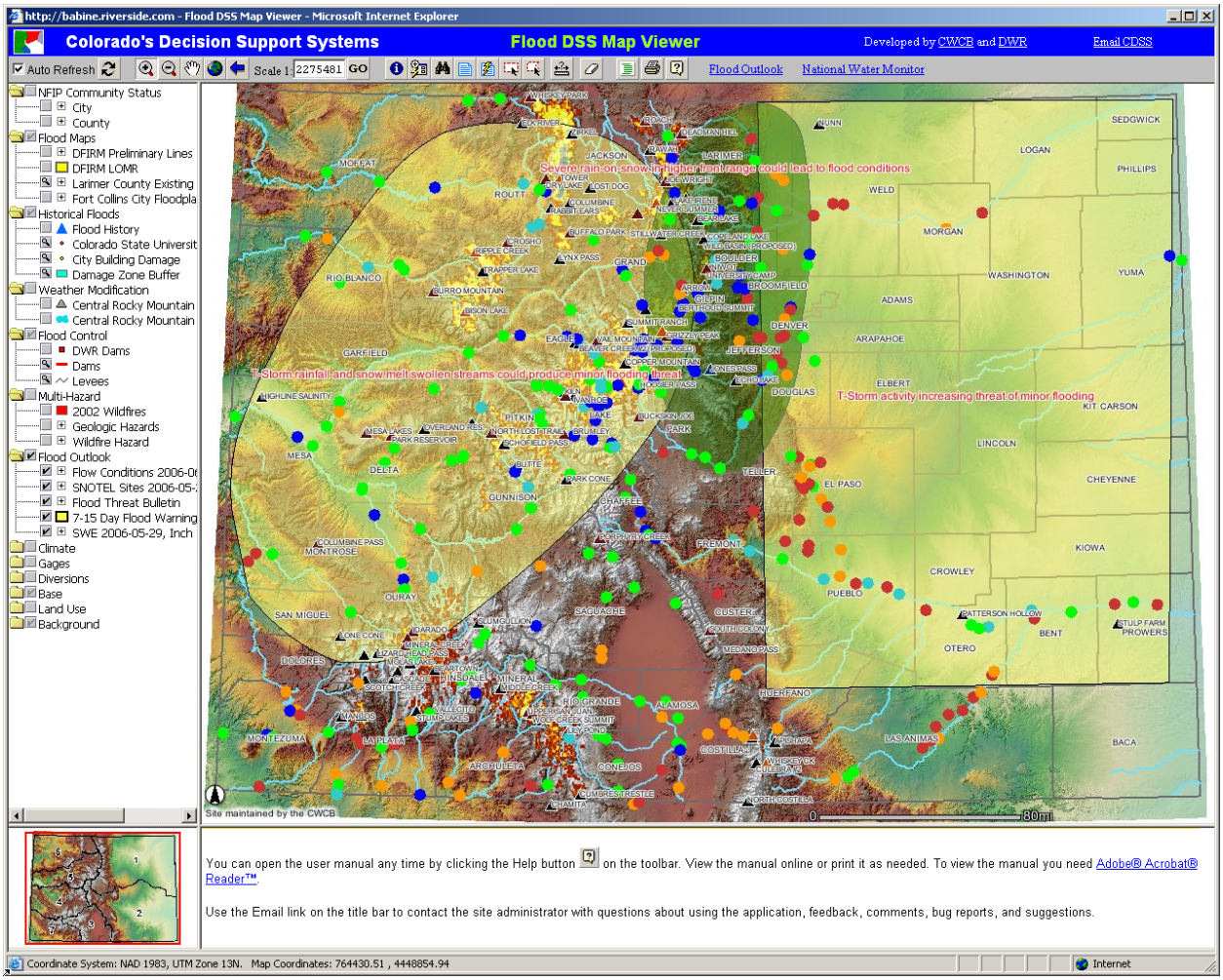
Prototype Flood DSS
(Flood Decision Support System)
Project Summary and Recommendations



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for the

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Table of Contents

1. Introduction

This document provides a summary of the outcomes of the Flood DSS (Decision Support System) prototype project, as implemented by Riverside Technology, inc., and provides recommendations for a full scale Flood DSS implementation. Project tasks are summarized to document activities that may need to be repeated in a full-scale implementation.

RTi wishes to acknowledge the help of Colorado Water Conservation Board (CWCB), Division of Water Resources (DWR), Larimer County, and City of Fort Collins staff, who facilitated the implementation of the prototype by providing data and technical support.

The CWCB has invested in Decision Support Systems (DSSs) for several years, in particular the basin DSSs collectively known as Colorado's Decision Support Systems (CDSS). The DSS efforts provide specific solutions to meet the prioritized needs of the CWCB and DWR and also provide a general framework for data management, modeling, analysis, and dissemination of information. The Flood DSS prototype described in this document recognizes the framework of CDSS and, as much as possible, was implemented in a way that reuses CDSS components and data, extends CDSS with additional data and capabilities, and allows for continued reuse and integration with CDSS components.

A Flood DSS was initially envisioned as an impetus to statewide digitization of FEMA (Federal Emergency Management Agency) FIRMs (Flood Insurance Rate Maps), a goal that has since been achieved in large degree through the State's document imaging program. Subsequently, the primary focus of the Flood DSS prototype is to meet the needs of the following user types:

1. Provide a clearinghouse of flood-hazard information for use by a variety of users, including developers, insurance industry, and government agencies.
2. Provide timely and well-organized flood outlook data products for the emergency managers (e.g., Flood Task Force).
3. Provide a clearinghouse of additional flood-related data, including weather modification, stream restoration, levy/dam stability, etc.

The ability to utilize flood hazard and related information from different sources in a GIS environment, as well as simultaneously access information from CWCB's Content Manager document system for interpretation together with spatial information, will greatly facilitate data access, understanding, interpretation, and can ultimately lead to better decision-making. The DSS prototype will demonstrate this utility, and be helpful in garnering support to fully develop a statewide flood DSS.

The specific objectives of Flood DSS Prototype development were thus to:

1. Implement a Flood DSS web site prototype to organize and disseminate spatial data, via an ArcIMS web site on a State web server, to demonstrate and allow for evaluation of the clearinghouse concept.
2. Provide links between selected spatial and non-spatial data, to demonstrate functionality at a prototype level.
3. Allow CWCB Flood Protection staff to evaluate the utility of an Internet map-based Flood DSS prototype in order to consider implementation of a full scale Flood DSS.

Section 2 below provides a summary of the tasks for the project. *Section 3* below provides a summary of recommendations for a full scale Flood DSS.

2. Project Summary

The following sections summarize the tasks that were completed during the implementation of the Flood DSS prototype.

Prototype development utilized the existing ArcIMS platform created by RTi for the CWCB/DWR (CDSS Map Viewer). This proven foundation allowed for a cost-effective means for rapid prototype development, creating the opportunity to concentrate primarily on gathering, processing, and entering appropriate data, and displaying it for effective assessment. Another major objective was to make information in Content Manager available through the DSS interface, enabling text and other data to be accessed and selected based on its geographic emphasis.

When available, flood data covering the entire state were collected. However, it was agreed at the kickoff meeting that much of the information would be specific to counties or communities. As it would be outside the scope of this prototype to collect data for multiple counties and communities, it was agreed that Larimer County should be the example focus of more spatially detailed data. This selection was based upon the range of representative physiographic and land cover conditions the area offers, the fact that the City of Fort Collins recently suffered a devastating flash flood (1997) leading to a state of emergency declaration, and the proximity of RTi to the County and City offices.

Prototype development activities included the following tasks:

1. **Project Kickoff** – to restate project goals and constraints, to allow initiation of work.
2. **Data Inventory –** preparation of a list of all data identified for inclusion in the Flood DSS.
3. **Data Collection –** assembling data files for data types listed in the data inventory.
4. **Data Processing –** prepare data for use in the Flood DSS web site.
5. **Adapt CDSS Map Viewer –** adapt existing CDSS Map Viewer files to create the Flood DSS Map Viewer.
6. **Implement Access to Non-Spatial Data –** make Content Manager information and other web-based data available to the Flood DSS Viewer interface.
7. **Implement Map Links to Non-Spatial Data** – link the spatial data to non-spatial data.
8. **Prototype Installation –** provide to State all data layers and available metadata, secondary data files implemented for the prototype, map viewer site files, and configuration documentation.
9. **Prototype Evaluation –** prepare recommendations in this document.
10. **Project Management** – participate in coordination and status meetings in order to deliver a quality product that meets the scope.

These tasks are summarized below.

2.1 Project Kickoff

A Flood DSS project kickoff meeting was held at the CWCB on May 5, 2006 and was attended by Tom Browning, Ray Alvarado, and Carolyn Fritz of the CWCB; Lori Torikai of DWR; and Steve Malers, Amnon Nevo, Jay Day, and Graeme Aggett of RTi. Minutes of the meeting were subsequently distributed to attendees and were updated to reflect feedback. Major decisions from the kickoff, which impacted later work in the project, were:

1. Although the full-scale system is envisioned to be statewide, the majority of interest by users is on a county level. Larimer County was identified as a suitable candidate for the prototype, when statewide data were not readily available.
2. Major categories of use include flood hazard mapping, flood outlook, and general data clearinghouse.

3. Approximately 75% of required data were estimated to be available internally (CWCB) with 25% being available from external sources.
4. The CDSS Map Viewer look and feel is to be maintained.
5. CDSS data layers should be shared with the CDSS Map Viewer, where possible.
6. The prototype can initially be evaluated from RTi but the final installation will be on a DWR server, similar to the CDSS Map Viewer.

2.2 Data Inventory

The initial data inventory was developed at the kickoff meeting and in subsequent communications with the State. The primary activity was to identify data types, sources, formats, extents, links to non-spatial data, and relevance to the project. This inventory evolved through the course of the project with data layers being added as appropriate, and comments entered into the inventory table regarding data availability, status of data collection, processing tasks conducted on data, and other relevant information. This inventory (see Appendix A) forms the main record of Flood DSS Prototype data, data collection, and data processing tasks. It quickly became obvious that a limited amount of spatial data were available from the CWCB and that identifying additional sources for spatial data would need to occur.

2.3 Data Collection

The data inventory (Appendix A) was utilized to perform data collection activities.

Data that were collected were subsequently reviewed for suitability and were processed as appropriate for inclusion in the prototype (see *Section 2.4 Data Processing*).

2.3.1 Statewide Data

The majority of statewide spatial data were available from the CWCB, or were created by the CWCB or RTi by linking tabular data to spatial data using a join on common attributes such as county or city name (e.g. National Flood Insurance Program [NFIP] City and NFIP County layers and the Flood History layer).

2.3.2 Larimer County and the City of Fort Collins

Other major sources of spatial data were the City of Fort Collins and Larimer County. Both agencies were helpful with provision of data, yet provided different experiences. Collection of data from the County involved the arrangement of a face-to-face meeting to discuss the DSS, and to request appropriate data for input into the system. Larimer County attempts to recover costs of their investment in GIS data using a subscription service; however, this was waived following the meeting. The process of receiving this waiver and access to the data involved Carolyn Fritz (CWCB) calling the data salesperson at Larimer County to inform the salesperson the data were for a State project. The CWCB was then given a username and password that allowed RTi to download all of the Larimer County GIS data. On request, the County later provided metadata for various data layers.

Collection of data from the City of Fort Collins involved face-to-face meetings with the GIS Manager and a City Floodplain Administrator to clarify what useful data existed. A Fort Collins GIS Analyst then provided all requested data on CD. Contacts for both agencies are included in ***Table A.1***.

2.3.3 Digitizing Data

Digitizing data can be a laborious and expensive effort; therefore, it was agreed at the kickoff meeting that digitizing should be limited for the prototype. The only digitizing necessary was to generate an example of the Flood Threat Bulletin and the 7-15 Day Flood warning produced by HDR for CWCB.

2.4 Data Processing

Data processing occurred after data collection for some layers in order to create data suitable for the prototype.

2.4.1 Data Quality Assessment and Utility of Data for Web-Serving

All data received for input into the DSS underwent an initial evaluation for data quality assessment and utility for web serving. This task primarily involved organizing the data in an ArcGIS project (mxd) and visualizing the information with various base layers. Once the line work and attributes were validated, the data were subjected to various pre-processing activities in order to prepare the information for serving in the DSS.

2.4.2 Data Pre-Processing

This task primarily involved converting data to a format usable by a map service, projecting data to the project coordinate system, symbolizing data, and organizing data into appropriate data groups. Details of this process for each data layer are contained in ***Table A.1***.

2.5 Adapt Existing CDSS Map Viewer for Main Interface

Existing CDSS Map Viewer files were utilized to create a website for disseminating the flood information. The look and feel and features of the existing site were maintained, and the map layers configured using a similar grouping system used in CDSS Map Viewer. Data layer symbols are consistent with the CDSS Map Viewer, and utilize standard symbols where possible. Feedback from the State on data layer grouping and symbols facilitated this process.

2.6 Implement Access to Non-Spatial Data

Non-spatial data refer to available, useful information that needed to be linked to the DSS, specifically Content Manager documents. In this task, the existing Content Manager system was evaluated to determine how to utilize scanned documents.

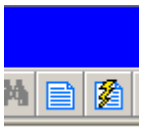
2.7 Implement Map Links to Non-Spatial Data

Non-spatial data refers to available, useful information that needed to be linked to the DSS, specifically Content Manager documents.

2.7.1 Content Manager

Links to Content Manager have been made available using a variety of combinations of user input. In the Flood DSS Prototype the primary access route is via hotlink information that has been embedded in spatial data attributes. This allows the user to access “all documents” or “documents by type” in Content Manager. This is achieved by making either the ‘Counties’, ‘Cities’, or ‘Rivers’ layers active in the Base data group, and selecting a County, City, or River using the document hotlinks on the DSS toolbar (*Figure 1*).

Toolbar



Document Tools

Figure 1. Content Manager Document Selection Tools – 'documents by type' (left: page with no lightning) and 'all documents' (right: page with lightning)

2.7.2 Access to Web Sites

Links to two useful Flood DSS web sites were provided in the Flood DSS prototype toolbar. The first is labeled 'Flood Outlook' and takes the user to CWCB's Flood Threat Information Services Product Menu (http://www.hdrweather.com/cwcb/cwcbinformation.htm). The second, labeled 'National Water Monitor' (http://watermonitor.gov/), takes the user to maps of flood and high water conditions, as well as other useful data.

2.8 Prototype Installation

The prototype was initially developed at RTi and made visible for review by CWCB staff using a web browser. For the final installation, RTi has provided the State with all data layers and available metadata, secondary data files implemented for the prototype, map viewer site files, and configuration documentation.

2.9 Prototype Evaluation

Prototype evaluation was possible soon after the project started by using a development web site at RTi. Several calls with CWCB staff occurred to discuss the prototype Flood DSS features. A final review meeting occurred at the CWCB on June 16. RTi subsequently produced this memorandum and also a PowerPoint slideshow that summarizes the Flood DSS features.

2.10 Project Management

Project management consisted of regular phone calls and email between RTi and CWCB staff to coordinate prototype development efforts, and preparation of project invoices.

3. Recommendations for Full-scale Flood DSS

The overall objectives of the prototype Flood DSS have been met, including providing an organized web site to serve as a clearinghouse for flood-related spatial data, demonstrating the link between spatial data and non-spatial data (scanned documents), and providing a tool that can be evaluated by CWCB staff.

Data and software components for the prototype Flood DSS utilize CDSS efforts, in particular the following:

- Base spatial data layers are shared between the CDSS and Flood DSS Map Viewers.
- The Flood DSS Map Viewer configuration and scripting are compatible with the CDSS Map Viewer, allowing maintenance to occur similarly on both.

- Overall coordination of the Flood DSS effort has been consistent with CDSS, involving RTi and CWCB staff that could efficiently contribute CDSS capabilities to the project.

The following sections provide recommendations for implementing a full-scale Flood DSS. A summary of level of effort estimates to implement a full-scale Flood DSS is provided in *Section 3.4*.

3.1 User Needs Assessment

To date, the focus of the Flood DSS has been on development of a data clearing house for State personnel and possibly other stakeholders. If the intention of the State is for the full Flood DSS to support stakeholder decision support as well as internal State needs, it is recommended that some form of user needs assessment be conducted. This should enable stakeholders to provide input on the types of decisions they need to make regarding flood hazard and other flood related issues, and the data and data formats that could support these. Such a user needs assessment might begin with a demonstration of the Flood DSS prototype at the Colorado Association of Stormwater and Floodplain Managers (CASFM) Annual Conference and/or other appropriate venues. Based on identified needs, requirements for the system can be defined and prioritized (e.g., "need" versus "want") in order to guide system development.

To facilitate additional needs assessment, the existing prototype Flood DSS should be configured to allow viewing by appropriate persons. This will require implementing some level of security to protect sensitive data, or removing such data from public viewing.

3.2 Data Recommendations

The foundation of the DSS has been developed for the prototype; consequently, the greatest costs in developing the full Flood DSS will occur for the collection, processing, and integration of data for input into the DSS. Based on prototype Flood DSS data collection efforts, it is clear that costs for complete development of the full Flood DSS will range depending on how ambitious the initial data integration will be. The recommended baseline – incorporation of FIRM/DFIRM (digital FIRM) data for each County – will require a relatively straightforward, and hence relatively inexpensive process of collecting standardized data sets that create few problems with symbolizing and other processing tasks prior to integration. Integration of more disparate data types by County (e.g. "Geologic-Hazard") is likely to vary county-by-county, and thus require more effort to locate, interpret, and process to format the data into something useful for the DSS. Collectively, data in the "Flood-Outlook" data group represents a relatively high data integration effort, primarily because development of a system(s) will be required in order to transfer, receive, process and integrate data on a regular basis. However, once completed, these capabilities will result in statewide data availability.

3.2.1 Data Collection

The experience of obtaining prototype data from Larimer County and the City of Fort Collins highlights a number of issues that are useful in planning for development of the full Flood DSS. Firstly, while face-to-face meetings may not always be necessary to obtain data, they often speed the process. These meetings also create opportunities to interact with people such as Susan Hayes (City of Fort Collins Certified Floodplain Manager), who uncovered the 1997 historical flood data. Secondly, not all data will be freely available, at least not without explaining its application – a conversation that can take time. Thirdly, these two agencies are relatively data rich and well resourced with available and well-trained GIS analysts who can smooth the process of identifying and supplying appropriate data and metadata. It is likely that other county and city GIS departments will not be able to handle data requests as effectively, and in some instances may have little or no quality data. Data collection for the full DSS is unlikely to be a trivial task, may require substantial contact and possibly travel time, and may not yield consistent results across the state.

3.2.2 Data Availability and Quality

FEMA FIRM maps are largely available, while DFIRM mapping in Colorado is in progress under the coordination of the CWCB. FIRM and DFIRM maps have clear and wide utility in flood decision support, and should thus form the core of flood information for the DSS. Digital FIRM maps should be used where DFIRM products are not yet available, thus if FIRM maps have not yet been scanned or digitized for use within a GIS then the local agency might be given assistance to do this via the full Flood DSS implementation. This would be most important if a proposed DFIRM is far from completion. In general, it is expected that the State's relationship with Certified Floodplain Managers (CFMs) across Colorado should greatly assist with the process of collecting and integrating FIRM and DFIRM data into the DSS. CFMs exist in many state and city agencies, and typically have understanding of FIRM-DFIRM data and experience using it in a GIS format. Some discussion may be warranted regarding the inclusion of both FIRM and DFIRM information in the DSS.

Other data layers typically available at the county scale, such as "Geologic Hazards" (6b in ***Table A.1***), are far less likely to be of consistent content and quality and may require considerable interpretation and processing to be of value in the DSS. Data layers describing aspects of historical floods in detail such as "Damage Zone Buffer" (3d in ***Table A.1***) are likely to be less common. Disadvantages to including these ad-hoc data are that they will be inconsistent in structure and quality from region to region, and may also be contentious – the Fort Collins data identify flood damage zones (and individual properties) outside of FEMA delineated floodways. Advantages are that they provide an example of the utility of this type of information that may encourage others to collect spatial data in future floods, and may lead to guidelines and standardization of the data produced in this process, enhancing its utility.

Data at the statewide scale should generally provide fewer problems in terms of availability and consistent content and quality. State-maintained data such as "DWR Dams" (5a in ***Table A.1***) will only require general maintenance to update for new dams over time, and to update attributes such as hazard status.

Incorporating data that require more regular update, specifically layers in the "Flood Outlook" data group (***Table A.1***), will require development of a process to receive, process, and integrate this information at the appropriate time intervals (see *Section 3.3.3* below). In the future, it may be possible to utilize web services to retrieve data from other sites, although such services have limited availability at this time.

3.2.3 Digitizing data

Digitizing was kept to a minimum for the Flood DSS prototype. However, it is likely that for the full DSS, digitizing FIRMs may be necessary. Counties and cities may have in some cases digitized their own FIRM maps (e.g. City of Fort Collins), although this may be less likely in more rural areas. DFIRMs will of course replace FIRMs, but in several locations these may not be completed for some time.

3.2.4 Background Data

National Agriculture Imagery Program (NAIP) color aerial photographs are available for the entire state. These data have a one-meter ground sample distance (GSD) with a horizontal accuracy that matches within five meters of a reference orthoimage. These image data are recommended for use in the full Flood DSS.

3.2.5 Develop Data Standards for Coordination Between Agencies

The focus of several important data layers is county or municipality. However, counties and municipalities have varying levels of resources to apply to flood-related spatial data. If the Flood DSS is to serve as a clearinghouse for flood-related data, it will be important to develop standards for data (format, attributes, metadata, etc.), and procedures to process and exchange the data. For example, well-

funded agencies should ideally make their data available in a standard format, for inclusion in the Flood DSS. Or, at a minimum, some level of data consistency should occur, to allow the Flood DSS to direct users to a county or municipal web site. For counties and municipalities without sufficient resources, the Flood DSS standards should be defined and applied consistently, to provide users with consistent data across political boundaries. Regardless of approach, effort to define standards and procedures should occur with the Flood DSS effort. The initial effort may be to coordinate standards development, perhaps initially as part of data inventory efforts, with follow-up via appropriate meetings or correspondence with agencies such as the CASFM and the State GIS Coordinator. An attainable goal may be to use the Flood DSS effort to standardize metadata and data processes, which will then allow for more rigorous inter-agency standards to be developed in future years.

3.3 Software/System Recommendations for Full-Scale Flood DSS

The following recommendations are related to the full Flood DSS software/system, involving additional software development and/or system integration. Additional evaluation performed below should consider the results of the User Needs Assessment described in *Section 3.1*.

3.3.1 Evaluate Alternative Technologies for Flood DSS

The Flood DSS prototype utilizes ESRI's ArcIMS software, which is mature but also has known limitations. ESRI also phases out older products over time as new products are released. An evaluation of user needs, CWCB IT plans, and ESRI support may identify cases where existing ArcIMS technology cannot meet requirements. Consequently, an evaluation of alternative technologies may be appropriate, before a full-scale Flood DSS is implemented.

ESRI's next generation of map server software is the Server product. ArcServer allows additional customization of features and allows software modules to be reused among various ESRI products. For example, a tool to process SNODAS data could be utilized similarly in desktop GIS and in the ArcServer web application. Based on recent information from ESRI, it is likely that ESRI will be encouraging existing ArcIMS users to convert to ArcServer in the near future.

3.3.2 Content Manager Replacement

The CWCB currently uses IBM's Content Manager software to manage and view scanned documents. However, Content Manager is being replaced by a new product, which has different functionality. Consequently, the features implemented for the prototype Flood DSS will need to be upgraded to integrate with the new document system. It is recommended that the requirements of the Flood DSS be considered when implementing the new system. The effort to utilize the new system cannot be fully estimated at this time until more is known about the CWCB's implementation of this new system.

3.3.3 Automate Flood Outlook, SNODAS, and SNOTEL Data Processing and Management

The prototype Flood DSS includes snapshots of the HDR flood outlook products, SNODAS gridded data (Snow Water Equivalent), and SNOTEL site data. Providing a statewide clearinghouse for these data to be provided in a timely fashion will require enhancement to automatically download, process, and manage data from the original sources, and provide as layers in the Flood DSS Map Viewer. An evaluation of user needs should occur to determine the number of days of products to display, and the data types and statistics utilized in displays (e.g., whether a layer for "change in SWE" is made available). Some level of quality control is likely also needed to verify the reliability of data products. However, since the original providers of the data are presumably performing review and validation before publishing the data, a totally automated solution may be appropriate. The procedures to process the data should be documented to allow for additional enhancements and maintenance of the system.

3.3.4 Implement Link to Real-time CDSS Flow Data

The prototype Flood DSS included a snapshot of current flow conditions, using real-time and historical data from HydroBase. The full-scale Flood DSS should include features to automatically process current (or suitably recent) flow data to create current data products (e.g., update products every hour). Procedures to develop the products should be documented to allow for additional enhancements and maintenance of the system. For example, a similar product is produced by the USGS (United States Geological Survey), and the USGS web site includes a description of the procedure. Links to real-time streamflow data (e.g., the State's web site) should be enabled to allow users to evaluate changing conditions.

3.3.5 Implement Link to Satellite Monitoring System Alert System

The prototype Flood DSS did not include a link to the Satellite Monitoring System Alert System. This system has been developed by DWR to analyze flow data for change in rate and threshold conditions, with a capability to notify users when critical conditions occur. Experience with this system as part of the Instream Flow DSS and other similar systems has shown that a map-based interface that indicates current alarm conditions can be an effective tool to summarize system conditions. A basic level of implementation involves querying the Alert System database and displaying suitable symbols to indicate alarm conditions. A more advanced implementation may involve coordinating system enhancements with DWR or developing new capabilities within the Flood DSS (e.g., to issue alarms only when flow rate of change and flow are both above critical levels). Alert features may only be suitable for internal use.

3.3.6 Add Links to Additional Web Sites

The prototype Flood DSS implemented limited links to external web sites. Feedback from the CWCB was that this capability was not critical. However, further evaluation of user needs may indicate that useful external data should be made available from the Flood DSS web site. Links to additional sites should therefore be evaluated during implementation of the full-scale Flood DSS.

3.3.7 Implement Internal and Public Versions of Flood DSS Web Site

The prototype Flood DSS includes some sensitive information that may not be suitable for a public web site. The full-scale Flood DSS may include additional sensitive information (e.g., current Alert System warnings). The needs assessment should identify if both internal and external versions of the site are needed and an appropriate system design should be developed. The eventual solution may utilize two web sites, or a single site that requires a login for extended features.

3.4 Level of Effort Estimates for Full-scale Flood DSS Implementation

The previous sections provided background for significant tasks recommended to implement a full-scale Flood DSS. The following tables summarize estimates for the level of effort necessary for specific activities. These estimates have been made based on experience gained in the prototype Flood DSS and other DSS projects. However, the actual effort that is required will vary, based on additional information that is gained during full implementation. It is recommended that the needs analysis be performed first (see Table 2, item 1) in order to fully understand requirements for the full system. This analysis may indicate that some data layers are more important than others, or that certain areas within the state are more critical. The analysis may also indicate that additional software/system features are required. Consequently, resources can be devoted to high-priority tasks that have a large return on investment.

Table 1 – Level of Effort Estimates for Flood DSS Data Collection/Processing Tasks

#	TASK/ DATA TYPE	INVENTORY/ COLLECTION	PROCESSING	TOTAL ESTIMATED EFFORT (STATEWIDE)	COMMENTS
1	NFIP Participation Status	2 days	2 days	4 days	Effort should be minimal – update of existing data with CWCB assistance. Task may be required to be repeated every 6 months.
2 a	DFIRM maps	4-6 hrs/county	6-8 hrs/county	80-112 days	DFIRM availability may vary widely by county, depending on progress. Effort required for collecting data for both 2a and 2b will vary. Estimates reflect rapid collection for most counties (phone calls and ftp transfers) with some travel time for others. The national FEMA web site may be a resource; however, the CWCB likely has more timely access to data.
2 b	FIRM maps	4-6 hrs/county	6-8 hrs/county	80-112 days	FIRM panels may require digitizing for GIS. Scanned documents may be sufficient.
3	Historical Flood data	6 hrs/county	11 hrs/county	136 days	Will require queries into existence of data – electronic data unlikely to exist for more than 10% counties.
4	Weather Modification	6 days/season	6 days/season	12 days per season	DSS Contractor will need to work with CWCB to obtain information. More regular updates may be required through each season as use of this technology becomes more prevalent.
5	Flood Control (dams, levees)	3-4 hrs/county	5-6 hrs/county	64-80 days	Most of this effort will be invested locating and extracting these data from other sources where they exist. Two different dams data layers exist in the Prototype DSS, and will require some updates as appropriate.
6	Multi-hazard	6-8 hrs/county	8-10 hrs/county	112-144 days	A considerable part of this effort will be invested in locating and integrating multi-hazards data based on a common methodology and cartographic representation.

#	TASK/ DATA TYPE	INVENTORY/ COLLECTION	PROCESSING	TOTAL ESTIMATED EFFORT (STATEWIDE)	COMMENTS
7	SNODAS, Flood Outlook, SNOTEL, Real-time flow	1 day/state	See Table 2.	See Table 2	See Table 2. Inventory is needed to confirm current availability of data from various sources.
8	Verify scanned document link.	4 hrs/ county		32 days	Need to confirm links for community and other data in spatial data and scanned document system (e.g., "Fort Collins" vs. "Ft Collins"). This may be a CWCB task.
9	CRS	2 days	2 days	4 days	Effort should be minimal – update of existing data with CWCB assistance. Task may be required to be repeated every 6 months.
10	Other Data	4-8 hrs/county	6-10 hrs/county	80-144 days	User needs assessment may identify additional categories and sources of previously unidentified data that should be incorporated into the DSS.

- * *Note*: Estimates are for collection of each data type individually. In most cases, several data types will be held in one or both of the County Seat and primary municipality offices of the 64 counties in Colorado. Collection of all required data simultaneously will reduce data collection costs considerably.

Table 2 – Flood DSS Software/System Tasks Level of Effort Estimates

#	TASK/FEATURE	DESCRIPTION	ESTIMATED EFFORT (STATEWIDE SYSTEM)
1	Evaluate full-scale Flood DSS needs; develop requirements.	Evaluate Flood DSS user needs through review of prototype Flood DSS, interaction with the CWCB, Flood Task Force, etc. Develop a requirements document that describes needed functionality and rationale for including the functionality. In particular, document whether the prototype must be enhanced to include additional functionality. The existing prototype must be updated to allow public viewing of the site without making sensitive data available.	20 to 30 days

#	TASK/FEATURE	DESCRIPTION	ESTIMATED EFFORT (STATEWIDE SYSTEM)
2	Evaluate alternative technologies.	Based on requirements, evaluate suitable technologies for the full-scale Flood DSS, including ArcServer. This evaluation should occur in conjunction with other CDSS technology upgrades and focus on meeting system requirements. The evaluation should result in one or more workable prototype, with limited functionality. Features deemed high-risk for development should be evaluated first. A design document should be produced if an alternative technology is chosen. Omit this task if the existing ArcIMS implementation meets user needs (however, ESRI support for ArcIMS will decrease as ArcServer support increases).	30 days+, depending on the number of technologies that are evaluated
3	Update to new document management system.	Convert/update existing Flood DSS Viewer software to use new document management system, to replace Content Manager features.	14 to 30 days
4	Automate Flood Outlook Data Management/ Processing	Implement data management and automated updates of Flood Outlook products from HDR (assuming that the CWCB will fund such products in 2007). Data management will include determining a standard format and naming convention for data products, and procedures describing data processing. QC of products will need to be considered.	14 to 30 days
5	Update SNODAS Data Management/ Processing	Implement data management and automated updates of SNODAS products. Data management will include determining a standard format and naming convention for data products, and procedures describing data processing. QC of products will need to be considered.	14 to 30 days
6	Update SNOTEL Data Management/Processing	Implement data management and automated updates of SNOTEL products. Data management will include determining a standard format and naming convention for data products, and procedures describing data processing. QC of products will need to be considered.	14 to 30 days
7	Enable Link to Real-time CDSS Flow Data	Implement tools to query and display current streamflow conditions (e.g., as percent of historical average). This layer will provide a current indication of flood threat based on streamflow. Flow graphs will be accessible using the hyperlinks to DWR's web site.	14 to 30 days
8	Enable Link to Satellite Monitoring System Alert System	In addition to displaying current streamflow conditions, locations where flows are exceeding pre-defined thresholds could be indicated on the map. Flow graphs will be accessible using the hyperlinks to DWR's web site.	14 to 30 days
9	Add Links to Additional Web Sites	Agencies like NOAA continue to update their web sites to provide useful data products. The full-scale Flood DSS should at a minimum consider adding links to other useful sites (e.g., federal agencies or perhaps county sites devoted to flood information). Some agencies may also offer web or map services to allow data to be utilized in core features of the Flood DSS (e.g., streamflow forecast data could be utilized in addition to observations).	3 days minimum, possibly much more if using external web or map services

#	TASK/FEATURE	DESCRIPTION	ESTIMATED EFFORT (STATEWIDE SYSTEM)
10	Implement protected and public versions of the Flood DSS web site.	Some Flood DSS data layers should not be viewable to the public. The needs assessment will identify layers and features that should only be available to CWCB staff. Implementation of a suitable solution may involve duplicating the site (with minor layer differences) or developing a single site with login capabilities to turn on all data/features. Note that this task is for the full-scale Flood DSS, whereas Task 1 is for the prototype Flood DSS.	2+ days Depends on approach
11	Evaluate Overall Data Presentation	The prototype Flood DSS included a few statewide layers but focused on Larimer County. The full-scale Flood DSS will present county-based data for the entire state. An evaluation of organization within the ArcIMS interface must occur to determine whether layers should be listed as statewide or by county. The results of this evaluation should be considered in data processing tasks.	5 days
12	Flood DSS Documentation	Documentation for the full-scale Flood DSS should be created for users and developers.	14 days
13	Flood DSS Training Materials	Training materials for the full-scale Flood DSS should be created to allow self-paced training by web site users.	7 days
14	Flood DSS Training Sessions	On-site training using the training materials and Flood DSS web site.	1 day each location
15	Flood DSS Support	Troubleshooting, support, and minor enhancements of the system.	At an acceptable level (e.g., 2 days/month).

Appendix A – Inventory of Data Layers Used in the Flood DSS Prototype

Table A.1 below lists data layers used in the Flood DSS Prototype, in the order listed in the Flood DSS Viewer.

A.1 Data Inventory Table Organization

Table A.1 is grouped into categories to help users find information. The columns "Data Group" (1) and "Data Layer name and Description" (2) are used to organize and identify data layers. The "Source/Contact" (3) and "Metadata" (4) columns were used to collect data, identify its source agency and key personnel, and to identify its attributes. The "Spatial Data Format" (5) column was used to document the spatial data format, while the "Extent" column (6) indicates whether a single statewide layer is available or can be created, or whether individual layers from Larimer County, City of Fort Collins, or other locations are used. "Content Manager and Other Non-spatial Information" (7) indicates whether relevant scanned documents are available in Content Manager and are related to spatial data via hot-links. Column (8), "Key Pre-Integration Processing Tasks" describes processing required to integrate data into the Flood DSS, and provides useful information on the level of work that may typically be required for such a dataset to be integrated into a full system. The final column (9) provides comments to clarify the Flood DSS database development process and offer suggestions to assist with full Flood DSS development.

A.2 Organization and Relevance of Data Groups

Data layers were organized and grouped into logical thematic categories to help users find information. Groups identify major themes such as "Flood Maps", which in this example contains all existing, automated and contemporary FIRM, DFIRM and City floodplain maps (i.e. County and Community scale). Historical flood map data are held under a separate data group, "Historical Floods", and contains both local information (Fort Collins City flood extent and damage maps for the 1997 flood) as well as statewide data (an inventory of major floods in Colorado).

At the bottom of ***Table A.1***, several statewide data layers are listed. These were developed previously by RTi for the CDSS Map Viewer, and are selected here for their utility in Flood Decision Support. Although it is valuable for users to have access to as much data as possible, offering too much information can result in confusing interfaces that are difficult to use, therefore the layers in these base, background and other data groups have been selected with guidance from the State. Details on these layers have not been included in ***Table A.1*** as CWCB and DWR staff is already familiar with these. One new layer included in the "Background" data group is the Larimer Aerial Photo. This image is National Agriculture Imagery Program (NAIP) data, available at 1m-resolution for the entire state.

A.3 Metadata

Metadata is always desirable, but is expensive to develop, especially if this is done retroactively. For the Flood DSS prototype, much of the information provided by various agencies had little or no metadata, and where it existed often came in hardcopy format. In order to focus on tasks more important to prototype evaluation, only basic metadata has been created for most layers. The full scale Flood DSS should include metadata for all layers.

Table A.1 – Flood DSS Prototype Data Inventory

#	Data Group (1)	Data Layer Name and Description (italics) (2)	Source / Contact (3)	Metadata Available (4)	Spatial Data Format (5)	Extent (6)	*Content Manager (CM)* and other aspatial information (7)	Key Pre-Integration Processing Tasks (8)	Comments (9)
1	National Flood Insurance Program **NFIP Community Status**								
	1(a)	Community Participation Status - **City**	http://bsa.nfipstat.com/comm_status/STATECO.HTM	Data Dictionary for Community Status Book in Appendix and at: http://bsa.nfipstat.com/comm_status/DataDict.pdf	Non-spatial format: converted from table to point shapefile via JOIN (see 8)	Communities (Cities) and Counties for entire State	N/A	Tabular information from the table at Source (3) was JOINED with a Colorado State CITIES shapefile, using the City name as the common attribute. The prefix "City of….." had to be removed prior the JOIN. Attribute information from the data dictionary (4) was included in the JOIN. The resulting point shapefile was projected to NAD_1983_UTM_Zone_13 N. Shapefile entered into project mxd and symbolized.	• Providing it has City or County attributes, other available tabular NFIP information may be incorporated into the full Flood DSS
	1(b)	Community Participation Status - **County**	As above	As above	N/A		N/A	As above, with the prefix "County of….." having to be removed prior to the JOIN.	

#	Data Group (1)	Data Layer Name and Description (italics) (2)	Source / Contact (3)	Metadata Available (4)	Spatial Data Format (5)	Extent (6)	*Content Manager (CM)* and other aspatial information (7)	Key Pre-Integration Processing Tasks (8)	Comments (9)
2	**Flood Maps** (Larimer County)								
	2(a)	**DFIRM Preliminary lines**	Susan Hayes, P.E., CFM Floodplain Administrator City of Fort Collins Ph: (970) 416-2233 email: shayes@fcgov.com	Preliminary metadata provided with files	Lines and Polygons (E00-coverage format)	Larimer County	N/A - DFIRM is preliminary so supporting data	DFIRM lines and polygons projected to NAD_1983_UTM_Zone_13 N. Data entered into project mxd and symbolized.	• City of Fort Collins specified this data: NOT EFFECTIVE FEMA MAPPING ("Use at own risk"). • Several other DFIRM data were provided and incorporated into Flood DSS prototype for examples, including model and base flood elevation cross-sections, and DFIRM structures. These were removed at State's request following 06/16/06 review meeting at CWCB. • Once integrated into CWCB's Content Manager, supporting aspatial (finalized) DFIRM documents can be made readily available using hotlink buttons in the Flood DSS. • DFIRM data created by PBS&J (GIS Coordinator - Josh Price) contact: 303-221-7275 Ext. 7052, email: jpprice@pbsj.com. • Preliminary DFIRM data also supplied by CWCB in shapefile format.
	2(b)	**DFIRM LOMR**	As above	Preliminary metadata and LOMR reports provided with files	Lines and Polygons (E00-coverage format)	Larimer County	N/A	As above	
	2(c)	**Larimer County Existing FIRM Zones**	Jeff Stark GIS Section (IT Division) Larimer County Phone: (970) 498-5024 email: starkjd@larimer.org	Basic metadata describing FIRM zones.	Polygons	Larimer County	Queries on Content Manager allow for simultaneous display of FEMA maps and documents, including LOMR materials.	FIRM polygons projected to NAD_1983_UTM_Zone_13 N. Data entered into project mxd and symbolized.	• FIRM zones digitized from original FEMA Flood hazard map panels. • In many cases, this data will be best available for Counties and communities until DFIRM process is complete. • It should be anticipated that several Counties have not automated these data, and that until DFIRM products become available no flood hazard maps may exist in some locations.
	2(d)	**Fort Collins City Floodplain**	Susan Hayes, P.E., CFM Floodplain Administrator City of Fort Collins Ph: (970) 416-2233 email: shayes@fcgov.com	N/A	polyline; polygon; point	City of Fort Collins	N/A	DFIRM lines and polygons projected to NAD_1983_UTM_Zone_13 N. Data entered into project mxd and symbolized.	• City floodplain map that reflects both FEMA hazard mapping and recent flooding experience. • Map layers indicate flood hazard (and depth) caused by subtle topographic influence and conveyance zones (roads etc.) as well as FEMA floodway. • May appear to 'conflict' with existing FIRM and/or DFIRM in places, raising an important discussion point for state: should all available flood map data be incorporated in DSS or could this be confusing?

#	Data Group (1)	Data Layer Name and Description (italics) (2)	Source / Contact (3)	Metadata Available (4)	Spatial Data Format (5)	Extent (6)	*Content Manager (CM)* and other aspatial information (7)	Key Pre-Integration Processing Tasks (8)	Comments (9)
3	**Historical Floods**								
	3(a)	**Flood History**	CWCB	N/A	Point shapefile	statewide	N/A	To enable demonstration of the utility of this information, CWCB generated a point file with limited attribute data indicating location and date of several major historical floods statewide.	• Creation of this data layer by CWCB creates the opportunity for augmenting and regular update of this information with attribute and other data that will assist flood managers better appreciate the spatial patterns and severity of flood events over time.
	3(b)	**Colorado State University**	Susan Hayes, P.E., CFM Floodplain	N/A	Point shapefile	City of Fort Collins	N/A	This data was generated primarily by post-flood GPS survey by City and other flood hazard emergency personnel following the 1997 Fort Collins Spring Creek flood (GIS manager at the time was Claudia Haack-Benedict). Information was provided to RTi by the City in Arc export (.E00) and coverage format. Data was converted to shapefile, projected to NAD_1983_UTM _Zone_13N, and an ArcGIS mxd project created to examine the data. Representative layers were selected for integration into the Flood DSS prototype.	• Spatial data of historical post-flood conditions at the level of detail described here is probably uncommon for most events, but could be very useful for local future flood mitigation efforts, including revising DFIRMs, localized flood mitigation strategies, and insurance activities. • Display of this innovative post-flood data in the DSS might encourage similar activities in other locations post-flood leading to enhanced coordination and recovery efforts. • Processes to achieve standardization of post flood mapping might be adopted by floodplain managers to both: (i) facilitate their adoption for disaster coordination and post-flood damage assessment and recovery planning, and (ii) enable better comparison of post-flood event data.
	3(c)	**City Building Damage**	Administrator City of Fort Collins Ph: (970) 416-2233 email: shayes@fcgov.com	N/A	Point shapefile	City of Fort Collins	N/A		
	3(d)	**Damage Zone Buffer**		N/A	Polygons	City of Fort Collins	N/A		
4	**Weather Modification**								
	4(a)	**Central Rocky Mountain Generator Sites**	CWCB	N/A	Point shapefile	Rocky mountains	N/A	Information was supplied as incomplete and somewhat disorganized data CD originally provided to CWCB by HDR. Data	• HDR (John Henz) was contacted regarding availability of this data. Information was not forthcoming so the best available data (held by CWCB) was used for example.

#	Data Group (1)	Data Layer Name and Description (italics) (2)	Source / Contact (3)	Metadata Available (4)	Spatial Data Format (5)	Extent (6)	*Content Manager (CM)* and other aspatial information (7)	Key Pre-Integration Processing Tasks (8)	Comments (9)
	4(b)	**Central Rocky Mountain Target Areas**	CWCB	N/A	Polygons	Rocky mountains	N/A	was interrogated, organized as best as possible, and representative data extracted for inclusion in Flood DSS. This information was projected to NAD_1983_UTM _Zone_13N and given symbols.	
5	**Flood Control**								
	5(a)	**DWR Dams**	DWR	Yes	Points	Statewide	N/A	DWR Dams projected to NAD_1983_UTM_Zone_13 N. Data entered into project mxd and symbolized.	• DWR approved CWCB to supply RTi with this data. • Security issue raised by the sensitivity of this data highlights discussion point for State - Will certain layers of full Flood DSS need to be excluded or remain internal to CWCB/DWR if DSS is made publicly available?
	5(b)	**Dams**	City of Fort Collins Katy Carpenter, GISP GIS Programmer/Analyst Phone: (970) 416-2048	N/A	Lines	Larimer County	N/A	Dams projected to NAD_1983_UTM_Zone_13 N. Data entered into project mxd and symbolized.	• Dams from 'DFIRM Structures' layer was originally integrated to provide example if the DWR dams data was not cleared for inclusion by DWR. • Data was left in the prototype to provide an example of more spatially detailed example (line traces the extent of the dam structure rather than a point location), and attribute data does not identify the security/vulnerability of the dam.
	5(c)	**Levees**	City of Fort Collins	N/A	Lines	City of Fort Collins	N/A		• Larimer County does not hold a flood control/levee database. • With the intention of incorporating an example from another County, RTi contacted Pueblo City (Dennis Moroney) - they have yet to map their levee system of ~2miles, and won't have this data for another year. • This and other calls indicated there will likely be a paucity of levee information statewide.

#	Data Group (1)	Data Layer Name and Description (italics) (2)	Source / Contact (3)	Metadata Available (4)	Spatial Data Format (5)	Extent (6)	*Content Manager (CM)* and other aspatial information (7)	Key Pre-Integration Processing Tasks (8)	Comments (9)
6	**Multi-hazard**								
	6(a)	**2002 Wildfires**	CWCB	N/A	Polygons	statewide	N/A	Wildfire polygons projected to NAD_1983_UTM_Zone_13 N. Data entered into project mxd and symbolized.	• Regular update of this data layer will provide flood managers with information regarding the potential for potential flood situations to be exacerbated by availability of soil and other material for ready transport and delivery to the channel, leading to damaging debris flow conditions.
	6(b)	**Geologic Hazards**	Larimer County Jeff Stark GIS Section (IT Division) Larimer County Phone: (970) 498-5024 email: starkjd@larimer.org	Yes- detailed hardcopy document describing data attributes, developed by the consultant involved (Robinson Engineering)	Polygons	Larimer County	N/A	Geo-haz polygons projected to NAD_1983_UTM_Zone_13 N. Data entered into project mxd and symbolized.	• Shapefile (called geohaz_lc) includes various geologic hazard themes such as land slide areas, debris fan areas, flash flood channels, and high water table areas. • This type of geologic hazard data may provide managers with a greater understanding of factors potentially exacerbating floods and flood-related damage. • Similar data are likely to be available for other counties in Colorado, but may have different classifications, making comparisons and development of a standard legend difficult.
	6(c)	**Wildfire Hazards**	As above	Yes- detailed hardcopy document describing data attributes, hazard ranking system, and methods.	Polygons	Larimer County	N/A	Wildfire hazard polygons projected to NAD_1983_UTM_Zone_13 N. Data entered into project mxd and symbolized.	• Layer is based on cover type, habitat structure stage, and primary terrain parameters. • This is used to develop a hazard ranking based on fuel characteristics and flammability potential. • Utility for the Flood DSS would likely be limited to mitigation planning. For example identifying areas of future potential post-fire erosion and hence exacerbated flooding effects should a heavy rainfall event occur some time after the fire had occurred. This type of analysis could lead to multi-hazard ranking and mapping, but the data would be of limited use for short term planning.

#	Data Group (1)	Data Layer Name and Description (italics) (2)	Source / Contact (3)	Metadata Available (4)	Spatial Data Format (5)	Extent (6)	*Content Manager (CM)* and other aspatial information (7)	Key Pre-Integration Processing Tasks (8)	Comments (9)
7	**Flood Outlook**								
	7(a)	**Flow Conditions 2006-06-14**	RTi		Points	statewide	N/A		
	7(b)	**SNOTEL Sites 2006-05-29**	Carolyn has point file of SNOTEL sites. SWE data for the points is downloaded from ftp://ftp.wcc.nrcs.usda.gov/data/snow/update/co/wy2006/ and joined to the point layer for display purposes	No. General information available at http://www.wcc.nrcs.usda.gov/snow/about.html.	Points	statewide	N/A		Currently the only layer with dynamic data that is joined to the attribute table rather than being part of the attribute table.
		Flood Threat Bulletin							
		7-15 Day Flood Warning	CWCB-HDR	http://www.hdrweather.com/cwcb/cwcbinformation.htm	Polygons	statewide	N/A	Data was digitized to reflect a recent typical flood outlook map, and projected to NAD_1983_UTM_Zone_13N. Data was entered into project mxd, basic flood outlook data assigned to the attribute 'report', and symbolized.	• HDR (John Henz) was contacted regarding availability of this data. Information was not forthcoming so a mock-up was created. • Integration of reports from the CWCB's Flood Threat Information Services Product Menu (updated daily) into the Flood DSS would likely enhance the outreach of this service. • Also allow for more sophisticated interpretation of the reports by flood managers who will be able to interpret the reports together with other complimentary spatial and other information.
		SWE 2006-05-29, Inch	ftp://sidads.colorado.edu/DATASETS/NOAA/G02158/	No. General information available at http://nsidc.org/data/g02158.html.	grid	statewide	N/A	Get a tar file from the download site, extract the raster from the tar file, and convert the raster format from bil to grid.	

LAYERS FROM CDSS

8 Climate
9 Gages
10 Diversions
11 Base
12 Land use
13 Background

UNAVAILABLE GROUP LAYERS

14 Restoration	Multi-objective stream restoration studies/ projects Watershed restoration studies/ projects	Robert Krehbiel at Matrix Design Group	• Robert Krehbiel at MATRIX design group was contacted regarding the Roaring Fork river watershed restoration project, which Tom Browning believes has GIS data associated. Unfortunately, we did not hear back from Robert on this data. • This type of river channel/watershed restoration information might be particularly useful if it allowed local floodplain managers to better appreciate where previously assessed hydrologic/hydraulic response to flood conditions may have been altered.

(1) The Data Group is used in the ArcIMS application to group categories of data
(2) Data Layer indicates the specific layer on the map interface, which may have attributes and links to non-spatial data
(3) The Source indicates if CWCB or other agency is the data source. Contact information or URL indicate where the provenance of the data
(4) Metadata Available indicates the type of metadata for spatial data (e.g., FGDC metadata) - blank if no metadata
(5) Spatial Data Format indicates whether spatial data are shapefiles, geodatabase, hardcopy maps, etc. - blank if no spatial data
(6) Extent indicates the spatial extent of data. Is one statewide layer available? Are separate county maps available? Local extent? Etc.
(7) Links to Content Manager (CM) or other associated aspatial information data and format
(8) Data processing tasks required prior to integration in the DSS
(9) Additional comments