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Memorandum

To:	Carolyn Fritz, Ray Alvarado, Tom Browning, Chris Sturm (CWCB)
From:	Jay Day, Amy Volckens, Amnon Nevo, Ian Schneider, Nils Babel, Steve Malers (Riverside)
Subject:	Recommendations for Potential Enhancements of the Flood DSS
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The Flood Decision Support System (Flood DSS) is a fully operational system that meets the requirements defined during the Phase 1 project. The system provides a clearinghouse of flood hazard data from local, state, and federal agencies; access to spatial and non-spatial data in one framework; and weather and flood outlook data that are updated on time scales of 15 minutes to one day, keeping users informed on the flooding potential across the State. Riverside anticipates that the CWCB will be able to maintain the Flood DSS with a small amount of support during the 2011 flood season.

This memorandum provides a summary of potential enhancements to the Flood DSS. These items are not requirements; they are provided as suggestions that may enhance the value or reliability of the system.

Operations Support

The Flood DSS became operational in October 2010, making the 2011 flood season the first test of the system's reliability and usefulness in providing flood hazard information to stakeholders. To maximize reliability and usefulness, Riverside recommends the following:

- Identify an ArcGIS Server administrator for the Department of Natural Resources (DNR) server. This would benefit all server applications by providing centralized administrative support, and would minimize the potential for individual applications to negatively impact other applications. If this is not feasible, it may be beneficial for the Flood DSS administrator to take an ArcGIS Server administrator course to provide some basic administration.
- Implement a development machine within the DNR information technology framework. This would allow the Flood DSS administrator to test changes to the system without interfering with the operational site. This could be achieved by using a second server or by virtualization of the existing server. Additional licenses may be required, depending on the configuration of the development machine.
- Provide training to external users. During the user needs assessment, stakeholders agreed that the CWCB should provide training on the Flood DSS, though responses were mixed regarding whether organizations would send personnel to Denver for the training. Users could benefit from self-paced training or training conducted via webinar, which could be recorded once and disseminated to other users or placed on the Flood DSS website.
- Perform periodic reviews to determine whether the Flood DSS is meeting the needs of the Watershed and Flood Protection Section staff, the Flood Task Force, and external stakeholders. Add or remove data and products based on this feedback.

Enhanced Risk Communication

- The Flood DSS has been developed to present statewide flood hazard information. A dashboard application could be added to better highlight flood risks and to help users focus on specific locations

and data types. For example, a dashboard could be configured to list active streamflow alerts for a specific river basin. This effort would be coordinated with functionality already available from the Satellite Monitoring System Alert System (SMSAS) to ensure no effort is duplicated.

- Streamflow conditions currently are symbolized as percent of historical average, consistent with the U.S. Geological Survey (USGS) and Division of Water Resources (DWR). For maximum utility in a flood application, in particular near municipal areas, it may be more meaningful to symbolize the gages by return period (e.g., <2, 2, 5, 10, 50, 100, and >100 year event) and to employ larger symbols for larger return periods. This would require collecting available data (e.g., from the USGS) or analyzing historical streamflow data to compute the flows for each return period and gage.

Enhanced Risk Identification (Rainfall Flooding)

- The Phase 1 project focused on integrating readily available statewide data into the real-time weather and flood outlook group. Valuable information from local networks has not been integrated (e.g., Urban Drainage and Flood Control District; Northern Colorado Water Conservancy District; Colorado Springs; Boulder; Fort Collins; Community Collaborative Rain, Hail, and Snow Network). Quality controlled data may be available from central data sources, such as the Applied Climate Information System (ACIS) or the Meteorological Assimilation Data Ingest System (MADIS). In addition to adding networks, it would be beneficial to incorporate a daily accumulated precipitation product that is available year-round.
- The precipitation data that have been incorporated focus on observed and forecasted precipitation amounts on time scales ranging from one hour to one day. To better identify areas at risk of flash flooding, warning levels could be established to flag areas based on rainfall intensity and/or precipitation accumulation. This may be feasible within the SMSAS.

Enhanced Risk Identification (Snowmelt Flooding)

The Flood DSS includes point snowpack observations, gridded snowpack estimates, and gridded estimates of change in snow water equivalent over 24-hour and 7-day periods. Large, rapid losses in snowpack may indicate an increased risk of snowmelt flooding. However, areas at risk of snowmelt flooding could be better identified using the following enhancements:

- Add data layers for forecasted air temperatures and current soil moisture. Establish criteria based on a combination of snowpack conditions, air temperatures, soil moisture, and streamflows over multiple days to flag areas at increased risk of snowmelt flooding. For example, indices computed from the National Integrated Drought Information System (NIDIS) may be useful for indicating whether snowmelt is likely to runoff (due to wet soil moisture conditions) or infiltrate (due to dry soil moisture conditions).
- Compute current SWE volume and 7-day change in SWE volume for watersheds delineated above locations of interest. Accumulating snowpack estimates over a watershed helps identify specific locations where a large snowpack may cause snowmelt flooding.

Additional Use Cases

- Because the Flood DSS was developed as an internet-based mapping system, the CWCB can access the information from any location. It may be useful to develop a module that allows the CWCB to upload field data and photographs to the system, for example when performing post-flood evaluations.
- The Flood DSS contains some wildfire burn area data to denote areas likely to experience increased runoff volumes and decreased water quality. To support this use case, water quality data and displays

could be integrated into the site, for example from the USGS, the DWR, Denver Water, etc.

- The Flood DSS currently represents high flow conditions at gaged locations. Routing models could be implemented to provide information at locations without streamflow gages or to help determine whether flooding is impacting downstream locations.
- The Flood DSS, in conjunction with Laserfiche, could provide access to floodplain rules and regulations, methodologies (e.g., floodplain mapping), educational materials (e.g., effect of watershed restoration on flood flows), and safety materials (e.g., emergency action plans for dams).
- The Weather Modification component could be enhanced to provide guidance on whether cloud seeding can proceed based on suspension and warning criteria that vary by calendar date.

Historical Flood Information

- The historical flood layers have been developed using a number of references, most of which are stored by CWCB in the Laserfiche system. This work could be augmented (e.g., additional floods, peak flows, photographs, historical documents, inundated areas) by incorporating materials available from other agencies, namely the USGS, the Colorado State University water archives, and the Urban Drainage and Flood Control District.
- Riverside recommends that a simple website based on Google Map technology be developed for the historical flood layers for users interested specifically in this aspect of the system.
- In developing the historical flood layers, several fields of interest were dropped due to a lack of information, but could be added in the future (e.g., local disaster declaration, state disaster declaration, mitigation funding, and mitigation source).

Additional Data

Many more data sources were identified during the Phase 1 project than could be incorporated. Some of the layers that were not included are:

- Multi-hazard data: Supplement this component by adding more comprehensive wildfire burn area data, as well as debris flows, landslides, areas affected by beetle kill, and Wildfire Watershed Protection Plan data.
- Flood mitigation: Incorporate hazard mitigation, pre-disaster mitigation, and flood mitigation project locations.
- Flood flows: Add 100-year flood flows from the digital flood insurance rate maps (DFIRMs), water mark surveys, largest flood of record by stream gage, and peak flows at all stream gages.
- Watershed restoration: Expand this component to include restoration projects funded by agencies other than the CWCB, bankfull stage, habitat, conservation and protective species data, Colorado gap analysis land cover maps from the Division of Wildlife, and Colorado Ownership Management and Protection (COMap) data from the Colorado State University.
- Local data: Incorporate the dataset collected for the Fountain Creek watershed, which was a high quality dataset that was not integrated into the Flood DSS due to the processing effort.

System Features

- Provide access to the existing system on mobile devices.
- Assess stability and reliability of external web services that were incorporated into the system as an efficient means of data integration. The external web services should be monitored for reliability; in

some cases, multiple services are available that provide the same data.

- Provide additional background information for new users (e.g., glossary of terms).
- Develop a tool for users to download data layers.
- Add functionality so users can copy and paste from the attribute table.
- Develop additional simple sites using Google Maps technology to meet specific needs.
- Modify the "zoom out" tool to work with a single-click, rather than the user having to draw a rectangle.

The Phase 1 project has resulted in a fully functional Flood DSS that meets the requirements defined for Phase 1. The recommended enhancements represent work that could improve the maintainability and usefulness of the system. Additional enhancements will likely be identified as the CWCB and external stakeholders gain experience in using the system to obtain flood information that supports their decision-making processes.