User's Manual for the New England Water-Use Data System (NEWUDS)

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ABSTRACT

Water is used in a variety of ways that need to be understood for effective management of water resources. Water-use activities need to be categorized and included in a database management system to understand current water uses and to provide information to water-resource management policy decisionmakers.

The New England Water-Use Data System (NEWUDS) is a complex database developed to store water-use information that allows water to be tracked from a point of water-use activity (called a "Site"), such as withdrawal from a resource (reservoir or aquifer), to a second Site, such as distribution to a user (business or irrigator). NEWUDS conceptual model consists of 10 core entities: system, owner, address, location, site, data source, resource, conveyance, transaction/rate, and alias, with tables available to store user-defined details. Three components—site (with both a From Site and a To Site), a conveyance that connects them, and a transaction/rate associated with the movement of water over a specific time interval form the core of the basic NEWUDS network model.

The most important step in correctly translating real-world water-use activities into a storable format in NEWUDS depends on choosing the appropriate sites and linking them correctly in a network to model the flow of water from the initial From Site to the final To Site. Ten water-use networks representing real-world activities are described—three withdrawal networks, three return networks, two user networks, two complex community-system networks. Ten case studies of water use, one for each network, also are included in this manual to illustrate how to compile, store, and retrieve the appropriate data.

The sequence of data entry into tables is critical because there are many foreign keys. The recommended core entity sequence is (1) system, (2) owner, (3) address, (4) location, (5) site, (6) data source, (7) resource, (8) conveyance, (9) transaction, and (10) rate; with (11) alias and (12) user-defined detail subject areas populated as needed. After each step in data entry, quality-assurance queries should be run to ensure the data are correctly entered so that it can be retrieved accurately. The point of data storage is retrieval. Several retrieval queries that focus on retrieving only relevant data to specific questions are presented in this manual as examples for the NEWUDS user.

INTRODUCTION

Water use in the broadest sense pertains to the interaction between human activity and the hydrologic cycle (Solley and others, 1998). Water use begins when water is diverted or withdrawn from surface-water or ground-water sources (fig. 1) and conveyed to a place of use. A withdrawal is made by a user or by a community-water system, which may treat the water and convey it to users through a distribution system. A public water system is defined by the U.S. Environmental Protection Agency (USEPA) as "a system for the provision to the public of water for human consumption through pipes or other constructed conveyances if such system has at least 15 service connections or regularly serves an average of at least 25 individuals."[1] A community-water system is a public water system that serves at least 15 service connections used by year-round residents of the area served by the system or regularly serves at least 25 year-round residents (U.S. Environmental Protection Agency, 1997). Community-water systems might serve towns, cities, military bases, apartment complexes, or mobile-home parks. Water use by a single user or aggregate of users (group of users in a specific geographic area) refers to water that is actually used for a specific purpose, such as for domestic use, irrigation, or industrial processing. Consumptive use refers to water that evaporates or is incorporated into a product during use. Water in a distribution system may leak back into the hydrologic system and(or) be put to public use, such as sanitation, fire fighting, or hydrant flushing. The combination of leakage and public use is called unaccounted-for water. After use, wastewater is conveyed to a wastewater treatment plant for treatment and return to a resource or is returned directly to the hydrologic system through septic systems. Wastewater in a collection system may leak back to the hydrologic system, or receive water from surface runoff (inflow) or ground water (infiltration). For a more comprehensive description of water use, see the National Handbook of Recommended Methods for Water-Data Acquisition—Chapter 11, Water Use (accessed August 30, 2002, on the World Wide Web at URL http://water.usgs.gov/pubs/chapter11/.

In many areas of New England, withdrawals of freshwater are approaching the operational capacity of developed water supplies. Local, State, and Federal agencies need data on all asp-ects of water use to develop comprehensive water-resource management plans and to make decisions regarding water-supply development and requirements for water conservation measures. Sound decisions about the development of new water supplies and the efficient use of existing supplies require current, accurate, and complete information on the path of water from points of withdrawal to points of return flow. Decisions such as whether to expand withdrawals in one area or limit them in another need to be supported by a geographic inventory of existing withdrawals, interbasin transfers, leakage, consumptive use, and returns. Water-use decisions also may affect the environment, often directly, when overuse of surface- and ground-water sources leads to reductions in streamflow and changes in habitat and biological communities, or when streamflow consists primarily of treated effluent of varying quality during part of a year. An effective water-resource management plan is contingent upon the data provided by a comprehensive water-use data program (Horn and Craft, 1991). Development and implementation of a well-planned and on-going water-use data program would allow efficient, cost-effective collection of data and generate data of known reliability. A water-use database is an essential component for any water-use data program.

In New England (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont), water-withdrawal data have been compiled and stored in a variety of ways since the 1970s. Since 1990, water-use data on all water-use activities were collected and analyzed and stored in the Site Specific Water-Use Data Systems (SWUDS) database. This database was developed by the U.S. Geological Survey's (USGS) cooperative water-use program to store and retrieve water-use data collected or compiled at the site-specific or individual-user level. The New England water-use programs needed a database that would enable data retrievals by town, so SWUDS was replaced by a series of spreadsheets that more easily accommodated this task. Beginning in 1997, the New England Districts of USGS coordinated development of the New England Water Use Data System (NEWUDS), a database that would store existing water-use data and promote efficient analysis and retrieval of water-use data in support of project activities throughout New England. An internal USGS workgroup was formed in late 1997 to develop a PC-based, stand-alone water-use data system for the USGS District offices in New England. Goals for this new database were to facilitate uniform data description and quality among the districts, provide a more flexible alternative to the optional national USGS database, be useful to employees new to water-use-data tasks, and be used for small, focused projects at the watershed scale. Workgroup members included water-use specialists from each District, an area water-use specialist, a management representative, a facilitator, and a database specialist. The workgroup discussed characteristics of water-use data, classification schemes, ancillary data, specific storage and retrieval needs for standard reporting, and the features of a system that would allow efficient and rapid examination of water-use data to provide enhanced customer service.

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[1]Federal Register, August 5, 1998, v. 63, no. 150, page 4, 1939.

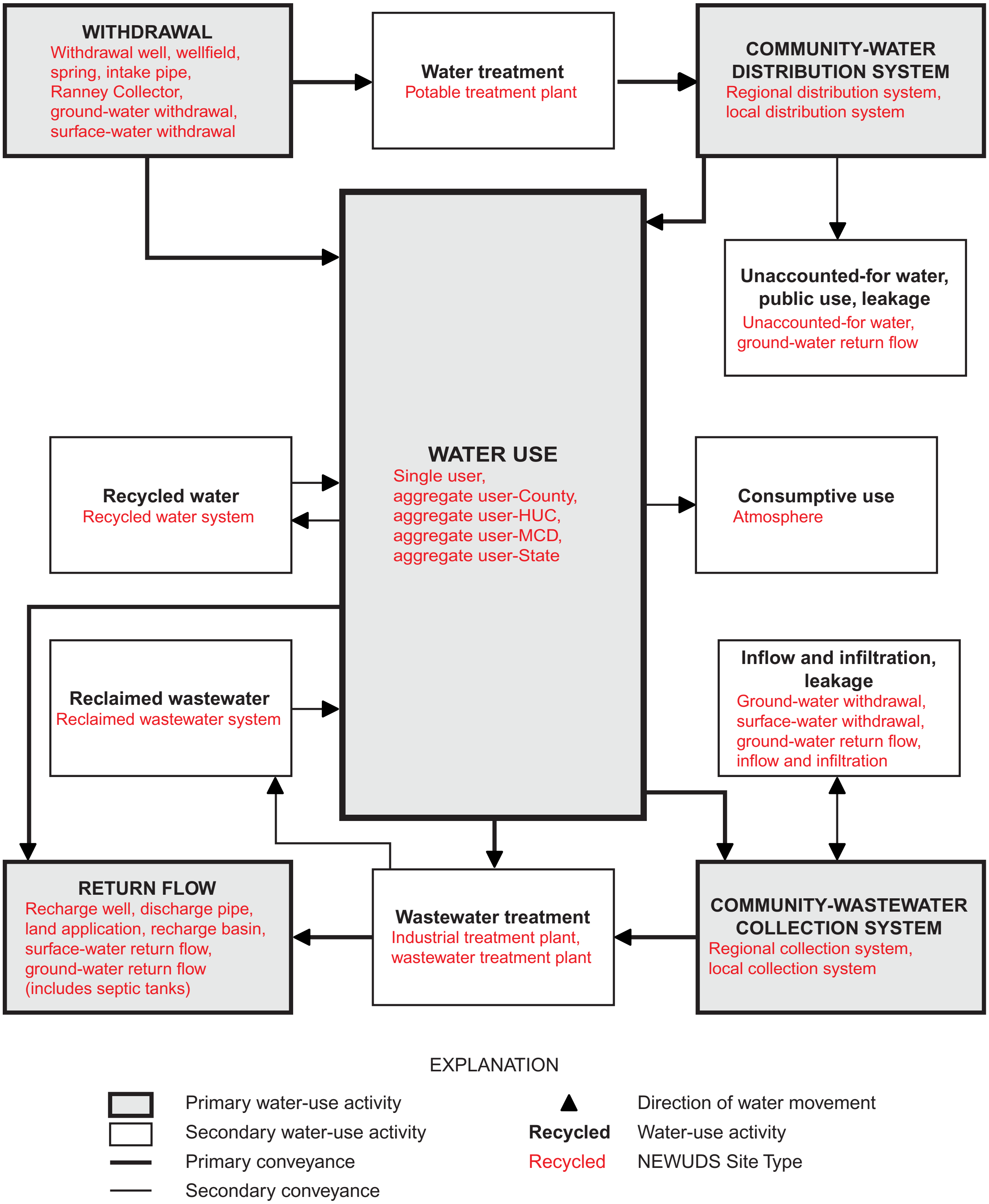

Figure 1. Flow chart showing relations between water-use activities in the New England Water-Use Data System (NEWUDS).

NEWUDS was developed to store water-use information that allows water to be tracked from a point of a water-use activity, such as withdrawal from a resource (reservoir or aquifer), to a second point of water-use activity, such as distribution to a user (business or irrigator). The links between water-use activities can start from the initial withdrawal from the resource and end with the point of final return back to a resource and can include complex interactions between multiple community-water or wastewater systems. The database was designed to accommodate data describing single users and aggregates of users by State, County, Minor Civil Division (MCD), and Hydrologic Unit Code (HUC) (basin or watershed) so that all the components of a complete watershed budget can be represented. NEWUDS has the following features.

- It is constructed from a conveyance-based data model rather than a site-based data model, thus promoting and encouraging a water network approach to water-use data storage and investigation.
- It handles water-use data for single users and aggregates of users in a single data model.
- It is implemented as a stand-alone (and portable) database in Microsoft® Access (MS Access) and therefore accessible to a large number of potential users. The design can be recreated in any other relational database management system with some modifications.
- It can be used for large projects (State and regions) and small, focused projects (such as watershed studies).
- It is fully open to customization and extension.

Throughout the remainder of this document, logical entities are denoted by capitalization (for example, Site and Owner); tables, fields and name parts are shown in italics (for example, the table *tblSite*, the field *SiteTypeCategory*, and the suffix *_ID*); example data values for fields are shown within quotes (for example, *SiteTypeCategory* = "*treatment*"); and query names are shown in boldface (for example, **qryRateUnitConversionFactor**).

Purpose and Scope

The purpose of this report is to serve as a reference for using the NEWUDS database and complement the technical documentation of the model design and its physical implementation in MS Access (Tessler, 2002). This report describes how to represent water-use activities in a form that can be completely and accurately represented in the database and subsequently retrieved to meet user needs.

A summary of the database structure is presented in the section titled "NEWUDS Conceptual Model" and is presented in terms of water-use activities. Ten water-use Networks are described to highlight how sites are identified and linked to conveyances in the database to represent different water-use activities. Procedures for entering data, including required data, data-entry sequence, and specific guidelines for entering and retrieving data into and out of NEWUDS are included in this manual. Ten case studies describing hypothetical water-use activities are given as examples of how the database can be used to describe actual activities (Appendix 1). Each case study includes a description of the activity; methods for capturing data; a completed form with case-study data; a network diagram of required sites; a diagram of Site, Conveyance, Transaction/Rate core entities, and a table of data values and fields. A glossary of water-use terms used in the database is at the beginning of this manual. Definitions of terms used in the database, such as the *SiteType* "wellfield" are provided as part of the domain-table descriptions in Appendix 2. The order of the domain-table descriptions matches that used in Tessler (2002). Data-entry forms were developed to assist in the compilation of water-use data and to track data that have been entered into the database. These forms also serve as a useful reference for ensuring that data has been correctly entered into the database. The sample forms and related worksheets are presented in Appendix 3. Detailed guidelines for entering data are critical because there is no data-entry program available yet to automatically populate the appropriate database tables from inventory forms—all data are entered individually into data tables by the user, unless the user creates their own data-entry form.

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NEWUDS CONCEPTUAL MODEL

The NEWUDS Conceptual Model describes how water-use activities can be organized and stored in a relational database. For a more complete description of the database design, refer to Tessler (2002). Conceptually, water-use activities are divided into 10 core entities in NEWUDS: System, Owner, Address, Location, Site, DataSource, Resource, Conveyance, Transaction/Rate, and Alias with tables available to store User-Defined Details. A core entity may include one or more physical tables in the database. Three components—Site, Conveyance, and Transaction/Rate (fig. 2) form the core of the basic NEWUDS network model. Two additional core entities, Location and Owner, complete the core of the data model defining the spatial representation of the water network and source of the data.

In the NEWUDS database, the place where water-use activity occurs is referred to as a Site. Examples of Sites include withdrawal wells, intake pipes, treatment plants, users (places of use), discharge pipes, distribution systems, and wastewater-collection systems. Rivers, lakes, aquifers, and other hydrologic features, termed Resources, are not considered as Sites in the database. In NEWUDS, structures such as withdrawal wells or discharge pipes, which either withdraw water from, or return water to, hydrologic features are considered Sites because they are the point at which the water-use activity begins or ends.

Any two Sites that exchange water are joined by a unidirectional Conveyance, which can be a virtual connection between Sites, or may represent an actual pipe or canal. Although distribution and wastewater-collection systems convey water, they are defined as Sites in NEWUDS. A distribution or wastewater-collection system is a focal point for many water-use activities—either system is essential for describing a community-water or wastewater system because it provides water to, or wastewater from, a specified number of people and leakage, inflow, and infiltration can occur through either system.

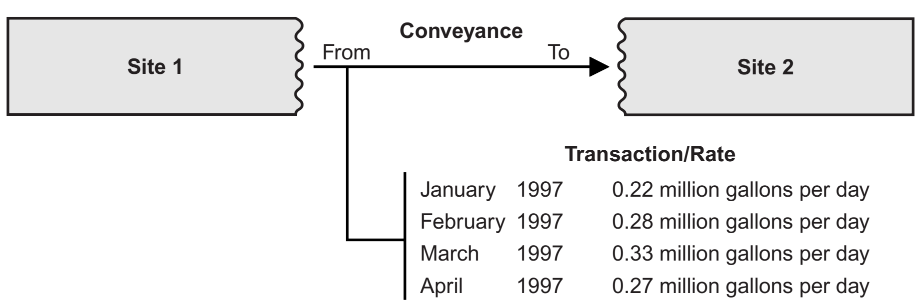

Figure 2. Basic New England Water-Use Data System (NEWUDS) network model.

Every Conveyance is associated with two Sites—a From Site and a To Site. If water moves away from a Site, the Site is called a From Site (open on right side of site box in figs. 2-12). If water moves toward a Site, the Site is called a To Site (open on left side of site box in figs. 2-12). Withdrawal wells and intake pipes are usually From Sites, whereas discharge pipes are usually To Sites. All other Sites can be From Sites or To Sites (open on left and right side of site box in figs. 2-12) depending on the water-use activity being described. Together, all Sites and their Conveyances form a water network.

A Transaction/Rate is a record of a single water-movement value reported or calculated for a specific Conveyance over a specified time interval. Each Transaction/Rate is characterized at minimum by a rate value (volume per unit time) for the water exchange, a unit of measurement, the time interval covered by the value, and the source and method for determining the value. Locations of Sites define the spatial representation of the water network, and information is stored about the Owner of each Site and source of data.

Core entities that describe Sites include System, Owner, Address, Location, Site, and Resource. These entities and the Conveyance that link the Sites form the water-use network. Once these networks are entered into the database, minimal updates will be needed. The Transaction/Rate entity is much more dynamic and will be updated every time new water-use flow values are obtained. DataSources and Aliases provide documentation of data in the database and ties to other databases. The physical implementation in NEWUDS of the 10 core entities are presented as subject areas (data tables, related tables, and supporting domain tables (Appendix 2)). These subject areas are presented in the following sections in the order in which they need to be entered in the database.

System

The System tables group Sites for water-use analysis (Appendix 2_table 8). Major types of Systems (Appendix 2_table 9) include community-water system, community-wastewater system, private, or MCD. A simple System will include all Sites owned by a single Owner, such as withdrawal wells and the facility that uses the water. Organizing data by System is a logical first step because many Sites in a System could share a single Owner, Address, and Location. A more complex System may include all of the Sites related to a community-water system, such as withdrawal wells, intake pipes, treatment plant, and the local distribution system.

Initially, Systems may be identified to organize information for data entry under a common Owner, Address, or Location. After the Sites have been entered, they may be combined into Systems through an association table. During data analysis, it may be useful to associate or relate many Sites under one System. For example, the community-water system Sites (withdrawal wells, intake pipes, treatment plant, and the local distribution system) can be combined with all the major users on that System. To estimate water-use demand, all users (single and aggregate) in an MCD could be associated with an MCD System composed of all the users in that geographic area. All the Sites related to a community-wastewater system in the MCD served could be included. A Site can be part of any number of Systems.

Owner

An Owner controls and maintains Sites and may be associated with Conveyances. An Owner also can serve as a source of data. An Owner can “own” one or more Sites. For example, a community-water system can own just a local distribution system, but may also own several withdrawal wells, intakes, pipes a treatment plant, and a regional distribution system. Owners can be part of a larger ownership organization. For example, an energy company may own several plants leased to local operators. The energy company would be a parent Owner of the local operators. An *OwnerType* (Appendix 2_table 36) can be a person, organization, municipality, or government agency. The *tblOwner* table includes contact information for the Owner and is linked through an association table with street and mailing addresses.

When an Owner is a source for data, many of the same rules apply. The U.S. Environmental Protection Agency (USEPA) is the Owner for Permit Compliance System (PCS) and Safe Drinking Water Information System (SDWIS) data. The USGS is the Owner for data estimated by staff. The New Hampshire Department of Environmental Services is the Owner for data reported to them by community-water systems. The community-water system is the Owner of data supplied directly to staff entering the data into NEWUDS.

Address

Address contains mailing and street addresses for Owners and contacts and street addresses for Sites. For codes, see Appendix 2_table 35.

Location

The spatial Location of each Site is defined by a scale term (point or area) (Appendix 2_table 25) and an optional latitude and longitude (actual point or centroid). The method used to determine the Location, such as “Centroid of County” (center point), “topographic map”, or “unknown” (Appendix 2_table 26) also is stored. Location information provides a spatial reference that can be linked with a geographic information system (GIS). Each Location links to tables with geopolitical attributes (State, County, and MCD; Appendix 2_tables 29, 30, and 31, respectively) as well as HUC (Seaber and others, 1987, Appendix 2_table 27) and any defined State Basin Code (SBC, Appendix 2_table 28). The *tblLocation* table is linked to the HUC and SBC tables through association tables because a Location, especially an aggregate Location, may include more than one HUC or SBC. It is not recommended that aggregates of County/HUC pieces be stored in NEWUDS because there are more efficient ways to summarize County/HUC pieces outside of NEWUDS. For example, data aggregated by County can be apportioned by HUC in a spreadsheet.

Site

A Site is a point or area where a water-use activity occurs, either as a source or destination, or both. Each object that can be named as a source or target of water movement is called a Site. Sites are characterized by type and use and include contact information, as well as links to other major data tables. *SiteTypes* are identified and defined in Appendix 2_table 3. There are six *SiteTypeCategories*: atmosphere, resource interactor, transfer, treatment plant, unaccounted-for water, and user. *SiteTypeCategories* are identified and defined in Appendix 2_table 1.

Resource interactor Sites interact with the hydrologic system or resource. Fourteen types of resource interactor Sites include eight types of withdrawals: ground-water withdrawal, wellfield, withdrawal well, spring, surface-water withdrawal, intake pipe, Ranney Collector, and inflow and infiltration (into wastewater systems). There are six types of return flow or discharge—recharge well, ground-water return flow, land application, recharge basin, discharge pipe, and surface-water return flow. The atmosphere *SiteTypeCategory* is used for consumptive use, which can occur as evaporation from an irrigated field, or through product incorporation at a bottling plant. The irrigation field and the bottling plant are From Sites and the To Site has the *SiteTypeCategory* of atmosphere.

The Transfer *SiteTypeCategory* Sites receive, contain, and distribute water to or from users. Transfer Sites include six types—regional and local distribution systems, regional and local wastewater-collection systems, reclaimed wastewater (from a wastewater treatment plant), and recycled water systems (within a single user).

The treatment plant *SiteTypeCategory* Sites receive either (1) water from resource interactor *SiteTypeCategory* Sites, treat it, and release it to transfer or user *SiteTypeCategory* Sites or (2) wastewater from transfer or user *SiteTypeCategory* Sites, treat it, and release to resource interactor, atmosphere, or transfer *SiteTypeCategory* Sites if the wastewater is recycled. *SiteTypes* for treatment plant *SiteTypeCategory* Sites include potable, industrial, and wastewater.

User *SiteTypeCategory* Sites are Sites where water is actually used. This can be either a single user Site or aggregate of users Site for a geographic area, such as a MCD, County, HUC (basin), or State. Public use is in this category; however, unaccounted-for water [the combination of public use and ground-water return flow (leakage)] is a separate *SiteTypeCategory*.

There are 12 subdivisions of *SiteTypeCategory*, called Subcategories, which are identified and defined in Appendix 2_table 2. The *SiteTypeCategory* and *SiteTypeSubcategory* make it easier to group sites for retrieval. For example, the *SiteTypeCategory* for resource interactor could be substituted in a retrieval query instead of listing all 14 types of resource interactors. If, however, information on only ground-water resource interactors are needed, the *SiteTypeSubcategory* could be used to separate ground-water from surface-water resource interactors.

There are four *UseType* tables associated with the Site subject area. Table *tdsUSGSUseType* (Appendix 2_table 4) corresponds to the categories used in the 5-year National Water-Use Compilations. Table *tdsNEUseType* (Appendix 2_table 5) is based on use categories used in New England that correspond to median values of water-use coefficients developed by Planning and Management Consultants, Limited, through application of the IWR-MAIN model to associate Standard Industrial Classification (SIC) code and employee population. Table *tdsSIC* (Appendix 2_table 6) incorporates the 4-digit SIC codes developed by the Department of Commerce. The North American Industrial Classification System (NAICS) code in table *tdsNAICS* (Appendix 2_table 7) was developed in 1997 and uses three to six digits.

The last three tables in the Site subject area, *tadSiteDetail* (no domain table), *tdxSiteDetailCategory* (Appendix 2_table 10) and *tdxSiteDetailLabel* (Appendix 2_table 11), are User-Defined Details that provide flexible storage for data elements related to a specific Site. Data that can be stored in these tables include population served, number of employees, count of livestock, irrigated acres, or kilowatt-hours generated.

Storage tanks, pumping stations, and interconnections between community-water systems are not considered Sites in NEWUDS. The volume of water stored in storage tanks continually increases and decreases so no single Rate value can represent a monthly or annual activity. Pumping stations are considered as part of a Conveyance that moves water either between resource interactor or transfer Sites, and interconnections are considered part of the Conveyance that moves water between transfer Sites.

DataSources

DataSource tables document the source of information for Transactions, Alias, Site-quantity (population served, acres irrigated), and Resource data. These tables are defined as needed by the database user and an example domain table is provided in Appendix 2_table 37. Examples of how these tables are used are provided in the section titled “Data Entry Sequence.”

Resource

Resource tables contain information on the aquifers and surface-water bodies from which water is withdrawn or returned. The Resource table contains a list of specific resources that are defined by the database user. Each Resource in the table is described by *ResourceType* (Appendix 2_table 32)—ground water or surface water, fresh or saline water, and *WaterBodyType* (Appendix 2_table 33). The Resource is connected to resource interactor Sites through an association table. Additional information on the Resource, such as reservoir surface area, in acres, or August median flow, can be stored in the User-Defined *tdsResourceDetail* table and *tdxResourceDetailLabel* table (Appendix 2_table 34). There is no domain table in Appendix 2 because *tdsResourceDetail* table is defined by the database user.

Conveyance

Two Sites that transfer water are joined by a unidirectional Conveyance. This Conveyance can be through a pipe, canal, aqueduct, conduit, truck, combination, or simply a virtual representation of the connection between Sites (Appendix 2_table 12). A single Site can have multiple Conveyances. All the Sites and their Conveyances form a water network. There are 172 *ConveyanceActions* (Appendix 2_table 15) that connect a specific *SiteType* to another specific *SiteType* and represent the general actions of withdrawal, distribution, use, collection, treatment, return flow, recycling, infiltration, inflow, leakage, consumptive use, and conveyance loss. The large number of *ConveyanceActions* available in the database identify a variety of acceptable specific water movements. For example, water moving directly from a resource interactor Site to a local distribution system can be distinguished from water that is treated before it enters a local distribution system. The *ConveyanceActions* are grouped into 25 categories (Appendix 2_table 14) that combine similar Site-to-Site Conveyances. For example, the *ConveyanceActionCategory* "withdrawal distribution" combines all Conveyances from withdrawal wells, wellfields, springs, Ranney collectors, intake pipes, ground-water withdrawal, and surface-water withdrawal to local and regional distribution systems. Additional information about a Conveyance, such as miles in the aqueduct system or pipe diameter in inches, can be stored in the User-Defined *tadConveyanceDetail* table and *tdxConveyanceDetailLabel* table (Appendix 2_table 13). There is no domain table in Appendix 2 because *tadConveyanceDetail* table is defined by the database user.

Transaction/Rate

A Transaction/Rate stores the quantity of water that moves through a Conveyance over a specific time interval. The Conveyance identification number (ID), *TimeInterval* (Appendix 2_table 20), effective date, and ending date are contained in the *tblTransaction* table. The default Rate value, in million gallons per day, which is entered through a query from the Rate table, is also contained in the *tblTransaction* table. Transaction information is linked to the Rate table that adds information on the method of Rate measurement or estimation, measurement unit, source, and the Rate value, in original units.

Data are entered and stored in the *tblRate* table in its original format (decimal and significant figures) and *RateUnit* (for example, cubic feet per second, Appendix 2_table 19). If the *RateUnit* represents a unit that has not been entered into *tdxRateUnit* table, a new *RateUnit* can be entered by combining the decimal component (Appendix 2_table 16), volume component (Appendix 2_table 17) and time component (Appendix 2_table 18) and executing the **qryRateUnitUpdateALLUnitPhraseAndMGDConversion** update query. Data in the *tblRate* table are converted to the common unit, million gallons per day, and entered in the *tblTransaction* table through the **qryRateUpdateAllRateValues** update query.

The DataSource tables are used again to record the source of the Rate value. A *tdxStaff* table (Appendix 2_table 21) defined by the database user provides the foreign key for the staff who entered the Rate data. Data on the accuracy or precision of the Rate can be stored in the *tadRateDetail* table and *tdxRateDetailLabel* table (Appendix 2_table 22). The *tadRateDetail* table is defined by the database user and, therefore, does not have a domain table in Appendix 2.

The Rate table may have more than one record associated with a single Transaction if different methods were used to determine those Rates. Rates that are determined by meters, field estimates, coefficient estimates, reports, permits, or a guess (Appendix 2_table 24) will each have a separate record in the *tdxRateMethod* table. This feature is particularly useful when comparing results from different methods. For example, reported data from an uncalibrated meter can be compared against values calculated from coefficients to characterize the accuracy of the reported data. Rate methods are grouped into major method type in the *tdxRateMethodCategory* table (Appendix 2_table 23).

Alias

The Alias tables allow multiple reference IDs for Sites, Conveyances, and Resources to be stored. An Alias can be used to easily cross-reference data in NEWUDS with data in other databases. Examples of other databases include USEPA National Pollutant Discharge Elimination System (NPDES) permit numbers, USEPA Public Water Supply (PWSID) identification numbers, State reference numbers, project numbers, station names, Ground-Water-Site Inventory (GWSI) *Site_IDs*, and National Hydrography Data (NHD) numbers. Examples of how data is entered into the Alias tables are provided in the "Data Entry Sequence" section of this manual and an example of the *tdxAliasLabel* table is provided in Appendix 2_table 38.

User-Defined Detail

The User-Defined-Detail tables provide storage for previously undefined attributes for Sites, Resources, Conveyances, and Rates. These tables allow flexibility in storing specific kinds of information that may be needed for specific *SiteTypes* such as "population served," or previously undefined fields, such as Site "Activity Status."

MODELING WATER-USE ACTIVITIES

For a database to contain useful information on water-use activities, the user has to be able to translate what occurs in the real world into a form that can be uniformly stored and retrieved in a database management system. The most important step in correctly translating real-world water-use activities into a storable format in NEWUDS is to choose the appropriate Sites and link them correctly to model the flow of water from the initial From Site to the final To Site. Figure 3 illustrates steps in the transition from (step 1) an observation of a well and user (photograph) to (step 2) creation of a schematic diagram representing the water-use activity to (step 3) selection of the network diagram that identifies the Sites needed to represent the water-use activity to (step 4) entering data into the tables in the NEWUDS database. This section describes step 3: the Network models that can be used to translate a variety of water-use activities accurately into the database. The section titled "Data Entry Sequence" describes step 4: how to enter data into the correct tables.

The four major types of Network models—withdrawal, return, user, and complex community system—are described in this section and illustrate how to chose the appropriate *SiteTypes* and properly link them to represent specific water-use activities. The database user may develop additional Network models if the water-use activity is more complex or customization is needed. The four major types of Network models are further divided into 10 specific Network models. Each of the 10 models include a diagram of the Network and a brief discussion of its capabilities and limitations. Case studies for each of the 10 Network models (Appendix 1) were developed to help the database user choose the appropriate network and consistently enter data on a variety of water-use activities.

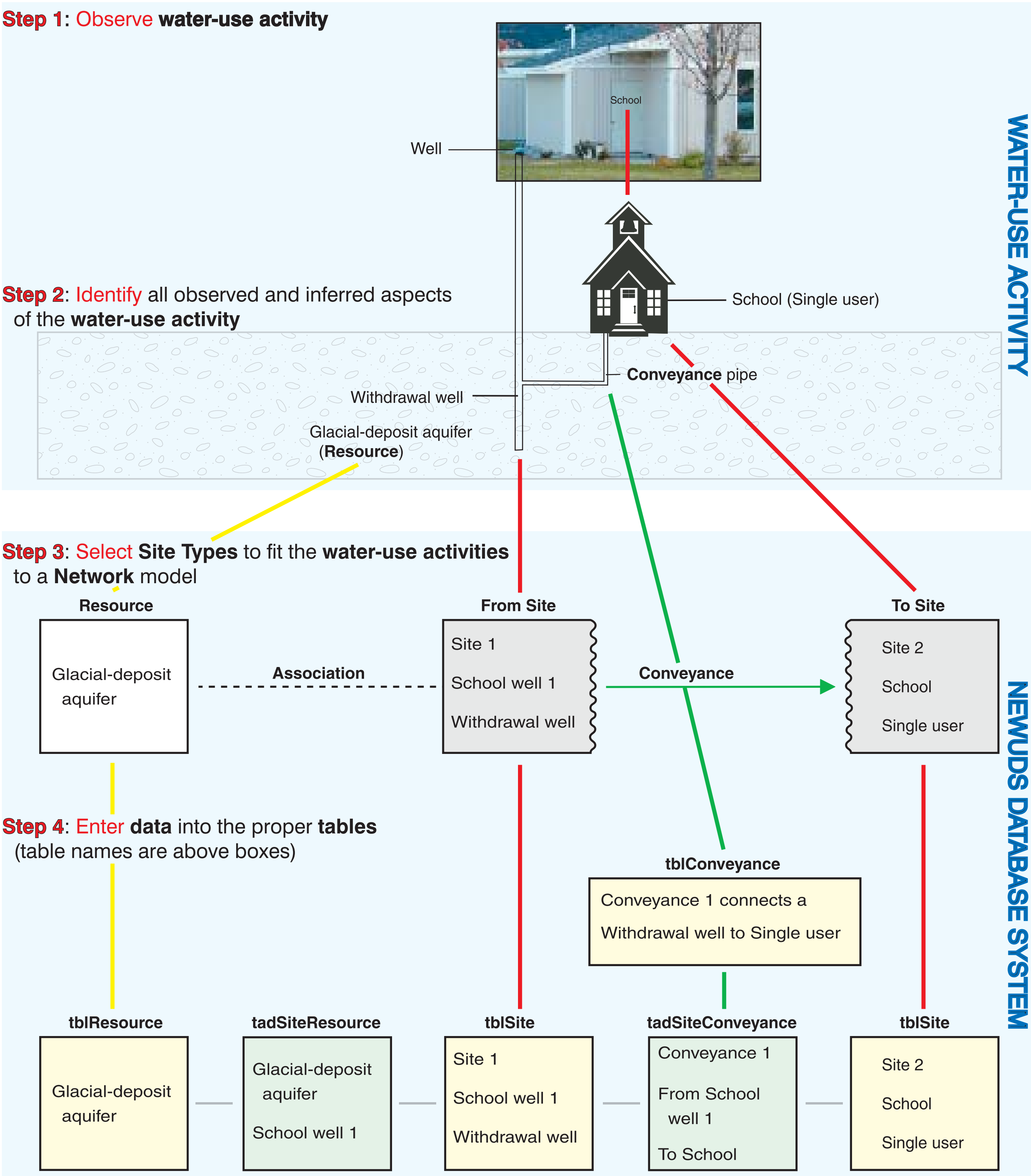

Figure 3. Four steps for translating observed water-use activity into the New England Water-Use Data System (NEWUDS).

Withdrawal Networks

There are three basic withdrawal Network models: single user, aggregate of users, and simple community-water system (fig. 4). Specific *SiteTypes* identify which water-use activity is being modeled. Network 1 models withdrawals that convey water from any resource interactor withdrawal Site to a single user Site or local distribution system Site. Network 2 models withdrawals by aggregates of users (HUC, County, MCD, or State level). Network 3 models withdrawals and distribution by simple community-water systems.

Withdrawal and Use by a Single User (Network 1)

The simplest network, Network 1 (fig. 5), links any resource interactor withdrawal Site to a single user Site usually a major user of self-supplied water. An example of Network 1 is provided in Case Study 1 in Appendix 1. A major user is defined based on the Rate of use that is significant (1-5 percent of the water budget) or as defined by the State allocation permit or registration program. A Site record is needed for the user's place of use, such as a factory or field and for each of the user's withdrawal wells, wellfields, springs, intake pipes, and Ranney Collectors. If information is not available on the user's withdrawal Sites, the *SiteType* of either ground-water withdrawal or surface-water withdrawal is used. The withdrawal Sites, which are resource interactors, are associated with the Resource—the aquifer or surface-water body from which water is withdrawn. The withdrawal Sites are linked to a single user Site through a Conveyance record. A community-water system can be modeled in Network 1 by having the withdrawal Sites connected to a local distribution system Site instead of a single user Site.

If database entries are limited to only Network-1-type entries, withdrawal summaries will include only withdrawals by major single users and community-water systems, ignoring withdrawals by minor users. This limitation would not include any domestic withdrawals, which are minor users, because any large domestic user (more than 25 people) is considered a community-water system (see Glossary). Summaries of water **use** by use category (such as domestic or industrial) will be much smaller than summaries of **withdrawals** because users who are on community-water systems are not entered into the database and, therefore, will not be included in a retrieval of use.

Withdrawal and Use by an Aggregate of Users (Network 2)

Network 2 (fig. 6) links withdrawals by an aggregate of users by geographic area with ground-water withdrawal and surface-water withdrawal Sites. An aggregate of users can include both major and minor users. If Network 1 is used for major single users of self-supplied water, then Network 2 would include aggregates of minor users of self-supplied water. NEWUDS can handle four types of geographic-area aggregate of users: State, County, HUC, or MCD. An example of Network 2 is provided in Case Study 2 (Appendix 1) along with a suggested method for estimating aggregated water use.

A summary of all withdrawals and a large portion of use will result by combining withdrawals by major single users (Network 1) with estimates of withdrawals by aggregates of minor users (Network 2) in NEWUDS. Users supplied by community-water systems are not included in this Network.

Withdrawal and Distribution by a Simple Community-Water System (Network 3)

Network 3 (fig. 7) provides a second method for entering information on community-water systems into NEWUDS. Network 1 provided for entry of withdrawals by community-water systems by linking the withdrawal Sites to a local distribution system Site. Network 1 does not provide for entry of data on treatment; distribution to domestic, commercial, and industrial users; or unaccounted-for water. Network 3 links withdrawal Sites with either the local distribution system Site or a potable treatment plant Site. The local distribution system Site can be linked to single user Sites and to aggregate user-MCD Sites for domestic, commercial, and industrial users. Network 3 also can store an estimate for either unaccounted-for water or for leakage and public use. The diagram in figure 7 shows how the unaccounted-for water Site is used as a To Site from the local distribution system Site. If there were sufficient data to estimate leakage and public use, the local distribution system would be linked to a ground-water

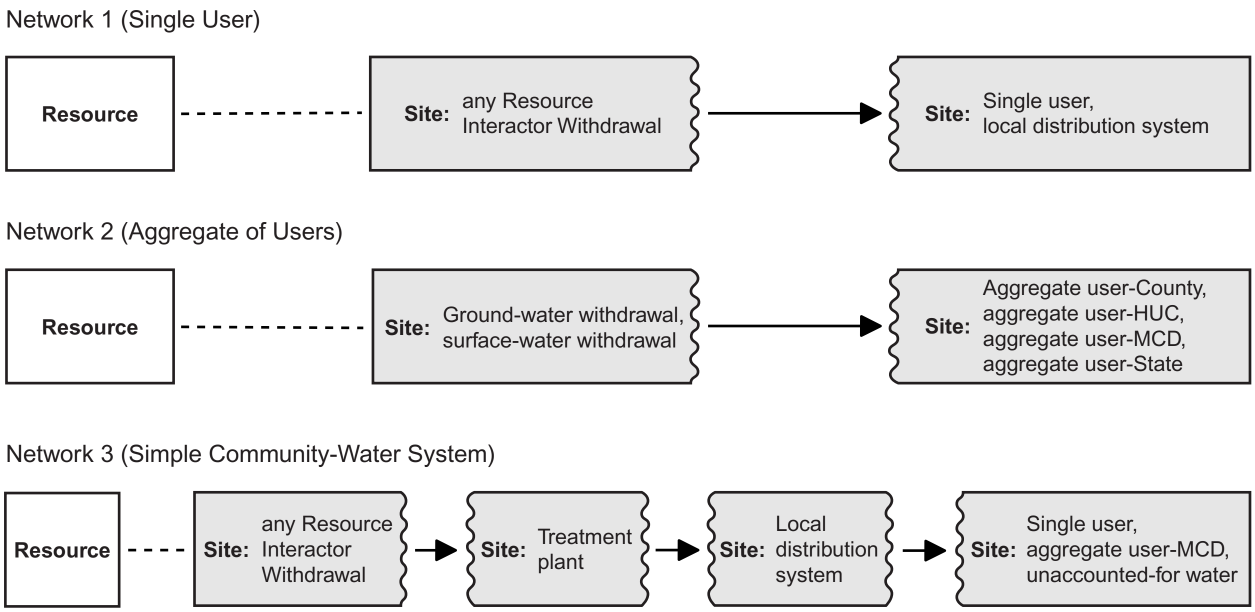

Figure 4. Withdrawal Network models 1, 2, and 3. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

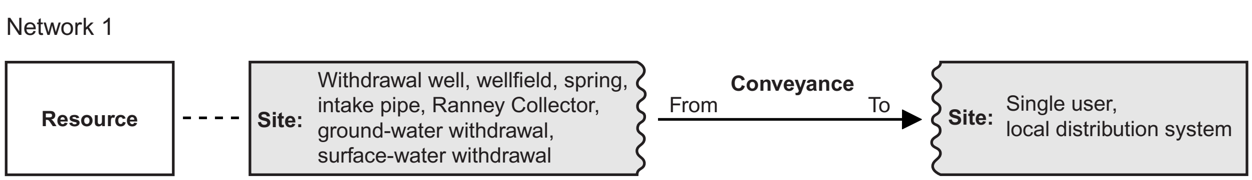

Figure 5. Network 1: Diagram for modeling withdrawal and use by a single user. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

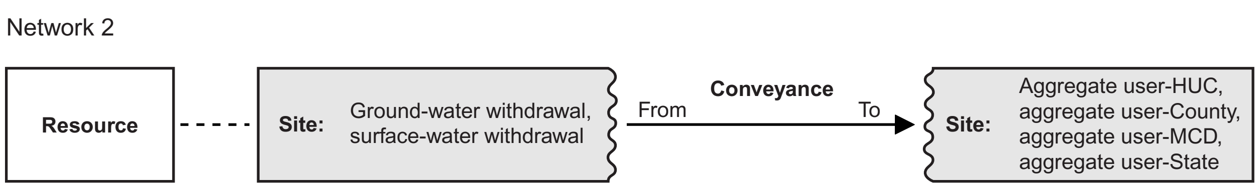

Figure 6. Network 2: Diagram for modeling withdrawal and use by an aggregate of users. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

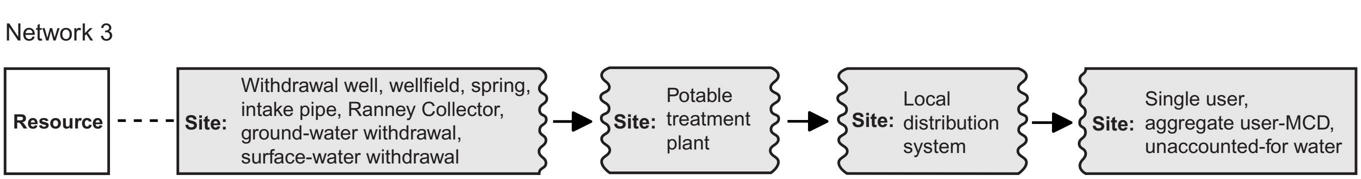

Figure 7. Network 3: Diagram for modeling withdrawal and distribution by a simple community-water system with single users, aggregates of users, and unaccounted-for water. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

return flow Site to represent leakage, and the local distribution system Site would be linked to an aggregate user-MCD Site with a NEUseCode (Appendix 2_table 5) of 85 for public use. An example of Network 3 is provided in Case Study 3 in Appendix 1 along with a spreadsheet (Appendix 3_Forms 4a-b and 5) that can be used to record and estimate community-water system data on withdrawal and distribution.

The methods for data compilation and retrievals for Networks 1-3 are summarized in table 1 using data from Case Studies 1-4 as an example of the water-use data each Network provides. Network 1 data on withdrawal by single users (in this example, major users of self-supplied water) including community-water systems, are combined with Network 2 estimates of aggregate commercial, industrial, and domestic use. Major users can be identified on the basis of meter readings and their rates of use subtracted from use by aggregates of users to determine use by aggregates of minor users. Unaccounted-for water can be estimated as the difference between community-water system withdrawal and distribution to users. By combining Networks 1-3, total withdrawal and total use by category can be estimated. A link then is established between the sources of supply and the population served directly by its community-water system. Networks 1-3, however, do not allow tracking of water sold between community-water systems and do not link multi-reservoir supply systems.

Table 1. Processes for compiling data for Networks 1 through 3 and related retrievals using Case Studies 1-3

[No., number; Mgal/d, million gallons per day; CWS, community-water system; MSS, major self-supplied user; x, multiplied by; %, percent]

Network No. and Case Study	Process of data compilation	Summary (Mgal/d)	Description of use	Water use (Mgal/d)
Network 1	Withdrawal and Use by a Single User using Data from Case Studies 1,3, and 4			
	Identify major users and obtain data on withdrawals		CWS1	80.0
			MSS1	3.0
			MSS2	2.0
	Summarize withdrawal	85.0	(Community-water systems = 80; Industrial = 5)	
	Summarize use	5.0	Industrial use (Community-water system is not "use")	
Network 2	Withdrawal and Use by an Aggregate of Users using Data from Case Studies 2 and 3			
	Determine total commercial and industrial use		Total commercial use =	6.5
			Total industrial use =	25.0
	Determine total domestic use		Total population (924,000) x per capita use (65 gallons/day/person)	60.0
	Determine use by minor users by category		Total commercial use – withdrawals and use by major commercial users = use by major users of community-supplied water	6.5
			Total industrial use – withdrawals and use by major industrial users = use by major users of community-supplied water	20.0
			Total domestic use =	60.0
	Obtain percent of population not on community-water systems (self supplied)		20%	
	Determine withdrawals and use by minor users by use category		Use by minor commercial users (6.5) x 20%	1.3
			Use by minor industrial users (20.0) x 20%	4.0
			Use by minor domestic users (60.0) x 20%	12.0
	Summarize withdrawal	102.3	(Community-water system = 80 Mgal/d; Commercial = 1.3 Mgal/d; Industrial = 9.0 Mgal/d (4 + 5); Domestic = 12 Mgal/d)	
	Summarize use	22.3	(Community-water system is not "use")	
Network 3	Withdrawal and Distribution by a Simple Community-water System using Data from Case Study 3			
	Determine use by major and minor users of community-supplied water by use category		Total commercial use – withdrawals by commercial users =	5.2
			Total industrial use – withdrawals by industrial users =	16.0
			Total domestic use – withdrawals by domestic users =	48.0
	Identify major users of community-supplied water and adjust aggregate use		Total use by commercial users of community-supplied water – use by major commercial users of community-supplied water =	5.2
			Total use by industrial users of community-supplied water – use by major industrial users of community-supplied water =	16.0
	Determine unaccounted-for water		Community-water system withdrawal – Community-water system distribution to users =	10.8
	Summarize withdrawal	102.3	(Community-water system = 80 Mgal/d; Commercial = 1.3 Mgal/d; Industrial = 9.0 Mgal/d (4 + 5); Domestic = 12 Mgal/d)	
	Summarize use	91.5	Commercial = 6.5 Mgal/d; Industrial = 25.0 Mgal/d; Domestic = 60.0 Mgal/d	
	Summarize conveyances	10.8	Unaccounted for water	

Return Networks

There are three basic return Network models: single user, aggregate of users, and simple community-wastewater system (fig. 8). Specific *SiteTypes* identify which water-use activity is being modeled. Network 4 models return that convey water from a single user Site or wastewater treatment plant Site to any resource interactor return Site. Network 5 models return by aggregates of users (County, HUC, MCD, or State level). Network 6 models wastewater collection, treatment, and return by simple community-wastewater systems.

Use and Return by a Single User (Network 4)

The simplest network, Network 4 (fig. 9), links a single user Site to any resource interactor return Site. The single user Site usually is a user with direct returns. An example of Network 4 is provided in Case Study 4 in Appendix 1. A major user is defined based on the Rate of use that is significant (1-5 percent of the water budget) or as defined by the State allocation permit or registration program. A Site record is needed for the user's place of use, such as a factory or field and for each of the user's recharge wells, recharge basins, and discharge pipes. If no information is available on the user's return Sites, the *SiteType* of either ground-water return flow or surface-water return flow is used. The return Sites, which are resource interactors, are associated with the Resource—the aquifer or surface-water body to which water is returned. The single user Site also may be linked with an atmosphere Site to represent consumptive use. The single user Site is linked to the return and atmosphere Sites through a Conveyance record. A community-wastewater system can be modeled in Network 4 by having the return Sites connected to a wastewater treatment plant Site instead of a single user Site.

If database entries are limited to only Network-4-type entries, return summaries will include only direct returns by major single users and community-wastewater systems, and ignore returns by minor users such as through septic systems. This limitation would not include domestic returns, which are minor users. Summaries of water **use** by use category will be much smaller than summaries of **return** because users who are on wastewater-collection systems (sewers) are not entered into the database and, therefore, will not be included in a retrieval of use.

Use and Return by an Aggregate of Users (Network 5)

Network 5 (fig. 10) links return by an aggregate of users by geographic area with ground-water withdrawal and surface-water return Sites. An aggregate of users can include both major and minor users. If Network 4 is used for major users with direct returns to the Resource, then Network 5 would include aggregates of minor users that return wastewater directly to the Resource. NEWUDS can handle four types of geographic-area aggregate of users: State, County, HUC, or MCD. An example of Network 5 is provided in Case Study 5 (Appendix 1) along with a suggested method for estimating aggregated water use.

A summary of all returns and a large portion of use will result by combining direct return by major single users (Network 4) with estimates of direct return by aggregates of minor users (Network 5) in NEWUDS. Users who release wastewater into community-wastewater systems are not included in this network.

Collection and Return by a Simple Community-Wastewater System (Network 6)

Network 6 (fig. 11) provides a second method for entering information on community-wastewater systems into NEWUDS. Network 4 provided for entry of direct returns by community-wastewater system by linking the return Sites to a wastewater treatment plant Site. Network 4 does not provide for entry of data on wastewater treatment; collection from domestic, commercial, and industrial users; or inflow and infiltration. Network 6 links the wastewater treatment plant Sites with the local collection system Site, which in turn can be linked to single user Sites and to aggregate user-MCD Sites for domestic, commercial, and industrial users. Network 6 also can store an estimate for inflow and infiltration. How the inflow and infiltration Site is used as a From Site to the local collection system Site is shown in figure 11. If there were sufficient data to estimate inflow and infiltration separately, the local collection system would be linked to a surface-water withdrawal Site to represent inflow and a ground-water withdrawal Site to represent infiltration. An example of Network 6 is provided in Case Study 6 in Appendix 1 along with spreadsheets (Appendix 3_Forms 4a-b and 7) that can be used to record and estimate community-wastewater system data on collection and return.

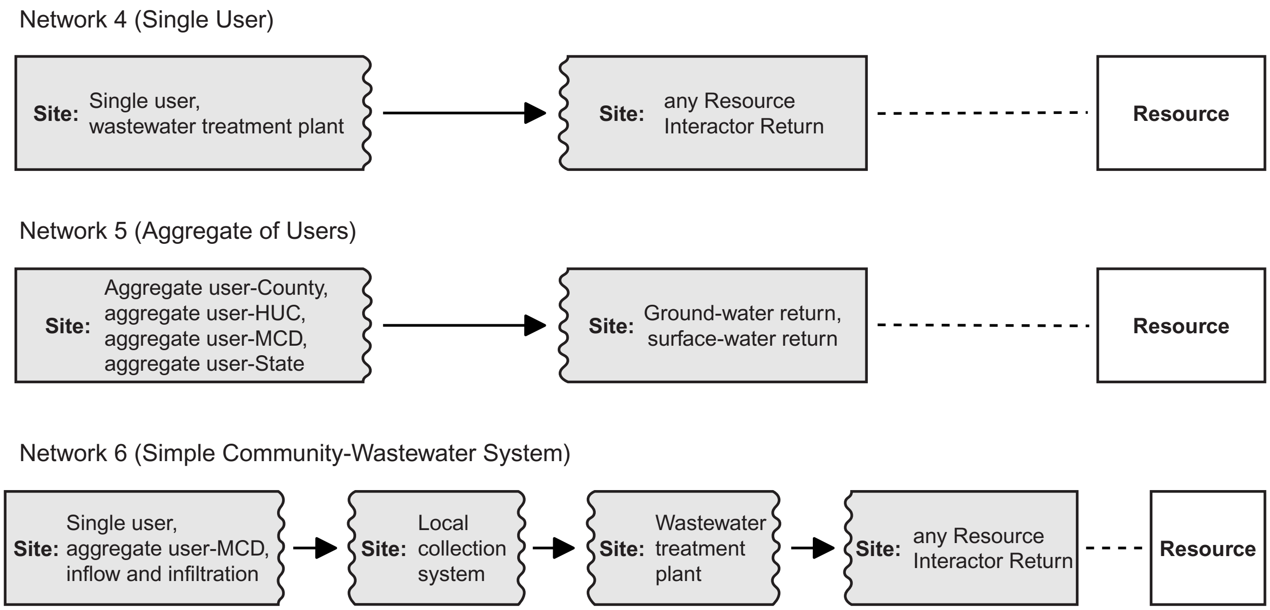

Figure 8. Return Network models 4, 5, and 6. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

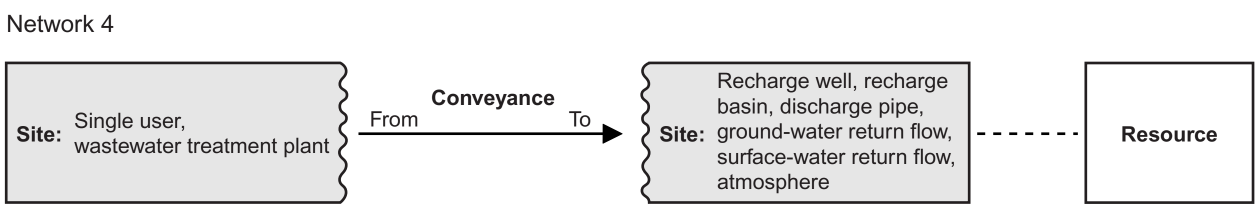

Figure 9. Network 4: Diagram for modeling use and return by a single user. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

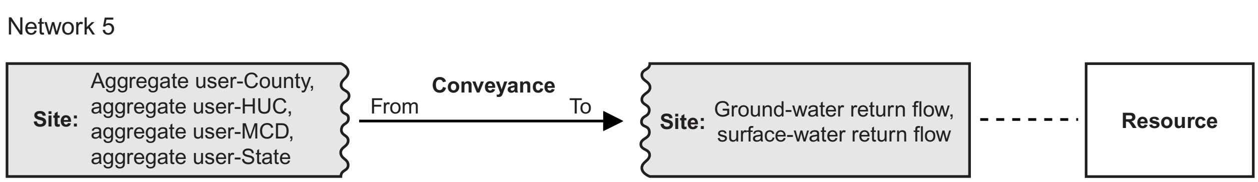

Figure 10. Network 5: Diagram for modeling use and return by an aggregate of users. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

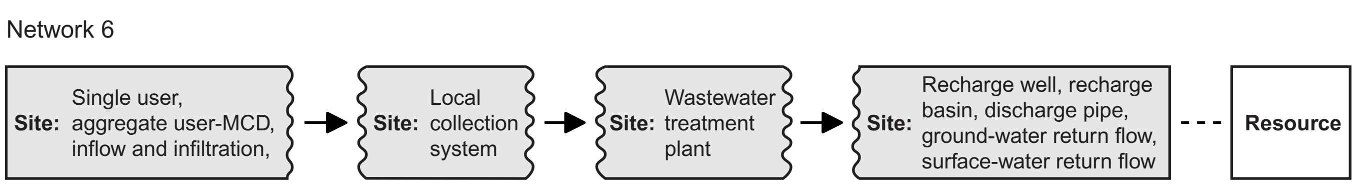

Figure 11. Network 6: Diagram for modeling collection and return by a simple community-wastewater system with single users, aggregates of users, and inflow and infiltration. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

The methods for data compilation and retrievals for Network 4-6 are summarized in table 2 using data from the case studies as an example of the water-use data each Network provides. Network 4 data on direct return by single users, (in this example, major users) including community-wastewater systems, are combined with Network 5 estimates of aggregate commercial, industrial, and domestic use. Major users can be identified on the basis of meter readings and their rates of use subtracted from use by aggregates of users to determine use by aggregates of minor users. Consumptive use can be estimated as 10 percent for commercial and industrial use and 15 percent for domestic use. Inflow and infiltration can be estimated as the difference between estimated discharge to sewers from users and volume received at the wastewater treatment plant. By combining Networks 4-6, total return and total use by category can be estimated. A link is then established between the population served by its community-wastewater system and the resources receiving the wastewater. Networks 4-6, however, do not allow tracking of water transferred between community-wastewater systems.

Table 2. Processes for compiling data for Networks 4 through 6 and related retrievals using Case Studies 4 through 6

Network No. and Case Study	Process of data compilation	Summary (Mgal/d)	Description of use	Water use (Mgal/d)
Network 4	Use and Return by a Single User using Data from Case Studies 4, 6, and 7			
	Identify major users and obtain data on returns		WTP1 =	110.0
			MSS1 use 3.0 Mgal/d – 1 Mgal/d consumptive use =	2.0
			MSS2 use 2.0 Mgal/d – 1 Mgal/d consumptive use =	1.0
	Summarize return	113.0	(Wastewater treatment plant = 110; Industrial = 3)	
	Summarize use	5.0	Industrial use (wastewater treatment is not "use")	
Network 5	Use and Return by an Aggregate of Users using Data from Case Studies 5 and 6			
	Determine total commercial and industrial use		Total commercial use =	6.5
			Total industrial use =	25.0
	Determine total domestic use		Total population (924,000) x per capita use (65 gal/d/person)	60.0
	Determine use by minor users by category		Total commercial use – use by major commercial users =	6.5
			Total industrial use – use by major industrial users =	20.0
			Total domestic use	60.0
	Obtain percent of population not on sewers (self returned)		30%	
	Determine consumptive use by minor users by category		Use by minor commercial users (6.5) x 10% =	0.6
			Use by minor industrial users (20.0) x 10% =	2.0
			Use by domestic users (60.0) x 15% =	9.0
	Determine direct returns by minor users by category		Returns through community-wastewater systems and direct returns by minor commercial users (use – consumptive use) (6.5-0.6) x 30% =	1.8
			Returns through community-wastewater systems and direct returns and direct returns by minor industrial users (use – consumptive use) (20.0-2.0) x 30% =	5.4
			Returns through community-wastewater systems and direct returns by domestic users (use – consumptive use) (60.0-9.0) x 30% =	15.3
	Summarize return	136.0	(Community-wastewater treatment plants = 110 Mgal/d; Commercial = 1.3 Mgal/d; Industrial = 8.4 Mgal/d (5.4 + 3); Domestic = 15.3 Mgal/d)	
	Summarize use	26.0	(Wastewater treatment is not "use")	
Network 6	Collection and Return by a Simple Community-Wastewater System using Data from Case Study 6			
	Determine returns through community-wastewater system by major and minor users by category		Total commercial use – consumptive use – direct commercial returns =	4.1
			Total industrial use – consumptive use – direct industrial returns =	12.6
			Total domestic use – consumptive use – direct domestic returns =	35.7
	Identify major users who return wastewater through community systems and adjust aggregate use		Total commercial returns through community-wastewater systems – major commercial user returns through community-wastewater systems =	4.1
			Total industrial returns through community-wastewater systems –major industrial user returns through community-wastewater systems =	12.6
	Determine leakage or inflow and infiltration		Wastewater plant returns – community-wastewater collection from users =	57.6
	Summarize return	136.0	(Wastewater plant = 110 Mgal/d; Commercial = 1.8 Mgal/d; Industrial = 8.4 Mgal/d; Domestic=15.3 Mgal/d)	
	Summarize use	91.5	Commercial = 6.5 Mgal/d; Industrial = 25.0 Mgal/d; Domestic = 60.0 Mgal/d	
	Summarize conveyances	11.8	Consumptive use	
		56.3	Inflow and infiltration	

User Networks

There are two basic user Networks—simple user, and complex user (fig. 12). Specific *SiteTypes* identify which water-use activity is being modeled. Network 7 models simple user networks where water is conveyed from any resource interactor withdrawal Site and its associated Resource to a single user or aggregate of users Site and from the single user or aggregate of users Site to any resource interactor return Site and its associated Resource. Network 8 models complex users where water is conveyed from any resource interactor withdrawal Site and its associated Resource **and** a local distribution system Site to single user Site or aggregate of users Site and from the single or aggregate of users Sites to any resource interactor return Site and its associated Resource **and** local collection system Site.

Withdrawal, Use, and Return by a Simple User (Network 7)

Network 7 (fig. 13) links any resource interactor withdrawal Site to a single user or an aggregate of users Site, which also are linked to any resource interactor return Site. An example of Network 7 is provided in Case Study 7 in Appendix 1. Most basic water-use programs focus on either withdrawals or returns. Greater flexibility in retrievals is gained when withdrawals, use, and returns by users are linked. Network 7 combines Network-1 and Network-2 data on self-supplied users with Network-4 and Network-5 data on self-returned users by linking through the user.

The link from withdrawal through return is particularly useful when data are obtained from different sources, such as discharge data from USEPA's Permit Compliance System (PCS) database and withdrawal data from a State's water-allocation program. The data sets can be compared, the accuracy evaluated, major discrepancies investigated, and consumptive-use values determined. Network 7 does not allow for water distribution to users from community-water systems or wastewater collection by community-wastewater systems. Only aggregates of users that do not include community-water or wastewater systems can use Network 7; therefore, irrigation (except those including golf courses), livestock, and mining use Sites and any domestic, commercial, and industrial use Sites that are in areas not served by community-water or wastewater system can use this model.

Withdrawal, Distribution from a Community-Water System, Use, Collection to a Community-Wastewater System, and Return by a Complex User (Network 8)

Network 8 (fig. 14) models complex user Networks that link withdrawal from a Resource and distribution from a community-water system to single users and aggregate of users and collection to a community-wastewater system and direct return to a Resource. In addition, users who have their own wastewater treatment plant that either directly discharge wastewater to Resources or into local collection system Sites can be modeled in Network 8. Finally, users who recycle water can add the recycled water-system Site. Network 8 includes a greater proportion of withdrawal, use, and return because the model incorporates distribution through a community-water system and collection through a community-wastewater system. Network 8 can be used to verify that all users who use community-water systems or who are sewered and have their own direct returns have been entered completely. Network 8 essentially will be used if Networks 1-3 and Networks 4-6 are completed linking major users and aggregated minor users to both their From Sites and To Sites so that a complete inventory of all users, community-water systems, and community-wastewater systems in the geographic area of interest is created. Network 8 will work well only for community-water systems that do not sell or buy water with other community-water systems. An example of Network 8 is provided in Case Study 8 in Appendix 1.

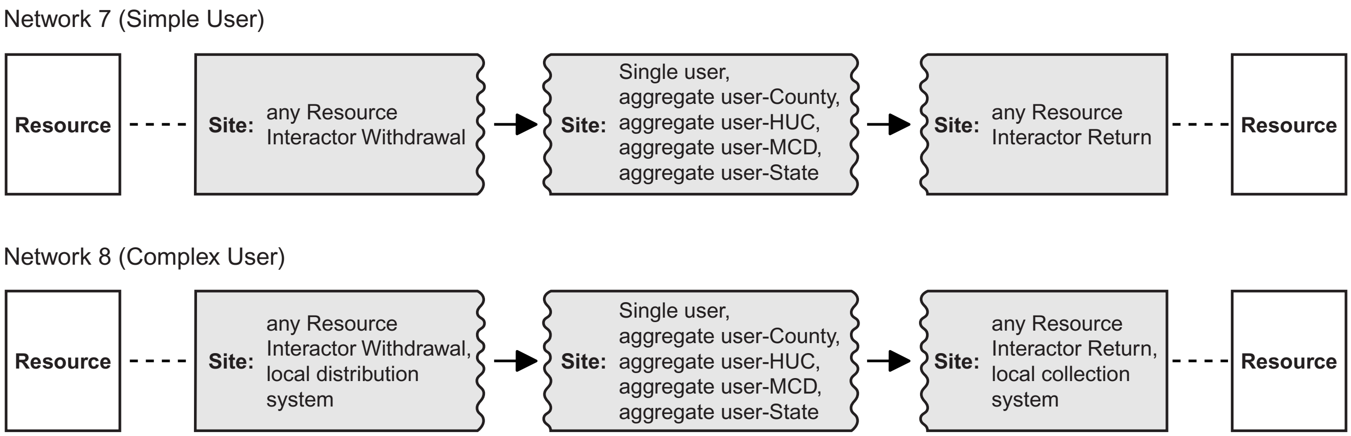

Figure 12. Diagrams for user network models 7 and 8. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

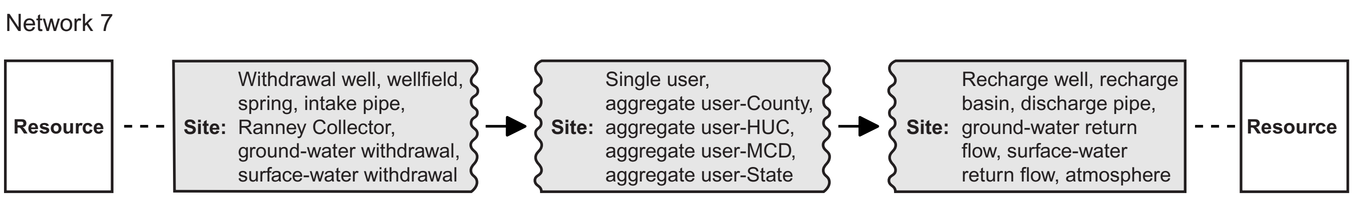

Figure 13. Network 7: Diagram for modeling withdrawal, use, and return by a single user or an aggregate of users. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

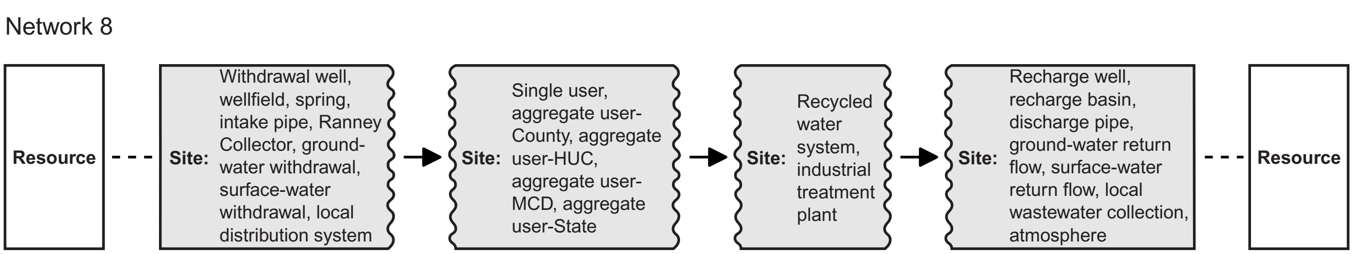

Figure 14. Network 8: Diagram for modeling withdrawal, distribution from a community-water system, use, collection to a community-wastewater system, and return by a complex single user or aggregate of users. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

Complex Community System Networks

There are two basic complex community system Networks: complex community-water system Networks and complex community-wastewater system Networks. Specific *SiteTypes* identify which water-use activity is being modeled. Network 9 models complex community-water system networks where water is conveyed from any resource interactor withdrawal Site through regional and local distribution systems Sites to single users or aggregate of users Sites and to unaccounted-for water Site or a ground-water return-flow Site for leakage. Network 10 models complex community-wastewater system networks where water is conveyed from single users or aggregate of users Sites through regional and local collection system Sites, to a wastewater treatment plant Site, to any resource interactor return Site. In addition, leakage is modeled from the local collection Site to a ground-water return flow Site and inflow and infiltration is modeled from a withdrawal resource interactor Site to the local collection system Site.

Withdrawal and Regional and Local Distribution by a Complex Community-Water System (Network 9)

If time and resources are available, Network 9 can reflect the actual complexity of regional community-water systems. Network 9 (fig. 15) can track wholesale deliveries (to other community-water systems) and retail deliveries (to their own customers). In NEWUDS, a regional distribution system conveys water to other regional or local distribution systems and(or) conveys water to more than one MCD. A local distribution system may receive water or have it’s own sources, but distributes water only within one MCD. There is no public use in regional distribution systems, only leakage. An example of Network 9 is provided in Case Study 9 in Appendix 1. The purpose of Network 9 is to track buying and selling between community-water systems. The links provide for analysis of population-served values and per capita use for conservation planning and predicting future demands. Network 9 also provides a comprehensive link between sources of supply and users (primarily for quality analysis).

Community-water systems may convey water between reservoirs before it is withdrawn for treatment and distribution. Network 9a (fig. 16) diagrams how to model Conveyances between Resources, usually reservoirs, through a series of withdrawals and returns. As will be discussed in the section titled “Entering or Transferring Data into NEWUDS,” a *ConveyanceAction* code will prevent double-accounting these withdrawals and returns.

Regional and Local Collection and Return by a Complex Community-Wastewater System (Network 10)

If time and resources are available, Network 10 can reflect the actual complexity of regional community-wastewater systems. Network 10 (fig. 17) can track regional collection from other community-wastewater systems, as well as local collection from their own customers. In NEWUDS, a regional collection system conveys water from other regional or local collection systems and(or) conveys water from more than one MCD. An example of Network 10 is provided in Case Study 10 in Appendix 1. The purpose of Network 10 is to track transfers between wastewater-collection systems. The links provide for analysis of per capita use and population served for conservation planning and predicting future demands. Network 10 also provides a comprehensive link between users and their releases (primarily for quality analysis).

The methods for data compilation and retrievals for Networks 7-10 are summarized in table 3 using data from Case Studies 7-10 to illustrate the part of water-use data each Network provides. Network 7 combines data on withdrawals to use (Network 1) and from use to returns (Network 3). Networks 8-10 incorporate the following data from community-water and wastewater systems: Network 8 models community-water and self-supplied sources of water for the user (Network 3) and community-wastewater and self-disposed destinations (Network 6). Network 9 models a more complex version of Network 3 that incorporates Conveyance of water between community-water systems (buying and selling). Network 10 models a more complex version of Model 6 that incorporates Conveyance of wastewater between community-wastewater systems.

Most distribution systems are developed within political boundaries and most collection systems are developed within basin boundaries. Interbasin transfers occur when withdrawal sources are outside the basin where the distribution system is located and when the distribution system includes more than one basin in the distribution area that are served by different collection systems. These interbasin transfers can be modeled by dividing a distribution system into local distribution systems that are bounded by basin divides. A more comprehensive discussion is found in Horn (2000).

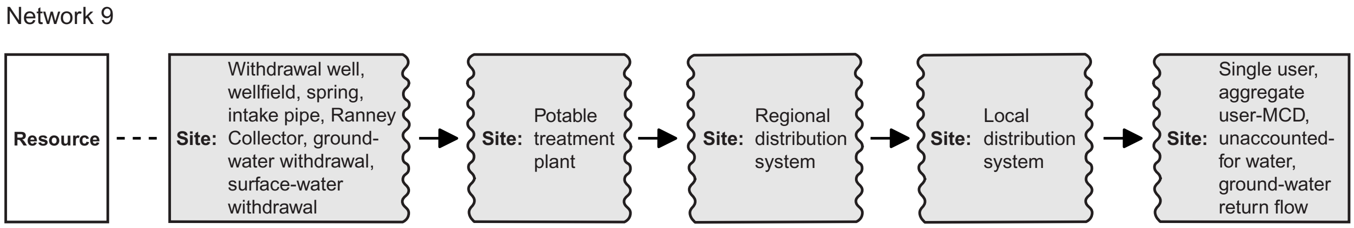

Figure 15. Network 9: Diagram for modeling withdrawal and regional and local distribution by a complex community-water system with single users, aggregates of users, and unaccounted-for water. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

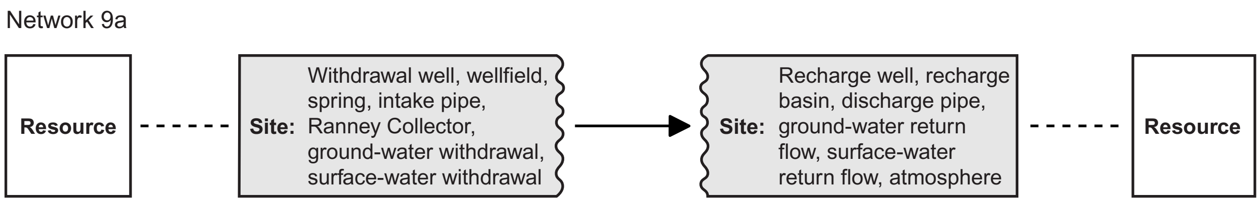

Figure 16. Network 9a: Diagram for modeling transfer between resources, generally reservoirs, used by community-water systems before potable water treatment and distribution. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

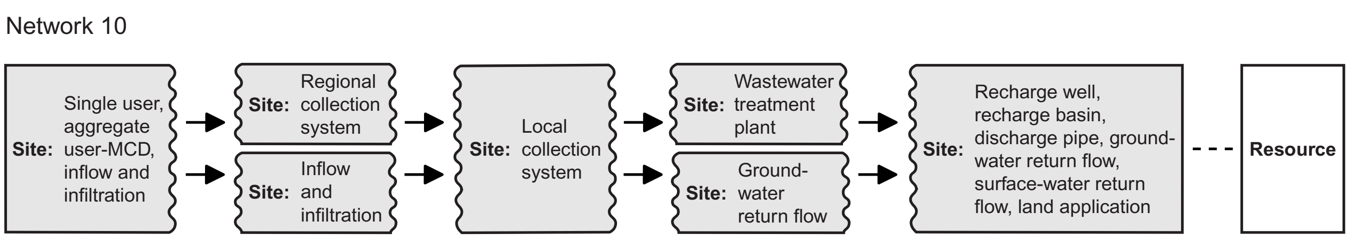

Figure 17. Network 10: Diagram for modeling regional and local collection and return by a complex community-wastewater system with single users, aggregates of users, and inflow and infiltration. (Dotted line represents a Site-Resource association, solid line represents a conveyance, and an arrowhead shows the direction of water movement.)

Table 3. Processes for compiling data for Networks 7 through 10 and related retrievals using Case Studies 7-10

[Note: Data from tables 1 and 2 are carried over to table 3. No., number; Mgal/d, million gallons per day; MSS, major self-supplied user; CU, consumptive use; x, multiplied by; %, percent]

Network No. and Case Study	Process of data compilation	Summary (Mgal/d)	Description of use	Water use (Mgal/d)
Network 7	Withdrawal, Use, and Return by a Simple User using Data from Case Studies 7 and 4			
	Identify major users and obtain data on withdrawals and returns		MSS1 withdrawals and use 3.0 Mgal/d – CU 1 Mgal/d =	2.0
			MSS2 withdrawals and use 2.0 Mgal/d – CU 1 Mgal/d =	1.0
	Summarize withdrawals	5.0	Industrial withdrawals	
	Summarize use	5.0	Industrial use	
	Summarize returns	3.0	Industrial returns	
	Summarize conveyance	2.0	Industrial consumptive use	
Networks 8-10	Withdrawal, Regional and Local Distribution, Use, Regional and Local Collection, and Return by a Complex User, Community-Water System, and Community-Wastewater System using Data from Case Studies 2, 3, 5, 6, 7, 8, 9, and 10			
	Determine total commercial, industrial, and domestic use (**Network 2**)		Total commercial use =	6.5
			Total industrial use =	25.0
			Total domestic use =	60.0
	Determine use of community-supplied water by category (**Network 3**)		Use of commercial users of community-supplied water =	5.2
			Use by industrial users of community-supplied water =	16.0
			Use by domestic users of community-supplied water =	48.0
	Determine withdrawals by category (**Network 2**)		Withdrawals by commercial users =	1.3
			Withdrawals by industrial users =	9.0
			Withdrawals by domestic users =	12.0
	Determine consumptive use for minor users (**Network 5**)		Commercial use (6.5) x 10% =	0.6
			Industrial use (20.0) x 10% =	2.0
			Domestic use (60.0) x 15% =	9.0
	Determine returns through community-wastewater systems by category (**Network 6**)		Returns through community-wastewater systems by commercial users =	4.1
			Returns through community-wastewater systems by industrial users =	12.6
			Returns through community-wastewater systems by domestic users =	35.7
	Determine direct returns by category (**Network 5**)		Direct returns by commercial users =	1.8
			Direct returns by industrial users =	5.4
			Direct returns by domestic users =	15.3
	Check To Sites		Check that all users are a To Site from community water system and(or) their own sources	
	Check From Sites		Check that all users are a From Site to wastewater collection and(or) their own returns	
	Summarize withdrawals	102.3	Network 1 and Network 2	
	Summarize use	91.5	Network 2	
	Summarize returns	136.0	Network 4 and Network 5	
	Summarize conveyances	10.8	Unaccounted-for water (**Network 3**)	
		11.6	Consumptive use (**Network 5**)	
		57.6	Leakage or inflow and infiltration (**Network 6**)	

ENTERING OR TRANSFERRING DATA INTO NEWUDS

Procedures for entering data into NEWUDS, including identifying required data and a data-entry sequence, and providing specific guidelines for entering and retrieving data are presented in this section. Currently (2002), NEWUDS does not have a program to automatically populate the tables from an inventory-type form. As a consequence, a thorough understanding of the actual NEWUDS table structure in MS Access is required for data entry.

NEWUDS is a complex water-use database with 62 tables consisting of 10 core entities: System, Owner, Address, Location, Site, DataSource, Resource, Conveyance, Transaction/Rate, and Alias, with tables available to store User-Defined Details. A list of tables in NEWUDS and the required and optional data elements for each table are provided in table 4. To facilitate identification of the function of different tables in the database, five distinct types of tables are defined by a three-letter prefix applied to the table name: *tbl* – basic data tables that contain primary data entered into the database; *tds* – static domain tables that contain a "list" of classification or descriptive items that are used by other tables; *tdx* – user-extendable domain tables that provide a "list" for the user to add data elements as needed; *tas* – simple association table that resolves "many-to-many" relations between two or more tables; *tad* – association table with data that resolves "many-to-many" relations between two or more tables and contains data. The reader is referred to Tessler (2002, p. 14-17) for a more detailed description of table types.

Required Data Set

NEWUDS can store detailed information about water use, but only requires 30 unique data elements in 10 tables per record to be able to retrieve Rate data (25 in 9 tables if the Resource has been previously entered). There are only seven *tbl* tables that require data for each record with a Transaction/Rate (after data-entry staff and source have been entered; two tables, *tblAlias* and *tblAddress* are optional) with three *tas* or *tad* tables to link them (seven *tas* and five *tad* tables relate optional tables). All of the 24 tables with a *tds* prefix are already populated (have data entered). Of the 14 tables with a *tdx* prefix, 8 pertain to auxiliary optional data, 4 are already populated, and only 2 require data entry—one for staff entering data and the other for the source of the data.

As few as 10 data elements are sufficient to provide the basic information needed to generate the 7 unique reference identification numbers, 13 unique data elements, and 12 repeated data elements using Network 1 (table 5). A hypothetical example of how 10 data elements provided by a State agency can yield the remaining required data elements is as follows: New Hampshire State information indicates that John Brown pumped 100 thousand acre-feet from his irrigation well during 1995. These 10 data elements, listed as Provided data (because they are provided to the data-entry staff) in table 5, are used to generate an additional 32 data elements, for a total of 42 data elements that are required to record this information.

Data Compilation

The data needed to populate NEWUDS may be available in another database, from publications, project files, or are collected directly in the field. Data collected in the field can be organized according to the Input Forms found in Appendix 3, which includes Form 1 for Single Users, Form 3 for Aggregate of Users, Form 6 for Community-Water Systems, Form 8 for Community-Wastewater Systems, and Form 9 for Transaction/ Rates Data. Compiling these data on paper forms is useful for tracking the data already available and identifying missing data. The forms provide a means for data verification and for tracking the various IDs required for the association tables. A series of worksheet forms, also provided in Appendix 3, include Form 2 for developing estimates of aggregate of users water use, Form 4 for developing geographic-area-based estimates of community-water and wastewater systems, and Form 5 for summarizing Form 4 data by community-water system.

Table 4. List of tables and required or optional data elements in NEWUDS

[ID, identification number; *, required table; MCD, Minor Civil Division; HUC, Hydrologic Unit Code; SIC, Standard Industrial Classification; NAICS, North American Industrial Classification System; NEUse, New England Use Code; MGD, million gallons per day; Water Note: the table design view in the MS Access database also provides information on whether a data field is optional or required]

Data table name	Related domain table name	Required data elements	Optional data elements
tdxSystem		*System_ ID (generated)*	*ParentSystem_ID*
	tdxSystemType	*SystemType_ ID*	*SystemMemo*
		SystemName	
***tblOwner**		*Owner_ID (generated)*	*ParentOwner_ID*
	tdsOwnerType	*OwnerType_ ID*	*OwnerContact*
		OwnerName	*OwnerPhone*
			OwnerMemo
tblAddress		*Address_ID (generated)*	*AddressLine 1*
	tdsAddressType	*AddressType_ID*	*AddressLine 2*
		City	*ZipCode*
		StateAbbrv	*AddressMemo*
		CountryAbbrv	
tasOwnerAddress		*Owner_ID*	
		Address_ID	
***tblLocation**		*Location_ID (generated)*	*LocationName*
	tdsLocationScale	*LocationScale_ID*	*LocationLatitude*
	tdxLocationDetMethod	*LocationDetMethod_ID*	*LocationLongitude*
	tdsState	*State_ID*	
	tdsCounty	*County_ID*	
	tdsMCD	*MCD_ID*	
			LocationMemo
***tadLocationHUC**	**tdsHUC**	*Location_ID*	
		HUC_ID	
tadLocationStateBasin	**tdsStateBasin**	*Location_ID*	
		StateBasin_ID	
***tblSite**	**tdsSICUseType**	*Site_ID (generated)*	*SIC_ID*
	tdsNAICSUseType	*Location_ID*	*NAICS_ID*
	tdsUSGSUseType	*Owner_ID*	*SiteContact*
	tdsSiteType	*SiteType_ID*	*SiteMemo*
	tdsNEUseType	*NEUseType_ID*	
	tdsSiteTypeCategory	*SiteName*	
	tdsSiteTypeSubcategory		
tdxDataSource		*DataSource_ID (generated)*	*DataSourceMemo*
		Owner_ID	
		DataSource	
tasSiteAddress		*Site_ID*	
		Address_ID	
tasSiteAlias		*Site_ID*	
		Alias_ID	
tasSystemSite		*System_ID*	
		Site_ID	
tadSiteDetail		*Site_ID*	*SiteDetailEndingDate*
		SiteDetailEffectiveDate	*SiteDetailMemo*
		SiteDetailLabel_ID	
		DataSource_ID	
	tdsTimeInterval	*TimeInterval_ID*	
		SiteDetailValue	
tdxSiteDetailLabel		*SiteDetailLabel_ID (generated)*	*SiteDetailLabelMemo*
	tdxSiteDetail Category	*SiteDetailCategory_ID*	
		SiteDetailLabel	
		IsNumbericDetail	
		SiteDetailUnit	

Table 4. List of tables and required or optional data elements in NEWUDS--Continued

[ID, identification number; *, required table; MCD, Minor Civil Division; HUC, Hydrologic Unit Code; SIC, Standard Industrial Classification; NAICS, North American Industrial Classification System; NEUse, New England Use Code; MGD, million gallons per day; Water Note: the table design view in the MS Access database also provides information on whether a data field is optional or required]

Data table name	Related domain table name	Required data elements	Optional data elements
***tblResource**		*Resource_ID (generated)*	*ResourceCodeName*
	tdsWaterbodyType	*WaterbodyType*	*ResourceMemo*
	tdsResourceType		
		ResourceName	
tadResourceDetail		*Resource_ID*	*ResourceDetailMemo*
	tdxResourceDetailLabel	*ResourceDetailLabel_ID*	
	tdxDataSource	*DataSource_ID*	
		ResourceDetail	
tasResourceAlias		*Resource_ID*	
		Alias_ID	
***tadSiteResource**		*Site_ID*	*ConnectionCount*
		Resource_ID	
tdxAliasLabel		*AliasLabel_ID*	*AliasLabelMemo*
	tdxDataSource	*DataSource_ID*	
		AliasSource	
		AliasLabel	
***tblConveyance**		*Conveyance_ID (generated)*	*ConveyanceName*
	tdsConveyanceType	*ConveyanceType_ID*	*ConveyanceMemo*
	tdsConveyanceAction	*ConveyanceAction_ID*	
	tdsConveyanceActionCategory		
tadConveyanceDetail		*Conveyance_ID*	*ConveyanceDetailMemo*
	tdxConveyanceDetailLabel	*ConveyanceDetailLabel_ID*	
		ConveyanceDetail	
tasConveyanceOwner		*Conveyance_ID*	
		Owner_ID	
***tadSiteConveyance**		*Conveyance_ID*	
		FromOrTo	
		Site_ID	
tasConveyanceAlias		*Conveyance_ID*	
		Alias_ID	
***tblTransaction**		*Transaction_ID (generated)*	*Rate(MGD) (generated)*
		Conveyance_ID	*TransactionMemo*
		TimeInterval_ID	
		TransactionEffectiveDate	
		TransactionEndingDate	
***tblRate**		*Rate_ID (generated)*	*RateMemo*
		Transaction_ID	
	tdxStaff	*Staff_ID*	
		DataSource_ID	
	tdxRateMethod	*RateMethod_ID*	
	tdxRateMethodCategory	*RawRateValue*	
	tdxRateUnit	*RateUnit_ID*	
		IsDefaultRate	
tadRateDetail		*Rate_ID*	*RateDetailMemo*
	tdxRateDetailLabel	*RateDetailLabel_ID*	
		RateDetail	
tblAlias		*Alias_ID (generated)*	*AliasMemo*
	tdxAliasLabel	*AliasLabel_ID*	
		AliasValue	

Table 5. Data elements required for a sample record with Transaction/Rate data

[ID, identification number; 3, red numbers preceding entries indicate order data is entered into NEWUDS; (1), number in parenthesis is ID number for field; *, Field identification number; **Data value already entered at least once before; NEUse, New England Water Use; DEP, as in Department of Environmental Protection; (y), default value for field is yes]

Provided data	Data selected from *tds* or *tdx* tables	Generated IDs	NEWUDS table
1 John Brown (*Owner*)	2 *Owner Type:* Private (1)	3* *Owner_ID*	**tblOwner**
	4 *Method used to determine location:* Unknown (1)	6* *Location_ID*	**tblLocation**
	5 *Location Scale:* Point (1)		
9 Well #1 (*Site Name*)	10 *Site Type:* Well (3)	7** *Location_ID* 8** *Owner_ID* 11* *Site_ID* (for well)	**tblSite**
12 *NEUse Type:* Irrigation (1)			
15 Field #1 (*Site Name*)	16 *Site Type:* Single user (20) 17 *NEUse Type:* Irrigation (1)	13** *Location_ID* 14** *Owner_ID* 18* *Site_ID* (for field)	
	19** *Resource_ID:* Unknown ground water (703)	20** *Site_ID* (for well)	**tadSiteResource**
	21 *Conveyance type:* Virtual (6)	23* *Conveyance_ID*	**tblConveyance**
	22 *Conveyance action:* Well to single user (39)		
	25 *From Site* (well)	24** *Conveyance_ID* 26** *Site_ID* (for well)	**tadSiteConveyance**
	28 *To Site* (field)	27** *Conveyance_ID* 29** *Site_ID* (for field)	
31 *Time interval:* Year (2)		30** *Conveyance_ID*	**tblTransaction**
32 *Effective date* (1/1/95)		34* *Transaction_ID*	
33 *Ending date* (12/31/95)			
36 *Data Source:* DEP (6)	37 *Staff:* Horn (2)	35** *Transaction_ID*	**tblRate**
38 *Rate Unit:* Thousand acre-feet/year (11)	39 *Rate Method:* Unknown reported (4)	42* *Rate_ID*	
40 *Raw Rate Value:* 100	41 *Is Default* (y)		

The most effective method for data entry is to transfer data sets into general (as opposed to table-specific) MS Excel spreadsheets and import the data set into a MS Access table. Once the table is in MS Access, Make-table, Append, and Update queries can be used to separate the data into the appropriate tables. Although it is possible to import data sets directly into MS Access from a variety of formats, some data types, especially data that appear as numbers but are actually reference IDs, such as HUC “01070002”, will lose the leading “0”. If these data are imported from MS Excel, the data type can be specified as text so that the leading “0” is retained. Although the heading/field names do not need to match the MS Access field names at this point, the spreadsheet should have only one row containing the heading/field names.

NEWUDS can be implemented by developing a linked database or “Front End” to prevent changes to the design of the database while allowing data entry and retrievals. The integrity of the database may be damaged and retrieval results invalidated if the design is changed in any of the NEWUDS tables.

Data Entry Sequence

Many of the tables in NEWUDS, like the Site table, include ID reference numbers of other tables (called foreign keys in MS Access), such as *Location_ID* and *Owner_ID*. These reference ID numbers need to be populated as primary keys in *tblLocation* and *tblOwner* tables before the *tblSite* table can be populated; therefore, the MS Access tables need to be populated in a specific order. The order for entering data into tables and their associated domain tables is summarized in figure 18. There is some flexibility in the order of data entry, but tables that provide primary keys to other tables as foreign keys need to be populated first. Even though *tds* tables are fully populated and *tdx* tables are partially populated, the user can add additional records. The case studies provided in Appendix 1 show detailed examples of how data can be entered into NEWUDS.

Create Systems

Systems are created to group Sites into meaningful units. For example, it’s useful to be able to retrieve all Sites owned or associated with a specific community-water system. Such a System may include withdrawal well, intake pipe, treatment plant, and local and regional distribution system Sites. To identify all customers of a community-water system, all single user and aggregate user-MCD Sites of the community-water system and other community-water systems purchasing water from the first community-water system would be included as part of the System, regardless of where the customers live. To identify the sources of supply for all of users in a particular town, the System would include all single user and aggregate user-MCD Sites in a specific MCD, regardless of which community-water system they were customers or if they used self-supplied water. Systems can be used to include a variety of Sites for analysis and a Site can be included in more than one System. The input forms in Appendix 3 are organized by System. Entering data into the System subject area is only recommended, not required.

There are two tables are in the System subject area (fig. 19). To create a System in NEWUDS, determine if the desired *SystemType* has been defined in the first table, *tdxSystemType* (Appendix 2_table 9); if not, add the new *SystemType* to the table. The *SystemType_ID* will automatically be assigned to the new *SystemType*. Then enter the *SystemType_ID* and *SystemName* to the second table, *tdxSystem* (Appendix 2_table 8). The *System_ID* will be automatically assigned. The step of identifying which Sites belong to the System will be done after the Sites have been entered into NEWUDS.

Establish Ownership and Address

The Owner subject area contains two tables (fig. 20). An <u>Owner</u> controls and maintains Sites and may be associated with Conveyances. An Owner also can serve as a source of data. Table *tblOwner* is required with two required data fields, *OwnerType_ID* and *OwnerName*. As shown in Appendix 2_table 36, *OwnerType* can be coded as “no actual owner” (0), such as for aggregate of users Sites; can be privately owned by a person or organization (1), or can be owned, operated, or supplied by a Municipal (2), County (3), State (4), or Federal agency (5).

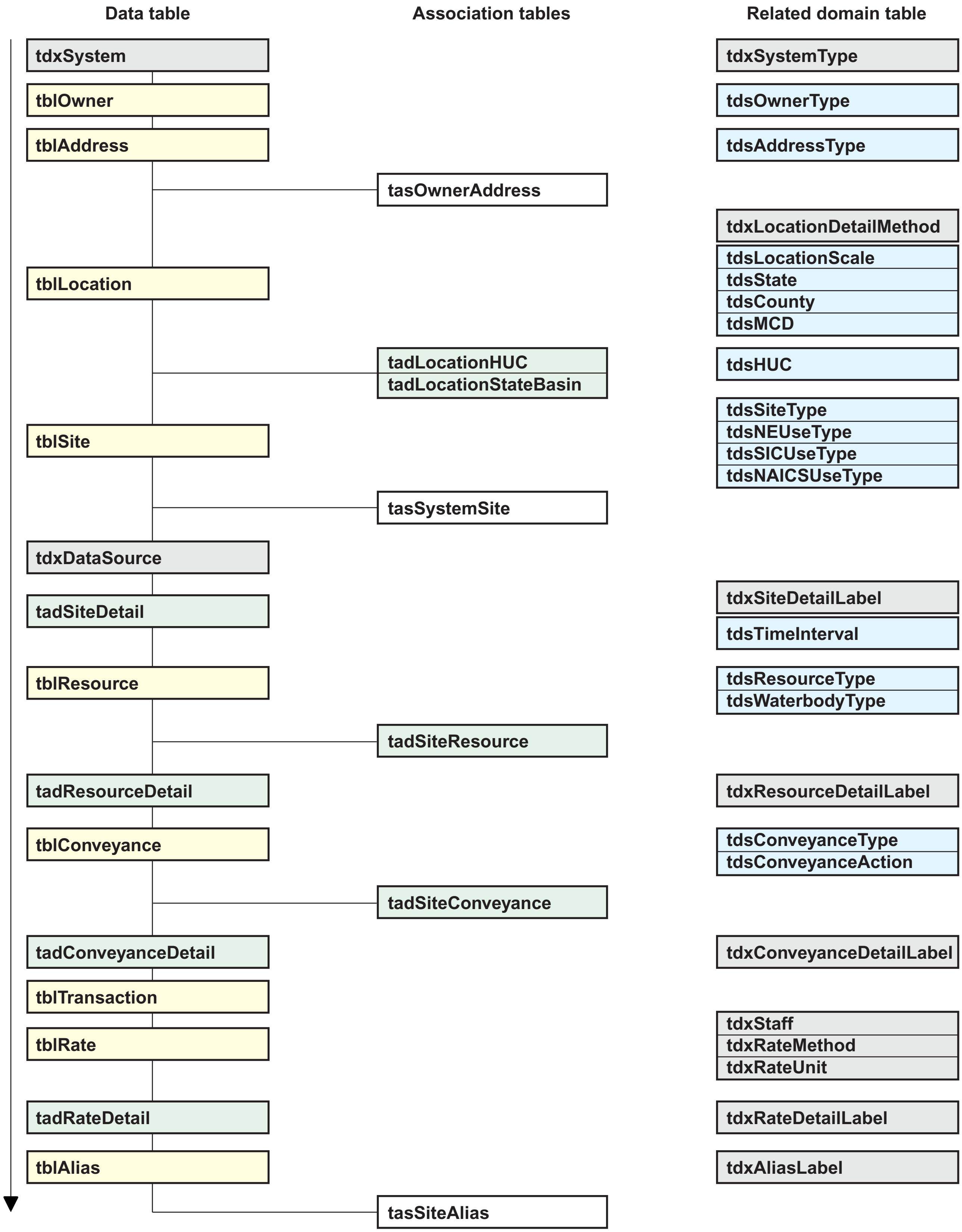

Figure 18. Suggested order of data entry into NEWUDS tables.

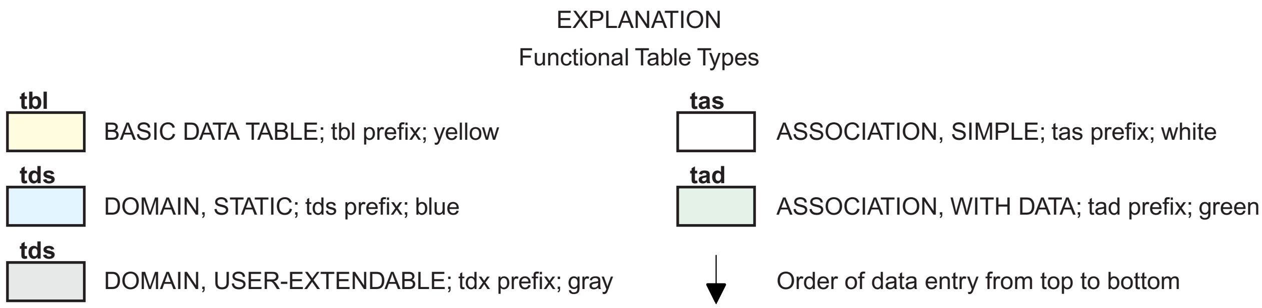

Figure 18. Suggested order of data entry into NEWUDS tables--Continued.

Figure 19. System subject area tables, fields, and relationships. (Box represents a field coming from another table, an asterisk represents a required field, and a black ball indicates a foreign key. See figure 18 for explanation of box color.)

Figure 20. Owner subject area tables, fields, and relationships. (Box represents a field coming from another table, an asterisk represents a required field in data tables, and a black ball indicates a foreign key. See figure 18 for explanation of box color.)

ParentOwner_ID is used if there are two levels of ownership. For example, a small company may manage an energy facility that actually is owned by a large energy company, or the parent Owner. The remaining data fields in the *tblOwner* table are not required, but may be useful in contacting the Owner.

The Address subject area consists of two tables (fig. 21). Mailing and street addresses for Owners and contacts and street addresses for Sites are included in the table *tblAddress*, which is not a required table. If used, the table has four required data fields: *AddressType_ID*, *City*, *StateAbbrv*, and *CountryAbbrv*. The only domain table associated with this table is *tdsAddressType* (Appendix 2_table 35), which is composed of three *AddressType* choices: Street address (2), Mailing address (3), or both (1). Aggregate of users Sites have no addresses.

The *tblOwner* table is associated with street and mailing addresses through an association table. *Owner_ID* and *Address_ID* are associated by table *tasOwnerAddress* (fig. 22). The association table uses IDs to allow two tables to relate to each other that have a many-to-many relation. An Owner may be associated with two *Address_IDs* if the Owner has separate mailing and street address. Occasionally, a Site may have a street address that differs from the Owner, such as an address for a treatment plant. In this case, the *tasSiteAddress* table (not shown here) would be used instead of *tasOwnerAddress*.

Establish Location

The Location of each Site is defined by a group of 8 tables (fig. 23) that define the geopolitical attributes, hydrologic basin Location, type of Location, and latitude and longitude. Location is a required table with only two required data fields: *LocationScale_ID* and *LocationDetMethod_ID*. The *LocationScale_ID* data field and its associated domain table, *tdsLocationScale* (Appendix 2_table 25), define the type of Location, point, or specified area for the Sites.

A user (place of use, such as a plant) that has a specific Location that can be plotted as a point on a map is considered to have a *LocationScale_ID* equal to 1 (point). If the withdrawal Site has a specific, small-area Location that is distinct from the user Location, then the withdrawal Site will have a different unique *Location_ID* from the single user Site. Withdrawal wells, springs, intake pipes, and treatment plants are examples of point Locations. If information is not available on the Location of any of the withdrawal Sites, then all withdrawal Sites under this Owner will have the same *Location_ID* because they are considered co-located. Aggregate of users Sites have a *LocationScale_ID* that matches the aggregation unit (2, MCD; 3, County; 4, State; 5, HUC). Ground-water withdrawals, surface-water withdrawals, and wellfields are considered as having an undefined (7) Location, whereas local and regional distribution and wastewater-collection system Sites are considered as irregular (6) Locations. Sites with an unknown scale (geographic coverage) have a *LocationScale_ID* code of “0.”

The second required field, *LocationDetMethod_ID* and its associated domain table (*tdxLocationDetMethod*, Appendix 2_table 26) describes the method used to determine the Location, such as County centroid (center point), topographic map, or unknown. The value for this field usually will be unknown (1) unless the data-entry staff determined the Location or the method used was included with the Location data received from the source agency (a suitable code would have to be assigned).

Three domain tables linked directly to the *tblLocation* table define geopolitical attributes—*tdsState* (Appendix 2_table 29), *tdsCounty* (Appendix 2_table 30), and *tdsMCD* (Appendix 2_table 31). Hydrologic Unit Codes defined in *tdsHUC* (Appendix 2_table 27) are related to the *tblLocation* table through the *tadLocationHUC* association table because a Location, especially an aggregate Location, may include more than one HUC. Similarly (but not shown in fig. 23), a State Basin Code defined in the *tdsStateBasin* table is related through the *tadLocationStateBasin* association table.

Each *Location_ID* needs to be associated with a *HUC_ID* from the *tdsHUC* table using the association table *tadLocationHUC* (fig. 23) to retrieve data by HUC. Most of the time, the entry will be “yes” for the field *IsPrimaryHUC*. If the *Location_ID* is for a County (as in a County aggregate), however, then there probably is more than one HUC within the County. In this case, the HUC that includes the largest portion of the County is marked as primary, and the other HUCs have “no” entered in the field *IsPrimaryHUC*.

Figure 21. Address subject area tables, fields, and relationships. (Box represents a field coming from another table, an asterisk represents a required field in data tables, and a black ball indicates a foreign key. See figure 18 for explanation of box color.)

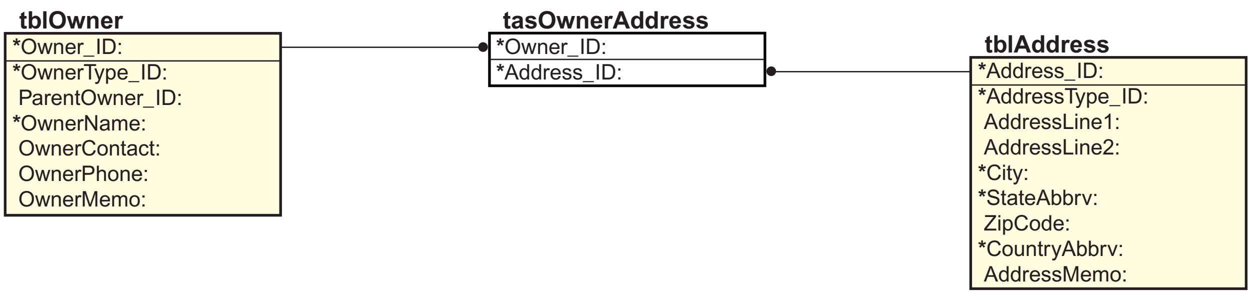

Figure 22. Tables and fields that define the Owner and Address subject area association. (Box represents a field coming from another table, an asterisk represents a required field, and a black ball indicates a foreign key. See figure 18 for explanation of box color.)

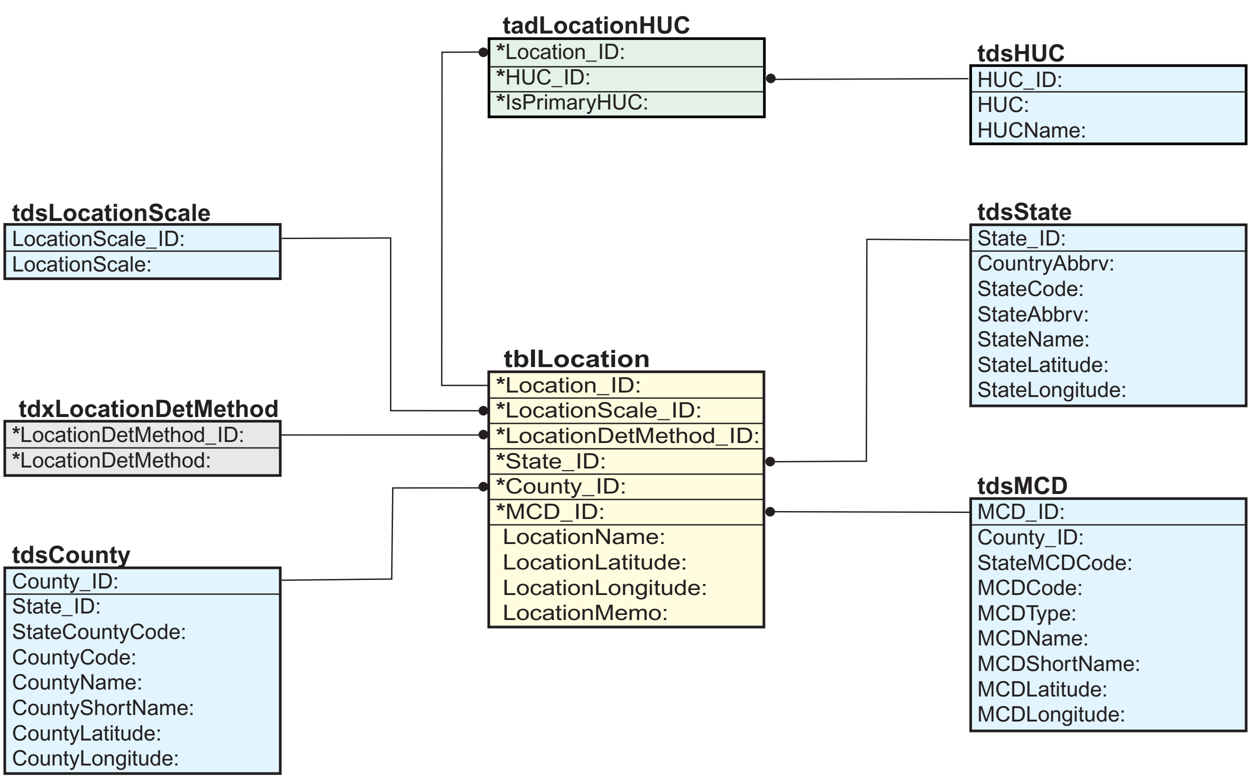

Figure 23. Location subject area tables, fields, and relationships. (Box represents a field coming from another table, an asterisk represents a required field in association, data, and user-extendable domain tables, and a black ball indicates a foreign key. See figure 18 for explanation of box color.)

Describe Site

A Site is a point or area where a water-use activity occurs, either as a source or as a destination. Each object that can be named as a source or target of water movement is called a Site. The System, Owner, and Location subject areas are all linked to the required *tblSite* table (fig. 24). The *tblSite* table has five required data fields: *Location_ID* (which is why *tblLocation* is a required table), *Owner_ID* (which is why *tblOwner* is a required table), *SiteType_ID*, *NEUseType_ID*, and *SiteName*. There are three *SiteType* domain tables (*tdsSiteType*, Appendix 2_table 3; *tdsSiteTypeCategory*, Appendix 2_table 1; and *tdsSiteTypeSubcategory*, Appendix 2_table 2). The four *UseType* domain tables—*tdsUSGSUseType*, Appendix 2_table 4; *tdsNEUseType*, Appendix 2_table 5; *tdsSIC*, Appendix 2_table 6; and *tdsNAICS*, Appendix 2_table 7—are used in association with the *tblSite* table.

As discussed in the "Modeling Water-Use Activities" section, selecting the correct *SiteTypes* is essential for accurately representing water-use activities in NEWUDS. The 30 *SiteTypes* provide flexibility in identifying the specific water-use activity so that retrievals will prevent double accounting of withdrawal, use, or return.

There are a few *SiteTypes* (table 6) that are associated with specific Sites and Resources. There should be a separate *SiteType* "1" (ground-water withdrawals) for each aquifer from which withdrawals occur and usually only one *SiteType* "5" for the surficial aquifer into which septic systems discharge or for system leakage. If there are recharge wells that discharge into other aquifers, then there would be a *SiteType* "5" for each aquifer. Use of *SiteType* "22" for consumptive use should occur only once in the database so that all consumptive-use conveyances have that site as the To Site. Similarly, the *SiteType* "23" (unaccounted-for water) and *SiteType* "30" (inflow and infiltration) should be used once. The Owner for these specific sites is "none" and Location is "no Location."

The *Site_ID* and *Location_ID* need to be recorded on forms as shown in Appendix 1_figures 34, 37, 40, 43, 46, 49, 52, 55, 58, and 61 for quality assurance. It is easy to lose track of *Site_IDs*, *Location_IDs*, *Conveyance_IDs*, *Transaction_IDs*, and *Rate_IDs* unless they are recorded in files that can be referenced. An alternative might be to make retrievals that display the IDs.

The *tadSiteDetail* table is available to store information on population served, number of employees, count of livestock, acres irrigated, kilowatt-hours generated, and other ancillary data. An example illustrating how data are stored in the User-Defined-Site Detail subject area tables is shown in figure 25.

In this example, the population-served ancillary data for CWS1 regional distribution system is entered into NEWUDS. The *SiteDetailCategory_ID* in the *tdxSiteDetailCategory* table (Appendix 2_table 10) is "1" indicating that the data type is "Count." The *Label_ID* in the *tdxSiteDetailLabel* table (Appendix 2_table 11) is "1" for "Population Served." The *TimeInterval_ID* in the *tdsTimeInterval* table (Appendix 2_table 20) is "2" for year and specifies the time period over which the *SiteDetail* applies. In most cases, the time interval will be 5 years, a year, or a month. The agency that supplied that data is USEPA Region I, which is stored in the *tblOwner* table with the *Owner_ID* of "15." Note that the *Owner_ID* is for the source of the data, not the Owner of the Site. The actual source in USEPA Region I of the data was the Drinking Water Program—*DataSource_ID* is "1" in *tdxDataSource* table (Appendix 2_table 37). Finally, the *tadSiteDetail* table records the *Site_ID* for CWS1 regional distribution system as "30", inherits the IDs from the *tdxSiteDetaiLabel*, *tdsTimeInterval*, and *tdxDataSource* tables, and contains a value of "1/1/95" for *SiteDetailEffectiveDate* and "859000" for *SiteDetailValue*. The *SiteDetailEndingDate* is the date for which this ancillary data is no longer valid. Although the structure may seem complex, the retrieval will appear simple (table 7).

Once *Site_ID*s are assigned for all Sites, the *tasSystemSite* table can be filled (fig. 19) by adding all *Site_IDs* with the *System_ID*.

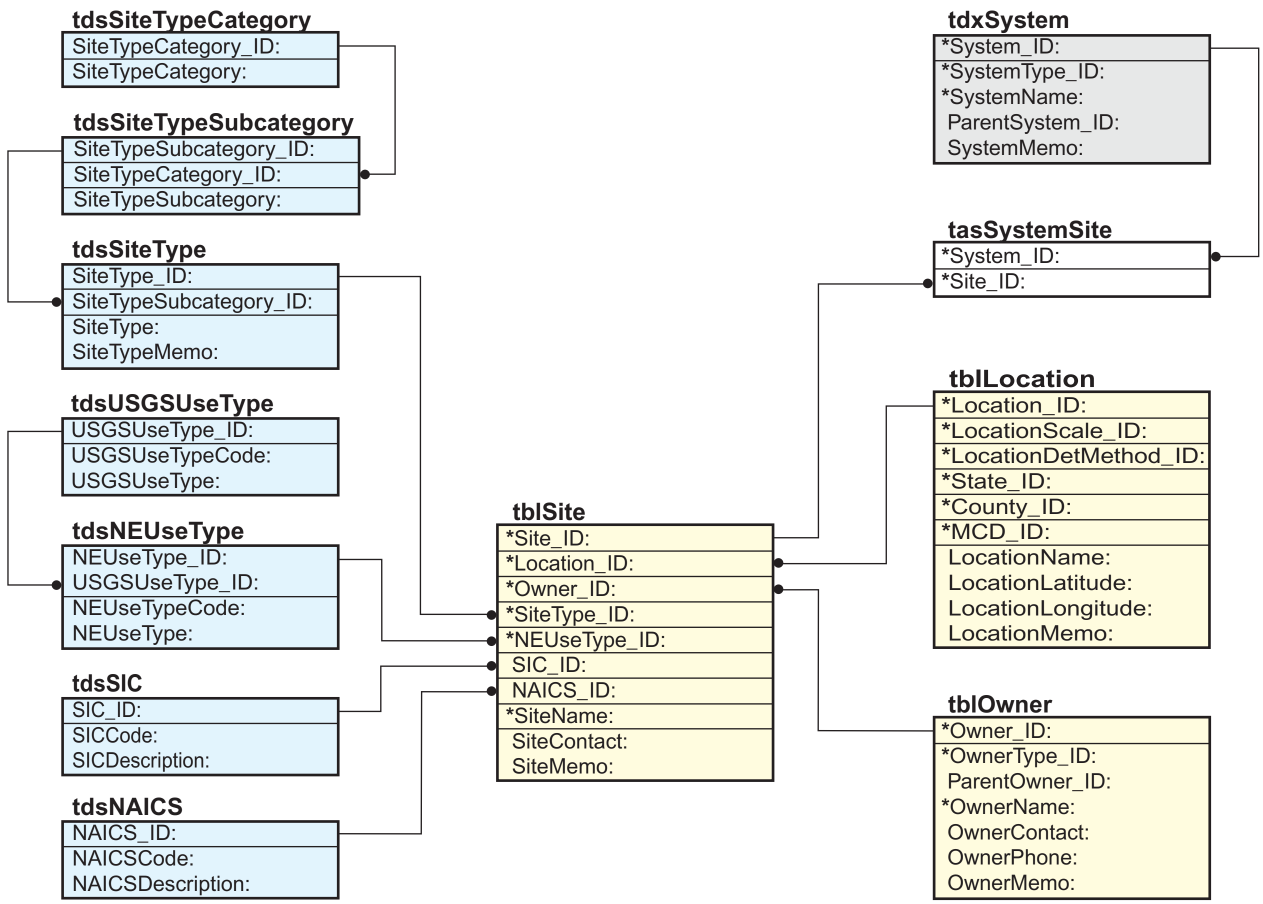

Figure 24. Site subject area tables, fields, and relationships. (Box represents a field coming from another table, an asterisk represents a required field in data and user-extendable domain tables, and a black ball indicates a foreign key. See figure 18 for explanation of box color.)

Table 6. General Sites and their associated Resources

[ID, identification number]

SiteType_ID	*SiteType*	*SiteName*	*ResourceName*	*WaterBodyType*
1	Ground-water withdrawal	Ground-water system-crystalline rock withdrawals	Crystalline rock aquifer	Aquifer
1	Ground-water withdrawal	Ground-water system-glacial deposit withdrawals	Glacial deposit aquifer	Aquifer
1	Ground-water withdrawal	Ground-water system-carbonate rock withdrawals	Carbonate rock aquifer	Aquifer
5	Ground-water return flow	Ground-water system-glacial deposit returns	Glacial deposit aquifer	Aquifer
7	Surface-water withdrawal	Unspecified surface-water withdrawals	Unknown surface water	Unknown surface water
22	Atmosphere	Atmosphere-consumptive use		
23	Unaccounted-for water	Leakage (Unaccounted-for Water) from Distribution and Collection Systems	Glacial deposit aquifer	Aquifer
30	Inflow and infiltration	Inflow and Infiltration to Wastewater Collection Systems	Unknown overland flow and glacial deposit aquifer	Unknown ground and surface water

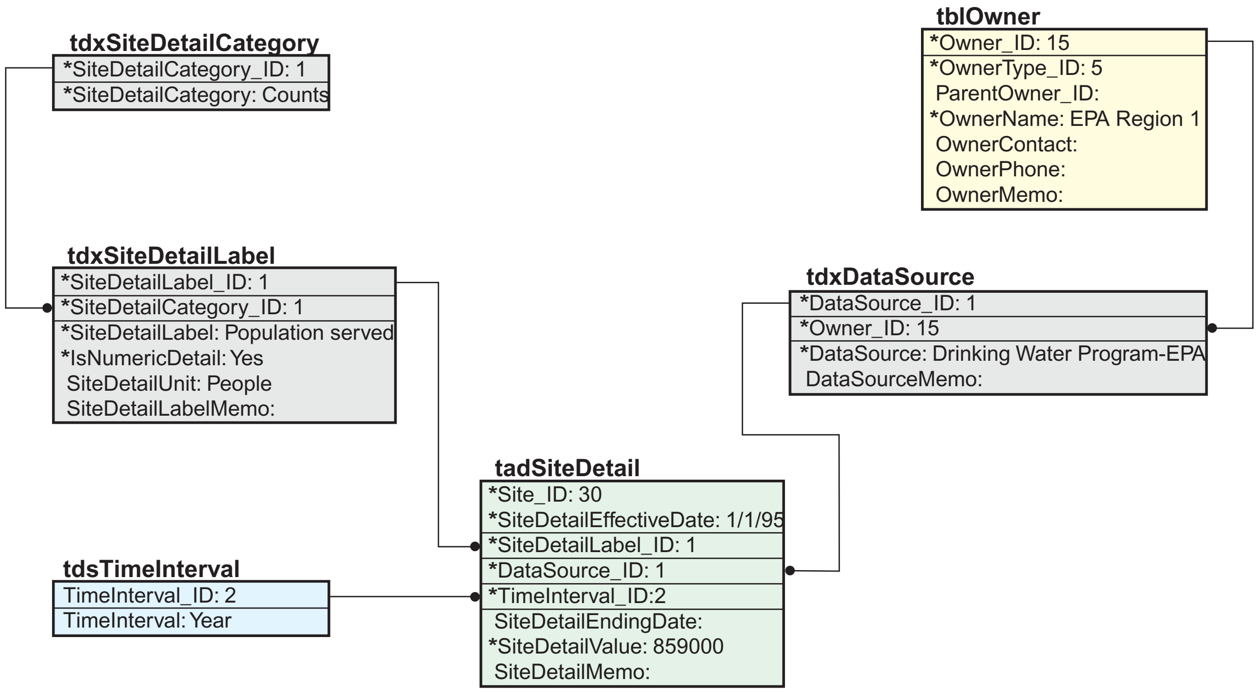

Figure 25. User-Defined SiteDetail tables, fields, and relationships showing the addition of population-served data for CWS1. (Box represents a field coming from another table, an asterisk represents a required field in a data, association, or user-extendable domain table, and a black ball indicates a foreign key. See figure 18 for explanation of box color.)

Table 7. Sample retrieval of Site detail information

[CWS, community-water system; USEPA, U.S. Environmental Protection Agency]

Site name	Population served	Source of data	Organization	Effective date
CWS1 Regional Distribution System	859,000	Drinking Water Program-USEPA	USEPA Region 1	1995

Link to Resource

Tables in the Resource subject area contain information on the ground and surface water from which water is withdrawn and returned. Information on specific Resources, such as the Happy Hollow Reservoir or the glacial-deposit aquifers, and general Resources such as “surface water” or “ground water” are contained in the *tblResource* table. The *tblResource* table is used so that retrievals can be made by Resource. The only two required fields in the *tblResource* table are *WaterBodyType_ID* and *ResourceName*.

There are two resource-related domain tables used in association with the Resource subject area (fig. 26). The *tdsResourceType* table (Appendix 2_table 32) splits Resources into ground or surface water; fresh, brackish, or saline water. The *tdsWaterbodyType* table (Appendix 2_table 33) uses this Resource classification with a more specific kind of surface- or ground-water body. The four types of freshwater Resources (waterbody type) are river/stream, lake/pond, reservoir, and aquifer. Saline *ResourceTypes*, used primarily as discharge waterbodies and occasionally as sources for cooling water, are estuary, bay, and ocean. There are only four tables in the User-Defined-Resource Detail subject area instead of the six needed for User-Defined-Site Detail subject area. Category tables for *tdxResourceDetailLabel* and the *tdsTimeInterval* tables are not needed. *ResourceDetail* labels can include “tributary to,” surface area in acres, dam name, or August Median flow. The tables represented in figure 26 store the data that the Happy Hollow Reservoir has a normal capacity of 11,000 acre-feet, according to OFR XX-XXX.

The *tblResource* table (fig. 26) is connected to the resource-interactor *SiteType* through the association table *tadSiteResource*. The *ConnectionCount* field is used to indicate the number of specific resource interactors that are included in the identified resource interactor, such as the number of wells in a wellfield. Some *SiteTypes*, such as a withdrawal well or intake pipe, link to a specific Resource, such as the glacial-deposit aquifer or Happy Hollow Reservoir. Refer to table 6 for suggested Resources associated with specific *SiteTypes*.

Link Sites Through Conveyances

Once Sites are described and resource-interactor *SiteTypes* are associated with the appropriate Resource, the Sites need to be connected through Conveyances in table *tblConveyance* (fig. 27). The *tdsConveyanceType* domain table (Appendix 2_table 12) lists *ConveyanceTypes*. In New England, the “virtual” type is commonly used unless additional information about the Conveyance is needed, which is stored in the *tadConveyanceDetail* table. The domain table *tdsConveyanceAction* (Appendix 2_table 15) stores *ConveyanceAction*, which pair up permissible *SiteTypes* for all Conveyances. The domain table *tdsConveyanceActionCategory* (Appendix 2_table 14), summarizes the *SiteTypes* involved in the Conveyance. There are 25 *SiteTypes*; however, there potentially could be 676 (26 x 26) *ConveyanceActionTypes*, but only 142 permissible or logical combinations. The requirement to select a single *ConveyanceAction_ID* from the *tdsConveyanceAction* table prevents illogical connections. For example, water does not move from a wastewater treatment plant to a potable treatment plant. Through use of the *ConveyanceActionCategory* field, the *ConveyanceAction_ID* also allows for general or specific retrievals depending on the level of detail of raw data and the overall objectives of the database. Once the database is fully populated for a given area, queries to determine summary information based on *ConveyanceTypes* can be developed. For example, queries can be created to retrieve information on Conveyances from withdrawal wells and intake pipes to treatment plants (*ConveyanceAction_ID* 13-18) **or** directly into the local distribution system (*ConveyanceAction_ID* 25-36). *ConveyanceActionCategories_IDs* of “21”, “22”, and “23” will determine total withdrawal. Water that is withdrawn from a Resource and discharged to another Resource (*ConveyanceActionCategory_ID* 13) will not be counted as a withdrawal because it is discharged and withdrawn again before use (See Case Study 9, Appendix 1).

The *tadSiteConveyance* table links the *Site_ID* from *tblSite* with the *Conveyance_ID* from *tblConveyance*. Each Conveyance requires two records: the first defines the From Site and the second the To Site. Examples for *ConveyanceDetailLabels* include pipe size, in inches, and canal system length, in miles.

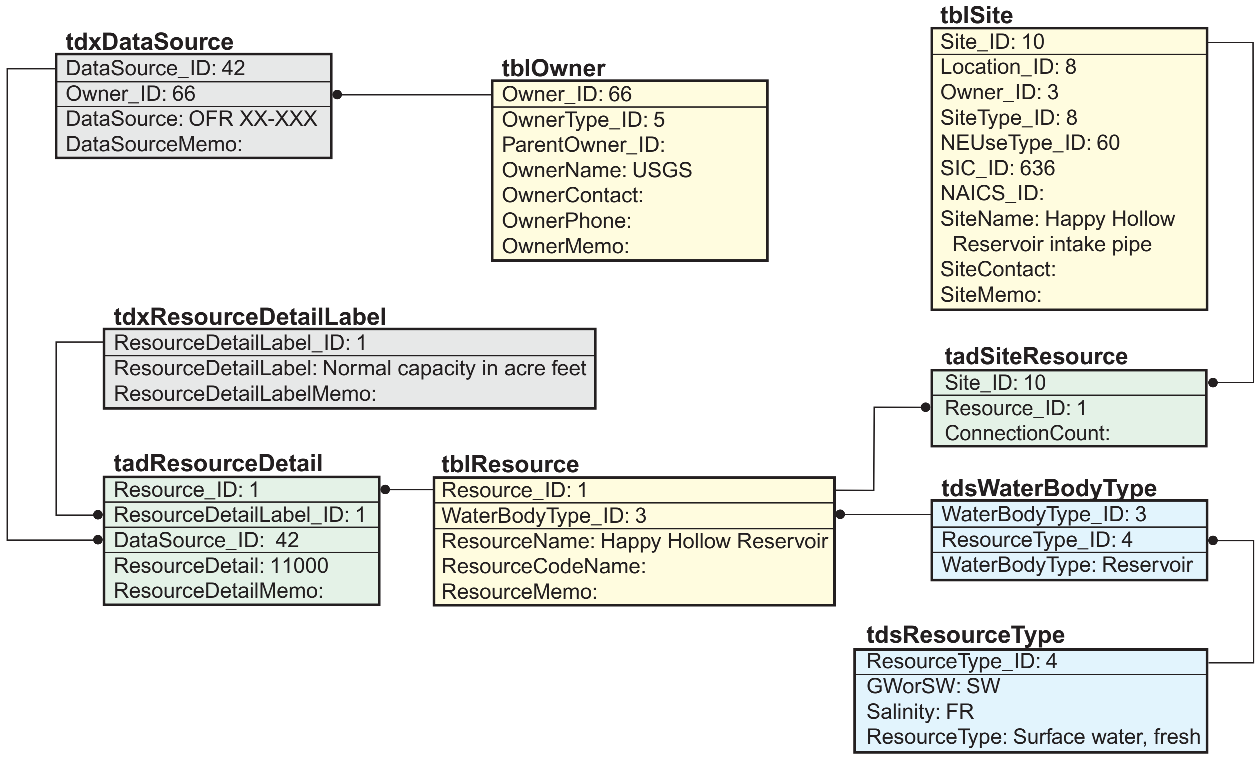

Figure 26. Resource subject area tables, fields, and relationships describing Resource data for Happy Hollow Reservoir. (Box represents a field coming from another table and a black ball indicates a foreign key. See figure 18 for explanation of box color.)

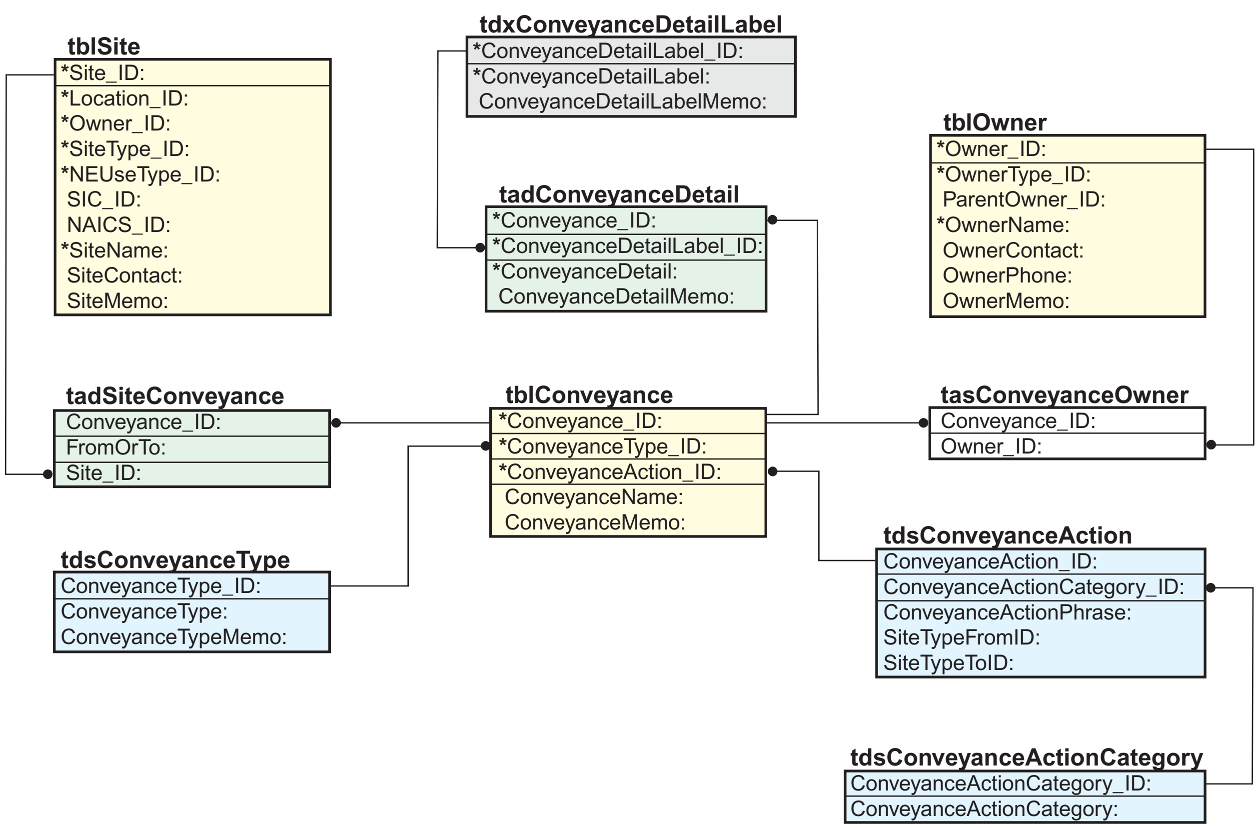

Figure 27. Conveyance subject area tables, fields, and relationships. (Box represents a field coming from another table, an asterisk represents a required field in data, association, or user-extendable domain tables, and a black ball indicates a foreign key. See figure 18 for explanation of box color.)

Establish Transaction

A *Transaction* is a record for movement of water through a Conveyance during a specific time interval. The fields required to identify the movement are the *Conveyance_ID*, *TimeInterval_ID* (from *tdsTimeInterval*), *TransactionEffectiveDate*, and default Rate value in million gallons per day (*RateMGD*), which are combined in table *tblTransaction* (fig. 28). Transaction information is linked to the *tblRate* table by the *Transaction_ID*. The *tblRate* table adds information on the method, measurement unit, source, and the Rate value in the original units obtained from the DataSource. *RateMGD* in the *tblTransaction* table is entered automatically through a query after the linked Rate record with the *RawRateMGD* is entered into the *tblRate* table and designated as the default Rate (*IsDefaultRate*). How to run this query will be discussed in the section titled "Retrievals."

Establish Rate

Data associated with table *tblRate* (fig. 28) include the staff who entered the data, source of the data, method used to obtain the Rate value, value in original units, units of the value, and whether that Rate value is the default for that unique Transaction (a unique Conveyance for a specific time interval).

The *tdxstaff* table (Appendix 2_table 21) refers to the person entering the Rate record. Details on the *tdxDataSource* table (Appendix 2_table 37) was described in the section titled "Describe Site." The *tdxstaff* and *tdxDataSource* tables serve as documentation to future users of NEWUDS. A single Transaction may have more than one Rate based on different methods. Examples of different methods used to determine Rate include calibrated cumulative meter, uncalibrated cumulative meter, local coefficient with Census Bureau values, power coefficient with power consumption Rate (Maupin, 1996), or unknown (Appendix 2_table 24). The *RateMethod* can be divided into *RateMethodCategories*, such as metered, field estimate (based on field data), coefficient-based estimate, reported, permit, or guess (Appendix 2_table 23). Data are entered and stored in the original format with the unit of measurement stored as a *RateUnit_ID*. The *RateUnit_ID* is defined in the table *tdxRateUnit* (Appendix 2_table 19) with each unit, such as cubic feet per second, divided into the decimal component (1), volume component (cubic feet), and time component (second). Commonly used *RateUnitPhrases* are presented in table 8. The data also are converted and stored in the *tblTransaction* table in the common unit, million gallons per day (*RateMGD*). Data on the accuracy or precision of the Rate can be stored in the User-Defined *tadRateDetail* table. More than one Rate value for a Transaction is allowed because Rate values can be determined with different methods for the same time interval.

The query **qryRateUnitConversionFactor**, is provided in the NEWUDS database to complete a new entry in the *tdxRateUnit* table (Appendix 2_table 19). A new Rate unit can be initiated in table *tdxRateUnit* (fig. 28) by manually entering a standard Rate-unit abbreviation in the field *RateUnitAbbrv*, which functions as a placeholder value in *RateUnitPhrase*, and then selecting values from the following three tables: *tdsRateUnitDecimal* (Appendix 2_table 16), *tdsRateUnitVolume* (Appendix 2_table 17), and *tdsRateUnitTime* (Appendix 2_table 18)**.** Running this query populates the *tdxRateUnit* fields of *RateUnitPhrase* and *MGDConversion* from the three tables. The *RateUnitPhrase* is constructed by combining "unit" terms used in each table: *DecimalUnit* + *VolumeUnit* + "per" + *TimeUnit*. The conversion factor is calculated as the product of the *ConversionToMillion*, *ConversionToGallon*, and *ConversionToDay* fields in the three tables. The *tdxRateUnit* table is updated by running the query **qryRateUnitUpdateNEWUnitPhraseAndMGDConversion**, which applies the query only to those records needing an update in the *RateUnitPhrase* and *MGDConversion* fields.

The default Rate value for each Transaction needs to be converted to common units (million gallons per day) and that value entered into the *tblTransaction* table in the field *RateMGD* (fig. 28). Initially, the *RateMGD* value for newly created Transactions is entered automatically as "-1" and is used as a flag for values not yet updated. Replacing the "-1" flag with a valid, converted Rate value is done using two queries. The first query, **qryRateDefaultRatesForTransactions**, identifies the default Rate entries in table *tblRate* for each record in the *tblTransaction* table, and calculates the equivalent *ConvertedRate*, in million gallons per day common units, based on the *RateUnit_ID* for the *RawRateValue*. This query provides the set of records representing converted default Rates from table *tblRate* to the next query. The second query, **qryRateUpdateNEWRateValues**, links table *tblTransaction* records where *RateMGD* = "-1" for the set of ConvertedRate values in the first query, and replaces the default "-1" *RateMGD* values in the *tblTransaction* table.

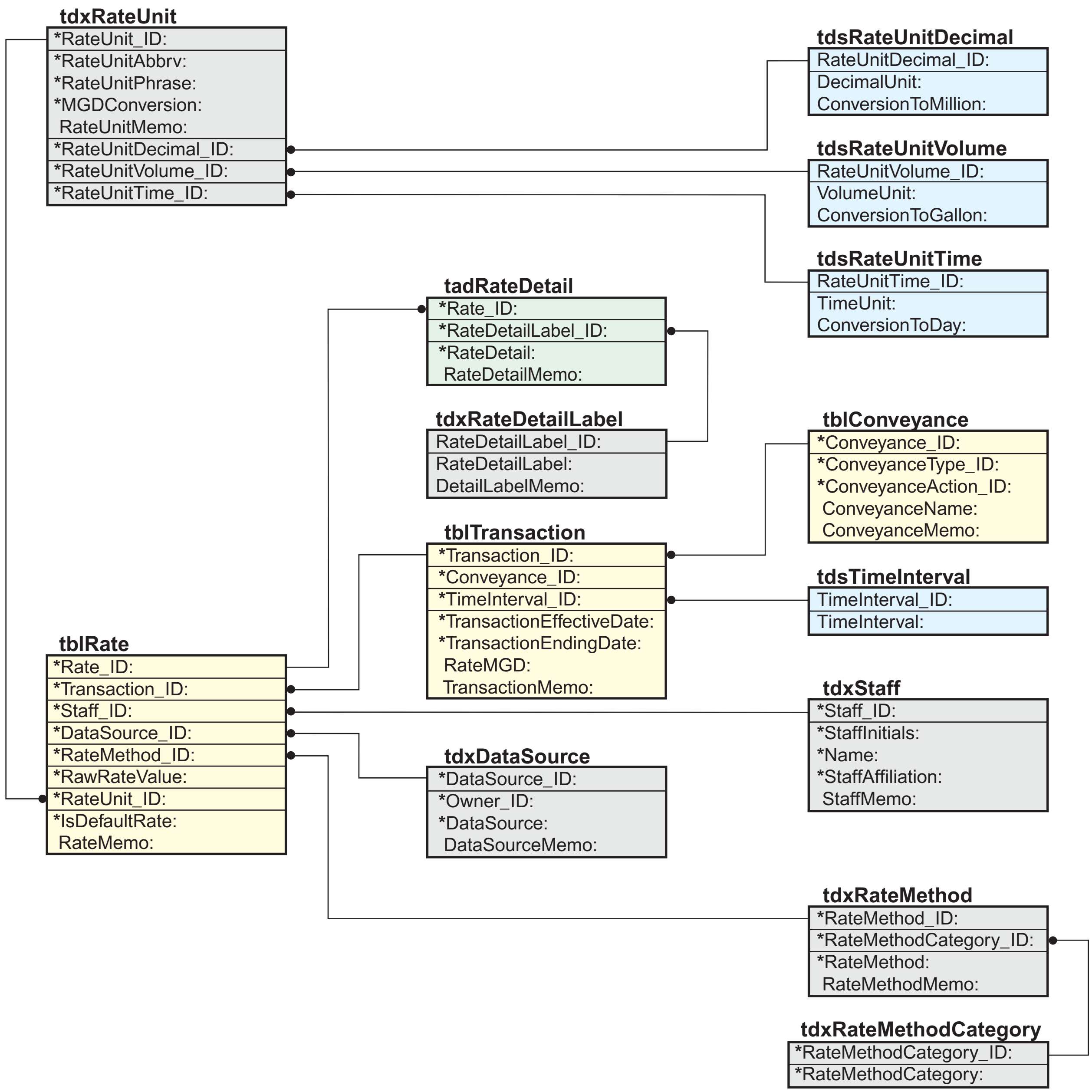

Figure 28. Rate and Transaction subject area tables, fields, and relationships. (Box represents a field coming from another table, an asterisk represents a required field in data, association, or user-extendable domain tables, and a black ball indicates a foreign key. See figure 18 for explanation of box color.)

Table 8. Commonly used raw Rate units and conversion table values for NEWUDS

[ID, identification number]

RateUnit_ID	Commonly used raw Rate unit	Raw *rate decimal unit*	Raw *rate volume unit*	Raw *rate time unit*
3	Million gallons per year	**6 (million)**	**1 (gallon)**	**6 (year)**
1	Million gallons per day	**6**	**1**	**4 (day)**
15	Thousand gallons per day	**3 (thousand)**	**1**	**4**
12	Gallons per day	**0 (one)**	**1**	**4**
11	Thousand acre-feet per year	**3**	**3 (acre-feet)**	**6**
4	Cubic feet per second	**0**	**2 (cubic feet)**	**1 (second)**
5	Thousand cubic feet per day	**3**	**2**	**4**

Enter Aliases for Sites

Aliases are used when referring to a Site by a reference other than the *Site_ID* or *SiteName*, such as a Public Water Supply Identification Number (PWSID) for a community-water system, a State Allocation Number for a withdrawal permit or State Registration number, or a National Water Information System (NWIS) Site ID. The network of tables related to assigning the Site Alias is shown in figure 29. The PWSID assigned through the Safe Drinking Water Program (SDWP) is the Alias that is being stored. This Alias is used in the Safe Drinking Water Information System Information System (SDWIS) database to identify community-water systems. The Owner of the Alias is actually the DataSource or Reference for the Alias, which is USEPA. The *AliasLabel* identifies the Alias as being the PWSID. The *AliasSource* refers to where the ID is obtained, which in this case was SDWIS. The ID could also have been retrieved from a State database or a report or from the community-water system. The *tadSiteAlias* table associates the *Site_ID* from the *tblSite* table with the *Alias_ID* from the *tblAlias* table**.**

RETRIEVALS

Data are entered into NEWUDS so they can be efficiently managed and retrieved. This section provides examples of how to retrieve the data in meaningful ways that provide a starting point for the user to develop their own queries. Nineteen ‘standard’ Views or queries were pre-assembled for use in NEWUDS. The standard Views can be used as templates for creating custom optimized queries and views because they contain all the value fields from nearby tables. Dropping unnecessary tables, fields, and relations will significantly increase query performance, whereas rearranging or renaming fields and imposing conditional criteria will create more meaningful retrievals. Ideally, a View would use only those tables holding the query output fields and the tables needed to create a link between those tables. Queries that include several Views are useful for reviewing data, inventorying users, and analyzing water-use activities. More complex retrievals that are used to calculate interbasin transfer need to combine retrievals from NEWUDS with spreadsheet calculations. A few examples of useful queries are provided in the following sections.

Location-Owner-SiteType Query

The purpose of a Location-Owner-SiteType query is to identify all *SiteTypes* of interest in a geographic area. The query is structured as shown in figure 30 and includes 5 tables. Different geographic areas can be selected by replacing the *tdsMCD* table with the *tdsState, tdsCounty*, or the combined *tdsHUC* and *tadLocationHUC* tables. *SiteTypes* can be broadened by replacing the *tdsSiteType* table with the *tdsSiteTypeCategory* or *tdsSiteTypeSubCategory* tables. The results of the Location-Owner-SiteType query are presented in table 9. In this example, the MCDShortName of Attleboro, Mass., and the *SiteType* of 12 (local distribution system) were specified. There are two distribution systems in Attleboro.

Owner-Site-Resource Query

The purpose of an Owner-Site-Resource query is to determine all the withdrawal and return points by Resource. The query is structured as shown in figure 31 and includes 7 tables. In this example, *GWorSW* is not limited to ground water or surface water, but is the first sort (records are ordered numerically and alphabetically by this field). *ResourceName*, also not specified for a particular Resource, is the second sort. Specifying ground-water system (GW) would return information on all ground-water resource interactors. Selecting a specific Resource would allow water-use activities affecting that Resource to be reviewed. *SiteTypes* can be specified to retrieve data only on withdrawal Sites by selecting *SiteType_ID* = 1, 2, 3, 6, 7, and 8 or retrieve data only on return Sites by selecting *SiteType_ID* = 4, 5, 9, or 10. The results of the Owner-Site-Resource Query for case-study data are presented in table 10.

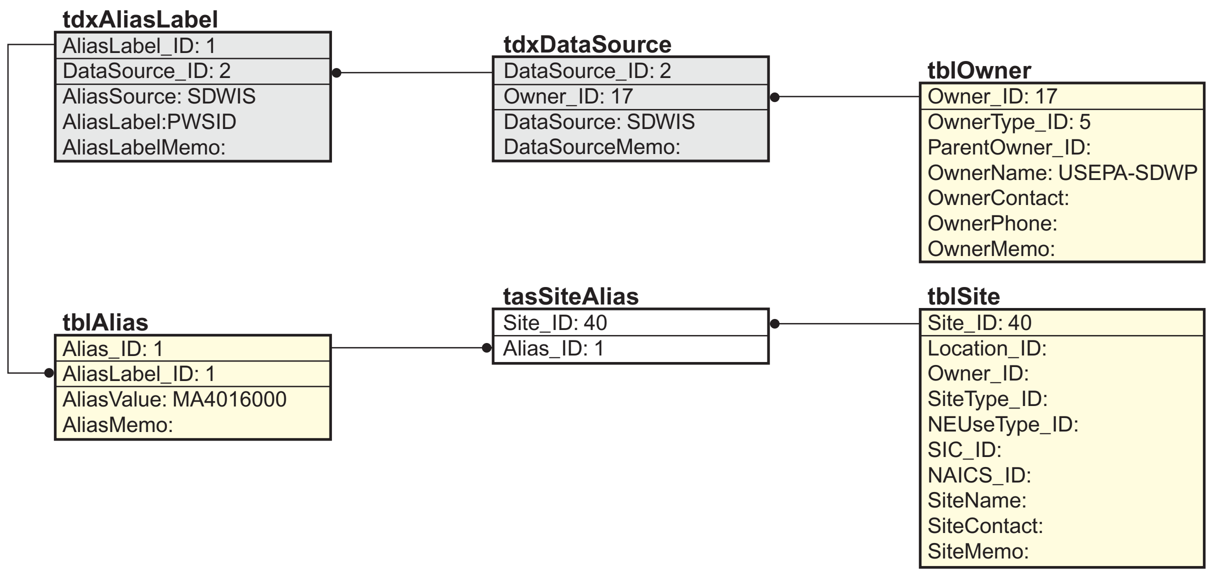

Figure 29. SiteAlias subject area tables, fields, and relationships showing PWSID value for a Massachusetts community-water supplier. (Box represents a field coming from another table and a black ball indicates a foreign key. See figure 18 for explanation of box color.)

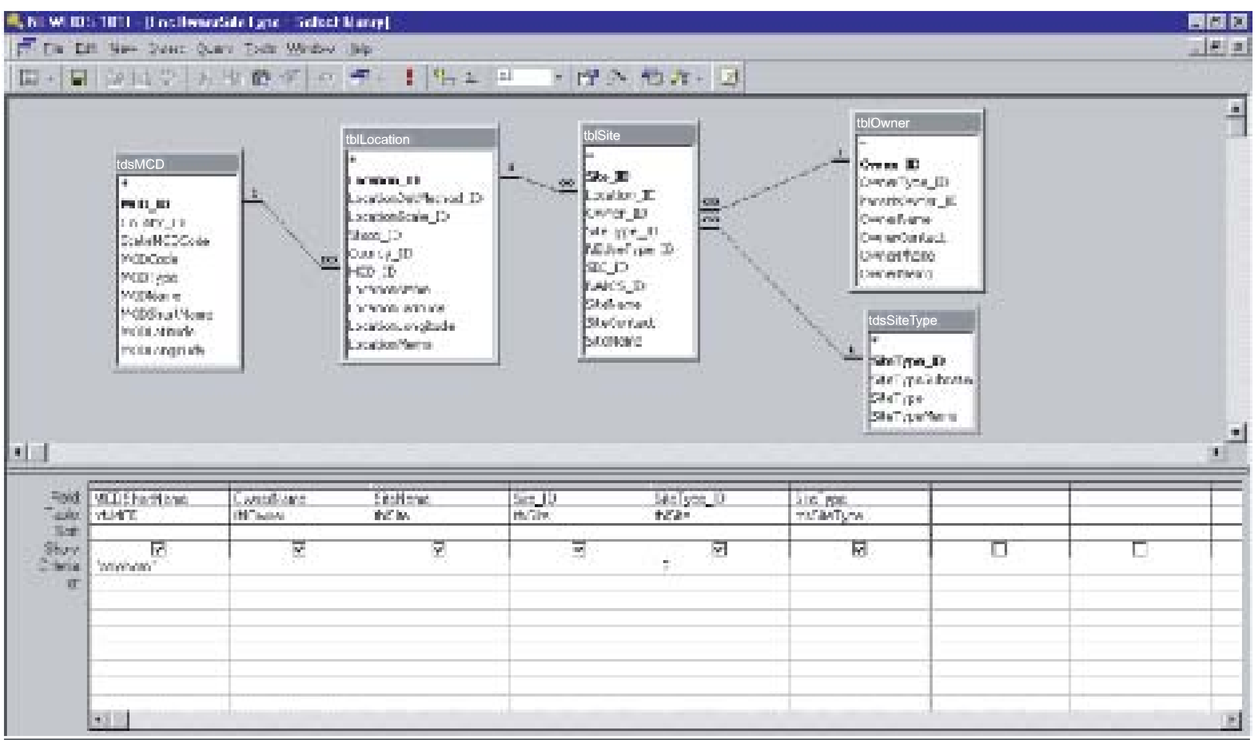

Figure 30. Location-Owner-Site-Type query for SiteType 12 (Local distribution system) in the Attleboro MCD geographic area in NEWUDS.

Table 9. Results of a Location-Owner-SiteType query in NEWUDS

[MCD, Minor Civil Division; ID, identification number]

MCDShortName	*OwnerName*	*SiteName*	*Site_ID*	*SiteType_ID*	*SiteType*
Attleboro	Attleboro Water Department	Attleboro Local Distribution System	480	12	Local distribution system
Attleboro	North Attleboro Water Department	North Attleboro Local Distribution System in Attleboro	109	12	Local distribution system

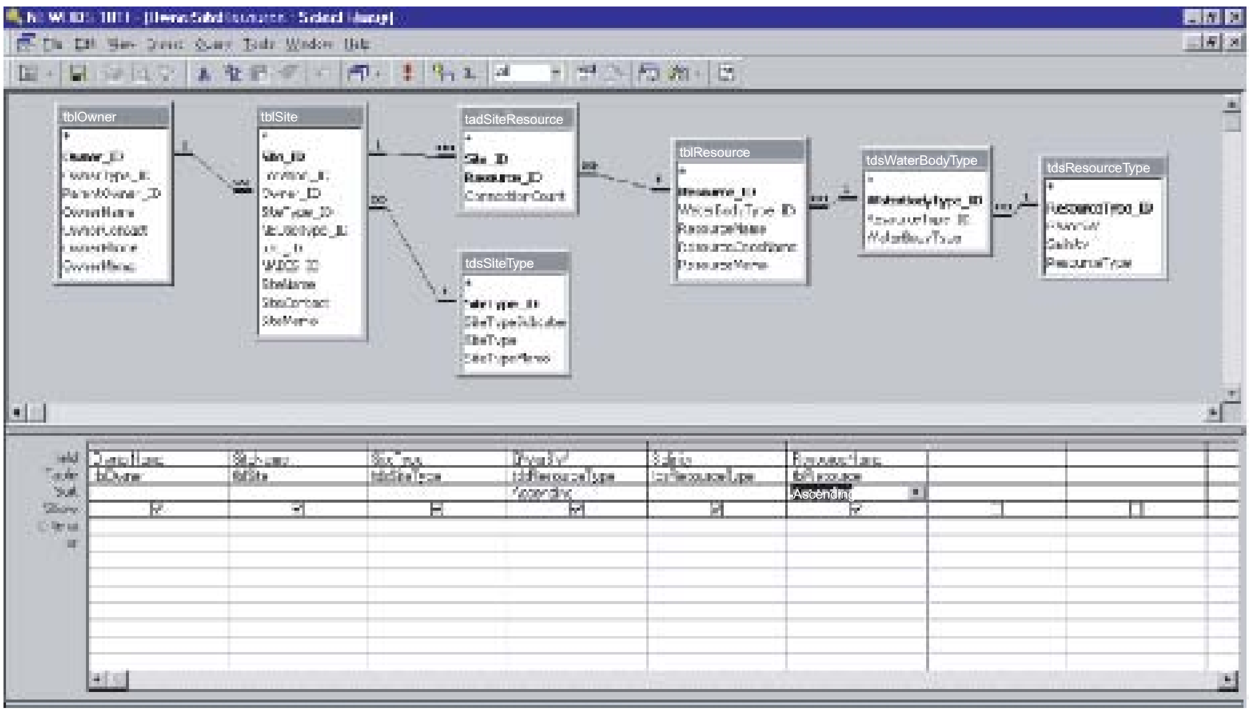

Figure 31. Owner-Site-Resource query in NEWUDS.

Table 10. Results of an Owner-Site-Resource query in NEWUDS

[Case studies are in Appendix 1; No., number; GW, ground water; SW, surface water; MSS, major self-supplied user; FR, freshwater; CWS, community-water system; MCU, major complex user; WTP, wastewater treatment plant]

Case study No.	*OwnerName*	*SiteName*	*SiteType*	*GWorSW*	Salinity	*ResourceName*
1, 7	MSS1	MSS1 well	Withdrawal well	GW	FR	Crystalline-rock aquifer
3, 9	CWS1	CWS1 well #5	Withdrawal well	GW	FR	Glacial-deposits aquifer
7	MSS1	MSS1 septic	Ground-water return flow	GW	FR	Glacial-deposits aquifer
3, 9	CWS1	Happy Hollow Reservoir-intake	Intake pipe	SW	FR	Happy Hollow Reservoir
8	MCU1	MCU1 industrial plant discharge pipe	Discharge pipe	SW	FR	Taunton River
6, 10	WTP1	WTP1 discharge pipe	Discharge pipe	SW	FR	Ten Mile River

Withdrawals-and-Returns-by-Resource Query

The purpose of a Withdrawals-and-Returns-by-Resource query is to determine all withdrawals and returns by Resource. The query is structured as shown in figure 32 and includes 11 tables. In this example, *GWorSW* is not specified, but is the first sort. *ResourceName*, also not specified, is the second sort. Specifying GW would retrieve information on all withdrawals and returns by ground-water resource interactors. A specific Resource can be selected to review “withdrawals from” and “returns to” that Resource. Withdrawal data only can be retrieved by selecting *ConveyanceActionCategory_ID* = 21, 22, and 23 from Appendix 2_table 15. Withdrawals by users can be retrieved by selecting *ConveyanceActionCategory_ID* = 23. Return data only can be retrieved by selecting *ConveyanceActionCategory_ID* =16 and 19. No year was specified, so withdrawals and returns from all years are retrieved. All years for a specific user or a specific year for all users can be analyzed. The results of the Withdrawals-and-Returns-by-Resource query with case-study data are presented in table 11.

Conveyance-Description Query

The purpose of a Conveyance-Description query is to describe Conveyances in terms of From Site and To Site. An example query is shown in figure 33 and includes 8 tables. There needs to be two sets of *tblSite* tables from which to extract information on the From Site and the To Site. Several queries need to be joined together to show the actual complexity of the linkage because most systems have more than one pair of Sites linked by a Conveyance. The results of the Conveyance-Description query with case-study data are presented in table 12.

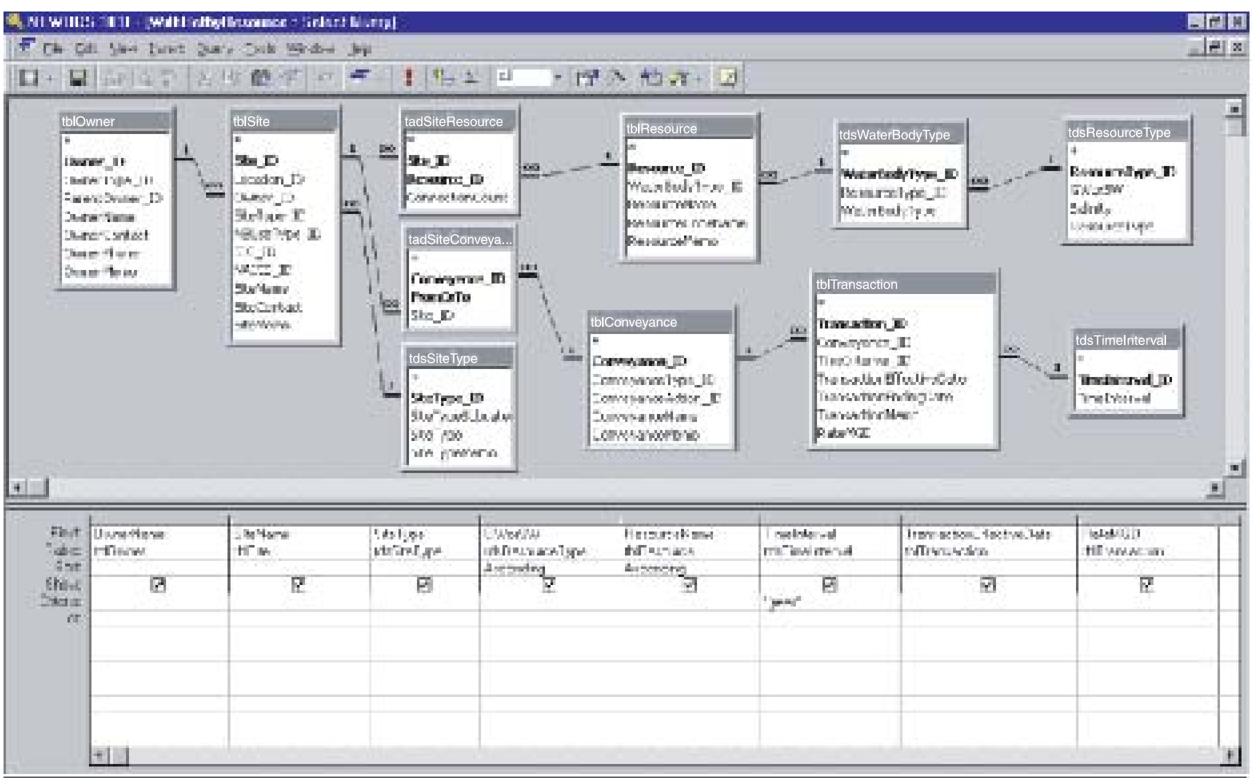

Figure 32. Withdrawals-and-Returns-by-Resource query for the time-interval of year in NEWUDS.

Table 11. Results of Withdrawals-and-Returns-by-Resource query in NEWUDS

[Case studies are in Appendix 1; No., number; GW, ground water; SW surface water; MGD, million gallons per day; MSS, major self-supplied user; CWS, community-water system; MCU, major complex user; WTP, wastewater treatment plant]

Case study No.	Owner-Name	SiteName	SiteType	GW or SW	ResourceName	TimeInterval	Transaction Effective Date	RateMGD
1, 7	MSS1	MSS1 well	Withdrawal well	GW	Crystalline-rock aquifer	Year	1/1/95	1.50
3, 9	CWS1	CWS1 well #5	Withdrawal well	GW	Glacial-deposits aquifer	Year	1/1/95	3.00
7	MSS1	MSS1 septic	Ground-water return flow	GW	Glacial-deposits aquifer	Year	1/1/95	2.00
3, 9	CWS1	Happy Hollow Reservoir-intake	Intake pipe	SW	Happy Hollow Reservoir	Year	1/1/95	69.00
8	MCU1	MCU1-industrial plant discharge pipe	Discharge pipe	SW	Taunton River	Year	1/1/95	0.33399
6, 10	WTP1	WTP1 discharge pipe	Discharge pipe	SW	Ten Mile River	Year	1/1/91	110.00

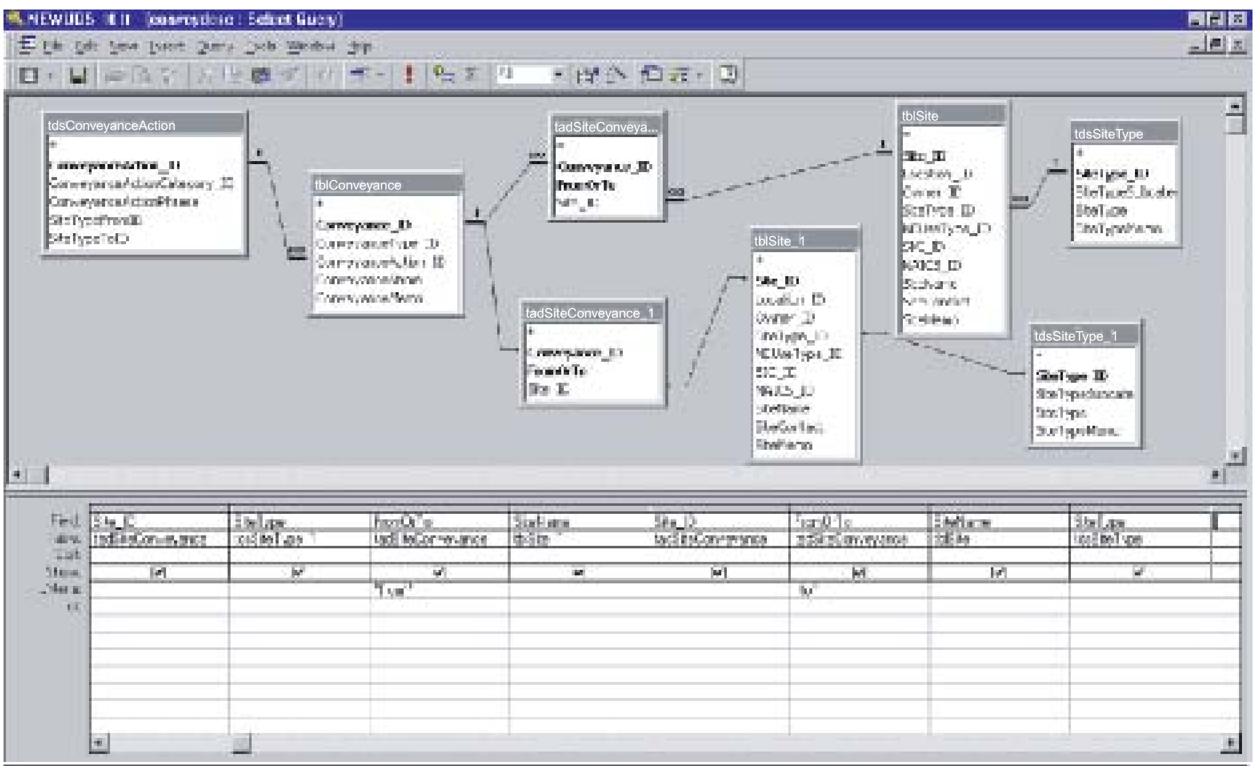

Figure 33. Conveyance description query in NEWUDS.

Table 12. Results from the Conveyance-Description query in NEWUDS

[Case studies are in Appendix 1; No., number; ID, identification number; MSS, major self-supplied user; CWS, community-water system; MCU, major complex user; WTP, wastewater treatment plant]

Case study No.	*Convey-ance_ID*	*From Site_ID*	*FromSiteType*	*FromSiteName*	*To Site_ID*	*To SiteType*	*To SiteName*
1, 7	1	1	Withdrawal well	MSS1 well	3	Single user	MSS1 plant
9	29	6	Withdrawal well	CWS1 well #5	30	Regional distribution system	CWS1 regional distribution system
7	23	3	Single user	MSS1 plant	26	Ground-water return flow	MSS1 septic
3, 9	8	10	Intake pipe	Happy Hollow Reservoir-intake	11	Potable water treatment plant	CWS1 water treatment plant
8	28	28	Single user	MCU1-industrial plant	29	Discharge pipe	MCU1 plant discharge pipe
6, 10	21	23	Wastewater treatment plant	WTP1 wastewater treatment plant	24	Discharge pipe	WTP1 discharge pipe

SUMMARY AND CONCLUSIONS

Water is used in a variety of ways that need to be understood for effective management of water resources. These water-use activities need to be categorized and included in a database management system to understand current water uses and to provide information to water-resource management policy decisionmakers.

The New England Water-Use Data System (NEWUDS) was developed by the U.S. Geological Survey to store water-use information that allows water to be tracked from a point of a water-use activity (called a Site), such as withdrawal from a Resource (reservoir or aquifer), to a second Site, such as distribution to a user (business or irrigator). NEWUDS Conceptual Model consists of 10 core entities: System, Owner, Address, Location, Site, DataSource, Resource, Conveyance, Transaction/Rate, and Alias with tables available to store User-Defined Details. Three components—Site (with both a From Site and a To Site), a Conveyance that connects them, and a Transaction/Rate associated with the movement of water over a specific time interval—form the core of the basic NEWUDS Network model. Location and Owner complete the core of the data model that defines the spatial representation of the water network and source of the data. Sites can be grouped together to form Systems based on any criteria such as common Owner, geographic Location, or *UseType*.

The most important step in correctly translating real-world water-use activities into a storable format in NEWUDS depends on choosing the appropriate Sites and linking them correctly to model the flow of water from the initial From Site to the final To Site. Withdrawal Networks include (1) single users, (2) aggregate of users, and (3) simple community-water systems (withdrawal, treatment, unaccounted-for water, and distribution to users). Return Networks include (4) single users, (5) aggregates of users, and (6) simple community-wastewater systems (collection from users, inflow and infiltration, treatment, and return). User Networks include (7) simple user and (8) complex user (withdrawal and distribution from community-water system, return, and collection to community wastewater). Complex community-system Networks include (9) complex community-water systems and (10) complex community-wastewater systems that include more than one local community in water distribution or wastewater collection. Ten case studies of water use, one for each Network, are included in this manual to illustrate how to compile, store, and retrieve the associated water-use data.

The sequence of data entry into NEWUDS is critical because there are many foreign keys. The recommended sequence is (1) System, (2) Owner, (3) Address, (4) Location, (5) Site, (6) DataSource, (7) Resource, (8) Conveyance, and (9) Transaction, (10) Rate; with (11) Alias, and (12) User-Defined-Detail tables populated as needed. After each step in data entry, quality-assurance queries should be run to ensure the data are correctly entered so that it can be retrieved accurately.

Retrieval of data stored in a database is the primary purpose for creating a database. Several retrieval queries are presented in this manual that focus on retrieving only relevant data to specific questions. The Location-Owner-Site-Type query identifies all *SiteTypes* of interest within a geographic area. The Owner-Site-Resource query determines all the withdrawals and return points by Resource. The Withdrawals-and-Returns-by-Resource query will summarize withdrawals and returns by Resource. The Conveyance-Description query relates the From Sites and To Sites for each Conveyance.

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