Mr. Victor Schmidt Jr.
Director
Water and Sewer Dept.

REPORT ON BARTON SPRINGS AND ASSOCIATED GROUND-WATER CONDITIONS WITH PARTICULAR REFERENCE TO POSSIBLE EFFECTS OF A PROPOSED SEWER LINE IN BARTON CREEK AREA

Prepared for

Water and Sewer Department
Austin, Texas

By

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December 7, 1964

Mr. Victor R. Schmidt, Jr.
Director, Water and Sewer Department
City of Austin
Post Office Box 1160
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Dear Mr. Schmidt:

Attached is our report on Barton Springs and associated ground-water conditions, with particular reference to possible effects of a proposed sewer line in the Barton Creek area.

The report presents our opinions regarding the danger of contamination of Barton Springs by leakage from a sewer line, areas where protection against leakage will be needed, and the possible effect of blasting for construction of a sewer line.

The field work was performed principally by R. W. Harden and J. K. Longacre and the report prepared by Mr. Harden, R. A. Scalapino and myself.

We wish to express our appreciation to you and to Mr. Dewey Nicholson for the cooperation and assistance we have received during this study. We also wish to acknowledge our appreciation of the cooperation of individual well owners in the area who gave data on their wells and allowed us to make water-level measurements in them.

Sincerely yours,

William F. Guyton

William F. Guyton

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SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

1. Rocks which occur at the surface and in the sub-surface in the Barton Creek area are principally limestone of Cretaceous age and alluvial deposits of Quaternary age. The Cretaceous rocks extend to depths of more than 1,000 feet. The Quaternary alluvium occurs principally in valleys of the Colorado River and Barton Creek and ranges in thickness from zero to about 50 feet.

2. The Edwards and Georgetown formations of Cretaceous age are the most important water-bearing formations in the area. They form a single aquifer which is called the Edwards Reservoir. The Edwards Reservoir supplies water to Barton Springs, smaller springs in the Colorado River, and to small to moderate sized wells.

3. The Edwards Reservoir is recharged by direct infiltration of precipitation on its outcrop and by seepage from streams which cross its outcrop. The total drainage area which contributes recharge to the Edwards Reservoir in the Barton Creek area is about 370 square miles.

4. Water is discharged from the Edwards Reservoir principally through Barton Springs. The discharge from Barton Springs has ranged from about 10 cubic feet per second to about 160 cubic feet per second and has averaged about 40 cubic feet per second, or about 26 million gallons per day.

5. Water levels in the Edwards Reservoir fluctuate as much as 43 feet. The elevations of the water levels generally are above the elevation of Barton Springs regardless of the stage of the reservoir.

6. Leakage from a sewer into the Edwards Reservoir would be a potential source of contamination of the spring water. The degree of danger of contamination from leakage would vary depending upon the location of the leakage and its distance from the springs.

7. The Barton Creek area has been divided into four sub-areas with regard to risk of contamination from a new sewer installation. The degree of risk in these areas ranges from none to great, and protection against sewer leakage is recommended in parts or all of three of the areas.

8. Protection against leakage may be provided by constructing water-tight sewer lines or by placing the sewer lines below the lowest water level in the Edwards Reservoir and providing protection against the sewer filling up and exceeding the external head, so as to insure inflow into the sewer rather than seepage from it.

9. There is some danger that blasting for construction of a sewer line in the Barton Springs area might damage the springs and decrease their flow. Even though the risk of such damage probably is slight, it is recommended that no blasting be done in constructing a sewer line. However, if the City should decide that advantages of blasting

outweigh the risks involved, it is recommended that the shocks from such blasting at least be limited to a magnitude that has already occurred in the area.

10. It is planned to drill test holes and make pumping tests in those holes encountering water along a proposed sewer line to determine insofar as practicable (1) the character of the materials that will be encountered in the excavation, (2) the amount of water inflow that will be encountered during excavation work, and (3) the elevations of water levels at the test holes.

INTRODUCTION

This report presents the results of a geologic and hydrologic investigation made in connection with the City of Austin's plans to lay a sanitary sewer line in the Barton Creek area. The primary purpose of the investigation was to determine, insofar as practicable, the effect that the construction and operation of such a sewer might have on Barton Springs.

The investigation included study and analysis of published and unpublished geologic reports, records of wells published by the U. S. Geological Survey and Texas Water Commission, and data in the files of these agencies, the City of Austin, local well drillers, and this firm. Additional well records were obtained during a field inventory, and water levels were measured in wells tapping the ground-water reservoir which supplies Barton Springs. A field check was made along Barton Creek of geologic mapping previously done by others.

GEOLOGY

The rocks which occur at the surface in the area of this study are comprised principally of limestone and clay of Cretaceous age and alluvial deposits of Quaternary age. The Cretaceous rocks occur at the surface in most of the area and have a total thickness of several hundred feet. The alluvial deposits occur principally in the valleys of the Colorado River and

Barton Creek. The alluvium is comprised of boulders, gravel, sand, silt, and clay and ranges in thickness from zero to about 50 feet.

The oldest Cretaceous formation exposed in the area is the Glen Rose limestone. It is exposed only northwest of a line running approximately from Oak Hill to Eane's School to Tom Miller Dam. The Glen Rose consists of beds of white and yellow limestone alternating with softer beds of limestone or clay. It has a thickness of more than 400 feet. The Walnut clay and Comanche Peak limestone overlie the Glen Rose. These formations probably are present in the subsurface but, so far as is known, are not exposed in the area covered by this report. They are not pertinent to the present study and are not discussed.

The Edwards and Georgetown formations occur southeast of the Glen Rose outcrop. The outcrop of the Edwards and Georgetown formations occupies a belt about three miles in width, trending northeast-southwest across the center of the area. The outcrop of these formations is shown on Figures 1 and 4. The Edwards and Georgetown formations have a total thickness of more than 350 feet. The Edwards consists of gray to tan, hard, massive limestone containing numerous flint nodules. The Georgetown consists of light gray, medium hard, chalky limestone interbedded with nodular, chalky limestones and soft, gray, calcareous shales.

The Del Rio clay overlies the Georgetown formation and is overlain by the Buda limestone. The Del Rio and Buda formations are both exposed along the south side of Barton Springs Road between South Lamar Boulevard and Zilker Park. They are also exposed in the bluffs east of the baseball fields in Zilker Park, in Barton Hills, and in the steep, westward-facing slopes of the Barton Creek drainage between South Lamar Boulevard and Barton Creek. Isolated outcrops of the Del Rio and Buda formations occur within the main outcrop belt of the Georgetown and Edwards formations, mostly in the area lying between Bee Caves Road and Barton Creek (see Figure 4). The Del Rio is a blue to dark gray clay which weathers a dull yellow. It ranges in thickness from 50 to 70 feet in the area. The Buda averages about 35 feet in thickness and consists of massive to thin-bedded, yellow limestone.

Cretaceous formations younger than the Buda limestone crop out in the southeasternmost part of the area. Due to their stratigraphic position and location, they are not significant to this study.

Unconsolidated alluvial deposits overlie the Cretaceous rocks along and beneath the Colorado River and in Zilker Park along Barton Creek. Both the thickness and character of these deposits vary considerably in short distances. The maximum thickness of alluvium known along the Colorado River is about 50 feet in wells drilled at the City Coliseum. The known thickness of alluvium in Zilker Park is more than 12 feet. Its maximum thickness in the park is not known but it probably is less than 50 feet. In Zilker Park and in adjoining areas along the Colorado

River, it is believed that the Edwards and Georgetown formations directly underlie the alluvium. The older rock surface upon which the alluvium was deposited probably is very irregular and a leached and weathered zone probably occurs in the Georgetown and Edwards formations at their contact with the alluvium. The thickness of this weathered zone is not known but may be 5 to 10 feet or more.

The Austin area lies in the geologic province known as the Balcones fault zone. This structural feature extends for many miles northeast and southwest of Austin. In the Barton Creek area the main fault of the Balcones zone trends northeast-southwest and extends from near Oak Hill to just west of Tom Miller Dam. The Glen Rose formation is exposed northwest of the fault and the Georgetown and Edwards formations southwest of the fault. The rocks are downthrown to the southeast, and displacement along the main fault has been measured to be more than 700 feet. Numerous smaller associated faults having the same general trend as the main fault occur east of the main fault.

Both the regional dip of the Cretaceous rocks and the general slope of the land surface is toward the southeast. The rate of dip of the beds northwest of the main Balcones fault is approximately the same as the slope of the land surface, being about 20 feet per mile. Southeast of the main fault, the rate of dip of the beds increases suddenly to about 100 to 130 feet per mile, which is considerably greater than the general slope of the land surface. As a result, progressively younger beds are exposed in a southeast direction.

The Edwards and Georgetown are by far the most important water-bearing formations with respect to the proposed sewer line in the Barton Creek area. The formations are hydraulically connected and form a single aquifer which extends for many miles northeast and southwest from Austin.

Water occurs in the Edwards aquifer in an intricate and unpredictable network of cracks, crevices, and solution openings in the limestone. The inter-connected solution openings are of different shapes and range from microscopic to cavernous in size. Drillers' logs of wells penetrating the Edwards commonly include notations such as "cave, two feet," indicating the cavernous character of the rocks.

EDWARDS RESERVOIR

Location

The Edwards aquifer supplies water to springs and wells along the Balcones fault zone from beyond Georgetown to the Rio Grande. Figure 1 shows the extent of the part of the Edwards aquifer which supplies ground water to the Barton Springs area. This part of the aquifer is called the Edwards Reservoir in this report. The Colorado River is the northeast boundary of this reservoir. Studies by the U. S. Geological Survey, Texas Water Commission, and consultants indicate a ground-water divide in the vicinity of Kyle, which essentially separates the Edwards Reservoir from that part of the aquifer southwest of Kyle. A study of all available chemical analyses of water from the Edwards aquifer indicates that there is an abrupt change in the quality of water approximately along the line which marks the eastern boundary of the Edwards Reservoir as shown on Figure 1. The presence of poor quality water east of this line indicates that the ground water does not circulate freely through the Edwards in that area.

Recharge, Discharge, and Movement

Replenishment, or recharge, to the Edwards Reservoir is by direct infiltration of precipitation on its outcrop and by seepage from streams which cross its outcrop. Seepage from streams is probably the most important. The total drainage area which contributes recharge to the Edwards Reservoir is about 370 square miles (see Figure 1). The streams which cross the Edwards Reservoir include Barton Creek, Onion Creek, Bear Creek, Slaughter Creek, Williamson Creek, and their tributaries.

Water moves through the Edwards from the recharge areas toward lower elevations and points of discharge. The general direction of movement of most of the ground water is to the northeast, where it is discharged from the Edwards at Barton Springs (elevation 434 feet), from smaller springs (elevation 428 feet) along the Colorado River, and from small to moderate sized wells.

Most of the ground water discharges from Barton Springs, even though the springs in the river are at lower elevations. According to published records, the flow of Barton Springs ranges from slightly less than 10 cubic feet per second to about 160 cubic feet per second. It averages about 40 cubic feet per second or about 26 million gallons per day.

The principal springs along the Colorado River are reported to occur at the base of Deep Eddy Bluff on the south side of the Colorado between Zilker Park and Tom Miller Dam. These springs have been referred to as Deep Eddy Springs and Cold Springs and are reported to join the river below present river level. The flow of these springs has been estimated from data collected by the U. S. Geological Survey during two seepage investigations of the Colorado River. The estimated flows of the springs and of Barton Springs at the times of the investigations are as follows.

Date of Seepage Investigation	Flow of Deep Eddy (Cold) Springs (cubic feet per second)	Flow of Barton Springs (cubic feet per second)
August 1916	3 to 4	28 to 30
August 1918	3.7	14.3

The discharge of Barton Springs from 1939 to 1964 and water levels in selected wells tapping the Edwards Reservoir are shown on Figure 2. The highest springflows occur after rains on the recharge area cause water levels to rise; the lowest flows occur after prolonged droughts. The graph of the water levels in Well 12 shows the relation between the flow of the springs and changes in the stage of the Edwards Reservoir, as indicated by changes in water levels. The Edwards serves both as a conduit which transmits water to the springs and as a reservoir which alternately partly fills and partly drains in response to changes in recharge rates.

Because of the wide variation in the sizes and shapes of the openings in the Edwards Reservoir, the rates and exact paths of movement of water in the reservoir are unknown.

Water Levels

As part of this study a field inventory was made to locate wells tapping the Edwards Reservoir in which water levels could be measured. In addition, water-level records in the files of the U. S. Geological Survey, Texas Water Commission, and this firm were compiled. The locations of all Edwards wells for which water levels are available are shown on Figure 3.

Elevations of water levels measured during this study are shown on Figure 3. Also shown are the estimated elevations of the highest and lowest water levels that probably have occurred in the past. The highest and lowest water levels were taken from historical water-level records for three of the wells and were estimated for nine wells by comparing recent water-level measurements with historical water-level and springflow records. Contours of the approximate elevation of the water surface in the Edwards Reservoir based on the above estimates also are shown on Figure 3. The contours can be used for planning purposes to obtain general estimates of the altitude of the water surface in any particular locality. These water-level elevations may be used to estimate whether a sewer will be above or below water level. Because of the few control points available, however, it will be desirable to confirm the elevation of the water surface at any particular sites of concern by test drilling.

The water-level fluctuation in wells shown on Figure 3 has ranged from essentially zero in a well near Barton Springs to about 43 feet in Well 2 about three miles southwest of Barton Springs. Available records show that water levels measured in Well 8 and Well 5 and reported for Well 11 are below the elevation of Barton Springs at low stages of the Edwards Reservoir. Thus, at these times water cannot move from these three wells to Barton Springs and probably moves toward the Colorado River. At other times the water levels in these wells are above the elevation of Barton Springs and water may or may not move from the wells to Barton Springs at those times. The elevations of water levels in the other wells at both high and low stages of the reservoir are above the elevation of Barton Springs. Thus, water can move from the vicinity of all wells measured to Barton Springs at some times.

POSSIBLE EFFECTS OF CONSTRUCTION AND OPERATION OF A SEWER LINE

The Water and Sewer Department has expressed concern over the possible effects on Barton Springs that might result from the construction and operation of a sewer line in the Barton Creek area. The matters of concern are (1) possible danger of pollution of water discharged from the Edwards Reservoir through Barton Springs when the sewer is in operation and (2) possible effects of blasting for construction of the sewer on the flow of Barton Springs.

Possible Danger of Pollution of Water from Barton Springs

For purposes of discussion, the area of study has been divided into four sub-areas as shown on Figure 4. The danger of sewer leakage affecting Barton Springs in each of these areas is discussed in the following paragraphs.

Area 1. In Area 1 the Edwards Reservoir occurs at the surface. The danger of pollution of the springs by leakage from sewer lines in Area 1 should be considered substantial. The Edwards Reservoir may be envisioned as a complex three-dimensional network of pipelines through which water moves. The local details of this network of openings are not known, and individual paths of movement cannot be predicted. Leakage from sewer lines constructed in Area 1 could move directly to Barton Springs without undergoing much natural purification. Some natural purification probably would occur, the amount depending on the distance of travel to the springs, the material through which the leakage travels, and the rate of movement. Thus, the danger of pollution becomes less as the distance between a sewer line and the springs becomes greater. It is not possible to determine a safe distance due to the unpredictable size, shape, and degree of interconnection of the openings in the Edwards Reservoir. If large, well-connected openings were present between a point of leakage and the springs, leakage could move directly to the springs from relatively long distances with little or no natural purification. Conversely, if only very small, poorly-connected openings were present between a point of leakage and the springs, more natural purification would occur before the leakage reached the springs.

Area 2. In Area 2 unconsolidated alluvial deposits occur at the surface. Available data indicate that the Edwards Reservoir directly underlies the alluvium in all of Area 2 except possibly in the vicinity of the City Coliseum. A sewer line in Area 2 might be in unconsolidated deposits along most of its route but in the Edwards along parts of its route. The thickness of alluvial deposits ranges from zero to about 50 feet, and the thickness of deposits encountered in a sewer trench will depend in part on the depths required for the trench. Area 2 has been separated into two parts by Line AB shown on Figure 4. Based on available data, the danger of sewer leakage polluting Barton Springs should be considered substantial in that part of Area 2 west of Line AB. Based on data now available, there is no apparent danger to Barton Springs from leakage generally east of Line AB. The position of Line AB is based largely on opinion as to where water levels always will be lower than Barton Springs. The position of this line thus probably is not exact, and if a sewer line is planned to cross from one side of Line AB to the other, test holes should be drilled to determine the water levels and check the location of Line AB.

Area 3. In Area 3 the Edwards Reservoir is overlain by thicknesses of Del Rio clay estimated to range from zero to about 30 feet. The Del Rio clay is relatively impermeable. It is believed that a thickness of 10 feet of Del Rio between the bottom of a sewer line and the top of the Edwards Reservoir would afford adequate protection to the reservoir. However, the danger of contamination would be greater, and it is believed that a sewer should be protected against leakage where there would be less than 10 feet of Del Rio present in Area 3.

Area 4. Area 4 is comprised of small, isolated areas in the central part of the Barton Creek area and relatively extensive areas in both the northwest and southeast parts. Northwest of the line extending from approximately Oak Hill to Tom Miller Dam, the Edwards Reservoir is not present. In the part of Area 4 lying in the southeast part of the Barton Creek area, the Edwards Reservoir is overlain by an estimated thickness of more than 30 feet of Del Rio clay and younger Cretaceous rocks. In the isolated localities in the central part of the Barton Creek area the Edwards Reservoir is overlain by an estimated thickness of more than 30 feet of Del Rio and generally the lower part of the Buda formation. Based on present knowledge of geologic conditions in Area 4, there is no apparent danger to Barton Springs from sewer leakage in this area.

It is recommended that Barton Springs be protected from leakage from sewer lines located in all of Area 1, in that part of Area 2 west of Line AB, and in Area 3 where 10 feet or less of Del Rio clay will be present below the bottom of a sewer ditch. Data now available indicate that there is no apparent danger to Barton Springs from sewer leakage in Area 4 and in that part of Area 2 east of Line AB.

Two ways of avoiding danger of contaminating Barton Springs by leakage from sewer lines in the areas where protection is recommended are (1) construction of water-tight sewer lines; and (2) placing of the sewer line below the lowest water level in the Edwards Reservoir so that there always would be a positive head from the reservoir into the sewer, thus precluding any leakage from the sewer. The latter method would require adequate provision for protection against the sewer filling up and creating an internal pressure greater than the head of water outside the sewer.

Blasting

Due to the nature of the openings through which water moves in the Edwards Reservoir, there is some risk of damage to Barton Springs by blasting. The risk probably is slight, but the degree of risk is not known and cannot be determined.

Water moving through a limestone reservoir constantly dissolves some material from the limestone and carries it in solution out of the reservoir.

Thus, new openings are continuously formed and older openings enlarged. Some of the solution openings eventually become very large caverns, the roofs of which may in time become too weak to support their overburden, and collapse may occur. Results of such collapse of caverns can be seen on the surface as sinkholes in the Edwards outcrop area. If caverns nearing the stage of collapse should exist in the vicinity of Barton Springs, a shock from any source could trigger the collapse. Should such a collapse occur in the system of openings that feeds Barton Springs, it might block the Barton Springs openings and divert part of the flow to some other outlet. Such outlets are present in the Colorado River at lower elevations than Barton Springs, although they apparently are not as extensive as the Barton Springs outlets. If collapse occurred in the Edwards Reservoir at or near Barton Springs, it is possible that part of the flow of the springs could be diverted to the Colorado River or to some other outlet.

As there is some risk of damage to Barton Springs, it is recommended that blasting not be used in construction of a sewer line in the Barton Springs area. However, if it is decided that advantages of blasting outweigh the risks involved, it is recommended that the shocks from such blasting at least be limited to a magnitude that already has occurred in the area with no apparent effect on the springs. [Should it be decided to use blasting, it is recommended that a qualified expert in this field be retained to write specifications and supervise the work.] Frank Bryant

FURTHER STUDIES

Test Drilling

The City plans to drill test holes along the route of a proposed sewer line in the Barton Springs area to determine, insofar as practicable, the character of the materials that will be encountered during excavation, the elevation of the water table, and the amount of water that will be encountered in making the excavation.

It is recommended that the test holes be drilled with rotary drilling equipment, using clean water as the circulating medium, if practicable. Undisturbed samples should be taken of the alluvium in some of the test holes, and drill cutting samples from the remainder. The Cretaceous formations encountered in all of the test holes should be drilled by continuous boring. It is recommended that the test holes be drilled to a depth of at least 10 feet below the bottom of the proposed sewer trench or to the base of the alluvium, whichever is the greater.

It will be desirable to set a pump and make a pumping test in each test hole which cannot be bailed dry. The final diameter of the holes which are pumped should be about 6 inches or greater. It will be necessary to install slotted casing in each test hole to be pumped in which the water-bearing materials are not sufficiently consolidated to prevent caving. The pump used for testing a well may be a construction type centrifugal pump if the lift is not too great, a small turbine or hi-lift type pump, or a jet pump. The pump that is used should be capable of pumping the maximum capacity of the well or the maximum capacity possible for a pump that can be set in the diameter hole drilled.

Before the pump is installed, the hole should be cleaned and developed by bailing so that the maximum water production may be obtained from the water-bearing material. A pumping test then should be made in the hole to determine insofar as practicable the hydraulic characteristics of the water-bearing materials.

Water levels should be measured for a period up to several hours after development of the test hole is completed and before a pumping test is commenced to determine the trend of water-level fluctuation and the static water level in the hole prior to pumping. The hole then should be pumped continuously for a period ranging between one hour and twelve hours, depending on the rate of pumping and rate of drawdown of the water level. Accurate measurements of the pumping rate and pumping level should be made periodically during the pumping period. The rate of water-level recovery in the test hole then should be measured for about two hours after the pump is turned off. The depths to water should be measured with a steel tape or electric water-level measuring device to the nearest 100th of a foot.

Detailed plots and interpretations of the pumping rates, drawdowns, and rates of recovery should be used to assist in estimating the general amount of water it may be necessary to pump during construction of the sewer line.

The temperature of the water should be measured and recorded during pumping, and samples of the water should be collected for possible chemical analysis.

Observations

If periodic checks for coliform organisms in the spring water are not already being made, it is recommended that such checks be started in advance of placing a new sewer in operation.