Environmental Monitoring Program to Support the Rouge River National Wet Weather Demonstration Project

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Abstract

The watershed-based approach being applied to the Rouge River in southeast Michigan under the Rouge River National Wet Weather Demonstration Project (Rouge Project) has included an extensive environmental monitoring program. Monitoring is considered a critical element to the Rouge Project because it is used to: 1) establish baseline conditions; 2) support the development of watershed models; 3) identify problems and their sources; and 4) evaluate control programs.

The environmental monitoring conducted by the Rouge Program Office (RPO) has involved the collection, management, and analysis of data on rainfall, stream flow, instream water quality, combined sewer overflows (CSOs) and storm water discharges, biological communities and habitats, sediments, toxics, aesthetics, and the performance of various control programs. Over 500 monitoring stations have been established throughout the 438 square mile watershed. The RPO has collaborated with the EPA, state, and local agencies in the development and execution of the monitoring program. Monitoring has been performed on an annual basis since 1993.

Computer applications have been built to facilitate quality control, data storage, accessibility, and analysis. Computer applications have been developed to display the results. The Rouge Project has also developed a series of water quality indicators that serve as a means of communicating information on water quality to the general public.

Introduction

The watershed-based approach is being applied to the Rouge River in southeast Michigan under the Rouge River National Wet Weather Demonstration Project (Rouge Project). The Rouge Project includes an extensive environmental monitoring program. This paper presents an overview of this watershed monitoring program.

Monitoring is recognized as a critical element in watershed management. The Intergovernmental Task Force on Monitoring Water Quality (ITFM) prepared the report, "The Strategy for Improving Water Quality Monitoring in the United States" (ITFM, 1995). In the report, the ITFM recommends adopting the use of goal-oriented monitoring as the means "to support sound water-quality decision-making." The Urban Wet Weather Flows Federal Advisory Committee (UWWFAC) agrees with the ITFM report and in their own report, "Draft Recommendations on Monitoring Requirements for Watershed Management Programs" (Murray, et al., 1996), discusses how watershed-based monitoring plays an integral part by tracking progress towards watershed objectives, while collecting more environmentally relevant data than traditional compliance monitoring.

The Rouge River, a tributary to the Detroit River in southeast Michigan, has been designated as a significant source of pollution to the Great Lakes system. (See **Figure 1**) The Rouge River Watershed is largely urbanized, spanning 438 square miles, and is home to 1.5 million people in 48 communities and three counties. Sources of pollution to the river include CSOs, storm water runoff, resuspension of contaminated sediment, inflow from abandoned dumps, and limited industrial and municipal point sources.

The Rouge Project is a United States Environmental Protection Agency (USEPA) sponsored program to manage wet weather pollution as the means for restoring the Rouge River. It is designed to identify the most efficient and cost effective controls of wet weather pollution, while assuring maximum use of the resource. A major element of the Rouge Project is CSO control. Controls that are being investigated include retention treatment basins and sewer

separation. Innovative storm water control technologies are also being evaluated, including various best management practices (BMPs) and the development of a general permit which will offer: discharge options; focus on hydrologic boundaries; and define management activities. The results of the CSO and storm water control projects are being incorporated into the detailed management plan for the Rouge River Watershed.

Methodology

Implementing the monitoring program to support the Rouge Project involved several elements. These elements were derived from strategies for the implementation of monitoring plans that are presented in the USEPA guidance document titled, "Guidance for the Data Quality Objectives Process" (USEPA, 1994) and in "Design of Networks for Monitoring Water Quality" (Sanders, et al., 1990). These elements included:

1. establishing monitoring objectives;
2. defining data needs;
3. developing individual sampling programs;
4. data collection and handling; and
5. data management.

The first element in developing the monitoring program for the Rouge Project was to formulate an overall direction for the program. This direction was expressed in terms of monitoring objectives. The objectives were formulated in terms of the information requirements to support the other major components of the Project.

The next element was to identify the data requirements. These requirements were expressed in terms of the data needed to support the monitoring objectives. Estimates of the data needs were made by identifying the database required to properly conduct a desired analysis and then evaluating the usability of the current database for the Rouge River.

Based on the data requirements, individual sampling and monitoring programs were identified to collect the data. A wide range of sampling programs were required for all the required data, such as water quality and chemistry, habitat status, and public health concerns. Programs were developed based on specific data quality objectives that were required to meet each objective.

Data collection and handling required that detailed information be provided to ensure all the environmental measurements and related activities under taken by the staff were performed in a manner consistent with the RPO's Quality Assurance Project Plan (QAPP). The QAPP defines the minimum requirements for quality control and describes applicable quality assurance activities for the Rouge Project. Field sampling plans (FSPs) were developed to provide this information. Specific activities that were undertaken on a routine basis were also documented in Standard Operating Procedures (SOPs). SOPs were available for laboratory methods (*i.e.*, 5-day biochemical oxygen demand determination), field sampling (*i.e.*, sediment core sampling technique), and data handling (*i.e.*, data uploading into database).

To manage the data, a database was needed with the capabilities to store the entire data set, given the data sea was very large with various data types. In addition, a series of tools had to be developed that would work within the database to locate the desired data and display the results using various format options.

Results

The objectives developed for the Rouge Project monitoring program were to:

- establish baseline conditions;
- support the development of watershed models;
- identify problems and their sources; and
- evaluate control programs.

Based on these objectives, a wide range of sampling and monitoring studies were developed and implemented to support each objective. These studies involved an extensive effort in the collection, management, and analysis of data on rainfall, streamflow, instream water quality, CSO and storm water quality, biological communities and habitat, instream bottom sediment, air deposition, and aesthetic conditions. In addition, the monitoring program included measurement of the performance of various structural controls, wetlands, and non-structural BMPs. Each of these individual programs are summarized below.

Rain Gaging—Monitoring of rainfall amounts has been conducted throughout the Rouge River Watershed using a network of 23 continuously recording gages. The data has been used to define wet weather responses and spatial variation, and to drive the hydrologic models of the watershed.

Flow Monitoring—A program to monitor instream flow rates has been implemented by the RPO on a seasonal basis since 1993. Flow levels are continuously monitored with readings taken and recorded every 15 minutes. Networks of eight to 20 stations are established for a monitoring season, which typically lasts six to nine months. Flow rates are then calculated from the level data using rating curves that have developed at each station. The United States Geological Survey develops the rating curves for the RPO using procedures that are consistent with the curve maintenance performed at their own gaging stations. The data are used to establish baseline conditions, define trends, and assist with the development of the hydraulic models of the Rouge River system.

Instream Water Quality Monitoring—A program to monitor instream levels of dissolved oxygen (DO), temperature, pH, and specific conductance has been implemented by the RPO on a seasonal basis since 1993. These parameters are continuously monitored with readings taken and recorded every 15 minutes. Networks of eight to 17 stations have been established six to nine months. The data are used to establish baseline conditions, define trends, and assist with the development of the water quality models of the Rouge River system.

Chemical Monitoring—Sampling programs have been performed to monitor instream levels of selected pollutants under both dry and wet weather conditions. The chemical parameters include oxygen demand, solids, nutrients, and metals (total and dissolved). Up to 60 sites are sampled over the same dry period one to three times per year. Sampling during wet weather is performed at 10 to 30 stations. Both autosamplers and manual grabs are employed to collect the samples at various times throughout a given wet-weather event. Two to seven events are typically monitored at each site in a given season. The data are used to establish baseline conditions and assist with the development of the water quality models of the Rouge River system.

Sediment Monitoring—Sediment monitoring has been conducted throughout the watershed to characterize sediment quality. The monitoring involved the collection of a single sample at 182 locations along the river. These samples were analyzed for metals, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs). Results were compared to a toxicity-based guideline as a means of identifying those sites with the potential for impacting aquatic organisms. Another monitoring program focused on defining the extent of PCB contamination in the sediments of Newburgh Lake. As a result of this program, Newburgh Lake is being dredged in order to return it to a viable recreational resource.

Bacteria Monitoring—Monitoring instream bacteria levels has been used to define the health risk associated with public contact with the Rouge River. Monitoring has focused primarily on *E. coli* bacteria under both dry and wet weather to establish existing levels. Detailed monitoring programs are conducted in areas with elevated dry-weather levels in order for results to be compared to water quality standards and to locate potential sources. Monitoring has also been used to define periods when certain sections of the river will be safe for use as a recreational resource. Similar programs will be conducted during wet weather to define the impacts that various CSO controls have on bacteria levels.

Aesthetic Monitoring—Each field visit to the Rouge River includes documentation of the aesthetics at the site. The aesthetic indicators selected for the Rouge Project include water clarity, odor, water color, visible debris, and signs of obvious pollution. Observations are documented on a standardized field sheet. The results have been used to develop a numerical index of aesthetic quality. This index is used to locate problem areas and track trends.

Toxics Assessment Plan—A toxicity evaluation of surface water, sediments and fish was conducted in the Rouge River Watershed to determine baseline toxicity conditions, upon which treatment alternatives could be measured. Many organic compounds and metals have been identified as parameters of concern because of their toxic effects in the environment. The RPO is conducting a toxic monitoring program to identify existing levels of organic compounds and metals in the water column and sediments. The program also assesses the impacts on aquatic life and human health through studies on the bioaccumulative and toxic properties of each compound.

Habitat Assessment—In 1996, the RPO performed an evaluation of habitat in the Rouge River Watershed. Over 80 habitat monitoring stations were established. The purpose of the study was to identify existing fish habitat in the watershed and those fish communities associated with a particular habitat.

Modeling Special Studies—Several field studies have been developed and conducted by the RPO to assist in the development of input values for the water quality models. These field studies include sediment oxygen demand, stream reaeration, time of travel, and impoundment limnology.

CSO Control Technologies—Several technologies to control CSO pollution are being demonstrated and

monitored in the Rouge Project. These include several conventional detention basins and sewer separation. The basins have been designed to test various design storms, shunt channels, first flush tanks, and a vortex separator. These projects will help demonstrate how much treatment can be expected from various sized retention structures and separate sewers. A two-year water quality benefit evaluation of CSO basins constructed during Phase 1 will begin in June 1997.

BMP Evaluation Monitoring—Monitoring is used to evaluate how various BMPs perform for storm water control. The BMPs tested by the RPO include structural (grassy swales, detention ponds, on-line filters, sand filters), wetlands (existing, enhanced, constructed), and source control (industrial/commercial and residential). Monitoring is performed either at the inlet and outlet of the structure or before and after implementation of the program. Treatment performance is based on differences found in the concentration or loading of various pollutants.

Air Deposition Monitoring—The County is working with the University of Michigan in Ann Arbor to measure the wet and dry deposition of toxic metals, PCBs and other contaminants from wet and dry air deposition in the watershed.

Illicit Connections—The Rouge Project has implemented an aggressive program to detect and eliminate improper connections to the storm sewer system. Several techniques are being used including dye testing, infrared photography, isotopes, and indicators like ammonia and whiteners. As illicit connections are found and eliminated, the volume and pounds of pollutants they contribute are calculated and their impact on river water quality estimated.

Outfall Monitoring—Monitoring discharges from selected combined sewer and separated storm water outfalls has been conducted throughout the watershed by the RPO. Flow rates are monitored continuously with autosamplers used to collect a series of discrete samples throughout a given discharge event. Samples are analyzed for a suite of parameters (oxygen demand, solids, nutrients, metals). Results are used to define loading for the hydrologic models of the watershed and the impacts land use has on quality. The results are also compared to the national databases for CSOs and storm water.

Outfall Inventory—Utilizing global positioning system (GPS) techniques, a pilot outfall inventory was performed on the Bell Branch and Tarabusi Creek tributaries to the Rouge River. The techniques and methods utilized were evaluated to develop a procedure for future outfall inventories conducted by municipalities. These inventories can assist communities to more accurately define outfall information for future use in the preparation of storm water discharge permits, and industrial discharges, as well as conducting river model calculations.

Septic System Studies—Septic studies are being undertaken in the Rouge Project since failing septic systems are believed to be a cause of elevated *E. coli* levels in the river during dry weather. Several options are being developed to have local governmental units review septic systems on a regular basis or at the time of sale of a property. If sanitary sewers are not available to a parcel served by a septic system, a septic system maintenance program will be encouraged or required.

Discussion

Monitoring began in the fall of 1993 and has continued on an annual basis. All field programs are conducted on a seasonal basis, typically when air temperatures remain above freezing and the water temperature remains above 12 ^{0}C. The overall monitoring program for the Rouge Project has evolved into a set of permanent and roving monitoring sites, depending on the data collection goals of each individual study. Close to 600 individual monitoring sites have been established.

To date, over 5 million pieces of data have been generated from the field studies. The majority of the data has come from the continuous monitoring of rainfall, river stage and flow, and water quality (DO and temperature). This type of information is collected every 15 minutes, 24 hours per day during the monitoring season.

Procedures have been established for maintaining this large data set and validating the accuracy of the various data. The data handling and management procedures are summarized in **Figure 2**. Raw data collected in the field or received from the laboratories are uploaded into the Rouge Project's ORACLE database management system through a loading routine. The loading routine also checks the data to ensure they are in the correct format, and generates reports and time-series plots that are used in the quality assurance/quality control (QA/QC) process for validating the data. Once the data enters the database, they are considered "preliminary." After loading, the data are sent through a rigorous QA/QC process whereby the validity of each data point is identified based on the data quality objectives (DQOs) of the individual field study. These steps are shown on the left-hand column and bottom row of **Figure 2**. Using specific QC data collected in the field and/or generated in the laboratories, the data are evaluated in terms of precision and accuracy.

When problems are found in the data that are caused by improper field or laboratories procedures, this information is passed on to crew members or lab mangers so corrective actions can be taken. The data are validated in terms of a "usability" factor. The basic categories include acceptable, questionable, or rejected. Flags identifying the validity of each data point are added to the database. Once the flags have been finalized, the data are considered final and available for distribution.

Accessibility of the data was a very important consideration in the Rouge Project. Several computer applications were developed that provided user-friendly interface with the database. DataView is one application that queries the database based on user-specified criteria (monitoring station, parameter type, dates) and displays the data in both tabular and graphical formats. The Rouge Information Manager is a multimedia based tool to provide information on Rouge activities addressing GIS, database management, CSO, nonpoint source, water quality modeling, and public involvement. This tool includes DataView in its suite of programs, as well as, maps of monitoring sites, specific site information, and reports. This tool is distributed on CD-ROM.

A method adopted by the Rouge Project to better communicate results of the monitoring program is the use of "indicators." Using water quality indicators, river quality measurements and observations can be expressed in fairly simple terms. This approach uses five water quality indicators: DO, river flow, bacteria, aquatic life, and stream habitat to rate river quality based on defined public use categories such as fishing, swimming, boating and aesthetics. Results are presented using graphical GIS displays which include color-coded icons and river segments. Staff have used these indicators to identify and rate the quality of river conditions which affect public uses of the Rouge River.

Total costs for Rouge Project monitoring program since 1993 and through 1998 has been $10 million. The majority of these costs have supported monitoring rainfall, flow, and water column programs. Parameters such as flow, DO, water chemistry and bacteria were found to be highly variable in the Rouge River and required large databases to accurately establish baseline conditions and identify trends. Programs with smaller budgets may want to consider less emphasis on this type of information.

Future monitoring is targeted at developing a long-term monitoring plan for assessing the "health" of the Rouge River. This program will be designed to assess long-term trends, document compliance with the water quality standards, and will be consistent with upcoming policy from the USEPA regarding wet weather monitoring for watershed planning. In addition, the Rouge Project is developing policies that are based upon resource monitoring as a trade off to end pipe monitoring. The concepts have been accepted by the UWWFAC and are in the process of being accepted by the local decision makers in the watershed.

Conclusions

The benefits gained from the intensive monitoring program implemented for the Rouge Project included:

- extensive database of baseline conditions
- able to support water quality models of the watershed
- evaluating CSO demonstration control programs
- identify wet-weather impacts from non-CSO sources
- identify remediation needs of recreational resources

A monitoring program designed in support of a watershed-based study must provide a broad range of information. Monitoring several chemical parameters for compliance with site-specific standards or criteria will not provide all the required information.

Planning a watershed-based monitoring program is very important. Without proper planning, the range of desired information will lead to a very large and expensive program with little focus. Using a goal- or objective-oriented approach has helped the Rouge Project to stay focused on the important issues. Without this information, the limited resources for implementing the monitoring program cannot be effectively applied.

Managing a natural resource on a watershed basis requires a comprehensive understanding of the natural systems and the impacts of human activities. Monitoring must be integrated into watershed management because it is a source of information that can provide answers to the complex questions that come with trying to understand the problems and solutions associated with watersheds.

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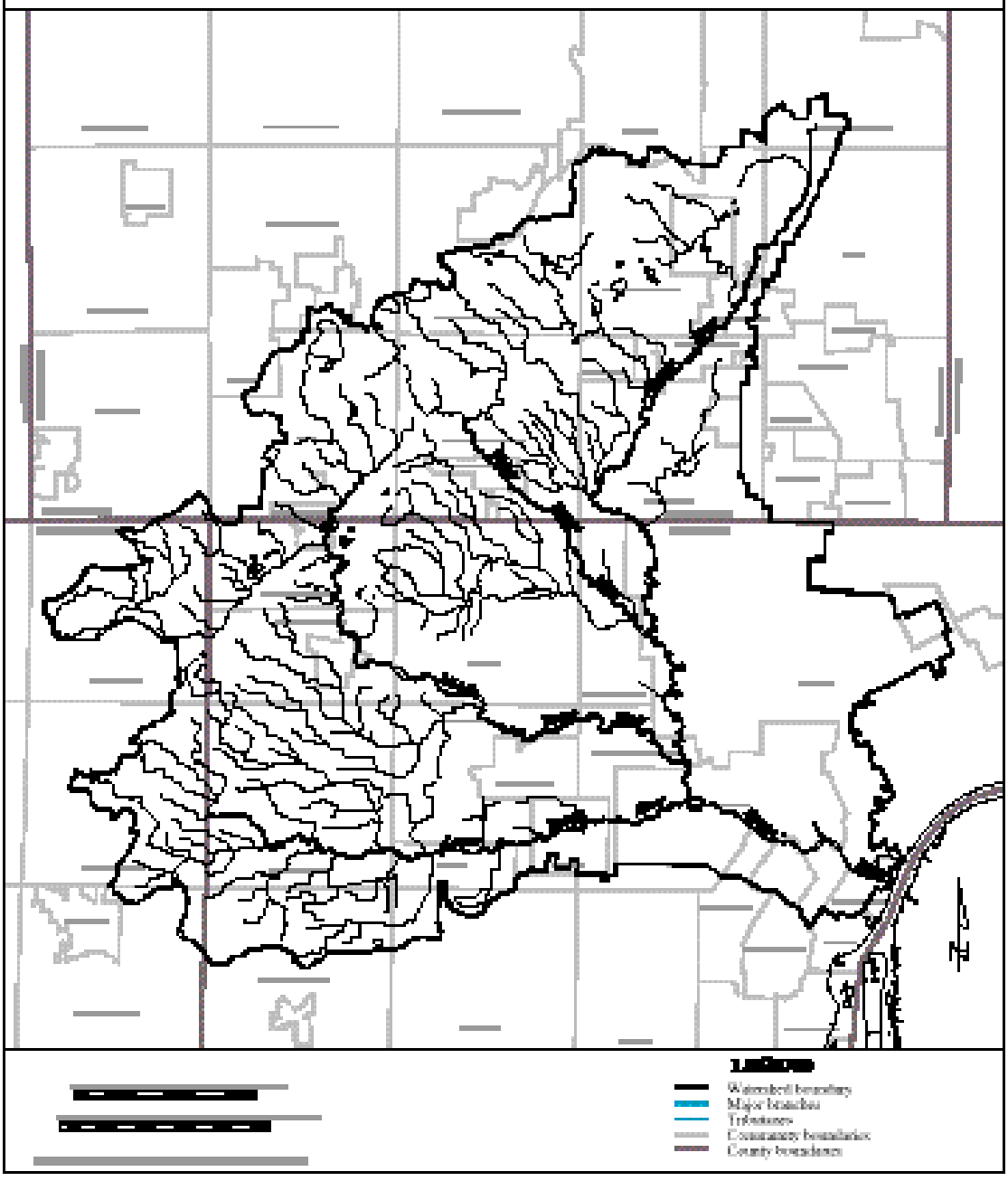
ROUGE RIVER WATERSHED

Base Map



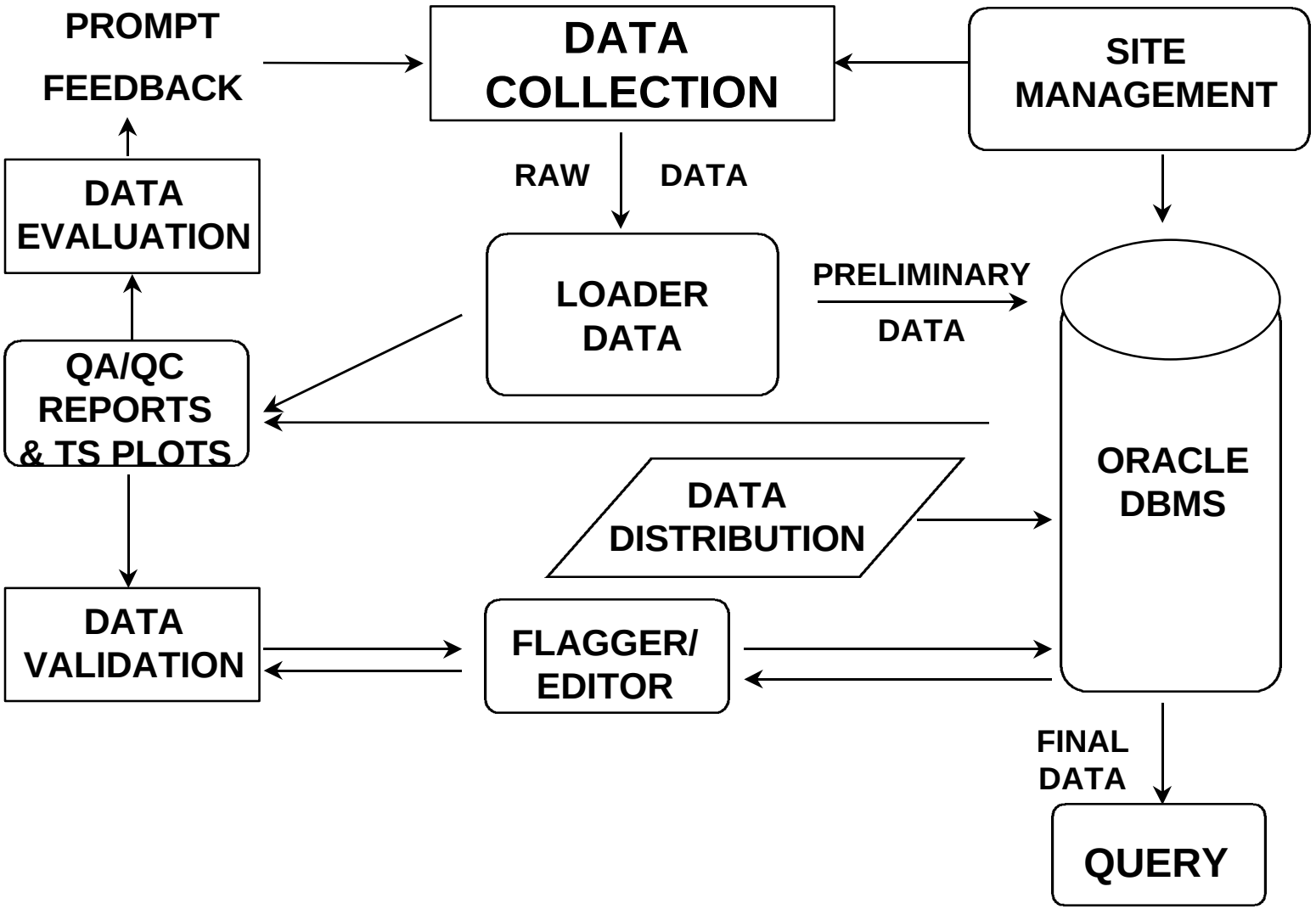


Figure 2: Data Flow Process