

Regional Trends in Water-Well Drilling in the United States

By Gerald Meyer and G. G. Wyrick

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A description of relations between water-well drilling and regional changes in economy and development, population growth and shifts, changes in irrigation practice, and natural phenomena such as earthquakes and droughts



United States Department of the Interior STEWART L. UDALL, Secretary



Geological Survey William T. Pecora, Director



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ABSTRACT

The well-drilling industry is one index of the importance of ground water to our national economy. National investment in water wells totals about one-half to three-quarter billion dollars annually. The overall industry is currently experiencing a sharp upswing in drilling activity, but activity varies from region to region. Regional changes in drilling activity are determined by regional changes in economy and development, population growth and shifts, changes in irrigation practice, and even natural phenomena such as earthquakes and droughts.

Analysis of estimates of the number of water wells drilled in the United States during the period 1960–64 reveals national and regional trends in water-well construction. Approximately 435,700 wells were drilled in 1964—an average of 1,700 well starts each working day. For the Nation as a whole, the net change between 1960 and 1964 was an increase of 14 percent in drilling activity.

INTRODUCTION

Information on well-drilling activity furnished by district offices of the U.S. Geological Survey's Water Resources Division, State engineers, State Geological Surveys, and other State water agencies permit realistic estimates of the number of water wells drilled in the United States during the period 1960–64. The tally of wells drilled in 1960 and 1964, by State, is given in table 1. Analysis of the data reveals national and regional trends in water-well construction (fig. 1, table 2) and intensity of drilling throughout the Nation (fig. 2).

The well-drilling industry is one index of the importance of ground water to our national economy. Practically all the rural population of the United States and sizeable segments of its urban population, industry, and agriculture rely upon the ground-water reservoirs as a source of supply. Water wells have been a significant factor in the habitation of rural and suburban areas, expansion of the practice of irrigation, and decentralization of industry.

An estimated 10 to 15 million wells are in existence today. In 1950, ground-water use totaled 30 to 35 bgd (billion gallons per day) (MacKichan, 1951; McGuinness, 1963, p. 83); in 1960, it totaled about 46 bgd (MacKichan and Kammerer, 1961). These estimated values indicate that ground-water use increased 30 to 50 percent between 1950 and 1960. On the basis of this 10-year rate of increase, withdrawals in 1965 of between 53 and 69 bgd are indicated. Projection of this rate of increase to 1980, 15 years hence, indicates ground-water use of about 80 to 100 bgd. In the past 15 years, ground water has supplied between onefifth and one-sixth of the Nation's total withdrawal use1 of water. Alfred Loehnberg (in Ackerman and others, 1960, p. 22) has predicted that the ratio of ground-water to surface-water withdrawal might increase to 1:2 or even 1:1 in the next 20 to 50 years. If so, the total ground-water use in 1980 might be considerably greater than the projected range just given. Although some hydrologists consider these predicted rates of increase in ground-water use too high, there is general agreement that ground-water use will continue to increase.

NATIONAL ANNUAL INVESTMENT IN WATER WELLS

Approximately 435,700 wells were drilled in 1964—an average of about 1,700 well starts each working day. The bulk of ground water used for domestic, irrigation, industrial, and public supply is withdrawn through wells. Well drilling is a sizeable industry: according to the editor of the "Water Well Journal," an estimated 13,000 contractors operate about 27,000 drilling machines.

¹⁴Withdrawal use" is defined as water diverted from its place of occurrence for use.

Table 1.—Estimated number of water wells drilled in the United States, by State

[Based mainly on data supplied by the U.S. Geol. Survey and State water agencies. Modified in part by other data available to the authors. NC, no change]

State	Estimated number	Percent change	
State	1960	1964	1960-64
Alabama	4,000	4,500	+13
Alaska	726	1,001	+38
Arizona	1,400	1,520	+9
	5,000	5,000	NC
Arkansas California	9,100	10,000	+9
Colorado	3,105	5,911	+55
Connecticut	6,500	6,500	NC
		3,440	-9
Delaware	3,797 12	12	NC
	33,900	55,000	+62
Florida			-5
Georgia		10,000 21	+24
Hawaii	17		
Idaho	1,400	1,400	NC
Illinois	21,000	19,500	-7 19
Indiana		15,000	-12
Iowa		15,000	+66
Kansas	4,700	5,500	+17
Kentucky	•	9,620	-3
Louisiana	974	2,620	+169
Maine		1,700	+13
Maryland	4,022	6,902	+72
Massachusetts		9,000	+13
Michigan	25,000	25,000	NC
Minnesota	13,000	9,000	-31
Mississippi	5,300	5,900	+11
Missouri	6,380	9,990	+57
Montana		2,000	+5
Nebraska		6,005	+9
Nevada	824	825	NC
New Hampshire		4,400	+22
New Jersey		3,440	-9
New Mexico		3,150	+41
New York		25,000	NC
North Carolina	20,000	25,000	+25
North Dakota	4,200	3,760	-10
Ohio	17,137	18,622	+9
Oklahoma	4,400	5,000	+14
Oregon	3,500	4,500	+29
Pennsylvania		16,220	+20
Rhode Island	200	250	+25
South Carolina	5,300	5,400	+2
South Dakota	6,077	5,426	-11
Tennessee	10,000	8,000	-20
Texas	19,000	25,000	+32
Utah	630	650	+3 +10
Vermont	1,240	1,460	+18
Virginia	8,500	10,000	+18
Washington	1,396	1,700	+22
West Virginia	5,500	5,900	+7
Wisconsin	11,000	12,000	+9 NC
Wyoming	1,000	1,000	NC

An estimated average cost per well of \$1,500, which seems reasonable but is merely a guess, indicates that national investment in water wells is about one-half to three-quarter billion dollars annually. These figures do not include the pump and plumbing segments of the industry. High-capacity irrigation, municipal, and industrial wells may cost 5 to 100 times the price of simply constructed moderate-yield domestic wells. Thus, the average value of a well in the West, where irrigation wells constitute a larger share of the total drilling effort, is higher than in the East. where domestic wells strongly predominate. However, the total dollar value of wells in the eastern half of the country may be greater inasmuch as it accounts for about 80 percent of all well drilling in the Nation.

Drilling activity in the 1960's, reported here, and estimates for the 1950's and earlier periods (Picton, 1956, 1959; Fiedler, 1957) show that the annual rate of drilling fluctuates but that the general trend is increased drilling from 1900 to the present. (See fig. 3.) The overall growth rate is 5,000 wells per year. In 1900, about 155,000 wells were drilled, approximately one-third the number in 1964. Major swings in well-construction activity relate to major events in American economy and history. The industry peaked during World War I, sagged during the following period of economic depression, recovered during the post-depression period as the accumulated backlog of well-drilling needs was erased and the value of irrigation with ground water was proved, accelerated following World War II, and peaked at about the start of the Korean war. It sagged again during and following that war, and as shown in figure 3, the industry currently is experiencing an upswing. Apparently the number of wells being drilled today (1966) equals or exceeds the highest peak period shown in figure 3.

Water-well trade jorunals have generally stated larger annual well-drilling totals for the Nation than those compiled by Federal Government agencies. The difference is explained in part by the exclusion in Government tallies, including the present one, of blast holes, tremies, foundation borings, test holes, and other holes not drilled specifically for construction of production water wells.

NATIONAL TRENDS IN WELL DRILLING

Intensity and distribution of water-well drilling are dependent on the vicissitudes of man and nature. As a general rule, it may be said that large numbers of wells are drilled where ground-water supplies are naturally abundant or adequate and that few wells are drilled where they are sparse. However, it does not necessarily follow that ground-water pumpage is heaviest where well density is greatest. In many parts of the Nation, the number of wells drilled may bear little relation to ground-water withdrawals because domestic supply wells constitute by far the greatest proportion of new wells, yet account for only a relatively small part of the withdrawals. Irrigation and industrial wells, though smaller in total number, are responsible for most of the ground-water withdrawal. Municipal and housing-development well fields, too, are characterized by large withdrawals from a moderate number of high-capacity wells.

Figure 3 indicates little net change in well drilling during the last 15 years, but groundwater withdrawals over the same period have increased appreciably. As knowledge of hydrology of the Nation's water resources expands and as competency in water-supply development and well technology increase, the trend seems to be toward a limited number of efficient wells located on the basis of technical knowledge of aquifer behavior rather than large batteries of wells as a means of increasing water supply. This trend is evident in Arizona, Nebraska, and some of the other States heavily tapped for ground water. A single modern irrigation well in Nebraska may yield as much water as 500 or more domestic or stock wells.

New rural and outer fringe suburban housing accounts for an appreciable share of the upward trend in well drilling throughout much of the country in the 1960's. Centrally supplied municipal water systems are expanding into suburbs, but suburbs are expanding into the countryside. New irrigation and industrial wells in the South and West account for part of the increased drilling. Regional population shifts between 1960 and 1964 relate only vaguely to changes in drilling activity. Middecade census data show greatest gains in population in Southwestern and Southern States and in a few Middle and North Atlantic Coast States (U.S. Department of Commerce Census Bureau, 1966). Well drilling also increased in the South, but in only parts of the Southwest, and in nearly every State along the Atlantic coast (fig. 1).

Natural phenomena account for part of the recent increase, too. The current severe

drought in the Northeastern and Middle Atlantic States has stimulated drilling, as did the 1932—37 drought in the Midwest. Ground-water reserves are depleted more slowly than streamflow and surface reservoirs during drought, but the multiyear drought in these regions has necessitated widespread construction of new wells. Following imposition of restrictions on public-supply water use on Long Island, N.Y., drilling of private wells to overcome the inconvenience of the water ban has increased several hundred percent over the normal rate. In Alaska, water-well replacement drilling jumped 28 percent following the Alaska earthquake of March 1964, which ruined many wells.

Nearly static agricultural economy, such as in the Northern Great Plains States, maturing

or leveling of industrial development, extension of municipal distribution systems, and local favored development of surface water account for the small change or decrease in drilling activity experienced in some parts of the country in recent years.

For the Nation as a whole, the net change between 1960 and 1964 was an increase of 14 percent in drilling activity.

REGIONAL TRENDS

Grouping of contiguous States with similar trends in well-drilling activity (fig. 2, table 2) reveals substantial differences in water-well construction trends throughout the Nation.

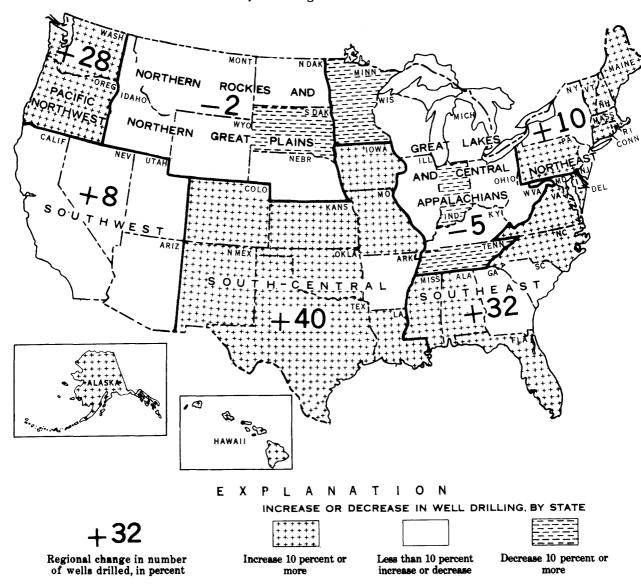


Figure 1. —Changes in well-drilling activity, 1960-64.

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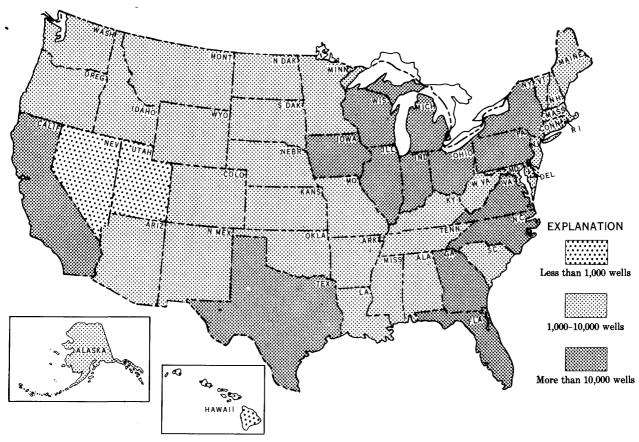


Figure 2.—Number of water wells drilled in 1964, by State.

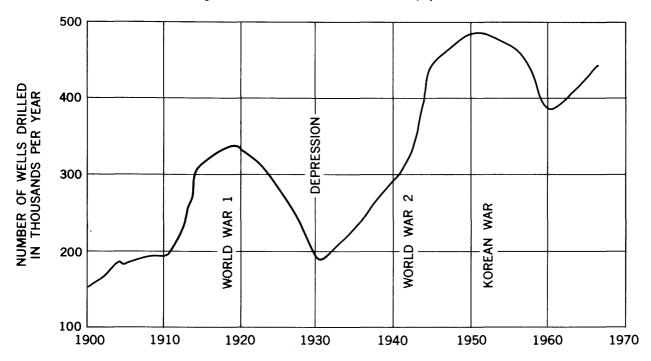


Figure 3.—Number of water wells drilled in the United States between 1900 and 1965 and relation to major events in American history. Graph adapted largely from Picton (1956).

Region	Number of wells drilled, 1960	Number of wells drilled, 1964	Percent of total drilled in 1964	
South-central	54,800	77,200	18	+40
Southeast	95,300	•	28	+32
Pacific Northwest (includes		,		
Alaska)	5,600	7,200	2	+28
Southwest (includes Hawaii)	12,000	13,000	3	+8
Northeast	63,300	70,000	16	+10
Northern Rockies and northern	•			
Great Plains	20,100	19,600	5	-2
Great Lakes and central	•	·		
Appalachians	130,200	122,600	28	-5
Totals	381,300	435,700	100	1 ₊₁₄

Table 2.—Regional trends in water-well construction in the United States, 1960–64

Three regions exceeded the national increase of 14 percent. Major numerical and percentage increases in drilling are centered in the Southeast and South-central States. These two regions account for the bulk of the national increase in drilling, about 54,400 wells, between 1960 and 1964. In 1964, drilling exceeded 10,000 wells in five States in these regions (fig. 2). These are regions of growing irrigation-well use, industrial development, suburban sprawl, and rural population. The magnitude of drilling in these two southern regions is illustrated by the fact that in any recent year they have accounted for nearly half the Nation's total well construction. These regions include the Gulf and Atlantic Coastal Plains where the well replacement rate is higher than in other parts of the country owing to corrosion, encrustation, and screen or wellpack failure. The high replacement rate stems from chemical characteristics and mineral constituents of the ground water and the complex well construction required by the unconsolidated multilayered materials of the Coastal Plains. Well life expectancy is especially short along parts of the gulf coast. In Louisiana, the drilling ratio of replacement wells to additional wells is 3:1, which apparently is the highest replacement rate in the country. In adjacent Mississippi, it is about 1:1. By contrast, the replacement rate in Colorado is only about 1 in each 100 wells drilled.

The Southeast region includes Florida, the State most intensively drilled in 1964, where approximately 55,000 wells were constructed as compared with the national average of

8,700 wells per State. Florida's economic and population boom and strong reliance on ground water are the reasons.

Regions bordering on the Great Lakes seem to be undergoing "peaking out" of well-drilling activity. Decline or leveling of drilling in States bordering the Great Lakes is attributed to widespread extension of municipal and suburban distribution systems that derive water from surface-water sources, in lieu of ground water that lies undeveloped underfoot in much of the region, and maturity of industrial development. The Great Lakes and central Appalachians region experienced a 5-percent decline between 1960 and 1964. The Northeast gained 10 percent, but this rise is explained by increases in drilling in New England Atlantic Coast States distant from the Great Lakes. These States are enjoying a moderate industrial revival and new recreational and tourist economic stimulus. New York, the only State in the Northeast region bordering on the Great Lakes (except for a small part of Pennsylvania), experienced virtually no net change in drilling during the 5-year period. In the central Appalachians, retardation of drilling activity relates to loss of population, reduction in farming, and the readjustments of the economy now underway.

However, despite these influences, the Great Lakes and central Appalachians region and the Northeast region together still constitute an important slice of the well-drilling industry; they account for 44 percent of all wells drilled

¹Comparison of national totals.

REFERENCES CITED 7

in the country in 1964. The Great Lakes are virtually ringed on the American side with States in which drilling exceeds 10,000 wells a year (fig. 2).

In terms of the number of wells drilled, regions of the far West account for less than 5 percent of the total national industry. In the Pacific Northwest, an area of current industrial growth, drilling increased 28 percent during 1960-64; but for the year 1964, it was only 2 percent of the national total. For convenience, Alaska is included in this region. Alaska's population increased greatly in the last five years, and including a 28-percent boost in drilling caused by the destructive Alaska earthquake of March 1964, well drilling rose 38 percent during 1960-64.

The Southwest accounted for less than 3 percent of the national total drilling in 1964, despite the fact that every State in the region (Hawaii is included) experienced a population gain considerably above the national average in the first half of this decade. California is the only State west of the Rockies in which drilling in 1964 totaled as much as 10,000 wells. Apparently the California advance of about 10 percent in drilling during the period covered by this tally resulted from suburban expansion, industrial growth, and a moderate increase in irrigation-well construction; but the data are in need of refinement. Other significant factors are replacements stemming. from well failure due to corrosion, faulty construction, or damage to wells from land subsidence.

Hawaii is the only State in the Southwest well-drilling region in which drilling advanced more than 10 percent during 1960-64.

The Northern Rocky Mountains and northern Great Plains constitute a well-drilling region of moderate activity in which, according to available data, drilling declined about 2 percent between 1960 and 1964. The Rockies remain thinly populated with little agriculture or industry, and the northern Great Plains is a region of mature and stable agricultural development with little or no change in production in the 5-year period covered by the tally.

SUMMARY

Growth trends of the well-drilling industry and numerical well counts, when analyzed by regions, relate in varying degrees to patterns and intensity of development of the Nation's ground-water resources. These trends indicate the following:

- 1. Ground-water pumpage is increasing about 4 percent (about 2 bgd) each year. As the use of ground water increases, the activity in well drilling increases, but at a slower proportional rate because of increased hydrologic knowledge and technical capability for locating and developing ground-water supplies.
- 2. The well-drilling industry totals about one-half to three-quarter billion dollars annually. The overall industry is presently experiencing a sharp upswing in drilling activity, but activity varies from region to region.
- 3. Grouping of States by increase or decrease in drilling activity delineates well-drilling regions whose boundaries are determined by regional changes in economy and development, population growth and shifts, changes in irrigation practice, and even natural phenomena such as earthquakes and drought.

Study of the data indicates that the above changes account in large measure for drilling trends. The study also raises many questions related to their significance. Are the regions now experiencing uptrends in drilling the ones that warrant greatest planning effort? Are these the ground-water problem areas of the future? Are areal ground-water investigations and well technology in tune with water-well needs of the future? Knowledge of the groundwater resources of the Nation is advancing and is enabling improvement in scientific methods of ground-water development. These advances, coupled with improvements in well technology, are permitting greater withdrawals of water from fewer wells.

The high replacement rate and the impact of drought on well supplies in some parts of the country indicate a need for additional technologic research directed toward better, but nevertheless moderately priced, materials and well design and toward greater compatibility of well materials and well design with the environment of the wells.

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