

A well-calibrated model should produce results that are similar to what control room operators see in the field.



AWWA WATER DISTRIBUTION MODEL CALIBRATION SUBCOMMITTEE OF THE ENGINEERING MODELING APPLICATIONS COMMITTEE OF THE ENGINEERING AND CONSTRUCTION DIVISION UNDER THE TECHNICAL & EDUCATIONAL COUNCIL

Committee Report: Defining model calibration

THIS ARTICLE PROVIDES AN OVERVIEW OF WATER DISTRIBUTION MODEL CALIBRATION AND IS THE FIRST OF SEVERAL PRODUCTS FROM THE COMMITTEE.

Hdraulic models of water distribution systems are widely used in system planning, design, and operations and serve as the basis for decisions involving consumer safety and large expenditures. The more accurate the model, the better it can support such decision-making. Model calibration is an important step in applying a model.

DEFINITION

Water-distribution-model calibration consists of comparing model results with field measurements, making adjustments to a model and reviewing field data to improve agreement between the two. The calibration process should result in a more accurate model as well as a better understanding of the strengths and weaknesses of the model—and in many cases a better understanding of the distribution system itself.

Calibration is one of many steps in the process of developing a model that is appropriate for use in a particular application. These steps are shown in Figure 1.



Depending on use of the model, hydrant flow tests can be useful for calibration.

Calibration differs from validation, which also consists of comparing model results with accurate field measurements but uses those comparisons to assess model accuracy for a given purpose. Validation may also refer to comparing the model with a different set of field data from that for which the model was calibrated. Also, as shown in Figure 1, the process is not purely a linear process but rather may involve multiple iterations before achieving an acceptable model.

DIFFICULTIES WITH CALIBRATION

The model and field data seldom perfectly match because of various factors:

- natural variability in systems—e.g., systems change from day to day;
- simplifications—e.g., not including all minor losses;
- approximations—e.g., location of unmetered water use;
- assumptions—e.g., summer demand pattern is similar to spring;
- inaccuracies—e.g., using nominal diameter instead of actual internal, rounding off elevations;
- model errors—e.g., wrong connectivity at complex intersections, closed valves;
- data collection errors—e.g., inaccurate sensors, incorrect data handling.

Therefore it is highly unlikely that any model will be perfectly calibrated for all purposes across an entire system under all conditions. Calibration can be evaluated only on a continuous scale from poor to excellent for a given intended use. There is no way to give a general yes or no answer to the question, “Is this model calibrated?” The model can be judged only on its suitability for specific tasks.

ACCEPTANCE OF MODEL AS CALIBRATED

A model is a decision-support tool and not an end in itself. There are two roles in modeling:

- (1) Modeler who builds the model and then performs calibration comparisons
- (2) Decision-maker (engineer, operator, planner) who relies on the model to help make decisions

These roles can be filled by any combination of two individuals (or teams) in the water utility, two consultants to the utility, or one individual (or team) who performs both tasks. The decision-maker should not ask the modeler if the model is calibrated; instead, the modeler should show the decision-maker what was done for calibration. The decision-maker and modeler can

then jointly decide if the model is sufficiently calibrated for the particular task and assess the need for additional calibration work.

A model may be well-calibrated for one task but not for another. For example, a model may be well-calibrated for fire flow analysis at a location but poorly calibrated for a systemwide water quality analysis. At some point, it must be decided that the model is adequately calibrated for the specific task for which it will be used.

Although it is not possible to provide general numerical guidelines for acceptability of model calibration, the modeler and decision-maker can reach an agreement on targets for model calibration for a particular task. The decision about the acceptability of model calibration depends on

- uses of the model,
- sensitivity of the decisions to model accuracy,
- quality and availability of field data,
- metrics used to evaluate calibration, and
- budget, resources, and time constraints.

Even in a well-calibrated model, there may be areas in which the model and the field data do not

agree and the utility does not have the resources to solve the problem. However, the model still may be a useful decision-support tool as long as the users understand its limitations. A model may have been well-calibrated in an area where growth in the system is expected and thus will be useful for evaluating capacity for land development. Yet the same model could have inaccurate pump efficiency and flow data—therefore it would do a poor job of assessing energy use in that system.

CALIBRATION AT DIFFERENT STAGES OF MODEL DEVELOPMENT

There are three situations in which model calibration can be assessed:

- (1) at completion of initial model building,
- (2) immediately before using the model for a particular problem,
- (3) during real-time modeling in which the model is run frequently.

In the first situation, the potential model uses are open-ended; thus, calibration requirements are open-ended. The utility needs to determine how it expects to initially use the model so that it can define the targets for model calibration. Especially when the model is being developed outside of the water utility, it is important to clearly establish the use of the model and the metrics used to assess calibration, realizing that the more stringent the targets, the greater the resources needed to achieve them. Although it is good to have numerical calibration targets, they may need to be adjusted as the water system, utili-



It's important to understand the accuracy of gauges, meters, and transmitters to support sound decision-making.

ty's priorities, available data, budget, and hydraulic model develop.

In the second situation, the use of the model is well-understood and the extent of calibration and the nature of comparisons are clear. For example, if the model is to be used for a new subdivision on the south side of town, the model accuracy in terms of hydraulic capacity in that part of town can be evaluated by comparing the model with fire flow tests at that location.

In the third situation, the model can be almost continuously compared with data provided by a supervisory control and data acquisition (SCADA)/remote sensing system. When the model and field data diverge, there is an opportunity to understand the cause and improve

the model (or identify inaccurate sensors). These comparisons can be made only at sensors connected to the SCADA system, which may be spatially fairly sparse.

It is desirable to have numerical targets, but situations will arise for a given model in which these prove to be too stringent or too lenient once the calibration process is under way. It is difficult to develop targets before the initial attempts at calibration have been completed. The end point of calibration should be when the cost does not exceed the benefits of additional calibration.

ADJUSTMENTS TO ACHIEVE CALIBRATION

When the calibration of a model is not adequate for its intended use, adjustments must be made. It is essential that the modeler understand, before adjusting the model, why a certain parameter is being adjusted. Adjusting the wrong parameter (for example, changing pipe roughness when an incorrect elevation was the root of the problem) can result in a model that may initially look calibrated but, in other situations, will not give accurate results because it has been calibrated by compensating errors. The goal of

FIGURE 1 Steps in model development



