FINAL REPORT
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Project Name: From Gray to Green: Tools for Transitioning to Vegetation-Based Stormwater Management (Category 3: Utilizing Green Infrastructure to Manage and Mitigate Stormwater to Improve Water Quality)

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Funding: Federal Share: $155,612 plus **Grantee Share:** $149,722 **= Total Project:** $305,334
Budget Sheet:
FS Grant Manager:
Address:
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Project abstract (as defined by initial proposal and contract):
Many cities recognize the potential of Low Impact Development (LID) and green infrastructure in managing and mitigating urban stormwater runoff (e.g. nutrient load), yet most lack systematic strategies for transitioning away from their existing conventional (gray) drainage systems. This project developed an open-source, decision support tool (DST) to aid the strategic planning process for transitioning to LID Best Management Practice (BMP) systems that emphasize trees and urban forests. The toolset is designed to

be easy to use by natural resource managers, planners, and engineers, using nationally available and locally relevant datasets. It relies on four step planning processes that involve 1) Mapping of existing hydrology and green infrastructure, 2) designing and fitting a development/redevelopment project to the site, 3) selecting appropriate green infrastructure BMPs for the site, and 4) evaluating how well the project and BMPs fit the site. The tool includes a GIS-based mapping tool to identify areas suitable for green infrastructure, and an optimization tool to identify and select an optimal mix of existing gray and new green infrastructure to achieve runoff quantity and quality goals. The tool is supplemented with supporting documentation, including case studies that were carried out in Tampa (Florida) and Milwaukee (Wisconsin).

Project objectives:

The main objectives of this project include:

- **G-1:** Establish a geographically and professionally diverse group of experts to provide guidance, critiques of all project deliverables, and assist with national dissemination (achieved)
- **G-2:** Develop a catalogue of stormwater BMP options with an emphasis on urban trees and forests – providing their cost, performance metrics, and site selection criteria (achieved)
- **G-3:** Identify the potential to implement green infrastructure BMP options in developed urban areas with existing conventional drainage systems (achieved)
- **G-4:** Identify the optimal combination of existing conventional gray drainage systems and new green BMP options that improves the performance at the lowest cost (achieved)
- **G-5:** Develop a decision support tool to identify the preferred transition pathway from gray to green infrastructure (achieved)
- **G-6:** Apply the three tools in two demonstration projects with different climatic conditions to illustrate the national applicability of the toolset (achieved)
- **G-7:** Produce a guideline that facilitates the transitioning process from gray to green drainage systems across the nation (achieved).

The project has accomplished all of its planned objectives. Objectives 1-6 have been reported in the previous progress reports. This report will add the accomplishments of the last objective and include deliverables as stated in the project proposal. Summary of the completed objectives is provided below.

1. **(G-1) A geographically and professionally diverse group of experts was established** to serve as an advisory group to the project. Members of the Advisory Group were identified through a rigorous consultation with project team members and others to ensure expertise in different aspects of urban water management, urban forestry, and urban planning. Members of the advisory group include:
    - Holly Greening, Director - Tampa Bay: EPA National Estuary Program
    - Kathy Beck, Natural Resources Supervisor, City of Tampa
    - Catherine Coyle, Principal Planner, City of Tampa

- John S. McGee, Chief Environmental Scientist, Hillsborough County Stormwater Environmental Programs
- Laura Jackson, Research Biologist, U.S. Environmental Protection Agency
- David Kramer, P.E., Environmental Resource Permit (ERP) Evaluation Manager, Southwest Florida Water Management District
- Ed Macie, Team Leader, U.S. Forest Service, Integrating Human and Natural Systems
- Michael T. Miller, Stormwater Engineer, City of Tampa
- Jayantha Obeysekera, Chief Modeler, South Florida Water Management District
- Lou Sheppard, Urban Forestry Coordinator, Florida Forest Service
- David Sivyer, Forestry Services Manager, City of Milwaukee
- Wayne Zipperer, Landscape Ecologist, U.S. Forest Service

The project team organized two meeting with the advisory group. In the first meeting that was convened on August 7, 2015, participants discussed the overall approach of the project and details of the objectives and deliverables. In the second meeting, the Advisory Group reviewed and commented on the BMP catalogue and the conceptual model guiding the development of the Decision Support Tool (DST).

2. (G-2) A catalogue of stormwater BMP options with an emphasis on urban trees and forests was developed

2.1. A review of state-of-the-art information - green infrastructure, low impact development BMPs, urban forestry and existing BMP siting tools was completed – while several tools that look at single steps of the transition process exist, these resources have yet to be combined into one, holistic approach that optimizes the entire technical transition process. State-of-the-art information on green infrastructure, low-impact development BMPs, stormwater management, and urban forestry from national and international sources have been reviewed and documented. A detailed review of the existing databases of BMPs such as the International Stormwater Best Management Practice Database, the SWITCH project, and the SUSTAIN tool has been completed. Information missing in most databases for green BMPs that emphasize urban forests will be completed based on the outcome of the review process. In addition, the site selection criteria for green BMPs with urban trees and forest (e.g., climate zone, soil conditions, pH, and space constraints) are documented to promote the suitability and long-term survival of urban trees.

2.2. Catalogue of stormwater BMPs options with an emphasis on urban trees and forests including their performance metrics, site selection criteria, and documentation was developed. Additional documentation was developed for the urban forest BMPs, including ways to quantify benefits related to air quality, CO_2 reductions, urban cooling, and aesthetics. The protection of existing urban forestry and the natural pathways for water are a key focus of this task.

3. **(G-3) Identify the potential to implement green infrastructure BMP options in developed urban areas with existing conventional drainage systems** – This objective focuses on mapping existing green infrastructure systems using nationally-available data and identifies the potential to implement green infrastructure BMP options. The project team has developed a tool to map and identify green infrastructure options. The tool, developed as an ArcGIS add-on, uses nationally-available and/or user-supplied data for land use, soils, elevations, hydrology, and other layers to develop a map of existing green infrastructure. The tool allows users to define a project site and create optional data layers, such as roof areas or managed landscapes that will be used as a part of the decision support tool. The tool allows users to identify existing green infrastructures systems and maintains/restores them to minimize the impact (i.e volume of runoff or pollutant load)

4. **(G-4) Identify the optimal combination of green BMP options that improve runoff volume and nutrient load removal performances. Scenario Analysis is used to determine an optimal combination of green BMP options** - The project team has developed an Excel-based platform that allows users to change the number/size of each BMP area and see how runoff volume and nutrient load can be reduced while maximizing other ecosystem benefits. Testing the performance of different combinations of BMPs (scenarios), and to link the excel scenario analysis tool with the other modules of the tool (GIS based green infrastructure mapping tool) has been completed. This will allow users to determine the best combination of BMPs that achieve the required target while maximizing additional benefits (air quality, carbon sequestration, urban cooling, aesthetics etc). The project team has presented the platform to workshops and conferences, and has incorporated any comments and suggestions.

5. **(G-5) Develop a decision support tool to identify the preferred transition pathway from gray to green infrastructure.** *Identify the runoff volume and pollutant load credits for protected/restored and new green infrastructure systems*- The project team has worked to identify protected area runoff volume and pollutant load reduction credits for restored or new green infrastructure systems. The work associated with this objective included testing, refinement, and implementation of specific calculations related to runoff volume and pollutant load reduction credits, development of the front-end user interface, and development of the linkage with the other components of the tool.
6. **(G-6) Apply the tools in demonstration sites in Tampa, FL and Milwaukee, WI for the purpose of preliminary testing and refinement**- The completed toolset was tested in two demonstration projects (Tampa and Milwaukee). The Tampa Case-Study project was completed in April and some refinements were made to the tool based on the information provided by the City and users. Data and suggestions for the case-study were provided to the City to compare their business-as-usual design approach. After refining the tool based on the Tampa case study, the tool was tested in the case study in Milwaukee in June 2017 along with a workshop to demonstrate the capabilities of the tool and to discuss how the tool can be useful to the city.

Testing of the tool in the two demonstration sites was very useful to validate data sets used for mapping green infrastructure (including trees), natural drainage pathways, buildings, and other impervious areas. The data sets include EnviroAtlas high resolution data (1 meter) and National Land Cover Data (NLCD) lower resolution data (25 meter). The testing was helpful in refining the criteria for identifying potential areas for siting different BMPs. Further tests helped identify the different processes that users will follow in siting BMPs for new development, retrofits for water quality restoration, retrofits for flood relief, and urban forestry.

7. (G-7) **Produce a guideline that facilitates the transitioning process from gray to green drainage systems across the nation**

1.1 Publication
As part of the dissemination of the tool, a paper has been submitted for peer reviewed publication in the journal Urban Forestry and Urban greening. The paper was submitted in November 2017 and is currently under review.

1.2 In parallel with the development of the documents, a webinar session was conducted on September 13, 2017 with the Center for Landscape Conservation and Ecology. The webinar was led by two members of the project team, Andrew Koeser and Rob Northrop. The webinar was very informative and generated a number of discussions in terms of its usefulness and applicability in different conditions. A recorded webinar and workshop is available online (https://gray2green.jimdo.com/resources/) under the gray to green webpage.

1.3 A users manual has been developed that facilitates the transitioning process from gray to green drainage systems across the nation. The Gray to green documentation and user guide includes step-by-step guidance, description of the methodology applied in the development of the tool and two case studies that describe the results of an application of the toll in demonstration projects. The documentation applied same editorial standards as for educational materials at the International Society of Arboriculture.
1.4 A website has been developed (https://gray2green.jimdo.com/) where the tool and documentations can be downloaded. The website also contains several video tutorials that will help users understand how the systems works and educate them how to apply the tool for different projects. Video content of the webinar is also included in the webpage.

How will this project increase the knowledge we have about urban forestry? How will the public benefit?
This project will increase the knowledge of urban forestry in a number of ways:

- The project will provide state-of-the-art information on green infrastructure and low-impact development BMPs, stormwater management, and urban forestry from national and international sources.
- The project will provide a matrix for identifying potential locations of urban forestry for stormwater management. This will be very useful in enhancing decision making

in preserving and identifying optimal location of urban forests in pre- and post-development sites.
- The project will provide mechanisms to quantify benefits of urban forest based on location.

How will the results be disseminated to the public?

The results of the project will be disseminated through:
- Documentation of the conceptual frameworks and tool set;
- Documentation of the application case studies;
- Publications in peer reviewed journals or conference proceedings; and
  - *Peer Reviewed Journal paper:* A paper titled "Transitioning from Gray to Green (G2G) – A green Infrastructure Planning Tool for the Urban Forest" is under review for publication in the journal of *Urban Forestry and Urban Greening*. Reviewers' comments have been addressed and it is expected to be published in 2018.
- Presentations in conferences, workshops and webinar. The preliminary outputs of the project have been presented at a local and international events:
  - *Urban Forestry Institute Conference:* The outcomes of the project were presented at the Urban Forestry Institute Conference in Tampa, Florida on May 26, 2016. A 3-hour session is dedicated to providing attendees an overview of the G2G decision support tool for transitioning to vegetation-based stormwater management. Continuing education credits for the session have been approved by the Florida Engineering Society and the American Planning Association.
  - *Florida Stormwater Association's Conference (FSA):* The project team submitted an abstract to FSA 2016 Annual Conference. The abstract was highly ranked by the conference review committee and is presented in two different sessions in Fort Myers, Florida on June 16, 2016.
  - *Global Water Partnership PanAsia Workshop:* The preliminary outputs of the project were presented at an international workshop (PanAsia) hosted by the Global Water Partnership in Singapore on July 14, 2016.
  - *The Environmental, Health, Safety (EHS) Workshop:* The result of the project was presented at the 2016 EHS Roundtable in Orlando, FL, on November 10, 2016
- A one-day workshop was conducted on May 24th, 2017 in Milwaukee that was attended by stormwater managers, GIS professionals, urban forests, and city managers.
- The outcome of the project was presented at the International Society of Arboriculture's 2017 Conference and Trade Show in Washington DC on 30th of July.
- A Webinar Workshop was conducted on September 13th, 2017 with the Center for Landscape Conservation and Ecology.
- A website has been developed that contains the user manual and video tutorials. It also allows users to download the tools and watch the webinar video.

Has the project met the projected timeline of accomplishments? Is the project on schedule? Is the project ahead of schedule? Is the project behind schedule? If a no-cost time extension has been requested for this project, why is (was) it needed?

The project has not met the project timeline as proposed due to 1) a initial delay in executing the federal contract, and 2) due to multiple changes of PIs during the course of the project period. As soon as the project was awarded, there was a significant change in leadership at the Patel College of Global Sustainability where the Principal and Co-Principal Investigators left USF. This required the assignment of a new PI and the addition of new project team members. This resulted in a seven-months delay in the project set-up and execution by USF's Sponsored Research office. Initially a no cost time extension for 12 months has been approved by the Grantor. Towards the end of the project again, there was a change of PI that resulted in some delays to organize the transfer of responsibilities and documentations. Hence, an additional 6 months of no cost extension was approved that extended the project period to the end of March 2018.

List the active partners (key individuals or organizations) involved in the project to-date:

1. Dr. Kebreab Ghebremichael, Patel College of Global Sustainability, USF
2. Dr. Shawn Landry, School of Geosciences, College of Art and Science, USF
3. Dr. Seneshaw Tsegaye, Florida Gulf Coast University, FGCU
4. Mr. Thomas Singleton, Thomas L. Singleton Consulting, Inc.
5. Dr. Mahmood Nachabe, Civil and Environmental Engineering, USF
6. Dr. Andrew Koeser, University of Florida
7. Mr. Rob Northrop, University of Florida/ IFAS Extension

In addition, three research graduate assistants with strong experience in stormwater management, green infrastructure systems and computer programming were actively involved in the project.

Comments considered of importance but not covered above:

- The preliminary test made on a project site in Tampa was very useful in addressing some issues with the development of siting tool.
- It was decided to develop a video supported user's guide. This has enhanced the documentation of the tool and it provides users a simple and easy to follow instructions on using the planning tool.
- A website has been developed where all materials related to the tool are uploaded. Users can download the tool and documentations from the site and also watch the video tutorials.
- The final version of G2G Toolkit and user guide are included in the following Dropbox link
- https://www.dropbox.com/sh/699qzqyrdwwzq51/AACSny_0BpAu1LKkj5YjkQZCa?dl=0

The toolkit includes two folders: i) ***BMP Scenario Analysis Tool (SAT)***--zip folder. Make sure to unzipped the folder if you would like to open the user-guide directly from the SAT tool. Also note that the three files have to be saved in the same folder. This part of the toolset allow users to use SAT without installing the GIS toolbar, ii) ***GIS .esriaddin Toolbar.*** The GIS tool bar include both the GIS-based Green Infrastructure Mapping Tool and the BMP Scenario Analysis Tool. Users need ArcGIS to use this toolbar.

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