IWRSS Interoperability and Data Synchronization:
Initial Operating Capabilities - Conceptual Design Report

Version 1.5

Approved By:

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NOAA			
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REVISION HISTORY				
Revision	**Version**	**Description of Change**	**Changed By**	**Effective Date**
1	1.0	Template		4/2/2015
2	1.1	Template revised for IDS Conceptual Design - content	All	7/29/2015
3	1.2	Numbering revised - content	All	7/30/2015
4	1.3	Draft - numbering changed - content	All	9/28/2015
5	1.4	Final Draft – content	All	10/1/2015
6	1.5	Deliverable for Governance Board	All	11/30/2015

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Table of Contents

1. INTRODUCTION 4
1.1.1. Scope 4
1.1.2. Background 4
1.1.3. References 4
1.2 Assumptions, Constraints and Recommendations 5
1.2.1 Assumptions 5
1.2.2 Constraints 6
1.3 Standards Compliance 6

2. METHODOLOGY 7
2.1. System Design Framework 7
2.2. System Design Alternatives 7
2.3. Risks 8

3. AGENCY ROLES AND RESPONSIBILITIES MATRIX FOR IDS SYSTEMS 8

4. DATA EXCHANGE THEMES 9
4.1. DECODES 9
4.1.1. Data Contents 9
4.1.2. Background 10
4.1.3. Dependencies 10
4.1.4. Design Workflow 11
4.1.5. Current Systems 11
4.1.6. Rough Order of Magnitude Costs 11
4.1.7. Proposed timeline for implementation 12
4.2. Operational Time-Series 12
4.2.1. Data Contents 13
4.2.2. Background 14
4.2.3. Dependencies 14
4.2.4. Design Workflow 15
4.2.5. Current Systems 15
4.2.6. Rough Order of Magnitude Costs 15
4.2.7. Proposed timeline for implementation 15
4.3. Rating Table Synchronization (Extensions and Discrete Measurements) 16
4.3.1. Data Contents 16
4.3.2. Background 16
4.3.3. Dependencies 16
4.3.4. Design Workflow 17
4.3.5. Current Systems 17
4.3.6. Rough Order of Magnitude Costs 17
4.3.7. Proposed timeline for implementation 18
4.4. IWRSS Data Exchange 18
4.4.1. Data Contents 19
4.4.2. Background 19
4.4.3. Dependencies 20
4.4.4. Design Workflow 20

4.4.5. Current Systems *20*
4.4.6. Rough Order of Magnitude Costs *21*
4.4.7. Proposed timeline for implementation *21*

5. SECURITY 21
5.1. Laws, Executive Order, Agency Policy 22
5.2. Control Points - Points of Contact for Agencies 22

6. OPERATIONAL CONSIDERATIONS 22
6.1. Audit Trail/Forensic-Forecast Analysis 22
6.2. Recoverability 23
6.3. System Availability 23
6.4. Data Retention 23
6.5. Conventions/Standards 23
6.6. Adaptability 24

7. Summary and Next-Steps 24

APPENDIX C – WORKFLOW TABLES AND SYSTEM DIAGRAMS 25

1. INTRODUCTION

This document is the follow-on to the 2013 IWRSS IDS Scoping and Requirements Report. It proposes a conceptual design for 4 data exchanges themes critical to IWRSS agency missions. This document also provides insight into the methodology used to develop the conceptual design as well as the underlying assumptions pertaining to interagency policy, security and data sharing practices.

1.1.1. Scope

This document establishes design elements for key requirements defined in 2013 to implement and establish a common operating picture for water resources information between IWRSS members systems through data exchange. These terms are used to differentiate between synchronization in order to ensure that authoritative data are propagated through the enterprise. Moreover, throughout the conceptual design effort, the team recognizes the need to establish semantic awareness, thus harmonizing the systems we have in place today.

This report provides outlines for 4 projects that will exchange information between the agencies or establish new data services for existing data that support the goals set forth in the IDS Requirements and Scoping report, specifically the Common Operating Picture for Water Resources.

1.1.2. Background

This Conceptual Design report builds upon the IWRSS Interoperability and Data Synchronization Requirements document completed in 2013. It specifically addresses key requirements related to the foundational goals of IDS -- developing a common operating picture for water resources, increasing efficiencies in information exchange, adopting community standards in data and metadata, and establishing authoritative sources of information within the IWRSS agencies collective mission areas.

1.1.3. References

The following documents and reports influence the conceptual design for IWRSS Interoperability and Data Synchronization:

- Integrated Water Resources Science and Services, *An Integrated and Adaptive Roadmap for Operational Implementation*. Cline et. al, 2009.
- IWRSS Interoperability and Data Synchronization Requirements Report, 2013
- USGS Water Mission Area Policy Memorandum No. 2011.01--Policy and Guidelines for Response, Documentation, and Reporting of Flood Events, USGS, 2011
- Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 2. Computation of Discharge, SE Rantz and others, USGS, 1982

- WRIR 01-4044, Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods, V.B. Sauer, USGS, 2002
- Community Hydrologic Prediction System (CHPS):http://www.nws.noaa.gov/oh/hrl/chps/
- USACE Engineering Regulation 1110-2-249, Management of Water Control Data Systems
- Corps Water Management System Project Management Plans, USACE, last dated 4 December, 2014

1.2 Assumptions, Constraints and Recommendations

1.2.1 Assumptions

The IWRSS IDS Design team continues to evolve the approach necessary to achieve the goals and requirements outlined in the IWRSS System Interoperability and Data Synchronization document of 2013. This is influenced not only by the changes to the federal water community through such efforts as the *Open Water Data Initiative*[1] but also by the strategic planning processes of the individual IWRSS consortium members. The following are set forth as underlying assumptions, or a philosophy, for achieving interoperability and data synchronization:

- Establish *interoperability* between IWRSS members systems through **standardized data exchange** (both in formats, protocols and services) that analogous with loosely coupled systems such as Electronic Funds Transfer Systems or EFTS.
- Differentiate from *synchronization* (or copying of data of unknown provenance) with the need to ensure that **authoritative data** are propagated through the enterprise. In this sense, system design to always pull information from the authoritative sources accomplishes "synchronicity" while potentially reducing the number of data exchange transactions.
- Throughout the conceptual design effort, the team recognizes the need to establish **semantic awareness & consistency**, thus harmonizing the systems we have in place today.

This report was written based on the requirements identified in the 2013 IWRSS Requirements Report. Since that time, the NOAA and NWS leadership have directed the National Water Center to accelerate the implementation of the WRF-Hydro framework as the basis for the National Water Modeling system. Additionally, all IWRSS agencies have been given a mandate to reduce their IT footprint. Therefore, it is important to recognize that the authors have developed this report to be system agnostic and to focus instead on the specific exchange of authoritative datasets across the IWRSS consortium.

Additionally, the authors made the following assumptions in developing the conceptual design:

[1] http://acwi.gov/spatial/owdi/

- Assume that each agency controls their own workflow and will retrieve data from the authoritative source as necessary (i.e. agency with authoritative data will not push data to others)
- Assume that the agencies will establish POCs or leads for each of the critical data exchange or workflows/projects. Assume that leadership will support implementation
- Assume that leadership will support culture changes necessary to ensure that systems are operated with the authoritative data set.
    - On a case by case basis, leverage the inter-agency teams to coordinate consistent solution for dissemination purposes.
    - Do not label non-authoritative (non-NWIS) discharge data as "observed" – instead use "calculated", "derived", or "simulated". Exception is that USACE may label discharges out of reservoirs as observed.

1.2.2 Constraints

The following constraints are placed on the conceptual design for each of the information exchange themes:

- Will not modify each other agency's software to work on the adjacent systems/platform
- No new Master or central owned/operated system will be developed establishing a DMZ or middleware for data exchange. *"Share information, not systems"*
- Adopt a "pull" versus "push" data-exchange paradigm

1.3 Standards Compliance

Standard Item	Compliance Status	System or Subsystem	Note
Identify the Community Adopted Standard	Yes/No		
WaterML2	y	Time-series	For public facing dataservice
WaterML2-2	y	Rating, gaugings (streamflow measurements, cross	JSON implementation is less verbose than the XML return

		sections	
ISO-8601	n	All	international standard covering the exchange of date and time-related data
ISO-191115	n		
ISO-191115-2	n		

2. METHODOLOGY

The IWRSS IDS working group/team identified thematic areas, or projects, that would address the extensive and wide-ranging requirements identified in the scoping and requirements definition phase of this project. Concurrent with these efforts, the team also refined and added detail to the high-level requirements for data synchronization and system interoperability. In doing so, the team arrived at a new way of thinking about data synchronization and system interoperability that adopts the *loosely coupled* approach for achieving these goals.

In this context *loosely coupled* means that interactions between systems require each of the systems to know only the *external interface* of the other, specifically, how to contact the other system (e.g., to request data or send an acknowledgement) and the format of the data being transferred.

2.1. System Design Framework

A key aspect of the conceptual design is the lack of a new mutually owned framework specifically dedicated to information exchange. Rather, the authors, upon consultation and review with their respective Information Technology Officers (ITOs) recognize that existing systems will be used to support and maintain standardized and centralized information exchange in compliance with all IT and system security policies of the respective agencies. During the technical design phase, software engineers and system owners will work with their respective agency policy representatives to establish memoranda of understanding and information exchange agreements as necessary.

2.2. System Design Alternatives

At the IWRSS Consortium agency level, the existing status quo methods for information exchange, often without standards and reliant upon non-authoritative data, are design alternatives. This alternative presents a level of risk to the establishment of the common operating picture for water resources. It also reinforces inefficiencies and potential duplication of efforts within IWRSS agency mission execution.

2.3. Risks

The authors identified the following risks during the conceptual design process:

- Status quo presents a risk that critical operations are based on conflicting sources of information
- Status quo presents a risk that inter-agency operations are adversely impacted by non-authoritative data propagating through the work flow, forecast, or project operations function
- Status quo presents a risk that operations are adversely affected by misuse of information received from another agency because of misunderstandings due to semantic differences.
- Status quo presents an elevated risk of unauthorized system access due to the multiplicity of local network connections between agencies.
- IWRSS MOU will expire in May 2016 unless resigned by Principles. Without the MOU in place, agency commitment can not be guaranteed.

3. AGENCY ROLES AND RESPONSIBILITIES MATRIX FOR IDS SYSTEMS

The following table outlines the responsibilities of the agencies across each of the 4 data exchange themes.

Data Exchange Theme	Originating Agency of Authoritative Data	Receiving Agencies	Notes:
DECODES	USGS	NOAA/NWS USACE	
Operational Time-series	NOAA/NWS USACE	USACE NOAA/NWS	*Assumes that USGS observation and event data are acquired from NWIS Web or other processes
Rating Tables Extensions	USGS	NOAA/NWS USACE	
IWRSS Data Portal	ALL	External Stakeholders	

4. DATA EXCHANGE THEMES

The authors propose four key information exchange themes for consideration by a technical design project. These four areas focus on this highest level and most mission critical elements of the interagency workflows require data consistency in order to achieve the goal of a common operating picture for water resources. These four areas include:

1. DECODES Consistency: GOES DCP message configuration between USGS (authoritative source) and NOAA and USACE (downstream users.)
2. Operational Time-series exchange: single, nationally support exchange for key time-series information between NOAA and USACE necessary for hydrologic forecasting and project operations.
3. Rating Table Extension: A Proposed method for authoritative and consistent extensions of USGS rating table to meet NOAA and USACE upper limits.
4. IWRSS Data Exchange: A 'service of services' exposing agency data through a common portal.

4.1. DECODES

DECODES is the existing software package used by all 3 agencies to convert the GOES message into the proper engineering units for observation(s). This theme, and the resulting agency projects, harmonize the semantics (codes) used to describe GOES platform measurements between the agencies. Currently, identifying and manually configuring the decodes values at NOAA and USACE require *human-in-the-loop* processes. This theme leverages the USGS DECODES data service as the authoritative source for decoding of USGS operated gages. Note that the USACE remains the authoritative sources for decoding schema for those gages owned and operated by the USACE. While, NOAA leverages data from a number of GOES telemetered platforms within the Hydrometeorological Automated Data System (HADS) NOAA, NWS only maintains the decoding schema for a small percentage of these platforms.

This theme will automate and harmonize the GOES decoding schema for USGS operated gages by replacing the manual process for change management to the decoding systems with an automated process that routinely queries the data service from the USGS. This project theme may extend to USACE and NOAA observation platforms when suitable data services are established.

4.1.1. Data Contents

DECODES uses and impacts the data from the following categories:

- Surface Water bodies (river, lakes, estuaries)
- Water control infrastructure (including reservoirs, lock and dam)
- Water quality monitoring sites

Note that a mapping matrix of decodes values has been developed by the IDS team and due to size is available in a separate document, attached to this report.

4.1.2. Background

Satellite telemetry of the USGS Data Collection Platforms began approximate 30 years-ago using the Geostationary Operational Environmental Satellites (GOES) operated by NOAA Command and Data Acquisition (CDA). GOES data are acquired from the satellite by Direct Readout Ground Stations (DRGS). NOAA, USACE and USGS also maintain the Domestic Satellite (DOMSAT) to redistribute data to Local Readout Ground Stations (LRGS) commonly referred to as DOMSAT receivers. This provides redundancy. A diagram of the GOES/DOMSAT relationship is presented as Figure 1 in Appendix C.

The DECODES software and configurations are implemented within NOAA at NOAA CDA and provide the agency-wide authoritative decoding configuration for the messages sent by the gage DCP. Other applications such as the NWS Hydrometeorological Automated Data System (HADS) and USACE application receiving data from USACE owned DRGSs, must replicate these configurations and order to ensure consistency across datasets. Within USACE, the DECODES software and configurations are implemented at Division and/or District offices without an agency-wide authoritative source. Currently, this is a manual process that requires NWS HADS and USACE staff to manually update the configurations on their respective systems.

DECODES configurations commonly need to be updated to reflect changes in field equipment and/or parameters collected and transmitted. Field equipment is replaced when broken or requiring upgrades. Additional parameters are collected to enhance the overall quality of the data provided or in response to specific scientific need at the site. Changes in the field are typically communicated to the NWS HADS and USACE staff by the USGS WSC office operating the gage. Changes to DECODES configurations usually only consist of formatting edits to properly decode the new incoming transmission. DCP IDs and transmitting times rarely change.

This project implements software solutions on the NWS and USACE systems to leverage the USGS data service to routinely update and validate DECODES configurations.

4.1.3. Dependencies

The following systems/projects must be completed in order to support this data exchange theme:

- USGS DECODES data service. Development of process to accept configurations from USACE for USACE-managed gages to incorporate into data service.
- NWS migration of HADS to the NCEP Meteorological Assimilation Data Ingest System (MADIS). HADS will exist as a subsystem within the MADIS platform

- USACE development of process to deliver configurations of USACE-managed gages to USGS for incorporation into their data service.
- Sutron and Cove Software may need to be contracted to update COTS software and firmware existing on government owned equipment.

4.1.4. Design Workflow

In order to ensure consistency on GOES decoding, NWS will:

- review and modify the workflow process within HADS that defines the DECODES configuration to routinely:
  - Acquire DECODES configuration from the USGS Data service
  - Compare current MADIS/HADS configuration to USGS configuration
  - Submit to MADIS/HADS change management system new configuration date.
- Update HADS to leverage the DECODES data service

In order to ensure consistency in GOES decoding, USACE will:

- Develop change management system to enable each DECODES instance to keep up to date with authoritative configurations at USGS.
- Develop process for delivering configurations for USACE-managed gages to USGS for inclusion in data service.

4.1.5. Current Systems

- USGS DECODES web service
- NOAA CDA
- MADIS/HADS
- USACE local DECODES instances

4.1.6. Rough Order of Magnitude Costs

Rough order of magnitude costs breakdown:

Agency	Direct Cost ($)	FTE (Hr)	Rationale
NWS	0	280	Substantial reworking of decodes application within HADS may be required. NCO CMS

			may also impact resourcing.
USACE		400	Development of a fairly simple process for data discovery and delivery and a non-simple change management system.
USGS	0	40	The USGS already has a DECODES data service in place. It may require slight modifications for efficient synching with NWS HADS and USACE systems.

4.1.7. Proposed timeline for implementation

The following timeline is proposed for implementation of this project:

- USGS: Establish DECODES data service. Complete in FY2015. Establish process to receive configurations for USACE-managed platforms and incorporate into data service in FY2016.
- NOAA/NWS: Complete migration of HADS to IDP/MADIS and begin enhancement development activities Q3 FY2016.
- USACE: Develop process for delivering configurations for USACE-managed gages to USGS for inclusion in data service in FY2016. Develop change management system to enable each DECODES instance to keep up to date with authoritative configurations at USGS in FY2017.

4.2. Operational Time-Series

In order to produce forecasts at locations downstream of major water management infrastructure projects, the NWS relies on an extensive collaboration between water management agencies such as the USACE and Bureau of Reclamation. This collaboration begins with the exchange in real-time of critical infrastructure states (i.e. pool elevation, release settings). Currently, *ad hoc* methods are in-place for exchange critical time-series between USACE, USGS and NWS. These methods have substantial limitations and risks that include:

- Multiple NWS and USACE offices retrieve the same data
- In recent months, NWS has overwhelmed systems with multiple requests for data.

This project-theme will provide consolidated collection and exchange between the agencies:

- USACE data will be centralized within CWMS server and placed on a USACE DMZ platform.
- NWS will provide a location (dependent upon the water resources data service project) for RFCs to place their forecasts, contingency forecasts or other supporting data.

4.2.1. Data Contents

The contents of the operational time series data vary based on the producer/consumer combinations. Currently the USGS is a data producer only, while the NWS and USACE act as producers and consumers of data.

Producer*	Consumer(s)	Data Content
USGS	NWS USACE	Various measured and derived characteristics of water in a stream: ● surface stage ● discharge ● velocity ● temperature ● pH ● concentrations of various gasses and chemicals ● turbidity
USGS	NWS USACE	Various measured characteristics of weather: ● precipitation ● air temperature ● wind speed and direction ● solar radiation ● humidity
NWS	USACE	Various stream stage and flow forecasts ● standard forecasts ● contingency forecasts ● ensemble forecasts
USACE	NWS	Projected discharges from reservoirs ● controlled ● uncontrolled

		• total
USACE	NWS	Various measured and derived characteristics of reservoirs: • surface elevation • storage • discharge • evaporation • inflow

*The producer of a dataset is considered to be its authoritative source.

4.2.2. Background

The U.S. Army Corps of Engineers and the National Weather Service rely on time-series information from each other in order to accomplish their programmatic missions. For the NWS, critical USACE time-series include the inflow to reservoirs, contents of reservoirs, the projected outlets discharges and any estimation of release occurring through spillways. For the USACE, NWS time-series may include simulated runoff upstream or into projects (simulations refer to both forecasts with only Quantitative Precipitation Estimates (QPE) and with Quantitative Precipitation Forecasts.) Additionally, USACE may leverage probabilistic forecast information or contingency forecast information. The USACE also relies on weather and water quality time series from the USGS to make reservoir release decisions.

Currently, mechanisms to transfer these time-series between agencies are varied and often times inefficient. In some cases, automated scripts are used to retrieve information for websites which has resulted in multiple hits to web pages that appears as system attacks. This theme will consolidate time-series transfer activities between the USACE and NWS and ensure efficient and redundant exchange of mission critical information.

4.2.3. Dependencies

- NWC Water Resources Data Service (WRDS), and Enterprise Data Store (EDS).
- CWMS Deployment of national database.
- Implementation of CWMS RADAR (RESTful[2] API for Data Retrieval) data service on the national database.

[2] Semantic Web Services: A RESTful Approach, Proceedings of IADIS International Conference WWW/Internet (ICWI), 2009, Rome, pp. 169-180; accessed: https://github.com/otaviofff/restful-grounding/blob/master/papers/official-paper-icwi.pdf

4.2.4. Design Workflow

The workflow for this theme is for each agency to stand up a network data service that:

- is accessible to the other agencies
- can serve time series for the entire agency
- can serve data in WaterML 2 format

4.2.5. Current Systems

- NWS: AWIPS and CHPS; regionally hosted FTP sites; regionally hosted Local Data Manager (LDM) servers
- USACE: Local CWMS and legacy systems, web pages.
- USGS: NWIS (ADAPS → AQUARIUS); NWISWeb

4.2.6. Rough Order of Magnitude Costs

Rough order of magnitude costs breakdown:

Agency	Direct Cost ($)	FTE (Hr)	Rationale
NWS		600	NWC, RFC and regional levels efforts to implement data service for time-series and to develop data collection strategy:
USACE	165,000	160	The $165K and 120 of the 160 FTE hours were expended in FY2015 to develop a RESTful data service in support of this theme. The remaining FTE hours are for implementation in FY2016
USGS	0	0	No additional work is required above current planned changes

4.2.7. Proposed timeline for implementation

- NWS: NWS can complete only after HADS migration has occurred. This is expected for FY16/17.

- USACE: FY2016
- USGS: Currently implemented

4.3. Rating Table Synchronization (Extensions and Discrete Measurements)

The proposal is that the USGS apply rating extensions to their ratings when needed by cooperating agencies. This will allow the NWS and US Army Corps to use the ratings as supplied to achieve their operational and forecast goals.

4.3.1. Data Contents

A stage-discharge rating is a logarithmic relationship between stage (independent variable) and discharge (dependent variable) that is graphically determined by best-fitting a line to a collection of discharge measurements taken at a range of stages. The graphical relationship conforms to known hydraulic principles (Rantz, 1982) governing flow in open-channels. The hydraulics that influence shape of the rating are known to be dynamic, requiring constant adjustments to the rating to match current observed conditions

A rating can be displayed as a table of stage-discharge coordinates. This table can be output in several formats but the old industry standard at this moment is an RDB file. If desired, the format could be changed to the new industry standard of WaterML2.2.

4.3.2. Background

Historically, the USGS has limited rating extension of stage-discharge ratings to two times the highest measured discharge. This limit is due to uncertainty surrounding hydraulic conditions at a site during high flow. This limitation has made USGS ratings unusable at times for the NWS and US Army Corps of Engineers. To achieve operational and forecast goals, the NWS and US Army Corps would modify the USGS rating by extending (in either direction) to the best of their ability to meet their respective goals. Issues arise when the USGS changes their rating to adjust for normal dynamic changes in the location hydraulics or in response to recently obtained high discharge measurements. These modifications may not easily merge with the NWS or US Army Corps version of the rating. At best, there is a delay until each agency can properly merge USGS changes into their version of rating. This can cause distinct difference in the computed discharge from each agency.

4.3.3. Dependencies

- USGS Policy (new and old)
- NOAA/NWS Policy to leverage USGS ratings as soon as they are developed. NWS and USACE will, the highest degree possible, refrain from developing alternative rating tables nor alternative methods for extending the rating tables to the mutually agreed up highest threshold.

- List of sites and extension criteria from NOAA and USACE that will be developed during technical project planning
- Inter-agency team of policy experts to draft the rules of engagement for rating table extension and adjudicate discrepancies in "approach"

4.3.4. Design Workflow

Two distinct workflows exist; One, develop initial extensions and, two, maintain and coordinate additional extensions/modifications.

- Development of initial extension:
  - Identify NWS and USACE required extent of ratings (e.g. Minor, Moderate, Major and Record flood stages) for all USGS gages
  - USGS will develop extension of rating to cover these stages
  - USGS will provide these ratings to the IWRSS partner agencies
  - USGS will mask these ratings on NWIS web consistent with policy pertaining to uncertainty in flow estimates
- Maintenance of Ratings
  - In coordination with NWS and USACE, USGS will refine the master rating table as additional stage-discharge relationships are measured in the upper and lower flow regions of the rating table.

4.3.5. Current Systems

The USGS will use the AQUARIUS software package to develop and modify ratings. AQUARIUS is a COTS software package publically available used for time-series data processing. Use of this software by all agencies is NOT required. The USGS will continue to provide updated ratings through the *Ratings Depot*. The *Ratings Depot* is a URL clearinghouse of current USGS ratings provided in RDB format for use by NWS and US Army Corps.

The NWS will use the IHFS database and CHPS to store and apply USGS Ratings. Depending on operational constraints, the latest USGS Rating may not be uploaded and used immediately.

The US Army Corps will use CWMS to store and apply USGS Ratings.

4.3.6. Rough Order of Magnitude Costs

Implementation will require effort by all agencies. The USGS will have to modify all ratings that do not currently cover the range of NWS forecast levels and US Army Corps of Engineers operational needs. The NWS and US Army Corps will need to provide a list of sites/ratings to the USGS and indications of their current rating extensions.

Agency	Direct Cost ($)	FTE (Hr)	Rationale
NWS	0	65	In conjunction with the NWC , NWS RFCs will identify locations where rating extensions are necessary to meet flood stage levels. Assumes 3-4 hr per RFC.
USACE	0	144	35 water management offices * 4 hours / office + 4 hours management updating ratings and shaving sheep
USGS	0	4,500	Assumption is 3 hours average time per rating for extension given the 1508 identified by NWS. Note that during an exercise performed in March of 2015, the NWS identified 1508 locations where the USGS rating did not reach Record, Major or Moderate Flood Stages. The USGS depot will also be enhanced to provide ratings in WaterML2-part 2 format.

4.3.7. Proposed timeline for implementation

- USGS - This process is dependent on the implementation of AQUARIUS which will allow the USGS to share extended ratings to NWS/US Army Corps without publishing *unknown* discharges to the public. The roll-out date of AQUARIUS is tentatively March 7, 2016 with an expected 6-month roll-out period to incorporate all USGS Water Science Centers (WSCs). At best, it would be September 2016 before all WSCs could extend ratings using AQUARIUS.
- NWS - Based on a preliminary investigation of NWS forecast stages and associated discharge/return year discharge values conducted in March 2015, approximately just under 50% of NWS forecast points requires rating extensions for Major flood stage. NWS will provide a definitive list of USGS gages that require rating table extensions for AHPS Forecast Services (e.g. minor, moderate, major stage/discharge relationships.)
- US Army Corps - The ratings that require extensions could be identified and the information provided to the USGS within two months of when the USGS could start to receive the information.

4.4. IWRSS Data Exchange

This project establishes a set of data servicesaccessible through a single web- portal for aggregating existing observations (USGS and USACE), and official forecast (USACE-projects

and NOAA-points) from the individual authoritative agencies in a common information model. In doing so, this demonstrates a principle of the Open Water Data Initiative by making water resources data available in community-adopted standards using machine readable protocols. In this case, Resource-Oriented Architecture (ROA) will be used to create a web service that seamlessly aggregates data services from the partner agencies and makes the data available in the WaterML2.0 format. Using Representational State Transfer (REST), the common web service will be able to be used as an Application Programming Interface (API) to access data in a simple and reliable way. The web service will allow users to easily build and execute data queries tailored to their needs, using a simple standard protocol. As a demonstration project, the benefits include:

- Open Water Data Initiative; IWRSS demonstration of Open Water Data Initiative ideals.
- Supports the Common Operating picture for Water Resources in the IDS Requirements Catalog -- System independent/software independent common visualization of critical data
- Enhanced discrepancy/ detection

This data exchange will leverage the NHDPlus as the authoritative geospatial dataset and agency information will be referenced to the "commonid" of the NHDPlus network flow line or water body as necessary.

4.4.1. Data Contents

- NWS: provisional and official forecast time-series
- USACE: provisional and official project water levels including pool, inflow, released and gate settings.
- USGS: provisional and approved stream observations.

4.4.2. Background

The notion of a common portal for water information is identified by IWRSS consortium stakeholders as a requirement from the combined agencies information sets. Legacy systems were developed to demonstrate this functionality and include RiverGages.com, now hosted by the USACE Mississippi River Valley District[3]. While this site combines, NWS, USACE and USGS information, it is not comprehensive across the United States (including OCONUS regions) nor does it leverage a common geospatial framework for registry of information.

[3] http://rivergages.mvr.usace.army.mil/WaterControl/new/layout.cfm

4.4.3. Dependencies

- Establishment of agency RESTful data services. It is incumbent upon the respective agencies to establish and operate REST based services exposing their own data.
- Geospatial water resources framework. Data content delivered to users must be provided in the standard WaterML2 format. Location of all observation and forecast values must be identifiable in a common spatial reference scheme.
- Clearinghouse/ common web service -- query builder for individual data services. Through capabilities under development at the NWC, NWS will incorporate support for a web-based tool needed to automate the process of building REST based requests pointed to the respective agency services.

4.4.4. Design Workflow

The project has two distinct portions; development of agency RESTful data services providing information in WaterML2.0 protocol, and the design, development and implementation of common web service that will take user queries, distribute the queries to the respective agency's data service, and collate the results.

4.4.5. Current Systems

This project will leverage the following systems currently operated by IWRSS Consortium Agencies:

- NWS: AWIPS including IHFS and CHPS
- USACE: CWMS
- USGS: NWIS and NWISweb

In addition, it may include systems that are currently under development or deployment and includes:

- NWS: The Water Resources Data Service (WRDS) and NWC Enterprise Data Store -- a centralized data repository and set of acquisition and dissemination services for water resources data.
- Implementation of CWMS RADAR (RESTful API for Data Retrieval) data service on the national database.
- USGS: AQUARIUS

It is important to note that this project requires investment in a new system or capability. During the conceptual design effort, the authors identified and propose two approaches for achieving a common portal; leverage the National Water Center's web presence (water.noaa.gov) or work through the Subcommittee on Spatial Water Data to implement a portal within the FGDC asset (GeoPlatform.gov.)

4.4.6. Rough Order of Magnitude Costs

Agency	Direct Cost ($)	FTE (Hr)	Rationale
NWS		100	Implement RESTful data service as part of WRDS Develop and deploy Common Portal
USACE	25,000		Funds disbursed in 2015 under CWMS implementation
USGS	0	0	Complete with NWIS

4.4.7. Proposed timeline for implementation

The following systems need to developed and implemented:

- NWS: Establish RESTful data service for RVF time-series and provisional QINE[4] time-series from CHPS - end-of-FY2016.
- USACE: Establish operational RESTful data service for CWMS data in FY2016.
- USGS: NWIS Complete
- Combined: Developed common portal code and transition to NWC web presence (Water.noaa.gov) Q2 FY2017.

5. SECURITY

Nothing in the conceptual design for the IWRSS IDS themes outlined in section four shall obligate the agencies to amend or supersede agency IT and security policies. Where necessary, memoranda of understanding and agreement will be established to ensure that mission critical information exchange is made redundant and hardened. A listing of Laws, Executive Orders and agency policies is provided in the subsequent sections.

Note that the authors endorse the establishment of standing control points or a 2-tiered points of contact structure for future IDS information exchange themes.

[4] This was demonstrated during the FY2015 National Flood Interoperability Experiment using a system hosted by University of Alabama running FEWS.

5.1. Laws, Executive Order, Agency Policy

Nothing within this design shall require the agencies to deviate from existing compliance with all laws, executive orders and agency policy.

5.2. Control Points - Points of Contact for Agencies

The IWRSS Design team recognizes the need to routine communication and coordination on information exchange. Therefore, the team recommends that the Technical level representatives as well as the Points of Contact be considered for control-points:

Agency	POC	Technical Reps
FEMA	TBD	TBD
USACE	Webb	Smith Perryman
USGS	Mason	Briar Wilson
NOAA	Rost	Clark Eicher Cajina

6. OPERATIONAL CONSIDERATIONS

Operational deployment of designs specified within this report are system agnostic and apply to the overarching exchange of information for loosely coupled IWRSS systems.

6.1. Audit Trail/Forensic-Forecast Analysis

The technical design for each of the 4 information exchange themes must include record of information posted to the exchange portal as well as records when the data is accessed by outside

partners. These capabilities will form the basis of an audit trail that will facilitate regular monitoring of system performance and ensure that latency between time of data posted and access by downstream applications in quantifiable measures that can be communicated across the IWRSS consortium.

In the event of significant adverse system performance, that audit trail[5] will ensure that the IWRSS agencies can communicate *who knew what, and when*. Specification for technical implementation need not be overly burdensome and may leverage log files of recommended technologies such as Local Data Manager.

6.2. Recoverability

Conceptual designs of systems specified within this report are required to be made operationally hardened during the technical design phase. Alternatively, should non-operational critical systems be of concern then mitigation data-unavailability strategies will be specified.

6.3. System Availability

Unless otherwise specified, all systems designed to meet the 4 thematic data exchanges are assumed to be 24x7 operational with redundancy to assume continuity of operations.

6.4. Data Retention

Data retention standards within the IWRSS portal will be defined during the technical design phase. However, data retention within agency owned and operated systems such as NWIS or AHPS will comply with existing policy and user-level agreements.

6.5. Conventions/Standards

Per section 1.2, and the underlying philosophy outlined in the IWRSS IDS Scoping and Requirements document, as appropriate, technical design should adopt and embrace community standards in data, metadata and data services. This includes, but is not limited to:

- WaterML2.0 for time-series information (expressed as XML or JSON objects)
- CF compliant (when applicable) netCDF for regularly and irregularly structured gridded data
- RESTful data service
- OGC compliant web-services for geospatial data (WMS, WCS, WFS or equivalent)
- OpenDAP/THReDDs

[5] National Institute of Standards and Technology Special Publication 800-92 Natl. Inst. Stand. Technol. Spec. Publ. 800-92, 72 pages (September 2006); http://csrc.nist.gov/publications/nistpubs/800-92/SP800-92.pdf

The authors recognize that interagency efforts such as the Open Water Data Initiative (OWDI) are engaged in similar dialogs and may provide insight to the IWRSS consortium.

6.6. Adaptability

As stated throughout this document, the authors adopted and emphasize a platform agnostic approach to information exchange. This ensure that as the agencies evolve or transform their service paradigm, underlying authoritative data sets (such as streamflow observations, water resources forecasts, and water control projects status) will be provided across the IWRSS consortium.

7. Summary and Next-Steps

Data exchange themes identified in section 4 are hereby entered as proposals to the IWRSS POCs and Governance board. The authors recommend these efforts as critical steps necessary to ensure that interagency data is synchronized and consistent across the IWRSS consortium. It is also important to recognize that the evolving nature of the IWRSS agencies' programs requires that a standing committee of technological experts remain engaged as a committee on Interoperability and Data Synchronization across the consortium.

APPENDICES

APPENDIX A – WORKFLOW TABLES AND SYSTEM DIAGRAMS

Figure 1: DECODES Locations within GEOS Telemetry and HADS