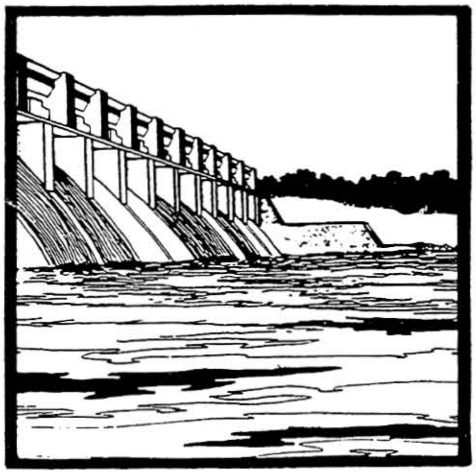
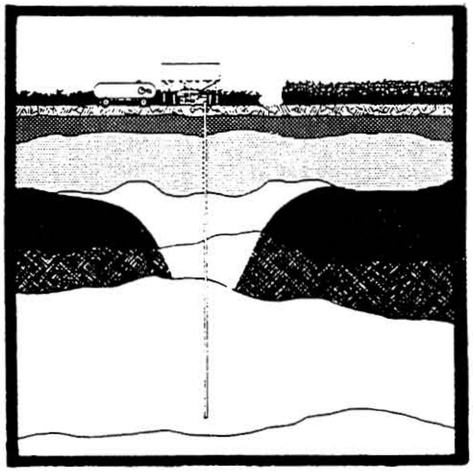
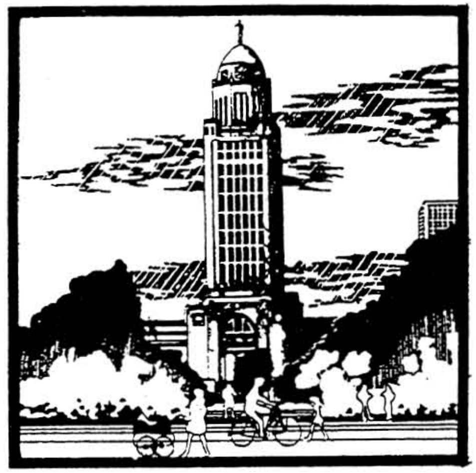
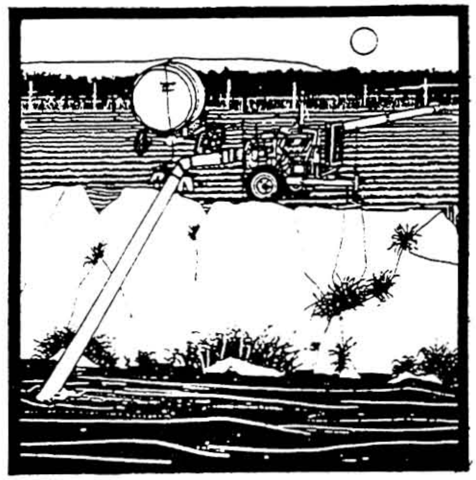


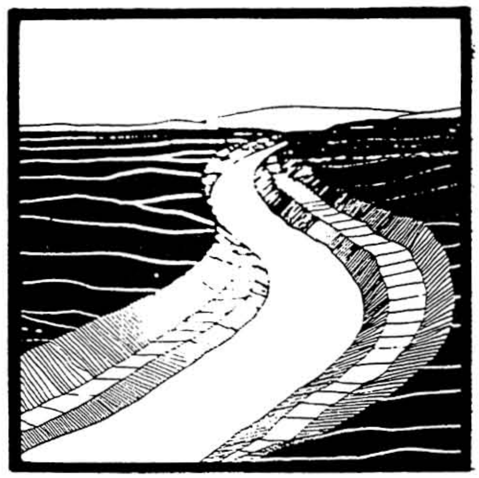






# POLICY ISSUE STUDY ON

# INTEGRATED MANAGEMENT OF SURFACE WATER AND GROUNDWATER



State Water Planning and Review Process
Nebraska Natural Resources Commission

**APRIL 1986**

# POLICY ISSUE STUDY
# ON
# INTEGRATED MANAGEMENT OF SURFACE WATER AND GROUNDWATER

## STATE WATER PLANNING AND REVIEW PROCESS

# INTEGRATED MANAGEMENT OF SURFACE WATER AND GROUNDWATER REPORT

A REPORT
OF THE
DIRECTOR OF NATURAL RESOURCES
TO
GOVERNOR ROBERT KERREY
AND
THE MEMBERS OF THE NEBRASKA LEGISLATURE

APRIL 1986

printed on recycled paper

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STATE OF NEBRASKA
NATURAL RESOURCES COMMISSION
301 CENTENNIAL MALL SOUTH • P.O. BOX 94876 • LINCOLN, NEBRASKA 68509-4876 • PHONE (402)471-2081

February 28, 1986

The Honorable Robert Kerrey
Governor, State of Nebraska
State Capitol, 2nd Floor
Lincoln, Nebraska 68509

Members of the Nebraska Legislature
State Capitol
Lincoln, Nebraska 68509

Dear Governor Kerrey and Members of the Legislature:

This report entitled "Policy Issue Study on Integrated Management of Surface Water and Groundwater" is being submitted by the Director of Natural Resources and the Natural Resources Commission. It is one of a series of studies of Nebraska water policy issues.

Twenty-two alternatives and a number of subalternatives related to integrated use of surface water and groundwater are analyzed in this report. The Director and Commission's recommended course of action is also provided and can be found in the blue pages immediately preceeding the summary.

It is the hope of the Director and the Commission that this report will be helpful in making policy decisions and statutory changes. We are prepared to answer any further questions you may have.

Dayle E. Williamson
Director of Natural Resources

Larry Moore
Chairman, Nebraska Natural Resources Commission

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# Foreword

This report was written as part of the Policy Issue Analysis Activity of the Nebraska State Water Planning and Review Process. It is a report of the Director of Natural Resources. Its form and content has been approved by the Natural Resources Commission. The Director and Commission jointly adopted the comments and recommendations contained near the beginning of this report. An interagency task force which helped develop the data and alternatives used in the final report included:

| | |
|---|---|
| Bob Kuzelka | Conservation and Survey Division, UNL |
| Bob Bishop | Department of Water Resources |
| Sue Miller | Water Resources Center, UNL |
| Gerald Chaffin | Game and Parks Commission |
| Rod Armstrong | Policy Research Office |
| Bill Lee | Department of Health |
| Owen Goodenkauf | Department of Health |
| Beth Rowan | Department of Environmental Control |
| Steve Gaul | Natural Resources Commission (Task Force Coordinator) |

The Natural Resources Commission was responsible for leading the work of the task force. The Director of Natural Resources is responsible for this final report. The Natural Resources Commission approved the form and content of the final report. Non task force members who contributed greatly to the report include: Annette Kovar, Jay Holmquist, Jerry Wallin, Ananta Nath and Bob Hiergesell of the Natural Resources Commission staff, Gene Murray and Marilyn Ginsberg of Conservation and Survey Division, and J. David Aiken of the Department of Agricultural Economics, UNL. A special three-member committee of the Natural Resources Commission monitored the study and provided guidance. Members of that committee were Cliff Welsh, Don Kavan, and Vince Kramper.

The expertise and experience provided by the designated representatives and other individuals from these agencies is reflected throughout this report. An effort has been made to provide references to source material, published and unpublished that have been incorporated in the report. However, any questions related to the scope, validity or interpretation of this report should be addressed to the Director of Natural Resources.

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# Comments and Recommendations of the Natural Resources Commission

## INTRODUCTION AND PURPOSE

The responsibility of the director and the Commission in preparing policy issue study reports is twofold. First, the policy alternatives presented should be both representative of the range of policy options available and objective in substance. It is hoped that this report accomplishes that purpose. Second, the director and the Commission are responsible for providing opinions and recommendations on the various alternatives presented in each report to the general public, the Legislature, and the Governor.

Comments and recommendations are offered in this section on each of the twenty-two alternatives presented in this report. These recommendations were adopted jointly by the Director of Natural Resources and the Natural Resources Commission. Some alternatives are recommended in whole, some in part with qualifications, and others are not recommended.

## RECOMMENDED OR PARTIALLY RECOMMENDED ALTERNATIVES

**PROBLEM AND ISSUE #1: WHETHER LEGAL MEASURES SHOULD BE TAKEN TO PROTECT PRIOR SURFACE-WATER USERS WHEN GROUNDWATER PUMPING REDUCES GROUNDWATER DISCHARGE TO SURFACE WATER OR INDUCES RECHARGE FROM SURFACE WATER.**

The current and future extent of this problem is difficult to determine. Groundwater use depletions to streamflow and other water bodies are site specific and vary depending upon geologic and hydrologic conditions, distance from the stream, and length of time following the groundwater use. In many locations, there is not enough known about the relationship between the groundwater and surface-water resources. Designing institutional mechanisms to deal with the problem is therefore difficult.

Nevertheless, it is recommended that Nebraska begin now to deal with depletion of surface-water resources caused by groundwater use. A positive approach to dealing with this issue will generate more activity and interest in improving our understanding of the problem than would a decision to do nothing until more is known. The alternatives recommended are Alternatives 2(d), 3, and 5.

**Alternative 2(d) Adopt principles of equity in cases of interference between groundwater users and surface-water users.**

Specifically, it is recommended that the Legislature adopt a statute similar to section 858(1)(c) of the Restatement (2d) of Torts (1977) which states as follows:

"A proprietor of land or his grantee who withdraws groundwater from the land and uses it for a benefical purpose is not subject to liability for interference with the use of water by another, unless the withdrawal of the groundwater has a **direct and substantial effect** upon a watercourse or lake and unreasonably causes harm to a person entitled to the use of its water." (emphasis added).

This alternative will have limited application in Nebraska but is the appropriate way of resolving conflicts between individuals or small numbers of groundwater and surface-water users. The rule has already been applied by the Sioux County District Court. Legislative enactment would insure judicial application of the same rule as future cases arise. It should be enacted in a manner that provides protection for surface water users only if they initiated their use prior to that of the conflicting groundwater user.

This recommendation is not intended to preclude administrative solutions to conflicts between large numbers of surface-water and groundwater users. The purpose of this recommended alternative is to simply provide a mechanism for dealing with isolated conflicts where the cause and effect relationship between a particular groundwater use or uses and a diminished surface-water resource can be pinpointed. When those conditions exist, a finding of liability for the benefit of the surface-water user who has been unreasonably harmed is appropriate. In determining whether that harm is unreasonable, a court will balance the gains and losses of the immediately impacted users.

**Alternative 3: Allow a groundwater control area to be declared when it is determined that groundwater pumping substantially impacts surface-water users.**

While the previously recommended alternative would establish a policy for dealing with isolated conflict situations, this recommended alternative is intended to offer at least a partial solution to the more typical situation where large numbers of groundwater users are affecting or will in the future affect previously vested surface-water users. In such cases, courts are not well equipped to develop solutions and administrative approaches are more feasible. The existing groundwater control area concept could be modified to incorporate surface-water impacts as a basis for designation of a control area and for management of the groundwater within that control area. Measures available to the natural resource district would include allocation of groundwater to eliminate waste and closing the control area to further groundwater development. Authority to prohibit additional development could be exercised only if the natural resources district concluded that the problem could not be solved otherwise and if the district made the policy determination that such extreme measures were justified. Then existing wells would not be affected by any such moratorium.

The early steps taken to resolve the groundwater/surface-water conflicts problems will not be perfect and this alternative is no exception. Not the least of the problems to be dealt with are jurisdictional issues. In many cases, the area where groundwater withdrawals are occurring and the area where the impact of the streamflow depletions are being felt will be different. In some cases, they may even be in different natural resources districts. Control area measures in the groundwater use area will, therefore, be unpopular when the purpose is to protect surface-water users in another jurisdiction. However, the fact that this problem exists does not mean necessarily that the natural resources districts will be unable to cope with it in an appropriate manner. One change in the Groundwater Management Act that should cause more equitable implementation of this suggested revision would be to grant the natural resources district in which the problems are being experienced the opportunity to request a hearing and decision on creation of a control area. If the Department of Water Resources determined that a control area was in fact appropriate, the natural resources district where the groundwater withdrawals were occurring would have an affirmative obligation to take steps to at least ensure efficient groundwater use and elimination of waste of water. It might also be appropriate to require the benefitting downstream users to share in the cost of administering the regulations by also subjecting them to the control area tax. Downstream surface-water users certainly ought to also be subject to water use-efficiency requirements if they are to receive the benefits of regulation upstream.

While *Alternative 4*, relating to inclusion of groundwater in the appropriative rights system, is not recommended at this time, modified versions of two of the authorities suggested as part of that alternative could be and should be incorporated in *Alternative 3* when it is enacted. Those authorities would be applicable only to the extent that additional groundwater development was being prohibited by a moratorium or by well-spacing requirements on new wells. These recommended authorities should be stated as follows: (1) allow additional groundwater use to occur if prospective groundwater users provide substitute water to senior surface-water appropriators by developing additional supplies for use by such senior users or by purchasing water for their use; and (2) allow additional groundwater use to occur if prospective groundwater users retire senior surface appropriations by voluntary purchase. Implementing these two authorities would allow groundwater users and surface-water users to work together to find what both consider to be equitable means of resolving the differences between them. Implementation of these authorities might require pooling of resources through special assessments or other methods of collecting funds from the groundwater users and perhaps from the surface-water users.

**Alternative 5: Expand research into the impact of groundwater pumping on streamflow, lakes, and wetlands.**

Adoption of this alternative is recommended because of the uncertainty and lack of information plaguing resolution of the conflicts problem. Further groundwater use depletions to streamflow can affect a wide range of water planning activity. For instance, plans for future surface-water development projects, or plans for in-stream flow maintenance can both be in error if the impact of groundwater use on streamflow is not considered. Furthermore, if the impacts of groundwater use on surface water increase, as they might, the additional information generated through implementation of this alternative will improve implementation of the other alternatives recommended and provide a basis for refinement to and supplementation of those alternatives in the future.

**PROBLEM AND ISSUE #2: WHETHER LEGAL MEASURES SHOULD BE TAKEN TO PROTECT MUNICIPALITIES, IRRIGATORS, AND SUBIRRIGATORS DEPENDENT UPON RECHARGE FROM SURFACE WATER TO MAINTAIN THEIR GROUNDWATER SUPPLY.**

Recommended in response to this problem are *Alternatives 7(c), 8(a),* and *9.*

**Alternative 7(c): Adopt principles of equity in cases of interference between streamflow users and groundwater users.**

This alternative is the mirror image of *Alternative 2(d)* recommended earlier. Legislation, similar to the following, could be enacted:

A person who withdraws water from a watercourse or lake in accordance with law and who uses it for a beneficial purpose is not subject to liability for interference with the use of groundwater by another, unless the withdrawal from the watercourse or lake has a direct and substantial effect upon the supply or level of groundwater and unreasonably causes harm to a person who initiated the use of the groundwater prior to that of the conflicting surface-water user.

If enacted, this alternative would apply only in cases where an easily identified surface-water use was affecting a previously existing groundwater use. When that condition existed and when, after balancing the interest of the directly-affected parties, the surface water use appeared unreasonable, it would be appropriate to provide the groundwater user with some relief. The relief provided by this alternative would be the right to bring an action in court for damages.

**Alternative 8(a): Allow public water systems to obtain surface-water rights if their source of supply is dependent on induced recharge from a stream.**

Adoption of this alternative is recommended. However, the water right should be granted only for the specific amount of water to be recharged, and should apply only for the time period in which that recharge is actually needed. This should not include flows used to scour the bottom of the stream.

A major source of difficulty in administering this alternative may be determination of the amount of time it may take for recharge water from a stream to reach a well and the amount of recharge a well or wellfield may receive naturally from other sources. It is appropriate to require municipalities applying for such rights to provide evidence indicating the rationale for the amount of flow required and when the call on surface water should be made to be effective.

It is recognized that this alternative may receive only limited use. The burden of proving the amount and timing of flow required will fall upon the municipality. The Metropolitan Utilities District (Omaha and surrounding communities) wellfield on the Platte is one case where such rights may be needed. The Grand Island situation may also need to be considered in adopting this alternative. There the flow may be needed to prevent seepage to municpal wells of nearby groundwater with high nitrate levels. However, the exact hydrologic situation in that case is open to discussion.

Although widespread adoption of surface water rights for induced recharge for irrigators and subirrigators is not recommended, it would be appropriate to study granting such rights for induced recharge wellfields for irrigation. Such study should specifically be considered in connection with *Alternative 11.*

**Alternative 9: Expand research and data collection related to impacts of streamflow uses on recharge of groundwater.**

Limited adoption of this alternative is recommended. In some cases, there may need to be data collected to determine whether there is a sufficiently direct relationship between surface flows and water level in the wellfield to justify issuing a water right. In addition, research into the impact of flows on municipal recharge may show whether there may be future problems due to inadequate scouring.

**PROBLEM AND ISSUE #3: WHETHER LEGAL MEASURES SHOULD BE TAKEN TO AUTHORIZE PUMPING OF GROUNDWATER TO SUPPLEMENT STREAMFLOW, LAKE, OR WETLAND LEVELS.**

**Alternative 11: Declare that groundwater may be transferred off the overlying land to meet instream, irrigation, or other needs, or maintain lake or wetland water levels.**

The Natural Resources Commission recommended allowing transfer of groundwater off the overlying land on a permit basis for agricultural purposes in the *Policy Issue Study of Supplemental Water Supplies.* Transfers for municipal and industrial purposes are allowed under current law. It is now recommended that such transfers be allowed by permit for instream, and lake or wetland needs as well. It is expected that transfers for any of the above purposes would often take place via streambed. Legislative action would be required to implement this alternative.

With sufficient safeguards this alternative may benefit both irrigation uses and environmental needs. If crop prices were to rise, the transfer of groundwater for irrigation purposes could provide fairly widespread economic benefits. If it reached the streambed, the pumped groundwater would need to be treated in the same legal manner as is stored water being transported for use downstream.

The degree to which the pumped groundwater is in hydrologic connection to the stream may paradoxically account for both the major potential benefits and problems of adopting this alternative. When pumping groundwater from an aquifer in close hydrologic connection and close proximity to the stream benefits can be realized by providing additional water for beneficial use during times of low flow and creating more unsaturated space for recharge during times of high flow. This alternative may therefore encourage use of the aquifer much like a surface storage reservoir which is drawn down in the season of highest need and refilled in the off season.

Wellfields designed to induce recharge from a stream should be specifically studied in adoption of this alternative. Transfer of water from such wellfields could provide a significant opportunity for expansion of irrigation. Some type of permitting system would be needed to allow this.

This alternative may also provide more effective total use of water. For instance, an irrigator may use surface water during all but a few critical weeks, at which time, groundwater is pumped into a stream and delivered to him or her. This may allow little surface water to flow away unused and make only a small demand on the groundwater reservoir.

Balanced against this, and needing to be assessed in the permitting process, are the potential negative impacts of a number of factors. These may include: (1) a fairly direct effect on flow in the irrigation season by utilizing groundwater that might have become stream baseflow in a matter of days or weeks, (2) long-term depletions to baseflow of gaining stream segments (especially those that already have sufficient surface storage), (3) in transit losses (especially in losing stream segments), and (4) depletion of local groundwater supplies. The major administrative difficulty to implementation of this alternative is likely to be the decision on when a permit to transfer groundwater should be granted. Criteria for granting the permit should be based on an examination of the potential benefits versus the magnitude of the negative impacts noted above. Pumping for instream flow maintenance would be made subject to an application process similar to that the Game and Parks Commission and natural resources districts now may use for instream flow appropriations. Economic constraints would probably limit such instream uses. The director of the Department of Water Resources would need to decide whether a permit would be in the public interest. The impact of large scale transfers on the immediate area of withdrawal should be considered. Confining transfers so that they must occur within a certain distance of the streambed might be considered as a permitting basis if groundwater levels in the basin could be severely impacted. Some study of a system for administering this alternative and specifically the basis for granting permits would be needed before it is implemented.

**Alternative 12: Expand research into the impacts of using groundwater pumping to supplement streamflow to meet instream, irrigation, municipal and other needs, or to maintain lake, wetland or reservoir levels.**

Implementation of the previous alternative authorizing permits for transfer of groundwater would require considerable data collection and/or research to determine its potential impacts in some areas.

**PROBLEM AND ISSUE #4: WHETHER LEGAL MEASURES SHOULD BE TAKEN TO ENCOURAGE WATER PROJECTS TO MANAGE GROUNDWATER LEVELS IN A MANNER THAT MAXIMIZES THE BENEFITS AND MINIMIZES THE NEGATIVE IMPACTS THAT RESULT FROM INCREASED WATER-TABLE LEVELS AND BASEFLOWS.**

**Alternative 14: Require new water development projects to address water use efficiency methods, potential drainage problems and recharge benefits in the planning stages of a project prior to application for a water right, or to secure state funding or advocacy.**

**Alternative 15: Require that groundwater be used instead of surface water in selected areas where a high water table has caused or is likely to cause damage. Districts could drill wells in such cases.**

These two alternatives should be adopted in a manner that requires new projects to include a water management plan which would maximize the benefits and minimize the damages that a rising water table and baseflows due to a project may provide. Such plans could result in groundwater being used where a high water table is a problem and surface water being used in areas where recharge is needed. Such plans could also be expanded to include more than just preventing high water table levels and could promote the most efficient possible water use through planning of an integrated management system for the project.

**Alternative 16: Expand research into the impacts of water table rises due to surface-water projects and how those impacts may be either minimized or masimized as desirable.**

Research on this topic would be helpful in formulating management plans for problems caused by high water tables. Both state and local level research could be useful.

**PROBLEM AND ISSUE #5: WHETHER OPPORTUNITIES EXIST AND LEGAL MEASURES SHOULD BE TAKEN TO INTEGRATE THE LONG TERM USE OF GROUNDWATER AND SURFACE WATER IN A MANNER THAT MAINTAINS OR INCREASES THE EFFECTIVELY USABLE SUPPLY.**

**Alternative 21(a): Give districts engaged in groundwater recharge the rights to use fees and regulation to attain exclusive control of water they have stored underground to achieve a balanced use of surface water and groundwater.**

Limited adoption of this subalternative is recommended. A district with authority for recharge should be allowed exclusive rights to control water they store under an individual's land. The district should be authorized to establish and maintain a flexible fee schedule, varying fees in such a way that groundwater use would be encouraged during times of surface water shortage and vice versa.

Presently, state law does not grant authority for new project sponsors to vary fees for use of recharge water or surface water to achieve a balanced use of each. Action explicitly granting this right would be helpful. Project sponsors are now allowed to charge for the costs of the project or the benefits the project provides. However, the motive for this alternative is to provide for balanced use of surface water and groundwater rather than the project repayment. This may require a different fee structure.

It is recommended that the right to vary fees be conditioned on state approval of a water management plan that provides for integrated management of water in the project area.

**Alternative 21(b): Allow districts to levy the following types of pump taxes:**
**(1) A general pump tax;**
**(2) A replenishment tax;**
**(3) A net pump tax on water used beyond an allocated amount.**

It is recommended that natural resources districts be authorized to levy any one of the above taxes. They are seen as equally valid ways to fund projects engaged in recharge. The authorizing legislation for these taxes should include a maximum limit on taxation rates. In the *Policy Issue Study on Supplemental Water Supplies,* the Natural Resources Commission previously recommended state implementation of water use fees and legislation allowing local governments to authorize water suppliers to assess such fees. In that study, the local option was assumed to be a locally imposed water severance tax. The options proposed in this subalternative would allow water users to be taxed at either a set rate per pump, or at a rate per acre-foot used geared to replenishing groundwater in areas of decline, or at increased rates when water is used above an allocated amount. However, selection of only one of these options should be allowed. These could all help bring about water use efficiency, or provide for supplemental water supplies. They would be especially pertinent to groundwater control or management areas. It should be noted that a type of replenishment tax is currently allowed for new recharge projects. Under the provisions of LB 198 (1983), new recharge projects can charge for their costs.

**Alternative 21(c): Allow districts to levy an additional property tax to generate funds for construction of groundwater replenishment projects.**

Natural resources districts should be allowed an additional property tax levy for supplemental water projects, including groundwater replenishment projects. The maximum levy should be specified. Allowing Natural Resources Districts to levy an additional property tax for building supplemental water projects was recommended by the Natural Resources Commission in the *Policy Issue Study on Supplemental Water Supplies.*

**Alternative 22: Expand research related to the impacts of integrating use of groundwater and surface-water supplies.**

Research related to the legal and economic impact of adopting *Alternatives 21 (a), (b),* and *(c)* would be helpful. Many of the physical impacts could be addressed through the expanded research proposed for other problems and issues.

## ALTERNATIVES NOT RECOMMENDED

*Alternatives 1, 6, 10, 13,* and *17:* Continue current policies. Changes were suggested in current policy rather than adoption of these alternatives.

**Alternative 2(a): Allow groundwater users to (1) make any beneficial use of groundwater under their land without incurring liability for any resulting injury to surface-water users or (2) make such beneficial use without liability if the groundwater is used on overlying and the purpose of use is reasonable.**

Adoption of this subalternative is not recommended. Groundwater users who have a direct and substantial effect on previous surface-water users should be subject to suit.

**Alternative 2(b): Establish a cut-off boundary system that creates either conclusive or rebuttable legal presumption that groundwater withdrawals between the streambank and a cut-off line directly affect streamflow.**

Adoption of this subalternative is not recommended due to the difficulty of accurately setting cut-off boundaries, the possible legal costs, and the potential for waste of water if relatively higher water tables result in more surface flow leaving the state in the off season or in higher transpiration from phreatophytes.

**Alternative 2(c): Make groundwater users liable only for injury resulting to surface-water users in higher preference categories.**

This subalternative is not recommended, in part, because it would receive very limited use. The number of surface-water users in the highest preference category of domestic use is small. In addition, this is probably an inequitable approach to solving groundwater user conflicts with surface-water users. It would probably be less inequitable if damages could be collected from users in the same preference category. However, even with that provision it would not be recommended.

**Alternative 2(e): Apply a common pool correlative rights principle.**

Adoption of this subalternative is not recommended. This is partially because a proportional decrease in use by all parties could leave all of them with insufficient water to accomplish their purpose.

**Alternative 4: Put groundwater rights in selected "tributary" areas in an appropriative system and coordinate with the surface-water rights sytem.**

While developing an appropriative system for groundwater might aid resolution of groundwater and surface-water conflicts, the "first in time, first in right" concept is contrary to existing groundwater management policies which are based upon reasonable and beneficial use by landowners. Incorporating this alternative in part into *Alternative 3* as was recommended earlier is a more appropriate way of impelementing the desirable parts of this alternative.

**Alternative 7(a): Establish a cut-off boundary system that creates either a conclusive or rebuttable legal presumption that wells within the cut-off boundary are dependent upon induced recharge from the stream.**

Accurate definition of cut-off lines would be very difficult given current hydrologic knowledge. Municipal wells can be protected by other means.

**Alternative 7(b): Make surface-water users liable if their actions result in injury to groundwater users in higher preference categories.**

There may be inequities to determining liability based upon the type of user injured rather than the extent of injury. This is especially true when damages cannot be collected from users in the same preference category.

**Alternative 7(d): Apply a common pool-correlative rights principle.**

Adoption of this subalternative is not recommended in part because of proportional decrease in use by all parties could leave all of them with insufficient water to accomplish their purpose. Furthermore, it would reduce certainty about the extent of a water right. Water users may need to base management decisions on the expectation of a certain amount of water being available.

**Alternative 8(b): Allow groundwater irrigators to obtain surface-water rights if their water source is substantially dependent on a stream.**

**Alternative 8(c): Allow irrigators to obtain surface-water rights if maintenance of a high water table is dependent on recharge from a stream.**

These alternatives are not specifically recommended at this time. However, study of granting such rights for induced recharge wellfields for irrigation for development purposes is recommended. Such rights may ultimately be in the state's interest.

**Alternative 18: Create and maintain a state fund specifically for integrated management projects or give special consideration to integrated management benefits under existing funding arrangements.**

It is recommended that integrated management projects be treated under existing funding arrangements rather than through a separate fund. The method of assessing recharge benefits in both funds should be subject to continual review and refinement. We should be certain such benefits are fully counted. However, they should not receive a preference over other types of benefits.

**Alternative 19: Provide financial incentives for recharge, especially in groundwater control or management areas. Allow additional water use if recharge measures are adopted.**

Adoption of this alternative is not recommended. With water spreading, it would be difficult to determine whether the technique was implemented for irrigation, soil moisture, or recharge purposes. Individual recharge wells would be expensive and could create water quality problems if run by individuals. It would be difficult to determine the recharge potential of small dams and ponds that individuals might propose.

**Alternative 20: Require senior surface-water appropriators in selected areas to use available groundwater before calling on junior surface-water appropriators that have no access to groundwater. Require or allow either public or private compensation for the costs involved.**

In *Alternative 11,* it was recommended that transfer of groundwater be allowed. It is not felt that we should go beyond those recommendations at the current time. If a workable and equitable way can be found to compensate prior surface-water users, then the recommendation on this alternative could be expanded. It seems possible that substantial economic benefits could be obtained from its adoption.

**Alternative 21(d): Allow basins to make "basin equity assessments".**

This alternative is not recommended because Nebraska does not generally have surface-water distribution systems serving basins in which few or no previous groundwater rights exist. California, where this alternative has been implemented, has surface water distribution systems with related recharge in well defined basins with no previous groundwater rights. This alternative would result in everyone paying the same total cost to utilize water in the basin. Parties allowed to use less expensive water sources would have fees to pay. Parties utilizing more expensive sources might have no such fees. It would be difficult to fit previously existing groundwater rights into such a system in an equitable manner.

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# Summary

The *Policy Issue Study on Integrated Management of Surface Water and Groundwater* was conducted as part of the Nebraska State Water Planning and Review Process. It is one of a series of studies which analyze Nebraska's water policy issues. The purpose of this report is to present alternative state policies related to the integrated management of Nebraska's surface-water and groundwater systems and evaluate their impacts. A second purpose is to assemble available physical information on surface-water and groundwater relationships, explain problems and issues related to those relationships, and identify additional research needs.

This report contains eight chapters. The first three deal with an overview of integrated management, physical interrelationships between surface water and groundwater in Nebraska, and integrated management technologies. The remaining chapters deal with five separate problems and issues related to integrated management. They also examine twenty-two policy alternatives. Chapter 4 deals with the impact of groundwater pumping on surface-water uses. Chapter 5 deals with the impact of streamflow uses on recharge of groundwater. Chapter 6 deals with the impacts of using groundwater pumping to maintain surface-water use. Chapter 7 deals with the impacts of groundwater-level rises due to surface-water projects. Chapter 8 presents alternatives related to more thorough integration of the entire surface-water and groundwater management system.

## INTEGRATED MANAGEMENT

As used in this report "integrated management" of surface water and groundwater refers to any combination of physical, technical, administrative, and legal practices relating to surface water and groundwater in a manner designed to increase combined benefits or achieve a more equitable apportionment of benefits from both sources. Nebraska's laws for administering surface water differ considerably from those governing the use of groundwater. The components of the physical environment however are not as easily separable as the components of a legal system. Groundwater and surface water are interrelated in different ways throughout Nebraska. In many areas research may be required before the extent, timing and significance of the relationship can be determined.

### POLICY RELEVANCE OF PHYSICAL RELATIONSHIPS BETWEEN GROUNDWATER AND SURFACE WATER

Streamflow in Nebraska, now as well as prior to water-resource developments, may be, in varying degrees, maintained by seepage from the groundwater reservoir. Only locally, however, is the groundwater reservoir recharged by seepage from streams. Man's use of surface water has altered the flow regime in many stream reaches within the state and in several places has augmented recharge to groundwater. His use of groundwater has depleted groundwater reserves significantly in some places and has reduced groundwater seepage into some stream reaches. In other areas, groundwater reserves and baseflows of streams have increased. Land use and land-management practices also have affected streamflow and probably have altered the rate of recharge to groundwater. Even greater changes in flow regime and in amounts of groundwater in storage can be anticipated with passing time. These future changes will result not only from water-use developments still to come but also from a few past and current developments whose effects on streamflow and groundwater storage are not yet measurable.

Water-use developments have already caused problems in some places and are likely to cause similar problems in other places in the future. In some areas, they have also resulted in increased baseflows and water table levels that may be worthwhile to preserve or encourage. Therefore, a growing need exists to establish State policy regarding water developments as they affect the relation of surface-water use to groundwater supplies and, conversely, as they affect the relation of groundwater use to the baseflow of streams. State policy to remedy existing water problems, to lessen or prevent future water problems, and optimize future water development benefits also needs to be formulated.

The complexity and lack of data availability on the relationship between groundwater and surface water may be a constraint to developing policy, especially a statewide policy. Determining what the actual physical situation is for an area can be both difficult and expensive.

## EQUITY, ENVIRONMENTAL, AND ECONOMIC BENEFITS OF ARTIFICIAL RECHARGE

The goal of most alternatives presented in this report is to increase economic or environmental benefits or change who receives benefits in a manner perceived as more equitable. Under current laws the assumption is usually made that groundwater and surface water are not impacting each other. A senior water user may have to bear a prohibitive expense to prove otherwise. Equity related policy may address how to change this situation.

Environmental costs and benefits are often by-products of projects intended for other purposes. However projects affecting recharge can impact baseflow in streams during critical periods, lake levels, and the extent of wetlands and subirrigated lands. There may not be legal incentives to see that actions providing environmental benefits are continued.

The economic impacts of recharge from existing irrigation projects in Nebraska are probably fairly high. There are substantial numbers of groundwater irrigation systems installed in areas where surface-water projects have recharged the aquifer. Recharge benefits can occur both in the form of expanded crop production and reduced pumping lifts.

However conclusions from one study indicate that the level of recharge benefits will generally not be sufficient to justify a single-purpose recharge project in the High Plains region under the cost benefit calculation methods used. That study found benefits in the Upper Big Blue area to most likely be in the $5 to $10 per acre-foot range. It also noted that it appeared unlikely that a project in the High Plains region could be designed with less than $30 per acre-foot cost and that least-cost alternatives may fall closer to the $57 to $90 range. Recharge benefits can nonetheless be a very substantial contributor to a multiple-purpose project.

No intensive study had been done in Nebraska of a large-scale project primarily for recharge until the O'Neill Alternatives Study. That analysis provides some information on the feasibility of such projects. More information is needed on the economic feasibility of small-scale, individual recharge projects.

Calculation of benefits requires an evaluation of the role of discount rates in recharge projects. Recharge benefits are especially adversely impacted by the use of a discount rate or rate of return in cost-benefit analysis because of the long-term nature of aquifer life extension benefits.

Another major area of potential economic benefits from integrated management is apportionment of groundwater and surface water in a manner that maintains or increases the effectively usable supply from both sources. Chapter 8 includes alternatives which could be used to extend water supplies to additional users or additional irrigable acres through policies encouraging a change in the source of water used.

Other important topics related to the economics of recharge and integrated management include: the role of integrated management in setting water use goals, balancing of equity and economic benefits, the method by which recharge benefits are determined and assessed to individual landowners, and the overall economic feasibility of water projects.

## CONJUNCTIVE USE IN NEBRASKA AND OTHER STATES

Among the areas in which surface-water projects have resulted in significant recharge are the Central Platte area, the North Platte Valley, the Republican Valley, the Mirage Flats project area, and the Ainsworth area. The groundwater development in the Central Platte Valley since Lake McConaughy was completed in the early 1940's has been especially significant. Groundwater users have capitalized on a "mound" of groundwater built up by seepage from canals carrying water in part of the Central Nebraska Public Power and Irrigation district. Deep percolation of applied irrigation water has probably also been a factor in the area. This development helped lead to enactment of LB 198 in the 1983 session of the Unicameral. That bill allows districts authority to assess limited fees for recharged water.

Western states which have adopted approaches to managing surface water and groundwater significantly different from Nebraska's include California, Arizona, and Colorado. In California local water districts have been given extensive powers to facilitate the transfer of surface-water supplies from areas of abundance to replenish or otherwise reduce dependence on groundwater. In combination with the ability to levy various fees and taxes for water use, their powers enable them to control effectively the amount of water use and whether it comes from groundwater or surface water. In Arizona extensive controls on groundwater use have been combined with a massive supplemental water project and provisions for former groundwater users to use new supplemental water. In Colorado groundwater deemed to be "tributary" to senior surface-water rights is regulated.

### PROBLEMS AND POTENTIALS OF INTEGRATED MANAGEMENT IN NEBRASKA

A number of potential problems and advantages would result from establishment of a comprehensive integrated surface-water and groundwater management system. One problem is that Nebraska currently administers groundwater and surface water through different legal policies. It is also missing some of those key components that favor the use of supplemental water in the integrated management systems established in Arizona and California. High-value uses of water, high-relief surface-water storage sites, and dramatic depletions of groundwater along major streams generally do not occur in Nebraska.

Nebraska also has some unique advantages for managing surface water and groundwater in an integrated manner. The Platte River system flows through or near regions in which unsaturated sediments provide a readily available recharge area. Nebraska is also blessed with extensive areas of aquifer and large areas in which sandy soils can facilitate higher recharge rates. Depending upon other economic factors generally affecting water projects, this could encourage construction of projects having significant recharge components.

Streamflow impacts of extensive groundwater development in recent years probably have not yet been fully realized in a few areas of groundwater level declines. Therefore, equity-related questions could expand in the future as the impacts of groundwater depletion on surface water are felt in those areas.

## THE PHYSICAL RELATIONSHIP BETWEEN SURFACE WATER AND GROUNDWATER IN NEBRASKA

The full report mentions specific instances of the more immediate or severe physical manifestations of each problem and issue. However, general information on the physical interrelationships between surface water and groundwater is needed in order to understand those situations and determine where similar situations may be developing or could occur under varying conditions.

Exchanges between surface water and groundwater are part of a complex system of water movement through the earth and its atmosphere known as the hydrologic cycle. Water that falls to earth as precipitation may fall directly on bodies of surface water such as oceans, streams, lakes, wetlands, or permanent snow and ice. It may fall on the land and run off as diffused surface water to a stream. It may also infiltrate below the surface of the earth. Some may evaporate back to the atmosphere before it can reach a stream or lake. In each of these cases the water will transfer eventually to another stage of the cycle.

A major factor in the relationship of surface water to groundwater is the time water spends in storage and transit underground. The speed with which water moves through the groundwater portion of the hydrologic cycle varies tremendously with aquifer characteristics and topography. In some areas water may make its way back to the surface in a few days or weeks. In other areas the water may remain in transit for long periods of geologic time. Water resources that make their way through the cycle slowly are sometimes thought of as non-renewable. Man's activities can influence the rate at which water moves through the cycle.

### SURFACE WATER IN NEBRASKA

In 1980 gross surface-water withdrawals were about 40 percent of the total water withdrawals in Nebraska. However, they probably comprised a much smaller percentage of consumptive use. The two principal sources of streamflow are overland runoff of precipitation, and groundwater seepage. Under ordinary hydrologic conditions some streams flow intermittently and some flow continuously. Naturally intermittent streams depend almost entirely on overland runoff for their flow. Naturally continuous flow at a given point along a stream indicates that upstream from that point at least some reach of the stream, or one or more of its tributaries, is receiving seepage from groundwater.

Development of our water resources has caused the flow of some streams to become intermittent and, vice versa, has made continuous the flow of some streams that formerly had intermittent flow. Stream reaches where the groundwater system loses flow to the stream are said to be gaining. Losing reaches of streams recharge the groundwater.

### GROUNDWATER IN NEBRASKA

It is estimated that Nebraska overlies nearly 1.9 billion acre-feet of recoverable groundwater of good to excellent quality. This enormous quantity of water is not evenly distributed throughout the state. Some areas have virtually none; in other areas the groundwater reservoir exceeds 1,000 feet in saturated thickness.

The amount and quality of recoverable groundwater, variations in the abilities of the geologic formations to yield water, the depth to water, and land suitability for irrigation produce differences in the potential for future use. For instance, eastern Nebraska is underlain primarily by fine-grained materials such as silt and clay, which yield water slowly and are suitable only for low volume rural domestic supplies.

Groundwater in Nebraska generally moves slowly southeastward. Variations in this directional trend occur in the vicinity of rivers and streams and where depressions in water levels occur in response to groundwater withdrawals. Rates of lateral movement range from several feet per day in gravel deposits to as little as a few inches per year in fine-grained materials. Most groundwater recharge results from infiltration of precipitation falling within the area or from surface water applied to the land.

Surface water can recharge groundwater through the unsaturated zone. Groundwater moves directly to surface water where the water table intercepts the surface of the land.

## EXCHANGES BETWEEN SURFACE WATER AND GROUNDWATER

There is a hydraulic connection of water in streams and water in aquifers adjacent to streams where the water table intersects the streambed. Because of this hydraulic connection, water is able to percolate through the streambed, either into the stream or away from it into the aquifer. The direction of percolation is determined by the slope of the water table.

The water table is nearly flat beneath the floor of broad river valleys. The direction of water movement toward or away from the stream in such valleys can change according to the river stage, the proximity of recharge or pumping, and rate of transpiration by nearby vegetation.

The magnitude of gain or loss of streamflow is also affected by river stages, the proximity of pumpage or recharge and rate of transpiration by nearby plants. Protracted dry weather can have a delayed effect because normal recharge to the aquifer is reduced and water levels and hydraulic gradients slowly decline.

In addition to natural causes, some human activities also influence the quantity of water exchanged between surface water and groundwater. Pumping from wells removes water from the saturated zone, lowering the water table in the vicinity of the well. If the well is close enough to the stream, the gradient of the water table can be reversed so that water percolates from the stream to the well. Putting surface water over more land surface can cause more water to enter the groundwater reservoir. If sufficient seepage occurs to raise the water table, the gradient toward the stream is increased and more groundwater will percolate toward it.

The magnitude and timing of the effects of groundwater withdrawals (or recharge) on streamflow are dependent on several factors. These include aquifer transmissivity, aquifer storage properties, the degree of hydraulic connection between the stream and aquifer, and the distance from the point of withdrawal (or recharge) to the stream. These relationships can also apply to other surface bodies, including natural lakes and wetlands.

Generally speaking, pumpage or recharge close to a streambed will have a more immediate effect on streamflow than pumpage or recharge at some greater distance. Withdrawals of groundwater at some distance do not necessarily cause direct reductions in streamflows by induced infiltration, as may occur when wells are located close to streambeds. Withdrawals at some distance reduce the hydraulic gradient toward the stream and thus decrease the amount of groundwater that otherwise would have entered the stream. In areas of shallow water table some of that water might never have reached the stream if it was intercepted and transpired by vegetation. Pumpage or recharge when the water table is nearly flat also has a more immediate effect the closer the proximity to the stream. Determination of the timing and extent of groundwater pumping on streamflow requires study of individual situations. Modeling studies have done this in some cases.

## GROUNDWATER INTERACTION WITH LAKES AND WETLANDS

Nebraska's lakes and wetlands also sometimes have a hydraulic connection with the groundwater. The exact nature of the flow system surrounding these lakes and wetlands is less well understood than the stream-aquifer flow relationship because fewer intensive investigations have been conducted examining their flow system.

The vast majority of naturally occurring lakes and wetlands within Nebraska are in the Sandhills region. The "rainwater basin" of south-central Nebraska is another area where natural lakes and marshes occur, but most lakes and wetlands in this area are, with a few potential exceptions, not in hydraulic connection with the groundwater. In other areas where lakes are a feature of the water table, wetlands and subirrigated areas may surround them. The areal extent of these lakes, wetlands, and subirrigated areas may change depending upon the fluctuating water table.

Evidence suggests that a diversity of hydrogeologic conditions probably surround lakes and wetlands in Nebraska. Specific studies will need to be conducted before these interactions can be understood for specific areas.

## RECHARGE IN NEBRASKA: ACTUAL AND POTENTIAL

Recharge is water that infiltrates to depths below the root zone and into an aquifer. Except in some areas most recharge is provided by precipitation. Among factors determining recharge potential are depth to groundwater, availability of water for recharge, land slope, soil types and characteristics, vertical permeability of the subsoil, storage potential, characteristics of precipitation events, and vegetation.

In addition to areas currently receiving recharge benefits from irrigation activities there are other areas across the state which would be suitable sites for recharge if sufficient water could be provided. These include both areas where the aquifer has been drawn down and areas naturally underlain by unsaturated material suitable for use in groundwater storage. Most of the recharge in surface-water project areas is seepage from canals, ditches, and reservoirs or seepage of excess irrigation water applied to cropland.

Seepage losses reach the groundwater reservoir as recharge. Generally this supplemental recharge provides significant benefits to surrounding groundwater users. However, it can be, and sometimes has been, detrimental when it is not part of an overall water management system. Pollution of groundwater and waterlogging are potential problems.

### WATER QUALITY IN RELATION TO INTERACTION OF SURFACE WATER AND GROUNDWATER IN NEBRASKA

Situations in which interaction of surface water and groundwater affect water quality in Nebraska include the following: (1) surface flow recharging groundwater for municipal use, (2) surface flow recharging a municipal groundwater source in order to stop an influx of poor quality groundwater, (3) seepage from canal flow recharging groundwater of a slightly different quality, (4) high total dissolved solids in surface flow affecting quality of water in an adjacent aquifer, and (5) surface-water contamination by groundwater discharge.

A number of Nebraska municipalities depend upon induced recharge wellfields for their water supply. In these cases the interaction performs an important function since surface water has microorganisms and sediment filtered out as it infiltrates to the groundwater. In the Grand Island case, loss of river water to the adjacent aquifer may be serving the further function of keeping surrounding high-nitrate groundwater from contaminating municipal wells near the river.

Surface flows from streams and canals along the South Platte and Platte have had some small adverse impact on water quality in their surrounding area. However, in no case are these impacts serious, nor do they pose problems.

## TECHNOLOGIES APPLICABLE TO INTEGRATED MANAGEMENT OF SURFACE WATER AND GROUNDWATER

Artificial recharge of groundwater is a means of supplementing recharge from precipitation. Techniques for recharging groundwater include: induced infiltration, water spreading, recharge pits and shafts, and recharge wells. Man can also supplement surface water sources by pumping groundwater into streams, lakes, or wetlands.

In Nebraska, a number of surface-water projects have resulted in significant rises in groundwater levels or have diminished groundwater declines. The Tri-County Area in the Central Platte region has resulted in a rise in the water level over a large area. Other reservoirs and projects contributing to significant water level rises include the Farwell Project, the North Platte Project, the Mirage Flats Project, the Ainsworth Project, and the following reservoirs or lakes: McConaughy, Sherman, Merritt, Box Butte, Enders, Harlan County, Oliver, Swanson, Hugh Butler, and Harry Strunk. A large number of irrigation reuse pits in the state have resulted in artificial recharge. There are also some cases where artificial well recharge systems and surface-water spreading systems have been or are being used.

Artificial recharge can provide such benefits as aquifer life extension and the lowering of pumping lifts. It can be detrimental if the storage potential for recharge is exceeded, or if the quality of the recharge water is undesirable.

## POLICY ALTERNATIVES ADDRESSING THE IDENTIFIED PROBLEMS AND ISSUES

This report describes and analyzes nineteen policy alternatives addressing problems and issues related to integrated management of surface-water and groundwater resources in Nebraska. The alternatives are grouped into five chapters, each of which presents in detail the nature of a specific problem and issue, current state policy, and legal or administrative mechanisms used to address the problem and issue in other states. Each chapter then presents policy alternatives addressing the identified problem and issue and describes and analyzes the impacts of adopting each alternative.

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## PROBLEM AND ISSUE (1) PUMPING GROUNDWATER IN SOME LOCATIONS MAY: (A) REDUCE GROUNDWATER DISCHARGE TO A STREAM, LAKE, OR WETLAND OR (B) INDUCE RECHARGE FROM A STREAM, LAKE, OR WETLAND. IN EITHER CASE THIS MAY HAVE A DETRIMENTAL EFFECT ON SURFACE-WATER USERS WHO INITIATED THEIR USE PRIOR TO THE GROUNDWATER DEVELOPMENT. THE ISSUE IS: SHOULD MEASURES BE ADOPTED BY THE LEGISLATURE TO PROTECT THE INTERESTS OF SURFACE-WATER USERS?

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On face value the alternatives presented for this problem and issue have equity between surface water and groundwater users as their primary emphasis. However, the alternatives also can have an impact on regional economic well being, or the degree to which future investment in water development takes place, on groundwater levels and stream discharge, and on environmental quality. Thus a change in the way surface-water and groundwater users are treated can be used to influence each of those factors.

## ALTERNATIVES

**Alternative 1** Continue current policies relating to the impact of groundwater pumping on streamflow, lakes and wetlands.

**Alternative 1a** Adopt rules of liability to be applied to the hydrologic relationship between groundwater and surface water.

**Alternative 2a** Allow groundwater users to (1) make any beneficial use of groundwater under their land without incurring liability for any resulting injury to surface-water users or (2) make such beneficial use without liability if the groundwater is used on overlying land and the purpose of use is reasonable.

**Alternative 2b** Establish a cut-off boundary system that creates either a conclusive or rebuttable legal presumption that groundwater withdrawals between the streambank and a cut-off line directly affect streamflow.

**Alternative 2c** Make groundwater users liable only for injury to surface-water users in higher preference categories.

**Alternative 2d** Adopt principles of equity in cases of interference between groundwater users and surface-water users.

**Alternative 2e** Apply a common pool-correlative rights principle.

**Alternative 3** Allow a groundwater control area to be declared when it is determined that groundwater pumping substantially impacts surface-water users.

**Alternative 4** Put groundwater rights in selected "tributary" areas in an appropriative system and coordinate with the surface-water rights system. Also prohibit new wells in "tributary" areas where groundwater pumping would impact surface flow within a specified number of years unless junior groundwater appropriators meet one of the following four requirements:

**Alternative 4a** Require junior groundwater appropriators to provide substitute water to senior surface-water appropriators by developing additional supplies for use as needed by senior surface appropriators or by purchasing water for their use.

**Alternative 4b** Require junior groundwater appropriators to retire senior surface appropriations by purchase.

**Alternative 4c** Require junior groundwater appropriators who deplete surface-water rights in areas with access to groundwater to provide wells that would allow senior surface-water appropriators to use groundwater.

**Alternative 4d** Allow surface-water users to transfer their priority date to a well.

**Alternative 5** Expand research into the impact of groundwater pumping on streamflow, lakes, and wetlands.

## PROBLEM AND ISSUE (2) A NUMBER OF MUNICIPALITIES AND IRRIGATORS HAVE WELLS LOCATED ALONG WATERCOURSES AND DEPEND ON INDUCED RECHARGE FROM THE STREAM OR RIVER TO MEET THEIR REQUIREMENTS. IN ADDITION, SUBIRRIGATION IN SOME AREAS MAY BE DEPENDENT TO SOME EXTENT ON STREAMFLOW. FUTURE DEPLETIONS OF STREAMFLOW COULD ENDANGER THESE USES. THE ISSUE IS: SHOULD LEGAL MEASURES BE ADOPTED BY THE LEGISLATURE TO PROTECT THE INTERESTS OF THESE GROUNDWATER USERS?

**Alternative 6** Continue current policies relating to the impacts of streamflow uses on recharge of groundwater.

**Alternative 7** Adopt rules of liability to be applied to the hydrologic relationship between groundwater and surface water.

**Alternative 7a** Establish a cut-off boundary system that creates either a conclusive or rebuttable legal presumption that wells within the cut-off boundary are dependent upon induced recharge from the stream.

**Alternative 7b** Make surface-water users liable if their actions result in injury to groundwater users in higher preference categories.

**Alternative 7c** Adopt principles of equity in cases of interference between streamflow users and groundwater users.

**Alternative 7d** Apply a common pool-correlative rights principle.

**Alternative 8** Allow groundwater users whose source is derived substantially from streamflow to obtain surface-water rights.

**Alternative 8a** Allow public water systems to obtain surface-water rights if their source of supply is dependent on induced recharge from a stream.

**Alternative 8b** Allow groundwater irrigators to obtain surface-water rights if their water source is substantially dependent on recharge from a stream.

**Alternative 8c** Allow subirrigators to obtain surface-water rights if maintenance of a high water table is dependent on recharge from a stream.

**Alternative 9** Expand research and data collection related to impacts of streamflow uses on recharge of groundwater.

## PROBLEM AND ISSUE (3) FLOWS OF SOME STREAMS AND WATER STORAGE IN SOME LAKES, RESERVOIRS, AND WETLANDS DO NOT MEET NEEDS ON EITHER A SEASONAL OR ANNUAL BASES. TO SOME EXTENT THESE NEEDS COULD BE MET BY INCREASING THE SURFACE-WATER SUPPLIES BY PUMPING GROUNDWATER INTO SOME OF THESE AREAS. THE ISSUE IS: WHAT LEGISLATIVE ACTION, IF ANY, SHOULD BE TAKEN TO AUTHORIZE SUCH USE OF GROUNDWATER?

**Alternative 10** Continue current policies related to use of groundwater to supplement streamflow needs, wetland needs, or maintain lake or reservoir levels.

**Alternative 11** Declare that groundwater may be transferred off the overlying land to meet instream, irrigation, or other needs, or maintain lake or wetland water levels.

**Alternative 12** Expand research into the impacts of using groundwater pumping to supplement streamflow to meet instream, irrigation, municpal, and other needs or to maintain lake, wetland, or reservoir levels.

## PROBLEM AND ISSUE (4) WATER-DEVELOPMENT PROJECTS HAVE CAUSED GROUNDWATER LEVELS AND STREAM BASEFLOWS TO INCREASE IN SOME REACHES. THE PROJECTS HAVE RESULTED IN POSITIVE IMPACTS WHEN THEY MAKE MORE WATER AVAILABLE FOR IRRIGATION, FOR MEETING INSTREAM NEEDS, OR FOR IMPROVEMENT OF WILDLIFE HABITAT. HOWEVER, RISING GROUNDWATER LEVELS HAVE A NEGATIVE IMPACT WHERE THEY RESULT IN WATERLOGGING OF VALUABLE LAND, CAUSE WET BASEMENTS, OR CAUSE BACKUP IN SEWER SYSTEMS. THE ISSUE IS: HOW TO ENCOURAGE PROJECTS TO MANAGE THEIR USE OF WATER IN A MANNER THAT MAXIMIZES POSITIVE IMPACTS AND MINIMIZES NEGATIVE IMPACTS THAT RESULT FROM A RISE IN GROUNDWATER LEVELS AND AN INCREASE IN BASEFLOWS OF STREAMS? SOME OF THE PROBLEMS AND ISSUES DISCUSSED HERE ARE ALSO RELEVENT TO ALTERNATIVES PRESENTED IN PROBLEM AND ISSUE #5.

**Alternative 13** Continue current policies in relation to water development projects which cause a rising water-table.

**Alternative 14** Require new water-development projects to address water use efficiency methods, potential drainage problems, and recharge benefits in the planning stages of the project prior to application for a water right or to secure state funding or advocacy.

**Alternative 15** Require that groundwater be used instead of surface water in selected areas where a rising water table has caused or is likely to cause damages. Districts could drill wells in such areas.

**Alternative 16** Expand research into the impacts of water-table rises due to surface-water projects and how those impacts may either be minimized or maximized as desirable.

## PROBLEM AND ISSUE (5) THE USE OF GROUNDWATER FOR IRRIGATION HAS INCREASED DRAMATICALLY OVER THE PAST 20 TO 30 YEARS AND SIGNIFICANT WATER-LEVEL DECLINES HAVE OCCURRED OR ARE ANTICIPATED IN MANY AREAS OF THE STATE. DURING THIS SAME PERIOD THE USE OF SURFACE WATER FOR IRRIGATION HAS REMAINED RELATIVELY CONSTANT IN SPITE OF AVAILABILITY OF UNAPPROPRIATED SURFACE WATER IN MANY STREAMS. WHEN CONSIDERED ALONE NEITHER SOURCE OF WATER MAY BE SUFFICIENT TO MEET THE LONG-TERM DEMAND FOR WATER IN A PARTICULAR AREA. INTEGRATING DAILY, YEARLY, AND/or LONG-TERM USE AND MANAGEMENT OF GROUNDWATER WITH SURFACE WATER AVAILABLE IN OR BROUGHT INTO THAT AREA MAY PRESENT OPPORTUNITIES FOR MAINTAINING OR INCREASING THE EFFECTIVELY USABLE WATER SUPPLY. THE ISSUE IS: WHAT OPPORTUNITIES EXIST FOR INTEGRATING USE AND MANAGEMENT OF GROUNDWATER WITH USE OF SURFACE WATER IN AN OPTIMUM

## MANNER AND WHAT LEGISLATIVE ACTION WOULD BE REQUIRED FOR THESE OPPORTUNITIES TO BE REALIZED?

The multiple powers granted to some special purpose entities in other states may not individually seem important to integrated management. However, when exercised in tandem they can provide extensive powers for comprehensive surface-water and groundwater management. Therefore many of the alternatives listed under this problem and issue deal with granting powers to districts. The districts would most likely be Natural Resources Districts or irrigation districts. They also could be newly created multiple-purpose water districts.

**Alternative 17** Continue current policies related to integrating long-term use of groundwater and surface-water supplies in a manner that maintains or increases the available supply.

**Alternative 18** Create and maintain a state fund specifically for integrated management projects or give special consideration to integrated management benefits under existing funding arrangements.

**Alternative 19** Provide financial incentives for recharge in groundwater control or management areas.

**Alternative 20** Require senior surface-water appropriators in selected areas to use available groundwater before calling on junior surface-water appropriators that have no access to groundwater. Require or allow either private or public compensation for the costs involved.

**Alternative 21** Grant more comprehensive powers to natural resources districts or irrigation districts.

**Alternative 21a** Give districts engaged in groundwater recharge the rights to use fees and regulation to attain exclusive control of water they have stored underground and to achieve a balanced use of surface water and groundwater.

**Alternative 21b** Allow districts to levy the following types of pump taxes:

(1) A general pump tax
(2) A replenishment assessment
(3) A net pump tax on water used beyond an allocated amount

**Alternative 21c** Allow districts to levy an additional property tax to generate funds for construction of groundwater replenishment projects.

**Alternative 21d** Allow districts to make basin equity assessments.

**Alternative 22** Expand research related to the impacts of integrating use of groundwater and surface-water supplies.

# Introduction

## PURPOSE

The purpose of this report is to present alternative state policies related to the integrated management of Nebraska's surface-water and groundwater systems and evaluate their impacts. A second purpose is to assemble available physical information on surface-water and groundwater relationships, explain problems and issues related to those relationships and identify potential additional research needs.

## NEED FOR STUDY

In 1978 Legislative Resolution 300 asked that the State Water Planning and Review Process address water policy issues and "that the policy issues to be considered include but not be limited to questions concerning conflicts among ground and surface water users" and "the conjunctive use of ground and surface waters" as well as eight other water policy topics.

The need for this study became apparent as other policy studies were completed and certain questions related to those two policy issues remained unclear or partially unaddressed. There was special concern that alternatives related to groundwater's impact on surface water had been addressed in only a very general manner when compared to the detailed systems that do exist in some western states. It was also believed that interrelationship problems would be better viewed under a comprehensive examination of surface-water and groundwater relationships.

## SCOPE

A definition of integrated management is provided in Chapter 1. That chapter sets the limits of the study with a general discussion of methods of integrating surface-water and groundwater use and how the concept may apply in Nebraska.

Chapter 2 presents a detailed examination of the physical relationship between surface water and groundwater in Nebraska.

Chapter 3 describes existing technologies which can facilitate integrated management. It also assesses the economic feasibility of technologies and assesses their potential for future development.

Chapter 4 discusses problems, issues and policy alternatives related to the impact of groundwater pumping on streamflow, lake, and wetland uses. It includes a survey of areas in Nebraska where the impact of groundwater pumping on streamflow have already been felt. It also includes five alternatives and nine subalternatives addressing the problem and issue.

Chapter 5 presents problems, issues and policy alternatives related to municipalities, irrigators, and subirrigators whose water supply is dependent upon induced recharge from streams. It includes four policy alternatives and eight subalternatives.

Chapter 6 contains three alternatives related to maintaining streamflow, lake, reservoir or wetland levels by utilizing groundwater.

Chapter 7 contains four alternatives which address the impacts of groundwater level rises due to surface-water development projects.

Chapter 8 concludes the report by presenting problems, issues, and policy alternatives related to integrating the long-term use of the groundwater and surface-water supply in a manner that presents an opportunity for maintaining or increasing the effectively usable water supply. The chapter contains six alternatives and five subalternatives. Because the alternatives relate to multiple powers for natural resources districts or irrigation districts they can also be helpful in managing water in a way that addresses some of the problems and issues discussed in previous chapters.

An appendix to the report contains additional material on the potential gaining or losing status of stream segments. References are included at the end of each chapter.

## RELATIONSHIP TO OTHER POLICY ISSUE STUDIES

Previous Policy Issue Studies on Instream Flow, Groundwater Reservoir Management and Supplemental Water Supplies generated a great deal of physical information and some policy material relevant to the issues discussed in this report. This report makes extensive use of the material produced by those studies.

Chapter 2 deals with the physical relationships between surface water and groundwater in Nebraska and relies heavily on material compiled in other policy studies. Maps, figures, and some of the accompanying text in Chapter 2 were largely drawn from the work of the Conservation and Survey Division in the three previously mentioned policy issue studies. Special credit should go to work produced by the Conservation and Survey Division, UNL and the Department of Water Resources for the *Instream Flow Policy Issue Study* in an unpublished report entitled *"Stream-Aquifer Relationships in Nebraska."* The map of "Flowing Waters in Nebraska" published as Figure 3 of in Chapter 2 was compiled by the Instream Flow Policy Study Task Force.

The report also contains information produced in other studies as a partial basis for some of the material on policy alternatives. Some of the information on induced recharge wellfields contained in Chapter 5 was previously included in the *Policy Issue Study on Municipal Water Needs*. The *Policy Issue Study on Supplemental Water Supplies* included a general discussion of many of the issues contained in this report. It also contained more detailed material relevant to alternatives on funding for recharge projects.

## Chapter 1

# Integrated Management

As used in this report "integrated management" of surface water and groundwater refers to any combination of physical, technical, administrative and legal practices applied to surface water and groundwater in a manner designed to increase combined benefits or achieve a more equitable apportionment of benefits from both sources. Nebraska's laws for administering surface water differ considerably from those governing the use of groundwater. The components of the physical environment however are not as easily separable as the components of a legal system. Groundwater and surface water are interrelated in different ways throughout Nebraska. In many areas research may be required before the extent, timing and significance of the relationship can be determined.

Integrating the management of water sources is a subject which has been discussed considerably by legislators, water resources planners, and water administrators in various states. The fact that a number of states have adopted differing approaches to the subject has helped lead to the examination of Nebraska's options as presented here. Often what this report identifies as "integrated management" has been referred to as "conjunctive use" by other sources. Although the terms are sometimes used interchangably, in this report the term "integrated management" will generally be preferred because of its implication of a planned system of use or a project design objective whereas conjunctive use of surface-water and groundwater sources may occur without such a planned system.

This chapter will introduce the concepts and issues which are developed more thoroughly in subsequent chapters of the report. It will also deal with concepts that are not strictly applicable to any one chapter or apply to more than one chapter. General topics with which this chapter will deal include: physical relationships between surface water and groundwater and their relevance to water policy, problems and issues related to integrated management, economics of artificial recharge and integrated management, conjunctive use in Nebraska and other states, and the problems and potentials of integrated management in Nebraska.

## PHYSICAL RELATIONSHIPS BETWEEN SURFACE WATER AND GROUNDWATER AND THEIR RELEVANCE TO WATER POLICY

Exchanges between surface water and groundwater are part of a complex system of water movement through the earth and its atmosphere known as the hydrologic cycle. That cycle is described in detail in Chapter 2. Perhaps the most important subcomponents of that cycle in terms of this report are the portions of streamflow derived from groundwater seepage, the portion of groundwater derived from seepage from streams, and the infiltration of water diverted from streams.

Naturally continuous flow at a given point along a stream indicates that upstream from that point at least some reach of the stream, or one or more of its tributaries, is receiving seepage from groundwater. Stream segments which receive such flow are said to be gaining reaches of a stream. Other segments of a stream may lose flow to the surrounding aquifer. In these cases a stream segment receives all of its flow from either overland runoff or upstream segments which receive groundwater seepage. Some stream segments may also vary between gaining and losing depending upon river stage and water-table levels.

These gaining and losing facets of streamflow (as well as with lakes, reservoirs, and wetlands) form the physical basis of most of the problems and issues discussed in this report. The actions of man such as groundwater pumping or use of streamflow can change the rate at which a stream is gaining or losing or that an aquifer is being recharged. However the impact on streamflow or water table levels as a result of these actions can differ greatly throughout the state depending upon a variety of physical conditions. In some areas confined aquifers and differing geologic materials result in a variance in the relationship. In the Sandhills the relationship is complicated by a labyrinth of surface relief and varying agricultural and ecological systems dependent upon the water resource. In parts of the Republican Basin there are significant questions as to what portion of streamflow depletions are caused by decreases in expected precipitation, changes in soil and water conservation practices, or increased ground-

water pumping. In areas throughout the state there is a significant question as to the degree to which groundwater withdrawals may impact surface flows and when such impact will occur. The complexity and lack of data availability on the relationship between surface water and groundwater is not confined to any one area of the state and may be a constraint to developing policy, especially the development of a statewide policy.

The complex situation throughout the state has led to problems in adapting the legal system to the physical situation. Determining the actual physical situation for a specific area can be difficult and expensive.

## PROBLEMS AND ISSUES RELATED TO INTEGRATED MANAGEMENT

This report deals with five problems and issues related to integrated management of surface water and groundwater. These include:

(1) Whether legal measures should be taken to protect prior surface-water users when groundwater pumping reduces groundwater discharge to surface water or induces recharge from surface water.

(2) Whether legal measures should be taken to protect municipalities, irrigators, and subirrigators dependent upon recharge from surface water to maintain their groundwater supply.

(3) Whether legal measures should be taken to authorize pumping of groundwater to supplement streamflow, and lake or wetland levels.

(4) Whether legal measures should be taken to encourage water projects to manage groundwater levels and baseflow in a manner that maximizes the benefits and minimizes the negative impacts that result from increased water-table levels and baseflows.

(5) Whether opportunities exist and legal measures should be taken to integrate the long term use of groundwater and surface water in a manner that maintains or increases the effectively usable supply.

Each of the above problems and issues is dealt with in greater detail in the later chapters of this report. However some general factors which pertain to more than one of the above problems and issues are discussed in the following sections of this chapter.

## EQUITY BENEFITS AND ENVIRONMENTAL BENEFITS OF ARTIFICIAL RECHARGE AND INTEGRATED MANAGEMENT

Achieving what some would consider a more equitable distribution of water use benefits is one of the primary aims of many of the alternatives presented in this report. Under current laws the assumption is usually made that groundwater and surface water are not impacting each other. A party being damaged because the two sources (groundwater and surface water) are interacting must go to considerable expense and effort to prove that use of one source is impacting supplies of the other. In some cases proof of the degree of influence that use of one water source is having on the other is simply not feasible. For instance there may be a large number of users who combine in varying degrees to bring about a depletion to the other source. Thus some would consider it equitable to provide a less cumbersome means for the senior user to protect his water source. Equity related policy may also provide compensation to those who are impacted adversely by other proposed policy changes.

Environmental costs and benefits are worthy of consideration in reviewing the problems and issues contained in this report. Projects affecting recharge also can impact baseflows in streams during critical periods, lake levels, and the extent of wetlands and subirrigated lands. In some cases groundwater level rises due to projects have caused losing streams to become gaining streams which have year-round flow. They have also created wetlands due to water table rises. When considering the total impacts of projects these water table related benefits must be compared with potential flow depletions which may occur in other areas.

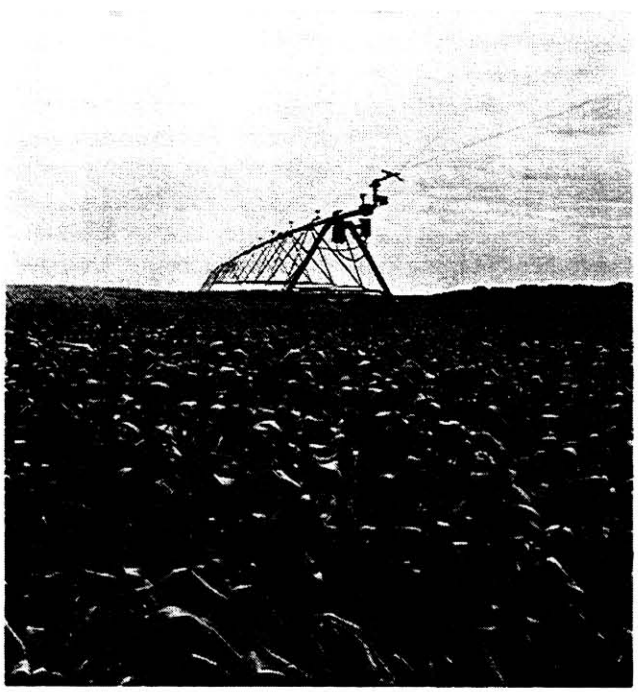
Because the environmental benefits are often by-products of projects intended primarily for other purposes there may not be legal incentives to see that those benefits are continued.

## ECONOMICS OF ARTIFICIAL RECHARGE AND INTEGRATED MANAGEMENT

The economic benefits of integrated management systems and recharge projects are major determinants of whether it is worthwhile for the state to adopt many of the policy alternatives presented in later chapters of this report. Discussion of economic impacts in those chapters is specific to each alternative. However, some of the general economic factors discussed in this section can help provide a perspective on items applicable to more than one alternative. The discussion of those factors also points out the economic importance surface-water and groundwater relationships can and do have to the state.

This chapter examines the following economic factors related to integrated management systems and artificial recharge: recharge benefits of existing projects; the multipurpose nature of recharge projects; the impact of discount rates on economic analysis of recharge projects; economic benefits of alternate management systems; and feasibility, financing and cost allocations for recharge projects.

The primary economic factor worth noting is the value of recharge from existing water projects and irrigation in Nebraska. Extensive irrigation from project water in the Central Platte Valley has resulted in the buildup of a groundwater mound beneath lands south of the Platte River. This has probably allowed additional land to be brought into production via groundwater irrigation.



However the economic benefits of irrigation projects will not necessarily be exclusively in the form of increased production or reduced pumping lifts from land overlying groundwater mounds. In some areas surface water projects may stabilize water levels or simply lessen the rate of decline in the water table. For instance seepage losses from the Box Butte Reservoir and Mirage Flats Irrigation District probably serve to lessen groundwater level declines in those areas. The economic effect may be just as important or more important in these cases.

Another benefit of existing projects and irrigation is the stabilizing of streamflow through use of the groundwater reservoir. The recharge a project provides to the groundwater reservoir may eventually make its way back to the river. The delay may provide needed baseflow at what otherwise would be a low-flow period. Similarly, irrigation from natural flow in a stream can augment natural recharge to the groundwater reservoir and thereby maintain groundwater storage and in return result in a greater contribution to baseflow at a later time. In some cases, such as in parts of the North Platte Valley, groundwater irrigators draw down the water table near the river, thus providing storage space for recharge in the off season. Whether irrigation results in long-term storage in the groundwater reservoir or simply results in a short-term delay before the water returns as baseflow, the opportunities for economic use of the water can be extended.

Chapter 3 presents additional information on recharge from existing surface-water projects. Quantitative information on the amount of recharge from projects is not readily available. Neither is information on the economic value of that recharge water available. However, it seems likely that the economic dividends resulting from groundwater recharge in Nebraska have been fairly high. Several projects have resulted in groundwater recharge and that many irrigation wells have been drilled in these areas. Benefits have probably been in both the form of expanded crop production and reduced pumping lifts.

A second major economic factor that should be mentioned here is that single purpose recharge projects may be difficult to justify economically. A 1981 study of recharge benefits in Nebraska found benefits in the Upper Big Blue area to be \$5 to \$10 per acre foot. It was also noted that it appeared unlikely that a single-purpose project in the High Plains region can be designed which costs less than \$30 per acre foot and that least cost alternatives may fall closer to the \$57 to \$90 range given conventional technology.[1]

As these figures show, the level of recharge benefits available will not generally be sufficient to justify a single-purpose project in the High Plains region under the benefit calculation method used. Nevertheless it could be an important factor in achieving project feasibility when combined with other benefits of a multiple-purpose project. There had not been an intensive study of a proposed large scale recharge project in Nebraska until the O'Neill Alternatives Study. That analysis provides some information on the feasibility of such projects.[2]

Additional information on the economics of individual small-scale recharge projects is needed. Since the $5 to $10 per acre-foot benefit from recharge was calculated using a discount rate, the time value of money (i.e. when benefits are received) has a bearing on the amount of recharge benefits available.

The third major economic factor to be treated in this section concerns how to treat discount rates in regard to projects providing groundwater recharge benefits. Discount rates are used to determine the present value of benefits or income that will be received in the future. Project costs and benefits are generally computed in a manner that holds the dollar value of the benefits constant over time and thus factors out inflation. However the interest rates normally charged for lending of money incorporate both inflation and a "real interest rate" component which reflects the investment value of the money beyond the inflation rate. At the time this report is being written that rate is very high. Inflation is now running at around 5 percent and the prime lending rate is 13 to 15 percent. However a correct analysis should probably use a real long-term interest rate which would reflect the expected rate over the life of the project.

The federal discount rate only partially reflects these differences, but it is still at record high levels. The effect of using a high discount rate is to make it very difficult to achieve a positive cost-benefit ratio on new federal public works projects.

However, the effects of any discount rate for recharge projects, even if low, can make it very difficult to achieve a positive cost-benefit ratio. The reason is that a great deal of the benefits of such projects can occur many years after the project is built. Reduction of pumping lifts helps throughout the life of the project. However, aquifer-life extension benefits, (the pumping from a groundwater reservoir that would otherwise be effectively depleted), may occur many years after the project is built. The exception is when an area that currently has no saturated aquifer is being recharged. There has been little study of the optimum starting time for recharge projects, either from an economic or physical perspective. One factor that should be kept in mind is that recharge can be very long term storage. Therefore there is potential for the value of that water to expand greatly if water scarcity or crop prices increase dramatically at some future point.

The Nebraska Resources Development Fund currently has a requirement for a 3 percent rate of return on projects it finances. The rate of return is used similarly to a discount rate. The Water Management Board has not yet adopted a policy on discount rates or rates of return. However, because many major projects use federal funds, the discount rate could be a major impediment to recharge projects versus other types of projects. Some would argue that while discount rates have application to shorter term investments, their applicability to sustaining natural resources in the long term is more questionable due to potentially much greater values for the resource in the future. The degree to which recharge projects are long term natural resources investments and the degree to which discount rates should be applied to such projects are substantial policy questions. The manner in which the state and federal governments answer them could have a major impact on the number of water projects built in the future and especially on the number of recharge oriented projects.

A fourth major potential economic benefit of alternate integrated management systems is that they may provide groundwater and surface water in a manner that maintains or increases the effectively usable supply for economic and other uses. Chapter eight presents a number of alternatives that would give natural resources districts or irrigation districts greater control over the total water supply in their district. These alternatives could give irrigation districts or Natural Resources Districts the power to extend the supply to additional users or additional irrigable acres. For instance if groundwater pumping was required in areas which have groundwater "mounds" but now use surface water there might be potential for additional surface water use in different areas.

Chapter eight contains comparatively little about the types of integrated management decisions the districts may face when they set their water-use goals. For instance, the comparative economic values of streamflow and groundwater recharge may be hard to determine. Groundwater provides baseflows for many streams in the state. If groundwater pumping lowers water levels to a point where those baseflows are altered, surface-water irrigation benefits and instream flow benefits may be lost. However, less water may flow from the state in the off season as baseflow and storage space for recharge may be provided in the local groundwater reservoir. Thus the total amount of economically usable water in some areas may be increased.

Sometimes equity impacts and economic impacts of operating a system may be at odds. For instance, shutting down groundwater pumpers to see that a senior surface water user receives water when needed may result in flow being wasted in the off season. The solution to this dilemma is often various forms of compensation or providing supplemental water to the senior surface-water user. In such cases it could be very difficult to determine the economic value of instream flows, the amount of baseflow reduction to surface users and its economic value, and the ultimate economic value for irrigation of groundwater that no longer leaves the state as baseflow.

Once questions surrounding discount rates and the best general method for managing water have been resolved, issues will remain on what constitutes an economically feasible project, how costs should be assessed to project beneficiaries, and how projects should be financed. These are basic problems in any supplemental water project, not just for recharge oriented projects. It should be emphasized again at this point that the vast majority of projects which are likely to provide groundwater recharge benefits will be multiple purpose in nature. Recharge may range from a minor benefit to the major project purpose.

This report does include some alternative methods of charging project beneficiaries and financing projects and operations. However the question of what constitutes an economically feasible project is not examined here beyond the topic of discount rates. The economic feasibility of water projects will probably remain a major area of disagreement.

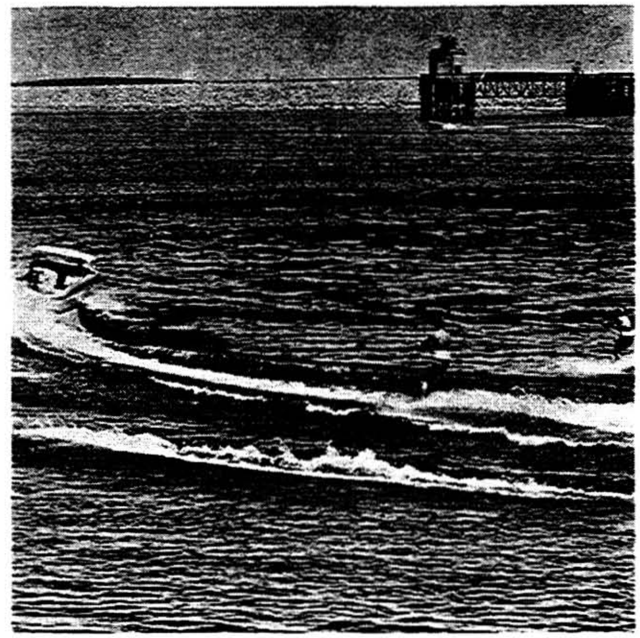
The question of how costs should be assessed to project beneficiaries is a major factor in recharge projects. As discussed in Chapter 8, with the passage of LB 198 in 1983, a small charge is now allowed for recharge benefits from existing projects. However there is landowner opposition to such a charge and that opposition probably would be stronger if higher charges were involved.

A number of problems can occur in determining recharge benefits and then assessing landowners. Landowners who already have access to groundwater may be reluctant to support charges for reducing their pumping lift or extending the useful life of the aquifer for some future time. If the water table is already high, a project may actually cause them some drainage problems. Charging landowners who do not use groundwater for recharge benefits also could be controversial. The amount of rise in the water table or degree of stabilization of an otherwise declining water table may be difficult to determine. Immediate, easily identifiable benefits are probably more likely to engender support for a project and support for fees than long-term benefit to an area.

The question of how water projects should be financed is a recurrent question on the Nebraska and national political scenes. These questions were addressed in part in the *Policy Issue Study on Supplemental Water Supplies.* Chapter eight of this report contains alternatives which would give a range of additional powers to Natural Resources Districts and Irrigation Districts. Although project financing is not the major topic of this study, some of those alternatives would make financing of recharge activities considerably easier.

## CONJUNCTIVE USE IN NEBRASKA AND OTHER STATES

As previously mentioned Nebraska already has one area where a type of conjunctive use is employed in an important system of irrigated agriculture. The Central Platte Valley first received extensive surface-water development in the late 1800's. By the turn of the century irrigators in the Platte Valley had begun to make use of groundwater in areas adjacent to canals and



streams. When Lake McConaughy was completed in the early 1940s surface-water irrigation was expanded in central Nebraska. A "mound" of groundwater was formed by seepage from canals carrying irrigation water in part of the Central Nebraska Public Power and Irrigation District. Subsequent development of groundwater irrigation in the region capitalized on this stable source of water and some irrigators began dropping out of the irrigation district to use the recharged groundwater. This created problems for the irrigation district in maintaining revenues. These problems and the threatened loss of water rights helped lead to the enactment of LB 198 by the 1983 session of the Unicameral. That bill allowed existing irrigation districts authority to to assess limited fees for use of water stored underground and for new projects would allow a more comprehensive ability to charge for such water. These new abilities may help turn an area of conjunctive use into a more planned integrated management system.

While the Central Platte area is the largest, other water projects have also resulted in similar areas of recharge in the Republican Valley, the Mirage Flats project area, the Ainsworth area, and the Farwell Project area. The just completed portion of the Big Sandy Project in the Little Blue should also result in recharge. However, it should be noted that any project where there is suitable geologic material in the project area and where the surface topography does not increase the material to be recharged can provide varying degrees of groundwater recharge. Furthermore, as previously mentioned, major projects and small dams slow the passage of surface water through the state giving it a longer time span in which to infiltrate. Thus a number of surface-water projects in the state, both large and small, probably contribute to recharge to some extent. However, water projects also contribute to additional evaporation from increased water surfaces.

The physical situations which have contributed to the development of conjunctive use in other states are sometimes quite different from those in Nebraska. The areal extent and quantity of water available in Nebraska's groundwater reservoir is much larger than that of most other western states. The more arid western states receive much of their precipitation in high relief, high elevation areas that provide excellent opportunities for storage and somewhat lower evaporation rates due to lower temperatures. The irrigation in those states occurs primarily in areas which have less precipitation and less dryland agricultural production potential than most areas in the eastern two thirds of Nebraska. Furthermore, those areas are sometimes conducive to growing higher value crops and high value municipal uses may provide additional incentives for water management and project construction.

The differing physical, political and economic conditions in those states have given rise to different systems of conjunctive use and different legal methods for dealing with the interrelationship between surface water and groundwater. Serious groundwater depletions have helped promote changes in the way California, Arizona, and Colorado manage their surface-water and groundwater supplies.

In California local water districts have extensive power to facilitate the transfer of surface-water supplies from areas of abundance to replenish or otherwise reduce dependence on groundwater. Their abilities to buy, sell, import, store, and distribute water as well as levy various fees and taxes for water use enables them to control effectively the amount of water use and whether it comes from groundwater or surface water. It also enables local districts to raise sufficient funds to purchase supplemental water and build surface-water projects and recharge facilities. Some significant differences exist between the California and Nebraska situation. In California some districts' water rights were not known prior to formation of the district. High value crops and higher value municipal uses make up a large share of California water use. This enables the districts to pay more for supplemental water and recharge facilities. In addition the California land has very limited value without water. The fact that rainfall is highly seasonal and there are ample storage sites and areas of unsaturated aquifer in California very conducive to recharge projects, supplemental water projects, and integrated management of surface water and groundwater.

In Arizona extensive controls on groundwater use have been adopted. In addition, a very large federal supplemental water project was built in order to address the problem of declining water-table and diminishing supply of groundwater. In the Arizona case the prospect of receiving federal project funds was a significant impetus to adoption of groundwater controls. One purpose of providing supplemental water is to reduce the amount by which total water use must ultimately be decreased. Thus access to supplemental water, pump taxes, regulation for conservation and retiring of water rights through purchase are major components of the Arizona system. In Arizona, the state Department of Water Resources sees that water is administered at State-mandated rates through active management areas. In California control is more local and based upon local goals.

Colorado has addressed the problem of groundwater withdrawals affecting senior surface water rights by regulating groundwater which is tributary to senior surface rights. Regulation can be avoided if the junior groundwater users provide replacement water for the senior surface right holders. The legal system Colorado uses to address surface-water and groundwater relationships is somewhat complex, cumbersome and expensive to operate. However, it does provide some protection for senior surface right holders and incentives for groundwater users to support supplemental water projects.

## PROBLEMS AND POTENTIALS OF INTEGRATED MANAGEMENT IN NEBRASKA

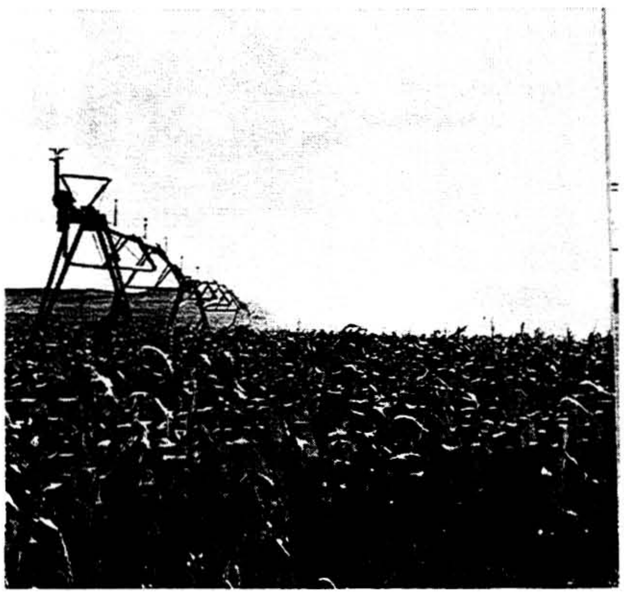
The potential for new policy on integrated management of surface water and groundwater depends on the specific issue and the state or area being addressed. Five problems and issues are discussed more completely in subsequent chapters.

There are a number of potential problems and a number of potential advantages Nebraska would have in establishing an integrated surface and groundwater management system with more comprehensive powers. One problem is that Nebraska currently administers groundwater and surface water through largely separate systems. It is also missing some of the key components which favor the systems of integrated management and supplemental water established in Arizona and California. High value uses of water, high-relief surface-water storage sites, and dramatic depletions of groundwater along major stream courses do not generally occur in Nebraska.

Nebraska also has some unique advantages for managing surface water and groundwater in an integrated manner. The Platte River system flows through or near regions in which unsaturated earth materials provide a readily available recharge area. Some of this potential has already been developed. Projects have been proposed which would use Platte River water for both in-basin and out of basin recharge. In addition, natural recharge rates are fairly high in some of the sandy soils occurring in much of Nebraska. If there are no geologic barriers this can leave excellent opportunities for artificial recharge. The current federal recharge research demonstration project may result in additional information on the feasibility of artificial recharge in such areas.

Nebraska is also blessed with extensive areas of aquifer. If the water level in an aquifer is drawn down, possibilities for recharge will exist. In some cases this could require transbasin diversion. Proposed diversions from the Platte to the Upper Big Blue River and the Upper Republican River Basin would both have significant recharge benefits.

The value of recharge activities and the construction of recharge-oriented projects in Nebraska is highly dependent upon economic factors. Since irrigation is the major use to which most recharge water is put, long-term crop prices are a very important factor in determining recharge value. Other factors are: reduced energy costs (due to recharge decreasing pumping lifts), municipal access to clean water, and construction costs. However recharge projects are usually multiple purpose in nature. Therefore flood control, soil erosion, recreation, and fish and wildlife benefits can be very important in determining whether a project with recharge benefits is built. The way in which all of these costs and values fluctuate in combination with methods of determining economic feasibility and political preferences will help determine what recharge oriented projects are built on the future.



Equity related questions could also expand in the future in some areas of groundwater level declines as the impacts of groundwater development reach the stream. There are a number of areas in Nebraska where groundwater pumping affects or will affect surface flows to some degree. The extensive groundwater development that has occurred and may continue to occur in some such areas may pose a significant potential problem for surface-water users. These potential impacts may result in some increased future attention for policies designed to provide compensation for senior surface-water users. Since that compensation could take the form of provision of supplemental water, solutions to the equity problems can be related to the administrative powers and systems to facilitate integrated management which are discussed in the final chapter of this report.

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Chapter 2

# The Physical Relationship Between Surface Water and Groundwater in Nebraska

The purpose of this chapter is to examine the physical relationship between surface water and groundwater in Nebraska with special emphasis on those factors most pertinent to integrated management of both sources. This report deals with four types of physical relationships between surface water and groundwater. Each of those relationships is the basis of a problem and issue examined later in the report. Those relationships and the chapters in which they are discussed are:

- Groundwater pumping that reduces surface flow, lowers lake levels, and/or causes loss of wetlands (Chapter 4);
- Streamflow reductions resulting in water-table declines (Chapter 5);
- Groundwater pumping supplementing streamflow amounts or lake levels or wetlands (Chapter 6);
- Surface-water projects causing water-table rises (Chapter 7).

A section in each of those chapters illustrates the immediate physical and legal problems and issues in Nebraska. However, the areas and situations examined may represent only the more immediate, severe, or controversial situations in which those relationships are occurring. A more thorough knowledge of the entire state is required to determine where similar situations are being brought about or where they could occur under changing development conditions. This chapter provides that background through detailed discussion of the physical relationship of surface water and groundwater in Nebraska. It is organized into three major parts. Part I deals with principles of interaction between surface water and groundwater. Part II deals with actual and potential recharge in Nebraska and Part III deals with water quality in relation to groundwater and surface-water interaction in Nebraska.

Many of the policy alternatives presented in subsequent chapters address and/or impact the physical relationships presented in this chapter. Therefore, this chapter can serve as a reference to regions which might at some point be affected by those alternatives if they are adopted as state policy.

## I. PRINCIPLES OF INTERACTION BETWEEN SURFACE WATER AND GROUNDWATER

The exchanges between surface water and groundwater are part of a complex system of water movement through the earth and its atmosphere. This system is known as the hydrologic cycle (Figure 1). Water that falls to earth as precipitation may fall directly on bodies of surface water such as oceans, streams, lakes, wetlands, or permanent snow and ice. However, if it falls on land it may evaporate directly back to the atmosphere, it may run off as diffused water to streams and lakes, it may infiltrate the soil but be intercepted by plant roots and be transpired back to the atmosphere, or it may infiltrate deeper until it reaches a zone of saturation. Once it enters such a zone it begins to percolate laterally toward some lower point or area of natural discharge at the land surface. If not drawn into a well being pumped, it eventually emerges as a spring, as seepage maintaining wet lands, as a source of water for subirrigation of vegetation, or as seepage into a lake, a stream, or the ocean. Thus all water is continuously in the process of being transferred from one stage to other stages of the hydrologic cycle.

A major factor in the hydrologic cycle is the time water spends in storage and transit. The amount of time water spends at any one stage of the cycle may range from less than a day to milleniums. Water that moves fairly quickly through the cycle often is thought of as renewable. Conversely, water that moves through the cycle slowly generally is regarded as non-renewable. It is possible for man to influence the rate at which water moves through the cycle.

Rates of water movement through the groundwater stage of the hydrologic cycle differs tremendously with aquifer characteristics and hydraulic gradient. In some cases water may make its way back to the surface in a few days or weeks. In others the water may remain in place for long periods of geologic time.

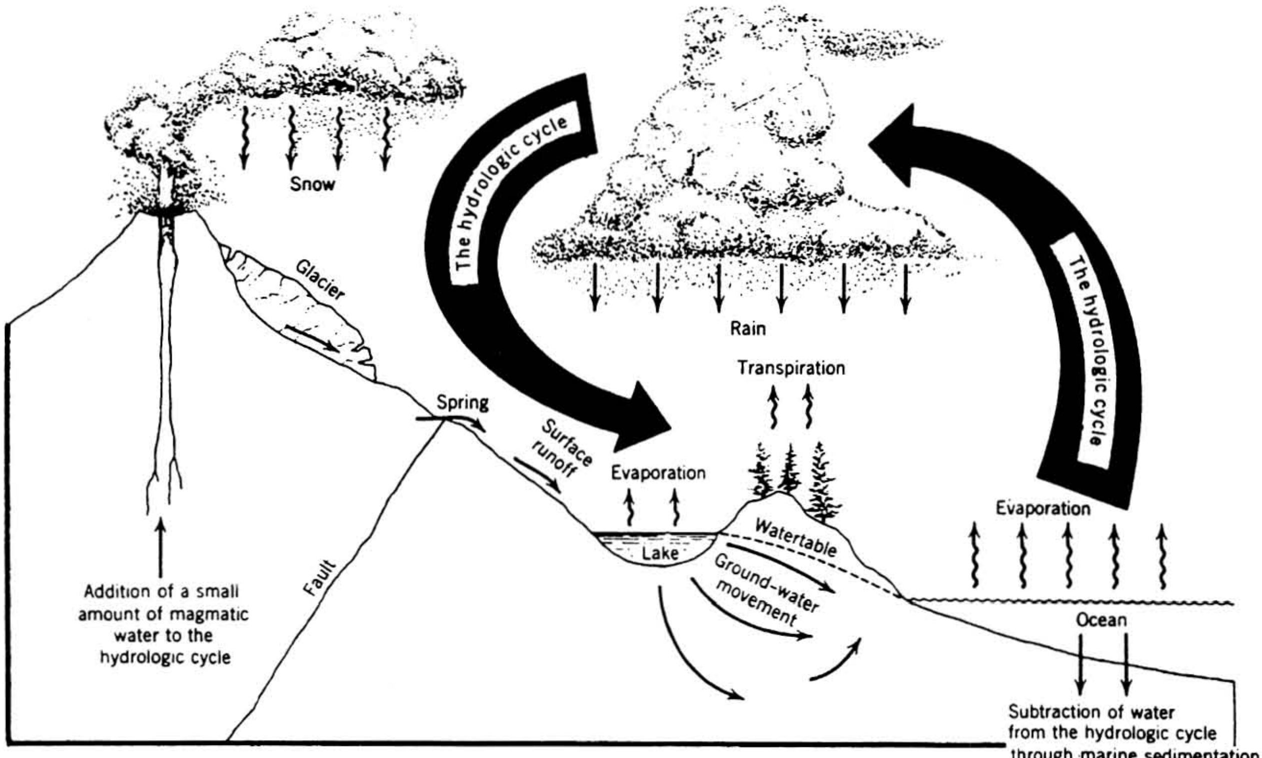


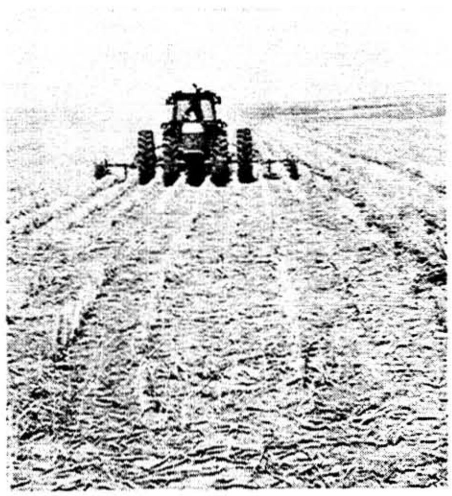

**FIGURE 1 THE HYDROLOGIC CYCLE**

## GENERAL FLOW CHARACTERISTICS OF NEBRASKA STREAMS

Streams are one of the major sources of water supply in Nebraska. In 1980 gross surface water withdrawals within the state constituted about 40 percent of total water withdrawals.[1] However, they probably comprised a much smaller percentage of consumptive use. The flow in a stream may come from one or more stages in the hydrologic cycle. Precipitation on open water surfaces, runoff from precipitation, and seepage from the groundwater reservoir are the principal sources. The types of vegetation, soils, geologic materials underlying a watershed, and surface topography are major factors governing the characteristics of stream runoff, groundwater recharge, and groundwater discharge to streams.

Nebraska's topography ranges from flat tablelands and river bottoms to steep rolling hills and dissected plains. Soils range from porous sand and gravel to tight clayey silt. Consequently, surface runoff differs greatly from one region to another.

Some streams flow intermittently and some flow continuously. Naturally intermittent streams depend almost entirely on overland runoff for their flow. Their discharge increases sharply in response to rainfall amounts large enough to produce overland runoff and then tapers off


to nothing as water returns from bank storage into the stream channel. In areas of silty or clayey soils, sometimes called "hard lands," a substantial portion of the rain in some storms can run off to streams. The rate of infiltration into these soils is less than others, and it decreases as the soils become wetter. Heavy storms in these areas can produce large amounts of runoff quickly, resulting in flooding.

The porous soils of the Sandhills allow precipitation to infiltrate at a high rate, resulting in large quantities of water percolating into the groundwater reservoir and in little direct runoff to streams. Therefore flood peaks are relatively small, and streamflow is continuous because the groundwater is released gradually from the groundwater reservoir.

Naturally continuous flow at a given point along a stream indicates that upstream from that point at least some reach of the stream, or one or more of its tributaries, is receiving seepage from groundwater.

The flow in many stream reaches is composed partly of groundwater seepage and partly of overland runoff. Flow in such reaches increases in response to overland

runoff and then decreases gradually to a relatively steady baseflow derived from groundwater seepage. Where the aquifer contributing seepage to streamflow is of small areal extent or not capable of transmitting large amounts of seepage, a stream may flow continuously during the larger part of the year but may become intermittent when bottomland vegetation intercepts the groundwater seepage that otherwise would maintain a low flow in the stream.

The effects of man and vegetation on the hydrologic system can be significant. Man's development of water resources has made intermittent the flow of some of Nebraska's streams that formerly flowed continuously and, vice versa, has made continuous the flow of some streams that formerly had intermittent flow. Withdrawal and use of streamflow and withdrawals of groundwater can cause depletion of streamflow. Water use by phreatohytes also can cause depletion. On the other hand, man induced factors such as irrigation return flow, drainage projects, and urban paving result in higher flows at some points at certain times.

The effects of withdrawals from, or additions to, streamflow are direct and usually measurable at the point of withdrawal. The effects of groundwater withdrawals on streamflow are not as direct and there may be a considerable lapse of time between withdrawal of groundwater and its impact on streamflow. In Nebraska, a significant portion of the surface water system is hydraulically connected to the groundwater in adjacent aquifers. Where they are connected, the effects of losses from and gains to the groundwater system are transmitted through the aquifer to the river as accretion or depletion to streamflow. However, withdrawals from the aquifer do not necessarily cause direct losses of water from the river; for example, groundwater withdrawals may not cause river water to enter the aquifer, but rather may just reduce the amount of groundwater that had previously been entering the river. Thus, the streams that are in efficient hydraulic connection with the aquifer are sources of recharge to groundwater or outlets from the groundwater system. Gaining reaches of streams are outlets from the groundwater system.

Losing reaches of streams are sources of recharge to the groundwater system. The amount of water that can be lost to the groundwater system from streams is limited to the available flow in the stream. Major stream reaches known to be losing are indicated in Figure 2. An Appendix to this report presents some further evidence on stream reaches that **may** be losing.

At certain times portions of the flowing waters of Nebraska are committed to existing water rights. Figure 3, entitled "Flowing Waters in Nebraska", was developed as a part of the *Instream Flows Policy Issue Study.* In it streams are divided into five categories depending upon their flow and commitment to water rights.

Figure 4 presents surface water discharges and their sizes in Nebraska for 1975. In combination with Figure 3 it can provide some information on availability of surface flows. However, detailed analysis is usually required to determine water availability for a given site. For a more detailed analysis the reader may wish to refer to the *"Policy Issue Study on Supplemental Water Supplies* - Appendix A Water Supplies in Nebraska's Streams."

## GENERAL CHARACTERISTICS OF NEBRASKA GROUNDWATER

Any explanation of the interaction between surface water and groundwater requires some understanding of the major components of the groundwater system. These include the concept of an aquifer, transmissivity of the aquifer, and the water table.

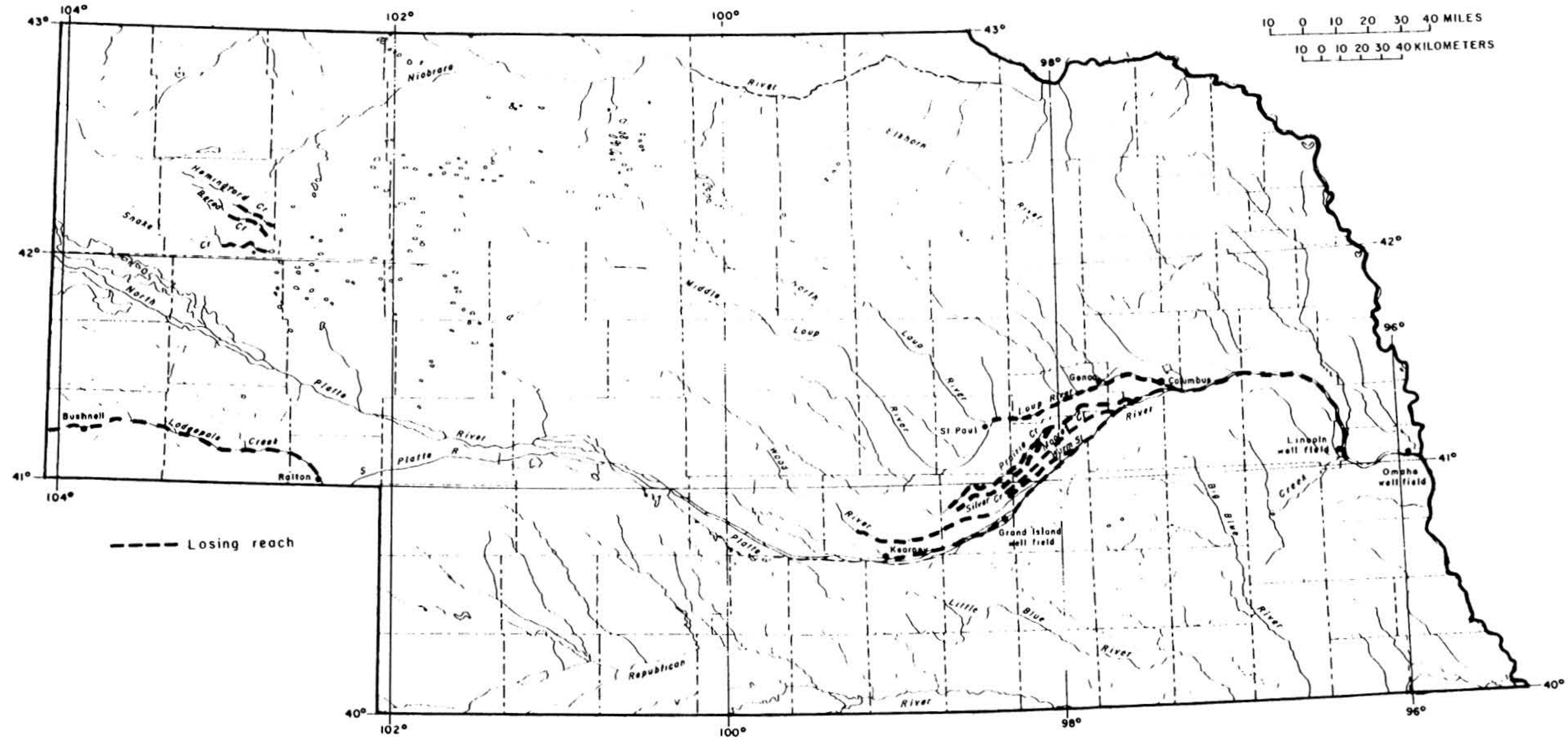
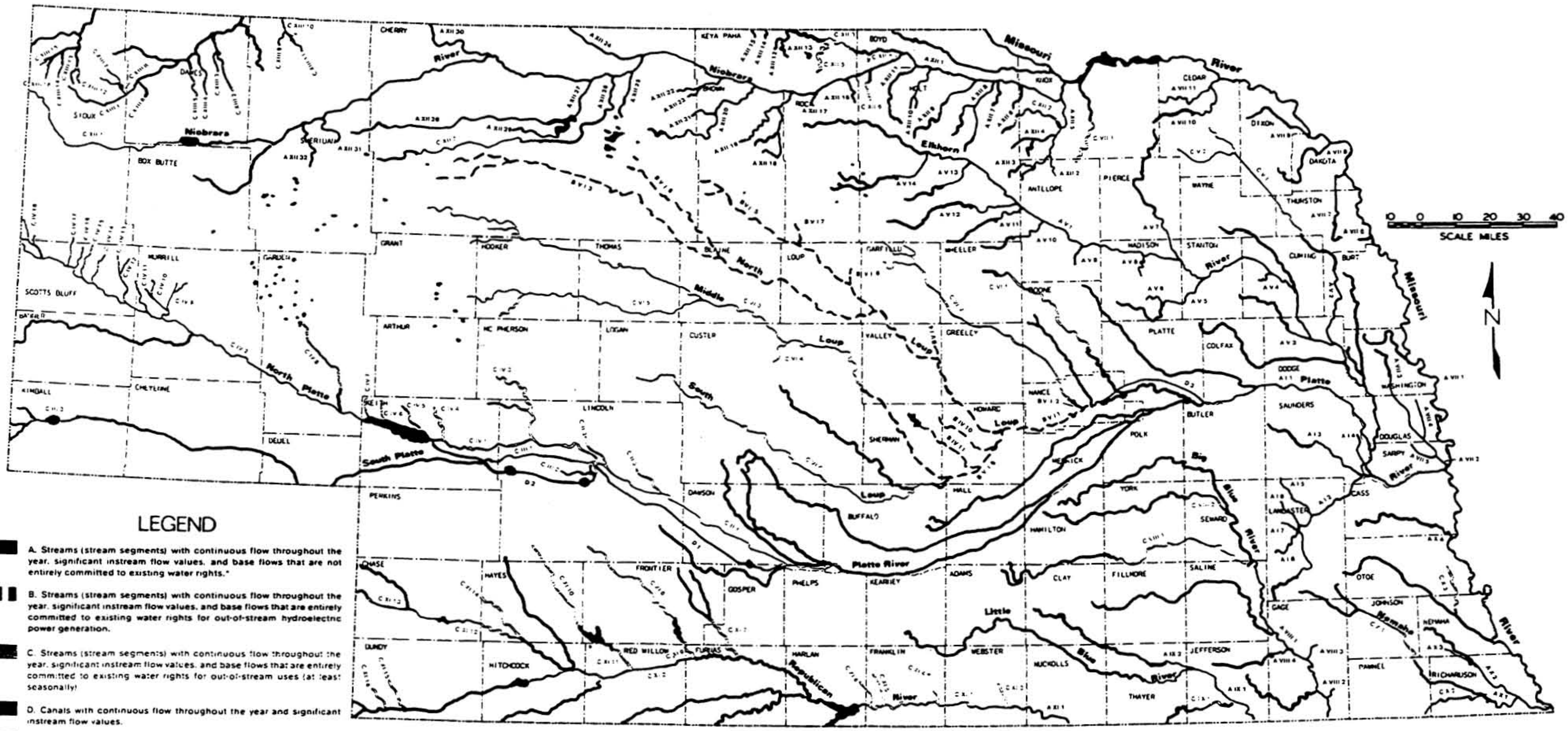



**FIGURE 2**

**LOSING REACHES OF STREAMS**

*Source: Policy Issue Study on Supplemental Water Supplies,* Nebraska Natural Resources Commission, 1984. From the Material Supplies by Conservation and Survey Division, University of Nebraska.

# FLOWING WATERS IN NEBRASKA




## LEGEND

A. Streams (stream segments) with continuous flow throughout the year, significant instream flow values, and base flows that are not entirely committed to existing water rights.*

B. Streams (stream segments) with continuous flow throughout the year, significant instream flow values, and base flows that are entirely committed to existing water rights for out-of-stream hydroelectric power generation.

C. Streams (stream segments) with continuous flow throughout the year, significant instream flow values, and base flows that are entirely committed to existing water rights for out-of-stream uses (at least seasonally)

D. Canals with continuous flow throughout the year and significant instream flow values.

E. Streams (stream segments) that do not exhibit continuous flow throughout the year. This category includes the intermittent stream segments above the point of effluence of several streams in categories A, B, and C.

*This category includes the streams covered by the Blue River Basin Compact.

Note: Numbers along stream segments correspond to segments listed in Chapter 2 of this report.

Published by the Nebraska Natural Resources Commission August 1981

**FIGURE 3**
**FLOWING WATER IN NEBRASKA**

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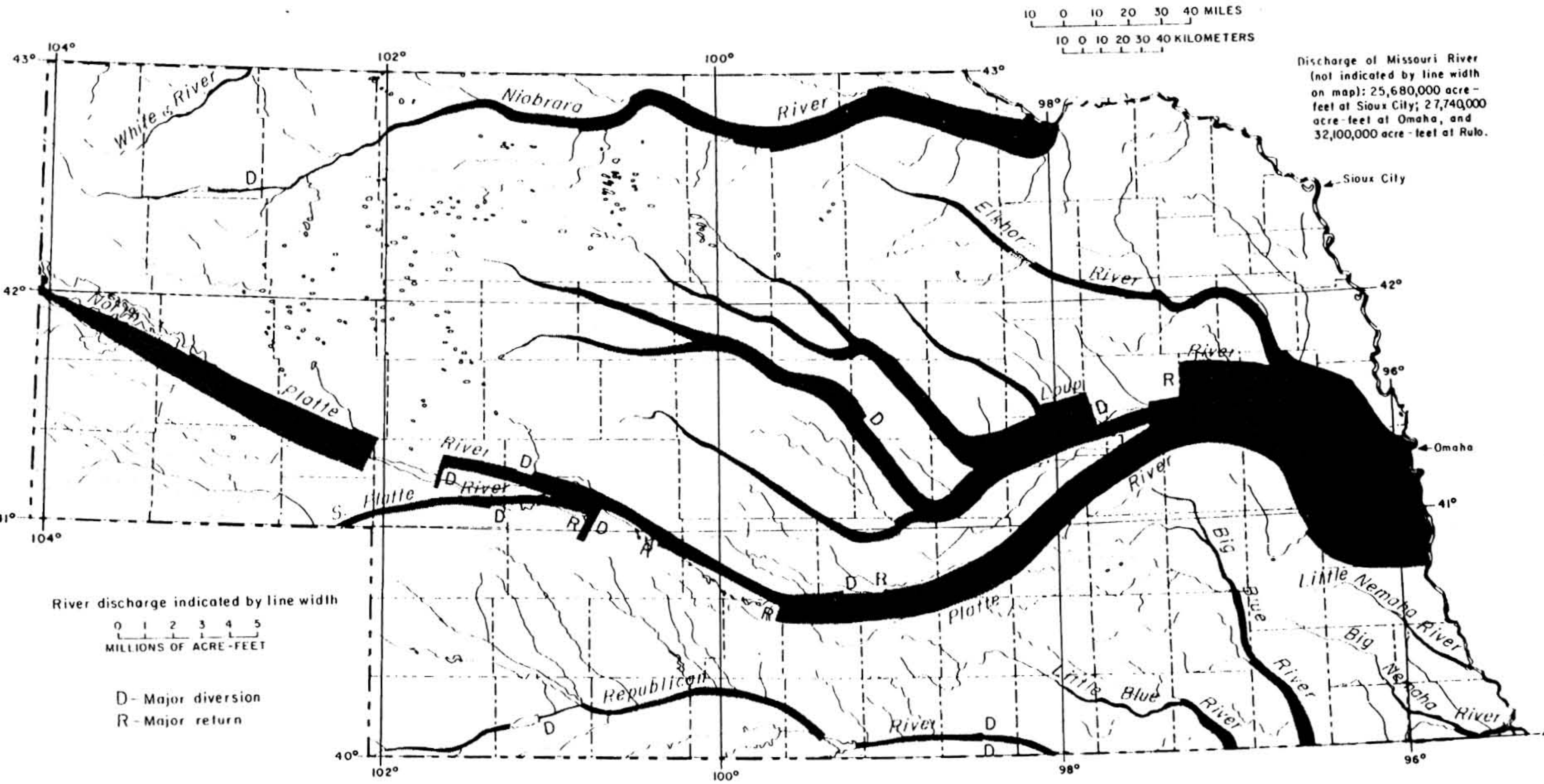



**FIGURE 4**

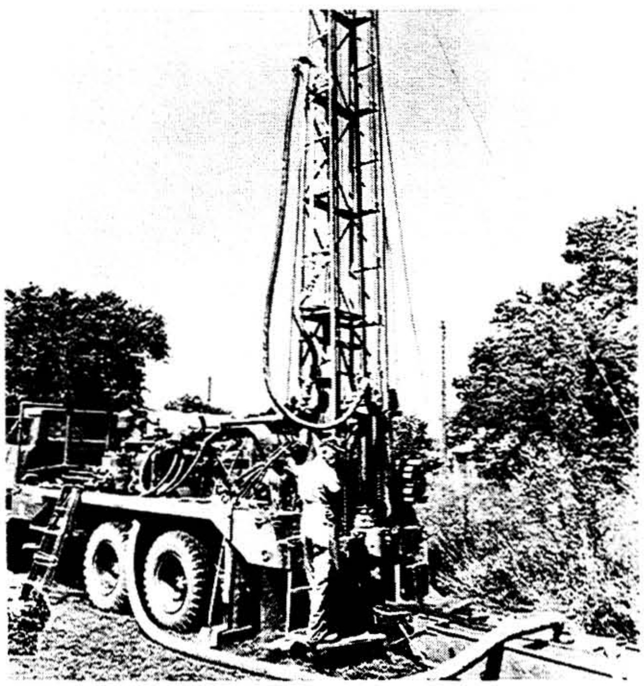
**DISCHARGE OF PRINCIPAL RIVERS IN NEBRASKA**

*Source:* Bentall, R. and Shaffer, F.B., Availability and Use of Water in Nebraska, 1975, Conservation and Survey Division, University of Nebraska-Lincoln.

An aquifer is a body of sand and gravel or fractured rock that contains sufficient voids or passageways to collect, store, and transmit water in significant quantities to supply wells and springs. If those voids and passageways are filled with water the aquifer is said to be saturated. The water table defines the top of the saturated zone in an aquifer. The aquifer used most as a source of supply is usually determined by its depth below the land surface and its transmissivity and by economic factors. Geologic materials differ widely in their ability to store and transmit the water that infiltrates from the surface. Most rock formations contain at least some water, but many are too fine textured for extraction of water to be practicable. Permeability, determined by the relative size of sands and gravels and interconnection of openings in the rocks which permit liquids to pass through, and saturated thickness determine the ability of the aquifer to provide water. Transmissivity, the ability of an aquifer to transmit water, is a function of aquifer thickness and permeability. It is important in determining the rate at which an aquifer will yield water to a well and is one of the determinants of how much water moves towards outlets at intersections with the land surface or into other subsurface rock units.

It is estimated that Nebraska overlies nearly 1.9 billion acre-feet of recoverable groundwater of good to excellent quality.[2] However, the supply of groundwater is not evenly distributed throughout the state. Thicknesses of saturated rock capable of yielding water to wells range from less than a foot to 1,000 feet or more.

The amount and quality of recoverable groundwater, differences in the ability of the geologic formations to yield water, the depth to water, and land suitability for irrigation are important factors affecting the potential for future use. For instance, eastern Nebraska is underlain by primarily fine- grained materials such as clay and silt, which yield water slowly and generally are capable of yielding only enough water for low volume rural domestic supplies.



Groundwater in Nebraska generally moves slowly southeastward. However, departures from this direction are numerous in the vicinity of rivers and streams and where depressions in water levels occur in response to groundwater withdrawals. Rates of lateral movement range from several feet per day to as little as a few inches per year. Most groundwater recharge results from infiltration of precipitation or from surface water applied to the land. As already pointed out, some stream reaches are sources of recharge to adjacent aquifers.

## GEOLOGIC UNITS

Nebraska is underlain by up to ten thousand feet of sedimentary rocks, and most of these rocks are saturated (Figure 5). There is, however, a tremendous difference in the potential of these rocks to serve as aquifers. These differences are due to the physical characteristics that affect water yield, the chemical characteristics that affect quality, and the technology and economics of obtaining the resource.

Most groundwater used in Nebraska comes from rocks of Tertiary and Quaternary age. The Ogallala (Unit A) is the most widely used Tertiary unit, but the Quaternary System, which overlies the units shown in the figure, mantles nearly the entire state and provides most of the groundwater used. Sediments of Quaternary age include sands and gravels, sands, silts, clays, and mixtures of these. The sands and gravels form a part or all of the principal water source in the south-central, southeastern, central, and northeastern parts of the state.

## BASE OF THE PRINCIPAL AQUIFER

The principal aquifer, defined by utilization, consists of the Arikaree and Ogallala deposits of Tertiary age in western Nebraska, the Ogallala and overlying Quaternary deposits in central Nebraska and Quaternary rocks only in eastern Nebraska.

The base of the principal aquifer in Nebraska usually is defined as the lower limit of those permeable Tertiary and Quaternary age rocks which constitute the major groundwater reservoir. These unconsolidated and semiconsolidated deposits are underlain by fine-grained materials which have a much lower water yield to wells. For mapping purposes, this lower limit is usually adjusted to a recognizable lithologic or geologic boundary in the rock sequence. Figure 6 shows the approximate configuration of the base of the principal aquifer.

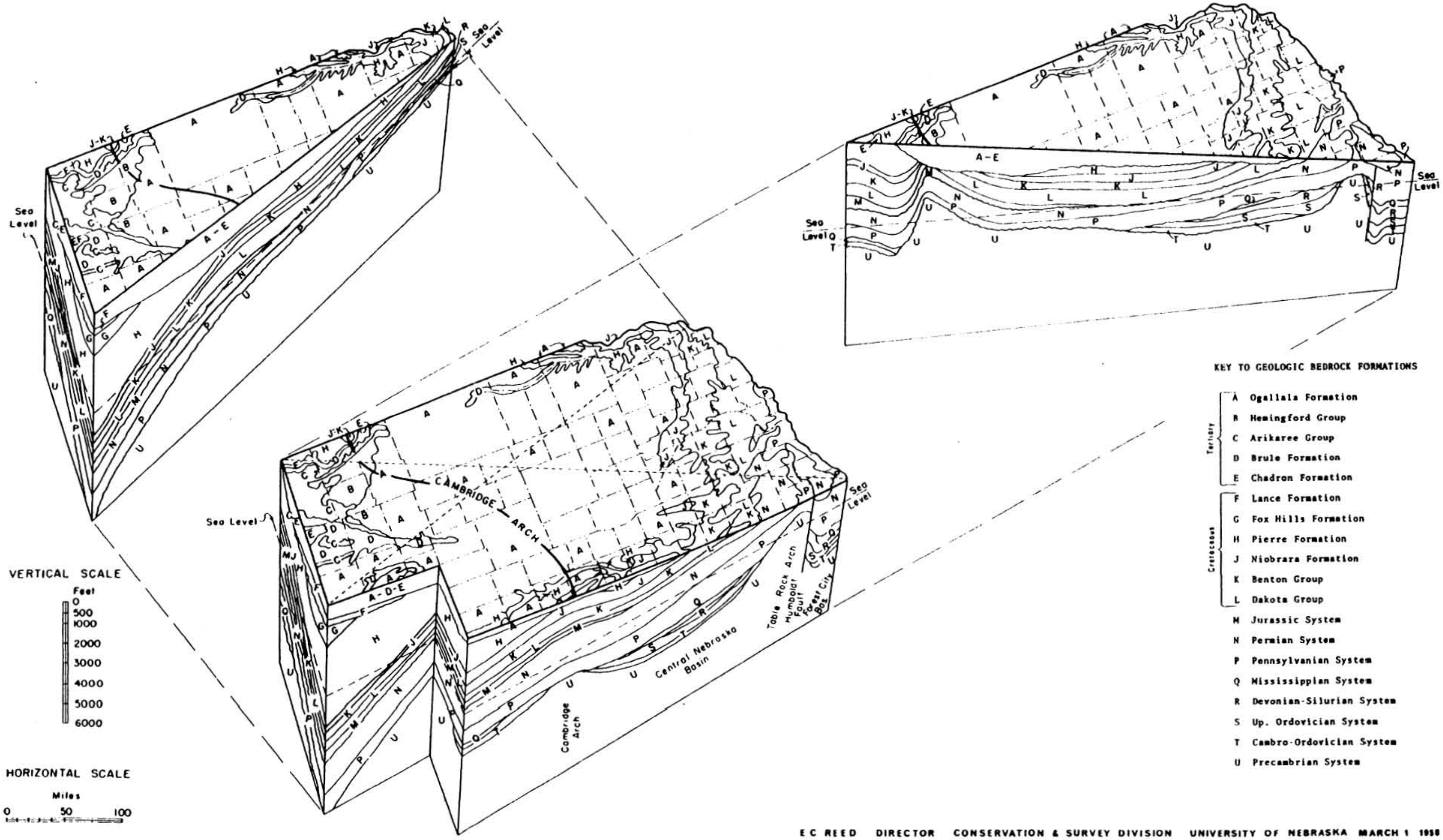



**FIGURE 5**

**BLOCK DIAGRAM ILLUSTRATING THE EXTENT AND THICKNESS OF GEOLOGIC UNITS**

## CONFIGURATION OF THE WATER TABLE

Another contour map was constructed to show the configuration of the water table in 1979 (Figure 7). The water table is the top of the zone of saturation and thus defines the upper surface of the aquifer. Differences in the elevation of the water table in relation to sea level and the land surface helps determine the rate and direction in which groundwater percolates, whether stream segments are intermittent or perennial, and the location of lakes, wetlands, and subirrigated lands. The configuration of the base of the aquifer and the depth to which rivers are incised are also important factors in determining the direction of groundwater movement.

Water levels used in preparing this map were derived from measurements of the depth to water in wells, most of which are completed in the principal aquifer. Most of the measured water levels represent fairly closely the position of the water table, or top of the principal aquifer, but some probably represent perched water tables, or the level at which water stands in wells that tap water confined under pressure. A perched water table is the upper surface of water that has accumulated on top of a nearly impervious layer that prevents or greatly hinders infiltration of water to the principal aquifer. Confined water results from geohydrologic conditions that cause some groundwater to be under greater pressure than that of unconfined groundwater at the same location. Multiple water levels may also occur where the groundwater in deeper aquifers is under a pressure head as the result of being confined below impervious materials. Contours east of the dashed line on Figure 6 are based mostly on measurements of the water level in shallow wells and in some areas represent the perched water tables common in eastern Nebraska.

Figure 6 does not include losing sections of all perennial stream reaches. Some segments are too small to depict and for others there may not be sufficient data to say they are losing year round. The previously mentioned Appendix to this report contains some further preliminary information on segments that may be losing. Naturally intermittent streams are also losing.

From a state-wide perspective, groundwater in Nebraska moves very slowly southeastward at right angles to the contours. Local changes in slope caused by large withdrawals may influence the direction of movement. The rate of movement will range from several feet per day in continuous coarse gravel deposits to as little as a few inches per year in fine-grained material. The slow movement of groundwater common to most areas in Nebraska does not allow lateral groundwater flow to replace the amount withdrawn in a local area. Most recharge results from infiltration of part of the precipitation falling within the area.

## THICKNESS OF THE PRINCIPAL AQUIFER

A map of the principal aquifer thickness (Figure 8) was prepared by superimposing the contour map of the base of the principal aquifer and the contour map of the water table for spring 1979 and comparing elevations of both surfaces at identical locations. In many areas near the borders of the state, the principal aquifer is very thin or absent. Within some of these areas, however, local or isolated aquifers may be present and provide for limited development. In eastern Nebraska, a considerable thickness of the principal aquifer is fine-grained material that yields water very slowly. This thickness map is only one source of information that should be used when considering aquifer potential and well yield.

## GROUNDWATER IN STORAGE

The thickness values of the principal aquifer plus a general knowledge of the pore space within the aquifer allow for estimates of the total amount of groundwater stored there. It has been estimated that the principal aquifer in Nebraska contains nearly 1.9 billion acre-feet of groundwater.[3] That estimate considers primarily the more readily available water in the permeable rocks. Amounts of groundwater in storage are illustrated in Figure 9.

This map shows the amount of mobile water contained in the pore space of the principal groundwater reservoir. It is based on the assumption that the aquifer will have a specific yield of two-tenths of its thickness. The actual yield within a period of time is a function of the rock's permeability. For instance, the water stored in the fine-grained rocks in eastern Nebraska moves very slowly and should not be expected to support high pumping rates.

## RECHARGE AND PRECIPITATION

Section II of this chapter presents a variety of physical information pertinent to both natural and artificial recharge of the groundwater reservoir.

The potential to recharge an aquifer can be an important factor in aquifer management. In some cases the impact of lowering a water table may be to allow more room for recharge.

Direct infiltration of precipitation is, by far, the principal source of recharge. Recharge also occurs through streambeds and a variety of man-induced recharge techniques and drainage changes. The impact of surface-water projects on groundwater recharge has been particularly significant in the Platte Valley. Chapter 3 deals with some of the techniques for artificially inducing recharge.

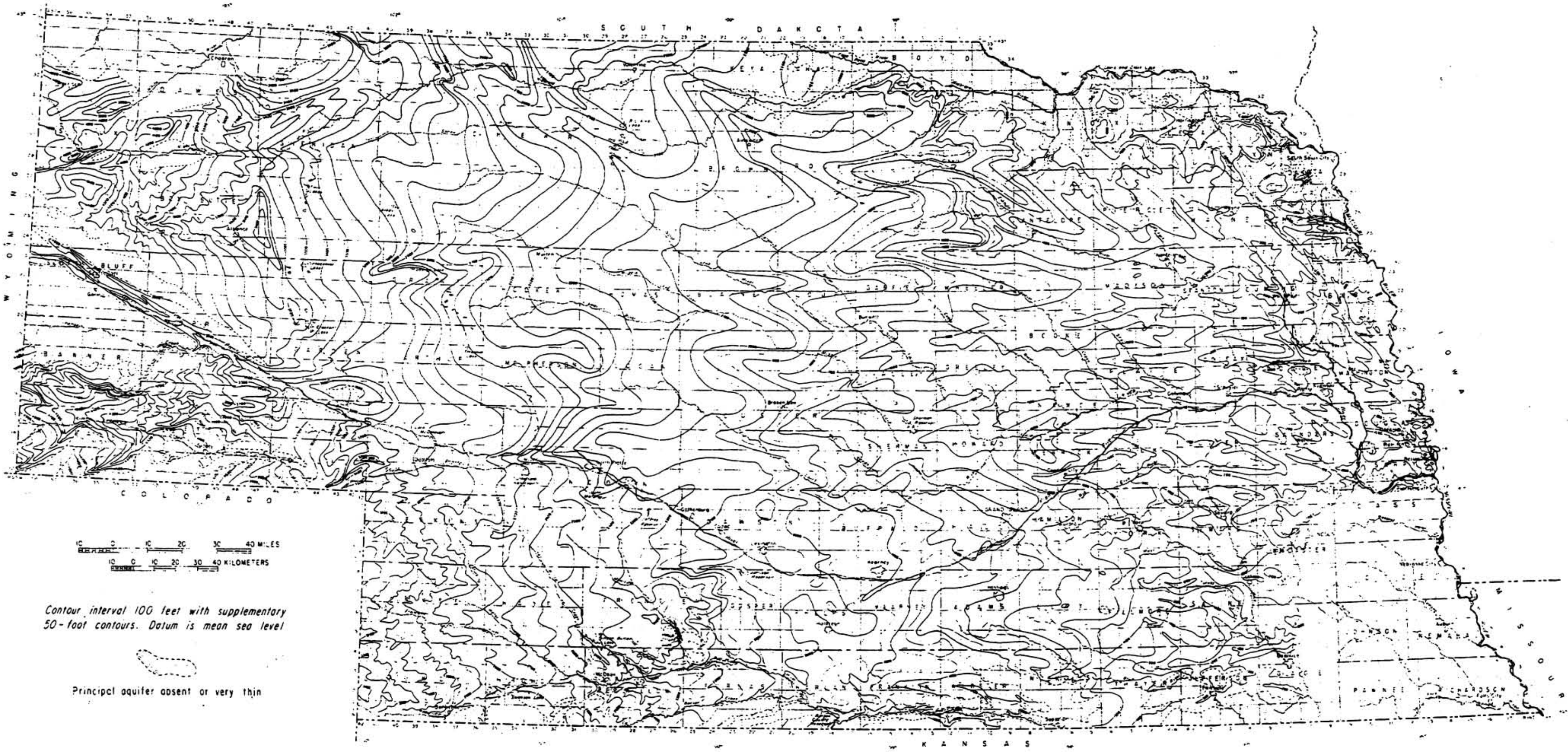



**FIGURE 6**

**CONFIGURATION OF THE BASE OF THE PRINCIPAL AQUIFER**

*Source: Policy Issue Study on Groundwater Reservoir Management,* Nebraska Natural Resources Commission, 1982, compiled by Conservation and Survey Division. University of Nebraska.

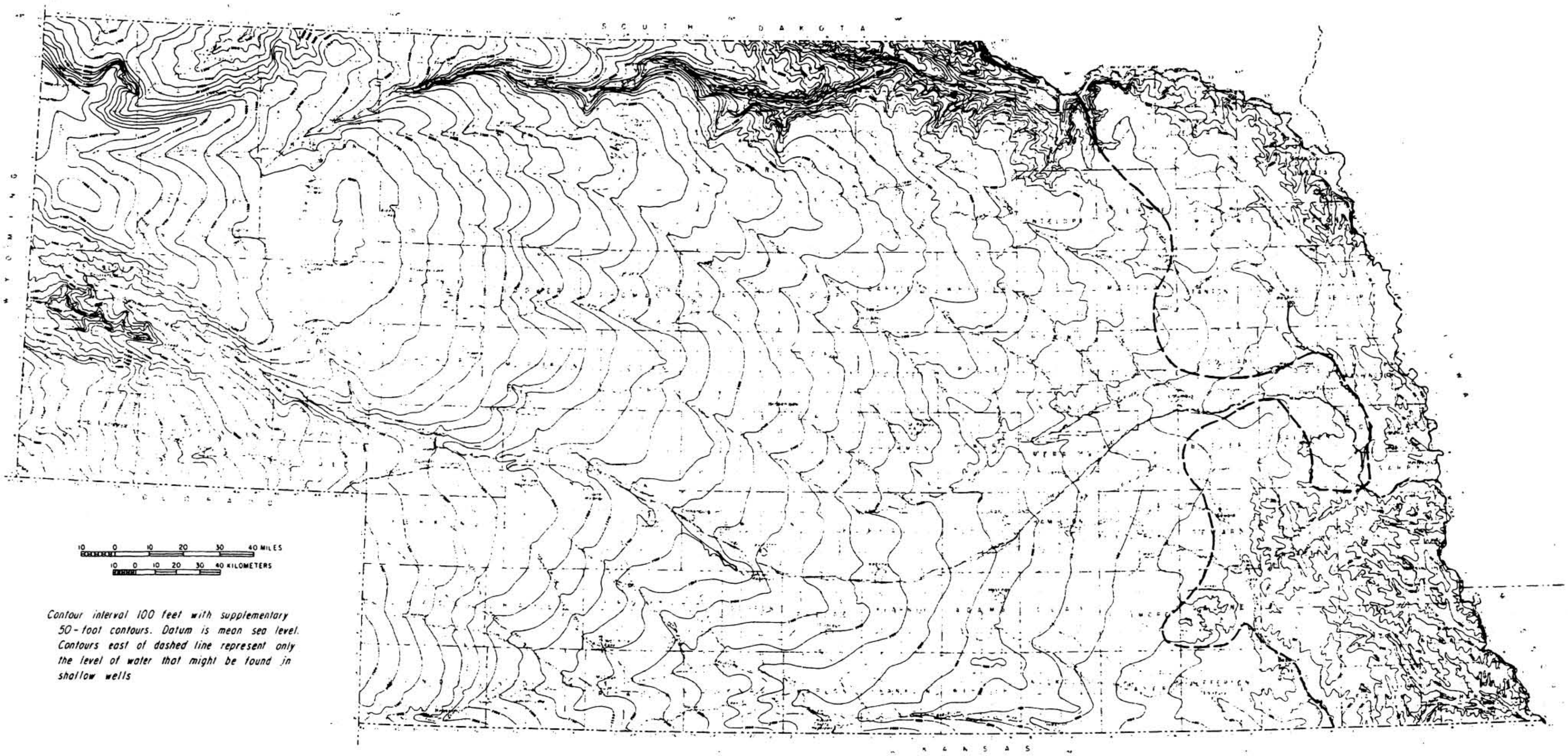



**FIGURE 7**

**CONFIGURATION OF THE WATER TABLE - SPRING 1979**

Source: *Policy Issue Study on Groundwater Reservoir Management*, Nebraska Natural Resources Commission, 1982, compiled by the Conservation and Survey Division, University of Nebraska.

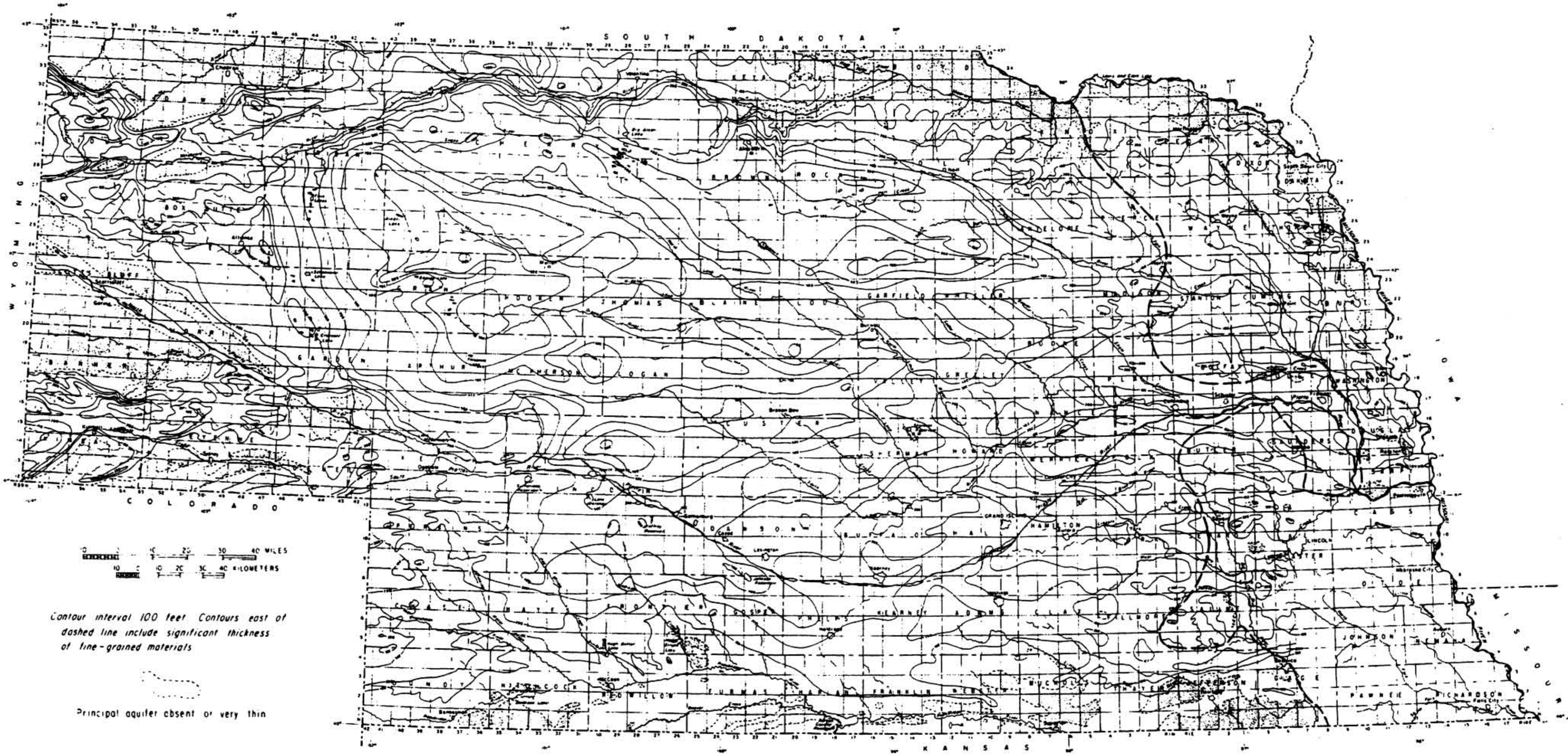



**FIGURE 8**

**THICKNESS OF THE PRINCIPAL AQUIFER**

Source: *Policy Issue Study on Groundwater Reservoir Management*, Nebraska Natural Resources Commission, 1982, compiled by the Conservation and Survey Division, University of Nebraska.

Thickness interval 100 feet. Thickness lines east of dashed line include significant thickness of fine-grained materials.

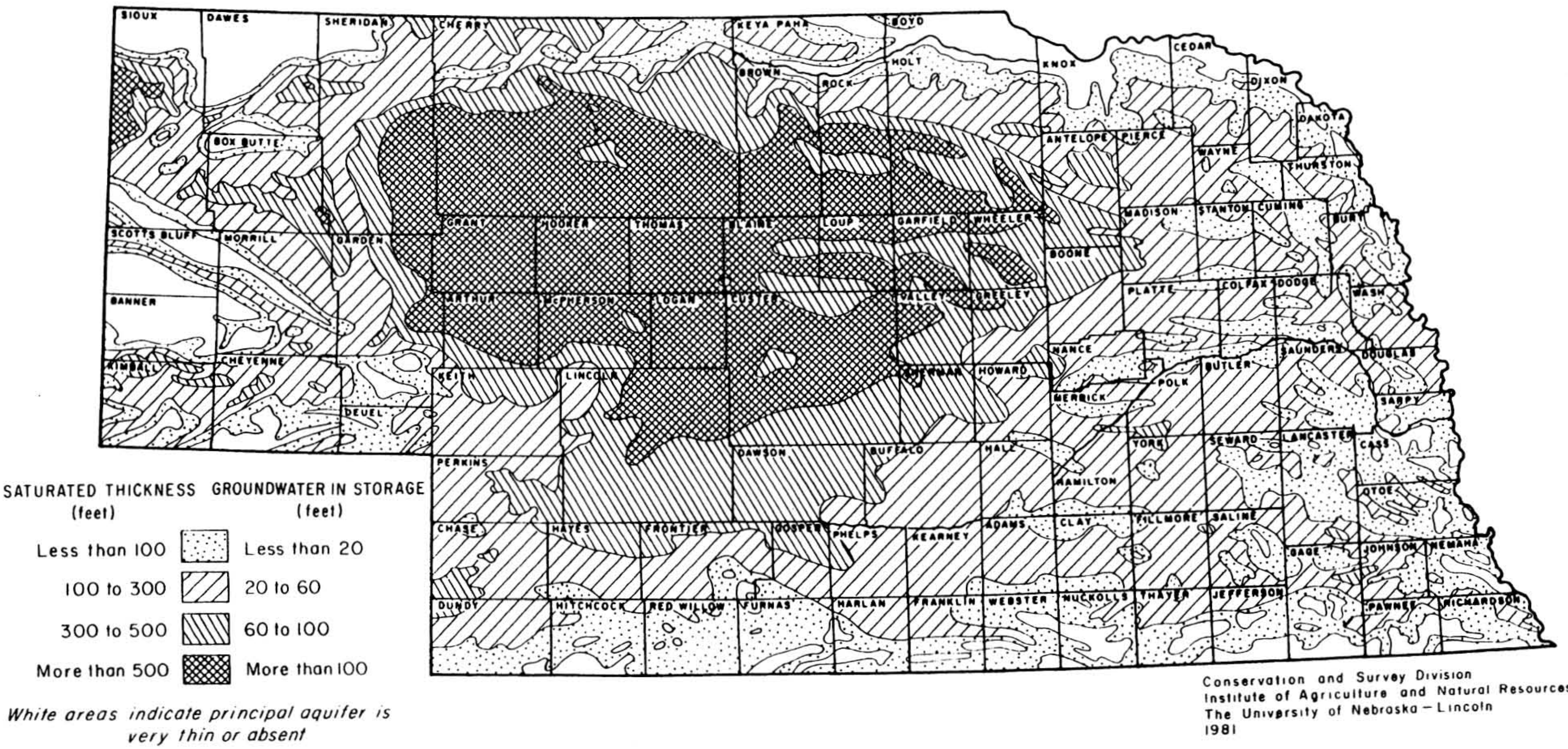



**FIGURE 9**

**GROUNDWATER IN STORAGE IN THE PRINCIPAL GROUNDWATER RESERVOIR**

### TRANSMISSIVITY

A transmissivity map was prepared (Figure 10) to illustrate the capacity of the principal aquifer to transmit water. Transmissivity is a function of the permeability of the reservoir and the aquifer thickness. The transmissivity values may be used to make estimates of well yield in any particular area.

The areas of lower transmissivity in large part reflect thinning of the principal aquifer. However, even some relatively thick portions of the aquifer, particularly in eastern Nebraska, have low transmissivity values and would support only low-yield wells. Those areas having values exceeding 20,000 gallons per day per foot generally are capable of well yields sufficient for irrigation. Although the values are not absolute well-yield values, this map does provide a perspective on the groundwater potential for irrigation development in any particular area of the state or for other large withdrawal.

### DEPTH TO WATER

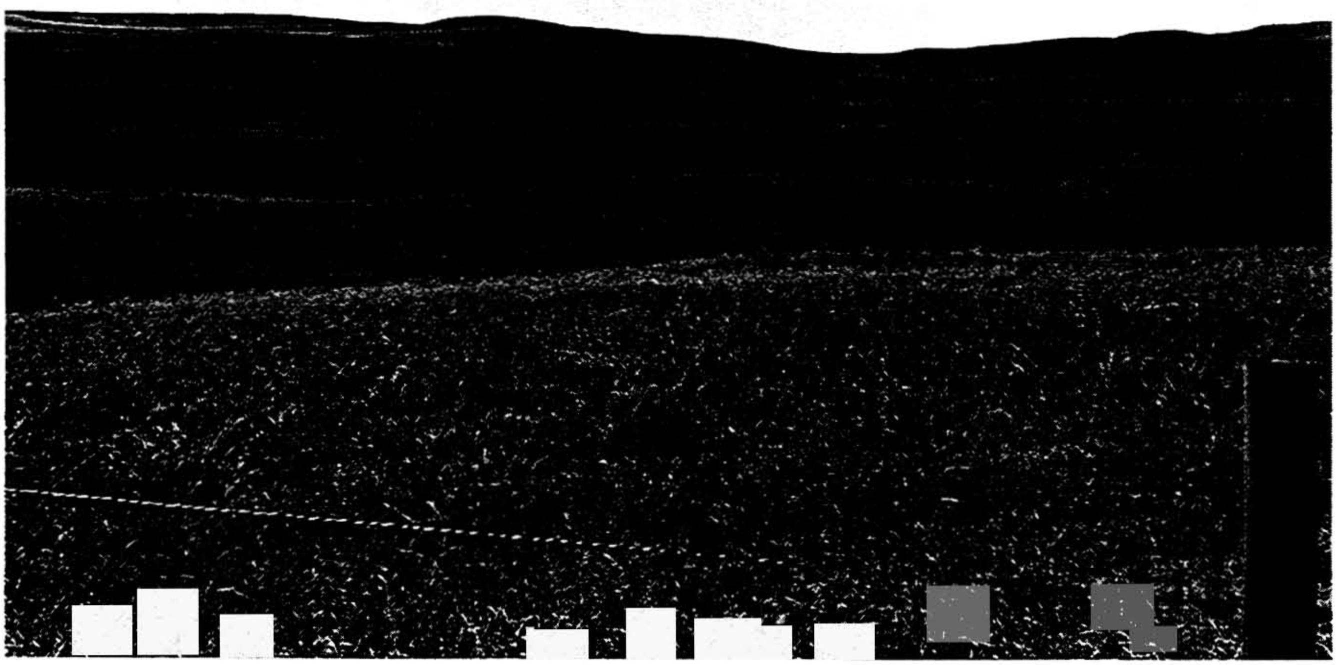
Figure 11 is a depth to water map indicating the total thickness of sediments above the top of the saturated zone in the spring of 1979. This thickness includes both fine-grained sediments, with limited water-yielding potential, and coarse-grained sediments. Generally speaking areas near streams and on flood plains have high water levels and thus have only limited potential for storage of water. The topography of the Sandhills area of the state is relatively rough and results in large differences in depth to water within short distances. The areas on the map indicate the approximate depth at which water would occur in a well, not necessarily the depth to groundwater.

The depth to water map is useful in identifying where problems and issues related to impacts of groundwater level rises due to surface-water development projects (Chapter 7) could occur if surface-water projects have been developed or are developed in the future. Saturation of materials above the presently existing water table may cause water-logging problems if that water is not pumped out before it can exit naturally.

## EXCHANGES BETWEEN GROUNDWATER AND SURFACE WATER

Surface water can reach, and recharge, groundwater through the unsaturated zone. Although direct infiltration of precipitation is, by far, the principal source of recharge, other surface water sources can be important locally. Groundwater moves directly to surface water where the saturated zone, marked by the water table, intercepts the surface of the land, as in a streambed or lake bed.

Precipitation or surface water, can percolate downward from the land surface through the unsaturated zone as shown in Figures 12 and 13 to reach the water table. Surface water can seep directly into the groundwater, and vice versa, where the water table is connected to the streambed.



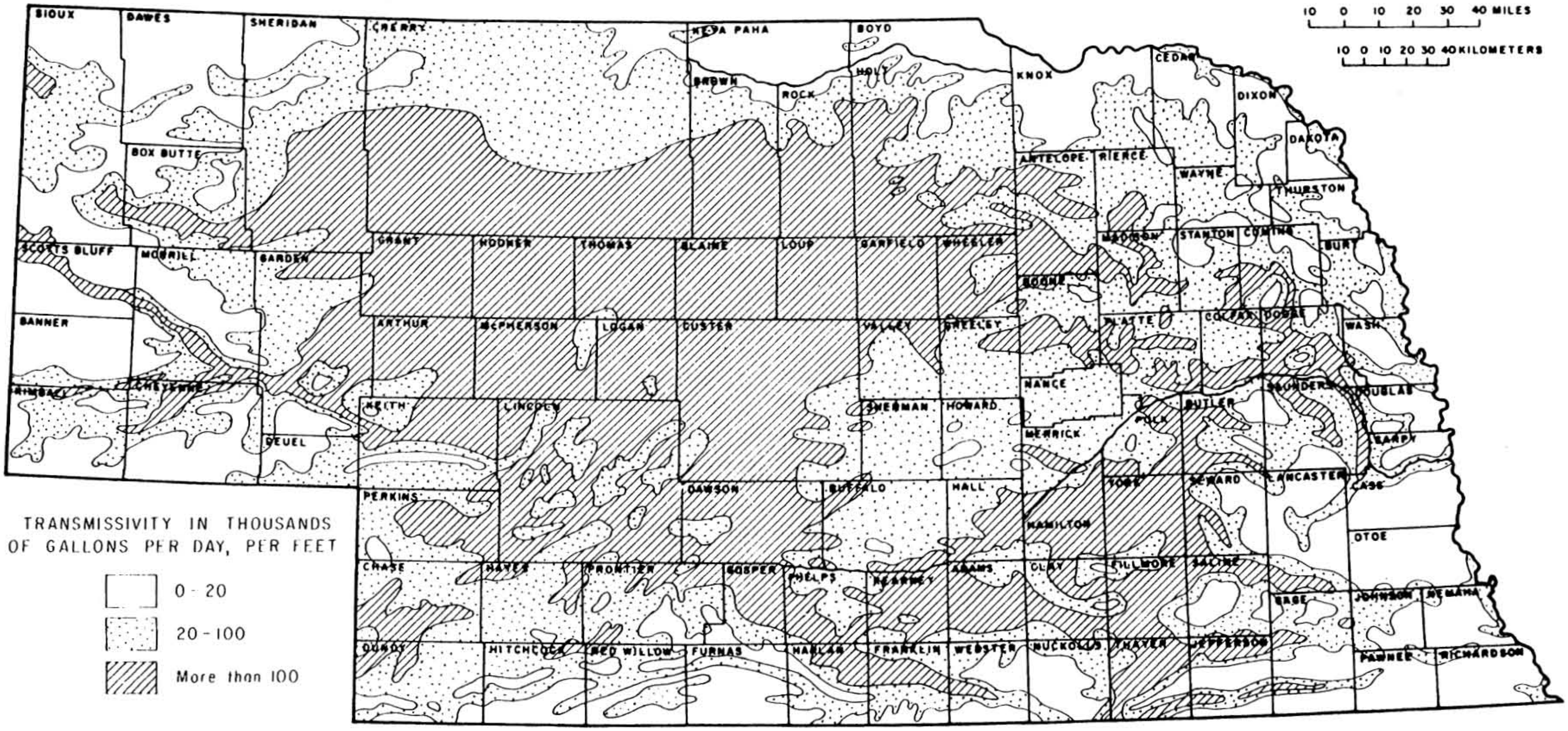



**FIGURE 10**

**TRANSMISSIVITY OF THE PRINCIPAL AQUIFER**

*Source: Policy Issue Study on Groundwater Reservoir Management,* Nebraska Natural Resources Commission, 1982, compiled by the Conservation and Survey Division, University of Nebraska.

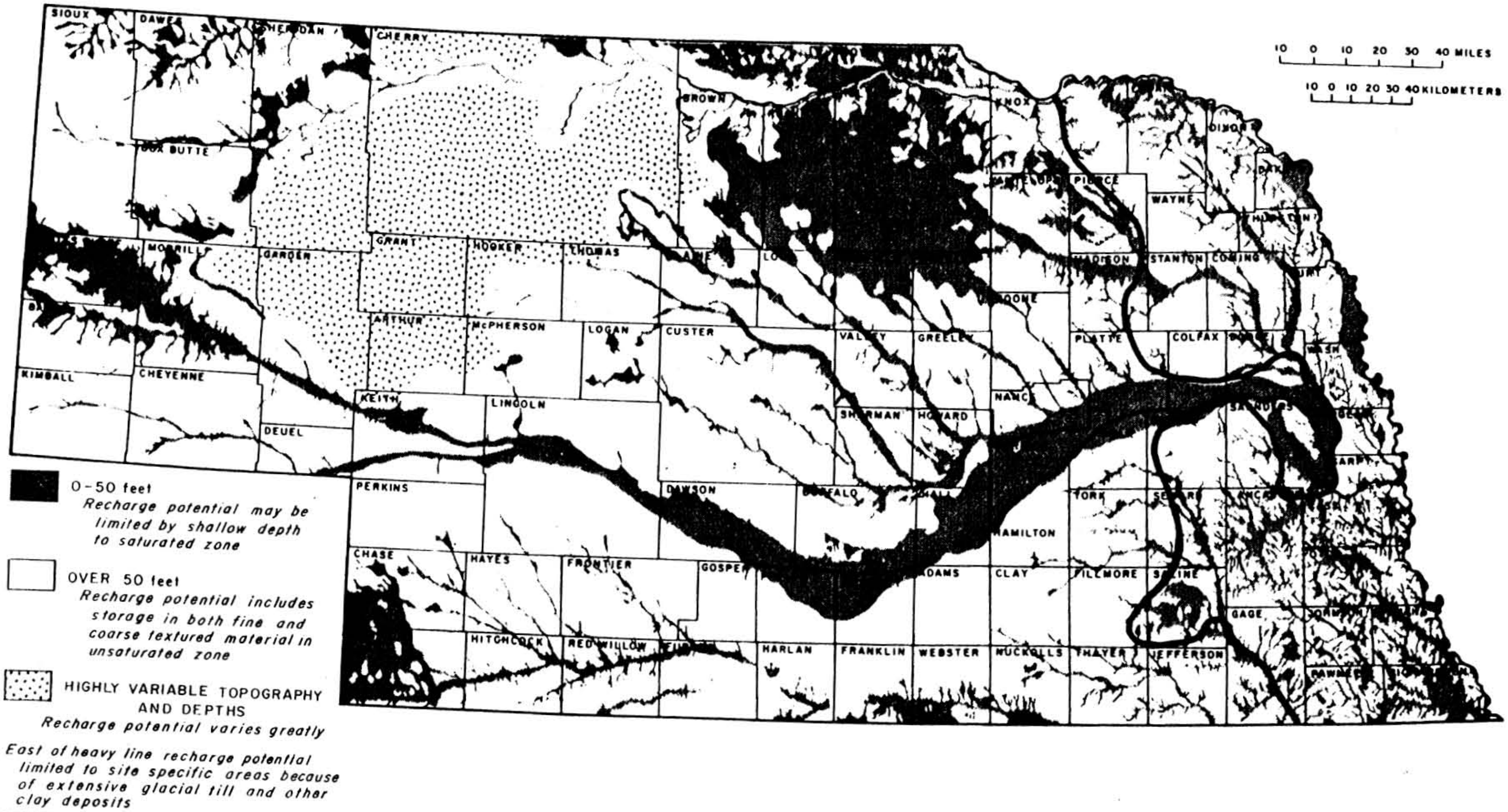



FIGURE 11

## GENERALIZED DEPTH TO WATER

*Source:* Conservation and Survey Division, University of Nebraska-Lincoln.

The following figures were taken from the *Instream Flow Policy Issue Study* and appear again a few pages later in connection with specific streams in the report. They illustrate some of the general types of relationships possible.

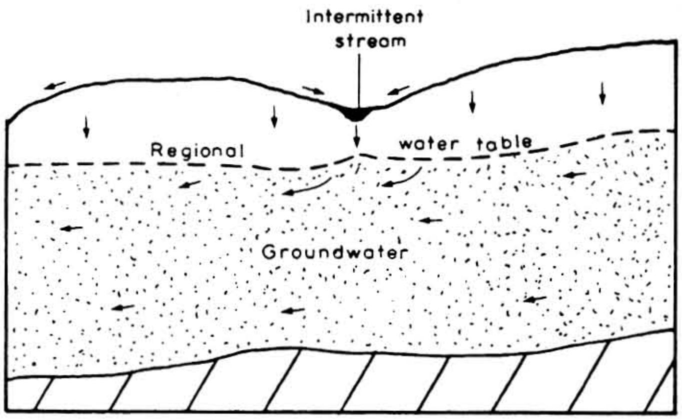



**FIGURE 12**

**INTERMITTENT STREAM FLOWING ON RELATIVELY PERMEABLE UNSATURATED SEDIMENTS**

*Source: Policy Issue Study on Instream Flows,* Nebraska Natural Resources Commission, 1982, compiled by Conservation and Survey Division, University of Nebraska

Figure 12 illustrates an intermittent stream flowing on relatively permeable unsaturated sediments. The stream flows when it receives overland runoff and it loses water by seepage to the underlying aquifer. In this case the stream, as well as the precipitation and runoff, is recharging the aquifer.

There is a hydraulic connection of water in streams and water in aquifers adjacent to streams where the water table intersects the streambed. Because of this hydraulic connection, water is able to flow through the streambed, either into the stream or into the aquifer depending on the hydraulic gradient. The hydraulic gradient, or slope of the water table, is the change in water table elevation per unit change in distance along the flow path of the water.

The configuration of the water table in the vicinity of a stream is important in determining whether the hydraulic gradient is toward or away from a stream. The rate of water movement is dependent on the slope of this gradient and the permeability coefficient of the adjacent aquifer. Water tables that slope steeply toward or away from streams have a greater water flux in the direction of the slope than a flatter water table, given the same aquifer permeability coefficient.

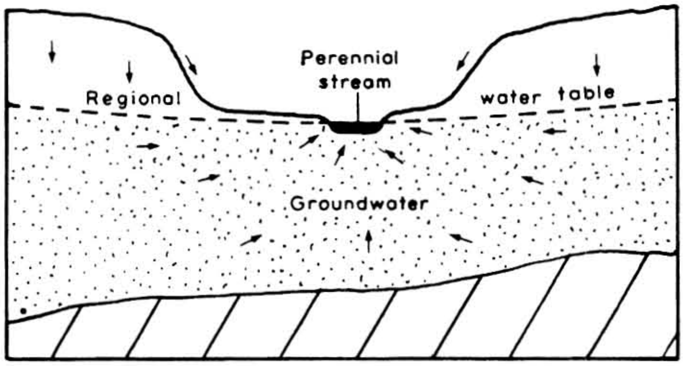



**FIGURE 13**

**STREAM IN CONNECTION WITH THE GROUNDWATER TABLE**

*Source: Policy Issue Study on Instream Flows,* Nebraska Natural Resources Commission, 1982, compiled by Conservation and Survey Division, University of Nebraska-Lincoln.

Figure 13 illustrates a stream which is in connection with the groundwater table over a relatively permeable aquifer. Such a stream will be perennial (have year-round flow) so long as the water table level does not drop below the bottom of the stream. Groundwater seeps into the stream except when the stream is in a high stage and temporarily loses water by seepage into the aquifer. Arrows indicate the groundwater flow lines at low stage of stream. In this particular diagram the hydraulic gradient does not appear to be large. However, other factors such as the transmissivity of the surrounding aquifer can determine how fast it transmits water to the stream. Water the stream receives from the surrounding aquifer is called baseflow.

The water table is sometimes nearly flat in the vicinity of stream reaches. The direction of water movement toward or away from the stream in this situation can change according to the river stage, the proximity of recharge or pumping, and rate of transpiration by nearby plants.

In addition to natural causes, some human activities also influence the quantity of water exchanged between surface water and groundwater. Pumping from wells removes water from the saturated zone, lowering the water table in the vicinity of the well. If the well is close to the stream, the gradient of the water table can be reversed so water flows from the stream to the well.

Putting more water on the surface of the ground can cause more water to enter the stream. If sufficient seepage occurs to raise the water table, the gradient toward the stream is increased and more groundwater will percolate toward it.

The magnitude and timing of the effects of withdrawals (or recharge) on streamflow are dependent on several factors. These include aquifer transmissivity, aquifer storage properties, the degree of hydraulic connection between the stream and aquifer, and the distance from the point of withdrawal (or recharge) to the stream. These relationships can also be applied to other surface bodies, including natural lakes and wetlands.

Generally speaking, pumpage or recharge close to a streambed will have a more immediate effect on streamflow than pumpage or recharge at some greater distance. Withdrawals of groundwater at some distance do not necessarily cause direct reductions in streamflows by induced infiltration, as may occur when wells are located close to streambeds. Withdrawals at some distance may reduce the hydraulic gradient toward the stream and thus decrease the amount of groundwater that otherwise would have entered the stream. Pumpage or recharge when the water table is nearly flat also has a more immediate effect the closer the proximity to the stream. Determination of the timing and extent of groundwater pumping on streamflow would require study of individual situations. Modeling studies have done this in some cases.

## TYPES OF STREAM-GROUNDWATER RELATIONSHIPS IN NEBRASKA

Specific stream reaches within the state have different relationships between groundwater and streamflow. These relationships are due to river valley morphology and the aquifer occurrence. The following diagrams from representative areas within the state help illustrate these different relationships. These diagrams and most of the material in the accompanying explanations were taken from work done by the University of Nebraska's Conservation and Survey Division for the *Instream Flow Policy Issue Study*. This section is followed by a more general discussion of the flow characteristics of each of Nebraska's major stream systems.

Figure 14 illustrates a perennial stream flowing on, and incised into, relatively impermeable rock. The adjacent upland is mantled by unconsolidated and partly consolidated sediments that are saturated in their lower part. Water discharging from the upland aquifer into tributaries or issuing as springs is only partly intercepted by phreatophytic vegetation; the remainder contributes to the stream's flow.

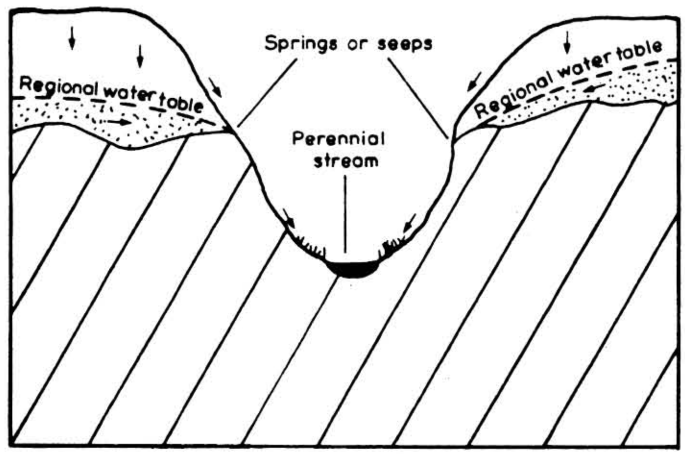



**FIGURE 14**

**NIOBRARA RIVER IN NORTHEASTERN CHERRY COUNTY**

Figure 15 illustrates a perennial stream hydraulically continuous with a limited alluvial aquifer within a valley incised into relatively impermeable rock. Adjacent upland mantled by relatively permeable unconsolidated and partly consolidated sediments are saturated in their lower part. Water discharging from the upland aquifer reaches the stream via tributaries or spring discharge or is lost, in part to evapotranspiration.

### EXPLANATION FOR FIGURES 14-25

**Moderately to highly permeable unsaturated sediments**

**Water table**

**Moderately to highly permeable saturated sediments (aquifer)**

**Stream**

**Relatively impermeable material**

**Direction of water movement**

Source for Figures 14-25: *Policy Issue Study on Instream Flows*, Nebraska Natural Resources Commission, 1982, Compiled by Conservation & Survey Division University of Nebraska.

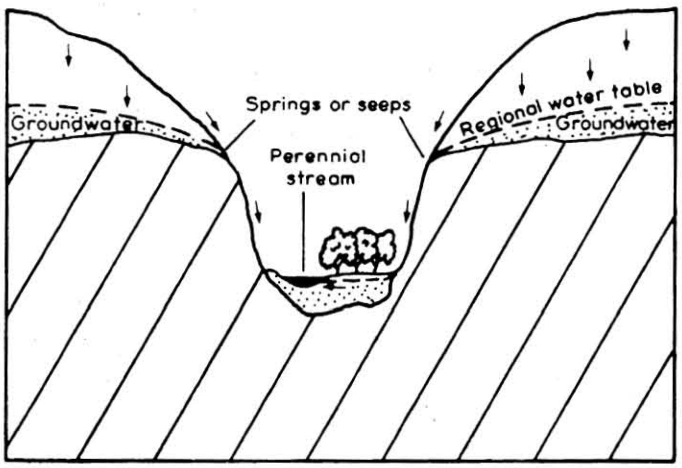



**FIGURE 15**

**NIOBRARA RIVER ALONG NORTH BORDER OF ROCK COUNTY**

Figure 16 illustrates a perennial stream incised into a relatively permeable alluvial fill aquifer that overlies relatively impermeable rock containing open water-filled fractures enlarged by a process called "piping." Pumping from wells drilled into fractures causes water to drain from the aquifer above and, in turn, may cause water to flow from the stream to the aquifer and possibly cause the stream to cease to flow.

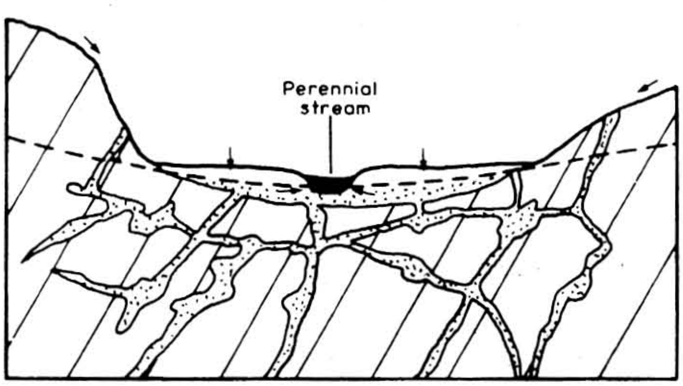



**FIGURE 16**

**LODGEPOLE CREEK**

Figure 17 illustrates a perennial stream incised into an areally extensive, relatively permeable unconfined aquifer. Groundwater seeps into the stream except when the stream is in a high stage and temporarily loses water by seepage into the aquifer. Arrows indicate groundwater flow lines at low stage of stream.

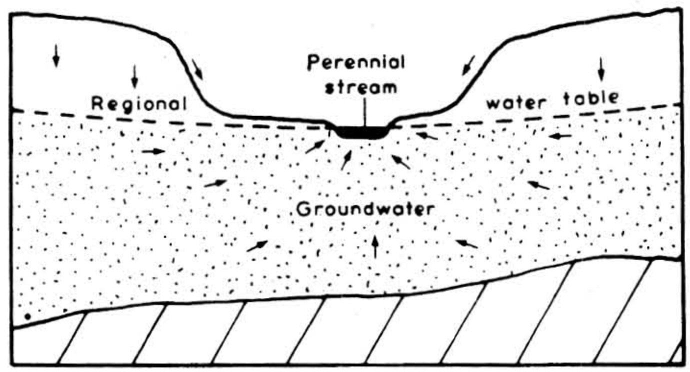



**FIGURE 17**

**PLATTE RIVER IN EASTERN LINCOLN COUNTY**

Figure 18 illustrates an intermittent stream incised into relatively permeable unsaturated sediments. There are no relatively impermeable sediments between the stream and the areally extensive zone of saturation. When the stream flows, it loses water by seepage to the underlying regional aquifer

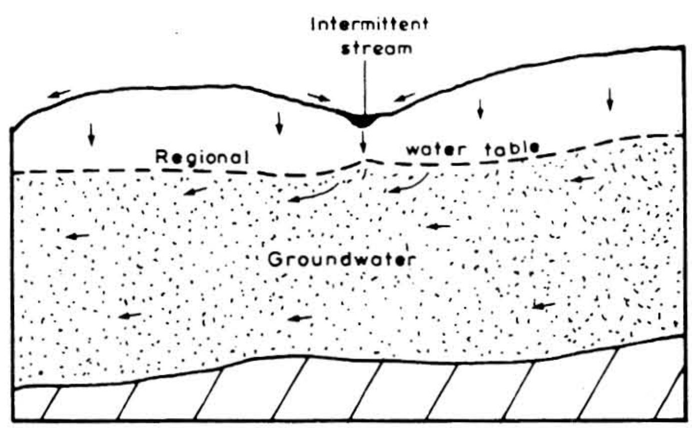



**FIGURE 18**

**WOOD RIVER NORTH OF KEARNEY IN BUFFALO COUNTY**

Figure 19 illustrates a perennial stream hydraulically continuous with the water table in an areally extensive, relatively permeable aquifer. As shown here, seepage loss leftward from the stream is caused by water uptake by phreatophytic vegetation. Pumping from wells close to the stream similarly would induce seepage from stream. Seepage loss to the right is due to a natural hydraulic gradient away from river. Such seepage losses can occur at low to high river stages.

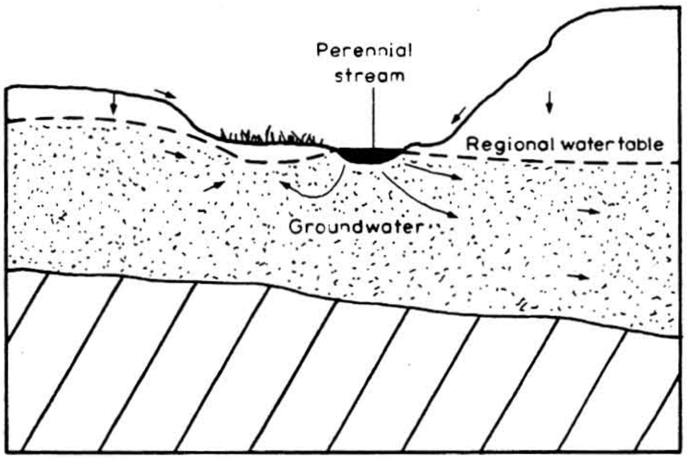



**FIGURE 19**

**PLATTE RIVER IN WESTERN MERRICK COUNTY**

Figure 20 illustrates an intermittent stream on a flat-floored interdunal valley. When infiltrating precipitation causes water table to rise above channel bottom, the stream flows. When water uptake by subirrigated vegetation lowers the water table to a level lower than the bottom of the stream channel, streamflow ceases.

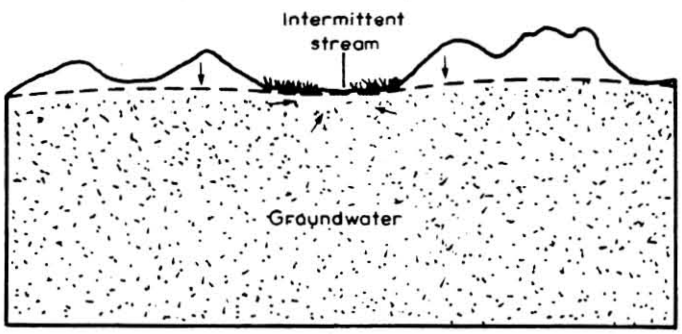



**FIGURE 20**

**UPPER REACH OF NORTH BRANCH OF THE MIDDLE LOUP RIVER IN SOUTHWESTERN CHERRY COUNTY**

Figure 21 illustrates two parallel, perennial streams, one at a lower altitude than the other. Both are incised into the same relatively permeable alluvial aquifer. The higher stream gains groundwater from one side but loses to groundwater on other side. The lower stream gains groundwater from both sides. The lower stream gain is partly loss from the higher stream.

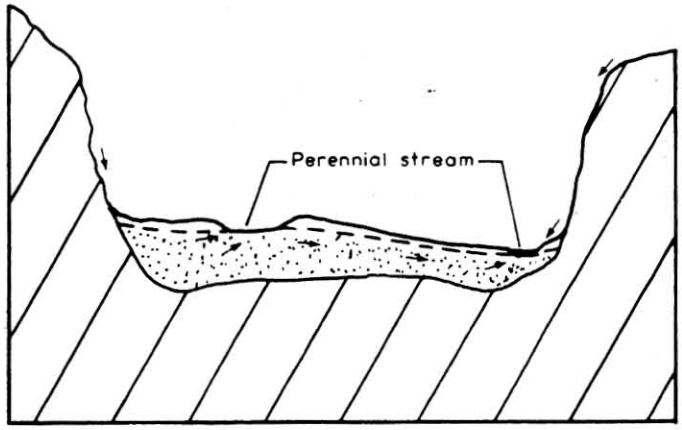



**FIGURE 21**

**PLATTE AND ELKHORN RIVERS IN WESTERN DOUGLAS COUNTY**

Figure 22 illustrates an intermittent stream flowing on thin relatively permeable alluvial deposits that are underlain and bordered by relatively impermeable materials. The stream flows when overland runoff occurs and/or when the water table in the thin alluvium remains higher than the bottom of the stream channel. During prolonged dry weather, the stream ceases to flow when water use by vegetation growing on bottom land adjacent to the stream causes th water table to decline to a level lower than the bottom of the stream channel.

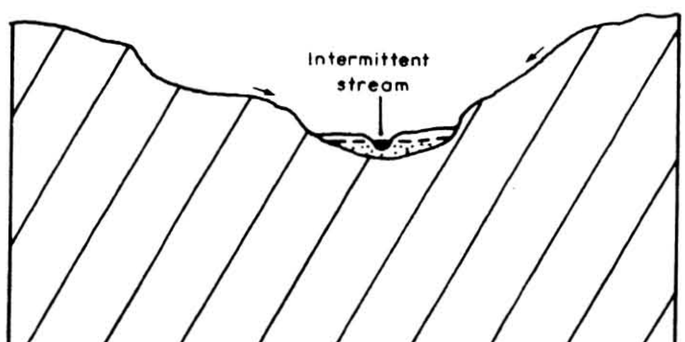



**FIGURE 22**

**DRIFTWOOD CREEK IN SOUTHEASTERN HITCHCOCK COUNTY**

Figure 23 illustrates an intermittent stream incised into relatively impermeable unsaturated sediments that are underlain by alternating layers of relatively permeable and impermeable unsaturated sediments. The regional water table at depth is not affected appreciably by influent seepage from the stream.

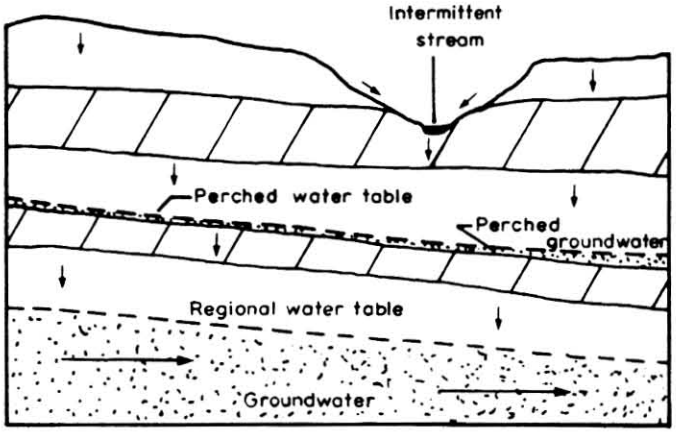



FIGURE 23

BIG BLUE RIVER IN EASTERN POLK COUNTY

Figure 24 illustrates a perennial stream incised into a relatively permeable unconfined aquifer that is hydraulically continuous with a deeper lying confined aquifer. Seepage from both aquifers contributes to the flow of the stream.

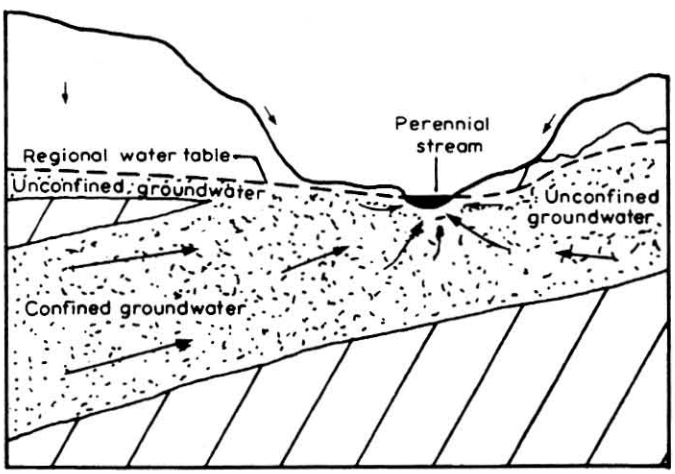



FIGURE 24

BIG BLUE RIVER IN SALINE COUNTY

Figure 25 illustrates an intermittent stream incised into relatively permeable unsaturated sediments that overlie a lens of relatively impermeable sediments. Seepage from the stream recharges a small perched aquifer which is supported by the relatively impermeable lens. The regional water table at depth is not appreciably affected by stream seepage.

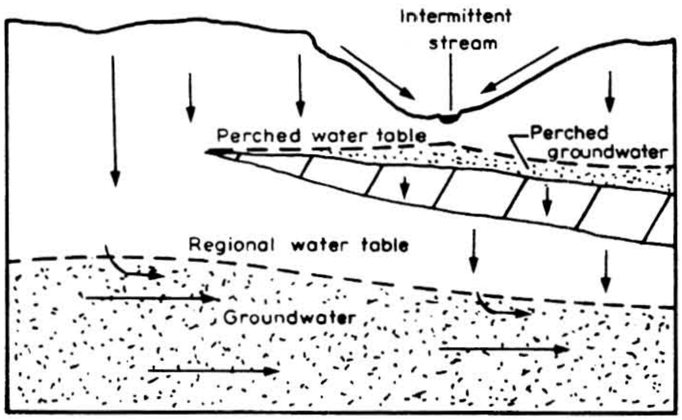



FIGURE 25

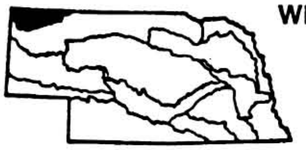
NORTH FORK JOHNSON CREEK IN FILLMORE COUNTY

The above illustrations show that a number of different relationships can exist between streams and groundwater. These flow conditions are highly dependent on the geologic conditions at any specific site. Detailed information on the geology and on the water table configuration must be gathered to fully understand the stream-aquifer flow system at specific sites. Those illustrations showing groundwater seeping into streams represent the common relationship existing along the state's perennially flowing streams.

## SUMMARY OF STREAMFLOW IN NEBRASKA RIVER BASINS

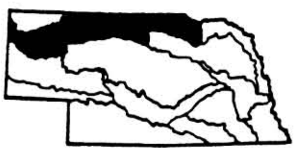
The following is a summary of the available data on gaining or losing reaches of streams in each river basin. Information generated for the *Policy Issue Study on Instream Flows* was used as the basis for much of the text.

## WHITE RIVER - HAT CREEK BASIN



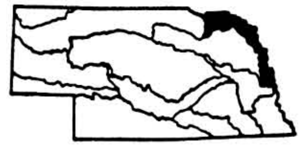
Streams that originate along the north side of the Pine Ridge receive groundwater discharge from a shallow aquifer that receives recharge from precipitation falling on the Pine Ridge. These streams converge to form the White River and Hat Creek. North and west flowing tributaries to the White River and Hat Creek cross a gently sloping area marked with clay hills and occasional badlands and are usually dry except when carrying direct runoff from precipitation. The water supply for the city of Crawford is obtained from a continuously flowing reach of the White River. Additionally, at present about 300 allocated water rights divert water for irrigation from Hat Creek, White River, White Clay Creek and their tributaries. It is not known if Hat Creek had perennial flow as far as the South Dakota state line before these developments took place. Now it becomes intermittent before it reaches the state line because many impoundments reduce inflow from tributaries and diversions for irrigation consume all the remaining flow during the growing season. Gaging records for White Clay Creek in South Dakota and the White River and South Dakota and Nebraska indicate that they probably flow at the state line except under drought conditions.

## NIOBRARA RIVER BASIN



The Niobrara River and many of its tributaries along the reaches from the Wyoming state line eastward to Valentine, are in efficient hydraulic connection with the regional aquifer and in most years groundwater seepage accounts for 90 to 95 percent of the river's total discharge. The Mirage Flats and the Ainsworth irrigation projects divert water in this upper reach from the Niobrara and Snake rivers upstream from Valentine. Eastward from Valentine the river has cut its valley into fine-textured rock that underlies the regional aquifer and yields virtually no groundwater seepage. In some places the river flows on this fine-textured rock but elsewhere it flows on this valley alluvium and is in hydraulic connection with the groundwater in it. The upper reaches of the tributaries to the Niobrara River, particularly those draining the upland to the south, are hydraulically continuous with the regional upland aquifer and have a steady discharge maintained by groundwater seepage. The Snake River, Long Pine Creek and Plum Creek are the three major Sandhills tributaries providing substantial contribution to the base flows of the main stem of the Niobrara. An increase in groundwater discharge due to a rise of the water table beneath the Ainsworth irrigation project accounts for some increase in the low flow of Long Pine Creek, an important tributary to the Niobrara River. Nowhere along its course is the Niobrara known to be a natural source of aquifer recharge. Except for the surface water diversions for irrigation, no progressive loss of flow by perennial streams in the Niobrara River system is certain. However, there may be a losing segment on the Keya Paha River upstream of the Naper Gage.

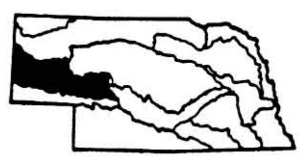
## MISSOURI RIVER BASIN AND MISSOURI TRIBUTARIES



The flow in the main stem of the Missouri River downstream from the Gavins Point Dam consists of releases from the Lewis and Clark Lake, inflows from tributaries and groundwater seepage from the valley alluvium. When at high stages the river may lose water by seepage into the adjacent valley alluvium, but ordinarily the river gains from groundwater seepage into the river channel throughout its length along Nebraska's eastern border.

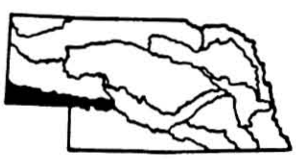
The principal tributaries flowing directly to the Missouri River between Gavins Point Dam and the mouth of the Platte River are Bazile, Beaver, Bow, Aowa, Elk, Omaha, Blackbird, Tekamah, New York, and Papillion creeks. In their uppermost reaches these streams and tributaries that join them flow only in response to overland runoff. When flow occurs, these reaches may be sources of small amounts of recharge to an underlying aquifer. Downstream from these reaches where the streams are hydraulically connected to the groundwater in the valley alluvium, groundwater discharges into the stream channel. As the fine textured valley alluvium transmits groundwater at relatively slow rates, base flow of these streams is small. In the lower reaches, several of these streams are bordered by levees and during high stages these streams probably lose some water by seepage into the Missouri River alluvium.

## NORTH PLATTE RIVER BASIN



Much of the flow of the North Platte River originates as snow melt and is controlled by several reservoirs in Wyoming. A large volume of released water from the reservoirs is conveyed by the Interstate and Fort Laramie canals into Nebraska for irrigation. In most years more water enters Nebraska via these canals than enters in the North Platte's main channel. This has resulted in considerably reduced flow in a long reach of the North Platte River near the state line. Vegetation has encroached on parts of the channel no longer scoured clean by high flows and has resulted in reduced groundwater recharge from or discharge to the river. Two important tributaries, Birdwood Creek and Blue Creek rise in the Sandhills region north of the river and have perennial flow maintained by groundwater seepage.

Infiltration of irrigation water below the reach of crop roots has resulted in a buildup of groundwater beneath terrace lands on both sides of the North Platte. Seepage from the groundwater reservoir thus created has given the river a base flow that it formerly did not have. Only part of this seepage enters the North Platte River directly, the remainder reaches the river via several drains plus a series of tributaries that formerly were intermittent but now flow continuously. Thus, due to use of water stored in Wyoming for irrigation of crop land along the North Platte in Nebraska, the North Platte and several tributaries, such as Sheep Creek, have changed from intermittent to perennial streams.

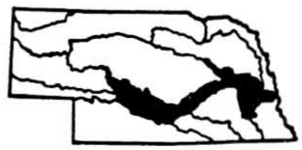


## SOUTH PLATTE RIVER BASIN

There is some groundwater discharge to the South Platte River which sustains the baseflow. However, most of the groundwater in the alluvium of the valley in the high region of eastern Colorado and Nebraska is extensively developed for irrigation and the water-table in some areas has been lowered by pumping for irrigation. Seepage to groundwater from beneath irrigated lands in northeastern Colorado helps account for the river not becoming dry near the state line despite average annual inflow being much less now than under predevelopment conditions.

Seepage of groundwater into the South Platte River channel within Nebraska is much greater now than it was under natural conditions. Most of the seepage is derived from the south side of the river—a small amount from beneath the land irrigated with water diverted into the Western Canal and a much larger amount from beneath the land where seepage losses from the South Platte Supply Canal, the Sutherland Supply Canal, Maloney Reservoir, and Sutherland Reservoir have caused a steepening of the water-table gradient northward to the South Platte River. The South Platte River in Nebraska became dry at times prior to 1939 but has not been dry since then. Whereas the South Platte River formerly was a losing stream throughout its length in the state, it now is a gaining stream downstream from the Paxton vicinity because the steepened groundwater gradient has increased seepage into the river.

Throughout a little more than half its length in Nebraska, the channel of Lodgepole Creek, a tributary of the South Platte River, is incised into the Brule Formation, which contains many fractures. Replenishment of storage by seepage from Lodgepole Creek occurs when the creek flows, and in each of the last several years enough of the openings in the Brule have been dewatered that storage space became available for much if not all of the available streamflow. Lodgepole Creek is a losing stream throughout much of its course in Nebraska. In recent years, all or virtually all of the inflow from Wyoming was lost to groundwater storage within the Nebraska reach of the stream. Because of pumping of groundwater, the town of Sidney, in particular, has experienced water-supply problems and is considering relocation of its well field outside the Lodgepole Creek Valley.



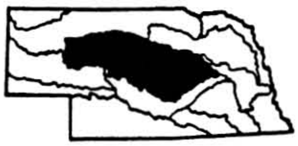
## MIDDLE AND LOWER PLATTE RIVER BASINS

The gain or loss of streamflow on the main stem of Platte River is influenced more by water-resources developments than by natural conditions.

Under natural conditions, the reach from the confluence of the North Platte and the South Platte rivers to the mouth of the Loup River probably was subject to long no-flow periods, but now the no-flow occurences are limited to the downstream half of the reach and occur infrequently. These changes in the river's flow regime are the combined results of the water-storage features and the water-use developments in the Platte's drainage area.

Groundwater seepage into the river occurs from both sides of the Platte River between North Platte and Kearney. This seepage is greater now than it was under natural conditions because mounding of the water table due to canal leakage and application of water for irrigation has steepened the water-table slope toward the river. Beginning at about Kearney and continuing into Merrick County, the water table slopes northeastward away from the river instead of toward it, and the river thus becomes a losing stream by providing recharge to the adjacent aquifer. In much of the same reach, the water-table slopes away from the river on the south side also and thus the river loses water by seepage in that direction too.

From central Merrick County to about the mouth of the Elkhorn River, the Platte River loses mostly to the east and north but gains from the south and west. From the mouth of the Elkhorn to the mouth of Salt Creek, the Platte River loses to the Lincoln city well field on its west side. Downstream from the mouth of Salt Creek, it is mostly a gaining stream but in the vicinity of the Omaha well field it is a source of induced recharge. Limited available information on the Platte River tributaries indicate Wood River to be a losing stream between Riverdale and Alda. The loss of flow is believed due to the water table decline that has been caused by groundwater withdrawals for irrigation. Some other tributaries in the Middle Platte basin namely Moores Creek, Prairie Creek and Silver Creek, were formerly groundwater drains, but now are sources of groundwater recharge when they convey overland runoff.



## LOUP RIVER BASIN

All of the Loup River's tributaries and in some respects the Loup River itself serve as groundwater drains, some more effectively so than others. Because soils in the Sandhills region are highly absorptive, they transmit to the underlying zone of saturation virtually all the precipitaton not returned to the atmosphere by evapotranspiration. Thus, in this region, comparatively little water reaches streams as overland runoff; instead, streamflow is maintained almost wholly by groundwater seepage into stream channels. In the hardlands region downstream in the basin, less groundwater is in storage and the water table gradient toward the hardlands stream reaches is not as steep toward these stream reaches as in the Sandhills resulting in less groundwater discharge to the streams.

Considerable quantities of water are diverted from the North Loup and Middle Loup rivers into canals that convey water to irrigation projects downstream from the Sandhills. Most diversions occur during the normal irrigation season, but diversions into the canal conveying water to Sherman Reservoir, which stores water for irrigation of the Farwell Project, generally begin earlier and continue longer than the others.

Water is also diverted from the Loup River near Genoa into the Loup River Power Canal. At times the entire river's flow is diverted and if not for inflow to the river from Beaver Creek and for seepage losses from the canal, the Loup River would be dry at its mouth. Most of the water diverted into the power canal becomes inflow to the Platte River about two miles downstream from the confluence of the Loup and Platte.

A curious feature of the Loup River is the unexplained natural loss of water from the river channel. Losses appear to be greatest in the reach between St. Paul and Genoa. For most months the sum of measured plus estimated inflows to the Loup upstream from Genoa is significantly greater than the sum of the amounts diverted into the power canal and remaining in the river. Total losses for the 10-year period 1961-70 were approximately equal to the storage capacity of Lake McConaughy. Because water losses from the reach were recognized by hydrographers at the turn of the century, the losses recorded in the 1961-70 decade can hardly be attributed to water-use developments. Moreover, the losses appear to be too great for evapotranspiration to be their sole cause. Nor due to the configuration of the acquifer can the losses be attributed to seepage into the adjacent aquifer.

A recent study on groundwater inflow characteristics of the Cedar River, Beaver Creek and some nearby streams conducted through extensive baseflow measurements has quantified the flow gains and losses in several continuous reaches of these streams. The study was conducted by the Department of Water Resources and include the following description of those streams.

"The Cedar River rises in the broad, marshy wet meadows of northern Garfield County. It begins its flow towards the Loup River as two small streams, Big and Little Cedar Creeks. Groundwater slowly oozes into the two streams from the surrounding marshes. Reach gains average less than 0.2 cubic feet per second per mile (cfs/mile) [in the upper reaches of Big Cedar Creek].

Further downstream, the small creeks enter more defined channels. It is in this region that the streams experience a considerable increase in baseflow. . . gains on Cedar Creek exceed 7 cfs/mile in the reach immediately downstream from the confluence of Big and Little Cedar Creek. . . . Large, but less dramatic gains characterize the remainder of Cedar Creek before it becomes the Cedar River at the mouth of Dry Cedar Creek near Ericson.

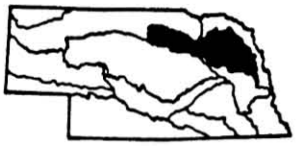
The Cedar River continues to receive substantial amounts of groundwater inflow from Ericson to Primrose. The Sandhills either bound or flank the river valley along much of this reach. Several tributaries, also supported by base flow, enter the Cedar Rier above Spalding. Groundwater enters the Cedar River above Spalding.

There is no significant base flow gain between Primrose and the Fullerton gage. A minor base flow loss occurs in the vicinity of Cedar Rapids. . . .

Beaver Creek, like the Cedar River, rises in the marshlands of the eastern Sandhills. Groundwater begins to enter the shallow channel of Beaver Creek in central Wheeler County. Gains in the headwater region. . . .average 0.2 cfs/mile.

The area of greatest groundwater inflow to the creek occurs in a 19-mile segment. In this reach [which is nearly divided by the Wheeler-Boone County line] the base flow gain amounts to over 2 cfs/mile. Groundwater inflow averages over 2.8 cfs/mile in [a] six mile long portion of the stream [in the northwest corner of Boone County].

Downstream, base flow gains drop to about 1 cfs/mile in Beaver Creek, in the reach just above Loretto. There is little increase in base flow between the gaging station at Loretto and the village of Boone. In a portion of that reach near Albion. . . .there is a slight base flow loss. Beaver Creek again becomes a gaining stream from Boone to its mouth near Genoa. Groundwater inflow amounts to roughly 1.3 cfs/mile in the lower reach of the stream."[4]



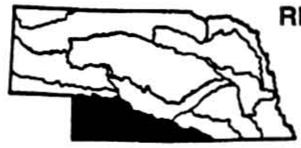
**ELKHORN RIVER BASIN**

Most of the upstream half of the Elkhorn River's length is in an area of sandy soils bordering the Sandhills area. All tributaries entering the Elkhorn River in this reach head in the Sandhills region lying to the south. Nearly all their flow, also of the upstream half of the Elkhorn River, is maintained by groundwater seepage.

Precipitation on the sandy terrain southwest of the North Fork of the Elkhorn River produces negligible overland runoff and the part not returned to the atmosphere by evapotranspiration infiltrates to the water table. Hence the flow of Willow Creek, a tributary flowing into the North Fork from the west, consists almost wholly of groundwater seepage.

A digital computer model of the hydrogeologic system of the Willow Creek Watershed quantified the recharge and discharge characteristics of the regional aquifer underlying the watershed.[5] According to this study, under average conditions represented by the period 1975-76, the regional aquifer of the Willow Creek Watershed receives recharge from deep percolation of precipitation at the rate of 47,900 acre-feet per year and discharges as baseflow of perennial streams at the rate of 30,800 acre-feet per year. The balance is groundwater moving down gradient.

Groundwater seepage additionally contributes to the discharge of the North Fork downstream from the mouth of Willow Creek. Thus, the Elkhorn River, and most tributaries entering the river upstream from the mouth of North Fork are probably groundwater drains throughout their entire lengths. The lower reaches of most tributaries entering the Elkhorn River downstream from the mouth of North Fork also receive contribution from groundwater, but at a slower rate. However, there are some indications that parts of Yankton Slough, Maple Creek, and part of the Elkhorn between Oakdale and Meadow Grove may be losing segments for at least part of the year.



**REPUBLICAN RIVER BASIN**

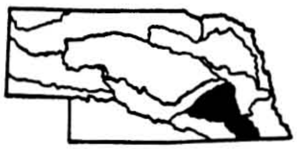
Flows in the Republican River are regulated by storage in reservoirs, reservoir releases and diversions for irrigation. In dry years, when inflows are not sufficient to fill reservoirs, river discharges immediately downstream from the dams are nil, but increase gradually with distance because of groundwater seepage into tributaries and into the river itself. Quantities of seepage are small because the hydraulic connection between water in the regional aquifer and the river or its tributaries is relatively poor. In reaches where adjacent lands are irrigated with river water there is return flow to the river.

Though the direction of groundwater movement throughout the upland in the Republican River Basin is toward the valley of the Republican, only some of the tributaries and part of the river receive enough groundwater seepage to have sustained flow. Tributaries known to have continuous flow are Rock, Frenchman, Red Willow, Medicine, Turkey, Thompson, and Elm creeks. Stinking Water Creek, which is tributary to Frenchman Creek, also has continuous flow. Each of these streams is on the north side of the Republican. Downstream from the mouth of Frenchman Creek, the Republican has continuous flow maintained largely by tributary inflow but in small part from groundwater seepage directly into the river channel. At several places along the Republican River upstream from the mouth of Frenchman Creek, the adjacent bottom land is slightly lower than the river surface and the river loses water by seepage. Phreatophytic vegetation in these low areas not only intercepts groundwater draining from beneath adjacent uplands but also consumes seepage losses from the river. Where the river swings from one side of its valley to the other in the reach downstream from the mouth of the Frenchman Creek, it probably gains from groundwater seepage along one side of its channel and loses by seepage into the adjoining aquifer along its other side.

Depletion of inflow to Enders Resevoir on Frenchman Creek is a matter of concern to irrigators dependent on releases from this reservoir. According to a recent study by Lappala (1978) [6], baseflow of Frenchman Creek near the point of inflow to the reservoir had been reduced by as much as a third by 1975. The reduction is attributed to a decrease of groundwater seepage into the stream channel. This decrease is due to the large aggregate withdrawals of groundwater for irrigation in the Frenchman Creek drainage area. However, lack of expected overland runoff in the study period may also have been a factor.

Some decline of inflow to Hugh Butler and Harry Strunk lakes may occur, via Red Willow and Medicine Creeks respectively, if groundwater withdrawals upgradient from those reservoirs continue to increase at the rate of the past few years.

Early records show periods of no inflow to the state and of no flow at gaging stations on the Republican River downstream to the mouth of Frenchman Creek before any significant water resources developments had occurred in the upstream part of the drainage basin.

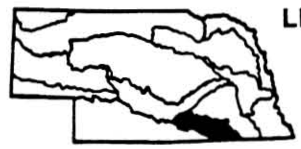


## BIG BLUE RIVER BASIN

The upper reaches of most streams in the Big Blue River Basin flow only when precipitation is sufficient to produce overland runoff. Some, however, have a flow maintained by discharge of municipal waste and/or cooling water that originally was pumped from wells. Upstream reaches of all streams are higher than the water table so probably are sources of some recharge to groundwater when they flow. Amounts of recharge generally are not great because the stream beds are mostly fine-textured sediments that transmit water slowly. A research study on stream channel recharge conducted on Lincoln Creek near Bradshaw indicates a relatively low seepage rate of 0.81 inch per day.[7]

Most of the middle and lower reaches are hydraulically continuous with the water table and may be groundwater drains except at times of high flow when the stream surface is temporarily higher than the adjacent water table. However, recent seepage measurements by the Department of Water Resources have given indications that there may be a losing reach between DeWitt and Beatrice.

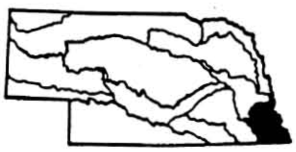
Despite the large groundwater supply beneath the western and central parts of the Big Blue River's drainage area in Nebraska, the Big Blue and its tributaries have relatively low base flows. Discharge of groundwater by evapotranspiration together with the fine texture of the sediments through which groundwater must seep to reach stream channels in this drainage area probably account for groundwater being a small component of total stream discharge. A stream-aquifer interrelationship study was conducted by the USGS in the Big Blue River Basin. It used seepage measurements at the main stem of the Big Blue and the tributaries in Gage County during the fall of 1978 to furnish data to represent groundwater contribution to the flow of these streams.[8] The findings of this study indicated that in the Big Blue River basin, the largest groundwater contributions to streamflow occur in the reaches of the river between the mouth of Turkey Creek and the Beatrice gaging station and between the mouth of Mud Creek and the dam at Blue Springs. However, recent seepage studies by the Department of Water Resources have indicated that the reach between Turkey Creek and Beatrice may not be a gaining reach. The gain in the reach between the mouth of Turkey Creek and the Beatrice gage cannot be determined exactly. The USGS study also indicated that significant groundwater contributions to streamflow occur in two tributaries from Bear Creek and Big Indian Creek.



## LITTLE BLUE RIVER BASIN

The Little Blue River and several of its important tributaries namely Big Sandy, Little Sandy, Cottonwood, Rose, Sand and Spring creeks are generally hydraulically continuous with the water table and have sustained flow in their middle and lower reaches. However, the groundwater component of flow is relatively small compared to the overland runoff component. Furthermore, there may be some segments which sometimes lose flow in Spring Creek, Big Sandy Creek, and the west-central portion of the Little Blue River in Thayer County. Pumping of groundwater in the basin appears to have caused very little depletion of the base flow of the Little Blue River and its tributaries. Much of the groundwater moving toward streams is lost to evapotranspiration due to being intercepted by trees and other deep-rooted vegetation on bottom lands. However, Kansas has never made a call for administration of the Kansas-Nebraska compact requirement for apportionment of 45 to 80 cfs of flow on the Little Blue at the state line between May 1 and September 30. In fact, the low flow of some streams may have been increased by the discharge of water from wastewater treatment plants. Also possible is an increase in the low flow of some streams (Big Sandy Creek in particular) due to an increase in the discharge of groundwater from a higher (perched) zone of saturation than the regional zone from which water is pumped for irrigation. Part of irrigation water infiltrating below the root zone of crops may not reach the regional zone, but instead adds to the storage in the higher zone and causes it to discharge to streams at a greater rate than previously. However, no specific data are available to demonstrate whether those possible gains to low flow are significant in amount.

Extensive seepage measurements by USGS on the Little Blue River and its important tributaries in Jefferson County during fall of 1978 provided information on the contributions of groundwater to the flow of these streams.[9] The findings of the USGS study indicate that in the Little Blue River basin the largest contributions to streamflow occur between the mouths of Big Sandy and Little Sandy Creeks (about 6.5 cfs) and the vicinity of Fairbury (about 16 cfs). A groundwater contribution to streamflow of about 6.5 cfs also occurs in Rose Creek, an important tributary of the Little Blue River. The study also concluded that during the growing season the effect of evapotranspiration, stream diversions, and groundwater pumping probably cause the groundwater contribution to streamflow to be somewhat less. Existing groundwater development for irrigation probably has, as yet, had no significant effect on streamflow. However, even at the current degree of development, it is probable that irrigation pumpage of groundwater will cause some decrease in the groundwater contribution to streamflow in the future. The areas of groundwater development likely to have the greatest effect on streamflow are located where buried Quaternary coarse-grained deposits occur in the Rose Creek drainage basin in the vicinity of Fairbury.



### NEMAHA RIVER BASIN

The flow of all streams in this southeastern part of Nebraska is highly variable. Large discharges occur in response to runoff generated by heavy rains in steep drainageways, maximum disharge in the Nemaha system of streams namely Weeping Water Creek, Little Nemaha, North and South Forks of Big Namaha, are several hundred times greater than the minimum discharges. Even though the middle and lower reaches of these Nemaha River Basin streams are incised into saturated sediments, the base flows are small because the sediments are fine textured and transmit groundwater at a very slow rate. However, it is interesting to note that certain seepage runs made on the South Fork Little Nemaha River in the vicinity of the town of Cook during fall of last several years through an UN-L Groundwater Geology class under the direction of Professor D.T. Pedersen, have observed a significantly gaining reach of that stream along the Johnson-Otoe county line.

## ESTIMATE OF STREAM GAIN OR LOSS FROM GROUNDWATER MODELS

A number of digital models have been developed to simulate groundwater flow in Nebraska. Several of these models have a feature which allows them to calculate streamflows for the perennial streams within their geographical boundaries. Computed annual baseflows for various gaging stations within modeled areas are easily compared with modeled baseflow for the same time periods. This comparison is often an important part of the calibration process for digital models. When a reasonably close match in modeled and actual baseflow is achieved, projected changes in streamflows can be estimated for future time periods.

Specific models which have been developed within Nebraska can be grouped into three catagories in regard to how they relate with historic streamflows.

Table 1 lists digital groundwater models developed for areas within Nebraska and shows which catagory the models fit into.

**TABLE 1**

**NEBRASKA DIGITAL GROUNDWATER MODELS**

| MODEL TITLE | CATEGORY |
|---|---|
| Hydrogeology of the Upper Republican Natural Resources District (USGS) | (1) |
| Hydrogeology of the Central Platte and Lower Loup Natural Resources District (USGS) | (2) |
| Platte River Basin - Nebraska Level B Study (MRBC) | (1) |
| Predicted Water Level Declines for Alternative Groundwater Developments in the Upper Big Blue River Basin, Nebraska (Conservation & Survey Division) | (3) |
| Interpretive Study and Numerical Model of the Hydrogeology, Upper Big Blue Natural Resources District Nebraska (Conservation & Survey Division) | (3) |
| Report on the Big and Little Blue Basins Area Planning Study Technical Appendix A: Development, Calibration, Verification and Utilization of the Groundwater Models (NNRC) | (1) or (2) |
| EDA High Plains Study Groundwater Model (NNRC) | (3) |

**CATEGORIES**

(1) Those that calibrate to historic streamflows and attempted to project future stream flows

(2) Those that calibrate to historic streamflows but do not attempt to project future streamflows

(3) Those that do not calibrate to historic streamflows

# INTERRELATIONSHIP OF NATURAL LAKES AND WETLANDS WITH GROUNDWATER IN NEBRASKA

## INTRODUCTION

Many of Nebraska's lakes and wetlands, as do its streams, have a hydraulic connection with the groundwater. The exact nature of the flow system surrounding these lakes and wetlands is less well understood than the stream-aquifer flow relationship because fewer intensive investigations have been conducted examining their flow system.

The vast majority of naturally occurring lakes and wetlands within Nebraska are in the Sandhills region. The "rainwater basin" of south-central Nebraska is another area where natural lakes and marshes occur. In the rainwater basin most wetlands are not features of the regional water table. In areas where the lakes are a feature of the water table, wetlands and subirrigated areas may surround them. All may change in size depending upon the fluctuating water table. Together, the Sandhills area and the rainwater basin area contain almost all the natural lakes and over 90 percent of the wetland areas in the state.

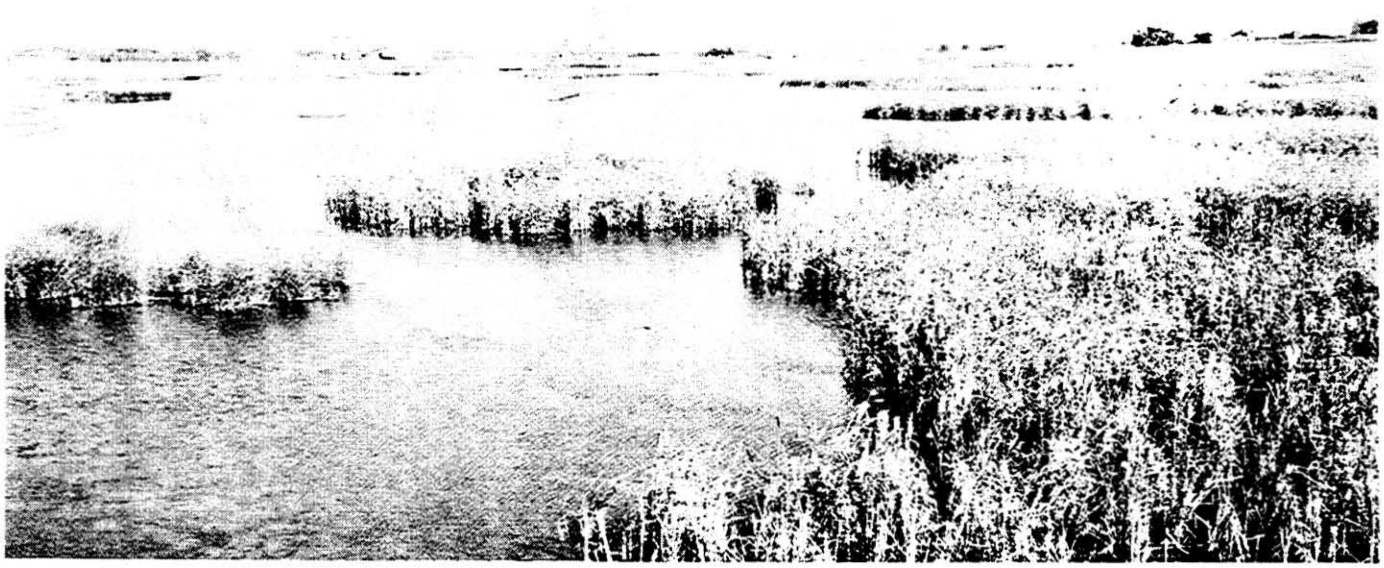
In areas where the water table is above the surface, lakes and wetlands occur. In areas where it is just below the surface, there is generally subirrigated vegetation. Figure 26 presents areas of the state featuring subirrigated vegetation. These areas occur in the Sandhills and many river valleys.

### THE RAINWATER BASIN AREA

The rainwater basin area includes approximately 4,200 square miles in south-central Nebraska. The region is characterized by flat and nearly level to gently rolling loess plains. Shallow depressions located within the region have become the site of marsh, wetland and some lake formation. The depressions are underlain by impervious clay rich soils thus water loss is chiefly from evapotranspiration. Most of the wetlands are perched and are not features of the regional water table, however in the vicinity of the water table rises surrounding the canal system of the Central Nebraska Public Power and Irrigation District some of the wetlands may be water table exposures. In other cases, the lakes and wetlands, although not features of the regional water table, may be exposures of a perched water table.

### THE SANDHILLS LAKE AND WETLAND AREA

The Sandhills region covers approximately 19,300 square miles in north-central Nebraska, extending a short distance into South Dakota. Figure 27 illustrates the Sandhills area with its lakes and drainageways. The area was once a desert where dunes actively migrated in the direction of the prevailing winds. These sand dunes formed in multiple phases of eolian activity during the past 12,000 years. The most recent episode of active dune formation occurred as recently as 3,500 to 3,800 years ago.[10] The dunes have now been stabilized by grass cover, brought about by a relatively recent change to a more humid climate. The Sandhills represent, by far, the largest sand sea in the western hemisphere, even though the area is not now considered to be a desert.



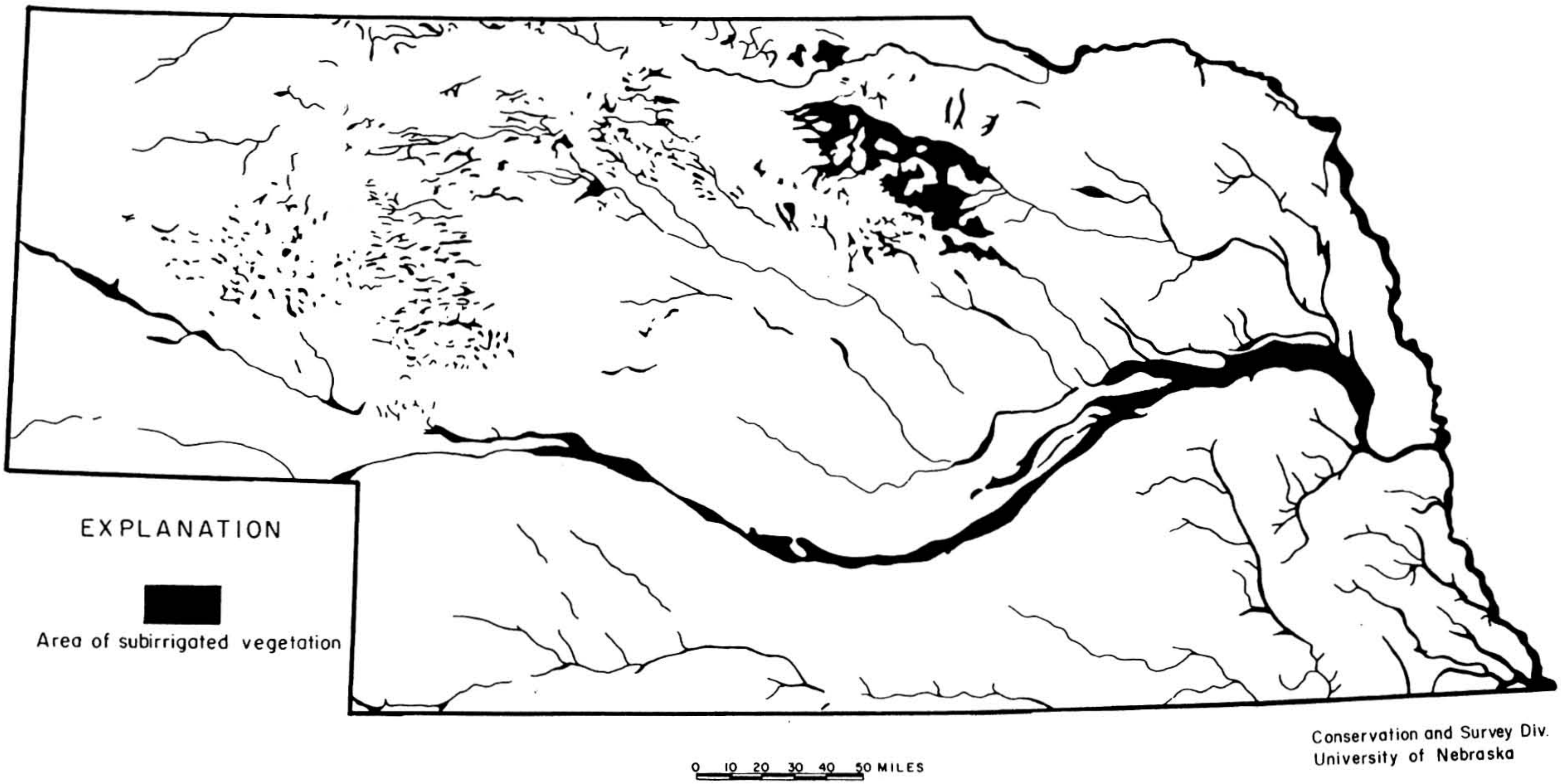



**FIGURE 26**

**PRINCIPAL AREAS OF SUBIRRIGATED VEGETATION**

*Source:* Shaffer, F.B., Availability and Use of Water in Nebraska, 1970. Nebraska Water Survey Paper #31, Conservation and Survey Division, University of Nebraska-Lincoln, 1972.

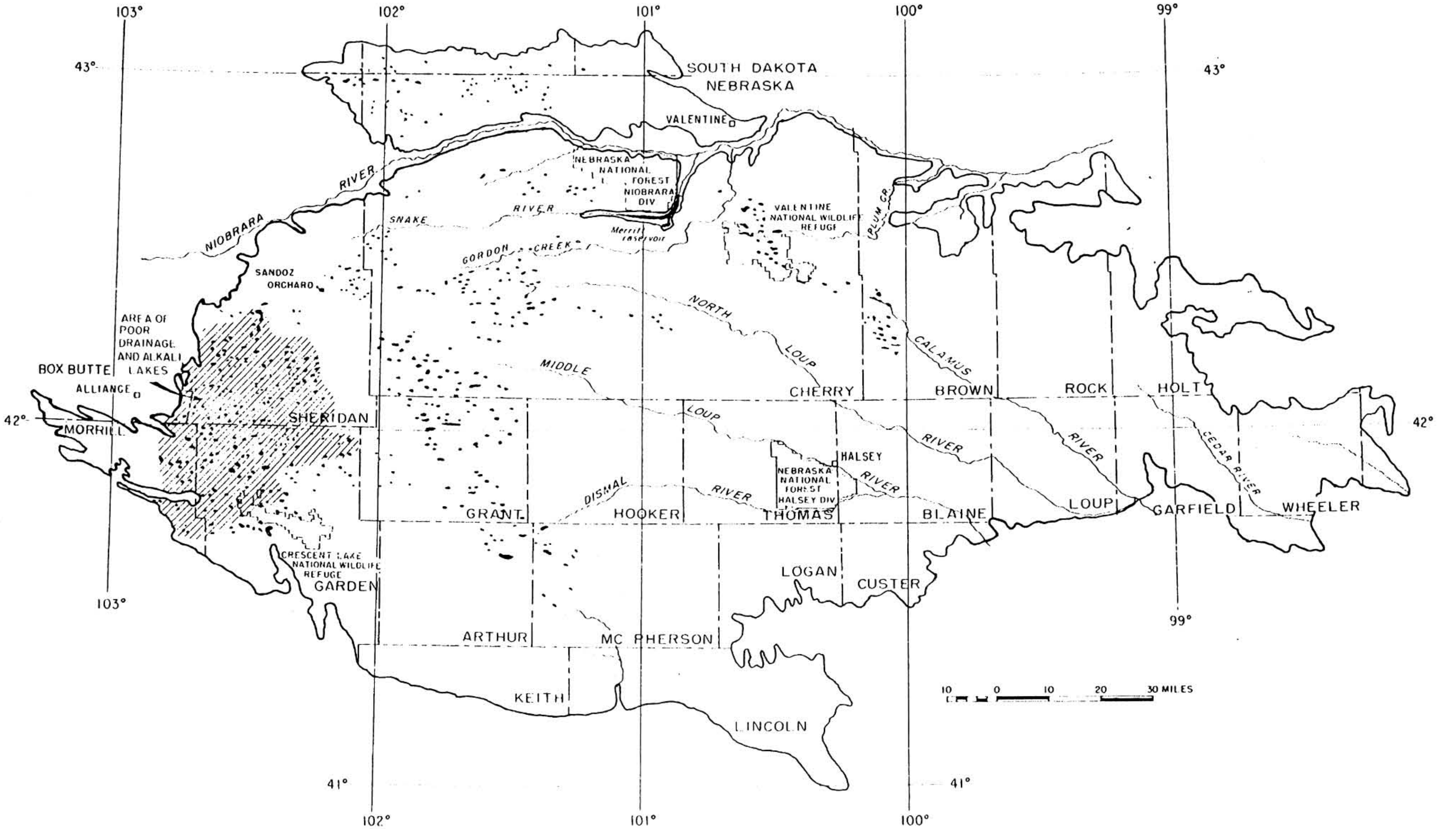



**FIGURE 27**

**ILLUSTRATION SHOWING NEBRASKA'S SANDHILLS REGION, INCLUDING RIVER DRAINAGE**

*Source:* C.F. Keech and Ray Bentall, Dunes on the Plains, The Sandhills Region of Nebraska, Resources Report #4, Conservation and Survey Division, University of Nebraska, Reprinted 1978.

Located between the sand dunes are flat-floored valleys. The larger valleys have linnear shapes while the smaller ones often have irregular shapes.[11] Larger valleys may contain one or more lakes. The larger of these lakes tend to be relatively permanent while the smaller ones often dry up temporarily during the summer months or during especially dry years.

Also within the valleys and usually immediately surrounding the lakes are marshes and subirrigated meadows. Marshes are areas that persistently have water at or above the surface of the soil while subirrigated meadows are areas where the root zone of the vegetative cover has access to the water table.

Estimates of the number of Sandhills lakes and of their surface areas have been reported by several sources. One estimate cites a total of 1,640 lakes ranging in size from 10 to 2,300 acres and an additional 850 lakes of less than 10 acres in size.[12] A combined surface area for the larger lakes was put at 65,800 acres. McCarraher (1972) reported the same number of large permanent lakes with almost the same surface area, but also reported between 2,000 and 2,400 intermittent, or ephemeral, lakes.[13] All of the lakes are quite shallow, having an average measured depth of 3.2 feet. A maximum depth of 13.8 feet has been measured in Blue Lake in northern Garden County.

Major concentrations of wetlands within the Sandhills are found in Garden, Morrill, Sheridan, Cherry, Grant, Brown, and Rock counties in Nebraska. Table 2 lists Sandhills wetland acreages by county.

## TABLE 2

### TOTAL NUMBER AND ACREAGE OF WETLANDS IN THE SANDHILLS

| County | Total Acreage | Total Number |
|---|---|---|
| Arthur | 5,025 | 309 |
| Box Butte | 2,526 | 105 |
| Brown | 7,601 | 883 |
| Chase | 2,281 | 605 |
| Cherry | 37,065 | 1,262 |
| Custer | 143 | 59 |
| Garden | 20,600 | 696 |
| Garfield a/ | 3,879 | 34 |
| Grant | 8,442 | 283 |
| Holt | 10,288 | 1,966 |
| Hooker | 298 | 8 |
| Keith | 1,832 | 408 |
| Lincoln | 2,642 | 710 |
| Logan | 513 | 59 |
| Loup | 981 | 180 |
| McPherson | 2,873 | 63 |
| Morrill | 4,800 | 276 |
| Perkins | 6,148 | 1,793 |
| Rock | 10,504 | 1,706 |
| Sheridan | 22,914 | 1,384 |
| Wheeler a/ | 4,026 | 552 |
| TOTAL b/ | 155,381 | 13,341 |

a/ Does not include number of Type II wetlands.
b/ No Type I wetlands have been included in survey.

*Source:* Nebraska Game and Parks Commission, Final Report, Investigation Projects as Required by the Federal Aid in Wildlife Restoration Act, Work Plan k-71 Survey of Habitat.

Wetlands in Nebraska range from seasonally flooded wet meadows to permanent, shallow, open water lakes. This includes the following wetland types identified by Shaw and Fredine in 1971:[14]

(1) **Seasonally flooded basins or flats** where soil is covered with water or is waterlogged part of the year, but is well drained during the growing season.

(2) **Fresh meadows** where soils usually are without standing water most of the growing season, but are waterlogged within a few inches of the soil surface.

(3) **Shallow fresh marshes** where soils are usually waterlogged during the growing season, often covered by as much as six inches of water.

(4) **Deep fresh marshes** where soils are covered by six inches to three feet of water during the growing season.

(5) **Open fresh water.** These water bodies include shallow ponds and reservoirs, usually shallow panels and reservoirs, usually less than ten feet deep and fringed by emergent vegetation.

## THE RELATIONSHIP OF LAKES AND GROUNDWATER

Although there are no intensive reports on the relationship of natural lakes and groundwater in the Sandhills, enough general information is available from a number of sources to suggest a diversity of hydrogeologic conditions surrounding these lakes.

Keech and Bentall (1978) report that the lakes differ in degree of hydraulic connection with the zone of saturation.[15] Where there is good connection the lake surfaces are continuous with the zone of saturation and they fluctuate in unison. Where lakes are sealed off from the zone of saturation (i.e. with low permeability lake bottom sediments) the water surfaces fluctuate independently. Keech and Bentall further state that the sealed lakes generally exhibit higher salt concentrations and are thus considered more strongly alkaline.

Buckwalter (1983) reported changes in lake surface areas observed from Landsat imagery taken on three separate dates per year in each of the years of 1973 to 1978.[16] A diversity in the fluctuation of lake levels from year to year and from season to season, even among lakes in close proximity, indicate that the lakes probably vary greatly in their hydrologic characteristics, including the degree to which they reflect groundwater levels.

The sandy soils which have developed on the dunesands within the Sandhills are highly conducive to infiltration of precipitation. Throughout most of the Sandhills there is little surface runoff that results from rainstorms.

In areas close to drainage ways, water that has infiltrated the dunesands and recharged the aquifer migrates toward, and if not transpired by vegetation, it is discharged to streams. In areas where there are no drainage ways but where numerous lakes or wetlands exist, groundwater migrates toward these lakes or wetlands and is either discharged into them and consequently evaporated or is transpired through plants where the water table is within reach of plant roots. These observations are noted by Keech and Bentall [17] who state that the current long term rate of replenishment is virtually equaled by the long term average rate of natural discharge to streams and lakes and by evapotranspiration.

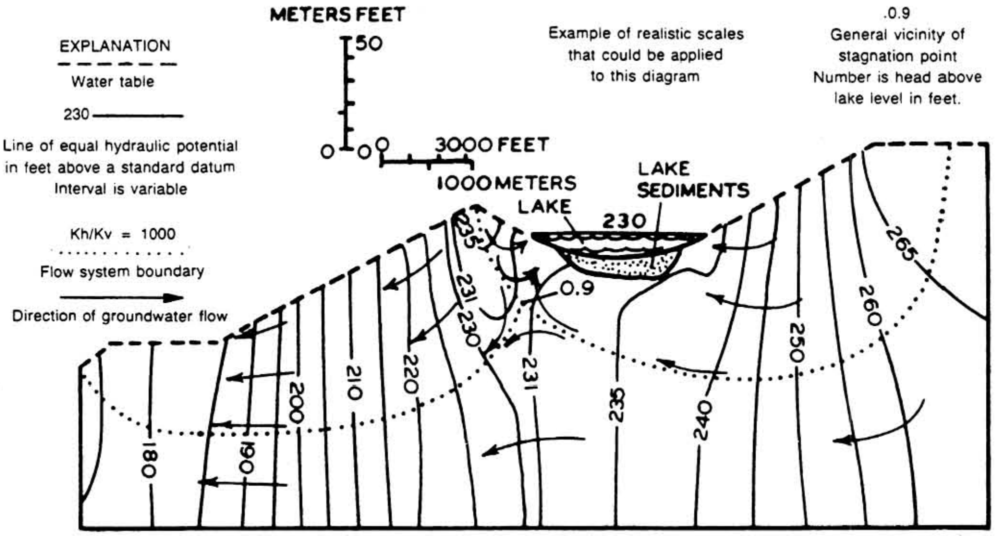
The diversity of water quality in the Sandhills lakes is well documented.[18] This observation is suggestive of locally diverse hydrologic and geologic conditions that allow for concentration of salts in the lake water. McCarraher (1978) suggests that the strongly alkaline lakes in the western closed basin have impervious seals beneath them, in their sediments, and are fed chiefly by surface runoff.[19] In the less alkaline lakes in the northern Sandhills he states that many of the lakes have flowing springs and seepages which help stabilize lake levels and provide a dilution source.

Winter conducted a theoretical study of the interaction of lakes and groundwater using a vertical two-dimensional digital model.[20] In this study it was shown that the presence or absence of a continuous local flow system boundary beneath a lake controls whether or not there is outseepage from a lake. It was noted that the continuity of this flow system boundary is controlled by the water table configuration within the lake's groundwater drainage basin and by the ratio of the horizontal hydraulic conductivity to the vertical hydraulic conductivity. Figures 28 and 29 illustrate the flow systems surrounding two lakes. In Figure 28 there is no outseepage from the lake to the regional flow system. A "stagnation point" has developed underneath the downgradient side of the lake. Figure 29 illustrates a lake which has outseepage to the regional flow system. In this configuration there is no "stagnation point."

Winter points out that knowledge about the flow system surrounding lakes can be important in understanding the water quality of lakewater and diversity of quality among waters of nearby lakes. Variations in water chemistry could be explained by the length of flow paths of water discharging into the lake and the nature of the geologic material the water flows through. Since each lake has its own unique groundwater system, the length of "residence" of water in the ground may help explain differences in the amount of dissolved chemicals being discharged into nearby lakes.

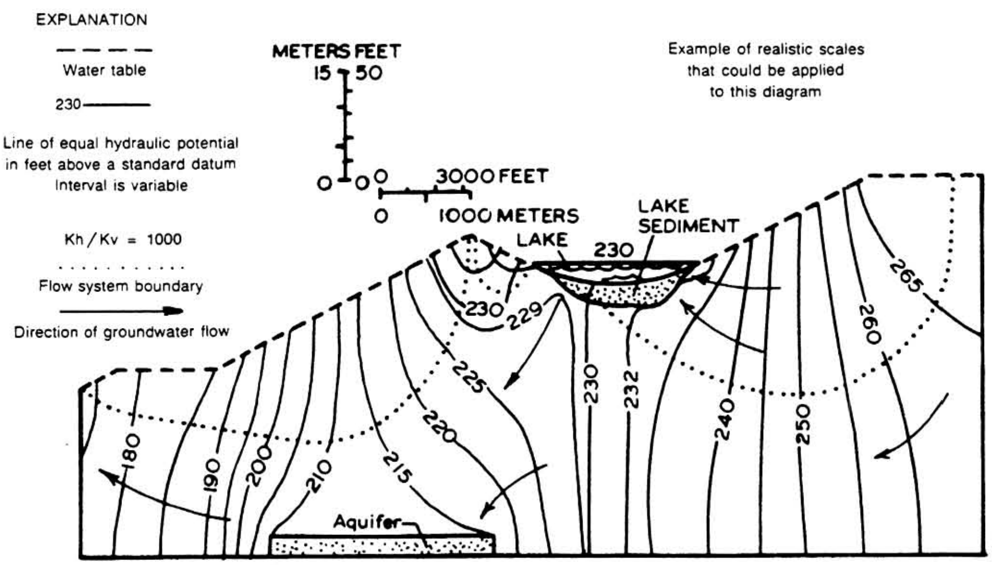
All in all, Winters' study is of interest because it provides a general concept of the flow systems surrounding lakes and points to the type of data that must be collected to understand the flow system surrounding natural lakes.

A study of lakes and wetlands in Arthur and McPherson counties is currently being made by the Conservation and Survey Division of the University of Nebraska. As part of this study nested piezometers have been installed at several locations within an area where numerous lakes occur. It is anticipated that this study will eventually yield more specific information about the flow systems surrounding the natural lakes in the Sandhills area.




## FIGURE 28

Groundwater flow system associated with a lake that has no outseepage. Kh/Kv is the ratio of hydraulic conductivity of the geologic materials in the horizontal direction to that in the vertical direction.
*Source:* Thomas C. Winter, Groundwater Component of Lake Water and Nutrient Budgets, Verh. Internat. Verein. Limnol., 1978.




## FIGURE 29

Groundwater flow systems associated with a lake that has outseepage through about one-third of its bed. Kh/Kv is the ratio of hydraulic conductivity of the geologic materials in the horizontal direction to that in the vertical direction. The aquifer is 1,000 times more permeable than the adjacent geologic material.
*Source:* Thomas C. Winter, Groundwater Component of Lake Water and Nutrient Budgets, Verh. Internat. Verein. Limnol., 1978.

## THE RELATIONSHIP OF WETLANDS AND GROUNDWATER

Wetlands receive their water from direct precipitation, surface runoff, or from groundwater seepage. The relationship of wetlands to groundwater is closely related to the relationship between natural lakes and groundwater. This is so because wetlands usually occur in close association with natural lakes. Emergent vegetation is common at the perimeter of the shallow lakes and often in areas between lakes where lakes occur in close proximity to one another. Like the natural lakes described in the previous section, wetlands can either be perched or represent water table exposures. Perched wetlands receive no inflow from groundwater seepage, they receive inflow exclusively from surface runoff and direct precipitation. However, the groundwater component of the wetland water budget is difficult to measure. In spite of accurate measurements of water table through observation wells and hydraulic potential through well spaced piezometers, the simultaneous occurence of recharge or discharge phenomena on a wetland makes it difficult to accurately quantify the wetland-aquifer relationship. Although most wetlands are considered groundwater discharge areas, recharge also occurs as infiltration from the surface through the unsaturated zone to the water table. Groundwater may move between the shallow water table and deeper, confined aquifers depending upon

the hydraulic gradient. These all depend solely on the properties of the soils in, and surrounding the wetland as well as those of underlying deposits because of the relationship between soil or aquifer characteristics and the movement of water. All wetlands are not, however, recharge areas.

In the subirrigated wet meadows of Nebraska natural subirrigation occurs where the water table is sufficiently near the surface to supply water to sustain plant life. The water table elevation required for natural subirrigation varies according to the species of plants dependent upon it. A high water table may be maintained by either seepage from losing streams or by groundwater moving toward the stream. The water table must be near the surface to supply water for wet meadows. However, because their roots can extend to a considerable depth, alfalfa and some trees may benefit from natural subirrigation in areas where many crop plants would not. Subirrigated wet meadows occupy extensive areas in Nebraska. This includes a portion of the Sandhills, the Elkhorn River, Beaver Creek, Cedar River, and the Platte River valleys. In addition, subirrigation also occurs in the islands in the Platte River.

The wetlands are areas of high evapotranspiration. Vegetation in the wetlands transpires water, while evaporation occurs from open water surfaces. Evapotranspiration from the aquifer occurs where the water table is sufficiently high that plants can extract water directly from the capillary fringe. In some cases evaporation may also occur directly from the water surface where the water table is within a few feet of the land surface. When the water table is lowered either by natural or man-induced processes, the rate of evapotranspiration from the aquifer is reduced, thereby resulting in evapotranspiration salvage. Where the vegetation is primarily grass, complete salvage may occur with groundwater level declines of even five feet or less. The actual evapotranspiration rates from subirrigated wet meadows of Nebraska are not known.

Very limited information is available on the effect of groundwater discharge on wetlands in Nebraska. A recent investigation by the USGS in connection with the Department of Interior's Upper Platte Management Study tried to determine some of the possible effects that changes in water management might have on the groundwater levels in wetland areas.[21] The study was conducted on the Morman Island Crane Meadows Wildlife Area, a subirrigated island in the Platte River 8½ miles south of Grand Island. The island is approximately 10 miles long and 1 mile wide. Groundwater levels in the alluvial aquifer beneath the subirrigated island and wetland areas adjacent to the Platte River are controlled by the presence and stage of the Platte River in its various channels, by evapotranspiration by the riparian vegetation and from areas where the water table is close to the land surface, by regional effects of pumpage and recharge, and by groundwater flow to the lower river system. In turn, the groundwater levels affect the wet meadows environment in two ways. The first is by directly controlling the depth and areal extent of standing and slow-moving water where the water table intersects the land surface and creates ponds. The second is by affecting the types and varieties of phreatophytes and their growth rate.

The data for the island show that groundwater levels in the wetland areas along the Platte River respond rapidly to changes in river stage - usually within 24 hours for distances up to 2,500 feet from the edge of the river. Thus temporary changes in river stages due to changes in surface water diversions will have an almost immediate effect on groundwater levels, and the change in groundwater level will be maintained as long as the change in river stage exists. There will be no long-term residual effect on groundwater levels and the wet meadows if the river is returned to its original stage.

Groundwater withdrawn by wells in the vicinity of wetlands is derived from change of storage within the aquifer, salvage of evapotranspiration and depletion of streamflow. Changes in groundwater withdrawals will have simultaneous effects of (1) directly changing water-table levels beneath the wet meadow areas, and (2) indirectly changing water-table levels due to changes in river stage caused by depletion of streamflow. Due to the aquifer characteristics and the distance of withdrawals from the wet meadow areas, the effects of the withdrawals will develop slowly and be long lasting, perhaps weeks or months. If most of the changes in withdrawal occur farther than 2,500 feet from the river, however, the resulting change in groundwater levels within 2,500 feet of the river will probably average less than one or two feet. Since most of the groundwater pumpage along the Platte River is at distances greater than 2,500 feet from the river, the greatest drawdowns and changes in groundwater storage due to increases in net groundwater withdrawals will occur beyond that distance from the river, and hence from the island wet meadows. Thus, groundwater levels beneath islands and areas between flowing river channels will not be affected directly, unless of course, the withdrawals are on the islands themselves. In the case of Platte River islands, any minor changes could be modified on a short term basis by controlling the river stage through controlling diversions and reservoir releases.

Apart from the above limited information on wetland-aquifer relationships of the Platte River island wet meadows, very few studies have investigated such relationships of wetlands in other areas in the state. A recent study on evaluation of the wetlands in Garfied and Wheeler counties by the Corps of Engineers identified charactersistics of three types of Sandhills wetlands, namely riverine, wet meadows, and upland or choppy wetlands.[22] The riparian wetlands associated with and located along the rivers and creeks include areas where there is obvious flowing water and areas in which there is usually standing water. The uppermost vertical and lateral/longitudinal part of this wetland type usually blends into a wet meadow zone and ends abruptly by a cultivated area. The second type is that of wet subirrigated meadow areas which are numerous on the broad river bottoms and in creek valleys in areas of choppy, upland sandhill dunes. The lowermost portions of the wet meadow areas eventually blend into the riparian wetland areas. The third type of wetland available in this part of Sandhills is that located in the lower lying areas or pockets of the choppy, upland sandhills themselves. The Sandhills areas which contain these wetlands are easily distinguished from other Sandhills areas. Generally, the lowermost of the Sandhills blend into the uppermost zone of the prairie or wet meadow area. These wetlands are typically concentric and vary in size from less than one acre to several acres. All of these vary considerably in geohydrology and ecology. The riverine wetlands have a greater variety of wetland communities because they are subject to floods, erosion, and deposition, which together produce a wide variety of geomorphic features along rivers, including oxbows, scour holes and channels, chutes, terraces and sand bars.

Most of the investigations in the Corps of Engineers study pertain to the wetlands in the drainage basins of Cedar River, Beaver Creek and Clear Creek. Many of the riverine wetlands exhibit characteristics typical of a "fen" and contain thick layers of peat overlying mineral sand and are apparently fed by an influx of groundwater. In certain cases the wetland complex in the deeper part of the channel area resembles that of a bog because the one-to-two-foot layer of soft ooze on the channel bottom is overlain by a thin vegetative-sediment layer submerged in one to two feet of water. Field evidence indicated that groundwater is a major water source. The upland sandhill wetlands studied have a large, open water zone surrounded by a shallower water zone occupied by tall emergent plants such as bulrushes, cattails, and the common reed. Some are fed by seeps and springs. However, an accumulation of peat and muck in the lower part of some of these wetlands permits a very slow release, and in some cases no release of water downward. The loss of water in these wetlands is primarily due to evapotranspiration.

## CONCLUSION

It is expected that diverse and complex flow systems exist in the vicinity of naturally occurring lakes and wetlands in Nebraska. To date the system of interaction between lakes and groundwater is poorly understood. Specific studies will probably have to be conducted in different parts of the Sandhills to determine, for example, if the type of interaction in the "closed basin" in the western part of the Sandhills is any different from the type of interaction in the other parts of the Sandhills.

Information from different kinds of studies will be of value in understanding the type of interaction between lakes, wetlands, and groundwater. The study by McCarraher on lakewater quality, Buckwalter on surface area fluctuations, and Keech and Bentall on certain hydrologic aspects are all interrelated in that they describe particular aspects of the total system surrounding the lakes. Understanding one aspect can help in understanding the others.

Finally, as more research studies yield more information, a better understanding of the interaction of lakes, wetlands, and groundwater will gradually evolve.

## II.RECHARGE IN NEBRASKA: ACTUAL AND POTENTIAL

Water in streams, lakes, or precipitation runoff can move through the unsaturated zone to the zone of saturation. This occurs naturally in most areas of Nebraska, and it can be increased by many methods. However, in some cases, care must be taken in the selection of the method and the quality of the recharge water. Areas in which the actions of man are augmenting the recharge of water are discussed in Chapter 3.

### NATURAL RECHARGE FROM PRECIPITATION

Groundwater in storage is part of a dynamic recharge/discharge system. Recharge is that water which infiltrates the soil and percolates below the root zone into an aquifer. Most recharge is provided by precipitation.

Extensive material on recharge was included in the recently completed Handbook for the Preparation of Groundwater Management Plans by the Conservation and Survey Division of UNL. That report noted a number of factors which determine the potential for natural or artificial recharge, including depth to groundwater, availability of water for recharge, land slope, soil types and characteristics, vertical permeability of the subsoil, storage potential, and characteristics of precipitation events. Vegetation is an additional factor which may influence recharge. While explaining that quantification of the amount of natural recharge is difficult for even small geographic areas the report also noted that recharge can be estimated by assuming that on the average a certain percentage of annual precipitation becomes groundwater recharge. The soils and topography were identified as two factors which have considerable control over potential for recharge. The report also included a table which presented the estimated percentage of average annual groundwater recharge from precipitation within topographic regions and a map presenting topographic regions (see Table 3 and Figure 30). In combination with the precipitation map which is included as Figure 31 these can be used to estimate general recharge rates throughout the state.

**TABLE 3**

**ESTIMATED PERCENTAGE OF AVERAGE ANNUAL PRECIPITATION WHICH BECOMES RECHARGE WITHIN TOPOGRAPHIC REGIONS**

| TOPOGRAPHIC REGION | NATURAL RECHARGE AS PERCENT OF AVERAGE ANNUAL PRECIPITATION |
|---|---|
| Valleys | 20-30 |
| Plains | 3-5 |
| Dissected Plains | 10-15 |
| Sandhills | 25-30 |
| Rolling Hills | 1-5* |
| Bluffs and Escarpments | 1-2 |

*Recharge is usually to perched aquifers

*Source:* Handbook for Preparation of Groundwater Management Plans, Conservation and Survey Division, University of Nebraska

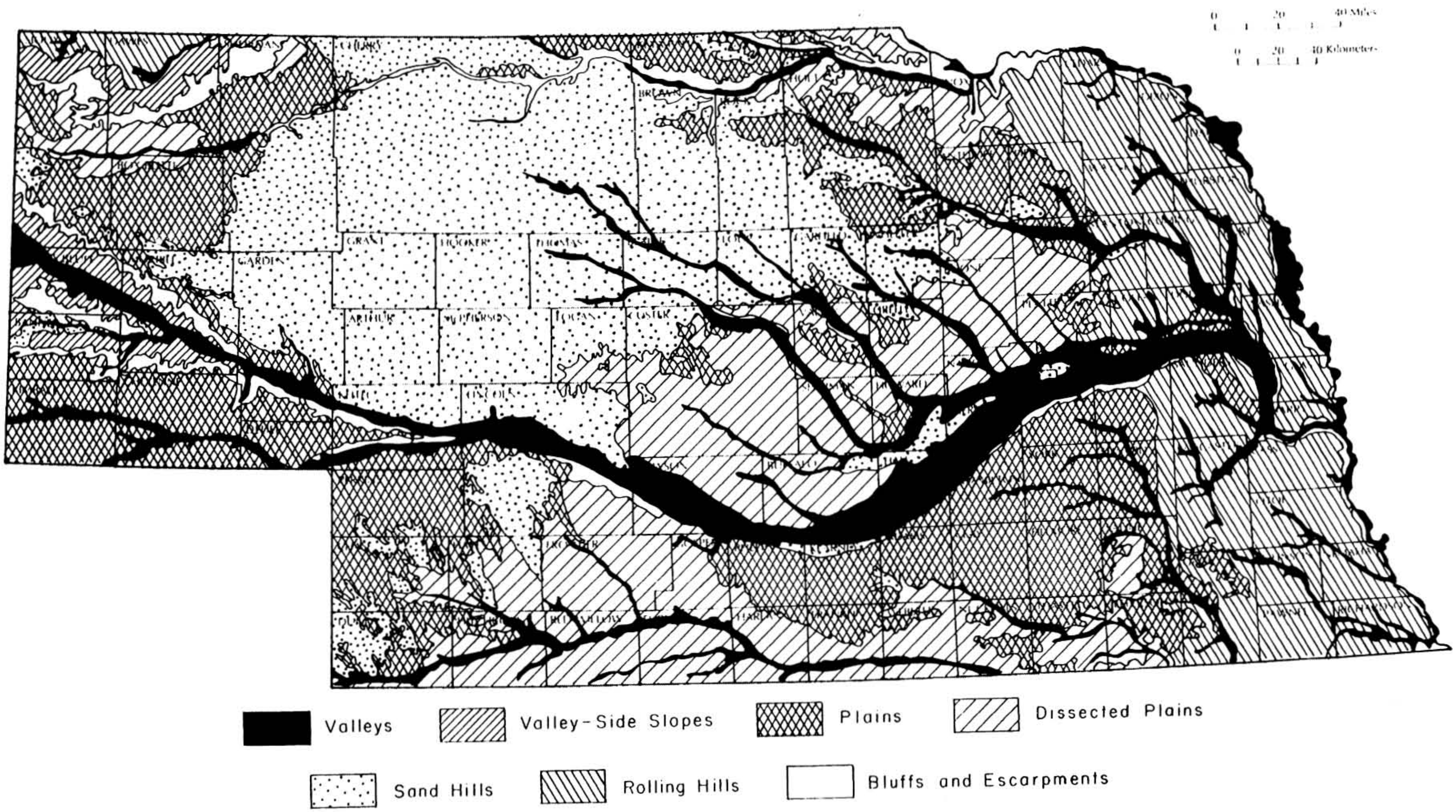



**FIGURE 30**

**TOPOGRAPHIC REGIONS MAP - Physical features at the land surface which are the result of geologic processes. These land features are a major influence on soil type, land capability, and utilization of groundwater.**

*Source:* Handbook for Preparation of Groundwater Management Plans, Conservation and Survey Division, University of Nebraska.

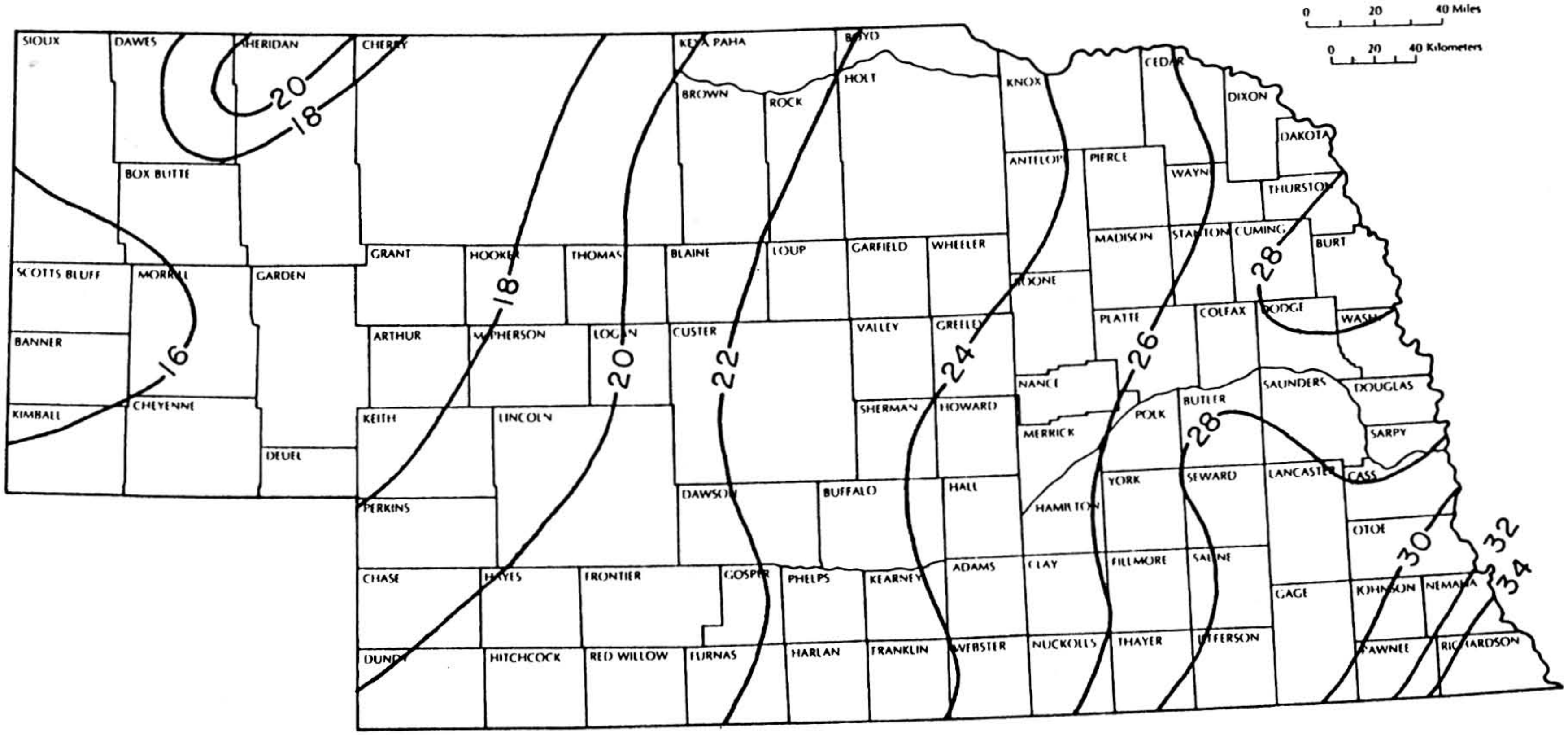



**FIGURE 31**

**MEAN ANNUAL PRECIPITATION (IN INCHES) FROM 1900 to 1979**

*Source:* This map is reproduced from "An Analysis of Nebraska's Precipitation Climatology with Emphasis on Occurrence of Dry Conditions," Agricultural Experiment Station, UN-L, Wilhite, D., 1981.

## POTENTIAL FOR SUBSURFACE STORAGE

In areas where groundwater is a component of streamflow a man-induced drawdown of the water-table may reduce baseflow and thus sometimes reduce water flowing out of an area. Simultaneously this can provide some storage space in the aquifer for natural recharge of water via precipitation percolating through permeable soils or recharge from natural or man-induced surface water sources. The degree to which such recharge may occur can vary greatly with soils, aquifer characteristics, topography, and climatic conditions. Lowering the water-table by pumping has a definite potential for reducing outflows and providing storage space for additional recharge.

In the past, unintentional subsurface storage has occurred in Nebraska. Figure 32 shows areas of significant rises or declines in groundwater levels from predevelopment conditions to the fall of 1984. On this figure red represents areas of significant declines while blue represents areas of significant rises. The largest area of rise is located along the area just south of the South Platte and Platte Rivers in western and central Nebraska. This area coincides with the area where the supply canal and distribution canals for Central Nebraska Public Power and Irrigation District were constructed in the early 1940's. Rises of up to 90 feet have been recorded in some places. This is an example of unintentional subsurface storage being realized from the seepage losses of a surface water project.

Intentional subsurface storage has also been tried in Nebraska. A report by the U.S. Geological Survey[23] documents experiments conducted at three sites within the state to determine the technical feasibility of several methods of artificial groundwater recharge.

Figure 33 shows the thickness of unsaturated coarse-textured material that existed in Nebraska prior to any water level declines resulting from pumping for irrigation. The thickest sequence of these materials occur in Nebraska's panhandle area, and ranges in thickness from 50 feet to more than 250 feet in parts of Sioux, Banner, Kimball, Cheyenne, and Morrill counties. Other areas having significant thicknesses (from 50 to 150 feet) include some large irregularly shaped areas in Hooker, Thomas, McPherson, Logan, Lincoln, and Custer counties, in Cherry County along the flanks of the Niobrara River, in Red Willow and Furnas counties south of the Republican River, and in Phelps, Kearney, Harlan, Franklin, and Webster counties north of the Republican River. Small areas having thicknesses of 50 to 150 feet occur in many other places scattered throughout the state.

These areas of unsaturated sediments were determined by the Conservation and Survey Division staff. The description log of every test hole within the state was examined to see if unsaturated sands or gravels existed above predevelopment water levels as estimated from past water-level records. The thicknesses of this material were then plotted onto a map and separated into the four catagories; ◄50 feet, 50-150 feet, 150-250 feet, and ►250 feet.

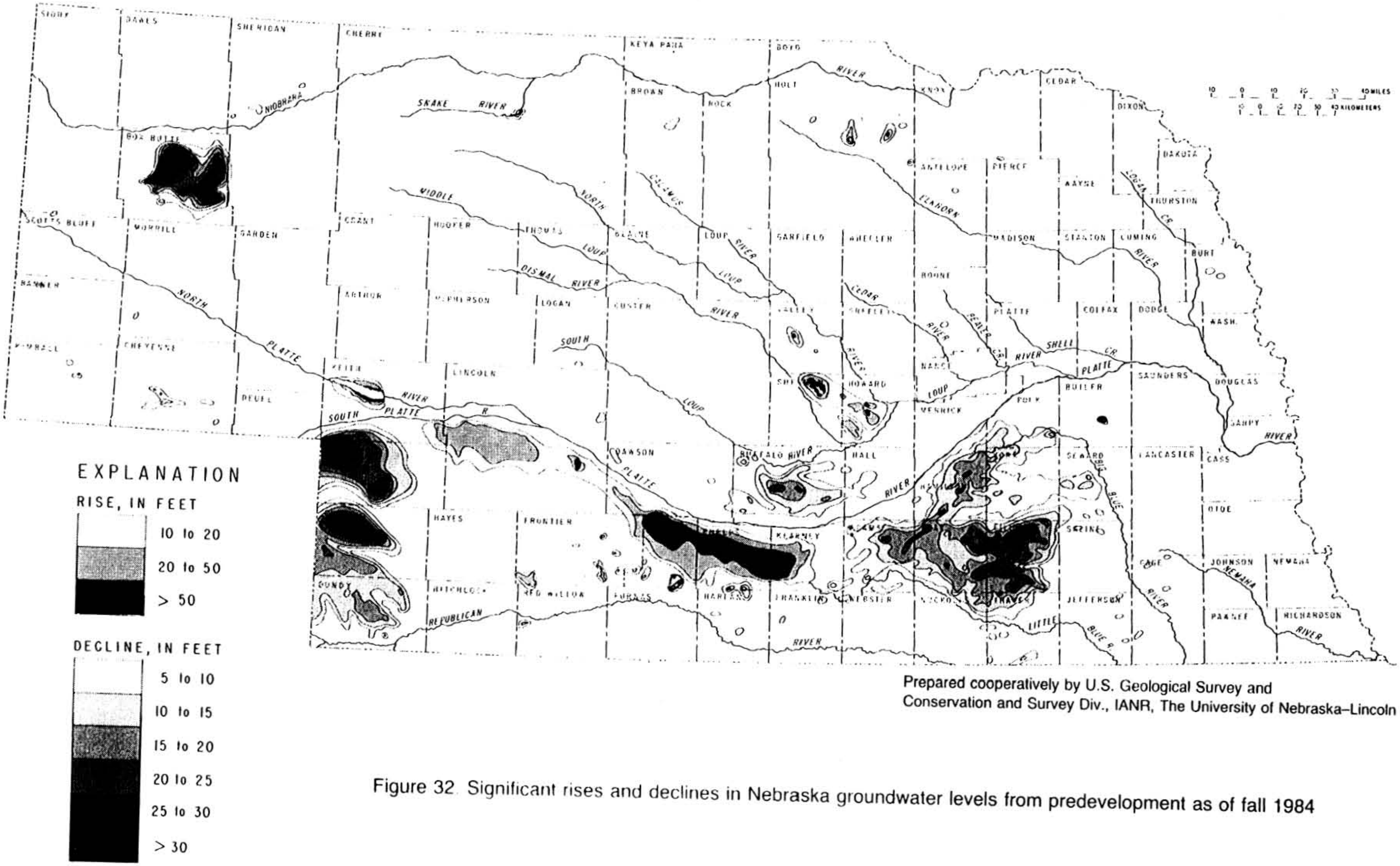
It should be noted that use of this material for supplemental groundwater storage might not be feasible because deeply incised drainages, as shown in Figure 34, prevent water levels from rising closer to the surface in the divide areas. If water were to be stored in this material it would drain to the incised canyons and become baseflow in the streams. This type of effect is noted in areas along the flanks of the Republican and Niobrara Rivers, and possibly in other areas as well. There may nevertheless be benefits to recharge in such areas if the water is pumped on a seasonal basis and there is sufficient time before the water would discharge to a stream. For instance, in the O'Neill area recharge water would be pumped out before it reached the stream.

In addition to those unsaturated coarse materials above the predevelopment water levels there are a number of places where such materials have been dewatered by irrigation pumpage. These unsaturated materials are also potential sites for supplemental groundwater storage. The areas shaded in by various intensities of red on Figure 32 represent these dewatered thicknesses. The largest areas of decline occur in Perkins, Chase, and Dundy counties in southwestern Nebraska, in the Big and Little Blue River basins (including parts of Adams, Hamilton, York, Clay, and Fillmore counties), in Buffalo County, and in Box Butte County. Small, isolated areas of water level declines have also been recorded in a number of other locations around the state.

The potential for the use of unsaturated coarse-textured materials for underground storage exists in Nebraska. However, care must be taken in evaluating this potential for any given site. In any sort of examination of these potentials, detailed physical data gathering studies would undoubtedly be required. Economic factors likewise must be considered and must be shown to be favorable for any such project to become reality.

## III. WATER QUALITY IN RELATION TO INTERACTION OF SURFACE WATER AND GROUNDWATER IN NEBRASKA

Water quality interaction of surface water and groundwater can occur in a number of cases. This section examines the following situations in Nebraska: 1) surface water flow being used to recharge groundwater for municipal use, 2) surface water flow recharging a municipal groundwater source in order to stop an influx of poor quality groundwater, 3) recharge from canal flow replacing previous groundwater of a slightly different quality, 4) high total dissolved solids in sur-




Prepared cooperatively by U.S. Geological Survey and Conservation and Survey Div., IANR, The University of Nebraska–Lincoln

Figure 32. Significant rises and declines in Nebraska groundwater levels from predevelopment as of fall 1984

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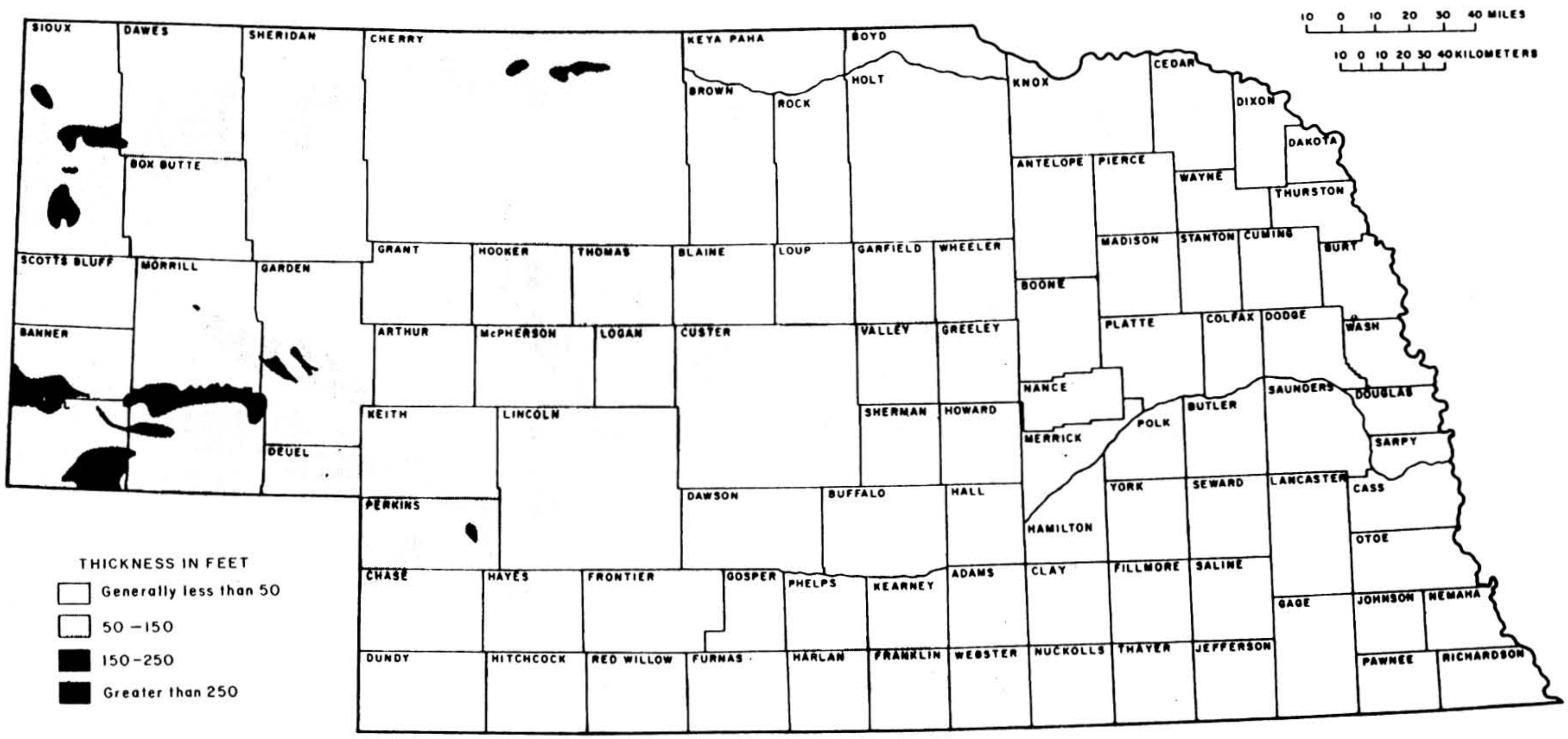
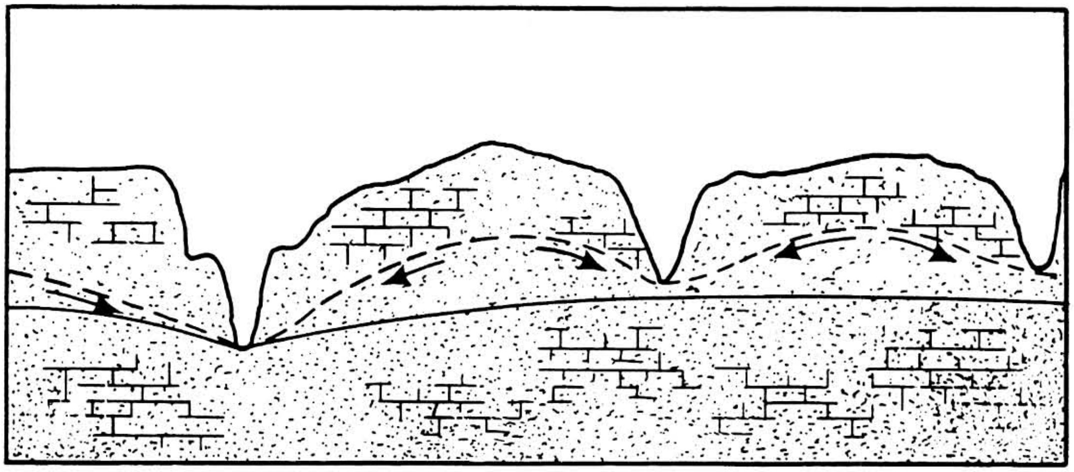



## FIGURE 33

## THICKNESS OF UNSATURATED COARSE MATERIALS, PREDEVELOPMENT CONDITIONS

*Source: Policy Issue Study on Supplemental Water Supplies,* Nebraska Natural Resources Commission, 1984, compiled by the Conservation and Survey Division, University of Nebraska.



——— EXISTING WATER TABLE
– – – – NEW WATER TABLE UNDER A RECHARGE PLAN
→ DIRECTION OF GROUNDWATER FLOW

**FIGURE 34**

**EFFECT OF INCISED DRAINAGEWAYS ON WATER LEVELS**

face flow affecting quality in the alluvial aquifer, 5) improperly constructed wells providing a means for infiltration of chemicals or contaminated surface water, and 6) surface water contamination by groundwater discharge. Case 6 includes the following situations: (a) natural discharge of naturally occurring poor quality groundwater to streams; (b) natural discharge of groundwater contaminated by man's activity; (c) surface discharge of groundwater that has been contaminated by man's activity and is later pumped to the surface; (d) surface discharge of groundwater that has been pumped and is of naturally poor quality.

## SURFACE WATER RECHARGING GROUNDWATER FOR MUNICIPAL USE

The water quality impact of surface flow recharging groundwater has significant effects on Nebraska water use. The primary instance in which this is important is in municipal and other wellfields adjacent to the Platte River. The groundwater recharge that comes from surface flows of the Platte is used as municipal supply in a number of major cities including Lincoln, Omaha, Fremont, Grand Island, and Kearney. The recharged groundwater has microorganisms and sediment filtered out as it infiltrates. The city may have directly designed its system for being recharged, such as the Lincoln or Kearney systems. However the system may have been built and later found to receive recharge incidentally such as Sidney's municipal system.

## SURFACE-WATER FLOW BEING USED TO RECHARGE MUNICIPAL GROUNDWATER SOURCE IN ORDER TO STOP AN INFLUX OF POOR QUALITY GROUNDWATER

The surface recharge may or may not be of better quality than groundwater in surrounding aquifers. In the Grand Island area there is concern that flows be maintained in the river to continue a certain level of recharge. This concern arises not so much for maintaining sufficient overall water quantity as for maintaining equilibrium with nearby lower quality groundwater. If the hydraulic gradient changes, lower quality - high nitrate water from the surrounding aquifer may begin to flow to the Grand Island wellfields along the river. The water quality and economic impacts of relocating the wellfield could be significant.

A procedure similar to Grand Island's is being used in Hardy, Nebraska. In that town, city wells in the center of town became polluted and the town began to look for new well sites. The test holes drilled revealed high nitrate at nearby sites. Therefore the city drilled a well a few feet from an existing irrigation canal (with permission). The dilution from the recharge water resulted in a significant improvement in quality versus other sites.

## RECHARGE ADDED TO GROUNDWATER OF DIFFERENT QUALITY

Surface recharge has also been important in the Tri-County irrigation area along the Central Platte where groundwater rises of up to 90 feet have been reported. The water diverted from the Platte River for irrigation in the Tri-County irrigation area has been added to the native groundwater in the irrigation area. Groundwater quality there is now about the same as the Platte River water quality. There has been some degradation of groundwater quality in the irrigation area with an increase in chloride, sulfate, and sodium. However, this degradation has not been very serious. The TDS, boron, nitrate and the sodium adsorption ratio (SAR) do not pose any problem in the "new" groundwater of the irrigation area. The TDS of the new groundwater is roughly 50 percent higher than the native water, but still not seriously high. Although boron normally increases if TDS in water increases, the boron concentration increase for the change from native to new groundwater in the irrigation area can be tolerated by the crops grown in the irrigation area. Since there are negligible clays in the irrigation area, any increase in SAR would not impact soil permeability in the irrigation area. Forty wells were sampled in the irrigation area in 1981 and the samples taken were analyzed for several constituents including nitrate. None of the 40 wells were found to have a nitrate concentration greater than the U.S. Environmental Protection Agency nitrate limit of 10 mg/l $NO_3$-N. In a separate area, there is some evidence that infiltration of surface water in Sherman and Howard counties has improved the groundwater quality in those areas.[24]

Studies to determine how pesticides will concentrate in the basin of a recharge structure are currently being conducted by the Little Blue Natural Resources District. The studies at the Bruning and MARC Dam sites may help determine what potential, if any, the recharge structures have for groundwater contamination.

## HIGH DISSOLVED SOLIDS IN SURFACE FLOW AFFECTING QUALITY IN THE ALLUVIAL AQUIFER

The South Platte River streamflow, consisting in Nebraska of mostly irrigation return flows from Colorado has an impact on groundwater in the alluvial aquifers next to the river. The TDS level of the river is relatively high (greater than 1,100 mg/l where the river enters Nebraska. This high TDS water can be found in the alluvial aquifers next to the river and can adversely impact crops with a low salt tolerance when used as irrigation water. A review of the SAR, nitrate, and boron levels indicates they were not high enough to cause any adverse impacts.

## IMPROPERLY CONSTRUCTED WELLS PROVIDING A MEANS FOR INFILTRATION OF CHEMICALS OR CONTAMINATED SURFACE WATER

The direct contamination of groundwater from the surface due to improper well construction is an additional source of water quality interaction between surface water and groundwater. Such wells can provide a direct means for chemicals to enter the groundwater. This is usually through improper chemigation practices. However, contaminated surface water also has the potential to enter improperly constructed or capped wells and infiltrate quickly to the groundwater. Little research has been completed on this topic.

## SURFACE WATER CONTAMINATION BY GROUNDWATER DISCHARGE

Direct groundwater impacts on surface water are difficult to identify on a specific basis. Indirect impacts are more common. For instance, municipalities utilize groundwater and then may create surface water pollution problems with sewage effluent. However, in that case the problem usually originates with the use of the groundwater and not its original quality.

In some situations contamination or original poor quality of a groundwater source can result in a degradation of surface flows either through human use and discharge of the groundwater or movement of the groundwater until it intersects with a stream. Four of those situations follow.

The first of four situations in which surface water can be contaminated by groundwater discharge is natural discharge of naturally occurring poor quality groundwater. Salt Creek in the Lower Platte Basin is a prime example of this. In times of low flow the river becomes appreciably saltier as the base flow becomes a larger portion of total flow. The problem is due to the qualities of the geologic formation which discharges the groundwater, rather than the activities of man.

A second situation in which surface water can be contaminated by groundwater discharge is natural discharge of groundwater contaminated by man's activity. An example of this would be gasoline from leaky storage facilites infiltrating and moving until it discharges to a surface stream. This has occurred on Antelope Creek in Lincoln.

A third situation is that of surface water discharge of groundwater that has been contaminated by man's activity and is later pumped to the surface. Instances of contaminated water being discharged on the surface have occurred with a gasoline spill near Grand Island, gasoline spilled near Antelope Creek in Lincoln, and a nitrogen fertilizer spill in Plymouth. In each of these cases there was some discharge to the surface during pumping and cleanup of the groundwater contamination. However, although some monitoring was done no surface water pollution above allowable levels was observed downstream in the Plymouth or Grand Island cases. It also seems likely that some of the high nitrate water in Merrick County and other areas may be utilized and occasional runoff from that use may become a part of surface flow.

The final situation in which groundwater discharge may contaminate surface water is via discharge of groundwater that has been pumped and is of low natural quality. There are some deep industrial wells in the Omaha area that pump low quality groundwater and then discharge it to surface water. It also seems likely that there would be a few irrigation wells which utilize lower quality groundwater from the Dakota aquifer and have some runoff. However, this has not been documented.

## PARAMETERS OF IMPORTANCE

A number of water quality parameters are important when considering interaction between surface water and groundwater. A few of the more important are discussed below.

**Total Dissolved Solids.** An increase in the TDS concentration of a stream due to a stream receiving a groundwater discharge having high TDS, could impact future use of the stream, particularly if the stream was used for irrigation water downstream. An increase in the salinity of the stream could cause some yield reduction problems in plants that are irrigated with the high salinity water. High total dissolved solids can restrict municipal and industrial use as well.

**Sodium.** An increase in the sodium concentration of a stream due to a stream receiving a groundwater discharge having high sodium could impact future use of the stream particularly if the stream was used for irrigation water downstream. An increase in the sodium adsorption ratio in irrigation water with a high sodium concentration could cause problems by changing the soil permeability. Sodium in drinking water can also lead to public health problems.

**Nitrate.** An increase in the nitrate concentration of a stream due to a stream receiving a groundwater discharge having a high nitrate concentration could impact the future use of the water if the stream should reach a surface water impoundment. Since no references could be found to support this statement, it should be accepted with some caution. Research has been done on nitrate in groundwater and surface water, but no research could be found that focused on the impact of nitrate on impoundments when the nitrate reached the impoundment as a result of groundwater discharge to streams. If enough phosphorus is also present in the impoundment, stream enrichment with nitrate from groundwater could cause the surface water impoundment to be eutrophic. This results in algal blooms causing the impoundment to (1) become unsuitable for swimming, and (2) to lack oxygen in the lower depths necessary for fish propagation. High nitrate concentrations in drinking water can lead to public health problems.

**Trace Elements.** An increase in the trace element concentration of a stream receiving a groundwater discharge having a high trace element concentration could impact the future use of the stream, particularly if the stream was used for irrigation downstream and the trace element of concern is boron. An increase in the boron concentration in irrigation water could cause some plant toxicity problems for certain crops that are not tolerant to boron.

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Chapter 3

# Technologies Applicable to Integrated Management of Surface Water and Groundwater

## ARTIFICIAL RECHARGE

Artificial recharge of groundwater resources is a means of supplementing natural recharge from precipitation. Artificial recharge techniques have been in use for more than 200 years and for a variety of purposes.[1] These include:

(1) Maintain or augment natural groundwater as an economic resource.
(2) Coordinate operation of surface and groundwater reservoirs.
(3) Combat progressive lowering of groundwater levels and salt-water intrusion.
(4) Provide subsurface storage for imported surface water.
(5) Reduce land subsidence.
(6) Reclaim wastewater.[2]
(7) Increase oil recovery by injecting water into the oil producing zone.

In addition, significant quantities of water have been artificially recharged from water-use projects designed for other purposes. Such recharge is mostly beneficial but becomes detrimental if the storage potential for recharge is exceeded.

### TECHNIQUES

Many techniques utilized to recharge groundwater are well-documented and many of the pitfalls in these operations are identifiable and in some cases avoidable if forethought and planning are exercised. Techniques used most often to augment natural recharge are discussed individually in the following sections.

**INDUCED INFILTRATION:** To induce recharge from a stream or lake into a hydraulically continuous aquifer, the saturated surface in the aquifer must be lowered artificially to a level lower than that of the stream or lake. The difference in head thus created causes percolation of water from the surface source into the adjacent aquifer. The process can be impeded by deposition of silt on the floor of the stream or lake. Conversely, it can be enhanced by periodic removal of the silt layer.

Induced infiltration occurs at several locations along the Platte River. In Merrick County, for example, the groundwater supply for irrigation has been maintained by seepage from the Platte. Also, the well fields for several municipalities and for at least one large industrial plant have been designed to take advantage of the Platte as a source of recharge. Even where an aquifer is thin but is associated with a perennial stream, large water supplies can be obtained by constructing galleries of collectors that extend horizontally beneath the streambed or parellel to the streambed.

**WATER SPREADING:** Water spreading is simply a method to increase infiltration of water. Water is released over the ground surface in order to increase the amount of water available to percolate to a groundwater system. The efficiency of this method is measured in terms of its recharge rate and is dependent upon several physical factors. Spreading methods include:

**Flooding** - Nearly level or gently sloping land is required for the flooding method of artificial recharge. On the land surface a thin sheet of water is applied, which should move as slowly as possible to avoid disturbing the soil. Excess runoff is collected at the downslope end of the site and then reused. This method is usually inexpensive because minimal land preparation is required.

**Basins** - The basin method utilizes an impoundment structure or structures to hold diverted surface water which then percolated to the groundwater system. Most basins require periodic maintenance due to silt accumulation at the bottom. It is advantageous to have a series of basins rather than a single basin. Multiple basins provide for continuity of operation during rehabilitation procedures and higher lying basins in a series of basins in the same drainageway can be reserved for the settling of silt.[3]

**Ditches** - Spreading ditches obtain water from a main canal and distribute it through a series of shallow, flat bottomed, and closely spaced ditches or furrows. This method can be used in areas with steep slopes, however, wire-bound check dams should be installed to minimize erosion. The gradient of the main feeder canal should be sufficient enough to carry suspended material through the system although some silting should be expected.

**Natural Channel Modification** - The objective in the stream-channel method is to increase the time and area over which water is recharged from a naturally losing portion of a channel. Many streams in Nebraska have reaches that will lose surface water to the groundwater system and vice versa. To increase the amount of infiltration, check-dams and dikes are constructed within the natural stream channel. The impounded water can then be distributed to small ponds for infiltration. These structures, usually consisting of stream-bottom material, are temporary and removed in periods of high flow.

**Irrigation** - Flood irrigation will recharge a groundwater system during normal operations. To increase the amount of water available for recharge, irrigators could allow ditches and furrows to fill during dormant or non-irrigating seasons. The advantage of this method is that it utilizes existing structures so no additional land preparation is needed. Among the disadvantages - a possibility of pollution of groundwaters and a loss of soil nutrients for the crop.

**RECHARGE PITS AND SHAFTS:** Surface spreading methods are least efficient where a nearly impermeable layer is present at a shallow depth below the land surface. To circumvent this obstacle the excavation of a pit or shaft may create a better hydraulic connection between the surface and the groundwater reservoir. Where an excavation has already occurred for another reason - such as, sand and gravel mining (borrow pits) - artificial recharge may occur if the excavation does not extend to the aquifer. However, borrow pits in areas of shallow water levels commonly extend into an aquifer and may result in a loss of groundwater through evaporation. Recharge shafts are generally deeper and of smaller diameter than pits and are filled in with sand and/or gravel.[4] It is common for shafts to be used in conjunction with pits.

**RECHARGE WELLS:** A recharge well is designed to inject water into an aquifer for the purpose of storage and subsequent reuse. Injection wells used for disposing of brine or industrial waste are not considered to be recharge wells. Generally, a recharge well is drilled into an aquifer and the well screen is installed in the saturated zone. However, research at the state-led O'Neill Unit Alternatives Study indicates that installing the well screen above the saturated zone may be feasible in some recharge wells.[5]

Recharge wells may appear to be simply the opposite of supply wells, but field testing shows that several factors can combine to impede well recharge projects in some cases. Silt carried into a well may become lodged in the openings of the well screen, gravel pack, and the aquifer itself. Moreover, recharge water may carry large amounts of dissolved air that may reduce permeability by air binding of those openings.[6] Bacteria introduced into a well when it is drilled or later by recharge water can form growths on the screen and in the aquifer. Another consideration is that mixing of waters of different chemical composition may cause reactions that are detrimental to water movement.

However, the above difficulties are sometimes overemphasized. Some studies suggest dissolved air may not be a problem. Clogging by silt can be minimized by proper design and maintenance. Remedies do exist to the clogging problem. It should also be considered that maintenance is a factor in any type of water project, not just recharge projects.

## POTENTIAL TECHNICAL PROBLEMS WITH ARTIFICIAL RECHARGE

Groundwater moves through interstices (small narrow spaces) in subsurface geologic materials. The rate at which groundwater moves is dependent upon the size and interconnection of these interstices and the existing hydraulic gradient. Permeability quantifies the size and interconnection of interstices of geologic materials. When permeability is reduced, the rate of water movement will likewise be reduced - therefore, in artificial recharge, permeability of the transmitting medium is most important. The rate at which water moves through the transmitting medium can be quantified by the term transmissivity. Permeability, hence transmissivity, can be reduced by physical, biological, and chemical processes. It should again be emphasized that technical problems exist with all water projects, not just recharge projects. Therefore, the following factors should be considered with the realization that for many projects they can be overcome.

**PHYSICAL CONSIDERATIONS:** The primary requirement for an artificial recharge project is an available source of water supply. An obvious source water for groundwater recharge is surface water, generally a stream. Streams carry in them a suspended load of silt and clay-sized particles. The load capacity of a stream is dependent in part upon the velocity of the stream. When velocity decreases, the suspended particles begin to settle out. In the surface spreading and recharge pit techniques mentioned previously, this settling out process becomes a major problem. Several studies have shown that these suspended sediments will settle out and seal the surface/ground interface.[7] & [8] When the seal is in place, recharge is slowed significantly. The seal can be removed periodically by scraping of the material to allow recharge to continue.

Air bubbles in source water may plug a recharge well or slow the percolation rate of a recharge basin. However, the exact manner in which the bubbles become lodged in the interstices of the aquifer during artificial recharge is not known.

In the O'Neill Unit Alternatives Study, plugging by air bubbles was avoided by (a) discharging the recharge water at the bottom of the well in a section of blank casing, and (b) by screening the well in the unsaturated zone where air was already in the interstices thus avoiding buoyancy problems.[9]

**BIOLOGICAL CONSIDERATIONS:** If water is artificially recharged into an aquifer without regard for certain micro-organisms in the recharge water, the aquifer could be destroyed as a source for domestic water. An artificial recharge project operating over a long period of time may eventually cause the water in the aquifer to become unpalatable, assuming that recharge water with a high micro-organism count could be introduced without clogging the screen openings or the surface water/ground interface.[10]

Microbial growth in a recharge well produces slime and other products which may clog the well screen and adjacent aquifer material. Normally, groundwater is free of or has only a minute number of microbes. Where groundwater contains abundant microbes, their presence is due to their introduction during drilling of wells or by importation of inhabited recharge water.[11]

The above problems may be controlled to varying degrees by use of chlorine in the water or by periodically discontinuing recharge, thereby killing the organisms dependent on the water.

**CHEMICAL CONSIDERATIONS:** When mixing waters of different chemical composition, as may occur in artificial recharge, reactions can occur that are detrimental to recharge operations. For instance, suspension of calcium carbonate ($CaCO_3$) in water depends on the temperature, pressure, and the amount of $CO_2$ in the water. When warmer water, saturated with $CaCO_3$, mixes with cooler water the $CaCO_3$ will precipitate and block interstices in the aquifer.

Geochemistry is a very complicated and diverse field of study. Its relation to artificial recharge is difficult to understand. However, the following examples of common geochemical concerns exemplify the significance of this field and its relation to artificial recharge.

Hardness in water results from precipitation of $CaCO_3$, as discussed previously. It shows up as lime deposits on pipes, pots and pans, etc.

Another element commonly present in groundwater is iron. Iron in the ferrous state is unstable in the presence of air and will change to the ferric state when exposed to oxygen. When this change occurs, iron precipitates out. Ferric iron in water is evident by brown stains in sinks and on handpumps or anywhere that iron-rock well water first comes in contact with air. Thus, when recharge water having high dissolved oxygen comes in contact with groundwater having ferrous iron in solution the iron may precipitate and block the interstices of the aquifer. Iron bearing water also fosters the growth of iron bacteria, such as Crenothrix. These organisms can change ferrous iron to the ferric state.[12]

Manganese in water resembles iron in its chemical behavior and occurrence. However, it is less abundant than iron. Manganese bicarbonate changes to manganese hydroxide when it comes in contact with oxygen. Slime-forming bacteria also may oxidize manganese to an insoluble form. Manganese hydroxide shows up as a black, sooty deposit and is harder to remove from surfaces than is iron.[13]

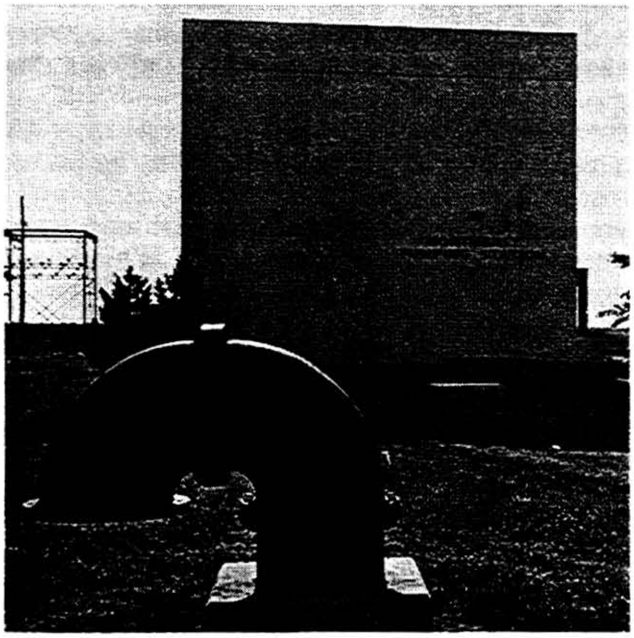
Dispersion and swelling of clay particles in sand and gravel aquifers can occur when recharge water is of a different chemical composition than the groundwater. This is a common problem in the secondary recovery of oil, where water is injected to force oil to move towards a recovery well. The electrostatic attraction between clay particles is reduced when the ionic concentration is reduced. This permits the clay particles to disperse and form a barrier to water movement.[14] To compensate for this problem in oil field operations, water having approximately the same ionic concentration as the native water is injected. In artificial recharge projects where fresh water is injected into materials saturated with saline water, clay swelling may be a problem. The oil field solution would not solve the problem in that case, because the water would not be of a usable quality.

## ARTIFICIAL RECHARGE PROJECTS IN NEBRASKA

### WELL RECHARGE SYSTEMS IN NEBRASKA

**Lincoln Well Field (1966)** - As part of a Masters of Science thesis at the University of Nebraska, R.A. Singleton, under the supervision of Professor R.R. Marlette, conducted an artificial recharge experiment to determine the feasibility of injecting water into the Dakota Sandstone which underlies Lincoln, Nebraska.

The purpose of the project was to reclaim part of the aquifer that had been degraded by salt-water intrusion. Formerly the aquifer served as the source of Lincoln's water supply, but now it is used primarily for peaking purposes.[15] Improvement of the quality of water in the Dakota Sandstone would make more suitable water locally available when the demand for water exceeds the capacity of the city's water supply system.



A total of 22 million gallons (67.5 acre-ft) of water was recharged during this project at a rate of about 420 gallons per minute. The project was successful because: (1) it was a closed system allowing no exposure of the water to air or other contamination; (2) the recharge wells had screen openings that matched the grain size of the aquifer; (3) the recharge water was of the same chemical composition as the native water and no significant chemical reactions occurred.[16]

**Big Blue River Basins (1977)** - Lichtler et al. conducted two recharge projects in Hamilton County. One, the Aurora project, involved surface spreading of water and is described later. The other involved injecting over 1 million gallons of water through a recharge well in a test that lasted 48 hours. No significant clogging of the well or aquifer was apparent. After this initial success, a permanent system was installed. The withdrawal well was about ½ mile from the Platte River and about 3 miles from the recharge well. During two long-term tests - the first for about 5 months and the second for about 7 months - 207 and 247 million gallons, respectively were injected. Some clogging occurred in both tests, most probably from sediment buildup in the recharge well. Results of the study indicate that any long-term artificial recharge through wells will require periodic redevelopment of recharge wells.[17]

O'Neill Unit Alternatives Study (1985) - As part of a state-led study into alternatives to the proposed dam at the O'Neill Unit, authorized by the U.S. Congress in 1972, a well was constructed on a farm north of Atkinson, Nebraska. The well was designed to inject water into an unsaturated sand and gravel layer, drainage from which then would directly recharge the underlying aquifer. From November 7, 1984 to January 30, 1985 approximately 35 acre-feet (11,050,960 gallons) had been injected.[18]

## SURFACE SPREADING SYSTEMS IN NEBRASKA

**Aurora (1977)** - Lichtler et al. conducted a surface spreading test project in Hamilton County by using a ring infiltrometer. Difficulties with algae buildup and less permeable layers at depth were encountered. Because of these problems and the low permeability of the surface water/ground interface, the infiltration rate was less than ½ foot/day. As a result of this test, artificial recharge by surface spreading at the study site was concluded to be not technically feasible.[19]

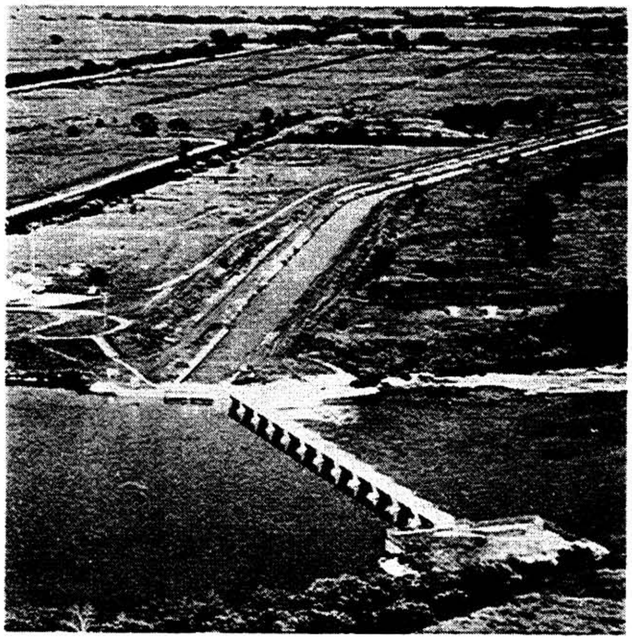
**Tryon (1979)** - Similar to the Aurora project, the Tryon project in McPherson County used a ring infiltrometer to recharge the groundwater. Although the subsurface conditions allowed a higher infiltration rate (as much as 10 feet/day) that the Aurora site, the recharge water become perched on a lower permeability layer above the water table at this site as well. Although water was able to infiltrate this zone, the layer did slow the rate of recharge. Research also showed that antecedent moisture conditions affected the infiltration rate.[20]

**Big Sandy Creek (1982)** - This project consists of a reservoir, located on Big Sandy Creek at the U.S. Meat Animal Research Center (MARC), and several monitoring devices. Artificial recharge, flood control, and wildlife habitat are planned benefits of the project. Water levels in observation wells that are in and adjacent to the reservoir have shown significant rise and there is no indication of water becoming perched. Further research is being conducted at the site to evaluate potential design and management practices for optimizing the recharge benefits of multi-purpose surface reservoirs.[21]

## INCIDENTAL RECHARGE IN NEBRASKA

**NPPD-CNPPD** - An unintentional by-product of storage and use of Platte River water for power generation and irrigation use in Nebraska by the Platte Valley Public Power and Irrigation District (later, the Nebraska Public Power District) and the Central Nebraska Public

Power and Irrigation District (Tri-County) has been groundwater recharge. Water levels have risen since 1935, when diversion by canals to storage in Sutherland Reservoir and Lake Maloney began and since 1941 when releases from Lake McConaughey were made to the Tri-County system of downstream canals, reservoirs, and irrigated lands. Water levels have risen more than 10 feet over a large area in Lincoln, Dawson, Gosper, Phelps, and Kearney counties and have risen 20 to more than 50 feet in large parts of that area. With approximately 600 miles of canals and laterals in the Tri-County system along, more than 97 percent of which are unlined, this project represents a very large artificial recharge operation. Leakage from



the reservoir and canals and percolation from water applied on the land has contributed to the building of a mappable groundwater "mound" [22] that is estimated to contain about 10 million acre-feet of water. Withdrawal of water from the large number of irrigation wells drilled in the last 30 years slowed water-level rises and has tended to bring the hydrologic system of recharge and discharge into its present-day balance. The NPPD-CNPPD projects are good examples of large scale conjunctive utilization of surface water and groundwater in Nebraska.

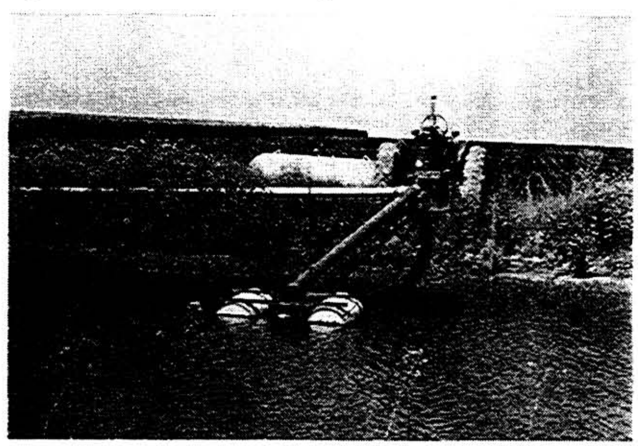
**Farwell Project** - The Farwell Project distributes water that was originally from the Middle Loup River and stored in the Sherman Reservoir. The lands that are irrigated are in Sherman and Howard counties. Wells in the area have recorded water-level rises ranging from 20 to 70 feet since irrigation began. In places the water-level rise has caused waterlogging of soils. The sediments that have been saturated by the supplemental recharge are mostly too fine textured for extensive development of irrigation wells that could serve to retard the rising water levels.[23]

**Lake McConaughy** - Lake McConaughy is a storage reservoir behind Kingsley Dam on the North Platte River in Keith County and is the principal source of water for the Central Nebraska Public Power and Irrigation District (CNPPD). This district is the state's largest irrigation project and includes the Tri-County region already described. Since storage began in 1941, water-level rises of more than 50 feet have occurred adjacent to the reservoir.

**Other Reservoirs** - There are many other reservoirs and lakes in the state that have contributed significantly to recharging groundwater in their respective areas. Among the most significant are: Sherman, Merritt, Box Butte, Enders, Harlan County, and Oliver Reservoirs, also Swanson, Hugh Butler, and Harry Strunk Lakes. Groundwater levels in the vicinity of some of the reservoirs has risen 20 to 50 feet. In some cases, recharge water can also serve to stabilize water levels or lessen the water-table declines which would have occurred due to groundwater use. Groundwater recharge, although not the purpose for storage of water, has provided a significant by-product from these surface-water projects. Water loss from canals and the distribution of water for irrigation on lands served by these projects (except Oliver Reservoir) has also contributed to groundwater recharge.

**North Platte Project** - The North Platte Project in Wyoming and Nebraska, authorized in 1903, stores snow melt water in a series of reservoirs in Wyoming and provides water for irrigation in the North Platte River Valley, significant groundwater recharge has occurred. Water levels have risen, stabilized, and have contributed to creating a groundwater source for wells and base flow of the North Platte River.

**Reuse Pits** - Reuse pits are constructed to collect runoff from irrigation. The water ponded in these pits is reused for irrigation. Lichtler et al. studied selected reuse pits in Hamilton County and showed that some had very high recharge rates whereas others did not. The large number of reuse pits in the state result in significant artificial recharge to the subsurface.[24]



## ECONOMICS

Although artificial recharge is technically feasible and is occurring at various locations throughout the state, a very significant factor in the future development of recharge oriented projects is whether or not they are economically feasible. Benefits and costs must be considered to determine the ultimate feasibility of an artificial recharge project.

**BENEFITS:** Artificial recharge becomes beneficial mostly where the supplemental storage is used as a source of water supply. The magnitude of the benefits depends on the accessibility of the water, the uses made of the water, and potential for economic benefits if the water supply is not supplemented. Additional benefits of artificial storage can be derived from its natural discharge. Subirrigated areas, desirable wetland areas, and maintenance of a base flow can result.

**Reduced Pumping Costs** - Overall pumping costs from an aquifer can be reduced by decreasing lift, or the distance a pump must push water. By reducing lift (i.e. by raising the water level in the well) horsepower requirements of the pump motor are less and well yield is greater. This means more water can be obtained at less cost.

**Extended Aquifer Life** - Pumping from an aquifer eventually may so deplete the groundwater supply that it becomes no longer adequate for the uses made of the water. In Nebraska, the term that describes the length of time for this to occur is called "groundwater reservoir life." Often an intended benefit of artificial recharge is to extend groundwater reservoir life. Estimating the value of extended aquifer life where the only significant water use is irrigation requires that one compute the difference between the amount pumped with and without recharge over the length of time being considered.[25] In addition to the benefits when public supplies are involved, the cost of importing water needs to be considered.

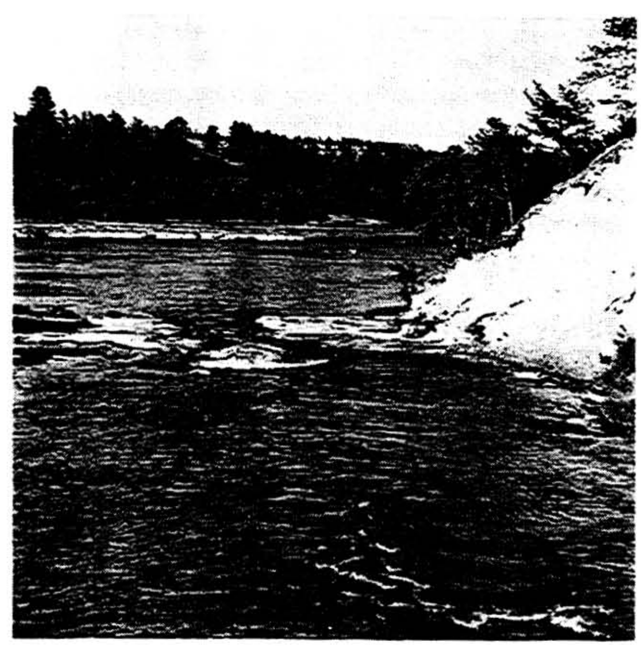
**Storage** - It is the usual purpose of a surface-water reservoir to store water and to release that water at a gradual rate during times of low flow. Groundwater reservoirs can also be used to provide water in what would otherwise be times of shortage. Areas underlain by thick unsaturated coarse-textured materials - especially in the western part of the state - provide potential for storing large volumes of water underground. Among the advantages of underground storage is avoidance of large evaporation losses that occur from surface-water reservoirs.

**COSTS:** Recharge project costs are necessarily project specific and depend upon numerous design specifications. A detailed cost assessment should be made to determine a specific project's economic feasibility. It is possible to make a preliminary or cursory review of project feasibility through a literature review. If such a review reveals that recharge costs are likely to fall well above the range of possible benefits, a preliminary detailed cost assessment may not be necessary. On the other hand, if past experience as revealed by the literature indicates that recharge costs for particular design specifications may be less than or commensurate with recharge benefits, detailed project cost analyses should be made before drawing any preliminary feasibility conclusions.[26]

**FEASIBILITY:** The economic feasibility of an artificial recharge project depends upon weighing the costs against the benefits. Single-purpose artificial recharge projects to augment irrigation supplies in Nebraska will usually be economically infeasible. On the other hand, recharge values may be the component which makes an otherwise infeasible multi-purpose project economically attractive.[27] Technical feasibility will also determine a project's economic feasibility and must be evaluated thoroughly before costs and benefits can be applied to a project.

### POTENTIAL FOR FUTURE DEVELOPMENT

In many places in Nebraska, particularly upland areas in the western and central parts of the state, there are geologic materials capable of both storing artificial recharge and yielding that water to wells. Chapter 2 notes some of the physical factors limiting recharge storage potentials throughout the state. However, except for the Niobrara River in north-central Nebraska,



virtually all the streamflow in those parts of the state, is appropriated for irrigation. In the remaining parts of the state, including the Niobrara River downstream from the Mirage Flats irrigation project, water is available for artificial recharge but opportunities to use water for that purpose are limited. Costs of transporting water for artificial recharge to distant up-gradient areas sometimes limits the potential for future development. This is not to say that no potential exists for artificial recharge because several proposed irrigation projects would have that benefit included in them. However, sufficient water for all proposed projects is not available unless transfer of water from distant sources becomes economically feasible.

## SUPPLEMENTING SURFACE WATER WITH GROUNDWATER

There are a few places in Nebraska and in other states where groundwater is pumped into a stream or lake in order to augment the current supply. Uses of such water are mostly for irrigation or wildlife management and occasionally recreation.

### PROJECTS IN NEBRASKA

Historically, fish, wildlife, and outdoor recreation benefits from development of supplemental water supplies have been largely incidental to projects which were constructed for other purposes. Some examples of exceptions to this have been: (1) pumping from a well into Walgren Lake in Sheridan County to overcome water-quality problems, (2) pumping from wells into south-central Nebraska Rainwater Basins to disperse waterfowl during spring migration and maintaining habitat quality, (3) pumping from the Little Blue River to maintain Crystal Lake near Ayr in southeastern Adams County, (4) holding and releasing cooling water from power production into Lake Hastings near Hastings in Adams County, (5) construction of Oliver, Maskenthine, and Willow Creek reservoirs with recreation as a prime benefit, (6) pumping from wells into the Sacramento-Wilcox Wildlife Management Area northwest of Wilcox, (7) pumping from a well into the East Branch Verdigre Creek fish rearing facility at Royal, and (8) pumping from wells into Goose Lake in Holt County.

Central Nebraska Public Power and Irrigation District (Tri-County) pumps groundwater into their E-65 canal which is four miles north of Loomis. Eight wells supplement water used to irrigate about 4,000 acres below the well-discharge point. Tri-County also utilizes two wells to supplement the Phelps canal system. These wells were constructed to supplement surface water irrigation systems during peak demand. No additional wells are planned at this time due to the expensive pumping costs.[28]

### POTENTIAL FOR FUTURE DEVELOPMENT

The practicality of using groundwater to supplement surface water is tied to periodic surface-water shortages. It is not recommended that groundwater be pumped continuously into streams, lakes, or wetlands. Rather, groundwater can be imported when a surface water supply fails to fulfill adequately the demands placed upon it. This procedure of pumping groundwater into streams, lakes, or wetlands is not very efficient nor economical and probably will be used only as a stopgap for periodic shortages. Thus, pumping groundwater to augment surface water is not likely to be a major source of groundwater use in the foreseeable future. However, the beneficial uses of these operations are quite evident and will be continued.

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Chapter 4

# Problems, Issues, and Policy Alternatives Related to the Impact of Groundwater Pumping on Streamflow, Lake, and Wetland Uses

## THE PROBLEM AND ISSUE

**PUMPING GROUNDWATER IN SOME LOCATIONS MAY: (A) REDUCE GROUNDWATER DISCHARGE TO A STREAM, LAKE, OR WETLAND OR (B) INDUCE RECHARGE FROM A STREAM, LAKE, OR WETLAND. IN EITHER CASE THIS MAY HAVE A DETRIMENTAL EFFECT ON SURFACE-WATER USERS WHO INITIATED THEIR USE PRIOR TO THE GROUNDWATER DEVELOPMENT. THE ISSUE IS: SHOULD MEASURES BE ADOPTED BY THE LEGISLATURE TO PROTECT THE INTERESTS OF SURFACE-WATER USERS?**

As discussed in Chapter 2, there is at least some degree of hydraulic connection between perennial streams and water in geologic formations throughout the state. However, the degree of connection differs widely.

In Nebraska the situation in which groundwater pumping induces recharge from a stream has less opportunity to occur than that of pumping reducing discharge to the stream. In a few parts of the Central and Lower Platte Basin, some of the Lower Loup Basin, Lodgepole Creek, Pumpkin Creek, and possibly a number of other stream segments streams do recharge the aquifer (see list in the Appendix). Some canals in these basins and the Republican River Basin also recharge the aquifer. Groundwater pumping will have some impact at the geographic point at which streams begin to lose flow to the aquifer. It may also affect the timing of that loss in those cases where a stream may fluctuate between gaining and losing. However, it should be noted that those losing segments are exceptions. The remainder of the live stream segments in the state almost all gain flow from the surrounding aquifer.

The extent to which groundwater discharge to streams is affected by groundwater pumping also varies throughout the state and is difficult to determine except on a stream segment basis. Areas examined in the following paragraphs are Frenchman Creek, the Central Platte, and the Cedar Rapids areas. Evidence indicates there has been some significant reduction of the flow of Frenchman Creek upstream from Enders Reservoir. However, the degree to which groundwater pumping has contributed to flow reductions has been the subject of debate. In the Cedar Rapids area the Bureau of Reclamation disapproved a surface water project because the projected flows of the Cedar River would become inadequate as the result of continued groundwater development in the area. There have been suggestions of significant lessening of groundwater contributions to baseflow in the Central Platte area and the Upper Niobrara where inflows to the Box Butte Reservoir have been reduced. It is also possible that groundwater pumping in Colorado may be diminishing the amount of surface water that flows in the South Platte River. That water is subject to a compact between Nebraska and Colorado.

The degree to which past and continuing groundwater uses impact future surface flows throughout Nebraska will help determine the importance of some of the alternatives presented in this chapter. In a few areas of groundwater decline, the impacts of groundwater development already in place may not have been fully realized. However, there is not thorough knowledge or universal agreement as to what the timing or magnitude of streamflow depletions in affected areas are likely to be.

Almost all groundwater at some point in time contributes to either surface water or subirrigation of vegetation. However, the ultimate effects of groundwater use on surface water sources may in many cases be small. Determining whether specific flow reductions are the result of groundwater depletions may involve examination of long-term precipitation patterns, tillage practices, potential evapotranspiration salvage, and surface diversions as well as groundwater depletions. Flow reductions can be caused by a combination of these factors. This makes the timing and magnitude of streamflow depletions difficult to estimate or project. However, several of the groundwater models mentioned in Table 6 of Chapter 2 do project groundwater depletions. Other cases of suspected depletions are mentioned in regard to specific streams in the following few pages. a result diminishing the baseflows of streams will always be a problem. It can have positive aspects. In some cases this can allow more complete economic use of the water in an area. When the water level in an aquifer is lowered, more storage space is created for storage of recharge from precipitation that otherwise might have been discharged from an area without any economic use having been made of it. There may also be less water loss through evapotranspiration.

In the case of groundwater pumping causing either reduced discharge to a stream or inducing recharge from a stream there can be a impact on holders of surface-water rights. Reduction in streamflow sometimes reduces the amount of water available to surface-water irrigators, many of whom have rights that pre-date the wells reducing the streamflow. Different states have adopted various legal measures to address this type of impact.

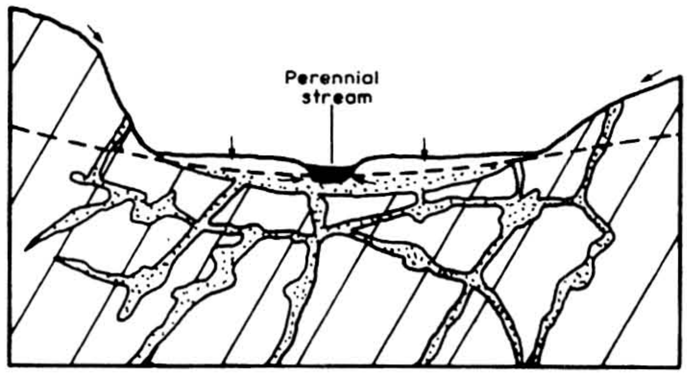


**FIGURE 35**

**STREAM-AQUIFER RELATIONSHIP: LODGEPOLE CREEK**

Further information on some of the individual situations noted above follows.

**Lodgepole Creek** - This is a very complex situation in the southern panhandle which illustrates the problems encountered by several groups of users. It applies to both this problem and the induced municipal recharge issue noted in Chapter 2. To better understand the explanation, refer to the following diagram which also appears as Figure 16 in Chapter 2. It shows a cross-section of Lodgepole Creek (not to scale) as it probably existed prior to irrigation development. The alluvium in the valley varies from½ mile to 2 miles in width and 20 to 50 feet in depth at its greatest point, according to USGS Water Supply Paper No. 1410. Originally, Lodgepole Creek may have been a gaining stream in which the water table in the alluvium sloped toward the stream and groundwater contributed to the baseflow of the stream. Surface water irrigation diversions from Lodgepole Creek probably began soon after Nebraska became a state. These diversions reduced streamflow during the irrigation season and they probably disturbed the groundwater and surface-water balance seasonally.

In 1970 Lodgepole Creek still flowed at the gaging station at Ralton. Gaging records at that station show that the flows were declining. By 1980 flows had declined to the point where no flow had been recorded for several years and the gage was discontinued. Seepage runs at various sites along Lodgepole Creek in late October 1983 indicated that most segments were losing flow to the aquifer.

The probable explanation for this phenomenon is that the irrigation and municipal wells pump so much water out of the alluvium and the connected fissures in the Brule Formation that they practically empty the aquifer during the irrigation season. It takes all the surface flow and all the recharge from precipitation during the off-season to refill the aquifer. Apparently the infiltration capacity of the streambed is adequate to allow the winter and spring flows to seep into the depleted aquifer. Sidney ran short of water in their wellfield because they tried to pump all year from an aquifer that is seriously depleted in the irrigation season. They have drilled new wells where the supply will be more dependable.

Enough irrigation wells have now been drilled in the Lodgepole Creek Valley so that some no longer can be pumped economically and so have been abandoned and those that are left just balance the amount of recharge available. A number of irrigators on the creek divert water only in the springtime to flood their fields and fill the soil profile with moisture because there is no streamflow available during the irrigation season for normal irrigation.

**Pumpkin Creek** - Pumpkin Creek is located in the western panhandle in Banner and Morrill counties. Seepage runs made along Pumpkin Creek in late October 1983 indicated that at least some segments were losing flow to the surrounding aquifer at that time. In a 1975 Conservation and Survey Division report "Groundwater Geology of Banner County, Nebraska"[1] the interaction of the surface water with the Brule Formation was noted in the following description of the hydrologic situation in parts of the Pumpkin Creek valley:

"Even where wholly fine textured, the Brule locally is an important source of groundwater. In some parts of Pumpkin Creek valley, for example, the Brule yields water readily to wells intersecting fractures that have been enlarged by the erosive action of circulating water.

It is significant that the most productive wells in the Brule Formation are located in topographically low sites receiving drainage from a large area. Generally, the Brule in such places is overlain by saturated alluvium that can supply water to fractures transmitting water to wells. Where the Brule contains fractures but is so situated that the water supply cannot be maintained by drainage from either upgradient Brule or overlying sediments, yields of wells tapping this stratigraphic unit generally diminish rapidly because water stored in the fractures is soon depleted. Thus, some irrigation wells that are pumped heavily in the early weeks of the growing season are incapable of yielding sufficient water for later needs. During the nongrowing season, however, infiltrating precipitation and seepage from streams usually refill the fractures, thereby replenishing the supply. Because most domestic and stock wells tapping the Brule have small yields compared to those of irrigation wells, their output is not likely to diminish seasonally unless they are located close to a heavily pumped irrigation well."

There is some similarity between this hydrologic situation in parts of the Pumpkin Creek valley and that in the Lodgepole Creek area. However, in other parts of the Pumpkin Valley are areas where groundwater supplements streamflow.

**Cedar Rapids** - The Bureau of Reclamation reconnaisance level report on the Cedar Rapids Division dated March 19, 1966, recommended a project that would irrigate about 27,000 acres from storage in a reservoir on the Cedar River in Greeley County. The groundwater model in the Level B Study predicted that flow in the Cedar River would be diminished by about 20 to 40 percent by the year 2020. As a result, it was recommended that the irrigated area be reduced, and the economic feasibility of the project became questionable. After the Level B Study was completed, the Bureau of Reclamation did another study of the hydrologic and economic feasibility of the Cedar Rapids Division. That study found that irrigated acreage in the Cedar River Basin above Spalding had increased from 4,000 acres in 1970 to 25,000 acres in 1978 and that irrigated acreage between Spalding and Fullerton had increased from 22,200 acres in 1970 to 48,400 acres in 1978. Between 1970 and 1977 the irrigation development rate exceeded the Platte Level B high rate by over 60 percent. The Bureau projected development that would occur by using those rates to the year 2000. It then computed depletions to streamflow based upon that development and found that there would be insufficient flow for even a project of 15,000 acres if those depletions occurred. The study did note the potential for conjunctive use in the area and suggested it "should be possible to manage the groundwater reservoir as a long-term carryover reservoir and reduce the need for surface water reservoirs."[2]

The flow reductions calculated included the effects of evapotranspiration. However, recent work on the Natural Resources Commission's *Sandhills Area Study* indicates the presence of a confining layer in the Cedar River watershed that may cause reconsideration of earlier results. It is now questionable how much of the flow of the Cedar River comes from the regional aquifer and how much comes from the "topwater" above the clayey confining layer.

**Enders Reservoir** - The Enders Reservoir is located in Chase County in southwestern Nebraska. In regard to Enders Reservoir the Bureau of Reclamation's *Annual Operating Plan*[3] which covers 1983 operations in the area notes the following.

"Due to extensive groundwater pumping above the reservoir, the inflow was only 50 percent of the average historical preconstruction runoff at the Enders damsite (60,700 acre-feet from 1929-1947). This year was the sixteenth consecutive year with below-normal inflows in which the conservation pool did not fill."

Precipitation at the damsite was 86 percent of normal during 1983.

There has been considerable discussion as to the role of conservation tillage practices on the land and the role of the amount or timing of precipitation in the declining inflows to the reservoir. However, it seems likely that groundwater depletions are at least a substantial part of this decline in inflow. In turn the thousands of acres with surface water rights no longer served results in equity issues due to surface water supplies being depleted by groundwater developments occuring after the surface supplies were developed and after considerable investment in facilities had taken place.

A 1978 U.S. Geological Survey study[4] projected further declines in baseflow. It showed that by 1992 the baseflow of Frenchman Creek (on which Enders Reservoir is located), Stinking Water Creek, and Spring Creeks would be reduced to less than 10 percent of 1975 values with no further develoment. According to the report baseflows would be eliminated by about 1992 under further development.

A related problem in the Upper Republican area (though not in the Frenchman Basin) has occurred on Rock Creek in Dundy County. The Game and Parks Commission has a fish hatchery at springs near the point where Rock Creek becomes perennial. In the 1970's Game and Park's personnel noticed a decline in springflow to the hatchery. Heavy center pivot development was occurring in the immediate area just prior to and during this period. The flow decline resulted in declining fish production. In order to mitigate this problem the Game and Parks Commission drilled two wells to supplement flows in critical periods. Fish production has now returned to previous levels.

**Central Platte** - Parts of this area are represented by both Figures 17 and 19 in Chapter 2. The primary problem with trying to write an explanation of the Platte River is that it is impossible to generalize. Surface and groundwater relationships on the Platte are very complex. There have been so many changes in the stream regimen and the groundwater levels that it is almost necessary to be specific as to place and time. However, Figure 19 (page 2-24), which is representative of western Merrick County and eastern Hall County, could probably be used as an illustration of this type of problem.

Groundwater irrigation north of the river in Hall County has lowered the water table 5 to 10 feet in western Hall County and 10 to 15 feet just across the line in eastern Buffalo County. In addition, groundwater irrigation south of the river has started lowering the water table, which increases the gradient away from the river. The magnitude of the effects of these declines on the groundwater contribution to streamflow and the loss of streamflow to groundwater has been the subject of controversy. Nevertheless, there does not seem to be any dispute over the fact that groundwater pumpage does decrease the streamflow to some degree, making it unavailable to irrigators or instream uses downstream of Grand Island. However, there is considerable question as to what degree that is occurring. The situation is complicated by the fact that some segments of the Platte may vary between gaining and losing depending upon the season and the year.

When examining the impact of an additional groundwater development scenario on the Platte, a Bureau of Reclamation report on "Water Use and Management in the Upper Platte River Basin"[5] modeled the basin upstream from Duncan and found that:

"Results indicate that streamflow depletions [upstream from Duncan] would be 568,000 acre-feet per year, or 384,000 acre-feet per year greater than at present. Groundwater storage would be depleted at a rate of 1.9 million acre-feet per year. In addition, some 357,000 acres of subirrigated land would be lost, resulting in the salvage of 473,000 acre-feet of water per year."

Not all of these depletions or impacts would be in Nebraska.

However, other studies have stated that groundwater depletion effects in the Platte were probably small. In a 1982 report *"Nebraska's Platte River - A Graphic Analysis of Flows"* Ray Bentall of the Conservation and Survey Division-UNL[6] states that at least in regard to the Overton-Duncan reach of the Platte "a reasonable conclusion is that consumptive use of groundwater resulting from pumping for irrigation is little, if any more, than was consumptive use of groundwater by the subirrigated prairie grasses that formerly thrived in this segment of the Platte's valley." However, others have suggested that a study of just August and September flows would show depletions more accurately.

**The Platte River Basin** - Nebraska Level B Study (1976)[7] indicated no sustained decrease in streamflow in the Platte Basin to date. However, a technical paper on Stream Aquifer Hydrology in the report simulated year 2000 sources of water pumped in the Middle and Twin Platte basins. Streamflow depletions accounted for between 25 and 41 percent of water pumped in those models with salvaged evapotranspiration accounting for between 3 and 14 percent of the water pumped. The figures varied between models of the two basins and two different development plans.

In a 1981 USGS modeling study[8] of the effects of possible groundwater development between Overton and Grand Island on streamflow of the Platte River found:

"The effects of water management practices in the area of the Platte River between Overton and Grand Island caused an average of about 32,300 acre-feet/year of simulated stream depletion over the last 50 years. This depletion would increase to about 124,900 acre-feet/year over a 50-year period, even if no changes occur in the water management activities due to the delayed effects of the historical increase in groundwater. pumpage to the current level. Adding about 270,000 acres of new surface water irrigated acreage would reduce the depletions to an average of 53,200 acre-feet/year over a 50-year period. If groundwater were used to irrigate about 270,000 acres of irrigable land, some in areas of current subirrigation, the computed 50-year period average depletion would be increased to 174,000 acre-feet/year."

Perhaps the best overall conclusion which can be reached from previous studies is that while groundwater pumping has had minimal streamflow depletion effects in the Central Platte area on an annual basis to date that depletion factor is likely to grow in the future as the effects of previous groundwater depletions reach the stream and as future groundwater withdrawals occur. However the magnitude of future streamflow depletion on an annual basis and the degree to which it will be offset by evapotranspiration salvage are not certain.

**South Platte** - Groundwater pumping in Colorado may be diminishing the amount of surface water that flows into Nebraska via the South Platte River. That water is subject to a compact between Nebraska and Colorado. Under that compact, Colorado shall not permit diversions from the lower section of the South Platte (Western edge of Washington County, Colorado to the state line) between April 1 and October 15 under certain conditions. Under those conditions, Colorado appropriations with priority dates after June 14, 1897 may not be served if it will diminish the flow on any day below a meanflow of 120 cfs, provided this flow is being beneficially used in Nebraska. On many occasions, this flow has not been available even though the specified Colorado surface diversions were shut down. One partial explanation for this may be that groundwater use impacts flows along that reach of the Platte. Colorado has markedly different procedures than Nebraska for dealing with groundwater and surface-water relationships. Some Colorado surface-water users may have changed their source to groundwater. Colorado's Groundwater Association for the South Platte may have had some impact on groundwater uses in this downstream reach. However, the degree of those impacts, if any, is not known.

The compact has another provision which requires Colorado to provide for diversions between October 15 and April 1 for a Perkins County Canal if it should be built. It is uncertain whether future development in the south Platte might jeopardize these rights.

**Lakes and Wetlands** - Diverse and complex flow systems probably exist in the vicinity of naturally occurring lakes and wetlands in the Sandhills. To date the system of interaction between lakes and groundwater is not completely understood. There are some lakes, wetlands and subirrigated areas that are in direct connection with the water table. If the water table changes there would be marked changes in those areas and their accompanying land uses. While lake acreages in the Rainwater Basin Area of Southern Nebraska have declined dramatically; evidence indicates these are generally perched lakes with no connection to the water table.

If there has been some ET salvage in the Central Platte area, it seems likely that some wetlands have been lost, but there is currently no documentation of such loss. There may have been some loss of wetlands in eastern Box Butte County also, because substantial declines of groundwater levels have been documented in eastern Box Butte County and the western edge of Sheridan County. A state map dated 1962 shows numerous wetlands and lakes in that area, so they might have been affected if they actually are in connection with the water table. However, that has not been researched.

There is the potential for loss of lakes and wetlands in northern Wheeler County and southern Holt County. Maps show a number of small lakes and wetlands in that area, and both the *Level B Study* and the *High Plains Study* project future groundwater declines in that area. If those lakes and wetlands are connected with the water table, it is possible they could be lost or reduced in size. This depends primarily on how well they are connected with the water table and whether they might become perched and ephemeral in nature. Little research is available on this topic.

Wet meadow acres in the Sandhills are of concern to Sandhills ranchers due to their value for producing winter feed and grazing. Wetlands in the Sandhills are of value to wildlife. These values would generally be threatened by water table declines.

In summary, few data exist concerning the relationship between groundwater and wetlands in Nebraska. It seems likely that water-level declines are impacting and/or will impact lakes and wetlands in some situations, but data do not exist on the number of such situations or their severity.

## APPLICABLE NEBRASKA LAW

### IMPACTS ON STREAMFLOW

Pumping water for irrigation purposes from pits located within fifty feet of the bank of a natural stream without first acquiring a permit from the Department of Water Resources (DWR), is prohibited by statute.[9] The legislature recognized that this use might have a direct effect on the stream's flow.[10] In deciding whether to grant a permit, the Director of DWR must consider the effect the pumping may have on the amount of water in the stream and whether the requirements of surface appropriators can be met.[11] The permits issued in these cases are generally appropriative rights to divert for direct irrigation. An interconnection is assumed for any pit located within fifty feet of a stream, and the permit applicant has the burden of proving otherwise. In reality, most existing pits are located within the streambed or more than fifty feet away. Streambed pits may be filled in with gravel or other material and the effect is fairly easy to determine. Irrigation pits located more than fifty feet from a stream may be registered as wells. Reusing groundwater from irrigation water reuse pits located within the headwaters segment of a natural stream is exempt from the provision requiring a permit.[12]

The history of this statute deserves some attention. In a 1962 report, the Nebraska Legislative Council Committee on Water Control pointed out that:

> In some areas of the state persons are drilling wells or scraping out pits close to the banks of natural streams and pumping water from them. The resulting pumping in many cases actually takes water which would otherwise be a part of the streamflow, water which is under a prior surface appropriation down stream.[13]

In view of the close relationship between streamflow and groundwater, the committee recommended adoption of legislation which would require a permit from DWR to pump water from any pit **or well** within two hundred feet of a natural stream. The presumption was that groundwater within two hundred feet of a stream was tributary and that rights to the use of this water should be acquired in the same manner as rights to use surface water.[14]

The result of this report was Legislative Bill 489 introduced in the 1963 session of the Legislature incorporating the committee's recommendation.[15] It provided for a presumption that pumping from wells or pits within two hundred feet of a natural stream had a direct effect on streamflow. A permit from the DWR was necessary before drilling a well or digging a pit having a capacity above 500 gallons per minute within this distance from a stream unless evidence refuting the "direct effect" presumption was shown. As finally enacted, the legislation did not restrict withdrawals from wells but did require that a permit be obtained to pump from pits located within fifty feet of the bank of a natural stream.[16]

Consideration of the possible adverse effects of large-scale industrial groundwater pumping on other surface and groundwater users is required by the Industrial Ground Water Regulatory Act.[17] This Act, passed by the Legislature in 1981, requires any person intending to withdraw a total of three thousand acre-feet or more of groundwater per year from aquifers in Nebraska for industrial purposes to first obtain a permit from the director of DWR authorizing such withdrawal and any transfer. Industrial purposes in this context include manufacturing, commercial, and power generation. In deciding whether to issue a permit the director is required to consider whether or not the withdrawal and transfer are in the public interest. Determination of the public interest is to include consideration of:

"...(a) Possible adverse effects on existing surface or ground water users;

(b) The effect of the withdrawal or any transfer of ground water on surface or ground water supplies needed to meet reasonably anticipated domestic and agricultural demands in the area of the proposed ground water withdrawal;

(c) The availability of alternative sources of surface or ground water reasonably accessible to the applicant in or near the region of the proposed withdrawal or use; ..."[18]

No permits have been issued to date under this Act.

There are, in addition, two interstate water compacts, also statutory creations, which contain provisions relating to the interrelationship of groundwater and streamflow. The Big Blue River Compact [19] between Kansas and Nebraska includes groundwater seepage into a stream within the definition of natural flow. Accordingly, the compact, which establishes a schedule of state-line flows, obligates the State of Nebraska to regulate withdrawals from irrigation wells installed after November 1, 1968, except for equivalent replacement wells, in the alluvium and valley side terrace deposits within one mile from the thread of the river as necessary to maintain those scheduled flows. Wells are not regulated currently. A study is being conducted by the Geology Department of UNL for Blue Compact Administration to determine the effects of pumping on surface flows in the area. The University of Nebraska-Lincoln Geology Department is cooperating with the Department of Water Resources and the Big Blue Compact Administration on the study.

The Upper Niobrara River Compact,[20] between Nebraska and Wyoming, also recognizes that the use of groundwater for irrigation in the Niobrara river basin may be a factor in the depletion of surface flows in the river. The states have agreed to undertake groundwater investigations in the basin and delay making any apportionment of groundwater until adequate data become available. No investigations under the auspices of the compact have been conducted.

Case law in Nebraska provides further insight into the legal complexities of the problem. The Nebraska Supreme Court in *State ex rel. Cary v. Cochran,*[21] in a discussion of the characteristics of the Platte River, gave tacit recognition to the relationship of groundwater to streamflow. It notes,

> The underlying sand and gravel beds thicken as the river [Platte River at some unknown point between North Platte and Gothenburg] moves east. With the bed of the river on the surface of these sand and gravel deposits, it requires a huge amount of water to recharge the river channel and surrounding water table after the river bed once becomes dry. Until the water table is built up to the surface of the river bed, the river channel will not support a continuous flow. It is also shown that the water table has been affected materially by pump irrigation.[22]

These gaining and losing aspects of the Platte river were related to a "futile call" by a senior appropriator on junior upstream appropriations. It was found that shutting off upstream junior appropriators would have been futile as the water freed up would not have reached the downstream senior appropriator anyway.

The next series of cases relates to some legal gray areas: theories of groundwater considered by courts in the past but probably no longer having any significant impact. At one time, the Nebraska Supreme Court recognized a distinction between underground streams and percolating groundwater. In *Olson v. City of Wahoo,*[23] the court observed that,

> There is a distinction made between underground waters flowing in known and well-defined channels, such as the water flowing in the gravel bed in Todd Valley, and also underground waters, the channels of which are undefined and unknown, and it is held that

the principles of law governing the former are not applicable to the latter.[24]

The underground stream doctrine allowed that a subsurface stream may be treated as a watercourse subject to surface water rules provided that... "its course must be discoverable from the surface of the ground, and it is generally held that an underground stream, the direction and course of which can be discovered only by excavation, is not a known stream subject to the rules applied to surface streams."[25]

Utilization of the underground stream doctrine in Nebraska would be significant because surface water rights are determined by prior appropriation, and groundwater rights are based on reasonable use on the overlying land. The effect would be that resolution of surface-groundwater conflicts invoking this doctrine would be accomplished on the basis of priority, as are surface water rights.[26] The concept, while recognized in case law, has not been applied to any factual situations in Nebraska.[27] Under the facts in Olson, the plaintiff could not prove causation and lost on that point. The court did not apply the underground stream doctrine, although it found that the evidence would appear to indicate that the Todd Valley was an underground stream.[28] It is probably of little consequence because, apparently, underground streams occur only very rarely, and the doctrine has more of a legal significance than anything else.[29]

A concept related to the underground stream doctrine, the subflow doctrine, recognizes that,

The underflow or subflow of a surface stream is the subsurface flow associated with a stream or river. The groundwater may be leaving or entering the stream. In many western states subflow is considered to be part of the stream and subject to the same rights of use.[30]

In *Metropolitan Utilities District v. Merritt Beach Co.*[31] the court was presented with a set of facts falling within the purview of this doctrine. The Omaha Metropolitan Utilities District had filed an application under the Municipal and Rural Domestic Ground Water Transfers Permit Act to withdraw water from wells located on the north bank of the Platte River. The Director of the DWR granted the permit and his action was challenged by appropriators, riparians, and groundwater users along the river who alleged that the primary source of water was recharge from the Platte River. The court upheld the granting of the permit finding no demonstrated harm to these other water users.

The importance of the case lies with the court's statements with respect to groundwater. The court appears to disregard distinctions made earlier in Olson between underground streams and percolating groundwater.

Underground waters, whether they be percolating water or undergroundwater streams, are a part of the waters referred to in the [state] Constitution as a natural want. Such waters are as much a part of the hydrologic cycle as the flow of water in a stream or river. It is true that such waters are not concentrated as in a river nor [sic] do they move with the velocity of a river, but they do percolate through underground formations and have the same source and termination as surface water flowing in a river.[32]

The court concluded that all of the water would be pumped from the ground rather than taken by a direct diversion of the Platte River. It was apparently felt of little import that the source of most of the recharge of the aquifer was the surface waters of the Platte River.[33] The court did not invoke either the underground stream doctrine or the subflow doctrine. It may be argued that by not doing so, the court implicitly repudiated these doctrines.[34]

The subflow doctrine may have been the reasoning behind the applications of various municipalities for surface water appropriations from the Platte River for their municipal wellfields, specifying wells as the methods of diversion.[35] The eventual denial of these permits, while explicitly based on other reasons, would suggest that little or no credence is given to the subflow or underground stream doctrines.[36]

### IMPACTS ON LAKES AND WETLANDS

There is no pertinent law on this subject in Nebraska. It may be interesting to note, however, that Section 858A of the Restatement (2d) of Torts, which recognizes as a general principle the right of a landowner to extract groundwater found under his land, includes as an exception, the withdrawal of groundwater having a direct and substantial effect on a watercourse or lake.[37]

## LEGAL AND ADMINISTRATIVE MECHANISMS USED IN OTHER STATES

## IMPACTS ON STREAMFLOW

Colorado, Montana, New Mexico, and Wyoming all have policies specifically addressing the impacts of groundwater use on surface-water rights. Colorado has the most complex system of the four, and will be dealt with first.

### COLORADO

In Colorado, legislation has been enacted to protect holders of vested surface-water rights from depletions in surface flows caused by withdrawals from relatively new wells drilled into aquifers that discharge groundwater to the Arkansas and South Platte Rivers. The regulation of well owners tapping groundwater that is "tributary" to a surface-water source did not begin in Colorado until 1965. In that year, surface-water irrigators from the Arkansas River Valley complained to the state engineer that pumping from wells in the valley was reducing streamflow and impairing surface-water users rights. The state engineer rejected their demand that groundwater irrigation in the valley be curtailed, contending he had no authority to regulate groundwater users.[38] The Colorado Legislature responded later that same year by directing the state engineer to "administer the laws of the state relative to the distribution of the surface waters of the state including the underground waters tributary thereto in accordance with the right of priority of appropriation..." and authorized the Attorney General to seek an injunction to enforce the engineer's directives if necessary. These provisions were intended to be applied to existing as well as new wells although the law contained a rebuttable presumption that the rights of other appropriators would not be injured by the operation of a well if that well was in existence prior to the effective date of the act, had been used continuously since that date and was not located in the "subsurface channel" of a continuously flowing stream.[39]

Following passage of this act, the state engineer attempted to regulate selected groundwater irrigators in the Arkansas River Valley. This action was overturned by the Colorado Supreme Court in 1968 on the ground that the state engineer had arbitrarily selected his subjects for regulatory action.[40] However, the principle that wells withdrawing tributary groundwater were to be integrated with surface-water uses remained unaffected. The court acknowledged that in integrating groundwater and surface-water users, state water administrators were faced with the difficult task of protecting vested surface-water rights while at the same time facilitating maximum utilization of the state's waters. However, the court stated that to be valid, the regulation of groundwater users had to be in accordance with reasonable regulations adopted prior to the issuance of closing orders, any regulation of wells must result in a lessening of material injury to senior rights and, if conditions could be placed upon well users which would allow the use of some or all of the water without injuring water users with senior priorities, such an arrangement should be approved by the state engineer.[41]

## THE 1969 ACT

The judicially enunciated principle that groundwater and surface-water rights should be integrated to protect vested surface-water rights while at the same time allowing the maximum use of the state's water was enacted into law by the Colorado Legislature in 1969.[42] Passage of the Water Right Determination Act of 1969 brought groundwater users of "tributary groundwater" into the same adjudication system used for determining priorities for surface-water rights, thereby bringing groundwater and surface-water rights into the same record keeping system and establishing priority dates for groundwater users. The law provided for a grace period during which well owners could obtain priority dates based on when they initiated their use and thereby avoid being given a priority date junior to other water users who had gone through the adjudication process since the time the well owner's use began.

The 1969 Act reiterated the Legislature's 1965 directive that groundwater and surface-water rights be administered on the basis of priority of appropriation and codified the requirement from *Fellhauer* that no well owner should be ordered to cease withdrawing water unless their groundwater use caused material injury to the holder of a senior water right.[43] In addition, the act provided that if the regulation of a well or wells would not result in making water available to senior appropriators at the time and place desired, the wells should not be ordered to cease their withdrawals.[44]

Strict application of the doctrine of prior appropriation would have placed well users at a serious disadvantage due to the relatively recent initiation of their uses in comparison to surface-water appropriators and would have severely inhibited additional groundwater development. Consequently a number of provisions were included in Colorado law to soften the impact that would have resulted from a strict application of the prior appropriation doctrine.

The 1969 Act provided that a well user could divert water using the priority of his well, and/or could obtain a decree allowing the well to be used as an alternate point of diversion for a surface-water right.[45] This provision, in conjunction with Colorado's liberal rules regarding transfers of surface-water rights, allows the owner of a well to improve his position by purchasing a senior surface-water right and applying that priority date to his well. The 1969 Act also provided that when a well has been approved as an alternate point of diversion for a decreed surface-water right, the well and surface diversion must be used to the maximum extent feasible to satisfy the water right before diversions by junior water users can be discontinued.[46]

Colorado law also allows junior appropriators to divert water out of priority if they provide substitute water to senior appropriators who would otherwise be injured by the junior appropriator's diversion. The senior must accept the substitute water if it is of sufficient quality and quantity to meet the senior user's needs.[47] Substitute water could consist of stored surface-water purchased by the junior appropriator for the senior's benefit, or the junior user could supply the senior appropriator with well water.[48]

A related provision contained in the 1969 Act provides procedures for approval of "plans of augmentation," another device which can be used to allow junior groundwater users to divert water out of priority. A plan of augmentation is:

> A detailed program to increase the supply of water available for beneficial use in a division or portion thereof by development of new or alternate means or points of diversion, by a pooling of water resources, by water exchange projects, by providing substitute supplies of water, by the development of new sources of water or by any other appropriate means.[49]

Plans for augmentation are to be approved by a water court if the plan will not injuriously affect holders of vested or conditional water rights. If it appears established users would be affected adversely the court is to provide the applicant or any objector with an opportunity to propose an alternative plan to avoid the adverse consequences.[50] In addition, the state and division engineers have been directed by the Colorado legislature to encourage and develop augmentation plans and voluntary exchanges of water to allow the continuance of existing uses and assure the maximum beneficial use of the waters of the state.[51] Under an amendment to the act passed in 1974, the state engineer was given authority to grant temporary approval to water augmentation plans pending water court review and action on the plans.[52]

The issue of what constitutes a valid augmentation plan has spawned some of the more significant water rights litigation in Colorado in recent years. Two cases involving augmentation plans, *Kelly Ranch v. Southeastern Colorado Water Conservancy District* [53] and *Cache La Poudre Water Users Association v. Glacier View Meadows,*[54] were the subject of Colorado Supreme Court decisions in 1976. Both cases involved plans by residential developers to supply groundwater for domestic use. If the domestic wells were administered on the basis of priority dates as of the dates of their construction they would have been so junior that their operation would have been curtailed during the irrigation season. The augmentation plans proposed by the developers involved the purchase and retirement of senior surface-water rights for irrigation to offset the consumptive use of the subdivision residents.

Objections to the augmentation plans were filed by agricultural water users who contended, among other things, that the plans were not proper augmentation plans because no new water was being added to the system. This argument was rejected by the Colorado Supreme Court and both plans were approved.[55]

## REGULATION OF NEW WELLS

The 1969 Act contained stringent requirements that must be met before permits for new wells can be granted and implementation of the Act has resulted in the denial of permits to construct new wells to tap tributary groundwater. The state engineer is required to find that there is unappropriated water available for withdrawal by the well and that vested rights of others will not be materially injured and this must be substantiated by hydrological evidence.[56] In *Hall v. Kuiper* [57] the Colorado Supreme Court was presented with a challange to the state engineer's denial of applications to construct two wells in the Cache La Poudre River Basin. The wells in question were to be located thirteen miles from the river. The state engineer had determined that the wells in question would affect vested water rights adversely and that denial of the permit application was appropriate under the terms of the 1969 Act. It was estimated that the water under the applicant's land, if left to flow towards the stream, would reach it in approximately 40 years. The applicants contended that the state engineer's decision should be overturned because it had not been proven their wells would affect any specific senior surface water users adversely. The court rejected this argument, stating that it was only necessary to show that senior appropriators in general would be injured by a new well in order to justify a permit denial.[58]

The issue of what constitutes tributary groundwater received additional attention two years later in *Kuiper v. Lundvall.* In this case the groundwater in question would have taken 178 years to reach the nearest river. The Colorado Supreme Court held any water taking over 100 years to reach a stream was not tributary groundwater.[59] The law regarding what constitutes tributary groundwater was clarified somewhat in 1979 when the Colorado Supreme Court decided *District 10 Water Users Association v. Barnett.* In that case the court stated that in determining whether groundwater is tributary to a stream, the courts must determine whether a groundwater is tributary to a stream, the courts must determine whether a groundwater withdrawal will **affect** the rate of flow in the stream and, if so, when. In this case the court stated that if it could be shown the withdrawal of groundwater would affect the stream within 40 years it should be regarded as a tributary well.[60]

## REGULATION OF EXISTING WELLS

The regulation of existing wells under the Fellhauer decision and the 1969 Act has proceeded somewhat fitfully over the 1970's and early 80's. At the same time the legislature was debating the 1969 Act, the state engineer was formulating rules regulating existing wells in the South Platte and Arkansas river basins based on a zone concept. These rules were only to be in effect during the 1969 irrigation season.

These rules provided for division of the area into three zones. Zone A included lands adjacent to the river in which well withdrawals would affect the river in less than ten days. Zone B consisted of lands from which pumping would affect the stream in ten to thirty days and Zone C included lands in which pumping would affect the stream in thirty to seventy-five days. Regulation of wells in Zone A was to cease on October 10th, wells in Zone B on September 25th and Zone C on September 1st. Wells beyond these zones would not be regulated and no well within the zones could be regulated for more than three days out of a week. Well owners could avoid this regulation by having a plan for replacing the stream depletion caused by the well with sufficient water to meet the needs of senior surface-water users. Furthermore, a written demand from a senior surface-water user was necessary before any regulation of groundwater users would occur.[61]

These regulations were challenged by well owners in the South Platte Basin and held invalid by the water court. This decision was later overturned by the Colorado Supreme Court which found the rules to be consistent with the 1969 Act.[62]

In spite of the Supreme Court's upholding the regulations, the state engineer changed his approach in the next set of rules issued for the South Platte in late 1972. These rules abandoned the zone concept and provided instead that all groundwater users would be continuously curtailed for four days each week unless the well in question was part of a plan of augmentation. These rules were also challenged and eventually a stipulated judgment that provided for the curtailment of all wells not operating as an alternate point of diversion or subject to a plan of augmentation for 5/7 of the time in 1974, 6/7 of the time in 1975 and continuously in 1976 and thereafter was agreed to by the parties. These rules are still in effect for the South Platte Basin.[63]

In 1973, the state engineer proposed new rules for the Arkansas basin that provided for the curtailment of pumping for up to four days per week. These rules were not challenged in court. However, an amendment proposed by the state engineer in 1974 to continuously curtail any well not operated as an alternate point of diversion for a surface decree or subject to a plan for augmentation was challenged in court. The water court found that the proposed amendment violated the 1969 Act in that the proposed change was not based on operating experience under the 1973 rules and there was no evidence the amendment was necessary to prevent material injury to senior surface-water appropriators. These rulings were upheld by the Colorado Supreme Court. Consequently the 1973 rules are still in effect.[64]

Rules providing for the total curtailment of all wells not operating pursuant to a plan of augmentation or as an alternate point of diversion were proposed by the state engineer for the Rio Grande and Conejos River Basins in 1975. These rules were also disapproved by the water court. Among the courts' holdings were that wells could not be regulated as a group but must be regulated on a case-by-case basis. Contrary to the holding of *Kuiper v. Well Owners Conservation Association*[65] the water court held that a specific well could not be shut down until "the materiality of injury to senior priorities" caused by the well was determined. The court also suggested that senior surface right holders should be required to drill a well to augment their supply before they could request the regulation of groundwater users. This was also contrary to the *Kuiper* decision.[66] The state engineer's office has appealed this decision to the Colorado Supreme Court. As of this writing the case had been argued but no decision had been handed down by the court.[67]

Although no regulations are in effect for the Republican or Arikaree Rivers in Colorado, the use of tributary groundwater in those basins is subject to some restrictions. The state engineer will not approve a permit for a new well located in the alluvial valleys of either of those rivers unless the well will be operated as an alternate point of diversion for a decreed surface-water right.[68]

## MONTANA

Groundwater is defined in Montana law as any water beneath the land surface or beneath the bed of a stream, lake, reservoir, or other body of surface-water which is not part of that surface water.[69] Both groundwater and surface water are administered in accordance with the prior appropriation doctrine[70] and permits for groundwater withdrawals that will deplete the water supply for senior surface-water users can be denied under Montana law.[71]

Applications for wells near a stream are referred to the Department of Natural Resources and Conservation's Water Management Bureau for an evaluation of the hydrologic impact of the proposed well. Available information on the local geology is reviewed as are the results of any pump test conducted by the applicant. If necessary, pump tests can be conducted by the Water Management Bureau to help determine the effect of a well on senior surface-water rights.

If it appears there is a hydrological connection between the well and the stream, the data obtained is fed into the Bureau's computer model to estimate the probable stream depletion effect of the well. This report is then forwarded to the Water Rights Division for use in deciding whether the appropriation will be approved by the Department. If the rights of senior appropriators will be impaired the permit may be denied. The Department may also approve a temporary permit to allow time for the stream depletion to be accurately measured.[72]

## NEW MEXICO

New Mexico law has long recognized the interrelationships between groundwater and surface water and has provided a judicial remedy for surface-water appropriators whose rights are infringed upon by junior groundwater users tapping groundwater that is tributary to a surface stream.[73] In addition, New Mexico was probably the first state to tackle the tributary groundwater problem in a systematic manner through administrative regulation. The regulation of groundwater appropriators was first undertaken by the state engineer in 1956. Studies had conclusively shown that the water bearing strata along the Rio Grande River were in close hydrologic connection with the river and that the use of groundwater in the river basin would deplete streamflows. The Rio Grande had been fully appropriated for many years and in addition, was subject to the 1938 Rio Grande Compact between Colorado, Texas and New Mexico and the 1906 Mexican Water Treaty. Any stream depletions caused by groundwater withdrawals threatened to impair New Mexico's compact and treaty obligations and impose substantial hardships on appropriators from the Rio Grande in New Mexico.[74]

Faced with the prospect of additional groundwater development in the basin, in 1956 the state engineer designated the groundwater reservoirs that were hydrologically connected to the river as the Rio Grande Underground Water Basin. To allow the continued development of the vast groundwater supplies of the basin and at the same time prevent the uncompensated impairment of existing surface water rights in the river, the state engineer decreed that no further appropriations would be permitted from the basin unless the applicant agreed to acquire and retire surface-water rights in sufficient quantities to negate the effect of the proposed groundwater withdrawal upon the river. To implement this policy, the state engineer employed a formula to estimate the effects of a proposed well on the Rio Grande over time. Based on this estimate a schedule for the acquisition and retirement of surface water rights would be developed.[75]

For example, the City of Albuquerque applied for permission to construct four wells within the declared Rio Grande Underground Water Basin. The state engineer found that over a 75-year period approximately one-half of the proposed appropriation would be taken from surface flows and one-half from underground storage and therefore the proposed use would impair existing surface-water rights. However, the state engineer also found that the appropriation could be made without harm to existing surface-water users if the applicant would agree to measure the amount of water pumped and the amount of return flow and retire a sufficient number of surface-water rights to compensate for the effects of the appropriation on the Rio Grande. The city insisted the state engineer did not have the authority to impose such requirements and consequently the applications were denied. In the ensuing appeal to the New Mexico Supreme Court the state engineer's authority to impose such requirements on applicants for groundwater permits was upheld.[76]

A different solution to the problem of surface-water depletions caused by groundwater withdrawals was worked out, with the aid of the New Mexico Supreme Court, in the area of the Roswell Underground Water Basin. This is an area of complex geology encompassing two major aquifers. The Pecos River and many small tributaries run through the area. The principal point of discharge for the groundwater system is the Pecos River.

The earliest water rights in the area are for direct use from the Pecos towards its downstream end. Priority disputes between surface-water users were rare due to the availability of groundwater to serve as a supplemental source of irrigation water and a large number of wells had been drilled in the basin by the early 1950's.

A surface-water user by the name of Templeton sought to join his neighbors who had drilled wells to obtain more reliable water supplies in the early 1950's but ran into a serious obstacle in the person of the New Mexico state engineer who denied his applications to drill wells in a shallow aquifer which historically had supplied his source of surface water. Mr. Templeton held a surface-water right in the Rio Felix, a tributary of the Pecos, with a priority date in the 1870's. The flow of the Rio Felix had been sufficient to supply his needs until 1952. By that time, however, groundwater development in the area above his point of diversion had lowered the water table to the point that the natural discharge to the stream was reduced, rendering Mr. Templeton's surface water right inadequate. Mr. Templeton's solution was to apply for a change in his point of diversion for his surface-water right, along with the 1870 priority, to the proposed wells.

The state engineer contended this was in fact a new appropriation of underground water and denied the applications on the ground that prior groundwater users would be affected adversely. The state engineer had adopted an order prohibiting further appropriations from the basin in 1937. The applicant contended he was entitled to "follow his water to its source" and the evidence supported his claim that the river and the shallow aquifer were one interconnected source. The New Mexico Supreme Court agreed with Mr. Templeton and allowed the construction of the wells with an 1870 priority date.[77]

The Templeton Doctrine has been reaffirmed in a series of cases since 1958 and retains vitality today.[78] In *Langenegger v. Carlsbad Irrigation District,* the New Mexico Supreme Court stated that surface-water appropriators are entitled to rely on all the sources that feed their surface-water source, "all the way back to the farthest limits of the watershed."[79] However, the Court has refused to extend the doctrine to allow a surface-water user whose surface source is no longer adequate to drill wells into a fully appropriated aquifer underlying his own land when that aquifer did not serve as a source of supply for his surface-water right.[80]

In contrast to the administrative solution employed in the Rio Grande Basin, the Templeton approach imposes the costs of surface-water depletions brought on by groundwater withdrawals on the senior surface-water users who have to drill new wells. However, one commentator has noted that the different circumstances existing in the Pecos River Valley may make this a more appropriate solution than the Rio Grande Basin approach. No new groundwater appropriations are being allowed in the Roswell Basin eliminating the gradual impact of new groundwater use. In addition, significant efforts have been underway to salvage water and improve efficiencies and the Pecos Valley Artesian Conservancy District has undertaken a program of water-right purchases and retirements in an effort to bring the basin into some balance.[81]

### WYOMING

In Wyoming, both groundwater and surface-water rights are administered on the basis of priority of appropriation. Wyoming law contains a provision which states that where groundwater and the water of a surface stream are so interconnected that they constitute one source of supply, the state engineer is to adopt a single schedule of priorities for both surface-water and groundwater users. Where such an interconnection is shown to exist, the state engineer is authorized to adopt a variety of controls to prevent or mitigate depletions of streamflows caused by groundwater withdrawals. He may close the area in question to the issuance of new permits to appropriate groundwater. He may also determine the total permissible withdrawal of groundwater from the area and allocate that amount among existing groundwater appropriators in accordance with the priority dates of their appropriations. If he determines that withdrawals by junior appropriators are impairing the rights of senior appropriators he may order the junior appropriators to reduce their withdrawals or cease them entirely. If the state engineer determines that a reduction or cessation of withdrawals by junior users will not bring about proportionate benefits for senior users he may adopt a system of rotation of use for groundwater users. Finally, the state engineer may adopt well spacing requirements for new wells to limit the density of groundwater development if additional groundwater appropriations are to be allowed.[82]

Groundwater appropriators are also authorized by law to enter voluntarily into agreements among themselves providing for any method of controlling withdrawals to prevent the impairment of senior surface-water rights. These agreements may include but are not limited to allocation, spacing, and rotation. The state engineer is to approve such agreements provided they are consistent with the state's groundwater management statutes, not detrimental to the public interest or to the rights of persons who are not parties to the agreement.[83]

Wyoming law contains another provision which authorizes any appropriator of groundwater or surface-water to file a written complaint with the state engineer alleging the the holder of a junior right (this section does not apply to any alleged interference with a surface-water right by the holder of another surface water right) is interfering with his water right. Any complaint must be accompanied by a fee of $100 to help defray the costs of an investigation.

Upon receipt of a complaint, the state engineer must conduct an investigation to determine whether any interference is in fact occurring and issue a report. If an interference is found, the state engineer may suggest any remedial measures felt to be appropriate. Any appropriator who is dissatisfied with the result may appeal and obtain a hearing before the appropriate water division superintendent. The superintendent then reports his findings to the Wyoming Board of Control, composed of the superintendents of the four water divisions in the state and the state engineer, which rules on the appeal.[84]

## IMPACTS ON LAKES AND WETLANDS

There are a large number of states with lake or wetland protection laws; California, Connecticut, Delaware, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, New Hampshire, New York, Pennsylvania, Rhode Island, and Wisconsin, to name a few. However, except for those discussed below, these statutes do not specifically address the situation where groundwater withdrawals affect wetlands. This is not to say that legal theories to protect wetlands or lakes from groundwater withdrawals could not be developed based on the policy expressed in these statutes.

### CONNECTICUT

In 1982, Connecticut adopted a permit system for the regulation of major water uses in the state.[85] Subject to certain exceptions, groundwater and surface-water users are required to obtain water use permits from the Commissioner of Environmental Protection. Information required in an application includes a description of the effect of the proposed water use on water-based recreation and wetlands and in deciding whether to issue or deny a permit, the commissioner is to consider the impact of the proposed use on these water uses.[86] No cases applying this statute to lakes or wetlands could be found.

## FLORIDA

Florida law provides that no one may drain or draw water from any lake greater than two square miles in area if it would lower the lake level, without first obtaining the written consent of all abutting property owners.[87] Although the statute does not explicitly deal with groundwater withdrawals that affect lake levels and no Florida cases could be found on the subject, the Florida Supreme Court has interpreted the statute broadly and it might be used successfully by an abutting property owner to prevent groundwater withdrawals that reduce lake levels. The Florida Supreme Court applied the statute in a case where a landowner was diverting water directly from a lake for irrigation and held that the applicability of the statute was not limited to traditional drainage activities. The court noted that there was no basis for holding that the statute only applied when the lowering is brought about by drainage "as opposed to 'pumping' or any other method whereby water can be drawn from a lake."[88]

## MICHIGAN

Michigan law authorizes the Department of Natural Resources or two-thirds of the landowners surrounding a lake to file a petition with the county board of supervisors requesting that a "normal water level" be established for any public or private lake. Normal water level is defined as that level which will provide the most benefit to the public, preserve the natural resources of the state, and protect public health and property values. Factors to be considered in establishing this level include established government surveys, testimony of inhabitants, **the extent to which drainage and other artificial causes have decreased the natural groundwater table** and the extent to which natural causes have increased or decreased the natural water table.[89]

Once the normal lake level is established, the board is to construct or maintain sufficient dams to keep the water level at its normal height. It may also drill wells to supply additional water for the lake.[90] Surrounding landowners may be assessed for the costs of any facilities necessary to maintain the lake level.[91]

## WASHINGTON

Under Washington law, persons desiring to appropriate groundwater for use must obtain a permit from the Department of Ecology.[92] Washington law also provides that rights to appropriate groundwater are not to impair senior surface-water rights and to the extent any groundwater is tributary to the source of any stream or lake, "or that the withdrawal of groundwater may affect the flow of any spring, watercourse, **lake, or other body of surface water,** the right of an appropriator and owner of surface water shall be superior to any subsequent right . . . to groundwater."[93] One should note that this section would only operate for the benefit of a surface-water appropriator and owner. Applications for groundwater appropriations which would conflict with existing rights or be detrimental to the public interest can be denied.[94]

## WISCONSIN

In 1974, the Wisconsin Supreme Court adopted the language of the tentative draft of section 858A of the Second Restatement of Torts as that state's law regarding liability for groundwater uses which interfere with other water uses.[95] Although the case in which the principles of the Restatement were adopted did not deal with a groundwater use reducing the level of a lake, and no subsequent Wisconsin case on point could be found, section 858A does specifically address the situation where groundwater use affects lake levels. The 1971 tentative draft states that one who withdraws groundwater for a beneficial purpose is not liable for lowering lake levels unless the withdrawal of groundwater has a direct and substantial effect upon the lake.[96] The court did not discuss what constitutes "a direct and substntial effect" since the subsection dealing with lakes was not relevant to the case. However, the comment on that subsection in the final version of the Restatement of Torts, Second indicates that the impact of the groundwater withdrawal would have to be "more or less immediate and substantial" for any liability to be incurred.[97]

# ALTERNATIVE STATE POLICIES RELATED TO THE IMPACT OF GROUNDWATER PUMPING ON STREAMFLOW, LAKE, AND WETLAND USES

The following alternatives provide some methods of addressing problems and issues caused by groundwater pumping impacting streamflow, lake, and wetland uses. On face value many of the alternatives presented for this problem and issue have equity between surface-water and groundwater users as their primary emphasis. However, the degree to which either of these groups benefits can have an impact on regional economic well being, the degree to which future investment in surface-water or groundwater development takes place, groundwater or streamflow levels, and environmental factors. Thus a change in the way surface-water and groundwater users are treated can be used primarily as a means to address these other factors. The policy alternatives presented in this chapter are listed below followed by a discussion of each.

## ALTERNATIVE #1

## CONTINUE CURRENT POLICIES RELATING TO THE IMPACTS OF GROUNDWATER PUMPING ON STREAMFLOW, LAKES, AND WETLANDS

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Current state policy on this problem and issue was described in the section on Applicable Nebraska Law. In general those laws do not specifically provide for a surface-water user's recovery of damages from an interfering groundwater irrigator. The exceptions are pumping from pits within 50 feet of a stream, provisions of the Big Blue River Compact, and large-scale industrial users. Neither do the laws specifically prohibit granting damages due to groundwater depletions. However, there is no case law on that point and the cost of proving causality would usually be prohibitive.

If current policies are continued, the impact of groundwater usage on surface-water rights may expand. There is a time and distance lag between groundwater pumping and the point at which any resultant groundwater level declines influence baseflow of surrounding streams. Because groundwater usage has expanded considerably in the last twenty years, one might expect that those effects will intensify in the future. For some streams in areas near groundwater development the point at which baseflow is received and they become perennial may move downstream.

The effects on senior surface-water right holders may be expected to become less equitable as depletions from previous groundwater development reach the stream and as new groundwater development occurs. The *High Plains Ogallala Aquifer Study* projected that although some irrigated acres would be removed from production due to groundwater depletions both surface-water and groundwater irrigated acres were likely to expand in the next forty years. This would result in continuing impacts.

Because surface-water irrigators will most often be senior and have invested in facilities, they could be forced to bear significant costs. This could be especially true if existing surface-water projects are affected. This could occur through expansion of impacts in the Enders situation. It could also potentially result in quantity reductions for other existing surface-water projects, although none of these have been identified. In addition, the threat of groundwater development impacts could inhibit the construction of potential new surface-water supply projects. This has already occurred in the Cedar Rapids case.

Current policies could tend to result in a more thorough use of our groundwater resources in comparison to some other alternatives. Management decisions for individual groundwater irrigators would remain easy in comparison to systems suggested in other alternatives. Administrative costs would remain relatively low.

A major potential impact of maintaining baseflows for surface-water users is that it could result in some water flowing downstream unutilized if (1) a storage project was not involved, or (2) exceptionally high flows caused a storage project to release some of the water generated by baseflows.

Environmental impacts of this alternative would be related to changes in baseflow of streams and lake or wetland water levels. This alternative would probably have some negative impact on habitat requirements related to baseflow and water levels as groundwater pumping lowers the water table in some areas.

## ALTERNATIVE #2

## ADOPT RULES OF LIABILITY TO BE APPLIED TO THE HYDROLOGIC RELATIONSHIP BETWEEN GROUNDWATER AND SURFACE WATER

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Adoption of this alternative and one of its subalternatives would provide guidance to those entities which may have some responsibility for regulating, managing, or resolving disputes attributable to, the interrelationship of groundwater and surface water. These entities may include courts, administrative agencies, and local districts. The number of alternatives reflect the variety of legal principles which have been applied to the interrelationship of groundwater and surface water by courts in other jurisdictions. The impacts of the five subalternatives are discussed together in a section following their descriptions.

(a) Allow groundwater users to (1) make any beneficial use of groundwater under their land without incurring liability for any resulting injury to surface-water users, or (2) make such beneficial use without liability if the groundwater is used on overlying land and the purpose of the use is reasonable.

The initial principle that beneficial use of groundwater can be made without liability to surface-water users is derived from the "absolute ownership" rule which has been used on occasion to allocate groundwater. It permits a landowner to make any use of the groundwater under his land without incurring liability for the resulting injury to his neighbor's groundwater supply. By applying this rule to the interrelationship issue one may argue that it ignores hydrologic reality. In effect it means that surface-water appropriators have no rights to water until it enters the stream. It has been suggested, however, that there may be some economic justification for such a rule. "By putting surface appropriators at a disadvantage, particularly in dry years, fiscal pressure encourages use of groundwater which is generally more costly. The theory is that this promotes utilization of all sources and discourages wasteful practices."[98]

The second principle that beneficial use may be made without liability if used for a reasonable purpose on overlying land is essentially the "reasonable use" rule which has also been applied to groundwater allocation cases. Overlying land would need to be defined under this option. A groundwater user who neither wastes, maliciously diverts, nor uses groundwater off the overlying land is not liable for subsequent injury to other water users resulting from his "reasonable use." In effect, the rule is only a modification of the absolute ownership rule (subalternative (a)(1)) - "a right of capture with the best right, in practice, going to the landowner in the hydrologically superior location."[99]

(b) Establish a cut-off boundary system that creates either a conclusive or rebuttable legal presumption that groundwater withdrawals between the streambank and cut-off line directly affect streamflow.

Under this subalternative, groundwater between the bank of a stream and the cut-off point would be subject to prior appropriation and beyond the cut-off point reasonable use would apply. If a conclusive presumption were applied that all wells within the cut-off boundary have a direct effect on streamflow, no proof could be used to show that a contrary set of facts may exist.

A more flexible approach would be to establish a cut-off system with a rebuttable presumption. In this case in cut-off areas the burden of proof would be on the groundwater user to show that there is in fact no hydrologic interrelationship between his groundwater supply and the stream. This is the principle behind the Nebraska statute which requires a permit from the Nebraska Department of Water Resources to pump from any pit located within fifty feet of the banks of a natural stream. Proof of a hydrologic interrelationship, or lack thereof, can be an expensive undertaking. The burden of proof and expense rests on the groundwater user. Cost can be a fairly effective deterrent. Consequently, the result of this subalternative may be the same as for a conclusive presumption.

Under either method of implementation administration could resemble the system explored more thoroughly under *Alternative #4*. Appropriation permits could be issued for wells inside cut-off boundaries and their use could be regulated according to appropriation statutes. Wells beyond the boundary would be subject only to a rule of reasonable use.

(c) Make groundwater users liable only for injury resulting to surface-water users in higher preference categories.

Both surface-water and groundwater law in Nebraska recognize statutorily preferred uses - domestic, agricultural, and manufacturing. Under Nebraska law, they may be applied to conflicts between users of the same water source. When water supplies are inadequate the more preferred use of water gets water before the less preferred use. Surface-water rules require compensation when preferences are invoked. Groundwater law does not appear to require compensation for the exercise of a preference, perhaps because priority does not enter into the picture.

This subalternative would apply preferences alone to conflicts between surface water and groundwater users. A groundwater user with the same or a more preferred water use than a surface-water user would not be liable for damages for interference with the surface-water use. However, if the surface-water user had the more preferred water use and had initiated use prior to the groundwater user, the groundwater user would most likely be liable for damages. Added protection could be granted to surface-water users by making the preferences absolute. In that event, any groundwater user would be liable to pay damages for interfering with a higher preferred surface-water use, regardless of when use was initiated.

(d) Adopt principles of equity in case of interference between groundwater users and surface-water users.

There are two potential approaches to this problem. One would be to follow a procedure outlined in the Restatement (2d) of Torts. A second approach would be to utilize the balancing of equities system formulated in the 1968 case of *Wasserburger v. Coffee*.

(1) Section 858 (1)(c) of the Restatement (2d) of Torts (1977) states:

"A proprietor of land or his grantee who withdraws ground water from the land and uses it for a beneficial purpose is not subject to liability for interference with the use of water by another, unless the withdrawal of the ground water has a direct and substantial effect upon a watercourse or lake and unreasonably causes harm to a person entitled to the use of its water."

As noted in the official comment to the Restatement text, even though the rule recognizes a correlation between groundwater and water-courses, it is a general rule of nonliability unless the groundwater use has a "direct and substantial effect" on a stream. If a substantial and direct interference is established then the reasonableness of the groundwater use is weighed by the following factors:

1. the purpose of the use,
2. the suitability of the use,
3. the economic value of the use,
4. the social value of the use,
5. the extent and amount of the harm it causes,
6. the practicality of avoiding the harm by adjusting the use or method of use of one proprietor or the other,
7. the practicality of adjusting the quantity of water used by each proprietor,
8. the protection of existing values of water uses, land, investments and enterprises, and
9. the justice of requiring the user causing harm to bear the loss[100].

In other words, "When a stream appropriator . . . seeks to protect his prior rights, a court should balance his gains against the losses junior well owners will suffer."[101]

(2) Balance the equities of conflicting uses based on the principles adopted by the Nebraska Supreme Court in *Wasserburger v. Coffee*.

*Wasserburger v. Coffee*, (1966)[102] involved the competing water claims of a surface-water appropriator and a riparian proprietor. A "balancing of the equities" approach was suggested in this case for resolving appropriation-riparian conflicts. This principle includes a consideration of the following factors:

1. the social utility associated in the respective water uses,
2. the extent of the harm caused by the interference,
3. the relative priorities of the parties,
4. the suitability of the water uses relative to the water supply, and
5. the parties respective ability to prevent or avoid the harm caused by the interference.[103]

Application of this principle could be extended to conflicts between groundwater and surface-water users.

(e) Apply a common pool-correlative rights principle.

This principle is based on sharing during times of shortage. It requires proportional reductions by all users of the interrelated water source to prevent depletion. The "common pool" doctrine developed for the oil and gas industry operates under similar assumptions.

The impacts of adopting subalternative (a) would be to provide groundwater users with a better defense against legal action than they now have. Currently groundwater irrigators may need to weigh the potential of having a successful suit brought by a surface-water user who is willing to go to the expense of proving the impact of their actions. This danger would now be removed. Because this alternative would be used in only a few cases, its impact would probably be small.

The impacts of adopting subalternatives (b), (c), (d), and (e) might be more widespread. In some areas they would tend to have the dual effect of encouraging surface-water development and inhibiting groundwater development. Surface-water users or project developers would be protected to varying degrees from subsequent development of groundwater which diminished their water source. However, potential groundwater developers might fear subsequent suit by surface-water users and therefore decide against development. The value of the water to the groundwater irrigator might be the determining factor. If it was sufficiently high the expense of reimbursing prior surface-water irrigators might be borne with only slightly diminished levels of groundwater irrigation. If groundwater development diminished there would be a negative economic impact which may or may not be offset by more surface-water use or perhaps additional project development.

There may well be more suits brought if alternatives (b), (c), (d), or (e) are adopted and the legal-administrative costs could be high. An especially difficult task would be determining the cut-off boundaries discussed in regard to subalternative (b). There may be no good hydrologic basis for determining these boundaries. Extensive research might be required.

Environmental impacts of these alternatives would vary depending upon whether groundwater use and development, and/or surface-water use and development were changed.

## ALTERNATIVE #3

## ALLOW A GROUNDWATER CONTROL AREA TO BE DECLARED WHEN IT IS DETERMINED THAT GROUNDWATER PUMPING SUBSTANTIALLY IMPACTS SURFACE WATER USERS

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Current Nebraska law provides for establishment of a groundwater control area in case of groundwater quantity becoming inadequate for use or in case of groundwater pollution. This alternative would allow districts wishing to declare a control area to use an additional criterion of groundwater withdrawals having a specified impact on surface flows or lakes and wetlands when asking for a hearing to designate a control area. Surface-water impacts could also be included as a basis for regulation once a control area was established. The funding for administering this alternative could be provided by NRD mill levies or a special levy for a control area.

If the Department of Water Resources decided that a control area could be designated, the local district would have a considerable amount of power to lessen the impact of groundwater withdrawals on surface-water rights or lakes and wetlands. Such powers include: establishing total permissible groundwater withdrawals and allocation of such withdrawals, rotation of groundwater use, well-spacing requirements, well metering, and moratoriums on new well permits.

Adoption of this alternative would involve a fairly simple amendment to existing law. Depending upon the control measures adopted by the local Natural Resources District it could have a substantial impact on baseflows for surface-water rights or lakes and wetlands. The position of senior surface rights could be improved versus the current situation. This alternative could also be adopted through groundwater management areas, although their powers to deal with this problem may not be as extensive. LB726 in the 1982 session of the Unicameral would have allowed creation of a control area where surface water or subirrigation may be adversely affected by groundwater withdrawals. The legislation failed to pass.

Perhaps the most severe problem in implementing this alternative would be a jurisdictional one. The area in which surface-water rights are impacted might be well downstream of the area where the groundwater use is occurring. This may not be insurmountable if both areas are in one Natural Resources District. However, in other cases it may be more difficult to achieve a solution.

A potential effect of this alternative if adopted for surface-water uses could be maintaining baseflow. If the baseflow is not captured by storage structures in the off season it could be lost to the state. On the positive side increased baseflows could help maintain instream values.

If this alternative were adopted groundwater development would be inhibited in control areas and that could have potential negative economic effects. Another possibility is that the measures adopted by the local Natural Resources District may not be sufficiently strict to result in any major effects or that Districts may decide not to declare a control area to protect surface-water users.

If a control area were declared for lakes and wetlands the exact relationship between groundwater pumping and lake or wetland levels could be very difficult to establish. It could be expensive and time consuming to determine that relationship and determine the nature and extent of pumping restrictions necessary to remedy the situation.

In most situations, groundwater pumping could be only one of the changes that has caused a drop in lake or wetland levels. In some cases runoff from fields may have even helped create a wetland. However, in other instances pumping could be the major cause of a drop in lake or wetland levels and adoption of this alternative would be effective. The economic impact of this alternative if adopted for lakes and wetlands could be to decrease crop production income in some cases. That decrease would have to be balanced against lake and wetland aquatic and riparian habitat values and possible economic values or any related wet meadow hay production.

Many administrative aspects of groundwater districts in other western states do not parallel those of Nebraska. However, the powers available in those states are often similar to those used in groundwater control areas in Nebraska and the impact on surface water is a factor in establishing controls.

## ALTERNATIVE #4

### PUT GROUNDWATER RIGHTS IN SELECTED "TRIBUTARY" AREAS IN AN APPROPRIATIVE SYSTEM AND COORDINATE WITH THE SURFACE-WATER RIGHTS SYSTEM. ALSO PROHIBIT NEW WELLS IN "TRIBUTARY" AREAS WHERE GROUNDWATER PUMPING WOULD IMPACT SURFACE FLOW WITHIN A SPECIFIED NUMBER OF YEARS UNLESS JUNIOR GROUNDWATER APPROPRIATORS MEET ONE OF THE FOLLOWING FOUR REQUIREMENTS

(a) Require junior groundwater appropriators to provide substitute water to senior surface-water appropriators by developing additional supplies for use as needed by senior surface appropriators or by purchasing water for their use.

(b) Require junior groundwater appropriators to retire senior surface appropriations by purchase.

(c) Require junior groundwater appropriators who deplete surface-water rights in areas with access to groundwater to provide wells that would allow senior surface water appropriators to use groundwater.

(d) Allow surface-water users to transfer their priority date to a well.

## DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

This alternative is closely related to *Alternative #2* which provides rules of liability to be applied between surface water and groundwater users. It builds upon some of the principles of the subalternatives noted in that alternative. However where liability generally is the primary emphasis in *Alternative #2,* here the emphasis is on an administrative system. Adoption of this alternative in selected areas would place surface-water and groundwater users on a coordinated "first in time, first in right" basis. It could be adopted in a manner that gave existing groundwater users relatively senior rights or a different type of right while future development would receive "junior" rights. This might help avoid a problem caused by existing groundwater development being generally junior to existing surface-water development. The areas selected might first be in basins where significant impacts of groundwater development on surface-water rights have been identified. Either a whole basin could be included, "cut-off lines" various distances from streams could be used, or studies could be done which would be used to help establish for legal purposes the number of years until pumping would impact a stream. An alternative approach would be to restrict groundwater use only when it would have an impact on surface-water rights a specific number of days in the future. This would help ensure a more direct relationship while seeing that the added baseflow was actually used rather than flowing away in off season. Because this approach could restrict the economic benefits of groundwater development and result in the loss of off season baseflow in streams, some means of lessening that impact may need to be implemented as part of the alternative. The four subalternatives presented above could help to lessen that impact.

Subalternative (a), which requires junior appropriators to provide substitute supplies to senior surface appropriators, would serve as an encouragement to the construction of water projects. A problem with this subalternative is that in some cases the cost of providing substitute water through a project might be more than collective groundwater users could bear and they could give up their groundwater use instead. This tendency could be strengthened by the fact that the groundwater irrigator already has pumping costs to bear whereas the surface-water irrigator does not. Nonetheless, in some areas, this subalternative in combination with other funding sources might compensate senior surface rights and contribute to demand for a water project.

Requiring junior groundwater appropriators to purchase supplemental stored water, surface water, or groundwater for use by senior surface-water appropriators would tend to create a market to which water storage projects could sell their rights. The problem in this case would be whether a water storage project exists in an area or could feasibly be built and if so whether its rights might sell for an amount groundwater irrigators would be willing to pay.

Subalternative (b) which requires junior groundwater appropriators to retire senior surface-water rights by purchase is a more direct approach. Arriving at a fair price under this alternative might be a problem because the number of buyers and sellers would be small. However this would help to keep water from being wasted by tending to see that whichever user had the highest economic use for the water would utilize it.

Subalternative (c) requires junior groundwater appropriators interfering with surface rights to provide wells allowing senior surface appropriators to use groundwater. It would encourage full use of the groundwater resource while providing some compensation for surface irrigators harmed by subsequent groundwater use. However senior surface irrigators would still have to bear increased pumping costs, maintenance of new equipment, and possibly the upkeep of separate systems for surface water and groundwater.

Subalternative (d) would allow surface irrigators to transfer their priority date to a well. In places where a supply of groundwater is readily available and pumping lifts are not great, this might be a fairly inexpensive option to obtain a more dependable supply even though it would entail well construction and pumping costs. If groundwater was in danger of being depleted, there would be hesitancy to use this subalternative.

A major problem with adoption of this alternative will be identification of which groundwater users are interfering with a senior surface-water right, the degree and timing of interference and how compensation to the surface-water user would be split among interfering groundwater users. In Colorado, water legally determined to reach a stream channel in 40 years and possibly as much as 100 years is regulated as "tributary" flow. Presumably each new groundwater permit issued in designated "tributary" areas could be required to provide for water for existing surface water users equivalent to what he pumps, or equivalent to that portion of baseflow those surface-water users would otherwise have captured.

One of the problems in implementing this alternative will be that the actual physical situation may be difficult to ascertain and that as in previous alternatives, legal presumptions will need to be made. The accuracy of data on which legal presumptions can be based is a natural concern.

The Department of Water Resources would most likely be the agency chosen to administer this alternative.

The Conservation and Survey Division of the University of Nebraska or the U.S. Geological Survey could help provide some of the physical information which might be used in implementing the alternative.

This alternative would have very high administrative costs, especially after regulations were established. It would require personnel to develop the needed technical information and then to administer groundwater appropriation regulations. It also would require a substantial amount of time and effort to deal with legal challenges. Colorado administrative costs for a similar system have been high. They have had to establish special "water courts" in which district judges are assisted by water clerks and water court referees. Adoption of this alternative could maintain riparian or aquatic habitat levels in areas where water tables or surface flow were maintained as a result of the alternative.

This approach closely resembles the Colorado "tributary" system for dealing with groundwater and surface-water conflicts. It also has some parallels with the Montana system where a groundwater right can be denied if it interferes with surface-water rights. Some basins in New Mexico are administered in a manner that requires new groundwater users to purchase and retire surface-water rights. In Wyoming, where both groundwater and surface-water rights are administered on an appropriation basis, junior groundwater appropriators may be controlled or forced to cease their withdrawals when the state engineer determines they are interfering with senior surface-water rights. Colorado has the most comprehensive of the above systems. However, it should be noted that Colorado has many more surface water irrigators than groundwater irrigators. In Nebraska groundwater irrigators far outnumber surface water irrigators. Therefore, similar measures may not receive the same level of support.

## ALTERNATIVE #5

## EXPAND RESEARCH INTO THE IMPACT OF GROUNDWATER PUMPING ON STREAMFLOW, LAKES, AND WETLANDS

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Adoption of this alternative could aid policymakers in determining need for adoption of other alternatives and subalternatives. It would also be of potential value in implementation of other alternatives or subalternatives.

This alternative could help overcome a timing problem inherent to this issue. Impacts of groundwater pumping on streamflow are delayed by an amount of time depending upon hydrogeologic factors and distance from the stream. Therefore by the time a flow impact is manifested it may be too late to address the problem effectively. Research may help us to learn where these problems will occur. Without research the number of options available to policymakers may be diminished.

Research would be of special help in establishing tributary areas or cut-off lines. It could also be useful in establishing a groundwater control area. Adoption of control areas, tributary areas, or some type of cut-off lines would not absolutely require detailed information. However, one of the purposes of alternatives presented in this chapter is to make the legal system reflect more closely the existing physical situation. Therefore research might be necessary and detailed research may be highly desirable before new administrative systems are imposed. Specific areas in which research might be helpful in establishing various cut-off lines or special areas include many of those described in the Problem and Issue section at the beginning of this chapter. An examination of the timing and amount of surface-water depletion from groundwater development in problem areas could be a special research topic. Such information could prove helpful in deciding whether to adopt an alternative or the severity of measures an alternative should include.

Research and especially data collection would be needed for any ongoing regulatory program. For instance, monitoring to prevent pumping from wells inside cut-off lines would be necessary. Research would be needed to determine pumping impacts when any cut-off lines were drawn.

It would be useful to have some data collection and study concerning the impact of Colorado groundwater pumping on flows in the South Platte River. This might be helpful in determining whether action is needed in the South Platte River Compact.

This alternative probably could be carried out through the University of Nebraska and State agency staffs. Positive impacts of allocating increased funding to research of surface-water and groundwater relationships include the potential for more informed decisions on the impacts of water policies, an ability to utilize different systems of water administration more effectively, and the ability to project future surface flows more accurately and thus plan projects and make individual investment decisions more prudently.

Other potential impacts of adopting this alternative would relate primarily to the costs required to carry out the research. If there was little use made of the data those costs could outweigh the benefits. Highly accurate data on pumping impacts on streamflow might be difficult or impossible to obtain in some cases, even with substantial expenditures for research.

1. Smith, Frank and Souders, Vernon, *"Ground-water Geology of Banner County, Nebraska,"* Nebraska Water Survey Paper Number 39, March 1975, Conservation and Survey Division, University of Nebraska-Lincoln, pp. 24 and 27.

2. U.S. Department of the Interior, Bureau of Reclamation, Cedar Rapids Division, Nebraska, Pick Sloan Missouri Basin Project, *"Working Paper on Water Supply,"* September 1979, pp. 1, 2 and 49.

3. U.S. Department of the Interior, Bureau of Reclamation, *"Annual Operating Plan, Niobrara and Lower Platte and Kansas River Basins,"* Calendar Year Operations, 1983, Calendar Year Outlook 1984, p. 14.

4. U.S. Geological Survey, *"Quantitative Hydrogeology of the Upper Republican Natural Resources District,"* Southwest Nebraska Water Resources Investigations 78-38, p. 2.

5. U.S. Department of the Interior, Bureau of Reclamation, *"Water Use and Management in the Upper Platte River Basin,"* August 1982, p.54.

6. Bentall, Ray, *"Nebraska's Platte River, A Graphic Analysis of Flows,"* Nebraska's Water Survey Paper 53, July 1982, Conservation and Survey Division, the University of Nebraska-Lincoln, p.18.

7. Missouri River Basin Commission, *"Report on the Platte River Basin, Nebraska, Level B Study,"* June 1976, p.54. Also Technical Paper on Stream-Aquifer Hydrology, May 1975, p. 65.

8. Burns, Alan W., *"Simulated Hydrologic Effects of Possible Ground-Water and Surface-Water Management Alternatives In and Near the Platte River, South Central Nebraska"*, U.S. Geological Survey Open File Report 81-1116, 1981, p. 35, this report used stream depletion factors from Lappala, Emery, and Otradovsky, 1979, *"Simulated Changes in Ground-water Levels and Streamflow Resulting From Future Development (1970-2020) in the Platte River Basin, Nebraska:"* U.S. Geological Survey WRI 79-26, 82 p.

9. **Neb. Rev. Stat.** §46-637 (Reissue 1978).

10. **Neb. Rev. Stat.** §46-636 (Reissue 1978).

11. **Neb. Rev. Stat.** §46-637 (Reissue 1978).

12. **Neb. Rev. Stat.** §46-287 (Supp. 1982).

13. Nebraska Legislative Council Committee Report No. 114, Report to the Committee on Water Control, November, 1962, p. 24.

14. **Ibid.** p. 25.

15. LB 489, 73rd Legislative Session (1963).

16. **Neb. Rev. Stat.** §§46-636 and 46-637 (Reissue 1978).

17. **Neb. Rev. Stat.** §46-675 et. seq. Cum. Supp. 1982.

18. **Neb. Rev. Stat.** §46-683 Cum. Supp. 1982.

19. Ratified by Nebraska in LB 609, 77th Legislature (1971), initiation of compact negotiations began in the late 1950's after the U.S. Bureau of Reclamation developed a study proposal to construct a dam and reservoir for irrigation and flood control in the Little Blue River Basin. In order to avoid conflicts with the State of Kansas, a compact was negotiated.

20. Ratified by Nebraska in LB 538, 73rd Legislative Session (1963), 1963 Laws, c. 332, p. 1063. Negotiations on this compact were initiated after a report was released in 1952 by the U.S. Bureau of Reclamation proposing a plan for irrigation development projects in the Niobrara River basin. It was felt that by apportioning the waters in the basin, controversies might be avoided.

21. *State ex rel. Cary v. Cochran,* 138 Neb. 163, 292 N.W. 239 (1940).

22. 138 Neb. 163, 171 (1940).

23. *Olson v. City of Wahoo,* 124 Neb. 804, 248 N.W. 304 (1933).

24. 124 Neb. 804, 811 (1933).

25. R.E. Clark, *Waters and Water Rights,* p. 323.

26. Aiken, J.D., *"Nebraska Ground Water Law and Administration,"* 59 **Neb. L. Rev.** 917, 937 (1980).

27. Aiken, **supra** note 29, fn 90 at 937.

28. *Olson v. City of Wahoo,* 124 Neb. 804, 805 (1980).

29. Harnsberger, Oeltjen, & Fischer, *"Groundwater: From Windmills to Comprehensive Public Management,"* 52 **Neb. L. Rev.** 179, fn. 55, 196; *Level*

*B Study-Legal and Institutional,* Missouri River Basin Commission, 1975.

30. Aiken, **supra** note 29 at 938.

31. *Metropolitan Utilities Dist. v. Merritt Beach Co.,* 179 Neb. 783, 140 N.W. 2d 626 (1966).

32. *M.U.D. v. Merritt Beach Co.,* 179 Neb. 783, (1966).

33. It would seem that the court interpreted **Neb. Rev. Stat.** §46-635 defining groundwater literally: "Groundwater is that water which occurs or moves, seeps, filters or percolates through the ground under the surface of the land."

34. Aiken, supra note 29, fn 94 at 938.

35. Application Nos. 4361 (Lincoln), 10002 (Grand Island), 10011 and 10012 (Fremont), and 10074 (Omaha).

36. Orders fcr Dismissal for Application Nos. 10002, 10011, 10012, and 10074 filed May 13, 1977. Order for Dismissal for Application No. 4361 filed January 15, 1979.

37. Section 858A (c), Restatement (2d) of Torts.

38. Hannay, Recent Developments in Colorado Groundwater Law, 58 Denver L.J. 810 (1981) [Hereinafter referred to as Hannay].

39. Colo. Sess. Laws Ch. 318, §1 1965; Hillhouse, Integrating Ground and Surface Water Use in an Appropriation State, 20 Rocky Mt. Min. L. Inst. 691, 697-98 (1975) [Hereinafter referred to as Hillhouse].

40. *Fellhauer v. People,* 167 Colo. 320, 447 P.2d 986 (1968).

41. **Id.** at 334, 447 P.2d at 993.

42. **Colo. Rev. Stat.** §148-21-2 (1974).

43. **Id.** at §148-21-34(1), -35.

44. **Id.** at §148-21-35.

45. **Id.** at §148-21-17(3).

46. **Id.** at §148-21-35(2).

47. **Id.** at §§148-21-21, -25.

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Chapter 5

# Problems, Issues, and Policy Alternatives Related to Impacts of Streamflow Uses on Recharge of Groundwater

## THE PROBLEM AND ISSUE

**A NUMBER OF MUNICIPALITIES AND IRRIGATORS HAVE WELLS LOCATED ALONG WATERCOURSES AND DEPEND ON INDUCED RECHARGE FROM THE STREAM OR RIVER TO MEET THEIR REQUIREMENTS. IN ADDITION, SUBIRRIGATION IN SOME AREAS MAY BE DEPENDENT TO SOME EXTENT ON STREAMFLOWS. FUTURE DEPLETIONS OF STREAMFLOW COULD ENDANGER THESE USES. THE ISSUE IS: SHOULD LEGAL MEASURES BE ADOPTED BY THE LEGISLATURE TO PROTECT THE INTERESTS OF THESE GROUNDWATER USERS?**

Areas previously mentioned in which groundwater is recharged by surface flow include portions of the Central and Lower Platte Basin, Lower Loup Basin, Lodgepole Creek and a few other stream segments. Some major Nebraska municipal water systems utilize induced recharge for at least a portion of their supply. These include the Omaha, Lincoln, Grand Island, Fremont, Sydney and Kearney systems.

A study of the Lincoln wellfields by Marlette (1968)[1] included a computer model to determine the drawdown of water levels in the aquifer with limited induced recharge from the river. He concluded that the wellfield could supply near maximum water pumpage for 80 million gallons per day for more than 30 days with no flow in the river before excessive decline of the water table would occur. However, if the Platte River were dry for over 60 days, drawdown of the groundwater level would require reducing the quantity of water being withdrawn and some wells would probably be shut off to prevent dewatering of the screens, Marlette cautioned that although. . . "the well field can operate for 30 days without recharge (this) does not mean that the well field is not dependent upon river recharge. Such recharge is the source of most of the water produced from the wells."

Downstream from the entrance of the Loup it seems unlikely that the Platte would, in the forseeable future, be depleted to a degree that the quantity of water contained in flow levels would be insufficient to recharge municipal wellfields. However, there is some question as to whether certain scouring flows are needed to allow recharge to occur and what the costs of mechanical scouring would be. Additional research may be required before that question can be resolved.

A discussion of factors affecting recharge is contained in Chapter 2. Minimum flow levels required to maintain other upstream municipalities or Platte Valley irrigators or subirrigated areas have not been determined. In the Grand Island area there is concern that if recharge is reduced, high nitrate groundwater from the surrounding area might reach the wellfield. In each case study would be required

An additional factor that should be considered is the amount of time it may take for recharge wter from a stream to reach a well and the amount of recharge a well or wellfield may recieve naturally This can vary considerable between well sites In some cases, the impact may occur in a few days in others it may take months.

## APPLICABLE NEBRASKA LAW

Wellfields on the banks of the Platte River serve a number of municipalities. The recharge characteristics of the river valley have provided for a reliable source of high quality groundwater. Dependent as these wellfields are on streamflow, municipalities have been particularly concerned about reductions in streamflow.

Statutory authority for the development of municipal wellfields was granted under the Municipal and Rural Domestic Ground Water Transfers Permit Act.[2] Any municipality or public water supplier may obtain a permit from the DWR ". . .to locate, develop, and maintain groundwater supplies through wells or other means and to transport water into the area to be served. . . ."[3] While the permits are optional, thirty-eight had been issued as of 1982.[4] Many of these permits cover wellfields in areas where an interrelationship between surface-water and groundwater exists.

The advantages to acquiring a permit are fairly abstract insofar as any impact they might have on this interrelationship.[5] Permits are issued priority dates but they are neither integrated with surface-water appropriations nor related to other groundwater uses, most of which are not issued permits.[6] It is interesting to note that permits are valid for five years and as long thereafter as the water for which the permit was granted is used. If the water has not been so used for more than three consecutive years, the permit is subject to cancellation or modification under the forfeiture provisions relating to surface-water.[7] This provision and the issuance of a priority date for permits are interesting in that they are rules generally applied only to surface-water appropriations in Nebraska. The legislative history of the Act sheds some light on this anomaly.

One important feature of the Act has never been utilized by any municipality or public water supply facility. In addition to permits for groundwater use, public water suppliers may be granted permits to store excess, unused, and unappropriated water for recharging groundwater reservoirs.[8] This is essentially a permit to recharge groundwater. Legislative Bill 198 now authorizes this activity for any surface-water appropriator. No public water suppliers have applied for a permit to recharge wellfields under either law, although the City of Lincoln has developed facilities capable of accomplishing it.

The legislative history of the municipal transfers permit act demonstrates a more ambitious attempt to address the problem of protecting municipal supplies from detrimental reductions in streamflows than the enacted law would indicate. The cities of Lincoln, Fremont, Grand Island, and Omaha, having located or planned to develop wellfields near the Platte River perceived a need to protect municipal groundwater supplies from upstream diversions which threatened to reduce the surface flows on which the municipal wells depended for induced recharge. These municipalities filed applications for surface-water appropriations, specifying wells as the method of diversion.[9] The applications were accepted by the DWR, but the cities did not seek an immediate ruling for two reasons. First, the director of the DWR has held the position that ". . .only the waters of a natural stream are subject to appropriation and he has construed the words natural stream to mean 'natural stream flows'."[10] Second, these cities were pursuing efforts to gain enactment of an underground municipal well appropriation statute.[11]

The proposal, Legislative Bill 440, was introduced in 1963 on behalf of the Omaha Metropolitan Utilities District. Its principal features were that:

(1) underground aquifers within one-half mile of any river bank were subject to appropriation in the same manner as water in lakes and streams;

(2) existing groundwater diversions by municipalities were confirmed and given priority from the date use commenced; and

(3) 'domestic use' was defined to include the 'use of underground water by or for municipalities and the inhabitants thereof.'[12] There was a great deal of opposition to LB 440, coming primarily from irrigation well owners who were afraid they might be deprived of water at a critical time. Of concern to other pump irrigators was the question of making all groundwater subject to appropriation.[13] Although LB 440 was eventually rejected by the legislature, it became the basis for compromise legislation.

A committee of sixteen individuals was appointed to work on language for a new bill. Legislative Bill 769, the City, Village and Municipal Corporation Ground Water Permit Act, in the opinion of its introducer, Senator T.C. Reeves, gave ". . .the legal right to cities and villages to do what they are already doing but does not involve streamflow appropriations and would have no competition with appropriation of surface water."[14] Passed by the legislature in 1963 and with only minor amendments since that time, it is the present Municipal and Rural Domestic Ground Water Transfers Permit Act. The law neither protects public water suppliers from upstream diversions nor permits instream appropriations for recharge. As an epilogue, the surface-water appropriation applications filed earlier by Lincoln, Fremont, Grand Island, and Omaha have since been cancelled as permits have now been granted under this act.

Some of these same municipalities are now fighting a transbasin diversion of water from the Platte River in court.[15] The recently enacted interbasin transfer statutes[16] may support the municipalities' cause. Beneficial use, for the purposes of the interbasin transfer statutes, is defined to include the ". . .reasonable and beneficial use of water for domestic, **municipal,** agricultural, industrial, commercial, power production, **subirrigation,** fish and wildlife, **groundwater recharge,** an interstate compact, water quality maintenance or recreational purposes."[17] The Legislature recognized that transbasin diversions could have a variety of impacts on water and other resources in the basin of origin. Several factors were delineated for consideration by the director of the DWR when evaluating an application for an appropriation involving an interbasin transfer. Included are ". . .any current beneficial uses being made of the unappropriated water in the basin of origin;"[18] An application must be denied if the benefits **to the state** from granting the application do not outweigh the benefits **to the state** for not doing so. Theoretically, a municipality and a landowner with subirrigated lands depending upon induced recharge from a stream should be able to make an argument in favor of their current beneficial use of unappropriated streamflow for groundwater recharge and subirrigation in a hearing on an out-of-basin transfer. Whether these uses will be perceived as a benefit to the state is another question, as yet, unanswered.[19]

The interbasin transfer issue was also raised in the context of groundwater use in *Metropolitan Utilities District v. Merritt Beach Co.* It was alleged that the granting of the municipal transfer permit to Omaha's M.U.D. amounted to an unlawful diversion of water from one watershed to another. Applying Nebraska's prevailing groundwater use theory, the court concluded that ". . .where the taking of water beyond a watershed causes no injury to appropriators or riparian owners, no reason exists for not permitting the use of waters for a public and beneficial purpose which would otherwise be lost.[20] This case was decided before the enactment of the interbasin transfer statutes, although, future interbasin groundwater transfers may be subject to the same consideration as transfers of streamflow.

An earlier case, *Osterman v. Central Nebraska Public Power and Irrigation District,*[21] dealt with a surface-water diversion out of the Platte River into the Blue and Republican River basins for irrigation. Based on its interpretation of Nebraska statutes, the court held that transbasin diversions were unlawful and unconstitutional. The court has since overruled itself on this issue of statutory interpretation[22] and transbasin diversions are now permitted in accordance with the interbasin transfer statutes discussed above. It is probable, however, that the court would have denied the transbasin diversion, regardless, because of the benefit of subirrigation to the basin of origin.

The court recognized the right of riparian landowners in the Platte River Valley to object to the diversion based on the alleged destruction of the natural subirrigation existing in the valley. The court found the evidence undisputed, that

> . . .subterranean flow retained in the Platte Valley, in its course, continues relatively close to the top of the soil. At times, in a measure it receives replenishment from rains, from the waters carried in the channel of the river and constitutes natural subirrigation for the entire valley, and especially the lands situated contiguous to the Platte river channel.[23]

The court noted further that, "It would be a sad commentary. . .if. . . the protection of its [the Platte Valley's] natural fertility did not constitute a public interest within the policy of our laws."[24] The court held that subterranean irrigation was a valuable right and loss of this natural subirrigation gave riparian landowners sufficient interest to challenge the transbasin diversion.

Another related case, *Johnson v. Edwards,*[25] was decided in the district court for Sioux County, Nebraska. It has been included here because it contains an issue relating to subirrigation being adversely affected by groundwater withdrawals. However, these same withdrawals also caused springs in the area to dry up, an issue more analogous to Chapter 4.[26] These two issues will be analyzed here to impress upon the reader the fact that the interrelationship of surface-water and groundwater frequently presents issues which overlap - those gray areas again. The law as it applies to one problem can, in some instances, confound resolution of another related problem, although that does not happen in this case.

The district court, in *Johnson v. Edwards,* found that Dry Spotted Tail Creek had not been a natural stream prior to the construction and operation of the Interstate Canal in the early 1900's. The court's reasoning, presumably, was that it had intermittent flow until after 1910, since which time it has had year-round flow. The court concluded that it is now to be recognized as a natural stream. The evidence established that the primary source of water to the creek is seepage from the canal and that the seepage caused the groundwater level around the creek to rise and springs to begin flowing in the creek. This rise in the water table benefitted Johnson's lands by providing subirrigation for pastures and streamflow in the creek.

Edwards installed irrigation wells, however, and the court found pumping from them caused the springs on Johnson's land to disappear in late winter and the creek to go dry. This, in turn, decreased the productivity of Johnson's subirrigated pasture. The court awarded damages for the resultant diminution in the market value of Johnson's land.

The court concluded that the principles set forth in Section 858A Restatement (2d) of Torts apply to the facts of this case. Section 858A states:

> A possessor of land or his grantee who withdraws groundwater from the land and uses it for a beneficial purpose is not subject to liability for interference with the use of water by another, unless
>
> (a) the withdrawal of water causes unreasonable harm through lowering the water table or reducing artesian pressure,
>
> (b) the groundwater forms an underground stream...[in which case other rules apply - see problem one], or
>
> (c) the withdrawal of water has a direct and substantial effect upon the water of a watercourse or lake...[in which case other rules apply].[27]

While not specifying further, the court apparently found support for its decision in exceptions (a) and (c) to the general principle of nonliability. The court's opinion was meager in this respect. For one thing, the court in its findings of fact, found no evidence that Edwards was making an unreasonable use of the groundwater pumped for irrigation. Exception (a) above, however, required that a finding of "unreasonable harm" before liability would attach. Also there was no finding that the pumping had a "direct and substantial effect" on the creek. The court's reasoning in this case was insufficient in establishing direct causation and clear application of Section 858A. The case was unique, however, in its treatment of the problem of attempting to correlate groundwater and surface water to resolve a specific controversy.[28]

## LEGAL AND ADMINISTRATIVE MECHANISMS USED IN OTHER STATES

California and Arizona were the only states researched where this issue had been partially addressed. An analysis of the applicable legal situation in each state follows.

### ARIZONA

No statutory provisions explicitly addressing the situation described in this problem and issue could be found in the Arizona statutes. However, Arizona is one of the few states in which this specific issue has been at least partially litigated. In *Maricopa County Municipal Water Conservation District No. 1 v. Southwest Cotton Co.*[29] the Arizona Supreme Court was confronted with the task of determining the rights of two groundwater users, Southwest Cotton Company and Valley Ranch Company, who claimed their groundwater supply was being reduced by surface-water users who had initiated their use of water subsequent to the groundwater users. The defendants in this case were the Maricopa County Municipal Water Conservation District No. 1, Beardsley Land and Investment Company, and a Mr. Pleasant, all of whom were storing and using waters of the Aqua Fria River for irrigation.

The lower court granted an injunction against the defendants. Under Arizona law at that time, surface water, subflow of a stream, and water in "definite underground streams" was subject to appropriation. Percolating groundwater was not. After determining the plaintiff's wells tapped a well- defined subterranean stream, the trial judge granted them the relief requested because the priority date of their "appropriation" was earlier than the priority date of the defendant's surface-water use.

The Arizona Supreme Court disagreed with the finding that the groundwater in question was flowing in a well-defined underground stream. Applying the established presumption that groundwater is percolating rather than flowing in an underground stream, the court found the plaintiffs, at least as far as the wells that were not located in or immediately adjacent to the river were concerned, had failed to rebut that presumption with clear and convincing evidence and therefore could not base their claim for relief on a prior appropriation of water.[30]

The Arizona Supreme Court remanded the case for a new trial and provided the trial court with guidance on the issues presented. The court stated that the plaintiffs might be able to claim an appropriative right for their wells immediately adjacent to or in the bed of the Aqua Fria River if they could clearly demonstrate that these wells were tapping subflow of the river. To accomplish this the court stated the plaintiffs would have to show that the water in question was under or near the bed of the stream and any diversion from their wells would "diminish appreciably and directly the flow of the surface stream."[31] The court was also willing to admit to the possibility that the plaintiffs might have protectable rights for their wells which were not in or adjacent to the stream channel but which were fed by the percolation of surface water simply by reason of their status as overlying landowners. However, no ruling on this question was made.[32] This case did not find its way back to the Arizona Supreme Court for further action on the issues presented.

### CALIFORNIA

The issue of protecting the rights of groundwater users against subsequent diversions of surface water that would reduce or eliminate recharge of the groundwater supply was first litigated in California in 1910. The plaintiff in *Miller v. Bay Cities Water Company*.[33] owned a 21-acre orchard overlying a aquifer that was fed by seepage from the Coyote River. That river also supplied irrigation water for his orchards. The water company was a corporation organized for the purpose of selling water to communities around San Francisco Bay lying outside of the watershed of the Coyote River. The defendant intended to dam and divert up to 20,000,000 gallons per day from the river and its subflow. The plaintiff sought an injunction to prevent diverting any of the surface or subsurface flow of the Coyote River. The trial court granted the injunction based on its finding that the plaintiff's long-standing use of the groundwater was dependent on the seepage of water from the stream.[34]

The ruling of the trial court was upheld by the California Supreme Court which appeared to place considerable reliance on the evidence showing that the water reaching the plaintiff's well arrived there by means of a discernable underground channel and the fact that there were hundreds of other overlying property owners who depended on the seepage of water from the stream to supply their wells.[35] The court stated:

"the owner of land having an underground water-bearing stratum supplied by the flood waters of a stream has a primary right to the full flow of such waters, in order to bring his stratum up to its water-bearing capacity. . . .While the owner of the underground stratum is only entitled to the flow of flood waters to the extent that they may replenish his water-bearing stratum, still his right to the accustomed flood flow of the stream for that purpose is paramount to that of an appropriator to divert any of the waters for use beyond the watershed."[36]

The defendant argued that because the lands on which the plaintiff's orchard was located were not riparian lands, he had no right to an injunction against an appropriator seeking to divert the waters of the stream. This contention was rejected by the court by noting that, if both of the parties were overlying groundwater users or both riparian landowners, the defendants would be prohibited from withdrawing waters from their common source of supply for use outside of the watershed. It could see no reason why the same rule should not be applied in a case involving an overlying groundwater user and an appropriator.[37]

The holding of the *Miller* case was modified somewhat in a 1933 California Supreme Court decision. In *Peabody v. Vallejo*[38] a variety of plaintiffs filed suit against the City of Vallejo to enjoin the construction of a dam on Gordon Valley Creek. At trial the plaintiffs established that they had for sometime been making various uses of the waters of the creek. In some cases they relied on the flood flows of the creek to saturate their lands and maintain their water table. The trial court granted the relief requested.

The California Supreme Court reversed this decision based primarily on a 1928 constitutional amendment. This amendment states that, owing to climatic conditions prevailing in California, the public welfare requires that the state's water resources be put to beneficial use to the fullest extent possible and that waste, unreasonable use, or unreasonable method of use be prevented. Riparian rights in streams were explicitly limited to apply to no more than that which could be put to a reasonable beneficial use.[39] The court stated that the claimed right of some of the plaintiffs to have the benefit of the full flow of the stream to maintain the underground water supply was subject to this newly enunciated policy. Although the court reaffirmed the principle enunciated in the Miller case that the rights of overlying groundwater users were superior to those of an appropriator attempting to divert streamflow for distant use, it went on to suggest that solutions other than injunctions would be more appropriate in light of the Constitutional amendment and that any real harm shown should be compensated by money damages or a physical solution in the form of a substitute water supply. In the case of the plaintiffs claiming rights to the full flow of the stream in order "to press a small amount of water into adjoining lands," the court stated this appeared to be an unreasonable use in which case they should not be entitled to any compensation. However, the court stated additional evidence on the question of the impact of the dam on groundwater replenishment should be taken on retrial.[40] It also stated that mere inconvenience, or even added expense such as that necessitated by deepening wells, within reasonable limits, should not be used to deny a subsequent appropriator from putting water to use. Only an interference causing "substantial damage" should be actionable.[41]

The principles first enunciated in *Peabody v. Vallejo* were applied by the California Supreme Court again just one year later in *Lodi v. East Bay Municipal Utility District.*[42] This action was filed by the City of Lodi to enjoin the East Bay Municipal Utility District and the Pacific Gas and Electric Company from storing and diverting water from the Mokelumne River. The city contended that the well fields from which it obtained its water supply were dependent on seepage from the river and that any interference with the normal or flood flows of the river would impair its prior right to the water.

The city's population was 8,000 and its annual use amounted to roughly 3,600 acre-feet. The average annual flow of the river measured at a point upstream from Lodi, was 815,000 acre-feet. The annual runoff varied from a high of 1,500,000 acre-feet to a low of 200,000 acre-feet. Defendant East Bay Municipal Utility District was proposing ultimate diversion of 224,000 acre-feet annually for domestic and municipal purposes. The population residing in the District was approximately 500,000 people. Pacific Gas and Electric's project was primarily for hydroelectric power generation, although a small diversion of water for municipal and domestic purposes was involved. All but a small amount of the water used at its several reservoirs was released back into the stream after use for power generation.

The District's water rights were granted on the condition that the vested rights and underground water users downstream from the dam would be protected. The District was required at its own expense, to undertake a study of the impact of their diversion on groundwater supplies in the area. The District contracted with the U.S. Geological Survey for this study, the results of which in many respects discounted the claims of the plaintiff.[43] At the beginning of the trial the plaintiff offered to withdraw its suit if the defendants would construct a series of five collapsible ponding dams in the vicinity of Lodi to maintain the seepage of flow into the groundwater reservoir. The cost of this was estimated to be several hundred thousand dollars and both defendants declined the offer. During the trial the District proposed to operate its facility to allow for certain releases that it claimed would maintain the groundwater recharge to the plaintiff's wells and to replace Lodi's water supply by drilling new wells or by directly furnishing water to the city through the District's facilities if the city could prove it was damaged by the District's operations. Pacific Gas and Electric also submitted a plan of operation it felt would avoid any adverse impacts on the plaintiff.

After a lengthy trial the lower court found that Pacific Gas and Electric's plan of operation would avoid any harm to the city's water supply and incorporated that plan into its decree, thereby making compliance with it mandatory. The court's decree also provided for a detailed schedule of releases from the District's facilities designed to maintain the recharge to the plaintiff's wells. Failure to comply with the provisions of the decree would result in an injunction against the defendant's operations.[44]

The California Supreme Court upheld the trial court's findings of fact for the most part but remanded the action for retrial on certain issues because it found the trial court had based its ruling on an incorrect application of the law. The court accepted the trial court's findings that the Mokelumne River was the source of supply for plaintiff's wells and that the defendant's operations would affect that supply adversely. The remaining question with which it was confronted was the nature of the conditions that should be imposed on the defendants. The court stated that the defendant's proposed uses were beneficial uses and should be permitted without unreasonable restrictions if they could be carried out without causing the plaintiff substantial injury.

At trial the court had taken the position that the only option available to it in the absence of an agreement between the parties regarding a physical solution, was to work out a plan of operation for the defendants that would maintain the historic percolation and enforce it by means of an injunction. The decree issued required the District to release anywhere from 120,000 to 360,000 acre-feet per year in order for the plaintiff to continue its annual withdrawal of 3,600 acre-feet from its wells. The California Supreme Court stated that the "mere statement of the essential provisions of the decree entailing the huge releases enumerated, with the tremendous waste entailed, is sufficient to cast grave doubt on its propriety."[45] The court was willing to assume that prior to the 1928 constitutional amendment first interpreted in Peabody, the plaintiff in this case would have been entitled to an injunction fixing releases provided for in the trial court's decree. It also assumed that prior to 1928 the plaintiff could not be forced to accept a physical solution developed by the court. However, the court stated that the rule laid down in *Miller v. Bay Cities Water Company* to the effect that the full flow of the stream may be used to force a relatively small quantity of water into adjacent groundwater reservoirs and that a prior appropriator is entitled to an injunction to maintain this natural condition even though the appropriator's right might be protected by the use of a much smaller quantity of water was no longer the law in California. Instead the constitutional mandate of reasonable use and reasonableness in method of use prevailed.[46]

Applying this law to the case before it the court noted they were presented with a different factual situation than had been presented in the *Peabody* case. Here the plaintiff had demonstrated that the District's operations would cause material injury to Lodi and the court felt that, under existing conditions, Lodi's method of diversion was reasonable. The court felt the plaintiff's right was entitled to protection and that the burden was on the defendant to prove there was a surplus.

The remaining question was whether there was any way to protect fully the city's right without that waste of water the court felt would result if the decree were enforced. The court stated the 1928 constitutional amendment required trial courts to determine whether some non-wasteful physical solution to the problem can be developed before issuing a decree which, as had occurred in this case, would result in a waste of water. Such a solution could not have an unreasonable adverse effect on the plaintiff's rights, however.

In this case the various solutions proposed by the parties had not been acceptable to all involved. Lodi suggested construction of a series of small dams. The District offered to drill new wells for the city closer to the river. Regarding the District's offer, the court noted that it amounted to a proposal to substitute a new and inferior right for the one already held by the city. Because withdrawals from the proposed well field would have affected surrounding users adversely and subjected the city to legal liability for damages, this did not appear to be an adequate physical solution.

The District also offered to supply the City with water from its pipeline. Lodi objected because in its opinion, the District was without authority to deliver water to a municipality that did not lie within its boundaries. The court felt this objection was groundless and that the District had the implied power to furnish Lodi with water if doing so was necessary to operate its project.

The trial court had taken the view that if the parties could not agree to one of the physical solutions proposed, it had no authority to force a solution on them. The California Supreme Court disagreed strongly with this, stating that the 1928 constitutional amendment imposed a duty on the trial court to admit evidence on possible physical solutions or propose them on its own motion with the assistance of the division of water rights. Furthermore, it held that if the parties could not agree the court had the power to force a solution on them. The court stated that, if upon remand of this case a physical solution selected by the trial court involved a substantial expense, that expense should be borne by the District since the city as a prior appropriator should not be expected to absorb substantial costs in order to accomodate a subsequent appropriator.[47]

Returning to the facts of this case, the court noted that one of plaintiff's experts had admitted that groundwater level declines of up to 25 feet could occur in plaintiff's wells before any substantial damage would result. Since the trial court had found that, if unregulated, the

District's operations would lower the water level in plaintiff's wells at a rate of one foot per year, and the Supreme Court could see no immediate danger. Under the circumstances, the court felt that the trial court should take evidence on the issue of how low the levels in plaintiff's wells could go before a substantial danger to the city's water supply would be posed and that the decree then should be amended to place a duty upon the District to maintain groundwater levels above the danger point. The court felt that, if this danger level was reached, the District should be required either to raise the water level or to provide an alternative water supply. If the District should fail to meet this obligation the court stated the trial court should issue an injunction compelling releases as provided in the original decrees. In addition, the trial court was directed to retain jurisdiction in order to modify its decree as the circumstances warranted.[48]

## ALTERNATIVE STATE POLICIES RELATED TO IMPACTS OF STREAMFLOW USES ON RECHARGE OF GROUNDWATER

The following four alternatives present some ways of addressing problems and issues caused by the impacts of streamflow uses on recharge of groundwater. Those uses include subirrigation, municipal wellfields and wells for other uses, including irrigation.

### ALTERNATIVE #6

### CONTINUE CURRENT POLICIES RELATING TO THE IMPACTS OF STREAMFLOW USES ON RECHARGE OF GROUNDWATER

#### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Current state policy regarding impacts of streamflow uses on recharge of groundwater was described in the section on Applicable Nebraska Law. Those laws generally do not provide instream surface-water rights for groundwater recharge purposes. However, the right to divert water for recharge outside the streambed does exist.

It is difficult to speculate how changes in surface flows might impact existing induced-recharge wellfields. What future storage projects might impact streamflows, the degree of groundwater development impact on baseflows, and the amount and timing of flow needs for induced recharge are all subject to question at this time. However, a number of projects for diversion of water from the Platte River have been proposed. Since most public water-supply systems inducing recharge from a river are along the Platte, there could be some future quantity impacts. However in the foreseeable future, those impacts probably would be confined to those areas above the confluence of the Platte and Loup Rivers. The impact that scouring flows may have on recharge is uncertain but probably small. If future projects lessen flows, the ability to recharge may or may not be affected along portions of the Platte. If scouring is a major factor, which is doubtful, this could include some areas downstream from the confluence of the Loup. Mechanical scouring would be a possibility in such cases. The amount and duration of flow and aquifer capacity are the primary determinants of recharge along most of the Platte.

In the Platte Valley and in other areas also, irrigation and subirrigation would be affected similarly to public water-supply systems by changes in water quantity. However many of these other uses occur in areas other than along the Platte. The quantity of surface water used has not been rising dramatically except for that required by new surface-water projects. For that reason it seems unlikely that many irrigation or subirrigation uses would be threatened outside of those areas where new projects are proposed.

One significant option available under current policy is diversion and storage of streamflow for recharge. This could be implemented by municipalities which hope to make their access to recharge more certain.

Potential impacts associated with continuing current policies include continued low administrative costs. Other major impacts would involve continued ability to divert water for immediate out-of-stream uses rather than risk its leaving the state. Quality of some municipal water may decline if insufficient recharge occurs. This may apply specifically in the Grand Island area, where induced recharge prevents inferior quality groundwater from seeping into the wellfield.

Public water suppliers, irrigators, and subirrigators who initiated their use of induced recharge water prior to surface-water depletions could bear the economic cost of continuing current policies. There may also be a reluctance by those users to make investments which depend upon their unsure sources of supply. They may also hesitate to make expenditures for out of stream diversion and recharge until subsequently appropriators have caused supplies to become inadequate.

### ALTERNATIVE #7

### ADOPT RULES OF LIABILITY TO BE APPLIED TO THE HYDROLOGIC RELATIONSHIP BETWEEN GROUNDWATER AND SURFACE WATER

(a) Establish a cut-off boundary system that creates either a conclusive or rebuttable legal presumption that wells within the cut-off boundary are dependent upon induced recharge from the stream.

(b) Make surface-water users liable if their actions result in injury to groundwater users in higher preference categories.

(c) Adopt principles of equity in cases of interference between streamflow users and groundwater users.

(d) Apply a common pool-correlative rights principle.

## DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Adoption of this alternative and one of its subalternatives would provide guidance to those entities which may have some responsibility for regulating, managing, or resolving disputes attributable to, the interrelationship of groundwater and surface water. These entities may include courts, administrative agencies, and local districts. This problem reflects the opposite or mirror image of the problem examined in the preceding chapter. Here, reductions in streamflow are adversely affecting groundwater users. As a result, many of the liability rules appear to be the same. They are being viewed, however, from the perspective of the groundwater user. The impacts are discussed together following a description of the four subalternatives.

(a) Establish a cut-off boundary system that creates either a conclusive or rebuttable legal presumption that wells within the cut-off boundary are dependent upon induced recharge from the stream.

Under this subalternative groundwater between the bank of a stream and the cut-off boundary could be subject to prior appropriation in conjunction with the surface flow appropriation system and beyond the cut-off boundary reasonable use would apply. If a conclusive presumption was applied that wells within the cut-off boundary are dependent on recharge water, no proof could be legally used to show that a contrary set of facts may exist.

A more flexible approach would be to establish a cut-off system with a rebuttable presumption. In this case in cut-off areas the burden of proof would be on the junior surface flow user to show that there is in fact no interrelationship between his surface use and the groundwater user. The economic burden rests, as does the burden of proof, on the junior surface-water user. Cost can be a fairly effective deterrent. Consequently, the result of this subalternative may be the same as for a conclusive presumption.

Under either method of implementation administration could resemble the system explored more thoroughly under *Alternative #4.* Appropriation permits could be issued for wells inside cut-off boundaries and their use could be regulated along with surface appropriations according to appropriation statutes. Wells beyond the boundary would be only subject to a rule of reasonable use.

(b) Make surface users liable if their actions result in injury to groundwater users in higher preference categories.

Preference statutes that have been enacted for both surface water and groundwater in Nebraska recognize domestic, agricultural and manufacturing uses specifically. The statutes provide that when water supplies are inadequate for all uses, the more preferred use has the opportunity to use the water first. Surface-water rules require compensation when preferences are invoked but groundwater rules do not appear to require it. This subalternative would apply preferences to interferences between groundwater and surface-water users.

Municipalities would be provided only partial protection by this subalternative because municipal use is not identified in the preferences sequence. The portion of municipal use which can be designated domestic, however, would be preferred.

(c) Adopt principles of equity in cases of interference between streamflow users and groundwater users.

There are two potential approaches to this problem. One would be to follow a procedure outlined in the Restatement (2d) of Torts. A second approach would be to utilize the balancing of the equities system formulated in the 1968 case of *Wasserburger v. Coffee.*

The Restatement does not have a rule which directly addresses problem two. However, there is a "test of reasonableness" which is applied to other situations involving conflicts between water users. Determining the reasonableness of a certain use depends on a consideration of the following factors:

(1) the purpose of the use,
(2) the suitability of the use,
(3) the economic value of the use,
(4) the social value of the use,
(5) the extent and amount of the harm it causes,
(6) the practicality of avoiding the harm by adjusting the use or method of use of one proprietor or the other,

(7) the practicality of adjusting the quantity of water used by each proprietor,
(8) the protection of existing values of water uses, land, investments and enterprises, and
(9) the justice of requiring the user causing harm to bear the loss[49]

This test could be used to determine relative reasonableness where a groundwater user dependent on streamflow for induced recharge is being injured by an upstream surface-water diversion. It would involve an examination of the interest alleged to be harmed, the respective uses, and the effects on society, the economy, and the environment.

*Wasserburger v. Coffee*[50] involved the competing water claims of a surface-water appropriator and a riparian proprietor. A "balancing of the equities" approach was suggested in this case for resolving appropriation-riparian conflicts. This principle includes a consideration of the following factors:

(1) the social utility associated in the respective water uses,
(2) the extent of the harm caused by the interference,
(3) the relative priorities of the parties,
(4) the suitability of the water uses relative to the water supply, and
(5) the parties respective ability to prevent or avoid the harm caused by the interference.[51]

Application of this principle could be extended to conflicts of the nature described in problem two. This "balancing the equities" test is essentially the Restatement "test of reasonableness" with the added consideration of the relative priorities of the conflicting uses involved.

(d) Apply a common pool-correlative rights principle.

This principle is based on sharing during times of shortage. It requires proportional reductions by all users of an interrelated water source to prevent disproportionate harm to any one user in any group of users. Collective rather than individual liability is the result here. All water users, including the one immediately injured, share equally the burden of a declining water supply. This subalternative may be most appropriate in those situations where it is difficult or impossible to specifically identify the water user causing the harm.

An impact of adopting this alternative would be to cause junior surface-water users legal uncertainty and thereby discourage surface water use in some areas. However, some senior groundwater users would retain their access to their source of water. A special problem in this alternative would be determination of the degree of impact a surface-water user was having on a groundwater user. It would need to be determined whether a lowering of pumping lift was allowable.

Subalternative (a) would present the same problem as in previous alternatives involving cut-off boundaries. Once again, there may be no hydrologic basis for setting those boundaries, and extensive research may be needed. Legal and administrative costs could be high for any of the subalternatives as more legal actions may occur.

Because this alternative might result in fewer streamflow diversions there could be improved riparian and aquatic habitat values in areas upstream of those receiving the groundwater recharge. However, if surface water flowed from the state unused when it could have been diverted there could be economic waste. There could be equity problems with this alternative in that some users may be harmed more by a proportional cut than others. In addition, some water uses may take a certain amount of water or they will not be done at all. For instance, reductions of water applied per acre will at some point result in very low or no crop yields for everyone.

## ALTERNATIVE #8

## ALLOW GROUNDWATER USERS WHOSE SOURCE IS DERIVED SUBSTANTIALLY FROM STREAMFLOW TO OBTAIN SURFACE-WATER RIGHTS

(a) Allow public water systems to obtain surface-water rights if their source of supply is dependent on induced recharge from a stream.

(b) Allow groundwater irrigators to obtain surface-water rights if their water source is substantially dependent on recharge from a stream.

(c) Allow subirrigators to obtain surface-water rights if maintenance of a high water table is dependent on recharge from a stream.

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

(a) Allow public water systems to obtain surface-water rights if their source of supply is dependent on induced recharge from a stream.

The portion of this alternative that deals with public water systems was previously considered in the *Policy Issue Study on Municipal Water Needs*. The description in that report stated:

"Acceptance of this alternative could result in legal recognition of the hydrologic relationship between groundwater and surface water and eventually lead to conjunctive management of the water resource. The most direct method of implementation would involve a statutory amendment clearly directing the Department of Water Resources to issue surface water rights for flows diverted through artificial or induced recharge of wells, wellfields, and infiltration galleries adjacent to streams. A second method could result from administrative decisions to issue such surface water rights with subsequent acceptance of the action by the courts. This latter method involves risking the anticipated result should the courts disagree with the administrative decision. A final possibility would be to allow municipalities to reserve such rights for future use.

Adoption of this alternative in itself, without elevating total municipal use in the preference system, would not benefit municipal interests in times of water shortage. The newly acquired municipal rights for induced recharge would be junior to other water rights and in the absence of a higher preference, continued surface flow for recharge in drought periods could not be acquired."

For adoption of this alternative it would be necessary to determine that the public water system was using groundwater that was substantially derived from a surface source. Because there are relatively few of these systems and they are often located very near the stream this might be an easier process than if irrigators or subirrigators were given such rights. However in some cases considerable time and effort might be involved. In any case "substantial" would need to be defined.

A special type of situation this alternative could deal with if desired would be one such as may be occurring at the Grand Island wellfield. There it is suspected that recharge from surface water keeps the water table sufficiently high that surrounding poor quality groundwater is kept from flowing into the wellfield. If the wells were to be pumped without sufficient surface recharge the water table gradient between the wells and the surrounding polluted groundwater would be sufficient that incoming groundwater would pollute the wellfield. In any application for a water right the Department of Water Resources would need first a study to determine whether an inflow of contaminated water to the wellfield was occurring and whether restriction on junior surface rights would inhibit that inflow by providing sufficient water to the alluvial aquifer to stem inflow of contaminated water.

The Grand Island case does provide an instance where this alternative could have an environmental-water-quality impact. To the degree this alternative maintained streamflows for a municipality it could also preserve riparian and aquatic habitat values.

One further item which would need to be addressed is when an induced recharge well user could call for his appropriation. The fact that some groundwater remains in storage might mean that a continuing appropriation amount could result in that water not being used. If a variant of the alternative were adopted to supply surface water to prevent contamination from incoming groundwater, considerable waste could be involved.

A major impact of this alternative would be equity related. Municipalities could receive surface-water rights which would allow them to have a senior appropriation to subsequent surface-water users. In times of shortage this could eventually result in municipalities receiving water and junior appropriators not receiving water. Thus in the future the economic value of the water would be acquired by the municipality rather than other potential appropriators. However, this would only happen when and if a stream was depleted to the point that a municipality was willing to exercise its appropriation. There could also be some additional willingness by municipal suppliers to invest in facilities, once a supply was assured.

(b) Allow groundwater irrigators to obtain surface-water rights if their water source is substantially dependent on recharge from a stream.

If surface-water rights were granted to groundwater users for irrigation, administrative difficulties would be considerably greater than implementing the alternative solely for public water systems. There would be a considerably larger number of sites where this type of right could be requested. Wherever there are losing streams, groundwater levels are affected to some extent by streamflows. The extent and timing of streamflow impact varies with distance from the stream and geologic characteristics. Thus determining what flow is "substantially" derived from surface recharge may require both research on individual sites and a definition of what constitutes "substantial." When combined with the large number of potential groundwater pumping sites this could prove very difficult to administer. It would probably be administered by the Department of Water Resources. However research help might need to be provided either through another public agency or the applicant. In some cases where water was used to maintain flows for recharge during irrigation season it may be wasted by intransit losses or wasted later when the water makes its way back to the stream as baseflow in the off season.

Conversely current appropriations can be diverted from the stream as needed. This subalternative would have the advantage of allowing groundwater irrigators to make investments in irrigation equipment without the fear that subsequently issued surface-water rights would deplete their suppliers.

The alternative bears at least some relation to surface water development projects whose primary purpose is groundwater recharge. In those cases rights to divert water for recharge water may be granted to a project, though not to each of the individuals utilizing recharged water. Existing projects are in turn allowed to charge a nominal fee for the water, though they may not control the pumping rate or the amount of water used. New projects can control the water they store and charge for all recharge benefits provided. Proposed projects with recharge as a goal such as that examined in the O'Neill Alternatives Study are potential sources of recharge rights for irrigation. However, those rights would be issued to projects, not individual landowners.

(c) Allow subirrigators to obtain surface-water rights if maintenance of a high water table is dependent on recharge from a stream.

There are limited areas of the state where surface flows help raise the water table near the stream and result in subirrigation of those adjacent areas. Some limited areas along losing segments of the Platte are known to utilize subirrigation. The number of areas affected and the extent and timing of surface flows affecting subirrigation could be difficult to identify. Thus, as in the previous subalternative, identifying areas "substantially" impacted by surface flows would require both a good definition of "substantially" and possibly site specific research. The other administrative impacts would be similar to the previous subalternative. This alternative would have the advantage of allowing subirrigators who had initiated use of the water first to continue those uses. It might also have the environmental benefit of maintaining wetlands near a subirrigated area. Also possible are continued low economic values of lands which cannot be drained.

### OTHER WESTERN STATES HAVING SIMILAR POLICIES

This issue has been at least partially litigated in Arizona and California. In Arizona (which did not issue appropriations for percolating groundwater at that time) the state supreme court found that wells directly tapping "subflow" of a river could obtain an appropriative right. However, it made no ruling on the question of whether wells not in or adjacent to the stream channel but which are fed by the percolation of surface-water might have protectable rights.

In California groundwater users having prior appropriation rights were judicially determined to be entitled to the raising of their water levels or an alternative water supply if the diversion of surface water by a junior appropriator would cause substantial damages. However, this was subject to using the water in a reasonable non-wasteful manner.

## ALTERNATIVE #9

## EXPAND RESEARCH AND DATA COLLECTION RELATED TO IMPACTS OF STREAMFLOW USES ON RECHARGE OF GROUNDWATER

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Adoption of this alternative could aid policymakers both in deciding whether adoption of other alternatives are needed and potentially in deciding how to best implement an alternative. There is currently incomplete knowledge at various locations as to how many days of no flow are acceptable, and total flow volumes needed if recharge is to be successful at the potential induced recharge sites along the Platte. Some disagreement may also exist on what the impacts of scouring flows may be. Research could give decisionmakers a better idea of the impacts of potential policy decisions.

Knowledge of how many days of no flow are acceptable could be especially helpful in deciding when to begin administering an instream flow right for recharge purposes.

If irrigation or subirrigation were to receive new rights additional research could be required for setting cutoff lines where different legal presumptions were applied. Information on the degree to which surface water affects groundwater levels and the timing with which it affects those levels could be helpful in administering alternatives presented for this problem and issue.

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2. **Neb. Rev. Stat.** §§46-638 to 46-650 (Reissue 1978, Supp. 1982).

3. **Neb. Rev. Stat.** §46-638 (Supp. 1982).

4. See Table, 44 Dept. of Water Resources Report 473 (1981-1982).

5. The Act provides clear authority to transfer groundwater off the overlying land and spacing protection for test holes and wells under construction. **Neb. Rev. Stat.** §§46-638 and 46-654 (Supp. 1982).

6. After June 27, 1963, the permit when granted has a priority date as of the time when the application is filed. For public water suppliers utilizing wells prior to June 27, 1963 for public water supply, a permit granted under this act for those existing wells shall have a priority date as of the first date of beneficial use.

7. **Neb. Rev. Stat.** §46-644 (Reissue 1978.) No permits issued under the Municipal and Domestic Groundwater Transfers Permit Act have been cancelled under the forfeiture provisions of §§46-229.02 to 26-229.05 (Reissue 1978, Supp. 1982, Supp. 1983).

8. **Neb. Rev. Stat.** §46-645 (Supp. 1982).

9. Application Nos. 4361 (Lincoln), 10002 (Grand Island), 10011 and 10012 (Fremont), and 10074 (Omaha).

10. Harnsberger et al., **supra** note 32 at 213.

11. Harnsberger, Richard, *"Nebraska Ground Water Problems,"* 42 **Neb. L. Rev.** 721, 737 (1963).

12. LB 440, 73rd Nebraska Legislative Session (1963).

13. Public Works Committee Hearing on LB 769, April 19, 1963, p. 2.

14. **Ibid.** pp. 2-3.

15. *Little Blue NRD v. Lower Platte North NRD,* 206 Neb. 535, 294 N.W. 2nd 598 (1980); parties to this lawsuit include the following municipalities: Lincoln, Wood River, Fremont, Kearney, Lexington, Grand Island, North Bend, Omaha M.U.D.

16. **Neb. Rev. Stat.** §§46-288 and 46-289 (Supp. 1982).

17. **Neb. Rev. Stat.** §46-288 (2) (Supp. 1982).

18. **Neb. Rev. Stat.** §46-289 (3) (Supp. 1982).

19. It will most likely be tested in future proceedings on the application of the Little Blue NRD on its proposed transbasin diversion.

20. *M.U.D. v. Merritt Beach Co.,* 179 Neb. 783, 801; 140 N.W. 2d 626, (1966). The prevailing theory, as described by the court, was that a landowner could not withdraw and use groundwater ". . .in excess of a reasonable and beneficial use upon the land he owns, unconnected with the beneficial use of the land, especially if the exercise of such use in excess of the reasonable and beneficial use is injurious to others who have substantial rights to the water."

21. *Osterman v. Central Nebraska Public Power and Irrigation Dist.,* 131 Neb. 356, (1936).

22. *Little Blue NRD v. Lower Platte North NRD, 206 Neb. 535, 294 N.W. 2d 598 (1980).*

23. *Osterman v. Central Nebr. Power & Irr. Dist.,* 131 Neb. 356, 361; (1936).

24. Osterman at 362.

25. *Johnson v. Edwards,* Case No. 2465 (D. Ct. Sioux County, Nebraska) reported at 44 Dept. of Water Resources Report 21 (1981-82).

26. In turn, the subirrigation and springs have existed only since operation of the Interstate Canal was begun, having benefited from canal seepage.

27. Section 858A Restatement (2nd) of Torts.

28. The precedential value of this case is quite limited. A court is only "required" to follow its own decisions or those of higher courts if it is overruled. Consequently, there is no statewide effect to this district court decision until such time as the Nebraska Supreme Court or higher court adopts its principles. The case was not appealed to that court. Other district courts could follow its reasoning, however, until a higher court makes a definitive ruling on the issue.

29. 39 Ariz. 65, 4 P. 2d 369 (1931).

30. **Id.** at 4 P. 2d at 382.

31. **Id.** at 380, 382.

32. **Id.** at 382.

33. 107 P. 115, 157 Cal. 256 (1910).

34. **Id.** at 119.

35. **Id.** at 120-21.

36. **Id.** at 122.

37. **Id.** at 124-25.

38. 40 P. 2d 486, 2 Cal. 2d 351 (1935).

39. **Cal. Const.** Art. 14, §3 (1928).

40. 40 P. 2d 493-95, 497.

41. **Id.** at 496.

42. 60 P. 2d 439, 7 Cal. 2d 316 (1936).

43. **Id.** at 440-42.

44. **Id.** at 444.

45. **Id.** at 448.

46. **Id.** at 449.

47. **Id.** at 450-51.

48. **Id.** at 451-52.

49. Restatement (2d) of Torts 850A (1977).

50. *Wasserburger v. Coffee,* 180 Neb. 149, 141 N.W. 2d 783 (1966).

51. Aiken, J.D., Surface-Ground Water Conflicts in Nebraska, Department of Agricultural Economics Staff Paper, University of Nebraska-Lincoln, 1981, # 3.

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Chapter 6

# Problems, Issues, and Policy Alternatives Related to the Impacts of Using Groundwater Pumping to Supplement Flow Needs, Wetland Needs, or Maintain Lake or Reservoir Levels

## THE PROBLEM AND ISSUE

**FLOWS OF SOME STREAMS AND WATER STORAGE IN SOME LAKES, RESERVOIRS, AND WETLANDS, DO NOT MEET NEEDS ON EITHER A SEASONAL OR ANNUAL BASIS. TO SOME EXTENT THESE NEEDS COULD BE MET BY INCREASING THE SURFACE WATER SUPPLY BY PUMPING GROUNDWATER INTO SOME OF THESE AREAS. THE ISSUE IS: WHAT LEGISLATIVE ACTION, IF ANY, SHOULD BE TAKEN TO AUTHORIZE SUCH USE OF GROUNDWATER?**

Use of groundwater can help meet demand for both instream flow needs and needs for streamflow for diversion. Limited transfer of groundwater in streambeds for irrigation is allowed by current law with the permission of landowners bordering the stream. However, if sale of pumped groundwater and transfer by stream channel over some distance were made clearly allowable there might be more use of such transfers. In addition, clear authority for maintenance of instream values and lake and wetland levels through groundwater pumping could provide some benefits.

Currently pumping of groundwater into a stream channel for use further downstream is allowed with certain restrictions. However, there has not been any specific statutory authorization for groundwater transfers off the overlying land either for irrigation purposes or for maintaining instream flows. Nor is sale of groundwater for transfer off the overlying land legally allowable. There is question as to what constitutes overlying land. There have been a few instances where groundwater has been pumped to supplement the level of lakes or wetlands. However, there are no statutes specifically pertaining to pumping groundwater for lake and wetland maintenance.

The map of flowing waters of Nebraska included in Chapter 2 presents detail on streamflow conditions throughout the state. That map was drafted for the *Policy Issue Study on Instream Flows* which also presented information on impacts of utilizing groundwater to supplement natural flow needs. Any area with sufficient groundwater (see figure 9 of Chapter 2) could potentially pump groundwater into a stream during low flow periods. However, in some cases a high degree of connection between surface water and groundwater might cause the impact of surface flows to be only very temporary. When supplementation is of streamflow it could be done to preserve either instream or out-of-stream uses. Currently there are legal constraints to this type of use. Pumping costs could also be high.

The *Instream Flow Policy Issue Study* found:

"If an ample groundwater supply underlies a stream, pumping of groundwater into the stream could supplement low flows sufficient for instream flow needs. A well discharging 1,800 gallons per minute would increase stream discharge by 4 cfs. Such supplementation of flow would be more feasible along smaller streams and probably would be impractical along a broad braided stream such as the Platte River. Where a good hydraulic connection exists between the aquifer and the stream, water pumped from the aquifer at a generally high rate would soon be replaced by seepage from the stream. Generally supplementation of flow would be necessary only for a week or two and in some years would be unnecessary."[1]

The report also found that on two streams studied, for fisheries purposes restocking would be more cost effective than maintaining flow through groundwater pumping.

Tributaries on the north side of the Little Blue River now have greater flows than they previously did because of indirect contribution from groundwater pumpage. In that case flow is being maintained by groundwater pumping even though the maintenance may be unintentional. Groundwater irrigation has raised a perched water table in the area to the point where it intersects with streams. Little Sandy and Dry Sandy Creeks in the area may now have greater flows because of the contribution from perched water tables. There is also some evidence that at certain times a substantial portion of flow in the Big Blue River has been derived from runoff of groundwater irrigation.

A case also mentioned in Chapter 4 was that of Rock Creek in the Republican Basin. In that area local groundwater pumping had caused a decline in springflow to the fish hatchery. The problem was solved when wells were installed to supplement flows to the hatchery at critical periods. A fish rearing facility at Royal also utilizes water that is pumped into the East Branch of Verdigre Creek.

An other area which has been studied as to the possibility of pumping groundwater to supplement surface water is Willow Creek Reservoir in the Elkhorn Basin. There was some concern before the reservoir was built that the flow in Willow Creek might not fill the reservoir and hold it at the level desired. A subsequent study by the U.S. Geological Survey found that it would be possible to raise the level of the lake with groundwater because there is a clay layer between the upper sands and the regional aquifer.

Groundwater pumping to supplement surface water has taken place on Goose Lake in Holt County to increase water levels for boating activities. Groundwater has also been pumped into Walgren Lake, a state recreation area in northeast Sheridan County in order to maintain lake levels that prevent winter kill of fish. In addition, the Game and Parks Commission has pumped water into the Sacramento-Wilcox wetland in southeast Phelps County in order to maintain wildlife habitat.

Another case of groundwater pumping for surface flow maintenance has occured on the E-65 Canal in the Central Nebraska Public Power and Irrigation District. The district has pumped into the canal to supplement its flow and reduce the problem of seepage from the canal.

A U.S. Fish and Wildlife Service proposal to drill and pump wells to supplement wetlands in the Tri-Basin Natural Resources District was subject to litigation in late 1977. In *Raun vs. Andrus*[2] some of the plaintiff's contentions included: (1) a required environmental impact statement had not been filed, (2) further pumping would harm plaintiffs by degrading agricultural land and diminishing water supplies, and (3) the defendent's use of groundwater was not a beneficial use under Nebraska law. The case was eventually settled without a trial by a consent decree. Groundwater pumping to supplement wetlands in the area now takes place under the terms of the agreement.

## APPLICABLE NEBRASKA LAW

Section 46-252 of the Nebraska statutes provides that:

> Any person may conduct water into or along any of the natural streams or channels of this state, and may withdraw all such water at any point without regard to any prior appropriation of water from such stream, due allowance being made for losses in transit to be determined by the Department of Water Resources. .[B]efore any person may conduct water into or along any of the natural streams or channels, he shall first obtain the consent in writing of the majority of the residents bordering upon such stream or channel.[3]

As an example, diversion of water into a natural stream, Strevor Creek, by the Dawson County Irrigation District whose ditch crossed the stream, was permitted under this statute in order to deliver water further downstream to a lateral of the Elm Creek Ditch Company. The diversion by the District, however, so increased the flow of water in the natural stream that it caused injury to a landowner bordering it. A suit by the landowners resulted in assessment of damages.[4]

While the intent of this statute was that it apply to surface irrigation waters being transported by way of a stream, the express language does not exclude groundwater. Some irrigators, particularly along the Big Blue and Little Blue Rivers, pump groundwater into the rivers for use on downstream lands. The DWR measures the amount of water at the point where the water is put into the stream and at the point where it is taken out. Allowance is made for losses in transit.[5]

The authority to transfer groundwater in this manner for irrigation is decidedly questionable. The Nebraska Supreme Court, in *Olson v. City of Wahoo*,[6] held that a landowner is limited to the use of underground waters only on lands which he or she owns. This use was restricted even further by the Court's decision in *M.U.D. v. Merritt Beach Co.*, which held that groundwater may be transfered off the overlying land ". . .only with the consent of and to the extent prescribed by the public through its elected representatives."[7] Finally, the Court's ruling in *State ex rel. Douglas v. Sporhase* confirmed that, "Since the Nebraska common law of groundwater permitted use of the water only on the overlying land, legislative action was necessary to allow for transfers off the overlying land, even for as pressing a need as supplying urban water users."[8]

There has not been, to date, any specific statutory authorization for groundwater transfers off the overlying land for irrigation purposes or for maintaining instream flows. The interstate transfer statute would appear to permit it in limited situations.[9] Industrial groundwater users and public water suppliers do possess statutory authority to transfer water off the overlying land.[10] In compliance with Section 46-252, they could conduct the water into a stream for use further downstream. There are no statutes specifically pertaining to use of groundwater to supplement lakes and wetlands.

## LEGAL AND ADMINISTRATIVE MECHANISMS USED IN OTHER STATES

A review of relevant statutes and case law did not reveal any other western states where this issue has been addressed.

## ALTERNATIVE STATE POLICIES RELATED TO THE IMPACTS OF USING GROUNDWATER PUMPING TO MAINTAIN STREAMFLOW, LAKE, RESERVOIR, OR WETLAND LEVELS

## ALTERNATIVE #10

## CONTINUE CURRENT POLICIES RELATED TO USE OF GROUNDWATER TO SUPPLEMENT STREAMFLOW NEEDS, WETLAND NEEDS, OR MAINTAIN LAKE OR RESERVOIR LEVELS

### DESCRIPTION AND GENERAL IMPACT OF ADOPTION

Current policies were detailed in the section on Applicable Nebraska Law. There are some unclear areas in current Nebraska statutes. However, with a few exceptions, there is no specific statutory authorization for groundwater transfers off overlying land for irrigation purposes or for maintaining instream flows. There have been some instances where groundwater pumping has been used to maintain the level of lakes or wetlands. However, there are no statutes specifically pertaining to that topic. It seems likely that the long-term impact of groundwater development may eventually result in reducing the baseflow of some streams. If no flow periods become more common, it is possible that instances of diminished instream values may also become somewhat more common. In areas where there is a water table connection to streams and wetlands as well as groundwater pumping, there may be some wetland loss or drop in lake levels. This could result in loss of wildlife habitat and fishery values. Instances in which a landowner may find it profitable to transport groundwater to an irrigation site by using a stream channel may also expand if there are higher numbers of low flow periods.

## ALTERNATIVE #11

## DECLARE THAT GROUNDWATER MAY BE TRANSFERRED OFF THE OVERLYING LAND TO MEET INSTREAM, IRRIGATION, OR OTHER NEEDS, OR MAINTAIN LAKE OR WETLAND WATER LEVELS

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

If implemented, this alternative could receive considerable use by irrigators. However, it could also be used to maintain lake and wetland levels.

If transport of groundwater off the overlying land was allowed a number of landowners having junior surface water rights and no access to groundwater could conceivably acquire groundwater which could be transported to them by the streambed. This would probably require revision in the requirements for gaining permission from landowners bordering the stream. It would also require addressing legal problems with transporting groundwater off overlying land. However, there could be substantial economic benefits. *Alternative 29* in Chapter 8 also deals with these types of benefits.

In regards to this type of alternative, the *Instream Flow Policy Study* noted:

"Another way to augment flow in stream reaches where the natural flow is fully appropriated at critical times is to authorize the pumping of groundwater into a stream when its flow falls below the level needed to maintain instream uses. When necessary to meet an emergency situation, a public entity or private party desiring to augment the natural flow of a stream would either construct a new well from which groundwater could be pumped into the stream, or contract with the owner of an existing well for a water supply. Although this alternative would be of limited usefulness on the state's larger streams, it would provide an effective method of temporarily supplementing streamflow in a relatively small stream having especially significant instream values, for example, a small trout stream.

For this alternative to be effective, groundwater pumped into a stream would have to be accorded the same legal status as stored surface water which is released into a stream. That is, the Department of Water Resources would need to be empowered to prevent appropriators from diverting or impounding this supplemental water as it moves downstream.

The Department of Water Resources would be assigned the primary management role under this alternative. The department would be responsible for "policing" a stream reach into which groundwater was pumped to maintain instream flows in order to prevent diversions of that water by other users along the stream. The public entity or private party who had constructed the well, or contracted for a water supply with the owner of an existing well, would be responsible for notifying the department when it intended to pump groundwater into the stream."[10]

Groundwater being pumped into a lake or wetland would probably not be subject to later use by an appropriator, therefore it may not be necessary for the Department of Water Resources to administer it or treat it as stored water. However there is some question as to whether this is a reasonable use of groundwater and legislative direction on that point might avert future legal controversy. There have been cases where groundwater has previously been pumped to supplement a lake's or wetland's level.

In the *Policy Issue Study on Instream Flows* it was noted that "The use of this alternative would be so costly that environmental benefits would be expected to be limited to local and site specific situations only." Similarly the number of lakes where this alternative may be economically used are probably small. Advantages to using the alternative include that it can help save fish populations in lakes and streams and preserve wetland habitat and prevent wildlife disease in periods of low water. If it were implemented for irrigation without sale of groundwater allowed there might be some limited instances in which the alternative was used for irrigation where an owner had scattered land holdings.

Potential problems with adopting the alternative include its rather high cost, the problems with having a groundwater well located near a lake, stream, or wetland at the critical place and time, and the degree of knowledge about how the groundwater source is connected to the surface-water the alternative is attempting to preserve. In addition there would need to be groundwater user notification of the Department of Water Resources in order that a right to the water could be obtained. However, the level of funding required for the Department to administer this alternative would probably not be high unless sale and transfer of groundwater for irrigation were allowed. Impacts of this alternative would depend on the degree to which the alternative was utilized. The expense of pumping and transporting groundwater may limit utilization depending on crop prices. The number of areas with access to groundwater near streambeds may also be a limitation. The administrative difficulties of such policies would probably be considerable if the alternative was heavily used.

## ALTERNATIVE #12

## EXPAND RESEARCH INTO THE IMPACTS OF USING GROUNDWATER PUMPING TO SUPPLEMENT STREAMFLOW TO MEET INSTREAM, IRRIGATION, MUNICIPAL, AND OTHER NEEDS OR TO MAINTAIN LAKE, WETLAND, OR RESERVOIR LEVELS.

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Adoption of this alternative would probably be most effective if carried out on a site specific basis for sites in which groundwater pumping to maintain surface-water values was anticipated. The physical impacts of pumping groundwater to maintain surface water values varies considerably between sites. Determining the effect at a particular site may be important since in some situations groundwater pumping may have little impact on surface values. If a lake or wetland is in close connection with the groundwater reservoir which is being pumped, pumping could be a futile activity in terms of preserving water levels.

Study may also be required if implementation of sale of groundwater and transfer by streambed is anticipated. In many cases groundwater pumped from near a stream will simply become a depletion to streamflow at a later point in time. However, that delay may allow a more economic use of the water by providing for immediate use of water that would have left the state as baseflow in the off season. Thus studies of the degree and timing of stream depletions may be helpful in determining how near the river pumping should occur in specific cases.

## REFERENCES


1. **Nebraska Natural Resources Commission, 1982,** *"Policy Issue Study on Instream Flows"*, p. 85.

2. *Raun vs. Andrus* No. 77-223 (D. Neb. Filed November 7, 1977).

3. **Neb. Rev. Stat.** §46-252 (Reissue 1978).

4. *Hagadone v. Dawson County Irrigation Co.,* 136 Neb. 258, 285 N.W. 600 (1939).

5. The restrictions in **Neb. Rev. Stat.** §46-252 apply only to surface water. The DWR cannot prohibit pumping groundwater into a stream in a similar manner. The Department can, however, regulate the use of the stream as a means of transport in order to protect surface appropriators using the streamflow.

6. *Olson v. City of Wahoo,* 124 Neb. 802, 248 N.W. 304 (1933).

7. *M.U.D. v. Merritt Beach Co.,* 179 Neb. 783,_____; 140 N.W. 2d 626,_____ (1966).

8. *State ex rel. Douglas v. Sporhase,* 208 Neb. 703, 706,_____ N.W. 2d_____, _____(1981).

9. **Neb. Rev. Stat.** §46-613.01 (Supp. 1983). "Any person, firm, city, village, municipal corporation or any other entity intending to withdraw ground water from any well or pit located in the State of Nebraska and transport it for use in an adjoining state. . ." In some cases, this may involve a transfer off the overlying lands.

10. Industrial Ground Water Regulatory Act, **Neb. Rev. Stat.** §§46-675 to 46-690 (Supp. 1982); Municipal and Rural Domestic Ground Water Transfer Permit Act, **Neb. Rev. Stat.** §§46-638 to 46-650 (Reissue 1978, Supp. 1982).

11. Nebraska Natural Resources Commission, 1982, *"Policy Issue Study on Instream Flows"*, p. 85.

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Chapter 7

# Problems, Issues, and Policy Alternatives Related to the Impacts of Groundwater Level Rises Due to Surface-Water Development Projects

## THE PROBLEM AND ISSUE

**WATER-DEVELOPMENT PROJECTS HAVE CAUSED GROUNDWATER LEVELS TO RISE LOCALLY AND STREAM BASEFLOWS TO INCREASE IN SOME REACHES. THE PROJECTS HAVE RESULTED IN POSITIVE IMPACTS WHEN THEY MAKE MORE WATER AVAILABLE FOR IRRIGATION, FOR MEETING INSTREAM NEEDS, OR FOR IMPROVEMENT OF WILDLIFE HABITAT. HOWEVER, RISING GROUNDWATER LEVELS HAVE A NEGATIVE IMPACT WHERE THEY RESULT IN WATERLOGGING OF VALUABLE LAND, CAUSE WET BASEMENTS, OR CAUSE BACKUP OF SEWER SYSTEMS. THE ISSUE IS: HOW TO ENCOURAGE PROJECTS TO MANAGE THE USE OF WATER IN A MANNER THAT MAXIMIZES POSITIVE IMPACTS AND MINIMIZES NEGATIVE IMPACTS THAT RESULT FROM A RISE IN GROUNDWATER LEVELS AND AN INCREASE IN BASEFLOW OF STREAMS? SOME OF THE PROBLEMS AND ISSUES PRESENTED IN THIS CHAPTER ARE ALSO RELEVANT TO ALTERNATIVES PRESENTED IN CHAPTER 8**

Rising groundwater levels due to water projects have resulted in increased streamflows in some areas. Some streams in the Tri-County Area that previously did not have perennial flow now have perennial flow. These include Lost Creek and Dry Creek. A number of streams in the North Platte valley that were intermittent are now perennial. These include Winters Creek and Nine Mile Creek. Other streams such as Center Creek and Thompson Creek have become perennial further upstream than previously. This has had positive impacts in terms of fishery potential and environmental values. A few lakes and wetlands in the western rainwater basin may now have a water table connection that did not previously exist. It is possible that some or all of these wetlands did not exist before the Tri-County Project was completed. There is little documentation as to how conservation measures may impact these areas. Rising water levels have also had widespread benefits of reducing pumping levels and providing access to groundwater.

The impacts of rising groundwater levels and stream baseflow levels in the Farwell project area have been mixed. Observation wells show definite groundwater rises in part of the area. There probably are more wetland acres and wildlife values, although this has not been documented. Rising groundwater levels have certainly resulted in some drainage problems for farmers and some wet basements.

It is interesting to note that the Bureau of Reclamation planned for most of this in the original surface-water project design. It was originally anticipated that deep percolation of irrigation water would cause groundwater levels to rise and thus keep some irrigated fields from draining. The amount of rise depends in part upon application practices of irrigators. A pool of money was therefore set aside and when a farmer encounters this problem the district has the Bureau construct a subsurface drainage project for that problem. With one exception this has been accomplished through the originally allocated monies. The exception was when a large subsurface drain had to be installed around the north and west sides of St. Paul, Nebraska to stop a wet basement problem which had not occurred in those parts of town until the project was constructed.

The degree to which the problem in the Farwell area is from seepage from Sherman Reservoir, leakage from irrigation facilities, or practices on irrigated lands has not been documented.

Similarly, some money has been set aside for project drainage for the North Loup Project. The drains would be installed as the need arises. Thus the Bureau can and does incorporate some groundwater related impacts of surface-water projects into design. However, gaining access to the full range of benefits a project provides is sometimes not allowed under current policy. For instance a segment of Turkey Creek downstream from Sherman Reservoir was made perennial because of the project. However, the Bureau of Reclamation is not allowed to recapture that water from the stream without an appropriation permit. If the streamflow is already fully appropriated their permit may not be of use.

## APPLICABLE NEBRASKA LAW

### MAINTAINING PROJECT BENEFITS

The state of Nebraska already has a law on the books which requires owners of irrigation ditches or canals to maintain the embankments so as to prevent waste and to return unused water with as little waste as possible to the stream from which it was taken or to the Missouri River.[1] Judicial interpretation has added that, "It has application to the conservation and return of the unused waters of an irrigation ditch or canal, but it does not purport to limit or define the scope of the use or re-use of the waters properly withdrawn from the ditch or the canal for beneficial application."[2] Therefore, the right to recapture seepage water is not implicitly denied by this section. This statute has never been strictly enforced.

Attempts by irrigation districts to recapture seepage waters have generated some case law on this issue and resulted in a rather amorphous set of rules. They emphasize the fact that more effort has been directed toward reusing seepage water than toward developing and implementing more efficient conservation measures. Some interesting questions as to the extent of the right to recapture are also posed by the courts.

The first case in this sequence is *Ramshorn Ditch Co. et al. v. United States* decided in 1920.[3] The facts are complicated. The U.S. Bureau of Reclamation, in its operation of the Interstate Canal, constructed a ditch in Dry Sheep Creek Valley to drain marshy and saturated lands which had to become wet because of seepage from the canal. There was not evidence to show whether Dry Sheep Creek ever had natural perennial flow. The water brought into this ditch was then turned into another irrigation ditch operated by Farmers Irrigation Company. The *Ramshorn Ditch Company,* meanwhile, had an old appropriation on the North Platte River. While water from the river appeared at all times to be available for diversion by Ramshorn, the difficulty and expense of maintaining its diversion work was high. The Bureau's ditch in Dry Sheep Creek was more convenient and less expensive to use. Consequently, the *Ramshorn Ditch Company* filed an application with the state to collect the seepage water in the Sheep Creek basin and convey it to the Ramshorn Ditch under their early North Platte priority date. The State Water Commissioner granted the application and attempted to regulate the water in the Bureau's ditch to satisfy the Ramshorn priority. The United States filed suit in the United States District Court for the District of Nebraska to prevent any interference with its ditch. The court held generally for the United States and was upheld on appeal.

The Eighth Circuit Court of Appeals, in its opinion held that an appropriator of water for irrigation has the right to save and use water which has escaped by seepage for the beneficial irrigation of lands under its canal. The court, however, further qualified its decision in a number of respects. In the first place, appropriated water which had seeped from the canal and been allowed to return to the river from which it was taken is considered to be part of the water of the river as though never diverted and it ". . .inures to the benefit of the appropriators on the river in the order of their appropriation."[4] Second, seepage and waste water which have been allowed to return to the stream with no intention by the appropriator to recapture it is abandoned.[5] Intent, the court noted, is a question of fact which depends on the evidence presented in each case. "The appropriator who has abandoned his rights to water may at any time resume the possession and exercise of them, if no new rights have intervened."[6] A reasonable time is allowed to an appropriator to save and use seepage and waste water that has escaped from a canal or ditch.[7] Reasonable time in this case was three years.

Apart from the judicial implications of this case, two questions not addressed by the court are suggested, one explicit, the other implicit. The first question was presented by the district court:

> Whether or not leakage, seepage, waste, return and percolating waters could be collected and then diverted and used for irrigation so as to decrease the natural flow of the stream, to the detriment of prior appropriators below, whose appropriations had been fed by the underground waters before they were diverted.[8]

The second is in regard to abandonment and is implied in the court's opinion. It is interesting to consider whether seepage and waste water have been constructively or impliedly abandoned if not recaptured within a long period of time. Particularly with the Nebraska Supreme Court's decision in *Northport Irrigation District v. Jess,*[9] these as yet unanswered questions could present stumbling blocks to the implementation of LB 198 in some situations.

Another Eighth Circuit court decision, in *United States v. Tilley,*[10] is important where questions regarding seepage are concerned. In that case, the United States was recapturing and collecting seepage waters from lands in the Pathfinder Irrigation District, one division of its North Platte Project, and applying them to lands of another division in the same project, the *Northport Irrigation District.* The basic question before the court was whether seepage waters from lands under an irrigation project or canal, which would return, if not intercepted, to the river from which they were diverted, could be collected by the appropriator and applied to other lands in the project.[11] The court found its decision in *Ramshorn* to be controlling. ". . .[It] is our interpretation of the Law of Nebraska governing appropriative rights that an appropriator of public waters for use under an irrigation project or canal is entitled to collect seepage waters upon any part of the lands under such project or canal, by means of drains or ditches, and to apply them to further beneficial use upon any of the lands under such project or canal."[12]

Finally, there is the case of *Northport Irrigation District v. Jess.*[13] This case involves an appeal by the Director of the DWR of a permanent injunction restraining him from requiring the *Northport Irrigation District* to obtain an appropriation permit to pump water from Upper Dugout Creek into its irrigation canals. The District had maintained that its original appropriation from the North Platte River entitled it to recapture seepage and return flows from its project lands which had found their way into the creek. The district court for Morrill County agreed. The Nebraska Supreme Court reversed this decision and ordered the case dismissed.

The Supreme Court held that seepage waters from lands under an irrigation project which have returned to a natural watercourse become public waters and subject to administration by the State. These waters cannot be recaptured and collected at this point and applied to further beneficial use without first acquiring a new appropriation permit. The Court found Upper Dugout Creek to be a natural watercourse even though its flow had not been continuous prior to the construction of the Northport Canal in 1920. This opinion appears consistent with the decisions of the Eighth Circuit Court in the *Ramshorn* and *Tilley* cases in spite of the fact that the Nebraska Supreme Court did ". . .not find either the *Tilley* or *Ramshorn* cases to be controlling or dispositive of the issues before this court."[14]

In an interesting aside, the Court pointed out that the seepage had occurred for over 55 years without any attempt to recapture it. The Court noted that, ". . .there are now several downstream appropriators with senior rights to the water."[15] The Court assumed arguendo that even if Northport had any appropriation rights to the water, they would have been lost through nonuse.[16]

The irony of this case is that LB 198 would appear to permit recovery of the seepage water before it reaches the stream. If Northport were now to seek a modification of its appropriation to claim underground recharge under LB 198 and change its method of operation in such a way as to recover that seepage water before it reaches Upper Dugout Creek, downstream appropriators might have no recourse save perhaps an action for damages.[17] An argument can be made, however, based on the *Ramshorn* case, that *Northport* has abandoned its rights to recapture seepage and waste water.[18] In addition, the dicta of the *Northport* case supports the argument that any rights to seepage water have been lost through nonuse. One might also presume an abandonment after ten years without any attempt having been made to recapture seepage water. These arguments could perhaps provide a basis for issuing an injunction against the implementation of LB 198.

**REMEDIES FOR PROJECT DAMAGES**

Article I, section 21 of the Constitution of Nebraska provides that property shall not be taken or damaged for public use without just compensation.[19] Irrigation districts organized under Chapter 46 of the Nebraska statutes are providing water for a public use and purpose.[20] They are liable under Article I, section 21 to anyone whose land has been injured by seepage from its ditches or canals without regard to whether the injury was caused intentionally or due to the faulty (negligent) construction or operation of the irrigation works.[21] Anyone injured by seepage from an irrigation district's project is entitled to monetary recovery for damages.[22] The Nebraska Supreme Court has stated that the ". . .right to damages is grounded upon the provisions of Article I, section 21, of the Constitution of Nebraska, and it is a right which the Legislature could not destroy."[23] This constitutional provision can be logically extended to cover all water project sponsors providing water for public use. Damages for injury caused by seepage from public power and irrigation districts organized under Chapter 70 of the statutes have also been allowed under this constitutional provision, even though there is statutory liability and a remedy at law.[24]

Section 70-671 of the Nebraska statutes makes any public power and irrigation district ". . .liable for all breaks, overflow and seepage damage. Damages from seepage shall be recoverable when and if it accrues." This section makes liability for damages from seepage absolute.[25] It applies only to public power and irrigation districts and has no applicability to an irrigation district.[26] This statute and the constitutional provision allowed the recovery of damages by a landowner from the Loup River Public Power District for destroying subirrigation of his lands by drainage into the district's tailrace canal.[27] It should be noted that court action is required to recover damages under either the constitution or statute.

## LEGAL AND ADMINISTRATIVE MECHANISMS USED IN OTHER STATES

The portion of this issue addressed by the policies of other states is the situation where groundwater levels in an area served by an irrigation district rise to an extent that cropland, basements, or sewer systems are affected adversely. The courts in other western states where the issue has arisen have generally held that a supplier of irrigation water is required to exercise reasonable care in the construction, operation, and maintenance of its canals and other water distribution facilities. When property is injured by seepage due to faulty design, construction, or maintenance, liability can be imposed for any damages occurring as a proximate cause of the supplier's negligence. Negligence has generally been shown by establishing that the soils in or through which the irrigation works have been constructed are porous and no, or inadequate, action has been taken to prevent the seepage of water. Western states following this rule include California, Colorado, Idaho, Kansas, Montana, Oregon, Utah, and Wyoming.[28]

The California Supreme Court has also utilized a rule of liability similar to that adopted by the Nebraska Supreme Court. In California, irrigation districts have been held liable for seepage damages proximately caused by their operations on the ground that such damages are a taking for public use for which compensation must be paid under Article I, section 14 of the California Constitution. No negligence need be shown.[29]

Under either theory causation must be established. In a recent California court of appeals decision, the court stated that a district should not be held liable for seepage damage resulting from the application of water to fields after it had been delivered to the district's customers, as opposed to seepage directly from the district's canals.[30]

In some states, irrigation districts are directed by statute to construct such drainage works as are necessary to prevent seepage damages from occurring. In North Dakota, irrigation districts are to provide drainage facilities to lands that receive water from the district which may become waterlogged and may levy special assessments to pay for construction.[31] Under Colorado law it is the duty of the board of directors of an irrigation district to construct drainage works whenever it appears "necessary, proper, or beneficial" to lands within the district affected by seepage water.[32]

Under California law, irrigation districts are to construct such drainage workds as are necessary to prevent damage to lands within the district by seepage from the district's operations if it is reasonable, from an economic standpoint, to do so.[33] How strict an obligation this statute imposes on irrigation districts is not clear. In two recent cases, state appeals courts have taken different views on whether the statute is mandatory, or discretionary.[34]

California law also authorizes an irrigation district to regulate the amount of water used for irrigation when seepage would damage land inside or outside of the district. In addition, the board may require construction of adequate drainage facilities on lands within the district. If the land to which water is to be delivered does not have an existing distribution system and it appears that flood irrigation would cause seepage or drainage problems, the district may require the use of overhead sprinkler systems.[35]

## ALTERNATIVE STATE POLICIES RELATED TO GROUNDWATER LEVEL RISES DUE TO SURFACE WATER DEVELOPMENT PROJECTS

The following alternatives provide some ways of addressing problems and issues caused by rising groundwater levels due to surface-water projects. The alternatives are first listed, then discussed. In many instances the problems and benefits the following alternatives are designed to address are the result of conjunctive use of surface-water and groundwater without the types of integrated management powers noted in Chapter 8. Thus additional alternatives which may be used to address this problem and issue are found in Chapter 8.

## ALTERNATIVE #13

## CONTINUE CURRENT POLICIES IN RELATION TO WATER DEVELOPMENT PROJECTS WHICH CAUSE A RISING WATER TABLE.

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Current policies were detailed in the section on Applicable Nebraska Law. That law requires owners of irrigation ditches or canals to maintain embankments to prevent waste, although whether there are rights to recapture seepage has not been entirely resolved. Damages from water-level rises due to project seepage are provided for through liability laws. In these cases redress must be obtained through the courts.

One might expect some impacts from existing districts adopting new efficiency measures in the future. The *High Plains-Ogallala Aquifer Study* projected agricultural prices to rise faster than prices in general over the next 40 years. It also seems likely that energy prices will rise. The combination of these factors, along with educational efforts, may result in more widespread adoption of efficient techniques. This may be especially true for existing projects which can make only nominal charges for the groundwater they provide. In turn these efficiency techniques may result in some curtailment of the water level related benefits provided by those projects.

Whether the amount of damages caused by groundwater level rises will increase in future years is open to speculation. The addition of new projects where groundwater recharge is a significant factor might also result in some damages in those areas. However in portions of existing projects with these problems the water table may have already risen to the point where baseflow additions to surface runoff will occur rather than further rises.

Newly designed projects usually provide for drainage in areas where groundwater rises may cause problems. However current liability laws can be applied to those areas not covered.

## ALTERNATIVE #14

### REQUIRE NEW WATER DEVELOPMENT PROJECTS TO ADDRESS WATER USE EFFICIENCY METHODS, POTENTIAL DRAINAGE PROBLEMS AND RECHARGE BENEFITS IN THE PLANNING STAGES OF THE PROJECT PRIOR TO APPLICATION FOR A WATER RIGHT OR TO SECURE STATE FUNDING OR ADVOCACY.

#### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Adoption of this alternative would result in analysis of the groundwater impacts of new water projects specifically becoming part of the plan and application for the water right. Such analysis could also be required if a state grant or loan was sought. Contingency funds to reimburse damages from high water could be required in the plan. Positive impacts such as increased baseflow and wetland- subirrigation would be computed in the cost benefit analysis for the Plan. Then there could be a requirement that those benefits not later be curtailed. Water use efficiency measures and long-term plans for them could be addressed at the beginning of the project, rather than changing conditions in a manner originally unplanned, after a project had been established.

The water rights requirements of this alternative could be adopted by the Legislature. They could also become part of the guidelines used by the Water Management Board on the Water Management Fund. The Natural Resources Commission could adopt similar guidelines for the Nebraska Resources Development Fund. The Department of Water Resources could be responsible for seeing that agreed upon management measures were implemented by the project sponsor.

This alternative could substantially change the design of a project, including who receives the benefits. The cost of the project may go up to account for design changes.

## ALTERNATIVE #15

### REQUIRE THAT GROUNDWATER BE USED INSTEAD OF SURFACE WATER IN SELECTED AREAS WHERE A RISING WATER TABLE HAS CAUSED OR IS LIKELY TO CAUSE DAMAGE. DISTRICTS COULD DRILL WELLS IN SUCH AREAS.

#### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

This alternative would allow irrigation districts or natural resources districts to require irrigators in selected areas of high water table to use groundwater rather than surface water. This would be done with the intention of keeping the water table lower and averting damages. It could be implemented either on a local or statewide basis. In the local option the district could investigate high water table areas upon vote of its board or upon receiving any damage complaints. If it was found that surface-water diversion and use was resulting in the water-table rises the district could require surface-water users in a specified high water table area to switch to groundwater use instead. In some cases an irrigation district may reduce canal diversions. In order to defray expenses of irrigators required to switch to groundwater a district could partially or fully bear the expense of drilling wells in these cases. In some instances this might allow some lateral canals to be shut down and thus diminish the unneeded recharge.

An alternate method of local implementation would be to have irrigation districts or multiple purpose water districts be charged with the responsibility of implementing plans to alleviate problems in such areas. There could be oversight by a state agency such as the Department of Water Resources. This alternative could also be administered by the Department of Water Resources at the state level. If plans were inadequate the Department of Water Resources could order the district to discontinue surface irrigation in areas where there were problems.

A final method of accomplishing the balanced use of water to which this alternative is directed would be to pass legislation giving districts some of the comprehensive powers noted in the following chapter.

A potential benefit of this alternative is reduction in damages from the high water table and a resultant production increase in those areas. Litigation costs to solve the problem could be reduced in the long run. It could also result in more water being available for use for storage downstream rather than being stored in an area where it is causing problems. If desired this alternative could be implemented in only selected high water-table areas where the soils made damage most likely to occur.

Other potential impacts of this alternative include the costs and difficulties associated with defining the high water table area, the costs to irrigators in switching from surface water to groundwater irrigation systems (and possibly back again) and reduction in any benefits from the high water table including subirrigated production, and fish and wildlife habitat values from wetlands.

This alternative could be implemented by Natural Resources Districts, irrigation districts, the Department of Water Resources, or possibly even a new multipurpose water district depending upon how the law was written. If a local district was chosen there could be oversight by the Department of Water Resources.

## ALTERNATIVE #16

## EXPAND RESEARCH INTO THE IMPACTS OF WATER-TABLE RISES DUE TO SURFACE-WATER PROJECTS AND HOW THOSE IMPACTS MAY EITHER BE MINIMIZED OR MAXIMIZED AS DESIRABLE

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Adoption of this alternative would help determine the scope of benefits and damages due to water-table level rises from existing water resources projects. It might help determine whether the scope of this problem and issue is sufficient to attempt to adopt alternative policies to address it. The research could probably be carried out through the University of Nebraska and the state agencies.

A potential negative impact of adoption of this alternative would be the cost involved in funding the research. This could be a major question if it was unlikely that the research would receive application in the near future.

## REFERENCES

1. **Neb. Rev. Stat.** §46-265 (Reissue 1978).

2. *United States v. Tilley,* 124 F. 850 (8th Cir., 1941).

3. *Ramshorn Ditch Co. et al. v. United States,* 254 F. 842 (D. Neb. 1918), aff'd, 269 F. 80 (8th Cir., 1920).

4. *Ramshorn Ditch Co. et al. v. United States,* 269 F. 80, 83 (8th Cir., 1920).

5. *Ramshorn,* 269 F. 80, 84 (8th Cir., 1920).

6. *Ramshorn,* 269 F. 80, 84 (8th Cir., 1920).

7. *Ramshorn,* 269 F. 80, 84 (8th Cir., 1920).

8. *Ramshorn Ditch Co. et al. v. United States,* 265 F. 842, 851 (D. Neb., 1918).

9. *Northport Irr. Dist. v. Jess,* 215 Neb. 152, N.W. 2d (1983).

10. *United States v. Tilley,* 124 F. 2d 850 (8th Cir., 1941).

11. ". . .[W]hether, under the law of Nebraska, seepage waters from lands under an irrigation project or canal, which, if not intercepted, would ultimately, by percolation or drainage, return, in part at least, to the river from which they were diverted, may be collected by the appropriator, in drains or ditches upon such lands, and be applied to further beneficial use upon other lands under such project or canal; or whether, when appropriated waters have once been applied to any lands under an irrigation project or canal, the appropriated rights therein, have been exhausted, so that the seepage waters resulting from such irrigation use are not susceptible of recapture by the appropriator, but must be allowed to return as fully as possible to the natural stream, and are to be regarded wholly as public waters, subject to administration by the state irrigation authorities." *United States v. Tilley,* 124 F. 2d 850, (8th Cir., 1941).

12. *United States v. Tilley,* 124 F. 850, (8th Cir., 1941). ". . .[T]he declaration in the *Ramshorn* case as to the law of Nebraska, on the right of an appropriator to recapture seepage waters, has apparently stood unchallenged by any expression on the part of either the courts or the legislature of that state for more than twenty-one years. ...In addition, the Supreme Court of Nebraska, by indicative expression, seems to us to have given confirmation to the view that it is the intention of the law of that state to grant to an appropriator the fullest possible beneficial use of waters of his appropriation."

13. *Northport Irr. Dist. v. Jess,* 215 Neb. 152, ___ N.W. 2d_____ (1983).

14. *Northport Irr. Dist. v. Jess,* 215 Neb. 152, 160 (1983).

15. *Northport,* 215 Neb. 152, 162 (1983).

16. Nonuse of a water appropriation for more than three years permits cancellation by statutory proceedings. **Neb. Rev. Stat.** §46-229.02 (Reissue 1978 & Supp. 1983). In addition, the Nebraska Supreme Court held that nonuse for more than ten years causes loss of the appropriation right by action of **Neb. Rev. Stat.** §25-202 (Reissue 1979), independently of any statutory cancellation procedure. *Northport,* 215 Neb. 152, 162 (1983).

17. See discussion with respect to *Ramshorn* case on page _____, **infra.**

18. This may depend on the status on the *Ramshorn* case after the *Northport* decision.

19. Const. art. I, sec. 21 states: "The property of no person shall be taken or damaged for public use without just compensation therefor."

20. *Board of Dir. of Alfalfa Irr. Dist. v. Collins,* 46 Neb. 411, 64 N.W. 1086 (1895).

21. *Halstead v. Farmers Irr. Dist.,* 200 Neb. 314, 263 N.W. 2d 475 (1978).

22. *Lindgren v. City of Gering and Gering Irr. Dist.,* 206 Neb. 360, 292 N.W. 2d 921 (1980). Case involved a flooded basement.

23. *Halstead v. Farmers Irr. Dist.,* 200 Neb. 314, 318 (1978).

24. *Snyder v. Platte Valley Public Power and Irr. Dist.,* 144 Neb. 308, 13 N.W. 2d 160 (1944).

25. *Asche v. Loup River Public Power Dist.,* 138 Neb. 890, 296 N.W. 439 (1941).

26. *Baum v. County of Scottsbluff,* 172 Neb. 225, 109 N.W. 2d 295 (1961).

27. *Luchsinger v. Loup River Public Power Dist.,* 140 Neb. 179, 299 N.W. 549 (1941). See problem two.

28. *Tormey v. Anderson-Cottonwood Irr. Dist.,* 53 Cal. App. 559, 200 P. 814 (1921); *North Sterling Irr. Dist. v. Dickman,* 59 Colo. 169, 149 P. 97 (1915); *Harris v. Preston-Whitney Irr. Dist.,* 92 Idaha 398, 443 P.2d 482 (1968); *Garden City Co. v. Bentrup,* 228 F.2d 334 (9th Cir. 1955) (Kansas); *Calvert v. Anderson,* 75 Mont. 551, 236 P. 847 (1925); *Kaylor v. Recla,* 160 Or. 254, 84 P.2d 495 (1938); *Mackay v. Breeze,* 72 Utah 305, 269 P. 1026 (1928); *Howell v. Big Horn Basin Colonization Co.,* 14 Wyo. 14, 81 P. 785 (1905).

29. *Tomey v. Anderson-Cottonwood Irr. Dist.,* **supra.**

30. *Hagemann v. West Stanislaus Irr. Dist.,* 193 Cal. Rptr. 70 (Cal. App. 5 Dist. 1983).

31. **N. Dak. Cent. Code Anno.** §61-07-16 (Supp. 1983).

32. **Colo. Rev. Stat. Anno.** §37-43-123 (1974).

33. **Cal. Water Code** §22098 (West Supp. 1984).

34. See, *Hagemann v. West Stanislaus Irr. Dist.,* **supra;** *Elmore v Imperial Irr. Dist.,* 205 Cal. Rptr. 433 (Cal. App. 4 Dist. 1984).

35. **Cal. Water Code** §22255 (West Supp. 1984).

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Chapter 8

# Problems, Issues, and Policy Alternatives Related to Integrating the Long-term Use of the Groundwater and Surface-water Supply in a Manner That Presents an Opportunity to Maintain or Increase the Available Supply

## THE PROBLEM AND ISSUE

**THE USE OF GROUNDWATER FOR IRRIGATION HAS INCREASED DRAMATICALLY OVER THE PAST 20 TO 30 YEARS AND SIGNIFICANT WATER-LEVEL DECLINES HAVE OCCURRED OR ARE ANTICIPATED IN MANY AREAS OF THE STATE. DURING THIS SAME PERIOD THE USE OF SURFACE WATER FOR IRRIGATION HAS REMAINED RELATIVELY CONSTANT IN SPITE OF AVAILABILITY OF UNAPPROPRIATED SURFACE WATER IN MANY STREAMS. WHEN CONSIDERED ALONE NEITHER SOURCE OF WATER MAY BE SUFFICIENT TO MEET THE LONG-TERM DEMAND FOR WATER IN A PARTICULAR AREA. INTEGRATING DAILY, YEARLY, AND/OR LONG-TERM USE AND MANAGEMENT OF GROUNDWATER WITH SURFACE WATER AVAILABLE IN OR BROUGHT INTO THAT AREA MAY PRESENT OPPORTUNITIES FOR MAINTAINING OR INCREASING THE EFFECTIVELY USABLE WATER SUPPLY. THE ISSUE IS: WHAT OPPORTUNITIES EXIST FOR INTEGRATING USE AND MANAGEMENT OF GROUNDWATER WITH USE OF SURFACE-WATER IN AN OPTIMUM MANNER AND WHAT LEGISLATIVE ACTION WOULD BE REQUIRED FOR THESE OPPORTUNITIES TO BE REALIZED? ONLY SOME SPECIFIC PROJECT FUNDING PROPOSALS ARE CONTAINED IN THIS SECTION. FOR FURTHER DISCUSSION OF THAT TOPIC THE READER IS ADVISED TO CONSULT THE POLICY ISSUE STUDY ON SUPPLEMENTAL WATER SUPPLIES.**

## APPROACHES IN OTHER STATES

As explained in the upcoming section, Nebraska considerably expanded its ability to integrate use with the passage of LB 198 in the 1983 session of the Unicameral. However, other states have granted even more extensive powers to multipurpose districts. An important question is whether granting similar powers in Nebraska would have positive economic results. Arizona and California are the states whose administative systems most directly relate to this issue.

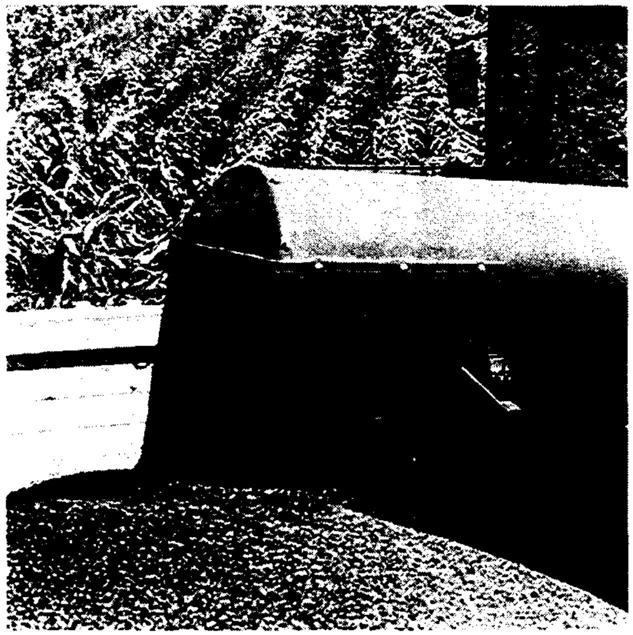
In 1980 Arizona passed legislation which placed significant restrictions on both existing and future groundwater uses, created management districts, and encourages maximum use of surface-water before groundwater is used. Among items instituted were measures to 1) disallow permits to pump groundwater to mines and industry when other reasonable sources of water are available, 2) impose irrigation water duties on groundwater which do not apply to surface water thereby encouraging surface-water use, 3) require farmers receiving Central Arizona Project water to decrease groundwater use by an equivalent amount, 4) allow irrigators using groundwater to retire irrigated land, move to a point where Central Arizona Project Water can be delivered and transfer groundwater irrigation rights to new land minus the amount of project water delivered, 5) require active management areas to have a water augmentation plan by 1990 funded by a $2 per acre-foot pump tax, and 6) provide financial assistance to encourage maximum use of expensive alternative supplies such as reclamation project water, sewage effluent, and brackish and saline groundwater.

In California, the phrase groundwater management has become synonymous with the transfer of surface-water supplies from areas of abundance to replenish or otherwise reduce dependence on groundwater. The California system of integrated management is implemented through both formation of various types of water districts with powers to undertake a groundwater management program and judicial appointment of a watermaster with powers similar to those of the Water District Board including adjudication of groundwater rights. The Orange County Water District Board presents an example of the types of powers California districts may have. They involve power to: 1) condemn land to construct or operate any water works necessary to replenish groundwater or otherwise augment supplies; 2) import, buy, or sell water; 3) store water underground; 4) control groundwater storage space within the district; 5) impose limitations on groundwater users; 6) distribute water to groundwater users in exchange for reducing groundwater withdrawal; 7) levy a property tax; 8) levy a "replenishment assessment" or pump tax on all groundwater users; and 9) charge a "basin equity assessment" to equalize the cost of water to all persons within the district (surface-water and groundwater users).

The number of districts involved in conjunctive management of surface-water and groundwater in California is quite large. Sixty-three such entities exist in the southern San Joaquin Valley alone. Over two million acre-feet of surface-water has been stored in the valley in a single year. Southern California has implemented large-scale conjunctive use. The degree to which those techniques may be applicable to Nebraska is examined here.

Granting these types of powers to local districts would require substantial changes in existing Nebraska law. At the heart of the California approach is local district control of an integrated surface-water and groundwater rights system. Some California districts had not had rights assigned prior to formation of the district. They then settled legal claims through a friendly adjudication in which water right holders agreed to a water management plan. In Nebraska there would be special problems involved in adopting either of these schemes. Surface-water rights are formally granted in Nebraska and probably would not need to be adjudicated to adopt the district system. While rights to use groundwater are attached to the land they probably also need to be adjudicated in the new system. The sheer number of such existing groundwater uses would probably create problems which did not exist in the California situation. Groundwater basins could be more difficult to define in Nebraska than in the mountainous California landscape. It is also possible that Nebraska'a hydrology could make it more difficult to determine for legal purposes what a "safe yield" may be. Safe yield is sometimes defined as a long-term balance between the amount of groundwater withdrawn and the amount of natural and artificial recharge. Once some of the above questions had been resolved the districts could begin to utilize some of the powers contained in this subalternative. It is likely that they would utilize those powers within the framework of a district integrated water management plan.

Perhaps a major difference between the Nebraska and California situation that must be considered is the financial one. The degree of success the California system has attained has been, at least to some degree, dependent upon different water values and supplemental supply opportunities than are found in Nebraska. In California municipalities account for a much higher percentage of total water use than they would in most Nebraska districts that could be formed. Some California districts are also faced with problems of salt water intrusion and land subsidence if they do not manage their supplies.



In addition, the crops that are irrigated in California are often specialty crops that can afford much higher water costs than most of the crops grown in Nebraska. Finally, there are some natural advantages that tend to make supplemental projects feasible in California. These include: high relief areas with good hydro-electric and water storage potential, highly seasonal rainfall, large areas of unsaturated aquifer suitable for potential recharge, and fertile land that receives very low precipitation, but has high agricultural potential with irrigation. A significant question is whether the Nebraska situation offers significant economic opportunities to make an administrative system like California's similarly successful.

## POTENTIAL APPLICABILITY TO NEBRASKA

The problem and issue addressed in this chapter deals with whether the state can or should adopt new administrative procedures that could facilitate the financing and operation of projects providing both surface and groundwater benefits. This can involve seeing that all beneficiaries are charged for a proportionate share of project costs or that costs are apportioned in a manner that results in maintaining or increasing the available water supply. It also can involve adding tax funding and regulatory powers that could make such projects more attractive to local districts. Alternatives presented in this chapter can help cause the rapidly moving surface water component which might otherwise flow from the state unused to be effectively utilized before the slower moving groundwater resource is tapped.

Nebraska has a number of existing and proposed projects where groundwater recharge is or would be a significant feature of a surface-water project. The existing Tri-County Project in the Central Platte, the

Sutherland Power Canal in the same region, several reservoirs and canals in the Republican Basin, the Mirage Flats Irrigation District, and the North Platte Project all result in groundwater levels maintained by project water. These groundwater level rises store water for irrigation and provide instream values. The Ainsworth and Sargent units also provide significant recharge to the groundwater reservoir. However, these areas were underlain by abundant groundwater reserves at easily accessible depths even without the projects. In some cases these projects result in drainage problems. Some other projects mentioned above; such as the reservoirs in the Republican River Basin and the Tri-County project; result in drainage problems due to recharge.

Proposed projects which are being designed to include significant recharge benefits are the O'Neill Project, the O'Neill Alternative, the Landmark Project, the Prairie Bend Project, the North Loup Project, and the partially completed Big Sandy Project. The O'Neill Project, as originally designed, would provide substantial recharge benefits to surrounding irrigated lands, some of which have experienced significant groundwater declines. However, it is primarily a surface-water supply oriented project. The O'Neill Alternative study is examining options which may expand the recharge benefits of the project and thus fulfill some of the water supply objectives of the project without expenditures necessary for the full project. However it would not provide the full range of benefits that would be supplied by the full project.

The Landmark Project would divert water from the Platte into the Big Blue Basin. In this project a system of canals and six medium-sized reservoirs would provide not only surface water for irrigation but also would help to stabilize groundwater levels that now are declining.

The Prairie Bend Project would divert water from the Platte River into portions of Dawson, Buffalo, and Hall counties. That water would be used for both surface-water irrigation and for groundwater recharge in the area.

The North Loup Project is currently under construction. When operation of the project is underway it should help to stabilize the water level in the part of Valley County where water levels are now declining.

An example of a much smaller scale project having primarily recharge and flood-control related benefits is under construction in the Little Blue Basin. Known as the Big Sandy Creek Watershed Project, it is being funded in part through the Nebraska Resources Development Fund. One unit of the project has been built and the second unit is near completion.

The physical ability to provide additional recharge projects was discussed to some degree in Chapter 2. The areas where recharge projects would appear to have most applicability would have the following characteristics: 1) either a significant water level drawdown in the existing aquifer or availability of unsaturated coarse textured geologic materials that would store water (see Figures 32 and 33 in Chapter 2); 2) economic access to a supply of surface water (Figures 3 and 4 in Chapter 2 provide partial information); and 3) a shortage or potential future shortage of groundwater. If agricultural use of the water is contemplated, the soils and topography of the immediate area may have an influence on whether the water can be recharged effectively or used. Areas which most effectively meet those conditions include the north side of the Platte River in Dawson, Buffalo and Hall counties, the Upper Big Blue and Little Blue River Basins, the upper Republican Basin, and parts of the lower Niobrara Basin. The upper Republican and the upper Big and Little Blue Basins would both require imported surface-water to accomplish the recharge. In all of the above cases projects have been proposed.

Other areas would have potential if an economic way could be found to transport the water for recharge. These include parts of the lower Republican, Lodgepole Creek, and Niobrara Basins. It should be noted that the economics of storage and transport of water will vary and that the amount of surface water economically available will depend upon many factors including: the cost of building and operating structures for diverting flow available only seasonally, and the profitability of uses for the water.

## APPLICABLE NEBRASKA LAW

The Legislature has recognized that the management of groundwater is essential and through its enactment of the Ground Water Management and Protection Act[1] has provided for the establishment of management areas and the creation of control areas where groundwater declines are serious. Prior to the passage of LB 198 in 1983, however, this was the extent of applicable law.

Although intended to address a different kind of problem, LB 198 may provide some alternatives for dealing with the identified problem. A brief analysis of the new law and some prospects on how it may be used to achieve a degree of integrated management in the future will follow.

The Central Nebraska Public Power and Irrigation District diverts from the Platte River and seepage from its systems of canals and laterals has added enough water to subsurface storage that the water table has mounded significantly. Once groundwater irrigation became a convenient and economically feasible alternative to accepting surface-water from the district, some irrigators whose lands were served by the district began to cancel their contracts. The problem apparently reached such proportions as to jeopardize the surface-water rights of the district because those rights are based on the number of acres irrigated with surface-water.[2] LB 198 was designed, in part, to prevent cancellation of those early priority surface-water rights by recognizing the intentional and incidental recharge benefits created by surface irrigation canals and laterals.

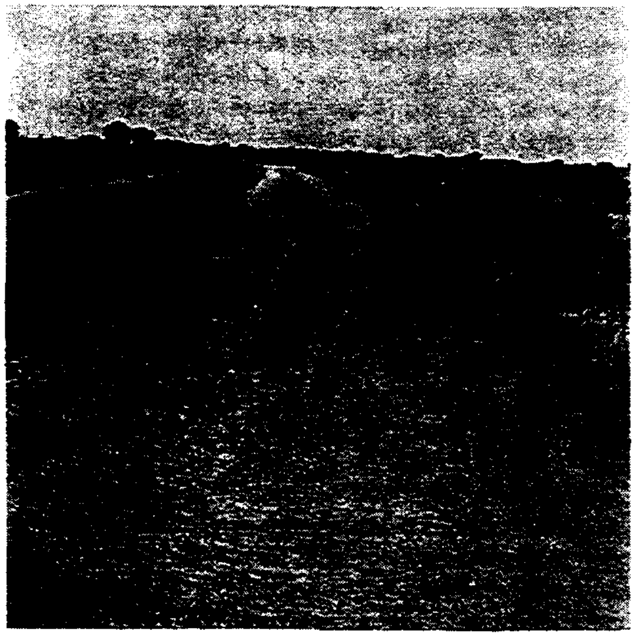
LB 198 grants the recognition that ". . .as a result of water project operations, surface water in some areas of the state has been, is, and will be in the future intentionally and incidentally stored in and withdrawn from underground strata."[3] The Legislature made it clear that the law applies only to water brought artificially into an area and that nothing in the act was intended to change existing law regarding the relationship between naturally occurring surface water and groundwater.

There are a number of key features in the law. For one, artificial groundwater recharge is recognized legally as a beneficial use of surface water.[4] Consequently, surface-water appropriations may now be issued solely for groundwater recharge. Second, the law acknowledges the right to store water underground, incidentally or intentionally, and the corresponding right to recover such water. Third, it provides for the financial responsibility of all beneficiaries of a project resulting in groundwater recharge to share proportionately in the costs of construction, operation, and maintenance.

Incidental underground storage occurs as an indirect result from reservoir seepage, seepage from canals and laterals, and deep percolation from irrigated lands.[5] A permit is required for incidental or intential underground storage.[6] Any person with a perfected surface-water appropriation may apply to the DWR for a modification of his or her appropriation permit to recognize incidental underground water storage and for recovery of such water.[7] Once recognition of incidental underground water storage has been obtained from the DWR, an appropriator may apply for approval to levy a maximum annual fee of fifty cents per acre of land irrigated by mechanical withdrawal from the storage facility.[8]

Intentional groundwater storage is defined as that ". . .which is an intended purpose or result of a water project or use."[9] It may be effected by the use of injection wells, infiltration basins, canals, reservoirs, or other reasonable methods. A new appropriation permit may be obtained to appropriate public waters for intentional underground water storage and recovery.[10] Any person who has acquired a permit may apply to the DWR for permission to charge an assessment ". . .against any person for the right or probable right to withdraw or otherwise use such stored water."[11] The assessment cannot exceed an amount sufficient to amortize the operations, maintenance, repair, and capital costs of the project apportioned on the basis of recharge which has or is likely to occur and any surface water which has been delivered.

The impact of LB 198 is speculative at this point. It may be used to prevent cancellation of water rights if it can be established that there are and have been in-



cidental benefits realized from surface water diverted into irrigation canals and laterals and into reservoirs. By law, water rights may be cancelled if not put to beneficial use for more than three consecutive years.[12] LB 198 makes the recharge itself a beneficial use. While LB 198's intent is clearly retroactive, the Nebraska Supreme Court's opinion in *Northport Irrigation District v. Jess*[13] may not permit recapture of seepage under LB 198 if it has occurred for longer than the statutory forfeiture or nonuse time periods without any attempt to recapture. At any rate, the new law will make the administration of surface-water rights more difficult.

The recognition in LB 198 of groundwater recharge as a beneficial use of surface water has an impact on a number of other appropriation laws. For example, a surface-water appropriation permit may now be issued to divert surface water for groundwater recharge. To the extent that unappropriated surface water is available, such water could be used for recharge in areas where the groundwater supply is being depleted. The interbasin transfer statutes, discussed under problem two, could be used to divert surface water from a basin having a surplus supply to one having declining reserves and could be benefited by intentional underground storage.[14]

Another surface-water law, Section 46-242 of the Nebraska statutes,[15] permits the diversion of water upstream from a storage reservoir under an appropriation for storage in the reservoir, only if downstream rights to storage releases from the reservoir would not be jeopardized. After the passage of LB 198, diversion of water in this manner for intentional groundwater recharge can now take place.

Since 1947 reclamation districts have had the authority to construct public projects[16] that will ". . .directly benefit lands now under irrigation by stabilizing the flow in streams and by increasing flow and return flow of water to such streams by replenishing and maintaining subsurface supplies. . ."[17] They possess authority to levy special assessments on lands receiving direct benefits from recharge of groundwater by water originating from the project.[18] Although five reclamation districts are active in the state, none have availed themselves of this provision in the state reclamation laws.[19] Although the state reclamation laws are indeed complicated and somewhat confusing, the provisions referred to above should be considered by reclamation districts as an attractive and less restrictive option for management than LB 198.

## LEGAL AND ADMINISTRATIVE MECHANISMS USED IN OTHER STATES

### ARIZONA

Arizona groundwater law underwent a major revision in 1980 with passage of a comprehensive Ground Water Management Act[20] that is designed, in part, to encourage the integrated management of groundwater and surface water. A major impetus for this legislation came from pressure by the federal government which had threatened to withhold construction funds for the Central Arizona Project, a large scale surface-water project designed to help alleviate the serious groundwater overdraft problem in Arizona. Generally, the doctrine of reasonable use applied throughout the state, although under the provisions of a 1948 enactment the State Land Department was empowered to declare critical groundwater areas where it was determined the groundwater supply was insufficient to provide a dependable supply of irrigation water for lands under cultivation at the time.[21]

In the absence of an effective groundwater management program, serious overdraft problems developed in Arizona. In 1977 Arizona had an estimated statewide annual groundwater overdraft of 2.5 million acre-feet.[22] Even with the surface water to be imported from the Colorado River through the Central Arizona Project, Arizona could expect the annual overdraft to be more than a million acre-feet.[23]

Consequently, Arizona is faced with the difficult problem of how to reduce a significant groundwater overdraft. The approach chosen was to authorize the placing of significant restrictions on both existing and future groundwater uses. The 1980 Act provides for designation of active management areas (AMAs), Irrigation Non-Expansion Areas, and preparation of groundwater management plans by the Director of Water Resources.[24] Existing uses in AMAs are allowed to continue but are subject to a pump tax to defray the costs of administration and can be taxed to provide for future augmentation of an area's water supply by importation, storage, and artificial recharge as well as to provide funds to retire irrigated lands from cultivation.[25] Irrigation uses are subject to irrigation water duties to improve conservation. Also, new land, in AMAs and irrigation non-expansion areas, cannot be put under irrigation.[26] Municipal, industrial, and mining uses are also subject to conservation requirements.[27]

The conjunctive use aspect of Arizona law is in the various provisions that encourage maximum use of surface water before groundwater can be used. No mine or industry may obtain a permit to pump groundwater unless other sources of water are unavailable. A permit may be obtained only if groundwater from dewatering the mine is insufficient and if surface-water from the Central Arizona Project is not available and sewage effluent or other alternative supplies of adequate quality cannot be obtained without increasing costs by more than 25 percent.[28] Irrigation water duties imposed on groundwater users do not apply to surface-water use and thereby provide some encouragement to use surface water. In addition, the federal government requires farmers who receive water from the Central Arizona Project to reduce their groundwater use by an amount equivalent to the project water received. The 1980 Act also provides that irrigators using groundwater may permanently retire their irrigated land and relocate on new land where Central Arizona Project deliveries can be made. The existing groundwater irrigation right on the retired land is transfered to the new land but the right is reduced to the amount of Central Arizona Project water can supply.[29]

Finally, since the intent of the act is to encourage the maximum use of alternative supplies of water such as reclamation project water, sewage effluent, brackish and saline groundwater and the cost of these supplies relative to normal groundwater supplies is generally prohibitive, the act provides for financial assistance to users of these alternative water supplies. The Director of Water Resources is authorized to offer alternative water supplies to any person capable of using them. Each AMA is required to have by 1990 a water augmentation plan funded by a $2 per acre-foot pump tax. These funds may be used by the director to reduce the cost and to encourage use of alternative water supplies.[30]

### CALIFORNIA

Like Arizona, California is experiencing a serious groundwater overdraft problem. In 1974 net water demand in California totaled 31 million acre-feet and was expected to increase by a minimum of 3 million acre-feet by the end of this century.[31] Roughly 40 percent of this demand is supplied by groundwater and 60 percent by surface water.[32] Annual overdraft of the state's groundwater supplies has been estimated to be 2.2 million acre-feet.[33]

California's response to this groundwater shortage has been to authorize local entities to manage groundwater use and develop supplemental surface-water supplies. Although no comprehensive statewide groundwater management program was instituted, groundwater management by local entities has not occurred without assistance from both the state and federal governments in the form of financial aid for water projects to supplement and replenish dwindling groundwater supplies.[34] In California, the phrase groundwater management has become synonomous with transfer of surface-water supplies from areas of abundance to replenish groundwater or to reduce dependence on groundwater.

Groundwater management by local entities generally has taken one of two forms. The first is formation of a water district having powers to undertake a groundwater management program. The second approach is the judicial appointment of a watermaster having powers similar to those held by the water management district board. The water master is responsible for the adjudication of all rights to use groundwater in the area under the watermaster's jurisdiction.[35] A number of different types of districts may have groundwater replenishment or management authority under the California Water Code. These include county water districts[36], municipal water districts[37], water conservation districts[38], water replenishment districts[39], and irrigation districts[40]. It is apparent from the liberal grants of powers to such a variety of public agencies that groundwater replenishment/management by increasing the use of surface-water is given a very high priority in California.

An example of the non-adjudication approach to groundwater management is the Orange County Water District. This district, created by a special act of the California Legislature, has been given very broad statutory authority to do whatever is necessary to ensure the continued availability of water to users within the district. The Orange County Water District Board has the power to condemn land within and outside of the district to construct or operate facilities such as reservoirs, canals, water spreading and recharge basins, or other water works necessary to replenish the district's groundwater supplies or otherwise augment water supplies within the district. The district has the explicit authority to purchase and import water, buy and sell water, store water in underground basins within or outside the district's boundries, control the use of groundwater storage space within the district, and may distribute surface water in exchange for reducing or eliminating groundwater withdrawals. The district may also determine the total permissable withdrawal of groundwater from the district, impose production limitations or requirements on groundwater users, and compensate persons who are required by the district to produce more or less groundwater than other groundwater users. The district may cooperate with any state or federal agency to carry out its mission under the act and has the power to levy a variety of assessments on landowners and water users in order to pay for the operation of the district and the construction of the necessary facilities.[41]

The Orange County Water District is authorized to levy a general tax on all real property within the district of up to twenty cents for each one hundred dollars in value. All funds derived from this general assessment in excess of eight cents per one hundred dollars must be deposited in a water reserve fund that may be used only for purposes such as the purchase of supplemental water for groundwater replenishment, purchase of spreading grounds, or cost of construction for projects to prevent salt water intrusion.[42]

In addition, the district has the authority to levy a "replenishment assessment" or pump tax upon all groundwater users. Proceeds from this assessment may be used to acquire water for groundwater replenishment or any other purpose of the district.[43]

The replenishment assessment is arrived at by the board of directors after determining, among other things, the estimated average annual overdraft for the preceding five water years, the then current water year, and the following water year, the amount of water that should be purchased for replenishment of groundwater during the following water year, and the amount of money needed to purchase the water. A replenishment assessment levied in any one year may not exceed the amount necessary to purchase sufficient water to replenish the average annual overdraft for the past five water years plus an additional amount sufficient to eliminate, over a period of not less than 10 nor more than 20 years, any accumulated overdraft. If the board so desires it may levy an additional assessment to carry out any of the district's authorized purposes.[44]

The replenishment assessment is to be levied at a uniform rate per acre-foot on all water "producers" in the district. However, an additional replenishment assessment may be levied on non-irrigation "producers" if the board finds after a hearing, that such an assessment is necessary for the protection of the district's water supply and is reasonable.[45]

The amount of any basin equity assessment is determined by consideration of a variety of factors. These include the amount of groundwater used during the preceding water year, the amount produced from supplemental sources, the amount produced from other sources, the condition of the area's groundwater supplies, the cost of using groundwater (including any replenishment assessment), and the cost of supplemental water.

"Basin equity assessments" may also be imposed to equalize the cost of water to all persons within the district by increasing or decreasing the cost of groundwater to influence the amount of groundwater used in relation to surface-water. To reduce groundwater overdraft in years when surface-water is available the assessment on groundwater users would be increased to encourage the use of surface water. The basin equity assessment also may be used to purchase water to replenish groundwater supplies.[46]

At the regular April meeting of each year the board considers the above information and determines the need for a basin equity assessment. If such an assessment is imposed it may be set at different uniform rates for irrigation and non-irrigation users. At the same time the board considers whether it should restrict groundwater use through the use of "production limitations" or require the use of groundwater through "production requirements." A surcharge on any groundwater withdrawn in excess of production limitations may be imposed. Production limitations and requirements and the surcharge are set in reference to a "basin production percentage." This is the ratio that all water produced from groundwater bears to all water produced from supplemental water and groundwater during the ensuing water year. Production limitations and requirements are expressed as a percentage of overall water produced from groundwater and from supplemental sources. Anyone required to produce more or in fact producing more than the basin production percentage must pay an amount arrived at by multiplying the excess water produced by the basin equity asessment plus the surcharge. Conversely, anyone required to produce less than the basin production assessment receives money from the basin equity assessment fund.[47]

The board may exclude from the basin equity assessment and any production limitations or requirements[48] any person who pumps 25 acre-feet or less from groundwater during the ensuing water year. Also excludable are groundwater users whose supply is not replenished by the Santa Ana River or its tributaries[49] or who withdraws groundwater that is unsuitable for domestic or agricultural use and whose use has no adverse effect on the district's groundwater supplies.[50]

The Orange County Water District presently imports supplemental surface-water through the Colorado River Aqueduct and the California Aqueduct from the Sacramento-San Joaquin Delta to replenish groundwater supplies directly by water spreading or other methods or "indirectly" by substituting surface-water for groundwater use.[51]

An example of the adjudication approach in bringing about groundwater management and conjunctive use of ground and surface-water can be found in the Main San Gabriel Basin, located within Los Angeles County. The area is primarily urban and includes the cities of Alhambra, El Monte, Arcadia, South Pasadena, and Azusa. Three municipal water districts (MWDs) overlie the basin. 75 percent of the valley is included in the Upper San Gabriel Valley MWD. The storage capacity, presumably both underground and surface, is 8.7 million acre-feet.

Groundwater pumping by cities, utilities, and rock and gravel companies in the main San Gabriel Basin resulted in serious groundwater declines by the early 1950s. Groundwater management through the integration of groundwater and surface-water use was brought about in three stages.[52]

The first step was the adjudication of surface-water rights on the San Gabriel River system. This took place as a result of a 1959 lawsuit by the City of Long Beach against users in the Upper San Gabriel Valley.[53] The major objective of the suit was to prevent upstream users from expanding their water use and force them to meet their increasing needs by purchasing supplemental water from the Los Angeles Metropolitan Water District. As a result of the *Long Beach* suit, most of the cities in the Upper San Gabriel Basin formed the Upper San Gabriel Valley MWD (USGVMWD) with the intent of being annexed to the Metropolitan Water District.

Under the terms of the *Long Beach* decision the upper basin area was required to supply the lower basin with "makeup water" or the funds to purchase it. The USGVMWD was required to supply this makeup water and obtained legislation authorizing it to levy a pump tax to obtain funds for the purchase of this water. The two other districts overlying the Upper San Gabriel Valley were not being assessed and did not have the power to levy pump taxes. One of the primary purposes of the subsequent groundwater adjudication was to rectify the inequitable distribution of costs resulting from the *Long Beach* judgment.

The allocation of surface flows between the upper and lower San Gabriel Basin was an important step in the evolution of a management plan for the upper basin. Once the amount of flow that had to be delivered to downstream users was quantified, the upstream interests were able to start planning for the conjunctive use of the remaining surface water and the area's declining groundwater supplies.

Water users in the upper valley formed the Upper San Gabriel Valley Water Association to arrive at a management plan. Rather than establish another district like the Orange County Water District or set up a joint administrative scheme through the three existing municipal water districts, the Association decided to negotiate and implement a management plan through a friendly adjudication which would empower a "watermaster" of locally selected individuals to administer and enforce the court approved plan.

A consultant was hired to negotiate and prepare a management plan which would result in the replenishment of the basin's groundwater supply through the use of surface water. After several years of negotiations the elements of the plan were agreed to and an adjudication action by the Upper San Gabriel Municipal Water District was commenced against the City of Alhambra and other water users in January of 1968. Arriving at a specific settlement agreeable to the 190 parties involved took approximately five years.

The stipulated judgment contains the details of administration for the area and specifies the powers of the watermaster. The watermaster is actually a committee composed of six local producer representatives, and two representatives from the Upper San Gabriel Valley MWD and one from the San Gabriel Valley MWD. The local representatives are elected by a procedure in which the quantity of water rights one holds determines the number of votes one may cast for the producer representatives. Upon the affirmative vote of five or more of its members the watermaster can levy assessments, obtain storage or spreading facilities, and require meters to be installed. The watermaster has sole control over all groundwater storage rights in the basin and may contract for the storage of supplemental water.

Under the stipulated judgment a natural safe yield for the basin was established at 152,700 acre feet and all groundwater users were enjoined from unauthorized pumping, recharge, or transportation of water from the watershed. The watermaster was given responsibility for setting the operating safe yield for the aquifer on an annual basis. The operating safe yield is adjusted annually to make the most efficient use of the basin's groundwater, local and imported surface-water supplies, and surface and underground storage space. Based on the adjudication of groundwater rights, each groundwater producer is entitled to a share of the operating safe yield. This adjudicated share may be sold or leased to either an existing or new groundwater user. Production in excess of a pumper's adjudicated share is allowed but is subject to a net pump tax. New users do not have an adjudicated share and so must either lease or purchase an existing user's share or pay the pump tax on their entire production. This revenue is used to purchase and/or distribute sufficient water to replenish the overdraft.

Operating safe yield can be set to discourage excessively high groundwater levels and the resulting waste of surface-water supplies that could be captured and stored underground, or it can be set to discourage excessively low levels which increase pumping lifts. If the amount of water in underground storage is low, the operating safe yield is set at a lower level. This increases the amount of production subject to assessment thereby discouraging groundwater pumping and raising revenue to purchase and spread replenishment water. When groundwater levels are high, operating safe yield is increased to encourage pumping and limit recharge from imported water.

Certain limits have been placed on the watermaster's discretion in setting the operating safe yield and replenishing the area's groundwater supply. Owners of rock and gravel pits in the valley were opposed to having water levels so high that their pits were flooded. On the other hand, area water users wanted lower pump lifts. Consequently, the judgment prohibits the watermaster from spreading imported water in a specific area where the groundwater level exceeds 250 feet above sea level. Water will be spread only to maintain water levels above 200 feet above sea level.

In addition to the net pump tax on any production in excess of a user's adjudicated share, all producers are subject to a gross pump tax to cover administrative expenses and a makeup water assessment to cover the cost of supplying water to downstream users as required by the *Long Beach* judgment. The gross pump tax is 45 cents per acre-foot, and the makeup water assessment is $3.50 per acre-foot on all production not subject to the net pump tax.

Adjudication costs to the Upper San Gabriel Valley MWD were approximately $424,000. Of this amount $221,000 were engineering costs and $202,000 were legal fees. If the district's in-house costs and the legal, administrative, and engineering costs of the other parties are included, it is estimated the adjudication costs would have been $750,000 to $1 million.[54]

The two examples given above are not isolated examples of integrated management programs in California. Large parts of the state are covered by various management entities whose primary purpose is to integrate the use of groundwater and surface water. A good example of a multi-agency effort throughout a large area is in the southern San Joaquin Valley.

The total area overlying usable groundwater in the southern San Joaquin Valley is approximately 3.9 million acres. Almost 90 percent of this land is included within entities having active integrated management programs. There are 63 such entities in the southern San Joaquin Valley. Management entities include cities, counties, irrigation districts, mutual water companies, special act districts, and water storage districts.

Roughly $500 million has been expended over the years by these various entities to bring about the integrated management of groundwater and surface water in a five-county area. An average of 9 million acre-feet of water is used annually in these conjunctive use operations. Of the 63 entities, 43 artifically recharge groundwater in natural channels, unlined canals, spreading basins or on cultivated lands, and 13 recover stored groundwater through their own wells. In the other management areas, the pumping of stored water is done by individuals. Delivery of surface water in lieu of groundwater pumping is used as a management tool by all the entities involved.

Direct recharge in the valley is provided through more than 15,000 acres of spreading basins, 3,500 miles of unlined canals, several hundred miles of natural stream channels and an undetermined amount of cropland. Over 2 million acre-feet of surface water has been stored underground in a single year. The surface-water has been obtained from local sources, the Central Valley Project, and the State Water Project.[55]

## ALTERNATIVE STATE POLICIES RELATED TO INTEGRATING THE LONG-TERM USE OF GROUNDWATER AND SURFACE WATER SUPPLY IN A MANNER THAT PRESENTS AN OPPORTUNITY FOR MAINTAINING OR INCREASING THE EFFECTIVELY USABLE SUPPLY

The multiple powers granted to some special purpose entities in other states may not individually seem important to integrated management. However, when used in tandem they can provide extensive powers for comprehensive surface-water and groundwater management. Therefore many of the alternatives listed as addressing this problem and issue deal with granting powers to districts. The districts listed for these alternatives are natural resources districts and irrigation districts. However, other types of special districts could also be formed if desired.

## ALTERNATIVE #17

## CONTINUE CURRENT POLICIES RELATED TO INTEGRATING LONG-TERM USE OF GROUNDWATER AND SURFACE-WATER SUPPLIES IN A MANNER THAT MAINTAINS OR INCREASES THE EFFECTIVELY USABLE SUPPLY

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Current policies were detailed in the section on applicable Nebraska law. LB 198, as passed in 1983, provides a number of statutory policies related to integrated management of surface water and groundwater in Nebraska. The bill provides recognition of groundwater recharge as a beneficial use, acknowledges the right to store water underground and recover it, and provides for beneficiaries of projects resulting in groundwater recharge to share in project costs. Reclamation districts had some powers to charge for recharge benefits even prior to passage of LB 198.

Determination of the degree to which economic benefits derived from integrated management under this alternative might compare to other alternatives is difficult. Determination of how the number of recharge oriented projects built under a continuation of current policies might compare with the number built under other approaches also is difficult.

For existing projects, current law provides for only a minimal charge for use of recharged groundwater. Due to the limit on the amount that can be charged, one might expect continuation of at least some problems resulting from project water users switching to groundwater in an attempt to pay a smaller charge. The degree to which allowed fees will abate this problem is unknown. Buildup of groundwater mounds may continue since districts would not be able to vary surface-water and groundwater use fees to achieve balanced use of each.

The number of new projects built under current state policies will depend at least in part upon federal spending and accountability policies on water projects. Discount rates applied to federal projects tend to work against recharge projects because the water quantity portion of their benefits often does not become substantial until many years after the original investment. Federal policies on cost-sharing with the states may be as important as federal policies on discount rates. These will interact with state funding policies and especially state individual yearly budget appropriation levels to help determine how many recharge oriented projects are built. State policies toward funding levels for most water projects, recharge oriented or otherwise, are set by yearly appropriations, especially to the Natural Resources Development Fund and the Water Management Board.

Although an ability exists under current law to charge for recharge water provided by new projects, the ability to control water under an individual's land is not given. No provision is made for variation of use fees proportionate to the water-management needs of an area or the state. Whether this type of power is needed to encourage maximum long-term economic development is subject to debate.

## ALTERNATIVE #18

## CREATE AND MAINTAIN A STATE FUND SPECIFICALLY FOR INTEGRATED MANAGEMENT PROJECTS OR GIVE SPECIAL CONSIDERATION TO INTEGRATED MANAGEMENT BENEFITS UNDER EXISTING FUNDING ARRANGEMENTS

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Adoption of this alternative would put a special state emphasis on groundwater recharge projects. Although that emphasis could be through a fund specifically for such recharge projects, more likely it would be through special recognition of recharge benefits in assigning priorities to projects receiving state funding under existing programs. Since some of those procedures are undergoing change with the introduction of a State Water Management Board, this may be an opportune time to reexamine this type of benefit. The existing funds which could give special consideration to recharge projects include the Natural Resources Development Fund, the Soil and Water Conservation Fund, and the recently authorized Water Management Fund. A major problem in counting benefits for recharge projects has been that many years often pass before benefits other than reduced pumping lift are achieved and discount rates negate any long-term economic benefit from prolonged aquifer life under current federal procedures. The Nebraska Resources

Development Fund does not currently use a discount rate.

This alternative could make state funds more available for recharge projects and in conjunction with other funding methods could result in considerable long-term recharge related benefits to the state.

Potential problems with adoption of this alternative would center on how economic benefits from recharge should be counted, who receives the benefits, and thus whether this is a wise investment of public funds. There may also be questions as to whether such projects should have preference over other types of supplemental water projects or other investments of public funds. The amount of funding to be provided could be a significant problem.

## ALTERNATIVE #19

## PROVIDE FINANCIAL INCENTIVES FOR RECHARGE, ESPECIALLY IN GROUNDWATER CONTROL OR MANAGEMENT AREAS. ALLOW ADDITIONAL WATER USE IF RECHARGE MEASURES ARE ADOPTED.

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

This alternative could include incentives at both the state and local level. However it could also provide tax breaks for such activities as surface water spreading by local landowners in the off season, or individual injection wells. Natural resources districts or multipurpose water districts also could offer technical assistance or possibly even a modest fund for small-scale individual recharge activities in groundwater management areas.

A portion of the Nebraska Resources Development Fund or Soil and Water Conservation Fund could be set aside for these activities. The Soil and Water Conservation Fund list of eligible practices could be expanded to include recharge related activities. The practices currently in the Soil and Water Conservation Fund and Federal Soil and Conservation Practices help to hold water in the soil profile, and sometimes result in recharge to the aquifer. Therefore, funding to these programs could be expanded. Small dams and ponds with recharge potential could receive more emphasis.

This alternative would have the advantage of tending to lengthen aquifer life especially in groundwater control and management areas. This alternative would target areas in which both a significant depletion is occurring and the local natural resources district has decided to take steps to address the problem. In conjunction with other actions incentives could make a significant difference in depletion rates.

Implementing this alternative would present some difficulties. Tax breaks or assistance for small-scale individual recharge activity would be difficult to administer and would require staffing of natural resources districts or other multiple purpose water districts to handle the funds. There could be political opposition from areas not receiving the tax breaks. It could also be difficult to determine the long-term economic impact of the recharge activities to which the incentives were applied.

## ALTERNATIVE #20

## REQUIRE SENIOR SURFACE-WATER APPROPRIATORS IN SELECTED AREAS TO USE AVAILABLE GROUNDWATER BEFORE CALLING ON JUNIOR SURFACE-WATER APPROPRIATORS THAT HAVE NO ACCESS TO GROUNDWATER. REQUIRE OR ALLOW EITHER PUBLIC OR PRIVATE COMPENSATION FOR THE COSTS INVOLVED.

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Although theoretically this alternative could result in expanded irrigated acreage and economic production in the state, it would entail massive legal, technical, and administrative problems as well as substantial costs. If adopted this alternative would result in some surface-water users switching to groundwater, at least in those years when downstream junior appropriators without access to groundwater made a call on that water. Thus the upstream senior appropriator's acres would remain irrigated while the additional available water resulted in increased irrigated acres downstream. Conceivably the economic benefits of such a change could be significant as all water sources were used to their maximum amount. An alternate approach to accomplishing much of this change is to amend the statutes pertaining to transferability of surface-water rights (§46-290 to 46-294). Currently voluntary sales of rights are restricted. *Alternative 11* in Chapter 6 deals with similar issues.

The legal problems are perhaps the most important. A change of this type could be considered as a damaging of a private property right. If a compensation mechanism were not a part of the law there would probably be a great deal of unpopularity attached to attempting a constitutional change for this reason. However, there could be substantial costs if reimbursement was offered to individual landowners.

Technical and administrative problems also present an extreme difficulty in implementing this alternative.

Determining what constitutes "access" to groundwater would be very difficult. Water quality, depth to water, groundwater in storage, and transmissivity characteristics all differ widely across the state. At individual sites data are often not available. Probably the only way to address those concerns with any practicality would be an area approach. For the area in which this alternative was adopted there would probably need to be ample groundwater in storage plus heavy demand for surface water in a definable downstream area having no reasonable access to groundwater. Defining and legally defending such areas could be a problem. If a reimbursement system were adopted it would be necessary to formulate rules to determine the amount of damages.

Equity issues arising from adoption of this alternative could be significant. Among the approaches for meeting the cost of installing a new well for the senior appropriator and then for pumping water from it could be state financed incentives or a requirement that the junior downstream appropriator defray those costs, which could be substantial.

The immediate economic costs of implementing this alternative would also be significant. Installation of new groundwater wells where surface water is already accessible could result in some duplication of facilities. Maintaining both facilities could also be expensive. However that would allow groundwater to be used in dry periods and surface water in other periods, thus prolonging aquifer life while utilizing both sources to the maximum. Although that approach would extend the overall period in which groundwater could be utilized this alternative could nonetheless have the effect of depleting long-term groundwater supplies in those areas switching to groundwater. Another potential problem with this alternative is that once groundwater pumping facilities were installed, the surface-water facilities might not be maintained and the senior surface right might not be used thus resulting in surface-water waste in years when downstream appropriators made insufficient calls. With some difficulty this type of alternative might be expanded into an overall system of marketability of water rights.

No other western states have adopted this policy. However, in California varying water use fees can in effect result in senior surface appropriators switching to groundwater.

## ALTERNATIVE #21

## GRANT MORE COMPREHENSIVE POWERS TO NATURAL RESOURCES DISTRICTS OR IRRIGATION DISTRICTS

(a) Give natural resources districts or irrigation districts engaged in groundwater recharge the rights to use fees and regulations to attain exclusive control of water they have stored underground and to achieve a balanced use of surface-water and groundwater.
(b) Allow districts to acquire water rights and purchase, sell, exchange, and import water.
(c) Allow districts to levy the following types of pump taxes
    (1) A general pump tax
    (2) A replenishment assessment
    (3) A net pump tax on water used beyond an allocated amount
(d) Allow districts to levy an additional property tax to generate funds for construction of groundwater replenishment projects.
(e) Allow districts to make basin equity assessments.

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

The following subalternatives are written to apply to natural resources districts and irrigation districts. They could also be applied to reclamation districts, public power and irrigation districts, or a newly created special water district designed to administer these powers.

(a) Give districts engaged in groundwater recharge the rights to use fees and regulation to attain exclusive control of water they have stored underground and to achieve a balanced use of surface water and groundwater.

This subalternative would go a step beyond the powers granted by LB 198 and state that not only are groundwater recharge entities allowed to levy fees for the use of recharged water but that they are allowed exclusive rights to control that stored water. It would require three legislative changes in the power that irrigation districts and natural resources districts currently have. One would be to allow districts to control use of water stored under an individual's land and allow pumping and surface transfer of that water to another point of use. A second change would be to allow existing irrigation districts the right to charge what the market would bear for recharge water rather than limiting them to a set maximum fee. A third change would grant existing and new districts the right to vary surface-water and groundwater use fees to achieve a balanced use of each or else use regulation to achieve the same ends. In total, these three changes would allow districts very substantial control of the use of stored water.

The first change would grant irrigation districts or natural resources districts (especially those with management or control areas) complete control and the ability to transfer recharge water from under an individual's land. It would be especially useful if the water was intended for a high value use. For instance, a municipality depending on recharge water might wish to prohibit surrounding irrigators from access to it. Another possibility is that water could be stored and then pumped as needed for a high value use downstream. Chapter 6 contains a discussion of pumping groundwater for surface uses.

The second change allows existing projects to charge what the market would bear. Conceivably existing projects rates could then be lowered to those currently charged and/or more money would be available for district operations. It is likely that fewer people would drop out of the project. New projects are allowed to charge the economic value of the water under existing law.

The third change would give irrigation districts, natural resources districts or, if desired, other types of water districts power to vary fees to raise the water table in areas of water table decline and to lower the water table where it is detrimentally high. Regulation could also be used instead of fees. Implementation of this would require the adoption of metering. The use fee portion of this subalternative was first presented in the *Policy Issue Study on Supplemental Water Supplies.* That study noted that a user fee related alternative:

"...probably would not provide enough of the new funds which might be necessary for new projects that would incorporate the concept of integrated management. However, these alternatives might allow existing projects, or those now authorized or under construction to use integrated management as a method to supplemental water....some projects in Nebraska are experiencing conjunctive use without the benefit of being allowed to totally manage it.

In areas of high water tables (Tri-County and Farwell Unit) integrated management could allow balancing of the source of water used with resulting reduction in lakes and wetlands, increased crop land, lowered water tables, reduced flow in drainage ditches and perennial streams and changes in the flow of source streams and storage reservoirs. In areas of declining water tables (Lodgepole Creek, and O'Neill area and elsewhere) the same balancing would occur and could result in more diversion from streams and stabilized groundwater levels and base flow in streams. These impacts would result in corresponding environmental impacts and would be similar to those experienced in the past with some possible differences in magnitude and timing.

If new fees are imposed on groundwater users, initial net returns to farmers and economic activity in the region would decrease to be offset from increased income and expenditures by water suppliers and by long-term net economic gains if the groundwater levels are stabilized. The same general economic impacts could result if fees are varied to balance the amount of use. Social impacts should not differ from those experienced under current policies except they would be positive if a stabilized groundwater level results. The exception is that negative attitudes towards new fees on groundwater could be a major social impact from the introduction of integrated management concepts. Those attitudes could hinder or kill such management attempts.

The costs to water suppliers for integrated management could be relatively large for a small district. This could limit its introduction and/or application."

Regulation would allow more precise control of surface-water versus groundwater use. However, it would have a disadvantage in that switching to a different type of use would cost some users more than others. A variation in the user fee would allow them more flexibility.

There would be technical problems in implementing this subalternative. The determination of what is existing groundwater and what is recharge water is a problem even under existing law. Problems with landowners on this point have occurred even though maximum fees for existing projects are set low. If fees are raised dramatically a determination might need to be made of whether an aquifer could be depleted to a certain point before recharge water was being used or whether uses of groundwater above a certain rate were using recharge water. However, that problem may also occur under existing law once a new project is built, if it is decided to charge more than a nominal fee.

This subalternative is intended to require that a maximum amount of surface water and recharge water is used rather than diminishing an area's groundwater supply. To the extent this subalternative was used it would tend to lessen the amount of surface water flowing out of an area unused and would tend to prolong the life of the groundwater reservoir. It would also tend to provide a market for projects which store surface water or recharge groundwater. This alternative would probably need to be implemented by local NRDs in management areas or possibly by irrigation districts. One option for implementing this subalternative would be to allow use of surface water with minimal charges while charging an increasing amount for groundwater use as groundwater reserves are depleted.

Not the least of the problems with implementing this subalternative would be the fact that reasonable use of groundwater underlying their land is now allowed to landowners. It is likely that going from a "free" source of water to one which is charged for would be unpopular and expensive for affected groundwater irrigators. Constructing diversions to see that stored water reaches their land could also be expensive. If this was implemented in an area with very depleted groundwater supplies it might receive more support than in an area where the problem was not as imminent. How domestic uses and existing groundwater would be charged under this system could become an issue. Some type of yearly water use plan would probably be needed to implement this alternative.

The policies of some other western states deal with the types of policies incorporated in this subalternative.

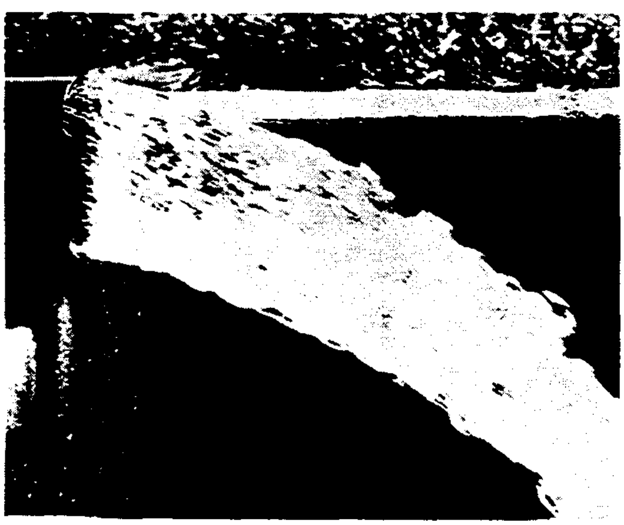
California's multipurpose water districts use a systems of fees and incentives that allow them to direct surface-water and stored water to be used as needed. In Arizona taxes on existing water uses can be levied to help in water supply augmentation and various provisions encourage maximum use of surface water before groundwater can be used. Irrigation water duties imposed on groundwater users do not apply to surface water. Users of Central Arizona Project are required to reduce groundwater use by an equivalent amount. Arizona also has methods of providing financial assistance to users of alternative water supplies.

All of the powers proposed by this subalternative are currently available to California districts.

(b) Allow districts to levy the following types of pump taxes
   (1) A general pump tax
   (2) A replenishment assessment
   (3) A net pump tax on water used beyond an allocated amount

A general pump tax could be assessed at a set rate on all water users. It would apply to all water used and would remain the same no matter what the amount of water pumped. It could be used as a method of raising funds for recharge projects and other supplemental water projects.

The replenishment assessment would be a special type of pump tax based closely on the California experience. A replenishment assessment is geared to generating enough money to provide replacement water for the amount by which withdrawals are expected to exceed the total allocation or goal for the area in a particular year or series of years. It would probably be levied at a uniform rate per acre-foot used, although different rates could be established for different types of users. The funds generated by the assessment would be used for supplemental water projects to provide the extra water needed.



It would require the natural resources district or irrigation district to set water use allocations. These allocations could be based upon various total rates or amounts of use for the area. Those rates or amounts could in turn be based upon some type of general long-term goal. One example of a type of goal would be achieving a long-term balance between the amount of groundwater withdrawn and the amount of natural and artificial recharge. A different type of goal might be to, on the average, deplete an aquifer no more than a certain percentage over a specified period. Whatever type of goal was elected, total amounts eligible for pumping in the area would be decided upon, either in a management plan or perhaps on a yearly basis.

A net pump tax on water used beyond an allocated amount would provide a means of assessing individuals for uses of water beyond their allocation. That assessment could then be used to construct recharge or other supplemental facilities. The net pump tax could be used in conjunction with limitations set by a gross pump tax or replenishment assessment. Beyond an allocated amount tax rates could be raised significantly. This could also be used as a mechanism to encourage water use efficiency and serve to limit or reduce the amount of replenishment water needed for an area.

These taxes and assessments can raise money for district operations or projects while simultaneously providing some economic incentives for efficient use. Replenishment assessments provide a method for manipulating total water supplies in an area to coincide with the goals the district sets. In addition the replenishment assessment provides some economic tie between the costs of using existing water in an area and the costs of replacing it.

Administering some parts of this subalternative could be difficult. Its adoption would require the installation of meters by all users. Implementation of replenishment assessments would require the district to determine allowable withdrawals within its goals and to set the replenishment assessments at a sufficiently high rate to replace water withdrawn beyond that amount. This could require considerable research on the part of the district. The net pump tax would require the districts to set maximum allocations for individuals and to tax at higher rates for water used beyond those amounts. This could also involve considerable effort for reading individual meters. In addition, a pump tax could cause social controversy regarding whether the benefits from recharge and other supplemental projects were being proportionately received by those paying the taxes. In California replenishment assessments are levied upon lands which receive recharge from surface-water projects.

General pump taxes are used in active management areas in Arizona and in various water districts in California. Replenishment assessments and basin equity assessments are both in use in California.

(c) Allow districts to levy an additional property tax to generate funds for for construction of groundwater replenishment projects.

Adoption of this subalternative would allow a specific tax levy to be used for construction of recharge facilities. It would require legislative action to raise the tax levy. The tax levy could be raised throughout the district if desired. Another variation would be to raise the tax levy only in replenishment areas. Groundwater recharge projects could be one of several purposes or even the sole purpose for this tax levy. The tax levy could go to a fund administered by either a local NRD or possibly other types of districts. This subalternative makes initiation of projects possible at the local level if local support could be generated. In combination with other funding sources this could provide a method to begin feasible recharge projects that could prolong the life of the aquifer and thereby help stabilize the economy in the area.

Potential areas of contention concerning this subalternative could include the equity aspect of those paying the taxes versus those receiving the benefits and how well those in control of the district receiving funds represented those paying the taxes. In addition, because of the effect discount rates have in regard to the long term nature of recharge benefits it might be necessary to combine these benefits in multi-purpose projects before many would become economically feasible under federal procedures. Questions on how recharge benefits should be counted for purposes of economic feasibility also are likely.

(d) Allow districts to make "basin equity assessments."

Basin equity assessments can be used to equalize the cost of water to surface-water and groundwater users within a district and to promote effective use of both sources of supply. Under this arrangement the district would project total yearly water use, set a water use goal and determine the proportions of water to be pumped from the ground and the proportions to come from surface water and imported sources. Water users can be required to use either surface water or groundwater. Users pumping more than their requirement are forced to pay a surcharge. Users who are required to utilize a more expensive source of water then receive funds from the basin equity assessment. Thus all users in the district pay about the same amount per unit of water regardless regardless of the source of that water.

Basin equity assessments in conjunction with diversion or withdrawal limitations could provide a very strong tool for achieving balanced use of groundwater and surface-water. However, the Orange County Water District, which uses this system in California, had the advantage of beginning from a situation in which the rights of pre-existing water users were unknown. Installing such a system in Nebraska would involve a considerable legal problem in dealing with existing rights. There could also be problems in defining the physical areas where such assessments were to occur. In California the assessments occur in fairly well defined basins where surface-water naturally recharges groundwater. In Nebraska the physical situation in which this occurs may be somewhat more complex. Additionally this can only work in areas where surface water and groundwater are available.

Basin equity assessments are used by the Orange County Water District in California.

## ALTERNATIVE #22

## EXPAND RESEARCH RELATED TO THE IMPACTS OF INTEGRATING USE OF GROUNDWATER AND SURFACE-WATER SUPPLIES

### DESCRIPTION AND GENERAL IMPACTS OF ADOPTION

Adoption of this alternative could help provide information on some of the impacts of adopting each of the alternatives included in this chapter. It could also prove useful in implementing alternatives which require determination of allowable groundwater depletion rates, or setting district total water use goals. Research into costs of district acquisition of water rights would be necessary before an alternative including that type of action could be adopted in a specific area.

Research into the degree to which soil and water conservation measures impact aquifer recharge might also be useful in making decisions on whether those techniques should be funded.

## REFERENCES


1. **Neb. Rev. Stat.** §§46-656 to 46-674.01 (Reissue 1978, Cum. Supp. 1982, Supp. (1983).

2. Cornell, Howland, Hayes & Merryfield-Clair A. Hill & Associates ($CH_2M$/Hill), *Project Report for Central Nebraska Public Power & Irrigation District: E-65 Master Plan* (Nov. 1971). For a summary, see Harnsberger, Oeltjen & Fischer, **supra** note 32, Appendix.

3. **Neb. Rev. Stat.** §46-295 (Supp. 1983).

4. **Ibid.**

5. **Neb. Rev. Stat.** §46-296 (Supp. 1983).

6. One application form is used currently for both types of storage. The initial application fee is five hundred dollars. **Neb. Rev. Stat.** §33-105 (Supp. 1983). Each application must be accompanied by a certified list of names and addresses of individuals who will be affected by the application. In addition, sufficient hydrologic information must be submitted to identify the extent and scope of the underground storage facility and recovery. Dept. of Water Resources Rules and Reg. 457 DWR 16-002.

7. The application, if approved, would be subject to the following conditions: (a) the rate, quantity, or time of surface diversion shall not be increased from the original appropriation, (b) additional or different lands for irrigation may be included, (c) the priority date of the original appropriation stays the same, and (d) any other reasonable conditions deemed appropriate to protect the public interest. **Neb. Rev. Stat.** §46-226.02 (Supp. 1983). The application may be made only by an appropriator of record who can show sufficient interest, by way of hydrologic information identifying the extent and scope of the underground water storage facility.

8. **Neb. Rev. Stat.** §46-298 (Supp. 1983). A hearing by DWR is required prior to the imposition of fees.

9. **Neb. Rev. Stat.** §46-296 (Supp. 1983).

10. **Neb. Rev. Stat.** §46-233 (Supp. 1983). An unapproved application pending on the effective date of the act may be amended to include appropriation for intentional underground storage.

11. **Neb. Rev. Stat.** §46-299 (Supp. 1983). Hearing required.

12. **Neb. Rev. Stat.** §46-229 et seq. (Reissue 1978, Supp. 1983).

13. *Northport Irr. Dist. v. Jess,* 215 Neb. 152,_____ N.W. 2d_____ (1983). See discussion under problem five generally.

14. The process is not so deceptively uncomplicated. A number of other factors must be considered by the DWR before issuing an appropriation permit or allowing an interbasin transfer. These include finding the action is "in the public interest" and in compliance with the Nebraska Nongame and Endangered Species Act, **Neb. Rev. Stat.** §37-435 (Reissue 1978).

15. **Neb. Rev. Stat.** §46-242 (Reissue 1978).

16. Reclamation Act, **Neb. Rev. Stat.** §§46-501 to 46-573 (Reissue 1978).

17. **Neb. Rev. Stat.** §46-501 (Reissue 1978).

18. **Neb. Rev. Stat.** §46-544 (Reissue 1978).

19. The constitutionality of the reclamation law was challenged in and upheld by the Nebraska Supreme Court in *Nebraska Mid-State Reclamation Dist. v. Hall County,* 152 Neb. 410, 41 N.W. 2d 397 (1950).

20. Senate Bill 1001, 34th Legislature, 4th Special Session, Ch.1 (1980).

21. Arizona Ground Water Management Study Comm'n., *Final Report* I-4, I-5 (1980).

22. **Id.** at I-3.

23. Johnson, Summary of the 1980 Arizona Ground Water Management Act, 1, (State Bar of Arizona Continuing Legal Education Series 1980) [Hereinafter referred to as **Johnson**.]

24. **A.R.S.**§§45-451.B, -466 (1980).

25. **Id.** at §§561.1, 565.A.4, 611.1, 611.2.

26. **Id.** at §§402.18.

27. Johnson, **supra** note 9, at 4,6,14,15.

28. **A.R.S.** §§45-514.A.3, 515.A.2 (1980).

29. **Id.** at §452.B

30. **Id.** at §§565, 611; **Johnson, supra** note 9 at 24.

31. California Depart. of Water Resources, *The California Water Plan Outlook in 1974* 2 (Cal. State Water Resources Bill. No. 160-74, 1974).

32. **Id.** at 91,96.

33. Governor's Comm'n. to Review California Water Rights Law, *Final Report* 140 (1978) [Hereinafter referred to as the Governor's Report].

34. **Id.** at 142-46.

35. **Id.** at 146.

36. Cal. Water Code Anno. §30000 **et seq.** (West 1968).

37. **Id.** at §71682 **et seq.**

38. **Id.** at §7400 **et seq.**

39. **Id.** at §60000 **et seq.**

40. **Id.** at §20500 **et.seq.**

41. **Id.** at §40-2(6).

42. **Id.** at §40-17 (Supp.1983).

43. **Id.** at §40-23.

44. **Id.** at §40-26, 27.

45. **Id.** at §40-27.1.

46. **Id.** at §40-31.5.

47. **Id.** at §40-31.5.

48. **Id.**

49. **Id.** at §40-38.

50. **Id.** at §40-38.1.

51. *Governor's Report*. **supra** note 19 at 147.

52. Lipson, Efficient Water use in California: The Evolution of Ground Water Management in Southern California 45 (Rand Corp. 1978) [Hereinafter referred to as Lipson].

53. *Long Beach v. San Gabriel Valley Water Company*, Los Angeles Superior Court Case No. 7226478, Sept. 12, 1965.

54. Lipson, **supra** note 38 at 46-55.

55. This material comes from an unidentifiable report from which I have only Chapter VI, entitled "Ground Water Management," The material is from pages 46-48 of that report.

## ADDITIONAL REFERENCES


1. Aiken, J.D., Evaluation of Legal and Institutional Arrangements Associated with Ground Water Allocation in the Missouri River Basin States, Nebraska Water Resources Center, University of Nebraska-Lincoln, December, 1984.

2. Aiken, J.D., Legal Aspects of Conflicts Between Users of Surface and Groundwater, Department of Agricultural Economics Staff Paper, University of Nebraska-Lincoln, 1980, #1.

3. Aiken. J.D., Legal Aspects of Ground Water Recharge. University of Nebraska-Lincoln, Department of Agricultural Economics, September, 1980, # 10.

4. Aiken. J.D., Surface-Ground Water Conflicts in Nebraska. Department of Agricultural Economics Staff Paper. University of Nebraska-Lincoln, 1981, # 3.

5. Trelease. Frank J., Conjunctive Use of Groundwater and Surface Water, Rocky Mountain Mineral Law Institute.

POLICY ISSUE STUDY
ON
INTEGRATED MANAGEMENT OF SURFACE WATER AND GROUNDWATER REPORT

STATE WATER PLANNING AND REVIEW PROCESS

# AN APPENDIX TO THE INTEGRATED MANAGEMENT OF SURFACE WATER AND GROUNDWATER POLICY ISSUE STUDY APPENDIX A AND B

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## APPENDIX A

# FIELD OBSERVATIONS ON POTENTIALLY LOSING STREAM SEGMENTS

When work began on this policy issue study the Department of Water Resources was requested to provide any data it had on what stream segments in the state might be "losing." The following two memos include field information the Department submitted on potentially losing segments. It should be noted that the data is **very preliminary** in nature and does not represent extensive research. In a number of cases the segments may be losing for only part of the year. It should also be noted that losing stream segments represent only a small portion of the state's total stream segments.

**Date** November 10, 1983

**From** Mark Nelson

**To** Bob Bishop

**Subject** Policy Issue Study on Integrated Management of Surface and Groundwater

Numerous river and stream reaches throughout the State have been identified which apparently lose water to the associated aquifer. Information on losing reaches was supplied by the Cambridge, Norfolk, Lincoln, and Ord divisions. The Bridgeport division provided data on Pumpkin and Lodgepole Creeks obtained in seepage runs conducted October 25th and 26th. The data from these sources and my own observations are summarized below:

A. **NIOBRARA RIVER BASIN**

1. KeyaPaha River. Wewela, South Dakota gage to Naper, Nebraska gage. - Observations during 10 years of water administration and comments by local residents.

B. **SOUTH PLATTE RIVER BASIN**

1. Lodgepole Creek. Kimball to Sunol. - October 1983 seepage run.

C. **PLATTE RIVER AND SMALL TRIBUTARIES**

1. Platte River. Odessa gage to Grand Island gage. - USGS published data on selected low flows.

2. Platte River. Grand Island gage to Duncan gage. - USGS published data on base flows and low flows.

3. Clear Creek. Northwest Polk County.—Lincoln division observations during water administration.

4. Deer Creek. Near Bellwood. - Lincoln division observations during water administration.

5. Lost Creek. Five miles southwest of Schuyler. - 1979 seepage run.

D. **LOUP RIVER BASIN**

1. Cedar River. Cedar Rapids to Belgrade. - Seepage runs 1979-1983.

2. Beaver Creek. Albion to Boone. - Seepage runs 1978-1983.

E. **ELKHORN RIVER BASIN**

1. Elkhorn River. Oakdale to Meadow Grove. - Seepage run in 1979 and Norfolk field office observations during the 1970's.

2. Yankton Slough. Lower portion near Pierce. - Conservation and Survey Division.

3. Maple Creek. Branches and tributaries straight north of Schuyler - Water administration in 1976.

F. **REPUBLICAN RIVER BASIN**

1. Republican River. Benkelman gage to Stratton gage. - Regular stream gaging measurement trips 1982-1983.

2. Beaver & Sappa Creeks. Beaver Creek at Beaver City gage to Sappa Creek at Stamford gage. - Regular stream gaging measurement trips 1982-1983.

G. **BIG BLUE RIVER BASIN**

1. West Fork of the Big Blue River. Stockham to McCool Junction. - Fall 1980 seepage run.

H. **LITTLE BLUE RIVER BASIN**

1. Little Blue River. West Central Thayer County. - Lincoln division observations during water administration.

2. Spring Creek. Thayer County. - Lincoln division observations during water administration.

3. Big Sandy Creek. Southeast Clay, northeast Nuckolls and west central Thayer County. - Lincoln division observations during water administration.

This list of river and stream reaches which appear to lose flow to the aquifer is very preliminary in nature. Additional research into the data files and possibly more seepage runs will be needed to develop an accurate list of Nebraska streams and rivers which consistently lose water. I've enclosed copies of reports submitted by Keith and Karl which document the data listed in this memo.

MEN/jm
Enclosures

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**Date** November 10, 1983

**From** Stan Christensen

**To** R. F. Bishop

**Subject** Losing streams in Western Nebraska

As per our conversation this date, here is a list of streams in our area that I suspect are "losing" streams:

North Platte River between Lisco and Lewellen
Deep Holes Creek near Bridgeport
Greenwood Creek near Bridgeport
Lawrence Fork Creek near Bridgeport
Willow Creek near Bridgeport

Lost Creek near Oshkosh
Ash Creek near Lewellen
Plum Creek near Lewellen
Lower Dugout Creek near Broadwater
Snake Creek near Alliance

Deadman Creek near Crawford
English Creek near Crawford
Squaw Creek near Crawford
Hooker Creek near Crawford
Indian Creek near Whitney

Trunk Butte Creek near Whitney
Alkali Creek near Chadron
Dead Horse Creek near Chadron
Big Cottonwood Creek near Dunlap
Pepper Creek near Dunlap

Pebble Creek near Dunlap
Antelope Creek near Harrison
Jim Creek near Harrison
Warbonnet Creek near Harrison
Monroe Creek near Harrison

SMC:db

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## Summary of Public Hearing Draft Policy Issue Study on Integrated Management of Surface Water and Groundwater

**7:00 p.m.**
**October 9, 1985**
**Natural Resources Commission Conference Room**
**State Office Building**
**Lincoln, Nebraska**

## PROCEDURE

Dayle Williamson, Director of Natural Resources, presided over the meeting. Steve Gaul of the Commission staff introduced the legal exhibits and summarized the contents of the draft report. Formal testimony was then taken, followed by a discussion period.

## TESTIMONY OFFERED

**Vince Dreeszen, Director of the Conservation and Survey Division, University of Nebraska**, gave an oral statement. Although he felt the draft report was quite well written, he believed there had been no need for the study. He said that Nebraska was already ahead of California in water management and that the Colorado system worked at a high cost. He explained that Colorado's was a complex system that made work for lawyers and consulting engineers. He said that Nebraska should not look to other western states for how to address surface water-groundwater relationships.

Dreeszen believed the report title was inaccurate because the report addressed integration of surface water and groundwater rights rather than integrated management. However, he stated the text was reasonably accurate and was in fact a contribution to Nebraska hydrology. He expressed concern that the alternatives seemed to stray from what is in the text. He said that there seemed to be a paranoia that groundwater is taking surface water. He stated that while groundwater pumping does diminish discharge to streams, much of that discharge is to evapotranspiration.

Dreeszen felt the report had assumptions that implied groundwater level declines are bad. He said that groundwater had been awfully good to surface water and that less than 1 million acre feet of use was from surface water while 6 to 7 million acre feet are from groundwater. On another point, Dreeszen said his agency and the Department of Water Resources had disagreed with the Bureau of Reclamation on groundwater depletion impacts to the potential Cedar Rapids project.

Dreeszen disagreed strongly with one statement in the draft recommendations. The recommendations had stated that streamflow impacts of groundwater development already in place probably have not yet been fully realized and that similarly the impact of future groundwater development and use will not be felt in many locations until years and sometimes decades after groundwater use is initiated. He said he didn't know in fact where that condition exists and he believed that the statement represented paranoia.

Although Dreeszen felt the recommendations did not adopt the Colorado system, he believed that several recommendations were the first step in adopting that system. He noted that the report said *Alternative 2d* would have limited application in Nebraska. Dreeszen said that the application would be so limited that he didn't know where it would apply. He had similar problems with *Alternative 7c.* He stated that *Alternative 3* represented a "Colorado" direction and although it may deserve future discussion, he questioned whether it should be implemented. He felt there won't be much new research on the subject unless the legislature appropriates money.

In regard to *Alternative 8a* Dreeszen said that he didn't know if there would be anything to be gained by issuing a surface water right to a city for a wellfield designed for induced recharge. He said that the recharge is fairly direct in the Metropolitan Utilities District wellfield, but that it is much less direct in others such as the Lincoln and Grand Island wellfields. He stated that except for the MUD wellfields rainfall and naturally greater recharge in the valleys were the main factors. Dreeszen felt that under some conditions there would be a tendency to ask for the glass to remain full and not allow the reservoir to be used as a reservoir. He said that this alternative has been discussed since the late 1950s and that the state should proceed cautiously.

Dreeszen said that he had no problems with the recommendation on *Alterantive 11*, although he suggested that reference to municipal transfers be deleted because that right already exists. He also stated that he had no problems with the recommendations on *Alternatives 14, 15,* and *16.* Dreeszen felt that L.B. 198 had made the recommendation of *Alternative 21(a)* unnecessary. He also disagreed with some of the draft language accompanying the recommendation.

Dreeszen agreed that discussion should continue on developing a funding mechanism for water management. He said that he didn't know whether a pump tax is the way to go.

**Mike Dennis, Education Project Director, for the Nebraska Water Conservation Council,** also gave an oral statement. He said that he would like to commend the NRC and the review staff for producing the report. Dennis felt that the report addressed one of the fundamental needs in the state; the problem of groundwater declines and how they should be addressed. He stated that large surface water impoundments are going in the wrong direction and are a misappropriation of state resources. He supported any effort tending toward systems of allocating groundwater and more local control of groundwater. Dennis said he especially supported recommendations advocating further research. He felt that those recommendations could help clear up any misunderstandings and lead to a better groundwater management system for the state.

## OTHER DISCUSSION

Dreeszen noted that Williamson had said the recommendations were long range and that he wasn't saying never. He explained that in most of Nebraska we are now working with surplus water. He said that doesn't mean that for all time we will not address surface water and groundwater relationships.

Bob Kuzelka, Conservation and Survey Division, asked whether, since the alternatives are long range, that some things would have priority to be implemented sooner than others. Gaul replied that a high priority recommendations package may be assembled for the *Summary and Review Policy Issue Study.* He said that many of the recommendations in the *Integrated Management Study* would have low priority, although he suspected a few would have higher priority.

Wayne Johnson, Natural Resources Commission member, asked whether *Alternative 2d* is contrary to the priority system already established. Annette Kovar, Commission staff, explained existing users would not be affected. She said future groundwater users would be affected if they begin to affect surface flow. Dreeszen said that the recommendation was unclear as to whether it was between groundwater users or groundwater users and surface water users.

Jim Ducey, Audobon Society, asked whether a control area could be declared to maintain an area's groundwater reserve to preserve values and uses at a certain point in time. He said that by the time a problem manifested itself in the Sandhills there may not be any wetland left. He asked whether the recommendation on *Alternative 3* would allow a control area to be declared to prevent lake or wetland depletion. Gaul said that the recommendation did not specify whether lakes and wetlands were to be included. However, the alternative description in the text does include lakes and wetlands.

Ducey said that fish and wildlife in the Sandhills are unique in Nebraska and a 20-foot decline would cause most of the lakes and wetlands in the Sandhills to go dry. He said a program could be implemented to save the lakes and wetlands. Gaul responded that complex hydrogeology such as sealed lake bottoms and perched water tables would cause some difficulties in implementation. He said that such areas might have to be handled on a case by case basis.

Hal Schroeder, Nebraska Water Resources Association, asked what was going to cause a 20-foot decline in the groundwater table in the Sandhills. Ducey responded that a large project or development in the Sandhills could conceivably cause such a decline. Schroeder said that he had never seen a combination of circumstances which lowered water levels enough to substantially lower lakes. He stated that historically the U.S. Fish and Wildlife Service had tried to get easements around some Sandhills lakes. Schroeder noted that many people forget the large amount of water being evaporated. He said that in some areas it could fail to rain for 200 years and there would still be water available for use. He said that the study was appropriate but that the state should get the information and details needed before it rushes into passing laws or restrictions. Schroeder stated that there was too much loose talk about lowering water tables by something happening in the Sandhills.

Dreeszen said that in the decades ahead there could be an attempt to put a massive wellfield in the Sandhills and that it would need to be done on a permit basis. He said that such a wellfield would affect only a small part of the Sandhills and that most of the lakes are in the north and west.

Ducey stated that he agreed with the need for further research. However, he asked why the state should wait until it had a problem. He said that something should be done beforehand to prevent the problem.

Jim Cook, Natural Resources Commission member, reported that study has proved marshes and lakes are being caused by groundwater pumping in southern Cherry county. Frank Bartak, Commissioner, said that in his area they had applied for a groundwater control area several years ago because they thought that groundwater pumping would dry up the Sandhills. He stated that they should have gotten a control area, but for a different reason. He explained that the pumping had brought water to the surface and caused flooding. He stated that they now had problems with people digging ditches and running water onto neighbors. He noted that he still doesn't like sandhills development but that the actual problem was the opposite of the expected one. He said that potholes have now become larger instead of drying up.