90-197

# WATER FACT SHEET

U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

## IMPORTANCE OF RETURN FLOW AS A COMPONENT OF WATER USE

### INTRODUCTION

Understanding the relation between the hydrologic cycle and water use is important for effective water-resources management. The hydrologic cycle is the natural pathway of water from evaporation to precipitation to infiltration or runoff and to storage from which evaporation can again occur. The science of water use is the study of human influences on the hydrologic cycle. Human activities affect the hydrologic cycle by changing the quantity, distribution, and quality of available water. Quantifying return flow is useful to water managers in evaluating such changes. Return flow is often thought of as what runs down the drain, or what is leftover after the water's purpose has been served. As innocuous as that may sound, return flow plays a significant part in the overall water-use picture.

Although water use is multifaceted and complex, it can be separated into five basic components: (1) withdrawal, (2) transfer, (3) user application, (4) consumptive use, and (5) return flow. Figure 1 illustrates these components, following the flow of water through the typical water-distribution system.

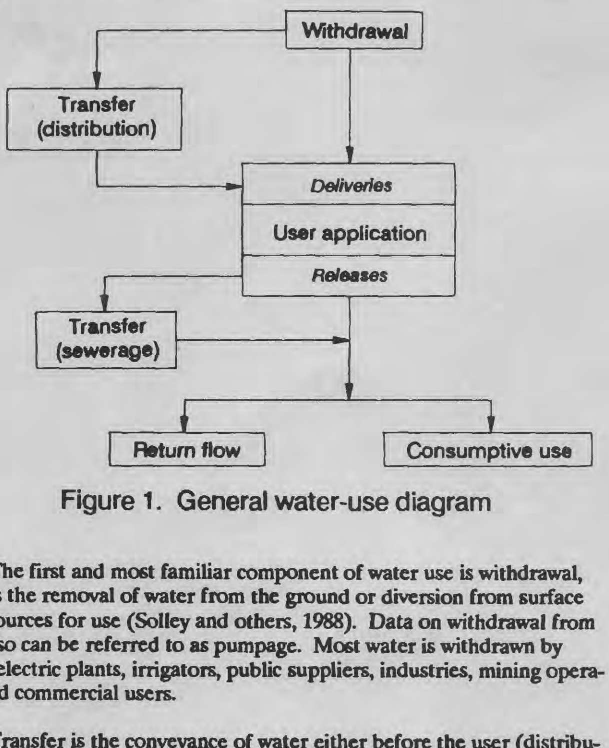


Figure 1. General water-use diagram

The first and most familiar component of water use is withdrawal, which is the removal of water from the ground or diversion from surface water sources for use (Solley and others, 1988). Data on withdrawal from wells also can be referred to as pumpage. Most water is withdrawn by thermoelectric plants, irrigators, public suppliers, industries, mining operators, and commercial users.

Transfer is the conveyance of water either before the user (distribution) or after the user (sewerage), typical aspects of a public supply. Distribution is the systematic dispersal of treated and/or subsequently pumped water. Distribution can occur outside the customer service area (primarily through interconnections to other public suppliers) or inside the customer service area to individually billed users. Sewerage is the volume of water discharged into a sewer system, where the water can be processed by a wastewater-treatment plant before it is returned to surface- or ground-water bodies.

The application of water for a particular purpose defines the user application--that is, the actual use of the water for a given purpose, such as industrial cooling or irrigation. The amounts of water associated with use can be separated into deliveries and releases. All activity prior to use entails the supply of water required by the user. All activity after use entails disposal of the wastewater. Several use categories, such as mining, industrial, domestic, and irrigation, have been defined to organize the analysis of water use.

Deliveries and releases are terms associated with the distribution of public water supplies. Deliveries are the sum of all water delivered to a user or general category of users (or to a purveyor) by way of a distribution system. The volume of water normally required for specific uses can vary with location and time of year. The volume of water required can be estimated by knowledge of the number of people served, the kilowatt-hours generated, the acres irrigated, the tons of metal processed, or the square feet cooled. Releases are defined, for the purposes of this report, as the amount of water released from the point of user application or point of wastewater treatment, and are normally equal to or less than the amount delivered to that point. Release of water is through, (1) discharge to sewers for wastewater treatment, (2) on-site treatment or recycling, (3) return flow to surface-water or ground-water bodies, (4) evaporation, and (5) incorporation into products. An accurate assessment of release rates or amounts can provide reliable data on return flow and consumptive use.

Consumptive use is water that is "evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment" (Solley and others, 1988 p. v). However, the specific definition of consumptive use can vary depending on the perspective of the water-resource manager. If the definition stipulates that water is consumed if it is not available for reuse, then discharge into the ocean (or other brackish or contaminated reservoirs) is consumptive use and discharge to a river is return flow.

Return flow is water that reaches a ground- or surface-water source after release from the point of use, thereby becoming available for reuse (Solley and others, 1988). The most commonly assessed return flow is the volume discharged by a municipal or industrial wastewater-treatment facility. There are other sources of return flow that are more difficult to quantify, however, such as recharge to (1) ground water from leaks in distribution and sewer lines, septic tanks, and excess irrigation water, and (2) surface water from dewatering and release of water from flooded fields.

The effect of return flows on the hydrologic cycle has not been studied as extensively as has the effect of withdrawals. The effect of withdrawals on water sources can be mitigated by subsequent return flow. It is important to understand and estimate withdrawals and return flows to determine the effects of water use on the availability and distribution of water resources. For example, detailed watershed water budgets require incorporation of return flow to the basin through sewer lines, drainage ditches, or irrigation operations (Trotta, 1988a). As the volumes of these transfers increase, their effect on the water budget also increases, affecting estimates of consumptive use and the effect of use on the local hydrologic system. An overview of the data-acquisition methods and flow totals observed in Minnesota is provided below as an example of the suitability of one return-flow analysis to meet water-resources-management needs.

### ESTIMATES OF THE RETURN-FLOW COMPONENT IN MINNESOTA

Return flow from some users is difficult or virtually impossible to quantify. The one water-use category in Minnesota for which data are readily obtainable is municipal sewage treatment. Analysis of data supplied by the Minnesota Pollution Control Agency (MPCA) indicates that wastewater releases from public facilities in Minnesota totaled 454 Mgal/d (million gallons per day) in 1985. The four largest treatment-plant releases occurred in South St. Paul (221 Mgal/d), Shakopee, Eagan, and Duluth (fig. 2). Although the treatment plants with the largest flows are usually in the largest cities, some are in relatively small cities (Grand Rapids and Rochester) that produce a large proportion of commercial and industrial wastewater, or in suburbs (Eagan, Shakopee, South St. Paul) that service a large metropolitan area.

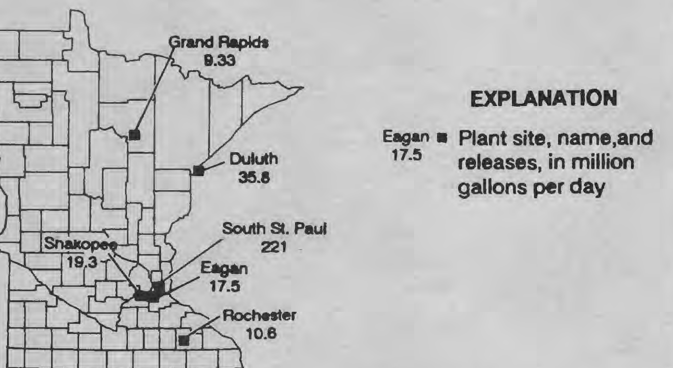


Figure 2. Estimated releases from Minnesota wastewater-treatment plants in 1985

Most releases (from 645 facilities) are returned to surface water. Part of the releases (from 32 facilities) are returned directly to land, though not always to the same aquifer from which they were withdrawn (Minnesota Pollution Control Agency, 1985). If the sewage-treatment methods release water to land (that is, the methods incorporate the use of wetland, lagoon, or spray or trickle irrigation techniques), unevaporated releases return to aquifers beneath the treatment area. Assuming a calculated State total release of 454 Mgal/d, the average release of the 677 treatment facilities in 1985 (Minnesota Pollution Control Agency, 1985) was about 0.7 Mgal/d. Assuming some evaporation, the small facilities that release water to land probably returned less than 20 Mgal/d to surficial aquifers.

## NEED TO IMPROVE ACCURACY OF RETURN-FLOW ESTIMATION

An examination of the process used to produce these return-flow estimates makes apparent the need to improve the reliability of the process. Site-specific information is preferred but is not available for every occurrence of return flow. The MPCA monitors about 1,500 active permits for wastewater discharge during administration of the U.S. Environmental Protection Agency's National Pollution Discharge Elimination System (NPDES) program (Minnesota Pollution Control Agency, 1986). Permitted dischargers measure and report the amount and quality of wastewater return flows to surface waters. These measurements are generally the best available site-specific measurements of return flow (Trotta, 1988b). The descriptions of treatment plants accompanying the permit application expedite the matching return of flows with the amount of public supply. Streamflow measurements can be used to calculate return flows if they are made upstream and downstream from a major discharger, such as a powerplant.

Even if site-specific data are available, difficulties in arriving at meaningful numbers for the return-flow component can limit the usefulness of these numbers in water-use planning. For example, in 1985, reported return flow from municipal sewage-treatment plants in Minnesota totaled 96 percent of the 473 Mgal/d public-supply withdrawals (Solley and others, 1988, p. 13, 51). A wastewater treatment plant can release more water than was originally withdrawn by the municipality (Trotta, 1988a; Cesareo and Field, 1974). These apparent discrepancies partly reflect undetermined inflow from a wide variety of sources (for example, internal roof-drain connections and ground-water infiltration into sewer lines). Some types of return flow, such as those to land or through septic systems, still need to be quantified in Minnesota. Return-flow-estimation techniques developed in other sewer districts and computerization of data can assist in the development of meaningful estimates of return flows.

Because studies of infiltration and line leaks are not available for every city in the State, studies specific to local areas can (with a knowledge of water-table conditions) be applied to other areas (Trotta, 1988a, p.14). For cost efficiency, the sophisticated measuring equipment needed for these studies requires application of the study results to other areas in the form of coefficients (for example, the ratio of average release to average withdrawal). However, coefficients need to be used with caution, and preferably for expanding on known site-specific data.

Computerization of records is essential to the difficult process of converting large volumes of raw data to useful information. Monitoring the effect of water use on the hydrologic cycle requires careful planning, coordination, analysis, and an efficient computerized data-management system. If the site-specific data are processed on a regular basis, difficulties in interpretation could be studied and rectified efficiently. Return flow is interrelated to all other aspects of water use and provides a quality-assurance check to calculations for these other components.

Water managers can use accurate water-use data to provide information or methods that will preserve the availability and purity of water for future generations. Complex decisions on the quantity of supply, such as whether to develop new water supplies or conserve existing supplies and whether to expand withdrawals in one area or limit them in another, need to be supported by accurate assessments of all five water-use components. Decisions relative to water quality are complex and dependent on return-flow data. Changes in water quality caused by dilution of wastewaters with natural waters are only definable in areas where return-flow quantities are clearly defined.

## SUMMARY


Water use has five basic components: (1) withdrawal, (2) transfer, (3) user application, (4) consumptive use, and (5) return flow. Return flow constitutes a significant part of water use. In Minnesota, sewage-treatment plant return flows totaled 454 Mgal/d in 1985, or about 96 percent of municipal withdrawals. Return-flow data are available in a variety of forms, the most accurate of which are site-specific measurements. If return-flow data are computerized and made available in conjunction with withdrawal data, water-resource planners and managers will be able to improve water-use decisions.


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