JOHNSON FIELD (RE)CREATION

ENTRY D14

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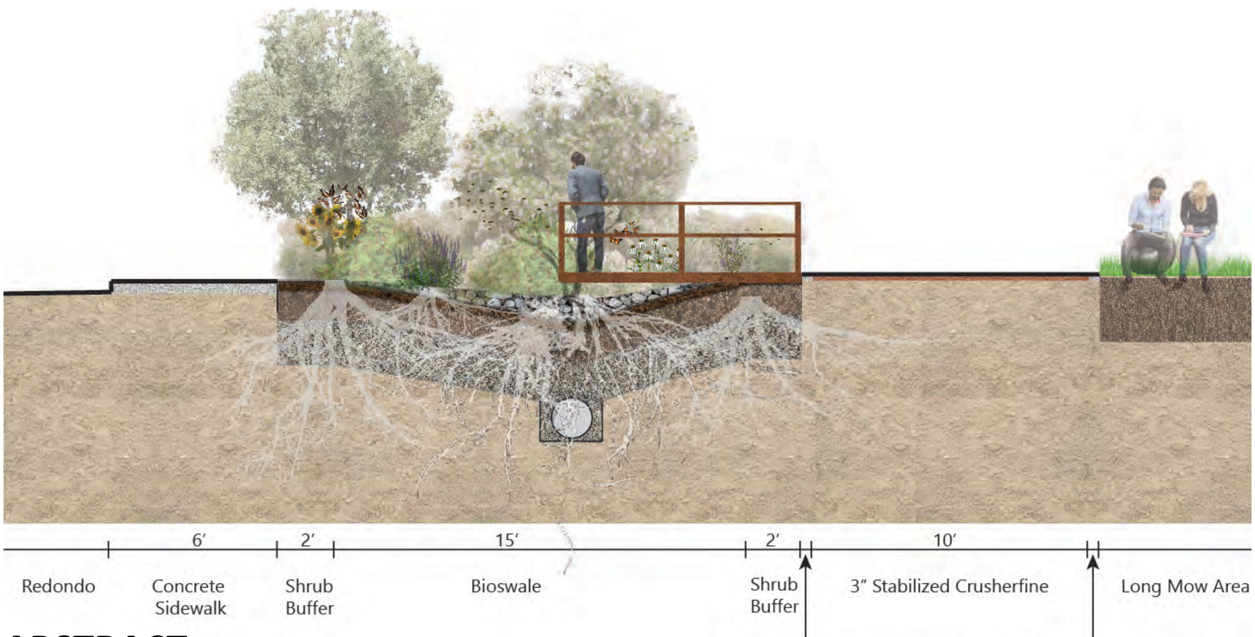


ABSTRACT

Johnson Field serves as the primary outdoor recreation area for the main campus of the University of New Mexico. With an estimated 35,000 visitors per week (West 2017), it is one of the most popular places in Albuquerque, and perhaps the state. Due to the heavy use and high visibility of the field, it is a top priority for renovation. Redesigning the field presents an opportunity to improve the services and benefits that the field provides to UNM and the larger community. Two upcoming projects in the area, the Johnson Center expansion and the Princeton Avenue realignment, expand the potential impact of a re-imagined Johnson Field. Incorporating green infrastructure (GI) into the field addresses issues of both water quantity and quality created by runoff from nearby surface parking and roads. The site is also a prime location for data collection and demonstration that would benefit not only UNM but the entire region as the Middle Rio Grande Valley expands the practice of Low Impact Development to comply with rigorous new standards laid out in the EPA-issued watershed-based Municipal Separate Storm Sewer Permit. In addition to supporting regional permit compliance, this design proposes multifaceted strategies for water conservation in the Southwest, as well as layered benefits to improve safety, access, health, habitat, and education. With the GI and LID features included in the proposed design, Johnson Field could expand beyond its current functionality to become a state-wide destination for recreation and learning.

SITE SELECTION

Elevations in UNM Watershed

Opportunitie

One of two large open spaces on campus, Johnson Field sits at the top of UNM's watershed and therefore meets the first rule of watershed management: start at the top (Lancaster 2013). Changes made at the top of the watershed more positively impact downstream flooding and help prevent the accumulation of contaminants. With an area of 11 acres, Johnson Field has the space needed to mitigate issues of water quantity and quality. The soil conditions, turf species, and irrigation system at Johnson Field are all outdated and inefficient. The team saw an opportunity for water conservation here unlike any other area on campus. As a highly used but otherwise rather dull space, Johnson Field could greatly benefit from added features for character, safety, enjoyment and comfort.

Visibility

With an estimated 35,000 users per week (West 2017), Johnson Field is one of the most-visited places in all of Albuquerque. Any interventions implemented would hold tremendous potential for education and public impact. In addition to heavy recreational use of Johnson field, students travelling from the dorms at the East end of campus walk through the field every day to reach the center of campus. With the planned addition of a new entrance to campus at Princeton Avenue, the field will greet even more visitors as they arrive at the University.

University Priority

The use and enjoyment of the field by students, classes, and the public merits a significant investment by the University. Although the University does not currently have money available for the renovation of Johnson Field, it is a top priority for funding in the next few years. The research and design proposal generated by the team has a realistic possibility to influence future development. Per the UNM Utility Master Plan, the implementation of landscaped designed to "control, slow, and retain stormwater" would be beneficial during landscaping renovations (WH Pacific 2013). According to the UNM Campus Master Development Plan Sustainability Goals (2009, 30), University objectives include, "Creating standards for site development and all landscaping that will reduce the use of potable water for irrigation, enhance the health of the living environment and create attractive, comfortable spaces for the University community," as well as, "supporting and encouraging interdisciplinary research that addresses the challenging issues of sustainable development." The latter objective includes, "Using the University campus as a living laboratory for research, practice, and development of sustainability principles, innovations, and practices." Implementation of the proposed renovations to Johnson Field would bring the campus closer to these goals.

SITE ANALYSIS

Water Quality

As a co-permittee of the watershed-based Municipal Separate Storm Sewer Permit (MS4) issued by the EPA in 2014 to fourteen entities in the Middle Rio Grande Valley, UNM is required to implement GI/LID Best Management Practices "where feasible" to meet surface water quality standards (EPA (b) 2014, Page 23 of Part 1). Currently, the Rio Grande River is listed as impaired, with E.coli bacteria, oxygen-depleting substances such as nutrients, and polychlorinated biphenyls (PCBs) being the primary contaminants (Ciudad SWCD 2014). Like many contaminants, PCB's attach to sediment and are carried to the river. Contaminants in runoff from Johnson Field include any unused fertilizer (nutrients) and herbicides as well as bacteria from dog waste. Contaminants from the road and parking lots south of Johnson include oil, grease, hydrocarbons, heavy metals, and bacteria, debris including cigarette butts, and sediment, while the runoff from nearby dorm and recreation center roof areas would primarily include E. coli from bird waste as well as collected sediment (Nichols et al 2005).

Water Quantity

Flooding on Redondo Drive 9.30.2017

Storm drains do not currently exist in the parking lots to the south of Johnson Field or along Redondo Drive. Due to the large areas of impervious surfaces, runoff during a precipitation event quickly causes flood conditions along Redondo Drive, at the entrance to campus on Stanford Drive, and in front of the School of Architecture and Planning. In winter, shade from the School of Architecture building ensures that remaining runoff freezes and causes a safety issue. Historically, campus runoff in the project area flows to Central Avenue, continuing to Downtown Albuquerque. Flooding in Downtown is severe and of great concern to the City. For example, the Central Avenue underpass located approximately 2 miles west of the project site has frequent flooding issues; in 2014, multiple vehicles were flooded within the underpass, forcing their occupants to swim to safety (McKee 2014).

Currently on Johnson Field, runoff only happens in events exceeding one inch (West 2017). When there is runoff, it flows to the southwest corner of the field. A berm was added to the west edge of the field along Johnson Center to prevent field runoff from entering the west entrance of the building. Now runoff flows along the berm and to Redondo Drive, washing out the crusher fine pathway in the process.

Water Use

Originally part of a golf course in the 1940's, the field has changed little in the past 75 years. Due to compacted soils and a 'hodgepodge' of irrigation zones and turf species, Johnson Field currently requires 70-75" of irrigation over its roughly 10-acre turf area every year. This equals approximately 60 acre-feet of water annually. The inefficient irrigation system creates maintenance problems when fields do require repair because the system is not zoned by field. Due to the short and intense nature of infrequent precipitation events in New Mexico, rain does not often provide the slow, steady water that turf requires, so irrigation is still necessary after most storms.

Human Use

Tens of thousands of people enjoy Johnson Field every week. Joggers, PE classes, intermural sports, ROTC training, marching band practice, the UNM Rugby teams, summer sports camps and tournaments, and local recreational sports leagues are just a few of the regular user groups. Students living in the dorms east of Johnson cross the field to reach the center of campus. In addition to daily use, Johnson also hosts large university events and public rallies. Due to these events, maintaining unobstructed visibility across the field is essential. Thousands of K-8 students visit UNM each year for tours and events. The busses that bring these students to campus park in the driving lane along Redondo Drive, causing a safety issue for cyclists and cars forced to share 1.5 lanes on a 2-lane road.

Ponding and washout on jogging path 9.30.2017

As the largest open area near the UNM Hospital (which is the regional trauma center), the north half of Johnson Field is a secondary helicopter landing site for the hospital and must also maintain access for ambulances at the northwest corner of the field.

Other issues include exposure, accessibility, and vandalism. Despite heavy year-round recreational use, Johnson Field currently provides limited shade at a few perimeter trees. The crusher fine pathway that rings the field is uneven, often washes out, exhibits ponding during rain events, and is generally not ADA compliant. Six to ten irrigation heads must be replaced every week due to vandalism. Damage caused by cars driving onto the field is also a concern.

Future Development

A realignment of Princeton Avenue is proposed. This realignment will provide a new campus entry that ties directly to Johnson Field. The construction of a 15,000-square foot addition to Johnson Recreation Center adjacent to the field is in the design process. These two projects will increase visibility and use of the field, as well as creating opportunities to connect the field to runoff generated by new and existing development.

DESIGN

Water Systems Overview

Upon inspection of existing grades and elevation, the team realized that it would be possible to capture stormwater runoff from large areas of the parking lots south and southwest of Johnson Field for filtration and use on the field(Basin J-1)[1]. Water from the southernmost parking lot (Basin J-3) flows through a stormwater tree trench before entering a C-inlet connected to a stormdrain system which leads to a manhole at the east end of the bioswale. Flow from the student residence parking lot (Basin J-2) drains directly to Redondo Drive, where it is collected via two C-inlets within Redondo Drive. This flow also enters the stormdrain system and flows

1 The lot to the southwest would require regrading or a significant pump system to carry water to Johnson Field and was therefore not included.

into the manhole. The manhole operates as an inverted siphon, carrying the stormwater under the roadway. Once the manhole fills with stormwater under pressure, the stormwater will flow out of the manhole's slotted cover and enter the bioswale. After the storm has cleared, a weather-based sensor signals a smart valve to open, allowing the system to drain through an 18" diameter perforated pipe located under the bioswale.

During storm events greater than the 10-year storm, the stormwater tree trench at the west end of Basin J-3 can overflow to Princeton Avenue via a series of sidewalk culverts and to the City of Albuquerque right to way via Central Avenue. During storm events greater than the 10-year storm, Basin J-2 will continue to be contained within the stormwater system under Redondo Drive and routed to the bioswale, which will then overflow to Redondo Drive via a sidewalk culvert at the southwest corner of the field.

Roof runoff from the new addition to Johnson Center is stored in two cisterns framing the entrance to the addition. This water is later released into the west end of the bioswale, providing non-potable irrigation in the many months without precipitation. The proposed system uses no pumps, as the aridity of New Mexico and the irregularity of precipitation events means pumps are infrequently used, which causes operation issues.

To mitigate runoff from the turf areas, the playing fields are recessed 2". This provides 40,800 cubic feet of detention and prevents runoff during all storms under the 200-year event. The sidewalk at the east and south edges of the field and the permeable loop path are both sloped to drain to the bioswale and planting buffers. In events exceeding the 200-year storm, the field runoff will follow historical drainage patterns, flowing to the bioswale in the southwest corner of the site. There, the flow will be guided to Redondo Drive via sidewalk culverts and will follow its historical path to Central Avenue. The reduction and slowing of the flow to Central Avenue will help to reduce flooding issues downstream, most notably in the underpass located approximately 2 miles downstream of the project site.

MS4 Requirements

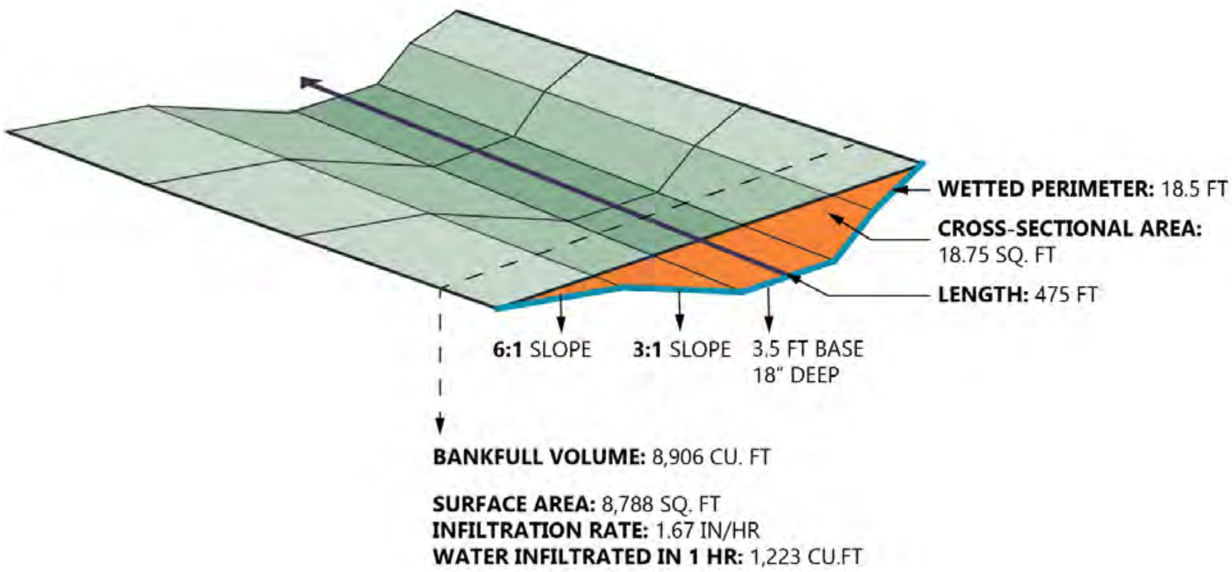
Per the watershed-based MS4 Permit, newly developed sites must capture all water from the 90^{th} percentile storm, while redevelopment must only capture the 80^{th} percentile event. As a demonstration site, it is imperative to design to the higher standard. In Albuquerque, the required treatment volume for on-site management of the 90^{th} percentile storm event is 0.65" (Holcomb et al 2017). This requirement drove decisions for the sizing of the bioswale to capture runoff from the road and parking lots. Another primary influence was selecting features that have demonstrated ability to filter the contaminants of concern. A hydrodynamic separator was considered to fill this role, but due to recommendations found in research (Nichols et al 2005), it was decided to rely on a bio-infiltration feature[2]. Bio-infiltration features have been shown to filter heavy metals, suspended solids, sediment, bacteria, oil and grease, and hydrocarbons (County of San Diego 2014, Jiang, Yuan, Piza 2015).

The two bio-infiltration features selected are a 2,350 square-foot stormwater tree trench and an 8,550-square foot bioswale. Both features include an 18-inch gravel base storage layer under a 12" layer of bio-infiltration medium. These design specifications are recommended for increased water storage in warm deserts (Houdeshel et al 2012). To allow infiltration to the subsoil and encourage deep root growth of drought-adapted plants, neither feature is lined. To encourage development of beneficial soil bacteria that reduce contaminants, both features

2. Bio-infiltration is a synonymous term with bio-retention, however, because retention of water is an illegal practice in New Mexico, infiltration is a preferred and descriptive term.

include a 4-5-inch layer of shredded wood mulch. The grasses in the upper end of the bioswale were selected for their ability to remove heavy metals from runoff (Zhejiang 2008). Although pedestrians will be discouraged from walking through the bioswale (to prevent compaction and maintain infiltration ability), the depth was limited to 18" and the side slopes do not exceed 3:1, both for public safety. The Bioswale has a 0.5% slope, dropping slightly from east to west to provide more time for infiltration.

The cisterns at the entrance to the new Johnson Center addition were sized to meet the irrigation demand of the bioswale plants during dry months (50,000 gallons). Each cistern has a 12 foot diameter and is 15 feet tall. Cistern water is released into the bioswale through a 10-inch PVC pipe outlet with a swing check valve at the west edge. This design avoids the use of additional pumps or filtration needed with drip systems, thereby reducing both cost and maintenance while simultaneously mimicking water flow in a natural riparian environment.



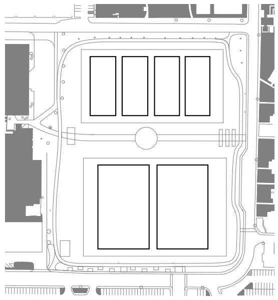
Bioswale Metrics

Water Conservatio

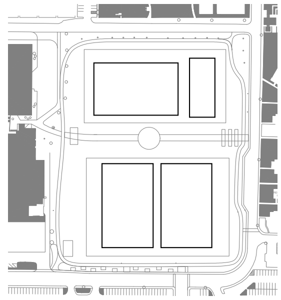
In an average year, the bioswale would capture and infiltrate approximately 1.1 million gallons of water (3.3 acre ft), and water harvested from the roof of the Johnson Center addition would direct and additional 83,000 gallons (0.25 acre feet) to the bioswale. The sum of these numbers, approximately 3.5 acre feet, represents an offset of potable water that would otherwise be used to irrigate trees, shrubs, and grasses at the perimeter of Johnson Field.

As a heavily used and beloved turf area, Johnson Field merits intensive water use. However, that could be greatly reduced with a multifaceted approach. First, this design proposes an overall reduction of turf area from 10 acres to 8.6 acres. Second, playing field areas requiring the most intensive irrigation to support grass regrowth and repair have been consolidated while maintaining field size requirements for popular sports.

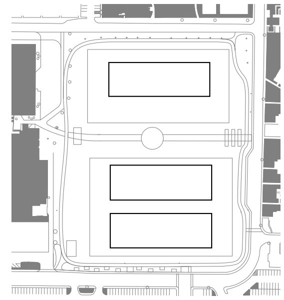
Third, playing areas are recessed 2" to collect rain for slow infiltration. The often short, intense nature of rain events in the Southwest does not provide the slow and deep water that turf needs. Recessing the playing fields allows rainwater to collect and slowly infiltrate, offsetting irrigation needs.



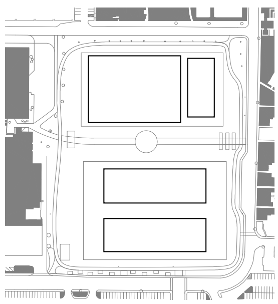
4 FLAG FOOTBALL FIELDS - 70 yds x 30 yds
2 REGULATION SOCCER FIELDS - 60yds x 100 yds



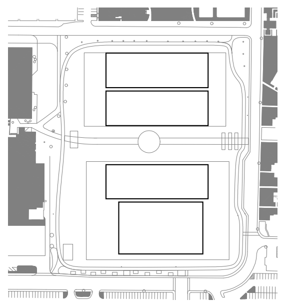
3 REGULATION SOCCER FIELD - 60yds x 100 yds
1 FLAG FOOTBALL FIELD - 70 yds x 30 yds



3 ULTIMATE FRISBEE FIELDS - 40 yds x 120 yds



1 RUGBY FIELD - 100 m x 70 m
1 FLAG FOOTBALL FIELD - 70 yds x 30 yds
2 ULTIMATE FRISBEE FIELDS - 40 yds x 120 yds



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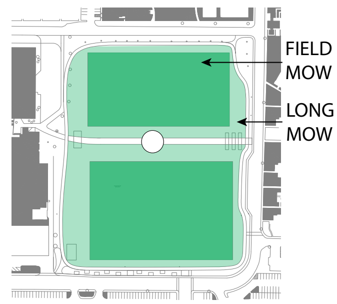


GRASS MOWNG

Combinations of Regulation Playing Field Sizes on Designated Low-Mow Areas

A differentiated mowing strategy removes 35% of turf area from the high maintenance zone. For playability, sports fields must be mowed to between 1.5 and 2 inches. The shorter mow results in higher evaporation and shallower root growth, which requires more frequent irrigation. The areas not designated for sports fields would have a higher mow of 4 inches. The longer grass blade length shades the surface, decreasing evaporation and encouraging deeper root growth, which reduces irrigation needs for this area.

The higher mow area would also improve safety by indicating to players that they are leaving the playing field through a subtle change in surface. This difference could keep players from running into light poles or trees at the perimeter, which is currently a safety concern, and would also trap runaway balls from rolling to the street.

The University stated a desire to excavate the entire field, amend soil to 24" depth, and re-sod as part of the renovation (West 2017). A silty loam soil would maximize plant-available water while maintaining infiltration (Leinauer and Smeal 2012). However, existing subsoil is the sandy loam present in most of the University area. The soil amendment would realistically be a sandy silty loam with higher infiltration and lower plant-available water. In either case, improved soil would allow for deeper root growth and reduced irrigation need.

Another design feature to conserve water is subsurface drip irrigation (SDI). SDI has been used for turf fields in arid regions for over twenty years, but is not yet widely practiced in Albuquerque. The City of Albuquerque is working with New Mexico State University to run two tests of SDI in city parks, and initial results show 30-50% water savings (Lopez 2017). Because the current Johnson Field irrigation system and soils are particularly inefficient (40-45%

efficiency), the 90% efficient SDI system would bring measurable water savings (Hammersmith 2015).

SDI tubes are laid at a 6-inch depth, encouraging deep root growth and greatly reducing the need for aeration to combat compaction resulting from overhead watering. Second, fertigation (application of liquid fertilizer through the drip lines) would eliminate contribution of nutrients to surface water runoff. Third, SDI doesn't involve the pop-up irrigation heads that cause vandalism and liability issues for the University.

Soil moisture sensors and a weather-based control system will also be incorporated to maximize water conservation. Although warm-season turf species would bring additional water savings, due to the heavy year-round use of the field, higher water use cold-season species must be used.

Demonstration and Visibilit

Although progress has been made, green infrastructure is not yet widely practiced in Albuquerque. The need for high quality demonstration projects and data collection have been identified as impediments to GI/LID practice in semi-arid regions (Lee and Fisher 2016). This design proposes monitoring of the bioswale for infiltration rate, flood risk reduction capability, reduction in concentration of key contaminants, and performance of soil and plant materials. Monitoring and data collection would be an interdisciplinary effort between Engineering and Landscape Architecture departments on campus. Data generated from this site would propel the widespread practice of green infrastructure in the Middle Rio Grande Valley.

In addition to regional demonstration significance, the water harvesting and filtration features of this project are designed to engage users. Visitors entering from Johnson Center would pass between two large cisterns and walk over pavement design indicating subsurface water flow. Visitors entering from the parking lots would walk across metal grate bridges. The change in surface texture draws attention to the space for water that has been created below. The C-inlets on Redondo are located next to the cross walk and also have a surface treatment on the pavement to show subsurface flow for pedestrian awareness. The piers over the bioswale provide spaces where people can inhabit a riparian system in the middle of the city.

The rain pavilion feature at the southwest corner of the field provides another opportunity for people to engage with rainfall. The roof collects water to the center trough pool, providing a dramatic show for people seeking refuge from a storm. Collected water then drains to the west end of the bioswale. Weather monitoring equipment housed at the impluvium adds another educational element and provides local weather data for the bioswale monitoring and weather-based irrigation system. Weather data specific to the site is critical in a state where one location might receive 2-inches of rain while an area one half-mile away might only receive a few drops.

Native vegetation in the bioswale and foothills grove provides an educational area for botany and landscape architecture students as well as the general public. The expansion of plant materials through a diverse plant palette and visible green infrastructure features connects human users to the natural environment. This reconnection has positive impacts on human psychology while also inspiring people to take better care of natural resources.

Creating a Plac

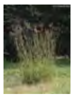
This design uses green infrastructure elements to bring a sense of place, interest, and comfort to the field. Seventy drought-tolerant shade trees trap air pollution, which is of particular relevance for a recreational area where most visitors will be exercising. Cooler temperatures

PHYTOREMEDIATION

For Heavy Metals:


Yarrow (*Achillea millefolium*)

For Hydrocarbons:


Big Bluestem (*Andropogon gerardi*)


Indian grass (*Sorghastrum nutans*)


Switch grass (*Panicum virgatum*)


Blue grama (*Bouteloua gracilis*)


Western wheat grass (*Pascopyrum*)

Plant selections for improved water quality and habitat

POLLINATORS

Pollinator Friendly Plant Varieties


Asters (*Aster spp.*)


Bee Balm (*Monarda spp.*)


Catmint (*Nepeta mussini syn. faassenii*)


Chamisa (*Chrysothamnus spp.*)


Coneflower (*Echinacea spp.*)


Globemallow (*Sphaeralcea spp.*)


Goldenrod (*Solidago spp.*)


Lupines (*Lupinus spp.*)


Penstemons (*Pestemon spp.*)


Salvia (*Salvia Merleau Blue*)


Sunflowers (*Helianthus spp.*)

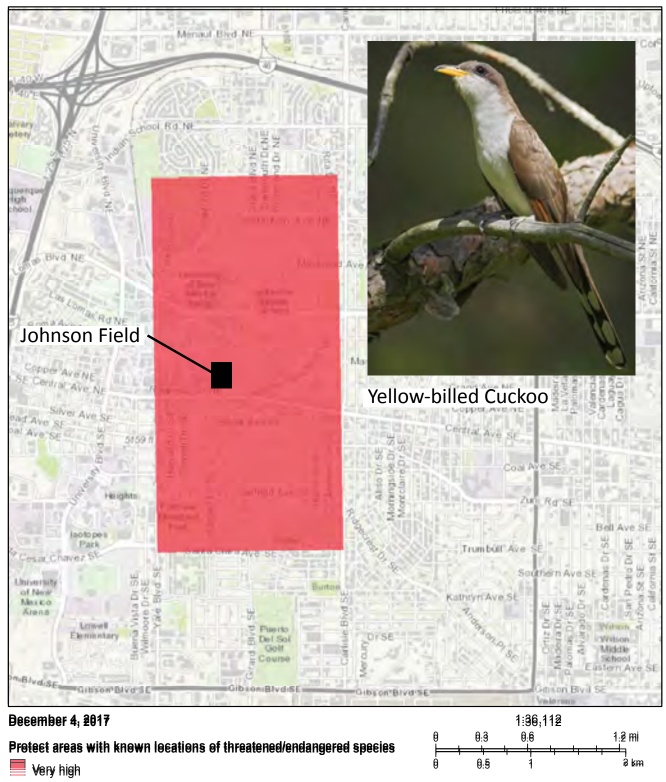
created by shade from trees also improves respiratory health and reduces the urban heat island effect. The foothills grove vegetation at the southeast corner of the field contains species native to the foothills of the Sandia Mountains, linking the field experientially to the mountains visible in the distance. In the bioswale, native riparian vegetation and built features such as piers and bridges signal to visitors the presence of water even when it is not raining, and evoke the Rio Grande. The allée, or double row of trees, at the north edge of the field provides a stretch of continuous shade for joggers. Plants in the bioswale and under shade trees were selected for pollinator habitat value and phyto-remediation ability.

The rain pavilion feature also offers shade in addition to being an educational and sculptural water harvesting feature. A central path bisecting the field provides a needed connection between main campus and the dorms to the east of Johnson Field. Sculptural gateway structures with vines at either end of the central path and provide much-needed summer shade. The reddish tint of the stabilized crusher fine jogging path contrasts with the green turf while also hinting at cherry red, one of UNM's school colors. The stormwater tree trenches on either side of the Princeton Drive create a dramatic entry.

Although they are not GI elements, a concrete sidewalk at the south and east edges of the field improve compliance with the Americans with Disabilities Act, thereby providing accessibility to all users and reducing liability to the University. Proposed additional path lighting increases visibility. A proposed bus bay at the east edge of the field will prevent buses from blocking travel lanes and creating a safety issue. The perimeter planting buffer separates the field from Redondo Drive while also discouraging people from driving onto the field and causing damage.

Habitat

In its present condition, the only potential habitat offered at Johnson Field is in the 26 trees. However, in the proposed design 1.14 acres of native and drought tolerant trees, shrubs, grasses, and groundcovers in the perimeter areas will provide habitat for birds and pollinators. In particular, it is hoped that the riparian system created in the bioswale will create needed habitat for the Yellow-billed cuckoo, a bird listed as federally threatened that has been observed on the UNM campus (New Mexico Natural Heritage Foundation 2017). The Yellow-billed cuckoo breeds in riparian woodlands and may find a home in or near the bioswale.



Map showing known location of Yellow-billed cuckoo

Materials

Materials were carefully selected for multiple benefits. The 6-foot wide concrete sidewalk at the south and east edges of the field has a cross slope to direct stormwater to the bioswale and planted buffer. It is lower maintenance and lower cost than a porous concrete or asphalt path. The stabilized crusher fine jogging path is 10-foot wide and permeable, providing a forgiving surface for joggers and walkers. The use of CorTen steel to signify entrances to the field is in line with university aesthetics and branding.

Plant materials fall into four main categories: native riparian vegetation, native foothills vegetation, drought-tolerant shade trees, and pollinator-plant understory.

MAINTENANCE

The maintenance for this design proposal would be less in some areas and more in others. There are not any current GI features on the site, so the addition of the bioswale, cisterns, impluvium pavilion, and shade trees would require additional maintenance, while the turf areas would require much less maintenance.

Currently, the field is mowed twice a week. With the new design proposal, the low-playing field areas would still be mowed twice a week, but they would be roughly half of the current low mow areas. The high mow field areas would be mowed once per week. This change would save an estimated 7-8 hours of labor per week.

The use of a subsurface drip irrigation system would reduce the maintenance efforts currently required for aerating eight times per year and applying granular fertilizer three to five times per year. Without overhead spray irrigation, aeration would be less frequently needed, and fertilizer would be applied through the drip system rather than being manually distributed. SDI would also decrease maintenance resources that currently go toward repairing vandalism damage to the above-ground irrigation system.

The addition of 44 shade trees as well as shrubs, perennials, and groundcovers for the pollinator habitat will increase the maintenance requirements for non-turf vegetation, and require light pruning twice a year. The bioswale would require inlet inspection after storms, outlet inspection and plant replacement every year, and a new layer of mulch every 2-3 years (County of San Diego 2014). The manhole and C-inlets will need to be kept free of debris and vacuumed out once a year.

The cisterns require minimal maintenance as they are gravity drained. Inspection of the first flush diversion and filters into the cistern would be needed monthly during the rainy season. Because the cisterns will not be connected to a pressurized drip system, only filtration of large debris would be required which is less maintenance than filtration of both large and fine debris that would be needed for a drip system.

BUDGET

In preliminary investigations into project cost, the University found that the renovation of Johnson Field, including soil prep, new overhead spray irrigation, and sod, would cost between $3.1 and $3.5 million. This design proposal includes a reduction in the sod, but an increase in tree and shrub material that would likely negate any savings from the reduced sod cost. According to a drip irrigation specialist, the labor for installation of SDI would be more than an overhead spray system, but the materials cost would be comparable (Hall 2017).

Item	Cost	Source for Cost Info
Field Renovation	$3.1-3.5 million	UNM PPD
Bioswale and Stormwater Tree Trench	$5,000	EPA Stormwater Calculator
Stormdrains, C-Inlets, Manhole	$60,000	City of Albuquerque Costs
Cisterns	$45,000	UNM PPD
Total	$3.2-3.6 million	

The construction of the bioswale would be a cost increase due to additional excavation and use of engineered soils. According to the EPA Stormwater Calculator, the stormwater tree trench and bioswale would cost between $4,000 and $5,300 to install. University guidelines on cistern installation show that the two cisterns, totaling 50,000 gallons of storage, would cost approximately $45,000 to install.

The cost of installing the C-inlets, overflow culverts, manhole with grate, and storm drain would be reduced if done at the same time as the Princeton entry construction. These elements would cost approximately $60,000 at City of Albuquerque prices. It is possible that these features could be included in the Princeton Entry construction budget rather than the Johnson Field renovation budget. If there is not room in the budget, one or two of the C-inlets could potentially be eliminated without significantly compromising the system.

The built and sculptural features, including the piers, bridges, and benches in the bioswale, the impluvium pavilion, are not expected to cost more than $100,000, and would be items dependent on University priority and budget.

Funding for the green infrastructure features of the project could be supported through the

New Mexico Environment Department Surface Water Quality grant for watershed-based planning projects, or through the National Fish and Wildlife Foundation Five Star and Urban Waters Restoration Grant Program. Both of these grants would require UNM to partner with other interested agencies. However, because of the need for green infrastructure performance data specific to Albuquerque, it would be easy to find other agencies interested in collaboration. Possible partners include the City of Albuquerque, the Albuquerque Metropolitan Arroyo Flood Control Authority, the Nature Conservancy, or Bernalillo County,.

CLIMATE RESILIENCY

Climate change will bring significantly higher temperatures to Albuquerque. It is predicted that "by mid-century, in Bernalillo County, average annual maximum and minimum temperature are projected to increase by 7.2° F and 6.2° F, respectively, compared to the 1950-2005 baseline period" (EPA 2016). Higher temperatures will increase evaporation rates and irrigation needs for vegetation. Although the annual amount of precipitation is not expected to change dramatically, it is likely that storms will become fewer and more intense (EPA 2016), making it even more critical to capture runoff to decrease flooding.

The university currently pumps its own water at a low cost. However, climate change and attendant effects on the mountain watersheds to the north of Albuquerque could result in a higher value of water in the future that would cause the university to consider using reclaimed water for irrigation. Climate change is likely to lead to water restrictions, such as the California ban on overhead spray irrigation in 2016. In either event, SDI would be a preferable system to use with reclaimed water from adjacent Johnson Center or dormitories. SDI eliminates public contact with reclaimed water and would not have the irrigation timing restrictions of an overhead spray system. SDI is also advantageous for climate resiliency because no additional water would be lost to higher evaporation rates.

Higher plant water needs were considered when determining the irrigation budget. Although a mature drought-adapted shade tree currently only needs 3,000 gallons of water annually to thrive (Phillips 2016), water budget calculations for the Phoenix area were used to determine irrigation needs for future temperatures (Difrancesco and Baker 2005).

The addition of 44 drought-adapted shade trees will mitigate the increased temperatures and urban heat island effect, keeping Johnson Field a usable place in summer months. The trees will also sequester carbon and capture pollutants. It is important that the trees have their own drip irrigation system and zone so that, in the event the University decides on overhead spray irrigation and spray irrigation is banned in the future, the trees will still have a reliable water source[3].

CONCLUSION

This redesign of Johnson Field demonstrates the many layers of benefits available with the inclusion of green infrastructure features. Capture and filtration of contaminants, reduction of flooding, generation of much-needed data that can have a regional impact, offset of potable water use for irrigation, and an increase in shade and vegetation diversity, all create a more habitable and enjoyable place for humans and other species.

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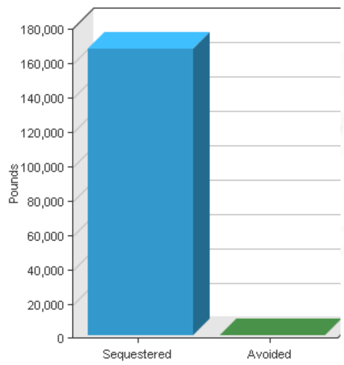
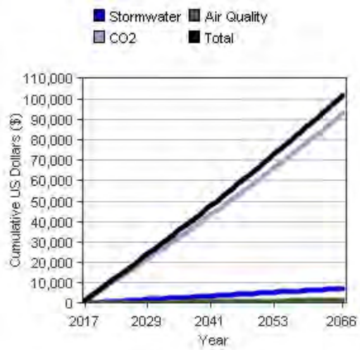
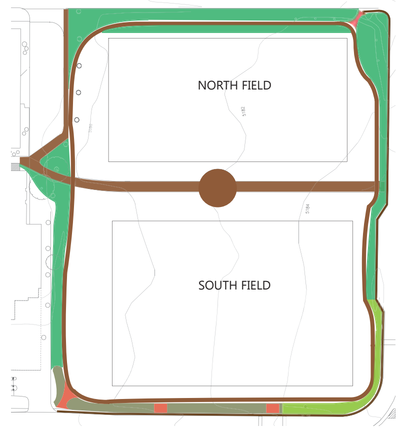
3. Many mature trees were lost in California during the drought because they were planted in turf with spray irrigation, and when that form of irrigation was banned, the trees died.

Tree Canopy Increase and Benefit
Existing: 26 Trees, 8164 sq ft canopy
Proposed: 70 trees, 21,980 sq ft canopy (170% increase)





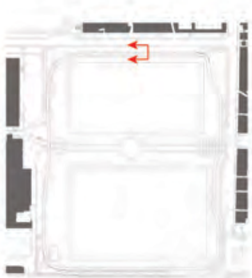
Annual Carbon Sequestration and Economic Benefits of Adding 44 trees to Johnson Field (Source: itree)



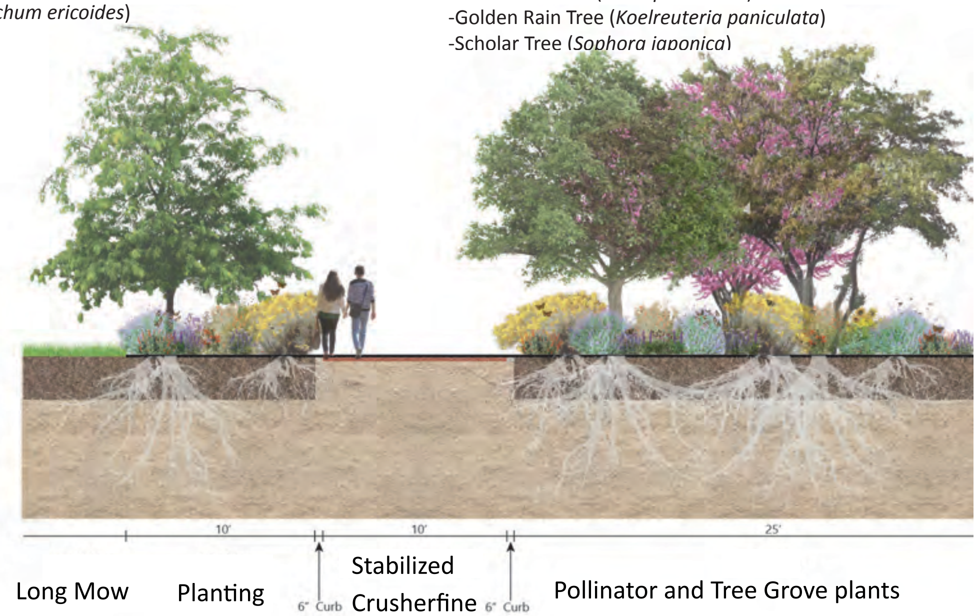
RIPARIAN ZONE PLANTING
Overstory
-Arizona Walnut (*Juglans major*)
-Soapberry (*Sapindus saponaria var. drummondii*)
-Arizona Sycamore (*Platanus wrightii*)
-Netleaf hackberry (*Celtis reticulata*)
-Shrub Live Oak (*Quercus turbinella*)
Understory
-Seepwillow (*Baccharis salicifolia*)
-New Mexico Olive (*Forestiera neomexicana*)
-Desert False Indigo (*Amorpha fruticosa*)
-Desert Willow (*Chilopsis*)
-Wolfberry (*Lycium barbarum*)
-Three Leaf Sumac (*Rhus trilobata*)
-Pink Muhly (*Muhlenbergia capillaris*)
-Alkali Sacaton (*Sporobolus airoides*)
-Giant Sacaton (*Sporobolus wrightii*)
-Western Wheat Grass (*Pascopyrum*)
-Yerba Mansa (*Anemopsis*)
-Rocky Mountain Bee Plant (*Cleome serrulata*)
-Golden Rod (*Solidago)*
-Globe Mallow (*Sphaeralcea*)
-Heath Aster (*Symphyotrichum ericoides*)

FOOTHILL ZONE LANDSCAPING
Overstory
-Gambel Oak (*Quercus gambelii*)
-Mountain Mohogany (*Cercocarpus montanus*)
-Pinon Pine (*Pinus edulis*)
-Ponderosa Pine (*Pinus ponderosa*)
Understory
-Apache Plume (*Fallugia paradoxa*)
-Three Leaf Sumac (*Rhus trilobata)*
-Bear Grass (*Nolina greenii*)

TREE GROVE LANDSCAPING
-Chinese Pistache (*Pistacia chinensis*)
-Purple Robe Locust (*Robinia 'Purple Robe')*
-Emerald Sunshine Elm (*Ulmus propinqua 'JFS-Bieberich'*)
-Frontier Elm (*Ulmus 'Frontier')*
-Oklahoma Red Bud (*Cercis reniformis 'Oklahoma'*)
-Net Leaf Hackberry (*Celtis reticulata*)
-Maverick Honey Mesquite (*Prosopis glandulosa 'Maverick'*)
-Texas Red Oak (*Quercus buckleyi*)
-Pinon Pine (*Pinus edulis*)
-Ponderosa Pine (*Pinus ponderosa*)
-Golden Rain Tree (*Koelreuteria paniculata*)
-Scholar Tree (*Sophora japonica*)



Section Looking Through Tree Grove



Basin	Area (sq ft)	Area (Ac)	Precipitation Zone	Land Type: A (Soil uncompacted by human activity, 0-10% slope)	Land Type: B (Irrigated lawns, parks and golf courses, 0-10% slope)	Land Type: C (Soil compacted by human activity; Minimal vegetation)	Land Type: D (Impervious areas, pavement and roofs)	$Q_{2\text{-Year}}$ (cfs)	$Q_{10\text{-Year}}$ (cfs)	$Q_{100\text{-Year}}$ (cfs)	$V_{2\text{-Year}}$ (cf)	$V_{10\text{-Year}}$ (cf)	$V_{100\text{-Year}}$ (cf)
$J\text{-}1_{EXIST}$	478240	11.0	2	0%	0%	90%	10%	8.0	20.3	36.2	2,842	4,543	8,170
$J\text{-}1_{PROP}$	478240	11.0	2	1%	89%	0%	10%	2.8	12.8	27.6	0*	0*	0*
J-2	98826	2.3	2	0%	1%	0%	99%	4.2	7.1	10.6	5,578	8,919	16,038
$J\text{-}3_{EXIST}$	108832	2.5	2	0%	7%	0%	93%	4.3	7.5	11.3	5,820	9,305	16,733
$J\text{-}3_{PROP}$	108832	2.5	2	3%	7%	0%	90%	4.2	7.3	11.1	-	6551.2**	21098**

Bioswale will be type A (8550 sq ft)

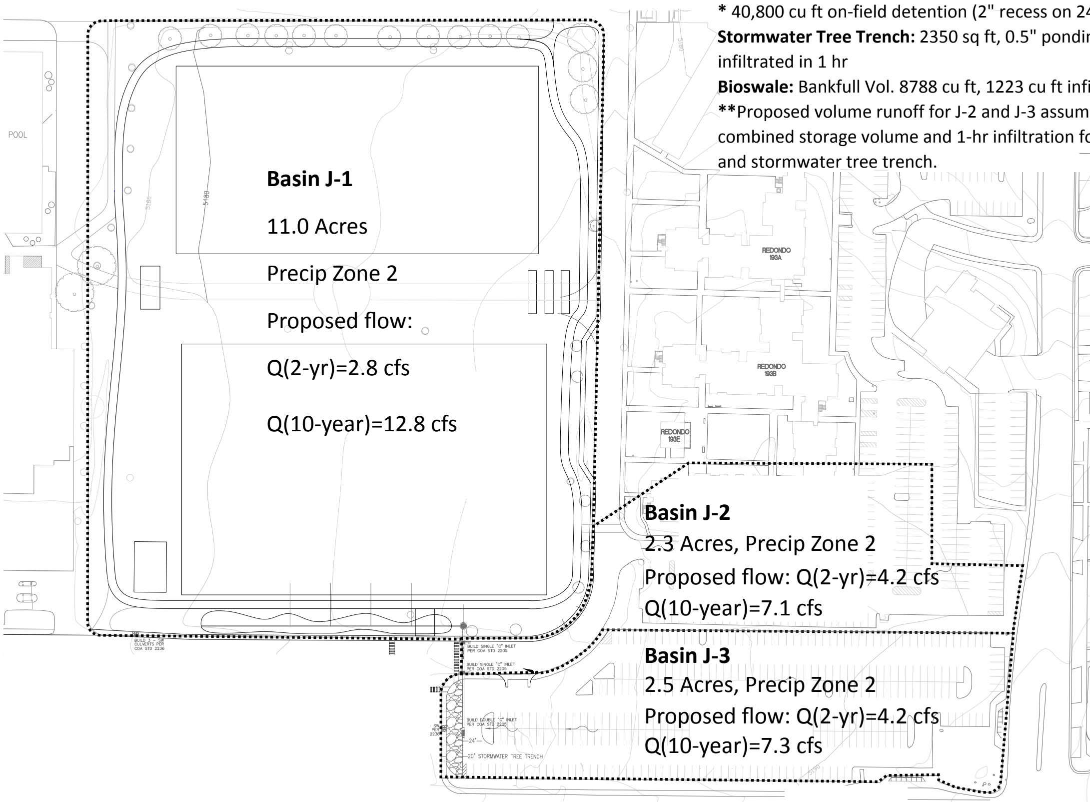
NOAA Atlas 14 Data used for 60-min storms

***** 40,800 cu ft on-field detention (2" recess on 244,840 sq ft)

Stormwater Tree Trench: 2350 sq ft, 0.5" ponding depth, 369 cu ft infiltrated in 1 hr

Bioswale: Bankfull Vol. 8788 cu ft, 1223 cu ft infiltrated in 1 hr

******Proposed volume runoff for J-2 and J-3 assumes 11,672.8 cf combined storage volume and 1-hr infiltration for bioswale and stormwater tree trench.



Water Budget

	Existing	Proposed
Turf Area	10 Acres	8.6 Acres
Turf Water	70-75"/yr = 60 af/yr	High Mow: 3 acres, 45.8"/year = 11.45 af/yr Low Mow: 5.6 acres, 54"/year= 25.2 af/yr **Total: 36.65 af/hr** *Leinauer and Smeal (2012)*
Tree/shrub water	None	70 trees (3500 gal/yr each) 98 shrubs (240 gal/yr each) **Total: 268,520 gal/year = 0.82 af/yr*** *Phillips (2015) DiFrancesco and Baker (2005)*
Irrigation Efficiency	40-45%	90-95% (weather-based control system, soil moisture sensors, subsurface drip irrigation) *Hammersmith (2015)*
Total Potable Water Use	**60 af/yr**	**37.92 acre feet/year** *does not include 15 trees and 30 shrubs in bioswale whose irrigation needs are met by runoff and cistern water

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