Kenai Peninsula Borough Fish Passage Prioritization Data Synthesis [DRAFT]

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2024-12-31

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# Introduction



Culvert installed near Tyonek, Alaska in 2024. Left: before replacement, Right: after replacement. (Photo Credit: USFWS & NCRS)

* Fish passage structures, including stream crossing structures like culverts and bridges, serve as critical infrastructure to accommodate floodplain function and aquatic organism movement where rivers intersect with roads, trails, and utility corridors. Historic fish passage structures are frequently compromised or under-designed, threatening both infrastructure and wildlife habitat.
* Prioritizing when and where limited rehabilitation funds for fish passage should be directed can be complex. To assist in this task, databases of fish passage structures have been developed through both fieldwork and GIS mapping exercises. Ecological and physical information such as culvert condition, quantity of upstream habitat, and others can help managers make informed decisions on how to best use funds to maximize benefits for people and wildlife.
* In Alaska, multiple, non-integrated fish passage databases exist from various agencies, complicating prospect of using all best available information to regionally prioritize rehabilitation funds.
* In 2024, [Kenai Watershed Forum](https://www.kenaiwatershed.org/) collaborated with [River Focus](https://www.riverfocus.com/) to draft a method to integrate fish passage assessment data from multiple sources for the Kenai Peninsula Borough (KPB) region of southcentral Alaska.
* We identified 412 documented structures where roads or trails intersect with documented anadromous streams within the Kenai Peninsula Borough. We then applied this synthesized dataset to develop scores on the relative value of improvement (for both infrastructure and stream freshwater habitat) that would be achieved by improving or upgrading individual sites.
* Our method employs a coded script-based approach to integrating various datasets, greatly simplifying the ease of annually updating results presented here. It is the first known attempt in the Kenai Peninsula Borough region to integrate and apply fish passage data inventories from multiple agencies.
* A multitude of additional factors beyond those described here should be considered when prioritizing fish passage rehabilitation, including community support, funding opportunities, and construction logistics. The intent of this work is to provide systematic perspective on the habitat and infrastructure values of improving individual fish passage sites.
* As of 2024-12-31 our results constitute a draft in progress and proof of concept, and should not yet be considered authoritative. Additional fieldwork and analysis efforts are needed to ensure complete information. See final chapter, Summary, chapter for details.

# 1. Methods

Methods described within this document are primarily for purposes of sharing example code to synthesize multiple fish passage datasets. A more detailed report with an expanded methods section is available for download at the link below.

## 1.1 Load and Integrate Datasets

We used the following datasets on Kenai Peninsula Borough area stream crossings to create the combined dataset:

* Fish Barrier Hunter 2022 (U.S. Fish & Wildlife Service)
* Fish Barrier Hunter 2023 (U.S. Fish & Wildlife Service)
* 2024 Anadromous Waters Catalog inventory (Alaska Department of Fish and Game)
* AquaticBarriers.org

Additional datasets may be integrated by modifying the script below, displayed by clicking the “Code” button. All scripts are hosted in Kenai Watershed Forum’s [GitHub account](https://github.com/Kenai-Watershed-Forum/fish-passage-prioritization/).

#| code-fold: true  
#| code-summary: "Show the code"  
  
### 1. Load Datasets ###  
# Load all data sets here  
# Can also use read\_excel() to load .xlsx and .xls files  
data\_aquatic\_barriers <- read\_csv("other/input/formatted\_data/Aquaticbarriers/aquatic\_barrier\_ranks\_aquaticbarriers\_org.csv", col\_types = cols(.default = "c"))  
data\_ADFG <- read\_csv("other/input/formatted\_data/ADFG/Kenai\_culvert\_prioritization\_ADFG.csv", col\_types = cols(.default = "c"))   
data\_FWS\_FBH22 <- read\_csv("other/input/formatted\_data/USFWS/2022fishbarrierhunter.csv", col\_types = cols(.default = "c"))   
data\_FWS\_FBH23 <- read\_csv("other/input/formatted\_data/USFWS/2023fishbarrierhunter.csv", col\_types = cols(.default = "c"))   
data\_FWS\_Kenai <- read\_csv("other/input/formatted\_data/USFWS/Kenai USFWS Fish Passage\_Projects\_Needs\_ 12\_20\_23.csv", col\_types = cols(.default = "c"))   
  
### 2. Format Labels ###  
# Create formatted labels to create links between subsets and master set  
labels\_aquatic\_barriers <- c("data source", "Latitude", "Longitude", "Name", "SARPID", "Source", "Snapped", "NHDPlusID", "StreamSizeClass", "LocalID", "CrossingCode", "NearestCrossingID", "Stream Name", "AnnualVelocity", "AnnualFlow", "TotDASqKm", "Road Name", "RoadType", "Structure Type", "Constriction\_Ratio", "PotentialProject", "BarrierSeverity", "SARP\_Score", "Recon", "Removed", "YearRemoved", "Condition", "PassageFacility", "TESpp", "StateSGCNSpp", "RegionalSGCNSpp", "Trout", "Landownership", "BarrierOwnerType", "ProtectedLand", "External Report Links", "EJTract", "EJTribal", "Basin", "Subbasin", "Subwatershed", "HUC2", "HUC6", "HUC8", "HUC10", "HUC12", "State", "County", "Excluded", "Invasive", "OnLoop", "HasNetwork", "Ranked", "Intermittent", "StreamOrder", "Landcover", "SizeClasses", "TotalUpstreamMiles", "PerennialUpstreamMiles", "Reported\_Upstream\_Fish\_Habitat\_miles", "AlteredUpstreamMiles", "UnalteredUpstreamMiles", "PerennialUnalteredUpstreamMiles", "TotalDownstreamMiles", "FreeDownstreamMiles", "FreePerennialDownstreamMiles", "FreeIntermittentDownstreamMiles", "FreeAlteredDownstreamMiles", "FreeUnalteredDownstreamMiles", "GainMiles", "PerennialGainMiles", "TotalNetworkMiles", "TotalPerennialNetworkMiles", "PercentUnaltered", "PercentPerennialUnaltered", "UpstreamDrainageArea", "UpstreamWaterfalls", "UpstreamDams", "UpstreamSmallBarriers", "UpstreamRoadCrossings", "UpstreamHeadwaters", "TotalUpstreamRoadCrossings", "TotalDownstreamWaterfalls", "TotalDownstreamDams", "TotalDownstreamSmallBarriers", "MilesToOutlet", "FlowsToOcean", "FlowsToGreatLakes", "ExitsRegion") # nolint:  
  
labels\_ADFG <- c("ADF&G Crossing Code", "ADF&G rating", "Sport Fish Area Boundary", "Area, Region, Quad or City", "Road Name", "Stream Name", "Prioritization", "AWCStreamNo", "Miles Used for Scoring", "MSB Culverts to 16pc Gradient with Green culverts removed ", "Reported\_Upstream\_Fish\_Habitat\_miles", "Pre-2022 Miles Data to NEXT BARRIER or END", "AWC Miles U/S- ", "Acres of Lake", "Fish\_Species\_Composition", "No of Anadromous Species", "Resident AFFI- Needs to be updated.", "No of resident species", "Red/Gray rating", "Rating w/ Perch", "Perch\_Height", "Perch", "Latitude", "Longitude", "Additional Notes") # nolint:  
  
labels\_FWS\_FBH22 <- c("x", "y", "ObjectID", "GlobalID", "CreationDate", "Creator", "EditDate", "Editor", "Date and Time Observed:", "Observer Name:", "Observer Phone:", "Number of Culverts at your Crossing Site:", "Culvert Material:", "Other - Culvert Material:", "Closest Town:", "Stream Name", "Enter more data?", "Tributary to:", "Subwatershed Name:", "Road Name", "Road Elevation:", "Road Surface:", "Landownership", "Culvert Condition:", "Structure Type", "Channel Wetted Width (feet):", "Upstream\_OHWM\_feet", "Upstream\_Bankfull\_Width\_feet", "Road Fill Height Over Top of Culvert:", "Tidal Site", "Structure Wetted Width at Inlet (feet):", "Water Depth at Inlet (feet):", "Substrate width in Culvert:", "Percent of Inlet Blocked by Debris:", "Grate at Inlet:", "Visible Deformation", "Structure Wetted Width at Outlet (feet):", "Water Depth at Outlet (feet):", "Percent of Outlet Blocked by Debris:", "Grate at Outlet:", "Visible Deformation at Outlet:", "Perch\_Height", "Outlet Scour Pool", "Would you like to add data for more culverts?", "Culvert or Bridge Cell 2 of:", "Cell 2 Structure Type:", "Cell 2 Inlet Structure Width:", "Cell 2 Inlet Structure Height above Water:", "Cell 2 Inlet Structure Wetted Width:", "Cell 2 Inlet Water Depth:", "Cell 2 Outlet Structure Width:", "Cell 2 Outlet Structure Height above Water:", "Cell 2 Outlet Wetted Width:", "Cell 2 Outlet Water Depth:", "Culvert or Bridge Cell 3 of:", "Cell 3 Structure Type:", "Cell 3 Inlet Structure Width:", "Cell 3 Inlet Structure Height above Water:", "Cell 3 Inlet Structure Wetted Width:", "Cell 3 Inlet Water Depth:", "Cell 3 Outlet Structure Width:", "Cell 3 Outlet Structure Height above Water:", "Cell 3 Outlet Wetted Width:", "Cell 3 Outlet Water Depth:", "Culvert or Bridge Cell 4 of:", "Cell 4 Structure Type:", "Cell 4 Inlet Structure Width:", "Cell 4 Inlet Structure Height above Water:", "Cell 4 Inlet Structure Wetted Width:", "Cell 4 Inlet Water Depth:", "Cell 4 Outlet Structure Width:", "Cell 4 Outlet Structure Height above Water:", "Cell 4 Outlet Wetted Width:", "Cell 4 Outlet Water Depth:", "Perched Culvert:", "Are you on private land?", "Please Fill Out Volunteer Form Below.", "Would you like to enter more data?", "Fish Species Present", "Length of Culvert (feet):", "Enter additional photos?", "Is there a hydraulic jump at the inlet?", "Fish Passage Barrier Severity", "Notes", "Is there a known site identification number for this crossing?", "Known Site ID (ADF&G No.)", "Additional Note for ADFG", "Longitude", "Latitude") # nolint:  
  
labels\_FWS\_FBH23 <- c("x", "y", "ObjectID", "GlobalID", "CreationDa", "Creator", "EditDate", "Editor", "Date\_and\_T", "Observer\_N", "Observer\_P", "Number\_of\_", "Culvert\_Ma", "Other\_\_\_Cu", "Closest\_To", "Stream Name", "Enter\_more", "Tributary\_", "Subwatersh", "Road Name", "Road\_Eleva", "Road\_Surfa", "Landownership", "Culvert\_Co", "Structure Type", "Channel\_We", "Upstream\_OHWM\_feet", "Upstream\_Bankfull\_Width\_feet", "Road\_Fill\_", "Tidal Site", "Structure1", "Water\_Dept", "Structur\_1", "Water\_De\_1", "Substrate\_", "Percent\_of", "Grate\_at\_I", "Visible Deformation", "Structur\_2", "Water\_De\_2", "Structur\_3", "Water\_De\_3", "Percent\_\_1", "Grate\_at\_O", "Visible\_\_1", "Perch\_Height", "Scour\_Pool", "Would\_you\_", "Culvert\_or", "Cell\_2\_Str", "Cell\_2\_Inl", "Cell\_2\_I\_1", "Cell\_2\_I\_2", "Cell\_2\_I\_3", "Cell\_2\_Out", "Cell\_2\_O\_1", "Cell\_2\_O\_2", "Cell\_2\_O\_3", "Culvert\_\_1", "Cell\_3\_Str", "Cell\_3\_Inl", "Cell\_3\_I\_1", "Cell\_3\_I\_2", "Cell\_3\_I\_3", "Cell\_3\_Out", "Cell\_3\_O\_1", "Cell\_3\_O\_2", "Cell\_3\_O\_3", "Culvert\_\_2", "Cell\_4\_Str", "Cell\_4\_Inl", "Cell\_4\_I\_1", "Cell\_4\_I\_2", "Cell\_4\_I\_3", "Cell\_4\_Out", "Cell\_4\_O\_1", "Cell\_4\_O\_2", "Cell\_4\_O\_3", "Perched\_Cu", "Are\_you\_on", "Please\_Fil", "Would\_you1", "Fish\_Speci", "Length\_of\_", "Enter\_addi", "Length\_of1", "Is\_there\_a", "Fish\_Passa", "Notes", "Is\_there\_1", "Known\_Site", "x\_1", "y\_1", "Additional", "Longitude", "Latitude") # nolint:  
  
labels\_FWS\_Kenai <- c("area", "category", "Title ", "Replacement Date", "Replacement Date Notes", "ADF&G Crossing Code", "KWF ID#", "Alt ID", "Landownership", "Funding ", "Category", "Latitude", "Longitude", "Last Eval", "Reported\_Upstream\_Fish\_Habitat\_miles", "Reported\_Upstream\_Lake\_Fish\_Habitat\_acres", "upstream habitat notes", "Salmon Species", "Issue", "Additional Notes")   
  
  
### 3. Prepare Master Dataset ###  
today <- format(Sys.Date(), "%m%d%Y") # MMDDYYYY format  
  
# Column Header Labels Defined Here, Items can be added, rearranged, or removed. # nolint:  
master\_column\_labels <- c(  
 "Latitude", "Longitude", "Priority\_Total", "Priority\_Ecological", "Priority\_Physical", "KPB Crossing Code", "ADF&G Crossing Code", "Fish\_Species\_Composition", # nolint:  
 "ADF&G rating", "Stream Name", "Road Name", "Structure Type", "Structure Dimensions", "Structure\_Slope", "Perch\_Height", # nolint:  
 "Outlet Scour Pool", "Constriction\_Ratio", "NHD+ Upstream Fish Habitat miles", "Reported\_Upstream\_Fish\_Habitat\_miles", # nolint:  
 "Reported\_Upstream\_Lake\_Fish\_Habitat\_acres", "Upstream\_OHWM\_feet", "Upstream\_Bankfull\_Width\_feet", "Road Material and Fill Height Over Top of Culvert", # nolint:  
 "Tidal Site", "Visible Deformation", "Landownership", "External Report Links", "Additional Notes" # nolint:  
)   
  
  
### 4. Relabel sub-data column names to prepare for combining ###  
# REMOVES any column that doesn't match the master column label list  
data\_aquatic\_barriers <- set\_names(data\_aquatic\_barriers, labels\_aquatic\_barriers) %>% select(any\_of(master\_column\_labels)) # nolint:  
data\_ADFG <- set\_names(data\_ADFG, labels\_ADFG) %>% select(any\_of(master\_column\_labels)) # nolint:  
data\_FWS\_FBH22 <- set\_names(data\_FWS\_FBH22, labels\_FWS\_FBH22) %>% select(any\_of(master\_column\_labels)) # nolint:  
data\_FWS\_FBH23 <- set\_names(data\_FWS\_FBH23, labels\_FWS\_FBH23) %>% select(any\_of(master\_column\_labels)) # nolint:  
data\_FWS\_Kenai <- set\_names(data\_FWS\_Kenai, labels\_FWS\_Kenai) %>% select(any\_of(master\_column\_labels)) # nolint:  
  
  
### 5. Correct errors in data set merging here to prep for bind\_rows() ###  
# Note here the only error so far is duplicated lines in this one dataset  
data\_FWS\_FBH23 <- data\_FWS\_FBH23[, !duplicated(as.list(data\_FWS\_FBH23))] # nolint:  
  
  
### 6. Combine data sets ###  
merged\_data\_set <- bind\_rows(data\_aquatic\_barriers, data\_ADFG, data\_FWS\_FBH22, data\_FWS\_FBH23, data\_FWS\_Kenai) # nolint:  
  
# 6.b Identify missing columns that didn't have any data linkages  
# Creates blank columns for missing items and rearranges the columns into the master\_column\_labels order # nolint:  
missing\_cols <- setdiff(master\_column\_labels, colnames(merged\_data\_set))  
  
  
### 7. Manipulate data as needed ###  
merged\_data\_set <- merged\_data\_set |>  
 mutate(Latitude = as.numeric(Latitude)) |>  
 mutate(Longitude = as.numeric(Longitude)) |>  
 mutate(Reported\_Upstream\_Fish\_Habitat\_miles = as.numeric(Reported\_Upstream\_Fish\_Habitat\_miles)) |> # nolint:  
 mutate(Upstream\_OHWM\_feet = as.numeric(Upstream\_OHWM\_feet)) |>  
 mutate(Upstream\_Bankfull\_Width\_feet = as.numeric(Upstream\_Bankfull\_Width\_feet)) |> # nolint:  
 mutate(Reported\_Upstream\_Lake\_Fish\_Habitat\_acres = as.numeric(Reported\_Upstream\_Lake\_Fish\_Habitat\_acres)) |> # nolint:  
 add\_column(!!!set\_names(map(missing\_cols, ~NA\_real\_), missing\_cols)) |> # Adds any columns that are missing from the master\_column\_labels # nolint:  
 select(all\_of(master\_column\_labels)) # Sorts the columns to be in the same order as master\_column\_labels # nolint:  
  
# Correct text entries in Perch Height  
merged\_data\_set <- merged\_data\_set |>  
 mutate(  
 Perch\_Height = case\_when(  
 Perch\_Height == ">1\_0'" ~ "1.5",  
 Perch\_Height == "<\_5'" ~ "0.5",  
 Perch\_Height == "0\_5'\_1\_0'" ~ "1",  
 TRUE ~ Perch\_Height # Keep other values as they are  
 )  
 ) |>  
 mutate(Perch\_Height = as.numeric(Perch\_Height))

## 1.2 Assign Priority Points based on Physical Attributes

We assigned ranking values on a scale of 1-10 for physical attributes associated with each site in the study area, which included:

* Perch height
* Crossing width to OHW (ordinary high water) ratio
* Constriction
* Crossing slope

### 8. Assign Priority Points based on Physical Attributes ###  
# 8.a Perch Height (ft)  
function\_perch\_height\_pts <- function(value) {  
 case\_when(  
 value == 0 ~ 0,  
 value <= 0.25 ~ 2.5,  
 value <= 0.75 ~ 5,  
 value <= 1 ~ 7.5,  
 value > 1 ~ 10,  
 TRUE ~ 0 # assigned to blank values  
 )  
}  
  
# 8.b Culvert Constriction  
function\_constriction\_pts <- function(value) {  
 case\_when(  
 value > 1 ~ 0,  
 value >= 0.8 ~ 2.5,  
 value >= 0.6 ~ 5,  
 value >= 0.4 ~ 7.5,  
 value < 0.4 ~ 10,  
 TRUE ~ 0 # assigned to blank values  
 )  
}  
  
# 8.c Crossing Slope (%)  
function\_crossing\_slope\_pts <- function(value) {  
 case\_when(  
 value < 0.5 ~ 0,  
 value <= 1.5 ~ 2,  
 value <= 2.5 ~ 3,  
 value <= 3.5 ~ 5,  
 value <= 4.0 ~ 7,  
 value > 4.0 ~ 10,  
 TRUE ~ 0 # assigned to blank values  
 )  
}

## 1.3 Assign Priority Points based on Ecological Attributes

We assigned ranking values on a scale of 1-10 for ecological attributes associated with each site in the study area, which included:

* Fish species composition
* Linear (stream) habitat quantity upstream
* Area (lake) habitat quantity upstream
  + *Note: the original analysis plan intended to use predicted (probable) upstream habitat quantity rather than solely known (documented) habitat quantity. The task was determined to beyond the scope of this project, but future analysis should incorporate this task. See the “Summary” chapter for details.*

### 9. Assign Priority Points based on Ecological Attributes ###  
# 9.a Presence of Anadromous Species vs. Resident (count)  
function\_anadromous\_pts <- function(value) {  
 species\_list <- str\_split(value, ",",simplify=FALSE)  
 species\_list <- unlist(species\_list)  
   
 anadromous\_species\_list <- c("CO", "COr", "COs", "COsr", "COp", "k", "Kr", "Ks", "Ksr", "Kp", "S", "Sr", "Ss", "Ssr", "Sp", "P", "Pr", "Ps", "Psr", "Pp", "CH", "CHr", "CHs", "CHsr", "CHp", "SH", "SHr", "SHs", "SHsr", "SHp") # nolint:  
 resident\_species\_list <- c("DV", "DVr", "DVs", "DVsr", "DVp", "W", "Wr", "Ws", "Wsr", "Wp") # nolint:  
   
 number\_anadromous <- sum(species\_list %in% anadromous\_species\_list)  
 number\_resident <- sum(species\_list %in% resident\_species\_list)  
   
 if (length(species\_list) == 0) {  
 return(0)  
 } else if (number\_anadromous == 0 && number\_resident == 0) {  
 return(0)  
 } else if (number\_anadromous == 0 && number\_resident > 0) {  
 return(5)  
 } else if (number\_anadromous == 1) {  
 return(8)  
 } else if (number\_anadromous > 1) {  
 return(10)  
 }  
}  
  
# 9.b Upstream Drainage Length (linear miles)  
function\_upstream\_length\_pts <- function(value) {  
 case\_when(  
 value < 0.1 ~ 0,  
 value <= 0.25 ~ 2,  
 value <= 0.5 ~ 4,  
 value <= 1.0 ~ 6,  
 value <= 1.5 ~ 8,  
 value > 1.5 ~ 10,  
 TRUE ~ 0 # assigned to blank values  
 )  
}  
  
# 9.c Upstream Drainage Area (acres)  
function\_upstream\_area\_pts <- function(value) {  
 case\_when(  
 value < 1 ~ 0,  
 value <= 5 ~ 2.5,  
 value <= 10 ~ 5,  
 value <= 15 ~ 7.5,  
 value > 15 ~ 10,  
 TRUE ~ 0 # assigned to blank values  
 )  
}  
  
  
### 10. Calculate points and update priority field ###  
# Physical Priority  
merged\_data\_set <- merged\_data\_set |>  
 rowwise() |>  
 mutate(Priority\_Physical = function\_perch\_height\_pts(Perch\_Height) + function\_constriction\_pts(Constriction\_Ratio) + function\_crossing\_slope\_pts(Structure\_Slope)) |> # nolint:  
 ungroup()  
  
# Ecological Priority  
merged\_data\_set <- merged\_data\_set |>  
 rowwise() |>  
 mutate(Priority\_Ecological = function\_anadromous\_pts(Fish\_Species\_Composition) + function\_upstream\_length\_pts(Reported\_Upstream\_Fish\_Habitat\_miles) + function\_upstream\_area\_pts(Reported\_Upstream\_Lake\_Fish\_Habitat\_acres)) |> # nolint:  
 ungroup()  
  
# Total Priority  
merged\_data\_set <- merged\_data\_set |> mutate(Priority\_Total = Priority\_Physical + Priority\_Ecological) # nolint:  
  
### 11. Write Data to Excel Sheet ###  
# Creates new .xlsx file for the master sheet in the current directory with the current date. # nolint:  
  
master\_data\_set\_file\_name <- paste0("other/output/","CombinedData\_", today, ".xlsx")  
wb <- createWorkbook()  
addWorksheet(wb, "Data")  
writeData(wb, 1, (merged\_data\_set), startRow = 1, startCol = 1)  
  
# Save Master Set to Excel File in current directory  
saveWorkbook(wb, file = master\_data\_set\_file\_name, overwrite = TRUE)

# 2. Results

## 2.1 Ranking by Site

We plotted each site by it’s physical and ecological scores on XY axes ([Figure 2.1](#fig-quadrant)). Each point represents an individual site. Click each point to see it’s location in Google Maps in a new web browser page.

Note that points in [Figure 2.1](#fig-quadrant) are jittered, meaning that they are deliberately spread out slighty in order to visualize values that would otherwise be superimposed atop each other.

# Export and prep  
  
# read in merged data set  
today <- format(Sys.Date(), "%m%d%Y") # MMDDYYYY format  
master\_data\_set\_file\_name <- paste0("other/output/","CombinedData\_", today, ".xlsx")  
merged\_data\_set <- read\_excel(master\_data\_set\_file\_name)  
  
# Prep master data sheet with coordinates hyperlinked to Google Maps  
merged\_data\_set <- merged\_data\_set |>  
 mutate(location\_hyperlink = paste0("https://www.google.com/maps/search/?api=1&query= ",Longitude,Latitude))  
  
  
# Create the plot  
#p <- ggplot(merged\_data\_set, aes(x = Priority\_Ecological, y = Priority\_Physical,  
# text = paste("Location:",Latitude,Longitude,"\n",  
# "Stream:",`Stream Name`,"\n",  
# "Google Maps", location\_hyperlink))) +  
# geom\_jitter(color = "blue", size = 2, width = .4, height = 0.4) +  
# labs(x = "Ecological Condition", y = "Physical Condition") +  
# theme\_minimal() +  
  
  
 # Add the priority zones (adjust colors and labels as needed)  
 #geom\_rect(xmin = 0, xmax = 10, ymin = 0, ymax = 5, fill = "pink", alpha = 0.3) +  
 #geom\_rect(xmin = 10, xmax = 20, ymin = 0, ymax = 5, fill = "#199e19", alpha = 0.2) +  
 #geom\_rect(xmin = 0, xmax = 10, ymin = 5, ymax = 10, fill = "lightblue", alpha = 0.2) +  
 #geom\_rect(xmin = 10, xmax = 20, ymin = 5, ymax = 10, fill = "yellow", alpha = 0.2) +   
   
 # Add priority labels  
# annotate("text", x = 5, y = 2.5, label = "4 = Lowest Priority", color = "black") +  
# annotate("text", x = 15, y = 2.5, label = "2 = High-Middle Priority", color = "black") +  
# annotate("text", x = 5, y = 7.5, label = "3 = Low-Middle Priority", color = "black") +  
# annotate("text", x = 15, y = 7.5, label = "1 = Highest Priority", color = "black") +  
  
 # Add axes labels  
# geom\_segment(aes(x = -.5, y = -.5, xend = 20, yend = -.5)) +  
# geom\_segment(aes(x = -.5, y = -.5, xend = -.5, yend = 12)) +  
# geom\_segment(aes(x = 10, y = -.5, xend = 10, yend = 12), linetype = 2) +  
# geom\_segment(aes(x = -.5, y = 6, xend = 20, yend = 6), linetype = 2)  
   
  
# make plotly  
#ggplotly(p)  
  
  
# cleate plotly object  
  
  
# prep plotly graph object  
# modified from River Focus draft by Benjamin Meyer 12/30/2024  
p <- plot\_ly(merged\_data\_set,   
 x = ~jitter(Priority\_Ecological),   
 y = ~jitter(Priority\_Physical)) %>%  
 layout(xaxis = list(zeroline = FALSE, title = "Ecological Priority"),   
 yaxis = list(zeroline = FALSE, title = "Physical Priority"),  
 # annotations  
 annotations = list(  
 list(x = 5, y = 2.5, text = "4 = Lowest Priority", color = "black", showarrow = FALSE),  
 list(x = 15, y = 2.5, text = "2 = High-Middle Priority", color = "black", showarrow = FALSE),  
 list(x = 5, y = 7.5, text = "3 = Low-Middle Priority", color = "black", showarrow = FALSE),  
 list(x = 15, y = 7.5, text = "1 = Highest Priority", color = "black", showarrow = FALSE)),  
 showlegend = FALSE) %>%  
 # interactive points  
 add\_markers(  
 text = paste("Location:",merged\_data\_set$Latitude,merged\_data\_set$Longitude,"\n",  
 "Stream:",merged\_data\_set$`Stream Name`,"\n",  
 "Click to Open Map in Web Browser"),  
 customdata = paste0("https://www.google.com/maps/search/?api=1&query= ",  
 merged\_data\_set$Latitude, ", ", merged\_data\_set$Longitude)) %>%  
 # line segments  
 add\_segments(x = -.5, y = -.5, xend = 20, yend = -.5, line = list(color = "black", width = 2)) %>%  
 add\_segments(x = -.5, y = -.5, xend = -.5, yend = 12, line = list(color = "black", width = 2)) %>%  
 add\_segments(x = 10, y = -.5, xend = 10, yend = 12, line = list(color = "black", width = 1, dash = "dash")) %>%  
 add\_segments(x = -.5, y = 6, xend = 20, yend = 6, line = list(color = "black", width = 1, dash = "dash"))  
  
  
# render plotly object with points hyperlinked   
onRender(  
 p, "  
 function(el) {  
 el.on('plotly\_click', function(d) {  
 var url = d.points[0].customdata;  
 window.open(url);  
 });  
 }  
")

|  |
| --- |
| Figure 2.1: Test |

## 2.2 Online Project Map

The project map may be accessed by following the link at [ArcGIS Online](https://kwf.maps.arcgis.com/apps/mapviewer/index.html?webmap=c61b78fa1cd24726ab90b40308f932d6)[[1]](#footnote-37) or in the interactive figure below. Toggle layers on/off as needed by clicking the “Layers” icon on the left hand side of the map.

# 3. Discussion

## 3.1 Future Steps

Our results constitute a proof of concept method that can annually integrate multiple, distinct data inventories of fish passage structures (e.g. culverts) and freshwater habitat data within the Kenai Peninsula Borough, then apply that data to calculate a relative prioritization score.

The regional prioritization scores provide a useful and important perspective to help managers decide how and when restoration funds should be directed. However, before considering this exercise to be complete, several additional needs must be resolved, which are described below (as of 2024-12-31):

1. **Address missing culvert physical descriptor data:** In the final combined data set, most fish passage structures inventoried do not have any associated physical data (~350 out of 412 sites). See [Table 3.1](#tbl-phys), which displays unique row counts for all locations in the final data set. The “row\_count” column indicates the number of instances with unique combinations of perch height, constriction ratio, and slope.
   * It is likely that the low number of sites with documented culvert structure conditions in the final data set is an artifact of the code synthesizing these data sets, rather than a lack of field data. Some data column may have been dropped when descriptors or methods appear incompatible among agencies. A solution can likely be achieved by revising how the structured of Alaska Dept of Fish and Game and US Fish and Wildlife Service data sets overlap.
   * As a result, most of the results described in this report do not currently incorporate physical descriptors data, as it is largely not present in the final combined dataset.

# read in merged data set  
today <- format(Sys.Date(), "%m%d%Y") # MMDDYYYY format  
master\_data\_set\_file\_name <- paste0("other/output/","CombinedData\_", today, ".xlsx")  
merged\_data\_set <- read\_excel(master\_data\_set\_file\_name)  
  
tbl <- merged\_data\_set |>  
 group\_by(Perch\_Height,Constriction\_Ratio,Structure\_Slope) |>  
 count() |>  
 rename(row\_count = n)  
  
tbl1 <- tbl |>  
 arrange(desc(row\_count))  
  
# publish table  
datatable(tbl1, options = list(pageLength = 5))

|  |
| --- |
| Table 3.1  Unique row count for culvert physical conditions data; combined Kenai Peninsula Borough fish passage datasets. (Version 1.0, 12/23/2024)  Unique row count for culvert physical conditions data; combined Kenai Peninsula Borough fish passage datasets. (Version 1.0, 12/23/2024) |

1. **Incorporate probable upstream anadromous habitat into analyses**: The current final combined dataset includes reported (e.g documented in the ADF&G Anadromous Waters Catalog, or AWC) stream miles above each fish passage structure. As a result the current analysis is incomplete in two ways:
   * The ADF&G AWC is estimated to include at most ~50% of all actual anadromous water bodies state-wide[[2]](#footnote-44). Water bodies are presumed to be *not* anadromous unless otherwise documented. Documenting and modeling anadromous waters is a topic of active research in Alaska and the Pacific Northwest[[3]](#footnote-46),[[4]](#footnote-48).
   * The initial work plan for this analysis included use of probable upstream anadromous habitat. Kenai Watershed Forum and [St. Mary’s University of Minnesota Geospatial Services](https://www.geospatialservices.org/) generated a draft modified shape file of the National Hydrography Database, which estimated the total extent of probable anadromous habitat based on the locations of potential barriers to upstream migration of adult salmon. However, during this project it was discovered that this shape file required multiple additional QA/QC steps, and addressing them was beyond the scope of current efforts.
2. **Document all locations in the Kenai Peninsula Borough where streams intersect with with transportation and utility corridor infrastructure**
   * Each site where streams intersect with linear infrastructure (roads, trails, and utilities) represents a potential freshwater habitat obstruction or point of degradation.
   * We recommend performing a desktop GIS exercise, intersecting all borough transportation and utility corridor shape files (roads, trails, rail, electrical) with the National Hydrography Databse. We will create a shape file of point locations from these intersections. (Results from this exercise may already be available from the Palmer Soil and Water Conservation District office). Where field assessment data does not exist for these sites, it will be necessary to conduct additional site assessments using a field protocol.
   * Once available, these data can be integrated into the analyses presented here.

## 3.2 National Efforts

The Aquatic Barrier Inventory and Prioritzation Tool ([www.aquaticbarriers.org](https://aquaticbarriers.org/)) is a national effort to provide a detailed tool that can help managers make informed and systematic decisions about regional fish passage prioritization. For the Kenai Peninsula Borough, this tool [currently lists 239 sites](https://aquaticbarriers.org/explore/?region=alaska), primarily those cross-listed in the Alaska Department of Fish and Game fish passage inventory (219 sites). Other agency data sources, such as the US Fish and Wildlife Service Fish Barrier Hunter App database, are not currently incorporated.

While some aspects of fish passage data management and results may be distinct for Alaska vs. the rest of the United States, the benefits of incorporating Alaska fish passage data into the aquaticbarriers.org database is readily apparent. Having a consistent, regularly updated, and centralized source of information will be of great benefit in addition to the various regional prioritization efforts.

We recommend that Alaska agencies and organizations engaged in collecting fish passage site assessment field data annually share their results with the Alaska Department of Fish and Game division of Habitat so that results can be integrated into the existing public database and displayed in the [Alaska Fish Resource Monitor online map](https://www.adfg.alaska.gov/index.cfm?adfg=fishpassage.database). Additionally, we recommend that the Alaska Department of Fish and Game formalize the process by which partner agencies and citizens can submit fish passage observations, which is currently by emailing information to a department habitat biologist.

Annually, after fish passage data is integrated from multiple sources throughout the state, we recommend the Alaska Department of Fish and Game share it’s updated database to be integrated into the national Aquatic Barrier Inventory and Prioritzation Tool.

1. <https://kwf.maps.arcgis.com/apps/mapviewer/index.html?webmap=c61b78fa1cd24726ab90b40308f932d6> [↑](#footnote-ref-37)
2. <https://www.adfg.alaska.gov/sf/SARR/AWC/> [↑](#footnote-ref-44)
3. <https://app.paperpile.com/view/plain/?id=ba5fcffa-9dec-4171-8b81-68831d4e99f9> [↑](#footnote-ref-46)
4. <https://www.kenaiwatershed.org/about-kwf/news-media/> [↑](#footnote-ref-48)