APPENDIX F

Changing Streamflow in Icicle, Peshastin, and Mission Creeks

and

Flow Charts of Instream Flow Benefit per Alternative Based on Climate Change Modeling

Changing Streamflow in Icicle, Peshastin, and Mission Creeks

Eightmile Lake, Chelan County, Washington

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Contents

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1 Purpose of this project

As part of the Icicle Work Group (IWG), a diverse set of stakeholders have been working to identify collaborative solutions to water management in Icicle Creek. Water management decisions that are made today will have implications for decades to come. Given the large changes in climate and hydrology anticipated in the coming decades, such plans will need to account for the effects of climate change if they are going to be robust.

The purpose of this project is to leverage existing hydrologic change datasets to estimate future changes in streamflow in Icicle, Peshastin, and Mission Creeks as well as seven regulated alpine lakes (Figure 1). These will be used to evaluate proposed alternatives for managing water in Icicle Creek.

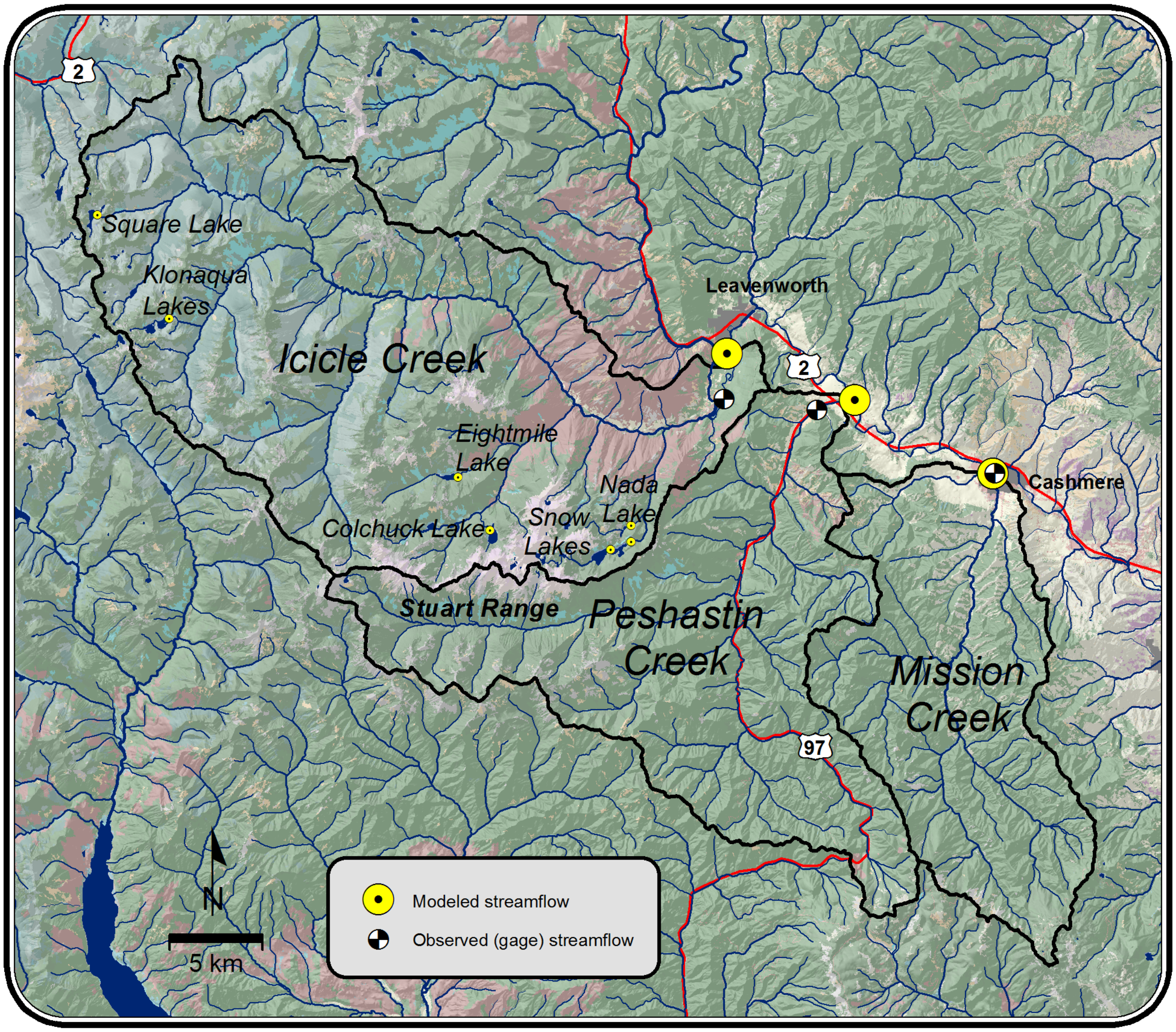


Figure 1. Map of the study locations, including the three watersheds – Icicle, Peshastin, and Mission Creeks, along with the locations of the seven Alpine lakes for which flows are regulated in summer.

2 Streamflow Change Datasets

Hydrologic projections are derived by transforming coarse-scale global climate model results, via downscaling, to fine-scale climate projections, which are then used to drive a hydrologic model (Figure 2; More information on climate scenarios can be found in Chapter 3 of Snover et al. 2013).

The datasets used in this project differ at each of the first three steps in Figure 2: they are based on different greenhouse gas scenarios, different global climate models, and different downscaling approaches. The hydrologic model is the same throughout, although slightly different versions of the model were used for each dataset.

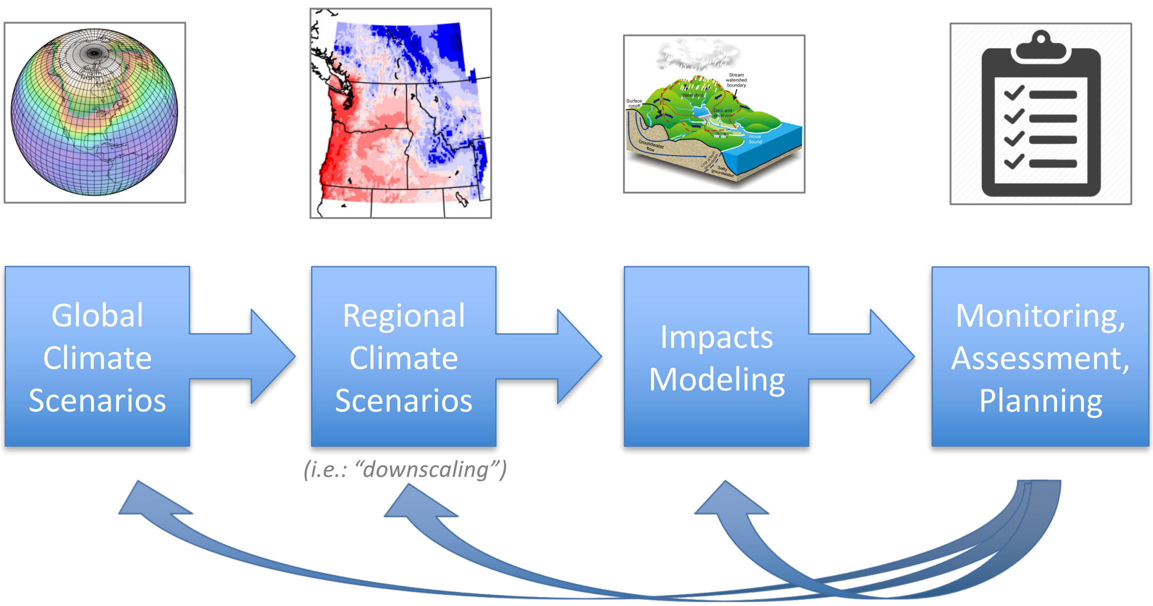


Figure 2. Modeling chain from global climate scenarios to impacts. This section describes the first three steps in the chain.

2.1 Greenhouse gas scenarios

Greenhouse gas scenarios are plausible scenarios of future greenhouse gas emissions that are used to drive global climate models. High scenarios assume continued increases in greenhouse gas emissions throughout the century, with concentrations more than quadrupling by 2100, relative to pre-industrial conditions. Low scenarios assume that multiple factors conspire to reduce the rate of emissions over time, ultimately resulting in about a doubling of greenhouse gas concentrations by 2100. Differences among greenhouse scenarios do not have a big effect on climate projections until after 2050.

The newest set of scenarios was developed for use in the latest Intergovernmental Panel on Climate Change report (IPCC, 2013). These are called Representative Concentration Pathways (RCPs, Van Vuuren et al. 2011). Scenarios used in the current study include both a low and a high greenhouse gas scenario (RCPs 4.5 and 8.5, respectively; Table 1). An older set of scenarios, used in the previous IPCC report, stem from the Special Report on Emissions Scenarios (SRES, Nakicenovic et al. 2000). Two of the datasets in this study are based on the SRES A1B scenario, a moderate greenhouse gas scenario in which emissions stabilize towards the end of the century.

Table 1. Greenhouse gas scenarios used in this report.

Scenario	***Scenario characteristics***	***Description***	***Citation***
RCP 4.5	A low scenario in which greenhouse gas emissions stabilize by mid-century and fall sharply thereafter.	"Low"	*Van Vuuren et al. 2011*
A1B	A medium scenario in which greenhouse gas emissions increase gradually until stabilizing in the final decades of the 21st century	"Moderate"	*Nakicenovic et al. 2000*
RCP 8.5	A high scenario that assumes continued increases in greenhouse gas emissions until the end of the 21st century	"High"	*Van Vuuren et al. 2011*

2.2 Global Climate Models

Greenhouse gas scenarios are used to drive global climate models, or GCMs, which simulate processes in the atmosphere, ocean, and land surface, along with the interactions between each. Coordinated experiments are regularly conducted in which international modeling groups agree to produce climate simulations using the same sets of conditions. This allows for intercomparisons among models and more robust estimates of future changes in climate. These experiments are called Climate Modeling Intercomparison Projects (CMIP).

The datasets used in this study stem from two CMIP generations: Phase 3 (CMIP3, Meehl et al. 2007) and Phase 5 (CMIP5, Taylor et al. 2012). The CMIP3 experiments use the older SRES greenhouse gas scenarios (in our case, the moderate A1B scenario), while the CMIP5 experiments make use of the newer RCPs (for this study, RCPs 4.5 and 8.5). Although the models in the more recent CMIP5 dataset include new features and improvements, they show the same sensitivity to greenhouse gas emissions as the older CMIP3 projections (i.e., they model the same amount of warming per unit of emissions).

2.3 Downscaling

Since GCMs are coarse in spatial scale, these must often be "downscaled" in order to produce climate projections at a scale that is compatible with the impacts that are to be assessed (labeled "regional climate scenarios" in Figure 2). All of the datasets used in this study were downscaled to a spatial resolution of 0.0625-degree (about 2.9 x 4.3 mi, or 12.6 sq. mi.).

Downscaling approaches generally fall into two categories: statistical downscaling and dynamical downscaling. Statistical approaches use empirical relationships derived by relating surface observations to coarse-scale global climate model fields. Dynamical approaches use a physical model that simulates the climate and weather processes occurring at the finer scales. Table 2 lists the three downscaling approaches used in this project.

Table 2. Downscaling methods used in this study.

ID	Name	Type	Citation
MACA	Multivariate Adaptive Constructed Analogs	Statistical	Abatzoglou and Brown 2012
BCSD	Bias Correction and Spatial Disaggregation	Statistical	Wood et al. 2004
WRF	Weather Research and Forecasting Mesoscale Climate Model	Dynamical	Skamarock et al. 2008, Salathé et al. 2010

Downscaling methods typically require an observationally-based historical dataset: either as a basis for the statistical downscaling or for applying corrections to the dynamically downscaled projections. All of the datasets used in this study are based on either the Livneh et al. (2013) or Hamlet et al. (2013) estimates of daily gridded meteorological fields.

2.4 Hydrologic model

A hydrologic model is used to translate from downscaled climate projections to changes in hydrology: snowpack, soil saturation, runoff, baseflow, etc. All of the datasets in this study were developed using the Variable Infiltration Capacity (VIC) macroscale hydrologic model (http://vic.readthedocs.io, Liang et al. 1994). VIC is a distributed model, providing gridded estimates of surface and sub-surface flows (runoff and baseflow, respectively), which can then be processed to estimate streamflow at select locations (see Section 3.2, below). Although there are differences in the model version and parameters used in each implementation, the datasets used in this study are all similar in terms of the VIC model configuration.

2.5 Time Periods

Flow projections were assessed for three future time periods: the 2030s (2020-2049), 2050s (2040-2069), and 2080s (2070-2099). However, not all datasets extended through 2099. In those cases, summaries were only created for the future time periods for which data exist. Future changes were assessed relative to 1970-1999, with the exception of the WSU dataset, as described below.

2.6 Datasets

2.6.1 MACA

A set of hydrologic projections that were developed as part of the Integrated Scenarios of the Future Northwest Environment project (Mote et al. 2014). Climate projections stem from the statistically downscaled MACA approach, and are based on the latest global climate model projections (CMIP5, Taylor et al. 2012). The MACA downscaling is applied to the top 10 GCMs based on the ranking of Rupp et al. (2013), each for both a low and a high greenhouse gas scenario (RCPs 4.5 and 8.5, respectively), for a total of 20 future climate scenarios. The projections extend from 1950-2099. Hydrologic simulations were made using VIC version 4.1.2.

Citation: Mote et al. 2014

URL: http://climate.nkn.uidaho.edu/IntegratedScenarios
http://maca.northwestknowledge.net

2.6.2 bcMACA

A modified version of the MACA dataset in which average monthly temperature and precipitation was adjusted (or bias-corrected, hence *bc*MACA) to match the estimates derived from the observationally-based Parameter-Elevation Regressions on Independent Slopes dataset (PRISM, version AN81M monthly, Daly et al. 2008). Over the U.S. the monthly time series was used to apply the adjustments, while over Canada the long-term average for each month was adjusted to match the long-term average from PRISM.

Projections are based on the same models and scenarios as MACA. Hydrologic simulations were made using VIC version 4.1.2.

Citation: Mauger et al. 2016

URL: https://cig.uw.edu/datasets/hydrology-in-the-chehalis-basin/
http://cses.washington.edu/rocinante/MACA/bc/

2.6.3 WSU

A new set of hydrologic projections developed for the 2016 Columbia River Basin Long-term Water Supply and Demand Forecast (Hall et al. 2016). Hydrologic model simulations are driven by the same MACA projections described in Section 2.6.1 above, except that only five of the 10 GCMs were used, each again for both a low and a high greenhouse gas scenario, adding up to a total of 10 future scenarios. Hydrologic simulations are performed using VIC-CropSyst v2.0 and run for two 31-year time periods: 1981-2011 and 2020-2050. This means that future changes are only available for the 2030s, and that changes for this time period are assessed relative to 1981-2010 instead of 1970-1999 as with each of the other datasets.

Citation: Hall et al. 2016

URL: http://www.ecy.wa.gov/programs/wr/cwp/2016Forecast.html

2.6.4 HB2860

A previous set of projections, developed with funding from Washington State House Bill #2860 (HB2860, Hamlet et al. 2013). Climate projections stem from the statistically downscaled BCSD approach, and are based on the previous set of global climate model projections (CMIP3, Meehl et al. 2007). The BCSD downscaling was applied to seven GCMs based on the ranking of Mote and Salathé (2010). In this project we analyzed results for a moderate greenhouse gas scenario (A1B). The projections extend from 1950-2099. Hydrologic simulations were made using VIC version 4.0.7.

Citation: Hamlet et al. 2013

URL: http://warm.atmos.washington.edu/2860/

2.6.5 bcWRF

Regional Climate Model simulations using the WRF model (Skamarock et al. 2008, Salathé et al. 2010). Projections stem from two GCMs selected from the previous set of global climate model projections (CMIP3, Meehl et al. 2007), both for a moderate greenhouse gas scenario (A1B). Daily temperature and precipitation from the WRF model were bilinearly interpolated to the 0.0625-degree grid, and bias-corrected (hence *bc*WRF, see Mauger et al. 2016) to match the daily statistics from Livneh et al. 2013 and the long-term monthly averages from PRISM (Daly et al. 2008). The projections extend from 1970-2069, meaning that future changes are not available for the 2080s. Hydrologic simulations were performed using VIC version 4.1.2.

Citation: Salathé et al. 2010

URL: http://cses.washington.edu/rocinante/WRF/

2.6.6 Summary of Datasets

Table 3 summarizes the details related to each of the five datasets used in this study. Note that even with the same VIC model version, simulations can result in different estimates of hydrologic conditions. Specifically, differences in the soil characteristics, vegetation properties, and the specification of sub-grid scale topographic variations can all have an effect on the model simulations. These have not been compared as part of the current study.

Table 3. Summary of the features of each of the five datasets used in this study. The column "Climate Models" lists the number of global climate model projections included in the projections.

	Greenhouse Gas Scenario			**Climate Models**		**Downscaling**		**Hydrologic Model**			**Years**		
	Low	Moderate	High	New (CMIP5)	Old (CMIP3)	Statistical	Dynamical	VIC v4.0.7	VIC v4.1.2	VIC-CropSyst v2.0	2030s	2050s	2080s
MACA	✓		✓	**10**		✓			✓		✓	✓	✓
bcMACA	✓		✓	**10**		✓			✓		✓	✓	✓
WSU	✓		✓	**5**		✓				✓	✓		
HB2860		✓			**7**	✓		✓			✓	✓	✓
bcWRF		✓			**2**		✓		✓		✓	✓	

3 Approach

The VIC hydrologic model produces gridded estimates of surface runoff and sub-surface flows on the model grid. Since any particular streamflow site may contain multiple grid cells within its catchment area, an additional step is needed to estimate total streamflow at each location. This process is referred to as streamflow "routing", because flows are routed through the stream network. Once daily streamflow estimates have been obtained at each site, an additional step is needed to estimate daily streamflow extremes. This section describes the post-processing steps used to obtain estimates of streamflow for select sites and metrics.

3.1 Streamflow sites

We assessed changes in streamflow for the three creeks and seven alpine lakes listed in Table 4. Daily flows were estimated at the mouth of the three creeks, while monthly average flows were assessed for the alpine lakes. The drainage area for each alpine lake is small compared to the spatial resolution of the datasets we are using (the area of each gird cell is about 12.6 sq. mi.). Since the smaller scales may result in greater uncertainties, projections for the alpine lakes were only evaluated at monthly time scales. As discussed in Section 4, this may be the most appropriate focus for the three creeks as well.

Table 4. Streamflow projections were developed for each of these sites. The final column lists the time step used for the projections (monthly or daily). The latitude and longitude refers to the output point of each lake or creek.

Site	*Latitude*	*Longitude*	*Area*	*Freq.*
Icicle Creek	47.58002N	120.66620W	214 sq. mi.	Daily
Peshastin Creek	47.55748N	120.57460W	136 sq. mi.	Daily
Mission Creek	47.52159N	120.47606W	93 sq. mi.	Daily
Square Lake	47.64692N	121.11992W	1.6 sq. mi.	Monthly
Klonaqua Lakes	47.59455N	121.06960W	1.3 sq. mi.	Monthly
Eightmile Lake	47.52035N	120.86521W	5.9 sq. mi.	Monthly
Colchuck Lake	47.49196N	120.83358W	1.5 sq. mi.	Monthly
Upper Snow Lake	47.48216N	120.75726W	4.2 sq. mi.	Monthly
Lower Snow Lake	47.48454N	120.74580W	4.8 sq. mi.	Monthly
Nada Lake	47.49611N	120.73874W	1.5 sq. mi.	Monthly

This analysis uses off-the-shelf models which were calibrated for these locations. In addition, the models do not account for flow regulation. Both factors could impact the absolute flow estimates (i.e.: the flow rate, in cfs). As a result, this analysis emphasizes relative changes in streamflow at each site. This information can be combined with knowledge of both existing and proposed flow modifications in order to produce absolute estimates of future flows under various management alternatives.

3.2 Streamflow

VIC simulations of surface and sub-surface flows from each grid cell (sometimes referred to as runoff and baseflow, respectively) were used to produce the routed streamflows at each site using a daily-time-step routing model developed by Lohmann et al. (1996). The within-cell routing uses a Unit Hydrograph (UH) approach to represent the temporal distribution of flow at the outlet point from an impulse input at each source point. The channel routing uses the linearized Saint-Venant equation to represent the flow at a downstream point as a function of the water velocity and the diffusivity, both of which may be estimated from geographical data (Lohmann et al. 1998). The river routing model assumes all runoff and baseflow exit a cell in a single flow direction.

A predetermined routing network provides the upstream-downstream linkage between VIC model grid cells. The three creeks listed in Table 4 were then located on the developed streamflow routing network and verified based on their true latitude-longitude location, the cited watershed area by the USGS and the World Hydro Reference Overlay Map showing flow of the rivers.

Since the catchments for the alpine lakes are all less than half of the area of a single 0.0625-degree grid cell (about 12.6 sq. mi.), routing is not needed for these sites. Instead, we used an area-weighted average for any grid cells that overlap with the catchment area for each lake. Since the gridded climate estimates are not designed for sub-grid scales, where unresolved microclimates may be important, these data are only produced at monthly time scales. Averaging from daily to monthly likely minimizes the impacts of any systematic differences between the climate datasets and the actual conditions present within each catchment.

3.3 Extremes statistics

In addition to monthly average flows, daily streamflow projections were synthesized according to the following metrics:

1. The 10% non-exceedance value (10-year event) for annual daily minimum flows, and
2. The 50%, 10%, and 1% exceedance value (2-, 10-, and 100-year events, respectively) for annual daily maximum flows.

To calculate extreme statistics, the Extreme Value type 1 distribution described Gumbel (EV1), the Log-Pearson type 3 (LP3) and the Generalized Extreme Value (GEV) distribution with L-moments are commonly used. In this study, we apply the GEV distribution with L moment to estimate flood and low flow statistics – following the methodology described in Salathé et al. 2014 and Tohver et al. 2014. These distributions are selected based on findings that indicate it is superior to the LP3 distribution (Rahman et al. 1999 & 2015, Vogal et al. 1993, Nick et al. 2011). Flood flows were computed for return intervals of 2, 10, and 100 years (50%, 10%, and 1% exceedance values). To estimate flood magnitude, the maximum daily flows were extracted for each water year (October to September) at each site. These were ranked for each 30-year period and fitted to the GEV with L-moments (Wang, 1997; Hosking and Wallis 1993; Hosking 1990). Similarly, the low flow statistic was calculated by taking the minimum daily streamflow in each water year and estimating the 10-year extreme (10% non-exceedance value).

4 Results

This section summarizes the results of the analysis. Although the emphasis of this project is on relative changes in flows, comparisons with observations provide useful context for interpreting the results from each dataset. Subsequent sections show the projections, along with one example of a way to synthesize the results.

All of the results presented in this report concern monthly average flows. Changes in daily extremes were also estimated, and these are available on the project website. However, given the approximate nature of the projections, our recommendation is to base decisions on the monthly average flow projections, since these are likely to provide more robust estimates of future conditions.

4.1 Comparison with Observations

4.1.1 Streamflow Observations

We obtained daily gauge observations of streamflow at sites on each of the three creeks (Table 5). As is evident from the observations shown in Figure 3, streamflow in all three creeks is heavily influenced by snowpack. This is particularly true for Icicle Creek, for which flows remain quite low for almost the entire year, then rise sharply for May and June before falling again to low values for the summer.

Figure 3 shows that the various datasets generally do a good job of capturing the seasonal cycle of streamflow for the three creeks. The absolute differences are large in some cases, but overall the timing and distribution of streamflow closely resembles the observations. This is important, since the seasonal pattern of streamflow is governed by the proportion of precipitation that is captured in the snowpack as well as the rate of snow accumulation and melt. A model that does not adequately capture these processes may not be able to accurately represent the consequences of warming for snowpack and, by extension, streamflow.

Table 5. Streamflow gauges used for comparison with model results.

Site	*ID*	*Latitude*	*Longitude*	*Years*
Icicle Creek	USGS #12458000	47.54111N	120.71889W	1936-2016
Peshastin Creek	Ecology #45F070	47.55250N	120.60170W	2002-2016
Mission Creek	Ecology #45E070	47.52140N	120.47470W	2002-2016

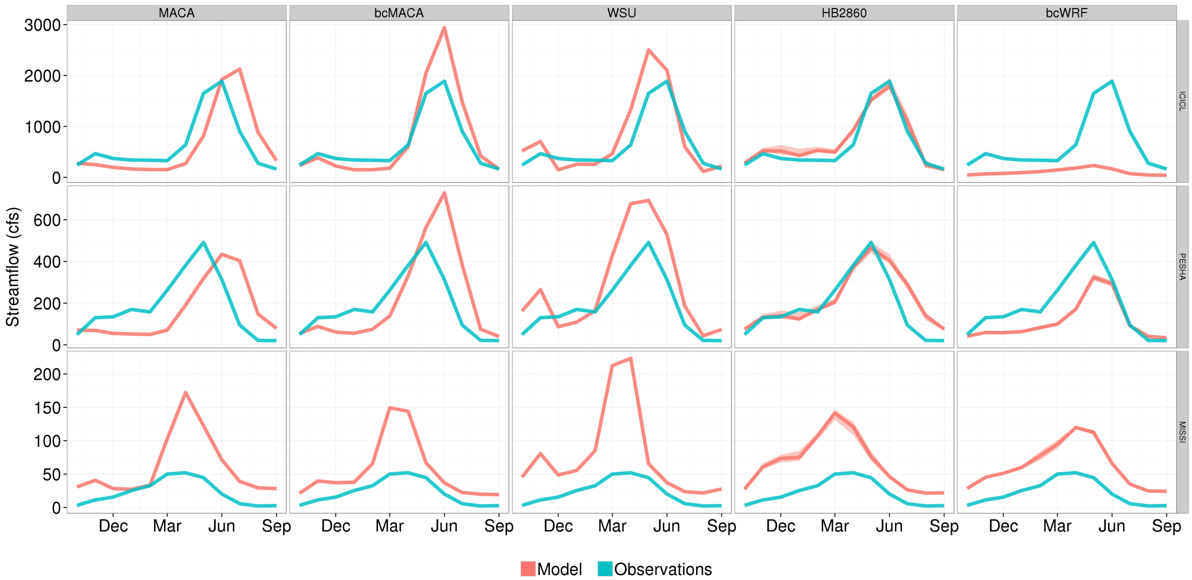


Figure 3. Comparing observed (blue) and simulated (orange) monthly streamflow for each of the five datasets (from left to right: MACA, bcMACA, WSU, HB2860, bcWRF) for Icicle (top), Peshastin (middle), and Mission (bottom) Creeks. Each plot shows the long-term average of monthly flows. For simulated streamflow, the average is for 1970-1999, with the exception of the WSU dataset, for which the 1981-2010 average is shown. For the observed flows, the average is for 1950-2015 for Icicle Creek and 2002-2016 for Peshastin and Mission Creeks.

4.2 Projections

In this section, we focus on the percent changes in monthly streamflow for each streamflow site. Figures 4, 5, and 6 show the projected changes for the three Creeks for the 2030s, 2050s, and 2080s, respectively. The magnitude of the change differs substantially from one dataset to the next. This reflects the uncertainties associated with representing changes in local climate and hydrology; this uncertainty would likely be reduced with careful calibration and improvements to model inputs (climate, soil, and vegetation). On the other hand, the overall pattern of change is remarkably consistent and reflects the expected reductions in snowpack with warming. Warming elevates the snowline, increasing the proportion of precipitation that falls as rain which results in reduced snow accumulation in winter. The combination of reduced snowpack and higher temperatures result in an earlier and less pronounced spring peak in streamflow, along with lower flows throughout the melt season and summer. Each of the datasets shows the same changes in the seasonal cycle of streamflow: increased flow in winter, an earlier peak in streamflow, and decreased flow in summer.

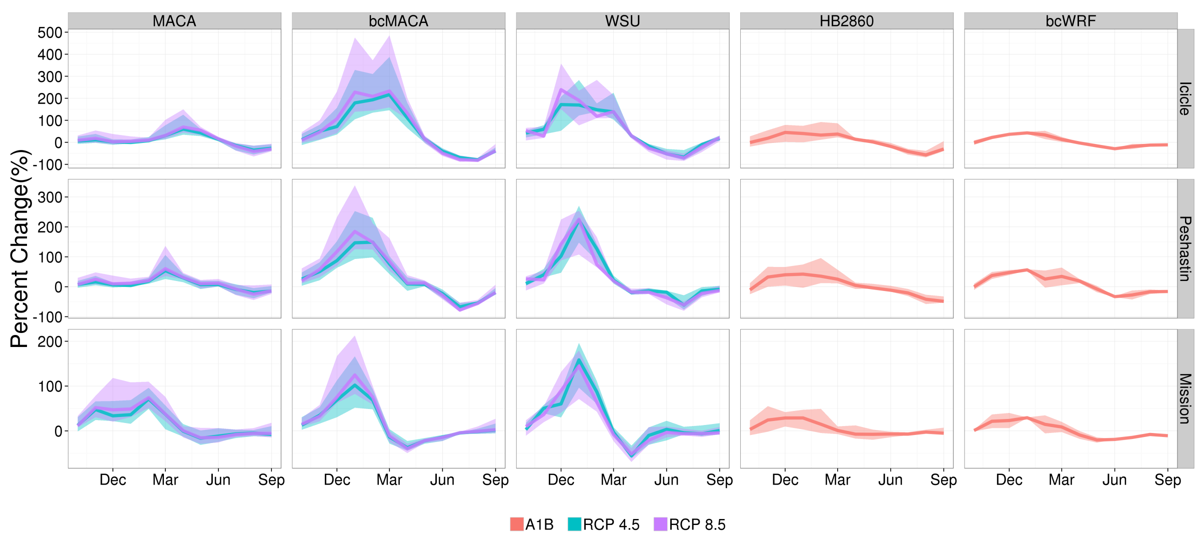


Figure 4. Projected changes in streamflow for the 2030s (2020-2049), relative to historical (see Section 2.5 for details), for Icicle (top), Peshastin (middle), and Mission (bottom) Creeks. Plots show the percent change in streamflow for each month for each of the five datasets (from left to right: MACA, bcMACA, WSU, HB2860, bcWRF). Thick lines show the average projection, while the shaded area shows the range among models for each dataset.

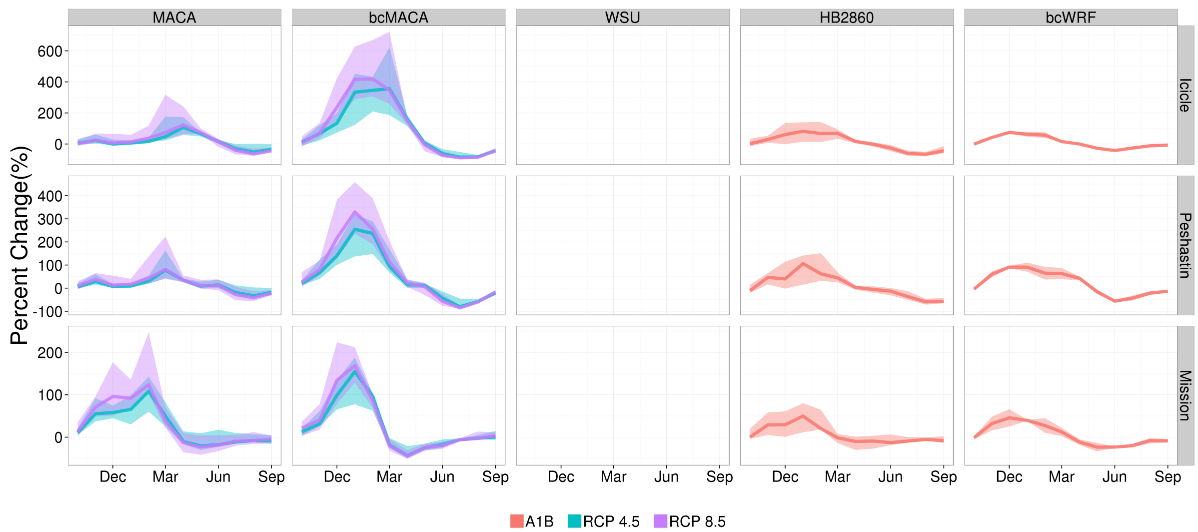


Figure 5. As in Figure 4 except showing results for the 2050s. The WSU plots are blank because the dataset does not include projections for the 2050s.

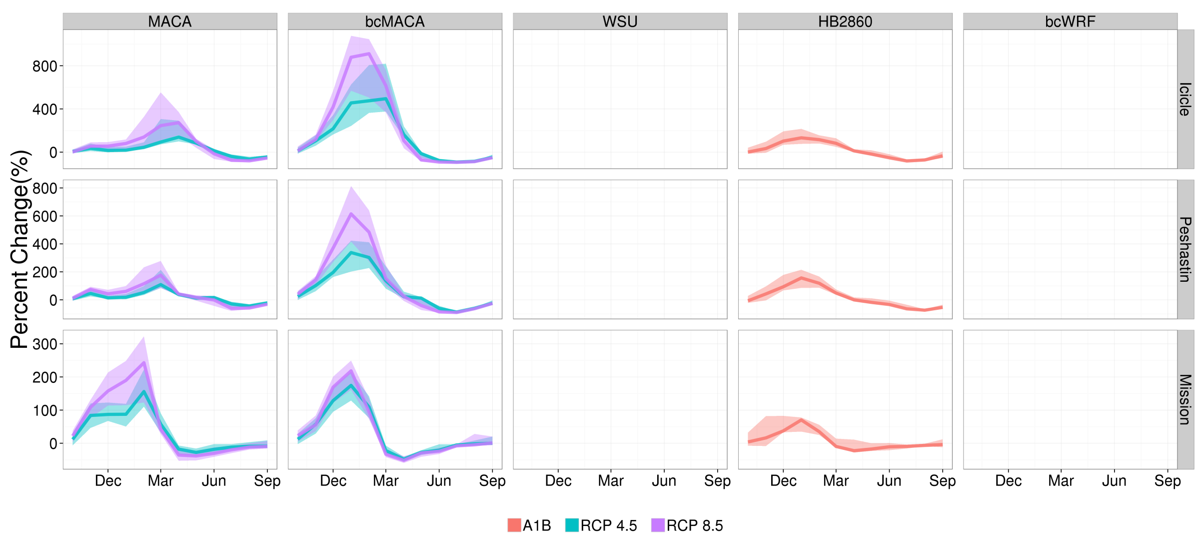


Figure 6. As in Figure 4 except showing results for the 2080s. The WSU and bcWRF plots are blank because neither dataset includes projections for the 2080s.

Changes for the seven regulated alpine lakes are shown in Figures 7, 8, and 9 (2030s, 2050s, and 2080s, respectively). These show a pattern of change that is consistent with the three creeks. This is likely a result of the fact that these are cold high-elevation catchments, which will continue to effectively retain snow in the future.

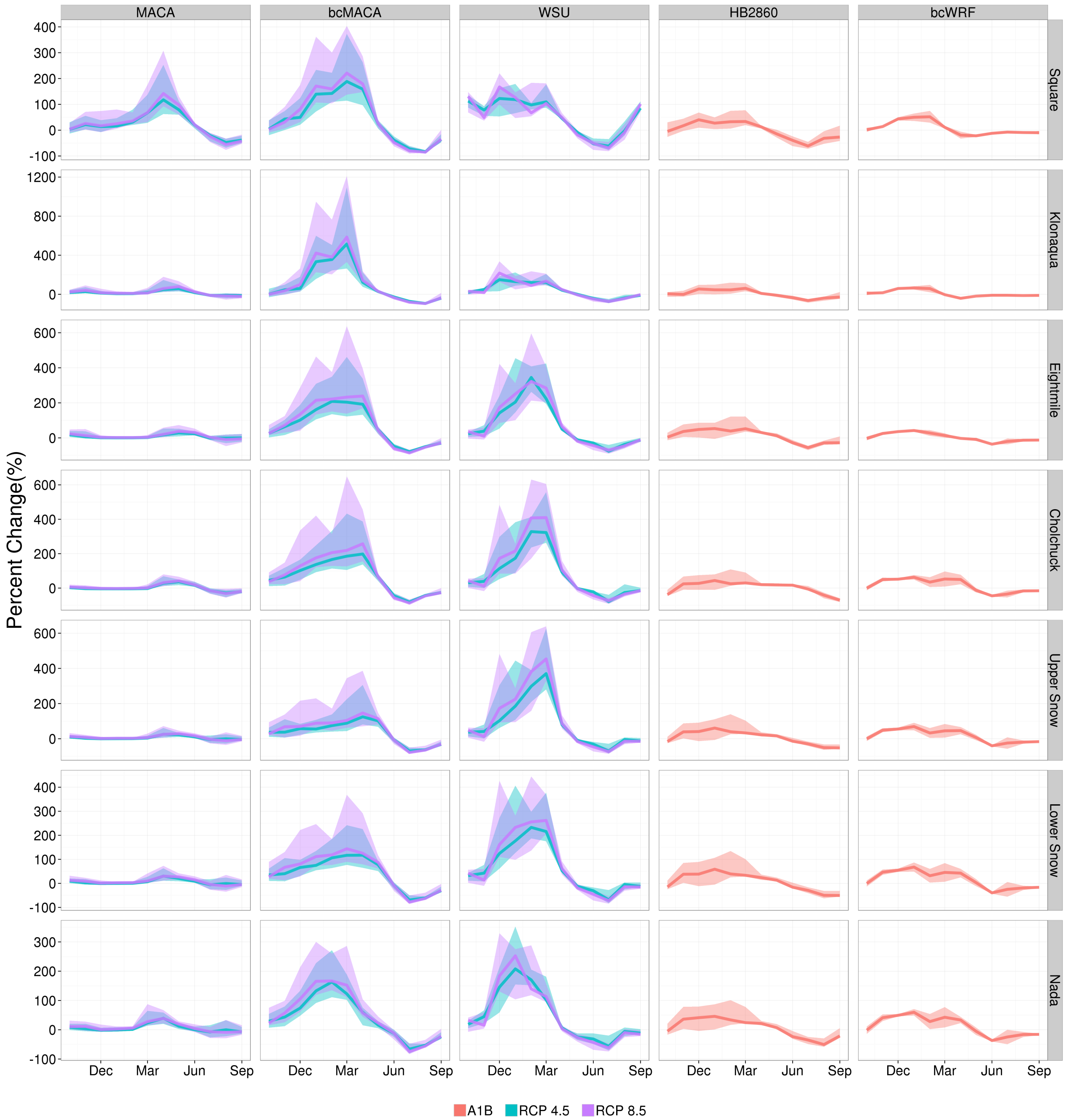


Figure 7. Projected changes in streamflow for the 2030s (2020-2049), relative to historical (see Section 2.5 for details), for the seven Alpine lakes with flow regulation. Plots show the percent change in streamflow for each month for each of the five datasets (from left to right: MACA, bcMACA, WSU, HB2860, bcWRF). Thick lines show the average projection, while the shaded area shows the range among models for each dataset.

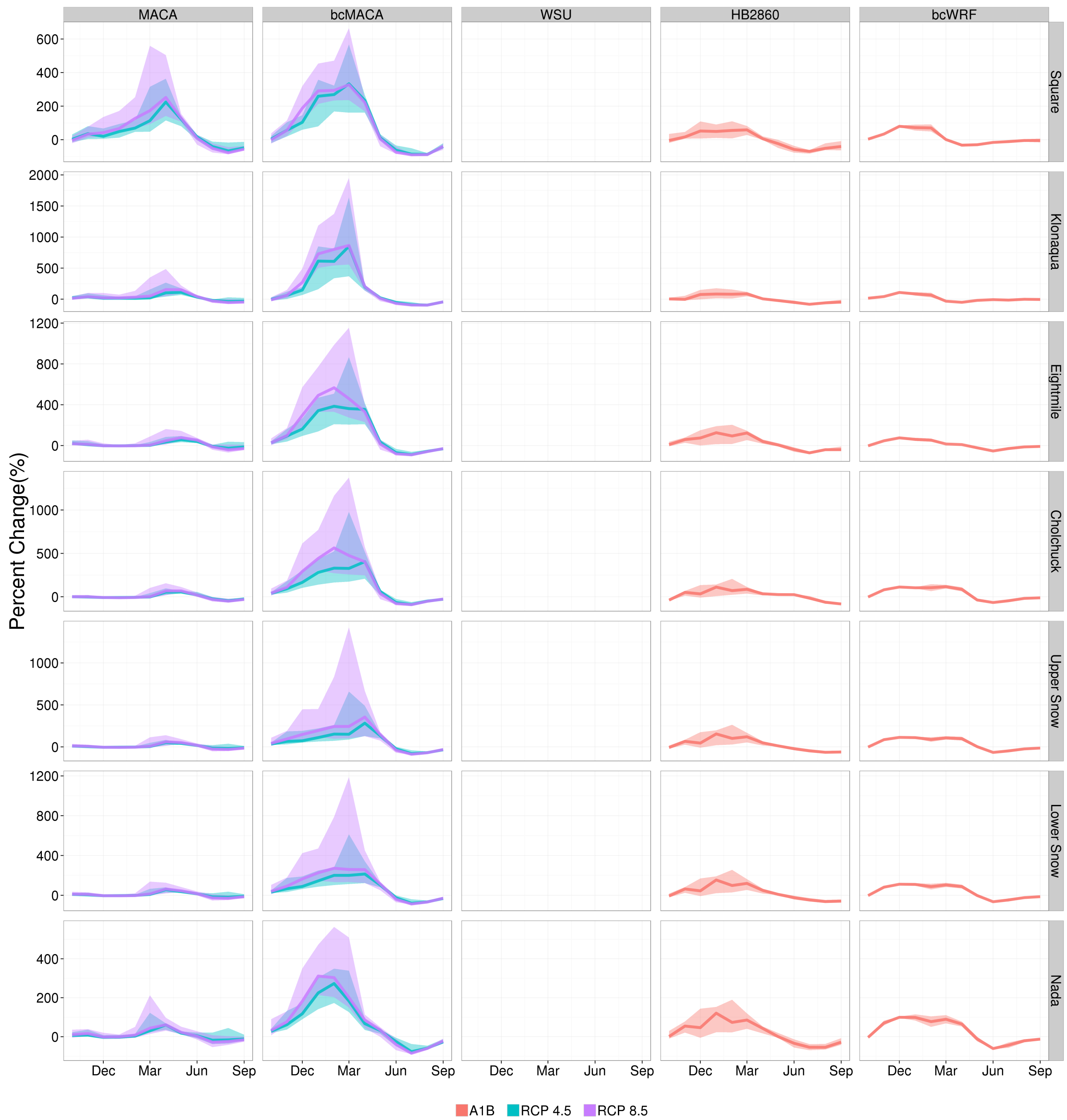


Figure 8. As in Figure 7 except showing results for the 2050s.

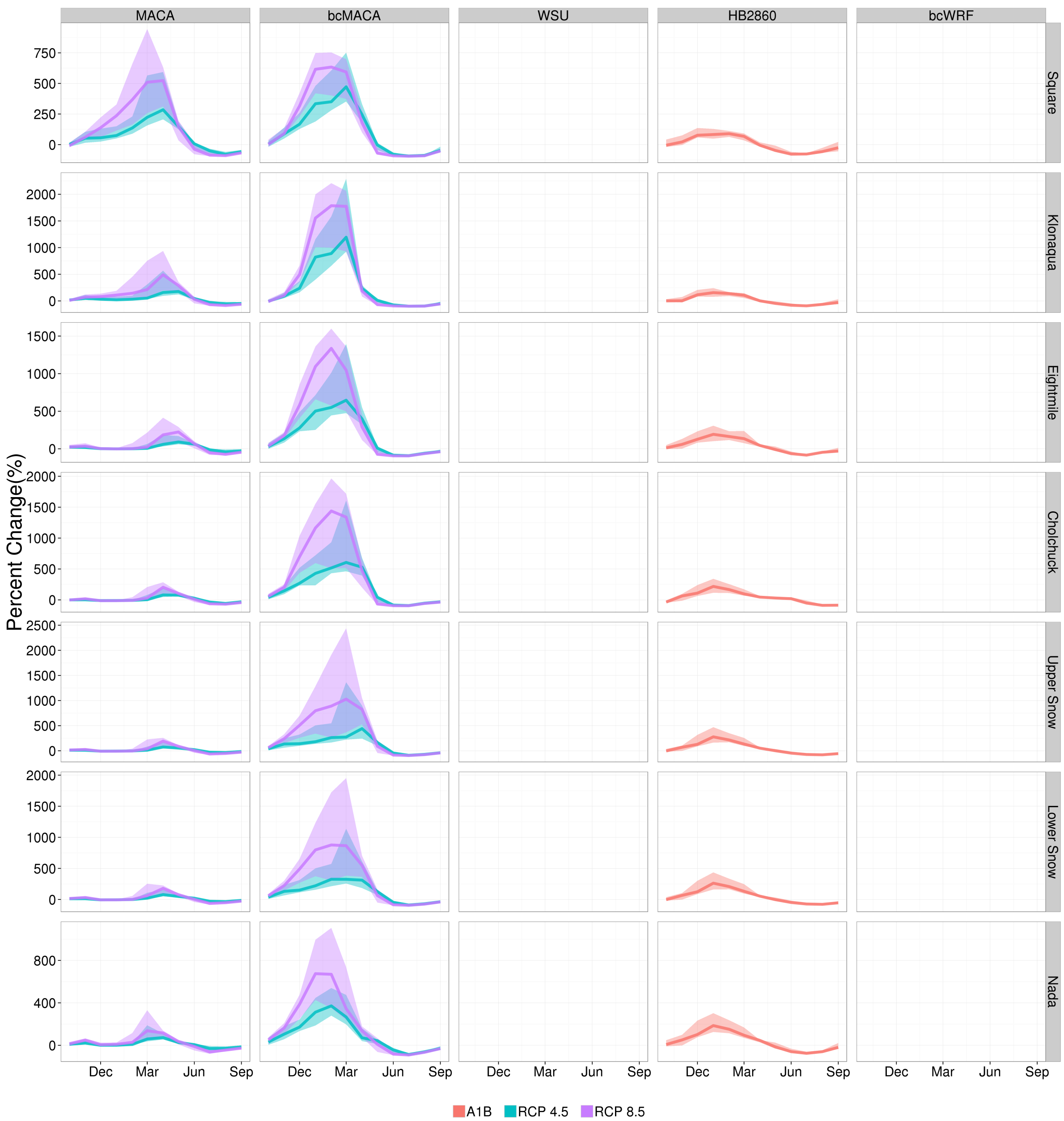


Figure 9. As in Figure 7 except showing results for the 2080s.

4.3 Average projections for Icicle Creek

The purpose of this project is to provide first estimates of changing hydrology in Icicle, Peshastin, and Mission Creeks. To do this we are using five different off-the-shelf datasets, each with its own set of models and assumptions, and none of which is calibrated for this area. Given the large number of future streamflow scenarios, it is not surprising that there is a wide range among the projections.

Although robust decisions can be made in spite of a large range among projections, it can be helpful to simplify the projections for the purpose of evaluating the impacts. Since the projections will primarily be used for a screening-level assessment of proposed infrastructure and management changes, one simple way to distill the results is by considering the average projection for each dataset. This is a very simplistic approach, since it involves averaging over different numbers of models for each dataset (Table 3) and, in some cases, averaging results from two different greenhouse gas scenarios.

Figure 10 shows the average ("average of the averages") and interquartile range for the average projected changes from each of the five datasets. These again reflect the expected patterns of decreased snow accumulation in winter, earlier melt, and dramatic decreases in streamflow in summer.

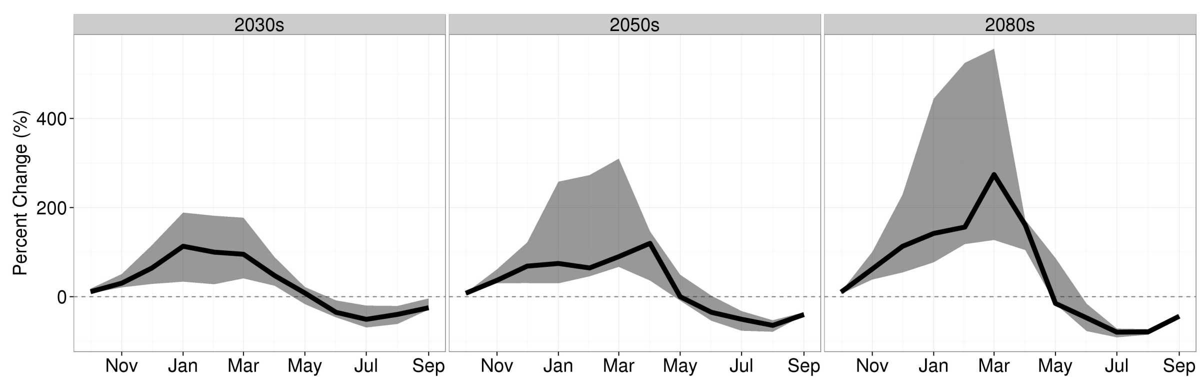


Figure 10. Projected changes in streamflow for the average among all scenarios within each dataset. The thick line is the "average of the averages", while the shaded area shows the interquartile range among the five average projections constructed from each dataset. Results are shown for 2030s (left), 2050s (middle), and 2080s (right), relative to historical (see Section 2.5 for details).

5 Interpreting the Results

This section describes some of the factors that should be considered in interpreting the results of this analysis.

5.1 None of the models were calibrated

The datasets used in this analysis were all previously developed in other projects without specific considerations given to Icicle, Peshastin, and Mission Creeks. As a result, no special attention was given to optimizing the models for these areas. This means two things: (1) the model inputs – the climate, soil, and vegetation patterns assumed for these locations – were not optimized to best represent the conditions found in the three creeks, and (2) the models were not calibrated to ensure that streamflow estimates match observed flows at each location. As a result, the absolute flows estimated for each location are not expected to match the observations exactly. In general, however, the models are expected to capture the seasonal cycle of flows (i.e.: relative changes in flows from month to month), even if the absolute flows do not match the observations. Daily streamflow estimates are more sensitive to deficiencies in model inputs or the model itself, and should also be regarded with greater caution than monthly average flows.

5.2 The hydrologic simulations assume no change in land cover

Streamflow is influenced by more than just temperature and precipitation; changes in soils and vegetation can also have an important influence on flows. The simulations analyzed here do not include such changes: land cover and soil characteristics are expected to remain the same throughout the simulations. Landslides and wildfires can reduce vegetation cover and soil water retention. If these or other related changes were to occur these could result in greater changes in streamflow than the current projections imply. If there are areas that are currently experiencing forest regrowth or densification these could also affect streamflow, though the net impact would depend on the balance between changes in snow accumulation, soil water retention, and changes in vegetative water demand as trees mature.

5.3 "Average of the averages" is just one approach

In the previous section, we presented results in which the average projection for each dataset was used. This is just one approach to synthesizing the results, and may not be the best approach for every application. In this case, averaging was deemed appropriate because of the screening-level nature of the Programmatic Environmental Impact Statement (PEIS) and the fact that none of the models had been calibrated for these watersheds.

In general, however, averaging across models is not recommended because it suppresses the range among model projections, which can provide important information for planning. For example, some planning contexts may require consideration of the worst-case scenario, while others may involve identifying approaches that are robust across a broad range of projections. In such cases, it would not be appropriate to consider only the average projections as opposed to the full range among different models and greenhouse gas scenarios.

Another reason one might want to take a different approach is if one dataset is considered more accurate than the others. This could be based on knowledge about how the datasets were developed, or based on the comparisons with observations. In this case, projections from just that dataset could be considered in lieu of lumping all datasets together as equals.

Ultimately, the best approach is to have a well-calibrated model that accurately represents the climate, soil, and vegetation characteristics of the watershed, and to be cognizant of potential biases in either the inputs or the model itself in order to appropriately interpret its results. The purpose of our current analysis is to provide a preliminary estimate of the impacts of climate change, the implications of which will help determine if more detailed modeling is necessary.

5.4 Can I trust these projections?

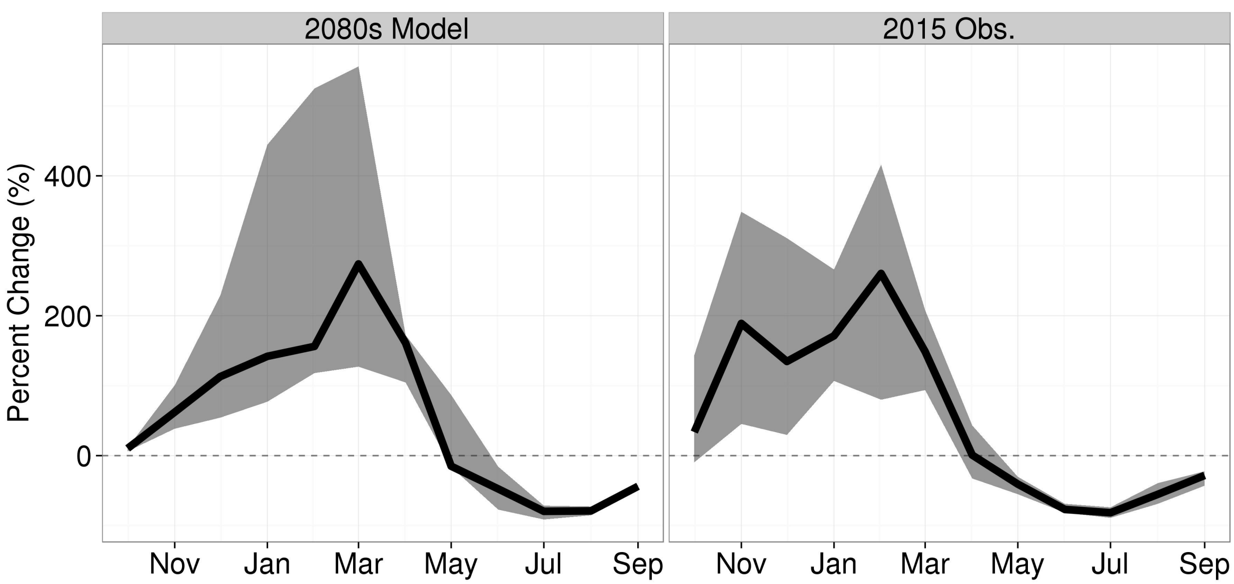


Figure 11. Comparing the projected changes for the 2080s (relative to 1970-1999, left panel) to the percent difference for 2015 flows relative to observed monthly flows for 1950-1999 (right panel). For each month, the average is shown (thick line) as well as the interquartile range (shaded area). For the 2080s projections (left), these are calculated from the five average projections constructed from each dataset. For the 2015 flows, the average and interquartile range is calculated by comparing monthly flows in 2015 to monthly flow for 1950-1999.

Table 6. Projected changes shown in Figure 11.

Month	2080s	2015
Oct	+10% (+6 to +11%)	+34% (-10 to +144%)
Nov	+62% (+38 to +101%)	+189% (+45 to +349%)
Dec	+113% (+54 to +229%)	+135% (+30 to +311%)
Jan	+142% (+77 to +444%)	+171% (+107 to +266%)
Feb	+156% (+118 to +525%)	+260% (+80 to +416%)
Mar	+274% (+127 to +556%)	+149% (+94 to +208%)
Apr	+161% (+105 to +172%)	+1% (-33 to +43%)
May	-15% (-16 to +87%)	-41% (-55 to -30%)
Jun	-48% (-77 to -16%)	-77% (-82 to -69%)
Jul	-80% (-91 to -72%)	-82% (-89 to -74%)
Aug	-79% (-85 to -73%)	-55% (-69 to -39%)
Sep	-44% (-50 to -42%)	-28% (-43 to -22%)

Model biases can lead to projections that are outside of the realm of what is physically possible. This is likely to be the case for a number of the individual model projections presented in the previous section. But which ones? This can be a challenging question to answer. Although many issues could be at play (ranging from hydrologic model formulation to greenhouse gas scenarios), one quick way to evaluate results is to compare model simulations to observed flows under similar conditions. For example: how does the model represent changes in streamflow during warm vs. cool years, and how does that compare to what we see in the observations? The same question could be asked about wet and dry years, or years with big vs. relatively low intensity rain events.

One specific example is the year 2015, in which statewide average temperatures for December through February exceeded the historical average by 4.6°F. These warmer temperatures led to drastically lower snow accumulation, earlier snowmelt, and a dramatic decrease in summer streamflow. Climate models project that temperatures will increase by 4.6°F, on average, by somewhere in between 2050 and 2100. On average, models project that 2015 conditions will become routine by the 2070s.

Figure 10 shows the percent difference between monthly flows for the year 2015 and the average, from observations, for the years 1950-1999. This longer time period was necessitated by the fact that the Icicle Creek gauge was not in operation from 1971-1993. Results were nearly identical for other choices of the historical reference period (e.g., 1950-2015). Alongside this plot are the 2080s projections; this figure is identical to the right-hand panel in Figure 10 above. In order to facilitate a direct comparison, Table 6 lists the average projection for the 2080s alongside the average monthly changes for 2015. Although the timing appears shifted by about one month, the overall magnitudes are very similar. This suggests that the model projections we presented above are robust, and is just one example of a way to produce an independent check on the results of this study.

6 Project Outputs

The following subsections describe the project outputs. These can all be accessed at the project website: https://cig.uw.edu/icicle_work_group_projections/

6.1 Data Archive

An online archive contains all of the observed and modeled streamflow data used in this study, as well as figures synthesizing the results. This includes the raw gridded hydrologic model projections as well as the streamflow time series for each of the 10 sites. All streamflow files are stored in a comma-delimited format (.csv) with a header line that describes the file's contents.

6.2 Tableau Tool

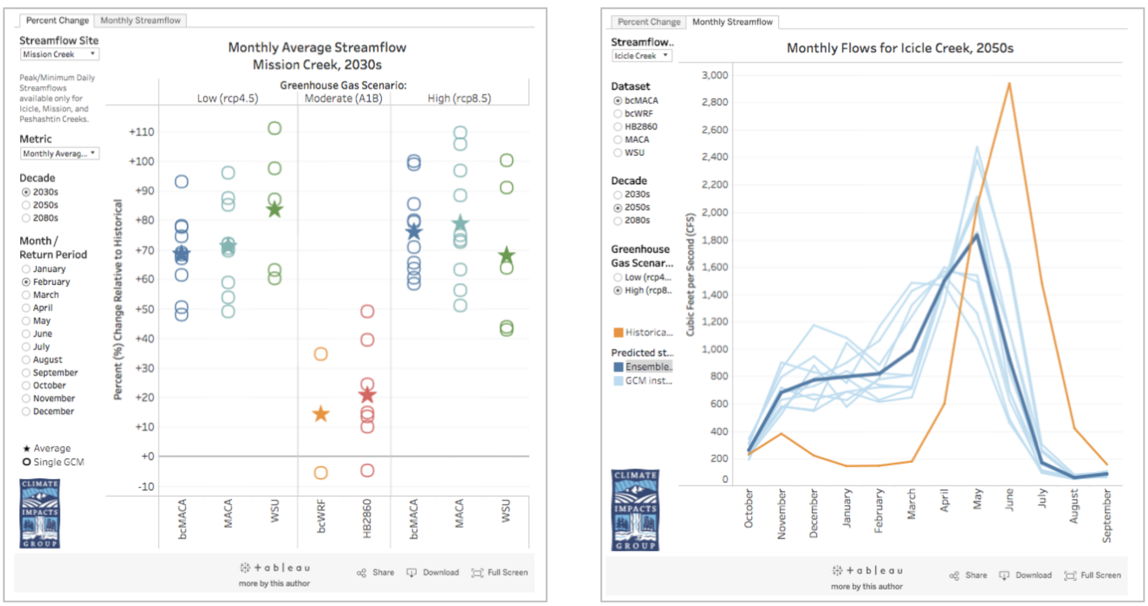


Figure 11. Screenshot of the online tool. The tool has two tabs: one showing the percent changes for each metric, facilitating comparisons across all datasets, and the other showing the full seasonal cycle of historical and future monthly flows, in which only one dataset and scenario can be viewed at a time.

As a complement to the reference data products, we have also produced a tool that is intended to allow users to easily visualize and query the projections across all datasets (Figure 11). The tool includes two tabs: one for viewing percent changes across all datasets, another for viewing the change in the seasonal cycle for one particular dataset and scenario. In each, users can select a streamflow site (Table 4) and a future time period (2030s, 2050s, 2080s) to visualize.

The percent changes tab is designed to facilitate comparisons across datasets. Users select a streamflow site (Table 4), a future time period, and a metric (e.g. January average streamflow). The visualization shows the percent changes for each of the five datasets, organized by greenhouse gas scenario. Individual model projections are shown, as well as the model averages.

The monthly streamflow tab is designed to allow users to view the change in the seasonality of streamflow with warming. Users select a streamflow site (Table 4), a future time period, a dataset, and a greenhouse gas scenario. The visualization shows historical and future monthly average streamflow for the water year (Oct-Sep) for all models included in the selected dataset.

References

Abatzoglou, J. T., & Brown, T. J. (2012). A comparison of statistical downscaling methods suited for wildfire applications. *International Journal of Climatology*, *32*(5), 772-780.

Daly, C., Halbleib, M., Smith, J. I., Gibson, W. P., Doggett, M. K., Taylor, G. H., ... & Pasteris, P. P. (2008). Physiographically sensitive mapping of climatological temperature and precipitation across the conterminous United States. *International journal of climatology*, *28*(15), 2031-2064.

Hamlet, A. F., Elsner, M. M., Mauger, G. S., Lee, S. Y., Tohver, I., & Norheim, R. A. (2013). An overview of the Columbia Basin Climate Change Scenarios Project: Approach, methods, and summary of key results. *Atmosphere-ocean*, *51*(4), 392-415.

Hosking, J. R. M., & Wallis, J. R. (1993). Some statistics useful in regional frequency analysis. *Water Resources Research*, 29(2), 271-281.

Hosking, J.R.M., 1990. L-moments: analysis and estimation of distributions using linear combinations of order statistics. *Journal of the Royal Statistical Society*, Series B, 52,105-124.

IPCC, 2013: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp, doi:10.1017/CBO9781107415324

Liang, X., D. P. Lettenmaier, E. F. Wood, and S. J. Burges (1994), A simple hydrologically based model of land surface water and energy fluxes for general circulation models, *J. Geophys. Res.*, **99**(D7), 14415–14428, doi:10.1029/94JD00483

Lohmann, D., R. Nolte-Holube, and E. Raschke, 1996: A large-scale horizontal routing model to be coupled to land surface parametrization schemes, *Tellus*, **48**(A), 708-721.

Lohmann, D., E. Raschke, B. Nijssen and D. P. Lettenmaier, 1998: Regional scale hydrology: I. Formulation of the VIC-2L model coupled to a routing model, *Hydrol. Sci. J.*, **43**(1), 131-141.

Mauger, G.S., S.-Y. Lee, C. Bandaragoda, Y. Serra, J.S. Won, 2016. Refined Estimates of Climate Change Affected Hydrology in the Chehalis basin. Report prepared for Anchor QEA, LLC. Climate Impacts Group, University of Washington, Seattle. doi:10.7915/CIG53F4MH

Meehl, G. A., C. Covey, T. Delworth, M. Latif, B. McAvaney, J. F. B. Mitchell, R. J. Stouffer, and K. E. Taylor, 2007: The WCRP CMIP3 multi-model dataset: A new era in climate change research, *Bulletin of the American Meteorological Society,* **88**, 1383-1394.

Mote, P., J. Abatzoglou, D. Lettenmaier, D. Turner, D. Rupp, D. Bachelet, D. Conklin, 2014. Final Report for Integrated Scenarios of climate, hydrology, and vegetation for the Northwest. Climate Impacts Research Consortium, Corvallis, Oregon. http://climate.nkn.uidaho.edu/IntegratedScenarios/pages/publicationsreports/IntegratedScenariosFinalReport2014-10-07.pdf

Mote, P. W., & Salathe, E. P. (2010). Future climate in the Pacific Northwest. *Climatic Change*, *102*(1-2), 29-50.

Nakicenovic, N. et al. 2000. *Special Report on Emissions Scenarios: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, U.K., 599 pp. Available online at: http://www.grida.no/climate/ipcc/emission/index.htm

Nick, M., Das, S. and Simonovic, S.P. 2011. The Comparison of GEV, Log-Pearson Type 3 and Gumbel Distributions in the Upper Thames River Watershed under Global Climate Models, the University of Western Ontario Department of Civil and Environmental Engineering, Report No:077.

Rahman, A., Karin, F, and Rahman, A. 2015. Sampling Variability in Flood Frequency Analysis: How Important is it? 21st International Congress on Modelling and Simulation, Gold Coast, Australia, Nov 29-Dec 4, 2015, 2200-2206.

Rahman, A., Weinmann, P.E. and Mein, R.G. (1999). At-site flood frequency analysis: LP3-product moment, GEV-L moment and GEV-LH moment procedures compared. In: Proceeding Hydrology and Water Resource Symposium, Brisbane, 6–8 July, 2, 715–720.

Rupp, D. E., Abatzoglou, J. T., Hegewisch, K. C., & Mote, P. W. (2013). Evaluation of CMIP5 20th century climate simulations for the Pacific Northwest USA. *Journal of Geophysical Research: Atmospheres*, *118*(19).

Salathé Jr, E. P., Hamlet, A. F., Mass, C. F., Lee, S. Y., Stumbaugh, M., & Steed, R. (2014). Estimates of 21st century flood risk in the Pacific Northwest based on regional climate model simulations. *Journal of Hydrometeorology*, (2014).

Salathé, E. P., Leung, L. R., Qian, Y., & Zhang, Y. (2010). Regional climate model projections for the State of Washington. *Climatic Change*, *102*(1), 51-75.

Salathé, E. P. (2005). Downscaling simulations of future global climate with application to hydrologic modeling. International Journal of Climatology, 25, 419–436.

Skamarock, W. C., & Klemp, J. B. (2008). A time-split nonhydrostatic atmospheric model for weather research and forecasting applications. *Journal of Computational Physics*, *227*(7), 3465-3485.

Snover, A.K, G.S. Mauger, L.C. Whitely Binder, M. Krosby, and I. Tohver. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision*

Makers. State of Knowledge Report prepared for the Washington State Department of Ecology. Climate Impacts Group, University of Washington, Seattle.

Taylor, K. E. et al. 2012. An overview of CMIP5 and the experiment design. *Bulletin of the American Meteorological Society*, *93*(4), 485-498, doi:10.1175/BAMS-D-11-00094.1

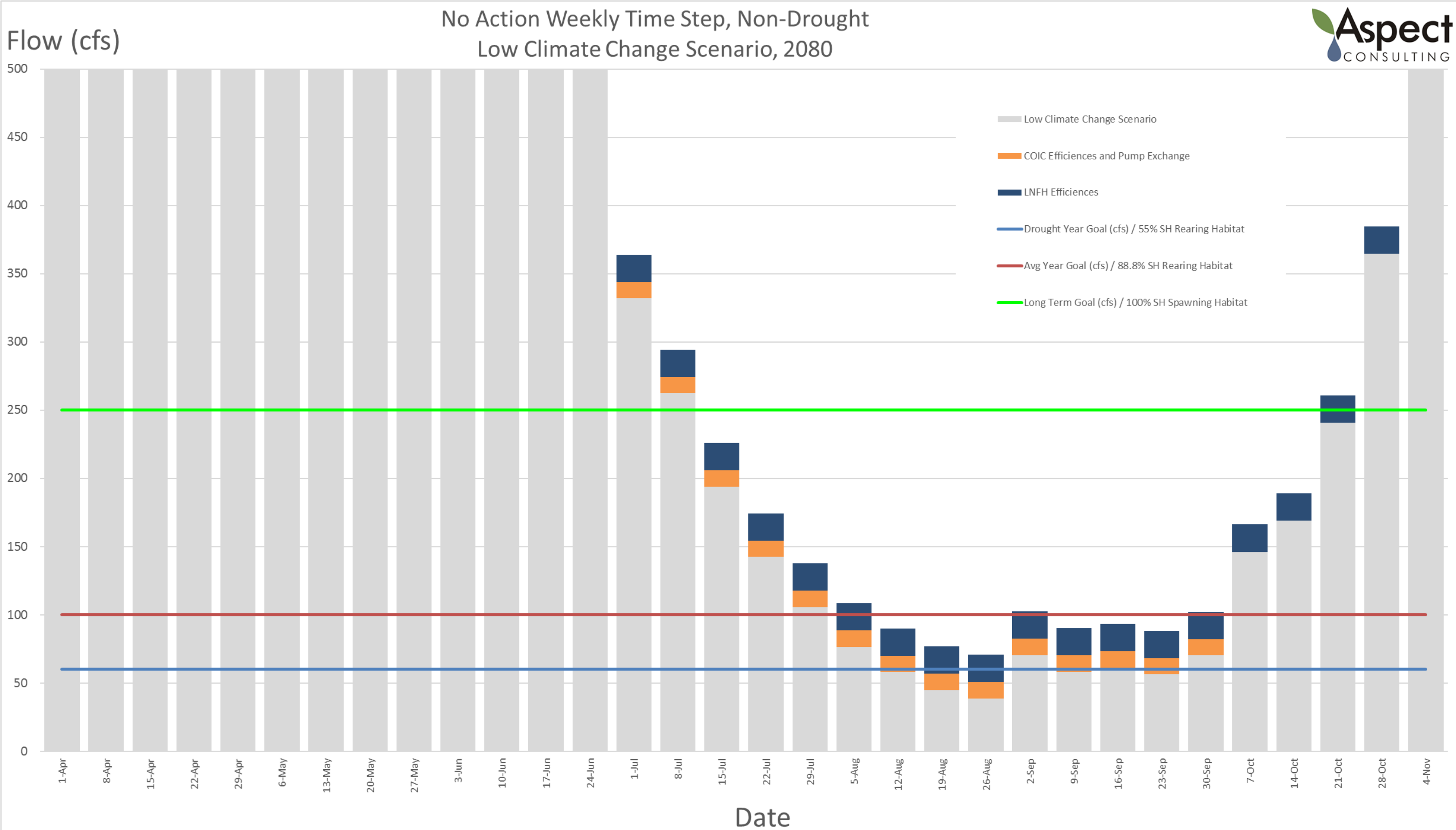
Tohver, I. M., Hamlet, A. F., & Lee, S. Y. (2014). Impacts of 21st-Century Climate Change on Hydrologic Extremes in the Pacific Northwest Region of North America. *JAWRA Journal of the American Water Resources Association*, *50*(6), 1461-1476.

Van Vuuren, D. P. et al. 2011. The representative concentration pathways: An overview. *Climatic Change* 109(1-2): 5-31.

Vogel, R.M., McMahon, T.A. and Chiew, F.H.S. (1993). Flood flow frequency model selection in Australia, Journal Hydrology, 146, 421-449.

Wang, Q.J. 1997. LH moments for statistical analysis of extreme events. *Water Resour Res*, 33(12), 2841- 2848.

Wood, A. W., Leung, L. R., Sridhar, V., & Lettenmaier, D. P. (2004). Hydrologic implications of dynamical and statistical approaches to downscaling climate model outputs. *Climatic change*, *62*(1), 189-216.



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LNFH Efficiences
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Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
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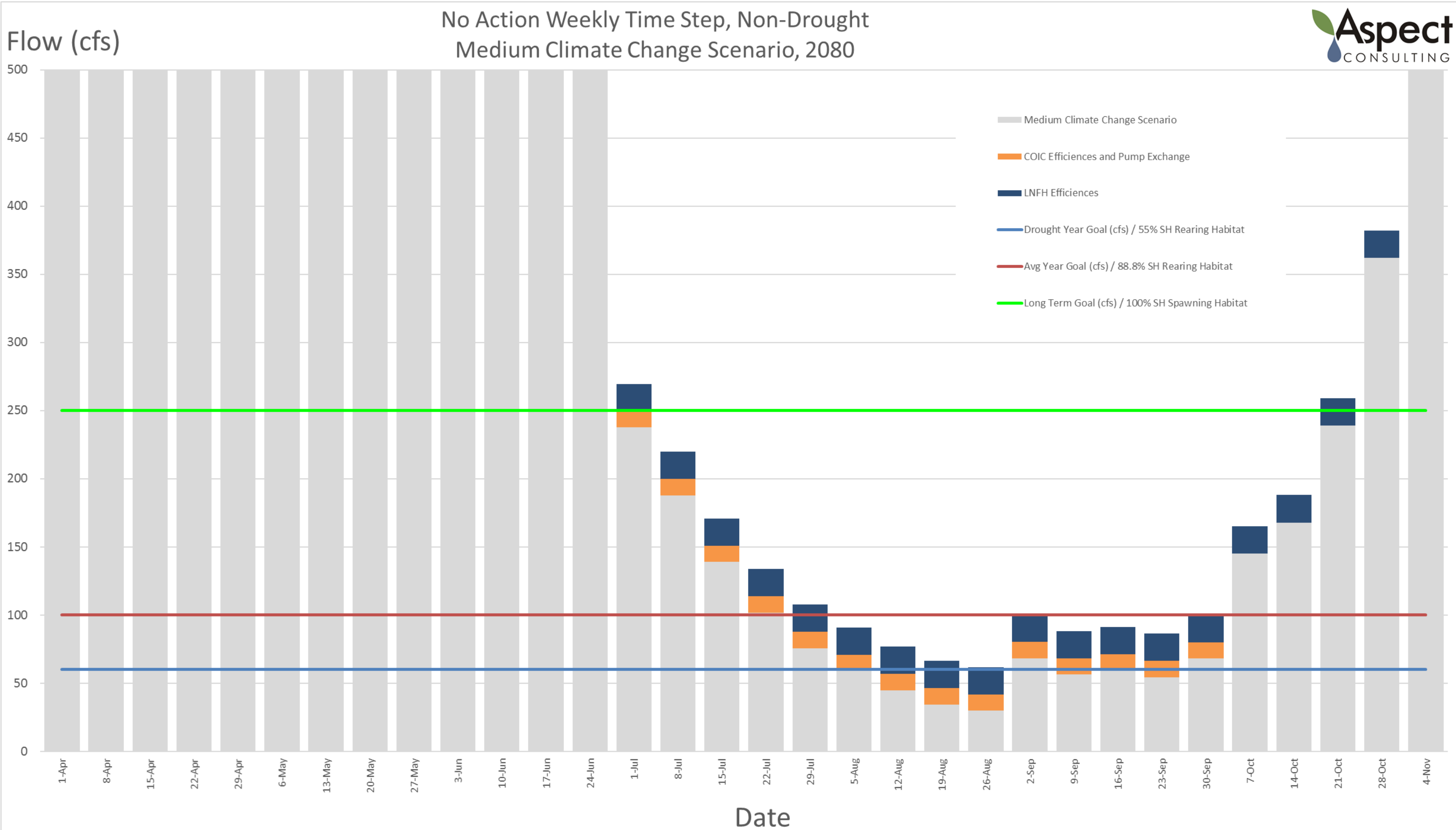

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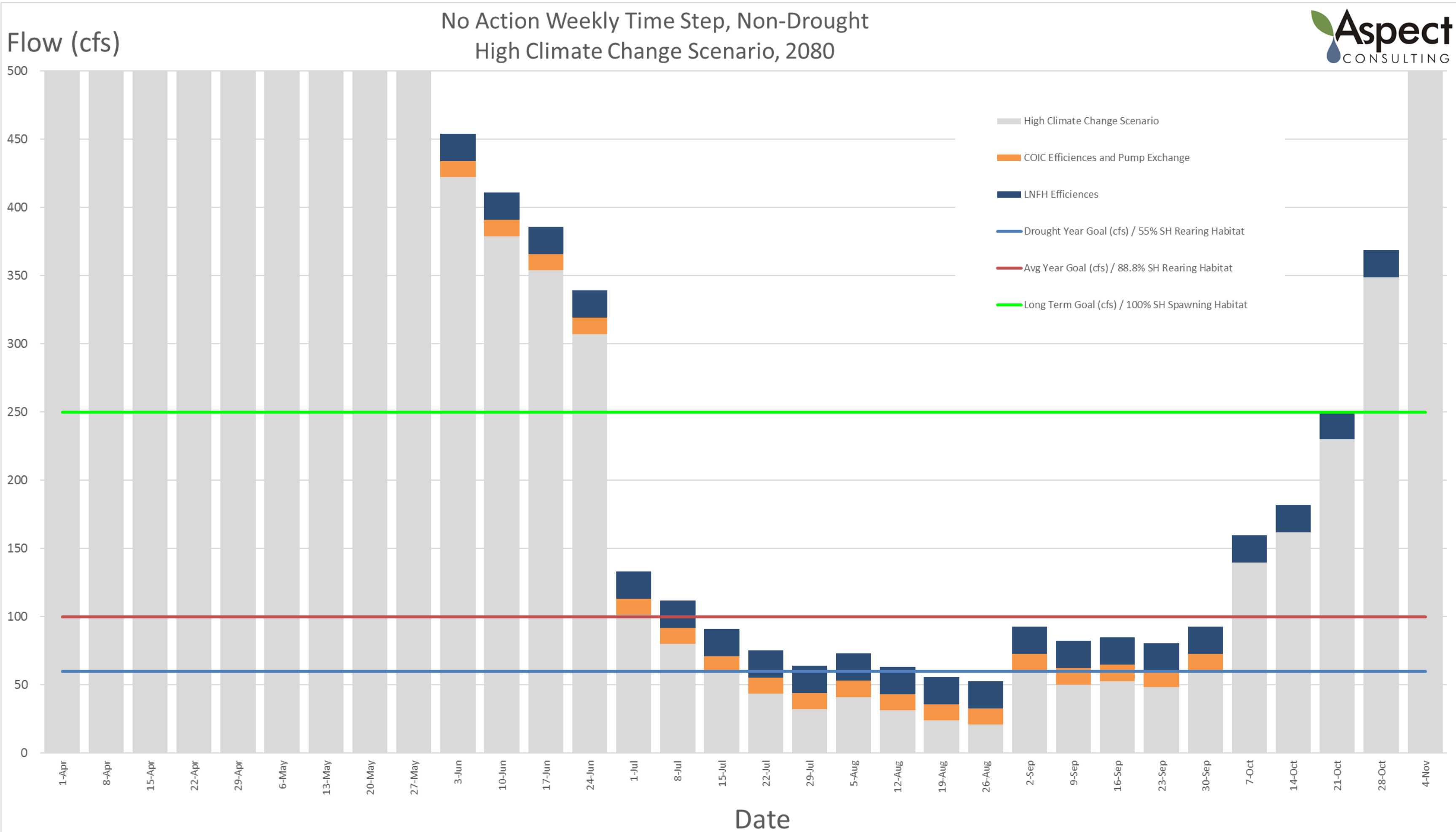

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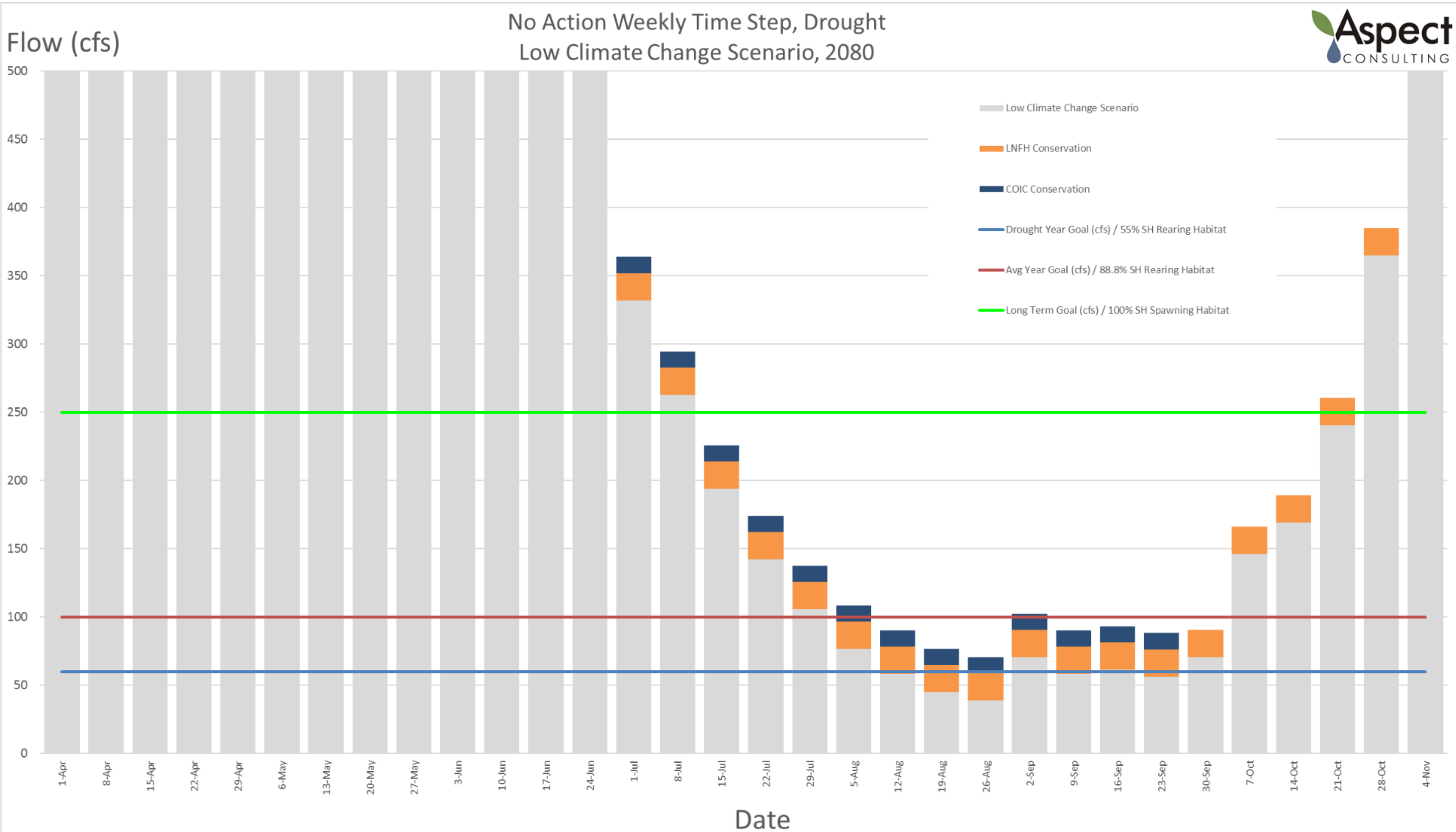
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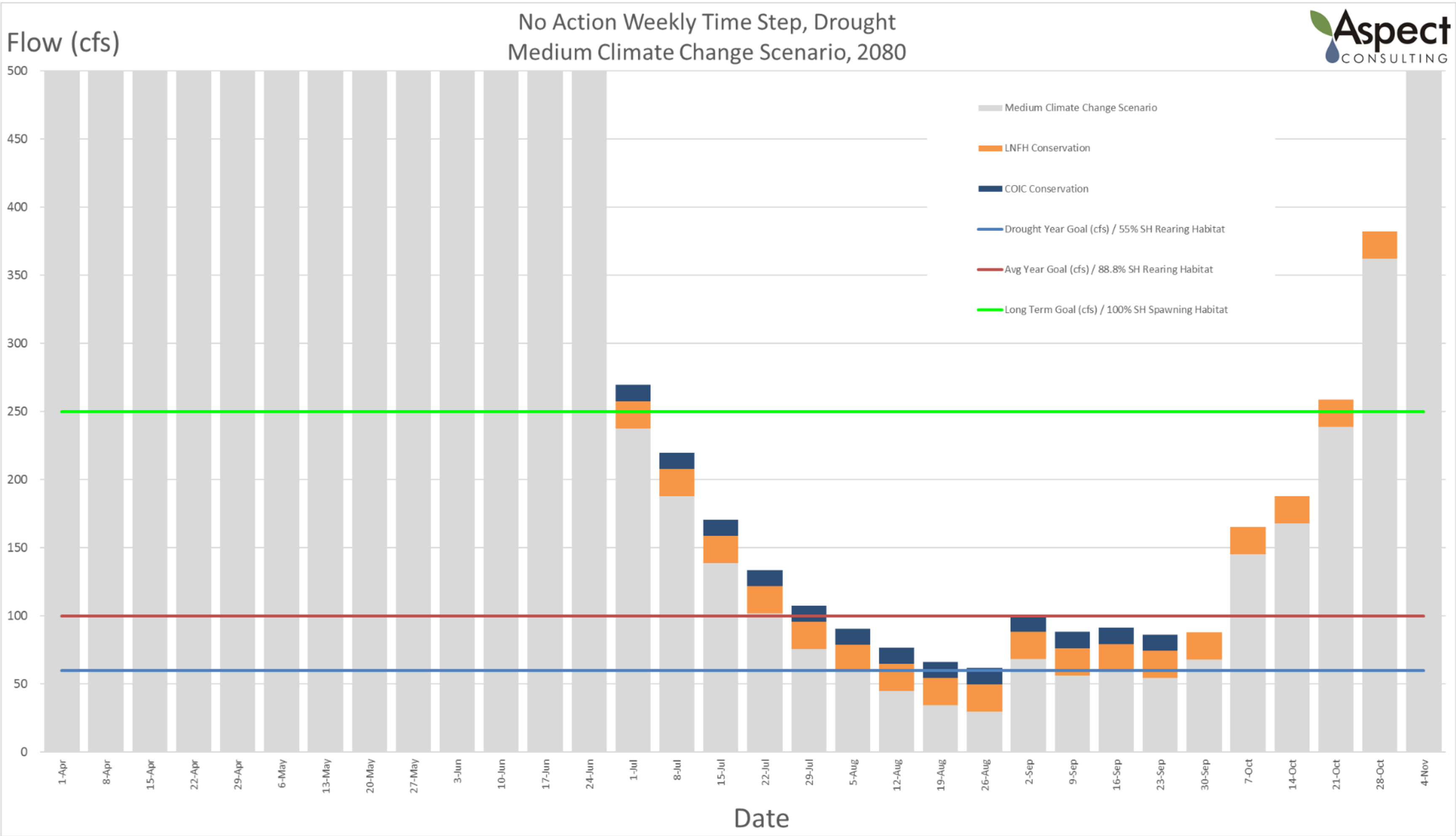

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Long Term Goal (cfs) / 100% SH Spawning Habitat
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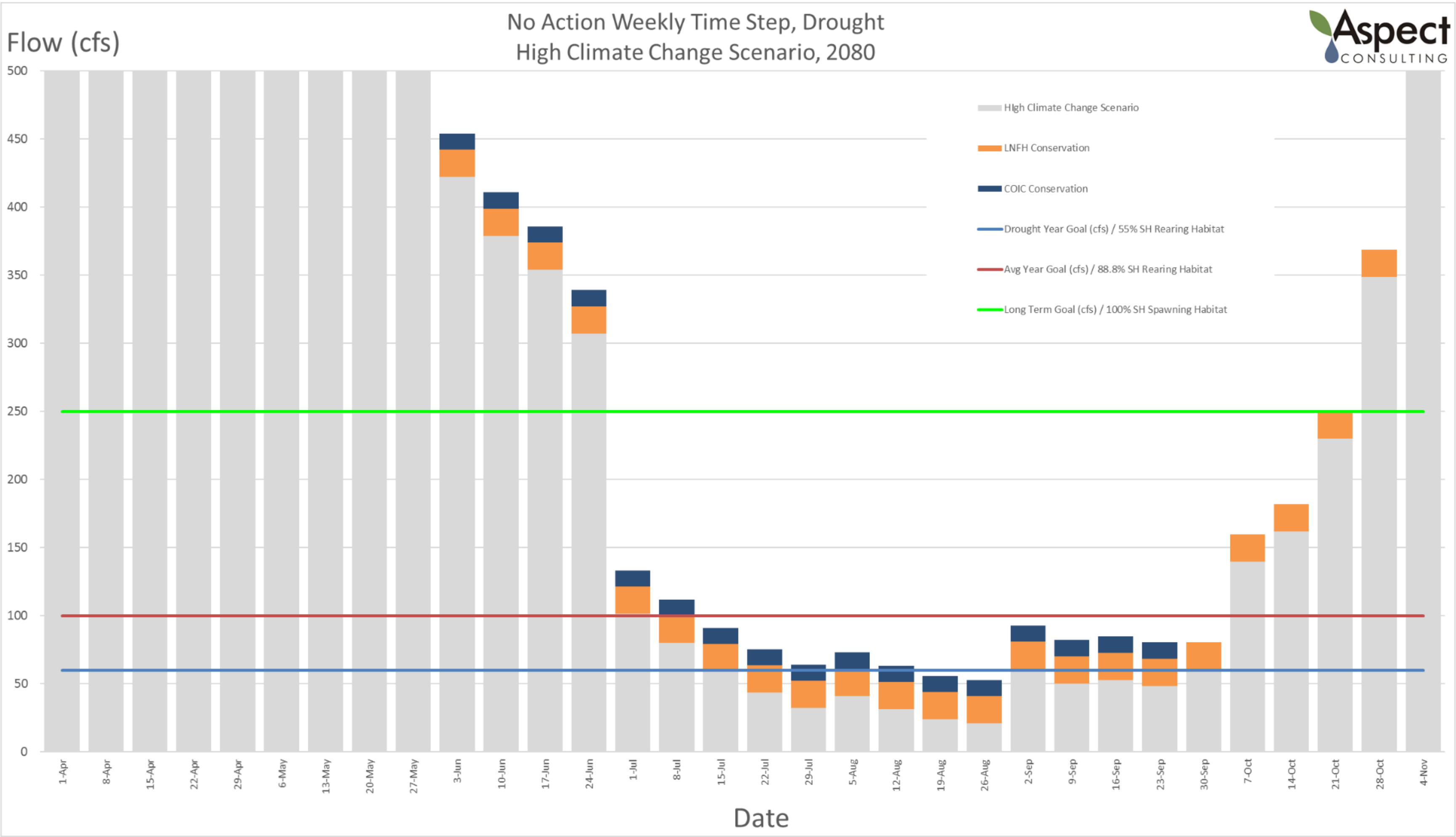

No Action Weekly Time Step, Drought
High Climate Change Scenario, 2080
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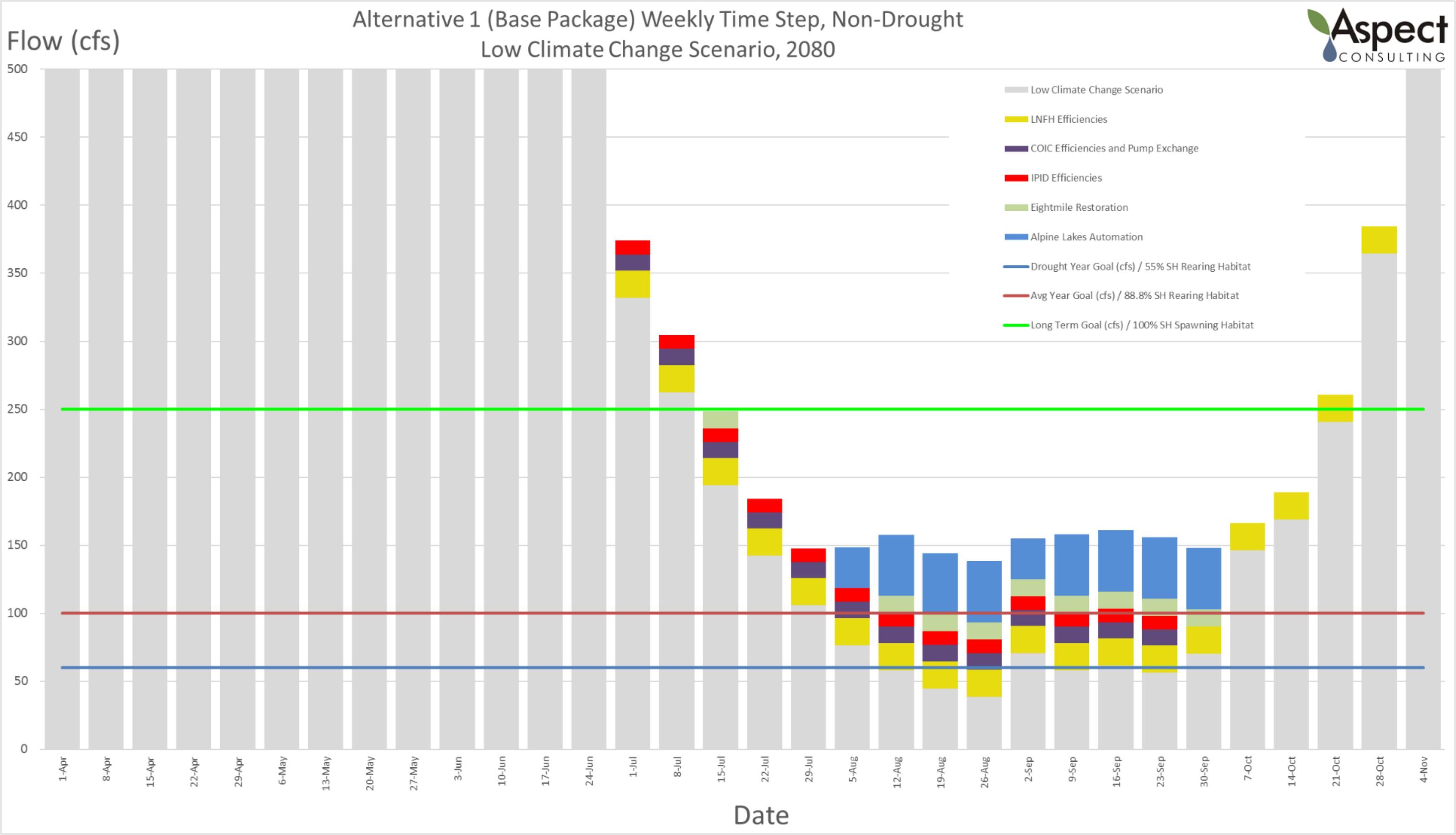

Alternative 1 (Base Package) Weekly Time Step, Non-Drought
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Low Climate Change Scenario
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Eightmile Restoration
Alpine Lakes Automation
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
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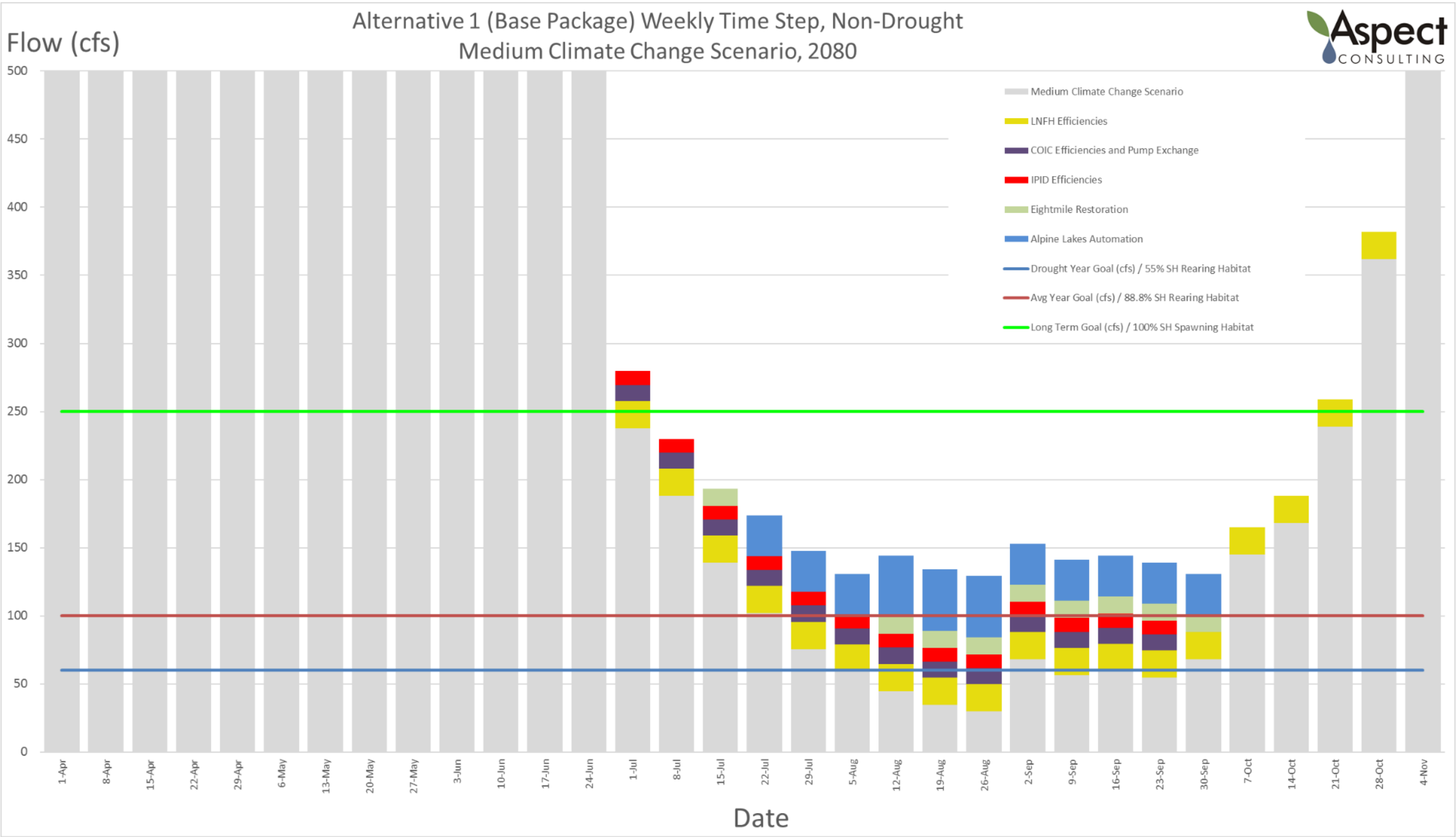

Alternative 1 (Base Package) Weekly Time Step, Non-Drought
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Drought Year Goal (cfs) / 55% SH Rearing Habitat
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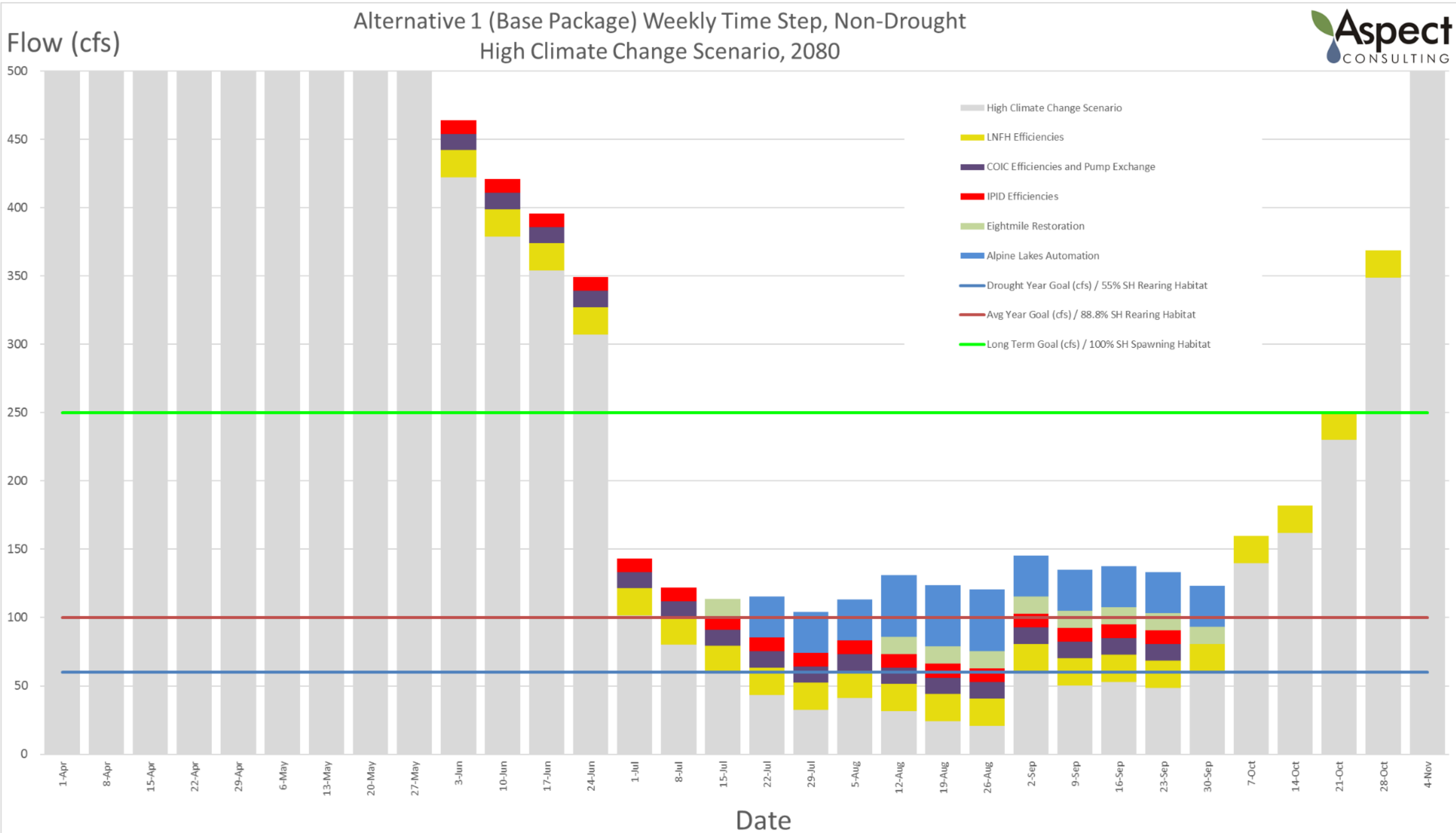

Alternative 1 (Base Package) Weekly Time Step, Non-Drought
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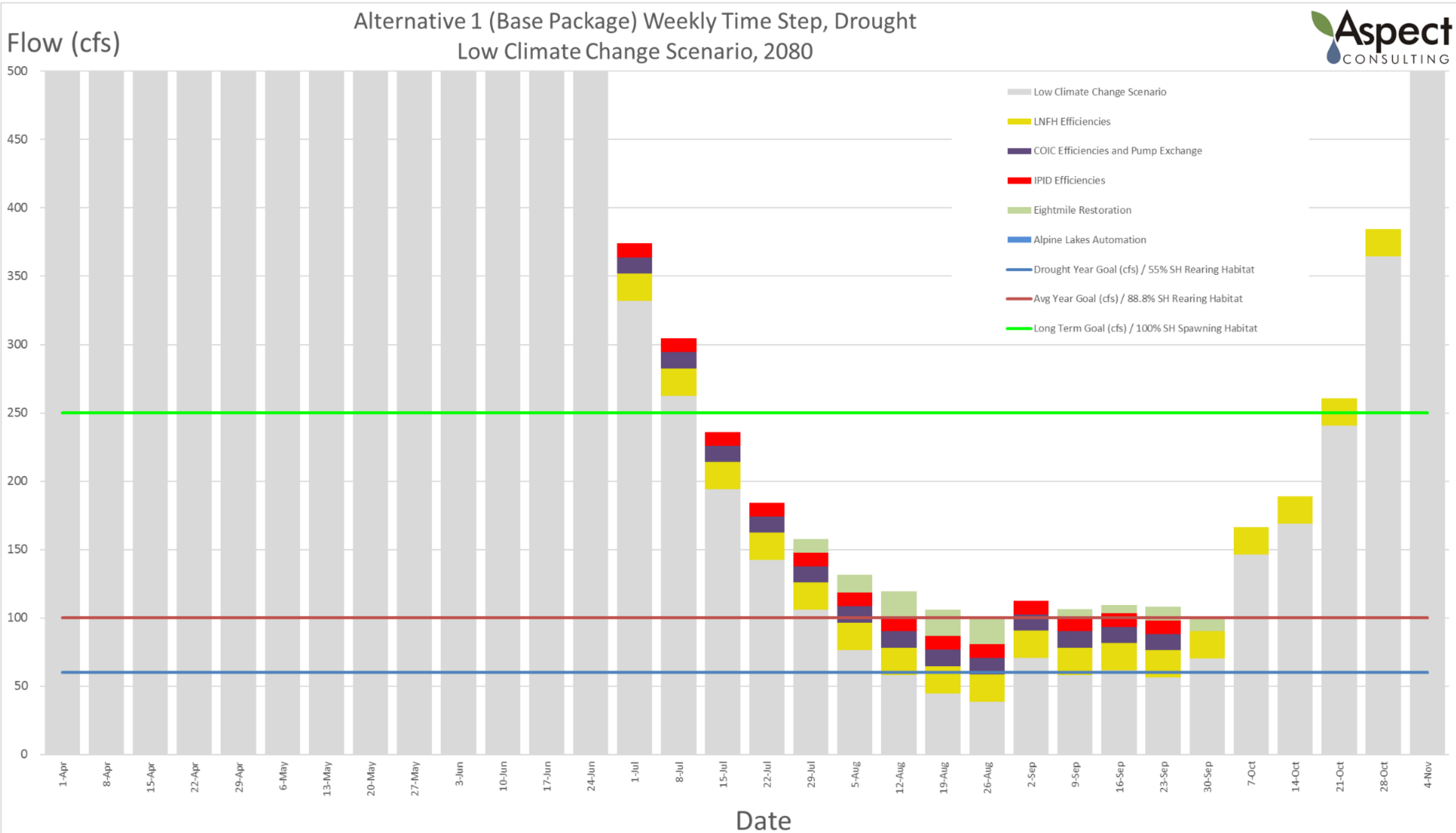

Alternative 1 (Base Package) Weekly Time Step, Drought
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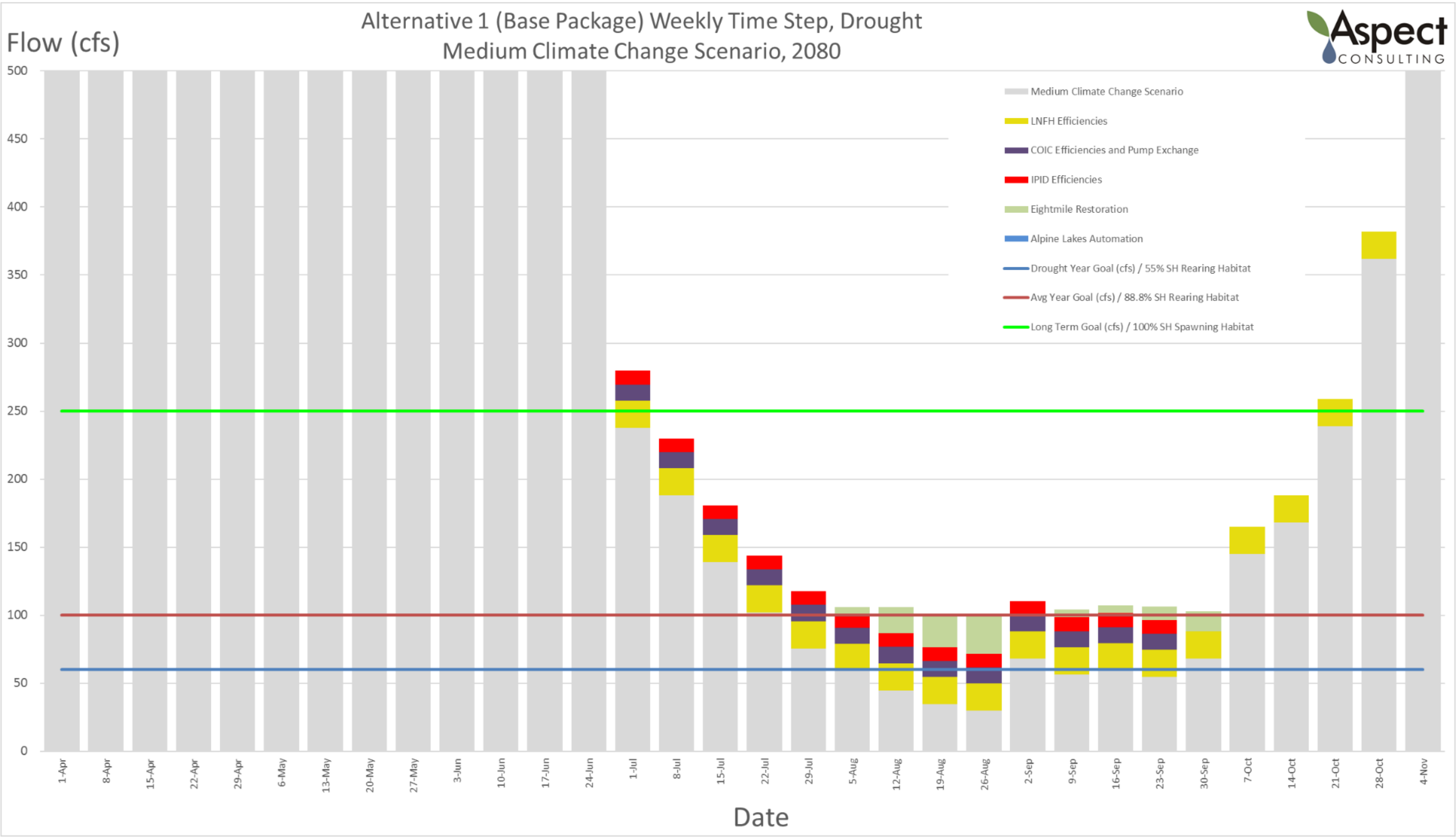
Date



Alternative 1 (Base Package) Weekly Time Step, Drought
Medium Climate Change Scenario, 2080
Aspect CONSULTING
Flow (cfs)
500
450
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350
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0
Medium Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
IPID Efficiencies
Eightmile Restoration
Alpine Lakes Automation
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
1-Apr
8-Apr
15-Apr
22-Apr
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
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8-Jul
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22-Jul
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5-Aug
12-Aug
19-Aug
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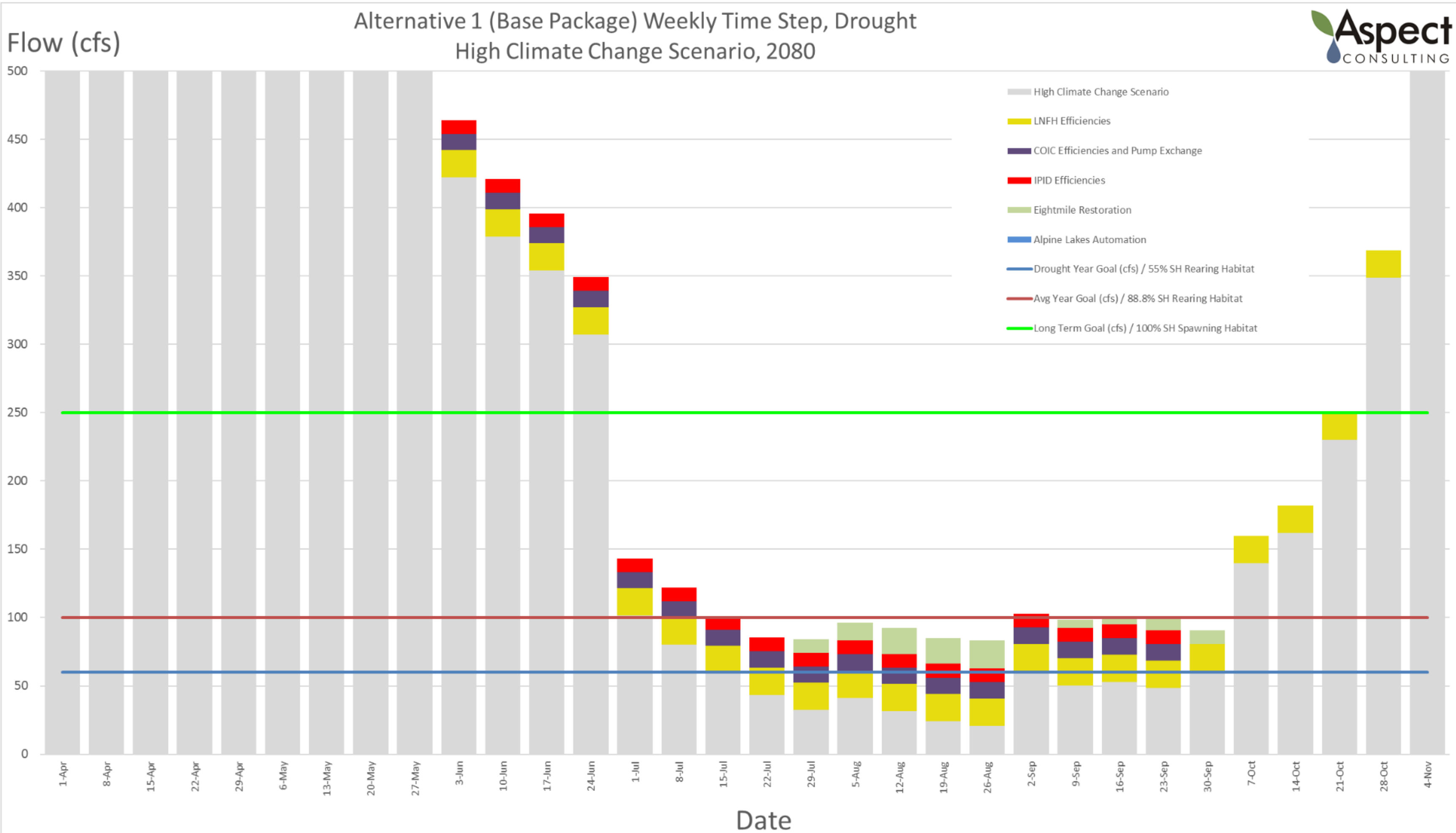
9-Sep
16-Sep
23-Sep
30-Sep
7-Oct
14-Oct
21-Oct
28-Oct
4-Nov
Date


Alternative 1 (Base Package) Weekly Time Step, Drought
High Climate Change Scenario, 2080
Aspect CONSULTING
Flow (cfs)
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High Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
IPID Efficiencies
Eightmile Restoration
Alpine Lakes Automation
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
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1-Apr
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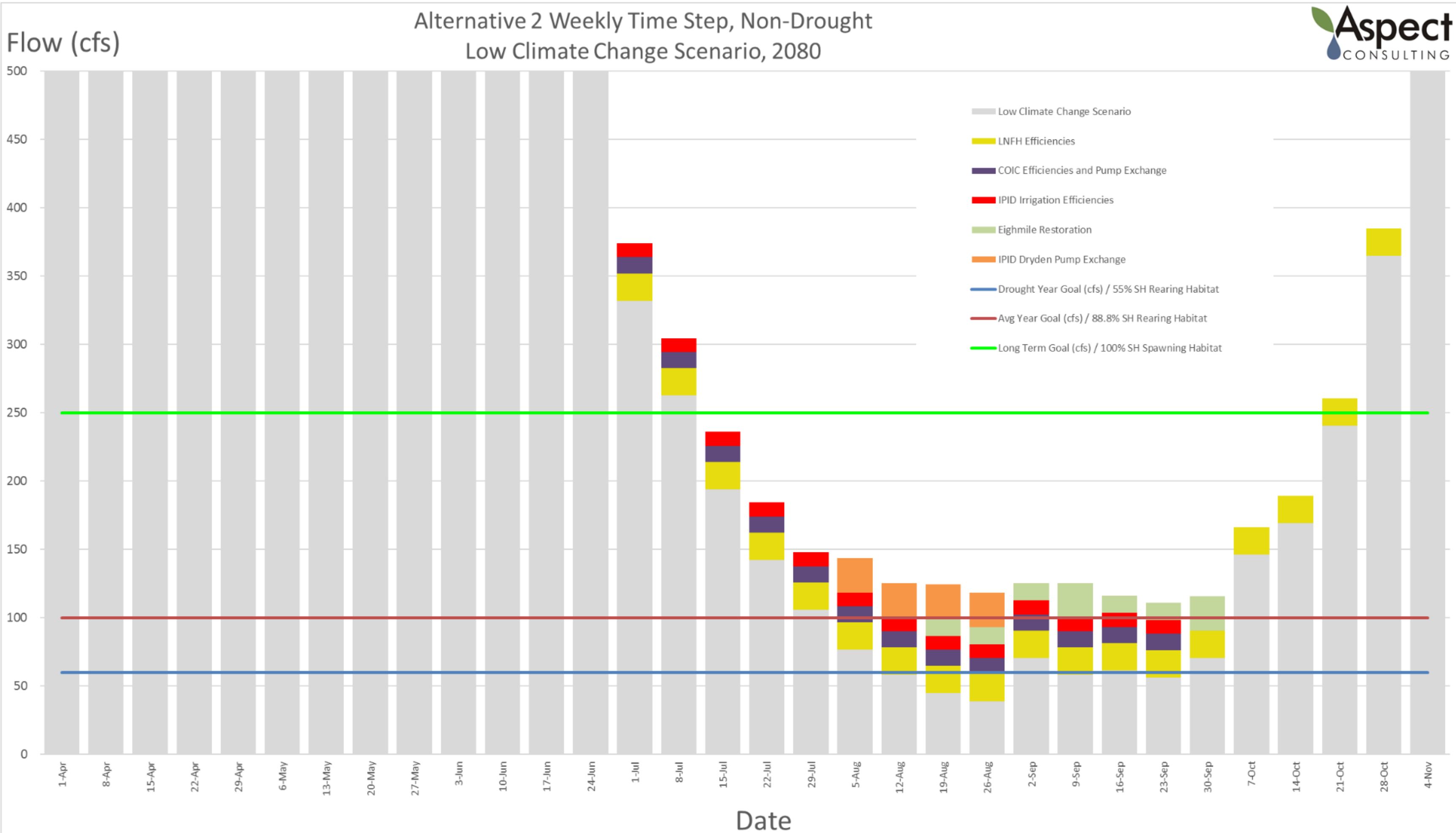
4-Nov
Date



Alternative 2 Weekly Time Step, Non-Drought
Low Climate Change Scenario, 2080
Aspect
CONSULTING
Flow (cfs)
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Low Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
IPID Irrigation Efficiencies
Eighmile Restoration
IPID Dryden Pump Exchange
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
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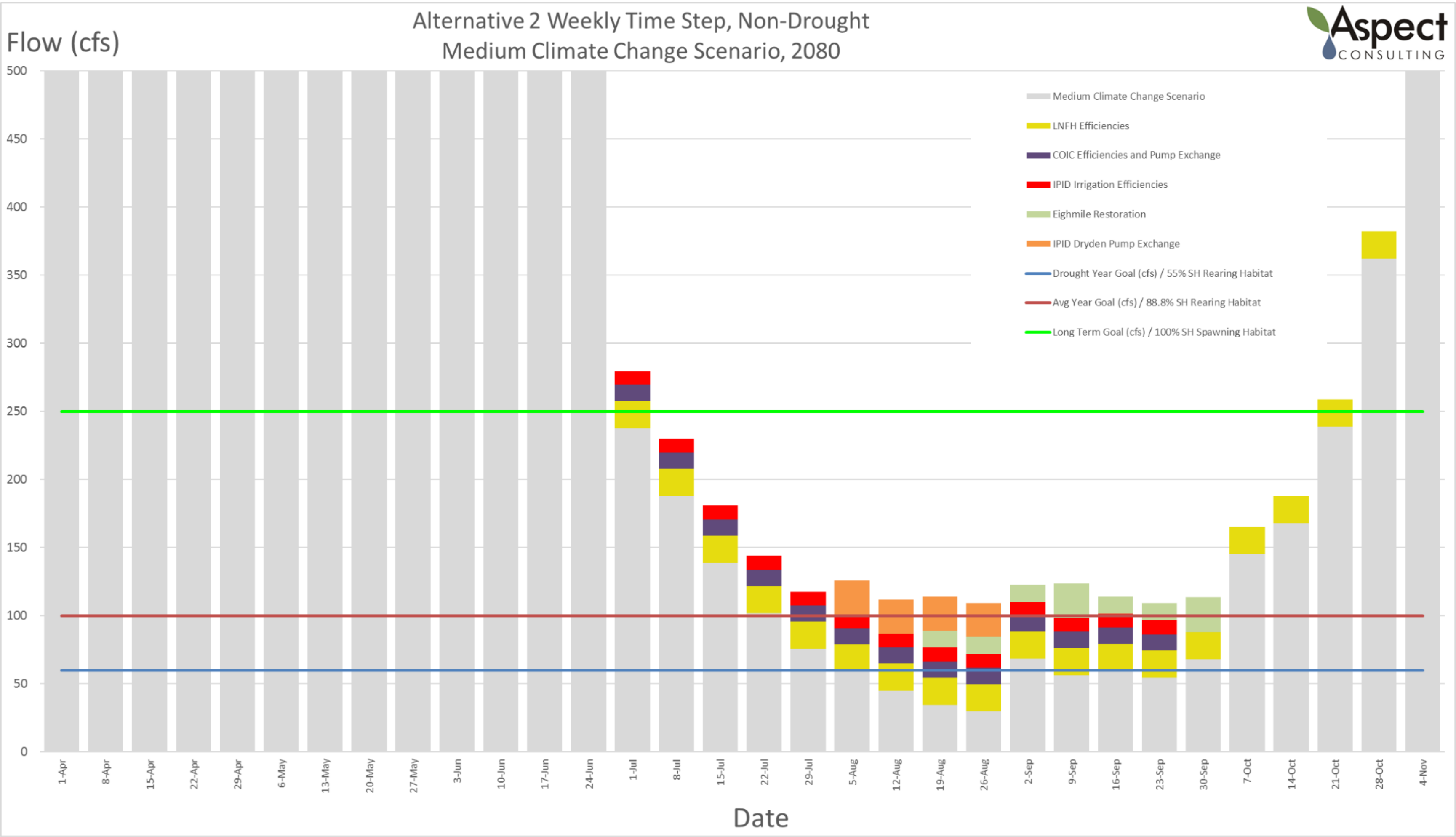
Date



Alternative 2 Weekly Time Step, Non-Drought
Medium Climate Change Scenario, 2080
Flow (cfs)
Aspect CONSULTING
Medium Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
IPID Irrigation Efficiencies
Eighmile Restoration
IPID Dryden Pump Exchange
Drought Year Goal (cfs) / 55% SH Rearing Habitat
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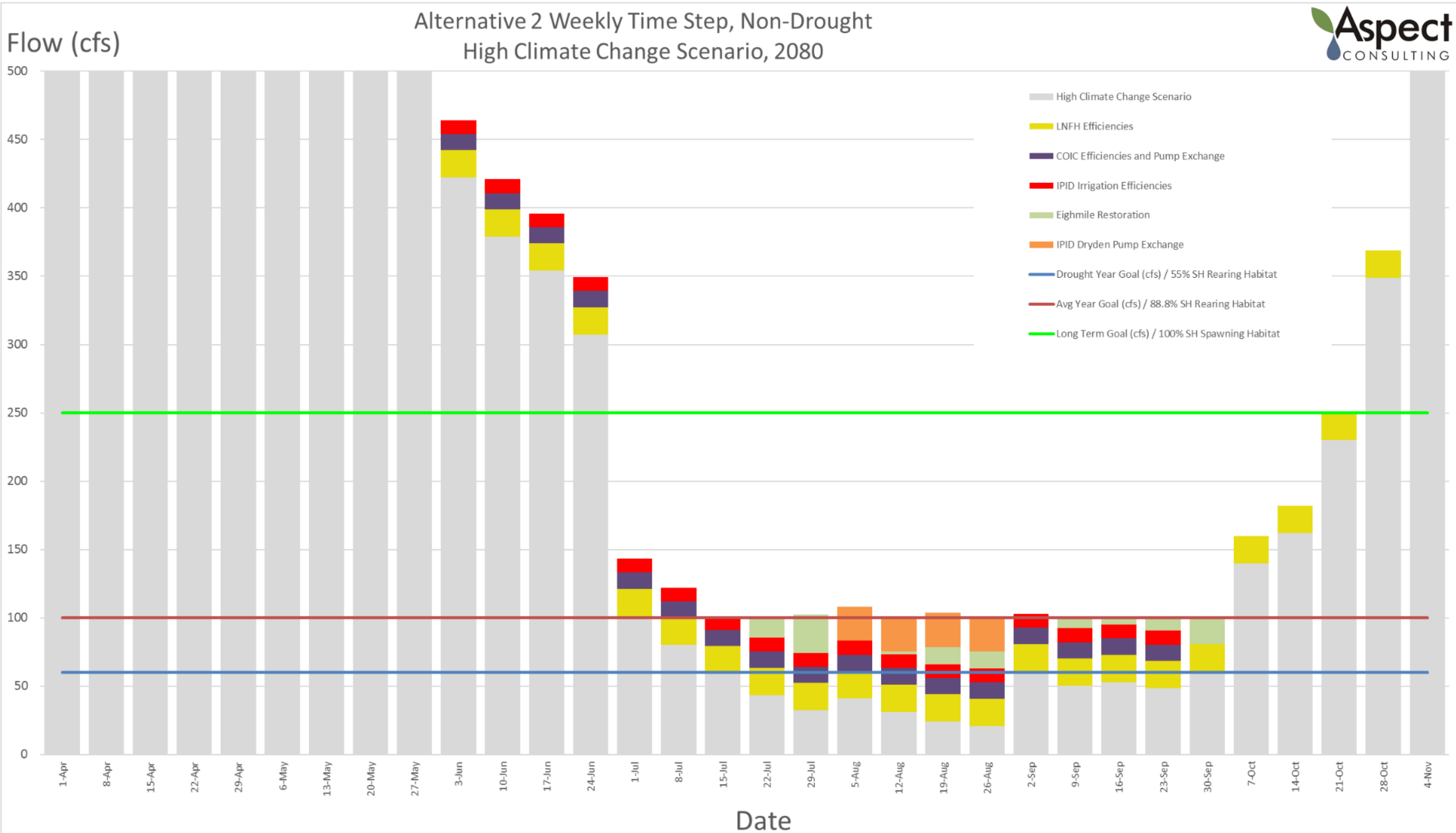
Date


Alternative 2 Weekly Time Step, Non-Drought
High Climate Change Scenario, 2080
Flow (cfs)
Aspect CONSULTING
High Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
IPID Irrigation Efficiencies
Eighmile Restoration
IPID Dryden Pump Exchange
Drought Year Goal (cfs) / 55% SH Rearing Habitat
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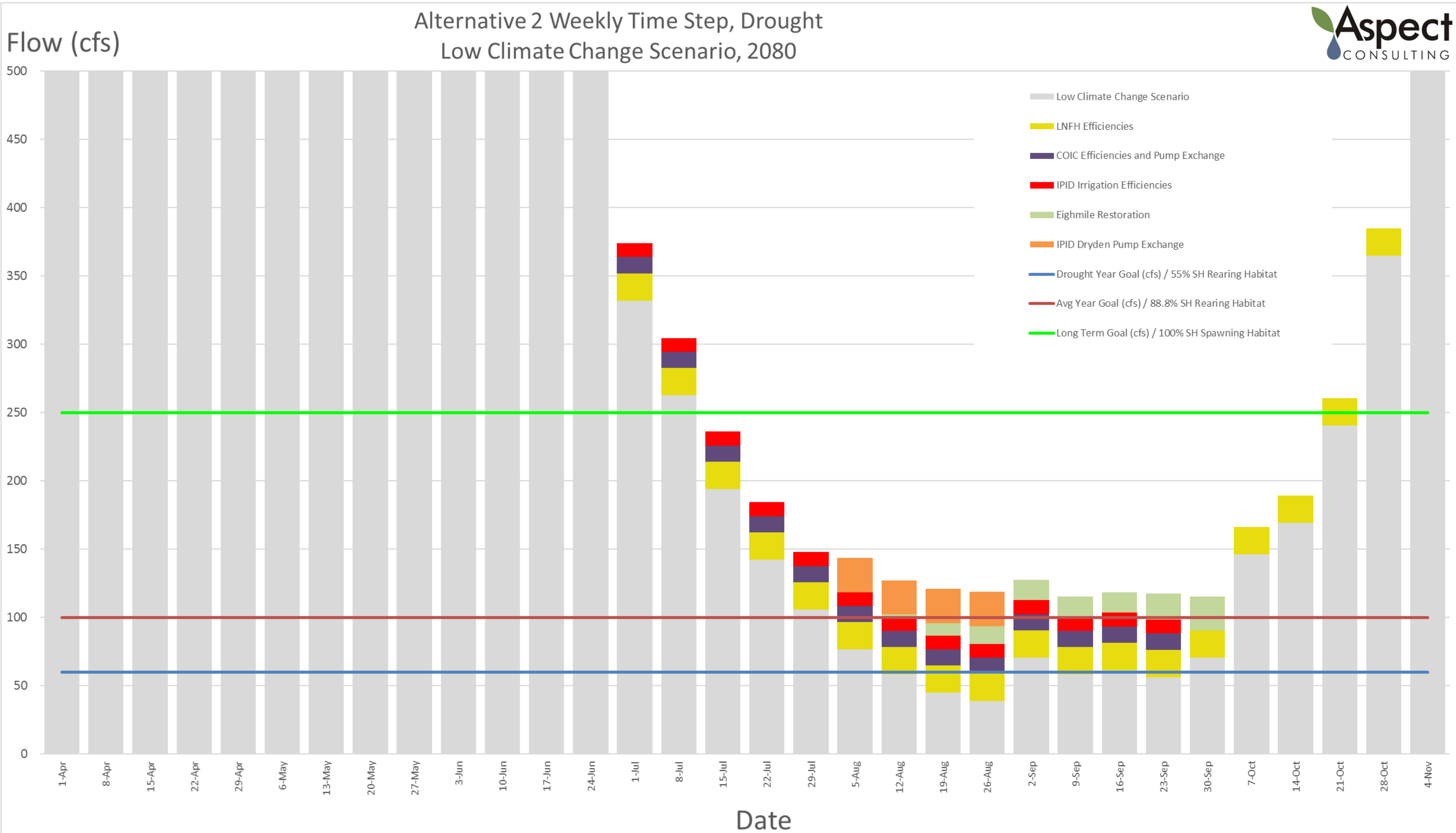
Date


Alternative 2 Weekly Time Step, Drought
Low Climate Change Scenario, 2080
Flow (cfs)
Aspect CONSULTING
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Low Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
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Eighmile Restoration
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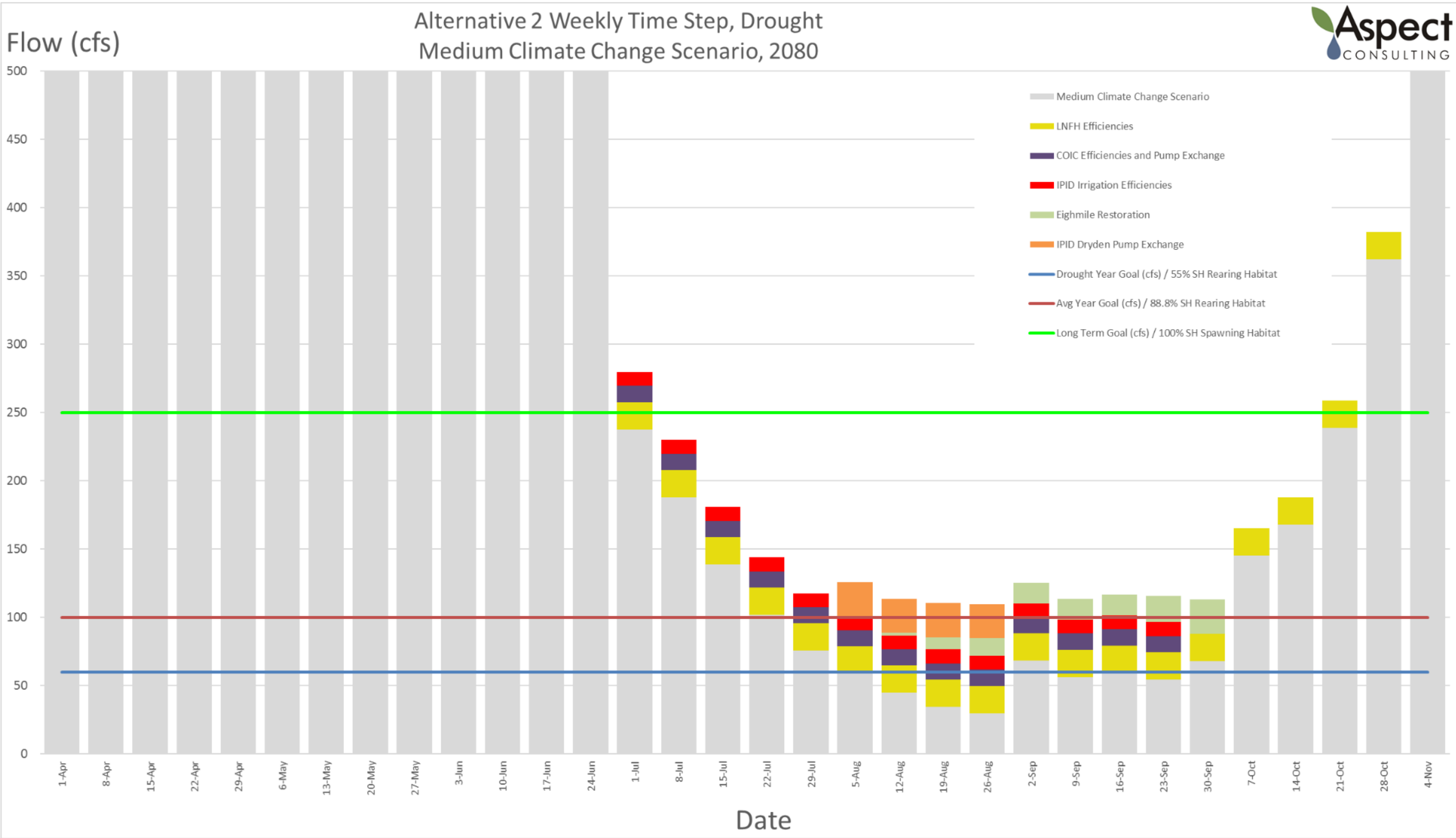
Date



Alternative 2 Weekly Time Step, Drought
Medium Climate Change Scenario, 2080
Aspect CONSULTING
Flow (cfs)
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Medium Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
IPID Irrigation Efficiencies
Eighmile Restoration
IPID Dryden Pump Exchange
Drought Year Goal (cfs) / 55% SH Rearing Habitat
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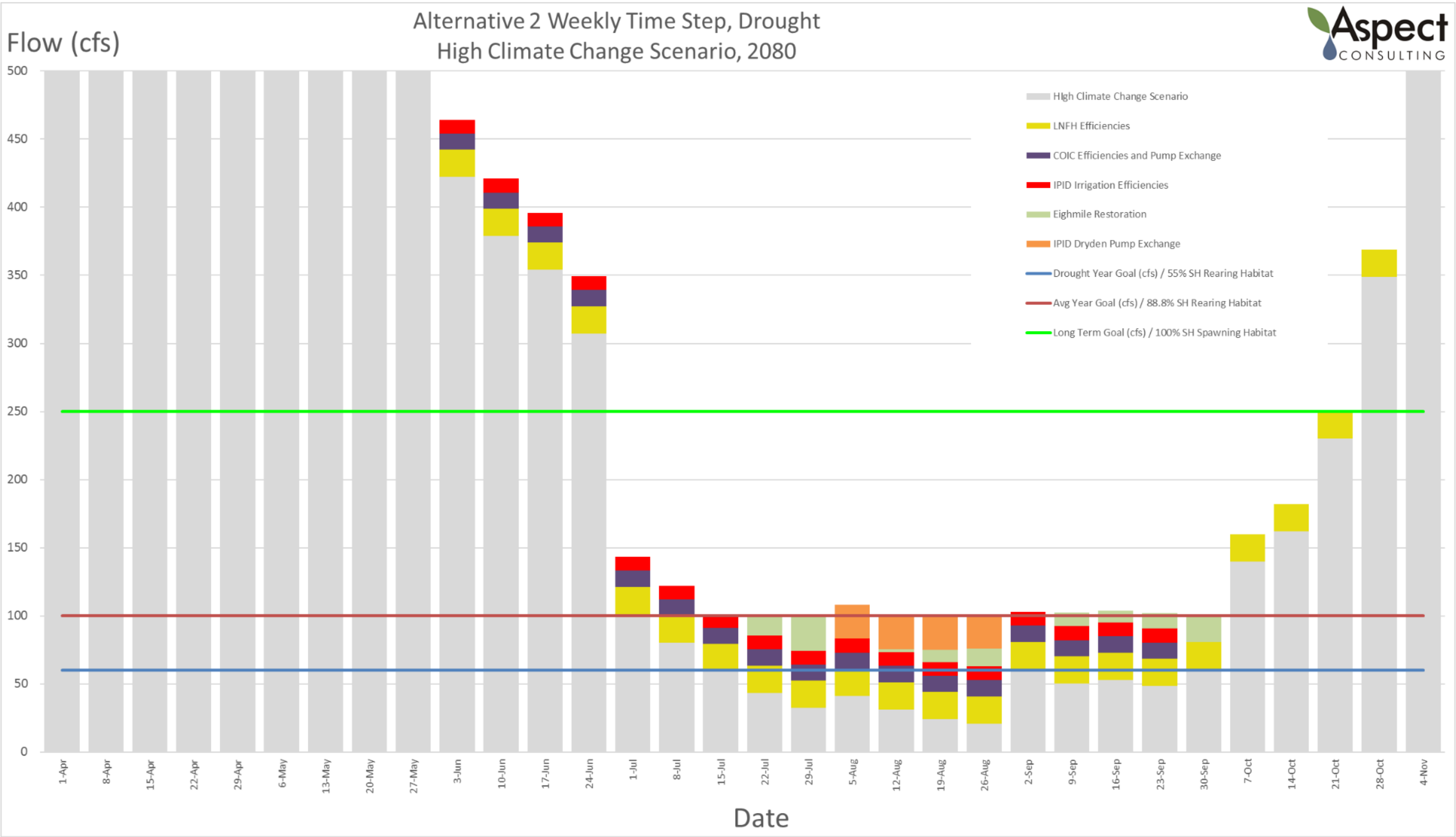
Date



Alternative 2 Weekly Time Step, Drought
High Climate Change Scenario, 2080
Flow (cfs)
Aspect
CONSULTING
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High Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
IPID Irrigation Efficiencies
Eighmile Restoration
IPID Dryden Pump Exchange
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
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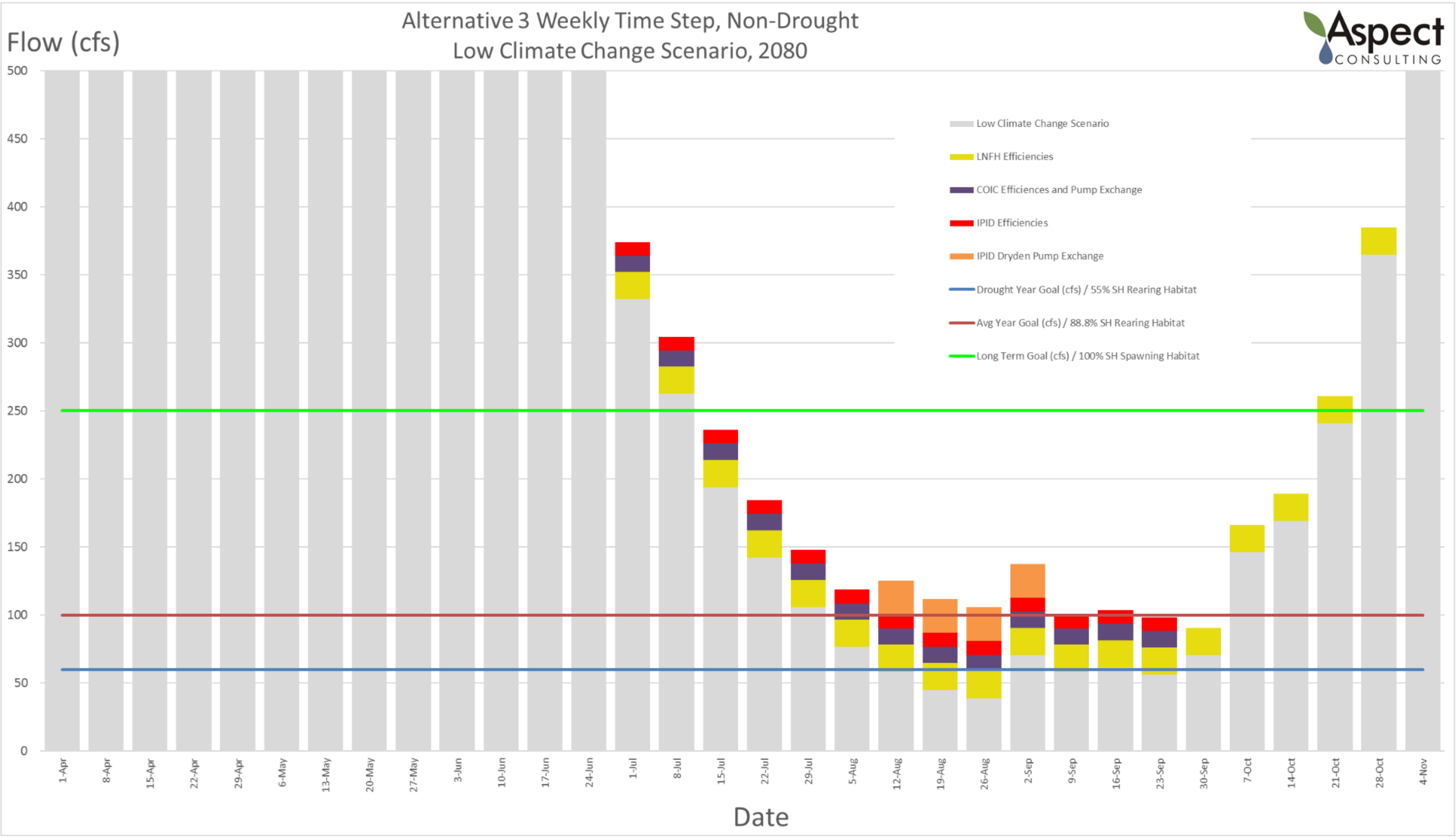

Alternative 3 Weekly Time Step, Non-Drought
Low Climate Change Scenario, 2080
Flow (cfs)
Aspect CONSULTING
Low Climate Change Scenario
LNFH Efficiencies
COIC Efficiences and Pump Exchange
IPID Efficiencies
IPID Dryden Pump Exchange
Drought Year Goal (cfs) / 55% SH Rearing Habitat
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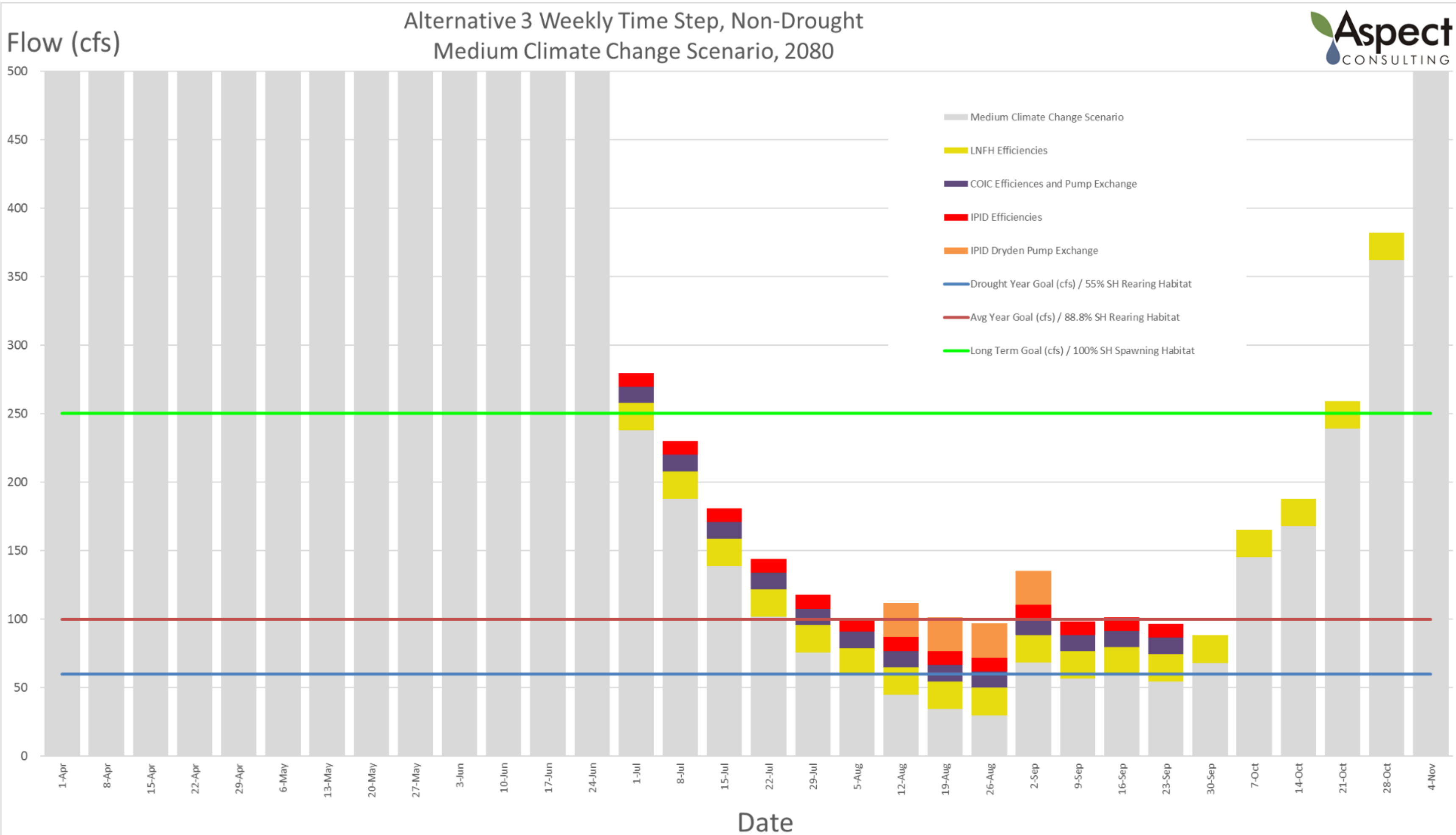
Date



Alternative 3 Weekly Time Step, Non-Drought
Medium Climate Change Scenario, 2080
Flow (cfs)
Aspect
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Medium Climate Change Scenario
LNFH Efficiencies
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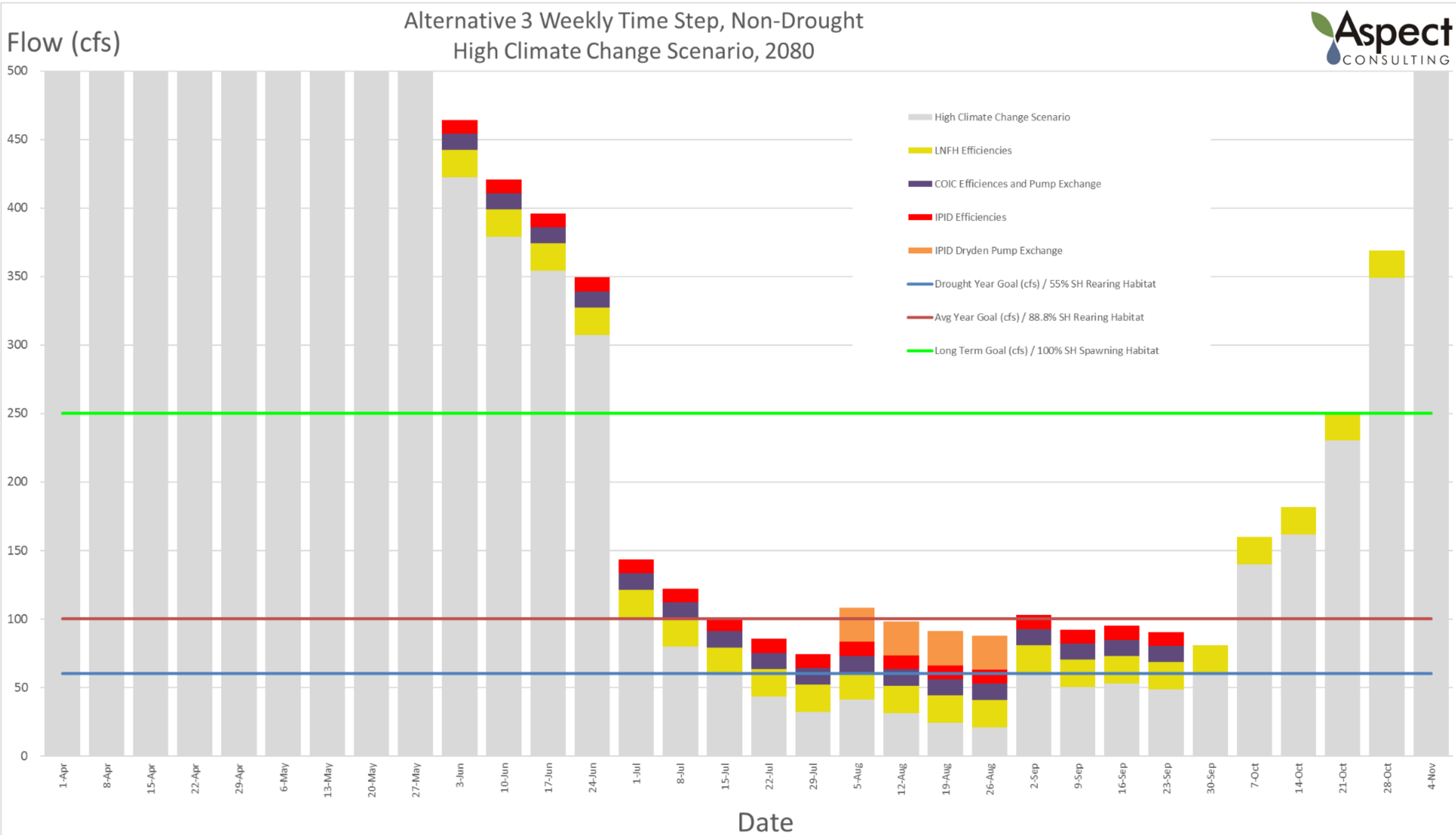
4-Nov
Date


Alternative 3 Weekly Time Step, Non-Drought
High Climate Change Scenario, 2080
Aspect CONSULTING
Flow (cfs)
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High Climate Change Scenario
LNFH Efficiencies
COIC Efficiences and Pump Exchange
IPID Efficiencies
IPID Dryden Pump Exchange
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
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27-May
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10-Jun
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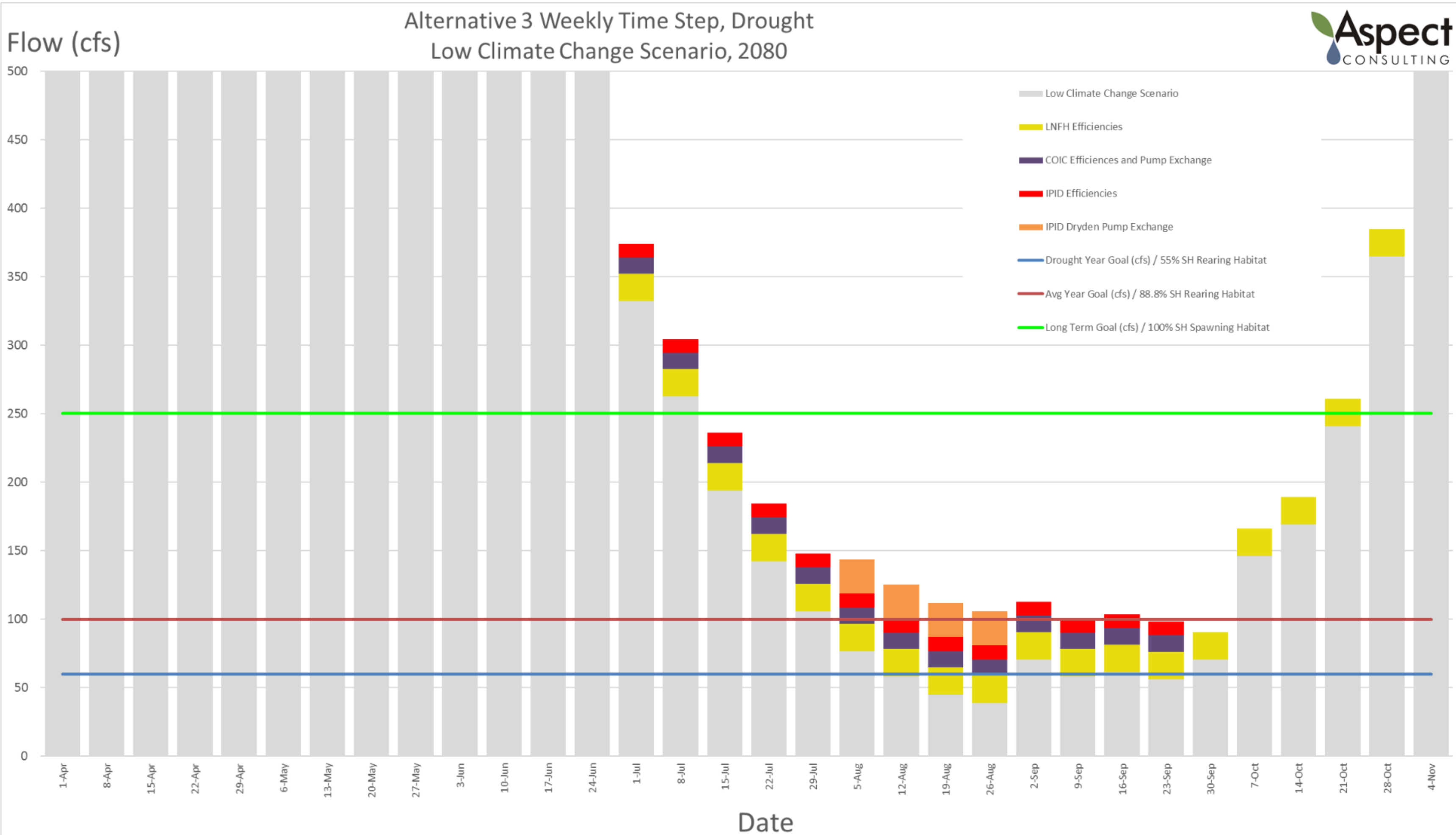
28-Oct
4-Nov
Date



Alternative 3 Weekly Time Step, Drought
Low Climate Change Scenario, 2080
Flow (cfs)
Aspect CONSULTING
Low Climate Change Scenario
LNFH Efficiencies
COIC Efficiences and Pump Exchange
IPID Efficiencies
IPID Dryden Pump Exchange
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
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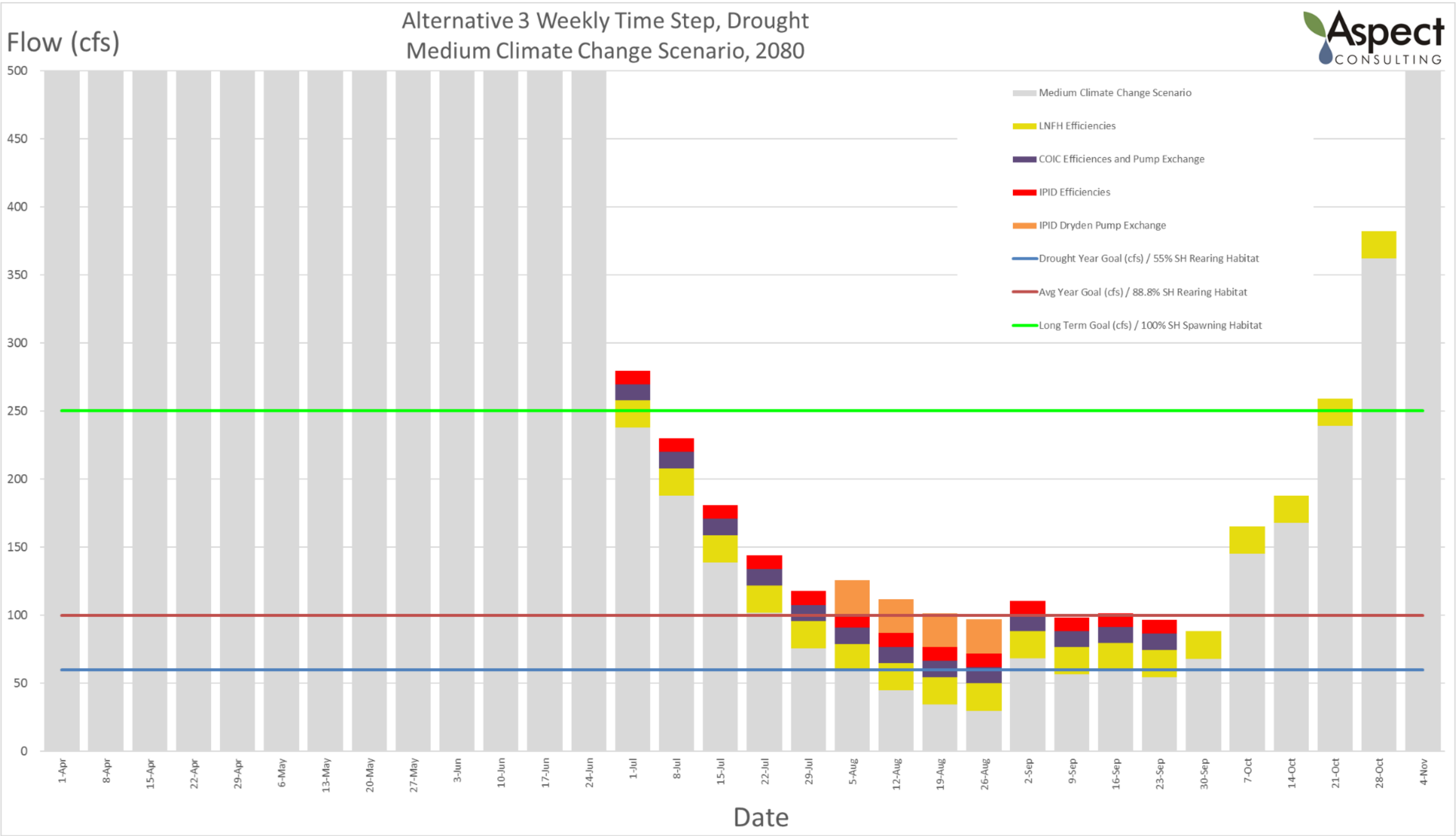
Date



Alternative 3 Weekly Time Step, Drought
Medium Climate Change Scenario, 2080
Flow (cfs)
Aspect CONSULTING
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Medium Climate Change Scenario
LNFH Efficiencies
COIC Efficiences and Pump Exchange
IPID Efficiencies
IPID Dryden Pump Exchange
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
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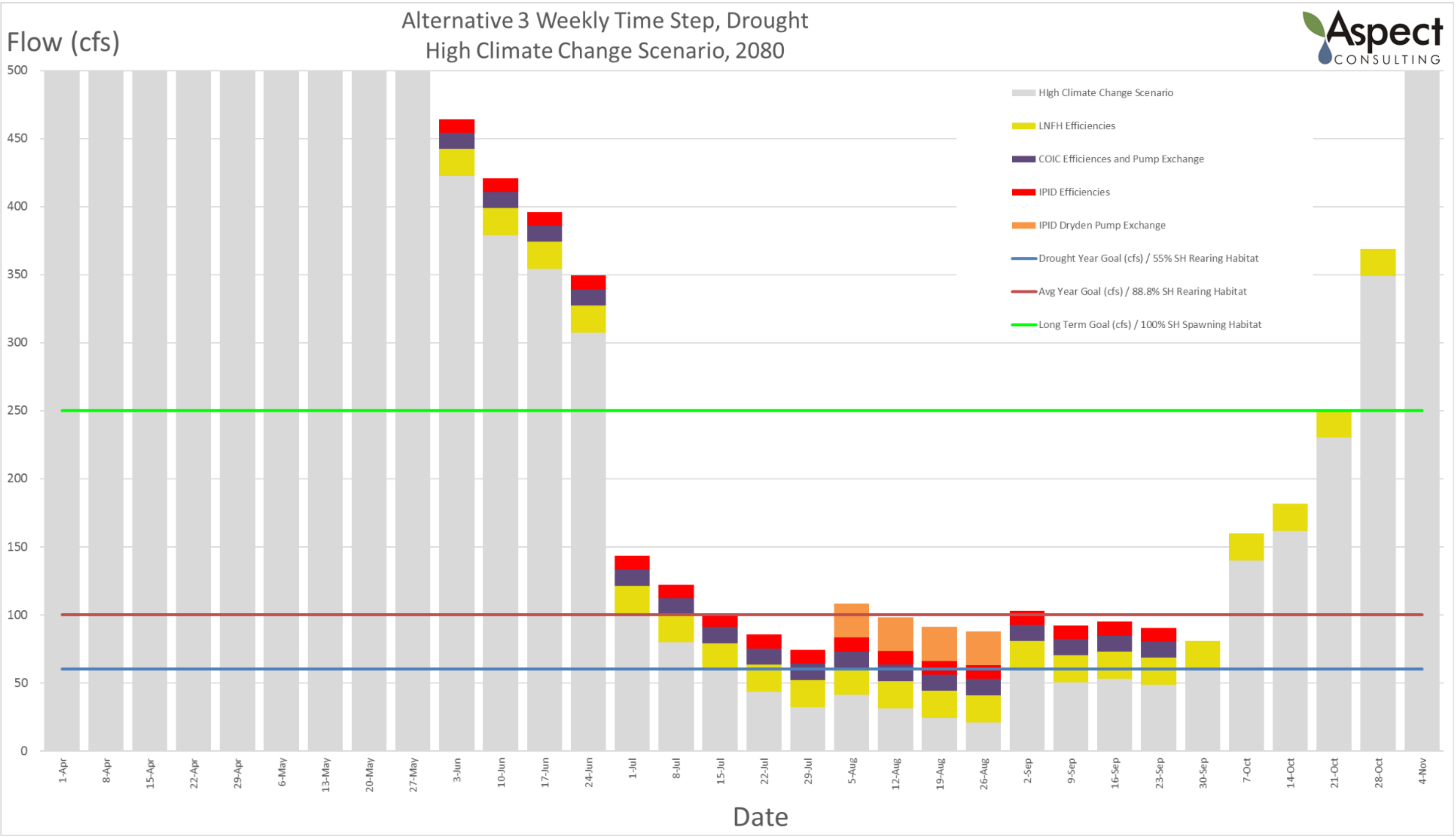
Date



Alternative 3 Weekly Time Step, Drought
High Climate Change Scenario, 2080
Aspect CONSULTING
Flow (cfs)
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High Climate Change Scenario
LNFH Efficiencies
COIC Efficiences and Pump Exchange
IPID Efficiencies
IPID Dryden Pump Exchange
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
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27-May
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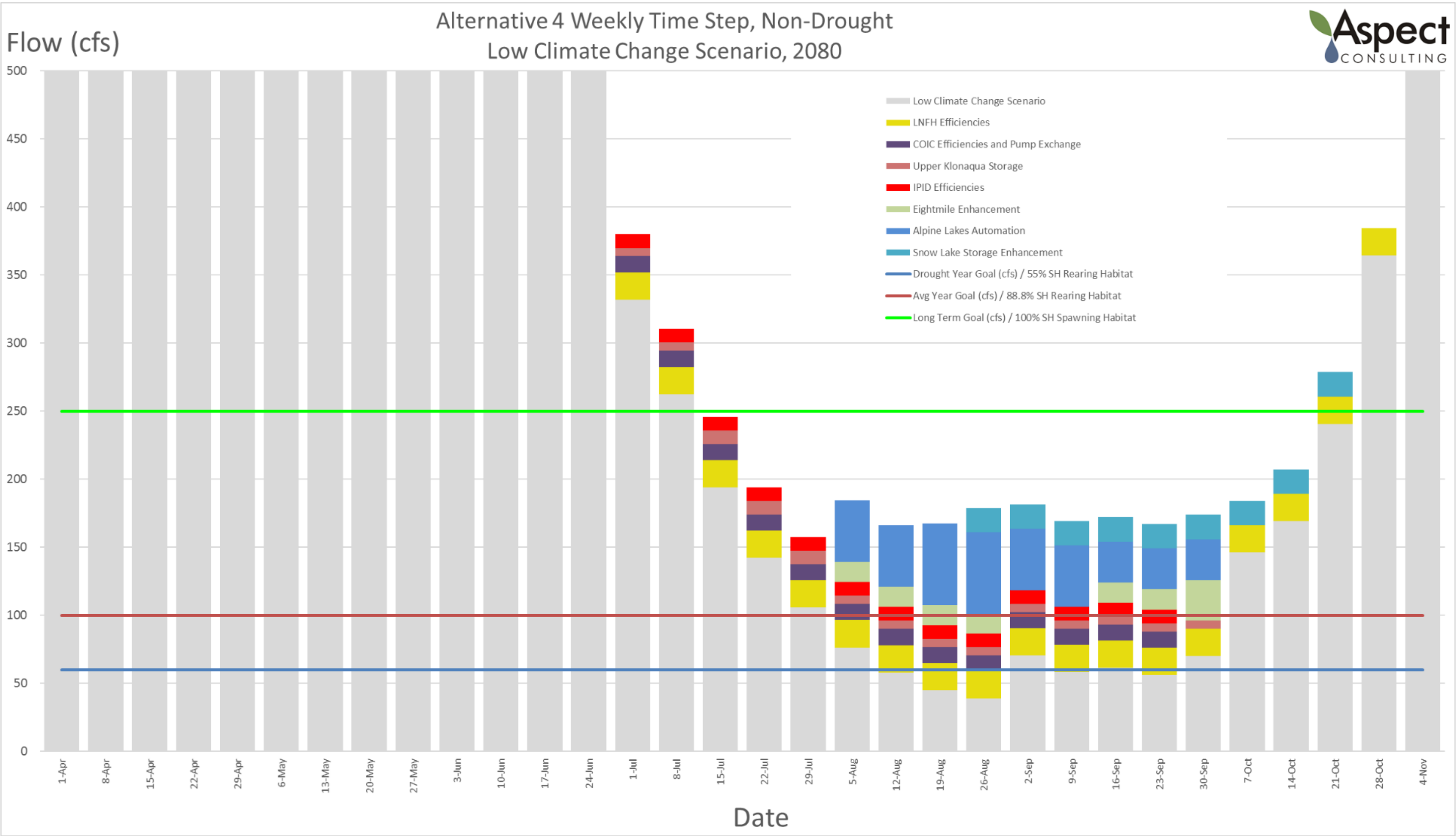
Date



Alternative 4 Weekly Time Step, Non-Drought
Low Climate Change Scenario, 2080
Aspect CONSULTING
Flow (cfs)
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350
300
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0
Low Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
Upper Klonaqua Storage
IPID Efficiencies
Eightmile Enhancement
Alpine Lakes Automation
Snow Lake Storage Enhancement
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
1-Apr
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15-Jul
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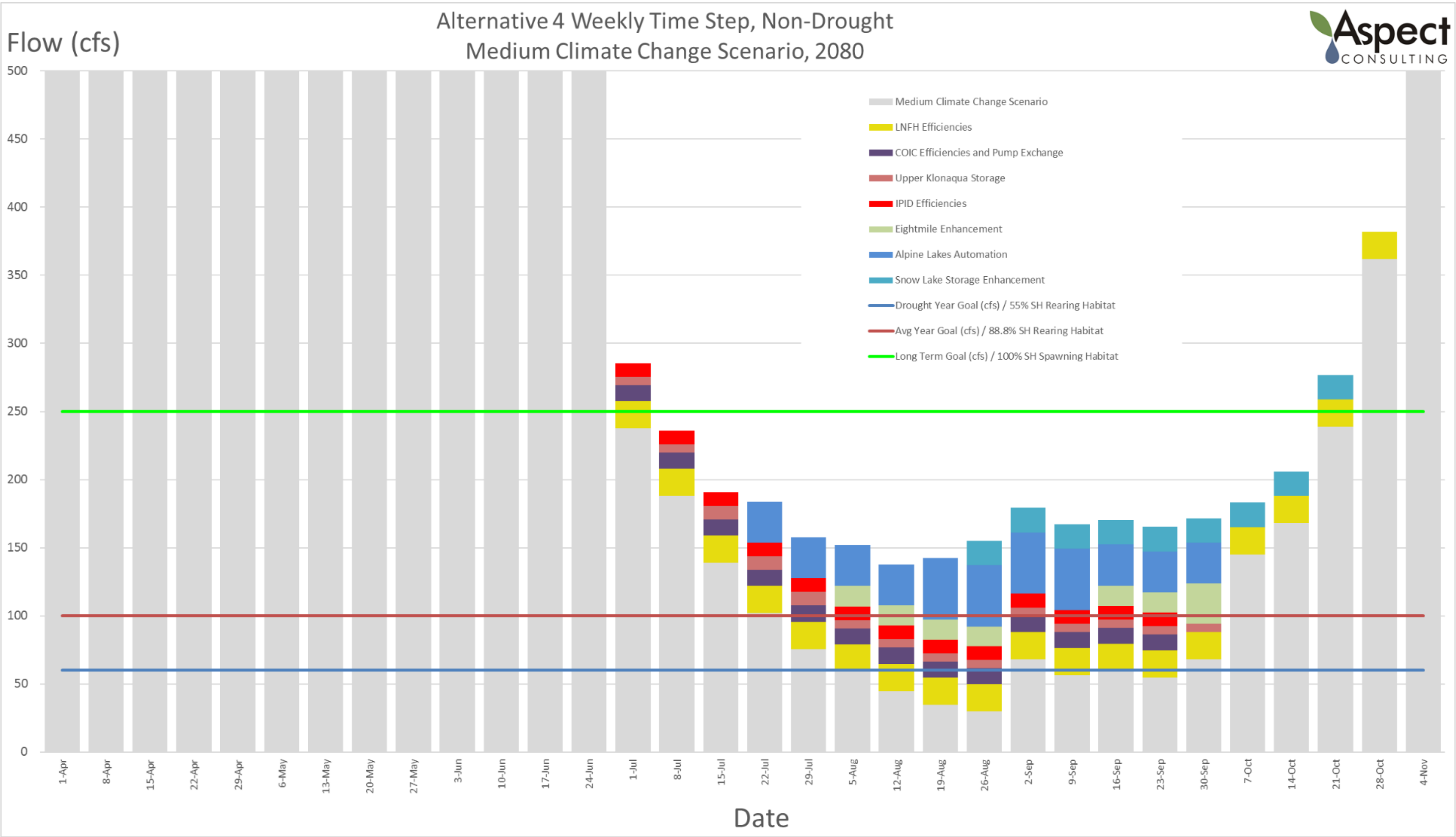
Date


Alternative 4 Weekly Time Step, Non-Drought
Medium Climate Change Scenario, 2080
Flow (cfs)
Aspect CONSULTING
Medium Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
Upper Klonaqua Storage
IPID Efficiencies
Eightmile Enhancement
Alpine Lakes Automation
Snow Lake Storage Enhancement
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
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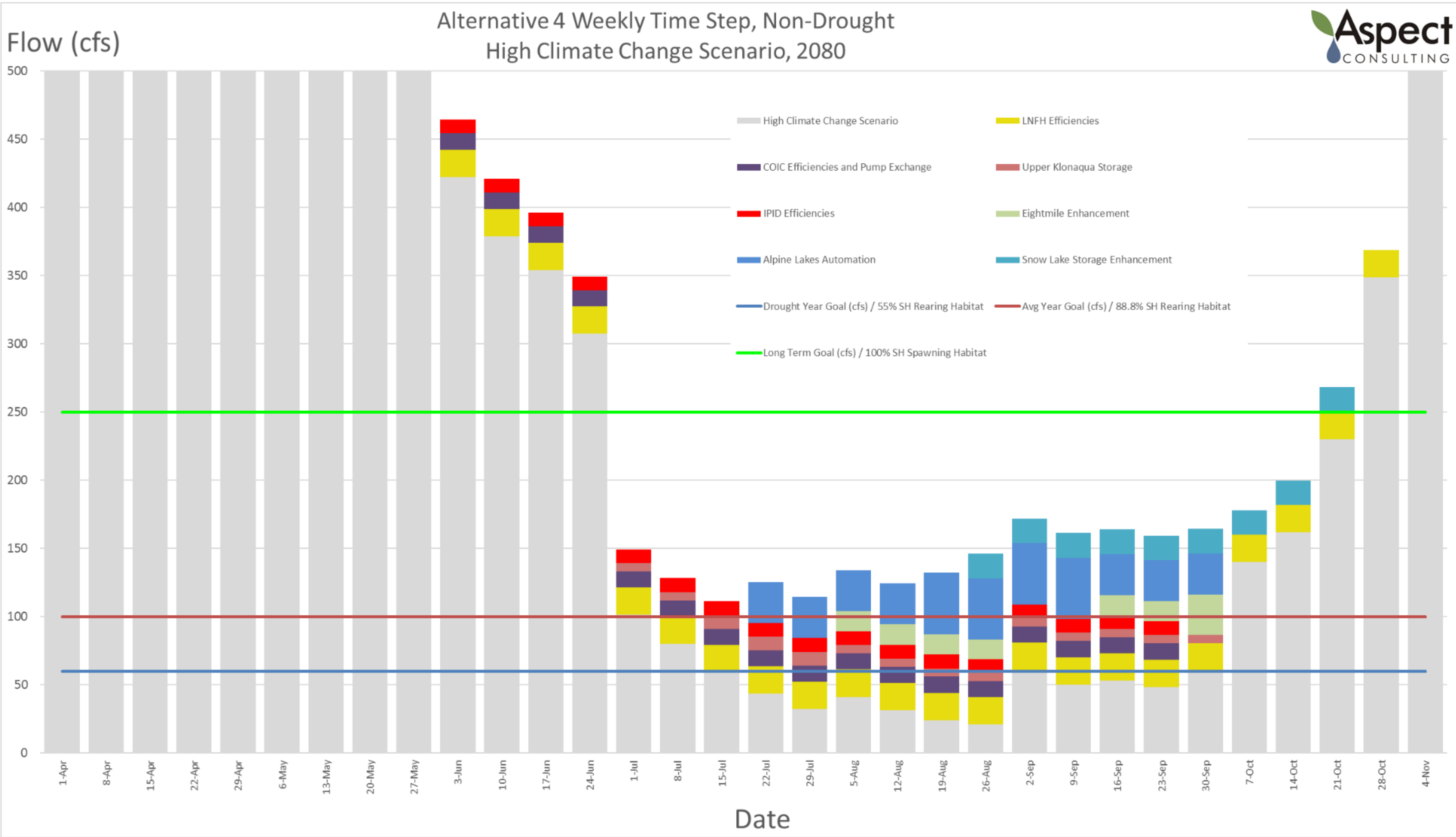
Date


Alternative 4 Weekly Time Step, Non-Drought
High Climate Change Scenario, 2080
Aspect CONSULTING
Flow (cfs)
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High Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
Upper Klonaqua Storage
IPID Efficiencies
Eightmile Enhancement
Alpine Lakes Automation
Snow Lake Storage Enhancement
Drought Year Goal (cfs) / 55% SH Rearing Habitat
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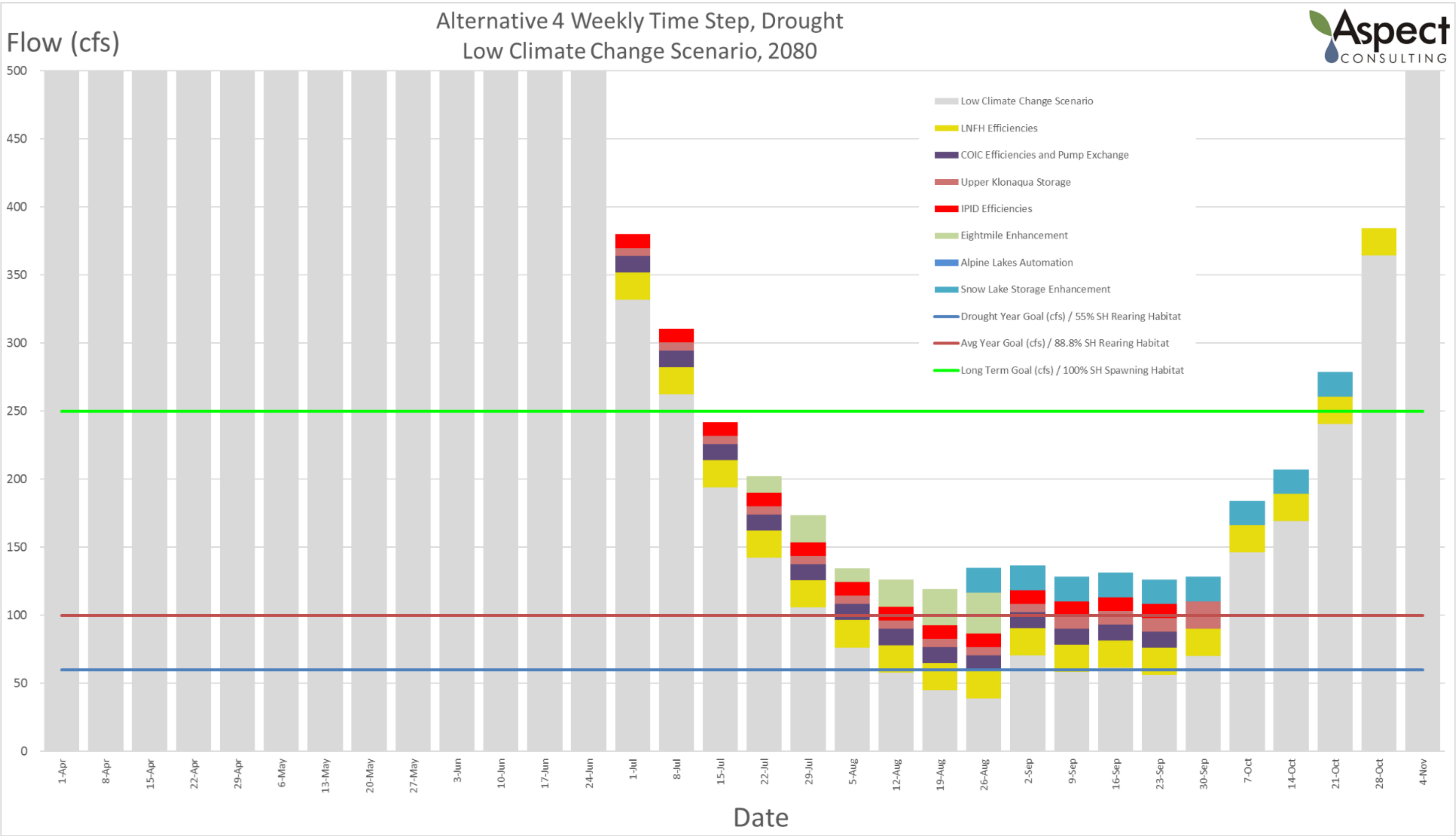
Date



Alternative 4 Weekly Time Step, Drought
Low Climate Change Scenario, 2080
Aspect CONSULTING
Flow (cfs)
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Low Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
Upper Klonaqua Storage
IPID Efficiencies
Eightmile Enhancement
Alpine Lakes Automation
Snow Lake Storage Enhancement
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
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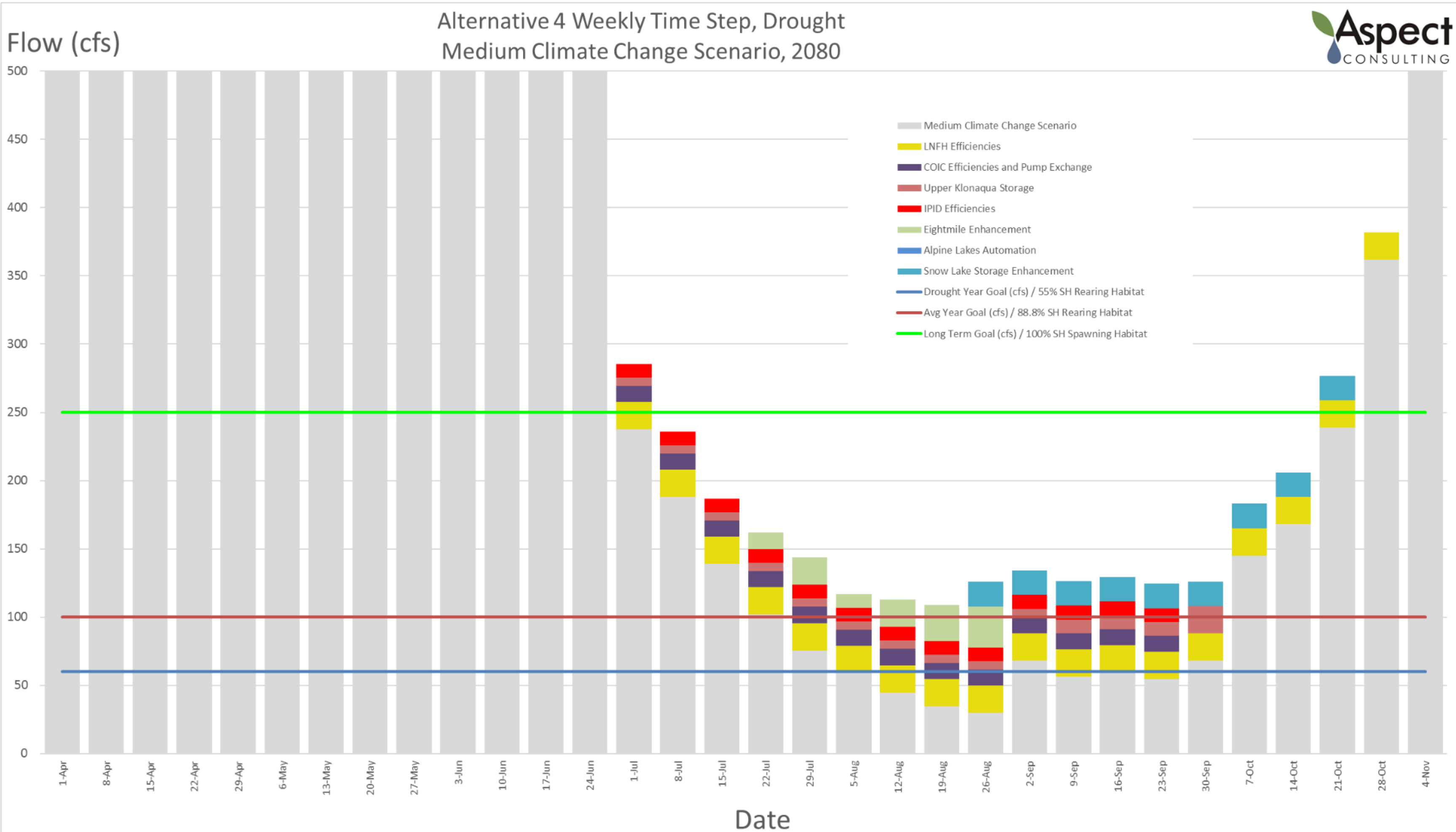

Alternative 4 Weekly Time Step, Drought
Medium Climate Change Scenario, 2080
Aspect CONSULTING
Flow (cfs)
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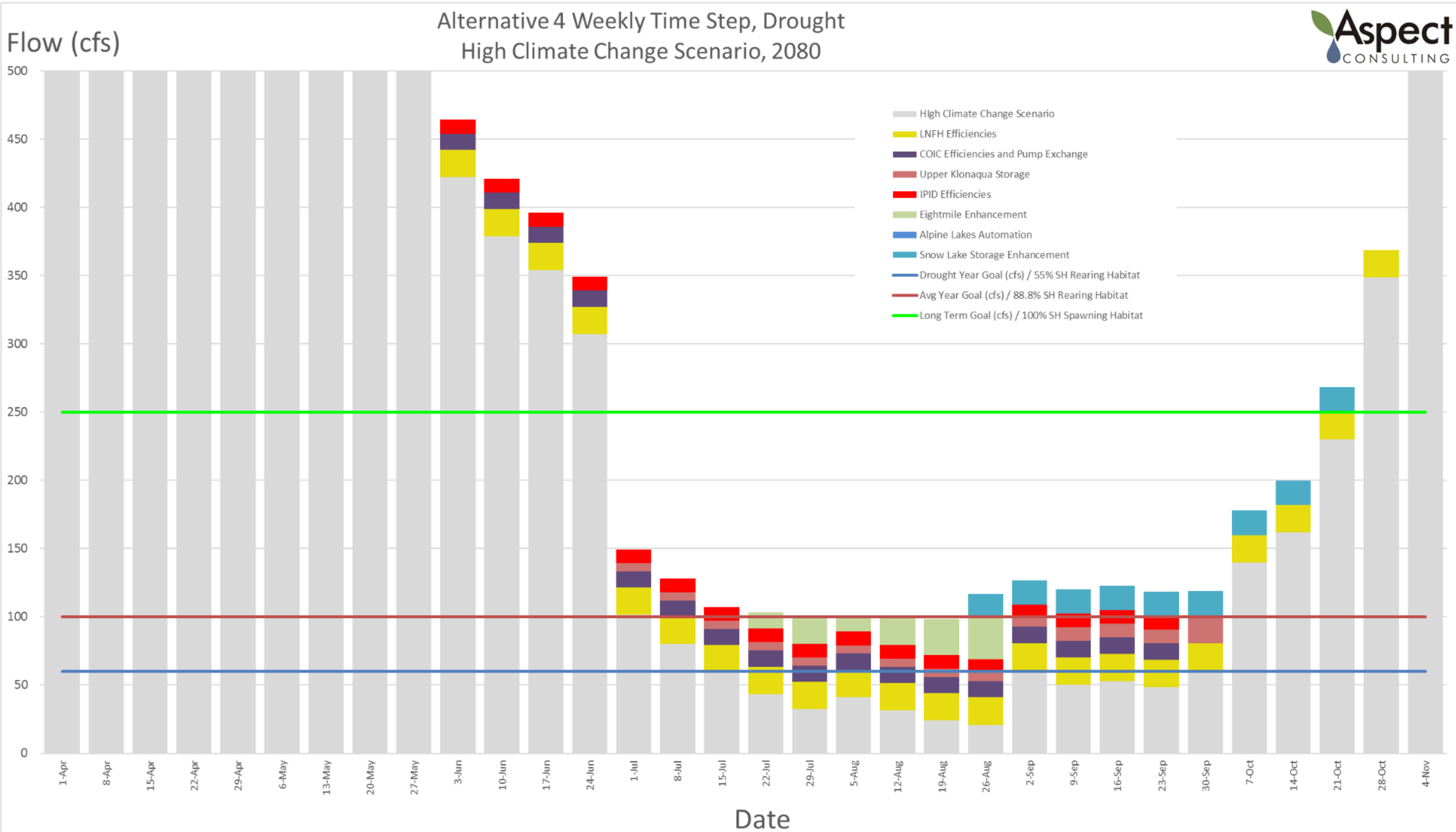
Medium Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
Upper Klonaqua Storage
IPID Efficiencies
Eightmile Enhancement
Alpine Lakes Automation
Snow Lake Storage Enhancement
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
1-Apr
8-Apr
15-Apr
22-Apr
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep
9-Sep
16-Sep
23-Sep
30-Sep
7-Oct
14-Oct
21-Oct
28-Oct
4-Nov
Date



Alternative 4 Weekly Time Step, Drought
High Climate Change Scenario, 2080
Aspect
CONSULTING
Flow (cfs)
High Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
Upper Klonaqua Storage
IPID Efficiencies
Eightmile Enhancement
Alpine Lakes Automation
Snow Lake Storage Enhancement
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
0
50
100
150
200
250
300
350
400
450
500
1-Apr
8-Apr
15-Apr
22-Apr
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
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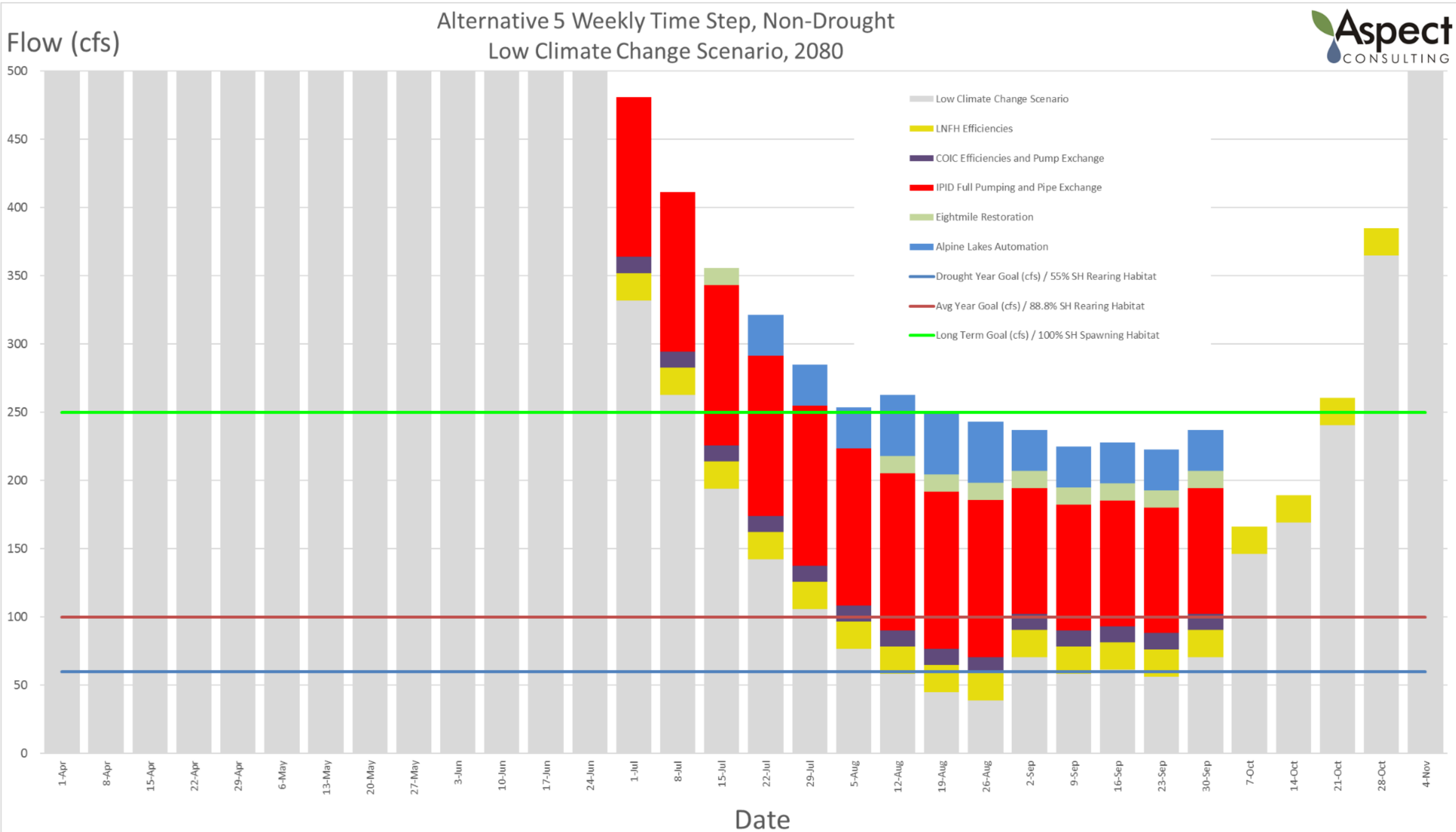
2-Sep
9-Sep
16-Sep
23-Sep
30-Sep
7-Oct
14-Oct
21-Oct
28-Oct
4-Nov
Date



Alternative 5 Weekly Time Step, Non-Drought
Low Climate Change Scenario, 2080
Flow (cfs)
Aspect CONSULTING
Low Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
IPID Full Pumping and Pipe Exchange
Eightmile Restoration
Alpine Lakes Automation
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
500
450
400
350
300
250
200
150
100
50
0
1-Apr
8-Apr
15-Apr
22-Apr
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
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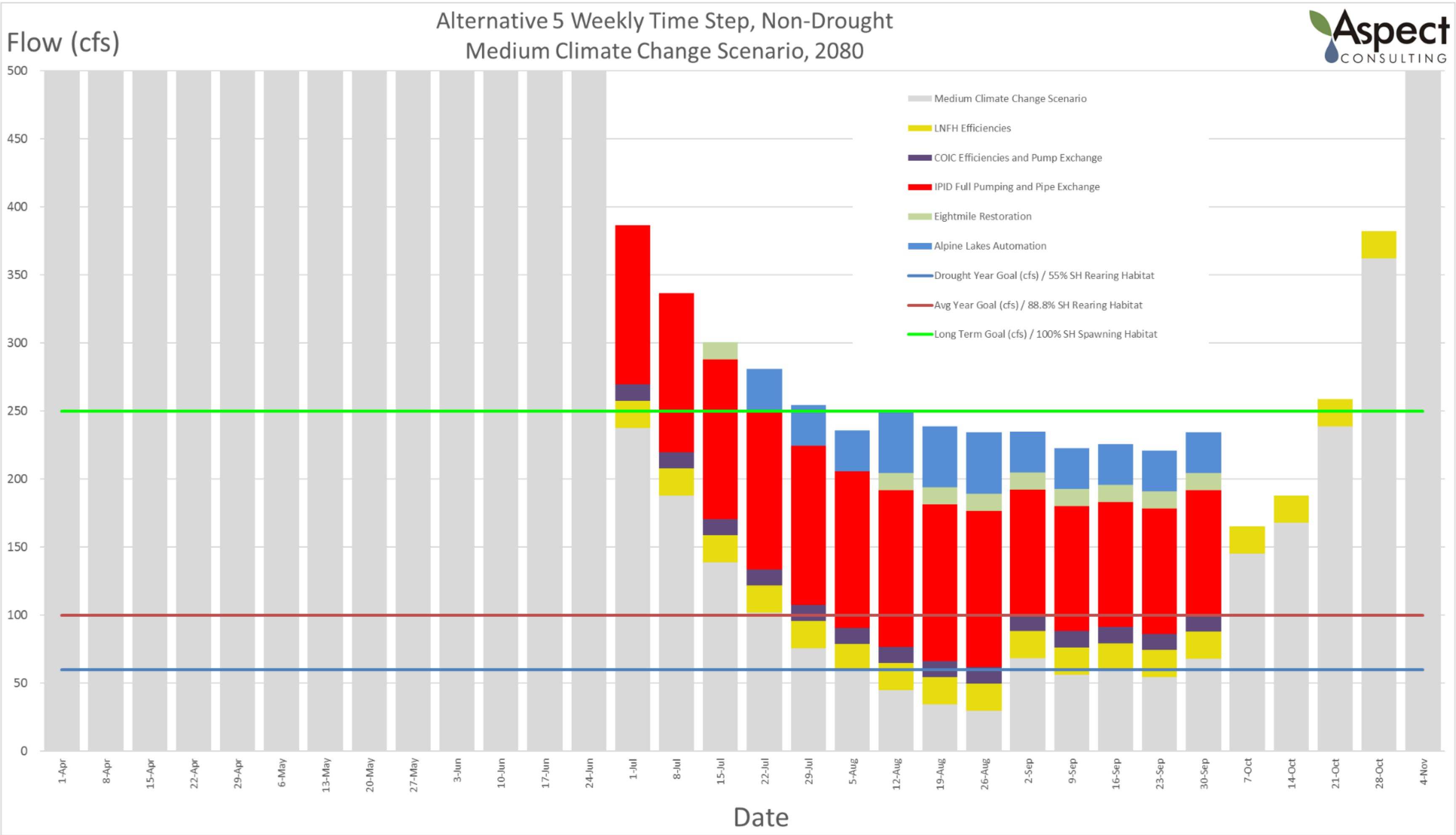
16-Sep
23-Sep
30-Sep
7-Oct
14-Oct
21-Oct
28-Oct
4-Nov
Date



Alternative 5 Weekly Time Step, Non-Drought
Medium Climate Change Scenario, 2080
Flow (cfs)
Aspect CONSULTING
Medium Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
IPID Full Pumping and Pipe Exchange
Eightmile Restoration
Alpine Lakes Automation
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
Long Term Goal (cfs) / 100% SH Spawning Habitat
500
450
400
350
300
250
200
150
100
50
0
1-Apr
8-Apr
15-Apr
22-Apr
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
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9-Sep
16-Sep
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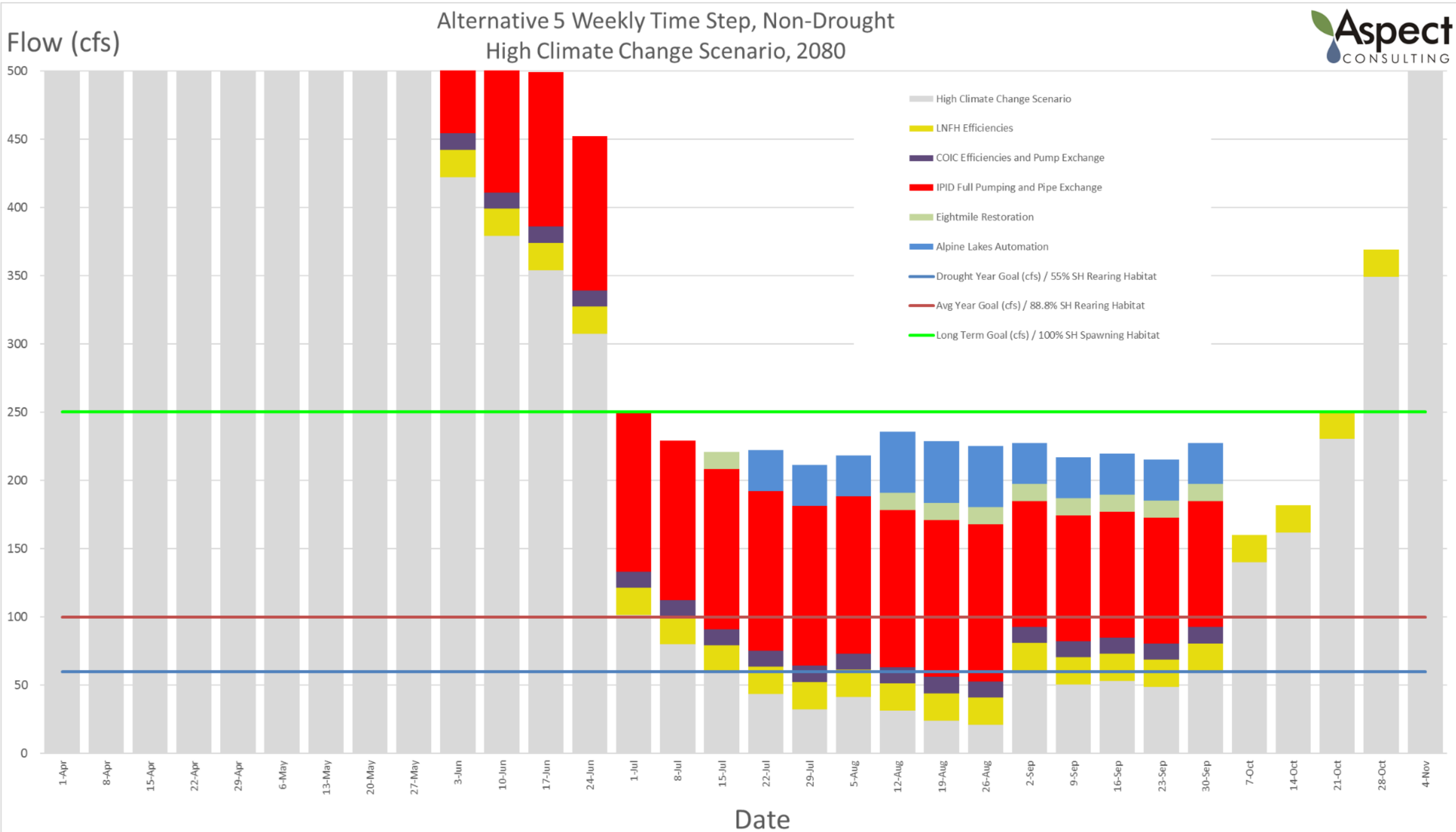
30-Sep
7-Oct
14-Oct
21-Oct
28-Oct
4-Nov
Date



Alternative 5 Weekly Time Step, Non-Drought
High Climate Change Scenario, 2080
Aspect CONSULTING
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
High Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
IPID Full Pumping and Pipe Exchange
Eightmile Restoration
Alpine Lakes Automation
Drought Year Goal (cfs) / 55% SH Rearing Habitat
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1-Apr
8-Apr
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16-Sep
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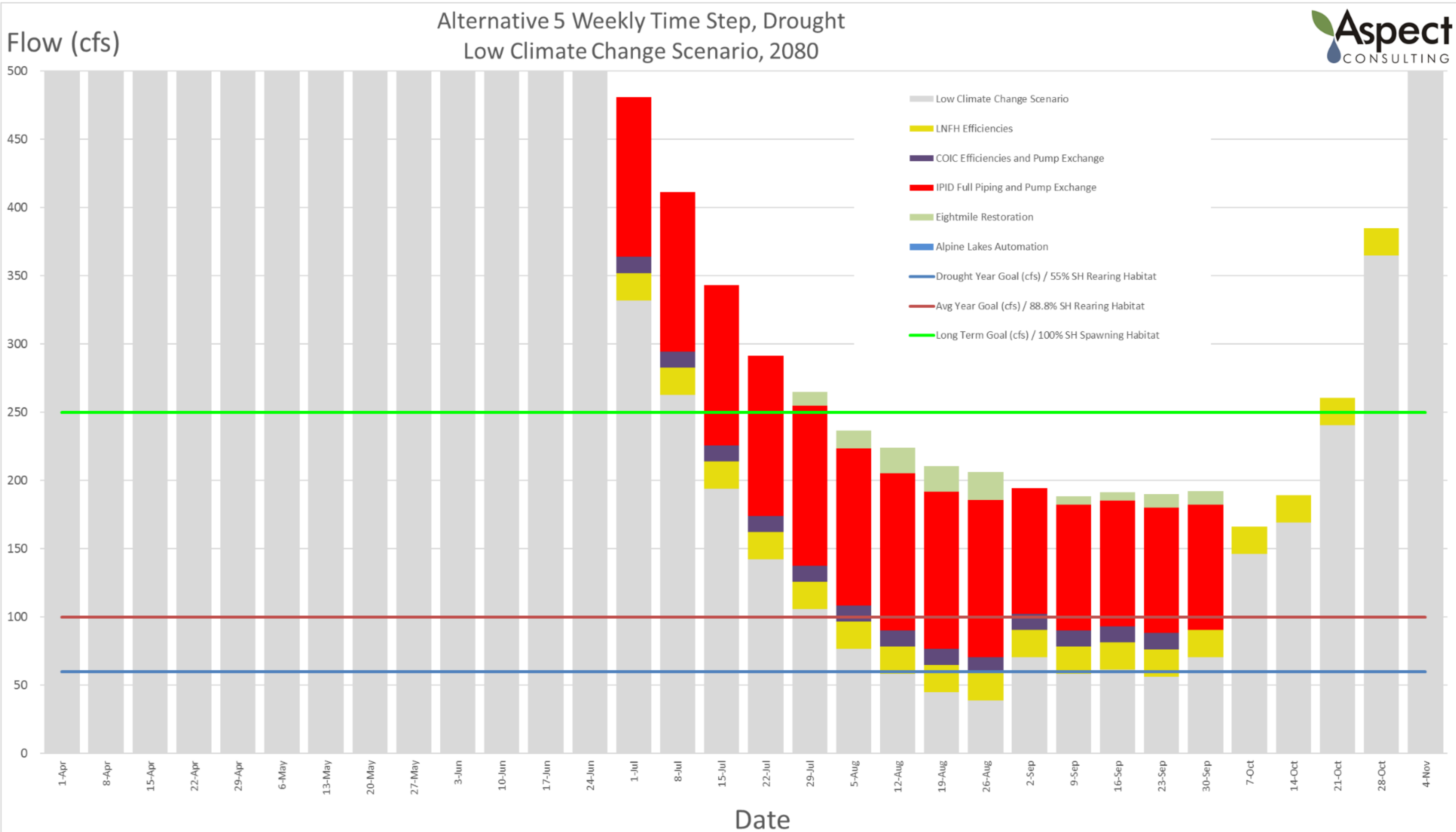
30-Sep
7-Oct
14-Oct
21-Oct
28-Oct
4-Nov
Date



Alternative 5 Weekly Time Step, Drought
Low Climate Change Scenario, 2080
Aspect
CONSULTING
Flow (cfs)
500
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Low Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
IPID Full Piping and Pump Exchange
Eightmile Restoration
Alpine Lakes Automation
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
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1-Apr
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8-Jul
15-Jul
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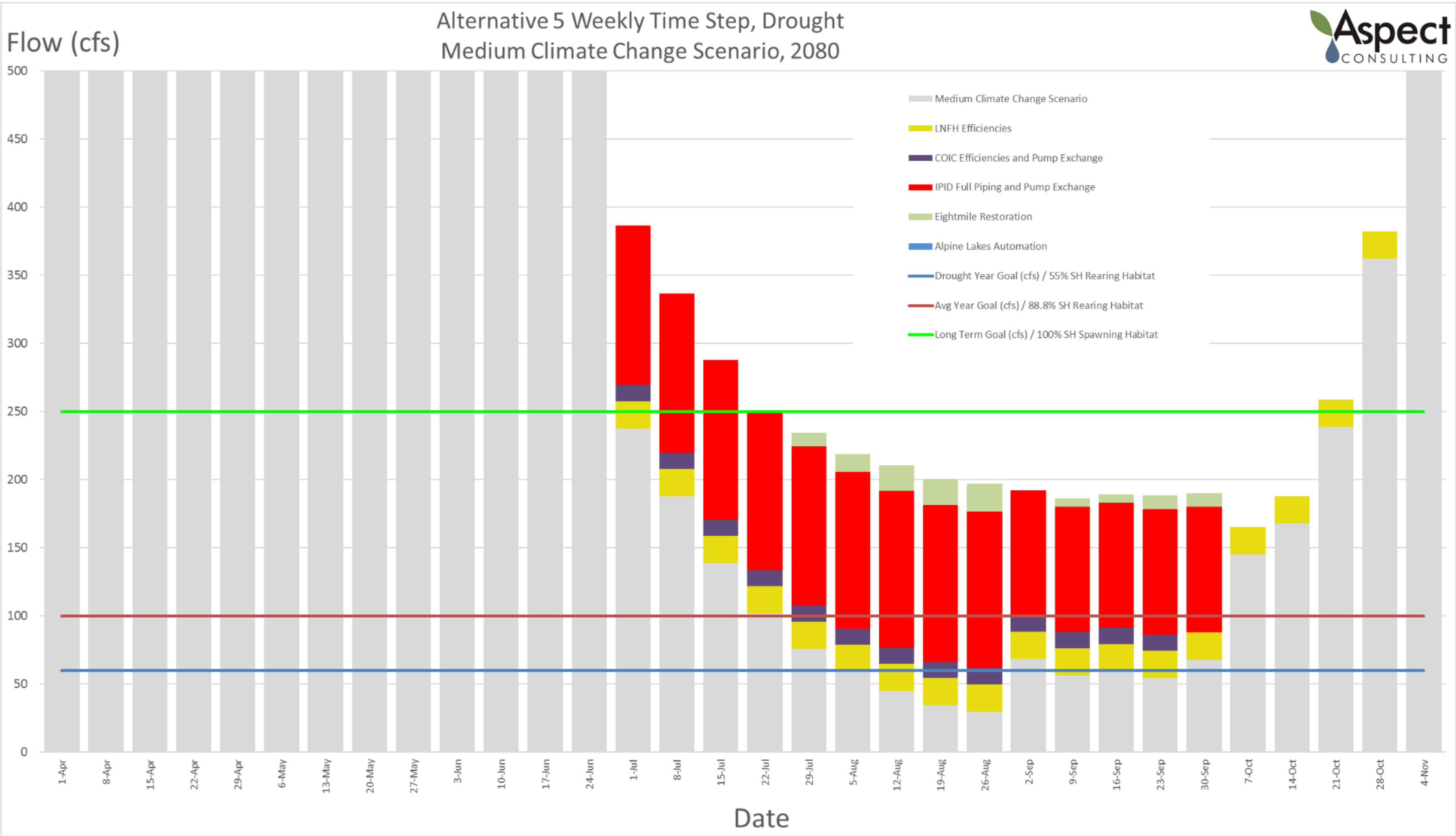
Date


Alternative 5 Weekly Time Step, Drought
Medium Climate Change Scenario, 2080
Flow (cfs)
Aspect CONSULTING
Medium Climate Change Scenario
LNFH Efficiencies
COIC Efficiencies and Pump Exchange
IPID Full Piping and Pump Exchange
Eightmile Restoration
Alpine Lakes Automation
Drought Year Goal (cfs) / 55% SH Rearing Habitat
Avg Year Goal (cfs) / 88.8% SH Rearing Habitat
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29-Apr
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20-May
27-May
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24-Jun
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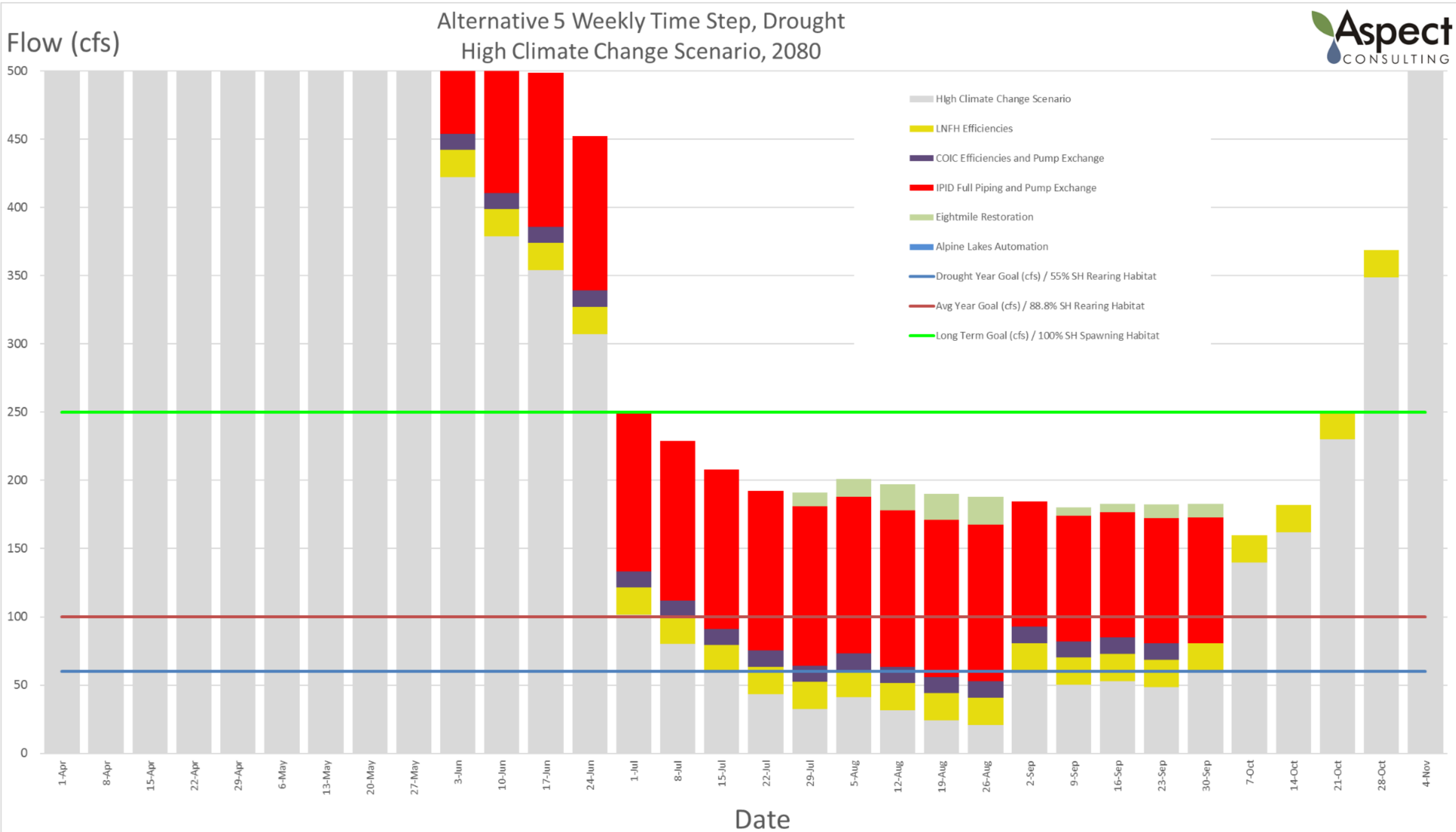

Alternative 5 Weekly Time Step, Drought
High Climate Change Scenario, 2080
Aspect
CONSULTING
Flow (cfs)
500
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High Climate Change Scenario
LNFH Efficiencies
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