US Army Corps of Engineers ®
St. Paul District

# Appendix L: Monitoring and Adaptive Management

Kinnickinnic River Continuing Authorities Program Section 206 Feasibility Report and Integrated Environmental Assessment

**May 2025**

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# Appendix L Monitoring and Adaptive Management

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# 1 Introduction

The Continuing Authorities Program (CAP) Section 206 is authorized under the Water Resources Development Act (WRDA) of 1996 (P.L.104-3030), as amended. The United States Army Corps of Engineers (USACE) may carry out aquatic ecosystem restoration and protection projects if the project will improve environmental quality, is in the public interest, and is cost effective. Section 2039 of WRDA 2007, as amended, directs the Secretary of the Army to ensure that, when conducting a feasibility study for a project (or component of a project) for ecosystem restoration, the recommended project includes a plan for monitoring the success of the ecosystem restoration.

The monitoring plan shall include a description of:

a. Types and number of restoration activities to be carried out;
b. Physical actions to be undertaken to achieve project objectives;
c. Functions and values that will result from the restoration plan;
d. Monitoring activities to be carried out;
e. Criteria for ecosystem restoration success;
f. Estimated cost and duration of the monitoring; and
g. A contingency plan for taking corrective actions in cases in which the monitoring demonstrates that restoration measures are not achieving ecological success in accordance with criteria described in the monitoring plan.

Applicable implementation guidance for Section 2039 is provided in CECW-P Memorandum, Subject: Implementation Guidance for Section 1161 of the Water Resources Development Act of 2016 (WRDA 2016), Completion of Ecosystem Restoration Projects, dated October 19, 2017.

At the programmatic level, knowledge gained from monitoring one project can be applied to other projects. Opportunities for this type of adaptive management are common within the Continuing Authorities Program (CAP). Using an adaptive management approach during project planning enabled better selection of appropriate design and operating scenarios to meet project objectives. Lessons learned in designing, constructing, and operating similar restoration projects within the Upper Mississippi River System (UMRS) have been incorporated into the planning and design of this CAP to ensure that the proposed plan represents the most effective design and operation to achieve the project goal and objectives.

This appendix outlines how the results of the project specific monitoring plan would be used to adaptively manage the project, including monitoring targets which demonstrate project success in meeting objectives. The intent of the project delivery team (PDT) was to develop monitoring and adaptive management actions appropriate for the project’s goal and objectives.

Adaptive management provides a process for making decisions in the face of uncertainty. The primary incentive for implementing an adaptive management plan is to increase the likelihood of achieving desired project outcomes given the identified uncertainties, which can include incomplete description and understanding of relevant ecosystem structure and function; imprecise relationships among project actions and corresponding outcomes; engineering challenges in implementing project alternatives; and ambiguous management and decision-making processes. Additional uncertainties (i.e., scientific and technological) relating to the proposed project that were identified by the PDT included:

- Success of forest and marsh establishment
    - Resulting soil makeup
    - Site specific inundation
    - Success of forest vegetation

- Impacts of competing vegetation
- Impacts of animal and insect herbivory
- Presence and introduction of invasive species
- Hydrological predictions

Adaptive management in the Kinnickinnic River CAP would involve iterative management decisions influenced by the results observed through monitoring. Actions of active adaptive management for the project may include the physical modification of project features and documentation of the changing conditions.

Specific tasks identified within this plan are either labeled “Monitoring” or “Adaptive Management.” Monitoring activities assumes that specific tasks will be monitored to collect data and information but won’t necessarily require further action. Adaptive management assumes that if an identified task is not meeting its desired performance criteria, as indicated through monitoring, that a follow up action may be implemented to improve the performance of a designed construction feature.

This Appendix is anticipated to be further revised for the Final Report. The monitoring plan is under review and discussion with natural resource agency partners.

Table 1. Summary of monitoring tasks for Kinnickinnic Cap 206 Project

| Monitoring Task | Assessment Measure | Lead Agency | Estimated Cost | Years | Total Cost |
|---|---|---|---|---|---|
| **A** | **<u>Trout Assessment</u>** | | | | |
| A1 | Water Quality Monitoring | WI DNR | | Pre, 2, 4, 6, 8, 10 | |
| A2 | Electrofishing Surveys | WI DNR | | Pre, 2, 4, 6, 8, 10 | |
| A3 | Hydrogeomorphic Surveys | USACE | $18,000 | 1, 5 | $36,000 |
| **B** | **<u>Terrestrial and Aquatic Vegetation Assessment</u>** | | | | |
| B1/B2 | Forestry Monitoring | USACE | $10,000 | 1, 3, 5 | $30,000 |
| B3 | Drone Surveys | USACE | $10,000 | 1, 5, 9 | $30,000 |
| Total | | | | | **$96,000** |
| Linked Task | Adaptive Management | | Estimated Cost | | Total Cost |
| B1/B2 | Tree Replanting | USACE | $142,000 | | **$142,000** |

* “Pre” indicates a pre-project timeframe of observation.

## 2 Project Objectives

The Kinnickinnic River CAP has two objectives that project features are addressing. None of the objectives are directly in competition with each other within this project. These priorities include:

1. Restore natural hydrothermal/hydrogeomorphic dynamics to support native cold-water species prior to impoundment.

2. Increase riffle and pool geomorphic sequence to increase the use and availability of cold-water habitat species.

In addition to the two objectives above, two opportunities would assist with achieving the project objectives. These opportunities, which would also be monitored, include:

3. Increase riparian forest habitat.
4. Increase emergent wetland habitat.

## 2.1 Riverine Habitat

**Objective 1:** Restore natural hydrothermal/hydrogeomorphic dynamics to support native cold-water species prior to impoundment.

**Objective 2:** Increase riffle and pool geomorphic sequence to increase the use and availability of cold-water habitat species.

**Habitat Target:** Increase the total acreage of aquatic habitat that qualifies as cold-water riverine fish habitat.

**Performance Criteria:**
a) After project construction, trout sampling fixed areas would be sampled and analyzed for:

- Dissolved oxygen (DO)
  - >10 mg/L
- Water temperature
  - < 66.2 °F

b) Within 10 years post-construction, fixed site electro-fishing catch per unit effort would be analyzed for density. No specific number for brown or brook trout is currently determined to constitute success; however, fixed sites within the Kinnickinnic Project Area would try to match trout numbers upstream and downstream of the project.

### 2.1.1 Task A1 – Water Quality Sampling (Monitoring)

**Rationale A1:** The specific water quality parameters under the performance criteria above are vital for the varying life stages for trout.

**Methodology:** Sampling of water quality would be conducted in designated fixed sites throughout the project area during the same time as Task A2 (prior to electrofishing). For hand measurements, the Wisconsin Department of Natural Resources (WI DNR) would use a YSI or similar water quality monitoring equipment within the open stream. Alternatively, continuous data recorders also may be deployed with periodic hand monitoring to verify logger observations. Assessments will be done in the years two, five, and 10, post-construction.

**Monitoring targets:** The monitoring goal would be that each fixed site meets the water quality criteria described under performance criteria of A1.

**Adaptive Management:** There is no specific adaptive management effort proposed with this water quality monitoring.

### 2.1.2 Task A2 – Electrofishing Surveys (Monitoring)

**Rationale A2:** Electrofishing has been an effective sampling method for determining quantity of trout species richness and density with cold-water streams for many years. Electrofishing surveys would be completed to assure that trout are using the newly restored sections of the Kinnickinnic River as part of the project.

**Methodology:** Backpack electrofishing surveys would be conducted sometime in late summer (August or September) within pre-determined fixed sites throughout the project area. The distance, in feet, would be tracked for each electrofishing survey. Catch would be sorted by species and size and counted. These same sites would be used every year to properly track species diversity and species density throughout the monitoring phase. Summary reports would be provided by the end of each sampling year.

**Monitoring:** Electrofishing surveys would be conducted semi-annually by WI DNR for a period of 10 years. Monitoring events would supply the data required for summary reports to track trout numbers through the project area.

### 2.1.3 Task A3: Hydrogeomorphic Monitoring

**Rationale A1:** Hydrogeomorphic surveys using discharge transects would be used to verify the changing flows throughout the project due to river restoration features. This information would provide velocity and discharge data for key restoration features throughout the project area.

**Methodology:** Discharge transects would be taken at specifically determined transect location with key restoration features (i.e., rock arch rapids, riffles) to assure flows and discharge number match what was assumed during planning. Data would be collected during either medium or low flow condition, to assure that proper connectivity for trout species is happening throughout restoration features. Flow velocities and discharge data would be compiled into a hydrogeomorphic summary report.

**Monitoring:** Discharge transects would be taken at years 1 and 5 following construction of the project.

**Adaptive Management:** If hydrogeomorphic surveys indicate that certain restoration features are limiting flow throughout the project area, features could be tweaked to assure connectivity. If this is the case, a conversation with the Corps, City and WI DNR would need to take place to determine best way to tweak river restoration features.

## 2.2 Riparian Forest Habitat

There are risks and uncertainties involved with the creation of bottomland and mesic forests. The following section describes these uncertainties with the intent of providing some context for the monitoring and adaptive management tasks that are anticipated to follow construction.

**Opportunity 3 – Increase riparian forest habitat within restored terrestrial areas.**

**Habitat Target:** Optimize conditions conducive to healthy bottomland and mesic forest habitat. Increased diversity and coverage of bottomland forest will be characterized by swamp white oak, silver maple, cottonwood, hackberry, white pine, and black walnut. The discussion below focuses on shorter-term project success that will lead to the longer-term objective that extends over 50 years. Performance metrics will be seedling survival and growth, with seedlings being both those that are planted (bare-root) and those that naturally regenerate.

**Performance Criteria: Bareroot seedling trees or shrubs**

**After the first year of project construction,** seedling survival and growth that is defined as:

a. Tree seedling survival greater than 75%.

b. Greater than 50% of tree seedlings with condition codes of 1 or 2 (annual growth of six or more inches,dominant leader may or may not be present, less than 10% branch dieback).

c. Constructed features have 510 (75%) surviving tree or shrub seedlings per acre greater than 1 foot tall.

**After the third year of project construction**, Seedling survival and growth that is defined as:

a. Tree seedling survival greater than 75%.

b. Greater than 50% of tree seedlings with condition codes of 1 or 2 (annual growth of 6 or more inches,dominant leader may or may not be present, less than 10% branch dieback).

c. Constructed features have 510 (75%) surviving tree or shrub seedlings per acre with greater than 50% being greater than 4 feet tall.

**After the fifth year of project construction**, Seedling survival and growth that is defined as:

a. Tree seedling survival of 60%.

b. Greater than 60% of seedlings with condition codes of 1 or 2 (annual growth of 6 or more inches,dominant leader may or may not be present, less than 10% branch dieback).

c. Constructed features have 409 (60%) surviving tree or shrub seedlings per acre with greater than 75% of this number being greater than 4 feet tall.

#### 2.2.1 Task B1 – One-year Seedling Survival and Growth (Adaptive Management)

**Rationale B1:** The first year following planting is a critical period to determine whether tree seedlings will become established. Low seedling survival combined with low growth rates for surviving seedlings may indicate deficiencies in planting procedures or seedling stock, the presence of significant site related stressors, or seedling-site incompatibility. Regeneration surveys monitoring seedling survival and growth are standard in most large-scale tree planting programs, both within the Corps and in many public and private organizations throughout the country. Results from one-year survival and growth surveys will allow for modifications in planting plans to account for agents responsible for low seedling survival, growth, and mitigation measures to account for these stressors.

**Methodology:** Seedling survival will be measured by using seedling regeneration surveys. 1-year survival and growth surveys will be conducted only on those areas that were planted in the previous year.

On newly constructed features with high density plantings, the row plantings methodology for regeneration surveys currently being used on St. Paul District's project lands by Environmental Section foresters will be implemented to assess one-year seeding survival and growth, with a target of sampling 5% of the area using 1/100th acre fixed area plots. Only planted seedlings will be measured in the 1/100th acre fixed area plots, using the medium sampling intensity.

Rather than placing plots on a grid within these areas, plots will be randomly located with an equal distribution of plots between the soil placement types and a minimum spacing between plots equivalent to twice the radius of an individual plot. A permanent marker will be placed at the center of each plot and individual trees within the plots will be marked. The high intensity survey method will be used on these plots, allowing measurement of tree height and diameter. Soil samples will be collected in these plots to measure soil texture and nutrients. A database of individual seedlings will be maintained over time to assess impacts of soil mixes on tree survival and growth.

**Adaptive Management:** If one-year seedling survival is below 75%, supplemental planting could be required to replace lost seedlings. If it is determined that mortality was due to factors that cannot be easily controlled (e.g., inundation, herbivory), re-planting in some locations may be implemented along with the use of herbivore repellant treatments. If natural regeneration targets are not met, supplemental seeding may be implemented on constructed features. If any of the monitoring targets are not met in contract year one or contract year two, planting plans for the following year may be modified based on interpretation of the drivers causing less than desirable success rates.

### 2.2.2 Task B2 – Long-term Seedling Survival and Growth (Adaptive Management)

**Rationale B2:** The one-year seedling survival is critical, but seedlings cannot be considered successfully established on a site generally until they reach 4.5 feet in height and free from competition for light. Long-term seedling survival and growth will be critical for determining whether the restoration effort was successful or not in establishing self-sustaining levels of forest regeneration and forest cover.

**Methodology:** The methodology for the one-year seedling survival and growth described above will also be used to assess long-term seedling survival and growth, though the timing will differ. For long-term seedling survival and growth, three surveys will be implemented. Surveys will be conducted for the entire area three years and five years following project completion, using the methodology in task B1. In addition, standard forest inventory plots will be located on the standard forest inventory sampling grid (1 plot/2.5 acres) and sampled according to Corps standard forest inventory procedures.

**Adaptive Management:** Re-planting may be implemented after completion of the initial planting cycle if the desired results are not met. If seedlings have a less than desired condition code, herbivory and competition controls may be implemented. Herbivory protection, such as tree shelters or chemical deterrent may be implemented. Additional herbicide application may also be recommended if herbaceous competition is the primary driver of low condition codes. If the desired results of Task B1 and B2 do not meet the performance criteria, the Corps and agency officials will reevaluate the best ways to obtain short and long-term plant survival. Currently, adaptive management for both task B1 and B2 would be a maximum of $142,000 (Table 1).

## 2.3 Marsh Habitat

**Opportunity 4:** Increase emergent wetland habitat within designated marsh restoration areas.

**Habitat Target:** Marsh habitat should consist of emergent aquatic plants that include grasses, bulrushes, cattails and arrowheads and provide habitat for waterfowl, herptiles small mammals, and fish. The bottom elevation of the marsh areas would be set to the elevation of the bottom of the main channel, which would allow the area to fall below the water table. Using an elevation to the stream bottom would keep the area saturated and maintain a wetland area.

### 2.3.1 Task B3 – Aquatic Vegetation Sampling (Drone Surveys)

**Rationale B3:** Drone surveys using video, still images, 2D orthoimagery and photogrammetry would be used to quantify wetland vegetation and the extend of marsh habitat. On top of quantifying marsh habitat. Drone surveys would assist with forestry analysis, stream feature stability and overall project health.

**Methodology:** Drone flights throughout the project area would use the following methods to collect data:

**Video:** Video fly- varying altitudes to pick up a greater overview of the area or get closer to specific areas. Video can be combined with a locator map to show throughs over the project can be done at what part of the project is currently being shown in the videos. Various types of cinematic shots are possible as well as basic fly-overs.

**Still images:** Still shots can be taken to show snapshots at overview height or zoomed in images of specific areas/plants. Generally, with low wind conditions, plant species can be picked out at greater zoom levels. Still images can be provide public affairs shots.

**2D Orthoimagery:** This is top-down high-resolution imagery, similar to satellite but much sharper and more timely (can be planned for specific days/times and flown under cloud cover unlike satellite imagery acquisition). This 2D top down imagery covers large areas of land and can merge all photos into a single image of the project. This could be combined with still images or video to reference further close-up details of areas of interest or seeing plant communities in relation to the whole project area.

**Monitoring:** Drones surveys would be taken at years 1, 5 and 9 following construction of the project.

# 3 Monitoring Roles and Responsibilities

USACE will lead the hydrogeomorphic monitoring, forest monitoring, and drone surveys.

Agency partners (WI DNR) are anticipated to conduct water quality sampling and electrofishing as a non-project effort but consistent with and usable for USACE project needs. If agency partners do not conduct such monitoring, USACE would do so. Monitoring will be as fully integrated as possible to allow comparison of project data with other locations over time to maximize understanding of physical and biological trends and whether those trends are due to the project or are more reflective of broader conditions in the Kinnickinnic River.

# 4 Contingency Planning and Project Modification

Monitoring will verify the effectiveness of restoration actions. Monitoring activities, including review of results, will be performed collaboratively between USACE and the agency partners. If restoration features are not performing as they should, the agency partners will work with the Corps to identify what can be done to rectify remaining issues through adaptive management.

# 5 Project Close Out

Close-out of the project would occur when the level of success of the project is determined adequate or when the maximum 10-year monitoring period has been reached. The level of success would be based on the extent to which the performance criteria have been or will be met based upon the trends for the site conditions and processes.

Additionally, project close-out will include technology transfer. This includes the dissemination of project monitoring results, analyses performed, management decisions made (Adaptive Management features or adjustments), and lessons learned. Technology transfer will occur via publications, presentations and discussions with the primary sponsor, stakeholders, among others.

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# Appendix M: Long-Term Assessment of Hydrometeorological Conditions for the Kinnickinnic River Feasibility Study

Kinnickinnic River Continuing Authorities Program Section 206 Feasibility Report

**May 2025**

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# 1 Introduction

The Kinnickinnic River (Kinni) Continuing Authorities Program (CAP) Section 206 Feasibility Study is evaluating the feasibility of removing Powell Falls Dam and/or Junction Falls Dam and restoring the river corridor surrounding those structures. A primary goal of the project is to optimize trout habitat within the project boundaries. Trout are dependent on consistently cool water temperatures. Water temperatures below 59°F (15°C) during the warmest time of year are optimal for fry, while optimal temperature range for juvenile and adult trout extends to 66°F (19°C). Water temperatures below approximately 79°F (26°C) are necessary for the survival of both age classes.

Project measures under consideration include the removal of Junction Falls Dam, (which is actively impounding water while Powell Falls is drained), and the reconnection and restoration of two spring-fed ponds to the river. Removing Junction Falls Dam would eliminate the impoundment and its warming effect. Temperature measurements taken above the impoundment show that the water reaches an average of 60.6°F (15.9°C) in July/August. Measurements taken downstream show that the impoundment increases water temperatures between 0.8-2.7°F (0.5-1.5°C) during the warmest months of the year (Johnson, 2022). The removal of Junction Falls Dam and its associated impoundment is anticipated to eliminate this temperature increase. Reconnecting the river to the spring-fed ponds also has the potential to add a thermal refuge. Additionally, project features are designed to allow fish passage and refuge under current annual low flow conditions.

This is a qualitative evaluation of the challenges the project may face due to changes in temperature, precipitation, and hydrology in the basin. This assessment has been conducted in accordance with the United States Army Corps of Engineers' (USACE) Engineering Construction Bulletin (ECB) 2018-14 (USACE, 2024). The primary business line considered for this project is Ecosystem Restoration.

The Kinnickinnic River watershed (Figure 1) lies in western Wisconsin in the St. Croix River basin and drains approximately 172 square miles across Pierce and St. Croix counties. The watershed encompasses the entirety of the USGS's Hydrologic Unit Code (HUC)-10 watershed 0703000511 (USGS, 2023).

# 2 Literature Review

Reports and journals from federal agencies, state agencies, and university publications are the basis for this literature review. These references summarize trends in observed hydrometeorology, as well as projected hydrometeorology. Air temperature trends are examined as a proxy for stream temperature trends and precipitation trends are used as a proxy for trends in baseflow conditions.

Hydroclimatologic measurements have been taken since the late 1800s and provide insight into how hydrometeorologic conditions have changed over the past century. Global Climate Models (GCMs) or Earth Systems Models (ESMs) are used in combination with different representative concentration pathways (RCPs) or shared socioeconomic pathways (SSPs) and their resulting radiative forcings up to year 2100. Radiative forcings encompass the change in net radiative flux. GCMs/ESMs are used to approximate future temperature and precipitation. Projected temperature and precipitation time series can be transformed to regional and local scales (a process called downscaling). Downscaled time series can then be applied as inputs to macro-scale hydrologic models (Basile et al, 2023).

Uncertainty is inherent to such modeling due to the coarse spatial scale of the GCMs/ESMs and the many inputs and assumptions required to create long term hydrometeorological projections (USGCRP, 2023). When applied, precipitation-runoff models introduce an additional layer of uncertainty. However, these methods represent the best available science to predict future hydrologic variables (e.g. precipitation, temperature, streamflow). It is best practice to use multiple GCMs/ESMs to understand how various model assumptions impact results (Gleckler et al., 2008).

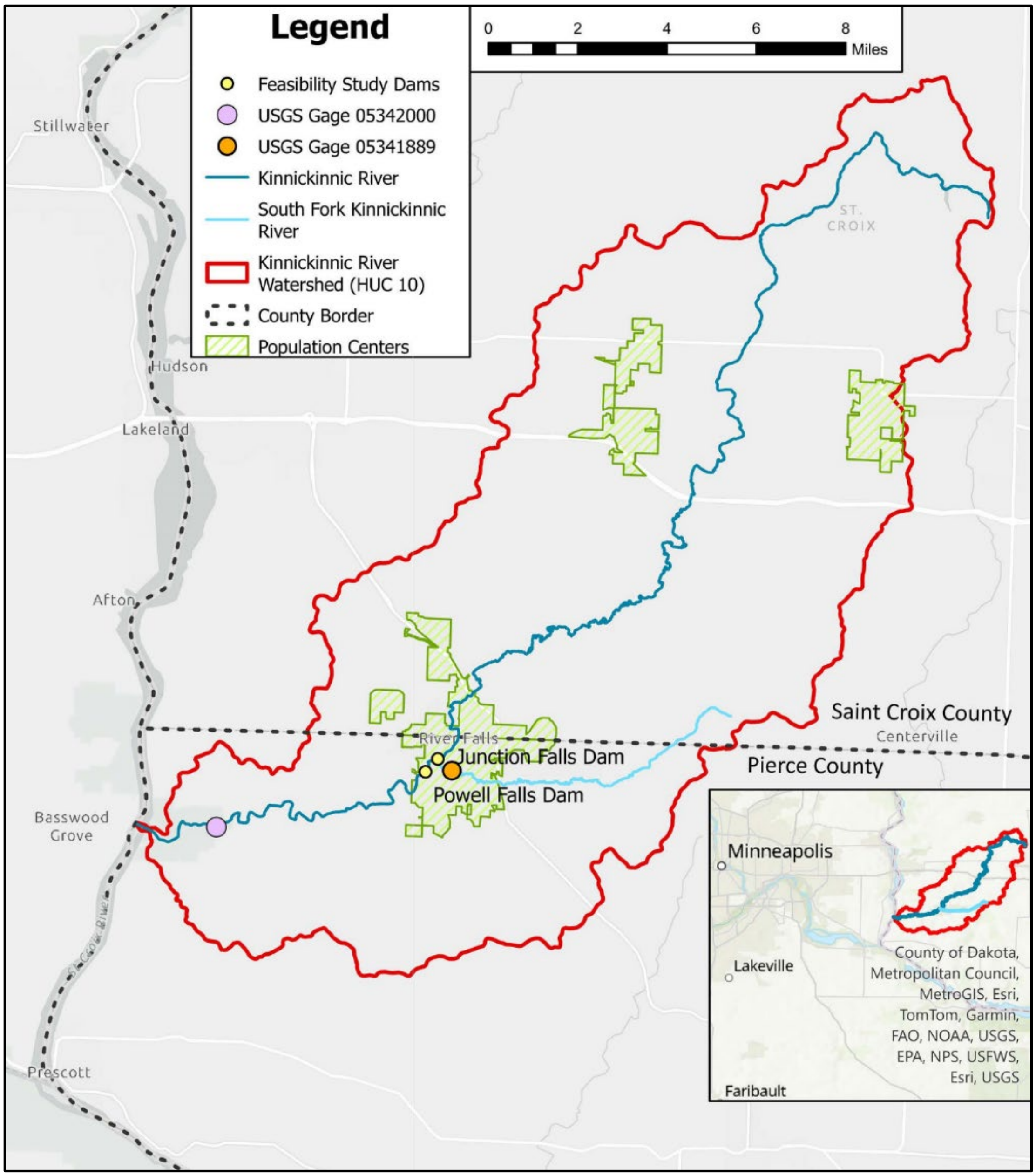


Figure 1: Kinnickinnic River Watershed

## 2.1 Temperature

Globally, average temperatures over the past decade (2012-2021) were close to 2°F (1.1°C) warmer than the preindustrial period (1850–1899) (Marvel et al, 2023). This has corresponded to a temperature increase of 2°F in Wisconsin (Frankson et al, 2022). This warming has been concentrated to winter, with summers warming less. This lack in summer warming is reflected in a below average occurrence of very hot days and no overall trend in warm nights (Frankson et al, 2022). In the Kinnickinnic River area, temperatures have increased by approximately 5.4°F (3°C) and 1.8°F (1°C) on an annual basis and over the summer months, respectively, as shown in Figure 2 (WICCI, 2023).

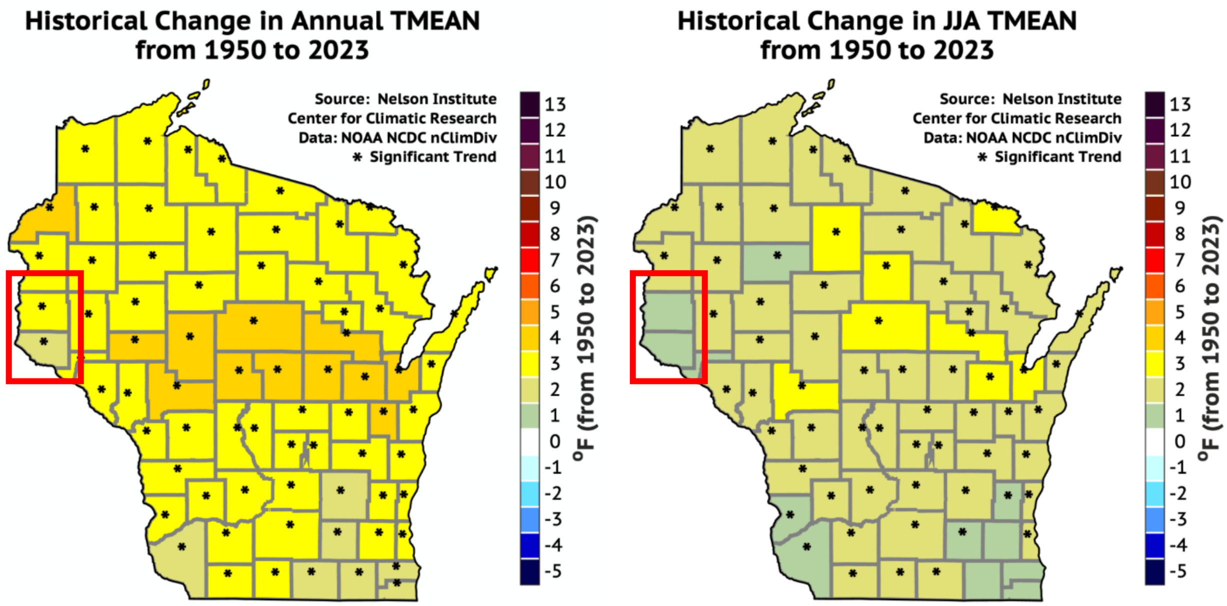


Figure 2: Historical Annual (left) and June-July-August (Right) Temperature Trends in Wisconsin, Pierce and Saint Croix Counties Outlined in Red (WICCI, 2024)

The timing and severity of future temperature changes varies under different scenarios. The range of long-term expected increase increased temperature for varying potential scenarios in the Kinnickinnic River watershed varies between 2.7°F and 7.2°F (Jay et al, 2023). Another study found that in the River Falls area, global projections correspond to a temperature increase of over 3°F, 5°F, 8°F, and 10°F under very low, low, high, and very high scenarios, respectively (Marvel et al, 2023).

## 2.2 Cool Water Habitat

How these air temperature increases may impact water temperature in the Kinnickinnic River and the quality of the cool water trout habitat there is uncertain. Baseflow in the Kinnickinnic River is primarily deep groundwater that discharges in the stream through a series of springs (Hare et al, 2023). Current average maximum annual groundwater temperatures in the headwaters of the Kinnickinnic at a depth of 10 m are modeled to reach 48°F (8.8°C). By the year 2100, annual maximum groundwater temperatures at this depth in the River Falls area are expected to rise to 54°F (12°C) and 57°F (14°C) under medium (SSP2-4.5) and very high (SSP5-8.5) scenarios, respectively – still below the maximum of the optimal temperature range for brown trout fry (Benz et al, 2024). Groundwater inputs remaining cool is likely why the Kinnickinnic River is projected to still have brown trout by mid-century, while 32% of overall brown trout habitat in Wisconsin is projected to be lost (Mitro et al, 2021).

## 2.3 Hydrologic Processes

Water cycle processes have already begun to change and are projected to continue changing. A warmer atmosphere can hold additional water, and thus directly impacts precipitation and evapotranspiration (Leung et al, 2023). NCA5 concluded that average annual precipitation in the Midwest has increased by 5% to 15% from the average data captured over 1901-1960 to the most recent period spanning from 1992-2021 (Marvel et al, 2023). The Kinnickinnic River watershed has met or exceeded this trend, seeing an overall increase in annual precipitation of between 15% and 20%, as shown in Figure 3 (WICCI, 2023). Additionally, long-term records show conditions in western Wisconsin have trended wetter from 1900 to 2022, with current average 5-year conditions being 1.0-1.5 standard deviations wetter than at the beginning of the 20$^{th}$ century, as measured by Standardized Precipitation Evapotranspiration Index (SPEI) values (Stevens et al, 2023).

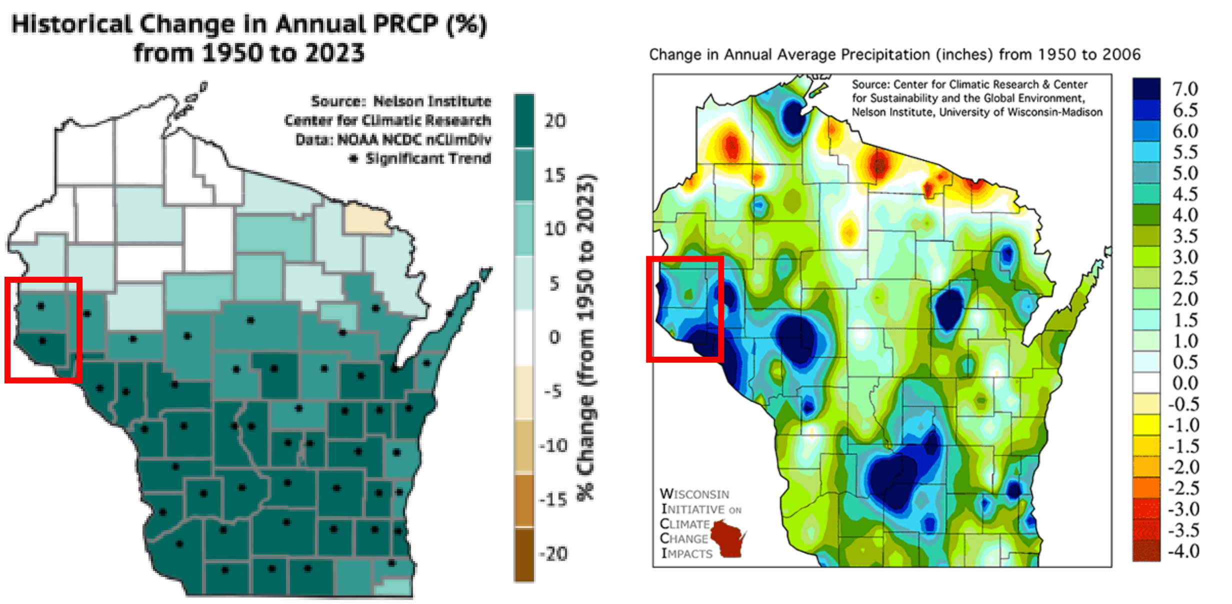


Figure 3. Historical Precipitation Trends in Wisconsin, Pierce and Saint Croix Counties Outlined in Red (WICCI, 2024 (left) and CCR, 2025 (right))

The averages of all available midcentury (2036-2065) projections of precipitation and evapotranspiration show approximately equal increases of 1.0 to 2.0 inches (3-5%) in the River Falls area relative to 1991-2020 under an intermediate scenario (RCP4.5), as shown in Figure 4 and Figure 5. Similar trends are expected under all assessed scenarios (Payton et al, 2023). This similar increase in both precipitation and evapotranspiration will likely cancel each other out in an average year. However, there are concerns that the increased temperatures and evaporative demand will exacerbate droughts in dry years (Payton et al, 2023).

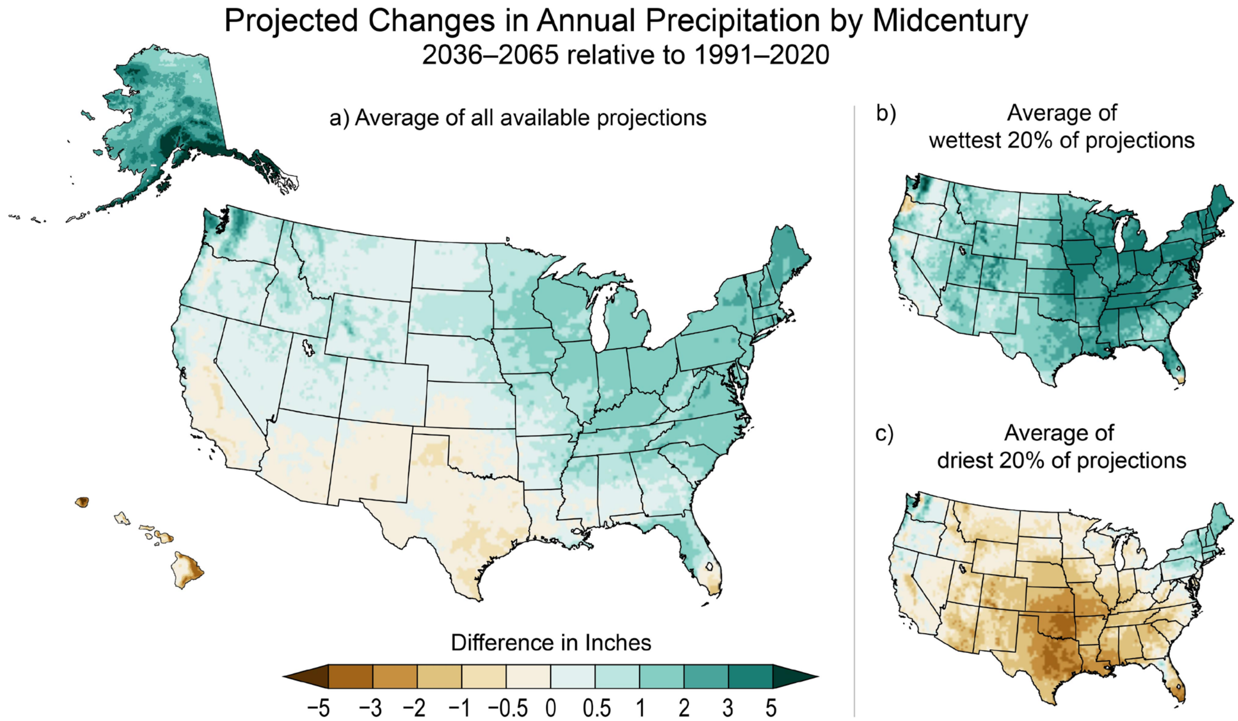


Figure 4: Projected Changes in Annual Precipitation by Midcentury (2036-2065) Relative to 1991-2020 under RCP4.5 (Payton et al, 2023)

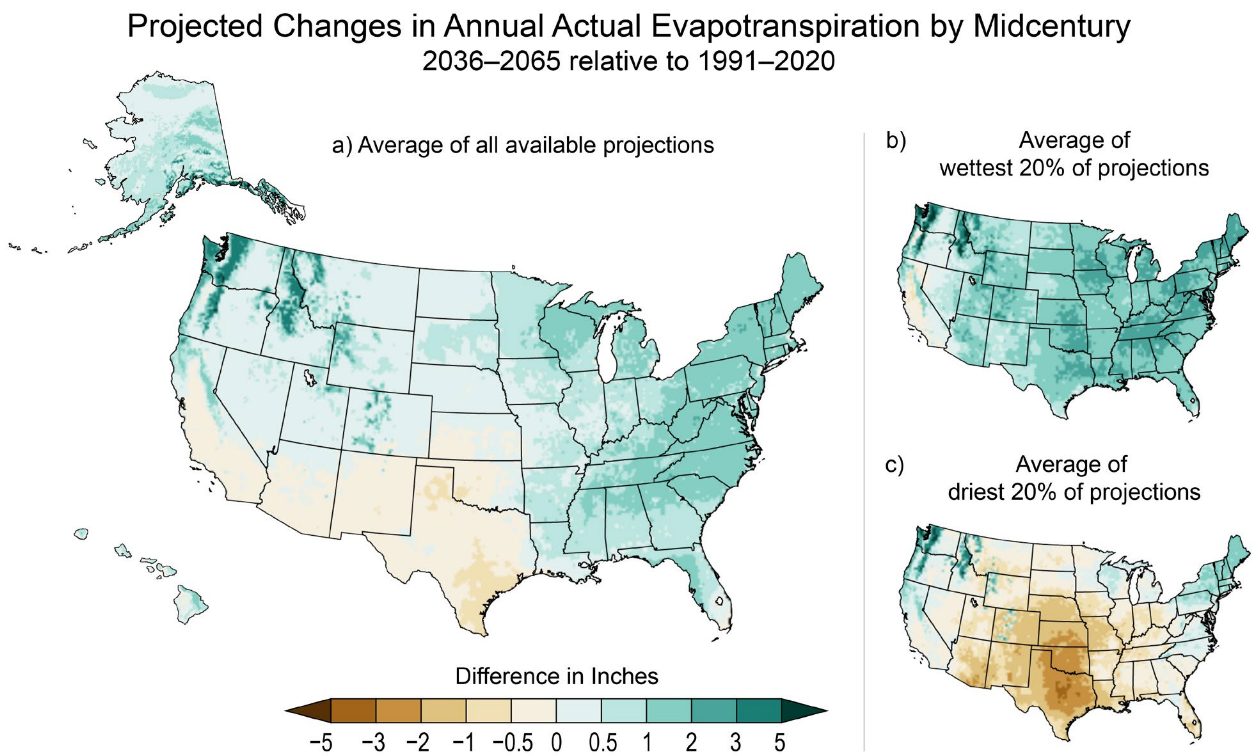


Figure 5: Projected Changes in Annual Actual Evapotranspiration by Midcentury (2036-2065) Relative to 1991-2020 under RCP4.5 (Payton et al, 2023)

Observed streamflow trends are strongly influenced by precipitation, temperature, and other factors such as land use and land cover in a region, groundwater dynamics, drainage patterns, channel geomorphology, and regulation. In the Upper Mississippi Region, multiple studies have identified increasing trends in the observed annual average streamflow (Novotny and Stefan, 2007; Mauget, 2004; Small, Islam, and Vogel, 2006) and in the observed annual mean/median baseflow (Juckem et al., 2008; Xu et al., 2013). Seasonally, the studies have reported increasing annual minimum 7-day low flows in the fall (Small, Islam, and Vogel, 2006) and annual average 7-day low flows in the fall and winter (Novotny and Stefan, 2007). Annual peaks have increased in the spring and summer (Novotny and Stefan, 2007).

There is little to no consensus in the literature regarding changes in projected, future streamflow in the Upper Mississippi Region. Some studies project higher stream flows due to increases in precipitation while others project decreases in streamflow due to increases in evapotranspiration (USACE, 2015). This inconsistency is due to the limitations of modeling software and the input assumptions. There is also variability throughout the year with studies showing increased streamflow in the winter and spring and decreased streamflow in the summer and fall (USACE, 2015). This is consistent with the projected precipitation increases in the winter and spring while summer and fall precipitation is projected to stay relatively constant.

### 2.4 Summary

Continued warming of air temperatures, with related effects on water temperature, increases the risk that trout habitat may no longer be viable in this region, but the Kinnickinnic River appears remarkably resilient relative to other streams in Wisconsin. This warming has also brought changes to the water cycle, with annual precipitation and evapotranspiration having increased over the past century and projected to continue increasing, with precipitation being more pronounced and resulting in greater streamflow. There is little consensus in the literature though on how these hydrologic processes will balance out in the future. If past trends continue though, increased baseflow may be expected in the Kinnickinnic, increasing overall trout habitat.

## 3 Trend and Nonstationarity Detection

The assumption that hydrologic datasets are stationary (that their statistical characteristics are unchanging over time), underlies many types of hydrologic analysis. Statistical tests can be used to check this assumption using the techniques outlined in Engineering Technical Letter (ETL) 1100-2-3 *Guidance for Detection of Nonstationarities* (USACE, 2017a).

The USACE Time Series Toolbox (TST) is a web-based tool that enables the user to perform the statistical tests outlined in ETL 1100-2-3. User-uploaded time series data can be tested for nonstationarities and monotonic trends using the TST (USACE, 2025). Linear and monotonic trend analysis is available by implementing the t-Test (linear), Mann-Kendall (monotonic), and Spearman Rank-Order (monotonic) tests. The p-value for each independent variable tests the null hypothesis that there is no correlation with the dependent variable. If the p-value is less than the accepted threshold, then there may be an association with changes in the dependent variable at the population and is deemed statistically significant (Frost, 2022). The accepted USACE threshold for statistical significance is a p-value less than 0.05 and is adopted for annual peak streamflow trend analyses.

Due to a lack of sufficient long-term stream temperature monitoring data in the proximity of the project, ambient air temperature that is representative of the study area was analyzed as a proxy for stream temperature as part of this assessment. Maintaining stream temperature is important to the trout habitat objective of this project. Although there are other factors that may impact stream temperature (such as flow velocity and impoundment time), this study uses annual temperature trends as one representation of stream temperature of the Kinnickinnic River near River Falls.

Additionally, the continuous record of the USGS Kinnickinnic River near River Falls stream gage (05342000) goes back only to 2002. This does not meet the 30-year requirement to complete trend and nonstationarity detection analyses. The relevant parameters for this study are related to baseflow. To maintain trout habitat, flow needs to be maintained during periods of the year when baseflow is the primary contributor to stream flow. Because of the lack of stream flow data, precipitation will be used as a proxy for stream flow to analyze potential resiliency of the project with respect to potential shifts in hydrology.

## 3.1 Precipitation

Precipitation data for Pierce and Saint Croix counties, wherein the Kinnickinnic River HUC-10 watershed lies, was obtained for this analysis from the County Time Series tool and uploaded into the TST. The tool generates temporally and spatially completed datasets for CONUS from 1895-2024. It is developed by the National Oceanic and Atmospheric Administration's (NOAA) National Center for Environmental Information (NCEI) (NOAA, 2025). The TST monotonic trend detection resulted in a statistically significant positive trend in annual precipitation for both counties for the period of record (1895-2024). Results are shown in Figure 6, Figure 7, and Table 1. The Nonstationarity Detection Tool detected no strong nonstationarities or breakpoints on the same datasets (Figure 8 and Figure 9).

This analysis indicates that atmospheric hydrologic inputs are increasing in the study area on an average annual basis since scientific measurements began in the region. This aligns with literature and trends in southern and southwestern Wisconsin, as discussed in Section 3.1.

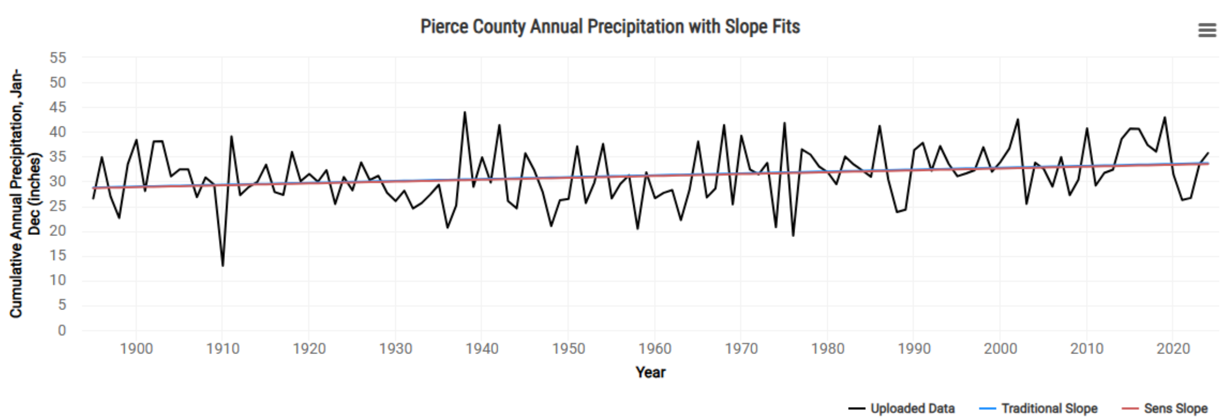


Figure 6: Pierce County Annual Cumulative Precipitation Time Series Toolbox Output (NSD)

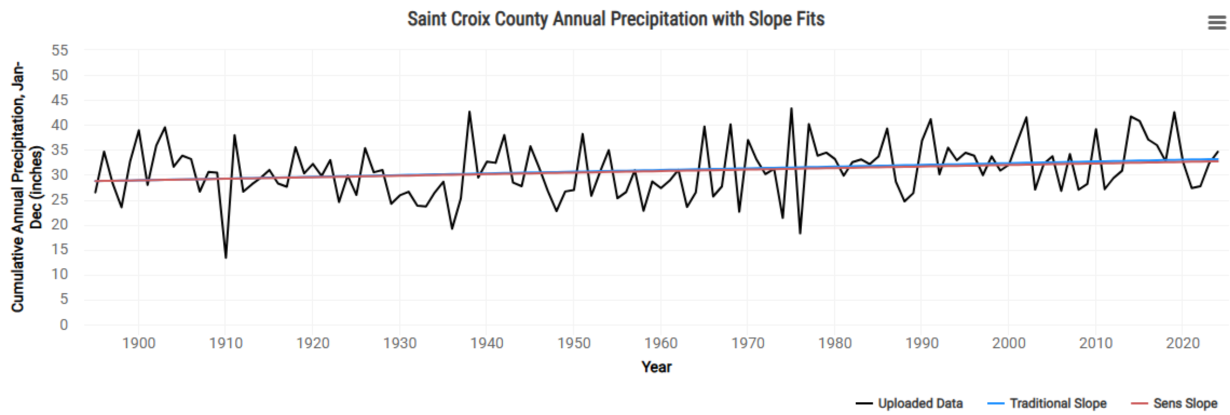


Figure 7: Saint Croix County Annual Cumulative Precipitation Time Series Toolbox Output (NSD)

Table 1: Trend Hypothesis Test Results for Cumulative Annual Precipitation

| | P-Values | | |
|---|---|---|---|
| | t-Test | Mann-Kendall | Spearman Rank-Order |
| Pierce County | .0029 | .00427 | .0027 |
| Saint Croix County | .00657 | .0126 | .00785 |

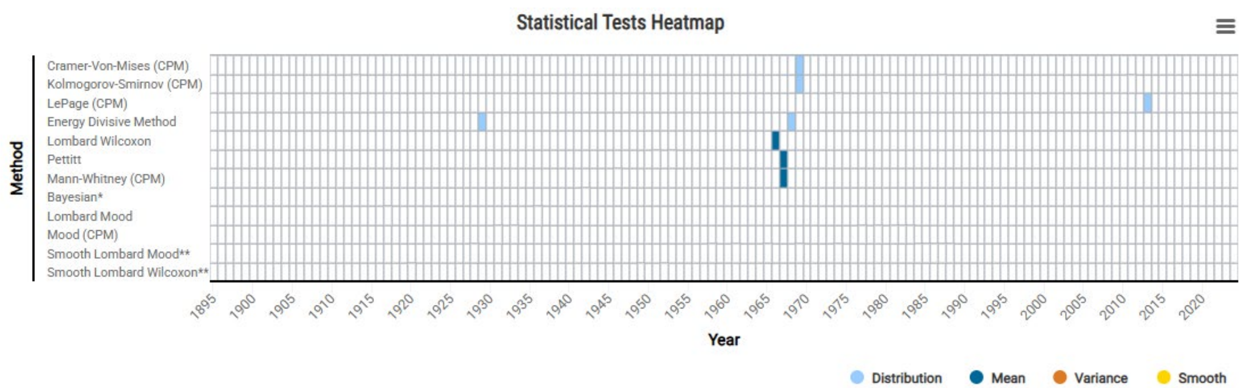


Figure 8: Pierce County Annual Cumulative Precipitation Nonstationarity Detection Time Series Toolbox Output (Heatmap)

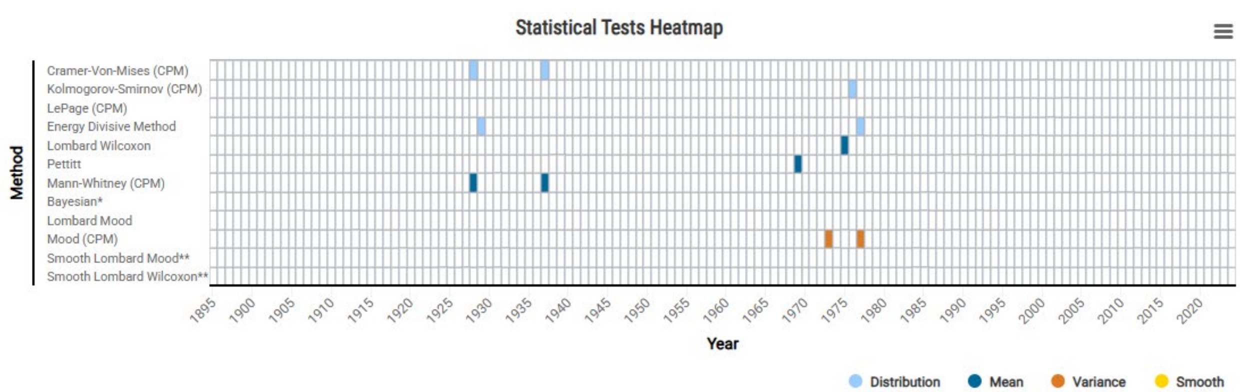


Figure 9: Saint Croix County Annual Cumulative Precipitation Nonstationarity Detection Time Series Toolbox Output (Heatmap)

## 3.2 Streamflow

Natural streamflow data with a sufficiently long period of record is unavailable for the study area. For this assessment, the literature review, CHAT analysis, and trend analysis on precipitation will be used to analyze potential impacts of changes in hydrometeorologic conditions in the Kinnickinnic River Basin.

## 3.3 Air Temperature

Temperature data for Pierce and Saint Croix counties, wherein the Kinnickinnic River HUC-10 watershed lies, was obtained for this analysis from the County Time Series tool. The tool generates temporally and spatially completed datasets for CONUS from 1895-2024. It is developed by the NOAA's NCEI (NCEI, 2025).

### 3.3.1 Annual Average Temperature

The TST monotonic trend detection for annual average temperature resulted in a statistically significant positive trend for the period of record (1895-2024). Mann-Kendall, Spearman Rank-Order, and t-tests all had a p-values less than0.001. Results are shown in Figure 10 and Figure 11.

The TST Nonstationarity Detection Tool detected a strong nonstationarities in 1996/1997 for both Pierce and Saint Croix Counties (Figure 12 and Figure 13). A strong nonstationarity is one that demonstrates a degree of consensus, robustness, and a significant increase or decrease in the sample mean and/or variance. In Pierce County, the magnitude of the mean annual temperature increased by 1.13 degrees F after the 1996/1997 nonstationarity. In Saint Croix County, the magnitude of the average annual temperature increased by 1.35 degrees F after the 1996/1997 nonstationarity. Both counties also saw an increase in variance and standard deviation after the 1996/1997 nonstationarity. A trend analysis could not be computed for the period following the strong nonstationarity as the NSD requires 30 years of data, whereas only 27 years of data are available from 1998 – 2024.

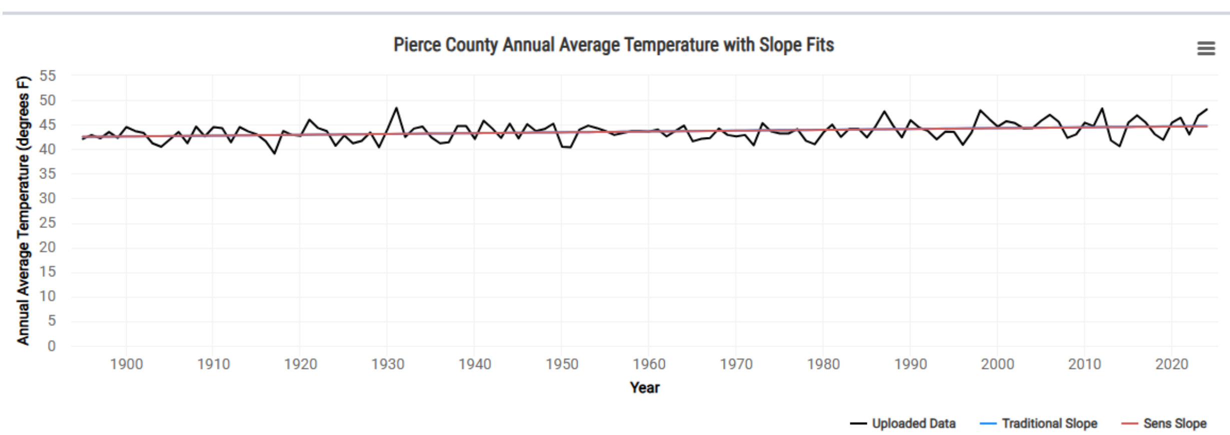


Figure 10: Pierce County Annual Average Daily Temperature Time Series Toolbox Output (NSD)

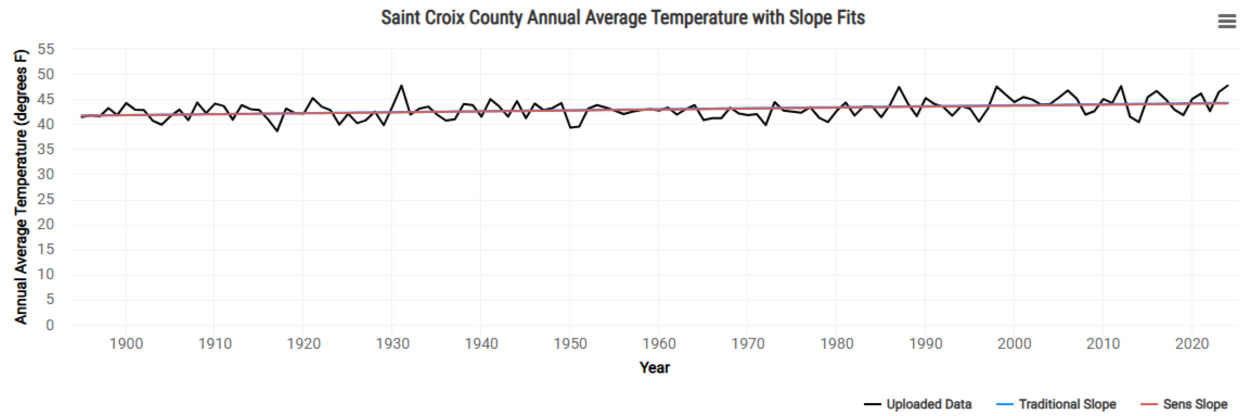


Figure 11: Saint Croix County Annual Average Daily Temperature Time Series Toolbox Output (NSD)

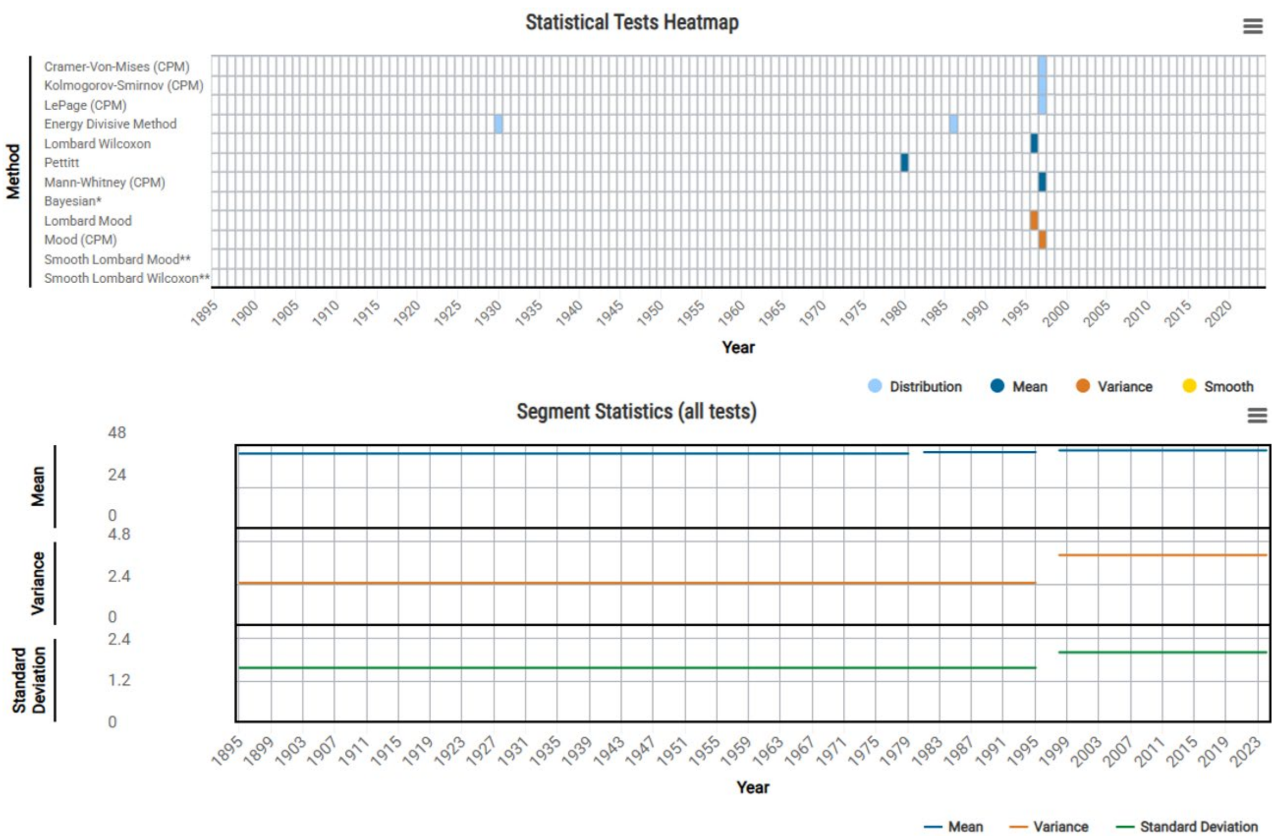


Figure 12: Pierce County Annual Average Daily Temperature Time Series Toolbox Output (Heat Map, top and Segment Statistics for Mean, Variance, and Standard Deviation, bottom)

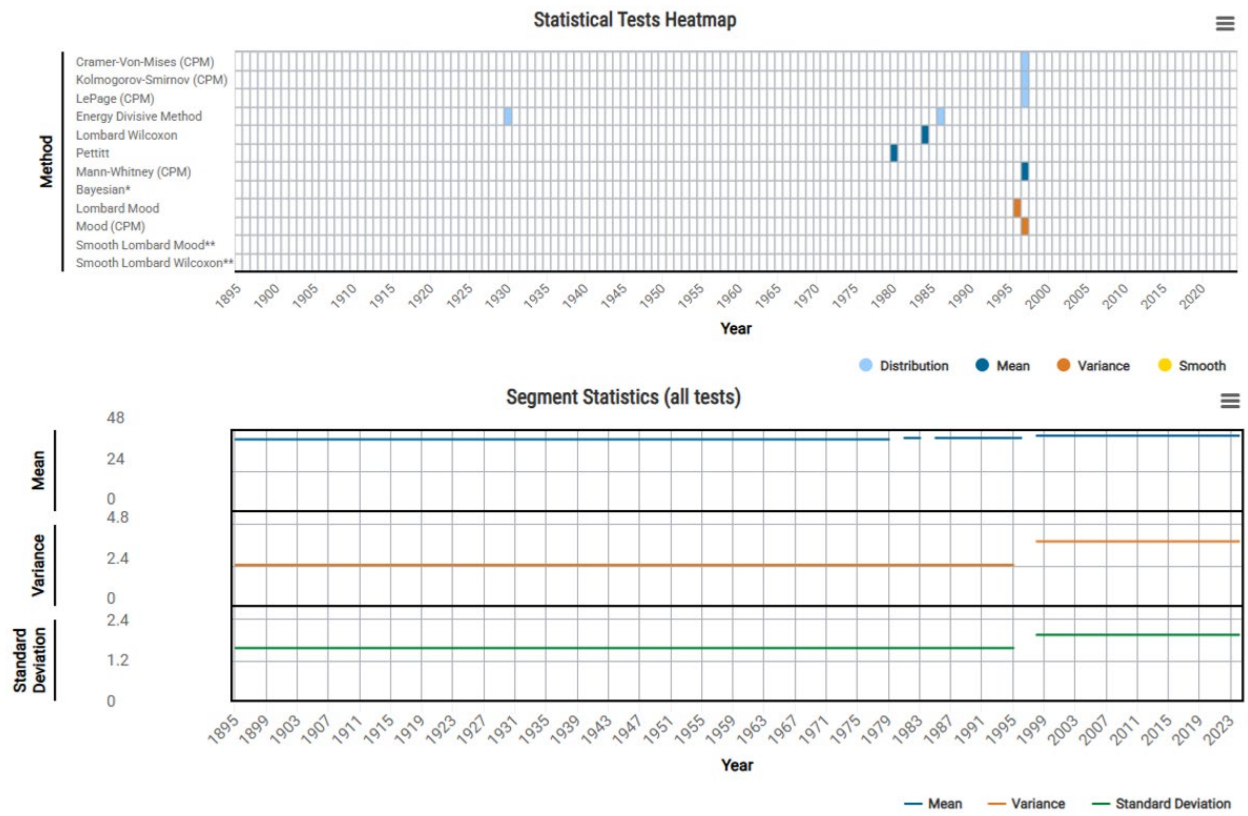


Figure 13: Saint Croix County Annual Average Daily Temperature Time Series Toolbox Output (Heat Map, top and Segment Statistics for Mean, Variance, and Standard Deviation, bottom)

### 3.3.2 June-July-August Annual Average Temperature

One of the main project impacts is to reduce the maximum stream temperature during the warmest months of the year to create robust trout habitat. For this reason, monotonic trend and nonstationarity analyses were completed on the annual average temperatures for June-July-August (JJA) for Pierce and Saint Croix Counties. This will give a better indication about impacts of potential temporal shifts on project benefits.

The TST monotonic trend detection for annual average JJA temperature resulted in no statistically significant trends for the period of record (1895-2024) for either Pierce County or Saint Croix County. Results are shown in Figure 14 and Figure 15 and in Table 2.

The Nonstationarity Detection Tool detected no strong nonstationarities in either county. Results are shown in Figure 16 and Figure 17.

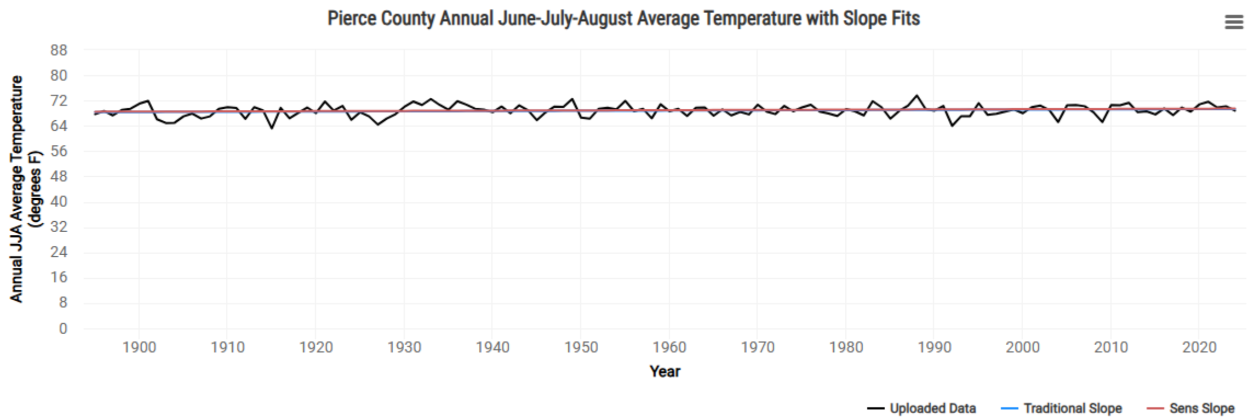


Figure 14: Pierce County Annual JJA Average Temperature Time Series Toolbox Output (NSD)

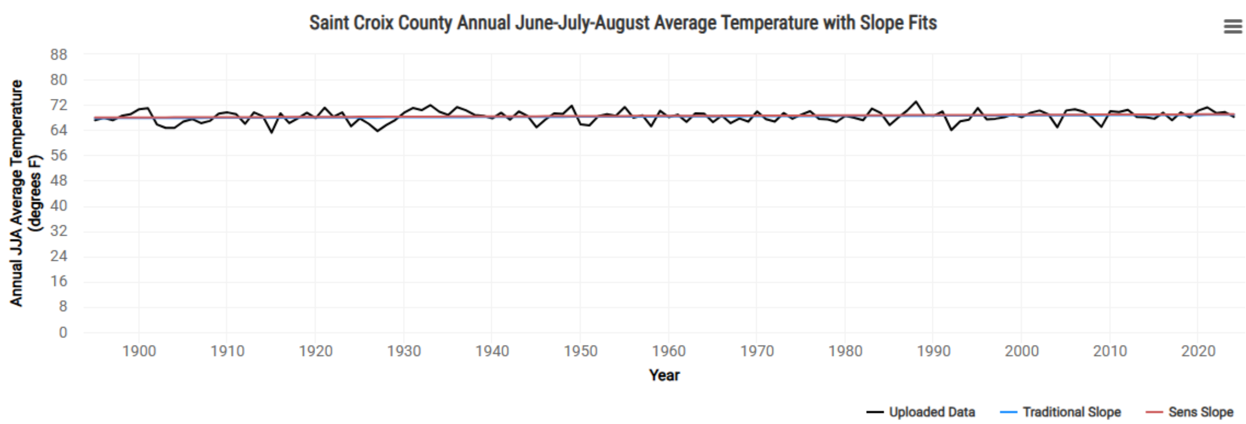


Figure 15: Saint Croix County Annual JJA Average Temperature Time Series Toolbox Output (NSD)

Table 2: Trend Hypothesis Test Results for JJA Annual Average Temperature

| | P-Values | | |
|---|---|---|---|
| | **t-Test** | **Mann-Kendall** | **Spearman Rank-Order** |
| **Pierce County** | .0847 | .0874 | .0991 |
| **Saint Croix County** | .0503 | .0538 | .0529 |

Although the statistical tests did not indicate any strong tests using a threshold of $p < .05$, all tests had p-values less than 0.1. This is a more conservative threshold than guidance requires but is still worth noting.

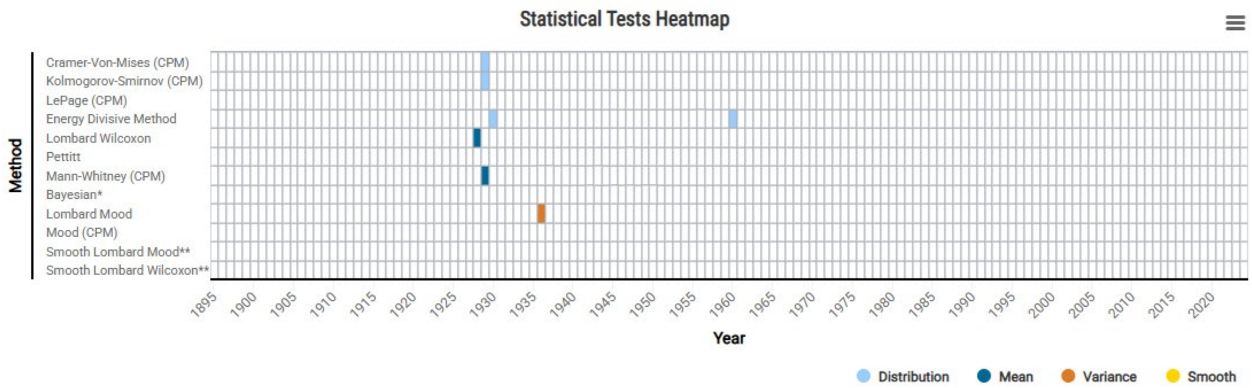


Figure 16: Pierce County Annual JJA Average Temperature Nonstationarity Detection Time Series Toolbox Output (Heatmap)

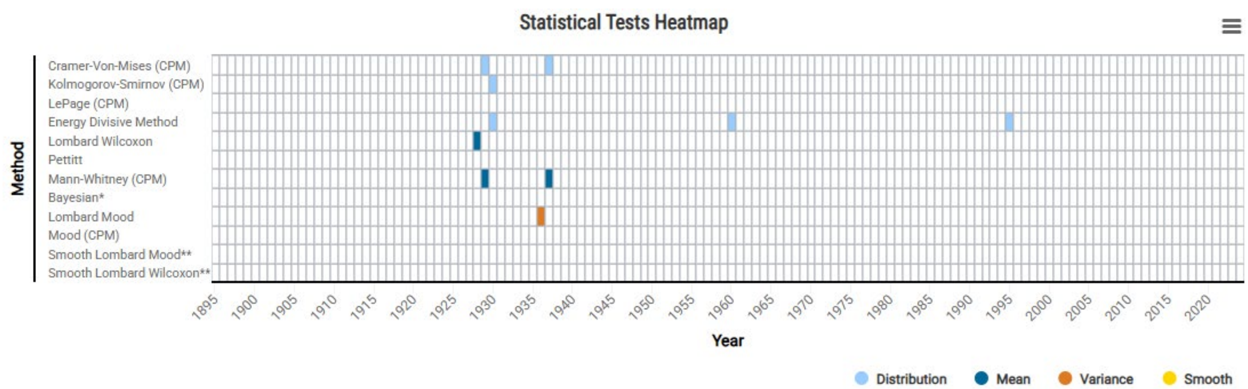


Figure 17: Saint Croix County Annual JJA Average Temperature Nonstationarity Detection Time Series Toolbox Output (Heatmap)

The analysis on annual average and annual JJA average indicates that the atmospheric temperature in the Kinnickinnic River Watershed has increased on an annual basis, but average summer temperature may not be increasing, or at least without a statistically significant trend. This aligns with literature on the same subject, as seen in Figure 2 (WICCI, 2024)

### 3.4 Summary

The results of the trend and nonstationarity analyses on precipitation show a statistically significant increase in annual precipitation over the Kinnickinnic River Basin for the period of record. The results of the same analyses on temperature show a statistically significant increase in temperature annually but show no definitive increase in temperature for the summer months. Using precipitation and ambient temperature as proxies for stream flow and temperature, these results do not show indication of decrease in water supply or increase in water temperature in the warmest months of the year.

## 4 USACE Comprehensive Hydrology Assessment for Projected Data

Derived using 32 GCMs, the USACE Comprehensive Hydrology Assessment Tool (CHAT) can display various simulated historic and future streamflow and precipitation within a particular watershed (USACE, 2023). Projects are at the spatial scale of a HUC-8 watershed, with flows generated using the U.S. Bureau of Reclamation (USBR) Variable Infiltration Capacity (VIC) model using temperature and precipitation data that has been statistically downscaled from GCMs using the Bias Corrected, Spatially Disaggregated (BCSD) method. The model is setup to simulated unregulated basin conditions. The model receives precipitation as an input, and it outputs flow.

The CHAT uses Coupled Model Intercomparison Project Phase 5 (CMIP5) GCM meteorological data outputs that have been statistically downscaled using the Localized Constructed Analogs (LOCA) method. To analyze runoff, LOCA-downscaled GCM outputs are used to force an unregulated, Variable Infiltration Capacity (VIC) hydrologic model. Areal runoff from VIC is then routed through a stream network using mizuRoute. The VIC model outputs represent the daily in-channel routed runoff (i.e., streamflow) for each stream segment – calid at the stream segment endpoint. Since the runoff is routed, the streamflow value associated with each stream segment is a representation of the cumulative flow including all upstream runoff, as well as the local runoff contributions to that specific segment. Within the CHAT, output can be selected for the terminal stream segment (outlet) associated with a given 8-digit HUC watershed.

For this assessment, the CHAT tool was used to access projected future water availability within the Lower St. Croix watershed (HUC 07030005) along stream segment 07000486, (representing the Kinnickinnic River near River Falls), using modeled annual mean 1-day streamflow, annual mean 1-day temperature, and annual maximum number of dry days. Annual mean 1-day streamflow is analyzed for this assessment to investigate if and how potential future streamflow conditions will change. Annual mean 1-day temperature is analyzed for this assessment as a proxy for water temperature. Annual maximum number of dry days is analyzed to investigate potential long term water availability in the study area. Figure 18, Figure 19, and Figure 20 show the range of 64 combinations of GCMs and RCPs applied to the general changed hydrology outputs. The range of data is indicative of the uncertainty associated with streamflow and temperature.

Figure 21, Figure 22, and Figure 23 show the averages of these CHAT simulations as trendlines. Trends are evaluated using the t-Test, Mann-Kendall and Spearman Rank-Order tests. All three statistical tests are applied using a 0.05 level of significance (p-values<.05 are considered statistically significant). Metrics on annual mean 1-day streamflow showed no statistically significant trend in historical or intermediate-scenario streamflow but did show a statistically significant increase (p-value <.001 for all tests) in streamflow in very-high-scenario streamflow. In that case the increase in mean daily streamflow was just over 5%.

Simulations on historical on annual daily mean temperature showed a statistically significant increase in historical and in projected scenarios. The historical analysis showed a 3% increase in temperature and the intermediate and very-high scenario analyses showed 6% and 12% increases, respectively.

The drought indicator showed no statistically significant trend in number of consecutive dry days in either historical or projected scenarios.

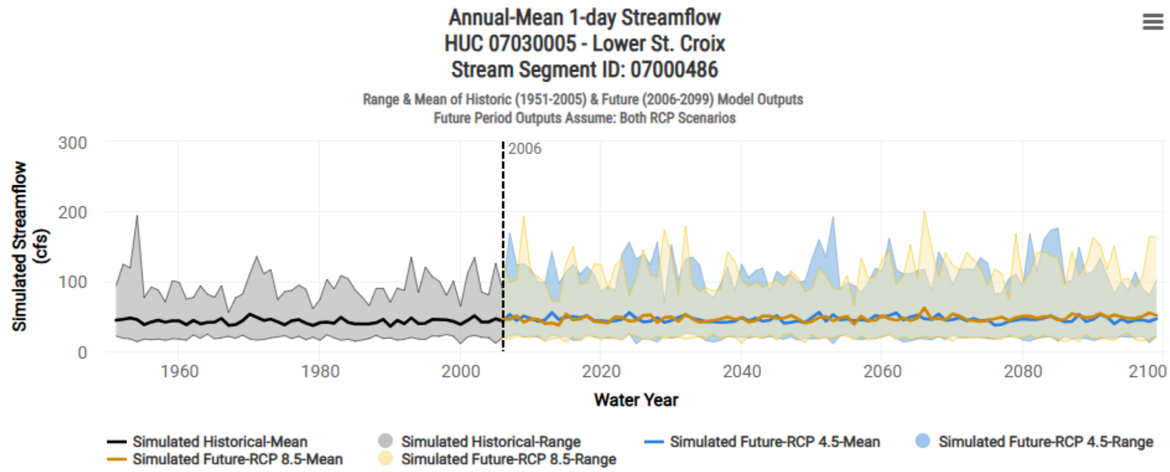


Figure 18: Range of Modeled Annual Mean 1-Day Streamflow for HUC 07030005 using the CHAT Tool

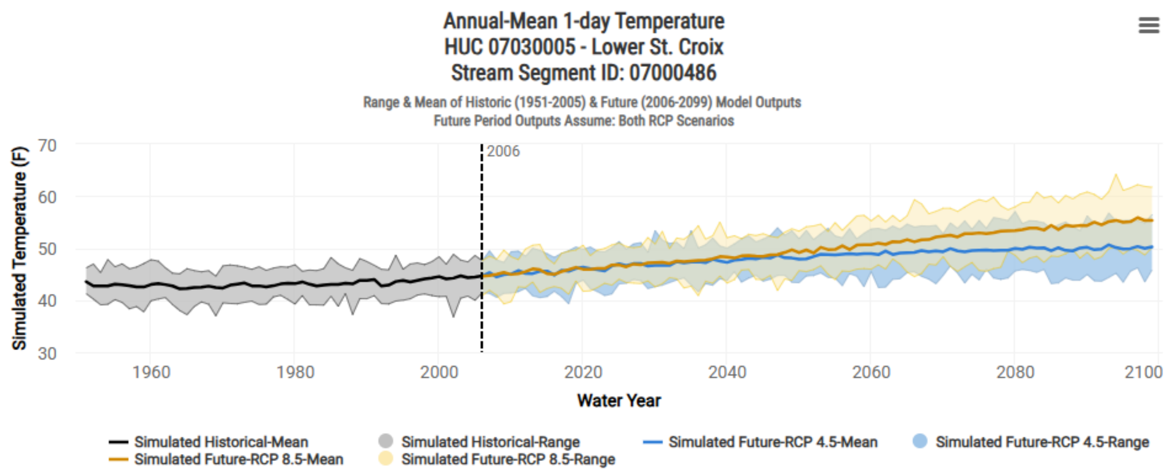


Figure 19: Range of Modeled Annual Mean 1-Day Temperature for HUC 07030005 using the CHAT Tool

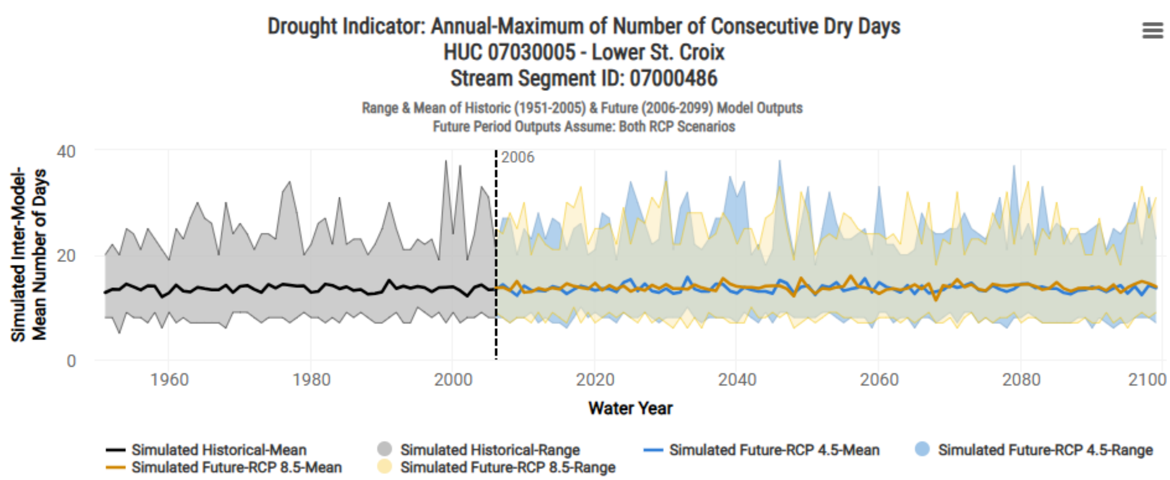


Figure 20: Range of Modeled Annual Maximum of Number of Consecutive Dry Days for HUC 07030005 using the CHAT Tool

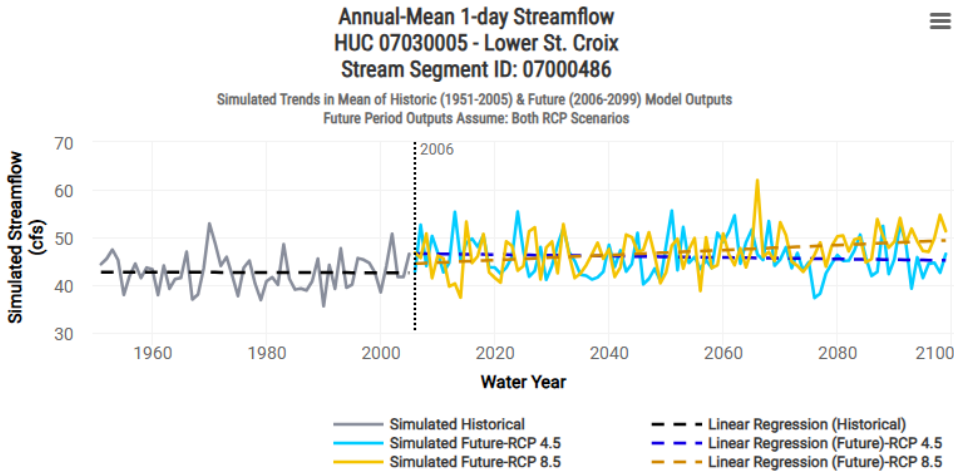


Figure 21: CHAT Tool Projected and Historical Annual Average 1-day Streamflow for HUC 07030005

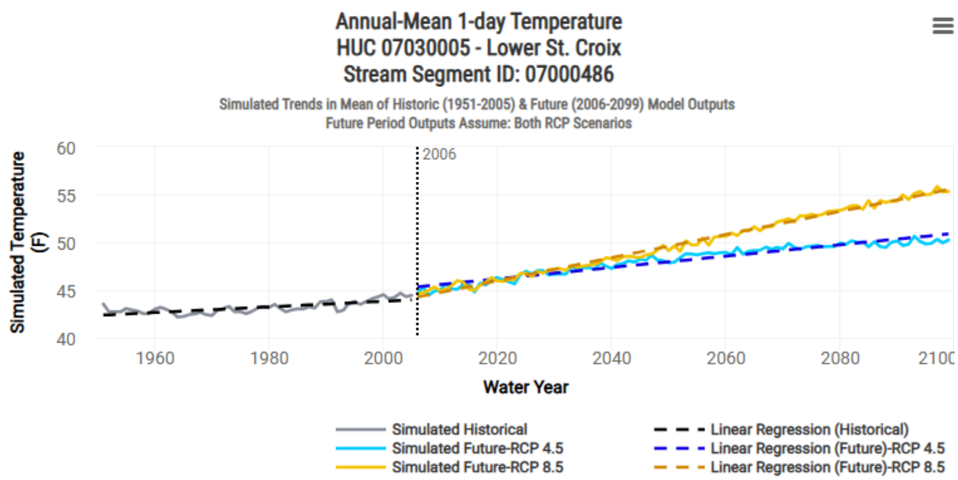


Figure 22: CHAT Tool Projected and Historical Annual Average 1-day Temperature for HUC 07030005

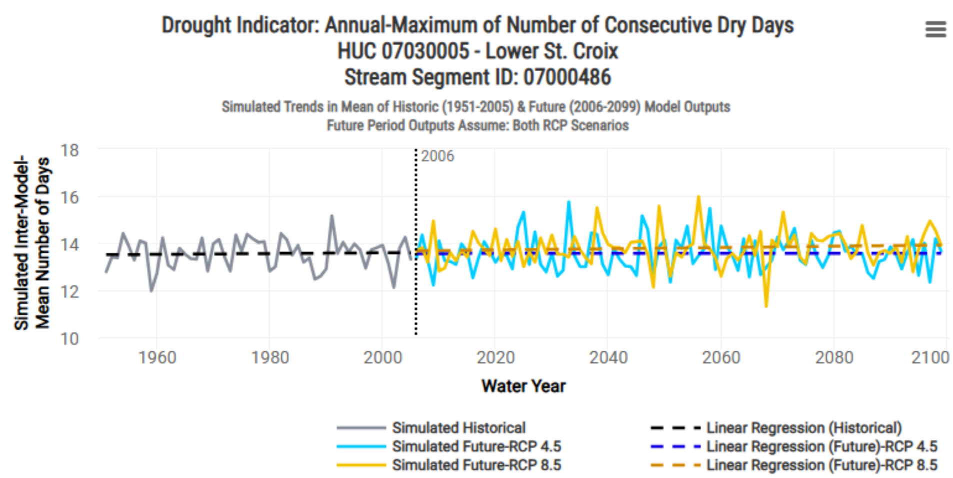


Figure 23: CHAT Tool Projected and Historical Annual Maximum of Number of Consecutive Dry Days for HUC 07030005

The CHAT provides temperature outputs analyzed by comparatively describing simulated changes in monthly streamflow and temperature between different epochs (time periods). Monthly temperature output is analyzed by determining the mean of the monthly value for the variable of interest for each GCM for three epochs: 1950-2005 (baseline), 2035-2064 (mid-century), and 2075-2099 (end of century). The difference between GCM/Month/Epoch means are determined for both the baseline vs. mid-century and baseline vs. end of century epochs and results are presented as box plots. These boxplots provide insight into both the range of results and the seasonality of changes in temperature overtime.

For stream segment 0700486 in the Lower St. Croix watershed (HUC07030005), changes in epoch-mean of simulated monthly mean temperature are presented in Figure 25. For the stream segment analyzed, temperatures across all months increase for both mid-century and end of century epochs for both RCP scenarios.

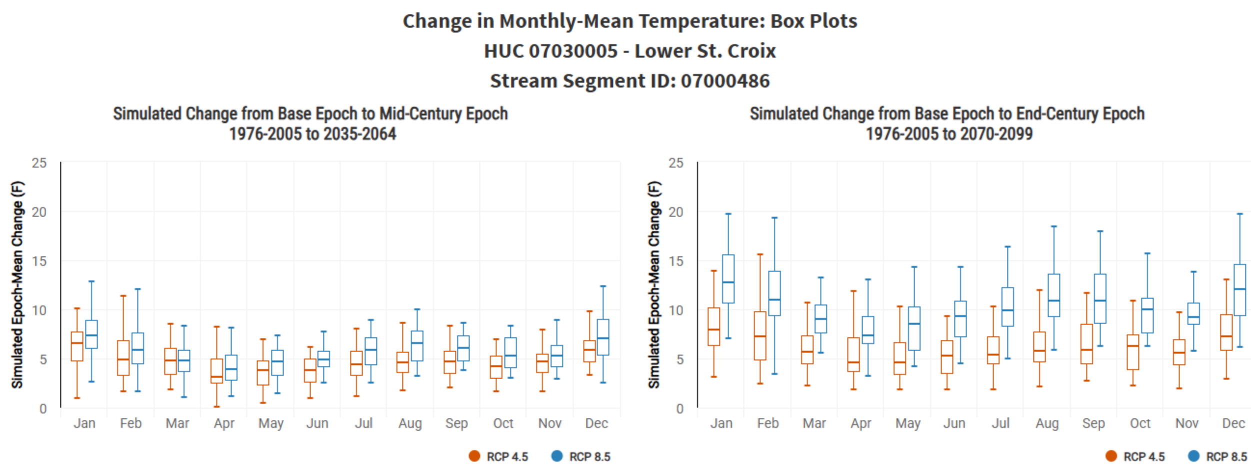


Figure 24: Change in Epoch-Mean of Simulated Monthly Mean Temperature for HUC 07030005 - Lower St. Croix

Summer month temperatures are of particular interest for the habitat restoration features of the project. Trend and nonstationarity detection tests did not detect increased temperatures in average June, July, and August (JJA) temperature. This contrasts the CHAT results, which show changes in monthly temperature for JJA. Results from the CHAT tool for JJA are presented in Table 3.

Table 3: Change in Epoch-Mean of Simulated Monthly Mean Temperatures for June, July, and August for HUC 07030005 - Lower St. Croix.

| | | | **Change in Temperature from Baseline (Degrees F)** | | | |
|---|---|---|---|---|---|---|
| | | | **June** | **July** | **August** | **JJA Average** |
| **Mid-Century Epoch** | **RCP 4.5** | **Minimum** | 1.0 | 1.1 | 1.7 | 2.3 |
| | | **Median** | 3.8 | 4.5 | 4.6 | 4.3 |
| | | **Maximum** | 6.2 | 8.0 | 8.6 | 7.6 |
| | **RCP 8.5** | **Minimum** | 2.5 | 2.5 | 3.2 | 2.7 |
| | | **Median** | 4.9 | 5.9 | 6.5 | 5.8 |
| | | **Maximum** | 7.7 | 8.9 | 9.9 | 8.8 |
| | **RCP 4.5** | **Minimum** | 1.8 | 1.8 | 2.1 | 1.9 |
| | | **Median** | 5.3 | 5.4 | 5.8 | 5.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **End-Century Epoch** | | **Maximum** | 9.3 | 10.2 | 11.9 | 10.5 |
| | **RCP 8.5** | **Minimum** | 4.5 | 4.9 | 5.8 | 5.1 |
| | | **Median** | 9.3 | 10.0 | 10.9 | 10.1 |
| | | **Maximum** | 14.2 | 16.4 | 18.3 | 16.3 |

# 5 USACE Civil Works Vulnerability Assessment Tool

The USACE Civil Works Vulnerability Assessment (VA) Tool was used to analyze the St. Croix watershed (HUC 0703) the Ecosystem Restoration business line, relative to the other HUC-4 watersheds within the continental United States. It uses the CMIP5 GCM-BCSD-VIC dataset (2014) to define projected hydrometeorological inputs, combined with other data types to define a series of indicator values to define a vulnerability score (USACE, 2020). The variables analyzed in this business line are: (8) % of freshwater plant communities at risk, (65L) Mean annual runoff (local), (156) Change in sediment load due to change in future precipitation, (221C) Monthly coefficient of variation (CV) of runoff (cumulative), (227) % change in runoff divided by % change in precipitation, (297) Macroinvertebrate index of biotic condition, (568) Flood magnification factor (both cumulative and local), and (700C) Low flow reduction factor (cumulative) (USACE, 2020). The tool was applied using its default, National Standard Settings.

Vulnerabilities are represented by a weighted-order, weighted-average (WOWA) score generated for two subsets of simulations (wet – top 50% of cumulative runoff projections; and dry – bottom 50% cumulative runoff projections). Data are available for three epochs. The epochs include the current historic period (“Base” epoch) and two 30-year, future epochs (centered on 2050 and 2085). The base epoch is not based on projections and so it is not split into different scenarios. In the context of the VA Tool, there is some uncertainty in all the inputs to the vulnerability assessments. The VA tool reveals some of this uncertainty by presenting separate results for each of the scenario-epoch combinations rather than presenting a single aggregate result.

Results from the VA Tool indicate that ecosystem restoration projects within the Saint Croix watershed are not vulnerable relative to those in other watersheds in the United States for either wet or dry scenarios considered for epochs 2050 and 2085. In all scenarios, the dominant indicator is (8) % of freshwater plant communities at risk, accounting for approximately 30% of the WOWA scores in all scenarios. Other factors with contributions to the WOWA score greater than 10% are (227) % change in runoff divided by % change in precipitation, (221C) Monthly coefficient of variation (CV) of runoff (cumulative), and (65L), Mean annual runoff (local). Results are shown in Figure 25 and Table 4.

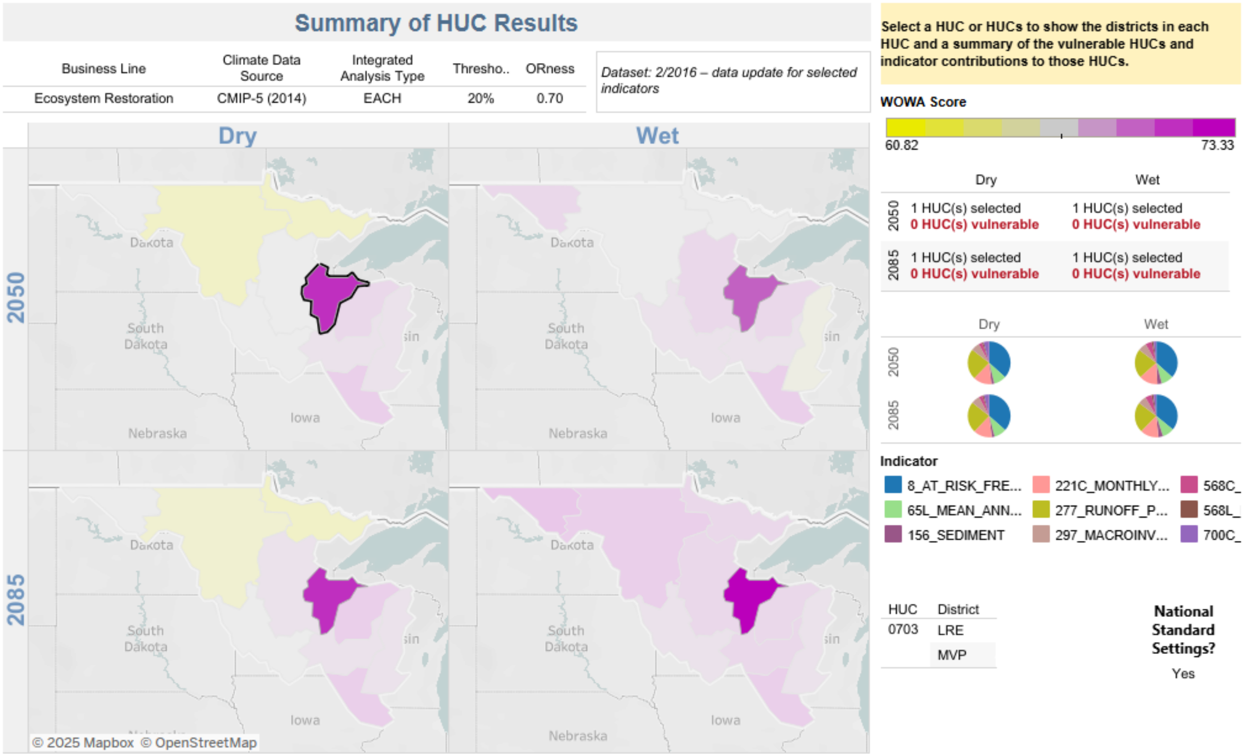


Figure 25: Output from the VA Tool for the Saint Croix Watershed (HUC 0703)

Table 4: VA Tool Output in HUC 0703 for the Ecosystem Restoration Business Line

| Subset | Epoch | VA Score | % Change in VA Score (2050 to 2085) | Dominant Indicator | Dominant Indicator % Change (2050 to 2085) | |
|---|---|---|---|---|---|---|
| | | | | | Contribution to Overall WOWA Score | Indicator Value |
| **WET** | 2050 | 70.55 | +2.10% | 8- At Risk Freshwater Plants | 0% | Constant Overtime |
| | 2085 | 72.03 | | 8- At Risk Freshwater Plants | | |
| **DRY** | 2050 | 71.10 | +0.46% | 8- At Risk Freshwater Plants | 0% | Constant Overtime |
| | 2085 | 71.43 | | 8- At Risk Freshwater Plants | | |

# 6 Conclusion

Analyses on historical meteorologic data has shown that temperature and precipitation in the Kinnickinnic River watershed have increased over time. Because of a lack of a long enough historical record, analyses regarding trends or nonstationarities in streamflow records cannot be completed at this time. It is uncertain how the meteorologic processes will impact overall hydrologic processes in the basin. For the Kinnickinnic River Restoration Feasibility Study, the primary potential concerns are a decrease in flow such that the Kinnickinnic River would not be able to maintain a baseflow or an increase in stream temperature during the warmest months of the year such that the river such that trout habitat would be impacted. Based on the literature review and analyses performed in this assessment, the Kinnickinnic River is not relatively vulnerable to these concerns as projections show an increase of precipitation as a hydrologic input and historical data does not indicate a significant increase in average temperatures for summer months. Analysis on projected ambient temperature analyses produced mixed results. TST trend analyses did not find statistically significant change in summer temperatures, while the CHAT projected increases in temperature for both mid-century and end-century epochs for summer months. Additionally, Kinnickinnic River baseflow is primarily generated through deep springs. The literature review found that though groundwater temperatures are projected to increase, they are projected to remain below the maximum threshold for trout habitat. Table 5 summarizes the residual risks to the project associated with temperature, baseflow, increased peak flow, and water surface elevation changes.

Table 5. Residual Risk Assessment

| Project Feature | Trigger | Hazard | Harm | Qualitative Likelihood | Justification of Likelihood Rating |
|---|---|---|---|---|---|
| Stream Habitat Restoration | Increased maximum summer air temperatures | Increased maximum stream temperatures | Cool water trout habitat may decrease | Unlikely | Wide literature research on trout habitat in the Kinnickinnic River suggests it water temperatures are likely to remain low enough to support cool water trout habitat, even during the warmest months of the year. Additionally, summer air temperatures have not increased. Maintaining coldwater refugia and removing Junction Falls Dam/Lake George will increase habitat resiliency. |
| Stream habitat restoration | Baseflow lowered or not maintained | Decrease in usability of pool and riffle structures by trout, decrease in stream connectivity | Project features have been designed to allow sufficient depth and velocities in pool and riffle structures to meet trout habitat needs | Unlikely | Hydrologic inputs (baseflow) appear to have increased and are projected to continue increasing into the future |
| Bank Protection | Increased flow and water surface elevation | Future flood volumes may be greater than at present | Increased peak flows could increase erosion or impact bank stabilization | Unlikely | The likelihood of increased peak floods on the Kinnickinnic River is unknown. A robust design to bank protection features would prevent impacts of peak floods. |

# 7 References

Basile, S., A.R. Crimmins, C.W. Avery, B.D. Hamlington, and K.E. Kunkel, 2023: Appendix 3. Scenarios and datasets. In: *Fifth National Climate Assessment*. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.A3

Benz, S.A., Irvine, D.J., Rau, G.C. *et al.* Global groundwater warming due to climate change. *Nat. Geosci.* **17**, 545–551 (2024). https://doi.org/10.1038/s41561-024-01453-x

Center for Climatic Research (CCR). *Statistical Downscaling for Wisconsin*. Nelson Institute for Environmental Studies, University of Wisconsin – Madison. Madison, WI. Accessed March 2025. https://ccr.nelson.wisc.edu/visualization-and-tools/statistical-downscaling-for-wisconsin/

Frankson, R., K.E. Kunkel, S.M. Champion, and L. Sun, 2022: *Wisconsin State Climate Summary 2022*. NOAA Technical Report NESDIS 150-WI. NOAA/NESDIS, Silver Spring, MD, 6 pp. https://statesummaries.ncics.org/chapter/wi/

Frost, Jim. (2022). *How to Interpret P-values and Coefficients in Regression Analysis*. Statistics by Jim. https://statisticsbyjim.com/regression/interpret-coefficients-p-values-regression/

Gleckler, P.J., et al, 2008: Performance metrics for climate models. Journal of Geophysical Research: Atmospheres, vol. 113, no. D6. https://doi.org/10.1029/2007jd008972.

Hare, D.K., Helton, A.M., Johnson, Z.C. *et al.* Continental-scale analysis of shallow and deep groundwater contributions to streams. *Nat Commun* **12**, 1450 (2021). https://doi.org/10.1038/s41467-021-21651-0

Johnson, K. (2023): *The Thermal Impacts of Kinnickinnic River Hydropower Dams and Impoundments in River Falls, WI, and Recent Thermal Benefits of the Lake Louise Drawdown.* Kiap-TU-Wish Chapter, Trout Unlimited. http://www.kiaptuwish.org/wp-content/uploads/2023/03/Kinni-Thermal-Impacts_DIV-UGP_1993-2022_Final.pdf

Juckem, Paul F., Randall J. Hunt, Mary P. Anderson, and Dale M. Roberston. 2008. “Effects of Climate and Land Management Change on Streamflow in the Driftless Area of Wisconsin.” Journal of Hydrology 355 (1–4): 20. https://doi.org/10.1016/j.jhydrol.2008.03.010.

Leung, L.R., A. Terando, R. Joseph, G. Tselioudis, L.M. Bruhwiler, B. Cook, C. Deser, A. Hall, B.D. Hamlington, A. Hoell, F.M. Hoffman, S. Klein, V. Naik, A.G. Pendergrass, C. Tebaldi, P.A. Ullrich, and M.F. Wehner, 2023: Ch. 3. Earth systems processes. In: Fifth National Climate Assessment. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.CH3

Marvel, K., W. Su, R. Delgado, S. Aarons, A. Chatterjee, M.E. Garcia, Z. Hausfather, K. Hayhoe, D.A. Hence, E.B. Jewett, A. Robel, D. Singh, A. Tripati, and R.S. Vose, 2023: Ch. 2. Climate trends. In: *Fifth National Climate Assessment*. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.CH2

Mauget, Steven A. 2004. “Low Frequency Streamflow Regimes over the Central United States: 1939–1998.” Climatic Change 63: 121–44. https://doi.org/10.1023/B:CLIM.0000018502.86522.57.

Mitro, M.G., Lyons, J.D., Stewart, J.S. *et al.* Projected changes in Brook Trout and Brown Trout distribution in Wisconsin streams in the mid-twenty-first century in response to climate change. *Hydrobiologia* **840**, 215–226 (2019). https://doi.org/10.1007/s10750-019-04020-3

NOAA National Centers for Environmental Information (NCEI). (March 2025). *Climate at a Glance: County Time Series*. Retrieved on March 26, 2025. https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/county/time-series

Novotny, E.V., and H.G. Stefan. 2007. “Stream Flow in Minnesota: Indicator of Climate Change.” Journal of Hydrology 334 (3–4): 319–33. https://doi.org/10.1016/j.jhydrol.2006.10.011.

Small, David, Shafiqul Islam, and Richard M. Vogel. 2006. “Trends in Precipitation and Streamflow in the Eastern U.S.: Paradox or Perception?” Geophysical Research Letters 33 (February). https://doi.org/10.1029/2005GL024995.

Stevens, L.E., M. Kolian, D. Arndt, J. Blunden, E.W. Johnson, A.Y. Liu, and S. Spiegal, 2023: Appendix 4. Indicators. In: *Fifth National Climate Assessment*. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.A4

USACE. (2017a). *Guidance for Detection of Nonstationarities in Annual Maximum Discharges*. Engineering Technical Letter 1100-2-3. USACE. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerTechnicalLetters/ETL_1100-2-3.pdf
USACE, 2020: *Vulnerability Assessment Tool*. https://dodclimate.sec.usace.army.mil/va

USACE, 2015. Recent US Climate Change and Hydrology Literature Applicable to US Army Corps of Engineers Missions – Water Resources Region 07, Upper Mississippi. Civil Works Technical Report. Washington, D.C. https://www.usace.army.mil/corpsclimate/Recent_CC_HydrologyLit_Applicable_USACE_Missions/

USACE. (28 January 2023). *Comprehensive Hydrology Assessment Tool (CHAT). Version 2.3*. Accessed March 27, 2018. https://climate.sec.usace.army.mil/chat

USACE. (2024). *Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects.* USACE Engineering Construction Bulletin (ECB) 2018-14. https://www.wbdg.org/dod/ecb/usace-ecb-2018-14

USACE. (2025). *Time Series Toolbox.* Accessed 26 March, 2025a. https://climate.sec.usace.army.mil/tst_app/

U.S. Geological Survey (USGS). (2023). *National Watershed Boundary Dataset.* Reston, VA https://viewer.nationalmap.gov/basic/?basemap=b1&category=nhd&title=NHD%20View

USGCRP, 2023: Fifth National Climate Assessment. U.S. Global Change Research Program. https://nca2023.globalchange.gov/

Wisconsin Initiative on Climate Change Impacts (WICCI). (2024). *Trends and Projections*. Nelson Institute for Environmental Studies, University of Wisconsin – Madison. Madison, WI. https://wicci.wisc.edu/wisconsin-climate-trends-and-projections/

Xu, Xianlu, Bridget R. Scanlon, Keith Schilling, and Alex Sun. 2013. “Relative Importance of Climate and Land Surface Changes on Hydrologic Changes in the US Midwest since the 1930s: Implications for Biofuel Production.” Journal of Hydrology 497 (8): 110–20. https://doi.org/10.1016/j.jhydrol.2013.05.041.

US Army Corps of Engineers ®
St. Paul District

# Appendix N: Mechanical/Electrical Engineering

Kinnickinnic River Continuing Authorities Program Section 206 Feasibility Report

**May 2025**

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# Appendix N: Mechanical-Electrical Engineering

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# 1 Mechanical/Electrical Considerations

This feasibility report assesses the potential removal of two existing dams—Junction Falls Dam and Powell Falls Dam—located along the Kinnickinnic River in River Falls, Wisconsin. Both dams are equipped with hydropower infrastructure.

Powell Falls previously housed an operational hydropower plant, but it was decommissioned in 2022. As a result, some equipment has already been removed and disposed of, and the plant no longer generates power for the City of River Falls.

Junction Falls still operates as a functional hydropower plant. However, the City of River Falls is considering decommissioning and removing this plant as part of a restoration project. While the Junction Falls Hydropower plant accounts for approximately 1% of the city's power usage, its operating and maintenance costs far exceed any potential benefits from keeping the plant running.

# 2 Mechanical/Electrical Quantities

Mechanical removal quantities were determined using plan sets from each site, as well as site visits to determine existing conditions. Previous cost estimates from Ayres Associates were also used to inform the project’s cost projectons.

## 2.1 Powell Falls

Powell Falls was decommissioned by the City of River Falls and FERC in 2022, which included the removal of the turbines and wicket gates. Some mechanical equipment remains in place, including two sluice gates with their associated actuators and the generator. Table 1 below outlines the items that will need to be removed.

Table 1: Powell Falls Mechanical/Electrical Removal Requirements

| Item Description | Quantity | Unit |
|---|---|---|
| Sluice Gate Removal | EA | 2 |
| Generator Removal | EA | 1 |

All electrical equipment was removed during the decommissioning.

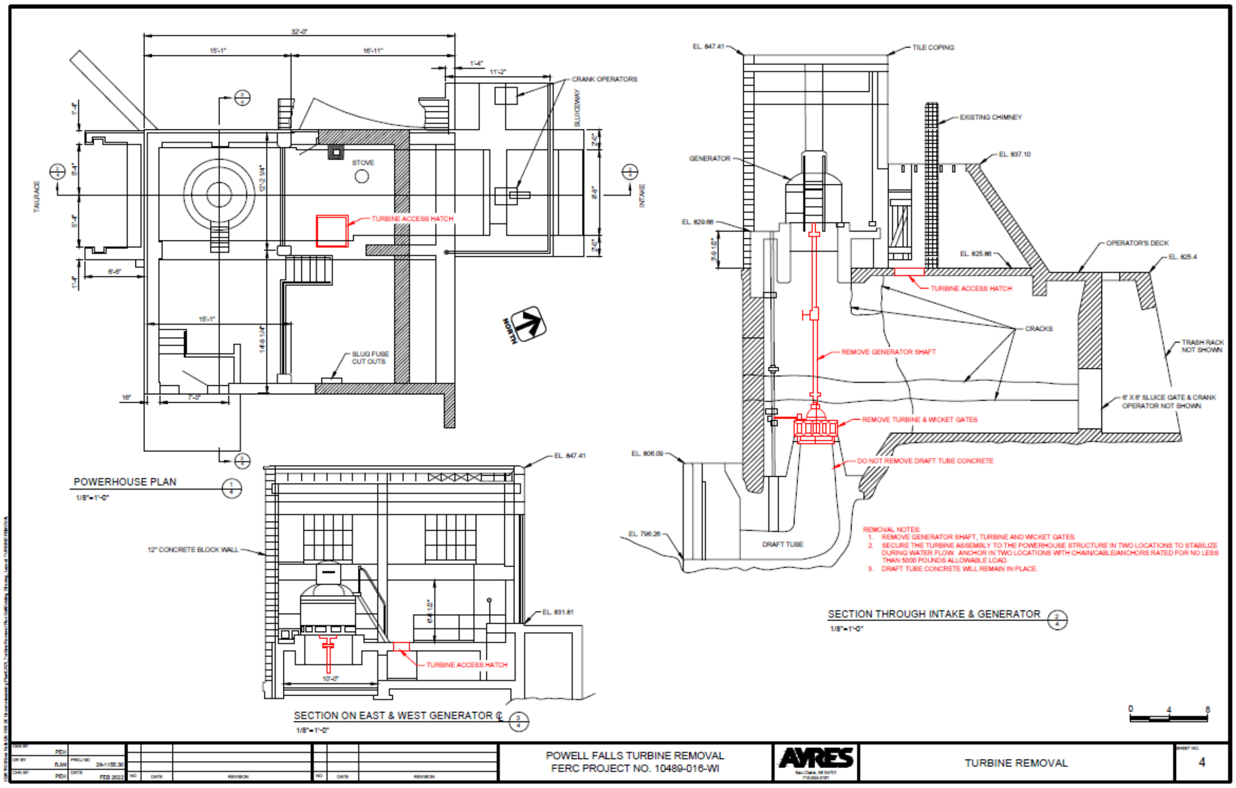


Figure 1. Powell Falls Turbine Demolition Drawings

## 2.2 Junction Falls

Junction Falls is currently operable, and all mechanical machinery associated with the power plant will need to be removed as part of the Restoration project. Mechanical Equipment at Junction Falls includes the generator, turbine, penstock, and two sluice gates with actuators. Table 2 below outlines the items that require removal.

Table 2: Junction Falls Mechanical/Electrical Removal Quantities

| Item Description | Quantity | Unit |
|---|---|---|
| Turbine Removal | EA | 1 |
| Sluice Gate Removal | EA | 2 |
| Penstock Removal | LF | 175 |
| Generator Removal | EA | 1 |
| Electrical Equipment Removal/Disconnection | EA | 1 |

All Electrical equipment for the Junction Falls Dam, including transformers, are housed in the basement of the attached municipal building. The blue shaded box shown in Figure 2 roughly shows the location of the tranformers, while the red shaded box shows the location of the powerhouse. Any work on the attached municipal building was not included in the original scope of the feasibility study. Two options exist for the removal of the Junction Falls electrical equipment.


Figure 2. Junction Fall Site Layout

### 2.2.1 Abandon Transformers in Place

One option for the electrical equipment removal for Junction Falls is to remove all electrical wiring back to the transformers and abandon transformers in place.

### 2.2.2 Transformer Removal

The second option for Electrical Equipment at Junction Falls is to remove all electrical wiring back to the transformers and removal of the transformers as well.

# 3 References

## 3.1 2021 Ayres Powell Falls Decommissioning

A decommissioning plan was prepared by Ayres Associates for Powell Falls and detailed in a 2021 report, written for the City of River Falls. The report details a removal and restoration plan for Powell Falls, including construction methodology, sequencing, and schedule. Annotated drawings from this report are attached to this appendix as Attachment I-7. The full report can be found at the following link: https://www.rfmu.org/DocumentCenter/View/4316/Powell-Falls-Decommissioning-Plan_Ayres2021013