Sanderson Gulch Redesign: Innovation and Resilience in Urban Stream Restoration

CASFM
2020 Colorado Association of Stormwater and Floodplain Managers
Grand Award for Engineering Excellence
Winner

Matrix
Excellence by Design

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Denver Parks and Recreation
Mile High Flood District
ICON Engineering

DENVER PARKS & RECREATION
ICON ENGINEERING
MHFD MILE HIGH FLOOD DISTRICT

ArcGIS Story Map

Drone Flyover

The Future of Urban Waterway Design

Organic Matter as a Force Multiplier for Restoration

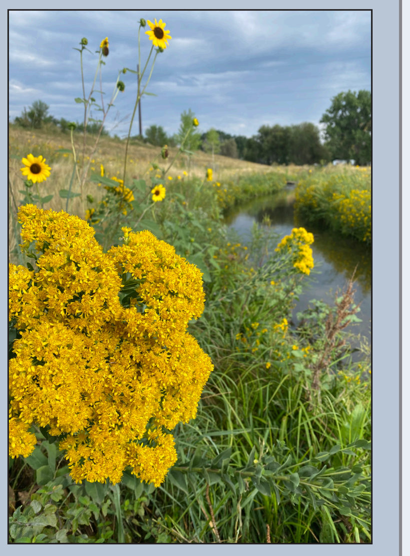
In arid and semi-arid regions where soil development is slow and often lacking organic matter, the use of organic amendments, specifically weathered wood chips (WC) that provide a high carbon to nitrogen ratio within the soil, has proven to be an effective strategy to enhance soil nutrients, improve native vegetation cover, and reduce weed pressure at degraded/disturbed sites (Blumenthal et al. 2003; Eldridge et al. 2012).

Organic matter provides nutrient retention, nutrient mineralization, increases cation exchange capacity, pH buffering, and microbial activity (Brady and Weil 2016; Marschner 2011; Paul and Zvomuya 2014).

WC are often readily available from urban forestry departments as a waste product of forestry operations. WC could be incorporated as a remediation strategy at revegetation sites with certain soil quality criteria, such as elevated levels of nitrogen or low organic matter.

A little goes a long way. Too much organic carbon from WC or other sources can immobilize nitrogen for too long causing nitrogen deficiencies. High C:N ratios can also slow down organic matter decomposition if there's not enough N to balance the excess C (Brady and Weil 2016; Marschner 2011). The target C:N ratio we were aiming for was 20:1.

Irrigation, Operations Management, and Plant Diversity



In urban systems within arid and semi-arid ecosystems, permanent and temporary irrigation may be an option to help establish restoration projects. More often irrigation is viewed as a short-term answer with the goal being a sustainable plant community that survives on natural moisture availability.

On Sanderson Gulch, temporary irrigation was used for the first three years of establishment which helped with plant germination and growth, but this additional resource support may have neutralized the benefit of adding WC as a soil amendment. It is hypothesized that plants that need more soil moisture to survive were sustained in the no wood chips (NOWC) plots because of the temporary irrigation. Had the irrigation not been present, the WC plots may have shown better plant cover and diversity than the NOWC plots.

An increase in non-native volunteer species by year four in WC plots could be attributable to improved soil health conditions. Non-native volunteer species are often well-adapted to better nutrient availability versus Colorado native species that are adapted to poor nutrient soils (Vila et al. 2011).

While unexplored at this point, using WC to improve soil health may be more beneficial for non-irrigated projects compared to irrigated projects.

Green Infrastructure and Flood Resilience

As increased urbanization continues across the globe, and more extreme weather events are occurring, it is important to understand the benefits of green infrastructure paired with grey infrastructure to help meet the needs of our communities. Returning to a vegetated stream channel and reconnecting the floodplain is helping with: floodwater absorption, soil stabilization, floodplain storage, floodwater filtration, biodiversity conservation, and improved aesthetics.

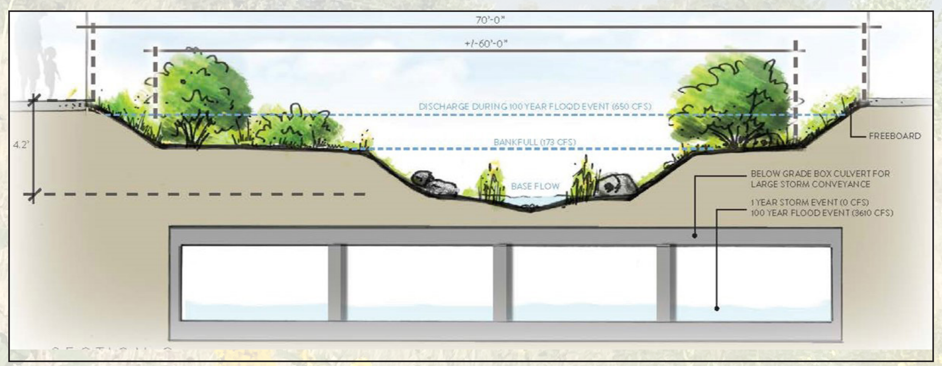
Sanderson Gulch Redesign has helped reduce local flooding and increased ecosystem services for the community. By splitting storm flows into two separate conveyance systems, the project has allowed base flows to remain in an open channel with improved wildlife habitat and water quality benefits while safely handling storm events that exceed a 10-year return interval. Since completion of the project, there have been several storm events that have filled the open channel floodplain and none have resulted in neighborhood flooding or caused damage to the channel's green infrastructure elements demonstrating that creating higher functioning, lower maintenance systems is achievable in urban areas.

Introduction

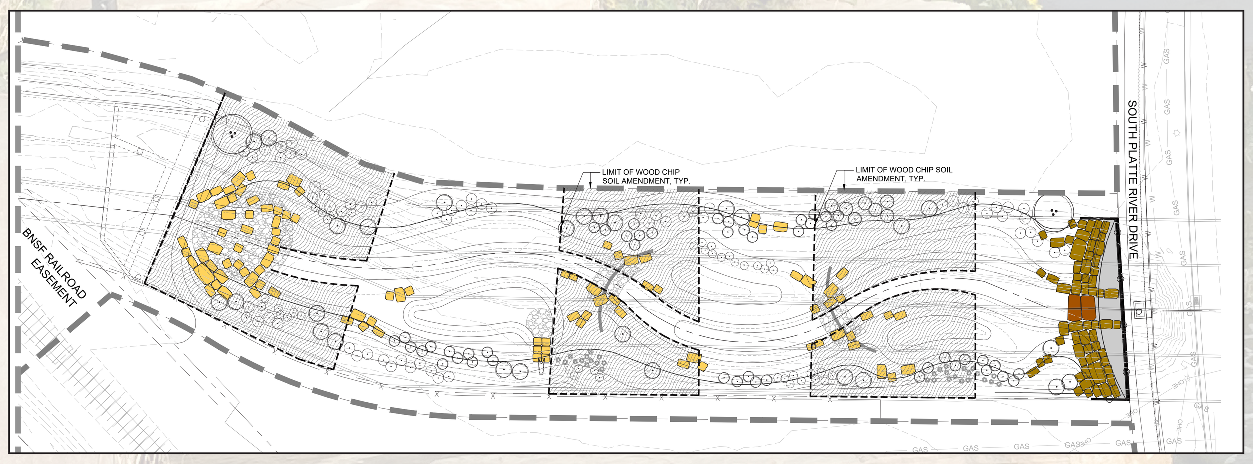
Sanderson Gulch drains an approximately **10 mi² watershed** from the west side of Denver to the confluence with the South Platte River (SPR). Just prior to the confluence with SPR, the gulch is constricted by road and railroad crossings that caused regular overtopping, **flooding more than 100 homes and businesses**. Additionally, the site is adjacent to a former **radium processing facility** that resulted in radioactive soil contamination. Matrix Design Group's Ecological Services team (Matrix; formerly part of Great Ecology) was brought in to lead **ecological restoration design elements** and help facilitate adaptive management activities post-construction. Within this project, test plots were implemented to **explore the effects of wood chips as a soil amendment with the hypothesis that it would benefit native species establishment by modifying the carbon to nitrogen ratio** and provide Denver Parks and Recreation (DPR) and Mile High Flood District (MHFD) with a new tool to promote the establishment of native areas while also reducing a waste product from municipal forestry operations.

Methods

The design team developed a **higher capacity drainageway system consisting of a naturalized, open channel, which conveys and filters base flows and runoff from smaller storms and also improves drainageway habitat.** The grading plan for the stream channel includes small meanders and overbank swales to provide habitat variability and water quality benefits. The plant palette and seed mixes are comprised of native wetland, riparian, and upland grasses, forbs, and shrubs. Below the channel, a **complex network of large capacity stormwater box culverts manages high-water flows during large storm events** and moves the water below the road and railroad crossings allowing increased conveyance and removing the homes and businesses from the floodplain.



The wood chip pilot study consists of two treatments: the control treatment is imported topsoil (NOWC) and the modified treatment is imported topsoil mixed with 4-parts topsoil and 1-part weathered WC. The seeding and planting for both treatments stayed the same and these treatments were replicated three times, for a total of 6 treatment plots.



A **temporary irrigation system was installed** throughout the project site to aid in native species germination and establishment; however, after two years, irrigation was cut back throughout the site as native grasses and forbs have established and one goal of this project is self-sustaining plant community.

In addition to routine monitoring and adaptive management recommendations, Matrix conducted annual vegetation and soil assessments of the wood chip pilot study. Beginning in 2020, the first-year post-construction, Matrix used **randomly selected quadrat sampling to assess total plant cover and diversity** of plant species in the WC and NOWC plots. Additionally, **six composite soil samples were collected across the two treatments** to test soil quality and nutrient availability.

References:
Blumenthal, D. M., N. R. Jordan, and M. P. Russelle. 2003. Soil carbon addition controls weeds and facilitates prairie restoration. Ecological Applications 13:605–615.
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Paul, Eldor A., and Francis Zvomuya. "Soil phosphorus: Characterization and analysis for precision agriculture." Advances in Agronomy 124 (2014): 1-44.
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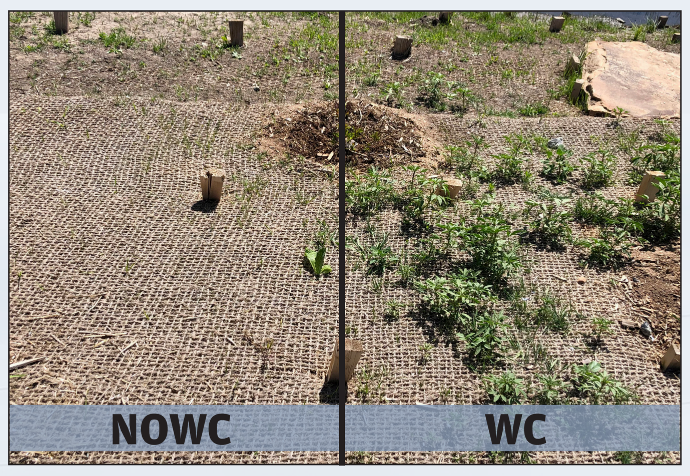
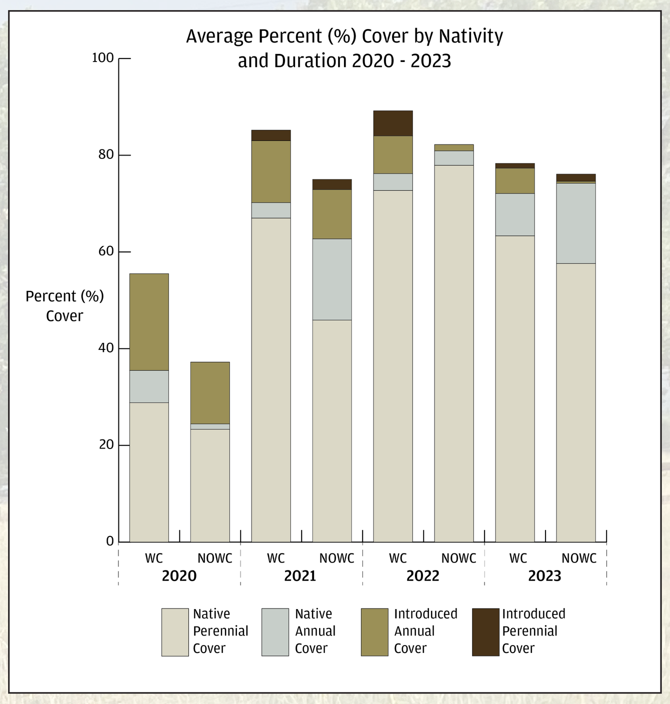
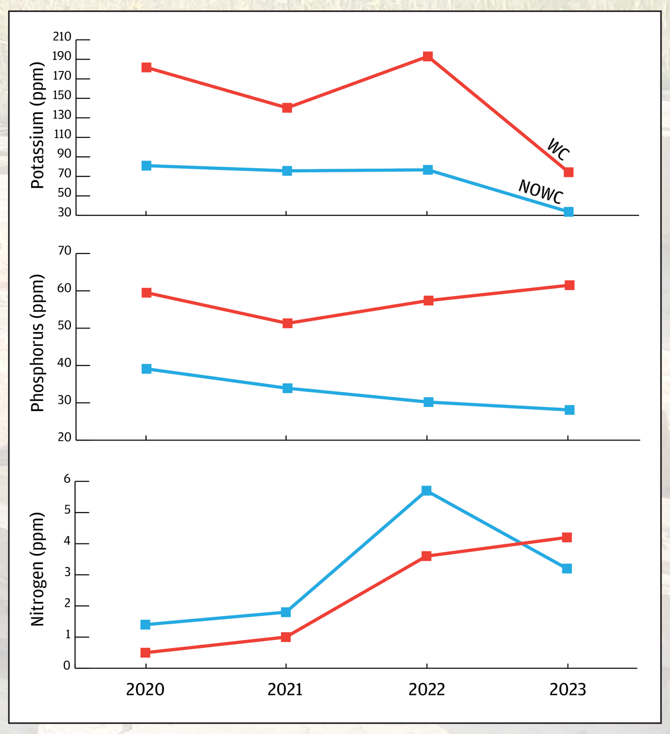
Results



The site is now **dominated by native species with high diversity** amongst grasses and forbs. Wetlands have formed adjacent to the stream providing numerous benefits such as **water filtration and wildlife habitat**. Wildlife have been observed using the site including a variety of bees and butterflies, many species of waterfowl, small mammals, snakes, and lizards.



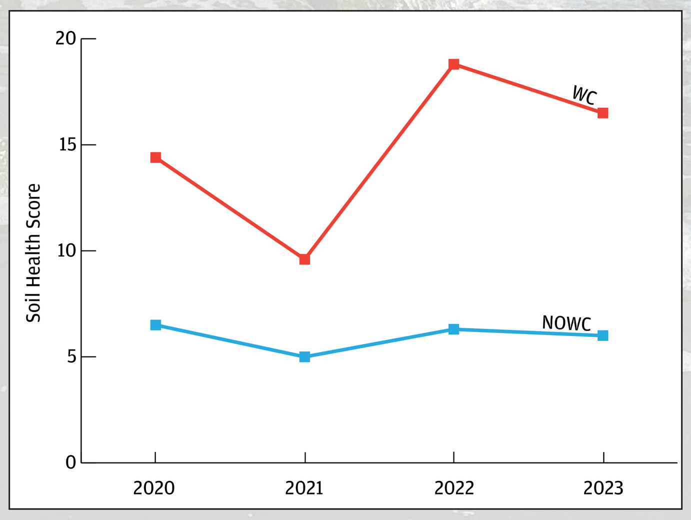
Post-construction vegetation monitoring has been conducted throughout the site to document the native, non-native, and noxious species establishment. Following each monitoring event, maintenance items and adaptive management recommendations such as non-native and noxious weed control, interseeding, and irrigation adjustments were communicated to the maintenance contractor which were performed monthly or as needed. By 2022, the third growing season post-construction, maintenance actions have significantly reduced because the **channel reached a state of dynamic stability** and needs less intervention to provide community benefits. The concerted efforts of the design, construction, and maintenance teams have resulted in a stream system that is aesthetically pleasing, provides wildlife habitat, green infrastructure, and reduced flooding to the community.



Wood Chip Study Results

Vegetation

First-year post-construction showed a significant difference in plant cover and diversity between the WC and NOWC plots, with **WC plots clearly showing improved establishment by native forb species.** The second year, total cover increased for both treatments, with NOWC plots having a significant increase in native annual species, primarily annual sunflower (*Helianthus annuus*) and Pennsylvania smartweed (*Polygonum pensylvanicum*). By year three, 2022, NOWC plots exhibited slightly higher native cover, but both treatments were near 80% native cover. 2023 saw total native plant cover decrease slightly to 72% and 74% for WC and NOWC, respectively, but there was a significant increase in native volunteer species in both treatments. **From a diversity perspective, by 2023, WC had 31 native species and 43 total species versus 27 and 32 for NOWC.**



Soils

Based on 2023 soil sampling data, **WC increased soil health relative to the NOWC plots.** WC plots contained higher levels of plant available nitrogren, phosphorus, and potassium on average. **Soil respiration, an indication of a soil's ability to sustain plant growth, was also higher in WC plots.** Additionally, the soil health calculation (or Haney Test), which measures the quantity of soil nutrients available to soil microbes, in WC was 16.5 compared to NOWC which averaged 6.0. Colorado native soils typically receive scores ranging from 2 to 15. **Generally, soil testing data indicate that WC amendments increase soil nutrients and improve overall soil health as compared to NOWC areas.**