BLUE LINES: RETHINKING WATER SUSTAINABILITY ON CAMPUS
Michigan State University, East Lansing
Team Registration #: M10

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ABSTRACT:
Michigan State University (MSU) was founded as the premier land grant university in 1855. Since then, MSU has been recognized as one of the most beautiful campuses in the United States by the American Society of Landscape Architects. At MSU, the Red Cedar River (RCR) is at the heart of the campus and its culture—which makes it more than just a blue line on a map. However, MSU faces several challenges with the river that affects the surrounding campus, one of which is flooding during the rainy season. Unfortunately, as a result of climate change, flood events are becoming more common and result in extensive damage to the surrounding campus infrastructure. The University has spent hundreds of thousands of dollars to mitigate these damages in recent years. In addition, the campus can greatly benefit from more public outdoor spaces offering diverse recreational opportunities to the campus community and local community. Through redevelopment and retrofitting, the proposed project will improve the campus by mitigating flood events using systematically designed stormwater management practices—as well as promoting social interaction within diverse recreational areas.

INTRODUCTION:
The Great Lakes Basin is home to the largest freshwater ecosystem in the world, which includes 20% of the world's supply of fresh surface water (8). The University is located in the downstream, urbanized portion of the 460 square mile Red Cedar River Watershed. Approximately two miles of the Red Cedar River (RCR) meanders through the heart of campus before discharging into the Grand River—the largest river system in the State that eventually flows into Lake Michigan (15).

Agricultural land use in the headwaters of the watershed and high–density urban development in the downstream portion put pressure on the RCR. The river segment that bisects MSU's north and south campus often exhibits seasonal flooding and degraded water quality as a result of these pressures. Nutrient pollution and sedimentation are prominent areas of concerns that stem various land uses. In addition, under certain conditions, high levels of *E. Coli* bacteria have been measured, indicating fecal contamination that renders the river unsuitable for both swimming and fishing (4).

The potential long-term impact of climate change on existing campus infrastructure is sobering. Since the 1950's, Michigan's total precipitation has increased by 14% and heavy precipitation events have increased by 35% (4). Michigan's State Climatologist, Dr. Jeffrey Andresen, recently stated "arguably the biggest challenges ahead for Michigan and the Midwest will be the frequency and magnitude of heavy rain events and flooding" (19). As the climate changes in the Great Lakes region it is likely to cause more frequent and severe rain storms and lengthen periods of drought. Campus planners and engineers are increasingly interested in retrofitting the campus to be more resilient to flooding and erosion after storms (3).

This project will address the 1.5 miles of the RCR flowing between South Harrison Road and Bogue Street, and the adjacent 100–year floodplain. Within the study area, the 100–year floodplain covers 117 acres of land including: 19 buildings, nine parking lots, and roughly 40 acres of impervious area, and 26 acres of river (12). In 2018, MSU experienced a 100–year flood event that cost the University an estimated $880,000 in both preparation and recovery costs (IPF, MSU).

PROJECT GOALS:

Throughout the proposed redevelopment of the Master Plan, the project team connects the existing and proposed green infrastructure with a recreation plan for MSU's campus. Our conceptual approach emphasizes that the blue line of the RCR running through the campus is more than simply a segment of the river—it is a home, a gym, and a classroom for the entire campus community.

This plan's goal spans over a period of 30 years and aims to manage rainfall where it lands by utilizing green infrastructure systems and to pretreat water before the water is discharged into the river to improve flood control and long-term water quality. The green infrastructure plan includes: bioswales, green roofs, and river bank stabilization. The plan removes impervious surfaces within the floodplain and implements sustainable stormwater practices to create a campus environment that inspires recreation, learning, and enhanced wellbeing.

COLLABORATION WITH MSU AND SURROUNDING COMMUNITY:

During the project period, the project team held a series of meetings with students, faculty, facilities managers, and community members to identify current challenges and gain valuable insight into the needs and priorities of MSU's community stakeholders.

These included the RCR Bank Restoration Committee, MSU Stormwater Committee, Infrastructure, Planning and Facilities (IPF) staff members, and the Student Sustainability Leadership Council (SSLC). MSU's Stormwater Management Program and the existing University Master Plan provided the foundation for the design process helping to ensure that the final result aligns with the University's goals for the future of its campus (14).

Our project site is located within the Greater Lansing area that is composed of 18 communities in three major urbanized watersheds. These communities are working together through the Greater Lansing Regional Committee for Stormwater Management (GLRC) to meet the Clean Water Act stormwater permitting requirements. Within the tri–county area of Clinton, Ingham and Eaton Counties, MSU is the largest contiguous land owner throughout the watershed (15). The existing water resources protection activities among the broader community—both on and off campus—demonstrate the high level of care that MSU and the surrounding communities have for the RCR and its tributaries. These networks helped inform, guide, and shape the design elements and processes that were used when approaching this project. When looking to the future, there is a strong sentiment that the University wants to make a positive change in transforming the physical space it inhabits.

SITE INVENTORY AND ANALYSIS:

Existing 'Grey' Infrastructure

MSU has separate storm and sanitary sewer systems (25). In the State of Michigan, stormwater infrastructure is rated a D- (2), a condition that is mirrored on MSU's campus. Within the 1.5 miles of our project scope, the existing grey infrastructure is in disrepair. Of the 64 MSU–owned outfalls on the river, 29, or 45%, are in critical need of repair or replacement (1). The industry standard for replacing stormwater infrastructure is about every 40–years; therefore, replacement and retrofitting of existing outfalls will be addressed in this 30–year plan.

The best management practices currently in place on campus include: pretreatment of some stormwater to remove trash, debris, and fine sediment using a variety of proprietary treatment devices. These devices treat water leading to the nine largest outfalls before it reaches the RCR. The plan would include implementing additional Nutrient Separating Baffle Boxes (NSBBs) as the standard for campus, which have been found to be more effective than other devices, such as smaller stormwater separators. Within the next 30 years, the goal would be to install the NSBBs to cover all outfalls. Currently, treatment devices cover 15% of the floodplain (15).

Red Cedar River Weir

A weir is currently in place on the campus portion of the RCR. A weir is a subcategory of a low head dam with the purpose of raising the water level upstream and regulating flow. The weir was built in 1876, and was built on a base of rocks and brush. The shape of the RCR weir is rectangular, meaning the cross-sectional shape is flat horizontally across the river. The RCR weir is also broad-crested, where the top extends upstream horizontally for a relatively longer distance than a sharp–crested weir. The nappe, or portion of the

river that flows over the weir edge, is clinging. Clinging means there is no air pocket between the weir's edge; the river and the water is directly in contact with the weir edge and has a downstream ramp. The slower moving water behind the weir allows for the deposition of sediment depriving the water flowing downstream of sediment (sediment starvation). Project team members worked with a Biosystems Engineering Team that spent a school year assessing the impacts of the weir and crafting a plan to remove it. The weir, which is the only dam within the RCR Watershed, is located behind the Hannah Administration Building. Originally built to channelize the RCR, the weir negatively impacts flooding. The weir makes the river inaccessible to navigation up and downstream—by both fish and humans. Due to the impact on flooding and river habitat, the University is considering the removal of the weir within the next decade. MSU is currently testing sediment surrounding the weir to begin this process. Therefore, within the 30–year plan, the weir removal is in the first 10–year phase. Removal of the weir will be the most impactful portion of this plan, affecting subsequent floods, habitat, recreation, and campus culture.

Existing 'Green' Infrastructure

The campus currently has three constructed wetlands, thirteen detention basins, nine green roofs, and ten sites of pervious pavement. Stormwater design standards are in place for new development projects, focusing on channel protection and water quality criteria. As part of its federal Clean Water Act stormwater permit, MSU receives credit for the installation of additional green infrastructure projects within its land area. The proposed plan will decrease impervious areas along the river corridor, which will benefit the existing stormwater management program.

Predevelopment Site Background

Historically, the RCR Watershed (RCRW) was predominantly forested wetlands. The upland ecosystem contained mostly Beech/Sugar Maple Forests or Oak/Hickory Forests. Lowlands contained an abundance of conifer swamps. The western portion of the watershed, compared to pre–settlement conditions, have experienced a 90% loss of forest cover and 60% loss of wetlands (18). The current plan is designed to mimic how the natural ecosystems would have managed precipitation. Due to the large amount of clay and developed soils on campus, amending the soils for increased infiltration is MSU's standard, and therefore has been applied within the current plan.

Buildings in the Floodplain

Within the 117 acres of the 100–year floodplain on campus, there are currently 40 acres of impervious area (34%). Nineteen buildings are located within this space, used for academic, cultural, residential sport and administration purposes. Additionally, there are nine parking lots in the floodplain. The remaining impervious surfaces is composed of roads and pathways.

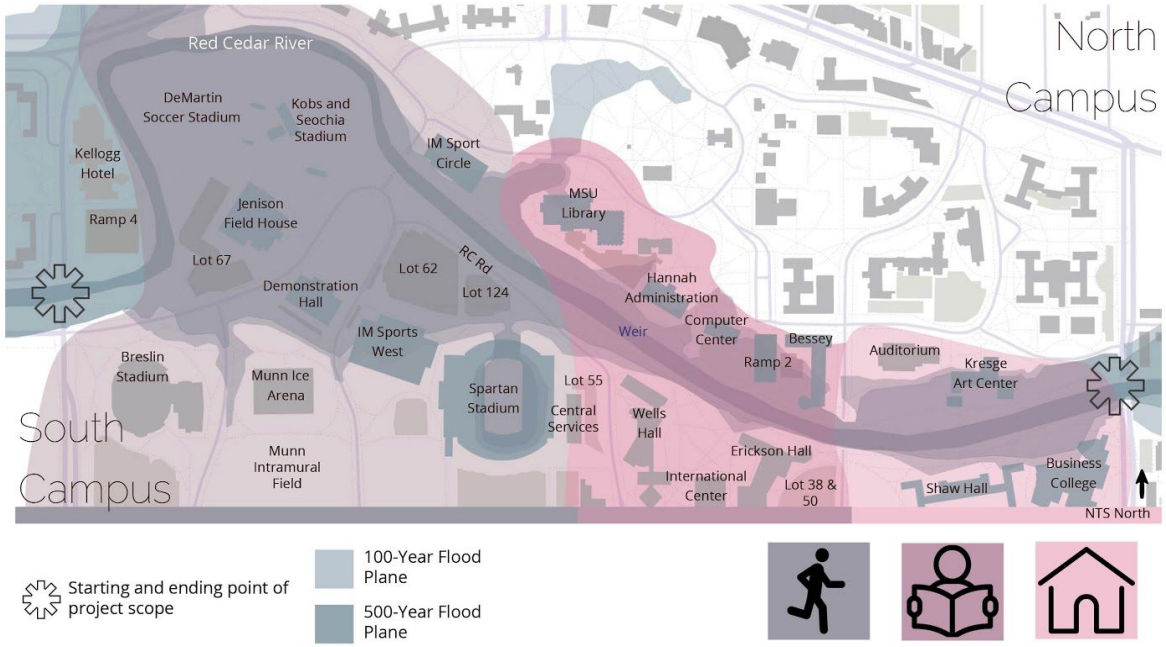
Since this is a re–development and refurbishment project, a majority of the buildings cannot be removed. As a result, the plan aims to install green roofs on existing structures that can handle the additional weight or are capable of being retrofitted. In additional to each green roof, the plans will install cisterns to collect rainwater and distribute the rainwater to the green roofs during droughts. Currently, MSU has nine green roofs and two cisterns on campus.

The campus Master Plan calls for removing surface parking lots from central campus (along the RCR) and demolishing an aging parking ramp (Ramp 2) that sits within the floodplain. Our plan removes the ramp, Central Services building, six surface parking lots (Lots 38, 50, 55, 62, 67, 124) and Red Cedar Road. MSU plans to expand the Spartan Stadium east tower in the next thirty years—adding additional suites. During this renovation, the plan proposes removing Central Services Building and the adjacent Lot 55. Our plan proposes dead-ending Red Cedar Road (RC Rd.) next to Wells Hall and creating a bus loop. This aligns with the campus Master Plan and Spartan Stadium Master Plan. Removing Lots 55, 62, 124 and Central Services Building and replacing the area with open green space will allow the space to be used for tailgating, while also improving flood storage and increasing infiltration within the floodplain.

CONCEPT FOR INTEGRATING THE RIVER INTO CAMPUS:

Planning Concept

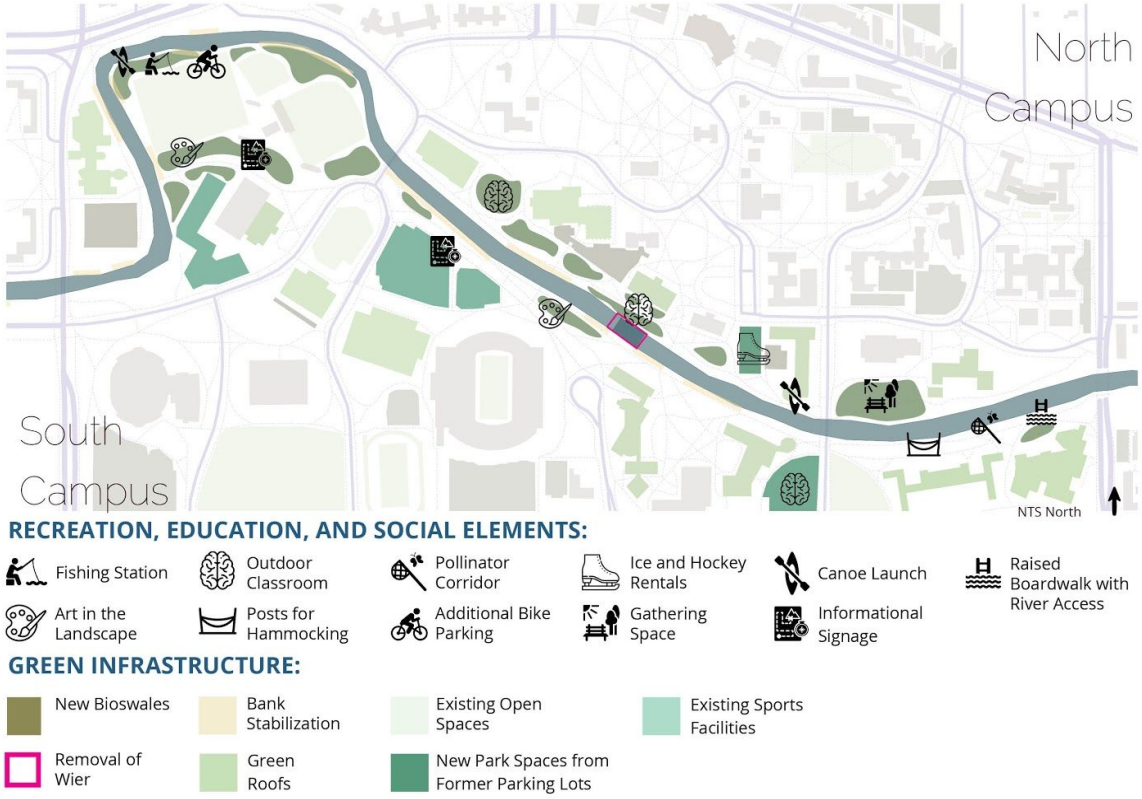
There are three distinct neighborhoods surrounding the RCR on MSU's campus, which include athletic, academic, and mixed residential and academic use. The programming for the river will draw from the existing neighborhood uses. The "Athletic Zone" (western zone seen in graphic) of the river will focus on recreation that addresses students' mental and physical well-being. The "Academic Zone" (central zone seen in graphic) of the river will emphasize outdoor learning and creating outdoor classrooms or living laboratories. The "Mixed Residential and Academic Zone" (eastern zone see n in graphic) on



campus will focus on creating a "backyard" environment, where students feel welcome to live on campus. Creating a campus environment that inspires recreation, learning, and enhanced wellbeing is the cornerstone for all projects along the river corridor.

Proposed Design: Blue Green Plan

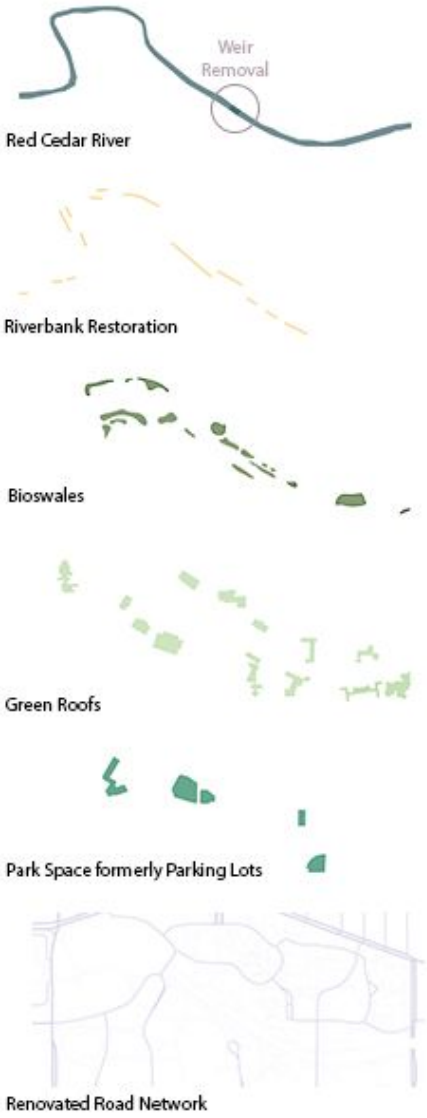
The goal of the proposed infrastructure on campus is to model the man–made green infrastructure after the ancient biota of a freshwater forest and shrub wetland. This proposal advocates for green infrastructure on campus that can store water during flood events and provide for a more diverse habitat for native species. The outer bounds of site design, the 100–year floodplain, address factors that influence water quality and quantity. The long–term goal is to meet EPA water quality standards making the river both fishable and swimmable. Each space will be designed to be accessible for a diversity of students.



Design Element Details

1. Upgrading Infrastructure:
    a. Installing additional NSBB and bioswales ensuring that all stormwater entering the outfalls is pretreated.
    b. Outfall repairs will be completed as the riverbank is stabilized and bioswales are installed.
2. Removal of Weir:
    a. The removal of the weir will improve flood control, aquatic species habitat, and navigability to the 32–mile Red Cedar River Water Trail. Removing the weir would help with re-establishing better bottom habitat and river connectivity.
    b. With input from Fisheries and Wildlife faculty, the new design will forster fish habitat within the river by placing large boulders to create rapids.

3. Removal of Impervious Surfaces on Campus:
    a. Removing Ramp 2, the ramp will be replaced with a beech-sugar maple forest, similar to Stanford Woodlot. During the winter this space will also host an ice rink with rentable hockey and ice skates. Other recreation opportunities along the river include the boardwalk behind the Business College and wetland gathering space behind the Auditorium. A small structure will be built near Auditorium Road outside of the floodplain where skates and kayaks/canoes will be rented out seasonally. This structure will be close enough to service as a resource to the canoe launch behind Bessey Hall.
    b. Removing Parking Lots, Central Services, and Red Cedar Road behind the stadium (Lots 55, 62, 124). This space will be used for Intramural (IM) fields, open space, bioswales. Because of its low elevation and location adjacent to the river, this increased green space will improve flood storage. Opening up the space to the east of the stadium and west of Wells Hall and creating a bus loop maintains the mass transit accessibility and walkability of this region. MSU mass transit (buses) are free to students; therefore, maximizing mass transit use is a benefit to the University.
    c. Removing Parking behind Erickson (Lots 38 and 50). Parking at Erickson will be converted into an outdoor classroom. Other educational resources in the plan include art in the landscape, outdoor classrooms, pollinator gardens and informational signage. The outdoor classrooms include the existing Beal Botanical Gardens, south of Hannah Administration Building and in the previous parking lot besides Erickson Hall. Stormwater art will provide opportunities for students to learn about the living laboratory.
4. Bioswales
    a. MSU has instituted 'No Mow Zones' for protecting the river's edge from erosion and polluted runoff (20). Expanding the riparian buffer into a series of bioswales along the river's edge and into campus will reduce the turf grass along the floodplain and floodway. In these newly renovated areas, native species will be planted that maximize infiltration. Additionally, bank stabilization and habitat restoration along the RCR fluvial system will be placed. The bioswales planting plans will be diverse from upland forest to wetlands.



5. Green Roofs
    a. Increasing the number of green roofs on campus from nine to 22 within the floodplain. Precipitation will be captured from the green roofs in cisterns and reused within the buildings for grey water uses.
6. Bank Stabilization
    a. An RCR Streambank Stabilization and Restoration Feasibility study identified over 4308 square feet of highly eroded river bank (according to the Bank Erosion Hazard Index (BEHI). Within our plan we have included 3.6 acres of bank stabilization that will follow the recommended methods outlined in the report (1). These methods include toe stabilization and regrading. Stabilizing the toe would likely require either building out the bank or protecting the toe with appropriate large stones. One way to improve the effectiveness and habitat quality of placed stones is called "joint planting." This entails using dormant, live cuttings 3⁄4 inch – 1 1⁄2 inch in diameter and 1.5ft to 3ft long from woody species, such as willows, dogwoods, ninebark, etc., and driving them through the interstices of placed stone and into the bank. The stakes will root then sprout, and both hold soil in place and act as energy dissipation near the toe of the banks (1).
7. Social Infrastructure / Recreation Amenities
    a. In order to better engage the campus community in the RCR, we have planned a diverse array of social infrastructure and recreational amenities. Amenities are separated into athletic, education and home.
    b. Raised walkways will be built on both sides of the banks, so students can access the river in areas near the existing weir.
    c. Recreation amenities along the river include: two canoe launches, one ice rink (as formerly described), one fishing station, additional bike parking and a raised boardwalk with river access. Since the weir will be removed in phase one of our plan, the river will be accessible for non-motorized boating. One canoe launch will be located behind Bessey Hall. The second will be north of the soccer and baseball fields. A kayak and canoe rental facility will be built in the current location of Parking Ramp 2. During the winter this space will also host an ice rink with rentable hockey and ice skates. Other recreational opportunities along the river include the boardwalk behind the Business College and wetland gathering space behind the Auditorium.

DESIGN PERFORMANCE METRICS:

Our plan resulted in a decrease in impervious area on campus from 40 acres to 12 acres—a reduction of 70%. As a result of the change in land cover, the proposed plan will decrease runoff across the site by 40% while increasing infiltration by 159% and evaporation by 136% (EPA National Stormwater Calculator, 6).

The largest storm event our design could handle is 2.46 inches of rain an hour. If our plan had been in place in 2018 during the 100–year flood event, the campus could have handled 94% of that stormwater (6).

Design Detail	Quantity	Economic Benefit	Environmental Benefit
Bioswales	11.1 acres	By replacing the 11.1 acres of sod with bioswale, we will be saving the university $35,591.00 a year, totalling $1,009,561.80	Tree Biomass: 963 tons, Rainfall Interception 50294500 gallons (76 Olympic sized swimming pools), Avoided Runoff 624,296 gallons (9 Olympic sized swimming pools) (iTree)
Green Roofs	15.2 acres (15 buildings)	The average asphalt roof lasts 23 years and costs $6,814,990.00. The average green roof lasts 50 years and cost $5,963,116.25. This means if you installed 2 asphalt roofs during the lifespan of the green roof, you would save $8,852,078.75 in total installed cost. Maintenance: Asphalt roof costs $95,410.00 per year, so multiplied by 2 equals $190,820.00. Green roofs cost $13,629.00 to maintain over 20 years, making a total maintenance savings of $177,191.00.	Decreasing impervious area from the floodplain by 38%
Rainwater Collections	15 buildings	Water cost savings of $172,402.00 annually, based on the City of Lansing commodity charge per 1,000 gallons.	Based on 2018 precipitation data, an estimated 12,770,543 gallons of rainwater will be collected off of green roofs in cisterns (equivalent to 19 Olympic sized swimming pools).
Riverbank Restoration	3.6 acres		Tree Biomass: 312 tons, Rainfall Interception 16,311,729 gallons (24 Olympic sized swimming pools), Avoided

			Runoff 2,024,625 (3 olympic sized swimming pools) (iTree)
New Park Space	12.7 acres		Removed 12.7 acres of impervious area in the floodplain, decreasing 56.7% of the total impervious area in the floodplain

EDUCATION AND COMMUNITY ASSETS:

Partnerships

This plan aims to build upon existing community partnerships, engage multiple stakeholders and implement educational programming. By working through the MSU Stormwater Committee, the proposed plan will complement work that is underway in support of the RCR Watershed Management Plan, the Greater Lansing Regional Committee for Stormwater Management (GLRC) and the Institute of Water Research at MSU. The GLRC periodically surveys citizens throughout the region about knowledge and behavior pertaining to water resources and stormwater management. This plan will build upon the regional education campaign that uses the survey results to encourage river stewardship.

MSU students have been active for many years in caring for the ecological health of the river. The Fisheries and Wildlife Club has an RCR cleanup event each fall and spring semester. Collaborations with student organizations such as the Student Greenhouse Project (20), MSU Sustainability Club, Spartan Sierra Club and MSU Greenpeace will provide linkages crucial for student engagement. While working on this project, the project team met with the Student Sustainability Leadership Council, a group comprised of all the sustainability oriented student groups on campus, as well as Amy Butler, the campus Sustainability Director, in order to assess student interest, existing efforts and potential collaborations

The river is a living laboratory and an important resource for academic enrichment. MSU has an estimated 113 classes that use the river, impacting more than 6,026 students in 2018 (13). The project team proposes to work with multiple colleges across the University, including Agriculture and Natural Resources, Business, Social Science, Natural Science and other colleges, in order to prepare students for a green economy. The ultimate goal is to have students from a diversity of majors walk away from their experience at MSU with lessons on sustainability that they can then implement in a wide cross section of fields.

Policy Improvements

As a public institution, MSU is an autonomous entity within the RCR Watershed. MSU has a high population density within the larger watershed, and can play a critical role in addressing stormwater management and water quality issues as part of its land grant mission.

By working with other communities throughout the region, there are numerous social, economic and environmental impacts this project can have on the community, and watershed-wide.

Pending the review and acceptance of this plan by MSU Administration, subsequent policy updates would include the MSU Masterplan and the Clean Water Act Stormwater Permit (MSU MS4- Ingham, No. MI0059342), as well as measuring the impact of the design during large scale flood events (14). The goal of these updates will be to improve the sustainability goals of the campus and to serve as a demonstration for communities throughout Michigan that are trying to manage stormwater and address impending climate change impacts.

In addition to addressing stormwater management concerns, long term research and policy initiatives that could be undertaken as part of this effort may include animal manure management in the headwater portions of the watershed, septic system policies across the neighboring jurisdictions and pesticide and fertilizer application across the watershed.

Effective stormwater management efforts across campus include the active participation among numerous campus service units, faculty and staff representing multiple departments, and colleges across campus. Ongoing communications with these groups, and viewing proposed actions through the lens of sustainability, will help focus the efforts.

COMMUNITY OUTREACH AND EDUCATION:

Several stormwater education activities have been implemented both on campus and regionally. Existing outreach and education activities on campus include a stormwater website, a stormwater walking tour, signage on campus to inform the public about "Grow Zones," signage warning against feeding the waterfowl, and working with the GLRC on social media campaigns, and the development of various educational material.

Individuals who engage with the river are more likely to be interested in protecting it. Educational programs will target various stakeholders, including: students, faculty, staff and visitors to campus. Recreation will be increased through place-making for fishing, art, outdoor classrooms, hammocking, biking, ice skating, and kayaking. Additionally, this plan will increase signage along the river to educate the public about campus sustainability practices.

For instance, signage about picking up pet waste, as well as doggy bag distribution posts, will be important for bacteria reduction efforts. Including the design elements as part of the mandatory freshman orientation tours will ensure that new students understand the importance of protecting water quality in the RCR. Past survey results have shown the importance of using social media to connect with our target audiences; therefore, an outreach campaign that includes multiple social media platforms will be included as part of this project.

Incorporating the river into existing educational programs will be more feasible than starting new programs from scratch. Stormwater management and the river design elements may be included in University-wide events such as the annual Grandparents University program and the MSU Science Festival, as well as college-specific events that occur throughout the year.

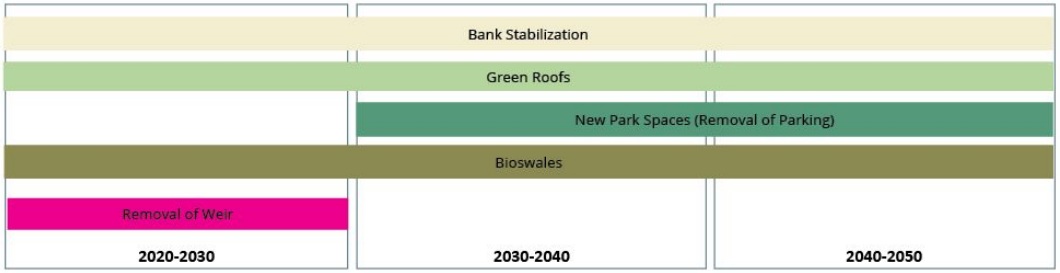
COST PROJECTIONS, FUNDING, AND PHASING:

Funding

The total budget for the project is approximately $5.10 million, broken down into $182,000 for recreation, $354,000 for green spaces, $3.22 million for water related projects, $1.03 million for hard surface/infrastructure, and $300,000 for educational related projects. Funding for these projects includes grants that range from 1:1 matching by the University to grants requiring no University march, thereby presenting the University with a diversity of funding options.In addition to using grants to cover a portion of the project costs, we are planning on working with the University to create a fundraising campaign aimed at involving University alumni in the process. The campaign will involve working with the University to approach alumni with incentives based on the level of donations. For example, larger donations may receive project naming rights, while smaller donations receive naming printed on individual bricks. Donations in excess of the funding goals can be allocated for sustainability based incentives on campus, similar to the Commemorative Tree Program previously implemented by the University.

	Green Spaces	Recreation	Education	Water	Energy	Maintenance
Grants:						
EGLE - Nonpoint Source Pollution Control Grants	x			x		
EGLE Advance GL Education			x			
EGLE-CMI Beach Monitoring Grant				x		
Great Lakes Commission (GLC)						
Great Lakes Fish and Wildlife Restoration Act	x					
Great Lakes Fishery Trust (GLFT)	x		x			
Great Lakes Iniative Grant						
Mi DNR Boating Infrastructure Grants		x				
Mi DNR Fisheries Habitat Grant Program	x			x		
Mi DNR Invasive Species Grant Program						x
Mi DNR Land and Water Conservation Fund		x	x			
Mi DNR Outdoor Rec. and Legacy Partnership Program		x				
Mi DNR Waterways Programs Grants	x	x	x	x	x	
Midwest Glacial Lakes Partnership (MGLP)	x					
National Fish and Wildlife Foundation: Sustain Our Great Lakes	x					
NFWF: Conservation Partnership Program	x					
U.S. Forest Service (USFS)						
U.S. EPA GLRI Reduce Nutrients and Stormwater Pollution				x		
USDA FS Tree Planting + Forest Health Improvement						x
Sustaining Our Great Lakes (SOGL): Restoring and Enhancing Stream and Riparian Habitat				x		
SOGL: Expanding Green Stormwater Ingrastructure in Great Lakes Communities				x		
SOGL: Maintaining and Enhancing Benefits of Habitat Restoration through Invasive Species Control						x

Recreation
Green Spaces
Water
Energy
Education



Phasing

The phasing of this project is prioritized based on the overall impact of individual project and funding resources. The removal of the weir is the first priority due to its environmental and recreational impact, and is included within the first phase of the project. Subsequent projects are based on existing efforts as well as the potential to obtain the grants discussed above. Bank stabilization, green roofs, and new bioswales have already begun to be implemented on campus, but will likely take the full thirty–years to be completed across the entire scope of the plan. Further, the existing campus Master Plan timeline dictates the timeline for the conversion of existing parking lots to park spaces.

Finances

Our long-term goal is to balance the cost of construction with return on investment from renewable water, maintenance cost savings, and recreational rental income. Installation of the recreational areas along the river—such as a canoe launch and ice skating rental facilities—would allow students to pay a minimal fee for using the rentals. Once the University has recuperated the cost required to purchase the canoes, ice-skates, and rental buildings, the fee would then be reduced to simply cover the cost of facility upkeep and student employees.

Additional cost savings can be achieved from money the financial resources saved during storm events. The plan is designed to handle 94% of a 100 year flood event (based on the 2018 flood levels)—therefore, there will be subsequent cost savings before, during and after flood events. For example, after the 2018 flood event, MSU was required to replace the baseball and soccer fields due to flood damage. Our budget was created by having access to the University's Infrastructure Planning and Facilities (IPF's) project costs for the past 10 years—in addition to estimates given to the team by IPF.

	Project Elements	**Cost**
Recreation	Canoe/Boat Launch	$20,000.00
	Bike Parking	$10,000.00
	Fishing Station	$10,000.00
	Art in Landscape	$20,000.00
	Gathering Space	$100,000.00
	Ice Skate Rentals	$10,000.00

	Hammock Posts	$2,362.00
	Raised Boardwalk with River Access	$10,000.00
Green Spaces	Green Roofs	$198,770.54
	Bioswales	$88,868.08
	Sod	$66,432.90
Water	Removal of the Weir	$2,000,000.00
	Rain Collection Systems	$1,215,538.57
Hard Surface/Infrastructure	Parking Lot Removals	$657,939.10
	Red Cedar Road Removal	$74,647.00
	Central Services Demolition	$280,140.00
	Bus Turn-Around Loop	$22,258.72
Education	Informational Signage	$1,000.00
	Outdoor Classroom	$300,000.00
	Pollinator Gardens	$2,500.00
Total Construction Estimate:		**$5,090,456.91**

Maintenance

The plan utilizes the three gardening zones that overlaps with the gardening zones on campus. Plant choice and specification are developed in collaboration with the gardeners who maintain each of the gardening zones on campus. Further, campus maintenance workers will also be involved ensuring optimal design for maintenance personnel. The plants that will be selected for the plan, will be carefully selected by utilizing the expertise on campus including: the gardeners, head arborist, and plant collector for MSU. These staff members work to maintain and upkeep the campus arboretum, and partake in seed collection and propagating new plants for campus. The plan would utilize their expertise and experience working on campus to help pick out species for our plan to create a lasting relationship with the existing professionals on campus and have them feel invested in this project—long after the plan is

completed. With the implementation of our green roofs in place of asphalt roofs, the University would save a total of $177,191.00, based off of MSU IPF standards, in maintenance cost over the 50 year life span of the green roof.

Along with green roofs, the installation of our 11.1 acres of bioswales—labeled as "no mow zones"—will save the University a total of $1,009,561.80 over the 30 year life span of the bioswale in opposition of mowing costs. When it comes to infrastructure, Ramp 2 will be deconstructed to further reduce associated maintenance costs, such as: repainting, resurfacing, and street sweeping. A self sustaining skating rink will be constructed in place of Ramp 2 as a place for the community to gather and meet in the winter months.

CONCLUSION:

As MSU continues to grow as one of the most prominent public universities, this project aims to instill sustainable alternatives to flood management on campus and throughout the greater Lansing community. Reducing the impact of flooding on campus, this plan will provide a leading example of how to manage flooding within neighboring communities. As a result of the site being located within such a large college community, this project creates a one-of-a-kind opportunity to engage students with some of the best management sustainability practices and demonstrates to the surrounding community the value of sustainable design. In keeping with MSU land grant philosophy, the University and the surrounding community can protect the river all while fostering higher water quality and land management practices that demonstrate how the land grant philosophy can be applied nationwide to help combat climate change. Evaluated through the cost of the 2018 flood event, the cost to do nothing was evaluated at roughly $880,000 (IPF), while the total cost for this project is $5.10 million. Thus, in as little as six flood events this cost saving project will pay for itself.

Finally, in the spirit of MSU's fight song, MSU students and alumni alike sing "On the banks of the Red Cedar" displaying that ever since the founding of MSU, that the Red Cedar River has been more than a blue line on campus; it is the blue line that unites the campus and is the very heart of the University. Go Green!

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