Review of Brazilian Institutional and Legal Frameworks for Flood Risk Management

Rainfall flooding in Santa Catarina in 2013

USACE Document 2.1

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1.0 EXECUTIVE SUMMARY

This document is a review of ANA Document 2.1 ("Survey and systematization of the Brazilian legal and institutional frameworks concerning inundation and flood control"). ANA Document 2.1 presents the concepts, laws, policies and institutions relevant to flood risk management in Brazil. A corresponding summary of the corresponding frameworks in the United States is presented here for comparison. Comparing these frameworks across the two nations from the USACE perspective helps identify the similarities and differences in approach between the two countries, and find any gaps in functional areas that may require a new law or agency to fill. Furthermore, through review of the approaches of the two nations, recommendations and guidelines are developed to inform future development of Brazilian regulatory policy regarding flood risk management.

The review of ANA Document 2.1 and the comparison of frameworks across countries did not identify any major gaps in Brazilian institutional macro-functional areas relating to flood risk management. Nor were any vital legal concepts or policies found to be missing. Several strengths of the Brazilian approach to floods were identified, including awareness of the risks associated with structural measures, coordination of actions across state and federal agencies, and the strong social capital of Brazilian society. These strengths should be recognized and leveraged further.

Some suggestions for further policy development were also made. Although Brazil has few levees, it has some, so establishment of a levee safety program is recommended. It is recommended that the solid foundation created by the dam safety program be built upon with a periodic inspection program. Post-flood reporting, knowledge management, and coordination of hydrometeorological data are areas where existing policies are adequate but implementation might be improved by a few suggested adjustments. And since flood seasons across Brazil are not simultaneous, it is recommended that ANA investigate the possibility of facilitating sharing of flood response personnel and equipment among states. Some of these recommendations may be outside ANA's mandate or may face obstacles to implementation, but they may still be useful in helping foster discussion and critical reflection. These recommendations, developed from the USACE perspective in consideration of ANA's competencies, are presented in the hope that they will help in development of flood risk management policies that reduce risk and improve safety for the people of Brazil.

2.0 INTRODUCTION

The Agência Nacional de Águas (ANA) and the US Army Corps of Engineers (USACE) entered into an agreement on 5 November 2013 to effect a mutual exchange of expertise, with the objective of increasing ANA's capacity to perform the duties required by Law 9,984 of 17 July, 2000 related to prevention of the impacts of critical hydrologic events. In particular, USACE agreed to provide training and products to ANA relating to flood control planning, reservoir operation and management, regulatory policy-making, and the planning and operation of hydrologic networks.

This USACE Document 2.1 represents Product 4, a part of Task 2, as detailed in the Scope of Work dated 16 Feb 2014. This document is a review, from the USACE perspective, of ANA Document 2.1, a Survey of the Brazilian Legal and Institutional Frameworks Concerning Flood Control. It is also a summary of the corresponding frameworks in the United States and a comparison between the two. There are significant geographic, climatological, political, cultural, and economic differences between the United States and Brazil, which contribute to their different approaches to floods. Approaches that are appropriate for one country may not be ideal for the other. Despite these differences, finding similarities and drawing contrasts between US and Brazilian flood risk management practices is an informative exercise which can help indentify guidelines and recommendations for development of Brazilian flood risk management[1] policies. The structure of this document was determined jointly by USACE and ANA personnel during the in-country portion of Task 2, in 2014.

[1] In accordance with ANA's areas of legal responsibility, discussion of floods in this document is limited to flash flooding, riverine flooding, and dam safety. Risk is understood to include both the probability and consequences of floods. Flood risk management is understood to include all activities related to identifying, assessing, reducing, sharing, and communicating the risks of flooding.

3.0 FLOOD RISK MANAGEMENT IN THE UNITED STATES

3.1 Overview

Definitions of flood risk management vary, but the USACE perspective is defined in the USACE National Flood Risk Management Guidance Letter (2009), which states "…flood risk management [is] defined as managing both floodwaters to reduce the probability of flooding (that is, structural approaches such as levees and dams) and floodplains to reduce the consequences of flooding. Flood risk management must be collaborative since other agencies external to USACE also have roles, responsibilities, and authorities in floodwater and floodplain management." The United States has no national water policy or a single agency responsible for water resources generally or flood risk management specifically. Flood risk is managed by many different entities and agencies within the federal, state, and local governments. In addition, many non-governmental organizations play important roles in flood risk management, including non-profits, industry groups, volunteer organizations, and public interest research groups. Numerous committees, commissions, work groups, and task forces exist to help coordinate the actions of these agencies and groups where they have shared missions and/or interests.

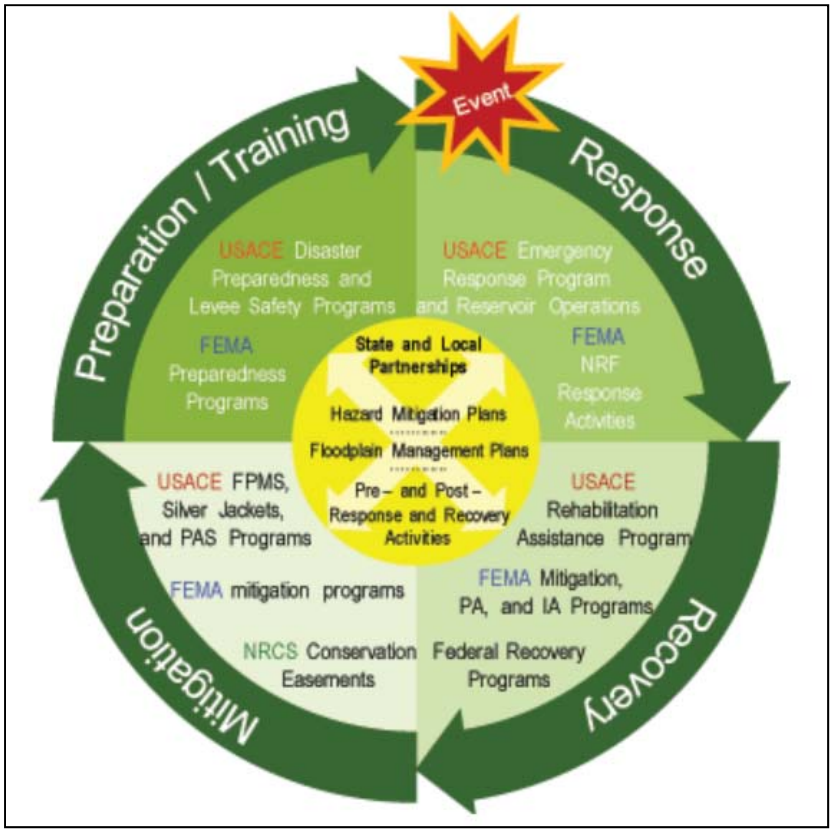

Figure 1: Flood Risk Management in the United States from the USACE perspective, showing responsibilities shared by multiple federal agencies, local governments, and cooperative initiatives

3.2 National Planning Frameworks

Homeland Security Presidential Policy Directive 8: National Preparedness (PPD-8) is a national policy issued by President Barack Obama on March 30th, 2011. PPD-8 required the establishment of the National Preparedness Goal: "A secure and resilient Nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk." It also created the National Preparedness System, an organized process for all agencies, organizations, and members of society to execute their preparedness activities in pursuit of that goal. The National Planning Frameworks are part of the National Preparedness System, setting the strategy and doctrine at the Federal level of government for building, sustaining, and delivering the core capabilities identified in the National Preparedness Goal.

The frameworks address the roles of individuals; nonprofit entities and nongovernmental organizations (NGOs); the private sector; communities; critical infrastructure; governments; and the Nation as a whole. There are five frameworks, each addressing a different function in the disaster management cycle. Through these frameworks the actions of numerous federal agencies, state agencies, non-profit organizations, and others are coordinated.

Like the USACE National Flood Risk Management Guidance Letter, the National Planning Frameworks make clear that disaster management in the United States is a fundamentally interagency activity.

Figure 2: The five National Planning Frameworks

3.2.1 National Prevention Framework

The National Prevention Framework describes what the community (including private-sector organizations, members of the government, and private citizens) should do upon discovery of an imminent terrorist attack. It includes such activities as planning, warning, and coordination. Because it is not related to flood risk management, this framework will not be discussed further here.

3.2.2 National Protection Framework

The National Protection Framework describes what the community should do to protect against man-made and natural disasters. This framework lays the foundation for the operational coordination and planning that synchronizes efforts across the other frameworks. It includes activities such as planning, warning, searching, physical measures, and supply chain integrity, to allow the nation to increase its protective posture when necessary.

3.2.3 National Mitigation Framework

The National Mitigation Framework describes how the nation manages and reduces risk to decrease loss of life or property by lessening the impact of disasters. It includes activities such as hazard identification, risk and resilience assessment, vulnerability reduction, and planning.

3.2.4 National Response Framework

The National Response Framework guides the nation's response to disaster and emergencies. Whether incidents can be handled effectively by local governments or require federal intervention, this framework focuses on ensuring an effective response that saves lives, protects property and the environment, and restores a stable and safe environment that can transition to recovery. It includes activities such as critical transportation, environmental health and safety, search and rescue, public health, and on-scene security.

3.2.5 National Disaster Recovery Framework

The National Disaster Recovery Framework guides recovery of disaster impacted states, tribes, and local areas, focusing on how to restore and redevelop these areas. It includes activities such as economic recovery, housing, infrastructure recovery, health and social services, and natural and cultural resource recovery.

3.3 Institutional Frameworks

3.3.1 Federal Government Agencies

The federal government of the United States has many agencies in several departments with missions related to flood risk management. There is no single agency to coordinate these missions, so the interactions between these agencies must be coordinated through various boards and councils. A complete description would be nearly impossible, but the most important agencies are described here. These descriptions illustrate how flood risk management duties are distributed across agencies of the US federal government, demonstrating similarities and differences between the US and Brazil that may lead to recommendations for development of Brazilian flood risk management policy.

3.3.1.1 Department of Defense

3.3.1.1.1 **US Army Corps of Engineers**

The US Army Corps of Engineers (USACE) performs many functions related to flood risk management, beginning with its authority to plan, design, and construct flood risk reduction projects such as dams and levees. The planning process begins with a study to determine whether a federal interest exists in reducing flood risk in a particular area. This study examines the projected economic costs of constructing a project as well as the economic benefits in terms of flood damages prevented. It may also examine other factors such as life safety, regional economic impact, and environmental impact, ultimately culminating in a recommendation to the United States Congress on whether the project should be constructed. If the Congress authorizes the project and allocates

funding, USACE will design and construct the project. Much more detail on the project planning process is given in USACE Document 2.5.

USACE is also responsible for operating some flood risk reduction projects such as dams and levees. Once a project is constructed, the operation of the project depends on its authorizing legislation. Depending on the requirements in the law and the agreements made with local authorities, USACE may turn the project over to another entity, such as a local or federal government, for operation and maintenance. Most federal flood risk reduction projects today are developed in partnership with a local government sponsor such as a state, who agrees to operate and maintain a project once it is complete. In certain instances, however, the law may specify that USACE keep possession of the project for operation and maintenance at federal expense. For example, Barkley Dam in the state of Kentucky is owned and operated by the Corps of Engineers.

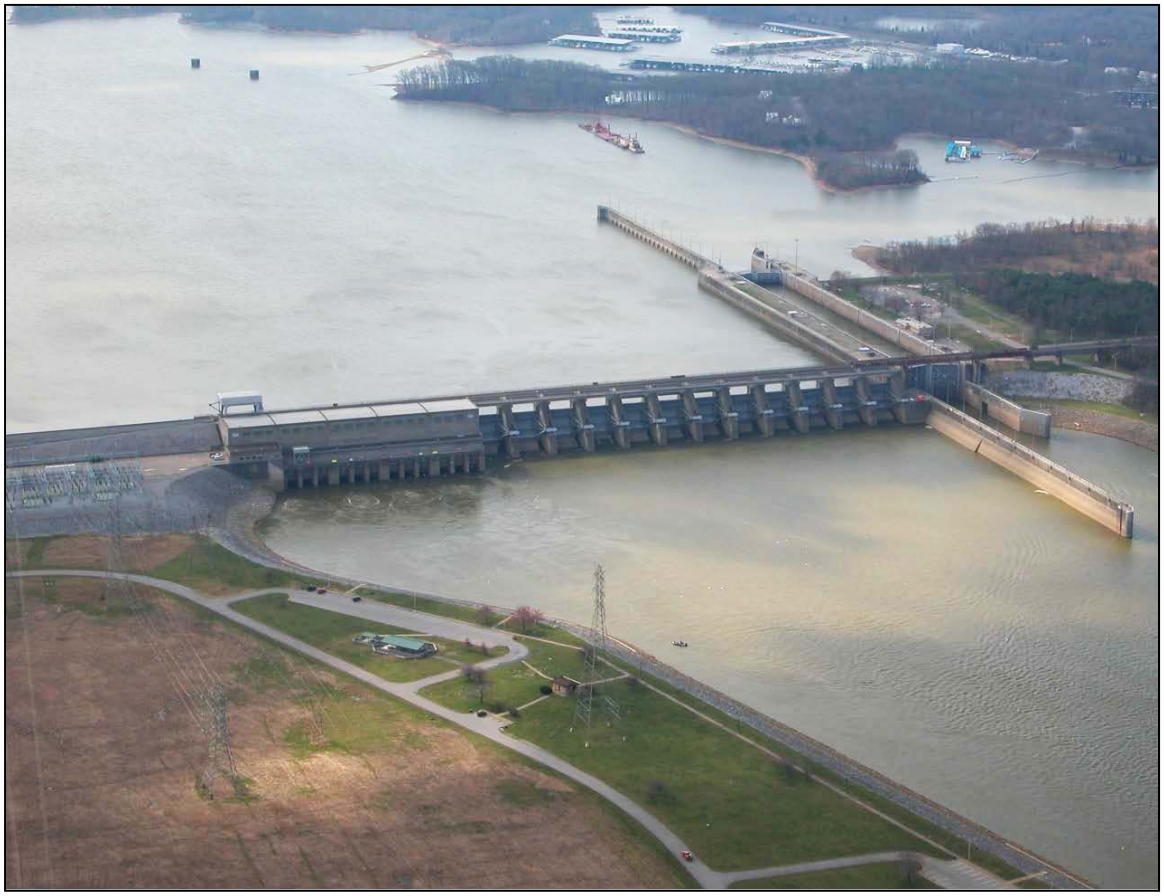

Figure 3: Barkley Dam is owned and operated by the USACE Nashville District

USACE is involved in flood response and recovery through Public Law 84-99, the Flood Control and Coastal Emergencies Act. This law establishes an emergency fund for preparedness and response to flooding. Preparedness activities include coordinating, planning, training, and conduction of exercises with local, state, and other federal

agencies, while response activities (also known as "flood fighting") include actions during the flood such as placement of temporary barriers or stopping of seepage areas. PL 84-99 authority also allows USACE to repair flood risk reduction systems damaged by floods under certain circumstances. This repair is at no cost to the owner if the system is federally owned, and at 20% of cost otherwise. To be eligible for repair, however, the system has to be maintained to at least a minimally acceptable rating by the USACE Rehabilitation and Inspection Program (RIP), as confirmed by periodic inspections performed at least every five years (see Engineering Regulation 500-1-1 for more information on this program).

A closely related program to the RIP, the Inspection of Completed Works (ICW) program also provides regular inspections of flood risk reduction infrastructure. Like the RIP program, the ICW program allows compliant projects to be rehabilitated with federal funds if damaged in a flood event. However, whereas the RIP is open to both federal and non-federal projects, the ICW program is only for projects that were federally authorized but locally maintained.

In addition to periodic inspections performed for the RIP, USACE also assesses flood risk reduction systems for the Dam Safety and Levee Safety programs. These programs include annual and periodic inspections of dams and levees and their protected areas. Each dam and levee in the USACE portfolio is classified according to its flood risk, so that resources can be allocated where they will be most beneficial. Dam and levee risk information is also communicated to the public and to key stakeholders so they can make appropriate risk-informed decisions. The National Levee Database and National Inventory of Dams are maintained to help facilitate storage of data for these programs.

While the Dam Safety and Levee Safety programs work with structural solutions, the National Nonstructural Flood Proofing Committee, within the Directorate of Civil Works at USACE Headquarters, works to promote the use of non-structural flood risk reduction measures. These measures serve to reduce the consequences of flooding by removing people and assets from the flooded area, rather than reducing the frequency of flooding, as a dam or levee would. Examples of non-structural measures include elevating structures to make them less vulnerable to flooding, relocating them to safer areas, and making structures more resilient to flooding by preventing water from entering or elevating valuable contents. The Committee publishes information on how to evaluate and use these techniques and provides expertise to USACE and other customers upon request.

The USACE flood risk reduction mission also includes coastal, hydraulic, and hydrologic research. The Engineer Research and Development Center (ERDC) is the primary USACE research facility, with important flood risk research conducted at the Coastal and

Hydraulics Laboratory (CHL), the Environmental Laboratory (EL), the Cold Regions Research and Engineering Laboratory (CRREL), and others. The USACE Institute for Water Resources (IWR) also performs research on flood risk science and policy at its headquarters and through its centers such as the Hydrologic Engineering Center (HEC) and Risk Management Center (RMC).

When state, local, or Native American tribal governments require assistance with water resources studies, including flood risk management studies, USACE can help through the Planning Assistance to States (PAS) program. This program allows USACE and a local partner to share the cost of a study evenly, with the local cost possibly being in the form of in-kind services rather than funding. There is an annual limit of $5,000,000 for studies to assist any individual state or tribe, though actual appropriations are typically much lower. Individual studies typically cost less than $75,000. State or local governments provide their requests for assistance on an annual basis; USACE will accommodate as many studies as congressional funding will allow.

The Floodplain Management Services Program (FMSP) is another program that allows USACE to assist local public agencies with flood risk management issues. When requested by state, local, or tribal governments, USACE offices can use program funding to provide assistance with floodplain management issues at no cost. Other federal agencies and private citizens can also request assistance but must pay full cost. Types of assistance include general technical services such as development of information on flood extent and duration, as well as studies on the effects of proposed changes to flood plain management. The extent of FPMS assistance that a USACE district can provide is limited by available funding, but the requestor can expand or accelerate the provision of services by providing funding, data, or information about past floods.

The Silver Jackets program is another method for USACE to facilitate local efforts in flood risk management. This program assembles a team for each state, where local, federal, and state agencies can share knowledge and coordinate efforts on flood risk management. The federal government is represented by team members from USACE and the Federal Emergency Management Agency (FEMA). Teams work collaboratively to identify, prioritize, and address flood risk management issues in their state. They also coordinate risk communication across agencies, provide assistance in implementing high-priority actions, and identify gaps between agency programs.

USACE is also an important partner in the Urban Waters Federal Partnership, which is led by the Environmental Protection Agency and is discussed in section 3.3.1.6. This partnership revitalizes city water bodies such as canals and lakes to help revitalize the economy and environment of the surrounding community. While flood risk management is not a primary goal of the partnership, actions to improve water quality such as retaining

runoff on-site can have beneficial effects on flood frequency. Actions taken to improve water safety can also improve life-safety risk during a flood.

Finally, the Responses to Climate Change (RCC) program is key to USACE flood risk management in a changing world. The RCC program facilitates knowledge transfer about climate change risks and opportunities for flood risk reduction as well as other USACE business lines. It also supports development of actionable climate science and develops policy, guidance, and tools for USACE to adapt to climate change. Because flood risk is highly sensitive to changes in climate, all USACE flood risk management projects must integrate climate adaptation into programs, projects, and plans.

3.3.1.2 Department of Commerce

The US Department of Commerce has several agencies with important flood risk management missions, all under the National Oceanographic and Atmospheric Administration (NOAA).

3.3.1.2.1 **National Weather Service**

The National Weather Service (NWS) produces and disseminates weather forecasts, watches, and warnings to the public. These products are published online, as public service announcements on radio and television, and through special weather radios. Forecasts are produced and published by 122 local Weather Forecast Offices (WFOs) throughout the United States, each with a geographic area of responsibility. These offices have support from central offices that maintain large-scale weather models. In addition to the WFOs, the NWS has 13 River Forecast Centers (RFCs) with responsibility for river forecasting, including flood warnings. Each RFC's area of responsibility is based on hydrological boundaries. While the RFCs produce the river forecast for each forecast point along a river, these forecasts are forwarded to the WFOs for publication, to help ensure coordination with the offices that have the most knowledge about local conditions. There are currently over 6,900 river gages in the NWS system, of which over 3,600 are river forecast locations.

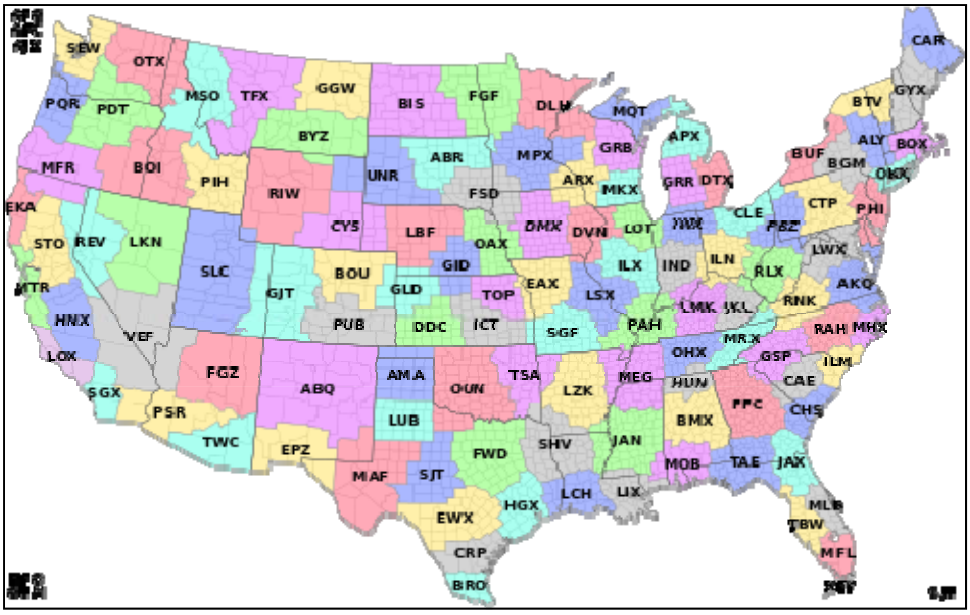

Figure 4: Map of the 122 Weather Forecast Offices of the National Weather Service

3.3.1.2.2 **National Geodetic Survey**

The National Geodetic Survey (NGS) is another NOAA agency with an important flood risk management mission. The NGS publishes and maintains geodetic datums for surveying purposes. This is essential for flood risk reduction projects, which must be built and maintained to the correct elevation in order to function properly. NGS continually evaluates and updates the most current geodetic datum (presently the North American Vertical Datum of 1988, or "NAVD88"), maps the shorelines of the United States, and provides rapid-response aerial imagery for emergency response. All of these are vital to flood risk management in the United States.

3.3.1.2.3 **National Climatic Data Center**

The National Climatic Data Center (NCDC) collects and maintains climate data for the United States, including data from satellites, aircraft, and hydrometeorological networks. The NCDC archives nearly all NOAA data, with its oldest data over 150 years old. It now holds over 14 petabytes (14×10^{15} bytes) of digital data. NCDC data on rainfall and wind are frequently used when planning and designing flood risk reduction projects.

3.3.1.2.4 **National Environmental Satellite, Data, and Information Service**

The National Environmental Satellite, Data, and Information Service (NESDIS) supports weather and river forecasting with satellite and ground-based weather data. NESDIS operates the Geostationary Operational Environmental Satellites (GOES) and related equipment, allowing near-realtime transmission of flood data from streamgages with satellite transmission equipment.

3.3.1.3 Department of the Interior

3.3.1.3.1 **United States Geological Survey**

The United States Geological Survey (USGS) provides scientific data and analysis on the Earth's natural environment, to facilitate management of the natural resources of the United States. It has a critical role in flood risk management as the manager of the primary hydrological network in the United States. The majority of streamgages on inland rivers in the United States are maintained by the USGS, though some are also maintained by USACE or other partners. The USGS also performs critical mapping and research functions in support of flood risk management, such as hydrological surveys to determine stage-discharge rating functions.

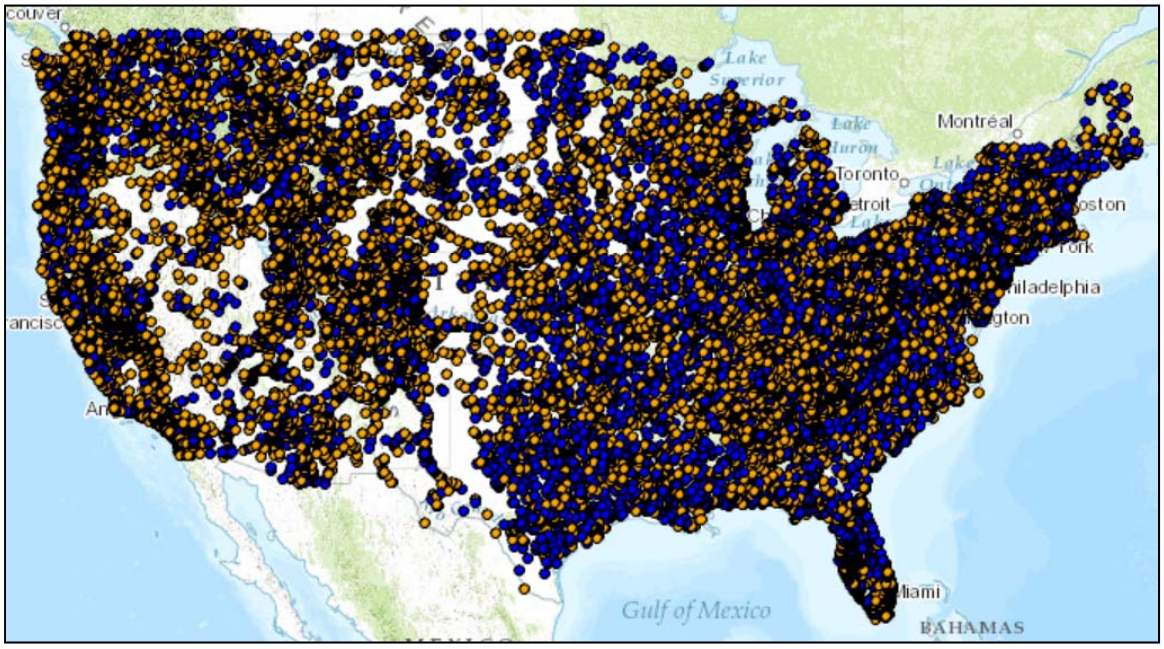

Figure 5: USGS streamgages provide vital real-time and historical river data for flood risk management

3.3.1.3.2 **Bureau of Reclamation**

The United States Bureau of Reclamation (BoR) operates in five regions across 17 western states. In this drier area of the country, water is a scarce and valuable resource. The BoR helps with the development and security of this area by ensuring a reliable supply of quality water. It is the largest wholesaler of water in the United States (in the western United States, water is a commodity that can be bought and sold, see USACE Document 4.1) and the second largest generator of hydropower (after USACE). Although water supply has historically been the major BoR mission, its projects are now typically multipurpose, providing benefits for navigation, environmental stewardship, recreation and flood risk management as well. In accordance with section 7 of the Flood

Control Act of 1944, all reservoirs constructed with public funding, including BoR reservoirs, must regulate their flood control storage in accordance with regulations defined by USACE. However, even BoR reservoirs without a dedicated flood control pool can impact flood risk through floodwave attenuation and dam safety.

3.3.1.3.3 **National Park Service**

The National Park Service (NPS) manages areas in the United States designated as National Parks. These areas are protected from development for the purposes of outdoor recreation and preservation. Parklands reduce flood risk through ecosystem services such as storage and infiltration of precipitation and attenuation of floodwaves. Flood-prone areas may also be designated as parks, reducing risk by preventing development in risky areas. However, such a decision is normally made on the basis of preserving an environmentally valuable area rather than reducing flood risk.

3.3.1.4 Department of Homeland Security

3.3.1.4.1 **Federal Emergency Management Agency**

The Federal Emergency Management Agency (FEMA) is the United States' emergency management agency. Its primary mission is to coordinate disaster response when state and local capacities have been overwhelmed by a manmade or natural disaster, such as a flood. It also provides preparedness services such as training and risk communication, and recovery services such as reconstruction funding for government infrastructure damaged by flooding. FEMA also manages the National Flood Insurance Program (NFIP), which provides subsidized flood insurance for qualifying homeowners. In many areas, flood insurance is prohibitively expensive on the private market, so the government is the only available insurer for flood policies. The NFIP is the subject of USACE Document 2.6; much more information on this program is available in that document.

3.3.1.4.2 **US Coast Guard**

The United States Coast Guard (USCG) is a branch of the United States armed forces, though it is organizationally within the Department of Homeland Security rather than the Department of Defense. The USCG is a maritime law enforcement agency as well as a military one, providing security along the coasts and rivers of the United States. The USCG mission in flood risk management is primarily in flood response, where it can use its boats and aircraft for search and rescue or assistance to other agencies. The USCG may also enforce navigation restrictions during floods to safeguard flood risk reduction infrastructure such as levees from vessel impact. USCG craft also perform icebreaking missions to reduce risk of ice-jam river flooding.

3.3.1.5 Department of Agriculture

3.3.1.5.1 **Natural Resources Conservation Service**

The Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service or SCS) uses voluntary incentive programs to promote agricultural productivity and conservation of natural resources. The impact of these programs on flood risk is primarily through preservation of ecosystem services provided by healthy habitats such as grasslands and forests. These services include such effects as storage and infiltration of rainwater and attenuation of floodwaves. One of the oldest functions of the NRCS is the promotion of wise land-use practices to reduce erosion of farmland, which reduces flood risk by lessening the sedimentation in rivers that can raise flood stages. The NRCS water management program also provides technical assistance to farmers and ranchers to optimize drainage systems to reduce flooding, make efficient use of limited water supplies, and improve water quality. The watershed program provides technical and financial assistance to states and local governments to create watershed plans and carry out improvement projects, with flood mitigation one of the potential purposes of such projects. One tool for executing these projects is a conservation easement, a voluntary contract in which NRCS pays a landowner for protecting the agricultural and conservation use of their land, either in perpetuity of for an agreed timeframe. These easements may effectively reduce flood risk by restricting development in flood-prone areas. Finally, the NRCS produces monthly water supply forecasts during the winter season based on snow surveys in mountainous areas. These forecasts are essential to the spring flood outlooks produced by the National Weather Service, particularly in western states.

3.3.1.5.2 **Risk Management Agency**

The Risk Management Agency (RMA) operates the Federal Crop Insurance Corporation (FCIC). Federal crop insurance provides a mechanism for sharing the risk of crop loss between farmers, insurance companies, and the federal government. While private insurance companies sell and service crop insurance policies, the FCIC approves the premiums they can charge, administers subsidies, and reinsures the companies. Although insurance merely shares, rather than reduces, overall flood risk, from the perspective of the farmer the risk of crop loss due to floods or other causes is reduced.

3.3.1.5.3 **Forest Service**

The US Forest Service (USFS) manages the United States' national forests and national grasslands. By managing these lands sustainably for forestry and other uses, ecosystem services are preserved, reducing runoff and therefore peak flood levels.

3.3.1.6 Environmental Protection Agency

The Environmental Protection Agency (EPA) is an independent agency, apart from any federal department. The EPA serves to protect the human health and natural environment of the United States by enforcing regulations based on federal law. It also executes projects to promote human and environmental health, including some that reduce risk of flooding. The EPA Urban Waters Partnership program helps make water bodies in cities cleaner, safer, more attractive and more accessible by establishing partnerships between government agencies and non-profit organizations. It also makes small grants to support activities that improve water quality and enjoyment, such as reducing stormwater discharge to water bodies through green infrastructure and wetland restoration. By retaining more water on-site and reducing runoff, such projects reduce flood risk while also improving water quality.

3.3.1.7 Department of Housing and Urban Development

The Department of Housing and Urban Development (HUD) uses the Community Development Block Grant (CDBG) program to fund community development programs at the state and local government levels. These programs include activities such as anti-poverty programs, affordable housing, and elimination of slums, but also include grants made after disasters such as floods. Disaster Recovery (CDBG-DR) grants are made available in presidentially-declared disaster areas when Congress appropriates additional funding for community disaster recovery. These grants can be used for activities such as buying out damaged properties and relocating residents to safer areas, debris removal, repairing damaged homes and buildings, constructing or repairing public utilities such as water and drainage systems, and incentivizing homeownership or job creation in affected areas through subsidies. These grants may be used where assistance from other agencies such as FEMA is not available; in fact, they must not be used to duplicate services from other agencies. The grants are also available only for activities that meet one of the three national program objectives of benefitting people of low and moderate income, aiding in prevention of slums or blight, or meeting urgent development needs because of hazardous existing conditions.

After Hurricane Sandy in 2012, HUD took the innovative step of setting aside some CDBG-DR grant funding for a design competition (Rebuild by Design) to incentivize innovative, resilient development concepts. The competition generated a greater number of creative solutions to development in flood-prone areas than could have been achieved with a single reconstruction grant.

3.3.1.8 Department of Health and Human Services

3.3.1.8.1 **Centers for Disease Control and Prevention**

The United States Centers for Disease Control and Prevention (CDC) is the national public health institute of the United States, providing research and education to improve the health of US citizens. The CDC plays an important role in maintaining population health during recovery from man-made or natural disasters, including floods.

The National Institute for Occupational Safety and Health (NIOSH) is the CDC institute responsible for recommendations and research for prevention of workplace injury and illness. NIOSH provides guidelines for reducing hazards to workers responding to disasters, including floods, to ensure their safety during and after the disaster response. It also performs Health Hazard Evaluations (HHE) to determine the healthfulness of a workplace and the health of its workers upon request. These evaluations are frequently requested after a disaster when a workplace may be at risk of contamination due to mold, contaminated water or sediment, or water-borne diseases. After Hurricane Katrina several workplaces in the affected area, including the New Orleans Police Department, requested HHEs from NIOSH.

The National Center for Emergency and Environmental Health Services is the CDC institute responsible for helping health systems and programs anticipate and respond to emergencies. It provides several environmental health services after a flood, such as guidelines for mold and microbial contamination hazards and cleanup, public outreach information on returning to previously flooded areas, and training on environmental health issues in emergency response.

3.3.1.8.2 **US Public Health Service**

The US Public Health Service (USPHS) is the federal agency that oversees the US Public Health Service Commissioned Corps, a uniformed service under the command of the US Surgeon General. After a disaster such as a flood, the officers of the Commissioned Corps may deploy to the affected area to provide emergency medical and health services. These deployments occur in three tiers: the first tier consists of doctors, nurses, pharmacists and other health professionals who deploy within 12 hours of the disaster to provide and coordinate health services; the second tier consists of public health and mental health professionals who deploy within 36 hours of the disaster to provide a mobile integrated public health functionality; and the third tier consists of the rest of the Commissioned Corps, who can deploy within 72 hours to augment the first two teams.

3.3.1.8.3 **Substance Abuse and Mental Health Services Administration**

The Substance Abuse and Mental Health Services Administration (SAMHSA) also has a role in post-disaster medical care. SAMHSA runs the Crisis Counseling Assistance and

Training Program (CCP) to counsel and assist disaster survivors, maintaining mental health and connecting those in need with professional services. SAMHSA also provides emergency response grants (SERG) to fund post-disaster counseling and substance-abuse treatment when normal funding sources are inadequate.

3.3.1.9 Federal Energy Regulatory Commission

The Federal Energy Regulatory Commission (FERC) regulates the interstate transmission of electricity, oil, and natural gas. It also licenses hydroelectric power plants, giving it an important role in dam safety and flood risk management. FERC regulates both the construction and operational phase of a hydropower project, reviewing plans, designs and specifications of a dam before granting a license. FERC staff inspect dams both during construction a periodically while under operation. FERC also produces tools and information for dam owners to use in their own safety programs, as well as training materials for owners, stakeholders, and other members of the dam safety and risk management communities.

3.3.1.10 Tennessee Valley Authority

The Tennessee Valley Authority (TVA) is a federally owned non-profit corporation providing hydropower, flood risk reduction, and navigation along the Tennessee River System. The TVA is not a government agency and no longer receives federal funding, but it was created by the US government to help develop the Tennessee Valley area with electrification, flood risk reduction, and navigation. TVA funding is generated by sales of electricity and related financing. As the operator of 47 dams along the Tennessee River System, the role of TVA in flood risk management is enormous in this area.

3.3.2 State Agencies

3.3.2.1 Departments of Water Resources

Some states, particularly in the western United States, have standalone Departments of Water Resources or similar agencies within their governmental structure. These departments issue and enforce permits for water use and regulate trade in water rights where such trade is allowed. They may also construct and operate infrastructure such as reservoirs and interbasin transfer projects for their state. While the primary mission of these departments is water supply rather than flood risk management, they still have a significant impact of floods through operation of dams and their associated dam safety programs. In some cases, they may cooperate with other federal or state agencies on topics related to floods, such as river forecasting, infrastructure planning, natural resources management, or seasonal water supply forecasts.

3.3.2.2 Departments of Environment and/or Natural Resources

Most states have a Department of Environment or similar agency. These agencies serve to evaluate and issue environmental permits, enforce compliance with state environmental laws, monitor air and water quality, and inform the public of environmental issues and requirements, among other duties. These agencies may provide information to the public about many environmental issues, including floods, including information such as how to access flood warnings, how to prepare for a flood, and what environmental or other hazards may exist upon returning to a flooded property. Departments of the Environment also affect flood risk when they set or enforce policies restricting development in flood-prone areas, though these are primarily for the purpose of protecting environmentally sensitive riparian habitats rather than managing flood risk. These departments are often partners on interagency teams addressing flooding related issues. For example, after a flood a team of state and federal agencies may be assembled to recommend a plan for redevelopment of the affected area, with the state Department of the Environment providing expertise on the environmental issues such as protection of important habitats or reducing the environmental consequences of future floods. Finally, state Departments of Environment are frequently partners in flood risk management planning studies performed by other agencies. These agencies will engage the Department of Environment early in the planning process to ensure that their project is compliant with all state environmental laws and policies, and to minimize the negative environmental impacts of the project.

3.3.2.3 Departments of Health

Every US state has a Department of Health or equivalent agency, responsible for the public health of the state's population, licensing of physicians, collection of records and statistics, and other related functions. Although the overall role of the health department in flood risk management is small, it can be an important component during the recovery phase. Health agencies provide information to the public on the dangers of health issues associated with flooding. These issues may include such hazards as mold, microbial contamination, or contaminated sediment or ash transported by the floodwaters. Health agencies may also provide information or other resources to ensure the occupational health of emergency workers responding to the flood, and resources such as crisis counseling for flood victims. These services all help the community recover from the flood and resume normal life as soon as possible.

3.3.2.4 Departments of Emergency Preparedness

All US states have a Department of Emergency Management or similar agency, though the words preparedness, coordination, or other related terms may be used in various states. Many states formerly used the term Civil Defense for these departments, and the

state of Hawaii still uses the term "Hawaii State Civil Defense." All other states have discontinued the use of the term Civil Defense because of the perception that this term emphasizes attacks by outsiders rather than management of all hazards. Nevertheless, the role of these agencies is somewhat similar to the state Civil Defense in Brazil. A state Department of Emergency Preparedness or similar agency is responsible for coordinating disaster preparedness, response, and recovery. Before a flood or other disaster, the department may coordinate preparedness actions such as practice exercises, publishing information for the public, or providing training for local governments. During a flood, this agency will typically be responsible for centralized command of all response functions under the power of the state governor. These functions include interpreting weather and other forecasts, collection of data on damages and impacts, negotiating contracts with vendors for supplies, and assisting local agencies. After the flood, emergency agencies may assist local governments and survivors with resources directly, or may help them navigate assistance available from other state or local agencies. Such resources may include emergency shelter, health and safety programs, and funding to rebuild homes and businesses.

3.3.2.5 National Guard

One difference between Emergency Management departments in the United States and the Civil Defense of Brazilian states is that Emergency Management departments do not typically perform search and rescue operations or provide emergency medical services. Instead, these functions are provided at the state level by the National Guard. The National Guard serves a dual role as a reserve force of the United States (federal) military and also as the militia of its home state. When not activated for military missions on the part of the nation, this militia may perform emergency services for the state, including during and after disasters such as floods. These services include activities such as search and rescue, flood fighting (placement of barriers, correcting seepage problems, building temporary dikes, etc.), emergency medicine, and security. Unless activated for federal duty, the National Guard is under the command of the State Governor. To supplement the capacity of the National Guard or replace it while activated for federal duty, some states also have a State Defense Force (also known as "State Guard" or "National Guard Reserve"), which under the sole command of the State Governor.

3.3.3 Local Agencies

3.3.3.1 Planning Commissions

Municipal or local governments often have some sort of planning department or commission responsible for establishing the rules of land use in that city or area. Proper urban planning guides the orderly development of settlements, helping ensure the city is safe, productive, and enjoyable. Managing flood risk is one aspect of urban planning.

Planning commissions have the power to enact zoning, which allows certain types of construction or economic activity only in designated areas. In terms of flood risk management, this may mean restricting residential construction in flood-prone areas, or completely prohibiting construction in certain areas by designating them as parks or other public space. Zoning certain areas as parks or other open space not only restricts risky development, but can also introduce storage areas and increase rainfall infiltration, reducing flood frequency.

3.3.3.2 Building Code Development and Enforcement

Building codes define the rules for how buildings may be constructed, to ensure that buildings are as safe as possible. When enacted by a local government, codes take on the force of law and can be enforced with civil or criminal penalties. At one time it was common for local jurisdictions to develop their own building codes, but as codes became more extensive and complex it became more common for cities to adapt a national or international code to their own unique circumstances. For cities at risk of flooding, these circumstances may demand that building codes reflect this risk. Codes can require that buildings in designated flood-prone areas be elevated to reduce their chance of flooding, or may require certain structural features intended to reduce damage if the structure is flooded. These can include measures such as elevated electrical equipment, enhanced structural strength to account for simultaneous wind and water loading, and breakaway elements or openings for walls below the design flood level, to allow hydrostatic forces across these walls to equalize before they do more serious structural damage. While building codes do not reduce flood frequency, they can reduce the consequences of flooding when it does occur.

3.3.3.3 Departments of Public Works

Departments of Public Works or similar agencies are responsible for local drainage and water supply in most localities. Some specific areas may have federal or state drainage projects, but these are the exception rather than the rule. Public works departments execute projects to reduce the risk of rainfall flooding and may also have a regulatory function to ensure that private projects do not impact public drainage projects. These projects may include canals, culverts, underground pipes, pump stations, and related infrastructure. They may also include "green" infrastructure designed to increase surface storage of stormwater and improve infiltration, such as permeable streets or sidewalks, swales, rain gardens, or green roofs.

3.3.3.4 Levee Districts and Boards

In areas with extensive levees, a specific governance structure may be required to manage the levee system and ensure it is maintained. Levee boards are typically independent of

local government, consisting of elected members from districts within the leveed area. A tax, typically in the form of a millage on property within the leveed area, is often used to fund the board and its activities. Other funding mechanisms exist, however; for example, the Yazoo-Mississippi Delta Levee Board in the state of Mississippi receives some of its operating funding by leasing space on the river side of its levees for use as ports. Levee board activities include inspections and maintenance of levees, protection of levees from damage, and operation of floodgates or other structures as necessary. Major maintenance, such as increases in levee height, and construction of new levees are often accomplished by state or federal entities.

3.3.4 Non-governmental Organizations

Non-governmental organizations (NGOs) are typically non-profit entities that exist to pursue some particular goal or interest. The term NGO is not well defined, and many types exist, some of which have important roles in flooding issues. Environmental NGOs are common in the United States, raising funds to preserve sensitive environmental areas, which can have positive effects on flood frequency as described earlier. Other NGOs may raise public awareness of issues or lobby the government for particular policies, including flood risk management policies. Some NGOs are trade groups, such as the American Association of Port Authorities, which may represent members of a particular business type in flood-related matters. Others are professional groups, such as the American Society of Civil Engineers or American Institute of Hydrology, which seek to enact wise flood risk management policies and ensure professional standards for flood related professions. It is estimated that the United States now has 1.5 million NGOs, with a significant combined influence on public perception and government policies. The role of NGOs was further increased with the Water Resources Reform and Development Act (WRRDA) of 2014, which allows NGOs to serve as local sponsors in federal flood risk management projects constructed by the US Army Corps of Engineers.

3.3.5 Tribal Governments

Native American tribes that are recognized by the United States Bureau of Indian Affairs have semi-autonomous governments that exist within but apart from the United States. These tribal governments perform many of the same functions as state or local governments, managing flood risks within their territories by constructing projects, enacting zoning laws and buildings codes, and performing disaster response functions. Tribal governments can also be partners with federal agencies on flood risk management projects.

3.3.6 The Role of the Public

As specified in the National Planning Frameworks, management of disasters such as floods is the responsibility of the whole community. Members of the public have a personal role to play in their own preparedness and response, through actions such as evacuation planning, maintenance of home basements and other flood-prone areas, preparing a kit of supplies in case of disaster, self-education on safe practices during a flood, and safe recovery and rebuilding practices after a flood. In some areas, flood insurance may be sensible or even required. Many federal and state agencies provide educational materials to the public on the steps they can take to minimize their personal flood risk.

3.4 Legal Frameworks

3.4.1 Constitutional Provisions

The United States Constitution is the shortest written constitution of any national government in the world. It no surprise, then, that it does not contain any provisions related to floods or flooding. In fact it does not mention water at all, except to say that Congress has the power to make rules regarding naval captures on water.

3.4.2 Property Rights

The risk of flooding that occurs on private property is normally borne by the property owner. As a result, restrictions on construction for the purposes of reducing flood risk, such as zoning laws and building codes, may be seen as infringing private property rights. Since the early 20th century, several landowners have attempted to sue the government on the grounds that zoning laws restrict the economic activity available to them and therefore constitute a "taking" as prohibited by the Fifth Amendment to the US Constitution. In general, courts have held that when zoning laws merely restrict certain types of development, the government is not required to compensate landowners for their loss. However, several times since 1987 the US Supreme Court has ruled against the government and required compensation in cases where zoning restricted all economic development on private property. In the case of *First English Evangelical Lutheran Church of Glendale v. County of Los Angeles, California*, the court found that the county government must pay compensation to a church, whose buildings in a flood-prone canyon area had been destroyed in a recent flood, because an interim ordinance prohibiting (re)building in the floodplain deprived the church of any economic use of its private property (http://openjurist.org/482/us/304/first-english-evangelical-lutheran-church-of-glendale-v-county-of-los-angeles-california). The court found similarly in several later cases. However, in each of these cases the court's decision was based on the particular facts of each case, and did not establish that zoning laws restricting

development in the floodplain constitute a "taking" in all cases. As a result, the exact legal status of zoning laws as "regulatory takings" remains somewhat unclear.

Eminent domain provides a separate method for the government to acquire private property for a public purpose, such as clearing buildings from the floodplain to create a park. In this mechanism, the government condemns the property and compels the owner to vacate it, but the government must compensate the owner for the taking. The courts' preferred method of determining this compensation is "fair market value," meaning the value of the land that a willing buyer would pay a willing seller in an open marketplace. This approach compensates the owner for the most profitable use of their land rather than its actual use, but does not compensate him for other losses such as the loss of a business located on the property.

3.4.3 Easements

An easement is a legal agreement allowing a non-owner some specific use of private property for some specific purpose. Easements are property rights that are permanently attached to the land, even if its ownership changes. Many types of easements exist, with a few forming useful tools for flood risk management. A *flowage easement* allows the government to flood a parcel of private property, and may be purchased when a floodway, storage area, or diversion channel passes through private land. Purchasing such an easement from a landowner may be cheaper than purchasing the land outright at fair market value, and also saves the government the expense of maintaining the land. However, the damage of a flood is so severe that the cost of a flowage easement may be almost as much as purchasing the property outright. Typically, such easements are only practicable for agricultural lands such as farms and ranches, which are not as severely damaged by occasional flooding as would a residential or industrial area.

A *conservation easement* restricts development on private land while allowing the landowner to retain ownership over it. These easements are often entered into by landowners who want to maintain their land in a natural state and a land conservation entity (such as a government entity or a non-profit environmental organization) with some interest in preventing development of the land. Conservation easements that keep floodplains in their natural state can preserve flood-reducing environmental services such as attenuation and infiltration, while also restricting development in risky areas.

3.4.4 Building Codes

As discussed in section 3.3.3.2, building codes are established by the local government of a city or town to specify the appropriate construction standards for buildings in that area. Because they are part of the municipal code of the city, these codes have the force of law and violations can be enforced with fines or criminal penalties. Cities typically have a

specific department of their government for code enforcement. Codes are used to enforce many types of construction standards, from fire safety to accessibility for disabled people. In flood-prone areas buildings codes can help reduce flood risk by requiring buildings to be robust or resilient to flooding. For example, codes that require houses to be elevated above the floodplain reduce the likelihood of flooding that house. Codes that require holes in walls that are below the floodplain, allowing hydrostatic pressures to equalize before more serious structural harm can occur, do not reduce the probability of flooding but reduce its consequences and make buildings easier and faster to repair after the flood passes. Nearly all local governments now use a customized version of a standard building code, rather than creating a new code themselves.

3.4.5 Zoning

As discussed in section 3.3.3.1, zoning laws specify the types of buildings that may be constructed in specified areas. For example, these laws establish areas of a city where industrial activity is allowed or those where only residential houses may be built. In flood-prone areas, zoning laws can reduce flood risk by totally prohibiting all development within the floodplain, though it is more common to restrict development in a more nuanced way. For example, floodplain area may be zoned only for use by agriculture or another use that would be relatively resilient to flooding. Alternatively, specific types of construction could be restricted based on the consequences of a potential flood (refineries, power plants, chemical plants, etc.), or because they would be difficult to evacuate quickly (schools, hospitals, nursing homes, etc.).

3.4.6 Flood Insurance

Flood insurance is not exactly a law or a legal framework, but it is an important tool in flood risk management in the United States. An insurance policy does not reduce overall risk, but allows it to be shared among several parties. At one time it was common to discuss insurance as a risk-transfer agreement, because the buyer of the policy pays the premium to transfer his risk to the insurance seller. However, the term risk-sharing is now more common, because it reflects the reality that the buyer is never totally free of risk (because the insurance company could go bankrupt or refuse to pay a claim). In either case, from the perspective of the buyer, the maximum financial impact of a flood is reduced, preventing a flood from becoming a catastrophic financial loss greater than he can bear with his savings alone.

Because floods are very damaging and affect a great many houses at once, providing flood insurance requires an extremely large and diverse pool of policyholders to balance the risk pool, as well as a very large cash reserve to allow payments in case of a disastrous flood. This makes flood insurance a highly volatile venture for the insurer, making it an unattractive business. As a result it is common in the United States for

standard homeowner's insurance policies to exclude flood damages, and private standalone flood insurance is very costly. To encourage homeowners to purchase flood insurance and keep it affordable, the National Flood Insurance Program (NFIP) allows the United States to use its cash reserves to support flood insurance policies. Much more information on the NFIP is available in USACE Document 2.6.

3.4.7 Legal Liability for Flood Damages

In general, in the United States property owners must use their property in a way that does not harm others. If a landowner modifies his property in a way that affects the natural flow of water across it, he may be liable for flood damages done to another person's property[2]. For example, a landowner who constructs a dam for the purpose of creating a pond may be liable for damages to property downstream if the dam fails and causes a flood. Likewise, a downstream property owner may be liable for damages to an upstream property if he impedes water flow and causes backwater flooding. The exact theory of liability used to determine whether one party is responsible for the damage done to another varies by state. A few states allow nearly any modification of flow over private property under the theory that floodwaters are a "common enemy" to all landowners, giving all landowners the right to protect themselves from this enemy regardless of consequences to others. This interpretation derives from English common law and was once the most common doctrine, but has since been modified in most states. A few states follow a civil law rule allowing no modification to natural flow if it changes the flow on adjacent land. Most states allow some harmful modification of flow, but only if "reasonable," which is a case-by-case determination based on intent or negligence. If a property owner is found liable for flood damages to another person's property he can be forced to pay for restoration and repair costs, for the reduction in value of the damaged property, and for the value of any lost crops, structures, or other objects on the property. One important aspect of this legal provision in the United States is the courts have held landowners responsible for the collapse of dams under the concept of *strict liability*, meaning that a person can be liable for damages without being culpable. In other words, without intent or even knowledge of the harm they could be causing, an owner can be responsible for damages caused by a dam failure because impoundment of water has been ruled to be an "ultrahazardous" activity (Kusler and Thomas 2007).

[2] Interestingly, this is similar to Brazil's Water Code of 1934. This law, which is no longer in force, stated that a person responsible for causing a flood by obstructing a watercourse would be responsible for repairing the damages caused by the flood.

4.0 FLOOD RISK MANAGEMENT IN BRAZIL

The following summary of flood risk management practices in Brazil is derived from a technical review of ANA Document 2.1, presentations given by ANA personnel, and discussions with personnel from ANA and other Brazilian state and federal agencies. As appropriate, recommendations for further development of Brazilian regulatory policy regarding flood risk management are offered at the end of each section. In addition, recommendations are summarized and explained more fully in section 0.

4.1 Aspects of Water Resources Management Related to Flood Risk Management

Brazilian government function, as in the United States, is divided into three "spheres" comprising functions of the federal, state, and local municipal governments. Flood risk in Brazil is managed as an element of disaster management. Because floods are disasters involving water, and because flood risk management infrastructure is also used for other water resources management functions, water resources management is an important part of flood risk management. Water resources management in Brazil is under the dual jurisdiction of the states and the federal government, though some state functions may be delegated under certain conditions to the municipal level by mutual agreement. The federal government is responsible for water resources management, including flood risk management, on rivers that form or cross state or national boundaries (federal rivers), while states are responsible for management of rivers that lie wholly within their borders (state rivers), even if these are tributaries to federal rivers. The federal government has determined which rivers are state rivers and which are federal.

The National Policy for Water Resources specifies that "The river basin is the territorial unit for the implementation of the National Policy for Water Resources and the operation of the National System for Water Resource Management," and furthermore that "the management of water resources should be decentralized, and depend on the participation of public authorities, users and communities." The mechanism for this decentralized, watershed-based management is the River Basin Committee. A committee is established either by the states (for state rivers) or the federal government (for federal rivers). It is comprised of the key actors and stakeholders in the basin's water sector, including representatives of water users (power generators, industry, agriculture, sanitation providers, government, and civil society). The River Basin Committee sets the water usage policies and fees for the water resources of the basin, and uses these fees to pay for its own costs as well as those of its counterpart executive agency, which carries out the policies established by the committee. The committee can include flood risk management in its basin plan and suggest structural and non-structural measures to manage these risks.

The functions of the state and federal governments, as well as the River Basin Committees and Agencies, are coordinated through SINGREH, the National System for Water Resources Management. The Agência Nacional de Águas is both the coordinator of this system and a member of it, as the executive agency responsible for carrying out policy on the federal level. Such a decentralized system keeps the federal sector lean and empowers the states to handle their own crises, but it requires a high degree of coordination among the various actors. Effecting this coordination is one of ANA's main missions.

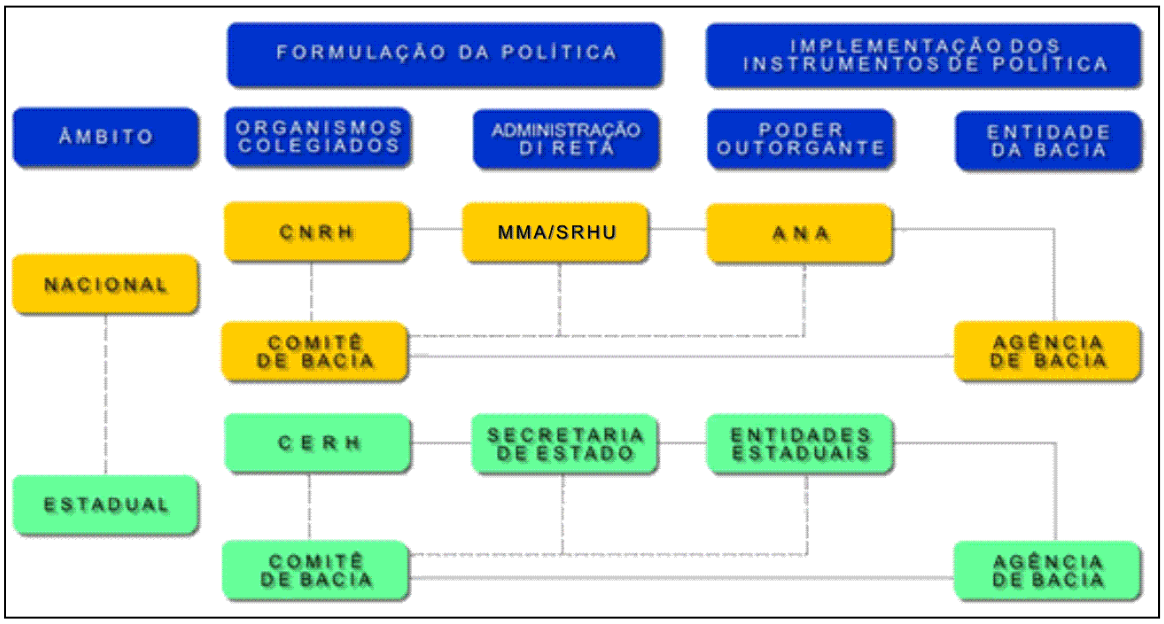

Figure 6: SINGREH, the National System for Water Resource Management. The left column (Forumulacão da Politica) contains deliberative bodies that formulate policies, while the right column (Implementação dos Instrumentos de Politica) contains executive bodies that implement those policy instruments. Entities in yellow are federal-level while those in green are state-level.

From the USACE perspective, management of water resources on a watershed basis is very sensible and familiar, because USACE districts and divisions are also defined roughly along watershed boundaries. However, the limited federal role is a key difference between Brazil and the United States, where the federal government can execute projects to benefit the nation, often through the Corps of Engineers.

4.2 Institutional Macro-functions in Brazilian Flood Control

ANA Document 2.1 defines five macro-functions in Brazilian flood control: prevention, protection, preparation, emergency response, and recovery. In this section, an analysis of these functions from the USACE perspective will be provided, with recommendations for development of Brazilian flood risk management policy.

Before discussing Brazilian government function, a brief description of Brazilian constitutional law may be helpful. The Brazilian constitution specifies four types of legal competences: *exclusive competences* are executive capacities that must be performed by the governmental level to which they are assigned in the constitution (i.e. they cannot be delegated to a lower level). *Private competences* are legislative capacities that initially belong to the federal union but may be delegated to lower levels. *Common competences* are executive capacities that initially belong to the union but may be delegated. *Concurrent competences* are legislative capacities that belong jointly to the states and the federal union (i.e. the states may take legislative action if the union does not; whereas a matter of private competence would have to be explicitly delegated by the union before the state could act). Flood risk management activities in Brazil, like any other government function, must be performed by the appropriate government entity as specified and/or allowed in the Constitution.

4.2.1 Prevention

The prevention function consists mainly of non-structural actions to reduce the impact of floods. These may include zoning, mapping areas of flood risk, and monitoring those areas. Zoning policy begins with the federal government, which has the exclusive constitutional competence to develop regional development plans and prioritize specific areas of the country for development. Zoning may be a part of these plans, but since they are of a very general and broad nature, these plans do not specify particular zoning rules.

Municipal master plans (PDM) are required for cities with more than 20,000 people (optional for smaller cities), and must specify, at a minimum, the areas of the city which may be developed, as well as mapping of risk areas. In practice, however, these master plans may not contain all the mapping they are theoretically required to have, due to lack of funding and staffing in municipal governments. The federal union has the competence to support the state and local governments in mapping vulnerabilities, but such support cannot occur without staff available in the local offices.

Two types of zoning that may be used beneficially for flood risk management are the ecological economic zoning (ZEE) and the permanent preservation areas. ZEE is intended to make development sustainable and compatible with environmental and cultural protection. The federal government has the competence to develop and implement ZEE, though state, regional, and local ZEE may also be implemented if they are compatible with and approved by higher zoning authorities. There are no particular requirements for how or how much land should be protected by ZEE, but restricting development in the floodplain is one possible strategy. In practice, ZEE is not currently used for disaster prevention due to its small scale and regional focus, but it could potentially be used in this way in future.

Permanent preservation areas (APP) are riparian corridors that must be preserved in their natural states, the widths of which vary according to the size of the river, as well as percentages of preserved area which must be set aside as part of any new development, which also vary in size depending on habitat. The size formulas for permanent preservation areas are defined by law. Permanent preservation areas are enforced through the issuance of environmental permits, which is generally a state attribution, though it can be federal in cases of federally-controlled areas (such as national parks), or when a proposed development overlaps a state or international boundary, or when the impacts of the development could extend beyond a single state. However, this state function may be delegated to the municipal level if the municipality has the ability and interest to perform it.

Although both ZEE and Permanent Preservation Areas may be used to restrict floodplain development in theory, enforcement is difficult in practice. River dimensions change as a function of flow, making it difficult to define the width of the river and therefore the width of the restricted corridor. States do not typically have a sufficient workforce to ensure that environmental zoning and preservation areas are being considered when issuing permits, and the sheer size of the country prohibits the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA, the ultimate authority on these codes) from inspecting all riparian areas. Finally, properties that pre-date these policies are exempted through a grandfather clause, complicating efforts to distinguish allowable from prohibited construction.

Recommendations

The most important issue hindering enforcement of these policies is that there are few incentives for municipal governments to restrict development in the floodplain, since a damaging flood will often yield emergency recovery funding from the federal government (a perverse incentive). Flood risk also tends to be a relatively low priority politically in many areas, so municipal governments tend to have more to lose than gain when they enact strict zoning laws. ANA could investigate this phenomenon to determine whether this is truly a serious issue in Brazil, and if so, how the preparation and recovery functions could be adjusted to incentivize preparation activities. This adjustment would likely involve other federal agencies in addition to ANA.

4.2.2 Protection

The protection function consists of structural measures taken to reduce the probability of floods. Establishing or modifying the operational instructions for these structures is a special case of a non-structural protection measure. ANA Document 2.1 identifies four types of structural protection measures: flood control reservoirs, levees, diversion channels, and urban drainage systems. Reservoirs in Brazil may be constructed by

agencies of the state or federal government, or by entrepreneurs, typically hydropower companies. The Ministry of National Integration (MI) has the power to construct works to mitigate the effects of droughts, primarily through agreements with states or through agencies such as the National Department of Works for the Control of Droughts (DNOCS) and the Company for Development of the Valley of the São Francisco River (CODEVASF). Whether a dam is built by a government or private entity, environmental and licensing criteria must be met before construction can begin. For example, any infrastructure costing R$10,000,000 or more that reserves or removes water and is constructed wholly or partially with federal funds must have a certificate of sustainability of water works (Certificado de Avaliação da Sustentabilidade da Obra Hídrica, or "Certoh"), which is issued by ANA. The actual operation of a dam, developing the plans thereof, and strategic planning for system-wide coordination of reservoirs on a seasonal basis are non-structural protective actions which are dependent on the existence of the structure (the dam).

Levees may also be constructed to reduce flood frequency, and DNOCS and CODEVASF have done so for large agricultural areas. As with dams, levees must satisfy environmental licensing requirements before they can be constructed. ANA Document 2.1 points out two issues with construction of levees: to prevent disaster, warning and evacuation systems must work efficiently to remove people from leveed areas when a forecast indicates that levees may be overtopped, and urban drainage systems must work well in leveed areas or the levee may impound rainwater and cause the "protected" area to flood.

Diversion channels are another form of structural solution, which serve to remove water from the river before it can do damage, and re-route it to a less vulnerable place. The federal government, through the MI, may also construct these works using the same mechanisms as for dams or levees. Due to their high monetary and environmental costs, these projects will typically require a Certoh from ANA.

Urban drainage systems serve to remove water from populated parts of urban areas and/or store it safely until the rainstorm is over. These systems are typically built by the municipal government, but may be a joint project of the state and municipal governments in cases where the system extends into a neighboring municipality. Although ANA personnel indicated that these systems are important to flood risk management in Brazil, ANA Document 2.1 does not contain much information about urban drainage systems or plans. However, Tucci (2002) explores the example of the Urban Drainage Master Plan for the metropolitan region of Curitiba. This area suffered severe damages in July 1983 and January 1995 due to heavy rainfall and high river stages. The normal approach in this situation would have been to increase the channel capacity of the Iguaçu River, but it was recognized that this would be only a temporary solution, as increasing urbanization

upstream would eventually increase peak flows enough to return flood risk in Curitiba to its pre-project condition. Instead, a large park was proposed as a storage area in Curitiba proper, and an Urban Drainage Master Plan was developed for the metropolitan area to reduce floods on the Iguaçu's main tributaries. This plan established urban parks along these tributaries to dampen the peak flow from the unregulated areas upstream, reducing flood stages in Curitiba.

Recommendations

From the USACE perspective, the list of structural measures for river flood risk reduction given in ANA Document 2.1 appears to omit a few measures. As described in Tucci (2002), storage areas provide a similar function to diversion channels, introducing storage and moving water away from valuable or populated areas. Storage areas may be thought of as off-channel reservoirs, or diversion channels with a single entry and exit. During periods of no flooding, these areas are often managed as parks or agricultural areas, so there is relatively little consequence for allowing them to receive flood waters when needed. There is also no mention of channel modifications, which reduce flood risk by increasing the conveyance capacity of rivers through deepening and/or widening. There is no mention of floodwalls, but these may be considered a type of levee.

The discussion of levee safety presented in ANA Document 2.1 is a very good one that shows a high level of understanding of the risks associated with events exceeding the design event, emphasizing how structural measures must work as part of a comprehensive system including risk communication to the public. In contrast to the discussion of the hazards of levees, ANA Document 2.1 does not contain a discussion of the risks associated with dams. This is somewhat surprising because it does mention the laws relating to dam safety, which is a major issue of concern in Brazil.

A site visit to the state of Pernambuco and discussion with employees of the state water agency revealed that maintenance and inspection of dams often falls into a grey area between state and federal responsibility, resulting in neither sphere of government successfully performing this function. As an example, the Capibaribe River is a state river in Pernambuco, with Jucazinho Dam one of several large dams in its watershed constructed by federal agencies. Legally, the entity that issues the construction permit for a dam (the state in this case, because this is a state river) is responsible for inspections, while the entity that constructed it is responsible for maintenance. However, state employees explained that poor states like Pernambuco are heavily reliant on the central government for funding in many areas, not just water resources. So they are hesitant to confront the federal government with unsatisfactory inspection reports for fear of damaging their working relationship. Meanwhile, the federal agency who constructed the dam (DNOCS) is gradually losing capacity and influence as its mission shifts from

construction to operations, and will not take maintenance action on its own, without a request from the state. Jucazinho utilized its emergency spillway in 2010 and 2011 but was not inspected after either operation. No periodic inspections are performed either.

In some cases, dams were constructed by federal agencies that no longer exist, and state agencies have been repeatedly reorganized, creating and eliminating state entities that could be responsible for operation and maintenance function. These examples point to a possible fundamental underlying issue: the impermanence of government institutions at both the state and federal levels. As a result, for lack of small, routine maintenance projects, the eventual cost of major maintenance continues to increase, along with the likelihood of a catastrophic dam failure.

Figure 7: Minor maintenance issues such as cracking concrete at Jucazinho Dam may increase the need for costly electrical system repair or other major maintenance later.

4.2.3 Preparation

The disaster preparedness function includes forecasting floods and warning the public, in addition to relocation planning and contingency planning. Forecasting can be further divided into weather forecasting, river forecasting, and issuance of warnings, alerts, and alarms. Within the Brazilian federal government, the Center for Modeling and Alerts of Natural Disasters (CEMADEN) performs weather forecasting for the purpose of flood preparedness, though other agencies perform weather and climate forecasts for other purposes. State governments may also have agencies to produce their own weather forecasts.

River forecasting may be performed by state or federal agencies, with ANA and CEMADEN being the most capable federal agencies in terms of hydraulic and hydrologic modeling. Under the terms of Joint Protocol 148, any of the protocol's four signatory agencies (ANA, CEMADEN, CENAD, and CPRM) may issue a warning to the other agencies and to the Civil Defense, which may include any information about disaster risk. Once a warning has been issued within the federal government, an alert may be issued to CENAD and to the affected municipalities, indicating that a risk of disaster is foreseeable in the short term. Under the National System for Protection and Civil Defense (SINPDEC), only CEMADEN can issue an alert. However, CEMADEN does not yet provide monitoring and alerts for the entire country. The National Plan for Disaster Risk Management, created in response to the disastrous 2011 floods and landslides in the state of Rio de Janeiro, defines 821 priority municipalities to receive formal monitoring and warning through CEMADEN. These municipalities must also have established risk maps, contingency plans, and plans to reduce the risk to their communities. Although Brazil has 5,570 municipalities, these 821 represent 80% of the country's total risk of floods, landslides, and flash floods. Once the alert is issued, it can be disseminated by any agency, or in fact any person. To ensure the alert is communicated, CENAD will transmit it to the municipalities and to the Civil Defense System. Within communities, the local Civil Defense is responsible for warning the public of an impending disaster.

Disaster preparation and forecasting is also facilitated through the use of situation rooms. There is a situation room located in each state government headquarters, as well as a central room at ANA. These rooms contain computer and audiovisual equipment to integrate meteorological and hydrologic information, as well as a physical space for gathering scientific and emergency response specialists. In these rooms, digital information from hydrometeorological and alert networks are collected and monitored, providing timely information for decision-makers. In the near future, the 27 local situation rooms (for the 26 states and the Federal District) will be integrated with the central situation room at ANA, to facilitate cooperation on critical events.

Contingency planning is a final piece of the emergency preparedness function. Municipalities are required to develop plans, with assistance from states, identifying people and agencies responsible for specific actions in an emergency, and how they work together. Municipal master plans must also include plans for resettlement of people displaced by disasters, including floods.

Recommendations

Visits to the situation rooms in the states of Goiás and Pernambuco demonstrated that while emergency preparedness functions are established in policy, opportunities exist to help them function better in practice. All three states visited (the two mentioned above

plus Alagoas) indicated that they would like to improve their working relationship with CEMADEN. A CEMADEN visit to one state occurred without prior notification of the state government, preventing a coordinated visit. Another state indicated that CEMADEN does not ask the states for hydrologic data, and furthermore that the state does not know who at CEMADEN to contact if they have useful data to share. This distant, overly centralized impression was exemplified in one instance by a CEMADEN-issued landslide warning for a flat area. Because CEMADEN is a very new institution with a very broad mission, such growing pains are perhaps understandable. Discussions with CEMANDEN indicated that the institution is sensitive to the concerns of states and is working to improve its relationships, and is in discussions with ANA and CPRM to be included in ANA's agreements with the states. Still, these issues show that the Brazilian system for emergency preparedness, which divides responsibility into many agencies at several levels of government with little overlap, requires close coordination and good working relationships to function. Fortunately, poor working relationships can be repaired through cooperative activities, conferences, and training. The benefits of improving the relationships between the agencies responsible for emergency preparedness are likely to be great, while the costs would almost certainly be much lower than any conceivable structural or even non-structural flood risk reduction measures. In the United States, the public often reacts negatively to news of government training events and conferences, seeing these as a waste of money. As a result, USACE experience has shown that it is important to communicate the need for these activities carefully. While such concerns may not be as great in Brazil, it is an issue to consider.

A more concerning issue relates to the capacity of the states to actually perform their assigned preparedness tasks. Brazilian law and policy assigns the states great responsibility for managing risk in their own areas, but poor states may not have the resources to carry out these activities effectively. For example, the entire Civil Defense force for the state of Alagoas consists of only fourteen people, making it challenging at best to warn the population of an impending flood anywhere in the state at any time. It would be naive to simply recommend increasing the number of staff at the state levels, given funding limitations. Instead, perhaps a system can be devised to share capacity across state lines, so that staff in one state where no flood is occurring can assist a neighboring state in need. At the same time, limited state resources could be used more efficiently. The state situation rooms are typically staffed at all times, whether an emergency is occurring or not. This improves readiness during a crisis, but may strain that capacity at other times, when an emergency does not require constant staffing. The possibility of staffing the situation room based on the likelihood of an emergency at a given time in a given area, rather than constant staffing, could be studied.

4.2.4 Emergency Response

Emergency response functions during and after a flood include evacuation, search and rescue, and emergency provision of essentials such as food, water, and medical care. CENAD coordinates these activities on the national level, while the municipalities and state Civil Defense agencies provide services and distribute supplies locally. CENAD determines when a flood constitutes an emergency situation for the purposes of federal assistance, as a function of the size of the event as well as the capacity of the affected area. CENAD also coordinates the Disaster Help Group (GADE), a rapid-response group consisting of both CENAD staff and outside specialists who operate on an on-call basis. Emergency supplies of food, water, bedding, clothing, etc., were formerly warehoused at several locations around the country for immediate distribution as needed, but this system proved wasteful as perishables would expire before they were needed. Now, CENAD has developed contracting mechanisms with private companies to provide these supplies anywhere in the country on short notice for a fixed price. USACE emergency management uses a similar contractual arrangement to provide supplies during and after an emergency. Private contractors may also be used for search and rescue operations along with units from the military and the ministry of health, again all coordinated by CENAD.

Recommendations

As with the other macro-functions, the strategy for emergency response established by Brazilian policy requires close coordination between agencies to function effectively. In particular, CENAD must manage disasters without the benefit of meteorological or hydrological modeling, using only publicly available information or the information they receive from CEMADEN. This is somewhat similar to the experience of USACE emergency management offices during a flood, which rely on the models and forecasts of another office (typically the Hydrology and Hydraulics Branch of the Engineering Division), or on another agency entirely (the National Weather Service and/or the National Hurricane Center). Close coordination and strong working relationships are essential in this situation, and close personal relationships can be helpful in some cases.

It is also worth emphasizing that after a disaster, the Brazilian public will frequently donate large quantities of supplies, which are distributed by the state Civil Defense. This can represent a significant form of emergency response, and is a result of the social capital possessed by the Brazilian people that should be used, cultivated, and recognized.

4.2.5 Recovery and Learning

The recovery and learning function encompasses assessing damages, mitigating impacts, and creating the conditions for the resumption of normal life. It also includes creating

damage reports and a database of disasters to learn from prior experience. Municipalities are responsible for damage assessment, while CENAD maintains the database of disasters and the Ministry of National Integration maintains a computerized system to track data and resources related to disaster recovery.

Recommendations

ANA Document 2.1 contains relatively little information on the recovery function, which is one of the biggest components of disaster risk management in the United States. In particular, there is no mention of rebuilding of private or public property after a flood, nor is there mention of post-flood reporting describing how the flood was managed in the event and identifying lessons learned for the future. This information is missing from both the text of the document and the institutional matrix. Based on discussions with ANA staff, it appears that this is an area where the consultant who wrote ANA Document 2.1 did not provide a complete description of institutional functionality, rather than a functional area that is truly missing in Brazil. The websites for the Civil Defense and the Ministry of National Integration do contain information about recovery activities. Although it is not necessarily in ANA's mission to perform activities in the recovery phase, as the national water agency ANA has a unique ability to advocate for policies throughout the disaster management cycle. If policies are lacking in this functional area, ANA may advocate or petition for such policies.

4.3 Institutional Frameworks

To explore how flood risk management is performed in Brazil versus the United States, the Brazilian institutions with roles in this area may be compared to their equivalents in the United States, if any. Contrasting how these functions are divided and coordinated among agencies in the two countries also helps illuminate the differences between the two approaches, and helps generate recommendations for further development.

4.3.1 Federal Actors

4.3.1.1 Ministry of Environment

4.3.1.1.1 **Agência Nacional de Águas (ANA)**

The National Water Agency was created by Law 9984 of the year 2000, for the purpose of implementing the National Water Resources Policy. Brazil's government is structured such that the states have a high degree of responsibility for management of flood risk within their borders, yet the federal government collects and distributes most government revenue. This creates a situation where state functions must be both highly coordinated and heavily supported by the federal government, though the federal union itself performs little actual design, construction, or operations. This situation points to the need for ANA, a facilitative, coordinating agency that synchronizes federal action and supports

the states so they can take care of themselves. Legally, ANA has three roles related to flood risk management: planning and promoting actions to reduce the risk of floods and droughts, defining and overseeing reservoir operations to ensure the multiple uses of water resources, and coordinating the annual report on dam safety. Accomplishing these tasks requires further sub-tasks including modeling, research and development, inspections, contracting, legal compliance, and communications, among others.

The United States does not have an equivalent for ANA, or a national water resources policy to implement. Each of the States funds its own budget through the collection of income, sales, property, or other taxes from its citizens, rather than receiving general operational funds directly from the federal government. At the same time, federal government agencies have a direct role in planning and constructing projects, preparing for disasters, and responding during and after a flood. As a result, a facilitative, coordinating agency for water resources is not such an essential figure in the United States as it is in Brazil, though it is possible that a national water agency could still have a useful role in the United States.

4.3.1.1.2 **Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA)**

The Brazilian Institute of Environment and Renewable Natural Resources executes and enforces the National Policy for the Environment, ensuring natural resources are conserved, used wisely, and promoted. In terms of flood risk management, IBAMA's most important functions include enforcement of environmental permits in accordance with the Ecological and Environmental Zoning (ZEE) and permanent preservation areas (APP), which may be used to restrict development in the floodplain.

The equivalent agency in the United States is the Environmental Protection Agency (EPA), which establishes and enforces regulations for protection of the environment. In terms of flood risk management, the EPA has a relatively minor role, limited mainly to providing information and incentives for urban stormwater management. A role somewhat analogous to IBAMA's preservation areas is played by the National Park Service, when areas along waterways are managed as parks instead of developed. In most areas, however, zoning is a matter for local city or municipal governments.

4.3.1.2 Ministry of National Integration

4.3.1.2.1 **Secretaria Nacional de Proteção e Defesa Civil (SEDEC)**

The National Protection and Civil Defense System consists of national, state and municipal components, with the organization of state and municipal components varying by local area. Among its many functions, the Civil Defense plays an important role in flood preparedness and response, by conducting preparedness training, warning the

public, and evacuating residents. It is important to point out that while CENAD is a part of the National Protection and Civil Defense Secretariat (SEDEC), the larger Civil Defense system receives the alert of an impending flood through CENAD.

The United States no longer has a standalone Civil Defense board or administration, its duties having been absorbed into the Federal Emergency Management Agency (FEMA) upon its creation in 1979. FEMA conducts some of the same functions as the Brazilian Civil Defense, such as coordinating federal response actions and conducting training. Other actions are dispersed through other agencies, such as medical response through the Department of Health and Human Services, and flood warning by the National Weather Service. Search and rescue operations are most often performed by the US Coast Guard, by the National Guard of each state, or by local emergency services such as police and fire departments.

Centro Nacional de Gerenciamento de Riscos e Desastres (CENAD)

As mentioned above, the CENAD is part of SEDEC, but it merits special mention due to its critical role in disaster preparedness and response, including floods. CENAD consolidates information on flood risks, monitors levels of risk, creates a flood alert and passes it to the larger Civil Defense System, and coordinates the federal response to disasters. The CENAD does not have its own modeling or forecasting capability, relying instead on forecasts made by CEMADEN or ANA and information from ANA, CPRM or on publicly available information to create an alert.

The flood warning function of CENAD is performed in the United States by the National Weather Service, which is the official river forecaster to the public (tropical cyclone forecasts and warnings are performed by the National Hurricane Center, but as ANA's mission is not coastal and tropical storms are rare in Brazil, this will not be discussed in detail). The response coordination function is generally performed by FEMA, with actual response functions performed by many state, local, and federal entities, as in Brazil.

4.3.1.2.2 **Departamento Nacional de Obras Contra as Secas (DNOCS)**

DNOCS operates in a specific region of the country (the "drought polygon" consisting of parts of nine northeast states), constructing works to improve the region, combat droughts, and facilitate irrigation. While its works may not be specifically or intentionally formulated for flood-risk management, large water supply reservoirs can serve to attenuate a flood wave even without a gated spillway or a dedicated flood-control volume. Several DNOCS dams do have a flood-control volume allocated.

The closest analogue to DNOCS in the United States is the Bureau of Reclamation, which constructs and operates works in 17 western states to ensure water supply and

hydroelectricity in this mostly-drier part of the country. Bureau projects are typically multi-purpose, providing flood control and reliable navigation along with water and power. However, any reservoir constructed with federal money must regulate its flood control (and navigation) storage in accordance with regulations defined by the Corps of Engineers (Sec. 7 of the Flood Control Act of 1944).

4.3.1.2.3 **Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba (CODEVASF)**

The Company for Development of the Valleys of the São Francisco and Parnaíba rivers is a public company established by the Brazilian federal government to promote economic development in this area. It performs several kinds of projects investing in sustainable local agriculture and rural communities, with water resource infrastructure being only a subset, though an important one, of the overall strategy. It is particularly well known for large multipurpose reservoirs and inter-basin transfers of water for irrigation. Although few CODEVASF dams were constructed for the purpose of flood control, by their sheer size they play a significant role in attenuating peak flows.

The closest equivalent to CODEVASF in the United States is the Tennessee Valley Authority (TVA). Like CODEVASF, the TVA was founded to develop a specific, economically poorer part of the country (the Tennessee River Valley). Also like CODEVASF, the TVA functions in some ways like a private company, receiving funding directly from its customers rather than from the federal budget. In contrast to CODEVASF, however, the TVA serves a more humid part of the country, so its infrastructure is more focused on hydropower and flood control than water supply.

4.3.1.3 Ministry of Mines and Energy

4.3.1.3.1 **A Companhia de Pesquisa de Recursos Minerais (CPRM)**

The Brazilian geological service performs many earth science research functions for Brazil. Their functions related to flood risk management include: coordinating and executing hydrologic surveys, developing information systems and maps, and carrying out research. They are the main operator of ANA's hydrometeorological network, and are also an important cooperator for many state networks.

The United States Geological Survey (USGS) is the analogous agency in the United States. The USGS also performs hydrological surveys, maintains a large network of hydrometeorological stations, and performs research. It also works in cooperation with other agencies, being funded in large part through reimbursable work performed for its partners.

4.3.1.3.2 **Empresa de Pesquisa Energética (EPE)**

The Electrical Research Company performs many kinds of research on energy sources, efficiency, and planning. It has only a small role in flood risk management, insofar as it performs studies to investigate the optimal locations for hydroelectric development, which can then influence the layout of the dam network.

The United States Department of Energy is the US equivalent to EPE. USDOE also performs studies of US hydropower potential, producing maps of potential new hydropower development as well as existing dams with capacity for electrification. USDOE performs these studies through the Water Power Program at Oak Ridge National Laboratory. In practical terms, the impact of these studies on flood risk management in both countries is minor.

4.3.1.3.3 **Operador Nacional do Sistema Elétrico (ONS)**

The National Electrical System Operator coordinates and controls operation of electric power generation and transmission within the interconnected national grid (SIN). Because hydropower represents 75% of the installed electrical generation capacity in Brazil (with its share of actual generation reaching nearly 90% in some wet years), ONS is closely involved with flood control because it decides when and where to generate energy through the release of water at hydroelectric dams. Many hydropower dams in Brazil lack gated spillways, so the only way to maintain a flood control pool in these reservoirs is through generation of power, or by sluicing flow through the turbines (which is not desirable because it puts hours on the turbine without generation of electricity or revenue), or by holding water in another dam upstream. Therefore, ONS must consider system-wide flood risk balancing when balancing electrical generation across the national grid. ONS also creates annual flood prevention plans for the reservoirs within the SIN, defining the flood control pools for these reservoirs based on the acceptable risk of flooding on each reach of the rivers in the SIN.

In the partially deregulated US electricity sector, there is no direct equivalent to ONS. The Federal Energy Regulatory Commission (FERC) is responsible for licensing of hydropower facilities (in addition to other power sources), and the North American Energy Reliability Corporation (NERC), a non-governmental nonprofit industry group, makes rules for ensuring a reliable power supply, but neither of these specifically directs the operations of hydropower dams. Utilities are free to generate as much power as they can sell on the market and transmit safely to customers. Although hydropower plants have the ability to increase or decrease energy output quickly, hydropower in the United States is used more for base load than for peaking, which is often accomplished with thermal plants fired by relatively cheap natural gas. In addition, most hydropower plants in the United States have gated spillway structures that allow them to release water

without generating power. These facts, combined with the relatively small share of US energy produced by hydropower, reduces the need for a national grid operator to balance energy generation with water releases for other purposes.

4.3.1.3.4 **Agência Nacional de Energia Elétrica (ANEEL)**

The National Electricity Regulatory Agency licenses hydropower dams as part of its mandate to regulate and inspect the production, distribution, and sale of electric energy in Brazil. This makes it responsible for inspection of dams whose primary purpose is hydroelectricity generation. ANEEL's inspection mandate covers a large number of dams, particularly large dams, but these still represent a relatively small fraction of the total number of dams in Brazil.

The FERC is the electricity regulator in the United States, and performs dam safety analyses for hydropower dams during the licensing process, safety inspections during construction, and periodic inspections post-construction. Other federal agencies such as the Bureau of Land Management, the US Fish and Wildlife Service, and the National Marine Fisheries Service may add mandatory conditions to a FERC license, though they would likely do so for environmental, rather than flood risk management, reasons. The Rivers and Harbors Act of 1899 prohibits construction of any dam or dike across any navigable waters of the United States without the approval of the Chief of Engineers and the Secretary of the Army, meaning that an Army Corps of Engineers permit is required for construction of a hydropower dam on a navigable river. The USACE may choose to serve as a cooperating agency in the FERC licensing process, or perform its permitting function separately.

4.3.1.3.5 **Departamento Nacional de Produção Mineral (DNPM)**

The National Mineral Production Department performs many functions related to mining, mine safety, and mineral production. Its role in flood risk management is through its mandate to ensure the safety of mine tailings dams, which are numerous in Brazil and have caused several disastrous floods in the past due to failures. DNPM defines the frequency of tailings dam inspections, the content of the inspection reports, and the qualifications of the inspectors.

The Mine Safety and Health Administration, within the US Department of Labor, is responsible for inspections of mines, including tailings dams. Under the Federal Mine Safety & Health Act of 1977 as amended (Sec. 103(a)), all mines must be inspected at least twice per year. All tailings dams must be inspected during these times to ensure conditions do not represent a hazard to miners, with more detailed inspections required for dams depending on the potential consequences of a failure.

4.3.1.4 Ministry of Defense

4.3.1.4.1 **Brazilian Army**

The engineer battalions of the Brazilian Army have performed water resource engineering and construction since 1855, during the time of the Brazilian Empire. The Army does not initiate projects, instead performing services when requested and funded by another agency. In this way it serves as a kind of internal contractor to the Brazilian federal government. The Army may be used in construction of dams, channels, dikes, etc. when directed through an authorization, as well as for search and rescue operations and emergency repairs of roads, bridges, etc. when requested by CENAD. The Army may also be used for demolition or deconstruction, as when a dam has been identified as being unsafe but its owner cannot be found.

The United States Army performs flood risk management design, engineering, and construction missions through its active-duty engineer battalions as well as the district offices of the US Army Corps of Engineers. Army National Guard Units may also perform search and rescue functions during or after a disaster. The US Army Corps of Engineers is the world's largest engineering, design, and construction-management agency, with many water resource projects related to flood risk management and coastal storm damage risk management.

4.3.1.5 Ministry of Science, Technology, and Innovation

4.3.1.5.1 **Centro Nacional de Monitoramento e Alertas de Desastres Naturais (CEMADEN)**

The National Center for Monitoring and Alerts of Natural Disasters was created in 2011 to alert the government of impending disasters, perform research and development related to disaster management, develop observation systems for disaster warning, and build capacity and training in these areas. CEMADEN is currently focusing its warning activities on 821 of Brazil's 5,570 municipalities, which were strategically chosen to represent 80% of the nation's risk of floods, flash floods and landslides. In the coming years, more municipalities will be added to this list, gradually expanding CEMADEN's mission until it issues warnings for the entire country.

In the United States, the National Weather Service is responsible for monitoring, modeling, and warning the public of river floods. The NWS issues warnings and forecasts directly to the public in addition to other government agencies, meaning that it serves some of the purposes of ANA, CEMADEN and CENAD. However, the NWS does not develop all of its own models. Instead, it relies on other entities such as the Army Corps of Engineers, academia, and international partners to develop software and collect data for modeling purposes. The NWS encourages the use of "community models" that can be used by all partner agencies without license or ownership

restrictions, to develop effective and consistent prediction tools across the government sector. Basic research and training are also not typically a part of the National Weather Service's functions, though they do produce post-event reports to capture the forecast performance and lessons learned for future reference. Basic modeling and forecasting research is performed by the academic community and by other government agencies, such as the US Geological Survey and US Army Corps of Engineers.

4.3.1.6 Ministry of Health

4.3.1.6.1 **Sistema Único de Saúde, (SUS)**

The Unified Health System plays an important role in response to and recovery from floods and other disasters. The Ministry of Health, through the SUS, has the power to declare a public health emergency, allowing emergency provision of medicine, water purification kits, and other health supplies to the affected area. The SUS also owns mobile hospital units and has the ability to establish temporary field hospitals rapidly. Much of the post-disaster emergency medical response and public health outreach is undertaken by the Unified Health System National Force (FN-SUS) which is an organization of over 12,000 volunteers in various specialties. The FN-SUS helps assist victims and manage epidemiological risk when the capacity of the state or local municipality has been overwhelmed. Accordingly, the state or municipality must declare an emergency in order to request the support of the FN-SUS. In addition to its volunteer workforce, the FN-SUS also has a small full-time staff of healthcare professionals, the PN-SUS. The FN-SUS may also utilize local services such as Civil Defense and firefighters as part of a coordinated disaster response.

Healthcare provision in the United States is quite different from Brazil, but the US government does perform some functions in disaster response and recovery that are analogous to the SUS. In the United States, the Department of Health and Human Services (HHS) is responsible for medical and public health response to disasters, primarily through the Centers for Disease Control and Prevention (CDC) US Public Health Service (USPHS). The CDC may provide emergency water supply planning and health evaluations for previously flooded areas, while the Public Health Service, including the USPHS Commissioned Corps under the Command of the Surgeon General of the United States, can deploy to disaster areas to provide emergency medical and health services. Nevertheless, most emergency medicine in the United States is carried out by local emergency services, which may be associated with local police or fire departments. Federal deployments are relatively rare.

4.3.1.7 Ministry of Cities

4.3.1.7.1 **Secretaria Nacional de Saneamento Ambiental (SNSA)**

The National Secretariat of Environmental Sanitation works to ensure universal access to high-quality drinking water; sewage collection, treatment, and disposal; solid waste management; and urban stormwater management including flood control. In many cities and towns in Brazil, the storm drainage system and sanitary sewer system are still the same, so that management of sewage and stormwater are two parts of the same challenge. There is an ongoing effort to improve sewage treatment in existing cities, and many new developments have separate sewage and stormwater systems. In many parts of Brazil, however, untreated sewage is still discharged directly to the urban drainage system. The SNSA provides sanitation services to municipalities with more than 50,000 inhabitants or which are members of metropolitan regions or integrated development regions. For municipalities smaller than 50,000 residents, the SNSA acts by financing water supply and sanitation development. In accordance with the National Law of Sanitation (Law #11,445 of 2007), sanitation plans (including urban stormwater drainage) must be consistent with the basin plan for the river basin in which they are located (article 19, par. 5, sec. 3).

In the United States, the Environmental Protection Agency is responsible for regulating local stormwater systems, including combined sewage and drainage systems. However, the major area of emphasis within EPA regulation of stormwater discharge is the quality of the discharged water, rather than the quantity. So the effect of this regulation on flood risk management is often incidental. When stormwater flooding creates a risk to life and property, the federal government, acting through an agency such as the Corps of Engineers, can undertake a study to determine if there is a federal interest in reducing this flooding. If so, the government can then implement structural and non-structural measures to reduce this risk.

Summary Table of Brazilian Agencies Involved in Flood Risk Management and US Counterparts

Brazilian Agency	US Counterpart
Agência Nacional de Águas (ANA)	none
Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA)	Environmental Protection Agency (EPA)
Secretaria Nacional de Proteção e Defesa Civil (SEDEC)	Federal Emergency Management Agency (FEMA)

Centro Nacional de Gerenciamento de Riscos e Desastres (CENAD)	National Weather Service (NWS)
Departamento Nacional de Obras Contra as Secas (DNOCS)	Bureau of Reclamation (BoR)
Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba (CODEVASF)	Tennessee Valley Authority (TVA)
A Companhia de Pesquisa de Recursos Minerais (CPRM)	US Geological Survey (USGS)
Empresa de Pesquisa Energética (EPE)	US Department of Energy (USDOE)
Operador Nacional do Sistema Elétrico (ONS)	none
Agência Nacional de Energia Elétrica (ANEEL)	Federal Energy Regulatory Commission (FERC)
Departamento Nacional de Produção Mineral (DNPM)	Mine Safety and Health Administration (MSHA)
Brazilian Army	US Army, USACE
Centro Nacional de Monitoramento e Alertas de Desastres Naturais (CEMADEN)	NWS
Sistema Único de Saúde, (SUS)	US Public Health Service (USPHS), Centers for Disease Control and Prevention (CDC)
Secretaria Nacional de Saneamento Ambiental (SNSA)	EPA

Table 1: Summary table of Brazilian Federal Agencies involved in flood risk management and their closest US counterparts

4.3.2 State Agencies

In Brazil, as in the United States, there is great variety among the states in the organization of government function. State agencies and departments in one state may house functions that, in other states, are distributed differently or not performed at all. In addition, the organization of agencies in some states tends to change frequently, as new governors reorganize their departments to reflect their priorities. Therefore, rather than examining specific state agencies, ANA Document 2.1 mentions three core systems: environment, water resources, and civil defense. The environment system provides services such as planning and zoning for development and occupation of territory. The

water resource system also does some planning, such as for water resource infrastructure, but also operates reservoirs, monitors river stage and discharge, creates river forecasting models, and produces forecasts. The civil defense system provides numerous preparedness and response functions such as alerting the public, assisting with evacuations, and constructing temporary shelters. Other functions, such as public works, may be involved in flood risk management, but are not necessarily so. Which of these core functions initiates flood risk management actions in a given state may be indicated by the location (physically and organizationally) of the ANA situation room within the government. Regardless of who initiates the action, each state must provide at least these three core functions in order to manage flood risk within its borders.

In the United States, the same three core functions must be performed, though the organization of these functions varies greatly by state. The environmental regulatory function is common to all states, though the impact of this function on flood risk management is generally minor and secondary. Evaluating applications for environmental permits and delineating conservation areas tends to improve flood risk by maintaining ecosystem services. For example, a healthy forest provides water storage that attenuates floodwaves, and a stable coastline or riverbank prevents water bodies from encroaching on inhabited areas. Nevertheless, these decisions are typically evaluated in terms of environmental quality, rather than flood attenuation or restriction on development in risky areas.

Water resources management in the United States follows a clear east/west divide. Historically, the 100th meridian west has been used as an approximate boundary between the eastern and western United States. States that are wholly or partly west of this longitude typically use some form of the "prior appropriation" legal doctrine for water rights, which allow water rights to be owned, and in some cases sold or traded. As a result, these states tend to have a Department of Water Resources or related agency within their government, to handle issues related to water rights and scarcity. States that are east of this line tend to follow the legal "riparian doctrine," which does not treat water as a commodity that can be owned. As a result these states do not typically require a standalone water resources agency, instead giving the water resource management function to other departments, such a department of environment. Regardless of organizational structure, these departments have an impact on flood risk management when they plan and operate water storage or diversion infrastructure and provide or assist with flood forecasts.

State governments in the United States, like the federal government, do not have a dedicated civil defense. Instead, they have their National Guard, with some states also having a State Defense Force (sometimes also known as State Guard or National Guard Reserve). The National Guard of each state serves a dual role as both the militia of each

state and a reserve military force of the United States. When called to federal duty, National Guard members and units serve alongside regular military units. At all other times they are available to be activated by the state governor, including in response to man-made or natural disasters such as floods. When responding to floods, these units may perform duties such as flood-fighting with sandbags or other temporary barriers, distributing food and medical care, setting up shelters, or preserving order. The State Defense Force (if a state has one) will supplement these forces or replace them during times of federal need, operating under the sole command of the state governor. These units provide many of the same civil defense functions in flood risk management as the National Guard.

4.3.3 Local Agencies

In Brazil, municipalities have the constitutional authority to plan the usage of local land, as well as to perform local civil defense functions. Both of these are important elements of managing the risk of floods, but their application may be more theoretical than practical in some cases. This is because many Brazilian municipalities lack the necessary organization to produce and enforce land-use plans, or the resources to mount an effective civil defense. These municipalities are reliant on the state and/or federal union for assistance. For larger, better funded cities, however, local planning and emergency response may represent a significant component of overall risk management.

Local capacity is also highly variable in the United States, with some cities having highly developed planning and emergency response agencies, while some small towns are little more than designated places, without any local services at all. Most cities do at least have their own zoning ordinances, which determine how and where land may be developed. These regulations may include flood risk elements, such as restrictions on development in the floodplain or requirements for on-site stormwater management. One clear distinction between Brazil and the United States is the provision of emergency medical services. In Brazil, emergency medicine or paramedicine may be provided by municipal fire departments, by the corps of military firefighters within the state government, or by the federal Unified Health System. In the United States, the responsibility to provide emergency services falls much more heavily on the local government (city or county). While the state National Guard or the US Public Health Service may deploy to the site of a flood or other emergency, in practice these deployments are rare and typically occur only due to a major national disaster. As a result, local emergency services typically bear the major burden of emergency medical response in the United States, even during natural disasters such as floods.

4.3.4 River Basin Committees

In accordance with the Brazilian National Policy for water resources, the watershed is the territorial unit for implementing that policy as well as the National System for Water Management. The governing body at the watershed level is the River Basin Committee, with the River Basin Agency serving as its executive counterpart. This governance structure allows the committee to make rules and policies that are sensible for its watershed, rather than creating policies at the state level to apply to all watersheds in the state. Furthermore, the committee system helps with inter-state watersheds, because delegates from each state can serve together on the committee to help ensure the needs of each state are met. This system has its drawbacks, however. First, many watersheds do not have committees established, or have committees that are inactive or minimally active. The most heavily utilized watersheds tend to have the most active and effective committees, while those that are important for non-economic reasons, such as environmental sensitivity, tend to have less active committees or none at all. Second, the power and monetary resources of the committees is limited, because the funding for the committee and agency come from usage fees. If usage is low, or if fees are set at a low level for political or other reasons, the committee and agency may not have the funding needed to carry out governance or enforcement.

The United States does not have river basin committees, nor is there a distinction between state and federal rivers. No national water law, policy, or system exists to specify how water is managed across the United States; rivers are the legal domain of the states in which they exist. Where rivers cross state boundaries, interstate water compacts (legal agreements) may exist to specify the quantity and timing of required water deliveries from state to state (see USACE Document 4.1). These compacts are often required by the federal government before a federal water project will be constructed on an interstate river. Where rivers cross international boundaries, treaties exist to specify how water is shared between countries, with commissions and boards established to address particular issues. The International Joint Commission exists to resolve disputes between the United States and Canada in accordance with the Boundary Waters Treaty of 1909, while the International Boundary and Water Commission exists to administer the many water rights treaties and agreements between the United States and Mexico.

4.3.5 Role of Entrepreneurs and the Public

The role of the entrepreneur in flood risk management is very significant in Brazil, as many dams are constructed and operated by private enterprises for hydropower generation. Some of these are multipurpose reservoirs with an explicit flood control function, but even dams built only for hydropower can play an important role in attenuating a flood wave. Dams in Brazil are operated in accordance with licensing conditions and with the annual flood prevention plan set forth by ONS and ANA.

Furthermore, actual reservoir releases are prescribed by or coordinated with ONS. Therefore it may seem that the entrepreneur has little role in actually determining the flood risk faced by the communities downstream of the dam. However, the dam operator helps determine the flood control volume in the reservoir along with ONS. If a downstream flood occurs due to the design event being exceeded, the entrepreneur could be held responsible, though this liability is not legally clear. The entrepreneur also has little incentive to minimize the flood control pool in order to maximize power generation, because payments for power are based on availability and capacity, rather than actual generation. This tends to reduce the incentive to take unnecessary risks, though it may reduce power generation. As a result, the entrepreneur must balance the risk of downstream flooding against power generation capacity and availability when determining the flood control pool, which then affects the downstream flood risk.

In the United States, entrepreneurs have a much smaller role in flood risk management. Hydropower is a much smaller part of the United States' energy portfolio, making up about 6% of US electrical power, as opposed to its 75-90% share in Brazil. Moreover, while 70% of hydropower facilities are owned by private sector entities, these plants represent less than 30% of the hydroelectric generation capacity of the United States. This indicates that most large storage projects are in the hands of the public sector, with private owners responsible mostly for smaller projects that are less critical to overall flood risk management.

4.4 Legal Frameworks

ANA Document 2.1 provides little detail on the legal frameworks surrounding flood risk management in Brazil, instead focusing mainly on institutional actors and functions. To the extent that is does discuss legal doctrine, it is mainly in addressing the definitions of various terms used in flood-related policies and laws. The following analysis is based on the limited information in ANA Document 2.1, supplemented with information provided by ANA personnel.

4.4.1 Constitutional Provisions

The Brazilian Constitution of 1988 includes several provisions related to floods and disaster risk management. *Article 21* is the only one dealing specifically with floods, stating that the federal Union has the exclusive competence (see section 4.2) to plan and promote defense against public calamities, such as droughts and floods. In other words, these functions must be performed at the federal level and cannot be delegated to lower levels of government.

Water related constitutional provisions are included in several articles. *Article 21* states that the Union has the competence, in coordination with the states, to explore energy

production from water sources. Because many dams in Brazil are constructed for generation of hydropower, this is a significant provision for overall flood risk management. *Article 20* defines as federal goods all lakes, rivers, and watercourses located in the federal domain, or which cross two or more states, or are international boundaries, or flow to or from other countries, or are river beaches. This provision is vital to understanding how jurisdiction for flood risk management (and all water management) is divided between federal rivers and state rivers. State rivers that are tributaries to federal rivers remain in the jurisdiction of the states, but in cases where ambiguity could exist between state and federal control, the federal government has determined which rivers are state and which are federal. *Article 22* states that the Union has the private competence (can be delegated to the states) to legislate water issues in general terms, though the states can pass laws on specific subjects. *Article 26* specifies that surface and ground water not belonging to the Union is the purview of the states.

Disaster risk management is covered in *Article 22*, which states that the Union has the private competence to pass laws relating to Civil Defense. *Article 144* also addresses this area, stating that firefighters, in addition to their legal attributions, should execute civil defense activities.

Master planning and the organization of territory are important tools for managing flood impacts, restricting development in flood-prone areas, and reducing impacts that could increase risk. Such planning is covered in several parts of the constitution. *Article 21* states that organization plans for national territory is the competence of the Union, while *Article 25* specifies that planning for regional territory is the competence of the states. *Article 30* states that urban planning is the competence of the municipal government. *Article 182* specifies that all municipalities with more than 20,000 inhabitants should have a master plan.

Compared to the United States Constitution, the Constitution of Brazil is much more detailed and specifies the parts of government that should perform specific roles relating to water and floods. The United States Constitution, in contrast, is more focused on restricting the government's power, specifying the kinds of laws which may not be passed. This is doubtless the result of the different histories of the two nations and reflective of the moments in history when the two documents were written. As it relates to development of federal regulatory policy regarding flood risk, the Brazilian Constitution provides an excellent framework to implement requirements for the purpose of better flood risk management.

4.4.2 Federal Laws and Policies

In addition to the provisions in the Constitution, there are several federal laws in Brazil that are vital to flood risk management. Law 6,983 of 1981, the National Policy for the

Environment, does not mention floods specifically, but endows IBAMA with the responsibility for environmental permitting, including permitting of structural works relating to flood risk reduction. Because this permit is required for any structural measure, it is an essential part of any flood risk reduction planning.

It is not surprising that Law 9,433 of 1997, the National Water Policy, has several important elements relating to floods. The goal of this policy, described in Article 2, is the "prevention and defense against hydrological critical events of natural origin or due to improper use of natural resources." As floods are clearly a type of hydrologic critical event, this makes flooding-related matters a central part of this policy. Article 3 specifies that floods are related to land use and environmental stewardship. This is an important point because many flood issues in Brazil are related to imperfect land use practices, such as occupation of the floodplain or erosion from farmland reducing river channel capacity through sedimentation in rivers. Finally, Article 7 addresses water resource plans, specifying that these plans should account for factors such as land use and population growth when properly managing water resources to reduce the effects of flood. This is a vital point. As described by Tucci (2002) and discussed in section 4.2.2, sometimes a structural solution can actually increase long-term flood risk rather than reducing it, by encouraging people to move into a floodplain which may become more hazardous as conditions change. By requiring future land use changes and population growth to be considered in water resource plans, Article 7 prevents short-term benefits from becoming long-term liabilities.

Law 10,257 of 2001, the City Statute, specifies in Article 2 its goal of "land use control and organization to avoid the risks of disasters to the population." In Article 4 it specifies the particular instruments to be used in such planning, including national, state, and regional plans for the organization and development of territory. Other instruments include municipal master planning, planning for subdivision of land, zoning for land use and occupation, and environmental zoning. This law is basis of the master planning which can restrict development in flood-prone areas and preserve the environmental services provided by natural areas that reduce flood frequency.

Environmental goods and services are also protected by Law 12,651 of 2012, the Native Forest Protection Law. This law protects forests by defining permanent preservation areas (APP) along river banks and along the edges of lakes, lagoons, and reservoirs. These areas reduce flood risk by increasing infiltration and storage of rainwater, by preserving floodplain areas that store and attenuate floodwaves, and by reducing the erosion that can reduce reservoir storage capacity and river channel capacity.

Law 12,334 of 2010 is the National Dam Safety Law, specifying that the dam operator, whether public or private, is responsible for dam safety. Article 12 of this law provides

specific requirements for dam emergency actions plans, stating that these plans must have strategies for alerts and other public outreach, including how communication should occur with authorities such as the civil defense. Article 18 clarifies that private entrepreneurs who do not follow safety requirements must repair or deactivate their dam. If they fail to do so, the federal authorities can repair the dam at the entrepreneur's cost. As a country with many dams, some of which have unknown owners and histories, the dam safety law is a very important one.

The National Policy of Protection and Civil Defense is specified in Law 12,608 of 2012. This law requires management of risk and disasters to focus on prevention, mitigation, preparation, response, and recovery actions. These functions are mirrored in the institutional macro-functions discussed in section 4.2.

In addition to these laws, several national policies regarding flood risk management bear mentioning. The National Plan for Risk Management and Response to Natural Disasters (published 2012) coordinates all the plans of the various relevant ministries (Integration, Cities, Science and Technology, Mines and Energy, Environment, and Foreign Affairs) into a single plan coordinated by the President's chief of staff (civil house). This is also the policy that defines the 821 priority municipalities (so far) to receive special monitoring by CEMADEN. These were chosen because they represent 88% of the people affected by floods and landslides in the country.

The CENAD/CEMADEN protocol was established in 2013 by ordinance 149. This decree indentifies the roles and actions of these two agencies relating to alerts, and guides how they should coordinate with states and municipalities. Because both of these agencies must coordinate with each other and with local partners, this ordinance is key for flood forecasting, response, and recovery.

Finally, the ANA/CPRM/CENAD/CEMADEN protocol was established by ordinance 148 of 2013. This protocol aims to create an integrated system of forecasting and monitoring of floods, enabling better preparation for floods and related disasters. This cooperative approach improves performance, reduces wasteful duplication, and allows better institutional learning than would be possible if each agency were to work alone.

While the United States has federal policies for flood risk management, and national frameworks to specify coordination mechanisms, in general they do not reach the level of specificity as these Brazilian federal laws and policies. Specific subjects such as dam safety remain the purview of particular agencies, such as USACE, BoR, and FERC. Working groups and boards exist to coordinate the activities of agencies, but these are usually organized by the agencies themselves rather than specified in law. The approach in the United States is arguably more flexible, but with the potential for less clarity and unity of vision. At various points in history, attempts have been made to establish a

national water policy for the United States that might be somewhat analogous to Brazil's, from the 1973 *Water Policies for the Future* report from the National Water Council to H.R. 3202, the (proposed) Water Protection and Reinvestment Act of 2009. Thus far, however, none of these attempts have been successful.

4.4.3 State Laws and Policies

As the nation with the most freshwater in the world, water issues in Brazil have always been important, leading the states to legislate on floods and water issues since early in the country's history. In fact, state laws in Brazil regarding various water issues pre-date federal water laws. In 1991, São Paulo was the first state to enact a comprehensive water law specifically mentioning concern over floods. Since the state of Roraima passed its water law in 2006, every Brazilian state now has a water law. Each of these laws addresses flood risk management in some way, either through objectives to be met, programs to be enacted, or principles or guidelines to be followed.

Various state laws exist in the United States regarding water, but few states have a single water policy. The few states that do have such policies tend to be in the drier western United States. However, some eastern states have recently been spurred to develop state-level water policies by some specific water issue, such as Georgia (population growth and environmental issues) and Florida (saltwater intrusion). Some states, such as Arizona and California, operate massive water transfer projects to move water to where it is scarce and needed. Such projects require many state laws and policies to build and operate. In general, water laws and policies vary from state to state to a greater degree in the United States than they do in Brazil. This is not surprising given the lack of a federal water policy in the United States, and the variation in style and history of government between states.

5.0 SIGNIFICANT SIMILARITIES BETWEEN FLOOD RISK MANAGEMENT IN THE US AND BRAZIL

5.1 National Planning Frameworks vs. Institutional Macro-Functions

ANA Document 2.1 describes five institutional macro-functions in Brazilian flood control: *prevention, protection, preparation, emergency response*, and *recovery*. The National Planning Frameworks describe five frameworks for delivering the disaster related capabilities in the United States' National Preparedness Goal: prevention, protection, mitigation, response, and disaster recovery. There are clear parallels between the functions and frameworks in use in the two countries. The *prevention* and *protection* macro-functions in Brazil are corollaries to the mitigation framework in the United States, as both describe risk reduction measures. The *emergency response* function is aligned with the response framework, describing actions to be taken as a flood or other disaster occurs. The *recovery and learning* function aligns with the disaster recovery framework, describing actions taken after the disaster. Only the *preparation* function in Brazil describes a particular responsibility that does not merit its own framework in the United States: the responsibility of forecasting and warning of threats, which is shared among several areas in the National Planning Frameworks. The prevention framework is the only one of the US frameworks without a corollary in the Brazilian macro-functions, being specifically about the risk of terrorist attacks. These differences highlight the different areas of emphasis in the two countries, which reflect their unique circumstances. But the similarities between the two nations' functional constructs in regards to disaster readiness are noteworthy.

5.2 Watershed-Based Management

In Brazil, the watershed is the territorial unit for water management, including flood-risk management. This is accomplished through the use of river basin committees and their corresponding agencies. The United States does not have river basin committees, and most water issues are delegated to the states. State borders may coincide with hydrological boundaries, particularly in the eastern part of the country, but these are the exception rather than the rule. Furthermore, water-based state borders tend to be shorelines or rivers, rather than watershed boundaries such as mountain ranges. Therefore, it may seem that this is a significant difference between water management in the two countries. However, there are certain aspects of flood risk management in the United States that are aligned with watershed boundaries. USACE districts and divisions, for example, are roughly aligned with watersheds. The 13 National Weather Service River Forecast Centers are also assigned watershed-based areas of responsibility. The Bureau of Reclamation has five organizational regions corresponding to major river basins in the western United States.

When water resources cross state boundaries in the United States, interstate water compacts can generate a watershed-based approach to state water resource management. Water compacts are legal agreements between states that help manage water distribution across state boundaries. In some areas, river basin commissions exist to help implement these compacts and resolve disputes, as with the Delaware River Commission described in USACE Document 4.1. In other instances, state agencies may enter into agreements to provide water resource services to other states in the same watershed, as when the Arizona State Water Bank stores water on behalf of the state of Nevada. Water and flood risk management along watershed boundaries is a much more developed concept in Brazil than the United States, but elements of this concept exist in both countries.

5.3 Federal Subsidy of Risk-Taking with Regard to Floods

Site visits in the state of Alagoas showed that in Brazil, a damaging flood will often result in population resettlement at federal expense. Flood-prone areas are condemned and new communities are constructed in a safer location, often with superior sanitation, education, and recreation facilities than before. This is a sensible strategy, reducing risk by moving people away from flood-prone areas along riverbanks. However, implementation of this strategy is problematic in practice. Frequently, people will repair and move back into their riverside properties, in addition to their newly constructed homes. The reasons for this are numerous: the old houses may be more conveniently located to work (or customers in the case of commercial properties); the river itself may provide water or other advantages not afforded by the new upland location, people may have a strong sense of place that makes them feel attached to their longtime homes, or their large family may simply need more room than a small government-built home can provide. Enforcement of restrictions on reconstruction is also problematic, as local politicians may be hesitant to stop their constituents from rebuilding their homes. State employees in Alagoas reported that political candidates may even campaign on a promise to allow reconstruction in risky areas, or provide utility connections in these areas at their own expense in an effort to win political support. Federal agencies with the authority to stop rebuilding in these areas may not have the resources or local knowledge to act. As a result, while the government intends to reduce flood risk, it effectively increases it. Citizens (and local governments) know that if they build in flood-prone areas and suffer damages in a flood, they may gain federally funded new construction projects, bringing work and housing to the area.

Figure 8: Reconstruction in the floodplain underway in União dos Palmares, Alagoas, where previously flooded buildings had been cleared by the government

A related kind of risk subsidy exists in the United States through the National Flood Insurance Program, which provides flood insurance at less than market rates for some properties. Originally intended to help reduce flood risk for homeowners while encouraging wise use of the floodplain, today the NFIP may actually increase risk by encouraging development in risky areas. Risk is still reduced from the perspective of the homeowner, but this risk is transferred to the government rather than reduced overall. There have been efforts to correct this effect by having the NFIP charge rates that reflect the actual risk of flooding, but, as in Brazil, such efforts are politically difficult. The Biggert-Waters Flood Insurance Reform Act of 2012 required NFIP policies to increase in price over time in order to reflect the true risk of flooding. However, the increases in policy premiums were highly unpopular, causing the law to be repealed in 2014 and replaced with the Homeowner Flood Insurance Affordability Act, which delayed implementation of several provisions of the Reform Act. These experiences show that in both Brazil and the United States, it can be very politically difficult to require citizens to face their true flood risk, and that policies intended to reduce risk may have the opposite effect.

Figure 9: Properties in Scituate, Massachusetts that have been destroyed multiple times by coastal storms and repeatedly rebuilt with funding from the National Flood Insurance Program

6.0 SIGNIFICANT DIFFERENCES BETWEEN FLOOD RISK MANAGEMENT IN THE US VERSUS BRAZIL

6.1 Centralization vs. Regionalization of Capacity

A major difference between flood risk management in the United States versus Brazil stems from the different structures of the two nations' federal governments. Although the overall structures of the two governments are quite similar (federal presidential constitutional republics with bicameral legislatures), the federal government in Brazil is less directly involved in local projects than in the United States. The Brazilian constitution is structured to increase local control and capacity by assigning many legislative and executive capacities to the states. The federal government provides technical and financial support to the states as needed. As a result, federal functions tend to be centralized in a few offices, requiring extensive coordination with state and local governments to leverage local expertise.

In the United States, many federal agencies have numerous local offices across the country. As examples, USACE has 39 district offices across the United States, the National Weather Service has 122 local Weather Forecast Offices, and the USGS has 42 local water science centers. Furthermore, federal agencies in the United States can undertake projects that benefit the nation, with or without the partnership of state governments (though today such partnership is very common). Expertise on local conditions is facilitated through local offices, in addition to partnership with local governments. As a result, more functionality is retained in the federal sphere, creating a larger federal government.

Each system has its advantages. The Brazilian system has the advantage of encouraging states to develop their own capacities, but at the cost of large variations in state effectiveness and reduced local familiarity within the federal sphere. The US system creates more uniform capacity for flood risk management across the country, but could de-incentivize states from addressing their own issues. Both countries could benefit from awareness of their approach, and conscious examination of whether this is the approach it intends to perpetuate.

6.2 Project Planning in Economic Terms

Many flood damage risk reduction projects in the United States, such as those constructed by the Corps of Engineers, are evaluated in economic terms, comparing the costs of construction and maintenance against the project benefits in terms of flood damages prevented. Such economic bookkeeping is not the norm for flooding issues in Brazil. Planning projects in terms of costs and benefits arguably makes decisions clearer and easier to communicate than attempting to quantify social impacts. However, the process

has issues with valuation of non-market goods such as human life, environmental preservation, or aesthetics. No system is perfect, and each has its advantages and disadvantages. Much more information about USACE project planning is available in USACE Document 2.5.

7.0 CONCLUSIONS

The review of ANA Document 2.1 yielded the following findings:

7.1 Completeness of Institutional Macro-Functional Areas

From the USACE perspective, ANA Document 2.1 shows that all relevant flood risk management functions are presently being performed in Brazil. The *recovery and learning* function appeared to be lacking in organized post-flood reconstruction, but discussions with ANA staff confirmed that this function is performed in Brazil, though it was not discussed in ANA Document 2.1. Post-flood reporting appears to be an area for further policy development, but there is some reporting occurring. Enforcement of zoning and incentivizing preparedness actions appear to be challenges, but these are implementation issues rather than functional gaps. Therefore, no major gaps in institutional macro-functions were found in this review of Brazilian flood risk management practices.

7.2 Challenges of Comparing Legal Frameworks between Nations

Comparing the agencies and laws surrounding flood risk management proved challenging for several reasons. First, there was no comprehensive compilation of this information available for the United States or Brazil before this agreement began. The consultant who wrote ANA Document 2.1 had to assemble information about Brazilian flood risk management from primary sources, while the information presented here on management of floods in the United States was similarly assembled from various resources. This research required time that might otherwise have been used in analysis and comparison, though at least now a starting point has been established for future work in this area.

Second, flood risk management is a very broad topic, the extent of which could expand or contract depending on one's perspective on the applicability of certain actions. Some actions included in this document, such as the role of the medical system or policies surrounding public housing, may appear too distant from the central issue of floods to be worth including. Conversely, there could be several other topics, particularly in the areas of risk communication and financial instruments for risk sharing, that might have merited more in this paper. The extent of the topic was determined in part by the author of ANA Document 2.1, the review of which provided the basis for this work. Nevertheless, flood risk management remains difficult to define precisely or encapsulate completely.

Third, the legal and institutional frameworks around this topic are still developing in Brazil and to a lesser extent in the United States as well. In Brazil, the National Water Policy, National Environment Policy, and National Policy for Disaster Risk Management are all fairly recent achievements. Exactly how they will be implemented, and where the

responsibilities of one will meet the others, is not yet fully known. In the United States, changes in climate change policy and project planning are now underway, and disaster resilience has recently emerged as a key concept in risk management. This makes it difficult to define the exact procedures used by some agencies, since there can be a significant time lag after a new policy is promulgated before guidance can be developed on implementing it, and another lag after such guidance is developed but before agency culture changes sufficiently that is becomes standard practice.

Finally, there are significant political differences between the United States and Brazil, owing to our different histories, cultural and religious heritage, and social norms. In some cases, these differences may explain our differing approaches to flood risk management, while in others, our different approaches to floods may explain our political differences. In either case, a strict comparison of practices and agencies may not always be possible. Not every recommendation from the USACE perspective may be implementable in Brazil. But through the challenging exercise of comparing our approaches, a greater understanding may be gained of ourselves and each other.

7.3 Impermanence of State Institutions

Discussions with state employees during site visits to Pernambuco and Alagoas indicated that state governments may often change in structure due to shifting political priorities. After an election, the new governor may prioritize or de-emphasize flood risk or related issues, and have the state government departments reorganized accordingly. This sort of frequent change could be damaging to institutional knowledge, as departments related to flood risk management are created, changed, closed, and created again. Such change could lead to wasteful duplication of effort, and puts a priority on systems to retain professional experience.

8.0 BEST PRACTICES IN BRAZILIAN FLOOD RISK MANAGEMENT POLICY

Review of ANA Document 2.1 and field visits in Brazil highlighted several commendable practices in Brazilian flood risk management.

8.1 Understanding of Risks Associated with Structural Measures

ANA Document 2.1, in section 3.2.3.2, presents a strong understanding of the risks associated with structural risk reduction systems such as levees (called dykes in ANA documents) and dams. This concern was also demonstrated in ANA Document 2.2 and in discussions with federal and state officials in Brazil. In particular, there appears to be an awareness that structures can fail and that some residual risk of flooding always exists. This is an essential strength that should be recognized and built upon. In the United States, it is all too common for members of the public to think that because a levee or dam is in place to reduce risk to their community, that they have no risk of flooding. A comprehensive risk management strategy recognizes that even when structures are in place, residual risk exists and must be managed through evacuation, insurance, forecasting, and other measures.

8.2 Coordination of Federal Function

The Brazilian Constitution, federal laws, and federal policies specify the principles and practices to be followed in flood risk management. Federal agencies, however, tend to be relatively small and centralized compared to their equivalents in the United States. This means that these agencies must coordinate their activities with other state and federal agencies in order to be effective. Federal policy recognizes this need and has established several protocols to specify how such coordination should occur. This is a strength that could be recognized and built upon.

8.3 Community Resilience

Site visits in Pernambuco and Alagoas demonstrated that people living along riverbanks in Brazil benefit from social and community resilience. Structures in the floodplain are constructed of cinderblocks or other materials that can resist floodwaters without significant damages, electrical connections enter the home from overhead wires and are routed along ceilings, and electrical appliances and outlets are well above ground level. These are not the results of building codes, but simply commonsense responses to living in a flood-prone area. These communities also have social structures that allow people to assist each other in evacuation, including moving large electrical appliances to higher ground. After the flood, these construction techniques and social connections allow the community to recover quickly. These natural strengths could be studied and leveraged further.

8.4 Social Capital and Mutual Aid

Social structures also benefit Brazil on the regional and national scales. After a disaster, it is common for the Brazilian public to donate large quantities of goods for the affected area, which are distributed by the Civil Defense. This social support should be celebrated and encouraged, as it represents an important aspect of flood recovery, reducing the risk of destitution for impacted communities.

9.0 RECOMMENDATIONS FOR FURTHER DEVELOPMENT OF BRAZILIAN FLOOD RISK MANAGEMENT POLICY

Review of ANA Document 2.1, interviews with federal and state officials, and field visits in Brazil yielded the following recommendations for further development of Brazilian flood risk management policy.

9.1 Strengthen Institutional Macro-Functional Areas

9.1.1 Post-Flood Reconstruction

Although ANA Document 2.1 addresses *recovery and learning* as one of the five institutional macro-functions in Brazilian flood risk management, it contains very little information on this function. There is information about municipalities having responsibility for collection of data on flood impacts, and CENAD having responsibility for management of a database of historical disasters. These are important functions. However, there is no mention of post-flood reconstruction, either of private buildings or of public infrastructure, in either the document or the institutional matrix. Discussions with ANA staff indicated that this omission was a shortcoming of ANA Document 2.1, and that there are in fact agencies in Brazil responsible for this function. In general, municipalities or state governments are responsible for post-flood reconstruction, though they can access federal resources if a disaster declaration is issued. This could create a perverse incentive, where local authorities find it both economically and politically profitable to wait for a disaster to occur rather than taking costly, unpopular steps to prevent it in advance. Although this function is largely the responsibility of SEDEC rather than ANA, as the national water agency ANA has a unique visibility and authority which it may use to advocate for improved water-related policies and laws. It is recommended that ANA investigate whether this perverse incentive effect exists in reality, and if so, how it might be corrected. One possibility could be through creation of a flood insurance program that requires local landowners and governments to pay premiums in accordance with their actual flood risk (see USACE Document 2.6). This would have the advantages of forcing residents to understand their actual level of risk, and incentivizing them to reduce those risks to drive down the cost of their insurance, all while supporting a fund to assist with disaster recovery. Honest, realistic implementation of this program is essential, however: in the United States, subsidized flood insurance has been criticized for encouraging risky behavior and creating exactly the sort of perverse incentive it was intended to reduce. Whatever the mechanism chosen, it is recommended that ANA consider taking steps to improve post-flood recovery when facilitating flood risk management projects. Recovering quickly from a flood reduces the social, financial, and environmental impacts of floods, allowing life as usual to resume as quickly as possible.

9.1.2 Post-Flood Studies and Reports

Another area that appears to be missing from the institutional matrix in ANA Document 2.1 is post-flood reporting. The *recovery and learning* macro-function includes collection and archiving of flood impact data, but not studying the flood and documenting lessons learned. After major floods, USACE personnel write post-flood reports to record how well the flood was forecasted, managed, and addressed. The National Weather Service also writes reports evaluating the accuracy of their forecasts. It is recommended that ANA write a policy requiring evaluation of each of the five macro-functional areas after each major flood. This will allow best practices to be captured, and failings to be documented and corrected so they do not recur. In future floods, successful actions can then be copied and strengthened while unsuccessful ones are avoided.

In addition to post-flood reports that document how the system was *managed* during a flood, USACE also writes post-authorization feasibility reports to assess the *structure* of the system itself and determine whether structural modifications to the system are needed. These reports can be one of two general types: reevaluation studies or reviews of completed projects. Reevaluation studies are for projects that are authorized but not yet constructed (or are under construction) and typically investigate whether any changes are required by changes in project planning criteria or design standards since the project was first authorized. Review of completed projects studies are used to review the operation of an existing project and recommend modifications due to changed physical or economic conditions. These studies are performed with operation and maintenance funding and can lead to a new planning study to determine how the project should be modified to account for changed conditions (see Appendix G, Amendment 1 of ER 1105-2-100). After a major flood, either of these kinds of reports may be written, and changes to the flood risk management project authorized, depending on whether the project is completed or in progress. It is recommended that the ANA policy recommended in the paragraph above include a requirement to assess projects using a systems approach after each major flood, in addition to assessing the management decisions made during the event.

9.1.3 Knowledge Management

Finally, knowledge management forms a related issue. Many institutions in Brazil are relatively new, a result of the present Constitution dating from 1988 and the new National Plan for Risks and Natural Disasters Management dating from 2012. Agencies tend to have relatively little institutional knowledge, with a few older employees having much more professional experience than the younger recently-hired majority. At the state level, both ANA Document 2.1 and interviews with local officials indicated that institutions tend not be robust, changing frequently as political leaders reorganize to reflect their priorities. These realities combine to make it difficult to preserve institutional knowledge. This is an issue for any governmental function, but it is especially

problematic for flood risk management because large floods are infrequent, only occurring a few times in a typical career. It is recommended that ANA develop a policy and system for creating and storing scientific and engineering practices and techniques, as well as knowledge about the behavior of past floods and storms. These may be stored in a database or other secure, organized format. As experienced employees prepare to retire or leave their agency, they may be encouraged to spend a larger portion of their time contributing to this knowledge base, to ensure their knowledge does not leave with them. Over time, such a system will reduce flood risks, as valuable professional experience is retained to be utilized in future studies and designs, while also reducing wasteful repetition of analyses.

Another way to improve knowledge management is through cooperative projects, conferences, and training exercises. Having a multi-agency team develop projects, rather than members of a single agency, helps agencies learn from each other. The latest scientific and engineering practices can be disseminated in this way, while agencies also learn about each others' realities so they can focus on what is realistic. Furthermore, agencies will learn how they are perceived and where they can improve, particularly if the team includes members of state and local government in addition to federal government. It is recommended that ANA encourage the use of multidisciplinary teams in flood risk management projects, including members of other state, local, and federal agencies, to the extent practicable and as allowed by its legal mandate. This will help agencies learn from each other, preserving institutional knowledge and spreading the latest professional practices.

9.2 Regionalization of State Capacity

In Brazil, the states have the legal mandate to perform many aspects of flood risk management, from forecasting and warning to response and evacuations. However, many states lack the capacity to actually perform these duties. For example, the entire Civil Defense force for the state of Alagoas consists of only fourteen people. This makes it nearly impossible for the Civil Defense to warn affected populations of an impending flood, much less assist with evacuations or emergency medicine. A similar situation may exist in the state situation room, where some states lack the large technical staffs with specialized skillsets needed to produce effective flood forecasts. It is important to recognize that the people working in these situations are dedicated, resourceful professionals who are masters of doing the best they can with what they have. Nevertheless, it is a simple fact that some poorer states do not have sufficient resources to manage flood risk at a high level. One solution to this situation would be a significant expansion of the federal mandate, but this is not a realistic possibility as it would require changing the structure of the federal government, and possibly the Constitution as well.

A better solution might be to facilitate regional cooperation among states. Flood seasons in Brazil are not simultaneous: floods generally occur between February and September in the north, between December and March in southeast, between May and August along the northeast coast, and between February and May in the northeast interior. Therefore, there are times of year when one part of the country may be experiencing flooding while a nearby part of the country has no flood to manage. This is not to say that state employees have nothing to do when there is no flooding to manage; maintenance, development, and training must all occur during such times. Still, it may be possible to help a neighbor in need without sacrificing critical duties at home.

When a flood is occurring in a neighboring state, a loan of personnel or equipment from a state with excess capacity to a state in need could generate numerous benefits for both states at low cost. First, a more effective flood preparedness and response could be mounted in the area of need, at much lower cost than expanding the permanent state capacity to a flood emergency level. Second, synergies may be gained by increasing cooperation across states, allowing monitoring networks and models to grow into larger, more regional systems that provide more functionality at lower cost due to economies of scale and reduced duplication. Third, the state lending personnel will gain valuable training, as their employees learn new ways of managing floods and gain perspective on their own methods. Finally, increased understanding and cooperation across state lines could be beneficial when planning projects in interstate watersheds.

USACE is currently undergoing a process of increased regionalization, where district offices are becoming more integrated into division-level organizations, rather than being stand-alone entities. This transition has not always been easy, but it has decreased duplication and reduced instances where one district has more workload than they can handle while another has little to do. In Brazil, state governments play a similar role to USACE districts, with federal capacity centralized and facilitative. Therefore, it is recommended that ANA develop a policy and system to facilitate flood risk management cooperation between states. Interstate agreements could be created specifying the resources to be shared, the funding to be exchanged, and the hydrometeorological conditions under which such sharing can occur. Mechanisms for requesting cooperation among states could be codified. ANA could also dedicate a small group of its own employees as liaisons to the states, who volunteer to deploy to flood-affected areas during times of need to coordinate state and federal efforts. Such “local government liaisons” are common in USACE, and help states access federal assistance while the federal agency gains local information on floods more quickly.

9.3 Coordination between Hydrometeorological Network and Climate Network

The national hydrometeorological network (RHN), maintained by ANA with CPRM as the major operator, is a major component of flood risk management in Brazil. Rainfall

and streamflow data are essential to flood forecasting during an event as well as model development. Brazil is such a large country with so many rivers that there will always be a benefit to expanding this network. However, installing and maintaining more gages is costly. In this context, it is surprising that a second, distinct network of gages is maintained by the Center for Weather Forecasting and Climatic Studies (CPTEC) within the National Institute for Space Research (INPE). If these two networks could be combined, both weather forecasting and flood forecasting could be improved, with only the cost of coordinating the integration. It is possible that overall costs could even be reduced, by eliminating duplication of efforts and making maintenance activities more efficient. It is recommended that ANA develop a policy promoting integration of all federal hydrometeorological networks, and an interagency team to study how such integration could take place, detailing the necessary steps and obstacles to achieving this integration. For example, this policy would define the agency to be responsible for managing the combined network, the format and the location of data storage, and how data is to be exchanged between agencies. Standards for data quality could also be defined, including practices for surveying of gages, data collection frequency, and required accuracy of discharge measurements. Finally, this policy should define how the cost of this work is to be shared across agencies, and whether funds will be transferred from one agency to another or if an external entity is needed to distribute funding.

9.4 Coordination of Radar Rainfall Data

Although great gains have been made in recent years, Brazil does not currently have complete radar coverage over its entire territory. Nevertheless, radar coverage does exist for many populated areas that are affected by flooding. Radar-estimated rainfall can be viewed online, but it is not available for download. Increasing the availability of quantitative rainfall data would advance flood risk management by improving research, model development, and real-time forecasting. It is recommended that ANA develop a position paper promoting open access to radar-rainfall data and illustrating how this will improve forecasting and reduce flood risks. ANA may also help create a team to bridge gaps between institutions in order to facilitate this open access.

9.5 Periodic Inspections of Dams

Inspections and maintenance of dams represents a gap between state and federal institutional functions. The legal responsibility for dam inspections belongs with the agency that issues its construction permit, while the constructing agency is responsible for maintenance. Inspections by the regulatory agency are supposed to be forwarded to the construction agency to guide maintenance activities. There are several reasons why this arrangement could be improved in practice, however. First, the constructing agency may no longer exist due to the structural changes made to the federal government during the re-democratization process following the military dictatorship. This is particularly

true with dams constructed by the National Department of Sanitation Works (DNOS), which was dissolved in the 1990s. Second, the owner of a dam may be unknown, leaving no one to request inspections or maintenance. The ANA Superintendancy of Inspections has used satellite imagery to identify thousands of dams whose purpose and ownership are unclear. Third, even when a dam owner and constructing agency exist and are known, the inspecting agency may be hesitant to submit negative inspection reports. This was observed in Pernambuco state, where the state issued a construction permit for Jucazinho Dam on the Capibaribe River to be constructed by the National Department of Works Against Droughts (DNOCS). Because the state of Pernambuco is reliant on the federal government for funding, state employees expressed hesitation about submitting an unsatisfactory inspection report to DNOCS, for fear it might jeopardize the working relationship between the state and the federal government. DNOCS, meanwhile, is gradually losing status and funding as its mission shifts from construction of projects to the less glamorous and less visible work of safety and maintenance. As a result, the Jucazinho Dam has not been inspected recently, despite two major floods that required the use of the emergency spillway.

The end result of this situation is that flood risk in Brazil is increasing due to poor dam safety practices. For lack of minor maintenance such as painting, corrosion repair, and removal of vegetation, the need for major maintenance or replacement is increasing. Furthermore, the likelihood of a catastrophic dam failure, though possibly still small, is increasing as time passes without inspections or maintenance. The ANA Superintendancy of Regulation and the Superintendancy of Inspections have worked hard to coordinate the National Dam Safety Information System (SNISB), identify dams, and create the dam safety atlas including consequence modeling. These are necessary and important actions, but they do not address maintenance requirements or periodic inspections. Law No. 12,334 of 2010 requires a dam safety plan including periodic safety reviews, but leaves the frequency of such inspections to the inspecting agency. Requiring periodic and post-flood inspections would leverage these actions, improving safety information and encouraging states to take action or ask for help. It is recommended that ANA develop implementation guidance for Law No. 12,334, requiring all dams to be inspected on a regular basis, not less than once every five years. This guidance could also specify inspections after a major flood, such as a flood requiring use of the emergency spillway. In accordance with Law No. 12,334, inspections leading to recommended maintenance actions would require a follow-up inspection to ensure the actions were taken satisfactorily. Brazil's many dams are a major benefit to flood risk management as well as hydropower and water supply. A few additions to existing policy will ensure they remain a strength rather than becoming a hazard.

9.6 Levee Safety Program

While dam safety is a matter of existing policy that could be improved with further requirements, levee safety in Brazil is a legal grey area that does not appear to be the responsibility of any agency or institution. This gap was apparent in discussions with ANA staff as well as in ANA Document 2.1, which does not mention levee safety or include it in the institutional matrix. Levees are rare in Brazil, but they do exist, particularly in agricultural areas. As with dams, levees require inspection and maintenance to ensure they function as part of a flood risk management system. It is recommended that ANA establish a levee safety program modeled after the dam safety program. This program could work to establish a national inventory of levees, including the area they serve to protect and their consequences of failure. Furthermore, it is recommended that ANA develop a policy establishing responsibility for inspection and maintenance of levees. This responsibility could fall with the constructing agency, permitting agency, the states, or another institution, but a policy is needed to ensure the responsibility for levee safety rests with someone.

Flood risk management in Brazil is similar in many ways to the United States. Functions are distributed differently across institutions, reflecting the different government structures in the two nations. However, with a few exceptions, all of the same functions are performed. Furthermore, some of the same challenges that face the United States, such as risk communication and helping the public face their true risk of flooding, also occur in Brazil despite the different agencies addressing these issues. The preceding findings and recommendations were presented in the hope that they will help ANA develop and improve flood risk management policies to benefit the people of Brazil, now and in the future.

10.0 References

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