HYDROGEOLOGIC REPORT

OF THE

PENNSYLVANIAN MINOR GROUNDWATER BASIN

AND THE

ASHLAND ISOLATED TERRACE GROUNDWATER BASIN

IN

COAL, PITTSBURG AND HASKELL COUNTIES

by
Kent Wilkins

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INTRODUCTION

The hydrogeologic report of the minor groundwater basins in Coal, Pittsburg, and Haskell Counties was conducted by the Oklahoma Water Resources Board (Board) under the authority of Oklahoma Statutes Title 82, Sections 1020.4 and 1020.5. Section 1020.4 authorizes the Board to conduct hydrologic surveys and investigations of fresh groundwater basins to characterize the availability, extent and natural hydrologic conditions of the resource. The Board is further directed by Section 1020.5, upon completion of the hydrologic survey, to determine the maximum annual yield of fresh water to be produced from each groundwater basin as well as the equal proportionate share of the maximum annual yield to be allocated to each acre of land overlying the basin(s). This determination is to be based on the following criteria:

1) The total land area overlying the basin or subbasin;
2) The amount of water in storage in the basin or subbasin;
3) The rate of recharge to the basin or subbasin and total discharge from the basin or subbasin;
4) Transmissivity of the basin or subbasin; and
5) The possibility of pollution of the basin or subbasin from natural sources.

The maximum annual yield determination and equal proportionate share results are subject of an accompanying report.

The purpose of this report is to review, assess, and evaluate hydrologic data pertaining to the groundwater resources in the study area. Data sources include records maintained by the Board, existing hydrogeologic reports and references which assess the study area and hydrologic reports or texts which evaluate hydrogeologic settings similar to the study area. In some instances, field measurements may be made to provide support for certain assumptions or estimates about a particular parameter.

This report will provide the hydrologic data necessary to determine or estimate the above criteria which will provide the basis for determining the maximum annual yield and equal proportionate share of the minor groundwater basins within the study area. The maximum annual yield determination and equal proportionate share results are subject of an accompanying report.

A minor groundwater basin is defined as a distinct underground body of water overlain by contiguous land and having substantially the same geological and hydrological characteristics and from which the groundwater wells yield less than 50 gallons per minute on the average basinwide if from a bedrock basin and 150 gallons per minute if from an alluvial and terrace basin.

Both a minor bedrock groundwater basin and a minor terrace groundwater basin were identified within the study area. The bedrock basin is named the Pennsylvanian Minor Groundwater Basin (PMGB) and the alluvial and terrace basin is named the Ashland Isolated Terrace Groundwater Basin (AITGB).

PHYSICAL SETTING

Location

This report will be limited to Coal, Pittsburg, and Haskell counties located in southeastern Oklahoma. The three counties contain approximately 1,573,120 acres. The counties were selected for this report on the basis of similar groundwater resources and geologic deposits. The principal groundwater basin for this study is comprised primarily of Pennsylvanian aged rocks with some minor areas of Mississippian, Silurian, Devonian, Ordovician and alluvium and terrace deposits. Also included as a separate basin is an isolated Quaternary terrace deposit in southwestern Pittsburg County and northeastern Coal County.

The alluvium and terrace deposits, associated with the Canadian and Arkansas River systems along the northern borders of Pittsburg and Haskell Counties, are potential major basins and will not be considered in this report. Also excluded from this report is an area in southwestern Coal County underlain by the Simpson Formation which is a major bedrock groundwater basin. Figure 1 shows the limits of the study area.

Setting

The land encompassed within the study area consists primarily of wooded areas and prairies. Topographic differences range from 460 feet above sea level along the Arkansas River in northeastern Haskell County to approximately 1600 feet above sea level in southeastern Haskell County.

The topography is the expression of the structure and stratigraphy through erosion. Rocks at the surface are predominately soft shales which are relatively nonresistant to erosion. Beds of resistant sandstone of various thicknesses are spaced at wide intervals. Erosion has worn away the thick, soft, nonresistant shales forming low valleys, but has left the thinner, more resistant sandstones as long high ridges (Marcher et al, 1987).

Climate

Climate is warm-temperate and continental of the subhumid type. The climate is characterized by pronounced daily and seasonal changes in temperature and variations in seasonal and annual rainfall. The changes between seasons are gradual, but the characteristics of each season are distinct. Rapid change is common and results in significant fluctuations of temperature, humidity, wind and precipitation. Winters are comparatively mild and short with only brief periods of low temperatures and snow cover. Summers are typically long and hot. Late spring and early summer are the most variable, bringing the heaviest precipitation and greatest number of severe storms (Moebius et al, 1974, Coal County; Brinlee, 1975, Haskell County; and Shingleton, 1971, Pittsburg County).

The mean annual precipitation ranges from 41 inches per year in western Coal County to 45 inches in southeastern Haskell County (OWRB, 1990). The mean annual precipitation for the study area

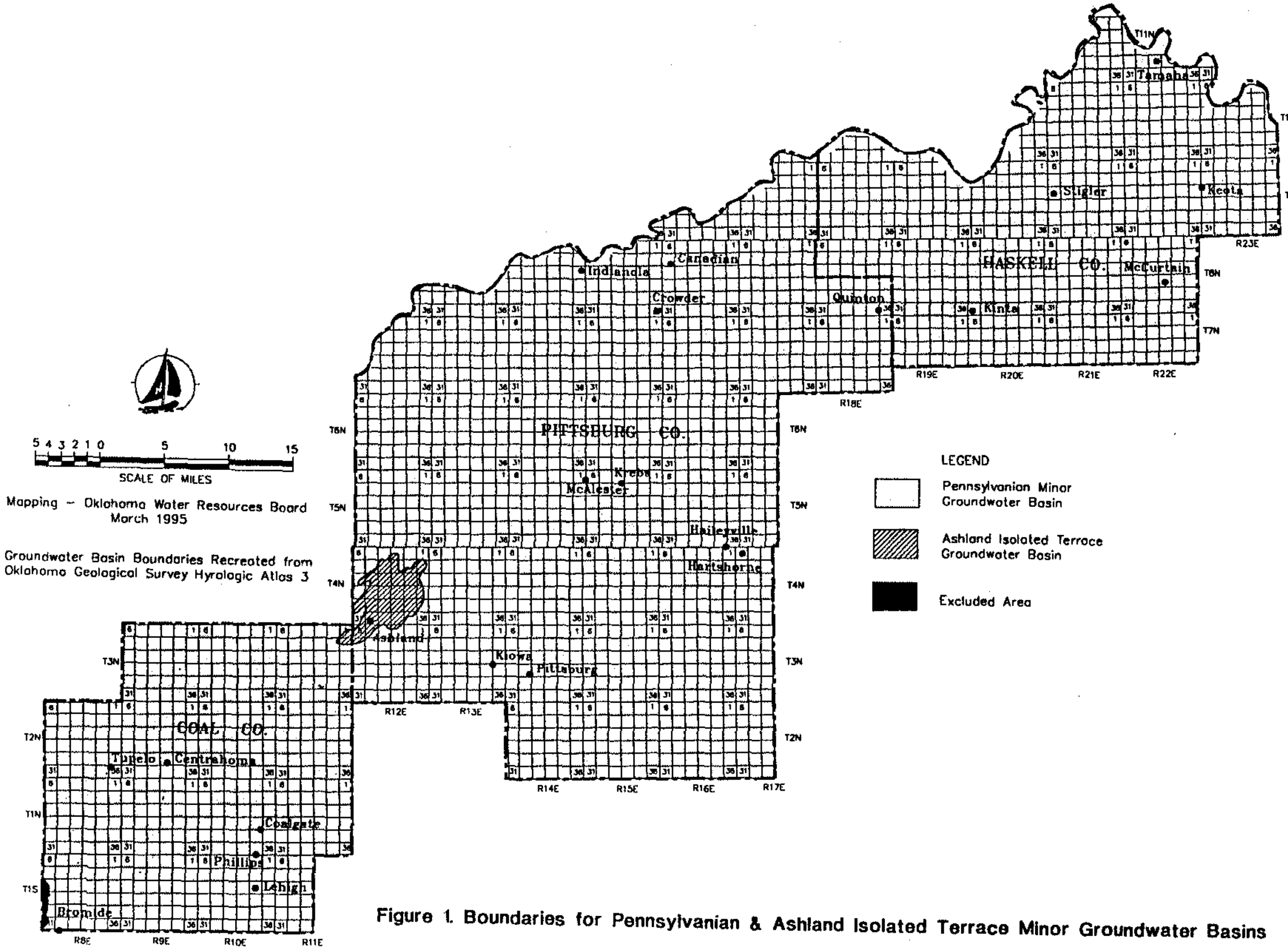

Figure 1. Boundaries for Pennsylvanian & Ashland Isolated Terrace Minor Groundwater Basins

was determined to be 43 inches. The minimum and maximum annual precipitation values have been 20.1 and 68 inches respectively in the study area. Snowfall ranges from about 3.5 inches per year in Coal County to 6 inches in Pittsburg and Haskell counties (Moebius et al, 1974, Coal County; Brinlee, 1975, Haskell County; and Shingleton, 1971, Pittsburg County).

Average monthly temperature ranges from 40.5 degrees in January to 83.5 degrees in July with an average annual temperature of 62 degrees. Winds generally prevail out of the south with the exception of December, January, February, and March when northerly winds prevail (Moebius et al, 1974, Coal County; Brinlee, 1975, Haskell County; and Shingleton, 1971, Pittsburg County).

Regional Geology

Coal, Pittsburg, and Haskell Counties are primarily located in the geologic feature known as the Arkoma Basin. The Arkoma Basin is an elongated trough that extends from the Gulf Coastal Plain in central Arkansas westward for 250 miles to the Arbuckle Mountains in south-central Oklahoma (Sutherland and Manger, 1984). Geologic formations in the basin have been folded to form northeast to east treading synclines and anticlines (Marcher et al, 1987). Dips on the limbs of the structures generally range from 10 to 40 degrees. The crests on some anticlines have been broken by thrust faults with displacement of several hundred feet (Marcher et al, 1987).

Geologic formations in the study area are primarily of Pennsylvanian age and consist of sequences of interbedded shale, siltstone, very fine to coarse grained sandstone and a few thin beds of limestone and coal. The formations outcropping at the surface range from the Stuart Shale in Pittsburg County to the Wapanucka Formation in southwestern Coal County. Minor outcrops of Mississippian, Devonian, Silurian, and Ordovician age shales, sandstones and limestones are also present. The formations range in thickness from a few hundred feet along the northern margin of the Arkoma Basin to about 18,000 feet along the southern margin. Shale and siltstone are the predominate lithologies comprising 60 to 80 percent of the exposed part of the stratigraphic section. Sandstone units become more numerous and thicker toward the south (Marcher et al, 1987).

The Arkoma Basin is flanked on the south by the Ouachita Mountains. South of the Choctaw fault in the Ouachita Mountains, the rocks are mostly shale, siliceous shale, and sandstone of Pennsylvanian age with some minor outcrops of Mississippian and Devonian aged shale, limestone and sandstone units. These formations dip steeply to the south as a result of intense faulting and folding.

Quaternary alluvium along the larger streams, such as the Arkansas and Canadian Rivers, is as much as 60 feet thick and consists of clay, silt, and sand with a few local thin layers of gravel at the base (Marcher et al, 1987). Alluvium along the smaller tributary streams generally is less than 20 feet thick and because of the predominantly shale bedrock in the area, consists mainly of sandy and clay silt. Terrace deposits also consist almost entirely of clay to sandy silt, but can consist of sand in localized areas.

GROUNDWATER RESOURCES

Pennsylvanian Minor Groundwater Basin

The PMGB for the three county area comprises approximately 1,571,840 acres of Pennsylvanian and some minor Mississippian, Silurian, Devonian and Ordovician deposits that occur as shale, siltstone, coal, thin limestones, and widely separated sandstone units. The boundary for the PMGB study area is shown on Figure 1.

The occurrence, storage, and movement of water in the Pennsylvanian and other minor deposits are largely controlled by the lateral and vertical distribution of rock units, the geologic structure, and their physical characteristics, particularly permeability (Marcher et al, 1987). The movement of water can also be governed by the location and altitude of areas of recharge and discharge. The slope of the potentiometric surface can be in the same direction as the land surface and may parallel the geologic structure in some areas, but may cut across the structure in others (Marcher et al, 1987).

The formations in the study area are tilted at the surface exposing bedding plane openings between the layers of sandstone and partings between laminae of shale. These openings are the principal avenues of water entry and movement. Other openings for water movement are fractures and joints formed during folding of the brittle rocks. Faults, where they are present, also may be water conduits. If, however, the rocks are so greatly crushed that the openings are sealed, the faults may act as water barriers. The number and distribution of bedding planes, fractures and joints differ both areally and with depth so that a well of given depth may yield enough water for household use whereas a nearby well of the same depth, or even deeper, may not yield any water (Marcher et al, 1987).

Aquifer Parameters

The hydraulic characteristics of an aquifer describe its ability to store and transmit water and can be represented in terms of storage coefficient and transmissivity. Groundwater in the PMGB is generally encountered at approximately 50 feet below land surface. The basin is under confined conditions and water typically rises in wells to within 25 feet below the land surface (Marcher et al, 1987 and OWRB, 1994A).

Review of OWRB Multi-Purpose Completion Reports indicates that fresh water has been encountered in wells within the PMGB at depths ranging from 300 to 500 feet. Oklahoma Corporation Commission (1982) Base of Treatable Water Maps indicate a decline in water quality throughout the basin at depths ranging from 300 to 500 feet. Based on the available data, the average base of the fresh water is determined to be 400 feet. Using an average depth to water of 50 feet and a value of 400 feet for the base of the fresh water zone, the average total saturated thickness for which fresh water could be expected is 350 feet.

Typical deposits from the PMGB range from coarse-grained sandstone to siltstone and shale with some fracturing present (Marcher and Bergman, 1983). Marcher et al (1987) reported that the sandstone units in the study area comprise an average of 30 percent of the total formation thickness. Using a total saturated thickness of 350 feet and an average of 30 percent, the combined sandstone units are estimated to comprise 105 feet of the saturated thickness. The shale and siltstone units constitute the remaining 70 percent of the saturated thickness or 245 feet.

Hydraulic conductivity for the sandstone units is estimated to range from 0.001 to 2.5 ft/day with an average of 1.25 ft/day (Heath, 1983). Hydraulic conductivity for fractured shale or siltstone is estimated at 0.0001 ft/day (Health, 1983). Transmissivity, a product of the saturated thickness and hydraulic conductivity, is estimated to be 131.0 ft^2/day for the sandstone units and 0.0245 ft^2/day for the shale units. The combined average transmissivity, based on the percentage of sandstone to shale, is estimated to be 131.03 ft^2/day. A storage coefficient of 0.001 is estimated for the confined portions of the basin and specific yields of 0.125 and 0.005 are estimated for the unconfined sandstone and shale units, respectively.

Recharge to the PMGB can be limited in areas of rugged topography, thin soils and finite bedrock permeability. The amount of annual recharge to the basin is estimated to be 1.1 inches per year, which is 2.5 percent of the average annual precipitation (Marcher and Bergman, 1983).

Aquifer Storage and Yield Capabilities

Initial storage for the PMGB is estimated at approximately 23,105,000 acre-feet of groundwater. This value is obtained by multiplying the specific yields for the unconfined sandstone and shale portions of the aquifer and the storage coefficient for the confined portion, by the estimated saturated thickness, and the area of the basin (1,571,840 acres) as shown in Table 1.

Table 1. Aquifer Storage Parameters for the PMGB

Aquifer Material	Specific Yield or Storage Coefficient	Saturated Thickness (Feet)	Area of Basin (Acres)	Storage (Acre-Feet)
Sandstone	0.125	105	1,571,840	20,630,000.00
Shale	0.005	245	1,571,840	1,925,000.00
Sandstone/Shale	*0.001	350	1,571,840	*550,000.00
Total		350	1,571,840	23,105,000.00

* Storage Coefficient and resulting storage attributed to confined groundwater conditions within the basin.

The yields of most wells in the PMGB, according to Marcher et al (1987) and reported by drillers on well records, generally are less than five gallons per minute and many yield only a fraction of a gallon per minute. Locally, a few wells penetrating thick units of fractured sandstone have been reported to yield as much as 80 gallons per minute.

Water Use

In many parts of the study area, adequate supplies of suitable groundwater are not available. Water districts have been established to meet the domestic, commercial, and industrial needs of rural areas. Thousands of farm ponds have also been constructed to provide water for livestock.

The total amount of groundwater currently permitted within the PMGB is 1979.0 acre-feet per year. Reported water use for 1995 from permit holders within the PMGB is 44.3 million gallons, or 136.0 acre-feet. All but 30 acre-feet was used to supply public water for three cities. Table 2 summarizes the permit and water use data for the basin.

Table 2. Permit and Water Use Information in the PMGB by County during 1995.

County	Purpose	No. of Permits	Permitted Amount	Reported Use
Coal	Municipal	5	827.0 ac-ft	105.4 ac-ft
	Irrigation	1	40.0 ac-ft	30.0 ac-ft
	Commercial	1	4.0 ac-ft	0.6 ac-ft
Haskell	Commercial	14	1069.0 ac-ft	0.0 ac-ft
Pittsburg	Industrial	1	39.0 ac-ft	0.0 ac-ft
	Total	22	1979.0 ac-ft	136.0 ac-ft

Prior Groundwater Rights

Groundwater rights established within this basin prior to July 1, 1973, and recognized by Board Order, total 996 acre-feet per year. This amount represents 543 acre-feet from Coal County and 453 acre-feet from Haskell County. No prior rights within the PMGB are recognized in Pittsburg County.

Ashland Isolated Terrace Groundwater Basin

The AITGB, located in southwestern Pittsburg County and northeastern Coal County, comprises approximately 24 square miles of terrace deposits that occur as unconsolidated clay, silt, sand, and gravel (Hart Jr, 1974). Terrace deposits are older alluvium which occupy positions topographically higher than recent alluvium and mark the former position of a stream. The distribution of deposits within the AITGB is shown in Figure 1.

OWRB well records indicate that the average total thickness of the terrace deposit is approximately 50 feet. The total depth of the wells ranges from 43 to 60 feet and averages 50 feet. Depth to water as reported on well records ranges from 18 to 30 feet. Average saturated thickness is estimated to be 21 feet.

Aquifer Parameters

The hydraulic characteristics of an aquifer describe its ability to store and transmit water and can be described in terms of storage coefficient and transmissivity (T). For unconfined aquifers, storage coefficient and specific yield are nearly equivalent.

The hydraulic conductivity (K) of alluvial and terrace sediments can be estimated using a relationship between grain size and hydraulic conductivity developed by Kent and others (1973). Kent generated four ranges of hydraulic conductivity for alluvial materials based on research involving field and laboratory permeability testing. Saturated lithologies presented on well logs are assigned to one of the following grain size classes. Each class has associated with it an average hydraulic conductivity value corresponding to the median grain size of that range. The following grain size classes along with their median grain size and K value are shown in Table 3.

Table 3. Hydraulic Conductivity Classes Used to Assign Permeability Values to Saturated Lithologies on Well logs.

	Silt - Very Fine Sand	Very Fine Sand - Fine Sand	Fine Sand - Medium Sand	Medium Sand - Coarse Sand
	Class 1	Class 2	Class 3	Class 4
Median Grain Size (mm)	0.06	0.125	0.25	0.5
K Values in Ft/day	0.70	6.00	27.00	167.00

For each log, a weighted hydraulic conductivity can be obtained for the entire saturated section of the lithologic record by multiplying the average K value associated with the assigned grain size class with the thickness of that interval, then summing the total for all classes divided by the total saturated feet of the well. Using this method, an average K value of 104 ft/day was estimated for the AITGB. A transmissivity of 2180 ft^2/day was calculated using the estimated hydraulic conductivity and a saturated thickness of 21 feet.

Another method to calculate hydraulic conductivity and transmissivity is available if well acceptance tests (short duration pump tests) have been conducted. As a means to compare the estimated T and K values derived from the grain size analysis, data from two wells with well acceptance tests were input into the OWRB's TOT computer program, which calculates K and T (OWRB, 1992). K and T values derived from this method are 120 ft/day and 3000 ft^2/day, respectively.

Hydraulic conductivity for the AITGB was also estimated from Heath (1983). Heath developed estimated hydraulic conductivities values for sand deposits dependent primarily upon grain size. The average hydraulic conductivity for fine to coarse sediments was estimated at approximately 125 ft/day. A transmissivity of 2625 ft^2/day was calculated using the estimated hydraulic conductivity and a saturated thickness of 21 feet.

A summary of the estimated aquifer parameters and their sources is shown in Table 4. The aquifer parameters used in this study represent the average of the estimated values listed below. For the purpose of this study, a specific yield of 0.20 was estimated for the AITGB. This value compares favorably with estimates by Driscoll (1986) involving similar types of aquifer materials.

The amount of annual recharge to the basin is estimated to be 9 percent of the average annual precipitation or approximately 3.9 inches per year. This percentage of recharge was selected by comparison of previous terrace deposit studies by Havens (1977).

Table 4. Estimated Aquifer Parameters for the Ashland Isolated Terrace Groundwater Basin.

Source	Hydraulic Conductivity (Ft/day)	Transmissivity (Ft^2/day)	Specific Yield	Aquifer Saturated Thickness (ft)
OWRB, TOT	120	3000	.20	25
OWRB, 1994*	104	2180	.20	21
Heath, 1983	125	2625	.20	21
Average	120	2600	.20	21

* - Determined from Kent and Others (1973)

Aquifer Storage and Yield Capabilities

The AITGB has an estimated storage of approximately 64,500 acre-feet of groundwater. This value was determined by multiplying the area of the basin (15,360 acres) by the specific yield (0.20), and the average saturated thickness (21 feet).

Yield capabilities from terrace deposits are variable, but some deposits can yield moderate to large quantities of water according to Johnston (1983) and Marcher (1969). Average well yield in the AITGB as determined from the available well records is 135 gallons per minute.

Water Use

Groundwater is not heavily relied on to supply agricultural crop water. Dry-land farming is prevalent in the basin and rainfall is relied upon to provide the necessary moisture for crops. Irrigation occurs primarily during months of prolonged dryness and in areas where adequate water is available (OWRB, 1994B). While only limited quantities of groundwater are pumped for irrigation and public water supply, individuals not served by rural water systems rely on the basin for domestic use.

The total amount of groundwater permitted in the AITGB is currently 960.0 acre-feet per year. Reported water use for 1995 from permit holders within the AITGB was 36.9 million gallons, or 113.3 acre-feet. This amount is used for public water supply for one rural water district and for irrigation. Groundwater rights and water use data for 1995 are summarized in Table 5.

Table 5. Permit and Water Use Information for the AITGB during 1995

Purpose	Number of Permits	Permitted Amount	Permitted Use
Municipal	2	380.0 ac-ft	46.6 ac-ft
Irrigation	2	580.0 ac-ft	66.7 ac-ft
Total	4	960.0 ac-ft	113.3 ac-ft

Prior Groundwater Rights

Groundwater rights established within the AITGB prior to July 1, 1973 and recognized by Board Order total 165 acre-feet per year. This total amount is allocated in Pittsburg County. There are no prior rights recognized in the basin for Coal County

GROUNDWATER QUALITY

Pennsylvanian Minor Groundwater Basin

The chemical quality of water in the Pennsylvanian rocks is extremely variable. No relationship between variations in groundwater chemistry and well depth, geographic distribution, or geologic formation is apparent according to Marcher et al (1987). Typically, groundwater is a sodium bicarbonate type although many variations in water type occur. Concentrations of dissolved solids range from 300 to 2,000 milligrams per liter (mg/l) and pH ranges from 6 to 8. In most of the area, the water is hard to very hard (more that 120 mg/l). Table 6 is a summary of selected physical and chemical properties of groundwater sampled from wells within Pennsylvanian age rocks. The table shows the minimum, mean, median and maximum concentrations for the selected parameters.

Table 6. Selected Physical Properties and Chemical Constituents in Water from 25 Wells Completed in Pennsylvanian Rocks.

Parameter	Minimum	Mean	Median	Maximum
Well depth (feet)	21	81	78	233
Specific Conductance (umho)	460	964	800	2,690
pH (units)	6.2	---	7.3	8.8
Hardness (Ca + Mg) (mg/l)	5	204	140	790
Calcium (mg/l)	1.8	36	24	120
Magnesium (mg/l)	0.1	27	19	120
Sodium (mg/l)	49	144	120	330
Chloride (mg/l)	3.4	46	30	190
Sulfate (mg/l)	4.3	151	56	870
Iron (ug/l)	20	955	110	17,000
Manganese (ug/l)	8	195	50	1,000
Dissolved solids (ROE in mg/l)	294	603	520	2,010

[umhos, micromhos per centimeter at 25° Celsius; mg/l milligrams per liter; ug/l, micrograms per liter; ROE, residue on evaporation at 180° Celsius] Taken from Marcher, et al, 1987.

In summary, the water quality of the PMGB is probably suitable for all beneficial uses except in localized areas. The major natural source of pollution in the area that might impact some portions of the basin include high iron, manganese, and dissolved solids. However, with proper well completion techniques (sealing out lower quality water zones), water treatment techniques, and water quality sampling and analysis, negative health affects can be mitigated.

Ashland Isolated Terrace Groundwater Basin

Groundwater quality information regarding the AITGB is limited. However, analytical data are available from three public supply wells operated by Hughes County Rural Water District #2. Table 7 is a summary of selected chemical properties of groundwater sampled from the District's wells in June, 1991. Properties of primary concern include low pH and elevated levels of iron.

Documentation from an Oklahoma State Department of Health report in 1991 indicated that water from the District's wells had a low pH and low alkalinity which would render the water highly corrosive. In addition, the water was high in iron in all of the wells. Based on this information, the groundwater was unacceptable for use as a public water supply, without treatment and only marginal with treatment (Oklahoma State Department of Health, 1991). Mr. Tim Ward of the Oklahoma Department of Environmental Quality (ODEQ) indicated that the low pH may be attributed to dissolved carbon dioxide (CO_2). No analytical data were available from the ODEQ or the rural water district office to confirm the presence or amount of dissolved CO_2.

According to Driscoll (1986), CO_2 typically remains in solution under constant ambient pressure conditions. However, when the pressure near a well is reduced by pumping, CO_2 is released out of solution as a gas. If the amount of CO_2 exceeds 50 mg/l, corrosive water can occur (Driscoll, 1986). To minimize the release of CO_2, pressure reduction must be kept as low as possible. Use of well screens that provide maximum inlet area can lower entrance velocities through well screen openings and reduce head loss (Driscoll, 1986). Domestic wells, which are typically pumped at a lower rate, have a lower potential for developing corrosive water due to the presence of dissolved CO_2.

In summary, potential problems from natural contamination within the Ashland Isolated Terrace aquifer include low pH and high iron. The water is probably suitable for most beneficial uses with the possible exception of public water supply. However, with proper well completion techniques (minimization of entrance velocity), water treatment techniques (reduction of CO_2 and iron), and water quality sampling and analysis, negative health affects can be mitigated.

Table 7. Summary of Selected Chemical Constituents in Groundwater from 3 Public Water Supply Wells Completed in the Ashland Isolated Terrace Deposit.

PARAMETER	VALUE	UNITS		PARAMETER	VALUE	UNITS
Chloride	24	mg/l		Fluoride, Total	< 0.1	mg/l
Nitrite -Nitrate as N	2.3	mg/l		pH Lab	* 5.35	std units
Specific Conductance	858	umhos/ cm		Sulfate	< 20	mg/l
Solids, Total Dissolved	119	mg/l		Alkalinity, Total	16	mg/l
Hardness, Total	56	mg/l		Turbidity	0.33	ntu
Arsenic, Total	< 15	ug/l		Barium, Total	67	ug/l
Cadmium, Total	< 2	ug/l		Chromium, Total	< 10	ug/l
Copper, Total	37	ug/l		Iron, Total	92	ug/l
Lead, Total	< 5	ug/l		Manganese, Total	11	ug/l
Mercury, Total	< 0.5	ug/l		Selenium, Total	< 5	ug/l
Silver, Total	< 3	ug/l		Sodium, Total	21	ug/l
Zinc, Total	25	ug/l				

* - Exceeds PWS Standards
ug/l - micrograms per liter
< - Less than Detection Limit
mg/l - milligrams per liter
umhos - micromhos per centimeter

Source - Hughes County Rural Water District #2 - All Results from June 19, 1991 Sampling

SUMMARY

Pennsylvanian Minor Groundwater Basin

The following data on Pennsylvanian Minor Groundwater Basin were derived in order to calculate and determine the Maximum Annual Yield and Equal Proportionate Share of the basin:

1) The total land area overlying the basin is 1,571,840 acres;
2) The amount of water in storage in the basin on July 1, 1994 was determined to be 23,105,000 acre-feet;
3) The estimated rate of recharge is 2.5 percent of the average annual precipitation (42 inches) and totals approximately 2,881,707 acre-feet, and the total discharge of the basin is 19,920 acre-feet over the life of the basin (20 years);
4) The transmissivity of the basin is estimated to be 131.0 ft^2/day;
5) The possibility of pollution of the basin from natural sources such as high iron, manganese, and dissolved solids can be minimized by proper well construction, treatment, and water quality testing and analysis.

Ashland Isolated Terrace Groundwater Basin

The following data on the Ashland Isolated Terrace Groundwater Basin were derived in order to calculate and determine the Maximum Annual Yield and Equal Proportionate Share of the basin:

1) The total land area overlying the basin is 15,360 acres;
2) The amount of water in storage in the basin on July 1, 1994 was approximately 64,500 acre-feet;
3) The estimated rate of recharge is 9 percent of the average annual precipitation (42 inches) and totals approximately 99,800 acre-feet, and the total discharge of the basin is 3300 acre-feet over the life of the basin (20 years);
4) The transmissivity of the basin is estimate at 2600 ft^2/day;
5) The possibility of pollution of the basin from natural sources such as low pH (dissolved CO_2) and iron can be minimized by proper well construction, treatment, and water quality testing and analysis;

The maximum annual yield and equal proportionate share results are provided in an accompanying report entitled Maximum Annual Yield Determination for the Ashland Isolated Terrace and Pennsylvanian Minor Bedrock Basin in Coal, Pittsburg, and Haskell Counties.

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GLOSSARY

Alluvium

A general term for clay, silt, sand, and gravel, or similar unconsolidated material deposited during comparatively recent geologic time by stream or other body of running water as a sorted or partially sorted sediment in the bed of the stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope.

Aquifer

A formation, group of formations, or a part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Equal Proportionate Share

That portion of the maximum annual yield of water from a groundwater basin which shall be allocated to each acre of land overlying such basin. The percentage of the maximum annual yield is equal to the percentage of the land overlying the fresh groundwater basin which is owned or leased by an applicant for a regular permit.

Fresh Water

Water which has less than five thousand (5,000) parts per million total dissolved solids. All other water is salt water.

Groundwater

Fresh water under the surface of the earth regardless of the geologic structure in which it is standing or moving outside the cut beds or banks of any definite stream.

Groundwater Basin

A distinct underground body of water overlain by contiguous land having substantially the same geological and hydrological characteristics and yield capabilities. The areal boundaries of a basin can be determined by political boundaries, geological, hydrological, or other reasonable physical boundaries.

Hydraulic Conductivity

The volume of water that will move through a medium in a unit of time under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow.

Life of a Groundwater Basin

That period of time during which pumping of the maximum annual yield for a minimum twenty year life of such basin will result in a final basin storage which approaches zero. Fifteen feet of saturated thickness is maintained in bedrock aquifers to provide for domestic use.

Major Groundwater Basin

A distinct underground body of water overlain by contiguous land and having substantially the same geological and hydrological characteristics and from which groundwater wells yield at least fifty gallons per minute on the average basinwide if from a bedrock aquifer and at least one hundred fifty gallons per minute on the average basinwide if from an alluvium and terrace aquifer, or as otherwise designated by the Oklahoma Water Resources Board (Board).

Maximum Annual Yield

A determination by the Board of the total amount of fresh groundwater that can be produced from each basin allowing a minimum twenty year life of such basin.

Minor Groundwater Basin

A distinct underground body of water overlain by contiguous land and having substantially the same geological and hydrological characteristics and from which groundwater wells yield less than fifty gallons per minute on the average basinwide if from a bedrock aquifer and less than one hundred fifty gallons per minute on the average basinwide if from an alluvium and terrace aquifer, or as otherwise designated by the Oklahoma Water Resources Board (Board).

Natural Recharge

All flow of water into a groundwater basin by natural processes including percolation from irrigation.

Permeability

The property of a porous medium to transmit fluids under a hydraulic gradient.

Porosity

The ratio, usually expressed as a percentage, of the total volume of voids of a given porous medium to the total volume of the porous medium.

Prior Groundwater Right

The right to use groundwater established by compliance with the laws in effect prior to July 1, 1973, the effective date of the Oklahoma Groundwater Act.

Specific Yield

The ratio of the volume of water which the porous medium after being saturated, will yield by gravity to the volume of the porous medium.

Storage Coefficient

The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head (virtually equal to the specific yield in an unconfined aquifer).

Terrace Deposits

Deposits of older alluvium which occupy positions topographically higher than recent alluvium and mark the former position of a stream.

Total Discharge from the Basin

Shall include but may not be limited to the amount of fresh groundwater withdrawn and placed to beneficial use prior to July 1, 1973, which amount shall be determined from the applicable final orders of the Board determining prior groundwater rights.

Transmissivity

The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient.