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DATA RETRANSMISSION FROM WATER SURVEY OF CANADA
GAUGING STATIONS USING ERTS-1

by
R. A. HALLIDAY *

The Water Survey of Canada operates over 2400 gauging stations at which water level data are collected. At nearly all of the stations that are located on rivers (as opposed to lakes), the water level data are used to compute river discharge. The water level and streamflow information is used by federal and provincial agencies, hydro companies and engineering firms for design of dams, irrigation systems, drainage systems and bridges, for flow and flood forecasting, for project regulation, and for pollution control. In many instances it would be desirable to obtain data on a near "real time" basis; however, because of the isolated locations of most gauging stations, the cost of doing this has been prohibitive.

Of the 2400 gauging stations, only 70 are equipped with Telemarks for telephone interrogation and only two are equipped with a radio telemetering systems. At other stations where information is required frequently during critical times of the year, a local observer visits the gauging station and telephones the gauge reading to the Water Survey of Canada office.

Obviously, there was a need to investigate other means of obtaining data from remote areas so, when information was first obtained concerning the Earth Resources Technology Satellite (ERTS) program, it seemed worthwhile to conduct an experiment using this satellite. In consultation with the Water Survey of Canada District offices, nine sites were selected for an experiment with data relay by ERTS satellite. The sites selected were the Illecillewaet River at Greely, Duncan River below B.B. Creek, and Kootenay River at Fort Steele in southeastern B.C., the Mackenzie River at Fort Simpson and at Norman Wells in the western Arctic, Lake Athabasca at Crackingstone Point in northern Saskatchewan, the Kazan River at outlet of Ennadai Lake in the eastern Arctic, the Winisk River below Asheweig River Tributary and the Albany River above Nottick Island in northern Ontario. We also agreed to co-operate with the Glaciology Division in an installation on the Rideau River at Ottawa. All of these sites are depicted in Figure 1.

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* Presented at the Ontario District Conference of the Water Survey of Canada at Guelph on January 25, 1973

2.

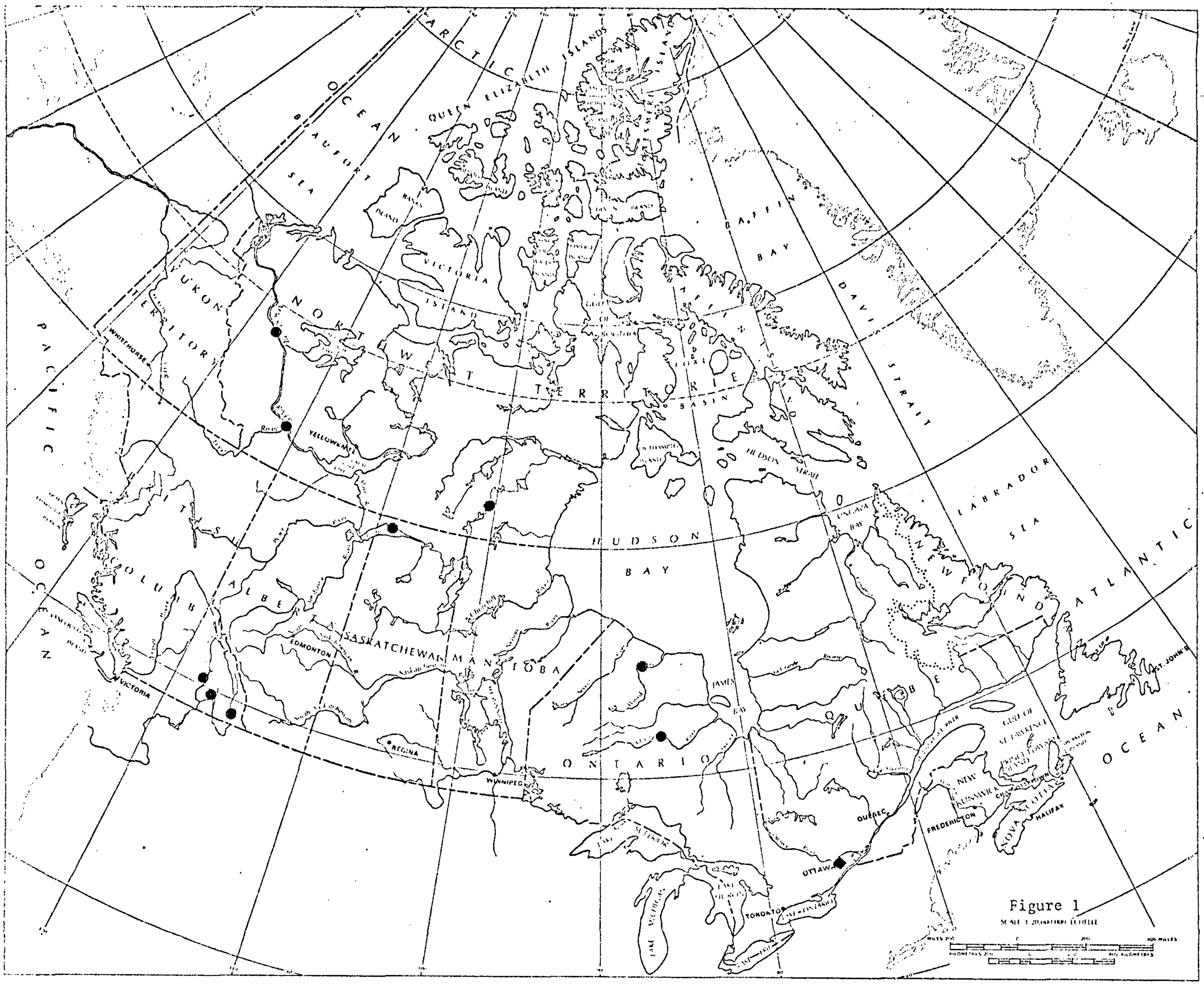
ARCTIC
OCEAN
BEAUFORT SEA
QUEEN ELIZABETH ISLANDS
BAFFIN BAY
DAVIS STRAIT
LABRADOR SEA
ATLANTIC OCEAN
PACIFIC OCEAN
HUDSON BAY
JAMES BAY
HUDSON STRAIT
FOXE BASIN
UNGAVA BAY
VICTORIA ISLAND
BANKS ISLAND
NORTHWEST TERRITORIES
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
WHITEHORSE
YELLOWKNIFE
EDMONTON
REGINA
WINNIPEG
VICTORIA
OTTAWA
TORONTO
QUEBEC
FREDERICTON
HALIFAX
ST. JOHN'S
LAKE SUPERIOR
LAKE MICHIGAN
LAKE ONTARIO

Figure 1

The objectives of the ERTS program stated by the United States National Aeronautics and Space Administration are:

> "Determine those natural and cultural resources and environmental data which can be acquired best from spacecraft.
>
> "Test and demonstrate a combination of data aquisition procedures and interpretive techniques for application of the data in discipline areas such as agriculture, forestry, geology, geography, hydrology, oceanography, and ecology.
>
> "Determine how repetitive, synoptic, multispectral observations by spaceborne instruments can be of economic or social value to commercial, scientific and governmental interests."

In order to fulfill these objectives, NASA designed a satellite that would perform two main functions, namely provide imagery of a portion of the earth's surface at regular intervals and secondly, provide a means of relaying data from ground based sensors to a central receiver. Imagery is obtained in two ways. A multispectral scanner (MSS) scans a 100 mile wide portion of the earth's surface and transmits the data obtained in four spectral bands ranging from the blue-green to the near infra-red to the ground stations in the United States. Also, a return beam videon (RBV) camera photographs an area measuring 100 nautical miles on a side and transmits the photographs to the ground stations in three spectral bands also ranging from the blue-green to the near infra-red. Both MSS and RBV imagery can be processed to provide 10 inch square colour or black and white prints or transparencies of an area measuring 100 nautical miles on a side.

The ERTS space craft is in a near polar "sun synchronous" orbit rotating around the earth about every 100 minutes. This orbit enables the satellite to pass over exactly the same point on the earth's surface at the same local time every 19 days. The orbit is such that on each successive day, overlapping coverage will be obtained by the spacecraft sensors. In Canada, this overlap will be in the order of 40% to 60% depending on latitude.

In addition to its photographic mission, the satellite may be used to relay data from ground based sensors to receiving sites in Goldstone, California or Greenbelt, Maryland, whenever the satellite is in mutual view of a receiving station and a transmitting remote station. Data can be received during the southbound passes each morning and the northbound passes in the evening.

Data are transmitted from the field site by means of a Data Collection Platform (DCP). The DCP collects the data from the sensors, encodes it and transmits it in a 38 millisecond burst approximately every three minutes. The data received by the spacecraft are then retransmitted in virtually the same instant to the ground receiving station. There is no provision for storage of data on the satellite.

Each DCP consists of a small electronic box which assembles and transmits the data and an omnidirectional antenna. The electronic unit is designed to function in temperatures of -40°F to +125°F and in humidities up to 97%. The antenna consists of a 46 inch diameter, 1 inch thick, flat ground plane with a crossed dipole element mounted in the center. The DCP requires a power supply of 24 ±3 volts. A platform costs about $3000.

The DCP will accept a data input of 8 words of 8 bits each for a total of 64 bits. The data can be in the analog, serial digital or parallel digital form. Each analog input takes up one word with a required input voltage level of 0 to +5 volts dc. The serial digital input consists of one channel which can be 8, 16, 24, 32, 40, 48, 56 or 64 bits long. The parallel digital input which is the most flexible can be treated as 64 channels one bit long or any smaller number of channels, as long as the total number of bits is less than 64.

At present, we are using a Leupold Steven Memomark II to convert the water level sensed by a float or a water stage servo-manometer to four binary coded decimal digits. This permits us to transmit water level data ranging from 0.00 to 99.99 feet using 16 of the 64 bits available in the DCP. An additional 16 bits will be used to transmit two temperatures obtained by thermistors. One of these will be air temperature and another could be the temperature under a snow pack or temperature inside the recorder shelter or water temperature. A further 12 bits would be used to transmit precipitation in BCD form covering a range of 0.00 to 9.99 inches. The remaining 20 bits (2½ words) could be used for other inputs such as river velocity, snow pillow data, total wind, ice movement, or battery checks.

When data from a DCP is retransmitted to Goldstone or Greenbelt, it is then sent over NASCOM lines to the Goddard Space Flight Center where it is processed for distribution to users. We receive the data in two forms. At the conclusion of each orbit, data are sent to the Canada Center for Remote Sensing in Ottawa by teletype where it can be sent on a real time basis by TELEX to Water Survey of Canada offices. Also every twenty-four hours, computer cards containing the data and error messages are mailed to Ottawa where we run the data and produce printouts to be mailed to the Districts. This procedure usually results in about a ten day time lag in receiving data in a District office.

Seven of the nine DCP's purchased have now been installed. Of these seven, five have been working well since installation. The other two have not, however in one case the fault was in the operation of the Stevens encoder while in the other case the source of the problem was a loose wire on the antenna. Several thousand transmissions were received by the end of 1972 at a rate of 10 to 25 readings on 3 to 7 orbits a day, depending on the gauging station. Of these readings, only <u>two</u> were obviously incorrect. One had an incorrect date and the other had an invalid digit (the hundredths). Spot checks of other apparently good data have indicated that the data are correct. While it is still too early to evaluate the reliability of the DCP's, it is noteworthy that we have not had a failure of a DCP once the DCP has started transmitting good data. Also, it appears that communication links from ground to satellite and back to ground are much more reliable than ground to ground radio links.

Since our ERTS experiment has been quite successful, it is fair to ask, where do we go from here? Our immediate objective is to have all nine platforms in operation and to add more sensors so that the full capacity of the platform is used. This program would be continued when ERTS-B is launched later this year. It is possible that some District offices will purchase additonal platforms in order to meet specific requirements for real time data from isolated locations. However, it should be kept in mind that ERTS is an experimental program and that NASA has made no commitment to continue the program beyond 1975.

After ERTS, there is a good possibility that there will be a Canadian satellite available for data relay purposes in 1976 or 1977. The Department of Communications is proposing to build a low capacity, geostationary, UHF communications satellite which would be very suitable for our purpose.

Because the satellite will be in a geostationary orbit, it will be possible to obtain data on an hourly or even more frequent basis. If development of this satellite does continue and if the ground data handling facilities to get the data into the hands of the users on a real time basis are constructed, then I believe there will be tremendous changes in Water Survey of Canada operations in the not too distant future.