Design and Analysis of Management Programs and Depletion Rules for the Conservation of Ground Water

Contract Report

by

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EXECUTIVE SUMMARY

On the basis of an analysis of available ground-water district rules, primarily from Nebraska, Colorado, and Kansas, three fundamental elements of ground-water management programs have been adopted to preserve and enhance ground-water resources in a designated area:

- An aquifer maintenance goal,
- The delineation of sub-areas of management, and
- Development and implementation of depletion rules.

This report summarizes the principal features of several ground-water management programs and then develops three hypothetical management plans for the Panhandle Ground Water Conservation District No. 3 (the District) Board of Directors (the Board) to consider as possible templates during the development of a management program for the District. The hypothetical management plans are also intended to illustrate to the Board the actual level of conservation that would be required to meet the various management goals.

INTRODUCTION

A significant portion of the Panhandle Ground Water Conservation District No. 3 (PGWCD No. 3) has experienced a declining water level in the Ogallala (High Plains) aquifer owing to over-drafting of ground-water reserves to meet municipal, industrial, and agricultural needs of the district. The potential remains for continued depletion of the area's principal water resource, a vital component of the local economy. The Board of Directors (the Board) of the PGWCD No. 3 is

responsible for ensuring the long-term availability of ground water in the district. In order to develop a ground-water management program with rules and regulations to conserve ground water, the Board has asked the Bureau of Economic Geology (the Bureau) to assist with the evaluation and development of depletion rules that might, in the future, be incorporated in some form within the PGWCD No. 3 operating rules. This report presents

- A review of selected ground-water management programs and depletion rules from ground-water management districts in Texas and other states, including Nebraska, Colorado, and Kansas,
- A synthesis of a set of hypothetical depletion rules that would be appropriate for the PGWCD No. 3, and
- An analysis of the potential impacts of these hypothetical depletion rules on different areas within the district.

The primary hydrologic parameter used to evaluate the effectiveness of a conservation or management plan is the elevation of the water table both locally and regionally. The difference in elevation between the water table and base of the aquifer is the saturated thickness of the aquifer. As water level changes, so does saturated thickness. Documenting the rate of water-level decline, therefore, is the primary method to track and control ground-water depletion. Consequently, when depletion rules are reviewed in this report, the conservation or management plans are also being summarized. The terms conservation plans and management plans are used interchangeably in this report.

A comprehensive ground-water management program includes state-of-the-art technology to maximize water conservation in all applications: agricultural, municipal, industrial, and domestic. Technologies may include extensive monitoring programs to monitor water levels, computer programs to manage the extensive data bases and to track the rates and locations of

depletion within the District, flow metering water wells to accurately track the amount of ground water produced, and numerical models of ground-water flow to evaluate the impact of changing production on new and existing water wells. A comprehensive program also can include public education and water conservation. If the PGWCD No. 3 establishes a ground-water management program, all of these elements should be considered during the design of the program.

REVIEW OF EXISTING DEPLETION RULES

The number of approaches taken by the various governmental entities responsible for the management, conservation, and protection of local and regional ground-water resources in the southwestern United States is quite broad. Through the efforts of the PGWCD No. 3, a request for rules, regulations, or information regarding the conservation or management of ground water was made to the member districts of the Ground Water District Managers Association. Ground-water management plans being used by a number of ground-water management districts (GWMD) were received and reviewed in this study. Existing management plans from ground-water management districts in Kansas, Colorado, and Nebraska, all with large areas overlying the Ogallala aquifer, were the primary resource used for this study because the significant decline in ground-water resources in these states is quite similar to the depletion problems being experienced by the PGWCD No. 3. As a follow-up to this survey, ground-water management districts in Arizona and California were also contacted, and requests for additional data made.

Management Criteria Components

Ground-water management plans have three fundamental elements:

- A stated aquifer management (conservation) goal,
- Delineated subareas of management, and
- Depletion and conservation rules and regulations.

Following are definitions of these components.

Aquifer Management (Conservation) Goal - the management goal defined by the ground-water district or the state for the aquifer. In some ground-water management plans, this goal is explicitly stated, for example, a specific period of time over which the aquifer is managed to yield water, typically, from 50 to 100 years. In other plans the management goal is incorporated within the depletion rules. One such example is an objective to have no further declines from current water levels (zero depletion). Another example is to maintain a certain volume of flow from one or more springs within the aquifer. The management goal may also address water quality issues, water conservation program development, and transportation and transfer issues.

Subareas of Management - a criteria for subdividing the district into smaller geographic areas in which to apply specific control measures. In some of the districts in Kansas, for example, subareas of management or management areas are delineated on the basis of townships or hydrogeologic basins. Texas law, however, suggests that district rules must be applied uniformly within the district (M. Booth, personal communication, 1996). This might prohibit the application of the submanagement area concept in Texas. Exceptions to this requirement of uniformity might be allowable, for example, where other factors are involved, such as protecting endangered species. If, for example, the Arkansas Shiner is eventually listed on the Endangered Species List, then a buffer zone around the critical area habitat might be established as part of a subarea of management rather than as a district-wide goal.

Depletion Rules - rules to manage withdrawals of water by new or

existing users in order to attain the aquifer management goal. The depletion rules are based on specific measurable aquifer attributes, such as water level or spring flow, that serve as indicators of the state of the aquifer. Reaching the specified attribute value may trigger a variety of actions by the ground-water management district. Depletion rules may lead to (1) the curtailment of allowable ground-water withdrawals, (2) implementation of rules controlling the spacing between new and existing wells, and (3) other water conservation measures.

Management Plans for New Versus Existing Well Withdrawals

Among the examples from Nebraska, Kansas, and Colorado, one of the principal differences in ground-water management criteria is whether they are applicable to new or existing wells. In Colorado and Kansas there is a system of water rights permits that appropriate allowable ground-water withdrawals. In these states, depletion rules may be applied to new wells and not existing wells. Natural Resource Districts in Nebraska apply depletion rules to existing and new wells.

Nebraska's Management Criteria and Depletion Rules

The 23 Natural Resource Districts (NRD) in Nebraska are required by 1991 State legislation to develop or update ground-water management plans. Although the development of these plans was driven primarily by concern over ground-water quality related to aquifer contamination from nitrate fertilizers, the Legislature also provided an opportunity for the NRDs to implement depletion rules to govern the quantity of ground water that can be withdrawn under conditions of declining water tables.

A relatively high degree of control is exercised by the Nebraska NRDs.

Each district designs its own ground-water management plan subject to approval by the Nebraska Department of Water Resources. The NRD can include all three management criteria: (1) the aquifer maintenance goal, (2) subareas of management authority, and (3) depletion. There are, however, some State legislative limits on the measures the NRD can employ to limit ground-water withdrawals from existing wells. The aquifer management goals, control areas, depletion indicators, and resulting actions of the four NRD's are summarized below and in table 1.

Aquifer Management Goals

Only the ground-water management plan of the Tri-Basin NRD in south-central Nebraska explicitly states the quantity of water in storage as an aquifer management goal. The goal of the Tri-Basin NRD is to maintain the current aquifer water supply forever. Although the three other NRDs from which we obtained plans have not specifically stated a management goal, they have adopted other ground-water management criteria that suggest an acceptable goal is to maintain a certain minimum value of saturated thickness (see table 1).

Geographic Subareas of Management

A feature common to the ground-water management plans of the NRDs in Nebraska is the use of geographic subareas of management smaller than the district. In the Lower Platte North NRD, for example, the geographic subdivisions are defined within the management plan and have their own depletion indicators (monitor wells). The boundaries of special management subdivisions in other NRDs would be established only after certain monitor wells show significant

declines.

Depletion Rules

Although there is some variability in the depletion rules among districts, as indicated in table 1, they all are triggered by changing water levels in monitor wells. Three of the NRDs compare the water level in the monitor well to some pre-established baseline saturated thickness. One NRD compares water level to a "Reasonable Acceptable Decline" that it is to establish.

A feature common to three of the NRDs is the multilevel approach to management, with increasingly stringent depletion rules coming into play as aquifer water levels continue to fall. In most cases the initial level of management by the NRDs is devoted to educational and monitoring actions. As water levels reach a specified trigger level, the NRD actions move toward required measures to reduce ground-water withdrawals.

Management Plans for New Wells

Ground-water management plans from districts in Colorado and Kansas that apply to the quantity of ground-water withdrawal are primarily affected on requests for withdrawals through new wells.

Colorado

The Colorado Ground Water Commission, an agency of the State government, has adopted very specific aquifer management goals for the different aquifers in the state. These goals are used to determine how much water can be withdrawn (appropriated) by applicants for new wells. The

management goal for the Ogallala aquifer in Colorado is a maximum of 40 percent depletion of existing ground water in storage over a 100-year period. Each proposed new well has an associated theoretical "cylinder of appropriation" of a 3-mile radius, a height equal to the saturated thickness of the aquifer at the time of permit application, and a specified water storage of 15 percent. The allowable annual withdrawal from the cylinder is 0.01 (equal to 1 year of the 100-year management period) of 40 percent of the water in storage plus a recharge allowance of 20 percent of the yearly average precipitation falling on the cylinder. If withdrawals from currently permitted wells in this same cylinder do not exceed the total allowable annual withdrawal then the new well may be permitted at a production rate not to exceed the remaining allowable amount. If, however, the total allowable withdrawal from the cylinder has already been appropriated, then a permit for the new well is denied. Although local GWMDs in Colorado have been authorized by the State to devise management plans that could include locally designed depletion rules for existing wells, there has been little effort by the districts in this regard (B. Saunders, personal communication, 1996).

Kansas

There are currently five GWMDs in Kansas, three of which provided their ground-water management plans for this analysis. State law in Kansas provides regulations for the management of ground water in areas outside of GWMDs but allows autonomy for GWMDs to implement their own management programs, which may not be equivalent to State law in terms of management goals and conservation tools. The only State requirement a GWMD must meet is that its management program be certified by the Kansas State Engineer as being compatible (not in conflict) with State law.

With an increasing rate of decline in water levels observed within the Ogallala aquifer in Kansas in the early 1990's, both the GWMDs and the State implemented new management programs that adopting a "zero depletion" management goal applicable to all ground-water withdrawals. The new

regulations in effect have (1) eliminated the drilling of new wells throughout almost all of the state of Kansas because ground-water withdrawals already exceed recharge in 98 to 99 percent of the state (W. A. Bossert, personal communication, 1996), (2) created aggressive conservation programs, and (3) significantly increased public education programs. Owing to a State law regarding the ownership of ground water, however, State officials seem reluctant to implement any depletion rules specifically targeting existing water wells.

The Northwest Kansas Groundwater Management District No. 4, for example, states that "The sum of the proposed appropriations, the vested rights, prior appropriation rights, and earlier priority applications legally described within the area of consideration shall not exceed the calculated quantity of annual recharge received by the aquifer underlying the area of consideration." If the correct interpretation of this rule is that the sum of all production, existing and new, cannot exceed the rate of recharge, then the obvious conclusion is that the maximum production allocation would be set at the designated rate of recharge. The rate of recharge and return flow combined for this district is set at 0.5 inch per year, unless otherwise determined. Therefore, it would appear that, by rule, the total amount of appropriation allowed within this district would be restricted to 0.5 inch per year over the district management area.

The Southwest Kansas Groundwater Management District No. 3 has adopted an aquifer management goal for the Ogallala aquifer of a maximum of 40 percent depletion of existing storage over a 25-year period. The remaining two GWMDs in Kansas have officially adopted an aquifer management goal of allowing only a "safe-yield" or "zero-depletion". Under the "safe-yield" goal, total withdrawals shall not exceed the amount of recharge reaching the aquifer. A summary of these ground-water management plans is contained in table 2.

All three of the Kansas GWMDs evaluate new well applications in a manner similar to that used in Colorado by calculating the total permissible withdrawals within a certain area and then comparing the total appropriation with

the sum of current and proposed well withdrawals in the specified area. New applications are also subject to final approval by the State.

In the Northwest Kansas GWMD No. 4, withdrawals (appropriations) from new wells are limited to the amount of recharge occurring in a circle with a 2-mile radius of the proposed well, minus the permitted withdrawals of any existing wells within the circle. Recharge to the aquifer is set at 0.5 inch per year unless site-specific data suggest otherwise. If these conditions are met, the maximum allowable irrigation pumpage for a new well is further limited to 2 acre-feet per year.

In the Equus Beds GWMD No. 2 of central Kansas the evaluation of new wells is essentially identical to that described above, except that recharge is pre-specified as either 3 or 6 inches, depending on location, and the maximum allowable irrigation water pumpage is 1.5 acre-feet per acre per year.

HYPOTHETICAL GROUND-WATER MANAGEMENT PROGRAMS APPLICABLE TO THE PANHANDLE GROUND WATER CONSERVATION DISTRICT NO. 3

To evaluate the impact of various types of ground-water management programs, three ground-water management scenarios were hypothesized and evaluated for a typical area within the PGWCD No. 3. In each of the three scenarios, the saturated thickness of the aquifer at the start of the management program was assumed to be 200 feet, which approximates the average saturated thickness of the Ogallala aquifer within the PGWCD No. 3. For comparison purposes, the distribution of saturated thickness in 1996 throughout the District is illustrated in figure 1.

As discussed above, a second element of a ground-water management plan is the designation of geographic subareas for selective management

Figure 1. Saturated thickness map of the Ogallala aquifer for the Panhandle Ground Water Conservation District No. 3.

practices. Within the PGWCD No. 3, four reasonable subareas might be

- Areas with irrigated agriculture,
- Areas with nonirrigated agriculture and ranching,
- Municipal areas, and
- Industrial areas.

The nonuniform application of depletion or production rules in Texas, based on existing ground-water law, is more problematic than in states where ground water, like surface water, is owned or appropriated by the State. Although the use of geographic subareas may not be an acceptable mechanism for the application of nonuniform depletion rules, it might be used to differentiate between other elements of the conservation plan such as monitoring requirements or recharge rates. For example, monitoring requirements might be less detailed, spatially or temporally, in an area where ground-water use is restricted to ranching than in an area where a municipal well field is operating. Another difference might result from the distribution of recharge rates on the basis of geologic factors such as soil type, playa density, and surface drainages.

In order to evaluate the impact of various management goals with respect to depletion of the aquifer, the following formula was used to compute the allowable amount of water that can be produced.

$$Q = A\left\{\frac{D}{100}(n \bullet b) + t \bullet R\right\} \bullet \frac{1}{t}$$

where

Q = the amount of water that can be produced per year
A = the surface area
D = the percent depletion after t years
t = the time of the management goal
n = specific yield
b = aquifer thickness
R = recharge rate

Using this formula, any scenario can be evaluated, as illustrated graphically in figures 2a and 2b. Figure 2a demonstrates the impact variations in saturated thickness will have on the amount of water that can be produced under a scenario where the rate of recharge and specific yield are held constant at 0.24 inches yr^{-1} and 0.25, respectively. Figure 2b illustrates the effect changes in recharge rate will have on the volume of water that can be produced when the saturated thickness and specific yield is held constant at 200 feet and 0.25, respectively. Clearly, the initial saturated thickness has the greatest impact on the volume of water that can be produced within any management goal scenario. The following three scenarios are based on the above described formula for determining allowable volumes of water that can be produced.

Scenario One

Scenario One is the most conservative of the three scenarios evaluated in this report. Its goal is zero depletion (no mining of the aquifer). Successful implementation of this management program would result in no future water-level declines within the Ogallala aquifer. The enforcement area selected for this scenario is one section (1 square mile). In this hypothetical scenario

- Saturated thickness is not considered because the amount of water withdrawn cannot exceed the amount of water entering the system through recharge.
- The Board elects to use recharge rates reported by Mullican and others (1994) for the Ogallala aquifer in this region of the PGWCD No. 3.

Mullican and others (1994) calculated the rate of Ogallala aquifer recharge to be approximately 6 mm yr^{-1} (0.24 inches yr^{-1}) for most of Carson County. Under this management scenario, the amount of ground water that could be produced per year throughout most of Carson County would be equivalent to the 6 mm yr^{-1} (0.24 inches yr^{-1}) or

- 6,414 gallons per acre per year, or

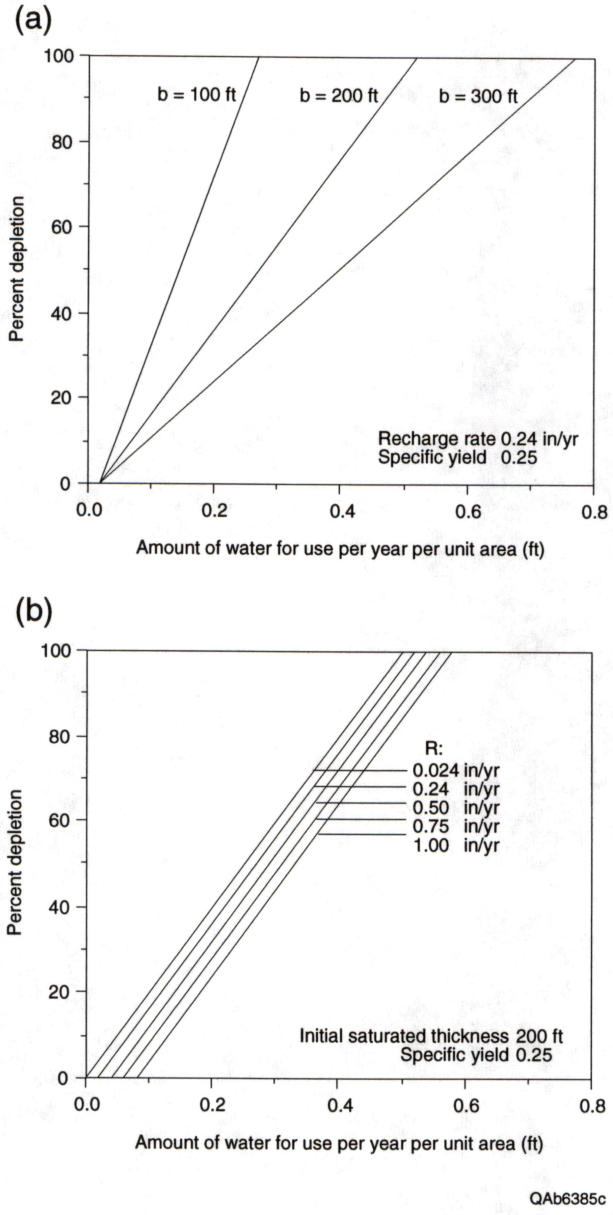

Figure 2. Sensitivity of allowed pumping per year to preserve saturated thickness in the Ogallalal in 100 years as a function of (a) initial saturated thickness and (b) assumed recharge rate. Parameter b in plot (a) is the initial saturated and parameter R in plot (b) is recharge rate.

- 4,105,000 gallons per section per year, or
- 12.6 acre feet of water per section per year.

Under Scenario One the impact to major water users in the district would be dramatic. Even if production rates were based on a much higher recharge rate, such as the one proposed by Dugan and others (1994) of 25.4 mm yr^{-1} (1.0 inch yr^{-1}), acceptable ground-water withdrawals would only be

- 27,152 gallons per acre per year, or
- 17,377,000 gallons per section per year, or
- 53.3 acre-feet of water per section per year.

Scenario Two

Scenario Two is also based on a long-term management goal of a specified acceptable level of reduction of the total water in storage. In Scenario Two, the Board is assumed to adopt the following management goal and criteria:

- The aquifer management goal is to ensure that 75 percent of the available water in the Ogallala aquifer in the first year of the program will still be available 100 years later.
- The saturated thickness of the Ogallala aquifer in the PGWCD No. 3 for year one shall be based on the water table map presented in figure 1 of this report, which was constructed from winter 1995-1996 water level measurements. An average saturated thickness value of 200 feet for a typical section of land in question is used to calculate acceptable production rates for the hypothetical area.
- The Board is assumed to use the recharge rates published by Mullican and others (1994) for the Ogallala aquifer in the region of the PGWCD No. 3. In a hypothetical area in Carson County, the rate of recharge is calculated to be 6 mm yr^{-1} (0.24 in yr^{-1}).
- A specific yield of 0.25 is used for determining the total water available.

Scenario Two requires additional input parameters to determine the volume of water that can be produced on an annual basis. First, the saturated thickness and the recharge rate for a property in question must be determined. Next, the total volume of available water under the property in question must be calculated, multiplied by 0.25 (the specific yield) to determine the total amount of water that can be produced, according to the management goal as defined, then divided by 100 to calculate the amount of water that can be produced each year during the 100-year management period. The final allowable production rate is then determined by adding this number to the amount of recharge received on an annual basis. Under Scenario Two, an hypothetical section of land would have an annual allowable production rate of

- 47,143 gallons per acre per year, or
- 30,172,000 gallons per section per year, or
- 92.6 acre-feet of water per section per year.

Scenario Three

Scenario Three is the perhaps the most realistic of the three hypothetical management plans presented in this report. In Scenario Three, the Board is assumed to adopt the following management goal and criteria:

- The aquifer management goal is to ensure that 50 percent of the water in the Ogallala aquifer available the first year of the program will still be available after 50 years of production.
- The saturated thickness of the Ogallala aquifer in the PGWCD No. 3 for year one shall be based on the water table map presented in figure 1 of this report, which was constructed from winter 1995–1996 water level measurements. An average saturated thickness of 200 feet for the section of land in question is used to calculate acceptable production rates for the hypothetical area.
- The Board is assumed to use recharge rates published by Dugan and

others (1994) for the Ogallala aquifer in the region of the PGWCD No. 3. In the hypothetical area in Carson County, the rate of recharge is calculated to be 25.4 mm yr^{-1} (1.0 in yr^{-1}).

- A specific yield of 0.25 is used for determining the total water available.

On the basis of this management goal and these criteria, a hypothetical section of land would have an annual allowable production rate of

- 352,964 gallons per acre per year, or
- 225,897,000 gallons per section per year, or
- 693.3 acre-feet of water per section per year.

Scenario Three results in an allowable production rate of 1.08 acre-feet of water per acre per year.

Questions To Be Answered

During the process of formalizing the PGWCD No. 3 aquifer management plan and depletion rules a number of questions will need to be answered. Questions include what will be the actual management goal for the district and what will be the time table for management plan implementation. Two fundamental questions need to be answered. (1) How will the District address existing unregulated appropriations for permitted irrigators, water utilities, and industry? (2) How will the District address requests for new wells with no established appropriations? In Kansas, as previously mentioned, the overall intent is that ground-water appropriations not exceed the rate of recharge, whereas, in practice, basically no new wells are permitted, and when existing appropriations are lost or allowed to lapse, they are not reappropriated until recharge exceeds discharge within the management area. Because of the extreme imbalance that currently exists throughout almost all of the irrigated portion of Kansas, a considerable volume of appropriated water rights would

have to be lost prior to any new appropriations being approved.

Another question to be answered is whether there will be a mechanism for adjustments to the allowable production rates for an area based on routine monitoring results, which might indicate that an adjustment is warranted. A situation might occur where the rate of decline in the water table is greater than that set as a goal by the Board, although the specified allowable production rates are being met. In such a situation, the assumed value for specific yield or recharge rate may need to be adjusted to better reflect the aquifer attributes. Additional questions that will need to be answered prior to the implementation of a ground-water management plan include the following. (1) What data source will be used to determine rates of recharge? (2) What specific yield will be used to calculate the volume of ground water available? (3) What will be the mechanism to locally adjust assumed values of aquifer attributes and to change the allowable production rates throughout the management program, dependent on how well management goals are met?

RECOMMENDATIONS

The choice of particular management goals and criteria must be made in light of the available physical data but also with regard to what is politically and operationally feasible. The determination of what is politically possible in other programs has been influenced by the amount of effort put into public education to explain the need for such a program and to seek public comments.

The most useful information with regard to ground-water management criteria and specific depletion rules is from the Natural Resource Districts of Nebraska and from the various GMDs in Kansas.

The use of management subareas would allow the PGWMD No. 3 to tailor the ground-water management program to the variations in aquifer properties and aquifer usage. The most prominent features of plans being followed in

Nebraska and Kansas are the use of geographic subareas in which specific management control measures and multilevel depletion rules are applied with increasing levels of control as water levels decline. One approach possibly applicable in Texas is analogous to municipal zoning laws, where an area might be zoned, for example, as ranching or dry land farming and be under a different set of rules from those for irrigated or municipal areas. If an owner sought to change the usage designation, some form of application and review process could be designed to evaluate the request, including potential impacts on the regional and local water resources. Management subareas could also be designated on the basis of similarities of hydrologic properties, such as saturated thickness or specific capacity. Areas of lower hydraulic conductivity will experience greater declines even though they may have similar levels of total storage. Water level declines might be allowed to be greater in areas where the saturated thickness is great and pose less risk for total depletion than in areas where the saturated thickness is thin.

In relation to management subareas, the spatial allocation of monitoring wells will also have to be considered. It will be important that a statistically significant density of monitoring wells has been designated within each subarea to ensure that the goals of the management plan are being met.

A final consideration has to do with the corrective action time table. Once the management goals and depletion rules have been developed, what will be the time frame for enforcement of rules at different levels of overdepletion. The Nebraska NRD management plans, for example, call for 2 to 3 consecutive years at a particular trigger level in order to invoke any given management actions by the District.

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Table 1. Summary of ground-water management criteria and depletion rules of Natural Resource Districts in Nebraska.

District	Aquifer Maintenance Goal	Subareas of Management	Depletion Indicator	Trigger Levels	Principal Management Actions[1]
Tri-Basin Natural Resources District	maintain aquifer forever	subareas of 72 square miles to be designated as necessary	spring static water levels in randomly chosen monitor wells	3 consecutive years with • 10% decline from 1983 saturated thickness, or • 25-ft decline from 1983 levels.	• increase spacing on new wells • 3 years to install meters on wells • water allocation: 15 inches per acre per year.
Lower Platte South Natural Resources District	maintain established "baseline saturated thickness"	subareas to be designated as necessary	spring static water levels in designated monitor wells, at least one per 2 mile-grid.	Phase 1 - always in place. Phase 2 - 2 consecutive years: • 8% decline from baseline saturated thickness[2] in 30% of monitor wells. Phase 3 - 2 consecutive years: • 15% decline from baseline saturated thickness in 50% of monitor wells.	Phase 1 - permits for new wells, *encourage* flow meters by cost-sharing. Phase 2 - *encourage* conservation measures with cost-sharing, *require* well operator training, *require* use of flow meters. Phase 3 - *require* conservation measures, increase new well spacing, *allocate* total permissible withdrawal, rotation of use, reduction of irrigated acres
Lower Platte North Natural Resources District	no decline below 1987 water table levels	predefined subareas of similar aquifer conditions	spring static water levels in designated monitor wells	Phase 1[3]3 consecutive years: • 10% decline in saturated thickness in 50% of monitor wells. Phase 2 - 3 consecutive years: • 15% decline in saturated thickness in 50% of monitor wells.	Phase 1 - *require* well operator training, permits for new wells, *encourage* flow meters by cost-sharing, *encourage* acre-inch allocation per crop. Phase 2 - *require* conservation measures, *require* use of flow meters, *require* acre-inch allocation per crop, increase new well spacing

Table 1. Summary of ground-water management criteria and depletion rules of Natural Resource Districts in Nebraska.

District	Aquifer Maintenance Goal	Subareas of Management	Depletion Indicator	Trigger Levels	Principal Management Actions[1]
Little Blue Natural Resources District	no decline below the District's "Reasonable Acceptable Decline"	subareas to be designated as necessary	spring static water levels in designated monitor wells	Phase 1 - always in place. Phase 2 - 2 consecutive years: • 80% of monitor wells show 50% of "Reasonable Acceptable Decline." Phase 3 - 2 consecutive years: • 80% of monitor wells show 100% of "Reasonable Acceptable Decline."	Phase 1 - permits for new wells, conservation education Phase 2 - *encourage* conservation through cost-sharing, *require* irrigation scheduling and reporting, *may* require flow meters, operator training, or increased well spacing. Phase 3 - *allocate* total permissible withdrawal, *require* use of flow meters

[1] In the case of multiphase rules, the listed actions are additive; in other words they are added to those of the preceding phase.
[2] One sub-area out of six has a trigger level of 15% decline for activating Phase 2 and 30% decline for Phase 3.
[3] The District has rules for both confined and unconfined aquifers. Those listed here are for the unconfined aquifer because of similar conditions for the Ogallala aquifer.

Table 2. - Summary of management criteria for new wells in Colorado and Kansas.

State/District	Aquifer Maintenance Goal	Subareas of Management	Depletion Zone for Each Well
Colorado	maximum of 40% depletion in saturated thickness over 100 years from time of application	subareas equal to predesignated aquifer boundaries	3-mile radius circle
Kansas/ Southwest Kansas Groundwater Management District No. 3	maximum of 40% depletion in saturated thickness over 25 years from time of application	townships (36 square miles)	2-mile radius circle
Kansas/ Northwest Kansas Groundwater Management District No. 4	maintain aquifer forever = "safe-yield" policy where withdrawals cannot exceed recharge	—	2-mile radius circle
Kansas/ Equus Beds Groundwater Management District No. 2	maintain aquifer forever = "safe-yield" policy where withdrawals cannot exceed recharge	Intensive Groundwater Management Areas to be established as needed	2-mile radius circle