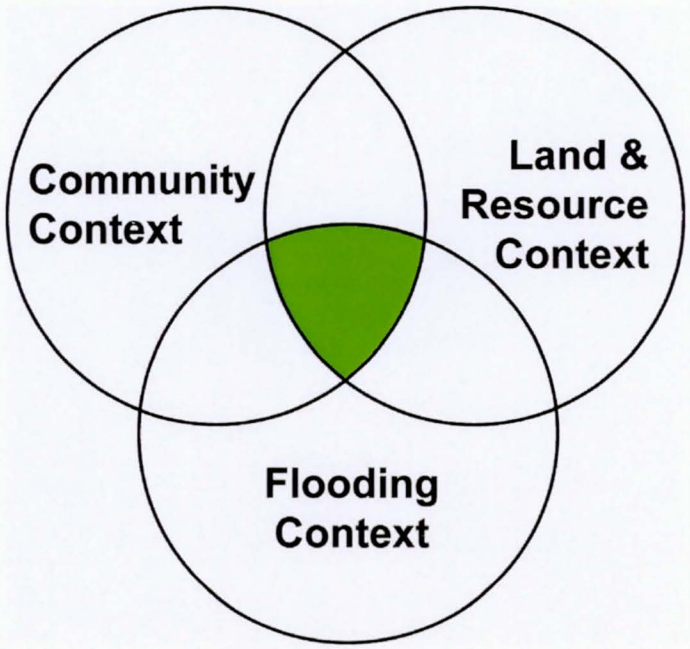
The Context Sensitive Flood Hazard Mitigation Planning and Design Approach



An Innovative Method for Development of Flood Hazard Mitigation Solutions that are Acceptable to Local Communities, Compatible with the Environment and Effective in Reducing Flood Hazards

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April 19, 2010

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Introduction

Floodplain managers and water resource professionals are being challenged today to produce flood hazard mitigation solutions in ways that meet the approval of local communities, protect the environment and reduce flood hazards. Additionally, they are challenged to produce flood hazard mitigation plans and designs that perform these required basic functions in ways that integrate or capture other desired values, such as multiple-uses, and demonstrate fiscal responsibility. The Context Sensitive Flood Hazard Mitigation (CSFHM) Planning and Design Approach was purposely developed to provide a more holistic and integrative method for effectively addressing the complexity of these interrelated challenges.

The CSFHM Approach to project planning and design provides a framework that is being successfully utilized by the Flood Control District of Maricopa County (the District) to enable it to deliver solutions that are **Acceptable** to local communities, **Compatible** with the environment and **Effective** in reducing the risks of flooding (**ACE**). The District regards this tool as a significant advancement in its ability to effectively deliver flood hazard mitigation (FHM) solutions that balance the need for protection of public health, safety and welfare with protection of the valued characteristics of the natural and human built environments, while meeting local community needs for open space, wildlife habitat, recreation facilities and desired sense of place.

The CSFHM Approach is scale independent. It is particularly well suited for watershed based approaches to floodplain management, but it can be applied equally well to smaller drainage areas, watercourses, site complexes or individual facilities. The approach is also functionally independent and could be adapted to the planning and design for a wide range of other land use activities including transportation systems, utilities, building facilities and resource management activities of land management agencies.

Background

Currently, the CSFHM Approach is assisting the District to be more effectual in fulfilling the intent of its basic mission, vision and pledge which are as follows:

> ***Our Mission*** *is to provide flood hazard identification, regulation, remediation and education to the people in Maricopa County so that they can reduce their risks of injury, death and property damage due to flooding, while enjoying the natural and beneficial values served by floodplains.*
>
> ***Our Vision*** *is that people of Maricopa County and future generations will have the maximum amount of protection from the effects of flooding through fiscally responsible flood control actions and multiple-use facilities that complement or enhance the beauty of our desert environment.*
>
> ***We Pledge*** *to show personal integrity and professionalism in all our actions, and to display continuous improvement, innovative thinking, and technical excellence in all our work.*

District authority, direction and responsibility for carrying out its mission can be found in: federal laws, executive orders, regulations and programs; state laws; and county policies, regulations and standards that govern District activities.

At the national level, Congress created the Unified National Program for Floodplain Management under the National Flood Insurance Act of 1968, in response to:

1. The failure of flood control projects to reduce flooding losses due to continued development in floodplains; and
2. Public concern for protecting the natural resources of floodplains and their beneficial functions.

The Unified National Program for Floodplain Management is directed by a Federal Interagency Task Force comprised of federal agencies involved with flooding or development that can be affected by flooding. The Task Force defines "Floodplain Management" as "a decision making process that aims to achieve the wise use of the nation's floodplains". "Wise use" means enjoying the benefits of floodplain lands and waters while minimizing the loss of life and damage from flooding *and,* at the same time, preserving and restoring the natural and beneficial resources of floodplains to the greatest extent possible. Thus, wise use is any activity, or set of activities, that is compatible with both the risks to the natural resources of floodplains and human life and property. The CSFHM Approach serves as a tool to enable the District, which has leadership responsibility for floodplain management in Maricopa County, to more effectively assist local communities in carrying out the intent of the wise use philosophy of floodplain management.

Under the Arizona Revised Statutes (ARS 48-3603.20), the District may undertake a wide array of flood hazard mitigation activities including preservation and restoration of the natural and beneficial functions served by floodplains. Protection of the natural and beneficial functions of floodplains is also a stated intent of the *Floodplain Regulations for Maricopa County*. The planning and design of FHM solutions to preserve, complement and enhance the existing character of the natural and built landscape settings throughout Maricopa County is a primary objective of the District's Board approved *Policy for the Aesthetic Treatment and Landscaping of Flood Control Projects*.

Maricopa County

A variety of societal, environmental and flooding factors contribute to the complexity of challenges facing floodplain managers and water resource professionals in delivering FHM solutions in Maricopa County. Located in south central Arizona and having a land area of approximately 6 million acres, Maricopa County is the 14th largest county in the United States. Including the city of Phoenix, the county contains twenty-four cities and towns with a current combined population in excess of 4 million people.

This region is a growth magnet. Historically an agricultural community, in recent years Maricopa County has experienced an average of 35,000 new housing starts and 75,000 new residents annually. Currently, 20 percent of the county is developed and this figure is expected to double within the next 10-20 years. Much of this development encroaches into floodplains. This rapid development has produced a dramatic shift in population demographics. Urban and suburban growth has led to increased public demand for the District to provide flood protection that 1) Protects, complements and enhances the landscape settings in the county; 2) Creates added value by providing year round opportunities for multiple uses; and 3) Protects the natural resources of floodplains and their beneficial functions. The CSFHM approach is a tool that assists the District in delivering flooding solutions that are acceptable to the communities it serves.

Maricopa County is situated within the northern extent of the Sonoran Desert. The Sonoran Desert is unique because it is drained by a large river system, rather than the basin playas that are more characteristic of the other deserts of the Southwest. Five of the largest rivers within the Sonoran Desert flow through Maricopa County, including the Verde, Salt, Agua Fria, Gila and Hassayampa. Additionally, the Sonoran Desert is characterized by a wide variety of natural settings that include rugged mountain islands separated by broad and open valley plains, rolling upland bajadas with a rich assortment of mixed Palo Verde-cacti woodlands, and dense riparian areas associated with rivers, washes, and arroyos. Because of this diversity, the Sonoran Desert is internationally recognized as one of the richest biotic eco-regions in the world and is often referred to as the "green desert". The Saguaro, the signature plant species of the Sonoran Desert, and many other native plants, are highly valued and protected under state law. The richest and most significant biotic communities occur within the floodplains of river and wash corridors of the Sonoran Desert. This is the precise geographic area of focus for a majority of District flood hazard mitigation activities. The CSFHM approach provides a method for developing FHM solutions that are compatible with the variety of valued landscape settings within Maricopa County.

The region is characterized by an arid climate. The majority of rainfall events are associated with a bimodal pattern that consists of summer monsoons and winter rains. The region also occasionally experiences a third rainfall pattern, tropical storms emanating from hurricanes in the Pacific Ocean. These are less frequent, yet still have potential for causing damaging floods. The summer monsoons that occur during the months of July, August and most of September, are typically are short in duration and localized. In contrast, winter storms typically occur over a period of several days and are wide-spread. Both of these seasonal rainfall patterns are typically intense and, combined with the imperviousness of local soils, produce dangerous flash flooding conditions. Maricopa County is situated within the Basin and Range province of the Southwest where topographic conditions are complex. Flash flooding combined with the wide range of topographic features, produces a broad spectrum of flooding types that include: riverine, distributary, tributary, sheet flow and ponding. The CSFHM approach is designed to produce solutions that are effective in mitigating hazards associated with this broad spectrum of flooding types.

Traditional Approaches

The traditional approach to flood hazard mitigation planning and design employed by the District has been to build large scale, extremely efficient and heavily engineered flood control structures with a mostly industrial character. These structures, which were built at great cost to taxpayers, were typically designed for the single purpose of storing or conveying storm water for an event that might occur once or twice in 100 years. Since these structures were not considered safe for public use, they were typically fenced off, posted with no trespass signs and continually policed in an effort to keep the public out.

The District built these single purpose structures, regardless of the sensitivity or valued characteristics of the landscape settings in which they were placed. These structures often devalued their surroundings. Local communities typically turned their backs and erected walls to hide them. As a result, these flood control solutions provided limited long term multi-purpose value and tended to impose major fiscal and social burdens on communities.

Early efforts by the District and other agencies to add aesthetic treatments and environmental mitigation to these structures produced solutions with a "decorated" appearance. Considerations for landscape aesthetics, environmental mitigation and multiple-uses were

typically incorporated as an afterthought in the planning and design process rather than as an integral part of the function and design of flood control structures.

Recent Planning Efforts

Approximately 10 years ago, the District embarked upon efforts to produce multi-purpose context sensitive flood hazard mitigation project plans and designs, utilizing an adaptation of the rational planning process. The results of these efforts were not always consistent with meeting the intent of the District's Policy for the Aesthetic Treatment and Landscaping of Flood Control Projects. Beginning approximately 6 years ago, the Landscape Architecture Branch began modeling flood hazard mitigation solutions and their compatibility with the visual character of various landscape settings in Maricopa County. The methodology utilized in these compatibility analyses was adapted from an approach previously developed and applied by one of the authors of this paper to the resource management activities of the USDA Forest Service. The Landscape Character Compatibility Analysis that resulted from this effort was designed to serve as a tool for guiding the development of FHM alternatives in ways that would be consistent with the District's Board approved Aesthetic Treatment Policy.

This work was soon expanded to include graphical modeling of the compatibility of FHM solutions with other resources including existing open spaces, parks and recreation resources. Efforts continue today to model the compatibility of FHM solutions with other resources of the land and resource context. More recently, application of this approach has been broadened to include modeling of the flooding and community contexts to predict the effectiveness of FHM solutions to reduce flooding hazards and the acceptability of FHM solutions to the community.

All of these graphical modeling efforts have their roots in Ian McHarg's modeling of land suitability in the 1960's. As with the District's compatibility assessments mentioned above, the purpose of McHarg's land suitability analyses was to serve as a tool for guiding the development of alternatives to achieve the basic functional requirements of the project, which in his case was environmental protection. This use of predictive graphical modeling as a tool to guide the development of alternatives to achieve the required basic functions of a project is a distinguishing characteristic of the systems planning process. Whereas McHarg's use of predictive modeling was limited in scope, the District's adaptation of his approach greatly expands its ability to address a wide variety of flood hazard mitigation solutions, contexts and functional outputs, thus enhancing its ability to address the divergent complexity of required basic functions needed to produce solutions that are acceptable, compatible and effective (ACE).

The development and application of predictive modeling to the community, land and resource and flooding contexts set the stage for the introduction of the CSFHM Approach in mid 2008 as a means of improving the District's ability to respond to the complexity of the goals and objectives it seeks to achieve. The Landscape Architecture Branch of the Flood Control District of Maricopa County undertook the challenge to develop a planning and design process that would accommodate the District's desire to produce value added context sensitive solutions for the communities that it serves. The approach has been modeled using a Venn diagram that displays the possibility for identifying the existence of complementary functional relationships between the community, land and resource, and flooding contexts.

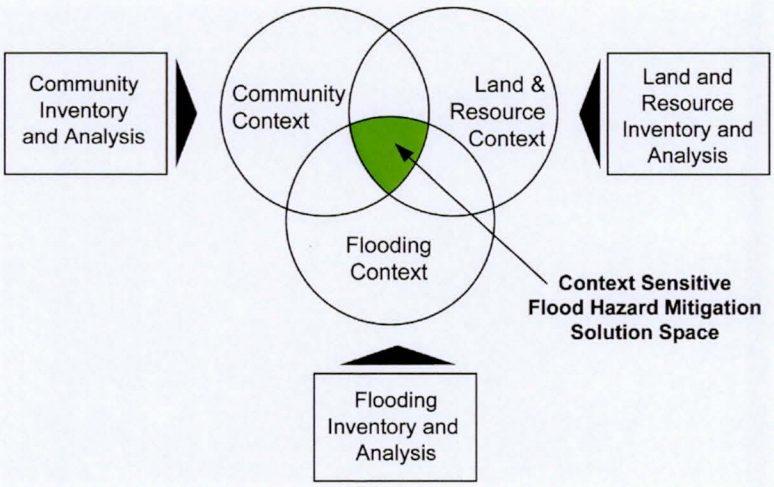
The CSFHM Approach

The Context Sensitive Flood Hazard Mitigation Planning and Design Approach serves as a framework for floodplain managers, water resource professionals, planners, engineers, landscape architects, environmental professionals and others, to guide the development of FHM solutions that integrate the three required basic functions of being **Acceptable** to local communities, **Compatible** with landscape resources and **Effective** in reducing flooding hazards (**ACE**). The CSFHM Approach provides water resource professionals with an innovative tool for consistently delivering multi-objective results.

A context sensitive solution, as defined in this document, is one that integrates and delivers all three basic functional outputs of being acceptable, compatible and effective. It should be recognized that achievement of only one or two of these functional outputs, does not constitute a context sensitive solution. It requires all three. Conversely, it should also be recognized that in real world application of the CSFHM Approach, the degree to which context sensitive solutions will be produced will depend upon the complexities, opportunities and constraints that are presented by the project. Nevertheless, performance of the required basic functions contained in the ACE challenge is a critically important initial intent.

The CSFHM model focuses on the interrelationship between three contexts: Flooding, Land and Resource, and the Community. The Flooding Context is defined through an analysis of risk and exposure to flooding. The Land and Resource Context is defined through the analysis of valued characteristics of landscape resources. The Community Context is defined through the analysis of direction and vision provided in local community plans and public sensing. The CSFHM Approach then identifies context sensitive solutions that lie within the interface between these three contexts. The range of FHM solutions that are identified through application of the CSFHM Approach are then used as the **"building-blocks"** for designing alternatives in FHM planning studies and project designs.

Figure 1 **The Context Sensitive Flood Hazard Mitigation Planning and Design Model**



The CSFHM approach utilizes a blend of civil engineering, hydrology and hydraulics, and landscape architectural planning and design technologies that borrow from the USDA Forest Service Visual Management System, the Federal Highway Administration Context Sensitive Design process, Lawrence Miles' value analysis theory, and Ian McHarg's classic application of land suitability analysis.

Application

The CSFHM Approach employs a six step planning and design process. The steps in this process, which are briefly described in the following sections, include:

1. Project Direction
2. Range of Possible solutions
3. Inventory
4. Analysis
5. Alternatives Formulation and Evaluation
6. Plan Selection and Refinement

The level of effort associated with implementing these steps will vary depending upon the scope, context and complexity of the project.

Step 1 Project Direction

Context sensitive solutions do not just happen. They are the product of purposeful intent and vision on the part of floodplain managers, community leaders, project managers, water resource professionals and others. Therefore, the first step in the CSFHM planning and design process is to define the full suite of multi-purpose goals, objectives and required functions related to the flooding, land and resource, and community contexts of the project. The use of project pre-scoping and visioning exercises that include a cross-section of water resource professionals, other disciplines, project stakeholders and representatives from the community should be exercised in defining the multi-purpose objectives and required basic functions (ACE).

CSFHM solutions require complete integration of all identified multipurpose functions into FHM solutions. To be successful, this integration must take place throughout the planning and design process. Therefore, it is essential that all members of the planning or design team and all others involved have a clear understanding of the complete suite of multi-purpose functional requirements from the outset of the project. Otherwise, it is unlikely the team will be able to deliver a fully integrated context sensitive plan or design in a productive and efficient manner. Knowing the multi-purpose functional requirements of the project can help to tailor the inventory and analysis and also serve as a basis for evaluating project alternative performance in Step 5 of the process.

Step 2 Range of Possible Solutions

Today, the District routinely considers and evaluates a variety of different floodplain management strategies, structure types, structural methods and landscape design themes for possible application as FHM solutions in project planning and design studies. Each of these possible solutions varies in terms of their potential to perform needed flood hazard mitigation functions. They also vary in terms of their size, form and other physical and visual characteristics that influence their potential impact upon the valued characteristics of different landscape settings.

A key step in producing context sensitive projects is the identification and selection of FHM solutions that have the potential to be acceptable to the community, compatible with the environment and effective in reducing flood hazards. Defining the range of possible FHM

solutions is the critical step that serves as the starting point and basis for identifying context sensitive solutions. Therefore, in the second step of the CSFHM planning and design process, the full range of possible solutions is identified and described in words and pictures.

Defining the range of possible solutions at the outset of the project provides a common frame of reference for members of the planning or design team. It also serves as a focus for the inventory of the three contexts and the common thread that links the analyses of acceptability, compatibility and effectiveness. Following is a brief summary of the range of flood hazard mitigation strategies, structure types, structural methods and landscape design themes routinely considered by the District in flood hazard mitigation planning and design studies.

Flood hazard mitigation strategies represent the broadest approaches to addressing flooding issues. The range of flood hazard mitigation strategies usually considered by the District in project planning and design includes the floodplain management strategies that are identified and described in the FEMA 480 Desktop Guide. These strategies include:

- Modify Human Susceptibility to Flood Damage - by reducing disruptions resulting from hazardous, uneconomic or unwise use of floodplains
- Modify the Impact of Flooding - through assistance to individuals and communities to prepare for, respond to, and recover from, flooding
- Modify Flooding - by developing structures that control floodwater
- Preserve and Restore the Natural Resources of Floodplains and their Purpose - by reestablishing and maintaining floodplain environments in their natural state

Under the strategy of Modifying Flooding, the District typically considers and evaluates a variety of different structure types at different scales as possible FHM solutions. The range of structure types that are routinely evaluated in project planning and design studies include:

- Underground Facilities
- Levees
- Conveyance Channels
- Storage Basins
- Dams and Flood Retarding Structures

Structural Methods refer to the different ways in which the structure types can be built both in terms of the materials that are used and their overall form. The structural methods that are typically considered and evaluated range from soft and semi-soft earthen structures with naturalistic organic forms to those built using hard materials (concrete, soil cement, etc) and having geometric forms. The range of the structural methods includes:

- Soft Structural
- Semi-Soft Structural
- Hard Structural with Aesthetic Treatment
- Semi-Hard Structural
- Hard Structural

Landscape Design Themes refer to the different ways of treating the surface of a structure to enable it to protect, restore or enhance the valued characteristics of the landscape setting in which it is located. The selection and application of particular landscape design themes based upon the existing or desired future character of the landscape setting is an important component in the development of CSFHM solutions. The Landscape Design Themes that are considered

and evaluated for application to District projects located within the Sonoran Desert vary from natural and semi-natural themes to those that are more culturally influenced. These themes include:

- Natural Sonoran Desert
- Semi-Natural Sonoran Desert
- Enhanced Desert
- Desert Park
- Desert Oasis
- Desert Plaza

Step 3 Inventory

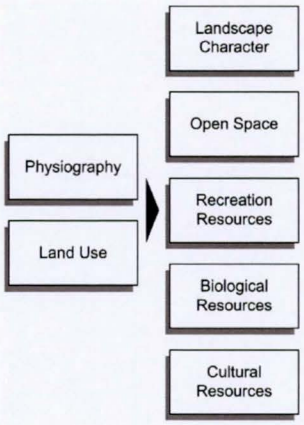
The third step in the CSFHM planning and design process involves the inventory and collection of data pertaining to the flooding, land and resource, and community contexts. The purpose of these inventories is to promote understanding of existing and desired future conditions within the project area. The inventory identifies important, or valued, resources and features and serves as a basis for identifying opportunities and constraints for development of CSFHM solutions. More specifically, the inventory and collection of data is designed to serve as a baseline for assessment of the acceptability, compatibility and effectiveness of the range of possible FHM solutions.

The Flooding Context Inventory includes an identification of flooding risk and exposure based upon inventory and interpretation of geomorphology and land use. In this assessment, the geomorphology is inventoried and analyzed to identify the presence of different flooding types within the project area. Flooding risk ratings are then assigned to various areas of the project based upon their identified flooding type(s). Future land use data obtained from the Maricopa Association of Governments and local communities is analyzed and utilized to assess and assign flood exposure ratings to various parts of the project area. The relationship between the assessments of risk and exposure is then evaluated to derive an overall flood hazard rating for various parts of the study area. The flood hazard assessment is utilized to identify geographic areas of highest priority for flood hazard mitigation. The flooding risk assessment serves as a tool for identifying the effectiveness of different possible FHM solutions in the analysis step of the CSFHM application process.

Figure 2 Flooding Context Inventory Process

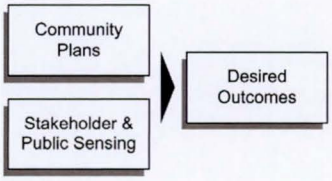
The inventory of the Land and Resource Context includes assessments of landscape character, open space, and parks and recreation, biological and cultural resources. The Landscape Character Inventory broadly identifies the complete range of landscape settings found within Maricopa County based upon an evaluation of land use and physiography (landform, vegetation and water). The Open Space Resource Inventory includes existing "Secured" open space resources such as federal wilderness areas and national monuments in Maricopa County, "Conservation" open space areas recommended for future acquisition, and "Retention" open space areas recommended for application of sensitive development guidelines. These open space resources were delineated based upon assessments of their scenic quality, recreation and biological values. The Open Space Inventory also includes delineated floodplains within Maricopa County. The Parks and Recreation Resource Inventory includes all existing federal, state, county and local parks and recreation areas in Maricopa County. It also includes existing golf courses and the proposed Maricopa County Regional Trail System. The Biological Inventory includes wildlife habitat patches and linkages. The Cultural Resource Inventory includes significant sites and habitation development periods. Taken together, the inventories in the Land and Resource Context serve as a tool to identify the valued characteristics of landscape resources and are utilized as a baseline for identifying compatible FHM solutions during the analysis step of the CSFHM application process.

Figure 3 **Land and Resource Context Inventory Process**



The Community Context is defined through an inventory and examination of local community goals, objectives and requirements for specific geographic areas. These are usually found in local community general plans, elements, ordinances and guidelines. This information is supplemented, refined and validated through sensing of stakeholders and the public during project planning and design. The inventory of the Community Context identifies desired community character and needed multi-purpose functions that could potentially be integrated into FHM solutions. This information is also used to establish the range of FHM solutions that would be acceptable to the community during the analysis step of the CSFHM application process.

Figure 4 **Community Context Inventory Process**

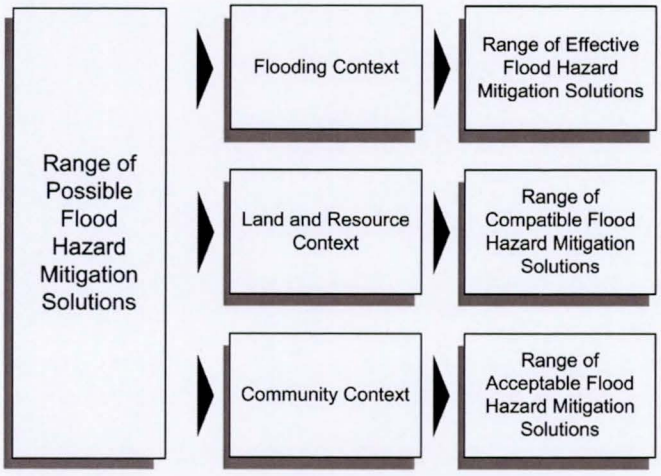


Step 4 Analysis

The range of acceptable, compatible and effective FHM solutions is identified in the analysis step of the CSFHM planning and design process. This is accomplished, first, by undertaking a predictive analysis of the range of possible FHM solutions and the information contained in the inventories of the flooding, land and resource, and community contexts. The product of this effort typically takes the form of a series of matrices containing ratings indicating whether or not each FHM solution is acceptable, compatible or effective. The information from the matrices and the inventory maps for the three contexts, is then utilized in GIS to produce flood hazard mitigation acceptability, compatibility and effectiveness maps for the project study area. The information from these maps is then subjected to a comparative analysis to identify the range of FHM solutions that have the ability to perform all three of the required basic functions of a context sensitive solution (i.e. those that are acceptable, compatible and effective).

The range of effective FHM solutions is identified by evaluating the relative ability of the FHM strategies, structure types, structural methods and landscape design themes to effectively reduce the risks of flooding associated with the different flooding types that were identified in the inventory step of the application process. This assessment takes into account opportunities for utilizing strategies other than "Modify Flooding" as sustainable approaches to effectively reduce flooding hazards. It also takes into account the relative ability of the structure types, structural methods and landscape design themes to perform the functions required in cases where structural solutions are necessary. Each FHM solution is rated as either effective or ineffective in this analysis, which is typically facilitated by a CSFHM process guide with input from engineering and water resource technical disciplines.

Figure 5 **Predictive Analysis Process**



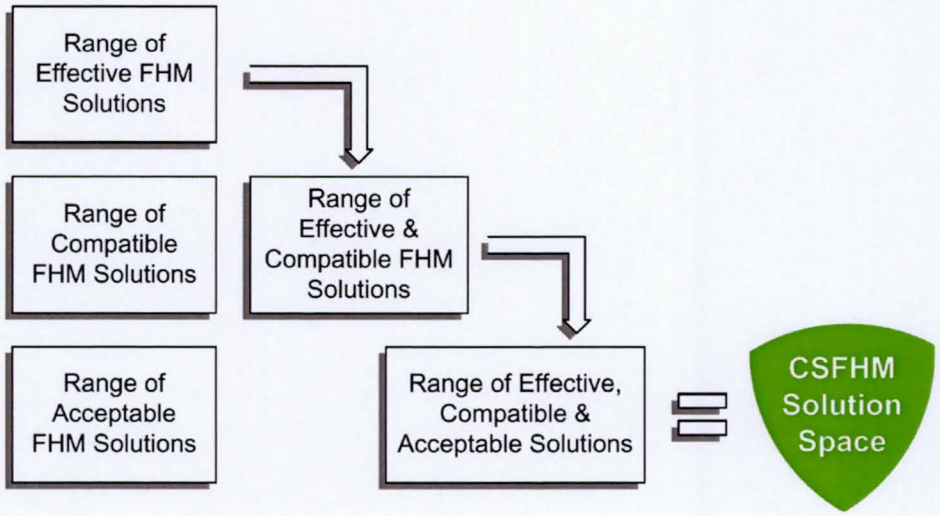
The range of compatible FHM solutions is determined by assessing the relative ability of the flood hazard mitigation strategies, structure types, structural methods and landscape design themes to sustain and complement the valued characteristics and beneficial functions of the landscape settings, open spaces and recreation environments found within the project study area. This determination is accomplished by taking into account the character, size and probable magnitude of landscape modification commonly associated with each FHM solution in comparison with the valued characteristics and level of modification that is associated with landscape settings and features identified in the Land and Resource Inventory. Each FHM solution is rated as either compatible or incompatible in this analysis, which is typically facilitated by a CSFHM process guide with input from land and resource knowledge experts.

The range of acceptable FHM solutions typically is established by assessing the potential of the various flood hazard mitigation strategies, structure types, structural methods and landscape design themes to complement and enhance desired local community character, achieve consistency with local community plans and ordinances and protect valued existing multi-use features such as parks and recreation areas. Each FHM solution is rated as either acceptable or unacceptable in this analysis, which is typically facilitated by a CSFHM process guide with input from stakeholders and members of the community.

The results of the above predictive analyses typically show that the various FHM solutions (strategies, structure types, structural methods and landscape themes) are arrayed as a spectrum, within each of the three contexts, according to their relative ability to be acceptable, compatible and effective. As a result, the geographic areas that are delineated on the analysis maps typically depict the range or number of FHM solutions that are expected to be acceptable, compatible or effective for each area.

In the final step of the analysis, the information from the analysis maps for the three contexts is compared to identify those FHM solutions that concurrently meet all three of the basic functional requirements for a CSFHM solution (ACE). The comparative analysis is carried out either manually or with GIS in the case of large or complex study areas. In either case, the comparative analysis begins with a comparison of the range of effective solutions with the range of compatible solutions to identify the set of solutions that is both effective and compatible. The effective/compatible set of solutions is then compared with the range of acceptable solutions to identify the set of solutions that meet all three of the required basic functions (ACE).

Figure 6 **Comparative Analysis Process**



The result of the synthesis step essentially defines the solution space in the CSFHM Planning and Design model. The floodplain management strategies, structure types, methods and landscape design themes that comprise this solution space constitute the "building-blocks" that are then used to develop CSFHM alternatives for planning and design projects.

Step 5 Alternatives Formulation and Evaluation

The fifth step in the CSFHM planning and design process is the formulation and evaluation of context sensitive flood hazard mitigation alternatives. This is achieved by utilizing the CSFHM "building-blocks" that are identified in the preceding Analysis Step for development of the alternatives. The project planning or design team can proceed with the assurance that virtually any alternative that is constructed using CSFHM "building-blocks" will result in a context sensitive solution, (i.e. one that is acceptable to the community, compatible with the environment and effective in reducing flood hazards).

Identifying the range of context sensitive solutions in the preceding Analysis Step 4 enables the planning or design team to invest more of their effort in development of alternatives that will meet the stated purpose and basic required functions of the project and produce win-win solutions. This also increases the opportunity for the team to invest more time and effort on development of alternatives that can be selected that have different emphases. These emphases could include, for example, CSFHM alternatives that focus on 1) least cost, 2) protection of the natural and beneficial values of floodplains, 3) opportunities to implement regional trail systems, 4) opportunities for park and recreation areas; 5) enhancement of local community character, 6) biological functions; or 7) development and transportation of energy.

The alternatives are typically evaluated based upon their performance of the required basic functions (ACE) and the degree to which they optimize delivery other desired functions. Value Analysis is a tool that is often employed at this stage to identify and evaluate alternative ways of delivering FHM solutions to maximize value and efficiency. The required basic functions of acceptability, compatibility and effectiveness that are identified in Step 1 of the CSFHM approach, constitute the required primary functions that serve as the foundation for the application of value analysis methodology.

Step 6 Plan Selection and Refinement

In the final step of the CSFHM planning and design process a comprehensive flood hazard mitigation project plan or design is developed for the project utilizing the information from all of the preceding steps of the process. In the case of planning studies, the plan will reflect a watershed based approach that identifies and allocates flood hazard mitigation strategies for the entire watershed. It will also identify: 1) the tools and guidelines required to implement the strategies and various aspects of the plan and to sustain them as viable solutions into the future; 2) the roles and responsibilities of the District and others for carrying out and financing the implementation and management of various aspects of the plan; 3) priorities for carrying out various components and projects of the plan; and 4) it will include conceptual designs and design guidelines for guiding the development of structural solutions in the next phases of project implementation to ensure they will be acceptable, compatible and effective and that the other desired functions of the plan are effectively integrated into the solutions.

Characteristics of the CSFHM Approach

The CSFHM Approach embodies unique characteristics that offer a variety of advantages that can be leveraged by agencies, project managers and consultants who are involved in floodplain management and flood control activities as well as local communities who are recipients of these services. Some of the characteristics and advantages that are being realized from the application of this approach include:

1. **Basic Premises**

   The CSFHM Approach is founded on the premise that flood hazard mitigation solutions may exist that are capable of concurrently performing all of the complex and seemingly divergent functions contained in the ACE challenge (i.e. the challenge of producing FHM

solutions that are capable of performing the required basic functions of being acceptable to local communities, compatible with the environment and effective in reducing flood hazards). It is also founded on the premise that knowledge about the possible presence such integrative solutions is important to the effective and efficient development of context sensitive flood hazard mitigation solutions in project planning and design.

2. **Integrative Process Design**
   The CSFHM Approach employs a model and a process that is purposefully designed to seek out and reveal the presence of integrative flood hazard mitigation solutions that are capable of performing the required basic functions of ACE, so that they can be used as the building blocks for development of context sensitive project alternatives, plans and designs.

3. **Integrates Divergent Functions**
   The CSFHM Approach implements a unique method of systematic predictive modeling and comparative analysis to reveal the presence of sets of flood hazard mitigation solutions that are capable of performing all three of the required basic functions of a context sensitive solution. Defining the full range of possible flood hazard mitigation solutions in the second step of the CSFHM planning and design process provides the common element that serves to focus and unify the predictive modeling of acceptability, compatibility and effectiveness and is a key mechanism that enables the CSFHM Approach to identify integrative solutions that are capable of performing these apparently divergent functions.

4. **Sequence and Timing are Critical**
   The CSFHM Approach is designed to reveal the presence of flood hazard mitigation solutions that are capable of performing all three of the required basic ACE functions ahead of the alternatives formulation stage. This is the strategic point in the planning process where knowledge about the presence of these integrative solutions can be most effectively and efficiently utilized to influence development of alternatives that are designed to perform the basic required functions of ACE.

5. **Solves for Functions**
   The CSFHM Approach focuses first on development of integrative solutions that will perform all three of the required basic functions of the ACE challenge. It then focuses on the inclusion and integration of other desired functions to the extent they are complimentary to the required basic functions of ACE and opportunities exist for their capture as part of an alternative.

6. **Effectiveness**
   The CSFHM Approach displays a variety of other characteristics that define its ability to serve as an effective planning process. These include a capacity for:

   - **Complexity** - the ability to deal with large amounts of information from a variety of sources on many different subjects from diverse disciplines

   - **Prediction** – the ability to estimate the potential effects of a proposal on existing or planned future environments

- **Defensibility** – the ability to provide a clear and logically correct framework to support claims

- **Communicability** – the ability to be understood by the general public

- **Applicability to Different Scales of Concern** – the ability to respond to different scales of concern or decision making

Other Benefits

The CSFHM Approach has demonstrated an ability to deliver a variety of other benefits associated with project planning and design. These include the ability to:

1. **Produce Win-Win Solutions**

   The CSFHM Planning and Design Approach produces integrated solutions that balance the functional requirements for effectively reducing flooding in ways that protect the environment and meet local community needs.

2. **Promote Partnerships**

   By increasing opportunities for meeting a variety of local community needs, the CSFHM Approach increases the interest of local communities in participating with the District as cost-share partners in the design, construction, operation and long term maintenance of FHM solutions.

3. **Increase Efficiency**

   The CSFHM Approach focuses the valuable time and efforts of planning and design teams on development of alternatives that are specifically designed to meet the stated purpose and complete suite of required basic functions (ACE). This leads to increased efficiency in meeting project delivery schedules at reduced costs.

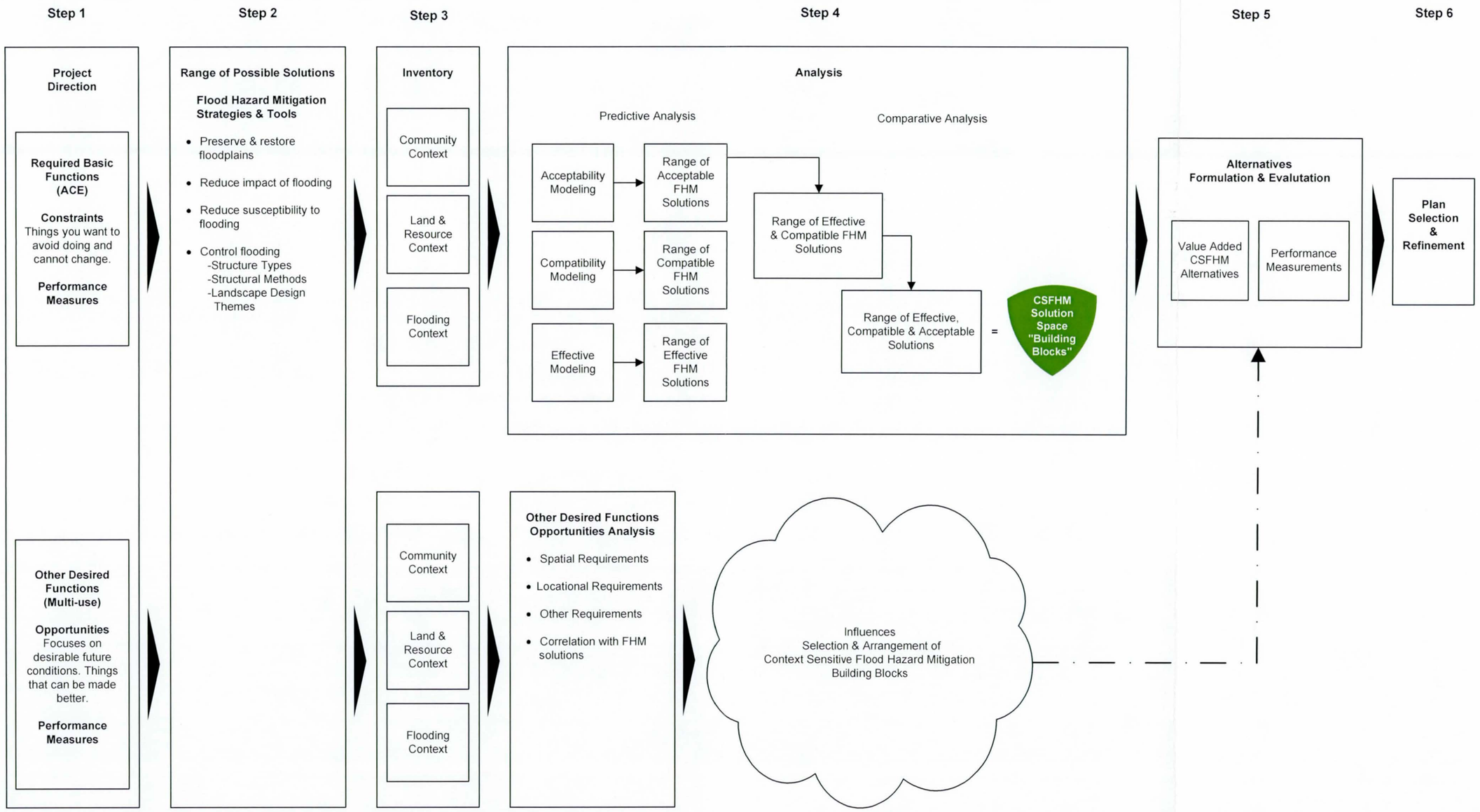
4. **Reduce Uncertainty**

   The CSFHM Approach provides a clear view of the range of FHM solutions that can be used for development of context sensitive alternatives at the outset of the alternatives formulation stage. This reduces uncertainty on the part of planners and interdisciplinary teams in terms of their understanding the range of solutions that are available for building context sensitive project plans and designs.

Conclusion

The CSFHM Approach provides floodplain managers and water resource professionals with a tool for meeting the complex challenge of producing FHM solutions that are **Acceptable**, **Compatible** and **Effective** (**ACE**). The **"building-blocks"** that are found within the solution space of the CSFHM model enables interdisciplinary planning and design teams to efficiently develop context sensitive project alternatives. The District regards this tool as a significant advancement of its ability to deliver FHM solutions that balance the need for protection of public health, safety and welfare with protection of the valued characteristics of the natural and human built environments, while meeting local community needs for open space, wildlife habitat, recreation facilities and desired sense of place. In closing, the benefits associated with application of the CSFHM Approach can be leveraged nation-wide.

Figure 7 **The context Sensitive Flood Hazard Mitigation (CSFHM) Planning & Design Process**



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