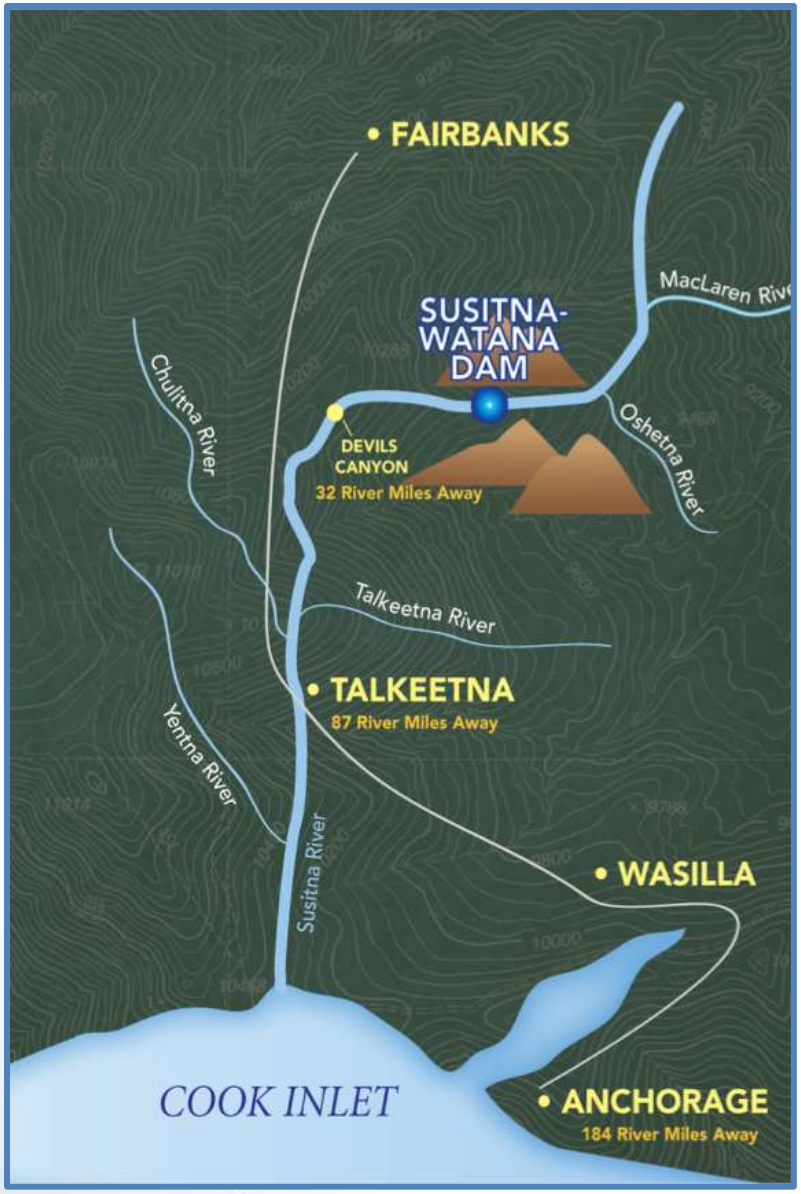


SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Instream Flow Technical Team (TT) Meeting

Study 8.5 IFS

Indicators of Hydrologic Alteration (IHA)

March 21, 2014

Prepared by

R2 Resource Consultants

Topics Discussed

- Indicators of Hydrologic Alteration (IHA) and Environmental Flow Components (EFC)
  - Parameters
  - Limitations
- Candidate Metrics
- Proposed Analysis

Indicators of Hydrologic Alteration

- *Developed by The Nature Conservancy (TNC)*
- *Provides hydrologic metrics to evaluate flow regimes under Existing/Baseline Conditions vs. Regulated Conditions*
  - *Magnitude, frequency, timing, duration and rate of change*
- *Considers "environmental flows"*
  - *"The quantity and timing of water flows required to maintain the components, functions, processes and resilience of aquatic ecosystems and sustain the goods and services they provide to people" (TNC)*

IHA Parameters Overview

- *33 Traditional IHA Parameters*
  - *5 Groups*
    1. *Magnitude of monthly water conditions*
    2. *Magnitude and duration of annual extreme water conditions*
    3. *Timing of annual extreme water conditions*
    4. *Frequency and duration of high and low pulses*
    5. *Rate and frequency of water condition changes*

IHA Parameters Overview

- *33 Traditional IHA Parameters*
  - *5 Groups*
    1. *Magnitude of monthly water conditions*
       - *Average flow for each month of the year*
       - *12 parameters*

IHA Parameters Overview

- *33 Traditional IHA Parameters*
  - *5 Groups*
    2. *Magnitude and duration of annual extreme water conditions*
       - *Annual minimum and maximum of:*
         - » *1, 3, 7, 30 and 90-day average flows*
       - *# of zero-flow days*
       - *Base flow: (7-day minimum flow)/(mean flow for year)*
       - *12 parameters*

IHA Parameters Overview

- *33 Traditional IHA Parameters*
  - *5 Groups*
    3. *Timing of annual extreme water conditions*
       - *Julian date of annual 1-day maximum*
       - *Julian day of annual 1-day minimum*
       - *2 parameters*

IHA Parameters Overview

- *33 Traditional IHA Parameters*
  - *5 Groups*
    4. *Frequency and duration of high and low pulses*
       - *# of high and low flow pulses within a water year*
       - *Average duration of high and low flow pulses (days)*
       - *4 parameters*

IHA Parameters Overview

- *33 Traditional IHA Parameters*
  - *5 Groups*
    5. Rate and frequency of water condition changes
       - *Rise rate*
         - » *Average of all positive differences between consecutive daily flow values*
       - *Fall rate*
         - » *Average of all negative differences between consecutive daily flow values*
       - *# of hydrologic reversals*
       - *3 parameters*

IHA Parameters Overview

- *34 Environmental Flow Component (EFC) Parameters*
  - *Hydrographs can be divided into repeating hydrographic patterns that are ecologically relevant*
  - *5 key flow events to* sustain riverine ecological integrity
    1. *Monthly low (base) flows*
    2. *Extreme low flows*
    3. *High flow pulses*
    4. *Small floods*
    5. *Large floods*

IHA Parameters Overview

- *34 Environmental Flow Component (EFC) Parameters*
  - *5 key flow events to* sustain riverine ecological integrity
    1. *Monthly low (base) flows (12 parameters)*
       - *Average of low (base) flows for each calendar month*

IHA Parameters Overview

- *34 Environmental Flow Component (EFC) Parameters*
  - *5 key flow events to* sustain riverine ecological integrity
    2. *Extreme low flows (4 parameters)*
       - *Average peak (minimum) value*
       - *Average duration (days)*
       - *Average timing (Julian date)*
       - *Frequency of extreme low flows during water year*

IHA Parameters Overview

- *34 Environmental Flow Component (EFC) Parameters*
  - *5 key flow events to* sustain riverine ecological integrity
    3. *High flow pulses (6 parameters)*
       - *Average peak (maximum) value*
       - *Average duration (days)*
       - *Average timing (Julian date)*
       - *Average rise rate*
       - *Average fall rate*
       - *Frequency of high flow pulses during water year*

IHA Parameters Overview

- *34 Environmental Flow Component (EFC) Parameters*
  - *5 key flow events to* sustain riverine ecological integrity
    4. *Small floods (6 parameters)*
       - *Average peak (maximum) value*
       - *Average duration (days)*
       - *Average timing (Julian date)*
       - *Average rise rate*
       - *Average fall rate*
       - *Frequency of small floods during water year*

IHA Parameters Overview

- *34 Environmental Flow Component (EFC) Parameters*
  - *5 key flow events to* sustain riverine ecological integrity
    5. *Large floods (6 parameters)*
       - *Average peak (maximum) value*
       - *Average duration (days)*
       - *Average timing (Julian date)*
       - *Average rise rate*
       - *Average fall rate*
       - *Frequency of large floods during water year*

IHA Limitations

- *Daily average flow data only*
- *67 total parameters*
  - *Surplus of information – difficult to make meaningful comparisons and conclusions*
- *Susitna River*
  - *Potential load following operations – hourly flow changes*
  - *What is most ecologically relevant?*
    - *Adult migration*
    - *Spawning*
    - *Egg incubation*
    - *Juvenile Rearing*
    - *Outmigration*

Candidate Metrics

- *Assess load following impacts*
  - *High flows*
  - *Low flows*
  - *Variability in flows*
- *Some could be calculated on a daily average basis within the IHA, others on an hourly basis outside of the IHA*

Candidate Metrics

- *Annual Low Flows (4 metrics)*
  - 7-day minimum
  - Baseflow
  - Number of low pulses
  - Duration of low pulses
  - Daily average or hourly
    - Daily average likely most meaningful

Candidate Metrics

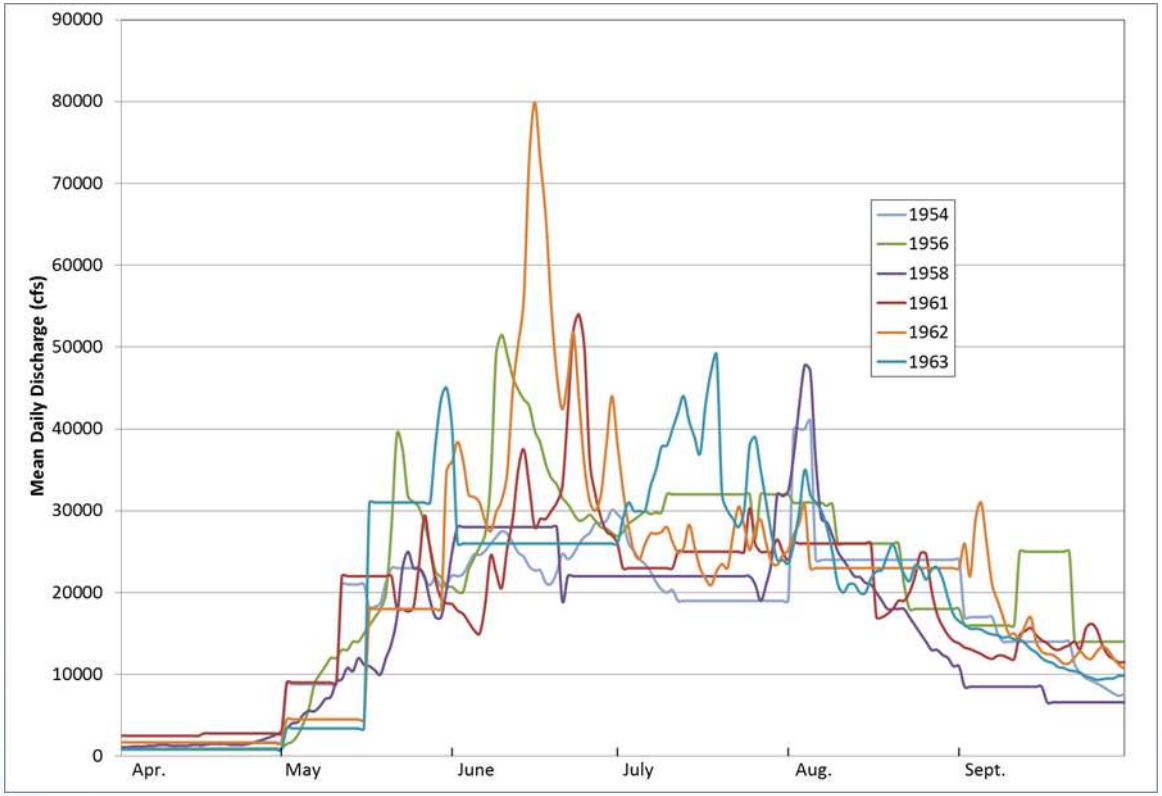
- *Annual High Flows (4 metrics)*
  - Maximum 1-hour flow
  - Number of high pulses
    - Daily average and/or hourly
  - Duration of high pulses
    - Daily average and/or hourly
  - # of freshets (where the average daily flow is greater than 1.5 times the average flow of the previous 3 days)

Candidate Metrics

- *Seasonal Flow Variability (3 metrics)*
  - Monthly flow medians
    - Daily average likely most meaningful
  - Monthly 2-day minimum
    - Daily average and/or hourly
  - Monthly 2-day maximum
    - Daily average and/or hourly

Candidate Metrics

- *Importance of good input data*
  - *Appropriate period of data record*



Source: TetraTech

Candidate Metrics and Proposed Approach

- *Compare existing and post-project conditions*
  - Run metrics through existing and regulated conditions (OS-1 and others)
  - Identify meaningful trends and conclusions
  - Define importance of relative change caused by project effects
  - Compute Hydrologic alteration factor (HAF)
    - $\frac{(regulated\ value - unregulated\ value)}{unregulated\ value}$
    - Allows end user to quantify the alteration a test regulated regime would cause on a given parameter compared to another

Candidate Metrics and Proposed Approach

- *Compute HAF*:
  - For each candidate metric (11 total)
  - For each representative year (# TBD)
- *Overall Hydrologic Alteration Index (HAI)*
  - If further aggregation needed
  - For each parameter: Sum the HAFs for each representative year, multiplied by a weighting factor that describes the likelihood of that type of year occurring
  - 1 value for each 11 parameters that represents overall hydrologic alteration that could be expected given a range of climatic conditions

IHA Analysis End Result

- *Spatial and Temporal understanding of project effects on existing hydrologic regime*
  - *Compute HAF and/or overall HAI for different locations:*
    - *Gold Creek*
      - *Represents project effects on Middle River*
    - *Sunshine*
      - *Represents project effects on Lower River including influence of Chulitna and Talkeetna Rivers*
        - » *Measures attenuation caused by 3 rivers confluence*
    - *Susitna Station*
      - *Represents project effects on Lower River including influence of Deshka and Yentna Rivers*
        - » *Expected minimal project effects with significant tributary inflow up to this point*
  - *Compare Results*