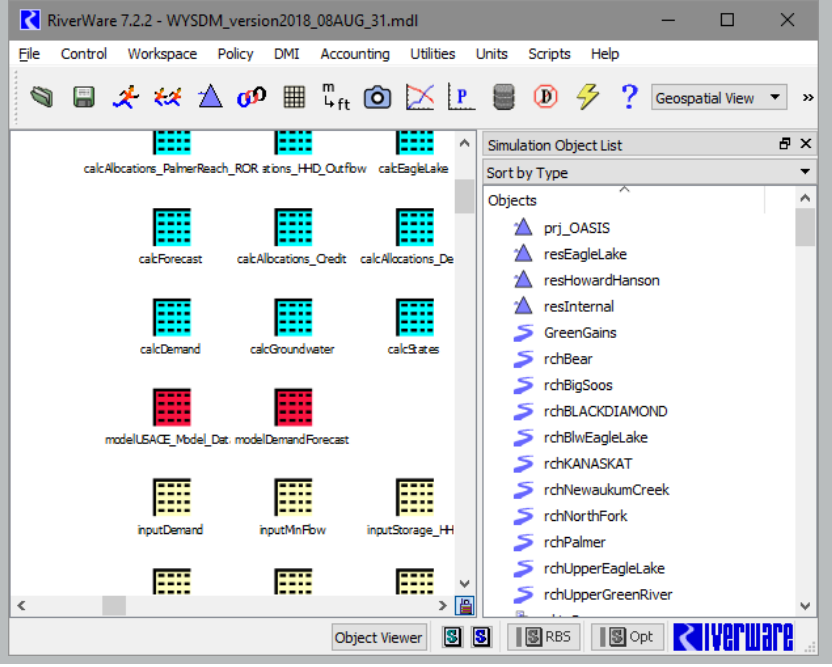


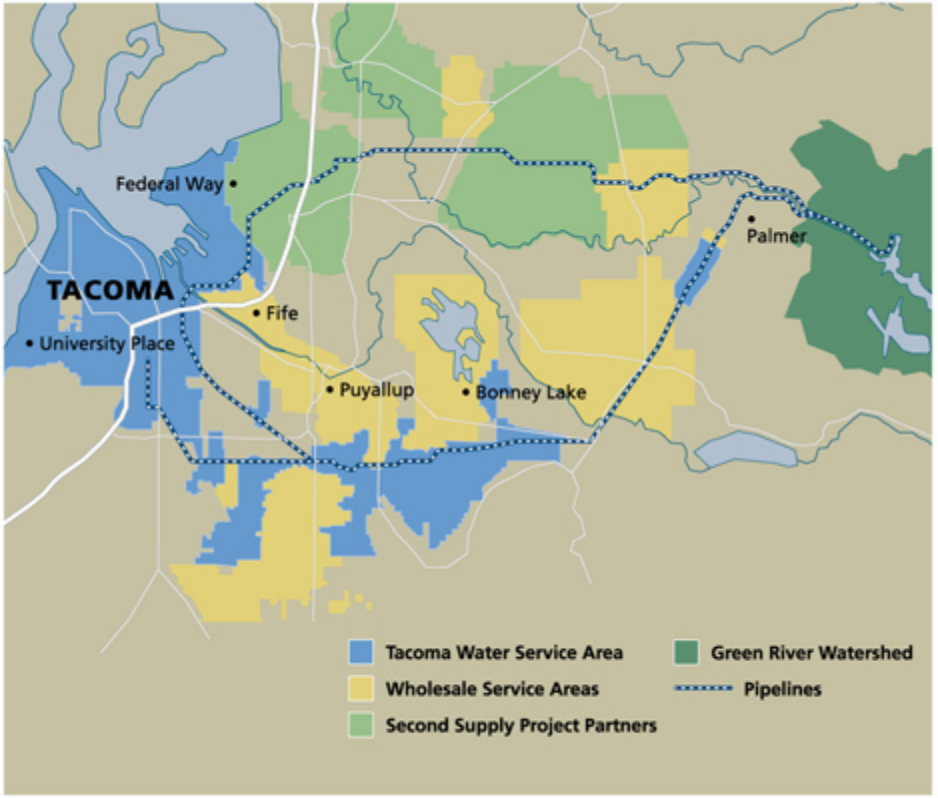
Tacoma Water's Water Yield, Supply and Demand Model for Analyzing Reliability of the Water Supply System

2019 RiverWare Users' Group Meeting

HDR

Setting

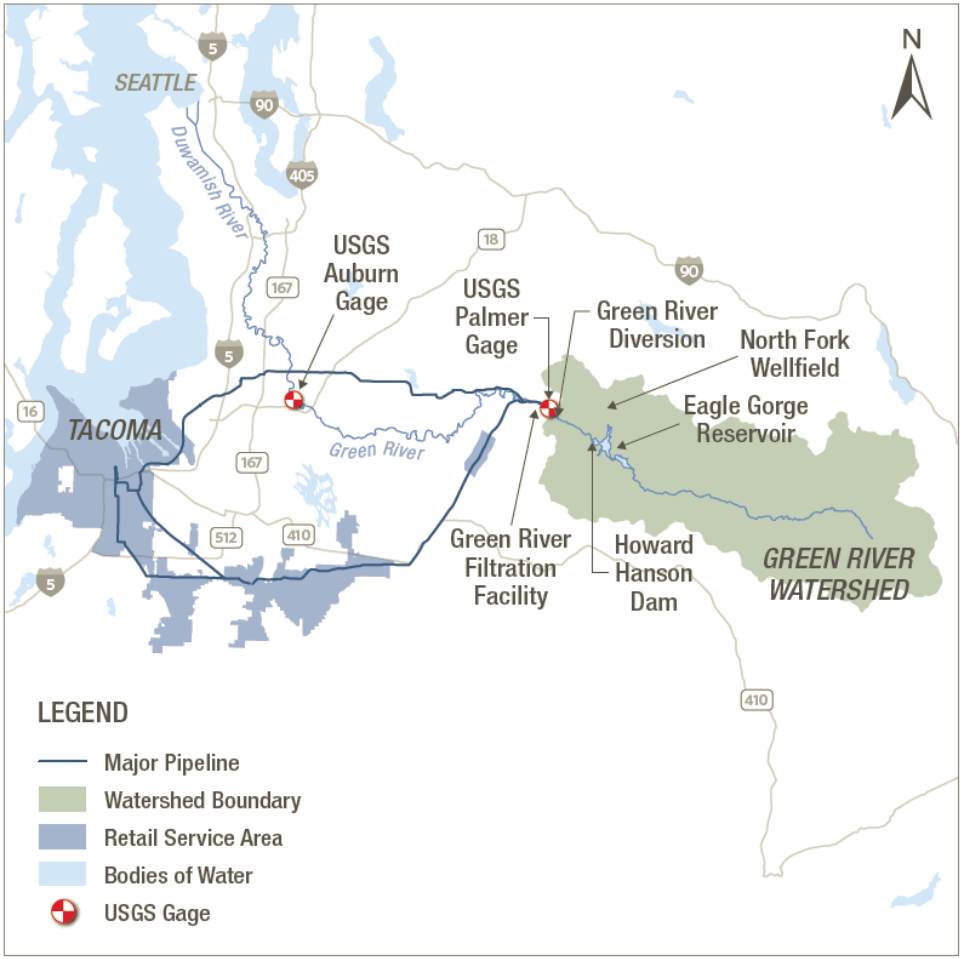
- City of Tacoma – incorporated in 1875
- Tacoma Water – incorporated in 1893
- Serves City of Tacoma and communities in Pierce and King County
- Retail service to 330,000 people
- Wholesale service to ~200,000 connections
- Tacoma service area typical demands:
  - 44 mgd winter demand
  - 90 mgd peak summer demand



Source: Tacoma Public Utilities

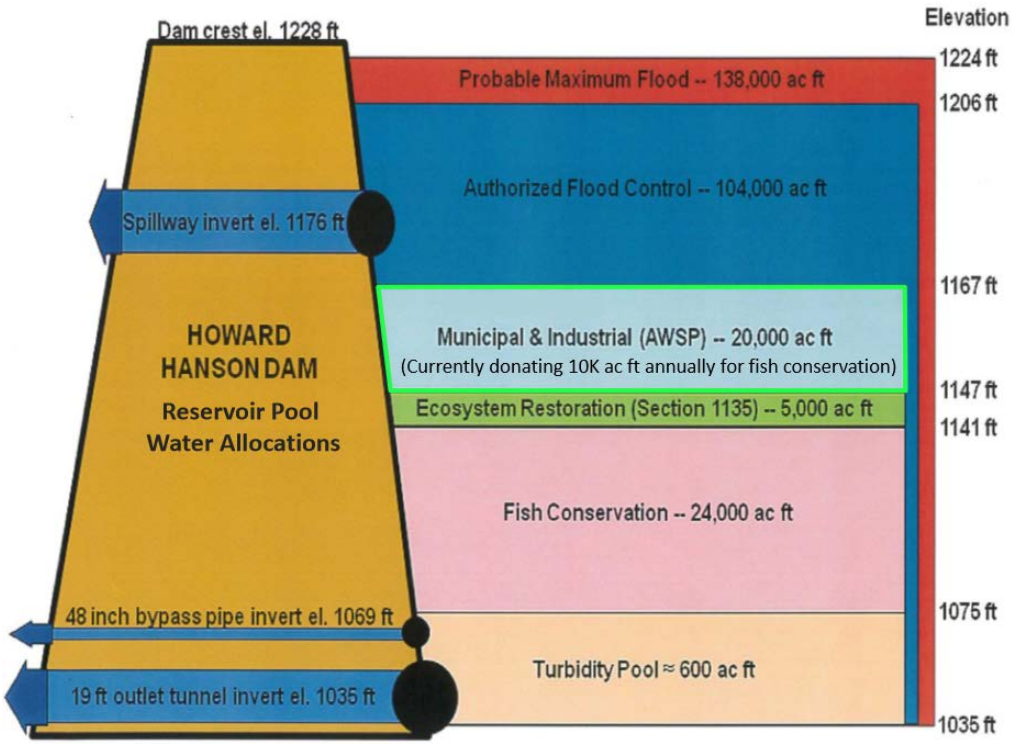
Water Supply

- Sources: Green River, groundwater
- First Diversion Water Right
  - 1906 priority date, 113 cfs
  - Run-of-River right
  - Initial service via Pipeline #1
- Second Diversion Water Right
  - 1933 priority date, permitted in 1986
  - 100 cfs
  - Storable in Eagle Gorge Reservoir
  - Second Supply Project Partners fund costs of operations in exchange for share of water produced
- TW manages upper Green River Watershed
- Stakeholders manage and coordinate lower Green River ecosystem flows



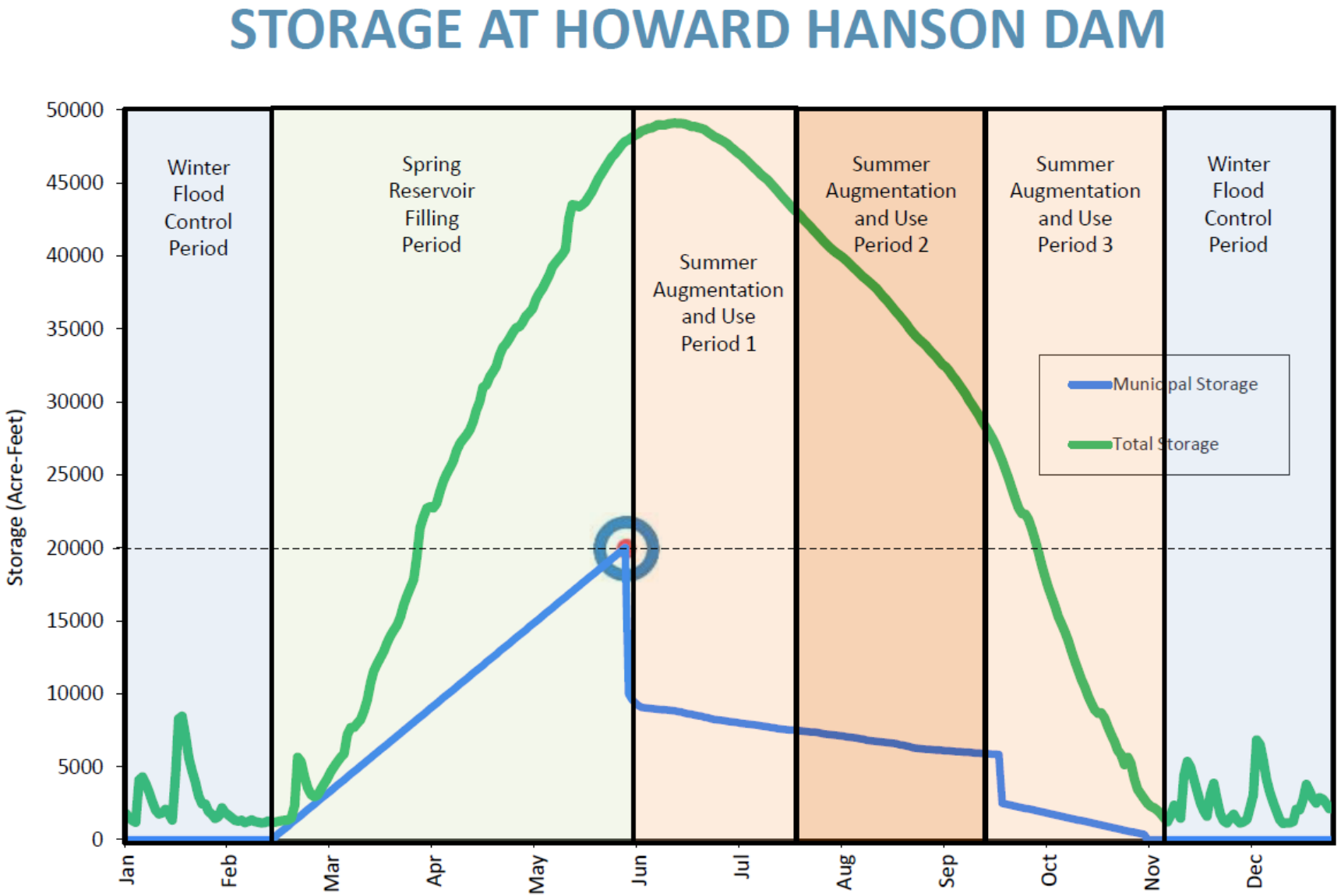
Howard A. Hanson Dam and Eagle Gorge Reservoir

- Completed in 1961/1962
- Owned-Operator: USACE
- Authorized purposes: flood management, water supply
- Supply Stakeholders:
  - USACE – Conservation for Palmer minimum flows
  - Natural resource agencies – Auburn minimum flows, fall freshet, and adaptive management
  - Second Supply Partners – Municipal water supply
  - Tacoma Water – Auburn minimum flows



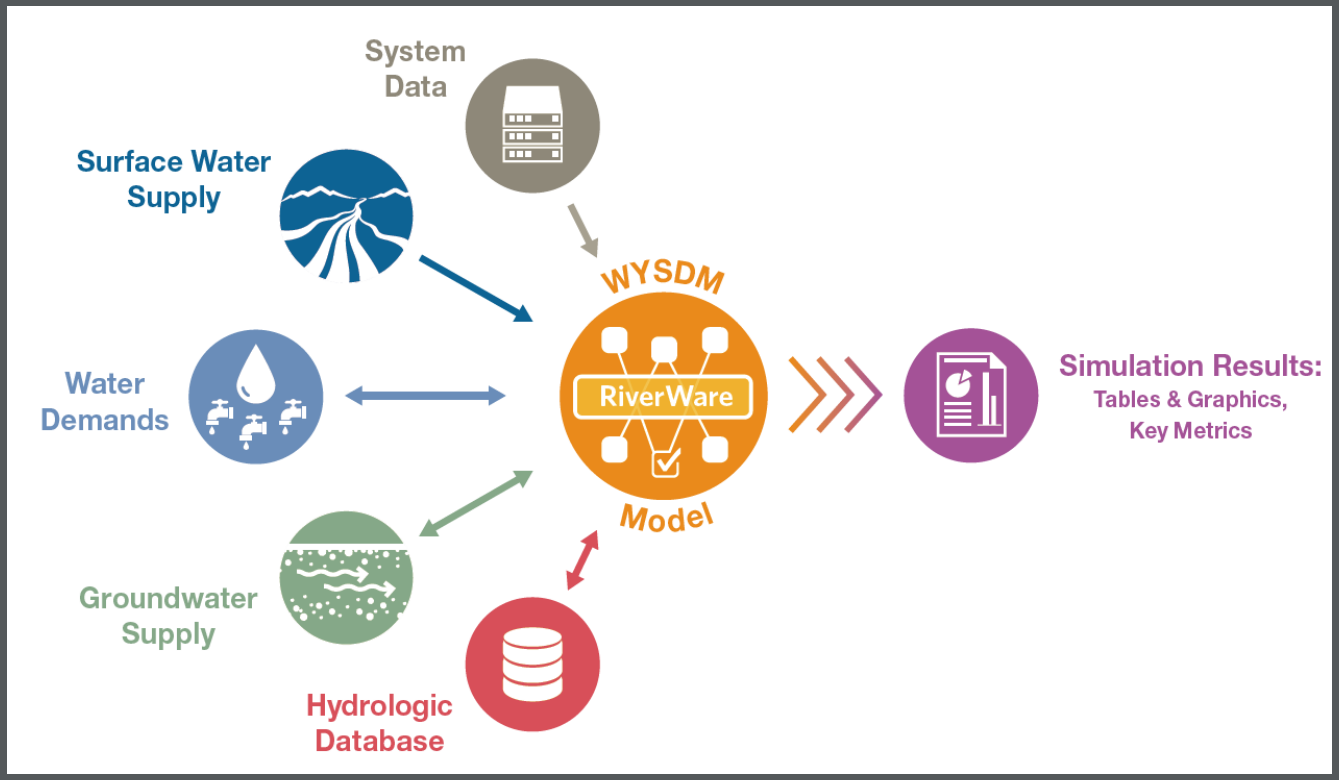
Source: Tacoma Public Utilities

Typical Storage Fill and Use



Water Yield Supply and Demand Model (WYSDM)

- Developed for the Integrated Resources Plan
- Established a Resource Adequacy Standard (RAS)
- Evaluated future population growth, conservation, and climate change
- Examined future projects to address conditions to improve RAS performance



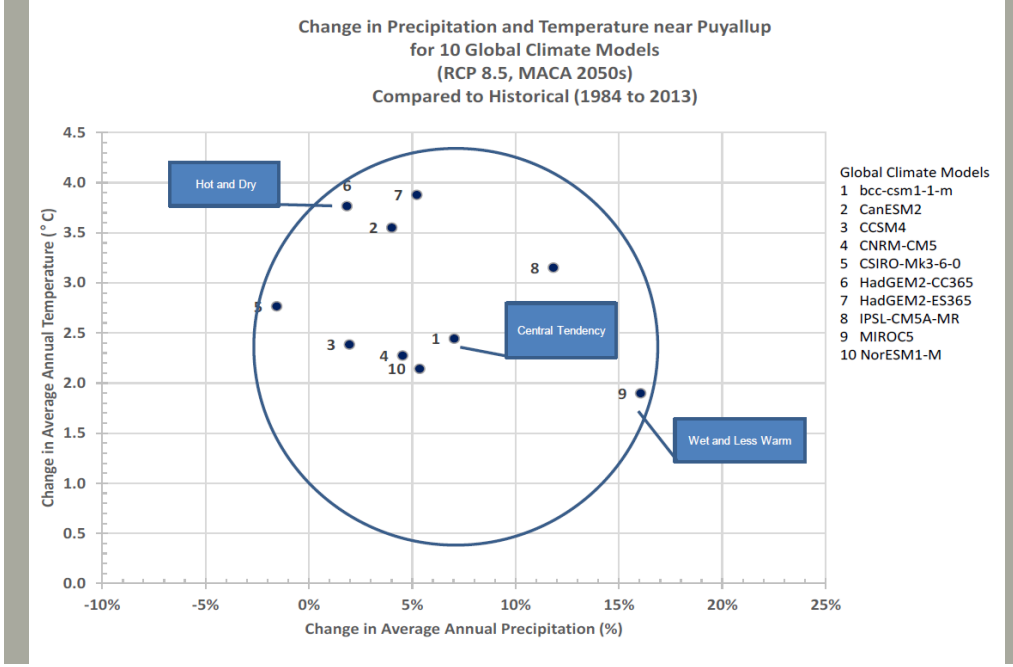
Hydrologic Data

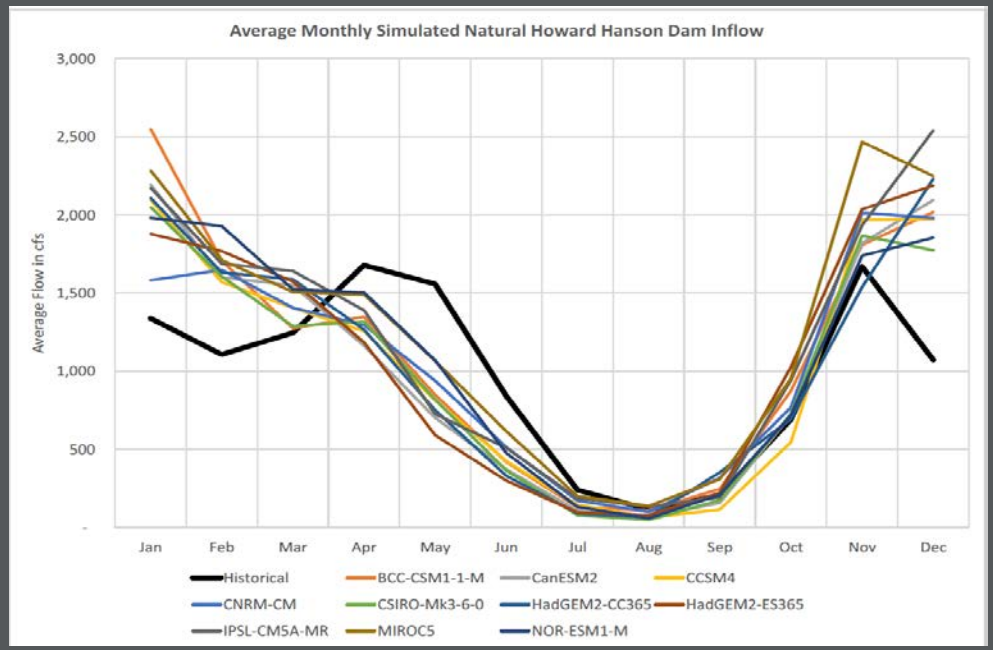
- Historical
  - Reconstructed from 1915 to 2017 (103 years)
  - Water budgets, regression analysis
- Synthetic
  - ARMA seasonal hydrology
- Future Climate
  - Leveraged King County Green River flooding study (2010) and USACE Howard Hanson Dam Climate Adaptation Study (2014)

Hydrologic Database

Surface Water Supply

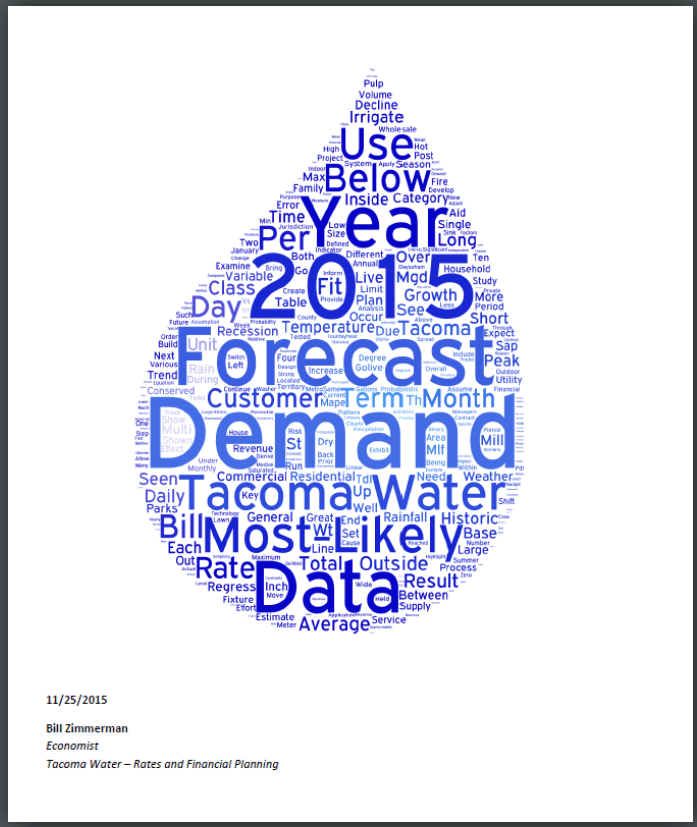
Climate Change Hydrology





Water Demands

- Partner and Wholesale demands – historical use with scaling; some future projections
- Tacoma Retail demands
  - TW Regression Model
  - Parameters:
    - Temperature
    - Weighted-Precipitation
    - Day of week
    - Weekends/holidays
  - Population and Conservation projections
- Demand Curtailment
  - Voluntary and Mandatory levels



Well Use

- North Fork wells – water quality blending
- City well fields – supplemental supply
- Operational Modes:
  - Automatic
  - Manually specified

inputGroundwater.PrioritySet0

File Edit Row Column View Adjust

PrioritySet0

Value:

	FieldSet NONE	January mgd	February mgd	March mgd	April mgd	May mgd	June mgd	July mgd	August mgd	September mgd	October mgd	November mgd	December mgd
0: 1B	2.00	0.03	0.17	4.27	0.00	4.12	3.48	3.01	2.74	3.48	2.59	0.00	4.49
1: 3A	2.00	0.00	0.00	4.62	0.00	4.85	4.43	4.03	4.58	4.68	4.39	4.72	4.90
2: 5A	2.00	5.76	6.15	5.70	0.00	5.49	4.55	4.50	4.29	5.45	5.32	5.04	5.79
3: 8B	2.00	0.00	0.00	4.54	0.00	4.53	4.63	4.72	3.95	4.02	4.89	5.00	5.10
4: 10C	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.50	0.44	0.00	0.00	0.54
5: 7B	2.00	0.00	0.00	0.93	0.00	0.89	0.91	0.88	0.84	0.77	0.00	0.85	0.80

Show: Description

Summary: A priority set of well use using 2015 maximum pumping rates and assigning pumping to most energy efficient wells

Settings:

Each row is a specific well. The row name is the name of the well. The modeler can add rows for new wells or delete rows if wells are retired.

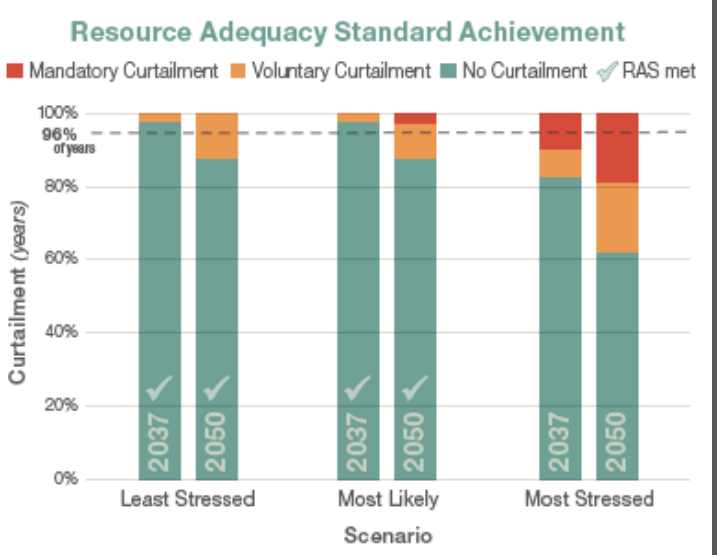
FieldSet = Well field number that a well is part of. There are four City of Tacoma wells fields.
Field 1 is the northern portion of the South wellfield

Scenarios and Infrastructure

- Flow, climate, and demand data
- Dam operations
- Storage accounts and water rights
- Account transfers
- Section 1135 operations
- Other supplies
- Future supply projects

IRP Results – Existing System

- Examined combination of population growth, conservation adoption, and future climate change
- RAS goals:
  - No demand delivery failures
  - Meet maximum four-consecutive days demand
  - Mandatory curtailment frequency: once in 25-years
  - Voluntary curtailment frequency and groundwater use reported but not part of RAS

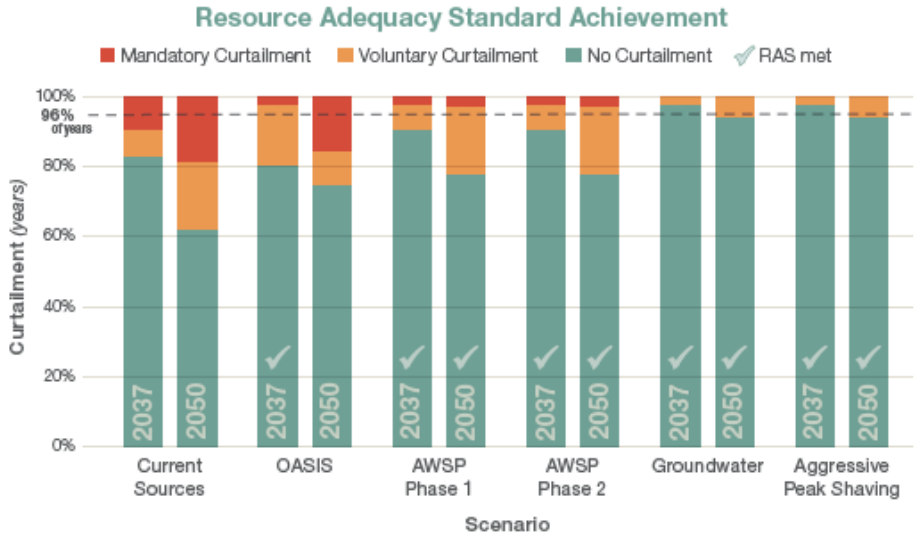


2037 results 2050 results

	Least-Stressed	Most-Likely	Most-Stressed
Number of voluntary curtailments *(out of 25 years)*	<1	<1	2
	3	2	5
Number of mandatory curtailments *(out of 25 years)*	0	0	3
	0	<1	5
Is the RAS met?	Yes	Yes	No
	Yes	Yes	No
Percent of groundwater rights utilized	50%	55%	60%
	60%	60%	70%

IRP Results – Future Projects

- Future Projects:
  - OASIS – regional aquifer storage and recovery
  - Future AWSP phases – fish passage at dam (Phase I) and use additional reservoir storage (Phase II)
  - Fully develop groundwater well fields
  - Conceptual demand “peak shaving”

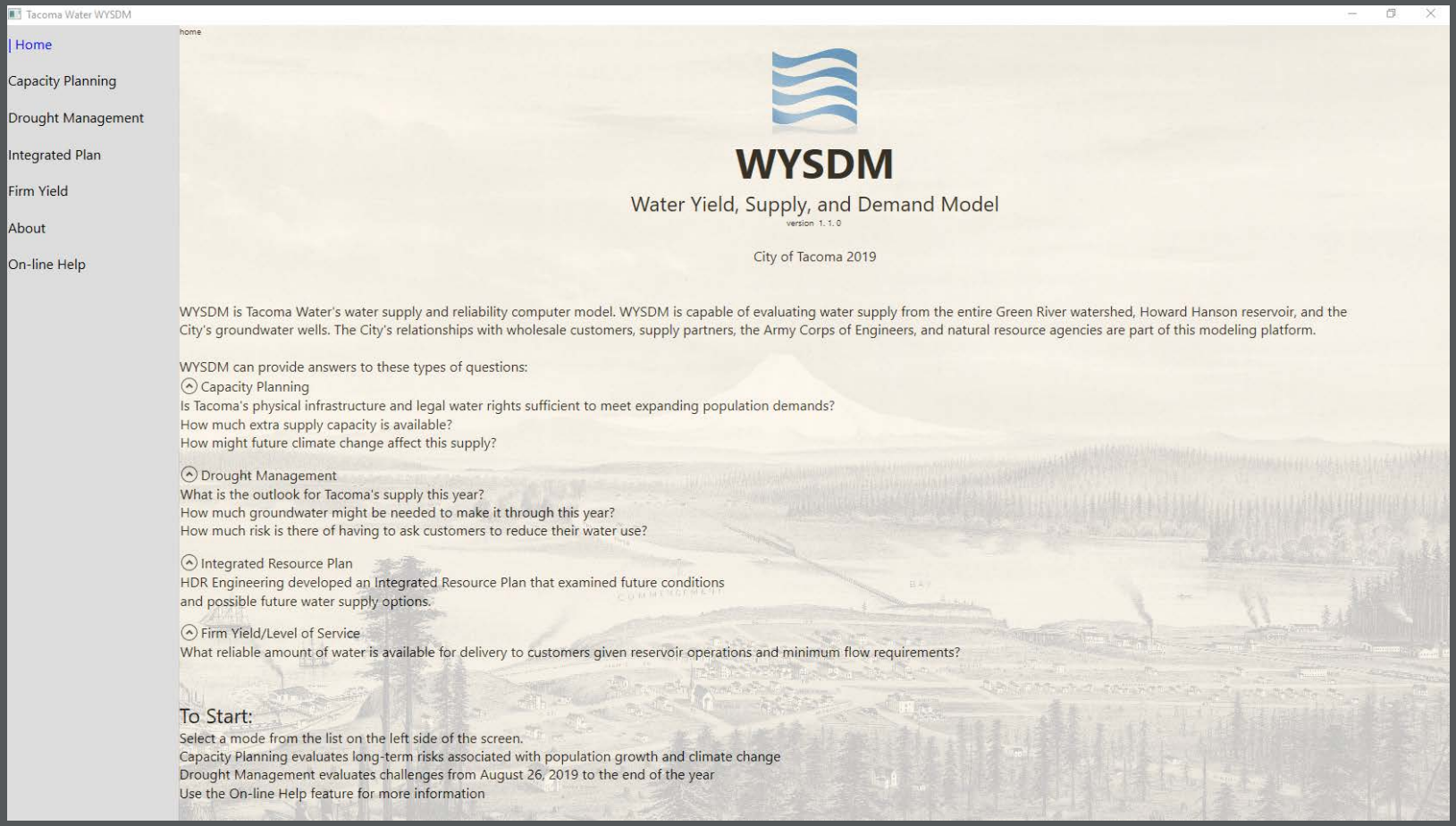


2037 results 2050 results

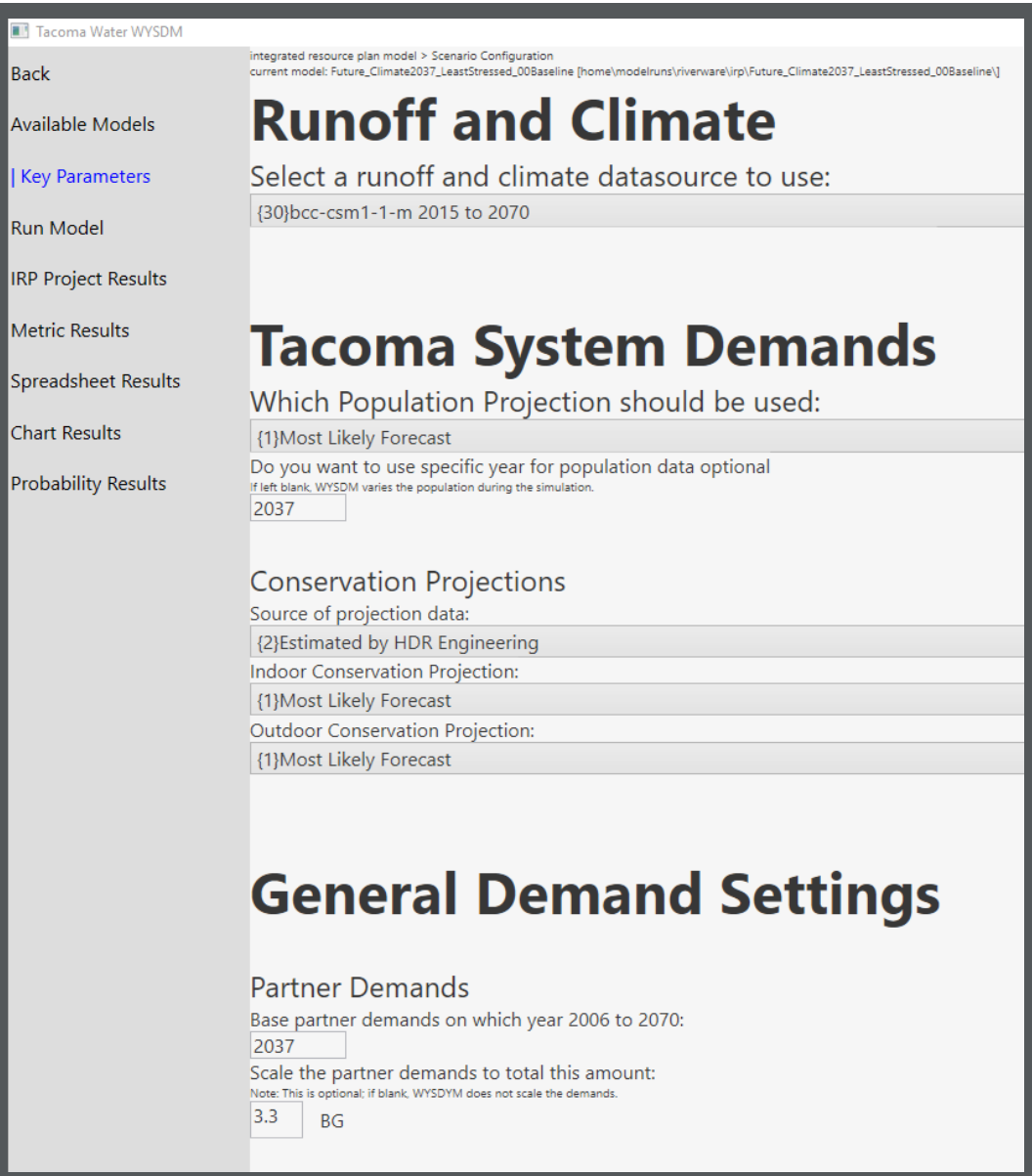
	Current Sources	OASIS	AWSP Phase 1 (Howard Hanson Fish Passage)	AWSP Phase 2 (Reservoir Pool Raise)	Develop Full Groundwater Rights	Aggressive Peak Shaving
Number of voluntary curtailments (out of 25 years)	2	4	2	2	<1	<1
	5	2	5	5	2	2
Number of mandatory curtailments (out of 25 years)	3	<1	<1	<1	0	0
	5	4	<1	<1	0	0
Is the RAS met?	No	Yes	Yes	Yes	Yes	Yes
	No	No	Yes	Yes	Yes	Yes
Percent of groundwater rights utilized	60%	60%	60%	60%	75%	55%
	70%	70%	70%	70%	95%	67%

Graphical User Interface

- Purpose:
  - Assist experienced modelers with scenario modeling and analysis
  - Expose other staff to capabilities of WYSDM
- Automates scenario management: input, model run, and display of results



Example of Scenario Parameters



Spreadsheet Template Output

Tacoma Water - WYSDM Simulation Run Summary

Scenario: Baseline Most Stressed Conditions (Year 2037)

Date: Saturday, May 19, 2018
Purpose: Establish baseline for Most Stressed Scenario for Year 2037

Assumptions and Input

Hydrology and Climate Dataset: Bias-Corrected CanESM2 RCP 8.5 climate change (2010-2070)

Start Date:	1/1/2015
End Date:	12/31/2054
Number of Years:	40

Model Settings

Use Demand Forecating Module:	YES
Allow Curtailment of Tacoma Demands:	YES
City of Tacoma Service Area Population Estimate:	414,603
Service Area Population projected to occur in year:	2037
End of flood control:	14-Feb
Start of flood control:	14-Nov
Allow donations between Partners:	NO
Allow donations to Section 1135	YES

Other Scenario Assumptions and Notes

Changes from 5/9/2018:
Constant demand for Partners and Wholesale;
revised filling of AWS Phase 2 project;
Employ more groundwater to avert Auburn flow deficits
Revisited calculation curtailment calculation method

Demands

Annual Demands (MG)

	Min	Average	Max
Tacoma	19,876.7	21,604.5	22,299.9
Wholesale	5,881.8	6,418.0	6,500.0
Partners	3,300.0	3,300.9	3,303.6
Total	29,058.5	31,323.4	32,092.3

Note: Tacoma Conservation Adoption is 440 MG per year.

Baseline Most Stressed Conditions (Year 2037)

Simulation Results

M&I Delivery Shortages

Average Annual Shortages

	Volume (MG)	Percent	Number of Years
Tacoma	0.0	0.0%	0 out of 40
Wholesale	0.5	0.0%	1 out of 40
Partners	428.9	13.0%	40 out of 40
Auburn Flow Target Deficit	125.6	n/a	2 out of 40

Highest Annual Shortages

	Volume (MG)	Percent
Tacoma	0.0	0.0%
Wholesale	19.9	0.3%
Partners	1,090.4	33.0%
Auburn Flow Target Deficit	241.8	n/a

Storage in Howard A. Hanson Reservoir

Average Annual Maximum Municipal Storage	18,094 acre-feet
Average Annual Maximum Total Storage	46,827 acre-feet

Percent of Years that Municipal Storage is:

Full	30%
75% to 99% full	55%
50% to 75% full	15%
25% to 50% full	0%
0% to 25% full	0%

Corrective Actions Taken

Annual Volume

	Min	Average	Max	
City Well Water Used	2,132.3	8,045.8	10,157.8	MG
	6,543.9	24,691.6	31,173.1	ACFT
Eagle Lake Pumping	-	-	-	MG

Demand Curtailment (MG)

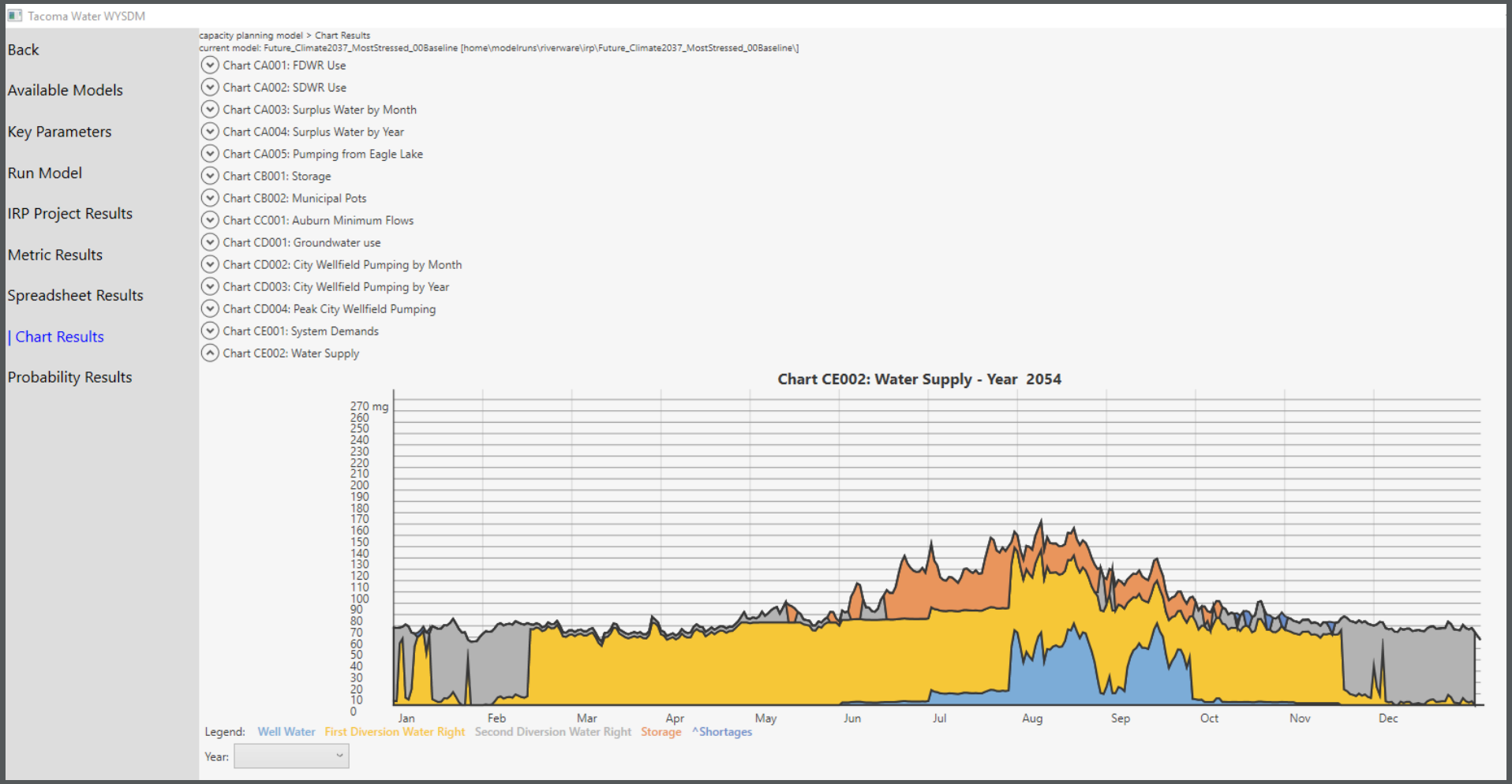
	Voluntary	Mandatory	Total Years
Commercial/Industrial		235.9	4 out of 40
Other Retail	609.2	1,976.7	7 out of 40
Wholesale	203.8	610.7	7 out of 40

Potential Extra Water Available

Annual Volume

	Min	Average	Max	
Extra Storage Donations	-	680.6	1,558.1	MG
	-	2,088.5	4,781.8	ACFT
Run-of-River water	8,206.0	11,230.0	16,173.2	MG
Firm extra water	-	4.3	15.5	mgd

Charts


Tacoma Water WYSDM
Back
Available Models
Key Parameters
Run Model
IRP Project Results
Metric Results
Spreadsheet Results
| Chart Results
Probability Results
capacity planning model > Chart Results
current model: Future_Climate2037_MostStressed_00Baseline [home\modelruns\riverware\irp\Future_Climate2037_MostStressed_00Baseline\]
Chart CA001: FDWR Use
Chart CA002: SDWR Use
Chart CA003: Surplus Water by Month
Chart CA004: Surplus Water by Year
Chart CA005: Pumping from Eagle Lake
Chart CB001: Storage
Chart CB002: Municipal Pots
Chart CC001: Auburn Minimum Flows
Chart CD001: Groundwater use
Chart CD002: City Wellfield Pumping by Month
Chart CD003: City Wellfield Pumping by Year
Chart CD004: Peak City Wellfield Pumping
Chart CE001: System Demands
Chart CE002: Water Supply
Chart CE002: Water Supply - Year 2054
270 mg
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Legend: Well Water First Diversion Water Right Second Diversion Water Right Storage ^Shortages
Year:

Probability Charts