BONNEVILLE POWER ADMINISTRATION'S HYDROMET DATA MANAGEMENT SYSTEM 1/

By

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Introduction

The Bonneville Power Administration (BPA) markets power generated by 30 Federal dams in the Pacific Northwest. As BPA's primary forecasting group, the Hydrometeorology Section forecasts streamflow, weather, and short-term system loads to assist the Branch of Power Supply with its power scheduling function. This paper will explain how BPA acquires and uses hydrometeorologic data to accomplish this forecasting function.

BPA's William A. Dittmer System Control Center in Vancouver, Washington became operational in November 1974. Since energization, Dittmer has provided the Pacific Northwest with efficient and reliable power system control in the face of continually increasing power system complexity. Dittmer is the nucleus of an integrated power system control program based on concepts of automatic data acquisition, realtime data processing and interpretation, advanced information display, and centralized control of generation and transmission facilities.

The heart of Dittmer is an array of 15 computers comprising several distinct operations that continuously interface with one another. Principal among these is the Real-time Operation, Dispatch and Scheduling (RODS) system. This system consists of two Digital Equipment Corporation PDP-10's and three PDP-11's.

Most data stored in the RODS system can be viewed on any one of 22 color CRT consoles located throughout the building. The consoles provide the primary man-machine interface for computer support in the operation of Dittmer. Most consoles have keyboard I/O and a variation of information request panels (push-button assemblies) in front of the CRT display.

Hydromet System (Figure 1a)

This system acquires hydrometeorologic data from 49 remote river gaging and weather stations located throughout the U.S. portion of the Columbia Basin. Stations are interrogated once an hour by the Hydromet Data Controller which utilizes a Varian 620/L computer. Data are transmitted to Dittmer via a complex microwave network, received by the Controller, and passed to the RODS PDP-10 computer through the PDP-11 acquisition system.

Data are tested for validity by the PDP-10 prior to storage and use. Validity testing of hydromet data consists of comparing incoming data with the previous hour's data and determining whether changes are within predetermined tolerances. Data that do not fall within tolerances are flagged and error messages are sent to the Hydromet console to advise technicians that corrections must be made. Once data are accepted by the RODS PDP-10 computer, they are available for viewing at CRT consoles and for use by analysis and forecasting computer programs.

Columbia Basin Teletype (Figure 1b)

The Columbia Basin Teletype (CBTT) Network was developed in 1957 by the U.S. Army Corps of Engineers as a means to collect and disseminate hydrometeorologic and powerhouse operational data for the region. The network expanded to include other agencies and is now a major communication link between utilities and government agencies. The CBTT network uses teletypewriter circuit equipment rented from American Telephone and Telegraph Company. All maintenance on the system is provided by local telephone companies.

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At Dittmer we receive thousands of CBTT messages daily. Many messages come in on an hourly basis, reporting powerhouse and reservoir status at the many Federal dams. Some messages are daily summaries of plant operations. And some messages are narrative in nature describing a specific operation which has occurred or is pending.

All non-narrative messages must be acted upon and decoded and data must be stored by the PDP-10 computer. CBTT data are transferred to the RODS PDP-10 computer in the same manner as Hydromet System data. Again, data are checked for completeness and; if incomplete or in the wrong format, error messages are sent to the alarm file and displayed to engineers or power schedulers. Data that have passed the CBTT software validity check are output to the appropriate disk file and may be viewed by consoler users (Figure 2). Data can be changed either by sending revision messages on the CBTT network or by use of special CRT displays on the RODS system.

National Weather Service Forecasts (Figure 1c)

Dittmer receives forecasts of temperature and precipitation amount daily from the National Weather Service (NWS) in Suitland, Maryland. These forecasts are prepared by the Model Output Statistics (MOS) method using formulas derived by NWS under contract with BPA. Data are transferred by the NWS to the U.S. Bureau of Reclamation computer center in Denver, Colorado, and subsequently to the RODS computer at Dittmer. Four-day weather forecasts for approximately 100 Columbia Basin weather stations are received and transferred into the RODS data base. Data are grouped by geographical areas within the Pacific Northwest and may be viewed on CRT displays. For example, Figure 3 shows that Bellingham (BLI) on March 10 has a 60 percent chance of precipitation of .24 inches or less. Forecast minimum and maximum temperatures for that station are 40°F and 50°F, respectively. These displays allow for changes to the forecasts if staff meteorologists deem them necessary.

The entire process of transferring data from the Denver computer to RODS takes about twenty minutes. This amount of time is expected to decrease as new equipment allows for faster transmission rates. No validity tests of NWS forecast data are made beyond the visual checks done by the mathematician, meteorologist, or engineer prior to use.

Program Executions and Outputs (Figure 4)

Once data reside in RODS disk files, execution of forecasting algorithm is possible. The following is a brief description of the four principal computer programs which use hydrometeorologic data:

1. The Hydraulic Summary Routines are a series of data handling programs which produce reports of power system conditions and indicate trends. Data that are received from the CBTT and stored in RODS files are used to prepare reports on status of streamflows, project data summaries, utility plant data summaries, storage energy summaries, and net generation reports. Prior to execution of these routines the data undergo further validity checking for consistency. Consistency between elevations and flows is determined by computing the change in content between midnight elevations on two consecutive days and comparing this value with the difference between the day's average inflow and outflow. Total discharge values must approximate the sum of turbine and spill discharges and fall within a tolerance reserved for miscellaneous flow. Project head is checked by comparing the difference between the average forebay and tailwater elevations. All data files are examined in a search for missing values.

   Availability of data required to adjust the observed flows for upstream reservoir regulation is noted separately. Checking the data prior to program execution relieves technicians from tedious day-to-day calculations and also reduces the number of unnecessary computer program executions that occur. Eventually, adjusted flows for selected locations are calculated by the Hydraulic Summary Routines for comparison to similarly adjusted historical flows. These flows are made available to other Federal agencies and utilities daily via the CBTT network.

TUE MAR 7 78 GRAND COULEE PLANT DATA TOP ELEV = 1288.0

ELEVATIONS IN FEET FLOWS IN KCFS AVERAGE GENERATION IN MW

DATE	MIDNIGHT FOREBAY	AVERAGE FOREBAY	AVERAGE TAILWATER	AVE NET HEAD	AVERAGE INFLOW NAT	AVERAGE INFLOW REG	AVE IRRIG PUMP	INFLOW LESS PUMP
MAR 1	1244.80	1244.93	954.78	290.15	39.7	90.2	0.0	90.2
MAR 2	1244.20	1244.51	955.35	289.16	35.2	90.1	0.0	90.1
MAR 3	1243.30	1243.74	956.08	287.66	33.4	88.2	0.0	88.2
MAR 4	1242.70	1242.94	954.84	288.10	31.7	86.0	0.0	86.0
MAR 5	1242.70	1242.56	952.95	289.61	29.7	87.1	0.0	87.1
MAR 6	1242.30	1242.46	952.67	289.79	33.0	73.6	0.0	73.6
MAR 7	1242.20	1242.25	952.71	289.54	36.7	84.3	0.0	84.3
TOTAL					239.3	599.5	0.0	599.5
AVERAGE					34.2	85.6	0.0	85.6

DATE	AVERAGE OUTFLOW	CONTENT CHANGE	AVE TURB DISCH	AVE SPILL	AVE GROSS GEN	ACTUAL KW-CFS	H-K	TOTAL GROSS GEN
MAR 1	102.9	12.7	102.9	0.0	2216.0	21.54	22.06	53183
MAR 2	109.1	19.0	109.1	0.0	2338.5	21.43	21.95	56124
MAR 3	116.6	28.4	116.6	0.0	2430.2	20.84	21.88	58326
MAR 4	104.8	16.8	104.8	0.0	2210.3	21.09	21.91	53047
MAR 5	87.1	0.0	87.1	0.0	1760.7	20.22	21.69	42258
MAR 6	86.2	12.6	86.2	0.0	1877.9	21.79	21.79	45069
MAR 7	87.4	3.1	87.4	0.0	1853.5	21.21	21.77	44485
TOTAL			694.1	0.0				
AVERAGE			99.2	0.0				

HGH ALF GCL CHJ WEL RRH RIS WAN PRD OWR LWG LGS LMN IHR

MCN JDA TDA BON HCR LOP DEX CGR GPR FOS DET BCL LOS LIB

CSP

HYDSUM INDEX SCHEDULING INDEX DAILY PLANT DATA

Figure 2

HYDROMET SYSTEM

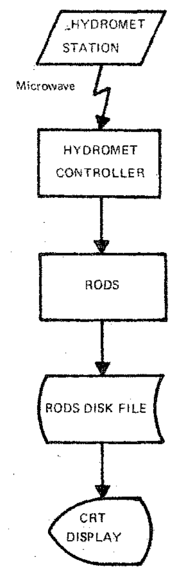

Figure 1a

CBTT SYSTEM

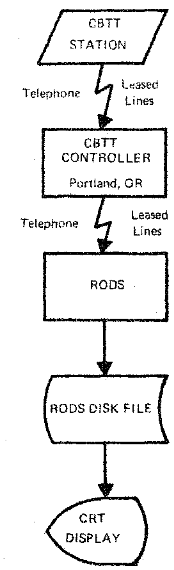

Figure 1b

NWS WEATHER DATA

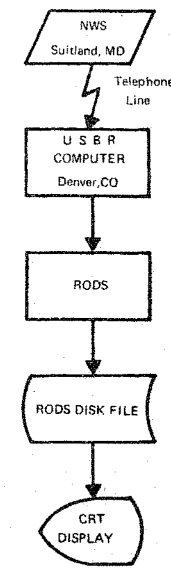

Figure 1c

BRANCH OF POWER SUPPLY – PROGRAM FLOW

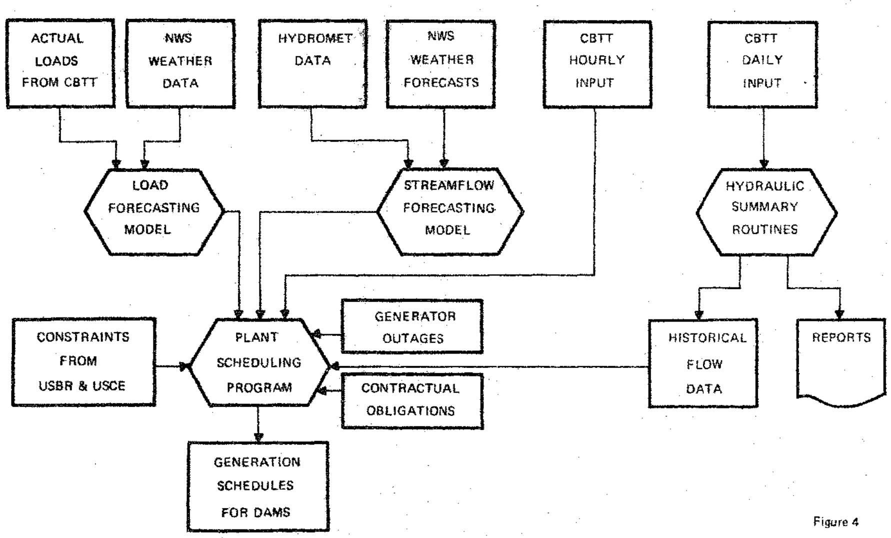

Figure 4

CLASS 1 .01 - .24
CLASS 2 .25 - .49
CLASS 3 .50 - .99
CLASS 4 1.00 -1.99
CLASS 5 OVER 2.00

(0000 HRS GMT) WESTERN VALLEYS WEATHER FORECAST

	MAR 9			MAR 10				MAR 11				MAR 12			
STA	POP	POPA	MX	POP	POPA	MN	MX	POP	POPA	MN	MX	POP	POPA	MN	MX
BLI	80	2100-1	54	60	1000-1	40	50	40	0000-1	36	49	60	1000-1	37	50
CLM	80	2100-1	53	60	1000-1	38	52	40	0000-1	37	50	60	1000-1	37	50
SEA	80	2100-1	56	80	1000-1	41	55	40	0000-1	37	54	60	1000-1	38	50
ILM	80	2100-1	57	60	1000-1	33	56	50	0000-1	32	50	60	1000-1	34	51
TDO	80	2100-1	57	60	1000-1	36	55	50	0000-1	35	54	60	1000-1	34	52
PDX	80	3100-1	59	60	1000-1	37	62	50	1000-1	43	59	60	1000-1	40	54
SLE	80	3100-1	61	60	1000-1	38	60	60	1000-1	35	58	60	1000-1	36	53
EXT	90	5310-3	46	60	1000-1	31	44	60	1000-1	30	43	40	1000-1	29	42
SP	30	5310-2	60	60	1000-1	39	57	60	1000-1	36	58	40	1000-1	34	56
MFR	80	310X-2	62	50	100X-1	37	59	30	000X-1	31	61	40	000X-1	34	54

STATION CODE ___ [redacted] PAGE [redacted]

SCHEDULING INDEX FORECAST NAT FLOW INDEX PUNCH FORECAST SYSTEM LOAD FORECAST INDEX

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2. The System Load Forecasting Model provides hourly forecasts of the BPA system load to aid in short-term operations planning. Load data are first broken down into components (nominal, weather sensitive, industrial) and each component is forecast separately. The nominal load is the product of the weekly effect, expressing growth and seasonal variation, a day-of-the-week effect and an hourly effect. Weather sensitive load component is caused by deviations from normal weather conditions. For example, a change of 10° F at the load centers can change the BPA system load by 500 MW, or an amount equal to the entire generating capacity of Bonneville Dam. The industrial load component is served contractually to large industrial customers. Once these components are defined and the portion of the load that they influence is determined, each is evaluated separately and the individual effects on the load are combined to form the total system load forecast.

   The known industrial load is isolated from the total load using manually prepared files. The remaining load follows patterns of behavior that are highly correlated with historical patterns, known events, and with measurable causes such as temperature and wind. An initial estimate of this load in the future is obtained from past conditions only. Further refinement of the estimate is provided by forecasting deviations from "normal" behavior.

   Data necessary to run the System Load Forecasting Model are permanently stored in RODS files. Observed and forecast weather data for the three major load centers (Portland, Seattle, Spokane) are filed in RODS daily from NWS, as explained previously. One hundred twenty hours of observed temperatures and wind are received daily and are checked for missing observations and errors. Missing data are computed by linear interpolation if missing for 3 or less consecutive hours or flagged otherwise. Unusual temperature or wind changes are flagged and checked by the meteorologist before the model is executed. Past hourly load data comes in via the CBTT shortly after the hour in the form of individual plant loadings.

   Easy access to these data allows the engineer or scheduler to model the BPA system load accurately and in a timely manner, with little or no manual data handling.

3. The Streamflow Model enables technicians to obtain objective estimates of short-term flow forecasts on an annual basis as inputs to the plant scheduling process. This is accomplished by using a version of the SSARR hydrologic model which employs a unique set of coefficients for each basin. These coefficients are developed for each area by executing the model in an off-line mode with historical weather and flow data as input. Adjustment of the coefficients on successive runs enables the hydrologist to obtain the set that results in the best fit in a least squares sense of model results to actual recorded conditions. This set of coefficients is then used to define the reaction of that particular basin to any set of forecast weather input.

   In the forecast mode, continuity of the model output with time is preserved by maintaining a set of basin conditions for each area at the time of the last forecast. These are input to the next forecast run defining initial conditions within each area.

   Observed streamflow and precipitation data are received via the various links of the Hydromet data management system and stored in RODS' disk files. Forecasts of temperatures and precipitation are received for approximately 100 stations via the NWS-Denver link. These data, coupled with manually prepared freezing level data, constitute the inputs to the streamflow processing model.

4. Ultimately, the Plant Scheduling process combines forecasts of BPA system load, streamflows and future interchange, scheduled interchange, current initial conditions of streamflow, generation, discharge, and reservoir elevations with plant characteristics and operating constraints. A detailed mathematical model of the system produces comprehensive plans, or schedules, for

reservoir operation. The process provides hourly, daily and weekly schedules of project generations and reservoir discharges and elevations.

Future Plans

The display consoles which currently display our input and output data are not high resolution CRT's and are not capable of properly producing a high quality graph. We are in the process of enhancing our system with a higher resolution graphic CRT (Tektronix Model 4014-1, with hard copy device). This facility will allow us to display graphically data that heretofore was only displayed in tabular form. We plan to display hydrographs, weather forecasts and observations (superimposed on a map of the Columbia Basin), system-load-forecast versus actual-system-load graphs, plant-elevation versus rule curve plots and storage-energy-content versus rule curves.

Hydromet System facilities will also be upgraded. Many proposed hydromet stations are in locations where radio transmission is impossible or at best poor. Transmissions from these proposed stations will be received via the GOES (Geostationary Operational Environmental Satellite). This proposal is still in the planning stage, but it appears that GOES data will be received via phone lines from the National Environmental Satellite Service (NESS) computer located in the Washington, D.C. area.

Several computer systems are in planning or developmental stages now and these systems will be linked to the RODS data collection system as they come on line. SNOTEL collects and transmits snow course data; CROHMS (Columbia River Operational Hydromet Management System) is a network of more than 1000 hydrometeorological stations reporting to a central collection computer; AFOS (Automated Field Operations and Services) is a large National Weather Service computer system for the transmittal and receival of weather observations and forecasts; PHDAS (Powerhouse Data Acquisition System) collects data directly from Northwest Federal dams.

We also plan to upgrade our telephone links. This will allow data to be transferred via phone lines with an automatic dial-up feature and at much faster transmission rates.

In conclusion, our present systems for collecting, displaying, and disseminating hydrometeorological data (CBTT, Hydromet, NWS) are adequate for our current requirements; however, growth and changes are inevitable and we will continually investigate new methods of hydromet data management.

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