MEETING THE CHALLENGE OF CHANGE

Implementing the Federal Flood Risk Management Standard and Climate-Informed Science Approach

A Summary Report based on the 5th Assembly of the
Gilbert F. White National Flood Policy Forum
Washington, D.C.
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Flood risk in the nation is changing, and the trends point to a dramatic escalation in future risk. Continuing population growth and development play a role, as do poor land use and infrastructure decisions. But the key concern is changing future conditions—bringing stronger storms, more extensive coastal and inland flooding, and the potential for immense economic and social impact when events occur. In the future, such events could overwhelm our traditional emergency programs of response, recovery, and mitigation. And the primary driver of changing future conditions is a changing climate.

Responding to the growing threat to investments by federal agencies and taxpayers, the President via Executive Order directed the adoption of a new Federal Flood Risk Management Standard, or FFRMS. It directs that federal actions be undertaken using methods that account for a changing climate through use of a "climate-informed science" approach (CISA).

CISA as a principle is solid in that it requires federal investments to be undertaken with some ability to estimate future flood levels. However, CISA pushes many outside their comfort zone, because from a technical perspective people are still grappling with how one consistently or uniformly implements such a standard based on what we currently understand. The FFRMS, sensitive to this issue, allows the use of a 500-year standard or freeboard as alternatives, as agencies work to develop this kind of approach.

With this backdrop, in September 2015 the ASFPM Foundation assembled 100 of the nation's leading flood risk management experts at George Washington University in Washington D.C. as part of the organization's Gilbert F. White National Flood Policy Forum series. Invitees came from all levels of government, and from non-government organizations, academia, and the private sector. Among them were technical experts in hydrology and engineering, program experts in flood risk management and flood insurance, climate scientists, risk communication specialists, realtors, insurance and banking professionals, environmental experts, and more. This report is a reflection of discussions held at the Forum and subsequent deliberation by the ASFPM Foundation's Forum planning team.

While CISA certainly pushes program managers and practitioners outside of their comfort zones, we observe that this is not the first time—nor will it be the last—that engineers, hydrologists, and scientists will be called on to make estimates of flood risk based on thoughtful assumptions. We conclude that such a CISA not only preserves our ability to estimate and manage future risk but, more importantly, moves towards proper (not over nor under) design to deal with it.

A climate-informed science approach as embodied in the FFRMS is the right step forward. Now we must move beyond CISA as a principle and make it operational, understanding that it will be improved as we learn more. This will be "CISA Version One." But there is no question that "CISA Version One" is a better path forward for the nation than "CISA Version None."

Doug Plasencia , P.E., CFM
President
ASFPM Foundation

CHANGING CLIMATE, CHANGING FLOOD RISK MANAGEMENT

An Environment of Changing Flood Risk Factors

As "freaky" weather makes headlines—a December North Pole warmer than Chicago; hurricanes in January; record-breaking spring rainstorms throughout the Americas; unprecedented summer-fall heat waves—the need to better understand and manage flood risk has never been more apparent. Sea levels are rising. Coastlines are changing. Weather patterns are shifting. Areas prone to flood events are seeing them more often. Intense storms are wreaking unprecedented economic and social havoc.

The risks we now face will grow over time as climate shifts affect urban communities and vital natural resources. The debate on climate change in Congress, state houses and local town halls is shifting from "if" to "when and to what extent." Evidence is indisputable that changes in coastal and riverine flooding pose near- and long-term challenges that must be addressed. The changes taking place are neither speculative nor reserved for some future date. What the press may call "freaky" weather appears to be trending towards a new norm.

Flooding is becoming more frequent and intense

With changes in climate, weather patterns are shifting. Areas are becoming wetter, or dryer, than before. Heavier precipitation is being felt in a number of areas. The Northeast and Midwest, in particular, are seeing increases in very heavy precipitation. Increases in precipitation, erosion, changes in land use, and other changing conditions in the watershed affecting vegetation and absorption will all contribute to further changes in riverine flooding.

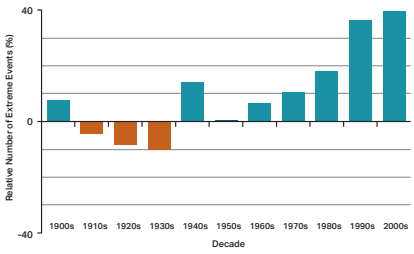


Figure source: adapted from Kunkel et al. 2013. Climate Change Impacts in the United States: The Third National Climate Assessment, 2014, http://nca2014.globalchange.gov.

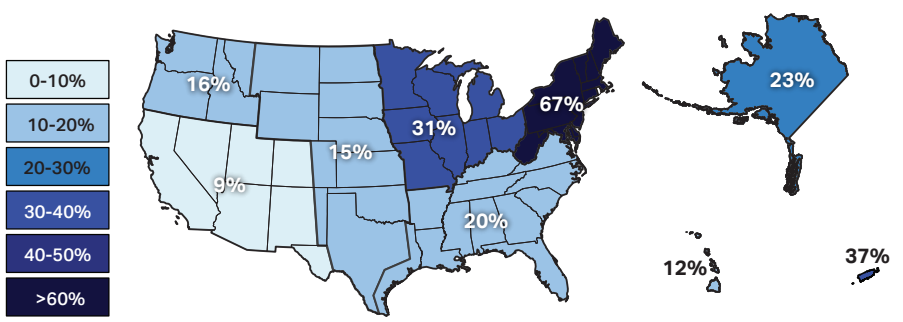


Figure source: UMD Earth System Science Interdisciplinary Center

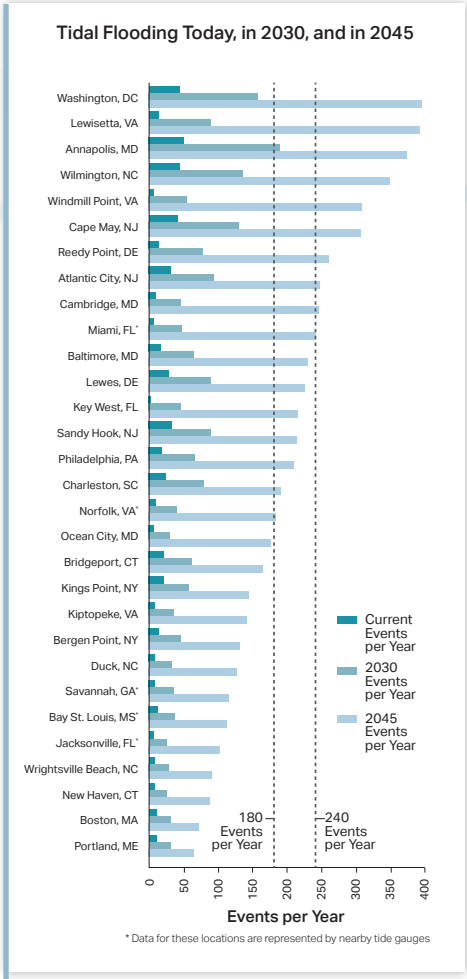


Figure source: Union of Concerned Scientists, www.ucsusa.org/encroachingtides

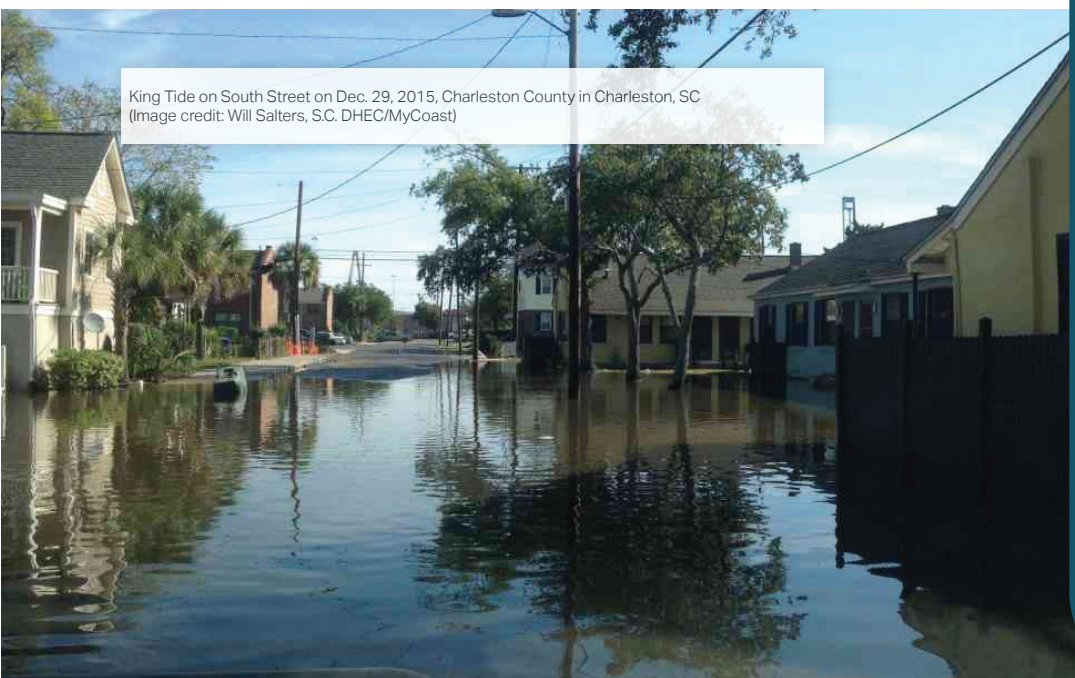
Sea level rise is already reshaping coastlines

Sea levels, which began climbing in the 20th century, are now rising at an accelerated rate. The National Oceanic and Atmospheric Administration (NOAA) estimates the rate of rise at .12 inches per year. Already, king tides (the especially high tides that occur when the moon exerts its strongest effects) are causing much more widespread flooding. By the year 2030 the risk of coastal floods 4 feet or more over high tide could be double what it is today. And as time goes on, flooding that now occurs with the highest tides will become the high tide norm.

The consequences of flood events are becoming immensely more costly

Recent storms have brought billions of dollars in damage. As the population grows and concentrates in coastal areas, and property values continue to rise, the trend can only escalate. Severe storms are only part of the equation. NOAA calculates that in 2015—a year not marked by major hurricanes—10 weather, water, and climate disaster events, including flooding, coastal inundation, and drought, each brought losses exceeding $1 billion.

Sea level rise is another major concern. As just one example, in Florida some 2,120 square miles of land lie less than 3 feet above the high tide line. Approximately $145 billion in property value, and 300,000 homes, sit on that land.



King Tide on South Street on Dec. 29, 2015, Charleston County in Charleston, SC (Image credit: Will Salters, S.C. DHEC/MyCoast)

In this environment, investment decisions must be based on more than immediate needs and current risk. They must take into account what is needed to protect the investment over time and to prevent future risk from becoming unsustainable.

The Challenge Ahead: Managing Future Flood Risk

Changes in flooding that affect our natural and human-made flood defenses are posing major challenges for **floodplain management**.

Natural flood-water storage in floodplains is being overwhelmed by higher flood volumes, often reclaiming for the floodplain areas we have encroached. Natural coastal barriers are experiencing frequent battering and are under threat of being decimated. And the changes are taking place in ways that cannot be fully predicted, presenting a challenge of increasing uncertainty for the scientists, economists, engineers and government officials who estimate and manage risk.

The challenge of uncertainty also affects the government and private sector decision makers who must plan, locate, fund, design and build our nation's infrastructure. Their choices must be based on an analysis of risk that considers the nature, likelihood and impacts of a variety of scenarios—a set of tomorrows that could look markedly different from today.

Floodplain Management
For nearly 40 years, floodplain management has been defined as having a dual purpose: to manage *flood risk* and the *natural functions of floodplains*. Climate change is altering flood risk and putting additional stress on the natural functions that affect our risk, our economy and the resources on which we rely. To manage future flood risk, floodplain management must maintain its duality in approach, inclusive of future development and redevelopment throughout the watershed.

Risk estimation must embrace uncertainty and the reality of non-stationarity

This is a new way of thinking about risk. Scientists and engineers have for decades estimated riverine and coastal flooding assuming **stationarity**. Against the backdrop of a relatively non-changing climate, they could use historical flood risk data to provide flood estimates and analyze flood flow frequency. We now know that future coastlines and floodplains will be different. However, the precise nature of future changes, and thus of future flood risk, is uncertain. Many scenarios of future hazard are possible, each leading to a different metric of risk. We must consider the different scenarios, and their likelihood within different timeframes, and plan accordingly.

Stationarity vs. Non-Stationarity
Stationarity means the processes that contribute to flooding do not change with time. Flood modeling today commonly predicts future flood hazard assuming stationarity. However, climate change, increasing urbanization, and other factors mean this assumption is not valid. We can no longer assume stationarity and must instead develop models to predict future flood conditions within a context where the processes are non-stationary: changing with time.

Risk management must include strategies for sustainability and resilience

As the disaster damage exposure to the federal taxpayer continues to grow, the nation can no longer afford to continue following a policy of buying its way back from disaster with emergency funding. Instead, steps must be taken earlier, during planning and implementation, to limit the impact of future disasters.

During the past several years the concept of **resilience** has been embraced by many as a viable approach. However, in planning, design, and management, resilience needs to be applied holistically. If practiced narrowly, it may yield awkward inward-looking solutions that do not fit the needs of the community, the environment or society. For example, "building stronger" alone does not yield true resilience. Past attempts to master the environment have too often yielded narrowly-focused, protective solutions that encourage more at-risk building and behaviors, and create the potential for catastrophe when structures and systems fail or are overwhelmed.

Resilience
Communities, businesses, and individuals become more resilient (able to withstand and recover quickly from disasters) by implementing not one, but a collection of actions of actions that mitigate the impacts of flooding and other hazards throughout the community. Building stronger by itself, while an important step, may not lead to resiliency. Resiliency must holistically include the built, the human, and the natural environment, and must also work day-to-day.

The good news is that growing numbers of communities, as well as federal and state programs, are increasing resilience by coupling proactive mitigation with community-led planning. The best examples employ mitigation actions that "buy down" risk while integrating the natural functions of the floodplain.

In Charlotte-Mecklenburg, North Carolina, the local floodplain buyout program, water quality regulations and future conditions floodplain maps are used in concert to reduce the risk of flood losses, expand greenways, and set aside natural areas to help filter pollutants. This $43 million project has already generated $430 million in development and redevelopment.

Image credits: Mecklenburg County, North Carolina

Milwaukee, Wisconsin is using a green infrastructure approach to lessen the percentage of rainfall that ends up in the stormwater system. Addressing heavy precipitation issues now will help Milwaukee adapt to future conditions.

Image credits: Milwaukee Metropolitan Sewerage District and the City of Milwaukee

In Colorado's Cherry Creek basin, a partnership among stormwater, water quality and flood control authorities and local and county government has restored urban drainageways while expanding recreational and educational amenities for the community. The images above show before and after conditions of the Happy Canyon Creek Confluence with new grade control.

Image credits: Cherry Creek Eco Park Stream Restoration Project

AN UPDATED FLOODPLAIN MANAGEMENT STANDARD FOR FEDERAL INVESTMENTS

A New Emphasis: Flood Risk Management Using Climate-Informed Science

On January 30, 2015, President Obama issued Executive Order 13690. It modified an earlier Executive Order in place since 1977 (EO11988, *Floodplain Management*) to establish a new *Federal Flood Risk Management Standard (FFRMS)* for federal taxpayer funded projects and actions. The new standard requires a climate-informed forward look to ensure that federal investments in or near floodplains are protected in the future.

Aimed at increasing resilience against flooding and helping to preserve the natural values of floodplains, the FFRMS directs approaches that will take into account both current and future flood risk to ensure that projects last as long as intended. The standard offers options for determining the vertical and horizontal extent of a floodplain in planning. The preferred option is an approach that incorporates the use of climate-informed science when providing estimates of future flooding.

New approaches to ensure federal actions will be resilient

Prior to FFRMS, approaches to floodplain investment varied by agency. The "1 percent flood"—the flood with a 1 percent chance of being equaled or exceeded in any given year—is used by the National Flood Insurance Program (NFIP) as a flood insurance rate standard. However, it is not a safety or investment standard. The level of protection provided by federal programs has historically been based on higher elevations than the "1 percent flood" or has been set by the project with the highest benefit/cost ratio. Another standard that has been used is the 0.2 percent annual chance (500-year) flood for "critical facilities," as directed in EO11988. The FFRMS does not necessarily replace this framework but directs that estimates for federal actions incorporate adjustments that reflect future change.

Increased emphasis on the use of nature-based approaches

In addition, EO13690 further strengthens the requirement in the 1977 Executive Order to minimize harm to lives, property and natural and beneficial floodplain values, and to restore or preserve these values where possible when taking actions in a floodplain. Throughout, the language of the new standard reflects a transition from an earlier emphasis on flood control and protection to a broader focus on risk management and resilience.

The FFRMS introduces a resilience directive: that federal investments in flood-prone areas incorporate measures to combat the impacts of climate change. It rightly suggests using "methods that integrate current and future changes in flooding, based on climate science" to determine floodplains.

FFRMS options to define the floodplain for federally funded actions:

1. "the elevation and flood hazard area that result from using a climate-informed science approach that uses the best-available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science…; or
2. the elevation and flood hazard area that result from using the freeboard value, reached by adding an additional 2 feet to the base flood elevation for non-critical actions and by adding an additional 3 feet to the base flood elevation for critical actions; or
3. the area subject to flooding by the 0.2 percent annual chance flood."

The standard also allows for future use of any other method identified in an update of FFRMS.

1 Climate-Informed Science Approach

2 Freeboard Value Approach

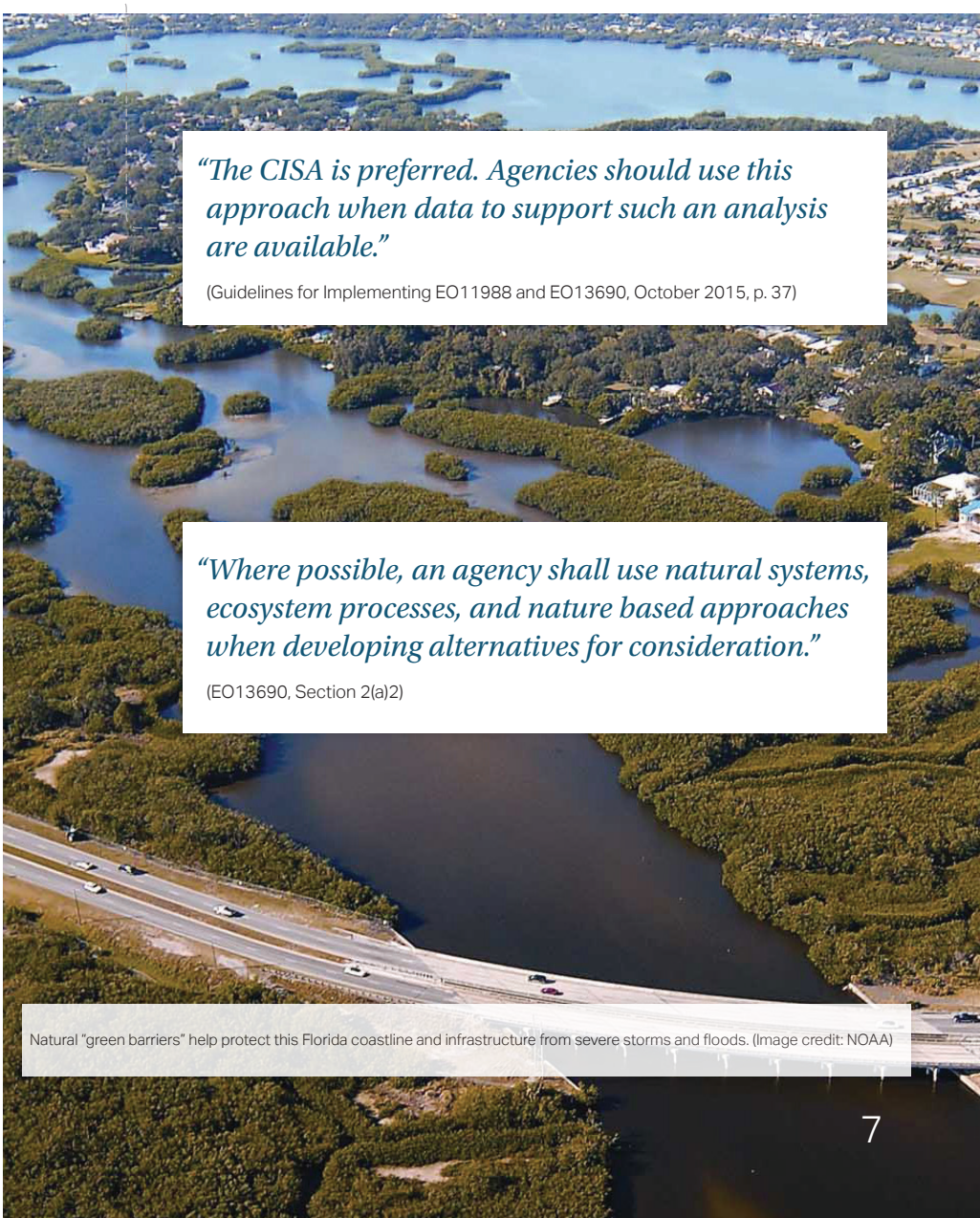
3 0.2 Percent Annual Chance Approach

Recognizing the role played by climate-informed science

The new EO introduces an important concept: use of a climate-informed science approach (CISA) in determining current and future flood risk.

Incorporating this approach into the estimating process is at the heart of the FFRMS and will be the chief technical issue of concern for the next two to three decades, if not longer.

The implementation guidelines for the standard broadly suggest supplementing existing hydrologic and hydraulic analysis with "best available and actionable climate science and consideration of impacts from projected land cover and land use changes, long-term erosion, and other processes that may alter flood hazards over the lifetime of a federal investment." The devil, of course, is in the details.



"The CISA is preferred. Agencies should use this approach when data to support such an analysis are available."

(Guidelines for Implementing EO11988 and EO13690, October 2015, p. 37)

"Where possible, an agency shall use natural systems, ecosystem processes, and nature based approaches when developing alternatives for consideration."

(EO13690, Section 2(a)2)

Natural "green barriers" help protect this Florida coastline and infrastructure from severe storms and floods. (Image credit: NOAA)

FFRMS IMPLEMENTATION

A Standard with Broad Implications Across All Levels of Government

FFRMS applies to programs traditionally involved in managing flood risk and to all federal taxpayer investments in the floodplain. Agencies as diverse as FEMA, USACE, HUD, EPA, US Department of Transportation (DoT) and the Economic Development Administration (EDA) will have major programs affected.

These include the hazard mitigation and post-disaster federal assistance programs shown below, but also federally funded projects. Basically, any federal agency formulating or evaluating water and land use plans should feel the impact. In addition, all newly constructed federal government buildings must comply with FFRMS, including military facilities, laboratories, post offices, emergency operation centers and office buildings. Given the number of federal programs affected by FFRMS, it is imperative that the different agencies collaborate to help ensure consistent implementation.

Implementation of FFRMS at the federal level will directly benefit state and local governments' cost-shared projects. Many states and local governments have standards similar or stronger than the FFRMS and aligning the approaches will be of benefit all. FFRMS is an investment strategy that pays long-term benefits regardless of the funder, and is simply good policy and use of taxpayer dollars.

Examples of Affected Federal Programs

Post-disaster federal assistance programs

- HUD Community Development Block Grant (CDBG)
- FEMA Hazard Mitigation Grant and Public Assistance Grant Programs
- Small Business Administration Disaster Loans
- USDA NRCS Emergency Watershed Protection Program

Hazard mitigation programs and grants

- FEMA Pre-Disaster Mitigation and Flood Mitigation Assistance Programs
- EPA Drinking Water and Clean Water State Revolving Funds
- EPA Smart Growth Grants
- USDA Emergency Community Water Assistance Grants
- USDA NRCS Agricultural Management Assistance Program
- USACE Planning Assistance to States Program

Agencies must take this implementation on with high seriousness, and work together to resolve policy and technical issues. We cannot afford not to ensure that investment for the future be efficient and effective and begin now.

Resolving Policy Issues

The FFRMS provides a framework. It allows agencies flexibility based on differences in authorizing legislation, agency priorities, project criticality and regional and local conditions—an explicit acknowledgment that "one size does not fit all."

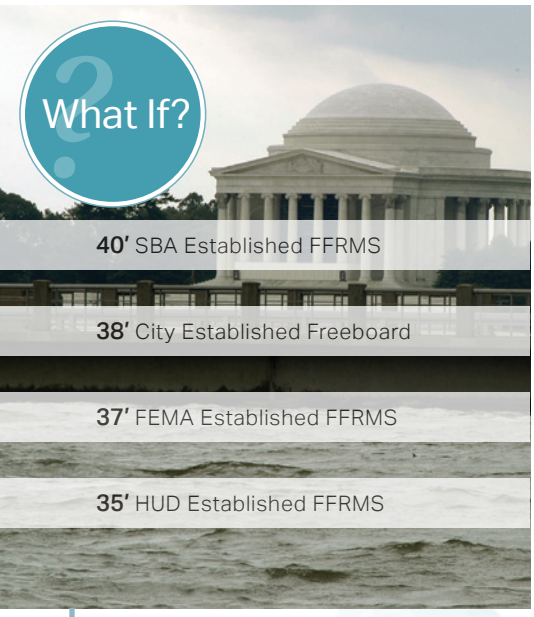
However, this flexibility can pose challenges as multiple agencies work to set forth rules and implement the standard. The adjacent table lists some issues surfaced by ASFPM and Forum participants.

Given the large number of agencies and programs that will be involved in applying the new standard, a formal mechanism is needed to resolve potential conflicts arising from the agencies' rule-making process.

Issue	ASFPM Suggests
Exempting emergency construction or mitigation projects	The EO exempts "emergency work essential to save lives and protect property and public health and safety" from the provisions of the FFRMS, but "emergency" should be limited to "emergency response" activities and not programs of recovery or mitigation. Recovery programs implemented under "emergency authorities" include the USACE PL84-99 program and the National Resource Conservancy Service Emergency Watershed program.
Addressing long-term benefit in benefit cost analyses	The resilience we buy today may not be realized until years into the future. Traditional benefit cost analysis shows a much lower investment return when spending money today for deferred benefits. This suggests the need to find a better way to incorporate FFRMS resilience requirements in planning and to determine cost effectiveness across a project's full life-cycle.
Recognizing higher local standards	Many state and local governments have adopted standards that exceed federal minimums. For example, 62 percent of NFIP communities require buildings to be built higher than the NFIP base flood elevation. For federal investment, higher local standards should be treated as the starting point to apply FFRMS, rather than the lower federal standard.
Setting minimum risk for critical facilities	Earlier Water Resources Council guidelines recommended protection to the level of the 500-year event or flood of record, whichever is greater. For critical facilities the highest of the methods available would be most appropriate.
Using a CISA for riverine areas	Protocols for applying a CISA to riverine areas need to be developed. In some cases, land use and drainage may pose more significant risks than climate change. These risks should be fully understood at the watershed level through local and state government collaboration.
Incentivizing a move to higher standards in design codes	Most construction decisions are made locally. Incentivizing mitigation and safer construction can pay major dividends.
Providing further guidance on "actionable" data and climate-informed science	More detailed guidance is needed to aid agencies in adopting the new standard, including protocols for adopting a CISA into decision support processes.
Providing guidance on a range of hazards, future conditions and uncertainties	Scenario-based planning would be aided by detailing a range of scenarios and attendant risks. Sea level rise (SLR), storms with SLR, riverine flooding, drought, subsidence, erosion and changes in vegetation and drainage can all provide multiple scenarios for consideration.

Building Cooperation and Collaboration

For both initial FFRMS implementation and the long-term effort to manage flood risk, cooperation among federal, state, local and private sector institutions is not an option. **It is a necessity.**



Problem:
In city X, HUD establishes a FFRMS at 35 feet, FEMA at 37 feet and SBA at 40 feet. The city already set its own at freeboard at 38 feet. What value should guide community actions?

Solution:
Interagency coordination in FFRMS implementation will ensure that this conundrum remains hypothetical.

Washington, D.C., September 2003 — The Tidal Basin is nearly overflowing from rains caused by Hurricane Isabel, a full four hours before high tide. (Image credit: Liz Roll/FEMA News Photo)

The case for greater coordination at the federal level

Over the past three decades, studies and reviews have pointed out the need to increase coordination among federal activities aimed at flood risk reduction. Stovepiping of agency activities has led to challenges in communicating risk, implementing new initiatives, and overseeing and maintaining federal investments in existing infrastructure.

Efforts to improve federal coordination have included establishing the Mitigation Framework Leadership Group (MitFLG). A national all-hazards coordinating body, it centers its efforts on integrating federal efforts to deliver mitigation capabilities. Another key group is the Federal Interagency Floodplain Management Task Force (FIFMTF) whose charter focuses on maintaining a Unified National Program for Floodplain Management (UNP). While these bodies have worked hard to address major policy issues, actions to improve coordination among agencies in implementation have been limited. Typically, agency-oriented implementation procedures prevail.

Implementation of the FFRMS must be coordinated. If each federal agency operating in a community, county or region determines its own standard, non-federal collaborators will have to deal with multiple federally determined flood elevations. Failure to coordinate will make comprehensive planning difficult and synchronization of local, state and federal activities almost impossible. It could also lead to shopping by local agencies to find the federal entity that would provide the most favorable standard for their jurisdiction. Elevation determination, inundation mapping, tool development, and related floodplain management activities must all be tightly coordinated. There is clear need for development of a mechanism to ensure coordination of federal FFRMS actions.

It is time to update the UNP to address FFRMS implementation. Consideration should also be given to appointing a lead federal agency for FFRMS coordination for each of the 221 sub-region hydrologic units.

The case for updating the Unified National Program of Floodplain Management

The Unified National Program (UNP) is a congressionally-mandated document designed to align federal actions and address critical issues of floodplain management, vision and direction. The most recent UNP was prepared in 1994, and in spite of efforts to move on development of a new UNP no action has been taken. The UNP is supposed to ensure that national flood risk reduction efforts are well coordinated and collaborative. Climate change and the FFRMS are perhaps the most significant changes in floodplain management since the passage of the NFIP in 1968. Now is the time to update the UNP and show how we can align the actions of federal, state, and local agencies.

The case for clear leadership at the sub-regional level

The key unit of government to reduce flood losses is the community. Federal and state actions must support, encourage and incentivize community actions, and for that to happen federal actions themselves must be well coordinated. If coordination and collaboration take place, use of the FFRMS should not result in demands for investments significantly beyond those already required for effective flood risk reduction. One way to assure such coordination and collaboration would be to appoint a lead federal agency for FFRMS coordination for each of the nation's 221 sub-region hydrologic units. The appointment would reflect the extent and complexity of the expected FFRMS activity in the sub-region. The lead agency would not have directive authority but would be responsible for ensuring coordination among federal agencies and compatibility with state and community planning.

Collaboration at Work

Lower Onion Creek Flood Buyout: Working with USACE in the Lower Onion Creek watershed, the City of Austin determined that acquiring flood-prone buildings was the best solution to growing flood risk. Additional HMA funding allowed 300 homes to be removed from the floodplain. Subsequent flooding proved this was an effective way to reduce damage and improve resiliency. The photo below shows flooding from October 2013, and a map of resulting buyout areas.

Image credit: City of Austin Watershed Department Engineering Division

The **Klein Creek Flood Mitigation Project** began early June 2014. The project along Klein Creek in Armstrong Park, IL located in Carol Stream, is a joint effort between DuPage County Stormwater Management, the Village of Carol Stream and the Carol Stream Park District to alleviate flooding in the area.

Image credit: DuPage County Stormwater Management

INVESTING FOR THE FUTURE

Incorporating Climate-Informed Science

Uncertainty is a given. Tomorrow's climate and built environment will be different from today's, and in many places the changes will be significant, requiring changes in how we manage flood risk.

Hydrologists and engineers will need to provide flood estimates with an incomplete understanding of the location, timing, and extent of impact, particularly in the riverine environment. The good news, however, is that professional floodplain managers have provided reasonable estimates in the past with less than certain data and knowledge, and we can do it again.

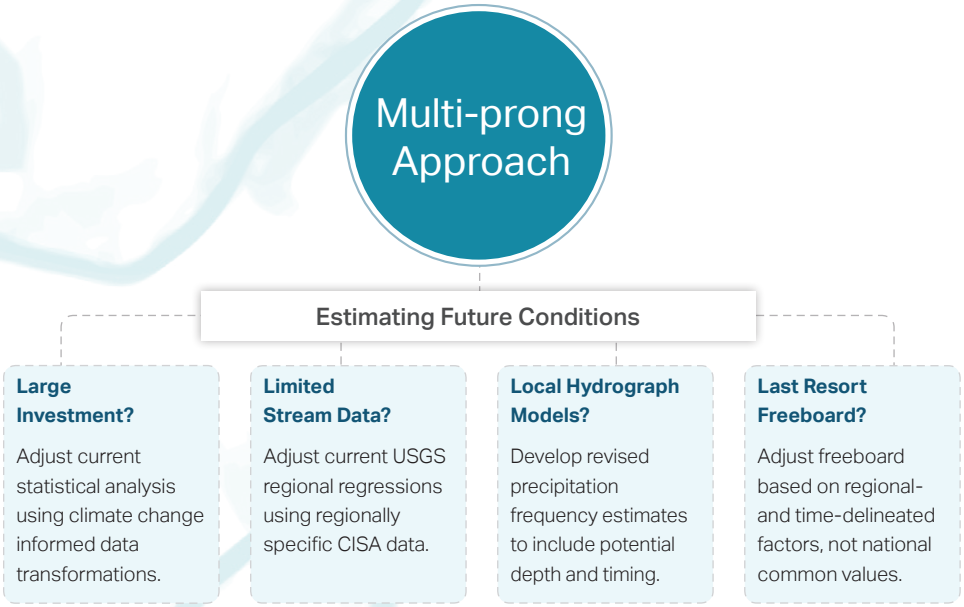
"One size fits all" estimates of future hydrology will *not* fit all

The FFRMS suggests, as alternatives to CISA in making estimates of future hydrology, a 2-foot freeboard, 3-foot freeboard for critical actions, or the 500-year flood in making estimates of future hydrology. Use of one-size-fits-all freeboard or the use of a one-size-fits-all safety factor, while simple in application, does not adequately address variation of uncertainty over time or from site to site. Use of the 500-year flood poses further concerns if used in coastal areas, because maps apply it as a stillwater boundary estimate, not taking into account the effects of future sea level rise or flooding due to wave action.

We must move to a multi-prong approach to estimating future conditions

Relying on one-size-fits-all estimates can result in poor investment choices, providing such an incomplete picture of uncertainty and risk that neither a community nor the nation develop a real understanding of the likelihood of loss of life or damage to property. However, variation can be accounted for, even if the estimates are based on simplifying assumptions. A multi-prong approach is warranted:

- For large investments, current statistical analysis can be adjusted using data transformations reflecting climate change. For example, California used predictions of future climate conditions coupled with watershed runoff and routing models to predict how flood flows would change. Then, current flood flow frequency curves were adjusted, permitting assessment of future flood risk.
- For the many areas with limited availability of stream data, current regional regression equations of the US Geologic Survey (USGS) can be adjusted similarly with the adjustments being regionally-specific.
- For local models that estimate peaks and the changing flood stage over time (hydrograph), revised precipitation frequency estimates can be developed that include the potential depth and timing of the rainfall.
- As the method of last resort a freeboard can be applied, but this freeboard must be adjusted based on regional- and time- delineated factors, rather than a common value across the entire nation for all future times.



Decision making must incorporate estimates of future conditions and of our confidence in the estimates

The issue of applying CISA also cross walks with how we view risk. It is entirely feasible using statistical methods such as risk-based modeling to estimate risk and to make an informed decision about (a) the level of risk tolerable for a given location, and (b)the level of certainty or uncertainty we can tolerate in our estimate of that risk. The answer we may be seeing is one that says that we are 90 percent confident a design or regulatory elevation will not be exceeded today, 60 percent confident for the year 2050, and 25 percent confident for the year 2090. A project can go forward if the confidence is great enough, taking into account the size of the investment, the life of the investment, and the population at risk. This is not to suggest that 25 percent confidence in future hazard estimates is acceptable. But the farther into the future we look the more uncertainty we can accept because much of the uncertainty has to do with lack of availability of data and not necessarily a pending failure of a system.

Our estimates can get better with time. But this requires a renewed commitment to existing and proposed data monitoring on streams and watersheds, and a commitment of resources from all levels of government and the private sector to share and shape the data into useful information. Unfortunately, congressional support for data collection has been declining for years. We must reverse this mindset, while becoming more innovative and accepting of data from non-federal sources.

Success in using CISA is dependent on several factors. Moving forward, we need data, we need information, and we need to keep improving both. The need for data collection and monitoring of the nation's streams and watersheds has never been more crucial.

We also need policy and consensus regarding tolerable levels of risk and uncertainty. And we need to re-evaluate where we are, periodically, over time.

Identifying and Communicating Future Risk

Among the challenges in managing future flood risk is that of presenting risk —or rather, the range of probabilities and possibilities that comprise the risk—in a useful and actionable way.

Meeting this challenge is vitally important. Planners, developers, regulators, residents and business owners everywhere need to understand the direction and magnitude of change that may come, including impacts of future development, land use change, erosion, sea/lake level risk and climate change.

6 foot SLR estimates for Charleston, SC using NOAA's Digital Coast Sea Level Rise and Coastal Flooding Impacts Viewer https://coast.noaa.gov/slr/ (Image credit: NOAA)

Moving from regulatory products to tools that visualize future conditions

Although a number of federal agencies and organizations have contributed significantly to flood risk identification over the years, the most wide-reaching effort has been that of FEMA's National Flood Insurance Program (NFIP). NFIP flood maps help determine flood insurance rates and set minimum requirements for construction in floodplains.

The maps present information based on historical data and current conditions; future conditions are not taken into account. However, that will change as FEMA acts on mapping provisions of 2012 reform legislation and develops additional advisory products. The Technical Mapping Advisory Council (TMAC) in its December 2015 report has urged FEMA, in cooperation with its mapping partners, to move toward showing future conditions as required by the 2012 law, and incorporating actionable science.

A key question for agencies seeking to develop future-facing products and tools is how best to indicate uncertainty. One approach is to allow users themselves to choose among possible scenarios of change and see the effects, as NOAA has done with its U.S. Climate Resilience Toolkit. In this toolkit, NOAA provides user-selectable sea level rise and coastal flood tools as well as a comparison matrix to help coastal communities compare web-based tools available for their state.

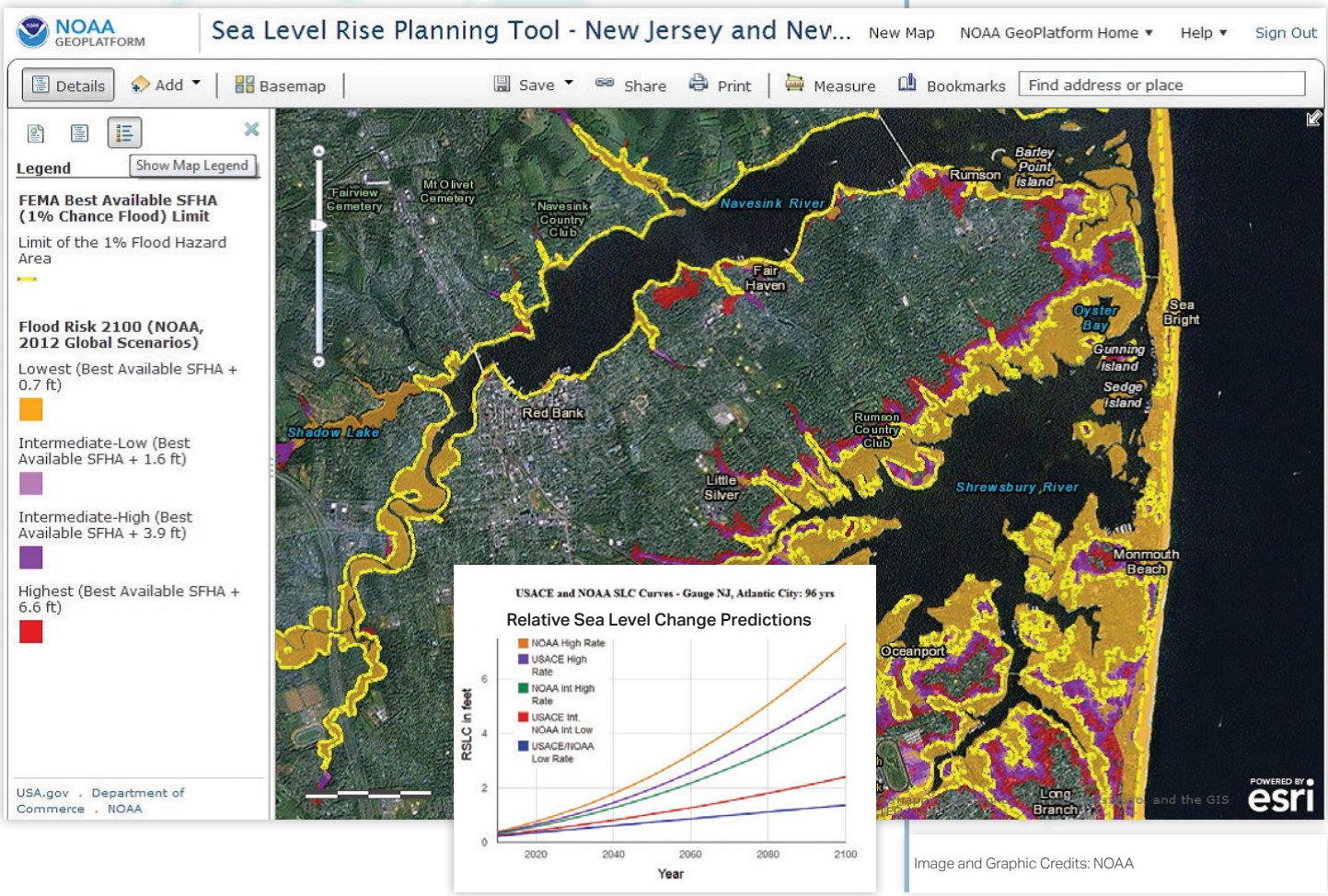
Future maps and their successors should not only incorporate updated data such as expanded rainfall records, but also show potential impacts of changes in rainfall, sea level rise, population growth, and urbanization. Sea level rise scenarios, like ones done for New York and New Jersey following Hurricane Sandy, provide one example. Other tools that have been suggested include maps with layers showing the risk shadow for leveed areas depending on levee placement, GIS layers containing risk information over time, and visualizations of future riverine risk scenarios.

To achieve resilience, agencies must fund communication strategies and tools that will help people visualize and act on future risks—risks that we are just beginning to understand.

Moving to a productive conversation about managing risk

Decisions about where and how to build (or not) are never easy. Decisions that require spending money now to gain security down the road are even harder. That which is not well understood will either be ignored or fought against, particularly when there are multiple and conflicting points of view to resolve, and when it is easier to simply delay tough choices. Ongoing, coordinated risk communication backed by appropriate decision tools can help. Risk messages, tools and resources must be coordinated across agencies and down to the state and local level so that messages are aligned and people will listen, hear, remember, and act. But none of this will happen without commitment and funding.

NOAA, in partnership with FEMA and USACE, created a set of map services to help communities, residents, and other stakeholders consider risks from future sea level rise in planning for reconstruction following Hurricane Sandy. These map services, which cover New York City and the states of New York and New Jersey, integrate the best available FEMA flood hazard data for each location with information on future sea level rise from two different peer-reviewed sources (*Global Sea Level Risk Scenarios for the United States Climate Assessment* and Climate Risk Information 2013: Observations, Climate Change Projections and Maps).



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Mitigating Future Risk

Too often, investments in the floodplain are short-sighted. One reason is that planners and designers underestimate the length of time a given project will continue to function—in many cases a life span of 100 years or more. Another is that planners continue to assume stationarity, although we now know that risk will change and in many cases will accelerate rapidly.

Mitigation, either in original design or in efforts to rebuild or retrofit, will be essential to control loss and reduce the nation's risk. This is true not only for federal FFRMS investments but for non-federal investments as well.

Mitigation Works.
A 2005 study of post-disaster rebuilding efforts by the National Institute of Building Sciences found that a dollar spent for mitigation yields four dollars in costs avoided. Even greater savings can apply for initial construction.

We must invest protectively

We have more reasons than ever to invest protectively and proactively, among them the growing potential for catastrophic losses if we fail to do so. Federal and state governments must take a close, hard look at policies, systems and funding that are based on stationarity. And local governments and the private sector must find ways for their own investments to look to the future.

Decisions on how best to mitigate a community's future risk will require choices and trade-offs among a range of factors. Scientific insights into the implications of climate change are important, but so are cultural and social considerations, including people's perception of risk, the relative importance of identified risks, and the socioeconomic context. Successful planning often combines quantitative science-based scenarios with participatory "visioning" processes that allow the community to explore desired futures and answer key questions about how those futures can be attained.

We must rebuild stronger, safer, and smarter

Rebuilding that considers a changing climate and future patterns of development is also a necessity. Mitigation efforts continue to be federal taxpayer funded on an emergency basis, following disasters. As disaster damage continue to escalate, the ripple effect from future disasters will shut down other critical programs and ultimately may cripple disaster programs themselves. To address the threat of a changing climate, we must address future risk even in a post-disaster environment, and give long-term benefits higher priority in analyses of benefits and costs.

To find the right answers, ask the right questions.

- What is our risk, and how will it change over time?
- What is our community willing to accept in risk versus action?
- How can the principles guiding higher federal floodplain management standards inform actions in our entire community?
- What partnerships (existing and future) can we leverage to make the community more resilient?

(adapted from Charlotte-Mecklenburg planning process)

Pacific, MO, Apr. 3, 2008 – The road crossing the Meramac River south of the Bend Road bridge lies submerged under the flooded river. Franklin County officials will be unable to assess the road's condition until the flood water subsides. (Image credit: Michael Raphael/FEMA)

Seattle, WA, and The Nature Conservancy are partnering to create 20,000 rain gardens which, in combination with floodplains and other natural solutions over the next five years, will capture and filter a billion gallons of stormwater before it reaches and pollutes Puget Sound.

Swale in Seattle is designed to slow rainfall and filter pollution. (Image credit: Paul Joseph Brown)

Following the 1993 Mississippi flooding, Cape Girardeau, MO participated in a FEMA buyout of 97 homes, converting the area to a park. As a result the area was able to survive further flooding in 2008 and 2016.

Cape Girardeau Fire and Rescue Captain Vicky Moldenhauer sets up a photo display that shows the differences between past and present flooding. (Image credit: Andrea Booher/ FEMA)

The Harris County Flood Control District in Texas is working with federal and other partners to mitigate flooding along the area's bayous. The Bays Bayou project is creating detention areas with welcome green space, and an ongoing effort to buy out flooded homes has restored more than 1,000 acres to the floodplain.

Freshwater tidal marsh, Mason Park, part of the Brays Bayou Project. (Image credit: Harris County Flood Control District)

Quantifying and communicating the benefits will aid acceptance of future-focused planning

One way to encourage mitigation on a non-emergency basis and speed adoption of higher local standards is to conduct studies that will quantify the long-term economic and environmental benefits, and then communicate the results. Access to quantified benefits data under different scenarios would underscore the value of adopting zoning and building codes that are in the interest of the nation and the community, and assist the private and public sectors to find common ground.

The private sector can play a key role

The private sector can help not only by building to higher standards but by contributing to their development. The Department of Defense (DoD) maintains a policy of selecting the best model code provisions and industry standards available for military construction. DoD has turned to the private sector in developing its Unified Facilities Criteria, incorporating important private sector standards into a model building code for design and construction of all military projects. Greater cooperation with the private sector on the civilian side could pay dividends as well.

We must ensure that emergency funding is used to build higher and stronger, not to repeat earlier mistakes. And, we must actively support protective investment at the local level, where most infrastructure building decisions are made.

An Overarching Conclusion:

CISA Version *One* is Better than CISA Version *None*.

It is well to remember that FFRMS, CISA, the scenarios we develop to encompass future risk, the tools we build to visualize it, and the actions we take to mitigate it are all first steps in a continuing process.

Over time, the data will get better. The models will more closely reflect anticipated changes. The collaboration across agencies will increase. As we implement CISA Version One there may be missteps along the way, but we will learn from them and improve over time. That's what effective flood risk management does.

The biggest misstep would be to wait any longer to begin.

SUMMARY OF RECOMMENDATIONS

Initial Implementation of the FFRMS and CISA

- Agencies must take the implementation on with high seriousness. Investment for the future must be efficient and effective, beginning now.
- Agencies will face a natural tendency to default to an easy, "one size fits all" freeboard approach. Instead, they should adopt a multi-pronged approach that enables them to make projections of future risk, and quantify the confidence level for those projections at various points in time.
- We are on the road to creating a true safety standard for the nation. In doing so it is important to ensure that the standard is replicable at the state and local level, by providing needed guidance and by building in appropriate incentives for adoption.

FFRMS Policy Issues

- FFRMS policies and recommendations need to be thought through broadly, so that implementation does not fall victim to the law of unintended consequences.
- The exemption of "emergency" rebuilding from the FFRMS needs to be clarified, so that longer-term mitigation and rebuilding efforts can proceed with appropriate consideration of future risk and resilience.
- The FFRMS should also be revised to ensure that when states and localities have adopted more stringent requirements and standards, those take precedence. Similarly, critical facilities should use the highest of available methods for determining the floodplain.
- Benefit cost analyses must take a "life cycle" approach to the system that recognizes the long-term benefit of actions that incorporate future resilience.

Data and Modeling

- The science will continue to evolve. Further research is needed, and more importantly, evaluation of our estimates over time. For example, protocols are needed for applying CISA to riverine areas.
- Data and modeling are not ends in themselves, but must be coupled with action that is reasonable and adaptable to what the science is telling us.
- Congress must fund current and proposed stream data collection efforts.

Collaboration in Implementation

- There is need for full collaboration between federal agencies in use of climate-informed science and in application of FFRMS. It is essential that we not have each agency going down a different path.
- The Unified National Program for Floodplain Management report needs to be updated as a means of achieving national integration. States and localities must be part of the national collaboration.

Review and Evaluation

- We will learn a great deal in implementing the climate-informed science approach. It will be important to have a five year review to evaluate what we have learned and what new information we have.

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Image credit: John McShane

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CDBG	Community Development Block Grant
CISA	Climate-Informed Science Approach
DoD	Department of Defense
DoT	Department of Transportation
EO	Executive Order
EDA	Economic Development Administration
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FFRMS	Federal Flood Risk Management Standard
FIFMTF	Federal Interagency Floodplain Management Task Force
HUD	Housing and Urban Development Agency
MitFLG	Mitigation Framework Leadership Group
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
SBA	Small Business Administration
SLR	Sea Level Rise
TMAC	Technical Mapping Advisory Council
UNP	Unified National Program
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geologic Survey

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