

Project in Review 2018-2021 Executive Summary

Charlotte-Mecklenburg Flood Management Risk Tools and Flood Sensors

A partnership between Charlotte-Mecklenburg Storm Water Services and the US
Department of Homeland Security

DELIVERABLE 7

Contract 70RSAT18CB0000022

April 23, 2021

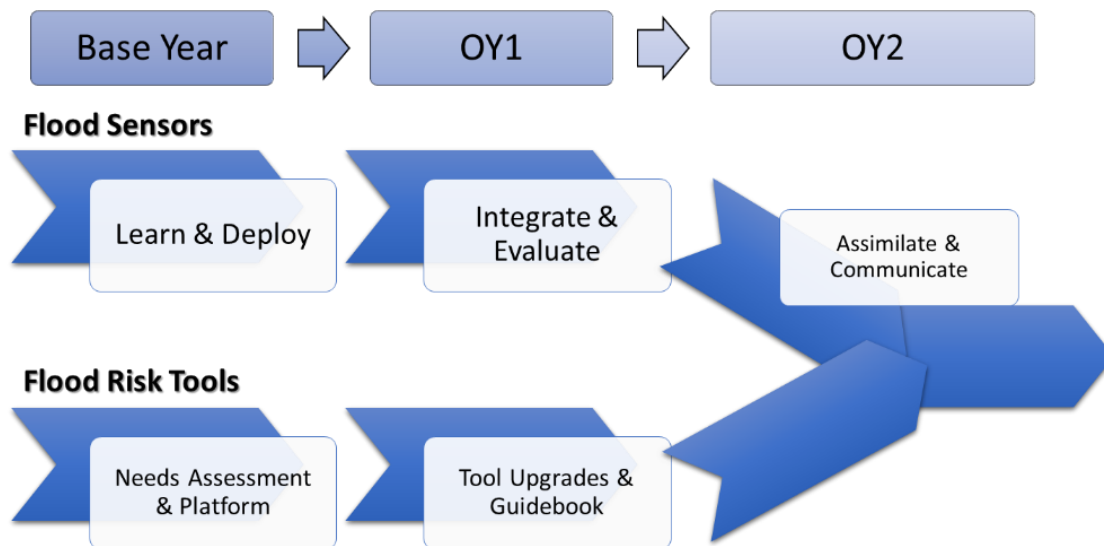
Prepared by:



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Background

This executive summary has been prepared to satisfy Deliverable 7 of the U.S. Department of Homeland Security Office of Procurement Operations S&T Acquisition Branch contract 70RSAT18CB0000022. In April 2018, Charlotte Mecklenburg Storm Water Services (CMSWS) contracted with the Department of Homeland Security (DHS) to test low-cost flood sensors (LCS) and further develop flood management risk tools already in use by CMSWS. The contract was structured to last 3 years (Base Year, Option Year 1 (OY1) and Option Year 2 (OY2)) and required annual deliverables. The following figure presents the high level objectives for each option year and aspect of the project. The main aspects of the project included testing Low Cost Flood Sensors (LCS) and developing additional flood Risk Assessment – Risk Reduction (RARR) capabilities. During OY1 and OY2 the LCS and RARR work progressed along parallel paths with the ultimate objective of merging the two aspects into a real-time flood detection, management and reporting tool for CMSWS.



The remainder of this Executive Summary is arranged by contract year and deliverable. CMSWS has developed 11 deliverables that capture all portions of the 3-year project. Deliverables approved for release by DHS can be obtained on our Storm Water Services website at the following URL:

<https://charlottenc.gov/StormWater/Flooding/Pages/FloodSensorsTechnicalResources.aspx>

Copies of software or reports can also be requested from:

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Base Year – Risk Tools

Deliverable 2A - Risk Assessment/Risk Reduction National Outreach Report

CMSWS, working with ESP Associates, Inc., developed a multi-prong outreach strategy to solicit and share flood risk assessment information from communities across the nation. The strategy included the development of a website, web based survey and outreach to advertise the survey. The web survey consisted of 19 questions primarily regarding flood risk. Nearly 900 responses were received from 46 states and the District of Columbia. CMSWS used the information gathered from the survey and any additional outreach to inform the development of the Community Guidebook and RARR enhancements in subsequent phases of the project. The Community Guidebook will share flood risk assessment and reduction methodologies as well as provide templates and tools to other peer-communities that can be used as a starting point for developing or expanding their own risk mitigation strategies. Conclusions from the survey that will be considered in the development of the Guidebook and RARR Tool enhancements are listed below.

The findings of the survey are detailed in the report referenced as follows:

Charlotte-Mecklenburg Storm Water Services (2018), *Risk Assessment / Risk Reduction National Outreach Report – Deliverable 2A; Milestone 1*. Report prepared for US Department of Homeland Security under Contract 70RSAT18CB0000022.

Deliverable 2B – Needs Assessment Report

This deliverable incorporates flood risk assessment needs that were initially identified during scoping of the project as well as those identified through a national outreach effort and subsequent interviews with CMSWS staff. Input from CMSWS was collected through user case exercises conducted in November 2018.

A total of 21 unique needs and enhancements to the flood risk tools were identified as part of this assessment. Five needs are applicable to the development of the Community Guidebook, which will be produced by the end of Option Year 1. The remaining needs are applicable to RARR tool enhancements. It is noted that in several cases, similar (or identical) needs were identified for both the Community Guidebook and the tool enhancements.

The needs assessment is detailed in the report referenced as follows:

Charlotte-Mecklenburg Storm Water Services (2019), *Needs Assessment Report – Deliverable 2B; Milestone 2*. Report prepared for US Department of Homeland Security under Contract 70RSAT18CB0000022.

Deliverable 2C – RARR Tool Enhancements

The primary objective of Deliverable 2C was to migrate and enhance the existing RARR toolset in preparation for further modifications during OY1 and OY2. A review was done to assess details of data and tool logic structures and to identify limitations, deficiencies, and/or opportunities for improvement. A number of changes/improvements were identified for both data structure and tool processes.

A summary of primary changes being implemented in the Base Year tools as a result of the evaluation are provided in Deliverable 2C referenced as follows:

Charlotte-Mecklenburg Storm Water Services (2019), RARR Tool Enhancements – *Deliverable 2C; Milestone 3*. Technical Memorandum and associated software prepared for US Department of Homeland Security under Contract 70RSAT18CB0000022.

Base Year – Flood Sensors

Deliverable 3A – Flood Sensor Deployment Plan

Deliverable 3A details the installation and testing 75 ‘alpha’ low-cost flood sensors (LCS) in Mecklenburg County during Base Year 1 of the contract. CMSWS received 25 LCS from 3 vendors for a total of 75 units. The 75 LCS were deployed to 25 sites split into 5 ‘mesh’ networks of 5 sites each. Each site was configured with a single LCS from each of the 3 vendors. Two of the sites were co-located with a pre-existing USGS stream gage for QA/QC purposes. Installation of the LCS began in July 2018 and were completed in November 2018. Generally, installation of a single vendor’s 25 LCS required approximately 5 field days to complete. In general, radio communication proved problematic and 3G and 4G cellular communication was significantly more reliable. Upon installation, most of LCS units performed reasonably, however battery life and communication challenges persisted. These challenges caused each vendor to perform firmware updates and in some cases remove problematic equipment from the field.

The full deployment plan is detailed in the report as referenced below:

Charlotte-Mecklenburg Storm Water Services (2019), *Flood Sensor Deployment Plan – Deliverable 3A; Milestone 4*. Report prepared for US Department of Homeland Security under Contract 70RSAT18CB0000022.

Deliverable 3B – Flood Sensor Limited Field Deployment Plan

Deliverable 3B details the planned deployment and testing of approximately 98 ‘beta’ low-cost flood sensors (LCS) in Mecklenburg County during Option Year 1 of the contract. The Deployment Plan was prepared to significantly increase flood sensor coverage in high risk areas and test the LCS’s performance under a variety of urban conditions and settings. Sites were identified through a GIS based tiered selection methodology that focused upon monitoring the most flood prone areas. The methodology scored sites in the following 7 categories:

1. Unmonitored flood risk.
2. Stream Crossings.
3. Critical Infrastructure.
4. Existing Capital Improvement Project (CIP) Sites.
5. Rapid Deployment.
6. USGS Validation.
7. Public Demonstration

The detailed site selection methodology and results are presented in the following report:

Charlotte-Mecklenburg Storm Water Services (2019), *Flood Sensor Limited Field Deployment Plan – Deliverable 3B; Milestone 5*. Report prepared for US Department of Homeland Security under Contract 70RSAT18CB0000022.

OY1-Risk Tools

Deliverable 4A – RARR Tool Enhancements

OY1 RARR Tool Enhancements focused on new functionality to improve tracking, communication, and program planning of risk, as well as new tools to aide in the evaluation and prioritization of mitigation actions. The logic associated with the calculation of risk scores was largely retained from the Base Year tools. However, one enhancement (“Incorporation of Mitigation Actions into Risk Scores”) did include a change in risk scoring that increased the risk pool by approximately 5% from the Base Year risk pool. Two new key concepts introduced in OY1 were “Residual Risk” and “Viability”. Residual risk is defined as the long-term risk remaining if mitigation actions were implemented that either bring all buildings into compliance or remove (i.e. acquire) high-risk properties. Residual risk defines the target of acceptable flood risk based on community values. Mecklenburg County allows development within and near floodprone areas, thus the residual risk is greater than zero. Viability is an additional level of evaluation that considers the overall practicality/feasibility of a given mitigation technique. Viability enhances the current technical effectiveness and mitigation prioritization evaluation and is now the key indicator for the “recommended” mitigation technique for a given building. The idea is that project viability can be used to evaluate individual mitigation techniques as well as to “roll-up” mitigation projects on a larger scale (total costs, risk points reduced, etc.).

The full report can be obtained at the following reference:

Charlotte-Mecklenburg Storm Water Services (2020), *Flood Risk Assessment and Risk Reduction (RARR) Enhancements – Deliverable 4A; Milestone 7*. Technical Memorandum and associated software prepared for US Department of Homeland Security under Contract 70RSAT18CB000022.

Deliverable 4B – Flood Risk Assessment and Reduction Community Guidebook

The Flood Risk Assessment and Reduction Community Guidebook summarizes the efforts needed to develop a *data-driven framework* that can be used by communities nationwide to assess flood hazards, evaluate and prioritize actions to mitigate risk, and provide a foundation to implement, measure, and track the success of a program over time. It incorporates needs that were initially identified during scoping of the project as well as those identified through a national outreach effort. The national outreach effort, performed in the summer/fall of 2018, included an online survey that yielded nearly 900 responses. The Community Guidebook aims to lead other communities through obtaining and developing data as well as demonstrate how that data can be used to assess risk and evaluate mitigation options within their community. It also discusses how communities can develop their own mitigation strategy, how to fund and implement that strategy, and how to monitor and communicate the strategy and results within their community. Additional data links and resources, sample checklists and basic calculators, and a case study are also provided.

The guidebook can be obtained at the following reference:

Charlotte-Mecklenburg Storm Water Services (2020), *Flood Risk Assessment and Reduction Community Guidebook – Deliverable 4B; Milestone 8*. Report prepared for US Department of Homeland Security under Contract 70RSAT18CB000022.

OY1 – Flood Sensors

Deliverable 5A – Low Cost Flood Sensors: Urban Installation Guidebook

The guidebook presents CMSWS's OY 1 experience deploying 98 beta LCS at locations in Mecklenburg County. It summarizes the steps taken by CMSWS to install, operate and maintain low-cost flood sensors. It is intended to serve as a reference for communities nationwide attempting to mitigate hazards associated with flooding through the installation and monitoring of real-time water levels in areas at risk of flooding. Installation of the LCS occurred between July 2018 and November 2018 and were tested until April 2019. The 98 LCS were distributed across 7 use-cases and included both wet (in-stream) and dry (floodplain) installations. CMSWS opted to equip all of the LCS units with 4G cellular modems, which have been effective. CMSWS operated the 93 beta and 20 alpha LCS through February, 2020. In general, the units functioned effectively and minimal disruptions in service were caused by communication (cellular) or firmware related issues. Problems were encountered with the ability of the integrated solar array to effectively charge the units during periods of extended cloud cover (>72 hours) and at sites with dense tree canopy. The accuracy of the LCS units was excellent and met the needs of all use-cases monitored by CMSWS. An active and ongoing operation and maintenance program has been essential to successful operation of LCS.

The LCS tested by CMSWS present an extremely useful tool for storm water programs of all sizes. They are relatively simple to install and operate but require an active maintenance program similar to other field equipment. They are highly versatile and can be permanently installed in a variety of settings including wet and dry sites or rapidly deployed in advance of storms at high risk areas. The LCS do not take the place of USGS gages and do not provide the same level of scientific accuracy or data. However, they can be quickly deployed almost anywhere a community needs reasonably accurate real-time flood data to warn citizens and first responders and support decision making.

The guidebook can be obtained at the following reference:

Charlotte-Mecklenburg Storm Water Services (2020), *Low Cost Flood Sensors: Urban Installation Guidebook – Deliverable 5A; Milestone 9*. Report prepared for US Department of Homeland Security under Contract 70RSAT18CB000022.

Deliverable 5B – Low Cost Flood Sensors Performance Analysis

Deliverable 5B details the performance of LCS in Mecklenburg County during Option Year 1 of the contract. CMSWS received 93 LCS from the vendor and were deployed at sites previously identified during the site selection analysis (Deliverable 3B). Two of the sites were co-located with an existing USGS stream gage for QA/QC purposes. Installation of the LCS began in July 2019 and was completed in September 2019. Upon installation, most of beta LCS units performed reasonably, however battery life and communication challenges persisted throughout 2019. These challenges caused the vendor to perform multiple firmware updates and, in some cases, remove problematic equipment from the field. The testing period for the LCS extended through February 2019.

One of the primary functions of the LCS is to support the generation of warnings and alerts to inform emergency responders of flood conditions endangering life and property. CMSWS integrated the LCS into the existing FINS system to expand the warning and alert capabilities to additional sites. Testing of the warning and alert capabilities of the LCS data was highly successful.

In general, the LCS performed as intended after the firmware updates. The accuracy of the units was approximately equivalent to the manufacturer specifications of 0.04 feet, which was determined through comparison with co-located USGS gages and field verification measurements during baseflow. After the firmware updates, the units transmitted data for approximately 90% of the testing period. Lapses in transmission were attributed to low battery voltage, damaged equipment and vandalism. Approximately 22% of the beta LCS units experienced equipment damage that resulted in lapses in data transmission. Most of the damage was to the in-stream sensors and head units. Causes of the damage were in-stream debris, fallen trees and vandalism.

Overall the beta LCS units performed effectively in Mecklenburg County. This is largely the result of an active operation and maintenance program to monitor the performance of the sensors, collect validation measurements, maintain site conditions and repair any damage encountered. It is critical that any community using LCS implement a comprehensive operation and maintenance program to ensure the equipment is functional when needed during emergencies.

The Performance Report can be obtained at the following reference:

Charlotte-Mecklenburg Storm Water Services (2019), *Low Cost Flood Sensors Performance Analysis – Deliverable 5B; Milestone 10*. Report prepared for US Department of Homeland Security under Contract 70RSAT18CB0000022.

OY2 – Flood Sensors

[Deliverable 6A – Low-Cost Flood Sensors: System Communication](#)

Deliverable 6.A presents CMSWS’s experience communicating LCS data to multiple systems. It was intended to serve as an example of how LCS data can be used to enhance existing systems for communities nationwide attempting to mitigate hazards associated with flooding through the installation and monitoring of real-time water levels in areas at risk of flooding. The LCS units are capable of transmitting data via 4G cellular modem or satellite.

Deliverable 6A can be obtained at the following reference:

Charlotte-Mecklenburg Storm Water Services (2021), *Low Cost Flood Sensors: System Communication Performance Analysis – Deliverable 6A; Milestone 12*. Report prepared for US Department of Homeland Security under Contract 70RSAT18CB0000022.

OY2 – Risk Tools

[Deliverable 6B - Communication, Automation and Display Summary](#)

Deliverable 6B presented inundation mapping tools that utilized LCS and USGS stream gage data to produce near real time representations of flooding via. The tools utilized a probabilistic approach that leveraged existing flood model output, cross section data and GIS processing to produce flood inundation maps. The maps can be used during flood events to provide event intelligence to first responders. The inundation mapping tools were also integrated with existing elevation certificate, flood risk and mitigated structures data to provide rapid post event damage assessments and losses avoided estimates.

Deliverable 6A can be obtained at the following reference:
Charlotte-Mecklenburg Storm Water Services (2021), Communication, Automation and Display
Summary – *Deliverable 6B; Milestone 13*. Report prepared for US Department of Homeland Security
under Contract 70RSAT18CB0000022