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TRONA RESOURCES IN THE GREEN RIVER BASIN, SOUTHWEST WYOMING

by

**Stephen V. Wiig, W.D. Grundy,
and John R. Dyni**

A cooperative study of the Wyoming trona deposits between the U.S. Bureau of Land Management and the U.S. Geological Survey

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by

Stephen V. Wiig[1], W.D. Grundy[2], and John R. Dyni[2]
[1]U.S. Bureau of Land Management, Rock Springs, Wyoming
[2]U.S. Geological Survey, Denver, Colorado

ABSTRACT

The lacustrine Eocene Green River Formation of the Green River Basin in southwest Wyoming contains the world's largest known resource of natural sodium carbonate in as many as 40 beds of trona ($Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$). In this study 127 billion tons of trona ore are estimated to be present in 22 of these beds that are 4 or more feet thick. Of this total, 76 billion tons of trona ore are estimated to be present in beds containing less than two percent halite, and 52 billion tons in beds containing two, or more, percent halite. These 22 beds underlie areas ranging from 50 to more than 775 square miles at depths ranging from about 650 to 3,000 feet below the surface.

Additional resources of sodium carbonate are also present in the mineral shortite ($Na_2CO_3 \cdot 2CaCO_3$) which occurs in abundant crystals, pods, and veinlets scattered through strata interbedded with the trona deposits. Also, sodium carbonate brines rich in organic acids are present at shallow depths in the northeastern part of the basin. Although the soda brines at Green River were produced early this century, neither resource is currently being developed nor were they evaluated in this study.

Five companies are presently mining trona in the Green River Basin. Three companies mine trona bed 17. One company operates in beds 19 and 20 and another company mines beds 24 and 25. All of the current mining activity is concentrated in the northern part of the trona district. N.A. Brown (1995) recently summarized trona operations in the basin.

Mining is by vertical shaft using room-and-pillar, short- and long-wall methods. At two mines, waste waters from the processing plant are used to dispose of tailings in abandoned parts of the mines. Additional trona is then dissolved from pillars by the tailings waters which are pumped back to the surface to recover the dissolved sodium carbonate. When the deeper beds southward in the Green River Basin are mined, changes in trona bed mineralogy, increased amounts of methane, and brine and tar seeps may be expected. The anticipated increased costs of mining these deeper beds by conventional methods might be reduced by introduction of new mining techniques, including horizontal drilling and solution mining similar to that used to extract nahcolite ($NaHCO_3$) in the Piceance Creek Basin in northwest Colorado.

INTRODUCTION

The world's largest known resource of natural sodium carbonate in the form of trona ($Na_2CO3 \cdot NaHCO_3 \cdot 2H_2O$) is found in many beds in the Wilkins Peak Member of the Eocene Green River Formation of the Green River Basin in southwest Wyoming. The district currently produces about 8 million tons of refined soda ash per year from five underground mines that extract a total of about 16 million tons of trona annually.

The five mines and their plant nameplate capacity are as follows (Kostick, 1992, p. 14):

Company	Soda ash capacity (10^6 tons/year)
FMC Wyoming Corp.	2.85
General Chemical Partners	2.40
Rhöne Poulenc of Wyoming	1.96
Solvay Minerals Inc.	2.00
Tg Soda Ash Inc.	1.30
	11.81

Figure 1 shows the boundary of the Federal Known Sodium Leasing Area (KSLA) in the Green River Basin. The original KSLA was established on March 4, 1954 and has subsequently undergone several revisions as additional subsurface data were aquired from new exploratory drilling. The last revision was made effective April 1978. The current KSLA includes 694,207 acres and is mostly in Sweetwater County, Wyoming, with a small portion of its southwest side in eastern Uinta County, Wyoming. Part of the Flaming Gorge National Recreation Area (N.R.A.) is shown on figure 1 and other maps of the trona district. Federal lands currently under lease for sodium are shown on figure 2 and currently approved Wyoming state mine permit areas for the five operating mines in the trona district are shown on figure 3.

Estimates of the total sodium carbonate resource in the district are incomplete because an insufficient number of wells have been drilled into the trona beds in the deeper southern part of the Green River Basin. Relatively few chemical analyses of the trona beds are available, especially of those beds that contain locally abundant halite. Some beds of trona contain significant amounts of other sodium carbonate minerals including nahcolite and possibly wegscheiderite ($Na_2CO_3 \cdot 3NaHCO_3$). Both minerals are water soluble and are of economic value.

A large potential resource of soda ash occurs in shortite, an abundant mineral in the Wilkins Peak Member. Shortite is found predominantly as disseminated scattered crystals, stringers, and veinlets in beds of marlstone, oil shale, and mudstone in the trona-bearing sequence. Estimates of the shortite resource have not yet been made.

Another potential resource of soda ash is sodium carbonate brine. Locally large amounts of potentially economic organic acids color the brine dark brown to black, hence the local name, "black trona water". The brine is found in many shallow wells drilled into the Wilkins Peak Member in the northeastern part of the Green River Basin near Farson and Eden, Wyoming, about 35-40 miles north of the town of Green River, Wyoming. This resource is not evaluated in this report.

PURPOSE OF STUDY

This study updates an earlier estimate of the Wyoming trona resources made by Burnside and Culbertson (1979). In the present study, the writers estimate the trona resources of 22 of 25 of the thickest trona beds that were originally numbered by Culbertson (1966). Beds 13, 22, and 23 are too thin, or sufficient subsurface data are lacking, for making meaningful resource estimates. Isopach maps were prepared for all 25 trona beds. For those beds containing halite, a line depicting areas containing 2 or more percent halite is shown. A generalized stratigraphic section of the Wilkins Peak Member in one of the core holes in the southern part of the Green River Basin and two generalized stratigraphic cross sections are also included in this report.

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EARLY DEVELOPMENTS

The earliest indications of naturally occurring sodium carbonate in subsurface rocks of the Green River Basin in southwest Wyoming was sodium carbonate brine encountered in shallow wells drilled into the Wilkins Peak Member of the Green River Formation in the early 1900's at Green River, Wyoming (Schultz, 1910). In 1938, a well being drilled for water into the Wilkins Peak Member near Eden in the NE¼SW¼ sec. 4, T.23 N., R.106 W., encountered dark-colored sodium carbonate brine containing abundant organic acids between the depths of 450 and 500 feet (Lindeman, 1954). In 1944, soda brine was encountered at a depth of about 700 feet in two wells, the Westvaco 1 and 2, drilled by the Westvaco Chlorine Products Corp. in the east half of T.19 N., R.110 W. Efforts to test the brine were abandoned in favor of exploring for deeper trona beds. By 1976, as many as 24 wells had been drilled in the vicinity of Farson and Eden, enlarging the area of known shallow soda brine occurrence to several townships (Dana and Smith, 1973, 1976).

Bedded trona was first discovered in the Green River Basin by the John Hay, Jr. well 1, an exploratory well drilled for oil and gas by Mountain Fuel and Suppy Company in 1938.

This well is located on Federal land in the $SE\frac{1}{4}NW\frac{1}{4}$ sec. 2, T. 18 N., R. 110 W., about 18 miles west of the town of Green River, in Sweetwater County, Wyoming. A mineralogical study of core from this well made by the U.S. Geological Survey revealed a bed of trona 10 feet thick (now identified as trona bed 17) at a depth of 1,600 feet. A brief note of this discovery was published by Mendenhall (1940). A lithologic log and X-ray diffraction and optical data on saline minerals found in the core from the Hay well were subsequently published by Fahey (1962).

Following the discovery of bedded trona in the Hay well, further drilling for trona, beginning in the early 1940's, led to the discovery of additional trona beds. In 1947, the Westvaco Company (now FMC Corporation) sank a vertical shaft to a depth of about 1,600 feet into bed 17. The company began large-scale production of soda ash in 1953 (Culbertson, 1966, p. B159).

The Wyoming soda ash industry continued to grow through the succeeding years to the present. Currently, five mines produce annually about 16 million tons of trona ore. As of May 1995, a new trona mine and processing plant located on the east side of the district is being planned by a Casper, Wyoming company. In the past few years, trona exploration holes have been drilled in anticipation of new sodium-mineral leasing of Federal lands within the KSLA by the Bureau of Land Management.

GEOLOGIC SETTING

Fine-grained marlstone, siltstone, mudstone, and oil shale of the Green River Formation were deposited in a large lake that occupied the Green River Basin during Eocene time. During dry evaporative stages of the lake, large quantities of trona and halite precipitated from highly alkaline lake waters forming beds as much as 35 feet thick and covering areas of more than 1,000 square miles. During higher water stages of the lake, algae flourished and their remains, with clastic sediments and authigenic minerals, formed organic marlstones and beds of low- to high-grade oil shale. The interstitial sediment waters were probably strongly reducing and were a favorable environment for sulfate-reducing bacteria. Redox conditions were such that essentially all of the dissolved sulfate entering the lake was reduced to sulfide that precipitated as iron sulfides and as iron-bearing carbonates.

Large quantities of carbonate and bicarbonate were produced by a variety of processes, including bacterial reduction of sulfate with production of bicarbonate, precipitation of calcium carbonate by algae, hydrolysis of silicate minerals and volcanic ash, as well as by direct contributions of dissolved bicarbonate in stream waters entering the lake. Eventually, authigenic calcite, dolomite, shortite, and trona, and a host of less common carbonate minerals, precipitated from the lake brines and interstitial sediment waters.

The first trona beds deposited were nearly free of halite, but beginning with trona bed 5, locally large quantities of halite commingled with trona were deposited in the hydrographically deeper parts of the saline lake. Not all of the chloride was deposited as halite; some occurs in northupite ($Na_2CO_3 \cdot MgCO_3 \cdot NaCl$) which is commonly found in trona and associated beds. The stratigraphic distribution of halite within trona beds is not clearly understood. One might expect the halite to make its first appearance near the top of a trona bed as the halite facies is approached, however, if the upper part of the trona bed was subject to dissolution by lake water prior to burial, the lateral and vertical distribution of halite may be difficult to predict. Additional geologic study of the occurrence of halite is needed for a better understanding of its abundance and stratigraphic distribution in the basin.

Bedded trona and halite were initially deposited in the southern part of the basin. Later, trona deposition shifted to the north as tectonism waned and sediments filled the deeper southern portion of the basin. Halite-free trona was deposited during this closing phase. Volcanic ash from episodic volcanic eruptions northwest of the basin settled into the lake forming numerous, thin, widespread layers of altered tuff within the lacustrine sediments.

STRATIGRAPHY

The Eocene Green River Formation is divided, in ascending order, into the Tipton Shale, the Wilkins Peak, and the Laney Shale Members. The Green River Formation reaches a maximum thickness of about 2,400 feet in the southern part of the basin. The Wilkins Peak Member is as much as 1,350 feet in the southeast part of the basin, thinning to about 600 feet in the northern part of the KSLA (Culbertson, 1969; Culbertson, Smith, and Trudell, 1980, p. 6-10 and pl. 1). The Wilkins Peak consists of marlstone, oil shale, trona, siltstone, mudstone, and a numerous laterally persistent volcanic tuffs.

A saline facies containing bedded trona and halite and disseminated shortite is present in the middle and lower portions of the Wilkins Peak Member. W.C. Culbertson (1966) noted the presence of 42 or more beds of trona or mixed trona and halite. Culbertson (1969) numbered 25 of the thickest trona beds, which range in maximum thickness from 5 to 35 feet, beds 1 through 25 from the stratigraphically lowest to the highest bed. Abundant shortite as disseminated crystals, lenses, and veinlets, is widely distributed through marlstone, oil shale, and mudstone beds, as well as in thin seams of marlstone and oil shale within the trona beds.

Within the trona district, the trona beds are nearly flat-lying and dips are about 1° or less throughout much of the area. Culbertson (1966, fig. 2) showed that the trona beds diminish in thickness toward the southern and southeastern margins of the Green River Basin where the saline facies passes rather abruptly into fresher-water marlstone, oil shale, and units of mudstone and sandstone. The saline facies of the Wilkins Peak Member migrates stratigraphically higher in the northern part of the basin where the youngest beds of trona are found.

The generalized lithology of the Wilkins Peak Member is shown on a log of the Union Pacific El Paso core hole 44-3 on figure 4. This well is in sec. 3, T.15 N., R.109 W. in the southeast part of the trona district where the Wilkins Peak reaches its maximum thickness. In this well, the Wilkins Peak Member is 1,183 ft thick.

Trona beds 1 through 18 are restricted to the lower half of the Wilkins Peak. With the exception of trona bed 23, the upper trona beds, 19 through 25, are not present the El Paso core hole because it lies south of the areas occupied by these beds. Several key tuffs are identified on figure 3 including the Firehole, Main and Tollgate (or layered) tuffs. These and several other unnamed tuffs are widespread in the trona district and serve as useful stratigraphic markers. Many thin beds of oil shale are present throughout the Wilkins Peak, commonly just below a bed of trona (fig. 4). These and organic marlstones within the saline facies are probably the source of much of the methane that is encountered in the active trona mines. Enough methane is present in these mines for them to be classified as gassy by the Federal Government (Mine Safety and Health Administration) requiring special precautions and mining methods.

Figure 5 shows the locations of the trona core holes and the oil and gas wells that were used in determining the trona resources of the district. The locations of two stratigraphic cross sections, S-N and NW-SE, are shown on the figure. Figure 6 is a south-north stratigraphic cross section of the trona beds in the Wilkins Peak Member along the eastern side of the Green River Basin. A similar stratigraphic cross section from the east side to the northwest side of the basin is shown on figure 7. The stratigraphic datum for the two cross sections (figs. 6 and 7) is the top of trona bed 17. Trona beds containing two or more percent halite are indicated on the cross sections as salty trona or halite.

The trona beds thin toward the southern margin of the Green River Basin (fig. 6). Trona beds 1 to 14 extend for considerable distances toward the northern part of the basin. The abundance of trona diminishes significantly above trona bed 18. Beds 19-25 underlie smaller areas and are thinner than those in the lower part of the member, although several of these beds are currently being mined.

In this study, it was found that trona bed 18 may not be a continuous unit as was once thought. On the east side of the basin, bed 18 lies about 25 feet above trona bed 17 and was assumed to be continuous with another bed on the west side of the basin that occurs about 50 to 60 feet above bed 17. These two beds now appear to be separate units and are tentatively identified as trona bed 18L, or lower bed, in the east half of the basin, and bed 18U, for the stratigraphically higher bed found in the west half of the basin.

Leigh (1990, 1991) noted that the lower trona beds, 1-18, have a typically very fine grained sucrosic texture and display well-developed stratification features including numerous laterally continuous marlstone laminae. Some beds display graded bedding and layers of brecciated trona consisting of rounded clasts of trona in a matrix of very fine grained brown trona. These lower beds were deposited in a extogenic-meromictic saline lake according to Sullivan (1985) and Leigh (1991). During low-water lake stages, trona crusts that formed on adjacent mudflats were swept into the shallow lake and were deposited as clasts. During periods of more intense evaporation, the salting stage for sodium chloride was reached and large quantities of halite co-precipitated with trona.

In contrast to the lower beds, Leigh (1991) noted that trona beds 19-25 consist typically of coarse, random to radiating bladed aggregates of trona and recrystallized trona, and lack the stratification features noted in the lower trona beds. He also noted vertical sedimentary dikes of shortitic mudstone that, in plan view, form large polygons similar to large-scale desiccation polygons found in the surficial sodic sediments of Lake Magadi, Kenya. Leigh (1991) believes that these features are consistent with a playa-lake setting in which the lake dried repeatedly. However, the apparent total absence of halite in these upper trona beds seems unusual, if the playa lake dried completely. Lenticular layers and pods of nearly pure spar trona (similar in appearance to satin spar, a fibrous variety of gypsum), were deposited postdepositionally in marlstone from interstitial sediment brine.

Although faults are rare in the Green River trona deposits, soft-sediment deformational structures in the trona beds are common. In trona bed 17 toward the area of mixed trona and halite in the southern part of the basin, slump structures and dissolution surfaces; rolls in the mine floor and roof with marked local thinning of the trona bed; large pods of coarse-grained, recrystallized trona, nahcolite or wegscheiderite; and pods and layers of brecciated trona have been encountered, as well as sodium chloride brine and tar seeps. Sedimentary dikes similar to those found in the upper beds are also common in bed 17.

Some high-pressure blowouts have also been encountered in bed 17 near the area of mixed halite and trona. The shapes of the blowout cavities are irregular in plan view, but they tend to be elongate parallel to bedding. One cavity was seen that was about 6 feet wide and extended into the trona bed about 7 feet. The maximum height of the cavity was 0.8 foot. The material ejected from the cavities appears to be small particles of clean recrystallized trona. Methane and carbon dioxide are likely gases in these blowouts and the odor of ammonia has been noted.

COMPOSITION OF TRONA BEDS

Few mineral analyses of the Wyoming trona beds have been published. Trona is assumed to be the principal mineral constituent of most beds. However, other sodium carbonate minerals, such as nahcolite and wegscheiderite, are locally abundant in some of the lower beds in the southern part of the basin near areas of mixed halite and trona.

Culbertson (1971) noted the occurrence of nahcolite in or just above trona beds 1, 2, 9, 15, 18, and 24 in seven drill cores. Robb and Smith (1976) found nahcolite in varied amounts in trona beds 1, 8, 9, and 15 in the Union Pacific Blacks Fork core hole 41-23 in the NE¼NE¼ sec. 23, T.17 N., R.109 W., Sweetwater County. Trona bed 1 contains as much as 50 percent nahcolite. Substantial quantities of nahcolite were also found in trona beds 1 and 4 in Vulcan Materials Co. core hole VMC-X-1 in sec. 16, T.16 N., R.109 W., about 5 miles south of the Blacks Fork 41-23 core hole by J.R. Dyni (unpublished X-ray diffraction analyses, 1985). These few data suggest that nahcolite is quantitatively important in some trona beds.

Although nahcolite may not have a significant effect on mining and processing the mineral for soda ash by the methods now used at the Wyoming trona mines, its presence may be important when solution mining is attempted. Nahcolite is much less soluble in water than trona. Furthermore, the theoretical soda ash content of nahcolite is 63.1 percent by weight compared to 70.3 percent for trona. No attempt was made to include nahcolite in rescurce computations because its abundance and distribution is not well known.

Published chemical analyses of the Wyoming trona beds are also scarce. Three analyses published by Deardorff and Mannion (1971, p. 27) (probably of trona beds 24 and 25 according to Burnside and Culbertson, 1979, p. 6), show the amounts of water-soluble sodium carbonate-bicarbonate ranging from 85.5 to 93.8 percent, chloride ranging from 0.02 to 0.07 percent, and sulfate averaging 0.02 percent. Water insoluble material ranged from 4.9 to 14.4 percent, and a trace of organic matter was reported in two of the three samples. These analyses illustrate the relatively high purity of the trona in terms of water-soluble constituents. The low sulfate content is typical of the trona beds. The chloride content is very low in the uppermost trona beds, but is locally much higher in beds below trona bed 19.

New chemical and X-ray diffraction analyses of drill core of several trona beds in six core holes were recently made by U.S. Borax Inc. in cooperation with the U.S. Geological Survey. The core holes are in the central part of the trona district, and their names and locations are given with the results of the analyses in tables 1 to 6. The locations of the holes are also shown on figure 5. The cores are part of the drill core collection of the U.S. Geological Survey's Core Research Center, Lakewood, Colorado.

Samples for analysis were prepared by sawing small 1- to 3-foot slabs from the drill core. The length of each slab was based on lithology. The slabs for each sampled interval were crushed and a small portion of the crushed material was powdered for analysis. The analytical results include water-soluble constituents calculated in weight percent as $Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$ (trona), $NaHCO_3$ (nahcolite), NaCl (halite), Na_2SO_4, and insoluble material. The carbonates were determined by CO_3/HCO_3 titration, halite by ion selective electrode analysis of chloride, and sodium sulfate by ion chromatography analysis of sulfate. The water leachates were analyzed for sodium, iron, magnesium, calcium, and potassium by induction-coupled plasma (ICP) spectroscopy. The abundance of these elements was also determined by ICP spectroscopy of acid leachates (10 percent hydrochloric acid) of the whole-rock samples. The mineralogy of the whole-rock samples was determined by qualitative X-ray diffraction analysis. "Insolubles" include the non-water soluble material in the samples. "Approximate weighted averages" of the analyzed constituents were determined for the entire bed by multiplying the weight percent of the constituent by its thickness, summing the products, and dividing this sum by the total thickness of the bed.

Trona was the dominant sodium carbonate mineral in most samples. However, in some samples from trona beds 14 and 17 in the Blacks Fork 41-23, Grierson 1, Finley 2 core holes, nahcolite is a major constituent. For the beds analyzed, the average trona content ranges from 57 to 94 percent. Bed 4 is highest in trona content, averaging 94.0 percent, contains only small amounts of insolubles averaging 5.9 percent, and less than 0.1 percent chloride. Sulfate was not determined, but is probably nil. On the basis of its composition and thickness, bed 4 appears to be a good candidate for mining.

Water-soluble sulfate, reported as sodium sulfate, is uniformly low in 7 of the 9 cores tested. The largest amount was 560 ppm (0.06 percent) found in a sample representing an interval 0.3 foot thick of bed 17 in the Diamond Alkali Sturm 2 core hole. Most sulfate analyses were less than 300 ppm (0.03 percent). These analyses confirm the very low water-soluble sulfate content of the Wyoming trona deposits reported by earlier workers.

Because all but one trona bed that was analyzed was outside of the two percent halite line, the sodium chloride content was uniformly low, ranging from about 0.06 to 0.29 percent. The one exception is bed 14 in Federal 6765 which is well within the halite-bearing area (fig. 14); this bed contained 25.5 percent sodium chloride.

In the water leachates, potassium commonly averages less than 100 ppm and rarely exceeds 200 ppm. Similarly, water-soluble magnesium is low, averaging between about 50 and 200 ppm, but with the notable exception of drill core of beds 14 and 17 in the Grierson core hole. In this well, the water leachates of beds 14 and 17 averaged 784 and 821 ppm magnesium. The abundance of water-soluble calcium averages between about 60 and 200 ppm in most of the trona beds analyzed, except for trona beds 14 and 17 in Finley 2 and trona bed 14 in Federal 6765 which average between about 1,100 and 2,100 ppm calcium.

Two elements that may be expected in notable quantities in the water leachates are fluoride and boron, but neither were determined in these analyses.

Table 1.—Chemical analyses of trona bed 14 in Diamond Alkali Co., Sturm 1 core hole; sec. 10, T.17 N., R.109 W., Sweetwater County, Wyoming. USGS well no. W019.

From (Feet)	To (Feet)	Diff (Feet)	Calculated water-soluble constituents and insols: Trona (Pct)	$NaHCO_3$ (Pct)	Insol (Pct)	NaCl (Pct)	Na_2SO_4 (PPM)	Total (Pct)
1,596.2	1,598.2	2.0	70.8	0.0	28.3	0.08	90	99.2
1,598.2	1,600.4	2.2	89.8	0.0	10.6	0.05	<75	100.5
1,600.4	1,602.4	2.0	81.3	0.0	18.9	0.08	<75	100.3
1,602.4	1,604.4	2.0	85.6	0.0	14.4	0.04	105	100.0
1,604.4	1,606.7	2.3	83.0	0.0	15.7	0.03	105	98.7
1,606.7	1,608.3	1.6	83.0	0.0	15.4	0.04	90	98.4
Bed thickness		12.1						
Approximate weighted average			82.4	0.0	17.1	0.1	ND	99.6

From (Feet)	To (Feet)	Diff (Feet)	ICP analyses of water leachates: Na_2O (Pct)	Fe_2O_3 (PPM)	MgO (PPM)	CaO (PPM)	K_2O (PPM)
1,596.2	1,598.2	2.0	28.8	17	110	70	71
1,598.2	1,600.4	2.2	37.1	9	110	60	74
1,600.4	1,602.4	2.0	32.9	10	260	60	95
1,602.4	1,604.4	2.0	34.2	6	60	50	59
1,604.4	1,606.7	2.3	33.9	5	50	50	51
1,606.7	1,608.3	1.6	32.7	5	50	50	57
Bed thickness	12.1						
Approximate weighted average			33.4	9	107	57	68

From (Feet)	To (Feet)	Diff (Feet)	ICP analyses of acid leachates: Na_2O (Pct)	Fe_2O_3 (Pct)	MgO (Pct)	CaO (Pct)	K_2O (Pct)
1,596.2	1,598.2	2.0	34.2	0.24	2.2	5.5	0.08
1,598.2	1,600.4	2.2	39.1	<0.10	1.2	1.5	0.08
1,600.4	1,602.4	2.0	37.7	0.13	1.8	2.1	0.10
1,602.4	1,604.4	2.0	38.1	<0.10	1.2	1.5	0.07
1,604.4	1,606.7	2.3	38.8	<0.10	1.1	1.5	0.08
1,606.7	1,608.3	1.6	38.2	<0.10	1.2	1.4	0.07
Bed thickness		12.1					
Approximate weighted average			37.7	ND	1.4	2.2	0.08

From (Feet)	To (Feet)	Diff (Feet)	Qualitative XRD analyses of whole-rock samples (X, major constituent): Trona	Shortite
1,596.2	1,598.2	2.0	X	X
1,598.2	1,600.4	2.2	X	
1,600.4	1,602.4	2.0	X	
1,602.4	1,604.4	2.0	X	
1,604.4	1,606.7	2.3	X	
1,606.7	1,608.3	1.6	X	
Bed thickness		12.1		

Table 1.—Sturm 1 core hole (continued)

Notes: Trona and $NaHCO_3$ determined by CO_3/HCO_3 titration.
NaCl determined by selective ion electrode analysis of Cl.
Na_2SO_4 determined by ion chromatography analysis of SO_4.
ND, not determined.

Table 2.—Chemical analyses of trona bed 14 in Union Pacific Railroad Co., Blacks Fork 41-23 core hole in sec. 23, T.17 N., R.109 W., Sweetwater County, Wyoming. USGS well no. W037.

			Calculated water-soluble constituents and insol					
From (Feet)	To (Feet)	Diff (Feet)	Trona (Pct)	$NaHCO_3$ (Pct)	Insol (Pct)	NaCl (Pct)	Na_2SO_4 (PPM)	Total (Pct)
1,736.2	1,738.0	1.8	70.8	0.0	27.8	0.06	120	98.7
1,738.0	1,740.0	2.0	67.8	0.0	30.6	0.07	120	98.5
1,740.0	1,741.0	1.0	64.3	0.0	34.1	0.07	120	98.5
1,741.0	1,743.0	2.0	87.2	0.0	11.5	0.05	90	98.8
1,743.0	1,745.7	2.7	85.7	0.0	13.2	0.05	90	99.0
Bed thickness		9.5						
Approximate weighted average			77.2	0.0	21.5	0.06	105	98.7

			ICP analyses of water leachates				
From (Feet)	To (Feet)	Diff (Feet)	Na_2O (Pct)	Fe_2O_3 (PPM)	MgO (PPM)	CaO (PPM)	K_2O (PPM)
1,736.2	1,738.0	1.8	28.3	7	170	70	140
1,738.0	1,740.0	2.0	28.0	7	170	80	130
1,740.0	1,741.0	1.0	25.9	8	120	70	100
1,741.0	1,743.0	2.0	35.2	6	210	50	53
1,743.0	1,745.7	2.7	34.4	6	220	50	59
Bed thickness		9.5					
Approximate weighted average			31.2	7	187	62	92

			ICP analyses of acid leachates				
From (Feet)	To (Feet)	Diff (Feet)	Na_2O (Pct)	Fe_2O_3 (Pct)	MgO (Pct)	CaO (Pct)	K_2O (Pct)
1,736.2	1,738.0	1.8	34.9	0.19	2.4	5.5	0.14
1,738.0	1,740.0	2.0	34.2	0.20	2.5	5.2	0.15
1,740.0	1,741.0	1.0	33.4	0.21	2.9	5.7	0.16
1,741.0	1,743.0	2.0	39.8	<0.10	0.8	1.1	0.06
1,743.0	1,745.7	2.7	39.9	<0.10	0.8	1.0	0.05
Bed thickness		9.5					
Approximate weighted average			37.0	ND	1.7	3.3	0.10

			Qualitative XRD analyses of whole-rock samples (X, major constituent)	
From (Feet)	To (Feet)	Diff (Feet)	Trona	Nahcolite
1,736.2	1,738.0	1.8	X	X
1,738.0	1,740.0	2.0	X	
1,740.0	1,741.0	1.0	X	
1,741.0	1,743.0	2.0	X	
1,743.0	1,745.7	2.7	X	X
Bed thickness		9.5		

Notes: Trona and NaHCO3 determined by CO_3/HCO_3 titration.
NaCl determined by selective ion electrode analysis of Cl.
Na_2SO_4 determined by ion chromatography analysis of SO_4.
ND, not determined.

Table 3.—Chemical analyses of trona beds 14 and 17 in Diamond Alkali Co., Grierson 1 core hole in sec. 4, T.16 N., R.109 W., Sweetwater County, Wyoming. USGS well no. W012.

Trona bed 17			Calculated water-soluble constituents and insols					
From (Feet)	To (Feet)	Diff (Feet)	Trona (Pct)	$NaHCO_3$ (Pct)	Insols (Pct)	NaCl (Pct)	Na_2SO_4 (PPM)	Total (Pct)
1,753.3	1,755.2	1.9	68.0	18.8	11.8	0.19	80	98.8
1,755.2	1,757.7	2.5	51.6	44.8	5.0	0.18	<75	101.6
1,757.7	1,759.2	1.5	51.9	9.8	39.6	0.37	105	101.7
Bed thickness	5.9							
Approximate weighted average			57.0	27.5	16.0	0.23	ND	100.7
Trona bed 14								
1,852.5	1,854.5	2.0	64.7	0	35.6	0.42	90	100.7
1,854.5	1,856.6	2.1	93.6	0	6.0	0.10	<75	99.7
1,856.6	1,858.9	2.3	91.1	0	8.5	0.08	<75	99.7
1,858.9	1,860.8	1.9	79.4	0	22.0	0.14	<75	101.5
1,860.8	1,863.2	2.4	95.9	0	4.4	0.06	<75	100.4
1,863.2	1,864.7	1.5	77.8	0	22.6	0.10	210	100.5
Bed thickness		12.2						
Approximate weighted average			84.7	0	15.5	0.15	ND	100.4

Trona bed 17			ICP analyses of water leachates				
From (Feet)	To (Feet)	Diff (Feet)	Na_2O (Pct)	Fe_2O_3 (PPM)	MgO (PPM)	CaO (PPM)	K_2O (PPM)
1,753.3	1,755.2	1.9	35.0	70	730	100	10
1,755.2	1,757.7	2.5	36.6	18	140	140	3
1,757.7	1,759.2	1.5	24.8	210	2,070	100	51
Bed thickness	5.9						
Approximate weighted average			33.1	84	821	117	17
Trona bed 14							
1,852.5	1,854.5	2.0	25.1	58	2,470	100	47
1,854.5	1,856.6	2.1	38.4	15	500	70	25
1,856.6	1,858.9	2.3	37.4	16	400	60	33
1,858.9	1,860.8	1.9	31.3	14	740	70	74
1,860.8	1,863.2	2.4	38.2	9	240	50	20
1,863.2	1,864.7	1.5	31.0	16	450	60	84
Bed thickness			12.2				
Approximate weighted average			34.0	21	784	68	44

Trona bed 17			ICP analyses of acid leachates				
From (Feet)	To (Feet)	Diff (Feet)	Na_2O (Pct)	Fe_2O_3 (Pct)	MgO (Pct)	CaO (Pct)	K_2O (Pct)
1,753.3	1,755.2	1.9	39.5	<0.10	0.7	1.2	0.01
1,755.2	1,757.7	2.5	43.2	<0.10	<0.1	<0.1	<0.10
1,757.7	1,759.2	1.5	35.0	0.23	2.3	4.3	0.04
Bed thickness		5.9					
Approximate weighted average			39.9	ND	ND	ND	ND

Table 3.—Grierson 1 core hole (continued)

Trona bed 14

From (Feet)	To (Feet)	Diff (Feet)	ICP analyses of acid leachates: Na_2O (Pct)	Fe_2O_3 (Pct)	MgO (Pct)	CaO (Pct)	K_2O (Pct)
1,852.5	1,854.5	2.0	36.4	0.13	2.10	5.80	0.04
1,854.5	1,856.6	2.1	41.8	<0.10	0.46	0.50	0.02
1,856.6	1,858.9	2.3	41.1	<0.10	0.50	1.00	0.03
1,858.9	1,860.8	1.9	37.8	0.11	1.50	2.10	0.08
1,860.8	1,863.2	2.4	41.6	<0.10	0.25	0.32	0.01
1,863.2	1,864.7	1.5	35.5	<0.10	1.50	2.00	0.08
Bed thickness		12.2					
Approx weighted average			39.3	ND	1.0	1.9	0.04

Qualitative XRD analyses of whole-rock samples
(X, major constituent)

Trona bed 17

FROM (Feet)	TO (Feet)	DIFF (Feet)	Trona	Nahcolite	Mica
1,753.3	1,755.2	1.9	X	X	
1,755.2	1,757.7	2.5	X	X	
1,757.7	1,759.2	1.5	X		
Bed thickness		5.9			

Trona bed 14

1,852.5	1,854.5	2.0	X		
1,854.5	1,856.6	2.1	X		
1,856.6	1,858.9	2.3	X		
1,858.9	1,860.8	1.9	X		X
1,860.8	1,863.2	2.4	X		
1,863.2	1,864.7	1.5	X		
Bed thickness		12.2			

Notes: Trona and $NaHCO_3$ determined by CO_3/HCO_3 titration.
NaCl determined by selective ion electrode analysis of Cl.
Na_2SO_4, determined by ion chromatrography analysis of SO_4.
ND, not determined.

Table 4.—Chemical analyses of trona beds 14 and 17 in Diamond Alkali Co., Finley 2 core hole in sec. 26, T.16 N., R.110 W., Sweetwater County, Wyoming. USGS well no. W044.

			Calculated water-soluble constituents and insols					
Trona bed 17								
From (Feet)	To (Feet)	Diff (Feet)	Trona (Pct)	$NaHCO_3$ (Pct)	Insols (Pct)	NaCl (Pct)	Na_2SO_4 (PPM)	Total (Pct)
1,862.45	1,863.25	0.8	72.0	0.0	27.7	0.80	190	100.5
1,863.25	1,864.65	1.4	95.7	0.0	4.0	0.28	220	100.0
1,864.65	1,866.15	1.5	98.4	0.0	2.4	0.18	130	101.0
1,866.15	1,867.45	1.3	89.0	0.0	11.1	0.41	240	100.5
1,867.45	1,868.85	1.4	99.5	0.0	1.0	0.13	210	100.6
1,868.85	1,869.95	1.1	90.9	9.1	0.4	0.13	190	100.5
1,869.95	1,870.65	0.7	61.8	26.4	13.0	0.34	190	101.5
Bed thickness		8.2						
Approximate weighted average			89.9	3.5	6.9	0.29	195	100.6
Trona bed 14								
1,969.8	1,972.1	2.3	91.4	0.0	9.3	0.27	160	101.0
1,972.1	1,974.1	2.0	64.5	0.0	35.7	0.82	210	101.0
1,974.1	1,976.1	2.0	85.5	0.0	14.8	0.42	180	100.7
Bed thickness		6.3						
Approximate weighted average			81.0	0.0	19.4	0.49	182	100.9

			ICP analyses of water leachates				
Trona bed 17							
From (Feet)	To (Feet)	Diff (Feet)	Na_2O (Pct)	Fe_2O_3 (PPM)	MgO (PPM)	CaO (PPM)	K_2O (PPM)
1,862.45	1,863.25	0.8	28.1	4	49	3,400	164
1,863.25	1,864.65	1.4	40.5	17	22	1,300	88
1,864.65	1,866.15	1.5	39.7	26	13	825	78
1,866.15	1,867.45	1.3	38.5	10	44	1,950	129
1,867.45	1,868.85	1.4	42.6	11	<12	625	63
1,868.85	1,869.95	1.1	38.2	21	<12	165	35
1,869.95	1,870.65	0.7	35.2	41	28	2,150	118
Bed thickness		8.2					
Approximate weighted average			38.4	18	ND	1,326	91
Trona bed 14							
1,969.8	1,972.1	2.3	33.9	41	30	1,300	160
1,972.1	1,974.1	2.0	24.5	<2	82	3,225	160
1,974.1	1,976.1	2.0	34.5	11	43	1,950	108
Bed thickness		6.3					
Approximate weighted average			31.1	ND	51	2,117	143

			ICP analyses of acid leachates				
Trona bed 17							
From (Feet)	To (Feet)	Diff (Feet)	Na_2O (Pct)	Fe_2O_3 (Pct)	MgO (Pct)	CaO (Pct)	K_2O (Pct)
1,862.45	1,863.25	0.8	35.7	0.21	0.81	2.11	2.60
1,863.25	1,864.65	1.4	41.8	0.04	0.54	0.35	0.34
1,864.65	1,866.15	1.5	43.8	0.03	0.50	0.29	0.12
1,866.15	1,867.45	1.3	40.3	0.09	0.09	0.89	0.90

Table 4.—Finley 2 core hole (continued)

1,867.45	1,868.85	1.4	43.3	0.02	0.46	0.14	0.08
1,868.85	1,869.95	1.1	42.3	0.01	0.42	0.04	0.03
1,869.95	1,870.65	0.7	38.8	0.06	0.76	0.69	1.18
Bed thickness		8.2					
Approximate weighted average			41.4	0.06	0.48	0.55	0.59
Trona bed 14							
1,969.8	1,972.1	2.3	42.6	0.07	0.60	0.81	0.91
1,972.1	1,974.1	2.0	36.6	0.24	1.09	3.08	3.60
1,974.1	1,976.1	2.0	39.9	0.09	0.72	1.36	1.38
Bed thickness		6.3					
Approximate weighted average			39.8	0.13	0.79	1.71	1.91

Qualitative X-ray diffraction analyses

0, not detected; 1, trace; 2, very minor; 3, minor; 4, major

			WHOLE-ROCK SAMPLES				
Trona bed 17							
From (Feet)	To (Feet)	Diff (Feet)	Trona	Nahcolite	Halite	Quartz	Dolomite
1,862.45	1,863.25	0.8	4	0	0	2	0
1,863.25	1,864.65	1.4	4	2	0	1	0
1,864.65	1,866.15	1.5	4	4	0	0	0
1,866.15	1,867.45	1.3	4	1	0	0	0
1,867.45	1,868.85	1.4	4	0	0	0	0
1,868.85	1,869.95	1.1	4	4	0	0	0
1,869.95	1,870.65	0.7	4	4	0	1	0
Bed thickness		8.2					
Trona bed 14							
1,969.8	1,972.1	2.3	4	1	0	0	0
1,972.1	1,974.1	2.0	4	0	0	3	0
1,974.1	1,976.1	2.0	4	0	0	0	0
Bed thickness		6.3					

			WATER-INSOLUBLE FRACTION				
Trona bed 17			Shortite	Northupite	Bradleyite	Quartz	Saponite
1,862.45	1,863.25	0.8	4	4	0	4	2
1,863.25	1,864.65	1.4	4	4	1	4	2
1,864.65	1,866.15	1.5	3	4	0	2	0
1,866.15	1,867.45	1.3	3	2	0	3	0
1,867.45	1,868.85	1.4	3	4	0	2	0
1,868.85	1,869.95	1.1	3	3	0	3	0
1,869.95	1,870.65	0.7	3	4	1	3	0
Bed thickness		8.2					
Trona bed 14							
1,969.8	1,972.1	2.3	3	4	3	3	0
1,972.1	1,974.1	2.0	3	4	2	4	1
1,974.1	1,976.1	2.0	3	3	4	4	2
Bed thickness		6.3					

Table 4.—Finley 2 core hole (continued)

Notes: Trona and nahcolite determined by CO_3/HCO_3 titration.
NaCl determined by selective ion electrode analysis of Cl.
Na_2SO_4 determined by ion chromatrography analysis of SO_4.
ND, not determined

Table 5.—Chemical analyses of trona beds 4 and 14 in Sinclair Oil and Gas Co., Federal 1 (6765) core hole in sec. 6, T.15 N., R.108 W., Sweetwater County, Wyoming. USGS well no. W051.

Trona bed 14			Calculated water-soluble constituents and insols				
From (Feet)	To (Feet)	Diff (Feet)	Trona (Pct)	$NaHCO_3$ (Pct)	Insols (Pct)	NaCl (Pct)	Total (Pct)
1,565.2	1,566.7	1.5	72.7	4.3	25.7	1.28	104.0
1,566.7	1,567.8	1.1	80.3	0.0	14.4	5.96	100.7
1,567.8	1,569.0	1.2	45.4	0.0	0.5	53.10	99.0
1,569.0	1,570.8	1.8	43.2	0.0	1.0	56.60	100.8
1,570.8	1,571.7	0.9	68.8	0.0	26.3	6.42	101.5
1,571.7	1,572.7	1.0	66.3	0.0	2.4	31.20	99.9
1,572.7	1,574.2	1.5	63.0	0.0	0.6	36.40	100.0
1,574.2	1,575.7	1.5	82.9	0.0	17.1	1.09	101.1
Bed thickness		10.5					
Approximate weighted average			64.4	0.6	10.4	25.46	100.9
Trona bed 4							
1,762.8	1,763.6	0.8	96.1	0.0	3.6	0.15	100.6
1,763.6	1,764.9	1.3	99.3	0.0	0.5	0.08	101.2
1,764.9	1,766.0	1.1	96.8	0.0	2.8	0.09	100.8
1,766.0	1,766.9	0.9	98.6	0.0	0.9	0.06	100.5
1,766.9	1,767.7	0.8			(Missing drill core)		
1,767.7	1,769.7	2.0	98.0	0.0	2.3	0.05	102.4
1,769.7	1,771.4	1.7	99.5	0.0	0.8	0.05	102.1
1,771.4	1,773.0	1.6	73.2	0.0	26.2	0.07	101.1
Bed thickness		10.2					
Approximate weighted average			94.0	0.0	5.9	0.07	99.9

Trona bed 14			ICP analyses of water leachates				
From (Feet)	To (Feet)	Diff (Feet)	Na_2O (Pct)	Fe_2O_3 (PPM)	MgO (PPM)	CaO (PPM)	K_2O (PPM)
1,565.2	1,566.7	1.5	28.8	45	28	3,225	225
1,566.7	1,567.8	1.1	40.5	50	86	150	130
1,567.8	1,569.0	1.2	54.3	9	36	100	62
1,569.0	1,570.8	1.8	50.3	3	48	110	38
1,570.8	1,571.7	0.9	31.5	42	130	2,950	205
1,571.7	1,572.7	1.0	46.8	6	39	290	59
1,572.7	1,574.2	1.5	50.4	4	15	12	39
1,574.2	1,575.7	1.5	36.0	28	76	2,225	130
Bed thickness		10.5					
Approximate weighted average			42.7	22	53	1,107	107
Trona bed 4							
1,762.8	1,763.6	0.8	42.1	79	73	230	78
1,763.6	1,764.9	1.3	44.6	10	32	22	52
1,764.9	1,766.0	1.1	45.6	33	53	500	75
1,766.0	1,766.9	0.9	45.0	9	7	33	28
1,766.9	1,767.7	0.8			(Missing drill core)		

Table 5.—Federal 6765 core hole (continued)

1,767.7	1,769.7	2.0	42.7	11	35	35	28
1,769.7	1,771.4	1.7	43.5	11	14	136	48
1,771.4	1,773.0	1.6	36.2	44	190	65	82
Bed thickness		10.2					
Approximate weighted average			42.5	25	60	127	54

			ICP analyses of acid leachates				
Trona bed 14							
From (Feet)	To (Feet)	Diff (Feet)	Na_2O (Pct)	Fe_2O_3 (Pct)	MgO (Pct)	CaO (Pct)	K_2O (Pct)
1,565.2	1,566.7	1.5	39.3	0.21	0.62	2.22	3.44
1,566.7	1,567.8	1.1	41.6	0.13	0.71	1.07	2.10
1,567.8	1,569.0	1.2	50.5	<0.01	0.33	0.04	0.04
1,569.0	1,570.8	1.8	52.2	<0.01	0.46	0.16	0.02
1,570.8	1,571.7	0.9	35.8	0.18	1.33	1.98	3.97
1,571.7	1,572.7	1.0	45.2	0.01	0.28	0.29	0.18
1,572.7	1,574.2	1.5	44.8	<0.01	0.25	0.08	0.04
1,574.2	1,575.7	1.5	35.3	0.08	1.18	1.47	1.90
Bed thickness		10.5					
Approximate weighted average			43.5	ND	0.62	0.88	1.35
Trona bed 4							
1,762.8	1,763.6	0.8	38.3	0.12	0.57	0.31	0.37
1,763.6	1,764.9	1.3	38.1	0.02	0.48	0.04	0.06
1,764.9	1,766.0	1.1	38.4	0.09	0.54	0.36	0.42
1,766.0	1,766.9	0.9	39.2	0.02	0.51	0.08	0.10
1,766.9	1,767.7	0.8		(Missing drill core)			
1,767.7	1,769.7	2.0	39.8	0.09	0.64	0.35	0.44
1,769.7	1,771.4	1.7	38.7	0.02	0.45	0.08	0.08
1,771.4	1,773.0	1.6	28.1	0.75	2.22	1.87	2.52
Bed thickness		10.2					
Approximate weighted average			37.0	0.18	0.82	0.49	0.64

			Qualitative X-ray diffraction analyses (0,not detected; 1, trace; 2, very minor; 3, minor; 4, major) WHOLE-ROCK SAMPLES				
Trona bed 14							
From (Feet)	To (Feet)	Diff (Feet)	Trona	Nahcolite	Halite	Quartz	Dolomite
1,565.2	1,566.7	1.5	4	4	1	2	1
1,566.7	1,567.8	1.1	4	1	3	0	0
1,567.8	1,569.0	1.2	3	0	4	2	0
1,569.0	1,570.8	1.8	3	0	4	0	0
1,570.8	1,571.7	0.9	4	0	3	0	1
1,571.7	1,572.7	1.0	4	0	4	0	0
1,572.7	1,574.2	1.5	4	0	4	0	0
1,574.2	1,575.7	1.5	4	0	2	1	0
Bed thickness		10.5					

Table 5.—Federal 6765 core hole (continued)

			Qualitative X-ray diffraction analyses (0,not detected; 1, trace; 2, very minor; 3, minor; 4, major)				
			WHOLE-ROCK SAMPLES				
Trona bed 4			Trona	Nahcolite	Halite	Quartz	Dolomite
1,762.8	1,763.6	0.8	4	0	2	0	0
1,763.6	1,764.9	1.3	4	0	0	0	0
1,764.9	1,766.0	1.1	4	0	1	0	2
1,766.0	1,766.9	0.9	4	0	1	1	1
1,766.9	1,767.7	0.8		(Missing drill core)			
1,767.7	1,769.7	2.0	4	0	0	0	1
1,769.7	1,771.4	1.7	4	0	0	0	0
1,771.4	1,773.0	1.6	4	0	0	2	3
Bed thickness		10.2					
			WATER-INSOLUBLE FRACTION				
			Shortite	Northupite	Bradleyite	Quartz	Dolomite
Trona bed 14							
1,565.2	1,566.7	1.5	3	4	3	3	0
1,566.7	1,567.8	1.1	4	4	2	1	0
1,567.8	1,569.0	1.2	0	3	0	0	0
1,569.0	1,570.8	1.8	0	3	0	3	0
1,570.8	1,571.7	0.9	4	3	1	2	0
1,571.7	1,572.7	1.0	0	3	0	1	0
1,572.7	1,574.2	1.5	1	4	0	0	0
1,574.2	1,575.7	1.5	3	1	0	0	0
Bed thickness		10.5					
Trona bed 4							
1,762.8	1,763.6	0.8	2	0	0	2	3
1,763.6	1,764.9	1.3	0	0	0	0	0
1,764.9	1,766.0	1.1	0	0	0	0	3
1,766.0	1,766.9	0.9	0	0	0	0	3
1,766.9	1,767.7	0.8		(Missing drill core)			
1,767.7	1,769.7	2.0	0	0	0	0	4
1,769.7	1,771.4	1.7	0	0	0	0	4
1,771.4	1,773.0	1.6	0	0	0	3	4
Bed thickness		10.2					

Notes: Trona and $NaHCO_3$ determined by CO_3/HCO_3 titration.
NaCl determined by selective ion electrode analysis of Cl.
Na_2SO_4 determined by ion chromatography analysis of SO_4.
Averages exclude missing core.
ND, not determined.

Table 6.—Chemical analyses of trona bed 14 in Diamond Alkali Co., Sturm 2 core hole in sec. 8, T.17 N., R.109 W., Sweetwater County, Wyoming. USGS well no. W160.

			Calculated water-soluble constituents and insols					
From (Feet)	To (Feet)	Diff (Feet)	Trona (Pct)	$NaHCO_3$ (Pct)	Insols (Pct)	NaCl (Pct)	Na_2SO_4 (PPM)	Total (Pct)
1,698.3	1,699.4	1.1	77.7	0.0	22.0	0.10	340	99.8
1,699.4	1,700.4	1.0	84.5	0.0	15.3	0.06	250	99.9
1,700.4	1,701.4	1.0	94.4	0.0	5.7	0.03	210	100.1
1,701.4	1,702.9	1.5	75.5	0.0	24.3	0.06	300	99.9
1,702.9	1,704.4	1.5	78.5	0.0	21.5	0.08	310	100.1
1,704.4	1,705.9	1.5			(Missing drill core)			
1,705.9	1,706.2	0.3	4.6	0.0	94.3	0.08	560	99.0
1,706.2	1,707.4	1.2	92.1	0.0	7.8	0.02	280	99.9
Bed thickness		9.1						
Approximate weighted average			79.9	0.0	19.9	0.06	296	99.9

			ICP analyses of water leachates				
From (Feet)	To (Feet)	Diff (Feet)	Na_2O (Pct)	Fe_2O_3 (PPM)	MgO (PPM)	CaO (PPM)	K_2O (PPM)
1,698.3	1,699.4	1.1	34.0	39	335	95	120
1,699.4	1,700.4	1.0	34.7	6	73	106	120
1,700.4	1,701.4	1.0	37.5	4	53	63	52
1,701.4	1,702.9	1.5	30.3	10	310	118	142
1,702.9	1,704.4	1.5	32.1	10	305	9	113
1,704.4	1,705.9	1.5			(Missing drill core)		
1,705.9	1,706.2	0.3	2.5	14	50	42	190
1,706.2	1,707.4	1.2	36.4	7	56	49	49
Bed thickness		9.1					
Approximate weighted average			32.6	13	106	197	70

			ICP analyses of acid leachates				
From (Feet)	To (Feet)	Diff (Feet)	Na_2O (Pct)	Fe_2O_3 (Pct)	MgO (Pct)	CaO (Pct)	K_2O (Pct)
1,698.3	1,699.4	1.1	39.0	0.28	1.62	2.99	1.14
1,699.4	1,700.4	1.0	38.9	0.16	2.25	3.02	1.19
1,700.4	1,701.4	1.0	42.0	0.06	1.07	1.07	0.84
1,701.4	1,702.9	1.5	35.2	0.20	3.12	4.32	1.32
1,702.9	1,704.4	1.5	39.2	0.22	2.48	2.24	1.15
1,704.4	1,705.9	1.5			(Missing drill core)		
1,705.9	1,706.2	0.3	2.5	0.64	10.20	12.10	3.85
1,706.2	1,707.4	1.2	40.6	0.04	0.73	7.42	0.76
Bed thickness		9.1					
Approximate weighted average			37.5	0.18	1.19	2.29	3.91

Qualitative X-ray diffraction analyses
(0, not detected; 1, trace; 2, very minor; 3, minor; 4, major)

			WHOLE-ROCK SAMPLES				
From (Feet)	To (Feet)	Diff (Feet)	Trona	Nahcolite	Halite	Quartz	Dolomite
1,698.3	1,699.4	1.1	4	0	0	2	1
1,699.4	1,700.4	1.0	4	0	0	2	1
1,700.4	1,701.4	1.0	4	0	0	3	1

Table 6.—Sturm 2 core hole (continued)

1,701.4	1,702.9	1.5	4	0	0	2	3
1,702.9	1,704.4	1.5	4	0	0	1	2
1,704.4	1,705.9	1.5		(Missing drill core)			
1,705.9	1,706.2	0.3	2	0	0	3	4
1,706.2	1,707.4	1.2	4	0	0	2	2
Bed thickness		9.1					

			WATER-INSOLUBLE FRACTION				
			Shortite	Northupite	Bradleyite	Quartz	Dolomite
1,698.3	1,699.4	1.1	3	3	3	4	4
1,699.4	1,700.4	1.0	2	1	2	2	4
1,700.4	1,701.4	1.0	0	0	2	3	4
1,701.4	1,702.9	1.5	3	0	2	3	3
1,702.9	1,704.4	1.5	1	1	4	3	2
1,704.4	1,705.9	1.5		(Missing drill core)			
1,705.9	1,706.2	0.3	1	0	2	3	4
1,706.2	1,707.4	1.2	0	0	1	3	4
Bed thickness		9.1					

Notes: Trona and $NaHCO_3$ determined by CO_3/HCO_3 titration.
NaCl determined by selective ion electrode analysis of Cl.
Na_2SO_4 determined by ion chromatography analysis of SO_4.
Averages exclude missing core.

METHODS OF DETERMINING TRONA RESOURCES

The trona resources detailed in this report were estimated from subsurface well information that was collected by the Bureau of Land Management Rock Springs District beginning in 1987 and entered into a computer database. The sources of data include exploratory core holes drilled specifically for trona and wells drilled for oil and gas in the Green River Basin. The data were compiled mostly from lithologic core descriptions and chemical analyses supplied by the companies holding Federal sodium leases in the basin and from the geophysical logs of these core holes.

Additional data were obtained from the geophysical logs of oil and gas wells drilled in the area. Currently, the database includes information from about 540 bore holes. The amounts of halite and water-insoluble material were estimated from detailed core descriptions using the format in table 7 for some of the core holes that are lacking chemical analyses. This format was developed by comparing a large number of core descriptions of trona beds with corresponding analytical data.

Table 7.—Method for visually estimating the volume percent of insolubles in a trona/halite bed.

Insolubles (Percent)	Core description
0	Trona or salt -- clean, pure, massive
5	Trona or salt -- contains minor shale; mottled, slightly argillaceous
10	Trona or salt -- contains some shale; impure, dirty, argillaceous
15-25	Trona or salt -- contains mixed shale, very impure, very dirty, shaly, very argillaceous
50	Shale -- contains mixed trona, contains trona bands, very shaly trona
75	Shale -- contains minor trona
100	Shale -- does not contain trona or salt

The above guide was applied during the evaluation of individually described layers within a trona bed. The weighted average amounts of trona, insolubles, and halite were determined by multiplying the thickness of layer by the percent of the constituent, summing the products for each constituent, and dividing these sums by the total bed thickness to get the weighted average for each constituent.

The depths to the top and bottom of each trona bed were usually determined from the gamma ray curve of each drill hole log. The curve on the gamma ray log through a trona bed is much lower (non-radioactive) compared to other lithologies in the trona-bearing sequence. Core logs, when available, were used to validate the thickness determined from the geophysical logs. In a few instances, the driller's log had to be used when better data were not available.

All of the compiled data were input into STRATIFACT©, a computer database program, for further analysis and quality control checks. This program can produce randomly oriented stratigraphic cross sections which permits the rapid checking of stratigraphic tops and bottoms of trona beds for typographical errors, miscorrelation of units, and errors in bore hole locations.

The geographic distribution of bore holes in the basin is not uniform. As might be expected, many development bore holes are located near the operating mines, whereas, in other parts of the basin, the distribution of wells is very irregular. Few trona exploratory holes have been drilled in the southern and western parts of the basin. In fact, no wells have been drilled in Twps. 16-17 N., R.111 W. For these townships, trona resource estimates are based on extrapolation from surrounding wells and are speculative.

ISOPACH MAPS

Using a two-foot contour interval, isopach maps were prepared for trona beds 1 through 25 (figs. 8-32). Only those wells used to prepare each isopach map are shown on the figures. The minimum isopach shown for each bed is 2 feet, which is about the minimum required thickness for confident recognition of a trona bed on geophysical logs. Because of insufficient well control, isopachs for some of the trona beds are not closed. The minimum isopach shown for trona bed 1 (fig. 8) is 4 feet with a four-foot contour interval because of the paucity of subsurface data in the deeper southern part of the basin.

The distribution and depocenters of the trona beds within the Green River Basin changed through time. The most pronounced change in trona deposition occurred between beds 18 and 19 (figs. 25 and 26), when the lake brines moved a considerable distance northward where they were confined to relatively small areas in the northwest part of the basin. At this time, beds 19 through 22 were deposited, then trona deposition shifted to the eastern side of the basin where bed 23 was deposited in an elongate north-south trough. The last trona brines were confined to relatively small areas on the northeast side of the basin where beds 24 and 25 were deposited (figs. 31 and 32).

The bulk density for trona ore ranges from about 132 to 135 lbs/ft^3. In this report a bulk density of 133 lbs/ft^3, or 2,900 tons per acre-foot, was used to compute trona resources. Tonnages were calculated for the area of each bed where it is 4 or more feet thick, but not beyond the limits of well control, as in the southern part of the basin where drilling data are nil. Tonnages of trona and trona ore for each township in the KSLA were calculated for trona containing less than two percent halite, and trona containing two, or more, percent halite.

GEOSTATISTICAL METHODS

Trona resources were estimated using a computerized gridding technique known as "minimum curvature splining". A concise explanation of this technique and documentation of the computer program used to implement it were given by Webring (1981). The splining technique was selected instead of the geostatistical kriging method because of the erratic spacing of sample points in the trona beds (see figures 8 through 32). This irregular configuration of sample points made it impossible to obtain the meaningful variogram models which are required by kriging. Because kriging could not be used, confidence limits for the estimates of trona tonnage and grade could not be obtained.

The trona drill hole data were separated into individual beds by geological correlation (figs. 6 and 7). For each of the beds for which estimates were made, grids were created for each of two variables—thousands of tons of trona per acre (KTTPA) and thickness of the trona beds. For each drill hole and for each bed the following transformation was used to determine the variable, KTTPA:

$$KTTPA = \frac{(Thick)*(Percent)*43{,}560}{15.04*100*1000}$$

where
KTTPA = thousands of tons of trona per acre
Thick = thickness of trona ore in feet
Percent = grade of ore in weight percent trona

43,560 = square feet in one acre
15.04 = cubic feet of rock in one ton of ore
100 = constant converting percent to decimal fraction
1,000 = constant converting tons to 1,000's of tons

For each bed a grid of values was created with grid nodes spaced 500 meters apart in north and east UTM coordinates. The origin of the grid for each bed was 4,550 kilometers north and 220 kilometers east (see lower left corner of figures 8-32). Each grid consisted of 182 rows and 143 columns. These grids completely encompassed the drill hole data for each bed. Each grid node can be considered to be the center of a square cell 500 meters on a side. The area of such a cell is 61.775 acres.

The splining techique is valid only for interpolation. For each bed, a large number of invalid extrapolated grid points was created in addition to the valid interpolated values. These invalid extrapolated grid points were deleted from the grid of each bed using an inside-outside computer filtering algorithm. The areas of each bed in which the valid grid points were retained are shown by solid thickness isopleths in figures 8-32. Dashed contour lines indicate that the grid points were deleted and the pattern of the dashed contours was drawn using geological inference.

Prior to estimating the trona resources for each bed, the grid value files were divided into high halite (≥2 percent NaCl) and low halite (<2 percent NaCl) sub-files according to where the boundaries between these two types of ore were drawn. These two types of ore, where present, were estimated separately following the procedures outlined below.

Trona resources were estimated using a cutoff thickness of four feet for each trona bed. To obtain tonnage of trona, tonnage of ore, and grade of ore for each bed, the following methods were used:

1. Interpolated grid values of less than four feet in thickness were deleted from each bed file.
2. The above bed file was then divided into individual files for each township.
3. The number of grid points in each township (N) and the arithmetic means of KTTPA and thickness of ore within each township were calculated.
4. Trona resources for each township were calculated as follows:

   Kilotons of trona = N*(Mean KTTPA for each township)*61.775.
5. Kilotons of ore for each township were calculated as follows:

   Kilotons of ore = N*(Mean Thick)*61.775*43,560/15,040.
6. Grade of the ore in weight percent trona was calculated as follows:

   Grade = 100*(kilotons trona)/kilotons ore)

The resource estimates are presented in tables 8 and 9. Resources were not estimated in the areas of dashed contours shown on figures 8-32.

TRONA RESOURCES

Culbertson (1966) estimated the halite-free trona resources in the Green River Basin at 67 billion tons for 25 of the thickest beds, whose average thicknesses range from 3.5 to 10.9 feet, and underlie areas ranging from 100 to 1,000 square miles. Burnside and Culbertson (1979) revised Culbertson's earlier estimate, reporting a total of 81.7 billion tons of halite-free trona and an additional 52.7 billion tons of mixed trona and halite for a total resource of 134.4 billion tons.

In this report, estimates of the trona resources are made for 22 of the 25 trona beds. The estimates were divided into two catagories: trona containing less than two percent halite, and trona containing two, or more, percent halite. A two percent halite line is shown on the isopach maps, however, the analytical data are too sparse in many places to accurately show the position of this line, and it should be viewed only as a guide to potential halite-free areas of a trona bed. Following these guidelines, we estimated 60 billion tons of trona containing <2 percent halite and 27 billion tons of trona containing ≥2 percent halite in the 22 beds of trona (table 9).

The trona resources were estimated by townships to provide detailed information for the trona industry and for the land owners. No attempts were made herein to quantify the disseminated shortite and its contained sodium carbonate content.

Table 8.—TRONA RESOURCES IN THE GREEN RIVER BASIN, WYOMING

TWP	RANGE	ACRES	BED THICK-NESS (FEET)	TRONA ORE (1,000'S TONS)	TRONA (WT PCT)	TRONA (1,000's TONS/ ACRE)	TRONA (1,000's TONS)
BED 1 (<2 WT PCT HALITE)							
17 N	111 W	62	19.3	3,461	85.6	47.9	2,962
17 N	110 W	9,452	13.5	370,329	87.4	34.2	323,487
17 N	109 W	14,517	13.1	552,029	84.7	32.2	467,796
17 N	108 W	14,209	5.1	209,011	81.5	12.0	170,318
17 N	107 W	4,263	6.0	73,666	77.4	13.4	57,020
16 N	111 W	8,402	20.8	506,668	85.6	51.7	433,959
16 N	110 W	22,610	21.3	1,396,538	86.2	53.2	1,203,380
16 N	109 W	22,301	21.7	1,402,004	87.2	54.8	1,222,845
16 N	108 W	10,996	5.2	164,049	85.1	12.7	139,685
16 N	107 W	3,151	5.5	50,507	77.3	12.4	39,030
15 N	111 W	2,100	20.2	122,786	86.4	50.5	106,051
15 N	110 W	21,066	22.6	1,377,350	88.0	57.5	1,211,891
15 N	109 W	21,313	18.4	1,133,139	88.0	46.8	996,972
15 N	108 W	494	5.3	7,528	83.3	12.7	6,268
15 N	107 W	988	5.0	14,222	85.0	12.2	12,090
14 N	110 W	2,780	20.1	161,649	87.3	50.8	141,137
14 N	109 W	4,571	17.7	234,801	87.5	44.9	205,473
SUBTOTAL		163,275	16.5	7,779,737	86.6	41.3	6,740,363
BED 1 (≥2 WT PCT HALITE)							
17 N	109 W	865	17.2	43,089	84.3	42.0	36,326
BED 2 (<2 WT PCT HALITE)							
18 N	109 W	988	11.9	34,090	80.3	27.7	27,385
18 N	108 W	371	9.9	10,605	77.3	22.1	8,198
17 N	111 W	8,093	10.5	246,224	84.5	25.7	208,023
17 N	110 W	15,568	13.6	613,335	85.5	33.7	524,567
17 N	109 W	20,324	15.2	896,987	85.9	37.9	770,377
17 N	108 W	13,035	12.1	455,068	79.1	27.6	360,034
16 N	112 W	4,571	14.4	190,923	85.5	35.7	163,182
16 N	111 W	22,795	14.0	926,949	85.4	34.7	791,436
16 N	110 W	22,301	16.1	1,037,132	85.7	39.9	888,705
16 N	109 W	17,853	19.9	1,026,409	87.9	50.5	901,898
16 N	108 W	18,718	14.8	801,921	93.2	39.9	747,550
15 N	112 W	3,027	15.5	136,031	86.0	38.7	117,044
15 N	111 W	18,718	16.6	899,288	86.5	41.5	777,555
15 N	110 W	22,857	18.1	1,199,958	87.4	45.9	1,048,279
15 N	109 W	22,919	20.9	1,390,193	88.2	53.5	1,226,558
15 N	108 W	22,425	16.1	1,046,580	88.2	41.2	923,544

15 N	107 W	1,421	15.5	63,670	88.1	39.5	56,112
14 N	111 W	2,533	18.6	136,145	87.4	47.0	119,018
14 N	110 W	17,730	19.4	997,020	87.7	49.3	874,807
14 N	109 W	11,676	19.2	647,816	87.5	48.6	567,090
14 N	108 W	6,239	14.5	262,898	85.2	35.9	223,883
SUBTOTAL		274,163	16.4	13,019,241	87.0	41.3	11,325,246

BED 2 (≥2 WT PCT HALITE)

17 N	109 W	2,348	17.0	115,638	76.5	37.7	88,409
16 N	110 W	309	10.7	9,599	78.3	24.3	7,519
16 N	109 W	4,448	17.9	230,156	66.5	34.4	153,146
SUBTOTAL		7,104	17.3	355,393	70.1	16.8	249,074

BED 3 (<2 WT PCT HALITE)

17 N	110 W	62	4.0	716	64.8	7.5	464
17 N	109 W	3,459	4.0	40,078	86.7	10.0	34,761
17 N	108 W	2,409	4.0	27,912	63.8	7.4	17,821
16 N	111 W	9,822	4.2	119,085	86.8	10.5	103,420
16 N	110 W	18,409	5.1	270,805	86.4	12.7	233,983
16 N	109 W	17,606	7.4	377,855	85.5	18.4	323,181
16 N	108 W	6,239	7.9	142,129	80.3	18.3	114,144
15 N	111 W	16,247	5.3	247,187	86.2	13.1	213,114
15 N	110 W	18,533	5.4	291,195	85.7	13.5	249,490
15 N	109 W	8,834	6.4	162,956	88.5	16.3	144,268
15 N	108 W	865	8.0	19,916	84.4	19.4	16,804
SUBTOTAL		102,487	5.7	1,699,834	85.4	14.2	1,451,451

BED 3 (≥2 WT PCT HALITE)

17 N	109 W	618	6.0	10,746	75.5	13.1	8,110
16 N	109 W	2,718	7.4	58,154	64.7	13.8	37,600
SUBTOTAL		3,336	7.1	68,900	66.3	13.7	45,710

BED 4 (<2 WT PCT HALITE)

17 N	110 W	1,730	5.3	26,782	73.2	11.3	19,596
17 N	109 W	16,124	6.2	289,297	82.0	14.7	237,356
17 N	108 W	2,595	4.6	34,335	91.6	12.1	31,447
16 N	111 W	10,626	6.1	186,370	80.1	14.1	149,321
16 N	110 W	22,301	7.3	473,837	80.7	17.1	382,288
16 N	109 W	22,301	9.3	603,535	80.8	21.9	487,662
16 N	108 W	14,765	7.8	332,562	83.4	18.8	277,455
15 N	112 W	1,853	6.9	37,219	81.3	16.3	30,255
15 N	111 W	21,622	7.8	487,391	81.5	18.4	397,451
15 N	110 W	23,043	9.2	613,586	84.0	22.4	515,324

15 N	109 W	22,919	9.7	646,141	87.9	24.8	567,956
15 N	108 W	18,595	6.9	371,225	86.8	17.3	322,227
14 N	111 W	18,965	8.6	471,949	83.0	20.7	391,938
14 N	110 W	21,375	9.3	572,886	84.1	22.5	481,549
14 N	109 W	15,506	8.8	396,504	85.3	21.8	338,105
14 N	108 W	5,745	6.3	104,081	86.0	15.6	89,493
SUBTOTAL		240,063	8.1	5,647,700	83.6	19.7	4,719,423

BED 4 (≥2 WT PCT HALITE)

17 N	110 W	1,421	4.7	19,399	66.0	9.0	12,805
16 N	110 W	185	5.1	2,758	69.2	10.3	1,909
SUBTOTAL		1,606	4.8	22,157	66.4	9.2	14,714

BED 5 (<2 WT PCT HALITE)

18 N	110 W	62	7.1	1,262	82.1	16.8	1,037
18 N	110 W	1,791	8.2	42,355	86.9	20.5	36,802
18 N	109 W	5,004	7.0	101,098	89.5	18.1	90,533
17 N	111 W	3,954	6.3	71,762	70.9	12.9	50,847
17 N	110 W	16,803	6.1	297,590	82.4	14.6	245,119
17 N	109 W	20,818	7.5	449,802	88.7	19.2	398,814
17 N	108 W	11,305	5.1	168,064	90.5	13.5	152,084
17 N	107 W	247	4.9	3,479	91.1	12.8	3,169
16 N	111 W	14,023	9.2	373,326	55.6	14.8	207,609
16 N	110 W	4,139	8.2	98,417	58.2	13.8	57,262
16 N	109 W	9,884	6.8	194,977	84.4	16.7	164,578
16 N	108 W	15,629	6.7	304,505	95.3	18.6	290,310
15 N	112 W	618	12.9	23,080	46.3	17.3	10,680
15 N	111 W	2,409	13.4	93,747	45.0	17.5	42,186
15 N	110 W	1,606	12.1	56,143	48.5	16.9	27,218
15 N	109 W	20,509	8.3	491,659	71.3	17.1	350,483
15 N	108 W	21,745	7.9	495,644	90.3	20.6	447,617
15 N	107 W	3,768	7.8	84,867	87.5	19.7	74,273
14 N	111 W	10,008	13.6	395,003	44.5	17.6	175,753
14 N	110 W	9,390	13.3	362,189	43.9	16.9	159,091
14 N	109 W	16,432	10.0	473,636	63.3	18.2	299,624
14 N	108 W	19,892	9.0	516,544	78.9	20.5	407,399
14 N	107 W	1,791	8.4	43,724	84.2	20.6	36,824
SUBTOTAL		211,765	8.4	5,141,612	72.5	17.6	3,728,275

BED 5 (≥2 WT PCT HALITE)

17 N	110 W	3,707	5.8	76,319	58.1	12.0	44,341
17 N	109 W	1,544	6.3	34,440	61.3	13.7	21,127
16 N	112 W	62	11.6	2,546	41.6	17.2	1,060
16 N	111 W	6,178	12.1	266,651	39.3	17.0	104,925
16 N	110 W	18,038	12.0	768,987	46.3	19.7	355,878
16 N	109 W	12,417	7.1	312,490	66.6	16.8	208,055

16 N 108 W	62	6.1	1,338	79.5	17.2	1,064
15 N 112 W	432	12.5	19,177	38.9	17.2	7,453
15 N 111 W	20,571	14.0	1,029,116	34.4	17.2	353,905
15 N 110 W	21,436	14.3	1,091,695	32.6	16.6	356,051
15 N 109 W	2,409	10.0	85,574	47.0	16.7	40,258
14 N 111 W	62	14.8	3,258	32.3	17.0	1,053
SUBTOTAL	86,917	11.9	3,691,591	40.5	17.2	1,495,169

BED 6 (<2 WT PCT HALITE)

18 N 110 W	185	5.8	3,132	88.5	15.0	2,772
18 N 109 W	1,112	5.5	17,794	86.3	13.8	15,354
17 N 111 W	1,112	4.8	15,394	67.8	9.4	10,430
17 N 110 W	5,066	4.7	69,426	94.1	12.9	65,327
17 N 109 W	16,618	4.9	235,162	89.3	12.6	210,000
17 N 108 W	12,108	4.6	161,947	84.5	11.3	136,871
15 N 112 W	680	9.2	18,178	35.3	9.4	6,411
16 N 111 W	4,201	7.1	86,566	49.7	10.2	43,029
15 N 111 W	2,780	9.9	80,088	29.3	8.5	23,490
14 N 111 W	2,656	10.2	78,283	28.0	8.3	21,923
15 N 110 W	494	11.0	15,722	17.6	5.6	2,761
14 N 110 W	5,189	9.9	148,686	25.7	7.4	38,203
16 N 109 W	5,869	5.0	84,155	82.4	11.8	69,345
15 N 109 W	5,127	7.4	109,775	42.9	9.2	47,049
14 N 109 W	2,286	8.6	57,224	35.5	8.9	20,341
16 N 108 W	8,834	5.5	140,696	80.1	12.8	112,643
15 N 108 W	1,544	6.1	27,263	66.1	11.7	18,022
SUBTOTAL	75,861	6.1	1,349,490	62.5	11.1	843,970

BED 6 (≥2 WT PCT HALITE)

17 N 111 W	185	4.8	2,562	65.5	9.1	1,679
17 N 110 W	2,965	4.3	37,299	77.6	9.8	28,950
17 N 109 W	1,544	5.1	22,602	86.3	12.6	19,503
15 N 112 W	124	9.3	3,321	35.0	9.4	1,163
16 N 111 W	13,591	7.7	303,762	43.6	9.7	132,402
15 N 111 W	19,151	10.0	556,875	27.8	8.1	154,891
16 N 110 W	22,425	8.2	533,747	49.0	11.7	261,451
15 N 110 W	22,548	10.5	688,720	23.0	7.0	158,244
14 N 110 W	309	10.3	9,243	21.5	6.4	1,987
16 N 109 W	16,247	6.3	294,290	64.7	11.7	190,303
15 N 109 W	11,305	7.9	257,161	39.8	9.1	102,424
SUBTOTAL	110,394	8.5	2,709,582	38.9	9.5	1,052,997

BED 7 (<2 WT PCT HALITE)

17 N 109 W	3,645	4.7	49,499	86.2	11.7	42,668
17 N 108 W	1,544	4.2	18,899	86.1	10.5	16,279
16 N 110 W	3,768	4.2	46,102	86.3	10.6	39,796
16 N 109 W	3,583	4.0	41,510	90.2	10.5	37,452
16 N 108 W	1,483	4.0	17,176	87.9	10.2	15,099

15 N	110 W	16,927	4.6	224,630	87.3	11.6	196,107
15 N	109 W	13,653	4.4	172,718	82.4	10.4	142,380
15 N	108 W	6,610	5.6	106,444	79.7	12.8	84,881
14 N	110 W	1,359	4.6	17,997	84.6	11.2	15,227
14 N	109 W	12,108	4.8	208,768	79.3	12.6	165,540
SUBTOTAL		77,838	4.8	1,071,896	83.2	11.5	891,603

BED 7 (≥2 WT PCT HALITE)

16 N	110 W	6,857	4.9	98,149	83.3	11.9	81,760
16 N	109 W	7,166	5.0	102,861	75.5	10.8	77,651
15 N	110 W	62	4.0	721	84.8	9.9	611
15 N	109 W	1,359	4.0	15,745	81.7	9.5	12,857
SUBTOTAL		15,444	4.9	217,476	79.5	11.2	172,879

BED 8 (<2 WT PCT HALITE)

17 N	110 W	124	4.0	1,431	69.3	8.0	992
17 N	108 W	62	5.8	1,044	76.3	12.9	797
16 N	111 W	247	4.0	2,863	68.3	7.9	1,955
16 N	110 W	5,375	4.7	72,678	71.1	9.6	51,698
16 N	109 W	8,031	5.2	121,207	76.5	11.5	92,677
16 N	108 W	8,649	5.8	146,336	75.8	12.8	110,989
15 N	112 W	494	4.9	7,014	86.9	12.3	6,097
15 N	111 W	2,965	4.0	34,353	70.6	8.2	24,250
15 N	109 W	680	5.1	9,953	81.0	11.9	8,063
15 N	108 W	6,548	4.6	88,058	70.5	9.5	62,045
14 N	111 W	1,668	4.0	19,324	80.2	9.3	15,505
14 N	110 W	1,050	4.0	12,167	75.6	8.8	9,202
SUBTOTAL		41,699	4.9	587,620	76.0	10.7	446,310

BED 8 (≥2 WT PCT HALITE)

16 N	110 W	2,100	4.9	29,930	78.1	11.1	23,371

BED 9 (<2 WT PCT HALITE)

18 N	108 W	185	5.1	2,722	87.2	12.8	2,375
17 N	111 W	309	4.8	4,320	75.6	10.6	3,264
17 N	109 W	6,610	4.1	77,823	88.3	10.4	68,731
17 N	108 W	18,348	6.5	347,161	85.5	16.2	296,827
16 N	112 W	7,475	9.4	202,942	82.7	22.4	167,775
16 N	111 W	3,521	5.7	58,132	75.9	12.5	44,118
16 N	109 W	6,981	5.4	109,481	81.8	12.8	89,570
16 N	108 W	16,741	7.7	373,695	81.9	18.3	305,882
15 N	112 W	4,386	12.6	159,733	85.6	31.2	136,746
15 N	109 W	62	4.6	821	75.5	10.0	620
15 N	108 W	11,738	5.4	183,777	80.7	12.6	148,374

14 N	112 W	2,471	12.3	87,815	83.8	29.8	73,628
14 N	109 W	3,645	5.1	53,584	77.6	11.4	41,558
14 N	108 W	3,892	4.8	54,264	76.1	10.6	41,309
13 N	109 W	1,236	5.5	19,803	78.9	12.6	15,628
13 N	108 W	556	5.3	8,552	78.4	12.1	6,702
SUBTOTAL		88,155	6.8	1,744,625	82.7	16.4	1,443,106

BED 9 (≥2 WT PCT HALITE)

17 N	109 W	865	4.0	10,020	80.5	9.3	8,064
16 N	112 W	3,954	10.6	120,865	84.9	25.9	102,563
16 N	111 W	18,718	7.4	402,099	78.3	16.8	314,934
16 N	110 W	16,618	5.2	249,938	53.5	8.0	133,757
16 N	109 W	11,058	4.9	157,669	73.9	10.5	116,496
15 N	112 W	10,687	14.0	434,307	87.8	35.7	381,248
15 N	111 W	23,290	12.3	832,712	87.8	31.4	731,529
15 N	110 W	23,043	6.6	442,004	72.8	14.0	321,674
15 N	109 W	22,857	4.9	325,113	77.4	11.0	251,658
15 N	108 W	1,853	5.0	26,999	80.8	11.8	21,817
14 N	112 W	3,398	12.5	122,575	83.8	30.2	102,689
14 N	111 W	15,197	11.6	508,369	85.0	28.4	432,065
14 N	110 W	20,139	7.7	447,904	82.1	18.3	367,780
14 N	109 W	19,274	5.5	309,653	79.1	12.7	245,072
13 N	109 W	865	6.1	15,260	80.0	14.1	12,215
SUBTOTAL		191,816	7.9	4,405,486	80.4	18.5	3,543,562

BED 10 (<2 WT PCT HALITE)

18 N	110 W	1,544	6.9	30,649	91.9	18.2	28,175
18 N	109 W	1,236	5.9	21,145	89.7	15.31	18,962
17 N	110 W	5,560	7.2	115,490	89.4	18.6	103,247
17 N	109 W	6,548	5.0	95,151	87.2	12.7	83,006
16 N	112 W	432	8.0	10,002	63.1	14.6	6,309
16 N	111 W	494	8.0	11,389	61.8	14.2	7,038
16 N	109 W	247	7.7	5,525	61.5	13.7	3,397
16 N	108 W	1,977	6.4	36,712	46.1	8.6	16,924
15 N	112 W	4,324	9.2	115,238	80.8	21.5	93,099
15 N	111 W	4,139	9.6	114,854	81.7	22.7	93,840
15 N	110 W	2,595	8.4	62,868	49.4	12.0	31,070
15 N	109 W	3,954	7.9	90,337	53.4	12.2	48,199
15 N	108 W	371	7.5	8,078	53.2	11.6	4,301
14 N	111 W	1,668	9.1	44,029	65.5	17.3	28,837
14 N	110 W	7,660	8.6	189,781	52.7	13.1	100,005
SUBTOTAL		42,749	7.7	951,249	70.1	15.6	666,407

BED 10 (≥2 WT PCT HALITE)

17 N	111 W	62	4.3	770	10.5	1.3	81
17 N	110 W	10,626	6.0	185,939	52.2	9.1	96,990

17 N 109 W	6,425	5.4	99,998	77.6	12.1	77,553
16 N 111 W	16,185	7.3	344,315	45.6	9.7	157,160
15 N 111 W	18,842	9.1	497,360	67.5	17.8	335,911
14 N 111 W	1,668	9.0	43,705	62.8	16.5	27,440
16 N 110 W	22,610	8.5	558,458	35.7	8.8	199,625
15 N 110 W	20,263	8.4	491,204	47.1	11.4	231,339
14 N 110 W	1,853	8.8	47,149	55.5	14.1	26,189
16 N 109 W	19,830	7.5	429,719	54.9	11.9	235,960
15 N 109 W	3,583	7.7	80,353	48.0	10.8	38,575
16 N 108 W	4,263	6.6	80,987	45.6	8.7	36,952
SUBTOTAL	126,209	7.8	2,859,958	51.2	11.6	1,463,774
BED 11 (<2 WT PCT HALITE)						
18 N 110 W	4,448	6.3	81,339	87.6	16.0	71,215
18 N 109 W	6,795	7.6	150,326	85.3	18.9	128,256
17 N 112 W	1,174	6.8	22,998	40.1	7.9	9,221
17 N 111 W	988	6.5	18,725	41.8	7.9	7,822
17 N 110 W	5,683	9.5	157,184	87.6	24.2	137,635
17 N 109 W	10,749	6.3	196,694	87.1	15.9	171,276
17 N 108 W	2,224	4.0	25,765	71.3	8.3	18,370
16 N 113 W	2,039	8.4	49,880	29.3	7.2	14,621
16 N 112 W	13,776	8.5	340,382	29.5	7.3	100,497
16 N 111 W	1,359	6.7	26,542	39.0	7.6	10,356
16 N 109 W	741	4.6	9,808	69.8	9.2	6,851
16 N 108 W	741	4.6	9,954	61.3	8.2	6,099
15 N 113 W	124	10.7	3,825	24.5	7.6	937
15 N 112 W	6,487	11.5	215,616	24.4	8.1	52,606
14 N 112 W	2,533	11.7	85,594	26.4	8.9	22,623
14 N 109 W	62	6.6	1,179	48.8	9.3	576
SUBTOTAL	59,923	8.0	1,395,811	54.4	12.7	758,961
BED 11 (≥2 WT PCT HALITE)						
17 N 110 W	8,340	6.4	153,791	75.4	13.9	115,982
17 N 109 W	3,459	5.9	59,136	74.2	12.7	43,856
16 N 112 W	5,498	9.3	147,313	26.6	7.1	39,251
16 N 111 W	20,324	7.5	443,902	28.7	6.3	127,617
16 N 110 W	22,178	6.6	424,707	39.0	7.5	165,490
16 N 109 W	20,757	8.2	493,145	55.9	13.3	275,464
16 N 108 W	11,738	9.0	305,854	35.4	9.2	108,419
15 N 112 W	11,985	11.9	412,676	22.5	7.7	92,857
15 N 111 W	23,290	9.7	654,433	21.1	5.9	137,852
15 N 110 W	21,931	6.8	434,330	30.4	6.0	132,066
15 N 109 W	22,919	7.2	478,200	51.1	10.7	244,386
15 N 108 W	10,873	7.1	223,013	48.4	9.9	108,041
14 N 112 W	2,780	11.9	96,086	26.6	9.2	25,575
14 N 111 W	12,293	10.0	354,487	26.0	7.5	92,164
14 N 110 W	13,961	8.1	326,361	31.5	7.4	102,700
14 N 109 W	13,838	7.2	288,965	44.0	9.2	127,046
SUBTOTAL	226,163	8.1	5,296,398	36.6	8.6	1,938,766

BED 12 (<2 WT PCT HALITE)						
18 N 111 W	4,201	5.6	67,549	89.0	14.3	60,134
18 N 110 W	13,961	6.6	265,262	89.4	17.0	237,261
18 N 109 W	14,209	6.2	256,294	90.0	16.2	230,719
18 N 108 W	309	5.4	4,872	89.3	14.1	4,351
17 N 112 W	9,699	7.7	215,399	69.5	15.4	149,722
17 N 111 W	21,436	6.9	429,074	82.2	16.4	352,586
17 N 110 W	16,741	6.9	333,110	89.4	17.8	297,762
17 N 109 W	20,757	7.5	452,866	88.5	19.3	400,670
17 N 108 W	10,193	5.0	148,407	82.8	12.1	122,939
16 N 113 W	5,251	8.7	132,373	49.1	12.4	65,060
16 N 112 W	20,016	8.7	503,126	50.7	12.7	254,938
16 N 111 W	3,645	8.1	85,865	64.7	15.2	55,569
16 N 109 W	4,324	5.2	65,428	85.3	12.9	55,793
16 N 108 W	4,510	7.1	93,035	73.2	15.1	68,110
15 N 113 W	2,965	8.9	76,521	39.9	10.3	30,554
15 N 112 W	11,614	7.9	265,600	44.1	10.1	117,092
15 N 108 W	1,977	11.3	64,875	39.8	13.1	25,835
14 N 112 W	5,498	6.2	98,888	60.6	10.9	59,924
14 N 111 W	6,610	9.0	172,435	47.0	12.3	81,086
14 N 110 W	2,224	9.7	62,563	48.8	13.7	30,555
14 N 109 W	1,050	10.0	30,468	49.5	14.4	15,093
14 N 108 W	7,228	11.0	230,921	42.8	13.7	98,754
13 N 111 W	247	9.7	6,919	46.6	13.1	3,225
13 N 110 W	2,780	9.8	78,550	49.2	13.9	38,644
13 N 109 W	3,583	9.8	101,927	50.5	14.4	51,442
13 N 108 W	247	10.1	7,255	48.7	14.3	3,533
SUBTOTAL	195,275	7.5	4,249,586	68.5	14.9	2,911,349
BED 12 (≥2 WT PCT HALITE)						
17 N 111 W	927	6.8	18,153	75.2	14.7	13,652
17 N 110 W	5,436	5.6	88,582	75.4	12.3	66,747
17 N 109 W	1,915	8.7	47,994	83.3	20.9	39,987
16 N 112 W	927	10.0	26,956	38.8	11.3	10,462
16 N 111 W	19,151	9.2	512,336	53.8	14.4	275,463
16 N 110 W	22,610	9.1	595,064	68.1	17.9	405,129
16 N 109 W	17,050	7.9	391,947	71.7	16.5	281,057
16 N 108 W	9,328	7.4	199,440	70.7	15.1	140,968
15 N 112 W	9,143	9.1	242,242	34.1	9.0	82,487
15 N 111 W	23,290	11.7	786,911	30.8	10.4	242,283
15 N 110 W	23,043	10.8	718,097	45.5	14.2	326,951
15 N 109 W	22,487	9.4	612,263	54.8	14.9	335,635
15 N 108 W	14,332	10.7	443,324	43.4	13.4	192,222
14 N 112 W	680	5.9	11,596	62.1	10.6	7,200
14 N 111 W	14,579	9.2	386,912	44.7	11.9	172,953
14 N 110 W	20,695	10.0	599,087	47.5	13.7	284,309
14 N 109 W	21,869	10.0	631,925	50.4	14.6	318,388
14 N 108 W	6,178	11.6	206,779	39.7	13.3	82,033
13 N 109 W	309	9.7	8,687	51.3	14.4	4,453
SUBTOTAL	233,947	9.6	6,528,298	50.3	14.0	3,282,378

BED 14 (<2 WT PCT HALITE)

19 N	109 W	3,459	6.8	67,863	89.1	17.5	60,492
19 N	108 W	124	7.8	2,793	90.8	20.5	2,535
18 N	112 W	618	8.1	14,407	79.1	18.5	11,401
18 N	111 W	12,911	7.3	274,813	81.8	17.4	224,875
18 N	110 W	16,062	7.1	330,661	84.8	17.5	280,472
18 N	109 W	22,178	8.8	562,551	83.4	21.2	469,369
18 N	108 W	13,961	7.6	305,779	87.1	19.1	266,329
17 N	112 W	9,575	10.3	286,924	64.5	19.3	185,197
17 N	111 W	22,981	10.5	696,471	79.3	24.0	552,160
17 N	110 W	23,043	9.2	614,053	86.8	23.1	533,159
17 N	109 W	21,622	11.0	691,164	84.8	27.1	586,122
17 N	108 W	17,977	8.1	422,048	86.7	20.4	365,992
16 N	113 W	185	14.6	7,832	32.8	13.9	2,569
16 N	112 W	17,421	12.2	615,763	46.1	16.3	284,135
16 N	111 W	9,514	10.2	282,069	66.0	19.6	186,294
16 N	110 W	4,757	8.2	112,764	76.5	18.1	86,255
16 N	109 W	8,340	11.1	268,065	83.6	26.9	224,157
16 N	108 W	6,734	7.7	150,598	81.1	18.1	122,101
15 N	113 W	9,019	15.3	398,995	28.9	12.8	115,231
15 N	112 W	4,633	17.5	234,512	24.8	12.5	58,087
15 N	110 W	2,656	11.1	85,122	71.8	23.0	61,142
15 N	109 W	1,297	11.5	43,123	73.3	24.4	31,620
15 N	108 W	3,212	6.9	63,760	68.8	13.7	43,849
14 N	112 W	4,015	21.5	249,729	21.1	13.1	52,699
14 N	111 W	11,120	14.2	457,903	37.6	15.5	171,945
14 N	110 W	7,722	11.2	249,953	55.6	18.0	138,896
14 N	109 W	6,672	10.2	196,462	58.4	17.2	114,809
14 N	108 W	12,973	9.8	369,498	60.7	17.3	224,122
13 N	110 W	2,533	10.9	80,143	56.7	17.9	45,444
13 N	109 W	4,510	10.3	134,427	59.8	17.8	80,403
13 N	108 W	865	10.0	25,087	61.2	17.8	15,364
SUBTOTAL		282,689	10.1	8,295,332	67.5	19.8	5,597,226

BED 14 (≥2 WT PCT HALITE)

17 N	109 W	1,050	11.5	35,119	85.1	28.5	29,898
17 N	108 W	618	10.1	18,098	81.9	24.0	14,813
16 N	112 W	556	11.1	17,898	42.5	13.7	7,601
16 N	111 W	13,282	8.4	321,209	63.3	15.3	203,386
16 N	110 W	17,853	7.4	381,452	59.8	12.8	228,273
16 N	109 W	13,961	11.5	463,723	79.9	26.5	370,635
16 N	108 W	12,788	10.3	379,960	75.3	22.4	286,266
15 N	112 W	16,124	18.1	843,795	21.2	11.1	178,972
15 N	111 W	23,290	9.7	653,691	52.9	14.8	345,549
15 N	110 W	20,386	10.1	596,935	71.6	21.0	427,111
15 N	109 W	21,622	10.9	679,517	61.9	19.5	420,694
15 N	108 W	17,668	9.3	478,249	66.2	17.9	316,417
14 N	112 W	2,718	24.9	195,798	16.8	12.1	32,933
14 N	111 W	10,502	15.0	456,858	34.4	14.9	156,931
14 N	110 W	15,197	10.9	481,124	58.6	18.5	281,706

14 N	109 W	16,247	10.1	474,751	52.8	15.4	250,532
14 N	108 W	2,409	10.1	70,366	57.5	16.8	40,490
SUBTOTAL		206,271	11.0	6,548,542	54.9	17.4	3,592,208

BED 15 (<2 WT PCT HALITE)

19 N	112 W	124	7.9	2,823	85.9	19.6	2,425
19 N	111 W	7,907	7.3	166,428	90.4	19.0	150,430
19 N	110 W	6,857	5.6	110,225	89.1	14.3	98,160
19 N	109 W	6,178	5.0	88,888	86.9	12.5	77,264
19 N	108 W	247	6.0	4,296	87.7	15.2	3,766
18 N	112 W	7,351	8.5	180,340	80.1	19.6	144,440
18 N	111 W	22,919	8.8	586,134	84.0	21.5	492,255
18 N	110 W	22,919	8.1	538,141	84.7	19.9	455,837
18 N	109 W	22,734	7.1	470,251	86.2	17.8	405,365
18 N	108 W	10,626	6.2	191,848	87.8	15.8	168,393
17 N	112 W	8,463	9.7	236,715	66.1	18.5	156,479
17 N	111 W	14,579	9.3	392,443	59.1	15.9	232,014
17 N	110 W	5,869	8.2	139,040	86.1	20.4	119,687
17 N	109 W	10,008	6.6	189,911	84.4	16.0	160,214
17 N	108 W	16,185	4.9	231,996	91.0	13.0	211,058
16 N	112 W	7,413	11.7	250,626	44.7	15.1	111,976
16 N	111 W	2,409	11.1	77,357	47.8	15.4	37,004
16 N	109 W	2,162	5.6	35,069	86.6	14.0	30,370
16 N	108 W	6,857	4.9	98,149	92.5	13.2	90,775
15 N	112 W	5,189	13.4	201,168	31.4	12.2	63,085
15 N	110 W	185	15.1	8,119	51.1	22.4	4,147
15 N	108 W	865	4.8	11,991	99.6	13.8	11,944
14 N	112 W	2,965	14.1	121,060	32.7	13.3	39,580
14 N	111 W	8,710	14.2	357,076	43.9	18.0	156,788
14 N	110 W	10,996	13.8	439,662	47.0	18.8	206,706
14 N	109 W	5,127	12.0	178,384	41.4	14.4	73,789
14 N	108 W	7,475	8.5	183,956	56.1	13.8	103,147
13 N	110 W	62	12.9	2,308	43.9	16.4	1,012
13 N	109 W	1,421	12.2	50,358	42.3	15.0	21,290
SUBTOTAL		224,804	8.5	5,544,762	69.1	17.0	3,829,401

BED 15 (≥2 WT PCT HALITE)

17 N	111 W	8,463	9.6	234,803	41.8	11.6	98,133
17 N	110 W	17,174	9.7	484,767	61.0	17.2	295,493
17 N	109 W	12,602	9.4	343,319	71.2	19.4	244,574
16 N	112 W	1,112	12.3	39,533	40.7	14.5	16,106
16 N	111 W	20,386	12.1	711,658	53.8	18.8	383,036
16 N	110 W	22,610	11.9	781,501	65.4	22.6	511,193
16 N	109 W	20,139	10.7	625,513	57.6	17.9	360,047
16 N	108 W	1,483	6.0	25,687	65.1	11.3	16,734
15 N	112 W	10,687	13.1	405,892	28.9	11.0	117,122
15 N	111 W	23,290	14.3	967,281	51.5	21.4	498,166
15 N	110 W	22,857	15.1	1,000,163	48.9	21.4	489,488
15 N	109 W	22,919	11.6	772,263	26.8	9.0	206,592
15 N	108 W	7,290	6.3	133,707	59.5	10.9	79,610

14 N	112 W	1,730	14.1	70,613	30.4	12.4	21,435
14 N	111 W	2,903	14.1	118,605	39.7	16.2	47,086
14 N	110 W	7,660	14.3	317,951	40.6	16.9	129,083
14 N	109 W	17,792	12.3	633,760	34.7	12.4	220,206
14 N	108 W	3,336	8.3	79,990	55.8	13.4	44,665
SUBTOTAL		224,433	11.9	7,747,006	48.8	16.8	3,778,769

BED 16 (<2 WT PCT HALITE)

19 N	111 W	309	4.0	3,578	81.3	9.4	2,909
19 N	110 W	9,761	4.1	114,972	88.8	10.5	102,038
19 N	109 W	803	4.0	9,304	66.5	7.7	6,183
18 N	112 W	1,606	4.0	18,608	76.7	8.9	14,279
18 N	111 W	11,676	4.0	135,265	76.8	8.9	103,856
18 N	110 W	8,958	4.2	109,430	85.6	10.5	93,642
18 N	109 W	10,193	4.0	118,088	79.8	9.2	94,205
18 N	108 W	1,792	4.0	20,755	52.4	6.1	10,873
17 N	112 W	7,907	4.9	111,464	77.6	10.9	86,515
17 N	111 W	17,730	4.3	221,320	80.1	10.0	177,263
17 N	110 W	5,992	4.4	76,537	84.5	10.8	64,663
17 N	109 W	18,904	4.8	261,376	86.8	12.0	226,918
17 N	108 W	1,668	4.0	19,324	57.3	6.6	11,067
16 N	112 W	6,054	9.2	160,684	77.7	20.6	124,890
16 N	111 W	9,575	6.4	178,793	72.0	13.4	128,673
16 N	110 W	1,606	4.0	18,608	70.6	8.2	13,145
16 N	109 W	3,398	4.0	39,363	84.6	9.8	33,318
16 N	108 W	5,375	5.1	79,963	85.3	12.7	68,192
15 N	112 W	6,054	12.2	214,760	78.5	27.9	168,691
15 N	109 W	432	5.5	6,940	85.7	13.7	5,946
15 N	108 W	4,880	5.0	70,292	70.1	10.1	49,243
14 N	112 W	3,892	12.0	135,524	74.1	25.8	100,407
14 N	111 W	7,166	11.6	240,072	66.5	22.3	159,545
14 N	110 W	4,633	10.0	134,768	57.4	16.7	77,338
14 N	109 W	1,606	7.8	36,295	51.6	11.7	18,715
14 N	108 W	7,043	7.1	145,268	51.2	10.6	74,397
13 N	110 W	1,668	9.5	45,927	56.0	15.4	25,703
13 N	109 W	3,583	8.4	86,755	52.9	12.8	45,934
13 N	108 W	124	7.5	2,680	52.4	11.4	1,403
SUBTOTAL		164,387	5.9	2,816,714	74.2	12.7	2,089,951

BED 16 (≥2 WT PCT HALITE)

16 N	112 W	247	11.1	7,940	78.2	25.1	6,210
16 N	111 W	13,158	8.3	318,030	54.5	13.2	173,454
16 N	110 W	15,012	6.0	261,607	42.2	7.4	110,351
16 N	109 W	309	4.3	3,880	77.9	9.8	3,022
16 N	108 W	865	5.5	13,729	85.9	13.6	11,792
15 N	112 W	10,502	12.5	381,273	82.1	29.8	313,201
15 N	111 W	23,290	12.5	844,651	55.3	20.1	466,958
15 N	110 W	23,043	10.5	698,210	28.0	8.5	195,401
15 N	109 W	19,768	7.3	418,189	53.3	11.3	222,909
15 N	108 W	15,135	6.1	265,645	65.7	11.5	174,630

14 N	112 W	2,533	12.0	87,707	76.8	26.6	67,371
14 N	111 W	13,776	12.0	480,629	64.0	22.3	307,442
14 N	110 W	18,286	10.6	560,854	46.0	14.1	257,848
14 N	109 W	21,313	8.6	529,749	47.1	11.7	249,254
14 N	108 W	3,459	7.4	73,895	49.3	10.5	36,442
13 N	109 W	309	8.6	7,656	52.5	13.0	4,021
SUBTOTAL		181,005	9.4	4,953,642	52.5	14.4	2,600,304

BED 17 (<2 WT PCT HALITE)

20 N	110 W	3,459	8.5	85,006	87.4	21.5	74,296
20 N	109 W	3,892	9.5	106,645	90.6	24.8	96,659
19 N	111 W	13,282	10.2	391,336	89.4	26.3	349,766
19 N	110 W	22,610	10.4	679,016	90.6	27.2	615,448
19 N	109 W	22,548	9.2	598,271	91.2	24.2	545,558
19 N	108 W	2,533	7.6	55,532	90.9	19.9	50,477
18 N	112 W	1,977	5.1	29,303	85.3	12.6	24,989
18 N	111 W	22,857	9.4	619,773	89.5	24.3	554,677
18 N	110 W	22,919	11.9	786,601	90.0	30.9	708,267
18 N	109 W	22,734	9.9	652,637	90.9	26.1	593,145
18 N	108 W	10,317	6.4	192,546	92.3	17.2	177,735
17 N	112 W	2,286	9.1	60,236	79.7	21.0	47,998
17 N	111 W	15,691	9.7	440,508	72.6	20.4	319,598
17 N	110 W	5,745	9.7	160,989	88.9	24.9	143,176
17 N	109 W	11,923	11.1	384,546	91.4	29.5	351,473
17 N	108 W	19,707	7.7	441,254	90.0	20.1	396,931
17 N	107 W	371	4.0	4,294	78.9	9.1	3,389
16 N	112 W	6,548	9.3	176,495	73.9	19.9	130,363
16 N	111 W	5,622	10.3	168,468	68.7	20.6	115,812
16 N	110 W	2,039	11.1	65,580	82.0	26.4	53,750
16 N	109 W	17,668	9.4	478,965	88.6	24.0	424,157
16 N	108 W	21,622	8.4	523,900	93.7	22.7	491,051
15 N	112 W	8,402	7.3	178,509	72.8	15.5	130,023
15 N	111 W	4,015	9.3	107,611	74.3	19.9	79,996
15 N	110 W	4,510	12.3	160,431	76.7	27.3	122,997
15 N	109 W	9,081	8.1	214,199	86.7	20.4	185,682
15 N	108 W	13,653	6.7	266,234	89.5	17.4	238,155
15 N	107 W	927	4.8	12,866	91.5	12.7	11,773
14 N	112 W	1,853	7.5	40,510	65.5	14.3	26,515
14 N	111 W	4,015	9.1	105,902	71.2	18.8	75,426
14 N	110 W	6,116	10.5	185,900	73.9	22.5	137,436
14 N	109 W	4,757	8.9	123,207	79.6	20.6	98,032
14 N	108 W	13,344	7.2	277,872	80.3	16.7	223,227
SUBTOTAL		329,021	9.2	8,775,144	86.6	23.1	7,597,978

BED 17 (≥2 WT PCT HALITE)

17 N	111 W	7,351	11.8	250,411	53.7	18.3	134,538
17 N	110 W	17,297	12.9	647,116	66.8	25.0	432,590
17 N	109 W	10,749	10.4	324,835	74.1	22.4	240,661
16 N	111 W	17,174	13.0	645,279	61.6	23.2	397,780

16 N	110 W	20,572	14.1	840,924	66.9	27.4	562,816
16 N	109 W	4,633	9.5	127,294	84.9	23.3	108,0[illegible]9
15 N	112 W	371	7.1	7,576	74.4	15.2	5,635
15 N	111 W	19,274	11.2	624,497	73.4	23.8	458,225
15 N	110 W	18,533	13.0	699,243	72.3	27.3	505,374
15 N	109 W	13,838	9.3	371,366	82.6	22.2	306,689
15 N	108 W	9,390	7.1	193,527	84.4	17.4	163,386
14 N	110 W	7,598	11.0	241,288	75.5	24.0	182,242
14 N	109 W	17,668	9.7	496,313	80.1	22.5	397,548
14 N	108 W	1,606	7.8	36,318	79.9	18.1	29,000
SUBTOTAL		166,055	11.4	5,505,986	71.3	23.6	3,924,574

BED 18 (<2 WT PCT HALITE)

15 N	110 W	309	4.7	4,160	38.9	5.2	1,618
14 N	110 W	432	4.5	5,607	41.2	5.3	2,310
15 N	109 W	7,351	4.0	84,613	47.6	5.5	40,234
14 N	109 W	6,054	4.0	66,402	51.7	5.7	34,321
SUBTOTAL		14,147	4.0	160,783	48.8	5.5	78,482

BED 18 (≥2 WT PCT HALITE)

17 N	111 W	1,174	5.0	17,093	10.1	1.5	1,734
17 N	110 W	7,969	5.1	118,151	20.1	3.0	23,764
17 N	109 W	62	4.6	818	25.4	3.4	208
16 N	111 W	8,278	6.7	160,492	15.4	3.0	24,660
16 N	110 W	18,965	8.2	449,208	17.3	4.1	77,910
16 N	109 W	432	4.3	5,416	36.6	4.6	1,981
SUBTOTAL		36,880	7.0	751,177	17.3	3.5	130,256

BED 19 (<2 WT PCT HALITE)

21 N	110 W	185	7.0	3,770	86.4	17.6	3,255
20 N	111 W	10,440	8.9	267,755	84.4	21.6	226,020
20 N	110 W	18,039	8.7	453,435	82.9	20.8	375,818
19 N	111 W	15,135	7.1	312,505	84.6	17.5	264,473
19 N	110 W	11,305	7.3	239,283	83.7	17.7	200,202
18 N	111 W	124	4.0	1,431	68.2	7.9	976
18 N	110 W	247	5.1	3,655	78.8	11.7	2,881
SUBTOTAL		55,475	8.0	1,281,834	83.8	19.4	1,073,625

BED 20 (<2 WT PCT HALITE)

21 N	110 W	62	6.1	1,097	83.9	14.9	920
20 N	111 W	7,537	8.9	195,299	88.1	22.8	172,086
20 N	110 W	19,892	8.4	481,930	85.9	20.8	414,012
20 N	109 W	309	5.7	5,126	80.4	13.4	4,124

19 N	111 W	7,846	7.7	174,763	86.0	19.1	150,212
19 N	110 W	13,961	6.0	242,173	80.5	14.0	195,000
SUBTOTAL		49,606	7.7	1,100,387	85.1	18.9	936,353

BED 21 (<2 WT PCT HALITE)

21 N	110 W	124	5.3	1,894	86.4	13.2	1,637
20 N	111 W	4,448	6.3	80,785	83.5	15.2	67,417
20 N	110 W	17,730	6.2	319,605	81.2	14.6	259,369
19 N	111 W	3,212	7.6	70,459	81.5	17.9	57,428
19 N	110 W	7,043	6.2	127,461	77.5	14.0	98,820
SUBTOTAL		32,556	6.4	600,204	80.8	14.9	484,671

BED 24 (<2 WT PCT HALITE)

21 N	109 W	6,548	6.7	127,791	91.9	17.9	117,385
21 N	108 W	5,498	8.1	129,048	87.3	20.5	112,700
20 N	110 W	494	8.7	12,494	92.2	23.3	11,517
20 N	109 W	18,100	10.9	573,938	88.2	28.0	506,089
20 N	108 W	3,707	8.7	93,762	81.6	20.6	76,493
19 N	109 W	2,286	7.4	49,161	74.5	16.0	36,624
19 N	108 W	2,471	8.1	58,114	72.3	17.0	41,993
18 N	108 W	7,166	5.3	109,669	77.1	11.8	84,552
18 N	107 W	803	4.1	9,599	86.3	10.3	8,283
SUBTOTAL		47,074	8.5	1,163,575	85.6	21.2	995,636

BED 25 (<2 WT PCT HALITE)

21 N	109 W	62	7.9	1,421	89.2	20.5	1,268
21 N	108 W	10,378	8.1	242,935	88.4	20.7	214,657
20 N	109 W	13,776	12.4	496,070	87.1	31.4	432,088
20 N	108 W	7,166	10.3	214,170	87.3	26.1	187,041
19 N	109 W	9,637	12.1	338,011	78.9	27.7	266,707
19 N	108 W	988	10.5	30,113	83.1	25.3	25,016
18 N	108 W	371	4.3	4,604	83.7	10.4	3,852
SUBTOTAL		42,379	10.8	1,327,325	85.2	26.7	1,130,629

Table 9.—SUMMARY OF TRONA RESOURCES BY BED

TRONA BED	ACRES	AVG BED THICK-NESS (Feet)	TRONA ORE (1,000's (of tons)	AVG GRADE (WT %)	TRONA (1,000's tons/acre)	TRONA (1,000's (of tons)
TRONA BEDS CONTAINING LESS THAN 2 WEIGHT PERCENT HALITE						
1	163,275	16.5	7,779,737	86.6	41.3	6,740,363
2	274,163	16.4	13,019,241	87.0	41.3	11,325,246
3	102,487	5.7	1,699,834	85.4	14.2	1,451,451
4	240,063	8.1	5,647,700	83.6	19.7	4,719,423
5	211,765	8.4	5,141,612	72.5	17.6	3,728,275
6	75,861	6.1	1,349,490	62.5	11.1	843,970
7	77,838	4.8	1,071,896	83.2	11.5	891,603
8	41,699	4.9	587,620	76.0	10.7	446,310
9	88,155	6.8	1,744,625	82.7	16.4	1,443,106
10	42,749	7.7	951,249	70.1	15.6	666,407
11	59,923	8.0	1,395,811	54.4	12.7	758,961
12	195,275	7.5	4,249,586	68.5	14.9	2,911,349
14	282,689	10.1	8,295,332	67.5	19.8	5,597,226
15	224,804	8.5	5,544,762	69.1	17.0	3,829,401
16	164,387	5.9	2,816,714	74.2	12.7	2,089,951
17	329,021	9.2	8,775,144	86.6	23.1	7,597,978
18	14,147	4.0	160,783	48.8	5.5	78,482
19	55,475	8.0	1,281,834	83.8	19.4	1,073,625
20	49,606	7.7	1,100,387	85.1	18.9	936,353
21	32,556	6.4	600,204	80.8	14.9	484,671
24	47,074	8.5	1,163,575	85.6	21.2	995,636
25	42,379	10.8	1,327,325	85.2	26.7	1,130,629
SUBTOTAL	2,815,391		75,704,460			59,740,416
TRONA BEDS CONTAINING 2, OR MORE, WEIGHT PERCENT HALITE						
1	865	17.2	43,089	84.3	42.0	36,326
2	7,104	17.3	355,393	70.1	16.8	249,074
3	3,336	7.1	68,900	66.3	13.7	45,710
4	1,606	4.8	22,157	66.4	9.2	14,714
5	86,917	11.9	3,691,591	40.5	17.2	1,495,169
6	110,394	8.5	2,709,582	38.9	9.5	1,052,997
7	15,444	4.9	217,476	79.5	11.2	172,879
8	2,100	4.9	29,930	78.1	11.1	23,371
9	191,816	7.9	4,405,486	80.4	18.5	3,543,562
10	126,209	7.8	2,859,958	51.2	11.6	1,463,774
11	226,163	8.1	5,296,398	36.6	8.6	1,938,766
12	233,947	9.6	6,528,298	50.3	14.0	3,282,378
14	206,271	11.0	6,548,542	54.9	17.4	3,592,208
15	224,433	11.9	7,747,006	48.8	16.8	3,778,769
16	181,005	9.4	4,953,642	52.5	14.4	2,600,304
17	166,055	11.4	5,505,986	71.3	23.6	3,924,574
18	36,880	7.0	751,177	17.3	3.5	130,256

Table 9.—SUMMARY OF TRONA RESOURCES (continued)

SUBTOTAL	1,820,545	51,734,611	27,344,831
GRAND TOTALS	4,635,937	127,439,071	87,085,247

The trona resources of southwest Wyoming are enormous. The resource of trona **ore** in 22 beds with less than two percent halite amounts to 76 billion tons. Including that ore containing halite, the grand total amounts to 127 billion tons. The total amount of **trona** containing less than two percent halite in the 22 beds is estimated at 60 billion tons (table 9).

Burnside and Culbertson (1979), estimated the total resource of trona ore for the same 22 beds, on a halite-free basis, to be 61.0 billion tons, and 113 billion tons for trona and mixed trona and halite combined. Thus, this study shows a 24 percent increase in the estimated amount of halite-free trona ore and a 13 percent increase overall for both halite-free trona ore and mixed trona and halite.

Considering only those beds, or portions thereof, that contain less than two percent halite, 13 of the 22 studied each contain in excess of 1 billion tons of trona (table 9). The largest resource is found in bed 2 which contains an estimated 11.3 billion tons of trona. Bed 17 contains an estimated 7.6 billion tons and bed 14 is estimated to contain 5.6 billion tons. Beds 1 and 2 are noteworthy because of their thickness (each averages about 16.5 feet) and concentration of trona in terms of tons per acre; each averages 41,300 tons/acre for halite-free portions of these beds—as much as twice that for most of the other beds. Remarkably, the ore grade for 12 of the 22 beds studied averages 80 or more percent trona. Of these higher grade beds, eight contain 1 to 11 billion tons of trona. Together, beds 1 and 2 contain an estimated 18.0 billion tons of trona, or 30 percent of the entire trona resource as determined in this study.

When trona resources are compared to the areas occupied by the beds, a strong association was found for 20 of the 22 beds (fig. 33). Trona beds 1 and 2 are anomalous and probably indicate a more rapidly subsiding basin during their deposition.

CONCLUSIONS

Trona resources for 22 beds, where thickness equals or exceeds 4 feet, in the trona district of southwest Wyoming are estimated at 127 billion tons of trona ore. Of this amount, 76 billion tons of trona ore, or 59 percent of the deposit, contains 60 billion tons of trona containing less than two percent halite. These beds, where they are 4 or more feet thick occupy areas ranging from 60 to 774 square miles and range in maximum thickness from 5 to 35 feet.

Some trona beds contain substantial amounts of nahcolite and halite. The halite is usually found toward the depocenters of the trona beds in those areas where they reach their maximum thickness. However, there is some evidence that the distribution of halite may be complicated by post-depositional dissolution and reprecipitation of trona and halite.

As deeper parts of the trona deposit are mined, increased amounts of methane (and other gases including carbon dioxide and possibly ammonia) as well as salt brine and tar seeps may be expected. High-pressure blowouts may also be encountered. It may be prudent to plan additional exploratory drilling with gas sampling prior to mining in new areas of the more deeply buried trona beds.

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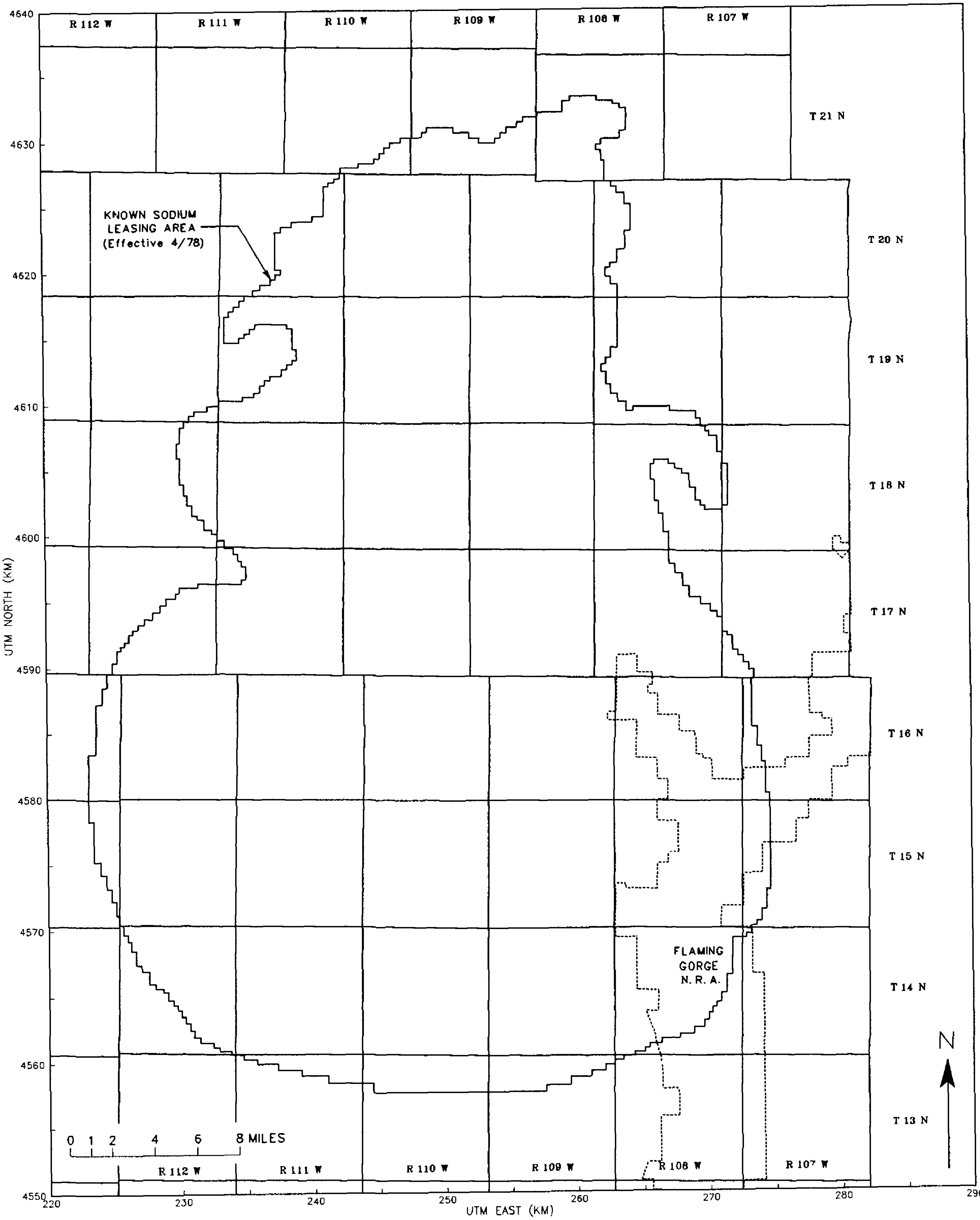

Figure 1. Known Sodium Leasing Area, Green River Basin, Wyoming.

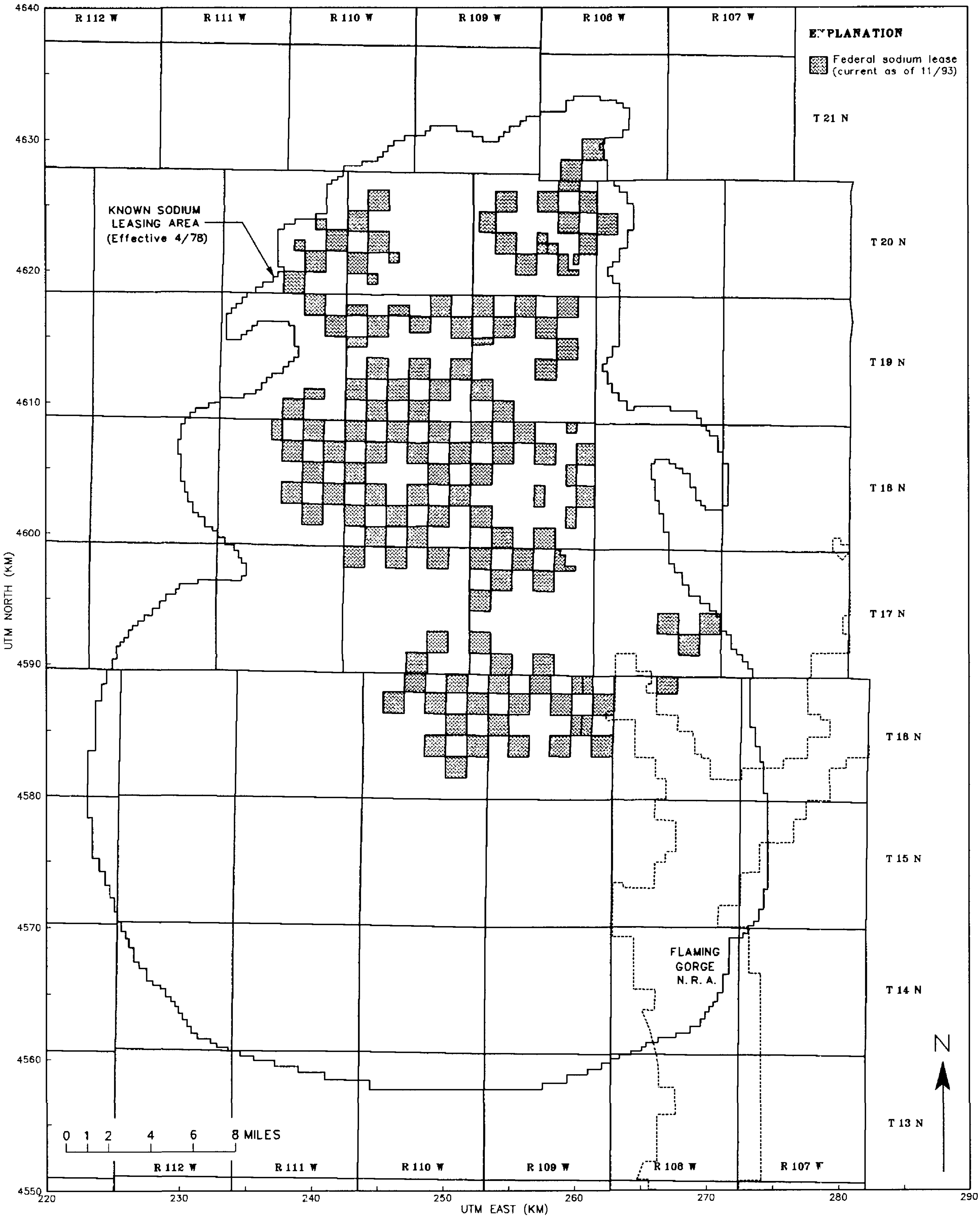

Figure 2. Federal sodium leases, Green River Basin, Wyoming.

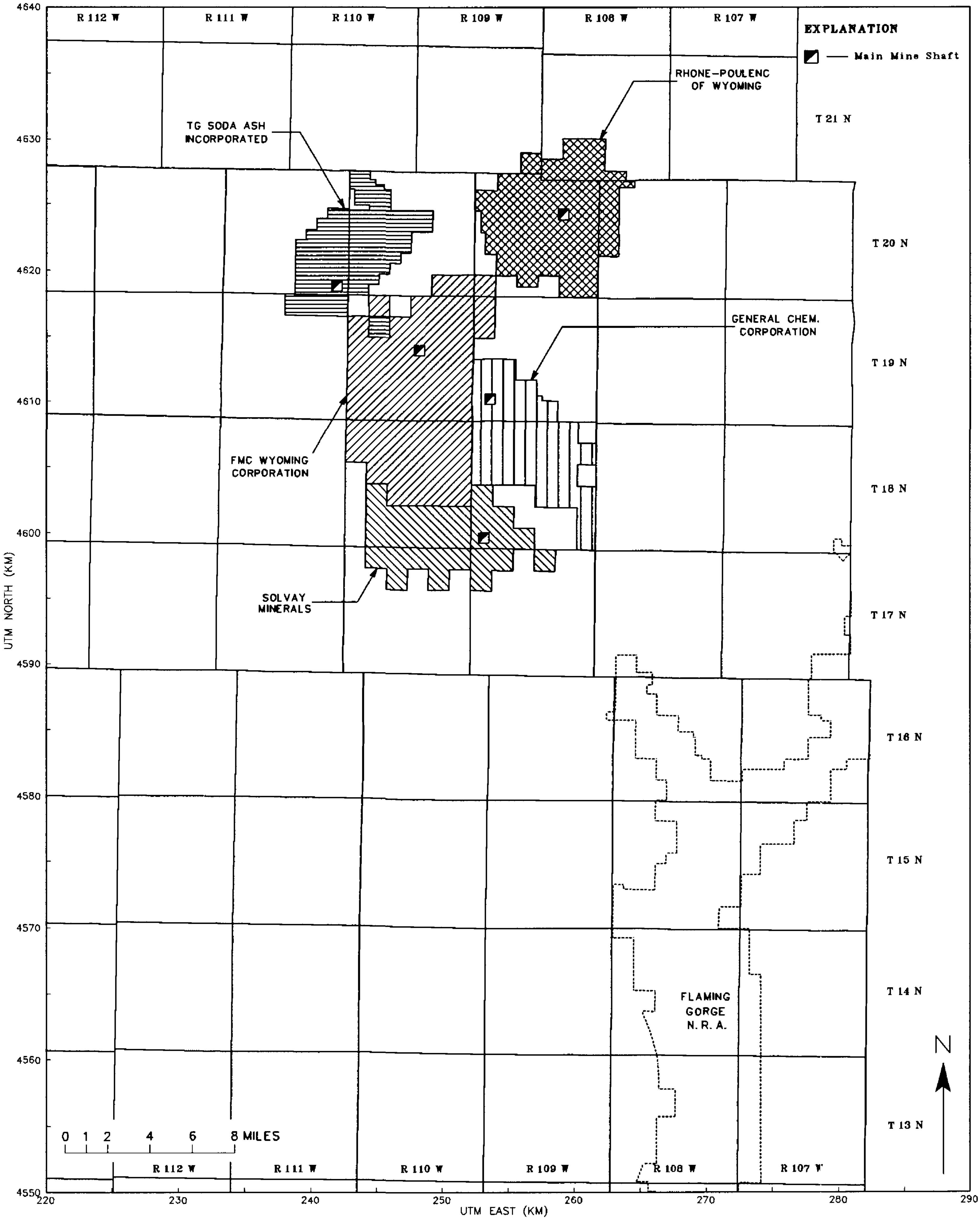

Figure 3. Current trona mine permit areas, Green River Basin, Wyoming.

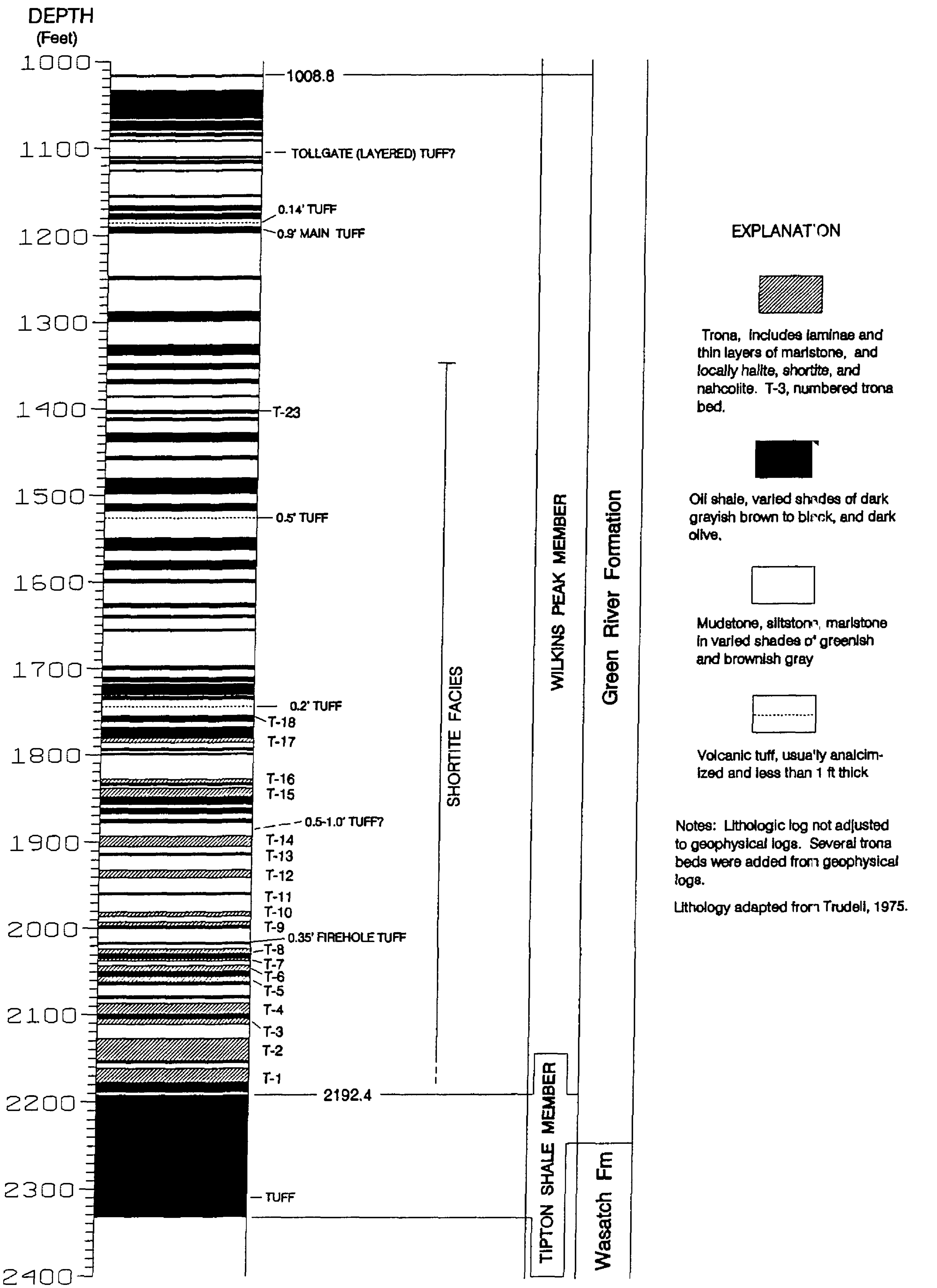

Figure 4.—Generalized lithologic log of Union Pacific Railroad, El Paso core hole 44-3 in sec. 3, T.15 N., R.109 W, Sweetwater County, Wyoming.

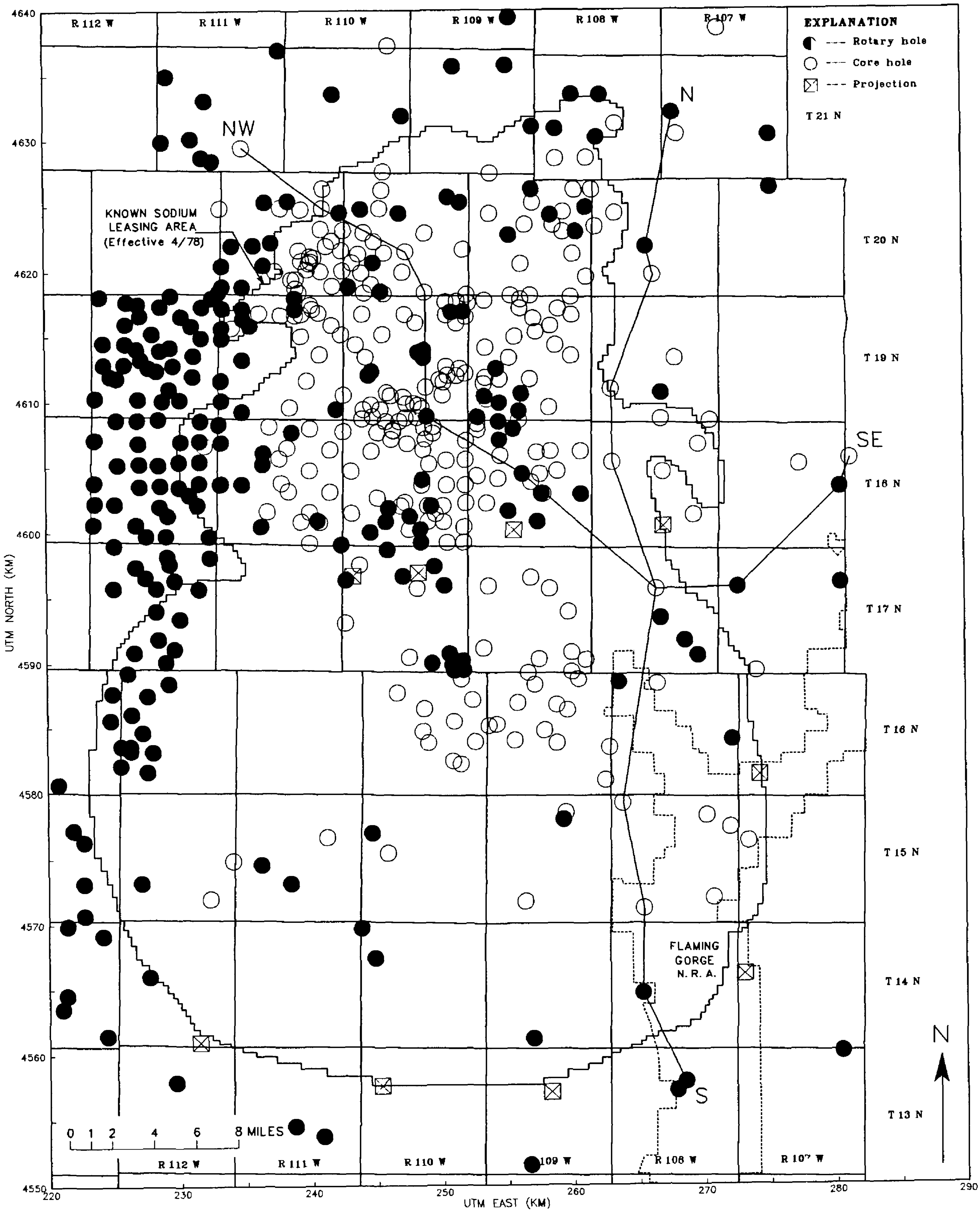

Figure 5. Bore hole locations and lines of stratigraphic cross sections S-N and NW-SE, Green River Basin, Wyoming.

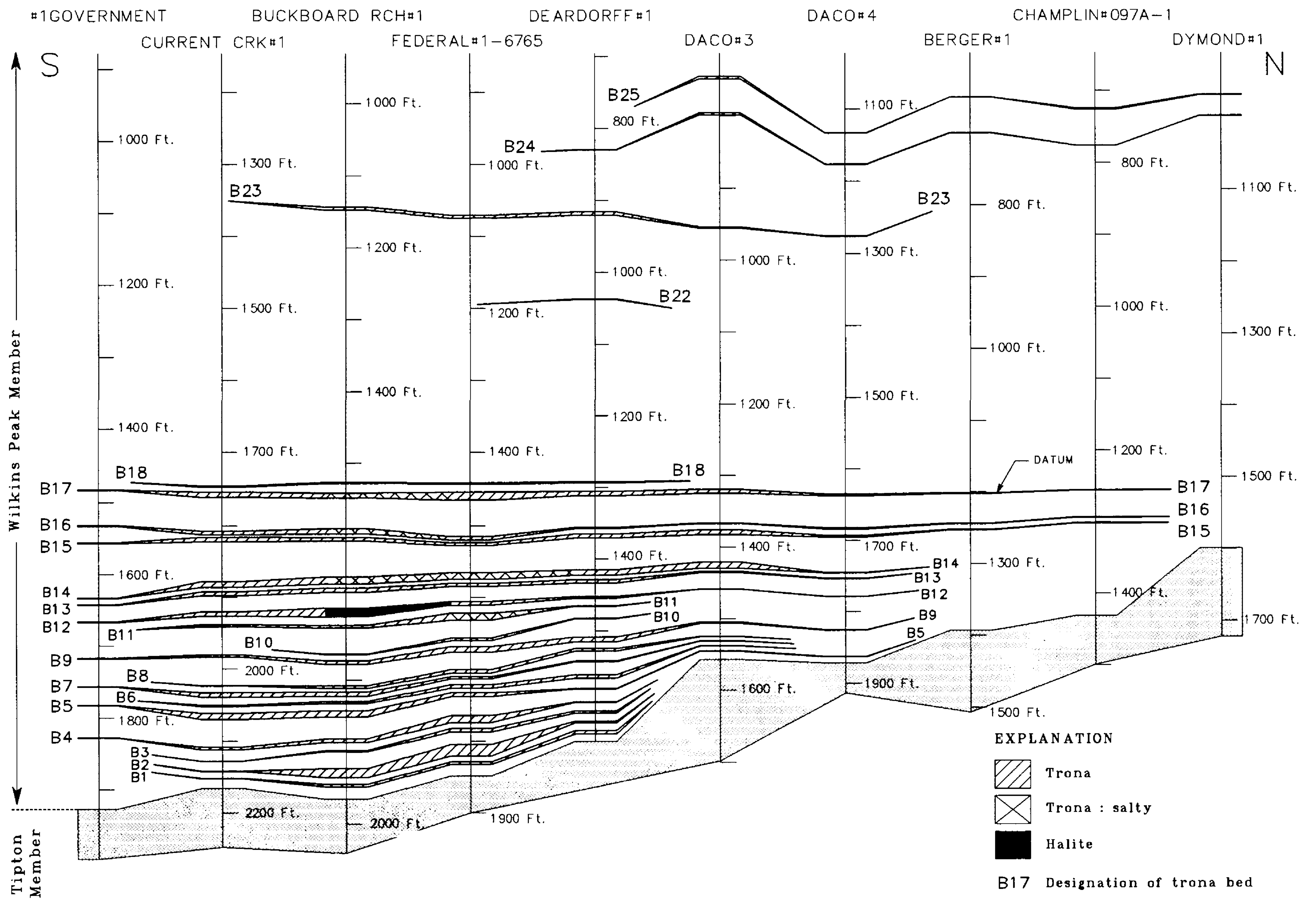

Figure 6. Stratigraphic cross section along line S – N, Green River Basin, Wyoming.

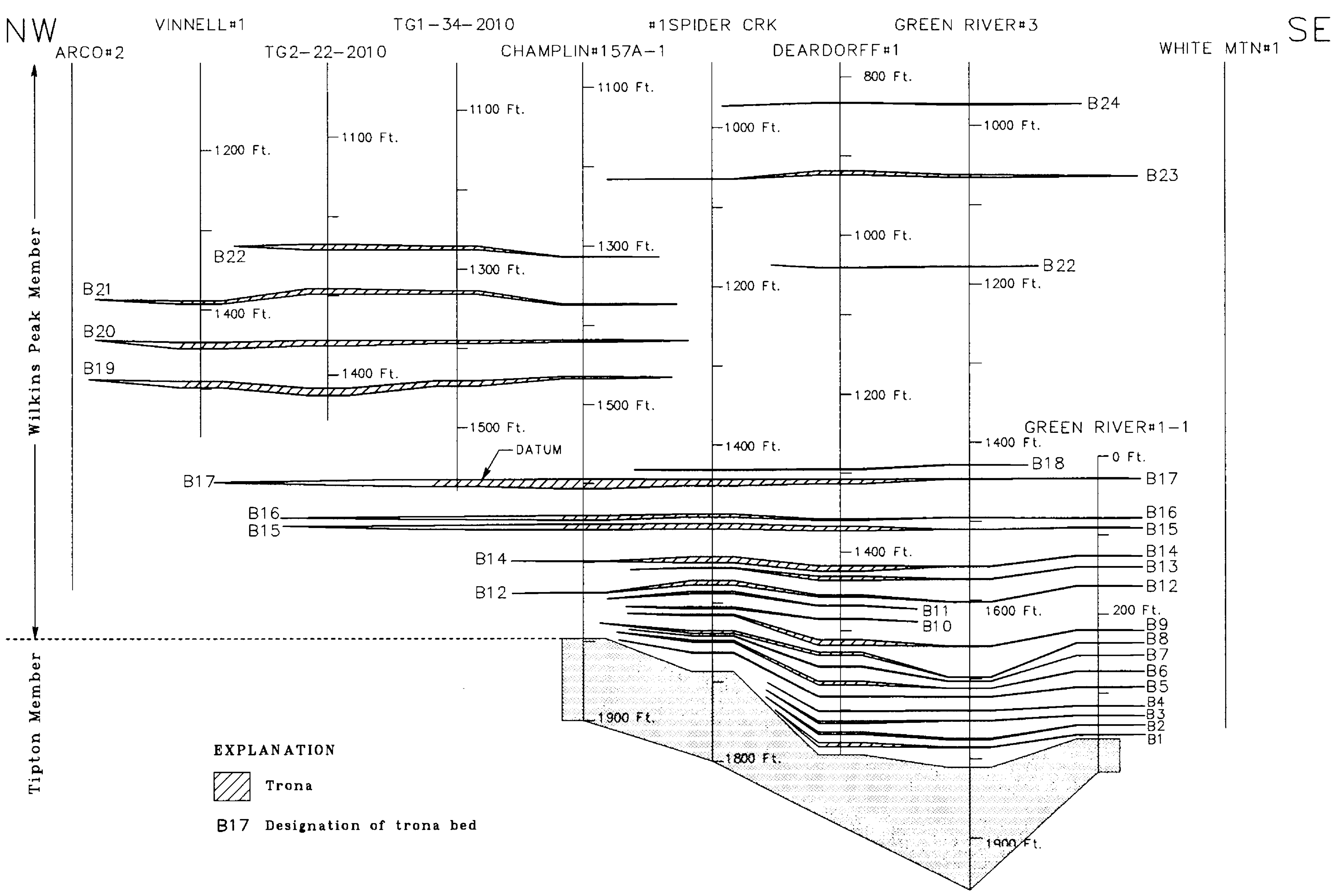

Figure 7. Stratigraphic cross section along line NW - SE, Green River Basin, Wyoming.

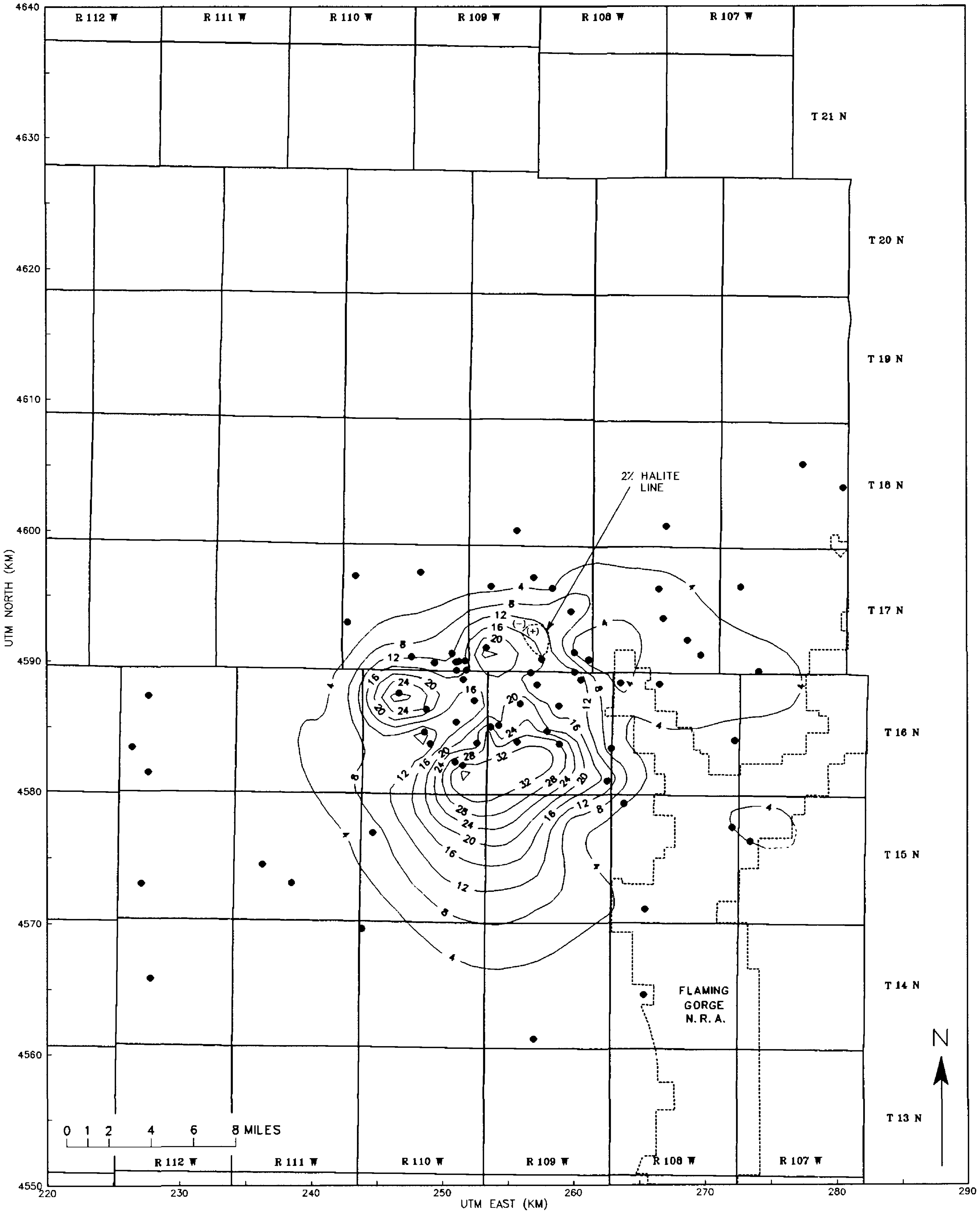

Figure 8. Total thickness of trona bed 1, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

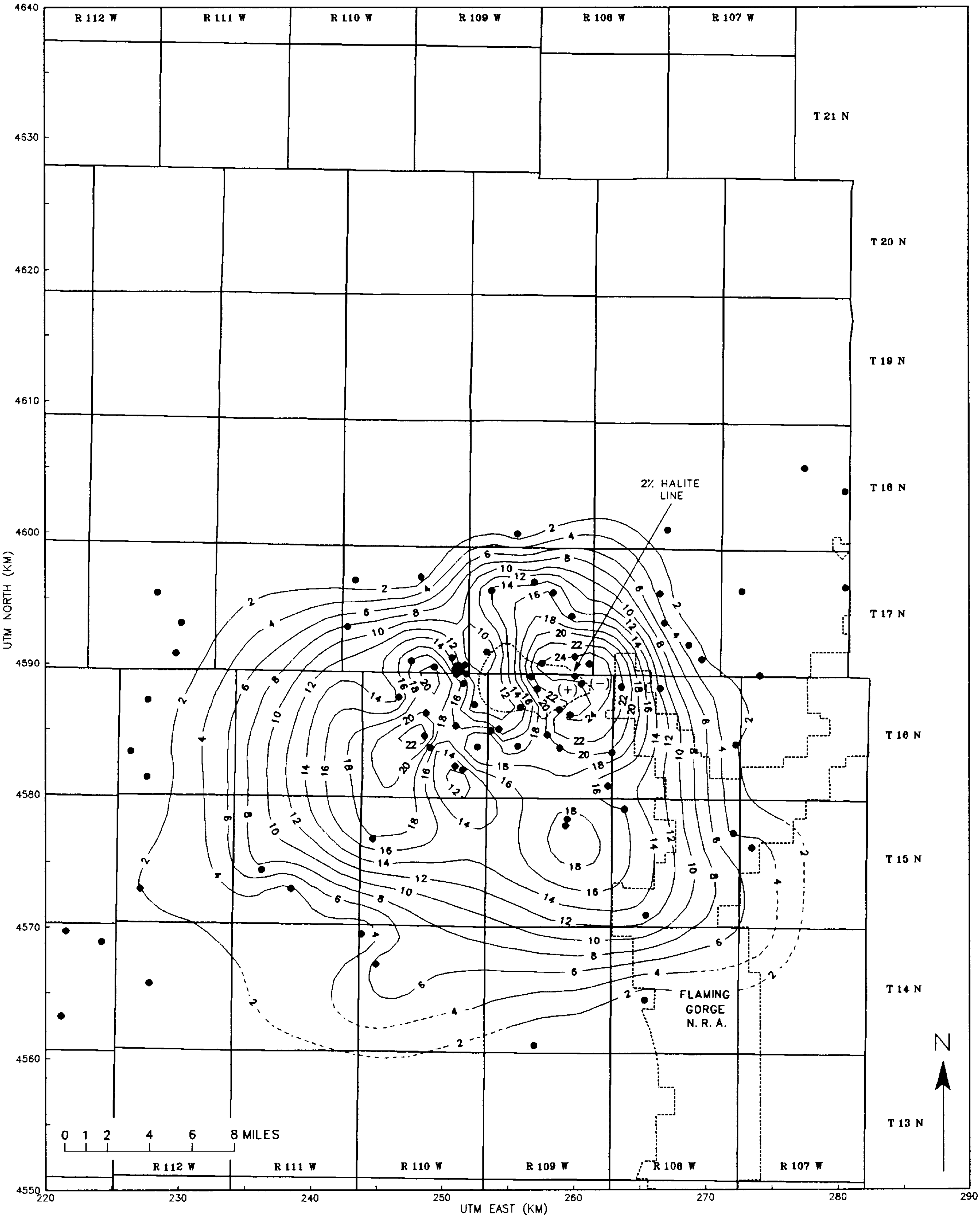

Figure 9. Total thickness of trona bed 2, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

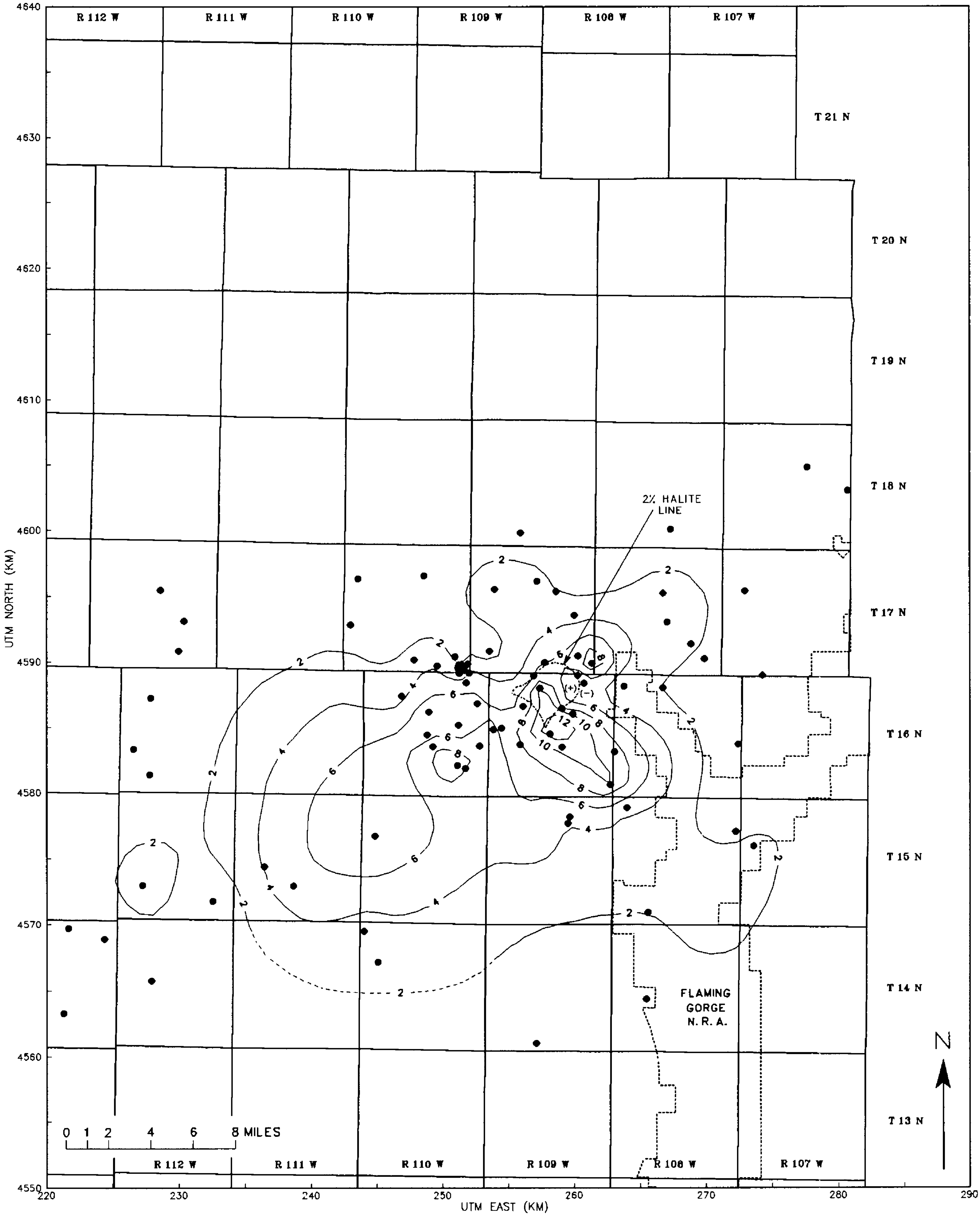

Figure 10. Total thickness of trona bed 3, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

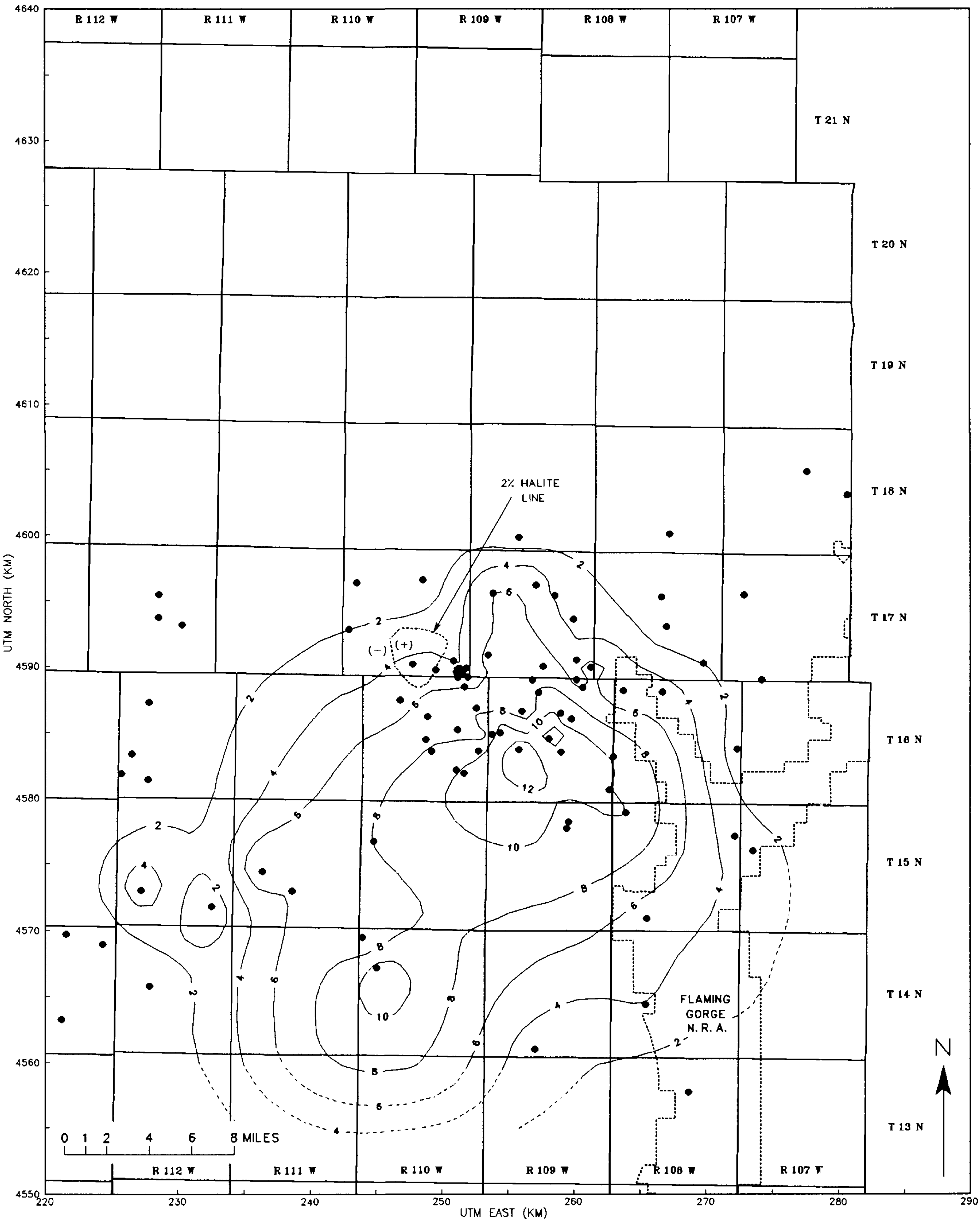

Figure 11. Total thickness of trona bed 4, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

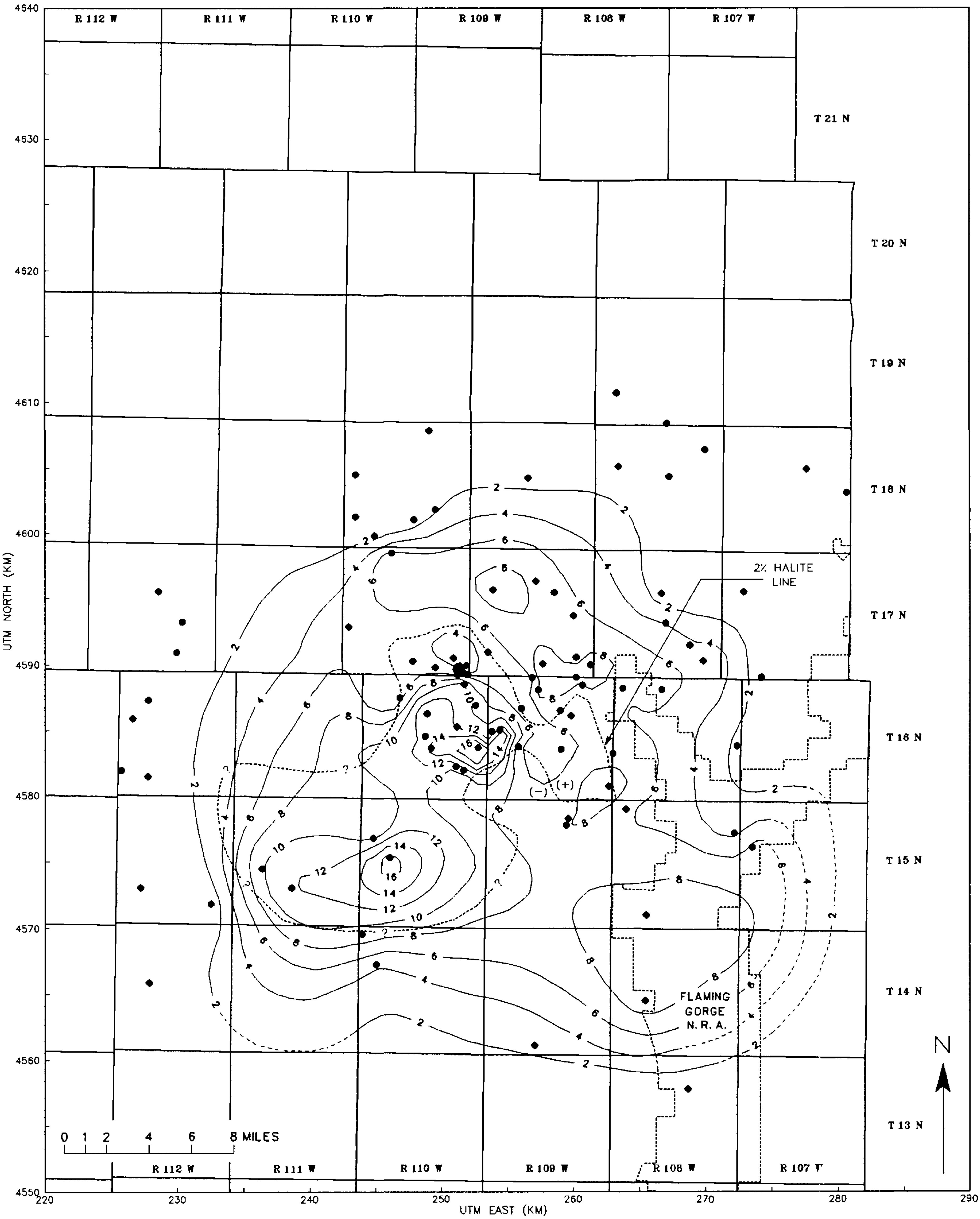

Figure 12. Total thickness of trona bed 5, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

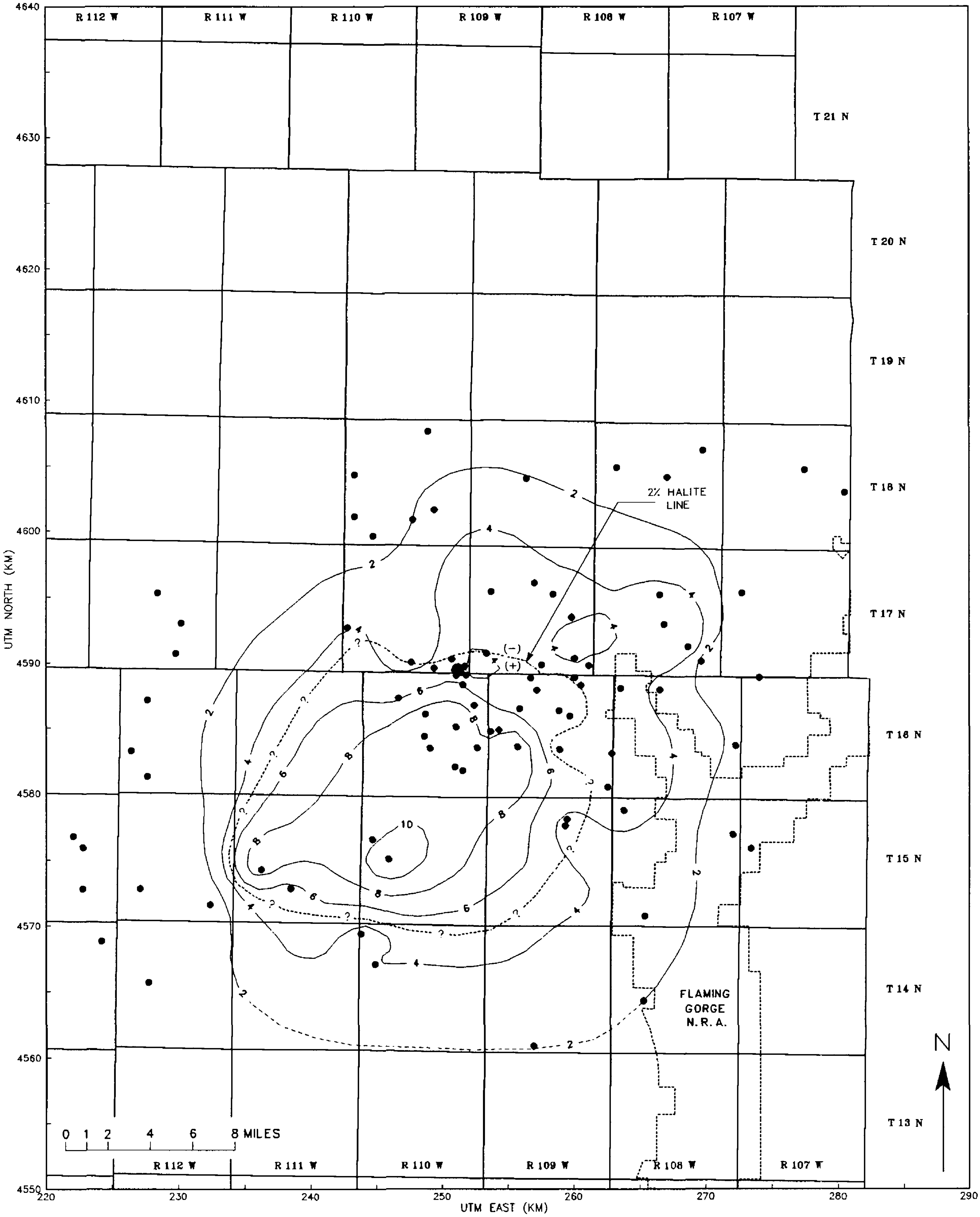

Figure 13. Total thickness of trona bed 6, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

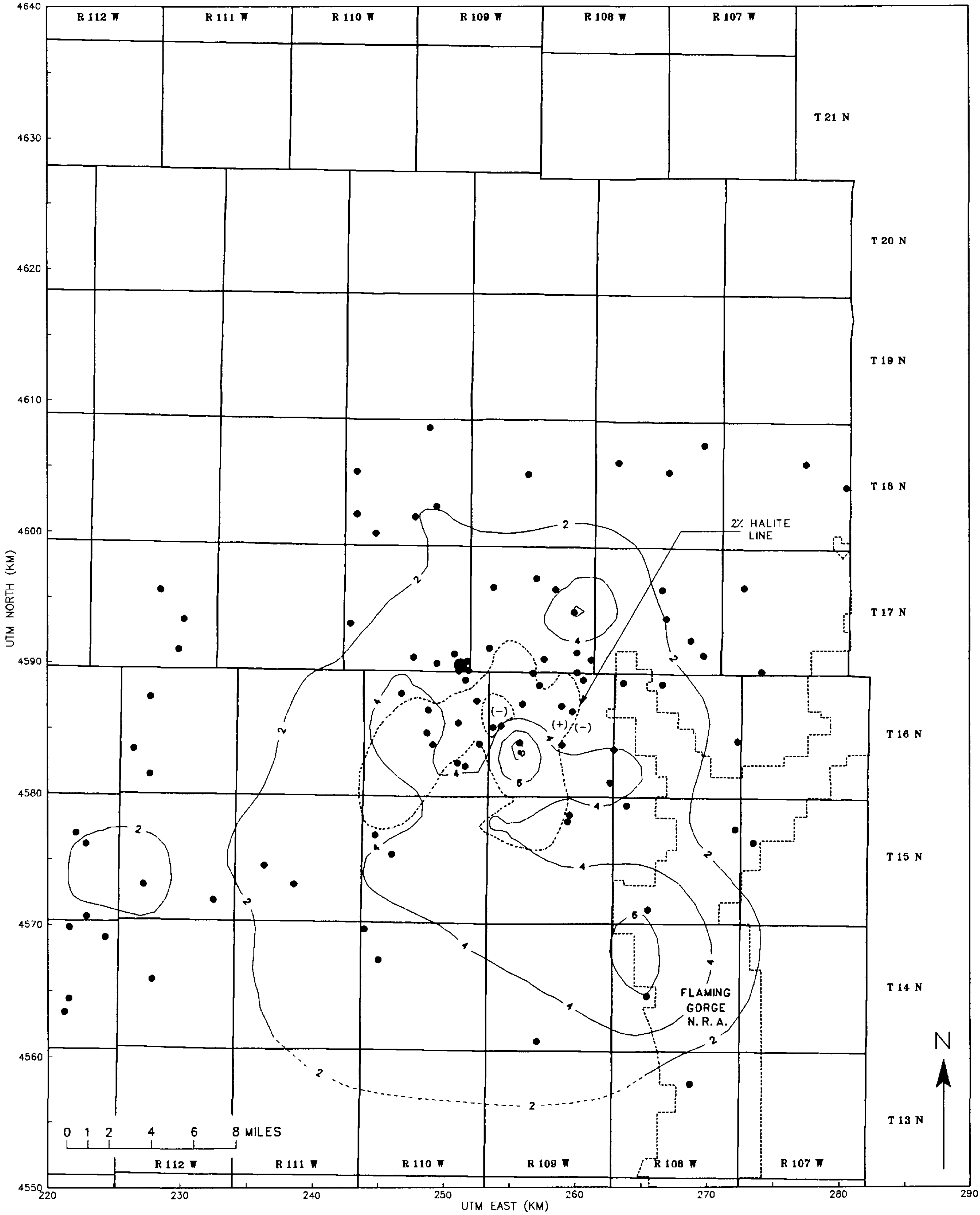

Figure 14. Total thickness of trona bed 7, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

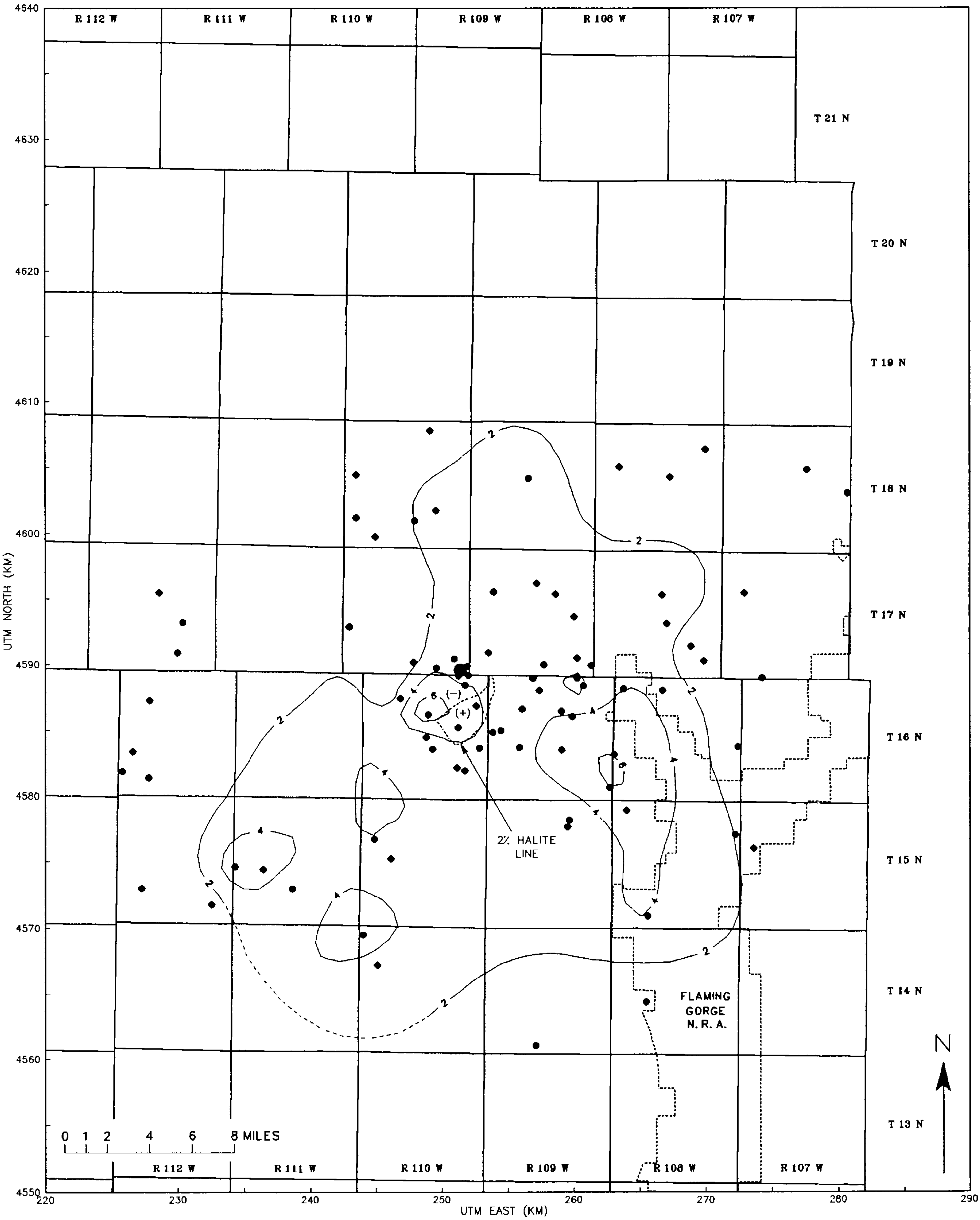

Figure 15. Total thickness of trona bed 8, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

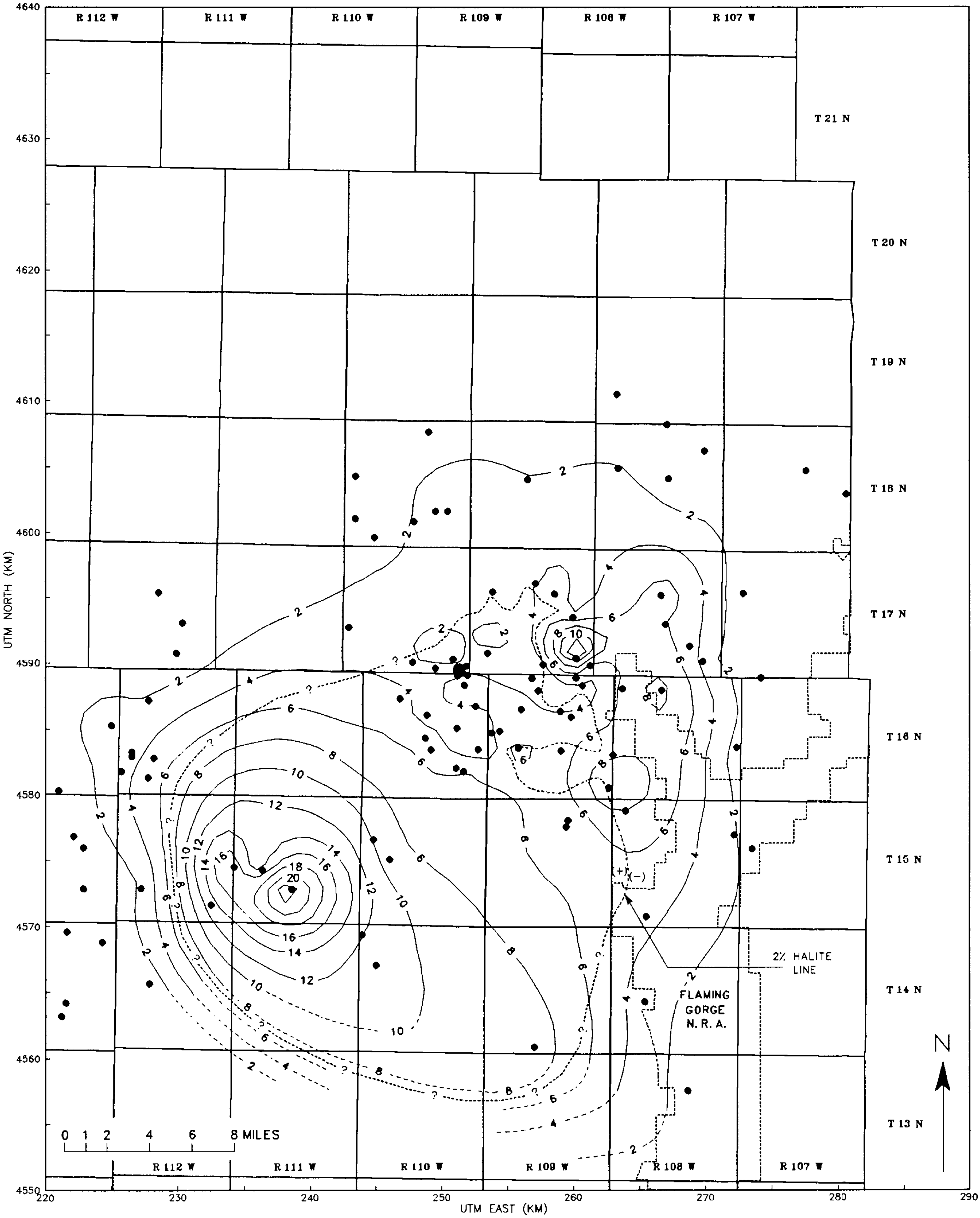

Figure 16. Total thickness of trona bed 9, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

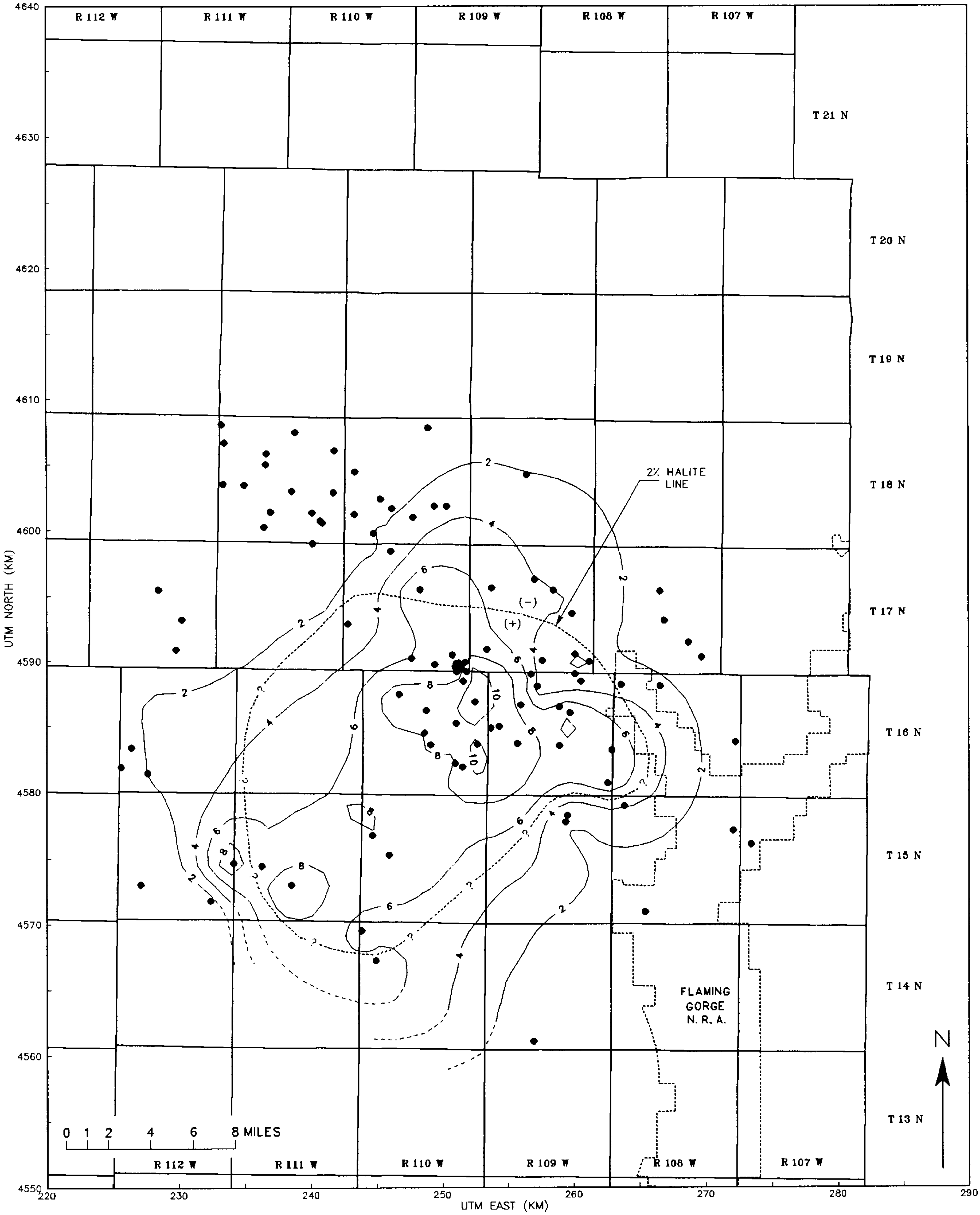

Figure 17. Total thickness of trona bed 10, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

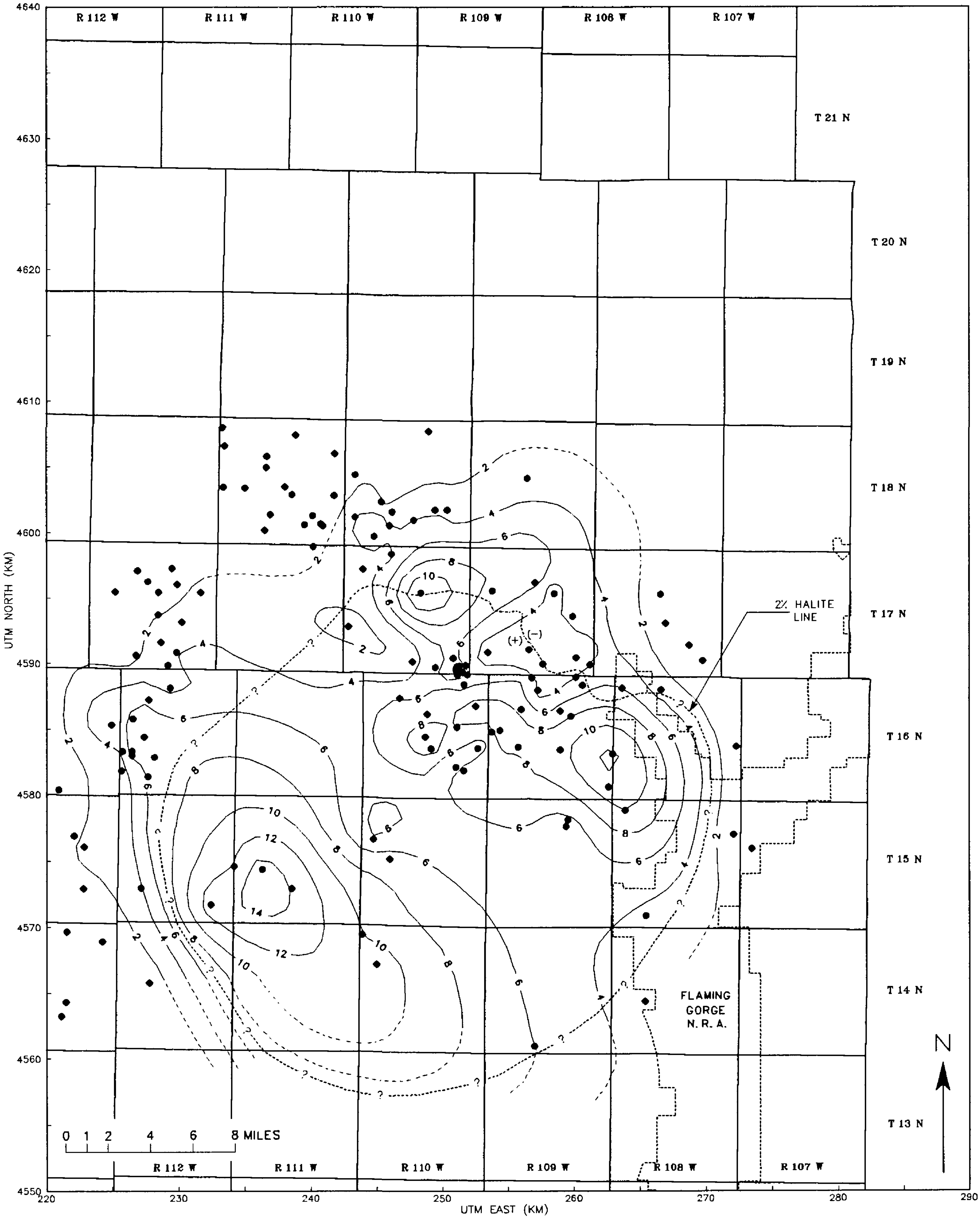

Figure 18. Total thickness of trona bed 11, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

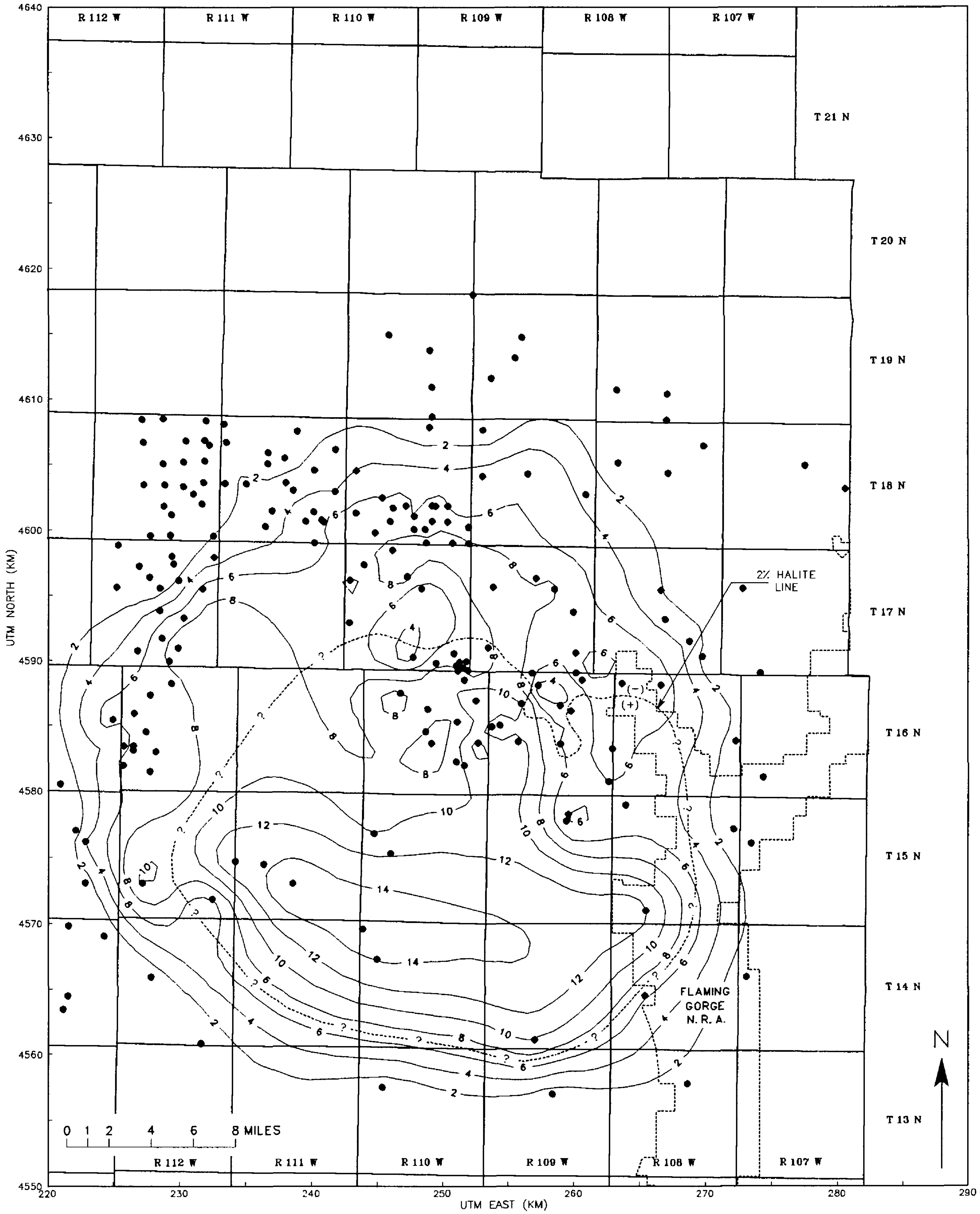

Figure 19. Total thickness of trona bed 12, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

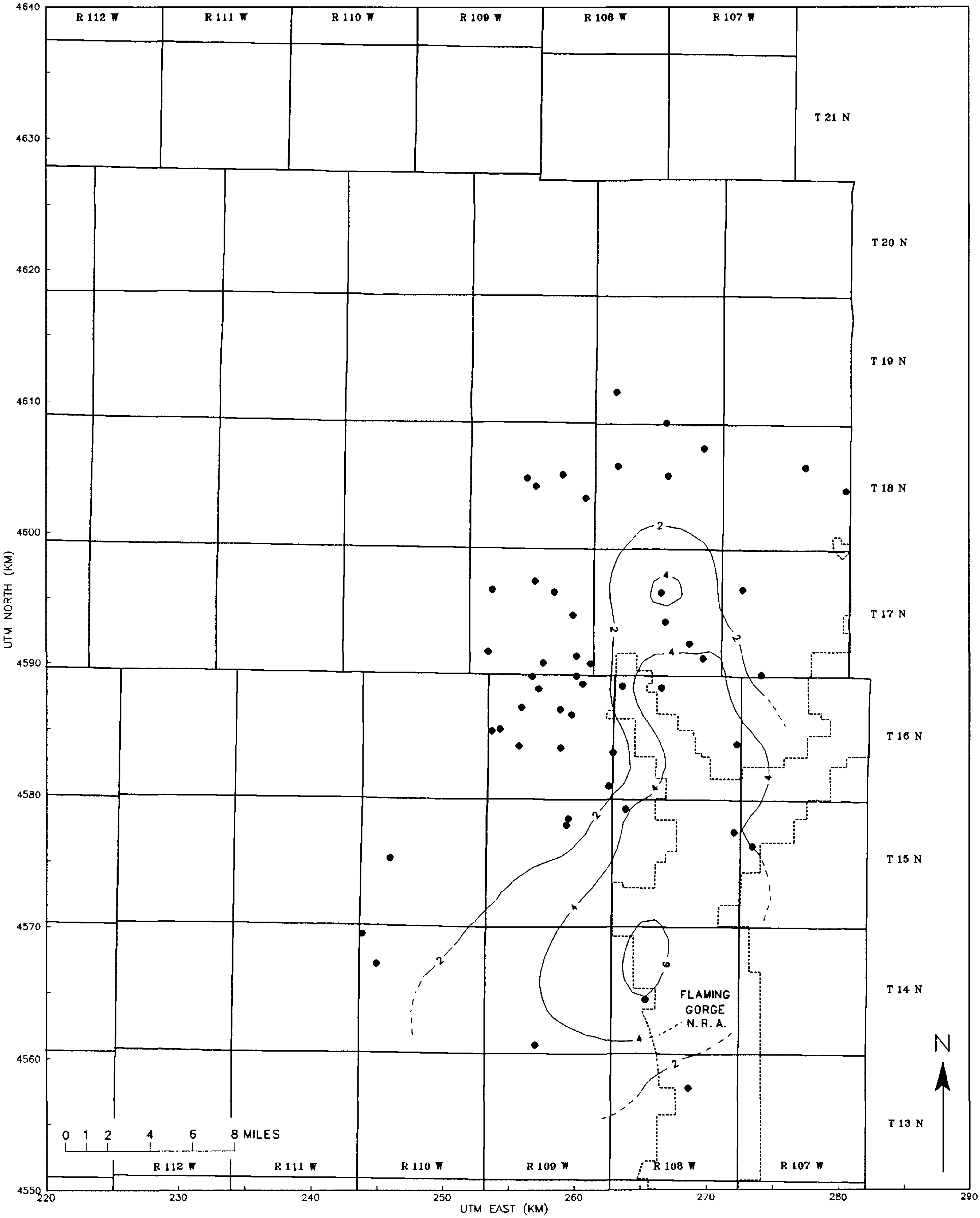

Figure 20. Total thickness of trona bed 13, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dot, data point location.

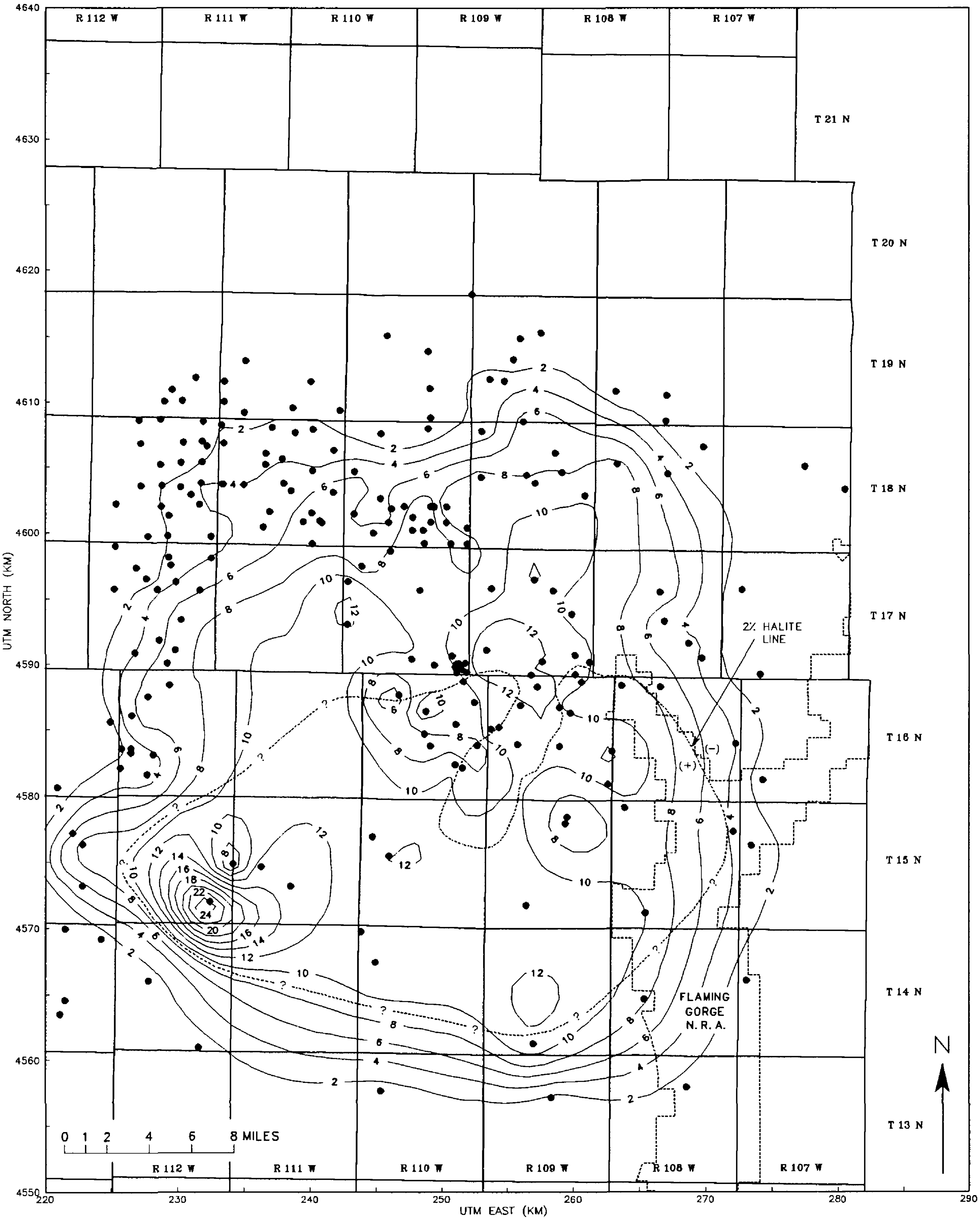

Figure 21. Total thickness of trona bed 14, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

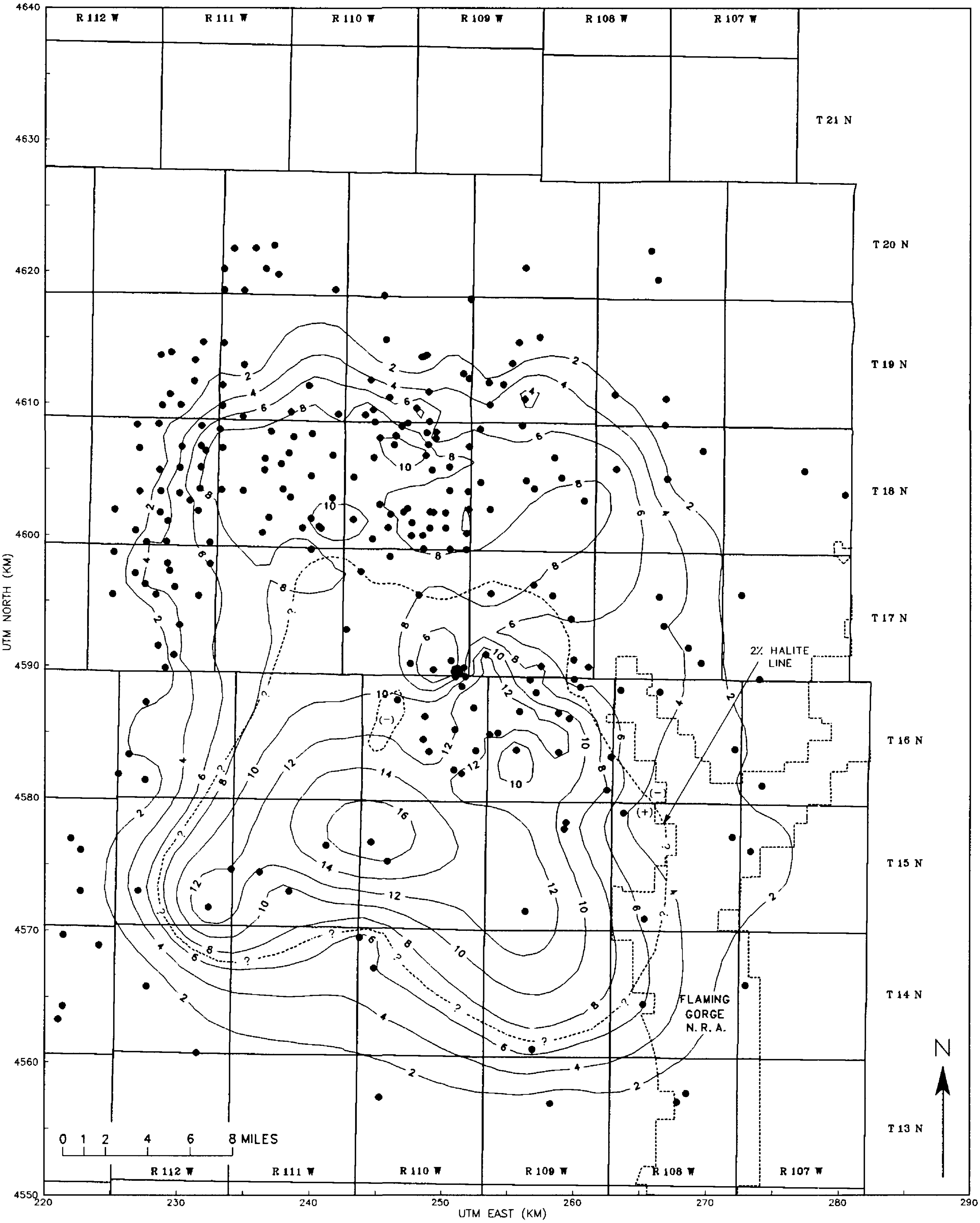

Figure 22. Total thickness of trona bed 15, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

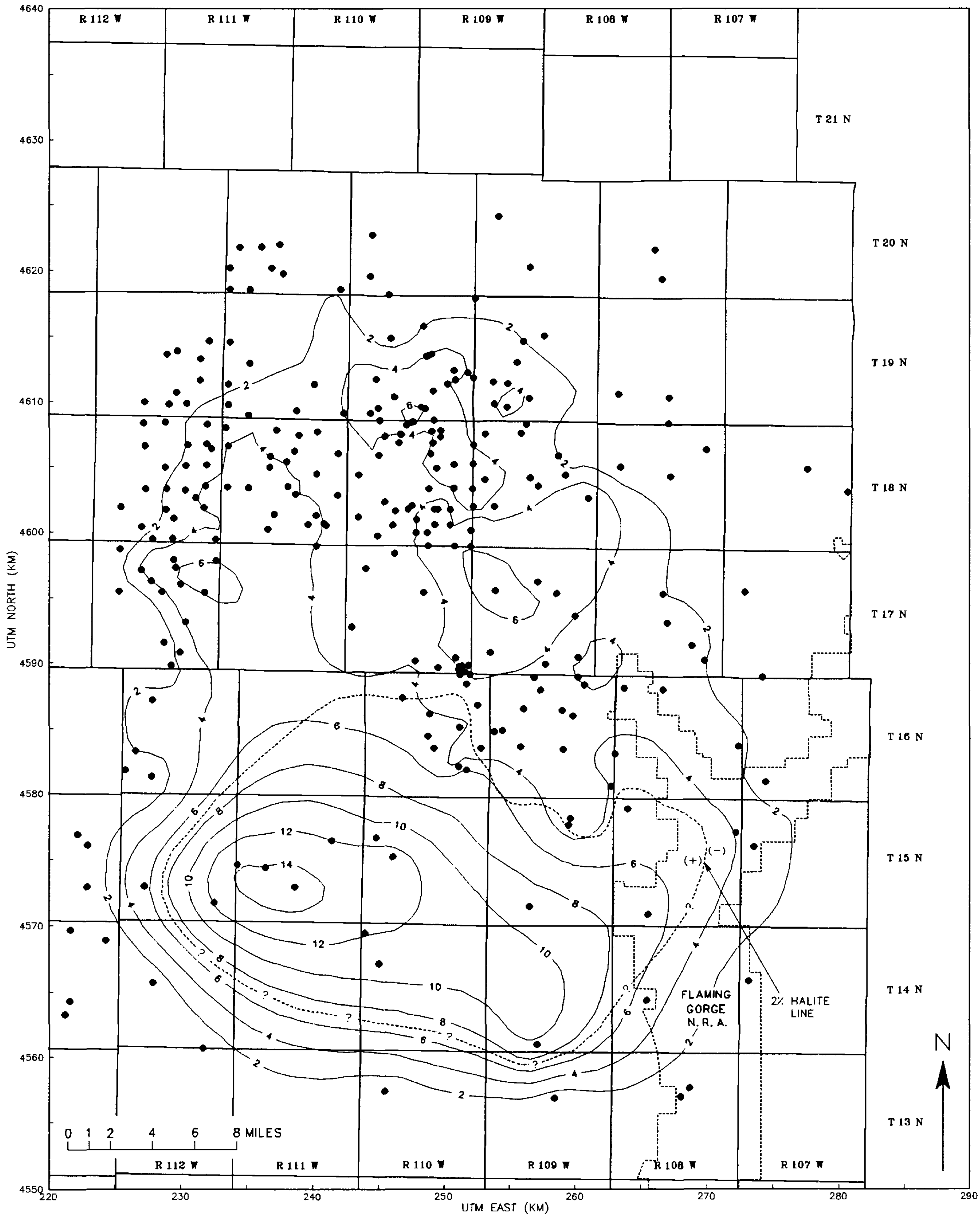

Figure 23. Total thickness of trona bed 16, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

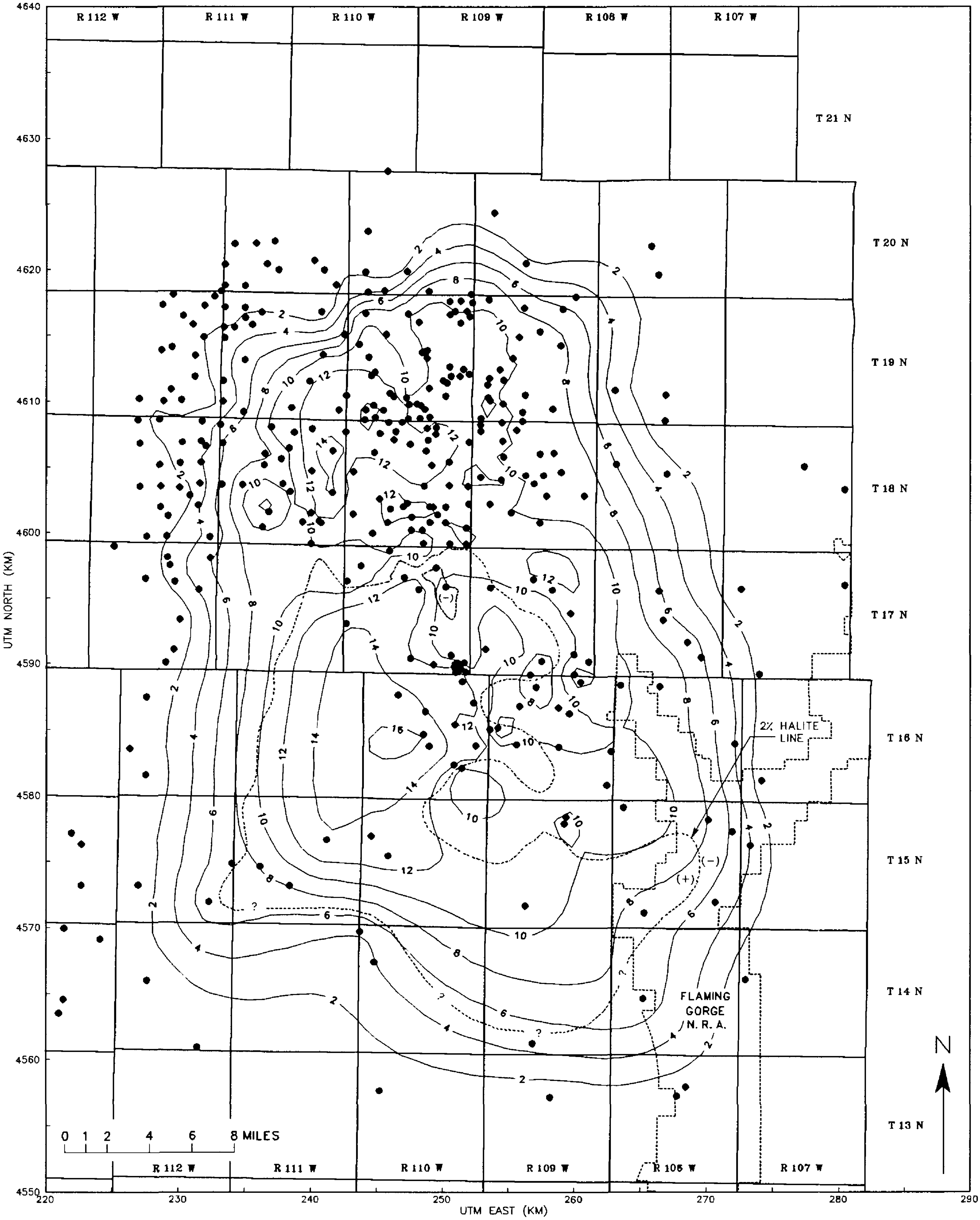

Figure 24. Total thickness of trona bed 17, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

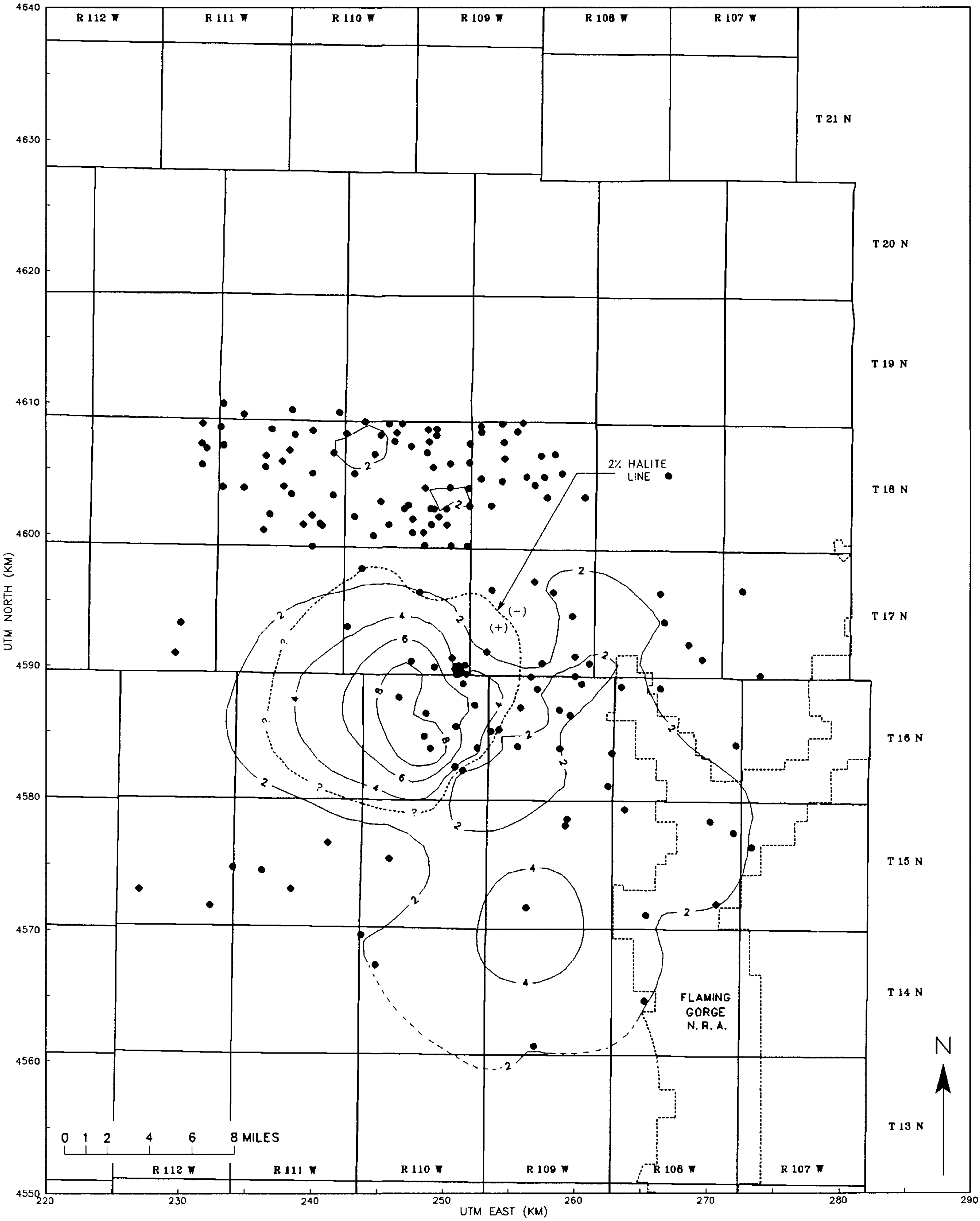

Figure 25. Total thickness of trona bed 18, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dotted line, 2 percent halite boundary; queried where approximate; (+) side > 2 percent; (−) side < 2 percent. Dot, data point location.

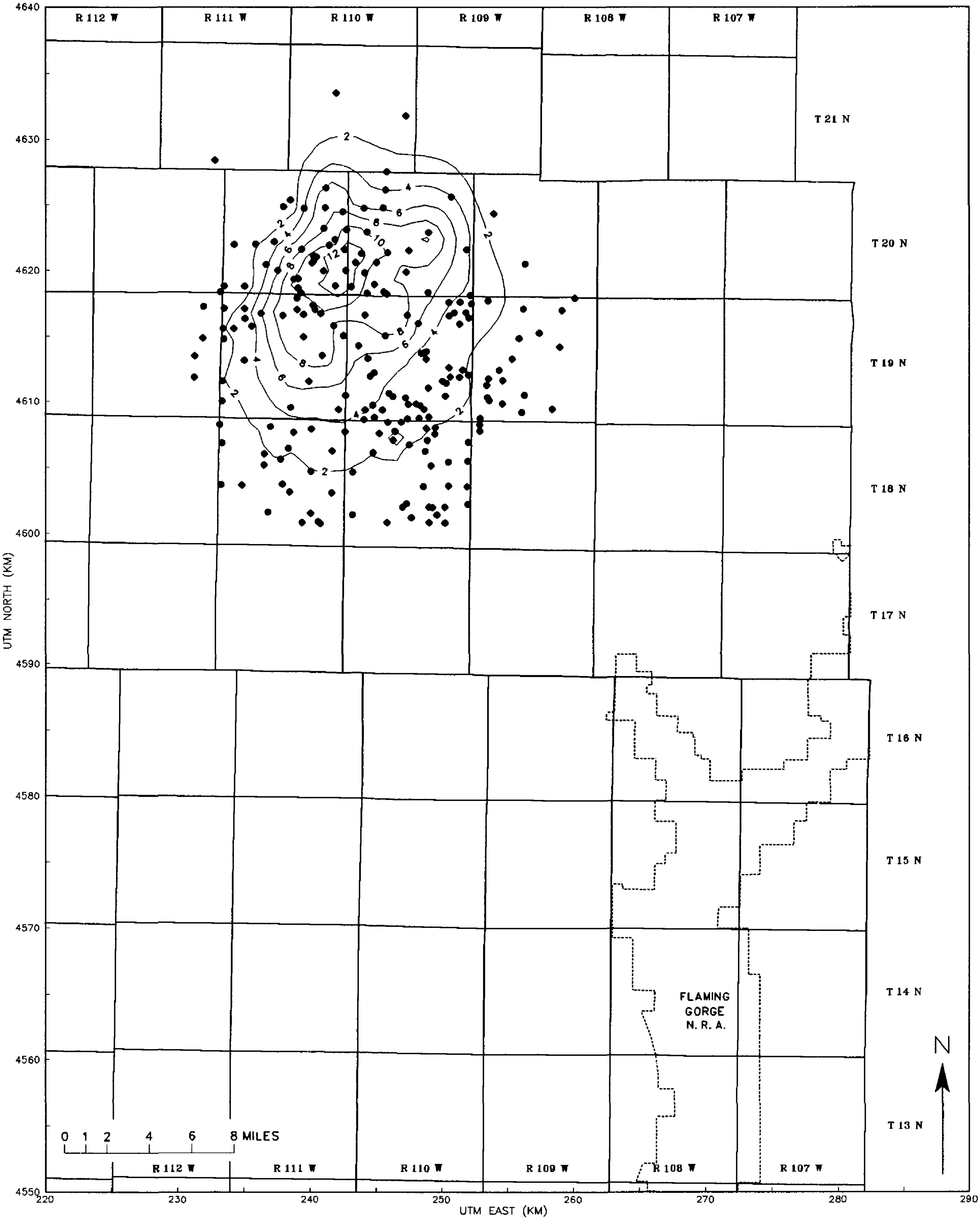

Figure 26. Total thickness of trona bed 19, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dot, data point location.

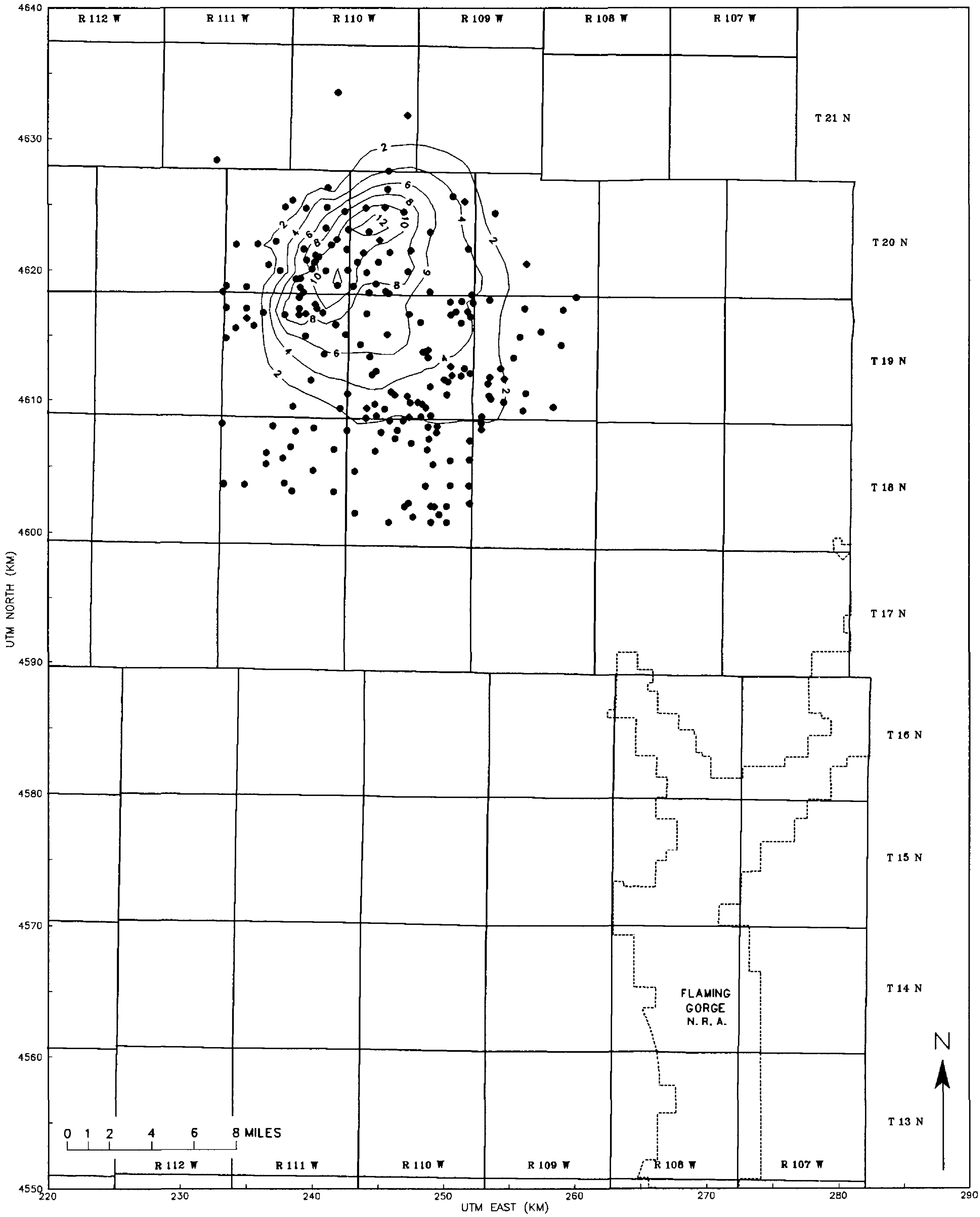

Figure 27. Total thickness of trona bed 20, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dot, data point location.

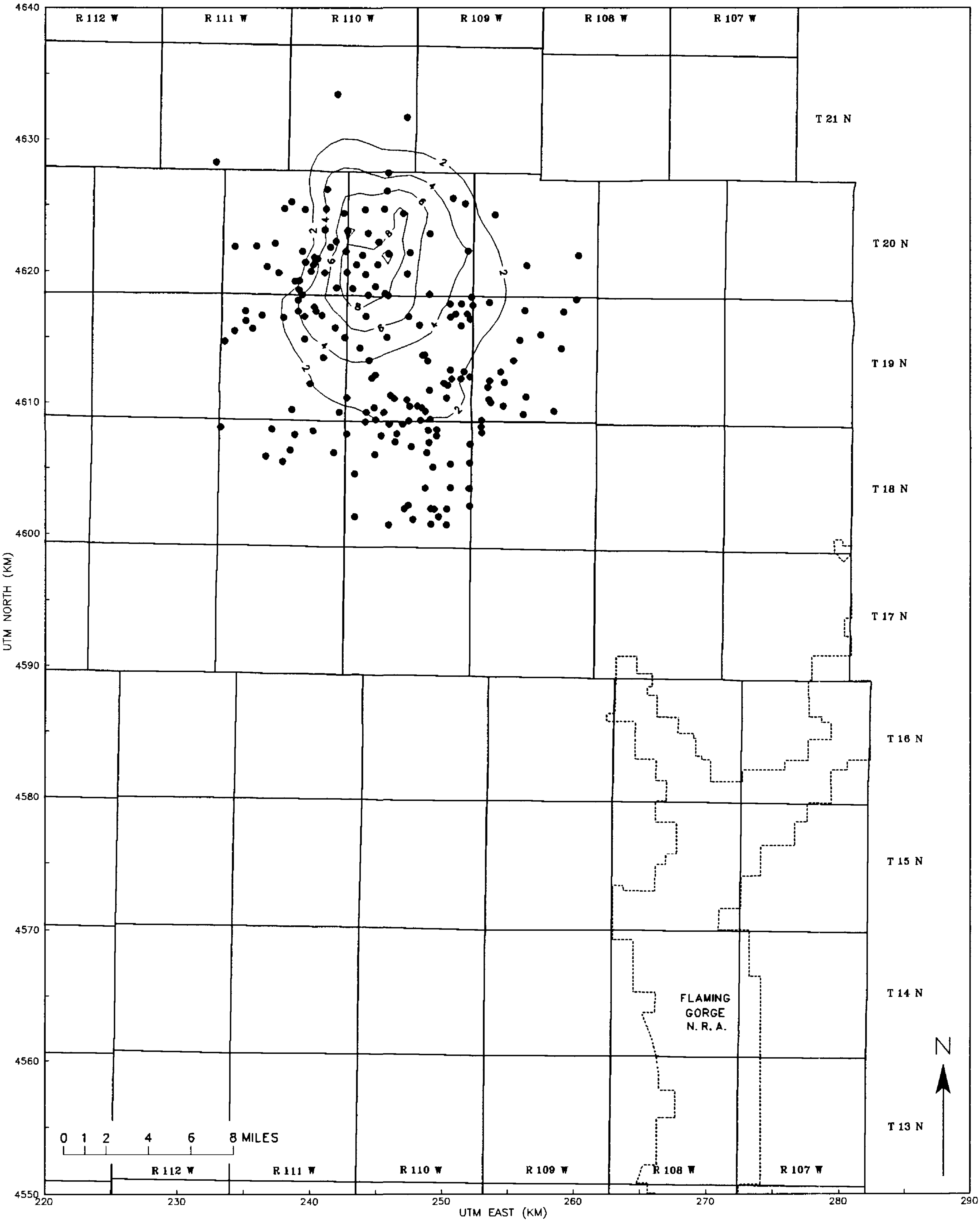

Figure 28. Total thickness of trona bed 21, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dot, data point location.

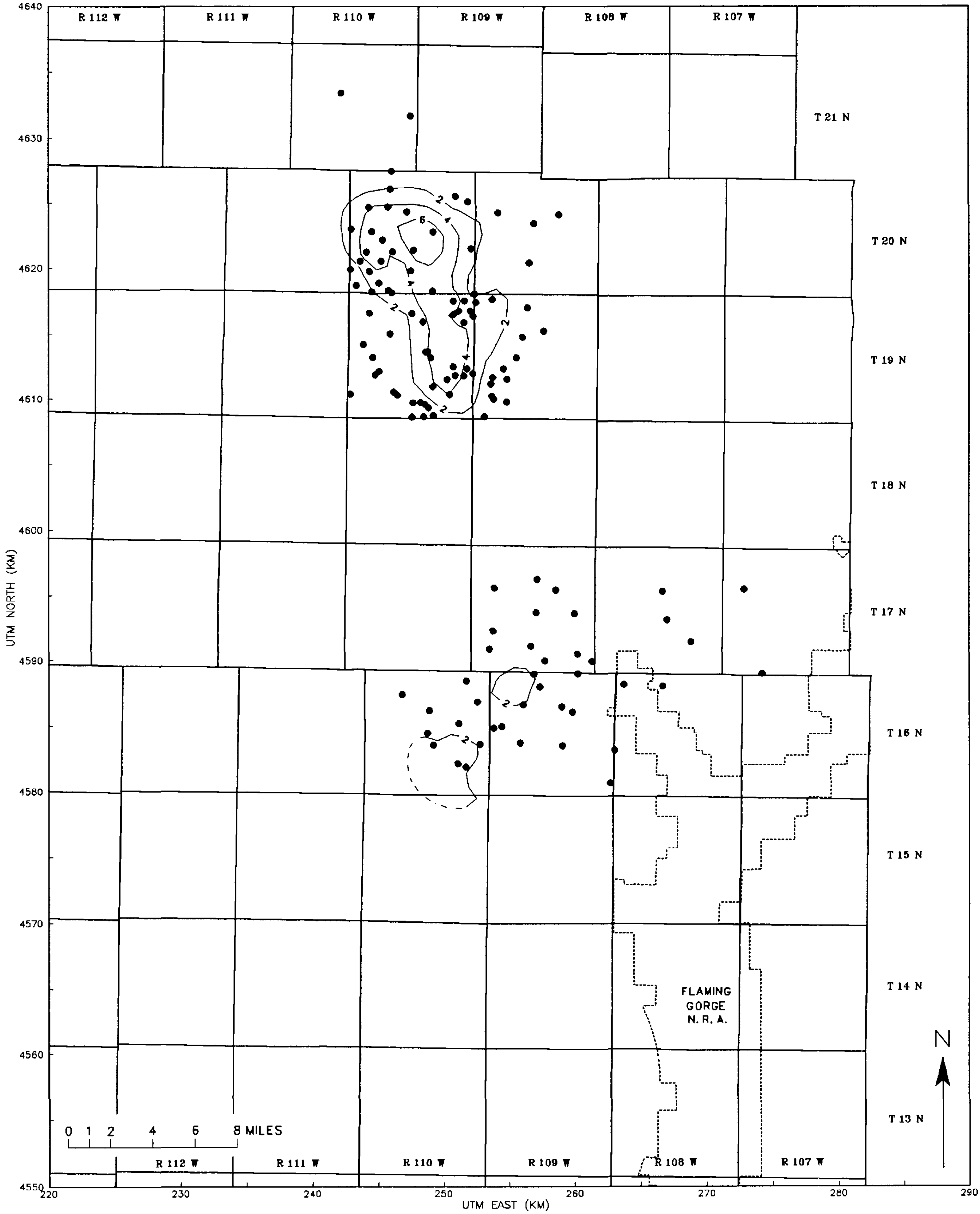

Figure 29. Total thickness of trona bed 22, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dot, data point location.

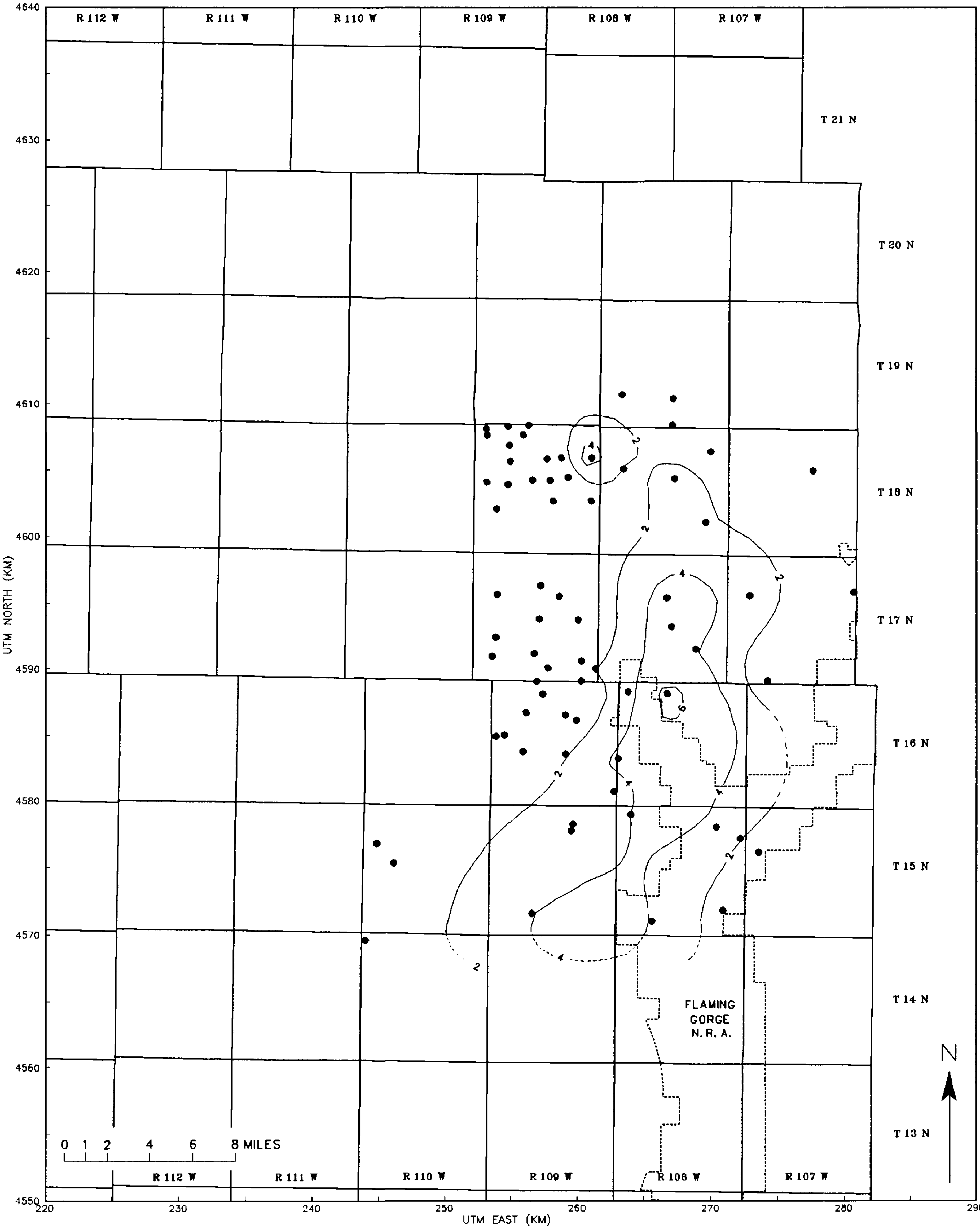

Figure 30. Total thickness of trona bed 23, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dot, data point location.

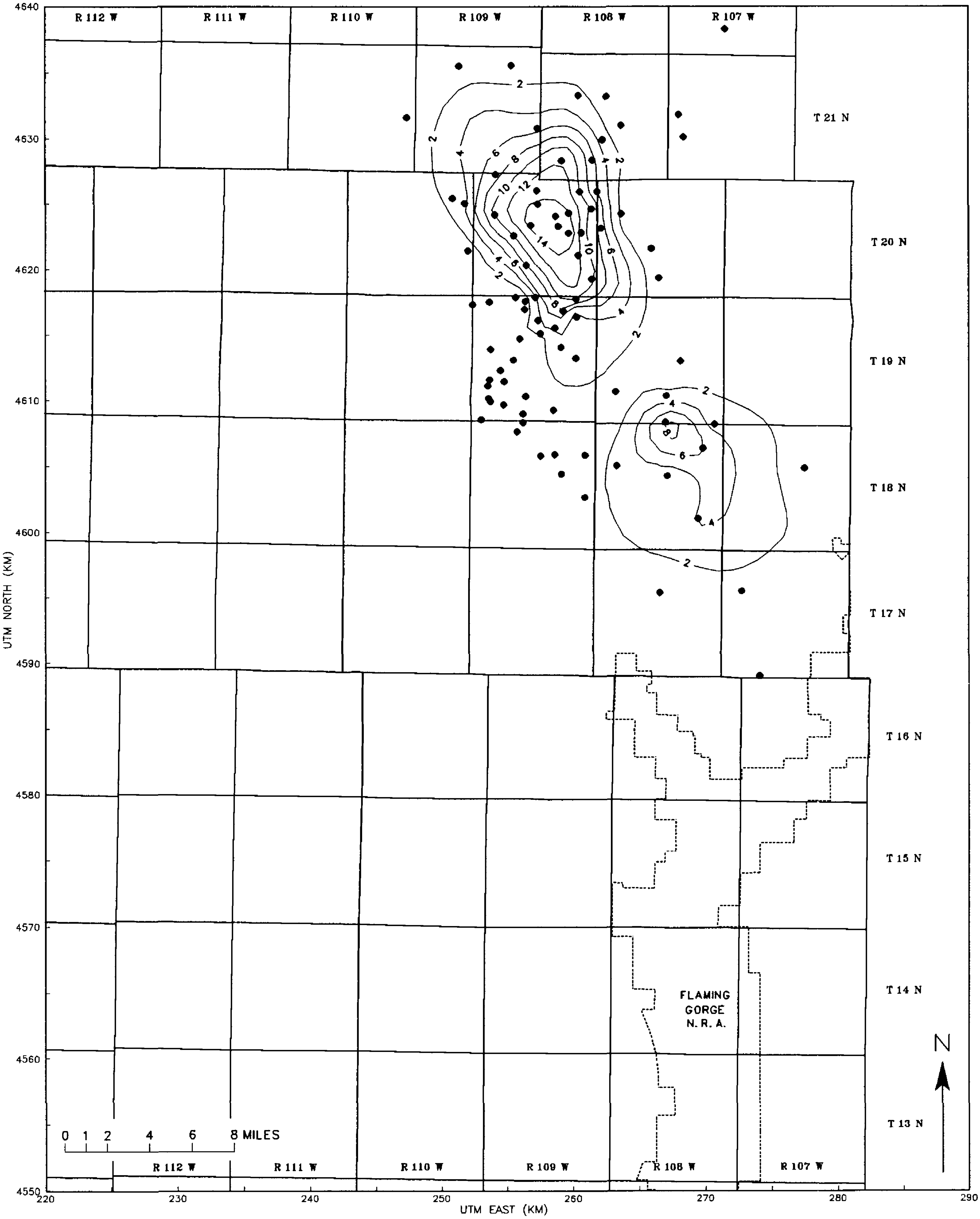

Figure 31. Total thickness of trona bed 24, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dot, data point location.

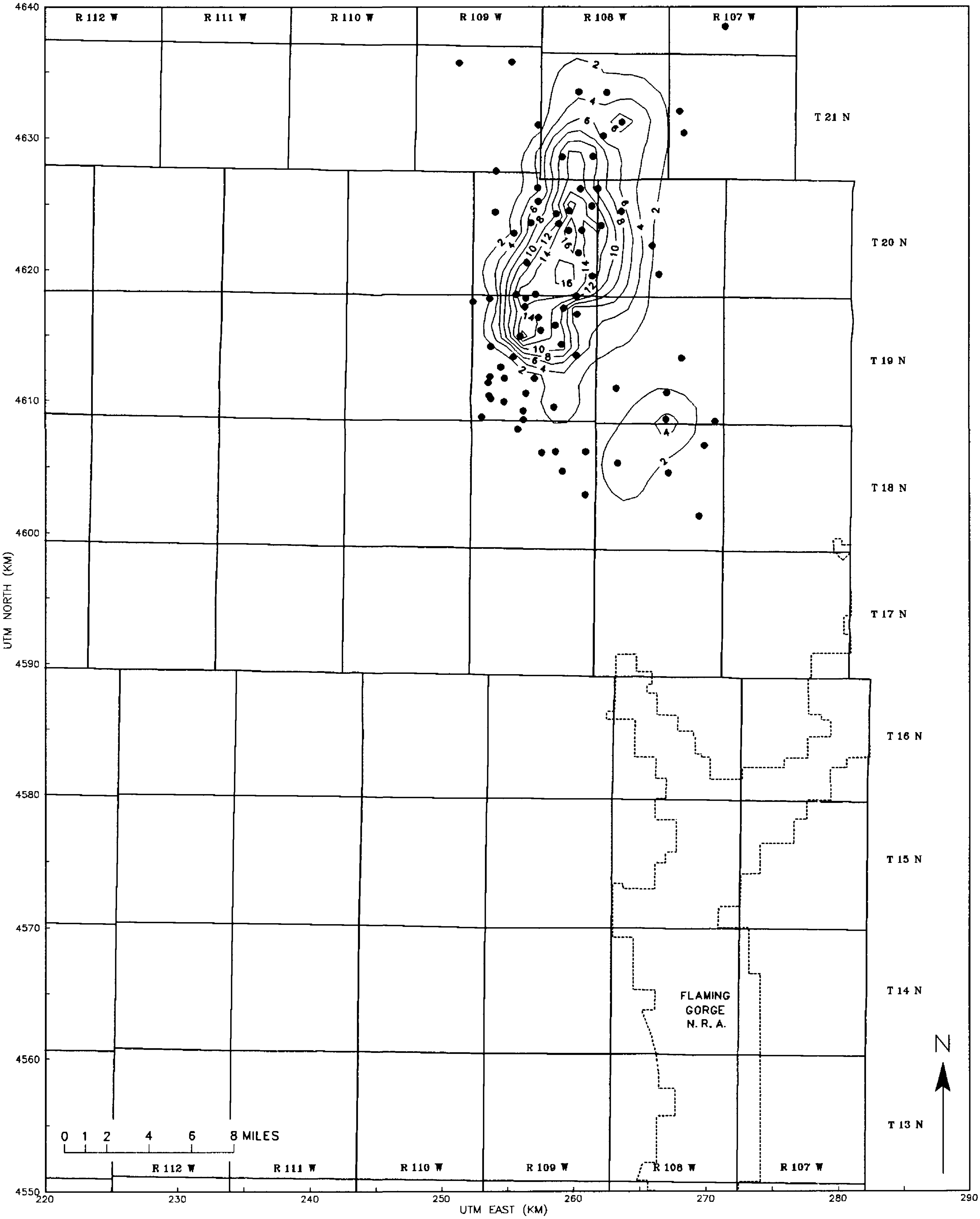

Figure 32. Total thickness of trona bed 25, Green River Basin, Wyoming. Contours in feet; dashed where inferred. Dot, data point location.

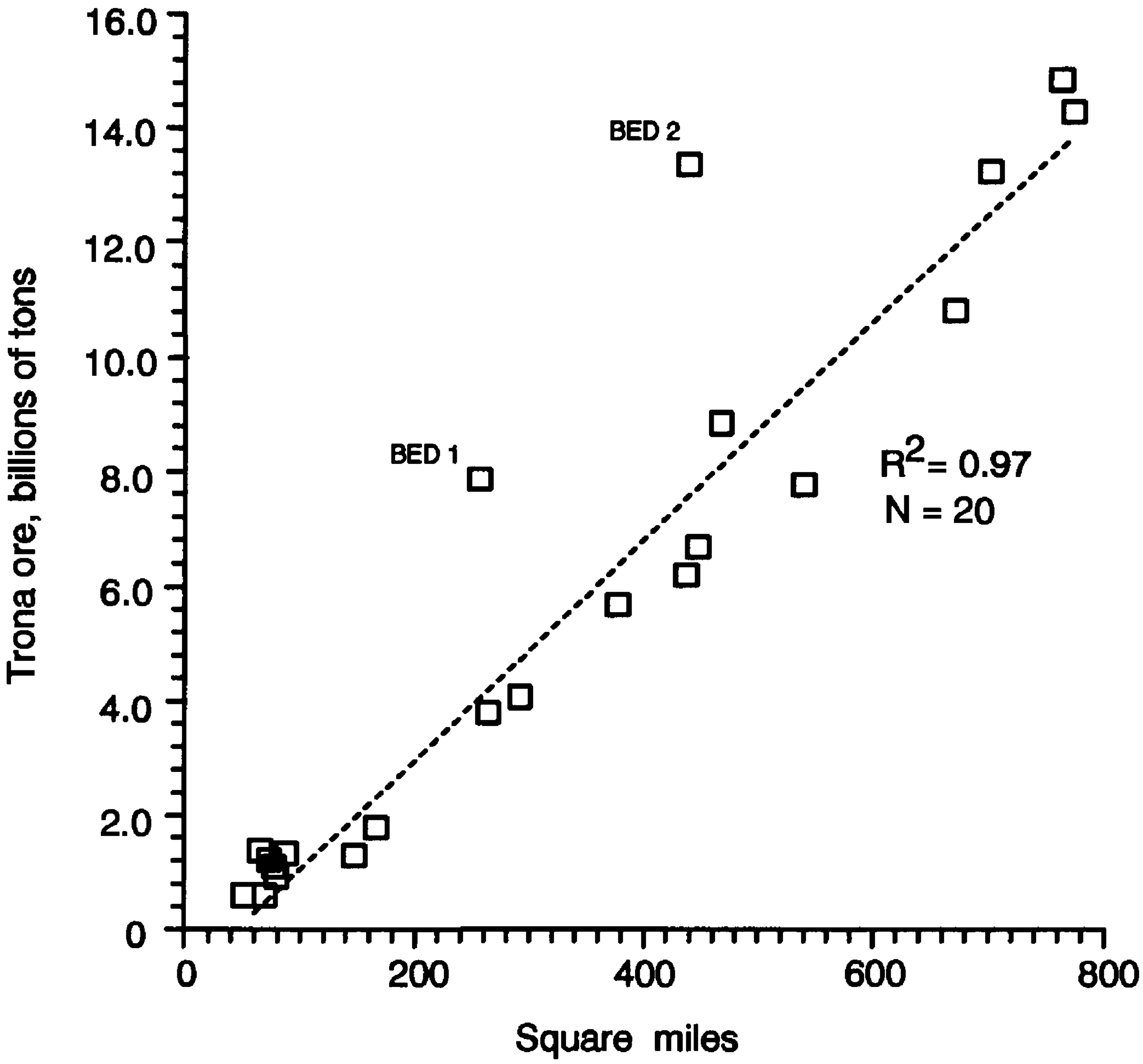

Figure 33.--Comparison of area of trona bed to tons of trona ore. Beds 1 and 2 are excluded from the correlation.