WALTER P MOORE

UNIVERSITY OF TEXAS ARLINGTON

PROPOSAL

FLOOD WARNING-FORECASTING SYSTEM

PHASE 2

CITY OF GRAND PRAIRIE
November 28, 2017

WALTER P MOORE

November 28, 2017

Ms. Stephanie W. Griffin, P.E., CFM
Stormwater Utility Manager and Floodplain Administrator
City of Grand Prairie
Stormwater Department
206 W. Church St.
Grand Prairie, TX 75053

Subject: Proposal for City of Grand Prairie Flood Warning-Forecasting System Phase 2

Dear Ms. Griffin,

Walter P. Moore and Associates, Inc. is pleased to submit our proposal for Phase 2 of the City of Grand Prairie Flood Warning-Forecasting System. Walter P Moore has provided Water Resources Engineering since 1983 with a focus on floodplain management, storm water services, and water supply. Relevant to this project, our experience includes multiple Flood Warning Systems for public agencies and private clients.

As with Phase 1, Walter P Moore has teamed with the University of Texas at Arlington for the second phase of the project. Our team provides complementary and overlapping capabilities to ensure additional manpower and expertise to help develop a better, more cost effective solution.

This proposal includes only those tasks and associated budgets that cover the services necessary to expand the City of Grand Prairie's Phase 1 flood warning/forecasting project. This proposal is designed to make the best use of available funding to provide the City with a product that is most beneficial and useful to City staff during flood emergency operations. It is recognized that much of the scope and budget are reflective of Walter P Moore's assumptions about the direction of the project, which may be altered following the meeting with City staff. Ultimately, it is our goal to serve the City's needs in the most efficient and cost effective manner possible.

We appreciate the opportunity to present our credentials. Should you have any questions, please contact me.

Sincerely,
WALTER P. MOORE AND ASSOCIATES, INC.

Andrew C. Yung, PE, CFM / Principal
713.394.5885 / ayung@walterpmoore.com

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Walter P. Moore and Associates, Inc.

Walter P Moore's water resources engineering services provide innovative engineering solutions for floodplain and watershed management. The results are cost-effective, environmentally responsible, and optimally designed to meet long-term needs. We create solutions for floodplain management, storm water management, erosion and scour mitigation, and flood protection. They result from our collaboration with owners and other stakeholders, including the design team, citizens, agency representatives, and others.

Our engineering is combined with current technologies—geographic information systems; steady and unsteady state modeling of surface, channel and pipe flow, and radar-derived rainfall data—to offer effective solutions to challenging drainage issues.

Our tools and technology include:

- Computer Aided Engineering Analysis, Design (e.g., XP-SWMM, MOUSE, EPA-SWM, EPANET, InfoWorks)
- H&H Modeling Software (e.g., HEC-RAS, HEC-HMS)
- Specialized Applications of Geographic Information Systems (GIS) (e.g., ArcHydro Data Model, HEC-GeoRAS)

Our designs have been recognized at the national level for conserving resources, improving water quality, and making other environmental improvements.

Floodplain Management

Sound floodplain management strategies are essential for responsible urban development in flood prone areas. We collaborate with public agencies and private clients to identify areas of flood risk, develop floodplain or inundation maps, take measurements to protect human lives and structures, and prevent adverse impacts to flood levels resulting from construction activities. Our floodplain management projects are based on our engineer's solid hydrologic and hydraulic concepts and their good judgment combined with state of the art modeling and mapping tools with consideration of the regulatory requirements and policies. Together all of these elements define a unique skill set we use every day to mitigate flood problems and protect our communities.

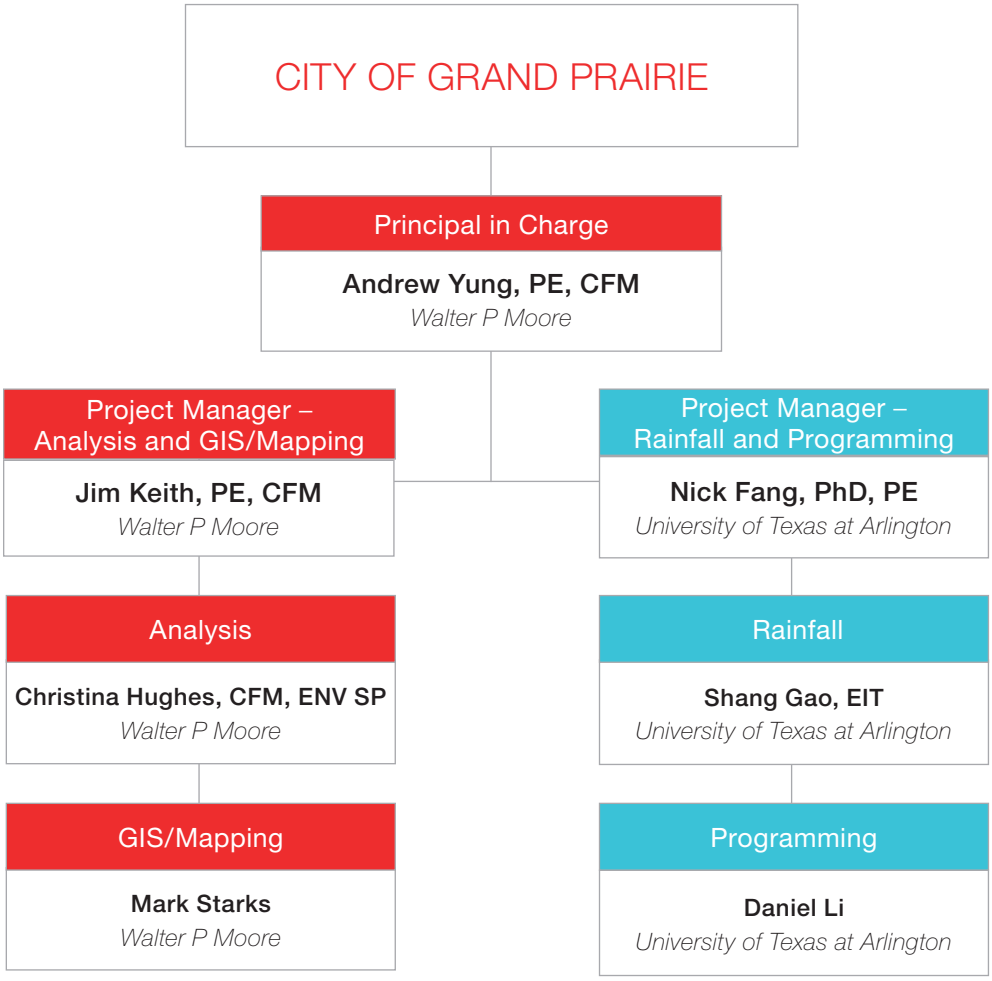
Flood Warning Systems

We gather information in real time about rainfall events to produce warnings and estimated water levels in streams and water crossings. We then produce models to create awareness for flood related risks in real time.

University of Texas at Arlington

The University of Texas at Arlington (UTA) is a major comprehensive research, teaching, and public service institution located in the heart of the Dallas/Fort Worth metropolitan area. UTA is more than 100 years old and is the second-largest component of The University of Texas System. With an enrollment of approximately 35,000 students, UTA ranks among the finest institutions of higher learning in the state, attracting scholars of international stature to its faculty. Emphasis on graduate education has resulted in a Graduate School population numbering more than 25% of the total student body.

The Fang Water Resources Group has approximately 1,400 SF of lab space that is connected to the campus backbone network. This provides research fellows/students access to main frame computers and allows them to communicate and transfer data with collaborators at other universities. The group is well equipped with the state of the art computing facilities including the following industrial software: ESRI ArcGIS, HEC-HMS, HEC-RAS, XP-SWMM, Vflo, HEC-ResSim, etc. Two external hard disks are also available for data storage and backup. The university high-performance computing (HPC) system is also available, which currently consists of 840 processors with more than 90 Terabytes of aggregate storage. The UT System Research Infrastructure (UTRC) facility is also available for this project. The new Lonestar supercomputing system of UTRC enables parallel computing applications, large shared memory applications, high throughput computing, and remote visualization of large scale data. Lonestar is a national TeraGrid resource and is one of the most powerful, productive, and comprehensive academic systems in the US, and its availability within UTRC presents a scientific advantage to us. The high bandwidth network connectivity (10 Gbps) enables high-speed data sharing and transferring.


CITY OF GRAND PRAIRIE
Principal in Charge
Andrew Yung, PE, CFM
Walter P Moore
Project Manager – Analysis and GIS/Mapping
Jim Keith, PE, CFM
Walter P Moore
Project Manager – Rainfall and Programming
Nick Fang, PhD, PE
University of Texas at Arlington
Analysis
Christina Hughes, CFM, ENV SP
Walter P Moore
Rainfall
Shang Gao, EIT
University of Texas at Arlington
GIS/Mapping
Mark Starks
Walter P Moore
Programming
Daniel Li
University of Texas at Arlington

Andrew Yung, PE, CFM

Principal in Charge / Chief Hydrologist
21 Years with **Walter P Moore**

Andy Yung has 30 years of experience as an engineer, planner, and hydrologist. He has managed a wide range of engineering projects involving hydrology, hydraulics, master drainage studies, channel modification and hydraulic structure designs, watershed impact analyses, detention facility designs, and dam safety analyses.
He served as the team leader for Independent Technical Review (ITR) for several federal projects currently under construction in Houston. He is very familiar with HEC-HMS/HEC-1, HEC-RAS/HEC-2, HEC-DSS, and HEC-SSP and provides technical support and training to users of these programs.

EDUCATION

Bachelor of Civil Engineering, Georgia Institute of Technology, 1987

REGISTRATIONS

Licensed Professional Engineer

Texas 79810

Additional Registrations

Certified Floodplain Manager 0103-98N

PROFESSIONAL AFFILIATIONS

Association of State Floodplain Managers

Texas Floodplain Managers Association

Association of State Dam Safety Officials

National Hydrologic Warning Council

RELEVANT PROJECT EXPERIENCE

- Grand Prairie Flood Warning System (Phase 1), Grand Prairie, TX – Provided oversight and technical support/guidance for this Phase 1 project for Technical Services in support of a flood-warning program for the City of Grand Prairie. The Phase 1 product presents advance notification of roadway inundation at six sites throughout the City.
- Harris County Flood Control District (HCFCD) FWS Gauge Ratings, Harris County, TX – Developed preliminary elevation vs. discharge rating curves for 87 stream gaging stations monitored by HCFCD as part of their Flood Warning System (FWS). As storm events occur, HCFCD will use stream flow measuring equipment to confirm/modify these ratings. These were coupled with ratings from 45 USGS gaging stations to cover nearly all gaging locations across the county, omitting rainfall-only gauges and coastal gauges.
- HCFCD Flood Event Modeling Program, Harris County, TX – Developed a comprehensive computer program to ingest radar-based rainfall data into a modeling system in order to provide HCFCD with flood inundation mapping in real-time. Buffalo Bayou and White Oak Bayou served as the two pilot studies for the system development. This effort included the calibration of the system to real-time stage (HCFCD FWS) and flow (USGS) data.
- HCFCD Cypress Creek Watershed Study and Physical Map Revision, Harris County, TX – Revision to the floodplain delineation of the main stem of Cypress Creek based on recalibration of existing hydrologic and hydraulic models to three historical flood events. The effort included redefining the rating curve at a critical USGS location based on understanding of downstream conditions, USGS observed field measurements, and historical high water marks. The USGS utilized the revised data to assist in reestablishing the rating for this gauge location.
- Confidential Flood Warning System, Harris County, TX – Provided technical support to a major corporation by creating a flood warning product that would be simplistic and useful in determining the potential for flooding and which could be used by non-technical personnel onsite during a flood emergency. The product required an understanding of the interaction of two local stream gauges in order to forecast flooding.
- East End Crossing Flood Investigation, Louisville, KY – Performed a forensic analysis of several minor flooding events on the Ohio River. The effort required several flood frequency analyses of the USGS gauge on the river and a thorough understanding of the non-typical rating procedure developed by the USGS to identify flows at that location.
- White Oak Bayou Flood Investigation, Harris County, TX – Performed a forensic analysis related to flooding along White Oak Bayou resulting from several flood events. This effort included investigating the reasonableness of rating data at two USGS gauges along the stream. Once confirmed, the flood event analyses were calibrated to these two gauges.

Jim Keith, PE, CFM

Project Manager – Analysis and GIS/Mapping /
Senior Project Manager
1 Year with **Walter P Moore**

Jim Keith has more than 16 years of technical and managerial experience in water resources planning and design projects including open channel and storm drain design, dam and levee design/breach analyses, and systems optimization modeling. Experienced in project management, stakeholder engagement, and recognized as a subject matter expert in his field, he has a proven track record of successfully delivering efficient solutions on complex projects for clients including DFW area municipalities, local water and levee improvement districts, USACE, and FEMA.

EDUCATION

Bachelor of Science, Hydrology & Water Resources, Tarleton State University, 2000

REGISTRATIONS

Licensed Professional Engineer

Texas 105043

Additional Registrations

Certified Floodplain Manager 0608-04N

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers

Society of American Military Engineers

Texas Floodplain Management Association

Texas Society of Professional Engineers

RELEVANT PROJECT EXPERIENCE

- Grand Prairie Flood Warning System (Phase 1), Grand Prairie, TX – Provided project management for this Phase 1 project for Technical Services in support of a flood-warning program for the City of Grand Prairie. The Phase 1 product presents advance notification of roadway inundation at six sites throughout the City.
- Grand Prairie Master Drainage Plan, Grand Prairie, TX – Oversaw updating of the Mountain Creek and Joe Pool Lake hydrologic models for current and future land use conditions, establishing revised floodplain limits, analyzing potential detention facilities and open space, and preparing a hydrologic report. The study integrated storm water quality and quantity aspects to assist the City in both improving water quality and providing flood control. Guidelines for controlling development and master planning the open space of these floodplains can be accomplished based on the results of the work completed in this area.*
- Lower Dudley Branch Flood Study, Carrollton, TX – Technical Director for the development of a dynamic 1D/2D coupled XP-SWMM model of the Elm Fork Trinity River near the confluence of Lower Dudley Branch, Indian Creek, and Timber Creek. New high resolution 1-ft LiDAR was obtained along with ground survey to develop an accurate surface for the 2D model development, supported by FEMA effective HEC-HMS and HEC-RAS models of the tributaries and USACE Fort Worth District HEC-1 and HEC-RAS models of the Elm Fork Trinity River. The results of the 2D analysis were used to determine base flood elevations within this complex riverine environment, providing an accurate basis for future infrastructure improvements and development within the project area.*
- Rush Creek Watershed Study, Arlington, TX – As part of the comprehensive watershed study, managed the Lower Rush Creek and Tributary RC-1 sub-watershed analyses, overseeing all aspects of model development. The project involved development of unsteady HEC-RAS models and a dynamic 1D/2D coupled XPSWMM model to determine existing and fully-developed volumes, velocities and base flood elevations within the sub-watersheds. The models were then used to develop flood mitigation projects within the watershed to reduce flooding and erosion with consideration to improving water quality and maximizing City dollars through multi-benefit mitigation solutions.*
- City of Dallas Public Works and Transportation Elm Fork Flood Study, Dallas, TX – Provided a flood study that included engineering, surveying, environmental, and recreational planning services for the Elm Fork of the Trinity River. The study deliverables included a local drainage master plan for three tributaries within the SPF limits of the Elm Fork, Richards Branch, Wesco Creek, and Daniels Creek. It also includes a report outlining overall watershed management concepts for the Elm Fork. The project limits included 43,200 LF of the Elm Fork from its confluence with SH183 north to Royal Lane. It also included 13,500 LF of Richards Branch, 15,000 LF of Wesco Creek, and 14,900 LF of Daniels Creek.*
- City of Dallas Public Works and Transportation Trinity River Interior Drainage Study, Dallas, TX – Provided a study and analysis of the interior drainage system for the Trinity River Floodway. The project included modeling and calibration of all sumps and pump stations using the HEC-HMS 3.0.1 program, as well as extensive mapping in ArcGIS. Improvements were recommended and cost estimates prepared in a report for use in the City of Dallas 2006 Bond Package. An analysis of the flood event that occurred during March 2006 was also performed as part of this project.*

*Projects prior to Walter P Moore

Christina Hughes, CFM, ENV SP

Analysis / Graduate Engineer

3 Years with **Walter P Moore**

Christina Hughes is a graduate engineer with experience in diversified aspects of water resources engineering analysis and design. She is proficient in the use of HEC-HMS, HEC-RAS, Vflo, ArcGIS, MODFLOW, MT3D/RT3D (Groundwater Vistas), AutoCAD.

EDUCATION

Master of Science, Environmental Engineering, Rice University, 2014

Bachelor of Science, Civil and Environmental Engineering, Rice University, 2013

REGISTRATIONS

Certified Floodplain Manager 2993-16N

Envision Sustainability Professional

PROFESSIONAL AFFILIATIONS

Texas Floodplain Management Association

Phi Beta Kappa

RELEVANT PROJECT EXPERIENCE

- Grand Prairie Flood Warning System (Phase 1), Grand Prairie, TX – Provided project development and analysis for this Phase 1 project for Technical Services in support of a flood-warning program for the City of Grand Prairie. The Phase 1 product presents advance notification of roadway inundation at six sites throughout the City.
- Harris County Flood Control District (HCFCD) FWS Gauge Ratings, Harris County, TX – Developed preliminary elevation vs. discharge rating curves for 87 stream gaging stations monitored by HCFCD as part of their Flood Warning System (FWS). As storm events occur, HCFCD will use stream flow measuring equipment to confirm/modify these ratings. These were coupled with ratings from 45 USGS gaging stations to cover nearly all gaging locations across the county, omitting rainfall-only gauges and coastal gauges.
- East End Crossing Flood Investigation, Louisville, KY – Performed a forensic analysis of several minor flooding events on the Ohio River. The effort required several flood frequency analyses of the USGS gauge on the river and a thorough understanding of the non-typical rating procedure developed by the USGS to identify flows at that location.
- May 2015 Flood Analysis of Brays Bayou, Houston, TX – Walter P Moore was engaged to analyze the Memorial Day Weekend storm to compare pre-Project Brays conditions (effective hydraulic model) with post-Project Brays conditions (high water marks). This effort included calibration of radar-based rainfall to ALERT system rainfall gauges for this event, inserting the calibrated rainfall into the hydrologic model for the Brays Bayou watershed, using the results of the hydrologic analysis as input into the effective hydraulic model, and comparing the results of the hydraulic model with observed high water marks. To confirm the analysis, floodplains based on the pre-Project Brays model and the post-Project Brays high water marks were developed. The post-Project Brays floodplain was also compared with FEMA “Quick Claims” for the City of Houston.
- Merritt Lake Dam Retrofit, Fort Leavenworth, KS – This project involved the analysis of a flood event that caused overtopping of the dam embankment. An analysis was performed using the HEC-HMS hydrologic model and included the evaluation of radar-based rainfall for the storm event for comparison of intensities frequency-based design storms. In addition, the effort included designing a retrofit of the existing dam spillway to provide additional capacity and reducing the risk of dam overtopping from future events.
- Country Creek Detention Preliminary Design, Houston, TX – Walter P Moore was engaged by Tax Increment Reinvestment Zone No. 20 to develop a plan for regional detention on a 13+ acre site along Brays Bayou. This site was evaluated as a dual use facility to address flood mitigation caused by increased runoff from City of Houston capital improvement projects, as well as recreational space to serve local neighborhoods. For flood mitigation purposes, this regional detention site was analyzed using unsteady flow HEC-RAS modeling routines, which ultimately identified significant benefits along Brays Bayou that could be used to offset the increased runoff.

Mark Starks

GIS/Mapping / Senior GIS Specialist
30 Years with **Walter P Moore**

Mark Starks is a Senior GIS Specialist with more than 30 years of experience in graphics creation and support for water resources planning and design. He has managed all CAD/GIS related efforts in the many projects performed at Walter P Moore. His support graphics include: floodplain management studies and Federal Emergency Management Agency submittals, transportation related drainage analyses, major hydrologic and hydraulic studies, channel improvements projects, master drainage studies, drainage criteria manual development, and watershed impact analyses.

EDUCATION

Bachelor of Science, Engineering Technology, University of Houston, 1986

RELEVANT PROJECT EXPERIENCE

- Grand Prairie Flood Warning System (Phase 1), Grand Prairie, TX – Provided mapping and GIS/graphical support for this Phase 1 project for Technical Services in support of a flood-warning program for the City of Grand Prairie. The Phase 1 product presents advance notification of roadway inundation at six sites throughout the City.
- Harris County Flood Control District (HCFCD) FWS Gauge Ratings, Harris County, TX – Developed preliminary elevation vs. discharge rating curves for 87 stream gaging stations monitored by HCFCD as part of their Flood Warning System (FWS). As storm events occur, HCFCD will use stream flow measuring equipment to confirm/modify these ratings. These were coupled with ratings from 45 USGS gaging stations to cover nearly all gaging locations across the county, omitting rainfall-only gauges and coastal gauges.
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- Confidential Flood Warning System, Harris County, TX – Provided technical support to a major corporation by creating a flood warning product that would be simplistic and useful in determining the potential for flooding and which could be used by non-technical personnel onsite during a flood emergency. The product required an understanding of the interaction of two local stream gauges in order to forecast flooding.
- HCFCD Sims Bayou RiskMAP, Harris County, TX – The emphasis of this project is to streamline the process associated with obtaining a Physical Map Revision (PMR) for Sims Bayou that reflects the construction of the Sims Bayou Federal Flood Damage Reduction Project. Phase 1 of this project involves public interaction and gathering information from the public in order to adequately define risks to the public. Phase 2 will include the actual remapping of the floodplains based on the benefits derived from the Federal Project and will be submittal to FEMA for review.
- Cumberland Oil Field Flood Investigation, Bryan and Marshall Counties, OK – Walter P Moore was tasked with investigating the reasons for flooding of the oilfield area during consecutive flood events in southern Oklahoma in 2015. Considerations were given to river flooding along the Washita River, failure of a levee protecting the oilfield, and localized rainfall events that contributed significant runoff directly to the site. This evaluation included USGS stream gauge analysis, the hydraulic effects of Lake Texoma, and the development of gauge-adjusted radar-based rainfall for the entire Washita River watershed.

Nick Fang, PhD, PE

Project Manager – Rainfall and Programming / Senior Project Manager
3 Years with **University of Texas at Arlington**

Nick Fang is an assistant professor of civil engineering at the University of Texas at Arlington. Dr. Fang has worked on surface water and groundwater issues for more than ten years. His experience includes floodplain studies, hydrologic/hydraulic modeling, reservoir operation and management, water treatment, hydrodynamic simulation, storm water management modeling, and water quality assessment for a number of watersheds and municipalities. Dr. Fang has actively worked in the area of hydrologic/hydraulic analysis for flood prediction and warning in real time. He has enhanced a radar-based flood warning system to achieve more accurate and timely flood forecasts. Dr. Fang also possesses in-depth knowledge of hydrologic, hydraulic, and groundwater packages including HEC-HMS, HEC-RAS, GW-Vistas, XP-SWMM, Visual MODFLOW, and ArcGIS.

EDUCATION

Doctor of Philosophy, Civil and Environmental Engineering, Rice University, 2008

Master of Science, Chemical Engineering, Lamar University, 2003

Bachelor of Science, Environmental Engineering, Zhejiang University, 1998

REGISTRATIONS

Licensed Professional Engineer

Texas 109861

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers

American Water Resources Association

American Geophysical Union

RELEVANT PROJECT EXPERIENCE

- **Grand Prairie Flood Warning System (Phase 1),** Grand Prairie, TX – Provided project management for rainfall analysis and programming in this Phase 1 project for Technical Services in support of a flood-warning program for the City of Grand Prairie. The Phase 1 product presents advance notification of roadway inundation at six sites throughout the City.
- **TxDOT SH 288 Real-time Flood Warning System,** Houston, TX – Developed a real-time flood warning system for the SH 288 junction over Brays Bayou using calibrated hydrologic/hydraulic models and real-time NEXRAD rainfall data. The recently developed hydraulic prediction tool (FPML) is also being incorporated into this flood warning system to visualize floodplain in near real time.
- **TxDOT Real-time Radar-Based Flood Warning System for Two Flood-prone Locations,** Houston, TX – Designed and developed a real-time radar-based flood warning system for Mandell Street near US 59 and Tellepsen Road near IH 45. Calibrated the SWMM models for both locations and developed rainfall – water surface elevation correlations with a detailed hydrologic/hydraulic study in order to provide flood warning information in real-time based on radar rainfall information.
- **City of Sugar Land Real-time Flood Warning System for Oyster Creek Cross Sections,** Sugar Land, TX – Designing and developing a real-time flood warning system for several cross sections over Oyster Creek. The flood alert system is based on real-time NEXRAD radar rainfall data, a well-calibrated hydrologic model, and an operational data transfer platform.
- **Texas Medical Center Re-evaluation of the Storm Water System in Harris Gully,** Houston, TX – Re-evaluating the storm water system in Harris Gully with updated drainage information, hydrologic and hydraulic models, land use information, and recently-installed flood control facilities.
- **Clear Lake City Water Authority (CLCWA) Analysis of Inland Flooding and Storm Surge Risk,** Harris County, TX – Performing an analysis of inland flooding and storm surge risk using information collected during Hurricane Ike and hydrologic and hydraulic models. The research results will be used to inform local residents and governmental agencies how to deal with floods and hurricane induced storm surge; funding for local infrastructural improvements will also be allocated based upon these research results.
- **Shell Sustainability Center Pilot Project,** Harris County, TX – Performing a pilot project that integrates a comprehensive coastal flood warning system with a “lifeline” evacuation analysis of the roadways and bridges in the Clear Lake area.
- **Severe Storm Prediction, Education, and Evacuation from Disasters (SSPEED) Center,** Houston, TX – With funding from Houston Endowment, coordinating major research universities and other public and private entities in the collaboration and exchange of technical information about inland flooding induced by severe storms.
- **SSPEED Center Study of Storm Surge Impacts on the Houston Ship Channel,** Houston, TX – Performing a study of storm surge impacts on the Houston Ship Channel using collected Hurricane Ike storm surge information, the results from Advanced Circulation Model (ADCIRC), and a 2-D MIKE-FLOOD model.

Shang Gao, EIT

Rainfall / UTA Student

4 Years with **University of Texas at Arlington**

Shang Gao is a PhD student in Civil Engineering at the University of Texas at Arlington. His main research topic is modeling the spatial and temporal dynamics of rainfall. He is proficient in processing and analyzing large amount of data with the use of various scripting languages, e.g., Matlab and Python. He also has extensive experience in hydrologic and hydraulic modeling using HEC-HMS, HEC-RAS, ArcGIS, Vflo, et al.

EDUCATION

Master of Science, Environmental Engineering, University of California, Irvine, 2013

Bachelor of Science, Environmental Science, Nankai University, Tianjin, China, 2011

REGISTRATIONS

Engineer-in-Training, Texas 151149

PROFESSIONAL AFFILIATIONS

American Geophysical Union

RELEVANT PROJECT EXPERIENCE

- **Grand Prairie Flood Warning System (Phase 1),** Grand Prairie, TX – Developed filtering algorithm to transform raw rain gauge data into error-free hyetographs. The system is an online real-time flood warning website not only displaying sensing (rainfall) and warning (predicted stream stages) information, but also delineating flood extent based on a library of floodplain maps.
- **Evaluation of Urbanization and Infiltration for the Fort Worth Floodway,** TX – Conducted extensive software scripting 1) to generate thousands of synthetic storms (Standard Project Storm and frequency storms) by integrating and automating software, like HMR52, HEC-MetVue, HEC-HMS, DSS-UTL; 2) to automatically calibrate HEC-HMS models of the Upper Trinity River Basin (UTRB) using long-term rainfall and USGS streamflow data; 3) to compare design storms with deterministically and stochastically transposed historical storms using Python scripting. Also developed a Dynamic Moving Storm (DMS) generator to incorporate spatiotemporal characteristics of rainfall into traditional Probable Maximum Precipitation (PMP) design.
- **Hydrologic and Hydraulic Analysis for Brays Bayou during Memorial Day Flood 2015,** Houston, TX – Performed sensitivity analysis to evaluate the hydrologic impacts from moving storms by shifting the center mass of the Memorial Day storm at various levels in relative to the Texas Medical Center area. The outcome of this task has enhanced the decision making process for emerging storms with rapidly varied movements.
- **Floodplain Delineation for Brays Bayou during Hurricane Harvey 2017,** Houston, TX – Simulated the flood inundation in Brays Bayou using HEC-HMS and HEC-RAS (1-D) as the hydrologic and hydraulic models, respectively. Also processed radar rainfall data (both QPE and QPF) into DSS format for all the subcatchments in Harris County, which provides other inundation-mapping teams with rainfall input on a daily basis.

Daniel Li, EIT

Programming / UTA Student

3 Years with **University of Texas at Arlington**

Daniel Li is a PhD student in Water Resource Engineering at the University of Texas at Arlington. He has hands on hydrologic and hydraulic modeling, flood warning system design and deploying, and reservoir operation modeling experience. He is proficient in the use of Python, Java, R, Apache server, MySQL, Linux shell, Spring framework, JavaScript, GitHub/Git Cloud service (AWS EC2, Google cloud), HEC-HMS, HEC-RAS, HEC-ResSim, Riverware

EDUCATION

Master of Science, Environmental Engineering, University of California, Irvine, 2015

REGISTRATIONS

Engineer-in-Training, Texas 58321

RELEVANT PROJECT EXPERIENCE

- Grand Prairie Flood Warning System (Phase 1), Grand Prairie, TX – Managed the building of the website and database (Warning Interface) integrated with google map and the backend based on Spring framework, with Git version control. Also managed the deploying of the web interface system through Amazon Web Service Beanstalk, which is integrated AWS's EC2 and RDS.
- Deep Learning in Water Resource – To apply the latest deep learning techniques in water resource. Using Recurrent Neural Network to forecast hydrologic inflow for water supply reservoirs. Deployed custom deep learning networks in TensorFlow.
- Georgia Water Rights Modeling, GA – Simulated the outflow from Lake Seminole in the Chattahoochee River under different water use conditions in HEC-ResSim. Compared the different simulation results from HEC-ResSim, Matlab model, USGS Precipitation-Runoff Modeling System for Georgia water supply reservoir system.
- Hydrologic Analysis of Urbanization and Infiltration for Fort Worth Floodway, TX – Scripted in Python environment to automate the CDC upper Trinity River HEC-HMS model calibration process. (More than 50 sub basins and 20 events). Studied the urbanization impacts on the hydrologic performance of the Upper Trinity watersheds.

03 | AVAILABILITY

We propose to staff the project with a core team of individuals. We have reviewed other commitments of our key team members and confirmed that each individual is available to participate in the project to the level indicated herein.

Each member of our team understands their role in integrating our services with those of the overall project team. Each individual is eager and currently available to work on the project, and will remain on the project from start to finish.

Meeting project schedules has always been a priority for Walter P Moore. We work closely with clients to establish aggressive and effective project schedules and then track our progress closely to maintain the commitment. Our team members have complementary and overlapping capabilities, which further enhances our ability to meet schedules.

Scope for Developing a Flood Warning System for Grand Prairie, Texas

Andy Yung, PE, CFM *Walter P. Moore and Associates, Inc.*
Nick Z. Fang, PhD, PE *The University of Texas at Arlington*

November 2017

This proposal includes only those tasks and associated budgets that cover the services Walter P Moore and Associates and the University of Texas at Arlington (UTA) believe necessary to expand the City of Grand Prairie's Phase 1 flood warning/forecasting system. This proposal is designed to make the best use of available funding to provide the City with a product that is most beneficial and useful to City staff during flood emergency operations. It is recognized that much of the scope and budget are reflective of Walter P Moore/UTA's assumptions about the direction of the project, which may be altered following the meeting with City staff. Ultimately, it is the goal of Walter P Moore and UTA to serve the City's needs in the most efficient and cost effective manner possible.

Objective

To provide a flood warning/forecasting system that will permit the City's Stormwater, Public Works and Office of Emergency Management departments to identify areas of inundation and allow the timely dispatch of first responders to these areas to close roads, evacuate, shelter-in-place, and/or begin rescue operations.

For Phase 2, the City has identified five (5) new critical locations of concern during flood events. These locations are as follows:

- Johnson Creek @ Ave J (Site 6030)
- Riverside (Site 6250/6270)
- Dalworth Creek @ Carrier Pkwy (Site 6050)
- Dorchester Levee (Site 6070)
- Gopher Branch @ Beltline Rd (Site 6060)

The specific site locations may change based on input from City staff, and the Phase 2 scope will cover a maximum of five locations.

In addition, the City operates and maintains several other rainfall/stream gauges and has identified additional locations for future installation of gauging systems. As more station locations come online, consideration can be given to expanding this scope of work. However, this present scope will focus only on five locations.

Task 1: Meetings with City Staff and Project Coordination

- Walter P Moore/UTA will meet with City staff (including primary users and first responders) to kickoff Phase 2, to provide updates, to determine what improvements may be necessary for the overall Flood Warning system moving forward, and to update emergency operations staff on new locations added to the system. This task assumes up to four meetings may be required by the City.

› Walter P Moore/UTA will provide overall project coordination for the various project subtasks.

Task 2: Data Collection

› Walter P Moore and UTA will determine what information is readily available from existing gauging systems, existing H&H models, radar data, topographic information, historic flood reports, GIS data, etc. This information will then be used to determine where additional data is needed and to utilize historical data to build a system to support flood emergency operations.

› Based on the aforementioned critical locations identified by City staff, this task will also include field reconnaissance of these sites to understand the nature of the flooding, to categorize the type of flooding (e.g., low water crossing, riverine floodplain, combination, etc.), and to gather hydraulic parameter information (such as Manning's "n" values) of the stream in the vicinity of each location.

Task 3: Simplified Flood Warning System

› To better support the City of Grand Prairie's emergency operations staff with real-time flood warnings for areas of risk (such as the five new critical areas noted above) during an event, Walter P Moore/UTA will work with the City to expand the flood warning system using the knowledge of radar/gauge rainfall data, LiDAR data, and existing hydrologic/hydraulic model data. The system will be designed to assist the City's emergency operations staff during rainfall events by timely notifications of locations where life safety is at risk, requiring emergency personnel response. The current system will be expanded using the following subtasks.

- For the critical locations listed above, establish the correlations between rainfall total values and/or intensities and inundation levels at the points of interest so that the City staff can easily understand the flood risks based on real-time rainfall information. Based on information provided by the City, Walter P Moore/UTA will determine critical thresholds of rainfall totals/durations that are likely to cause flooding at the critical locations. This will be done by analyzing historical storm events from existing gauge data along with numerous frequency-based storms using existing hydrologic and hydraulic models of the streams at the identified locations. Once analyzed, a correlation between the total rainfall and/or intensity of rainfall and the stream levels will be determined.
- Evaluate the performance of Multi-Radar Multi-Sensor data as potential rainfall source(http://www.nssl.noaa.gov/projects/mrms/) and compare them against the rain gauge data from the City. MRMS data has been proven to be a viable source for flash flood warning systems (http://www.nssl.noaa.gov/projects/flash/) and is currently in operational mode. MRMS radar-only product has a spatial resolution of 1km by 1 km with a temporal resolution of 2 minutes. Therefore, we will evaluate the performance of MRMS in terms of accuracy and feasibility of real-time operation, which will provide the City with another valuable option to supplement the rain gauge network.
- Perform a sensitivity analysis to evaluate the hydrologic impacts from dynamic moving storms by transposing the center mass of a severe storm relative to the catchment area. Existing HEC-HMS models (non-real-time) will be used to analyze these impacts. The May 2015 event can be used for this sensitivity analysis. The outcome of this subtask will enhance the decision making process for emerging storms with rapidly varied movements.

- Calibrate and validate the determined thresholds at points of interest with two recent events. Two observed storms will be analyzed to verify the reasonableness of results and how well the correlation in the previous subtasks above is able to project flood elevations at the critical points of interest. Adjustments will be made as necessary to create better correlation and replication of known flood events.
- Develop a GIS information library associated with a series of pre-determined rainfall thresholds. An algorithm will also be developed to call up appropriate GIS files to indicate impending flood risks for the desired locations. As thresholds of rainfall are exceeded for contributing drainage areas to the points of interest, appropriate maps of the watersheds/critical locations will be called up from the GIS data library and published to the City internal web site. Inundation maps will be in whole-foot increments.
- With information from the previous subtask along with additional information related to how much precipitation has fallen, it will be possible to determine where the points of interest will become critical if certain amounts of estimated additional rainfall occur.
- A software program will be developed to extract data from publicly available sources (radar and/or precipitation gauge data), analyze the rainfall, and apply the algorithm to call up the appropriate map.
- Results will be published to the City's internal web location for each point of interest and will include mapped locations of concern (i.e., non-flood, near-flood, flooding exceeding threshold) and mapping of inundated areas using the library of pre-prepared inundation maps.

Task 4: Building Rating Curves and Defining Thresholds

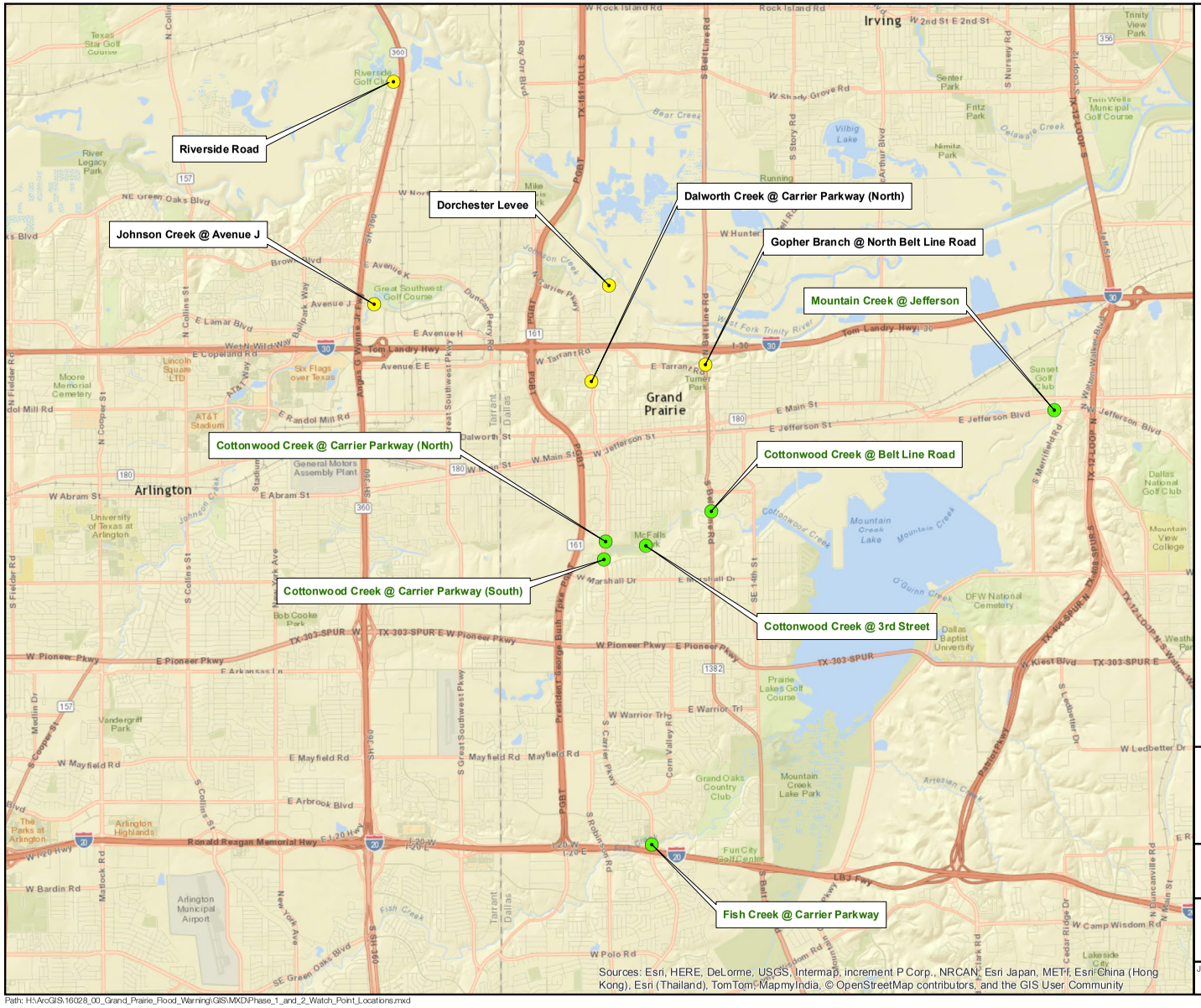
› Develop rating curves for the five (5) critical points of interest based on previously developed HEC-RAS models for the City of Grand Prairie's Flood Insurance Rate Maps (FIRMs) along with other study efforts that the City staff deems pertinent. Rating curves will be set up by running 25 profiles for the pertinent streams at the five selected locations. These profiles will be based on ratios of the 100-year discharge from 5% to 125% (in 5% increments). From these profiles, elevation vs. discharge ratings will be created at the stream gauge locations.

› Establish thresholds for each rating curve to identify elevations associated with road closures, structural flood damage, and/or other critical flood levels. It is assumed that much of this information is available from the City or can be provided by survey (not included in this scope of work). If survey is needed, Walter P Moore/UTA will develop a survey plan for the City to ensure that all necessary data related to critical thresholds are captured. This data will be necessary to determine timing of emergency responses.

Task 5: Documentation/Optimization/Maintenance of Systems

› Walter P Moore/UTA will document assumptions, development of system, and procedures for use in a report to the City.

› Walter P Moore/UTA will train the City staff and related emergency personnel on how to use and interpret the real-time information of the newly developed features.



Legend

- Proposed Phase 2 - Watch Points
- Phase 1 - Watch Points

N

6,000 3,000 0 6,000

Feet

Coordinate System
Projection: State Plane NAD83 (Grid)
Zone: Texas North Central
Units: Feet

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City of Grand Prairie
FWS Phase 2

Project Extents

Job Number:	Date:	Prepared By:	Exhibit:
H20-16028-00	November 2017	ams	1

Path: H:\ArcGIS\16028_00_Grand_Prairie_Flood_Warning\GIS\MXD\Phase_1_and_2_Watch_Point_Locations.mxd

Budget and Project Duration

To complete the aforementioned tasks, a budget of **$149,900** is needed. As stated above, this budget is subject to change in direction following the meeting with City staff, and it is further noted that based on Walter P Moore/UTA assumptions, the Phase 2 outcome will be a useful and beneficial product.

Task	Chief Hydrologist	Senior Project Manager	Graduate Engineer	UTA Student	Senior GIS Specialist	Budget
Task 1: Meet with City Staff and Project Coordination						
1 Prepare/Meet/Follow-up Documentation	8	16	12	12	8	
2 Project Coordination		16				
Subtotal	8	32	12	12	8	$12,600
Task 2: Data Collection						
1 Obtain Data	2	4	16	16	8	
2 Field Reconnaissance	8	16	16	16		
Subtotal	10	20	32	32	8	$14,700
Task 3: Simplified Flood Warning System						
1 Establish Correlations between Rainfall/Elevations	4	8	40	40		
2 Storm Movement Sensitivity Analysis	2	24	12	80	8	
3 Calibrate/Validate Rainfall/Elevation Relationships	4	8	32	40	8	
4 GIS Library of Maps and Algorithm Development for Calling Up Maps	1	16	4	80	40	
5 Forecast Elevations	2	4	4	8		
6 Software Development to Analyze Rainfall Data and Call Maps	1	4		80		
7 Publish Results to City Internal Web Location	1	8		80		
Subtotal	15	72	92	408	56	$74,400
Task 4: Building Rating Curves and Defining Thresholds						
1 Develop Rating Curves	2	4	40	40	8	
2 Establish Thresholds	2	2	16	16	8	
Subtotal	4	6	56	56	16	$16,500
Task 5: Optimization/Maintenance of System						
1 Documentation	8	32	32	60	24	
2 Train City Staff	8	16	8	12	16	
Subtotal	16	48	40	72	40	$31,700
Total Hours	53	178	232	580	128	
TOTAL BUDGET						**$149,900**

This budget is considered lump sum, but is based on hours assigned to various tasks (estimated based on Phase 1 effort) and the following hourly rates:

Category	Rate
Principal	$250
Chief Hydrologist	$225
Senior Project Manager	$220
Senior Programmer	$160
Senior GIS Specialist	$160
Graduate Engineer	$125
UTA Student	$85

WHO WE ARE

Walter P Moore is an international company of engineers, innovators, and creative people who solve some of the world's most complex structural and infrastructural challenges. Providing structural, diagnostics, civil, traffic, transportation engineering, and parking consulting services, we engineer solutions that are resource-efficient, forward-thinking, and help support and shape our communities. Founded in 1931, we are headquartered in Houston, Texas and have more than 600 professionals working across 16 U.S. offices and 5 international locations.

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