Lahontan Basins IRWMP

Integrated Regional Water Management Plan

Integrated Flood Management

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1. Introduction

1.1 Background

Flooding is a chronic problem that is experienced throughout the Lahontan Basins region, even with a semi-arid climate, which can result in significant losses and economic damages. The Lahontan Basins region is comprised of three watershed units which are unique in their hydrologic responses, as well as their floodplain functions, which lend the flood management planning assessments to a watershed approach. However, flood and stormwater runoff generated from watersheds can also represent a valuable water resource that can be managed successfully rather than being typically viewed as a hazard. This report has been prepared as a companion document to support the addition of multi-benefit floodplain management into the *Lahontan Basins Integrated Regional Water Management (IRWM) Plan* as a key water resource element in regional water planning. Floodplain management and flood hazard mitigation is extremely complex with multiple issues and different watershed responses throughout the region to storm/rainfall events. There is not a one size fits all solution, but comprehensive planning is required on a watershed basis to develop an implementable system-wide answer. **Integrated Flood Management (IFM)** combines land and water resources development in a floodplain, within the context of IRWM with a view to maximize the efficient use of the floodplains and minimize loss of property and life.

Mountains

Heavy Snowfall

Honey Lake Valley

Susan River

Figure 1 - Lahontan Basins region has a range of different type of flood hazards and associated watershed response based on watershed characteristics

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This regional study is not the traditional watershed/flood management planning document since it does not provide specific regional flood mitigation projects as a conventional master plan would provide. However, the report is intended as a "guidance document" to facilitate an integrated water resources approach to flood management. This assessment is based on readily available information to perform planning level risk assessment in order to provide high level recommendations. In addition, it defines general applicable strategies/approaches, as well as provides planning level tools, to guide flood management decision making on a watershed basis. Watershed management embraces a wide range of watershed considerations and specialized control strategies to preserve the hydrologic functions of the watershed and corresponding water resources. The approach embraces an understanding that with responsible planning of the watershed to take care in protecting the natural integrity of the floodplain and to ensure the maximum value will be realized from protecting key natural resources. The focus of integrated planning is on balancing the community flood management needs with the environmental constraints and watershed resources which will ensure an acceptable solution with the flexibility to adapt to future changes. A sustainable flood and water management approach would recognize the:

- Interconnection of flood risk management actions within broader water resources management, ecosystems, and land use planning
- Value of coordinating across geographic and agency boundaries
- Need to evaluate opportunities and potential impacts from a system perspective
- Importance of environmental stewardship and sustainability
- Need for system flexibility and resiliency in response to changing conditions, such as climate change and population growth

1.2 Integrated Flood Management Approach

IFM is an approach that varies from traditional flood protection with a focus on maximizing the efficient use/net benefit of a floodplain while promoting public safety. IFM is a process that promotes an integrated, rather than fragmented, approach to flood management, and recognizes the connection of flood management actions to water resources management, land use planning, environmental stewardship, and sustainability. Flood risk management requires the holistic development of a long-term strategy, balancing current needs with future sustainability. Incorporating sustainability means looking for solutions of working towards identifying opportunities to enhance the performance of a watershed system as a whole.

An integrated strategy usually requires the use of both structural and non-structural solutions. Depending on the characteristic of an individual watershed, various resource management strategies may be used such as:

land stewardship, conjunctive water management, conveyance, ecosystem restoration, forest management, land use planning and management, surface storage, urban runoff management, and watershed management. It is important to recognize the level and characteristics of existing risk and likely future changes in risk. Integrated flood management also includes the recognition that flood risk can never be entirely eliminated and that resilience to flood risk can include enhancing the capacity of people and communities to adapt and cope with flooding.

The benefit of using a regional and system-wide approach is that it takes into account a wide range of causes and effects, reducing potential negative unintended consequences in nearby regions. Regional approaches allow for the best use of public resources by increasing the number of issues considered. This also promotes system flexibility and resiliency by developing solutions that provide the best benefit to the overall system or region. In contrast, localized and narrowly focused projects may solve an issue or problem while transferring the problem up or downstream. One of the benefits of using an IFM approach is the potential to access funding sources that might not have been available to single-benefit projects. This can lead to achieving sufficient and stable funding for long-term flood management.

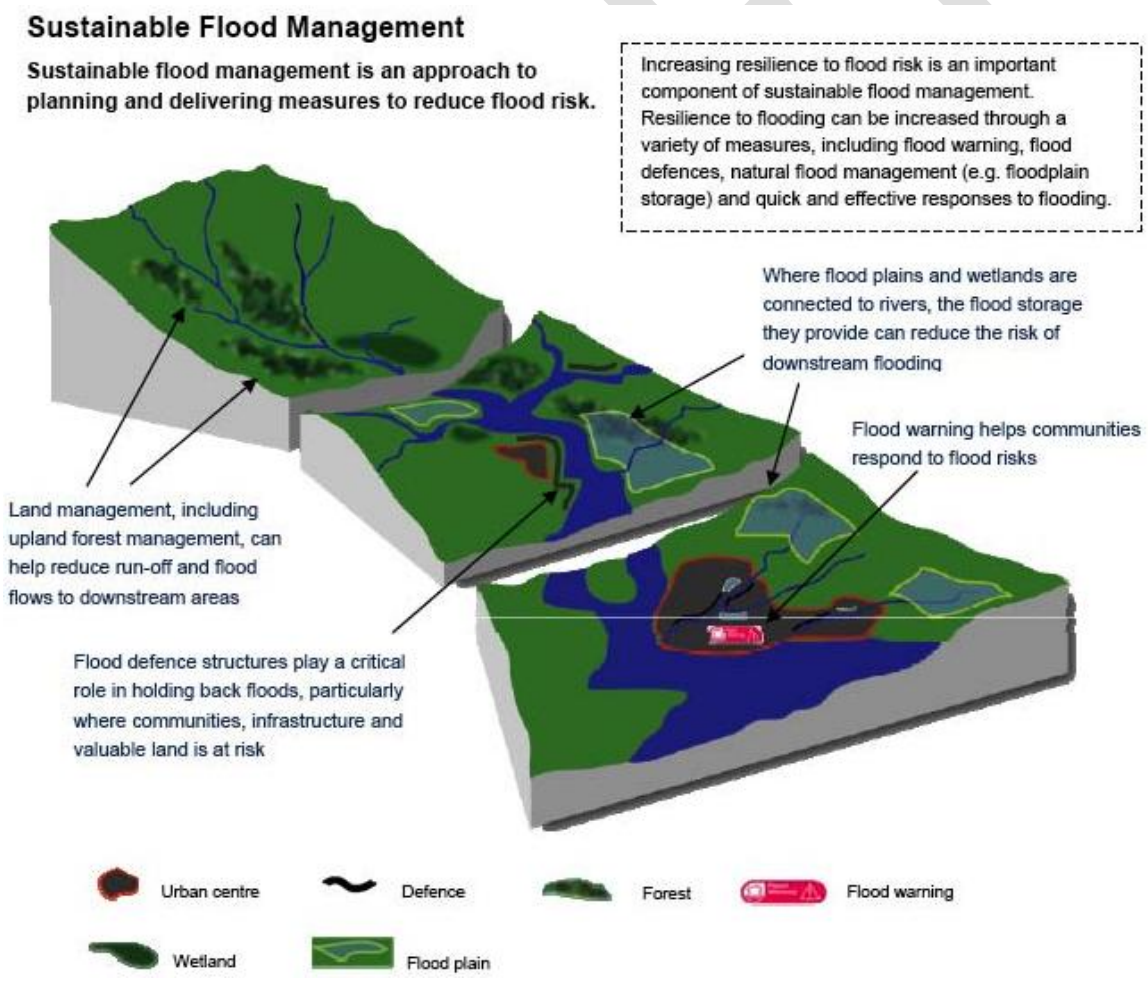

Figure 2 - Sustainable Flood Management

1.3 General Regional Flood Management Issues

Infrastructure project development, implementation, and operation constraints have changed as public values have evolved. Today, infrastructure projects, including flood management projects, face increased stakeholder involvement, land use constraints, changing regulatory requirements, and new environmental considerations. These issues have led to an increase in the cost of flood management. Addressing these issues will require a move away from the traditional approach to developing flood management projects. Many of these issues were identified during the stakeholder meetings that were conducted as part of the IRWMP study process. The stakeholders cited specific examples of flood management problems and roadblocks associated with implementation. Many of these same issues have also been encountered by other communities which have been identified during the statewide Flood Management Program Study (see *Section 1.4*).

Specific issues impacting flood management projects include the following:

Projects require extensive stakeholder involvement, which increases project planning costs. Stakeholders have become more educated about project development and environmental requirements. Successful projects require proper engagement of a diverse set of stakeholders. The cost associated with stakeholder engagement activities must be included in planning and implementation costs.

Flood management responsibility is fragmented. Responsibilities for planning, administering, financing, and maintaining flood management facilities and emergency response programs are usually spread among several agencies or between departments within a large agency. There is not a centralized agency coordinating all the flood management activities within the county which makes the Lahontan Basins unique. Flood management responsibilities are often spread out within and between these agencies.

Different methodologies and inadequate data make risk assessment complex and costly to complete. Insufficient data on the specifics of flood hazards in many areas makes it difficult to assess the level of problems. Much of the available data is based on FEMA flood hazard mapping, but this does not identify the chronic flood problems which occur on a frequent basis and on smaller storm events other than a 100-year event. In addition, the data related to existing drainage facilities and the original design capacities are not readily available in digital format which makes it difficult to perform rapid assessments at a regional scale.

Land use decisions may not adequately prioritize public safety. Uninformed residents and policymakers can make decisions that inadvertently put people and property at increased risk. In some cases, providing adequate space for flood management facilities to meet existing and future needs during the development approval process would reduce flooding impacts. Internal and intra-agency coordination is important when local agencies make development decisions. Improving coordination within and between agencies could inform the potential land use decisions to considerations in General Plans, flood managers are not always included in land use discussions.

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Delayed permit approvals and complex permit requirements are obstacles to flood risk reduction. Many agencies wait years for permits, resulting in poorly maintained projects and missed funding opportunities for new projects. Often, agencies face conflicting or confusing requirements regarding project permits. Also, regulatory requirements to renew existing permits or obtain new permits frequently require extensive mitigation. This mitigation can greatly increase project costs and cause project delays.

Flood management projects are not prioritized from a "watershed" system-wide or multi-benefit perspective. State and federal flood management funding has traditionally been provided to local projects by analyzing a narrowly focused and localized set of benefits. In addition, funding levels for flood management are often set without regard to a system-wide prioritization of needs.

Flood risk funding as well as long term funding for operations and maintenance. Funding for flood projects is based upon the potential that a significant flood will occur, rather than providing for day-to-day flood management needs. Inadequate funding for flood management maintenance, operations, and improvements makes flood risk reduction difficult or impossible for many local agencies. Agencies at all levels are facing funding constraints. Local agency funding is often based on county general funds, which have been impacted by the economic downturn. Reductions in Federal funding have occurred, resulting in potential reductions in funding levels for flood risk studies and projects.

1.4 California Statewide Flood Management Program Study

California Department of Water Resources (DWR) has recently completed the initial phase of a statewide flood management planning study which is similar in many respects to the flood management planning study being development for the Lahontan Basins IRWM. The database development for this study mirrored the statewide information process and resulted in the similar database, as well as inventory issues. The results of the initial statewide study are available to the public. This report, *California's Flood Future: Recommendations for Managing the State's Flood Risk* (Flood Future Report) presents an overview of the flood threats facing the state, approaches for reducing flood risk, and recommendations for managing California's flood risk. The Flood Future Report is the first statewide report to be developed through collaboration between DWR and the United States Army Corps of Engineers (USACE). This report is the first product of DWR's State Flood Management Planning (SFMP) Program. The SFMP Program was developed under the FloodSAFE Initiative to expand the focus of California's flood management planning statewide in compliance with Public Resources Code (PRC) Section 75032. The SFMP Program was funded under Proposition 84 as part of the DWR FloodSAFE Initiative and the IRWM Program.

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The first step of the Flood Future Report was accomplished by interviewing representatives of 142 local flood management agencies throughout the state, and asking them to define and characterize the type and location of existing and future flood threats and issues in their local area. Agencies were interviewed regarding existing flood infrastructure, planned flood management projects (including IRWM projects with flood benefits), and flood management challenges and opportunities facing the agency. As a result of the meetings with local agencies, more than 3,800 different documents related to flood management in California were collected. A review of these documents, combined with information from interviews, formed the foundation to explore approaches that address the array of flood risk management issues identified. Using this information, an analysis of exposure to flood hazards was completed to expand the understanding of the exposure threat to flooding statewide. This analysis identified population, structures, crops, and endangered species exposed to flood hazards statewide.

Once a basic understanding of the flood threats in California was attained, different approaches to flood management mitigation solutions arose, including structural and nonstructural measures and IWM. Financing and institutional strategies also were explored based on past funding and new, innovative ideas. Finally, an appropriate path forward to manage California's flood risk was identified by formulating technical, legislative, policy, financial, and other recommendations. These recommendations were synthesized from information developed as part of the SFMP Program, including suggestions from flood experts, previous flood management studies, and local agency recommendations.

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2. Flood Management Database

2.1 Data Needs

A wide range of data was required to develop a minimum "baseline" database that would assist in developing background and understanding in order to characterize the existing watershed and flooding conditions. The general categories and types of data that were researched as part of the initial "baseline" included the following:

- **Watershed** – Data related to characterizing the watershed conditions, including hydrologic parameters
- **Hydrology** – Studies and information related to estimates of the surface hydrology quantities and watershed response for different storm events
- **Meteorological** – Information related to the types of rainfall events characteristic of the region and the historical rainfall magnitudes including frequency as well as aerial distribution
- **Flood Control Facilities** – Existing regional flood control facilities within the watershed that have been constructed
- **Urban Drainage Facilities** – Existing local drainage facilities that have been installed
- **Drainage Facility Masterplans** – Watershed plans for proposed drainage facilities
- **Floodplain Mapping** – Studies delineating the existing floodplain boundaries, which define the limits of flood hazards
- **Historical Flooding** – Locations where existing flooding has historically occurred from storm events and chronic flood locations
- **Flood Damage Estimates** – Monetary estimates of the amount of flood damage associated with different storm events
- **Geomorphology** – Historical information on landform changes within the watershed and particularly trends for changes within the alluvial creeks of the floodplains
- **Erosion/Sedimentation** – Different erosion/sedimentation processes occurring within the watershed including historical trends related to locations of sedimentation and erosion hazards
- **Biological** – Existing biologic resources and habitats within the floodplain
- **Environmental / Regulatory** – Existing environmental permitting requirements related to restrictions for modifications within the active floodplains

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Table 1 - Provides a detailed listing of the data and information collected as part of this planning study.

Flood Hazards / Floodplain Analysis
Historical Flooding Locations / Issues
Flood Maintenance Records
FEMA Floodplain Mapping / DFIRM
FEMA Technical Backup / Floodplain Models
Floodplain Hydraulic Models (other than FEMA)
Environmental Documentation
Watershed Assessments
Biology / Wildlife
Plant Community Maps
Critical Habitat Maps
Animal Communities Maps
Riparian Habitat Maps
Prior Reports, Studies, or Data on Biological Resources, Species Occupation & Wildlife Movement
Water Quality
Point Sources
Non-Point Sources
GeoTracker GAMA
Previous Watershed Hydrology / Hydraulic Studies
Municipal Drainage Masterplans
Development Drainage Masterplans / Hydrology Studies
Flood Control Deficiency Studies
Hydrology Studies - Proposed Developments
Development Drainage Masterplans / Hydrology Studies
Hydraulic Studies - Roadway Bridge / Culvert Crossings
USACE Regional Watershed Studies or Flood Control Planning Studies
Landuse
General Plan - Landuse
Future Landuse Plans
Census Population Demographic Data
Available GIS Mapping Data Layers
Soils
Geologic Features
Property Ownership / Property Boundaries / APN
Existing Landuse
Planned Development
Utilities
Roadways
Vegetation
Jurisdictional Boundaries
Habitat / Wildlife / Endangered Species / Conservation Areas
FEMA Flood Hazard Zones
Existing Condition Floodplain Boundaries
Government / Civic Boundaries
Tract Maps

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Parcel Maps
Right of Way Data
Plot Plans
Traffic Circulation Elements
Specific Plans
Environmental Impact Reports
County / City Maintained Flood Control / Stormwater Facilities
Mapping / Right-of-Way
Topographic Mapping - Digital DTM
Aerial Photography - Rectified Digital Color
Property Ownership / Property Boundaries / APN

2.2 Data Sources

The information about watershed characteristics and existing flooding was gathered in order to establish a database of the baseline flood problem conditions in the region and was obtained in the following ways:

- **Existing flood documents** - A search was conducted for existing flood-related documents. This included flood control plans, stormwater/flood evaluation studies, surface flow studies, Federal Emergency Management Agency (FEMA) maps, drainage plans, master plans, general plans, flood assessments, and other documents related to climate change and wetlands.

- **Historical Flooding –** Locations of historical flooding, flood damage, and chronic flooding areas based on eye witness accounts, maintenance efforts, and newspaper articles. This information was obtained through phone calls, emails, outreach efforts, and periodical searches.

- **Data requests** - Specific data requests were made to participating municipalities and floodplain management agencies for records of current, ongoing flood problems in their respective municipal and unincorporated areas. A similar request for available data was also solicited to the "flood committee" members related to existing reference documentation, studies, and data related to watershed flood information. An attempt to maximize the initial information gathering effort was made by contacting multi-agency and/or multi-regional entities with known flood management responsibilities in the county. In addition, stakeholder outreach provided an opportunity to initiate relationship building between watershed stakeholders utilizing the floodplain managers' forum. Once provided, this information was used to develop maps of flood hazards and watershed information.

- **Existing GIS databases** – Available digital Geographic Information Systems (GIS) databases were consulted through a variety of agencies. In particular, the local database generated through the Lassen County and Honey Lake Valley RCD was utilized as the initial data source.

2.3 Data Gaps

Available information was limited to fulfill the data needs, particularly in a geographic information format to facilitate regional planning. This is similar to the issues encountered by the contractor for the

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Flood Future Report. Flood infrastructure information is very limited and it is difficult to obtain digital mapping to inventory existing facilities on a regional basis or within local municipalities. No single agency in the county was familiar with all existing infrastructure across the county. In many cases, agencies did not have a complete inventory of infrastructure that they owned and/or maintained. In addition, it was difficult to find information related to locations of flood deficiencies, problem "hot spots", and recurring problem areas. Some of the issues that occurred in the development of a comprehensive database sufficient for watershed planning on a system wide basis include:

- Database utilized for the current study is limited primarily to the available GIS data and a single Capital Improvements Plan for the Honey Lake Valley
- Data inventory conducted at a regional scale
- Existing flood hazards data limited to FEMA and DWR database
- Insufficient information to identify locations of flood problem sources and deficiencies
- Insufficient information to generate a comprehensive inventory of existing flood protection infrastructure

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3. Existing Flood Hazards and Management Programs

3.1 Definition of Flood and Nature of Hazard

A flood occurs when excess water from snowmelt, rainfall, or storm surge accumulates and overflows onto a river's bank or adjacent floodplains. Floodplains are lowlands adjacent to rivers, lakes, and oceans that are subject to recurring floods. Most injury and death from floods occur when people are swept away by flood currents, and property damage typically occurs as a result of inundation by sediment-filled water.

Several factors determine the severity of floods, including rainfall intensity and duration. A large amount of rainfall over a short time span can result in flash flood conditions. A sudden thunderstorm or heavy rain, dam failure, or sudden spills can cause flash flooding. The National Weather Service's definition of a flash flood is, a flood occurring in a watershed where the time of travel of the peak of flow from one end of the watershed to the other is less than six hours. There are no watersheds in the county that have a longer response time than six hours. Flash floods in the county range from the stereotypical wall of water to a gradually rising stream. The central and eastern portions of the Lahontan Basins are most susceptible to flash floods where mountain canyons, dry creek beds, and high deserts are the prevailing terrain.

The region is also subject to shallow flooding. Shallow flooding occurs in areas where there is a lack of channels which means water cannot drain away easily. Shallow flooding problems fall into three categories: sheet low, ponding, and urban drainage. Sheet low occurs where there are inadequate or no defined channels, floodwater spreads out over an area at a somewhat uniform depth. Sheet low flooding is common after intense or prolonged rainfall during which the rain cannot soak into the ground. In some flat areas, runoff collects in depressions and cannot drain out, creating a ponding effect. Ponding floodwaters do not move or flow away. Floodwaters will remain in the temporary ponds until they can infiltrate, evaporate, or are pumped out.

An urban drainage system comprises the ditches, storm pipes, retention ponds, and other facilities constructed to store runoff or carry it to a receiving stream or lake. Other constructed features in such a system include swales that collect runoff and direct it to storm drains and ditches. Most systems are designed to handle the amount of water expected during a 10-year storm. Larger storms overload them and the resulting backed-up storm drains and ditches produce shallow flooding.

Dam failures can result in severe flood events. When a dam fails, a large quantity of water is suddenly released with a great potential to cause human casualties, economic loss, lifeline disruption, and environmental damage. A dam failure is usually the result of age, poor design, or structural damage caused by a major event such as an earthquake or flood.

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Table 2 - Characteristic Flooding Types within the Lahontan Basins

Flood Hazard	Description Cause
Debris Flow Flooding	Heavy localized rainstorms on hillsides and high sediment producing or unstable areas subject to erosion or post-watershed fires
Slow Rise Flooding	Floodplain with limited hydraulic capacity and heavy precipitation generate runoff greater than capacity
Flash Flooding	High volume rainstorm, thunderstorms, and slow moving storms
Alluvial Fan Flooding	High volume rainstorm and thunderstorm displacing high volume of sediment to alluvial fan geographic features
Urban Drainage Flooding	Large rainstorms which exceed the capacity of the local urban drainage system resulting in flooding

3.1.1 Critical Flood Prone Facilities/Assets

Flood hazards and the potential damage or loss of "critical facilities" is an important consideration in watershed planning as well as for prioritization of flood management projects. A critical facility is a facility in either the public or private sector that provides essential products and services to the general public, is otherwise necessary to preserve the welfare and quality of life in the county, or fulfills important public safety, emergency response, and/or disaster recovery functions. These critical assets can also be "lifeline" type facilities which are essential for the public. Some of the common critical facilities identified are: hospitals and other health care facilities, emergency operations facilities, fire stations and police stations, schools, hazardous material sites, airport facilities, bridges, bus facilities, rail facilities, and highways; utility systems that include electric power facilities, natural gas facilities, crude and refined oil facilities, potable and waste water facility, communications facilities, government office/civic centers, jails, prisons, military facilities, religious facilities, and post offices.

3.2 Historical Flooding

From 1901 until 2012, 30 floods were recorded in the Lassen County. The Flood of 1973 caused extensive damage to homes, businesses, schools, roads, bridges and water systems throughout Honey Lake Valley.

The following table displays a history of flooding in the County of Lassen, as well as the loss estimation associated with each flood event where available.

Table 3 - Historical Records of Large Floods in Lassen County*

Date	Property Damage	Crop Damage	Hazard Description
12/22/1964	$1,785,714.29	$178.57	Flooding
1/8/1973	$0	$35,714.29	Flooding - Severe Storm / Thunder Storm
1/16/1973	$86,206.90	$0	Flooding - Severe Storm / Thunder Storm
02/17/1986	$500,000.00	$0	Flooding
2/14/1992	$9,090.91	$0	Flooding - Winter Weather
12/10/1992	$1,315.79	$0	Flooding - Wind - Winter

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			Weather
3/1/1995	$0	$11,241,379.31	Flooding - Severe Storm / Thunder Storm - Wind
01/02/1997	$36,670,000.00	$0	Flooding
12/31/2005	$500,000.00	$0	Flooding

*Additionally, to indicate the potential for a flooding event, this table lists an excerpt of large-scale flooding events in Lassen County that have resulted in a presidential emergency declaration and associated damage.

3.3 Flood Hazard Identification

Regional mapping of the existing flood hazards for the Lahontan Basins region has been prepared by FEMA as part for the National Flood Insurance Program (NFIP), which requires each community to identify a 100-year recurrence interval flood prone areas as part of adopting floodplain management regulations. The minimum federal flood protection goals and requirements are administered by FEMA as part of the NFIP. The NFIP originally established in 1968 provides low-cost federally subsidized flood insurance to those communities that participate in this program. Participation in the program requires that the community adopt floodplain regulations which meet the requirements of the NFIP defined in *44CFR Chapter 1 Part 59* which includes mapping of existing flood hazards.

Hydrologic-hydraulic studies are required to analyze the delineation of the 100-year recurrence interval floodplain limits. The published FEMA flood hazard maps provide an approximation of the regional floodplain limits based on the standards for FEMA alluvial fan hazards. The mapped flood hazards focus on regional flood hazards and do not evaluate localized flooding, particularly in urbanized areas, so there can be areas which may flood in even small storm events but may not be within a mapped flood hazard zone.

FEMA is the federal entity responsible for producing Flood Insurance Rate Maps (FIRMs). The flood risk information presented on the FIRM is based on historic, meteorological, hydrologic, and hydraulic data, as well as open-space conditions, flood-control works, and development within the study area. The FEMA flood hazard zones represent the areas susceptible to the 1% annual chance flood (commonly referred to as the 100-year flood), and the 0.2% annual chance flood (500-year flood). The 1% annual chance flood has at least a 1% chance of occurring in any given year. FEMA designates this area as a Special Flood Hazard Area (SFHA) and requires flood insurance for properties in this area as a condition of a mortgage backed by federal funds.

Information found on a flood map includes:

- Common physical features, such as major highways, secondary roads, lakes, railroads, streams, and other waterways
- Special Flood Hazard Areas (SFHAs)
- Base (1% annual chance) Flood Elevation (BFE) depths
- Flood insurance risk zones
- Areas subject to inundation by the 0.2% annual chance (500-year) flood

FIRMs provide the information so that users can:

- Identify SFHAs
- Identify the location of a specific property in relation to the SFHA
- Identify the BFE at a specific site
- Identify the magnitude of flood hazards in a specific area
- Locate regulatory floodways

3.4 Defining Flood Risk

Flood risk can be defined by three different components which include: (1) "flood hazard" which is generally the probability of occurrence of a particular flood event, (2) the "exposure" of human activity to the flood which is equated to the flood damage potential, and (3) the specific "vulnerability" or the lack of resistance to damaging/destructive forces. Flood risk can be mathematically calculated as the product of hazard, exposure, and vulnerability. Understanding these definitions is an important foundation in flood management planning. A smaller flood that causes less damage occurs more frequently than a very severe flood that can cause greater damage. However, from a loss prevention standpoint, it may be more beneficial to protect for the more frequent events. The assessment of community vulnerabilities can be evaluated through review of existing codes, plans, policies, programs, and regulations used by local jurisdictions to determine whether existing provisions and requirements adequately address the flood hazards that pose the greatest risk to the community. Figure 3 shows different types of flood risk/damage and exposure throughout the county

Flood Risk – likelihood of consequence from inundation. Identifies the cause and the frequency of the problem (how often).

Flood Exposure – relationship between the flood hazard and the effect on loss of property, life, and environmental resources.

Commercial/Industrial

Residential

Agricultural

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Recreation

Utilities/Roadways

Stream Corridor Damage

Figure 3 - Different types of flood risk/damage and exposure throughout the County

Vulnerability – identifies level of exposure expected (how flooding adversely affects people and property).

3.4.1 Flood Event-Specific Factors Influencing Flood Damage

Although there are many issues that affect flood damage, there are several key factors associated with the flood characteristics which influence the amount and severity of the flood damage. In addition, Figure 4 provides a general outline of the types of flood losses and the assessment of the type of damage. A description of the primary factors that influence the severity of flood damage includes the following:

Flood depth: The height flood waters reach is an important consideration affecting flood losses. Structures are more susceptible to damage as flood depths increase. Generally, the plains areas of the county are subject to lower flood depths, and more mountainous regions where narrow floodplains and steep terrain along the stream corridor prevails are subject to greater flood depths during flood events.

Flood duration: The longer flood waters are in contact with building components (such as structural members, interior finishes, and mechanical equipment), the greater the potential for damage. The duration of flooding is very specific to the nature of an event. However, the structures closest to a flooding source (such as a river, bay, or canal) are more likely to sustain longer durations of flooding and be more vulnerable to flood damage. As flood waters recede, these structures will remain flooded for longer durations than structures located along the edge of the floodplain, increasing the potential for damage.

Velocity: The velocity of flood waters is an important factor impacting potential flooding damage. Flowing water exerts forces on the structural members of a building, increasing the likelihood of significant damage. In addition, flowing waters can increase erosion and scour around the foundation of a structure, which can further increase the vulnerability of a building to flood damage.

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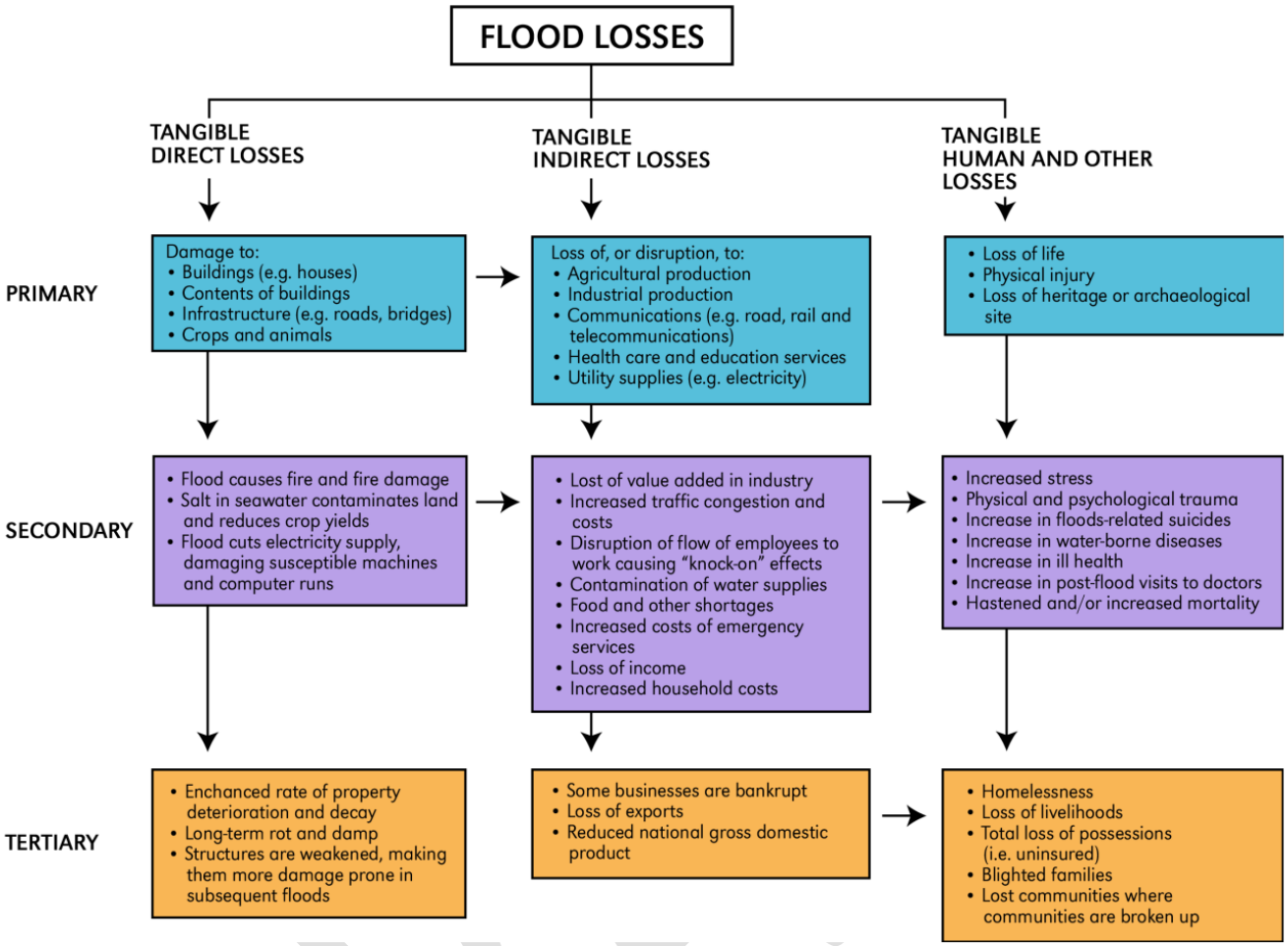

Figure 4 - Illustration of different types of flood losses and the associated impacts

3.4.2 Repetitive Flood Damage Losses

A "repetitive loss property" is one in which two flood insurance claim payments of at least $1,000 have been paid by the NFIP within any 10-year period since 1978 (e.g., two claims during the periods 1978-1987, 1979-1988, etc.). These properties are important to the NFIP because they cost $200 million per year in flood insurance claim payments. Repetitive loss properties represent only one percent of all flood insurance policies, yet historically they account for nearly one-third of the claim payments (over $4.5 billion to date). Mitigation of the flood risk to these repetitive loss properties will reduce the overall costs to the NFIP as well as to individual homeowners. FEMA programs encourage communities to identify the causes of their repetitive losses and develop a plan to mitigate the losses. Repetitive flood damage loss illustrates areas of an existing recurring chronic flood hazard which should be targeted as a priority to be addressed. Repetitive loss areas and properties should be prioritized for attention and analysis. This "area analysis" should follow FEMA guidelines to determine whether acquisition, elevation, or other flood protection measures are appropriate and feasible for the repetitively flooded buildings. The county is vulnerable to specific "hot spot" areas that have experienced repeated flooding.

3.5 Assessment of Flood Risks

Assessment of the flood risk is a complex problem that can only be solved through interdisciplinary research. In general, a two-step approach is utilized. First the assessment was needed to characterize the flood hazard using a selected set of indicator maps, like the spatial distribution of flow velocity, water height, speed of propagation, duration, etc. The second step was to estimate how the flood hazard indicators interfere with human activities in the flooded area. Agricultural activities will suffer damage in different ways than for instance an industrial zone or an urban area.

An initial assessment of the magnitude of the existing "flood risk" which correlates directly to the potential amount of flood damage can be developed through quantifying encroachment of different land uses within the floodplain. Any area located within a 100-year floodplain flood hazard area is considered to be at high risk of flooding. An overlay of the land use plan with the mapped flood hazard zones can be generated. The FEMA flood hazard zone "A" is the 100-year floodplain designation, although there are different types of this flood hazard for insurance purposes. The mapping indicates that the majority of the areas have land use zoning which is compatible with the floodplain being zoned primarily as "open space." However, it is important to note the amounts of other general land uses within the floodplain, particularly the more urban type of uses which would result in more extensive flood damage. The magnitudes of the general land use designations within the flood hazard zones have been developed utilizing the existing database available. This generalized mapping overlay can be utilized as an effective planning tool as part of the initial plan formulation. The land use areas which have a high dollar value within flood hazard zones would indicate locations to target and prioritize projects. Other benefits of this mapping assessment include:

- Identification of flooding vulnerable structures based on flood inundation hazards
- Approximate magnitudes of potential flood losses
- Potential critical public lifeline facilities and infrastructure that could be impaired by flooding
- Identification of key transportation facilities, including roadways that could reduce public access and emergency response
- Identification of the different land uses encroaching within the 100-year flood hazard zones as well as quantifying the amount of these areas for different land use

3.6 Existing Community Watershed Programs

There are a variety of community-based watershed protection programs that provide a basis for community involvement for the preservation and management of the watershed resources. The community groups provide multiple benefits for the watershed through enhanced monitoring and performing volunteer watershed management projects. The community watershed programs should be an integral component of the watershed management program development and implementation. Table 4 provides a select few of the organizations who administer watershed protection programs.

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Table 4 - Examples of Community Watershed Programs

Watershed	Organization	Website
Susan River Watershed	Susan River Watershed Group	http://honeylakevalleyrcd.us/rcd-board-and-staff/watershed-coordinator-page/
Pine Creek	Pine Creek Coordinated Resource Management and Planning (CRMP)	http://eaglelakeguardians.org/
Honey Lake Valley	Honey Lake Valley Resource Conservation District (RCD)	http://honeylakevalleyrcd.us/
Madeline Plains/Smoke Creek	Sierra Nevada Conservancy Trout Unlimited	http://www.sierranevadaconservancy.ca.gov/ http://www.tucalifornia.org/

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4. Regional Watersheds Description

4.1 Regional Watersheds Hydrologic Characteristics

The Lahontan Basins IRWM Region is comprised of **3 watersheds** illustrated on Figure 6. The Region's watersheds are located either completely within incorporated communities within the county or within undeveloped unmapped areas of the eastern part of the county. The river systems affecting the unincorporated areas of the county include: Susan River, Pine Creek, and Long Valley Creek. The watersheds are the surface hydrology features or the tributary basin areas corresponding to the regional drainage systems and floodplains. The hydrologic response of these watershed units for rainfall events as well as the channel processes/geomorphology trends, which influence the flooding characteristics which are examined at a regional scale. In addition, different characteristics of the watersheds and floodplains that may limit potential flood management solutions are also explored. The "watershed units" provide a useful method to divide the region into basins focusing on flood management planning utilizing a regional watershed basis.

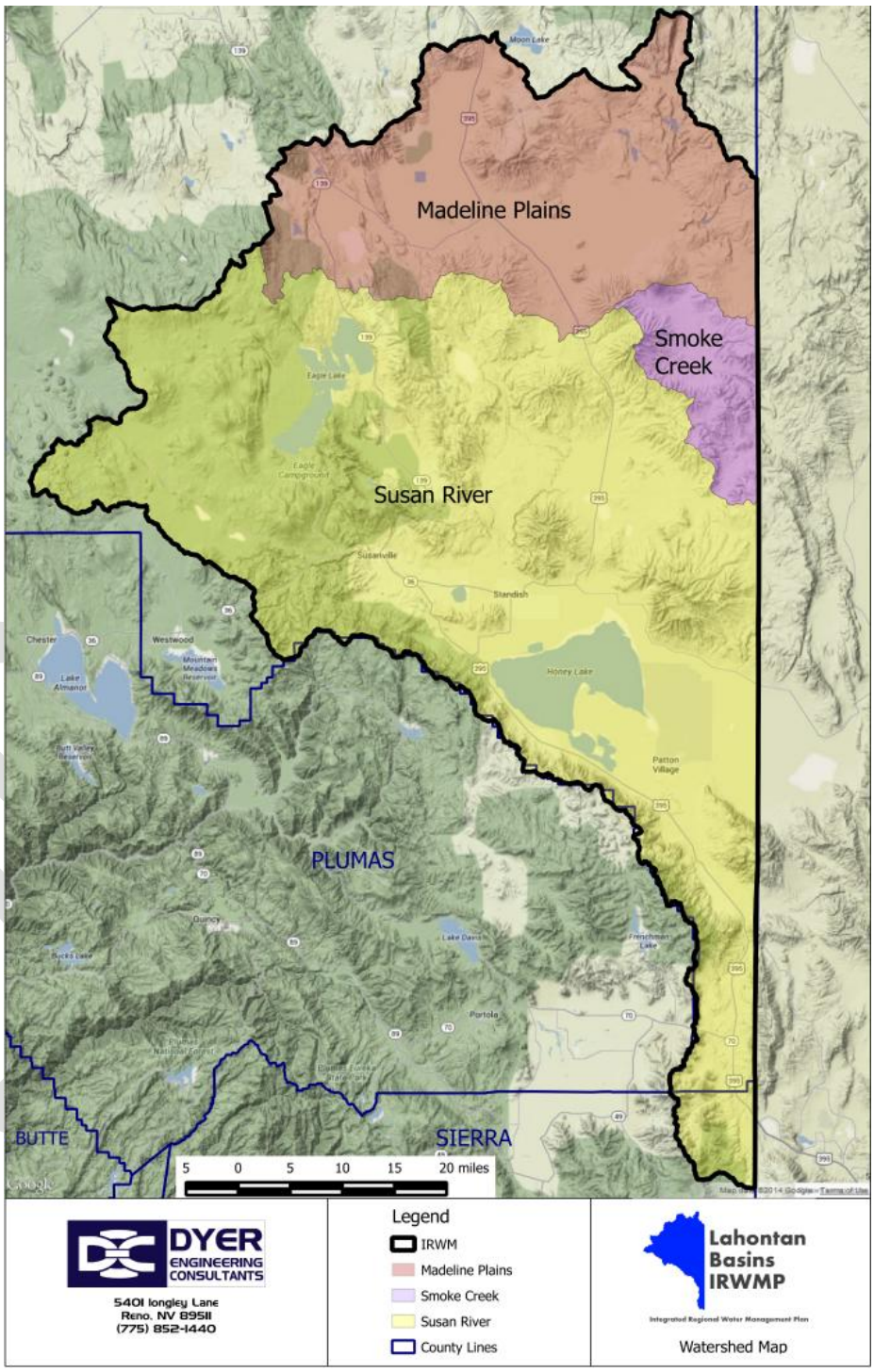

Figure 5 - Regional Delineation of major watershed units utilized for watershed planning

4.1.1 Susan River

The Susan River watershed encompasses a region of approximately 2,221 square miles and a portion of the watershed stretches into the state of Nevada. The watershed originates at the southern end of the Cascade Range, immediately east of Lassen National Park (Figure 6). Beginning above 7,000 feet in elevation, the Susan River flows for a distance of over 40 miles in a southeasterly direction until it drains into Honey Lake at an elevation of approximately 4,000 feet. Agricultural land, timber, rangeland, and fish and wildlife habitats are highly valuable resources within the Susan River Watershed.

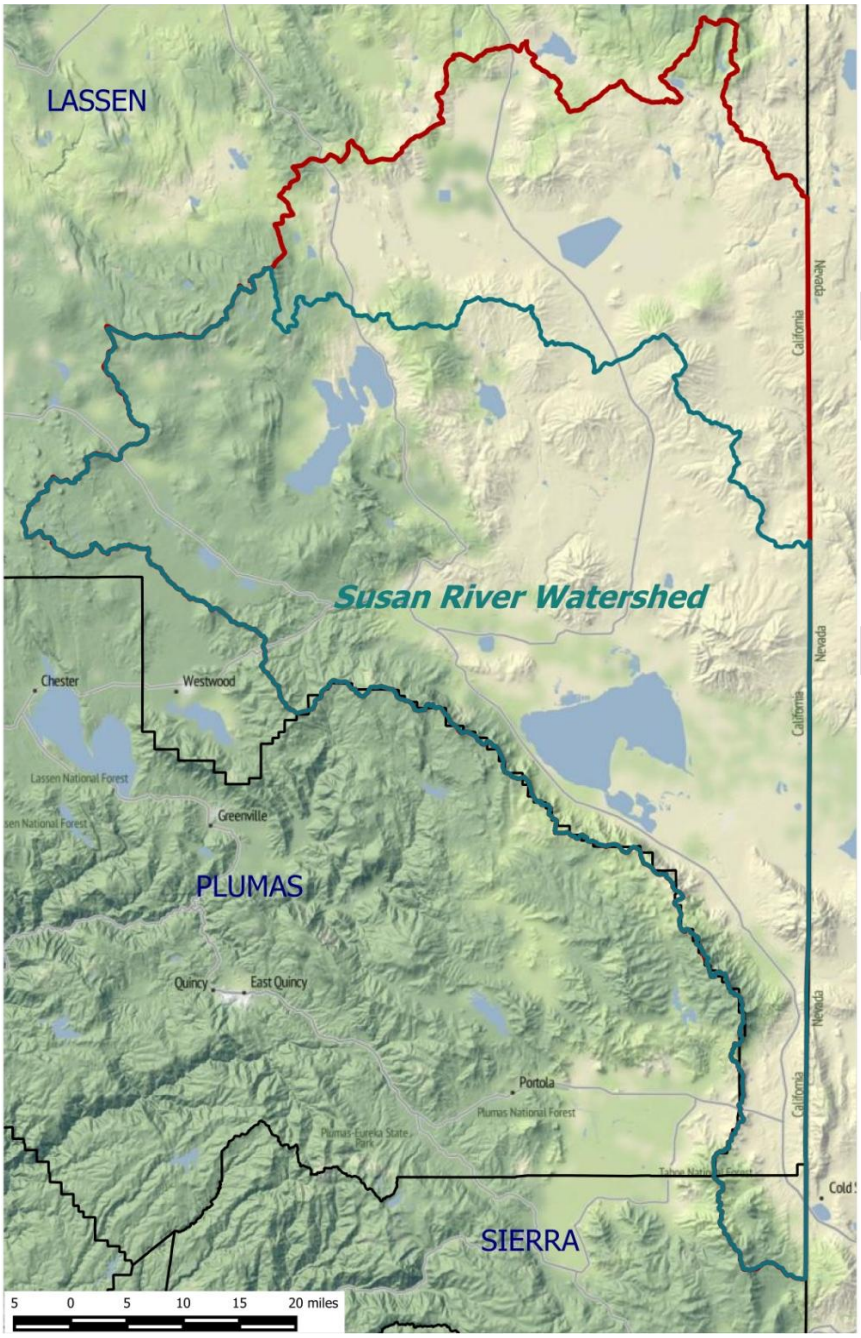

Figure 6 - Susan River watershed unit

There are four major tributaries of the Susan River Watershed: Paiute Creek, Gold Run Creek, Lassen Creek, and Willow Creek. Paiute Creek enters the Susan River from the north at Susanville. Willow Creek enters from the north near Standish. Gold Run Creek and Lassen Creek enter the Susan River from the south, between Susanville and Johnstonville. Below its confluence with Willow Creek, the Susan River spreads into a complex of delta-like slough channels that carry water and sediments to their terminus at Honey Lake.

The city of Susanville is the only incorporated urban population with the Susan River Watershed. The current population of the entire watershed is approximately 33,000. Precipitation ranges widely with elevation, higher elevations receive over 45 inches of precipitation per year in the Caribou Wilderness on the west end of the watershed, mainly in the form of winter snowfall. In contrast, the alluvial valleys (such as along the mainstream Susan River) are more arid, receiving 7-12 inches of

precipitation per year mainly as rain and rapidly melting snow. Runoff is captured by the Hog-Flat Reservoir, McCoy Flat Reservoir, and Lake Leavitt on the Susan River. There are seven dams in the watershed highlighted by the Susan River Capital Improvements Plan controlling 90% of the area.

Table 5 - Susan River watershed unit characteristics and background information

Watershed Characteristics Information	Watershed Unit Area (within county): 2,175 sq. miles Number of Dams: 17 DWR other dams / 4 National Flood Hazard Dams Average Precipitation per Year: 13.3 in Maximum Elevation: 7,943 ft Minimum Elevation: 3,984 ft Watershed Elevation Difference: 3,959 ft Average Map Slope: 17.85%
Major Water Bodies	Susan River, Eagle Lake, McCoy Flat Reservoir, Long Valley Creek, Leavitt Lake, Horse Lake, Willow Creek
Population Centers in Watershed	Susanville, Janesville, Johnstonville, Herlong, Patton Village, Doyle, Litchfield, Spalding
River / Creek Lengths (ft)	Susan River 353,760 Pine Creek 290,400 Long Valley Creek 325,000

4.1.1.1 Water Quality

The Susan River watershed is classified as an impaired watershed by the State Water Resources Control Board due to a wide variety of water quality problems. The pollutants leading to the 303(d) listing of the Susan River are: mercury and an unknown toxicity which will be analyzed further.[1] These problems are largely a result of non-point agricultural sources. Chemical analyses were conducted on several water samples exhibiting duckweed toxicity. Four samples contained low levels of clopyralid (the primary ingredient in some herbicides), esfenvalerate (an insecticide), nonyphenol and nonyphenol ethoxylate. Individual chemical concentrations detected were all below published LC50 values and applicable numeric water quality objectives as well (e.g., CTR aquatic life protection criteria, US EPA reference dose levels).

According to the University of California Davis - Aquatic Toxicology Laboratory (UCD-ATL), the current data set is consistent with low-level or no impacts on aquatic life beneficial uses. However, observed toxicity and pesticide detections in Susan River water samples isolates narrative water quality objectives for toxicity and pesticides contained in the Lahontan Basins Plan. The Susan River will continue to be 303(d) listed for "unknown toxicity", but a TMDL is not currently recommended as the appropriate regulatory response since the pollutant(s) causing toxicity has not been decisively identified by this study. Water Board staff have notified the Department of Pesticide Regulation (DPR) of the pesticide and toxicity detections in the Susan River.

Eagle Lake with an assessed area of 20,704 acres, was placed on the 303(d) list in 2002 for known pollutants of Nitrogen and Phosphorus.

[1] Lahontan Water Control Board Susan River Toxicity Testing Report (2005)

4.1.1.2 Biological / Habitat Natural Resources

The Susan River winds its way through three bioregions, the Great Basin, the Sierra Nevada and the Cascade Range. The watershed encompasses semi-arid canyons, landscapes of high desert, grasslands, and oak woodlands, to a dense forest of pine and cedar, and riparian vegetation dominated by willows and cottonwoods.

4.1.2 Madeline Plains

The Madeline Plains watershed encompasses approximately 800 square miles at an elevation of 5,400 ft. The watershed is located in northeastern Lassen County, approximately 10 miles south of the Modoc county line. Madeline Plains area is a closed basin bound by various peaks and ridges including Anderson and Whitinger Mountains to the east, Heavey Mountain to the southeast, McDonald Peak to the north, Observation Peak to the southwest, and Cottonwood and Button Mountains to the west.

There are few natural surface water bodies in the area, with few streams and a playa lake in Grasshopper Valley. The major populations in the management area are in unincorporated Madeline, Termo, and Ravendale. No population information was found for these communities.

Northeastern Lassen County is characterized by numerous valleys or basins separated by

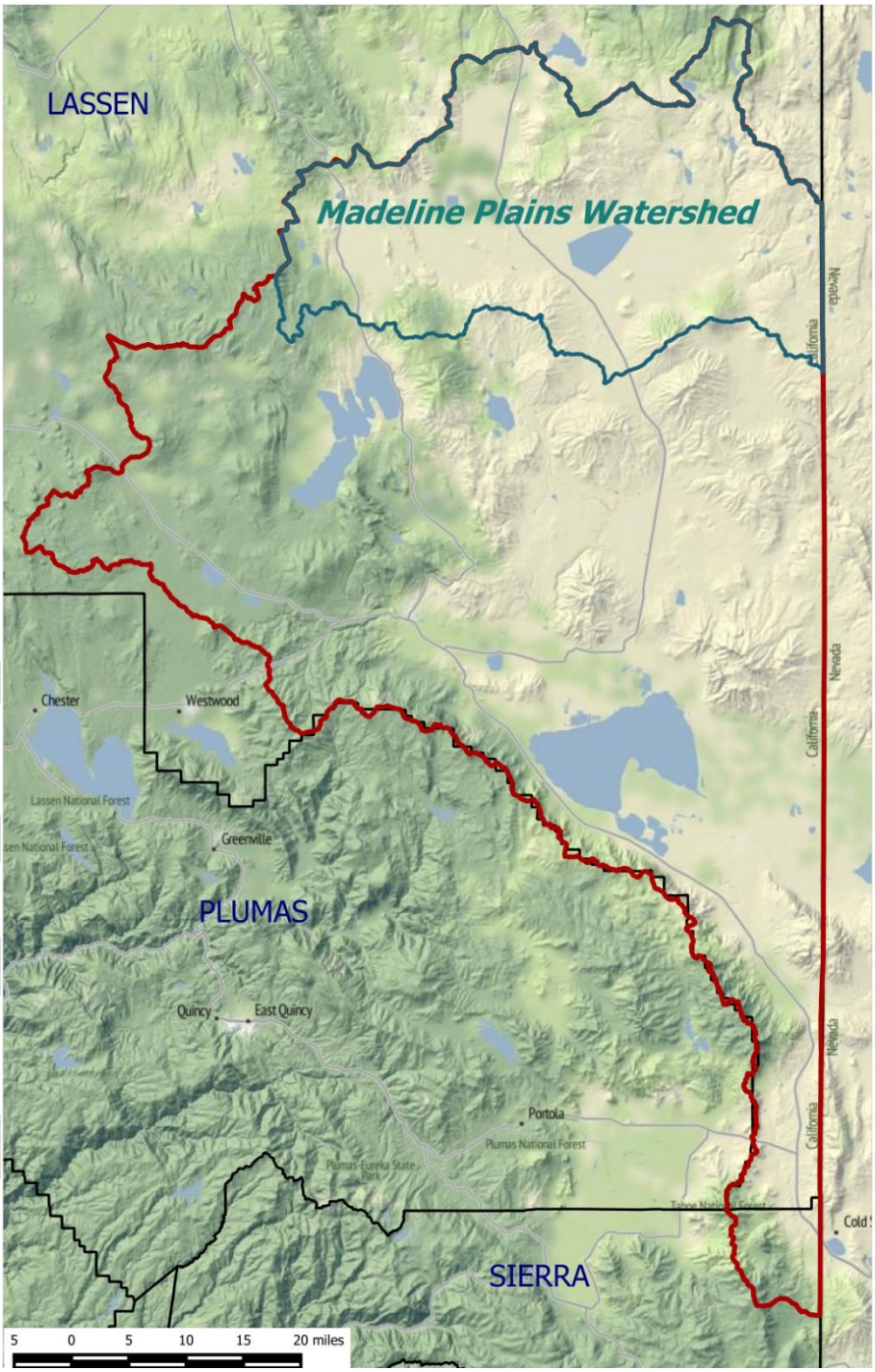

Figure 7 - Madeline Plains watershed unit

mountains. Native vegetation is sparse and drought resistant. Annual average precipitation ranges from 11 to 17 inches[2]. Precipitation trends are consistent with the semi-arid, Mediterranean-type climate of California, characterized by heaviest precipitation occurring in the winter and spring months and little to no precipitation during summer months.

Table 6 - Madeline Plains watershed unit characteristics and background information

Watershed Characteristics Information	Watershed Unit Area (within county): 800 sq. miles Number of Dams: 7 DWR other dams / 6 NFHL dams Average Precipitation per Year: 14 in Maximum Elevation: 7,931 ft Minimum Elevation: 5,290 ft Watershed Elevation Difference: 2,641 ft	
Major Water Bodies	Alaska Canyon Creek, Red Rock Creek, Dry Creek, Slate Creek, Buckhorn Reservoir	
Population Centers in Watershed	Madeline, Termo and Ravendale	
River / Creek Lengths (ft)	Alaska Canyon Creek	29,568
	Red Rock Creek	79,200
	Dry Creek	36,432
	Slate Creek	18,480

4.1.2.1 Water Quality

Most of the water quality concern in the Madeline Plains watershed is related to the effect of grazing management on the already limited fisheries potential of the streams in the area. Enhancement of the streams with the greatest potential has been incorporated into the IRWMP.

No surface water bodies in the Madeline Plains unit are listed on the 303(d) impaired waters list.

4.1.2.2 Biological / Habitat Natural Resources

Land in the Madeline Plains management area is predominately native habitat with areas used for pasture and other crops. Residential areas are sparsely dispersed. Agricultural use is concentrated primarily in the north part of the management area surrounding Highway 395 and the western part of the management area near Madeline Plains. Some land is used for pasture in Grasshopper Valley, in the southeastern part of the management area to the west of Highway 139.

A number of reservoirs have been established as a water supply for livestock. Since many of these reservoirs support fish populations, a complementary recreational activity is enjoyed. Migratory fowl also take advantage of these surface waters along the flyway.

Irrigated agriculture in the Madeline Plains management area is derived from a mixture of surface and groundwater. Surface water is used more predominantly in the western and northern parts of the management area, with water coming from reservoirs and small streams. Groundwater is used in the central portion of the area, west of Termo.

[2] Department of Water Resources [DWR], 2003

4.1.3 Smoke Creek

The Smoke Creek drains the southeast portion of the Madeline Plains Hydrologic Area before flowing into Nevada. Dead cattle have reportedly been left either in the channel or in areas subject to flood irrigation in those portions of lower Smoke Creek which are under private ownership in Nevada. This condition does not affect waters passing through Public Lands in California.

Figure 8 - Smoke Creek watershed unit

Smoke Creek drainage is primarily used for the grazing of range cattle. This range use has led to both existing and suspected impacts on other uses of the stream. Of the 12 lineal miles of channel, from its source at Big Springs to the point where Smoke Creek enters Smoke Creek Reservoir and flows into Nevada, nine miles of the creek are in public ownership.

Table 7 - Smoke Creek watershed unit characteristics and background information

Watershed Characteristics Information	Watershed Unit Area (within county): 190 sq. miles Number of Dams: N/A Average Precipitation per Year: 10 in Maximum Elevation: 7,700 ft Minimum Elevation: 5,100 ft Watershed Elevation Difference: 2,600 ft
Major Water Bodies	Smoke Creek, Smoke Creek Reservoir, Shin Canyon
Population Centers in Watershed	N/A
River / Creek Lengths (ft)	Smoke Creek 79,200

4.1.3.1 Water Quality

There is very little data regarding surface water quality in the Smoke Creek planning unit. What is available has been collected by different organizations, for various purposes, and is not cohesive. The nature of the data does not lend itself to meaningful interpretation for general management purposes. Water quality in the area is suitable for existing or proposed uses.

The principal groundwater reservoirs in the Smoke Creek Desert area occur in the younger and older alluvium. Some springs issuing from consolidated rocks discharge significant quantities of water and make them locally useful in the development of groundwater. No known well has penetrated into the consolidated rocks deeply enough to test their water-yielding capability. The scarcity of wells also limits detailed knowledge of groundwater movement in the Smoke Creek area.

No surface water bodies in the Smoke Creek unit are listed on the 303(d) impaired waters list.

4.1.3.2 Biological / Habitat Natural Resources

A BLM Wildlife Biologist[3] conducted a stream survey of Smoke Creek and documented that the general condition of the stream banks indicated moderate to heavy surface disturbance with moderate surface erosion. Bank conditions appear to be in equilibrium with environmental and grazing stresses. Past grazing practices, including use by wild horses, have altered the condition of the stream banks and thereby contributed to the degradation of the stream. Contributions of sediments to the streambed may have been the result of bank sloughing by cattle and wild horses, overland transport by runoff from compacted and denuded banks, and increased stream bank scour.

4.2 Metrologic Conditions / Historic Precipitation

Precipitation is influenced by the mountains within the Lahontan Basins region; greater precipitation typically occurs in the western portion of the county at higher elevations,as shown in Figure 10. Precipitation amounts presented in Figure 10 are estimated based on data from precipitation stations, topography, and other factors. Precipitation is caused by orographic uplift, as air temperatures cool as the air mass rises over the mountains, resulting in condensation that falls as precipitation. Table 8 presents average annual precipitation and snowfall for the three stations, illustrating the significant variability in

[3] Proposed Livestock Grazing Management for the Cal-Neva Planning Unit, Environmental Impact Statement, US BLM

precipitation between different water years.

Table 8 - Average Annual Precipitation and Snowfall at Lassen County Weather Stations[4]

Station	Average Precipitation (in)	Average Snowfall (in)
Hills South of Doyle	17.2	20.0
Susanville	13.3	19.2
Termo	11.0	36.0

Figure 11 portrays the average monthly precipitation, including snowfall over the period of record for the three stations, reported in inches of water. In summer months, areas of high pressure are commonly established over northern California, effectively blocking the inland movement of moist marine air, causing extended periods of little precipitation. Because of this, precipitation is strongly seasonal, occurring mostly in November through March. Most precipitation in winter at Termo occurs as snowfall, as indicated in Table 8. On average, little rain occurs in the months of July, August, and September. Annual precipitation totals in the Honey Lake Valley reflect wet periods and drought periods. Table 8 shows annual precipitation by year at the hills south of Doyle and Susanville weather stations. Both stations show less than 10 inches of precipitation during the 1976 drought, and rainfall totals less than 20 inches during the 1987 through 1994 drought period. (Fig 9)

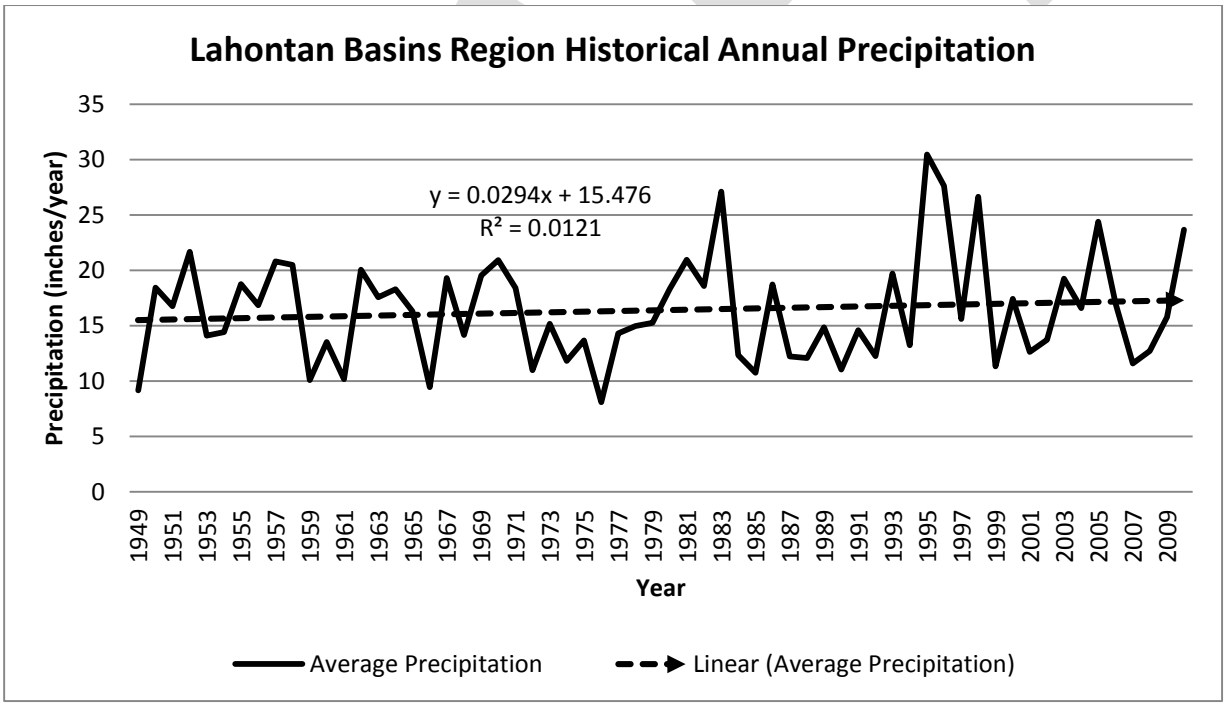

Figure 9 - Lahontan Basins Region Historical Annual Precipitation[5]

[4] University of California Statewide Integrated Pest Management Program (UP IPM), www.ipm.ucdavis.edu, Western Regional Climate Center, www.wrcc.dri.edu

[5] The data is distinct from reanalysis products in that precipitation is a gridded product derived directly from observations, and both the land surface water and energy budgets balance at every time step. The data taken from: Maurer, E.P., A.W. Wood, J.C. Adam, D.P. Lettenmaier, and B. Nijssen, 2002, A Long-Term Hydrologically-Based Data Set of Land Surface Fluxes and States for the Conterminous United States, J. Climate 15(22), 3237-3251.

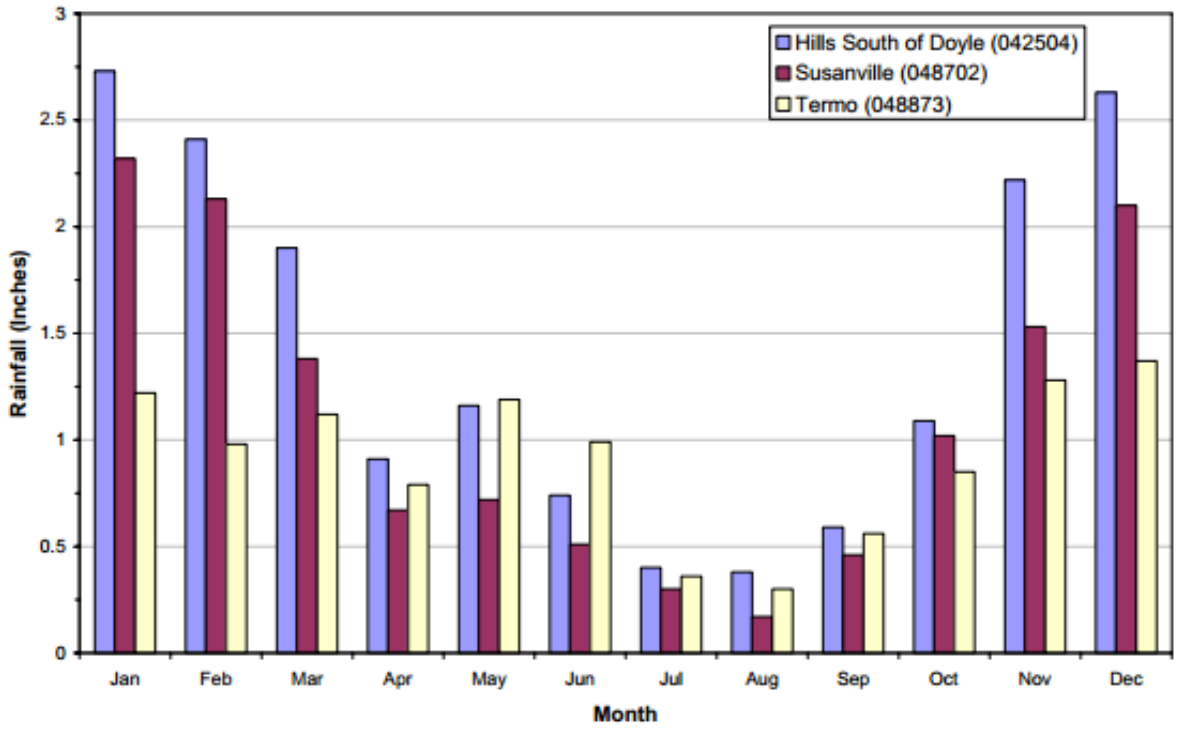

Figure 10 - Average Precipitation at Lassen County Weather Stations

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5. Integrated Flood Management (IFM) Planning Guiding Principles

5.1 Overview of IFM and Basic Planning Principles

Integrated Flood Management (IFM) is a different approach that deviates from traditional flood protection approaches by combining land and water resources development within a watershed, within the context of IRWM, and with a focus on maximizing the efficient use/net benefit of the floodplain while promoting public safety. IFM is a process that promotes an integrated rather than fragmented approach to flood management and recognizes the connection of flood management actions to water resources management, land use planning, environmental stewardship, and sustainability. Flood risk management requires the holistic development of a long-term strategy balancing current needs with future sustainability. Incorporating sustainability means looking for ways of working towards identifying opportunities to enhance the performance of the watershed system as a whole. Traditional flood management practices focus on reducing the chance of flooding and flood damages through physical measures intended to store and convey floodwaters away from the areas to be protected. Although this approach can reduce the intensity and frequency of flooding, it can also limit the floodplain's natural function and have other unintended consequences. In addition, the traditional approach has typically been reactive or piecemeal in addressing the negative aspects of flooding without looking at the larger watershed processes and riverine ecosystem.

IFM uses various techniques to manage flooding, including structural projects (such as levees), nonstructural measures (such as land use practices), and natural watershed functions. Depending on the characteristics of individual watersheds, various resource management strategies may be used, such as: agricultural land stewardship, conjunctive water management, conveyance, ecosystem restoration, forest management, land use planning and management, surface storage, system reoperations, urban runoff management and watershed management. In recent years, flood managers have recognized the potential for natural watershed features to reduce the intensity or duration of flooding. Natural watershed features include: undeveloped floodplains that can store and slowly release floodwaters and wetlands acting as sponges, soaking up floodwaters, filtering runoff, and providing opportunities for infiltration to groundwater. Natural watershed features also include healthy forests, meadows, and other open spaces that can slow runoff during smaller flood events, reducing peak flows, mudslides, and sediment loads in streams.

5.1.1 Basic Planning Principles of IFM

The following provides basic guiding principles that supply the foundation in planning integrated flood management:

1. Every flood risk scenario is different: there is no flood management blueprint.

Understanding the type, source and probability of flooding, the exposed assets and their vulnerability are all essential if the appropriate urban flood risk management measures are to be identified. The suitability of measures to context and conditions is crucial: a flood barrier in the wrong place can make flooding

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worse by stopping rainfall from draining into the river or by pushing water to more vulnerable areas downstream, and early warning systems can have limited impact on reducing the risk from flash flooding.

2. Designs for flood management must be able to cope with a changing and uncertain future.
The impact of urbanization on flood management is currently and will continue to be significant. But it will not be wholly predictable into the future. In addition, in the present day and into the future, even the best flood models and climate predictions result in a large measure of uncertainty. This is because the future climate is dependent on the unpredictable actions of humans – and because the climate is approaching scenarios never before seen. Flood risk managers need therefore to consider measures that are robust to uncertainty and to different flooding scenarios under conditions of climate change.

3. Rapid urbanization requires the integration of flood risk management into regular urban planning and governance.
Urban planning and management which integrates flood risk management is a key requirement, incorporating land use, shelter, infrastructure, and services. The rapid expansion of urban built up areas also provides an opportunity to develop new settlements that incorporate integrated flood management at the outset. Adequate operation and maintenance of flood management assets are also an urban management issue.

4. An integrated strategy requires the use of both structural and non-structural measures and good metrics for "getting the balance right."
The two types of measures should not be thought of as distinct from each other. Rather, they are complementary. Each measure makes a contribution to flood risk reduction but the most effective strategies will usually combine several measures – which may be of both types. It is important to identify different ways to reduce risk in order to select those that best meet the desired objectives now – and in the future.

5. Heavily engineered structural measures can transfer risk upstream and downstream.
Well-designed structural measures can be highly effective when used appropriately. However, they characteristically reduce flood risk in one location while increasing it in another. Urban flood managers have to consider whether or not such measures are in the interests of the wider catchment area.

6. It is impossible to entirely eliminate the risk from flooding. Hard-engineered measures are designed to defend to a pre-determined level.
They may fail. Other non-structural measures are usually designed to minimize rather than prevent risk. There will always remain a residual risk which should be planned for. Measures should also be designed to fail gracefully rather than catastrophically if they do fail, causing more damage than would have occurred without the measure.

7. Many flood management measures have multiple co-benefits over and above their flood management role.

The linkages between flood management, urban design, planning and management, and climate change initiatives are beneficial. For example, the greening of urban spaces adds amenity value, enhances biodiversity, protect against urban heat island and can provide fire breaks, urban food production, and evacuation space. Improved waste management has health benefits as well as maintaining drainage system capacity and reducing flood risk.

8. It is important to consider the wider social and ecological consequences of flood management spending.

While costs and benefits can be defined in purely economic terms, decisions are rarely based on economics alone. Some social and ecological consequences such as loss of community cohesion and biodiversity are not readily measureable in economic terms. Qualitative judgments must therefore be made by city managers, communities at risk, urban planners, and flood risk professionals on these broader issues.

9. Clarity of responsibility for constructing and running flood risk programs is critical.

Integrated urban flood risk management is often set within and can fall between the dynamics and differing incentives of decision-making at national, regional, municipal, and community levels. Empowerment and mutual ownership of the flood problem by relevant bodies and individuals will lead to positive actions to reduce risk.

10. Implementing flood risk management measures requires multi-stakeholder cooperation.

Effective engagement with the people at risk at all stages is a key success factor. Engagement increases compliance, generates increased capacity, and reduces conflict. This needs to be combined with strong, decisive leadership and commitment from national and local governments.

11. Continuous communication to raise awareness and reinforce preparedness is necessary.

Ongoing communication counters the tendency of people to forget about flood risk. Even a major disaster has a half-life of memory of less than two generations and other more immediate threats often seem more urgent. Less severe events can be forgotten in less than three years.

12. Plan to recover quickly after flooding and use the recovery to build capacity.

As flood events will continue to devastate communities despite the best flood risk management practices, it is important to plan for a speedy recovery. This includes planning for the right human and financial resources to be available. The best recovery plans use the opportunity of reconstruction to build safer and stronger communities which have the capacity to withstand flooding better in the future.

5.1.2 General Elements of IFM

An integrated strategy usually requires the use of both structural and non-structural solutions. It is important to recognize the level and characteristics of existing risk and likely future changes in risk. Integrated flood management also includes the recognition that flood risk can never be entirely eliminated and that resilience to flood risk can include enhancing the capacity of people and communities to adapt to and cope with flooding.

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The defining characteristic of IFM is integration simultaneously occurring in different forms such as: mix of different strategies, types of mitigation (structural and non-structural), short-term or long-term, and a participatory approach by multiple agency stakeholders within the watershed to decision making. Key elements of IFM would include:

Enhanced Level of Watershed Stakeholder Communication

- Open communication and participation by stakeholders, planners, and decision makers at all levels
- Public consultation and involvement of watershed stakeholders for decision-making
- Promote coordination/communication across jurisdictional boundaries within the watershed including information management and exchange

Integrate Land and Water Management

- Land use planning and water management combined through coordination of authorities to obtain consistency in planning
- Main elements of watershed management (water quantity, water quality, and processes of erosion/sedimentation) should be linked in planning
- Effect of land use changes on the hydrologic cycles should be evaluated and considered

Manage the Water Cycle as a Whole

- Flood management linked with drought management in the effective use of flood water
- Promote multi-benefit solutions that achieve multiple water resource benefits simultaneously

Adopt a Best-Mix of Strategies

- Flood management strategies should involve a combination of complementary strategies
- Formulate a layered strategy based on economic and watershed characteristics that is adaptable to changing conditions
- Appropriate combination of structural and non-structural measures should be evaluated recognizing the different advantages and disadvantages for the most effective plan

Adopt Integrated Hazard Management Approaches

- Flood management should be integrated into the risk management process

5.2 Risk Assessment and Management

Identifying flood risks is an important element in reducing flood damage and prioritizing flood management infrastructure needs. Appropriate assessment of flood risks can help local community government make informed decisions about priorities. The balancing of development needs and risks is essential. Uncertainty and risk management are defining characteristics of choice, and risk management is a necessary component of the development process, essential for achieving sustainable development. The

application of a risk management approach provides measures for preventing a hazard from becoming a disaster. Flood risk management consists of systematic actions in a cycle of preparedness, response, and recovery. Risk management calls for identification, assessment, minimization of risk, or the elimination of unacceptable risks through appropriate policies and practices. Flood risk management also includes the efforts to reduce the residual risks through such measures as flood-sensitive land-use and spatial planning, early warning systems, evacuation plans, the preparations for disaster relief and flood proofing and, as a last resort, insurance and other risk sharing mechanisms.

5.3 Resource Management Using an Ecosystem Approach

Riverine aquatic ecosystems, including rivers, wetlands and estuaries, provide many benefits, such as clean drinking water, food, materials, water purification, flood mitigation, and recreational opportunities. Variability in flow quantity, quality, timing and duration are often critical for the maintenance of river ecosystems. For example, flooding events serve to maintain fish spawning areas, help fish migration and flush debris, sediment and salt. This is particularly so for regions with dry climates that experience seasonal flooding followed by a period of drought. Different flood management measures have varying impacts on the ecosystem, and at the same time, changes in the ecosystem have consequential impacts on the flood situation, flood characteristics, and river behavior.

Some flood management interventions adversely impact riverine ecosystems by reducing the frequency of flooding in the wetlands that develop around flood plains, which are subject to frequent flooding and owe the large variety of wildlife to this phenomenon. In these situations it is desirable to avoid changes in high frequency floods, since to do so would damage the ecosystems that have developed around the existing flood regime. What is desirable is to reduce extreme floods. Thus a tradeoff between competing interests in the river basin is required to determine the magnitude and variability of the flow regime needed within a basin in order to maximize the benefits to society and maintain a healthy riverine ecosystem.

5.4 General Flood Management Opportunities / Constraints

The characteristics of the region provide background into understanding potential opportunities as well as constraints for developing potential IFM solutions for the existing flood hazards. Flood management projects are planned and implemented to solve problems reducing risk to public safety and property, meet challenges, and seize opportunities. A problem can be thought of as an undesirable condition, while an opportunity offers a chance for improvement, and constraints limit the ability for implementation. The Lahontan Basins IRWM region includes a wide variety of terrain conditions, as well as geographic features which can generate a range of different types of watershed responses. The geography, as well as meteorological conditions, are conducive to sudden flooding. The semi-arid climate, where the total rainfall is typically concentrated in a few short months, adds to the uncertainty of flood prediction. In addition, the unique issues associated with the watershed conditions also limit the application of even conventional flood management solutions. It is important to identify and recognize the areas within the watershed which have specific unique properties as part of the planning process to assist in the formulation of alternative solutions. This study is utilizing a watershed scale assessment as part of an IFM approach that allows examination of flood hazards and their management in combination with other water resources and environmental restoration on a broad scale.

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Based on the characteristics discussed above, the region's flood management opportunity/constraints may be divided into four major categories which include: (1) physical conditions, (2) regulatory, (3) landuse, and (4) environmental/biological.

Physical

Different physical features define the types of flooding issues since the topographic features greatly influence the response of the watershed. The nature of the flooding created by the topography also results in different constraints and limits the ability to apply different conventional solutions for the flood hazard mitigation. Table 9 illustrates the opportunity and constraints with floodplain management that are associated with "physical features" within the watershed.

Table 9 - Opportunity / Constraints for regional floodplain management - Physical features

Physical	
Opportunity/Constraint	**Reference**
Hydraulic conveyance limitations of existing roadway and utility crossings	• Identification of hydraulic limitations as potential target areas for fixes that may reduce areas of flooding and sedimentation
Existing facilities and structures located within the floodplain	• Define existing flood risk from existing facilities/uses within the floodplain
Sediment delivery with flood flows from foothill areas	• Excessive sediment delivery causes deposition and will ultimately be deposited at a downstream location with flatter slope • High sediment yields bulk the flood waters and increase depth of flooding
Limited topographic relief/slope that limits hydraulic conveyance in valley areas	• Facility sizes will increase further downstream within the watershed because of the reduced slope
Soils/geology primarily alluvial deposits that are highly erodible	• Channel migration routinely occurs • Erosion hazards for development adjacent to channels
Specialized geographic/geomorphic features which include alluvial fans	• Hydraulic conditions are unique and conventional flood management solutions are not applicable
Topographic features result in steep slopes in the mountains/foothills and extremely flat slopes on the valley floors	• Changes in hydraulic conveyance and sediment delivery because of the change in slopes

Regulatory

The existing regulations related to floodplain management/flood control influence the existing level of flood protection provided to the community. Table 12 illustrates the opportunity and constraints with floodplain management that are associated with "regulatory" items within the watershed.

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Table 10 - Opportunity / Constraints for regional floodplain management - Regulatory Elements

Regulatory	
Opportunity/Constraint	**Reference**
No centralized regional flood agency for the entire Lahontan Basins region	• Flooding problems within the county area are extremely varied and associated with the different individual watersheds • Comprehensive planning required that reflects the current though process for flood management and the environmental considerations for each of the regional watersheds that will cross over political boundaries
FEMA/NFIP requirements for community floodplain regulations	• NFIP requirements have the most influence on floodplain restrictions
Water quality limitations and restrictions based on the Basin Plan and identified TMDLs	• Water quality restrictions should be implemented as part of the regional planning solution

Landuse

Existing land use and future proposed development should be closely coordinated with the existing mapped flood hazards. Land use restrictions are one of the primary tools for floodplain management in order to reduce flood risks. Table 11 illustrates the opportunity and constraints with floodplain management that are associated with "land use features" within the watershed.

Table 11 - Opportunity / Constraints for regional floodplain management - Landuse features

Regulatory	
Opportunity/Constraint	**Reference**
Various urban/commercial land use and additional manmade encroachments within the floodplain	• Cost/benefit assessments should be performed to evaluate cost effectiveness of flood control facilities or removing these uses from the floodplain
Limitations of development and land use restrictions within active flood hazard zones	• Modifications to current General Plan modifying land uses so that they are compatible with the floodplain overlay

Environmental/Biological

Existing biological resources within the floodplain corridor are an important opportunity to integrate into the regional planning as part of the preservation of these resources. However, in addition to an opportunity these resources can represent constraints in the different types of solutions that can be applied for flood mitigation and may result in additional costs. Table 12 illustrates the opportunity and constraints with floodplain management that are associated with "environmental/biological" elements within the watershed.

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Table 12 - Opportunity / Constraints for regional floodplain management - Environmental / Biological

Regulatory	
Opportunity/Constraint	**Reference**
Environmental permitting limitations for activities/structures within the floodplain (i.e., endangered species, etc.)	• Additional costs or limitations on the potential solutions available because of environmental regulatory restrictions
Many existing floodplain corridors have special defined ecological preserve or similar designations because of their habitat for sensitive species	• Existing floodplains and streams are valuable biological resources for preservation

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6. Formulation of Integrated Flood Management Strategies

6.1 Global IFM Management Strategies

IFM includes a broad range of management strategies and can be grouped into four general approaches— (1) Nonstructural Approaches, (2) Restoration of Natural Floodplain Functions, (3) Structural Approaches, and (4) Emergency Management. These approaches and the management actions within them serve as a toolkit of potential actions that local agencies can use to address flood-related issues, and advance IFM throughout the region's watersheds. These actions range from policy or institutional changes to operational and physical changes to flood infrastructure. Such actions are not specific recommendations for implementation; rather, they serve as a suite of generic management tools that can be used individually or combined for specific application situations. A variety of management actions can be bundled together as part of a single flood management project to provide a multiple benefit outcome related to water resources.

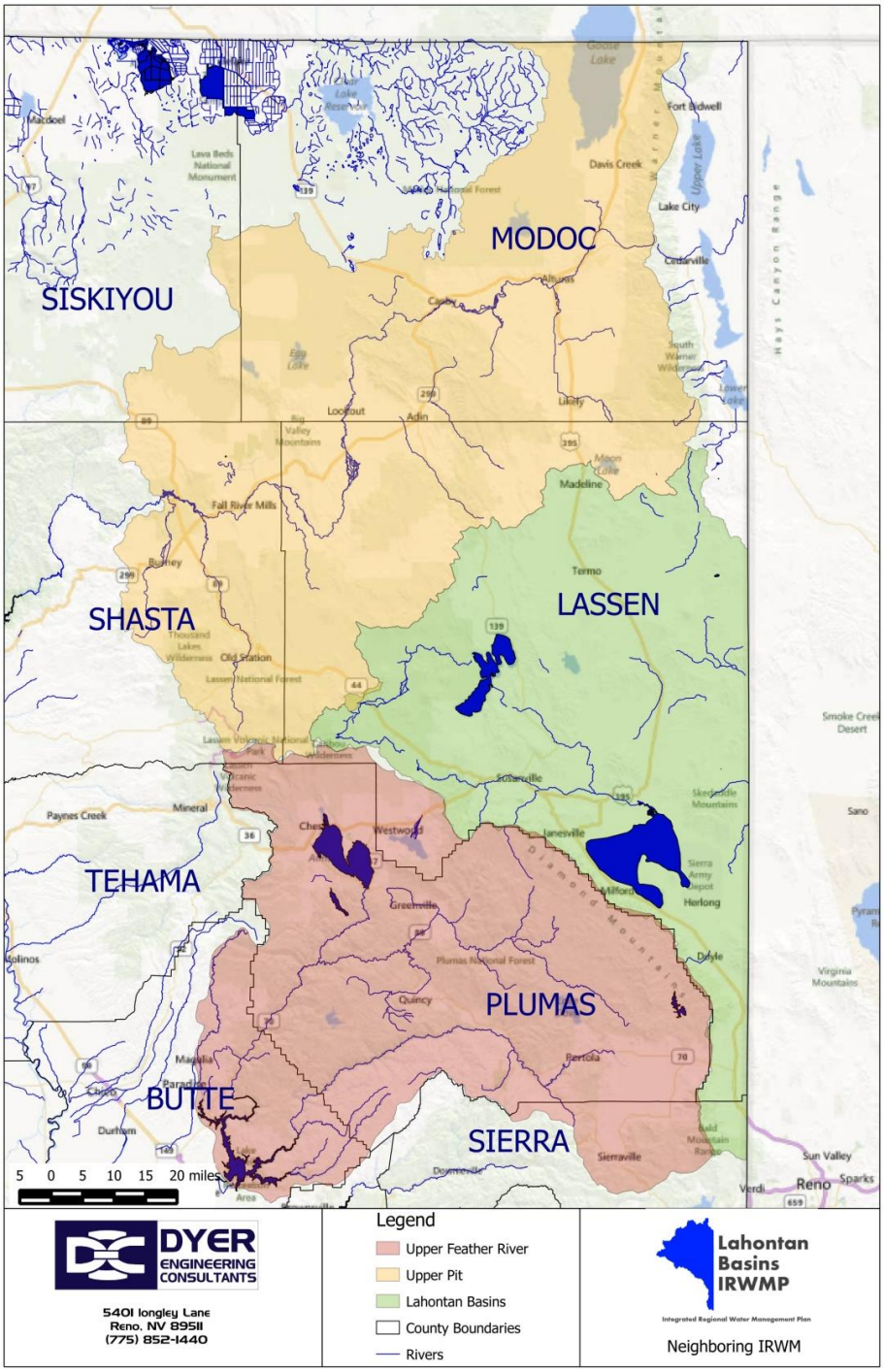

Figure 11 - Lahontan Basins Neighboring IRWM Regions

6.2 Nonstructural Approaches

6.2.1 Land Use Planning - Floodplain Basis

Land use planning employs policies, ordinances, and regulations to limit development in flood-prone areas and encourages land uses that are compatible with floodplain functions. This can include policies and regulations that restrict or prohibit development within floodplains, restrict size and placement of structures, prevent new development from providing adverse flood impacts to existing structures, encourage reduction of impervious areas, require flood-proofing of buildings, and encourage long-term restoration of streams and floodplains.

6.2.2 Land Use Planning - Watershed Basis

Landuse controls on a watershed basis provide the opportunity to assist in controlling the response of the watershed and influence or correct potential problems through non-structural means. In addition, land use planning and regional water management can be coordinated between land management and water management authorities to achieve consistency and maximum benefits. Landuse impacts different elements of the watershed including water quantity, water quality, and the processes of erosion/deposition. It is important to understand these linkages between land use and the watershed functions in order to develop collaboration to improve the watershed performance on a regional basis.

6.2.3 Floodplain Management

Floodplain management generally refers to nonstructural actions in floodplains to reduce flood damages and losses. Floodplain management actions include:

- **Floodplain Mapping and Risk Assessment –** Floodplain mapping and risk assessment serve a crucial role in identifying properties that are at a high risk to flooding. Accurate, detailed maps are required to prepare risk assessments, guide development, prepare plans for community economic growth and infrastructure, utilize the natural and beneficial function of floodplains, and protect private and public investments. Development of needed technical information includes topographic data, hydrology, and hydraulics of streams and rivers, delineation of areas subject to inundation, assessment of properties at risk, and calculation of probabilities of various levels of loss from floods.
- **Land Acquisitions and Easements** – Land acquisitions and easements can be used to restore or preserve natural floodplain lands and to reduce the damages from flooding by preventing urban development. Land acquisition involves acquiring full-fee title ownership of lands from a willing buyer and seller. Easements provide limited-use rights to property owned by others. Flood easements, for example, are purchased from a landowner in exchange for perpetual rights to periodically flood the property when necessary or to prohibit planting certain crops that would impede flood flows. Conservation easements can be used to protect agricultural or wildlife habitat lands from urban development. Both land acquisitions and easements generally involve cooperation with willing landowners. Although acquisition of lands or easements can be expensive, they can reduce the need for structural flood improvements that would otherwise be needed to reduce flood risk. Maintaining agricultural uses and/or adding recreational

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opportunities, where appropriate, provide long-term economic benefits to communities and the state.

- **Building Codes and Flood-proofing** – Building codes and flood-proofing include specific measures that reduce flood damage and preserve egress routes during high- water events. Building codes are not uniform; they vary across the state based on a variety of factors. Example codes could require flood-proofing measures that increase the resilience of buildings through structural changes, elevation, or relocation and the use of flood resistant materials.
- **Flood Risk Awareness (Information and Education)** – Flood risk awareness is critical because it encourages prudent floodplain management. Flood hazard information is a prerequisite for sound education in understanding potential flood risks. If the public and decision makers understand the potential risks, they can make decisions to reduce risk, increase personal safety, and expedite recovery after floods. Effective risk awareness programs are critical to building support for funding initiatives and to building a connection to the watershed.
- **Flood Insurance** – Flood insurance is provided by the Federal Government via the NFIP to communities that adopt and enforce an approved floodplain management ordinance to reduce future flood risk. The NFIP enables property owners in participating communities to purchase subsidized insurance as a protection against flood losses. If a community participates in the voluntary Community Rating System and implements certain floodplain management activities, the flood insurance premium rates are discounted to reflect the reduced flood risks.

6.2.4 Restoration of Natural Floodplain Functions

This strategy recognizes that periodic flooding of undeveloped lands adjacent to rivers and streams is a natural function and can be a preferred alternative to restricting flood flows to an existing channel. The intent of natural floodplain function restoration is to preserve and/or restore the natural ability of undeveloped floodplains to absorb, hold, and slowly release floodwaters, to enhance ecosystem, and to protect flora and fauna communities. Natural floodplain conservation and restoration actions can include both structural and nonstructural measures. To permit seasonal inundation of undeveloped floodplains, some structural improvements (e.g., weirs) might be needed to constrain flooding within a defined area along with nonstructural measures to limit development and permitted uses within those areas subject to periodic inundation. Actions that support natural floodplain and ecosystem functions include:

- **Promoting Natural Hydrologic, Geomorphic, and Ecological Processes –** Natural hydrologic, geomorphic, and ecological processes are key components of promoting natural floodplain and ecosystem functions. Human activities (including infrastructure such as dams, levees, channel stabilization, and bank protection) have modified natural hydrological processes by changing the extent, frequency, and duration of natural floodplain inundation. These changes disrupt natural geomorphic processes such as sediment erosion, transport, and deposition, which normally cause channels to migrate, split, and rejoin downstream. These natural geomorphic processes are important drivers in creating diverse riverine, riparian, and floodplain habitat to support fish and wildlife, and in providing natural storage during flood events. Restoration of these processes might be achieved through setting back levees, restoring channel alignment, removing unnatural hard points within channels, or purchasing lands or easements that are subject to inundation.

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- **Protecting and Restoring Quantity, Quality, and Connectivity of Native Floodplain Habitats** – Quantity, quality, and connectivity of native floodplain habitats are critical to promote natural floodplain and ecosystem functions. In some areas, native habitat types and their associated floodplain have been lost, fragmented, and degraded. Lack of linear continuity of riverine, riparian habitats, or wildlife corridors, impacts the movement of wildlife species among habitat patches and results in a lack of diversity, population complexity, and viability. This can lead to native fish and wildlife becoming rare, threatened, or endangered. Creation or enhancement of floodplain habitats can be accomplished through setting back levees and expanding channels or bypasses, or through removal of infrastructure that prevents flood flows from entering floodplains. Wetlands have been severely reduced, resulting in a loss of habitat for freshwater, terrestrial, and plant species. Restoration of these habitats could provide a buffer against storm surges.
- **Invasive Species Reduction** – Minimizing invasive species can help address problems for both flood management and ecosystems. Invasive species can reduce the effectiveness of flood management facilities by decreasing channel capacity, increasing rate of sedimentation, and increasing maintenance costs. Nonnative, invasive plant species often can out-compete native plants for light, space, and nutrients, further degrading habitat quality for native fish and wildlife. These changes can supersede natural plant cover, eliminate, or reduce the quality of food sources and shelter for indigenous animal species, and disrupt the food chain. Reductions in the incidence of invasive species can be achieved by defining and prioritizing invasive species of concern, mapping their occurrence, using BMPs for control of invasive species, and using native species for restoration projects.

6.3 Structural Approaches

Structural approaches to flood management include flood infrastructure, reservoir and floodplain storage and operations, and operations and maintenance (O&M).

6.3.1 Flood Infrastructure

Flood infrastructure varies significantly based on the type of flooding. There are many alternative components that can be applied to correct flood control deficiencies. These components can be used individually or in different combinations with other available alternative components. The alternative structural flood control infrastructure solutions that are available to select from for any type of flood control problem are limited to three major categories of solutions from which the individual components will generally fall within one of these categories and include (1) conveyance oriented, (2) storage, and (3) diversion. The major categories of structural solutions can be further expanded to define additional classifications of the primary components which include: (1) flow redirection, (2) structural rigid revetments, (3) other structural techniques, (4) biotechnical techniques, (5) channel geometry, (6) channel alignment, (7) diversion, (8) storage, and (9) other techniques. Flood infrastructure can include:

- **Levees and Floodwalls** – Levees and floodwalls are designed to confine flood flows by containing waters of a stream or lake. Levees are an earthen or rock berm constructed parallel to a stream or shore (or around a lake) to reduce risk from all types of flooding. Levees could be

placed close to stream edges, or farther back (e.g., a setback levee). Ring levees could be constructed around a protected area, isolating the area from potential floodwaters. A floodwall is a structural reinforced-concrete wall designed and constructed to hold back floodwaters. Floodwalls have shallow or deep foundations, depending on flood heights and soil conditions. Although levees and floodwalls are structural flood management approaches, they are not recommended. Due to strict FEMA regulations and intensive maintenance requirements, other alternatives are preferred within the Lassen County.

- **Channels and Bypasses –** Channels and bypasses convey floodwaters to reduce the risk of slow rise, flash, and debris- flow flooding. Channels can be modified by deepening and excavating the channel to increase its capacity, or lining the streambed and/or banks with concrete, riprap, or other materials, to increase drainage efficiency. Channel modifications can result in increased erosion downstream and degradation of adjacent wildlife habitats, and often the modifications require extensive permitting. Bypasses are structural features that divert a portion of flood flows onto adjacent lands (or into underground culverts) to provide additional flow-through capacity and/or to store the flows temporarily and slowly release the stored water.
- **Retention and Detention Basins** – Retention and detention basins are used to collect stormwater runoff and slowly release it at a controlled rate so that downstream areas are not flooded or eroded. A detention basin eventually drains all of its water and remains dry between storms. Retention basins have a permanent pool of water and can improve water quality by settling sediments and attached pollutants.
- **Culverts and Pipes** – Culverts and pipes are closed conduits used to drain stormwater runoff. Culverts are used to convey stream-flow beneath a road embankment or some other type of flow obstruction. Culverts and pipes allow stormwater to drain underground instead of through open channels and bypasses.
- **Shoreline Stabilization and Streambank Stabilization** – Shoreline stabilization reduces risk to low-lying areas from flooding. Streambank stabilization protects the banks of streams from erosion by installing riprap, matting, vegetation or other materials to reduce erosion.
- **Debris Mitigation Structures** – For debris and alluvial flooding, debris fences and debris basins separate large debris material from debris flows, or the structures contain debris flows above a protected area. These structures require regular maintenance to periodically remove and dispose of debris after a flood. Deflection berms (or training berms) can be used to deflect a debris flow or debris flood away from a development area, allowing debris to be deposited in an area where it would cause minimal damage.

6.3.2 Reservoir and Floodplain Storage and Operations

Reservoir and floodplain storage provide an opportunity to regulate flood flows by reducing the magnitude of flood peaks occurring downstream. Many reservoirs are multipurpose and serve a variety of functions, including water supply, irrigation, habitat, and flood control. Reservoirs collect and store water behind a dam and release it after the storm event. Floodplain storage occurs when peak flows in a river are diverted to adjacent off-stream areas. Floodplain storage can occur naturally when floodwaters overtop a bank and flow into adjacent lands, or storage can be engineered using weirs, berms, or bypasses to direct flows onto adjacent lands.

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- **Storage Operations –** Storage operations can reduce downstream flooding by optimizing the magnitude or timing of reservoir releases, or through greater coordination of storage operations. Coordination can take the form of formal agreements among separate jurisdictions to revise reservoir release operations based on advanced weather and hydrology forecasts, or it can simply involve participation in coordination meetings during flood emergencies.
- **Groundwater Recharge** – In some areas, opportunities may exist to provide recharge to the aquifer and enhance water supplies by capturing surface water sources. In addition, the opportunities for flood storage should be coordinated with recharge opportunities to ensure that these storages are located where optimum benefits occur, including recharge capabilities.

6.3.3 Operations and Maintenance

Operation and maintenance (O&M) is a crucial component of flood management. O&M activities can include: inspection, vegetation management, sediment removal, management of encroachments and penetrations, repair or rehabilitation of structures, and erosion repairs. Because significant flood infrastructure constructed in the early to mid-twentieth century are near or have exceeded the end of their expected service lives, adequate maintenance is critical for this flood infrastructure to continue functioning properly.

6.4 Flood Emergency Management

Flood emergency management includes the following preparedness, response, and recovery activities:

- **Flood Preparedness –** Flood preparedness consists of the development of plans and procedures on how to respond to a flood before a flood emergency, including: preparing emergency response plans, training local response personnel, designating evacuation procedures, conducting exercises to assess readiness, and developing emergency response agreements that address issues of liability and responsibility.
- **Emergency Response** – Emergency response is the aggregate of all the actions taken by responsible parties at the time of a flood emergency. Early warning of flood events through flood forecasting allows timely notification of responsible authorities so that plans for evacuation of people and protection of property can be implemented. Emergency response includes flood fighting, emergency evacuation, and sheltering. Response begins with, and might be confined to, affected local agencies or operational areas (counties). Depending upon the intensity of the event and the resources of the responders, response from regional, state, and federal agencies might be required.
- **Post-Flood Recovery** – Recovery programs and actions include restoring utility services and public facilities, repairing flood facilities, draining flooded areas, removing debris, and assisting individuals, businesses, and communities to protect lives and property. Recovery planning could include development of long- term floodplain reconstruction strategies to determine if reconstruction would be allowed in flood-prone areas, or if any existing structures could be removed feasibly. Such planning should review what building standards would be required, how the permit process for planned reconstruction could be improved, funding sources to remove

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existing structures, natural habitat restoration, and how natural floodplains and ecosystem functions could be incorporated.

6.5 Application of Common IFM Strategies

The value of using an IFM approach within the watershed is in the results—improved public safety, enhanced environmental stewardship, and statewide economic stability. Localized, narrowly focused projects are not the best use of public resources and might have negative, unintended consequences in nearby regions. The IFM approach can help deliver more benefits at a faster pace using fewer resources than what is possible from single-benefit projects. The following list provides examples of different recommended IFM strategies to assist in formulating alternatives within the different watersheds in order to produce high-value multi-benefit projects.

1. Increase hydraulic conveyance capacities and remove flow restrictions
2. Provide flood relief structures or bypass systems to reduce downstream flows
3. Construct setback levees to preserve natural floodplain vegetation corridors
4. Preservation of natural active washes and floodplain corridors
5. Clearing of debris and snags within channel systems
6. Watershed and floodplain vegetation management plan including current levee requirements
7. Streambank stabilization to reduce sedimentation downstream
8. Update O&M procedures and methods to reflect other functions in the flood management system, including ecosystem functions
9. Acquire floodplain areas to reduce flood damages and preserve natural floodplain corridors / ecosystem values
10. Sediment deposition removal projects to enhance hydraulic capacity and maintain fluvial processes
11. Update local flood management plans and coordinate with landuse planning
12. Designate additional floodways based on current hydraulic and hydrologic conditions
13. Encourage compatible landuse with flood management system and floodplain
14. Mange urban stormwater runoff to natural floodplain to reduce the potential for "hydromodification" impacts including flooding and stream stability
15. Improved accuracy of floodplain mapping/delineation, including urban areas, as well as better assessment of flood risks
16. Increased public information on floodplain hazards through access to floodplain hazard delineation with GIS tools on web based applications
17. Increased awareness and participation of FEMA Community Rating System (CRS) for flood insurance rate adjusting program
18. Identify locations and structures which have repetitive flood damage losses and eliminate
19. Land use planning and decision-making should be based on a more accurate assessment of flood risk from multiple hazards (i.e., influence of wildfires on flooding)
20. Construct new or enlarge existing temporary floodplain storage to attenuate peak flooding downstream
21. Increase flood control allocation by expanding existing or building new off-stream storage

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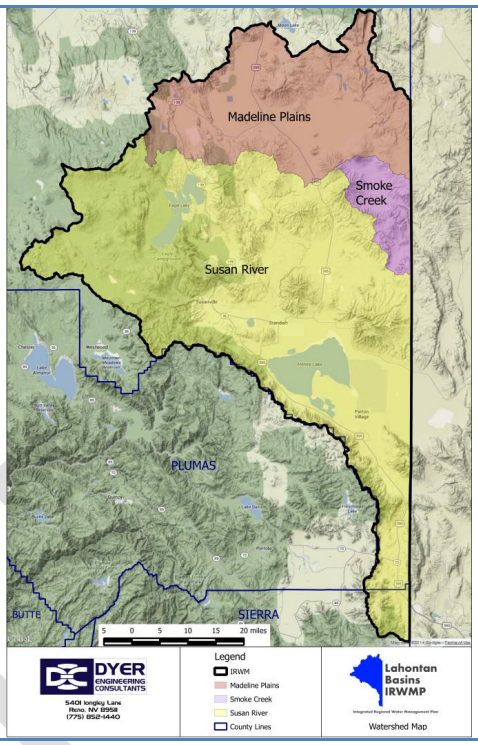
22. Implement advanced weather forecast-based operations to increase reservoir management flexibility on a watershed basis such as with the County ALERT Network
23. Manage runoff through watershed management. Runoff from watershed source areas increases, in varying extents, due to increases in impermeable surfaces in developed areas, soil compaction from agriculture, reductions in vegetative cover, incision of stream channels, and losses of wetlands.
24. Remove unnatural hard points in or on the banks of streams (such as bridge abutments, rock revetment, dikes, limitations on channel boundaries, or other physical encroachments into a channel or waterway) can affect the hydraulics of river channels, constraining dynamic natural fluvial geomorphologic processes of erosion.
25. Develop hazardous waste and materials management protocols to identify, contain, and remediate potential water quality hazards within floodplains
26. Operate reservoirs with flood reservation space to more closely approximate natural flow regimes
27. Reduce the incidence of invasive species in flood management systems
28. Remove barriers to fish passage
29. Encourage natural physical geomorphic processes, including channel migration and sediment transport
30. Improve the floodplain and watershed, quantity, and connectivity of wetland, riparian, woodland, grassland, and other native habitat communities
31. Develop regional advanced mitigation strategies and promote networks of both public and private mitigation banks to meet the needs of flood and watershed infrastructure projects
32. An effective and sustainable flood/watershed management system will encompass critical habitat and migration corridors through integration of public safety, water supply, and ecosystem function—managing flood infrastructure as a system
33. Coordinate flood response planning and clarify roles and responsibilities of the different flood management agencies/entities related to flood preparedness and emergency response
34. Use Building Code amendments to reduce consequence of flooding
35. Encourage multi-jurisdictional and regional partnerships on flood planning and improve agency coordination on flood management within watersheds to provide system wide planning

6.6 Detailed Application of IFM Strategies

A more detailed assessment was developed for commonly utilized IFM strategies that are applicable to the county. A variety of the different specific strategies or projects were generalized or lumped to ten different types of strategies or applications that could be utilized in Northern California. A series of fact sheets were developed for the different generalized application in order to assist in the guidance and formulation of specific projects.

Strategy Application No. 1 - Watershed Management Planning
IFM Objectives / Principles: • Landuse Planning

- Natural resource preservation
- Sustainable development
- Water quality
- Runoff management



Description of Representative Actions / Elements:

Apply core underlying watershed management planning guidelines in developing the proposed strategies and infrastructure for future development. These guidelines would ensure that development (i) mimics existing runoff and infiltration patterns within the project area, (ii) does not exacerbate peak flow rates or water volumes within or downstream of the project area, (iii) maintains the geomorphic structure of the major tributaries within the project area, (iv) maintains coarse sediment yields, storage and transport processes, and (v) uses a variety of strategies and programs to protect water quality. The principles refine the planning framework and identify key physical and biological processes and resources at both the watershed and sub-basin level. The Watershed Planning Principles focus also on the fundamental hydrologic and geomorphic processes of the overall watersheds and of the sub-basins. These principles can be utilized to guide the initial planning of the development program relative to watershed resources and to minimize impacts thereto through careful planning by integrating the initial baseline technical watershed assessments. Non-structural watershed protection planning principles would include minimization of impervious areas/preservation of open spaces, prioritization of soils for development and infiltration, and establishment of riparian buffer zones. Examples of watershed planning principles that can be used include:

Principle 1 – Recognize and account for the hydrologic response of different terrains at the sub-basin and watershed scale.

Principle 2 – Emulate, to the extent feasible, the existing runoff and infiltration patterns in consideration of specific terrains, soil types and ground cover.

Principle 3 – Address potential effects of future land use changes on hydrology.

Principle 4 – Minimize alterations of the timing of peak flows of each sub-basin relative to the mainstem creeks.

Principle 5 – Maintain and/or restore the inherent geomorphic structure of major tributaries and their floodplains.

Principle 6 – Maintain coarse sediment yields, storage and transport processes.

Principle 7 – Protect water quality by using a variety of strategies, with particular emphasis on natural treatment

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systems such as water quality wetlands, swales and infiltration areas and application of Best Management Practices within development areas to assure comprehensive water quality treatment prior to the discharge of urban runoff into the floodplain corridor

Potential Benefits:

- Integrated land planning process with watershed functions
- Managed runoff from development and commercial watershed activities
- Maintain natural runoff process
- Minimize long term maintenance costs within floodplain

Strategy Application No. 2 - Floodplain Management

IFM Objectives / Principles:

- Integrated landuse planning
- Natural floodplain corridor preservation
- Sediment management / stream stability
- Natural streambed groundwater recharge

Description of Representative Actions / Elements:

Facilitating improved alignment and coordination between land use and flood management would result in better understanding of flood risk and potential impacts to proposed developments, as well as improved decision making. Specifically, flood risk information has the potential to influence land use policy decisions related to developing and expanding communities within a floodplain, which would result in reductions to flood damage claims and long-term O&M costs on projects. At the planning stage, additional measures might be incorporated into the initial proposed projects that could provide community benefits, such as setback areas that act as greenways or trails, and greatly reduce the need to retrofit or replace undersized infrastructure in the future. Too often, regional and land use policymakers realize flood risk and economic losses only after a damaging flood event. Some of the additional actions associated with this item include defining increased floodways to limit development along the floodplain fringe, floodplain retreat through purchase of properties within the floodplain, ensuring that different landuses are compatible with the floodplain risks.

Potential Benefits:

- Reduction in flood damage subsidies to chronic flood locations

Strategy Application No. 3 - Stream Stabilization

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IFM Objectives / Principles:

- Sediment Control
- Increased floodplain capacity
- Water quality
- Reduce sediment deposition downstream

Description of Representative Actions / Elements:

Channel erosion, with substantial stream incision can be a large contributor of sediment to downstream receiving waters and deposition in portions of channels that reduce flood capacity. In addition, increased sediment transport will bulk the runoff flows in the channel and further diminish the flood conveyance capacity. Watershed based regional studies/investigations of the fluvial processes and watershed sediment yields as well as geomorphic assessments/monitoring can evaluate those critical locations within the watershed that require stabilization. Stream erosion and sedimentation adversely impact water quality beneficial uses of both the stream and the receiving waters, and sediment TMDL. Stabilization of the natural alluvial channel system to eliminate future erosion of the streambed and streambank will assist in critical channel areas as a major sediment source as well as disrupting the loss of vegetative habitat within the floodplain. Detailed streambed stability assessments provides part of the technical support for the evaluation of the benefits of and opportunities for alternative stream stabilization / restoration techniques to ensure that the natural geomorphic and fluvial process are maintained in balance.

Potential Benefits:

- Minimize maintenance in floodplains
- Reduce long term operations costs
- Reduce apparent peak discharge through reduced sediment bulking
- Reduce loss of land
- Improve recharge in streambed
- Reduce sediment deposition in riverine / estuarine habitat areas

Strategy Application No. 4 - Watershed Sediment Control / Erosion Management

IFM Objectives / Principles:

- Landuse planning
- Development sustainability
- Water quality enhancement

Description of Representative Actions / Elements:

Soil is considered a water pollutant because it can significantly affect water used for public consumption, recreation

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and habitat. Therefore, the most effective way to control soil erosion is at its source. Erosion control best management practices (BMPs) are required on all land disturbance sites to provide a defense against soil erosion in addition to different commercial activities within the watershed. Watershed planning implementing and requiring different BMPs can be applied as well as the modification of these commercial activities to minimize sediment disturbances. There are also natural areas which may be de-stabilized and be a significant sediment source which require specialized treatments to reduce the amount of sediment production.

Potential Benefits:

- Receiving waters improved water quality
- Reduce flooding through reduced sediment bulking of flows
- Reduction of sediment deposition in undesirable locations within floodplain

Strategy Application No. 5 - Multi-Function Flood Storage / Recharge Basins

IFM Objectives / Principles:

- Flood reduction
- Groundwater recharge
- Stormwater recycling / alternative water source

Description of Representative Actions / Elements:

Regional watershed evaluation and planning to provide flood peak flow attenuation through either off-channel or adjacent in-channel temporary flood volume storage. The reduction in peak flow rates will minimize downstream flooding in addition the stored flood runoff volumes can be recharged into the aquifer to enhance groundwater supplies. Coordination with groundwater management agencies should be performed on a watershed basis to determine the optimum location to ensure that maximum recharge can be provided to the aquifer since different areas of the watershed may not provide any benefit to groundwater supplies. Coordination of both groundwater and flood benefits is necessary as part of advance planning with multiple agencies. In addition, floodplain enlargement can result in increased habitat corridors as well as the in-channel flood storage capabilities.

Potential Benefits:

- Reduced flooding downstream
- Stormwater recycling and additional water source capture

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Strategy Application No. 6 - Urban Water Quality Treatment / Retention

IFM Objectives / Principles:

- Water reuse / recycling
- Groundwater recharge
- Natural floodplain protection
- Stream stabilization
- Water quality treatment
- Urban flood management

Description of Representative Actions / Elements:

Management of urban stormwater runoff and the associated water quality as well as increased runoff quantities impacting the natural floodplain corridors which result in a variety of impacts, not just increased flooding. Projects involving the capture of non-stormwater flows provide an opportunity for recycling this water source which was a waste-stream in the past.

Potential Benefits:

- Improved water quality and reduce impact to downstream receiving waters
- Restore natural floodplain functions
- Reduce impacts of urban hydromodification

Strategy Application No. 7 - Floodplain Habitat Corridor Preservation / Buffer

IFM Objectives / Principles:

- Vegetation buffer
- Habitat preservation
- Stream corridor stabilization

Description of Representative Actions / Elements:

Wetlands and floodplain vegetation can provide a hydrologic buffer to the watershed response through reduced velocity and increased time of watershed. The watershed vegetation can buffer the intensity of rainfall events and the corresponding watershed response which will reduce the flooding downstream. The preservation of natural vegetation reduced water flow connectivity by interrupting surface flows of water, for example, by water storage or planting buffer strips of grass or trees.

Potential Benefits:

- Reduction of streambank/streambed erosion through natural protection

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- Enhanced wildlife habitat benefits
- Natural water quality biological uptake benefits

Strategy Application No. 8 - Enhanced Floodplain Storage / Recharge

IFM Objectives / Principles:

- Floodplain preservation
- Flood storage / groundwater recharge
- Peak flow reduction
- Flooding reduction
- Maintain natural hydrologic processes

Description of Representative Actions / Elements:

Creative use of the floodplain to provide temporary in-channel storage to reduce peak flow rates downstream. The identification of potential flood storage within the floodplain involves integrating wetland and floodplain natural and beneficial functions into floodplain management planning. Integrate the protection and restoration of floodplain and wetland natural and beneficial functions into comprehensive land use planning, watershed planning, and floodplain management planning effort. Protection of floodplain and wetland vegetation to erosion is particularly important for high velocity areas

Potential Benefits:

- Enhanced groundwater supplies
- New water source
- Habitat enhancement and increased corridor

Strategy Application No. 9 - Coordination between programs/agencies for water management and flood management planning

IFM Objectives / Principles:

- Communication between agencies within watershed
- Watershed planning guidance / regulations
- Enhanced water supplies
- Water management

Description of Representative Actions / Elements:

Improving coordination between regional water management and flood management planning is a key strategy to increase implementation of IWM projects. Existing planning groups and forums should be utilized to the extent possible. By coordinating water and flood management planning with balanced representation, a common understanding of flood management, water supply, water quality, environmental stewardship, public safety, and economic sustainability factors would be developed. Where possible, policy changes that promote this holistic approach to IWM should be proposed and sponsored (for example, changes to existing IRWM legislation). In addition, coordination in watershed planning process provides the opportunity to optimize the benefits of joint-use regional facilities to maximize water resources as well as flood mitigation benefits.

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Potential Benefits:

- Maintaining natural watershed response
- Increased groundwater replenishment
- Reduced flood damage
- Reduction in flood maintenance

Strategy Application No. 10 - Watershed / floodplain information management and data exchange

IFM Objectives / Principles:

- Communication between agencies within watershed
- Community involvement
- Increased watershed monitoring

Description of Representative Actions / Elements:

Improving the watershed database to ensure that different watershed stakeholders have access to the different available information and studies being performed. The sharing and the exchange of data, information, knowledge among experts, general public, policy makers, and floodplain managers in a most transparent manner is essential for comprehensive planning and effective management. Significant studies and mapping information are being performed within the watershed on an individual basis with single users or sole functions, but could become a valuable asset is shared with other users as well as saving significant costs. Fragmentation of data is common and providing a common data repository as well as manager provides the technical foundation for comprehensive planning.

Potential Benefits:

- Improved tracking and monitoring of watershed characteristics
- Reduction in data acquisition
- Enhanced community involvement in watershed, include active participation in data collection

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7. Watershed Management Planning Recommendations and Guidelines

7.1 Watershed Level Planning Procedures

Effective IFM planning should be conducted at a regional scale in order to study the cause and effect of solutions through a system-wide approach. Although each watershed plan emphasizes different issues and reflects unique goals and management strategies, some common features are included in every watershed planning process. The watershed planning process is iterative, holistic, geographically defined, integrated, and collaborative. A holistic watershed planning approach usually provides the most technically sound and economically efficient means of problems and is strengthened through the involvement of stakeholders that might have broader concerns than just flood mitigation.

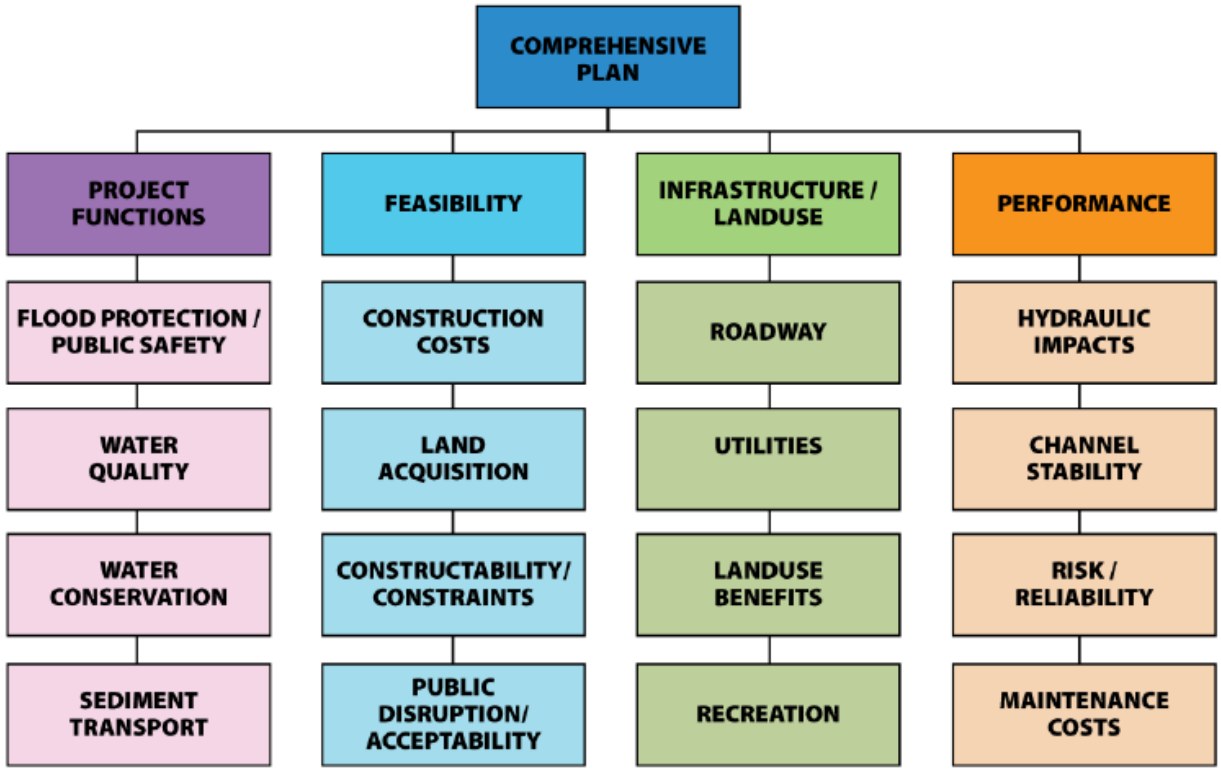

Figure 12 - Comprehensive watershed planning involves multiple objectives with an integrated approach to ensure that maximum benefits are achieved

Watershed flood management planning is a specialized discipline of planning that deals with floodplain management and implementation of flood protection systems and facilities to correct existing deficiencies or flooding problems. Flood management planning requires integrating a wide range of disciplines to ensure success of the plan and detailed understanding of the physical processes and system functions so that the "cause" can be effectively treated rather than the "symptom." The typical approach is an integrated planning process which evaluates multiple technical factors and evaluates multi-purpose objectives as part of the plan formulation program.

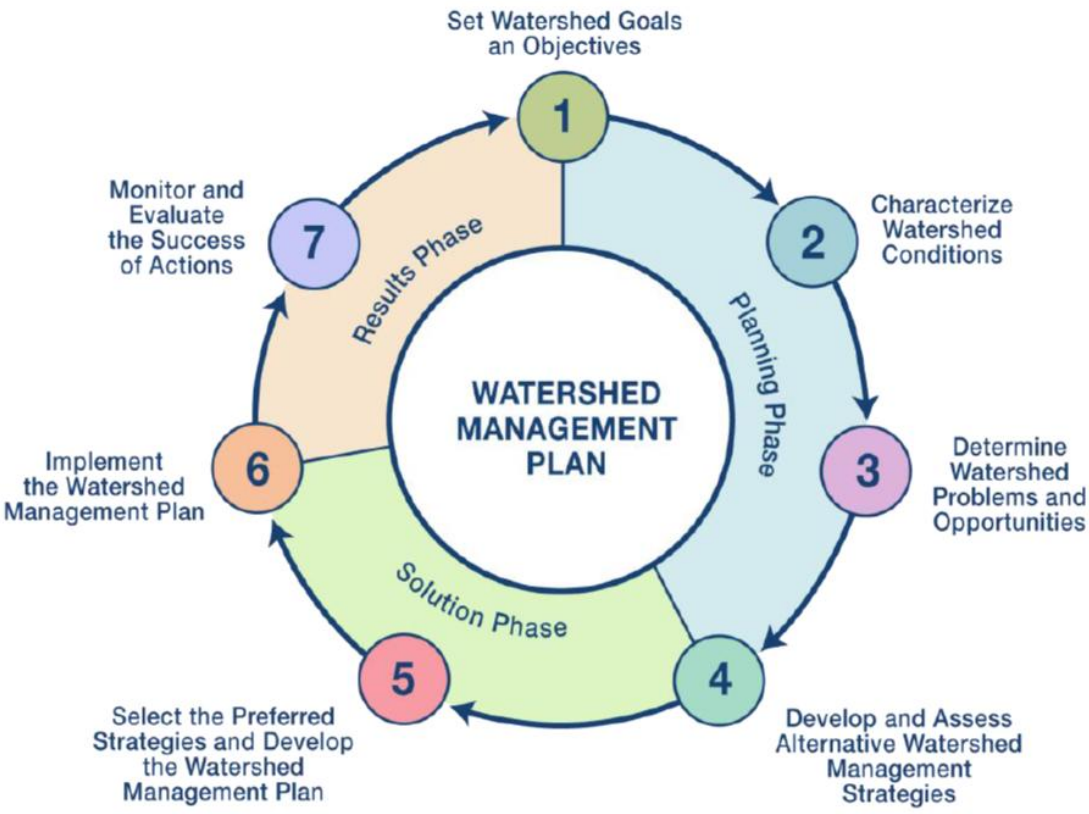

Figure 13 - Overview of the typical comprehensive watershed planning process involving sequential plan formulation

The general flood control planning and plan formulation process consists of a series of tasks:

Step 1 – Define Objectives and Criteria: Selection of an appropriate flood control solution requires identifying all the objectives associated with the project, since most projects will have multiple objectives, many which may be in conflict with each other. Objectives should be stated in terms of the desired outcome to be achieved and should not include the method in the objective. Design criteria are a key to establishing understood expectations for implementing a solution and are specific, measurable attributes of project components developed to meet objectives.

Step 2 – Prepare Data Inventory: Develop a database to provide a suitable technical foundation that defines the physical attributes of the system and the constraints. The data and information obtained during the inventory provides the factual basis for all future assessments and analyses.

Step 3 – Baseline Assessments and Analysis: Developing a baseline understanding of the existing conditions is essential through the application of different engineering analysis and modeling techniques.

Step 4 - Identify Problems and Opportunities: Determine the potential problems and identify the corresponding cause/source of the problem or failure mechanism.

Step 5 – Alternatives Plan Formulation: Develop a range of conceptual alternative approaches and solutions which will serve as a toolkit to draw from in order to formulate the different "systems" alternative plans. The systems can incorporate naturalized solutions and minimize impacts to environmental constraints. Plans should develop conceptual projects and should align the proposed facilities for each alternative utilizing different IFM strategies, including structural and non-structural approaches. The alternative formulation process will conceptually identify the range of potential alternative that can be screened to the most feasible alternatives.

Step 6 – Forecasts Analysis / Impacts & Risk Assessment: Prepare "planning level" assessment and analyses, which include conceptual facility hydraulic/hydrologic sizing and assessments of facility hydraulic operation or modifications of floodplain/flood hazards. The engineering analysis should be performed to sufficient level of detail in order to develop approximate construction costs of facilities and assess potential impacts, both to the floodplain and other impacts such as encroachments to biological corridors or integrating environmental habitat restoration and preservation as a key element. An initial assessment of the risk for failure of the solution is evaluated in relation to the return period of flood events, particularly if "soft" solutions or management vs. structural solutions are implemented.

Step 7 – Feasibility and Screening Analysis: A feasibility analysis is performed to screen the number of conceptual alternatives to select the recommended alternative which meets the project objectives. The screening process allows for promising alternatives to be evaluated in more detail while inferior alternatives are excluded from further evaluation. This process will qualify the alternatives different levels of feasibility in order to rank the alternatives. The "feasibility" evaluation addresses the (1) economic suitability, (2) constructability, (3) acceptability so that many of the conceptual alternatives can be eliminated from further investigation. A decision matrix can be utilized for the assisting in the screening of the flood control alternatives which identify the (1) advantages, (2) disadvantages, (3) preliminary construction costs, (4) design constraints, (5) physical constraints, (6) implementation requirements, (7) flood protection, and (8) economic factors including intangible costs. The alternatives are weighted and ranked through this process to identify the most suitable alternatives. A typical decision matrix presents the alternatives comparison based upon the degree of satisfying the various multiple watershed objectives in order to facilitate the decision making process for the recommended alternative.

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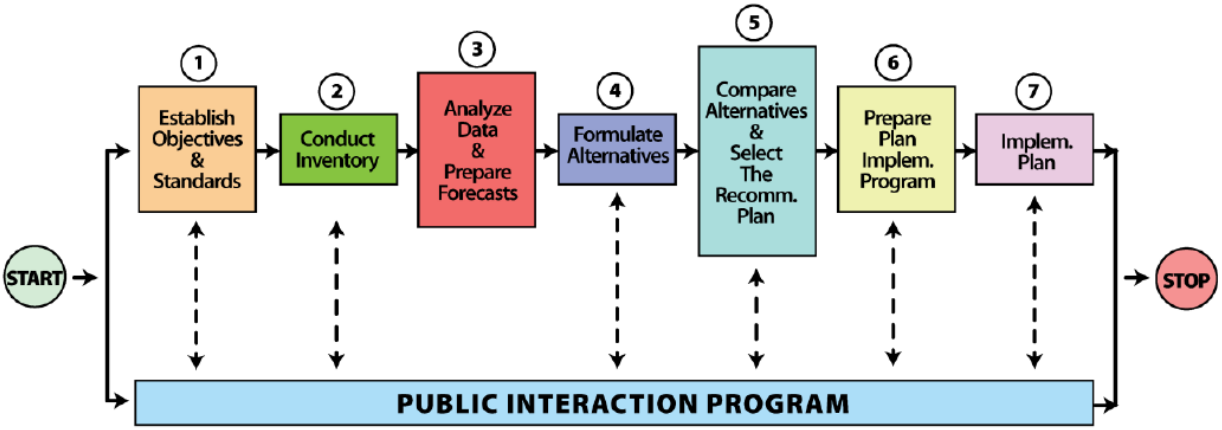

Figure 14 - General work flow of the watershed planning process, which includes stakeholder interaction as key element throughout the process

7.2 Communication Process - Watershed/Floodplain Managers Forum

The Lahontan Basins IRWM Region is unique with regards to floodplain management administration as compared to other areas within the state. There is not a single agency which administers and coordinates the floodplain management activities throughout the county. The county has the responsibility for areas within the unincorporated areas of the county, while Susanville is responsible for the floodplain management within their municipal boundary. The fragmentation of floodplain management responsibility makes watershed scale planning more difficult.

It is recommended that a Watershed/Floodplain Managers Forum be established that promotes the collaboration with the different floodplain managers as well as coordinating with the other water resource agencies in order to implement IFM strategies. This forum would assist in define the framework and process for different levels of communication of the different levels of flood managers and watershed stakeholders. The process will define different strategies and media for communication and disseminating of information or updating of management activities as well as planning. In addition, the forum can engage the different managers and stakeholders through workshops in order to provide participation in the plan development. This working forum is a critical element that should continue into the future after the initial plan structure has developed with this contract. It can be used as an annual or more frequent vehicle for communication and collaboration to ensure effective watershed planning.

7.3 Project Plan Formulation

The initial project formulation process should provide numerous alternative general concepts or approaches that cover an entire range or spectrum of available potential solutions. The range of alternatives generated from this process should be of sufficient extent that it would satisfy an alternative analysis as part of the environmental documentation or regulatory permitting. These different options are developed through the application of a variety of available conventional tools and flood protection techniques that can be developed into different creative and effective solutions.

Conceptual design solutions are developed through an in-depth understanding of the problems and fundamental hydraulic/hydrologic processes. A hierarchy of design components is pieced together

utilizing the engineering "toolbox" to develop creative alternatives that provide the desired hydraulic/hydrologic function. Techniques are selected with respect to the hydraulic conditions and fulfilling the objectives/design criteria. The intent of this process is to ensure that novel and innovative solutions are generated rather than focusing on routine alternatives.

An integral component is application of different techniques as part of these solutions that embrace the natural river function/ecology and preservation/enhancement of these resources. An important first step in formulating alternative plans is the process of creating measure of performance of evaluating each alternative since the performance measures often assist in defining potential alternatives. The performance measure must be easily understood and directly related to the planning objective. For example for the flood protection evaluation the change in water surface elevation within the floodplain will be a clear indicator of the alternative performance related to that particular primary objective.

7.4 Project Review and Screening Process

There are many unique challenges associated with the selection and prioritization of watershed projects in order to ensure that the correct or optimum is selected that provides the maximum benefits while addressing multiple watershed objectives, or ensuring the needs of all the watershed stakeholders are adopted. It is desirable to have a planning tool to assist in the alternative screening process which can provide guidance in understanding the relative importance of many different objectives through a numerical weighting scale which can be used in ranking alternatives in forming the decision nexus.

A useful technique where multiple objectives are evaluated in making a decision in the selection of many different alternatives is known as the Analytical Hierarchy Process (AHP). The main advantage to the masterplan process is its ability to rank choices in order of their effectiveness in meeting conflicting objectives. The essence of this process is to construct a matrix expressing the "relative" values of a set of different objectives or attributes. A pairwise comparison or numerical ranking is performed for each different combination of two different objectives, say cost vs. environmental protection, in order to form the matrix. The AHP involves calculating the eigenvector for the matrix which can be performed applying a relatively simplified mathematical process which otherwise would be rather daunting. (Note: an "eigenvector" of a square matrix that when multiplied by another non-zero vector yields the eigenvector multiplied by a single number) AHP is an effective tool to objectively numerically rank and prioritize projects when faced with numerous projects and multiple competing objectives on a planning basis.

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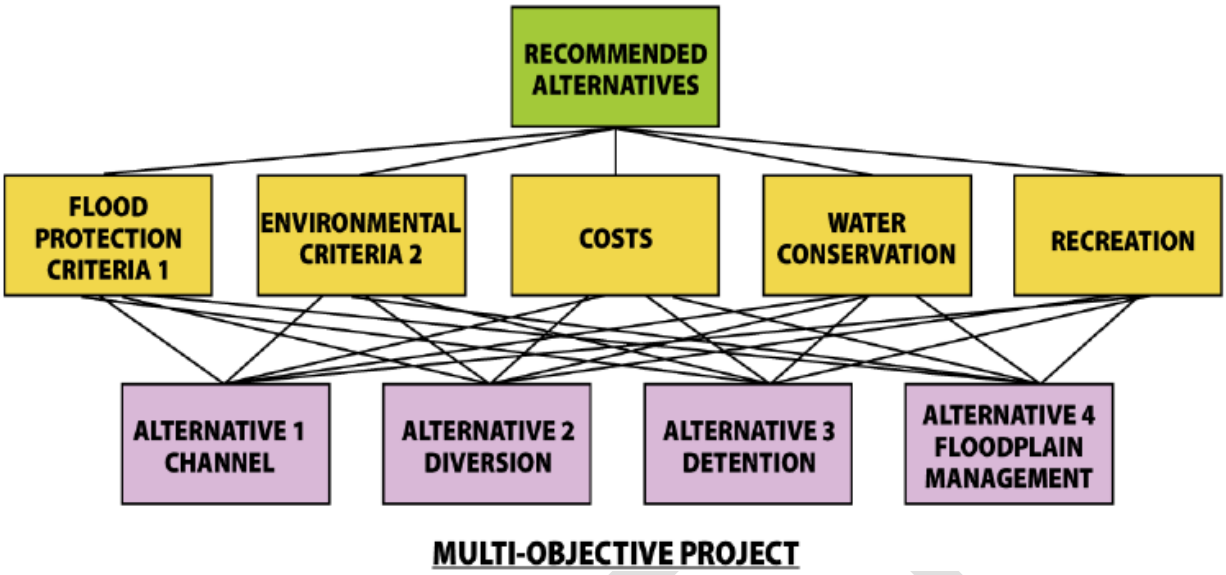

Figure 15 - Complexity of evaluating multiple projects with different objectives which requires specialized planning tool such as AHP

7.5 Recommended Actions

This study is intended to identify a general framework for the application of an integrated flood management approach throughout the county on a regional basis that will ensure maximizing water resources benefits. General principles and strategies are also provided as guidance to assist in watershed planning. IFM combines land and water resources development in a floodplain, within the context of IRWM with a view to maximize the efficient use of the floodplains and minimize loss of property and life.

Flood management practices have evolved from single purpose projects to a more holistic water resources management approach focusing on a watershed perspective. Using an IFM approach provides significant benefits including high-value multi-benefit projects, which the community can leverage through broader access to funding sources. This report is intended as a "guidance document" to facilitate an integrated water resources approach to flood management. This assessment is based on readily available information to perform planning level risk assessment in order to provide high level recommendations. Based on the findings, the following actions are recommended to advance the use of IFM on a county-wide basis for development of flood management solutions:

1. Increase collaboration/communication of agencies responsible municipal and regional floodplain management which will increase effectiveness of flood management

- Develop framework and process for different level of communication for floodplain managers
- Provide basis for regional working forum (Watershed/Floodplain Managers Forum) of floodplain managers that allows increased collaboration and future regular meetings

- Provide basis for a regional work-group forum of floodplain managers and watershed stakeholders that allows increased collaboration and future regular meetings. Utilize existing industry forums or planning groups such as the Floodplain Mangers Association to establish these initial working groups.

2. Improve understanding and accuracy of regional and local flood risks on a watershed basis

- Develop understanding of the different types of flooding from both regional level and local level and include specific flood problems for the different areas as well inventory of common "hot spots" of chronic problems
- Provide methodology to define the magnitude of flood risks to better prioritize the level of flood risk which integrates potential flood damage
- Review common recurring flood damage losses and evaluate the sources of these flood problems

3. Develop regional watershed database to assist in flood management planning that will provide a data exchange of information for all watershed stakeholders as well as sharing of information between public agencies to foster collaboration

- Ensure that different watershed stakeholders have access to the different available information and studies being performed
- Develop community based watershed groups to provide monitoring of floodplains and reduce costs of performing these services while increase the active field database
- Collect and compile watershed mapping information related to flood hazards and watershed information in a GIS format as well as developing a schema for managing the data to benefit future watershed planning
- Develop an updated GIS database of all the different flood control and flood management infrastructure

4. Develop watershed based planning, which includes collaboration with all the different stakeholder groups to minimize conflicts and define specific watershed goals

- Develop understanding of the different priority goals of the watershed stakeholders based on the common recurring flooding issues/problems/hazards
- Involve environmental groups and agencies in the planning process as well as develop an understanding of additional environmental resources

5. Initiate understanding and awareness of "integrated flood management" (IFM) for agencies and the community

- Prepare educational material and information on background of IFM to encourage better understanding of the required thought process
- Provide examples of IFM projects to assist in understanding how to apply and the basis of the key planning principles which are different from conventional watershed planning

6. Identify applicable IFM strategies on a watershed basis that can be utilized within the county to assist agency's understanding on how IFM can be implemented given the nature of the types of flood hazards within the county

- Define common types of IFM strategies which integrate different planning principles through different scales (1) watershed level, (2) city level, and (3) neighborhood/local level for the semi-arid climate
- Develop regional mapping of both opportunities and constraints related to integrated flood management
- Develop a specialized GIS based tool which assists in the defining locations of IFM projects at a regional scale and can provide maximum multiple benefits and provides method for prioritizing flood management projects

7. Develop watershed planning guidance program implementing IFM through different land planning regulations and collaboration with agencies during the development planning process

- Develop watershed planning process framework with key planning principles for implementing IFM that focuses on linking sustainability, water resource management, and landuse planning to flood management and the entire hydrologic cycle
- Prepare guidance on integrating "landuse planning" as central element of IFM and define how it can be utilized for different type of floodplain hazards issues
- Develop overall guidance document that provides stakeholders the basis for watershed planning with IFM

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