Perennial Stream Reclamation

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About Mosaic Reclamation

> In carrying out its mission to help the world grow the food it needs, Mosaic couples recovery of phosphate resources with stewardship of the land that ultimately fuels thriving communities as well as American and global food production. While mining is a temporary use of the land, reclamation offers tremendous benefits for generations to come. In respecting this important balance, Mosaic continuously improves its reclamation practices to create sustainable habitats and other land use across the reclaimed landscapes.

Mosaic's dedicated team of reclamation scientists, engineers, ecologists and biologists develop detailed reclamation plans for the productive use of mined lands years before any phosphate is extracted from the ground. With Mosaic reclaiming any lands it disturbs, the reclamation plans focus on connecting preserved and reclaimed habitats to create a diverse and sustainable habitat network that is integrated into the larger regional ecosystem.

Enhancing the Science

Reclaimed habitats include streams and their associated floodplains as well as connected and isolated wetland and upland natural habitats, which include unique natural systems that are vital to the ecosystems of West Central Florida, such as bay swamps and palmetto prairies. Reclamation also offers an opportunity to enhance the broader quality of lands that were drained or otherwise affected by development, agricultural or other land uses many years before mining ever began. Mosaic designs its reclamation plans from a holistic perspective. The plans are centered upon creating a diversity of habitats that provide wildlife a place to call home, and increase the sustainability of the broader regional ecosystem. <

The Maron Run headwater tributary was reclaimed with a variety of wetlands communities, helping regulate the quality and quantity of water entering the Maron Run system.

Mosaic

INTRODUCTION

A Legacy of Connectivity

> Streams play an important role in the overall functionality of a watershed, as they are vital connectors between upstream and downstream habitats. Not only are streams responsible for supporting the watershed by managing water flow to surrounding habitats, they are a central feature for creating wildlife corridors that promote migration across habitats.

Perennial streams flow nearly year-round, offering homes and food supplies for a diverse group of water-dependent species. Even during the dry season, perennial streams provide habitat for fish, amphibians and aquatic insects (frogs, minnows, etc.) through water-filled pools.

Perennial streams can be located anywhere within a watershed. "Headwaters" are the beginning of the stream at its highest location. There, the water supply is provided by a combination of rainfall runoff from the lands that drain into the stream and movement of water through sub-soils during dry periods, also known as "seepage" or "base flow." Flow in "downstream segments" is contributed by rainfall runoff, seepage, and flow from one or more stream channels that flow into the downstream segment.

Two examples of successful perennial stream reclamation are Mosaic's Maron Run and Little Manatee River No. 8 (LMR 8) sites located in Polk and Hillsborough counties respectively. Maron Run is a "downstream segment" whereas LMR 8 is a "headwater segment." <

In Mosaic's reclamation projects, we connect stream systems with wetlands and lake systems, providing wildlife corridors and aquatic habitats.

Plants within a wetland system are highly dependent on how much water they receive and retain.

Natural Channel Design

> Stream design has advanced significantly in recent years because of the significant growth in the area of land restoration science. This includes advancements in digital mapping and hydrologic modeling.

Today, conceptual designs of reclaimed streams call for an increased level of intricacy and complexity on the front end of a project. Restoration designs are supported by leveraging sophisticated methods, such as the use of reference stream segments to assist in stream channel designs that are appropriate for the watershed. Such details include: channel dimensions; the strategic placement of sand and overburden soils; and defining the proper meander patterns. Computer models and techniques specifically map water flow and flood storage patterns; in-stream habitat for fish and aquatic insects; and corridors for connecting other habitats – natural and reclaimed – to allow for wildlife movement.

When reclamation began at Mosaic's Maron Run, circa 2000, its conceptual designs were less prescribed than those in use today. In fact, older designs allowed the stream channel to develop on its own over time. At that time, the methods used in upfront design primarily focused on the creation of the stream valley. Today, there are two methods of stream creation – hydraulic and mechanical.

When a stream channel is hydraulically carved, water is pumped and recirculated in a manner to simulate storm events, creating the stream channel within a few months. Post channel creation, woody debris is strategically installed, the banks are stabilized with biodegradable fabric, and the banks and floodplain is revegetated.

The other method to create functional streams is through mechanical construction. This method consists of excavating the meandering channel to the design dimensions in the stream valley, installing woody debris, and stabilizing the banks with vegetation and biodegradable fabric. Stream channel meanders and design dimensions are determined by classifying and assessing existing streams in order to mimic natural conditions. The design is based on characteristics of stable streams with similar drainage areas known as the reference-reach method or through use of mathematical equations based on the study of numerous streams representing a range of drainage area sizes.

For streams created through hydraulic carving, target channel dimensions are based on the same principles applied to mechanically constructed streams.

Whether carved hydraulically or constructed mechanically, streams constructed using the current state of the science have been extensively measured and monitored by applying stream habitat and condition assessment methods developed by the Environmental Protection Agency and the Florida Department of Environmental Protection (FDEP). <

Mosaic designs reclaimed streams to return the systems to a more natural state.

Perennial Stream Design At-a-Glance

Design Components	Maron Run	LMR8
Pre-mining Condition	• Site included an existing stream system but with reduced quality. • With the main channel and associated floodplain for this stream preserved, the two headwater tributaries to Maron Run were permitted for mining.	• Pastureland unsuited for most wildlife. • Pre-mining land uses included cattle ranching and sod farming.
Project Timeline & Milestones	• Mining occurred at this site in 1995. • Reclamation began in 2000 and was released in 2006. Mosaic reconnected the Maron Run headwater tributary and adjacent wetland systems to the watershed that now serve the Peace River watershed as fully functional wetland systems.	• Mining occurred on this site at Mosaic's Four Corners mine in 2004-2005. • Reclamation construction took place between 2006-2010. • Currently the site is continuing maintenance and supplemental planting.
Design Methods & Points of Focus	• Original emphasis was on construction of the forested wetland and initial vegetation. • Design of the stream channel was a secondary design consideration. Stream was allowed to form naturally with an emphasis on developing a stable stream valley and establishing stream bank vegetation. • Channel enhancements were subsequently performed using the reference stream and dimensional parameters. (A reference stream is a high-quality stream in the vicinity of the mining area that displays the same characteristics as the proposed reclaimed stream system.)	• An engineered Rosgen design class was determined. (The Rosgen classification system developed by Dave Rosgen is the most widely applied river classification system used in the U.S.) • Modeling was done to ensure the channel width and depth was sized to convey flows without excessive bank erosion (flow speed too high) or shoaling (flow speed is so slow that sediments build up and the channel becomes weed infested). • Reference stream was used to design the stream classification.
Connectivity Aspects	• Maron Run is fed by water from two headwater herbaceous wetlands. Maron Run then flows to Bowlegs Creek, on to the Peace River, and eventually to Charlotte Harbor.	• LMR8 is connected to an upland xeric habitat by way of an upstream seepage slope wetland. • It is also connected to a downstream wetland system as well as nearby Howard's Prairie. • Howard's Prairie is a wetland basin that flows to the Little Manatee River.

Perennial Stream Design At-a-Glance continued

Design Components	Maron Run	LMR8
Drainage & Hydrology	• Again, Maron Run is fed by water from two headwater herbaceous wetlands. Maron Run then flows to Bowlegs Creek, on to the Peace River, and eventually to Charlotte Harbor.	• Utilized data from the broader watershed/ basin size to determine the velocity of water flow that would drive the stream's width as well as calculated the number and dispersing of pools and riffles to create proper water flow. • Use of woody debris and biodegradable erosion control matting to control bank erosion. • Groundwater flow provides connectivity to the upland seepage-slope component and supports consistent stream baseflow. • Stream offers channel margins and diversity of water depths that provides habitat for macroinvertebrate and fish.
Vegetation	• Initial vegetative focus was on establishing the stream bank to ensure stability for the system. • Plantings were done to mimic the floodplain vegetation that existed prior to mining.	• The use of woody debris and vegetated floodplain helped to create species habitat. • Native plant communities along the stream corridor provide a source of organic matter that contributes to the overall ecology of the stream.

Building Success

> Converting the conceptual designs of a reclamation plan into on-the-ground streams and associated habitats is accomplished by first backfilling and grading the mined areas and developing the stream channels (mechanically or hydraulically). Next, the site is planted with native vegetation. From there, each site undergoes an extensive period of monitoring and maintenance until it is self-sustaining and meets the design criteria. The monitoring and maintenance phase help gauge the site's development through the availability of various performance data. Once constructed, improvements occur over short- and long-term periods as can be seen in the evolution of Maron Run.

Backfill and grading requirements to return the mined land to the design topography are determined using computer models and advanced digital aerial imagery. Most often, sand separated from the phosphate ore matrix is pumped to bring the site to the necessary grade. This is known as "sand backfill." At this time, for stream design, it is important to ensure the remaining overburden is cut down to an appropriate level to assure proper groundwater flow to the stream. Earth-moving equipment, typically outfitted with GPS-based technology, is used to contour sand and overburden to approved vertical tolerances as narrow as three inches.

Once the foundation has been established, the process of revegetation begins. On many reclaimed stream sites, Mosaic relocates desirable native vegetation from donor sites (often sites permitted for mining) and constructs upland buffers surrounding stream systems to enhance wildlife corridors as well as connect other habitats. To help establish floodplain vegetation, Mosaic often relocates top soil from wetland areas not yet mined. Known as "muck," these top soils contain diverse seed banks, which help establish desirable native vegetation and reduce the growth of unwanted non-native vegetation.

Mosaic enhances stream habitats like this one by planting wetland sod along the banks to develop wetland floodplain systems that connect to adjacent upland areas.

After construction, each stream and adjoining wetland is monitored routinely to measure habitat and conditions, flow patterns, water quality, the growth and development of vegetation, and the presence of unacceptable plant material. Maintenance, such as removing unwanted vegetation or adding in-stream habitat enhancements, occurs as needed. Over time, as the site matures, additional planting of shrubs and groundcover is completed as the tree canopy provides the necessary shade for light-sensitive species. <

EXECUTION

Perennial Stream Execution At-a-Glance

Execution Components	Maron Run	LMR8
Establishing the site's topography	• Sand was used to fill the site to elevations and provide soil types that would generate year-round base flows.	• Sand was used to fill the site to elevations and provide soil types that would generate year-round base flows.
Construction Methods & Techniques	• Following the final contouring of the land, the stream valley was constructed to accommodate the designated flow/ velocity of water.	• Utilizing engineered construction drawings of channel design, stream dimensions were demarked using survey tools. • Contouring stream banks, riffles, pools and slopes were installed using a combination of heavy equipment and by hand.
Stream Channel Development	• Stream channel was created by water naturally flowing down the stream system. • Pools created in the stream help to manage velocity/flow.	• Biodegradable erosion fabrics were used in the channel banks to aid in stabilization.
Revegetation	• Initially planted vegetation along the stream banks and floodplain to stabilize the stream system. • Planting profile was based on forested wetland floodplains in Bowlegs Creek/ Peace River.	• Native vegetation was planted along the slopes and stream banks. • Native topsoil from similar habitat in the area was transplanted. • Leaf litter was used in the channel to populate biological components such as aquatic insect populations.
Establishing Water Flow & Quality	• Protective ditch and berm and sump system remained in place until vegetation was established, water quality met Class III standards and the FDEP approved reconnection to state waters.	• Coconut fabric was used for stabilization. Trees/ plants were installed through the matting to establish erosion control near the banks. • Woody debris was installed to add roughness and create scour pool habitat as well as create diverse flow fields. • Once control methods were in place, the flow from the upstream wetland was reconnected to the newly constructed stream and the stream became active.

Perennial Stream Execution At-a-Glance continued

Execution Components	Maron Run	LMR8
Monitoring Water Quality & Vegetation	• Stream was reconnected to Bowlegs Creek in 2002 based on water quality monitoring. Annual vegetation monitoring indicates the stream has met success criteria.	• Since flow was established, it has maintained a perennial character. • Performed supplemental plantings; performed maintenance to control undesirable/nuisance vegetation. • Because this system is young, the trees do not yet provide a shade component; therefore, excess vegetation has been removed from the flow way. • Piezometer network installed to monitor ground water fluctuations. • Installed flow monitor gauge and monitoring transect.
Post-reclamation Improvements	• In 2009, the installation of woody debris helped create additional habitat for aquatic species as well as improved stream flow and water quality. • Post-reclamation increase of stream bank vegetation has expanded the available habitat.	• No enhancements needed, as newer design standards were used.

Measures of Success

> Success of any stream reclamation project is ultimately based on measurable attributes and conditions that are analogous to its natural counterparts, known as reference streams. A successful stream must demonstrate that it is a self-sustaining system that provides habitat connectivity and support to dependent species.

Determining the success of a reclaimed perennial stream includes the evaluation of several factors, including water flow characteristics, water quality, and appropriate breeding and foraging areas for fish and insects. Independent assessments of Maron Run and LMR8 applying the Florida Department of Environmental Protection Stream Condition Index (SCI) methodology found both streams to be "healthy." SCI is a biological assessment procedure that measures the degree to which flowing fresh waters support a healthy, well-balanced biological community, as indicated by benthic macroinvertebrates. <

The addition of woody debris to a reclaimed stream helps to create aquatic and macroinvertebrate habitat.

Mosaic uses sophisticated stream design techniques to ensure reclaimed stream systems provide proper hydrological functions to the systems they connect, as well as valuable wildlife habitat and corridors.

Perennial Stream Success At-a-Glance

Success Components	Maron Run	LMR8
Drainage & Hydrology	• Project restored water flow to Bowlegs Creek. • Flow monitoring indicates Maron Run has perennial flow.	• Flow stage monitoring indicates that reclaimed stream LMR8 is an intermittent stream, perennial in nature, with only short periods of no-flow conditions during the dry season and sustained flow during the rest of the year. • Water quality parameters measured meet Florida water quality standards: turbidity, conductivity and pH.
Site Performance	• Creation of several flourishing habitats within the stream bed and along the stream banks and vegetative surroundings. • Passed the FDEP SCI assessment criteria one year after the installation of woody debris, post-reclamation. • Maron Run provides high-quality ("optimal") stream habitat based on 2010 FDEP Stream Habitat Assessment score of 131. • Diverse fish population based on 2010 sampling (10 different species, including bluegill and largemouth bass). • Maron Run stream and headwater wetland project received the highest wetland quality score in the industry based on the FDEP's Peace River Cumulative Impact follow-up study (FDEP Uniform Mitigation Assessment Method [UMAM] functional assessment).	• Despite its young age, its SCI score of 35 suggests that LMR8 is supporting a macroinvertebrate community similar to healthy reference streams. • Macroinvertebrate colonization of LMR8 has resulted in a macroinvertebrate community that is typical of central Florida seasonal headwater streams. • Aquatic vegetation is abundant in the channel, trapping organic matter and allowing in-stream processing by biological organisms.

Connected Corridors

> Frequently, the types of streams that Mosaic requests to mine have been historically impacted through ditching or other agricultural use. Accordingly, stream-associated habitat values can be quite low. Therefore, a stream created in the reclamation process generally improves upon the pre-mining stream.

Overall, when Mosaic reclaims streams versus mining around them, the entire post-reclamation landscape can benefit. Reclaimed streams allow for more precise connections of surrounding habitats, which can result in superior stream function compared to that of existing streams, whose functions are often diminished by historic man-induced activities.

Reclaimed streams can more closely match the needs of the contributing watershed in conveying flows at proper speeds (velocities), improving floodwater storage to reduce downstream flooding, and the creation of habitat continuity along created corridors, connecting both other reclaimed lands and off-site property.

Because many of Florida's remaining natural habitats are small and fragmented by agricultural fields or development, reclamation offers an opportunity to make large-scale improvements for the benefit of many species. These large contiguous habitat blocks ultimately benefit the regional ecosystem.

With public funding unable to fully support expensive conservation land acquisition programs, mining and stream restoration may also provide permanent protection through conservation easements to help ensure the availability of high-quality habitat for generations to come. <

Each variety of wetland habitat contains unique plant species that require differing amounts of water at the right times of year for support.

If streams that connect wetland systems do not deliver the needed water, those habitats will not thrive.

All photos were taken at Maron Run and Little Manatee River No. 8 (LMR8), reclaimed perennial streams located in Polk and Hillsborough counties respectively.