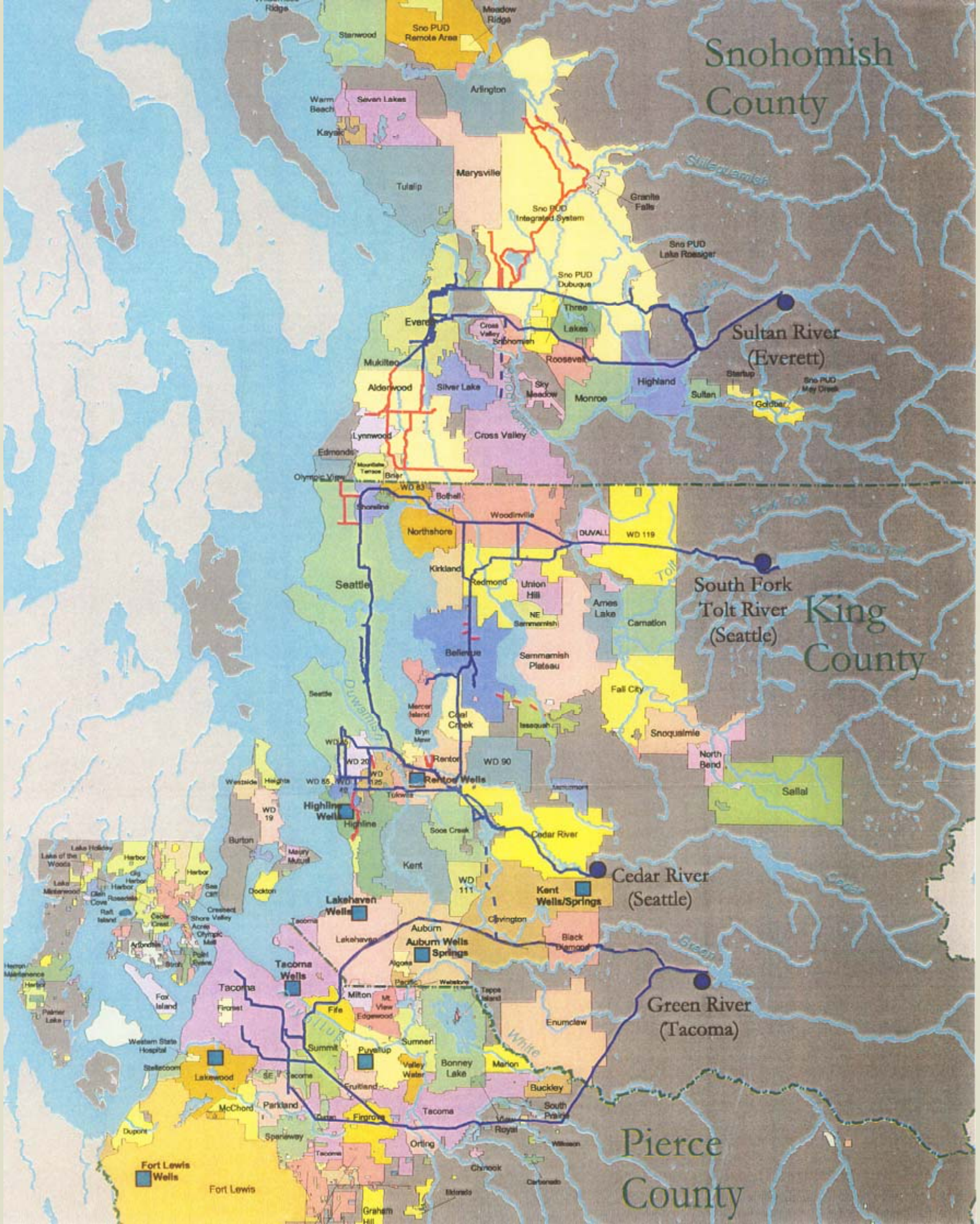
Impact of Climate Change on Water Supplies of Everett, Seattle, and Tacoma

December 2007

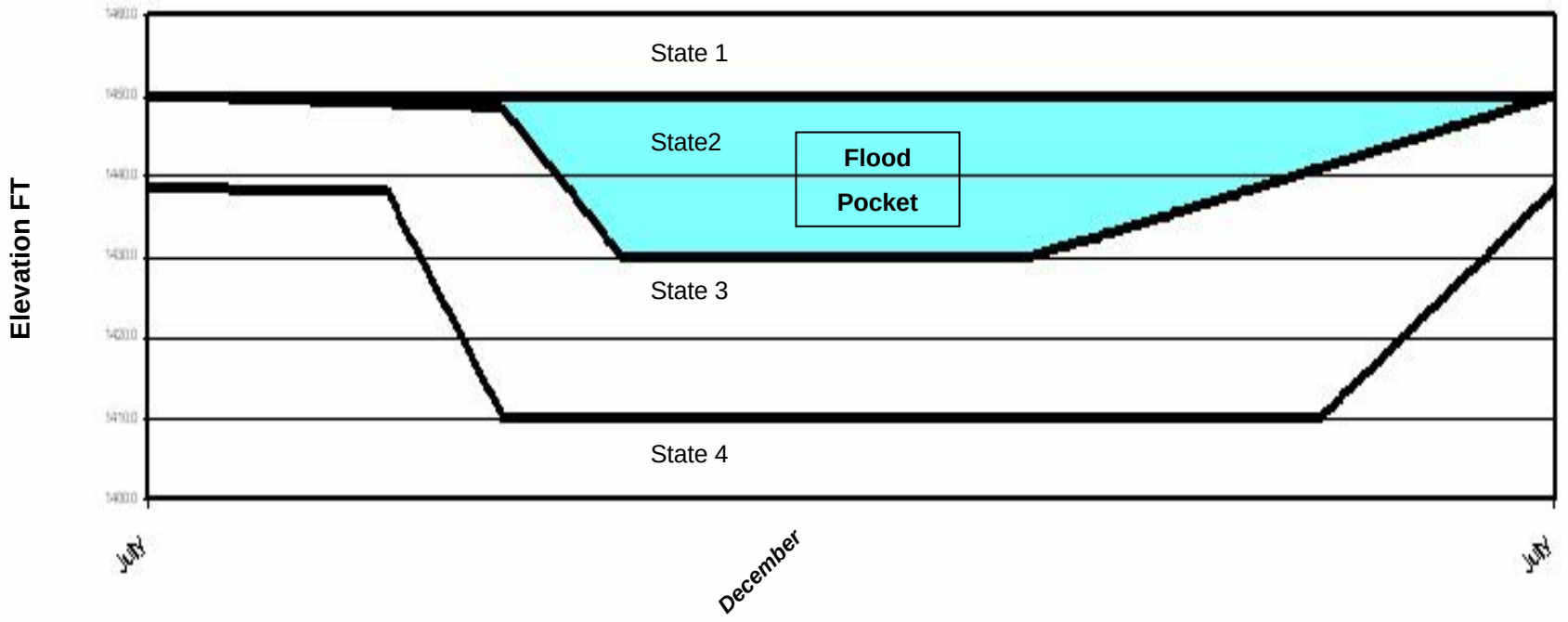
Based on Work of Climate Change Technical Committee of Regional Water Supply Planning Process


Snohomish County
Sultan River (Everett)
South Fork Tolt River (Seattle)
King County
Cedar River (Seattle)
Green River (Tacoma)
Pierce County
Stanwood
Arlington
Seven Lakes
Tulalip
Marysville
Granite Falls
Sno PUD Integrated System
Everett
Mukilteo
Alderwood
Silver Lake
Snohomish
Monroe
Highland
Sultan
Lynnwood
Cross Valley
Edmonds
Bothell
Woodinville
Northshore
Shoreline
Kirkland
Redmond
Seattle
Bellevue
Sammamish Plateau
Carnation
Fall City
Snoqualmie
North Bend
Sallal
Renton Wells
Highline Wells
Cedar River
Kent
Kent Wells/Springs
Lakehaven Wells
Auburn Wells Springs
Tacoma Wells
Tacoma
Fife
Milton
Puyallup
Sumner
Bonney Lake
Enumclaw
Buckley
Lakewood
Parkland
Spanaway
Orting
Fort Lewis Wells
Fort Lewis

Everett's Water Source Storage

Spada Reservoir (50 billion gallons) with Culmback Dam in the forefront

Spada Reservoir Rule Curves



Everett's Water Supply and Rights

Supply Yield

- Firm Yield = Avg. Annual Withdrawal Available 98% of Years
- Firm Yield of Sultan Source = **200 MGD**
  With Existing Facilities (Storage and Pipelines)

Water Rights

- Existing Water Rights on Sultan = 137.5 MGD (Q_A)
- Pending Water Right Application:

  Q_I = 200 cfs; if Q_A = 100 CFS = 64.5 MGD (Est. Q_A)

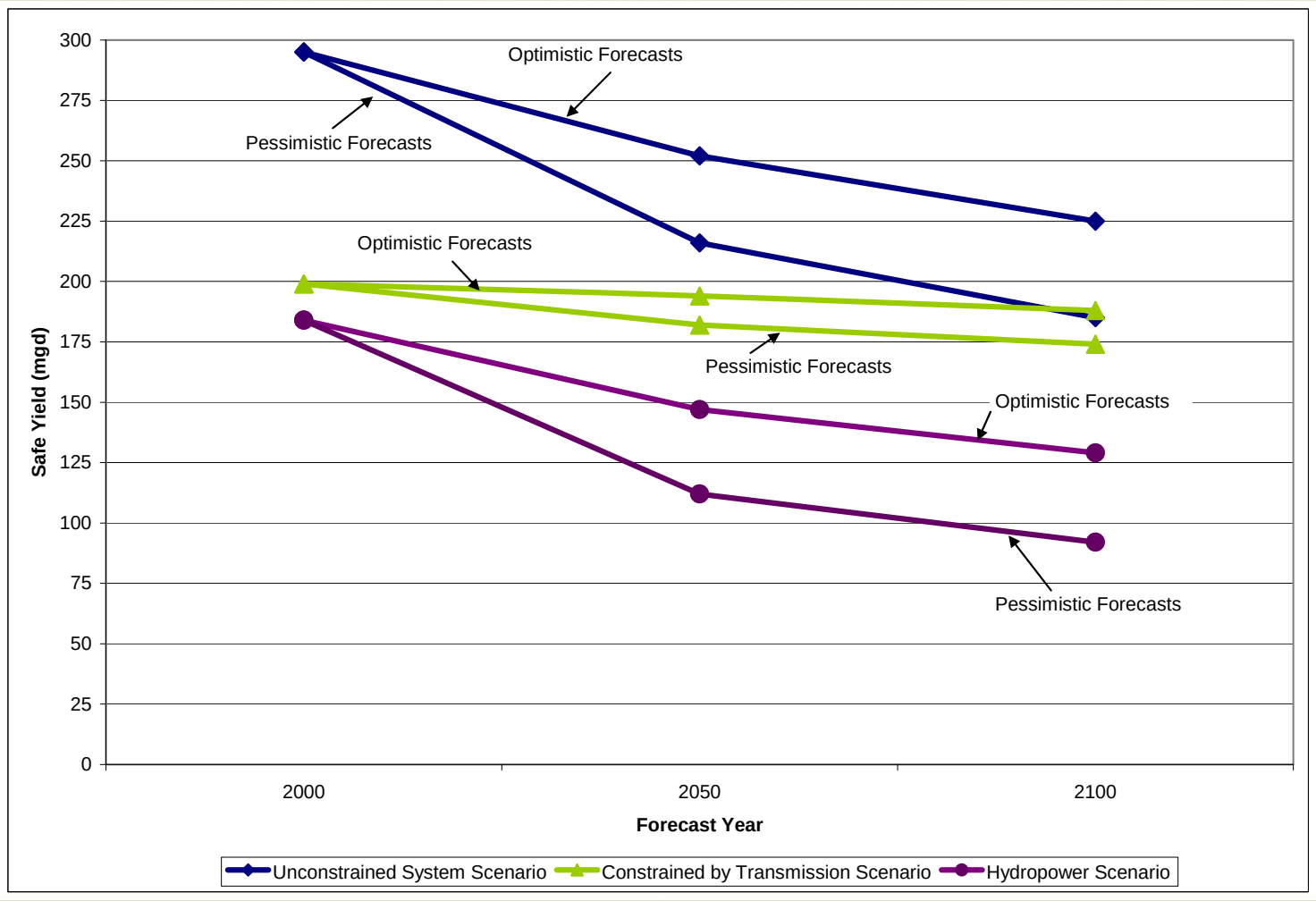
202 MGD

Three Scenarios

Three operational scenarios were evaluated:

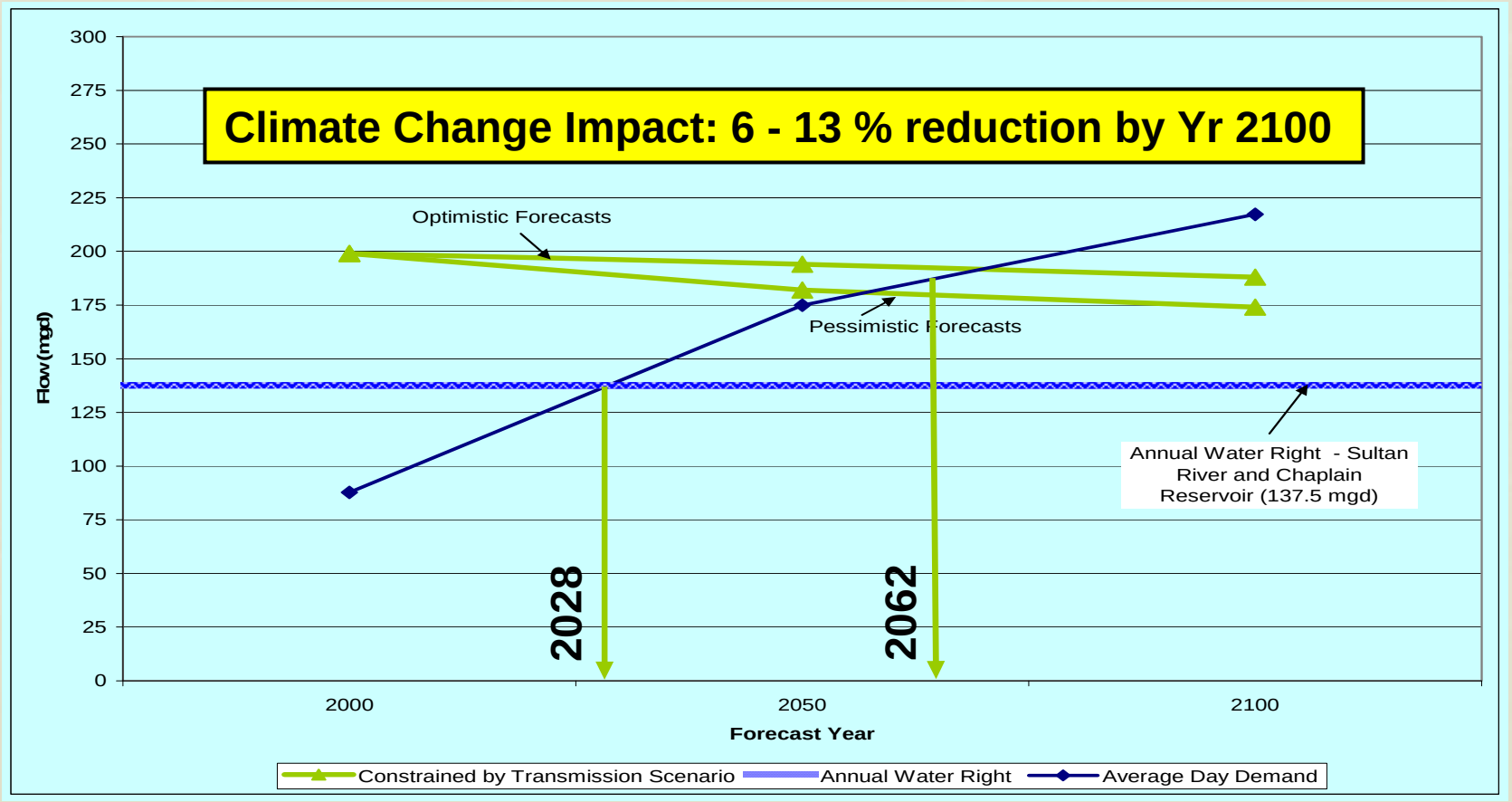
- Unconstrained Yield (Storage: 153,000 AC-FT)
- Yield Constrained by Transmission Upstream of Chaplain Reservoir (Storage: 153,000 AC-FT)
- Yield Constrained by Hydropower Operations and Spada Minimum Surface Elevation of 1,380 ft (Storage: 101,000 AC-FT)

Impact of Climate Change on Three Scenarios



Comparison of Existing Conditions and Projected Demand

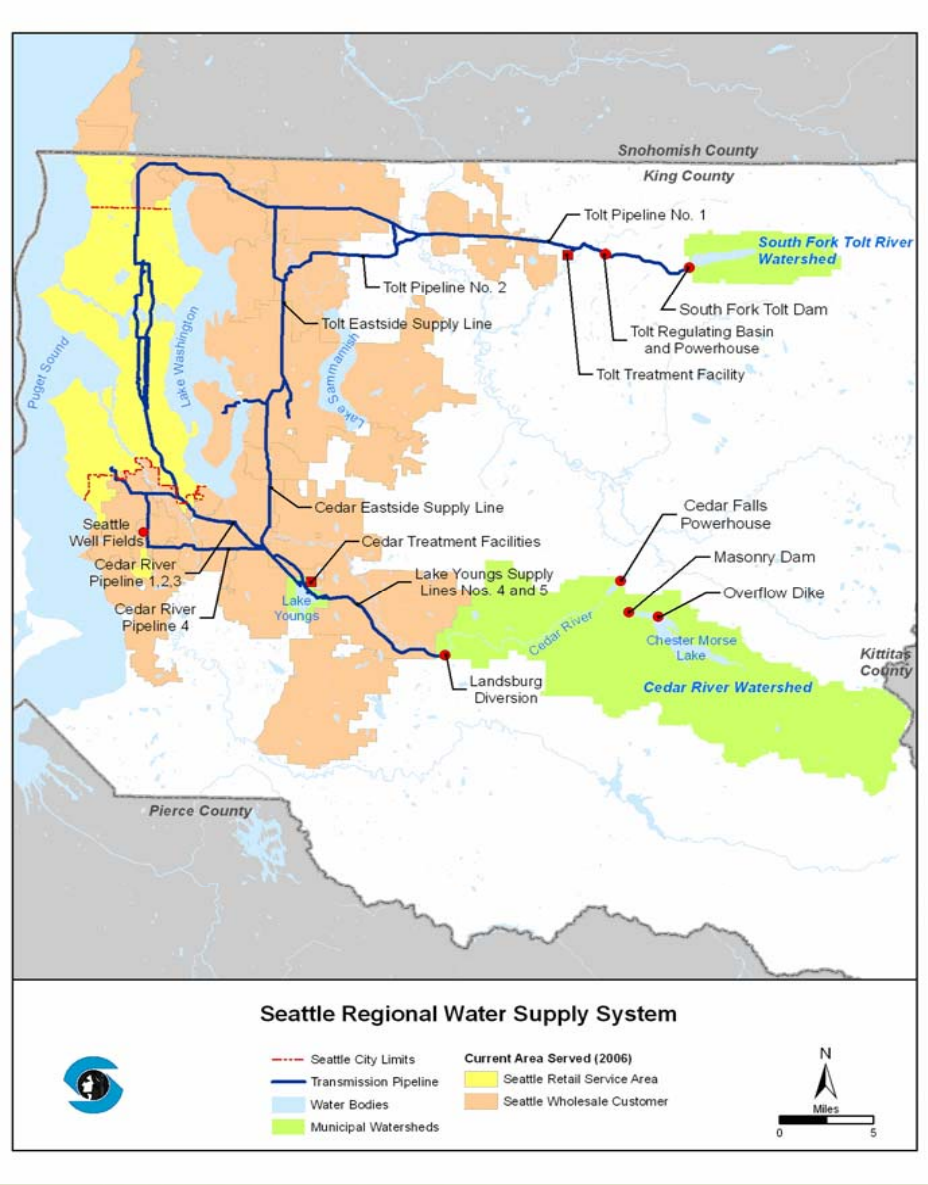
20 Years on Existing Right; 50+ Years on New Right



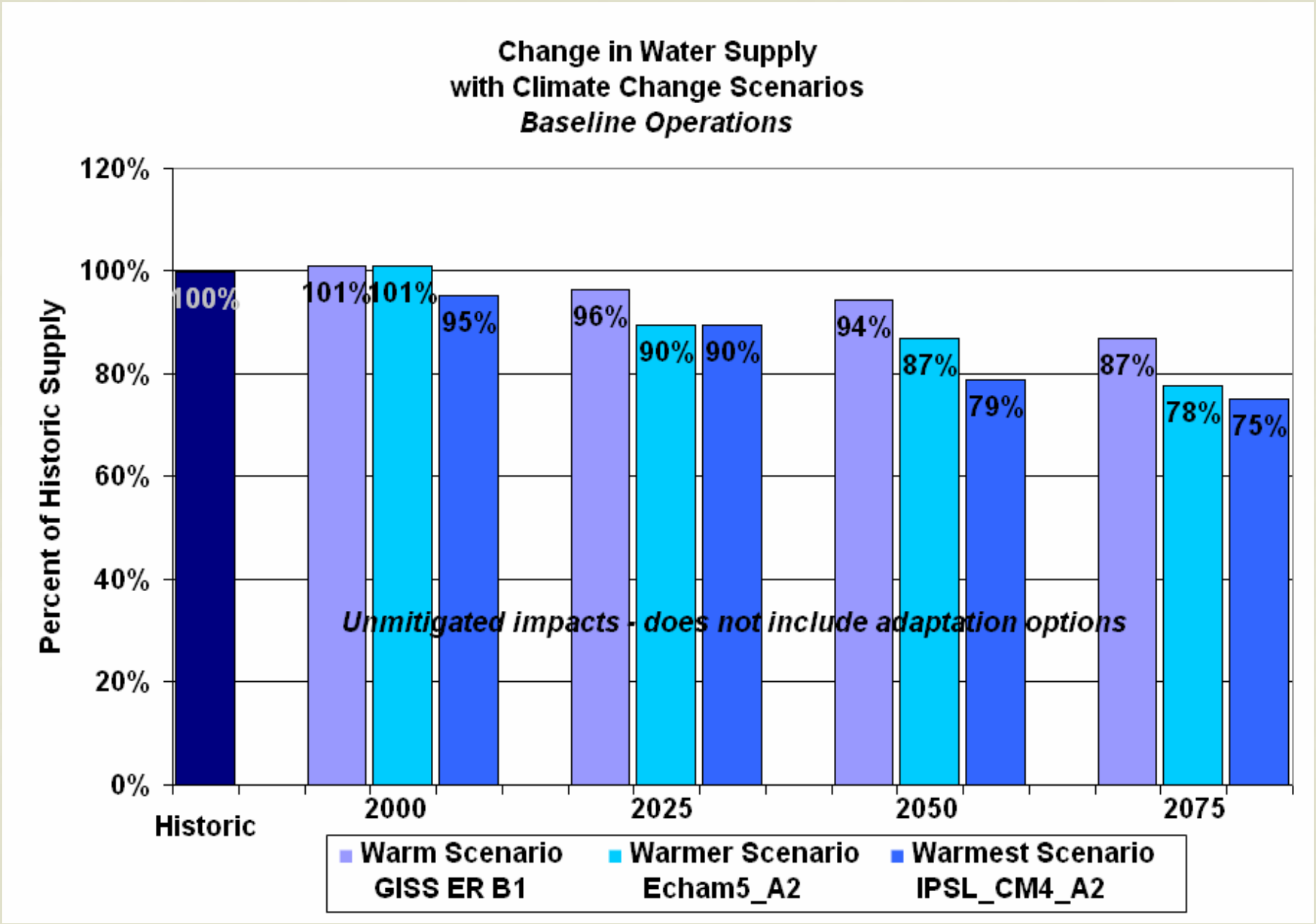
Summary of Climate Impact on Water Supply

- No Impact on Existing Water Right – Good for next 20 years
- Firm Yield would be Reduced 6 – 13% by 2100
- Modification of SPADA Rule Curves would probably offset some of this impact (To be determined in future studies)

Seattle's Regional Water System



- Provides retail and wholesale water to 1.45 million people in region
- Sources of supply
  - Cedar River Watershed
  - South Fork Tolt River
  - Wellfields
- Firm yield 171 mgd
  - Based on past 76 years
  - 98% reliability
- Total Demand:
  - 2007: 126 mgd
  - 2060: 159 mgd

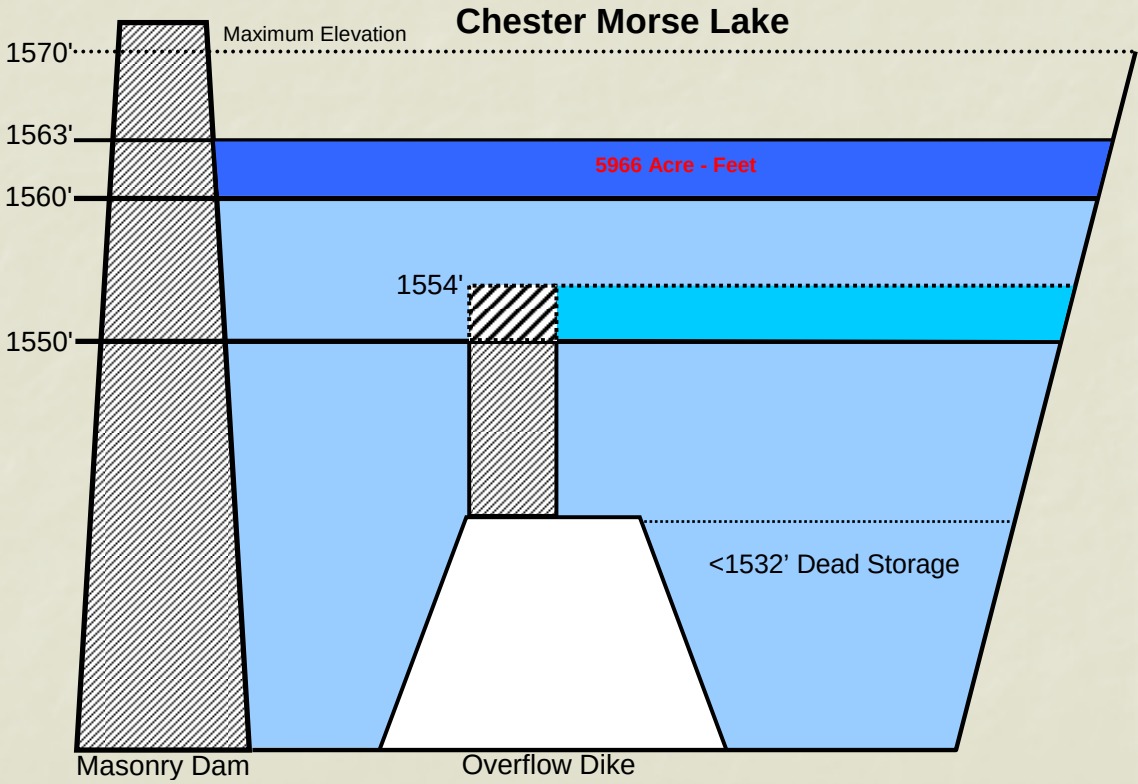

Change in Water Supply
with Climate Change Scenarios
Baseline Operations
Percent of Historic Supply
120%
100%
80%
60%
40%
20%
0%
100%
101%
101%
95%
96%
90%
90%
94%
87%
79%
87%
78%
75%
Unmitigated impacts - does not include adaptation options
Historic
2000
2025
2050
2075
Warm Scenario
GISS ER B1
Warmer Scenario
Echam5_A2
Warmest Scenario
IPSL_CM4_A2

Adaptation Options

- SPU identified a series of intra-system modifications and new supply options – and grouped them into Tiers.
- Applied the effects on supply using Tier 1 intra-system modifications.
- Where Tier 1 modifications did not restore supply fully, identified the need for subsequent Tiers.
- Subsequent Tiers include, but not limited to, options such as:
  - Conservation programs after 2030
  - Reclaimed water
  - Cedar dead storage

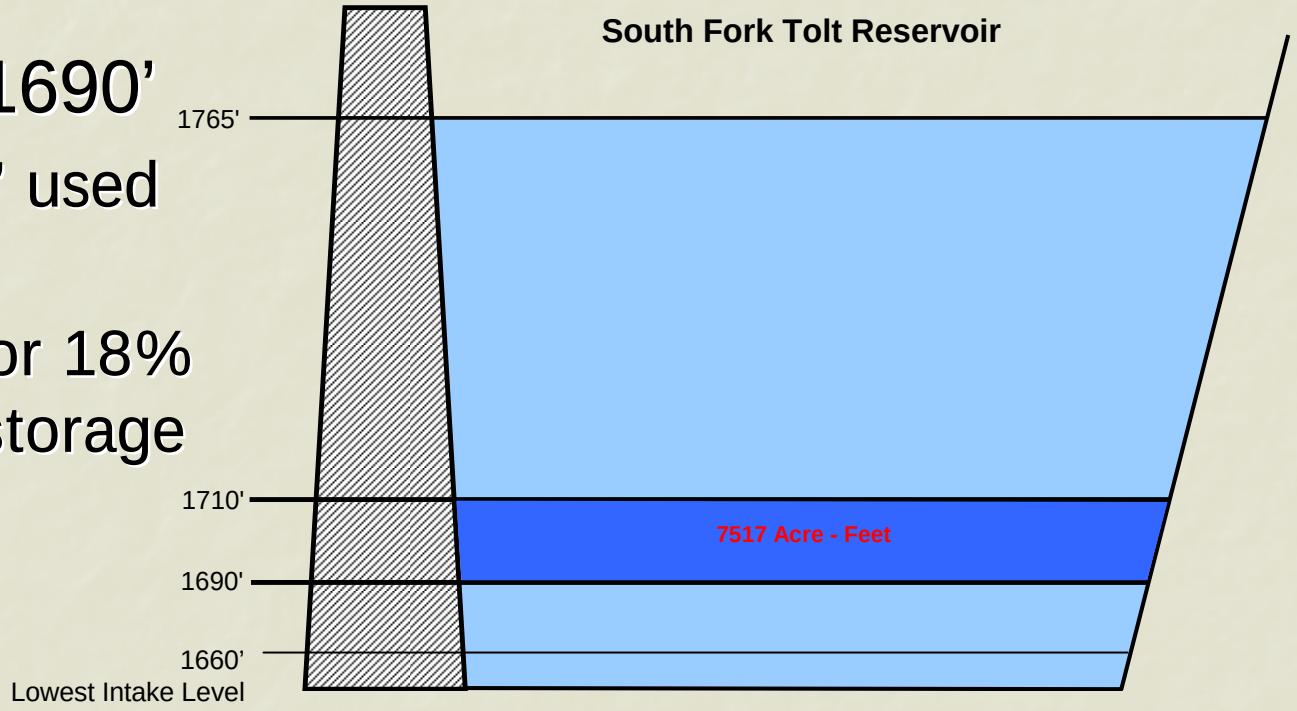
Tier 1 Modifications - Cedar

- Refill to 1563’
  - Current practice but 1560’ used for firm yield
  - Adds 5966 AF or 12% more useable storage
- Modify Overflow Dike to 1554’
  - Current crest is at 1550’
  - Reduces seepage losses
  - New project under development



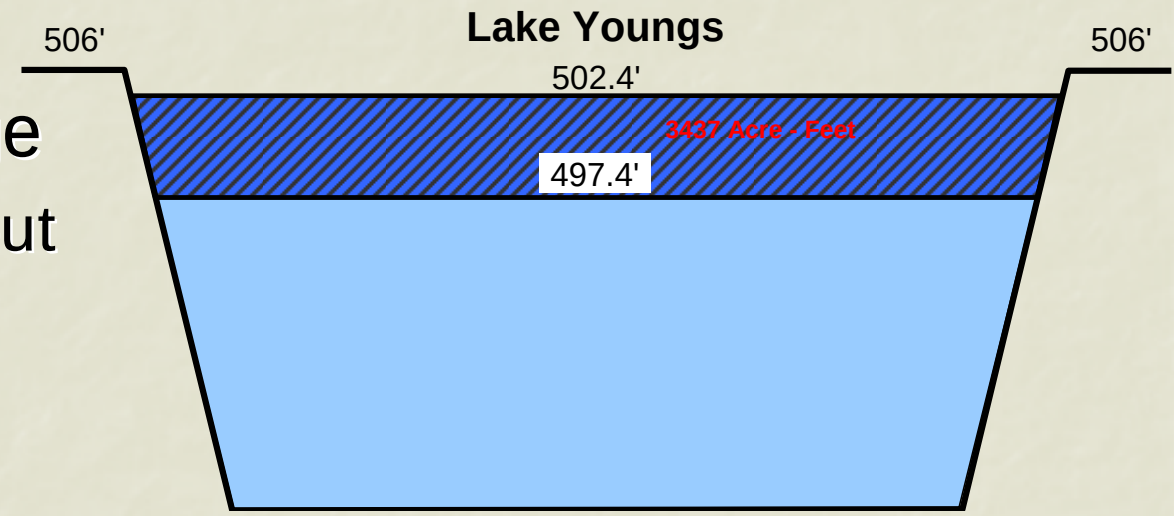
Tier 1 Modifications - Tolt

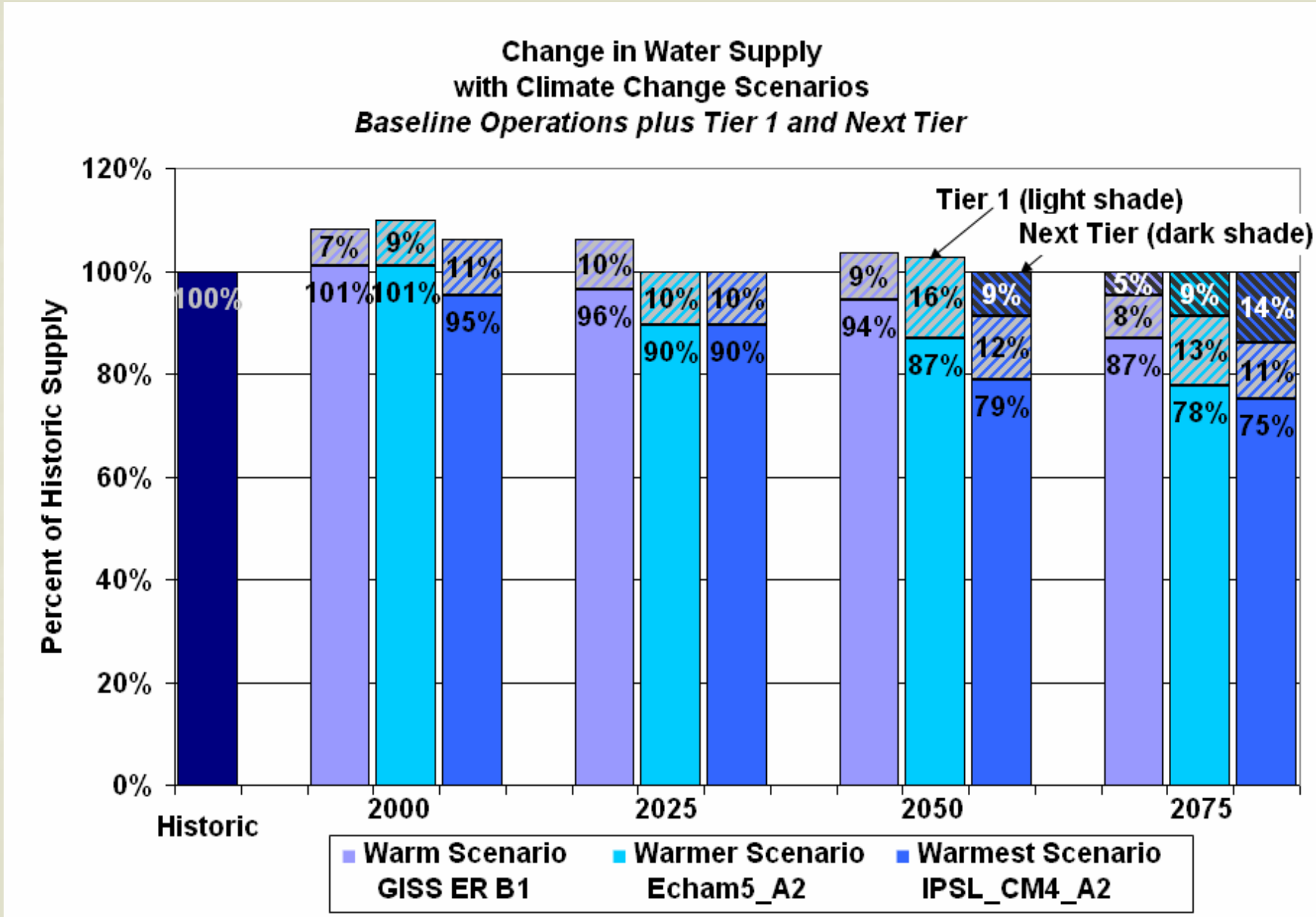
- Draw down to 1690’
  - Currently 1710’ used for firm yield
  - Adds 7517 AF or 18% more useable storage

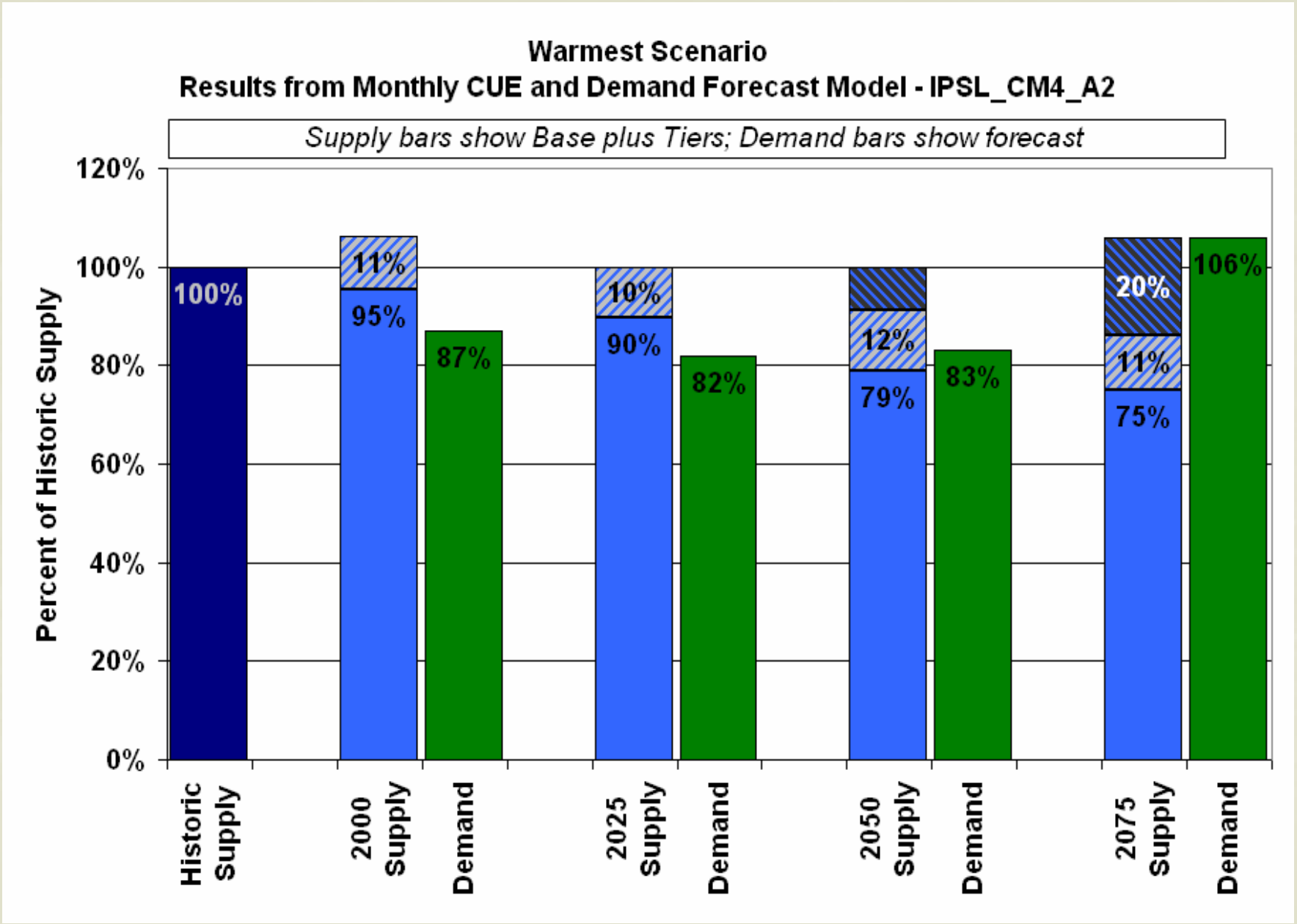


Tier 1 Modifications – Lake Youngs

- Model 5’ of storage
  - Current practice but not modeled
  - Adds 3437 AF of useable storage




Change in Water Supply
with Climate Change Scenarios
Baseline Operations plus Tier 1 and Next Tier
Percent of Historic Supply
120%
100%
80%
60%
40%
20%
0%
Tier 1 (light shade)
Next Tier (dark shade)
100%
7%
101%
9%
101%
11%
95%
10%
96%
10%
90%
10%
90%
9%
94%
16%
87%
9%
12%
79%
5%
8%
87%
9%
13%
78%
14%
11%
75%
Historic
2000
2025
2050
2075
Warm Scenario
GISS ER B1
Warmer Scenario
Echam5_A2
Warmest Scenario
IPSL_CM4_A2


Warmest Scenario
Results from Monthly CUE and Demand Forecast Model - IPSL_CM4_A2
Supply bars show Base plus Tiers; Demand bars show forecast
Percent of Historic Supply
120%
100%
80%
60%
40%
20%
0%
100%
11%
95%
87%
10%
90%
82%
12%
79%
83%
20%
11%
75%
106%
Historic Supply
2000 Supply
Demand
2025 Supply
Demand
2050 Supply
Demand
2075 Supply
Demand

Conclusions

- Climate change would result in decrease in available supply if no change in operations
  - Would need new source of supply some time after 2050, consistent with SPU's 2007 Water System Plan
- SPU is addressing the potential impacts of climate by investing in:
  - Portfolio of Tier 1 intra-system modifications to enhance flexibility of the system
  - Ongoing conservation programs through 2030
  - Ongoing research and collaboration with the water industry
- The Tier 1 modifications SPU is currently making and investigating will mitigate modeled effects for all but the largest reductions in supply in 2075
  - Use of CML below 1532' (Dead Storage) could mitigate the largest reductions – other options are also available for consideration

Climate Change Impacts on Tacoma Water Supply

December 3, 2007

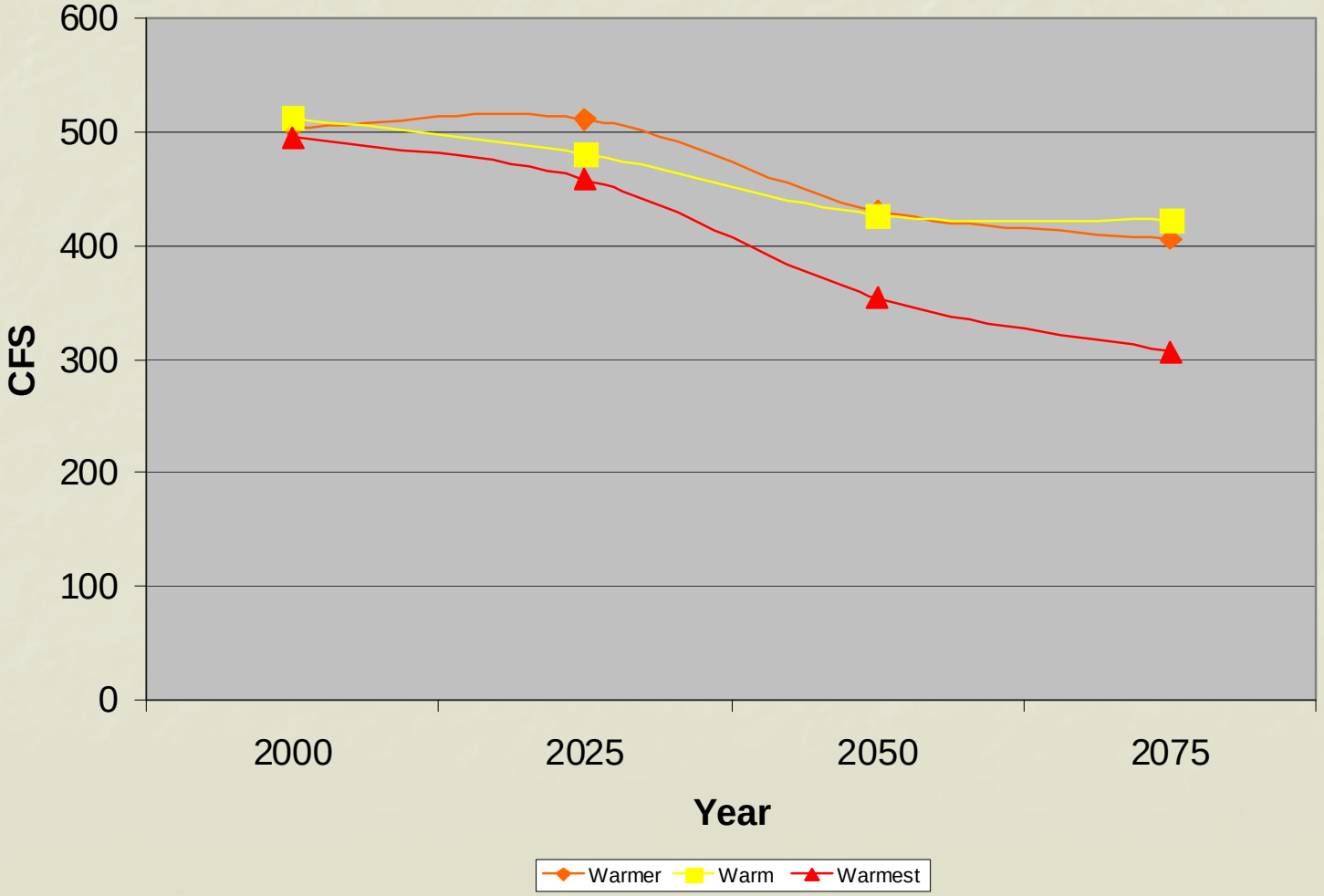
Current Supply & Demand Summary

- 2006 average daily demand was 61 MGD
- In 2006, approximately 88% of supply was from the Green River and 12% was from in-town wells
- Annual well use has varied over the last 10 years from as low as 4% of total supply to 19%
- Overall system yield is approximately 105 MGD
- based on historical data

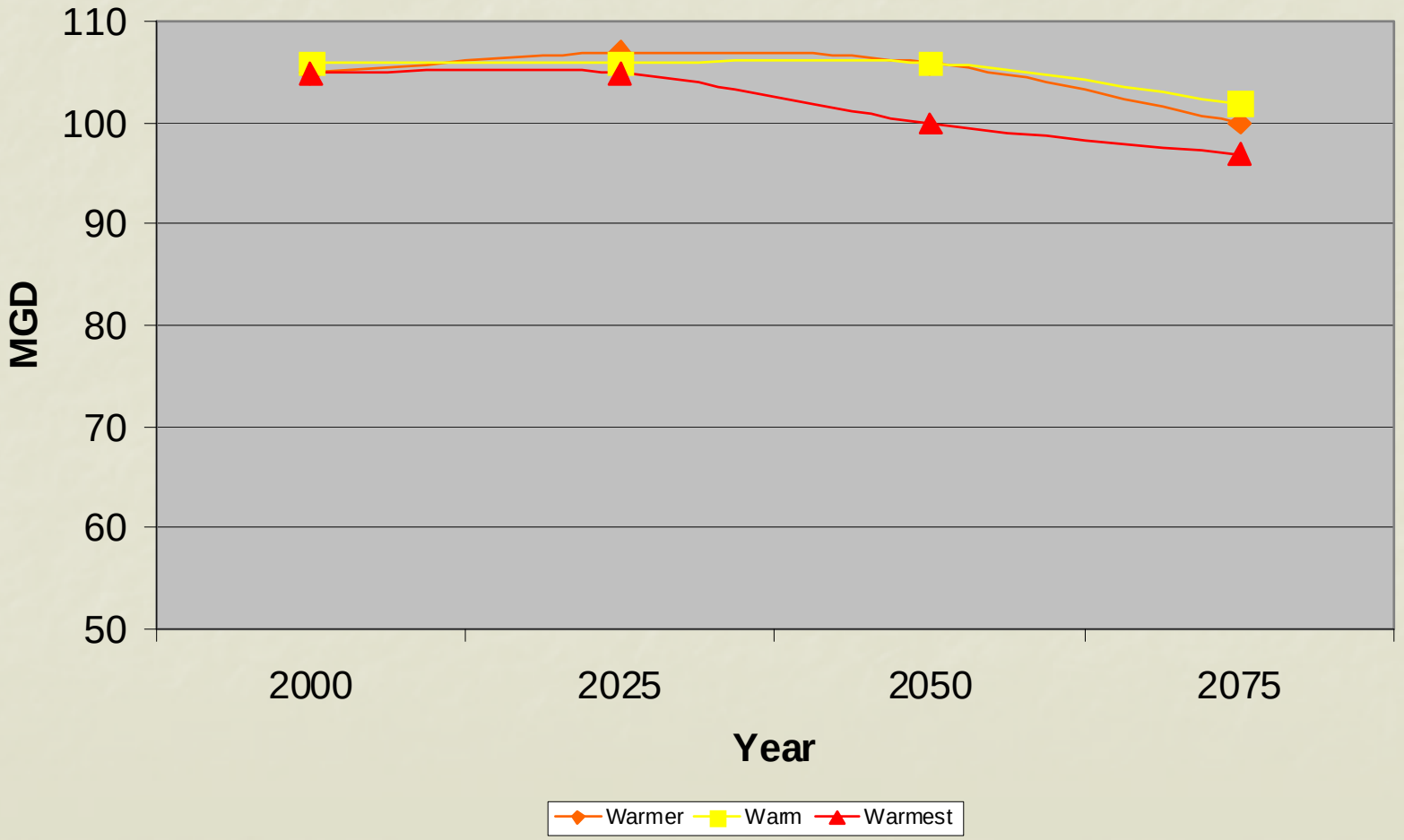
Basic Effects of Climate Change on Tacoma's Sources

- As temperatures increase, snowpack decreases
- Surface sources see higher late fall & winter flows, and lower late spring & summer flows
- Groundwater sources may be affected by changes in precipitation, but these effects are likely to be much less significant than changes to surface sources that are caused by temperature rise

Average Summer Inflow Upstream of Hanson Dam



Tacoma System Yield



Operational Adaptations to Climate Change Impacts

- Operational adaptations would be made prior to constructing new projects. Some examples include:
- Begin Hanson refill earlier to capture more late winter & early spring runoff
- Increase reliability of Hanson refill by using more wells in the spring and storing more river water which otherwise would be used in the spring
- Store any excess first diversion water in late winter or early spring, in addition to second diversion water

Conclusions

- Climate change is expected to cause higher fall and winter river flows and lower spring and summer river flows as snowpack decreases
- Tacoma's system yield is projected to decline in the range of 4 to 8% by 2075
- While operational adaptations should be sufficient to counter the effects in the near term, additional water projects would be needed in the future to maintain current levels of water supply

Summary of Climate Change Impacts

	Everett	Seattle	Tacoma	TOTAL
Existing				(Avg.)
Yield	137.5	171	105	138
Demand	85	126	61	90
				(65% of Yield)
Future				
Demand > Yield	2028	2025+	2025+	2025+
Range of Climate	-6%	-13%	-4%	-8%
Impact on Yield	-13%	-25%	-8%	-15%

Conclusions

Climate Change Will Cause:

- Higher Fall and Winter Flows
- Lower Summer Flows
- Higher Temperatures
- Higher Snow Line, Less Snow Pack
- Lower Water Supply Yield
- Little Impact in Near Term -- 0-20 Years
- Operational Changes to Offset Impacts Mid-term -- 20 – 40 Years
- Additional Water Actions (e.g. Projects, Reuse, Higher Conservation) to Offset Impact in Long Term -- 40 – 75 Years

Questions?