FLOW: A PROPOSAL FOR STORMWATER DESIGN ON THE UNIVERSITY OF NEW MEXICO CAMPUS

Registration No. D20

Proposal by:

Nirit Finkelstein – MS Water Resources

Jeremiah Gwin – MS Landscape Architecture

Rachael Miera – BS Civil Engineering

Fatima Quarashi – BS Civil Engineering

Jared Romero – BS Civil Engineering

Maggie Seibert – Ph.D Health Communication

Matthew Segura – MS Community and Regional Planning & Water Resources

Christopher Simmons – BS Civil Engineering

Faculty Advisor: Dr. Mark Stone, Ph.D., P.E., D.WRE: Civil Engineering

FLOW: A Proposal for Stormwater Design on the University of New Mexico Campus

ABSTRACT

FLOW: A Proposal for Stormwater Design on the University of New Mexico Campus seeks to reduce the amount of runoff generated on the selected Project Site at the University of New Mexico (UNM), to address city-wide issues including the increase in Urban Heat Island (UHI) effects due to city urbanization, and violations of water quality standards through the use of Low Impact Development (LID) techniques and green technology, while also increasing environmental awareness on campus, and creating a more knowledgeable and resilient campus community. Our design takes into consideration the guidance received from our Facilities advisor. This project focuses on areas of UNM with recurring flooding problems and areas that showed promise for effective reduction of stormwater runoff, runoff disconnection, rain water harvesting, and rain gardens while adhering to constraints imposed by the local climate and water authorities. Our group was able to measure on-campus community support, engagement, and awareness of stormwater issues as well as other environmentally related topics through the development and distribution of a campus-wide survey. *FLOW: A Proposal for Stormwater Design on the University of New Mexico Campus* will serve as an example for other campuses in arid regions to achieve effective stormwater managed environments that are resilient and sustainable; include aesthetically enhanced areas that provide greater enjoyment and educational opportunities; and are composed of low impact development practices that will provide numerous environmental benefits over their life-cycles.

A Special Thanks to:

Dr. Bruce Thomson, Ph.D., and P.E: Civil Engineering

Dr. William Fleming, Ph.D.: Architecture and Planning

Mark Manzutto, Engineer: Physical Plant Department

Adrienne Martinez, EIT and Research Engineer: Civil Engineering

Jerry Lovato - Executive Engineer, Albuquerque Metropolitan Arroyo Flood Control Authority

BACKGROUND

City-Wide Problem

FIGURE 1: PROJECT LOCATION

UNM is located centrally in Albuquerque, New Mexico and is part of the Rio Grande watershed, which extends from Southern Colorado to the border between Texas and Mexico at the Gulf of Mexico. New Mexico's climate is classified as semi arid: dry with low precipitation; with approximately 9 inches of precipitation per year. New Mexico's summers are characterized by monsoon events that bring high volumes of water over short periods of time. As such, the storm sewer system in Albuquerque is extensive and suffers from these repeated high-intensity short-duration monsoon events, which further leads to degraded infrastructure and pollution of water resources. As part of the Rio Grande Watershed and a partner in the Rio Grande Compact (1938), Albuquerque is responsible for delivering allocations of water to downstream users in Southern New Mexico, Texas, and eventually Mexico. As a consequence, businesses and residents are not allowed to permanently store stormwater on their properties (This created considerable design constraints that lead to many non-traditional design aspects, which will be addressed in a later section.) In addition to the stormwater retention constraint described earlier, the City of Albuquerque often is in violation of the TMDL (total maximum daily load) for E.coli set by the Environmental Protection Agency (EPA) with guidance from the National Pollutant Discharge Elimination System and the Clean Water Act (AMAFCA, 2016). These violations, typically for E. coli, pose a continuing issue for the city and it's local water authorities. Our group will focus on improving the quantity and quality of stormwater runoff following a storm event on campus.

Site Description

The site chosen will thus be known as the "Project Site" and is located centrally within the Main UNM campus as a 7.15 acre section beginning at the west side of the Student Union Building (SUB) and loading dock, heading west between the Humanities Building (Humanities) and Woodward Hall (Woodward), moving north through Yale Mall, and ending at a popular relaxation area known locally as the Duck Pond. The decision to chose this location was made after several meetings with UNM Campus Facilities (Facilities) where areas that posed significant problems were described. UNM's topography is classified as moderately flat (< 5% slope), so stormwater runoff tends to accumulate in puddles. The current drainage system involves a network of storm sewer pipes, which are frequently overwhelmed due to high intensity storms. The project site land cover is 30% impermeable land cover (concrete, impervious brick), 47% untreated rooftop areas, and 23% permeable land cover (gravel, grass, etc.). High percentages of impermeable land cover and untreated rooftop areas increase stormwater runoff and prevent percolation of runoff into the ground. For this project, the design storm is a storm with 0.425 inches of excess precipitation over a 6-hour period, the equivalent of the 2-year storm event.

DESIGN GOALS

The focus of our design is to reduce the volume of stormwater runoff from the Project Site, decrease UHI effects due to impervious or untreated surfaces, and remove contaminants, focusing on E. coli removal from the runoff before releasing it to the City of Albuquerque drainage system. Our design was created by not only considering the restrictions set by the Rio Grande Compact (New Mexico Office of the State Engineer, n.d.), but also by utilizing LID practices, green infrastructure, and collaborating with Facilities. We have tailored a plan that will improve flood prevention on the project site while ensuring its future resilience and maintenance through researching climate constraints, examining landscape slopes and drainage outlets, and using the Stormwater Calculator provided by the EPA to determine the overall results of our design.

As guided by our Facilities advisor, our design focuses on solutions to the following problems:

- Flooding of the SUB Loading Dock and Woodward Basement
- Reducing UHI at locations of extreme contribution
- Reducing the volume of stormwater runoff to undersized existing storm sewer system
- Increasing awareness of water conservation and resilience in an arid environment

D2: Disconnection, Detention

The flooding of the SUB loading dock, which is at an elevation lower than the ground level surface, is caused by two sources of runoff during stormwater events. Surface runoff from the walkway south of the SUB flows down an approximately 15% graded ramp and frequently exceeds the capacity of the existing pipe drainage system. A second source adding to the flooding issues is stormwater runoff from the rooftop of the SUB itself. To reduce contributions from runoff on the loading dock ramp, an elevated concrete pad or “speed table” will be installed to divert water to existing vegetated areas.

This exceedance of the pipe capacity at the loading dock results in the backwatering of adjacent storm drains, often flooding the low-lying areas and basement rooms of Woodward. The existing stormwater drainage system between Woodward and Humanities includes undersized pipes and capture basins that run along and underneath a group of Mulberry trees planted along the walkway between these two buildings. To address this flooding, our design attempts to disconnect the stormwater runoff from reaching the existing drainage system by installing flashing and runnels, which will divert water for detainment. The detained water will be slowly released to rain gardens and will allow for infiltration into the ground. This same technique will also be applied to other areas of our Project Site. Table 1 describes the amount of water collected from each location.

TABLE 1: RAIN CATCHMENT VESSEL PERFORMANCE RESULTS

<table>
<tr><th>Building</th><th>Rooftop Area (ft^2)</th><th>Excess Precipitation (in)</th><th>Runoff Volume (gal)</th><th>Number of Rain Catchment Vessels</th><th>Size of Vessels (gal)</th><th>Percentage Capture</th></tr>
<tr><td>Student Union</td><td>63000</td><td rowspan="6">0.425</td><td>8300</td><td>8</td><td rowspan="4">96</td><td>9%</td></tr>
<tr><td>Woodward Hall</td><td>26000</td><td>2400</td><td>5</td><td>20%</td></tr>
<tr><td>Ortega Hall</td><td>17000</td><td>3400</td><td>6</td><td>17%</td></tr>
<tr><td>Mitchell Hall</td><td>21000</td><td>2800</td><td>4</td><td>14%</td></tr>
<tr><td>Humanities</td><td>16000</td><td>1000</td><td rowspan="2" colspan="2">Separate Cistern Used</td><td rowspan="2">31%</td></tr>
<tr><td>Skywalk (Part of Humanities)</td><td>5500</td><td>730</td></tr>
</table>

Flashing along the roofs of the SUB, Woodward, Mitchell Hall (Mitchell), and Ortega Hall (Ortega) will divert rooftop capture towards downspouts along the walls, and into the rain catchment vessels on the ground below. The flashing systems were sized by using the design storm and the given roof area and roof slope. The rain vessels chosen have a capacity of 96 gallons and are made of 100% recycled High-Density Polyethylene, and with the help of UNM's Department of Art & Art History, will be aesthetically consistent with Native New Mexican pottery. The 96-gallon capacity is a physical representation of what is known as the "96-Hour" rule to local stormwater experts. This rule is the statute that limits the detention of stormwater from entering the system to a 96-hour period.

Humanities consists of two stormwater runoff infrastructure levels; the building roof and a skywalk that surrounds the building's second floor. Vertical 1,800-gallon capacity cisterns made of corrugated pipe will be directly connected to roof downspouts and will rest on top of the skywalk. In lieu of flashing on the skywalk, pre-cast concrete runnels will be used to divert runoff overhead to rain garden spaces below in the walkway between Woodward and Humanities.

Rain gardens will replace the two open spaces on the north side of Woodward, which will reduce runoff velocity and volume from this area. During a storm event, runoff from the skywalk (via runnels) and sidewalk can flow uninhibited to these gardens. The runoff will support arid adapted pollinator plants through infiltration, and excess stormwater will be diverted to the existing 12-inch stormwater pipe system. A visual representation of this system can be seen in Figure 2. The rain gardens are 650 square feet and 800 square feet in size, respectively. The gardens are 2 feet below the existing 12-inch pipe drain elevation rims, providing 9,750 and 12,000 gallons of capacity, respectively. This technique was also applied at a student gathering area near Mitchell Hall.

FIGURE 2: RENDERING OF ALLEYWAY BETWEEN HUMANITIES AND WOODWARD.

Habitat Creation

When creating habitat, it is important to think holistically and understand the interactions that will take place. The most effective and healthy ecosystems will not only encompass these ideas, but also have a rich diversity of species. Combinations of plants and fungi keep the soils healthy and allow for the persistence of green space. This symbiotic mutual relationship benefits the plants, fungi and surrounding organisms. Other important species that aid in ecosystem health are invertebrates like earthworms, ladybugs, and bees. They create stable soils, help break down nutrients, deter pests, and help pollinate and propagate plants. For this design, plants and fungi implemented were selected to perform best in arid environments and can be found in Table 2.

TABLE 2: BENEFICIAL PLANTS FOR IMPROVING HABITAT

Common Name	Plant Species	Plant Performance (phytoremediation, attraction of pollinators, etc.)
Indian mustard	*Brassica juncea*	Has been found to transport lead from the roots to the shoots, which is an important characteristic for the phytoextraction of lead. (USEPA, 2000).
Indian grass	*Sorghastrum nutans*	Has been found to transport lead from the roots to the shoots, which is an important characteristic for the phytoextraction of lead. (USEPA, 2000).
Common Sunflower	*Helianthus annuus*	After one hour of treatment, sunflowers reduced lead concentrations in soils significantly (Raskin, 2000). It has also been supported that sunflowers pick up other heavy metals like cadmium and zinc. This is due to their fast growth, high biomass, and high tolerance and accumulation of metals and other inorganics (Blaylock and Huang, 2000; Salt et al., 1995b).
Curly Dock	*Rumex crispus*	A noxious local weed, can extract large amounts of cadmium from water and soil sources (Cha, 1992). Curly Dock was also found to be an efficient translocator for Boron and Copper, with TF factors at 1.1 and ranging from 1.2-3.2 (Kifner, 2014).
Common Yarrow	*Achillea millefolium*	A perennial that attracts pollinators and is tolerant of poor soils and seasonal flooding.
Spreading Rush	*Juncus patens*	An easy to grow native rush; tolerates poor drainage, flooding, drought, and shade; has shown strong performance in bioretention areas.

Heat Abatement

To address the UHI effect at the Project Site, simple temperature readings were collected to determine locations of extreme heat differences. Surface temperature readings were taken with an infrared thermometer on two separate days. Temperatures ranged from 52.5°F to 121.9°F (80°F ambient temperature) on the first day and from 50.4°F to 92.9°F (68°F ambient temperature) on the second day. With these measurements, a UHI index was developed. Temperature differences between the surface temperatures at each location were discretized into indices for every 3°F of temperature difference. A temperature difference of 3°F was used to determine the index because major ecological health changes occur in 3°F intervals (NASA, n.d.). Areas with high index values were determined to be areas that contribute to the UHI effect, and were then targeted as areas for LID applications. The areas with the highest index values were the walls on skywalk surrounding Humanities, and the tree well areas in Yale Mall. Implementing green walls on the skywalk to be passively irrigated from vertical rain catchment vessels are expected to decrease the UHI in this area. Green walls increase albedo - shortwave electromagnetic reflectance- which is measured on a scale of 0 to 1, 0 representing 0% reflectance and 1 representing 100% reflectance (Garrison, Horowitz, Lunghino, and Devine, 2012). Typical aged concrete has an albedo of 0.25, and green wall installations approximately 0.75 (Pomerantz, Akbari, Chang, Levinson and Pon, n.d.). By installing green walls, this reduces the UHI effect and heating/cooling costs of building. The Yale Mall tree wells were connected and expanded as well as deepened. By expanding the permeable space and improving conditions around the trees, growth is supported, canopy expanded, passive stormwater infiltration increased, urban heat island effect reduced, and we expect pedestrian experience to be improved, as shown in Figure 3.

Duck Pond and Remediation Practices

FIGURE 3: RENDERING OF TREE WELLS IN YALE MALL.

The Duck Pond serves as the coup de grâce of our proposal. There exists an 18-inch storm sewer pipe that is undersized and is recommended for replacement with a larger diameter pipe by a third party consultant, which will be an expensive and intrusive project to undergo. As a low-impact and sustainable alternative, our design suggests that a 4-inch siphon pipe be inserted into the existing 18-inch pipe, to divert up to 0.5 cubic feet per second of stormwater runoff (approximately 13% of peak flow) to the Duck Pond for temporary storage and to alleviate pressure on the existing storm sewer system. This also serves as an opportunity to remove pollutants, specifically E. Coli, from the Duck Pond and diverted runoff.

Facilities currently does not test stormwater runoff. We would encourage Facilities to begin a monitoring program that mirrors the City of Albuquerque Stormwater Management Plan. This plan, in accordance with the Municipal Separate Storm Sewer System permit, protects and regulates the amount of harmful contaminants leached by industry, development, agriculture, roadways and other forms of transportation. In creating a system of best management practices (BMP), UNM campus can effectively filter water before it is sent out to the Rio Grande River. Many inexpensive and efficient techniques like phytoremediation and mycoremediation can be used to remove heavy metals, pesticides, herbicides, pathogens, and salts from UNM's water and soil using direct applications of plants and fungi. The implementation of green techniques can be aesthetically pleasing and provide community education and engagement through the use of volunteer and student led activism. There has been extensive research done on these topics however there are a limited number of applied, full-scale demonstrations. Direct application of such techniques may allow UNM a chance to become a leader in this area.

As previously stated, the E.coli pollutant impact on the health of the Rio Grande is at the top of the list of concerns for the City of Albuquerque and UNM. In the most recent summary of Urban Stormwater Quality in Albuquerque, New Mexico (USGS, 2015 as quoted in Martinez, 2016), the median concentrations for E. Coli bacteria in stormwater samples were above the New Mexico water quality standard. Levels of E. Coli are also high in the UNM Duck Pond due to fecal contamination by waterfowl. Reducing the E. coli on campus will help mitigate its flow into the river, and set an example for the rest of the city to follow. Research with the local P. ostreatus, the pearl oyster mushroom, has shown great success in removing E. Coli from a contaminated water sources. We wish to focus on E. coli removal from the Duck Pond using mycofiltration, as well as create several different habitats to improve overall water and soil quality.

Using data collected from Savannah Martinez's thesis work at UNM, we wish to add mycofiltration to the schools BMPs for removal of E. Coli from the Duck Pond. The results of this study show that the P. ostreatus mycofilters reduced the concentration of E. Coli at the water surface compared with controls (Martinez, 2016). Although there is support of long-term application of P. ostreatus mycelium in a pond setting, Martinez's results are only based on shallow ponding surface testing. Our recommendation would be to perform additional tests with P. ostreatus on varying pond depths. On average, the mycofilter reactors removed an overall amount of 98% of the E. Coli concentration. P. ostreatus mycelium is known to "attack and destroy bacterial colonies, which then serve as a nutrient source for the fungus" (Barron, 1987). The fungi are necessary organisms that use competition and chemical defense to stabilize an environment that has been overtaken by bacteria.

Operations and Maintenance

To implement and maintain our proposed design, we have developed a maintenance schedule that considers suggestions from Facilities and current maintenance operations (can be seen in Figure 4). This schedule shows two phases: the construction phase during the fall of 2018 and spring of 2019, and future maintenance operations.

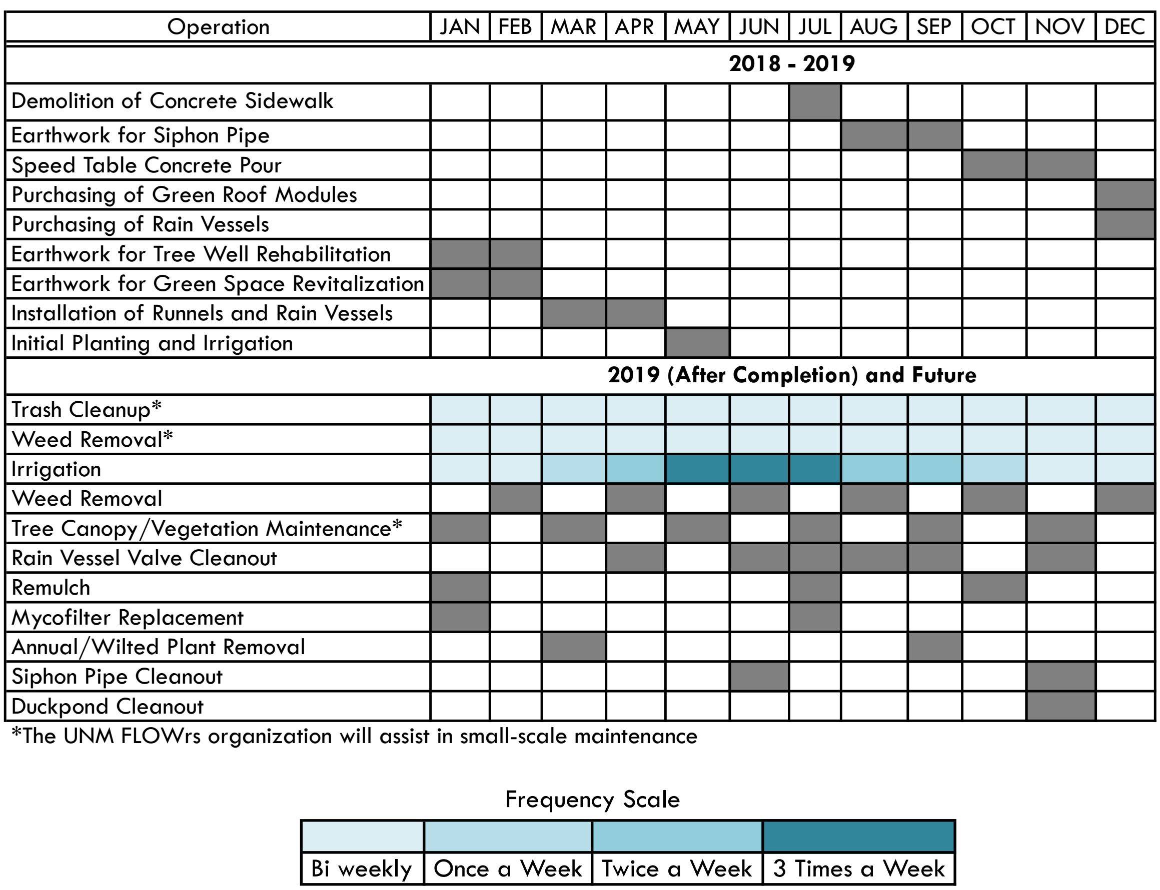


FIGURE 4: OPERATIONS AND MAINTENANCE SCHEDULE

Future LID Practices

Future construction on the UNM campus will serve as opportunities to improve and incorporate more LID techniques to reach a greater state of resiliency. With a potential remodeling of Humanities planned within the near future, an implementation of greywater reuse may be incorporated into our design. Pending permission from the state, a large-scale greywater system directing greywater from bathroom sinks and water fountains along the southern side of Humanities would provide a convenient source of water for our proposed landscaping. It would decrease the dependence on irrigation from a groundwater-pumping source for the landscape and make the design area more drought resistant. An additional problem plaguing the walkway between Humanities and Woodward is the slip hazard created by ice in the winter months due to a lack of direct sunlight in the corridor. Environmentally harmful deicing salts are frequently used to melt ice on these sidewalks, which eventually are washed away during rainfall events, contributing to the pollutant load in the Rio Grande. By adding additional ductwork to the remodeled heating system inside Humanities, airflow would be routed to the walkway. Warm air could be used to help thaw ice, reducing or eliminating the need for deicing salts.

COMMUNITY ENGAGEMENT

Our team created a survey to gauge UNM campus community support, engagement, and awareness of a stormwater catchment and treatment plan that would solve the current stormwater problems while simultaneously beautifying campus and providing educational opportunities for students. The full survey results, excluding qualitative data, can be found here (https://www.surveymonkey.com/results/SM-C3GBGPVF/) and below follows a summary of results.

Eligible participants were UNM students, staff, and faculty members over the age of 18. At the time of this analysis, 90 respondents had completed the survey. The average respondent was an undergraduate student, 18-21 years of age, and female; which closely aligns with the demographics of the UNM community (University of New Mexico, 2016). Approximately 92% of survey respondents were in support of the proposed project. The walking corridors on the site of the proposed project were the most frequently used by students who walk through campus, especially the corridor between the Duck Pond and Mitchell Hall (49-54% collected in two respective questions). Respondents were asked about their favorite place to visit on campus, and of those who chose to write in a response, 77%, indicated the Duck Pond. Respondents used the following terms to describe what they liked about the Duck Pond: “very relaxing”, “openness to students”, and “the animals and plants”. Since the results of the survey indicate that the Duck Pond and the walking corridors nearby are heavily trafficked, this further supports our choice to target these areas for campus beautification, recreation, and education.

Survey respondents rated the categories found in Figure 5 to be ‘very important to me’. The values indicated by the UNM community will be used in the development of educational signage and interactive exhibits placed throughout the site. Signs will also be placed along a walking route for individuals who are in transit utilizing the proposed site.

About Us: Creation of UNM FLOWRS Group

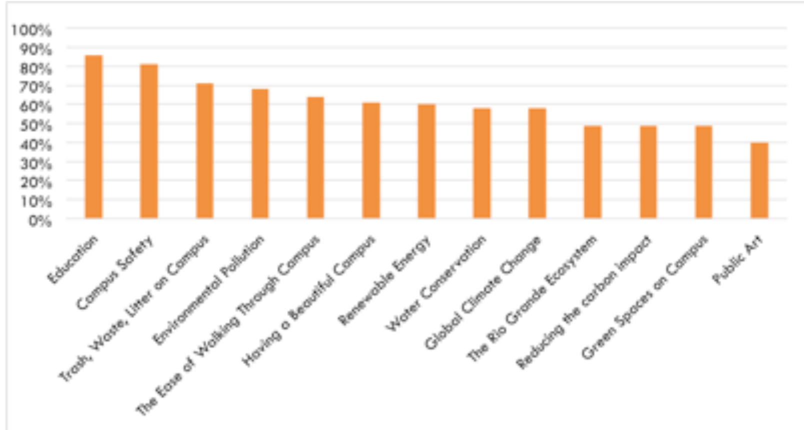


FIGURE 5: SURVEY RESULTS - PERCENT ANSWERING "VERY IMPORTANT TO ME"

Our group is composed of multiple scholarly disciplines from civil engineering, health and environmental communication, landscape architecture, water resources, and community and regional planning. We connect on our desire to create environmentally responsible spaces that link human enjoyment, recreation, beautification, and education to build environments that are sustainable, symbiotic, and effectively designed for performance and aesthetics over time. We imagine ourselves as exchanging ideas across disciplines and we metaphorically draw from the permaculture practice of stacking functions as we envision spaces that address and resolve multiple environmental quandaries all while adding multiple benefits to the campus community. The name of our team, UNM FLOWRS, stands for University of New Mexico Future Leaders of Water and Resilience, since we imagine our work will *flow* into the future since our design mimics the natural processes of our Southwestern environment, and we all envision ourselves continuing to further collaborate on this work after graduating and moving into our respective careers. We are also looking to the future chartering of the UNM FLOWRS group and increasing our presence on campus. In addition, this design will serve as an example for other campuses in arid regions to achieve effective environments that are resilient, sustainable as well as to enhance aesthetic enjoyment and education, while self maintaining over time.

CONCLUSION

According to the White House's Office of the Press Secretary, if current climate change trends persist, New Mexico is predicted to become increasingly hotter and drier (2014). As such, our design seeks to find a compromise between what is currently expected and what is to come in terms of stormwater runoff from the Project Site. The number of rain catchment vessels was conservatively chosen, and arid adapted vegetation was selected for use in the rain gardens.

Expected results for scenarios before and after LID technique application and with and without climate change, that the near future (approximately 20 years) will be hotter, were determined using EPA Stormwater Calculator analyses and can be seen in Figure 6, and full results can be found at the end of this proposal. The results of these analyses showed a 7% infiltration increase in both existing and future climate conditions, with an average 7.5% decrease in runoff with little to no change in total evaporation.

The overall goal of FLOW: A Proposal for Stormwater Design on the University of New Mexico Campus was to reduce the amount of runoff generated by the Project Site at UNM, to address city-wide issues like the increase in UHI effects due to city urbanization and violations of water quality standards, while also increasing environmental awareness of campus, creating a more knowledgeable and resilient campus community.

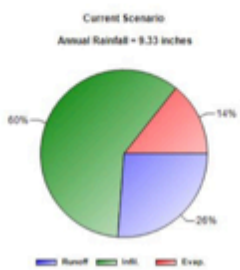
FIGURE 6: EPA STORMWATER CALCULATOR GRAPHICAL RESULTS

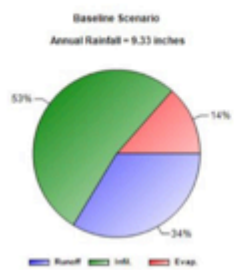
ORIGINAL EPA STORMWATER CALCULATOR RESULTS

National Stormwater Calculator Report

Summary Results

Statistic	Current Scenario	Baseline Scenario
Average Annual Rainfall (inches)	9.33	9.33
Average Annual Runoff (inches)	2.35	3.15
Days per Year With Rainfall	24.58	24.43
Days per Year with Runoff	7.69	10.79
Percent of Wet Days Retained	68.70	55.83
Smallest Rainfall w/ Runoff (inches)	0.26	0.18
Largest Rainfall w/o Runoff (inches)	0.38	0.35
Max. Rainfall Retained (inches)	1.18	1.06



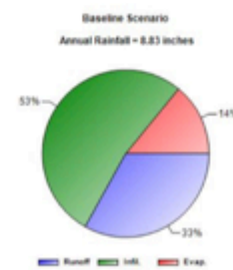


US EPA National Stormwater Calculator - Release 1.1.0.2 Page 2 Of 5

National Stormwater Calculator Report

Summary Results

Statistic	Current Scenario	Baseline Scenario
Average Annual Rainfall (inches)	8.83	8.83
Average Annual Runoff (inches)	2.18	2.93
Days per Year With Rainfall	24.13	24.13
Days per Year with Runoff	7.34	10.19
Percent of Wet Days Retained	69.57	57.76
Smallest Rainfall w/ Runoff (inches)	0.24	0.19
Largest Rainfall w/o Runoff (inches)	0.40	0.31
Max. Rainfall Retained (inches)	1.02	0.90



US EPA National Stormwater Calculator - Release 1.1.0.2 Page 2 Of 5

REFERENCES AND RESOURCES

Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA). (2016, December). Stormwater management program. Retrieved from http://www.amafca.org/documents/2016_AMAFCA_SWMP.pdf

Cha, Y.I. (1992). Studies on the removal of Cd2+ ion in wastewater by plants: I. Absorption of Cd2+ by dock (Rumex crispus L.) plants. Kor. J. Ecol., 15, 137-145

Castro-Rodríguez, V., García-Gutiérrez, A., Canales, J., Cañas, R. A., Kirby, E. G., Avila, C., & Canovas, F. M. (2016). Poplar trees for phytoremediation of high levels of nitrate and applications in bioenergy. Plant biotechnology journal, 14(1), 299-312.

Garrison, N., Horowitz, C., Lunghino, C., and Devine, J. (2012, June). Looking up: how green roofs and cool roofs can reduce energy use, address climate change, and protect water resources in southern California. National Resources Defense Council. Retrieved from https://www.nrdc.org/sites/default/files/GreenRoofsReport.pdf

Kifner, L. H. (2014, October). Phytoremediation of metal contaminated soils in the southwestern region of the United States. In 2014 GSA Annual Meeting in Vancouver, British Columbia.

Martinez, S. (2016). E. Coli Removal by Pleurotus Ostreatus mycofilter in simulated wet environmental pond.

National Aeronautics and Space Administration (NASA). (n.d.). The consequences of climate change. Retrieved December 16, 2016, from http://climate.nasa.gov/effects/

New Mexico Office of the State Engineer. (n.d.). Rio Grande Compact commission meeting information. New Mexico Office of the State Engineer / Interstate Stream Commission. Retrieved from http://www.ose.state.nm.us/Compacts/RioGrande/isc_RioGrande.php

Office of the Press Secretary. (2014, May). Fact sheet: what climate change means for New Mexico and the southwest. The White House. Retrieved from https://www.whitehouse.gov/sites/default/files/docs/state-reports/NEWMEXICO_NCA_2014.pdf

Perfecti, F., Stamets, L. P., Beutel, M., Taylor, A., Flatt, A., Wolff, M., & Brownson, K. (2013). Mycofiltration biotechnology for pathogen management. Chicago

Pomerantz, M., Akbari, H., Chang, S.-C., Levinson, R., and Pon. B. (n.d.). Examples of cooler reflective streets for urban heat-island mitigation: Portland Cement concrete and chip seals. Lawrence Berkeley National Laboratory. Retrieved from https://eetd.lbl.gov/sites/all/files/lbnl-49283.pdf

Raskin, I. And B. D. Ensley. (2000). Phytoremediation of toxic metals: using plants to clean up the environment. John Wiley & Sons, Inc., New York.

Thomas, S. A., Aston, L. M., Woodruff, D. L., & Cullinan, V. I. (2009). Field demonstration of mycoremediation for removal of fecal coliform bacteria and nutrients in the Dungeness watershed, Washington. Final Report. Pacific Northwest National Laboratory. PNWD-4054-1.

United States Protection Agency (USEPA). (1999). Phytoremediation Resource Guide. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response Technology Innovation Office Washington, DC. Taken from: https://www.epa.gov/sites/production/files/2015-04/documents/phytoresgude.pdf

United States Protection Agency (USEPA). (2000). Introduction to phytoremediation. EPA 600/R-99/107. U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, OH.

University of New Mexico. (2016, September) Fall 2016 official enrollment report Albuquerque campus. The University of New Mexico: Office of Institutional Analytics. Retrieved from http://oia.unm.edu/facts-and-figures/oer-fall-2016.pdf