

# Fish studies of the Eagle River downstream of the Eagle Mine.

Results of restoration activities from  
1990 to present.

Part 2. 2005-2010.

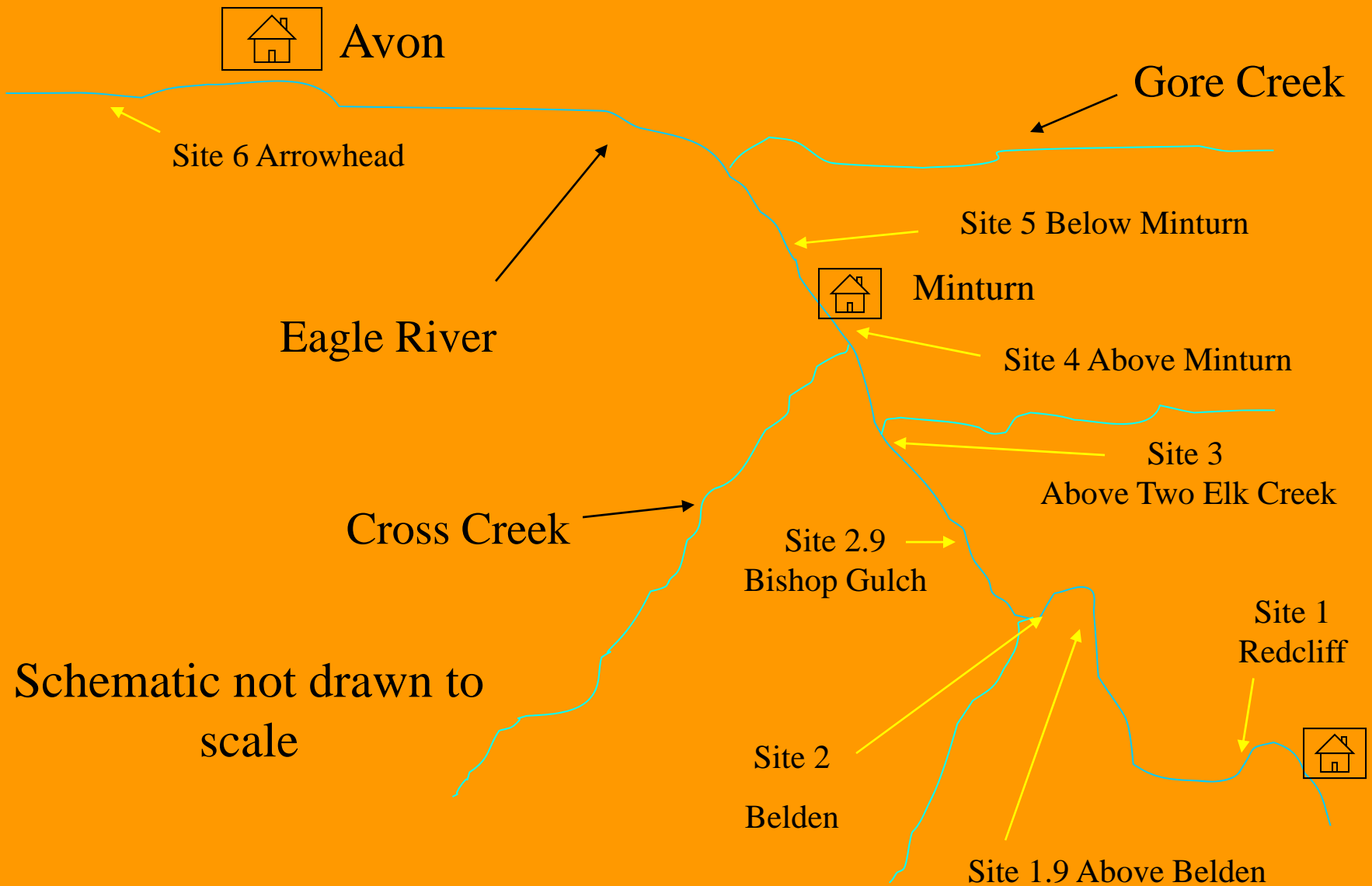
Presented by ERWC Eagle Mine Limited.

## Eagle River sampling since 2005

- **Sampling effort reduced since 2005**

- Fish sampling efforts from 2005-2010 funded and performed by Colorado Division of Wildlife and volunteers including those from the Eagle River Watershed Council (ERWC).
- CBS allows access and provides some on-site physical assistance. Colorado HAZMAT assists with water quality data acquisition and analysis.
- Severe winter conditions in 2008 and 2009 precluded fish sampling at some sites.
- Water quality data available for only three sites for 2008, 2009 and 2010.

# Schematic map Eagle River sampling sites



Avon

Gore Creek

Site 6 Arrowhead

Site 5 Below Minturn

Eagle River



Minturn

Site 4 Above Minturn

Site 3

Above Two Elk Creek

Cross Creek

Site 2.9  
Bishop Gulch

Site 1  
Redcliff

Schematic not drawn to  
scale

Site 2  
Belden



Site 1.9 Above Belden

## Eagle River fish sampling since 2005

Site	2005	2006	2007	2008	2009	2010
1	X		X		X	X
1.9	X		X			X
2	X		X			X
2.9	X		X		X	X
3	X		X		X	X
4	X		X	X	X	X
5	X		X	X	*	*
6	X		X	X	X	X

X = site sampled. \* = Site 5 physical habitat altered as part of “habitat improvement project.” Consequently Site 5 results in 2009 and 2010 not comparable to previous years. (Eagle River Study Area = yellow site numbers, black = reference sites).

## Eagle River sampling since 2005

- Lack of a complete sampling data set (fish and water chemistry) limit the way data could be examined.
- Historically data examined three ways,
  - Data from sampling sites within the Eagle River Study Area (Sites 2, 3, 4, 5) were compared to data from the reference sampling sites (1, 1.9 and 6).
    - Site 1 and 1.9 are upstream of the Eagle River Study Area.
    - Site 6 is downstream of the Eagle Mine Study Area.
  - Trends through time within each site were examined.
  - Water quality was compared to stream standards.

## Eagle River fish sampling since 2005

- The current analysis addressed changes in the fish assemblage within each site from 2005 through 2010. The analysis includes,
  - - 1. A brief examination of limited water quality data.
    - 2. A within site examination of brown trout population estimates.
    - 3. Presentation of brown trout length frequency analysis and numbers of one year old fish to assess reproduction success.
    - 4. Comparison of relative weight to assess health of brown trout within sites as well as between reference locations and Eagle River Study Area Locations.
    - 5. A Brief examination of data concerning other fish species.



## Water quality standards since 2005

- The Colorado Water Quality Control Commission adopted new zinc, copper and cadmium standards in the Eagle River through the Eagle River Study Area in 2008.
- These new standards are less restrictive than the “Table Value Standards” the Commission assigns to most Colorado waters.
- However, the new standards are more restrictive than those in place prior to 2008.
- The standards adopted by the Commission were set at levels agreed to by CBS and HAZMAT through negotiation.
- Zinc concentrations are greater in the Eagle River than any other metal of concern both before and after restoration projects.



## Water quality standards since 2005

- The following discussion emphasizes zinc. An assumption was made that if zinc levels decrease to the point fish in the Eagle River are not harmed other metals such as copper will likewise be reduced to nontoxic concentrations.
- Standards have been adopted for other metals such as copper and cadmium to guide future restoration and attainment issues.
- Restoration actions by 1997 reduced cadmium concentrations to nontoxic levels.
- Zinc however is the primary metal of concern at this time in the Eagle River, although copper may remain an issue, especially in combination with zinc.

## Water quality standards in Colorado

- Metal standards in Colorado are based on hardness.
- The toxicity of a given metal concentration decreases as hardness increases.
- Calcium and magnesium mitigate metal toxicity.
- So as hardness increases the allowable level of a metal increases as defined by a stream standard.

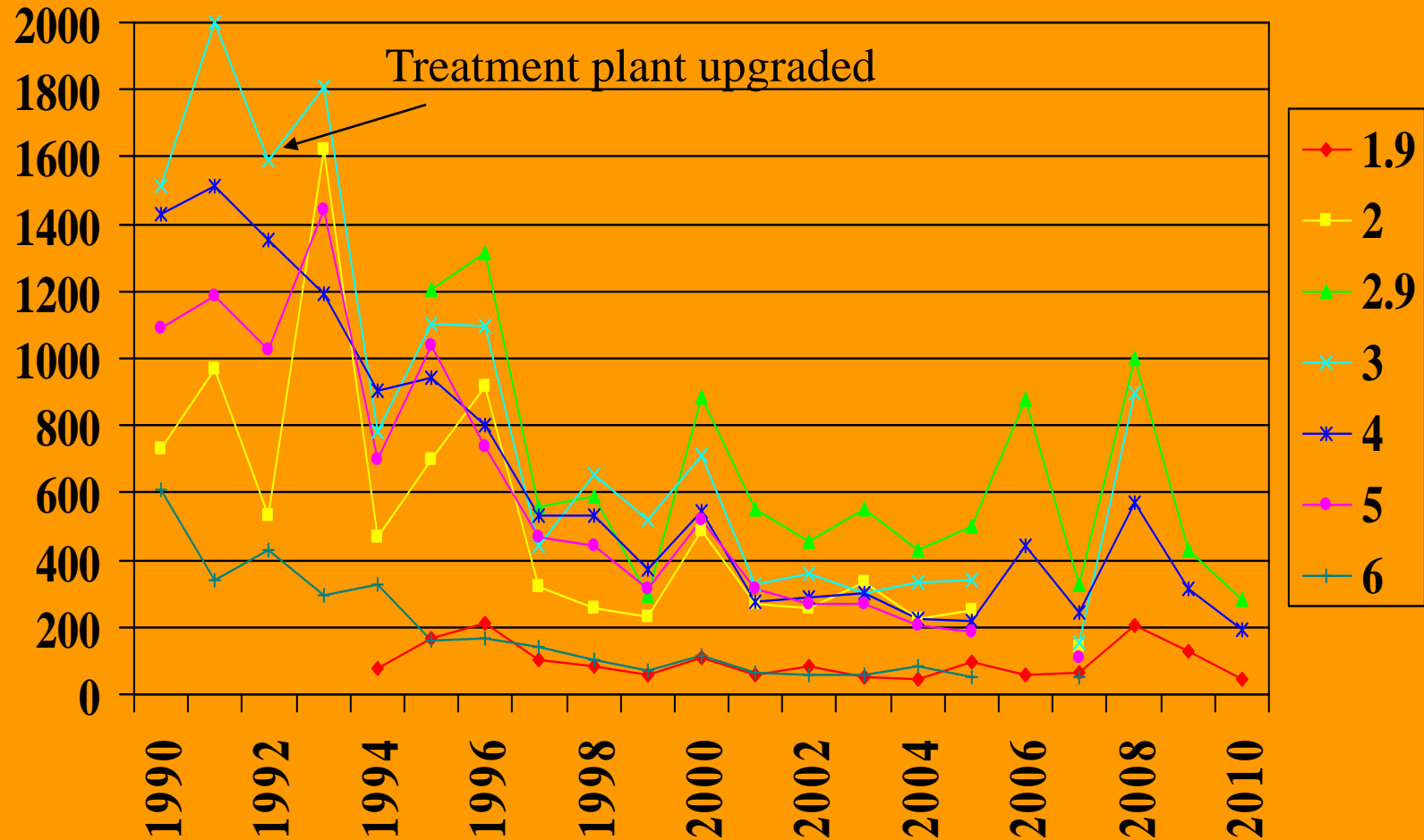
## Water data used in this analysis

- Water quality sampling was an integral component of the fish sampling program in the Eagle River from 1990 to 2007.
- Colorado Division of Wildlife (DOW) collected water samples once a year when fish populations sampled from 1990 - 2007.
- DOW data are not available for 2008 – 2010.
- CBS water quality data are used instead.
- CBS collects water samples at only three locations where fish samples collected. One of the CBS sites is 0.7 miles downstream of Site 2.9 Bishop Gulch. CBS samples other locations for other regulatory reasons.
- So metals data are not available for remaining fish sampling sites for 2008 – 2010.

## Metals data Eagle River synopsis since 1990

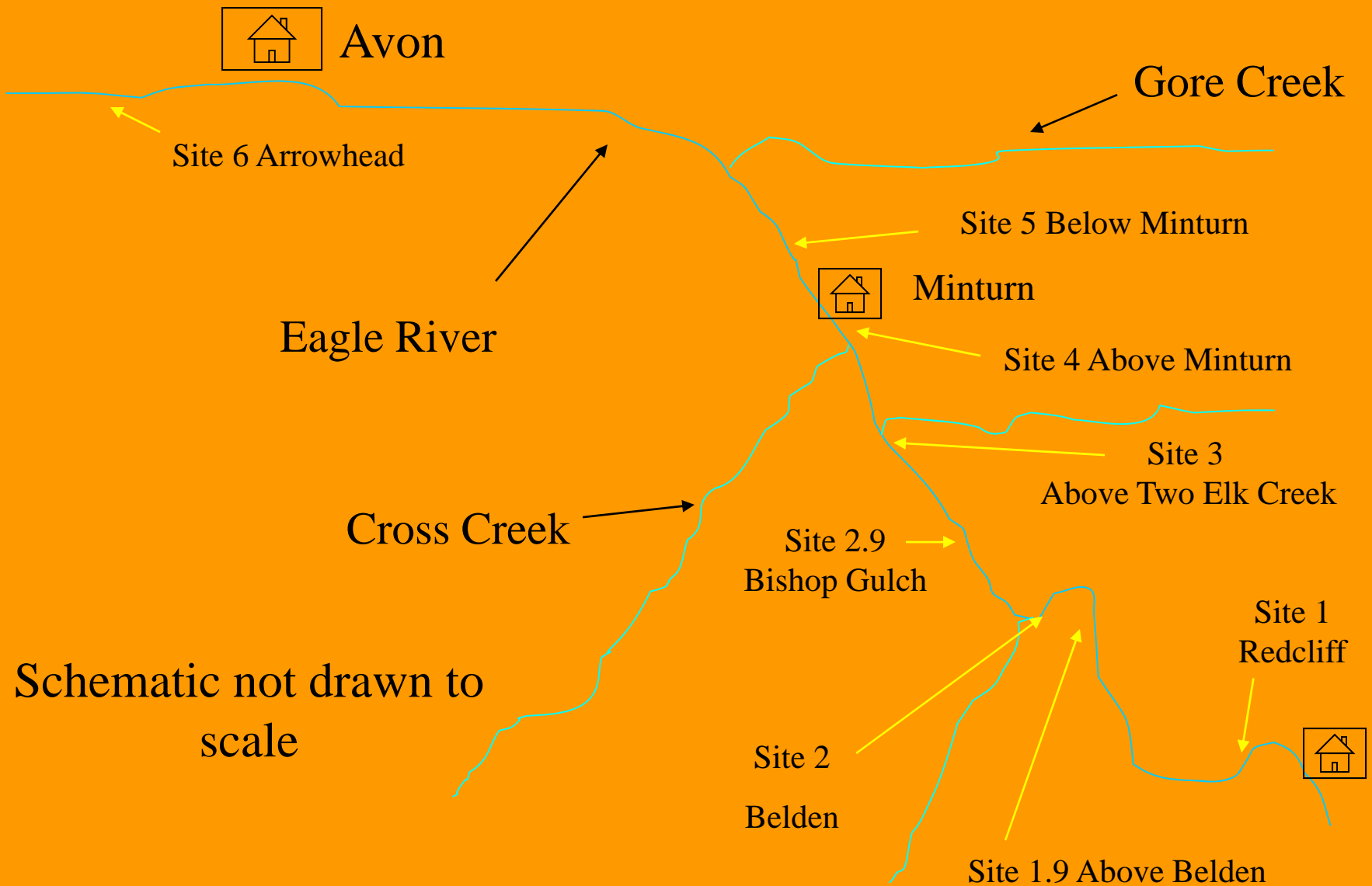
- Metals concentrations have decreased since 1990 due to restoration projects at the Eagle Mine Site (next slide).
- Rapid decreases in metals such as zinc occurred from 1990 through 1996.
- Metals were relatively stable from 2001 to 2005.
- Metals increased in 2006 and 2008, high snow fall years.
- Dissolved zinc concentrations at reference site 1 were mostly less than detection limits and never toxic to brown trout.

# Dissolved zinc (ug/L) Eagle River sampling sites 1990-2010.



Sites 1.9 and 6 are reference sites, above and below Eagle River Study Area, respectively, where zinc was lowest. Zinc concentrations were often highest at Site 2.9 (Bishop Gulch).

# Schematic map Eagle River sampling sites

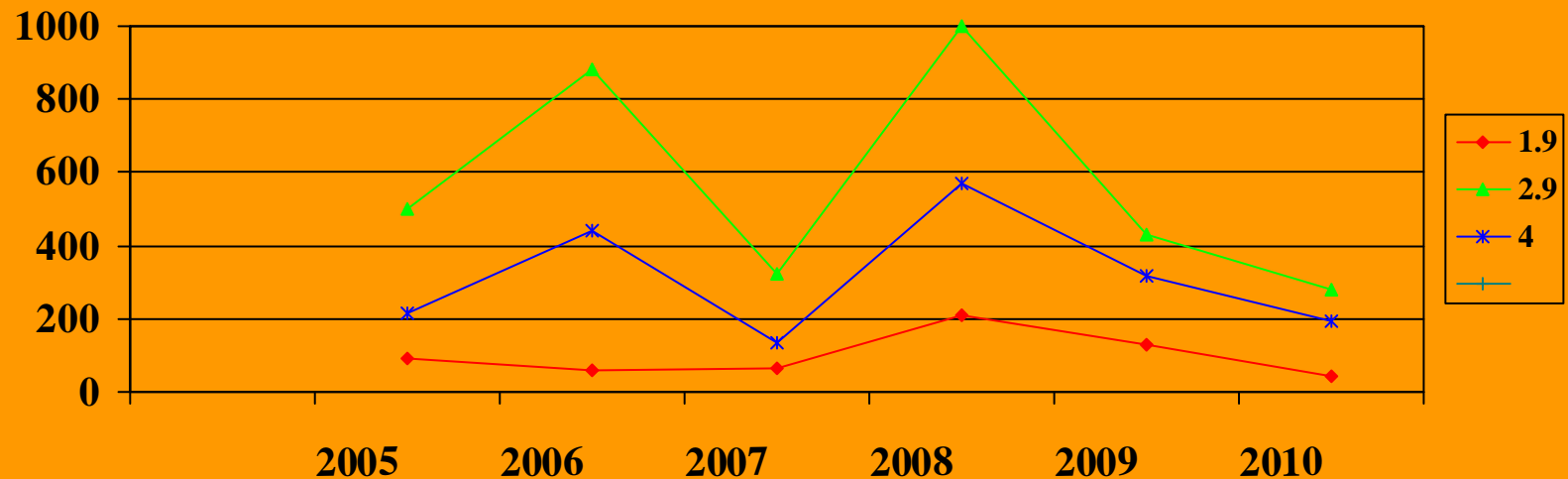


## Metals data Eagle River since 2005

### What we know about zinc and brown trout

- Negative impacts to fish could result if metal concentrations increase compared to concentrations found prior to 2000.
- Dissolved zinc concentrations greater than 225 ug/L may harm brown trout according to an informal analysis performed by the Colorado Division of Wildlife many years ago.
- Dissolved zinc concentrations greater than 380 ug/L have caused mortality to brown trout in laboratory tests at hardness concentrations somewhat less than those found in the Eagle River.

## Dissolved zinc (ug/L) Eagle River sampling sites 2005-2010.



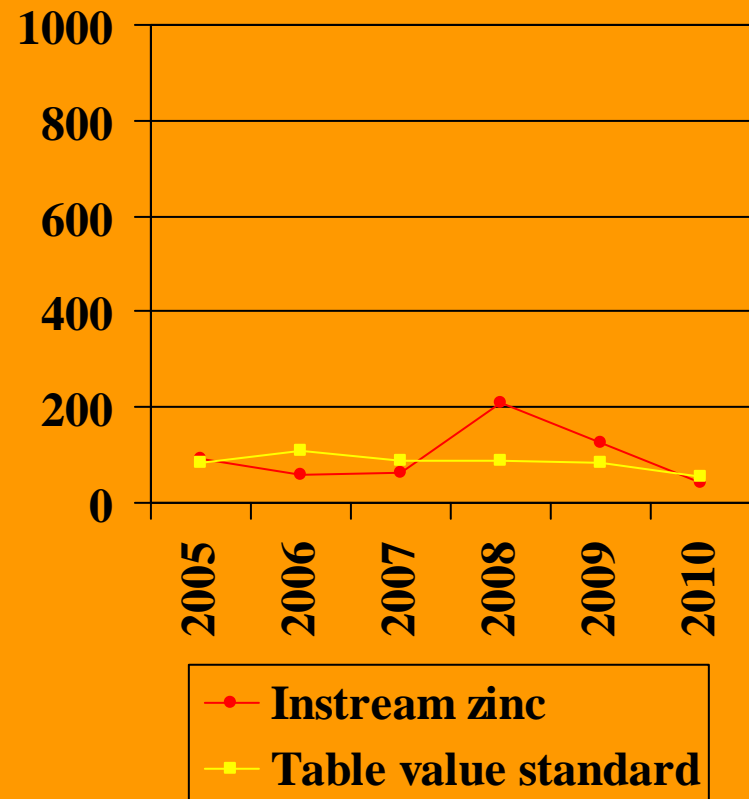
Sites 1.9 is a reference site located just upstream of Belden. Dissolved zinc increased at Site 1.9 in 2008 possible due to high snow pack levels mobilizing contaminants.

Site 1.9 results demonstrate Eagle River is contaminated by metals upstream of Eagle Mine Site which is not part of restoration program



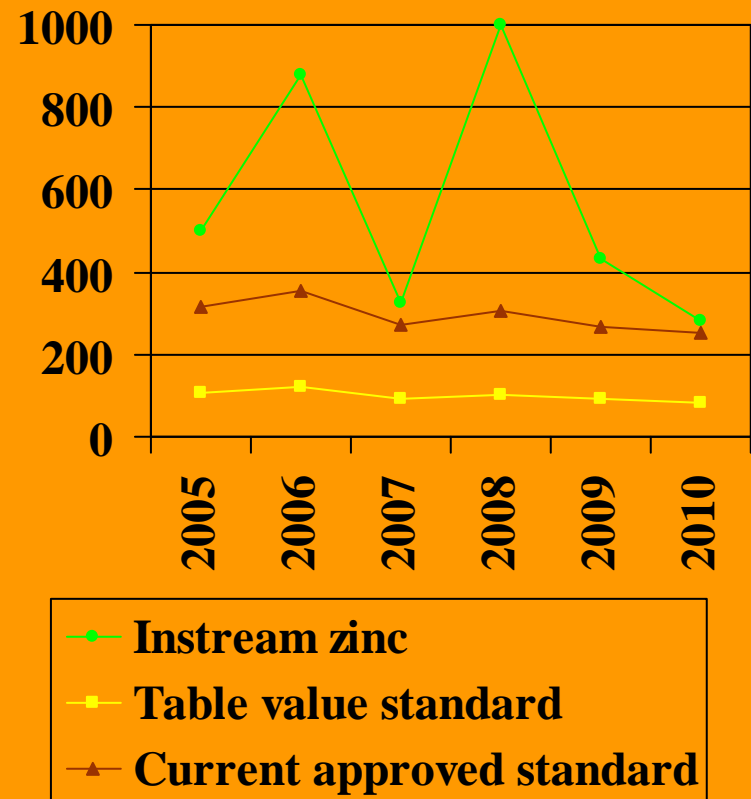
## Dissolved zinc (ug/L) Eagle River reference site 1.9, 2005-2010.

- Note that zinc concentrations at Site 1.9 upstream of the Eagle Mine Site do not meet Table Value stream standards in some years.
- The Eagle River cannot meet table value standards within the mine site if water flowing into the mine site already exceeds those standards.
- Sculpin require zinc concentrations even lower than Table Value levels.
- Stream standards for metals vary as a function of hardness levels in water. Metal toxicity decreases as hardness increases. Metal standards thus increase as hardness increases.



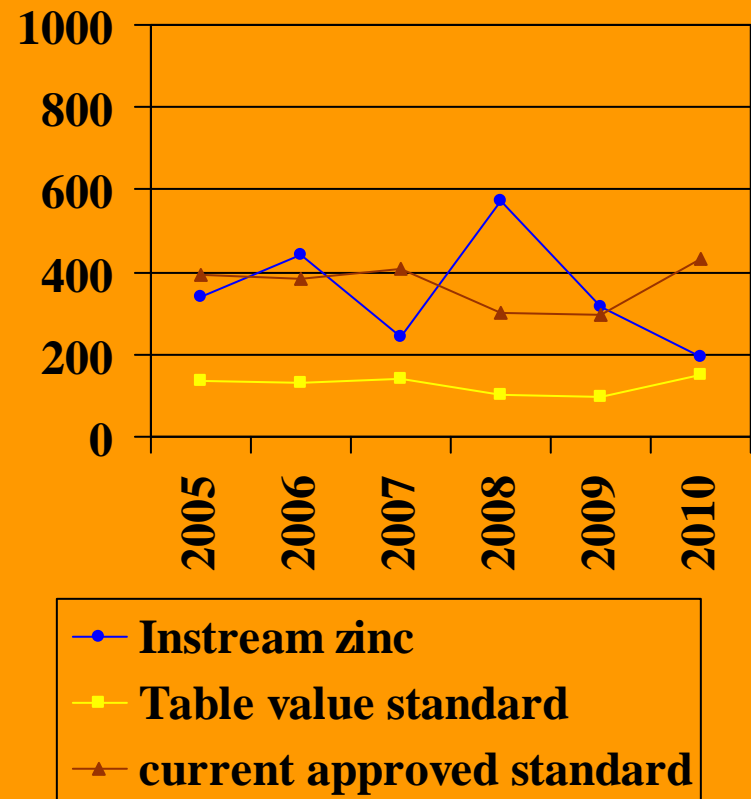
## Dissolved zinc (ug/L) Eagle River Mine Site 2.9 (Bishop Gulch), 2005-2010.

- Instream zinc concentrations do not meet either the table value standards or the more relaxed standards approved by the Colorado Water Quality Control Division in 2008.
- Brown trout would not be impacted by zinc levels between the table value standards and the currently approved zinc standards (about 225 ug/L).
- Sculpin require zinc concentrations even lower than Table Value levels.



## Dissolved zinc (ug/L) Eagle River Mine Site 4, (south edge of Minturn) 2005-2010.

- Instream zinc concentrations do not meet Table Value Standards but are close to the relaxed standards approved by the Colorado Water Quality Control Division in 2008.
- Brown trout would not be impacted by zinc levels between the table value standards and the currently approved zinc standards (about 225 ug/L).
- Sculpin require zinc levels lower than Table Value levels.



## Summary water quality data Eagle River since 2005

- Metal concentrations have not decreased since major restoration projects completed in 1996.
- Metal concentrations (as illustrated by zinc) were rather stable from 2001 – 2005.
- Metal concentrations increased in 2006 and more so in 2008.
- Current zinc levels in the Eagle River through the Eagle River Study Area site will not support reproducing populations of sculpin.
- Current zinc levels in the Eagle River through the Eagle River Study Area do support brown trout although sublethal chronic toxicity or reduced numbers of fish remain possibilities.



# Eagle River reference site brown trout population estimates 2005-2010

Analysis of reference site fish data is used to determine if any change in fish numbers is due to variation in the natural environment rather than the Eagle River Study Area.

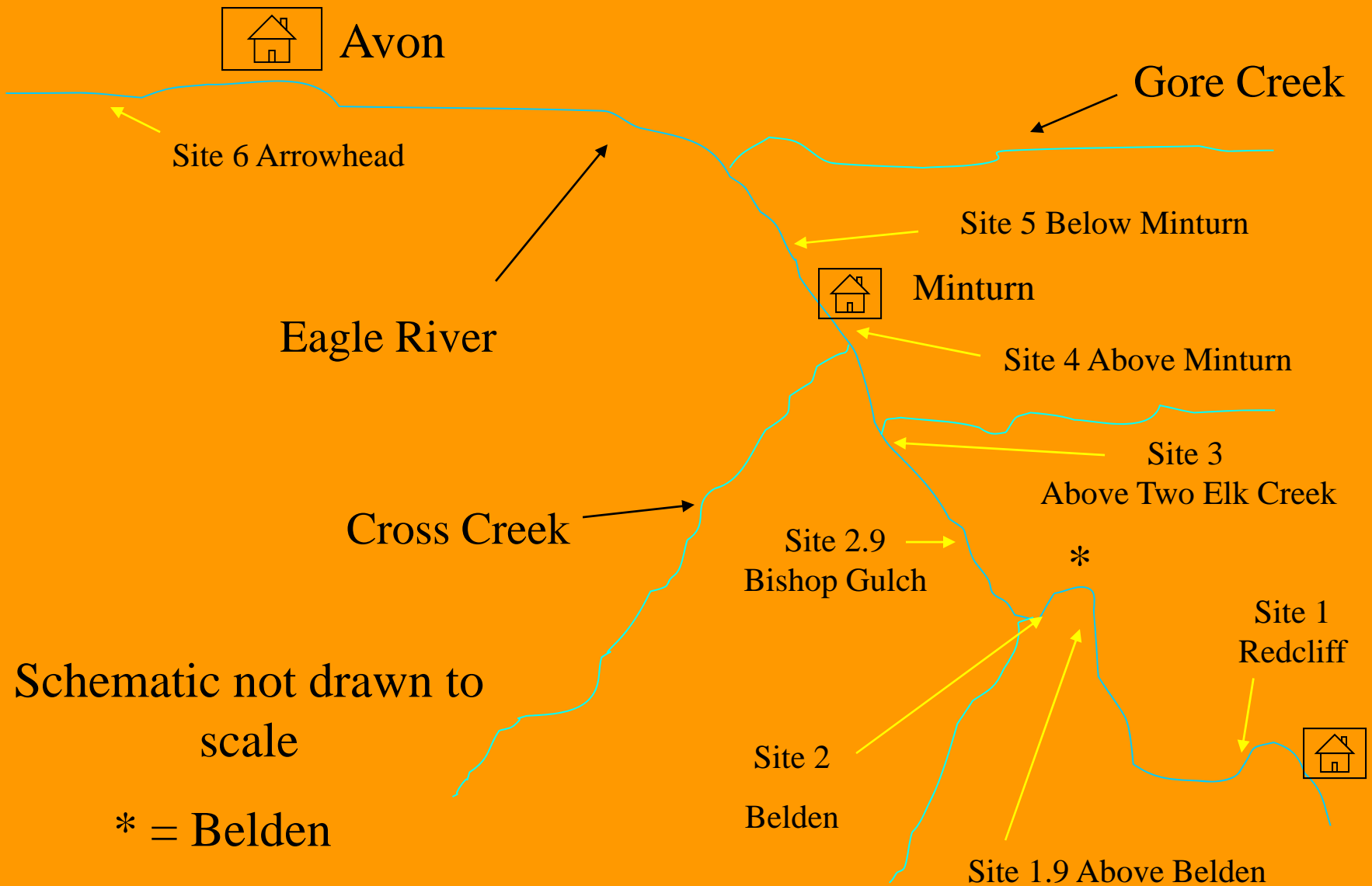
Site 1 (The Eagle River at Redcliff) sampled in 2007, 2009 and 2010.

Site 1.9 (The Eagle River upstream of Belden) sampled in 2007 and 2010.

Site 6 (the Eagle River at Avon) was the only reference site sampled each year from 2007 through 2010.

Site 1 and 1.9 are upstream of the Eagle River Study Area while Site 6 is downstream of the Eagle River Study Area.

# Schematic map Eagle River sampling sites



Avon

Gore Creek

Site 6 Arrowhead

Site 5 Below Minturn

Eagle River



Minturn

Site 4 Above Minturn

Site 3

Above Two Elk Creek

Cross Creek

Site 2.9  
Bishop Gulch

\*

Site 1  
Redcliff



Site 2  
Belden

Site 1.9 Above Belden

Schematic not drawn to  
scale

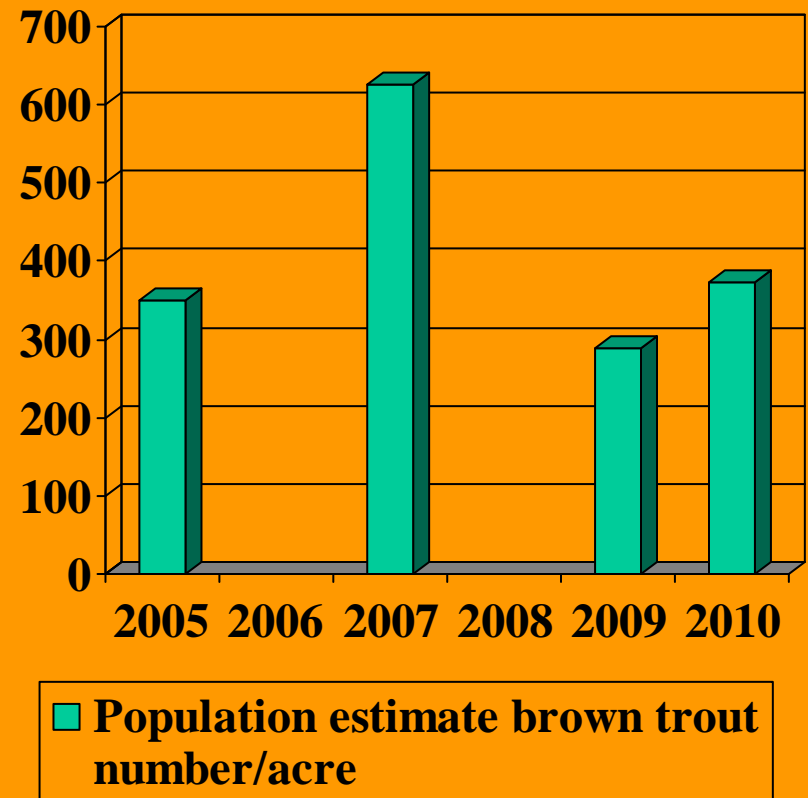
\* = Belden

## Eagle River brown trout since 2007 downstream of Redcliff , reference Site 1.

The 2007 population estimate exceeded the value for all other years. Cause of the increase not known.

Population estimates in 2009 and 2010 similar to all previous years (See part 1 of this report series).

Environmental stressors did not reduce brown trout population estimates at reference Site 1 from 2005 – 2010.



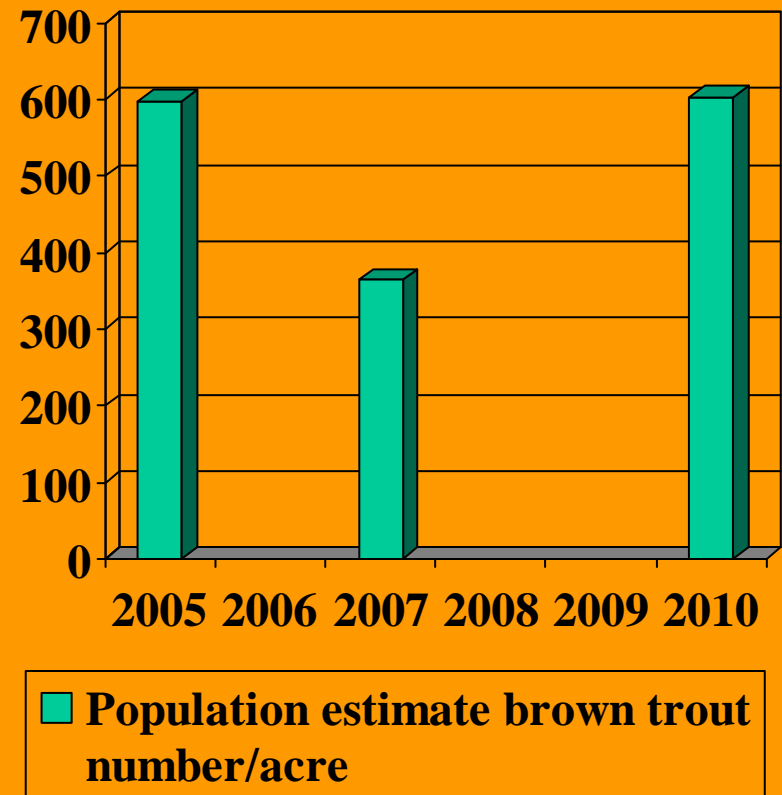


# Eagle River brown trout since 2007 upstream of Belden, reference site 1.9.

2007 population estimate  
decreased compared to  
2005.

The 2010 population estimate  
was the third highest  
during entire sampling  
period.

Population estimates from  
2005 to 2010 were within  
the range of estimates at  
this location since 1994.



# Eagle River brown trout Reference site 6 (Avon) since 2005

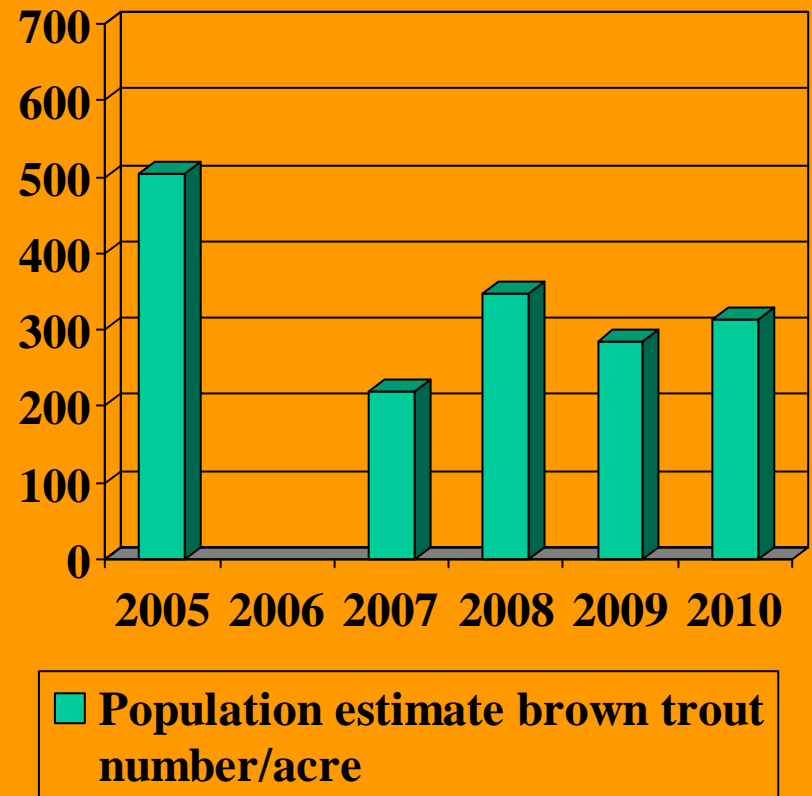
2007 population estimate decreased compared to 2005.

2009 population estimate decreased compared to 2008 and 2010.

Site 6 population estimates from 2007 through 2010 were the lowest since 1997 at Site 6.

Population estimate decreases were not observed at other reference locations from 2005 to 2010.

An environmental stressor (not the Eagle Mine Site) reduced brown trout numbers at Site 6 from 2007 – 2010.



## Eagle River reference site brown trout population estimates summary since 2005

- Fish data collected at reference sites indicate that brown trout population estimates decreased in 2007 at two of three Eagle River reference sites Site 1.9 just upstream of the Eagle River Study Area and Site 6 the Eagle River at Avon.
- No reduction was observed at the most upstream reference site (site 1, the Eagle River at Redliff) in 2007.
- Brown trout numbers decreased at reference site 6, the Eagle River at Avon for the entire period of 2007 through 2010. This reduction in numbers does not appear to be associated with discharges from the Eagle Mine Site.

# Eagle River Study Area brown trout population estimates since 2005

Analysis of fish data was conducted to determine if any change in population estimates that occurred were attributable to variation in conditions within the Eagle River Study Area.

Site 2 (Belden) was sampled in 2007 and 2010.

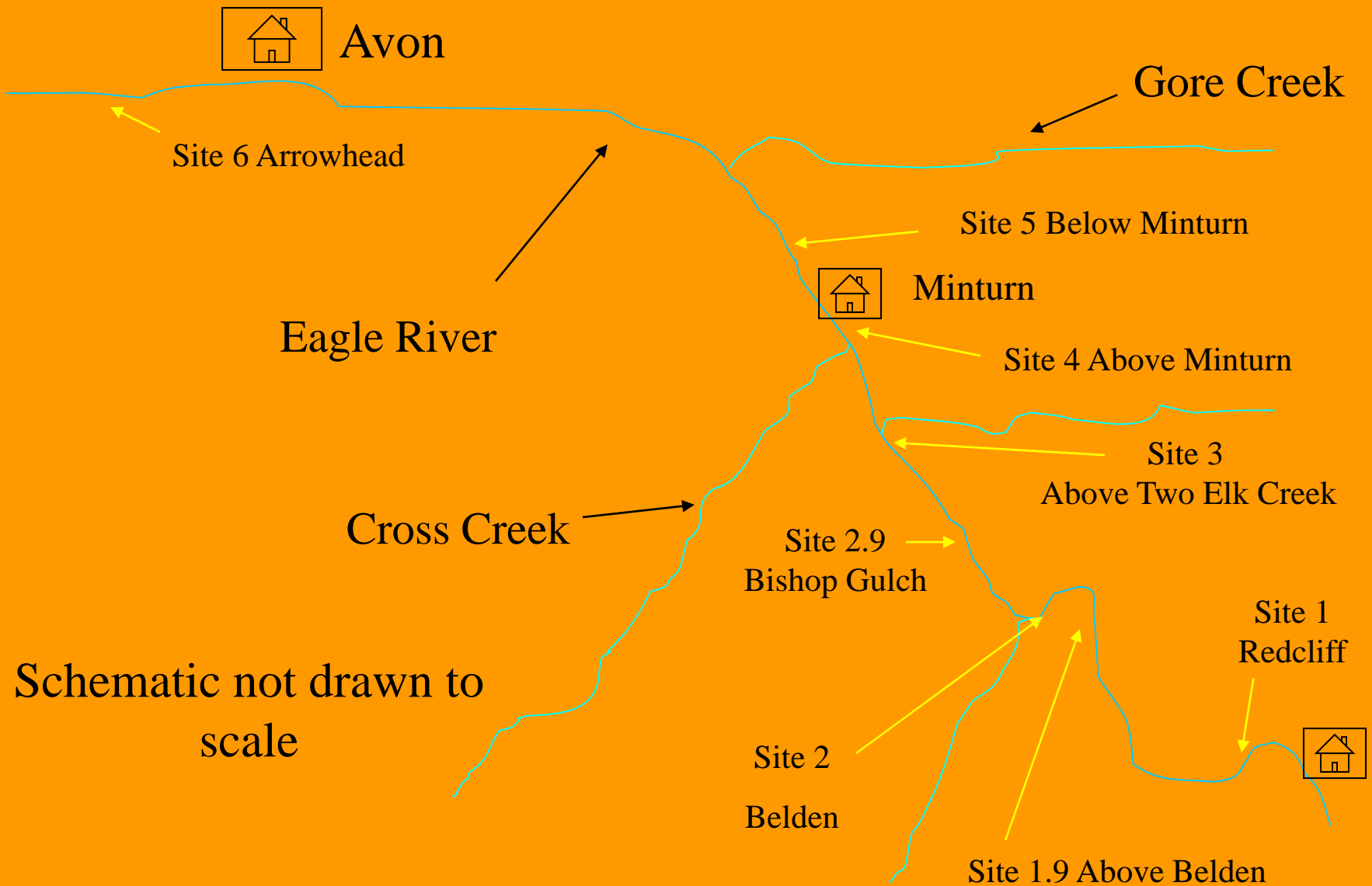
Site 2.9 (Bishop Gulch) was sampled only in 2007, 2009 and 2010.

Site 3 (the Eagle River below the CBS effluent) was sampled in 2007, 2009 and 2010.

Site 4 (southern edge of Minturn) was sampled in 2007, 2008, 2009 and 2010.

Site 5 (north of Minturn) not included because the stream habitat altered by human activity in 2008.

# Schematic map Eagle River sampling sites



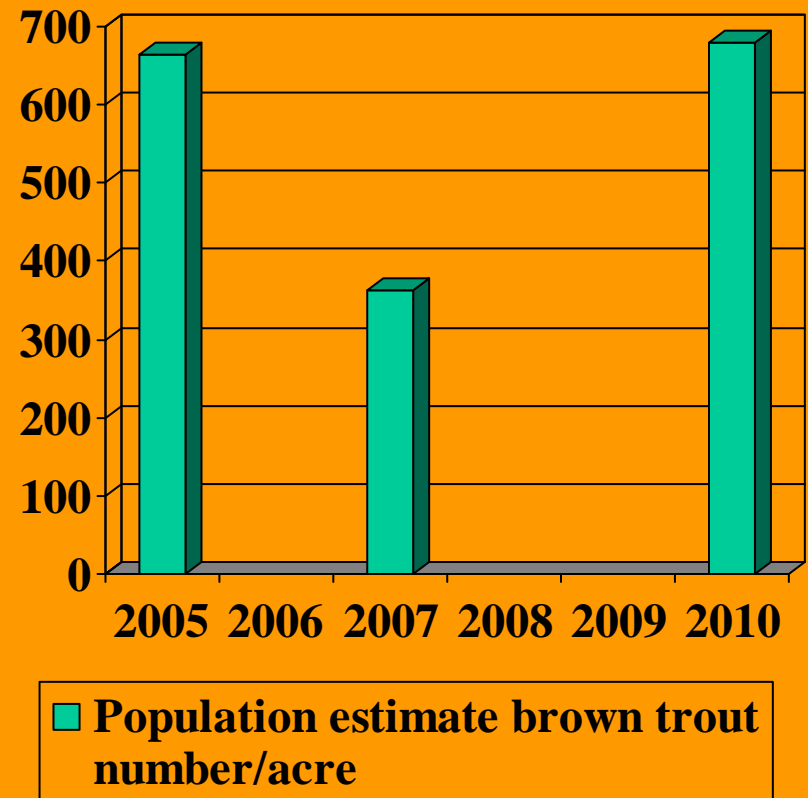
## Eagle River brown trout since 2005, Eagle River Study Area site 2 (Belden)

2007 population estimate decreased compared to 2005. The 2007 population estimate was the lowest since 1998.

The population estimates at Site 2 were higher than at any other Eagle River site including reference locations in 7 of 8 years from 1998 through 2005.

Cause of the 2007 decrease cannot be determined although instream metal concentrations increased in 2006.

Brown trout numbers in Belden increased dramatically due to the restoration program.

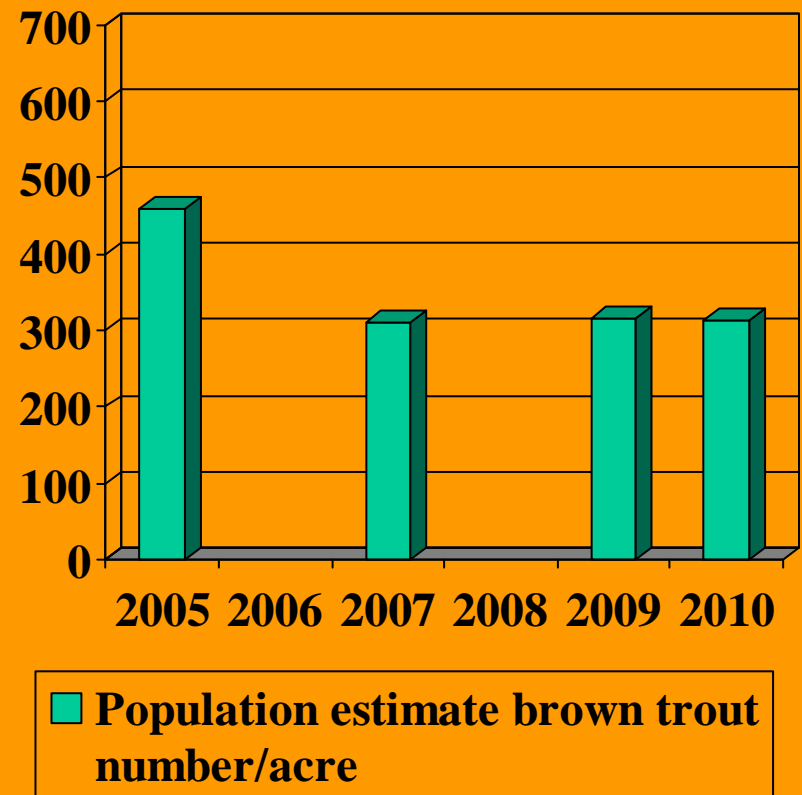


## Eagle River brown trout since 2005, Eagle River Study Area, site 2.9 (Bishop Gulch)

The 2007 population estimate at Site 2.9 decreased compared to 2005.

Site 2.9 population estimates for 2007-2010 did not vary in relation to entire period of record (1995-2010, median = 225).

Site 2.9 population estimates were lower than all other Eagle River Study Area sites including reference locations in 4 of 8 years (1998-2005) while zinc concentrations exceeded measurements at all other Eagle River sampling sites in the same time period (slide 11).

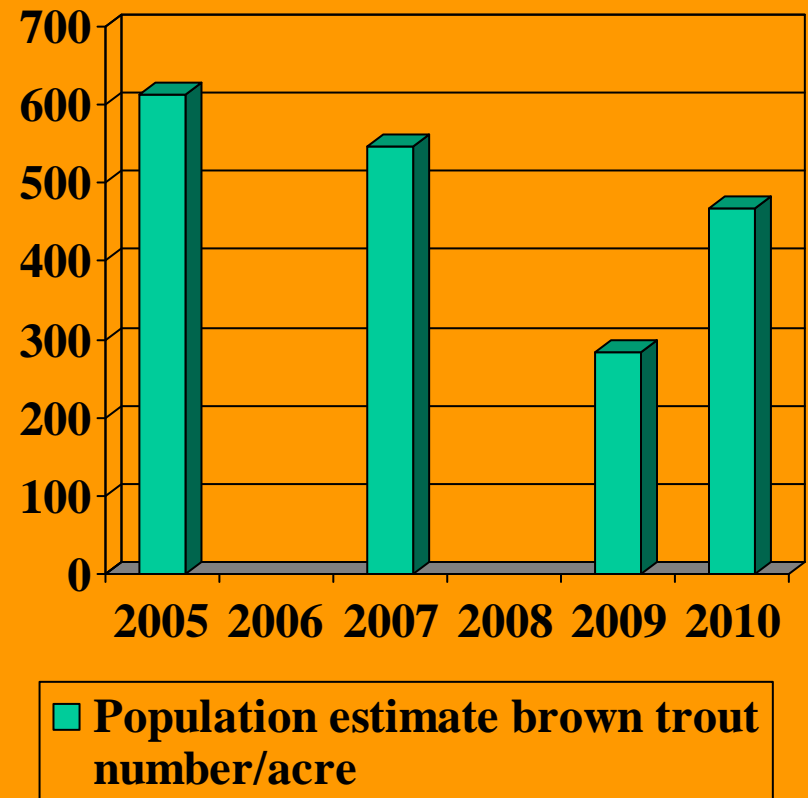


# Eagle River brown trout since 2005, Eagle River Study Area site 3(upstream of Two Elk Creek)

2007 population estimate decreased compared to 2005.

The 2009 population estimate was the lowest since 2005.

The population estimates in 2009 and 2010 were lower than the years 2002 through 2005 (See Part 1 of this slide show series).



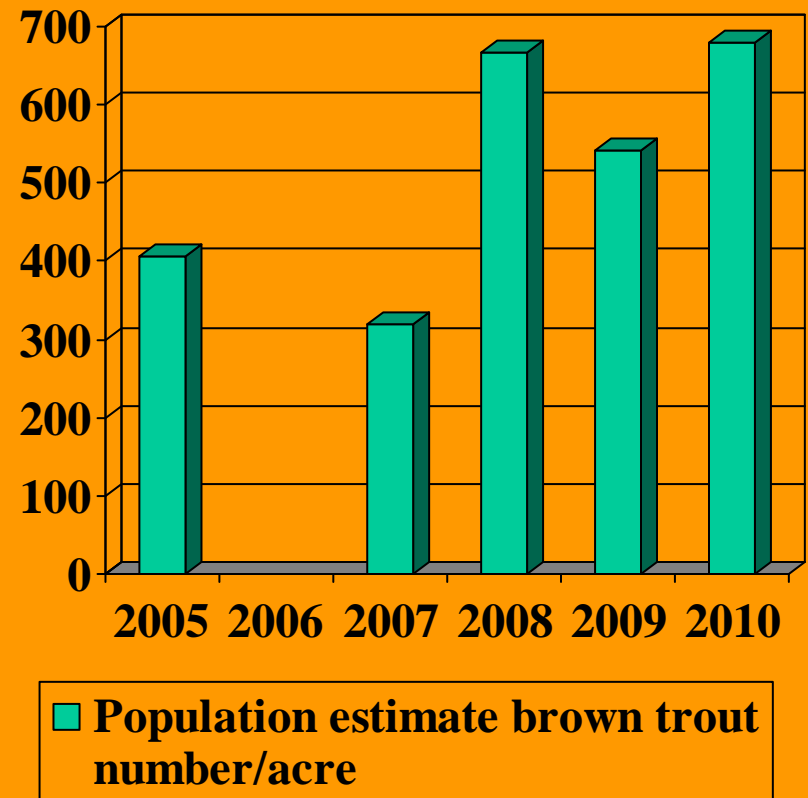


# Eagle River brown trout since 2005, Eagle River Study Area, site 4 (south end of Minturn)

2007 and 2009 population estimates decreased compared to previous year.

The 2008 and 2010 population estimates exceeded the value for all years at Site 4 (1990-2010).

Brown trout population estimates at Site 4 were about twice as high as at the downstream reference location in Avon (Site 6) from 2008 - 2010.



# Summary Eagle River River Study Area brown trout population estimates 2005-2010

- Analysis of Eagle River brown trout data from 2005–2010 is limited. Not all sites were sampled each year.
- Brown trout in the upper portion of the Eagle River Study Area at Site 2 generally decreased in 2007 compared to 2005 and 2010.
- Number of brown trout at Site 2.9 remained reduced compared to rest of the sampling locations within the study area perhaps related to zinc concentrations. Zinc at site 2.9 was higher than at other sampling locations.
- Numbers of brown trout at Site 3 were reduced in 2009 compared to 2010.
- The number of brown trout in the lower portion of the study area (Site 4) were relatively high in 2008 through 2010 compared to numbers from prior years and compared to the downstream reference sampling location at Avon (Site 6), although annual reductions were observed in 2007 and 2009.

# Summary Eagle River Study Area brown trout population estimates 2005-2010

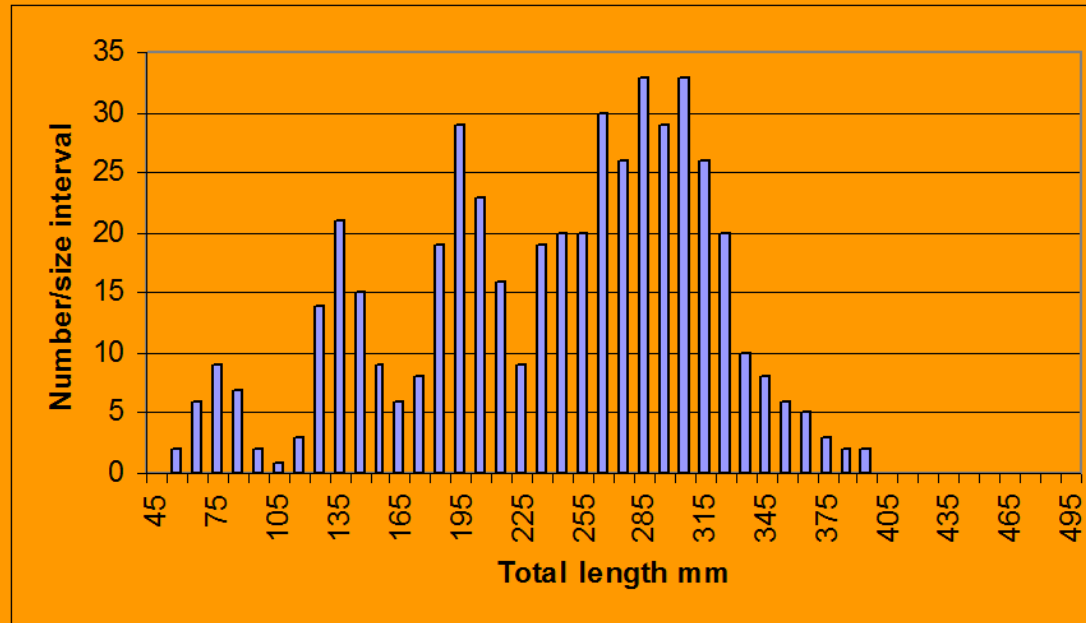
- Population estimates seemed to decrease in both 2007 and 2009 at Eagle River Study Area for which data are available. Elevated zinc concentrations were also observed in 2006 and 2008. Increased metal concentrations may well have been responsible in part for decreased brown trout population estimates.
- As will be presented in the following section of this slide show other factors were also responsible for decreased population estimates, especially high spring flows associated with high snow fall winters.



# Eagle River brown trout length frequency analysis 2005-2010

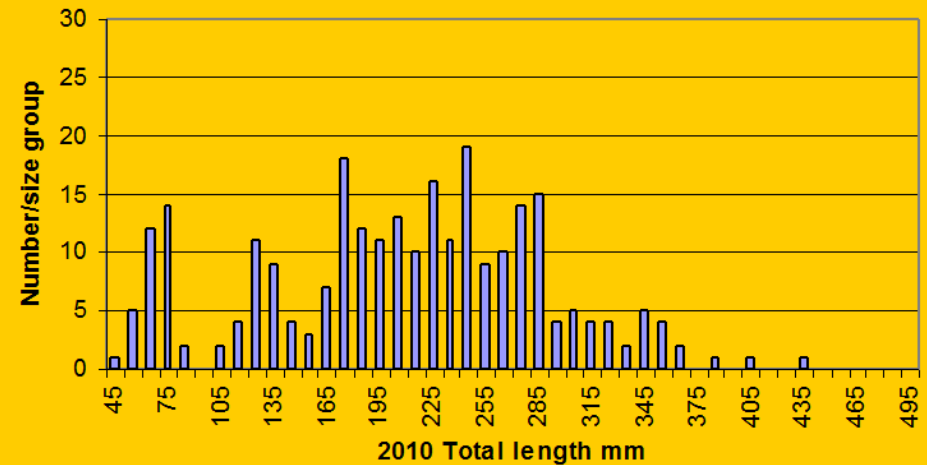
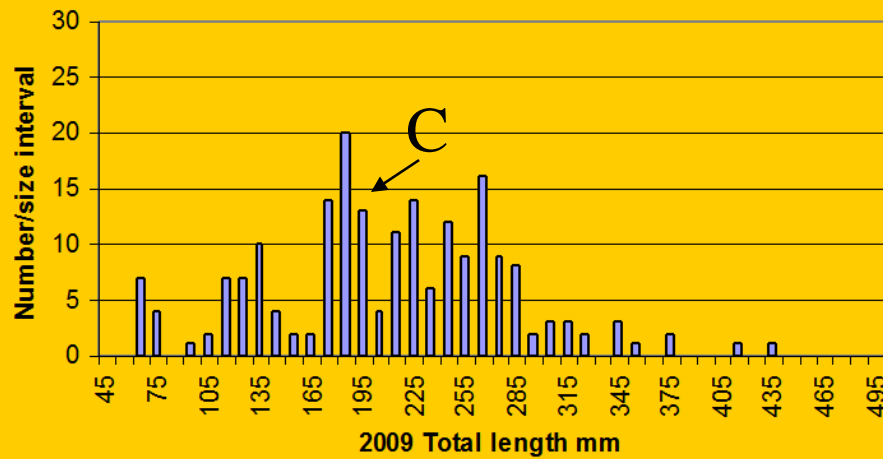
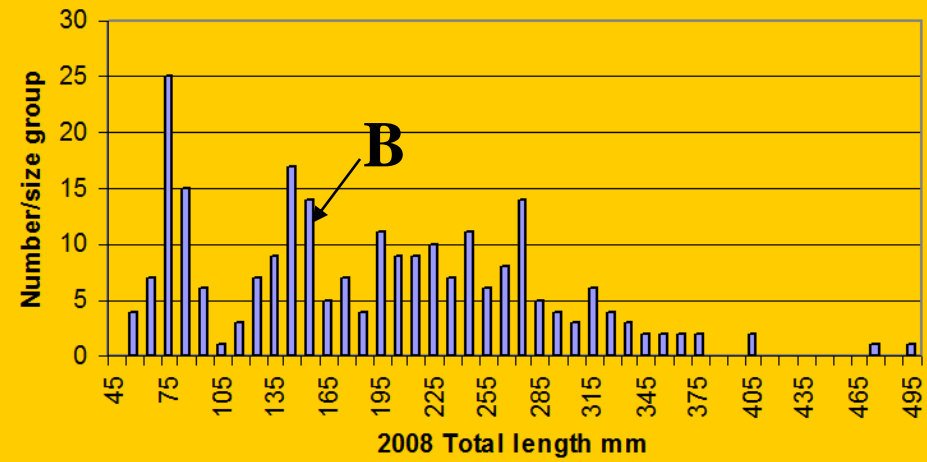
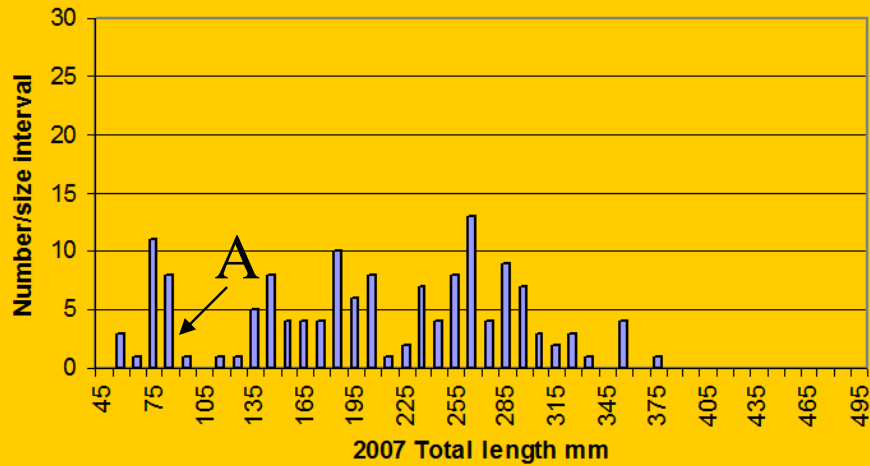
- Brown trout collected at each site were measured for total length. The length measurements were collated by approximately  $\frac{1}{2}$  inch groups and counted.
- Length frequency graphs depict each length group on the x axis of each graph and the number of each group on the y axis (see next slide).

## How to read a length frequency histogram



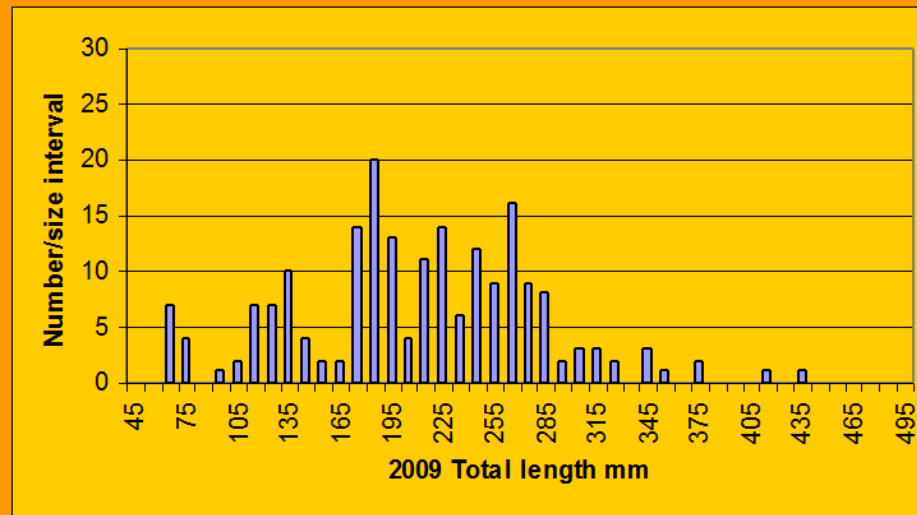
- Length frequency distributions indicate reproductive success of each age class. All brown trout eggs hatch at about the same time each year. Most fish of the same age are about the same total length. In the example above (The Eagle River downstream of Minturn in April 2010) all one year old brown trout are from about 55 mm total length to 105 mm total length (2-4 inches). Two year olds are from 115 mm to 160 mm (4.5-6 inches) total length, etc. As fish age growth slows. Fish greater than three years of age cannot be aggregated accurately using length frequency.

# Length Frequency distribution brown trout Site 4, April 2007-2010



A = one year old fish hatched the previous spring, B = two year old fish, C = three year old fish. Eggs of this age class laid in fall 2006.

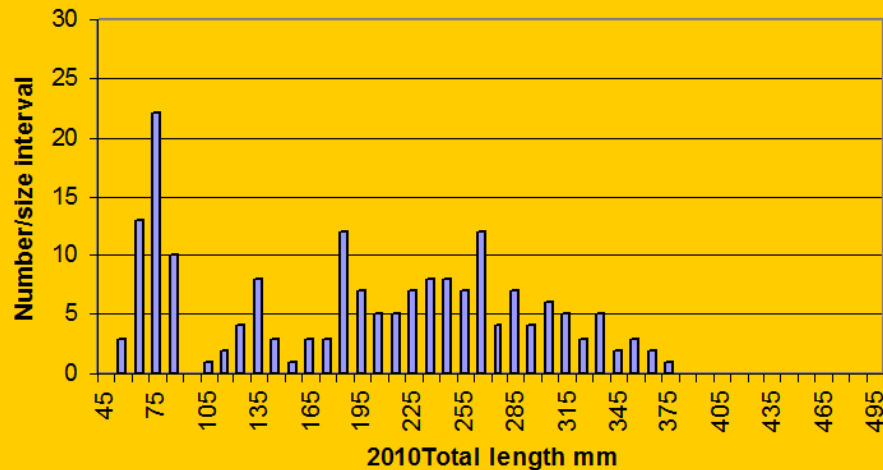
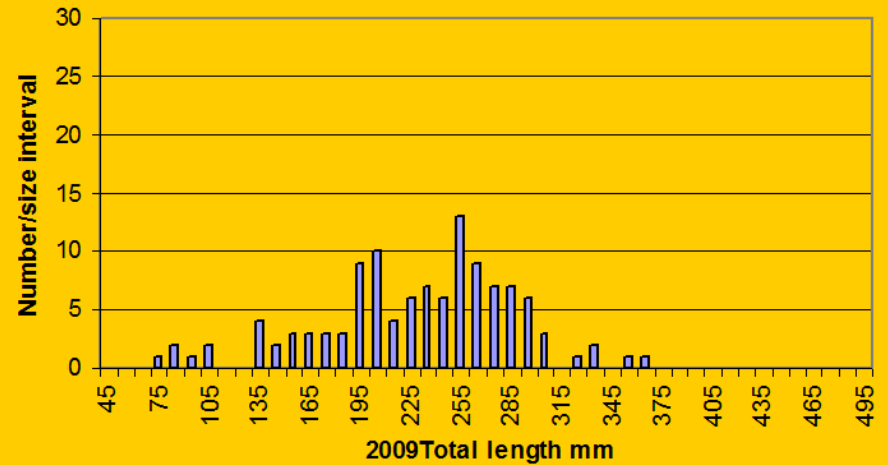
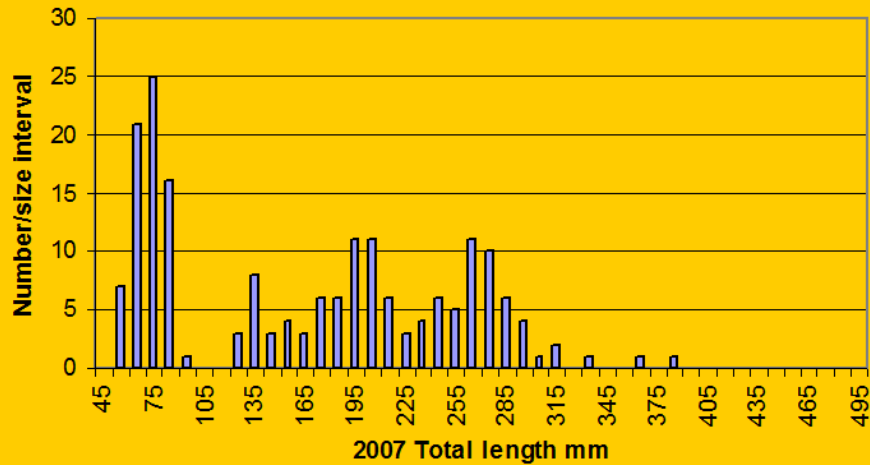
# Length Frequency distribution brown trout Site 4, April 2007-2010



- Multiple age classes present at Site 4 in all years.
- The number of each age class changes from year to year.
- Very few one year old fish present in the spring of 2009. The year 2008 was a high flow year. High flow years result in lower reproductive success for brown trout.
- A high number of one year old brown trout were collected at Site 4 in 2008 (previous slide) due to a low spring flow in 2007.



# Length Frequency distribution brown trout Site 3, 2007-2010



- Like Site 4, multiple age classes of brown trout present each year at Site 3 (no 2008 sample) with very few one year old fish present in 2009 due to high spring runoff in 2008.

# Eagle River brown trout length frequency analysis since 2005

- The length frequency graphs for Site 2 (Eagle River at Belden) and Site 2.9 (Eagle River at Bishop Gulch) are not presented due to limited sampling results but
  - indicated that multiple age classes were present the few years the two sites were sampled.
  - Few one-year old fish were usually collected in the spring at Bishop Gulch where the highest metal concentration were measured.

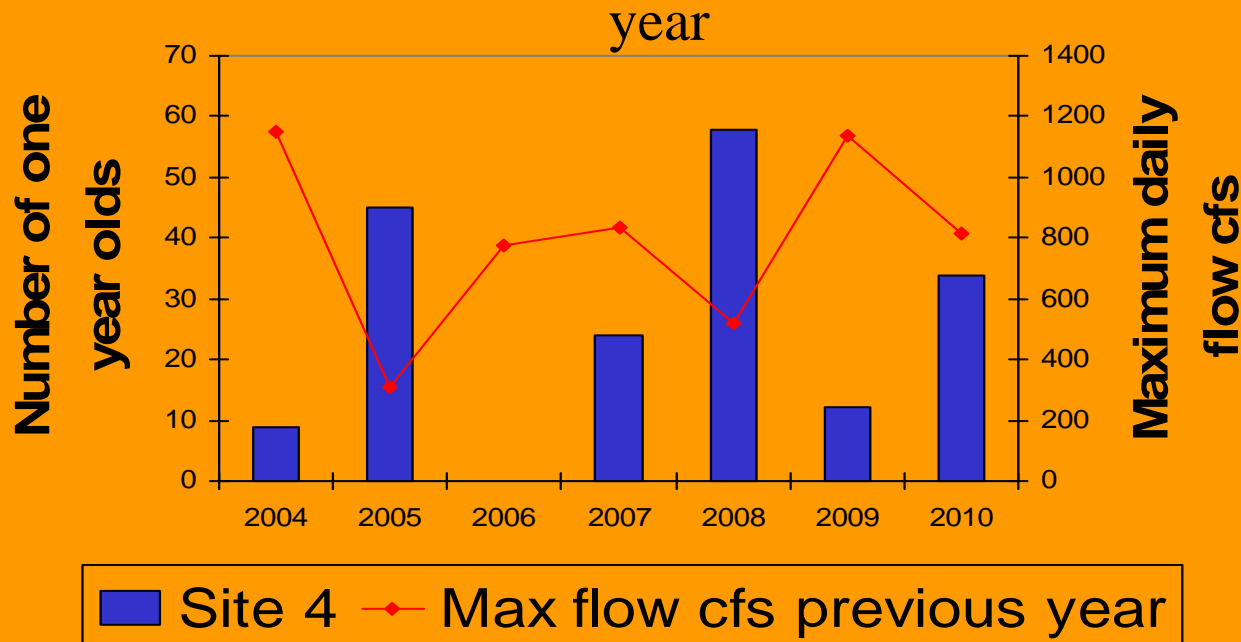
# Eagle River number of one year old brown trout since 2005

- One year old brown trout numbers change from year to year. The lowest numbers counted in 2009.

Site/Year	2005	2006	2007	2008	2009	2010
1	21	ns	33		1	11
1.9	22	ns	6			4
2	30	ns	17			14
2.9	101*	ns	23		4	28
3	101*	ns	70		6	48
4	45	ns	24	58	12	26
6	51	ns	20	41	3	34

The number one year old brown trout are related to the magnitude of spring snow melt stream flows the year before. High spring runoff flows in 2008 reduced the number of newly hatched brown trout surviving to the following year. Note – Site 5 data not presented due to altered stream habitat in 2009 and 2010. \* = yes number at both sites = 101

An example of the relationship of spring snowmelt flows one spring compared to survival of newly hatched brown trout the next year



- Comparison of number of one year old brown trout collected at Site 4 in 2004 – 2010 to the maximum daily flow recorded the previous spring runoff period (Late May and early June) at USGS gauge upstream of Minturn.
- In wet years (2003 and 2008) few newly hatched brown trout survive to the next year, so number of one year old brown trout in 2004 and 2009 were low.
- In dry years (2004 and 2007) the number of one year old trout found the next year relatively high.
- In intermediate runoff years (2006 and 2009) numbers of one year old fish the following year were at intermediate levels

## Summary Eagle River brown trout length frequency since 2005

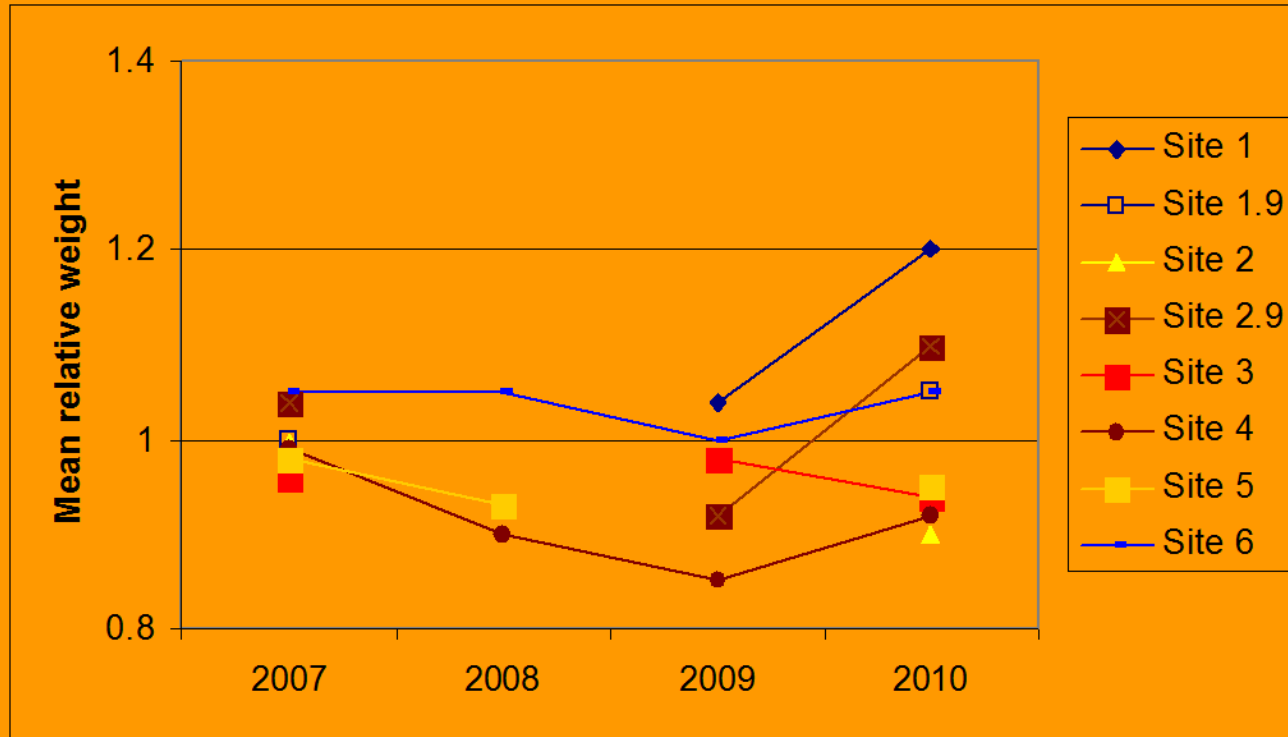
- Although data are missing for some sites for some years the length frequency analysis demonstrated that multiple age classes of brown trout were found at all sampling sites.
- The number of one year old brown trout was reduced in 2009 compared to all other years due to an elevated stream flow event in the spring of 2008 associated with a relatively high snow pack level and high snow fall levels that year.



# Eagle River brown trout relative weight 2005-2010

- The weight of fish can be assessed by using a relative weight analysis, a dimensionless estimate. The weight of each fish is compared to the “Standard” weight based on the length of each fish using a formula specific to each species.
- The actual weight of each fish is then divided by the standard weight to determine the relative weight, a dimensionless value.
- Fish with a relative weight greater than a value of 1.0 are considered to be very fit. Brown trout with a relative weight equal to 0.93 are average for each length group.
- The mean relative weight of each species at a site can be compared to the mean relative weight at other sampling locations.
- Relative weight analysis is presented only for Eagle River brown trout since few individuals of other species are present.

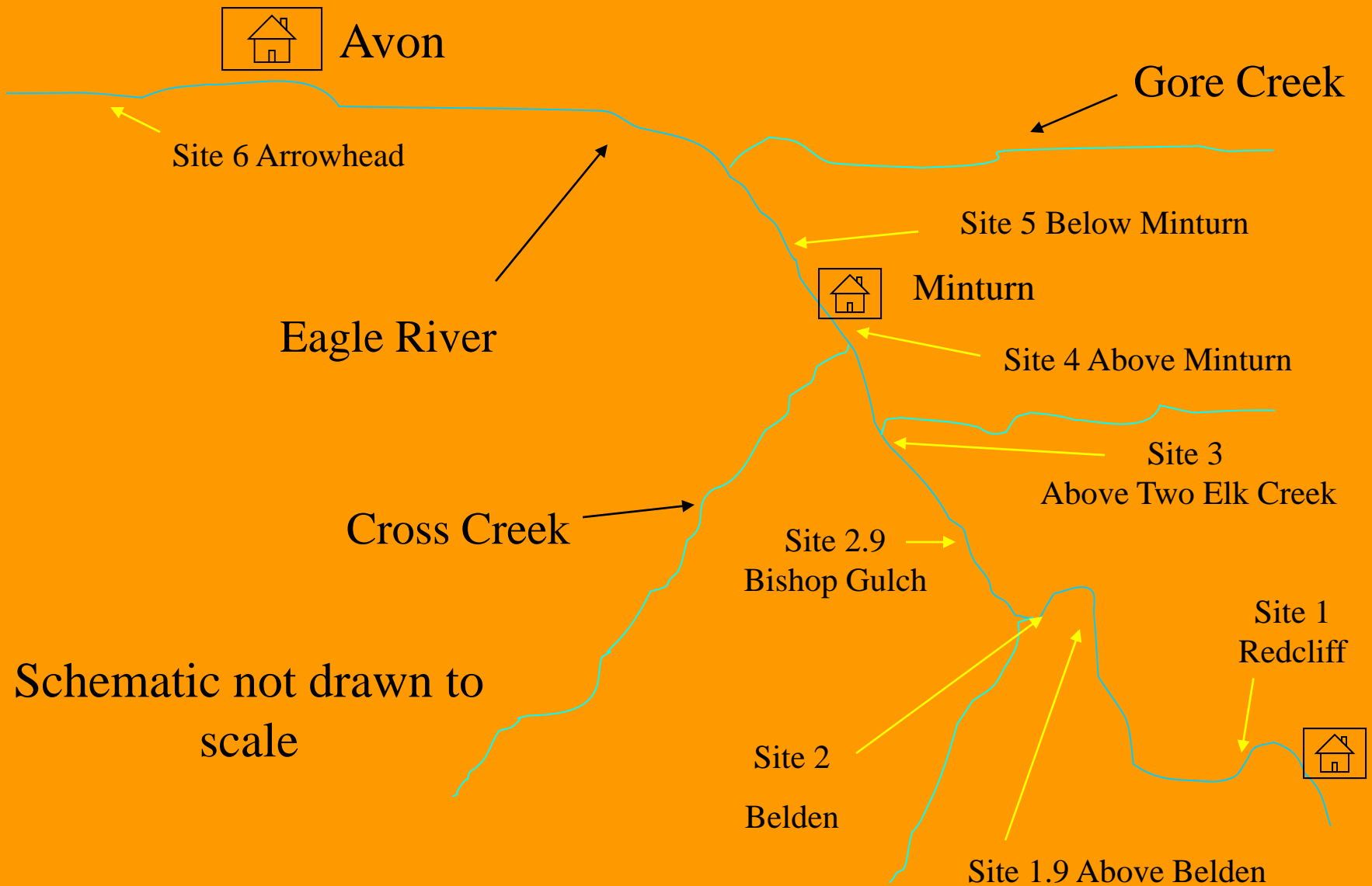
## Average brown trout relative weight reference sites compared to Eagle River Study Area



- The higher the relative weight the plumper (healthier) the brown trout. Notice that the relative weight at reference locations (blue lines and dots) is generally higher than at Eagle River Study Area locations (red or orange or yellow lines and dots). In 2010 Site 1.9 and Site 6 overlap.



# Schematic map Eagle River sampling sites



# Summary Eagle River brown trout relative weight 2005-2010

The higher relative weights at reference sites was somewhat unexpected since brown trout population estimates were generally lower at the reference locations than at the mine site sampling locations.

The relative weight of most fish in the Eagle River is somewhat higher compared to the weight of brown trout in all Colorado streams and rivers. However the fish within the mine site are not as “plump” as brown trout at the reference locations. The mean for each sampling site normally exceeded 0.93 indicating that even within the Eagle Mine Site weights for each fish were average or better.



# Eagle River brook trout data

- Brook trout were collected from the middle 1990s to the end of the Twentieth Century within mine site. (Eagle River Study Area = yellow site numbers, black = reference sites). Numbers = population estimates, number/acre. Red coloration added for emphasis.

Site/Year	1992	1994	1995	1997	2000	2007	2008	2010
1	10	17	0	5	5	0	---	0
2	0	133	60	206	27	48	---	34
2.9	---	---	42	32	2	0	---	6
3	11	27	50	29	22	2.5	---	2
4	12	54	68	32*	24	0	4	4
5	---	17	13	13	28	2	6	0

Some years of data eliminated due to space limits.

No brook trout ever collected at Site 6 (Avon) due to high stream temperatures not metals.

--- = site not sampled.

\*=population estimate is an approximation reached by a method different than all other values.

## Summary Eagle River brook trout

- Brook trout colonized the Eagle River within the mine site in the first years of the cleanup. Treatment plant upgraded in 1992 and roaster piles removed in 1994.
- As zinc levels continued to decrease in the 1990s and early 2000s brook trout numbers also decreased.
- Brook trout tolerate more zinc more than brown trout but brown trout replaced brook trout as zinc levels fell further in the late 1990s and remained relatively low in the 2000s.

# Eagle River rainbow trout data 2005-2010

- Rainbow trout not found within mine site (Eagle River Study Area = yellow site numbers, black = reference sites). \* = One year old fish collected evidence of natural reproduction. Number collected is presented NOT population estimates.

Site/Year	2005	2006	2007	2008	2009	2010
1	0	ns	0		1	0
2	1	ns	2			4
2.9	0	ns	0		0	0
3	0	ns	0		0	0
4	0	ns	0	0	0	0
5	0	ns	0	0		0
6	13	ns	4*	13*	20	34*

Rainbow trout not found within the Eagle Mine site except at Site 2.

Rainbow trout more sensitive to zinc than brown trout and brook trout.

Absence of rainbow trout may be due to whirling disease at Site 1 and

Site 1.9. Note –No rainbow trout collected at site 1.9.

## Eagle River sculpin data since 2005

- Sculpin not found within Eagle River Study Area until 2005 (study area = yellow site numbers, black = reference sites). Only 2 sculpin ever collected at Eagle Mine Site locations since 1990. Number collected is presented NOT population estimates.

Site/Year	2005	2006	2007	2008	2009	2010
1	70	ns	97		46	129
1.9	19	ns	13			39
2 and 2.9	0	ns	0			0
3	0	ns	0		0	1
4	1	ns	0	0	0	0
5	0	ns	0	0		0
6	69	ns	53	84	4	64

Sculpin not found within the Eagle River Study Area. Sculpin are more sensitive to zinc than all trout species. A complete stream restoration would be demonstrated if naturally reproducing sculpin populations were found in the Eagle River Study Area.

## Summary Eagle River sculpin

- Sculpin inhabit the Eagle River upstream and downstream of the Eagle River Study Area.
- Sculpin are not found in the Eagle River through the Eagle River Study Area due to elevated zinc levels.
- Sculpin numbers are reduced in the Eagle River at Site 1.9 upstream of Belden due to slightly elevated zinc levels not attributable to the Mine Site.



## Eagle River summary of sampling results since 2005

- Fish sampling efforts indicated that brown trout remain the dominant fish species in the Eagle River within the Eagle River Study Area and at reference locations upstream and downstream of the study area.
- Population estimates decreased at most sites in 2007 and some sites in 2009. The reason for this decrease is not known. Elevated stream flows and associated increased metals correlated with years of high winter snow pack were likely causes.
- Multiple age classes of brown trout are present at all locations although the number of one year old fish have been reduced when stream flows the previous summer were elevated due to high winter snow pack.
- Brown trout population estimates at the downstream reference location (Site 6, Avon) have decreased since 2005. Site 6 does not appear to be representative of a reference condition at this time.

## Eagle River summary of sampling results since 2005

- Sculpin are very abundant both upstream and downstream of the Eagle River Study Area but zinc concentrations within the mine site preclude the colonization of this native fish.
- Sculpin numbers are reduced in the Eagle River at Site 1.9 upstream of Belden due to slightly elevated zinc levels not attributable to the Mine Site.
- Sculpin numbers would be reduced in the Eagle River throughout the Eagle River Study Area even if all zinc loading attributable to the mine site were successfully removed due to metal loading from sources upstream of the Eagle Mine Site.
- Rainbow trout have not colonized the Eagle River through the Eagle River Study Area due to elevated metal concentrations.

## Eagle River summary of sampling results since 2005

- Water quality sampling is important when assessing the success of mine restoration actions at the Eagle Mine Site on fish populations.
- CBS collects a lot of water quality data but for different purposes and mostly at different sites.
- Lack of water quality data precluded many analyses of impacts of metals on brown trout since 2007.
- The data provided by CBS is important . Without the CBS data no comparisons concerning metals and fish populations could have been made for this analysis.

## Recommendations for future water quality sampling

- Specifics of a suggested water quality sampling program are as follows.
  - Monthly water samples need to be collected at all sites except,
  - weekly samples are needed during the last two weeks of March and through the entire month of April at as many of the Eagle River Study Area locations as possible (Site 2, 2.9, 3, 4 and 5) if access can be obtained and samples collected in a safe manner.
- One sample per month could be analyzed for a complete suite of parameters while weekly samples could be analyzed only for hardness, dissolved zinc and dissolved copper.
- The objective of this sampling is to clearly describe the seasonal water quality regime of the Eagle River and impact of the changes in metals to aquatic organisms in the river, specifically brown trout population estimates.

## Recommendations for future fish sampling

- The DOW should be encouraged to continue their annual sampling efforts.
- Cause of the reductions in numbers of brown trout at the downstream reference location needs to be determined and corrected if this site is to be utilized for comparison purposes in the future.
- Further zinc reductions are needed for brown trout population numbers to increase to “normal” levels at some Eagle River Study Area sites.
- Zinc reductions are also needed for relative weight of brown trout at the Eagle Mine Study Area sites to equal the relative weight of fish at reference locations.
- Further zinc reductions would be needed for sculpin to re-colonize the Eagle River through the Eagle River Study Area.