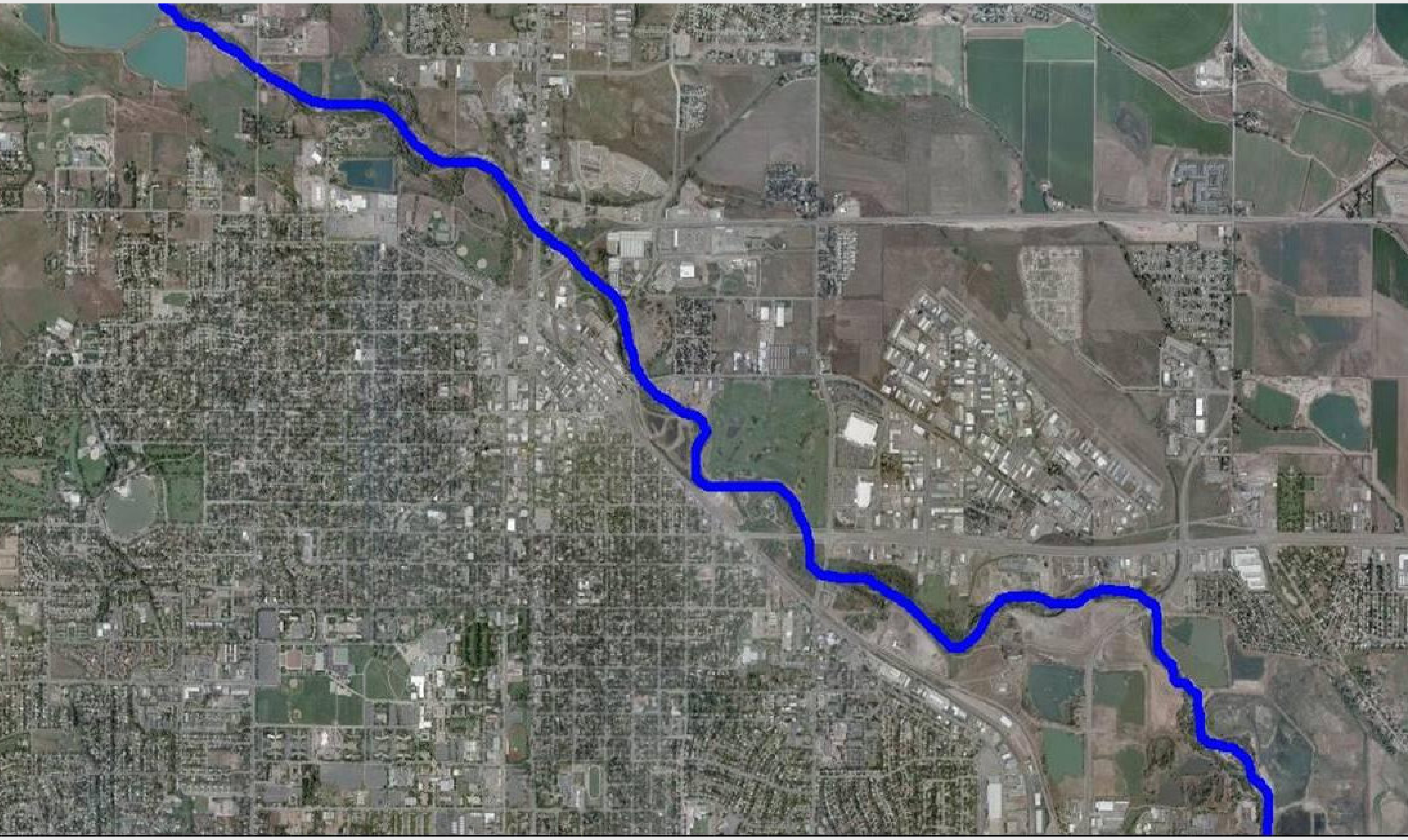
Characterizing the Cache La Poudre River: Past, Present, and Future

A summary of key findings by the Poudre Technical Advisory Group



Summarized by City of Fort Collins Staff

Final Report
April 2008

City of Fort Collins

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Introduction

Background of the Poudre Technical Advisory Group
In 2007, Fort Collins City Council tasked the City's Natural Resources and Utilities staff to analyze the possible impacts of the proposed Northern Integrated Supply Project (NISP) and associated water depletions on the Poudre River through Fort Collins. NISP is a collaborative effort between the Northern Colorado Water Conservancy District (NWCD) and sixteen municipalities and water districts to increase regional water supply (http://www.ncwcd.org). The project intends to use water exchanges and water depletions in the Poudre River to fill two off-river reservoirs including Glade Reservoir (which would be located just north of Ted's Place on US 287), and Galeton Reservoir (northeast of Greeley).

On November 1st 2007, city staff assembled a group of four river scientists from Colorado State University and three Federal river experts (the "Advisory Group") for a half-day panel to explore the history, current status, and possible future conditions of the Poudre River through Fort Collins. This half-day panel discussion was high-level and preliminary in nature and focused exclusively on specified issues of river health and history. The Advisory Group did not examine the River as a recreational, economic or aesthetic resource, nor did it consider the River as a quality of life amenity for the community. The Advisory Group did not have final data on NISP project depletions, impacts or mitigation, and therefore has not made any final conclusions on these matters. Further, the Advisory Group did not evaluate whether NISP will comply with the 404(b)(1) guidelines or other applicable authority. Rather, the Advisory Group's discussions are subject to review, revision and supplementation.

Collectively, the expert panel represents a broad range of expertise on western river systems including river geomorphology, hydrology, fluvial mechanics, aquatic life, riparian vegetation, and restoration ecology. The goal of this panel session was to help inform staff on the ecological history of the Poudre River, the health of the river system today, and the possible impacts of NISP on the future condition of the Poudre River through Fort Collins. This paper summarizes the significant findings and outcomes from the panel discussion. The seven panel members of the Advisory Group included:

Experts from Colorado State University:

- Dr. Brian Bledsoe- environmental engineering, fluvial geomorphology, aquatic ecology
- Dr. Kurt Fausch- fisheries, river ecology, wildlife conservation
- Dr. Boris Kondrateiff- aquatic wildlife, river ecology
- Dr. Ellen Wohl- fluvial geomorphology, human impacts to river ecology

Experts from the Federal Government:

- Dr. David Merritt- US Forest Service, Stream Team, Riparian Plant Ecologist
- Dr. Mike Scott- US Geological Survey Riparian Ecologist
- Dr. Jonathan Friedman- US Geological Survey Riparian Ecologist

The Advisory Group was asked to frame the discussion to a 10-mile section of the Poudre River flowing through the City of Fort Collins and referred to as the "urban reach". This reach runs roughly from Overland Trail Rd. in the northwest corner of Fort Collins to Interstate 25 on the southeast side of the city. The Advisory Group was tasked to describe the conditions for the urban reach for three time periods:

1. *The pre - European settlement period (circa 1850).* The objective of this discussion was to understand the condition and function of the river prior to the influences of land settlement and use. This provides a baseline against which present or future conditions may be compared.

2. *The present day.* It was city staff's desire to understand within an ecological context the condition and function of the river through Fort Collins in today's urbanized environment with a highly regulated/managed water flow.

3. *Future condition post-NISP.* Based on anticipated changes to water flows in the Poudre River as a result of NISP, the Advisory Group was asked to predict possible future outcomes in terms of condition and function of the river under the NISP scenario.

Spectrum of Ecosystem Complexity

River ecosystems, like other ecosystems, are inherently complex due to a broad range of system components (water, climate, geology, nutrients, wildlife, vegetation, etc.), each with a variety of functions (i.e. bank scouring, nutrient cycling, habitat creation, seed dispersal, food availability), multiplied by a host of interactions between the physical, chemical, and biological components of the system. Thus, the degree of ecological complexity of an ecosystem is one way to understand condition and function of the river with the assumption that increasing complexity of the river system lends to a more "natural" or "healthy" system.

Format of this document
Each of the three time periods considered by the Advisory Group are broken out into the physical and biological components of the river ecosystem. The physical component of the ecosystem includes the non-living elements of the river ecosystem, including the flow regime, the lateral movement of the river due to bank scouring and sediment deposition, the formation and destruction of sand bars, and characteristics of the water such as temperature and chemical composition. The biological or living components of the river ecosystem are organisms ranging from microscopic algae and microorganisms to insects that spend part or all of their life cycle in the water (aquatic insects), fish, and all vegetation growing along or near the banks of the river (the riparian vegetation). Only in a few instances did the discussion incorporate other wildlife living in the river corridor such as songbirds, beavers, otters etc. as the Advisory Group had less expertise in that area.

Profile of the Past: The Native River System

The Physical Past
Prior to European settlement, the Poudre River through present-day Fort Collins was not managed for human use with the possible exception of localized, small-scale use by Native Americans. The urban reach of the Poudre River represents a geological and ecological transition zone between the high velocity flows within steep, straight, and confined channels in the mountains to the gentle flows, meandering channel, and shallow banks of the river in the eastern plains.

Within this transition zone, the river was wide and wandering in some places and narrower with more defined banks in others. Both small and larger flood events eroded sediment from the outer banks of the river and deposited the material downstream forming new bars and backwater channels. High annual spring flows were a reliable annual occurrence. These flows moved the finer half of the streambed sediment and during years with larger snowmelt floods, coarser streambed materials would have been very mobile

Less frequent, rainfall-generated flash floods probably "set the template" for a braided wandering river by creating many of the secondary channels, causing large lateral channel shifts across the floodplain, and transporting substantial amounts of the coarsest streambed sediment. Larger flows (from spring snowmelt or rainfall) typically carried coarse material including boulders, trees, and cobbles downriver contributing to channel diversity and riparian zone diversity. The continuous erosion and deposition of sediment is a defining characteristic of western rivers that has evolved with flow patterns resulting from snow melt. As a result, all living components within this type of river are adapted to and dependent on flood disturbance events for survival. Thus, the Advisory Group generally agrees that Poudre River had high variability both in flow regime and channel form.

The Biological Past

Historic variability and the interaction between flow depth, flow velocities, and substrate movement spawned a high diversity of species, habitats, and food chain interactions. Continuous movement of riverbed material forced the paraphytic communities (microscopic plants and animals) to "reset" yearly. Consequently, the river remained well-oxygenated and supported abundant microscopic plants and animals. Filamentous algae which is widely seen in the present day condition was largely absent and did not impact dissolved oxygen levels.

While few formal records exist, experts agree that historic assemblages of aquatic insects in the pre-European condition included a wide array of species typical of a mountain to plains transition zone. The list would have included species found both in the plains and those adapted to the mountain stream environment. It is estimated that 40 to 50 different taxa (species groups) of aquatic insects existed in the area. Similarly, the transitional section of the Poudre River through Fort Collins also supported a "hot spot" of fish diversity in the region. Assemblages of fish present prior to European settlement included a mixture of species typical of plains streams, and those like greenback cutthroat trout typical of coldwater reaches upstream. Species relics from the earlier glacial age that were once widespread (but were extirpated from plains reaches to the east as climates warmed) were also present. Many of these fishes that inhabited the transition zone require coarse gravel substrate, cool water, and woody debris in the channel.

Tributaries to the Poudre River such as Fossil, Boxelder, and Spring creeks exhibited distinct water and channel conditions that supported additional species of fish and aquatic insects not found in the main channel of the Poudre. Thus, an important function of these tributaries was to provide "refuge" habitat for a wide array of fish and aquatic life. These species would disperse out of the main channel following large flow events such as a 100-year flood.

Vegetation growing along a river corridor is commonly referred to as "riparian vegetation." Flow patterns of the river and local groundwater hydrology largely determine the makeup of vegetation in the riparian zone. Historically, all plant life along the banks of the Poudre River was adapted to a snow melt driven hydrology of the late spring and early summer. High spring flows scoured banks, provided sediment transport, and made new deposits in low velocity areas creating the optimal germination grounds for riparian vegetation. Most local native riparian trees and shrubs are adapted to flood-related disturbances and can survive fluctuations in water level (from the extremely high levels in the spring to low late season flows). These species persist in drier conditions of late summer and fall as long as they have root contact to the groundwater table or residual moisture in the soil mantle. It is important to distinguish the riparian vegetation native to the Poudre River from species that grow along rivers with less variable annual flow patterns. The latter group has evolved to survive a different set of stresses and is more similar to plants found along the shoreline of natural lakes where water depth and availability is stable and consistent.

During the pre-settlement period, vegetation along the urban reach consisted of a wide range of non-woody plants and a smaller selection of shrubs and trees. Seeds were transported by the river from higher elevations and foothills tributaries and contributed significantly to the diversity of non-woody plants growing in an understory of a mosaic willow and cottonwood forest. Along some sections, older riparian forests consisting of established bands of willows and older cottonwoods grew in contrast to disturbed areas where a recent flood may have scoured the bank carrying existing willows and cottonwoods into the river. Bare, sunny surfaces exposed by the floods would provide ideal germinating conditions for sedges, rushes, grasses, forbs as well as willow and cottonwood seedlings.

One important feature for the urban reach would have been the persistence of cottonwood forests along oxbows; former river channels with no active running water. Groundwater levels adjacent to any river within the floodplain usually mimic river water levels, and high spring water levels are believed to "recharge" the local groundwater system. Once established, cottonwoods can persist even if the main channel of the river moves to a different location as long as the groundwater table persists and is connected with river water levels.

Summarizing the Pre-Settlement Condition

Prior to European settlement the Poudre River was characterized by the influence of high spring flows and periodic flood and flood related events followed by significantly lower flows later in the year. These high flows continuously reworked channel and floodplain sediments creating a diversity of in-channel and riparian habitats. Native wildlife and flora in the river ecosystem were adapted to and highly dependent on periodic patterns of disturbance. High flows also allowed for the movement of species from tributaries into the main channel and between the inner channel and riparian floodplain. Finally, the urban reach of the Poudre River is located in a unique geographical and ecological transition zone between the mountain and plains environments that supported a unique blend of wildlife utilizing a dynamic river habitat.

Profile of the present: River Modification and Human Use

The condition of the urban reach in 2008 is highly modified from the historic condition due to human use and influences since the settlement period. Water use, regulations, and river management have significantly modified historic flow patterns and flooding regime. Total annual flow during this time has been reduced in comparison to historic conditions. Since there are inputs into and outputs from the river above the mouth of the canyon that tend to balance out, it is appropriate to consider the reduction in flows from the mouth of the canyon to the Lincoln St. gage to quantify change due to human alteration. Current total native annual flows at the mouth of the canyon are approximately 300,000 acre feet and this is reduced to roughly 100,000 acre feet before it reaches the Lincoln St. gage.

Modifications to the river channel through urban areas including "armoring" of the channel for flood protection has greatly altered channel shape and form. The placement of rubble and riprap along the river's banks for bank stabilization has severed the river's access to the adjacent riparian forests, backwater channels, oxbows, and adjacent ponds. Furthermore, channelization of the river has straightened and deepened the channel through continuous down-cutting causing the river to take on a more “homogenous” character.

Agricultural diversions or “calls” on the river throughout the growing season further reduce water levels and result in major fluctuations in water levels from one day to the next. Flood-prevention management results in the active clearing of large downed trees within the river’s channel that normally would provide habitat for fish, aquatic insects, and microorganisms. The combination of lower flows and significant chemical inputs into the water from urban and agricultural runoff has detrimentally raised the water temperature and nutrient loading increasing the potential for negative shifts in the algal community and cascading effects on the river’s food web.

Lastly, extensive gravel mining along the Poudre River has created hundreds of ponds adjacent to the river that in most cases interact with the river’s local groundwater table. High evaporative demands in a hot and dry climate likely act to siphon groundwater away from the river and toward the ponds in nature’s act of balancing groundwater levels.

The Physical Present

While flow levels still rise each year in the late spring, the magnitude of these peak spring flows are reduced due to timing of dam releases and agricultural calls for irrigation water. Furthermore, large, naturally occurring floods such as the 50 or 100-year flows that historically played an important role in the river’s ecology have been diminished and mitigated through active flood control. The combination of lower annual peak flows, mitigation of large flow events, bank armoring, and channelization has had far reaching effects in the diminished capacity of the river to scour and deposit sediment, nutrients, and biological material.

Channelization and bank stabilization for the purposes of river management and flood protection has reduced the river’s capability to create braided channels, flood backwater channels, scour banks and deposit new sediment bars critical for the continued regeneration of cottonwood forests. The net effect of narrowing the riparian corridor and the abrupt interface with adjacent uplands fragments the connectivity of aquatic, riparian, and terrestrial habitats and related movement (or interaction) of wildlife communities in both habitats.

Warmer water temperatures in the urban reach (relative to the historic condition) exhibits a higher capacity to bind phosphorus and nitrogen which are the building blocks of the most common pollutants in most aquatic and riverine systems. The additional stress of drastic day-to-day changes in water levels caused by agricultural “calls” on the river’s water (or even “dry days” when sections of the urban reach are not flowing at all), create conditions that inhibit the life cycle to some forms of aquatic life.

The Biological Present

Negative alterations to the river's physical condition directly impact the health of the biological community. Lack of flushing flows and reduced sediment movement have created an armored river substrate characterized by cobbles compacted in place by fine sediment.

This contrasts with the historical condition (and those of "healthy" rivers), where a variety of riverbed materials were diverse in size class and were constantly shifting. The lack of substrate diversity has been detrimental to aquatic microorganisms, insects, and fish that flourish when they are able to feed upon a variety of organisms from a variety of river bottom habitats.

The river's physical environment is becoming increasingly well-suited for filamentous algae common to stillwater habitats. These algae can be prolific and "choke out" native flora by occupying growing space and reducing dissolved oxygen loads in the water. Similarly, many native aquatic insects (and other microorganisms) are not able to complete their life cycle in the modified environment because of poor habitat quality, rapid changes in water levels (associated with river and irrigation management), and reduced water quality associated with urban and agricultural inputs. In fact, the expert panel suggested that only one-quarter of the number aquatic insects that once occupied the urban reach remain today because of an "unforgiving" flow regime. Furthermore, the diversity of river fauna decreases continuously downstream through the urban reach. As in most flow-altered aquatic ecosystems, the present assemblage of aquatic insects represents a limited group of highly adapted species resilient to erratic flows.

The profile of fish species has also changed considerably since pre-European settlement. Trout and carp often make up substantial portions of the river's fish biomass, however, the variety of species is dominated by tolerant native minnows and suckers able to withstand the impacted conditions. Daily fluctuations in water levels throughout the summer months likely hinder the success of spawning and larvae survival of many fish. Warmer water temperatures negatively impact the survival of trout. Overall, fish biologists conclude that native, coldwater fishes currently inhabiting the river's transition zone in Fort Collins may be sustained in the future only in reaches farther upstream where there is adequate flow and cooler temperatures.

Changes in the vegetation are analogous to changes in the insect and fish communities. The number of native species has declined and introduced species (weeds) have been established. Dominant non-native plants such as reed canarygrass, Russian olive, Siberian elm, and crack willow are adapted to surviving under reduced and static water levels. The system of seedling dispersal and establishment of native cottonwoods trees on new surfaces such as sand bars is not functioning as the existing physical environment is not very conducive to sediment transport and deposition required to form new sand bars.

The last time cottonwoods naturally established to any extent along the urban reach was following the 1983 flood. While most of the cottonwoods along the urban reach are older than this (the life span of cottonwoods in this region is generally over 100 years), the expert panel expects most of the older individuals to die back within this century. The lack of new seedling recruitment suggest that cottonwood forests along the Poudre will slowly revert to other vegetation types, many of which may not be native or desirable.

Existing cottonwood galleries occupying backwater channels and former oxbows are likely highly dependent on the recharge to the groundwater provided by the high spring flows. The higher groundwater is critical to supplying sufficient water for annual growth in addition to the water and energy required for the process of "leaf-out" each spring.

Summarizing the Present Condition

The Poudre River system has been highly modified by river management, utilization, and flood protection. The sum effect of river channelization, bank armoring and lower average peak flows has reduced the river's capacity to scour banks, transport and deposit sediment, and interact with the floodplain. Native microorganisms, insects, fish, and vegetation have decreased in diversity since pre-settlement times, while non-native species have increased, with pollutant tolerant aquatic fauna predominating. Despite these changes, the roles of existing peak spring flushes and periodic flood years are believed critical to the survival of native wildlife and flora.

Profile of the future (post NISP): Future Threats

Prior to the following discussion, city staff presented the Advisory Panel with a broad overview of NISP and anticipated changes on flows in the urban reach.* NISP is described by the Northern Colorado Water Conservancy District (NWCD) as a collaborative effort between sixteen municipalities and water districts to increase water supply (http://www.ncwcd.org). Its' key components include the construction of two off-river reservoirs including Glade Reservoir north of Ted's Place on US 287, and Galeton Reservoir (northeast of Greeley). A combination of water exchanges and depletions out of the Poudre River would be used to fill these reservoirs.

Based on hydrologic models available to city staff at the time of the panel presentation, it is anticipated that flows within the urban reach would be subject to an average reduction of approximately 30 – 40% per year. Most of this water would be taken from the river during the high runoff months (May, June, and July). Reductions during these peak flow months could be as high as 70% depending on the year.

***NOTE: The information provided above on the likely outcomes of NISP are based on preliminary computer modeling that city staff are highly confident to be accurate. Final computer hydrologic modeling is anticipated to be part of release of the draft Environmental Impact Statement (EIS). Furthermore, the draft EIS may contain proposed mitigation measures that could modify anticipated outcomes.**

Response by the Advisory Group
The historical river ecosystem was driven by disturbance from high spring flows that are critical to the system for physical characteristics, for creation and maintenance of habitat, and for species diversity. Because the NISP project will significantly reduce peak flows from the current flow regime it is likely to further reduce its complexity and preclude future opportunities to restore habitat or ecosystem functions at the local level. Survival of some of the remaining native aquatic species will become further imperiled.

Anticipated physical conditions post-NISP
Future reductions in peak flows are expected to directly affect the physical environment in three primary ways. The Advisory Group anticipates:

1. Further deposition of fine sediment and little opportunity for scouring and movement of fine or coarser sediment;
2. Reduced scouring of plants in the main channel and consequent narrowing of the channel through adjacent vegetation “growing in” or ”encroaching”, and;
3. An undesirable increase in water temperature, human generated chemicals and sewage related to stagnation and reduced capacity for dilution of pollutants.

The first two points will lead to the “river miniaturization” phenomenon that is occurring worldwide on highly managed river systems. In this process the combined effects of reduced flushing flows, increased sediment deposition, and encroachment of rooted vegetation act to narrow the active flow in the channel and result in a “creep” of the terrestrial environment into the riverine and riparian systems. In a river system with reduced flushing flows, continuous deposition of fine sediment begins to fill pools. As pools fill with sediment, rooted vegetation (such as willows in the case of the Poudre) are able to establish within the channel, further reducing the velocity of river flows and trapping additional sediment. Filamentous algae growth dominates stagnated areas and lowers the dissolved oxygen in the water. Through time, vegetation establishing along the edge begins to mature extending its root system. In the absence of the scouring effect of the river through annual high flows and/or flood events, this positive feedback cycle continues requiring increasingly more powerful flows to flush sediment and tear up roots to restore the natural channel. As the river shrinks there will be less diversity of habitats, greater homogeneity, and reduced flood conveyance capacity.

As stated in point 3 above, the Advisory Group anticipates critical negative changes in water quality. Reduced water levels during the late spring and summer months available to dilute chemical inputs into the system will result in higher concentrations of pollutants and related increase in costs for water treatment. Furthermore, suspended fine sediments that result from reduced velocities will support higher chemical and toxin levels in the river water by serving as “attachment sites” for these pollutants. A potential increase in organic matter and dissolved oxygen content would affect the water treatment process. An increase in disinfection byproducts in the drinking water would then have increased public health risks. The Advisory Group was also concerned about the set of less studied and regulated group of synthetic pollutants. These include pharmaceuticals and endocrine disruptors such as antibiotics, steroids and other legal and illegal drugs. Current water treatment systems do not treat for these pollutants and reduced water levels and lack of flushing flows would magnify the concentrations. In sum, the compound effect of reduced flushing and reduced quantity of water throughout the year for dilution is likely to significantly impact water quality and the biological life that depends on it.

An important yet more subtle impact from reduced peak flows is the affect this change has on water levels later in the summer. The high flows of May and June create a rise in the adjacent water table and some of this water flows back into the main channel later in the season (referred to as “return flows”). When there are lower levels in the spring to recharge the adjacent groundwater, there is typically less return flow. A small difference in return flows late in the summer when the water level is already very low can have a large impact on water quality. Water temperature and chemical composition are important factors when considering public health issues as well as the effects on aquatic algae, insects, fish, and wildlife.

Anticipated post-NISP biological conditions

Further reductions in peak flows will change the flow pattern from a snowmelt peak pattern to that of a spring-fed river. The native biological community is adapted to the snowmelt flow pattern. If NISP is permitted one would expect to see a shift to an assemblage of (non-native) species adapted to a more stable (or flat) flow pattern. These predicted trends are disturbing in that, for instance, mosquito larvae require still water to hatch eggs and complete their larval and pupa stages as an aquatic form which is problematic for the residents of Fort Collins

At the microscopic level, higher nutrient and fine sediment concentrations are likely to increase the dominance of filamentous algae, which support less diverse insect communities. Similarly, fish depend on minimum water levels, the presence of pools for feeding and reproducing, compatible water temperatures, nutrients, and oxygen levels conducive to providing abundant food supply and a nourishing environment for hatching fish eggs. Low flows anticipated by NISP are likely to impact essential environmental factors and further limit fish diversity to mostly non-natives and tolerant native species that can persist under impacted conditions. Under the NISP flow regime it is unlikely that the urban reach will support trout.

Along the banks and within the riparian corridor, hydrological changes brought about by NISP are likely to severely impact the long-term survival and recruitment of cottonwoods and associated plant communities. Cottonwood roots develop at depths that correlate with annual patterns of the water table in any given area. The combined impact of reduced springtime water levels and lower levels throughout the rest of the year is likely to restrict the water available for uptake by mature cottonwoods. A lower water table in the spring can significantly impact cottonwoods because (as stated earlier) this time is critical to leafing out and the annual growth period for the cottonwoods. One example has been observed in a study of riparian cottonwoods east of Denver where a sustained drop of 1 meter or greater in the water table caused 88% mortality over a 3-year period (Scott et. al., 1999).

The anticipated reduction in peak flows related to NISP may also alter the health and persistence of native riparian vegetation below the tree canopy. Native willows and non-woody plants growing along the urban reach thrive in this environment based on the availability of water during portions of the year. Native species are likely to become stressed, and consequently more easily outcompeted by aggressive (non-native) species such as reed canarygrass, Russian olive, Siberian elm, tamarisk, and other invasives. Within the current riparian corridor there will be changes in three zones paralleling the existing waterway. Farthest away from the river, species more representative of upland areas such as sage, rabbitbrush, and aggressive, non-native grasses are likely to dominate. Closer to the river, a transition to species capable of vegetative reproduction (capable of establishing from branches of adult trees rather than from seed) and aggressive non-natives adapted to drier soil conditions is likely. Changes within the existing channel (as described above) are likely to be characterized by encroaching vegetation and channel miniaturization.

All of these changes in the vegetation are likely to further modify non-aquatic wildlife and other wildlife that live in the riparian corridor and depend on specific plants or trees for food, nesting, and cover. A major shift from native species would negatively affect songbird diversity and increase utilization by urban wildlife.

Summarizing the Possible Future Condition

The Advisory Group anticipates a worsening of conditions to the river's overall health within the Urban reach through Fort Collins primarily due to reduced spring flows and possibly reduced flows during low flow months. Over the course of time, the river is likely to look and behave more like a long, narrow lake bordered primarily by aggressive non-native trees and understory plants. Flood conveyance in this scenario may be compromised. Cottonwood forests along the river will become decadent more quickly due to lower groundwater levels and there will be an absence of younger forest age classes to replace them. These changes to the forest structure will reduce habitat for birds. Stagnant water reduces water quality which directly increases costs for water treatment in order for Fort Collins to meet Federal and State water quality standards. Finally, the reductions in peak flows may preclude future opportunities to restore habitat or ecosystem function of the river.

Future management options:
What could be done to improve the overall health of the River?

During our half-day forum with the Advisory Group, the panel was asked what management actions would be most effective in improving the function and health of the river's ecosystem. Without exception, the panel agreed measures could be taken to improve the overall health of the river within the urban reach.

The panel recommended two primary goals for improving the health of the river. First, plan for and manage to allow erosion and deposition to occur. Second, explore opportunities to restore the connectivity between the river and its floodplain. Doing this would permit spring water levels (as they are currently) to most profoundly affect the river system in a positive way. The Advisory Group suggested the following specific steps* to achieve these goals:

**Note: the discussion did not include the challenges of implementing each of these recommended strategies within current urban constraints and management.*

1. Allow the river to access its floodplain in areas where there are few structures at risk. Wherever possible, limit armoring of banks and remove riprap to allow for erosion and deposition in planned and strategic locations.

2. Improve the river's connectivity with side pools, ponds, and backwater channels where possible.

3. Tie down large woody debris (i.e. trees) in the channel where possible to create critical habitat for fish and insects.

4. Coordinate the timing of water delivery to minimize drastic changes in water levels, especially during the summer irrigation season when fish spawn and larvae hatch and rear.

5. Retain existing river functionality by protecting current spring peak flows.

Dr. David Merritt of the US Forest Service's Stream Team accurately summarized the groups concluding thoughts with the following statement:

> "*It's not incompatible to protect infrastructure, manage for flood mitigation and have floodplain connectivity and some channel movement in strategic locations. This is happening on several rivers in Europe right now where they are breaking down riprap, grading, lowering the banks, reconnecting oxbows. When you have done some mechanical refiguring to link the floodplain- you get a lot of benefits at a low cost. This must be coupled with retaining peak flows*."

In conclusion, the Advisory Group emphatically expressed that these future management opportunities (and the success of related river restoration projects) are not likely to exist under the NISP scenario because of the critical dependence on peak flows in May and June.

Citations

Scott M., Shafroth P., and G. Auble, 1999. Responses of Riparian Cottonwoods to Alluvial Water Table Declines. Environmental Management. Vol 7, pp 347-358.

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