The University of Texas at Austin

RESEARCH NOTE 4

1976

AGGREGATE RESOURCE CONSERVATION IN URBAN AREAS

L. E. Garner

Reprinted from
Twenty-sixth Annual Highway Geology Symposium, August, 1975
with permission of Highway Geology Symposium
National Steering Committee and Idaho Transportation Department

BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN
C. G. Groat, *Acting Director*

CONTENTS

FIGURES

TABLE

AGGREGATE RESOURCE CONSERVATION IN URBAN AREAS*

By

L. E. Garner
The University of Texas at Austin

ABSTRACT

Future utilization of aggregate resources in urban areas must be considered during early planning stages of an urban complex. This is of particular importance because urban land values are commonly greater than the mineral value of these low unit value materials and the use of the land for construction pre-empts exploitation of the aggregate materials. In addition, zoning restrictions may also prohibit resource exploitation of urbanized land. Sequential land use practices which allow the development of resource areas prior to urban encroachment can result in more efficient mineral production and lower consumer costs.

Environmental planning studies in the Austin, Texas area, serve as an example of how urban expansion can affect aggregate resource reserves. Sand and gravel and limestone deposits in this area which were considered as reserves a few years ago are now covered by developments. Furthermore, evaluation of projected aggregate consumption and population trends indicate that substantial quantities of reserves will be lost to future development if current practices prevail. Even though similar materials are present in nearby areas the unit price will be significantly increased by added transportation costs. A comparison of the possible alternatives indicates that transportation costs would be significantly higher than the cost of rehabilitating land after mineral extraction in local areas.

Many important aggregate resource deposits have been engulfed in the urban development of large cities during the past several years. Zoning regulations which promote resource preservation and sequential land use can extend the productive lives of many such deposits.

INTRODUCTION

The preservation of mineral resources within and adjacent to growing metropolitan areas is a necessary part of urban planning and a vital aspect of our mineral industry. Materials suitable for development as mineral resources occur only in certain areas; if these areas are covered by an urban complex, potential economic benefits are lost. Therefore, a knowledge of the distribution of suitable deposits and a plan for their systematic extraction prior to development is essential to obtain the maximum benefit from local resources.

---

*Published with permission of the Acting Director, Bureau of Economic Geology, The University of Texas at Austin.

Aggregate materials are key resources for urban development because they provide the construction materials that are basic components of our roads, commercial buildings, and homes. The five-fold increase in aggregate production in Texas since 1950 (Figure 1) is closely related to the increase in construction (Figure 2) and the population increase (Figure 3). The relative importance of aggregates located in or near urban areas is also emphasized by the fact that suitable deposits in remote areas are commercially less attractive than deposits near developed areas. Transportation cost is of course the basic reason that production areas of these low unit value resources are located as near as possible to high demand areas. Even in cases where market areas are near production areas, transportation cost is commonly equal to or greater than the value of the aggregate material at the source.

Although sand and gravel and crushed stone are important resources, the relatively high real estate values, stimulated by rapidly expanding urban areas, have often caused potential mineral lands to be used for other purposes.

The Austin area of Texas is presented in this paper as an example of how urban growth can affect the availability and cost of local resources and what can be done in metropolitan centers to incorporate exploited areas into urban development. Conditions described herein are not unique to Austin or Texas.

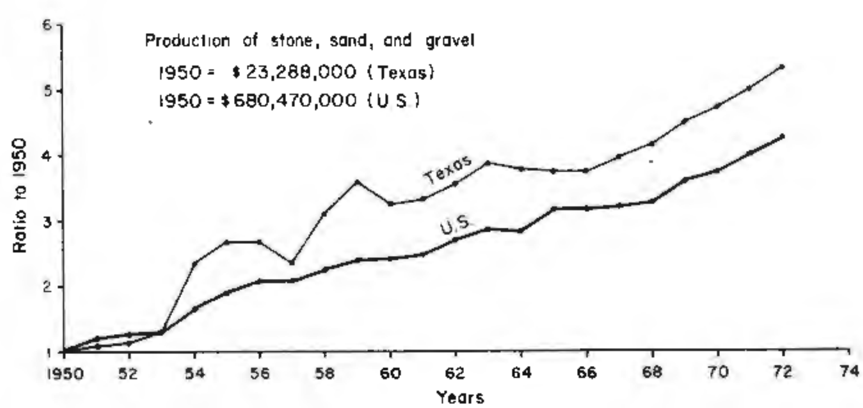

FIGURE 1. Aggregate Production in Texas and United State, 1950 to 1972 (based on U.S. Bureau of Mines, Minerals Yearbook statistics).

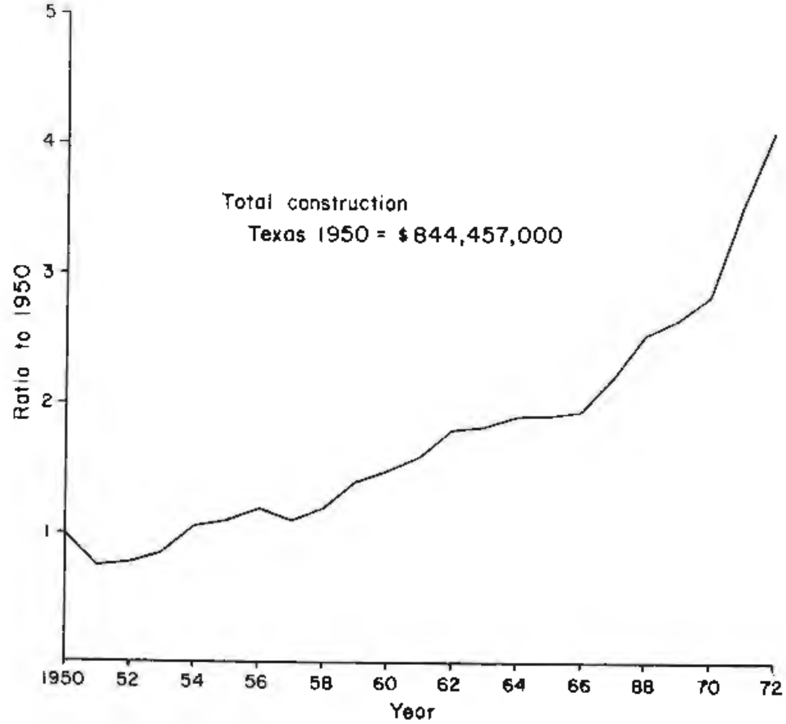

FIGURE 2. Total Construction in Texas, 1950 to 1972 (based on statistics from Bureau of Business Research, The University of Texas at Austin).

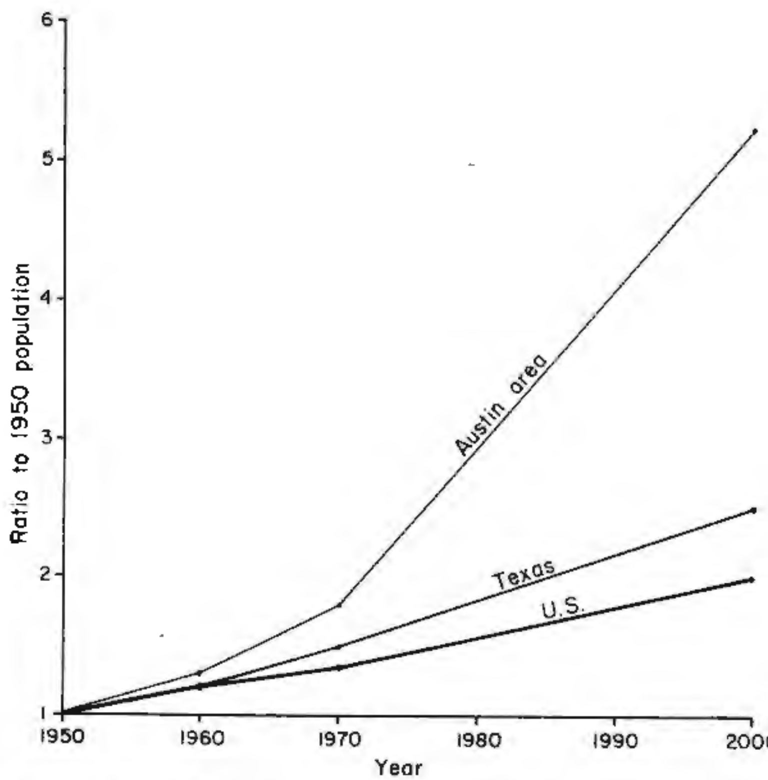

FIGURE 3. Population Growth, 1950 to 1970, and Projected Population Growth, 1970 to 2000, for Austin area, Texas, and the United States (based on statistics from Population Research Center, The University of Texas as Austin).

GROWTH

Approximately half of Austin's areal growth (Figure 4) has taken place in the past 20 years (Figure 5). This correlates with population growth which has also almost doubled in the same period (Figure 3). Even if growth is slowed somewhat, Austin's population is expected to reach or exceed one-half million during the 1980's. The growth rate for Austin (Figure 3) is several times larger than the rates for Texas and the United States. If these projected rates prove to be accurate, Austin's population in the year 2000 will be more than five times greater than the 1950 population.

The rate of development for the 1960-1970 period was approximately 2 square miles per year (Figure 5). At present population densities, this rate must increase to about 5 square miles per year to accommodate Austin's projected population in 2000.

AGGREGATE RESOURCES

Aggregate resources in the Austin area are available from limestones and alluvial materials which have been described in detail by Rodda and Fisher (1966) and Garner (in preparation).

Limestone reserves, suitable for crushed stone, occurring in the Austin area prior to urban expansion (Figure 6) totaled about 6 billion tons. Approximately 80 percent of this total is within five miles of existing railroads. As of 1970, about 350 million tons of original reserves had been eliminated from the reserve list by aggregate production and urban encroachment.

Sand and gravel deposits containing materials suitable for aggregates cover an area of about 120 square miles in the Austin vicinity (Figure 6). Estimated reserves for this area were originally about 1 billion tons. Production and urban development has eliminated about 125 million tons from the reserve list as of 1970.

The quantity of potential aggregate materials covered by urban development for the period ending in 1970 totaled about 475 million tons. A survey of abandoned pits and quarries within the urban area indicates that only about 10 percent of these aggregate materials had been extracted for use. Therefore the loss of potential resources due only to urban encroachment is about 425 million tons. At current prices, the total lost mineral value amounts to more than $600 million.

CONSUMPTION PATTERN

The current statewide average consumption for construction materials is about 7 tons per capita (3 tons per capita for sand and gravel and 4 tons per capita for crushed stone). The national consumption rate for aggregate materials is about 9 tons per capita. Projected consumption rates for the

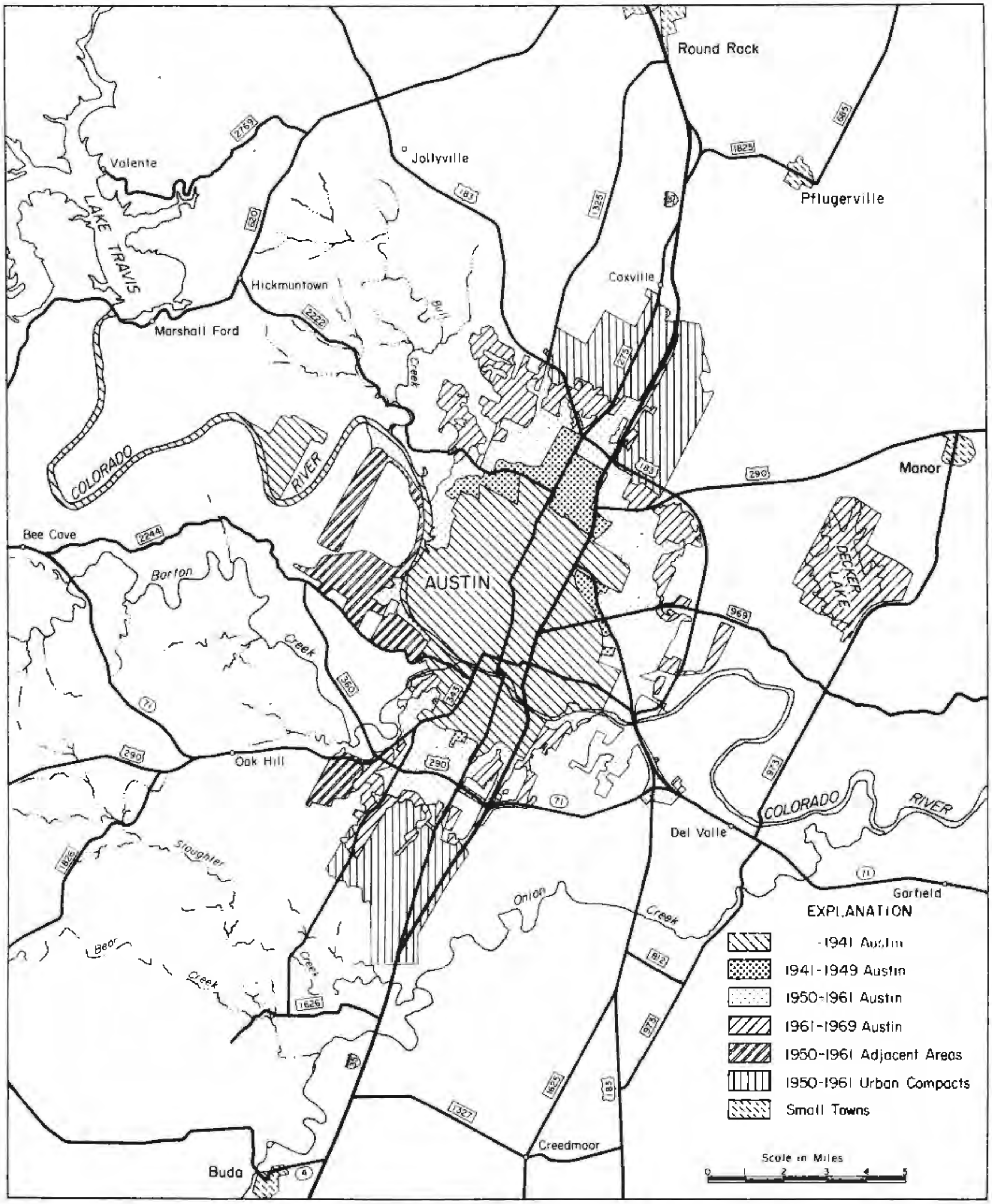

FIGURE 4. Urban Growth of the Austin Area, Texas, 1940 to 1970

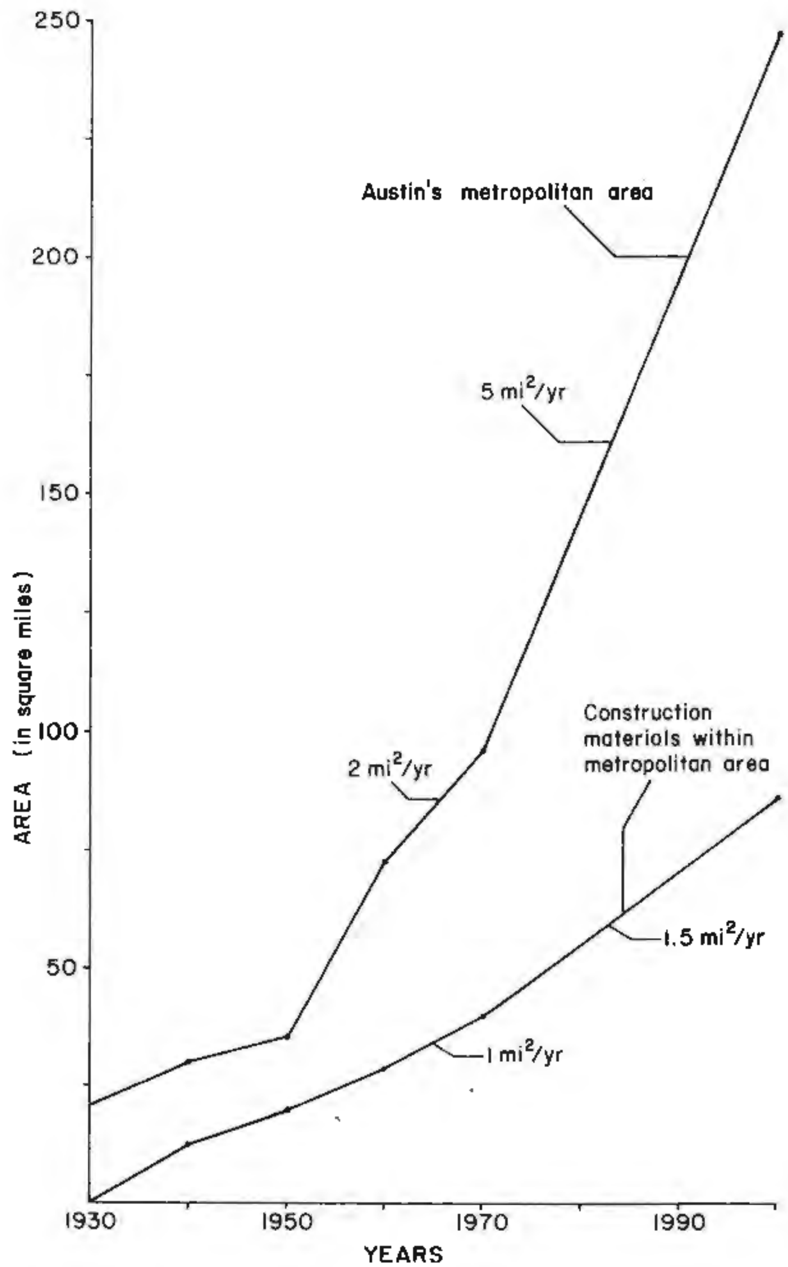

FIGURE 5. Rate of Urban Areal Growth and Rate of Urbanization of Potential Construction Materials, Austin Area, Texas

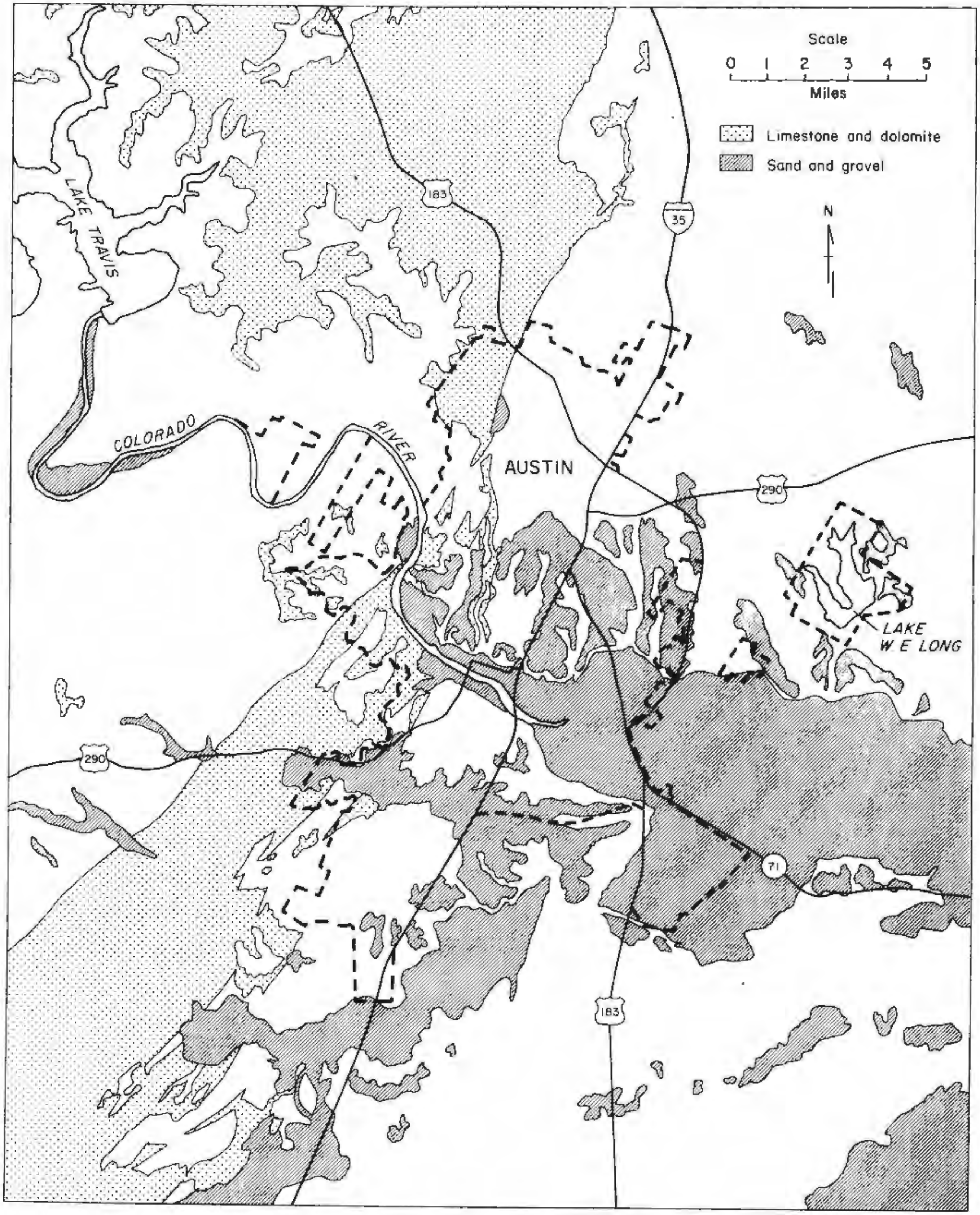

FIGURE 6. Aggregate Materials in the Austin Area, Texas

year 2000, based on forecast figures from the U.S. Bureau of Mines Mineral Facts and Problems (1970) and the U.S. Census Bureau, are about 18 tons per capita. If a constant ratio is maintained between Texas and United States total aggregate production, as indicated in Figure 1, the rate of aggregate consumption in Texas will be about 12 tons per capita in 2000.

RESERVES AND URBAN GROWTH

One can observe from the above array of numbers that Austin is not about to run out of aggregate material resources. By applying the current consumption rate to Austin's population of about 300,000 it is obvious that literally hundreds of years of reserves are present. This is true even at the projected rate of 12 tons per capita and the projected population of 850,000.

The problem with calculating reserves strictly on a numerical basis is that the area consumed by urban growth is not considered. Unless conservation measures are taken, urban development will probably obscure many times the amount of aggregate material actually produced. Based on current development patterns, urban growth (5 square miles per year) would consume approximately 1.5 square miles per year of construction materials (Figure 5), compared to a 1 square mile per year for the 1960 to 1970 period.

At the average rate of 1.5 square miles per year and assuming a production of about 50,000 tons per acre, urban growth would engulf almost 1.5 billion tons of construction materials by the year 2000 or about 25 percent of current reserves. At today's prices, this would be a mineral value loss of about $2 billion.

The problems resulting from increased urban growth are not limited to loss of aggregate resources. The total impact must also consider the interrelation of urban growth, resource conservation, and consumer cost. Evaluation of these relationships requires the consideration of present and projected haul distance, transportation cost, and consumption rate.

The average haul distance at present is about 10 miles. It is estimated that the increase in urban area will cause at least a 50-percent increase in the average haul distance by year 2000, bringing the total distance to 15 miles.

Transportation costs are currently approximately $0.04 per ton mile. Even before the energy crisis, some authorities were predicting a 100-percent increase in haul costs by year 2000. This would raise transportation rates to $0.08 per ton mile.

In Table 1, the current and projected values which contribute to the average annual per capita haul cost are listed. Currently this total value is $2.80. Projected values for the year 2000 result in an average annual per capita haul cost of $14.40 which is an increase of more than 400 percent. In the event that transportation cost is increased by only 50 percent, the average annual haul cost would still be increased by about 280 percent to $10.80.

TABLE 1. Current and Projected Transportation Cost for Aggregate Materials

Year	Average Haul Cost (per ton mile)	Average Haul Distance	Annual Per Capita Consumption (tons)	Average Annual Per Capita Haul Cost
1970	$0.04	10	7	$ 2.80
2000	$0.08 $0.06	15 15	12 12	$14.40 $10.80

As mentioned previously, these problems are not peculiar to the Austin area. A similar evaluation by the California Division of Mines and Geology (Bulletin 198, 1973) indicates that the average annual per capita haul cost in that State will increase from $10 in 1970 to $54 in year 2000. They predicted a statewide loss of construction materials for the 30-year interval of almost $17 billion, based on current development practices.

RESOURCE CONSERVATION

There are alternatives to the dim picture painted in the foregoing paragraphs. The most likely of these alternatives if the implementation of sequential land use practices to exploit mineral land prior to urban development. Although conservationists have suggested the utilization of sequential land use for many years, the economic stimulus may ultimately be the factor which causes its acceptance as a normal conservation practice. For example, in California it was estimated that about 90 percent of the predicted $17 billion construction material loss could be saved if conservation practices known and available in 1972 were rigorously applied. The estimated cost of this loss-prevention for the period from 1970 to 2000 would be about $90 million, giving a benefit to cost ratio of 170 to 1.

Fairfax County, Virginia pioneered this approach to resource conservation in 1961 when it enacted zoning ordinances to preserve land for resource development. Much of the land originally set aside has now been exploited. Completion of the project is scheduled for 1976. In 1973, Colorado passed a statute which requires a study of available mineral deposits and preservation of commercial deposits in counties having a population greater than 65,000. Sand and gravel and quarry aggregates were specifically designated. This action was prompted in part by rapid urban development in the Denver area several years ago, which radically reduced available sand and gravel resources. Vermont has also enacted a law which limits urban development of resource areas, and several other states are currently working on legislation of similar statutes.

Sequential land use practices can easily be incorporated into urban master plans. The initial reaction is that reclamation of mining sites is expensive and costs may be prohibitive. However, when reclamation of pit areas is compared to increased haul distance and higher transportation cost, it is apparent that conservation can be profitable.

An investigation of surface mining in Texas (Groat, in preparation) shows that the cost of fully reclaiming sand and gravel mining areas (including grading, revegetation, and fertilization) ranges from \$335 to \$635 per acre. Recovery of dredging operations and simultaneous reclamation during extraction using company-owned equipment is less expensive (about \$335 per acre), while secondary recovery of land after extraction is most expensive (about \$635). The cost for reclaiming crushed stone quarries is assumed to range somewhat higher than for sand and gravel pits because of the indurated nature of the materials. Reclamation cost may in some difficult situations range as high as \$1000 per acre.

For the purpose of calculations in this article, the highest reclamation cost is assumed (\$1000 per acre). Therefore, an aggregate yield of \$50,000 tons per acre would require an increase in price to the consumer of only \$0.02 per ton to offset producer overhead.

In order to see the economic benefit of sequential land use, compare the projected values for haul costs and haul distance in year 2000 (Table 1).

Haul distance x Haul cost = Total cost

15 miles x \$0.08/ton mile = \$1.20/ton

If the average haul distance could be reduced by 3 miles through the implementation of sequential land use,

Haul distance x Haul cost = Total cost

12 miles x \$0.08/ton mile = \$0.96/ton

savings in haul cost would be \$0.24 per ton. Thus, the consumer cost would be decreased by a net total of \$0.22 per ton. This would result in decreasing the annual per capita cost by \$2.64, a significant saving. Increased land values associated with reclaimed mine sties will result in additional savings.

ENVIRONMENTAL ASPECTS OF SEQUENTIAL LAND USE

The exploitation of mineral resources located within or adjacent to an urban area has many unsavory aspects. Environmental problems commonly associated with sand and gravel or crushed stone industries are stream pollution by excess sediment, air pollution by dust, land disturbance, increased traffic, noise, and general unsightliness. Objections stem primarily from the economic necessity of locating extraction and plant sites as close as possible to consumers.

Little can be done about some problems such as noise and traffic in the immediate area of mining sites. Advance planning can delay the development of nearby residential areas until extraction is complete. Vegetation and landscaping can also be used to screen pit and quarry operations, and stream and air pollution can be reduced or eliminated by trapping sediment and dust.

The most appealing aspect of sequential land use is that once mineral extraction is complete and the land is reclaimed the site is available for other uses. Therefore, it not only provides for the most effective mineral conservation but also enables property owners to obtain maximum benefit from their land.

CONCLUSION

The rapid growth of urban centers has caused a re-evaluation of many concepts about lifestyles and economic development. Increased consumer demand, increased transportation cost, and the loss of mineral reserves are causing a keener awareness of current and future resource-related problems. The finite nature of resources is realized today more than ever. Alternatives illustrated in previous sections show how resource availability and cost can be affected when development is not adequately planned.

It is possible that economic factors related to rapid urban expansion will serve to retard the development rate and the attendant price increases. In this case, the foregoing projections may be much higher than actual conditions. These circumstances would not, however, negate the premise that planned resource development can result in many benefits to both producers and consumers.

REFERENCES

Bureau of Business Research, monthly publication, Texas Business Review: Univ. Texas, Austin, Bur. Business Research.

California Division of Mines and Geology, 1973, Urban Geology Master Plan for California: Califor. Div. Mines and Geology, Bull. 198, 112 p.

Garner, L. E., in preparation, Environmental Geology of the Austin Area, Texas: Univ. Texas, Austin, Bur. Econ. Geology, Rept. Inv.

Groat, C. G., in preparation, Inventory and Environmental Effects of Surface Mining in Texas: Univ. Texas, Austin, Bur. Econ. Geology, Rept. Inv.

Rodda, P. U., and Fisher, W. L., 1966, Limestone and Dolomite Resources, Lower Cretaceous Rocks, Texas: Univ. Texas, Austin, Bur. Econ. Geology, Rept. Inv. No. 56, 286 p.

United States Bureau of Mines Staff, 1970, Mineral Facts and Problems: U.S. Bur. Mines Bull. 650, 1,291 p.

United States Bureau of Mines Staff, Annual, Minerals Yearbook: U.S. Bur. Mines.