Challenges in Implementation of the Corps Water Management System (CWMS) in U.S. Army Corps of Engineers, Nashville District

William R. Barron, Jr.
Lead Hydraulic Engineer
U.S. Army Corps of Engineers, Nashville District
P.O. Box 1070
Nashville, TN 37202-1070
615-736-2024
william.r.barron.jr@usace.army.mil

Abstract

Numerous challenges must be overcome in the implementation of the Corps Water Management System (CWMS) in the Nashville District of the U.S. Army Corps of Engineers. The less demanding of these challenges are related to setup, installation, modeling, and forecasting. A more demanding challenge is providing a good quality control process to ensure that the system is working correctly. The greatest challenge, however, may be the human component of implementation of change.

The less demanding challenges are those that deal with setup, installation, and modeling. These challenges are associated with data collection and storage, geographic information products, physical systems, data backup, model accuracy, and physical limitations of computer equipment.

A more demanding challenge is making sure that the system is working correctly. Quality control procedures must be developed for the data collection, storage, modeling, and forecasting configurations within CWMS. This includes reviews of all of the above plus comparison of old system results and new system results.

The greatest challenge is convincing the personnel who currently operate the system that changing to a new approach is a good thing. Existing attitudes, beliefs, and opinions must be altered. Because the two systems are so different considerable training must occur. The new system must produce better forecasts than the old system and must be reliable. Only then will personnel accept the new system and trust the results.

1.0. Introduction

1.1. Numerous challenges must be overcome in the implementation of the Corps Water Management System (CWMS) in the Nashville District of the U.S. Army Corps of Engineers. The less demanding of these challenges are related to setup, installation, modeling, and forecasting. A more demanding challenge is providing a good quality control process to ensure that the system is working correctly. The greatest challenge, however, may be the human component of implementation of change.

2.0. Getting CWMS Working

2.1. Installation

2.1.1. Installation of CWMS was accomplished primarily with on-site assistance from Hydrologic Engineering Center (HEC) personnel. The installation was helpful, but a great deal of work remained to be finished with very little documentation. By the time HEC personnel left the district, a watershed was able to be mapped for visualization, some data collection platform (DCP – satellite transmitted) data was being processed, at least one basin was producing results from radar rainfall (although using a Hydrologic Rainfall Analysis Project (HRAP) grid rather than a Standard Hydrologic Grid (SHG)), and at least one basin was producing results from the HMS model. At that time no Reservoir Simulation (ResSim) models or hydraulic models had been developed for the system. A framework or template was established as a basis and an example for the development of the river system. Troubleshooting was difficult and was compounded by lengthy Unix directory pathnames, changes that had occurred since the introductory sessions, and vague and cryptic error messages. As problems occurred, the availability by remote access, the patience, and the persistence of HEC personnel was a great help in the continuing development of CWMS.

2.2. Data Collection and Storage

2.2.1. With time and with new versions of the software, CWMS began to develop. Installation of a new version was now done remotely over the Internet and was relatively painless. However, those doing the implementation still encountered a variety of problems. A diligent system administrator constantly made substantial efforts to get the system to ingest more and more data, often changing the pathnames of the data. Extraction lists were developed so that models could find the data. Lots of errors were discovered. A lot of those errors dealt with and continue to deal with pathnames, data transmission or lack thereof, and incorrect data. Pathname difficulties are the result of the Oracle/shefit conventions being more exacting compared to the previous DSS/shefit conventions. Even though data was going into CWMS, useable validated data required additional time and effort to develop. Five possible sources of data error have been identified: data from the gauged network, errors in transmission or reception of the data, errors caused by National Weather Service, transmission problems between CELRD and CELRN, and problems at CELRN. In addition, bugs and quirks within CWMS were often discovered and are still being discovered.

2.3. Geo-spatial Data Systems Considerations

2.3.1. Many decisions must be made prior to modeling of the basin. Several of these decisions fall within the Geo-spatial Data Systems (GDS) arena. For example, someone must decide the vertical and horizontal datum to be used. The most recent vertical datum is North American Vertical Datum of 1988 (NAVD 1988), but in the Nashville District the datum for all of the stream-gauging network is National Geodetic Vertical Datum of 1929 (NGVD 1929), our elevation storage tables are based on NGVD 1929, the

elevations of the dams are based on NGVD 1929, all model cross sections were surveyed in NGVD 1929, high water marks are NGVD 1929, and digital elevation models are NGVD 1929. So even though NAVD 1988 is more accurate, we have decided at least in the near future to stay with NGVD 1929. We are possibly one of the luckier districts because the difference in elevations between NAVD 1988 and NGVD 1929 range only from 0.5 feet in the upper end of the basin to 0.1 feet in the lower end of the basin. Some river basins will have a substantial difference in datum. In addition, we do not have a lot of different datum to consider. Some river basins have NGVD 1929, Ohio River Basin, and Sandy Hook datum, to mention just a few. The North American Datum (NAD) 1983 horizontal datum is being used in Nashville District.

2.3.2. The projection of the GDS data must be decided upon. Nashville District has decided to use UTM, zone 16 for the entire district even though the very upper end of the district is UTM, zone 17. This decision was based upon a recommendation of an AE firm several years ago. We hope the AE firm was right. Early in the implementation of CWMS this presented a problem because Geo-HMS required an Albers Equal Area projection for creation of a Standard Hydrologic Grid.

2.3.3. Designation of river miles is another major problem. Originally river miles were drawn by hand on paper maps. The methodology of determining the river miles was crude and the maps were certainly subject to stretching and/or to shrinkage. River miles that are created using GDS techniques are much more accurate, but simply do not agree with river miles marked on the old paper mapping. The differences are not major, but are significant enough to be a nuisance. On some river systems the differences may be major if a consistent method of designating river miles is used across the nation.

2.3.4. The quality of digital elevation models should also be examined. First, the resolution of the data should be checked. In the Nashville District 30-meter x 30-meter data are acceptable in areas that are steep, but are unacceptable in relatively flat areas. In addition, most of the 10-meter x 10-meter data is quite old. A 10-meter x 10-meter set of digital elevation models currently being used for a basin was flown on 15 May 1951. Generally, water surface elevations are high during collection of this type of data.

2.3.5. If inundation mapping is to be used and developed, the source of the mapping and the resolution must also be considered. In addition, inundation mapping for long stream reaches can require considerable computer resources, especially as the resolution improves. Flood damage centers should have top priority for inundation mapping.

2.3.6. Flood damage analysis data may or may not be available. Even if it is available, it may be out of date. Also, funding is seldom available for maintaining the data and keeping it up-to-date.

2.4. Knowledge of Computer Software

2.4.1. Anyone working with CWMS must have a reasonably strong background in using computer software. At least rudimentary knowledge of the UNIX and Windows 2000

operating system is necessary. In addition, a plethora of software tools are needed to successfully model the river basin. Below are listed some of those tools:

Hummingbird
3D Analyst
ArcPress
Spatial Analysis
ArcGIS
ArcView
- Xtools
- Geo_HMS
- Geo-RAS
- Cedra-Avcad
- Overview Window
- CADTools
- MrSID

ArcGIS8.3
SnagIt
DSSVUE

2.5. Computer Hardware

2.5.1. Considerable computer hardware resources must also be available. Nashville District is currently using one of the smaller SUN systems, a U60. This machine is totally dedicated to running CWMS. In the near future the interface will be placed on a Blade 2000 and the U60 will serve as the Oracle host. Because of GDS processing of large data sets, the personal computer that is used consists of a 1,700 MHz Xeon processor, a total of 290 GB of disk space, 4 GB of memory, and dual monitors.

2.6. Modeling

2.6.1. In Nashville District, considerable effort is being placed on the modeling that CWMS forecasts will be based on. The modeling includes using the HEC programs Geo-HMS, ResSim, Geo-RAS, UNET – using null interior boundary conditions, and eventually FDA. Current plans are to model the storage (tributary projects – Martins Fork, Laurel River Lake, Lake Cumberland, Center Hill, Dale Hollow, and J. Percy Priest) individually using radar rainfall, a Geo-HMS model for runoff, and a ResSim model to determine releases. The releases from the tributary projects (Lake Cumberland, Dale Hollow, Center Hill, and J. Percy Priest) will be used as upstream boundary conditions for a UNET model that has been developed for the lock and dam, run-of-the-river projects (Cordell Hull, Old Hickory, Cheatham, and Barkley). The UNET model uses null interior boundary conditions to determine local area inflows. At a later date, Geo-HMS and Geo-RAS unsteady flow models will be developed for the lock and dam projects. Rating curve problems are known to exist at Cordell Hull, Old Hickory, and Cheatham so a comparison of the two models for the lock and dam projects will be made to see which model works best.

2.6.2. Progress has been made on developing the Geo-HMS models for Dale Hollow, Center Hill, and J. Percy Priest. Progress has also been made on developing the ResSim

model for Dale Hollow. A first cut version of the UNET, null interior boundary condition model has been completed. At some point, a more systematic approach to modeling may have to be undertaken.

2.7. Forecasting

2.7.1. Forecasting efforts have been minimal at this time. Comparisons of calculated versus actual runoff have been made for Dale Hollow, but at the time of this writing, not enough modeling has been satisfactorily completed within ResSim to forecast releases with any accuracy. Eventually releases will be for forecasted and compared to actual operations. In addition to traditional operation of the projects, forecasting of chemical spills will eventually be included within CWMS. Also, water supply reallocation studies will eventually be done within CWMS.

3.0. Getting CWMS Working Correctly

3.1. Quality Assurance/Quality Control

3.1.1. Quality assurance and quality control (QA/QC) are an on-going process within CWMS. Problems are noted by using the system on a daily basis. This is likely the most realistic method for conducting QA/QC, but a more formal method needs to be developed. CWMS is so complex that no one person could easily conduct a QA/QC of the entire system. Such a person would have to have considerable knowledge of computer systems, data acquisition and storage, system operations, GIS data, HMS modeling, RAS modeling, ResSim modeling, and flood damage data. No one in the Nashville District has sufficient experience to be able to conduct a thorough, overall QA/QC of the entire CWMS system. Even when multiple personnel review individual elements of the whole, problems can easily be overlooked.

3.1.2. Development of a number of check lists would be useful to district personnel. Even for those areas in which the district has expertise, such as modeling, a checklist of items to look at with ranges of acceptable values should be developed. Obviously, there are numerous areas within CWMS that no one other than the person working within that area has a clue on how to check to see that everything is correct. In cases such as that, a formal arrangement for review should be made with someone outside of the district that has expertise in the area, and even then a thorough review may be difficult because a reviewer from outside the district will not be familiar with the operation of the particular system.

3.2. Long Term Comparisons

3.2.1. The ultimate QA/QC of CWMS will be a comparison of how well it works to how well the current way of doing business works. This will likely be a lengthy and expensive effort. Just for the short period of time that I have been working on CWMS, about six months, I have often had to wait for a good rainfall event before I can see if something is working properly or I have had to wait to get a data record from a different

entity (such as Tennessee Valley Authority) entered into the system. Comparison of both methods to a good flood would be an excellent method, but no one really wishes for a good flood just so that you can do a good QA/QC on CWMS. Historical data does not help very much because we are trying to use radar rainfall, and in our district radar rainfall has only been available since about 1997 and has only recently been good enough to use. Nonetheless, as CWMS is better developed, daily comparison of results will have to be made and adjustments made as appropriate.

4.0. Implementation of Change

4.1. The greatest challenge to implementation of CWMS within the Corps will be to overcome resistance to change. Resistance to change is a natural reaction for anyone. Operation of the Cumberland River system with CWMS will be a major change to our engineers that forecast on a daily basis. These engineers have been using the same system for operating the Cumberland River for approximately twenty years. They have a great deal of experience. They are comfortable with the existing system. Even though they know that the existing system that they are using is not the best and does not always give them the most timely and correct answers, they know enough about the system to recognize when the answers are wrong and to adjust accordingly. These engineers are conservative in the operation of the Cumberland River. Their job requires them to be highly structured because they must operate the river within the limitations of a number of rules and regulations and for a number of purposes that are often contradictory. They are dedicated to giving the best forecast possible because they are very much aware of the consequences to navigation, hydropower producers, homeowners, fishermen, etc. Before accepting anything new and different, they will thoroughly evaluate it over a period of time. They genuinely want a better tool to perform their job, but, like all of us, are reluctant to abandon proven methods. If they do not see definite advantages, then CWMS will not be used.

4.2. Based upon The Inter Change Cycle, by Lillie R. Brock and Mary Ann Salerno, (Interchange International Incorporated, www.changecycle.com) as CWMS is implemented you will be able to see these engineers go through what the authors have identified as six cycles of change.

1. Loss,
2. Doubt,
3. Discomfort,
4. Discovery,
5. Understanding, and
6. Integration.

4.3. Typical statements to expect during the loss cycle are “I’m not giving up my system model!” or “Well, there goes the district!” During this cycle personnel feel as though something is being lost and often feel victimized.

4.4. Typical statements to expect during the doubt cycle are “That will never work with our system!” or “ This is ridiculous!” or “I don’t like being forced into something that

will never work!" During this cycle personnel will see things only from their perspective, they will defend what they are familiar with, and they will have a *me* versus *them* mentality.

4.5. Typical statements to expect during the discomfort cycle are "Anything is better than this!" or "This #%&*@ thing isn't working!" During this cycle personnel do not want to participate, being unorganized is the rule, and things seemed to be going around in circles. Confusion reigns supreme. During this cycle there is an urge to give up and you believe that you are working hard for nothing.

4.6. Typical statements to expect during the discovery cycle are "I want to try all of these options." or "This option is good, but so are several others." During this cycle personnel want to follow every idea, they experience a false sense of reality, or they find something wrong with every idea. It is during this cycle, however, that they may start to see some good to the change.

4.7. Typical statements to expect during the understanding cycle are "I have to get this done!" or "I'm tired of everyone dragging their feet." During this cycle personnel will become very structured, will be domineering and dictatorial, and will show little patience with others.

4.8. Typical statements to expect during the integration cycle are "It has to be done this way or not at all!" or "I am the one that should teach everyone." During this cycle personnel want to do things their way, they give themselves credit for everything good that happens, and they point to their own accomplishments.

4.9. Recognition of the above cycles will be helpful to the persons trying to implement the change. However, making change more acceptable to the personnel who have to deal with the change is the more important issue. During implementation of change, personnel should be trained in recognition of the above cycles and should be able to place themselves in the appropriate cycles. Personnel should also be well informed and should be given the opportunity to see the benefits of what they are doing. They should also be given tasks to perform to help set up CWMS, thereby, becoming stakeholders in the new system.

4.10. Nonetheless, operation of a major river system is a serious business. Forecasters must provide timely and accurate answers. Any computer/software system that is used by them must be robust, flexible, relatively easy to use, and dependable. In short, it must be a better mousetrap than they are currently using. CWMS will be implemented only if the forecasters see it is a better mousetrap.