Ground Water and Surface Water
A Single Resource

U.S. Geological Survey Circular 1139

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FOREWORD

Traditionally, management of water resources has focused on surface water or ground water as if they were separate entities. As development of land and water resources increases, it is apparent that development of either of these resources affects the quantity and quality of the other. Nearly all surface-water features (streams, lakes, reservoirs, wetlands, and estuaries) interact with ground water. These interactions take many forms. In many situations, surface-water bodies gain water and solutes from ground-water systems and in others the surface-water body is a source of ground-water recharge and causes changes in ground-water quality. As a result, withdrawal of water from streams can deplete ground water or conversely, pumpage of ground water can deplete water in streams, lakes, or wetlands. Pollution of surface water can cause degradation of ground-water quality and conversely pollution of ground water can degrade surface water. Thus, effective land and water management requires a clear understanding of the linkages between ground water and surface water as it applies to any given hydrologic setting.

This Circular presents an overview of current understanding of the interaction of ground water and surface water, in terms of both quantity and quality, as applied to a variety of landscapes across the Nation. This Circular is a product of the Ground-Water Resources Program of the U.S. Geological Survey. It serves as a general educational document rather than a report of new scientific findings. Its intent is to help other Federal, State, and local agencies build a firm scientific foundation for policies governing the management and protection of aquifers and watersheds. Effective policies and management practices must be built on a foundation that recognizes that surface water and ground water are simply two manifestations of a single integrated resource. It is our hope that this Circular will contribute to the use of such effective policies and management practices.

(Signed)

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BOXES

- Understanding the interaction of ground water and surface water is essential to water managers and water scientists. Management of one component of the hydrologic system, such as a stream or an aquifer, commonly is only partly effective because each hydrologic component is in continuing interaction with other components. The following are a few examples of common water-resource issues where understanding the interconnections of ground water and surface water is fundamental to development of effective water-resource management and policy.

WATER SUPPLY

- It has become difficult in recent years to construct reservoirs for surface storage of water because of environmental concerns and because of the difficulty in locating suitable sites. An alternative, which can reduce or eliminate the necessity for surface storage, is to use an aquifer system for temporary storage of water. For example, water stored underground during times of high streamflow can be withdrawn during times of low streamflow. The characteristics and extent of the interactions of ground water and surface water affect the success of such conjunctive-use projects.

- Methods of accounting for water rights of streams invariably account for surface-water diversions and surface-water return flows. Increasingly, the diversions from a stream that result from ground-water withdrawals are considered in accounting for water rights as are ground-water return flows from irrigation and other applications of water to the land surface. Accounting for these ground-water components can be difficult and controversial. Another form of water-rights accounting involves the trading of ground-water rights and surface-water rights. This has been proposed as a water-management tool where the rights to the total water resource can be shared. It is an example of the growing realization that ground water and surface water are essentially one resource.

- In some regions, the water released from reservoirs decreases in volume, or is delayed significantly, as it moves downstream because some of the released water seeps into the streambanks. These losses of water and delays in traveltime can be significant, depending on antecedent ground-water and streamflow conditions as well as on other factors such as the condition of the channel and the presence of aquatic and riparian vegetation.

- Storage of water in streambanks, on flood plains, and in wetlands along streams reduces flooding downstream. Modifications of the natural interaction between ground water and surface water along streams, such as drainage of wetlands and construction of levees, can remove some of this natural attenuation of floods. Unfortunately, present knowledge is limited with respect to the effects of land-surface modifications in river valleys on floods and on the natural interaction of ground water and surface water in reducing potential flooding.

WATER QUALITY

- Much of the ground-water contamination in the United States is in shallow aquifers that are directly connected to surface water. In some settings where this is the case, ground water can be a major and potentially long-term contributor to contamination of surface water. Determining the contributions of ground water to contamination of streams and lakes is a critical step in developing effective water-management practices.

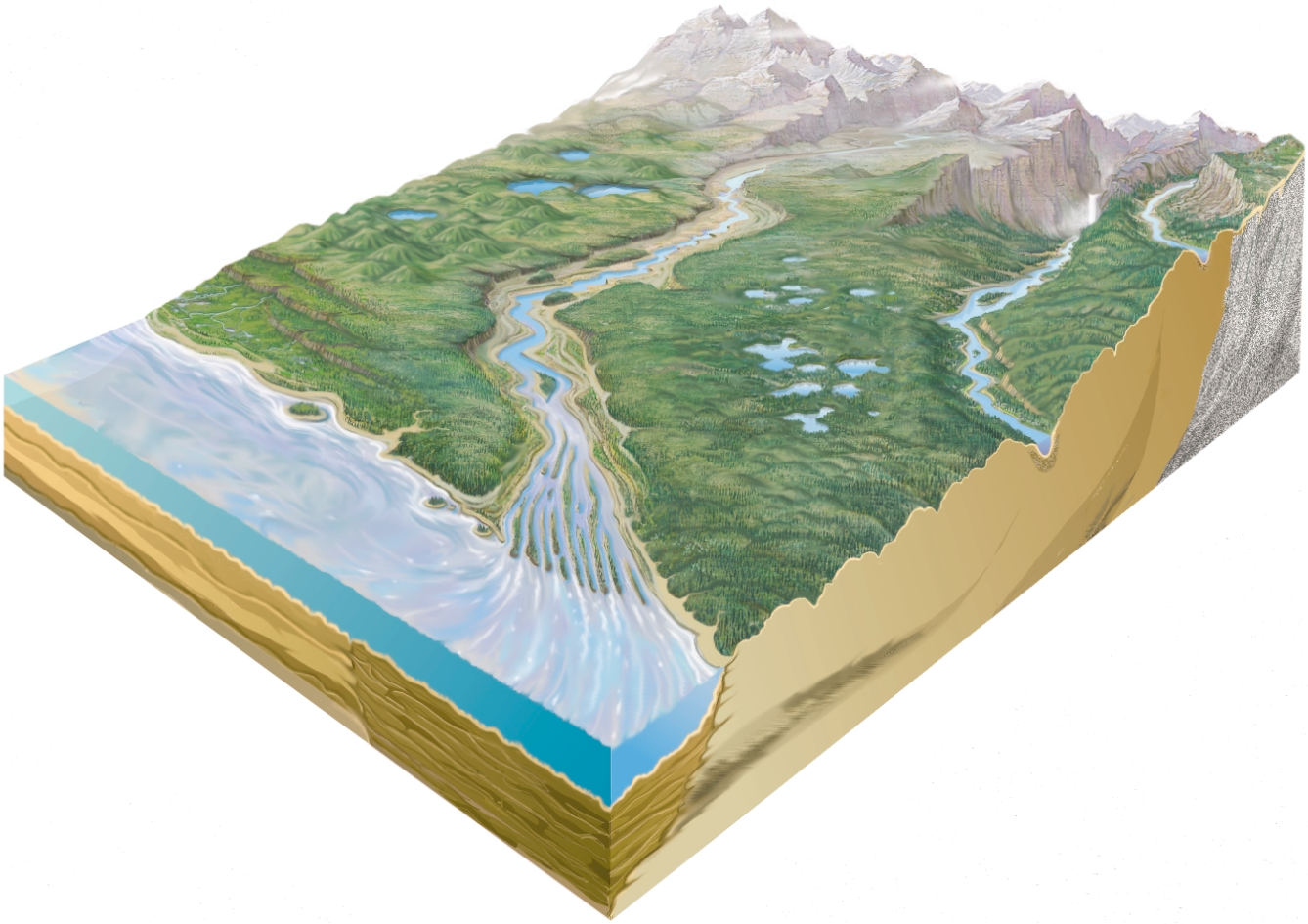
- A focus on watershed planning and management is increasing among government agencies responsible for managing water quality as well as broader aspects of the environment. The watershed approach recognizes that water, starting with precipitation, usually moves

through the subsurface before entering stream channels and flowing out of the watershed. Integrating ground water into this "systems" approach is essential, but challenging, because of limitations in knowledge of the interactions of ground water and surface water. These difficulties are further complicated by the fact that surface-water watersheds and ground-water watersheds may not coincide.

- To meet water-quality standards and criteria, States and local agencies need to determine the amount of contaminant movement (wasteload) to surface waters so they can issue permits and control discharges of waste. Typically, ground-water inputs are not included in estimates of wasteload; yet, in some cases, water-quality standards and criteria cannot be met without reducing contaminant loads from ground-water discharges to streams.
- It is generally assumed that ground water is safe for consumption without treatment. Concerns about the quality of ground water from wells near streams, where contaminated surface water might be part of the source of water to the well, have led to increasing interest in identifying when filtration or treatment of ground water is needed.
- Wetlands, marshes, and wooded areas along streams (riparian zones) are protected in some areas to help maintain wildlife habitat and the quality of nearby surface water. Greater knowledge of the water-quality functions of riparian zones and of the pathways of exchange between shallow ground water and surface-water bodies is necessary to properly evaluate the effects of riparian zones on water quality.

CHARACTERISTICS OF AQUATIC ENVIRONMENTS

- Mixing of ground water with surface water can have major effects on aquatic environments if factors such as acidity, temperature, and dissolved oxygen are altered. Thus, changes in the natural interaction of ground water and surface water caused by human activities can potentially have a significant effect on aquatic environments.
- The flow between surface water and ground water creates a dynamic habitat for aquatic fauna near the interface. These organisms are part of a food chain that sustains a diverse ecological community. Studies indicate that these organisms may provide important indications of water quality as well as of adverse changes in aquatic environments.
- Many wetlands are dependent on a relatively stable influx of ground water throughout changing seasonal and annual weather patterns. Wetlands can be highly sensitive to the effects of ground-water development and to land-use changes that modify the ground-water flow regime of a wetland area. Understanding wetlands in the context of their associated ground-water flow systems is essential to assessing the cumulative effects of wetlands on water quality, ground-water flow, and stream-flow in large areas.
- The success of efforts to construct new wetlands that replicate those that have been destroyed depends on the extent to which the replacement wetland is hydrologically similar to the destroyed wetland. For example, the replacement of a wetland that is dependent on ground water for its water and chemical input needs to be located in a similar ground-water discharge area if the new wetland is to replicate the original. Although a replacement wetland may have a water depth similar to the original, the communities that populate the replacement wetland may be completely different from communities that were present in the original wetland because of differences in hydrogeologic setting.



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INTRODUCTION

As the Nation's concerns over water resources and the environment increase, the importance of considering ground water and surface water as a single resource has become increasingly evident. Issues related to water supply, water quality, and degradation of aquatic environments are reported on frequently. The interaction of ground water and surface water has been shown to be a significant concern in many of these issues. For example, contaminated aquifers that discharge to streams can result in long-term contamination of surface water; conversely, streams can be a major source of contamination to aquifers. Surface water commonly is hydraulically connected to ground water, but the interactions are difficult to observe and measure and commonly have been ignored in water-management considerations and policies. Many natural processes and human activities affect the interactions of ground water and surface water. The purpose of this report is to present our current understanding of these processes and activities as well as limitations in our knowledge and ability to characterize them.

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