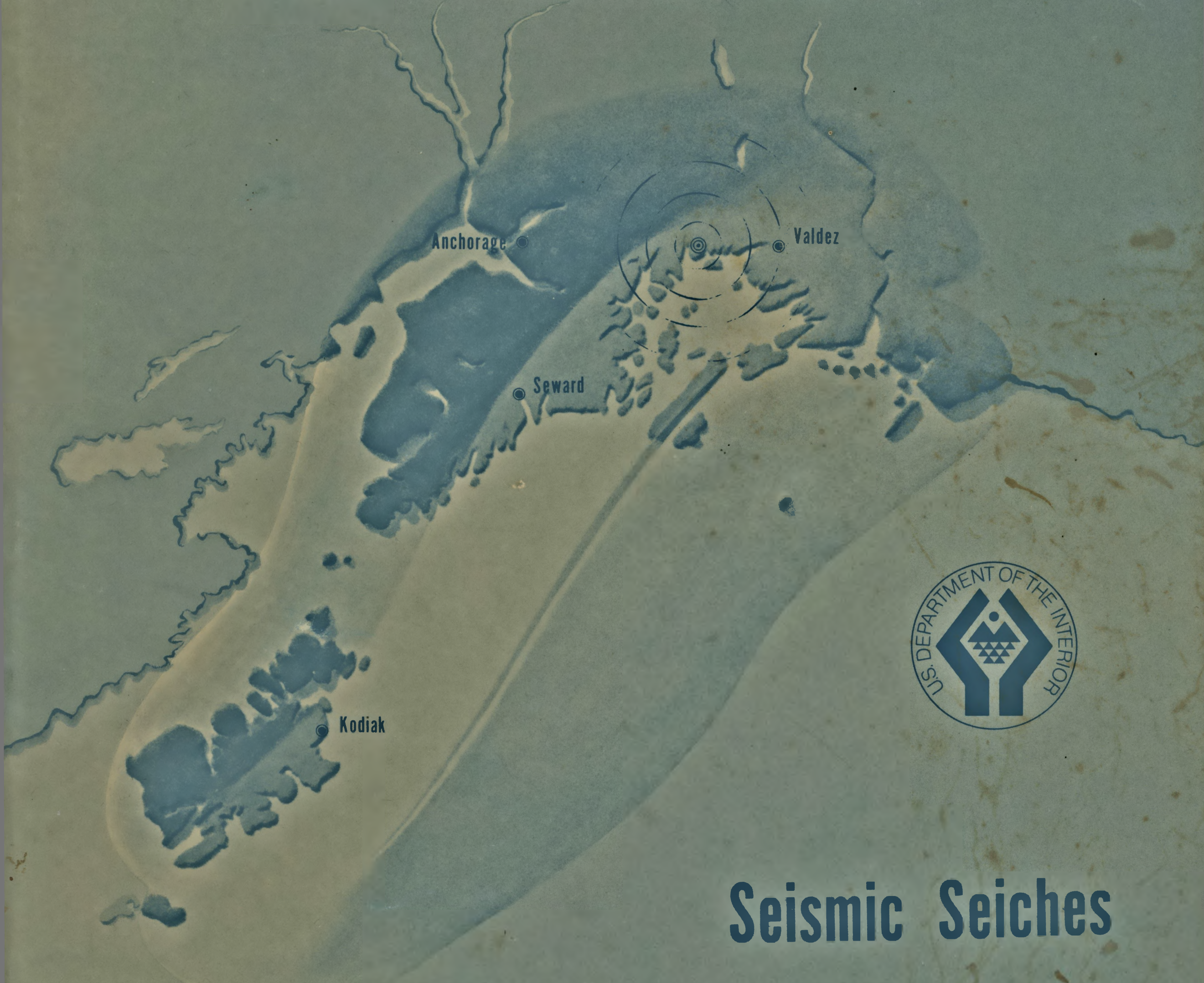
The Alaska Earthquake
March 27, 1964

Effects on Hydrologic Regimen



U.S. DEPARTMENT OF THE INTERIOR

Seismic Seiches

GEOLOGICAL SURVEY PROFESSIONAL PAPER 544-E

THE ALASKA EARTHQUAKE, MARCH 27, 1964:
EFFECTS ON THE HYDROLOGIC REGIMEN

Seismic Seiches From the March 1964 Alaska Earthquake

By ARTHUR McGARR and ROBERT C. VORHIS

An interpretation of the continental distribution of seiches from the earthquake

GEOLOGICAL SURVEY PROFESSIONAL PAPER 544-E

UNITED STATES DEPARTMENT OF THE INTERIOR

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THE ALASKA EARTHQUAKE SERIES

The U.S. Geological Survey is publishing the results of investigations of the Alaska earthquake of March 27, 1964, in a series of six Professional Papers. Professional Paper 544 describes the effects of the earthquake on the hydrologic regimen. Other chapters in this volume describe the effects of the earthquake on the hydrology of south-central Alaska, the Anchorage area, areas outside Alaska, and the effects on glaciers.

Other Professional Papers in the series describe the history of the field investigations and reconstruction; the effects of the earthquake on communities; the regional effects of the earthquake; and the effects on transportation, utilities, and communications

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SEISMIC SEICHES FROM THE MARCH 1964 ALASKA EARTHQUAKE [1]

By Arthur McGarr, Lamont Geological Observatory of Columbia University, Palisades, N.Y., and Robert C. Vorhis, U.S. Geological Survey

ABSTRACT

Seismic seiches caused by the Alaska earthquake of March 27, 1964, were recorded at more than 850 surface-water gaging stations in North America and at 4 in Australia. In the United States, including Alaska and Hawaii, 763 of 6,435 gages registered seiches. Nearly all the seismic seiches were recorded at teleseismic distance. This is the first time such far-distant effects have been reported from surface-water bodies in North America. The densest occurrence of seiches was in States bordering the Gulf of Mexico.

The seiches were recorded on bodies of water having a wide range in depth, width, and rate of flow. In a region containing many bodies of water, seiche distribution is more dependent on geologic and seismic factors than on hydrodynamic ones. The concept that seiches are caused by the horizontal acceleration of water by seismic surface waves has been extended in this paper to show that the distribution of seiches is related to the amplitude distribution of short-period seismic surface waves. These waves have their greatest horizontal acceleration when their periods range from 5 to 15 seconds. Similarly, the water bodies on which seiches were recorded have low-order modes whose periods of oscillation also range from 5 to 15 seconds.

Several factors seem to control the distribution of seiches. The most important is variations of thickness of low-rigidity sediments. This factor caused the abundance of seiches in the Gulf Coast area and along the edge of sedimentary overlaps. Major tectonic features such as thrust faults, basins, arches, and domes seem to control seismic waves and thus affect the distribution of seiches. Lateral refraction of seismic surface waves due to variations in local phase-velocity values was responsible for increase in seiche density in certain areas. For example, the Rocky Mountains provided a wave guide along which seiches were more numerous than in areas to either side. In North America, neither direction nor distance from the epicenter had any apparent effect on the distribution of seiches.

Where seismic surface waves propagated into an area with thicker sediment, the horizontal acceleration increased about in proportion to the increasing thickness of the sediment. In the Mississippi Embayment however, where the waves emerged from high rigidity crust into the sediment, the horizontal acceleration increased near the edge of the embayment but decreased in the central part and formed a shadow zone.

Because both seiches and seismic intensity depend on the horizontal acceleration from surface waves, the distribution of seiches may be used to map the seismic intensity that can be expected from future local earthquakes.

INTRODUCTION

Seismic waves from the Alaska earthquake of March 28, 1964,[2] were so powerful that they caused water bodies to oscillate at many places throughout North America. Those oscillations, or seismic seiches, were recorded at hundreds of surface-water gaging stations although they had rarely been reported following previous earthquakes and, when reported, had received little study. Local reports of numerous seiches resulting from the Alaska earthquake prompted one of the authors, Vorhis, to request records of Alaska earthquake seiches from his colleagues in the U.S. Geological Survey and from other hydrologic organizations both in North America and throughout the world. The replies identified most locations where seiches were recorded. In the United States, of all gages which could have recorded a seiche at the time of the Alaska earthquake, slightly more than 10 percent did. Factors other than the nature of the recording installation and the

[1] Lamont Geological Observatory Contribution 1070.

[2] The date and time of an earthquake can be given either as local or Greenwich time. In and near the epicentral region, it is customary to give the local time, such as 5:36 p.m. A.s.t. on March 27, 1964, for the Alaska earthquake. In studies of a worldwide nature, the date and time of an earthquake are usually given in Greenwich time. Thus, the Alaska earthquake occurred at 03:36 on March 28, 1964, G.c.t.

geometry of the water body seem to have controlled the pattern of seiche occurrence.

PURPOSES OF THE STUDY

The purposes of the study were (1) to assemble and present the data on all known seismic seiches resulting from the Alaska earthquake, (2) to analyze their distribution in relation to possible controls, (3) to apply existing theory to analysis of seiches recorded in bodies of known dimensions, and (4) to determine what hydrologic and seismologic implications can be drawn from seiche data.

In attempting to interpret seiche distribution, there are at least two approaches. One is to assume that the seismic waves causing the seiches were uniform throughout North America. Regional variations in seiche distribution would then result from variations in the capacity of water bodies to couple into the seismic waves. After preliminary studies, the authors decided that an alternative approach was needed.

There were 6,435 analog-type surface-water gages operating in the United States at the time of the earthquake. This number is assumed to be large enough to average out the varying response characteristics of individual stations within discrete regions of the country. The preferential concentration of seiches in certain regions implies varying amplitude distribution of seismic waves and serves to demonstrate again that geologic features materially influence seismic waves.

It should be noted that surface-water recorders are just one of at least three types of instruments maintained for nonseismic studies that can detect the passage of seismic waves. The other two are microbarographs and recorders on ground-water observation wells. In a sense, the three types of instruments provide complementary seismic data: the surface-water gages record the effect of horizontal acceleration of seismic waves, microbarographs record the air-pressure fluctuations caused by vertical velocity of the ground, and the instruments on wells record the influences of transient and permanent strain induced by seismic waves on aquifers. Barometric disturbances due to the Alaska shock have been discussed by Donn and Posmentier (1964) and ground-water fluctuations have been treated by Vorhis (1967).

This auxiliary instrumentation was more important than usual at the time of the Alaska earthquake because nearly all operating seismographs in North America were temporarily put out of action by the extremely large amplitudes of the seismic waves.

DEFINITION OF TERMS

Because this paper is concerned with both hydrology and seismology, some of the terms which may be unfamiliar to the hydrologist or the nonseismologist are defined as they are used in this paper.

Amplitude. One half the wave height.

Double amplitude. The height of a wave from crest to trough.

Lateral refraction. A horizontal deflection of a seismic surface wave due to change in its phase velocity in passing from one rock medium to another.

Love wave. A seismic surface wave whose motion is horizontally polarized in a direction transverse to the direction of wave propagation.

Mode. One of the stationary patterns of vibration of which an oscillatory system is capable. In this paper, "mode" may refer both to seismic surface waves and to water waves. The application to water waves is shown in figure 1. First-order mode is also commonly referred to as the fundamental mode.

Phase velocity. The velocity of a particular spectral component of a wave form.

Radiation pattern. The relative directional intensity of seismic surface waves.

Rayleigh wave. A seismic surface wave whose ground motion is elliptical in the plane defined by the vertical and the direction of propagation.

Seiche. A term first used by Forel (1895) to apply to standing waves set up on the surface of Lake Geneva by wind and by changes in barometric pressure. The term has been extended to all standing waves on any body of water whose period is determined by the resonant characteristics of the containing basin as controlled by its physical dimensions.

Seismic intensity. A measure of earthquake severity based on the damage produced by seismic waves in a given region.

Seismic seiche. A term first used by Kvale (1955) in discussing oscillation of lake levels in Norway and England caused by the Assam earthquake of August 15, 1950. His usage has been extended in this paper to apply to standing waves set up on rivers, reservoirs, ponds, and lakes at the time of passage of seismic waves from an earthquake.

Seismicity. The relative frequency of earthquake occurrence in a given region.

Shadow zone. An area or region where seiche activity is small or absent because of some sort of barrier to the transmission of seismic surface waves.

Standing wave. A single-frequency mode of vibration in which the nodes and antinodes have fixed positions. In this paper, standing waves have the form shown in equation (1) on page E5.

Surface wave. A wave of Love or Rayleigh type that travels around rather than through the earth.

Teleseismic distance. A distance of 1,000 kilometers (600 miles) or more from the earthquake epicenter.

Wave guide. A part of the earth's crust and upper mantle that tends to channel seismic energy.

PREVIOUS STUDIES OF SEISMIC SEICHES

The first published mention of seismic seiches known to the authors is with respect to the great earthquake of November 1, 1755, at Lisbon, Portugal. In a review of hydrologic effects of that earthquake, Wilson (1953) referred to an article in Scot's Magazine in 1755 that described remarkable seismic seiches in Loch Lomond, Loch Long, Loch Katrine and Loch Ness. Richter (1958, p. 110) mentioned other descriptions of seismic seiches caused by the Lisbon earthquake. These were observed in English harbors and ponds and were described originally in the Proceedings of the Royal Society in 1755.

Earthquake effects recorded by surface-water gages were first noted by Piper (1933, p. 475, fig. 2). He reported that two of six gages on the Mokelumne River in California showed a slight fluctuation caused by the December 20, 1932, earthquake at Lodi, Calif. Two other gages on a nearby diversion canal showed double amplitudes of 0.08 and 0.04 feet (24 and 12 mm) from the same earthquake. These phenomena were definitely seismic seiches although they were not so designated by Piper.

The U.S. Coast and Geodetic Survey (1945, p. 26) listed effects recorded on 18 stream gages in New York State that were caused by the September 5, 1944, earthquake in the St. Lawrence Valley.

The earthquake of January 25, 1946, in Switzerland in the Canton of Valais was recorded on two gages maintained by the Swiss Federal Water Survey on Lake Geneva, or Lac Léman (Mercanton, 1946). According to Mercanton, not a single seismic seiche was recorded during the 17 years in which Forel studied the seiches of Lake Geneva. This absence is especially surprising because during those years 69 earthquakes with 123 shocks were felt in the area. Thus, seiche records, even though numerous for the Alaska earthquake, may be relatively rare for other earthquakes or generally restricted to small bodies of water.

Kvale (1955) discussed previous seismic seiches, mainly those from the Lisbon earthquake; he also described 29 seiches recorded in fiords and lakes in Norway and 4 seiches on reservoirs in England, all caused by the Assam earthquake of August 15, 1950. He did not mention any seiches recorded on river gages. Surprisingly, no surface-water body in Norway or England is known to have responded to the Alaska earthquake. Most of the seiches that Kvale described from Norway were recorded in the western part of the country where the surface geology consists of sedimentary units. This distribution suggests that these seiches, if compared with local geological features in Norway, would give interpretations similar to those obtained from study of the distribution of seiches from the Alaska earthquake.

Stermitz (1964, p. 144, table 10) listed 54 stream gages that recorded seiches caused by the Hebgen Lake earthquake of August 17, 1959. They were in Montana, Wyoming, Idaho, and Alberta, Canada, the most distant one being 340 miles from the epicenter. Three of these gages later recorded seismic seiches caused by the Alaska earthquake.

SOURCES OF DATA

Some data on seismic seiches from the Alaska earthquake have been obtained from published sources. Miller and Reddell (1964, p. 661) mention a reservoir at Lubbock, Tex., that registered a seiche of about 0.5 foot. Wigen and White (1964, p. 6, figs. 1–4) listed seiches at 10 locations on the west coast and one on the north coast (Cambridge Bay) of Canada. The periods of the seismic seiches were smaller than the seiche-wave periods that are frequently recorded on tide records. P. W. Strilaeff (1964, written commun.) listed nine seiches that were recorded in the Winnipeg District of Canada. He pointed out that on Lakes Winnipeg and Manitoba, seiches were recorded only at the narrows of the lakes. Similarly, at Lake of the Woods, only the recorder at Clearwater Bay indicated a seiche.

Seiche data for Texas were compiled by W. B. Mills (written commun., 1964) and for Tennessee by Milburn Hassler (written commun., 1965). Donn (1964) mentioned reports of waves on the Gulf Coast as high as 6 feet (1.8 m) that were caused by the Alaska earthquake and suggested that these and a seiche recorded by a tide gage at Freeport, Tex., were generated in resonance with seismic waves.

Using the same record from Freeport, Tex., McGarr (1965) developed a theory to explain the interaction between seismic surface waves and a channel filled

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with water. The analysis included a few factors influencing the size of the seismic surface waves and several possible damping mechanisms. This theory is discussed in the section on "General Theoretical Background" (p. E5).

In a paper on hydrologic effects of the Alaska earthquake outside Alaska, Vorhis (1967) summarized seiche records for the conterminous United States and Hawaii. Those records and others that were obtained subsequently are described and interpreted in the present paper. Most of the data were received from the Water Resources Division of the U.S. Geological Survey, others were furnished by the Tennessee Valley Authority, the Walla Walla District of the U.S. Corps of Engineers, and the Illinois State Water Survey.

Data on seiches in Canada were compiled by the Water Resources Branch of the Canadian Department of Natural Resources and were supplied by the Canadian National Committee for the International Hydrologic Decade. Some additional unpublished seiche data for Manitoba, Saskatchewan, and Ontario were compiled by P. W. Strilaeff (written commun., 1964).

Records of four seiches were received from Australia. One on the Victoria River in northern Australia was furnished by the Northern Territory Administration of the Commonwealth of Australia, one on the Tantangara Reservoir in New South Wales was furnished by the Snowy Mountains Hydro-Electric Authority, one on a reservoir at Canberra was furnished by Robert Underwood of the Australian National University, and one on the Melicke Munjie River in eastern Victoria was furnished by the State Electricity Commission of Victoria. These seiches were the most distant and were the only ones known from outside North America and Hawaii.

ACKNOWLEDGMENTS

A world-wide solicitation for seismic-seiche data from a major earthquake had never been undertaken prior to the Alaska earthquake. To ascertain the geographic distribution of seiches resulting from the earthquake, all organizations in the world that might be expected to operate a hydrologic network were requested to submit copies of all charts that seemed to show earthquake effects. Professor Gerard Tison of the International Association of Scientific Hydrology and Dr. R. Ambroggi, Food and Agriculture Organization of the United Nations, assisted in the solicitation of data.

The agencies that furnished seiche data have been mentioned above, and their help is acknowledged with gratitude. Many other agencies went to considerable expense and trouble to examine a large number of charts for seismic seiches. Even though they found none, the negative reports were useful. The efforts of the following countries and their hydrologic organizations are acknowledged with appreciation:

- Austria: Hydrographical Central Office
- Australia:
  - Victoria State Rivers and Water Supply Commission
  - South Australia Engineering and Water Supply Department
  - New South Wales—Sydney Metropolitan Water Sewerage and Drainage Board
  - Snowy Mountains Hydro-Electric Authority
  - Queensland Irrigation and Water Supply Commission
- British Guiana: Ministry of Works and Hydraulics
- Ceylon: Department of Meteorology
- China: Geological Survey of Taiwan
- Ethiopia: Ministry of Public Works and Communications, Water Resources Department
- Ghana: National Construction Corporation
- Hungary: Research Institute for Water Resources
- Indonesia: Hydrological Survey
- Nepal: Ministry of Irrigation, Hydrological Survey Department
- New Zealand: Ministry of Works
- Norway: Water Resources and Electricity Board
- Papua and New Guinea Administration
- Portugal: Geological Survey
- Republic of the Philippines:
  - Department of Public Works and Communications
  - Bureau of Public Works
- Southern Rhodesia: Geological Survey Office
- Switzerland: Federal Office of Water Resources
- Tasmania:
  - Rivers and Water Supply Commission
  - Hydroelectric Commission
- Turkey: State Hydraulics Works
- Uganda: Water Development Department
- Zambia: Ministry of Lands and Natural Resources, Department of Water Affairs

Mr. F. A. Ekker of the Dow Chemical Co. furnished the original records of seiches in tanks at Plaquemines, La., to Dr. D. H. Kupfer of Louisiana State University, who in turn made the charts available to the authors. Mr. Claud R. Erickson, engineer with the Lansing Water Department, furnished data on seiches in reservoirs at Lansing, Mich.

Dr. Jack Oliver of Columbia University made many helpful suggestions and reviewed the manuscript. Other reviewers include J. P. Eaton, J. H. Feth, R. M. Waller, and C. L. O'Donnell, all of the U.S. Geological Survey; Dr. William Stauder, S. J., of Saint Louis University; and Dr. L. E. Alsop and Dr. J. E. Nafe of Columbia University.

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GENERAL THEORETICAL BACKGROUND

The seiches caused by the Alaska earthquake can be considered for purposes of analysis to have occurred in two distinct regions. One region, comprising most parts of Alaska, is an area of great seismic intensity where seiches can be caused by mechanisms such as landslides, submarine slides, tilting, tsunamis, and seismic surface waves. This variety of mechanisms makes the determination of the cause of a given seiche difficult. Seiches in this epicentral region of the Alaska earthquake are therefore not discussed.

The other region is in effect the rest of the world outside Alaska. In this region, most of which is at teleseismic distances from the epicenter, inelastic effects are unimportant and seismic seiches are generated solely by seismic surface waves. Although tsunamis also may occur in coastal areas, they travel so much more slowly than surface waves and have such long periods that the two cannot be confused.

The data considered in this paper are chiefly from charts of water-level recorders operating on continental bodies of water, primarily rivers, reservoirs, small lakes, and ponds. The primary problem, then, is to determine how seismic surface waves interact with bodies of water of various sizes and shapes. A theory of interaction has been developed only for the long channel with rectangular cross section (McGarr, 1965). Although this model is idealized, it contains most of the interesting features of realistic and complicated situations. Further, the natural periods of response for water bodies can be approximated fairly well by using the long-channel results.

According to McGarr (1965) the free surface level of an infinitely long channel will behave under the influence of a uniform time-dependent horizontal force per unit mass, $F(t)$, according to

$$\eta(x,\ t)=+\frac{4H}{\pi c}\sum_{n=0}^{\infty}\frac{\cos\left[(2n+1)\pi xL^{-1}\right]}{2n+1}\cdot\int_0^t F(\tau)e^{-k(t-\tau)/2}\cdot\sin\left[\frac{(2n+1)\pi c(t-\tau)}{L}\right]d\tau \quad (1)$$

where

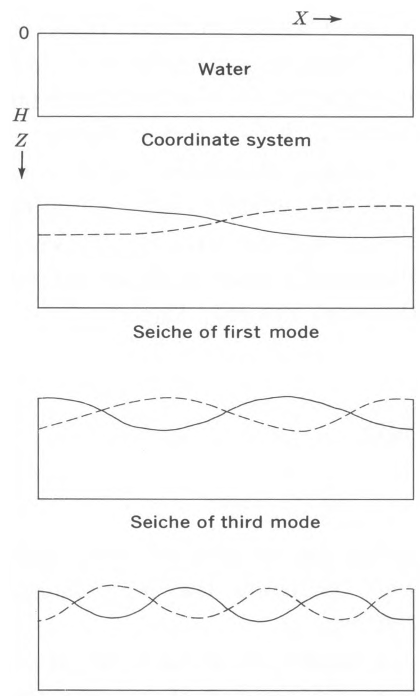
$\eta(x,\ t)$=height of the free surface above the undisturbed level, H=depth, L=width, $c=\sqrt{gH}$, the velocity of long water waves, g=gravity field strength, k=a damping constant, τ=an integration variable, t=time in seconds, n=an integer variable of summation.

Figure 1 (next page) shows the cross section of a theoretical channel and the coordinate system applied to it. The force per unit mass due to the horizontal acceleration is in the x direction. A water level recorder at the edge of the channel will record

$$\eta(0,\ t)=+\frac{4H}{\pi c}\sum_{n=0}^{\infty}\frac{1}{2n+1}\int_0^t F(\tau)e^{-k(t-\tau)/2}\cdot\sin\left[\frac{(2n+1)\pi c(t-\tau)}{L}\right]d\tau \quad (2)$$

where

$\eta(0,t)$=the height of the free surface above the undisturbed level at the edge of the channel.



1.—The coordinate system applied to a theoretical water body and seiches of the first, third, and fifth modes. Because of the nature of the seismic forcing function, only the odd-order modes are excited.

This expression shows that the height of a seiche is directly proportional to the horizontal acceleration provided by the seismic surface waves and $\sqrt{H}$, because $c=\sqrt{gH}$. Thus for a given surface-wave acceleration, a deeper channel will produce a higher seiche.

The damping constant k is included in equation (2) under the assumption that the attenuation of the seiche will be proportional to the velocity of water-particle motion. This assumption is not exactly true for all the factors contributing to the damping. However, the most important factors in dissipation, such as a sloping beach, will yield damping curves that look similar to $e^{-kt/2}$; the assumption of a linear damping term is therefore probably acceptable.

The most important term in computing η (0, t) is $F(t)$, the driving force. The fact that both Love and Rayleigh waves have a horizontal component of motion means that, no matter what the orientation of the channel, there will always be a component of horizontal acceleration parallel to the width. The primary problem is to determine the Love- and Rayleigh-wave amplitudes as a function of period for various distances and directions from the source. Because the horizontal acceleration produces the seiches, the short-period components of the seismic surface waves are very important. The tilt caused by the Rayleigh waves has been shown to be unimportant in causing seiches, especially for periods less than 600 seconds (McGarr, 1965, p. 851). The predominant surface-accelerations probably lie in the period range of 5 to 15 seconds. If everything else is equal, bodies of water with fundamental modes of oscillation in this period range should have the most numerous seiches.

In the Alaska earthquake of 1964, almost all of the known recorded seiches occurred in North America. Furthermore, most of the recorded seiches in North America were in the United States, most occurring in the Gulf Coast region. Our main attempt has been to explain the distribution of seiches in the United States because there we have the best data control and the greatest density of records.

Throughout the United States the network of water-level recorders is reasonably well distributed. Our main assumption has therefore, been that, in a given geographical area containing a large number of them, a certain percentage of the water-level recorders are on bodies of water that are favorable for generating seiches. Because information about the size and shape of the various bodies of water is not readily available, such an assumption is the only realistic way to treat the data in a preliminary study such as this. Therefore, the problem of explaining the seiche distribution becomes one of identifying places where the horizontal components of the shorter period seismic surface waves were large enough in amplitude to provide a generating force. Other forces, such as seismic body waves, might induce seismic seiches, but preliminary studies imply that they are unimportant.

The fundamental hypothesis of this paper is that seiche distribution is a direct function of the amplitude distribution of Love and Rayleigh waves in a period range from 5 to 15 seconds. The occurrence of seiches is explained in terms of those waves, although surface-wave theory does not explain many features of the seiche distribution. The actual explanation may involve factors other than seismic surface waves or aspects of the behavior of surface waves that are not yet known. Perhaps this presentation of seiche data will promote further development of surface-wave theory.

LOCATION AND NATURE OF THE SEICHES

SEICHE DATA

The authors considered two types of data to ascertain seiche distribution: negative and positive. They did not examine the negative data, that is, the water-level records which showed no trace of a seismic seiche. A few recordings of seismic seiches may have been missed, but this source of error is not considered significant. All the recorded seismic seiches were examined by both authors. The locations and double amplitudes of the seismic seiches in the conterminous United States and southern Canada are shown on plate 1.

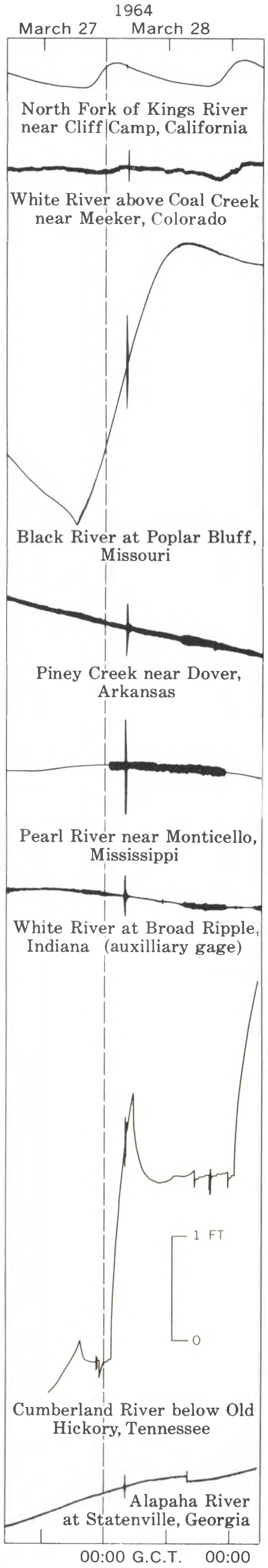
The seiche data are summarized in table 1 by State or Province; data from gages on rivers and streams are grouped separately from those from gages on lakes, reservoirs, and ponds. The seiches recorded on rivers and streams generally were of short duration, lasting no more than 5 to 10 minutes. Seiches recorded in reservoirs, especially in the west, lasted for 2 hours or longer. The fluctuations decreased so gradually that the point of cessation of fluctuation and resumption of normal water level could not be distinguished on the records. These seiches lasted longer than stream seiches because reservoirs usually have much greater resonance qualities than other types of water bodies, as is discussed under "Hydrodynamic Factors" (p. E12).

TABLE 1.—*Summary of 859 seismic effects from the Alaska earthquake on surface-water bodies throughout the world*

State or Province	On rivers and streams				On lakes, reservoirs, and ponds				Gages at time of earthquake	
	Number recorded	Amplitude of maximum seiche (feet)	Discharge with seiche (cu ft per sec) Maximum	Discharge with seiche (cu ft per sec) Minimum	Number recorded	Amplitude of maximum seiche (feet)	Storage (acre-feet) Maximum	Storage (acre-feet) Minimum	Number	Percent that recorded earthquake
United States										
Alabama	24	0.22	109,000	11	5	0.18	1,100,000	120,000	103	28.1
Alaska	32	------	400	4	0	------	----------	--------	42	76.2
Arizona	6	.02	260	3.1	2	.35	14,952,000	77	119	6.7
Arkansas	36	.48	58,000	1	5	1.45	1,970,000	--------	89	46.0
California	8	.05	1,580	15	19	.42	3,257,100	4,000	661	4.1
Colorado	14	.30	260	.1	0	------	----------	--------	212	6.6
Connecticut	0	------	----------	--------	0	------	----------	--------	70	.0
Delaware	0	------	----------	--------	0	------	----------	--------	6	.0
Florida	97	.66	26,800	2	3	.04	?	--------	288	34.7
Georgia	28	.22	43,000	100	0	------	----------	--------	75	37.4
Hawaii	5	.17	302	7.4	0	------	----------	--------	146	3.4
Idaho	3	.03	1,110	18	2	.56	146,000	?	191	2.6
Illinois	6	.10	8,700	1,200	2	.05	?	?	144	5.6
Indiana	13	.39	15,000	35	3	.07	?	?	131	12.2
Iowa	1	------	225	--------	1	.02	?	--------	129	1.6
Kansas	12	.17	400	.2	2	.05	15,000	13,000	82	17.1
Kentucky	0	------	----------	--------	4	.57	200,000	88	84	4.8
Louisiana	69	.68	31,000	.2	0	------	----------	--------	103	67.0
Maine	0	------	----------	--------	0	------	----------	--------	52	.0
Maryland	3	.04	?	?	0	------	----------	--------	46	6.5
Massachusetts	0	------	----------	--------	0	------	----------	--------	7	.0
Michigan	13	.10	860	.8	3	1.83	30	21	140	11.4
Minnesota	1	.03	5.0	--------	0	------	----------	--------	91	1.1
Mississippi	22	.37	22,500	24	0	------	----------	--------	61	36.1
Missouri	18	.87	1,600	5	0	------	----------	--------	108	16.6
Montana	16	.10	2,150	6	0	------	----------	--------	168	9.5
Nebraska	13	.18	1,300	23	1	.08	267,100	--------	152	9.2
Nevada	0	------	----------	--------	0	------	----------	--------	76	.0
New Hampshire	1	Tr.	2,200	--------	0	------	----------	--------	11	9.1
New Jersey	0	------	----------	--------	1	.08	20,000	--------	82	1.2
New Mexico	27	.26	470	1	0	------	----------	--------	156	17.3
New York	4	Tr.	130	80	0	------	----------	--------	176	2.3
North Carolina	0	------	----------	--------	1	.05	1,000,000	--------	63	1.6
North Dakota	2	.06	57	47	1	------	21,000	--------	89	3.4
Ohio	16	.14	1,650	11	9	.25	60,600	1,500	188	13.3
Oklahoma	28	.13	1,870	.1	9	.44	1,117,000	7,100	129	28.7
Oregon	10	.14	21,000	2.8	7	.11	272,000	18,000	239	7.1
Pennsylvania	2	.05	1,400	7.7	0	------	----------	--------	108	1.8

TABLE 1.—*Summary of 859 seismic effects from the Alaska earthquake on surface-water bodies throughout the world*—Continued

State or Province	On rivers and streams				On lakes, reservoirs, and ponds				Gages at time of earthquake	
	Number recorded	Amplitude of maximum seiche (feet)	Discharge with seiche (cu ft per sec)		Number recorded	Amplitude of maximum seiche (feet)	Storage (acre-feet)		Number	Percent that recorded earthquake
			Maximum	Minimum			Maximum	Minimum		
United States—Continued										
Rhode Island	0	------	----------	--------	0	------	----------	--------	3	0. 0
South Carolina	8	. 12	34, 500	500	0	------	----------	--------	40	20
South Dakota	6	. 14	24, 500	2	0	------	----------	--------	90	6. 7
Tennessee	24	. 42	170, 000	35	8	. 14	3, 400, 000	150, 000	130	24. 6
Texas	57	. 67	6, 920	. 0	13	. 14	1, 777, 200	50	346	20. 2
Utah	8	. 06	90	2	0	------	----------	--------	126	6. 4
Vermont	0	------	----------	--------	2	. 23	29, 000	8, 500	8	25. 0
Virginia	0	------	----------	--------	0	------	----------	--------	155	. 0
Washington	6	. 45	<10, 000	6	15	1. 04	6, 900, 000	?	356	5. 9
West Virginia	0	------	----------	--------	0	------	----------	--------	91	. 0
Wisconsin	6	. 02	1, 300	50	0	------	----------	--------	74	8. 1
Wyoming	12	. 08	660	1	0	------	----------	--------	199	6. 0
Total	658	------	----------	--------	118	------	----------	--------	6, 435	12. 0
Puerto Rico	0	------	----------	--------	0	------	----------	--------	16	0. 0
Virgin Islands	0	------	----------	--------	0	------	----------	--------	9	. 0
Australia										
Australia Capital Territory	0	------	----------	--------	1	Tr.	21	------	------	-------
New South Wales	0	------	----------	--------	1	0. 02	23, 680	--------	------	-------
Northern Territory	1	0. 02	----------	--------	0	------	----------	--------	------	-------
Victoria	1	. 02	----------	--------	0	------	----------	--------	------	-------
Total	2	------	----------	--------	2	------	----------	--------	------	-------
Canada										
Alberta	28	0. 31	----------	--------	0	------	----------	--------	------	-------
British Columbia	4	. 29	----------	--------	23	3±	----------	--------	------	-------
Northwest Territory	5	. 15	----------	--------	2	. 30	----------	--------	------	-------
Ontario	6	. 14	----------	--------	2	. 13	----------	--------	------	-------
Saskatchewan	7	. 30	----------	--------	2	. 08	----------	--------	------	-------
Total	50	------	----------	--------	29	------	----------	--------	------	-------
Grand total	710	------	----------	--------	149	------	----------	--------	------	-------



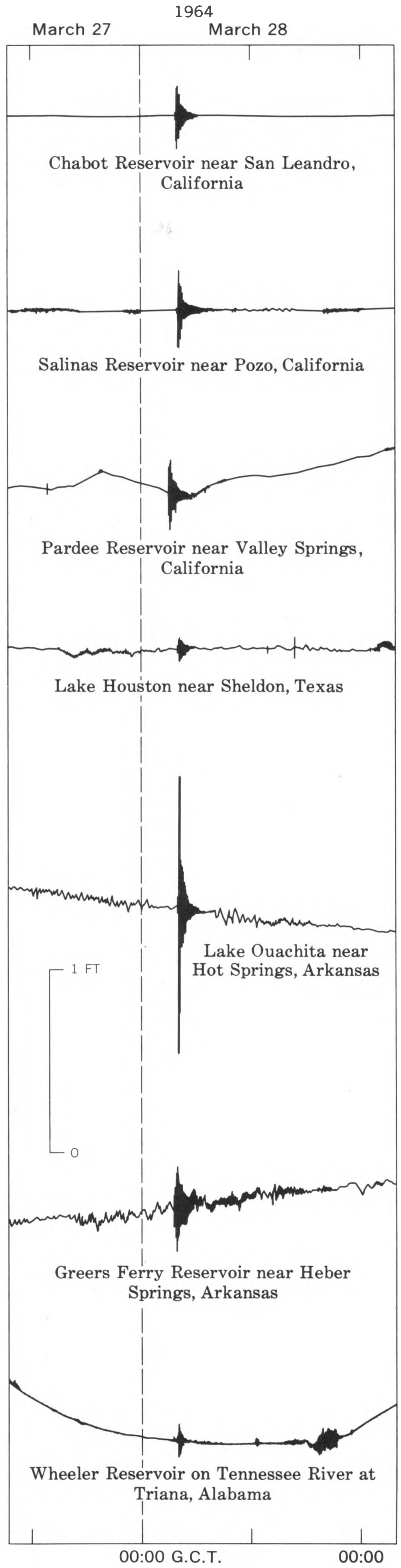
2.—The largest seiche recorded on a stream in each of eight States.

The seiches from the Alaska earthquake at surface-water gages that have been reported from throughout the world are separately listed and described in table 3 (p. E25); the station number, name, and location are those in current use.

Ideally, the table should give average depth and width of the body of water on which the seiche was observed. In their place a more easily obtained measurement is given, either the discharge in cubic feet per second ($\times 28.317$ = liters per second) for flowing streams or acre-feet of water in storage ($\times 1{,}233.49$ = cubic meters) for lakes, reservoirs, and ponds. The recorded seismically caused water-level motion is given under "seiche double amplitude." This amplitude may be less than the true amplitude because of the response of the gage. Furthermore, the fluctuations at the bubble-gages and at some of the float-gages were not symmetrical above and below the stage immediately prior to the seiche. For the asymmetrical double amplitudes, motion upward from prior stage is shown above a slash line and motion downward is shown below.

The largest seiche recorded on a stream in each of eight States is shown in figure 2. The largest one in California was only 0.05 feet (15 mm) in double amplitude. This seiche contrasts markedly both in size and duration with the seiches recorded in California reservoirs. The thinness of some of the pen lines on recorder charts suggests that there may have been only one or a very few oscillations associated with the seiche and that the oscillations were damped out almost immediately after passage of the seismic wave.

Some of the largest seiches recorded in reservoirs are shown in figure 3. Most of the seiches



3.—Some large seismic seiches on reservoirs.

shown continued for 2 hours or more, but the one for Wheeler Reservoir on the Tennessee River at Triana, Ala., lasted only about 40 minutes.

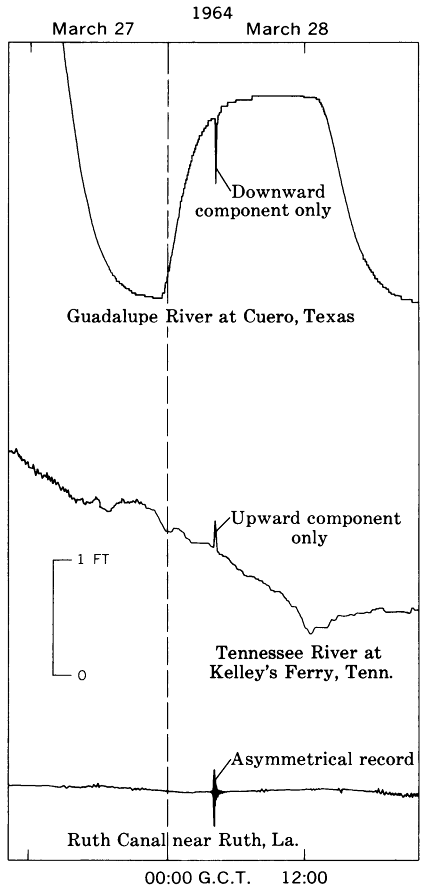
GAGING STATIONS, INSTRUMENTS, AND THEIR RECORDS

At the time of the Alaska earthquake, the Water Resources Division of the U.S. Geological Survey had about 8,150 recorders in operation, of which 6,435 were equipped to give a continuous record on which an event such as a seismic seiche could be recorded. Seiches were recorded on 763 charts. About half (356) were recorded in the States on or near the Gulf Coast and most distant from the epicenter, namely, Alabama, Arkansas, Florida, Georgia, Mississippi, Louisiana, and Texas (pl. 1).

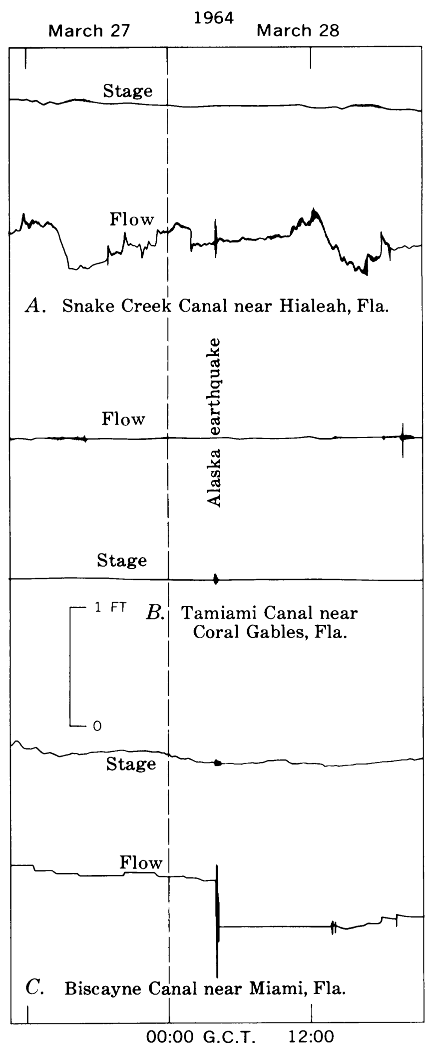
The remaining 1,700 stations were equipped with a digital-type instrument that records a water-level measurement at 15-minute intervals and consequently cannot record any sudden changes such as seismic seiches. Because the trend currently is to install such instruments in place of the continuous-record type, the Alaska earthquake may be the last major earthquake for which seismic seiches can be widely recorded.

Seismic seiches were recognized on charts from three types of recorders, the continuous-analog, the bubble-gage, and the deflection-meter. The last records direction and velocity of flow and is used on streams and canals in Florida where stage-discharge relations that prevail elsewhere cannot be used, because gradients are so low and directions of flow vary with changing stages of the ocean tides.

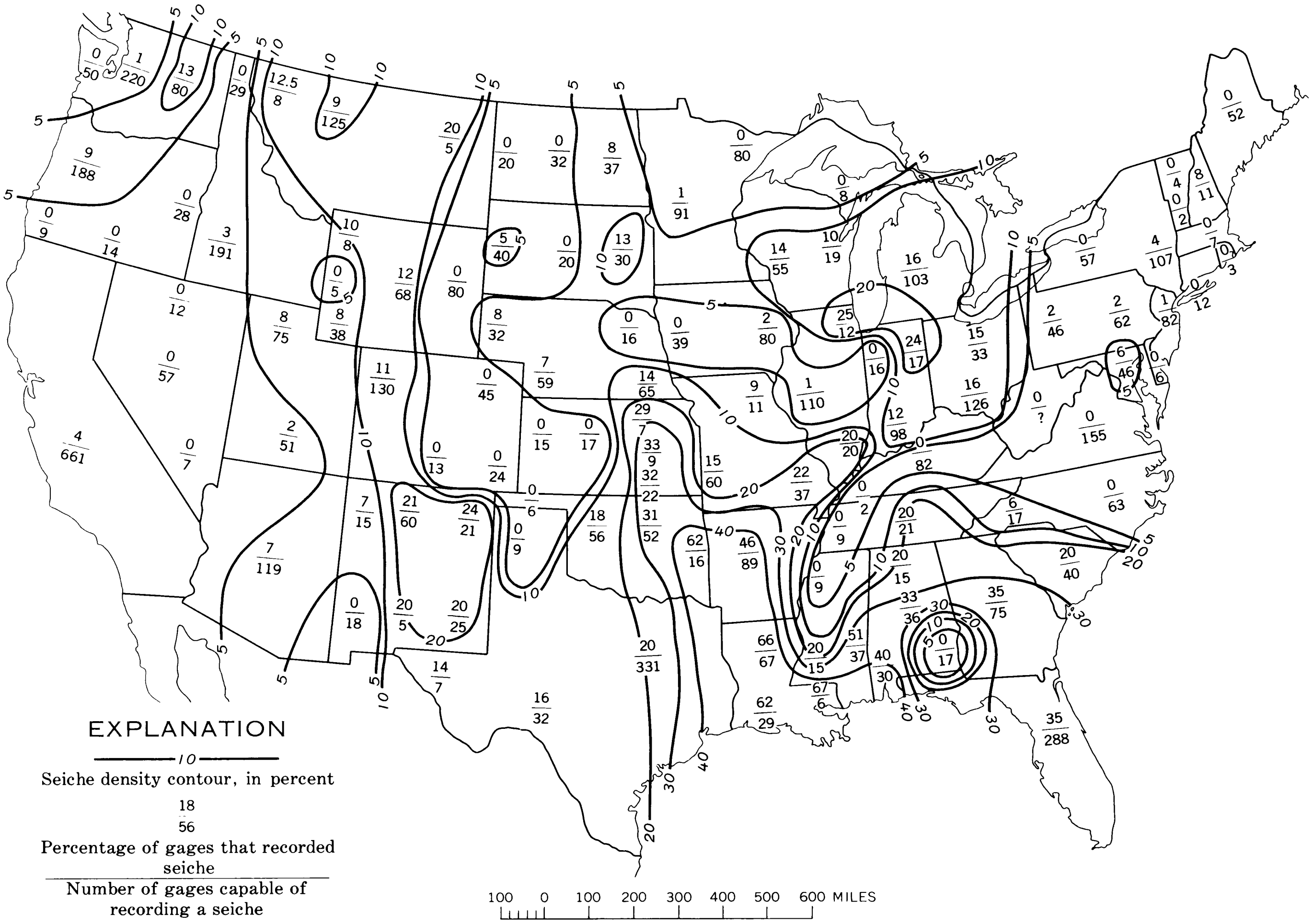
Each type of gage and recorder has its special characteristics that in part govern the kinds of seiche records that were obtained. Those characteristics and their effects were discussed in some detail by Vorhis (1967, p. C5, C6, C9). In brief, the continuous-analog records of stage generally are the most revealing. The movement tends to be symmetrical above and below the level prevailing before the onset of the seiches. Because of damping effects in the stilling wells in which the recorder floats operate, the fluctuations in stage recorded during seiches are smaller than the actual amplitudes of the seiche waves. There is no consistent degree of damping, for each installation has its individual character. Consequently, it is impossible currently to derive a factor by which to convert recorded amplitude to true amplitude. The seiches illustrated in figures 2 and 3 are from continuous-analog recorders. The bubble gages have a built-in delay that may cause a seiche to be recorded as a brief or prolonged drop in stage or rise in stage or as an asymmetrical fluctuation (fig. 4). Simultaneous traces of stage and flow, recorded on continuous-analog charts in Florida, and the effects of the seiches are shown in figure 5.



4.—Three types of bubble-gage records of Alaska earthquake seiches.



5.—Seiche effects of Alaska earthquake on stage and flow, Miami area, Florida. *A*, Fluctuation in flow, no change in stage: *B*, fluctuation in stage, no change in flow; *C*, fluctuation in both stage and flow, "permanent" decrease in flow.



6.—Map of conterminous United States showing seiche density, in percent, by State and by river basin.

GEOGRAPHIC DISTRIBUTION

With the exception of four in Australia, three on the Island of Kauai, and two on the Island of Hawaii, all known seismic seiches caused by the Alaska earthquake were recorded at gaging stations in Canada and the continental United States. All data from other parts of the world were negative.

Seiche distribution was studied by areas, in terms of the percentage of the total number of gages that showed seiches. It was necessary to assume that all the charts had been examined and that the reported instrumentation of gaging stations was accurate. Neither assumption is entirely valid. Therefore, the method is not highly precise, but it does permit a reasonably accurate comparison of seiche density by area.

The areas chosen are the major river basins within each State, that is, about 100 areas in the United States, for which percentage of seiche density could be computed. The map (fig. 6) presents the data. The percent values have been contoured to display the gross features of the distribution.

The southeastern part of the United States, notably, Louisiana, Arkansas, Florida, eastern Oklahoma, and eastern Mississippi, had by far the highest density of seiches. Other high-density areas include north-central New Mexico, eastern Kansas, and the area adjacent to the southern tip of Lake Michigan. The areas west of the Rocky Mountains, the area immediately to the east of the Rockies, and the Middle Atlantic States and New England experienced few or no seiches. Anomalous low-density areas occur in a strip along northwestern Mississippi, western Tennessee, and western Kentucky and in an area of southern Alabama. The distribution does not have any obvious dependence on distance or azimuth from the epicenter. On the other hand, the distribution seems to form definite regional patterns. It is highly improbable that these regional patterns have anything to do with the abilities of the individual bodies of water to couple into the seismic waves. Possible controls over the distribution pattern are considered after the following discussion of hydrodynamic factors.

HYDRODYNAMIC FACTORS

Alaska earthquake seiches occurred in many different kinds of water bodies, including lakes, rivers, streams, ponds, and reservoirs, and in tanks that contained chemicals. Several factors influence the amplitude and duration of seiches in different types of fluid bodies affected by a given seismic surface wave. These factors include the regularity of the geometry, the depth, and the size of the fluid body as well as the physical characteristics of the fluid. The following discussion deals only with water. In principle, the exact response, including the effects of damping, can be calculated for a body of water of any shape and size. In this study, however, the necessary information was not available so calculations of various responses are only approximate.

Seismic surface waves excite maximum response in deep, regular bodies of water that have low-order odd modes (fig. 1) and periods of 5–15 seconds. These waves excite only odd-order seiches. Rivers and creeks are considered to be similar to the idealized channel for which the exact response is known. Assume a river with width L and average depth H. The approximate periods of the normal modes of the river are then given by

$$T_{2n+1}=\frac{1}{2n+1}\frac{2L}{\sqrt{gH}};\, n=0,1,\ldots$$

These periods are approximate to the extent that the river departs from the shape of the idealized channel. The theory for a long canal may also be applied in a rough fashion to a narrow lake or a lake with a narrow inlet. In fact, in this paper the cross section of any body of water is considered to be the cross section of an infinitely long channel. For instance, the normal modes of a cylindrical tank are given approximately by

$$T_{2n+1}=\frac{2D}{(2n+1)\sqrt{gH}}$$

where D is the tank diameter. Table 2 lists the periods for modes 1, 3, and 5 for various combinations of width and depth where depth represents the average depth of the cross section. Table 2 shows that there are many possible cross sections that will have at least one of the periods of the first three nonzero modes in the 5- to 15-second period range. The periods of table 2 were computed on the basis of assumed long wavelength; these assumptions are not entirely valid for places where the length is not much greater than the depth. For those places, the period of the table is an underestimate of the true period. Table 2 shows which dimensions are in the optimal range for producing seiches.

TABLE 2.—*First-, third-, and fifth-order modes, in seconds, for seiches on water bodies with selected widths and depths*

Depth (meters)	Mode	Width (meters) 5	10	20	40	60	100	200
1	1	3.2	6.3	12.7	25.3	38.0	63.3	126.6
	3	------	------	4.2	8.4	12.7	21.1	42.2
	5	------	------	------	5.1	7.6	12.7	25.3
2	1	2.2	4.5	9.0	17.9	26.9	44.8	89.7
	3	------	------	3.0	6.0	9.0	14.9	30.0
	5	------	------	------	3.6	5.4	9.0	17.9
4	1	------	3.2	6.3	12.7	19.0	31.6	63.3
	3	------	------	------	4.2	6.3	10.5	21.1
	5	------	------	------	2.5	3.8	6.3	12.7
6	1	------	------	5.2	10.3	15.5	25.8	51.6
	3	------	------	------	3.4	5.2	8.6	17.2
	5	------	------	------	------	3.1	5.2	10.3
10	1	------	------	4.0	8.0	12.0	20.0	40.0
	3	------	------	------	2.7	4.0	6.7	13.3
	5	------	------	------	------	------	4.0	8.0
20	1	------	------	------	5.7	8.5	14.1	28.4
	3	------	------	------	1.9	2.8	4.7	9.4
	5	------	------	------	------	------	2.8	5.7
30	1	------	------	------	4.6	6.9	11.6	23.1
	3	------	------	------	------	------	3.8	7.7
	5	------	------	------	------	------	------	4.6

In general, the seiches having the highest amplitudes and longest durations occurred in reservoirs. The lowest amplitudes and shortest durations were on creeks and small rivers, owing probably to the combination of shallowness and irregularity of cross section.

The dimensions of a few of the bodies of water for which seiches were recorded are known. In California, a seiche in the Isabella Reservoir lasted more than 3 hours. The recorder on this reservoir which is formed behind a dam, is near one end of the dam. The most likely cross section to consider seems to be that parallel to the dam; its length is about 300 meters and its average depth is roughly 15 meters. The approximate periods of the first three modes are $T=49$, 16, and 10 seconds. These periods are in the approximate range required for coupling into the seismic surface waves.

Two partly buried water-storage reservoirs at Lansing, Mich., recorded fluctuations of 22 inches and 15 inches shortly after the Alaska earthquake. The reservoir which recorded the 22-inch seiche is cylindrical; its depth is about 8 meters and its diameter is about 50 meters. The periods of the first two seiche modes for that reservoir would be 11 and 4 seconds. The reservoir that had the 15-inch seiche is a rectangular prism whose length, width, and depth are about 130, 41, and 8 meters, respectively. If the seiche had water movement parallel to the length, then the first three modes had periods of 29, 10, and 6 seconds. If the seiche was parallel to the width, then the periods of the first two seiche modes were 9.2 and 3.1 seconds.

Two seiches, that lasted somewhat more than an hour each, were recorded in two drums of liquid ethylene (density=0.529 gm per cm^{-3}) at the Louisiana Division of the Dow Chemical Co. in Plaquemine, La. The tanks are about 18 meters long and the average depth of the liquid was about 1.0 meter. The fundamental seiche mode would have had a period of about 10 seconds and the third mode a period of 3⅓ seconds.

Thus, in all examples where the size and shape of the body of liquid is known, and for which a seiche was recorded, at least one of the first three seiche modes lies in the period range of 5 to 15 seconds. Modes which are of higher order cannot be expected to be important because of the factor $\frac{1}{2n+1}$ which occurs in equation (2).

For the purposes of this study, it would have been ideal if all the bodies of water had been of the same shape, size, and orientation. Then measurements of the seiche amplitudes would indicate only the distribution of seismic surface-wave acceleration. This ideal situation is not even approached, so some assumptions were necessary. As stated on page E6, one major assumption was that in an area having a large number of surface-water recorders, most of the recorders were able to record a marginally detectable seiche. If the seismic waves were amplified, a larger percentage of recorders would show a seiche. Conversely, if the seismic waves were attenuated, no seiches would have been generated or recorded. The data support these assumptions. To make the data more homogeneous, little emphasis was placed on those from reservoirs and canals, which are such good resonators that any in any part of North America probably would have experienced a seiche at the time of the Alaska shock. The data considered most valid for deducing the seismic surface-wave horizontal-acceleration distribution are from creeks and small rivers, which are generally poor resonators. As table 2 shows, nearly all the bodies of water in this study (mostly small rivers and streams) have low-order modes whose periods are in the 5- to 15-second range.

The observed geographic distribution of seiches from the Alaska earthquake was apparently controlled both by geologic features and by certain characteristics of seismic surface waves. The two kinds of control will be discussed separately, but their effects are not wholly separable because the surface waves may be strongly modified by the geologic materials and structural features they traverse.

INTERPRETATION OF SEICHE DISTRIBUTION

RELATION TO GEOLOGIC FEATURES

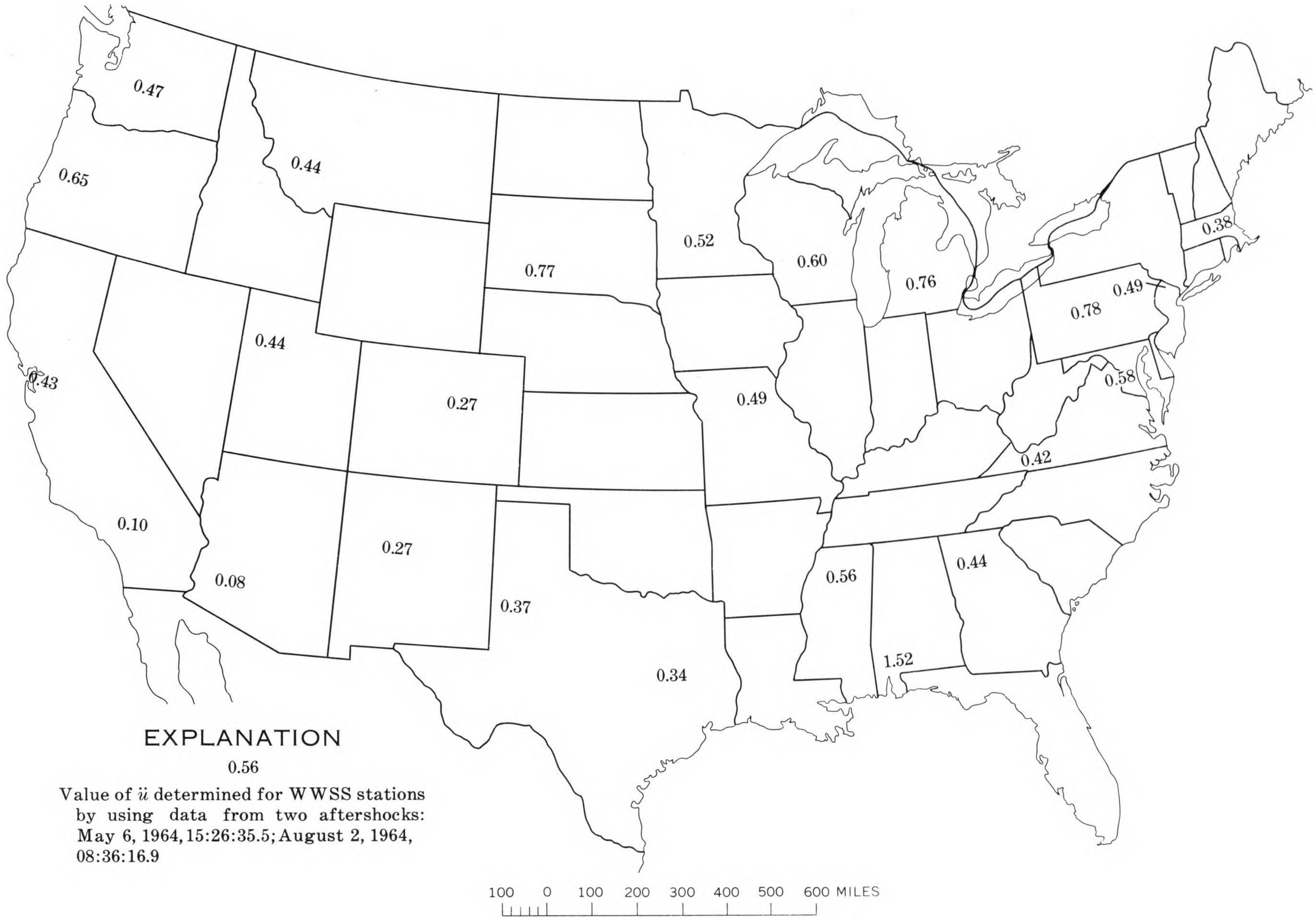
The influence of major geologic features on the distribution of seiches became apparent when seiche locations were plotted on the tectonic map of the United States (U.S. Geol. Survey and Am. Assoc. Petroleum Geologists, 1962). A simplified version of this map is shown as plate 1.

SEDIMENT THICKNESS

In all but three areas of North America—the northeast end of the Mississippi Embayment, the area near Miami, Fla., and the Great Valley of California—the density of seiches seems to be roughly proportional to the thickness of low-rigidity sediments. Extreme examples of this density distribution are shown by the concentration of seiches in the Mississippi Delta region along the Gulf Coast of Louisiana, where sediment thickness is maximum, and by near absence of seiches on the Canadian Shield, where sediments are almost nonexistent. Along the Gulf Coast eastward and westward from Louisiana the regular decrease in number of seiches as the deposits become thinner is particularly striking. The anomalously high density of seiches near Miami and the anomalously low densities at the head of the Mississippi Embayment and in the Central Valley of California are discussed on pages E19 and E20.

THRUST FAULTS

Thrust faults apparently provide a favorable environment for the generation of seiches. The relationship is especially clear in Georgia, where seiches were recorded at gages on the Brevard Rome, Towaliga, and Whitestone



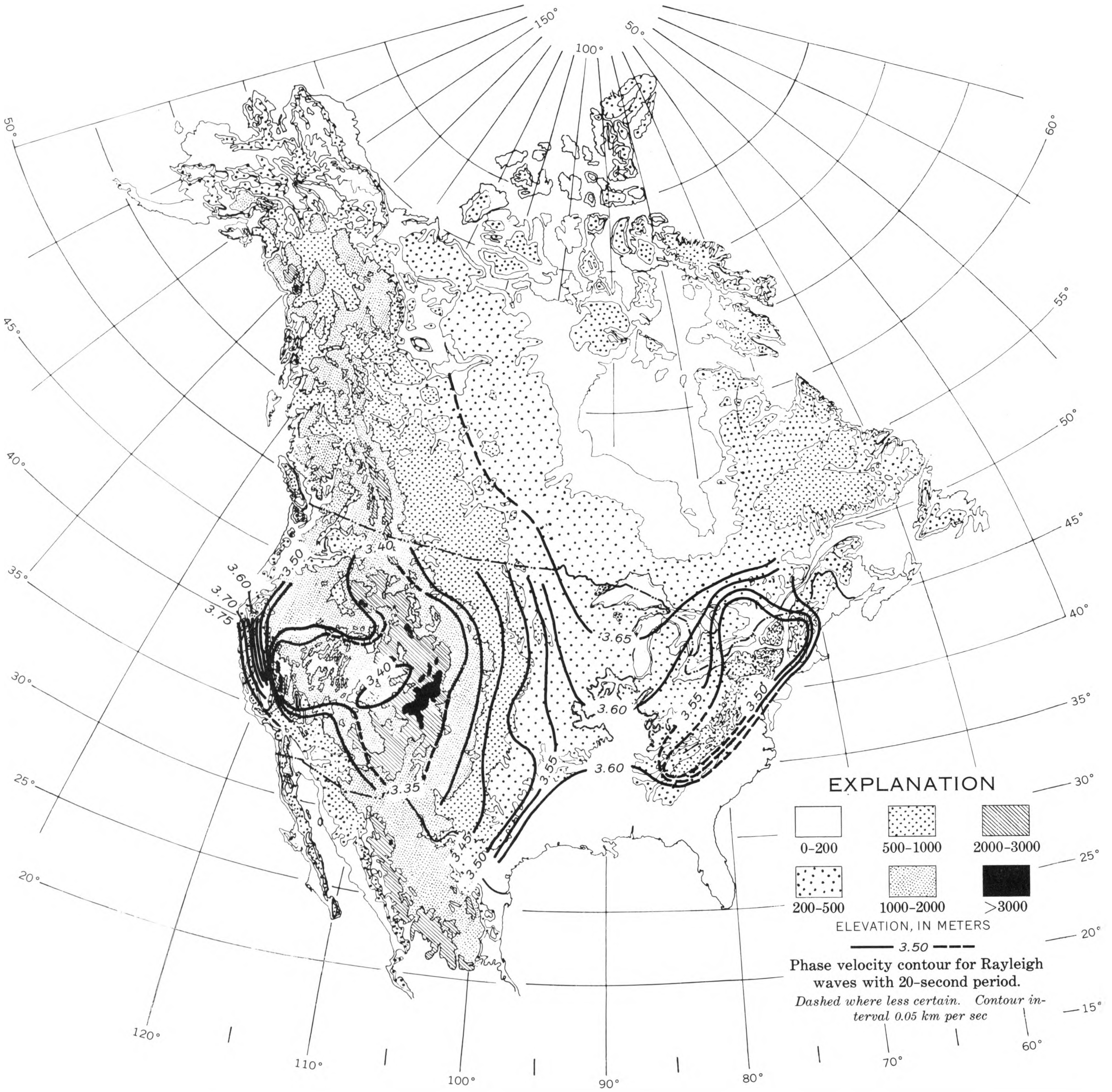
7.—Maximum horizontal acceleration ($\ddot{u}$) at stations of the World-wide Standard Seismograph Network in the United States calculated for two aftershocks of the Alaska earthquake.

decrease in amplitude according to $1/\sqrt{\sin \Delta}$, because of geometrical spreading on a sphere. The effect of this decrease is probably unimportant within North America in comparison with other factors. In theory, this effect would cause the surface-wave amplitude 10° from the epicenter to be about twice as large as the amplitude at the tip of Florida. The seiche data definite'y do not suggest such a relation. Seismograms of Alaskan aftershocks indicate similarly that these smaller earthquakes in the epicentral region of the main shock sent out surface waves that did not diminish materially with distance within North America (fig. 7).

The effect of dispersion of seismic surface waves on seiche amplitudes is not well understood. In theory, surface-wave trains decrease in amplitude proportionally to either $1/\sqrt{\Delta}$ or $1/\sqrt[3]{\Delta}$ because of dispersion. This effect was seemingly unimportant in determining the amplitude distribution of either the seiches or the aftershocks.

LATERAL REFRACTION

The seiche data suggest that lateral refraction of seismic surface waves occurred in some areas. Exact theoretical calculation of this effect is impossible because detailed knowledge is lacking on phase velocity of surface waves in North America. An example of lateral refraction was the apparent concentration of seismic energy along the Rocky Mountains (pl. 1, fig. 6). This effect could have been predicted qualitatively on the basis of work by John T. Kuo on distribution of phase velocity (fig. 8). Although the map shows contours of phase velocity for waves with a period of 20 seconds, it is probably also a valid guide to the relative distribution of velocity of the 5- to 15-second period waves considered in the present paper. According to geometrical ray theory, energy would have been concentrated in the low-velocity channel down the axis of the Rockies that is nearly parallel to



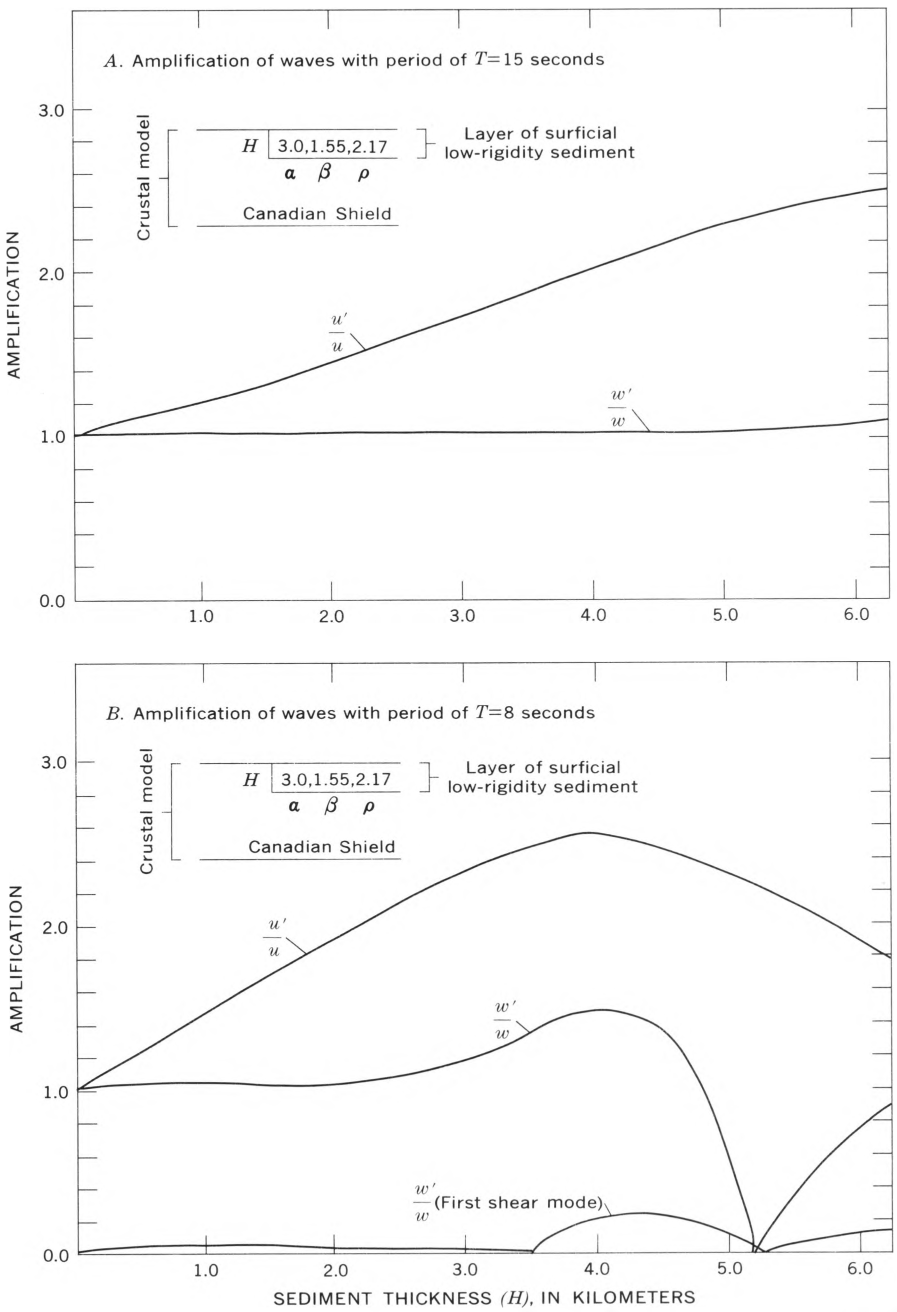
8.—Phase-velocity distribution of 20-second Rayleigh waves in North America. Map used by courtesy of Prof. John T. Kuo of Columbia University.

a great-circle path from the epicenter. The greatest seiche density in that region occurred along the 3.35 km/sec contour shown in figure 8, especially that part of it in north-central New Mexico.

Other evidence exists for the lateral refraction or channeling of surface waves by geosynclinal features. For instance, waves in the period range from 0.5 to 12 seconds propagate very efficiently parallel to the Appalachian basin (Oliver and Ewing, 1958). Seismic energy in the 0.5- to 2-second period range was also channeled toward the northeast by the Appalachians (Sutton and others, 1967). The Appalachians trend normal to the direction of wave propagation from the Alaska earthquake; thus they would not channel surface-wave energy. In fact, short-period waves propagated very inefficiently across the Appalachian basin as demonstrated by the few seiches recorded east of the mountains. In contrast, the long-period waves were not similarly affected, for in New Jersey alone 40 ground-water observation wells recorded hydroseisms from the earthquake.

Large circular basins seem to be capable of focusing surface-wave energy. In the Michigan and the Williston basins the seismic surface waves traveled from northwest to southeast. The fact that local concentrations of seiches occurred on the southeast sides of the basins suggests that seismic energy was focused by the lenticular shape of the sedimentary basin fill. Because the sediments are deepest in the center of a basin, the local phase velocity of the surface waves would be smallest at the center and would increase with distance from the center of the basin. Geometrical ray theory indicates that wave crests, which were parallel while the waves were still northwest of the basin, would cross each other to the southeast of the basin and would produce amplification there. The analogous situation for water waves passing over a circular shoal was shown by Stoker (1957, p. 135).

In summary, lateral variations in phase velocity appeared to channel seismic energy along geosynclinal belts and focus energy on the lee sides of basins.



9.—Amplification of Rayleigh-wave displacements $\frac{u'}{u}$ and $\frac{w'}{w}$ $\left(\text{(also accelerations } \frac{\ddot{u}'}{\ddot{u}} \text{ and } \frac{\ddot{w}'}{\ddot{w}}\right)$ in low-rigidity sediment overlying high-rigidity rock, for (*A*) 15- and (*B*) 8-second period waves.

LOCAL CRUSTAL STRUCTURE

The thickness of sediments of low rigidity seems to be an important cause of amplification of horizontal motion resulting from surface waves. The following examples indicate the type of amplification this mechanism may produce.

Application of an approximate theory of Rayleigh-wave transmission and reflection developed by McGarr and Alsop (1967) shows (fig. 9) the amplifications of horizontal and vertical components of motion of 15- and 8-second period Rayleigh waves that have crossed a structural boundary. In those examples, waves traveling in a Canadian Shield model (Brune and Dorman, 1963) are incident on a model in which the upper part has been replaced by a layer of elastic surficial sediments. The layer has a compressional velocity, α, of 3 km sec^{-1}, a shear velocity, β, of

1.55 km sec^{-1} and a density, ρ, of 2.17 gm cm^{-3}. The thickness of the layer ranges from $H=0$ to $H=6.0$ km. As shown in figure 9, an amplification of as much as 2.5 can be provided by a thick layer of sediments. This mechanism for amplification of surface horizontal displacement and acceleration predicts that the density of occurrence of seiches will be approximately proportional to the thickness of the elastic sedimentary layer. This theory seems to agree well with the density of seiches along the Gulf Coast.

In the northeast part of the Mississippi Embayment, however, the theory is less well substantiated, for the seiche density was much lower in the embayment where sediments are thick than in the surrounding areas (pl. 1, fig. 6). We have considered the possibility that the theory for normal-mode surface waves may explain the apparent attenuation of horizontal acceleration in the areas of extremely low rigidity sediments such as may be found in that part of the Mississippi Embayment.

Figure 10 (next page) shows the variation in amplitude of surface horizontal acceleration (which is proportional to the amplitude of surface horizontal displacement) as a function of "layer" shear velocity for 6- and 10-second period Rayleigh waves propagating in a crustal model. This crustal model has the same structure as the Canadian Shield except that the upper 1 km has been replaced by a layer with a compressional-wave velocity of 3.0 km sec^{-1}, a density of 2.3 gm cm^{-3}, and a shear velocity that ranges from 1.0 to 0.1 km sec^{-1}. The horizontal displacement has been normalized, so all the waves of a given period transport the same amount of energy. For reference, the horizontal acceleration produced by 6- and 10-second waves in an unmodified Canadian Shield model are -0.94 and -0.93 (expressed in the same relative units used in fig. 10). If only the waves of 10-second period are considered, then low horizontal acceleration would result if the shear velocity were in a narrow region near 0.475 km sec^{-1}. However, the 6-second waves have a horizontal displacement of more than 2 for $\beta=0.475$. Similarly, the value for the 6-second waves is zero where the 10-second waves provide a horizontal acceleration of more than 1.5. We are considering a band of periods between 5 and 15 seconds and low accelerations for the entire band, or even for a large fraction of the band, obviously will not occur where shear velocities are greater than 0.1 km sec^{-1}. Thus, ordinary surface-wave theory does not seem to explain the low seiche density observed in the northeastern part of the Mississippi Embayment.

The data suggest that the boundary between hard and soft material and possibly the finite extent of the sediments must be considered in any theory that seeks to explain phenomena such as those observed in the upper Mississippi Embayment.

In summary, sediments of low rigidity seem to be capable of amplifying or, in isolated cases, attenuating the horizontal acceleration of surface waves. Surface-wave theory can predict the amplification of horizontal acceleration for crustal models having a surfical layer of elastic sediments, but it cannot predict attenuation.

IRREGULAR STRUCTURES

Short-period surface waves are generally observed to travel more efficiently parallel to tectonic features than perpendicular to them (Sutton and others, 1967). Waves traveling in a direction perpendicular to a tectonic trend are attenuated rather rapidly, although the mechanism of attenuation is not understood at present (Richter, 1958, p. 143). The distribution of seiches indicates that, in addition, the horizontal displacement of short-period surface waves is amplified in regions of rapidly changing crustal structure, especially where surface waves travel across structural features in a direction normal to their trends.

In the Appalachian basin, nearly all of the seiche activity occurred on the northwest side of the basin; there was a pronounced shadow zone to the southeast. Seiche activity was strongest in the region where the beds begin to dip under the Appalachian basin. In Ohio, there is a belt of activity parallel to the contacts of Pennsylvanian beds that dip under the basin.

In the Valley and Ridge province of southern Tennessee, the areas of high seiche density coincide with surface contacts of southeast-dipping beds and with traces of thrust faults. There is no pronounced shadow zone on the lee side of the tectonic belt; rather, the seiche activity seems to continue at a somewhat diminished, but constant, level across Georgia and South Carolina to the coast. The Arkoma basin did not produce a shadow zone, perhaps because it is narrower and not nearly as deep as the Appalachian basin.

In summary, beds that thicken in the direction of wave propagation seem locally to amplify the horizontal acceleration of seismic surface waves; extremely deep sedimentary basins may attenuate short-period surface waves and thus cause shadow zones.

The continental margin also appears to attenuate short-period waves. Great-circle paths from the

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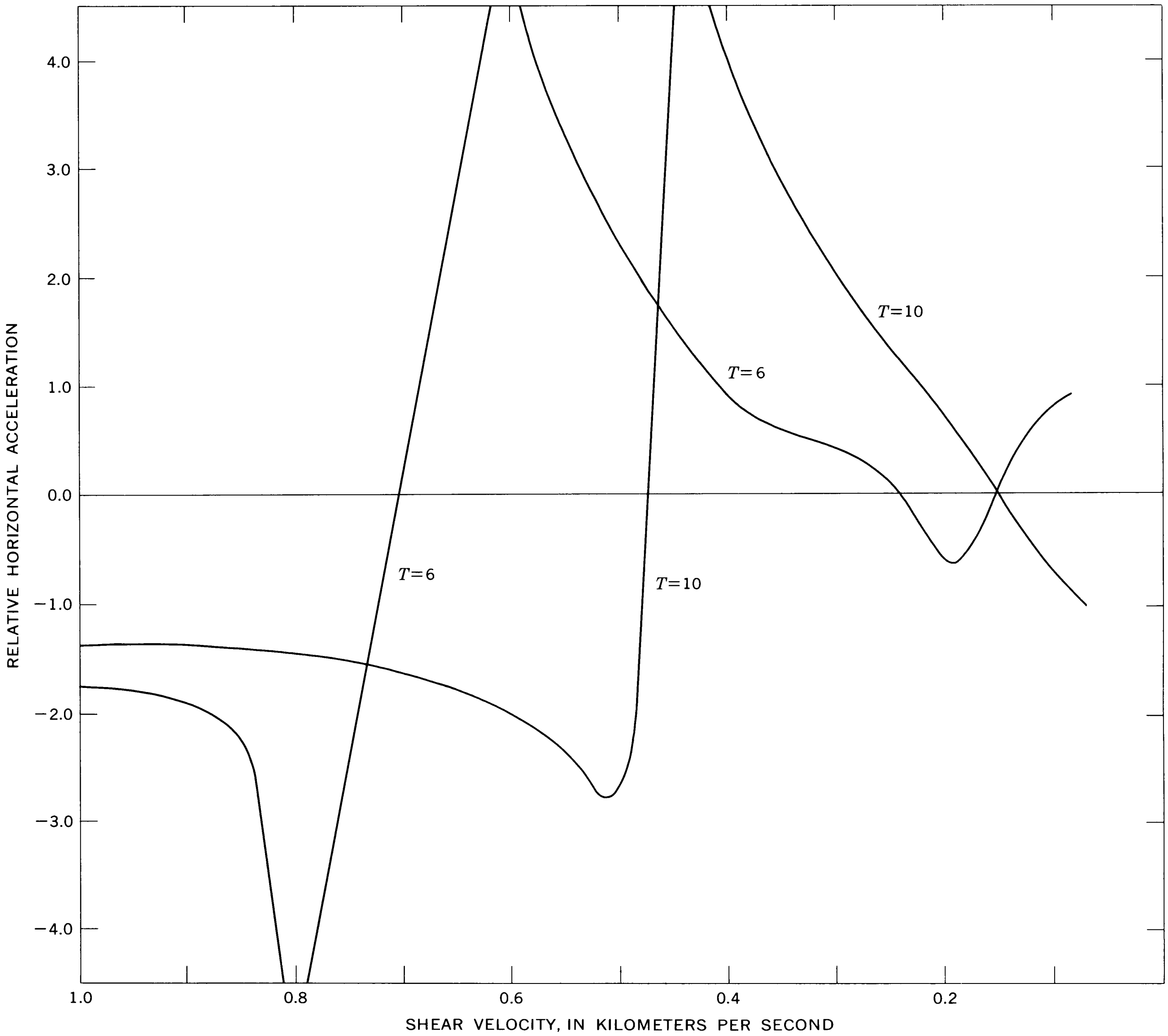


10.—Variation in amplitude of surface horizontal acceleration, as a function of "layer" shear-wave velocity, for 6- and 10-second period Rayleigh waves propagating in the modified Canadian Shield model discussed in the text.

epicenter of the Alaska earthquake to all of California and parts of Oregon, Washington, and Nevada cross part of the Pacific Ocean. The data suggest that seiches in that part of the United States occurred for the most part only on bodies of water, such as reservoirs, that were capable of coupling into rather long-period seismic surface waves. Otherwise, the Central Valley of California might have had a very high seiche density because of its thick filling of low-rigidity sediments.

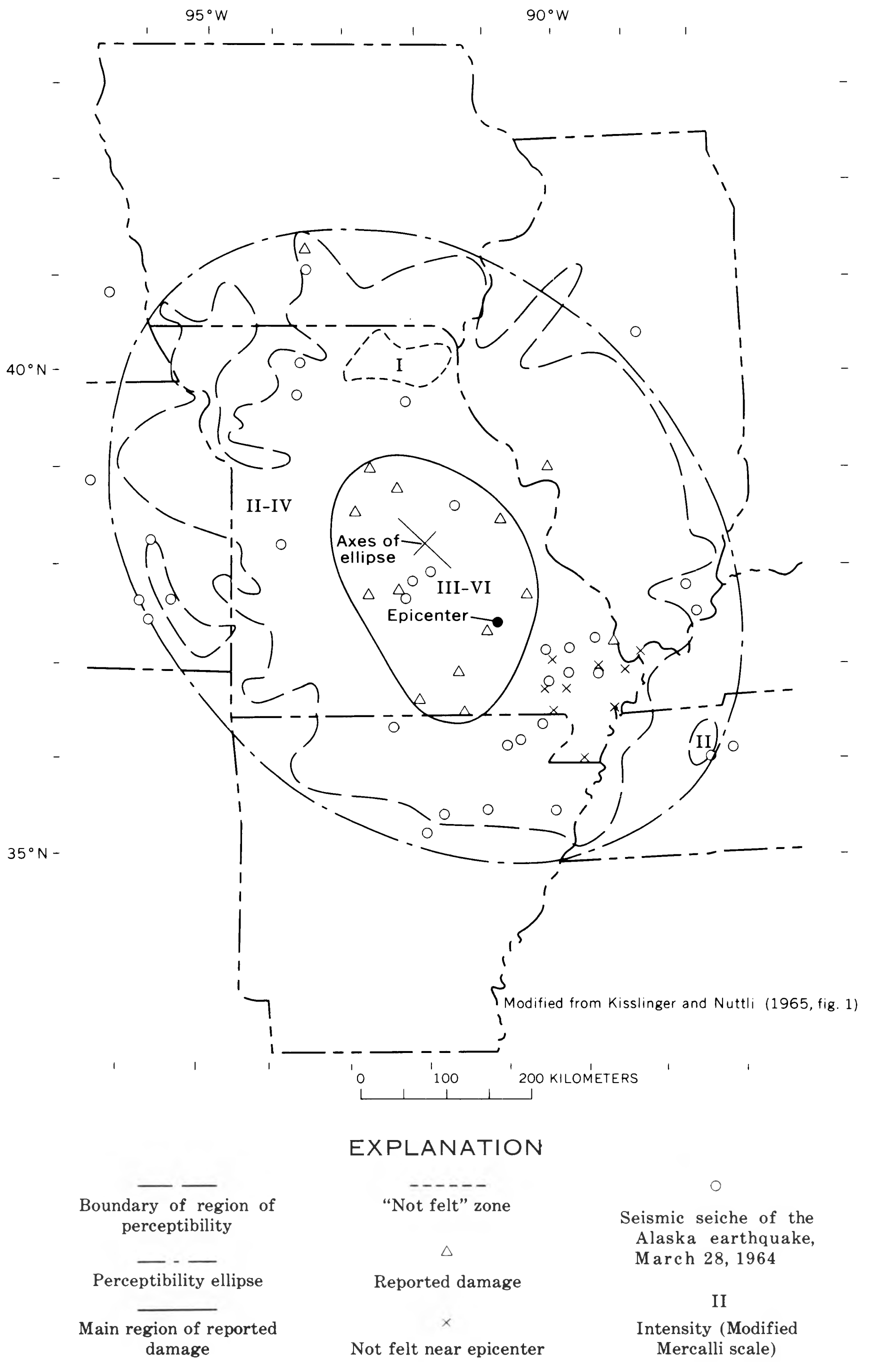
SEICHES AND SEISMIC INTENSITY

According to Richter (1958, p. 140), a passable relation between ground acceleration and the modified Mercalli intensity scale is given by the expression $\log a=\frac{I}{3}-\frac{1}{2}$ where I is the intensity and a is the acceleration in centimeters per second per second. Because both seiches and seismic intensity are related to horizontal ground acceleration, the authors investigated the possibility of using seiches in seismic-intensity studies. Richter (1958, p. 138) included seiche occurrence among the long-period intensity effects. Distribution of analog water-level recorders in the United States is now sufficiently dense that their records might be a more reliable indication of intensity than eyewitness reports, at least in some situations.

The seiche distribution from a major shock, such as the Alaska earthquake, might also be used to predict the potential distribution of intensity in areas before a local earthquake occurred. To find out how effectively seiche distribution from the Alaska earthquake might be so used, the seiche distribution was plotted on an intensity map (prepared by Kisslinger and Nuttli, 1965) of the south-central Missouri earthquake of October 21, 1965. All seiches resulting from the Alaska shock, which occurred within the perceptibility ellipse of the Missouri shock, were plotted to see whether or not seiche distribution was correlated with ground response to horizontal acceleration caused by local shocks (fig. 11). Several features of the intensity map could have been predicted from the seiche distribution. Both the seiche distribution and the local-intensity were anomalously low in the Mississippi Embayment. A local high in seiche density occurred near the axis of the perceptibility ellipse, about 125 km northwest of the epicenter. There was a local high in both seiche density and local-shock intensity at the southeast end of the ellipse, which is also on the southeast side of the embayment.

Some features of the intensity map, of course, would not have been predicted from study of the seiche distribution, possibly because:

1. Seiches from the Alaska shock were caused by seismic surface waves having periods greater than 5 seconds, whereas most intensity effects are caused by seismic waves having periods of less than 1 second.
2. The direction of wave propagation seems to have a strong effect. High correlations occurred northwest and southeast from the epicenter, that is, parallel or antiparallel to the waves from the Alaska



11.—Alaska earthquake seiches plotted on the intensity map of the Missouri earthquake of October 21, 1965.

shock. Perhaps if the seiche distribution which resulted from waves traveling from the northwest could be combined with the distribution of seiches resulting from waves propagated either from the southwest or from the northeast, we would be able to predict potential seismicity more precisely for any area desired.

Apparent attenuation of seismic intensity, such as occurred in the

Mississippi Embayment, seems to occur in other areas as well. Richter (1958, p. 143) stated that where seismic waves emerge from hard rock into alluvium or unconsolidated sediments there is considerable absorption, accompanied by increase of local intensity. This statement was based largely on observations of seismic intensity in California. It agrees with the seiche distribution in the Mississippi Embayment for an unusually high number of seiches occurred at the northwest edge of the embayment along the Tertiary overlap, but there were almost none across the rest of the embayment.

CONCLUSIONS AND RECOMMENDATIONS

The factors of greatest influence on the distribution of short-period seismic surface-wave amplitudes seem to be (1) local crustal structure, especially the thickness of surficial material of low rigidity, (2) tectonic trends, (3) homogeneity of the path of surface-wave travel from the epicenter to a given locale, and (4) focusing of surface-wave energy by lateral phase velocity variations. Epicentral distance and radiation pattern seem to be of little importance.

There may be other controls on the seismic amplitude distribution. In areas of soft sediments, such as the Gulf Coast, there may have been horizontal displacements of as much as 10 cm due to the surface waves. If the period of the waves was as short as 6 seconds, then the horizontal displacement at land surface was about 0.01 of gravity. Locally, this displacement may have been sufficient to cause inelastic effects, some of which may correspond to the square symbols on plate 1.

There seems to be a correlation between the distribution of seiches and the potential intensity of a local earthquake in a given region. If seiches are indeed valid indicators of potential intensity, then an earthquake of a given magnitude in Louisiana might be of greater intensity than one of comparable magnitude at any other location in North America.

The distribution of seiches may contain implications that will lead to further developments in seismic surface-wave theory. For instance, the seiche distribution resulting from the Alaska earthquake suggests that:

1. Unusually large horizontal amplitudes of short-period seismic surface waves occur in areas where absorption of the waves is most rapid. Waves that travel transverse to tectonic trends produce large horizontal amplitudes in the vicinity of the trend.
2. Lateral variations of local-phase velocity can focus and channel surface waves.

If the assumptions made in this study are valid, then analog water-level recorders are a valuable tool both for the theoretical and for the disaster-prevention aspects of seismology because the recorders are equivalent in many respects to a relatively dense network of horizontal accelerometers. For further study of seismic seiches, the authors recommend that:

1. A network of analog water-level recorders be maintained throughout the United States, or preferably throughout the world.
2. Analog recorders with an expanded time scale be maintained on selected bodies of water in areas of high seismicity.
3. Seismographs be installed on appropriate tectonic features to permit study of the local amplification of surface waves such as is suggested by the seiche data.
4. Seiche recordings for smaller magnitude shocks be collected to investigate the possibility of a relation between seiche distribution and earthquake magnitude.
5. Seiches or their absence in epicentral areas be studied as a potentially reliable method for measuring earthquake intensity.

Because this study of seiches resulting from a major earthquake is the first of its type, the interpretations must be regarded as preliminary. Furthermore, the seiche data have not been used fully, for little attention was paid to amplitudes, periods, or durations. Most of the interpretation is based on the number of seiches that were recorded in a given region compared to the number of recorders in operation. Because of the great variation in response at the various recording sites and because more than 750 seiches were recorded in the United States, it seemed prudent to keep the data analysis relatively simple. In the future, it may be possible to analyze the records of seiche amplitudes from sites where the response to seismic surface waves can be calculated. Bodies of water with well-known regular shapes, such as canals and reservoirs, would be the best sites for such studies.

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TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*

[North latitude, west longitude, unless otherwise indicated. Time: March 28, 1964, Greenwich civil time. Discharge (in cubic feet per second) in roman type, *storage (in acre feet) in italic;* for asymmetrical double amplitudes, motion upward is shown above a slash line and motion downward is shown below. Latitude and longitude in degrees, minutes, and seconds where the location has been accurately determined; in degrees and minutes or in degrees only where location is less certain. Datum is altitude of an arbitrary point at each gaging station below the lowest level to which streamflow is likely to fall and from which all stage levels at a station are measured; altitude of the water surface above sea level is the sum of the stage plus altitude of the datum. Time is given mainly to indicate that the reported fluctuation occurred at about the time the seismic waves arrived. Many of the times as given might be subject to some correction if the entire chart could be examined for systematic clock error]

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES								
	Alabama								
2-3440	Chattahoochee River at Alaga	31°07′	85°03′	62.72	19.50	04:00	40,000	0.18	Seiche lasted about 30 min.
2-3785	Fish River near Silver Hill	30°32′45″	87°47′55″	20	1.93	03:50	75	.03	
2-3995	Coosa River at Weiss Dam at Leesburg.	34°11′	85°45′	517.77	68.42	04:00	----------	.15/.00	On Rome fault. Bubble gage.
2-4001	Terrapin Creek at Ellisville	34°04′	85°37′	539.07	9.45	04:10	1,750	.13	In Coosa syncline and on a possible extension of a thrust fault.
2-4015	Big Canoe at Gadsden	33°54′11″	86°06′37″	490.56	12.65	04:00	3,900	.10	On a thrust fault.
2-4120	Tallapoosa River near Heflin	33°37′	85°31′	830	17.20	03:45	6,400	.12	On Whitestone thrust fault.
2-4285	Flat Creek at Fountain	31°37′	87°25′	45.43	2.68	04:10	240	.12	
2-4295	Alabama River at Claiborne	31°32	87°31′	.4	40.7	04:15	109,000	.18	On possible extension of fault zone.
2-4380	Buttahatchee River below Hamilton	34°06′	87°58′	360.80	5.30	04:00	1,350	.22	Fault(?) buried under Cretaceous overlap.
2-4420	Luxapalila Creek near Fayette	33°43′	87°52′	322.33	1.60	02:40	280	.03	On possible extension of a buried fault.
2-4450	Lubbub Creek near Carrollton	33°15′	88°05′	174.24	6.40	04:00	345	.05	On crest of compressed anticline.
2-4451.55	Tombigbee River at Epes	32°41′45″	88°06′55″	----------	36.90	04:00	----------	.12	On west edge of buried Appalachian front.
2-4565	Locust Fork at Sayre	33°42′35″	86°59′00″	258.64	21.00	04:00	13,500	.20	On en echelon fault.
2-4645	North River near Tuscaloosa	33°21′10″	87°33′25″	155.24	2.93	04:10	840	.08	
2-4670	Tombigbee River at Demopolis Lock and Dam near Coatopa.	32°31′15″	87°52′05″	56.00	37.40	04:00	78,000	.06/.10	On possible extension of Appalachian faults.
2-4680	Alamuchee Creek near Cuba	32°26′	88°20′	161.50	2.53	04:00	92	.04	On west edge of buried Appalachians.
2-4695	Tuckabum Creek near Butler	32°11′	88°10′	----------	1.94	03:45	170	.10	On possible extension of Appalachian faults.
2-4695.5	Horse Creek near Sweetwater	32°03′	87°52′	130	2.55	04:05	62	.07	On possible extension of a buried fault.
2-4696	Bashi Creek near Campbell	31°56′	87°59′	----------	4.92	04:10	205	.11	Do.
2-4700	Tombigbee River near Leroy	31°34′	88°02′	7.28	35.4	04:30	*120,000*	.18	On Hatchetigbee anticline. Bubble gage.
2-4701	East Bassett Creek near Walker Springs.	31°32′	87°47′	60.02	3.40	04:30	300	.10	On fault zone.
2-4710.65	Montlimar Creek at U.S. Hwy 90 at Mobile.	30°39′03″	88°07′28″	----------	2.38	04:00	11	.05	
2-4795	Escatawpa River near Wilmer	30°52′	88°25′	60	5.23	04:15	720	.08	On Wiggins uplift.
3-5853	Sugar Creek near Goodsprings	34°56′40″	87°09′20″	575	4.25	04:10	460	.05	
3-5905	Tuscumbia Spring at Tuscumbia	34°43′45″	87°42′15″	409.65	9.03	04:15	121	.06	A residual 0.02-ft. rise in stage.
3-5923	Little Bear Creek at Halltown	34°29′19″	88°02′07″	499.30	4.10	03:20	380	.06	
----------	Tennessee River at Waterloo	34°	88°	----------	----------	04:15	*900,000*	.03	A re sidual 0.01-ft. drop in stage.
----------	Tennessee River at Triana	34°	86°	MSL	559.78	04:35	*1,100,000*	.18	
----------	Tennessee River near Smithsonia	34°	87°	----------	12.60	04:00	*900,000*	.07	Seiche lasted about 50 min.
	Alaska								
30-0115	Red River near Metlakatla	55°08′29″	130°31′50″	5	2.72	03:45	140	0.15	Tsunami crests were recorded at 08:30, 10:00, 11:50, 21:20, and 22:20.
30-0120	Winstanley Creek near Ketchikan	55°25′00″	130°52′05″	290	1.51	03:30	50	.12	
30-0201	Tyee Creek near Wrangell	56°12′54″	131°30′25″	4.62	1.05	03:55	22	.12	Tsunami waves superimposed on high tide.
30-0220	Harding River near Wrangell	56°13′	131°38′	20	4.65	04:00	100	No seiche	Water rose 0.02 ft. in 20 min, then dropped and rose once during 80-min period.
30-0260	Cascade Creek near Petersburg	57°01′	132°47′	120	1.86	04:00	30	.02/.00	
30-0340	Long River near Juneau	58°10′00″	133°41′50″	183	1.44	03:20	45	No seiche	Water level rose 0.07 ft. in 30 min, declined 0.65 ft. in next 340 min, then gradually rose to preearthquake level during 24 hr.
30-0360	Speel River near Juneau	58°12′10″	133°36′40″	140	.34	03:30	400	.46	Bubble gage; seiche lasted about 60 min.
30-0400	Dorothy Creek near Juneau	58°13′40″	134°02′25″	350	1.79	03:40	19	----------	At 04:30, water level began decline of 0.08 ft. during 70 min.
30-0480	Sheep Creek near Juneau	58°16′30″	134°18′50″	629.8	1.55	03:50	4	.04	
30-0600	Perseverance Creek near Wacker	55°24′40″	131°40′05″	600	1.65	03:30	10	----------	A residual 0.02-ft drop in stage.
30-0720	Fish Creek near Ketchikan	55°23′30″	131°11′40″	20	.98	03:25	120	.52/.16	
30-0760	Manzanita Creek near Ketchikan	55°36′	130°59′	140	2.10	04:00	200	.35	
30-0780	Grace Creek near Ketchikan	55°39′28″	130°58′14″	15	2.01	03:40	100	.07	Tsunami crest at 09:20.
30-0865	Neck Creek near Point Baker	56°05′55″	133°08′20″	4	1.10	04:00	80	.06/.03	Tsunami crest at 10:40.
30-0940	Deer Lake Outlet near Port Alexander	56°31′10″	134°40′10″	1	2.01	03:25	56	.07	Stage dropped 0.05 ft after seiche was recorded, then recovered in 2½ hr; Tsunami crests superimposed on high tide at 09:25, 10:05, 10:55, and 22:35.
30-0980	Baranof River at Baranof	57°05′15″	134°50′30″	140	3.05	04:00	170	.025/.075	Bubble gage.
30-1000	Takatz River near Baranof	57°08′35″	134°51′50″	4	1.63	03.45	50	.02	Waves from lake or tsunami crests at 09:55 and 10:45.

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Alaska—Continued								
30-1020	Hasselborg Creek near Angoon	57°39′40″	134°14′55″	295	1.45	?	80	0.15	
30-1080	Pavlof River near Tenakee	57°50′30″	135°02′10″	15	4.18	03:50	30	.72	
30-2115	Tebay River near Chitina	61°13′55″	144°11′50″	1,796.23	----------	03:50	ice	.03+	Float was frozen solidly in ice.
30-2160	Power Creek near Cordova	60°35′15″	145°37′05″	33.5	.70	----------	50	.27	Stage dropped 0.07 ft, rose gradually 1.88 ft in 70 min, then declined 0.46 ft in 3 hr.
30-2370	Nellie Juan River near Hunter	60°25′20″	148°43′30″	90	4.97	----------	28	.02+	Earthquake dislodged batteries of manometer control unit and caused loss of record.
30-2390	Bradley River near Homer	59°45′25″	150°51′00″	1,050	.97	04:00	30	.25/.33	Chart indicates only one up-and-down seiche motion. Water level then receded 0.40 ft in 6 hr, and gradually rose. Many aftershocks were recorded.
30-2435	Snow River near Divide	60°18′05″	149°14′10″	1,050	2.88	03:30	16	No seiche	Water rose 1.02 ft in 20 min, then returned to normal over 24 hr. Three aftershocks were recorded.
30-2480	Trail River near Lawing	60°26′00″	149°22′20″	460	2.8	----------	63	1.02	
30-2610	Cooper Creek at mouth near Cooper Landing.	60°28′30″	149°52′30″	450	----------	03:20	6	Tr.	Float was frozen in before and after quake.
30-2760	Ship Creek near Anchorage	61°13′25″	149°38′00″	530	.23	03:00	11	.95/.58	Earthquake dammed creek upstream and thus shut off flow till March 29th.
30-2900	Little Susitna River near Palmer	61°42′40″	149°13′40″	920.6	----------	03:30	19	.17/.13	Float released from ice by quake. Irregular change of stage during 18 hr after quake.
30-2957	Terror River at mouth near Kodiak	57°41′50″	153°10′10″	10	1.90	03:20	13	.27	Tsunami crests 330, 460, 500, 530, and 610 min after seiche was recorded.
30-2960	Uganik River near Kodiak	57°41′05″	153°25′10″	20	4.17	03:25	75	.00/.03	Tsunami crests 330, 450, and 520 min after seiche was recorded.
30-2963	Spiridon Lake outlet near Larsen Bay.	57°40′40″	153°39′00″	440	.52	03:35	30	1.18/.02	0.2 ft surge began shortly after quake was recorded; it continued through Mar h 28 and diminished through 29th.
30-2972	Myrtle Creek near Kodiak	57°36′15″	152°24′10″	50	1.15	04:10	----------	.25	Tsunami crests 60, 120, and 170 min after seiche was recorded.
	Arizona								
9-3834	Little Colorado River at Greer	34°01′	109°27′	8,500	1.97	03:30	1.6	No seiche	Temporary 0.002 ft drop in stage.
9-3880	Little Colorado River near Hunt	34°39′	109°42′	5,371.59	6.32	04:00	.0	No seiche	A residual 0.005-ft drop in stage.
9-3935	Silver Creek near Snowflake	34°40′00″	110°02′30″	5,204.1	1.70	04:15	3.1	.02	
9-3975	Chevelon Fork below Wildcat Canyon, near Winslow.	34°38′	110°43′	5,905.16	2.66	03:30	3.3	.1	
9-4210	Lake Mead at Hoover Dam	36°00′58″	114°44′13″	MSL	1,123.75	03:45	*14,952,000*	.11	Seiche lasted about 60 min near a fault.
9-4690	San Carlos Reservoir at Coolidge Dam.	33°10′30″	110°31′45″	MSL	2,412.22	03:50	*53,460*	.35	Seiche lasted about 90 min near both a fault and a graben.
9-4897	Big Bonita Creek near Fort Apache	33°40′10″	109°50′45″	5,910	2.77	03:40	25	.02	On extension of a fault.
9-4975	Salt River near Chrysotile	33°48′	110°30′	3,354.57	1.81	04:00	200	Tr.	A residual 0.005-ft drop in stage.
9-4985	Salt River near Roosevelt	33°37′10″	110°55′15″	2,177.14	7.80	03:40	260	.02	On a fault.
	Arkansas								
7-0475	St. Francis River at Marked Tree	35°31′58″	90°25′25″	196.44	6.60	03:50	2,080	0.26	
	Auxiliary	35°31′	90°25′	----------	8.18	04:05	2,080	.06	
7-0480	West Fork White River at Greenland	35°59′	94°10′	1,233.00	1.14	03:50	34	.08	
7-0490	War Eagle Creek near Hindsville	36°12′02″	93°51′16″	1,170.06	----------	----------	----------	.05	
7-0560	Buffalo River near St. Joe	35°59′	92°45′	560.35	5.56	03:40	1,250	.12	
7-0640	Black River near Corning	36°24′05″	90°32′03″	272.90	10.70	03:30	4,100	.04	Near edge of Tertiary overlap.
7-0690	Black River at Pocahontas	36°15′	90°58′	242.43	14.40	04:00	11,200	.11	On edge of Tertiary overlap.
7-0695	Spring River at Imboden	36°12′	91°10′	254.07	5.08	04:00	1,500	.04	Do.
7-0745	White River at Newport	35°36′20″	91°17′20″	194.09	16.93	03:50	36,000	.30	Seiche may have lasted about 30 minutes near edge of Tertiary overlap.
7-0759	Greers Ferry Reservoir near Heber Springs.	35°31′15″	91°52′42″	----------	441.12	04:10	*1,345*	.44	Seiche lasted about 110 min.
7-0768.5	Cypress Bayou near Beebe	35°01′30″	91°52′23″	----------	10.90	04:10	----------	.04	On edge of Tertiary overlap.
7-0770	White River at De Valls Bluff	34°47′	91°27′	152.93	22.40	03:50	58,000	.16	
7-1950	Osage River near Elm Springs	36°13′15″	94°17′20″	1,052	1.58	04:10	36	.02	
7-2470	Poteau River at Cauthron	34°55′08″	94°17′55″	569.53	5.00	03:30	40	.02	On Choctaw thrust fault.
7-2494	James Fork near Hackett	35°09′45″	94°24′25″	459.71	3.02	03:50	64	.16	
7-2495	Cove Creek near Lee Creek	35°43′20″	94°24′30″	852	1.57	03:50	8	.07	On extension of anormal fault.

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Arkansas—Continued								
7-2515	Frog Bayou at Rudy	35°31′25″	94°16′30″	475.08	2.96	04:00	106	0.15	
7-2540	Six Mile Creek Subwatershed 5 near Chismville.	35°13′45″	93°54′50″	475.83	13.44	----------	1	.03	On possible extension of axis of anticline.
7-2551	Six Mile Creek subwatershed 23 near Branch.	35°21′15″	93°59′00″	400.00	22.58	----------	3.3/77	.01	On extension of a normal fault. Bubble gage.
7-2555	Hurricane Creek near Branch	35°21′	93°56′	379.87	2.60	04:00	31	.03	On extension of a normal fault.
7-2570	Piney Creek near Dover	35°33′00″	93°09′25″	487.66	3.56	04:10	580	.48	On axis of syncline. Seiche from long way round world at 05:05?
7-2575	Illinois Bayou near Scottsville	35°27′58″	92°02′28″	447.54	6.40	03:50	485	.06	
7-2615	Fourche La Fave River near Gravelly	34°52′	93°39′	410.50	2.48	03:50	188	.26	Seiche lasted about 30 min. On possible extension of thrust fault.
7-2640	Bayou Meto near Lonoke	34°44′10″	91°54′58″	199.11	10.80	04:00	370	.03	On possible extension of thrust fault.
7-3370	Red River at Index	33°33′05″	94°02′25″	246.87	6.62	04:05	36,600	.14	On edge of Tertiary overlap.
7-3395	Rolling Fork near DeQueen	34°03′	94°25′	318.24	4.50	04:00	340	.04	Near edge of Cretaceous overlap.
7-3400	Little River near Horatio	33°55′10″	94°23′15″	272.89	9.37	03:50	3,000	.00/.08	Bubble gage.
7-3405	Cossatot River near DeQueen	34°03′	94°13′	335.48	6.20	04:10	982	.08	Near edge of Cretaceous overlap.
7-3410	Saline River near Dierks	34°06′	94°05′	353.09	5.90	04:05	95	.07	Do.
7-3494.3	Bodcau Creek at Stamps	33°22′00″	93°31′20″	----------	4.82	03:55	429	.01	On South Arkansas fault zone.
7-3565	Ouachita River South Fork at Mt. Ida.	34°34′	93°38′	612.05	2.30	03:50	96	.11	A residual 0.02-ft. drop in stage.
7-3575	Lake Ouachita near Hot Springs	34°34′20″	93°11′50″	----------	573.10	03:20	*1,970,000*	1.45	Seiche lasted about 140 min. Near both an anticline and a fault.
7-3605	Lake Greeson near Murfreesboro	34°08″55′	93°42′55″	----------	537.10	04:00±	*209,000*	.45	Seiche lasted about 60 min. On fault and near intrusive body.
7-3615	Antoine River at Antoine	34°02′20″	93°25′05″	229.33	4.10	03:45	165	.00/.02	Near edge of Cretaceous overlap. Bubble gage?
7-3621	Smackover Creek near Smackover	33°20′40″	92°46′45″	----------	5.80	03:50	235	.18	Near Arkansas fault zone.
7-3625	Moro Creek near Fordyce	33°47′	92°20′	160.63	6.35	04:00	286	.06	
7-3633	Hurricane Creek near Sheridan	34°19′10″	92°20′40″	----------	9.70	03:40	300	.04	
7-3635	Saline River near Rye	33°42′	92°02′	95	11.03	04:00	2,090	.10	
7-3658	Cornie Bayou near Three Forks	33°02′	92°56′	----------	5.08	03:55	72	.02	
7-3659	Three Creek near Three Creeks	33°04′	92°53′	----------	1.91	04:00	13	.05	
	California								
10-2904	Lower Twin Lake near Bridgeport	38°09′20″	119°20′20″	MSL	7,208.58	03:50	*4,000*	0.06	Seiche lasted about 240 min. On a normal fault.
10-3385	Donner Creek at Donner Lake near Truckee.	39°19′25″	120°14′00″	5,930	1.70	03:10	23	No seiche	Slight drop in stage.
11-1445	Salinas Reservoir near Pozo	35°20′15″	120°30′05″	MSL	1,293.41	04:00	*20,600*	.42	Seiche lasted about 300 min. On a fault.
11-1812	Chabot Reservoir near San Leondro	37°43′17″	122°07′15″	MSL	227.30	03:50	------------	.30	Seiche lasted 190 min.
11-1814.9	San Pablo Reservoir near Residence	37°56′31″	122°15′40″	MSL	305.88	03:45	------------	.06	Seiche lasted about 140 min but was poorly recorded. On Hayward fault.
11-1829.2	Lafayette Reservoir near Briones Valley.	37°53′05″	122°15′40″	MSL	445.64	04:00	------------	.00/.02	Bubble gage? Seiche lasted about 240 min. On Hayward fault.
11-1905	Isabella Reservoir near Isabella	35°38′50″	118°28′50″	MSL	2,557.45	03:20	*157,700*	------------	May be effect of wind. Duration about 230 min. Near Kern Canyon fault.
11-2047	Lake Success near Success	36°03′40″	118°55′18″	MSL	598.42	04:00	*13,400*	No seiche	Water level rose 0.02 ft in 10 min. Near edge of Sierra Nevada batholith.
11-2109	Lake Kaweah near Lemoncove	36°24′53″	119°00′07″	MSL	571.06	04:00	*8,450*	.06	Seiche lasted about 50 min. On edge of Sierra Nevada batholith.
11-2150	North Fork Kings River near Cliff Camp.	36°59′38″	118°58′50″	6,143.95	3.03	03:50	15	.05	Do.
11-2210	Pine Flat Reservoir near Piedra	36°49′55″	119°19′25″	MSL	861.01	03:50	*543,000*	.14	Seiche seemingly lasted about 560 min.
11-2501	Millerton Lake at Friant	37°00′00″	119°42′10″	MSL	518.07	03:50	*274,300*	.03	Seiche lasted about 100 min. Near edge of Sierra Nevada batholith.
11-2713.5	Merced River at Cressey	37°25′28″	120°39′47″	----------	10.34	03:45	------------	.01	In Central Valley.
11-2745.5	San Joaquin River at Crows Landing Bridge.	37°26′52″	121°00′44″	----------	38.75	04:00	------------	.04	Do.
11-2875	Don Pedro Reservoir near La Grange	37°42′48″	120°24′14″	MSL	575.40	03:30	*200,700*	.02	Record rather indistinct.
11-2884	Tuolumne River at La Grange Bridge.	37°39′59″	120°27′40″	----------	167.34	04:00	------------	.01	
11-2905	San Joaquin River at Maze Road Bridge.	37°38′28″	121°13′37″	----------	14.56	03:50	------------	.02	In Central Valley.
11-2999.95	Tulloch Reservoir near Knights Ferry.	37°52′30″	120°36′15″	MSL	496.10	04:20	*51,400*	.07	Seiche may have lasted about 270 min.
11-3087	New Hogan Reservoir near Valley Springs.	38°09′00″	120°48′45″	MSL	598.45	03:50	*25,800*	.12	Seiche lasted about 60 min.
11-3166	North Fork Mokelumne River above Tiger Creek.	38°26′45″	120°29′15″	----------	2.73	03:45	------------	.02	Slight residual drop in stage.
11-3200	Pardee Reservoir near Spring Valley	38°15′30″	120°51′00″	MSL	551.83	04:00	*176,400*	.38	Seiche lasted about 180 min.
11-3700	Shasta Lake near Redding	40°43′10″	122°25′10″	MSL	1,018.75	04:00	*3,257,100*	.25	Seiche lasted about 120 min.
11-3879.95	Black Butte Reservoir near Orland	39°48′50″	122°20′10″	MSL	429.40	03:45	*27,900*	.02	Seiche lasted about 60 min. On a fault.

Table 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	California—Continued								
11-4180	Yuba River at Englebright Dam	39°14′22″	121°16′00″	MSL	627.76	03:30	1,580	0.05	Storm or seiche recorded about 240 min. On edge of batholith.
11-4270	North Fork American River at North Fork Dam.	38°56′15″	121°01′25″	MSL	715	03:30	599	.02	Seiche lasted about 60 min.
11-4539	Lake Berryessa near Winters	38°30′50″	122°06′15″	MSL	437.76	03:50	*1,559,300*	.18	Seiche lasted about 190 min.
11-4560	Napa River near St. Helena	38°29′40″	122°25′50″	200	1.05	03:45	20	.01	Temperature record unaffected by earthquake.
	Colorado								
	[About 40 gaging stations were out of operation owing to ice conditions during period of earthquake. All those that did record were in western half of State]								
9-0664	Red Sandstone Creek near Minturn	39°40′55″	106°24′05″	9,150	2.42	03:55	0.9	0.02	Close to several faults.
9-0802	Fryingpan River at Ruedi	39°21′40″	106°49′10″	7,500	2.15	04:00	30	Tr.	On a fault.
9-0850	Roaring Fork at Glenwood Springs	39°32′50″	107°19′50″	5,720.73	.92	03:45	260	.02	West of a thrust fault.
9-0890	West Divide Creek below Willow Creek, near Raven.	39°16′32″	107°31′10″	7,820	1.90	04:10	2.4	.04	At southeast end of Piceance basin.
9-1122	East River below Cement Creek, near Crested Butte.	38°47′25″	106°52′20″	8,450	3.76	04:20	42	.03	On a fault.
9-1465	East Fork Dallas Creek near Ridgway.	38°05′40″	107°48′40″	7,980	1.95	04:00	5.0	.01	On west edge of San Juan volcanic area.
9-1712	San Miguel River near Telluride	37°56′55″	107°52′35″	8,622.81	----------	04:00	16	.01	On a fault.
9-2410	Elk River at Clark	40°43′03″	106°54′55″	7,267.75	.75	04:00	32	Tr.	On west edge of Sierra Madre uplift. A 0.001-ft. rise in stage.
9-3028	White River near Buford	40°02′	107°31′	----------	2.75	03:50	121	.03	On White River uplift.
9-3042	White River above Coal Creek, near Meeker.	40°00′20″	107°49′30″	6,400	1.56	03:45	260	.30	Do.
9-3443	Navaho River near Chromo	37°01′55″	106°43′56″	7,700	3.41	04:00	26	.01	Near dikes and faults.
9-3610	Hermosa Creek near Hermosa	37°25′30″	107°50′20″	6,705.88	.51	04:00	14	Tr.	
9-3612	Falls Creek near Durango	37°22′00″	107°52′00″	7,120	3.05	04:00	.1	.02	
9-3614	Junction Creek near Durango	37°20′05″	107°54′30″	7,045.65	2.44	03:50	3.0	Tr.	
	Connecticut								
	No seismic seiche was recorded at any gaging station.								
	Delaware								
	No report received.								
	Florida								
2-2310	St. Marys River near Macclenny	30°21′35″	82°04′55″	40.00	5.20	04:15	490	0.66	Seiche lasted about 40 min.
2-2313.5	St. Johns headwaters near Vero Beach.	27°38′35″	80°40′26″	18.56	6.05	04:50	----------	.02	
2-2321	Lake Washington near Eau Gallie	28°08′50″	80°44′10″	10.39	4.17	03:55	*4,298*	.04	
2-2324	St. Johns River near Cocoa	28°22′10″	80°52′22″	MSL	12.50	04:20	870	.10	
2-2332	Little Econlockhatchee River near Union Park.	28°31′29″	81°14′39″	56.19	6.60	04:20	20	.02	
2-2360	St. Johns River at St. Francis Landing, near Deland.	29°02′14″	81°25′05″	−1.11	1.66	04:10	3,700	.02	
2-2369	Palatlakaha Creek at Cherry Lake outlet, near Groveland.	28°36′	81°49′	MSL	95.64	04:35	20	.01	
	Auxiliary	28°36′	81°49′	MSL	94.56	04:10	20	.05	
2-2445	Little Haw Creek near Seville	29°19′	81°23′	5.74	3.83	04:10	80	No seiche	Stage declined 0.34 ft in 20 min, then began to rise.
2-2465	St. Johns River at Jacksonville	30°19′13″	81°39′32″	−10.00	?	04:05	----------	.06	
	St. Johns River at Naval Air Station, near Jacksonville.	30°13′39″	81°39′58″	−10.00	10.78	04:30	----------	.03	
2-2469	Moultrie Creek near St. Augustine (State Hwy. 207).	29°50′50″	81°21′39″	14.24	4.11	04:00	19	No seiche	A 0.01-ft drop in stage.
2-2500	Turkey Creek near Palm Bay	28°00′46″	80°36′28″	−1.03	2.36	03:45	34	.05	
2-2520	Fellsmere Canal near Fellsmere	27°49′18″	80°36′27″	7.90	1.50	04:10	34	.01	
2-2540	North Fork St. Lucie River at White City.	27°22′26″	80°20′33″	MSL	----------	04:15	----------	.13	Seiche lasted about 20 min.
2-2560	Fisheating Creek near Venus	27°03′57″	81°25′52″	46.52	9.92	04:35	2	.04	
2-2638	Shingle Creek at airport, near Kissimmee.	28°18′14″	81°27′04″	60.66	5.02	04:05	45	.04	Seiche lasted about 15 min.
2-2674	Lake Hatchineha near Lake Wales	28°00′00″	81°22′50″	47.23	4.90	04:40	*6,636*	Tr.	
2-2691	Kissimmee River at Fort Kissimmee	27°35′27″	81°09′20″	37.98	7.03	04:40	----------	.04	
2-2715	Josephine Creek near DeSoto City	27°22′26″	81°23′37″	52.99	3.75	04:20	21	Tr.	
2-2720	Istokpoga Canal near Cornwell	27°22′56″	81°09′45″	27.91	35.00	04:10	10	Tr.	
	Auxiliary	27°23′16″	81°10′50″	----------	5.46	04:10	10	Tr.	
2-2784.5	West Palm Beach Canal near Loxahatchee.	26°41′05″	80°22′15″	MSL	----------	04:35	135	----------	0.14/0.06 units on deflection meter.
	Auxiliary	26°41′05″	80°22′00″	MSL	12.75	03:50	135	.22	Seiche lasted about 60 min.
2-2975	Joshua Creek at Nocatee	27°09′59″	81°52′47″	3.94	4.32	04:20	13	.07	Seiche lasted about 20 min.
2-2980	Horse Creek near Arcadia	27°11′57″	81°59′19″	10.96	3.03	04:10	76	.04	
2-2982	Myakka River at Myakka City	27°20′47″	82°09′27″	23.81	5.91	04:20	433	Tr.	
2-2990	Myakka River near Sarasota	27°14′25″	82°18′50″	7.92	4.31	04:15	74	.02	
2-3014	Turkey Creek near Durant	27°56′15″	82°11′39″	43.00	2.52	03:50	----------	.03	
2-3034	Cypress Creek near San Antonio	28°19′25″	82°23′03″	MSL	73.18	04:25	29	Tr.	
2-3038	Cypress Creek near Sulphur Springs	28°05′20″	82°24′33″	MSL	28.52	04:15	----------	.02	

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Florida—Continued								
2-3045	Hillsborough River at 22d Street, near Tampa.	28°01′15″	82°26′05″	MSL	0.50	04:15	472	0.15	Seiche superimposed on tidal curve.
2-3065	Sweetwater Creek near Sulphur Springs.	28°02′33″	82°30′44″	30.68	.50	04:20	41	Tr.	
2-3103	Pithlachascotee River nr. New Port Richey.	28°15′19″	82°39′37″	7.06	4.28	04:40	33	Tr.	
2-3105.5	Weekiwachee River near Bayport	28°31′56″	82°37′38″	−10.00	10.34	03:45	----------	.01	0.38 units on deflection meter.
2-3106.5	Chassahowitzka River near Homosassa.	28°42′54″	82°34′38″	−10.00	11.64	04:00	----------	.03	
2-3107	Homosassa River at Homosassa	28°47′06″	82°37′05″	−10.00	?	04:15	----------	Tr.	Possibly 0.2 units on deflection meter.
2-3107.5	Crystal River near Crystal River	28°54′17″	82°38′13″	−10.00	----------	03:50	----------	.06	Seiche superimposed on tidal curve.
2-3142	Tenmile Creek at Lebanon Station	29°09′39″	82°38′21″	15.00	6.35	04:40	63	.02	
2-3155	Suwannee River at White Springs	30°19′32″	82°44′18″	48.54	----------	03:50	4,450	Tr.	
2-3155.5	Suwannee River at Suwannee Springs	30°23′34″	82°56′00″	MSL	55.25	03:40	----------	.13	
2-3195	Suwannee River at Ellaville	30°23′04″	83°10′19″	27.22	18.50	03:45	17,700	.06	
2-3235	Suwannee River near Wilcox	29°36′	82°56′	MSL	12.10	03:45	26,800	.24	
2-3590	Chipola River near Altha	30°22′02″	85°09′55″	19.95	17.25	03:50	4,120	.30	
2-3680	Yellow River at Milligan	30°45′10″	86°37′45″	45.00	6.34	03:40	1,860	.01	
2-3765	Perdido River at Barrineau Park	30°41′25″	87°26′25″	25.77	3.44	03:10	855	.20	
2-2785	West Palm Beach Canal near Loxahatchee (S-5A).	26°41′00″	80°22′10″	MSL	12.70	04:35	132	.03	On head water; brief decline of 0.01 ft on tail water.
2-2785.5	Levee 8 Canal at West Palm Beach Canal, near Loxahatchee.	26°41′05″	80°21′35″	MSL	7.30	04:35	112	.32	No trace on deflection meter.
2-2790	West Palm Beach Canal at West Palm Beach.	26°38′40″	80°03′32″	MSL	8.23	04:20	182	.06	0.02 units on deflection meter.
2-2805	Hillsboro Canal below HGS-4, near South Bay.	26°42′00″	80°42′45″	MSL	−.52	04:20	238	.30	A 0.08-ft drop in stage.
2-2813	Hillsboro Canal near Deerfield Beach	26°21′20″	80°17′58″	MSL	15.83	04:00	46	.01	No trace on deflection meter.
2-2815	do	26°19′39″	80°07′51″	MSL	1.22	04:30	67	.13	Seiche superimposed on tidal curve; no trace on deflection meter.
2-2817	Pompano Canal at S-38, near Pompano Beach.	26°13′45″	80°17′50″	MSL	6.50	04:00	3	.20	
2-2820	Pompano Canal at Pompano Beach	26°13′51″	80°07′28″	MSL	3.74	04:10	----------	.04	No trace on deflection meter.
2-2821	Cypress Creek at S-37A, near Pompano Beach.	26°12′20″	80°07′57″	MSL	3.82	04:00	----------	.03	0.44 units on deflection meter.
2-2832	Plantation Road Canal at S-33, near Fort Lauderdale.	26°08′05″	80°11′42″	MSL	5.96	03:55	----------	.04	
2-2850	North New River Canal near Fort Lauderdale (auxiliary).	26°05′39″	80°13′50″	MSL	?	04:40	39	?	Seiche superimposed on tidal curve.
2-2854	South New River Canal (east of S-9) near Davie.	26°03′40″	80°26′30″	MSL	?	04:10	0	----------	0.02 ft on lower stage; 0.05 ft on upper stage. 0.04 units on deflection meter.
2-2861	South New River Canal at S-13 near Davie.	26°03′57″	80°12′32″	MSL	?	04:15	----------	----------	No trace on upper stage; trace on lower stage. 0.09 units on deflection meter.
2-2861.8	Snake Creek Canal at S-30 near Hialeah.	25°57′22″	80°25′54″	MSL	5.53	04:00	----------	.06	0.48 on deflection meter with a slight decrease in flow.
2-2862	Snake Creek Canal at NW 67th Ave., near Hialeah.	25°37′50″	80°18′40″	MSL	2.52	04:00	----------	.00	0.16 deflection units on deflection meter.
2-2863	Snake Creek Canal at S-29 at North Miami Beach.	25°33′41″	80°09′22″	MSL	2.52	03:55	26	.11	Seiche lasted about 60 min; 0.29/0.36 units on deflection meter followed by slight decrease in flow.
2-2863.4	Biscayne Canal at S-28 near Miami	25°52′24″	80°10′55″	MSL	2.00	04:15	36	.01	0.41 units on deflection meter of which 0.19 was lasting decrease in flow.
2-2863.5	Little River Canal at Palm Avenue, in Hialeah.	25°52′13″	80°17′00″	MSL	2.05	04:35	----------	.01	
2-2863.8	Little River Canal at S-27, in Miami	25°51′11″	80°11′36″	MSL	----------	04:40	----------	Tr.	Seiche lasted about 60 min; 0.40 units on deflection meter with small permanent decrease in flow.
2-2864	Miami Canal at HGS-3 and S-3, in Lake Harbor.	26°41′55″	80°48′25″	MSL	13.45	04:15	----------	.15	Quake affected the lakeside gage but not the landside gage; 0.56/0.12 units on deflection meter with apparent lasting increase of 0.02 units.
2-2864	Miami Canal south of S-3 at Lake Harbor.	26°41′55″	80°48′25″	MSL	----------	04:00	----------	----------	0.38/0.40 units on deflection meter with no lasting change in flow.
2-2874	Miami Canal at broken dam near Miami.	25°56′00″	80°25′50″	MSL	----------	----------	----------	----------	Trace of quake on both stage and deflection records.
2-2875	Miami Canal at Pennsuco near Miami.	25°53′40″	80°22′45″	MSL	2.95	?	----------	.05	Seiche lasted about 150 min.
2-2882	Miami Canal at Palmetto By-pass, near Hialeah.	25°51′11″	80°19′22″	MSL	2.55	04:05	----------	.07	0.02 units on deflection meter.
2 2886	Miami Canal at NW 36th St., Miami	25°48′29″	80°15′44″	MSL	2.42	04:15	----------	.04	0.33/0.29 units on deflection meter; seiche lasted about 40 min.
2-2888	Tamiami Canal outlets, Monroe to Carnestown (at bridge 84).	25°53′10″	81°15′30″	MSL	1.33	03:30	----------	.05	
	Tamiami Canal at bridge 77 near Carnestown (auxiliary).	25°54′	81°21′	3.14	4.00	03:30	----------	.05	Seiche superimposed on tidal (?) curve.
2-2889	Tamiami Canal at 40-mile bend, near Miami (auxiliary).	25°45′50″	80°49′50″	MSL	7.28	03:45	10	.06	
2-2890	Tamiami Canal at bridge 45, near Miami.	25°45′40″	80°37′40″	----------	6.22	04:45	----------	.10	

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Florida—Continued								
2-2890.4	Tamiami Canal below S-12-C, near Miami (auxiliary).	25°45′40″	80°43′34″	0.04	6.88	05:00	....	0.03	
	Tamiami Canal below S-12-B, near Miami (auxiliary).	25°45′40″	80°46′05″	.04	6.98	03:35	....	.05	
	Tamiami Canal above S-12-B, near Miami (auxiliary).	25°45′42″	80°46′05″	.05	7.15	04:15	....	.04	
	Tamiami Canal above S-12-C, near Miami (auxiliary).	25°45′42″	80°43′34″	....	7.15	03:40	....	.04	
2-2895	Tamiami Canal near Coral Gables	25°45′43″	80°19′42″	MSL	2.50	05:00	50	.04	No trace on deflection meter.
2-2905.1	Miami Canal at NW 27th Ave., Miami	25°47′32″	80°14′24″	MSL	1.20	04:10	....	.37	Seiche superimposed on tidal curve.
2-2905.2	South Fork Miami River at NW 29th Ave., Miami.	25°47′00″	80°14′32″	MSL	....	04:10	....	.03	
2-2905.3	Miami River at Brickell Ave., Miami	25°45′11″	80°11′25″	MSL	0.87	03:55	....	.17	Seiche superimposed on tidal curve. 1.09 units on deflection meter with no lasting change in flow.
2-2905.6	Coral Gables Canal at Red Road, in Coral Gables.	25°44′17″	80°17′13″	MSL	2.53	04:30	....	.02	
2-2905.8	Coral Gables Canal near South Miami.	25°42′20″	80°15′40″	MSL	.25±	04:25	....	.15	Seiche superimposed on tidal curve. 0.70 units on deflection meter.
2-2906	Snapper Creek Canal near Coral Gables.	25°45′40″	80°23′05″	MSL	3.05	04:10	....	.02	Pen lines of stage and deflection were both slightly displaced downward; 0.1 units on deflection meter.
	Snapper Creek Canal at Miller Drive, near South Miami (auxiliary).	25°42′56″	80°22′59″	MSL	3.00	04:10	....	.09	Seiche lasted about 40 min.
2-2907	Snapper Creek Canal at S-22, near South Miami.	25°40′11″	80°17′03″	MSL	2.94	03:45	....	.03	0.07 units on deflection meter; seiche lasted about 30 min.
2-2907.15	Goulds Canal near Goulds	25°32′15″	80°19′55″	MSL	....	03:25	....	.03	
2-2907.2	Military Canal near Homestead	25°29′20″	80°20′55″	MSL	.79	04:05	....	.05	Seiche lasted about 20 min.
2-2907.45	Model Land Canal at control, near Florida City (auxiliary).	25°21′59″	80°25′53″	MSL	....	04:20	....	.05	Seiche lasted about 20 min.
2-2908.5	Shark River near Homestead	25°23′10″	81°01′00″	....	....	04:00	....	.30	Seiche superimposed on tidal curve; 0.75 units on deflection meter.
2-2934.8	Lake Otis at Winter Haven	28°01′10″	81°42′35″	120.00	6.15	03:55	*144*	Tr.	
2-2949	Saddle Creek at structure P-11, near Bartow.	27°56′17″	81°51′05″	94.08	1.02	03:55	2	.01	
2-2962	Little Charlie Bowlegs Creek near Sebring (auxiliary).	27°48′40″	81°33′25″	62.32	16.52	04:40	3	.02	
2-2965	Charlie Creek near Gardner	27°22′29″	81°47′48″	21.66	3.21	?	322	Tr.	
	Georgia								
2-1872.5	Hartwell Reservoir near Hartwell	34°21′25″	82°49′20″	....	664.39	03:50	....	0.05	
2-1975.5	Little Brier Creek near Thomson	33°20′24″	82°27′29″	313.95	6.47	04:20	100	.04	On edge of Cretaceous overlap.
2-1980	Brier Creek at Millhaven	32°56′00″	81°39′05″	95.88	6.94	04:20	1,380	.05	
2-2030	Canoochee River near Claxton	32°11′05″	81°53′25″	80.5	8.00	03:55	1,190	.09	On Ochlockonee Fault of Sever (1966).
2-2130.5	Walnut Creek near Gray	32°58′20″	83°37′10″	390	2.10	04:00	60	.03	
2-2210	Murder Creek near Monticello	33°25′	83°40′	498.21	1.32	04:00	60	.02	On Towaliga fault.
2-2255	Ohoopee River near Reidsville	32°04′	82°11′	73.8	10.75	04:30	2,750	.09	On possible extension of Ochlockonee fault of Sever (1966).
2-2261	Penholoway Creek near Jesup	31°34′00″	81°50′18″	....	6.74	04:05	118	.03	On fault of Callahan (1964, fig. 5).
2-2265	Satilla River near Waycross	31°14′	82°19′	66.43	11.78	04:40	2,000	.06	Do.
2-3145	Suwannee River at Fargo	30°41′	82°34′	91.90	10.76	....	2,200	.07	
	Auxiliary	30°	....	....	....	....	....	.03	
2-3160	Alapaha River near Alapaha	31°23′	83°10′	209.34	9.80	03:35	1,480	.09	On possible extension of Ochlockonee fault of Sever (1966).
2-3175	Alapaha River at Statenville	30°42′	83°01′	76.77	12.19	04:40	2,650	.22	On fault of Callahan (1964, fig. 5).
2-3275	Ochlockonee River near Thomasville	30°52′	84°03′	133.6	14.10	04:30	3,300	.05	On Ochlockonee fault of Sever (1966).
2-3316	Chattahoochee River near Cornelia	34°33′	83°37′	1,128.53	3.24	04:10	3,000	.03	
2-3350	Chattahoochee River near Norcross	34°00′	84°12′	878.14	....	....	....	.18	On Brevard fault zone.
2-3390	Yellowjacket Creek near La Grange	33°05′25″	85°03′45″	601	4.35	03:40	245	.12	
2-3432	Pataula Creek near Lumpkin	31°56′	84°48′	224.34	2.44	04:10	120	.15	On edge of Tertiary overlap.
2-3465	Potato Creek near Thomaston	32°54′15″	84°21′45″	600	4.35	05:00	880	.03	On SE flank of Wacoochee anticlinal belt.
2-3490	Whitewater Creek below Rambulette Creek, nr. Butler.	32°28′	84°16′	365.85	1.86	04:10	180	.015	Near edge of Tertiary overlap.
2-3499	Turkey Creek at Byromville	32°12′	83°54′	....	8.34	04:20	130	.05	Near Andersonville fault.
2-3506	Kinchafoonee Creek at Preston	32°03′	84°33′	337.7	4.86	04:10	375	.06	
2-3534	Pachitla Creek near Edison	31°33′	84°41′	212.64	5.34	04:30	440	.11	
2-3560	Flint River at Bainbridge	30°55′	84°34′	58.06	20.80	04:00	15,000	.13	
2-3570	Spring Creek near Iron City	31°03′	84°43′	85.7	9.60	04:20	1,100	.09	
2-3800	Ellijay River at Ellijay	34°42′	84°29′	1242.32	5.63	04:40	800	.06	On Murphy syncline.
2-3870	Conasauga River at Tilton	34°40′	84°56′	622.28	21.30	04:00	12,000	.10	On Rome fault.
2-3885	Oostanaula River near Rome	34°18′	85°08′	561.70	32.10	04:05	28,000	.09	Do.
2-3970	Coosa River near Rome	34°12′	85°16′	553.05	31.10	04:00	43,000	.12	In Coosa syncline extended and near Rome fault.

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Hawaii								
	[No effects of the Alaska earthquake were found on records of stations on the islands of Oahu, Maui, and Molokai in the Hawaiian group nor of stations on Okinawa and on the islands of Guam and Tutuila, American Samoa]								
40-0310	Waimea River near Waimea, Kauai	21°59′02″	159°39′46″	25	4.59	03:50	169	Tr.	
40-0610	North Wailua ditch near Lihue, Kauai.	22°03′55″	159°28′12″	1,105.45	7.23	04:00	24	0.03	
40-1000	Hanalei tunnel outlet near Lihue, Kauai.	22°04′57″	159°27′52″	1,201	1.00	03:45	45	Tr.	
40-7040	Wailuku River above Hila School ditch, near Hilo, Hawaii.	19°42′55″	155°09′10″	1,060	4.58	03:45	302	.17	
40-7580	Waikoloa Stream at Marine Dam, near Kamuela, Hawaii.	20°02′48″	155°39′58″	3,450	1.60	03:45	7.4	.01	
	Idaho								
13-0320	Bear Creek above reservoir near Irwin.	43°16′45″	111°13′15″	5,640	------	------	18	0.01	
13-0505	Henrys Fork at St. Anthony	43°58′	111°40′20″	4,950.7	------	------	1,110	.02	
13-0522	Teton River near Driggs	43°47′	111°13′	5,952.9	------	------	236	.03	
------	Disposal Pond at National Reactor Testing Station.	43°	112°	------	4,919.10	03:40	------	.56	Seiche lasted about 140 min.
3-2015	Lucky Peak Reservoir near Boise	43°32′	116°04′	MSL	2,991.30	------	*146,100*	.24	Seiche lasted more than an hour. On a normal fault.
	Illinois								
3-3815	Little Wabash River at Carmi	38°03′40″	88°09′35″	339.91	26.74	04:00	8,700	Tr.	On a fault trending north-northeast.
	Auxiliary	38°05′30″	88°09′20″	339.91	26.23	04:00	8,700	0.10	Do.
3-3825	Saline River near Junction	37°41′52″	88°16′00″	320.40	37.07	------	1,200	.02	On extension of a fault trending north-northeast.
	Auxiliary	37°39′15″	88°15′10″	320.42	36.25	03:50	1,200	.02	Do.
4-0925	Wolf Lake at Chicago	41°39′53″	87°32′22″	580.45	1.25	04:00	------	.04	
4-	West Branch Du Page River	41°43′20″	88°07′45″	------	2.00	------	------	.04	
4-	East Branch Du Page River	41°44′10″	88°07′59″	------	2.14	------	------	.03	
5-	Money Creek at Lake Bloomington	40°39′47″	88°56′23″	700.00	8.32	04:00	------	.052	
	Indiana								
3-3285	Eel River near Logansport	40°46′55″	86°15′50″	621.50	5.80	04:00	2,000	Tr.	Bubble gage.
3-3301.4	Smalley Lake near Washington Center	41°18′52″	85°35′03″	------	2.77	04:15	*63*	0.03	A residual 0.01-ft rise in stage. On south side of Michigan basin.
3-3355	Wabash River at Lafayette	40°25′19″	86°53′49″	504.14	9.40	04:20	13,000	.07	
3-3405	Wabash River at Montezuma	39°47′33″	87°22′26″	457.75	10.70	04:00	15,000	.24	
3-3485	White River near Noblesville	40°07′	85°38′	763.08	5.38	04:40	760	.02	
3-3488	White River at Clare	40°06′	85°58′	------	15.40	03:50	------	.08	
3-3510	White River at Broad Ripple near Nora (auxiliary).	39°52′18″	86°08′30″	710.94	3.55	03:50	1,300	.39	
3-3530	White River at Indianapolis	39°45′05″	86°10′30″	662.26	4.72	04:00	1,720	.04	A residual 0.02-ft drop in stage.
3-3532	Eagle Creek at Zionville	39°56′56″	86°15′22″	816.85	3.34	03:50	146	Tr.	A residual 0.01-ft drop in stage.
3-3630	Driftwood River near Edinburg	39°20′21″	85°59′11″	636.99	4.35	03:25	1,200	No seiche	A 0.05-ft drop in stage.
3-3715	East Fork White River near Bedford (auxiliary).	38°49′33″	86°30′48″	473.59	------	03:50	5,100	.06	
3-3752	Beaver Creek Reservoir near Jasper	38°24′10″	86°50′30″	------	27.82	04:00	------	0.07	On east side of Illinois basin.
4-0930	Deep River at Lake George outlet at Hobart.	41°32′05″	87°15′30″	588.17	2.32(?)	04:10	100	.03	
4-0976.8	Jimerson Lake at Nevada Mills	41°43′31″	85°04′55″	964.44	4.45	04:15	*283*	.05	On south side of Michigan basin.
4-0995	Pigeon Creek at Hogback Lake outlet near Angola.	41°37′24″	85°05′44″	940.00	8.93	03:50	35	.05	Do.
4-1004.5	Syracuse Lake at Syracuse	41°25′23″	85°44′41″	858.57	8.20	04:00	414	.02	Do.
	Iowa								
5-4870	Lake Ahquabi near Indianola	41°17′35″	93°35′40″	------	5.42	03:45	------	0.02	
5-4590	Shell Rock River at Northwood	43°24′50″	93°13′10″	------	------	------	225	No seiche	A lasting 0.02-ft. drop in stage. On southwest flank of syncline.
	Kansas								
6-8535	Republican River near Hardy	40°00′	97°56′	1,501.46	3.80	04:05	157	0.00/.07	On northeast flank of Salina basin. Bubble gage.
6-8665	Smoky Hill River at Mentor	38°47′54″	97°34′28″	1,211.40	6.20	03:50	66	.00/.04	On Abilene arch. Bubble gage.
6-8870	Big Blue River near Manhattan (auxiliary).	39°14′14″	96°34′16″	991.86	3.80	03:55	400	.00/.17	On Nemaha uplift. Bubble gage.
6-9110	Marais des Cygnes at Melvern	38°31′50″	95°46′40″	939.11	5.60	04:00	.2	.00/.07	Bubble gage. A residual 0.02-ft. drop in stage.

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—**Continued**

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Kansas—Continued								
7-1423	Rattlesnake Creek near Macksville	37°52′20″	98°52′30″	1,963.46	3.85	04:00	26	0.00/.03	South-southeast of Central Kansas uplift. Bubble gage.
7-1478	Walnut River at Winfield	37°14′	97°00′	1,082.86	2.67	03:55	40	.00/.05	On trough on east side of Nemaha uplift. Bubble gage.
7-1659	Toronto Reservoir near Toronto	37°44′30″	95°56′00″	897.46	----------	04:10	*13,000*	.05	On crest of Precambrian rise.
7-1675	Otter Creek near Climax	37°42′30″	96°13′30″	977.76	2.99	04:10	0	.02	A residual 0.002-ft drop in stage.
7-1680	Fall River Reservoir near Fall River	37°39′	96°04′	943.11	----------	04:10	*15,000*	.04	
7-1685	Fall River near Fall River	37°38′	96°03′	898	3.81	04:10	14	.14	
7-1800	Cottonwood River near Marion	38°21′	97°04′	1,289.85	1.84	03:55	13	.03/.06	On east flank of Nemaha uplift. Bubble gage.
7-1832	Neosho River near Chanute	37°43′49″	95°26′26″	887.94	7.75	04:05	71	.00/.13	On crest of Precambrian rise. Bubble gage.
	Kentucky								
3-2808	Buckhorn Reservoir at Buckhorn	37°20′24″	83°28′13″	MSL	766.70	03:30	*17,000*	0.57	
3-2960	Plum Creek subwatershed 4 near Simpsonville.	38°10′27″	85°22′05″	687.99	15.84	03:45	*88* 2.1	.02	
3-3109	Nolin River Reservoir near Kyrock	37°16′40″	86°14′51″	MSL	514.38	03:40	*200,000*	.40	Reservoir covers about 5,800 acres. At east end of Moorman syncline.
3-3180.05	Rough River Reservoir near Falls of Rough.	37°37′11″	86°29′59″	MSL	462.43	04:00	*19,000*	.02	Reservoir covers about 5,000 acres. On a northeast-trending fault.
	Louisiana								
2-4895	Pearl River near Bogalusa	30°47′35″	89°49′15″	55.00	19.15	04:30	31,000	0.34	
2-4900	Bogue Lusa Creek near Franklinton	30°52′05″	90°00′10″	210.56	1.87	03:55	12	.02	
2-4901.05	Bogue Lusa Creek at Hwy 439 at Bogalusa.	30°46′56″	89°52′24″	76.60	4.10	04:00	120	.00/.03	Float gage.
2-4920	Bogue Chitto near Bush	30°37′45″	89°53′50″	44.25	6.20	04:00	2,000	.62	
7-3444.5	Paw Paw Bayou near Greenwood	32°31′00″	93°58′20″	170.35	2.77	03:40	23	.05	
7-3470	Kelly Bayou near Hosston	32°51′25″	93°52′20″	165.53	3.18	04:00	70	.05	
7-3487	Bayou Dorcheat near Springhill	32°59′40″	93°23′45″	173.91	9.08	----------	450	.15	
7-3488	Flat Lick Bayou near Leton	32°46′10″	93°16′00″	182.79	3.82	04:00	40	.03	
7-3490	Bayou Dorcheat near Minden (auxiliary).	32°38′40″	93°20′15″	----------	6.90	----------	----------	.14	Between a dome and a basin.
7-3498	Cypress Bayou near Benton	32°43′20″	93°41′15″	165.98	4.48	03:45	94	.07	
7-3500	Loggy Bayou near Ninock	32°14′10″	93°25′35″	----------	19.75	04:00	----------	.28	On southeast side of crest of Sabine uplift.
	Auxiliary	32°11′40″	93°26′30″	----------	18.90	04:00	----------	.68	Do.
7-3510	Boggy Bayou near Keithville	32°22′35″	93°49′20″	145.13	9.87	06:00(?)	14	.05	
7-3517	Bayou Na Bonchasse near Mansfield	32°06′05″	93°41′45″	165.78	2.34	04:00	4	No seiche	A lasting 0.01-ft drop in stage.
	Bayou Dupont near Marthaville	31°42′00″	93°22′45″	----------	1.90	----------	----------	.02	
7-3519	Bayou Dupont near Robeline	31°42′15″	93°19′38″	123.51	1.83	04:00	6	.07	
7-3520	Saline Bayou near Lucky	32°15′00″	92°58′35″	152.65	3.68	04:10	55	.05	
7-3528	Grand Bayou near Coushatta	32°02′55″	93°18′10″	136.26	2.25	03:45	25	.02	
7-3530	Saline Bayou near Clarence	31°49′05″	92°56′55″	72.75	10.0	04:00	900	.12	
	Auxiliary	31°49′	92°56′	72.97	7.85	04:10	----------	.18	
7-3545	Horsepen Creek near Provencal	31°36′05″	93°12′05″	149.06	2.31	----------	----------	No seiche	Water-level trend changed at time of quake.
7-3641	Ouachita River near Arkansas-Louisiana State Line	33°01′55″	92°05′10″	44.09	20.10	04:20	----------	.00/.10	Bubble gage.
7-3642	Bayou Bartholomew near Jones	32°59′25″	91°39′20″	79.21	15.00	03:50	2,390	.17	
7-3643	Chemin-a-Haut Bayou near Beekman.	32°58′55″	91°48′20″	85.58	2.66	04:30	31	.06	
7-3645	Bayou Bartholomew near Beekman	32°52′20″	91°52′04″	70.60	11.5	04:00	----------	.26	
7-3647	Bayou de Loutre near Laran	32°57′20″	92°30′00″	112.34	3.06	04:10	118	.04	
7-3650	Bayou D'Arbonne near Dubach	32°40′50″	92°39′10″	83.25	6.7	04:10	200	.08	
7-3662	Little Corney Bayou near Lillie	32°55′40″	92°37′55″	91.48	3.88	04:10	100	.14	
7-3677	Boeuf River near Arkansas-Louisiana State line.	32°58′35″	91°26′20″	74.11	3.07	04:50	580	.57	
	Auxiliary	32°57′35″	91°27′35″	74.35	2.60	04:50	----------	.00/.09	On Monroe uplift. Bubble gage.
7-3695	Tensas River at Tendal	32°25′55″	91°22′00″	50.07	6.65	----------	70	.05?	Seiche masked by wind.
	Auxiliary	32°23′35″	91°19′55″	50.07	5.78	04:00	70	.00/.20	A residual 0.05-ft drop in stage but trace was jerky. Bubble gage.
7-3697	Bayou Macon near Kilbourne	32°59′35″	91°15′45″	77.41	2.07	03:50	250	.08	
7-3700	Bayou Macon near Delhi	32°27′25″	91°28′30″	50.05	7.04	04:00	450	.28	
7-3705	Castor Creek near Grayson	32°04′55″	92°12′25″	89.89	6.15	04:10	200	.06	
7-3722	Little River near Rochelle	31°45′15″	92°20′40″	24.79	16.68	04:00	1,400	.41	
	Auxiliary	31°47′25″	92°21′40″	24.79	17.72	04:10	1,400	.28	
7-3725	Bayou Funny Louis near Trout	31°43′00″	92°13′20″	81.51	2.92	03:50	42	.08	
7-3730	Big Creek at Pollock	31°32′10″	92°24′30″	76.79	2.24	03:40	40	.08	
7-3750	Tchefuncta River near Folsom	30°36′55″	90°14′55″	62.11	7.15	03:50	175	.23	
7-3758	Tickfaw River at Liverpool	30°55′47″	90°40′41″	206	2.37	04:10	68	.19	
----------	Comite River trib. at Sharp Station Pond near Baton Rouge.	30°28′45″	91°03′23″	----------	1.95	04:00	----------	.12	
7-3780	Comite River near Comite	30°30′45″	91°04′25″	25.85	—.29	03:50	240	.52(+?)	On an east-west normal fault.
7-3813	Bayou Lafourche at Golden Meadow	29°23′25″	90°15′55″	MSL	.20	04:00	----------	.52/.00	On Golden Meadow fault zone. Float gage.
7-3820	Bayou Cocodrie near Clearwater	31°00′00″	92°22′46″	40.00	13.67	03:40	815	.00/.02	Float gage.
----------	Cocodrie Lake near Clearwater	31°00′00″	92°22′57″	----------	13.85	04:20	----------	.35	
7-3825	Bayou Courtableau at Washington	30°37′05″	92°03′20″	MSL	19.22	04:00	1,200	.11/.19	Do.
7-3835	Bayou des Blaises diversion channel at Moreauville.	31°01′59″	91°58′57″	28.30	8.40	04:30	480	.10	

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Louisiana—Continued								
7-3840	Twelve mile Bayou near Dixie	32°38′45″	93°52′40″	140.00	4.63	04:10	1,400	0.14	On south side of dome.
7-3855	Bayou Teche at Arnaudville	30°23′50″	91°55′50″	MSL	13.60	03:55	1,140	.11/.17	Float gage.
7-3865	Bayou Bourbeau at Shuteston	30°25′40″	92°05′30″	27.14	2.00	04:00	.2	.02	Sharp change in water-level trend after seiche.
7-3867	Ruth Canal near Ruth	30°14′35″	91°53′05″	MSL	10.45	03:40	186	.09/.15	Bubble gage.
8-0120	Bayou Nezpique near Basile	30°28′50″	92°37′55″	3.39	8.95	03:55	----	.22	
8-0130	Calcasieu River near Glenmora	30°59′45″	92°40′25″	110.77	9.25	04:00	----	Tr.	
8-0135	Calcasieu River near Oberlin	30°38′25″	92°48′50″	39.43	8.96	03:50	920	.20	
8-0140	Six mile Creek near Sugartown	30°48′52″	92°55″34′	82.16	3.70	04:05	165	.08	
8-0142	Ten mile Creek near Elizabeth	30°50′11″	92°52′26″	94.38	3.76	----	82	----	Chart time not corrected. Two possible earthquake effects.
8-0145	Whiskey Chitto Creek near Oberlin	30°41′55″	92°53′35″	46.24	5.07	04:05	450	.10/.13	Float gage.
8-0148	Bundick Creek near De Ridder	30°49′09″	93°13′51″	113.75	3.81	04:00	92	.14	
8-0150	Bundick Creek near Dry Creek	30°40′55″	93°02′15″	56.92	3.90	04:00	170	.12	
8-0155	Calcasieu River near Kinder	30°30′10″	92°54′55″	11.95	6.80	04:00	1,800	.04	A residual 0.03-ft drop in stage.
8-0160	English Bayou near Lake Charles	30°16′17″	93°10′37″	MSL	1.99	04:00	----	.24	Earthquake recorded at time of high tide.
8-0164	Beckwith Creek near De Quincy	30°28′15″	93°21′35″	25.29	3.40	04:00	54	.05	
8-0168	Bear Head Creek near Starks	30°13′59″	93°37′44″	16.34	9.14	04:00	56	.12	
8-0230	Bayou Castor near Logansport	31°58′25″	93°58′10″	171.20	2.65	04:00	12	.03	
8-0235	Bayou San Patricio near Noble	31°43′15″	93°42′25″	169.73	5.16	04:15	64	.04	
8-0240.6	Blackwell Creek at Many	31°34′50″	93°27′45″	224.12	2.35	04:00	.3	.04	
8-0255	Bayou Toro near Toro	31°18′25″	93°30′56″	138.00	4.30	03:50	80	.15	
8-0275	Bayou Anacoco near Leesville	31°09′35″	93°21′05″	190.58	6.82	03:55	212	.07	
8-0280	Bayou Anacoco near Rosepine	30°57′10″	93°21′10″	118.09	6.23	03:55	380	.16	
	Maine								
	No seiche was recorded at any gaging station.								
	Maryland								
1-4900	Chicamacomico River near Salem	38°30′45″	75°52′50″	10	1.85	03:50	30	0.04	
1-5892	Gwynns Falls near Owings Mills	39°26′16″	76°46′57″	520	1.24	03:50	4.0	.006	
1-5948	St. Leonard Creek near St. Leonard	38°26′57″	76°29′43″	5	2.94	04:10	7.6	.01	
	Massachusetts								
	No seismic seiche was recorded at any gaging station.								
	Michigan								
4-0964	St. Joseph River near Burlington	42°06′10″	85°02′25″	930	2.74	04:00	140	0.01	On edge of Michigan basin.
4-0966	Coldwater River near Hodunk	42°01′45″	85°06′25″	900	2.99	04:00	120	.01	On edge of Michigan basln; a residual 0.01-ft rise in stage.
4-1115	Deer Creek near Dansville	42°36′30″	84°19′15″	889.08	2.98	04:00	5	.01	On south side of Michigan basin; a residual 0.01-ft drop in stage.
4-1120	Sloan Creek near Williamston	42°40′30″	84°21′50″	862.12	1.89	03:50	2.1	.01	Do.
4-1125	Cedar River at East Lansing	42°43′40″	84°28′40″	824.39	3.65	03:40	115	No seiche	Do.
4-1300	Cheboygan River near Cheboygan	45°34′40″	84°29′15″	591.21	1.40	04:10	860	.00/.03	East of 10-mgal high.
4-1355	Au Sable River at Grayling	44°39′35″	84°42′45″	1,123.49	1.28	03:40	60	.03	East of 0-mgal high.
4-1356	East Branch Au Sable River at Grayling.;	44°40′10″	84°42′20″	1,110	3.42	04:10	34	.05/.00	Do.
4-1460	Farmers Creek near Leaper	43°02′	83°20′	805.79	15.50	03:40	19	.02	On southeast side of Michigan basin.
4-1505	Cass River at Cass City	43°35′10″	83°10′35″	----	----	?	----	No seiche	A residual 0.01-ft rise in stage.
4-1606	Belle River at Memphis	42°54′03″	82°46′09″	720	1.78	04:00	27	.02	On southeast side of Michigan basin.
4-1635	Plum Brook near Utica	42°35′01″	83°01′49″	610	1.58	03:40	12	.015	Do.
4-1640.1	North Branch Clinton River at Almont.	42°54′59″	83°02′42″	830	2.95	04:00	2	.01	Do.
4-1644	Deer Creek near Meade	42°42′39″	82°51′32″	610	.70	04:00	.8	.02	Do.
4-	Kent Lake near New Hudson	42°30′45″	83°40′35″	868.00	13.55	04:00	----	.07	On Howell anticline. On south east side of Michigan basin and 10-mgal high.
----	Reservoirs of City of Lansing	42°	84°	----	----	03:55	21	1.83	7-million gallon reservoir.
----		42°	84°	----	----	03:55	30	1.25	10-million gallon reservoir.
	Minnesota								
5-1075	Roseau River at Ross	48°54′37″	95°55′18″	1,018.44	1.55	03:50	5.0	0.03	Near edge of Cretaceous overlap.
	Mississippi								
2-4330	Bull Mountain Creek near Smithville	34°05′	88°24′	234.81	10.16	04:10	2,700	0.06	Preseiche effect(?).
2-4340	Old Town Creek near Tupelo	34°17′40″	88°42′35″	244.24	5.92	05:00	190	.08	
2-4345	Euclautubba Creek at Saltillo	34°22′20″	88°42′00″	280	4.10	04:10	24	.03	
2-4365	West Fork Tombigbee River near Nettleton.	34°03′32″	88°37′40″	194.01	10.48	04:20	940	.17	

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Mississippi—Continued								
2-4370	Tombigbee River near Amory	33°59′10″	88°33′05″	178.34	18.35	03:40	9,800	0.27	
2-4400	Chookatonchee Creek near Egypt	33°50′30″	88°46′30″	226.07	1.80	03:50	215	.04	
2-4750	Leaf River near McLain	31°06′10″	88°48′30″	42.15	7.81	03:20	4,600	.18	On Wiggins uplift.
2-4765	Sowashee Creek at Meridian	32°22′10″	88°40′40″	305.95	3.08	04:00	70	Tr.	
2-4790	Pascagoula River at Merrill	30°58′40″	88°43′35″	26.25	11.56	04:00	12,500	.66	Do.
2-	Pascagoula River at Cumbest Bluff	30°35′10″	88°34′20″	----------	9.28	04:00	------------	.37	
2-4793	Red River at Vestry	30°44′10″	88°46′50″	20.10	7.80	04:00	800	.16	
2-4825.5	Pearl River near Carthage	32°42′25″	89°31′35″	315.24	?	04:30	?	.12?	No vertical scale on chart.
2-4830	Tuscolameta Creek at Walnut	32°35′	89°28′	332.70	15.65	04:20	------------	.11	
2-4840	Yockanookany River near Kosciusko	33°02′	89°35′	374.34	9.33	04:30	340	.02	
2-4845	Yockanookany River near Ofahoma	32°42′20″	89°40′20″	311.15	6.00	03:30	402	.08	A residual 0.03-ft rise in stage; on east edge of Ouachita tectonic belt.
2-4860	Pearl River at Jackson	32°17′20″	90°10′45″	234.90	27.72	04:00	18,000	.05	On Jackson dome.
2-4885	Pearl River near Monticello	31°33′	90°05′	158.66	21.77	04:00	22,500	.90	
2-4892.4	Lower Little Creek near Baxterville	31°09′30″	89°37′40″	180	3.20	03:55	120	.07	
2-4905	Bogue Chitto near Tylertown	31°11′	90°17′	227.40	----------	?	600	Tr.	Pen trace indistinct.
7-2680	Tallahatchie River at Etta	34°29′00″	89°13′30″	273.48	11.45	05:00	980	.26	
7-2830	Skuna River at Bruce	33°58′25″	89°20′50″	238.75	4.40	03:55	1,280	.06	
7-2900	Big Black River near Bovina	32°20′51″	90°41′48″	84.93	26.85	?	9,000	.06	
	Missouri								
5-5023	Salt River at Hagers Grove	39°49′40″	92°14′10″	----------	4.12	04:30	------------	0.06	A residual 0.03-ft rise in stage.
6-8990	Weldon River at Mill Grove	40°18′	93°36′	786.03	.71	04:00	25	.00/.02	Bubble gage.
6-8995	Thompson River at Trenton	40°04′45″	93°38′35″	721.87	3.83	03:50	113	.02/.00	Do.
6-9067	Flat Creek near Sedalia	38°39′35″	93°15′10″	765	2.25	03:45	10	.13	
6-9216	South Grand River at Urich	38°27′08″	94°00′13″	715.9	2.40	04:00	5	.00/.04	Do.
6-9270	Maries River at Westphalia	38°25′55″	91°59′20″	542.74	2.25	03:45	75	.00/.01	
6-9278	Osage Fork at Dryrot	37°38′00″	92°27′12″	927.85	3.79	04:30	90	.01	On southeast of Decaturville uplift.
6-9280	Gasconade River near Hazlegreen	37°45′35″	92°27′05″	844.75	3.40	04:00	500	.03	Do.
6-9285	Gasconade River near Waynesville	37°52′20″	92°13′40″	738.60	3.30	03:50	720	.03	Do.
6-9355	Loutre River at Mineola	38°53′20″	91°34′30″	539.86	3.29	03:50	40	.02	
7-0210	Castor River at Zalma	37°08′45″	90°04′30″	350.38	5.58	04:30	500	.04	On southeast of domal structure.
7-0375	St. Francis River near Patterson	37°11′40″	90°30′10″	370.45	6.25	04:30	1,600	.04	Do.
7-0395	St. Francis River at Wappapello	36°55′42″	90°17′04″	----------	13.15	04:00	------------	.12	At edge of Tertiary overlap.
7-0435	Little River Ditch 1 near Morehouse	36°50′05″	89°43′50″	280.76	5.98	04:00	600	.05	Near edge of Tertiary overlap.
7-0630	Black River at Poplar Bluff	36°45′35″	90°23′15″	317.38	8.50	04:15	760	.87	At edge of Tertiary overlap.
7-1866	Turkey Creek near Joplin	37°07′15″	94°34′55″	848.80	1.96	04:10	11	.02	
----------	Headwater Diversion Channel at Dutchtown.	37°13′54″	89°39′31″	----------	8.70	04:30	------------	.26	Seiche lasted about 40 min. On southeast of domal structure.
7-1890	Elk River near Tiff City	36°38′	94°35′	750.61	3.28	03:50	200	Tr.	
	Montana								
5-0145	Swiftcurrent Creek at Many Glacier	48°48′10″	113°39′20″	4,860	1.55	04:30	16	0.08	On a thrust fault.
6-0375	Madison River near West Yellowstone.	44°39′20″	111°04′00″	6,650	1.93	04:10	378	.07	May lie on buried extension of thrust faults that trend northwest-southeast. This gage also recorded seiche from Lake Hebgen earthquake.
6-0525	Gallatin River at Logan	45°53′10″	111°26′20″	4,082.3	3.33	04:30	712	.05	On possible extension of a thrust fault.
6-1185	South Fork of Musselshell River above Martinsdale.	46°27′	110°23′	4,900	2.47	03:50	16	.02	On southeast end of Little Belt uplift.
6-1220	American Fork below Lebo Creek, near Harlowtown.	46°24′	109°46′	4,170	2.25	03:45	14	.02	
6-1235	Musselshell River near Ryegate	46°18′	109°12′	3,580	2.86	04:00	21	.01	
6-1307	Sand Creek near Jordan	47°15′	106°51′	2,586.28	2.06	04:10	------------	.01	South of axis of Blood Creek syncline.
6-1322	South Fork of Milk River near Babb	48°45′20″	113°10′00″	----------	2.94	----------	6	.05	
6-1975	Boulder River near Contact	45°33′20″	110°12′00″	4,930	1.66	04:00	56	.015	On extension of a small fault and on north edge of Beartooth uplift.
6-2000	Boulder River at Big Timber	45°50′05″	109°56′20″	4,060	3.44	03:45	110	.04	On southeast end of Crazy Mountains basin.
6-2890	Little Bighorn River at State Line near Wyola.	45°01′	107°37′	4,450	1.84	04:05	71	.03	On a small fault.
6-3075	Tongue River at Tongue River Dam, near Decker.	45°08′	106°46′	3,050	.93	04:00	126	.10	On north end of Powder River basin.
12-3018.5	Kootenai River at Warland Bridge, near Libby.	48°30′00″	115°17′10″	----------	5.22	04:00	2,150	.00/.02	Nontypical seiche with water-level decline and recovery. Bubble gage? On northeast flank of anticline.
12-3235	German Gulch Creek near Ramsey	46°00′50″	112°47′30″	5,200	1.41	04:00	6.2	Tr.	On edge of batholith.
12-3588	Middle Fork Flathead River near West Glacier.	48°29′50″	114°00′30″	3,130	.90	04:00	350	Tr.	On a normal fault.
12-3895	Thompson River near Thompson Falls.	47°35′35″	115°13′40″	2,410	1.78	04:05	115	.04	

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Nebraska								
6-4541	Niobrara River at Agate	42°25′	103°47′	4,440	2.73	04:10	23	0.09	North end of Denver basin.
6-6875	North Platte River at Lewellen (North channel).	41°19′	102°08′	3,284.6	4.20	04:05	1,200	.085	
	North Platte River at Lewellen (South channel).	41°19′	102°08′	3,383.7	5.02	03:55		.12	
6-7635	Lodgepole Creek at Ralton	41°02′00″	102°24′00″	3,590	1.60	04:00	24	.07	
6-7655	South Platte River at North Platte	41°07′	100°46′	2,790.30	2.75	04:05	192	.015	On Cambridge arch.
6-7665	Platte River at Cozad (South channel).	40°50′	99°59′	2,474.07	4.26	03:55	------------	.06	Do.
6-7680	Platte River near Overton	40°41′	99°32′	2,299.83	2.78	----------	1,300	.12	On a normal fault.
6-7890	North Loup River at Scotia	41°27′30″	98°42′40″	1,893.13	2.87	----------	1,100	.18	A residual 0.04-ft rise in stage.
6-7920	Cedar River near Fullerton	41°23′45″	98°00′15″	1,640.40	2.48	03:50	330	.05	
6-8050	Salt Creek at Ashland	41°02′50″	96°20′30″	1,047.04	2.28	04:05	236	.10	On a dome.
6-8490	Harlan County Reservoir near Republican City.	40°04′10″	99°12′30″	MSL	1,939.72	03:40	*267,100*	.075	
6-8810	Big Blue River near Crete	40°35′40″	96°57′35″	1,311.7	?	03:50	132	.025	
6-8829	Little Blue River below Pawnee Creek near Pauling.	40°23′50″	98°13′20″	1,740	3.52	04:00	65	.06	
6-8830	Little Blue River near Deweese	40°20′00″	98°04′10″	1,632.67	3.35	04:00	72	.01	
	Nevada								
	No seiche was recorded at any gaging station.								
	New Hampshire								
1-0535	Androscoggin River at Errol	44°46′55″	71°07′45″	1,227.30	------------	04:20	2,200	Tr.	
	New Jersey								
1-3830	Greenwood Lake at Awosting	41°09′36″	74°20′03″	608.86	10.20	04:00	*20,000*	0.08	In Green Pond syncline.
	New Mexico								
7-1535	Cimarron River near Guy	36°59′15″	103°25′25″	4,900	0.63	04:10	1	0.02	
7-2050	Six Mile Creek near Eaglenest	36°31′09″	105°16′30″	8,195.16	.75	04:10	3	.01	On a normal fault.
7-2062	McEvoy Creek near Eaglenest	36°33′00″	105°13′30″	8,600	.36	04:10	.1	No seiche	A lasting 0.002-ft drop in stage. On fault between volcanics and Precambr ian.
7-2070	Cimarron Creek near Cimarron	36°31′00″	104°58′35″	6,599.58	.79	03:45	2	.01	
7-2085	Rayado Creek at Sauble Ranch, near Cimarron.	36°22′	104°58′	6,880	1.78	03:40	4	.01	
7-2165	Mora River near Golondrinas	35°53′40″	105°09′30″	6,734.1	1.75	--------	4	.00/.03	
7-2171	Coyote Creek above Guadalupito	36°10′30″	105°13′35″	7,700	1.53	03:55 04:40	3	.01/.02	On fault at contact of volcanics and Precambrian.
7-2210	Mora River near Shoemaker	35°48′	104°47′	6,170	.11	04:00	2	.10	At edge of volcanics.
7-2245	Canadian River below Conchas Dam.	35°24′30″	104°10′10″	4,021.90	4.72	04:00	6	.06	
8-2635	Rio Grande near Cerro	36°44′05″	105°41′05″	7,100	3.07	03:55	270	.26	On east edge of volcanics.
8-2645	Red River below Zwergle Dam Site, near Red River.	36°40′25″	105°22′50″	8,871.88	1.70	03.50	4	.02	On a fault.
8-2650	Red River near Questa	36°42′10″	105°34′03″	7,451.92	2.05	04:10	12	.03	On volcanics near a fault.
8-2675	Rio Hondo near Valdez	36°32′30″	105°33′20″	7,650.0	1.72	04:00	7	.03	On contact of Precambrian and Tertiary.
8-2763	Rio Pueblo de Taos below Los Cordovas.	36°22′38″	105°40′04″	6,650	2.08	03:50	24	.03	On Tertiary sediment near volcanics.
8-2842	Willow Creek above Heron Reservoir, near Park View.	36°44′30″	106°37′35″	7,210	.56	--------	2	.02	
8-2855	Rio Chama below El Vado Dawn	36°34′50″	106°43′30″	6,696.12	1.55	03:40	62	.03	
8-3145	Rio Grande at Cochiti	35°37′10″	106°19′20″	5,224.70	3.77	04:00	470	.08	Do.
8-3295	Rio Grande near Bernalillo (site B)	35°17′	106°35′	5,030.57	2.05	04:10	100	.04	
8-3320	Bernardo Interior Drain near Bernardo	34°25′	106°48′	4,713.99	6.00	04:20	------------	.03	
8-3435	Rio San Jose near Grants	35°04′30″	107°45′00″	6,269.47	1.41	04:00	5	No seiche	A lasting 0.005-ft drop in stage. On southeast edge of volcanics.
8-3575	San Antonio Drain near San Marcial	33°44′45″	106°55′15″	4,489.12	3.74	03:50	------------	.03	
8-3810	Gallinas River at Montezuma	35°39′15″	105°16′30″	6,675	3.93	04:00	2	.02	
8-3860	Pecos River near Acme (auxiliary)	33°32′10″	104°22′40″	3,500	3.26	04:20	8	.01	
8-3995	Pecos River (Kaiser Channel) near Lakewood.	32°41′22″	104°17′53″	3,268.53	1.92	03:45	22	.04	
8-4050	Pecos River at Carlsbad	32°25′05″	104°13′25″	3,080.28	1.14	04:00	30	.04	
8-4055	Black River above Malaga	32°13′40″	104°09′05″	3,070	.66	03:50	3	.01	
8-4085	Delaware River near Red Bluff	32°01′25″	104°03′15″	2,900.66	------------	04:10	1	.04	
	New York								
1-3874.5	Mahwah River near Suffern	41°08′27″	74°07′01″	325	------------	04:00	33	No seiche	A lasting 0.01-ft drop in stage. In Great Pond syncline.
1-3710	Shawangunk Kill at Pine Bush	41°37′05″	74°17′40″	305	------------	04:00	130	Tr.	
1-4240	Trout Creek near Rock Royal	42°10′40″	75°16′45″	1,165.70	------------	04:00	100	Tr.	
1-4365	Neversink River at Woodbourne	41°45′25″	74°35′55″	1,180	------------	04:00	80	Tr.	

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
				UNITED STATES—Continued					
				North Carolina					
----------	Fontana Dam Hydro Plant headwater.	35°	83°	1,669.91	------------	----------	*1,000,000*	0.05	
				North Dakota					
5-0590	Sheyenne River near Kindred	46°37′35″	97°00′05″	925.55	3.45	03:00	47	0.06	Do.
6-4690	Jamestown Reservoir near Jamestown.	46°56′03″	98°42′38″	MSL	1,425.44	03:50	*21,000*	No seiche	A lasting 0.08-ft drop in stage. On southeast side of Williston basin.
6-4705	Jamestown River at La Moure	46°21′20″	98°18′15″	1,290.00	7.20	----------	57	Tr.	On southeast side of Williston basin.
				Ohio					
3-0865	Mahoning River at Alliance	40°55′55″	81°05′45″	1,037.3	1.75	04:00	77	Tr.	
3-0910	Milton Reservoir at Pricetown	41°07′40″	80°58′35″	MSL	47.00	04:10	*43,000*	0.07	Near edge of Pennsylvanian overlap.
3-0920	Kale Creek near Pricetown	41°08′25″	80°59′45″	914.7	1.10	03:50	13	.04	
3-1180	Middle Branch Nimishillen Creek at Canton.	40°50′30″	81°21′20″	1,046.6	1.64	04:20	25	.03	
3-1200	Leesville Reservoir near Leesville	40°28′10″	81°11′45″	928.0	36.10	04:15	*8,000*	.04	
3-1280	Tappan Reservoir at Tappan	40°21′35″	81°13′35″	870.0	28.55	04:00	*25,000*	.06	
3-1313	Black Fork at Melco	40°41′55″	82°21′35″	----------	4.63	04:10	------------	.03	
3-1585	Burr Oak Reservoir at Burr Oak	39°32′35″	82°03′30″	MSL	721.40	03:50	*9,400*	.10	
3-2205	O'Shaugnessey Reservoir near Dublin.	40°09′15″	83°07′34″	MSL	848.75	04:20	*17,500*	.08	
3-2210	Scioto River below O'Shaughnessy Reservoir.	40°08′36″	83°07′14″	775.00	5.50	03:20	------------	.04	
3-2215	Griggs Reservoir near Columbus	40°00′54″	83°05′38″	630.38	------------	04:00	*4,820*	.02	
3-2284	Hoover Reservoir at Central College	40°06′30″	82°53′00″	MSL	90.20	03:50	*60,600*	.03	
3-2305	Big Darby Creek at Darbyville	39°42′05″	83°06′35″	713.6	3.00	03:50	490	.08	On east of 20-mgal high.
3-2340	Paint Creek near Bourneville	39°15′49″	83°10′01″	665.2	7.13	04:00	1,650	.14	
3-2395	North Fork Little Miami River near Pritchin.	39°49′40″	83°46′25″	1,011.46	1.95	03:00	------------	.01	
3-2440	Todd Fork near Roachester	39°20′05″	84°05′10″	679.40	6.60	03:30	370	.03	
3-2565	West Fork Mill Creek Reservoir near Greenhills.	39°15′40″	84°29′40″	600.00	75.05	04:30	*1,500*	.09	
3-2580	West Fork Mill Creek at Lockland	39°13′35″	84°27′20″	539.00	4.20	04:00	------------	.01	
3-2640	Greenville Creek near Bradford	40°06′08″	84°25′48″	948.9	2.27	04:00	160	.03	
3-2728	Sevenmile Creek at Collinsville	39°31′23″	84°36′39″	691.95	2.00	04:00	86	.01	Near top of 10-mgal high.
4-1920	Miami and Erie Canal near Defiance	41°17′30″	84°16′50″	656.12	1.60	04:00	11	.03	On south edge of Michigan Basin and on northwest side of Findlay arch.
4-1925	Maumee River near Defiance	41°17′30″	84°16′50″	659.12	------------	03:50	------------	.02	Do.
4-1965	Sandusky River near Upper Sandusky.	40°51′02″	83°15′23″	792.8	2.78	03:50	520	.03	
4-2115	Mill Creek near Jefferson	41°45′10″	80°48′00″	822.59	2.59	04:00	160	.00/.04	Bubble gage(?).
----------	Mill Creek near Jefferson Lake gage	41°45′20″	80°48′00″	----------	0.62	03:50	------------	.25	
				Oklahoma					
7-1505	Salt Fork of Arkansas River near Jet	36°45′	98°08′	1,092.20	4.23	04:00	40	0.04	
7-1510	Salt Fork of Arkansas River at Tonkawa.	36°40′30″	97°18′40″	930.22	4.50	04:05	74	.02	
7-1650	Heyburn Reservoir near Heyburn	35°57′	96°18′	MSL	760.33	03:55	*7,100*	.20	Two seiches(?).
7-1655.5	Snake Creek near Bixby	35°49′10″	95°53′20″	625	2.41	04:00	.2	.01	
7-1713	Oologah Reservoir near Oologah	36°25′19″	95°40′43″	MSL	607.06	04:20	*52,730*	.06	
7-1725	Hulah Reservoir near Hulah	36°56′	96°05′	MSL	726.40	04:05	*15,450*	.055	
7-1746	Sand Creek at Okesa	36°43′10″	96°07′56″	689.20	2.88	03:50	.1	.00/.04	Bubble gage.
7-1760	Verdigris River near Claremore	36°18′30″	95°41′40″	538.62	3.90	04:05	26	.00/.02	Float gage.
7-1765	Bird Creek at Avant	36°29′	96°04′	651.28	2.46	03:50	1.1	.06	
7-1775	Bird Creek near Sperry	36°16′42″	95°57′14″	579.43	1.21	04:15	9.7	.015	
7-1900	Lake O' The Cherrokees at Langley	36°28′	95°02′	MSL	730.90	04:00	*1,117,000*	.44	Unusual rise in stage 40 min before earthquake was recorded. Near Seneca Fault.
7-1912.2	Spavinaw Creek near Sycamore	36°20′00″	94°38′30″	875	2.67	04:00	30	.01	
7-1930	Fort Gibson Reservoir near Fort Gibson.	35°52′	95°14′	MSL	551.70	04:00	*323,000*	.12	
7-1955	Illinois River near Watts	36°07′48″	94°34′12″	893.78	2.30	04:00	126	.11	
7-1960	Flint Creek near Kansas, Okla	36°11′54″	94°42′30″	854.59	6.27	04:00	40	.13	
7-1965	Illinois River near Tahlequah	35°55′	94°55′	664.14	4.05	04:30	320	.11	On a normal fault.
7-1970	Barren Fork at Eldon	35°55′	94°50′	701.14	4.88	03:40	90	.04	
7-2305	Little River near Tecumsah	35°10′25″	96°55′55″	898.52	4.46	04:10	5.4	.03	Do.
7-2315	Canadian River near Calvin	34°58′	96°14′	684.72	1.61	04:00	63	.00/.02	Float gage.
7-2365	Fort Supply Reservoir near Fort Supply.	36°33′	99°34′	MSL	2,001.93	04:15	*11,010*	.055	
7-2375	North Canadian River at Woodward	36°26′	99°17′	1,830.43	3.83	03:40	36	.01	
7-2395	North Canadian River near El Reno	35°33′44″	97°57′32″	1,299.02	5.12	03:20	14	.02	
7-2400	Lake Hefner Canal near Oklahoma City.	35°33′11″	97°37′11″	1,200.96	5.14	03:40	.2	.00/.015	Do.
7-2410	North Canadian River below Lake Overholser near Oklahoma City.	35°28′44″	97°39′47″	1,194.66	10.74	03:40	1.4	.12	
7-2450	Canadian River near Whitefield	35°15′45″	95°14′20″	478.16	4.97	03:55	8.3	.02	
7-2455	Sallisaw Creek near Sallisaw	35°28′	94°52′	474.78	2.48	04:10	35	Tr.?	
7-2465	Arkansas River near Sallisaw	35°21′	94°46′	413.42	?	04:00	1,870	.05?	

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Oklahoma—Continued								
7-2480	Wister Reservoir near Wister	34°56′10″	94°43°10″	MSL	471.60	03:50	*30,030*	0.13	
7-3025	Lake Altus at Lugert	34°54′	99°18′	MSL	1,544.85	04:00	*68,430*	2.9	On Wichita Mountains uplift.
7-3165	Washita River near Cheyenne	35°37′35″	99°40′05″	1,905.98	2.14	04:00	3.5	.02	
7-3250	Washita River near Clinton	35°31′50″	98°58′00″	1,467.60	5.26	04:00	10	.04	
7-3335	Chickasaw Creek near Stringtown	34°27′41″	96°01′36″	540.26	3.45	03:45	5.0	.02	On a thrust fault.
7-3340	Muddy Boggy Creek near Farris	34°16°17″	95°54′43″	444.58	3.10	03:55	67	No seiche	A lasting 0.06-ft drop in stage. Bubble gage.
7-3342	Byrds Mill Spring near Fittstown	34°35′45″	96°39′55″	1,022	2.7	04:00	1.4	No seiche	A lasting 0.15-ft drop in stage; after 80 min water level had recovered to preearthquake level. Float gage. On normal fault at west end of a graben.
7-3375	Little River near Wright City	34°04′10″	95°02′47″	346.76	6.89	04:00	380	No seiche	A lasting 0.01-ft drop in stage.
7-3379	Glover Creek near Glover	34°05′51″	94°54′07″	378.70	4.05	04:00	350	.00/.05	Bubble gage.
	Lake Shawnee near Shawnee	35°20′50″	97°03′45″	MSL	??33.53	04·00	?	.21	
	Oregon								
14-0260	Umatilla River at Yoakum	45°40′40″	119°02′00″	768.21	2.58	04:10	550	0.03	
14-0525	Quinn River near Lapine	43°47′10″	121°50′10″	4,442.1	----------	----------	17	.04?	Poor copy.
14-0575	Fall River near Lapine	43°47′50″	121°34′20″	4,220	1.32	03:40	150	.04	
14-1134	Dog River near Parkdale	45°24′30″	121°31′10″	4,347	2.45	03:30	2.8	.02	Near a normal fault.
14-1451	Hills Creek Reservoir near Oakridge	43°42′30″	122°25′25″	MSL	1,508	03:50	*271,600*	.11	Seiche lasted about 80 min.
14-1490	Lookout Point Reservoir near Lowell	43°54′50″	122°45′00″	MSL	876.8	03:40	*258,000*	.06	Seiche lasted at least 100 min.
14-1530	Cottage Grove Reservoir near Cottage Grove.	43°43′00″	123°02′55″	MSL	876.3	03:50	*18,000*	.05	Seiche lasted about 30 min.
14-1550	Dorena Reservoir near Cottage Grove	43°47′10″	122°57′15″	MSL	810.9	03:40	*41,000*	Tr.	
14-1585	McKenzie River at outlet of Clear Lake.	44°21′40″	121°59′40″	3,015.32	2.24	04:00	300	.02	
14-1594	Cougar Reservoir near Rainbow	44°06′15″	122°14′20″	MSL	1,606.5	03:50	*121,000*	.09	Seiche lasted about 60 min.
14-1680	Fern Ridge Reservoir near Elmira	44°07′15″	123°18′00″	MSL	369	?	*72,000*	Tr.	
14-1700	Long Tom River at Monroe	44°18′50″	123°17′45″	270.57	4.60	?	210	Tr.	
14-1735	Calapooia River at Albany	44°37′15″	123°07′40″	180.85	4.90	03:30	600	Tr.	
14-1805	Detroit Reservoir near Detroit	44°43′20″	122°14′55″	MSL	?	?	*272,000*	Tr.	
14-1980	Willamette River at Wilsonville	45°17′31″	122°46′05″	MSL	56.60	03:30	21,000	.14	
14-2010	Pudding River near Mount Angel	45°03′47″	122°49′45″	119.76	6.84	03:30	620	.10	On axis of buried syncline.
14-3232	Tenmile Creek near Lakeside	43°34′40″	124°11′30″	MSL	9.55	03:30	350	.02	Tsunami crest arrived 4⅜ hr after seiche.
	Pennsylvania								
	[Only 2 of 102 analog-recorder installations in Pennsylvania recorded the quake]								
1-5520	Loyalsock Creek at Loyalsock	41°19′25″	76°54′40″	585.63	4.57	04:10	1,400	0.04	On axis of anticline.
3-1111.5	Brush Run near Buffalo	40°11′54″	80°24′28″	980	2.20	03:50	7.7	.05	
	Puerto Rico								
	No seiche was recorded at any gaging station.								
	Rhode Island								
	No seiche was recorded at any gaging station.								
	South Carolina								
2-1309.1	Black Creek near Hartsville	34°23′50″	80°09′00″	----------	7.24	04:20	550	0.01	Near buried southwest border of slate belt.
2-1315	Lynches River near Bishopville	34°15′	80°13′	161	----------	04:15	2,000	.05	On edge of Tertiary overlap.
2-1360	Black River at Kingstree	33°39′40″	79°50′10″	25.66	10.21	04:40	2,700	Tr.	
2-1480	Wateree River near Camden	34°14′40″	80°39′15″	119.36	18.00	04:00	19,500	.04	On edge of Cretaceous overlap.
2-1545	North Pacolet River at Fingerville	35°07′15″	81°59′10″	715.56	4.48	04:25	500	.08	
2-1615	Broad River at Richtex	34°11′05″	81°11′48″	184.84	10.00	03:50	34,500	.08	Seiche lasted about 60 min.
2-1705	Lakes Marion-Moultrie diversion canal near Pineville.	33°23′15″	80°08′25″	MSL	75.85	04:10	26,000	.12	Seiche lasted about 30 min.
	Auxiliary	33°23′	80°08′	60.00	0.96	04:30	26,000	.00/.02	Bubble gage?
	South Dakota								
6-4040	Battle Creek near Keystone	43°52′18″	103°20′08″	3,790	0.88	03:30	3	Tr.	A residual 0.005-ft rise in stage; on south edge of Williston basin.
6-4100	Castle Creek below Deerfield Dam	44°01′50″	103°46′35″	5,805	1.24	04:15	2	0.03	Do.
6-4675	Missouri River at Yankton	42°52′	97°24′	1,159.68	1.15	04:00	24,500	.14	May be due to reflection from Sioux uplift.
6-4730	James River at Ashton	45°00′02″	98°28′57″	1,244.4	4.58	03:30	20	.01	On southeast edge of Williston basin.
6-4760	James River at Huron	44°21′55″	98°11′45″	1,223.44	9.04	03:30	20	.03	Do.
6-4795	Big Sioux River at Watertown	44°56′30″	97°08′50″	1,710	5.68	04:15	3	.04	Do.

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Tennessee								
3-4250	Cumberland River at Carthage	36°14′42″	85°57′15″	456.33	18.60	04:15	41,300	0.36	Seiche lasted about 30 min. On Cincinnati arch.
----------	Cumberland River at Rome	36°15′50″	86°04′10″	449.43	11.75	03:40	------------	.21	Do.
3-4265	Cumberland River below Old Hickory.	36°15′39″	86°40′30″	399.55	19.60	04:10	37,400	.42	On northwest side of Nashville dome.
3-4280	West Fork Stones River near Murfreesboro.	35°49′20″	86°25′03″	569.51	3.35	04:00	400	.05	On crest of Nashville dome.
3-4670	Lick Creek at Mohawk	36°12′09″	83°02′53″	1,072.17	11.57	03:45	1,110	.03	In Bays Mountain syncline.
3-4910	Big Creek near Rogersville	36°25′34″	82°57′07″	1,131.67	2.76	04:00	138	.01	On a thrust fault.
3-4955	Holston River near Knoxville	36°00′56″	83°49′54″	818.06	2.23	03:50	1,260	?	Bubble gage; poor record. Between two thrust faults.
3-5350	Bullrun Creek near Halls Crossroads.	36°06′52″	83°59′16″	858.51	3.60	04:00	210	.03	Between two thrust faults.
3-5359.1	Clinch River at Melton Hill Dam (head water).	35°53′04″	84°18′13″	MSL	793.20	04:00	54,800	.13	Seiche lasted about 160 min. On a thrust fault.
3-5380	Whiteoak Creek at Whiteoak Dam	35°53′58″	84°19′34″	756.56	6.20	04:00	37	.06	On a thrust fault.
3-5382.25	Poplar Creek near Oak Ridge	35°59′55″	84°20′23″	750.59	6.90	04:00	416	.04	Do.
3-5382.75	Bear Creek near Oak Ridge	35°56′50″	84°21′48″	755.66	1.75	03:40	35	.02	Do.
3-5396	Daddys Creek near Hebbertsburg	35°59′53″	84°49′24″	1,450.45	5.35	03:45	858	.07	Between two thrust faults.
3-5660	Hiwassee River at Charleston	35°17′16″	84°45′07″	681.54	16.00	04:00	17,800	.08	Do.
3-5675	South Chickamauga Creek near Chickamauga.	35°00′50″	85°12′27″	663.41	12.25	04:00	5,820	.15	On an anticline between two thrust faults.
3-5710	Sequatchie River near Whitwell	35°12′22″	85°29′48″	644.72	12.00	04:25	4,110	.11	Between a thrust fault and an anticline.
3-5845	Elk River near Prospect	35°01′39″	86°56′52″	579.64	17.20	04:00	13,700	.11	
3-5884	Chisholm Creek at Westpoint	35°08′04″	87°31′45″	603.29	3.08	03:55	134	.04	
3-5935	Tennessee River at Savannah	35°13′29″	88°15′36″	374.82	------------	04:20	170,000	.04	On edge of cretaceous overlap.
3-5995	Duck River at Columbia	35°37′05″	87°01′56″	549.80	14.30	04:15	7,460	.14	
3-6055.5	Trace Creek near Denver	36°03′26″	87°53′54″	391.39	1.87	03:50	54	.04	
3-6065	Big Sandy River at Bruceton	36°02′19″	88°13′42″	385.14	4.38	04:15	216	.13	Near edge of cretaceous overlap.
	TVA Stations								
----------	Tennessee River at Chattanooga (Walnut Street).	35°	85°	621.12	17.69	04:00	*150,000*	.09	Between two thrust faults.
----------	Emory River at Harriman	35°	84°	MSL	736.50	04:00	5,000	.25	Seiche lasted about 60 min.
----------	Holston River near Morristown	36°	83°	MSL	1,050.80	04:30	*940,000*	.10	
----------	Tennessee River at Kelleys Ferry	----------	----------	MSL	633.07	04:00	*150,000*	.12/.00	Bubble gage.
----------	Tennessee River at Doughertys Ferry.	----------	----------	MSL	?	04:00	*450,000*	.14	
----------	Indian Creek at Cerro Gordo	35°	88°	390.0	4.48	04:00	860	.04	
----------	Tennessee River at Kingston	35°	84°	MSL	736.20	04:15	*800,000*	.04	
----------	Tennessee River at Clifton	35°	87°	MSL	369.10	04:45	*3,400,000*	.07	
----------	Cherokee Dam headwater	----------	----------	MSL	1,050.74	----------	*940,000*	Tr.	
----------	Norris Dam headwater	36°	84°	MSL	1,000.97	----------	*1,450,000*	.09	Seiche lasted about 80 min.
	Texas								
7-2996.7	Groesbeck Creek near Quanah	34°21′20″	99°44′25″	1,425.69	5.21	04:15	6.4	0.02	On south side of basin.
7-3121	Wichita River near Mabelle	33°45′35″	99°08′35″	1,062.72	3.79	04:00	144	.04	
7-3150	Little Wichita River near Henrietta	33°50′00″	98°12′30″	831.57	6.19	03:55	.1	.08	Seiche lasted 30 min or more.
7-3315	Lake Texoma near Denison	33°49′05″	96°34′20″	MSL	604.13	----------	*1,777,200*	.00/.04	On Ouachita tectonic belt. Bubble gage.
7-3326	Bois d'Arc Creek near Randolph	33°28′30″	96°21′50″	564.38	2.25	04:20	.4	.03	On Ouachita tectonic belt.
7-3355	Red River at Arthur City	33°52′30″	95°30′10″	380.07	8.84	03:55	3,240	.04	On basin in East Texas embayment.
7-3368	Pecan Bayou near Clarksville	33°41′07″	94°59′41″	365.00	3.68	03:55	18	.08	
7-3425	South Sulphur River near Cooper	32°21′	95°36′	374.91	1.09	04:00	4.5	.02	A residual 0.005-ft drop in stage.
7-3435	Whiteoak Creek near Talco	33°19′	95°05′	286.45	3.31	04:00	12	.02	A residual 0.01-ft drop in stage.
7-3450	Boggy Creek near Daingerfield	33°02′05″	94°47′10″	258.41	4.92	04:00	25	.03	
7-3460.5	Little Cypress Creek near Ore City	32°40′21″	94°45′03″	232.67	4.53	04:00	84	.05	Seiche lasted about 45 min. On westward extension of Rodessa fault zone.
7-3460.7	Little Cypress Creek near Jefferson	32°45′	94°30′	174.60	5.59	04:00	197	.03	On Rodessa fault zone.
8-0173	South Fork Sabine River near Quinlan.	32°53′52″	96°15′11″	461.40	3.27	04:00	.1	.00/.01	Float gage. On Ouachita tectonic belt.
8-0193	Lake Winnsboro near Winnsboro	32°53′10″	95°20′40″	MSL	410.95	04:00	*2,960*	.00/.03	Bubble gage. On north end of East Texas embayment.
8-0195	Big Sandy Creek near Big Sandy	32°36′12″	95°05′32″	278.38	4.92	04:00	78	No seiche	A lasting 0.005-ft rise in stage. Bubble gage. On east edge of East Texas embayment.
8-0207	Rabbit Creek at Kilgore	32°23′17″	94°54′11″	299.80	2.90	04:00	20	.03	
8-0222	Murvaul Lake near Gary	32°02′04″	94°25′15″	MSL	264.04	04:00	*40,940*	.10	Seiche lasted about 30 min. with 0.04 ft of motion. Between two normal faults.
8-0223	Murvaul Bayou near Gary	32°01′54″	94°22′31″	217.82	3.10	04:00	7.5	.03	On a normal fault.
8-0285	Sabine River near Bon Weir	30°45′00″	93°36′30″	46.42	5.40	04:00	3,950	.19	Seiche lasted about 30 min. On a normal fault.
8-0305	Sabine River near Ruliff	30°18′10″	93°44′40″	4.08	11.85	03:50	6,920	.67	Seiche lasted about 50 min.
8-0320	Neches River near Neches	31°53′32″	95°25′50″	264.06	6.30	04:00	294	.11	Southeast side of East Texas embayment.
8-0385	Angelina River near Zavalla	31°12′41″	94°17′40″	104.48	9.89	04:00	2,010	.63	Seiche lasted about 50 min.
8-0410	Neches River near Evadale	30°21′22″	94°05′36″	8.25	12.04	04:00	6,200	.31	Seiche lasted about 60 min.
8-0680	West Fork San Jacinto River near Conroe	30°14′41″	95°27′26″	95.03	6.42	04:00	208	.27	Seiche lasted about 40 min.

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Texas—Continued								
8-0720	Lake Houston near Sheldon	29°54′58″	95°08′28″	−0.70	44.61	03:45	*59,600*	0.13	Seiche lasted about 120 min.
8-0760	Greens Bayou near Houston	29°55′05″	95°18′24″	−.66	49.71	04:00	6.4	.07	Seiche lasted about 30 min.
8-0815	Salt Croton Creek near Aspermont	33°24′05″	100°24′30″	1,668	1.30	03:40	.5	.02	
8-0848	California Creek near Stamford	32°55′50″	99°38′30″	----------	6.21	04:00	.7	.02	
8-0873	Clear Fork of Brazos River at Eliasville.	32°57′30″	98°46′10″	1,027.77	7.53	03:45	13	.02/.13	Bubble gage.
8-0883	Oak Creek near Graham	33°12′40″	98°37′05″	----------	.76	04:10	0	.03	
8-0884	Lake Graham near Graham	33°08′05″	98°36′55″	MSL	1,072.99	03:50	*48,640*	.08	Seiche lasted about 50 min. Bubble gage.
8-0953	Middle Bosque River near McGregor	31°30′33″	97°21′56″	530.51	2.90	04:00	27	.04	On Ouachita tectonic belt.
8-0954	Hog Creek near Crawford	31°33′20″	97°21′22″	560.54	2.26	04:00	11	.04	Do.
8-0956	Bosque River near Waco	31°36′04″	97°11′36″	365.44	4.04	04:00	149	.04	Do.
8-0968	Cow Bayou Subwatershed 4 near Bruceville.	31°20′	97°16′	574.46	10.01	04:00	58.3	.008	Do.
8-1020	Belton Reservoir near Belton	31°07′	98°28′	MSL	569.28	04:00	*212,700*	.06	Seiche lasted about 45 min. Near a normal Fault.
8-1065	Little River at Cameron	30°50′	96°57′	281.89	7.72	04:00	1,400	.00/.03	Float gage, near edge of tertiary overlap.
8-1087	Middle Yegua River near Dime Box	30°20′20″	96°54′15″	295.4	1.26	04:00	1.9	.03	
8-1100	Yegua Creek near Somerville	30°19′18″	96°30′27″	199.21	2.53	04:00	26	.07	Seiche lasted about 20 min.
8-1103	Lake Mexia near Mexia	31°38′45″	96°34′39″	MSL	426.52	04:00	*7,000*	.14	Seiche lasted about 20 min. on Mexia-Talco fault zone.
8-1105	Navasota River near Easterly	31°10′10″	96°17′55″	276.46	1.56	04:00	12	.02	
8-1115	Brazos River near Hempstead	30°07′34″	96°11′05″	117.90	4.14	04:00	2,000	.00/.12	Bubble gage.
8-1175	San Bernard River near Bowling	29°18′47″	95°53′36″	30.80	4.18	04:00	62	.005/.035	
8-1180	Lake J. B. Thomas near Vincent	32°35′09″	101°12′18″	MSL	2,249.44	04:00	*143,200*	.05	
8-1190	Bluff Creek near Ira	32°35′29″	101°03′05″	2,177.95	3.18	04:00	.1	No seiche	Slight shift downward during 20 min.
8-1236	Champion Creek Reservoir near Colorado City.	32°16′55″	100°51′30″	MSL	2,055.62	04:00	*13,290*	.06	Seiche lasted about 60 min.
8-1270	Elm Creek at Ballinger	31°45′00″	99°56′50″	1,617.72	3.90	04:00	1.0	.04	Seiche lasted about 20 min.
8-1280	South Concho River at Christoval	31°13′	100°30′	2,010.22	1.85	04:00	8.3	.015/.035	A residual 0.01-ft drop in stage.
8-1365	Concho River near Paint Rock	31°31′	99°55′	1,574.43	12.63	04:00	1.9	.05	Seiche lasted about 120 min.
8-1400	Deep Creek subwatershed 8 near Mercury.	31°23′05″	99°08′30″	1,377.13	8.99	03:55	*214*	.08	A residual 0.002-ft drop in stage near a normal fault.
8-1435	Pecan Bayou at Bronwood	31°43′54″	98°58′25″	1,318.58	.52	04:00	.9	.04	Seiche lasted about 90 min. On north side of Llano uplift.
8-1535	Pedernales River at Johnson City	30°18′	98°24′	1,096.70	2.84	04:00	58	.005/.000	Float ga e. On southeast side of Llano uplift.
8-1610	Colorado River at Columbus	29°42′20″	96°32′05″	155.52	1.61	04:00	238	.04/.06	Seiche lasted about 35 min. On northeast extension of fault.
8-1676	Rebecca Creek near Spring Branch	29°55′08″	98°22′09″	985.55	2.14	----------	3.8	.04	On Ouachita tectonic belt.
8-1713	Blanco River near Kyle	29°58′42″	97°54′30″	620.12	4.30	----------	20	.05	Seiche lasted about 30 min. On Balcones fault zone.
8-1758	Guadalupe River at Cuero	29°03′57″	97°19′16″	128.64	5.16	----------	710	.00/.39	Bubble gage.
8-1780	San Antonio River at San Antonio	29°24′35″	98°29′40″	612.26	1.07	----------	16	.03	Seiche lasted about 30 min. Near a normal fault and on edge of Tertiary overlap.
8-1790	Medina River near Pipe Creek	29°40′	98°59′	1,067.37	4.41	----------	66	.03	On Ouachita tectonic belt.
8-1824	Calaveras Creek subwatershed 6 near Elmendorf.	29°22′53″	98°17′34″	516.06	14.85	04:00	*49.6*	.018/.000	Water-level rise lasted about 15 min. Float gage. Near a normal fault.
8-1825	Calaveras Creek near Elmendorf	29°15′38″	98°17′34″	406.45	4.77	04:00	1.7	No seiche	A 0.005-ft drop in stage.
8-1839	Cibola Creek near Boerne	29°46′25″	98°41′52″	1,339.61	2.37	----------	5.6	.02	On Ouachita tectonic belt.
8-1875	Escondido Creek at Kenedy	28°49′11″	97°51′32″	246.40	8.99	04:00	1.6	.02	Seiche lasted about 40 min.
8-1879	Escondido Creek subwatershed 11 near Kenedy.	28°51′39″	97°50′39″	288.12	15.58	03:55	*158*	.018	Seiche lasted about 10 min.
8-1893	Media Creek near Beeville	28°28′58″	97°39′23″	163.00	5.10	----------	No flow	.02	
8-1895	Mission River at Refugio	28°17′30″	97°16′44″	1.00	2.07	----------	4.5	.05	
8-2027	Seco Creek at Cook Ranch near D'Hanis.	29°21′43″	99°17′05″	900.88	4.37	----------	No flow	.03	
8-2055	Frio River at Derby	28°44′10″	99°08′45″	449.11	.49	----------	----do------	.005	
8-2070	Frio River at Calliham	28°29′30″	98°20′45″	153.47	2.84	----------	8.6	.005	Seiche lasted about 15 min.
8-2110	Nueces River at Mathis	28°02′17″	97°51′36″	27.53	2.18	----------	7.3	.00/.08	On a normal fault. Bubble gage.
8-4275	San Solomon Springs at Toyahvale	30°56′	103°47′	3,311.02	.96	04:00	30	.07	Seiche lasted about 30 min.
----------	Reservoir in Bailey County	34°	102°	----------	------------	04:10	*15*	.5	Miller and Reddell (1964, p. 661).
	Utah								
10-0201	Bear River above reservoir near Woodruff.	41°26′05″	111°01′00″	6,455	------------	04:00	50	Tr.	On north-south fault.
10-0210	Woodruff Creek near Woodruff	41°29′	111°16′	6,600	------------	04:00	8	Do	
10-1345	East Canyon Creek near Morgan	40°55′20″	111°36′20″	5,460	------------	----------	14	Do	
10-1376	Southfork Ogden River at Huntsville	41°14′50″	111°45′45″	4,910	------------	----------	38	Do	On a buried fault.
10-1376.8	North Fork Ogden River near Eden	41°23′20″	111°54′50″	5,750	------------	----------	4	Do	
10-1377	North Fork Ogden River near Huntsville.	41°17′40″	111°49′40″	4,903.81	0.55	04:40	2	.04	
10-1705	Surplus Canal at Salt Lake City	40°43′40″	111°55′35″	4,219.02	1.00	04:10	70	.06	
10-1940	Sevier River above Clear Creek near Sevier.	38°34′20″	112°15′25″	5,560	------------	----------	90	Tr.	Near a normal fault.

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Vermont								
4–2835	East Barre Detention Reservoir at East Barre.	44°09′20″	72°26′40″	MSL	1,130.67	04:00	*8,500*	0.06	Near axis of north-south syncline.
4–2850	Wrightsville Detention Reservoir at Wrightsville.	44°18′35″	72°34′30″	MSL	618.72	04:00	*29,000*	.23	
	Virginia								
	No seiche was recorded at any gaging station.								
	Washington								
12–1555	Snohomish River at Snohomish	47°54′45″	122°06′30″	−9.86	3.49	03:45	<10,000	<0.45	Seiche superimposed on tidal curve. Seiche lasted about 30 min. On small structural complex.
12–3971	Outlet Creek near Metaline Falls	48°50′45″	117°17′15″	2,550	9.18	04:15	17	No seiche	Temporary drop in stage of 0.005 ft.
12–3980.9	Pend Oreille River at Metaline Falls	48°51′55″	117°22′20″	---	11.80	03:45	?	.16	On a fault.
12–4087	Mill Creek at mouth near Colville	48°34′25″	117°56′40″	1,540	1.36	03:50	27	.03	
12–4360	Franklin D. Roosevelt Lake at Grand Coulee Dam.	47°57′20″	118°59′10″	MSL	1,253.30	03:45	*6,900,000*	1.04	Seiche lasted at least 2 hr and perhaps about 12 hr on Colville batholith.
12–4390	Osoyoos Lake near Oroville	48°59′15″	119°27′15″	MSL	911.15	04:00	---	Tr.	Near north edge of Columbia River Basalt.
12–4395	Okanogan River at Oroville	48°55′55″	119°25′05″	899.77	3.55	03:45	575	Tr.	Do.
12–4440	Whitestone Lake near Tonasket	48°47′15″	119°27′50″	---	4.35	03:30	---	.13	Do. A 0.03-ft rise in stage.
12–4500	Alta Lake near Pateros	48°01′30″	119°56′30″	1,175	8.03	04:00	---	.13	Seiche was recorded during 60 min.
12–4545	Wenatchee Lake near Plain	47°49′50″	120°46′30″	MSL	1,870.10	04:10	---	No seiche	Slight temporary rise in water level on axis of anticline.
12–4670	Crab Creek near Moses Lake	47°11′25″	119°16′00″	1,070.39	1.40	03:00	6	No seiche	A lasting 0.005-ft rise in stage. In Quincy basin.
12–4690	Blue Lake near Coulee City	47°34′25″	119°25′15″	MSL	1,093.27	03:50	---	.04	On axis of syncline.
12–4695	Lenore Lake near Soaplake	47°31′	119°30′	MSL	1,078.20	04:00	---	Tr.	Pen trace became darker. On axis of syncline.
	U.S. Corps of Engineers								
---	McNary Reservoir at Port Kelly	46°	118°	MSL	337.38	03:45	---	.69	Bubble gage.
---	McNary Reservoir at Wallula Junction.	46°	118°	MSL	337.39	04:00	---	.15	Stevens A–35 recorder.
---	McNary Reservoir at Union Pacific RR bridge near Kennewick.	46°	119°	MSL	337.26	03:45	---	.08	Do.
---	McNary Reservoir at Snake River Bridge near Burbank.	46°	119°	MSL	337.30	03:45	---	.12	Do.
---	McNary Reservoir at Pasco-Kennewick Highway bridge.	46°	119°	MSL	337.40	03:45	---	.22 (est.)	Do.
---	McNary Reservoir at Richland Pumping Plant.	46°	119°	MSL	337.82	03:45	---	.10	Do.
---	Ice Harbor Reservoir Navigation Lock.	46°	119°	MSL	437.56	03:45	---	.20	Preexisting wind seiches were amplified by seismic waves.
---	Ice Harbor Reservoir near Page	46°	119°	MSL	437.58	03:45	---	.30	Bubble gage.
	West Virginia								
	No seiche was recorded at any gaging station.								
	Wisconsin								
4–0790	Wolf River at New London	44°23′30″	88°44′25″	749.37	---	03:50	710	0.01	On south edge of Precambrian felsic intrusive body.
4–0800	Little Wolf River at Royalton	44°24′45″	88°51′55″	774.00	1.28	03:50	140	.02	Do.
5–3360	St. Croix River at Grantsburg	45°55′25″	92°38′20″	848.98	---	03:40	1,300	.01	
5–4050	Baraboo River near Baraboo	43°28′55″	89°38′00″	788.21	---	03:50	170	.01	On axis of syncline.
5–4240	East Branch Rock River near Mayville.	43°31′45″	88°34′00″	857.20	---	04:00	50	.01	
5–4330	East Branch Pecatonica River near Blanchardville.	42°47′10″	89°51′40″	796.8	---	04:00	64	.01	
	Wyoming								
6–2316	Middle Popo Agie below the Sinks, near Lander.	42°45′25″	108°47′50″	6,150	2.00	04:20	18	Tr.?	
6–2355	Little Wind River near Riverton	42°59′51″	108°22′29″	4,901.84	3.24	03:35	270	.01	On west side of Wind River basin.
6–2445	Fivemile Creek above Wyoming Canal near Pavillion.	43°18′04″	108°42′04″	5,495	1.95	04:00	4	.02	Do.
6–2765	Greybull River at Meeteetse	44°09′20″	108°52′35″	5,739.42	---	04:15	68	Tr.	On west side of Big Horn basin.
6–2785	Shell Creek near Shell	44°34′	107°42′	4,367.20	---	03:30	35	.08	
6–2803	South Fork Shoshone River near Valley.	44°12′30″	109°33′15″	6,200	2.47	04:00	59	.02	

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	UNITED STATES—Continued								
	Wyoming—Continued								
6-2844	Shoshone River near Garland	44°44′	108°36′	4, 100	4. 74	04:00	660	0. 08	On possible extension of a thrust fault.
6-6377.5	Rock Creek above Rock Creek Reservoir.	42°32′59″	108°46′26″	8, 330	4. 43	04:00	1	. 01	
9-1985	Pole Creek below Little Half Moon Lake near Pinedale.	42°53′	109°43′	7, 350	2. 80	04:20	11	. 07	On buried thrust fault.
9-2105	Fontenelle Creek near Herschler Ranch, near Fontenelle.	42°05′45″	110°25′10″	6, 950	3. 25	04:10	32	Tr.	On axis of an anticline.
9-2230	Hams Fork near Elk Creek Ranger Station.	42°06′40″	110°42′40″	7, 455	3. 94	03:30	23	. 02	In area of thrust faults.
13-0110	Snake River at Moran	43°51′	110°35′	6, 727. 84	----------	04:00	408	. 005	Lake Hebgen earthquake was also recorded by this gage. Near end of a thrust fault.
	AUSTRALIA								
	Australia Capital Territory								
----------	O'Conner Reservoir at Canberra	35° S.	149° E.	----------	----------	04:45	*21*	Tr.	Previous earthquakes in Kurile Islands (Oct. 13, 1963), Banda Sea (Nov. 4, 1963), and New Hebrides were recorded on this reservoir (Robert Underwood, written commun., Sept. 20, 1965).
	New South Wales								
----------	Tantangara Reservoir	35°47′53″ S.	148°39′44″ E.	MSL	3, 971. 51	04:40	*23, 680*	0. 02	Recorder is near dam.
	Northern Territory								
113A	Victoria River	16°22′ S.	131°06′ E.	----------	----------	04:45	----------	0. 00/. 02	Servomanometer recorder.
	Victoria								
M17	Melicke Munjie River	37°14′40″ S.	148°08′30″ E.	2, 100	----------	04:00	----------	0. 02	
	CANADA								
	Alberta								
5-0130	Waterton River near Waterton Park	49°07′	113°50′	----------	0. 84	04:00	----------	0. 03	
6-1345	Milk River at Milk River	49°09′	112°05′	----------	2. 45	03:50	----------	. 02	
6-1355	Sage Creek at "Q" Ranch near Wild Horse.	49°08′	110°13′	----------	2. 25	04:00	----------	. 09	
----------	Athabasca River near Hinton	53°25′	117°35′	----------	7. 02	03:55	----------	. 05	
----------	Belly-St. Mary Diversion Canal	49°20′	113°32′	----------	3. 55	05:00	----------	. 01	
----------	Bow River at Calgary	51°03′	114°03′	----------	----------	04:00	----------	. 03	
----------	Clearwater River at Draper	56°41′	111°15′	----------	----------	03:45	----------	. 00/. 05	A sudden 0.13-ft rise in stage. Bubble gage.
----------	Clearwater River near Rocky Mountain House.	52°21′	114°56′	----------	3. 84	----------	----------	. 07	
----------	Elbow River at Bragg Creek	50°57′	114°34′	----------	5. 40	03:45	----------	. 03	
----------	Highwood River near Aldersyde	50°42′	113°51′	----------	4. 61	----------	----------	. 01	
----------	Lesser Slave River at Highway 2	55°18′	114°35′	----------	86. 60	04:00	----------	No seiche	A lasting 0.02-ft rise in stage. Bubble gage.
----------	Little Smokey River near Guy	55°27′	117°10′	----------	9. 73	04:20	----------	. 03/. 045	A residual 0.01-ft drop in stage. Bubble gage.
----------	Oldman River at Lethbridge	49°42′	112°52′	----------	2. 32	04:20	----------	. 02/. 04	Bubble gage.
----------	Peace River at Fort Vermilion	58°24′	116°00′	----------	57. 95	03:45	----------	. 08/. 10	Do.
----------	Peace River at Peace Point	59°07′	112°26′	----------	58. 79	04:10	----------	. 03	Do.
----------	Peace River at Peace River	56°15′	117°19′	----------	21. 33	04:30	----------	. 025/. 05	Do.
----------	Prairie Creek near Rocky Mountain House.	52°16′	114°56′	----------	3. 06	03:00	----------	. 02/. 00	
----------	Red Deer River at Drumheller	51°28′	112°42′	----------	----------	04:15	----------	. 31	
----------	Sheep River at Aldersyde	50°43′	113°53′	----------	5. 00	04:00	----------	. 00/. 04	Bubble gage.
----------	Slave River at Fitzgerald	59°52′	111°35′	----------	657. 37	04:10	----------	. 00/. 10	Do.
----------	South Saskatchewan River at Medicine Hat.	50°03′	110°41′	----------	7. 35	05:00	----------	. 00/. 07	Do.
----------	Stimson Creek near Pekisko	50°26′	114°10′	----------	----------	03:45	----------	. 03	
----------	Twin Creek near Seebe	50°58′	115°10′	----------	----------	----------	----------	. 025	
----------	Middle Creek near Alberta Boundary.	49°26′	110°03′	----------	3. 10	----------	----------	. 01	
6-1340	North Fork Milk River near International Boundary.	49°01′20″	112°58′20″	4, 120	3. 45	03:20	8. 3	. 03	Stage rose 0.03 ft after seiche was recorded.
6-1330	Milk River at Western Crossing of International Boundary.	49°00′	112°33′	3, 820	3. 96	03:20	20	. 01	
6-1360	Sage Creek at International Boundary	49°00′10″	110°12′30″	2, 800	2. 63	04:00	6	. 08	
5-0205	Saint Mary River near International Boundary.	49°00′	113°18′50″	4, 120	5. 06	03:50	69	. 02	

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
	CANADA—Continued								
	British Columbia								
----------	Prince Rupert	54°19′	130°20′	----------	----------	03:45	----------	0.25	Data from Wigen and White (1964).
----------	Bella Bella	52°10′	128°08′	----------	----------	03:45	----------	.35	Do.
----------	Tasu	52°45′	132°01′	----------	----------	03:45	----------	1.10	Do.
----------	Victoria	48°25′	123°24′	----------	----------	03:45	----------	.15	Do.
----------	Point Atkinson	49°20′	123°15′	----------	----------	04:00	----------	.40	Do.
----------	Vancouver	49°17′	123°07′	----------	----------	03:45	----------	.40	Do.
----------	Port Moody	49°17′	122°52′	----------	----------	----------	----------	.35	Do.
----------	Ballenas Island	49°20′	124°09′	----------	----------	----------	----------	.40	Do.
----------	Frazer River at New Westminster	49°11′52″	122°54′42″	----------	----------	03:45	----------	.15	Do.
----------	Link Lake near Ocean Falls	52°21′	127°41′	----------	----------	----------	----------	.26	Do.
8BB-1	Taku River at Tulsequah	58°38′20″	133°32′25″	----------	3.30	03:50	----------	.05	20 min after seiche, water level began rise of 0.34 ft in 2 hr.
8EG-14	Rainbow Lake near Prince Rupert	54°11′36″	130°04′50″	----------	2.35	02:40	----------	.20	
8FA-7	Owikeno Lake near Wadhams	51°40′40″	127°10′30″	----------	4.66	03:40	----------	.12	Seiche lasted about 4 hr.
8KB-1	Fraser River at Shelley	54°00′40″	122°37′00″	1,859.67	10.30	04:00	----------	.05	Trace of upward shift.
8LA-10	Mahood Lake near Clearwater Station	51°56′18″	120°14′28″	----------	3.05	04:00	----------	.10	Wind seiche amplified by seismic seiche.
8LA-12	Clearwater Lake near Clearwater Station.	52°07′55″	120°11′10″	----------	4.40	03:45	----------	.15	
8LE-53	Shuswap Lake at Sicamous	50°51′05″	119°00′43″	1,131.93	1.90	04:20	----------	.14	
8ME-17	Seton Lake near Shalath	50°43′40″	122°14′00″	0.36	774.18	04:00	----------	.55/.00	Seiche lasted about 10 hr. Maximum observed seiche was about 3 ft.
8MH-16	Chilliwack River at outlet Chilliwack Lake near Vedder Crossing.	49°05′02″	121°27′24″	----------	1.70	03:50	----------	.00/.10	30 min required for water level to recover, but did not rise to previous level.
8MH-52	Pitt Lake near Alvin	49°26′10″	122°30′45″	----------	5.50	03:45	----------	.46	Pitt Lake is tidal.
8MH-62	Pitt Lake near outlet near Pitt Meadows.	49°21′27″	122°34′38″	----------	6.60	03:50	----------	.22	Do.
8NE-45	Upper Arrow Lake at Nakusp	50°14′12″	117°48′07″	1,374.07	1.70	04:00	----------	1.25	Seiche lasted about 12 hr. Lake highly resonant. Exponential decay well defined.
8NH-64	Kootenay Lake at Queen's Bay	49°39′16″	116°55′47″	0.38	1,739.20	03:45	----------	.06	
8NH-67	Kootenay Lake at Kuskanook	49°17′56″	116°39′31″	1,735.20	4.62	03:45	----------	.10	
	Manitoba								
----------	Nelson River at Cross Lake	54°36′	97°47′	----------	----------	03:35	----------	0.29	
----------	Lake Winnipeg at Pine Dock	51°38′30″	96°47′45″	----------	----------	03:50	----------	.05	
----------	Lake Manitoba at the Narrows	51°05′00″	98°47′45″	----------	----------	04:10	----------	.03	
----------	Deloraine Reservoir near Deloraine	49°06′50″	100°24′40″	----------	----------	03:50	----------	.44	P. W. Strilaeff (written commun., 1964).
	Northwest Territories								
----------	Cambridge Bay	69°07′	105°04′	----------	----------	----------	----------	0.30	Seiche lasted 15 min. (Wigen and White, 1964).
----------	Talston River at outlet Tsu Lake	60°39′	111°57′	----------	85.20	04:00	----------	.00/.15	Bubble gage.
----------	Willowlake River near the mouth	62°39′	122°55′	----------	62.20	03:50	----------	.00/.03	Water level rose 0.01 ft. Bubble gage.
----------	Great Bear Lake at Port Radium	66°04′	117°52′	----------	389.53	03:50	----------	.00/.22	Bubble gage.
----------	Lockhart River at outlet Artillery Lake.	62°53′	108°28′	----------	96.08	03:40	----------	.055/.035	Do.
----------	Hay River above Hay River	60°45′	115°21′	----------	65.73	03:50	----------	.00/.09	Do.
----------	Mackenzie River at Wrigley	63°16′	123°36′	----------	70.94	03:40	----------	.00/.10	Do.
	Ontario								
----------	English River at Sioux Lookout	50°04′15″	91°56′40″	----------	----------	03:50	----------	0.14	Two maximums of equal size about 12 min. apart.
----------	Lake of the Woods at Clearwater Bay	49°43′06″	94°48′10″	----------	----------	03:45	----------	.09/.03	Bubble gage.
----------	Gull River at Norland	44°43′55″	78°49′08″	----------	61.47	04:00	----------	.03	
----------	Skootamata River at Actinolite	44°32′39″	77°19′35″	----------	10.90	04:00	----------	.055	
----------	Wanapitei-Wanup River	46°21′	80°50′	----------	708.36	04:00	----------	.02	Water level began decline of 0.05 ft after seiche recorded.
----------	Lac la Croix at Campbell's Camps	48°21′20″	92°12′50″	----------	----------	03:30	----------	.13	
----------	Mississagi River	46°54′	83°14′	----------	4.85	----------	----------	.03/.04	Bubble gage.
----------	French River-Dry Pine Bay	46°03′01″	80°34′26″	----------	593.12	04:00	----------	.03	
	Saskatchewan								
----------	Buffalo Pound Lake at Pumping Station.	50°35′	105°23′	----------	71.85	03:30	----------	0.075	
----------	Fond du Lac River at outlet Black Lake.	59°09′	105°33′	----------	93.16	04:00	----------	.00/.075	Bubble gage.
----------	South Saskatchewan River near Lemsford.	51°01′	109°08′	----------	4.24	04:20	----------	Tr.	
----------	Spruce River below Anglin Lake Reservoir.	53°40′	106°00′	----------	2.88	04:00	----------	.03	

TABLE 3.—*Seismic effects from the Alaska earthquake at surface-water gages*—Continued

Station number	Station name and location	Latitude	Longitude	Datum of gage (ft)	Stage (ft)	Time	Discharge (cfs) or storage (acre ft)	Seiche double amplitude (ft)	Remarks
				CANADA—Continued					
				Saskatchewan—Continued					
6-1495	Battle Creek near International Boundary.	49°00′10″	109°25′20″	2,729.8	2.22	03:50	4	0.09/.00	
6-1580	Frenchman River above Eastend Reservoir near Ravenscrag.	49°29′	109°00′	3,040	1.76	03:45	12	.19	
6-1785	East Poplar River at International Boundary.	49°00′00″	105°24′30″	2,410.92	2.65	04:00	4.5	.16	
----------	Long Creek below Boundary Reservoir.	49°06′43″	102°59′42″	----------	------------	03:35	------------	.30	P. W. Strilaeff (1964, written commun.).
----------	Weyburn Reservoir near Weyburn	49°36′28″	103°49′24″	----------	------------	03:50	------------	.04	Do.

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STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

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