

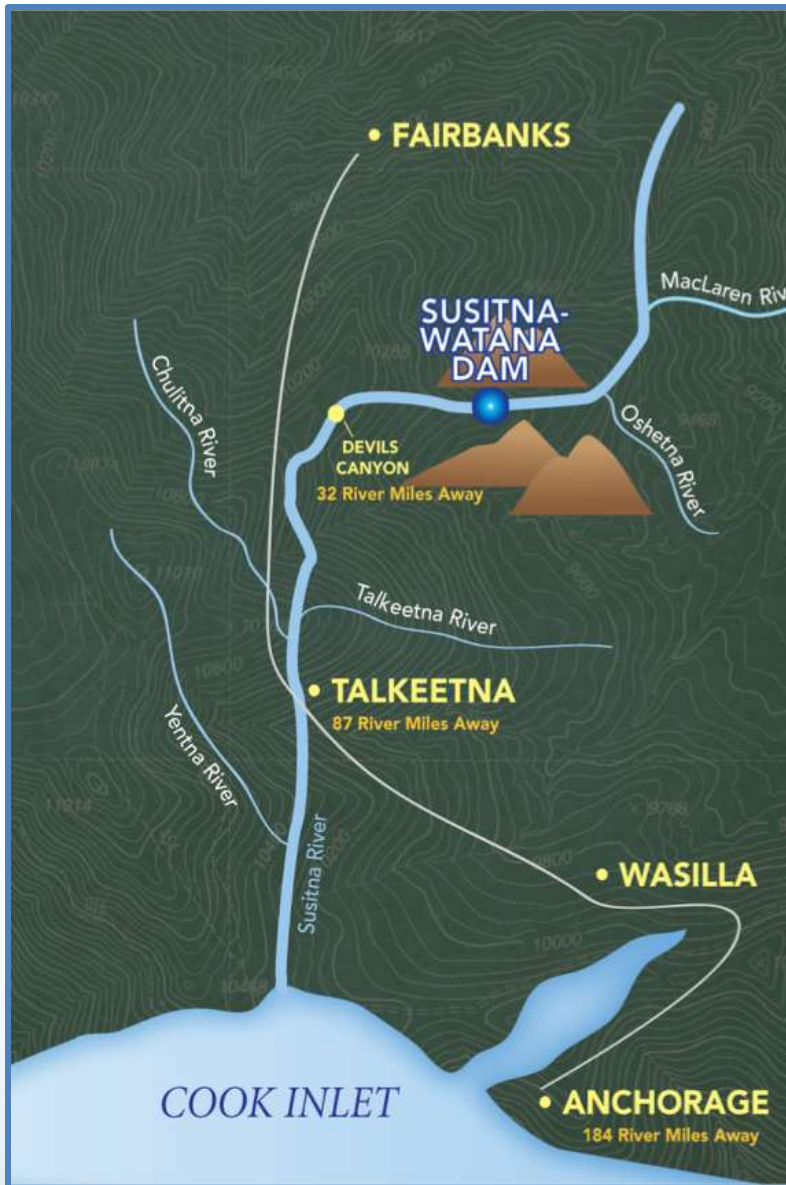
Technical Team Meeting

Riverine Modeling Proof of Concept

Representative Year Selection

April 15-17, 2014

Prepared by
Tetra Tech, R2 & HDR



 SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Riverine TT Meeting – Issues Raised

- How will representative years account for wet, average, and dry runoff years versus warm, average, and cold winters?

Background*

- “... a 50-year, continuous period of record ... will be used for 1-D modeling,”
- “and shorter periods will be used for 2-D modeling...”
- “The 50-year period will be divided ... to provide comparison: yr-0, yr-25, & yr-50.”
- “... specific years or portions of annual hydrographs for selected wet, average, and dry hydrologic conditions and warm and cool PDO** phases.”

* RSP Section 6.6.4.2.2.1

** PDO – Pacific Decadal Oscillation, a climate index based on sea surface temperatures in the North Pacific (Mantua et al. 1977)

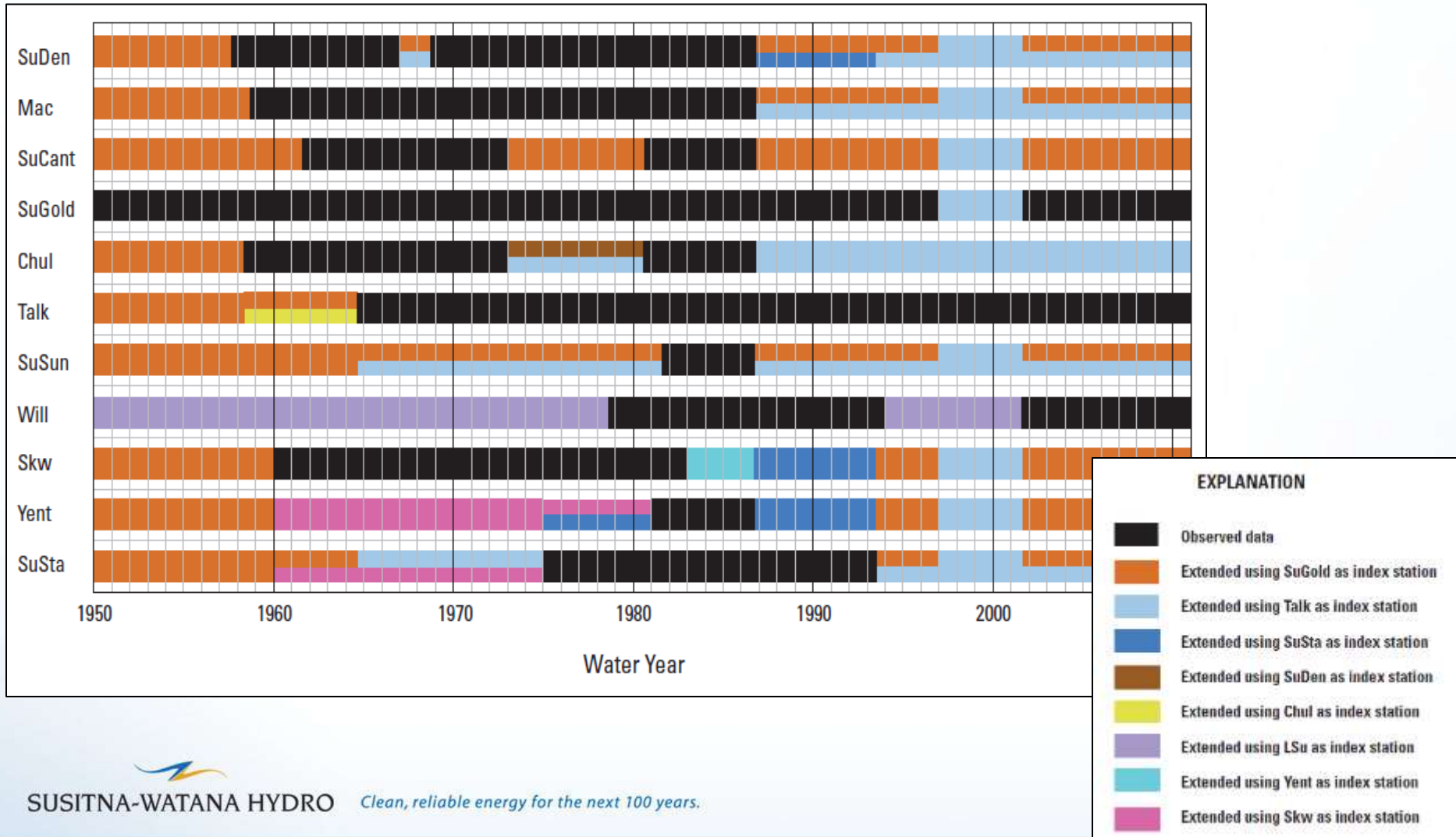
Objectives

- Identify 50 years out of 61 years available in USGS streamflow record extension study.
- Identify candidate representative years for (wet, average & dry) X (warm and cool PDO)
 - Fluvial Geomorphology Modeling (FGM) concerned with open-water period
 - Ice Processes concerned with ice cover period
 - IFS concerned with both

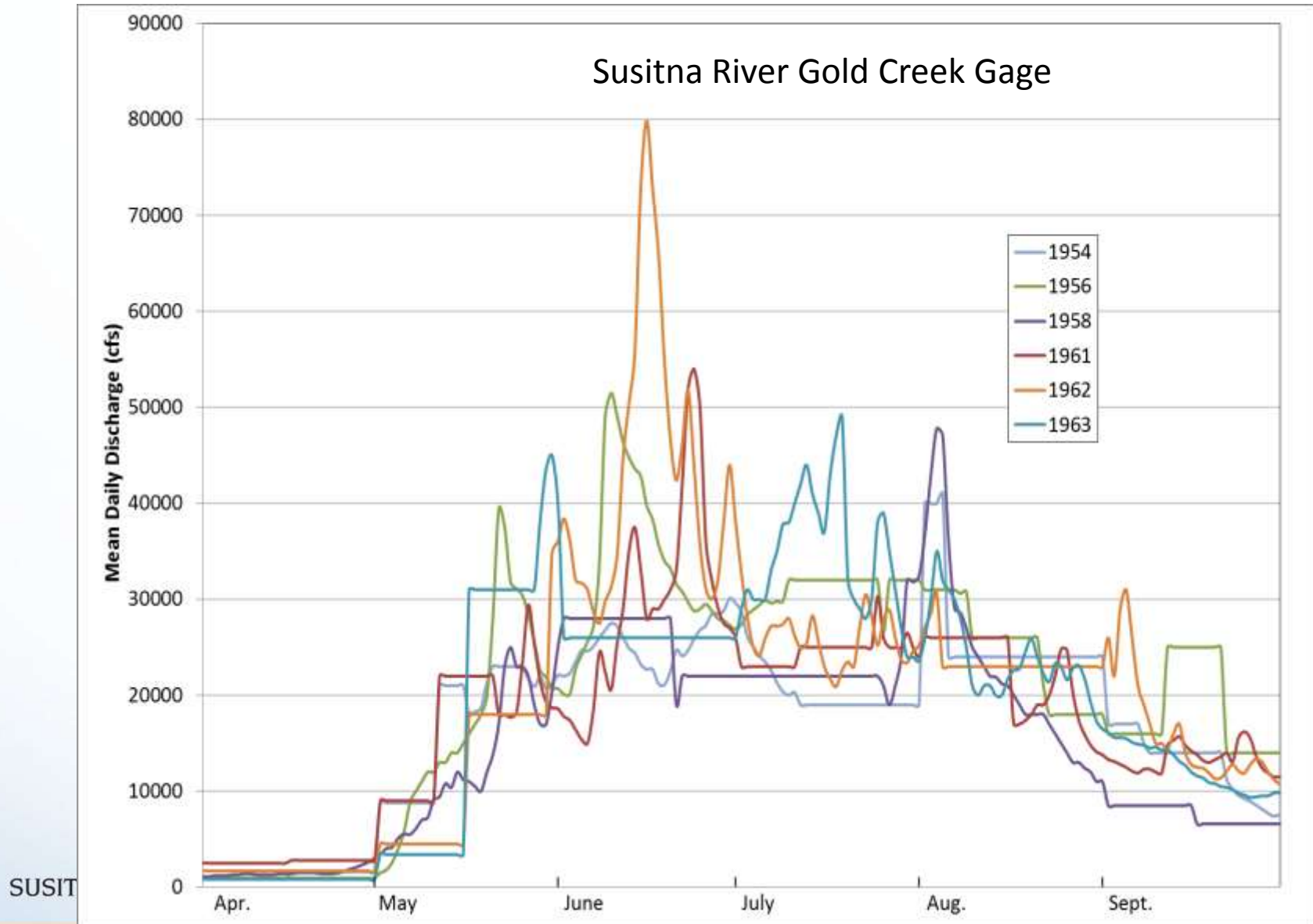
Methods - FGM

- Focus on Susitna River Gold Creek Gage – longest period of record (56 of the 61 years) to select 50 years.
- Group by PDO
- Rank by runoff volume (water year and open water periods) and maximum flows
- Identify candidate years and recommend representative years.

USGS Streamflow Record Extension



Likely Estimated Flows (USGS)

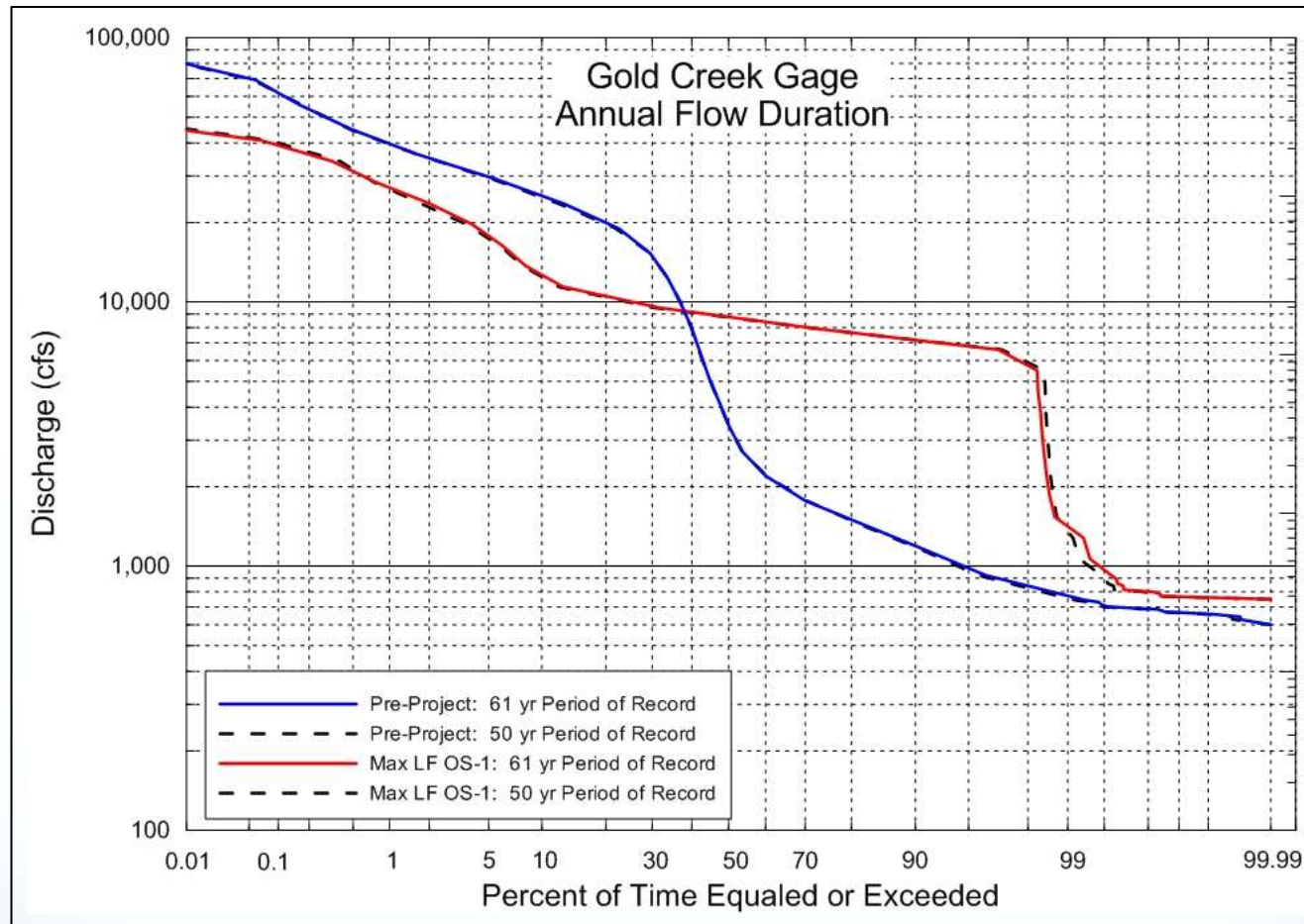


Selected 50-year period

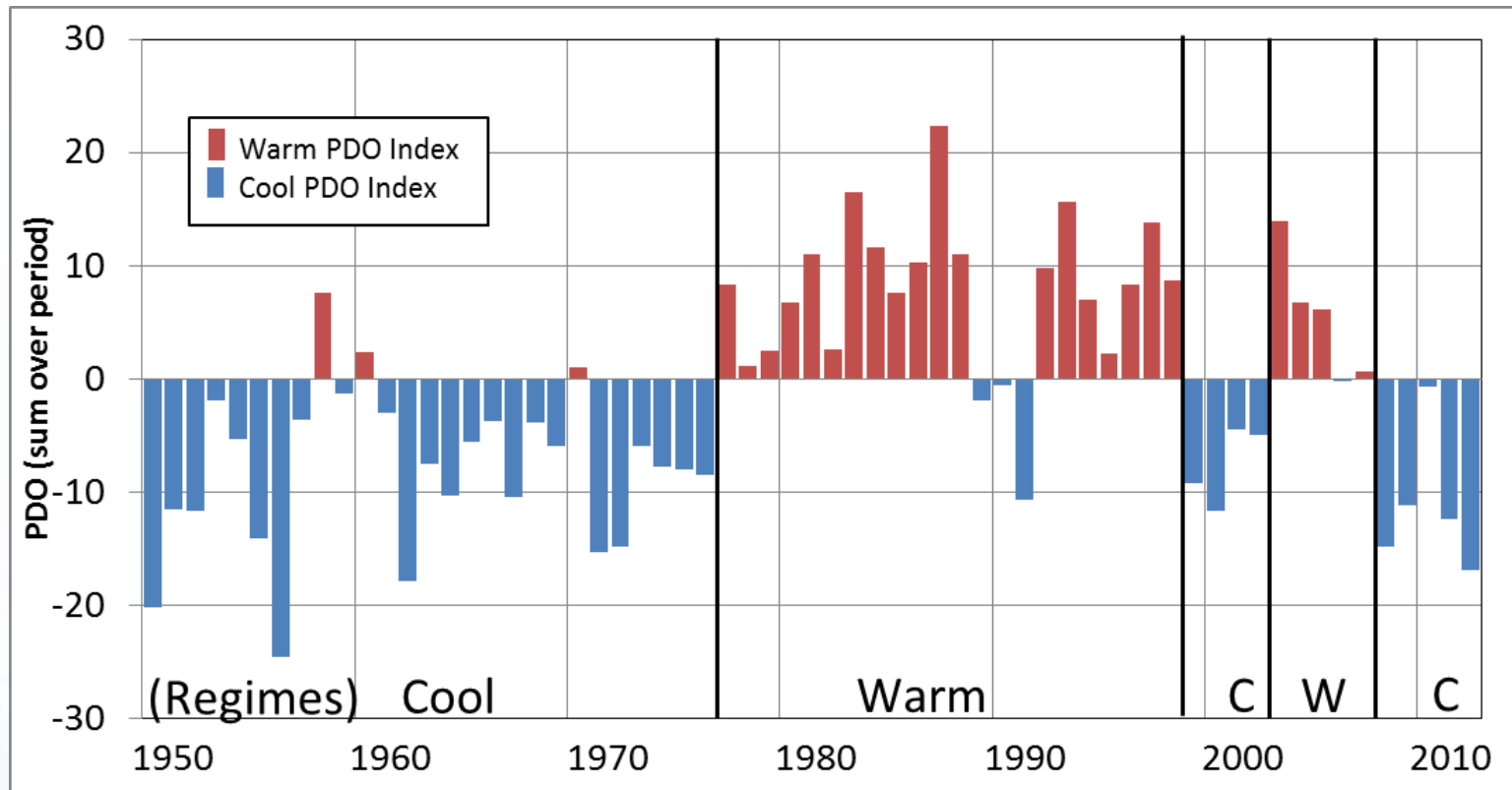
- Exclude 1997-2001 when all other gages synthesized from USGS Talkeetna River Gage
- Exclude 1954, 1956, 1958, and 1961-1963 when long periods (weeks to >1 month) were estimated as constant.
- Selected period is 1950 – 2011 minus excluded years.



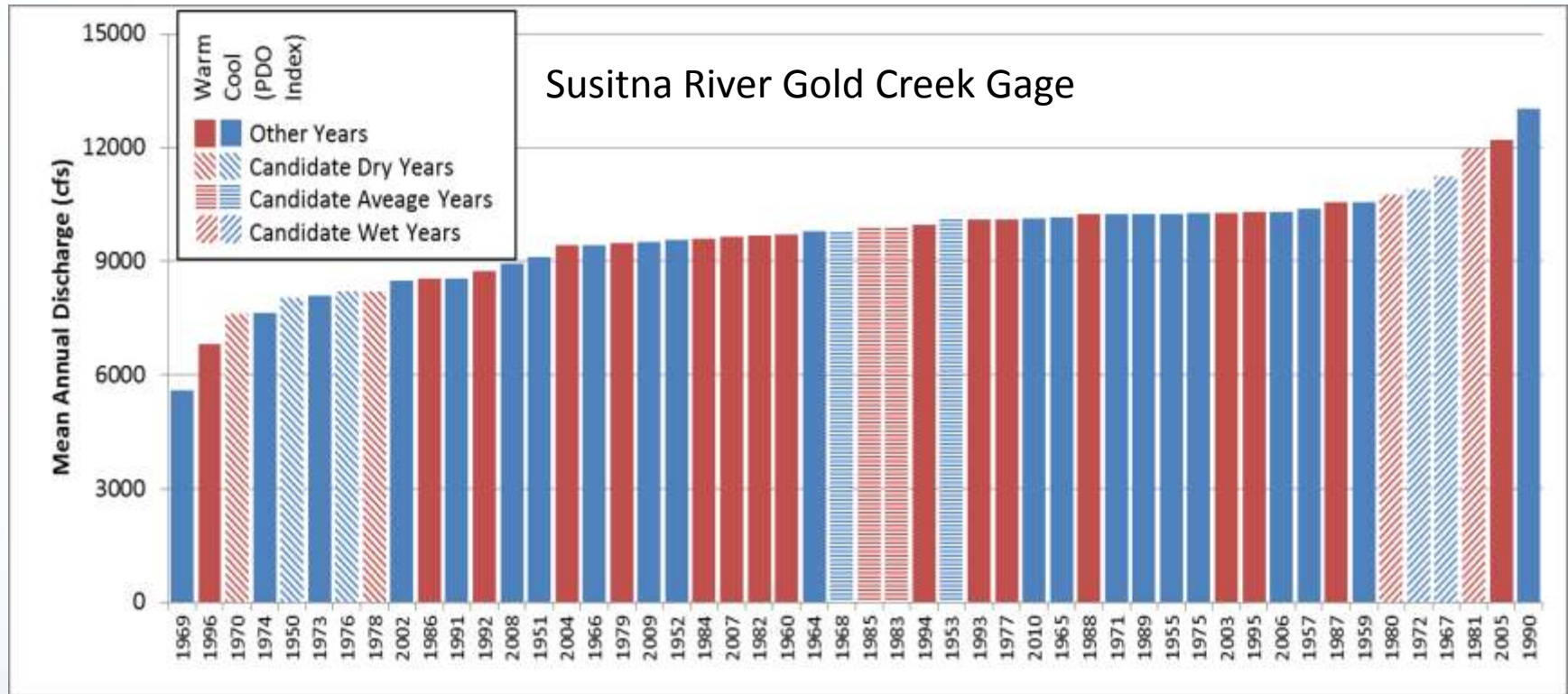
Flow Duration Curves, 50 and 61 years



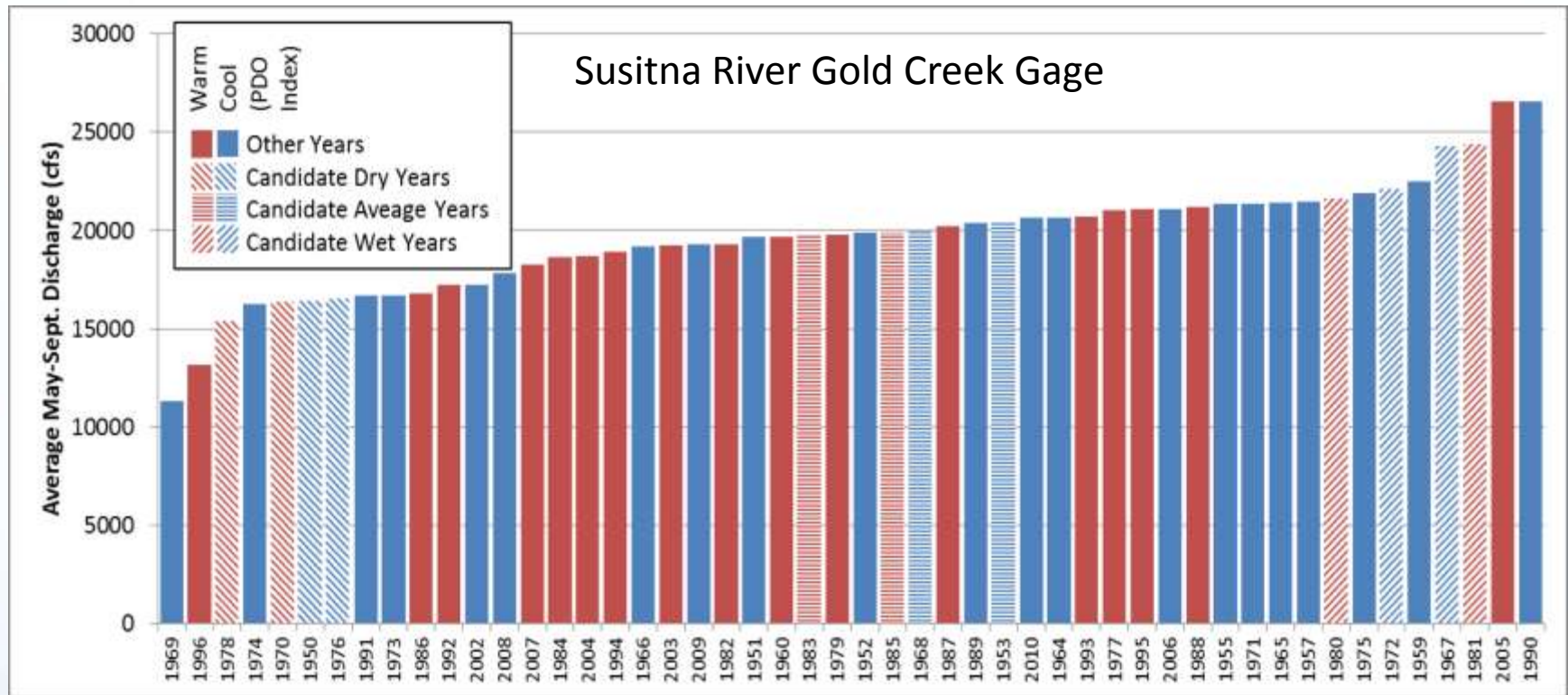
Water Year PDO Index and Regime



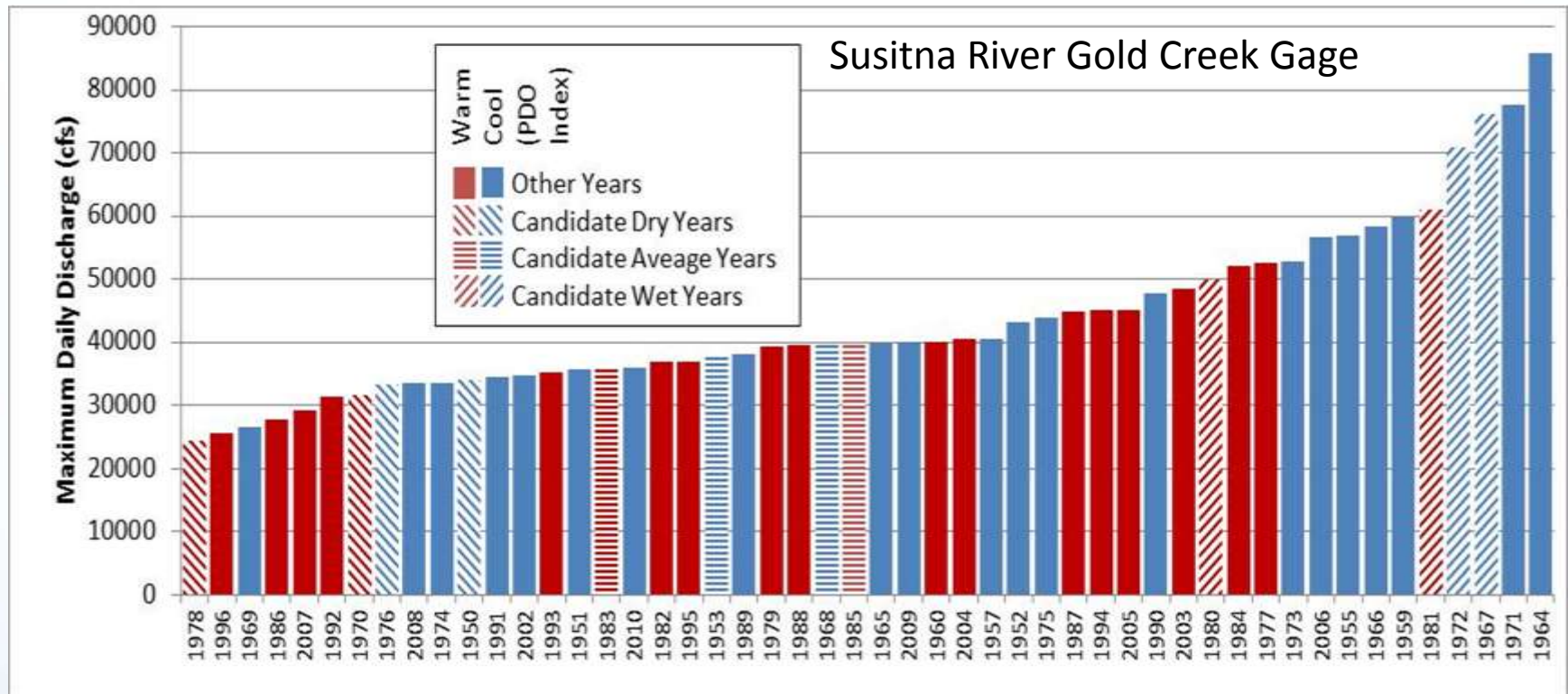
Runoff Ranking - Water Year



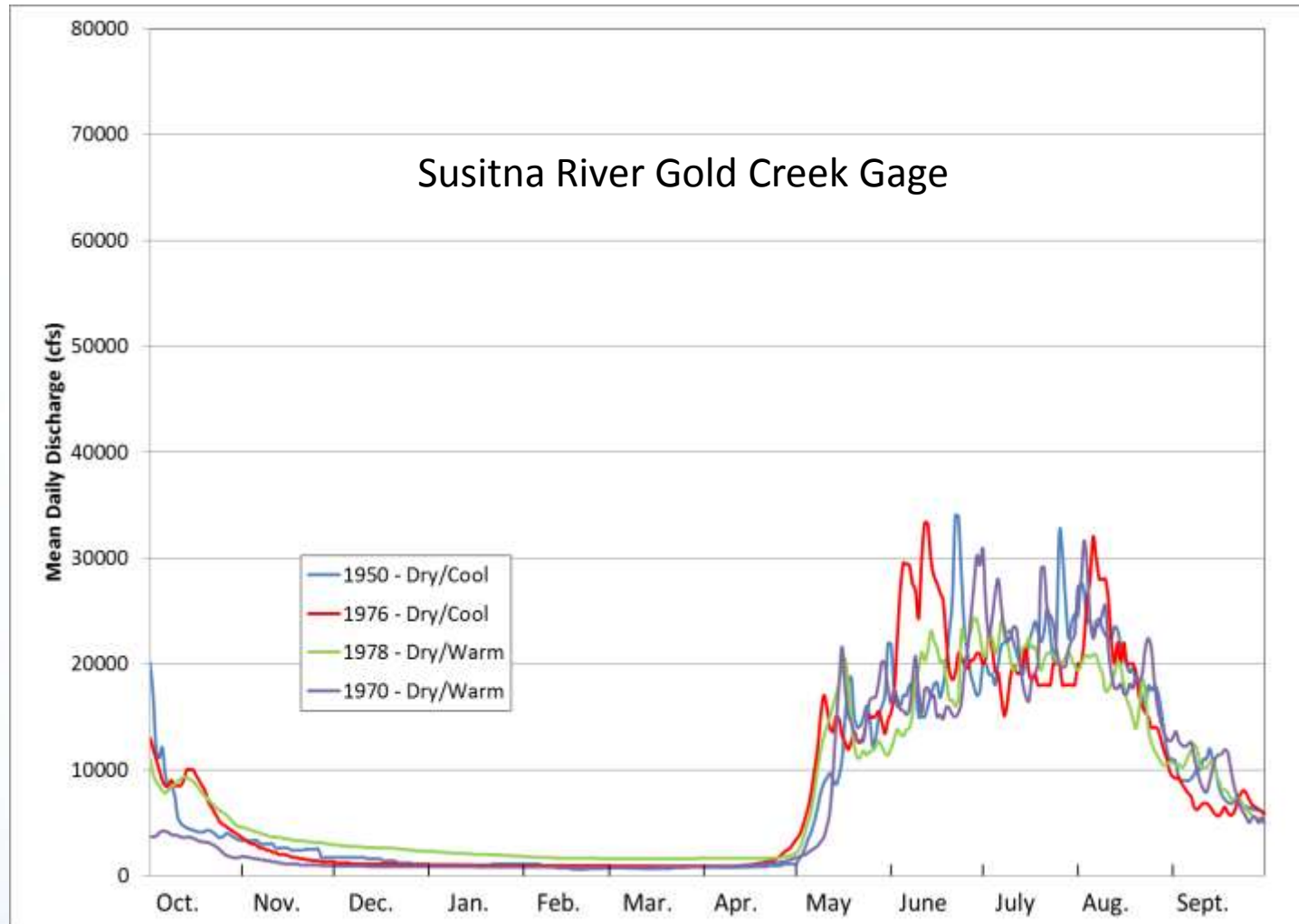
Runoff Ranking - Open Water (May-Sept.)



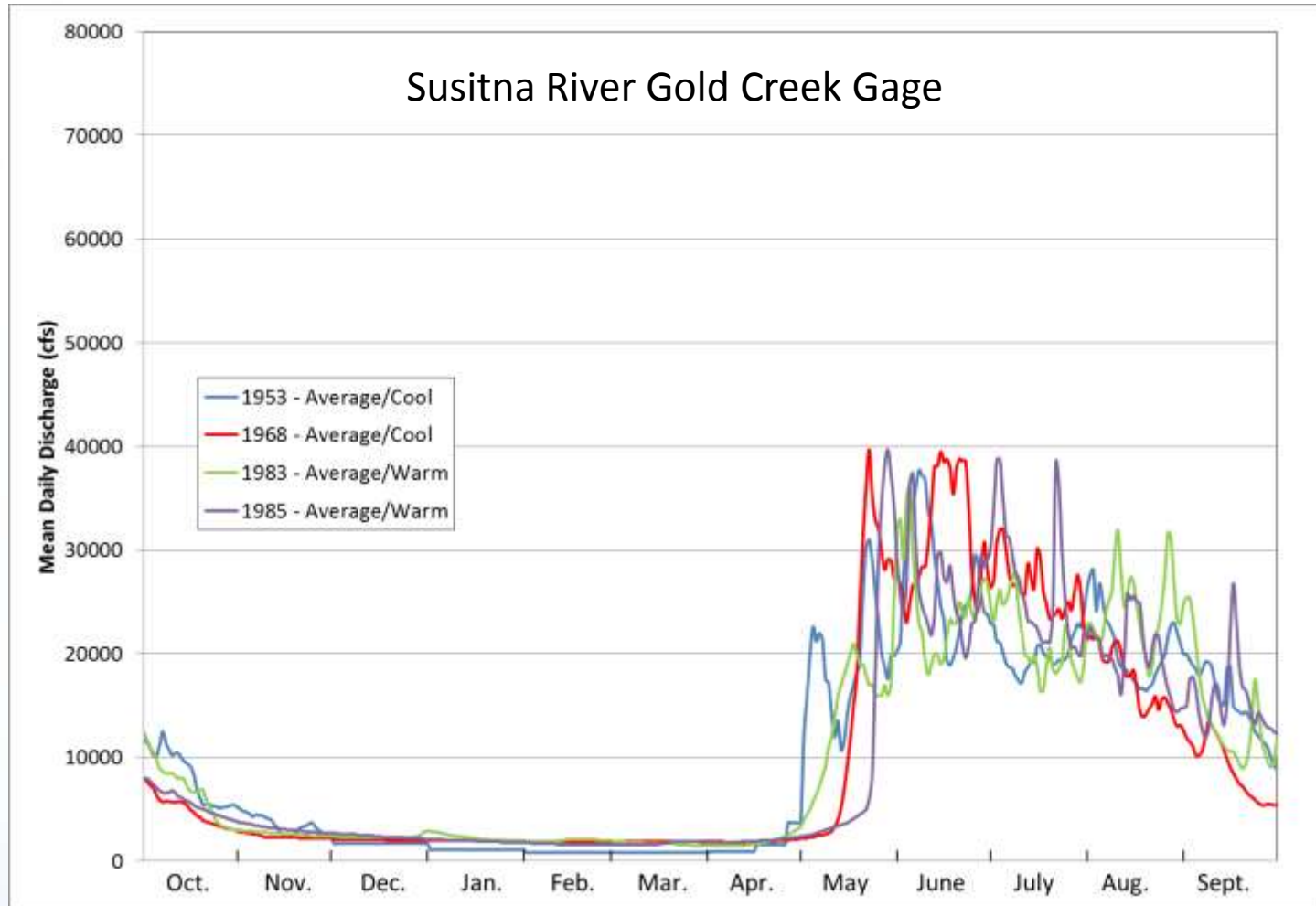
Runoff Ranking – Maximum Daily Flow



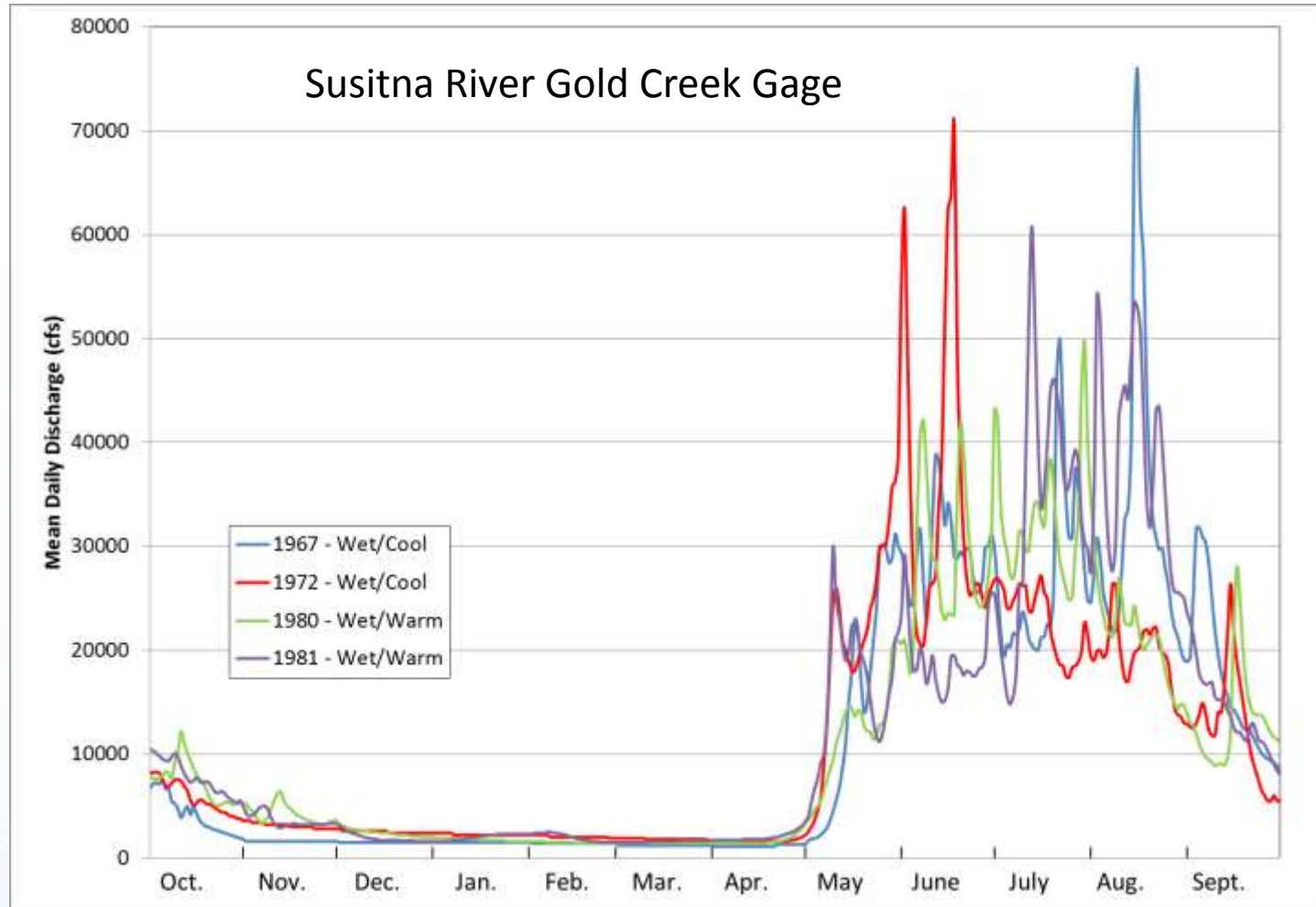
Candidate Dry Years



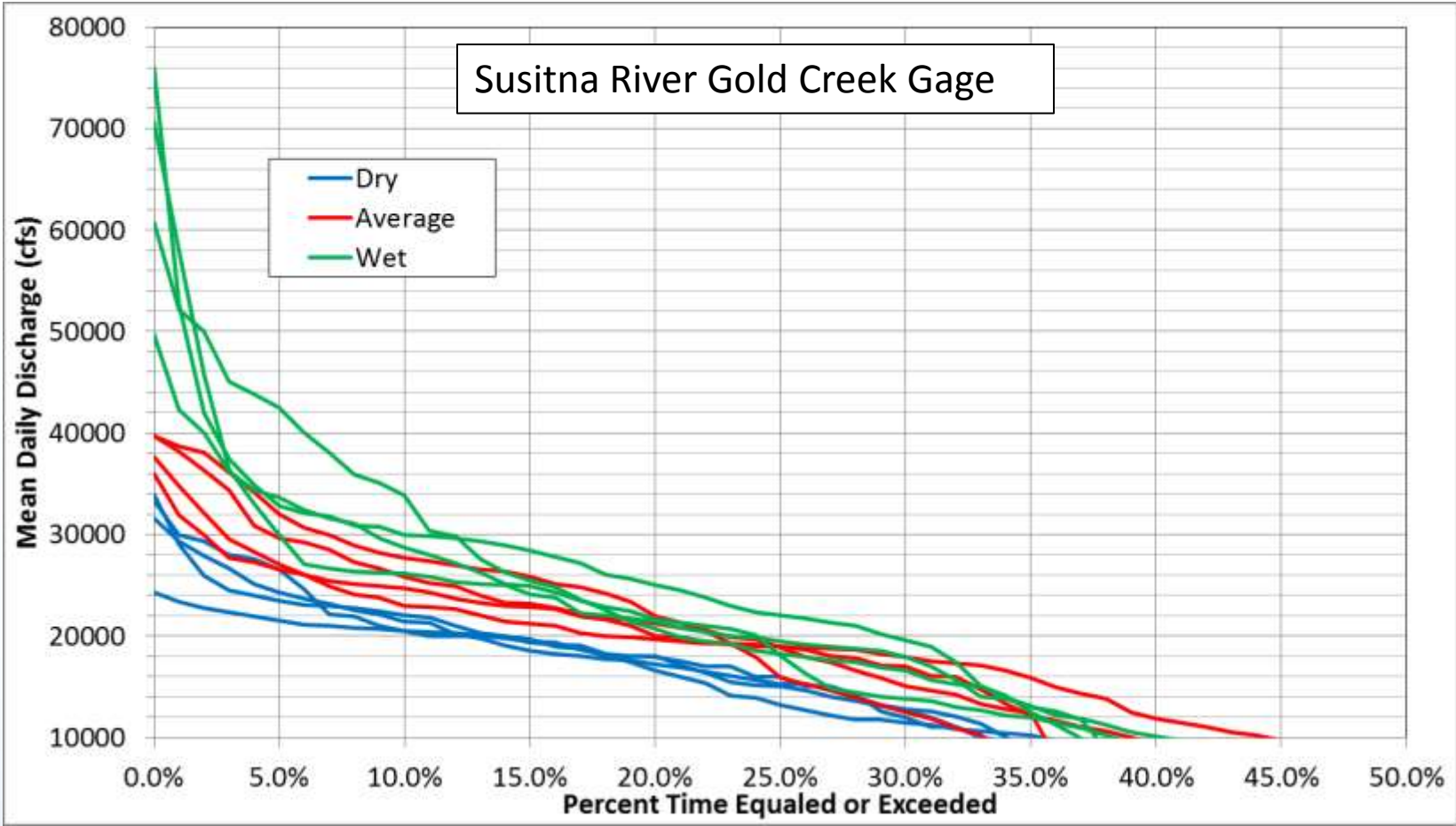
Candidate Average Years



Candidate Wet Years



Candidate Years Flow Duration Curves



Pacific Decadal Oscillation

- Wilcoxon Rank Sum test used to compare warm vs. cool conditions
- Results similar to Yukon River findings (Brabets and Walvoord 2009)

Wilcoxon Rank Sum Test – PDO Regime

Monthly and other periods

Period	Gold Cr. Gage mean flow for period (cfs)			Diff. %	Z (Stand. Normal) $Z_{crit} = 1.96 \alpha=.05$	p
	Cool	Warm	Difference			
	N = 25	N = 25	(Warm-Cool)			
Water Year	9347	9939	592	6	1.310	0.20
May-Sept.	19388	19866	477	2	0.068	0.95
Oct.-April	2100	2775	675	32	4.414	0.00
October	5445	7198	1753	32	3.095	0.00
November	2362	2981	619	26	2.639	0.01
December	1660	2062	402	24	2.978	0.00
January	1376	1777	401	29	3.609	0.00
February	1196	1652	456	38	4.153	0.00
March	1094	1528	433	40	4.366	0.00
April	1468	2104	636	43	4.249	0.00
May	13204	14593	1389	11	0.883	0.38
June	26157	25513	-644	-2	-0.126	0.90
July	22829	24348	1519	7	1.154	0.25
August	21113	20914	-199	-1	-0.417	0.68
September	13673	13951	278	2	-0.184	0.85

Adopt alternative hypothesis that there is a difference between Warm and Cool PDO

Wilcoxon Rank Sum Test – PDO Regime Flow Exceedances

Period	Gold Cr. Gage mean flow for period (cfs)			Diff. %	Z (Stand. Normal) $Z_{crit} = 1.96 \alpha=.05$	p
	Cool	Warm	Difference			
	N = 25	N = 25	(Warm-Cool)			
Maximum	46500	40720	-5780	-12	-0.776	0.44
90% (May-Sept.)	30561	29619	-942	-3	-0.553	0.58
75% (May-Sept.)	24254	25142	888	4	0.728	0.47
50% (May-Sept.)	19212	20028	816	4	0.805	0.42
25% (May-Sept.)	13726	14281	554	4	0.243	0.81
10% (May-Sept.)	7695	9249	1553	20	1.329	0.19
Min. (May-Sept)	3355	4315	960	29	1.407	0.17
Min. (annual)	1048	1456	408	39	4.176	0.00

Adopt alternative hypothesis that there is a difference between Warm and Cool PDO

Pacific Decadal Oscillation

- Results similar to Yukon River findings (Brabets and Walvoord 2009)
 - 16 gages x 5 summer months = 80 comparisons
 - 69 comparisons no statistical difference ($p = 0.10$)
 - 6 higher and 5 lower for warm PDO
 - 15 of 16 gages had higher flows for warm PDO in winter (Jan. - March) & April
 - 6 gages higher for fall recession (Oct. – Dec.)

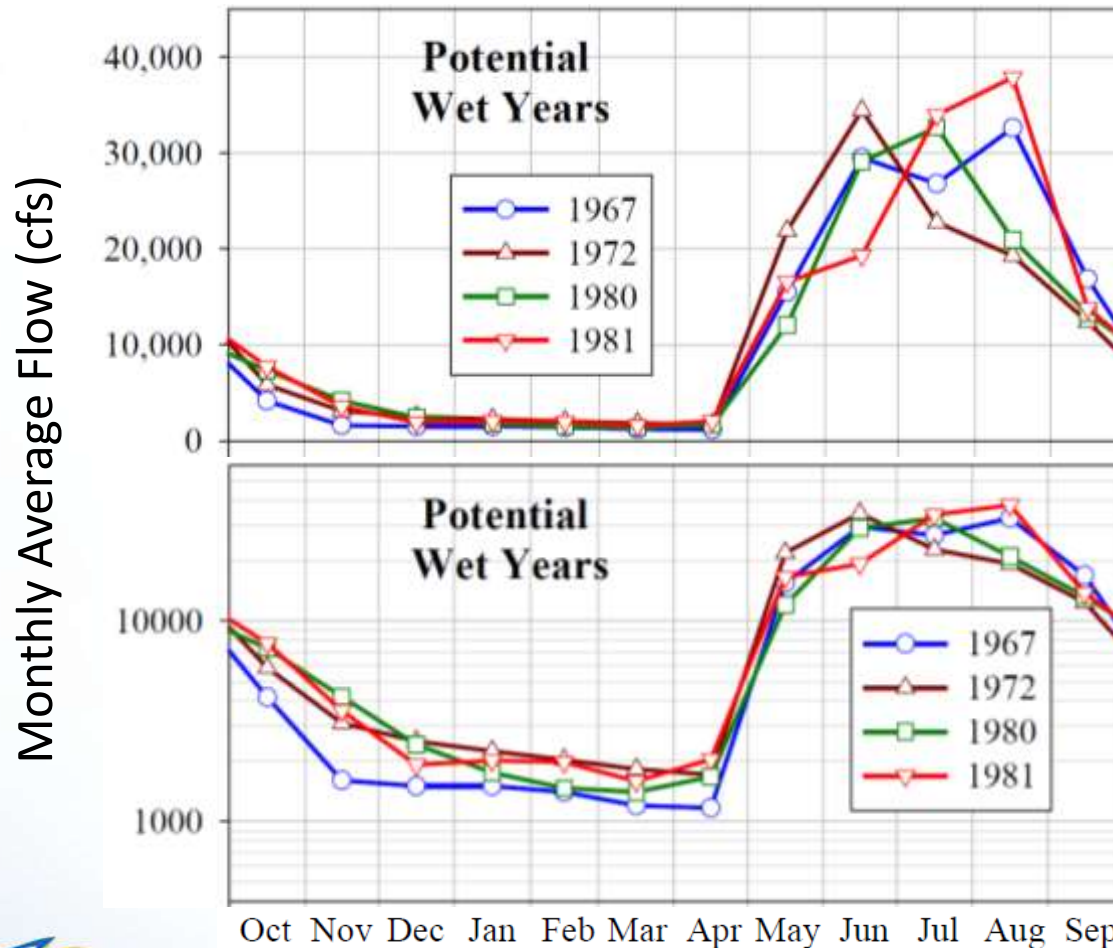
FGM Recommendations

- 50 years 1950-2011 excluding 1954, 1956, 1958, 1961-1963, and 1997-2001
- No differentiation between PDO for representative years
- Representative years initial recommendation:
 - 1950 (dry), 1985 (avg.), 1981 (wet)
- IFS: ~~1950~~ 1970 for dry
- Ice Processes: ~~1970~~ 1976 (dry, severe winter)

IFS – Representative Years from Fish Habitat Perspective

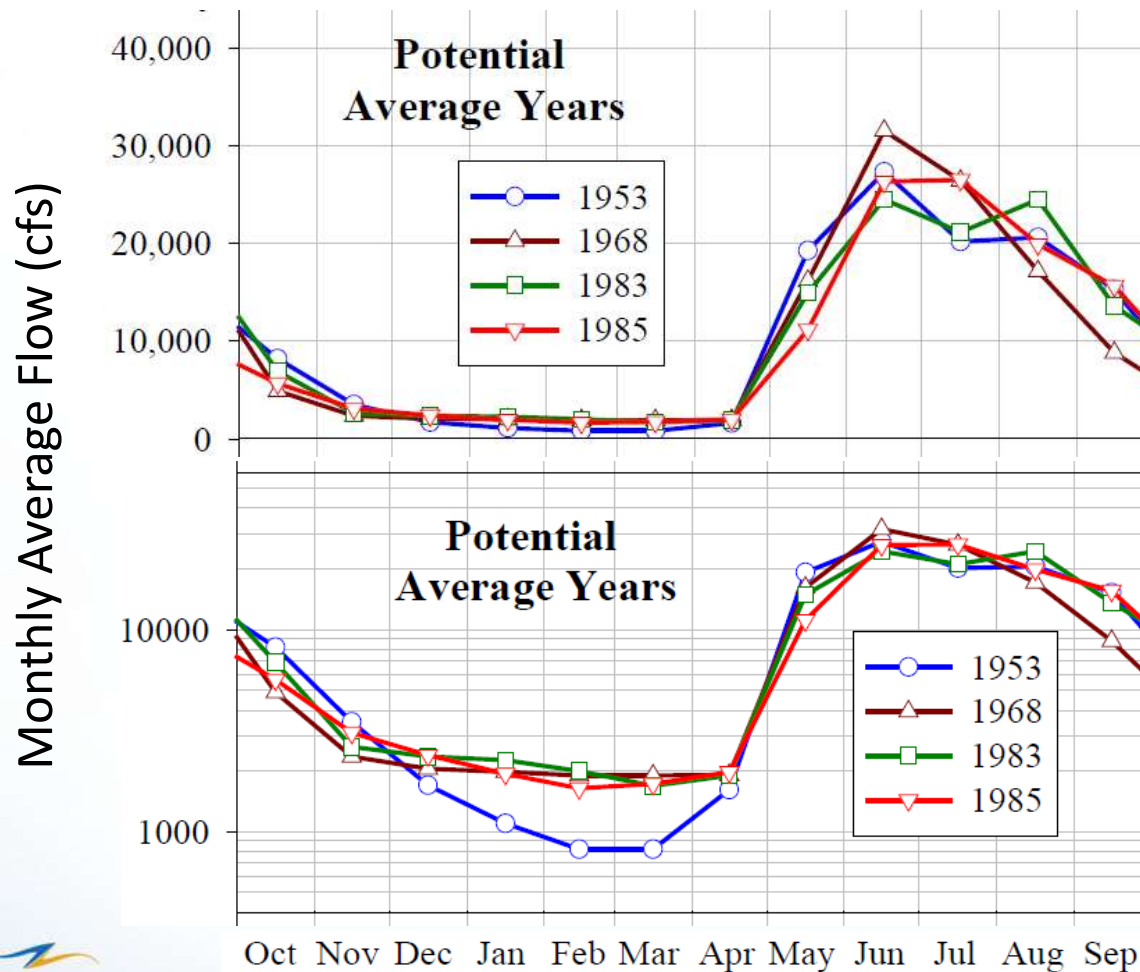
- Assumed same 50 – year record.
- Evaluated gaged flows on an average monthly basis
 - 1st Approach – 12 month frequency analysis:
 - Ranked the 50 years by month and determined the years with the greatest number of months characterized as dry, average, or wet conditions.
 - 2nd Approach – 5 month frequency analysis:
 - Performed a similar analysis for summer months only (i.e., May – Sep) since there is little variability from year to year during winter months

IFS – Representative Years from Fish Habitat Perspective



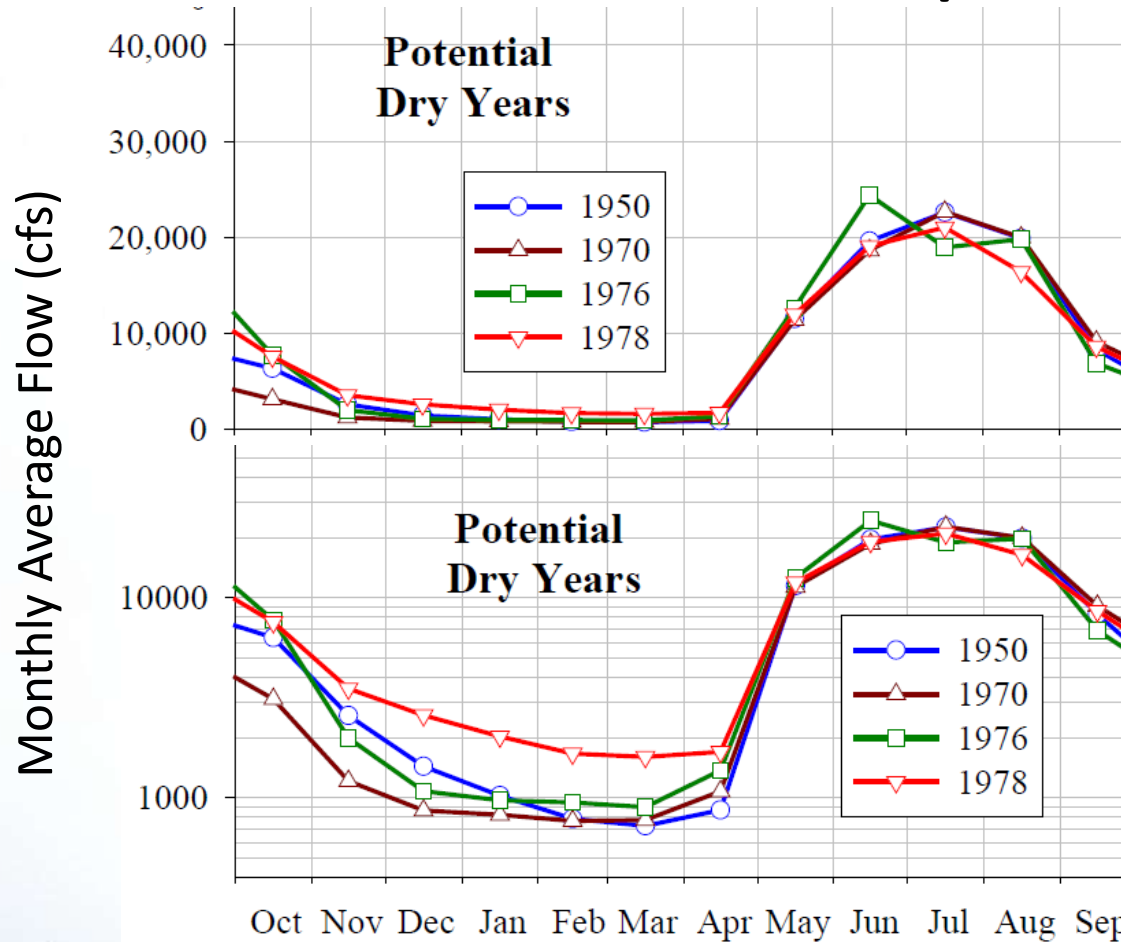
Agreement on Preference for 1981

IFS – Representative Years from Fish Habitat Perspective



Agreement on Preference for 1985

IFS – Representative Years from Fish Habitat Perspective



IFS Preferred
1970 – Low Fall
& Winter Flows

Ice Processes
considered
1976 - Freeze
and Break-up
Conditions

Ice Processes - Representative Years

- *1976 was very cold (dry year)*
 - *8th coldest for AFDD at 1795°C-days*
 - *Very early Freeze-up, short duration*
 - *Winter precipitation (10/18 to 04/07) was 6.71”*
 - *52” snow depth on 03/14 but very little early in winter*
- *1970 was very warm (dry year)*
 - *6th warmest for AFDD at 899°C-days*
 - *Very late, long duration freeze-up*
 - *Winter precipitation (10/20 to 03/13) was 4.37”*
 - *18” snow depth on 02/06*

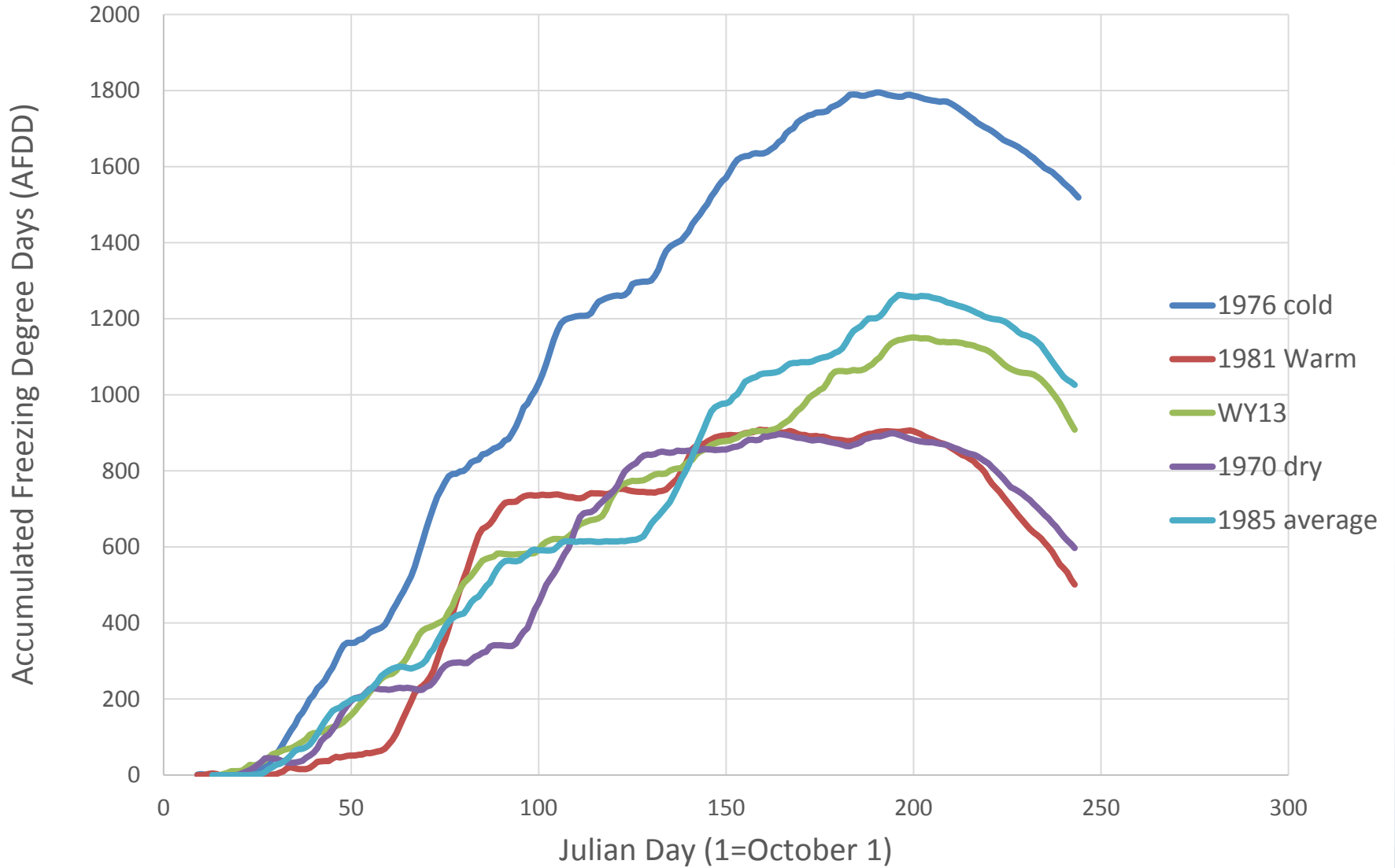
Ice Processes - Representative Years

- *1985 was average cold (average year)*
 - *35th coldest/28th warmest for AFDD at 1263°C-days*
 - *Median Freeze-up date, average duration*
 - *Winter precipitation (10/18 to 04/07) was 11.12”*
 - *62” snow depth on 03/12*
- *1981 was very warm but not too wet in winter (wet year)*
 - *7th warmest for AFDD at 908°C-days*
 - *Very late, long duration freeze-up*
 - *Winter precipitation (10/26 to 03/08) was 5.81”*
 - *26” snow depth on 02/28 but almost none in Dec*

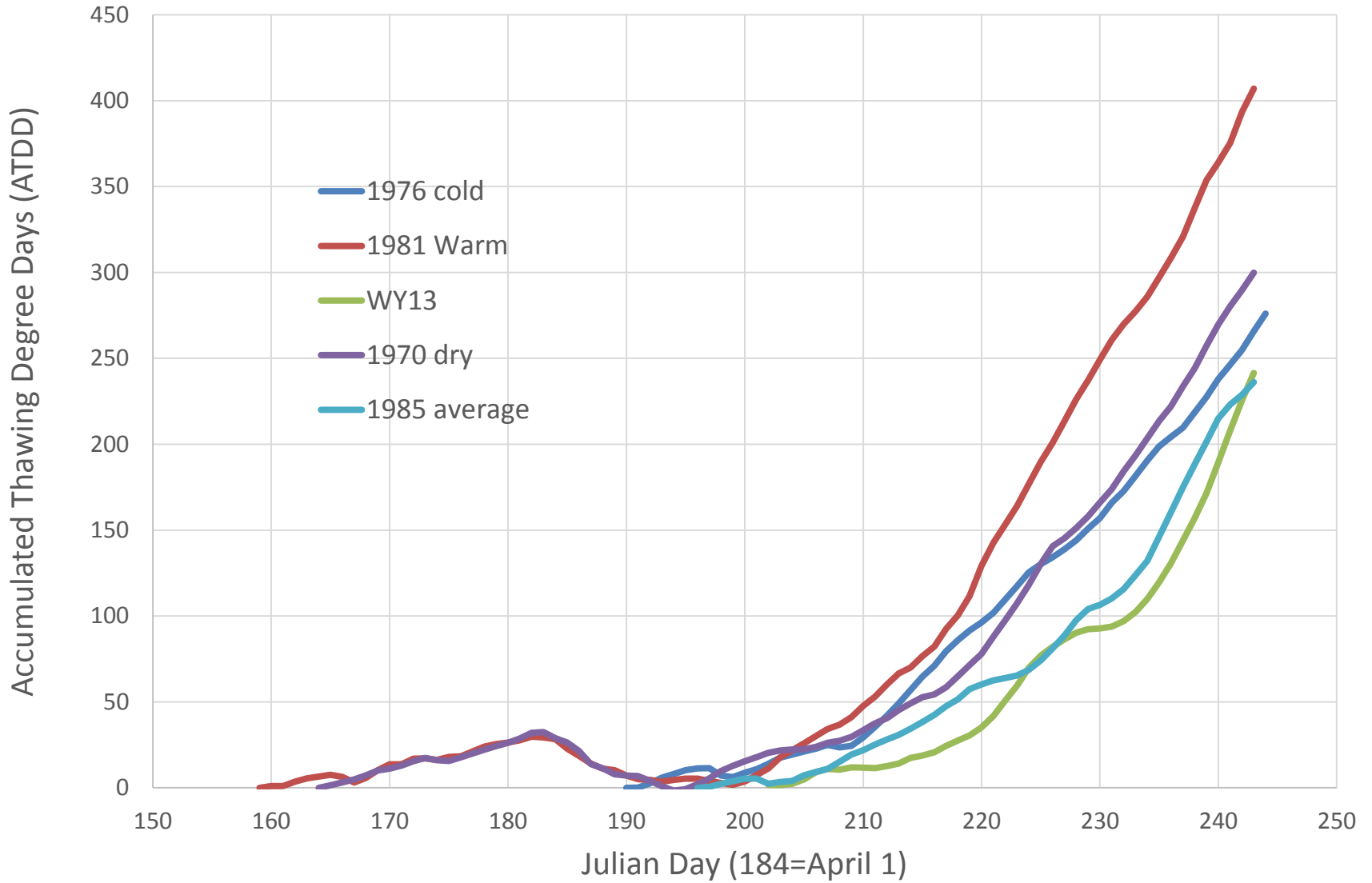
Ice Processes - Representative Years

- *As a comparison 2013 had massive breakup*
 - *Warmer than average AFDD at 1151°C-days*
 - *Average to late, long duration freeze-up*
 - *Very late breakup (May 25-29)*
 - *Winter precipitation (10/14 to 04/18) was 8.22”*
 - *41” snow depth on 03/25*
- *Dry, average, wet designations don't work well for winter period. Use cold, average, warm.*

AFDD for WY



ATDD for WY



Representative Years – Summary

Runoff

- 1981 – wet
- 1985 – average
- 1976 – dry

Winter

- 1981 – warm
- 1985 – average
- 1976 – cold