Glen Canyon Dam Adaptive Management Work Group
Agenda Item Information
February 25-26, 2015

Agenda Item

Long-Term Experimental and Management Plan EIS

Action Requested

✓ Information item only; we will answer questions but no action is requested.

Presenters

Kirk LaGory, Argonne National Laboratory
Rob Billerbeck, National Park Service
Glen Knowles, Bureau of Reclamation

Previous Action Taken

N/A

Relevant Science

N/A

Background Information

The LTEMP Team has been finalizing the modeling, analysis and writing for a draft EIS to be completed in March 2015. The final results of the extensive modeling analysis of the seven alternatives, including the newly developed hybrid alternative, will be presented, including the results of the extended power systems analysis.

Glen Canyon Dam
LTEMP EIS

LTEMP Alternatives Modeling Update

Adaptive Management Working Group

February 26, 2015
Salt Lake City, Utah

USGS science for a changing world
Argonne NATIONAL LABORATORY
NATIONAL PARK SERVICE
U.S. DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

Presentation Objectives

- Provide an update on the 7 alternatives to be included in the LTEMP EIS
- Describe a new alternative ("Hybrid" Alternative) developed over the last year that emerged after modeling the original 6 alternatives and discussions with stakeholders
- Compare the performance of this alternative with that of others

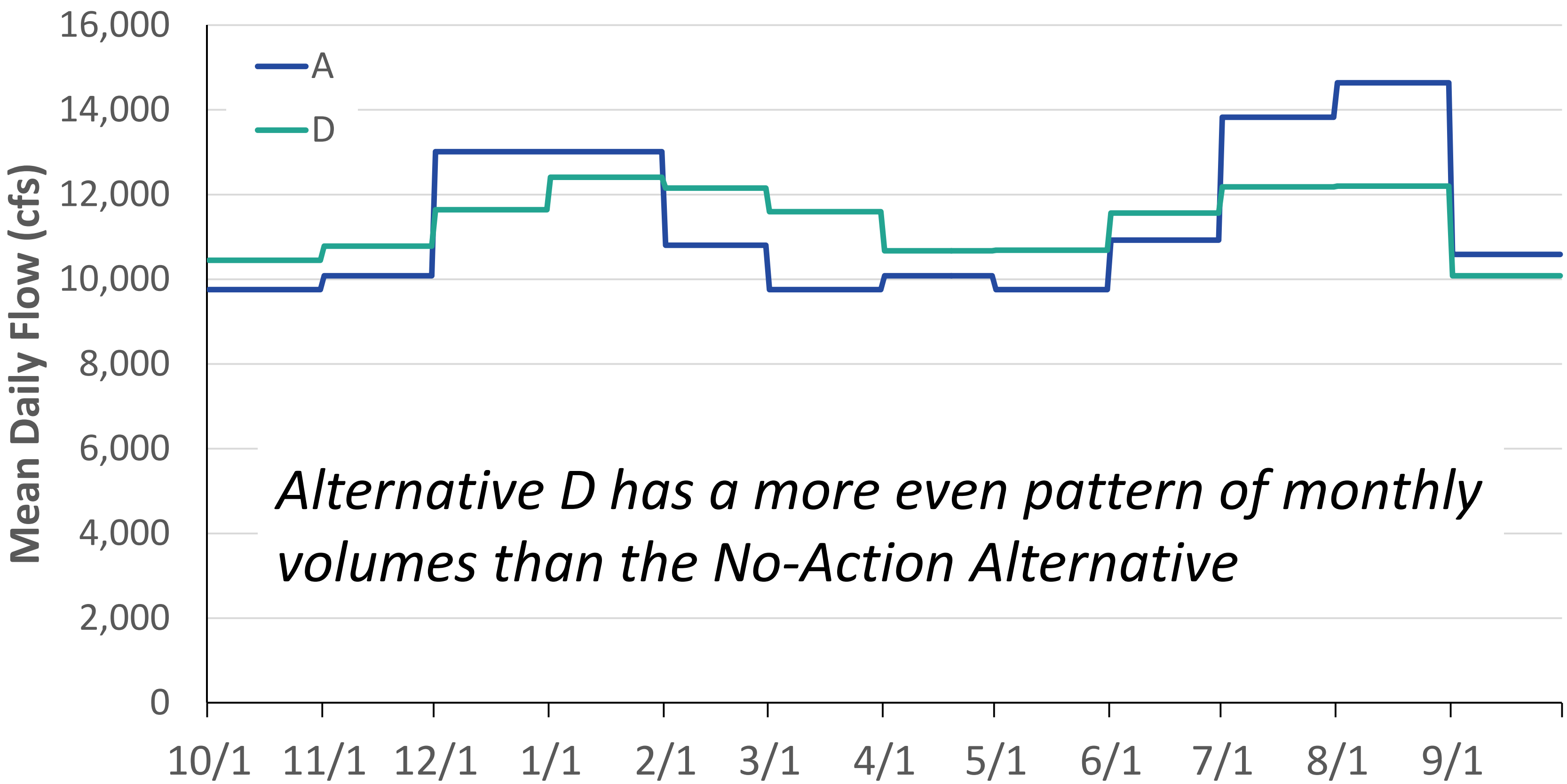
Alternatives Analyzed in LTEMP EIS

- Alternative A: No-Action Alternative
- Alternative B: Balanced Resource Alternative
- Alternative C: Condition-Dependent Adaptive Strategy
- Alternative D: Hybrid Alternative
- Alternative E: Resource-Targeted Condition-Dependent Alternative
- Alternative F: Seasonally Adjusted Steady Flow Alternative
- Alternative G: Year-Round Steady Flow Alternative

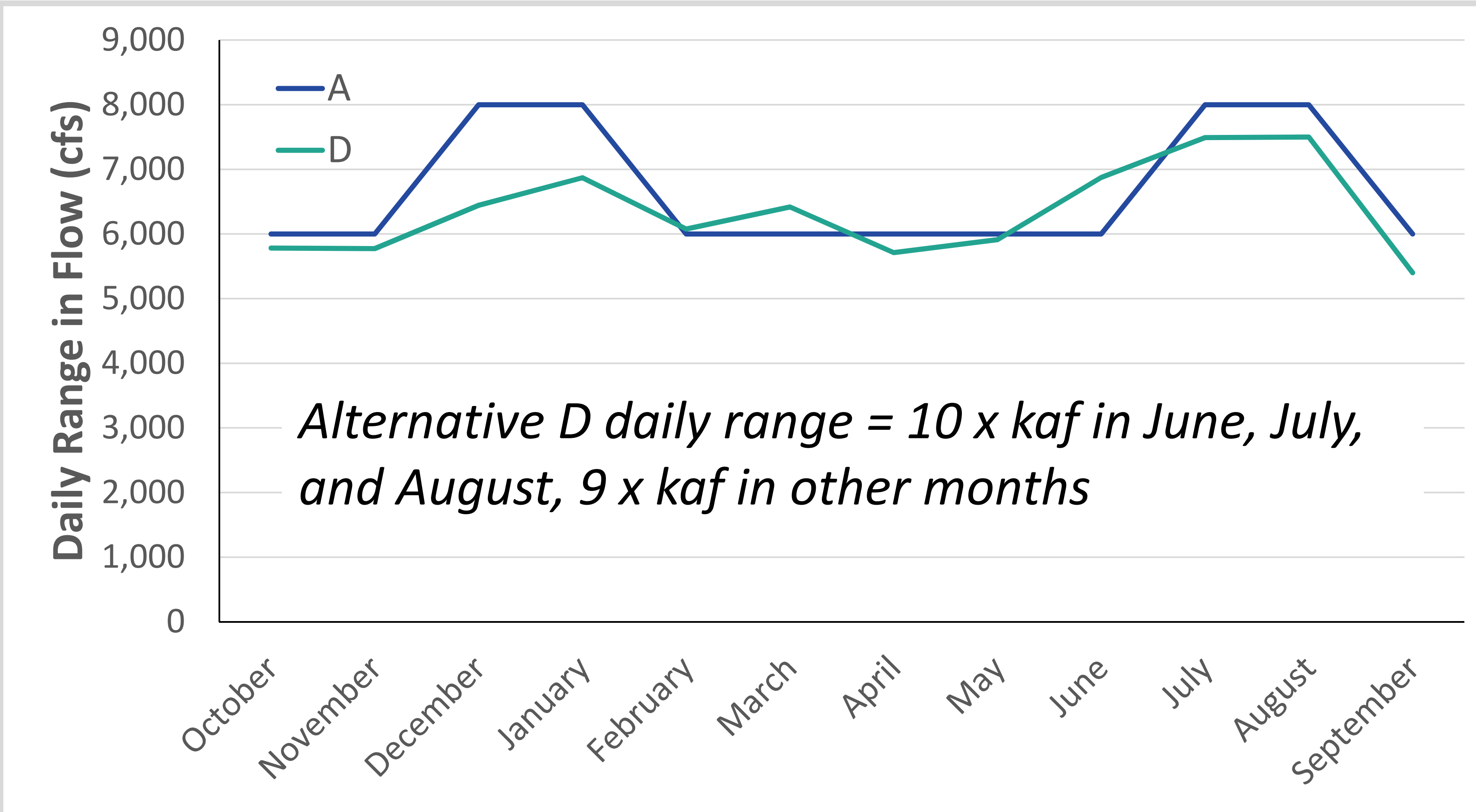
Origins of Alternative D (Hybrid Alternative)

- Original modeling results demonstrated some important effects of various components of base operations and experimental flow options such as HFEs
- These results suggested several possible changes in base operations that could be incorporated into an improved alternative
  - Retain sediment by providing a more even pattern of monthly release volumes
  - Increase daily fluctuations to improve hydropower generation value, reduce trout production, and increase humpback chub production
  - Increase August volume to improve hydropower capacity value
- *Alternative D does all of these to improve performance*

Mean Daily Flow—Alternative D vs No-Action



Daily Range in Flow—Alternative D vs No-Action



Some Alternatives Have Associated Long-Term Strategies

- Long-term strategies are different implementations of the alternative that are dependent on uncertainties in system response
- Alternatives with multiple long-term strategies
  - Alternative B (2)
  - Alternative C (4)
  - Alternative D (4)
  - Alternative E (6)
- 19 alternative/long-term strategies were evaluated

Glen Canyon Dam

Long-Term Experimental and Management Plan EIS

Alternative Key (Handout)

Characteristics of Alternative	A (No-Action)	B1	B2	C1	C2	C3	C4	D1	D2	D3	D4	E1	E2	E3	E4	E5	E6	F	G
Spring High Flow Experiments (HFEs)	until 2020	max of 1 HFE every other year*	max of 1 HFE every other year*	yes	yes	no	no	2-yr ban	2-yr ban	2-yr ban	2-yr ban	for second 10 yr period	for second 10 yr period	no	no	no	no	yes*	yes
Fall High Flow Experiments (HFEs)	until 2020			yes	yes	no	yes	yes	yes	yes	yes	yes	yes	no	yes	no	no	yes	yes
Spring Proactive HFE	no	no	no	yes ≥ 10 maf years	yes ≥ 10 maf years	no	no	yes ≥ 10 maf years	yes ≥ 10 maf years	yes ≥ 10 maf years	yes ≥ 10 maf years	no	no	no	no	no	no	no*	yes ≥ 10 maf years
Extended- Duration HFEs	no	no	no	yes, but fixed volume	yes, but fixed volume	no	yes, but fixed volume	4 fall to 250 hours	4 fall to 250 hours	4 fall to 250 hours	4 fall to 250 hours	no	no	no	no	no	no	no	spring and fall to 336 hours
Load-Following Curtailment	no	no	no	yes, before and after HFE	yes, before and after HFE	yes, before and after HFE	yes, before and after HFE	yes, before and after HFE	yes, before and after HFE	yes, before and after HFE	yes, before and after HFE	yes, before fall HFE	yes, before fall HFE	yes, before fall HFE	yes, before fall HFE	yes, before fall HFE	yes, before fall HFE	no	no
Low summer flows (LSFs)	no	no	no	no	yes	no	no	yes, second 10 years only	yes, second 10 years only	yes, second 10 years only	no	no	yes	no	no	yes	no	no	no
Bug Flows	no	no	no	no	no	no	no	no	yes	no	no	no	no	no	no	no	no	no	no
Mechanical Trout removal	until 2020	yes	yes	no	no	yes	yes	triggered by HBC & trout #	triggered by HBC & trout #	triggered by HBC & trout #	triggered by HBC & trout #	no	no	yes	yes	no	no	no	yes
Trout Management Flows (TMFs)	Test only	yes	yes	yes	no	no	no	yes	yes	no	yes	yes	no	no	no	no	yes	no	yes
Hydropower Improvement Flows	no	no	yes	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
Daily Fluctuation Range Avg	MLFF	140% of MLFF	250% of MLFF	76% MLFF	76% MLFF	76% MLFF	76% MLFF	102% MLFF Sep-Jun;95% Jul-Aug	102% MLFF Sep-Jun;95% Jul-Aug	102% MLFF Sep-Jun;95% Jul-Aug	102% MLFF Sep-Jun;95% Jul-Aug	114% MLFF	114% MLFF	114% MLFF	114% MLFF	114% MLFF	114% MLFF	none	none
OND Volumes	MLFF	same as MLFF	same as MLFF	90% MLFF	90% MLFF	90% MLFF	90% MLFF	same as MLFF	same as MLFF	same as MLFF	same as MLFF	same as MLFF	same as MLFF	same as MLFF	same as MLFF	same as MLFF	same as MLFF	73% MLFF	104% MLFF
Fall (Aug-Nov) monthly volumes	MLFF levels	same as MLFF	same as MLFF	77% of MLFF	77% of MLFF; 70% w/ LSF	77% of MLFF	77% of MLFF	96% of MLFF; 82% w/ LSF	96% of MLFF; 82% w/ LSF	96% of MLFF; 82% w/ LSF	96% of MLFF	92% of MLFF	92% of MLFF; 82% w/ LSF	92% of MLFF	92% of MLFF	92% of MLFF; 82% w/ LSF	92% of MLFF	70% of MLFF	105% of MLFF

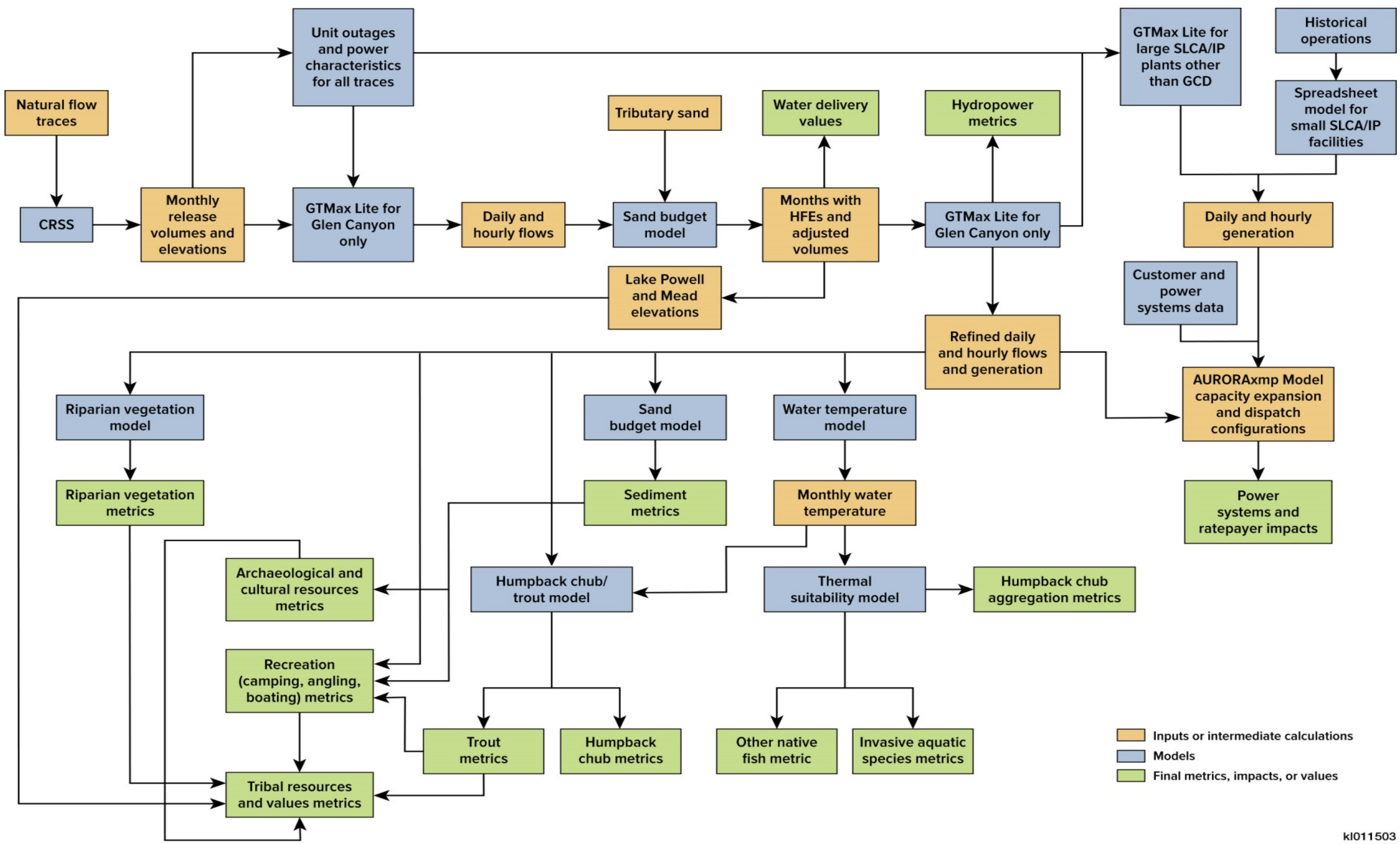
Elements of Alternative D

Characteristics of Alternative	D1	D2	D3	D4
Spring High Flow Experiments (HFEs)	2-yr ban	2-yr ban	2-yr ban	2-yr ban
Fall High Flow Experiments (HFEs)	yes	yes	yes	yes
Spring Proactive HFE	≥ 10 maf years	≥ 10 maf years	≥ 10 maf years	≥ 10 maf years
Extended- Duration HFEs	4 in fall up to 250 hours	4 in fall up to 250 hours	4 in fall up to 250 hours	4 in fall up to 250 hours
Load-Following Curtailment	before and after fall HFE	before and after fall HFE	before and after fall HFE	before and after fall HFE
Low summer flows (LSFs)	second 10 years only	second 10 years only	second 10 years only	no
Bug Flows	no	yes	no	no
Mechanical Trout removal	triggered by HBC & trout #	triggered by HBC & trout #	triggered by HBC & trout #	triggered by HBC & trout #
Trout Management Flows (TMFs)	yes	yes	no	yes

Resource Goals and Performance Metrics

- 12 resource goals, 33 performance metrics
  - Aquatic ecology
    - Humpback chub (1 goal, 2 metrics)
    - Other native fish (1 goal, 1 metric)
    - Trout fishery (1 goal, 4 metrics)
    - Non-native aquatic species (1 goal, 2 metrics)
  - Archaeological and cultural resources (1 goal, 3 metrics)
  - Hydropower and energy (1 goal, 1 metric)
  - Natural processes (1 goal, no metric)
  - Recreational experience (1 goal, 6 metrics)
  - Riparian vegetation (1 goal, 1 metric)
  - Sediment (1 goal, 4 metrics)
  - Tribal values and resources (9 elements to goal, 9 metrics)
  - Water delivery (1 goal, calculated metrics not used in swing-weighting)

Modeling Framework

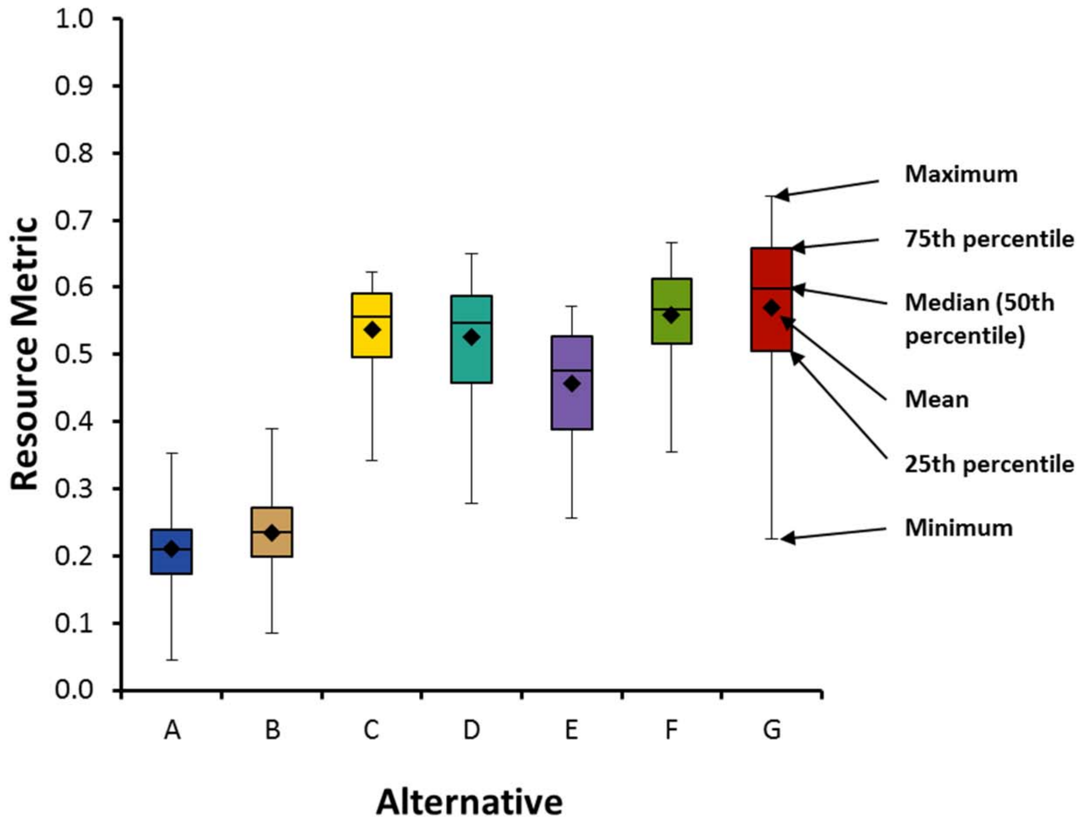


Results—Some Caveats

- Results are based on modeling a variety of hydrology and sediment conditions
  - 21, 20-year traces based on sampling the historic record
  - 3 sediment traces representing low, moderate, and high inputs
- Climate change effects will not be presented, but analysis will be included in EIS
- Some results are considered preliminary pending QA and peer review
- Presentation does not include results for all metrics

How to Interpret Performance Metric Results

- Alternatives and long-term strategies are color coded
- Box and whisker plots are used for comparison of alternatives
- Represent the full distribution of values across full range of hydrology and sediment conditions, not the mean and confidence limits
- Values are weighted based on probabilities of low, moderate, and high sediment input



Major Factors that Impact the Economic Value of the Glen Canyon (GC) Dam Hydropower Plant

- **Power production capacity**
  - System capacity needs
  - Shortfalls in available capacity and the need for replacement
- **Timing of water releases and energy production**
  - Seasonal
  - Monthly
  - Daily patterns
- **Routing of water**
  - Turbine releases
  - Non-turbine releases
- **Response/reaction to change**
  - Initial system configuration and attributes
  - Capacity expansion paths
  - Dispatch

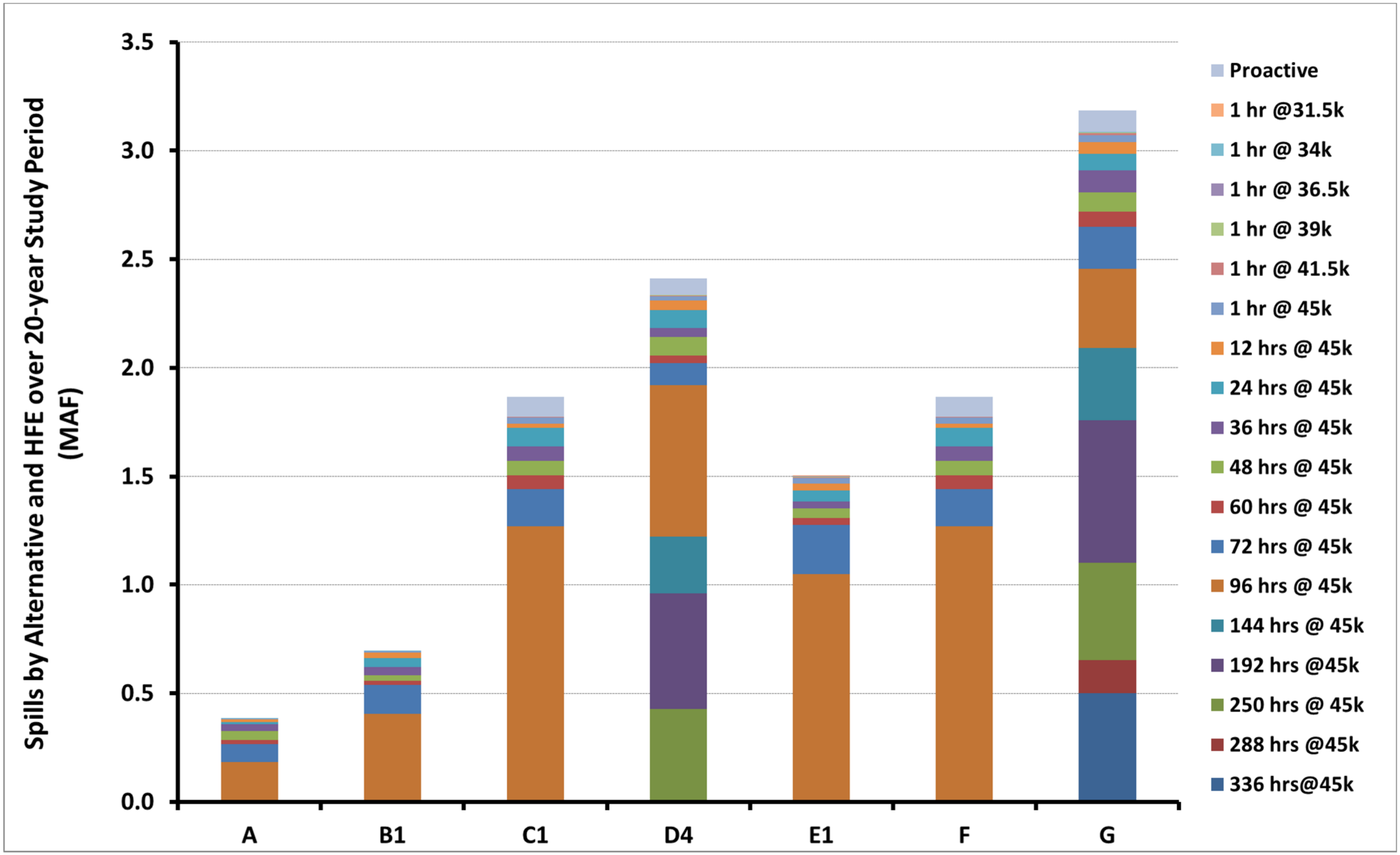
Glen Canyon Water and Energy Production Concepts

- **Annual production/releases**
  - Nearly identical across alternatives; varies by no more than 1% or 2% for each trace
  - Hydrological conditions affect the relative costs among alternatives
  - Near-term costs are weighted higher than costs incurred in the distant future
  - Value of energy is expected to increase over time
- **Seasonal production/releases**
  - Turbine water releases during the winter and summer have a relatively high value
  - Each alternative has distinct monthly water release volume pattern
- **Daily production/water release pattern**
  - Energy value has distinct hourly pattern that changes with the season
  - Turbine releases during peak demand hours typically have a relatively high value
  - Operational flexibility to respond to hourly prices differ by alternative

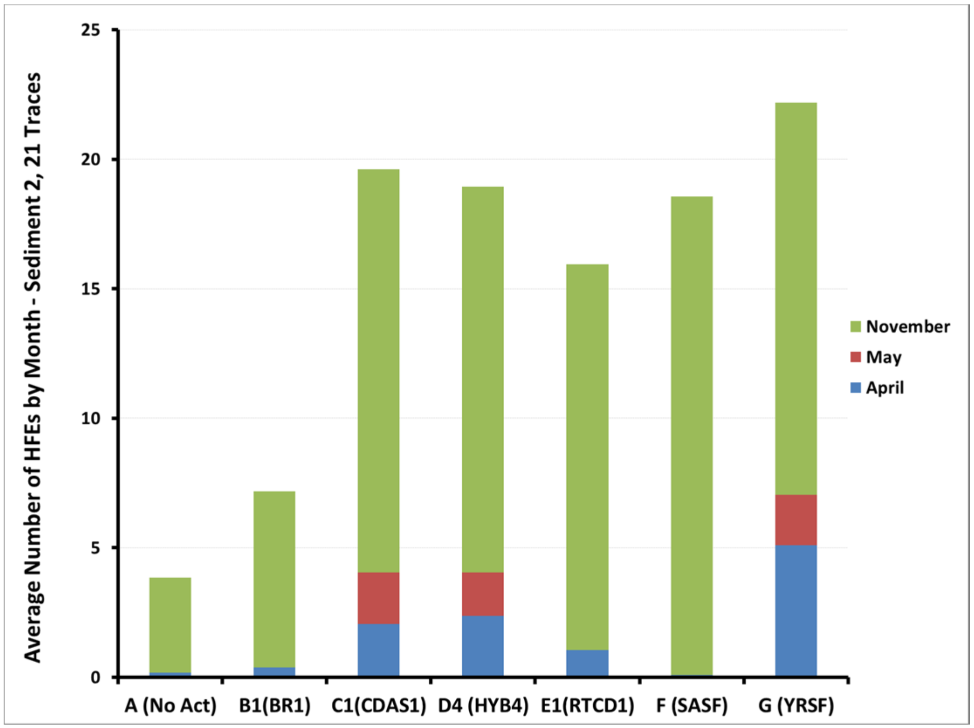
Glen Canyon Water Routing Concepts

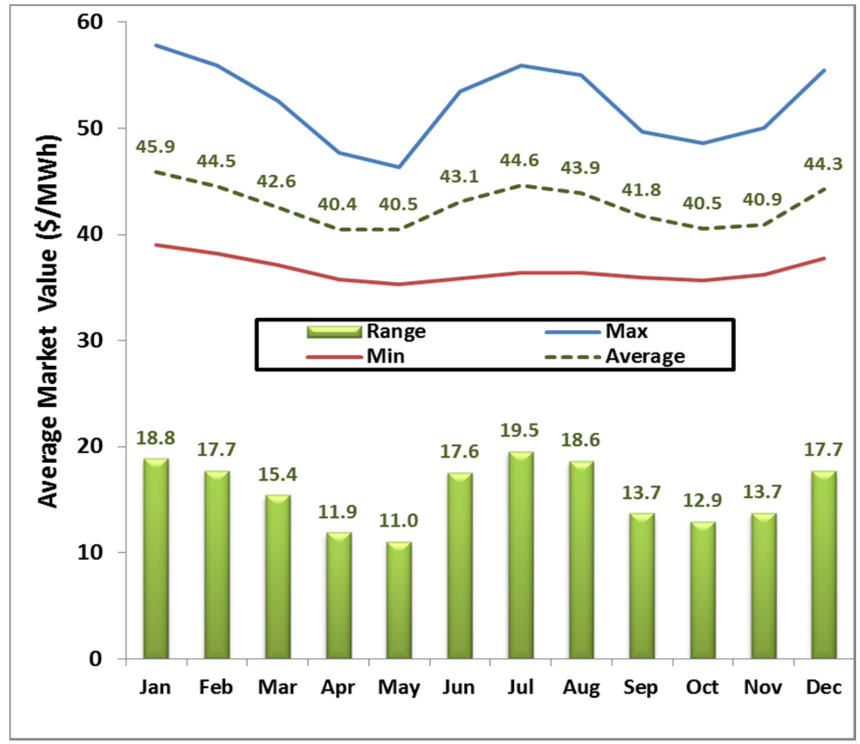
- **Turbine releases**
  - Produce power and almost always have a positive economic value
  - For a given water release volume, more electricity is produced when the reservoir elevation is higher than when it is lower
- **Non-power releases**
  - Use river bypass tubes or spillway
  - Required when water releases are greater than the maximum turbine flow rate
  - Also occurs when reservoir elevations are below the power plant penstock intake and water must still be released from the reservoir
  - Precipitated by HFE, changes in the forecast, power plant outages, and low reservoir elevations

Average Amount of Water Spilled During the 20-Year LTEMP Period



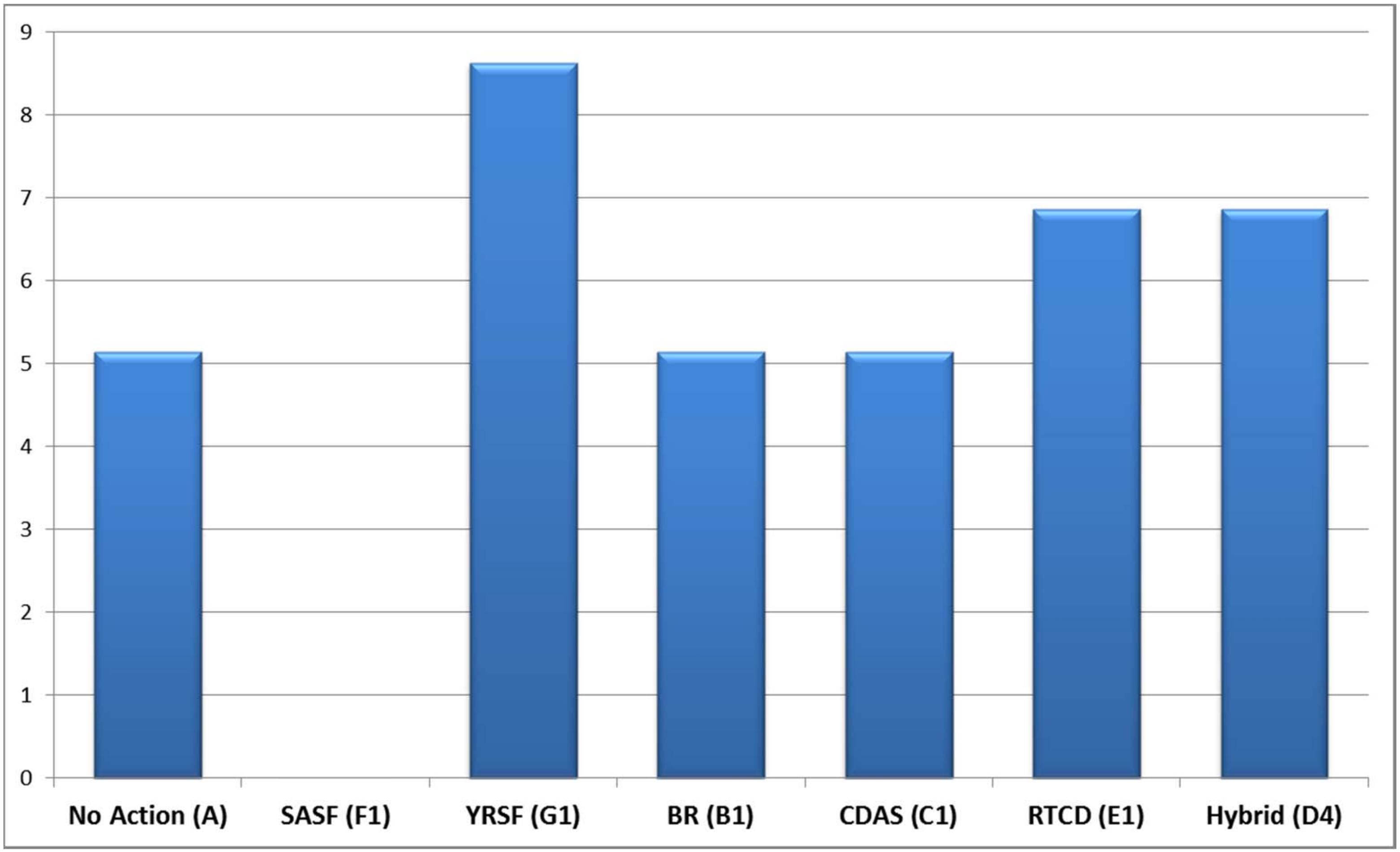
The Economic Impact of an HFE Is Dependent on When it Occurs and Absolute Prices





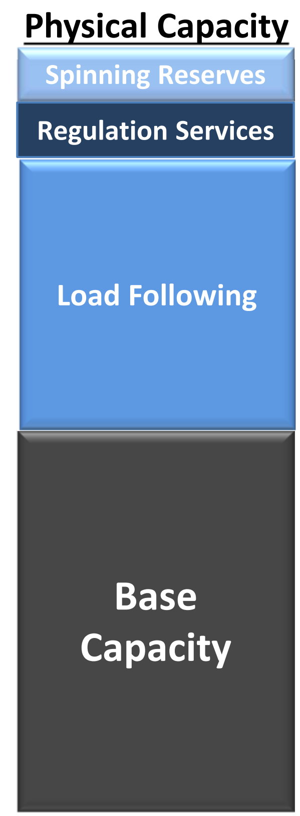
- **An HFE may redistribute water among months of a year**
- **An HFE may affect reservoir elevations**
  - Tends to lower the reservoir elevations and hence GC water-to-power conversion efficiency

Average Annual Number of Hours Lake Powell Elevation Is Below the Penstock Intake (All Traces)



Glen Canyon Power Plant Capacity Concepts

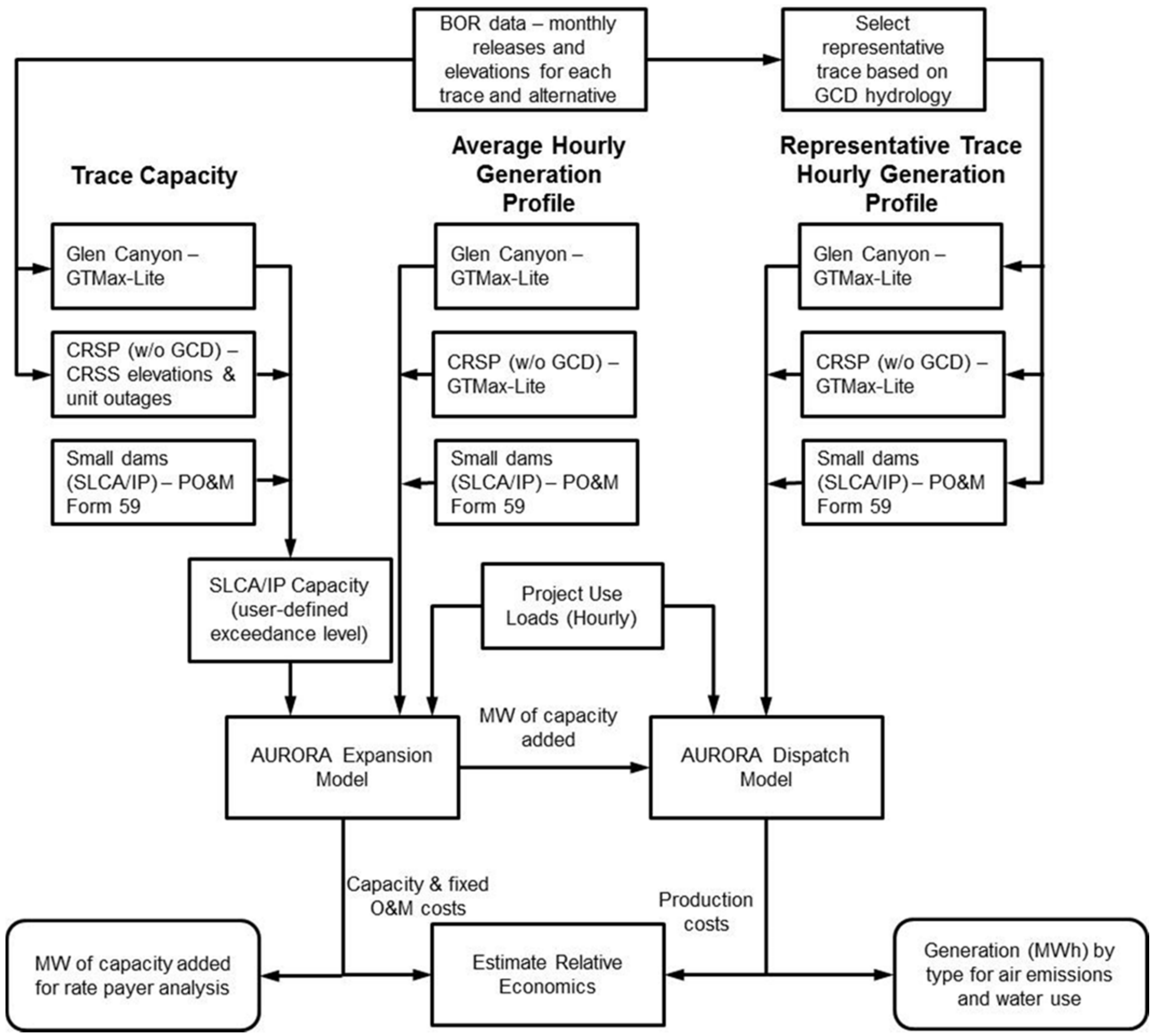
- **Operationally the plant's capacity is divided into functional blocks**
  - Base capacity (technical minimum), peaking, and grid services
- **Capacity levels change over time varying as a function of:**
  - Number of turbines on line – outages are scheduled and occur randomly
  - Reservoir elevation level
  - Allowable water release volumes during a specified time span (i.e., month)
  - Operating criteria: daily change, max/min, volume, etc. impact capacity
- **Capacity value is dependent on**
  - When and where the grid needs capacity
  - Duty cycle and functions the capacity needs to perform
  - Costs to build the type of capacity that is needed
- **The amount that is credited toward meeting system needs is based on the probability that it will be available when most needed**



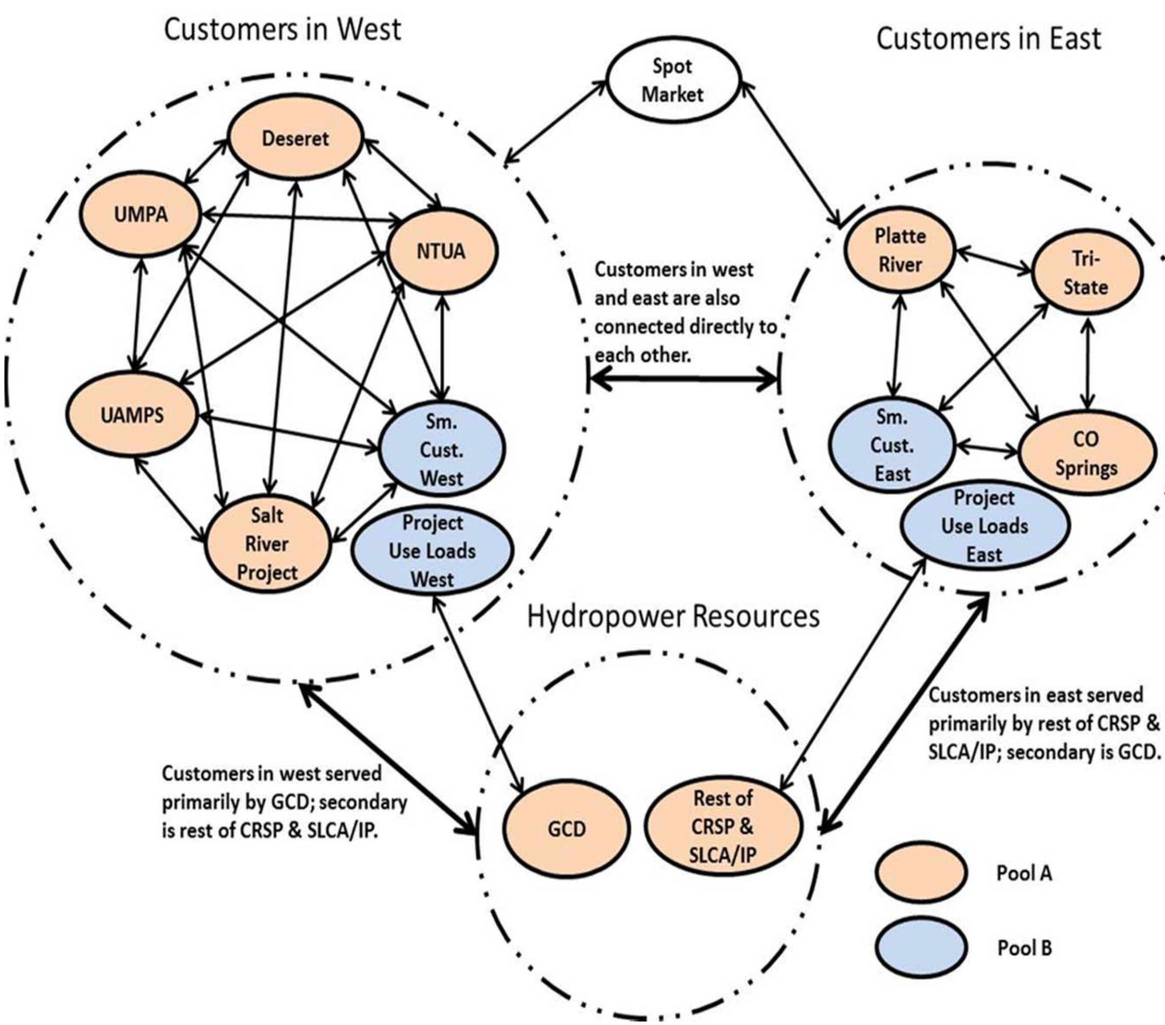
Overview of the Modeling Approach and Methods

- Models used include
  - GTMax-Lite – developed by Argonne for the Western Area Power Administration
  - AURORAxmp – commercial electric power system expansion planning and unit dispatch model
  - Several spreadsheet routines/models
- Performed high resolution analysis on a smaller network topology rather than running Aurora on the entire U.S. western interconnection (WI)
- 8 large customers modeled in detail
  - SRP, UAMPS, UMPA, Tri-State, Deseret, NTUA, Colorado Springs Utilities, and Platte River Power Authority
- Remaining small customers (about 121) aggregated into a small customer entity
- Small customers account for 25% of energy/capacity and each receives less than 2.5% of the total

Power Systems Analysis Flow Diagram



Aurora Geographic Scope and Features



- Transfers among utilities incur a charge that varies by on-peak & off-peak periods
- Transfer limits are placed on power flows between CRSP resources and its customers roughly representing its transmission limits and the SRP exchange agreement
- CRSP resources first serve project use obligations and then, as a second priority, they serve firm customer load
- Customer load is based on several years of historical utility-specific patterns and load growth projections

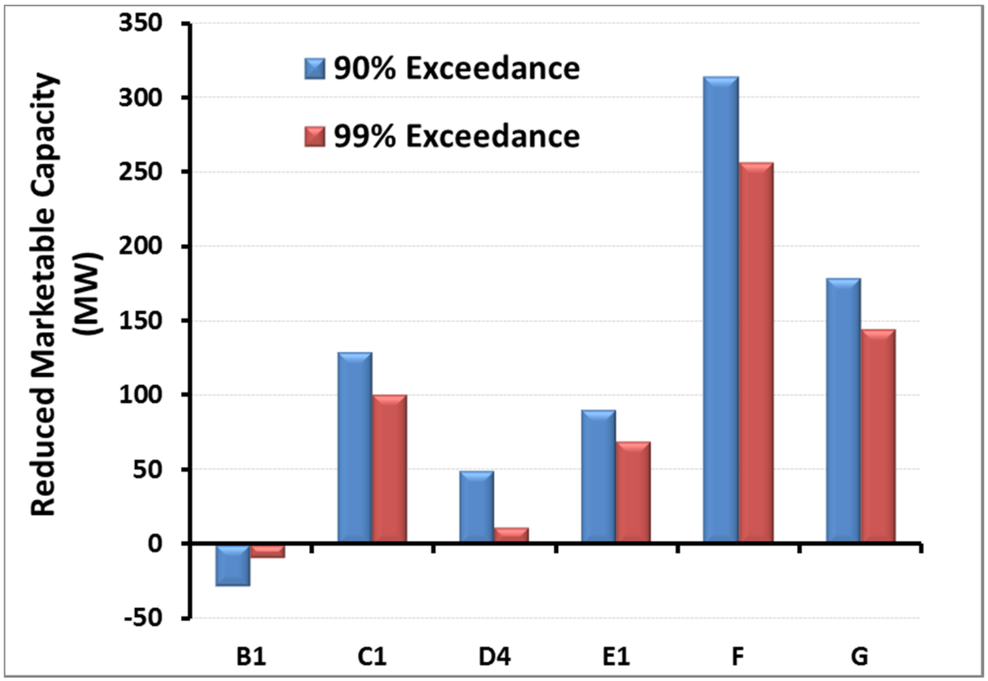
Replacement Capacity Assumptions

- **Cost data from the EIA 2013 Annual Energy Outlook**
- **Used two plants for cost comparison**
  – Advanced natural-gas fired combined cycle plant
  – Advanced natural-gas fired combustion turbine
  – Chosen to determine a cost range considering Glen Canyon Dam's duty cycle

Plant Characteristics	Nat. Gas Combined Cycle	Nat. Gas Combustion Turbine
Size	400 MW	230 MW
Lifetime	30 years	30 years
Capital cost (incl. IDC)	$1,113/kW	$717/kW
Fixed O & M	$15.63/kW-yr	$7.16/kW-yr
Cost per unit capacity	$82,200/MW-yr	$50,100/MW-yr

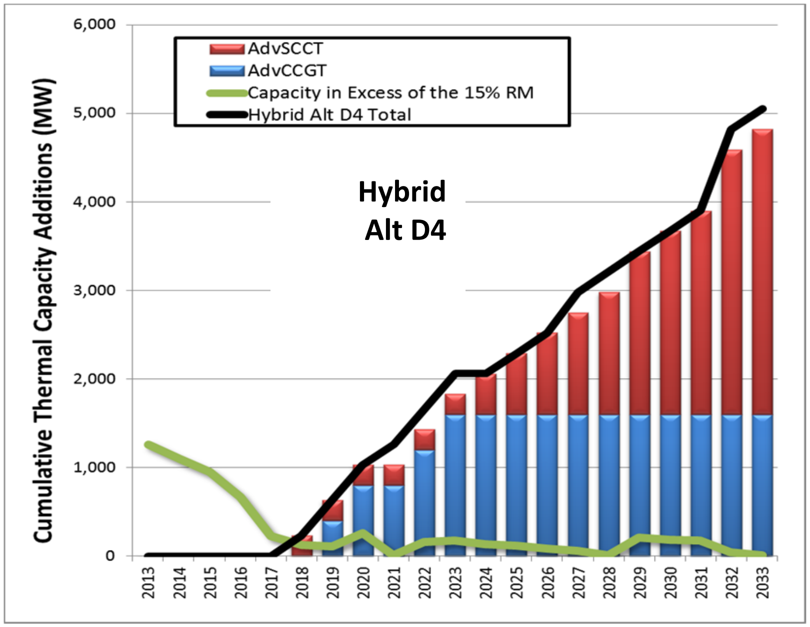
SLCA/IP Marketable Capacity (MW)

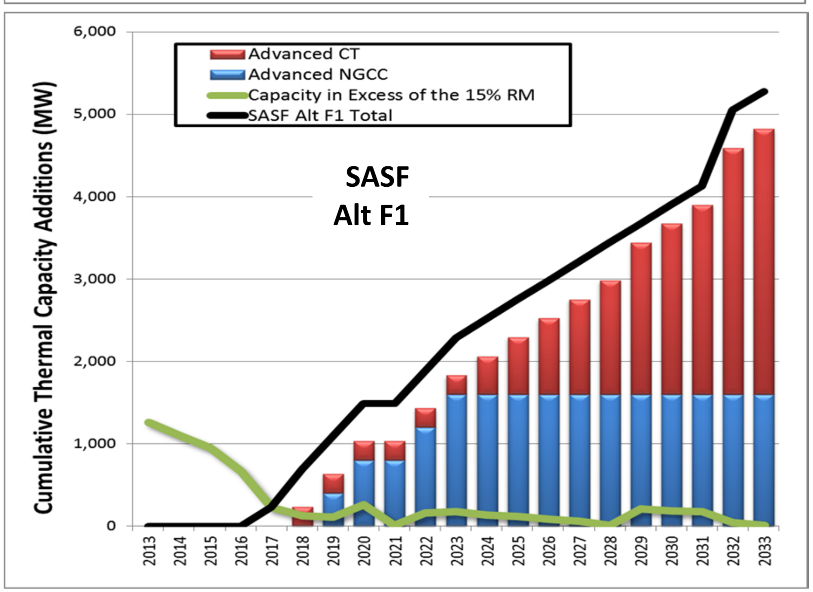
Alternative	90% Exceedance	Capacity Reduction	99% Exceedance	Capacity Reduction
A	737.2	na	611.2	na
B1	765.3	-28.1	619.9	-8.8
C1	608.1	129.1	510.7	100.5
D4	687.6	49.6	599.8	11.3
E1	647.0	90.2	542.2	68.9
F	423.1	314.1	354.5	256.7
G	558.2	179.0	466.8	144.3



- Marketable capacity based on exceedance value (risk):
  - 90% exceedance values are the MW produced in 90% of years during peak demand month
  - 90% values higher than 99%
- Steady flow alternatives have lower marketable capacity than those with fluctuating flows
- Alternative D has a loss of about 50 MW relative to A

Preliminary Results—Do Not Cite or Distribute

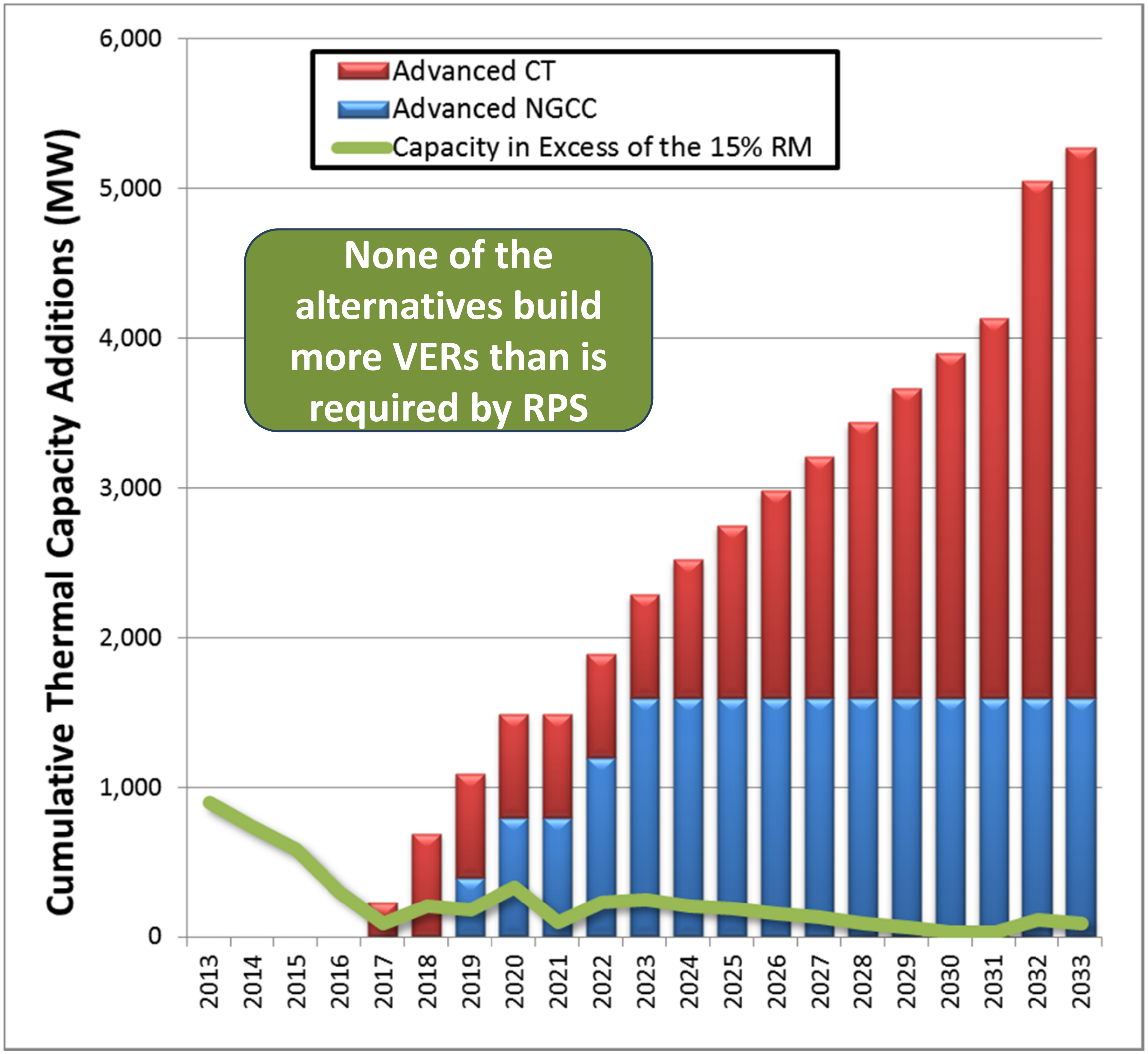




Capacity Additions Relative to No-Action

		Capacity Additions Above Alternative A					
Year	Cumulative Capacity Expansion (MW) under A	B	C	D	E	F	G
2013	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0
2017	0	0	0	0	0	230	0
2018	230	0	230	0	0	460	230
2019	630	0	230	0	0	460	230
2020	1030	0	230	0	0	460	230
2021	1030	0	230	230	230	460	230
2022	1430	0	230	230	230	460	230
2023	1830	0	230	230	230	460	230
2024	2060	0	230	0	0	460	230
2025	2290	0	230	0	0	460	230
2026	2520	0	230	0	230	460	230
2027	2750	0	230	230	230	460	230
2028	2980	0	230	230	230	460	230
2029	3440	-230	0	0	0	230	230
2030	3670	0	0	0	0	230	230
2031	3900	0	0	0	0	230	230
2032	4590	0	230	230	230	460	230
2033	4820	0	230	230	230	460	230
	Average	-11.0	142.4	76.7	87.6	328.6	175.2
	Capacity Reduction	-28	129	49	90	314	179

Cumulative Capacity Additions Under Alt F – SASF (90% Exceedance)

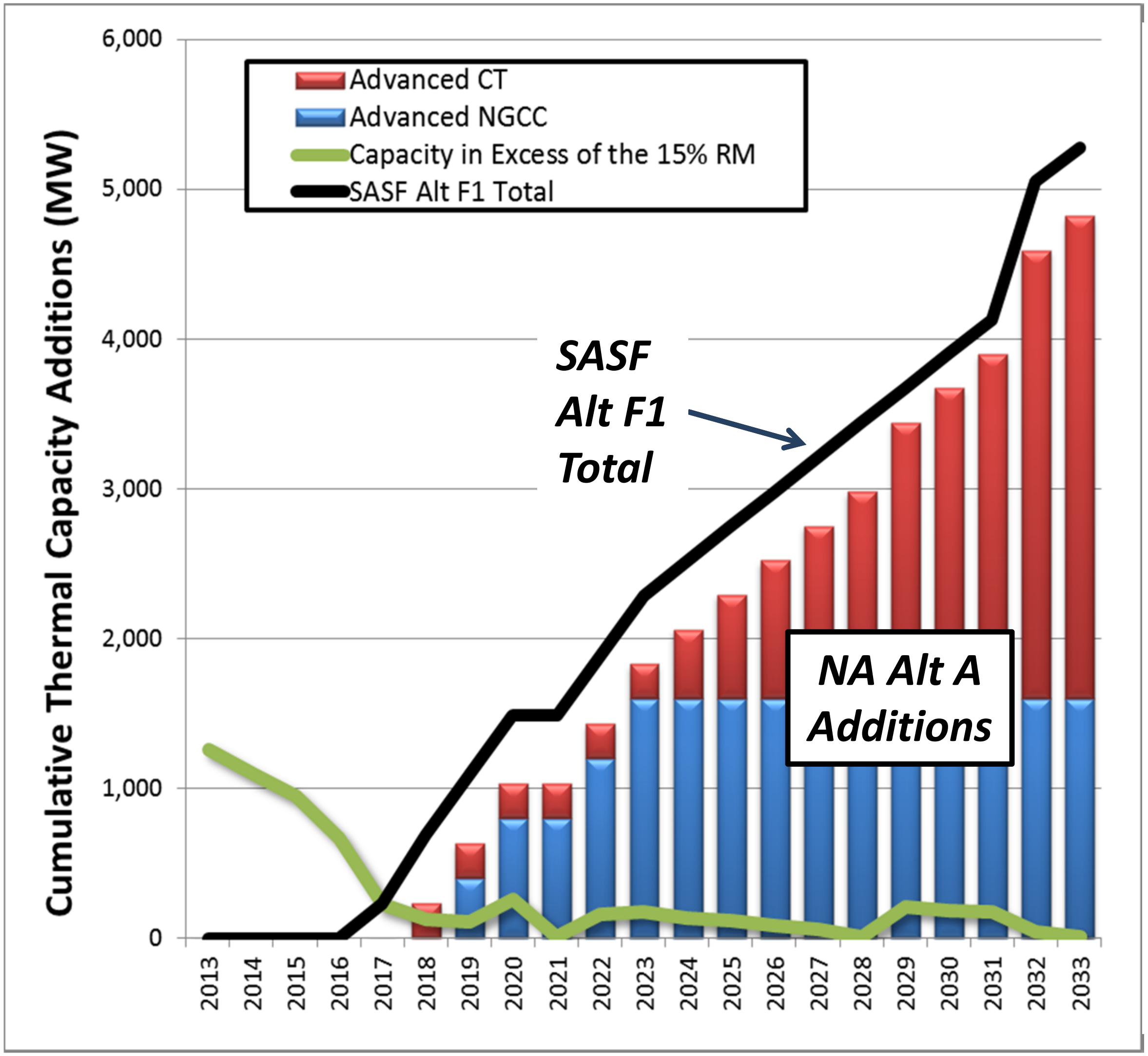


New Additions

On Line Date	NA Alt A	SASF Alt F
2014		
2015		
2016		
2017		CT1
2018	CT1	CT2 & CT3
2019	NGCC1	NGCC 1
2020	NGCC2	NGCC 2
2021		
2022	NGCC3	NGCC 3
2023	NGCC4	NGCC 4
2024	CT2	CT4
2025	CT3	CT5
2026	CT4	CT6
2027	CT5	CT7
2028	CT6	CT8
2029	CT7 & CT8	CT9
2030	CT9	CT10
2031	CT10	CT11
2032	CT11-CT13	CT12 - CT15
2033	CT 14	CT16

2 more units

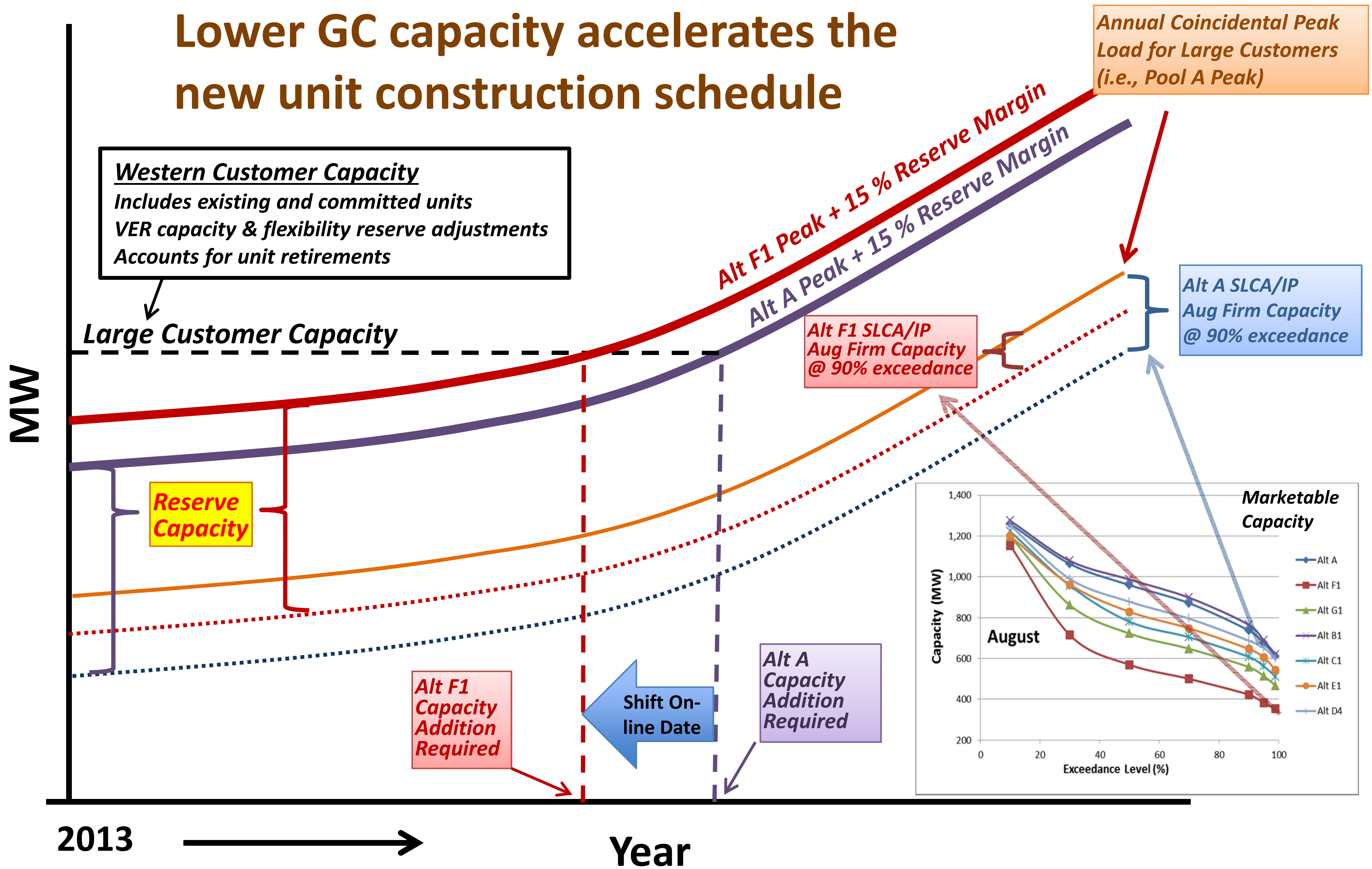
The Difference Between Alternatives Is "Lumpy"

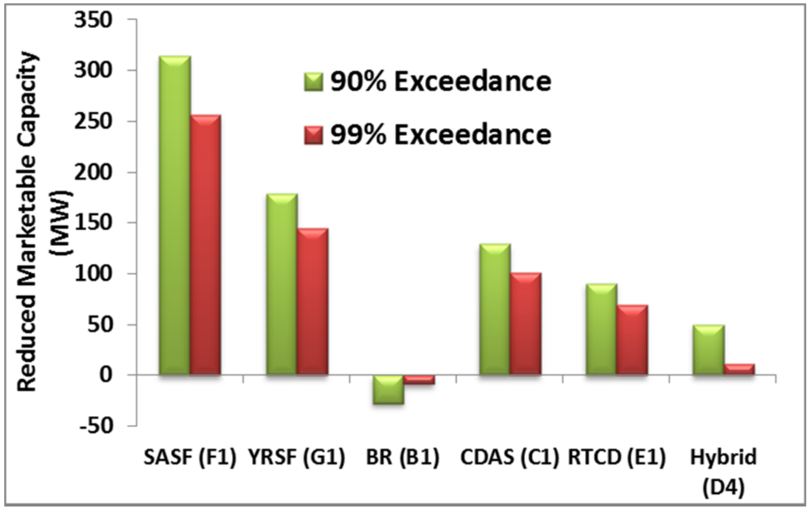


Cumulative New Capacity (MW)

Line Date	NA Alt A	SASF Alt F	Higher Alt F Capacity	
2013	0	0	0	System Excess None Added
2014	0	0	0	
2015	0	0	0	
2016	0	0	0	
2017	0	230	230	
2018	230	690	460	Additions > GC Loss
2019	630	1,090	460	
2020	1,030	1,490	460	
2021	1,030	1,490	460	
2022	1,430	1,890	460	
2023	1,830	2,290	460	
2024	2,060	2,520	460	
2025	2,290	2,750	460	
2026	2,520	2,980	460	
2027	2,750	3,210	460	
2028	2,980	3,440	460	
2029	3,440	3,670	230	Additions < GC Loss
2030	3,670	3,900	230	
2031	3,900	4,130	230	
2032	4,590	5,050	460	
2033	4,820	5,280	460	
		Average	329	
Lower GC Capacity			314	

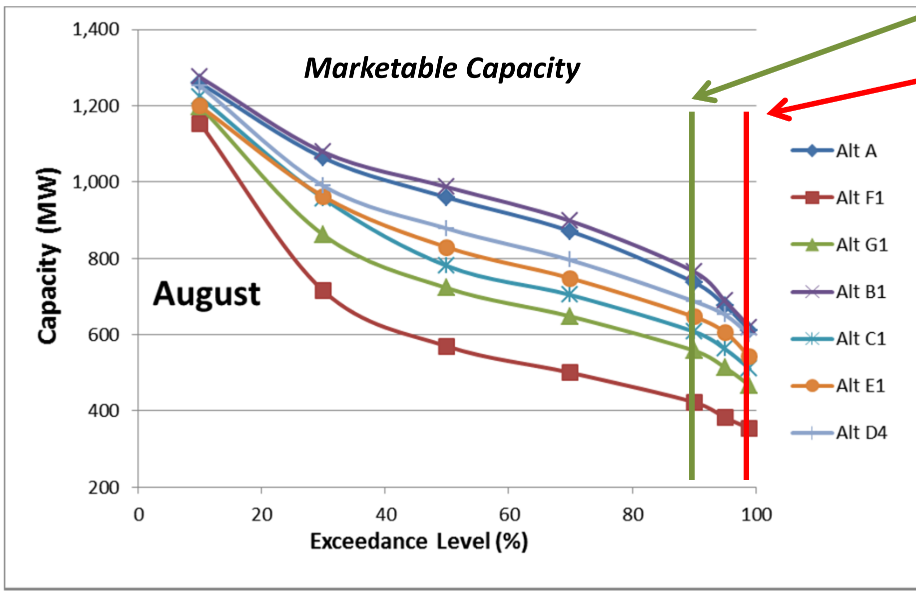
Lower GC capacity accelerates the new unit construction schedule

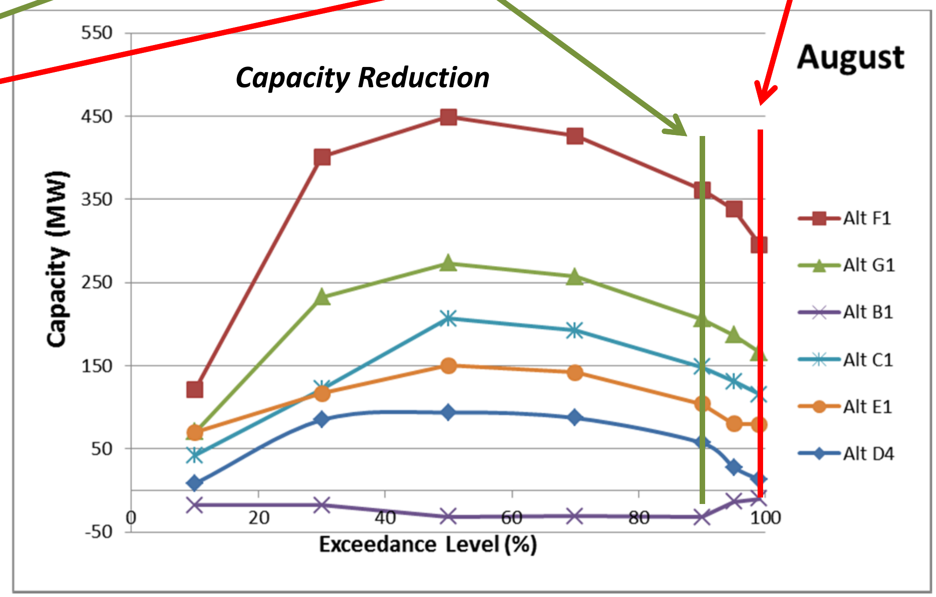




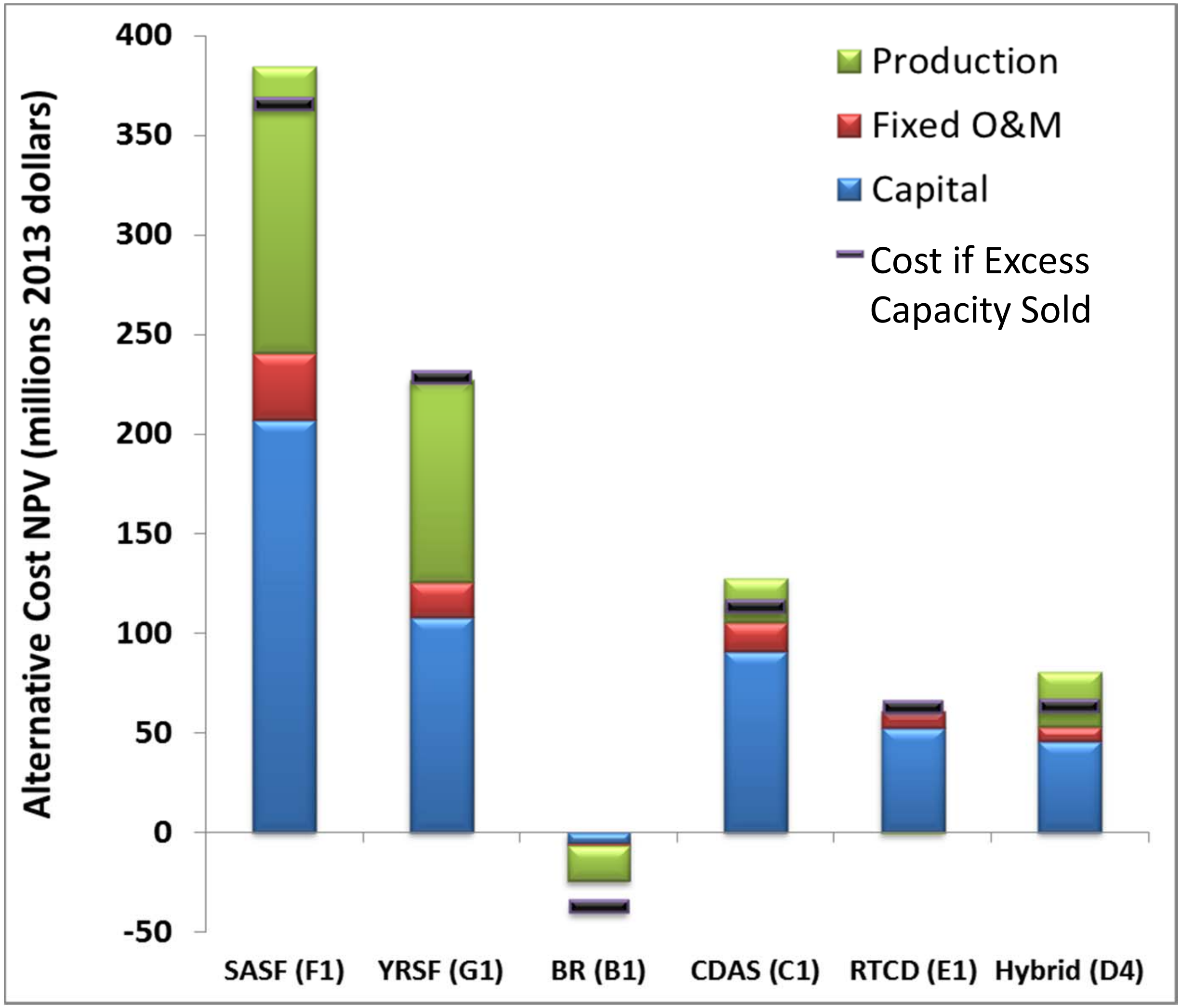
SLCA/IP Marketable Capacity (MW)

Alternative	90% Exceedance Capacity	Capacity Reduction	99% Exceedance Capacity	Capacity Reduction
No Action (A)	737.2	na	611.2	na
SASF (F1)	423.1	314.1	354.5	256.7
YRSF (G1)	558.2	179.0	466.8	144.3
BR (B1)	765.3	-28.1	619.9	-8.8
CDAS (C1)	608.1	129.1	510.7	100.5
RTCD (E1)	647.0	90.2	542.2	68.9
Hybrid (D4)	687.6	49.6	599.8	11.3





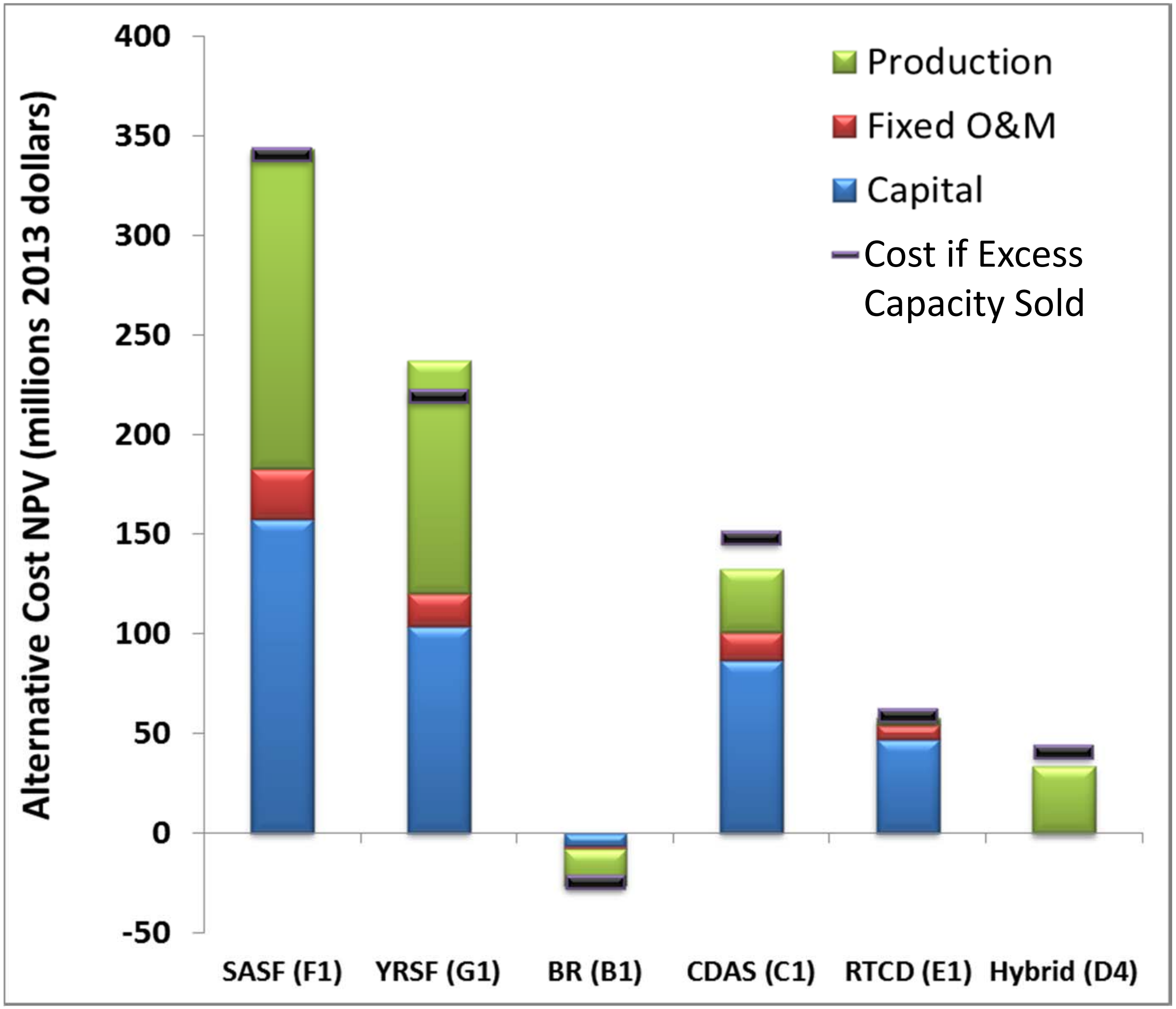
Net Present Value for the 90% Capacity Exceedance Case



- D has slightly lower capacity cost than E
- D has higher generation cost than E
- B improves capacity and generation value relative to A
- F and G have the largest capacity and generation cost of all alternatives

Preliminary Results—Do Not Cite or Distribute

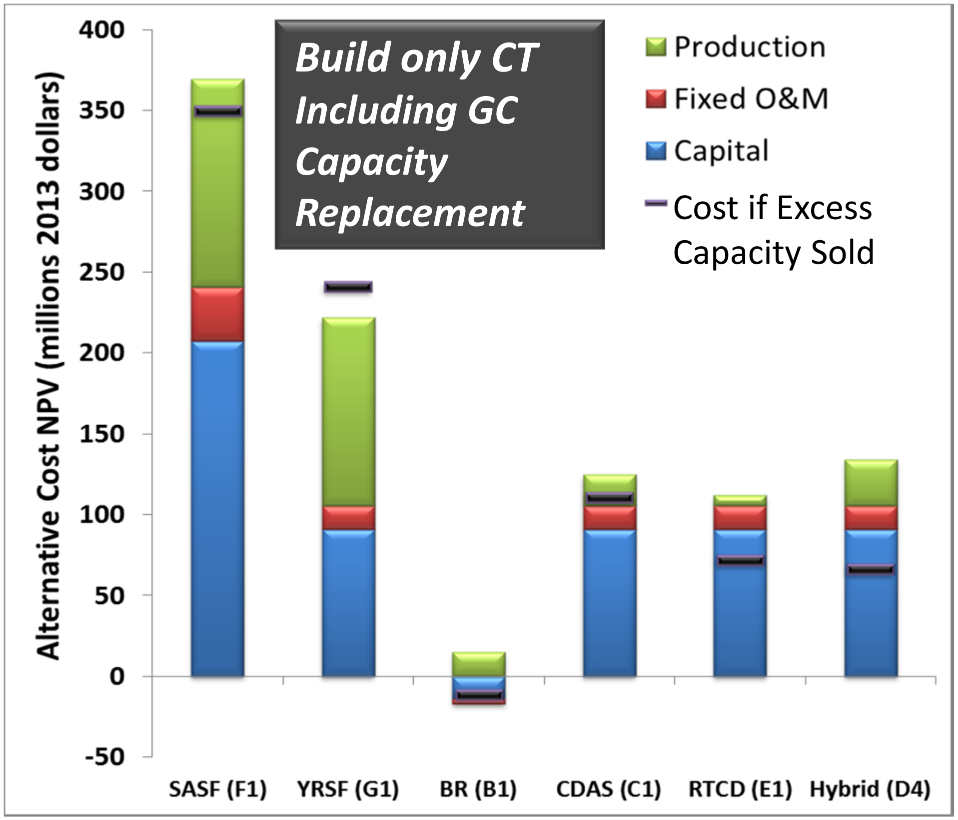
Net Present Value (NPV) for the 99% Capacity Exceedance Case

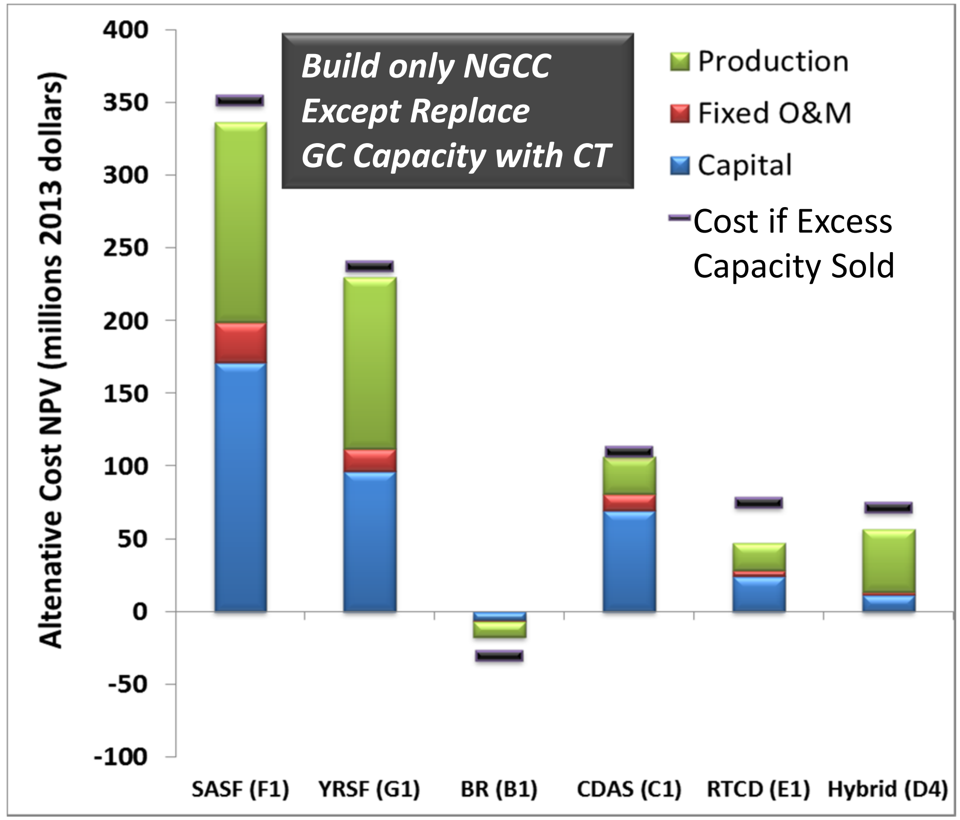


- Relative to the 90% exceedance case, there are smaller differences in:
  - Capital cost, due to smaller capacity replacements
  - Fixed O&M costs,
  - Production cost differences

Preliminary Results—Do Not Cite or Distribute

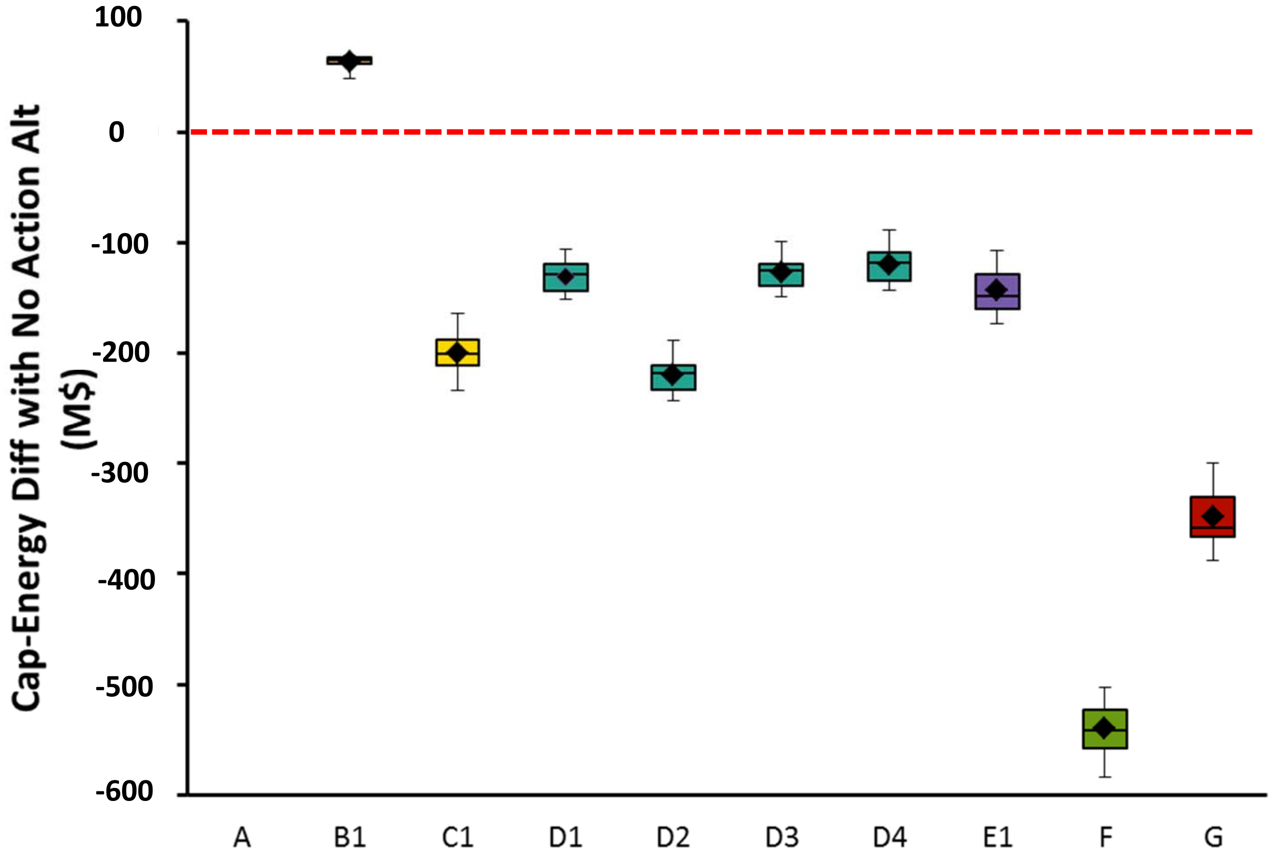
Base Expansion Plan Sensitivity Analysis (90% Exceedance Case T14)





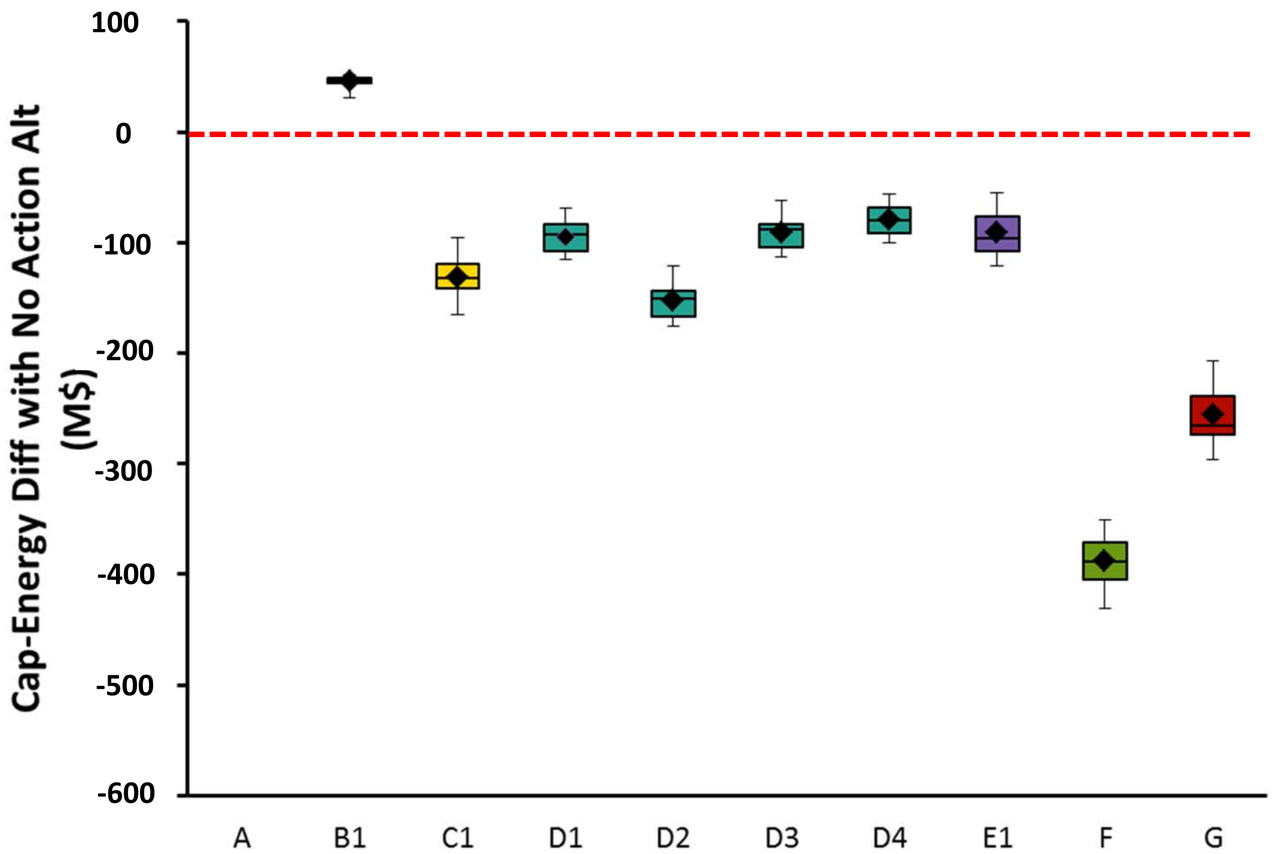
Preliminary Results—Do Not Cite or Distribute

Difference from No Action in NPV of Capacity and Energy with NGCC Replacement



Alternative	A	B1	C1	D1	D2	D3	D4	E1	F	G
Mean (M$)	0.0	63.3	-200.1	-130.8	-219.3	-127.3	-120.2	-143.4	-540.4	-348.0
Rank	2	1	7	5	8	4	3	6	10	9

Difference from No Action in NPV of Capacity and Energy with NGCT Replacement



Alternative	A	B1	C1	D1	D2	D3	D4	E1	F	G
Mean (M$)	0.0	45.4	-131.4	-94.8	-152.8	-91.3	-79.8	-91.5	-387.9	-255.9
Rank	2	1	7	6	8	4	3	5	10	9

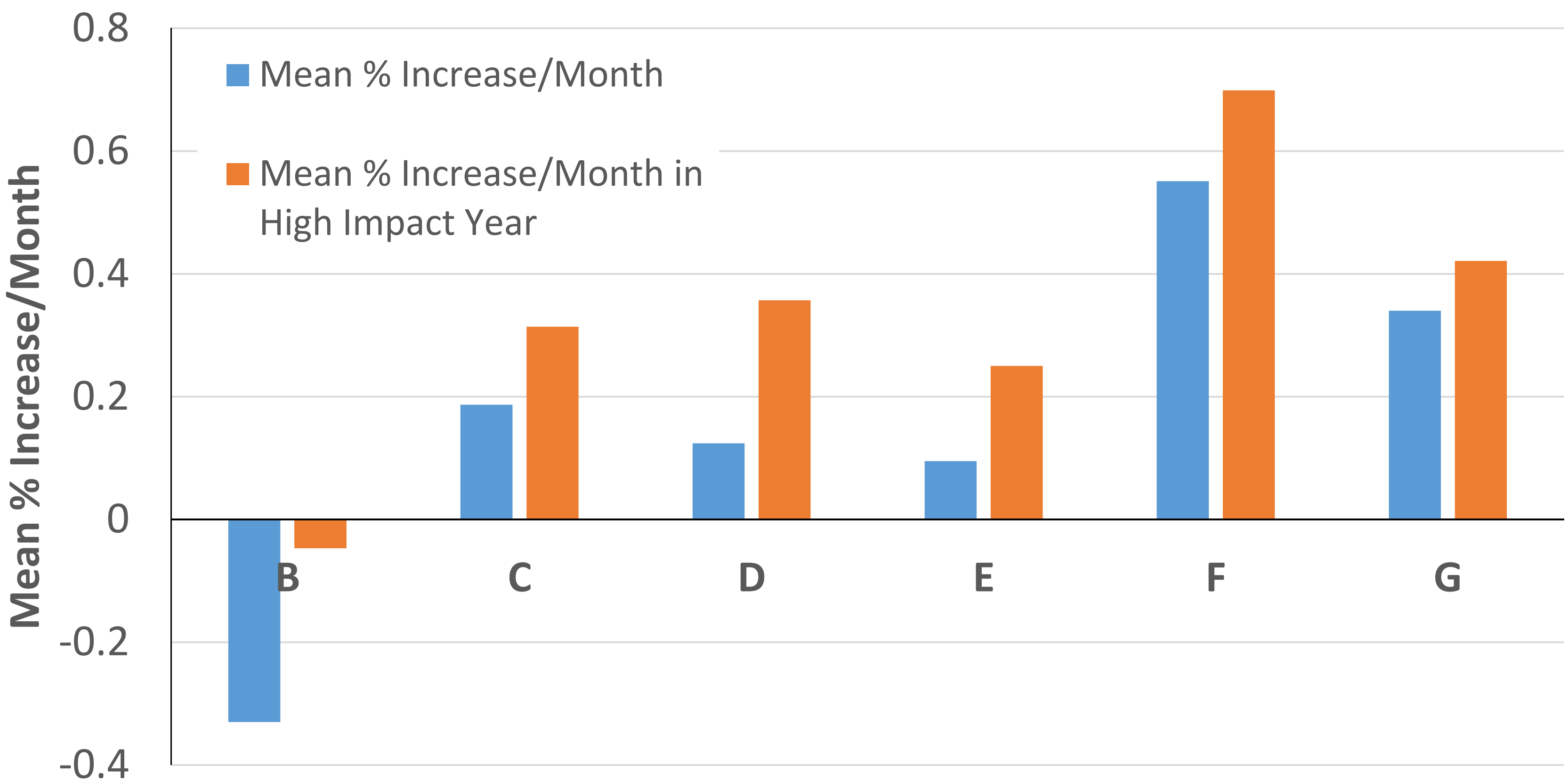
Rate Impact Analysis and Performance Metrics

- Objective
  - Compute impacts on household and business consumers from LTEMP alternatives
  - Evaluate year-by-year impacts using publicly available information
  - Include range of rate impacts for different individual municipal and cooperative systems
- Rate Impact Analysis Metrics
  - Average percentage impacts for retail (household and business) consumers and impacts on residential bills across all systems that receive federal preference power
  - Weighted average impacts accounting for size of systems
  - Distribution of retail rate percent impacts and residential bill impacts for individual systems on un-weighted and weighted basis

Factors Affecting Retail Rate Impacts

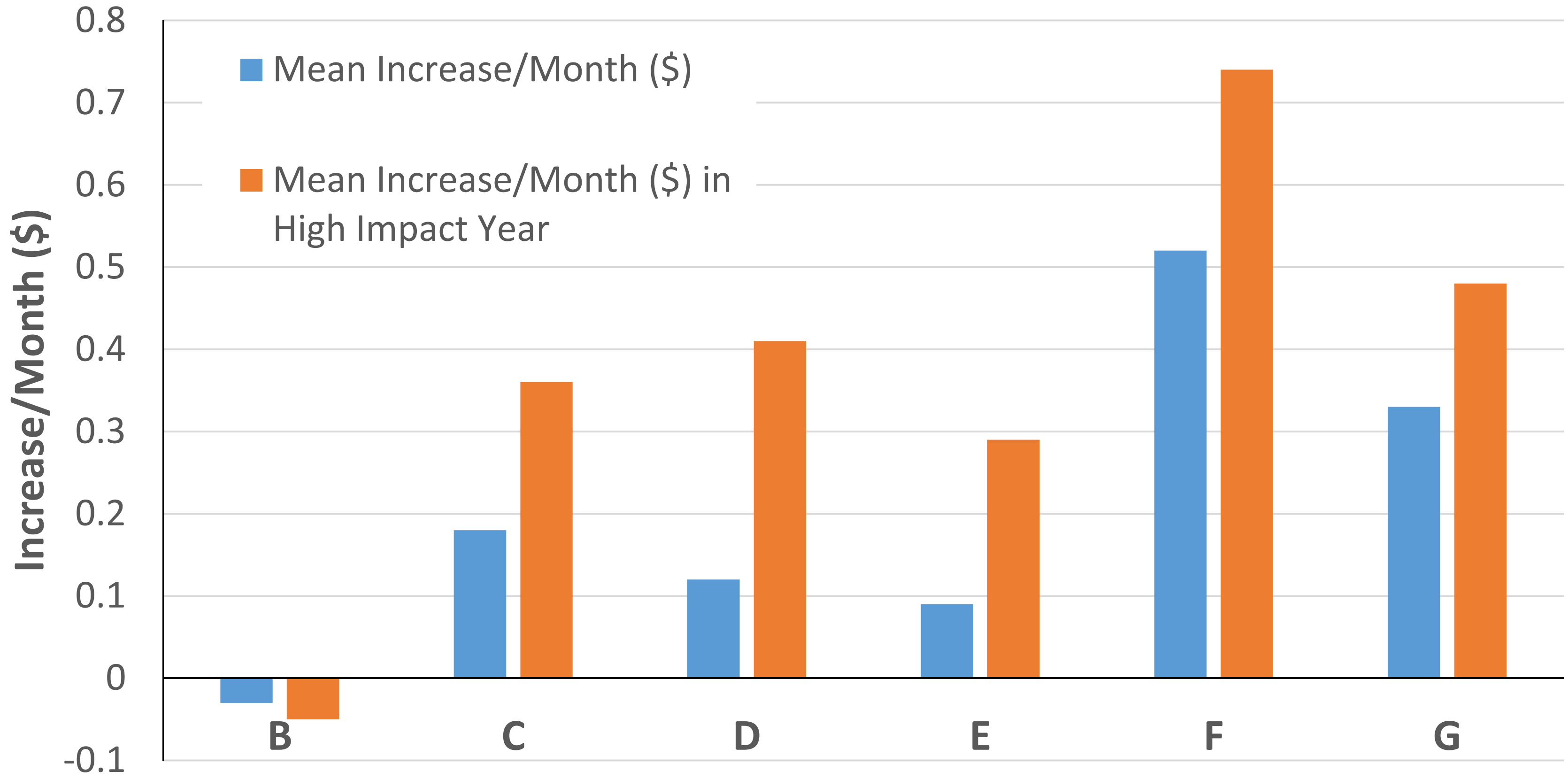
- Alternatives
  - Alternatives with release patterns that more closely match demand result in lower impacts
- Hydrology
  - Impacts are greater in drier years
- Size of customers
  - Impacts are greater on smaller customers (up to about 4% increase)
- Reliance on CRSP power
  - Impacts are greater on customers that receive a higher proportion of their power from CRSP facilities (up to about 4% increase)

Overall Rate Impact Differences Among Alternatives



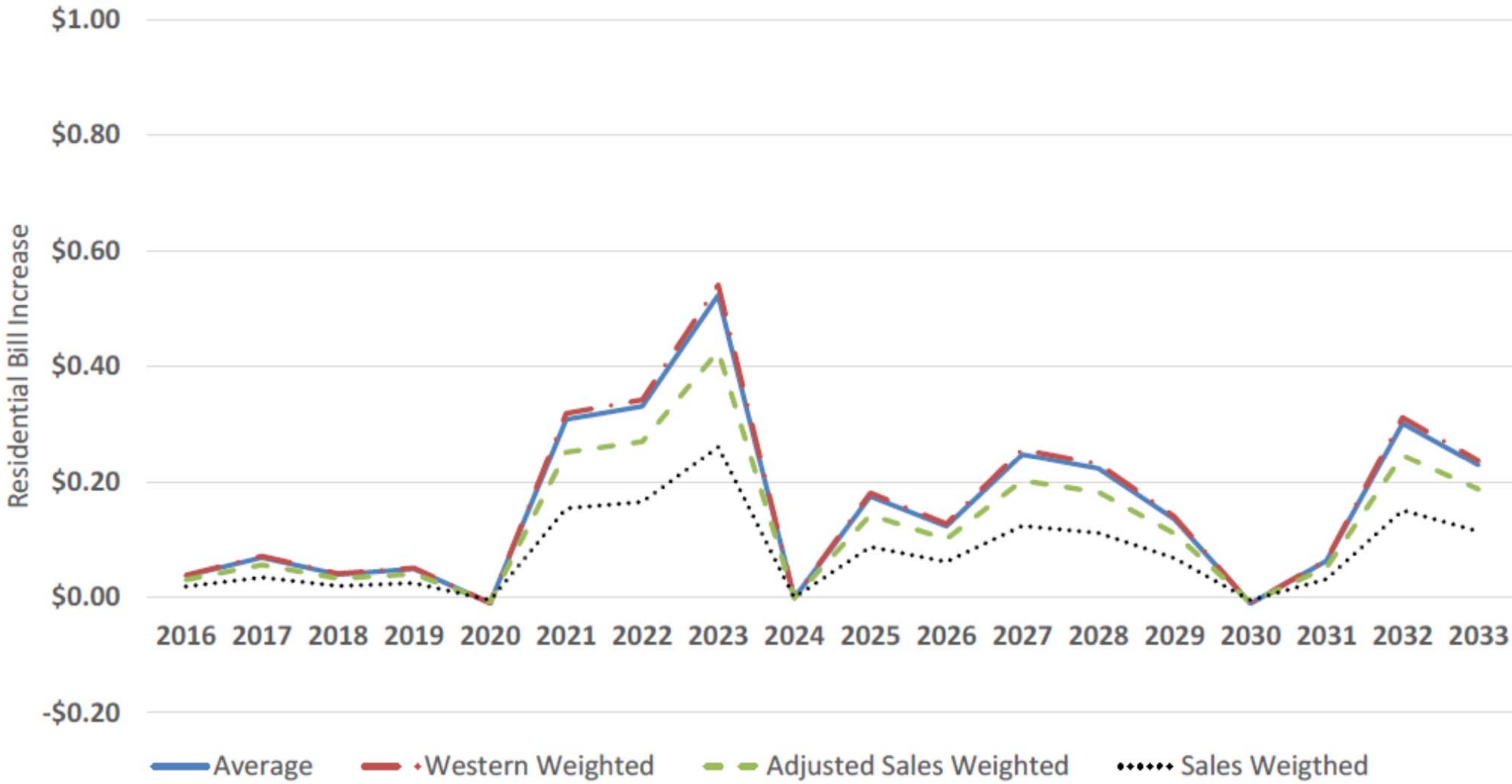
Preliminary Results—Do Not Cite or Distribute

Residential Bill Impact Differences Among Alternatives



Preliminary Results—Do Not Cite or Distribute

Residential Bill Increase From 2016 2033 with Alternative Weightings LTEMP Scenario: Alternative D4



Rate Increase (%) According to Size of Customers

LTEMP Scenario: 2023 — Alternative D4

Percent Retail Revenue Increase

Rank		Percent Retail Revenue Increase	Preference Ratio	Energy Sales
1	Frederick	0.01%	0.26%	69,079
2	Salt River Project	0.04%	1.09%	26,870,266
3	Los Alamos County	0.04%	0.98%	576,514
4	Wellton-Mohawk I.D.	0.04%	1.24%	90,452
5	Intermountain R.E.A.	0.06%	2.27%	2,187,742
6	Grand Valley E.C.	0.08%	3.33%	219,846
7	Central Valley E.C., Inc.	0.09%	2.04%	752,881
8	Lea County E.C., Inc.	0.09%	1.89%	815,715
9	ED-	0.10%	3.54%	611,001
10	Washington (UAMPS)	0.10%	2.89%	92,323
11	Farmers E.C., Inc.	0.11%	2.93%	431,392
12	Colorado Springs Utilities	0.12%	3.29%	4,564,279
13	Holy Cross E.A.	0.12%	3.59%	1,154,227
14	Safford	0.12%	4.91%	68,361
15	Yampa Valley Rural	0.13%	4.15%	566,376
16	Santa Clara (UAMPS)	0.14%	3.84%	35,231
17	Mesa (APPA)	0.15%	4.85%	321,733
18	Navopache E.C., Inc.	0.17%	6.96%	393,634
19	Torrington (WMPA)	0.19%	5.66%	101,893
20	Glenwood Springs	0.20%	5.00%	125,951
21	Fort Laramie (WMPA)	0.20%	8.98%	1,250
22	Gallup	0.20%	6.83%	221,688
23	Lamar Utilities Board (ARPA)	0.21%	9.53%	91,469
24	Lehi (UAMPS)	0.22%	6.26%	235,319
25	Kaysville (UAMPS)	0.22%	6.01%	136,008
26	Sierra Electric Cooperative, Inc. Eleph	0.22%	11.56%	39,236
27	Tohono O'odham Reservation	0.23%	9.20%	92,532
28	Thatcher	0.23%	7.26%	23,800
29	Raton	0.24%	12.46%	46,424
30	Sangre de Cristo Electric Association, I	0.24%	11.56%	103,318

Rank		Percent Retail Revenue Increase	Preference Ratio	Energy Sales
118	Beaver (UAMPS)	1.03%	25.5%	29,637
119	Ephraim (UAMPS)	1.03%	28.2%	34,869
120	Manti (UMPA)	1.04%	28.6%	18,079
121	Murray (UAMPS)	1.05%	27.9%	425,169
122	Spanish Fork (UMPA)	1.05%	28.6%	223,630
123	Dixie Escalante R.E.A., Inc. (Deseret	1.07%	19.7%	392,574
124	Brigham City	1.08%	26.6%	150,835
125	Provo (UMPA)	1.09%	28.6%	779,742
126	Ocotillo I.D.	1.10%	21.4%	12,599
127	Paragonah (UAMPS)	1.10%	37.2%	1,780
128	Fairview (UAMPS)	1.13%	36.5%	7,405
129	Flowell E.A., Inc. (Deseret)	1.17%	27.7%	31,965
130	Morgan (UAMPS)	1.18%	41.8%	18,839
131	Levan (UMPA)	1.20%	28.6%	4,877
132	Nephi (UMPA)	1.26%	28.6%	70,071
133	Parowan (UAMPS)	1.31%	31.3%	15,941
134	Monroe (UAMPS)	1.36%	32.7%	12,387
135	Navajo Tribal Utility Authority	1.37%	30.7%	654,770
136	Cocopah Reservation	1.37%	30.8%	64,267
137	Helper	1.45%	16.1%	10,300
138	Bountiful (UAMPS)	1.48%	42.8%	293,765
139	Oak City (UAMPS)	1.51%	34.5%	2,912
140	Gunnison	1.55%	35.1%	63,853
141	Ak-Chin Municipal	1.59%	43.0%	28,935
142	Truth or Consequences	1.61%	53.7%	43,492
143	Holden (UAMPS)	1.62%	57.2%	1,910
144	Maricopa County MWCD No.	1.73%	37.1%	41,126
145	Kanosh (UAMPS)	1.86%	58.2%	2,022
146	Meadow (UAMPS)	1.98%	62.2%	1,751
147	Enterprise (UAMPS)	1.98%	50.7%	8,730

Rate Increase ($/Month) According to Size of Customers

LTEMP Scenario: Alternative D4

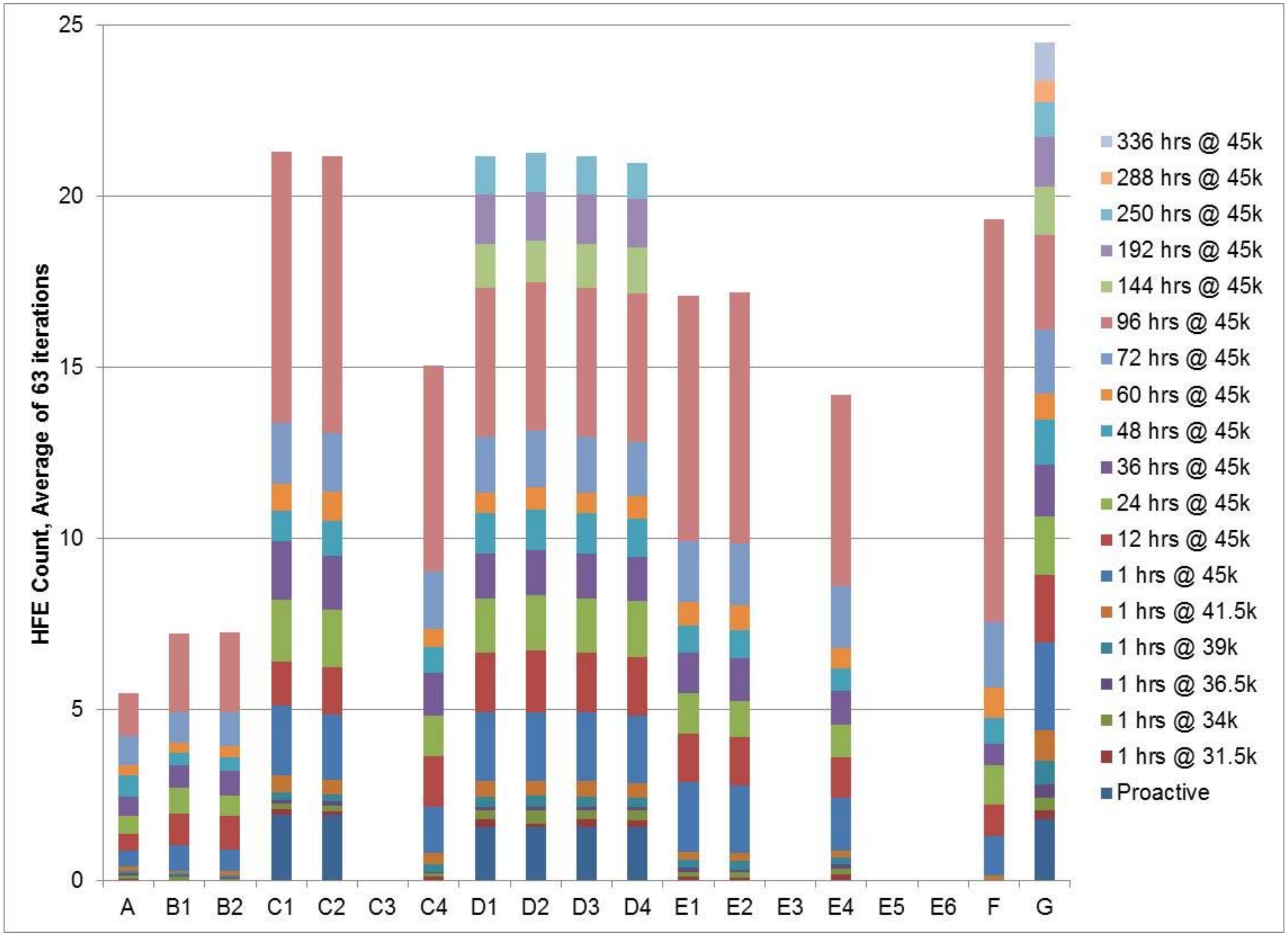
Residential Bill Increase

2023

Rank		Residential Bill Increase	Preference Ratio	Energy Sales
1	Maricopa County MWCD No.	0.00	37.09%	41,126
2	Frederick	0.01	0.26%	69,079
3	Los Alamos County	0.03	0.98%	576,514
4	Wellton-Mohawk I.D.	0.05	1.24%	90,452
5	Salt River Project	0.06	1.09%	26,870,266
6	Intermountain R.E.A.	0.08	2.27%	2,187,742
7	Washington (UAMPS)	0.09	2.89%	92,323
8	Lea County E.C., Inc.	0.09	1.89%	815,715
9	Central Valley E.C., Inc.	0.09	2.04%	752,881
10	Farmers E.C., Inc.	0.10	2.93%	431,392
11	Colorado Springs Utilities	0.11	3.29%	4,564,279
12	Grand Valley E.C.	0.11	3.33%	219,846
13	Glenwood Springs	0.13	5.00%	125,951
14	Yampa Valley Rural	0.13	4.15%	566,376
15	Gallup	0.14	6.83%	221,688
16	Navopache E.C., Inc.	0.15	6.96%	393,634
17	Safford	0.15	4.91%	68,361
18	Torrington (WMPA)	0.16	5.66%	101,893
19	Holy Cross E.A.	0.16	3.59%	1,154,227
20	Fort Laramie (WMPA)	0.17	8.98%	1,250
21	Price	0.17	7.93%	76,515
22	Mesa (APPA)	0.17	4.85%	321,733
23	Santa Clara (UAMPS)	0.18	3.84%	35,231
24	ED-	0.18	3.54%	611,001
25	Lusk (WMPA)	0.18	8.98%	15,082
26	Mora-San Miguel Electric Cooperative,	0.20	11.56%	70,042
27	Lehi (UAMPS)	0.20	6.26%	235,319
28	Farmington	0.20	6.73%	1,136,894
29	Cody (WMPA)	0.20	8.98%	111,437
30	Kit Carson Electric Cooperative, Inc Ta	0.22	11.56%	284,238

Rank		Residential Bill Increase	Preference Ratio	Energy Sales
118	Bridger Valley E.A., Inc. (Deseret)	0.83	23.8%	148,987
119	Murray (UAMPS)	0.83	27.9%	425,169
120	Paragonah (UAMPS)	0.84	37.2%	1,780
121	Provo (UMPA)	0.84	28.6%	779,742
122	Gunnison	0.90	35.1%	63,853
123	Monroe (UAMPS)	0.91	32.7%	12,387
124	Salem (UMPA)	0.92	28.6%	27,027
125	Parowan (UAMPS)	0.92	31.3%	15,941
126	Nephi (UMPA)	0.96	28.6%	70,071
127	Spanish Fork (UMPA)	0.97	28.6%	223,630
128	Truth or Consequences	0.98	53.7%	43,492
129	Garkane Power Assn., Inc. (Deseret)	0.98	27.2%	233,314
130	Manti (UMPA)	0.99	28.6%	18,079
131	Page (AZ) +	1.00	24.9%	110,179
132	Morgan (UAMPS)	1.02	41.8%	18,839
133	Dixie Escalante R.E.A., Inc. (Deseret	1.04	19.7%	392,574
134	Willwood	1.07	16.4%	1,012
135	Levan (UMPA)	1.07	28.6%	4,877
136	Holyoke	1.08	29.2%	22,216
137	ED- (APPA)	1.08	14.5%	111,302
138	Oak City (UAMPS)	1.10	34.5%	2,912
139	Kanosh (UAMPS)	1.18	58.2%	2,022
140	Ocotillo I.D.	1.29	21.4%	12,599
141	ED- Maricopa County	1.38	16.6%	63,165
142	Bountiful (UAMPS)	1.49	42.8%	293,765
143	Meadow (UAMPS)	1.52	62.2%	1,751
144	Holden (UAMPS)	1.52	57.2%	1,910
145	Enterprise (UAMPS)	1.64	50.7%	8,730
146	Flowell E.A., Inc. (Deseret)	1.80	27.7%	31,965
147	Ak-Chin Municipal	2.72	43.0%	28,935

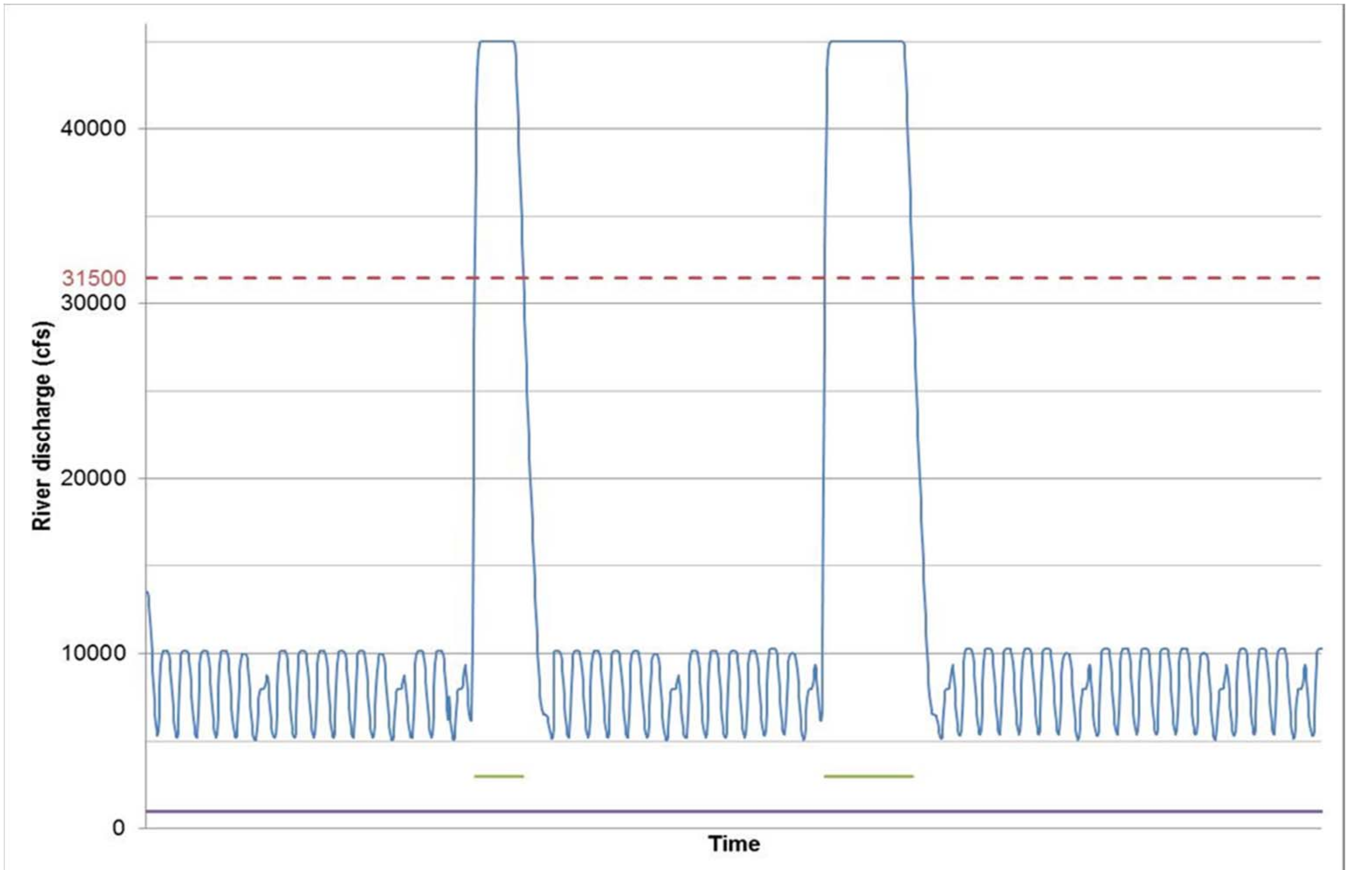
Mean Number of HFEs



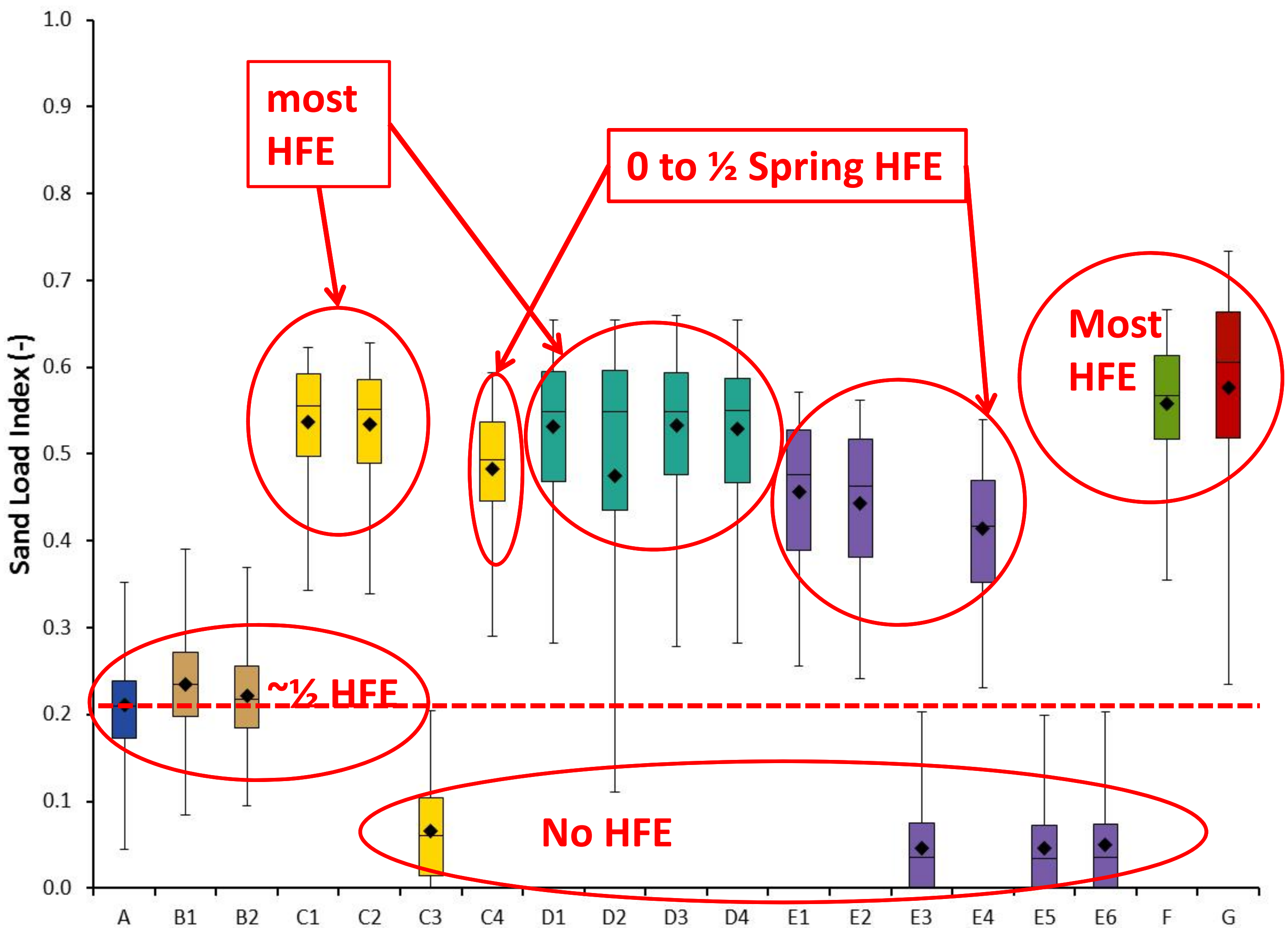
Preliminary Results—Do Not Cite or Distribute

Sand Load Index

- Ratio of the amount of sand transported at flows > 31,500 cfs to the total amount of sand transport over the entire LTEMP period.
- Assumed to be related to the capacity to build sandbars



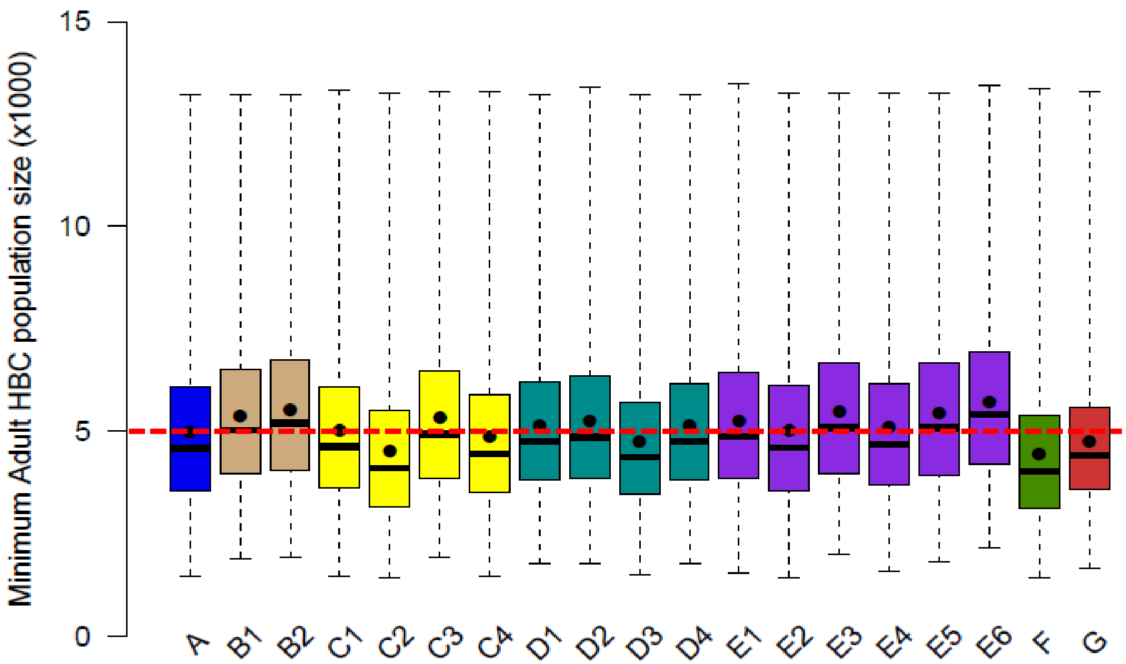
Sand Load Index



Preliminary Results—Do Not Cite or Distribute

- More HFEs = higher SLI
- Alternative D in top tier, performs as well as C, better than E

Minimum Adult HBC Population

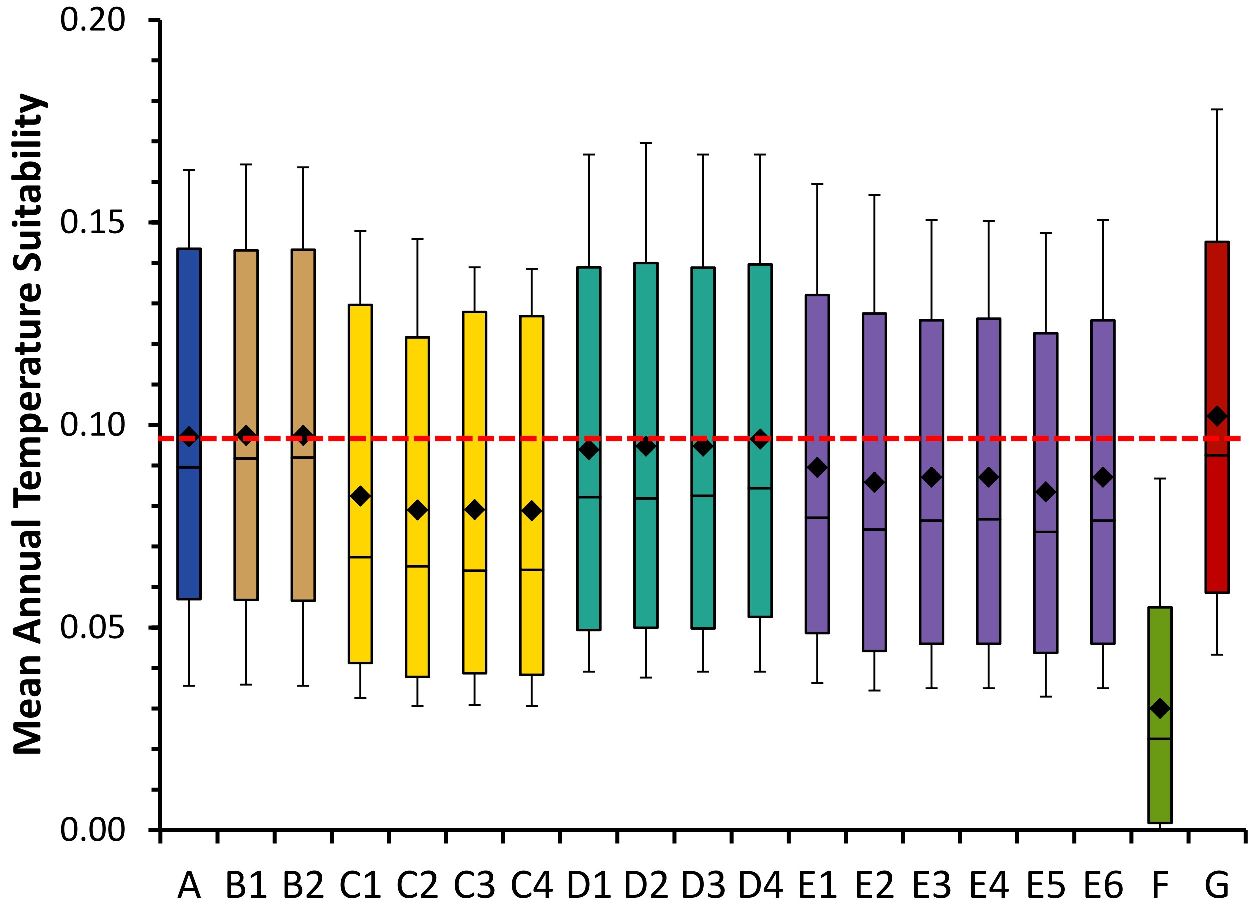


- Fewer trout and warmer temperatures result in more chub
- Because of the effect on trout, number of chub increases with increasing fluctuations, fewer HFEs, or more TMFs
- D1, D2, D4, C1, C4, E1, E4 are comparable to A (No-Action)
- B1, B2, C3, E3, E5, and E6 have more than no-action (fewer HFEs and/or higher fluctuations)
- D3, C2, C4 have fewer than no-action (no TMFs)
- F, G have fewer than no-action (steadier flows)

Preliminary Results—Do Not Cite or Distribute

Humpback Chub Aggregations – Temperature Suitability

Overall Mean for RM 157 and RM 213



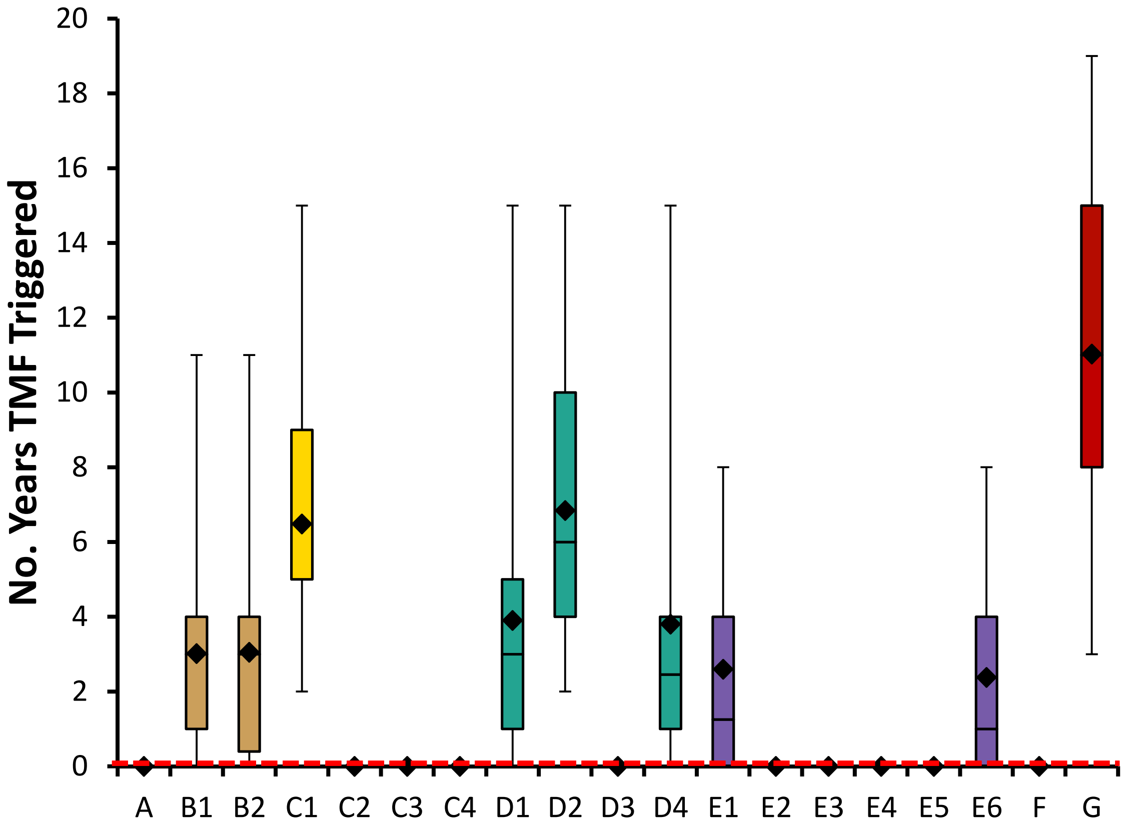
- Suitability of temperatures to support spawning, egg incubation, growth
- D, E, B, G very similar to A
- C and F lower

Preliminary Results—Do Not Cite or Distribute

Tribal Values—Trout Management

- Some Tribes view trout management flows and mechanical removal as having an adverse effect on the sanctity of the canyons, which are a traditional cultural property
- Past agreements with the Tribes required notification and consultation when mechanical removal and trout management actions are planned
- Location of actions is important
- Options to mitigate impacts will be explored in the EIS

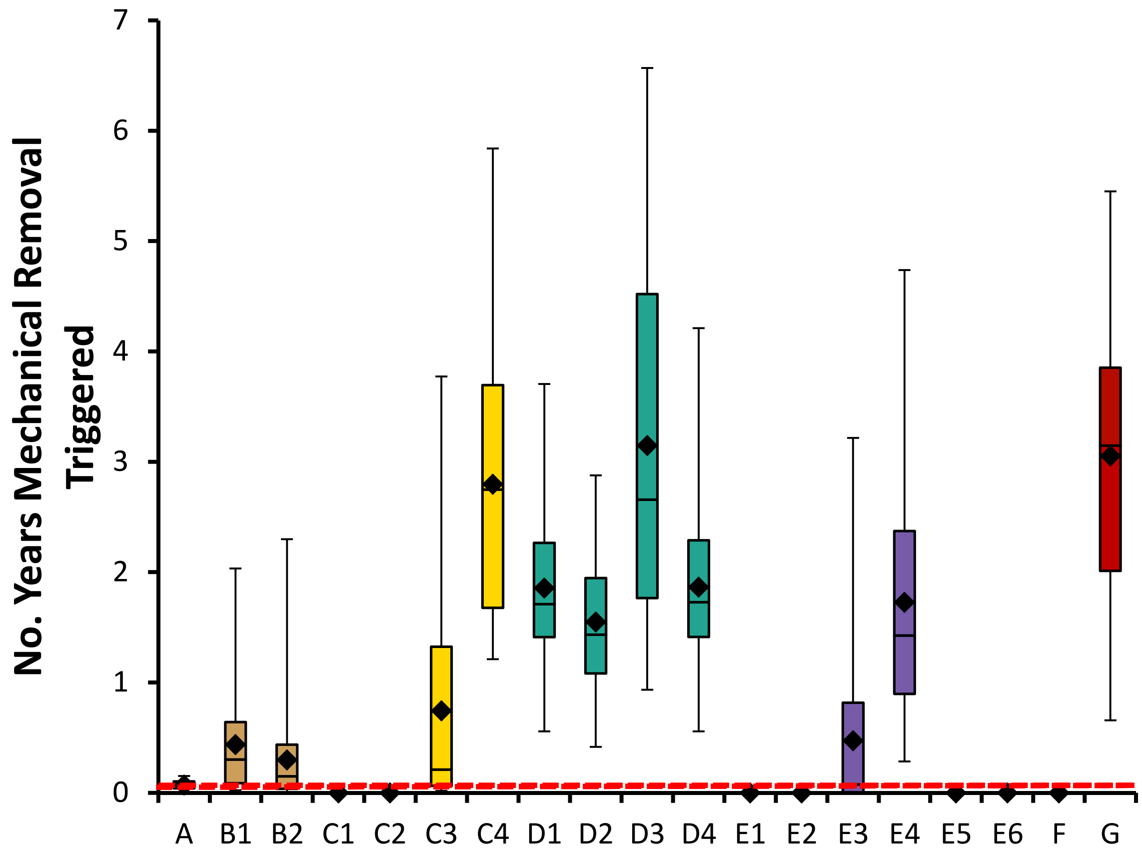
Tribal Values—Trout Management Flows



- G increases trout production and triggers significantly more TMFs (more HFEs, steady flows)
- No TMFs allowed in A, C2, C3, C4, D3, E2-5, F
- D1, D4 comparable to B, E1, E6, lower than C1 and D2 (bug flows)

Preliminary Results—Do Not Cite or Distribute

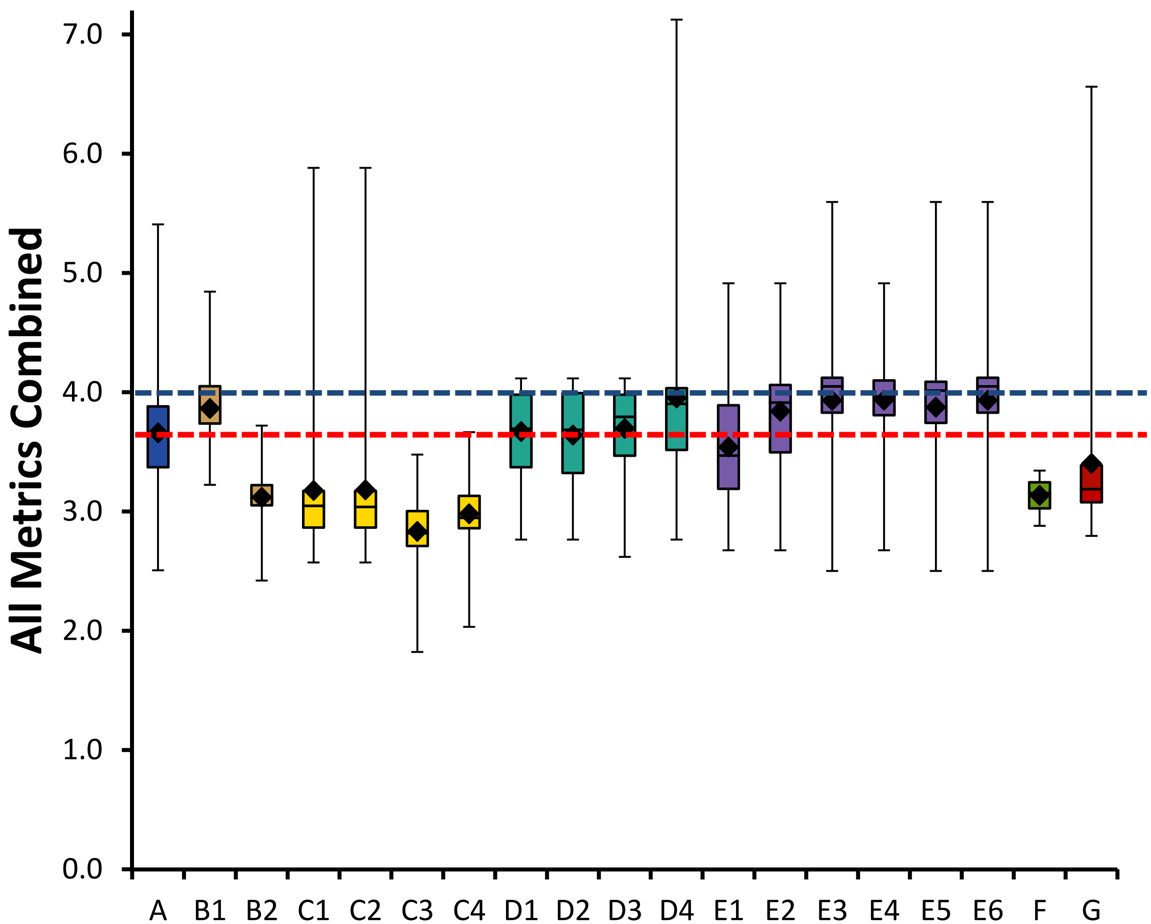
Tribal Values—Mechanical Removal



- Number of years where mechanical removal is triggered is relatively low (mean 3 or less)
- Higher in alternatives without TMFs
- Mechanical removal not allowed in C1, C2, E1, E2, E5, E6, or F
- D3 has highest number of removal years (no TMFs)
- D1, D2, and D4 have intermediate number of years with removal

Preliminary Results—Do Not Cite or Distribute

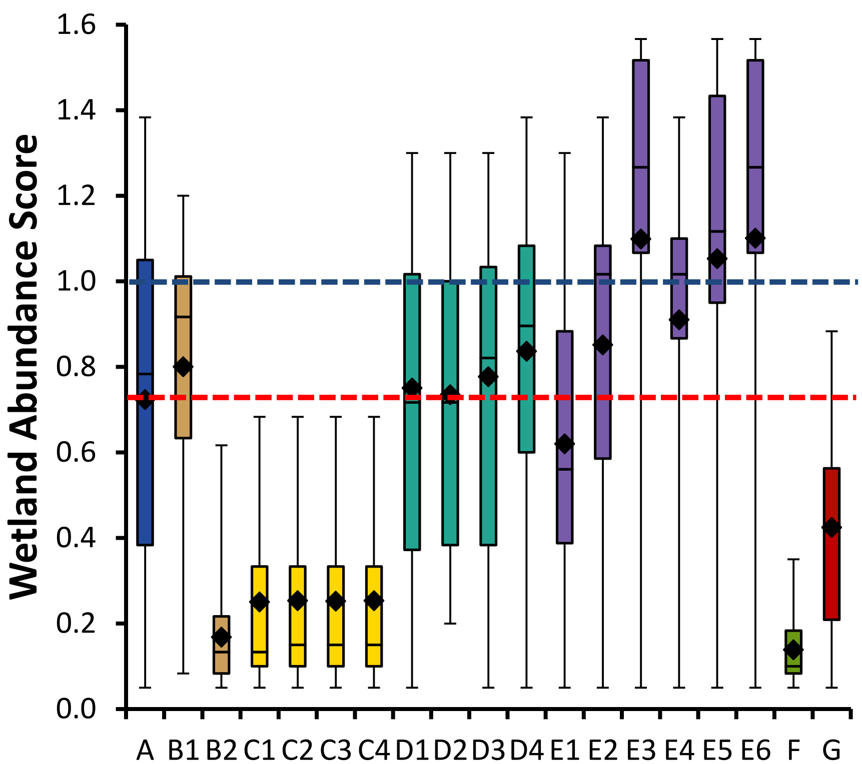
Riparian Native States and Diversity Index



- Values > 4 indicate an improvement over current conditions at the end of 20 years
- D4 has the highest index value of all LTSs
- D1, D2, and D3 are comparable to A (No-Action)
- B1 and E2-6 have higher index values than A
- B2, C1-4, F, and G have index values less than A

Preliminary Results—Do Not Cite or Distribute

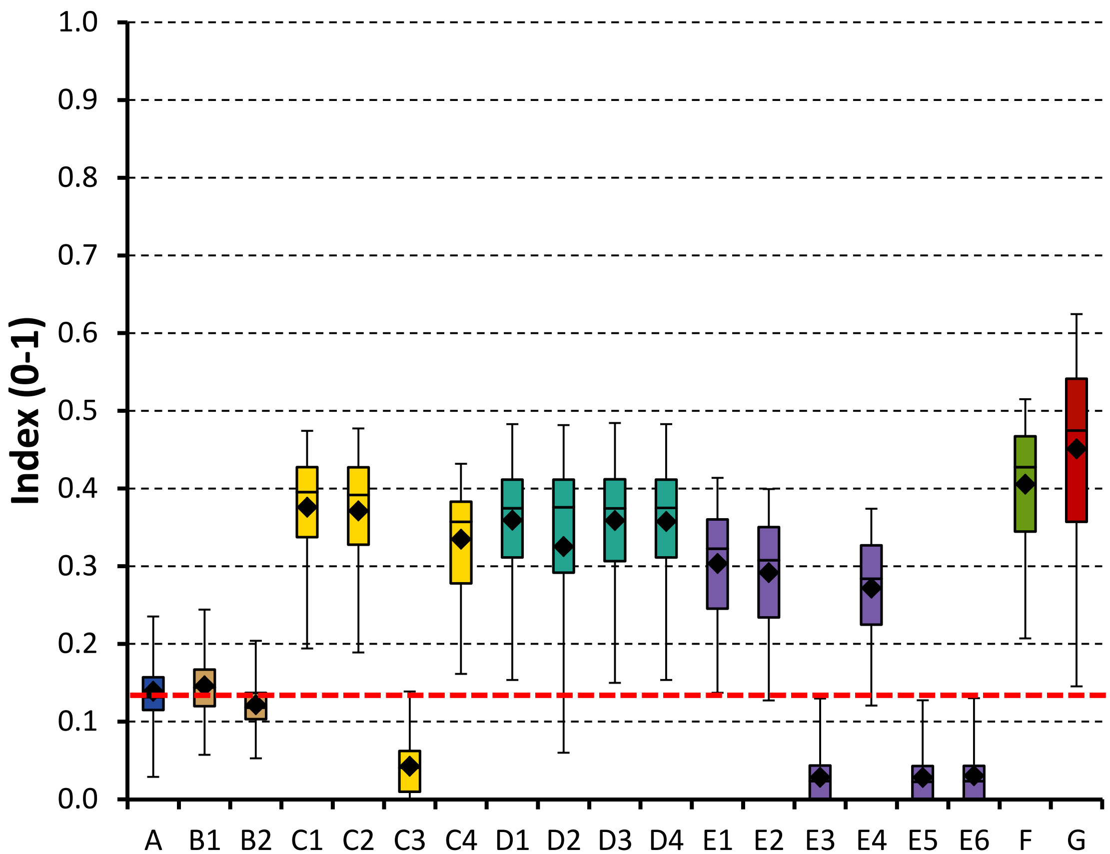
Tribal Values—Wetland Abundance



- A value of 1.0 = 4.6 acres of wetlands maintained, lower values indicate a net loss, higher values an increase
- D would result in a small increase in wetland abundance relative to A (No-Action)
- Some versions of E would result in increases relative to starting condition (those without HFEs)
- B2, C, F, G all show large decreases in wetland abundance (more HFEs, low maximum flows or high maximum flows)

Preliminary Results—Do Not Cite or Distribute

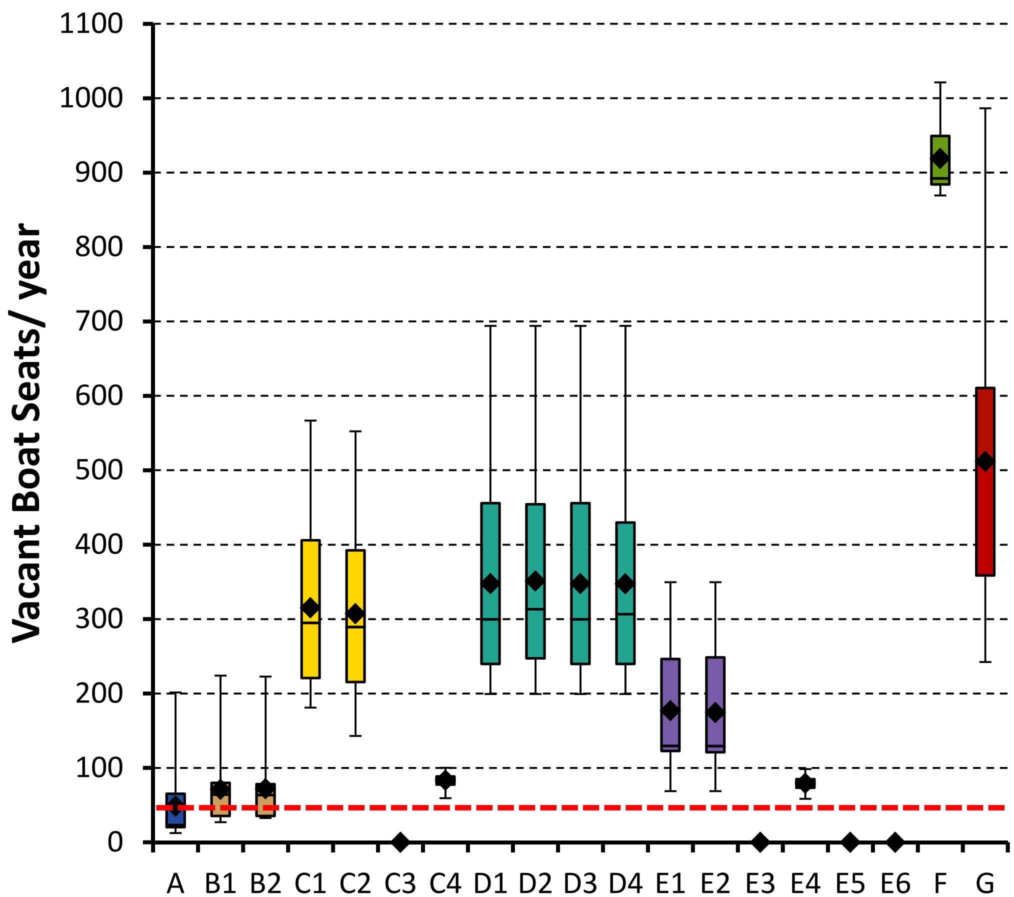
Camping Area Index



- Higher index = conditions better to create/retain campsite area
- Index driven by number of HFEs (SLI)
- Very low values for LTSs without HFEs
- D much higher than A (No-Action), comparable to C, higher than E, lower than F, G

Preliminary Results—Do Not Cite or Distribute

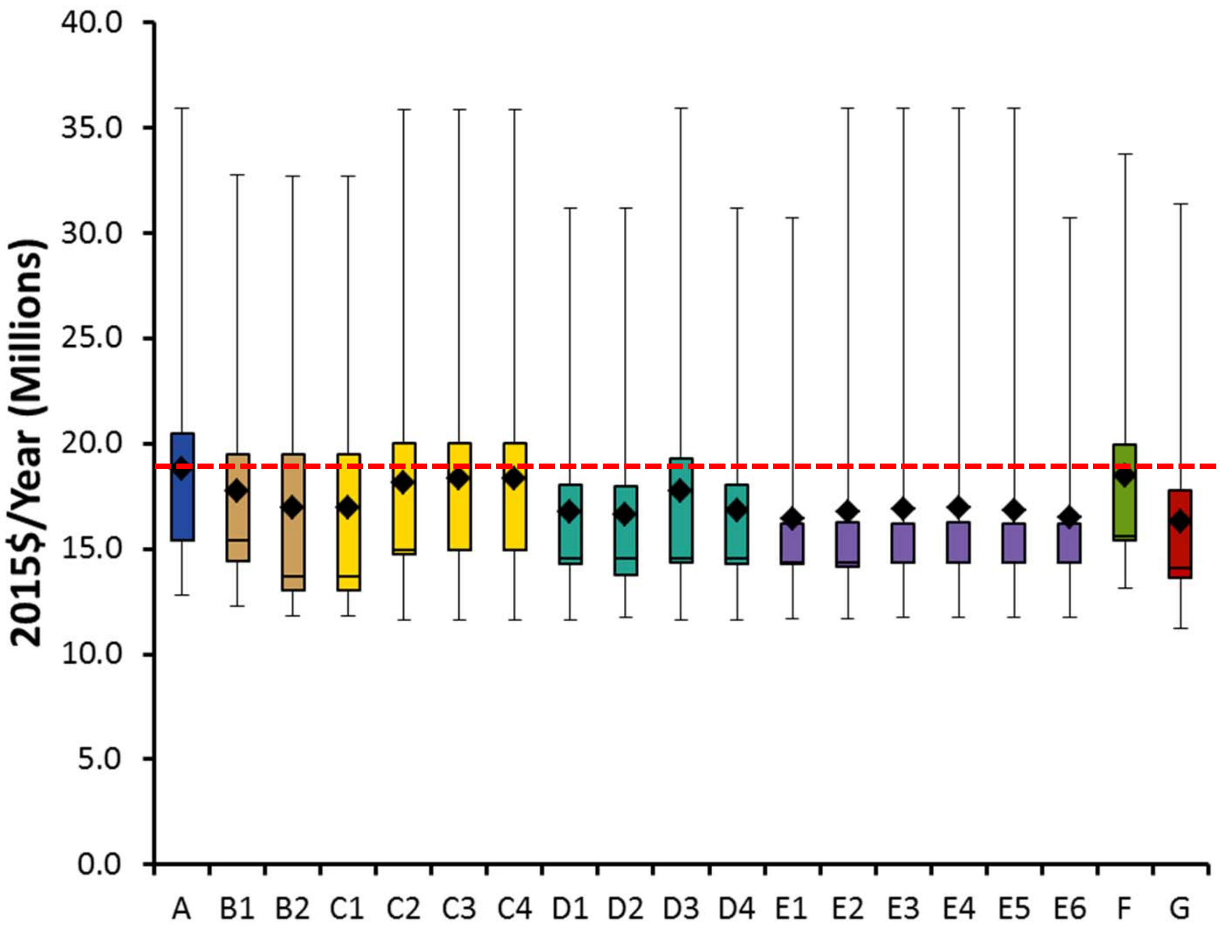
Glen Canyon Rafting Use Metric



- Higher value = more HFE lost trips
- F, G have highest values (most HFEs)
- D, C relatively high (more HFEs and extended duration HFEs)
- E relatively low (no spring HFEs the first 10 years)
- A (No-Action), B, C3, E3, E5, E6 have lowest values (fewest HFEs)

Preliminary Results—Do Not Cite or Distribute

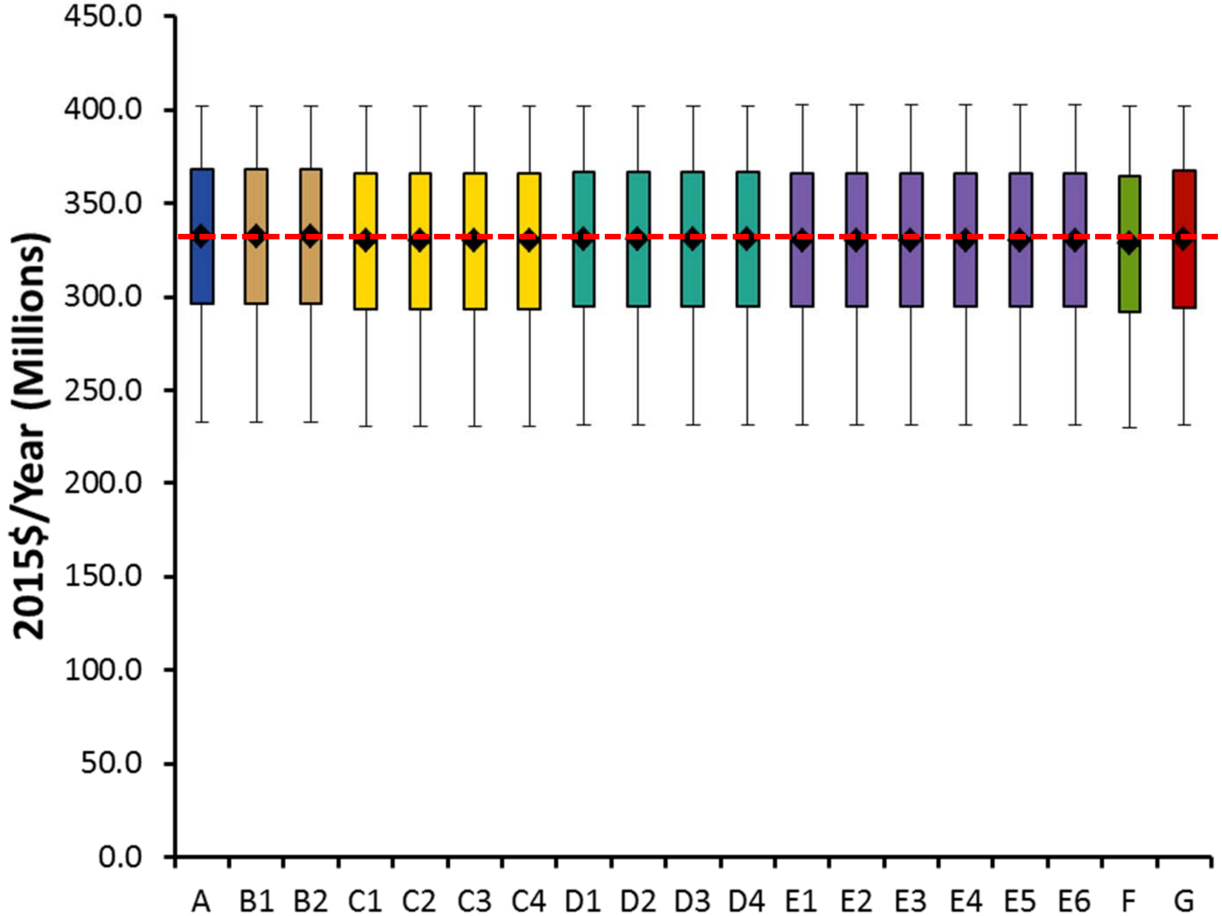
UGC Commercial WW Boating Annual NEV (2015$)



- Net economic value is the value over and above the amount spent on the trip (willingness to pay)
- Most alternatives have lower values than A (No-Action) (effect of HFEs and fluctuation levels)
- F is comparable to A because of high steady release volume in May and June

Preliminary Results—Do Not Cite or Distribute

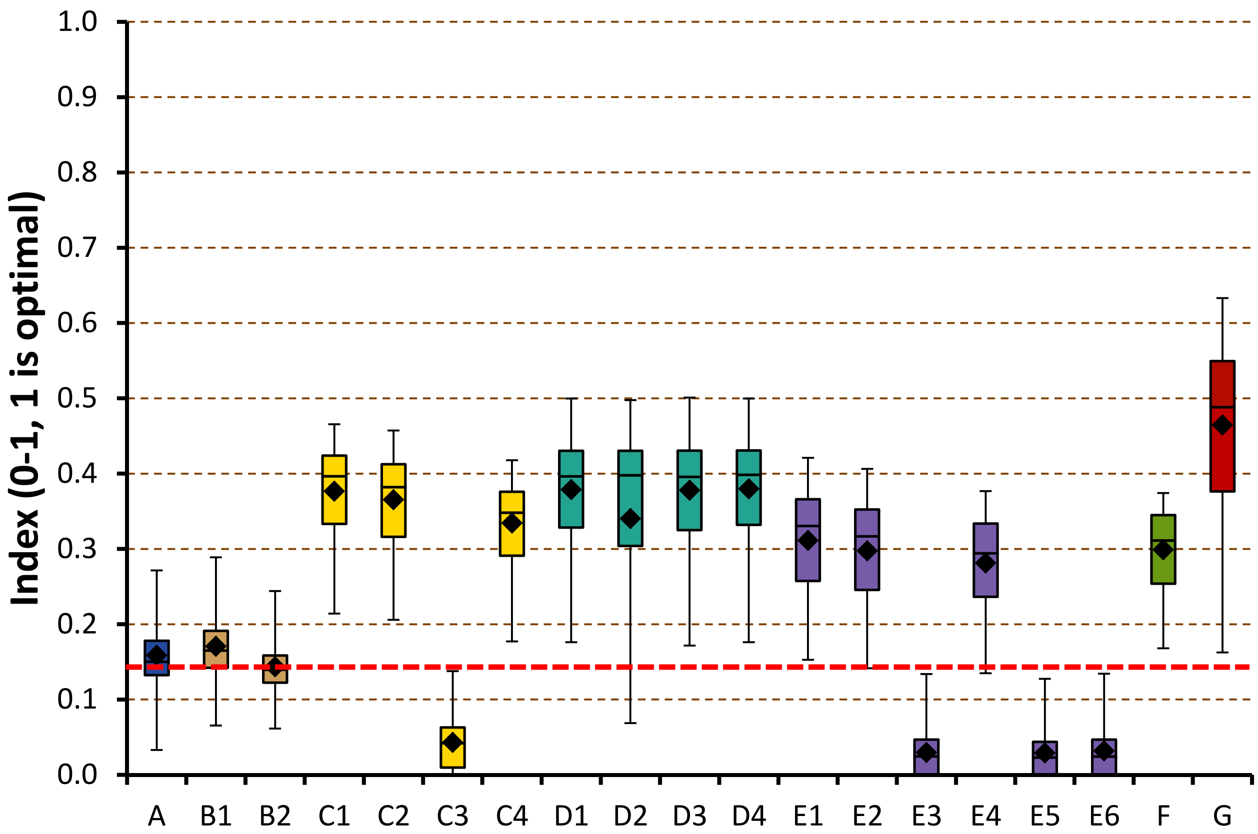
Lake Powell General Recreation Annual NEV (2015$)



- No difference among alternatives for NEV of lake recreation

Preliminary Results—Do Not Cite or Distribute

Cultural Resources--Wind Transport Index



- Higher index = better conditions
- D has higher values than all other alterna-tives but G, considerably higher than A (more HFEs, moderate flows in windy season)

Preliminary Results—Do Not Cite or Distribute

Conclusions—Alternative D Performance

- Alternative D performs well with regard to:
  - Compliance with operating tiers
  - Capacity and generation value, rate payer impacts
  - Bar-building and sand mass balance
  - Chub and trout numbers
  - Riparian vegetation (native communities, diversity, and wetland abundance)
  - Recreational values
  - Potential for cultural resource protection