GROUND WATER MANAGEMENT IN VIRGINIA: A COMPARATIVE EVALUATION OF THE INSTITUTIONAL FRAMEWORK

by

William Edward Cox

Dissertation submitted to the Graduate Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Civil Engineering

APPROVED:

W. R. Walker, Chairman

J. E. Hackett

B. F. Long

P. H. King

J. M. Wiggert

March, 1976

Blacksburg, Virginia

ACKNOWLEDGMENTS

Sincere gratitude is expressed to all those who have been of assistance and support in this research effort and with respect to the other elements of my graduate program. Special appreciation is extended to William R. Walker, chairman of the advisory committee, and to the other members of the committee, including James E. Hackett, Paul H. King, Burl F. Long, and James M. Wiggert.

Acknowledgment is also given to the National Science Foundation's program of Research Applied to National Needs for support of research on which a portion of this dissertation is based; to the Office of Water Research and Technology for support of other contributing research; and to state agency personnel whose cooperation was invaluable, especially Elmer Ramsey and Ted Swearingen of the State Water Control Board.

A special debt of gratitude is owed to my wife Clara. In addition to the many other forms of support, her efforts in typing the preliminary draft of this dissertation and the majority of the final draft have made an invaluable contribution.

TABLE OF CONTENTS

INTRODUCTION

Scope and Objectives of Study

Ground water is an abundant resource in considerable portions of Virginia and exists in varying quantities throughout the state. It has played an important role in supplying municipal and industrial needs and is the major source of supply for individual and small community systems. Management of the resource has traditionally been decentralized in nature, with private individuals and industrial firms constituting the principal decision-makers with regard to development and utilization. In the past, the primary governmental control has consisted of judicial enforcement of private rights as they apply to ground water, and even this institutional mechanism has remained at a low level of development.

However, recent years have seen considerable expansion in direct governmental involvement as a result of substantial deterioration of ground water conditions in many areas and a greater recognition of the significance of this occurrence. This increased concern has been manifested by the adoption of new legal controls and administrative procedures at both the federal and state levels of government. At the federal level, the primary development consists of the program for protection of ground water quality authorized by the Safe Drinking Water Act (221) enacted in 1974. Within the Commonwealth, a major institutional development is the passage of the Groundwater Act of 1973 (109) which focuses on the issue of allocating ground water supplies among competing users.

Development of new institutions for ground water management attests to the existence of serious management problems and the deficiencies of the previous institutional structure in dealing with these problems, but the effectiveness of these new institutional arrangements has yet to be determined. Both of the programs referred to above are untried approaches since neither has been fully implemented. Thus questions remain concerning such basic factors as the inherent effectiveness of the new programs and their compatibility with other institutions applicable to ground water management such as private rights and other governmental programs affecting certain aspects of management.

Due to the expressed inadequacy of traditional ground water management institutions and the unimplemented status of newly initiated institutions, there is need for a basic examination of this aspect of ground water management. The general purpose of this study is the examination of management institutions, with specific consideration given to Virginia as a case study. The case study approach provides a mechanism for detailed analysis of the institutional framework in Virginia within the context of a broader, more general consideration and evaluation of management institutions. Within this general goal of institutional evaluation, the following objectives can be enumerated:

(1) Determination of the special institutional requirements necessitated by the physical characteristics of the ground water resource;

(2) Identification and description of the existing institutional structure for ground water management in Virginia;

(3) Comparative evaluation of the comprehensiveness and potential effectiveness of the Virginia institutional framework; and

(4) Development of general institutional guidelines applicable in any jurisdiction and specific recommendations to improve the institutional structure for ground water management in Virginia.

Each of these four objectives is expanded and discussed below.

Determination of Institutional Requirements

The basic physical characteristics of the resource must be viewed as the major physical determinant of the institutional requirements for management. Institutions which do not give adequate recognition to the role of ground water in the hydrologic cycle and the processes governing its occurrence and movement cannot serve as the basis for effective management. In addition to definition of these basic physical processes, other important elements of the physical framework upon which institutions must be based include the availability of ground water, the significance of the resource as a source of supply, and the nature and extent of existing and potential management problems in the area of interest.

Identification of Existing Institutional Structure in Virginia

In order to evaluate managerial effectiveness, it is necessary to identify the existing institutional structure. The elements of this framework for management include a variety of private rights and governmental programs at the federal, interstate, state, regional, and local levels. Private rights of possible interest include rights to withdraw ground water pursuant to judicial doctrines, privately enforced constraints on activities that contaminate or otherwise adversely affect ground water, and property rights affecting use of subsurface space in connection with artificial recharge and storage operations. A wide range of governmental programs relate either directly or indirectly to ground water management, including allocation controls, protection of water quality, land use control, and data collection activities.

The analysis of federal institutional mechanisms that have an impact on ground water management at the state level is primarily concerned with data collection and water quality protection programs. Although federal water quality programs continue to place the traditional emphasis on surface waters, the Federal Water Pollution Control Act Amendments of 1972 (85) contain provisions applicable to ground water quality, and the Safe Drinking Water Act passed in 1974 provides for federal control over subsurface waste injection. In addition to these programs having direct applicability to ground water management, certain other federal controls not directly associated with ground water may also have an impact. For example, the National Environmental Policy Act of 1969 (169) and other institutional mechanisms requiring full evaluation of environmental consequences of alternative water resource projects may have an impact on ground water development. Therefore it is necessary to include such controls within the analysis of federal institutions affecting ground water management at the state level.

Analysis of direct state controls encompasses several relatively independent programs in the State of Virginia. The most significant with regard to control of withdrawal is the critical ground water area program administered by the State Water Control Board (SWCB). In addition to an analysis of the elements of this program, this study evaluates the potential conflicts between the Virginia controls and private property rights recognized in the state. Another state program basic to ground water management concerns the protection of water quality. All state controls over handling and disposal of potential contaminants are evaluated with regard to their effectiveness in protecting ground water quality. A third relevant activity consists of certain non-regulatory programs such as data collection and management.

Governmental programs at the interstate, regional, and local levels have less direct impact on ground water management but may be significant in certain areas. Interstate agreements primarily focus on surface water but have some applicability to ground water. The principal impact of regional and local governmental units is in the area of land use controls. Regional entities such as planning districts exercise certain land use responsibilities while actual controls traditionally have been the responsibility of local units of government.

Comparative Evaluation of Existing Institutions

The evaluation of existing institutions involves an assessment of their adequacy to deal with the problems associated with the resource. The issue of institutional effectiveness includes consideration of the strengths and weaknesses of each program element and also involves consideration of compatibility and coordination among the various elements. For example, governmental controls on ground water pumping potentially conflict with the property right to pump as defined in judicially developed ground water doctrines. In addition, coordination among the various governmental programs is a significant determinant of feasibility.

Evaluation of institutions for ground water management in Virginia is facilitated by comparisons with the experience of other states where management programs and institutional mechanisms have seen more intensive development and refinement through long-term utilization. For example, the ground water rights of individual landowners are not well-defined in Virginia, but the doctrines of rights which have seen limited application have been much more fully developed in other jurisdictions. Thus a logical source of information exists which can be used to tie together and extend the somewhat fragmentary and piecemeal pronouncements of the Virginia judiciary. Likewise, the experience of other states with regard to the effectiveness and constitutionality of various governmental controls provides a valuable source of information in evaluating the Virginia situation.

However, caution must be used in making such comparisons. Although institutions do have a certain degree of transferability, their effectiveness requires adaptation to the special circumstances of the individual situation. One basic factor affecting the applicability and effectiveness of a particular control mechanism consists of the degree of similarity between the ground water systems and the particular problems involved. Another relevant factor involves the nature of supporting and related institutions within which a ground water management program must function. Basic differences in such areas may significantly alter the effectiveness of a particular institutional mechanism when transferred between jurisdictions.

Development of Recommendations for Ground Water Management Institutions

Recommendations for management institutions can be developed at two levels--in the form of generalized guidelines of relatively broad applicability and in a form specifically applicable to Virginia. At the broader level, the evaluation of Virginia institutions and comparisons with those of other states facilitate the development of general guidelines for ground water management institutions. Examples of issues to be encompassed in the guidelines include the balance between private rights and governmental controls with respect to the resource, the relative managerial roles of the different levels of government, coordination among the various aspects of a comprehensive management program, and general provisions for such program elements as allocation and quality protection.

At the second level of analysis, the general guidelines will be applied to the institutional structure existing in Virginia in order to develop recommendations for improvements. The evaluation of the existing structure will have identified specific weaknesses and therefore will facilitate formulation of needed modifications in considerable detail.

Impact of Ground Water Characteristics on Management Institutions

Externalities Assoicated with Ground Water

A characteristic of the ground water resource which becomes a basic factor in its management is the existence of extensive physical interrelationships among the activities of individual ground water users and among the activities of water users and the developers of land and other resources. Natural resource management in general is complicated by the existence of "spillover" effects that are external to the decision-makers and therefore tend to distort the decision-making process. Ground water exhibits a great propensity toward such externalities due to the dependence of its occurrence and movement on a broad range of natural processes. Considerable potential exists for externalities to be created whenever there is interference with the individual processes making up the ground water system.

One of the most common types of externality consists of the detrimental impact that ground water withdrawal by means of wells can have on other water users. Despite court declarations to the contrary, ground water is not like the soil and rock underlying the land, and pumping by one landowner can adversely affect the supply available on other land. Pumping reduces the level of the water table or, in cases of artesian aquifers, the hydrostatic pressure and thereby increases the flow of water toward the well. Such withdrawal can result in decreased natural discharges such as occur at springs and can affect the amount of water made available to streams and other surface water bodies. With regard to the potential impact of pumping on surface water supplies, it should be noted that ground water is a major source of stream flow. It has been estimated that between one-third and two-fifths of the stream discharge in the United States to the oceans has passed through ground water reservoirs (151, p. 34). Therefore the impact of pumping may be felt by surface water users to a greater extent than by other ground water users in some situations. Withdrawal of surface water can also adversely affect ground water supplies where surface waters are the source of ground water recharge. These interrelationships indicate the futility of attempting to manage surface and ground water as independent physical systems.

Where more than one well extracts water from the same aquifer, interference between wells can also result. Each well lowers the water table or artesian pressures to produce a three-dimensional "cone of depression" around itself, and interference results when these cones overlap. The likelihood that interference between wells will occur is dependent on well spacing and the extent of the area of influence of the individual wells. This latter factor is controlled largely by recharge rates, aquifer characteristics, and pumping rates (151, pp. 49-50). In the extreme case, the withdrawals of one party may completely exhaust the common supply. In the more frequently occurring situation, water levels or artesian pressures are simply reduced such that withdrawal becomes more costly for others.

A basic characteristic of ground water that is significant to management of withdrawal is its rate of replenishment in comparison with the total amount of water in storage. Rate of recharge is dependent on physical conditions that vary with location but in general constitutes a relatively small proportion of precipitation. The amount of water in storage in ground water reservoirs at a given time represents the accumulated reserve of a long period of time. It has been estimated that current storage above a depth of half a mile, estimated to constitute one-half of total ground water storage, represents 160 years of recharge (168, p. 3). Thus only a small portion of the water in storage can be viewed as a flow resource which is replenished on a continual basis. The remainder must be viewed as a stock resource that is exhausted by use in the same manner as is petroleum or any other non-renewable resource.

Management efforts can either seek the objective of limiting withdrawals by users to the amount of recharge, the "sustained-yield" concept, or withdrawals can be allowed to exceed the rate of replenishment, a practice referred to as "ground water mining." Where ground water exists in unconfined aquifers, mining produces a continuing decline in the level of the water table. Under artesian conditions, the initial impact of excessive withdrawals is reduction in artesian pressures, followed by eventual dewatering of the aquifer if mining continues for a sufficient period. Both mining and the concept of limiting the rate of withdrawal to that of replenishment are currently being utilized among the various managerial jurisdictions in the United States (151, pp. 59-61).

Where ground water mining is practiced, adverse impacts of withdrawal are not limited to water level reductions but may include other effects such as aquifer damage and subsidence of the land surface (197). Aquifer damage results from settlement and compaction of the formation materials that permanently reduce the storage capacity and/or permeability. Subsidence resulting from aquifer compaction can produce damage to man-made structures or otherwise interfere with surface activities.

Still another detrimental impact of pumping activities having external aspects consists of salt water intrusion which impairs the quality of the water in an aquifer. In coastal areas where aquifers are hydraulically connected to the sea, salt water intrusion results when pumping lowers fresh water levels to the extent that the normal gradient toward the sea is reversed, with the result that the aquifer is recharged with seawater. Salt water intrusion can also occur in inland areas where alternations of aquifer pressures can cause saline water, generally from deeper-lying strata, to migrate into fresh water zones (151, pp. 72-80).

In addition to externalities resulting from ground water withdrawal, management efforts to replenish supplies through artificial recharge are also likely to have external effects since the water introduced into an aquifer will move away from the point of recharge in response to the artificial gradient created and will also be affected by the natural hydrodynamic system. External diseconomies are created where the increased water levels interfere with subsurface drainage or otherwise adversely affect land use. External economies can also be created since an augmented supply may be made available to other ground or surface water users not involved in the recharge operation.

Externalities are also important in ground water management because of the adverse impact which a variety of land development activities can have on subsurface hydrologic patterns. For example, many activities in addition to pumping affect the movement of ground water to the detriment of those using it as a source of supply. In some instances, excavation on one tract of land has the effect of interrupting the continuity of aquifers and thereby destroying the source of water supply for wells and springs on neighboring lands. This problem can be significant in the case of major excavations such as mining and quarrying, especially where dewatering operations are conducted as a part of such operations.

Since the principal source of ground water is infiltration of rainfall, any activity which modifies the infiltration capacity of the soil has an impact on renewability of ground water supplies. The general effect of urbanization with its modification of the land surface and increase in land coverage by buildings and pavement is an increase in the relative amount of surface runoff and a corresponding decrease in the amount of infiltration (144). The extent of the impact of this factor varies with the location of developmental activities since natural recharge is a function of soil type and geologic conditions. Major recharge areas often occur where aquifers outcrop or where highly permeable soil exists while natural recharge may be insignificant where the aquifer in question is overlain by materials of low permeability. Infiltration is also reduced by drainage projects which facilitate surface run-off. The long-term effect of such projects is a reduction in natural aquifer recharge.

A variety of land use activities also has the potential of adversely affecting ground water quality (163, pp. 124-285). The most obvious source of contaminants consists of the many land-based techniques of waste management. Septic tanks, landfills, waste lagoons, injection wells, drainage wells, and wastewater irrigation all have an inherent potential for ground water contamination. Use of land-based systems is generally increasing as a result of expanded efforts to reduce effluent discharge to surface water, thereby creating a greater threat of ground water pollution.

Other activities not directly associated with waste management which result from urbanization and industrial development also have the potential of causing ground water contamination. A multitude of potentially deleterious materials are handled and utilized in connection with industrial operations, and their escape is a common occurrence. In some instances, accidental spills of such pollutants directly affect surface waters but more frequently enter the ground water. Residential development results in greater use of fertilizers and pesticides which can affect ground water quality. Greater numbers of streets and highways result in increased use of de-icing salts that have been associated with ground water quality deterioration. Natural resource development is a significant source of pollution, with mining and oil and gas extraction having been responsible for major problems. Intensive agricultural practices such as feedlot operations and use of large quantities of fertilizers and pesticides also serve as sources of contamination. As these examples suggest, the scope of activities having ground water pollution as a possible external consequence is essentially unlimited.

With regard to the issue of water quality, an important management consideration is the rate of movement of ground water. The capacity of subsurface formations to transmit water varies greatly with the nature of the formation materials. Of course the most important factor consists of the amount and characteristics of the openings within the material (151, p. 8). The amount of void space is measured by the porosity of a material and consists of pore space such as that between grains of sand and other openings such as joints and fractures. While porosity indicates the storage potential of a material, the movement of water through the material is controlled by permeability, which is highly dependent on the nature, size, and degree of inter-connection of the voids.

Although the rate of ground water movement varies over a considerable range, slowness is a basic characteristic. Where stream velocities are commonly measured in terms of feet per second, ground water velocities frequently are expressed as feet per day or even feet per year (256, p. 71). Therefore cleansing of a contaminated aquifer by natural processes may involve a much longer period of time than in the case of a polluted stream, a fact which emphasizes the importance of preventive measures.

Regardless of whether quantity or quality is at issue, a basic factor affecting management of ground water consists of the difficulty of measurement and the uncertainty associated with the physical characteristics of the resource. Ground water systems are often quite complex because of such factors as hydraulic interconnection between aquifers or between aquifers and surface waters. Unlike surface waters whose characteristics can be readily observed and measured, ground water conditions cannot be easily determined, making data collection more difficult. In many cases, even such basic information as recharge rates and location of principal recharge areas are unknown. The quantity of water in storage is often obscured by lack of information concerning aquifer dimensions, and the production potential of vast land areas is unknown. The direction and rates of movement at a specific point are often uncertain, a fact which is significant whenever prediction of impact is necessary.

Although the uncertainty traditionally associated with ground water continues to be a factor in ground water management, there have been many technological advances which reduce its significance. The general status of knowledge has been summarized as follows:

> Scientific research has progressed to the point where the fundamental principles of the occurrence of ground water have been firmly established, and good general knowledge is available as to the manner of its replenishment, movement and discharge. There are, indeed, uncertainties as to the details of occurrence of ground water in many places, because essential basic data have not been obtained, but it is now possible, in any area, to collect sufficient data for a quantitative appraisal of the ground water resources and their development. Some of these data, however, must be collected over long periods of time, and at considerable expense (101, p. 3).

As indicated by this quotation, data deficiencies may be a serious problem in many situations, but the occurrence and movement of ground water is not as mysterious as is still commonly assumed. However, the concept of uncertainty has been incorporated into certain institutions as a basic characteristic of the ground water resource, and recognition and application of scientific advances in the area of ground water management may be impeded thereby.

Requirements for Management Institutions

A basic implication of the propensity of ground water toward a diversity of externalities is the need for social institutions to protect and control use of the resource. A fundamental managerial requirement consists of mechanisms to act as constraints on activities that are wasteful and inefficient from the perspective or maximizing the total social benefit obtainable from the resource. The need for such mechanisms arises because the nature of ground water is such that the negative impacts of action affecting the commonpool resource do not have to be borne fully by the beneficiary of the action. This shifting of costs removes a basic constraint on detrimental activities that may be limited in scope if the responsible party were fully accountable. In the absence of such accountability, pumping rates are likely to be excessive, contaminating activities proceed unchecked, and incentives for restricting other detrimental activities in general do not exist.

The oldest institution for imposing accountability for detrimental externalities associated with the ground water resource consists of systems of property rights enforceable through the judicial process. Doctrines of ground water rights developed through the accumulated decisions of the courts establish guidelines for allocating ground water supplies between competing users and place certain constraints on other activities affecting either the quantity or quality of ground water available on other property. Rights existing under these doctrines may be enforced through the mechanism of injunction which consists of the issuance of a court order prohibiting or compelling certain future activities and/or an action for damages to reimburse an injured party for losses in connection with past activities.

Constraints on externalities associated with ground water have also been imposed through the institution of direct governmental controls. These controls have been established at essentially all levels of government, including federal, interstate, state, local, and a variety of regional and special district governmental units. These controls have generally not been instituted as part of coordinated management programs but rather on a somewhat fragmented, piecemeal basis designed to solve narrowly-defined problems.

In some cases, externalities adversely affecting ground water are subject to institutional controls having primary objectives not directly related to ground water management. A good illustration of this situation consists of land use controls usually administered at the local level of government. Although such controls likely constitute the only effective mechanism for protecting ground water from certain adverse effects, their implementation has generally been directed toward other goals with little consideration of their application to ground water management.

In addition to the need for institutional mechanisms for controlling detrimental activities, a second fundamental managerial requirement is the need for institutions to provide for collective action to initiate and carry out programs of non-regulatory managerial activities. Such programs as data collection are essential to scientific management, and certain ground water problems require planning and implementation of technological solutions to supplement restrictions on undesirable practices. For example, resolution of problems arising from inadequate supply may be accomplished most efficiently in some situations through a program of artificial recharge, and problems of salt water intrusion may lend themselves to solution by creation of artificial barriers in some cases. Data collection and other non-regulatory operations generally cannot be successfully accomplished on a scale comparable to the individual interest but must be approached in a comprehensive manner that encompasses broad geographical areas such as entire hydrologic units.

Due to these requirements of scale, the non-regulatory elements of ground water management programs have traditionally been undertaken by public agencies. Data collection programs have been the primary function of federal and state governmental agencies while activities at a more operational level have generally been conducted by lower units. The particular institutional structure that usually has been employed in such management efforts consists of the administrative agency because of the necessity for initiation and implementation of forward-looking programs of activities.

It is apparent that the ground water resource can accommodate a large degree of institutional ineffectiveness. Many benefits have been obtained from the resource under poorly developed or otherwise flawed institutions. However, under conditions of continuously increasing use and other adverse pressures, interest in the development of institutions heightens with the realization that they constitute the decision-making framework within which managerial programs must be implemented. The following statement from a study prepared in connection with a reorganization of water resource management institutions in North Carolina is relevant:

> Two factors have largely stimulated eastern water law innovation: cyclical drought conditions and developmental pressures associated with population growth and industrialization. Periodic droughts alone would not ordinarily suffice as a reason for revolutionizing water laws and institutions . . . . However, at some point along the rising curves of population and economic growth, problems of local scarcity or overdevelopment of water resources become sufficiently chronic and widespread to demand new water laws and institutions (319, p. 72).

The reorganization of ground water management institutions in response to increased competition for water and other pressures on the resource has traditionally involved a heightened level of public control. Ground water legislation is generally enacted as a supplement to the controls defined by water rights doctrines, and administrative bodies are usually established and given authority for a much more active managerial program than is possible under the institutional framework consisting largely of passive controls enforced through the courts. In the western states, there has been a trend toward application of the doctrine of prior appropriation in ground water management (51). In the East, several states in recent years have adopted legislation for direct state controls over ground water withdrawal to be initiated in specially designated areas (109, 112, 308).

Efforts to institute a program of public controls often encounter substantial opposition from ground water users. A basic reason for such opposition is the view that ground water is a private rather than a public resource. Although doctrines of surface water rights have traditionally defined individual rights in terms of use instead of ownership of the water, a fundamental concept of one ground water doctrine which is still a factor in the law of many jurisdictions is that ground water is the property of the owner of the land in which it is found. The ownership concept has now been abandoned or qualified in most jurisdictions, but rights with respect to ground water apparently are still generally viewed as more absolute than rights in surface water. Thus attempts at public regulation have often been viewed by ground water users as an unconstitutional taking of property, and a few control programs have been invalidated by the courts on the basis of such challenges (47, 128).

Much variation exists with regard to organizational arrangements for administration of public ground water management programs, particularly concerning the degree of centralization of control. Institutional structure has ranged from largely autonomous local control programs to management strictly at the state level, with many programs in between these extremes that utilize various combinations of state and local control.

Just as ground water users oppose public regulation in general, they also usually oppose centralization of control and tend to prefer local programs (262). The principal factor on which this position is based is the size of the ground water area affected by the activities of one individual relative to the extent of the impact possible where surface waters are involved. Because of the inherent characteristics of the resource, external effects of one party's operations are likely to be limited to property in close proximity to the responsible activity. This factor lends support to the view that ground water management is a matter of local and not of state-wide concern.

Although management at the local level has had some degree of success in certain cases, experience with this type of management institution has indicated serious limitation with this approach in general. Local programs are often largely under the control of the principal ground water users, and self-regulation has frequently proven to be ineffective, even in cases where ground water problems were rapidly intensifying as the result of the lack of controls. (119, pp. 755-756). Local management is also likely to be handicapped because of the limited scope of financial, planning, and general administrative capabilities, limitations leading to difficulties with such functions as operation of comprehensive programs of data collection and analysis. Finally, the inability to deal with management problems having elements external to the management jurisdiction is a basic weakness (235).

Management institutions have seen their greatest development and refinement in traditional areas of water scarcity, but not always before institutional weaknesses have exacted a heavy toll. A good example is given by the Roswell area of the State of New Mexico where the lack of controls on drilling new wells facilitated an intensive development of an artesian basin after World War I. The resulting situation has been described as follows:

> Pressures went down. Pumping costs went up. By 1925 there were mortgage foreclosures by the thousands on good farm land. In fact, virtually the whole valley was in receivership. At this time not a dime could be borrowed on the lands. The mortgagees said no funds would be lent until there were controls on drilling (51, p. 45).

The State of New Mexico enacted legislation (142) in 1927 that placed controls on drilling and offered protection to existing water users. The constitutionality of these controls was challenged in 1930, and the legislation was invalidated because of technical deficiencies in its construction (321). The basic concepts of the law were held to be valid, and the law was reenacted shortly thereafter. The controls were upheld by the New Mexico Supreme Court in a 1950 case (23) and the court noted that the value of 100,000 acres of land in the Roswell area was in excess of $25,000,000. Thus the institutional change accomplished in 1927 had been successful in effecting a major change in the economic foundation of the Roswell area.

Although institutions have seen considerable development in some jurisdictions and have been effective in solving particular problems, institutional weaknesses are still not uncommon, even in water-scarce states where management programs have evolved over substantial periods of time. For example, a 1973 analysis of Texas ground water management notes severe deficiencies in the existing institutional structure and states that "[t]he defects in Texas ground water conservation practices derive from a single source--the lack of an effective mechanism to harmonize the relationship between ground water producers and those hurt by ground water production" (235, p. 299). Management problems attributable to institutional defects have been identified in most of the other western states (44), including California (44, pp. 52-59) where management techniques have seen their greatest development. In fact, it appears that existing technological capabilities for optimization of the benefits obtainable from the ground water resource and for solving particular problems are generally much further advanced than is the development of the institutional framework and mechanisms for implementation of such technology.

Since institutions for ground water management are society's rules for controlling the resource, their development requires a determination of societal objectives and a definition of the public interest in the resource. The existence of such an interest is generally conceded, but the basic issue of balancing the degree of public control with the rights of the individual remains. Since this issue involves a divergence of views, its resolution requires the amalgamation of conflicting positions and therefore must involve action through the political process. Optimization of the returns from the ground water resource is but one of the various factors that will influence the design of institutions, but the ultimate degree of success toward the achievement of this objective will in large measure be determined by the form of these institutions.

Virginia Ground Water Management Needs

Occurrence and Distribution of Ground Water in Virginia

Comprehensive evaluation of the ground water resource has never been undertaken on a state-wide basis in Virginia, but relatively detailed appraisals have been conducted in the southeastern part of the state. In addition, general information exists concerning the occurrence of ground water in the remainder of the state.

The first systematic ground water study in Virginia was published in 1913 by Sanford (222) and encompassed an investigation of the ground water of the Coastal Plain Province. The same basic area was the subject of further study in a 1945 publication by Cederstrom (43). These two studies describe the basic geologic framework for the occurrence of ground water in the Coastal Plain Province and provide information concerning early ground water conditions and uses in this area. A more recent evaluation of the ground water of southeastern Virginia and related problems is contained in a 1970 report by the Virginia Division of Water Resources (DWR) (105) and a 1974 revision prepared by the Virginia State Water Control Board (110), to which DWR and its responsibilities were transferred in 1972.

The ground water of the other sections of the state has not been studied in as much detail as has that of the southeastern coastal plain area, but a number of studies contain relevant data. A general summary of state-wide conditions is contained in Ground Water in Virginia (102), originally published in 1958 by DWR and revised in 1961 and 1969. This information is supplemented by analyses of the ground water hydrology contained in the river basin plans prepared by DWR and SWCB and special area studies conducted by state and federal agencies on an individual basis.

Due to the control which such factors as topography, rock type, and geologic structure have on the ground water resource, its occurrence and distribution is related to the existence of five physiographic provinces within the state, including the Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and Cumberland Plateau.

Coastal Plain Province

The Coastal Plain Province includes that portion of Virginia lying east of the fall zone, a north-south line passing through Emporia, Petersburg, Richmond, Fredericksburg, and Washington. This province is the section of the state where ground water availability is at its highest. It consists of a series of unconsolidated sediments starting at its eastern edge with a thickness of a few feet and thickening in a seaward direction to more than 2,200 feet at Chesapeake Bay, to about 2,900 feet at the Atlantic Ocean, and to more than 12,000 feet near the eastern extent of the Continental Shelf, sixty miles offshore. The strata consists of alternating beds of sand, silt, and clay of both continental and marine origins, deposited upon the granitic basement rock. These strata are not flat lying but slope generally southeastward at a rate of twenty-five to thirty feet per mile (102, pp. 21-22).

Two separate ground water systems exist in the coastal plain. A shallow water table system lies above relatively impermeable clay beds and is the source of water for many domestic and other small capacity wells, production from which was estimated to be on the order of 15,000,000 gallons per day in 1970. Recharge to this system consists essentially of downward infiltration of surface water and precipitation. A deeper system of artesian aquifers constitutes the principal source of ground water in the area. These aquifers outcrop along the fall zone at the western boundary of the coastal plain, the principal recharge area for the aquifers in their natural state. As is typical of coastal plain strata, the artesian aquifers and their confining strata increase in depth and thickness in an eastward direction (105, p. 8).

Due to the thickness and areal extent of the coastal plain aquifers, their storage capacity is immense. It has been estimated that the total amount of recoverable water that can be stored in the artesian aquifers under water table conditions is of the order of 3,180,000,000,000 gallons. Under the original artesian conditions that existed prior to heavy utilization, an additional 255,000,000,000 gallons is estimated to have been contained in the aquifers due to the slight expansion of the void space occupied by pressurized water (105, p. 10). The original aquifer conditions have been modified by pumping which has resulted in a general lowering of artesian pressures, with significant cones of depression existing at some locations.

Natural quality of water from the Coastal Plain sediments is generally acceptable for domestic and other uses with the exception of localized problems, but the deeper aquifers contain high chloride water in the easternmost section of the province. Water from the lower aquifers generally has chloride concentrations of greater than 500 milligrams per liter on much of the lower York-James Peninsula and in the Norfolk-Virginia Beach area. Chloride concentrations appear to increase east of Suffolk, but the precise location of the fresh water/salt water interface is not known (78, p. 32).

In the Accomack County area of the Eastern Shore of Virginia, a ground water study (106) has indicated that the depth to the crystalline basement rock varies from 4,500 to 6,500 feet below sea level. Unconfined water table aquifers occur from near land surface to depths of approximately 100 feet, where thick, relatively impermeable clays are encountered. Below this clay layer, other aquifers exist and alternate with generally thin layers of material which retard vertical water movement. These aquifers may be locally artesian where these layers are sufficiently thick to become impermeable and function as aquicludes, but these layers between aquifers are usually sufficiently permeable to permit substantial vertical flow. These deeper aquifers are likely to be good ground water producers, but chloride concentrations become objectionable below a depth of 300 feet (106, p. 16). The potable water above the 300 foot depth is believed to be a floating lens overlying the saline water of greater density. Natural movement of the fresh water is from the central land area toward the Ocean and Bay. The eastward or westward extents of the fresh water lens have not been determined, but the water in the aquifers becomes saline as the aquifers extend beneath the Ocean and the Bay (106, pp. 33-34).

Substantial quantities of ground water are being pumped in the Accomack area. Small domestic wells withdraw water from the shallow aquifers while the aquifers between the depths of 120 and 300 feet have seen the greatest development for domestic, municipal, and industrial supplies. Industries processing poultry and produce are the largest ground water users on the Eastern Shore (106, pp. 27-28).

Piedmont Province

The central section of Virginia lying between the Blue Ridge Mountains on the west and the fall zone on the east is known as the Piedmont Province. The principal geologic characteristic of this area with regard to ground water potential is the relatively shallow depth to crystalline bedrock throughout most of the province. Due to the absence of the extensive unconsolidated deposits overlying the bedrock in the Coastal Plain, fractures and fault systems in the bedrock itself are a principal source of ground water. Since the size and number of water-bearing fractures decreases with depth, water is generally limited to a zone within a depth of a few hundred feet (45, pp. 6-14).

Ground water production potential is generally much less in the Piedmont than in the Coastal Plain. Well yields are generally in the range of three to twenty gallons per minute with yields in excess of fifty gallons per minute considered exceptional. Where fracture and fault systems are extensive relatively large yields of water may be obtained. It has been indicated that such conditions are most likely to exist near the western portion of the Piedmont, along the eastern foot of the Blue Ridge Mountains. However, detailed information on the specific areas of the western Piedmont that will produce large amounts of ground water is generally unavailable (45, pp. 6-13).

Quality of ground water from the Piedmont bedrock is generally soft to moderately hard with a low dissolved solids content. This low mineralization is due to the insolubility of the crystalline rocks (45, pp. 6-28). Iron content occasionally exceeds acceptable amounts for public water supply from some of the crystalline rocks (135, p. 325).

In some instances, a zone of granular material resulting from disintegration and decomposition of the underlying granite serves as an aquifer that can supply modest quantities of water to shallow wells. Such aquifers are generally not very thick, and recharge is slow since the overlying soil mantle is usually clay. In addition to quantity restrictions in connection with these shallow aquifers, water from these zones frequently contains objectionable amounts of iron and sulfur (102, p. 33).

Three areas of sedimentary rocks exist within the Piedmont province. One such area is known as the Richmond Basin and underlies most of western Chesterfield County, extending from as far south as Dinwiddie County north almost to Hanover County. The Farmville Basin occupies an area about seventeen miles long, principally in western Cumberland County. The Scottsville Basin extends from eastern Nelson County to the Hardware River in Albermarle County. Small to moderate yields of water are available from these sedimentary rocks, with few exceeding twenty gallons per minute (135, pp. 320-21).

With regard to the general ground water potential of the Piedmont province, quantity and quality restrictions are likely to be severe at many locations. Variability of subsurface conditions limits the extent to which generalization is possible, giving more importance to the selection of well sites. Variation in well yield with location is noted as an important factor by Le Grand (143, p. 1) in a generalized evaluation of the ground water of the Piedmont and Blue Ridge provinces in the southeastern states. Guidelines presented for site evaluation emphasize topography and soil conditions, with higher potential associated with low topographic areas and thick soils.

Blue Ridge Province

To the west of the Piedmont lies the Blue Ridge Province, a relatively narrow zone of mountainous terrain containing the highest elevations in the state. The province extends from the North Carolina boundary in a northeasterly direction across the state, varying in width from about four to about twenty-five miles (102, p. 35).

A shallow soil mantle and weathered zone exists in some areas, but the bedrock is generally near the surface. These rocks below the weathered zone are relatively impervious and contain water primarily in joints, fractures, and fault zones. Conditions most favorable for accumulation of ground water exist along the lower slopes of the mountains (102, p. 36).

A recent study of the influences of geology on the water resources of the upper Roanoke River Basin (302) indicates that significantly greater ground water supplies may be available at some locations within the Blue Ridge Province than traditionally believed. One explanation advanced for such increased supplies involves inflow via faults from areas broader than the individual surface watershed. For example, a subsurface diversion of water from the New River to the Roanoke drainage is believed to be occurring (302, pp. 115-18).

Due largely to the rugged terrain, little developmental activity has occurred in this province. Thus ground water use has been primarily limited to domestic needs. Such water may come from wells but springs are relatively common and have often been utilized. Wells have yielded as much as 300 gallons per minute, but yields are usually less than 20 and rarely exceed 50 gallons per minute (135, p. 290).

Ground water in the province is generally of low mineralization due to the relative insolubility of the rocks. Iron content of the water is high in some locations (102, p. 36).

Valley and Ridge Province

The Valley and Ridge Province lies to the west of the Blue Ridge Mountains and is underlain by consolidated sedimentary deposits that have been extremely folded along parallel axes. Limestone, sandstone, shale, and conglomerate are the predominate rock types, all of which can serve as sources of water with the exception of shale. Limestone, sandstone, and conglomerate contain water in fractures, and limestone is frequently characterized by widespread development of solution channels which store and transmit ground water (102, pp. 36-37).

There is a more apparent relationship between ground water and surface water in the Valley and Ridge than in the other physiographic provinces. Sizeable surface streams disappear into subterranean channels while large springs exist which serve as origins of surface flow. Aquifers are often recharged directly from streams where they cross fault zones. A fault may act to divert surface flow, and it may serve as a conduit for the transmission of the water to other areas. For example, measurements have indicated that New River loses water to aquifers in a faulted area near Narrows (171, pp. 150-51). Yields of wells in this area are the maximum for the basin. Other wells in the Valley and Ridge Province with greater than average yields are generally located in such areas. Since faults are essentially linear in nature, location of wells to take advantage of this method of recharge requires detailed information on the location of faults.

In addition to recharge via faults, direct recharge also occurs when surface run-off enters subterranean drainage systems by means of sinkholes. Direct aquifer recharge with surface water can produce serious water quality problems since the principle mechanism for protecting ground water purity is eliminated when percolation through the soil is by-passed. Water withdrawn from aquifers that are directly recharged may therefore exhibit quality characteristics closely resembling those of surface water.

Ground water quality is also affected by the chemical composition of the formations with which it comes in contact. In the Valley and Ridge Province, a major quality factor is the presence of limestone which results in hardness. In addition to the impact on chemical quality, limestone formations can result in turbidity where solution channels contain deposits of fine sediment (102, p. 41).

Cumberland Plateau Province

The Cumberland Plateau Province, also known as the Appalachian Plateau Province, includes a small section of southwestern Virginia bordering the state of West Virginia. This province is underlain by sedimentary rocks, principally sandstone, shale, and coal. These rocks have undergone relatively little deformation from their original horizontal positions. Gentle folding has produced a series of domes and basins, and some faulting has occurred.

There has been only limited development of ground water in the plateau province, and few wells have been drilled in the lower portions of the valleys, with yields generally ranging from ten to fifty gallons per minute. Maximum yields have been in the range of a few hundred gallons per minute.

Use of ground water in the province includes public water supply, industrial use, and private domestic use. In 1971, total withdrawals for all public systems was about 1,000,000 gallons per day. An important industrial use is coal processing. For example, one of the largest mining companies was using nearly 500,000 gallons of water per day from fifteen wells in 1971.

Ground water quality in the province varies with location and depth. The best quality water is generally obtained from bedrock above stream level. The first 100 feet of rock below stream level often has water with high concentrations of sulfate, sulfite, nitrate, iron, and free carbon dioxide. Better quality water is found at depths of 150 to 300 feet. Water from coal seams and water contaminated by mine drainage is usually of undesirable quality (251, pp. 12-9 to 12-15).

Importance of Ground Water as a Source of Supply in Virginia

Although ground water is an abundant resource in large areas of Virginia and is used throughout the state, ground water withdrawals have traditionally constituted a relatively small proportion of the total water use in the state. Table 1 contains United States Geological Survey estimates of ground water withdrawals in Virginia for 1970 (167, pp. 18-29) in terms of quantities and as percentages of total withdrawals. These percentages are substantially below the national averages for ground water use. For example, estimates for total United States withdrawals in 1970 indicate that ground water constituted more than 18 per cent of the 370,000,000,000 gallons of water withdrawn per day (167, pp. 28-29). Ground water generally makes up a greater proportion of total water use in more arid regions, as indicated by the states of Oklahoma, Arizona, and Kansas where approximately 59, 62, and 82 per cent, respectively, of total 1970 withdrawals came from subsurface sources (167, pp. 28-29).

Although considerations of total water withdrawals are useful with regard to determining the over-all significance of the ground water resource, a better indication of its importance arises when specific types of uses are considered. Although ground water constituted only 5 per cent of total 1970 withdrawals in Virginia, it constituted

TABLE 1.--Ground Water Withdrawals in Virginia, 1970[a]

Type of Use (1)	Ground Water in Million Gallons Per Day (2)	All Water in Million Gallons Per Day (3)	Ground Water Percentage of Total (4)
Public Supplies	74	390	19
Rural Use:			
Domestic	73	74	99
Livestock	12	29	41
Total	84	100	84
Irrigation	5.2	35	15
Self-Supplied Industrial Water[b]	120	4900	2.4
Total Water Withdrawn[c]	280	5300	5.3

[a]Source: (71).

[b]Excludes water withdrawn for hydroelectric power generation.

[c]Columns may not add to totals due to independent roundings.

19 per cent of water withdrawn for public supplies. Many small communities are totally dependent on wells and springs, and ground water is often an important supplement to surface water supplies. For example, the City of Norfolk has utilized wells capable of yielding 15,000,000 gallons per day as a supplemental supply during periods when surface reservoirs were at low levels. SWCB records indicate that over 900 public systems are totally or partially supplied by ground water (103, p. 129). Table 2 contains a summary of public and industrial ground water use in Virginia localities based on data available in 1972 (103, pp. 131-77).

The significance of ground water as a source of supply comes into focus even more clearly when rural water use is considered. The water use data in Table 1 indicates that approximately 99 per cent of all water withdrawn in 1970 for rural domestic use in Virginia was ground water, while some 41 per cent of water use for livestock consisted of ground water.

In areas where low population densities make centralized water distribution systems infeasible, it is often the ability to obtain water from a spring or well that makes habitation or other use of land possible. Many tracts of land are not in contact with surface water and therefore do not possess water rights with regard to this source. Under the Virginia system of water law, rights to water in streams

TABLE 2.--Public and Industrial Ground Water Use in Virginia Localities in 1972[a]

Location (1)	Use in Million Gallons Per Day		
	Public (2)	Industrial (3)	Total (4)
Accomack County	1.056	3.000	4.056
Albermarle County-Charlottesville	0.345	0.459	0.804
Alleghany County-Covington - Clifton Forge	0.367	1.454	1.821
Amherst County	0.034	0.000	0.034
Appomattox County	0.127	0.000	0.127
Augusta County-Staunton - Waynesboro	4.917	11.774	16.691
Bath County	0.626	0.040	0.666
Bedford County-Bedford	0.062	0.009	0.071
Bland County	0.160	0.000	0.160
Botetourt County	0.323	0.007	0.330
Brunswick County	0.090	0.000	0.090
Buchingham County	0.089	0.010	0.099
Campbell County-Lynchburg	0.899	0.213	1.112
Caroline County	0.193	0.010	0.203

[a]Values are for 1972 or the nearest previous year for which data was available at that time. Source: (103).

TABLE 2--Continued

Location (1)	Use in Million Gallons Per Day		
	Public (2)	Industrial (3)	Total (4)
Carroll County - Galax	0.075	0.218	0.293
Charlotte County	0.070	0.015	0.085
Chesterfield County-Colonial Heights	0.178	0.116	0.294
Clarke County	0.118	0.035	0.153
Craig County	0.075	0.006	0.081
Culpepper County	0.050	0.000	0.050
Cumberland County	0.018	0.000	0.018
Dickenson County	0.300	0.281	0.581
Dinwiddie County-Petersburg	0.091	0.008	0.099
Essex County	0.301	0.001	0.302
Fairfax County-Fairfax - Falls Church	2.010	0.182	2.192
Fauquier County	0.464	0.004	0.468
Floyd County	0.010	0.000	0.010
Fluvanna County	0.016	0.032	0.048
Franklin County	0.313	0.014	0.327
Frederick County-Winchester	0.088	0.569	0.657
Giles County	0.626	4.922	5.548
Gloucester County	0.129	0.013	0.142

TABLE 2--Continued

Location (1)	Use in Million Gallons Per Day		
	Public (2)	Industrial (3)	Total (4)
Goochland County	0.122	0.000	0.122
Grayson County	0.171	0.036	0.207
Greene County	0.099	0.000	0.099
Greensville County-Emporia	0.036	0.003	0.039
Halifax County - South Boston	0.020	0.002	0.022
Hanover County	0.859	0.041	0.900
Henrico County-Richmond	2.875	0.079	2.954
Henry County-Martinsville	1.850	0.211	2.061
Highland County	0.033	0.015	0.048
Isle of Wight County	0.362	38.661	39.023
James City County-Williamsburg	2.973	5.165	8.138
King George County	0.884	0.180	1.064
King and Queen County	0.002	0.000	0.002
King William County	0.280	15.075	15.355
Lancaster County	0.391	0.050	0.441
Lee County	0.206	0.000	0.206
Loudoun County	0.806	0.150	0.956
Louisa County	0.270	0.100	0.370

TABLE 2--Continued

Location (1)	Use in Million Gallons Per Day		
	Public (2)	Industrial (3)	Total (4)
Madison County	0.065	0.000	0.065
Mathews County	0.011	0.000	0.011
Mecklenburg County	0.305	0.007	0.312
Middlesex County	0.180	4.198	4.378
Montgomery County-Radford	0.238	0.040	0.278
Nelson County	0.049	0.018	0.067
New Kent County	0.075	0.000	0.075
Northampton County	0.312	0.222	0.534
Northumberland County	0.155	0.044	0.199
Nottoway County	0.164	0.000	0.164
Orange County	0.446	0.006	0.452
Page County	0.601	0.310	0.911
Patrick County	0.008	0.395	0.403
Pittsylvania County-Danville	0.054	0.050	0.104
Powhatan County	0.030	0.000	0.030
Prince Edward County	0.135	0.000	0.135
Prince George County-Hopewell	0.212	0.545	0.757
Prince William County	1.851	0.007	1.858
Pulaski County	0.166	0.020	0.186

TABLE 2--Continued

Location (1)	Use in Million Gallons Per Day		
	Public (2)	Industrial (3)	Total (4)
Rappahannock County	0.047	0.000	0.047
Richmond County	0.122	0.011	0.133
Roanoke County-Roanoke - Salem	5.673	2.882	8.555
Rockbridge County-Buena Vista-Lexington	1.180	2.643	3.823
Rockingham County-Harrisonburg	1.239	9.784	11.023
Russell County	0.569	0.021	0.590
Scott County	0.105	0.007	0.112
Shenandoah County	0.308	0.367	0.675
Smyth County	2.476	0.000	2.476
Southampton County-Franklin	2.079	8.011	10.090
Spotsylvania County-Fredericksburg	0.081	0.010	0.091
Stafford County	0.177	0.009	0.186
Surry County	0.091	0.089	0.180
Sussex County	0.431	0.170	0.601
Tazewell County	0.617	0.034	0.651
Warren County	0.093	0.012	0.105
Washington County-Bristol	2.250	0.035	2.285

TABLE 2--Continued

Location (1)	Use in Million Gallons Per Day		
	Public (2)	Industrial (3)	Total (4)
Westmoreland County	0.826	0.172	0.998
Wise County - Hampton	0.098	0.246	0.344
Wythe County	0.237	0.000	0.237
York County	0.103	0.000	0.103
City of Chesapeake	0.465	0.470	0.935
City of Nasemond	0.463	0.037	0.500
City of Newport News	0.000	0.002	0.002
City of Norfolk	0.000	0.168	0.168
City of Portsmouth	2.953	1.661	4.614
City of Virginia Beach	0.627	0.068	0.695
Grand Total	55.181	116.111	171.292

and lakes attach only to land which is in physical contact with such water (302). In addition, surface water is generally not of adequate sanitary quality as a source of domestic water to be used in the untreated condition. Thus the occurrence of adequate ground water supplies is intimately related to development and continued utilization of rural land which makes up the vast majority of Virginia.

Although ground water constitutes only a small proportion of total industrial water use in Virginia, certain industries are heavily dependent on this source of supply and are the largest individual users of ground water. The Union Camp Corporation at Franklin has been the state's largest single user, with 1970 withdrawals exceeding 38,000,000 gallons per day. Other major industrial users have included the Chesapeake Corporation at West Point where 1972 withdrawals exceeded 15,000,000 gallons per day and the Dupont Company at Waynesboro with 1968 withdrawals in excess of 10,000,000 gallons per day. Other firms whose uses have approached or exceeded a daily withdrawal rate of 5,000,000 gallons include Celanese Fibers in Giles County; the Dow Badische Company in James City County; Hercules, Incorporated of Southampton County; and Merck and Company of Rockingham County (103, pp. 131-77). It is likely that the availability of ground water has been and will continue to be an important factor in industrial site selection in the state.

Although availability is a basic determinant of ground water's significance as a source of supply, institutional factors are also of fundamental importance. Evaluation of management institutions is undertaken in the following sections of this study, but one direct example of their impact on significance of ground water as a source of supply is appropriate at this point. The Fifth Planning District Commission has adopted a policy that development of surface water supplies is preferable to further ground water development and has recommended that small water systems utilizing springs and wells be phased out. This position has been taken apparently because of the view that ground water supplies are unreliable and because of concern regarding possible contamination.

Ground Water Problems in Virginia

Although over-all ground water supplies in Virginia are more than adequate to meet total demand for the resources at present and for considerable future periods, problems related to both allocation of supplies and quality exist. These problems are primarily localized in scope at present, but certain problems have the potential to reach or have already attained a regional scale. Existing problems of supply result primarily from patterns of ground water use causing over-pumping in some locations and from natural resource recovery operations that lower ground water levels in their vicinity. Ground water quality problems have resulted from various waste disposal practices and land use activities. A potentially serious water quality problem about which little is presently known is salt water intrusion in the coastal area of the state.

Over-pumping of ground water and the associated interference between individual wells can occur under certain conditions throughout the state, but the problem has been most extensive and has the most potentially significant scope in the southeastern coastal plain area of the state. The large areal extent which makes the coastal plain aquifers excellent sources of water makes this area especially susceptible to well interference problems, and large-scale pumping operations have adversely affected the ground water supplies of adjacent lands in several locations.

The most extensive problem exists at Franklin as the result of industrial pumping. For the period from 1939 to 1968, it has been estimated that 158,000,000,000 gallons were pumped from the artesian system at Franklin, resulting in a cone of depression with a radius of twenty-five to thirty miles. The pumping has produced a decline in the artesian head from a level of about twenty feet above sea level in 1939 to 170 feet below sea level in 1968. Based on the volume of the resulting cone of depression in the piezometric surface, the DWR has calculated that pumping at

Franklin during this period resulted in the removal from storage or mining of 52,000,000,000 gallons of water, 35,000,000,000 of which is estimated to have occurred in Virginia. The remainder of the reduction in storage occurred in North Carolina (105, pp. 11-15, 107, p. 16).

There does not appear to be full agreement as to the long range impact of the maintenance of present pumping rates at Franklin. On the basis of an assumed constant recharge rate of 15,000,000 gallons per day and an average daily pumping rate of 46,000,000 gallons per day, the DWR in a 1970 publication (105, p. 15), estimated that the remaining artesian water would be depleted in about twenty years, after which water levels would begin to drop below the top of the pumped aquifer and dewatering would begin.

However, more recent predictions do not foresee dewatering under current pumping rates. A computer model of the aquifer system initiated by the DWR as a management tool has predicted that maintenance of 1971 pumping levels would result in a maximum decline in the water level at the center of the cone of depression during 1971 and a future decrease and eventual ceasation in the decline of the water level in the outer areas of the cone. Data collected since 1971 indicate that the cone of depression has stabilized outward from the center, suggesting that inflow to the aquifer is approximating the outflow (110, p. 16).

One factor relevant to this stabilization is the increase in vertical recharge to the pumped aquifer which has been induced by reduction in artesian pressures. To the extent that this vertical recharge represents a balancing of the water pressures in the three principal artesian aquifers, the apparent stabilization of the cone of depression in the pumped aquifer may be only temporary (78, p. 29). Of course the reduced pressures in the artesian aquifers will increase the total amount of recharge to the system (151, p. 53), and at some point the stabilization will become permanent.

There are several important consequences of the continued depressurization of the artesian aquifers in addition to interference between wells and the continuing increase in pumping lifts produced by the declining artesian head. Of course a long range consequence may consist of the exhaustion of the ground water supply and other effects of dewatering such as surface subsidence.

Another effect of pressure declines is the water quality deterioration produced by shifts in the fresh/salt water interface. The chloride content in the aquifers increases to unacceptable levels on the lower York-James Peninsula and in the Norfolk-Virginia Beach area. The dynamic balance between the fresh water and salt water zones is controlled by the piezometric pressure in the fresh water zone, and depressuring of the artesian aquifers will lead to an inland shift of the salt water zone which will destroy parts of the aquifers. The cone of depression already extends into the high-chloride zone of artesian water, and there has been an over-all drop in piezometric pressure in the artesian aquifers of twenty or more feet since the turn of the century. Thus inland movement of salt water may have been occurring for a number of years (78, p. 32). The situation has been summarized as follows:

> Heavy pumping has reversed the hydraulic gradient in many areas, especially in Lower Cretaceous aquifers. Where the reverse gradient encompasses salty water, the salty water must be moving westward and encroaching into fresh-water zones. Few data are available to document this movement, but hydraulic principles and the fact that no materials in nature are completely impermeable assure us that it must be occurring. The movement of the salty water is probably slow, but, as surely as water flows downhill, it also moves down a hydraulic gradient. Detailed studies are needed before the rate and extent of salt water encroachment into fresh-water aquifers can be determined (146, p. 51).

A significant cone of depression also exists in the Accomack Courthouse area as the result of industrial pumping beginning in January, 1970. The cone is approximately two miles in diameter and includes about three and one-half square miles. Water level declines range from a few feet on the periphery to approximately 100 feet near the center of the cone. This pumping has interfered with other wells, and pump intakes have had to be lowered in response to the decline in water levels. Monitoring of water levels indicates that the cone of depression has stabilized, but increased pumping can be expected to produce an expanding cone and further water level declines.

Because of the proximity of high chloride water, continuing water level declines present potential ground water quality problems. Salt water encroachment could occur from below as pumping reduces the weight of overlying fresh water and causes a rise in saline waters. Withdrawal of ground water can also result in salt water intrusion from the Ocean or Bay when the natural gradient is reversed (106, pp. 21, 28, 33-34).

In addition to the problems at Franklin and Accomack Courthouse, significant cones of depression have developed in connection with water use at other locations. In the West Point area, water level declines range from seventy to 100 feet, and water levels have fallen about eighty feet in the Williamsburg area (107, p. 64). Well interference problems have also occurred in the City of Suffolk (formerly Nansemond County) where large capacity municipal wells have adversely affected shallow wells in their vicinity. Pursuant to an agreement between the municipality and the governing body of the county where the wells are located (3), a number of private wells adversely affected by the pumping have been deepened or replaced by means of a special fund established by the municipality.

Ground water supply problems associated with natural resource recovery operations have also arisen in various areas. The principal problem of this type in the eastern part of the state appears to be associated with the mining of sand and the associated dewatering operations. One such operation in the city of Virginia Beach has been the subject of several complaints related to alterations of both quantity and quality. According to Welford Lucy, Vice President of the operating firm, a number of wells which allegedly had been adversely affected have been replaced or improved. Other remedial measures have included the construction of a trench around most of the circumference of the excavation into which the pump water is discharged, thereby reducing the impact of pumping on ground water levels of adjoining lands. A requested permit for authorization of a large scale sand mining operation in the City of Chesapeake was rejected by the City Council in February, 1974 (165), due at least in part to objections related to anticipated water problems. In this instance a principal concern was the disposal of water from the project site and the resulting effect on local drainage patterns.

In the southwestern portion of the state, ground water supply problems have arisen in connection with coal mining. Water problems related to mining have been the source of most of the ground water litigation that has arisen in Virginia, with respect both to interference with flow and quality (34, 53, 64, 175, 244). As a necessary aspect of such operations, coal and other strata in close proximity to the coal are removed or extensively altered, some of which may serve as aquifers. Thus mining activity has caused the destruction of springs and wells on adjacent property located downgradient. Conflicts between water users and miners have also occurred in situations where mineral rights have been purchased separately, leaving the surface and subsurface property interests in different ownerships. Projected increases in the use of coal as an energy source suggest that mining-related water resource problems are likely to intensify in the future.

In addition to problems associated with allocations of ground water between users and interference with its natural movement, problems related to quality have also occurred in Virginia. Reference has been made to potential problems of salt water intrusion and to contamination associated with mining. The existence of large numbers of facilities and operations which either intentionally or accidentally discharge potential pollutants on or below the land surface suggests that contamination is likely to exist at many other locations, but the full occurrence and extent of such problems has not been documented due to the absence of comprehensive ground water quality investigations and data collection programs.

Ground water quality problems may be most widespread in areas underlain by limestone, which occur largely in the Valley and Ridge Province. An indication of the ground water quality problems in such areas is given by a study under preparation for the New River Planning District Commission involving an area of approximately 3700 acres in the Thorn Springs area of Pulaski County (122). This area is sparsely to moderately populated, with septic tanks constituting the primary method of sewage disposal. Although small in size, the area is believed to be typical of a large section of western Virginia.

The study was designed to determine the correlation between ground water quality and soil and geologic conditions and to determine the suitability of the area for disposal of domestic wastes. During the course of the investigation, 127 water samples were collected and analyzed for various parameters. Of special interest are the data concerning the presence of coliform organisms, an indication of undesirable sanitary conditions. Of the 118 samples tested for coliforms, 37 per cent showed evidence of contamination. Another parameter indicating contaminated conditions consisted of the nitrate-nitrogen determinations. This parameter was above acceptable limits in one sample and approached the limit in others.

The investigation did not reveal definite relationships between well contamination and soil and geologic conditions. However, an inadequate thickness of soil over the fractured bedrock in much of the area is seen as a basic problem. In the absence of an adequate depth of soil to filter waste effluent, impurities may be carried for considerable distances through the openings in the underlying carbonate rock. The existence of extensive fracture systems is an important factor in water quality degradation, and the study indicates an apparent correlation between well contamination and location near such fractures. Based on the findings of a soil survey, the preliminary report indicates that 52 per cent of the study area has severe limitations for satisfactory operation of domestic sewage disposal systems.

A variety of other somewhat isolated well contamination problems have occurred. Gases of gasoline contamination have been discovered in some situations near service stations and storage facilities. Salt contamination has occurred in connection with the storage of highway salts. Approximately ten wells in a limestone area of Rockingham County have experienced high bacteria levels, probably resulting from septic tank use (145). Problems associated with septic tanks and the disposal of domestic wastes in general appear to have been of most frequent occurrence on a statewide basis.

A potential contamination problem exists in the northern area of the City of Roanoke due to the underground disposal of storm runoff. During the 1955-69 period, 127 drainage wells were drilled to alleviate ponding problems resulting from interference with natural subsurface drainage that occurred prior to urbanization. A substantial economic incentive existed in favor of the use of drainage wells since an alternative system of surface drainage would have cost an estimated $5,000,000 while the cost of the wells was only $85,000.

The impact of the operation of the drainage wells is not fully known. A preliminary study (31) indicates high over-all water quality in the area of the wells although local contamination may exist in close proximity to individual wells. The direction of flow of ground water in the area is believed to be toward Tinker Creek, with the principal discharge occurring at the points where faults cross the stream. Further studies are being conducted by the SWCB.

It should be emphasized that the true extent of the ground water pollution problem cannot be accurately appraised at present due to information deficiencies. Although efforts appear under way to initiate monitoring programs that will yield greater amounts of data, no information is currently available concerning the impact of a number of potentially significant sources of ground water contamination such as landfills and waste lagoons. Although widespread quality problems are likely to exist in the state's limestone areas, comprehensive investigations have never been conducted. In light of this status of knowledge, the existing cases of contamination that are currently known can only be viewed as a limited indication of the true extent of the ground water problem.

PRIVATE RIGHTS AS A GROUND WATER MANAGEMENT INSTITUTION

The oldest institutional framework for ground water decision-making consists of private rights that define the limits of individual interests in the resource and, conversely, provide judicially-enforceable controls that can be asserted in opposition to related externalities.

With respect to ground water management, the most significant rights are those arising from the ownership of land. The concept of private property is a major factor in natural resource management in the United States due to the emphasis that has traditionally been placed on private ownership of land. The belief that private ownership promotes the best use of land and enhances national well-being has been a central philosophy in national development. The extent of the weight given to this philosophy is indicated by the fact that approximately one-half of the total land area in the United States has been transferred from public to private ownership under the various federal land acts (74, p. 96). This transfer has largely taken place in the western part of the country. In the East, most land has never been subject to federal ownership but passed into private ownership through grants from the British Crown.

Although the concept of private property assigns to individuals the rights to exclusive use of certain resources, property rights are not independent of public controls. They depend upon recognition and enforcement by the proper public authority for their creation and continued existence (13, p. 377), and the extent of the rights encompassed by the concept of property is publicly determined. Of course private property is subject to governmental exercise of the police power, but certain inherent constraints are also embodied within the definition of property itself.

The extent of a property right is largely defined through the judicial process. The accumulated decisions of the courts represent a compilation of social constraints on property rights that acts as precedent for resolution of individual conflicts that occur. The legal principles embodied in past decisions are subject to modification over time but generally have considerable impact on the outcome of any particular decision. This reliance on general principles established through a social mechanism means that the public is involved in the final interpretation of private rights whenever they are enforced by means of private litigation.

In addition to providing a basis for the resolution of conflicts after they occur, the body of legal precedent formed by past decisions also serves as a standard of behavior and an institutional force which guides future action to some extent. As Professor Frank Trelease has said,

> . . . the law at any particular time and place represents the will of the majority for encouraging action deemed desirable by them and for discouraging or forbidding action thought to be in conflict with the public interest. By encouraging some actions, but discouraging others, a state may use the actions of individuals to reach its own desired goal. There are few laws that are self-executing in the sense that they control all conduct and leave no choice of action to the individual. Much law does not literally regulate conduct in the sense of requiring or forbidding certain action, it instead provides an area of free choice, setting outside limits within which a person may act as he chooses. Many of these laws, such as those relating to property and contracts, unobtrusely form the basic framework of our society (264, p. 4).

Property rights can influence use or otherwise affect ground water in a number of ways. They have often served as the sole institutional mechanism for allocating ground water between lands sharing common aquifers. This function involves both the definition of the extent of the right to withdraw and use ground water and the right to conduct other land use activities affecting the supply available to other landowners. A second basic way in which property rights affect ground water concerns the extent to which the landowner may conduct activities that adversely affect the quality of ground water on other land. A third impact of property rights concerns the extent to which the landowner exercises control over aquifer storage space located beneath his land. This factor is potentially significant since it may act as a constraint with respect to artificial recharge operations designed to utilize such space and increase subsurface storage.

A characteristic of the body of law defining property rights as they relate to ground water is the classification of such water into legal categories. The two generally recognized categories are underground streams and percolating ground water, and the rights that attach to each often exhibit basic differences. Therefore consideration will be given to this classification system prior to evaluation of private property rights as they relate to ground water allocation, quality, and artificial recharge.

Legal Classification of Ground Water

The Virginia Supreme Court of Appeals has followed the common practice of classifying ground water as either an underground stream or as percolating ground water for purposes of defining private rights. One of the most comprehensive considerations of the distinction between ground water types is contained in the 1927 case of _Clinchfield Coal Corp._ v. _Compton_ (53), which consisted of an action for damages for the destruction of a spring by mining operations beneath the land on which the spring was located. The court defined percolating waters as follows:

> Percolating waters are those which ooze, seep, or filter through the soil beneath the surface, without a defined channel, or in a course that is unknown and not discoverable from surface indications without

> excavation for that purpose. The fact that they may, in their underground course, at places come together so as to form veins or rivulets, does not destroy their character as percolating waters.
>
> . . . .
>
> It is well settled that, unless it is shown that the underground water flows in a defined and known channel, it will be presumed to be percolating water. . . . This presumption it is difficult to overcome, as in a great majority of cases the exact condition or course of the underground water is not known, nor readily ascertainable, but the burden of proof is on him who alleges that the water flows in a known and defined channel, and he must lose unless he can overcome the presumption by affirmative proof to the contrary (53, pp. 311-12).

The fact that all ground water is presumed to be percolating in the absence of proof to the contrary shifts the emphasis from defining percolating water to the conditions necessary for establishing the existence of an underground watercourse. The court has made the following statement with regard to this determination:

> Surface depressions or sinks extending in a line on either side of a spring of considerable volume may give notice of the existence of an underground stream which the owner of the surface has no right to divert [citation omitted]; also the existence on the surface of a line of vegetation usually found nowhere except over water courses [citation omitted]. So also a stream which sinks into the ground and continues underground for a considerable distance and then reappears, but whose course and direction distinctly appears on the surface, is an underground stream between the points where it appears on the surface (53, p. 312).

Overcoming the burden of proving that an underground watercourse exists is not easy. The following quotation explains the restrictions on the party undertaking this task:

> The onus of proof lies, of course, on the plaintiff

> claiming the right, and it lies upon him to show that, without opening the ground by excavation, or having recourse to abstruse speculation of scientific persons, men of ordinary powers and attainments would know, or could with reasonable diligence ascertain, that the stream, when it emerges into light, comes from, and has flowed through, a defined subterranean channel (53, p. 311).

If it is properly established that ground water does flow in an underground watercourse, the same rules of law apply as if the stream were on the surface (53, p. 311). The basic effect of application of surface water law is that the use of each landowner is constrained by the impact of the use on others. Surface water law places relatively rigid limitations on water use and interference with the flow of watercourses. It is therefore to the advantage of the party injured by interference with ground water flow to allege the existence of an underground watercourse in an attempt to invoke the principles of watercourse law.

The difficulties of proof, however, limit the success of this approach. In fact, there does not appear to be a single Virginia decision which holds the ground water involved to be other than percolating. Thus the concept of having different doctrines of rights applicable to separate classes of ground water is largely theoretical; essentially all ground water, or at least the vast majority of such water, is uniformly treated as percolating.

Another legal classification system not considered by the Virginia Court that has been applied in other states concerns the hydrologic relationship between surface and ground water. In some cases different rules of law have been applied to ground water classified as tributary to surface waters and that which is non-tributary. In general, ground water in the tributary category has been subjected to the same legal controls as the surface water itself (65, p. 225). This approach has been necessitated in several of the water-scarce western states to prevent parties unable to secure a surface water right from intercepting the source of streamflow as a means of circumventing legal requirements. The question of whether ground water in a particular situation is tributary is a question to be decided by a court, but some western states have adopted the approach whereby all ground water is presumed to be tributary in the absence of evidence to the contrary (65, p. 226).

Private Rights as an Allocation Mechanism

Development of Ground Water Doctrines

The right of the landowner to use percolating ground water or otherwise interfere with the supply available to others has varied considerably among the states. In the eastern United States, three ground water doctrines have been given recognition: the English doctrine, also known as the absolute ownership rule; the American doctrine, also known as the reasonable use rule; and the doctrine of correlative rights. In the western states, ground water use has also been subjected to the doctrine of appropriation in addition to the other three.

The absolute ownership doctrine had its origins in the early English case of Acton v. Blundell (1). The underlying concept of this doctrine is that the landowner owns everything beneath the surface of the land, including water as well as the soil and rock. Thus the owner may make unlimited use of the water or any use of the land which affects the movement of ground water without accountability to others who may be adversely affected. The fact that activities on one tract of land can affect the ground water available on other lands indicates the inconsistency of unrestricted property rights relative to a fluid resource not fixed in position, but the rule was developed at a time when prediction of ground water movement was viewed as impossible. Thus the original basis for the doctrine was the concept that a person should not be held responsible for adverse consequences of activities that cannot be anticipated in advance.

The English doctrine of absolute ownership found considerable acceptance in the United States during the early development of ground water law. One of the earliest American decisions to adopt the concept was Roath v. Driscoll (213), an 1850 Connecticut case. The following passages from the court's opinion in that case provide insight into the basis for the doctrine and the status of knowledge concerning ground water hydrology during the formative period of the law:

> Water combined with the earth, or passing through it, by precolation [sic], or by filtration, or chemical attraction, has no distinctive character of ownership from the earth itself; not more than the metallic oxides of which the earth is composed. Water, whether moving or motionless in the earth, is not, in the eye of the law, distinct from the earth. The laws of its existence and progress, while there, are not uniform, and cannot be known or regulated. It rises to great heights, and moves collaterally, by influences beyond our apprehension. These influences are so secret, changeable and uncontroulable [sic], we cannot subject them to the regulations of law, nor build upon them a system of rules, as has been done with streams upon the surface. . . .
>
> . . . .
>
> Such streams are recognized as private property: and their use is regulated by principles of obvious equity and necessity. Their nature is defined; their progress over the surface seen, and known, and uniform. They are not in the secret places of the earth, and a part of it; nor is there any secresy [sic] in the influences which move them. As soon as they appear and pass over the surface, they assume a distinct character, and are subject to the great law of gravitation. The purchaser of land knows what he purchases, and what controul [sic] he can exercise over such a stream, and what are the rights of those above or below him. . . . But in the case of a well, sunk by a proprietor in his own land, the water which feeds it from a neighboring soil, does not flow openly in the sight of the neighboring proprietor, but through the hidden veins of the earth, beneath its surface. No man can tell what changes these under-ground sources have undergone, in the progress of time; it may well be, that it is only of yesterday's date that they first took the course and direction which enabled them to supply the well (213, pp. 541-43).

Although the absolute ownership concept received wide acceptance during the early developmental period of ground water law in the United States, some of the early decisions expressed dissatisfaction with the underlying logic of the rule and its consequences. Although not constituting the earliest rejection of the doctrine, the following statement from the 1909 New Jersey case of Meeker v. City of East Orange (157) contains one of the most incisive repudiations of the concept that ground water can be subjected to absolute ownership in the same manner as the soil:

> Here [in the absolute ownership concept] the impracticability of applying the rule of absolute ownership to the fluid, water, which by reason of its nature is incapable of being subjected to such ownership, is apparently overlooked. If the owner of Whiteacre is the absolute proprietor of all the percolating water found beneath the soil, the owner of the neighboring Blackacre must, by the same rule, have the like proprietorship in his own percolating water. How, then, can it be consistent with the declared principle to allow the owner of Whiteacre to withdraw, by pumping or otherwise, not only all the percolating water that is normally subjacent to his own soil, but also, and at the same time, the whole or a part of that which is normally subjacent to Blackacre? . . .
>
> It is sometimes said that, unless the English rule be adopted, landowners will be hampered in the development of their property because of the uncertainty that would thus be thrown about their rights. It seems to us that this reasoning is wholly faulty. If the English rule is to obtain, a man may discover upon his own land springs of great value for medicinal purposes or for use in special forms of manufacture, and may invest large sums of money upon their development: yet he is subject at any time to have the normal supply of such springs wholly cut off by a neighboring landowner, who may with impunity sink deeper wells and employ more powerful machinery, and thus wholly drain the subsurface water from the land of the first discoverer (157, pp. 384-85).

Other courts, while not totally rejecting the underlying concept of the doctrine in general, excepted certain cases from its rule by recognizing that in some instances the impact of withdrawing ground water could be anticipated. Forbell v. City of New York (89), a 1900 New York decision, is a case in point where the court made the following statement in refusing to apply the doctrine to the case before it:

> The case is not one in which, because the percolation and course of the sub-surface waters are unobservable from the surface, they are unknown and thus so far speculative and conjectural as to be incapable of proof or judicial ascertainment.
>
> Before the defendant constructed its wells and pumping stations it ascertained, at least to a business certainty, that such was the percolation and underground flow or situation of the water in its own and the plaintiff's land that it could by these wells and appliances cause or compel the water in the plaintiff's land to flow into its own wells, and thus could deprive the plaintiff of his natural supply of underground water. This it has accomplished just as it expected to do it; the evidence to that effect is about as satisfactory and convincing as if the case were one of surface waters (89, p. 645).

In response to such dissatisfaction with the absolute ownership doctrine, certain courts began to place restrictions on the right of landowners to withdraw ground water to the detriment of others. These restrictions form the basis for the ground water rights doctrines that have come to be known as reasonable use and correlative rights. However, the restrictions were developed on a case-by-case basis to suit the needs of individual situations, and the labels used at present to describe particular rules were not applied in a consistent manner by the courts.

In fact, a number of early decisions exist in which the terms "reasonable use" and "correlative rights" are used somewhat interchangeably. For example, the 1862 New Hampshire decision of Bassett v. Salisbury Manufacturing Co. (14), frequently cited as the origin of the reasonable use rule (153, p. 768; 157, p. 380; 259, pp. 1062-63), contains the following statement regarding ground water rights:

> The rights of each land-owner being similar, and his enjoyment dependent upon the action of the other land-owners, these rights must be valueless unless exercised with reference to each other, and are correlative. The maxim "Sic utere," etc. [Use your own property in such a manner as not to injure that of another (22, p. 1551)], therefore applies, and, as in many other cases, restricts each to a reasonable exercise of his own right, a reasonable use of his own property, in view of the similar rights of others (14, p. 577).

Likewise, the California case generally regarded as the origin of the correlative rights doctrine (138) appears to give acceptance to the concept of reasonable use. Labels have continued to be used somewhat carelessly even to the present, indicating the need for caution in determining the actual concept being applied in many cases.

However, review of a wide sample of the ground water allocation decisions that have been decided to date indicates the existence of two distinct ground water allocation theories in the East, in addition to that of absolute ownership. The doctrine that is most generally referred to as reasonable use or the American doctrine has seen widest acceptance. This doctrine states that the landowner has the right to use percolating ground water for any reasonable purpose in connection with use of the land from which it is taken or the right to undertake usual land development activities without accountability to other landowners whose ground water supplies may be adversely affected. Although the ownership concept is replaced with a qualified right of use, the actual degree of restriction on the right of the landowner is limited in scope. The principal restriction is the prohibition which is generally imposed concerning the export of water for use on non-overlying land. The cases of Forbell and Meeker, often cited as basic precedent for the reasonable use concept, both arose from pumping of water to export for municipal purposes, and the court in each case held that large scale pumping of water for export was in violation of the rights of other landowners adversely affected. Other decisions upholding the restriction on export for use on non-overlying land include a 1917 Michigan case (224), a 1924 North Carolina case (217), and a 1956 Florida case (141).

With regard to use on the overlying land, waste and malicious interference are usually prohibited (65, p. 202), but few other restrictions have been applied. "Reasonableness" has been given a very broad interpretation that encompasses most customary or traditional uses of water or uses of land affecting the supply of water available on other lands (196).

A key factor in the determination of reasonableness is that it does not depend on comparison with other uses of the source of supply. It appears that a landowner engaged in a "reasonable" use is under essentially no constraints with regard to the impact of his use on others and can legally destroy his neighbor's supply. This feature distinguishes the reasonable use ground water doctrine from the reasonable use concept that is a central aspect of the riparian doctrine for allocation of water in surface streams. In the case of surface streams, reasonableness is a relative concept and the rights of each party are determined with regard to the needs of the other users (302, pp. 11-13). Although the two doctrines have been described as equivalent, fundamental differences exist, with rights under the ground water doctrine of reasonable use being considerably more absolute.

The doctrine of correlative rights as it has been developed in the eastern states has much closer equivalence with the riparian doctrine. Under this rule, each landowner has a co-equal right to make a reasonable use of ground water, with reasonableness based on a comparison of the nature of conflicting uses. Application of this doctrine has been limited. An example of its use is given by the 1957 Arkansas case of Jones v. Oz-Ark-Val Poultry Co. (137) in which pumping of ground water by a chicken processing plant that caused domestic wells to go dry was held to be unreasonable. Another apparent example is given by Mac Artor v. Graylyn Crest III Swim Club, Inc. (150), a 1963 Delaware case in which the owner of an adversely affected domestic well sought to enjoin use of a deeper well for filling a swimming pool. The court endorsed the doctrine of "reasonable user," which was described as follows:

> This rule permits the court to consider and evaluate the various factors on both sides and arrive at an "accommodation" of the conflicting rights, if that is feasible. It also permits the court to consider the intentions of the offending party and his actions subsequent to the discovery of the consequences of his use of the water (150, p. 419).

The court in Mac Artor decided that the contested use was not reasonable for the area in question due to its recreational nature and the size of the withdrawal relative to conventional residential use. As a condition for not granting the injunction, the court required that the swimming pool owner share in the costs of deepening the domestic well or allow connection to its commercial water supply. This holding is generally consistent with the eastern concept of correlative rights although the term is not used in the case, a fact which emphasizes the limitations of using labels to identify doctrines.

As developed in the western states, primarily California, the correlative rights concept bases water allocations on a proportional division of the water available from a common source (138). Where rights acquired under other doctrines have resulted in ground water mining, the western correlative rights doctrine has been used to require a proportional reduction in water use such that total withdrawal is restricted to the average aquifer recharge.

The doctrine of appropriation has been limited in application to the western states. As originally developed for allocation of scarce surface water supplies, the basic concept of the doctrine is that the right to a given water use is superior to all uses having a subsequent date of vesting and inferior to prior uses. Thus the concept of equality of right among landowners is absent from the doctrine of appropriation. If the supply of water is inadequate to meet the needs of all users, the subsequent or junior appropriators must curtail or cease use to the extent necessary to protect the rights of the prior appropriators.

This protection of prior users is a feature which distinguishes appropriation from the other ground water doctrines. This protection is generally not limited to the right to withdraw a certain quantity of water but also encompasses the means of diversion. Thus the rights of junior ground water appropriators may be restricted because of potential lowering of the water table or artesian pressure. In some jurisdictions, protection of the means of withdrawal has been strictly upheld, with subsequent appropriators having to pay the full costs of any well modifications necessitated by the subsequent use. In other cases, protection has been extended only to a particular pumping level determined to be reasonable on the basis of economic considerations, thereby permitting some reduction in levels or pressures to accomodate continued development (29, 126).

Since the enactment of the first ground water appropriation statutes in 1927 by Oregon (93) and New Mexico (142), there has been a strong trend toward the appropriation system in the western states. It has been reported that sixteen states have applied the appropriative doctrine either exclusively or in combination with other doctrines to ground water, including Alaska, Arizona, California, Colorado, Idaho, Kansas, Montana, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Washington, and Wyoming (50, p. 441).

Ground Water Allocation in Virginia

Although the Virginia Supreme Court of Appeals has decided a limited number of cases arising out of disputes between different ground water users and between water users and land developers, ground water rights have been incompletely defined, and no clear choice as to legal doctrine has been made. Two early cases arising from disputes between competing water users imply acceptance of the absolute ownership rule. The first case suggesting this approach is Miller v. Black Rock Springs Improvement Co. (164). The case consisted of an action by the owner of two springs for an injunction to restrain an adjoining landowner from intercepting the flow of the springs by means of a ditch constructed close to the dividing line between the two tracts of land. The Virginia court reversed a lower court decision granting the injunction and thereby recognized the right of the adjoining landowner to intercept the underground sources of his neighbor's springs.

In support of its decision, the Virginia court cited a number of authorities and other court decisions which upheld the absolute ownership concept. The following passages from material quoted by the court indicate approval of this doctrine:

> Water percolating through the ground and beneath the surface, either without a definite channel or in courses which are unknown and unascertainable, belongs to the realty in which it is found. . . .
>
> . . . .
>
> In 27 Am. & Eng. Enc. Law, at page 425, it is said: "The correlative rights of adjoining proprietors in reference to running streams, whether on the surface or subterraneous, and the general principles relating thereto, have no application to undefined subterranean waters, which are merely the result of natural and ordinary percolations through the soil. Such waters are part of the land itself, and belong absolutely to the proprietor within his territory; and it has been well settled by a long and unbroken line of authority that a proprietor of land may dig a well upon his own premises, mine, drain it, or in any way change its natural condition, even though in so doing he may intercept or impede the natural underground percola-

tions, the sources of supply of his neighbor's spring or water. He may as lawfully draw the natural percolations from his neighbor's land as prevent the percolations of his own well going into the well of his neighbor's. Such underground waters are as much the property of the owners of the land as the ores, rocks, etc., beneath the soil" (164, pp. 29, 31).

Although the underlying concept of the absolute ownership doctrine is that each landowner has complete dominion over the water underneath his land, these quotations indicate that in effect there are no enforceable legal rights in ground water under the doctrine since no right of action exists for injury produced by the activities of others. In the Miller case where a preference for the absolute ownership doctrine was indicated, the Virginia court quoted with apparent approval a statement providing that the only remedy for the landowner whose water supply is diverted ". . . is to sink his own well deeper" (164, p. 30). Thus the absolute ownership doctrine does not provide any protected interest but merely establishes an unrestricted rule of capture for all landowners.

As noted previously, the reasoning upon which this lack of recognition of rights is based is that ground water movement cannot be predicted with sufficient accuracy to justify imposition of rules of law concerning interference with such movement. This philosophy is expressed by the following statement quoted by the Miller court:

> The laws of its existence and progress, while there, are not uniform, and cannot be known and regulated. It rises to great heights, and moves collaterally, by

> influences beyond our apprehension. These influences are so secret, changeable, and uncontrollable, we cannot subject them to the regulations of law, nor build upon them a system of rules, as has been done with streams upon the surface (164, p. 31).

A special consideration in the Miller case was the question of whether the ditch which intercepted the water flowing to the plaintiff's springs was constructed with a malicious intent as alleged by the owner of the springs. The court did not indicate acceptance of this view but implied that its decision may have been the same even if malice had been clearly shown. After a brief reference to the malice issue, the court noted that ". . . it is, we think, irrelevant" (164, p. 29).

Malicious interference with another landowner's ground water supply has generally been viewed as an exception to the general rule of the absolute ownership doctrine that any interference is lawful, but court decisions exist where even this action has been upheld. An example of such a decision is the 1903 Wisconsin case of Huber v. Merkel from which the following statement is taken:

> From this brief review of the law and the cases relied upon as modifying the ancient common-law rule as to percolating waters, it seems clear that it must be held that the appellant had a clear right at common law, resulting from his ownership of land, to sink a well thereon, and use the water therefrom as he chose, or allow it to flow away, regardless of the effect of such use upon his neighbors' wells, and that such right is not affected by malicious intent. Whether this right results from an absolute ownership of the water itself, as stated in some of the authorities, or from a mere right to use and divert the water while percolating through the soil, is a question of no materiality in

> the present discussion. In either event, it is a property right, arising out of his ownership of the land, and is protected by the common law as such (128, p. 357).

The position taken by the Virginia court in the Miller case, which was decided two years prior to Huber, appears to lean toward that adopted by the Wisconsin court.

A second Virginia case that appears to adopt the absolute ownership doctrine is the 1921 decision of Heninger v. McGinnis (123) which arose from the diversion of the waters of a spring. The plaintiff alleged that the spring water prior to diversion had served as the source of an underground stream which in turn supplied a surface stream. The court makes the following statement concerning rights in the water from the spring:

> Conceding that the waters of the "mountain spring" flowed by a definite, marked channel to the point where they sank, and thence by a subterranean channel to the mountain hollow, reappearing there in such fashion that they could be identified, and thence proceeded by natural flow in the hollow to the 50-acre tract, it would be true that McGinnis would be entitled to such portion only of these waters as would be necessary for the reasonable use and purposes of the tract on which the spring was located, and could not dispose of or interfere with the natural flow of the surplus. But if the waters of said spring disappear wholly on the McGinnis land, and do not appear in the hollow below the ridge, save in the form of seepages in the hollow, resulting from percolation through the soil, or if the waters that run in the hollow cannot be identified with the spring waters that disappear on the McGinnis land, then McGinnis would be entitled to dispose at will of the waters of the "mountain spring" (123, p. 673).

The state court concurred with the holding of the lower court that the party claiming rights in the flow of an underground watercourse had failed in his task of proving that the spring fed the stream in question other than by percolations through the soil, and it therefore affirmed the decision of the lower court denying the requested injunction that would have prohibited diversion of water from the spring.

Consideration of the Miller and Heninger cases alone leads to the conclusion that Virginia follows the absolute ownership doctrine of percolating water rights, but the court in a later case has indicated that the choice of doctrine has not been made. In the case of Clinchfield Coal Corp. v. Compton (53), the court recognizes the existence of the reasonable use doctrine and notes that the trend of modern opinion is in favor of this rule rather than that of absolute ownership. The Miller and Heninger cases are cited as granting acceptance to the absolute ownership rule, but the court indicates that it is not bound by this previous acceptance on the grounds that the decisions of the two cases were justified under either doctrine.

> Miller v. Black Rock Spring Co. [citation omitted] is an ideal case of percolating water, and its interception was for domestic purposes, which was authorized on any theory of the case; but the English theory of the absolute ownership of percolating water was there approved. It was said, however, in the course of the opinion, that whether there would be liability on the defendant if cutting off the supply of percolating water was attributable to malice or negligence on the part of the defendant was a question not before the court. The facts of that case did not necessitate a

> choice between the English and the American rule, as the interception of the water was warranted by either. That case was quoted with approval in Heninger v. McGinnis [citation omitted] for the proposition that the owner of the surface is owner of the underlying percolating waters. Here again the doctrine of "reasonable use" was not involved (53, p. 313).

With regard to the basic principles of the reasonable use rule, the court makes the following statement:

> The "reasonable use" rule does not forbid the use of the percolating water for all purposes properly connected with the use, enjoyment, and development of the land itself, but it does forbid maliciously cutting it off, its unnecessary waste, or withdrawal for sale or distribution for uses not connected with the beneficial enjoyment or ownership of the land from which it is taken . . . (53, p. 313).

Although the court's consideration of the reasonable use doctrine appears to indicate the development of a preference for this rule, no final choice is made in the Clinchfield case.

> In the instant case, the coal company was making a legitimate use of its land for mining purposes, even under the "reasonable use" rule, and we are not called upon to decide between the different theories, but, if the question shall again come before this court, we shall feel free to consider it de novo (53, p. 313).

Regardless of the lack of a decision in the case concerning legal doctrine, the principle is established that disturbance of percolating ground water sources by mining operations on adjoining land does not produce liability. This issue has been the principal focus of a majority of the ground water cases decided by the Virginia Supreme Court of Appeals.

Other cases that uphold the no liability concept with regard to ground water interference from mineral development include C & W Coal Corp. v. Salyer (34) and Couch v. Clinchfield Coal Corp. (64). In the C & W case, blasting operations in connection with strip and open pit mining on adjoining property had resulted in the drying up of a spring. The court notes that the corporation was aware of the existence of the spring before it was caused to go dry and that the diversion was caused by the blasting operations, but liability is not imposed since the presumption that the water is percolating is not overcome. The Couch case involves the destruction of a well as a result of subsurface mining on adjoining property. The defendant corporation had removed the subjacent support from the adjoining land, causing the strata above the coal to crack and fall into the mine. The court held that the landowner whose well had been destroyed by the resulting diversion of percolating water could not recover for his injury.

These Virginia decisions which deny the right of the injured ground water user to recover damages where coal mining operations interfere with supplies are consistent with the position taken in other states where mining is a significant economic activity. For example, similar results were reached in decisions in West Virginia in 1927 (70) and Kentucky in 1942 (250).

The only Virginia case to resolve the conflict between mineral development and water supply in favor of the ground water user is Stonegap Colliery Co. v. Hamilton (244), decided in 1916. The parties in the case were not adjoining landowners but rather consisted of the surface owner and the owner of the minerals underlying the property. The mining activities of the defendant had left inadequate surface support and resulted in the breaking and falling of strata overlying the coal which in turn caused the diversion of the surface owner's percolating water supply.

The surface owner's right of recovery for the destruction of his water supply in Stonegap appears to have been based on the right to subjacent support rather than on ground water rights. The court in Stonegap notes that exercise of mineral rights generally encompasses some disturbance of percolating water and apparently would not have imposed liability if subjacent support of the surface had not been removed in the mining operation. The Couch case cited previously states that liability will not be imposed where ground water diversion results from removal of subjacent support on property adjoining that where the injury to water supply occurs.

The Virginia Supreme Court of Appeals has never decided a case involving interference between wells, but the issue has been discussed in one of the cases involving interference from mineral development. In the Couch case, the court quotes with apparent approval the following statement concerning the relative rights of well owners:

> An owner of a tract of land may sink a well, and appropriate to his own use all the percolating water found therein, although it may entirely destroy the well on his neighbor's land (64, p. 315).

Since consideration of the issue of competition between wells was somewhat incidental to the actual decision in the case before the court, caution must be used in deciding the effect and weight to be given these declarations. Nevertheless, they do give an indication of the court's likely position should the issue come before it.

An exception to this rule concerning interference between wells may be recognized by the Virginia court where ground water is pumped to the detriment of others for export and use on non-overlying land. The court has indicated that it leans toward the reasonable use rule, and one of the general principles of the doctrine as it has been developed in other jurisdictions is that use is limited to the land from which the water is taken. This principle has seen the greatest application in situations where municipal water supplies are pumped from parcels of out-lying land and piped into urbanized areas. The Virginia court has never directly considered this issue, but the following passage in Clinchfield is quoted from Meeker v. City of East Orange (157), an often cited reasonable use decision:

> But it does prevent the withdrawal of underground waters for distribution or sale for uses not connected

> with any beneficial ownership or enjoyment of the land whence they are taken, if it results therefrom that the owner of adjacent or neighboring land is interfered with in his right to the reasonable use of subsurface water upon his land, or, if his wells, springs or streams are thereby materially diminished in flow, or his land is rendered so arid as to be less valuable for agriculture, pasturage, or other legitimate uses (53, p. 313).

This statement is part of a longer quotation included to indicate the extent of the landowner's right under the reasonable use concept to use or divert ground water on the land where it is found. Inclusion of the statement regarding the restriction of use on non-overlying land is an indication that the Virginia court views this qualification of the ground water right as a basic feature of the reasonable use doctrine.

Although never considered by the Virginia Supreme Court of Appeals, the issue of municipal pumping of water for export was the subject of a suit in the Circuit Court of Nansemond County (now the City of Suffolk) in 1966. The suit was brought by the Board of Supervisors of Nansemond County for the purpose of obtaining an injunction to prohibit construction and use of municipal water supply wells by the City of Norfolk on property located within the county. The circuit court declined to enjoin construction of the wells but did temporarily enjoin Norfolk from pumping water from the wells for the purpose of using it in the water supply system of the city.

Prior to expiration of the injunction in 1967, the county and city resolved the issue by means of mutual agreement (3). In return for the county's pledge that it would in no way interfere with use of the wells prior to December 31, 1972, the city agreed to limit its pumping during the period such that the amount pumped in any two consecutive months would not exceed an average of fifteen million gallons per day. The city also agreed to pay to the county the sum of $25,000 to be held as a fund from which awards could be made to the owners of wells in Nansemond County that required adjustment or replacement because of the lowering of the ground water level. Provision was made for the city to pay an additional sum not to exceed $10,000 in the event that the original fund was not sufficient to make all the awards due well owners during the effective period of the agreement. Guidelines for determining payments from the fund were based on the extent of water level reduction and the type of pumping equipment used.

Payment of awards to individuals was subjected by the agreement to the condition that the owner of the well and the land involved agree to release the city from all other damage claims and to grant the right to pump in accordance with the terms of the agreement. Each agreement in connection with an award from the fund was to constitute a covenant running with the affected land in order to protect the city against claims from future owners.

The expiration date of the agreement was December 31, 1972. Provision was made for the county to retain any non-expended part of the original $25,000 fund to be applied against the cost of administering the fund and the cost of studies and surveys in connection with the wells. The agreement provides that nothing therein shall prejudice the right of Nansemond County to attempt to restrain later use of the wells or to seek damages for use after the expiration date. It is also provided that the agreement shall not prejudice Norfolk's subsequent right to use water from the wells or constitute any basis for liability for such use.

Although the Virginia court has acknowledged and discussed the absolute ownership and reasonable use doctrines, it has given little consideration to the third doctrine given some acceptance in the East, that of correlative rights. In fact, the court appears to have flatly rejected the doctrine. In the Couch case, the court quotes language stating that ". . . no correlative rights exist between proprietors of adjacent lands with respect to percolating waters . . . (64, p. 315). And in Miller, the statement that "[t]he correlative rights of adjoining proprietors in reference to running streams, whether on the surface or subterraneous, and the general principles relating thereto, have no application to undefined subterranean waters, which are merely the result of natural and ordinary percolations through the soil" (164, p. 31) is quoted.

The Virginia court appears to have drawn a sharp distinction between rights concerning allocation of ground water and those applicable to water from streams. The apparent inclination to accept the reasonable use doctrine suggests that the extreme withdrawal rights of the absolute ownership doctrine (e.g., malicious withdrawal, waste, or export to non-overlying land) will not be recognized, but the broad right to use ground water under the reasonable use concept actually constitutes a somewhat qualified right of capture which imposes few constraints concerning on-site water use or use and development of land affecting ground water supplies. The extent of the right of the landowner to withdraw water is emphasized by the following statement attributed to an official of one of the state's largest industrial ground water users:

> I had my lawyers in Virginia research the question, and they told us that we could suck the state of Virginia out through that hole in the ground and there was nothing anyone could do about it (79, pp. 95-96).

In addition to the possible adverse effects of ground water withdrawal on the availability of water to other users, withdrawal may also produce other externalities which raise questions concerning legal rights. Two such effects which are potentially significant in Virginia involve salt water intrusion and land subsidence, neither of which has been considered by the Virginia court. In the case of salt water intrusion, there also appears to be an absence of legal precedent in other states as well, possibly because of the difficulty of identifying any particular withdrawal as the cause of the salt water movement.

Subsidence is another generally widespread phenomenon which is difficult to relate to specific withdrawal operations, but the law in this area has seen some development. Certain courts have held that a landowner is not accountable for subsidence damage that is a consequence of withdrawing ground water in connection with the use of property. For example, the court in the 1968 Maryland case of Finley v. Teeter Stone Inc. (86) found a quarry operator free from liability in connection with sinkholes formed on adjacent land as a result of his dewatering operations. The decision was based on the concept that the landowner can use percolating waters in connection with any legitimate use of land, a classification held to encompass quarrying operations.

The holding in Finley was consistent with the then existing statement of the law as perceived by the American Law Institute that "[t]o the extent that a person is not liable for withdrawing subterranean water from the land of another, he is not liable for a subsidence of the other's land which is caused by withdrawal" (210, sec. 818). However, this position has been reversed in a subsequent revision which now states that "[o]ne who is priveleged to withdraw subterranean water, oil, minerals, or other substances from under the land of another is not for that reason privileged to cause a subsidence of the other's land by such withdrawal" (212, sec. 818). This statement is not binding as law, but the commentaries of the American Law Institute are generally highly regarded as authoritative works of legal scholarship and are perhaps more persuasive in the courts than any other legal analyses (55, pp. 196-97). Thus this reversal in position may indicate a general trend toward the imposition of greater accountability for subsidence in connection with ground water withdrawal.

Limitations of Private Rights as an Allocation Mechanism

Although ground water rights establish general allocation principles that can be enforced through private litigation to provide a degree of control over externalities affecting ground water availability, there are certain basic characteristics of the system of rights existing in Virginia and other states which limit their effectiveness as an allocation mechanism. One such factor is the strong reliance placed on unscientific concepts concerning the physical behavior of ground water. As a result of this unscientific perspective, many of the externalities associated with use of ground water and certain types of land use are not subject to legal control because of the often erroneous view that the external effects could not have been anticipated. A second weakness, which arises from the lack of effective controls over many ground water uses, is the high degree of uncertainty concerning the future availability of the resource. This insecurity in tenure is an important factor in private decision-making with regard to ground water development and has adverse implications for ground water conservation. A third limitation arises from the inherent constraints of private litigation as a mechanism for comprehensive resource management.

Extent and effect of scientific misconceptions

As noted previously, the basic ground water doctrines presently in effect were developed to a considerable extent prior to widespread acceptance and understanding of the physical processes affecting the ground water resource. One of the basic misconceptions that arose concerning ground water was its assumed independence from the other phases of the hydrologic cycle. Once this isolated view of ground water was accepted, the courts proceeded to establish separate principles regarding rights in this special type of water.

In many of the early decisions instrumental in establishing the basic legal concepts of ground water rights, the typical view expressed is that its movement is too mysterious and unpredictable for application of rules to govern activities which interfere with such movement.

Thus the early decisions generally refused to protect ground water supplies from external effects originating in the activities of other landowners since the necessary restrictions on use of water and land were viewed as unreasonable constraints on the exercise of property rights.

Although there have been many advances in the field of ground water hydrology since development of the basic ground water doctrines, little of this scientific advancement has been reflected in the law controlling ground water allocation. Since judicially-created law is conservative in nature and rests to a large extent on established precedent, progress in science can generally be expected to occur far in advance of its acceptance and application in the determination of legal rights (257, p. 424).

Although the reasonable use doctrine which apparently has been accepted in Virginia at least theoretically places certain restrictions on the right of the individual landowner to interfere with the supply of ground water available on other lands, legal accountability has not been imposed in most situations where the activities of one party have had an adverse effect on the water supply of others. Thus the doctrine inherently favors the landowner with the hydrologically superior position or with the financial capability to drill deep, large capacity wells. For example, a coal miner may destroy springs and wells on surrounding lands, including lands on which he does not own mineral rights, with impunity where his operations are conducted in the usual manner. Likewise, this doctrine allows an industrial user to pump unlimited quantities of water for on-site use without accountability although a number of other wells over a wide area are adversely affected. As these examples suggest, the degree to which the doctrine provides a mechanism for forcing the internalization of external diseconomies is limited.

Impact on ground water conservation

In addition to the questions of equity and efficiency of resource utilization that arise at a particular point in time as a result of using the existing system of ground water rights as an allocation mechanism, allocation by this means also has the potential to lead to a wasteful distribution of water use over time. From society's viewpoint, decisions concerning the inter-temporal allocation of water should be based on considerations of maximizing the total benefit available from the resource. Use during any particular period which precludes use during a subsequent period when the return to society would have been higher is therefore wasteful.

Such inefficient over-utilization is an inherent consequence where rights to a common pool resource such as ground water are defined by a rule of capture such as the English doctrine or a qualified rule of capture such as the

American rule. Where a resource is subject to exclusive ownership, the decisions of the owner regarding the intertemporal pattern of use are usually influenced to some extent by considerations of maximizing returns. However, the absence of exclusive rights makes the possibility of future use uncertain since the landowner who foregoes present ground water withdrawal has no assurance that the water will be available under similar conditions at a future time. Lowered water levels may make future withdrawals more costly, even to the extent of precluding use. This uncertainty concerning future availability tends to cause each individual ground water user to heavily discount future benefits (90). This factor, together with the absence of accountability for externalities associated with excessive withdrawal, creates a strong incentive for ground water extraction that exceeds the socially desirable rate.

Limitations of litigation as an allocation mechanism

Ground water rights as defined through previous decisions of the courts establish general principles that can have a potentially widespread impact on decision-making affecting the ground water resource, but the mechanism through which such rights are legally interpreted and enforced consists of litigation between or among parties involved in conflicts over such rights. Thus the inherent limitations of judicial decision-making as it relates to resource management are significant as well as the substantive weaknesses of the ground water doctrines themselves.

Probably the most fundamental weakness is the fragmented, piece-meal nature of decision-making that arises from the case-by-case approach that must be employed by the courts. The courts do not initiate action; they become involved in a resource management issue only upon the motion of a party whose interests are sufficiently injured or threatened to create the incentive for initiation of a court action. This dependence on private initiation of action interjects an element of randomness into court involvement in resource management issues. There are several reasons why the individual whose ground water use is adversely affected may be reluctant to initiate court action, even where he feels his rights are being violated. A primary consideration is the fact that the injured party as plaintiff in a legal proceedings has to overcome a substantial burden of proof, including the preparation of scientific evidence likely to require a considerable investment. This necessity of risking even greater financial losses in the event of an unfavorable decision acts as a significant deterrent to initiation of court proceedings. Thus the existence of management problems does not in itself assure an institutional response for their resolution, and the potential role of the courts in resolving management issues is restricted.

In addition, the scope of judicial considerations within the cases that do arise is essentially limited to the aspects of the problem affecting the litigants. Broader consideration of the public interest is generally a factor in judicial deliberations to some extent, but the principal concern in a case under litigation is the settlement of specific damage claims or other narrowly-focused issues. Thus a court can rarely treat a management problem in its entirety, and the public interest appears to be relegated to secondary importance where the principal mechanism for decision-making consists of adversary proceedings for resolution of conflicts between individuals.

In a limited number of cases in other jurisdictions, the scope of judicial considerations has been sufficiently broad to encompass the essential elements of a particular ground water management problem. Prime examples are given by the basin adjudications that have occurred in California. Probably the best illustration consists of City of Pasadena v. City of Alhambra (49), the so-called "Raymond Basin" case. This litigation was initiated by the City of Pasadena against the City of Alhambra and other major water users in the forty square mile Raymond Basin to determine ground water rights within the area and to enjoin an alleged overdraft to prevent eventual depletion of the supply. Rather than attempt to determine the rights of Pasadena in relation to the various defendants, the Supreme

Court of California upheld the lower courts approach of adjudicating the rights of each major user as against each and every other such user, excluding only those private users who pumped comparatively small amounts. This broad approach was facilitated by the reference procedure in effect in California whereby the Division of Water Resources of the Department of Public Works was appointed as referee, a role allowing it to act as investigator and expert witness for the court.

Based on the findings of the referee, the court concluded that total usage exceeded the safe yield of the basin and enjoined each user from pumping more than his proportionate share of the safe yield, which was calculated from the ratio of his existing rights to the total of all existing rights in the basin. Existing rights were based on a concept of "mutual prescription," and each user was held to have acquired a prescriptive right to the amount of water pumped continuously for the previous five year period. These rights were then proportionally reduced such that total use equaled the safe yield of the basin. In recognition of the problem of changing physical conditions with time, the California court upheld the right of the lower court to retain jurisdiction in the case to review its determination of the safe yield of the basin and read-just the rights of all parties as affected by other changes such as abandonment of rights.

However, eastern courts are unaccustomed to dealing with complex questions of water management, and legal authority for the reference procedure which incorporates the technical expertise of water resource management agencies does not exist. Thus it is unlikely that such an approach would be adopted in Virginia. Even if it could be assumed that the obstacles of limited and discontinuous jurisdiction could be overcome by the courts, other inherent institutional weaknesses from a managment perspective would still exist. The functional role of the courts is essentially limited to imposition of constraints to restrict undesirable activities, with no institutional capability for accomplishment of planning and other continuously-functioning program elements basic to comprehensive management.

A study prepared for the National Water Commission regarding the water-related role of the courts, although generally endorsing the decision-making capabilities of the judicial process, is critical of its water allocation function. Without any enumeration of specific shortcomings, the study makes the following statement relative to court allocation of water in general:

> The allocation of water among competing users demanding varying interests in the same limited supply is now almost universally viewed as an administrative function rather than a judicial one. The courts, when they play any role, serve quasi-ministerial functions which could and ought to be taken over by agencies subject to only normal judicial review in order to insure

fairness and consistency (260, p. 115).

Private Rights as a Quality Protection Mechanism

Nature and Status of the Right to Uncontaminated Ground Water

A basic factor with regard to private rights as they relate to ground water quality is that contamination generally results from use of land as opposed to use of the water itself. Land use is also involved in certain conflicts between landowners concerning ground water allocation, but the quality issue is even more intimately related to land use activities. Thus the courts in deciding contamination cases generally must seek some compromise between the right of one landowner to use and develop property against that of another to an uncontaminated water supply.

In a limited number of ground water contamination cases, the courts have specifically applied the concepts of certain ground water allocation doctrines in resolving conflicts between landowners. For example, the early Michigan case of Upjohn v. Board of Health of Richland (281) applied the absolute ownership concept to deny the right of a landowner to uncontaminated ground water. The reasoning of the court was that destruction of springs or wells by pollution is no different from diversion of the supply since both result in the same loss. Therefore the court refused to impose liability on the party responsible for the contamination.

The premise in Upjohn that the right to use water is the same as the right to contaminate it has been rejected by other courts. Noting a "manifest distinction" between the right to use water and the right to contaminate it, the court in the 1890 Kentucky case of Kinnaird v. Standard Oil Co. (140) held that a landowner could not pollute ground water to the detriment of others although it acknowledged his unrestricted right to use the water for legitimate purposes. The court supported its position through analogies with law applicable to the use of surface water and air. As indicated by the comparison of Kinnaird with Upjohn, the right to uncontaminated ground water has been subject to varying interpretations by the courts.

Most of the cases concerning ground water quality have not been decided on the basis of water rights doctrines but rather have been based on considerations of tort law--that body of legal concepts for resolving civil wrongs that involve interference with person or property. The law of torts is primarily concerned with the allocation of losses arising out of conflicting activities and also provides a basis for injunctive relief before threatened damages occur (201, pp. 1-6). Development of the concepts of tort liability with regard to ground water pollution has not been uniform among the states. Decisions in certain states regarding the fundamental conflict between uncontaminated water and other land uses have tended to favor the water user while the freedom to use property to the detriment of water quality has been emphasized in other states.

Liability based on proof of negligence

A substantial number of court decisions exist which deny the right of the landowner to uncontaminated ground water where the source of the degradation consists of the lawful use of property by others, provided that negligence is not involved. The stipulation that the contaminating activities must be conducted in a non-negligent manner suggests that the party who pollutes ground water as a consequence of his land use may be liable for resulting injury under some circumstances. However, proof of negligence can be a difficult burden to be overcome by the injured party.

Negligence is a theory of liability based on the concept of fault, and recovery by an injured party requires proof of conduct that falls below a reasonable standard. An underlying premise of the negligence concept is that liability should not be imposed for unforeseen injury from strictly accidental occurrences. Thus one of the basic elements of proof of negligence is the concept of foreseeability, which is concerned with the question of whether injury could have been reasonably anticipated as a consequence of the activity in question (201, pp. 250-70). The presumption that ground water contamination is not a foreseeable consequence of lawful uses of land conducted with ordinary prudence has been used as the basic reason for denying recovery by the injured party in a number of court decisions. Thus the "mysterious" character of ground water which has hindered application of sound allocation rules is also a central factor in protection of quality.

One of the early cases involving ground water pollution where this reasoning was applied is the case of Dillon v. Acme Oil Co. (66) where the court made the following statement:

> The question is therefore presented as to whether there could be a recovery for contaminating a subterranean water stream or vein, when the defendant is pursuing a legitimate business with works constructed and operated as well as they could be. It is said to be a legal maxim that every man must so use his own property as not to injure that of another; but this maxim is not to be construed so as to deprive a party from using that which he owns for legitimate purposes provided, in so doing, he exercises proper care and skill to prevent unnecessary injury to others. . . .
>
> It is only in such exceptional cases that the owner can know before hand that his works will affect his neighbor's wells or supply of water; and we are therefore of the opinion that, in the absence of negligence and of knowledge as to the existence of such subterranean water-courses, when the business is legitimate, and conducted with care and skill, there can be no liability if such subterranean courses become contaminated (66, p. 291).

In reaching its decision in favor of the defendant in Dillon, the court relied in part upon the classic case of Brown v. Illius (32). Although the Brown case upholds liability for contamination of a well resulting from the washing of pollutants along the surface of the ground, the court's comments with regard to ground water pollution have had considerable influence on later decisions. The court in effect said that liability does not arise in connection with activities which unknowingly contaminate subterranean water which supplies a well. Thus a distinction was drawn between the situation where an activity pollutes a well by means of surface flow and where the mechanism for pollution is ground water flow. The court in Dillon goes even further and distinguishes legal rights concerning the pollution of flowing ground water from pollution of a well by means of direct percolation of a contaminant itself through the soil without mixing with the ground water. The court indicated that liability would be imposed in the latter situation but not in the former.

In denying the right of the injured landowner to recover for ground water pollution, the courts have in some cases applied the maxim damnum absque injuria, which is defined as a loss which does not give rise to an action for damages against the person causing it (22, p. 470). An example is given by Long v. Louisville and Nashville R.R. Co., a case involving well pollution from burial of an animal carcass, where the following statement is made:

> The rule is elementary that a person is not liable for a mere accident which ordinary care on his part could not have anticipated or guarded against. If, in the

> lawful use of his property, a man accidentally does an injury to his neighbor which ordinary prudence would not have anticipated to result from his act, it is damnum absque injuria (148, p. 205).

In addition to the concept of foreseeability, another element of proof in negligence proceedings is the showing of specific negligent acts. Failure to prove these specific acts where negligence is the basis of a legal action can be fatal to the case of the plaintiff. For example, the decision in Bollinger v. Mungle (26) was in favor of the defendant because the plaintiff was unable to offer adequate proof in support of the charge that the defendant had negligently allowed the escape of gasoline which resulted in the contamination of a well. The requirement imposed on the plaintiff is contained in the following quotation:

> On the record now before us, appellant having alleged negligence on the part of respondent, it was incumbent upon her, in order to be entitled to recover, to prove negligence of respondent either in the original construction and installation of the gasoline tank and pump, or to prove negligence by his failure to repair or remedy defects in said equipment which were either known to him or by the exercise of ordinary care could have been discovered by him and remedied (26, p. 916).

The necessity for the plaintiff to prove the specific acts of negligence by the defendant and the foreseeability requirement have often been combined into a defense known as the "custom of trade or industry." The essence of this defensive tactic is the claim that the defendant has followed the generally accepted practices and usages of his trade or industry. Thus the injured party may not be allowed to recover his losses simply because the party responsible for the contamination did nothing to distinguish his operation from those of others engaged in similar activities. Typical of this type of decision is the 1962 North Carolina case of Bayer v. Nello L. Teer Co. (16) which arose from the contamination of a well as a result of pit quarry operations. The court did not allow the well owner to recover for his losses since it found the quarry to be operated according to the best practices of open pit mining. Similar reasoning was used in the 1967 Rhode Island case of Gagnon v. Landry (92) involving well pollution from a septic tank failure. The court denied the right of recovery since the owner of the septic tank had employed standard practices for the area in question.

In contrast to these decisions which have relied on a requirement of negligence to deny the right of recovery for injury from ground water pollution, another group of decisions exists which does impose liability for contamination. Recognition of the right to an uncontaminated ground water supply has been accomplished through a variety of mechanisms. One of the simplest involves a relaxation of some of the requirements of the negligence concept. One of the most significant modifications of the negligence doctrine that has been applied concerns removal of the requirement that specific acts of negligence be proved by the plaintiff. As an alternative, the courts have developed a doctrine of circumstantial evidence known as _res ipsa locquitur_, the thing speaks for itself (22, p. 1470). Acceptance of the doctrine is generally restricted to cases where an injury has occurred as a result of an accident that does not normally occur in the absence of negligence. Its use allows the jury to infer from the fact that the accident occurred that negligence was involved, thus placing the burden on the defendant to exculpate itself from fault (201, pp. 211-14). As has been stated in _Watkins_ v. _Gulf Refining Co._, a case involving injury from the drilling of an oil well, "[t]he defendant in a damage suit coming under the doctrine of _res ipsa loquitur_ must show that he did not do anything that he should not have done and that he neglected no legal duty owed to the plaintiff" (310, p. 275).

Criteria which have been accepted as guidelines in the application of the doctrine are indicated in the following quotation:

> The conditions usually stated in America as necessary for the application of the principle of res ipsa loquitur were derived originally from the first edition of Wigmore on Evidence, which appeared in 1905. They are as follows: (1) the event must be of a kind which ordinarily does not occur in the absence of someone's negligence; (2) it must be caused by an agency or instrumentality within the exclusive control of the defendant; (3) it must not have been due to any voluntary action or contribution on the part of the plaintiff. Some courts have at least suggested a fourth condition, that evidence as to the true explanation of the event must be more readily accessible to the

defendant than to the plaintiff (201, p. 214).

This doctrine has been specifically applied to cases of subsurface pollution. For example, the court in Texas Co. v. Giddings (252), where a well was polluted by leakage from an oil pipe line, held that the plaintiff was not required as a basis for establishing negligence to show what particular defect was causing the leak since such information would be peculiarly within the knowledge of the defendant.

Another relaxation in the requirements for proof of negligence concerns the issue of foreseeability. Courts in certain cases have abandoned the view that ground water contamination injury cannot be anticipated. For example, the court in Collins v. Chartiers Valley Gas Co. (56) noted that the absence of liability for injury to wells was generally based on the fact that damage could not be foreseen or avoided, but it denied the defendant's contention that the landowner was not bound to pay any regard to the effect of his operations on subterranean waters. In deciding that the driller of an oil well was liable for injury resulting from the contamination of a fresh water aquifer by salt water from another stratum, the court gave specific recognition to advancements in geological knowledge.

> If this is the state of knowledge at the present day; if the existence of a stratum of clear water, and its flow into wells and springs of the vicinity, and the existence of a separate and deeper stratum of salt water, which is likely to rise and mingle with the

> fresh, when penetrated in boring for oil and gas, are known, and the means of preventing the mixing are available at reasonable expense, then, clearly, it would be a violation of the living spirit of the law not to recognize the change, and apply the settled and immutable principles of right to the altered conditions of fact (56, p. 1014).

Relaxation of the requirements for proving negligence can lead to rejection of the defense that the responsible activity was carried out according to generally accepted customs and practices. An example is given by the 1952 Iowa case of Iverson v. Vint (134) which involved contamination of a well resulting from the dumping of a truckload of spoiled molasses into a ditch. In rejecting the defendant's claim that no liability should attach to this action since it was a customary means of disposal, the court made the following statement:

> Evidence of the custom or common usage of a business or occupation is generally admissible on the question of negligence although it is not a conclusive test. . . . However, such evidence is ordinarily inadmissible where the act itself is clearly careless or dangerous (134, p. 495).

In addition to relaxation of some of the requirements of proving negligence as a mechanism for giving greater recognition to the right to uncontaminated ground water, the courts have also accomplished this result by means of accepting other theories of liability that place a lesser burden of proof on the injured party. Other theories of legal action through which liability may be imposed include nuisance, strict liability, and trespass.

Ground water contamination as a nuisance

A principal effect of treating ground water pollution as a nuisance is to lessen the significance of the lawfulness of the activity responsible and the degree of care associated with it. The fact that an activity is a lawful use of property conducted in a careful manner does not preclude its operation from being held to constitute a nuisance as indicated by the following quotation from Hauck v. Tide Water Pipe Line Co., a Pennsylvania case involving pollution by escaping oil:

> If the mere fact that the business is a lawful business, and has been conducted with care, would be a defense where a neighbor's land has been injured in consequence of the business carried on there,--the escape of gas, for instance, or the escape of oil,--the result would be that a man might lose his farm, might be compelled to leave it, and have no compensation, simply because the business which brought about this loss was a lawful business, and was carried on carefully. That is not the law. No man's property can be taken, directly or indirectly without compensation, under the law of this state; hence there are cases--and a great many of them--where a defendant is held liable in damages, although his business is lawful, and he has exercised care in carrying it on (120, p. 645).

With regard to the degree of care employed, proof that conduct has fallen below a reasonable standard is sometimes used in support of an allegation that a nuisance has been created, but such proof is not an essential element of a nuisance action. The following quotation from Swift and Co. v. Peoples Coal and Oil Co., a 1936 Connecticut ground water contamination case involving leakage of petroleum, delineates between the two theories:

> Some decisions qualify the right of the one who suffers injury from the pollution of subterranean water to recover damages therefor by holding that no liability exists for its pollution unless the person causing that pollution has been negligent in the use of his property. . . . If the pollution of subterranean waters constitutes a nuisance, it has been held to be immaterial whether or not the person responsible has exercised reasonable care in the conduct of his business. . . . A nuisance may grow out of negligence. . . . But it may exist where the use a person is making of his property is not in any respect negligent but nevertheless results in damage to his neighbor. . . . As the percolating of oil into the plaintiff's premises would constitute a nuisance, it was not necessary for it to prove negligence on the part of the defendants (249, p. 633).

The requirement of foreseeability is also modified in nuisance proceedings. In Beatrice Gas Co. v. Thomas, an early Nebraska case involving pollution of a well as a result of waste disposal into a large excavation referred to as a "condense well," the court made the following statement:

> It is true that some of the cases base the right to recover upon defendant's knowledge that he was committing the injury; but the injury was as great before as after notice. An action in tort is not a proceeding to punish a defendant for a willful act, but to compensate the plaintiff for the invasion of his rights. It was not necessary, in order to constitute the pollution of the well a tort, that it should be done willfully. The most that can be said is that the defendant would not be liable for damages unless the injury was one which was the natural and probable consequence of those acts. While the defendant may not have known, and probably did not know, that its condense well would pollute the plaintiff's well, it was bound to know that the natural and probable consequence of collecting waste matter in its condense well would be the injury of some wells which might be connected with the condense well by the stratum of sand referred to (17, p. 928).

The determination of whether a given activity will be included with those protected from liability for their consequences in the absence of negligence or subjected to classification as a nuisance where other property is damaged has depended largely upon court discretion. The Supreme Court of Pennsylvania has elaborated upon this determination in the previously cited Hauck case where the defendant attempted to bring a situation involving ground water pollution within the doctrine of Pennsylvania Coal Co. v. Sanderson (189), a classic case representing the right of a corporate landowner to use property with immunity from legal action by those adversely affected thereby. In refusing to apply the doctrine, the court placed substantial restrictions on its scope.

> In the consideration of this class of cases, care must be taken to distinguish between the natural and necessary development of the land itself and injuries resulting from the character of some business, not incident and necessary to the development of the land, or the minerals or other substances lying within it. The owner of the land has the right to develop it by digging for coal, iron, gas, oil, or other minerals; and if, in the progress of this development, an injury occurs to the owner of adjoining land, without fault or negligence on his part, an action for such injury cannot be maintained. If this were not so, a man might be utterly deprived of the use of his property. It is not so where the injury is caused by the prosecution of a business which has no necessary relation to the land itself, and is not essential to its development (120, pp. 645-46).

Of course the principle of Pennsylvania Coal Co. that private rights must yield to the needs of business operations has been rejected by many courts (8, 115, 185, 245, 247), but the delineation in Hauck between development of land itself and businesses incidental to such development suggests a basic distinction between the type of operation to be protected from liability in the absence of negligence and those that are likely to be controlled by the nuisance doctrine.

In addition to serving as a basis for recovery of compensable damages, the theory of nuisance also provides a basis for anticipatory injunctive relief. While negligence is more applicable in cases of completed injury resulting from a single act or omission, nuisance generally applies to a maintained condition rather than one act or failure to act, therefore making injunctive relief more appropriate. Of course an injunction to restrain a potential source of contamination is generally not issued without a showing that injury is a relatively certain result of the activity in question (207, 246).

Nuisance also provides a frequent basis for injunctive relief where an activity has already produced injury. In considering the appropriateness of an injunction in a particular situation, the court in its decision may weigh social and economic factors in an attempt to balance the injury between the parties. Thus an injunction may be refused where its issuance would result in disproportionately greater hardship to the plaintiff and to the public than would accrue to the defendant by its denial.

The principal case illustrating the application of this so-called balance of convenience doctrine is Boomer v. Atlantic Cement Co. (27), a recent New York case. The plaintiff in Boomer had brought suit to enjoin the operations of the cement factory, but the court, while admitting the injury and stating the case was a proper one for an injunction, limited the recovery to damages. The court cited several reasons for its decision, one of them being the argument that the question of pollution was a political question not subject to judicial determination. A second basis for the decision was the disparity in economic loss. The court noted that, "[t]he total damage to plaintiffs' properties is, however, relatively small in comparison with the value of defendant's operation and with the consequences of the injunction which plaintiffs seek" (27, p. 872). Thus the solution chosen was to refuse the injunction in order to avoid closing down the plant and instead make an award of permanent damages as compensation for a servitude on the land involved.

This doctrine has also been applied in cases of surface water pollution (166), but the Virginia court has specifically rejected this concept in such situations. For example, the court in Blue Ridge Poultry and Egg Company v. Clark (24) upheld a lower court's injunction against a firm which employed about 250 persons and had an investment of almost one million dollars because of injury inflicted on one landowner. The defendant corporation had maintained that the injured party's remedy should be limited to an award of monetary damages since the losses to the corporation and its employees and suppliers as a result of an injunction would be far greater than the loss sustained by the complaining party. In denying this contention, the court made the following statement:

> The doctrine of "balancing the equities" must be viewed in light of our long-standing pronouncement that a private landowner is to be protected for injuries he may sustain "even though inflicted by forces which constitute factors in our material development and growth" (24, p. 327).

Imposition of strict liability for contamination

Adoption of the strict liability concept with regard to activities responsible for contamination constitutes the most direct means of recognizing the right to uncontaminated ground water. Under this theory of action, all need to prove fault as the underlying cause of ground water pollution is eliminated. Liability is automatically imposed on the party responsible for the contaminating activity without regard to the degree of care utilized. Thus acceptance of this theory of liability establishes an absolute right to non-polluted ground water.

The concept of strict liability has not been accepted in all jurisdictions, and its application is generally limited to certain types of activities that pose a considerable threat to others even when conducted with proper precautions. The underlying concept is that such activities, while useful enough to be tolerated, should absorb full responsibility for injuries inflicted because of their inherently dangerous nature (201, p. 492).

The concept of strict liability for escape of hazardous materials had its origins in the English case of Rylands v. Fletcher (87). In the Rylands case, the defendant had constructed a reservoir in an area underlain by mines, and water subsequently escaped through some abandoned shafts to the injury of plaintiff's mines. The court held that failure to restrain a dangerous substance brought onto one's land and stored there made the owner responsible for any resulting injury regardless of the skill and care with which the operation was carried out.

Application of the Rylands doctrine in cases of ground water contamination has been somewhat restricted. The courts in certain cases have explicitly rejected it because of the severity of the rule with regard to developmental activities (216). However, strict liability has been accepted in a number of ground water contamination cases. For example, the court in the 1895 Minnesota case of Berger v. Minneapolis Gaslight Co. (19), after noting that many courts had disapproved the authority of Rylands, applied the doctrine to the case before it where petroleum had escaped from storage tanks without indication of negligence. In the 1934 case of Berry v. Shell Petroleum Co. (20), strict liability was imposed for injury resulting from the escape of oil field brine. Plaintiff's water supply had been ruined by percolation of salt water from a municipal drainage canal into which the salt water had been allowed to flow. Liability under a state statute prohibiting the escape of oil field wastes was noted by the court, but it also indicated approval of the common law concept embodied in the Rylands doctrine.

The Berry case indicates the fact that imposition of strict liability in connection with certain contaminating activities can result from legislative enactments as well as from acceptance of judicially developed doctrines. However, a statute adopted in Oklahoma (180, sec. 296) imposes strict liability for salt water pollution of surface water but does not apply to ground water contamination (173). The Oklahoma court has stated that "[t]he basis of liability for injury or damages to property by pollution of subterraneous waters, from oil, gas, salt water or like substances, in oil wells must be either negligence or nuisance" (46, p. 684). Another mechanism for imposition of strict liability is illustrated by the 1956 Texas court decision of Gulf Oil Corp. v. Alexander (114) in which an administrative regulation is interpreted as producing this result in connection with pollution of fresh water by salt water. The case consisted of an action for damages for pollution of a fresh water stratum by a salt water disposal pit used in oil and gas operations on adjoining land. The court agreed with the defendant's contention that negligence was not involved but held that the following rule of the Texas Railroad Commission imposed liability for salt water escape even in the absence of negligence:

> Fresh water, whether above or below the surface shall be protected from pollution, whether in drilling, plugging or disposing of salt water already produced (114, p. 794).

The result of this interpretation is a drastic alteration of the previously existing position of the State of Texas with regard to liability for the escape of salt water. Specific proof of negligence had been a requirement for liability in such cases since the decision in Turner v. Big Lake Oil Co. (265) where the court thoroughly repudiated the strict liability concept embodied in Rylands. Since the position of the court regarding this common law concept has not been modified, its application to ground water pollution from the escape of deleterious substances outside the scope of the Railroad Commission rule is doubtful.

Although application of the strict liability concept may involve explicit acknowledgment of a common law doctrine, statutory provision, or administrative regulation, in some cases the principle is applied in effect without specific acceptance or even reference to the concept. One manner in which this result can be achieved is through imposition of liability with no consideration of legal theories upon which the decision is based. For example, the Supreme Court of North Carolina in the 1926 case of Masten v. Texas Co. involving gasoline contamination of a well categorically stated that "[a] person has no right to befoul, corrupt, or poison underground water so that when it reaches his neighbor's land it will be unfit for use by either man or beast" (156, p. 90). The absence of restrictions or conditions concerning the holding implies that liability is an absolute consequence of ground water contamination.

The effect of strict liability can also be achieved through application of the nuisance doctrine. The difference between the two theories is only a matter of degree since neither requires a showing of fault, and they become essentially indistinguishable when nuisance is applied without regard to the lawfulness of a given activity nor to the degree of care employed in its conduct. In fact, some decisions that hold an injurious activity to be a nuisance cite the Rylands case, the basic precedent for the strict liability concept, as support for the imposition of liability (71, 188). The only real difference in the two theories appears to be that the court has more flexibility under the nuisance concept to balance the opposing interests of the parties before it. Overt acceptance of the strict liability concept indicates a direct preference for the rights of the injured party where a particular activity is involved, thereby eliminating the balancing process as a part of the individual decision. Thus the imposition of liability is somewhat more dependent on the facts of the specific situation where nuisance is employed than where strict liability is expressly applied.

The effect of strict liability can even be achieved under the guise of a negligence proceeding. For example, the Court of Appeals of Georgia, in the 1973 case of North Georgia Petroleum Co. v. Lewis (174) arising from the contamination of wells by gasoline, referred to the escape of the gasoline from storage tanks as consisting of actionable negligence, but no consideration was given to particular negligent acts or to factors that would distinguish the storage operation in question from commonly accepted practice. Liability appears to have been viewed as an inherent consequence of the escape and resulting contamination rather than as the result of actual negligence. Thus the case appears to fit squarely into the mold of a strict liability proceeding, with the concept of negligence serving merely as a touchstone which gives the case the appearance of following a perhaps more traditional approach.

An even more direct illustration of the application of the strict liability concept under the umbrella of negligence is given by the early Florida decision of Pensacola

Gas Co. v. Pebly (191). The Supreme Court of Florida, in affirming a lower court's award of damages for pollution associated with the operation of a gas works, stated that the escape of refuse water was ". . . in itself an evidence of negligence on the part of the gas company" (191, p. 595). This approach is in sharp contrast with the position taken in the previously cited Bollinger case that recovery for injury resulting from the escape of gasoline required proof of specific negligence in the original construction and installation of a tank and pump or in their maintenance.

Due to the various methods of applying the concept of strict liability, some of which are less than obvious, any determination of the level of its acceptance is difficult. However, its acceptance as a general concept in law appears to be increasing. Professor William L. Prosser in his treatise on tort law explains the initial reception of the doctrine in the United States and the current trend in acceptance as follows:

> In the United States Rylands v. Fletcher was promptly accepted by the courts of Massachusetts and Minnesota. Almost immediately afterward the whole doctrine was received with a triple bath of ice water, and entirely repudiated, by decisions in New Hampshire, New York, and New Jersey. . . .
>
> On the heels of these decisions, the doctrine was condemned by legal writers as an unjustifiable extension of liability to unavoidable accidents, in a field where the law of negligence, aided by the principle of res ipsa loquitur, would be adequate to cover the cases where recovery should be allowed. One important reason often given for the rejection of the strict liability

> was that it was not adapted to an expanding civilization. Dangerous enterprises, involving a high degree of risk to others, were clearly indispensable to the industrial and commercial development of a new country and it was considered that the interests of those in the vicinity of such enterprises must give way to them, and that too great a burden must not be placed upon them. With the disappearance of the frontier, and the development of the country's resources, it was to be expected that the force of this objection would be weakened, and that it would be replaced in time by the view that the hazardous enterprise, even though it be socially valuable, must pay its way, and make good the damage inflicted. After a long period during which Rylands v. Fletcher was rejected by the large majority of the American courts which considered it, the pendulum has swung to acceptance of the case and its doctrine in the United States.
>
> At this writing, Rylands v. Fletcher still is rejected by name in seven American jurisdictions: Maine, New Hampshire, New York, Oklahoma, Rhode Island, Texas, and probably Wyoming. It has been approved by name, or a statement of principle clearly derived from it has been accepted, in some thirty jurisdictions, with the number expanding at the rate of about one a year (201, pp. 508-09).

With regard to the specific sources of ground water contamination to which strict liability has been applied, the processing, handling, and storage of petroleum products has perhaps seen the highest level of application. Without attempting an exhaustive listing, a number of examples can be cited. One of the earliest cases to explicitly accept the concept is the previously cited <u>Berger</u> case, which arose out of the escape of petroleum from storage facilities. Other cases that have applied the concept in situations involving escape from storage facilities, some without explicit reference to strict liability, include an 1890 Kentucky decision (140), a 1936 Connecticut decision (249), a 1969 Maryland decision (322), and a 1973 Georgia decision (174). Strict liability in connection with ground water contamination resulting from the operation of gas works has been imposed by court decisions in 1889 in Florida (191), 1894 in Nebraska (17), and 1908 in New Jersey (183). Strict liability has not been applied, however, in all cases arising from petroleum contamination of ground water. In a 1934 Rhode Island case (216), for example, the court expressly rejected the Rylands doctrine which had been relied upon by the plaintiff. The court concluded that liability could not be imposed without a finding of fault on the part of the defendant.

A related type of activity which has seen frequent application of the strict liability concept in connection with contamination problems is the handling and disposal of oil field brines produced during petroleum extraction operations. Reference has been made to cases where statutory and administrative provisions as well as principles of common law have been evoked in support of the strict liability concept.

A factor which must be considered in connection with private rights concerning contamination from oil field operations is the effect of leases that may exist concerning the production operation. Such leases, like those granting coal mining rights, generally convey to the lessee certain incidental rights necessary in the exploration and production operations, and the rights of the lessor with respect to uncontaminated ground water may be adversely affected. For example, the Appellate Court of Illinois in the 1953 decision of Phoenix v. Graham (194) held that the lessee was not liable to his lessor for salt water damage unless it was caused by negligence in his operations.

It is difficult to identify other types of activities where strict liability has seen frequent application in ground water contamination cases, but other random examples exist. In a 1968 Kansas decision (10), the court adopted this doctrine with regard to contamination from a cattle feedlot operation. Although making no specific reference to strict liability, the Kansas court in an earlier decision (96) appeared to apply this concept in a situation where ground water contamination had resulted from a salt dump. The following statement by the court indicates that strict liability would have been imposed regardless of the source of the contamination:

> We regard it as well settled by the weight of authority, and in accordance with sound reason, that one has no right to deposit upon his land refuse matter of any sort, whether in itself offensive or not, by which the water underlying his neighbor's land may be so affected through percolation as to be unfitted for its ordinary use, or injurious to vegetation (96, p. 543).

A similar statement implying broad applicability of strict liability in cases of ground water pollution is also contained in the previously cited Masten case which involved gasoline contamination. Thus it is difficult to define limits for the application of the doctrine, but the probability that it will be applied appears to increase with the inherent danger of contamination associated with the particular activity.

Application of the theory of trespass

Theoretically, trespass appears to be a valid basis for a legal action to recover for ground water pollution injury since the pollution process involves the unauthorized invasion of property by a physical substance as the result of the action of another party, the traditional situation for application of this theory. However, this basis of recovery for ground water pollution has not been employed to any appreciable extent, and the cases brought under this theory usually have been unsuccessful. The courts generally have refused to hold that ground water contamination constitutes a trespass because of the view that such injury is indirect and does not indicate intent on the part of the defendant. The following quotation from Phillips v. Sun Oil Co. expresses these obstacles to the establishment of liability on the basis of trespass:

> We hold, as did the courts below, that plaintiff did not make out a case in trespass. Trespass is an intentional harm at least to this extent: while the trespasser, to be liable, need not intend or expect the damaging consequence of his intrusion, he must intend the act which amounts to or produces the unlawful invasion, and the intrusion must at least be the immediate

> or inevitable consequence of what he willfully does, or which he does so negligently as to amount to willfulness. . . .
>
> The application of the above-stated rule, in the few pertinent New York cases, to damage claims arising from the underground movements of noxious fluids, produces this conclusion: that, even when the polluting material has been deliberately put onto, or into, defendant's land, he is not liable for his neighbor's damage therefrom, unless he (defendant) had good reason to know or expect that subterranean and other conditions were such that there would be passage from defendant's to plaintiff's land (193, pp. 250-51).

In the 1934 case of Pan American Petroleum Co. v. Byars (186), also involving ground water pollution, the plaintiff had withdrawn an original complaint based on trespass, but the Alabama Supreme Court indicated that trespass might not have been a suitable grounds for recovery. The court noted that an injury is to be regarded as a trespass only when it is directly occasioned by and is not merely a consequence resulting from the act in question. It was also stated that trespass is not a proper form of remedy in the absence of a showing of intent in the production of injury. Thus it appears from the historical perspective that trespass is a questionable basis for recovery of injury resulting from ground water pollution.

The evidentiary issue in ground water contamination suits

The foregoing survey of the different approaches that the courts have utilized with regard to ground water contamination indicates considerable variation in the burden of proof facing the injured party. Another element of proof which is largely independent of the nature of the legal theory involved concerns causation, which is concerned with the cause-and-effect relationship between the injury and the alleged source of contamination. The injured party as plaintiff before a court must be able to produce evidence proving that the defendant was responsible for the contamination in question before the court will consider the extent of his legal rights and the merits of his claim against the defendant. This evidentiary question is a basic consideration regardless of the theory of liability involved in the case and often becomes the central issue before the court.

This burden can sometimes be overcome by direct evidence such as the results of tests where some easily identified substance is deposited at the alleged source of pollution and detected at the site of the pollution damage. For example, the plaintiff in the 1922 Tennessee case of Love v. Nashville Agricultural & Normal Institution (149) involving pollution of a well by a sewage system established causation by having indigo, potassium iodide, and aniline poured into the sewer drain, all of which appeared in the contaminated well. In the more recent case of Reinhart v. Lancaster Area Refuse Authority (208) involving contamination of a well by a sanitary landfill operation, causation was established by the fact that the well water turned red after a truckload of a red substance was dumped into the landfill and became sudsy after a large quantity of soaplike material was deposited in the landfill.

Although such direct evidence is the most satisfactory means of establishing causation, this approach is possible in only a limited number of cases arising from ground water contamination due to physical factors such as the slow rate of movement. The difficulties associated with direct evidence have resulted in considerable reliance by the courts on inference based on circumstantial evidence. The following rationale for reliance on inference is contained in a 1970 South Dakota case involving well pollution:

> If the administration of justice had to depend on demonstration by absolute proof, there would be few issues open to litigation, for such proof is rarely obtainable outside the realm of science. When a finding is a reasonable inference from the facts and conditions directly proved, it must be classed as legal evidence and not as a mere conjecture, surmise, or guess (311, p. 317).

There is no generally accepted rule as to what types of inferences constitute sufficient proof of causation, but there are several factors which are generally relevant to this determination. Included are the proximity of the alleged source, the existence of other possible sources, the time relationship between the alleged pollution-causing activity and the injury, evidence of the escape of the pollutant from the suspected source, and the potential for the pollutant to travel between the suspected source and the site of pollution injury.

The proximity of the alleged source and the existence of other possible sources are generally considered jointly. For example, the determination regarding causation in Joldersma v. Muskegon Development Co. (136) involving ground water pollution from salt water was resolved negatively after it was shown that the alleged source was located 600 feet from the site of the injury and that other possible sources of salt existed which had not been excluded by the evidence. In contrast, the plaintiff in Hall v. Galey (117) was successful in establishing a causal connection between salt water injury and defendant's oil well. Other oil wells that were potential sources were eliminated by evidence that they had been properly plugged to prevent seepage of salt water whereas the defendant's well had not and by the fact that the other wells were from 200 to nearly 800 feet farther from the contaminated water well than was the defendant's well.

Although failure to eliminate other possible sources of pollution may be fatal in some cases to the establishment of causation, it is not always necessary for the plaintiff to eliminate all other possible sources. The following statement is from Donley v. Amerada Petroleum Corp.:

> It may, also, be noted that appellees were not obliged to exclude every other possible source of pollution after establishing facts from which it reason-

> ably could be inferred that appellants had polluted the stream (67, p. 655).

The relationship between the time of pollution and an action by the defendant is often an important factor in showing causation. In the 1960 Pennsylvania case of Bumbarger v. Walker (33), a spring in use for nearly forty years became contaminated shortly after polluted water was removed from a nearby strip mine by blasting. The court made the following statement regarding the time factor:

> Where conditions, which have continued for a long period of time, change coincidentally with the occurrence of a new event which in common experience may have caused the change there is sufficient evidence of causation present for the case to go to the jury (33, pp. 148-49).

The court found that causation had been established when the timing coincidence was considered with other evidence such as the proximitey of the strip mine to the spring and the topography of the land. However, the timing factor alone may not be sufficient evidence for an inference of causation. For example, the only evidence presented in Pine v. Rizzo (195), a case concerning alleged salt water pollution from defendant's oil well, was that plaintiff's well had always contained good water but had become polluted with salt shortly after the oil well was drilled. The court ruled that this evidence in itself was insufficient to show causation.

Proof that the pollutant could have escaped from the alleged source generally includes identification of defects in facilities for containing the material involved and actual evidence of leakage and seepage. In the Hall case, it was shown that the soil surrounding the suspected oil well was saturated with salt water and that vegetation around the well had been killed. This evidence, together with the elimination of other possible sources of salt water, was accepted as an adequate showing of causation. In some cases proof of the potential for escape alone has not been viewed as an adequate establishment of causation in the absence of actual evidence of the escape of a pollutant. For example, the court in Shell Oil Co. v. Blubaugh (228), a case involving salt water contamination of a water well, did not infer causation from the fact that the defendant's oil well containing salt water had been improperly plugged because there was no evidence that salt water had actually escaped from the well.

Evidence establishing the potential of a pollutant to travel from the alleged source to the site of the contamination consists of such factors as the respective elevations involved, topography, the nature of the soil and rock in the area, and the direction of ground water movement. In Sinclair Refining Co. v. Bennett (232), a case involving gasoline contamination of a well, the court inferred causation on the basis of evidence showing the defendant's filling station to be located at the top of a ridge a short distance above the contaminated well. The plaintiff in Haveman v. Beulow (121) was able to establish causation by showing that defendant's refuse sump was higher than plaintiff's well and that natural drainage from the sump ran towards the well. In the 1927 North Carolina case of Masten v. Texas Co. (156), the evidence indicated that the general contour of the land was sloping from the defendant's gas tank to the plaintiff's well, that strata of rock ran from the tank to the well, and that the vein of water running into the well came from the direction of the tank. This evidence, along with the fact that the pollution began when a new pump was installed on the tank, was held sufficient to show causation.

As indicated by this consideration of individual cases, the particular combination of factors necessary for an inference of causation varies among jurisdictions and with the circumstances of each situation. As noted by the Supreme Court of Kansas, "[c]ircumstantial evidence, in a civil case, need not rise to that degree of dignity which excludes every reasonable conclusion other than that reached by the jury" (220, p. 274). What is generally necessary is that evidence be presented from which it can reasonably be concluded that the alleged source is responsible for the contamination in question.

Generalizations and trends with regard to water quality rights

Due to the lack of uniformity in the legal approach taken in ground water pollution cases, few generalizations concerning the nature of the water quality right can be made. The range in legal recognition extends from the view that an uncontaminated water supply is an absolute right to a very restricted view that such a right is enforceable only where the contamination results from negligence.

With regard to variation among jurisdictions, few patterns are discernible. One regional characteristic that can be noted is the traditional lack of a strong recognition of such rights in areas where natural resource development would be constrained. Two such areas are those associated with oil and coal extraction. Courts in some of these states have required proof of negligence as a condition for establishing liability and have refused to recognize a legal cause of action for ground water contamination where resource recovery operations were carried out in the conventional manner. However, this traditional approach has been modified in some instances due at least in part to recognition of the extent of the water quality problem caused by such operations. Perhaps the best illustration is given by the petroleum producing states where legislation, administrative regulations, and judicial doctrines have been increasingly used to impose strict liability for contaminating activities previously requiring proof of negligence as a basis for recovery by an injured party.

Although there appears to be a trend toward greater acceptance of the strict liability concept in the law in general, and with regard to certain sources of ground water contamination, there does not appear to be a general shift toward this approach with regard to liability for ground water pollution, and cases are still being decided wherein the courts require proof of negligence as a necessary condition for imposition of liability with respect to activities causing ground water contamination. Trends are difficult to detect because of the relative infrequency with which ground water quality cases reach the courts. Detection of trends is also complicated by the flexibility with which the various legal theories can be interpreted and applied by the courts. For example, it has previously been noted that a court can impose strict liability in effect while addressing the conflict in terms of negligence.

Another source of flexibility in handling ground water pollution cases concerns the evidentiary issue which often becomes the principal focus of attention. The difficulty confronting an injured ground water user with regard to establishment of a causal relationship between the contamination and the alleged source is dependent largely on the discretion of the court. The nature of the requirements imposed can have a significant impact on the final decision in a case.

The flexibility and discretion that can be exercised by the courts within a given ground water contamination case tend to diminish the importance of the theoretical differences in the legal doctrines. The approach often appears simply to be one of balancing the equities in the particular case, which lowers the predictability of the outcome of legal disputes concerning ground water quality and lends a substantial degree of uncertainty to the individual ground water user's right to continuance of an uncontaminated supply.

The Ground Water Quality Right in Virginia

The right of the Virginia property owner to an uncontaminated ground water supply has not been well defined due to the fact that very few cases concerning water quality have been decided. The cases that have arisen are somewhat contradictory and have involved special circumstances which limit the development of general principles of broad applicability.

One of the principal decisions is Oakwood Smokeless Coal Corp. v. Meadows (175), a 1945 case arising out of the pollution of a spring by mine drainage. The source of the contamination was percolating water which dripped from the roof of a mine, flowed out a ventilation shaft and by gravity down the side of a mountain, finally entering a spring on adjoining land by seepage into the ground. The Virginia Supreme Court of Appeals refused to impose liability on the mine operator for the resulting injury.

A special condition which affected the court's decision was that the two pieces of property involved had been in common ownership when the mining rights had been conveyed to the defendant corporation, along with all other usual mining privileges necessary for the exercise of the rights conveyed. Although no specific reference to drainage was made in the conveyance, the court held it to be included since "[t]he right to mine coal without the right to drain the mine is no right at all" (175, p. 396). Thus the rights of the subsequent owner of the spring were limited by this contractual arrangement and were not the same as those of a landowner not affected by a conveyance of mining rights.

Although the rights of the injured party in the <u>Oakwood</u> case had been affected by the conveyance of mineral rights, the court's considerations in reaching its decision indicate that this factor was not the sole basis for its holding. In the course of the court's written opinion in the case, reference is made to the principle that liability does not arise for mining activities on adjoining land which cause springs to go dry. As noted previously, denial of the right to uncontaminated ground water has been based on an analogy with the absence of a right concerning continuance of supply by other courts (281). The reasoning in such cases has been that destruction of springs or wells by pollution is no different from destruction by interference with the source of supply; therefore liability should not be imposed for pollution where it is not imposed for drying up the supply.

The Oakwood court does not specifically state its acceptance of the view that the right to contaminate ground water is the same as the right to use it, but reference to the rule of no liability that it has applied in cases of interference with flow indicates acceptance since its inclusion served no purpose in the case other than use as an analogy with the contamination situation. Since the Virginia court has held that no liability exists where mining operations destroy springs or wells on adjacent land not subject to a conveyance of mining rights (53), this implied acceptance of the use-contamination analogy suggests that the outcome in Oakwood may have been the same in the absence of the mineral rights conveyance.

Another factor which suggests that liability would not have been imposed even if the conveyance of mining rights had not been an issue is the court's reference to the Pennsylvania case of Pennsylvania Coal Co. v. Sanderson (189), a decision which holds that no liability arises in connection with stream pollution from mine drainage where the mining operations are carried out in the ordinary way and the mine drainage is discharged into the natural drainage system for such water. The Oakwood court does not elaborate on the merits of Pennsylvania Coal Co., but it refers to this decision as the leading case on the subject of mine drainage and quotes a lengthy passage from the case which expresses the concept that liability does not arise in connection with contamination from mine drainage. The court makes no reference to the fact that in two previous Virginia decisions (8, 231) involving stream pollution it had expressly rejected the holding in Pennsylvania Coal Co.

The other principal Virginia decision involving ground water pollution, Panther Coal Co. v. Looney (187), suggests some recognition of a basic right in uncontaminated ground water, but special conditions again limit the extrapolation of general principles from the case. This case involves alleged pollution of two wells from mine drainage, but in this instance the mine water was first drained into a surface stream. Although the court did not impose liability on the mine operator due to evidence that the injured landowner had himself contributed substantially to the complained of contamination, it stated that ". . . the defendant did not have the legal right to pollute in a material and substantial way the stream and the wells" (187, p. 301).

A significant factor affecting the general applicability of this rule to other situations involving ground water contamination is that contamination of a surface stream was involved in the Panther Coal Co. case. The primary basis for the court's conclusion regarding rights to alter water quality appears to consist of considerations of rights in surface streams. The Panther Coal Co. court relied heavily on two Virginia stream pollution cases, Arminius Chemical Co. v. Landrum (8) and Shoffner v. Sutherland (231), both decided prior to the previously discussed Oakwood decision. Although the Oakwood decision implies acceptance of the premise of Pennsylvania Coal Co. that rights regarding water quality must give way to mineral development, these two earlier cases had both rejected this concept as indicated by the following quotations:

> That decision [Pennsylvania Coal Co.], as it seems to us, is based upon two grounds, neither of which is sound, viz.: That the rights of one riparian owner are to be determined by the necessities of another and by the importance of the latter's business to the community or public (8, p. 463).

> It would . . . be a source of regret if, in the administration of justice by the establishment and enforcement of sound principles, the prosperity of our people should be hindered or checked, but it would be not only a source of regret, but of reproach, if material prosperity were stimulated and encouraged by a refusal to give to any citizen a remedy for wrongs he may sustain, even though inflicted by forces which constitute factors in our material development and growth (231, p. 997).

The different treatment given to the underlying principle of Pennsylvania Coal Co. in these cases suggests a basic difference in philosophy with regard to ground water quality and surface water quality.

Limitations of Private Rights as a Ground Water Quality Protection Mechanism

Due to the slow rate at which a contaminated body of ground water is cleansed, protection of quality must be largely preventive in nature. Thus the effectiveness of property rights as a mechanism for protecting ground water quality is dependent on the extent to which these rights act as a deterrent to activities responsible for contamination. This deterrent effect is in large measure determined by the potential polluter's perception of the likelihood that legal accountability will be imposed. Greater precautions to prevent contamination are likely to be taken where strict liability is anticipated than in the situation where a significant probability of escaping liability exists. The deterrent effect of property rights can be expected to be minimal where proof of negligence is a necessary condition for liability.

A basic institutional weakness of property rights with regard to quality protection is that implementation of controls requires initiation of a lawsuit by an adversely affected party. Therefore a pollution-causing act is subject to direct legal constraints only where a neighbor's well happens to be located such that injury occurs. The mechanism of injunction allows constraints to be imposed in some situations prior to the actual occurrence of injury, but application of this control requires the existence of a ground water use that is directly threatened. The courts will generally not grant an injunction where the potential injury is merely speculative but restrict this form of relief to those cases where injury is relatively certain. Thus application of controls embodied in property rights is a somewhat random process that may exclude major sources of contamination with the potential to produce significant water quality problems in the future.

The ineffectiveness of this system of control is illustrated in Virginia by the essential lack of its application to ground water quality problems. Although contamination problems are widespread in certain areas and continue to grow in significance, in very few situations have property rights been asserted in the courts as a constraint on the responsible activities. A number of reasons may exist for this scarcity of cases, including the absence of a ground water user whose interests have been sufficiently injured to date, difficulties in determining the specific source of contamination, or the belief that the courts will not impose liability with regard to certain sources. In any event, the existing situation illustrates the point that the degree of quality protection provided by property rights is considerably less than complete.

The inherent weaknesses of property rights as a quality control mechanism are similar in nature to those related to ground water allocation. The application of after-the-fact constraints primarily in the form of monetary damage awards on a discontinuous, case-by-case basis does not provide an adequate foundation for a comprehensive program of controls necessary to afford actual protection to the resource. The judicial process through which private rights are enforced does not have the institutional capability for the essential planning and other forward-looking managerial activities that are preventive rather than remedial in nature. Thus property rights are basically unsuitable as the primary institutional mechanism for quality protection. Their principal contribution is the equitable resolution of conflicts between individual interests, with any role in actual management best viewed as a supplemental one.

Private Rights as a Control over Use of Aquifer Storage Space

The utilization of aquifer storage space by the process of artificial recharge has not seen extensive practical application in Virginia, but the concept has proven to be a feasible and beneficial element of comprehensive water resources management in other areas. Because of hydrologic variability, natural patterns of water supply seldomly conform to patterns of demand for water, making storage an essential aspect of management even in humid areas. Storage has most frequently been accomplished through the construction of surface facilities, but in certain situations, substantial advantages may accrue to the use of subsurface storage in natural geologic formations.

The principal advantages of subsurface storage arise from the fact that extensive construction of facilities and alteration of natural environmental conditions are unnecessary. The absence of a need for major construction may result in a considerable economic advantage for the subsurface alternative where physical conditions are compatible with this approach. The relatively small amount of interference with existing land uses in an area where subsurface storage is accomplished is an advantage of increasing significance. Much opposition is currently being expressed with regard to new proposals for surface water impoundments because of the need to relocate people and their activities and the destruction of natural environments, thereby increasing the attractiveness of any alternative which reduces these effects.

Other advantages also exist in addition to the elimination or reduction in need for construction of surface impoundments. Included are the reduction of evaporation losses of stored water, maintenance of a more uniform water temperature, and accomplishment of the distribution function with regard to wells served by the aquifer systems involved (152). Of course these positive factors must be viewed in conjunction with the disadvantages of subsurface relative to surface storage such as the absence of recreational potential and physical difficulties of carrying out recharge operations. Selection of a storage system in a particular situation requires a comparative evaluation of both surface and subsurface options, but large amounts of unused subsurface storage potential exists while favorable sites for surface storage are becoming increasingly scarce. Therefore the potential for future utilization of subsurface storage, possibly in combination with the use of surface facilities, appears high.

Use of subsurface storage is generally associated with water scarce areas where severe problems of supply exist, a classification into which Virginia and many of the eastern states do not appear to fit. However, the relative abundance of water in terms of total quantity available does not assure a reliable supply, and regulation of natural supplies has been necessary in all states. A recent report (9) prepared for the U.S. Army Institute for Water Resources concerning the integration of surface and ground water use in humid areas such as Virginia concluded that an integrated approach offerred advantages from the viewpoint of both economics and water conservation. This study did not consider use of artificial recharge, but a combination of surface and subsurface storage may be potentially advantageous under some conditions.

One of the major population centers of Virginia is the extreme southeastern section of the state where the potential for surface impoundment of water is limited and existing ground water supplies are unsuitable due to the mineralized nature of the water, making necessary the procurement of water supplies from areas located further inland. A potential solution to this problem that has been investigated (30) consists of the injection and storage of fresh water in the large capacity saline aquifers that are present in the area. Such storage would utilize fresh water which presently flows into the ocean during winter months when water demand is low and streamflows are high. It has been estimated that as much as two and one-half billion gallons of water each winter could be made available for use in the Norfolk area if adequate storage facilities were available (30, p. 381).

The concept of recharging fresh water into brackish water aquifers was first tested in Virginia at Camp Peary in 1946, but a more recent attempt was initiated in 1971 as part of a cooperative program between the U.S. Geological Survey and the City of Norfolk. This project was designed to determine the feasibility of injecting treated water not needed during the winter months into saline aquifers for storage and subsequent withdrawal during the summer months when peak water demands and low water levels in surface reservoirs combine to create problems of supply. The study project involved four tests with varying quantities of injected water and storage periods prior to withdrawal.

A report on the project states that "[p]reliminary indications are that a well field could be constructed and operated economically to store surplus water" (30, p. 405). On the basis of tests using short storage periods, the proportion of recovered water meeting drinking water standards was between 85 and 90 per cent. The principal difficulty encountered consisted of injection well clogging due to chemical changes that the fresh water produced in clays found in the aquifer, but efforts to stabilize the clays through chemical treatment of the aquifer at the beginning of injection were described as "very encouraging" (30, p. 405).

Although physical and economic feasibility are essential if subsurface storage of water is to be a viable management alternative, evaluation of feasibility also requires consideration of possible institutional constraints. One potential constraint consists of the property rights of the owners of the land overlying the aquifer to be utilized. Since these rights have a vertical dimension and encompass certain interests in the subsurface, it is necessary to consider the extent to which such rights impact on the utilization of aquifer storage space.

Questions concerning property rights arise in connection with subsurface storage because of the necessity for such operations to encompass hydrologic units likely to underlie the lands of several owners. Just as naturally occurring ground water can be extracted by pumping on other land, water can be stored under a given piece of property by recharge on other land where underlying aquifers are continuous. Since the physical continuity of storage formations and the hydrodynamic processes that govern the subsurface movement of recharged water are not generally subject to control, the question of the extent of the landowner's rights relative to the storage operation is a basic determinant of the feasibility of artificial recharge.

In many instances, subsurface invasion of property by recharged water would not be directly discernible by the landowner and would not produce damage with regard to other utilization of the land; however, an unauthorized invasion of this type may constitute a violation of a property right even in the absence of measurable injury due to the possible exclusive nature of such rights. This issue is unlikely to arise where the storage is for the benefit of the overlying landowners but may become significant where storage is for the purpose of subsequent withdrawal for use on lands not overlying the recharged aquifer. The principal factor upon which this determination depends is the extent of the subsurface property rights recognized in the jurisdiction involved.

A somewhat different property rights issue would arise in the event that storage operations produced actual injury to overlying property or interfered with its utilization by the owner. Examples of such occurrences might include waterlogging of agricultural lands, interference with construction, or interference with mineral extraction. The issue in this type of situation is not limited to the theoretical extent of an abstract property right of the landowner but concerns the nature of liability arising from activities producing direct property damage.

Since storage of water beneath land creates the physical possibility for the landowner to capture the water by means of wells located on his property, a third property rights issue that arises concerns rights that attach to the stored water. The basic question here is whether exclusive rights in the stored water are retained by the party responsible for storage or whether any landowner overlying the aquifer can withdraw the water by virtue of his property rights.

Extent of Private Ownership of Aquifer Storage Space

Since subsurface space has not been widely viewed as a valuable resource in itself, consideration of its ownership has not been extensive. However, reference has frequently been made to the potential problems that private ownership of aquifer storage space poses with regard to artificial recharge operations (21, 98, 258). The 1972 revision of the American Society of Civil Engineers manual on ground water management states that "[t]he law relating to ownership and rights in operational storage is almost nonexistent" (104, p. 60). In a study on ground water law and management prepared for the National Water Commission, Charles Corker (62, pp. 183-84) declares that the use of such storage space should not be prohibited by the laws of private property but makes no attempt to determine the status of this law.

Regardless of this acknowledged lack of definitive law concerning aquifer ownership, applicable subsurface property rights have been developed to some extent. Rights in the subsurface have evolved largely in relation to the development and utilization of extractable natural resources. These rights have also been developed through decisions arising in connection with the use of caves, subsurface disposal of oil field brines, injection of liquids as a means of increasing production of oil and gas, construction of tunnels and pipelines, and storage of natural gas in subsurface formations. In addition, the development of law related to the use of airspace may have some relevance with regard to the determination of the extent of subsurface property rights.

These possibly analagous areas of law present a somewhat contradictory view of the extent of the landowner's exclusive property interests in space underlying his land. One group of cases indicates that the landowner exercises complete and exclusive dominion over such space while other cases suggest that subsurface storage space may be viewed as a public resource subject to use without regard to land ownership in the absence of interference with the overlying owner's use and enjoyment of his property.

Precedent for the view that subsurface space is subject to exclusive control by the landowner

The concept that all subsurface space is subject to the use and exclusive control of the owner of the land surface is embodied in the maxim *cujus est solum, ejus est usque ad coelum ad infernos*, which means "to whomsoever the soil belongs, he owns also to the sky and to the depths" (22, p. 453). This concept of ownership to the sky and to the center of the earth has seen considerable application in defining rights with regard to solid minerals and has also been applied in support of the landowner's exclusive rights relative to use of the land surface and to use of airspace overlying the land. Of course this concept has been modified to the extent that a landowner cannot prohibit use of airspace above his land for aviation purposes when such use does not interfere with the landowner's use and enjoyment of his property (124, 275), but it still has considerable impact regarding the protection of property rights from infringement in other ways.

The basic reason for establishment of this unbounded concept of ownership appears to have been the desire to assure the landowner the right to use overlying and underlying space to any extent necessary or desirable and to protect such uses from interference by others. The simplest method of assuring such protection was the infinite extension of property rights. In cases involving mineral rights, for example, the courts have not always limited their consideration to actual resources physically or economically recoverable but have defined ownership without practical lower limits. This approach apparently gives no consideration to the possibility of use by others which does not affect or interfere with use by the landowner. However, a strict interpretation of such unbounded property rights excludes any use by others regardless of the lack of impact on the landowner or his inability to make the use in question himself.

The 1936 Kentucky case of Edwards v. Lee's Administrator (73) is a good example of a strict application of the exclusive ownership concept to subsurface space not usable by the surface owner. The case supports the right of a landowner to exercise exclusive control over a portion of an underlying cave whose entrance was located on the property of another. The owner of the land underlain by the cave was awarded damages from the adjacent owner who had made commercial use of the cave. This decision was reached in spite of the fact that the plaintiff had no means of access to the cave located 360 feet beneath his land. The primary consideration appears to have been the fact that the defendant made an economic use of space theoretically owned by another, therefore incurring liability for a portion of the profits accruing from such use.

The concept of the surface owner's exclusive control over unusable subsurface space is also supported by the 1937 Indiana case of Marengo Cave Co. v. Ross (154). Like Edwards, this case arose out of a dispute as to the ownership of a cave which extended beneath land adjacent to that where the entrance was located. In this instance the party who controlled the cave's entrance did not contest the overlying owner's original claim to the portion of the cave in question but claimed title on the basis of adverse possession. Although possession for the necessary period of time was conceded, the court held that the conditions of the possession were not adequate to effect a transfer of title. One of the essential elements for the establishment of title by adverse possession is that the possession must be open and notorious, a condition not fulfilled since the overlying owner of the cave was not aware that it extended beneath his property during a major portion of the period of possession.

In addition to the cave cases, court decisions exist in other areas where the proprietary rights of the landowner in subsurface space have been recognized. For example, slant drilling wherein oil wells are drilled at an angle such that they cross property boundaries beneath the land surface has been held to constitute trespass (18, 268, 269). Also, it has been held that fracturing of a formation across property boundaries as a part of a natural gas recovery operation constitutes trespass. The following language is from the case of Gregg v. Delhi-Taylor Oil Corp.:

> While the drilling bit of Gregg's well is not alleged to have extended into Delhi-Taylor's land, the same result is reached if in fact the cracks or veins extend into its land and gas is produced therefrom by Gregg. To constitute a trespass, "entry upon another's land need not be in person, but may be made by causing or permitting a thing to cross the boundary of the premises" (99, p. 416).

Although an early court decision (118) holds to the contrary, the proprietary rights of the landowner with regard to subsurface formations suitable for natural gas storage have also been generally recognized. Subsurface storage in natural geologic formations in lieu of artificial containers is generally subject to statutory controls which provide for acquisition of storage rights from the overlying owners, in some cases through the process of eminent domain (59, 94, 129, 177). The principles that have been formulated for valuation of natural gas storage strata are of interest since they involve the balancing of compensable private property interests against public use of such property, a category that would likely include large-scale ground water recharge operations. The valuation of a natural gas storage stratum was the principal issue in the 1962 Illinois case of <u>Peoples Gas Light and Coke Co.</u> v. <u>Buckles</u> (192). The landowner in the case sought compensation based on a proportionate share of the net future revenues from use of the storage stratum located partially beneath his land. The court rejected this measure of compensation and applied the rule that fair market value in such cases should be based on loss to the owner without consideration of special value arising from a use not available to the landowner.

> Plaintiff's [gas company] taking amounts to no more than an easement, and the usual measure of damages payable to such cases is based upon the diminution of the fair cash market value of the property burdened by the easement [citations omitted].
>
> . . . It is difficult for us to see how a commercially valueless salt-water-filled sandstone formation 1600 feet below the surface and which is unusable by the defendants, can take on any added value by virtue of a possible special use unavailable to them.
>
> . . . .
>
> [A]t the very heart of defendant's position is the fact that the St. Peter sandstone formation under the defendant's land achieves value solely because it is a part of the certified storage project of the plaintiff and therefore, runs headlong into a well established rule in determining values, i.e., that no consideration is to be given to the value to the condemnor for some special use [citations omitted]. "The question is, What has the owner lost? not, What has the taker gained?" [citations omitted]. The taking of a salt-water-filled sandstone strata lying some 1600 feet below the surface of the defendant's land would not appear to be of substantial monetary loss to the defendants (192, pp. 176, 180).

In reaching this conclusion, the court noted that the situation involving subsurface storage rights is analogous to water reservoir and hydro-electric power project cases wherein value of land for a special use by the taker had been rejected in determining the amount of the award. A principal reason behind the rejection of inherent physical adaptability in the determination of value was the lack of a reasonable possibility that the landowner could have successfully put the land to such use.

> In this case defendants' position relies on the "physical adaptability" of their land or what might be called the "strategic location" of their property. In United States v. Chandler-Dunbar Water Power Co. [citation omitted], the court specifically rejected any value due to the fortuitous location of the property, stating: "It is not proper to attribute to it any part of the value which might result from a consideration of its value as a necessary part of a comprehensive system of river improvement which should include the river and the upland upon the shore adjacent. . . . The 'strategic value' for which $15,000 has been allowed is altogether speculative."
>
> Neither is there a "reasonable possibility" that the defendants could use their land together with the other lands necessary for a gas-storage field. Such a project not only depends on the putting together of some 5,000 acres, the minimum for the pilot operation of Mahomet, but also the obtaining of a certificate for the project from the Commerce Commission. Therefore potential value based on such use by the landowner was viewed as too remote and speculative for consideration in a condemnation proceeding (192, p. 179).

Another case giving consideration to the measure of damages for the condemnation of a permanent easement for the underground storage of natural gas is Midwestern Gas Transmission Co. v. Mason (162), decided by the Illinois court in 1964. The court accepted the concept that the measure of damages was the difference in fair market value of the property before and after imposition of the burden of the easement. Since the award of damages for surface easements was not in controversy, the court limited its deliberations to the value of the storage formations. The court upheld the finding of a lower court that the formations involved, porous limestone strata lying in excess of 1800 feet below the surface, were valueless to the landowner. It was held that a provision for just compensation in eminent domain proceedings did not necessarily mean that some award had to be made.

Although the court in the Mason case upheld the principle of exclusive landowner control of subsurface storage zones, in reality it gave no practical effect to such rights. The following quotation from an article concerning the legal problems of the underground storage of natural gas is critical of this decision:

> It is submitted the court erred in the Mason case. If a storage easement is conceded to be a property right, as indeed it is, the owner of the right must be entitled to compensation for its taking. It is well established that when the damage is slight or diminutive, the taking will support a verdict for at least nominal damages. If no other evidence is presented, at least evidence of rental paid for competitive leasing of storage rights should be considered. The point is well stated in the following Discussion Note:
>
> "It is a startling proposition that a thing of value to its would-be acquirer (for which he would otherwise have to pay) can be taken without compensation through condemnation. Value, in everyday life and law . . . is not what a thing is worth to an owner who cannot or will not develop it himself, but its market value, which means what buyers will pay for it" [citation omitted].

> These observations are unquestionably correct. Failure to repudiate the result reached in the Mason case will undermine the most fundamental concept of property law embodied in the Fifth Amendment to the Constitution (225).

Precedent in support of non-ownership

Although the concept of exclusive ownership to the center of the earth is still a viable aspect of property rights, there are definite exceptions. For example, ground water rights have been tied to land ownership, but as noted previously, capture and reduction to possession have played a basic role in defining legal rights. The exclusive ownership concept has also been modified in the case of other fugitive resources. The "nonownership" theory has been adopted in some states with regard to oil and gas. This theory holds that no person owns oil and gas until it is produced and that it is subject to capture by any person able to do so. Of course the right of capture is limited to those holding property interests to drill wells for production purposes, but the rule allows one owner to produce oil which originally is located beneath adjacent property. The nonownership theory is only one of several given acceptance by the various states. Williams and Meyers in Oil and Gas Law (317) indicate that the theories include nonownership, qualified ownership, ownership in place, and ownership of the strata. They note that the opinions of the various state courts are not always clear as to the theory accepted and that legal writers are not always consistent in their classification schemes. The states listed by Williams and Meyers as presenting some evidence of the adoption of the nonownership theory include Alabama, California, Illinois, Indiana, Kentucky, Louisiana, New York, Ohio, and Wyoming (317, p. 31).

In addition to these limitations on the ownership of oil and gas, there is evidence in some jurisdictions that the right of the landowner to exclude uses by others may be limited where there is no interference with the landowner's use of his property. One area where non-injurious invasion of subsurface space has been upheld involves the injection of oil field brines into strata extending under the land of others. The leading case where this use has been permitted without accountability to the landowner in the absence of injury is a 1950 decision of the Supreme Court of Oklahoma, West Edmond Salt Water Disposal Association v. Rosecrans (312). The overlying owner in this case viewed the unauthorized injection of oil field brine as a taking of property and brought suit to enjoin the injection operation and to obtain damages for alleged trespass in connection with previous infringement of subsurface property rights. The landowner was requesting a monetary judgment for profits accruing to the injector as a result of the unauthorized use of the subsurface space; physical damages to the land, although no evidence of actual damages was presented; and punitive damages for the disregard of property rights. The injectors admitted liability for any actual damages resulting from the injection but denied that damages had occurred since the injection zone was saturated with salt water prior to the initiation of injection. The court concurred with the contention of the defendant that liability should be limited to actual damages.

Regarding the allegation of trespass, a principal consideration of the court was whether the salt water remained the property of the defendant upon its escape to the property of others. Had ownership remained with the injector, storage beneath adjoining land apparently would have constituted trespass, but the court held that ownership and control were lost upon escape and that consequently there was no trespass. In reaching this conclusion concerning loss of possession, the court compared the salt water with natural ground water and petroleum which are not necessarily fixed in position beneath one proprietor's land but are subject to migration and change of ownership. The court specifically noted that the migration of the injected fluid under plaintiff's land constituted only a displacement of a similar resident fluid.

The decision of the court was also likely to have been influenced by the importance of subsurface injection in disposing of the large quantities of salt water produced during oil and gas extraction. The attorney general of Oklahoma had filed a brief in connection with the case calling attention to the large production of salt water as a necessary incident to the production of oil and gas and the detriment resulting if this waste material was allowed to enter into surface water and underground fresh water strata. This brief maintained that a requirement on oil producers of obtaining the consent of all persons under whose lands injected salt water might migrate would practically prohibit the most logical solution to the salt water disposal problem. Consideration of the public interest aspects of water storage could lead to similar outcomes in cases involving artificial recharge.

In addition to cases arising from disposal of oil field brines, several cases concerning the issues of exclusive ownership and subsurface trespass have arisen in connection with the oil field practice of secondary recovery wherein water is forced into an oil-bearing stratum by means of injection wells for the purpose of pushing remaining oil toward producing wells. Since the injected water moves according to physical laws and is not restrained by property boundaries, such operations have the potential of affecting land beyond the immediate property on which the injection is carried out.

Although liability for actual damage resulting from secondary recovery may be imposed, the courts have generally shown a reluctance to prohibit such operations solely on the basis of exclusive property rights in subsurface formations. The contemporary trend of the law regarding oil field injection is indicated in the following quotation from Williams and Meyers:

> For purposes of cycling, recycling, secondary recovery operations, disposal of salt water produced with oil, or storage of gas near a market, a landowner (or his mineral grantee or lessee) may desire to inject fluids (gas, water or air) into an underground structure. The fluid injected may migrate to a portion of the structure underlying the land of another and in the course of such migration displace valuable substances in such land.
>
> . . . .
>
> Contemporary authority appears to support the proposition that, apart from possible liability for such special damages as were incurred in the above mentioned Oklahoma case, there is no liability for the migration of injected substances on a theory of trespass. Thus another Oklahoma case denied recovery for trespass on a showing of injection of salt water into a stratum which already included salt water and no other substance. The view was taken that when the salt water was injected into the formation by defendants, they thereby lost title thereto.
>
> What may be called a "negative rule of capture" appears to be developing. Just as under the rule of capture a landowner may capture such oil or gas as will migrate from adjoining premises to a well bottomed on his own land, so also may he inject into a formation substances which may migrate through the structure to the land of others, even if this results in the displacement under such land of more valuable with less valuable substance (e.g., the displacement of wet gas by dry gas). The law on this subject has not as yet been fully developed, but it seems reasonable to suggest the qualification that such activity will be permitted, free of any claim for damages, only if pursued as part of a reasonable program of development and without injury to producing or potentially producing formations (317, pp. 53-55).

Adoption of this position in the oil producing states is based largely on recognition of the importance of secondary recovery as a conservation measure. The Supreme Court of Texas has explained the need to modify the traditional rules of property with regard to such operations as follows:

> Secondary recovery operations are carried on to increase the ultimate recovery of oil and gas, and it is established that pressure maintenance projects will result in more recovery than was obtained by primary methods. It cannot be disputed that such operations should be encouraged, for as the pressure behind the primary production dissipates, the greater is the public necessity for applying secondary recovery forces. It is obvious that secondary recovery programs could not and would not be conducted if any adjoining operator could stop the project on the ground of subsurface trespass. . . .
>
> The orthodox rules and principles applied by the courts as regards surface invasions of land may not be appropriately applied to subsurface invasions as arise out of the secondary recovery of natural resources. If the intrusions of salt water are to be regarded as trespassory in character, then under common notions of surface invasions, the justifying public policy considerations behind secondary recovery operations could not be reached in considering the validity and reasonableness of such operations. . . . Certainly, it is relevant to consider and weigh the interests of society and the oil and gas industry as a whole against the interests of the individual operator who is damaged; and if the authorized activities in an adjoining secondary recovery unit are found to be based on some substantial, justifying occasion, then this court should sustain their validity (202, p. 568).

Thus it is obvious that certain individual rights have been modified where secondary recovery is involved, as in the case of subsurface oil field brine disposal, because of considerations of the public interest. Both operations are viewed as indispensable to petroleum production and are given favorable legal treatment in the oil-producing states. Extension of these property rights limitations existing in connection with the petroleum industry to water storage operations may be realistic since this type of operation also involves an overriding issue of public interest.

Precedent for the right to use subsurface strata without accountability to the landowner in the absence of injury also exists in areas other than petroleum production. A somewhat related area is that of subsurface storage of natural gas. Although representing a minority position, one of the most interesting cases in this area is Hammonds v. Central Kentucky Natural Gas Co. (118), a 1934 Kentucky decision, in which a landowner brought suit under the concept of trespass for compensation from a company engaged in the storage of natural gas in an underground reservoir extending beneath the plaintiff's property. By applying the theory that oil and gas are of a wild and migratory nature, the court reasoned that the act of releasing the gas in question into the earth resulted in loss of exclusive ownership. Therefore the company was not liable for the value of the use of the adjacent property since it no longer exercised ownership and control over the gas. The loss of ownership holding has detrimental implications with regard to injection of substances for later recovery, but other courts have since refused to accept this aspect of the decision (147, 315). It should also be noted that ownership and right of recovery of injected natural gas are currently subject to statutory regulation in several states (59, 129, 177, 190, 266, 314). Thus the potential effect of this case on natural gas storage operations has been somewhat nullified, but the decision still supports the use of subsurface space without accountability to the overlying owner.

Another case which somewhat restricts the exclusive rights of the landowner in subsurface space is the 1931 New York decision of Boehringer v. Montalto (25). This case arose from a dispute between the buyer and seller of property involving an undisclosed sewer line located 150 feet below the surface. The court held that the sewer was not an encumbrance on the basis of the view that a landowner's rights are restricted to a depth of "useful ownership." The absolute concept of indefinite ownership upward and downward was rejected as an unacceptable principle of law.

After holding the sewer line not to be an encumbrance, the court went on to add that even if it were, the depth at which it was constructed and the absence of surface access would entitle the owner to nominal damages only. This conclusion is consistent with decisions in earlier New York cases concerning the construction of tunnels. In a 1913 case (131), the court held the damage from a tunnel to be constructed approximately 150 feet below the surface to be so slight as to be practically negligible. On another occasion (7), the construction of a tunnel at a depth of nearly 500 feet was described as only a technical damage to property which did not call for the award of more than nominal damages.

Airspace rights: An analagous situation?

Although the exclusive rights of the landowner in overlying airspace, like those in the subsurface, were once considered to be without vertical limit, these rights have been expressly restricted in the interest of public use for aviation purposes. Since the existence of a major public need for the use of airspace has resulted in greater consideration of the boundary between private and public property, it is of interest to consider the nature of the restrictions and whether a close analogy exists between the two areas of law.

When confronted with a conflict between this infinite ownership concept and the public interest, the federal courts have simply renounced the concept. The following statement is from United States v. Causby, one of the landmark cases concerning rights in airspace:

> It is ancient doctrine that at common law ownership of the land extended to the periphery of the universe--Cujus est solum ejus est usque ad coelum [citation omitted]. But that doctrine has no place in the modern world. The air is a public highway, as Congress has declared. Were that not true, every transcontinental flight would subject the operator to countless trespass suits. Common sense revolts at the idea. To recognize such private claims to the airspace would clog these highways, seriously interfere with their control and development in the public interest, and transfer into

private ownership that to which only the public has a just claim (275, pp. 260-61).

The infinite ownership concept had also been considered as follows in the earlier case of Hinman v. Pacific Air Transport:

> If we could accept and literally construe the ad coelum doctrine, it would simplify the solution of this case; however, we reject that doctrine. We think it is not the law, and that it never was the law.
>
> This formula "from the center of the earth to the sky" was invented at some remote time in the past when the use of space above land actual or conceivable was confined to narrow limits, and simply meant that the owner of the land could use the overlying space to such an extent as he was able, and that no one could ever interfere with that use.
>
> This formula was never taken literally, but was a figurative phrase to express the full and complete ownership of land and the right to whatever superjacent airspace was necessary or convenient to the enjoyment of the land (124, p. 757).

Although the court in Hinman renounced the infinite ownership concept, the actual issue in the case was a narrower one. Two landowners located near an airport were seeking awards of damages for past trespasses and injunctions to prevent further invasions of airspace in connection with low elevation overflights. The landowners did not claim exclusive ownership to the sky but maintained that they had exclusive rights to such airspace as could reasonably be expected to be put to use, in this case to an altitude of not less than 150 feet above the land surface.

In the following statement, the court denies the contention that airspace can be reserved on the basis of its reasonable susceptibility to future use:

> We believe, and hold, that appellants' premise is unsound. The question presented is applied to a new status and little aid can be found in actual precedent. The solution is found in the application of elementary legal principles. The first and foremost of these principles is that the very essence and origin of the legal right of property is dominion over it. Property must have been reclaimed from the general mass of the earth, and it must be capable by its nature of exclusive possession. Without possession, no right in it can be maintained.
>
> . . . .
>
> We own so much of the space above the ground as we can occupy or make use of, in connection with the enjoyment of our land. This right is not fixed. It varies with our varying needs and is coextensive with them. The owner of land owns as much of the space above him as he uses, but only so long as he uses it. All that lies beyond belongs to the world.
>
> . . . .
>
> Any use of such air or space by others which is injurious to his land, or which constitutes an actual interference with his possession or his beneficial use thereof, would be a trespass for which he would have remedy. But any claim of the landowner beyond this cannot find a precedent in law, nor support in reason.
>
> It would be, and is, utterly impracticable and would lead to endless confusion, if the law should uphold attempts of landowners to stake out, or assert claims to definite, unused spaces in the air in order to protect some contemplated future use of it (124, p. 758).

The court notes that use of the airspace in question by airplanes cannot result in the creation of an easement by prescription. Thus the relative rights of the parties, in the event the landowners had actually attempted to physically utilize the airspace in question, apparently would have required further determination.

Renunciation of the infinite ownership concept and limitation of the right to reserve space for future use does not, however, mean that no private rights in airspace are recognized. Consideration of the extent of these restricted rights is the principal issue in Causby. This case involved a suit brought by a landowner to recover for a taking of property and for damages resulting from use of the space over the property as a glide path for a nearby airport. The glide path passed over the property at a height of eighty-three feet, and use of the airport by military aircraft substantially interfered with the landowner's habitation of the property and conduct of a poultry business. The following quotation indicates the extent of the landowner's rights as recognized by the Supreme Court:

> We have said that the airspace is a public highway. Yet it is obvious that if the landowner is to have full enjoyment of the land, he must have exclusive control of the immediate reaches of the enveloping atmosphere. Otherwise buildings could not be erected, trees could not be planted, and even fences could not be run. The principle is recognized when the law gives a remedy in case overhanging structures are erected on adjoining land [citation omitted]. The landowner owns at least as much of the space above the ground as he can occupy or use in connection with the land. See Hinman v. Pacific Air Transport [citation omitted]. The fact that he does not occupy it in a physical sense--by the erection of buildings and the like--is not material. As we have said, the flight of airplanes, which skim the surface but do not touch it, is as much an appropriation of the use of the land as a more conventional entry upon it. We would not doubt that, if the United States erected an elevated railway over respondents' land at the precise altitude where its planes now fly, there would be a partial taking, even though none of the supports of the structure rested on the land [citation omitted]. The reason is that there would be an intrusion so immediate and direct as to subtract from the owner's full enjoyment of the property and to limit his exploitation of it. While the owner does not in any physical manner occupy that stratum of airspace or make use of it in the conventional sense, he does use it in somewhat the same sense that space left between

> buildings for the purpose of light and air is used. The super-adjacent airspace at this low altitude is so close to the land that continuous invasions of it affect the use of the surface of the land itself. We think that the landowner, as an incident to his ownership, has a claim to it and that invasions of it are in the same category as invasions of the surface [citation omitted].
>
> . . . .
>
> The airplane is part of the modern environment of life, and the inconveniences which it causes are normally not compensable under the Fifth Amendment. The airspace, apart from the immediate reaches above the land, is part of the public domain. We need not determine at this time what those precise limits are. Flights over private land are not a taking, unless they are so low and so frequent as to be a direct and immediate interference with the enjoyment and use of the land. . . . We need not speculate on that phase of the present case. For the findings of the Court of Claims plainly establish that there was a diminution in value of the property and that the frequent, low-level flights were the direct and immediate cause. We agree with the Court of Claims that a servitude has been imposed upon the land (275, pp. 264, 267).

Thus the property rights issue regarding airspace has been restricted to considerations of actual interference with the use of property. The capacity to exclude others to unlimited heights by means of trespass actions has been abolished as is indicated by the following assessment by the American Law Institute:

> Flight by aircraft in the air space above the land of another is a trespass if, but only if,
>
> (a) it enters into the immediate reaches of the air space next to the land, and
>
> (b) it interferes substantially with the other's use and enjoyment of his land (211, sec. 159).

In attempting to assess whether the restrictions on property rights in airspace have applicability to subsurface property rights, it is interesting to consider the similarity in development of the unlimited ownership concepts which existed in both cases prior to the birth of aviation. It appears that the principal reason for adoption of the infinite concept in both cases was the need to express the landowner's complete dominion over his property and to offer protection from interference with the proprietor's use by others. There was no obvious need to place limitations on the ownership of such space since use in excess of that within the capabilities of the landowner was essentially inconceivable.

As long as use of airspace was limited to erecting structures and the use of subterranean property limited to relatively shallow excavations for such purposes as mineral recovery, maintenance of the exclusive ownership concept was equally valid in both the upward and downward directions. The development of aviation created a need for public use and for a restriction on private rights to airspace not existing in the case of subsurface space. Thus the principal factor supporting a distinction between rights in airspace and those in underground space has been the difference in their susceptibility and significance for public use. There is no question as to the involvement of the public interest in the case of use of airspace for aviation. The public right of interstate transportation, based on the commerce clause of the Constitution, has always been strictly upheld, as evidenced by the extensiveness of governmental controls over navigable waters. In contrast, most of the uses of the underground are largely private in nature. Underground space is in large part occupied by solids and fluids, some of which are potentially exploitable as economic resources by private enterprise. In comparison with airspace therefore, underground space has greater potential for being reduced to the landowner's possession and control.

However, the possibility of subjecting subsurface space to public use without interference with the landowner's use of property exists in certain cases. Subsurface storage of water is one potential example. It does not appear that the typical property owner would be adversely affected by an increase in ground water levels in many situations to a greater extent than in the case where an air lane is established above his property. Of course it is conceivable that recharge could result in unanticipated injury, but it is also possible that an aircraft could crash into his house. In both cases, appropriate rules of law could be employed to obtain compensation for the landowner's losses.

Ownership of aquifer storage space in Virginia

Since large-scale artificial recharge has never been conducted in Virginia, direct consideration has not been given to the issue of ownership of aquifer storage space. However, on at least four occasions the Virginia Supreme Court of Appeals has appeared to give acceptance to the unlimited private ownership concept. Three of the cases involved mineral rights. In Interstate Coal and Iron Co. v. Clintwood Coal and Timber Co., the court noted that the general presumption " . . . is that the owner of the surface owns all beneath and above the surface . . ." (133, p. 598). In Yellow Poplar Lumber Co. v. Thompson's Heirs, the court stated that "[i]t is a general presumption that one who has the possession of the surface has the possession of the subsoil also . . ." (320, p. 362). In Steinman Coal Corp. v. Fleming, it was stated that " . . . possession of the surface is the possession of the coal and minerals under the land" (243, p. 698). The Virginia court in these cases therefore adopted the standard approach utilized where questions concerning the ownership of solid minerals arise.

The fourth case where the infinite ownership theory was applied, Norfolk and Western Railroad Co. v. Carter (172), involved interference with the flow of diffused surface waters. The court made the following statement:

> His right to it [his land] extends beneath the surface to the center of the earth, and above it to the skies. He is entitled to the free and unfettered control of it above, upon, and beneath the surface, and cannot be held liable for any injury which its reasonable use and enjoyment may cause to other lands in interrupting the flow of surface water (172, p. 518).

Application of the infinite ownership concept in this case appears to have been for the sole purpose of expressing the extent of the landowner's rights to exercise dominion over the land surface since neither the subsurface nor airspace was involved.

Since the recognition of mineral rights or rights concerning interference with surface water does not require property rights of infinite vertical extent, adoption of the concept was not necessary to the decision in these four cases, and it therefore may be argued that the court is not bound by this principle in future decisions concerning other aspects of the subsurface ownership issue. The Virginia court has not been called upon to consider the ownership issue in situations more closely related to artificial ground water storage such as oil field injection or underground storage of natural gas. Therefore few indications exist as to what position the court may take if it is required to resolve the question with regard to artificial recharge operations.

Evaluation of private rights as an allocation mechanism for aquifer storage space

Interest in the use of underground space for storage of water and other purposes is currently undergoing expansion, thereby increasing the significance of the institutions for controlling use. Due to the relative newness of recognition of the utility of subsurface space, little consideration has been given to the issue of allocation mechanisms.

The basic question involved in evaluating the effectiveness of private rights is whether this mechanism is the most efficient means of allocating subsurface space to its highest use. With regard to the land surface, exclusive private ownership has been the traditional approach to controlling use. Although the need for certain limitations on property rights has been recognized, the transfer of such rights by the market mechanism has proven to be a relatively efficient institutional arrangement. The question of whether the institution of property rights is equally suitable with regard to allocation of subsurface space requires a comparison of the nature of the surface and subsurface "property" and the uses to which each is susceptible.

Such a comparison indicates the existence of fundamental differences in the two cases. The primary distinction is that the land surface is amenable to a wide range of uses that are compatible with division of space into independent management units while subsurface space is suitable for relatively few uses, many of which are feasible only on a scale encompassing entire physical units such as aquifers and cannot be accomplished on a compartmentalized basis.

Thus the fundamental characteristics of subsurface space raise questions as to the appropriateness of subjecting the resource to a system of fragmented ownership. In fact, recognition of private ownership may have largely negative results. Uses such as storage of water are of a public nature, and the vast majority of individual landowners will not have the capability of applying the space beneath their land to the uses to which it is adaptable. Therefore recognition of private rights is not likely to provide incentive for individual utilization. With regard to use by broader managerial entities, recognition of private rights will serve as a direct obstacle. Due to the large number of individual owners that such recognition would create, transfer of rights to a feasible management unit is likely to involve complex proceedings and high transactions costs as the individual owners attempt to maximize returns. Thus it does not appear that the concept of private property is an efficient mechanism for allocation of aquifer storage space.

Liability for Injury Resulting From Artificial Recharge

In the event that an artificial recharge operation results in injury to the owner of overlying land, the issue of legal accountability arises. The question of responsibility for injury resulting from recharge may arise even if the landowner is held not to have exclusive rights to underlying aquifer storage space and may also arise in the situation where storage is accomplished under a lease arrangement.

The recent California decision of Alameda County Water District v. Niles Sand and Gravel Co., Inc. (5) involved a situation where recharge operations interfered with the use of property for extraction of commercial sand and gravel. The water district's replenishment program raised the water table on the land used for the extraction operation, thereby contributing to flooding of the excavations of the owner. Prior to trial of the case, the mining operator was pumping the water from the quarry and discharging it to surface drainage at a rate of five million gallons per day. Thus the district was involved in replenishing the ground water basin involved while the quarry owner was engaged in draining it.

Each of the two parties initiated legal action against the other. The quarry operator sought damages on the basis that the flooding was a taking of property. The district sought to enjoin the discharge which wasted water from the basin and to recover damages for the loss of water previously wasted. The two actions were consolidated by the trial court, and a judgment was entered which (1) enjoined the quarry operator from discharging water from the excavations without the written consent of the district or further order of the court, (2) reserved court jurisdiction to determine the amount of damages in connection with the previous waste of water, and (3) denied relief to the quarry owner for the alleged taking of his property. The California Court of Appeal upheld this judgment.

With regard to the right of the landowner to pump water in such quantities as necessary for the operation of the quarry, the appeals court upheld application of the correlative rights doctrine which limits the rights of each landowner to a reasonable use in relation to the rights of others. It also upheld the finding that the pumping in question was unreasonable because it operated to the general detriment of the water basin and the restorative program of the district. The fact that the water level was the result of artificial recharge does not appear to have affected rights governing its use.

Two reasons were given by the court in support of the denial of relief to the landowner for the alleged taking of his property. The first was based on the fact that the particular use of the land in question had been authorized by a revocable use permit specifically subject to the condition that the quarry operator "shall cooperate with the Alameda County Water District . . . to the end that water pumped in connection with . . . their . . . operations shall not be wasted to San Francisco Bay nor shall ground water percolation capacity be diminished in quality or quantity" (5, p. 848). Thus judicial imposition of the requirement that further pumping be approved by the district, subject to judicial review of the reasonableness of district action, was not seen as a "taking" of any right actually possessed by the landowner.

The second reason for denial of the landowner's claim of a right to compensation was based on the view that the restriction was a result of the exercise of the district's police powers. After quoting a section of the California Constitution stating that the general welfare of the people of the state requires that water be put to beneficial use and waste or unreasonable use be prevented, the court noted that water conservation is generally recognized as a valid exercise of the police power of the state. The district's activities were viewed in this manner, and the effect on the property of the quarry owner was held not to constitute a compensable taking.

There are several factors relative to this case that limit its value as precedent applicable to other jurisdictions. With regard to the imposition of pumping controls, a basic factor is the applicability of the correlative rights doctrine. In a reasonable use or absolute ownership jurisdiction, limitations would not be imposed on pumping in connection with quarry operations since they constitute a generally-recognized use of land (86). With regard to the lack of compensability for the interference with the use of land, the existence of a land use permit conditioned with respect to water use and a constitutional provision prohibiting the waste of water are key factors. The decision in the case favorable to the water district appears to depend directly on the existence of these two conditions.

Since decisions directly concerning the issue of interference with the use of land from recharge operations do not exist in most jurisdictions, areas of law that may be analogous are of interest. One area where several cases concerning raised ground water levels have arisen consists of construction of surface impoundments. These cases have not considered the right of the landowner to dispose of the ground water involved but have been limited to the issue of accountability for resulting injury.

In an article by Peter N. Davis (65) exploring the extent of legal recognition of the hydrologic connection between surface and ground water, reference is made to sixteen cases involving the situation where surface impoundments raised ground water levels. Eleven of these sixteen cases were decided in favor of the injured landowner, most frequently on the grounds that the raised water level constituted a trespass (65, pp. 216-17). Therefore the majority position where reservoirs increase ground water levels is that liability will be imposed on the reservoir owner whenever other landowners are injured.

Another area in which the liability issue has been considered in connection with injury from use of subsurface space consists of oil field injection practices for disposal and secondary recovery purposes. As noted previously, the traditional rules of trespass have apparently been suspended with regard to non-injurious subsurface invasions; however, liability has been imposed for actual injury resulting from such operations. For example, the operator of a salt water disposal well was held accountable in a 1954 Oklahoma decision (313) for costs that his pressurized injection imposed on another party attempting to abandon and remove the casing from his own well. In a 1963 federal court decision (261) involving secondary recovery, an operator engaged in a large scale injection project authorized by the state regulatory agency was held liable for injury to the producing oil wells of another party.

However, the landowner injured by state-authorized secondary recovery operations may not always have a legal remedy available. The Supreme Court of Texas has indicated that certain private property interests may have to yield to the necessities of the oil and gas industry. In the following statements from the 1962 case of Railroad Commission of Texas v. Manziel, the court explained the extent to which private property rights must be considered by the state oil and gas regulatory agency, the Texas Railroad Commission, and the weight which the court will give to the decisions of the agency:

> The Commission has two primary dutues in the adminis-

> tration and control of our oil and gas industry. It must look to each field as a whole to determine what is necessary to prevent waste while at the same time countering this consideration with a view toward allowing each operator to recover his fair share of the oil in place beneath his land. In carrying out these duties, there has devolved upon the Commission the power to promulgate rules, orders and regulations that control the industry, and such are issued pursuant to the police power of the state, and that power may invade the right of the owner of the land to the oil in place under his land as long as it is based on some justifying occasion, and is not exercised in an unreasonable or arbitrary manner (202, p. 572).
>
> Regardless of the other questions that may appear, as to matters within the discretion of the Railroad Commission, the ultimate decision of this court, as to the validity of the Commission's orders, must turn upon the application of the substantial evidence rule. Of course, we recognize that it is not the province of this court to substitute itself for the Commission in determining the wisdom and advisability of the particular order in question, but the Court will sustain the action of the Commission so long as its conclusions are reasonably supported by substantial evidence. . . . When the orders are supported by evidence establishing that they are necessary in order to prevent waste or to protect correlative rights, <u>the fact that the application of the order has resulted in economic loss to some does not warrant a finding that there has been a deprivation of property without due process of law</u> [emphasis added] (202, p. 265).

The principles developed for resolution of legal conflicts concerning aviation-related interferences with the use of property are also of value as an analogy with respect to the issue of liability for injury caused by utilization of subsurface space in artificial recharge operations. As noted previously, the courts have rejected the concept of private ownership "to the sky" where in conflict with the needs of aviation, but property rights in the lower reaches of airspace have continued to be recognized. In United States v. Causby, the leading case concerning aviation interference with the use of property, the United States Supreme Court stated that "[t]he landowner owns at least as much of the space above the ground as he can occupy or use in connection with the land" (275, p. 264). The Court held that the exclusive property right was not limited to that space physically occupied by structures but also included the adjacent airspace closely related to the enjoyment of the surface itself. Inclusion of space above that occupied by structures was necessitated because of the noise and psychological impact associated with the operation of aircraft. These aspects of aircraft interference with the use of property have little relevance as an analogy with interference from recharge; however, the legal principles for resolution of direct conflict between the needs of aviation and physical utilization of property may be applicable to conflicts between land use and recharge.

An important factor concerning private rights in airspace is the existence of federal aviation controls that proclaim the sovereignty of the United States in navigable airspace and establish the public's right of transit therein (81, sec. 1304). Since "navigable airspace" is defined to include that space needed to insure safety in take-off and landing of aircraft (81, sec. 1301 (26)), the question arises as to whether a private property interest remains in such space. The U.S. Supreme Court in Griggs v. County of Allegheny, Pennsylvania (100) has held that exercise of control over airspace needed for airport approaches requires payment of compensation to the landowner.

Several cases have been decided in the state and lower federal courts concerning the rights of landowners located near airports to maintain or establish potential obstructions such as trees, buildings, or other structures. In many instances, the cases have involved the validity of local ordinances that restrict the height of structures in airport approach zones. The courts have generally held that such ordinances represent an unconstitutional taking of private property without compensation where substantial interference with use exists. Similarly, suits by airports against owners of obstructions have usually been unsuccessful (6).

Although the right of the landowner to make full utilization of property has generally been upheld with respect to both existing uses and those initiated after establishment of a nearby airport, there is some precedent for the position that future uses will be restricted. An example is given by Shipp v. Louisville and Jefferson County Air Board (230), a 1968 Kentucky case involving the right of a landowner to maintain trees on his property near an airport. The trees in question interfered with rays emitted by special landing equipment, but the Kentucky

Court of Appeals held that the right to maintain the trees could be taken only by condemnation since the trees had exceeded the elevation objected to prior to use of the equipment and the adoption of applicable rules and regulations. However, the court stated that "[a]fter the adoption of the rules and regulations . . . , no property owner in the path of the rays . . . may erect or allow to grow any structure or tree so as to interfere with the operation of such equipment" (230, p. 870). This decision therefore places a considerable burden on future uses of the affected property.

In summarizing the prospects of the landowner to recover for injury or interference with the use of property resulting from artificial recharge operations, there is considerable precedent in analogous areas of law to the effect that legal accountability will be imposed where substantial injury or interference occurs. The case of <u>Alameda County Water District</u>, one of the few decisions directly concerning this issue, holds to the contrary, but as noted previously, the special conditions involved in this case limit its value as precedent. The cases involving salt water injection, water level increases from reservoir construction, and cases involving use of airspace all indicate that the right to make all uses will be recognized and can be taken only through exercise of eminent domain condemnation and the payment of compensation.

This situation would appear to apply to all established uses, and there is precedent to the effect that the right to initiate future uses will be upheld. However, the right to recover may be somewhat dependent on the degree of injury and may not extend to slight interferences where an over-riding issue of the public interest is involved. In addition, injury may not be compensable where recharge operations are implemented prior to exercise of the property rights in question. Thus a number of questions remain that cannot be answered prior to consideration by the courts when cases arise from actual conflicts between recharge and specific uses of private property.

Nature of Rights in Artificially Stored Ground Water

The nature of rights in artificially recharged water becomes a significant consideration whenever aquifer conditions are such that withdrawal is physically possible on lands not subject to the control of the party responsible for the storage operation. As in many other areas of ground water law, the only cases that have directly considered this issue arose in the West.

One such case is the previously discussed Alameda County Water District case. One of the principal issues in the case was the right of the landowner to pump ground water for the purpose of dewatering the excavations involved. The court prohibited pumping at the rate necessary for dewatering through application of the correlative rights doctrine. Rights in the artificially recharged water were therefore defined by the same principles applicable to naturally-occurring ground water. Application of basic ground water law in Virginia or other jurisdictions where either the absolute ownership or reasonable use doctrine is in effect would essentially result in the absence of constraints with respect to on-site use of water stored underground since these doctrines place few restrictions on such use of ground water in general.

Another California decision concerning rights in recharged water is City of Los Angeles v. City of Glendale (48). The water in question was being imported by Los Angeles from distant watersheds into the San Fernando Valley where it was recharged by spreading and by sale to irrigators located such that seepage joined the spread waters. The court held that Los Angeles retained exclusive rights in the imported water since it was released to the subsurface with the intent of subsequent recapture. In upholding the city's exclusive rights, the court compared the use of subsurface reservoirs for water storage and distribution to the similar use of natural surface drainage systems.

> Early in the history of the state, this court recognized the advantage of permitting the use of natural surface facilities, stream beds, dry canyons and the like, for the transportation of water . . . for "It would be a harsh rule . . . to require those engaged

> in these enterprises to construct an actual ditch along the whole route through which the waters were carried, and to refuse them the economy that nature occasionally afforded in the shape of a dry ravine, gulch, or canyon." . . . It would be as harsh to compel plaintiff [Los Angeles] to build reservoirs when natural ones were available as to compel the construction of an artificial ditch beside a stream bed (48, p. 294).

Thus the California court relied on the well-established precedent existing in the western states that exclusive rights can be maintained in water that is added to a natural stream for purposes of transportation. The issue of whether exclusive rights can be maintained in water released to a natural stream has been given very little consideration in the eastern United States. One of the few eastern decisions relevant to this issue is the early Illinois case of Druley v. Adam (69), which holds that water released into a stream has been legally abandoned and is subject to use by the downstream riparian landowners. This decision serves as adverse precedent with regard to the maintenance of exclusive rights. The eastern courts therefore do not have available the surface water analogy applied in City of Los Angeles to support the position that exclusive rights could be maintained in water artificially stored underground. In the absence of direct precedent and closely analogous law, it is difficult to predict the position which will be adopted with regard to the issue of rights in water stored underground.

GOVERNMENTAL MANAGEMENT OF THE GROUND WATER RESOURCE IN VIRGINIA

Due to the problems of scale associated with certain aspects of ground water management and the shortcomings of private constraints with respect to a variety of externalities affecting the public interest in the resource, direct involvement of all levels of government is a fundamental aspect of management. State government has traditionally been viewed as the focus of managerial activity with respect to public resources such as water, but authority delegated to lower units of government and that surrendered to higher levels by means of interstate agreements and the United States Constitution has a significant impact on ground water management.

With regard to the division of management responsibilities between the state and its political subdivisions, there is considerable diversity among the states. Although there is always some division of authority, management is primarily a local responsibility in certain cases while predominantly a state function in others. There is also some variability among the states regarding the extent to which management authority is vested in interstate bodies, but the division of authority between the individual state and the federal government is more constant due to the uniform application of federal law. The principal variation in this area arises in connection with federally reserved water rights associated with the public domain. Since most of the land in the western states has been subject to federal ownership, the reserved rights issue is a significant management consideration in these jurisdictions, but this issue has not been a factor in water resources management in Virginia.

The State Management Program

The Commonwealth's ground water management program encompasses a number of regulatory and other governmental activities. The various aspects of managerial involvement were not initiated as parts of a comprehensive management program but have been somewhat independently developed over a considerable period of time. As a result, the various program elements are not administered by a single management entity but cut across jurisdictional boundaries to some extent. For purposes of analysis, the state program can be divided into the areas of ground water policy, allocation controls, protection of quality, and non-regulatory managerial activities.

Ground Water Policy

Virginia water policy is expressed through constitutional provisions, legislative enactments, and administrative declarations. The Constitution of Virginia does not specifically make reference to ground water but contains the following statement concerning water and natural resources in general:

> To the end that the people have clean air, pure water, and the use and enjoyment for recreation of adequate public lands, waters, and other natural resources, it shall be the policy of the Commonwealth to conserve, develop, and utilize its natural resources, its public lands, and its historical sites and buildings. Further, it shall be the Commonwealth's policy to protect its atmosphere, lands, and waters from pollution, impairment, or destruction, for the benefit, enjoyment, and general welfare of the people of the Commonwealth (61, Art. X, sec. 1).

The Constitution provides that the General Assembly, in furtherance of this policy, may undertake ". . . the protection of its atmosphere, lands, and waters from pollution, impairment, or destruction, by agencies of the Commonwealth or by the creation of public authorities . . ." (61, Art. X, sec. 2). It therefore appears that enactment of state laws and establishment of administrative programs reasonably intended to protect and conserve the ground water resource is a valid constitutional function of the General Assembly.

Legislative statements of water resource policy appear at several locations in Virginia law. A number of policy provisions such as those pertaining to hydroelectric power and scenic rivers relate exclusively to surface waters, but provisions applicable to ground water also appear. Two general statements of water policy exist in legislative form. The earliest provision applies to ". . . all waters, on the surface and under the ground . . ." (296, sec. 62.1-10(a)) and declares that state waters are ". . . a natural resource which should be regulated by the State" (296, sec. 62.1-11(a)). The basic thrust of this policy statement is that control over water resources is a proper exercise of the police powers of the state. The policy provides that water use should be limited to beneficial purposes and that waste or unreasonable use should be prohibited. However, it is stated that these provisions shall not be ". . . construed as applying to the determination of rights in any proceeding now pending or hereafter instituted" (296, sec. 62.1-12). This qualification appears to severely limit the usefulness of the stated policy. If policy does not apply to the determination of rights to use water, it is unlikely that it will be a significant factor in management.

A second general policy provision in Virginia law authorizes the SWCB to formulate a statement of water policy consistent with the following statutory guidelines:

> (1) Existing water rights are to be protected and preserved subject to the principle that all of the State waters belong to the public for use by the people for beneficial purposes without waste;
> (2) Adequate and safe supplies should be preserved and protected for human consumption, while conserving maximum supplies for other beneficial uses. When proposed uses of water are in mutually exclusive conflict or when available supplies of water are insufficient for all who desire to use them, preference shall be given to human consumption purposes over all other

uses;

(3) It is in the public interest that integration and coordination of uses of water and augmentation of existing supplies for all beneficial purposes be achieved for the maximum economic development thereof for the benefit of the State as a whole;

(4) In considering the benefits to be derived from drainage, consideration shall also be given to possible harmful effects upon ground water supplies and protection of wildlife;

(5) The maintenance of stream flows sufficient to support aquatic life and to minimize pollution shall be fostered and encouraged;

(6) Watershed development policies shall be favored, whenever possible, for the preservation of balanced multiple uses, and project construction and planning with those ends in view shall be encouraged;

(7) Due regard shall be given in the planning and development of water recreation facilities to safeguard against pollution (298, sec. 62.1-44.36).

The first guideline quoted above goes beyond recognition of the state's right to regulate water use and declares that all "state waters" belong to the public. The term "state waters" is not defined in this particular statutory enactment. Although the principal emphasis of the policy guidelines is directed toward surface waters, ground water is also encompassed to some extent as indicated by the provision concerning evaluation of drainage projects.

Pursuant to this legislative mandate, the SWCB has developed a comprehensive statement of policy (58) that encompasses both surface and ground water. Policy concepts applicable to ground water management include guidelines for controlling withdrawal, protection of recharge, and protection of quality.

Policy with regard to withdrawals sets general limitations and provides criteria for evaluating specific withdrawal proposals. Limitations on withdrawals expressed in the following quotation indicate concern for salt water intrusion and withdrawal in excess of recharge:

> Total withdrawals from coastal zone aquifers should be limited to such a quantity as to prevent the intrusion of salinity beyond the limit determined acceptable for the beneficial uses of the aquifer.
>
> Total withdrawals from a specific aquifer shall not exceed estimated recharge except for short (one or two year) periods of time: the divergence should not be so great as to affect unreasonably legal rights to withdrawal or to affect the capability of the aquifer to be recharged fully in the future (58, secs. 3.1-2, -3).

The prohibition against long-term withdrawal in excess of recharge is an endorsement of the sustained-yield concept and constitutes rejection of ground water mining.

Criteria for evaluating individual withdrawals are as follows:

> The relationships between groundwater and surface water in the area.
>
> Information relating to the planned use of the groundwater, considering use for domestic drinking water as of greatest importance.
>
> The economic effects involved in both the withdrawal and non-withdrawal of groundwater in the area and the State.
>
> The urgency of the need for groundwater in a given area (58, secs. 3.5-7.1 to -7.1).

Policy adopted by the Board contains the following provisions designed to protect ground water recharge:

> Community, natural resource and transportation development should proceed in such a way that the adverse effect on runoff (rates, quality and quantity) and groundwater recharge are minimized and that remedial

> structures (such as spreading basins and flow retarding structures) are incorporated as permanent features of developments and that adequate financial and legal provisions are made for the maintenance of such structures.
>
> . . . .
>
> Agricultural and urban channelization projects in natural water courses should be limited in size to that essential for the protection of property and should be developed and/or constructed in such a way that fish and wildlife and aesthetic values are protected, that erosion and flood hazards are not increased, and that groundwater is not adversely affected (58, secs. 3.1-1, -3).

Policy also indicates a positive philosophy with regard to artificial recharge.

> Sub-surface storage and groundwater recharge should be encouraged subject to the provisions that such practices do not cause pollution of underground water resources (58, sec. 3.5-5).

A number of policy provisions reflect concern for protection of ground water quality. For example, previously quoted passages regarding salt water intrusion and artificial recharge indicate that water quality is a primary policy consideration. One of the most direct provisions for protection of ground water quality concerns subsurface injection of liquid wastes.

> The discharge of pollutants into deep groundwater aquifers shall be contrary to Board policy except that brine derived from aquifers may be returned to these aquifers and chemicals and water may be used in connection with the exploration for and development of water, brines, oil and natural gas to the extent that such uses do not result in pollution of groundwater (58, sec. 3.4-5).

Consideration of these provisions indicates that the statement of water resource policy adopted by the SWCB has considerable applicability to ground water. These policy provisions are broad in scope and in some cases exceed the implementation capabilities of the state. Since the scope of state controls for ground water protection and use are discussed in a later subsection, only one example will be considered at this point. With regard to the policy provisions concerning withdrawals, state-wide implementation is not possible due to the absence of state regulatory authority over withdrawals outside officially-designated critical ground water areas. Thus the SWCB's statement of policy represents a combination of legally enforceable requirements and statements of general goals which at present cannot be directly implemented as controls.

The most recent statement of ground water policy appears in the Groundwater Act of 1973 where the following language appears:

> It is the policy of the Commonwealth of Virginia and the purpose of this law to recognize and declare that the right to reasonable control of all groundwater resources within this State belongs to the public and that in order to conserve, protect and beneficially utilize the groundwater of this State and to ensure the preservation of the public welfare, safety and health, it is essential that provision be made for control of groundwater resources (109, sec. 62.1-44.84).

The part of this statement which declares that the right to <u>control</u> ground water belongs to the public provides an interesting contrast with an earlier statutory declaration quoted previously to the effect that state waters belong to the public. One factor which may explain this inconsistency is that the principal focus of the earlier statement was surface water. It appears that private rights are given a somewhat higher degree of recognition in the case of ground water, possibly a remaining influence of the absolute ownership doctrine of ground water rights.

Allocation Controls

With the enactment of the Groundwater Act of 1973, the Virginia General Assembly established a state system of ground water allocation by providing controls over withdrawal. However, one of the first features of the Act to be noted is that the regulatory provisions for withdrawal are not statewide in application but are intended to be restricted geographically to those areas having identified ground water management problems.

Implementation of controls over withdrawal in a particular area requires that it first be designated as a "critical ground water area" by the SWCB according to procedures established by the Act.

Designation of critical ground water areas

Proceedings to designate a critical ground water area may be initiated by the SWCB upon its own motion or, within its discretion, upon the petition of a political subdivision whenever it believes any of the following conditions to exist:

> (1) Groundwater levels (elevations relative to mean sea level of water table or of artesian water head) in the area in question are declining or have declined excessively; or
> (2) The wells of two or more groundwater users within the area in question interfere substantially with one another; or
> (3) The available groundwater supply in the area in question is being or is about to be overdrawn; or
> (4) The groundwater in the area in question has been or reasonably may be expected to become polluted (109, sec. 62.1-44.95(a)).

Although the SWCB exercises considerable discretionary authority with respect to critical area designation, this discretion is subject to certain constraints. One fundamental restriction consists of the requirement that a public hearing be held with regard to the question of establishing any proposed critical area. After the required hearing is held, the agency is under legislative mandate to designate the area as a critical ground water area only if it finds any of the four above-listed conditions for initiation of the proceedings to be true <u>and</u> if it finds the public welfare, health, and safety to require adoption of corrective controls (109, sec. 62.1-44.96(a)). If these requirements are met, the SWCB has the authority to determine the boundaries of the critical area and officially designate it for implementation of the state control program, even if some of the political subdivisions encompassed in the area are opposed to such designation. Thus creation of management districts under the Groundwater Act is directly subject to state control although the program is regional in application and is constrained by procedural requirements providing the opportunity for local input into the proceedings for designation.

Effective February 26, 1975, an area in the southeastern corner of the state became Virginia's first critical ground water area (182). The designated area encompasses the section of the coastal plain lying south of the James River and includes the major portion of the extensive cone of depression centered at the City of Franklin which has been described earlier. In terms of political subdivisions, the area encompasses the counties of Isle of Wight, Prince George, Southhampton, Surry, Sussex and the cities of Chesapeake, Franklin, Hopewell, Norfolk, Portsmouth, Suffolk, and Virginia Beach.

The record of the required public hearing (130) held on September 3, 1974, with regard to the critical area designation indicates lack of agreement among the political subdivisions involved concerning the desirability of the designation. The counties in the western portion of the area were generally in favor of the designation while the cities in the eastern portion requested exclusion, primarily on the basis of a lack of evidence of ground water problems in the eastern portion. The principal concern appears to be that implementation of controls will hinder location of new industry in the area (215). However, these cities were included within the boundaries of the designation due to the fact that the entire area constitutes a single hydrogeologic unit, making its division impractical from a physical management viewpoint.

Other areas under consideration for critical area designation include the Eastern Shore and other sections of the Coastal Plain to the north of the existing critical area. Studies are underway to determine the magnitude of existing and potential problems and the need for application of controls. It should be noted that the feasibility of the critical area program is largely limited to the Coastal Plain. The controls established by the Groundwater Act are primarily applicable to large withdrawals from geographically extensive aquifers, conditions that are essentially limited to this physiographic province.

Controls on withdrawals in critical areas

The principal control of the Groundwater Act with respect to withdrawal is the requirement that certain ground water uses within critical areas cannot be initiated without a permit from the SWCB. Before considering specific permit requirements, it is of interest to note the special provisions for existing uses and the exemptions provided by the Act.

Requirements for existing uses

One special category of withdrawals exempted from the permit requirement includes those in existence on the date an area is declared critical or on any date within two years prior to designation. This exclusion also applies to any proposed use where the party involved is engaged in the construction or alteration of a well at the time of designation. The Act provides recognition of such rights to the prior extent of their application to beneficial use. Although existing rights are preserved by the Act, specific recognition is given to the fact that such rights are subject to future control by the General Assembly if it determines that the continued unrestricted use will ". . . contribute to pollution or shortage of groundwater thereby jeopardizing the public health, safety or welfare" (109, sec. 62.1-44.93(c)).

The Act requires that all persons claiming rights on the basis of existing use must file with the Board a registration statement concerning the use within six months after designation, and the Board must issue to the registrant a certificate of ground water right upon receipt of the registration statement. Failure to comply with the registration requirement leads to a presumption that the claim to the right has been abandoned, a presumption which is subject to rebuttal at a hearing that can be requested within a one year period (109, sec. 62.1-44.99(e)).

One aspect of the "grandfather clause" which requires interpretation due to the absence of statutory guidelines concerns the means of measuring the pumpage rights encompassed. The method of measuring such rights can have a substantial effect on the level of pumping recognized. For example, the difference between the maximum daily pumpage and average daily pumpage based on a time period such as the month or year is very large in some cases due to fluctuations in use rates. It would be expected that ground water users claiming rights under the grandfather clause would base such claims on maximum rates. Some members of the SWCB in considering the first registration statements from the recently designated critical area have expressed concern over this practice, but official agency action has given acceptance to this approach in certain cases. For example, Norfolk's registration for 15,000,000 gallons per day was approved although this amount has been pumped only rarely, creating a much lower average use rate (241, pp. 25-34).

Another somewhat unclarified aspect of the grandfather clause concerns the extent of the restriction on existing uses imposed by the requirement of beneficial use. Although the requirement is a potential constraint on existing pumping, the term "beneficial use" is not defined in the Act. In a separate legislative statement of water policy, "beneficial use" is defined to mean ". . . domestic, agricultural, recreational and commercial and industrial uses" (296, sec. 62.1-10(b)). Under a more restrictive view, "beneficial" could also relate to the method of using water for a particular purpose and therefore conceivably could be used to prohibit inefficient and wasteful practices, but the Act provides no guidance as to this possible interpretation.

The question as to whether the SWCB can impose conditions on existing users through the beneficial use requirement received some preliminary consideration during a hearing at which the first registration statements were acted upon. The issue raised was whether the use of cooling towers and the recycling of cooling water could be required as an alternative to once-through use of ground water for cooling. The following exchange between a SWCB member (Brion) and the Assistant Attorney General of Virginia (Ryan) indicates a negative resolution of the question concerning restrictions based on the beneficial use requirement:

> Mr. Brion: I guess I am going further in saying without trying to talk in curcular manner that just because water is pumped and put to productive use, if at the same time we are aware of the existing state of the art technology that could be used to reduce the quantity of that use, we could, therefore, say that that is not necessarily beneficial use if there are alternatives that are reasonable in the circumstances.
>
> Mr. Ryan: That is getting pretty far afield, I think, Mr. Brion. I cannot accept that constructure

> of the statute. I think the situation we have here, Hercules is pumping the water out of the ground and is using it to cool certain unit processes in its plant, and I think it would be difficult to say that is not beneficial use as contemplated by the Legislature. I think, moreover, once the application is timely made, I think you have a ministerial duty to issue the registration statement for grandfather certificate (241, p. 23).

Exemptions from the permit requirement

Another group of special uses will remain exempt from the permit requirement even if not covered by the "grandfather" clause. Special types of uses that are exempt include ". . . the use or supplying of groundwater for agricultural and livestock watering purposes, for human consumption or domestic purposes, or for any single industrial or commercial purpose in an amount not exceeding fifty thousand gallons a day" (109, sec. 62.1-44.87).

The Act does not make specific reference to municipal or public water supply use, giving rise to the question of whether such uses are to be included within the domestic classification and therefore exempt from the permit requirement. The SWCB staff has determined that public water supplies do not come within the domestic exemption and will require permits for such uses (248, p. 7). There was an attempt to amend the Groundwater Act during the 1975 session of the General Assembly to provide a specific exemption for municipalities (116), but the proposed change was not enacted into law.

Requirements for new uses

Any person desiring to establish a new use or enlarge an existing use within a critical ground water area for a purpose not coming within the list of exemptions must first apply to the SWCB for an authorizing permit. The agency may grant a permit for a new or enlarged use as requested, but it is authorized to impose conditions and limitations in the permit, approve the permit for less water than requested, or reject the application. The basic legislative criteria to guide the SWCB's decisions with regard to a new or enlarged use are that such uses are to be limited by the requirement of beneficial use and that undue interference with existing wells is not to be allowed (109, sec. 62.1-44.100(d)). The definition of what constitutes "undue interference" is a matter subject to interpretation. The SWCB staff has adopted an operating rule that some further artesian water level reductions will be allowed but that reductions will be restricted such that dewatering of the principal aquifers does not occur. Actual reductions will be limited to the top of a buffer zone established to provide a margin of safety for the aquifers themselves (248, p. 22). Thus the amount of allowable reduction will vary with location in the critical area, with the most restrictive conditions existing at Franklin where the maximum reductions exist currently.

The basic philosophy of the permit program is the regulation of future ground water uses in order to protect existing uses, making priority in time a central factor in the definition of private rights. The Act provides that "[n]o application shall be approved when the same will deprive those having prior rights of beneficial use of the amount of groundwater to which they are lawfully entitled" (109, sec. 62.1-44.100(e)). This provision expresses the basic concept of the doctrine of prior appropriation which has not seen previous utilization in Virginia. Provisions for registration of existing uses and permitting of new uses place considerable emphasis on priority in time. With regard to registration of existing uses, the Act requires a recording of the date of return of registration statements (109, sec. 62.1-44.99(f)). Dates are also to be recorded for receipt of permit applications for new uses, and it is provided that "[a] right to use groundwater under a permit shall have a priority from the date on which the application was filed with the Board" (109, sec. 62.1-44.100(j)). The Act does not specify what weight is to be given to such priorities in making permit determinations where conflicting uses are proposed, but it appears that the time of filing is to be considered as a factor.

The concept of priorities and protection of water uses first established is a radical departure from the system of rights existing previously. The right to pump water traditionally existed as an incident of landowner-ship, and the right could be exercised after any period of non-use. Thus the requirements of the critical ground water area program represent a substantial alteration of previously existing property rights.

Administration of critical area controls

Operations of the permit program, like designation of critical areas, is a state responsibility, but the law contains provisions for local input. Procedural requirements for disposition of permit applications by the SWCB include sending a copy of each application to the local governing bodies in the critical area and to each local governing body having ground water rights in the area. The SWCB is also required to give public notice of each application and the time and place of the meeting where it will be considered. The Act authorizes governing bodies receiving copies of such applications to comment to the Board, and any person possessing a ground water right in the critical area may file a protest against the issuance of the requested permit. The SWCB may in its discretion hold a public hearing in connection with a proposed use (109, sec. 62.1-44.100).

Provision is also made for use of advisory committees and voluntary agreements among ground water users within critical areas. The SWCB may establish an advisory committee within any critical area to provide advice on the implementation of plans and procedures for ground water control (109, sec. 62.1-44.98). The Groundwater Act also provides for approval of voluntary agreements among ground water users to function in lieu of formal orders or regulations when such an agreement is consistent with the intent and purposes of the Act (109, sec. 62.1-44.91).

The Groundwater Act provides that the SWCB, after a public hearing, may cancel a permit or certificate of ground water right if it finds that the holder has willfully violated its terms or the provisions of law (109, sec. 62.1-44.102). However, it does not make provision for permit expiration after a specified term, giving rise to the presumption that rights are granted in perpetuity. Neither does the Act provide for periodic review and possible modification of permits to reflect changed conditions after issuance.

An alternative mechanism for transferring water rights to more beneficial uses consists of market transactions. A basic characteristic of the appropriative doctrine, after which the Virginia allocation system is modeled, is that water rights are transferable as a market commodity. However, no provision for transfer of rights between water users is included in the Groundwater Act. Thus the assumption arises that such rights are not transferable.

Political subdivisions and other parties adversely affected by a decision of the SWCB in the administration of the Act have the right of judicial review. The first appeal is to the circuit court of the county or city in which the well in question is located, with provision for appeal to the Supreme Court of Appeals. The circuit court may modify or reverse the decision or remand the case for further consideration under the following conditions:

> (1) If the order or decision of the Board will not adequately achieve the policy and standards of this chapter or will not reasonably accomodate any guidelines which may have been promulgated by the Board; or
> (2) If the substantial rights of the appellant have been prejudiced because the findings, conclusions or decisions are:
> (a) In violation of constitutional provisions; or
> (b) In excess of statutory authority of jurisdiction of the Board; or
> (c) Made upon unlawful procedure; or
> (d) Affected by other error of laws; or
> (e) Unsupported by the evidence on the record considered as a whole; or
> (f) Arbitrary, capricious, or an abuse of discretion (109, sec. 62.1-44.106(13)(b)).

<u>Constitutionality of Virginia's allocation system</u>

The constitutionality of the Virginia Groundwater Act of 1973 has not been challenged in the courts, but the Act represents a substantial modification of previously existing water rights, making its validity potentially subject to question on the grounds that it constitutes an unconstitutional taking of private property without compensation.

The provisions of the Act suggest three possible constitutional issues. The first concerns the impact of the beneficial use requirement on existing users. As noted previously, this requirement may not be used to regulate existing use, thereby reducing the likelihood of a legal challenge. However, the question of whether existing use can be restricted by means of this approach is a fundamental management consideration. A second potential issue concerns the validity of the restrictions placed on future uses, particularly with regard to the possible prohibition of such use where in conflict with existing use. A third possible issue is the validity of the critical area approach itself since it results in unequal treatment of ground water users across the state.

Can existing rights
be restricted to
beneficial use?

Considerable precedent exists to the effect that imposition of reasonable restrictions of vested water rights in the interest of the public welfare is a valid exercise of the police power and not an unconstitutional taking of property. Basic precedent for state imposition of conservation measures to prevent waste of privately owned natural resources exists in the form of an early United States Supreme Court decision, Ohio Oil Co. v. Indiana (176), which upheld the right of a state to regulate the production of oil and gas. The constitutionality of statutory measures for prevention of ground water waste has been upheld by certain state courts. For example, the validity of statutes prohibiting the waste of artesian water was upheld by the California Court of Appeals in Ex Parte Elam (77) and by the New Mexico Supreme Court in Eccles v. Ditto (72). Contentions that the statutes in question deprive owners of artesian wells of property without due process were specifically rejected.

State legislation restricting existing riparian rights to beneficial use has also been upheld. In Gin S. Chow v. City of Santa Barbara (97), the California Supreme Court in commenting on the validity of such restrictions stated that "[t]here is nothing novel about the limitation of the riparian right to a reasonable, beneficial use of water." The federal court in the case of California-Oregon Power Co. v. Beaver Portland Cement Co. stated that ". . . it cannot be doubted that in the course of the development of western water law, previously recognized riparian rights have been subjected to various modifications by legislative and judicial action" (35, p. 564).

The Supreme Court of Wyoming in Farm Investment Co. v. Carpenter expressed the basic rationale for application of controls to previously existing rights in the following statement:

> [T]here exists no difference between claimants whose rights accrued prior to, and those acquiring rights after, the adoption of the constitution and the statute

> in question. . . . It is certainly a mistaken notion that the legislature is powerless to require an owner of a property right, however long that ownership may have subsisted, to submit his claims to a legal tribunal, in an authorized proceeding, upon due and proper notice for determination, as between him and others claiming interests in the same subject-matter. . . . With any jurisdiction to determine the rights of claimants to the use of public waters, the state board of control would be greatly hampered in its supervision if the jurisdiction did not extend to and cover all claims independently of the date of their inception. The supervisory power of the board unquestionably embraces all public waters, as well as all appropriations thereof, and the distribution and diversion of all such waters. The legislative power of regulation must be and is equally as comprehensive (80, pp. 267-68).

Discussion of the constitutionality of state attempts to impose conservation measures on the use of ground water would be incomplete without inclusion of the Wisconsin case of Huber v. Merkel (128). This case held invalid a state law prohibiting waste of artesian water on the grounds that such water was exclusively private and did not involve the public interest. This decision represents the pinnacle in development of the absolute ownership doctrine since the court held that the landowner ". . . had a clear right at common law, resulting from his ownership of land, to sink a well thereon, and use the water therefrom as he chose, or allow it to flow away, regardless of the effect of such use upon his neighbors' wells, and that such right is not affected by malicious intent" (128, p. 357).

An article analyzing Wisconsin ground water law (127) indicates that the validity of the statute held unconstitutional in Huber may have been subject to question because it was apparently aimed at a particular water user, but the opinion of the court goes beyond this interpretation and clearly represents the view that ground water is not subject to state control. However, this position has been generally rejected by other states, and the Huber decision itself was expressly overruled by the Supreme Court of Wisconsin in the 1974 case of State v. Michels Pipeline Construction, Inc. (240).

The underlying concept of Huber that ground water is a private resource and therefore less subject to public control than is surface water is obviously illogical in view of the physical relationships among the various phases of the hydrologic cycle, but this concept has not been totally disregarded. In Virginia, for example, it has been noted that a policy statement specifically applicable to ground water expresses the state's right of reasonable control while a more general statement of policy focusing primarily on surface water indicates public ownership of water. This variation is apparently based on a distinction in the nature of the property interests in the two water sources arising from the traditional common law treatment.

Although the private ownership concept persists as a factor in considerations of the constitutionality of controls over ground water production, it should be emphasized again that ground water in its natural state never in the real sense has been subject to exclusive private ownership. Although the so-called absolute ownership doctrine declares such ownership, the interest of the individual landowner in water underlying his property is not protected since the water can be legally withdrawn by other landowners. It is therefore likely that the average party applying ground water to a particular use under a system of state control, although subject to certain constraints, has a more secure and enforceable property interest than the party subject to no controls under the absolute ownership doctrine.

Recognition of this basic misconception with respect to the nature of the property interest under the absolute ownership concept appears to be one approach through which the claim of private ownership as a bar to imposition of conservation measures can be overcome. This approach appears to have been relied upon to some extent by the Supreme Court of Kansas in the case of Williams v. City of Wichita (318) where it upheld the constitutionality of legislation subjecting ground water to the doctrine of appropriation. The court acknowledged previous acceptance of the absolute ownership rule but noted the absence of a legally protected interest under the doctrine. In stating that the right of the landowner is simply one of use and not ownership, the court referred to the effect of the absolute ownership doctrine as ". . . little more than legal fiction" (318, p. 594).

Can proposed use be prohibited?

A basic effect of critical area designation is to abolish ground water rights in connection with non-exempted uses not being exercised at the time of designation. The landowner who desires to initiate such a use in a previously-designated critical area may apply for state authorization, but the request can be denied. Thus the Act clearly gives the SWCB the authority to prohibit new uses in specific situations. Since the landowner possesses a definite right under either of the common law doctrines to initiate a water use at any time, the question arises as to whether an unused water right is a vested right protected from abolishment under the Constitution by virture of its traditional recognition in the common law.

The 1929 Hawaii case of City Mill Co. v. Honolulu Sewer and Water Commission (47) is of interest with regard to the issue of the prohibition of proposed uses. An act passed by the legislature of the Territory had prohibited the drilling of new artesian wells except by permit of the Commission, and the application of the milling company for such a permit had been rejected on the grounds that the artesian basin involved was being overdrawn and because of danger of salt water intrusion. The Supreme Court of Hawaii indicated acceptance of the correlative rights doctrine, under which all landowners were viewed as possessing certain rights to use ground water. Thus the court set aside the order of the Commission and invalidated the statute authorizing the prohibition.

> However broad and far-reaching the police power may be, it cannot, we think, be deemed to justify, under the showing made in this case, the prohibition of the appellant's proposed well while at the same time permitting all existing wells to continue to be operated without diminution. . . . The remedy for any threatened increase of salinity is by a lessening of the use already being had and not by wholly preventing the appellant from having his reasonable share of the water. . . . All that need be now said is that it would be abhorrent to a sense of justice and violative of the appellant's rights as a co-owner of the waters in the artesian basin to prevent him from using any of the waters of that basin while at the same time to permit an unrestrained use of the same waters by others of his co-owners.
>
> In our opinion . . . [the enabling legislation], in so far as it seeks to authorize the Honolulu sewer and water commission to wholly deprive any co-owner of the waters of the basin under consideration, without due compensation, of his right to share in the artesian waters of that basin, violates the provisions of the Constitution and is invalid (47, pp. 946-47).

One significant factor in the City Mill Co. case was the apparent absence of conclusive proof as to the necessity of the prohibition of the new use in question. The court noted the absence of a legislative declaration of emergency conditions and the fact that evidence in the case did not so indicate. It was noted that twenty-seven active artesian wells existed in the basin, none of which had been abandoned nor diminished in use due to increases in salinity. Thus the court was obviously unconvinced as to the actual need for the action taken in addition to its opposition based on the common right of each landowner to use ground water under the correlative rights doctrine.

However, the position taken in City Mill Co. that unused rights cannot be abolished through state action appears to represent a minority position, and a number of court decisions exist which hold such abolishment to be a valid exercise of the police power. Most of the court cases in this area have arisen in the western states in connection with the transformation from the riparian to the appropriative doctrine. Standard procedure employed in the conversion process includes the limitation of vested rights to those being exercised as of a certain date and the declaration that all other water is subject to public control. Since future uses are conditioned on governmental authorization, unused rights as an incidence of land ownership are essentially abolished. In general, the state and federal courts have upheld the right of state legislatures to modify existing doctrines of water rights, including the restriction of the definition of vested rights to exclude those not being exercised. For example the supreme courts of Oregon (132) and Kansas (239) have upheld the validity of contested appropriative statutes which eliminated unused riparian rights. The United States Supreme Court (184, 279) has also indicated that the states may modify existing water rights doctrines.

A case which specifically considers the right of a state to abolish unused ground water rights is the federal decision of Baumann v. Smrha (15), which was subsequently affirmed by the U.S. Supreme Court. Concerning the authority of the State of Kansas to apply the appropriative doctrine to unused water, the court stated:

> Of course, such a modification in the law of the state must recognize valid existing vested rights, but we do not regard a landowner as having a vested right in underground waters underlying his land which he has not appropriated and applied to beneficial use.
>
> We hold that the state could properly apply the doctrine of prior appropriation and application to beneficial use to unused and unappropriated waters so long as it recognized and afforded protection to rights which landowners had acquired at the time of the effective date of the Act to appropriate and use water.
>
> . . . .
>
> There is no vested right in the decisions of a court and a change of decision does not deprive one of equal protection of the laws or property without due process of law.
>
> Even though prior decisions of the state court have established a rule of property, a departure therefrom in a subsequent decision does not, without more, constitute a deprivation of property without due process of law under the Fourteenth Amendment.
>
> The Fourteenth Amendment in guaranteeing equal protection of the laws does not assure uniformity of judicial decisions or immunity from judicial error. Likewise, it is well settled that a legislature may change the principle of the common law and abrogate decisions made thereunder when in the opinion of the legislature it is necessary in the public welfare (15, pp. 624-25).

Of course the restriction or prohibition of future water uses to protect users with vested rights is the cornerstone of the appropriative doctrine. Since the concept itself is not subject to question once the doctrine is accepted, the only issue that remains to be resolved in a particular situation is whether there is actual need for the restriction or prohibition. Thus the principal concern of the court in the previously discussed Hawaii case of City Mill Co. with respect to unequal treatment of landowners is not a factor in such proceedings. The actual necessity to restrict ground water production, another issue which troubled the City Mill Co. court, is also generally recognized in the western appropriative states. Thus the restriction or prohibition of future uses in the physical and institutional setting prevailing in much of the West can generally be expected to be upheld as a valid exercise of governmental authority.

An example of the extent to which state action to prohibit new water use has been upheld is given by the 1970 Colorado case of Fundingsland v. Colorado Ground Water Commission (91), a case arising from the denial of a permit to appropriate ground water in a specially designated management area. Since the withdrawal rate from the ground water basin in question exceeded the replenishment rate, the Commission had adopted a regulatory approach which would limit the rate of extraction such that a 40 per cent depletion of available water would be achieved over a 25 year period. Since the registered withdrawal rate from the basin was already in excess of the rate calculated to achieve this planned depletion, the requested permit had been denied. Although the basis for the Commission's denial of the permit would have appeared to have been susceptible to an attack of arbitrariness, particularly in view of the incomplete nature of data available, the Supreme Court of Colorado upheld the permit denial because of the recognition of the need for public control and the absence of a more desirable approach.

In considering the constitutionality of the Virginia attempt to abolish certain unused ground water rights within critical areas and subject future use to potential prohibition, it should be noted that the Virginia approach differs from most of the examples previously considered. One distinction is that the state has not formally declared acceptance of the appropriative doctrine as in the other cases. Certain basic elements of the appropriative doctrine are incorporated into the Groundwater Act of 1973, but explicit references to specific doctrines are absent from the Act. Of course there is no reason to believe that the validity of the exercise of the police power to regulate water use necessarily requires the adoption of appropriation, but this doctrine is most compatible with the concept of restricting future uses to protect existing ones. Another distinction is the fact that unused ground water has not been declared to be subject to public ownership as in the case of most of the previously considered cases. However, the Virginia Constitution declares control of water resources to be in the public interest, and the Groundwater Act may constitute a valid regulatory measure within the scope of the constitutional provision. Thus the validity of state action prohibiting a proposed use may be upheld, but there remains at least some potential for a decision adverse to such state action.

Is the critical area
approach valid?

With regard to the validity of imposing controls only within specially designated management districts, there appears to be little doubt that this approach would be upheld if challenged. Special management districts have seen a variety of applications both for the provision of services and for imposition of governmental regulations. The best established use of the district approach for restricting the exercise of property rights consists of zoning, which has been generally accepted as a valid exercise of the state's police power since upheld by the United States Supreme Court (283) in 1926.

A case which serves as direct precedent in support of the critical areas approach in ground water management is Southwest Engineering Co. v. Ernst (238) a 1935 decision of the Supreme Court of Arizona. The suit was originated by a landowner not allowed to pump ground water because of his location within a special management district who maintained that such restriction was unconstitutional since pumping was unregulated outside such districts. The court answered this challenge as follows:

> To this we think there are two answers. First, discrimination or inequality is not forbidden if based on a reasonable classification. [Citation omitted]. Second, necessity requires, where the health, safety or general welfare of the people of a particular locality or area is imperiled, that the law although universal in nature be limited in its operation by circumstances to the particular area where a different treatment is required (238, p. 770).

Comparative evaluation of Virginia's allocation system

Due to the recent initiation of Virginia's ground water allocation system, there is little basis for an actual post facto analysis, but several potential strengths and weaknesses can be identified concerning the scope and structure of the management program and the specific regulatory measures contained in the Groundwater Act.

In evaluating the scope and structure of the Virginia ground water management program, three issues appear to be of principal concern, including (1) the separation of surface and ground water for purposes of management, (2) reliance on a district approach as opposed to a state-wide approach, and (3) the provision for state as opposed to local control in the program.

In addition to dependence on scope and administrative structure, the effectiveness of the Virginia ground water management program will also depend on the adequacy of the specific regulatory measures encompassed in the program to constrain excessive ground water withdrawal. The principal management problems leading to initiation of direct state controls were a direct result of the absence under previously existing common law allocation system of effective constraints that would promote conservation of ground water by prohibiting pumping at rates in excess of the socially desirable rate. Thus the primary question regarding the effectiveness of the new state permit system is whether the defects of the common law approach have been remedied.

There are three issues that need to be evaulated with regard to the potential of the permit program to effectively regulate pumping. The first concerns the potential impact of the grandfather clause which grants preferential treatment to existing uses. A second item of interest with regard to potential effectiveness concerns the matter of exemptions from the permit requirements. A third area of concern involves the absence of provisions for permit duration and modification. Each of these three issues and the three previously enumerated ones relating to the scope and administrative structure of the program is individually considered in the following sections.

Ground water v. comprehensive water resources management

As the title of the Virginia Groundwater Act implies, the management program established therein encompasses sub-surface water only. In this regard, the legislative controls are similar to the common law controls which they largely supplant in designated critical areas. As noted in the previous analysis of allocation doctrines, legal controls based on property rights have tended to treat ground water independently of that found on the surface at a given point in time. Certain states in addition to Virginia that have developed statutory allocation schemes have perpetuated the separation of surface and ground water while others have adopted a management approach encompassing both sources. In the eastern United States, states that treat surface and ground water independently for purposes of management include Georgia (112), New Jersey (170), and South Carolina (111). Eastern states that utilize the joint management approach include Florida (88), Kentucky (139), Maryland (155), and North Carolina (308). In the western states, both the common and statutory law have shown a greater tendency to recognize the physical relationships between surface and ground water, but management programs for the two sources of water still have not been fully integrated in most cases (50, 65).

Adoption of a management program applicable to one source of water only is generally the result of temporal differences in development of allocation problems with respect to the two sources. The problem-oriented approach often utilized in development of statutory laws tend to produce programs of narrow rather than comprehensive scope. Thus an inherent tendency exists for adoption of separate legislation for surface and ground water.

With respect to the desirability of a separate ground water management program, the somewhat unique characteristics of ground water give some support to this approach. The principal management concern unique to ground water arises from the potential for use to exceed the rate of replenishment. Since water contained in an extensive aquifer under natural conditions generally represents many years of recharge, withdrawals may greatly exceed the capacity of the resource to renew itself on a short-term basis and may permanently reduce renewal capability where subsidence occurs. Due to this potential for use to create long range adverse effects, management must be viewed in a different perspective than in the case of surface water where use during a given period is limited by natural replenishment as augmented by artificial storage.

Although this short term irreversibility of ground water use is a special management consideration which lends support to an independent approach to ground water, other factors must be considered in evaluating the desirability of this approach. One such factor is the continuity of the hydrologic cycle and the interrelatedness of its various elements. This consideration indicates that any institutional arrangement for management which treats different sources of water independently is fundamentally incompatible with the physical nature of the resource. These interrelationships are more pronounced in some areas of the state than others due to variations in geologic conditions. For example, a substantial degree of connection between surface and ground water exists in the Ridge and Valley Physiographic Province due to the presence of extensive solution channels in the underlying limestone. On the other hand, direct interchange between surface water and the principal aquifers in the coastal plain is limited due to the existence of strata of low permeability above these aquifers. Thus the problems of independent management are somewhat mitigated with respect to the southeastern Virginia critical area already established.

Even if the degree of physical interchange is small, however, joint management of surface and ground water appears to represent a more logical approach than does independent consideration. Since the total water supply of an area constitutes the primary management constraint, optimization of total water use regardless of source should be the management goal. There is a basic inconsistency involved in an approach which attempts to achieve the maximum benefit from one "type" of water while neglecting other sources that may serve as an alternate supply.

The SWCB has indicated that it will consider the relationship between surface and ground water in administering the Groundwater Act. This intent is expressed in the SWCB's formulation of state water policy (58) and in implementation provisions for the Act itself (248). This approach will somewhat remedy the deficiencies of the enabling legislation, but the efforts of the agency to conduct joint management will be hindered by lack of direct authority to regulate surface water use.

The district approach v.
state-wide controls

Another basic consideration with respect to the scope of Virginia's ground water allocation system concerns its selective application to particular regions with existing or potential management problems. In contrast to this regional approach which is utilized by a number of other states in addition to Virginia, several states have applied ground water allocation controls on a state-wide basis. In an analysis of western ground water law, Robert E. Clark (50) lists thirteen states as falling within the state-wide category while only two states are described as employing a district approach. In the East, states employing state-wide controls include Florida (88), Kentucky (139), Maryland (155), and South Carolina (111), while the district approach is utilized in Georgia (112), New Jersey (170), and North Carolina (308).

It appears that the states in areas of general water scarcity tend to favor state-wide controls while those with predominately localized problems are somewhat more likely to adopt the special district approach. The application of controls on a regional basis is a logical approach where specialized problem areas exist since it allows concentration of management efforts where the need is greatest and adoption of a laissez-faire attitude elsewhere. Since the Virginia legislation provides for ongoing studies with respect to the need for critical area designation, this approach will allow timely application of controls in areas where management problems develop at a future date.

State control v. local control

Although Virginia's ground water allocation program is based on a regional approach, management responsibility is vested at the state level of government. The SWCB has the authority to initiate on its own motion proceedings to designate critical areas, establishes the boundaries of such areas, makes the final determination regarding designation, and administers the regulatory controls contained in the Groundwater Act. State actions under the Act are subject to legislative constraints and judicial review, but the program represents a centralized approach to management.

The degree of centralization of control is a controversial ground water management issue. Although allocation is somewhat centralized in most states, local control is still exercised in certain cases. The states which best typify the local approach are California and Texas. The State of California exercises direct control over water flowing in known subterrenean streams (38) and the underflow of surface streams (203) but not with respect to that classified as percolating. In Texas, state government exercises no direct authority over ground water allocation. Ground water management is of special concern in both of these states due to intensive utilization in arid areas where recharge is minimal.

In California, voluminous legislation exists with regard to creation of a host of special districts for various aspects of water resources management, but the oldest ground water management entity of a local nature is the Orange County Water District (OCWD), created by special act (36) of the state legislature in 1933. OCWD possesses comprehensive authority (181, sec. 40-2) to manage water resources within its jurisdiction. Since local sources of supply are inadequate, a principal responsibility is the importation of a supplementary supply, some of which is used for ground water recharge.

The authority of OCWD to manage ground water includes control over withdrawal. However, control is not in the form of direct restrictions on pumping but is based on economic incentive and consists of a number of special taxes. The basic constraint on withdrawal is a pump tax which serves the dual function of curtailing excessive production and providing a source of funds to purchase imported water. In addition to the general pump tax, a special levy applies to all non-agricultural pumping. A third allocation levy is called an "equity assessment tax" designed to balance the amount of pumping and the use of water from surface facilities. On the basis of total ground water available for pumping without undesirable effects on the basin, the district determines the percentage of each use that can be pumped without payment of a special assessment. Pumping in excess of this percentage is not prohibited, but the extra assessment of the additional pumping increases the cost of ground water and creates a dis-incentive for such pumping. On the basis of the theory that provision of an assured water supply is a general benefit to the lands in the district, OCWD also is authorized to levy a general ad valorem tax on all such lands (181, secs. 40-18, -27, -27.1, -31.5).

Although the State of California does not administer a ground water allocation program, it is involved in several aspects of ground water management. The most extensive involvement is authorized by the Porter-Dolwig Ground Water Basin Protection Law (42) which declares the existence of a public interest in the correction and prevention of irreparable damage of impairment or ground water basins caused by overdraft, depletion, sea water intrusion, or degraded water quality. State actions authorized under the act include initiation of participation in studies, plans, and design criteria for ground water protection projects and evaluation and provision of technical assistance in connection with local agency projects.

A number of other special purpose statutes related to ground water management also exist. The state becomes involved in adjudications of ground water rights by virtue of legislation (39) allowing the Department of Water Resources to be designated by the courts as a referee and fact-finder. Another statute (37) related to ground water rights provides that a right is not lost because of cessation of use as a result of use of an alternative source. This statute only applies to certain counties and was enacted to encourage use of other water sources and thereby prevent depletion of overdrawn ground water basins. Legislation (41) requires that withdrawals in excess of twenty-five acre-feet in any year be recorded with the state. Another statute (40) authorizes the Department of Water Resources to seek a preliminary injunction to prohibit pumping causing sea water intrustion where rights in the affected area are under adjudication.

The system of local control in effect in California has achieved a substantial degree of stability in ground water management. As indicated by the foregoing summary of legislation, however, local control is supplemented by considerable involvement by the state. In the case of

OCWD, and the other districts to a lesser extent, the state legislature has devoted considerable effort to tailoring legislation to their specific needs, in effect serving as the districts' manager. In addition, complementary institutions have been developed which facilitate operation and contribute to the feasibility of local management districts. A primary example consists of the Metropolitan Water District of Southern California developed pursuant to an act (161) of the state legislature which serves as a water wholesaler in making imported water available. Without this service and the state's extensive investment in water transportation facilities, the local districts' programs of recharge and managerial stability would not be possible.

There appears to be considerable support for maintenance of the California system of local control over ground water allocation, but some interest exists in expanding state control. For example, Ronald B. Robie, Vice Chairman of the California State Water Resources Control Board, in a presentation (214) at a 1973 California ground water conference strongly endorsed establishment of a statutory procedure for allocation of ground water similar to the state-administered surface water allocation program. The following comments indicated the advantages of statutory allocation and recognize the problems of modifying existing law:

> The practical benefits of including ground water within the statutory adjudication process will encourage the orderly determination of both surface and subsurface water rights and will enable the State to identify potential overdrafts before the damage is done.
>
> There has been considerable opposition by local interests to include ground water within the statutory adjudication process. At one point, the suggestion of extending the special exception made for the Scott River to another basin was termed by one prominent Southern California water leader as "the camel's nose under the tent" in giving new power to the State Board.
>
> As long as attempts to rationally deal with management of our resources are treated in such simplistic terms as power struggles between individuals or levels of government the possibility of finding solutions to incredibly difficult problems becomes more elusive.
>
> . . . .
>
> The maximum use of our water resources mandated by the California Constitution is not possible as long as we have a fragmented, incomplete system of allocation of the total water resource using a variety of legal theories coupled with inadequate local institutions to coordinate surface and ground water use (214, p. 148).

With regard to the Texas situation, the state administers a comprehensive program of controls with respect to use of surface water (253), but state involvement in ground water management is minimal. The principal statutory measure of general applicability consists of authorizing legislation (254) for creation of "underground water conservation districts" (UWCDs).

The procedure for creation of these local management districts is complex, making establishment difficult. The process consists of three basic steps. First, the boundaries of an underground water reservoir must be officially designated by the Texas Water Rights Commission (TWRC) (254, sec. 52.023). Second, approval must be obtained from the county governing body where the district involves a single county or from TWRC in other cases. Approval by local governing body or TWRC requires a determination that the district is feasible and that it would be beneficial to land in the district (254, secs. 51.021, .025). Such approval does not, however, constitute final disposition of the district creation process. Final confirmation requires a favorable vote of a majority of the voters who participate in a special election that must be called within a tentatively approved district (254, secs. 51.033, .034). This complicated creation process appears to have impaired the program's utility as a ground water management device. It has been reported that efforts to create districts have not been initiated in many areas of the state with significant conservation problems and that attempts to form districts have often been unsuccessful (235, p. 296).

In addition to the obstacles that the Texas UWCD system poses to overall district formation, the emphasis of the process on local option also detrimentally affects the jurisdictional scope of districts that are created. This problem results from provisions of the enabling legislation (254, secs. 51.035, .036) permitting individual political subdivisions to exclude themselves from a district even though its entire area overlies a designated ground water reservoir. For example, it has been reported that the

High Plains UWCD, described as the most active in the state, was substantially undermined at its confirmation election when several counties voted to exclude themselves (235, p. 297). One county that voted for exclusion is completely surrounded by the district and agricultural use of ground water is probably higher within its boundaries than anywhere else in the state (28, p. 49). Such restrictions on jurisdiction make basin-wide management impossible and reduce the effectiveness of the total program.

The impact of local control is also significant with respect to UWCD operation. The enabling legislation provides a wide array of powers for the districts to exercise, including the regulation of ground water production (254, sec. 52.117). However, none of the districts have utilized this authority to impose production controls but rather have chosen to rely principally on public education as a means of achieving conservation. The following evaluation of the effectiveness of the High Plains UWCD indicates the limitations of this approach:

> The High Plains Underground Water Conservation District has the most extensive management program of the four active districts, but it still falls short of effective conservation. . . . The High Plains District's chief weakness is its failure to institute ground water production controls. Because the ground water conservation problem is caused by excessive production, a conservation program that fails to confront this basic factor can achieve only moderate success. Residents throughout Western Texas are opposed to production controls, partly because they fear that production controls would reduce their economic return below the level required to maintain mortgage payments and

> other operating expenses, and partly because they believe that the use of private property, including ground water, should be free of governmental regulation. Officials of the High Plains District are acutely aware of the attitudes of their electorate. Publicly, they denounce any conservation proposal that even suggests the possibility of production regulation. Whatever their private views, these officials could not keep their jobs if they implemented the district's statutory power to control production (235, p. 298).

Thus the existing UWCD approach does not appear to have the potential to significantly alter the ground water production patterns in Texas. In fact, withdrawals remain relatively free of public control, and the individual pumpers constitute the principal decision-makers concerning water use. However, the freedom to pump at maximum rates cannot be maintained indefinitely. Current pumping rates greatly exceed recharge rates, and exhaustion of the recoverable supplies is the long-term prospect. The rate of ground water depletion is so substantial that a special depletion deduction has been allowed for income tax purposes in certain areas (280).

It appears that considerable reliance is being placed on future importation of supplementary supplies as a solution to the Texas ground water depletion problem. Since the largest water use in many of the areas of overpumping is irrigation, the concept of present maximization or production and development of other supplies for future needs has received support from recent emphasis on food shortages and the need for increased food production (52,

p. 1). However, the existing districts would not likely be able to pay for such supplies, thereby necessitating the need for subsidization by larger units of government. In view of this potential dependence on public assistance, it appears that there is need for a re-evaluation of the present policy which treats ground water management as strictly a local concern.

There are indications that ground water management in Texas may become somewhat more centralized in the future. In a presentation (125) at a 1974 Texas ground water management conference, Texas Lt. Governor William P. Hobby stated that "[w]hile our water needs should be dealt with on a local basis, with state-wide support, the State cannot afford to allow irresponsibility to result in no action at all" (125, p. 13). In accord with this view, a proposed revision of existing UWCD legislation has been drafted which would allow the state to carry out the functions of a UWCD in state-declared critical areas where residents failed to create a district within a specified period of time (125, p. 13). Passage of such legislation may be difficult due to the well-entrenched concept of exclusive local control.

A compromise institutional arrangement falling somewhere between state and local control was presented by the management approach previously existing in the State of South Carolina. The original legislation authorized a special management district approach and provided for state administration after district establishment, but proceedings to delineate such districts could be initiated only upon the request of a county, municipality, or other political subdivision. Due to the absence of a request from a political subdivision to initiate the proceedings, the state agency responsible for administration was unable to apply the provisions of the law to the problem responsible for its enactment during a three year period after its passage (229, p. 725). The provision for local control has subsequently been deleted, and current ground water legislation (111) applies on a state-wide basis. This experience raises questions as to the desirability of subjecting a state management program to local control with respect to initiation of action.

In a general evaluation of the relative merits of state and local control over ground water allocation, certain advantages can be attributed to each system. Factors in support of local control include the relatively small areal extent of many ground water basins, the somewhat unique nature of many ground water problems, and the general attractiveness of self-governance. On the other hand, state control is suggested by the need for broad capabilities in such areas as data collection, planning, and financing. It is possible in some situations that inherent deficiencies of local and regional governing bodies with respect to such management capabilities can be remedied through programs of state assistance, thereby maintaining managerial viability at a level of government below that of the state itself.

However, consideration of the difference in perspectives with which state and local governments view ground water management indicates that some degree of state control is desirable. Ground water must be viewed in relation to a broad spectrum of natural resource and environmental management considerations, and the needs of various localities must be viewed jointly rather than independently. Such considerations are likely to fall outside the interests as well as the capabilities of local units of government.

The differences between state and local perspectives are likely to result in considerable divergence in a variety of decisions concerning use of the resource. One such area of potential divergence consists of the rate of ground water withdrawal. The desirable rate based strictly on local considerations may differ significantly from the rate determined from the state view. For example, maximization of current use may appear desirable from the local view while a lower rate of use to achieve long term economic stability of the area may be desirable from the state perspective. Divergence is also likely with respect to decisions concerning transport of water. Movement of water from areas of abundance to those of scarcity or to more productive uses may produce a net benefit, but the local view in the area of export is generally in opposition since the benefits accrue elsewhere. Thus it appears that the state level of government must exercise control if long-range managerial effectiveness is to be maintained.

In evaluating the potential effectiveness of the structure of the allocation program in effect in Virginia, vesting of management authority in a state agency must be viewed as a positive factor. Although provision is made for local input and the use of local agreements in lieu of state controls under certain conditions, basic management decisions are a state responsibility. This approach recognizes ground water problems as an issue of state wide concern and constitutes a sound institutional structure.

Effect of grandfather clause

The Groundwater Act recognizes the right of existing ground water users to continue such uses to the extent of application to beneficial purposes. As noted previously, the beneficial use requirement which would appear to provide a potential basis for exercising a degree of control over existing use may be interpreted so broadly as to encompass any use of water related to a productive enterprise. If this approach is adopted, state sanction of essentially all existing pumping will be granted automatically upon proof of historical pumping levels, and essentially all regulatory effects of the act with regard to existing users will be eliminated.

This approach reduces the potential effectiveness of the Act since it exempts from control the principal sources of existing ground water problems in a critical area. Current predictions indicate that maintenance of existing pumping levels in the one critical area that has been designated will allow a stabilization of water levels in the near future, but water levels in such critical areas conceivably could continue to decline for substantial periods where large withdrawals were initiated just prior to critical area designation. At the least, failure to consider reductions in existing pumping represents acceptance of the status quo as an appropriate allocation of water among existing users and as a desirable base level for pumping. In the existing critical area, little additional pumping can be accomodated under current pumping levels at certain locations, a condition which has long range implications for water supply development in the region. For example, a water supply study (305) for the Southeastern Water Authority of Virginia indicates that existing pumping precludes further ground water development in the area as a source of public supply. As an alternative, the study recommends importation of water from the Roanoke River Basin as the solution to a water shortage projected for the near future.

There is no question concerning the fact that existing uses of ground water in a critical area must be given some degree of legal recognition and protection. The state has a moral obligation to protect investments in industrial and other facilities made in expectation of a continued water supply, and constitutional limitations on governmental control over private property prohibit complete abolition. However, the state should not be precluded from seeking reasonable reductions in existing use where the water can be used more beneficially in another application.

Since development of existing uses in many cases has been based on the view that ground water is a free, unrestricted commodity, it is conceivable that considerable reductions in such use may be feasible without curtailment of related activities by means of water reuse and adoption of other process modifications. In fact, voluntary reductions in pumping have been accomplished in some cases (63, p. 16). However, a water conservation program based totally on the cooperative approach is limited in its potential effectiveness, and regulatory authority to require feasible reductions where the cooperation approach fails is a necessary management agency power. The beneficial use requirement of the Groundwater Act is a potential source of such authority, but its effectiveness has not been tested.

Another aspect of the grandfather clause which poses a potential problem in the effective implementation of the Groundwater Act involves determination of the extent of the rights to be preserved. As indicated previously, the Act does not specify the method of measurement, leading to varying interpretations. Acceptance of the view that such rights are recognized to the extent of maximum daily use within the prescribed period prior to critical area designation will weaken the effectiveness of the Act. If this daily maximum is the only constraint, considerable expansion in total use would be possible on a long range basis simply by means of increasing the number of days during which the maximum quantity is pumped. Since prevention of uncontrolled expansion in use is the major objective of the Act, this interpretation of the Act is in violation of its basic intent.

A third potentially detrimental effect of the grandfather clause consists of the possibility that it will serve as a stimulus to ground water pumping in areas under consideration for critical area designation. Since uses initiated prior to designation are exempted from the permit requirement and the possibility of restriction or prohibition, a natural tendency is created for accelerated development. Problems of this nature have developed in other areas where water rights have been based on pumping levels. For example, use of this standard to establish rights by the California courts in certain ground water basin adjudications (49) has led to increased pumping in other overdrawn basins, with the result that a legislative provision (37) had to be enacted to counter this effect by preserving unused rights where an alternative source of water is used. The amount of increased pumping likely to result from the grandfather clause in the Virginia Act is limited by the provision that existing uses will be recognized only to the extent of beneficial use. This limitation would prevent rights from being established where water was pumped and wasted but may provide little restriction in other situations since "beneficial use" has been given a broad interpretation that apparently encompasses any productive use of water.

Effect of exemptions

The Act exempts all agricultural and domestic uses of ground water and industrial and commercial uses not exceeding 50,000 gallons a day. Exemption of home wells and other minor uses is a standard feature of ground water controls and can be justified on the basis that the resulting impact of such uses is inconsequential. Since small uses are likely to exist in considerable number, their exclusion also eases the burden of administering the control program. Although most of the exemptions contained in the Virginia statute can be justified on such grounds, a question may be raised concerning the desirability of including all agricultural uses within this category. Such uses, particularly irrigation, are generally among the least efficient and most highly consumptive of all water uses. The impact is mitigated in a state such as Virginia where rainfall is relatively abundant and irrigation is not extensively practiced, but blanket exclusion of agricultural uses without regard to quantity may pose a problem if future increases in such uses occur.

As noted previously, the SWCB has decided that municipal use does not fall within the exemption for domestic uses. Consideration of the magnitude of municipal withdrawals and the wide variety of purposes to which public supplies are applied in addition to strictly domestic purposes indicates that such uses should be subject to state regulation. Effective management requires that all large withdrawals be controlled, and the existence of special exemptions seriously weakens the effectiveness of the management program.

Effect of permit conditions

A significant omission in the Groundwater Act with regard to permits concerns their duration and provisions for review and modification subsequent to issuance. Since permit duration is not specified, the assumption arises that a ground water right so established is granted in perpetuity. Furthermore, provisions concerning permit review procedures are limited to public hearings for cancellation of permits where willful violations of the permit or of the Act occur. No provision is made for review and modification of permits to reflect changed conditions affecting the desirability of a given water use in relation to the public interest. Thus the granting of permits adds to the inflexibility created by the inability to regulate uses existing at the time of critical area designation.

Protection of Quality

Major facilities for handling and disposal of liquid wastes

General authority for protection of ground water quality is vested in the SWCB by the State Water Control Law (SWCL) (242), enacted in 1946 (284). The declared purposes of the Law are to safeguard the clean waters of the state from pollution and reduce existing pollution (242, sec. 62.1-44.2). The Law encompasses ground water since the term "state waters" is defined to include ". . . all water, on the surface and under the ground, wholly or partially within or bordering the State or within its jurisdiction . . ." (242, sec. 62.1-44.3(4)).

The basic approach provided by the Law for protection of quality consists of restricting waste handling and disposal operations. The mechanism for imposition of specific restrictions on individual operators is the requirement that certain facilities for waste handling must be approved and certified by the SWCB. Wastes are classified in the SWCL as industrial wastes, sewage, and "other wastes," a category including all substances other than industrial wastes and sewage which may cause water pollution. Legal requirements are somewhat different with respect to each of these categories.

In the case of an establishment involving an actual or potential discharge of industrial wastes to state waters, prior approval of waste control facilities and acquisition of a SWCB certificate are mandatory (242, sec. 62.1 - 44.16). This requirement encompasses facilities discharging to both surface and ground water. From the viewpoint of ground water quality, methods of industrial waste disposal that are particularly significant include injection wells and waste lagoons. Industrial waste injection has never been utilized in Virginia, and the present policy of the SWCB is opposed to injection (58, sec. 3.4 - 5). Waste lagoons have been utilized and subjected to regulation, but the emphasis of control measures traditionally has been on prevention of discharge to surface waters. The fact that ground water protection has not been of primary concern is indicated by such factors as the widespread authorization of unlined waste impoundments, reliance on non-comprehensive site investigation, and the essential absence of monitoring to determine the impact of such operations on ground water quality.

Policies and procedures with regard to authorization of industrial waste facilities such as lagoons that are potential sources of ground water pollution have recently been re-evaluated and are currently in a state of evolution. The principal manifestation of this change consists of development of a more comprehensive site evaluation process, including provision for monitoring in appropriate situations. The newly developed requirements are reflected in a new site evaluation procedure that requires evaluations of soils, geology, and hydrology by qualified personnel and includes determination of background ground water quality (233). Implementation of this more comprehensive approach should result in a considerably higher degree of ground water protection.

In the case of sewage, regulatory procedures are more complex due to involvement of another state agency, the State Department of Health (SDH). The Law provides that "[a]ll sewerage systems and sewage treatment works shall be under the general supervision of the State Department of Health and the Board [SWCB] jointly" (242, sec. 62.1 - 44.18(1)). However, more detailed statutory provisions distinguish between control procedures for large sewage treatment and disposal facilities and smaller facilities. In the case of facilities designed to serve more than 400 persons, the SWCL requires prior submission of all plans to the SDH. The SDH in turn is required to file a copy of such plans with the SWCB, indicating its approval or disapproval. The SDH's action on such proposals is of an advisory nature since the final decision with respect to granting of an authorizing certificate is the responsibility of the SWCB (242, sec. 62.1 - 44.19(4)). Although a movement is underway to encourage land application of effluents from large treatment works, disposal of such effluents in Virginia to date has consisted of discharge to surface waters.

Although provisions of the SWCL specifically applicable to sewage facilities serving more than 400 persons indicate that the general authority of the SWCB with respect to smaller systems is not limited because of the more detailed provisions regarding larger systems (242, sec. 62.1 - 44.19(7)), SWCB authority with respect to smaller systems is limited in practice. Legislation independent of the SWCL exists which vests certain regulatory responsibility for sewage disposal solely in the SDH (291, sec. 3.9). Pursuant to this authority, the SDH operates a regulatory program encompassing septic tanks and other small sewage disposal systems. SWCB involvement with sewage systems serving less than 400 persons has apparently been limited to facilities with a discharge to surface waters. Thus the SDH exercises primary responsibility with regard to those sewage disposal operations with the greatest potential impact on ground water quality. The SDH's regulatory program for small sewage disposal systems is discussed in the next section.

The authority for the SWCB to regulate the handling of "other wastes," defined to include ". . . all other substances, except industrial wastes and sewage, which may cause pollution in any State waters . . ." (242, sec. 62.1-44.3(9)), would appear to provide considerable flexibility for the control of activities posing a threat to ground water quality. Many sources of ground water pollution consist of handling and storage of raw materials or commercially valuable products rather than actual waste disposal activities. Since any party responsible for such potential contaminants can be required to implement approved control facilities or measures and obtain a certificate upon the request of the SWCB (242, sec. 62.1-44.17), the potential regulatory authority of the agency is extended considerably. However, it does not appear that this authority has been exercised to any appreciable degree for the protection of ground water quality, and a number of potential sources of contamination continue to be essentially unregulated with respect to quality protection. For example, the installation and maintenance of gasoline and other chemical storage facilities are not subject to state control in the interest of ground water quality protection. Regulatory activity is essentially reactionary in nature and is generally initiated only after contamination has occurred and adversely affected a water supply.

<u>Small sewage disposal systems</u>

In addition to the controls over sewage disposal contained in the State Water Control Law, state law provides that "[t]he Board [of Health] may regulate and prescribe the method or methods of disposal of sewage in this State" (291, sec. 32-9). This authorization was enacted prior to the SWCL and it continues to serve as the primary legislative basis for state control over small sewage disposal systems. Pursuant to this authority, the Board of Health has adopted regulations (206) requiring a permit from the State Health Commissioner or his authorized agent for the construction or alteration or any sewerage system. Acquisition of such permits requires compliance with SDH specifications for the particular system involved.

Of particular interest with respect to protection of ground water quality are SDH regulations regarding use os septic tanks (206, part III). These provisions cover design, construction, and location of septic tanks and related drainfields. Since satisfactory operation of a septic tank system is dependent on soil type and geologic conditions, site evaluation requirements are a key factor with regard to potential for groundwater contamination. The following provisions for soil evaluation are contained in the regulations:

> Soil evaluation for a drainfield system shall follow a systematic approach including consideration of physiographic province, position of landscape, degree of slope and soil profile (thickness of horizon, color, texture). Such evaluation shall indicate whether or not the soil has problems relative to the position of the landscape, seasonal water table, shallow depths, rate of absorption, or a combination of any of the above. If absorption rate problems are suspected and there is no indication of a water table, percolation tests should be made but their result shall not be presumptive, prima facie or conclusive evidence as to the suitability for effluent absorption. Such percolation tests may be considered and analyzed as one of many criteria in determining soil suitability for absorption of effluent (206, part III, art. 1, sec. B(7)).

The percolation test referred to in the above quote is based on the assumption that the ability of soil to absorb water in a relatively short period of time is an indication of its long term ability to absorb septic tank effluent. Thus the test involves measuring the rate at which the water level decreases in an excavation at the proposed septic tank site. The measurement is made in a specially prepared test hole twenty-four hours after water is added in order that the soil be given an opportunity to become saturated and to swell. The rate of drop in water level is measured according to specified procedures and is converted into a percolation rate, which is expressed as the time required for the water to fall one inch. This rate is used to determine the required absorption area, with a rate in excess of sixty minutes requiring special design (206, part III, art. 1, sec. B(8)). Of course the restriction on slow percolation rates reflects the fact that a main concern of septic tank regulation is prevention of surface contamination.

Although the regulatory provisions regarding soil evaluation state that percolation tests should not be considered conclusive evidence as to the suitability of a site for effluent absorption, the apparent specificity of the test and its general association with suitability for septic tank use creates a natural tendency toward over-reliance on test results. The fact that the test must be used and interpreted with caution is indicated by the following statement by Harold A. Thomas in an article assessing household sewage disposal systems:

> In certain soils the percolation test is known to have a fair correlation with long-term septic tank effluent absorptive capacity and so provides a useful tool for design. In other soils the correlation is low or completely lacking . . . (255, p. 123).

Even if the percolation test is a reliable indication of the continuing performance of a septic tank at a given site, the test does not necessarily serve as an indicator of the degree of ground water quality protection offerred. In fact, a rapid percolation rate, which is generally considered a positive factor, may indicate greater risk of ground water contamination. Course grained soils that give the best percolation test results are less satisfactory than fine grained materials for removing potential pollutants such as bacteria and nutrients, and high percolation rates may indicate the close proximity of fractured or cavernous rock to the surface which serves as a direct means of access for pollutants to enter ground water.

A basic weakness of septic tank regulations with regard to water quality protection consists of their failure to consider the effect of population density. Since the impact of individual installations is cumulative, the problem of water quality degradation becomes more serious as the number of septic tanks in an area increases, but the evaluation of each new proposal continues to be based largely on the soil characteristics of the individual site. As a result of this approach, cases have been reported in Virginia where septic tank permits have continued to be issued in areas where effluent from existing tanks already poses a significant pollution hazard (227).

Administration of septic tank controls is a difficult task because such regulations serve as a direct constraint on land use and development. Since septic tanks provide the only feasible system of domestic waste disposal in many areas, denial of a septic tank permit severely limits the potential for development. Thus the administrators of the permit program are generally under considerable pressure from development interests, and the question of permit issuance is likely to become a local political issue in locations where extensive areas are unsuitable for septic tank use. In consideration of the fact that existing septic tanks are one of the leading sources of ground water pollution in areas that have undergone substantial development (163, p. 164), their control must be viewed as one of the most troublesome aspects of ground water quality management.

Solid wastes

Basic authority for control of solid waste disposal is vested in the SDH by legislation specifying that "[t]he Board [of Health] shall regulate and prescribe the method or methods of disposition of garbage, refuse and other solid wastes or any combination thereof in this State to be utilized by each county, city and town in the State" (291, sec. 32 - 9.1). The Board has adopted regulations (218) requiring a permit from the Health Commissioner for operation of any solid waste disposal system. In order for the necessary permit to be issued, design of any disposal system must comply with applicable regulatory requirements which are quite general in nature. These requirements prohibit open dumping and specifically forbid disposal of solid wastes in state waters (218, part II, art. 1, 2). Although "state waters" is not defined within the regulations, the term encompasses both surface and ground water in the SWCL, therefore indicating that disposal of solid wastes below the water table is unlawful.

Disposal methods specifically approved include sanitary landfills and incinerators. With regard to ground water quality, landfills are of principal interest. Landfill requirements reflect concern for water quality protection as indicated by the provision that "[t]he site shall be so located and the operation so designed as to prevent pollution of ground and surface waters" (218, part IV, art. 1, sec. D). A more specific requirement states that the final cover for a site must be graded such that surface water will not pool on the surface (218, part IV, art. 2, sec. D). This restriction reduces the likelihood of infiltration and the formation of leachates which constitute a significant source of surface and ground water pollution. With the exception of this one condition, the regulations are not specific with regard to water quality protection measures, leaving the detailed controls to the discretion of departmental personnel on a case-by-case basis.

There are a number of solid waste management objectives in addition to protection of water quality such as prevention of unsightly appearance, odors, and insect and rodent problems, and greater emphasis appears traditionally to have been placed on these other objectives. The fact that protection of ground water quality has not been of high priority is indicated by the previous lack of comprehensive site investigations and monitoring to determine the impact on water quality.

However, regulatory procedures are being revised to reflect a new concern for protection of ground water quality. In recognition of the relationship between solid waste disposal and water quality, the SWCB and SDH have entered into an agreement to insure proper protective measures. The current agreement was adopted in March of 1975 and establishes the following procedures for approval of solid waste disposal facilities:

1. Any person wishing to establish a solid waste disposal facility will make application to the State Health Department.

2. A cursory inspection of the site will be made by representatives of the State Health Department. If the site is obviously unacceptable, the applicant will be so notified by the State Health Department. If it appears that the site might be used, the State Health Department will notify the Water Control Board's Regional Geologist.

    (a) On sites where the Regional Geologist determines that it is obvious that extensive geological investigation is not necessary, the Board's Regional Geologist will complete the abbreviated site evaluation form and send his preliminary recommendations to the State Health Department. The State Water Control Board will limit this procedure to sites that can be evaluated within one working day.

    (b) When in the judgment of the State Health Department and/or the Water Control Board there is need for a more thorough evaluation of the proposed site than provided above, the Health Department will require the applicant to supply more detailed hydrogeological information (Site Evaluation Form SW-75 (2)).

3. Upon receipt of the completed Site Evaluation Form SW-75 (2), the State Health Department will send a copy to the Regional Geologist for his recommendations. Also, a copy of the applicant's development and operational plan will be sent to the Water Con-

trol Board for final review to insure that State waters will be protected.

4. Final approval or disapproval will be made by the State Health Department.

5. Before final approval is made, the applicant will be required to furnish background information on ground water quality. Form SW-75 (3) will be used for this purpose.

6. All inquiries coming to the Water Control Board concerning solid wastes, whether from local health departments, communities, industries, or others, will be directed to the State Health Department for proper processing (160).

These provisions supercede an earlier agreement (159) between the two agencies of a somewhat similar nature. The basic difference in the later agreement consists of its use of a more detailed site evaluation procedure (234) somewhat similar to that employed where waste lagoons are proposed.

Radioactive wastes

The SDH is designated by statute (292) as the State Radiation Control Agency and is vested with regulatory powers regarding certain radioactive materials. A potentially significant radiation control function with regard to water quality protection consists of the authority to acquire radioactive waste material sites (292, sec. 414.4(e)(i)). The SDH may also assume responsibility for ". . . perpetual custody and maintenance of radioactive materials held for custodial purposes at any publicly or privately operated facility located within the State, in the event the parties operating such facilities abandon their responsibility and whenever the federal government or any of its agencies has not assumed the responsibility" (292, sec. 414.4(e)(iii)). Authority for acquiring disposal sites and assuming custody of radioactive materials can be exercised only upon approval of the Governor and has not been used to date.

Policies and programs of the state relating to radioactive materials are subject to review and evaluation by a legislatively created Radiation Advisory Board consisting of ten members appointed by the Governor and seven ex officio members. The ex officio members include the Commissioner of Health, the Director of the Division of Industrial Development or his designee, the Commissioner of Labor and Industry, the Commissioner of Agriculture, the chairman of the SWCB or his designee, the Governor's representative on the Southern Interstate Nuclear Board, and the Director of the Virginia Institute of Marine Sciences (292, sec. 414.5).

Pesticide application

Pesticide use is an activity generally considered to be a potentially significant source of ground water pollution. Much environmental concern has been focused on the effects of pesticides in recent years, and governmental controls have undergone considerable development. The existing regulatory program is a combined federal-state effort wherein the federal government exercises primary responsibilities with respect to labeling and sale (84) and classification for use (82) while the state controls actual use consistent with federal standards and classifications.

The basic state control over pesticide use in Virginia consists of the Virginia Pesticide Use and Application Act of 1975 (301). The Act provides that the Board of Agriculture and Commerce (BAC) may adopt regulations concerning pesticides classified by EPA for restricted use on the basis of such factors as toxicity, persistence, and mobility. These regulations may relate to the ". . . time, place, manner, materials, amounts and concentrations, in connection with the application of such pesticide, and may restrict or prohibit use of such pesticides in designated areas during specified periods of time and shall encompass all reasonable factors which the Board [BAC] deems necessary to prevent unreasonable adverse effects on the environment" (301, sec. 3.1 - 249.2). This authorization gives the BAC broad discretion in preparing regulations to provide environmental protection. Specific reference to protection of ground water or water resources in general is absent from the legislation but would appear to be encompassed. Due to the recent passage of the 1975 Act, regulations have not yet been established.

Another basic control contained in the 1975 Act consists of the provisions for certification and licensing of users of restricted pesticides. This requirement encompasses both commercial (301, sec. 3.1 - 249.4) and private applications upon land owned by the user (301, sec. 3.1 - 249.6). However, commercial applicators are subject to special record-keeping requirements (301, sec. 3.1 - 249.11) not applicable to private users.

The Act creates a Pesticide Advisory Committee to advise the BAC on matters related to the use and application of pesticides, including legislation, regulations, and agency programs. The Committee encompasses a broad spectrum of interests within its twelve members, including three pesticide applicators; one commercial producer of food or feed commodities; one industrial user; one private citizen; one environmental health specialist from the Virginia SDH and one representative each from the agricultural chemical industry, the Virginia Department of Agriculture and Commerce, the Virginia Commission of Game and Inland Fisheries, the SWCB, and Virginia Polytechnic Institute and State University (301, sec. 3.1 - 249.13).

Well construction

Since wells provide a direct means of access among individual aquifers and between ground water and the surface, they serve as a potential route of ground water contamination. Wells can result in water supply contamination by allowing the movement of water from an aquifer having undesirable quality to one of satisfactory quality or by allowing the entry of contaminated surface water or shallow subsurface water such as septic tank effluent. The first well likely to be adversely affected by such pollution will be the improperly constructed well itself but continued entry of pollutants may also have more widespread effects. This latter consequence can be of considerable significance where wells are improperly sealed upon abandonment.

Due to their obvious relationship to public health, public water supply wells traditionally have been subjected to greater control by the state than have private wells. Law applicable to public water supplies (299) requires approval and acquisition of a permit from the SDH for use of a public supply well. Waterworks regulations (309) adopted by the Board of Health in 1974 reflect concern for prevention of well contamination from surface and undesirable subsurface sources. These regulations specify minimum distances for such wells to be located from septic tanks or other potential sources of pollution, minimum requirements for casing, and grouting requirements (309, sec. 8.03).

Control over well construction was expanded by provisions of the Groundwater Act of 1973 which authorizes the SWCB and the SDH jointly to prescribe standards for the construction and maintenance of wells (109, sec. 62.1 - 44.92(4)). This authority is not limited to public water supply wells and applies statewide rather than to officially designated critical ground water areas only. Standards adopted by the SWCB pursuant to this authority provide that water wells must not serve as a channel of pollution (219, p. 10). It is provided that wells must not connect aquifers or zones such that deterioration of water quality results (219, p. 6). However, the standards are silent with respect to most detailed control measures to protect quality such as casing and grouting. Guidelines (306, 307) developed by the SDH are somewhat more specific but appear to be more in the form of an informational service rather than enforceable regulations. Thus the actual degree of control appears somewhat questionable, especially in view of the fact that the only wells requiring state approval prior to construction and/or use are ground water recharge wells, public water supply wells, permanent observation wells located within the zone of influence of a public supply well, and wells requiring certificates of ground water right within critical areas (113, p. 16).

The standards adopted by the SWCB require that abandoned wells be sealed. Provision is made for bored wells to be filled with cement grout or clay. Wells penetrating zones of consolidated rock may be filled with sand or gravel opposite the water-bearing zones of rock, but the top of such fill must be at least five feet below the top of the consolidated rock, with the remainder of the well filled with cement grout (219, p. 10).

Mineral extraction

Mineral extraction operations can be major sources of ground water contamination. In Virginia, principal mining activities are located in the Cumberland Plateau Province of the southwestern part of the state where significant deposits of coal exist. Limited operations associated with oil and gas production have also been conducted in this region. Extraction operations for other minerals, primarily involving surface mining and quarrying, have been distributed across the state. State government exercises certain controls over each of these activities.

Control over mining is divided between the Division of Mines (DM) of the Department of Labor and Industry and the Division of Mined Land Reclamation (DMLR) of the Department of Conservation and Economic Development. Authority of the DM is contained in the Virginia Mine Safety Law of 1966 (300) and is limited to protection of the health and safety of persons engaged in mining and quarrying and the protection of property. Environmental controls are administered by DMLR and apply to mining operations and the reclamation of mined land, but this program is limited to surface mining (294, 295). Certain aspects of underground mining operations such as discharge of mine water to surface streams is subject to regulation, but the impact of subsurface operations on ground water is largely controlled.

Legislation applicable to oil and gas production is administered by DM and provides authority for requiring ". . . that the drilling, redrilling, deepening, casing, completion, plugging and abandonment of wells be done in such a manner as . . . to prevent the pollution or contamination of freshwater supplies by oil, gas or salt water . . ." (293, sec. 45.1-108). Specific requirements for plugging abandoned wells (293, secs. 45.1-128 to -130) serve to prevent such wells from becoming avenues for contamination from the surface or interchange of fluids between strata.

Oil and gas operations have not posed a significant regulatory problem in Virginia due to the low level of activity, but the potential importance of controls is indicated by the fact that such operations, especially disposal of oil field brines, have been a principal source of contamination in regions of intensive petroleum production (223, pp. 83-88). Current Virginia legislation does not address the issue of brine disposal.

Adequacy of quality protection program

The primary issues with regard to the adequacy of Virginia's ground water protection program concern the scope of existing legal authority, the extent of implementation and enforcement of controls, and the effectiveness of the institutional structure for administration.

Scope of existing legal authority

Due to the wide range of activities that serve as potential sources of ground water pollution, legal authority for an effective control program must be broad in scope and cannot be limited to control of waste discharges alone. It has been generally recognized in recent years that surface water quality is significantly affected by contaminants originating from sources other than discrete waste discharges, and this fact has even more applicability in the case of ground water.

In Virginia, legal authority for implementing ground water protective measures appears to exist in the case of most potentially significant sources of ground water pollution. Waste disposal practices of special concern with regard to ground water quality such as septic tanks, landfills, and waste lagoons are encompassed by the SWCL or other legislation of more restricted scope. With regard to activities other than waste disposal, state controls exist in most cases although protection of ground water quality is not always a major consideration. The provisions of the SWCL concerning "other wastes" offer a supplemental source of control over non-disposal activities involving potential pollutants. Therefore it appears that existing legal authority provides a reasonably adequate basis for a ground water quality protection program.

Implementation and enforcement of controls

Just as significant as the existence of adequate legal authority is the issue of whether existing controls have been fully applied toward the objective of ground water quality protection. It appears that lack of aggressive implementation of existing controls has been a primary weakness in the Virginia program. Although given some consideration, protection of ground water quality has not been a high priority issue and generally has assumed a secondary role to other objectives encompassed within applicable controls. For example, implementation of the SWCL, which applies to both surface and ground water, has placed primary emphasis on surface water, and the full potential of the Law for protection of ground water has not been realized. Likewise, implementation of controls applicable to septic tanks and landfills appears to have been somewhat biased toward prevention of surface problems.

This lack of attention to ground water does not generally appear to have been the result of conscious decision-making but rather has been the consequence of a rather low level of general awareness of the extent and potential significance of ground water quality problems. This approach may have been somewhat justifiable in the past due to the greater urgency of other problems such as surface water pollution. However, ground water problems are intensifying and can no longer be ignored. Established programs must be modified to reflect a new concern for such problems, and new programs should be developed with ground water protection as a basic objective.

An unprecedented interest in ground water quality protection has developed in recent years, and regulatory procedures are already being revised to reflect this greater concern as indicated by the adoption of more stringent requirements for waste lagoons and landfills. These modifications and development of more comprehensive controls are being accomplished within the framework of existing law, and it is apparent that a substantially improved program of protection can be achieved without appreciable expansion of existing enabling legislation.

Institutional structure for administration

One of the basic characteristics of the state program for protection of ground water quality is its fragmented structure. The various controls which constitute the individual elements of the program are authorized by a number of separate statutes and administered by several independent agencies. Legislation related to quality protection includes the SWCL, the Virginia Pesticide Use and Application Act of 1974, solid waste disposal controls, sewage disposal controls, legislation concerning radioactive materials, and legislation concerning mineral extraction. Agencies responsible for implementation include the SWCB, the SDH, the Department of Agriculture and Commerce, the Department of Labor and Industry, and the Department of Conservation and Economic Development.

Several mechanisms for coordination among the various program elements have been established. An example of a voluntary arrangement for agency coordination is given by the agreement between the SDH and SWCB concerning regulation of solid waste disposal. In certain cases legislative provisions provide for interagency action, e.g., in the case of certain sewage disposal facilities within the jurisdiction of both agencies. Legislation provides another mechanism for coordination in some cases in the form of multi-agency advisory committees. Principal examples of this institutional arrangement include the Radiation Advisory Board and the Pesticide Advisory Committee.

Another mechanism for coordination among agencies having ground water protection responsibilities consists of the Governor's "cabinet." Under this institutional arrangement, the various administrative agencies are classified into six functional groupings, with the agencies in each group administratively responsible to one cabinet officer. Most of the agencies with water resource management functions are responsible to the Secretary of Commerce and Resources (287, sec. 2.1-51.9(e)). The most notable exception is the SDH, which is answerable to the Secretary of Human Affairs (287, sec. 2.1-51.9(d)). Although this arrangement is understandable in view of the major functions of this agency, it does create a potential problem with respect to coordination of the programs of the Engineering Division which encompass significant water quality management functions.

The Governor's cabinet has only been in existence since 1972, but preliminary indications are that significant improvements in administration have not yet been accomplished. A 1974 interim report (226) of the Commission on State Governmental Management stated that the Secretaries had not provided the management and supervisory assistance contemplated by a 1970 state governmental management study (57) and authorized by the 1972 enabling legislation. More specifically, the report suggested that each individual Secretary should devote more attention to his own area of responsibility with regard to such areas as ". . . resolving disputes, coordinating planning and operations, evaluating program performance, setting goals and policies, reviewing budgets, and identifying duplication and ineffectiveness with respect to the agencies assigned to him" (226, p. 13).

The existing interagency agreements and provisions for multi-agency input into certain program elements serve to somewhat mitigate problems resulting from fragmentation of responsibility, but coordination problems would appear to be an inherent consequence of the existing structure of the ground water protection program. Although separation of the various components of the program may be justified because of other objectives associated with the various control measures, such separation is likely to have primarily negative consequences with respect to implementation of a comprehensive, integrated program of water quality protection.

Non-Regulatory Management Activities

Governmental regulation is the primary mechanism for restricting excessive ground water withdrawals and controlling other activities adversely affecting the resource. This element of the state management program is its most visible aspect; however, regulation alone does not constitute the total management effort. Principal activities of a non-regulatory nature consist of the collection and management of data and the provision of advisory services.

<u>Data collection and management</u>

The oldest ground water management activity engaged in by the state consists of collecting and handling information concerning the physical conditions of the resource. Since all other management functions are dependent on the existence of sufficient quantities of accurate data, this aspect of the state program is one of the most fundamental elements.

With regard to data collection, a number of somewhat independent approaches exist rather than a single unified effort. State agencies involved in collection of data relevant to ground water management include the Division of Mineral Resources (DMR) of the Department of Conservation and Economic Development, the SDH, and the SWCB.

Due to the intimate relationship between the occurrence of ground water and geologic conditions, the DMR has traditionally played a major role in ground water data collection. However, expansion of this activity within the programs of other agencies has reduced the role of the DMR, and the 1974 Legislature deleted statutory authority to conduct water resource investigations and collect data from well drillers (285). Nevertheless, the DMR will continue to collect data that is relevant to ground water management since geologic knowledge is of fundamental importance to the program.

The ground water data collection program of the SDH primarily consists of information obtained from the owners of public water supply wells. Information concerning both water quality and quantities pumped is obtained. Under newly initiated procedures for site evaluation, the agency also obtains background ground water quality data as part of its regulation of landfills.

The principal ground water data collecting agency is the SWCB. This agency makes its own field collections of data, engages in a cooperative program with the United States Geological Survey (USGS), and requires certain water users to report data through its regulations. Both the SWCB and USGS operate a network of observation wells for determining ground water levels, and the SWCB measures water levels in a number of private wells. In addition to the routine data program, special studies provide detailed information in particular areas. As noted earlier, studies are currently underway in certain areas to determine the need for critical area designation.

The Groundwater Act and regulations developed pursuant to the Act greatly expand the SWCB's data acquisition potential. Within designated critical areas, the required registration statements and permit applications will provide detailed information on extent of water use and ground water conditions. On a broader scale, SWCB regulations require certain reports from ground water users on a state-wide basis (219, pp. 10-11). One such data collecting device is the water well completion report required from any person completing a water well anywhere within the state. This report requires such information as static water level, yield, presence of unusable water, and a description of the rock or soil penetrated by the well. Also required is a ground water pumpage and use report from the owner of any industrial or public supply well, to be submitted on a quarterly basis. Since such wells are required by regulation to be equipped with flow meters (219, p. 6), the pumpage and use report should provide accurate information as to the extent of ground water use by large users. The report will also provide information on ground water levels. A third report (219, p. 11) required on a state-wide basis concerns abandonment of any industrial or public supply well.

Management of ground water data by the SWCB is facilitated by a computerized storage and retrieval system, and it operates a digital computer model (63) of the principal coastal plain aquifers included in the critical ground water area. This model can be used to predict the impact of new wells on ground water levels in the area and therefore will be used as a management tool in evaluating permit applications for new uses.

Advisory services

Legislation provides that the SWCB may make technical advice and information concerning water resources available to governmental entities and individuals (298, sec. 62.1-44.39). One aspect of the SWCB's advisory service consists of ground water consultations, which include such responsibilities as assistance with location of well sites and investigation of ground water pollution complaints. As a partial alternative to individual consultations, county or regional ground water reports are being prepared which will provide information on expected ground water occurrence and quality.

Adequacy of non-regulatory management activities

The principal concern regarding non-regulatory activities is whether the data collection program is adequate to supply necessary information for sound managerial decision-making. Data collecting activities have concentrated on the southeastern region of the state, but substantial information gaps still exist even in this area. For example, information is deficient with regard to location and movement of the fresh water/saline water interface within the coastal plain. The lack of such basic information is a serious weakness in the management program.

As noted previously, the adequacy of data collection directly related to regulatory activities has also been subject to question. Monitoring which would indicate the impact of various waste disposal operations on ground water quality has been largely neglected. The current revision of regulatory procedures applicable to waste lagoons and landfills includes increased monitoring considerations and will provide needed water quality information when fully implemented.

With the exception of information collection and dissemination, the State of Virginia has been relatively inactive in the area of non-regulatory management. The state has not become involved in such projects as artificial recharge or prevention of salt water intrusion, either directly or by providing assistance to its political subdivisions. This inaction has been facilitated by the relative abundance of ground water and the scarcity of serious management problems. However, the increasing occurrence and severity of ground water problems may require a reassessment of this philosophy.

Local and Regional Management Responsibilities

The State of Virginia has not delegated direct ground water management responsibilities to its political subdivisions, but these governmental units exercise powers having a substantial impact on use and protection of the ground water resource. The political subdivisions of principal interest in this regard are the counties and municipalities, but the planning district commissions also have responsibilities related to ground water management.

Counties and Municipalities

The primary responsibility of the counties and municipalities of the state having impact on the ground water resource consists of land use planning and control. The 1975 session of the General Assembly amended applicable legislation to require the governing body of every county and municipality to create a local planning commission (289). This requirement modifies the previous approach which authorized but did not specifically require the creation of such commissions. A principal duty of each local planning commission is the preparation of a comprehensive plan for the physical development of land within its jurisdiction. Since these plans theoretically establish general patterns of development, they can be significant with regard to ground water development and protection. Statutory guidelines for such plans do not make specific reference to ground water but provide for a survey of natural resources during plan preparation and specify that the plan may include the ". . . designation of areas for various types of public and private development and use, such as different kinds of residential, business, industrial, agricultural, conservation, recreation, public service, flood plain and drainage, and other areas . . ." (289, sec. 15.1-

446.1). This provision appears to authorize incorporation of ground water and other natural resource considerations into the planning process but leaves such considerations to the discretion of the local commissions.

In addition to authority to conduct planning, authority to adopt and implement controls over land use is also delegated to local governmental units (289, sec. 15.1-486). The governing body of any county or municipality may enact a zoning ordinance through which special controls can be enforced. Provisions of the enabling legislation for zoning specifying the purposes of such ordinances and the extent of regulatory authority delegated are essentially silent with regard to water, but it is provided that consideration is to be given to ". . . conservation of natural resources . . ." (289, sec. 15.1-490). Specific authority is granted for the regulation of ". . . excavation or mining of soil or other natural resources . . ." (289, sec. 15.1-486(d)). Control over excavation or mining can be significant with regard to ground water due to possible effects on quality or modifications in subsurface hydrology.

Land use controls are an essential element of a ground water management program since they constitute the only effective mechanism for controlling certain externalities affecting the resource. For example, maintenance of natural replenishment and the renewable character of the resource may require restriction or prohibition of development in recharge zones. However, the fact that recharge is not confined to limited areas in Virginia reduces the significance of this factor. Of greater relative importance in the Commonwealth is the need to control use of land areas where contaminants have easy access to aquifers such as outcrop areas or limestone terranes.

The fact that responsibility for land use planning and implementation of controls has been delegated to the counties and municipalities therefore creates a significant role for the local level of government with respect to ground water management. State government has reserved powers of control concerning certain specific land use activities such as establishment of landfills and installation of septic tanks, but the basic decisions concerning development patterns are primarily matters of local determination. Local governing bodies possess the necessary authority to adopt and implement controls containing adequate ground water protective measures, but it does not appear that natural resource conservation traditionally has been a primary factor in local programs of land use controls. As evidenced by such legislation as the Virginia Wetlands Act (297), a trend toward more state involvement has developed. Continued neglect of ground water quality may likewise necessitate a more active state role in land management.

In addition to land use controls, another delegation of authority of possible significance with respect to ground water management is contained in legislation enacted by the 1975 General Assembly concerning the operation of extra-jurisdictional water supply systems (290, sec. 15.1-875). This new addition to state law provides that no municipality after July 1, 1976, can operate a water supply system outside its boundaries without the consent of the county or municipality in which the system is to be located. The consent requirement will not apply to existing systems or those under construction or for which the site has been purchased. In the event consent is withheld, the party seeking approval is authorized to petition for the convening of a special court to review the decision.

This authority may become significant as localities are forced to go outside their boundaries to meet increasing water needs. The southeastern area of the state at present is actively seeking an outside source of water. The alternative recommended in a study (305) conducted by consultants involves the diversion of water from the Roanoke River Basin, but strong opposition has been expressed within the Roanoke Basin. Although this particular project may be encompassed by the grandfather clause of the new requirement, reaction to the proposal indicates the potential significance of the provision as a factor in water resources management.

Planning District Commissions

In addition to delegations of authority to counties and municipalities, certain authority for planning and limited land use controls have also been delegated to the state's planning districts, each of which encompasses several local units of government. The state has been divided into twenty-two such districts, the boundaries of which were determined by the Division of State Planning and Community Affairs pursuant to legislative mandate (288, sec. 2.1-63.5).

Under the provisions of the Virginia Area Development Act (286), the responsibilities of each district are carried out by a planning district commission (PDC) created by agreement among the governmental subdivisions included. A basic responsibility of each PDC is the preparation of a comprehensive plan encompassing elements of district development involving more than one of the subdivisions included within the district. Provision is made for the plan to be submitted to the governmental subdivisions encompassed for adoption, with the plan to become effective for the district upon adoption by a majority (286, sec. 15.1-1406). After adoption by a governmental subdivision, construction of public improvements or acquisition of land for public purposes must be in conformity with the plan (286, sec. 15.1-1407). All applications of governmental subdivisions to state and federal agencies for loans or grants-in-aid must be submitted to the appropriate PDC for a determination as to consistency with the comprehensive plan (286, sec. 15.1-1410).

The planning district concept has considerable potential as an institutional mechanism through which certain elements of a ground water management program can be accomplished. For example, the PDC's can develop a coordinated approach to regional water supply problems which encompasses both surface and ground water. Water resource management can also be facilitated by formulation of regional waste disposal plans. A significant aspect of such plans with respect to ground water involves the location of landfills due to the pollution potential. However, the regional approach is based largely on cooperative agreements among localities and has been limited in its effectiveness to date.

An example of a potentially significant action at the planning district level affecting ground water management consists of the water resources policy adopted by the Fifth PDC. This policy holds that development of surface water supplies is preferable to further ground water development and recommends that small water systems utilizing springs and wells be phased out. Although it has been reported that ground water supplies in the area in question are adequate to accommodate additional development, the PDC views this source of supply as unreliable (302, pp. 211-

13). The position taken has the potential to greatly reduce the significance of ground water as a source of supply. The PDC's have no direct implementation authority, but the existence of such policy and the general requirement for consistency of local action with the district plan are likely to have a significant long-range impact on ground water utilization.

Interstate Programs

A level of government which has seen limited involvement in ground water management consists of interstate organizations based on agreements with adjacent states. Existing interstate agreements were developed principally for surface water management, but certain of these agreements apply to some extent to ground water. Those having the greatest potential application include the Ohio River Valley Water Sanitation Compact (178), the Potomac River Basin Compact (199), and an agreement between the states of Virginia and North Carolina (4).

Ohio River Valley Water Sanitation Compact

The Ohio River Valley Water Sanitation Compact creates the Ohio River Valley Water Sanitation Commission (ORSANCO), an interstate river basin commission made up of three representatives from each of the states of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia, and West Virginia. The principal purpose of ORSANCO is the control of pollution in the Ohio River Basin. The primary regulatory authority of the Commission is its power to issue orders for the reduction or elimination of waste discharges into interstate streams within its jurisdiction. However, such an order goes into effect only if it receives the assent of a majority of the commissioners from a majority of the signatory states, including the assent from a majority of the commissioners from the affected state (178, sec. 62.1-71, art. IX).

The Commission is not directly involved in the management of ground water quality, but ORSANCO has been active with respect to advisory services in the area of injection wells. Activities in this area have included adoption of a statement of policy, recommendation of administrative procedures for state regulatory programs, evaluation of the geology and geohydrology of the Ohio Valley region with regard to the feasibility of injection (267), and maintenance of an injection well registry (205).

ORSANCO policy states that "[u]nderground injection is a technically acceptable method of wastewater disposal or long-term storage whereby pollutants can be removed from the surface environment and placed in isolated underground locations . . ." (267, p. III). In view of this finding and recognition that the techniques, trained personnel, and organizations are available in the ORSANCO district for evaluation of the geologic and engineering feasibility of underground disposal, the Commission declares that injection is an acceptable method of waste disposal under specified conditions. As noted previously, Virginia has not accepted this recommendation and prohibits use of injection wells.

Proposed Potomac River Basin Compact

Virginia has enacted legislation agreeing to enter into the proposed Potomac River Basin Compact when approved by all the potential signatories, which include, in addition to Virginia, the states of Maryland, Pennsylvania, West Virginia, the District of Columbia, and the United States.

The Potomac River Basin Commission, to be created upon formal approval of the Compact by the proposed members, will possess considerable authority to manage the waters in the Potomac Basin. The members of the Commission will consist of one representative of each signatory state and one member to be appointed by the President of the United States. Each member will be entitled to one vote on all matters under consideration, with Commission action requiring a favorable vote from four of the six members (199, sec. 62.1-69.1(2.05)). Since no signatory possesses the power to individually veto Commission action where the required majority votes in favor thereof, it therefore will be possible for the Commission to take action affecting a particular signatory even if that signatory is opposed. The proposed Commission will exercise a wide range of authority with respect to management of water resources, a term defined to include ". . . all waters within the basin . . ." (199, sec. 62.1-69.1(1.02)(1)). Thus the Commission's authority will extend to ground water to the extent necessary to accomplish the goals of the Compact.

There are several areas where the Commission's authority may become significant with respect to ground water management. One such area is the power to operate facilities for the ". . . development, storage and release of water and for the regulation of flows and supplies of surface and ground waters of the basin . . ." (199, sec. 62.1-69.1(4.01)). This provision would appear to authorize development of ground water supplies and possibly the artificial recharge of aquifers within the basin. The Commission also possesses authority for water quality management and may adopt water quality criteria that relate to pollution from a variety of sources, including the disposal of solid wastes or the failure to prevent the entry of oils, chemicals, or other materials which might adversely affect the quality of the waters of the basin (199, sec. 62.1-69.1(5.03)). Certain water resource projects within the basin will require the approval of the Commission, including such projects as those involving the transfer of water into or out of the basin or those which have a substantial effect outside the boundaries of the state where located (199, sec. 62.1-69.1(3.08)). With regard to regulation of water use, the Commission will have the power to designate special "protected" and "emergency" areas within which it can exercise certain control over withdrawals of surface and ground water (199, sec. 62.1-69.1(11.02-11.04)).

Agreement Between Virginia and North Carolina

An agreement less formal than an interstate compact was entered into by the Governors of Virginia and North Carolina on August 15, 1974, for the cooperative management of water resources affecting both states (4). Activities encompassed in the agreement include water resource planning, reservoir development in river basins common to both states, and ground water withdrawal in adjoining coastal areas.

The agreement provides for formulation of ". . . suitable institutional arrangements for interstate and federal cooperation on water resources matters that are of mutual interest to the two states" (4, p. 2). One problem area identified in the agreement consists of ground water withdrawal in adjoining coastal zones of each state, and a ground water subcommittee has been formed. Coastal plain aquifers are continuous across the state boundary, and pumping on one side of the boundary has the potential to produce external effects in the other state. Reference previously has been made to the extension into North Carolina of the cone of depression created by pumping in the area of Franklin, Virginia.

The ground water subcommittee has served to date primarily as a mechanism for information exchange. As the ground water management programs of the two states are developed, its activities and significance are likely to increase. Preliminary assessment of the statutes and regulations in effect in the two states has indicated that differences in the two programs make joint management infeasible but that enough compatibility exists for the successful utilization of a cooperative approach. Procedures for coordination will have to be developed at an operational level as the management programs of the states are further implemented.

Federal Program

Although the history of federal involvement in water resources management is long and detailed, the federal effort traditionally has been focused on control and development of surface water. In fact, with the exception of ground water data collection by USGS, federal programs for water resources management have essentially ignored the ground water resource prior to the present decade. This historical emphasis on surface water is largely attributable to differences in the physical characteristics of the two water sources. Surface waters are geographically more extensive and are more susceptible to large scale development projects that exceed the capabilities of private developers or even those of lower levels of government. In the case of water quality management, the convenience of using surface waters as waste depositories resulted in the earlier intensification of widespread pollution problems than in the case of subsurface waters. In addition to these physical reasons for earlier federal involvement in surface water management, an important jurisdictional factor consists of the navigability issue which has long served as the basis for federal authority in the water resource field.

However, federal involvement in ground water management has been considerably expanded by recently enacted legislation. The most prominent extension of federal authority consists of direct controls to protect ground water quality. These direct controls supplement previously existing management programs having a general relationship to ground water quality protection such as those involving pesticides, atomic energy, and solid wastes. Another expansion of involvement of a more indirect nature consists of several recently adopted requirements and procedures for water resource and related land use planning. Some of these developments are primarily applicable to federal project planning. Others give recognition to the intimate relationship between water resources management and land use, and programs and procedures have been developed for federal involvement in land use planning at the local and regional levels.

Data Collection

The oldest ground water management function of the federal government consists of ground water investigation and data collection by USGS. The legislative mandate of the agency is the ". . . examination of the geologic structure, mineral resources, and products of the national domain" (270, sec. 31(a)), authority which has been extended to encompass such examinations outside the national domain when in the national interest (270, sec. 31(b)). Within these very general guidelines, USGS exercises broad discretion in conducting its programs.

Water supply investigations encompassing both surface and ground water have always constituted a key USGS program element. Current studies in Virginia consist of special investigations in certain areas and the operation of hydrologic data collection stations, including a network of observation wells for measurement of ground water levels. Water quality data are also obtained from a limited number of observation wells (303). Many ground water investigations are cooperative efforts between USGS and the state, and the ground water model used by the SWCB as a management tool was originally developed by USGS and cooperatively adapted for use in Virginia. USGS also participates in cooperative projects with local governing bodies as indicated by the previously discussed study of the feasibility of storing fresh water in saline aquifers in the Norfolk area. A statutory constraint on funding of cooperative projects is that the federal share cannot exceed 50 per cent of project costs (270, sec. 50).

Protection of Quality

Controls over the underground injection of wastes

Involvement of the federal government in the area of ground water quality protection has resulted from concern over the use of subsurface waste injection. Injection of liquid industrial and municipal wastes evolved from the practice of returning mineralized waters that are commonly extracted in combination with petroleum production to subsurface formations. Injection is based on the concept that liquid wastes can be injected into and contained within confined geologic strata not subject to a more beneficial use, thereby providing long term isolation of the waste material from man's usable environment. However, the possibility that injected wastes may escape from the disposal zones and contaminate valuable aquifers has made this method of waste disposal highly controversial, with the result that the federal government has become involved in the regulation of injection wells.

Development of controls

The initial federal entry into injection well control is marked by the 1970 adoption of an injection well policy statement (198) by the Federal Water Quality Administration (FWQA), an action not specifically mandated by legislation. This policy statement was revised in 1973 (2) by the Environmental Protection Agency (EPA), successor of FWQA. The essence of EPA injection well policy is that the agency ". . . will oppose emplacement of materials by subsurface injection without strict controls and a clear demonstration that such emplacement will not interfere with present or potential use of the subsurface environment, contaminate ground water resources or otherwise damage the environment" (2). The policy statement views subsurface injection as a ". . . temporary means of waste disposal until new technology becomes available enabling more assured environmental protection" (2). Although developed without a specific legislative mandate, this policy subsequently has been ratified by Congress (271, p. 648) and continues in effect at present.

The first federal legislation to reflect concern for the practice of waste injection consists of the Federal Water Pollution Control Act Amendments of 1972 (FWPCA)

(85). The most direct reference to injection is contained in the requirement that states desiring to implement provisions of the act authorizing state administration of a waste discharge permit program in lieu of federal administration must have adequate authority to issue disposal well permits (85, sec. 1342(b)(1)(D)). Pursuant to a directive in FWPCA (85, sec. 1314(e)(D)), EPA in 1973 published a report (108) describing processes, procedures, and methods for the control of pollution from deep well injection and other sources.

Although a principal feature of FWPCA is the establishment of a federal waste discharge permit program, the National Pollutant Discharge Elimination System (NPDES) (85, sec. 1342), provisions of law for the program do not specifically encompass injection wells. The basic provision of NPDES is that the discharge of any pollutant without a permit from the EPA Administrator is unlawful, but "discharge of any pollutant" is defined in the act to mean "(A) any addition of any pollutant to navigable waters from any point source, (B) any addition of any pollutant to the waters of the contiguous zone or the ocean from any point source other than a vessel or other floating craft" (85, sec. 1362(12)). This definition would appear on its face to exclude subsurface waste discharge from its scope, but the vague and ambiguous definition of "navigable waters" contained in the act requires further consideration. The definition states that "navigable waters" means "the waters of the United States, including the territorial seas" (85, sec. 1362(7)), and therefore lacks the necessary specificity to serve a useful purpose.

Although no explicit inclusion of disposal wells exists in legislative provisions for NPDES, the apparent broadness of the scope of the act led EPA to promulgate rules and regulations for implementation which extended federal jurisdiction to disposal wells in certain situations.

> If an applicant for a permit is disposing or proposes to dispose of pollutants into wells as part of a program to meet the proposed terms and conditions of a permit, the Regional Administrator [of EPA] shall specify additional terms and conditions in the permit which shall (i) prohibit the disposal, or (ii) control the disposal in order to prevent the pollution of ground and surface water resources and to protect the public health and welfare (54, sec. 125.26).

This provision was intended to encompass the situation where both injection and surface discharge facilities were operated by a firm. Applicability would also have extended to an injection well used as a replacement for a previously existing surface discharge. In a 1973 memorandum (158) concerning the applicability of NPDES to injection wells, an EPA spokesman indicated that the only situations outside the scope of the permit requirement consisted of existing and new installations which had no surface discharge but relied on wells for all disposal operations.

The position taken by EPA regarding extension of jurisdiction to injection wells related to surface discharge facilities was given some support by precedent in the form of a 1971 federal court decision, United States v. Armco Steel Corp. (273). The suit was brought by the United States to enjoin the discharge of certain toxic wastes to the Houston Ship Channel in Texas in violation of provisions of the Refuse Act (204), the principal legal basis for direct federal control over waste discharge prior to enactment of FWPCA. The proposed solution to the discharge problem was an injection well disposal system which was authorized and ordered by the state regulatory agency. After this state authorization, the United States amended its complaint to additionally enjoin use of the injection well system and enforcement of the state order for its use, primarily because of the existence of abandoned oil and gas wells in the area which might have allowed the injected waste to escape from confinement.

Because of the existence of legislation in the form of the Refuse Act, the authority of the United States to regulate the waste discharge to the ship channel was upheld by the court without question. The United States based jurisdiction over the injection well proposal primarily on the theory of "pendent jurisdiction"--that a federal court in resolving a federal controversy can also settle closely related state claims. Although the language of the court in the case never deals conclusively with the question of jurisdiction, it appears that jurisdictional limitations were recognized. Nevertheless, the suit for injunction was not dismissed completely; rather, a compromise solution was imposed. After noting that it was not within the province of the court to affirmatively direct any one method of waste disposal, the court granted an injunction prohibiting certain discharges to the ship channel and also conditionally enjoined the injection well proposal. The condition imposed as a necessary requirement for using the injection technique was that a number of abandoned wells within a two and one-half mile radius be plugged, a requirement based on the recommendations of EPA. The court also noted that it was impressed with testimony that other economically competitive methods of waste disposal were available for use, thereby creating feasible alternatives to the steel corporation if the conditions for use of subsurface injection were unacceptable.

The question of EPA's regulatory jurisdiction over injection wells under FWPCA was officially answered in early 1975 by the U.S. District Court for the Southern District of Texas in United States v. GAF (277), a suit brought by EPA challenging the authority of an industry to engage in deep well injection without EPA approval. The court decided the jurisdictional question in the negative and dismissed EPA's attempt to obtain an injunction against the use of the injection wells in question.

The primary basis for the court's decision consisted of its interpretation that FWPCA does not apply to waste discharges into subsurface waters. EPA's position was based on several provisions of the act which the agency interpreted as granting implied jurisdiction. Two definitions were relied upon by EPA. It was noted that the definition for point source of pollution specifically encompassed wells. The exclusion of certain injections made in connection with oil and gas production was also seen as support since the exclusion was viewed as unnecessary if all subsurface waste discharges were already excluded. Another attempt to establish implied jurisdiction was based on joint consideration of two provisions, one subjecting the federal permit program to the same terms, conditions, and requirements as apply to a state permit program and the other establishing the authority for issuance of injection well permits as a necessary condition for state assumption of NPDES administration. However, the court noted that a proposed amendment that specifically would have extended federal control to ground water had been rejected. Thus it viewed EPA's interpretation that ground water was encompassed by provisions of the act as attempts to build a "jurisdictional back-door" (277, p. 1584) that were opposed by "irrebuttable language and unambiguous action found in the legislative history" (277, 1584).

Provisions of SDWA

Although the district court's decision in this case if upheld on appeal effectively would have ended EPA efforts to regulate injection wells under the provisions of FWPCA, the decision had no lasting effect since jurisdiction had clearly been conferred by passage of the Safe Drinking Water Act (SDWA) (221) approved in December, 1974, prior to the final decision in GAF. The SDWA is the most comprehensive federal legislation enacted to date with regard to protection of ground water quality. A major concern reflected in the act is protection of underground sources of drinking water (221, secs. 300h to h-3), and direct controls over waste injection are provided. The principal regulatory measure is contained in the provision that the Administrator of EPA develop regulations for state injection control programs which contain minimum requirements to prevent waste injection which endangers underground sources of drinking water (221, sec. 300h-1). The act provides that injection endangers drinking water if it may result in the failure of any public water system to comply with water quality standards to be developed by EPA pursuant to SDWA or otherwise adversely affect the health of persons (221, sec. 300h(d)(2)). The act's legislative history indicates that this provision is to be construed liberally so as to protect potential drinking water sources as well as currently used sources. It is indicated that

Congress intended the Administrator to provide protection for all subsurface water having less than 10,000 parts per million dissolved solids (271, p. 6484).

The act provides for state assumption of enforcement responsibility upon the approval by the Administrator of EPA. A state must comply with various procedural requirements in order to acquire and maintain enforcement responsibility, but the primary condition is adoption and implementation of an injection control program consistent with regulations developed by EPA under SDWA. If a given state does not apply for enforcement responsibility or if the state program is disapproved, the Administrator is authorized to prescribe a program for such state. Where EPA has enforcement authority in a given state, the Administrator is to enforce compliance with the injection control program by means of civil actions in U.S. district court. EPA is also authorized to bring such actions to compel compliance where a state has obtained enforcement authority, but exercise of such authority cannot be accomplished prior to exhaustion of specified procedural requirements designed to give the state an opportunity to act (221, sec. 300h-2). The enforcement authority of a state can be terminated after a public hearing by rule of the Administrator where requirements for approval are no longer being met (221, sec. 300h-1(b)(3)).

The SDWA gives the EPA Administrator considerable discretion in developing injection well regulations, but certain specific requirements are enumerated. The act provides that the regulations shall prohibit unauthorized injection effective three years after the enactment date of SDWA; provide that injection which endangers drinking water not be authorized; include inspection, monitoring, record-keeping, and reporting requirements; and apply to injection by federal agencies and all injection on federal property (221, sec. 300h(b)(1)).

The act contains provisions stating that the regulations cannot prescribe requirements which interfere with or impede injection of brines or other substances brought to the surface in connection with oil or natural gas production or with injection for secondary or tertiary recovery of oil or natural gas unless such requirements are essential to assure protection of underground drinking water sources (221, sec. 300h(b)(2)). These special provisions reflect the fact that the goal of ground water protection is somewhat in conflict with maximizing energy production. While injection related to energy development is to be given special consideration, the act does not exclude such operations from regulation as did FWPCA. The legislative history indicates an intent that such operations be regulated where essential to assure protection of underground drinking water sources but not be subjected to requirements that would stop or substantially delay production of oil or gas (271, pp. 6484-85).

The SDWA contains special provisions applicable during the three year interim period while injection control programs are being developed. Although federal jurisdiction generally will not be established during this period, the act provides for designation of special management areas within which new injection wells cannot be operated without an EPA permit. Such areas can be designated by the Administrator upon the petition of any person if he finds that the area has one aquifer which is the sole or principal source of drinking water and which, if contaminated, would create a significant hazard to public health. A permit for a new injection well in such designated areas can be issued only if the Administrator finds that operation of the well will not cause contamination of the aquifer so as to create a significant hazard to public health. The issuance of permits may be conditioned on such control measures necessary to prevent hazardous contamination (221, sec. 300h-3).

Another aspect of such designation consists of restrictions on federal funding of projects within the area. The act provides that, after designation, ". . . no commitment for Federal financial assistance (through a grant, contract, loan guarantee, or otherwise) may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone so as to create a significant hazard to public health . . ." (221, sec. 300h-3(e)). This provision is therefore a potentially significant constraint on the development of designated areas.

The SDWA-mandated underground injection control (UIC) regulations (68) were published in proposed form in October, 1975. They provide separate controls for each of three categories of underground disposal. The first consists of conventional injection wells exclusive of those associated with oil and gas production and includes industrial and municipal injection wells, subsidence control wells, barrier wells, recharge wells, and mining wells. The second category consists of conventional injection wells related to oil and gas production and includes injection for disposal and production purposes. The third category consists of "all other underground injections" and includes certain disposal operations other than conventional injection wells having a potential impact on ground water quality.

The provisions of the UIC regulations applicable to conventional injection wells not associated with oil and gas production (68, pp. 961-63) require that each such well must be authorized by permit with the exception that wells in existence on the effective date of the regulations may be authorized by rule until December, 1982. The regulatory provisions for wells in this category set forth detailed procedural requirements and conditions for authorization. These requirements encompass such areas as data to be submitted with permit applications, well construction techniques, monitoring, contingency planning, assignment of liability for the injected contaminants, permit modification or revocation, inspection of facilities, and well abandonment.

UIC provisions applicable to injection wells related to oil and gas production (68, pp. 963-66) also require specific authorization in the form of a permit on a case-by-case basis. In the case of wells existing on the effective date of the regulations, provision is made for an additional five year period for review of data and issuance of permits in compliance with prescribed guidelines. Comprehensive requirements are presented for authorization of new injection wells encompassed by this category.

Requirements applicable to "all other underground injections" (68, p. 966) are much less detailed than those applicable to conventional injection wells. Provision is made for regulation by either permit or rule. Where the permit approach is adopted, the proposed regulations require submission of adequate information to satisfy the state regulatory agency; public notice and provision for public comment concerning each permit application; and that permits issued will be conditioned on compliance with specific inspection, monitoring, recordkeeping, and reporting requirements. State regulations that employ the rule approach must provide for prohibition of injection that endangers underground drinking water sources, notification of the state agency concerning the existence of injection and submission of information, and periodic testing and maintenance of test records in appropriate cases.

Although these requirements provide for considerable flexibility in implementation and will likely allow a number of states to continue existing controls to a large degree, their inclusion in the UIC regulations proposed by EPA may become controversial due to the lack of explicit authority in SDWA for control of activities other than conventional injection wells. Provisions of SDWA authorizing the UIC regulations refer exclusively to "underground injection" as the activity to be regulated, but the act does not place clear limits on the meaning of the term, defining it simply as ". . . the subsurface emplacement of fluids by well injection" (221, sec. 300h(d)(1)).

Although this definition on its face would appear to limit the scope of the regulations to conventional injection wells, EPA is seeking to expand the traditional meaning of this provision by further defining "well injection" to encompass conventional injection wells and another category of activities described as shallow injection wells. The definition proposed by EPA reads as follows:

"Well injection" means any or all of the following practices:

(1) "Conventional Injection Well"--subsurface emplacement through a drilled, cased and cemented hole, except when the hole is used only to dispose of or store fluids resulting from agricultural operations, urban run-off, septic tanks or cesspools.

(2) "Shallow Injection Well"--subsurface emplacement resulting from the disposal or treatment of fluids, or the use of fluids in a manufacturing process, in a natural or manmade opening or excavation including those openings or excavations having a surface diameter, width or length greater than their depth; except that "shallow injection well" does not include septic systems or cesspools serving only a single residential unit (68, p. 959).

EPA explains the reasons for this approach and its possible basis of support in the following manner:

> As noted above, the Act defines "underground injection" as "the subsurface emplacement of fluids by well injection" [citation omitted]. However, "well injection" is not defined in the Act. EPA believes that "well injection" should be defined in the regulations because that term establishes the jurisdictional limits of the regulatory programs contemplated by the Act.
>
> Certainly, "conventional" injection wells--injection through drilled, cased and cemented holes--are included within the definition of "well injection." The House Report on the SDWA makes several references to well injection by conventional wells. . . . However, it is also clear that "well injection" encompasses more than conventional injection wells. The House Report refers specifically to septic systems serving more than one residential unit [citation omitted]. And there is no suggestion in the legislative history or the Act that wells which inject contaminants underground are not covered simply because they are not drilled, cased and cemented.
>
> The term "well" encompasses any opening or excavation by which fluids are emplaced underground. And, "injection" necessarily encompasses practices other than emplacement under pressure, since many conventional injection wells operate by gravity flow rather than pressure. For these reasons, and because "shallow wells" such as industrial pits, ponds and lagoons pose a greater hazard to underground drinking water sources

> than do conventional injection wells, Section 146.2(r) defines "well injection" broadly. This broad definition is consistent with the language of the statute and carries out the Congressional intent of protecting underground drinking water sources. Comments are invited on the proposed definition (68, p. 955).

The statement in the above quotation that ". . . it is also clear that 'well injection' encompasses more than conventional injection wells" does not appear to have strong support. The principal support relied upon is a reference in the Act's legislative history to septic systems serving more than one residential unit. The reference to septic systems is contained in the following passage from a legislative report accompanying the Act:

> The definition of "underground injection" is intended to be broad enough to cover any contaminant which may be put below ground level and which flows or moves, whether the contaminant is in semi-solid, liquid, sludge, or any other form or state.
>
> This definition is not limited to the injection of wastes or to injection for disposal purposes; it is intended also to cover, among other contaminants, the injection of brines and the injection of contaminants for extraction or other purposes. While the Committee does not intend this definition to apply to septic tanks or other individual residential waste disposal systems, it does intend that the definition apply to a multiple dwelling, community, or regional system of injection of waste (271, p. 6483).

It is significant to note that the statement concerning septic systems serving more than one residential unit to which reference is made in the above-quoted EPA statement does not necessarily apply to all multiple connection septic systems but applies to a ". . . multiple dwelling, community, or regional <u>system</u> <u>of</u> <u>injection</u> <u>of</u>

waste" [emphasis added]. Conventional injection wells have been used to dispose of sewage and can be distinguished from the typical facility for underground sewage disposal.

The primary intent of the above passage from the legislative history of SDWA appears to be an elaboration of the types of injected materials encompassed, with a principal concern consisting of the inclusion of substances injected during oil field operations. An obvious intent is also expressed that domestic wastes from septic systems serving more than one residential unit be included in the regulations when injected. However, there is no positive statement in these provisions which suggest that the regulations are intended to encompass methods of disposal other than injection by means of wells.

A provision in SDWA which suggests that its authors did not view waste lagoons as coming within the meaning of the term "underground injection" consists of the directive for the EPA Administrator to carry out various studies, including the following:

> The Administrator shall carry out a study of methods of underground injection which do not result in the degradation of underground drinking water sources.
>
> . . . .
>
> The Administrator shall carry out a study of the nature and extent of the impact on underground water which supplies or can reasonably be expected to supply public water systems of . . . (C) ponds, pools, lagoons, pits, or other surface disposal of contaminants in underground water recharge areas (221, sec. 300j-1(a)(5, 6)).

While there is no explicit statement in these provisions to the effect that injection does not include the other waste handling operations enumerated, the fact that separate provisions are utilized implies that the different categories enumerated were viewed as distinct.

It appears that the strongest support for inclusion of these other waste handling operations within the scope of "injection" is the expressed intent of SDWA to protect underground sources of drinking water. As noted in the above-quoted statement by EPA, the activities categorized as "shallow injection wells" in aggregate pose a greater hazard to ground water than do conventional injection wells and therefore need to be regulated. Thus a liberal interpretation would likely uphold the proposed scope of the UIC regulations as a valid exercise of authority while a stricter interpretation based on the precise language of the statute possibly would result in a determination that EPA is attempting to construct another "jurisdictional backdoor" as was held by a federal court when EPA attempted to extend the provisions of FWPCA to activities not encompassed by that statute.

Other programs related to quality protection

In addition to direct federal controls over underground injection of waste authorized primarily by SDWA, other programs exist that relate to ground water quality protection although this objective is not explicitly stated in the enabling legislation. One of the oldest federal programs having a general relationship to protection of ground water quality consists of pesticide controls. The first federal legislation in this area was the Federal Insecticide Act of 1910 (83) which prohibited the manufacture, sale, or transportation of adulterated or misbranded insecticides and regulated sales of insecticides. This act was replaced by more comprehensive legislation in 1947, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (84). FIFRA provided for registration of pesticides prior to sale, labeling requirements, and instructions for use. However, misuse was not prohibited by the law, and it did not apply to pesticides limited to intrastate movement. In 1972, the Federal Environmental Pesticide Control Act (FEPCA) (82) completely revised FIFRA and extended the scope of the federal control program. The 1972 act prohibits pesticide use inconsistent with label directions and extends controls to pesticides used within individual states. FEPCA requires EPA to classify pesticides for general or restricted use and provides for certification by the states of applicators who use restricted pesticides.

A second governmental program related to ground water quality protection consists of federal controls over use of atomic energy and specified radioactive materials. The federal program was first established by the Atomic Energy Act of 1946 (11) which originally created the Atomic Energy Commission (AEC). This legislation was completely revised by the Atomic Energy Act of 1954 (12) and replaced in 1974 by the Energy Reorganization Act of 1974 (75). This 1974 legislation abolishes the AEC and creates two new agencies, the Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC). The act grants responsibility for research and development for all forms of energy to ERDA while NRC assumes the regulatory activities of AEC, including control over waste disposal operations. This new structure therefore terminates the controversial arrangement existing previously wherein responsibilities for both development and regulation of atomic energy were vested in one agency.

A third federal program of general interest with regard to protection of ground water quality is authorized by the Solid Waste Disposal Act (SWDA) (236) as expanded by the Resource Recovery Act of 1970 (209). The primary purposes of SWDA include research concerning improved methods of solid waste disposal and financial assistance for states and other governmental units. The 1970 addition to the law provides for investigations concerning the recovery of useful energy and materials and planning for a system of disposal sites for hazardous wastes.

Constitutionality of federal controls over ground water quality

Extension of federal regulatory activity to encompass ground water quality is a substantial expansion in scope of federal water resources jurisdiction, and the constitutional validity of this activity has not been considered directly by the courts. Nevertheless, there is considerable legal precedent which suggests that this action is a constitutional exercise of federal authority.

The primary basis for federal regulatory programs with respect to water resources has been the commerce clause of the Constitution of the United States (60, art. I, sec. 8). The most direct application of the commerce clause to water resources arises through governmental control over navigable waters. The commerce clause was first held to encompass navigation by the U.S. Supreme Court in the 1824 case of Gibbons v. Ogden (95) and has continued to serve as the basis for most governmental controls. The authority to regulate navigation has subsequently been expanded to include a wide range of controls over navigable waters themselves, and the definition of "navigable" has likewise undergone expansion to include several classes of water not falling within the strict physical meaning of the term. Specific expansions of the navigable classification have included those that can be made navigable by reasonable improvements (272); those that at some past period have been navigable (179); and those that, although non-navigable themselves, affect the navigable capacity of a navigable body of water (278).

Consideration of the extension of the definition to non-navigable tributaries affecting the navigable capacity of a navigable body of water gives rise to the question of whether the constitutionality of ground water controls could be based on the navigability concept. Although classification of ground water as navigable at first appears implausible due to its nature, a legal analogy might be drawn with the extension to non-navigable tributaries since ground water is often tributary to surface waters. In fact, the greatest portion of streamflow may be attributable to ground water discharge during substantial periods of time. Thus the argument that ground water is subject to federal control because of its effect on the navigable capacity of surface waters does not appear implausible.

However, it is unlikely that such a tenuous approach would be necessary to sustain the validity of federal controls. The commerce clause is considerably broader than the navigation power alone, and protection of water quality, both surface and subsurface, appears to be justified on other grounds. The following language from the legislative history of SDWA suggests the possible justifications for federal jurisdiction arising from other aspects of the commerce clause:

> That the causes and effects of unhealthy drinking water are national in scope is evident from a variety of facts. Federal air and water pollution control

legislation have increased the pressure to dispose of waste materials on or below land, frequently in ways, such as subsurface injection, which endanger drinking water quality. Moreover, the national economy may be expected to be harmed by unhealthy drinking water and the illnesses which may result therefrom. This is the case for several reasons. First, outbreaks of water-borne disease are likely to inhibit interstate travel and tourism in or through the areas in which the water is unsafe. Second, the economic productivity of those engaged in interstate commerce or activities affecting commerce is likely to be diminished to the extent that unsafe drinking water causes illness and absence from the place of employment. Third, agricultural employees who migrate across State lines may properly be reluctant to work in areas with only contaminated water supplies. Those who have contracted communicable disease may be barred from entering other States. Fourth, diseases caused by contaminated drinking water may be communicable beyond State lines. Fifth, contaminants which endanger the public health when present in drinking water are frequently generated by business engaged in or enterprises affecting interstate commerce. Sixth, the unavailability of a reliably safe drinking water supply may well be a primary limiting factor in the economic growth of a town or region and ultimately in the growth of the Nation's economy.

Other factors also illustrate the need for national concern about unsafe drinking water. Underground drinking sources which carry contaminants may cross State boundaries. In general, water in the hydrologic cycle does not respect State borders. The Nation also has an important fiscal interest in minimizing drinking water related disease, since such disease may well contribute significantly to the drain on the Federal health care financing system--Medicare, Medicaid, etc.--unless the quality of the Nation's drinking water supplies is protected (271, p. 6461).

Prior decisions of the Supreme Court interpreting the extent of the Commerce Clause indicate that the suggested relationships of water pollution to interstate commerce would be accepted by the Court as a basis for upholding the constitutionality of federal controls to protect ground water quality. A number of cases exist where only an indirect impact on interstate commerce has been viewed as sufficient grounds for upholding the validity of federal controls. For example, the Supreme Court in Wichard v. Filburn (316) upheld the validity of agricultural production controls even where the crops were not placed in interstate commerce but were consumed on the farm. The rationale for this holding was that the crop in question satisfied a need which otherwise would have been reflected by purchases on the open market, thereby competing in effect with similar crops in commerce. Another example of the extensive reach of the commerce clause is given by United States v. Darby (276), a case upholding the validity of labor standards legislation applicable to employers engaged in interstate commerce on the grounds that interstate shipments of goods produced under substandard labor conditions constituted injurious competition. This case may serve as an analogy with the water pollution situation since inadequate waste treatment also constitutes unfair competition for goods shipped in interstate commerce, even if the effects of the pollution are solely intrastate.

Perhaps the most direct precedent in support of the proposition that ground water quality protection is a constitutionally valid function of the federal government consists of the 1974 federal court decision of United States v. Ashland Oil (274) which upheld the constitutionality of the application of FWPCA to non-navigable waters. Since the controls of FWPCA do not apply to ground water, the constitutionality of such controls was not directly at issue in Ashland Oil, but the reasoning on which the holding concerning non-navigable tributaries is based would appear to be applicable to ground water quality controls. The court noted the necessity of controlling the pollution of non-navigable tributaries if the pollution of navigable streams is to be controlled, a factor easily transferable to the ground water situation. Of even more direct applicability is the court's recognition that water pollution affects commerce in innumerable ways. This broader view of the commerce power eliminates the need for strained interpretations of navigability and would appear to be a more realistic basis for the constitutionality of ground water quality regulation.

Ground Water Considerations in Federal Project Planning and Evaluation

A major factor in water resource management consists of federal projects for development of water and other natural resources. Federal development programs generally have not involved ground water to an appreciable extent, but recent changes in procedures for planning and evaluation of federal project proposals are likely to increase the degree of consideration given to subsurface water. The primary impetus for this development consists of the National Environmental Policy Act of 1969 (NEPA) (169) and the Water Resources Planning Act of 1965 (WRPA) (304) and planning guidelines (200) developed by the Water Resources Council (WRC) pursuant to the Act.

Impact of NEPA

The provisions of NEPA designed to implement the stated policy of environmental protection and enhancement require a considerable broadening of the scope of federal project planning and evaluation. This expanded process encompasses an identification of adverse environmental consequences (169, sec. 4332(c)(ii)) and consideration of alternatives to a particular project (169, sec. 4332(c)(iii)). Both of these requirements can have an important relationship to ground water management.

The identification of adverse project effects would encompass a variety of previously unconsidered ground water externalities such as modifications of ground water hydrology or aquifer contamination. The identification of such consequences early in the planning process will facilitate project modifications to minimize their effects and therefore has the potential to result in greater protection of the resource.

The requirement to consider alternatives to each project proposed may also become a significant factor in ground water management. Federal water resource development projects have almost exclusively involved surface waters, with the construction of surface reservoirs a principal activity. A feasible alternative to such projects may involve utilization of natural ground water supplies or subsurface water storage capacity, and the mandate for federal agencies to consider alternatives creates an increased potential for adoption of subsurface projects.

Since a primary impact of NEPA is to place the project alternative having the lesser adverse environmental impact in a favorable light, it is of interest to compare the impacts of surface impoundments with those connected with subsurface storage. In general, surface reservoirs require substantially greater amounts of construction and disruption of natural environmental conditions. Much opposition has been directed toward dam construction due to destruction of free-flowing rivers and other natural phenomenon, alteration of ecological systems, and dislocation of people and their activities. The fact that subsurface storage minimizes interference with existing land use makes this alternative particularly attractive where environmental impact is a determinant of feasibility.

Impact of WRPA

The primary impact of WRPA arises through the "Principles and Standards for Planning and Evaluating Water and Related Land Resources" (200) developed by WRC in response to a directive in WRPA. A basic effect of the WRC Principles and Standards is the establishment of the multi-objective planning approach, which provides that federal water resource projects are to be planned for the enhancement of national economic development and environmental quality (200, p. 5). Provisions for project evaluation require an accounting of the beneficial and adverse effects on these two planning objectives as well as with respect to regional development and social well-being (200, p. 76).

As in the case of NEPA, the potential impact of the Principles and Standards on ground water arises as a result of emphasis on broadening the consideration of alternatives. The following guidelines are presented with regard to preparation of alternative plans:

> One alternative plan will be formulated in which optimum contributions are made to the national economic development objective. Additionally, during the planning process at least one alternative plan will be formulated which emphasizes the contributions to the environmental quality objective. Other alternative plans reflecting significant physical, technological, legal or public policy constraints or reflecting significant trade-offs between the national economic development and environmental quality objectives may be formulated so as not to overlook a best overall plan.
>
> . . . .
>
> From its analysis of alternative plans, the planning organization will select a recommended plan. The plan selected will reflect the relative importance attached to different objectives and the extent to which the two objectives can be achieved by carrying out the plan.
>
> . . . .
>
> In addition to the recommended plan with supporting analysis, other significant alternative plans embodying

> different priorities between the objectives will be presented in the planning report. Included with the presentation of alternative plans will be an analysis of the trade offs among them. The trade offs will be set forth in explicit terms, including the basis for choosing the recommended plan from among the alternative plans (200, pp. 15-17).

The requirement of developing a plan emphasizing environmental quality would appear to mandate consideration of alternatives involving ground water development and subsurface storage due to their generally lesser environmental impact.

Direct Federal Involvement in Land Use Planning

Since land use planning is a basic component of comprehensive ground water management, increasing federal involvement in this activity is a significant institutional development. Although a wide variety of federal programs have an impact on land use, the two most direct forms of involvement in planning consist of areawide waste treatment management planning mandated by FWPCA (85, sec. 1288) and the urban studies program of the United States Army Corps of Engineers (282).

FWPCA requires that areawide waste treatment management plans be developed for areas designated as having "substantial water quality control problems." Since this term is not restricted to surface waters, ground water quality problems can be a factor in area designation. Provisions of FWPCA specifying the scope of water quality plans for such areas make several explicit or implied references to inclusion of ground water quality considerations. For example, such plans must address processes for the identification and control of underground mine runoff, salt-water intrusion resulting from ground water extraction, and for controlling the disposal of pollutants on land or in subsurface excavations (85, sec. 1288(b)(2)). Specific provision is made for control methods and procedures to include land use requirements, with the result that the required planning must be comprehensive in nature. FWPCA provides that these areawide plans are subject to the approval of the EPA Administrator (85, sec. 1288(b)(3)), thereby establishing a degree of federal control over the substance of the plan itself.

The urban studies program of the Corps provides a mechanism for even broader federal involvement in land use planning. The primary emphasis of this program is water resources management, but the plans developed will affect other urban problems and functions. The stated objective of the program is ". . . to develop, in conjunction with the public, plans which not only offer a realistic prospect for solving specific urban water resource problems, but, equally important, also have the potential to serve as a catalyst for solving other related urban problems" (282, sec. 264.14). The Corps indicates that it seeks ". . . to provide urban water resource plans that are compatible with comprehensive urban development goals of the region under study" and that its plans will provide ". . . an integrated approach to water resources management" (282, sec. 264.17).

The water resource management functions identified as falling within the scope of the program include urban flood control; flood plain management; municipal and industrial water supply; wastewater management; bank and channel stabilization; lake, estuarine, and ocean restoration and protection; recreation management at Corps civil works projects; and regional harbors and waterways (282, sec. 264.15(c)). Some of these program elements are limited in applicability to surface water, but certain functions (e.g., municipal and industrial water supply and wastewater management) must encompass both surface and ground water if viewed comprehensively.

Inclusion of wastewater management planning in the Corps urban studies program has necessitated the development of inter-agency coordination mechanisms since primary responsibilities in this area are vested in EPA by FWPCA. The two agencies have signed an agreement defining the relationship between the Corps urban studies program and areawide waste treatment management planning under the jurisdiction of EPA (282, appendix A). The agreement states that the existence of either program in a given area does not preclude the establishment of the other, but it prohibits duplicate funding for a specific task in development of wastewater management plans and provides for coordination between the programs.

Another basic consideration regarding coordination is the division of responsibilities between the Corps and the local entity involved. The program guidelines indicate that "[c]omprehensive urban area planning is to remain a local responsibility" (282, sec. 264.16(a)). The procedure to be utilized by the Corps is to develop alternative water resource plans, one of which may be selected by the appropriate public officials as a component of the comprehensive plan. Thus the Corps program is intended to augment local planning efforts rather than to supplant them.

It is notable that both the areawide waste management and urban studies programs provide for consideration of implementation mechanisms within the planning process. In the case of the urban studies program, implementation considerations include analysis of institutional requirements imposed by alternative plans and the capability of existing institutions to meet these requirements (282, appendix C). This analysis is to include ". . . financing capabilities, legal authorities, programs and policies, existing capabilities to implement programs for management and capital facilities, and availability of competent personnel in formal organizations and agencies, as well as widespread attitudes and local customs relevant to water resources planning" (282, appendix C, 4). Inclusion of institutional analysis in the planning process constitutes recognition of the fundamental significance of this aspect of water resources management.

RECOMMENDATIONS

General Guidelines for Ground Water Management Institutions

Private v. Public Control

A basic consideration relative to the institutional framework for ground water management concerns the degree of governmental involvement. At one extreme, participation by the legislative and administrative branches of government is minimal, with management consisting largely of the decisions of individual water users within the framework of private property rights. In this system, the primary "management" forces are economic constraints and judicially-defined limitations on activities adversely affecting other parties. In contrast to this relatively passive institutional approach, the legislative and administrative branches of government may assume a more active role and become directly involved in ground water decision-making. This involvement is likely to consist of regulation of water use and may also include governmental investment in such programs as artificial recharge.

A management framework where governmental regulation and other involvement is minimal has an inherent attractiveness. This approach appeals to such basic desires as individual freedom of action and free operation of economic forces to efficiently allocate resources. Proponents of this approach emphasize a number of weaknesses associated with the regulatory approach, including inefficiency, costliness, and the unresponsive nature of the bureaucracy associated with the administrative process.

Yet in direct opposition to what at first appear to be compelling reasons to limit the managerial role of government is a definite trend toward greater governmental involvement in ground water management. The fundamental explanation for this trend is that existing systems of private rights in ground water do not provide a workable framework for the operation of economic forces to protect and allocate the resource. Some of the defects of these systems of rights are enumerated earlier in the study, but a general weakness that permeates this institutional arrangement is an uncertainty as to the extent and enforceability of the private ground water right with respect to both quantity and quality. In the case of the allocation function, the limited accountability under the widely-accepted reasonable use doctrine for the externalities associated with pumping offers little security for the individual user. The probability that legal responsibility will be imposed for quality degradation is also uncertain due to the existence of substantial precedent exonerating from liability those causing contamination as the result of lawful land use. This uncertainty regarding legal accountability for externalities affecting ground water use substantially weakens the potential deterrent effect of private rights on activities adversely affecting the resource. Therefore prospects are reduced that considerations of optimizing the use of the resource for the public good will have a significant impact on individual decision-making. In addition to reducing the incentive for the individual to voluntarily attempt to control adverse external effects associated with his activities, the lack of well-defined rights also makes private negotiations to control externalities impractical. Transactions involving private rights are feasible only where the nature and extent of the rights can be established to a considerable degree of certainty.

The fact that existing systems of private controls over the ground water resource are defective does not necessarily mean that an alternative institutional arrangement is necessary. Doctrines of private rights evolve over time and conceivably may become more effective as controls over externalities affecting ground water. The courts in resolving legal conflicts involving ground water should renounce out-moded concepts and place decision-making on a more scientific basis. With regard to allocation, the absolute ownership doctrine should be rejected as inconsistent with the nature of the ground water resource since its basic premise that one water user cannot anticipate the impact of his use on others cannot be supported. Similarly, the traditional lack of restrictions with respect to on-site use under the reasonable use doctrine makes this approach inappropriate where the potential exists for individual users to adversely affect the supply of a large area. A more rational approach is presented by the correlative rights doctrine which considers the interrelationships among users as a factor in defining individual rights, therefore providing a basis for some degree of control over externalities relating to pumping. There is also need for increased control over other externalities affecting ground water through greater recognition of physical processes in judicial proceedings. The issue of legal accountability in connection with ground water externalities such as contamination requires the balancing of opposing interests, and such proceedings should not be biased by the presumption that ground water processes are incomprehensible.

Although evolution in judicial doctrines ultimately may result in improvement in this mechanism as a control over ground water externalities, the judicial process is conservative by nature and change from established precedent is a slow process. Management problems in some cases have approached crisis proportions without appreciable modification of judicial doctrines. Therefore it appears that the trend toward adoption of new institutional arrangements is justified and can be expected to continue.

In addition to this lack of judicial responsiveness to the problem of external diseconomies, the scope of many non-regulatory aspects of ground water management (e.g., data collection, salt water intrusion control, artificial recharge operations) indicates the need for direct governmental involvement. These programs generally are not divisible to a scale manageable at the individual level. Just as ground water production can have adverse effects with respect to others using the same aquifer, management programs designed to protect or improve the resource produce benefits to others using the common supply. Third party recipients of such benefits generally cannot be excluded, nor can they be required to contribute to the cost of the responsible project where undertaken by a private interest. Thus effective private action is unlikely to be achieved, and governmental management programs appear to be the most practical approach.

With regard to private rights concerning use of aquifer storage space through artificial recharge operations, the courts should uphold the right of the landowner to utilize resources or otherwise develop property without interference from others; however, these rights should extend only to actual or reasonably predictable use and should not be allowed to prohibit use of subsurface space for water storage in the absence of direct interference with the use of property. This concept of limiting private rights in the subsurface to a depth of useful ownership is consistent with existing theories of mineral rights and is similar to the restriction of property rights in airspace to accommodate the needs of public aviation.

Managerial Roles of the Different Levels of Government

If it is assumed that direct governmental involvement is an inevitable aspect of ground water management, the relative responsibilities of government at the various levels becomes a significant consideration. At present, management functions are distributed among all levels, including federal, interstate, state, regional, and local governmental units. However, management programs are not highly developed in many areas, and considerable diversity exists among existing management programs with respect to this aspect of institutional organization.

On the basis of considerations of the physical characteristics of ground water and previous experience with various institutional arrangements, it appears that the state is the appropriate level of government to exercise primary management responsibilities. The principal advantage of state government arises from the perspective with which it views ground water management issues. While remaining close enough to management problems to give consideration to geographical and other variables, the state can view such problems in relation to a broad spectrum of natural resource and environmental needs. The viewpoint is neither too far removed from consideration of individual problems and issues nor too parochial to exclude the proper scope of management considerations.

However, the fact that the state is viewed as the locus of ground water management authority does not mean that other levels of government should have no management responsibilities. Governmental units ranging from the international to local levels can play key roles. Where aquifers cross national boundaries, management institutions must have an international structure in order to constitute a viable approach. Within the United States, a federal role in ground water management is indicated by requirements of scale with respect to program elements such as data collection and analysis and the need for uniformity among the states with respect to ground water quality protection.

In addition to the need for federal involvement, ground water management may necessitate institutional mechanisms less extensive than the federal scope but yet broader than the state level in situations involving interstate aquifers. Where aquifers cross jurisdictional boundaries, the management efforts of one state can be frustrated by application of incompatible concepts in others. Thus an institutional structure consisting of independent management approaches by the individual states is not likely to be a viable approach, and creation of management units based on hydrologic boundaries or development of coordination mechanisms among the jurisdictions involved is essential to effective management.

Within the boundaries of a given state, management institutions involve delegation of certain responsibilities to local or regional units of government. Considerations of managerial efficiency and responsiveness to individual problems suggest that management decisions having only local impact be made at this level of government. Similarly, managerial functions affecting two or more local units of government but not involving a state-wide interest ideally should be performed by regional governmental bodies. However, the potential role of regional institutions is somewhat limited by the traditional restriction of the scope of regional governmental authority to non-regulatory functions such as planning. This restriction arises in large part from the reluctance of independent localities to voluntarily surrender delegated authority to broader units of government. This fact suggests that regional authority must be delegated from a higher unit of government rather than consolidation from lower units if this institutional arrangement is to be a viable approach.

Although certain management functions can be performed effectively at regional or local levels, delegation of authority to these governmental bodies should be accompanied by proper safeguards. Aspects of managerial decision-making having potential impacts extending beyond such jurisdictions should be reserved for the state or at least subject to state level review. This principle is not limited to such direct management functions as allocation but also applies to other somewhat indirect but nevertheless significant aspects of management. Land use regulation is one such area where some degree of state control is necessary. Protection of the resource from adverse effects of land use practices can be accomplished to some extent through regulation of specific activities such as waste disposal operations, but protection in certain situations may be feasible only through control of type and/or density of land use. Therefore the state has a potential interest in land use controls at least to the extent that it has an interest in the protection of the ground water resource.

Although the extent of direct ground water management authority that can be vested in the local level of government is limited, local participation in management is essential due to the existence of a substantial local interest. Possible mechanisms for local input include public hearings, commenting procedures, advisory committees, and representation on decision-making bodies. The appropriate type of local involvement varies with the management function involved, but some input is necessary with respect to all the elements of a management program.

Institutional Requirements for Allocation

Sources of water included

One of the most basic institutional considerations relative to water resource allocation is the scope of water encompassed within the allocation program. The focus of attention in this study is ground water, but a fundamental requirement of management institutions is compatibility with the physical processes affecting the resource and the capability of dealing comprehensively with existing or potential problems. Therefore management institutions for water allocation should generally encompass both surface and ground water due to the interdependencies between these phases of the hydrologic cycle and the fact that development alternatives for a particular use may involve both sources of water.

The inclusion of both surface and ground water within an allocation program does not necessarily preclude application of special controls to either source of water where dictated by special considerations. For example, a separate control program may be desirable with respect to withdrawals from artesian aquifers having limited connections to surface waters. However, the management agency responsible for allocation should have authority to give recognition to any physical relationships and to jointly regulate use from both sources where a comprehensive approach is desirable due to overall water shortage or other conditions.

Size of management unit

Another consideration relative to the scope of an allocation program is the geographical scope of its coverage. Existence of interstate aquifers may require that control programs extend beyond the boundaries of a single state or even an individual country in some situations, but within a given state, the basic question concerning scope of coverage is whether controls should apply on a statewide basis or to smaller intra-state regions. Considerations of the physical characteristics of ground water suggest that controls be applied on the basis of hydrologic units indicating that a regional approach such as the critical area program employed in a number of states is desirable. The regional application of controls focuses attention on special problem areas while leaving other areas unburdened by unnecessary controls, but this control program can be expanded to include an entire state if physical conditions so dictate.

Determination of the maximum pumping rate for an aquifer

Water resource allocation involves decisions with regard to distribution of water over time and also among competing users at a particular point in time. Accomplishment of the former goal requires establishment of policies with regard to maximum rates of use while the latter involves priorities among different categories of uses and among users within categories.

A central issue regarding inter-temporal allocation of ground water is the relationship between the rate of use and rate of replenishment. Where total use is less than replenishment, the ground water involved is a flow resource and the time element is not important to management since the uses involved can be continued indefinitely. Therefore determination of the maximum rate of use which can be sustained indefinitely--the sustained yield--is a basic management consideration. However, the sustained yield is not a fixed quantity of water but is a dynamic concept dependent on a number of factors. For example, the rate of recharge to an aquifer may depend on the level of pumping since it tends to reject more water at stages of higher water levels or artesian pressures. Therefore pumping may increase the effective rate of recharge by reducing the amount of water rejected, but the increased yield of the aquifer is accomplished by a corresponding reduction of water available to the surface sources formerly receiving the rejected water. Other factors affecting the sustained yield include such phenomenon as modification of natural recharge rates due to alternations of the condition of the land surface, use of artificial recharge, and the spacing and pattern of pumping from wells (104, pp. 17-19).

In areas where natural recharge is small and artificial recharge not feasible for economic or other reasons, appreciable use of ground water as a source of supply may necessitate a rate of withdrawal exceeding that of replenishment--the situation known as ground water mining. Continued use under such conditions involves the eventual depletion of the aquifer being pumped. Although ground water mining may be viewed by some as an undesirable if not immoral concept, its adoption has been necessitated in some areas by severe water scarcity. A commonly expressed rationale for this approach is that mining of the available ground water will facilitate expansion of the economic base of the area involved, thereby providing the financial support for acquisition of alternative supplies prior to exhaustion of the ground water.

In addition to the impact of the pumping rate on longevity of a given water supply, pumping rates and the resulting effect on ground water levels or artesian pressures must also be viewed in terms of other factors. For example, pumping may result in contamination of an aquifer where pressure modifications induce movements of brines or other pollutants. The pumping lift rather than quantities of water may determine the limits of ground water mining or prevent the attainment of maximum sustained yield. In addition, lowering of water tables or dewatering of artesian aquifers may result in subsidence of the land surface and permanent damage to aquifer storage capacity (197).

Therefore the selection of a maximum pumping rate for a given aquifer is a complex undertaking involving a diversity of considerations. Of course restricting use such that the resource is renewable either by natural or artificial means has inherent advantages where feasible. This approach is likely to continue to receive wide acceptance in areas where recharge is significant. However, mining as either a temporary or long-term management option may be necessary where recharge is negligible. This approach therefore is more likely to be adopted in arid areas but may see selective use in humid areas. The final choice of management philosophy must depend on a complete analysis of alternatives and the long-range implications associated with each.

Apportionment of available supplies among users

Existing uses

After the maximum pumping rate is determined, the next consideration is allocation of the total withdrawal among individual users. A significant issue in this regard is the treatment of uses existing when controls on use are initiated. Such uses are likely to be substantial since actual or potential overuse is the primary reason for application of controls; therefore their treatment is likely to be an important management consideration.

A special complication in resolving this issue is the fact that an established water use is a constitutionally-protected property right, but consideration of this issue earlier in the study has indicated that some control may be feasible. Such regulation as is necessary to prevent excessive and wasteful use should be justified in the public interest regardless of whether the initiation of such use precedes the application of controls. Therefore existing use should be recognized only to the extent of application to a beneficial purpose, a determination which should be based not only on type of use but also on the efficiency of the particular application. The agency with allocation responsibilities should be authorized to establish water rights of existing users below the level of historical use where application of water-saving technology and practices is reasonably practicable without undue interference with a particular operation. As precedent for this approach, an analogy might be drawn with pollution control regulations. Phased upgrading of equipment and processes to achieve effluent reductions consistent with available technology is an integral aspect of such controls. The fact that a particular discharge was initiated prior to controls does not create an exemption from application of technological advancements and achievement of reasonable efficiency objectives.

In addition to questions of degree of control to be imposed on existing uses, another basic issue concerns measurement of such uses. The magnitude of existing uses is particularly significant in view of the fact that they represent to some extent an irreversible commitment of a substantial portion of ground water supplies. Although existing uses have some period of historical record, determination of magnitude for purposes of legal recognition is complicated by fluctuations that occur in use rates.

Since recognition of existing use generally implies preservation of the status quo as to overall water use associated with a particular operation, long-term average values must be the fundamental factor in determining the magnitude of such uses. Provision should be made to allow average use rates to be exceeded for short periods in order to accommodate such fluctuations in use as can be expected on the basis of historical records and reasonable requirements of the particular use, but the recognized water right must be tied to long-term averages in order to provide effective control. Granting of water rights on the basis of maximum use rates alone establishes a situation within which average use rates conceivably could be expanded without further approvals, thereby circumventing the allocation process.

Exemptions

In addition to the issue of regulating existing uses, the question of exemptions from allocation controls is a significant management concern. Exemptions are necessary due to the large number of small uses of negligible impact on the resource that would pose a substantial administrative burden if regulated. However, listing of a variety of categorical exemptions creates problems of interpretation and leads to development of unforeseen regulatory loopholes. Therefore the only exemption from controls should consist of all uses below some specified magnitude, e.g., 100,000 gallons per day. Such a provision would encompass all individual domestic and other uses of negligible impact while leaving all major uses subject to controls. Specific exemption of domestic use raises the question of whether public water supplies are included. While such use may be given special preference in the allocation system, it should not escape all regulation due to the wide diversity of uses in addition to domestic purposes supplied from public systems and the potential magnitude of such withdrawals. Other uses such as agricultural which traditionally have been given high preferences in water allocation also should not be exempted but subjected to controls when in excess of the prescribed use rate. Complete exemption of any potentially large use interjects an uncontrollable variable in an allocation program that tends to undermine its overall effectiveness.

Criteria for approval
of new uses

Since the basic reason for adoption of an allocation system is the scarcity of water and the need to make choices between competing uses, there is need for development of criteria for systematic evaluation and comparison of proposed withdrawals. One possible basis for selection is priority of application. This approach has the advantage of administrative simplicity and bears some relationship to the fundamental concept of the appropriative doctrine that priority in time establishes a superior right. However, establishment of a ranking among uses on the basis of priority of actual initiation of use can be justified as a mechanism to protect investment in related facilities, whereas no such rationale exists at the application stage. It therefore appears that time of application is not a sound criterion for choice between applicants competing for a water right.

A more meaningful criterion for allocation between competing uses is the value of the water in the proposed alternative uses. With regard to maximization of the return from a given quantity of water to be allocated, the primary value consideration is the change in value of output associated with incremental changes in amount of water applied, which is known as the marginal value product

(MVP). The MVP generally tends to increase initially as more water is applied to a particular use, but a point is reached after which addition of further water causes MVP to decrease. The specific relationship between MVP and units of water applied varies with the individual use, but some particular allocation of an available supply of water generally exists such that the MVP's of the competing uses are equal. This point is the most economically efficient allocation since a transfer of water from one use to the other under this condition of equality will not increase the return to the resource.

Allocation on the basis of MVP analysis is theoretically possible at the level of the individual water using activity, provided that data is available concerning the relationship between product output and water use. Due to the likely absence of such information with regard to individual water uses, a more generalized level of analysis may be more feasible wherein comparisons involve general categories rather than specific water uses. Although some attempts have been made to determine values at this level (323), major data deficiences exist, indicating the need for increased efforts to determine the value of water in its alternative uses. Non-economic factors will continue to be significant in water resources management, but there is a need for greater incorporation of economic efficiency considerations than has been accomplished to date.

Permit limitations

Allocation of water that is surplus at a particular point in time should be viewed as a conditional grant subject to a specified period of duration. Since the future cannot be predicted with accuracy, granting of unalterable water rights in perpetuity is an unsound management concept. Water-using activities require investments of varying periods of amortization, indicating that duration should be variable with regard to different types of use; but some time limit should be established. Water users should be authorized to apply for renewal of rights at the date of termination, and certain preference may be shown to such established uses; however, the management agency should have the authority to assign a particular water right to a different application if this course of action is dictated by considerations of the public interest.

Water rights assigned within the allocation process should be subject to a forfeiture procedure providing for loss of rights and reversion to the state upon ceasation of use for a prescribed period of time. This provision is necessary to allow the rights to unused water to be transferred to another application, thereby increasing the utility of a given supply.

Role of economic incentive

As a supplement or partial alternative to direct regulatory action to restrict wasteful use of water and encourage more optimal application, an allocation program may employ various economic incentives to accomplish these objectives. One approach consists of a system of government-imposed charges on water use such as a pump tax. If such charges were applied on the basis of units of water pumped, an economic incentive would be created that would tend to limit the excessive withdrawal likely where the only cost of water relates to installation and operation of pumping facilities. This approach would be opposed by ground water users on the basis of the theory that the state cannot impose a charge for use of a privately-owned resource, but this argument has little substance where pumping withdraws water from land other than that of the well owner. In addition, a tax imposed as a conservation measure would likely be justified as a valid regulatory measure encompassed by the police power. Precedent for the successful imposition of a pump tax exists in the form of previously discussed programs operating in the State of California. Utilization of taxes has potential applicability to all uses, including those initiated both before and after development of regulatory programs.

The allocation function also can be facilitated by means of economic incentive if water rights are made transferable. The need for continuous governmental review of existing use would be decreased if water rights were a marketable commodity free to move toward more productive uses by means of individual transactions. Historically, substantial impediments have existed to water rights transfers even where given explicit governmental recognition due to the need to protect third parties and the public in general from possible detrimental effects associated with such transfers (263). Regardless of such problems, however, transferability offers potential advantages and should be recognized subject to a minimum of constraints to protect the public interest.

The water allocation program should contain provisions for short term constraint of water withdrawals under special emergency conditions. Examples of conditions where such constraints may be necessary include water shortages causing interference between users, threat of aquifer damage from dewatering and resulting subsidence, and danger of ground water contamination from pumping-induced movement of pollutants. The agency responsible for administration of controls should be authorized to require reductions in all uses or to curtail certain uses in a pre-determined order on the basis of such criteria as established preferences between types of water use and priority in time where the doctrine of appropriation is in effect.

Provision should be made for imposition of constraints without hearings or other formal proceedings where problems require immediate attention, but special requirements for hearings and other procedural safeguards should be established for continuance of such constraints beyond a short period of time.

Vesting of administrative responsibility

The allocation function is one likely to involve substantial disagreement as to vesting of administrative responsibilities. Consideration of the principle that a particular management function should be exercised at the lowest level of government possessing adequate managerial perspective and capabilities suggests that primary control be exercised by the state. However, allocation of ground water supplies is a matter of local concern, and mechanisms for local input are necessary. In one approach, local input is advisory only and utilizes special committees, public hearings, and commenting procedures.

Provision can also be made for direct local participation in decision-making. A possible mechanism for such participation consists of establishment of a special administrative board composed of both local and state appointees. However, the authority and composition of such a board must be designed to insure maintenance of state control. Therefore a majority of the membership of the special board should be state appointees. Special provisions must also exist to insure that the actions of the board are coordinated with other elements of the state water resource management program, either through a requirement that the state representatives be selected from the decision-making body of the agency primarily responsible for water resources management or through some other mechanism.

Institutional Requirements for Protection of Quality

Protection of ground water quality encompasses an extremely diverse group of activities. Some of the potential sources of contamination consist of waste discharge operations while others involve the handling and utilization of a wide range of products not related to waste disposal. A number of activities are known sources of ground water contamination while others remain only potential sources, but even the latter cannot totally be disregarded in a comprehensive quality protection program.

Degree of centralized control

Due to the diversity of activities that can result in ground water contamination, a basic institutional question involves the degree to which regulatory responsibility can be centralized. At present, considerable fragmentation of responsibility exists, including control of waste disposal operations.

Wastewater management programs traditionally have been divided into surface and subsurface components. At the federal level, a degree of separation in surface and ground water controls is promoted by the existence of separate legislation in the form of FWPCA and SDWA. Rather than inclusion of basic controls over ground water quality in SDWA, a more desirable approach would have been the expansion of the scope of FWPCA to include subsurface as well as surface water. The adverse consequences of separate legislative mandates are mitigated by the fact that administrative responsibilities under the two statutes are delegated to the same agency, but the existence of independent requirements produces an inherent obstacle to an integrated approach. At the state level, pollution control programs typically encompass both surface and ground water, but independent controls applicable to specific sources of ground water contamination such as septic tanks sometimes exist concurrently. Separate administration of such controls tends to limit the effective scope of the general pollution control program.

The result of this separation of water quality management into surface and subsurface components has been to hinder application of uniform policies to the two sources of water. To date, considerably more emphasis has been placed on protection of surface water quality than ground water quality. One inherent consequence of employing stricter regulations in the case of surface water is to encourage methods of waste disposal that endanger ground water quality. Where the agency with primary water quality protection responsibilities must enforce non-uniform policies or has its perspective limited by the vesting in another agency of authority to control certain sources of ground water pollution, bias is introduced into the evaluation of specific waste disposal proposals. Alternatives involving a subsurface discharge are likely to be viewed more favorably than those involving discharge to surface waters, with the result that an element of objectivity in project evaluation is lost. In order to provide more comprehensive environmental protection, pollution controls should require consideration of all adverse effects of each individual waste disposal operation rather than selective aspects only. Therefore sound management would be facilitated by consolidation of regulatory controls applicable to surface and subsurface waste disposal operations.

Although a degree of consolidation of regulatory controls over waste disposal would be advantageous, complete centralization of control over all activities having a potential impact on ground water quality is not feasible due to their wide range and diversity. No existing governmental body possesses such power, and the establishment of an agency with such broad authority does not appear desirable or politically feasible. However, some mechanism must exist to insure systematic consideration of the impacts of these activities on ground water quality such that relevant decision-making takes place with full cognizance of adverse consequences.

In order to accomplish this objective, direct inter-agency agreements must exist to insure proper input to related decision-making processes. The agency with primary responsibilities for ground water quality protection should have an express mandate to participate in formulation of policy and promulgation of regulations in related areas. The responsible agency should also provide input into individual regulatory decisions such as actions on permit applications in order that ground water protection be treated as an integral aspect of related management programs at the operational level. Of specific concern are such areas as solid waste disposal, mining and quarrying operations, pesticide application, use of highway de-icing chemicals, and storage and handling of petroleum products and other potential pollutants. These activities are generally subject to some degree of state control, thereby facilitating development of mechanisms for input from a ground water management program.

In addition to the need for incorporation of ground water considerations into these regulatory programs applicable to specific activities, there is also need to insure that ground water considerations are encompassed within general land use planning and control. A special institutional complication concerning coordination of ground water management and land use control arises from the widespread practice of delegating authority for land use controls to the local level of government. The fact that land use controls must be viewed as a component of ground water management indicates the need for state government to exercise powers of review with respect to local land use decisions having a potential impact extending beyond the local jurisdiction.

Application of the district approach

In some cases, a feasible alternative to a general state-wide consolidation of land use controls and other ground water-related regulatory functions at the state level of government may exist in the form of the management district approach that has seen considerable utilization in allocation programs. Such an approach would allow greater centralization of controls for application on a selective basis than may be possible or desirable on a state-wide basis. This centralization of controls would involve vertical consolidation of functions now performed at lower levels of government as well as horizontal merger of responsibilities normally vested in different state agencies. The types of activities encompassed would include land use in general, all waste disposal activities, and other activities normally not regulated within the scope of water quality management programs. Included in this last group would be private operations such as pesticide application and location of storage facilities for gasoline and other products as well as public operations such as storage and use of highway de-icing chemicals.

In addition to a more centralized administration of controls, more stringent criteria and specifications could be developed for application where required to insure ground water protection. These more rigorous control measures would include special requirements for site investigation, design, and monitoring in connection with facilities posing a contamination hazard. Special controls would also need in some cases to encompass designation of certain areas to be reserved from development where high potential for contamination exists.

Designation of ground water quality management districts would be based on consideration of over-all potential of an area for ground water contamination and the significance of such an occurrence. Criteria for designation would include the importance of the ground water supply of the area; the number and rate of growth of possible contamination sources; and the existence of physical conditions creating a high risk of contamination, including aquifer outcrops, karst topography, shallow soils, and high water tables.

The concept of ground water quality protection districts is equally applicable to the problem of protecting recharge. In areas where the replenishment, and therefore the renewability, of the ground water resource depends on recharge occurring within a relatively small area, control of land use activities having an impact on infiltration capacities can be a significant aspect of management. Protection of the quality and quantity of recharge are administratively compatible goals that can be performed jointly within the institutional framework of the special district.

Institutional Requirements for Non-Regulatory Functions

Data collection and analysis

Since adequate knowledge concerning the ground water resource is essential to its management, data collection and analysis must be viewed as the cornerstone of a management program. Data collection programs must encompass both quantity and quality. There is much room for expansion of knowledge concerning existing conditions, and an ongoing effort is necessary in order to detect changes and trends in water levels and quality.

Data collection programs should include special investigations by public agencies to fill specific information needs but also must include required reporting from private drilling and pumping operations as a basic program element. Drilling cores, test results, and other information from drillers provides basic data concerning aquifer conditions and ground water potential, and periodic reporting from producing wells provides a valuable indication of trends in ground water conditions. Requirements for data reporting should be continually reviewed by the agency responsible for ground water management with regard to such factors as adequacy of coverage and form of reporting.

Comprehensive programs of data collection and analysis generally have been conducted through cooperative programs between the individual states and the USGS. This institutional arrangement has proven satisfactory and can be expected to continue. Due to the states' intimacy with individual problems and direct involvement with other aspects of management, general guidance for data collection activities should be provided by the state agency involved. The primary federal role should be to maintain a high level of capability and expertise which can be utilized to complement individual state programs.

Physical project planning and implementation

Although substantial increases in the benefits obtainable from the ground water resource can be achieved through regulation of use and control of activities having an adverse impact, management should not be viewed as strictly a regulatory activity. In some cases, further increases in the returns from the resource may be feasible through physical control measures such as artificial recharge or barriers to salt water intrusion. As noted previously, such projects are not likely to be undertaken by private interests due to the necessary magnitude of such operations and the problem of assessing costs to all parties who benefit. Thus some public role is suggested.

With regard to the issue of administrative and financial responsibility for such projects, the localized nature of the benefits indicates the necessity for local participation. However, such projects cannot be viewed strictly as matters of local concern due to necessary management and financial capabilities and the fact that a broader interest exists concerning the basic welfare and stability of individual localities. Therefore a role exists for the state level of government that appears to include at a minimum the responsibility for general planning and evaluation of the need for such undertakings. The state should also exercise regulatory control over projects such as artificial recharge having the potential for adverse external effects.

Recommended Changes in the Virginia Institutional Framework

Evaluation of law and administrative structure currently serving as the institutional framework for ground water management in Virginia indicates that the program is consistent with the preceding generalized guidelines in a number of areas. However, substantial deviation from the model institutional framework occurs in several instances and creates weaknesses in the existing program; therefore, recommendations have been formulated that suggest specific modifications of Virginia law and administrative structure to remedy these deficiencies. The basic rationale for the recommendations is contained in the preceding guidelines, but each proposal is followed by a brief summary of conditions in Virginia that create the need for change.

1. The scope of the Virginia critical area program should be broadened to allow application to all water within a given area or to any particular source of water as dictated by special management needs.

The existing critical area program reflects the traditional approach to development of water resource management institutions in the Commonwealth. The program was designed in response to a specific type of problem rather than on the basis of a general assessment of long-range management needs. Thus it does not provide a basis for dealing with other developing problems that have not reached crisis proportions.

The State of Virginia traditionally has followed a relatively passive approach in the area of surface water management, with the allocation function having been accomplished by the courts within the framework of private property rights. Although this passive approach possesses certain advantages under conditions of relative water abundance, experience in a number of states indicates that this allocation system becomes inadequate as the number and complexity of water use conflicts increase. At some point it becomes desirable to establish a more comprehensive management approach, within which an administrative body controls water use to promote development consistent with relevant plans and policies. The judicial process is not completely by-passed since it hears appeals from administrative decisions, but the over-all decision-making process is strengthened where management decisions are made in the first instance by an administrative body encompassing relevant expertise and adequate capabilities for data collection and analysis.

Surface water is still an abundant resource in Virginia when total natural supply is compared to total use, but local and regional supply problems are developing as the result of uneven temporal distribution and disparities between geographical distribution of water and population. For example, the populous southeastern region of the state is facing an imminent shortage, with a large scale inter-basin transfer of water from the Roanoke River Basin proposed as the most promising solution (305). This particular proposal involves many complex issues and has generated an intense inter-regional conflict, indicating the need for state involvement to provide a broader perspective for analysis and evaluation.

2. The critical area program should be expanded to encompass protection of quality.

Under present law, one of the conditions authorizing designation of critical areas is for ground water pollution to have occurred or be expected (109, sec. 62.1-44.95). However, the regulatory provisions contained in the Groundwater Act are limited to control over pumping and therefore provide little protection for quality. One exception is the case of salt water intrusion since control of pumping is an effective remedy. In order to establish an improved institutional capability for comprehensive quality protection, the legislation providing for designation of critical areas should vest authority for the administering body to assume regulatory responsibility and adopt special controls for all significant sources of ground water contamination.

In addition to the consolidation of state level quality protection functions, incorporation of a mechanism for state review of local land use decisions affecting ground water quality is also of fundamental importance. At present there is no procedure in the Commonwealth for direct state review of land use decisions on the basis of water quality protection. Virginia law provides for control of specific activities such as use of septic tanks on a case-by-case basis, but the state does not have a voice in the decision as to designation of appropriate types and density of use of a particular area. Due to the fundamental significance of these decisions to ground water quality protection, the absence of review authority is a serious handicap to the state effort. Incorporation of this authority into the critical areas program would remedy this deficiency in those areas of greatest need while leaving existing institutional arrangements intact in the rest of the state.

If this suggested expansion of the critical area program to encompass water quality protection is combined with the previous recommendation concerning application to surface water, an improved institutional structure for protection of surface water quality will result. As in the case of ground water, a principal improvement will consist of the centralization of responsibilities that currently are somewhat fragmented administratively. At the state level, primary responsibility for discharge of wastes to surface waters is vested in the SWCB (242), but limitations on authority to regulate certain sources of surface pollution exist in the form of specific powers granted to other agencies. For example, the control of mined land reclamation is within the jurisdiction of the Department of Conservation and Economic Development (294, 295), and certain state controls regarding other land disturbing activities that are potential sources of pollution are within the jurisdiction of the Virginia Soil and Water Conservation Commission (76). Although there is need for coordination of such programs with the state water quality management effort on a state-wide basis, actual consolidation of administration would be advantageous in areas with severe water quality problems.

Management of surface water quality would also be facilitated by the provision for review of land use decisions within specially-designated critical areas. Recent recognition of the significance of non-point sources of pollution indicates the important relationship between land use and management of surface water quality. Provisions for ongoing areawide waste treatment management studies contained in FWPCA (85, sec. 1288) require identification of non-point sources and development of control methods, indicating the need to review the existing institutional framework. The critical area approach appears to offer potential as an approach to management of the non-point problem.

3. <u>"Beneficial use" should be specifically defined in the Act to apply to the efficiency as well as type of water use</u>.

Present law does not define the term "beneficial use," leaving the extent of this restriction on water use subject to interpretation. As indicated in the previous analysis, doubt has been expressed as to the authority of the SWCB under the beneficial use requirement to restrict excessive withdrawals by requiring adoption of water conserving practices in the case of existing users covered by the grandfather clause of the Act (241, p. 23). Since very few if any applications of water to a productive enterprise are unreasonable per se, the inability to evaluate the special circumstances of the individual application essentially eliminates the significance of the beneficial use requirement. Subject to judicial review as to reasonableness, the SWCB should be authorized under the beneficial use requirement to impose conditions on individual water users restricting water withdrawals consistent with available water saving technology and practices. Due to continuing technological and other changes, evaluation of each use must be repeated on a periodic basis.

An alternative to application of the beneficial use requirement to increase efficiency of water use which should be given consideration for application in Virginia is the imposition of a charge per unit of water pumped. This approach has the potential to reduce excessive use without requiring extensive governmental review of individual water-using operations and technology.

4. Provisions of the Act relative to registration of existing uses should specify that the extent of the right to be recognized is to be based on the average beneficial use during the year prior to area designation.

Existing law provides for recognition of uses to the extent of beneficial application on any date within a two year period prior to area designation (109, sec. 62.1-

44.93). This provision may be interpreted as recognition of peak daily usage as the sole measure of grandfathered water rights, a development which circumvents the basic intent of the Act to restrict uncontrolled ground water development. Peak usages should be recognized to accommodate necessary fluctuations in use rates, but the extent of the right should be based on yearly averages in order that an effective control on overall use be established.

5. <u>All exemptions to the permit requirement of the Act except the one applicable to uses less than 50,000 gallons per day should be abolished</u>.

In addition to all small uses, existing law exempts domestic use and all agricultural use (109, sec. 62.1-44.87). Exemption of individual domestic uses is justified, but such use is automatically covered by the 50,000 gallons per day exemption. However, the term "domestic use" is not defined in the Act, giving rise to the question of whether public water supplies are encompassed. Due to the need for all large uses to be subject to control, this potential regulatory loophole should be eliminated by abolition of the domestic exemption. Similarly, the agricultural exemption should be abolished to eliminate another potentially significant limitation on the scope of critical area controls.

6. <u>Permits under the Act should be issued for fixed terms and not in perpetuity</u>.

The only provision of existing law concerning permit review and duration is one authorizing cancellation or modification in cases of willful violation of permit conditions or the Act (109, sec. 62.1-44.102). Thus it appears that a permit grants an unalterable right in perpetuity if it continues to be legally exercised. Due to the need for managerial flexibility to accommodate future changes, the law should be modified to provide for a maximum duration to be established on the basis of type of use. Upon expiration of the right to make a particular use, the management agency should be authorized to review the use in view of then-existing water needs and other conditions, with the option of renewal of the former permit, issuance of a modified permit, or transfer of the right to a new application if dictated by considerations of the public interest.

7. Provisions of the Act authorizing cancellation or modification in cases of willful violations of permit conditions or the Act should be expanded to include forfeiture upon non-use for a specified period.

Existing regulations of the SWCB require submission of a special form indicating an intent to abandon a water well, and abandonment procedures are subject to Board approval (219, pp. 10-11). However, the apparent intent of these provisions is protection of water quality, and no reference is made to loss of related rights. Failure to clarify this issue may lead to future legal disputes concerning the right of a water user to resume pumping at some period subsequent to ceasation of use.

8. <u>Certificates of water right issued pursuant to the Act should be transferable</u>.

Existing law does not address the transferability issue, creating doubt as to whether transfers would be legally recognized. More efficient allocation would be facilitated if water rights were explicitly made transferable, subject to administrative approval for protection of the public interest.

9. <u>The advisory committee now established after critical area designation to assist in the management of such areas should be appointed during the preliminary phase of the proceedings leading to designation</u>.

The primary function of the advisory committee (109, sec. 62.1-44.98) is to provide local input to critical area management. This role should be expanded to include the designation proceedings themselves, thereby increasing the scope and quality of such input.

10. <u>Consideration should be given to an alternative arrangement for administration of critical areas that involves direct local participation while maintaining state control</u>.

Existing provisions for administration of critical ground water areas vest sole responsibility in the SWCB. The SWCB is authorized to recognize voluntary agreements among ground water users in lieu of its own regulation (109, sec. 62.1-44.91), but statutory guidelines for such agreements do not exist. An alternative arrangement offering certain advantages of both state and local administration consists of a special administrative board composed of state and local appointees. Local representation on the decision-making body would serve as a better mechanism for input than the present provisions for hearings and commenting. However, state control should be maintained by provisions for a majority of the special board members to be state appointees. SWCB involvement in the program should be continued by designation of a ground water committee from the policy-making body of the SWCB to serve as state representatives on the special board.

11. The SWCL should be amended to give explicit recognition to the wide range of activities that cause ground water pollution, and the SWCB should be granted additional regulatory and coordinating authority to make possible a more comprehensive quality protection program.

Although the SWCB currently possesses general authority with respect to protection of both surface and ground water quality, the scope of its program under existing law does not encompass a variety of activities that are potential sources of ground water contamination. This scope of the program should be expanded by transfer to the SWCB of certain authority now vested in other agencies and the creation of a coordination responsibility with respect to other quality-related programs. The primary authority that should be transferred is that relative to septic tanks (291, sec. 32-9) and sewage disposal in general (242, secs. 62.1-44.18, .19) which is currently exercised by the SDH.

Areas where consolidation of control is not feasible, but where inter-agency coordination is necessary, include landfills (291, sec. 32-9.1) and radioactive materials (292), both within the regulatory jurisdiction of the SDH; pesticide application (301), controlled by the Department of Agriculture and Commerce; mining and quarrying, regulated by the Department of Labor and Industry (293, 300) and the Department of Conservation and Economic Development (294, 295); and general land use regulated at the local level of government (289). The legislative statement of SWCB coordinating authority should provide for access to necessary information, participation in the formulation of policy and regulations, and review and comment regarding individual regulatory actions such as disposition of permit applications. Vesting of final authority in these areas would not be modified, but water quality protection would be enhanced due to its more direct consideration in relevant decision-making processes.

A fundamental aspect of the coordination function consists of data management. The SWCB should compile data from all available sources in order to establish an overview of quality conditions and the impact of land use practices and specific activities on ground water quality. This information would serve as the basis for input to management programs in areas related to ground water quality and for the formulation of recommendations for needed modifications in existing programs or creation of new controls. This overview function is also necessary for the identification of special problem areas if the previous recommendation concerning application of the critical area approach is to be implemented.

12. The Virginia Supreme Court of Appeals should adopt an approach to ground water allocation which recognizes some legally protected right in each user sharing a common supply.

The Virginia court has never officially approved any of the allocation doctrines but has been relatively consistent in refusing to impose liability in cases of interference with supply. A certain degree of interference without liability may be necessary to allow development and utilization of land and available water supplies, but failure to recognize any protected interest in ground water does not appear to be a realistic approach. The correlative rights doctrine appears to provide an appropriate framework for balancing opposing interests, and the court should reverse its previous refusal to adopt this theory of rights.

13. <u>The Virginia Supreme Court of Appeals should restrict absolute property rights to a depth of useful ownership</u>.

The Virginia court has endorsed the concept of ownership to unlimited depths in cases involving mineral rights but has never been asked to define the extent of property rights to use of aquifer storage space through artificial recharge operations. Due to the potential public benefits associated with artificial recharge, this activity should not be constrained by the existence of theoretical rights of unlimited extent. However, the right of the landowner to develop resources or otherwise utilize subsurface space should be protected through continued imposition of liability for injury or property interference resulting from recharge operations.

APPENDIX.-REFERENCES

1. Acton v. Blundell, 12 Mees. and W. 324, 152 Eng. Rep. 1223 (1843).

2. "Administrator's Decision Statement No. 5," U.S. Environmental Protection Agency, Washington, D.C. Feb., 1973.

3. Agreement between the City of Norfolk and the County of Nansemond, April 1, 1967.

4. "Agreement Between the Governors of North Carolina and Virginia Concerning the Conservation, Development and Management of Water Resources for Mutual Benefit," Aug. 15, 1974.

5. Alameda County Water District v. Niles Sand and Gravel Co., Inc., 37 Cal. App. 3d 924, 112 Cal. Rptr. 846 (1974).

6. "Annotation: Airport Operations or Flight of Aircraft as Taking or Damaging of Property," American Law Reports Annotated, Second Series, Vol. 77, Lawyers Cooperative Publishing Co. and Bancroft-Whitney, Rochester and San Francisco, pp. 1355-66.

7. Application of Gillespie, 173 Misc. 591, 17 N.Y.S. 2d 560, affirmed 285 N.Y. 771, 22 N.Y.S. 2d 127 (1940).

8. Arminius Chemical Co. v. Landrum, 113 Va. 7, 73 S.E. 459 (1912).

9. Aron, Gert, et al., "A Method for Integrating Surface and Ground Water Use in Humid Regions," IWR Contract Report 74-3, U.S. Army Institute for Water Resources, Fort Belvoir, Va., Feb., 1974.

10. Atkinson v. Herrington Cattle Co., 200 Kan. 298, 436 P. 2d 816 (1968).

11. "Atomic Energy Act of 1946," Act of Aug. 1, 1946, c. 724, 60 Stat. 755.

12. "Atomic Energy Act of 1954," Act of Aug. 30, 1954, c. 1073, 68 Stat. 921.

13. Barlowe, Raleigh, Land Resource Economics, Prentice Hall, Inc., Englewood Cliffs, N.J., 1958.

14. Bassett v. Salisbury Manufacturing Co., 43 N.H. 569 (1862).

15. Baumann v. Smrha, 145 F. Supp. 617 (D.C. Kan. 1956), affirmed 352 U.S. 863 (1956).

16. Bayer v. Nello L. Teer Co., 256 N.C. 509, 124 S.E. 2d 552 (1962).

17. Beatrice Gas Co. v. Thomas, 41 Neb. 662, 59 N.W. 925 (1894).

18. Bell Corp. v. Bell View Oil Syndicate, 24 Cal. App. 2d 587, 76 P. 2d 167 (1938).

19. Berger v. Minneapolis Gaslight Co., 60 Minn. 296, 62 N.W. 336 (1895).

20. Berry v. Shell Petroleum Co., 140 Kan. 94, 33 P. 2d 953 (1934).

21. Berry, William L., "Ground Water in California's Future," Proceedings Biennial Conference on Ground Water Recharge, U.S. Department of Agriculture, California Department of Natural Resources, University of California, 1966, pp. 1-14.

22. Black, Henry C., Black's Law Dictionary, Rev. 4th Ed., West Publishing Co., St. Paul, Minn., 1964.

23. Bliss v. Dority, 55 N.M. 12, 225 P. 2d 1007 (1950).

24. Blue Ridge Poultry and Egg Co. v. Clark, 211 Va. 139, 176 S.E. 2d 323 (1970).

25. Boehringer v. Montalto, 142 Misc. 560, 254 N.Y.S. 276 (Special Term 1931).

26. Bollinger v. Mungle, 175 S.W. 2d 912 (Mo. App. 1943).

27. Boomer v. Atlantic Cement Co., 26 N.Y. 2d 219, 257 N.E. 2d 870 (1970).

28. Booth, Frank R., "Alternative Ground Water Laws for Texas," Proceedings of the 1974 Conference on Water for Texas, Texas Water Resources Institute, Sept., 1974, pp. 29-60.

29. Broadbent, Lorin J., "Notes: Protection of Ground-Water Diversions," Utah Law Review, Vol. 5, No. 2, Fall, 1956, pp. 181-95.

30. Brown, Donald L. and Silvey, William D., "Underground Storage and Retrieval of Fresh Water From a Brackish-Water Aquifer," Preprints of Papers Presented at the Second International Symposium on Underground Waste Management and Artificial Recharge, The American Association of Petroleum Geologists, United States Geological Survey, International Association of Hydrologic Sciences, Vol. 1, 1973, pp. 379-419.

31. Brown, Phillip E., "A Study of the Effect of the Artificial Recharge of Urban Runoff in Roanoke, Virginia," thesis presented to the Virginia Polytechnic Institute and State University, at Blacksburg, Va., in 1974, in partial fulfillment of the requirements for the degree of Master of Science.

32. Brown v. Illius, 25 Conn. 583 (1857).

33. Bumbarger v. Walker, 193 Pa. Super. 301, 164 A. 2d 144 (1960).

34. C. & W. Coal Corp. v. Salyer, 200 Va. 18, 104 S.E. 2d 50 (1958).

35. California-Oregon Power Co. v. Beaver Portland Cement Co., 73 F. 2d 555 (9th Cir. 1934), affirmed on other grounds, 295 U.S. 142 (1935).

36. California Statutes, 1933, c. 924.

37. California Water Code, sec. 1005.1 (1971), as amended (Supp. 1975).

38. California Water Code, sec. 1200 et seq. (1971), as amended (Supp. 1975).

39. California Water Code, sec. 2000 et seq. (1971).

40. California Water Code, sec. 2020 (1971).

41. California Water Code, sec. 4999 et seq. (1971).

42. California Water Code, sec. 12920 et seq. (1971).

43. Cederstrom, D.J., "Geology and Ground-water Resources of the Coastal Plain in Southeastern Virginia," Bulletin 63, Virginia Geological Survey, Charlottes-

ville, Va., 1945.

44. Chalmers, John R., "Southwestern Groundwater Law: A Textual and Bibliographic Interpretation," Arid Lands Resource Information Paper No. 4, University of Arizona, Office of Arid Lands Studies, Tucson, Ariz., 1974.

45. "Chowan River-- Dismal Swamp Basins Comprehensive Water Resources Plan," Vol. III, Planning Bulletin 239P, Virginia Division of Water Resources, March, 1972, pp. 6-14 CD.

46. Cities Service Oil Co. v. Merritt, 332 P. 2d 677, (Okla. 1958).

47. City Mill Co. v. Honolulu Sewer and Water Comm., 30 Ha. 912 (1929).

48. City of Los Angeles v. City of Glendale, 23 Cal. 2d 68, 142 P. 2d 289 (1943).

49. City of Pasadena v. City of Alhambra, 33 Cal. 2d 908, 207 P. 2d 17 (1949), rehearing denied June 27, 1949.

50. Clark, Robert E. and Clyde, Edward W., "Western Ground-Water Law," Waters and Water Rights, Robert Emmet Clark, ed., Vol. 5, The Allen Smith Co., Indianapolis, Ind., 1972, pp. 407-74.

51. Clark, Robert E., "Ground Water Legislation in the Light of Experience in the Western States," Montana Law Review, Vol. 22, No. 1, Fall, 1960, pp. 42-59.

52. "Clayton Discusses Water Importation," The Cross Section, High Plains Underground Water Conservation District No. 1, Lubbock, Texas, Vol. 21, No. 3, March, 1975.

53. Clinchfield Coal Corp. v. Compton, 148 Va. 437, 139 S.E. 308 (1927).

54. Code of Federal Regulations, Title 40, sec. 125.26 (1973).

55. Cohen, Morris L., Legal Research in a Nutshell, 2d ed., West Publishing Co., St. Paul, Minn., 1971.

56. Collins v. Chartiers Valley Gas Co., 131 Pa. 143, 18 A. 1012 (1890).

57. "Commonwealth of Virginia Governor's Management Study," Governor's Management Study, Inc., Richmond, Va., Nov., 1970.

58. "Commonwealth of Virginia Water Resources Policy," Virginia State Water Control Board, Richmond, Va., June, 1974.

59. Consolidated Laws of New York, sec. ECL 23-1301 et seq. (McKinney 1973), as amended (Supp. 1975-76).

60. Constitution of the United States.

61. Constitution of Virginia, 1971.

62. Corker, Charles E., "Groundwater Law, Management and Administration," Report No. NWC-L-72-026, National Water Commission, Arlington, Va., Oct., 1971.

63. Cosner, O.J., "A Predictive Computer Model of the Lower Cretaceous Aquifer, Franklin Area, Southeastern Virginia," Water-Resources Investigations 51-74, U.S. Geological Survey, Richmond, Va., April, 1975.

64. Couch v. Clinchfield Coal Corp., 148 Va. 455, 139 S.E. 314 (1927).

65. Davis, Peter N., "Wells and Streams: Relationship at Law," Missouri Law Review, Vol. 37, No. 2, Spring, 1972, pp. 189-245.

66. Dillon v. Acme Oil Co., 49 Hun. (N.Y.) 612 2 N.Y.S. 289 (1888).

67. Donley v. Amerada Petroleum Corp., 152 Kan. 518, 106 P. 2d 652 (1940).

68. "Draft Environmental Protection Agency Proposed Regulations on State Underground Injection Control Programs," Environment Reporter: Current Developments, Vol. 6, No. 23, Part II, Oct. 3, 1975, pp. 954-66.

69. Druley v. Adam, 102 Ill. 177 (1882).

70. Drummond v. White Oak Fuel Co., 104 W. Va. 368, 140 S.E. 57 (1927).

71. Ducktown Sulphur, Copper and Iron Co. v. Barnes, 60 S.W. 593 (Tenn. 1900).

72. Eccles v. Ditto, 23 N. Mex. 235, 167 P. 726 (1917).

73. Edwards v. Lee's Administrator, 265 Ky. 418, 96 S.W. 2d 1028 (1936).

74. Ely, Richard T. and Wehrwein, George S., Land Economics, University of Wisconsin Press, Madison, Wis., 1964.

75. "Energy Reorganization Act of 1974," United States Code, Title 42, sec. 5801 et seq.

76. "Erosion and Sediment Control Law," Virginia Code Annotated, sec. 21-89.1 et seq. (1975).

77. Ex Parte Elam, 6 Cal. App. 233, 91 P. 811 (1907).

78. "Existing Hydrologic and Climatologic Data Base Part B: Groundwater Hydrology," James River Comprehensive Water Quality Management Study, Vol. VII-4, Virginia State Water Control Board, Richmond, Va., Oct., 1972.

79. Fallows, James M., The Water Lords, Grossman Publishers, New York, N.Y., 1971, pp. 95-96.

80. Farm Investment Co. v. Carpenter, 9 Wyo. 110, 61 P. 258 (1900).

81. "Federal Aviation Act of 1958," United States Code Annotated, Title 49, sec. 1301 et seq.

82. "Federal Environmental Pesticide Control Act," United States Code Annotated, Title 7, sec. 136 et seq.

83. "Federal Insecticide Act of 1910," Act of April 26, 1910, c. 191, 36 Stat. 335, repealed 1947, c. 125, sec. 2, 61 Stat. 163.

84. "Federal Insecticide, Fungicide, and Rodenticide Act," United States Code Annotated, Title 7, sec. 135 et seq.

85. "Federal Water Pollution Control Act Amendments of 1972," United States Code Annotated, Title 33, sec. 1251 et seq. (Supp. 1975).

86. Finley v. Teeter Stone, Inc., 251 Md. 428, 248 A. 2d 106 (1968).

87. Fletcher v. Rylands, 3 H. and C. 774, 159 Eng. Rep. 737 (1865), reversed in Fletcher v. Rylands, L.R. 1 Ex. 265 (1866), affirmed in Rylands v. Fletcher, L.R. 3 H.L. 330 (1868).

88. "Florida Water Resources Act of 1972," Florida Statutes Annotated, Title 26, sec. 373.013 et seq. (1974), as amended (Supp. 1975-76).

89. Forbell v. City of New York, 164 N.Y. 522, 58 N.E. 644 (1900).

90. Friedman, Alan E., "The Economics of the Common Pool: Property Rights in Exhaustible Resources," UCLA Law Review, Vol. 18, No. 5, May, 1971, pp. 855-87.

91. Fundingsland v. Colorado Ground Water Commission, 171 Colo. 487, 468 P. 2d 835 (1970).

92. Gagnon v. Landry, 103 R.I. 45, 234 A. 2d 674 (1967).

93. General Laws of Oregon, 1927, c. 410.

94. Georgia Code Annotated, sec. 93-801 et seq. (1972).

95. Gibbons v. Ogden, 22 U.S. (9 Wheat) 1 (1824).

96. Gilmore v. Royal Salt Co., 84 Kan. 729, 115 P. 541 (1911).

97. Gin S. Chow v. City of Santa Barbara, 217 Cal. 673, 22 P. 2d 5 (1933).

98. Gindler, B.J., "Summary of Views on Ground Water Basin Management as Developed in Panel Discussion," Proceedings Biennial Conference on Ground Water Recharge and Ground Water Basin Management, U.S. Department of Agriculture, Fresno Recharge Center, 1963, pp. 4-7.

99. Gregg v. Delhi-Taylor Oil Corp., 162 Tex. 26, 344 S.W. 2d 411 (1961).

100. Griggs v. County of Allegheny, Pennsylvania, 369 U.S. 84 (1962).

101. "Ground Water Basin Management," ASCE Manual of Engineering Practice No. 40, American Society of Civil Engineers, New York, N.Y., 1961.

102. "Ground Water in Virginia," Information Bulletin 502, Virginia Division of Water Resources, Richmond, Va., 1969.

103. "Ground Water in Virginia: Quality and Withdrawals," Basic Data Bulletin 38, Virginia State Water Control

Board, Richmond, Va., June, 1973.

104. "Ground Water Management," Manual of Engineering Practice No. 40, American Society of Civil Engineers, New York, N.Y., 1972.

105. "Ground Water of Southeastern Virginia," Planning Bulletin 261, Virginia Division of Water Resources, Richmond, Va., April, 1970.

106. "Ground Water of the Accomac-Onancock Area," Preliminary Basic Data Bulletin 37P, Virginia Division of Water Resources, April, 1972.

107. "Ground Water of the York-James Peninsula, Virginia," Basic Data Bulletin 39, Virginia State Water Control Board, Richmond, Va., June, 1973.

108. "Ground Water Pollution from Subsurface Excavations," EPA-430/9-73-012, U.S. Environmental Protection Agency, Washington, D.C., 1973.

109. "Groundwater Act of 1973," Virginia Code Annotated, sec. 62.1-44.83 et seq. (Supp. 1975).

110. "Groundwater of Southeastern Virginia," Planning Bulletin 261-A, Virginia State Water Control Board, Richmond, Va., Aug., 1974.

111. "Groundwater Use Act of 1969," Code of Laws of South Carolina, sec. 70-31 et seq. (Supp. 1974).

112. "Groundwater Use Act of 1972," Georgia Code Annotated, sec. 17-1101 et seq. (Supp. 1975).

113. "Guide for Water Well Contractors and Groundwater Users," Informational Bulletin 508, Virginia State Water Control Board, Richmond, Va., Oct., 1974.

114. Gulf Oil Corp. v. Alexander, 291 S.W. 2d 792 (Tex. Civ. App. 1956).

115. H.B. Bowling Coal Co. v. Ruffner, 117 Tenn. 180, 100 S.W. 116 (1907).

116. H.B. 323, Virginia General Assembly, 1975.

117. Hall v. Galey, 126 Kan. 699, 271 P. 319 (1928).

118. Hammonds v. Central Kentucky Natural Gas Co., 255 Ky. 685, 75 S.W. 2d 204 (1934).

119. Harnsberger, Richard S., "Nebraska Ground Water Problems," Nebraska Law Review, Vol. 42, No. 4, 1963, pp. 721-764.

120. Hauck v. Tide Water Pipe Line Co., 153 Pa. 366, 26 A. 644 (1893).

121. Haveman v. Beulow, 35 Wash. 2d 185, 217 P. 2d 313 (1950).

122. Hendricks, Albert, et al., Quality of Groundwater in a Karst Carbonate Terrain in Western Virginia, New River Valley Planning District Commission, Radford, Va., Oct., 1974.

123. Heninger v. McGinnis, 131 Va. 76, 108 S.E. 671 (1921).

124. Hinman v. Pacific Air Transport, 84 F. 2d 755 (9th Cir. 1936).

125. Hobby, William P., "Ground Water Issues Facing Texas," Proceedings of the 1974 Conference on Water for Texas, Texas Water Resources Institute, Sept., 1974, pp. 11-13.

126. Hoskin, Gregory K., "Comments: Who Pays When the Well Runs Dry," University of Colorado Law Review, Vol. 37, No. 3, Spring, 1965, pp. 402-414.

127. Hostak, Kenneth F., "Comment: Wisconsin Ground Water Law--A New Era," Wisconsin Law Review, Vol. 1957, March, 1957, pp. 309-38.

128. Huber v. Merkel, 117 Wis. 355, 94 N.W. 354 (1903).

129. Indiana Statutes Annotated, sec. 32-11-4-1 et seq. (Burns 1973).

130. "In Re: Southeastern Virginia Critical Groundwater Area," Virginia State Water Control Board, Richmond, Va., Sept. 3, 1974.

131. In re Tunnel Street in City of New York, 160 App. Div. 69, 144 N.Y.S. 1002, affirmed 212 N.Y. 547 (1913).

132. In re Willow Creek, 74 Ore. 592, 144 P. 505 (1915).

133. Interstate Coal and Iron Co. v. Clintwood Coal and Timber Co., 105 Va. 574, 54 S.E. 593 (1905, rehearing

1906).

134. Iverson v. Vint, 243 Iowa 949, 54 N.W. 2d 494 (1952).

135. "James River Basin Comprehensive Water Resources Plan," Vol. III, Planning Bulletin 215, Virginia Division of Water Resources, March, 1970.

136. Joldersma v. Muskegon Development Co., 286 Mich. 520, 282 N.W. 229 (1938).

137. Jones v. Oz-Ark-Val Poultry Co., 228 Ark. 76, 306 S.W. 2d 111 (1957).

138. Katz v. Walkinshaw, 141 Cal. 116, 70 P. 663, 74 P. 766 (1902-03).

139. Kentucky Revised Statutes, sec. 151.100 et seq. (1971), as amended (Supp. 1974).

140. Kinnaird v. Standard Oil Co., 89 Ky. 468, 12 S.W. 937 (1890).

141. Koch v. Wick, 87 So. 2d 47 (Fla. 1956).

142. Laws of New Mexico, 1927, c. 182.

143. LeGrand, H.E., "Ground Water of the Piedmont and Blue Ridge Provinces in the Southeastern States," Geological Survey Circular 538, U.S. Geological Survey, Washington, D.C., 1967.

144. Leopold, L.B., "Hydrology for Urban Land Planning," Geological Survey Circular 544, U.S. Geological Survey, Washington, D.C., 1968.

145. Letter from Kenneth R. Hinkle, Regional Geologist, Virginia State Water Control Board, to William E. Cox, Feb. 26, 1975.

146. Lichtler, William F. and Wait, Robert I., "Summary of the Ground-Water Resources of the James River Basin, Virginia," Open File Report 74-139, U.S. Geological Survey, Richmond, Va., July, 1974.

147. Lone Star Gas Co. v. Murchison, 353 S.W. 2d 870 (Tex. Civ. App. 1962).

148. Long v. Louisville and Nashville R.R. Co., 128 Ky. 26, 107 S.W. 203 (1908).

149. Love v. Nashville Agricultural and Normal Institution, 146 Tenn. 550, 243 S.W. 304 (1922).

150. Mac Artor v. Graylyn Crest III Swim Club, Inc., 41 Del. Ch. 26, 187 A. 2d 417 (1963).

151. McGuinness, C.L., "The Water Situation in the United States with Special Reference to Ground Water," Geological Survey Circular 114, U.S. Geological Survey, Washington, D.C., 1951.

152. Mack, Leslie E., "Ground Water Management in Development of a National Policy on Water," Report Number NWC-EES-71-004, National Water Commission, Arlington, Va., Jan., 1971.

153. Maloney, Frank E. and Plager, Shelton J., "Florida's Ground Water: Legal Problems in Managing a Precious Resource," University of Miami Law Review, Vol. 21, No. 4, Summer, 1967, pp. 751-76.

154. Marengo Cave Co. v. Ross, 212 Ind. 624, 10 N.E. 2d 917 (1937).

155. Maryland Code Annotated, sec. NR8-801 et seq. (1974), as amended (Supp. 1975).

156. Masten v. Texas Co., 194 N.C. 540, 140 S.E. 89 (1927).

157. Meeker v. City of East Orange, 77 N.J.L. 623, 74 A. 379 (E. & A. 1909).

158. Memorandum from Robert V. Zener, EPA Acting Deputy General Counsel to Regional Council, EPA Region IX, Dec. 13, 1973).

159. "Memorandum of Understanding Between the Virginia State Department of Health and the Virginia State Water Control Board on the Disposal of Solid Wastes (Refuse) as It May Affect Ground or Surface Waters," Virginia State Department of Health and Virginia State Water Control Board, Richmond, Va., (not dated).

160. "Memorandum of Understanding Between the Virginia State Department of Health and the Virginia State Water Control Board on the Disposal of Solid Wastes (Refuse) as It May Affect Ground or Surface Waters," Virginia State Department of Health and Virginia State Water Control Board, Richmond, Va., March,

1975.

161. "Metropolitan Water District Act," California Water Code, Appendix, sec. 35-1 et seq., repealed by California Statutes, 1969, c. 209.

162. Midwestern Gas Transmission Co. v. Mason, 31 Ill. 2d 34, 201 N.E. 2d 379 (1964).

163. Miller, David W., De Luca, Frank A., and Tessier, Thomas L., "Ground Water Contamination in the Northeast States," Environmental Protection Technology Series EPA-660/2-74-056, U.S. Environmental Protection Agency, Washington, D.C., June, 1974.

164. Miller v. Black Rock Springs Improvement Co., 99 Va. 747, 40 S.E. 27 (1901).

165. Minutes of City Council meeting, City of Chesapeake, Va., Feb. 19, 1974.

166. Monroe Carp Pond Co. v. River Raisin Paper Co., 240 Mich. 279, 215 N.W. 325 (1927).

167. Murray, C. Richard and Reeves, E. Bodette, "Estimated Use of Water in the United States in 1970," Geological Survey Circular 676, U.S. Geological Survey, Washington, D.C., 1972.

168. Nace, R.L., "Water Management, Agriculture, and Ground-Water Supplies," Geological Survey Circular 415, U.S. Geological Survey, Washington, D.C., 1960.

169. "National Environmental Policy Act of 1969," United States Code Annotated, Title 42, sec. 4321 et seq. (1973), as amended (Supp. 1975).

170. New Jersey Statutes Annotated, sec. 58: 4A-1 et seq. (1966), as amended (Supp. 1975).

171. "New River Basin Comprehensive Water Resource Plan," Vol. III, Planning Bulletin 203, Virginia Division of Water Resources, July, 1967.

172. Norfolk and Western Railroad Co. v. Carter, 91 Va. 587, 22 S.E. 517 (1895).

173. Norman v. Greenland Drilling Co., 403 P. 2d 507 (Okla. 1965).

174. North Georgia Petroleum Co. v. Lewis, 128 Ga. App.

653, 197 S.E. 2d 437 (1973).

175. Oakwood Smokeless Coal Corp. v. Meadows, 184 Va. 168, 34 S.E. 2d 392 (1945).

176. Ohio Oil Co. v. Indiana, 117 U.S. 190 (1900).

177. Ohio Revised Code Annotated, sec. 4161.01 et seq. (Page 1973).

178. "Ohio River Valley Water Sanitation Compact," Virginia Code Annotated, sec. 62.1-70 et seq. (1973).

179. Oklahoma ex. rel. Phillips v. Guy F. Atkinson Co., 313 U.S. 508 (1941).

180. Oklahoma Statutes Annotated, Title 52, sec. 291 et seq. (1969), as amended (Supp. 1975).

181. "Orange County Water District Act," California Water Code, Appendix, sec. 40-1 et seq. (1968), as amended (Supp. 1975).

182. "An Order of the Virginia State Water Control Board," Virginia State Water Control Board, Richmond, Va., Jan. 27, 1975.

183. P. Ballantine and Sons v. Public Service Corp. of New Jersey, 76 N.J.L. 358, 70 A. 167 (1908).

184. Pacific Live Stock Co. v. Lewis, 241 U.S. 440 (1916).

185. Packwood v. Mendota Coal and Coke Co., 84 Wash. 147, 146 P. 163 (1915).

186. Pan American Petroleum Co. v. Byars, 228 Ala. 372, 153 So. 616 (1934).

187. Panther Coal Co. v. Looney, 185 Va. 758, 40 S.E. 2d 298 (1946).

188. Peden v. Furman University, 155 S.C. 1, 151 S.E. 907 (1930).

189. Pennsylvania Coal Co. v. Sanderson, 113 Pa. St. 126, 6 A. 453 (1886).

190. Pennsylvania Statutes Annotated, Title 52, sec. 2301 et seq. (Purdon 1966), as amended (Supp. 1975-76).

191. Pensacola Gas Co. v. Pebley, 25 Fla. 381, 5 So. 593

(1889).

192. Peoples Gas Light and Coke Co. v. Buckles, 24 Ill. 2d 520, 182 N.E. 2d 169 (1962).

193. Phillips v. Sun Oil Co., 307 N.Y. 328, 125 N.Y.S. 2d 161, 121 N.E. 2d 247 (1954).

194. Phoenix v. Graham, 349 Ill. App. 326, 110 N.E. 2d 669 (1953).

195. Pine v. Rizzo, 186 Okla. 35, 96 P. 2d 17 (1939).

196. Piper, Arthur M., "Interpretation and Current Status of Ground Water Rights," Geological Survey Circular 432, U.S. Geological Survey, Washington, D.C., 1960.

197. Poland, Joseph F., "Land Subsidence Due to Ground-Water Development," Journal of the Irrigation and Drainage Division, ASCE, American Society of Civil Engineers, Vol. 84, No. IR 3, Sept., 1958, pp. 1774-1 to 1774-11.

198. "Policy on Disposal of Wastes by Subsurface Injection," Com. 5040.10, U.S. Federal Water Quality Administration, Washington, D.C., Oct., 1970.

199. "Potomac River Basin Compact," Virginia Code Annotated, sec. 62.1-69.1 et seq. (1973).

200. "Principles and Standards for Planning Water and Related Land Resources," Federal Register, Vol. 38, No. 174, Part III, Sept. 10, 1973.

201. Prosser, William L., Law of Torts, 4th ed., West Publishing Co., St. Paul, Minn., 1971.

202. Railroad Commission of Texas v. Manziel, 361 S.W. 2d 560 (Tex. 1962).

203. Rancho Santa Margarita v. Vail, 11 Cal. 2d 501, 81 P. 2d 533 (1938).

204. "Refuse Act," Act of March 3, 1899, sec. 13.

205. Registry of Wells for Use in Underground Injection of Wastewater in the Ohio Valley Region, Ohio River Valley Water Sanitation Commission, Cincinatti, Ohio, Mar., 1974.

206. "Regulations of the Board of Health, Commonwealth of

Virginia, Governing the Disposal of Sewage," Virginia State Department of Health, Richmond, Va., 1971.

207. Reid v. Memphis Memorial Park, 5 Tenn. App. 105 (1927).

208. Reinhart v. Lancaster Area Refuse Authority, 201 Pa. Super. 614, 193 A. 2d 670 (1963).

209. "Resource Recovery Act of 1970," United States Code, Title 42, sec. 3253a, 3254a to 3254f (1973).

210. Restatement of Torts, Vol. 4, American Law Institute Publishers, St. Paul, Minn., 1939, sec. 818.

211. Restatement (Second) of Torts, Vol. 1, American Law Institute Publishers, St. Paul, Minn., 1965, sec. 159.

212. Restatement (Second) of Torts (Tentative Draft No. 15), American Law Institute, Philadelphia, Pa., 1969, sec. 818.

213. Roath v. Driscoll, 20 Conn. 533 (1850).

214. Robie, Ronald B., "Carley Porter Memorial Luncheon Address," Proceedings Ninth Biennial Conference on Ground Water, California Department of Water Resources and University of California Water Resources Center, Dec., 1973, pp. 137-51.

215. Rohrer, Bert, "Most Officials Unruffled by Groundwater Ruling," The Virginian Pilot, Norfolk, Va., Feb. 3, 1975, p. Bl.

216. Rose v. Socony Vacuum Corp., 54 R.I. 411, 173 A. 627 (1934).

217. Rouse v. City of Kinston, 188 N.C. 1, 123 S.E. 482 (1924).

218. "Rules and Regulations of the Department of Health: Disposal of Solid Wastes," Virginia State Department of Health, Richmond, Va., April, 1971.

219. "Rules of the Board and Standards for Water Wells," Virginia State Water Control Board, Richmond, Va., May, 1974.

220. Rusch v. Phillips Petroleum Co., 163 Kan. 11, 180 P. 2d 270 (1947).

221. "Safe Drinking Water Act," United States Code Annotated, Title 42, sec. 300 F et seq. (Pamphlet No. 1 1975).

222. Sanford, Samuel, "The Underground Water Resources of the Coastal Plain Province of Virginia," Bulletin No. 5, Virginia Geological Survey, Charlottesville, Va., 1913.

223. Scalf, M.R., Keely, J.W., and LaFevers, C.J. "Ground Water Pollution in the South Central States," Environmental Protection Technology Series EPA-R2-73-268, U.S. Environmental Protection Agency, Corvallis, Ore., June, 1973.

224. Schenk v. City of Ann Arbor, 196 Mich. 75, 163 N.W. 109 (1917).

225. Scott, Roger R., "Underground Storage of Natural Gas: A Study of Legal Problems," Oklahoma Law Review, Vol. 19, No. 1, Feb., 1966, pp. 47-94.

226. "Second Interim Report of the Commission on State Governmental Management: Recommendations on the Roles of the Secretaries," Virginia Senate Document No. 3, 1974.

227. "Septic Permits Granted Despite Pollution Hazard," Daily News Record, Harrisonburg, Va., April 19, 1975, p. 19.

228. Shell Oil Co. v. Blubaugh, 199 Okl. 353, 185 P. 2d 959 (1947).

229. Sherrod, H. Floyd, Jr., "The Groundwater Use Act of 1972: Protection for Georgia's Groundwater Resource," Georgia Law Review, Vol. 6, No. 4, 1972, pp. 709-41.

230. Shipp v. Louisville and Jefferson County Air Board, 431 S.W. 2d 867 (Ky. 1968), certiorari denied 393 U.S. 1088.

231. Shoffner v. Sutherland, 111 Va. 298, 68 S.E. 996 (1910).

232. Sinclair Refining Co. v. Bennett, 123 F. 2d 884 (C.A. 6th Tenn. 1941).

233. "Site Evaluation Form (For Use with Industrial Waste Applications)," SWCB-GW-10, Virginia State Water

Control Board, Richmond, Va.

234. "Site Evaluation Form," SW-75, Virginia State Department of Health, Richmond, Va.

235. Snyder, Stephen E., "Comments: Ground Water Management: A Proposal for Texas," Texas Law Review, Vol. 51, No. 2, Jan., 1973, pp. 289-317.

236. "Solid Waste Disposal Act," United States Code Annotated, Title 42, sec. 3251 et seq. (1973).

237. South Carolina Acts and Joint Resolutions, 1969, p. 640.

238. Southwest Engineering Co. v. Ernst, 79 Ariz. 403, 291 P. 2d 764 (1955).

239. State ex. rel. Emery v. Knapp, 167 Kan. 546, 207 P. 2d 440 (1949).

240. State v. Michels Pipeline Construction, Inc., 68 Wis. 2d 278, 217 N.W. 2d 339 (1974), rehearing denied 219 N.W. 2d 308 (1974).

241. "State Water Control Board Hearing in Re: Groundwater Act of 1973--Issuance of Certificate of Groundwater Right--Hercules Inc. and City of Norfolk," Virginia State Water Control Board, Richmond, Va., June 10, 1975.

242. "State Water Control Law," Virginia Code Annotated, sec. 62.1-44.2 et seq. (1973), as amended (Supp. 1975).

243. Steinmen Coal Corp. v. Fleming, 145 Va. 731, 134 S.E. 696 (1926).

244. Stonegap Colliery Co. v. Hamilton, 119 Va. 271, 89 S.E. 305 (1916).

245. Sullivan v. Jones and Laughlin Steel Co., 208 Pa. 540, 57 A. 1065 (1904).

246. Sunray Oil Co. v. Cortez Oil Co., 118 Okl. 690, 112 P. 2d 792 (1941).

247. Sussex Land and Livestock Co. v. Midwest Refining Co., 294 F. 597 (8th Cir. 1913).

248. Swearingen, T.L., "Staff Report: Implementation of

the Groundwater Act of 1973," Virginia State Water Control Board, Richmond, Va., Feb. 21, 1975.

249. Swift and Co. v. Peoples Coal and Oil Co., 121 Conn. 579, 186 A. 629 (1936).

250. Sycamore Coal Co. v. Stanley, 292 Ky. 168, 166 S.W. 2d 293 (1942).

251. "Tennessee and Big Sandy River Basins Comprehensive Water Resources Plan," Vol. III, Planning Bulletin 233, Virginia Division of Water Resources, Nov., 1971.

252. Texas Co. v. Giddings, 148 S.W. 1142 (Tex. Civ. App. 1912).

253. Texas Water Code, sec. 5.001 et seq. (1972), as amended (Supp. 1974-75).

254. Texas Water Code, sec. 52.001 et seq. (1972), as amended (Supp. 1974-75), incorporating portions of sec. 51.001 et seq. (1972), as amended (Supp. 1974-75).

255. Thomas, Harold A., Jr., Coulter, James B., Bendixen, Thomas W., and Edwards, Allan B., "Technology and Economics of Household Sewage Disposal Systems," Journal Water Pollution Control Federation, Vol. 32, No. 2, Feb., 1960, pp. 113-41.

256. Thomas, Harold E., "Underground Sources of Our Water," The Yearbook of Agriculture 1955: Water, U.S. Department of Agriculture, Washington, D.C., 1955, pp. 62-78.

257. Thomas, Robert O., "Ground Water Development: A Symposium--Planned Utilization," Transactions, American Society of Civil Engineers, Vol. 122, 1957, pp. 422-33.

258. Thomas, Robert O., "Legal Aspects of Ground Water Utilization," Journal of the Irrigation and Drainage Division, ASCE, Vol. 85, No. IR 4, Dec., 1959, pp. 41-63.

259. Thompson, David G. and Fiedler, Albert G., "Some Problems Relating to Legal Control of Use of Ground Water," Journal of the American Water Works Association, Vol. 30, No. 7, July, 1938, pp. 1049-91.

260. Thompson, Grant P., "Courts and Water: The Role of the Judicial Process," Report No. NWC-L-72-055, National Water Commission, Arlington, Va., July, 1972.

261. Tidewater Oil Co. v. Jackson, 320 F. 2d 157 (10th Cir. 1963).

262. Towner, P.A., "Summary of Views on the Problem of Ground Water Basin Management," Proceedings of the Biennial Conference on Ground Water Recharge and Ground Water Basin Management, Fresno Recharge Center, U.S.Department of Agriculture, 1963, pp. 8-10.

263. Trelease, Frank J., "Changes and Transfers of Water Rights," Rocky Mountain Mineral Law Institute, Vol. 13, 1967, pp. 507-29.

264. Trelease, Frank J., "Law, Water and People: The Role of Water Law in Conserving and Developing Natural Resources in the West," Wyoming Law Journal, Vol. 18, No. 1, Fall, 1963, pp. 3-16.

265. Turner v. Big Lake Oil Co., 128 Tex. 155, 96 S.W. 2d 221 (1936).

266. "Underground Gas Storage Act," Georgia Code Annotated, sec. 93-80 et seq. (1972).

267. Underground Injection of Wastewaters in the Ohio Valley Region, Ohio River Valley Water Sanitation Commission, Cincinatti, Ohio, Aug., 1973.

268. Union Oil Co. of California v. Mutual Oil Co., 19 Cal. App. 2d 409, 65 P. 2d 896 (1937).

269. Union Oil Co. of California v. Reconstruction Oil Co., 20 Cal. App. 2d 170, 66 P. 2d 1215 (1937).

270. United States Code Annotated, Title 43, sec. 31 et seq. (1964).

271. United States Code, Congressional, and Administrative News, Vol. 4, P. 6454 (1974).

272. United States v. Appalachian Electric Power Co., 311 U.S. 377 (1940).

273. United States v. Armco Steel Corp., 333 F. Supp. 1073 (S.D. Tex. 1971).

274. United States v. Ashland Oil, 7 ERC 1114 (Ct. Ap. 6th Cir. 1974).

275. United States v. Causby, 328 U.S. 256 (1946).

276. United States v. Darby, 312 U.S. 100 (1941).

277. United States v. GAF, 7 ERC 1581 (D.C. S.D.T. 1975).

278. United States v. Grand River Dam Authority, 363 U.S. 229 (1960).

279. United States v. Rio Grande Dam and Irrigation Co., 174 U.S. 690 (1899).

280. United States v. Shurbet, 347 F. 2d 103 (5th Cir. 1965).

281. Upjohn v. Board of Health of Richland, 46 Mich. 542, 9 N.W. 845 (1881).

282. "Urban Studies Program," Federal Register, Vol. 40, No. 212, Part 264, Nov. 3, 1975.

283. Village of Euclid v. Ambler Realty Co., 272 U.S. 365 (1926).

284. Virginia Acts of Assembly, 1946, c. 399.

285. Virginia Acts of Assembly, 1974, c. 204.

286. "Virginia Area Development Act," Virginia Code Annotated, sec. 15.1-1400 et seq. (1973), as amended (Supp. 1975).

287. Virginia Code Annotated, sec. 2.1-51.7 et seq. (1973), as amended (Supp. 1975).

288. Virginia Code Annotated, sec. 2.1-63.1 et seq. (1973), as amended (Supp. 1975).

289. Virginia Code Annotated, sec. 15.1-427 et seq. (1973), as amended (Supp. 1975).

290. Virginia Code Annotated, sec. 15.1-837 et seq. (1973), as amended (Supp. 1975).

291. Virginia Code Annotated, sec. 32-1 et seq. (1973), as amended (Supp. 1975).

292. Virginia Code Annotated, sec. 32-414.1 et seq.

(1973), as amended (Supp. 1975).

293. Virginia Code Annotated, sec. 45.1-106 et seq. (1974).

294. Virginia Code Annotated, sec. 45.1-180 et seq. (1974), as amended (Supp. 1975).

295. Virginia Code Annotated, sec. 45.1-198 (1974), as amended (Supp. 1975).

296. Virginia Code Annotated, sec. 62.1-10 et seq. (1973).

297. Virginia Code Annotated, sec. 62.1-13.1 et seq. (1973), as amended (Supp. 1975).

298. Virginia Code Annotated, sec. 62.1-44.35 et seq. (1973).

299. Virginia Code Annotated, sec. 62.1-45 et seq. (1973).

300. "Virginia Mine Safety Law of 1966," Virginia Code Annotated, sec. 45.1-1 et seq. (1974), as amended (Cum. Supp. 1974 and Supp. 1975).

301. "Virginia Pesticide Use and Application Act of 1975," Virginia Code Annotated, sec. 3.1-249.1 et seq. (Supp. 1975).

302. Waller, James O., "Influence of Geology on the Water Resources of the Upper Roanoke River Basin, Virginia," dissertation presented to Virginia Polytechnic Institute and State University, at Blacksburg, Va., in 1976, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

303. "Water Resources Investigations in Virginia," U.S. Geological Survey, Richmond, Va., 1973.

304. "Water Resources Planning Act," United States Code Annotated, Title 42, sec. 1962 et seq. (1974), as amended (Supp. 1975).

305. "Water Sources for Southeastern Virginia: A Development Plan Prepared for the Southeastern Water Authority of Virginia," Henningson, Durham, and Richardson, Norfolk, Va., July, 1975.

306. "Water Supplies for Suburban and Country Homes: Drilled Well Supplies," Virginia State Department of Health, Richmond, Va., 1973.

307. "Water Supplies for Surburban and Country Homes: Dug Well Supplies," Virginia State Department of Health, Richmond, Va., 1973.

308. "Water Use Act of 1967," General Statutes of North Carolina, sec. 143-215.11 et seq. (1974), as amended (Supp. 1974).

309. "Waterworks Regulations," Virginia Department of Health, Richmond, Va., 1974.

310. Watkins v. Gulf Refining Co., 206 La. 942, 20 So. 2d 273 (1944).

311. Watson v. Great Lakes Pipeline Co., 85 S.D. 310, 182 N.W. 2d 314 (1970).

312. West Edmond Salt Water Disposal Association v. Rosecrans, 204 Okl. 9, 226 P. 2d 965 (1950).

313. West Edmund Hunton Lime Unit v. Lillard, 265 P. 2d 730 (Okla. 1954).

314. West Virginia Code Annotated, sec. 22-7-1 et seq. (1973).

315. White v. New York State Natural Gas Corp., 190 F. Supp. 342 (W.D. Pa. 1960).

316. Wichard v. Filburn, 317 U.S. 111 (1942).

317. Williams, Howard R. and Meyers, Charles J., Oil and Gas Law, Vol. I, Matthew Bender, New York, N.Y., 1972.

318. Williams v. City of Wichita, 190 Kan. 317, 374 P. 2d 578 (1962), appeal dismissed, 375 U.S. 7 (1963), rehearing denied, 375 U.S. 936 (1963).

319. "Wise Management of North Carolina Water Resources Through Law (An Orientation Brochure)," Vol. 1, State of North Carolina Department of Natural Resources, Raleigh, N.C., 1966.

320. Yellow Poplar Lumber Co. v. Thompson's Heirs, 108 Va. 612, 62 S.E. 358 (1908).

321. Yeo v. Tweedy, 34 N.M. 611, 286 P. 970 (1930).

322. Yommer v. McKenzie, 257 A. 2d 138 (Md. App. 1969).

323. Young, Robert A. and Gray, S. Lee, "Economic Value of Water: Concepts and Empirical Estimates," Report No. NWC-SBS-72-047, National Water Commission, Arlington, Va., March, 1972.

VITA

William Edward Cox was born in Pulaski, Virginia, on February 18, 1944. After graduating from the public schools of Pulaski County, he received a Bachelor of Science degree in 1966 and a Master of Science degree in 1968, both from Virginia Polytechnic Institute and State University. Between 1968 and 1972, he was employed as an assistant professor at Virginia Commonwealth University in Richmond, Virginia.

The author currently is employed as a research associate at the Virginia Water Resources Research Center. He and his wife Clara, along with their daughter Wendy, reside in Radford, Virginia.

William E. Cox

GROUND WATER MANAGEMENT IN VIRGINIA:
A COMPARATIVE EVALUATION OF THE
INSTITUTIONAL FRAMEWORK

by

William Edward Cox

(ABSTRACT)

The general purpose of this study is the examination of the institutional framework for ground water management, with specific consideration given to Virginia as a case study. The following objectives are encompassed within the general goal of institutional evaluation: (1) identification of the physical determinants of institutional structure, (2) description of current management institutions in Virginia, (3) comparative evaluation of the Virginia institutional framework, and (4) development of institutional guidelines of general applicability and specific recommendations for Virginia.

The principal physical characteristic of ground water that determines institutional requirements for management is the dependence of the resource on a broad range of natural processes and the resulting propensity toward a variety of externalities. These external effects exist

among individual water uses and also involve a variety of land use practices, indicating the need for a management framework with the capability for integration of a broad scope of considerations.

The oldest institutional framework for ground water decision-making consists of private rights that define the limits of individual action affecting the resource. Private rights are significant with regard to withdrawal of ground water, use of land that affects the resource, and use of aquifer storage space through artificial recharge operations. Development of rights in these areas has proceeded at varying rates among the states and has reached differing results, but private rights in general have been relatively ineffective in restraining excessive pumping and other activities adversely affecting the resource.

The institutional framework for ground water management also encompasses a variety of statutory laws and programs involving all levels of government. Primary responsibilities of the federal government consist of quality protection and data collection. Developing federal planning procedures have a potentially significant impact on ground water management. In Virginia, state law establishes an administrative ground water allocation system for application within specially designated districts. The state also regulates a number of activities that threaten ground water quality and carries out a data collection and management program. The primary authority of the local level of government concerning ground water is land use control.

The development of guidelines for improved ground water management institutions involves a variety of issues. One of the most basic consists of the dgree of governmental involvement and the division of responsibilities among the levels of government. Due to the traditional inability of private control measures to constrain ground water externalities and the need for mechanisms to provide for planning and other non-regulatory management functions, direct governmental involvement and control appear inevitable as burdens placed on the resource increase. With regard to vesting of governmental authority, considerations of managerial capabilities and perspectives indicate that the state level of government should exercise primary authority.

Other issues addressed in the general guidelines and the Virginia recommendations include the feasibility of an allocation program applicable solely to ground water, guidelines for determination of "beneficial use," scope of exemptions from controls, criteria for permit issuance, permit duration, and the scope and administrative structure of ground water quality protection programs.