FLOODPLAIN MANAGEMENT PLAN

TSMS Phase V(a) (FINAL DRAFT)

November 4, 2020

Acknowledgements

Mayor and Council Adoption

The City of Tucson Mayor and Council formally adopted the Floodplain Management Plan (FMP) Phase V on August 9, 2016. This 2020 FMP Phase V(a) report is the first formal update, adopted on October 20, 2020.

2020 Mayor and Council
Mayor Regina Romero
Lane Santa Cruz - Ward One
Paul Cunningham - Ward Two
Paul Durham – Ward Three
Nikki Lee – Ward Four
Richard Fimbres – Ward Five
Steve Kozachik – Ward Six

2020 City Manager
Michael Ortega

Project Team

The Tucson Floodplain Management Project team would like to thank the Floodplain Management Plan (FMP) committee members for their support and participation in the 2020 update of the 2016 plan. During the annual FMP committee meeting in November 2019, the committee determined that the formal 2020 update for the plan should concentrate on the action item list. Over a four-month period (March through June 2020), the committee members met monthly to discuss the action item list and identify the current flooding risks and erosion hazards that Tucson faces. The FMP committee worked diligently keeping in mind the goal of protecting Tucson's citizens by using their expertise in planning, engineering, real estate, environmental sciences, and policy formation to update the FMP.

Elizabeth Leibold, P.E., CPM, CFM, Civil Engineer, in Tucson's Department of Transportation & Mobility (DTM), was the lead advocate for completing the Tucson FMP Update, and was assisted by Peter McLaughlin, Lead Planner in the Planning and Development Services Department (PDSD), as well as Fred Felix, P.E., Tucson City Engineer, who serves as the City of Tucson Floodplain Administrator and champions the FMP update with the general goal of reducing flood hazards and reducing flood-related costs to the Tucson citizens. Scott Clark is the Director of PDSD during this update. For the original 2016 FMP, guidance and support was provided to the City by FEMA Region IX, Arizona Department of Water Resources (ADWR), and FEMA Region IX's Production and Technical Services (PTS) Contractor. For this year's update, City staff took the lead.

Committee Member List

A diverse group was convened to form the committee, including key participants listed below. A complete listing of committee members is provided in the Appendix (p.59) of this report.

Table 1. Key committee participants for 2020 FMP Update

Name	Organization	Title	FMP Committee Function/Role
Eric Shepp, P.E., CFM	Pima County Regional Flood Control District	Deputy Director	Public/Structural Flood Control Projects
Katie Gannon	Tucson Clean & Beautiful	Executive Director	Tucson/Natural Resource/Tree Canopy Protection
Fred Narcaroti	Ninyo & Moore	Principal, Geotechnical & Environmental Sciences Consultant	Public/Property Protection
Claire Jean Prager	Coldwell Banker Realty / Tucson Association of Realtors	Associate Broker	Public/Preventive Measures
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Linda Morales, AICP	The Planning Center	Local Planning Consultant, Stormwater Technical Advisory Committee Chair	Public, Planning
Catlow Shipek	Watershed Management Group	Policy and Technical Director	Public/Natural Resource Protection
Larry Roberts, P.E., MS	Arroyo Engineering	Principal Engineer	Public/Preventive Measures, TSMS (lead contributor)
Victor Palma	Tucson Airport Authority (TAA)	Airport Authority	Critical Infrastructure Protection
Peter McLaughlin	City of Tucson, Planning & Development Services Dept	Lead Planner	Tucson/Structural Flood Control
Mead Meir	Pima Association of Government	Sustainability Coordinator	Regional/Planning & Public Information
Frank Souza	Resident, Geologist	Retiree	Natural Flood and Erosion Function
Sgt. Malorie Denzler	Tucson Police Dept	Sergeant	Tucson/Emergency Services
Fred Felix, P.E.	City of Tucson, Transportation & Mobility, Engineering	Floodplain Administrator	Tucson/Structural Flood Control Projects

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Executive Summary

The City of Tucson has actively managed its floodplain resources since the mid-1970's and continues to undertake programs that will improve its resilience to flooding. The City has experienced sixteen (16) flooding and three (3) major storm events since 1983. Economic and environmental impacts of flood are severe, and may increase in the future. The City of Tucson, with support from FEMA Region IX, had created the City's first "Floodplain Management Plan" (FMP) to address community-wide flooding hazards and mitigation measures based on Community Rating System (CRS) guidelines.

As a participating National Flood Insurance Program (NFIP) community, City of Tucson performs various floodplain and erosion hazard management activities and gets credits based on performance. Tucson has a CRS rating of 6 which provides Tucson property owners a discount on their low-risk and high-risk flood insurance policies (10% and 20% respectively).

During the last two FEMA Discovery Processes, several at-risk areas in the Upper Santa Cruz Watershed were identified, and community members and local agency representatives participated in discussions to address floodplain mitigation. By creating and continuing to update this FMP as one of the CRS activities, City of Tucson can better address floodplain management decisions, consider all mitigation alternatives or consequences, and improve its class as a participant in FEMA's CRS program.

Figure 1: Downtown Tucson 1988

The FMP is considered Phase V of the Tucson Stormwater Management Study (TSMS), and this 2020 formal update will be task 2 of Phase V of the TSMS. The 2016 adopted FMP is considered task 1. Phase V does not override the previous phases but enhances and re-instates TSMS by becoming current in the city's assessment of floodplain management needs and direction. This 2020 FMP includes an updated action plan to best address the highest priority action items identified by FMP Committee Members, and prioritizes actionable mitigation measures, that will reduce the risk to life and property associated with flooding.

Like other NFIP communities, FEMA performs annual recertifications, which are like audits to review Tucson's CRS activities including FMP Updates, flood use permitting, mapping, stormdrain system maintenance, flood & erosion hazard information outreach, drainage infrastructure installation, and other CRS activities.

The City receives assistance from the Pima County Flood Control District. In addition, small portions of capital project budgets are allocated for only some of the needed drainage improvements. Since funding for flood and erosion hazard mitigation has limited resources, the City of Tucson has been actively pursuing FEMA grants since 2017 through DEMA, the State's emergency management program. Many factors are considered by FEMA when awarding FEMA grants. By adopting updates to the FMP, and performing other CRS activities, the City's opportunities for FEMA grants improve.

A FEMA 5-year Cycle visit (another audit performed approximately every 5 years) is expected spring 2021, so adoption of the updated FMP report helps the City show compliance, increases chances for more grants, and improves our flood resiliency.

Pima County has experienced 13 Major Disaster Declarations and 2 Emergency Declarations.

Table 2. Tucson's FEMA major disaster declarations.
Pima County Presidentially Declared Flood Disaster Events

Major Disaster Declarations		
FEMA Disaster #	Date	Description
4203	11/5/2014	Severe Storms and Flooding*
1940	10/4/2010	Severe Storms and Flooding*
1888	3/18/2010	Severe Winter Storms and Flooding
1660	9/7/2006	Severe Storms and Flooding
1477	7/14/2003	Wildfire*
977	1/19/1993	Severe Storms, Tornadoes, Flooding
884	12/6/1990	Flooding, Severe Storm
691	10/5/1983	Severe Storms, Flooding
570	12/21/1978	Severe Storms, Flooding
551	3/4/1978	Severe Storms, Flooding
540	11/4/1977	Severe Storms, Flooding
343	7/3/1972	Severe Storms, Flooding
217	4/30/1966	Flooding
Emergency Declarations		
3307	1/24/2010	Severe Winter Storms and Flooding
3241	9/12/2005	Hurricane Katrina Evacuation

** Pima County included under statewide Hazard Mitigation Grant Program assistance.*

Figure 2: Sinaloan Narrow-Mouthed Toad - native to the West Branch Santa Cruz River

Given that Tucson is currently rated at a CRS Class 6, this FMP process was built on the community's existing floodplain management practices and programs and focused on expanding available resources and utilizing them efficiently. In 2016, FMP committee had agreed that Tucson's multiple hazard vulnerabilities could be grouped into seven (7) main categories, and these hazards (in order of descending vulnerability to Tucson) were:

1. **Public Infrastructure Conveyance**
2. **Flood Areas with Utility/Municipal Structures**
3. **Urban High-Density Flood Areas**
4. **Private Drainage Infrastructure**
5. **Natural Floodplains**
6. **Vegetated Associated Flood Hazards**
7. **Geomorphological Flood Hazards**

Categories from the 2016 adopted FMP were revisited during the 2020 update; see Chapter 3. In 2016, the FMP committee summarized Tucson's Floodplain Management Plan goals as:

- **Continuing to identify high-risk areas;**
- **Providing safe, efficient and balanced conveyance for stormwater runoff;**
- **Maintaining, enhancing and/or restoring riparian ecosystems and wildlife corridors;**
- **Increasing community awareness of water harvesting methodologies, floodplain preservation measures, and general flood and erosion information; and,**
- **Expanding incentives for private property owners and developers to implement sustainable flood and erosion hazard mitigation strategies.**

In 2020, the FMP committee updated the Tucson's Floodplain Management Plan goals; see Chapter 5.

Figure 3: Panorama of the Rillito downstream/west of Campbell Avenue

Chapter 1

Purpose and Intent of the FMP

INTRODUCTION TO TUCSON

Tucson experiences a desert climate with a rainy summer thunderstorm season called "monsoon" and gets an average of 12 inches of rain annually. While a majority of Pima County is considered rural or moderately developed, Tucson is decidedly an urban area and the challenges it encounters differ and are more pronounced than those endured by the other Pima County communities. Precipitation in Tucson is higher than most desert climates, which is cause for more flash flooding than in other parts of the state. Because many areas of the city do not have storm drain systems, Tucson often experiences flooding in the streets. The most common risks identified within the City of Tucson are flooding, erosion, sediment transport, and flash flood events.

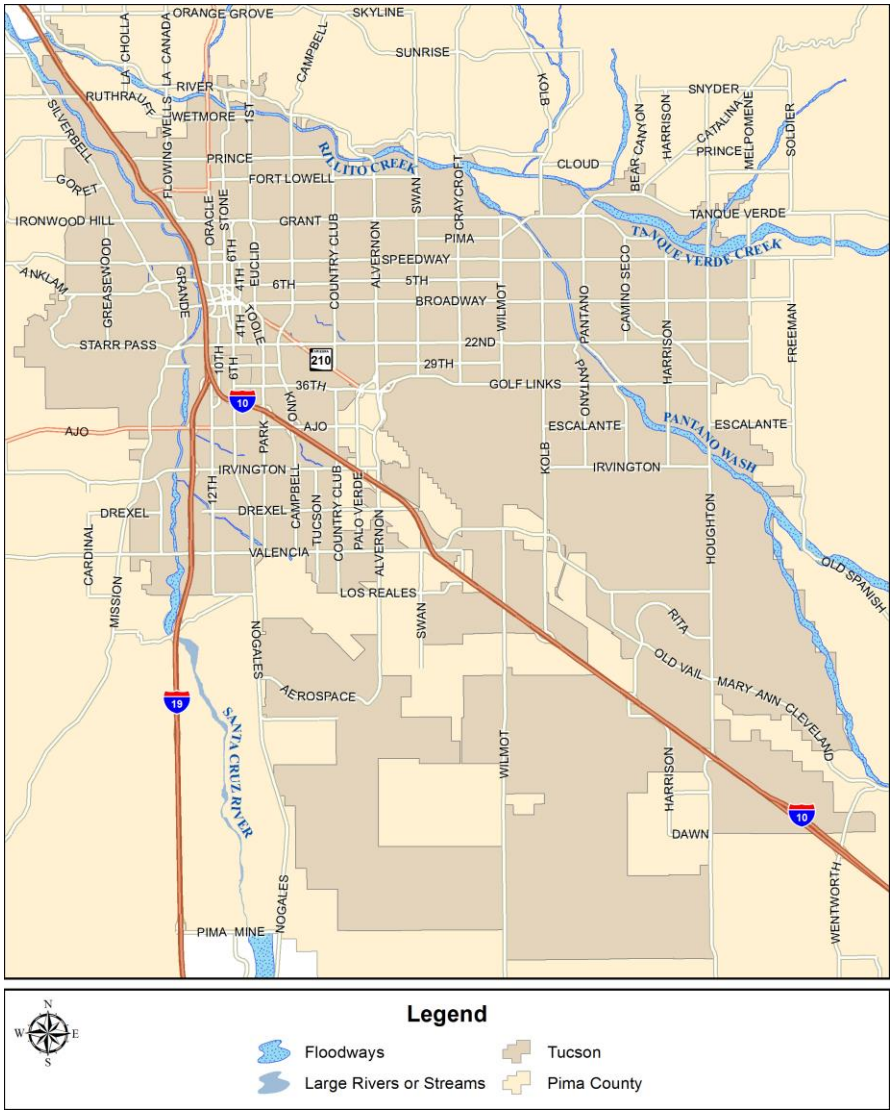

Figure 4: Map of Tucson Arizona with Regional Watercourses labeled

Tucson is in the top 10 metro areas that are in the best position to quickly recover from the coronavirus-caused economic disaster, according to Moody's Analytics[1]. Tucson's population rate has increased slowly over the last ten years from a rate of just below 1 percent to 1.13%. With the City's ongoing need for flood and erosion hazard mitigation, the lack of funding and slowed economic growth due to the pandemic, it is essential to update the FMP to mitigate floodplain hazards, while taking into account the potential for public infrastructure deterioration and needed maintenance. Also, with the potential for climate change conditions, communities are at risk for a higher potential for damage caused by natural disasters. Ultimately the City of Tucson Floodplain Management Plan concentrates efforts on life and safety, flood control function, environmental conservation, and resiliency.

Figure 5: Tucson's Arid Old Growth Desert

1. May 20, 2020 Information from Michael Coretz: https://www.commercial-real-estate-tucson.com/tucson-economy-likely-will-recover-quickly-from-covid-19/

TUCSON'S UNIQUE FLOODPLAINS, EROSION AREAS, AND WATERSHEDS

Located in the upper Santa Cruz River watershed basin, Tucson is bounded by several mountain ranges: Sierrita Mountains and Black Mountain to the southwest, Tucson Mountains to the west, Santa Catalinas to the north, Rincons to the east, and Santa Ritas to the south. Pantano Wash conveys runoff from the eastern portion of the Tucson area, northerly to the confluence with the Tanque Verde Wash where the flow turns westerly. Within the Rillito Creek, the flow combines with Santa Catalina foothill runoff, and then continues to the Santa Cruz River at the north western side of the City. The Santa Cruz River, flowing from Mexico, conveys flows northerly along the western side of the City. Located at the south portion of the City of Tucson limits, the Lee Moore Wash area (a 50 square mile watershed management area), has east-to-west uncertain flow distribution of transitional or braided sheet flooding and channelized flows.

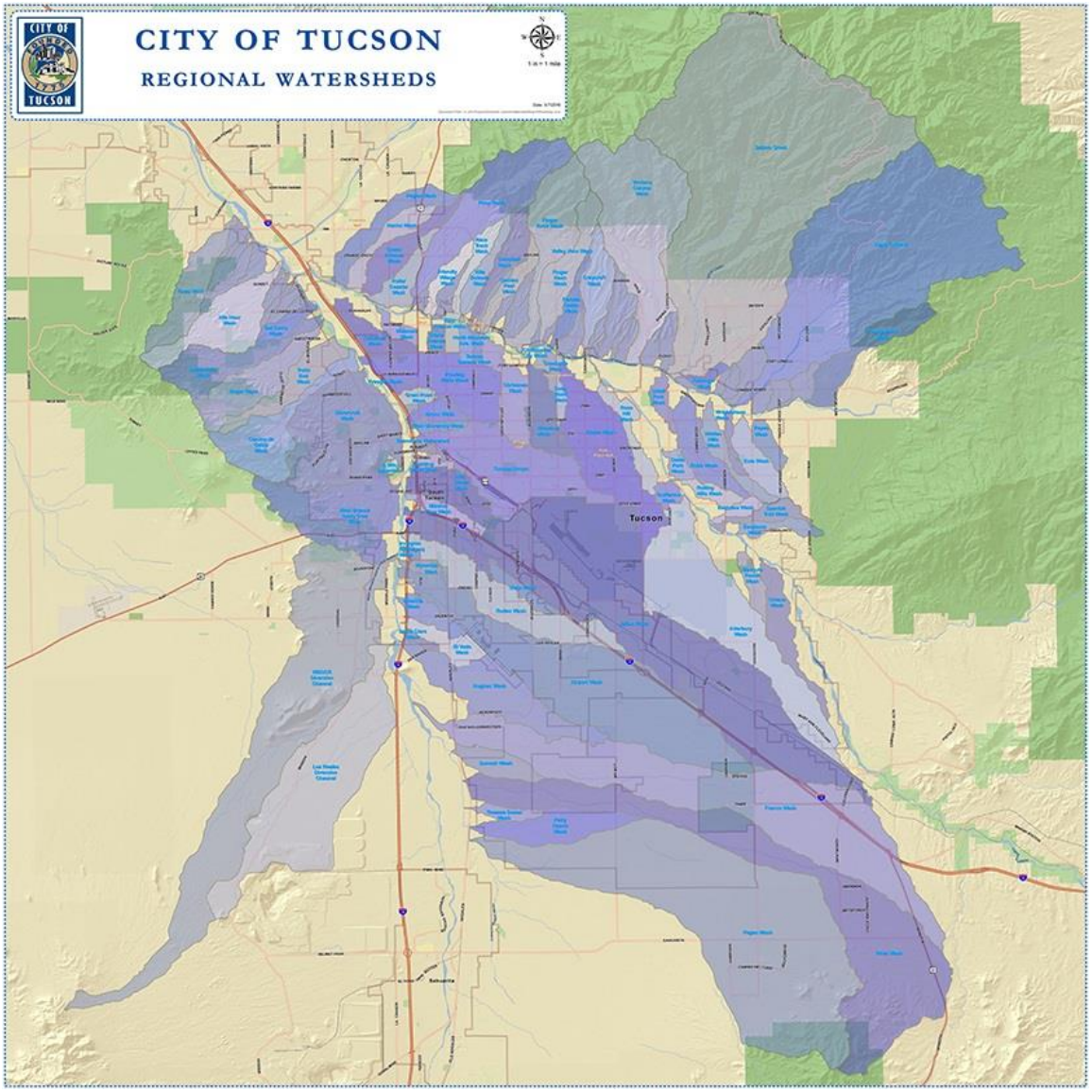

Figure 6: Tucson Region Watershed Map - existing watershed boundaries overlap county-city jurisdictional line, with general flow direction for southern watersheds from southeast to northwest, northern watersheds entering the Rillito Creek from north to south-southwest, western watersheds flowing southwest to northeast to the Santa Cruz River. All of these watersheds contribute to the Upper Santa Cruz Watershed.

As mentioned, the City of Tucson receives about a foot of rain every year, with approximately eight inches in the summer and early fall, and the remaining approximate four inches during winter rains. Tucson experiences a series of summer thunderstorms for several months of the year called “monsoon”. Since 2008 the National Weather Service has identified Tucson's official monsoon season as starting June 15 and ending September 30. Although thunderstorms can occur at anytime, however the majority of storm s typically occur during this time. A smaller thunderstorm that suddenly occurs in a localized manner and produces very strong winds is called a “chubasco”.

Figure 7: Chubasco

For monsoon and chubasco events, rain is typically heavy and downpours can last for several minutes to a few hours. When atmospheric vapor from tropical storms (also known in Spanish as “tormentas”) travels continually from the Baja California or the Gulf of Mexico regions, these storm systems can sometimes last several days. (See Appendix for anecdotal story by a hydrometeorologist specializing in “atmospheric vapor trains”.)

Tucson hazards include not only flooding within the streets, overtopping of washes and channels, flash flooding, erosion along channel embankments, channel migration, but also subsidence or sinkholes, excessive heat, and other hazards. Tucson experiences excessive heat exceeding 100 degrees during June and July, although not as excessive as Phoenix area due to our slightly higher elevation (average elevation of Tucson is approximately 2500 feet above sea level NGVD 88).

Figure 8: Downed power lines along Oracle Road following a storm event

Monsoon hazards include risks of adverse impacts from flooding, erosion, damaging winds, hail, microbursts, dust, and lightning. Tucson experiences high incidents of lightning strikes as well as short, concentrated heavy downpours called microbursts with violent and strong winds during Monsoon. These thunderstorm events can cause power outages during the hot summer months taking out air conditioning and creating life-threatening conditions if not restored quickly. Among other flood related issues, Tucson residents are concerned about power outages and access issues across the City of Tucson’s bridge and street system during flooding.

Swift water rescues by Fire and Police are common occurrence during the monsoon. Erosion and flooding along regional watercourses have resulted in injuries, deaths, and private and public property damage with high repair costs, during catastrophic flood events. Tragically, a large number of flood-related deaths have occurred in cars stranded in deep, fast-moving floodwaters.

Figure 9: Emergency responders often conduct swift water rescues. Vehicles or people are sometimes swept away in the fast-moving water, and many City resources are required. A.E. Araiza / Arizona Daily Star

Tucson has a semiarid climate where post-storm evaporation rates are high, and soils are more permeable in the regional watercourses where the fastest rate of infiltration to the underground aquifers occurs. Regarding soil characteristics, Tucson is different than Phoenix and other jurisdictions to the north. Tucson has variable terrain with grade changes throughout the city and experiences infiltration challenges including harder, slower percolating soils such as caliche and hydrologic soil groups "C" & "D" as determined by the United States Department of Agriculture Natural Resources Conservation Service. These soils are harder for rainwater to infiltrate and thus ponding issues typically arise.

Figure 10: Rillito regional watercourse
- **soil cement embankment with railing**
- **and naturally sandy bottom.**

Soil cement embankments are commonly used for the regional watercourse containment and erosion protection, with a few segments having levee protection. Soil cement has been successfully used along most of the regional watercourses. In the past, many manufactured housing structures in the Tucson area were located near or within medium to high risk flood zones, posing risks to manufactured home property owners. Apartment complexes and other rental properties pose different challenges for the City as it addresses flood hazard mitigation.

Figure 11: Santa Cruz River bank protection

Figure 12: Solar infrastructure in HOA common area is elevated above the overbank waters of the Santa Cruz River for the reduction of electrical costs to this manufactured home subdivision community.

Solar infrastructure has been introduced successfully in shallow floodplain areas and within existing basins, providing safe opportunities to double the use in a floodplain area.

Subsidence can occur when there is seepage or other underground issues within the bedding soil in utility line trenches. Floodwater that seeps into the soil can undermine utility trenches causing an underground path for floodwaters to follow which can cross into other utility trenches or lead to pipes breaking.

The Tucson Water utility has invested approximately five million dollars in a 20-mile Acoustic Fiber Optics (AFO) monitoring and advance warning system that signals Tucson Water staff prior to a large water main failure, which could cause flooding to nearby buildings and potential loss of hundreds of thousands of gallons of water. A failure of this type occurred in 1999 resulting in millions of dollars in property damage from the 38 million gallons of water that flooded the neighboring properties as a result of the pipe break. An example of the effectiveness of the warning system involved a 84-inch diameter water main along San Marcos Boulevard between Greasewood and Mission Roads. Tucson Water was alerted by electronic signal that the main was in danger of breaking. The monitoring system allowed the utility to shut down the water main, drain the water from the area, and make the needed repairs.

The AFO monitoring system with other programs in Tucson Water, led to a 2014 Association of Metropolitan Water Agencies (AMWA) Platinum Award recognizing Tucson Water for their Attributes of Effective Utility Management. Tucson Water was the first American utility to install an AFO system in all of its prestressed concrete cylinder pipeline. Not only does this Tucson program save valuable resources, it provides reduced flooding potential for those areas near large water pipelines.

Figure 13: Sediment transport in a natural riparian floodplain

Development within the floodplain increases as less developable area exists in central urban Tucson. Developable areas are still available especially in Tucson's western, eastern, and southern periphery; however these locations tend to have floodplain and erosion hazard development design challenges including riparian floodplain and increased elevation changes. Guidelines and requirements are set forth in the City's Environmental Resource Zone, Hillside Development Zone, Lee Moore Wash watershed master plan, Watercourse Amenities, Safety and Habitat Ordinance, and other regulations. Opportunities exist for aesthetic development designs that incorporate floodplain and human activity zones, setbacks for erosion hazard that also provide for natural floodplain function, recreational areas, trails, and conservation of riparian floodplain habitat.

Many communities look to the City of Tucson for its innovations, regulations, and applications of water harvesting, Green Stormwater Infrastructure (GSI), stormwater quality, and Low Impact Design (LID). In the 1990, Tucson floodplain ordinance prohibited unnecessary alteration of riparian habitats of watercourses and adjacent bank areas. In 1998, the City of Tucson Land Use Code (LUC), now called the Unified Development Code (UDC), went further to dictate the necessary alteration for proposed development as exclusively: necessary access to a property, necessary utility installation, and/or trail improvements.

In 1998, City of Tucson Mayor and Council required new development to utilize stormwater harvesting to the maximum extent possible. In October 2005, the Water Harvesting Guidance Manual became ordinance and in October 2008, the City adopted the Commercial Rainwater Harvesting Ordinance. A water bill fee for stormwater generates funds for stormwater quality management, and a rebate program was developed to promote water harvesting. City's Green Infrastructure Active Practice Guidelines for public right-of-way is used for all road projects. Beginning in May 2020 a Green Infrastructure Fee was added to water bills to:

- Provide a funding source for maintaining hundreds of existing GSI features in city neighborhoods
- Support growing more trees and plants on streets, and in parks and public areas using stormwater as a primary water source
- Address and reduce flooding issues on neighborhood streets

The City continues to assess the function of the green infrastructure within erosion and floodprone areas and look for ways to improve these regulations, methodologies, procedures and guidelines. For new development whether private or public, the City encourages the review of flood and erosion hazard regulations in the early stage of the review process to help identify areas of hazards so designs can address these constraints early in the review / permitting process. City Staff performs pre-submittal meetings for private development and provides early concept reviews for public projects to assist in this effort. To save development community time and money, customers also have the option to submit a floodplain use permit application with preliminary drainage report to be reviewed at project concept stage to help weed out potential erosion hazards or flood hazards that will need to be addressed in the formal design submittal.

Figure 14: Rillito – a regional watercourse

Rainfall runoff generally flows from the southeast to the northwest across the Tucson area. Flows are not allowed to be obstructed per code. Runoff flows within streets, rights-of-way, and in other drainage systems, from property to property, matching pre-developed flow conditions. Stormwater conveyance in the City of Tucson includes storm drains, side yard swales, wall openings, improved structural channels, natural channels, semi-natural channels, sheet flow, and other systems to continue its path to feed vegetation and eventually, with remaining flow, recharge in the regional watercourses.

Larger detention or reservoir systems (Rita Ranch Regional Basin, Bridges Regional Detention Basin, Ajo Detention Basin, and the Cherry Fields Regional Detention Basins) work to lessen flooding conditions within the City of Tucson with their capacity to handle large storm runoff. These systems also help to lower heat island effect with increased tree canopy, as summer storms travel north and divert around the City of Tucson. In this year's FMP Committee meetings, enhancement of tree canopy was prioritized with efforts to further build awareness of the important role that tree canopy plays in the community, and to increase the planting of trees throughout the City.

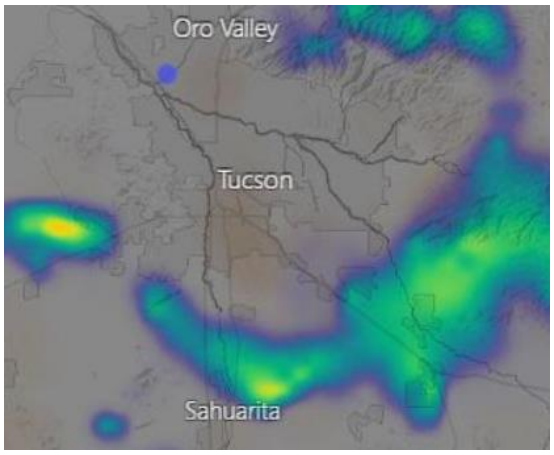

Figure 15: Radar - storm approaching from the southeast

Pima County Regional Flood Control District (PCRFCD)'s ALERT system provides an excellent resource for accessing City of Tucson rainfall data, watercourse stage (depth) gauge data, and recent post-fire inundation mapping, which assists floodplain management by providing information about recent or historic storm events, and potential areas of flooding. In June 2020, the Bighorn Fire increased burn runoff potential in the Santa Catalina Mountains, and overtime, an increase in sediment transport will occur and impact capacity of the Rillito regional watercourse. PCRFCD has been performing sediment removal from the regional watercourses to help maintain flow capacities. To reduce flood risk along the Santa Cruz River, PCRFCD removed approximately 85,000 cubic yards of sediment that was accumulating between Silverlake Road and Cushing Street. Utilizing the ALERT system's data, warning systems help prevent flooding damage.

Tucson's Basin (watershed) Management plan includes non-designated basin management areas, Balanced Basin Management Areas, and Critical Basin Management Areas (where severe flooding issues exist). Development in Balanced Basin Management Areas requires post developed runoff to not exceed pre-developed conditions. In Critical Basin Management Areas, detention requirement includes a reduction of the post-construction flowrate by a minimum of 15% as compared to pre-developed conditions.

Figure 16: View of Tucson watershed basin from A Mountain

The most successful basin designs (where there are less post-construction and maintenance issues) include a detention concept, incorporating low-flow outlets and positive gradients. When detention is used, there are reduced potential for termites, mold, ponding/stagnant water, structural issues to nearby foundations, and contamination of the groundwater aquifer from fertilizers, herbicides, and other chemicals. Mosquito-borne illnesses are being reduced by the use of detention systems since standing water is minimized. Heidi E. Brown, PhD, MPH, of the Epidemiology and Biostatistics Department at The University of Arizona, concurred that Tucson's drain-down time requirements of 12-hours and 24-hours help to reduce mosquito populations.

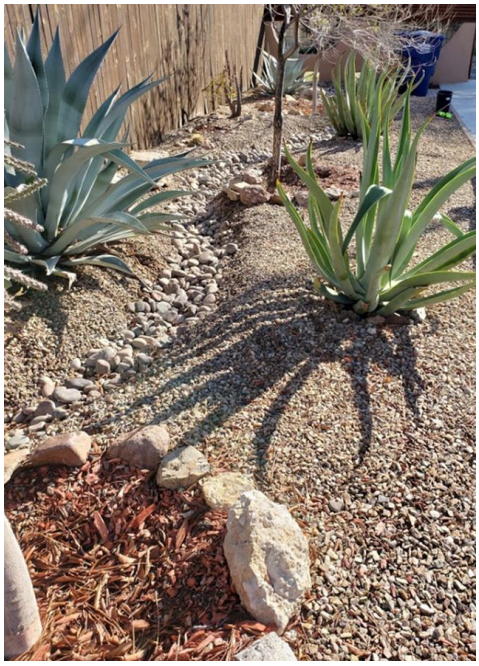

Figure 17: Water Harvesting in Side Yard Swale

DECISION MAKING CONSIDERATIONS FOR TUCSON FLOODPLAIN MANAGERS

Optimal results for flood, erosion, or other hazard management decisions can be realized by utilizing the various documents including the Floodplain Management Plan and reports and data from other phases/reports of TSMS, Flood Risk Map (FRM), MapTucson, and other local GIS data, as well as master drainage plans, City of Tucson Drainage Manual, current detention / retention manual, and specific City of Tucson plans such as Plan Tucson.

HAZUS is a nationally applicable standardized methodology that contains models for estimating potential losses from floods. HAZUS FRM map was one of the tools created in the FMP project and was generated with collaboration between the FEMA consulting firm and the FMP Committee members' data with effort and special assistance by the City of Tucson's Transportation GIS Technician. A pared down version of the map was provided to the City by the FEMA consultant in April 2016. This RiskMAP document is kept for floodplain management purposes and provided to floodplain administrative staff only since some of the data, such as locations of critical facilities, is restricted due to security concerns.

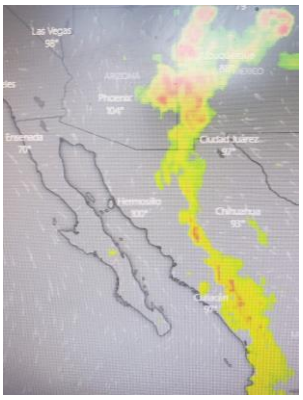

Figure 18: Precipitation plumes coming up from Mexico

Plan Tucson is the City of Tucson's General & Sustainability Plan, which was ratified by voters in 2013 and acts as a master planning document providing broad planning focus for Tucson, including reducing hazards. Plan Tucson goals and policies are intended to reduce, through preventive measures, the potential harm to life and property in natural hazard areas as well as hazards resulting from human activities and development. All Ward offices encourage the use of Plan Tucson, and other Tucson planning documents, when making decisions regarding the management of floodplain and other hazards.
https://www.tucsonaz.gov/files/integrated-planning/PT_Goals_and_Policies.pdf

TUCSON HYDROLOGIC MODELING

Tucson Stormwater Management Study (TSMS)

Tucson Stormwater Management and Tucson Watershed Modeling Systems are the City's adopted methodologies. This modeling is ideal for the Tucson area since it models the type of short storms with high intensity rainfall most often experienced during Tucson's Monsoon. Hydrologic modeling of watersheds located within the City of Tucson was previously completed in 1993 as part of the TSMS Phase II, Stormwater Master Plan (Existing-Conditions Hydrologic Modeling, Simons, Li and Associates, November 1995). The development of the TSMS hydrologic modeling resulted in a uniform and consistent technique for predicting stormwater discharges within the City of Tucson. (For more detailed information and background on TSMS see page 16.)

The TSMS hydrologic methodology replicates physical processes of rainfall, runoff, and flood routing. In addition, the physically-based modeling was calibrated to recorded flow events and statistical flood-peak estimates. The results of the TSMS hydrologic modeling was subsequently approved by the Federal Emergency Management Agency on May 21, 1996. On January 22, 1996, the results of the TSMS, Phase II Stormwater Master Plan were adopted, by Resolution, by Mayor and Council.

The TSMS hydrologic modeling was comprised of two main components – (1) the Stormwater System Planner (SSP), a proprietary software program used to compile HEC-1 input files and generate watershed reports from a new extensive City-wide data base, and (2) HEC-1 software used to perform the hydrologic modeling for 59

major watersheds within the geographical boundaries of the City. Numerous additional software components were utilized in calibration, SSP access, and data-base retrievals. The SSP software package was meant to be used by the City and water-resource consultants for stormwater management purposes and the consistent and reliable calculation of stormwater discharges.

Tucson Watershed Modeling System (TWMS)

A new version of TSMS called Tucson Watershed Modeling System (TWMS) is currently under development. TWMS is a more modern map-based system using GIS, ArcView and HEC-HSMS. The hydrologic modeling software developed for the TSMS had consisted of DOS-based programs that had become outdated over time. In order to utilize more current software, as well as utilize more advanced GIS-based data management tools, the City of Tucson initiated development of the TWMS (User's Manual, June 2008) as a replacement for TSMS software package. TWMS incorporates automated watershed management tools in a GIS environment. The TWMS provides the City with the ability to calculate stormwater flow values for use in planning, floodplain management, and hydraulic design.

Figure 19: Regional watercourse near flood stage

INTRODUCTION TO THE FMP PROCESS

2016 FMP

The FMP is an outgrowth of the Upper Santa Cruz Discovery initiated by FEMA in the fall of 2011. After the Discovery process ended, FEMA had recognized that there was potential to expand on best management practices and encourage a more resilient community within Tucson and had granted the City funding in the form of FMP consulting services. Discussions between FEMA and city officials had resulted in the 2016 plan being created to facilitate floodplain management activities in Tucson.

FEMA's Risk Mapping, Assessment, and Planning, or Risk MAP program, helps communities identify, assess, and reduce natural hazard risks. Through Risk MAP, FEMA had provided information to enhance local mitigation plans, improve community outreach, and increase local resilience to hazards. Flood risk products are created to provide concrete evidence and reference materials to those who manage floodplain material data. With the development of the 2016 FMP, participants had been able to create an action plan for floodplain management, which could ultimately reduce region-wide flood insurance rates.

2020 FMP

Another Discovery engagement occurred in May 2019 and included the City of Tucson and nearby municipalities. After further discussions with FEMA, FEMA Region IX hosted a Risk MAP Post-Discovery webinar with the City Tucson on August 23, 2019 the City was granted re-allocated FEMA Region IX funds for consulting services to provide feasibility studies and preliminary designs for the Cushing Street Levee Extension project and the Christmas Wash Watershed stormdrain and regional detention basins. The 2016 FMP required the update to the FEMA product to be completed by October 2020. The 2019 FMP committee decided to schedule three of more FMP Committee meetings in the Spring 2020 to perform the 2020 FMP update. The 2019 annual meeting determined that the focus of the update should concentrate on the Action Plan lists. Five meetings and two public virtual meetings were provided and Action Plan (Table 5 in Chapter 6) and comments for the prioritized categories were discussed by the FMP Committee in the meetings. Additional comments were received and reviewed by the FMP Working Group and incorporated in the report.

Upper Santa Cruz Discovery Report and more information regarding the Discovery process is available on FEMA's website, www.fema.gov.

Figure 20: Sunset after a Tucson storm

In 2016, the FMP process had been unique in that FEMA assisted primarily with the project management, oversight, and production of final products, while the City of Tucson had led the planning efforts and discussions. This process proved beneficial in obtaining the community's first-hand perspectives and objectives. In creating Tucson's FMP, the best assessment had been provided by the committee for potential floodplain and erosion hazards, along with the most efficient mitigation actions for alleviating disaster potential.

With the city's current CRS Rating, it's apparent that Tucson has already achieved major goals with regard to Floodplain Management. By going a step further in the Risk MAP process by creating and updating the FMP, community representatives (and the public) will be able to access tools for floodplain management in the years to come.

As floodplain management increases overall, the flood risk potential for a community will decrease. This FMP update not only considers the well-being of the people, but also takes into consideration the natural and built environment. The intent of this updated comprehensive report is to further discuss existing flood and erosion risks, areas of potential hazard, and ways to address these concerns. Updating the FMP will continue to allow for the utilization of concrete and realistic flood risk products, and at the same time, it increases the public's awareness of flood risk potential. Updating this report also increases the ability of state and local officials and their constituency to adapt to current hazards and risks that may arise. It allows committee participants to take part in a discussion of ongoing efforts and can be used for a more coordinated effort in case of emergencies. It also helps to increase federal funding for hazardous events and decreases insurance premiums for local property owners. Currently, property owners in Class 6 communities are eligible for premium reductions of 20% if they are located in the Special Flood Hazard Area (SFHA), and 10% if they are outside the SFHA. Improving Tucson's CRS rating will result in increased savings for its residents and other property owners.

The goal is to update the FMP, continue to emphasize the unique flood and erosion characteristics of Tucson, and outline every issue faced by the urban community. This FMP Update intends to:

- Facilitate an update to the TSMS
- Identify current, existing and future flood-related hazards and their causes
- Ensure a comprehensive review of all possible activities and mitigation measures is conducted so that the most appropriate solutions will be implemented to address the hazard
- Ensure the recommended activities meet the goals and objectives of the community, are in coordination with land use and comprehensive planning, do not create conflicts with other activities, and are coordinated so that the costs of implementing individual activities are reduced
- Ensure the criteria used in community land use and development programs account for the hazards faced by existing and new development
- Look for ways to improve education for residents and property owners about the hazards, loss reduction measures, and the natural and beneficial functions of the floodplain
- Continue to build public and political support for activities and projects that prevent new problems, reduce losses, and protect the natural and beneficial functions of floodplains
- Expand a constituency that wants to see the plan's recommendations implemented

QUICK RISK MAP PRODUCT DISCUSSION

Because flood hazards change over time, the Discovery process provides an opportunity to engage in a comprehensive review of activities that contribute to flood risk. Engaging local officials in this process increases their understanding of flood risk and gives them an active role in identifying proactive steps that can be implemented to protect the lives and property of community residents. Through Risk MAP, FEMA provides communities with information that can improve risk communication and enhance local mitigation plans, resulting in decreased flood risk. FEMA has developed a suite of multi-hazard risk assessment products, referred to as Flood Risk Products (FRPs), to assist with this endeavor. FRPs can help community officials assess, visualize, and communicate local flood risk. The FRPs developed as part of the overall project are included in the Appendix of the 2016 report. As part of the 2016 project, the following FRPs had been developed for Tucson:

- **Flood Risk Report** - The Flood Risk Report (FRR) provides community and watershed-specific flood risk information extracted from the Flood Risk Database (FRD), explains the concept of flood risk, and identifies useful tools and reference materials. The FRR, used in combination with the Flood Risk Map (FRM), is a good tool for communities to use for raising local flood risk awareness.
- **Flood risk database** (including Hazus-MH) - The FRD stores all of the flood risk assessment data, which provides an evaluation of potential financial consequences and other impacts associated with structures located in the Special Flood Hazard Area (SFHA). This data also enables communities to make informed decisions regarding future land development and community infrastructure.
- **Flood Risk Map** - The FRM depicts flood risk data (not necessarily flood limits) for a flood risk project area and is typically used to illustrate an overall picture of flood risk for the area.

Figure 21: Erosion in right-of-way.

Figure 22: Increased pavement damage without curb.

Planning Phase

The FMP Working Group (WG) which were core members of the project team, met in November 2019 and a portion of the 2019 annual update agenda included determining how the planning process should go in order to meet the CRS requirements and maximize the resulting points that Tucson will receive toward increasing the City's CRS rating. In 2019, core FMP members determined that the 2020 formal update should focus on the Action Plan and updating the priority list. The WG met about once a week beginning in February 2020 to identify availability of 2016 committee participants for 2020 FMP Committee, also planned the meeting dates, agendas, and invitations, discussed meeting activities and format, committee tasks, and potential outcomes. The WG continues to meet throughout the entire FMP process. Annual FMP meetings for 2017, 2018 and 2019 were held in September through November of each year.

Figure 23: John Wise P.E. addressing 2016 FMP Committee – emphasizing the importance of natural functions of floodplains

TUCSON STAFF INVOLVEMENT

Per CRS requirements, the WG cited that it was very important to try to include stakeholders from as many departments within Tucson as possible to provide action item recommendations that could actually be supported and adopted by those departments. Having a wide range of participants would also provide the committee with a fresh perspective on Tucson as a whole. Without the appropriate community backing, the recommendations and the FMP will not succeed. The different groups within Tucson's governmental structure include the Tucson Department of Transportation and Mobility (DTM which includes engineering, stormwater management, and floodplain administration), Planning and Development Services Department (PDSD which includes engineering and planning), Trees for Tucson, Tucson Clean & Beautiful, Tucson Airport Authority, Tucson Water, Tucson City Council Ward Offices, Tucson Police Department, and Environmental and General Services Departments.

Per the CRS Manual, the FMP committee included stakeholders that covered six categories that reflect the possible activities that can prevent or eliminate the problems caused by flood hazards:

1. Preventive measures (e.g., codes and standards) (PDSD, TDOT, Tucson Water)
2. Property protection (e.g., elevation) (PDSD, TDOT)
3. Natural resource protection (Tucson Clean & Beautiful)
4. Emergency services (Tucson Fire and Police Departments)
5. Structural flood control projects (TDOT with assistance from PCRFCD)
6. Public information (PDSD, Tucson City Council Ward Offices, TDOT)

The list of committee members that attended each committee meeting is included with the 2020 FMP meeting agendas in the Appendix of this report.

Figure 24: Desert monsoon sky

OTHER AGENCY COORDINATION

In addition to local Tucson staff, the WG also reached out to other agencies to participate in the process. Those agencies included FEMA, ADWR, the U.S. Army Corps of Engineers (USACE), Pima County Regional Flood Control District (PCRFCD), Arizona Floodplain Management Association, Southern Arizona Home Builders Association, Tucson International Airport Authority, and the Tucson Association of Realtors (TAR). PCRFCD, TIA, and TAR were active in the 2020 FMP Update meetings. TAR has been active in collaborating with the City of Tucson for floodplain management, including educational trainings at TAR meetings, and assistance with City's request to assure Multiple Listing Service (MLS) forms include both FEMA and local floodplain information. City of Tucson has 3 chairs in the monthly multi-jurisdictional PCRFCD flood advisory board, although openings are available and need to be filled. Communications with TIA occur regularly to assure understanding of floodplain use permitting requirements for the airport's critical facilities and this year, included discussion of proposed updates to code for critical facilities to meet current CRS minimum standards. With assistance from FEMA, the City performed a presentation for TAR for floodplain updates. Tucson Botanica Gardens had interest in attending future FMP meetings.

Figure 25: Desert flora

REPORT OVERVIEW

The City of Tucson initiated TSMS in 1988 in order to develop a comprehensive stormwater management program. Fortunately for the FMP committee, Larry Roberts P.E. was a member of the team that created the TSMS and Mr. Roberts provided the following TSMS description. The TSMS was planned as a multi-year project with the following four phases:

Phase I: Establish Framework, Goals, and Objectives
Phase II: Develop Stormwater Master Plan
Phase III: Prepare Implementation Program and Maintenance Management Program, Assess Institutional and Financial Elements
Phase IV: Implementation

Phase I of the TSMS was adopted by Mayor and Council in March 1990. The Phase I study utilized an extensive public participation program for soliciting citizen involvement. The Phase I study also redirected future stormwater management efforts toward an emphasis upon nonstructural approaches which maintain or enhance naturally vegetated watercourses.

Phase II of the TSMS was initiated in 1992 in order to develop a Stormwater Master Plan for controlling both stormwater quantity and quality. One of the primary purposes of Phase II of the TSMS was to expand on the results of the Phase I study and develop a Stormwater Master Plan that adequately and economically addresses City-wide stormwater management. The Stormwater Master Plan was prepared under the direction of the City of Tucson by a multi-disciplined consultant team with areas of expertise in water resources, stormwater quality, environmental aspects, public participation, and legal issues. The Stormwater Master Plan was approved by Mayor and Council in 1996.

The Final Report presented the recommended Stormwater Master Plan (Simons, Li & Associates, 1992). Seventeen additional key documents were also prepared as the foundation for the Stormwater Master Plan.

The Tucson Floodplain Management Plan is TSMS Phase V and follows the Implementation Phase IV. Although implementation includes actions like floodplain management planning, the City chose to start TSMS Phase V.

The Final Report of the TSMS, Phase II, Stormwater Master Plan provided a 30-year framework for managing the surface water resources by integrating those technical, economic, social, and environmental factors which are essential for sound stormwater management. The comprehensive, watershed-based plan consisted of six major elements, described as follows:

1. Preservation of Naturally Vegetated Watercourses

Riparian habitat was identified and classified along the naturally vegetated watercourses within the City of Tucson. Approximately 77 miles of these watercourses, representing 570 acres of riparian habitat, were recommended for preservation. This represented 98% of the riparian habitat that was identified. Since then the City has created / adopted code for Environmental Resource Zone and Wash Amenities Safety and Habitat (W.A.S.H.) Ordinance, as well as water harvesting requirements.

2. Flood hazard studies

Flood Hazard Studies were proposed for approximately 41 miles of watercourses where nonstructural stormwater management measures were recommended. These studies were designed to better define the extent of flooding risks and identify possible nonstructural measures such as the purchase of flood insurance or floodproofing. Public education regarding results of the Flood Hazard Studies was also recommended.

The Flood Hazard Studies were proposed to be prepared by the City of Tucson for local floodplain management, and not create any new regulatory floodplains under the jurisdiction of the Federal Emergency Management Agency (FEMA). However, some Flood Hazard Studies may result in the remapping of existing FEMA floodplains in order to provide more accurate information which may reduce the size of the regulatory FEMA floodplain. The new data were to also be used by the City to determine whether additional studies were warranted.

3. Stormwater Quality Investigations

Although no significant problems with the quality of stormwater runoff were documented. The stormwater sampling equipment however was outdated, and it was recommended to be updated for the 5 sampling sites in order to obtain more reliable data. New stormwater management equipment and new SAMS software for stormwater surface water quality was purchased in 2018-2019. Today, seasonal sampling of rainwater runoff are indicating increases in E.coli. Stormwater quality continues to be an important topic to many constituents and is a priority to the City of Tucson who will continue to develop an historical scientific database of testing results to support monitoring efforts and protecting City's water quality.

4. Stormwater Capital Improvement Programs

The major structural component of the TSMS was 47 capital improvement projects which generally involved channelization, bank protection, storm drains, or detention/retention facilities. The 47 projects, which were prioritized into a series of 5-year programs, would result in over 2,000 homes and 3 million square feet of commercial and industrial buildings protected from flooding. Some of these projects have been completed and others are being designed or awaiting funding source.

5. Miscellaneous Capital Projects

The need for various small, less costly projects was identified to address localized flooding problems throughout the City. These smaller projects generally consisted of roadway culverts, storm drains, channel improvements, and grade control structures. Due to funding issues, these types of projects have been limited.

6. Recommendations for Implementation

Recommendations were prepared for new or revised City policies, regulations, standards, and practices which were necessary to fully implement the Phase II Stormwater Master Plan. The actual development of new or revised polices was completed as part of the TSMS, Phase III, Implementation Program.

The Phase III Implementation Program was initiated in 1996 to develop new or revised City policies, regulations, standards, and practices in order fully implement the Phase II Stormwater Master Plan. The key new or revised items are listed as follows:

1. Revised Drainage Standards Manual,
2. Draft Stormwater Quality Ordinance,
3. Implementation Plan for Preservation of Naturally Vegetated Watercourses,
4. Detailed Scope of Work for Flood Hazard Studies,
5. Detailed Scope of Work for Design Analyses of Capital Improvement Projects,
6. Identification of remapping needs for existing FEMA Flood Insurance Study,
7. Implementation Plan for Miscellaneous Capital Projects, and
8. Plan for Addressing Stormwater Quality and NPDES Requirements.

TSMS serves as the foundation for the FMP, and many reports listed below share the same goals as TSMS. The reports included:

- 2012 Upper Santa Cruz Discovery Report (FEMA)
- 2012 Pima County Flood Insurance Study (June 16, 2011) (FEMA)
- 2008 Tucson Watercourse Maintenance Guidelines (Tucson)
- 2006 Water Harvesting Guidance Manual (Tucson)
- 2017 Pima County Multi-Jurisdictional Hazard Mitigation Plan (HMP) (PCRFCD)
- 2003 City of Tucson Habitat Conservation Plan (PCRFCD)
- 2013 Pima County Community Wildfire Plan (Pima County)
- 2011-2015 Action Plan for Water Sustainability (Tucson)
- 2016 Tucson Parks & Recreation 10-year Strategic Plan (Tucson)
- Tucson Police Department Strategic Plan (2013-2018) (Tucson)
- Solving Flooding Challenges with Green Stormwater Infrastructure in the Airport Wash Area (2015) (Tucson Ward 1)
- Plan Tucson: City of Tucson General & Sustainability Plan (2013) (Tucson)
- 2013 City of Tucson Unified Development Code (Tucson)
- 2014 Tucson Emergency Operations Plan
- Multiple PCRFCD Studies on behalf of the City of Tucson

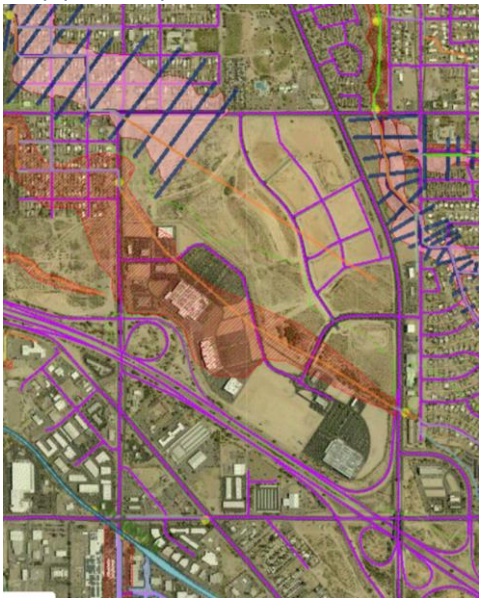

Figure 26: New mapping is needed to reflect new regional detention basin

IN-PROGRESS /RECENTLY COMPLETED FLOODPLAIN MAPPING STUDIES OF MOST CONCERN FOR TUCSON

1. Downtown Links project remapping includes Pima County Regional Flood Control District and the City of Tucson in cooperation with the U.S. Army Corps of Engineers (ACOE) which have jointly undertaken a multi-phase flood control, environmental restoration and recreation project called the Tucson Drainage Area/Arroyo Chico Multi-Use Project. After Downtown Links project is completed in construction of drainage system and road improvements, PCRFCD will use City as-built data to complete the LOMR.

2. There are several Santa Cruz River studies that incorporate mapping. Paseo de Las Iglesias Phase I: Santa Cruz River Bank Protection, Ecosystem Restoration, and Linear Parkway Project changes flow pattern to allow for PCRFCD riparian habitat enhancement. Santa Cruz River Management Plan – multi-jurisdictional comprehensive management plan for flood risk management, drainage infrastructure protection, water resources, recreation, education opportunities and riparian habitat preservation for the Santa Cruz River. Planning project on-going, sediment removal for conveyance improvement through much of the reach from Cushing St. to Grant Rd completed July 2020. Pantano Wash Linear Park-Craycroft to Tanque Verde - Phase 3 bank protection, Rose Hill Wash bridge, and green infrastructure river park construction completed February, 2018.

3. Alamo Watershed Study - Alamo Wash Letter of Map Revision: expected to be effective December 2020 or January 2021, from the study performed by the Pima County Regional Flood Control District on behalf of the City (Ward 3 and Ward 6), some homes were placed into the SFHA, although many homes were removed. Outreach letters have gone out to all impacted properties (summer 2020). Additional outreach will occur once FEMA's approval letter is sent to the City and an Effective Date is set. This date will provide guidance for property owners to plan for obtaining a flood insurance policy, or researching other options such as elevation certificate surveys, which may help lessen the cost of flood insurance for those properties having to purchase flood insurance by the Effective Date.

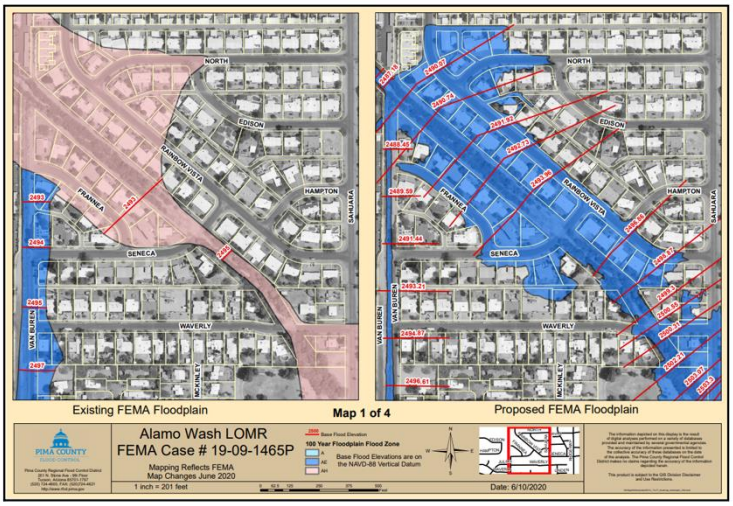

Figure 27: Outreach included existing and proposed floodplain maps

4. Updated Erosion Hazard Setback requirements are being proposed for Mayor and Council adoption to address increases in development along regional watercourses of the Santa Cruz River, Rillito, and Pantano Wash. Erosion Hazard setback mapping for regional watercourses will be started.

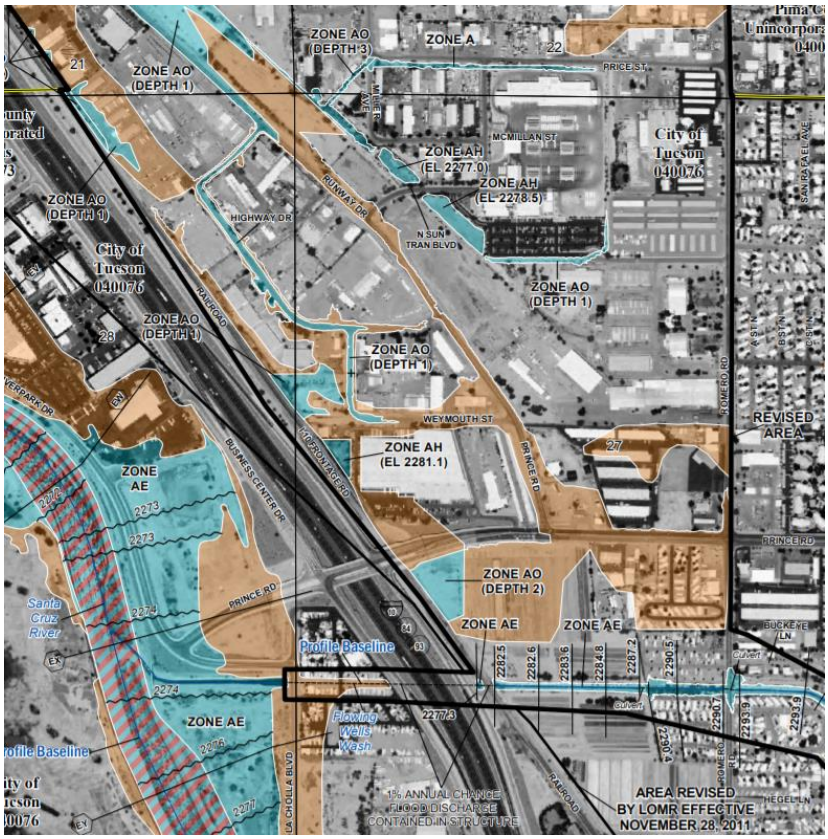

Figure 28: Reduced areas of floodprone property north of Flowing wells Wash

5. Gardner Lane area remapping. The City of Tucson Mayor and Council adopted the Ruthrauff Basin Management Study on October 24, 2017. Per this multi-jurisdictional basin management plan, the Ruthrauff South/Highway Drive will collect flows along Highway Drive and Wetmore Road and direct the flows to a drainage channel to be constructed parallel to the Union Pacific Railroad (UPRR) tracks. With coordination with Arizona Department of transportation (ADOT) and UPRR a conveyance structure (pipe culverts under the railroad) is intended to provide relief for stormwater runoff towards the Santa Cruz River on the west side of I-10. At the time of the study, revised flood conditions were determined t exist and a map revision was performed for the area east of the I-10 freeway. Additional map changes may occur after the construction of the relief pipes, however it is not anticipated for some years. The area, both in the City and the unincorporated county, will eventually see the economic benefit for the commercial/ industrial properties that may see additional lessening in flood insurance as well as less flooding conditions near Prince Rd and the freeway in Ward 3.

6. Silvercroft Watershed study with remapping. Various segments of the Silvercroft watershed have inconsistent base flood data and flood limit delineations so a full watershed study with remapping is being scheduled.

7. City's TSMS Watershed Management Area Map will be updated. Current and Future watershed studies are being assessed by floodplain administration and at time of study to assess watershed boundaries and assure appropriate basin management designation is used for each watershed in the City of Tucson. For each watershed management study that gets adopted, the basin management area designation (non-designated, balanced, or critical basin management area) is being updated.

Figure 29: Construction of High School Wash storm drain

CITY OF TUCSON PARTICIPATION: FLOOD & EROSION HAZARD MANAGEMENT PROJECTS

Santa Cruz River Management Plan is a multi-jurisdictional, comprehensive plan for flood risk management, drainage infrastructure protection, water resources, recreation, education opportunities and riparian habitat preservation for the Santa Cruz River. Tucson is active in this on-going planning project which is led by Pima County Regional Flood Control District Manager, Evan Canfield, P.E., PhD., CFM. As part of the project, regional watercourse conveyance was studied and sediment removal was performed by the PCRFCD to improve conveyance, completing the work in July 2020 through much of the Santa Cruz River reach from Cushing Street to Grant Road. Conveyance of flood waters is a crucial aspect of the function of the regional watercourses especially during large storm events.

The City of Tucson has played a major role in the overall Tucson Arroyo and Arroyo Chico phased improvements. Tucson Drainage Area/ Arroyo Chico Multi-Use Project". This is a US Army Corp of Engineers (USACE) project, in partnership with the PCRFCD and the City of Tucson.

Phase 1 (Randolph South Detention Basin): Completed April 1996
Phase 2A (Cherry Field Detention Basin): Completed December 2008
Phase 2B (Park Avenue Detention Basins): Completed December 2012
Increment 4 (High School Wash Storm Drain): Complete April 2015
Increment 3 (Upstream Channel Improvements): in final design phase 2020

The new LOMR maps will reflect the reduced flood hazards as a result of these projects. This is a multi-phase flood control project, and each phase of the project has provided additional benefits to the community and users beyond the direct flood control benefits. The watershed is almost fully developed and contains a mix of residential, commercial and industrial areas.

The downtown drainage infrastructure was originally constructed in the 1920s, 30's and 40's, which includes 1.7 miles of underground culverts. Because of the increased runoff due to urbanization the capacities of the existing drainage infrastructure were inadequate to convey the peak flows caused by intense thunderstorm events, resulting in frequent and severe flooding of residential, commercial and industrial areas along the entire length of the arroyo. Potential flood damages to both private properties and public infrastructure were estimated by the USACE at $2.7 million (1998 prices) annually.

Figure 30: Broadway Boulevard Project includes installation of sixteen 90-inch diameter underground storm drains as part of the Broadway Improvement Project from Euclid Ave to Country Club Road including approximately 192 tons of stormdrain pipe installed in one day.

The City provided the land for Phase 1 Randolph South Detention Basin, participated in the design and were the contracting agency for the construction of the Randolph South Basins. The City also donated a significant portion of the land needed for development of the Phase 2B Park Avenue Basins. The City also donated other lands to TUSD, provided improvements Tucson High School, and allowed temporary use of their parks to offset impact to TUSD during construction of Phase 2A Cherry Field basins as part of the IGA. Increment 3 (Upstream Channel Improvements) located east of Kino Boulevard and west of Tucson Boulevard is to be redesigned to provide channel capacity and green infrastructure. This section of the watercourse is W.A.S.H. Ordinance watercourse, so vegetation enhancements at top of banks are being looked at for green infrastructure. The PCRFCD is working with the Army Corps of Engineers to finalize design.

The City Transportation Department & Mobility also installed storm drain system in the area of Main Avenue at the downstream portion of the Tucson Arroyo. The City has also replaced the Arroyo Chico storm drain along 8th Street for the "Downtown Links" (DTL) transportation improvements. The City is constructing (two) ten-foot by 12-foot concrete box culverts and many other upgrades to the storm drain system on the upstream portion of Tucson Arroyo as part of the DTL road improvements started August 31 2020. After construction, PCRFCD will perform a LOMR for the area to revise the FEMA floodplain data.

Figure 31: Downstream of the Arroyo Chico drainage improvements is the "Downtown Links" road improvement project which was not formally a part of the Tucson Arroyo Chico Conditional Letter of Map Revision (CLOMR).

PROJECT WEBSITE AND EDUCATION TOOLS

An important component of the FMP process is encouraging community participation in the FMP's development. A project-specific FEMA Web page had been created on RiskMAP Region IX's Website prior to the first 2016 FMP committee meeting. The FMP meeting logistical information was posted to this website at: www.R9map.org for the duration of the 2016 FMP project. In addition, meeting minutes and other pertinent information were posted to this location. This information had been also posted to Tucson's project Web page www.tucsonaz.gov/pdsd/floodplain-information.

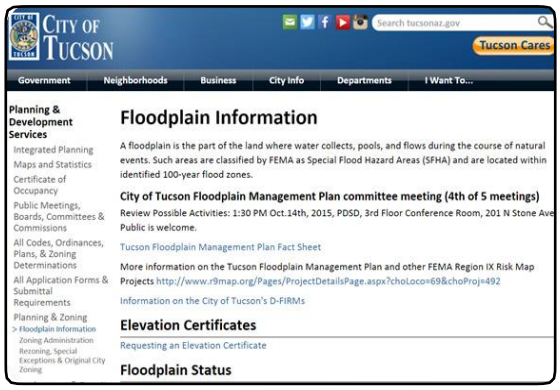

Figure 32: The City of Tucson's 2016 FMP information website

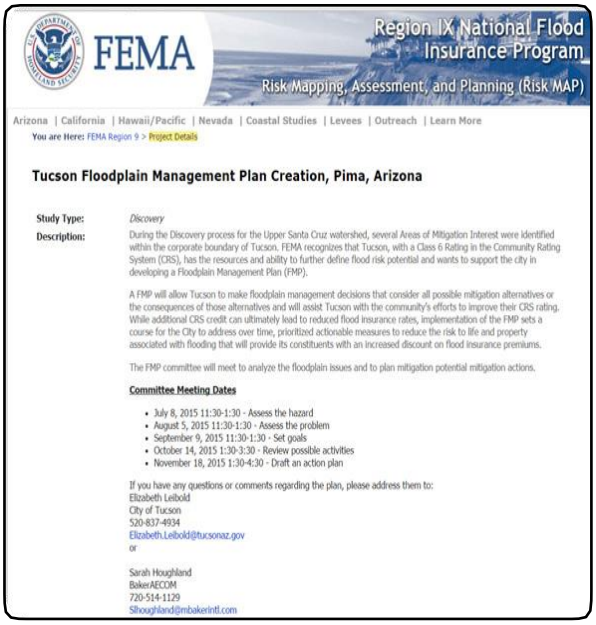

Figure 33: FEMA's 2016 Tucson FMP website

Since the FMP process is a foreign concept to many, the 2016 project team drafted a Fact Sheet as a quick way to convey important components of the FMP process. This Fact Sheet was posted to the project Web page and was displayed in the PDSD on the first floor of the County- City Public Works Building at 201 North Stone Avenue.

As discussed in the 2020 FMP committee meetings, education is a top priority for all aspects of Floodplain Management. Website FAQ and Flood and Erosion Hazard Protection information has been made available on the Floodplain Administration websites. In 2020, the FMP Update was advertised in the Territorial Newspaper, emails, City Floodplain Administration webpage, and on other social media. The 2020 FMP Update also provided updates on the City websites including posted recording of public meetings.

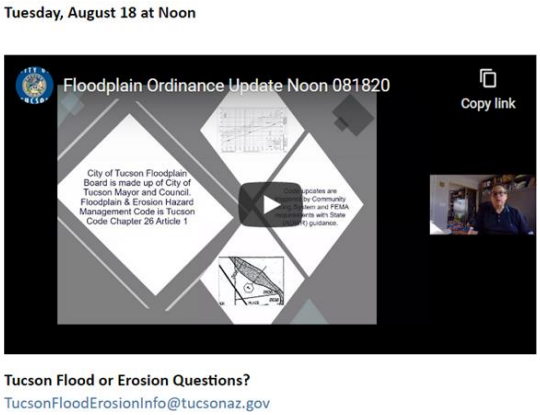

Figure 34: 2020 FMP Virtual Public Meeting on City website

PUBLIC INVOLVEMENT

Planning Process Conducted Through A Planning Committee

In addition to representatives from Tucson's local government, the WG solicited participation in the FMP process from the public and other stakeholders outside of Tucson's local government. As part of the planning process, Tucson residents, as well as individuals from local engineering and planning consulting firms, the PCRFCD, the University of Arizona, and the Tucson Association of Realtors lent their time and expertise to the 2020 FMP Update that will guide future flood and erosion hazard mitigation project planning in the city. The 2020 FMP Update committee lists and meeting attendance lists are located in the Appendix of this report.

Virtual Public Meetings Held on Draft Plan/Other Public Information to Encourage Input for 2020 FMP Update

On August 17 (5:30 – 6:30 PM) and August 18, 2020 (noon – 1 PM), Tucson hosted two virtual public meetings. These public meetings were held virtually due to COVID-19 restrictions in lieu of public open house that was provided at 2016 FMP. Members of the WG presented the draft FMP to the community with the intent of soliciting review comments to improve the report's content. In addition to the FMP plan, the City took the opportunity to explain the NFIP CRS system benefits, present the new Levee Manual (draft) and to present the draft floodplain ordinance to Tucson's residents. Tucson advertised the Open House in The Daily Territorial Newspaper on August 15, 2020 and on the Tucson Web site at www.tucsonaz.gov/pdsd/floodplain-information beginning March 2020. The virtual public meeting notices, agendas, attendee list are included in the Appendix of this report. The public comments and responses were prepared for the public hearing.

CITY OF TUCSON

NOTICE OF VIRTUAL PUBLIC MEETINGS

NOTICE IS HEREBY GIVEN that City of Tucson will hold two virtual public meetings on **Monday August 17, 2020** from 5:30 PM to 6:30 PM, https://bit.ly/30aaBi2 +1 213-293-2303 / Conference ID: 222 658 537# There will be a second virtual meeting on **Tuesday August 18, 2020** from Noon to 1:00 PM, https://bit.ly/39LBWuo +1 213-293-2303 / Conference ID: 697 255 60#. These virtual public meetings will be held so all interested persons will have opportunity to learn about & comment on the following:

Draft City of Tucson Floodplain Ordinance Update and
Draft City of Tucson Floodplain Management Plan Update and
Draft City of Tucson Levee Manual

City of Tucson, a participating community in the National Flood Insurance Program, is proposing revisions to Floodplain & Erosion Hazard Area regulations of Tucson Code, Chapter 26, Article I, to reflect updates as guided by the Federal Emergency Management Agency for community rating system requirements. City of Tucson is also performing periodic update to the 2016 Mayor & Council adopted Floodplain Management Plan, as Phase V.b to the Tucson Stormwater Management Study. A City of Tucson Levee Manual is also being proposed to meet maintenance requirements per Code of Federal Regulations Section 44CFR65.10(d). For more information on these drafts proposed for adoption, see: https://www.tucsonaz.gov/tdot/floodplain-administration

For other information or if you have questions about the meetings, please email TucsonFloodErosionInfo@tucsonaz.gov or you may contact Elizabeth Leibold, Civil Engineer, Transportation & Mobility Department, at (520) 429-4905, or Peter McLaughlin, Lead Planner, Planning & Development Services Department, at (520) 837-4898. Spanish captioning will be available during both meetings. Los subtítulos en español estarán disponibles durante la reunión.

Figure 35: Advertising for Virtual Public Meetings

Community Rating System FMP Steps

The 2016 FMP planning process was based on hazard mitigation planning steps and is summarized below:

Phase 1

Organize to prepare the plan.
a) Involvement of Office Responsible for Community Planning.
b) Planning committee of department staff
c) Process formally created by the community's governing board.

Phase 2

Involve the public
a) Planning process conducted through a planning committee.
b) Public meetings held at the beginning of the planning process.
c) Public meeting held on draft plan.
d) Other public information activities to encourage input.

Phase 3

Coordinate with other agencies.
a) Review of existing studies and plans (REQUIRED).
b) Coordinating with communities and other agencies.

Phase 4

Assess the hazard.
a) Plan includes an assessment of the flood hazard (REQUIRED).
b) Plan includes assessment of less frequent floods.
c) Plan includes assessment of areas likely to flood.
d) The plan describes other natural hazards (REQUIRED).

Phase 5

Assess the problem.
a) Summary of each hazard and their impact on the community (REQUIRED).
b) Description of the impact of the hazards.
c) Review of all damaged buildings/flood insurance claims.
d) Areas that provide natural floodplain functions.
e) Development/redevelopment/population trends
f) Impact of future flooding conditions outlined in Step 4, item C.

Phase 6

Set goals.

Phase 7

Review possible activities.
a) Preventive activities.
b) Floodplain Management Regulatory/current & future conditions.
c) Property protection activities.
d) Natural resource protection activities.
e) Emergency services activities.
f) Structural projects.
g) Public information activities.

Phase 8

Draft an action plan.
a) Actions must be prioritized (REQUIRED).
b) Post-disaster mitigation policies and procedures.
c) Action items for mitigation of other hazards.

Phase 9

Adopt the plan.

Phase 10

Implement, evaluate, and revise.

a) Procedures to monitor and recommend revisions shall be determined the prior year and the annual FMP meeting (as was performed in November 2019 for the 2020 FMP Update). Formal Updates shall occur at minimum every 5 years.
b) Same planning committee/successor committee that qualifies under Section 511.a.2 (a) does the evaluation.

Assessing the Hazard

To the credit of the diverse participants of the 2016 FMP process, the hazard brainstorming sessions had included a wide array of hazards Tucson faces. Hazards were identified by participants based on experiences and known issues caused by the hazard and via technical data gathered as part of the FEMA Discovery Process, Existing Flood Insurance Rate Map (FIRM) and Flood Insurance Study (FIS), Tucson data studies, PCRFCD data studies. Also, public complaints had been considered to help identify and prioritize the hazards. The SFHA shown on the FIRMs generally had formed the basis of the assessment, but Tucson and the PCRFCD flood studies, not yet included on the FIRM's and FIS, had also been considered. In addition, the repetitive loss properties in the city had also been evaluated. As the 2016 committee progressed through the brainstorming sessions, they also had considered areas not mapped on the FIRM that experience flooding, either due to riverine or localized flooding issues.

It is important to note that while TSMS had been generally organized on a watershed basis, the FMP considers Tucson as a whole. The FMP committee decided that the FMP should be more broadly based than TSMS. Since the 2016 FMP was the first RiskMAP floodplain management plan for Tucson, the FMP document acts not only as the Phase V of TSMS, but is also intended to currently perform as a higher-level planning document. During the 5-year review of the plan, the 2020 FMP committee was informed that floodplain administration was performing watershed-based floodplain management while continuing to look at Tucson as a whole. This type of floodplain management identifies issues within a watershed and looks at impact to the watershed, and when needed, also looks at watershed boundaries and beyond / upstream or downstream of the watershed to include a wholistic view to the City and the watershed's surrounding areas. RiskMAP looks at the whole City and provides a planning tool for flood and erosion hazard management to help identify risk areas for flood and erosion hazard mitigation projects and assist PCRFCD with flood studies generated on behalf of the City of Tucson.

Other uses for RiskMAP, since the base product was provided in 2016, includes assisting other flood assessment tools including PAG's Watershed Toolkit and the Tucson Water's Green Stormwater Infrastructure tool.

Pima Association of Governments (PAG) created a comprehensive GIS map to help municipalities, non-profits, and neighborhood groups to determine best locations that would benefit from increased access to shade trees, higher property values, enhanced recreation, improved air quality, reduced urban heat island effect, traffic calming, pavement preservation, energy conservation, enhanced stormwater quality, better mobility and livability. The City is currently working with Mead Mier at PAG to assist with the toolkit development to add soil data that assists with determining potential for infiltration, which can help determine areas with detention (low infiltration potential) or retention basins (high infiltration potential) would best be utilized.

Tucson Water's Green Stormwater Infrastructure (GSI) GIS tool is similar to the PAG tool and uses GIS data to help identify areas where GSI can be best located within the City. Since May 1, 2020, a new Green Stormwater Infrastructure fee was included water bills within the City of Tucson generating approximately $3 million annually to build and maintain GSI projects to capture rain runoff from public streets and parking lots and divert it into vegetated water harvesting areas. This program, championed by Tucson Water Department, provides a funding source for maintaining hundreds of existing GSI features in city neighborhoods, enhancing vegetation and tree canopy on streets, parks and other public areas, providing a rainwater source for irrigation, assist with stormwater quality, provide shade to cool streets, sidewalks, bikeways, and parking areas, and for beautifying the community. Aside from conducting training for maintenance staff and contractors and requiring qualifications to provide appropriate care of GSI features (building on Cooperative Extension/Tucson Water collaboration), the key to successful GSI projects will be in designing sustainable projects with low maintenance needs.

RiskMap data along with the type of hazard category, associated flood and erosion risk, drainage complaint areas, hydrologic soil type, and infiltration potential all play a part in potential success for sustainable GSI designs as well as conventional flood mitigation projects.

The 2016 FMP committee's brainstorming session revealed multiple hazards, so the FMP WG decided that it would be beneficial to group the hazards into seven main categories. These hazard categories are listed below along with the hazards that were identified. Not all hazards listed in the groupings carry the same weight, but for the sake of this report they will all be discussed in terms of the main category subject. In addition, some hazards are listed in multiple categories.

FLOOD AREAS WITH UTILITY/MUNICIPAL STRUCTURES

This hazard statement describes the types of structures that are at risk during the 1-percent-annual-chance flood event, and possibly lower frequency flood events. These structures include the different types of utility and municipal structures that are at risk from flood.

- **Buildings with sensitive storage**
- **Critical facilities**
- **Dams/reservoirs**
- **Emergency Management buildings**
- **Existing underground contamination plume areas**
- **Groundwater contamination**
- **Land subsidence/sinkholes**
- **Landfills**
- **Nursing homes**
- **Overhead utility lines**
- **Police/Fire Stations**
- **Railroads**
- **Sand & Gravel operations**
- **Underground utility lines**
- **Undersized drainage structures**
- **Wastewater/Effluent Discharge**
- **Wells**

GEOMORPHOLOGIC FLOOD HAZARDS

This group of hazards designate the multitude of different geomorphological hazards that result from flooding. Debris flow as defined in this grouping consists of debris on steep terrain, like what is seen in canyon areas.

- Channel headcutting
- Contamination plumes
- Debris flows
- Erosion zone setbacks – mostly an issue in older neighborhoods
- Groundwater contamination
- Land subsidence
- Lateral erosion
- Mud flows
- Natural earth fissures
- Sand and gravel operations
- Sedimentation
- Septic tanks
- Uncertain flow paths
- Wells

NATURAL FLOODPLAINS

This hazard grouping involved all potential hazards associated with floodplains.

- Alluvial fans
- Bajadas – not as steep as alluvial fans
- Braided flows
- Buffel grass
- City of Tucson Flood Hazard Areas – jurisdictional floodplains
- Erosion hazard areas
- Environmental Resource Zone floodplain areas
- FEMA SFHAs
- Habitat issues
- Homeless encampments
- Invasive species
- Monsoons
- Post-wildfire areas
- Regional Watercourses
- Riparian habitat issues
- Sedimentation
- Sheet Flows
- Uncertain flow paths
- Vados
- W.A.S.H. Ordinance watercourses
- Watershed boundaries
- Watersheds

PRIVATE DRAINAGE INFRASTRUCTURE

This hazard subset is the most difficult to regulate because the hazards occur on private property.

- Channel headcutting
- Detention
- Drywells
- Green infrastructure
- Homeless encampments
- Low Impact Development (LID)
- Low-flow crossing
- Ponding
- Retention
- Riparian habitat issues
- Sedimentation
- Standing water
- Water harvest areas – techniques should not cause adverse impacts

PUBLIC INFRASTRUCTURE CONVEYANCE

The hazards in this grouping encompass all potential hazards that arise in the public infrastructure domain.

- Bridges
- Channel headcutting
- Dams
- Detention
- Dip crossings
- Green infrastructure
- Homeless Encampments
- Levees
- LID
- Lowflow crossing
- Maintenance of Drainage Facilities
- Non-levee embankments
- Ponding
- Railroads
- Retention
- Riparian habitat issues
- Sedimentation
- Standing water
- Undersized drainage systems
- Undersized drainage structures
- Water harvest areas - techniques should not cause adverse impacts

Figure 36: Maintenance is needed to re-establish flowline.

VEGETATION ASSOCIATED FLOOD HAZARDS

This category highlights potential flood hazards that are a result of vegetation in the floodplain.

- Buffelgrass
- Debris flows
- Habitat issues
- Illegal dumping
- Invasive species
- Lightning
- Ponding
- Riparian habitat issues
- Standing water

Figure 37: Streets are part of the urban stormdrain system (J. Hayt)

URBAN HIGH-DENSITY FLOOD AREAS

Tucson is primarily an urban setting and differs from the PCRFCD urban watercourse. Due to the city's higher population density, encroachment in the floodplain is an issue. As land becomes scarcer, more development begins occurring in the floodplain. Concerns of floodplain preservation, natural floodplain function, and safety result from this encroachment.

- Buffel grass
- Channel headcutting
- City of Tucson Flood Hazard Areas- jurisdictional floodplains
- Critical facilities
- Development
- Drug Paraphernalia
- Drywells
- Erosion zone setbacks
- FEMA SFHA's
- Green infrastructure
- Homeless encampments
- Illegal dumping
- Invasive species
- Low Impact Design
- Low-flow crossing
- Mobile Home parks
- Ponding
- Railroads
- Riparian habitat issues
- Sedimentation
- Septic tanks
- Standing water
- Urban agricultural areas in the floodplain
- Water harvest areas – techniques should not cause adverse impacts.

The 2016 committee then had prioritized the hazards according to group consensus regarding Tucson's overall vulnerability to each hazard. Results were as follows, where 1 was the hazard Tucson was most vulnerable to, and 7 was the hazard to which Tucson was least vulnerable.

2016 Tucson's hazard Vulnerability assessment:

1. **Public Infrastructure Conveyance**
2. **Flood Areas with Utility/Municipal Structures**
3. **Urban High-Density Flood Areas**
4. **Private Drainage Infrastructure**
5. **Natural Floodplains**
6. **Vegetated Associated Flood Hazards**
7. **Geomorphological Flood Hazards**

In 2020 the categories for hazard vulnerabilities were reviewed to determine if the prioritization of these vulnerabilities had changed since 2016. From the 2020 FMP Committee exercise, the Public Infrastructure Conveyance category continues to rank as the highest vulnerability.

2020 Tucson's hazard Vulnerability assessment:

1. **Public Infrastructure Conveyance**
2. **Urban High-Density Flood Areas**
3. **Natural Floodplains**
4. **Vegetated Associated Flood Hazards**
5. **Flood Areas with Utility/Municipal Structures**
6. **Private Drainage Infrastructure**
7. **Geomorphological Flood Hazards**

Figure 38: Santa Cruz River Bike Lane Underpass – flooded

OTHER HAZARDS IN TUCSON

In addition to flood hazards, as previously stated, Tucson is also vulnerable to a variety of other natural and man-made hazards. A review of the 2017 Pima County Multi-Jurisdiction HMP showed that while Tucson is generally affected by all risk hazard profiles, 2020 FMP Update Committee determined that there is only significant risk from the following weather-related hazards (in addition to flood):

- Drought
- Severe Wind (Straight Winds)
- Subsidence
- Post-Fire Flood

Another risk found in the City stormdrain system is the impact from homeless encampments. Homeless encampments and drug paraphernalia in Tucson's watercourses have increased substantially since 2015 and have posed a safety concern for the homeless persons in the floodprone areas as the persons are vulnerable to flash flooding related drowning, cave-ins where encampments are set near soils subject to floodwaters that have an increase potential to slumping (collapse of slope). Fire Department frequently responds to fires set by

Figure 39: Blackened concrete at location where encampment was removed from box culvert after a fire.

persons within encampments inside box culverts or stormdrain pipes. City Floodplain Administration is assisting the Fire Department responders with training on how to find and use the drainage plans to speed up time to access the stormdrain system to save persons that may be trapped by the fire. Trash, blankets, and furniture from encampments increase potential for blockage, flow diversion, clogging and obstructions during storm events in the watercourses, reducing capacity for floodwaters to remaining eh drainageway, thereby increasing flooding risks to homeless persons and neighboring residents and properties. As human feces increase in the watercourses, potential for spreading of communicable diseases increase, and stormwater quality is impacted as increases in E. Coli are found in more and more City stormwater sampling. Public safety is also an issue for other recreational users and maintenance staff when drugs or drug paraphernalia is present at or near an encampment. Homeless persons have used children's park area water fountains for washing under garments, and electrical outlets are used to recharge batteries that are used in the camps.

There is an increased financial burden to the City in the form of police assistance to help homeless in the watercourses, assisting the neighboring property owners, and implementing Homeless Protocol which requires notification time for the persons within the homeless encampment. Neighboring commercial properties have seen an increase in revenue with police presence in areas prone to homeless activities. Department of Transportation and Mobility Streets Maintenance and Stormwater Inspection staff as well as and Parks and Recreation staff have experienced increase staff time and costs to perform homeless clean-up, vactoring (vacuuming), and other environmental hazard remediation services.

Staff from many departments are working together to look for ways to help the homeless community as well as reduce the associated floodplain risks to the stormdrain system, the environment, and neighboring properties. Police presence, as mentioned, has had a positive result for Tucson's public drainageways, however repeated time and effort is needed for visits to sites to monitor. Tucson Police Department identified a solution to assist with encampment issues; adding a "No Loitering" sign to the drainageway or culvert can aid officers when asking persons to leave the drainageway. Tucson Police Department also works with maintenance staff to coordinate clean-up efforts, by posting the homeless protocol notices prior to maintenance crew performing clean-up activities. The City of Tucson Housing and Community Development Department staff has assisted with making services available to the homeless. CODAC services appear to be a successful partner and have been assisting in the efforts. Human Activity Control (HAC) structures to keep persons from entering box culverts, have pros and cons for implementation due to potential to be pinned against the inlet grate during a flood event. Serious concern for drowning can occur with or without a HAC in place. Recreational users, pets, or children playing in a wash could be pinned against the grate and not be able to get out of the floodwaters and drown. Various types of fencing or constructed barriers around drainageways have been found to provide limited success as persons have been seen to use crow bars to open fencing or dig under the barrier. Fencing also can be constrained by floodplain limits; placement of fencing is not permitted to obstruct the floodwaters. If channel contains the jurisdictional floodplain, then fencing may be an alternative. Special drop-inlet catch basin designs can also be used as HAC structures with elevated grates so velocity is reduced and potential for pinning in lessened. These features have been found to be successful in detention types of drainage systems. One experimental Human Activity Control structure with a slanted grate, to facility better access out of the channel, was designed and constructed for the City in Ward 3. The City continues to develop proactive coordination tools between departments and with other agencies to address homeless camp trash, excrement (E.coli water quality issue), and debris in the floodplain.

Figure 40: Debris from homeless activities in a mapped FEMA urban floodplain (3-foot flood depth expected during jurisdictional / 100-year storm event)

LESS FREQUENT FLOOD HAZARDS

An investigation of the numerous hazards that were identified showed that, somewhat surprisingly, Tucson is not seriously vulnerable to the hazards listed below:

Alluvial Fans: Despite being located in the desert, where conditions are favorable, there are no known alluvial fans in Tucson. Most of Tucson is located in the valley and not in the foothills or mountains, where alluvial fans most commonly occur. Although there are no formal alluvial fans, there are areas throughout the city that exhibit similar characteristics. Watersheds on the north side of the City of Tucson flow toward the Rillito Creek regional watercourse conveying alluvial sediments from the Catalina foothills. Sediment transport increases as changes to riverbed slope lessens with increasing grade control improvements such as riparian habitat enhancements within the riverbeds of the regional watercourses. Regional Flood Control dredging to remove excess sediment occurred in 2019-2020 for Rillito and Santa Cruz River after capacity analyses identified high risk zones for overtopping.

Dams: In Tucson, there are four locations of dams in the city, with one being located Lakseside, in Kennedy Park, another located in Randolph South, and the Cherry Field / Park Avenue Detention Basins. These dams do not pose a significant danger to the community and are considered reservoirs.

Figure 41: Floodwall Levee on the Silvercroft (ERZ) watercourse at termination point (see page 39)

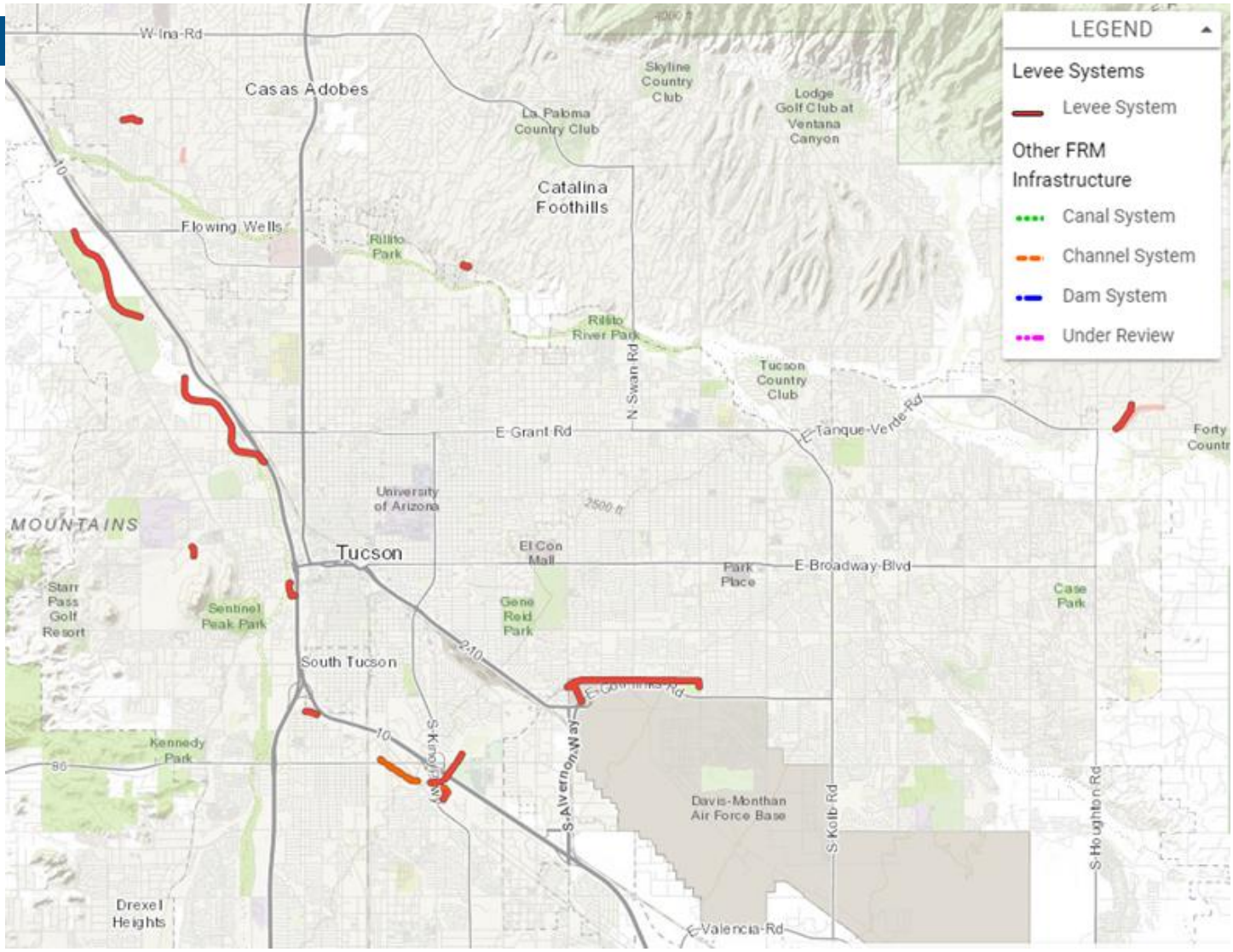

Figure 42: Locations of flood control structures and levees per national database

Levees: Levees also do not present a significant hazard to Tucson. FEMA accredited levee segments occur along the Santa Cruz River on FIRM panels 04019C1666L, 04019C1667L, 04019C1669L, 04019C1688L, and 04019C2276L for two separate levee segments in northwestern Tucson. An accredited levee also is located in an annexed area on panel at the northeast side of the city along the Agua Caliente watercourse that provides soil cement berm protection for lowering flood risk to a residential community. Levee-like structures are part of the Tucson Diversion Channel system which were designed to intercept flows from the Arroyo Chico, Tucson Arroyo, Julian Wash, and Railroad Wash and divert those flows to the Santa Cruz River. Floodwalls are rarely utilized although exist along the Silvercroft Wash to protect a non-profit hospital, medical offices, and residences for nuns, as well as along the Santa Cruz River southeast of the Cushing Street Bridge. A third floodwall on the north side of River Road in unincorporated Pima County lessens flood risk for downstream commercial and residential structures within the City limits on FIRM Panel 1695 L. A Tucson levee manual is being created to provide City of Tucson information on emergency response planning, levee requirements and maintenance checklists.

FUTURE CONDITION CONSIDERATIONS AND THEIR POTENTIAL IMPACT TO FLOODPLAINS

Population: Since the last Census in 2010, the Pima Association of Government (PAG) estimates Tucson's population has grown at a steady, but slow, pace from below 1 percent to 1.13 percent. According to the PAG's 2013-2050 Incorporated Places Population Projects for Pima County and Incorporated Areas, Tucson's population is expected to grow by approximately 1 percent per year through 2050. Since the population growth isn't expected to increase rapidly and is expected to be on a steady projection, Tucson can take this opportunity to get out ahead of future development in areas where the floodplain mapping is outdated or non-existent.

Figure 43: Erosion Hazards can cause structural issues

Development/Redevelopment: Since Tucson is largely developed, new development will occur mostly on the outskirts of the city which also correlates to the more rural areas in the city where the SFHAs are likely old or non-existent. Also, redevelopment in Tucson is likely to occur to replace aging infrastructure. Tucson's floodplain ordinance addresses development issues by defining setbacks along watercourses, outlining other subdivision and development project requirements, and outlining detention and retention system constraints.

Like many floodprone properties built prior to flood mapping, roads have also been constructed in floodprone areas. The main issue is funding to build or reconstruct all weather access public routes. Development for properties that do not have all weather access have subdivision restrictions in City codes, so no new subdividing can be approved if access is not already physically provided at the development site.

Erosion hazard setbacks and changing flowline slopes are a serious concern for City floodplain management. Setbacks are becoming a frequent constraint for development, especially along the City's major and regional watercourses. More accurate flowrates have been determined based on the City of Tucson Flood Insurance Study (effective 2012) and so updated flood and erosion hazard management code is being considered to address increase in setbacks between the top of embankment and the proposed needed development improvements (necessary all weather access, emergency access, utility and building setbacks).

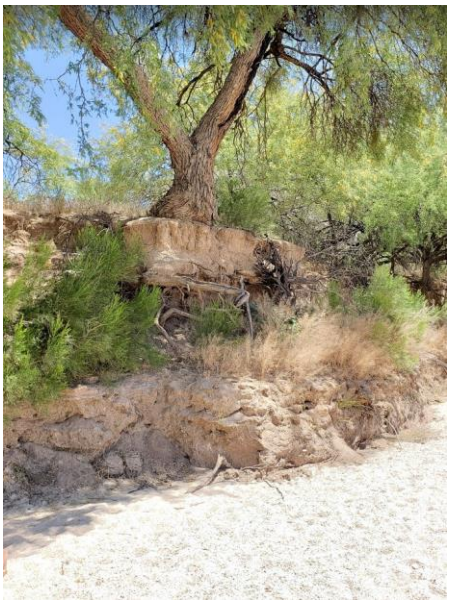

Figure 44: Tanque Verde Creek side slope

Technological updates also impact future considerations. Survey datums will be changing for both vertical and horizontal datums with the upcoming National Geodetic Survey updates. This will impact upcoming FIRM mapping as current benchmarks are based on NAVD 88 datum. Also the use of LiDAR and other new technology increase accuracy for floodplain studies and mapping.

As Green Infrastructure is used more, successful design aspects need to be considered. There are concerns regarding removal of the first ½ inch of rain runoff from the watercourses. The first discharge is the primary watering feature for vegetation along all watercourses. Starvation of vegetation impacts critical erosion stabilization as vegetation dies. Stopping flow in retention features also increases potential for sediment impoundment and thus more erosion of the watercourse as "clean water" conditions occur.

Sustainable approaches include the use of sediment traps for collection of parking lot runoff or locations where trash or debris may occur. In most other locations, new low-flow bypass systems will need to be designed to allow for the smaller storm events to continue through the watershed. Using detention features also helps to provide continuation of some of the rainwater runoff to help feed downstream riparian floodplain and neighbor's citrus trees.

Climate Change: Currently, aside from Plan Tucson policies, Tucson does not have specific regulations to address climate change outside of the conditions prescribed in Executive Order 13677, *Climate-Resilient International Development*, that was released on September 23, 2014. To meet the requirements in the Executive Order, federally-funded floodplain management projects and activities are required to include evaluations of potential climate change impacts in Tucson as part of the analysis. The climate change assessment will consider if there are noticeable changes to weather patterns and if there are side effects caused by these changes. The evaluations should include Plan Tucson policies (Energy & Climate Change Element) which may have an impact on Tucson's floodplain management practices by influencing regulations, maintenance practices, and hydrologic and hydraulic analysis methodologies.

- EC8 Assess and prepare for the effects of climate change on City infrastructure, facilities, and operations.
- EC9 Assess and address the vulnerability of the community's health and safety, economy, and natural resources to climate change, and develop assurances that vulnerable and disadvantaged populations are not disproportionately impacted by climate change.
- WR11 Conduct ongoing drought and climate variability planning

Figure 45: Climate change will be considered for future federally-funded flood risk projects

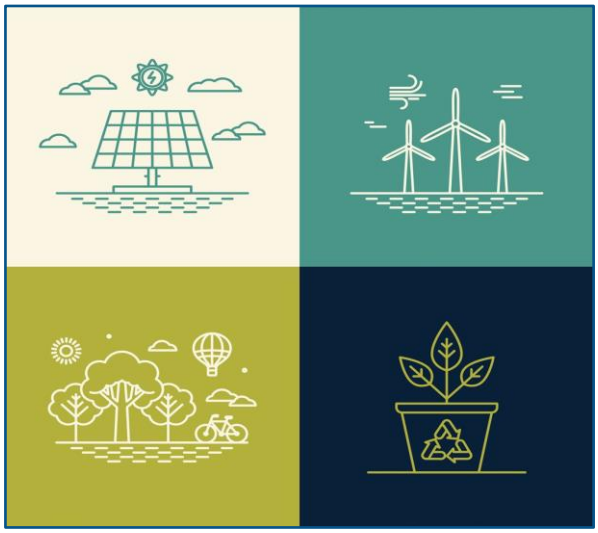

Figure 46: Sustainable practices create vibrant communities

Figures 47 & 48: Before & after: dual purpose: ineffective flow area floodplain & solar project – reduces community's electrical costs

Assessing the Problem

Seven main hazards were identified and sub-groups formed based on these hazards which include:

1. Public Infrastructure Conveyance
2. Flood Areas with Utility/Municipal Structures
3. Urban High-Density Flood Areas
4. Private Drainage Infrastructure
5. Natural Floodplains
6. Vegetated Associated Flood Hazards
7. Geomorphological Flood Hazards

For each of the seven main hazard groupings, the problems were assessed according to these five criteria, which represent the impact of the hazards on:

i. Life, safety, health, procedures for warning and evacuation
ii. Public health including health hazards due to floodwaters/mold
iii. Critical facilities and infrastructure
iv. The community's economy and tax base
v. Number and type of affected buildings

Questionnaires were provided during these 2016 breakout sessions to help the committee members organize their thoughts. In the end, the top five problems caused by the seven identified hazards were listed.

1. Public Infrastructure Conveyance
   a. Ingress/egress for access and evacuation
   b. Inundation, etc., from embankment breach
   c. Swept away hazard at low water, etc.
   d. Drowning hazard for ponding
   e. Loss of utility service
2. Flood Areas with Utility/Municipal Structures
   a. Emergency response plans are current and active
   b. Inadequate access to hospitals and emergency resources during a flood event
   c. Impacts to the cost of developing and attracting new businesses
   d. Hazards from contamination and debris
   e. Loss of tax base due to disruptions
3. Urban High-Density Flood Areas
   a. Erosion
   b. Contamination of stormwater
   c. Standing water/ponding – mobility (car, bike, pedestrian, etc.) and West Nile Virus
   d. Wash clogging (debris, vegetation) – maintenance
   e. Unplanned historic growth

4. Private Drainage Infrastructure
   a. Access – ensuring community flow during all issues that may arise with varying problems
   b. Contamination of groundwater and natural facilities near or adjacent to properties. Be able to make proper notification of hazards whether private or public contaminants
   c. Erosion and sediment from basins
   d. Ponding water in all areas and the hazards that may be produced.
   e. Public/private notifications.
   f. West Nile Virus/mosquito transference of unhealthy viruses throughout the neighborhoods and surrounding communities.

Figure 49: Christmas W.A.S.H. (Watercourse Amenities Safety and Habitat) watercourse. Flood stage for this watercourse extends over the wash embankments.

5. Natural Floodplains
   a. Access
   b. Utilities
   c. Flood warning program and process
   d. Pre-1980 structures not compliant
   e. Regulations and enforcement – keep development out of natural floodplains which poses both a challenge and an opportunity for the community

6. Vegetated Associated Flood Hazards
   a. Debris flows – naturally generated vegetation debris that blocks flows, water conveyance, etc.
   b. Invasive species – Buffel Grass and Salt Cedar fire effects and intensity, power poles, utility structures
   c. Riparian habitat – human occupancy within the riparian corridor, notification and evacuation of occupants when events occur Ponding – mosquito breeding, public use, potential health issues
   d. Riparian habitat – lack of mapping of what vegetation is actually in the floodplain, where are concentrations of invasive species/good native habitats, etc.

Figure 50: As floodwater erode side banks, natural lateral migration of washes occur

7. Geomorphological Flood Hazards
   a. Groundwater contamination – runoff from the auto service industry and airport-related facilities (surface contamination leading to groundwater contamination); landfills and sand and gravel operations
   b. Channel headcutting and erosion – loss of taxable land; economic hardships on the community, property owners; the general public
   c. Subsidence – leads to property damage and economic hardship-condemned facilities and structure collapse; leads to fissures/roads and structure damage; alters flow paths
   d. Mud flows – road and structure/property damage; infrastructure/facility damage
   e. Wells – impacted groundwater; monitoring wells; flumes

Figure 51: Flooding can easily damage city infrastructure

REVIEW OF ALL DAMAGED BUILDINGS/FLOOD INSURANCE CLAIMS (HAZUS)

Hazus, FEMA's loss estimation and hazard modeling software, was used to conduct a flood risk analysis based on the 1-percent-annual chance flood event for structures within Tucson. This enhanced analysis leveraged locally managed inventory, hazard, and terrain data.

Parcel boundaries were used in conjunction with assessor data tables to create building centroids representing structure types and values. A comprehensive 1-percent-annual-chance flood event floodplain was developed by combining FEMA and local data sources, and a flood depth grid was developed using a citywide elevation surface derived from Tucson's LiDAR data. These enhanced data inputs were modeled in two Hazus scenarios in order to estimate damages to structures and aggregated census block data within the city.

Tucson has had 1,783 flood insurance policy claims as of February 2016. The policies account for $1,623,950 in total premiums that represent $387,788,700 in total coverage. There have been 620 claims in the community. This information was taken from FEMA's Community Information System (CIS) database.

REPETITIVE LOSS PROPERTY

There are only seven properties in Tucson that are considered Repetitive Loss Properties (RLP). RLP properties receive letters from the city to inform the owners of ways to protect against future flood damage. At this time, Tucson has been looking into mitigation actions for the property owners. One property owner had taken steps to hire a civil engineer to prepare a drainage report to look at floodproofing and to physically help protect the home from flooding from Christmas Wash. Two of the properties are located along Bronx Wash, and the other property is located along Navajo Wash. The City is also researching possible funding for mitigation projects for one or more of these RLP areas from our City contributions to PCRFCD, federal mitigation funding such as a Flood Mitigation Assistance (FMA) Grant, BRIC, or possible future Stormwater Utility funds. Repetitive Loss Maps have been generated by the city floodplain engineering staff, and due to federal privacy protection laws, are located with the Floodplain Administrator and floodplain management staff.

Setting Goals and Defining Actions

In 2016, working on the Action Plan as an FMP Committee had included prioritizing action items and making recommendations as to which actions were to be included in the report. Time had also been utilized by the group to discuss post-disaster mitigation policies and procedures and action items of mitigation of other hazards. The goals the 2016 FMP committee had identified align with Tucson's overall goals, and they support the FMP committee's vision for how Tucson can address flood hazards in the future.

In the 2020 FMP Update, the FMP Committee kept the 2016 goals with some minor changes – to emphasize the importance of promoting tree canopy and green infrastructure. The goals can be directly correlated to the community's hazard mitigation activity strategies, and a brief discussion of how each goal furthers Tucson's objectives has been included below the goal statement.

THE CITY OF TUCSON 2020 FLOODPLAIN MANAGEMENT PLAN GOAL IS TO:

Reduce flood and erosion hazards, damage, and associated costs by:

- ✓ Identifying high-risk areas.
- ✓ Providing safe, efficient, and balanced conveyance for stormwater runoff.
- ✓ Preserving and promoting tree canopy, maintaining, enhancing and restoring riparian ecosystems and wildlife corridors.
- ✓ Increasing community awareness of green infrastructure, water harvesting and low impact design methodologies, stormwater quality protection, floodplain preservation measures, and general flood and erosion information.
- ✓ Expanding incentives for private property owners and developers to implement sustainable flood and erosion hazard mitigation strategies.

1. Identifying high-risk areas. While many flooding sources in Tucson have been mapped and officially recognized by FEMA, the city acknowledges that some flooding sources are in need of restudy due to development and other pressures. In addition, determining the locations of the high-risk areas will help inform capital improvement plans, outreach strategies, and emergency management plans in addition to having many other purposes.

Figure 52: Sediment transport is common in the desert

2. Providing safe, efficient, and balanced conveyance for stormwater runoff. Whether this goal is referring to capital improvement projects or to restoring natural watercourses, the intent is for Tucson to address areas where stormwater runoff causes an issue for its residents in the manner described by the goal statement. For Tucson, safety is the ultimate objective.

3. Preserving and promoting tree canopy, maintaining, enhancing and restoring riparian ecosystems and wildlife corridors. This goal is important to Tucson because the community is proud of and protective of its natural resources. Tucson is a unique desert community, and its natural features make it a desirable place to explore. Promoting tree canopy and enhancing vegetation can reduce heat island effect and other benefits which are sought by floodplain administration and the community. Protecting the natural habitat while balancing the pressures an urban community faces is of the highest importance.

4. Increasing community awareness of green infrastructure, water harvesting and low impact design methodologies, stormwater quality protection, floodplain preservation measures, and general flood and erosion information. Enhancing and diversifying community outreach and educational activities will be a primary focus for Tucson. It is important to understand your community prior to formulating an outreach plan. For Tucson, a systematic and targeted approach to disseminate information is likely the best way to deliver the messages regarding the topics listed in the goal statement.

5. Expanding incentives for private property owners and developers to implement sustainable flood and erosion hazard mitigation strategies. The intent of this goal is to foster community support for resiliency and awareness of flood hazards. By providing incentives to property owners, Tucson will likely be more successful in achieving its floodplain management objectives.

REVIEWING POSSIBLE ACTIVITIES

All major problems caused by the hazards were assessed by reviewing them in consideration to the possible activities that can be implemented to address the hazards and further Tucson's FMP goals. The possible activity topics included:

i. Preventive activities
ii. Floodplain management regulatory/current and future conditions
iii. Property protection activities
iv. Natural resource protection activities
v. Emergency services activities
vi. Structural projects
vii. Public information activities

The 2016 FMP committee considered all possible activities as potential mitigation measures, noting which ones were valid and which ones should not be considered. The problem statements were arranged in matrices according to hazard, and the top five problems were listed so that they could be assessed against their potential mitigation activities in a systematic way. Blanks in the matrices mean that the activities were considered, but the FMP committee did not deem them applicable. The full spreadsheets are located in the Appendix of this report. As the committee filled out the matrices, they were asked to highlight the activities the committee recommended most for those problem statements. Although not all activities were selected for inclusion in the action plan, the city will catalogue all responses for consideration in future updates to the FMP, including this 2020 FMP Update.

Figure 53: Tucson's landscape in bloom

Action Plan

Building on the work completed by reviewing the potential mitigation activities, the 2020 committee then reviewed the activities that were adopted in 2016. In the 2016 FMP committee meetings, of the activities determined and considered as valid, three to five activities were then recommended that could be implemented for each of the seven major hazard groups. Projects in the 2012 Pima County Hazard Mitigation Plan and identified by City Floodplain Administration are also identified in this 2020 FMP Update report.

The following four questions were evaluated for each recommendation and these items must be identified in the Action Plan:

1. Who is responsible for implementing the action?
2. When it will be completed?
3. How it will be funded?
4. What goal does the action support?

Figure 54: Sandbagging is an easy and cost-effective technique to battle flooding

MITIGATION ACTIVITY SUMMARY PRIORITIZATION

The following flood hazard mitigation projects are either beginning, completed, or ongoing and some were included in the 2017 Pima County HMP:

Table 3. Actions for Flood Hazards to be Mitigated (List to be updated in the PCHMP if not already in the PCHMP)

Mitigation Action/Project	Hazard(s) Mitigated	Estimated Cost/Funding Source	Completion Date	Responsible Agency
Identify funding source and construct two bridges (Harrison Bridge at Pantano and First Avenue at Rillito - First Avenue Master Plan) and 50 box culverts with 380 back-up power units for signalized intersections at high flood hazard crossings - in the City of Tucson limits in accordance with the City's Department of Transportation & Mobility 5-year plan. If a bridge or box culvert cannot be constructed, an automated warning device, consisting of a barricade, signs, and flashing lights will be installed or upgraded.	Flood, Severe Wind	$100 million, Staff Time Grant Funds	Ongoing effort with long-term horizon. Schedule dependent upon funding.	Department of Transportation & Mobility / Streets Administrator and Streets Chief Engineer
Tucson Green Streets Active Practice Guidelines – City shall update the Green Streets Active Practice Guidelines.	Erosion / Ponding	Staff time	2021	Department of Transportation & Mobility / Director
Alamo, Christmas, West University, Bronx, Flowing Wells Watershed Studies and other **drainage studies** - Watershed Study to include proposed solutions to drainage issues.	Flood / Erosion / Sediment Transport	(underway / continuing) / PCRFCD, FEMA Region IX funding	Annual - Ongoing	Department of Transportation & Mobility / Director
Barrio Veijo - Re-direct the drainage canal at Barrio Viejo.	Flood	$425,000 Grant Funds, General Fund, PCRFCD	2025	Department of Transportation & Mobility / Project Administrator
CLOMR - In compliance with National Flood Insurance Plan (NFIP), City of Tucson will continue to require the preparation and submittal of a Conditional Letter of Map Revision (CLOMR) or Conditional Letter of Map Revision based on Fill (CLOMR-F) for all proposed development within FEMA-delineated SFHA's.	Flood	Staff Time	Annual - Ongoing	Department of Transportation & Mobility and Planning and Development Services Department / Directors
Compliance - City of Tucson will maintain compliance with NFIP regulations by enforcement of current floodplain management ordinance through review of new development located in the floodplain and issuance of floodplain use permits.	Flood / Erosion	Staff Time	Annual - Ongoing	Planning and Development Services Department and Department of Transportation & Mobility / Directors
Storm Inspections - improve floodplain administration under the NFIP program by sending inspectors into the field when we receive a flood warning from the National Weather Service, to assess bridges, washes and other critical infrastructures within City of Tucson.	Flood / Erosion / Sediment Transport	Staff Time	Annual - Ongoing	Department of Transportation & Mobility and Planning and Development Services Department / Directors
Plan Tucson - City of Tucson General & Sustainability Plan (and associated updates) includes broad, sustainability planning focus for Tucson, including goals and policies to reduce hazards.	All	Staff Time	Annual - Ongoing	All departments
Acoustic Fiber Optics (AFO) monitoring and advance warning system - Promote Disaster-resistant water delivery system by constructing redundant water transmission lines. Utility and community will be less susceptible to loss of water delivery due to natural or manmade disasters. Pipeline management program including electromagnetic (EM) assessment and AFO monitoring to provide warning so pipeline can be fixed before pipe breaks and causes sinkholes, flooding and erosion.	Flood, Erosion, Subsidence, Sinkholes	$7.9 million / Operations Budget	Ongoing with full completion by 2020	Tucson Water Department/Water Administrator Maintenance & Operations
Critical Facility Assessment - Assess the vulnerability of critical facilities to flooding and erosion from stormwater runoff and encourage reducing runoff and means for mitigating critical facilities when runoff cannot be reduced. Outreach to encourage emergency response planning. Look at how to keep information secure.	Flood / Erosion	Staff Time	Annual - Ongoing	Department of Transportation & Mobility and Planning and Development Services Department / Directors

Mitigation Action/Project	Hazard(s) Mitigated	Estimated Cost/Funding Source	Completion Date	Responsible Agency
Alamo Gabion Project – design and construction of gabion infrastructure for erosion protection in W.A.S.H. Ordinance watercourse (riparian floodplain protected watercourse). Includes repetitive loss property protection.	Flood / Erosion / RLP mitigation	DEMA Grant (75% Federally funded, 25% City/PCRFCD funded)	2025	Department of Transportation & Mobility / Director
Broadway Boulevard Corridor (Euclid to Country Club) – Also known as SR3A / Broadway West, this phase includes six travel lanes and large diameter underground storm drain system will be installed throughout the project limits.	Flood	Cost just under $26.5 million, Drainage just over $8 million Funding: Hurf & RTA	Began January 2020, completed late 2021	Department of Transportation & Mobility / Director
Broadway Boulevard Corridor (Camino Seco to Houghton) – Also known as SR10 / Broadway East, multi-lane road improvements with drainage infrastructure.	Flood	$13.5 million, Drainage: $3 million Funding: Hurf & RTA	Completed in 2020	Department of Transportation & Mobility / Director
Christmas Watershed Flood Mitigation - feasibility study and subsequent potential construction project for stormdrain system to reduce SFHA and regional basins to help mitigate flood.	Flood / Erosion	FEMA funded 100% for feasibility study	2024	Department of Transportation & Mobility / Director
Grant Road Phased Road Project - Road improvements with drainage features – box culvert/siphon structures, catch basins, and green infrastructure.	Flood	$1 million / PAG, HURF	Completed in 2023	Department of Transportation & Mobility / Director
Cushing Street Bridge Levee Extension – Feasibility study and subsequent potential construction project for floodwall levee extension along Santa Cruz River, to include protection to hotel and electric substation (Critical Facility) servicing downtown area.	Flood / Erosion	FEMA Region IX Reallocated Budget, Partnerships with hotel and utility	Grant awarded May 2020, Completed 2024	Department of Transportation & Mobility / Director
Downtown Links - Roadway and drainage improvements for last phase of the Tucson Arroyo - Arroyo Chico master drainage project. (St Mary's Road stormdrain phase completed already by City of Tucson, and Cherry Field & Park Avenue detention systems completed in 2016.)	Flood	$53 million / RTA	Began August 2020, Completed: 2023	Department of Transportation & Mobility / Director
Dip Crossing Flood Mitigation Projects – including Noesha Project - safety improvements for residential access, including erosion bank protection and guard rail.	Erosion	DEMA grant, plus $20,000 City	2022	Department of Transportation & Mobility / Director
El Rio Detention Basin – Flood mitigation project along Silvercroft Wash at El Rio City Golf Course, lessening residential flood conditions downstream.	Flood	$1 million PCRFCD / City of Tucson	2020	Department of Transportation & Mobility / Director
1st / Grant Road Detention Basin - Part of Grant Road master project green infrastructure improvements.	Flood	$650,000 / PCRFCD	Completed 2018	Department of Transportation & Mobility / Director
Gardner Lane Improvements Drainage infrastructure improvements to provide relief for floodprone area east of UPRR railroad/I10.	Flood	$18,600 / RTA / HURF	2021	Department of Transportation & Mobility Director
Houghton Road, Valencia Road to Mary Ann Cleveland Way - Roadway Widening - Drainage improvements with all-weather six lane divided roadway, multi-use lanes, median, multi-use paths, and drainage improvements improving cross town mobility, reducing congestion and improving safety.	Flood	Drainage Project Total Costs: $1,717,164 / PC Impact Fees, PC Bonds, PAG HURF, SE District Prior to 2012, & RTA	January 2022	Department of Transportation & Mobility / Director
Kolb Road Extension to Sabino Canyon Road - Extend Sabino Canyon Road South of Tanque Verde Road to Kolb Road. Work includes fixing failing gabions, a new 4 lane roadway with curb, sidewalks, raised median, and two roadway bridges. One bridge across the Mullin's Landfill and another across the Pantano Wash.	Flood / Erosion	$18,000,000 / RTA / HURF	Completed June 2017	Department of Transportation & Mobility / Director
Ponding Mitigation Projects – including Euclid and 35th Street and other right-of-way projects to improve runoff.	Flood	$20,000 City	2021	Department of Transportation & Mobility / Director
Silvercroft Watershed – watershed study to determine base flood elevations and flowrates. Subsequent channel improvements to assure all weather access to vulnerable residential properties.	Flood / Erosion	DEMA grant, PCRFCD, plus potential partnership with gas company	2025	Department of Transportation & Mobility / Director

POST-DISASTER MITIGATION POLICIES AND PROCEDURES (2014 TUCSON)

The 2014 Tucson Emergency Operations Plan defines activities that need to be conducted following a disaster. The Emergency Operations Plan lists organizations that take part of the emergency response and the different roles the organizations are responsible for during a disaster. The Tucson Office of Emergency Management and Homeland Security and the Emergency Support Function Leaders Group are the main organizations responsible for coordinating policy and the different groups within Tucson that oversee the management of the Emergency Operations Plan. Multiple support agencies participate in long-term incident management and recovery operations. The plan also specifies the information that is required in the After-Action Report (AAR) that summarizes emergency response successes along with recommendations for future improvements. The next update for the Emergency Operations Plan is expected to include more information on levee emergency response.

ACTION ITEMS FOR MITIGATION OF OTHER HAZARDS

The following mitigation actions and projects summaries were taken from the 2017 Pima County HMP. This project list only contains action items for non-flood hazards. All flood hazard projects have been included in the recommendation matrices listed in a previous section.

Table 4. HMP Action for other Hazards

Mitigation Action/Project	Hazard(s) Mitigated	Estimated Cost/Funding Source	Completion Date	Responsible Agency
Tucson Water, a division of the Utility Services Department, will secure its assets and facilities by implementing actions as identified in the Federally mandated Water System Vulnerability Assessment completed in October 2002.	Terrorism, Vandalism	$20 million Operations Budget	On-going with full completion by 2020	Water Department/Water Engineer & Operations
Work with the Arizona Geological Society and USGS on projects that mitigate geo-hazards (e.g., continue the feasibility study with the AZGS and USGS Water Plan 2000-2050. Construct second recharge facility to be known as the Southern Avra Valley Recharge and Recovery Project (SAVSARP). The utility could then use its entire allotment of Central Arizona Project water and provide capacity for recharging additional water supplies. Construction will take 5 years.	Drought, Earthquake, Subsidence, and other geo-hazards	$51.2 million Operations Budget	Ongoing effort with long-term horizon. Schedule dependent upon funding	Water Department/Staff

The Tucson FMP committee came up with one defining Action Plan Goal that aligns with Tucson's overall goals. This goal can be directly correlated to the community's hazard mitigation activity strategies, and a brief discussion of how each goal furthers Tucson's objectives has been included below the goal statement.

THE CITY OF TUCSON FLOODPLAIN MANAGEMENT PLAN GOAL IS TO;

Reduce flood and erosion hazards, damage, and associated costs by:

1) Identifying high-risk areas.
2) Providing safe, efficient, and balanced conveyance for stormwater runoff.
3) Preserving and promoting tree canopy, maintaining, enhancing and restoring riparian ecosystems and wildlife corridors.
4) Increasing community awareness of green infrastructure, water harvesting and low impact design methodologies, stormwater quality protection, floodplain preservation measures, and general flood and erosion information.
5) Expanding incentives for private property owners and developers to implement sustainable flood and erosion hazard mitigation strategies.

Figure 55: Houghton Road Improvements on Atterbury Wash Watershed

The following chart (Table 5) looks at these 5 Goals and the Activities identified by the 2020 FMP Committee and provides updated information about the responsible entity for the Activity and schedule.

Table 5. Action Plan

Problem Statement	Recommended Activity	Responsible Party	Target Completion Date	Goal Activity Supports 1	2	3	4	5
Public Conveyance Infrastructure	Research high-risk dip crossing locations and look into replacing dip crossings with 100-year drainage structures. Areas of interest: 12th Av at Rodeo Watercourse, Betelgeux at Alamo Wash, and others. Increase public awareness of dip crossings hazards. Working with Tucson Fire Department, map all-weather access routes.	City Engineer, DTM, Floodplain Managers, Permits Manager. TDOT Planning & GIS, mapping in progress.	On-going effort with long-term horizon. Schedule dependent upon funding.	X	X		X	
	Provide outreach to changes in Santa Cruz flood levels and erosion hazards.		2022	X	X		X	
	Map areas where barricades are used for low water crossing. Assess / expand Operation Splash & Operation Freeze. (DTM Engineer)		2017	X	X		X	
	Assure Utilities are obtaining required permits in floodplain and erosion hazard areas.		Annual - On-going		X		X	
	Provide 100 yr conveyance structures. Prioritize watercourses based on City defined parameters of importance, w/ safe conveyance of floodwaters as top priority. Educate & implement projects that include sediment transport is a natural function. Consider inlet structure designs that allows flows from frequent storm events to bypass stormdrain so as to continue to feed downstream riparian areas.		On-going effort with long- term horizon. Schedule dependent upon funding.	X	X		X	
Utility Municipal Structures	Annual Plan and Implement: Educate by learning from each other - crews and engineering staff. Encourage consistency between agencies/jurisdiction. Continue to improve procedures for Operations & Maintenance Forces to steward watercourses by removing trash, debris, landscaping clippings from public ROW. Develop Routine Maintenance with a plan for crew / educate crews including in the field during monsoon. Develop city-wide maintenance and operation procedures regarding debris removal; including vegetation clearance protocols; include annual (minimum) workshops to inform staff, contractors and NGOs of protocols to explain and show how to preserve and protect habitat and tree canopy while maintaining conveyance capacity.	DTM, Tucson Water, (TW), Environmental Services, Parks & Rec Operations & Maintenance	Annual - On-going	X			X	
	Meetings on an "Annual" Basis, Educate & Outreach, Open Houses/PSA's/HOA's, Newsletters, Annual Outreach to the Public and share the Emergency Response Plan(s). Public awareness program be developed to provide regular and routine education outreach; timed seasonally when most needed.	Floodplain Managers, Public Information Office	Annual - On-going			X	X	X
	Map water lines, note condition of lines running under flood retarding structures ie. UPRR & ADOT embankments. Prepare for All Utilities.	TW, DTM, Floodplain Managers						
Urban High Density	Improve systems for identifying locations along stormwater conveyance systems that are at high risk of erosion, by enhancing analysis of drainage complaint GIS data; routinely monitor at least annually, especially after major flow events. Identify and inventory high value riparian areas for protection, stewardship and enhancement, including those that provide quality habitat, tree canopy, intact ecosystems, functional natural drainage systems, and/or recreational opportunities. Assess & address barriers to GI/LID implementation. Conduct an assessment to review distribution of flood infrastructure efforts for equity of efforts for more vulnerable or low-income communities using the City's new Neighborhood Vulnerability Index or Title Six assessment.	DTM Engineering, TW, PCRFCD, TCB, WMG, Sonoran Institute?	2025 and monitor on an annual basis	X	X			
	Improve procedures for routine maintenance to prevent and remove accumulation of debris; and provide public information on how to prevent clogging and obstruction of stormwater conveyance systems. Provide more outreach for flood status and insurance information to public. Incorporate outreach in various outlets (for example: radio in English, Spanish, T'Ohno Odham; billboards, transit stops/benches; wraps on buses; info/ads in buses/streetcar; K-12 school outreach programs)	DTM, Tucson Water, Environmental Services (ES)	Annual - On-going	X			X	X
	Include Stormwater Management Plan policy to update every 5 - 10 yrs or as reasonable to address population migration and annexations.	DTM Stormwater	On-going	X	X			
	Coordinate with ecologist/biologists ramification of standing water in natural resource areas and implement acceptable sustainable mitigation practices. Mitigation practices developed with ecologists/biologists should be transparent with information available and accessible on-line; providing teaching/outreach opportunity to inform public of practices.	PDSD, DTM Landscaping & Stormwater Management	On-going effort with long-term horizon. Schedule dependent upon funding.	X		X	X	X
	Assure procedures comply with MS4 permit requirements. "Only Rain In the Drain". Look at how to lessen clogging or conveyance issues for homeless' blankets. Floodplain Administration will review clogging factors, compare to other arid climate cities.	DTM Stormwater Management	Annual - On-going	X	X	X	X	X
Private Drainage Infrastructure	Create list and obtain focused flood hazard studies with assistance from PCRFCD to rank areas that need to be addressed. Create map of high incident of access issues for emergency response activities.	DTM/PDSD	2022 and monitor on an annual basis	X			X	
	Educate property owners, HOA's, realtors, insurance agents, landlords, and general public. Utilize case studies to share with other HOA's (i.e. Hans Huth's HOA where water harvesting was used to handle erosion, nuisance flooding, and high-water bills). Provide training to all staff levels involved in LID/GI related permits. Since codes, ordinances, and standards already exist, discussion with reviewers is valuable to be on the same page. Need support and to address concerns at all levels. City will look at NHA outreach as well as property management conference / meetings as opportunities for outreach.	PDSD, DTM, ES, & TW	Annual - On-going				X	X
	Incorporate proper sediment trap (first flush) basins/utilize waterharvesting to minimize sediment from unstable soil. Establish positive drainage during design, construction & maintain throughout life of facility. "Provide template designs & a case study/demonstration to ease implementation of first flush / sediment traps."	PDSD, DTM Project Managers	On-going		X	X	X	
	Establish regulations that help clarify the 17 criteria required for drywell installation. Limit use of pumps to truck well enclosures and temporary drain down scenarios. Update development codes to promote LID practices; incentivize and/or update codes to promote distributed GSI to be integrated into landscape and zero (Or predevelopment conditions for runoff on site) runoff from onsite.				X	X	X	
	R & D BMP to improve soil infiltration & minimize compaction utilizing native grasses/trees/organic desert mulch.	PDSD, DTM	Annual - On-going					X
	Update development codes to promote LID practices; incentivize and/or update codes to promote distributed GSI to be integrated into landscape and zero (Or predevelopment conditions for runoff on site) runoff from onsite.	DTM Stormwater & Floodplain Management	Annual - On-going		X	X	X	

Table 5. Action Plan

Problem Statement	Recommended Activity	Responsible Party	Target Completion Date	Goal Activity Supports 1	2	3	4	5
Natural Floodplains	Produce overlays of priority areas where known roadway, infrastructure, structure areas have had flooding issues from garbage, dumping and vegetative debris flow - City of Tucson to map and describe flood plain road crossing (bridge span, culvert crossing, low water hardened crossing) and rate the effectiveness of flood water conveyance, and structure integrity (High Impact: in channelized waterways - not going in for natural areas?). Review channel reaches with excess flood capacity (see Frank Sousa mapped channel reaches) to consider opportunity for riparian habitat enhancement and floodplain restoration and/or pedestrian/bike greenways with green infrastructure amenities.	PDSD, TDOT Planning & Stormwater Management	2022 and monitor on an annual basis	X	X	X		
	City of Tucson will develop and implement habitat management plans along with maintenance guidelines and best practices that include and are complimentary to WASH ordinance requirements, ERZ code (restricting development within the flood plain), the ERR reporting requirements for proposed floodplain disturbance and all other applicable local, state, and federal codes, ordinances or regulations (High Impact). Assess how to ensure field personnel are aware of and adhere to management plans.	PDSD, TDOT Stormwater Management (collaborate with community groups, i.e., Sonoran Inst., TCB, WMG)	2022		X	X		
	City of Tucson to work with Tucson Clean and Beautiful, Ward offices, Community Housing and Development Dept. and neighborhood groups to delineate target areas for intense public outreach on managing flood waters and family safety tips during floods and other hazards such as lightning, hail, dust, & erosion, in addition to public education and awareness about community clean-ups, canopy preservation, and homeless protocols. (Maintenance Practices, flood prevention, opportunities, involvement)	Tucson Clean & Beautiful (TCB) Ward Offices, HCD, NA's, and other depts	2021 and monitor on an annual basis				X	
	City of Tucson to locate, map and prioritize areas of significant channel head cutting adjacent to private property.	DTM Engineering, Stormwater Management	2025	X				
	City of Tucson will develop recommendation for acquisition, relocations or additional flood protective measures for at-risk properties (PCRFCD, Ward offices, Community Housing and Development Dept. and neighborhood groups Involvement)	DTM Engineering, PCRFCD, Ward offices, HCD,. and neighborhood	2025 and monitor on an annual basis	X	X			X
	City of Tucson Floodplain Administration would work with Tucson Clean and Beautiful, Tucson Water, Arizona Sonora Desert Museum\ Sonoran Desert Weedwackers, and the Sonoran Desert Cooperative Weed Management Area (SD-CWMA) in producing information brochures designed for city elected officials, administrator and additional information for the general public informing of the value of healthy riparian floodplain corridors within the City of Tucson and planned management activities to maintain and enhance riparian corridors for the City resident's quality of life (TCB Involvement)	Tucson Clean & Beautiful, Tucson Water, Arizona Sonora Desert Museum, Sonoran Desert Cooperative Weed Management Area (SD-CWMA)	2021 and monitor on an annual basis				X	
	Multi-jurisdictional Flood Panel - for Realtors - floodplain info outreach activity. City of Tucson to develop informational pamphlets, bulletins and other communication to be delivered to transient encampment warning of dangers of occupancy in the flood plain due to potential flood and fire.	Tucson Realtors Association, TDOT Streets & Maintenance,	2020 and monitor on an annual basis	X			X	
	City of Tucson to produce geo-database of all critical facility infrastructure within flood plain and flood prone areas.	PDSD, DTM Engineering, GIS, Stormwater	2016 and monitor on an annual basis	X	X		X	
	City of Tucson to review ERZ code, WASH ordinance, ERR standards to develop vegetation management guidelines including trimming woody vegetation to 6 feet above ground, describe seed mix for herbaceous understory of perennial grasses for soil stabilization within 0.5 miles upstream of priority water conveyance impact areas. Update development codes to promote LID practices; incentivize and/or update codes to promote distributed GSI to be integrated into landscape and zero (Or predevelopment conditions for runoff on site) runoff from onsite	PDSD, DTM Engineering, Stormwater Management	2017	X	X	X		

Table 5. Action Plan

Problem Statement	Recommended Activity	Responsible Party	Target Completion Date	Goal Activity Supports 1	2	3	4	5
Vegetated Hazards	City of Tucson will map and describe vegetative associations to the alliance level within watercourses using Manning n values, hydraulic vegetation density (COT GIS - COT Engineering) City of Tucson, collaborating across city department (TDTM, P&R, EGSD, HCD, TW) will identify and coordinate Integrative Weed Management practices to control invasive vegetation in the washes; and also practice industry-accepted tree pruning protocols; while being cognizant of the Migratory Bird Species Treaty.	TDOT Engineering, GIS	GIS shapefiles 1st qtr 2021, vegetation mapping 2nd 3rd qtr 2021 and 2022 priority HUCs, density calculations find mapping 4th qtr 2021, COT Engineering appropriate funds, FEMA grant 2021 BRIC / FMA	X	X	X		
	City of Tucson will work with the Arizona Sonora Desert Museum\ Sonoran Desert Weedwackers, and the Sonoran Desert Cooperative Weed Management Area (SD-CWMA) to develop (or expand) and recommend incentives for private land owners and developers to implement programs to reduce invasive species within flood prone areas while protecting toboso swale areas - and assist in riparian habitat restoration.	PDSD, TDOT Engineering Tucson Clean & Beautiful, AZ Sonora Desert Museum, Sonoran Desert Cooperative Weed Management Area (SD-CWMA	3rd qtr 2022 after #1 vegetation and density mapping completed Funding - SABCC, COT Engineering appropriated funds			X	X	X
	City of Tucson to review ERZ code, WASH ordinance, ERR standards to develop vegetation management guidelines including trimming woody vegetation to 6 feet above ground, describe seed mix for herbaceous understory of perennial grasses for soil stabilization within 0.5 miles upstream of priority water conveyance impact areas	PDSD, TDOT Engineering	2017			X		
Geomorphological	Watershed management planning that includes restrictions for retention systems where groundwater contamination occurs. Onsite Containment (require properties with hazardous materials to construct basins to store and treat runoff) Contamination Hotline	TDOT Engineering, PDSD, Stormwater Management	2020 and monitor on an annual basis	X	X		X	
	Inspection & Maintenance program. Also, map locations of high-risk erosion hazard areas. Erosion Damage Hotline (where residents can call a central phone # to report erosion risk or damage to infrastructure like roads and utilities).	TDOT Streets, Engineering, Stormwater Management	Annual - On-going	X		X	X	
	Emergency Service & Utility Notification Hotline	TW, Fire/Police, TDOT Engineering	2017 and monitor annually				X	
	Bank Stabilization. Revegetation of Slopes. Post-fire reseeding programs to help reduce soil transport after storm events in rural areas. Mapping to include LiDAR channel data to better evaluate changes over time.	PDSD, TDOT Streets, Engineering, PCRFCD	Annual - On-going		X	X		
	Erosion Hazard setback regulations - update to reflect higher risk are as. Mapping Risk Areas (PCRFCD)	TDOT Engineering, Floodplain Managers	2020, Annual - On-going		X	X		
	PSAs, public information through utility bills and building permits. Explain what is practical for erosion prevention for desert climate area.	TDOT Stormwater Management	Annual - On-going				X	

Plan Adoption and FMP Updates

ADOPTION BY TUCSON CITY COUNCIL

The Action Plan for the Floodplain Management Plan as adopted by Mayor and Council by formal resolution can serve as a floodplain and erosion hazard management reference tool for all City of Tucson departments and divisions.

FMP UPDATES

The FMP committee will continue to convene on a yearly basis to monitor and assess the action plan implementation process. The committee will continue to prepare an evaluation report to submit with Tucson's annual CRS recertification documentation. Per CRS guidelines, the report "must be submitted to the governing body, released to the media, and made available to the public."

In 2025, the Tucson FMP committee will convene for a formal FMP Update to review the 2020 FMP and to recommend updates by October 1, 2020, or five years after the plan was updated. CRS Cycle Visit by FEMA is scheduled for spring 2021. Following the initial 2020 update, the FMP evaluation and updates are to be scheduled to occur concurrently or before the community's normal 5-year CRS Cycle Visits for the review of the other CRS activities. As the Pima County Regional HMP was updated in 2017 and is expected to be updated in 2022, it would be beneficial if the FMP and CRS Cycle Visits synced up with the Pima County Regional HMP process so that the project lists in the FMP and HMP match. The formal 5-year FMP review cycle tasks should include at a minimum:

1. Convene the same committee that prepared the 2020 plan or one that meets the criteria identified in the CRS manual.
2. Hold a public meeting to review the updated report.
3. Review new studies and information that was completed after the FMP was created.
4. Review the hazard and problem assessments and update if necessary.
5. Review goals and update if necessary.
6. Review the action plan and update to account for actions that were completed, ones that are no longer necessary, and to add in new actions.
7. Prepare formal update for adoption by Tucson Mayor and Council.

References

- Tucson Stormwater Management Study Phases I-V (Tucson)
- 1990 Tucson Flood & Erosion Hazard Management Ordinance (Tucson)
- 1991 Watercourse Amenities, Safety and Habitat - W.A.S.H. Ordinance (Tucson)
- 2001 Unified Development Code Environmental Resource Overlay code (Tucson)
- 2003 City of Tucson Habitat Conservation Plan (PCRFCD)
- 2005 Water Harvesting Guidance Manual (Tucson)
- 2008 Tucson Watercourse Maintenance Guidelines (Tucson)
- 2011 Pima County Flood Insurance Study (June 16) (FEMA)
- 2011-2015 Action Plan for Water Sustainability (Tucson)
- 2013 Pima County Community Wildfire Plan (Pima County)
- 2013 Plan Tucson: City of Tucson General and Sustainability Plan (Tucson)
- 2013-2018 Tucson Police Department Strategic Plan (Tucson)
- 2014 Tucson Emergency Operations Plan (Tucson)
- 2016 Tucson Green Streets Active Practice Guidelines (Tucson)
- 2016 Tucson Parks and Recreation 10-year Strategic Plan (Tucson)
- 2017 Community Rating System Manual (FEMA)
- 2017 Pima County Multi-Jurisdictional HMP (PCRFCD)
- 2017 Stormwater Summit (multi-jurisdictional)
- 2017 Stormwater in Pima County: A Blessing & A Curse (PCRFCD)
- 2019 (March 13) Engaging Homeowners Associations on Water Harvesting in Common Areas (Hans Huth)
- 2019 (August 23) Risk MAP Post-Discovery webinar with the City Tucson
- 2019 FEMA Discovery multi-jurisdictional meeting (May) (FEMA)
- 2019 Upper Santa Cruz Watershed Discovery (FEMA)
- ALERT System Map & Rain Gauge Data (PCRFCD)
- Arroyo Chico Phase 3 Channelization Project (Army Corps of Engineers, PCRFCD)
- Census www.factfinder.census.gov
- Center for Western Weather and Water Extremes Scripps Institution of Oceanography cw3e.ucsd.edu
- El Rio Golf Course Detention System Improvements (PCRFCD)
- ERZ and WASH Ordinances Watercourse Analysis: Southeast Region and TSMS Recommendations (Tucson DTM)
- FEMA's Community Information System (CIS)
- FMP Committee Meeting Minutes & CRS 510 FMP Checklist
- Grant Road Phase 2 Green Infrastructure / Detention System Improvements
- Lee Moore Wash Basin Management Study (PCRFCD/Tucson)
- Mission View Wash Drainage Improvements (PCRFCD)
- National Levee Database https://levees.sec.usace.army.mil/
- PAG's 2013-2050 Incorporated Places Population Projects for Pima County and Incorporated Areas
- PAG Green Infrastructure Prioritization Tool (PAG)
- Paseo de las Iglesias Phase I: Santa Cruz Bank Protection, Ecosystem Restoration & Linear Parkway, Ajo Wy to Silverlake Rd (PCRFCD)
- Tucson FMP Update Public Meeting Attendee List & Public Comment Summary
- Ruthruaff 2017, Airport Wash South 2014, Alamo 2017, Christmas 2019 Basin Management Plans (PCRFCD)
- Santa Cruz River and Rillito Sediment Removal Projects (PCRFCD)
- Solving Flooding Challenges with Green Stormwater Infrastructure in the Airport Wash Area (PCRFCD, Tucson Ward 1)
- Sustainability Tools for Assessing and Rating Communities/STAR (Tucson Office of Integrated Planning)
- The University of Arizona Epidemiology and Biostatistics Department

Appendices

The 2016 and 2020 City of Tucson Floodplain Management Plan reports can be downloaded at https://www.tucsonaz.gov/tdot/floodplain-administration
The appendices to this report include the following:

a. Flood Risk Map (see FMP Report 2016, upon request to Floodplain Administration)
b. Step 7 Spreadsheets from 2016 Report
c. Public Meeting Notices
d. Flood & Erosion Hazards within the City of Tucson PowerPoint for Realtors
e. 2020 FMP Update Committee Attendance Tracking, Comments, and Meeting Agendas

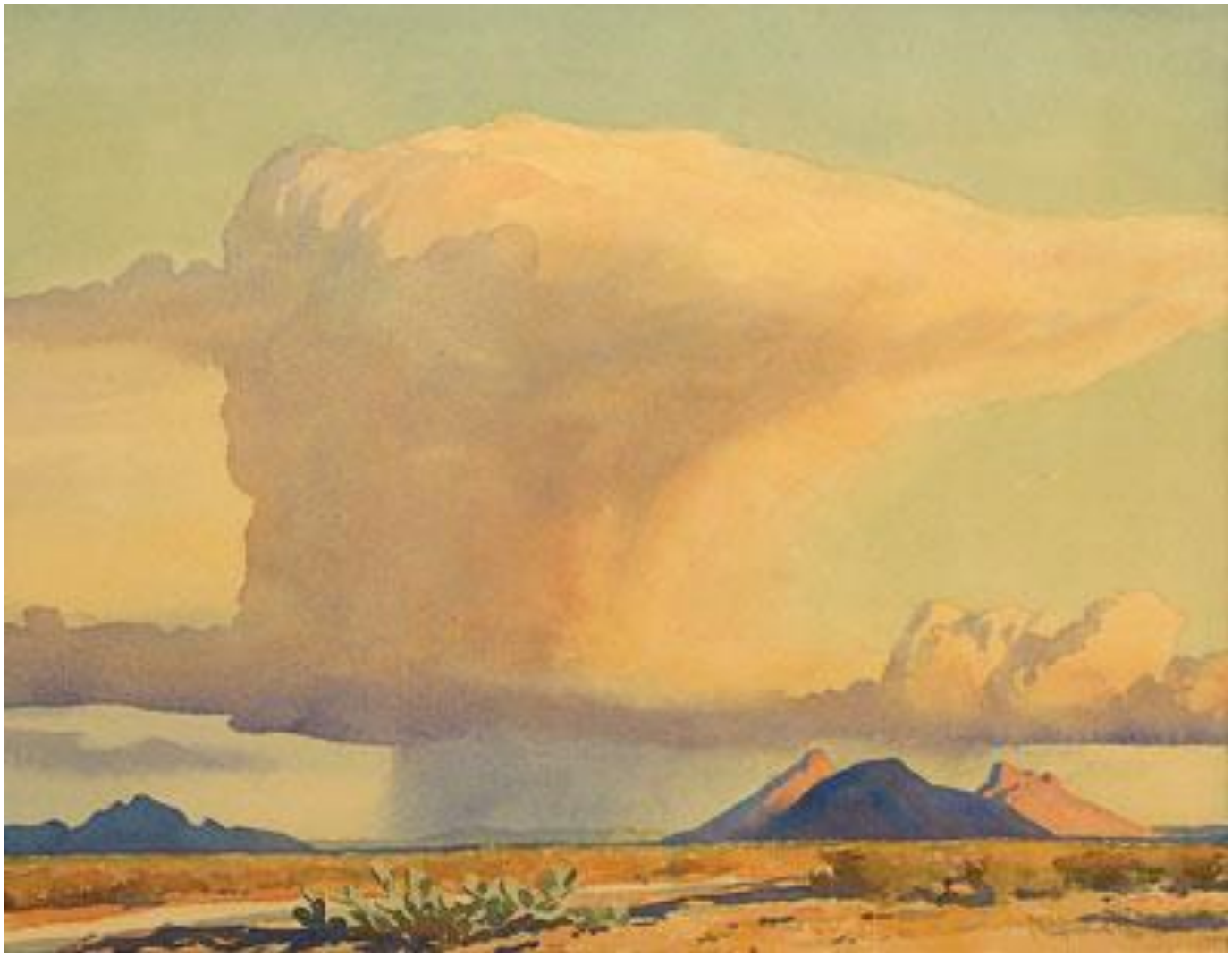

Figure 56: A storm over Tucson (Painting by Maynard Dixon)