V1.0 [WCWPMv3.201.gsp]

FILE VIEW MODEL HELP

Model Dashboards SuppliesC

WASHINGTON COUNTY WATER CONSERVANCY DISTRICT

POPULATION GROWTH AND WATER SUPPLY

MAIN MENU

- MAIN HOME
- CONTROLS
 - Diversion
 - Hydro Plants
 - Quail Lake
 - Sand Hollow
 - Trans Pump
 - QC WTP
 - Conservation
 - Supply Demand**
- SCHEMATIC
- RESULTS

259 Per capita demand (gal/person/day)

100000 Initial total population

1.6 Demand uncertainty standard deviation

1.6 Growth rate standard deviation (for uncertainty)

Growth type:
Manual
Stochastic
Historic - Projection

GROWTH TABLES

Growth rate (1=most aggressive, 15 least) [Slider: 1 to 15, set at 8]

Enable the Lake Powell Pipeline

Quail Crk Hydro [Bar chart]

Hurricane Hydro [Bar chart]

WWTP [Bar chart]

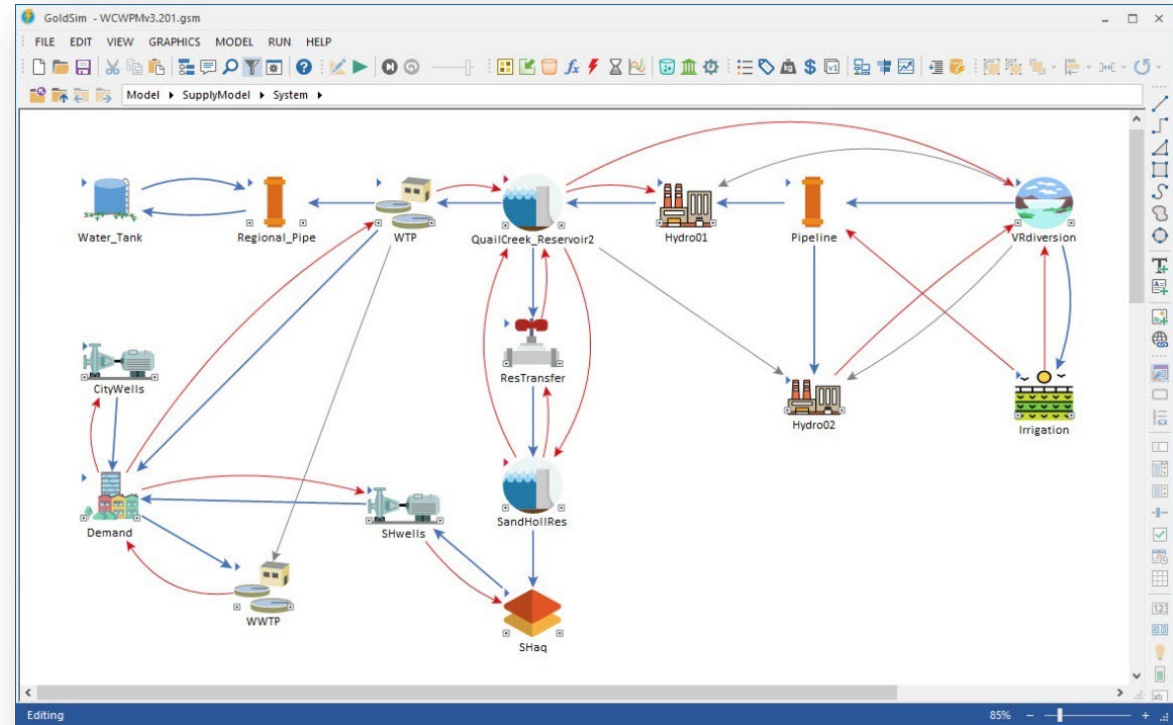
WTP [Bar chart]

City Wells [Bar chart]

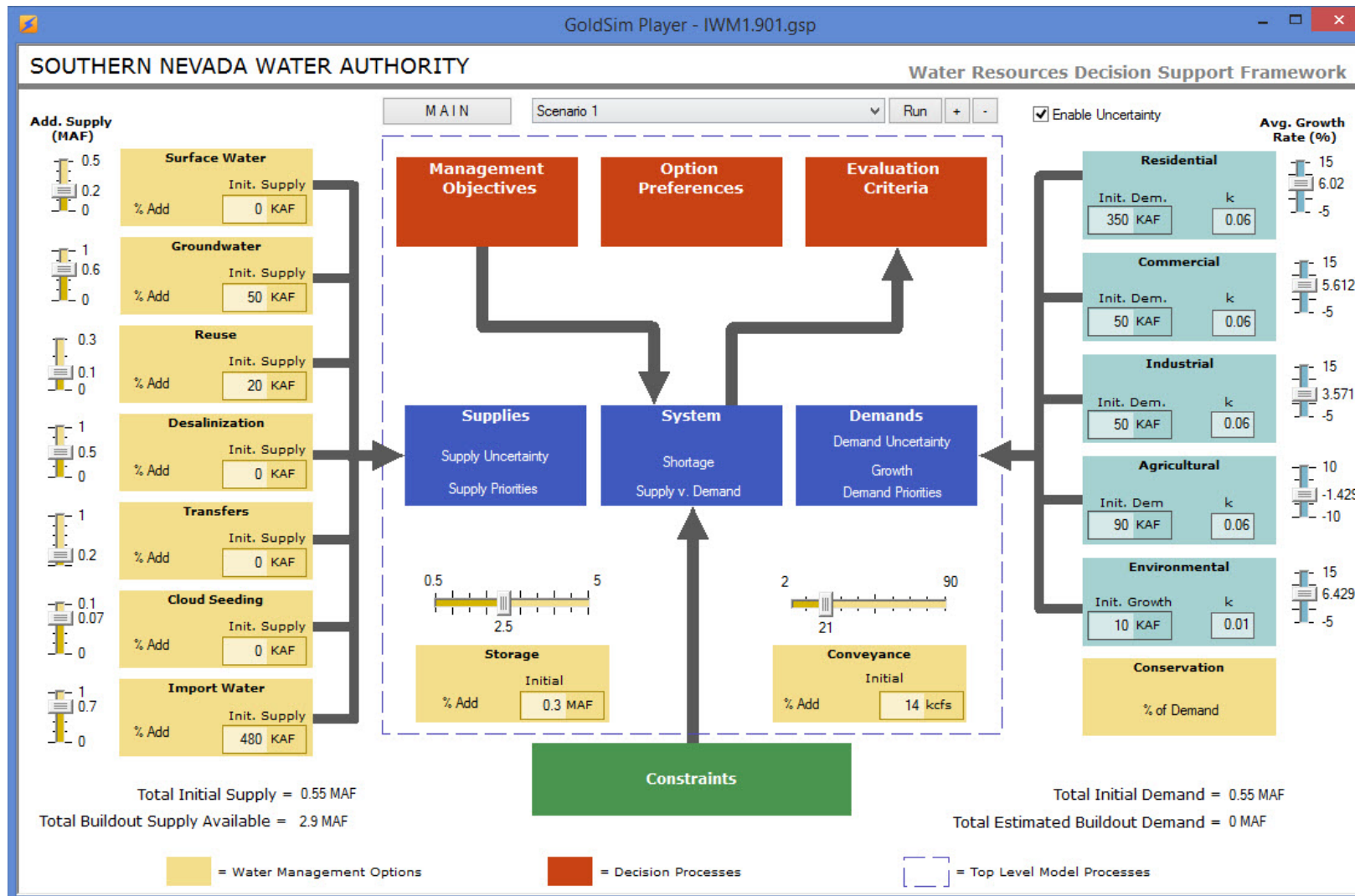
Irrigation [Bar chart]

M&I [Bar chart]

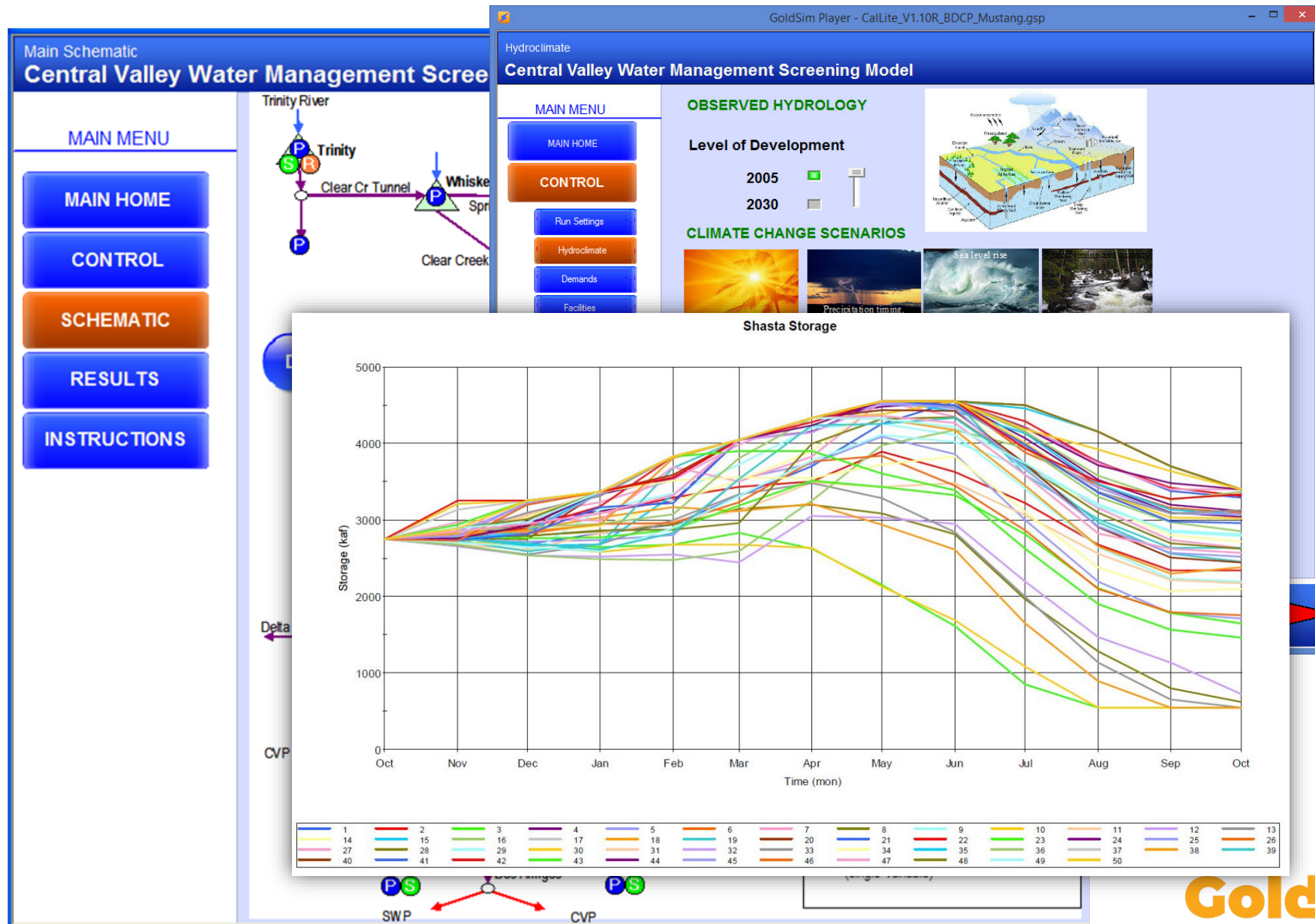
Ready 100%



Water Supply Planning

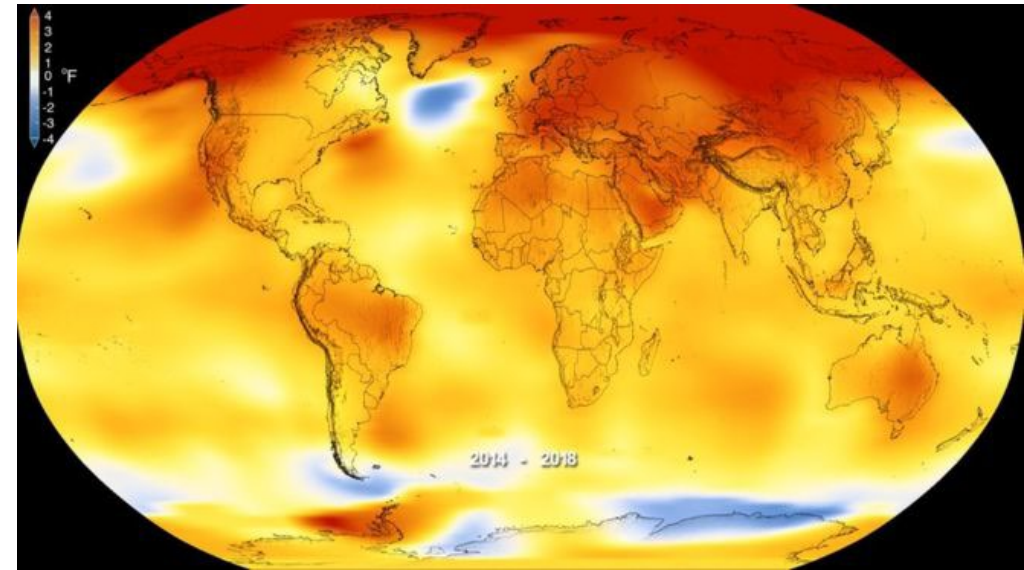
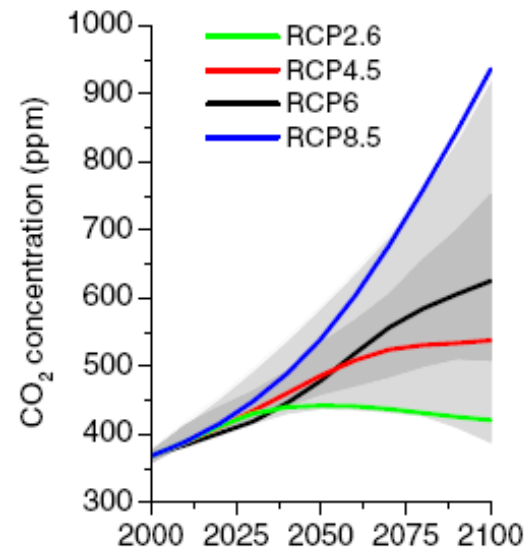
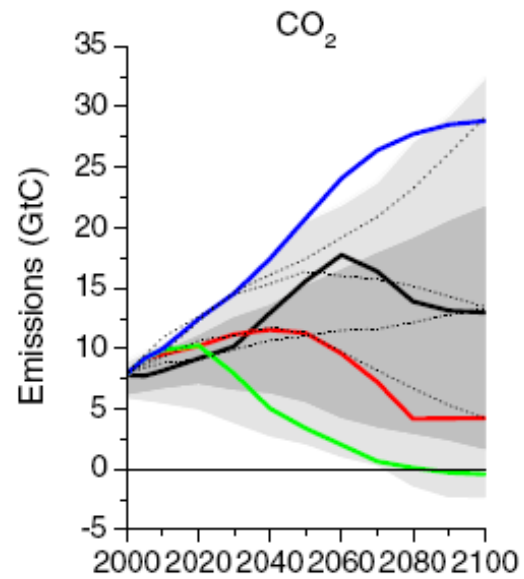


Long-Term Water Planning

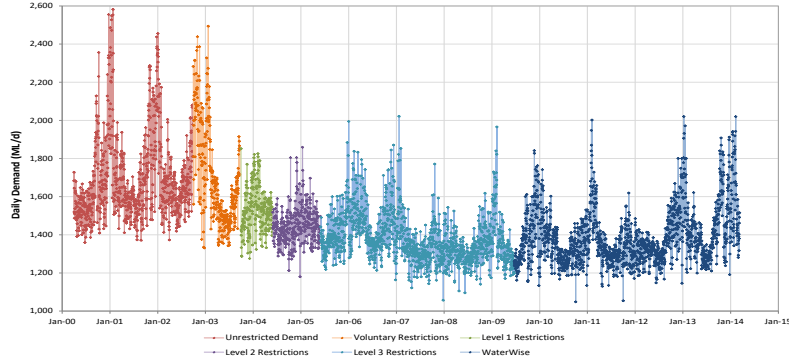


Climate Change and Variability

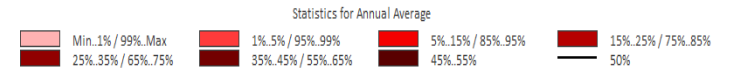
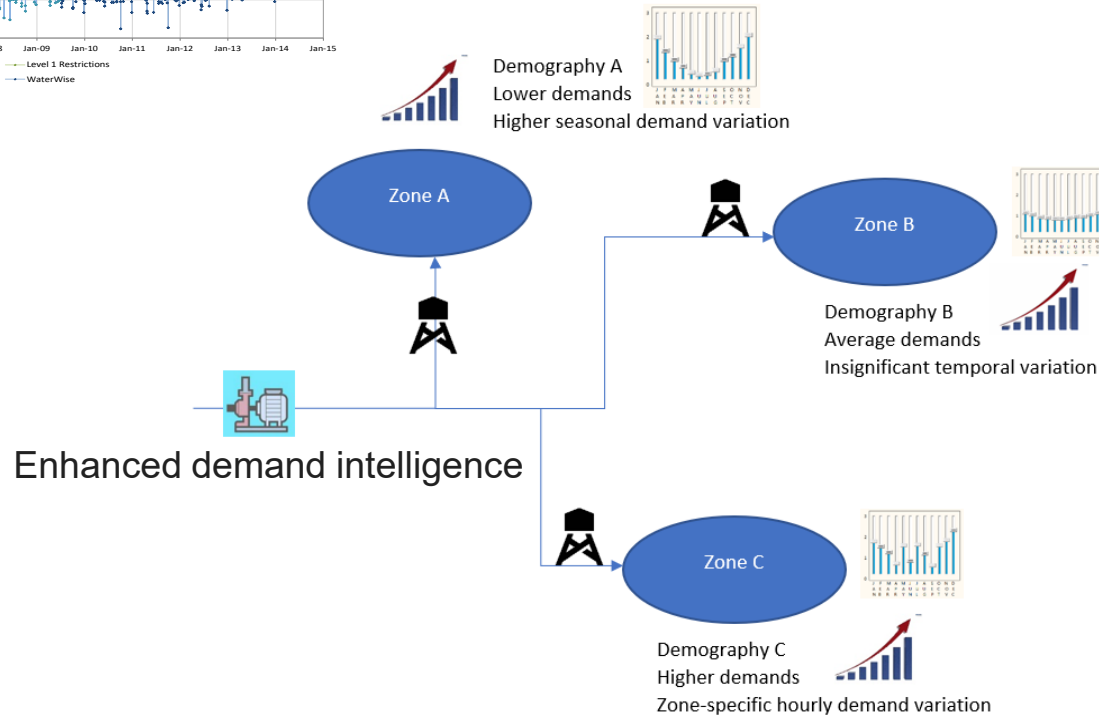
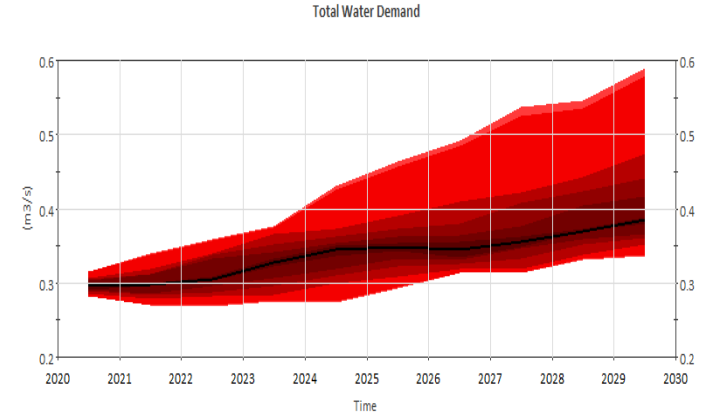
Assessment of the system performance under projected climate conditions to identify the shortfalls and necessary mitigative measures at future milestones.



Evidence-based Water Supply Planning

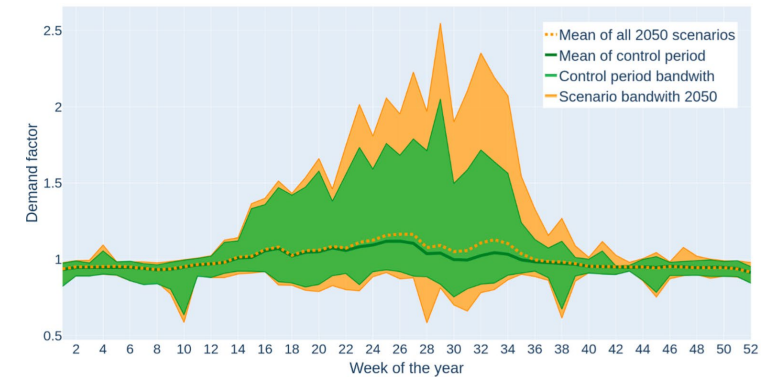
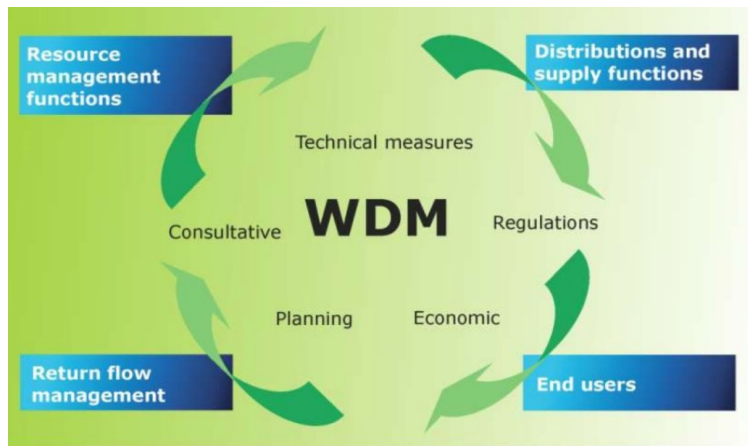


More informed/robust Demand Projections



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.

Water Supply Reliability Metrics



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



The recovery speed of the system from a failure condition



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

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

