Surficial Deposits in the Bear Lake Basin

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This report has not been reviewed for stratigraphic nomenclature.

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Introduction

Mapping and dating of surficial deposits in the Bear Lake drainage basin were undertaken to provide a geologic context for interpretation of cores taken from deposits beneath Bear Lake, which sometimes receives water and sediment from the glaciated Bear River and sometimes only from the small drainage basin of Bear Lake itself. Analyses of core sediments by others are directed at (1) constructing a high-resolution climate record for the Bear Lake area during the late Pleistocene and Holocene, and (2) investigating the sources and weathering history of sediments in the drainage basin. Surficial deposits in the upper Bear River and Bear Lake drainage basins are different in their overall compositions, although they do overlap. In the upper Bear River drainage, Quaternary deposits derived from glaciation of the Uinta Range contain abundant detritus weathered from Precambrian quartzite, whereas unglaciated tributaries downstream mainly contribute finer sediment weathered from much younger, more friable sedimentary rocks. In contrast, carbonate rocks capped by a carapace of Tertiary sediments dominate the Bear Lake drainage basin.

Information on the type, composition, age, and distribution of surficial deposits can be used in several ways to understand changes in streamflow and lake level. First, the distribution and age of deposits such as glacial deposits, landslides, and stream terraces tell us when large amounts of sediment were eroded from hillslopes, transported by streams, and potentially deposited in Bear Lake. Second, careful mapping of marsh, lake, and river deposits between modern Bear Lake and the Bear River (fig. 1) provides information on how the lake and river have interacted over time scales of the past several thousand years to the past half-million years. Surficial mapping, radiocarbon ages, and amino-acid racemization ages (Laabs, 2001; Laabs and Kaufman, 2003; and data in this report) suggest that Bear Lake has expanded and contracted several times in the last 10,000 years and that it may have overflowed northward through channels on the west side of the valley. During this time, Bear River migrated northward through the intervening marsh to its present position. Some of these changes may be related to climate change but others probably were caused by faulting or tilting of the valley floor.

This report presents information obtained from stratigraphic sections described from outcrops and auger holes (fig. 1) in the area around Bear Lake. Stratigraphic sections measured by Reheis are graphically portrayed on Figures 2 and 3. Sections measured by Laabs and Kaufman are shown graphically in Laabs (2001). Table 1 presents locations and descriptive information for sediments that were sampled from all of the measured sections as well as from a few supplementary sites. Table 2 presents radiocarbon ages from samples of lake, marsh, and alluvial deposits. This information, combined with age data of Laabs (2001) and Laabs and Kaufman (2003), provides the stratigraphic and chronologic basis for a surficial geologic map of the Bear Lake basin (Reheis, unpub. data). Table 3 presents ostracode identifications and interpreted paleoenvironments for selected samples. The stratigraphic and paleoenvironmental data can be used in concert with much more detailed information from analyses of the Bear Lake cores to reconstruct the lake-level history and the changing relation between Bear Lake and Bear River.

In addition to the surficial mapping, dust traps were constructed at three sites around the shoreline of Bear Lake to sample the annual vertical dust deposition to the lake area. These data (table 4) provide an estimate of the modern aerosolic inputs to help interpret paleohydrologic history from the chemistry and mineral content of lake-sediment cores.

Methods

Mapping surficial deposits in such a large area (2,000 km^2) usually relies heavily on interpretation of features visible in aerial photographs combined with field investigations. In this study, field work also was hampered by the difficulty in obtaining access to private land and by the abundant vegetation (~100 percent cover on lower slopes and valley floor) in this relatively moist, agricultural area. Deposit types such as river terraces of different heights and channels incised into lake plains (fig. 1) were tentatively identified on aerial photographs. Locations where deposits with certain surface expressions were exposed in road or canal cuts then were visited to examine the sedimentary layers and surface features. Field work also revealed how a particular

type of deposit is related to another in time and space; for example, lake deposits that overlie fluvial deposits indicate a rise in lake level, potentially caused by either subsidence along faults, an increase in effective moisture (runoff), or river migration toward the lake. Where no exposures were available, a bucket auger was used to obtain sediment in 10–20–cm depth increments. Auger holes usually terminated in loose sand or gravel beds that could not be cored by hand. Materials such as shells or organic matter, suitable for radiocarbon dating and for interpretation of hydrologic environments, were obtained from outcrop exposures and auger sediment. In the latter case, where sediment might be mixed by collapse within the auger hole, care was taken to ensure that shells chosen for dating were representative of the beds encountered during augering by selecting shells from within intact large (2–5 cm diameter) clods of sediment.

Shell fragments were isolated from clay by soaking in a weak Calgon solution for several hours. The solution then was poured over a 1,000-μm sieve; the shell fragments retained on the sieve were hand picked and thoroughly rinsed in distilled water. When necessary, the shells were sonicated in distilled water for 1 hour to remove additional surface sediment. In certain cases, when the shell material was still encrusted in sediment or the shells showed signs of surface alteration, the sample was soaked in dilute (0.1 M) HCl to etch the surfaces clean.

The dust-trap design (Reheis and Kihl, 1995) samples both wet and dry dust deposition. Briefly, the dust trap consists of a Teflon- or enamel-coated angel-food cake pan mounted on a steel post about 2 m above the ground. This height nearly eliminates trapping of coarse grains traveling by saltation. Glass marbles fill the upper part of the pan above a supporting piece of ¼-inch-mesh metal screen that rests 3–4 cm below the rim. The marbles simulate the effect of a gravelly fan surface and prevent dust that has filtered or washed into the bottom of the pan from being resuspended. To prevent birds from roosting, dust traps are fitted with two metal straps looped in an inverted basket shape over the pan, and the top surfaces of the straps are coated with Tanglefoot Bird Repellent. Samples are retrieved by washing the trap components with distilled water into plastic 1-L bottles. In the laboratory, a dust sample was dried at about 35 °C in large evaporating dishes, and coarse organic material was removed. Total carbon and inorganic carbon were analyzed using a coulometer, and organic carbon content was calculated by difference. Soluble salt content was approximated by using measurements of electrical conductivity.

Acknowledgments

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Figure Captions

Figure 1. Map of Bear Lake Valley showing site locations and generalized traces of Quaternary faults and modern and abandoned stream courses. Site numbers beginning with year (for example, 99BL-35) were described and sampled by Reheis; prefixes for some sites were omitted for ease of drafting, but all the omitted prefixes are for sites described in 1998 (for example, site 98BL-47 is abbreviated to 47). Site numbers beginning with BL- were described and sampled by Laabs; those beginning with DK- were described and sampled by Kaufman. A, airport; B, Bloomington; D, Dingle; GC, Garden City; M, Montpelier; P, Paris; SC, St. Charles.

Figure 2. Stratigraphic sections measured by Reheis from outcrops and auger holes in Bear Lake valley. Site locations are on figure 1 and table 1. Sections are shown in approximate order from north to south on the following four pages. Column to

right of lithology gives descriptive information such as color (informally described in field, not Munsell), sample data, and soil horizons. On some sections, brackets group depositional layers into different types of deposits (for example, loess) as interpreted from sedimentary characteristics.

Figure 3. Stratigraphic sections of exposures along the Rainbow Canal (see table 1). Most sections are outcrops, and correlation lines are physically traced, except that BL99-49 is an auger hole within a channel fill cut into older sediment, and correlations are uncertain. Surface altitudes were measured using a Trimble GPS and differentially corrected in the office. The base of the outcrop sections is the water level, thus the section bases essentially reflect the water gradient in the canal over a 2-day period when flow rate in the canal remained relatively constant. Measured sections then were plotted and their altitudes slightly adjusted to yield a smoothly sloping water level at the base of the outcrop sections.

Table 1. Description of measured sections, auger holes, and sediment samples from the Bear Lake drainage basin, 1998–2001.

[**m:** meters; **cm:** centimeters]

Sample Number[1]	General location	Latitude	Longitude	Surface altitude (m)	Description of unit (depth below top of section, in cm except as noted)	Sample depth (cm)	Split for ostracodes? (see table 3)
98BL-1	Auger hole W of Poleline Road, S of Bloomington Creek, in small graben	~42º 09.4' from map	~111º 22.1' from map	~1805.5 from map	0–10: Organic-rich muck 10–110: Light-gray marl, becoming oxidized downward		
98BL-2	Auger hole W of Poleline Road, on upthrown side of graben at BL-1	~42º 09.4' from map	~111º22.0' from map	~1807.5 from map	0–~40: Brown silt, plow zone plus subsoil 40–110: Greenish-tan marl 110–130+: Oxidized marl, sandy at base		
98BL-5	Waterline trench for house, W of Bear River	~42º24.1' from map	~111º 20.7' from map	~1830 from map	0–20: Ap (surface soil formed in loess) 20–40: B1t 40–88: B2t 88–106: B3tk 106–132: Bk 132–152: 2Btk1b (paleosol formed in marl) 152–192: 2Btk2b 192–215: 2Cb (slightly oxidized marl)	0–20 20–40 40–88 88–106 106–132 132–152 152–192 192–215	X
98BL-10A	Sinkholes, S and E of Ovid. Auger hole in center of depression	~42º17.5' from map	~111º25.9' from map	~1813.5 from map	0–30: Gray silt and clay (non-calcareous throughout) 30–80: Oxidized silt and clay, Bw? 80–210: Sand, silt, clay, a few pebbles; carbon present as plant remains; mottled with Mn nodules below 125 cm 210–245: Massive reddish clay	 85, 105	
98BL-10B	Sinkholes, S and E of Ovid. Auger hole on SE rim of depression	~42º17.5' from map	~111º25.9' from map	~1812 from map	0–120: Calcareous tan silt and clay 120–150: Oxidized sand and silt, carbonate nodules 150+: Rocky layer, possibly gravel or large carbonate nodules		
98BL-11	Dingle scarp, S of Dingle, roadcut next to old barn	~42º 12.1' from map	~111º 16.0' from map	~1818 from map	0–150: Loess, Bw/Bk, stage II $CaCO_3$. Cicada burrows. 150–250+: Reddish fine sand over river gravel. Weak paleosol (Bwj/Bk) in sand, stage II $CaCO_3$		
99BL-26	Rainbow Canal N of airport road crossing, at minor channel	42º 13.992'	111º 17.821'	1810.37	0–145: Moderately sorted sand, silt, and pebbles in two channel fills, 0–80 and 80–145 cm. Underlain by well-washed, crossbedded sand with abundant bivalves and snails to 200 cm, in turn by gravel to water at 310 cm	B, 80–100 A, 170–200	
99BL-31	Auger hole S of Bloomington Creek	42º 09.9483'	111º 22.1540'	1809.00	0–10: Organic-rich silty clay 10–60: Bk in marl 60–150: Carbonate nodules in marl; oxidation below 120 cm 150–270: Interbedded fine, well-sorted sand and silty clay; probably lacustrine		

Table 1. Description of measured sections, auger holes, and sediment samples from the Bear Lake drainage basin, 1998–2001—Continued.

Sample Number[1]	General location	Latitude	Longitude	Surface altitude (m)	Description of unit (depth below top of section, in cm except as noted)	Sample depth (cm)	Split for ostracodes? (see table 3)
99BL-32	Auger hole to NW of 99BL-31 on same geomorphic feature	~42°10.0' from map	~111°22.5' from map	~1808 from map	0–60: Organic-rich soil formed in silt loam and fine sand; levee deposits? 60–80: Organic-rich A horizon formed in marl and fine sand 80–120: Fine silty sand 120–155: Marl		
99BL-33	Auger hole N of St. Charles. Large abandoned channel	42° 08.8632'	111° 23.3393'	1810.00	0–10: Organic-rich layer 10–70: Marl 70–80: Silty sand 80–150+: Marl		
99BL-34	Auger hole, east of Bloomington scarp	42° 11.0637'	111° 22.6253'	1809.00	0–50: Organic-rich silty clay with snails 50–110: Marly silty clay; shell fragments 110–200+: Slightly calcareous mottled orange/gray clay	0–50 100–120	
99BL-35	Old railroad cut NE of Paris	42° 14.2122'	111° 23.5704'	1815.00	0–95: Pale sandy silt (loess?), cicada burrows; 20 cm A on Bk 95–245: Weak paleosol (Bw) in massive silt and sand; bedded fine sand at base 245–280: Paleosol in silt and clay: Organic-rich A, dark Bt 280–340: Btk, less strong structure 340–460: Oxidized, bedded calcareous marl; interbedded with sand at base 460–530+: Well-bedded, fine-medium reddish lacustrine sand	40–60 190–210 390–410 430–450 480–510	 X X X
99BL-36	Auger hole on refuge road, E of Bloomington, down side of fault cutting meander	42° 12.6589'	111° 21.7521'	1808.00	0–20: Organic-rich calcareous clay 20–80: Marl; oxidized below 60 80–170: Calcareous reddish silt and v. fine sand, well sorted 170–240: Reddish fine sand		
99BL-37	Auger hole E of Bloomington, up side of fault at 99BL-36	42° 12.7752'	111° 21.8142'	1810.00 (at base of cut)	0–80: Organic-rich clay 80–200: Calcareous silt and fine sand, orange mottled, shelly 200–230+: Reddish well-sorted fine sand, with shells	70–80 80–100 200–230	 X
99BL-38	Auger hole on N side Paris-Dingle road, W of outlet canal, abandoned channel of Bear River	42° 14.1401'	111° 21.6109'	1807.92	0–20: Organic-rich silty clay 20–85: Calcareous silty clay, upper part is Bk horizon 85–180: Oxidized slightly calcareous clay, silt, and sand 230–280+: Gray shelly medium-coarse sand	0–20 230–250	
99BL-39	Auger hole E of airport, N side, abandoned channel of Bear River	42° 15.1191'	111° 19.4917'	1808.73	0–50: Organic-rich A (10 cm) overlies pink silty clay 50–70: Black, organic-rich shelly mud. Grades down into 70–175: Reddish sand, coarsening downward	 60–70 130–175	

Table 1. Description of measured sections, auger holes, and sediment samples from the Bear Lake drainage basin, 1998–2001—Continued.

Sample Number[1]	General location	Latitude	Longitude	Surface altitude (m)	Description of unit (depth below top of section, in cm except as noted)	Sample depth (cm)	Split for ostracodes? (see table 3)
99BL-40	Auger hole E of airport, S side, abandoned channel of Bear River	42° 14.1014'	111° 19.5588'	1809.69	0–10: Spoil 10–30: Organic-rich sandy mud 30–80: Bk horizon, mud 80–130: Marly mud 130–220: Reddish calcareous medium sand	160–215	
99BL-41	Outlet canal cut and auger, S of bridge on airport road; lake plain	~42° 14.1' from map	111° 21.5' from map	1804.4 from map	0–20: Organic-rich shelly mud 20–110: Bk grading down into reddish marly clay 110–270: Reddish marly clay (augered below 140)		
99BL-42	Auger hole, W of outlet canal, N of Mud Lake dam; Bear River or Bear Lake channel?	42° 12.8604'	111° 20.5828'	1807.51	0–25: Organic-rich mud w/ shell fragments 25–125: Calcareous gray marl, oxidized toward base 125–180: Reddish fine sand, a few shells 180–225: Orange medium sand, shell fragments	0–25 140–160 200–220	 X
99BL-43	Auger hole, E of outlet canal, N of airport; lake plain—delta top?	42° 17.1812'	111° 21.0170'	1807.59	0–60: Silty sand, gray at top, soil structure and color increases downward 60–145: Reddish silt, clay, and fine sand 145–270: Interbedded? muddy medium and fine sand, reddish, slightly to non-calcareous, monotonous	 155–180 240–270	 X X
99BL-44	Cut, W side Rainbow Canal, N end canal; loess over river (delta) gravel?	42° 14.4883'	111° 17.5449'	1810.61	0–105: Loess or marl, A/Bk (stage II); carbonate groundwater nodules at base 105–150: Alluvial sand, but bedding not obvious; obliterated by surface soil 150–250: (canal level) Pebble-cobble gravel	120–140	
99BL-45	Cut, W side Rainbow Canal. Abandoned channel of Bear River, inset into deposits exposed at 99BL-44	42° 14.2702'	111° 17.6390'	1810.28	0–60: Light gray mud, finely laminated at base, little or no soil formation, rare snails 60–130: Calcareous, organic-rich silt and clay, abundant snails throughout. [n.b.: Entire unit 0–220+ is cut-and-fill into older loess over gravel as at 99BL-44] 130–200: Orange medium sand (sharp upper contact) 200–220+: Sandy pebble gravel w/ common clam shells	60–65 120–130 200–220	 X
99BL-46	Cut, W side Rainbow Canal. Abandoned channel of Bear River, inset into river gravel	42° 13.5771'	111° 17.7503'	1810.74	0–110: Alluvium w/ minor pebble beds; abundant shells 110–250+: Pebble to cobble gravel w/ clam shells. Locally a cicada-burrowed tan silt preserved at upper contact, presumed same as loess at 99BL-44	60–90 110–140	
99BL-47A	Cut, W side Rainbow Canal, S of airport road. Gradual burial of sediments at 99BL-25	42° 13.0992'	111° 17.7060'	1810.13	0–60: Accretionary floodplain and marsh deposits 60–85: Grayish-black organic-rich layer 85–250: Bk formed in calcareous reddish marl; coarsens downward into silty fine sand 250–260+: Pebble to cobble gravel w/clam shells		

Table 1. Description of measured sections, auger holes, and sediment samples from the Bear Lake drainage basin, 1998–2001—Continued.

Sample Number[1]	General location	Latitude	Longitude	Surface altitude (m)	Description of unit (depth below top of section, in cm except as noted)	Sample depth (cm)	Split for ostracodes? (see table 3)
99BL-47	Cut, W side Rainbow Canal, S of airport road. Gradual burial of sediments at 99BL-25	42° 13.0010'	111° 17.7616'	1810.52	0–85: Accretionary floodplain and marsh deposits 90–110: Grayish-black organic-rich layer 110–200: Bk formed in calcareous reddish marl; coarsens downward into silty fine sand at least 40 cm thick	0–80	
99BL-48A	Cut, W side Rainbow Canal, S of airport road, a few meters up-canal from corral gate	42° 12.6575'	11117° 7048'	1808.795	Green clay, locally oxidized, below 165 cm to water level; overlain by calcareous pink marl and in turn by black organic-rich layer at 110–115 cm; in turn by accretion sediment	165–185	X
99BL-48B	Cut, W side Rainbow Canal, S of airport road. Black layer becomes multiple black layers	42° 12.6540'	111° 17.7060'	1809.99	Bands of accretionary sediment, finer grained than to north, with interbedded thin black layers overlying marly deposits	110–140	
99BL-49	Auger hole, E side Rainbow Canal at flume. Abandoned channel of Bear River	42° 12.4719'	111° 17.7213'	1808.97	0–55: Organic-rich silt and clay; rare shells 55–100: Marly silt and clay 100–175: Reddish mud, slightly calcareous 175–270: Reddish-gray silt and sand, abundant plant fragments, slightly calcareous 270–320: Gray silty sand, slightly calcareous, shell fragments 320+: Gravel (did not penetrate)	20–50 190–215 270–300	 X X
99BL-53	NE side of US-30 roadcut, SE corner Montpelier Quad	42° 15.5642'	111° 15.8441'	1867.69 (top of sand beds)	~20 m of dominantly well-sorted well-bedded fine-med. sand. Capped by terrace gravels. 5 m above base are green clay beds (location of A and paleomagnetic samples)	~10 m (B) ~15 m (A)	X X
99BL-59	Drainage-ditch cut, along fault S of Dingle, E side road	42° 11.6398'	111° 16.0818'	1820.5	Colluvium overlies lacustrine deposits extending from GPS point at road level, 2 m below road and ~4 m above. Interbedded lake gravel, sand, and mud. 2 beds of shells near base. Lower is scattered snail shells in mud; upper (1 m higher), at top of silty sand, is shell hash	upper (B) lower (A)	
00BL-8	W of Garden City at edge of raspberry patch	41° 56.3445'	111° 24.2478'	1824.9	Orange calcareous mud with black organic remains and sticks present at ~200 cm, dated at 320 ± 40 ^{14}C yr. Massive, silt-rich. Grades down into mottled mud, less organics, contains thin f-m sand lenses	151–162 235–333	 X
00BL-12 (not in fig. 1)	E-central edge Meadowville quad at irrigation ditch blowout	~41° 49.1' from map	~111°22.9' from map	~1823 from map	Pale pinkish fine-grained deposits, deeply weathered, about 3 m thick, right on 6000-foot contour. Probable loess. Sampled at base of exposure		
00BL-27	Outlet canal S of US-89, W-central Montpelier quad	~42° 30.0' from map	~111° 21.5' from map	~1804 from map	Minor channel fill inset into organic-rich sediment interbedded with pale white marly layers. Sandy channel fill has abundant snails	10–20	

Table 1. Description of measured sections, auger holes, and sediment samples from the Bear Lake drainage basin, 1998–2001—Continued.

Sample Number[1]	General location	Latitude	Longitude	Surface altitude (m)	Description of unit (depth below top of section, in cm except as noted)	Sample depth (cm)	Split for ostracodes? (see table 3)
00BL-29 (not in fig. 1)	Roadcut S of Boy Scout Aquatics Camp, E side Bear Lake	41° 53.3940'	111° 15.7980'	1835.7	Highest point of well-rounded beach clasts in small fan-delta. Overlain by 1–2 m of angular fan gravel and in turn by red fine-grained alluvium. Surface soil has Btjk horizon with stage I $CaCO_3$		
00BL-54	Powerline roadcut N of Indian Creek, NE corner Bear Lake N quad	42° 06.4185'	111° 15.6659'	1851.7(base) 1866.3 (top)	Sequence of lacustrine deposits ~22 m thick intercalated with fan gravel. Base is beach gravel interbedded with silty sand (A), fining upward into brown silt and mudstone (B), gray mdst. (C), pale gray fine silty sand (D), pale gray silty mdst. (E), and reddish mdst., coarsening upward into fan gravel. Measurements are meters above base of lacustrine deposits	E, 6.8 m D, 9.2 m C, 10.4 m B, 13.2 m A, 19.0 m	X X X X X
00BL-59	Faulted fans and beach gravel N of Indian Creek, Bear Lake N quad	42° 06.2895'	111° 15.6281'	1852.0	Upper of two beach gravels overlain by a thin shell-bearing reddish mudstone capped by fan gravel. Beach gravels are cut by several faults		
00BL-60	Landslide outcrop above highway just N of Indian Creek, NE corner Bear Lake N quad	42° 05.7446	111° 15.4779'	1846.3	Lacustrine deposits overlain by fan gravel. Basal part is olive-green clay (A), overlain by several meters of gray sand (B), and in turn by reddish mudstone (C) near top of cut. At S edge of cut, a thin beach gravel lies between the reddish mudstone and overlying fan gravel	C B A	X X X
00BL-61	East of highway above 00BL-60 (above landslide), NE corner Bear Lake N quad	42° 05.8253'	111° 15.3732'	1869.7	Similar to 00BL-60 but much higher in elevation and lacking basal green clay. Possibly same lake unit as 00BL-60, separated by fault. Gray sand (A) at base of lake deposits overlain by reddish mudstone (B) capped by fan gravel	B A	X X
00BL-63	Waterline trench being backfilled as I sampled. S of Indian Creek, NE corner Bear Lake N quad	42° 05.1810' 42° 05.1811'	111° 15.2927' 111° 15.3086'	1842.8 (top) 1837.2 (near base)	Lacustrine deposits interbedded with fan gravel. Sediments are impregnated with gypsum crystals. Shells are abundant and beach gravel crops out on slope to south. Upper part of trench cut in spring-discharge deposits	B (upper) A (lower)	X X
00BL-64	Old borrow pit, S of Indian Creek, NE corner Bear Lake N quad	~42° 05.3 from map	~111° 15.4' from map	~1816.5 from map	Beach gravel overlain by 1 m of massive red sandy mudstone, overlain by 15–20 cm channel gravel containing shells, in turn by weakly bedded alluvium		
01BL-23	W side of small pond N of Merkley Lake, E-central Dingle quad	42° 11.59'	111° 16.38'	~1810.5 from map	Lacustrine? or spring discharge deposits atop reddish Bear River sand. Reddish fine sand (A) >50 cm thick overlain by ~25 cm of calcareous pink marl (B). May be downfaulted lake-plain deposits	B (37–44) A (sand)	X

Table 1. Description of measured sections, auger holes, and sediment samples from the Bear Lake drainage basin, 1998–2001—Continued.

Sample Number[1]	General location	Latitude	Longitude	Surface altitude (m)	Description of unit (depth below top of section, in cm except as noted)	Sample depth (cm)	Split for ostracodes? (see table 3)
01BL-24	Roadcut E of road just S of small pond at 01BL-23, E-central Dingle quad, footwall block	42° 11.48' (base of section; measured on road)	111° 16.05' (base of section; measured on road)	1820.5 (on road, est. from 99BL-59)—top 1841.9	21.4-m measured section. Shoreface deposits interbedded with fault-scarp colluvium and spring-discharge deposits. Measurements begin 10.5 m above roadbed. A, nearshore sand between beach gravel beds, rare shells; B, reddish silty clay, rare shells, Bear River into lake?; C, mixed clay and gravel, spring + colluvium?; D, similar to B	D, 100–320 C, 320–420 B, 420–610 A, 660–730	 X X X
01BL-30	Leach test hole just S of road to Bern cemetery, W of highway, Ovid 7.5' quad	42° 19.81'	111° 23.26'	~1820 from map	Loess overlying lake and marsh deposits; entire section noncalcareous. Surface soil to ~1.45 m; mollic A horizon over argillic Bt; buried soil with argillic Bt to 2.3 m. A, pale olive-green sandy silt, well bedded. B, silty fine sand to coarse sand, unbedded. C, pale olive silt and sand, root traces; capped by 2 cm of fine-medium, well-sorted sand	C, 233–250 B, 250–285 A, 285–300	 X
01BL-34	Borrow pit W of US 30 at mouth of Bear Hollow, SE Montpelier quad	~42° 16.5'	~111° 17'	~1815 from map	Fan-delta of Bear Hollow drainage merging with Bear River fluvial deposits. Sampled snails in sandy lens ca. 3.5 m below surface on S side pit	350	
01BL-35	Bear River cutbank N of US 30 and E of outlet canal, W-central Montpelier quad	42° 19.81'	111° 23.26'	~1806 from map	Marl, presumably lake-bottom sediment, with A/Btj/Bk/C profile. Marl (sample B) overlies well-sorted, fine-medium crossbedded sand (sample A), probably fluvial; contact may be erosional. Snails in both samples	B, 150–190 A, 190–250	X
01BL-39	Bear River cutbank WSW of Bennington, down-stream of railway bridge	~42° 22.9' from map	~111° 20.7' from map	~1844 from map	Bear River pebble-cobble gravel 5 m thick at base, overlain by ~8 m well-sorted, fine reddish sand fining upward to sandy silt. Three samples from interval 5–7 m above river	C B A	X
01BL-42	W-central Pegram quad, S side Bear River; same locality as 99BL-58 but lower in section	42° 12.031'	111° 14.491'	~1865 from map	35-m section in Bear River and side-fan fluvial deposits and lake deposits. Two tephra layers (A, B) in basal alluvium. Marl bed (C) in center of section, overlain by cemented fan-delta and lacustrine mud; overlain by loess. Units are meters above base of section	99BL58B 99BL58A C, 11.8 m B, 1.0 m A, 0.0 m	X X X
BL00-02 (DK99-18)	North Eden canyon, W of highway, NE Bear Lake South quad	41° 59.38'	111° 15.95'	1814 from map	0–50: Red, massive, unsorted, imbricated alluvium 50–190: Pink, massive marl with *Stagnicola* shells 190–210: Gray, bedded, sorted, rounded, lacustrine gravel 210–250: Gray, massive marl with *Stagnicola* shells	DK99-18A	
BL00-02C	North Eden canyon, N of creek, NE Bear Lake South quad	41° 59.38'	111° 15.95'	1830 from map	0–40: Pink and green massive marl 40–100: Greenish-gray, massive marl with *Valvata* and *Stagnicola* shells 100–250: Red, massive, unsorted, angular colluvium	DK98-03A, B	

Table 1. Description of measured sections, auger holes, and sediment samples from the Bear Lake drainage basin, 1998–2001—Continued.

Sample Number[1]	General location	Latitude	Longitude	Surface altitude (m)	Description of unit (depth below top of section, in cm except as noted)	Sample depth (cm)	Split for ostracodes? (see table 3)
BL00-07	Bee Hunt hollow, E of highway, NE Bear Lake North quad	42° 04.07'	111° 15.10'	1830 from map	0–160: Reddish-brown, massive lacustrine mud 160–180: White, massive marl with *Stagnicola* shells 180–230: Grayish-green, massive, lacustrine mud with *Stagnicola* and *Valvata* shells 230–265: Greenish-brown, massive lacustrine mud 265–310: Red, massive, lacustrine mud	DK99-20C	
BL00-08 (00BL-37)	Bedrock gully, E of Mud Lake, SE Dingle quad	42° 08.849'	111° 15.723'	1845	0–80: Brown, massive, unsorted colluvium 80–150: Gray, bedded, sorted, angular lacustrine gravel 150–300: Brown, massive, unsorted colluvium		
BL00-09 (99BL-25)	Rainbow canal, W of Dingle, NE Dingle quad	42°13.14'	111° 17.75'	1810.372	0–70: Dark gray, weakly bedded, organic-rich; Lymnaea shells 70–110: Pink, massive silty marl 110–140: Sorted fine to medium sand, gradual upper contact 140–250: Pink, bedded, sorted, sandy gravel	60–70 cm, DK98-02A	
BL00-10	Cisco Beach, exposure above beach, NE Bear Lake South quad	41° 58.45'	111° 16.17'	1814 from map	0–180: Gray, bedded, sorted, rounded, beach gravel with *Stagnicola* and *Carinifex* shells 180–215: Pink, massive, lacustrine mud 215–320: Gray, weakly bedded, marl		
BL00-11	Hen House, E of highway, NE Bear Lake N quad	42° 05.02'	111° 15.28'	1830 from map	0–60: Brown, massive, silty colluvium 60–300: White and gray, massive, marl with *Stagnicola* shells	BL00-11	
BL00–12	Bear Hollow pit, E of US 89, SE Montpelier quad	42° 16.27'	111° 16.98'	1832 from map	0-20: Red, massive loess 20-110: Brown, massive, unsorted, imbricated, coarse–grained alluvial sand and gravel; 20-cm-thick Bk horizon (stage I) 110–165: Brown, massive, organic-rich mud 165–200: Brown, massive, unsorted, imbricated, coarse alluvial sand and gravel; 30-cm-thick Bk horizon (stage II) 200–350: Covered 350–380: Brown, massive, unsorted, imbricated, coarse alluvial sand and gravel; 30-cm-thick Bk horizon (stage I) 380–395: Yellow and brown, bedded, gently dipping, fan-delta coarse sand with *Stagnicola* and *Valvata* shells 395–435: Brown, massive, unsorted, imbricated, coarse alluvial sand and gravel; 20-cm-thick Bk horizon (stage II) 435–460: Gray and brown, bedded, gently dipping, fan-delta coarse sand and gravel with *Stagnicola* and *Valvata* shells 460–500: Brown, massive, unsorted, imbricated, coarse alluvium; 35-cm-thick Bk horizon (stage II+)		

Table 1. Description of measured sections, auger holes, and sediment samples from the Bear Lake drainage basin, 1998–2001—Continued.

Sample Number[1]	General location	Latitude	Longitude	Surface altitude (m)	Description of unit (depth below top of section, in cm except as noted)	Sample depth (cm)	Split for ostracodes? (see table 3)
BL00-13	Bennington, N of Pescadero, SW Georgetown quad	42° 23.80'	111° 21.20'	1823 from map	0–100: Yellow, massive, unsorted, imbricated, coarse alluvium 100–115: Greenish-brown, massive, lacustrine mud 115–125: White, massive marl 125–185: Yellowish-green, massive, lacustrine silt 185–200: White, massive marl 200–260: Red, massive marl 260–330: Brown, weakly bedded, lacustrine, silty sand 330–350: Brown, massive, lacustrine silt; *Sphaerium* shells	 DK97-10A	 X X
BL00-14 (99BL-84); not on Figure 1	Georgetown gravel pit, W of Georgetown, NE Nounan quad	42° 28.83'	111° 24.00'	1826 from map	0–200: Gray, massive marl with *Stagnicola* shells 200–285: Yellow, weakly bedded, fine- to medium-grained lacustrine sand 285–305: Gray, massive, lacustrine mud 305–355: Yellow, bedded, rounded, alluvial sand and gravel with *Sphaerium* shells 355–400: Yellow, planar-laminated, coarse alluvial sand 00–455: Reddish-brown, planar cross-bedded, coarse-grained alluvial sand 455–660: Yellow, planar cross-bedded, fluvial sand and rounded quartzite-rich gravel with *Sphaerium* shells 660–700: Yellowish-red, ripple laminated medium-grained fluvial sand 700–780: Yellow, planar cross-bedded, fluvial sand and rounded quartzite-rich gravel	DK99-28C	X
BL00-15 Not on Figure 1	Nounan Road, divide between Bear Lake and Nounan valleys, NE Nounan quad	42° 27.00'	111° 23.75'	1828 from map	0–90: Red, massive loess 90–225: Yellowish-brown, weakly cross-bedded, medium-grained beach sand with *Sphaerium* shells 225–300: Gray, massive marl		
BL00-17 Not on Figure 1	Highway 30 cut N of Bear Lake-Caribou County line, E of highway, NW Fossil Canyon quad	42° 35.42'	111° 29.33'	1828 from map	0–90: Red, massive loess. 90–355: Yellow, massive, slightly weathered marl with *Stagnicola* shells 355–465: Yellow, massive, sorted, rounded, imbricated, alluvial sand and gravel.		X
BL00-18 Not on Figure 1	Highway 30 cut S of Bear Lake-Caribou County line, E of highway, NW Fossil Canyon quad	42° 35.25'	111° 29.00'	1828 from map	0–165: Yellow, massive marl; *Stagnicola* and *Valvata* shells 165–240: Yellow, massive, angular, alluvial sand and gravel 240–250: Gray, massive marl 250–275: Yellow, planar cross-bedded, sorted, medium-grained alluvial sand		 X

Table 1. Description of measured sections, auger holes, and sediment samples from the Bear Lake drainage basin, 1998–2001—Continued.

Sample Number[1]	General location	Latitude	Longitude	Surface altitude (m)	Description of unit (depth below top of section, in cm except as noted)	Sample depth (cm)	Split for ostracodes? (see table 3)
BL00-19 Not on Figure 1	Highway 30 cut S of Bear Lake-Caribou County line, E of highway, NW Fossil Canyon quad	42° 34.67'	111° 28.75'	1828 from map	0–50: Red, massive loess 50–150: Brown, massive marl with 40-cm-thick B horizon 150–175: Brown, massive marl with 25-cm-thick B horizon 175–250: Green, massive marl with *Stagnicola* shells		X
BL00-22 (98BL-8)	Bern borrow pit, W of road, NE of Bern, NW Montpelier quad	42° 21.06'	111° 21.98'	1817 from map	0–85: Pink, massive loess 85–125: Yellow, bedded, rounded, imbricated, alluvial sand and gravel with 15-cm-thick Bk horizon 125–200: Yellow, bedded, rounded, imbricated, alluvial sand and gravel with 15-cm-thick Bk horizon 200–220: Yellow, planar cross-bedded, sorted, coarse-grained lacustrine nearshore sand with *Stagnicola* and *Valvata* shells 220–305: Yellow, bedded, rounded, imbricated, alluvial sand and gravel with 40-cm-thick Bk horizon 305–375: Yellow, bedded, rounded, imbricated, alluvial sand and gravel with 40-cm-thick Bk horizon		
BL00-23 (99BL-18)	Ovid spit, N of Ovid, SE Ovid quad	42° 18.00'	111° 23.62'	1817 from map	0-55: Red, massive loess 55–230: Yellow, ripple laminated, sorted, medium-grained nearshore sand with fragments of *Sphaerium* shells		
BL00-24	Bear River bridge, borrow pit N of Pescadero on E side of Bear River, SW Georgetown quad	42° 24.05'	111° 21.20'	1811 from map	0–150: Brown, massive loess 150–260: Yellow, bedded, rounded, imbricated, sand and quartzite-rich gravel with *Stagnicola* shells		
BL00-41	Garden City pit, W of US 89, NE Garden City quad	41° 57.13'	111° 23.82'	1814 from map	0–115: Yellow, massive, unsorted, angular, imbricated alluvial sand and gravel; 115-cm-thick Bk horizon (stage I) 115–180: Brown, weakly ripple-laminated, sorted medium-grained nearshore sand with *Stagnicola* and *Valvata* shells 180–240: Brown, massive, unsorted, angular, coarse-grained sand and gravel colluvium		
BL00-42 (98BL-7)	Bear River cutbank, W of Bear River, NW Montpelier quad	42° 22.17'	111° 21.33'	1813 from map	0–100: Brown, bedded floodplain mud 100–140: Yellow, bedded, sorted, rounded, coarse-grained alluvial sand and gravel 140–190: Yellow, ripple-laminated, sorted, medium-grained nearshore sand with *Stagnicola* and *Valvata* shells 190–220: Yellow, massive, sorted, medium-grained nearshore sand with 25-cm-thick B horizon		

Table 1. Description of measured sections, auger holes, and sediment samples from the Bear Lake drainage basin, 1998–2001—Continued.

Sample Number[1]	General location	Latitude	Longitude	Surface altitude (m)	Description of unit (depth below top of section, in cm except as noted)	Sample depth (cm)	Split for ostracodes? (see table 3)
DK93-23	Mud Lake just north of dam; sampled as outcrop when control structure broke in 1993	42° 07.4' from map	111° 18.8' from map	1804 from map	0–100: Peat and organic-rich silt with shell hash layers		
					100–170: Dark gray fine and medium sand; layers of snails		X
					170–190: Organic-rich silt and peat with silty sand layers; snail shells and shell hash		X
					190–270: Laminated marl, rhythmically bedded gray silt and white silt-clay; abundant snails		X
					270–280: Sedge peat		X
DK96-06	Fish ladder west of Lifton pumping station, NW Bear Lake North quad	42° 07.35'	111° 20.15'	1806 from map	0–140: Stratified medium sand with pebble gravel; paleosol (Bw horizon) at 30 cm; abundant reworked mollusc shells, mainly *Carinifex* and *Sphaerium*; basal contact abrupt	X	
					140–235: Bedded marl and organic-rich mud; abundant in-situ snails, dominantly *Stagnicola* and *Valvata*		X

[1]Sample sites beginning with numbers followed by BL, for example 00BL-64, described and sampled by Reheis; first two numbers designate year of collection. Sites beginning with letters described and sampled by Laabs (BL) and Kaufman (DK); middle numbers designate year of collection. Numbers following dashes are site numbers.

Table 2. Radiocarbon dates from outcrop and auger holes in the Bear Lake drainage basin, 1998-2001.

[**cm:** centimeters; **m:** meters; **yr:** year]

Sample Number	General location	Latitude	Longitude	Material dated	Sample depth (cm)	^{14}C lab number[1]	Radiocarbon age (yr)
99BL-26B	Rainbow Canal N of airport road bridge	42° 13.992'	111° 49.166'	Gastropod shells	80–100	WW-3049	1,400±40
99BL-34	Auger hole, S side of road east of Bloomington	42° 11.0637'	111° 22.6253'	Gastropod shells	0–50	WW-2583	7,760±70
99BL-37	Auger hole, E of Bloomington, up side of fault cutting meander	42° 12.7752'	111° 21.8142'	Shell fragments	70–80	WW-2584	1,955±70
				Gastropod shells	80–100	WW-2585	10,420±80
				Gastropod shells	200–230	WW-2586	9,820±75
99BL-38	Auger hole on Paris-Dingle road, W of outlet canal, Bear R. abandoned channel 2?	42° 14.1401'	111° 21.6109'	Gastropod shells	0–20	WW-2587	2,645±55
				Gastropod shells	230–250	WW-2588	7,985±70
99BL-39	Auger hole E of airport, Bear River abandoned channel 3?	42° 15.1191'	111° 19.4917'	Gastropod shells	60–70	WW-2589	2,445±55
99BL-42	Auger hole, W of outlet, N of Mud Lake dam; Bear River or Bear Lake channel?	42° 12.8604'	111° 20.5828'	Gastropod shells	0–25	WW-590	1,720±55
				Gastropod shells	200–220	WW-2591	12,220±100
99BL-45	Cut, W side Rainbow Canal. Bear River abandoned channel 3	42° 14.2702'	111° 17.6390'	Gastropod shells	60–65	WW-2592	5,130±65
				Gastropod shells	120–130	WW-2593	8,520±70
				Bivalve shells	200–220	WW-2594	11,015±85
99BL-47	Cut, Rainbow Canal, S of airport road	42° 13.0010'	111° 17.7616'	Gastropod shells	0–80	WW-2595	7,150±70
99BL-48A	Cut, Rainbow Canal, S of airport road	42° 12.6575'	111° 17.048'	Gastropod shells	165–185	WW-3048	8,460±40
99BL-48B	Cut, Rainbow Canal, S of airport road	42° 12.6540'	111° 17.7060'	Gastropod shells	110–140	WW-3050	7,870±40
99BL-49	Auger hole, Rainbow Canal. Bear River abandoned channel 1	42° 12.4719'	111° 17.7213'	Gastropod shells	20–50	WW-2596	4,000±60
					270–300	WW-2597	6,925±70
99BL-59	Drainage-ditch cut, along fault S of Dingle, E-central Dingle quad	42° 11.6398'	111° 16.0818'	Shell fragments	B, 180	WW-2599	40,800±1,600
					A, 200–250	WW-2598	39,100±1,100 (minimum age)
00BL-27	Outlet canal S of Hwy 89, W-central Montpelier quad	~42° 30.0' from map	~111° 21.5' from map	Gastropod shells	10–20	WW-3047	4,880±40
00BL-63A	Waterline trench E of road, S of Indian Creek, NE Bear Lake N quad	42° 05.1811'	111° 15.3086'	Gastropod and bivalve shells	Several meters	WW-3369	39,870±490
00BL-64	Borrow pit S of Indian Creek, NE Bear Lake N quad	~42° 05.3 from map	~111° 15.4 from map	Gastropod and bivalve shells	100–120	WW-3370	10,810±40
01BL-34	Borrow pit W of US-30, Bear Hollow, SE Montpelier quad	~42° 16.5'	~111° 17'	Gastropod shells	350	WW-3721	45,950±1,020
01BL-35	Bear River cutbank N of US 30, W-central Montpelier quad	42° 19.81'	111° 23.26'	Gastropod shells	B, 150–190	WW-3723	13,675±50
					A, 190–250	WW-3722	16,350±50
DK93-23D	Mud Lake north of Lifton dam control structure, N-central Bear Lake N quad	42° 07.4' from map	111° 18.8' from map	*Carinifex* shell	130	NSRL-10572	6,750±60
DK96-01	Cisco Beach, exposure into an 8-m-high terrace, NE Bear Lake South quad	41° 58.45'	111° 16.17'	Mollusk shell	150	WW-1557	10,420±50
DK96-06D	Fish ladder, W of Lifton pumping station, NW Bear Lake North quad	42° 07.35'	111° 20.15'	*Stagnicola* shell	70	NSRL-1566	7,210±40

Table 2. Radiocarbon dates from outcrop and auger holes in the Bear Lake drainage basin, 1998-2001—Continued.

Sample Number	General location	Latitude	Longitude	Material dated	Sample depth (cm)	^{14}C lab number[1]	Radiocarbon age (yr)
DK96-06B	Fish ladder, W of Lifton pumping station, NW Bear Lake North quad	42° 07.35'	111° 20.15'	*Stagnicola* shell	150–160	WW-1561	5,650±40
DK96-06B	Fish ladder, W of Lifton pumping station, NW Bear Lake North quad	42° 07.35'	111° 20.15'	*Stagnicola* shell	150–160	NSRL-1566	5,580±50
DK96-06B	Fish ladder, W of Lifton pumping station, NW Bear Lake North quad	42° 07.35'	111° 20.15'	Charcoal	150–160	WW-1566	5,530±50
DK96-06A	Fish ladder, W of Lifton pumping station, NW Bear Lake North quad	42° 07.35'	111° 20.15'	*Valvata* shell	210–220	NSRL-10940	8,520±65
DK96-06A	Fish ladder, W of Lifton pumping station, NW Bear Lake North quad	42° 07.35'	111° 20.15'	*Valvata* shell	210–220	NSRL-10941	8,550±65
DK97-10A	Bennington, N of Pescadero, SW Georgetown quad	42° 23.80'	111° 21.20'	*Sphaerium* shell	Several meters	WW-1559	>43,260
DK98-02A	Rainbow canal, W of Dingle, NE Dingle quad	42° 14.27'	111° 17.63'	*Stagnicola* shell	200–250	NSRL-10569	8,350±70
DK98-03A	Road cut north of North Eden canyon, NE Bear Lake south quad	41° 59.53'	111° 15.88'	*Stagnicola*; 2 shells	several meters	NSRL-10570	37,900±460
DK98-03B	Road cut north of North Eden canyon, NE Bear Lake south quad	41° 59.53'	111° 15.88'	*Stagnicola* shell	several meters	NSRL-10571	38,700±790
DK99-11	Ovid spit, N of Ovid, SE Ovid quad	42° 18.00'	111° 23.62'	Shell fragments	180–210	NSRL-11353	41,240±640
DK99-13	Bear River cutbank, W of Bear River, NW Montpelier quad	42° 22.17'	111° 21.33'	*Stagnicola* shell	170–180	NSRL-11354	36,800±790
DK99-18A	North Eden canyon, W of highway, NE Bear Lake south quad	41° 59.22'	111° 15. 56'	Charcoal	50–150	NSRL-11355	8,780±90
DK99-18B	North Eden canyon, W of highway, NE Bear Lake south quad	41° 59.38'	111° 15.95'	*Discus* shell	50–150	NSRL-11356	10,490±100
DK99-19B	North Eden canyon, W of highway, NE Bear Lake south quad	41° 59.38'	111° 15.95'	*Discus* shells	50–160 (?)	NSRL-11357	10640±80
DK99-20C	Bee Hunt hollow, E of highway, NE Bear Lake North quad	42° 04.07'	111° 15.10'	3 *Stagnicola* shells	80–130	NSRL-11358	44,240±730
DK99-28C	Georgetown gravel pit (site BL00-14), W of Georgetown, NE Nounan quad	42° 28.83'	111° 24.00'	*Discus* shell	100–140	NSRL-11359	>45,200
BL-00-11	Hen House, E of highway, NE Bear Lake North quad	42° 05.02'	111° 15.28'	*Sphaerium* shell	100–150	NSRL-12061	36,000±320
BL-00-41A	Garden City pit, W of US 89, NE Garden City quad	41° 57.13'	111° 23.82'	Mollusk shell	125–160	NSRL-12062	13,540±70
BL-00-41B	Garden City pit, W of US 89, NE Garden City quad	41° 57.13'	111° 23.82'	Mollusk shell	125–160	NSRL-12063	13,280±70
BL-00-42	Bear River cutbank, W of Bear River, NW Montpelier quad	42° 22.17'	111° 21.33'	*Stagnicola* shells	175–185	NSRL-12064	44,300±920

[1]Letter prefixes indicate laboratory: WW-, U.S. Geological Survey, Reston, Va.; NSRL-, Institute of Arctic and Alpine Research, Boulder, Colo.

Table 3. Ostracodes in sediment samples from outcrops in the Bear Lake drainage basin, 1998-2001.

[**cm:** centimeters; **m:** meters]

Site and sample number	Description of unit (see table 1)	Depth below top of section (cm unless noted)	Age (if dated; see table 2)	Ostracode taxa	Other taxa	Comments
98BL-5	Base of paleosol formed in marl	192-215		None		
99BL-35	Massive silt and sand; bedded fine sand at base	190-210		None		
99BL-35	Oxidized, bedded calcareous marl	390-410		None		
99BL-35	Oxidized, bedded calcareous marl; interbedded sand laminae	430-450		None		
99BL-37	Calcareous silt and fine sand, orange mottled, shelly; overlies reddish, well-sorted fine sand, with shells	80-100	10,420 ± 80	Ilyocypris bradyi Limnocythere itasca Cypridopsis vidua Candona caudata *Candona* sp. aff. *C. rawsoni*	Mollusk shell fragments	All of the taxa are juveniles that were probably reworked from a wetland sediment
99BL-42	Reddish fine sand, some shells	140-160		None	Gastropods, charophytes	Probably a wetland
99BL-43	Reddish silt, clay, and fine sand	155-180		None		
99BL-43	Interbedded? muddy medium and fine sand, reddish, slightly to non-calcareous, monotonous	240-270		Heterocypris sp. aff. H. incongruens *Candona* sp. aff. *C. rawsoni*	Mollusk shell fragments	Spring/seep
99BL-45	Calcareous, organic-rich silt and clay, abundant snails throughout	120-130	8520 ± 70	Cypridopsis vidua *Candona stagnalis* *Limnocythere itasca* *Potamocypris* sp. *Cyclocypris ovum* *Candona* sp.? Cyclocypris serena	Numerous aquatic gastropods, bivalves	Wetland
99BL-48A	Green clay, locally oxidized; overlain by calcareous pink marl	165-185	>8460	Candona caudata *Cypris pubera* *Cyclocypris serena* *Candona distincta* *Candona renoensis* *Candona stagnalis* *Candona* sp. Limnocythere paraornata *Strandesia horridus* *Cypria obesa?* *Ilyocypris gibba* *Candona decora* *Dolerocypris* sp. Candona rawsoni *Strandesia* sp.	Aquatic and terrestrial gastropods, bivalves	Hydrologically complex wetland having springs, seeps, standing water, and flowing water

Table 3. Ostracodes in sediment samples from outcrops in the Bear Lake drainage basin, 1998-2001—Continued.

Site and sample number	Description of unit (see table 1)	Depth below top of section (cm unless noted)	Age (if dated; see table 2)	Ostracode taxa	Other taxa	Comments
99BL-49	Reddish-gray silt and sand, abundant plant fragments, slightly calcareous	190-215	>4000, <6925	Ilyocypris bradyi *Limnocythere paraornata* *Physocypria globula* *Cyclocypris ovum* *Cypridopsis vidua* *Cavernocypris wardi* *Candona* sp. *Cyclocypris serena?* Candona stagnalis	Gastropods	Stream and wetland complex with cold flowing springs
99BL-49	Gray silty sand, slightly calcareous, shell fragments	270-300	6925 ± 70	None		
99BL-53B	Well-sorted, well-bedded fine-medium silt and sand	~10 m				
99BL-53A	Green clay interbeds	~15 m		Limnocythere paraornata *Candona* sp.?		Stream?
99BL-84 (same as BL00-14)	Gray, massive marl	0-200		None	Root tube coquina, gastropods (*Stagnicola*)	Wetland
00BL-8	Mottled orange calcareous mud, thin fine sand lenses	235-333		None	Gastropods	
00BL-54E	Pale gray, silty lacustrine mudstone	6.8 m		Cypridopsis vidua *Cyclocypris serena* *Candona* sp. cf. *C. rawsoni* Cytherissa lacustris	Aquatic and terrestrial gastropods, charophytes	Wetland environment with reworked lacustrine ostracodes, or wetland and lake environments integrated with sampling
00BL-54D	Pale gray, silty lacustrine sand	9.2 m		*Candona* n. sp. 1 Candona n. sp. 2 Candona caudauta	Gastropods	Lacustrine deposition. The two taxa identified as new species 1 and 2 are taxa endemic to Bear Lake. The presence of *Candona caudata* may indicate this site is near the littoral zone of Bear Lake
00BL-54C	Gray lacustrine mudstone	10.4 m		*Pelocypris* sp. Ilyocypris bradyi *Candona* sp. cf. *C. rawsoni*	Aquatic gastropods, bivalves, and fish bone	Stream environment. Pelocyprids are common stream ostracodes, and ilyocyprids typically live in flowing water, whether in spring or stream flow
00BL-54B	Brown lacustrine silt and mudstone	13.2 m		None		
00BL-54A	Beach gravel interbedded with silty sand	19.0 m		None		

Table 3. Ostracodes in sediment samples from outcrops in the Bear Lake drainage basin, 1998-2001—Continued.

Site and sample number	Description of unit (see table 1)	Depth below top of section (cm unless noted)	Age (if dated; see table 2)	Ostracode taxa	Other taxa	Comments
00BL-59	Thin shell-bearing reddish mudstone capped by fan gravel; overlies beach gravel			None		
00BL-60C	Reddish mudstone, probably lacustrine	upper		*Candona* sp. cf. C. *rawsoni*, juveniles *Candona* spp?		Unknown depositional environment
00BL-60B	Gray lacustrine sand	middle				
00BL-60A	Olive-green lacustrine clay	lower		*Candona* sp. cf. *C. acutula* ? *Candona* spp. ? *Limnocythere* spp. ?		Candonid and limnocytherid species unknown, some of these taxa resemble Pliocene and early Pleistocene ostracodes known from large lakes
00BL-61B	Reddish mudstone, probably lacustrine	upper		Reworked candonids, some species the same as in 00BL61A		Depositional environment unknown
00BL-61A	Gray lacustrine sand	lower		*Candona* spp? Limnocythere sappaensis *Limnocythere* spp? Cytherid genus and species unknown		Depositional environment unknown, taxa resemble species known from large Pliocene lakes in the region
00BL-63B	Gypsiferous lacustrine deposits grade upward into gypsiferous spring-discharge deposits	upper		Cavernocypris wardi *Candona* sp.? juveniles	Aquatic and terrestrial gastropods	Cold flowing spring
00BL-63A	Gypsiferous lacustrine deposits interbedded with fan gravel	lower	>39,870 + 490			
01BL-23B	Calcareous pink marl	37-44		Ilyocypris bradyi	Aquatic and terrestrial gastropods, charophytes	Wetland to flowing spring setting
01BL-24C	Mixed greenish-gray clay and gravel, unbedded	3.2-4.2 m		Cyclocypris serena Cyclocypris ovum *Candona* sp. cf. *C. rawsoni*, juvenile	Terrestrial gastropods	Wetland
01BL-24B	Reddish, blocky silty clay and sand layers, rare shells	4.2-6.1 m		None	Terrestrial gastropods, seeds	Environmental setting unknown, wet ground possible
01BL-24A	Thinly bedded well sorted silt and fine sand between beach gravel beds, rare shells	6.6-7.3 m		Candona rawsoni *Cytherissa lacustris* *Candona caudata* *Physocypria globula* *Limnocythere paraornata* *Limnocythere* sp.?	Aquatic gastropods, bivalves	Lacustrine, but likely with a nearby stream or through-flowing wetland setting, such as might exist in a marginal lacustrine site like modern-day Mud Lake

Table 3. Ostracodes in sediment samples from outcrops in the Bear Lake drainage basin, 1998-2001—Continued.

Site and sample number	Description of unit (see table 1)	Depth below top of section (cm unless noted)	Age (if dated; see table 2)	Ostracode taxa	Other taxa	Comments
01BL-30A	Pale olive-green sandy silt, well-bedded, noncalcareous	285-300		None	None	Sample contains volcanic ash, most grains are clear to frosty, rare grains are black
01BL-35B	Marl; overlies well-sorted, fine-medium crossbedded sand	150-190	13,675 ± 50	*Heterocypris* sp. *Candona* sp. *Limnocythere paraoranata*	Aquatic snails	Spring seep complex
01BL-39C	Well-sorted, fine reddish sand fining upward to sandy silt, about 8 m thick; underlain by Bear River terrace gravel	~6 m		None	Terrestrial gastropods, insects	Environment unknown, wet ground possible
01BL-42 old sample 99BL58B	Well- sorted, interbedded, reddish sand, silt, and mud layers, locally reduced greenish color	22-22.7 m	<760 ka (Bishop ash bed)	*Limnocythere* sp.? *Limnocythere staplini*? Candonids, ground-water taxa		Environment unknown, could be related to a fluvial or alluvial aquifer
01BL-42 old sample 99BL58A	Well-sorted, interbedded, reddish sand, silt, and mud layers, locally reduced greenish color	22-22.7 m	<760 ka (Bishop ash bed)	*Candona rawsoni*		Material is composed of only broken shells of juveniles; they looked reworked
01BL-42C	Marl, 3-cm thick in sequence of reddish, thinly bedded fine silty sand	~24 m	<760 ka (Bishop ash bed)	Limnocythere ceriotuberosa *Candona* sp. cf. *C. rawsoni*		Ostracodes are reworked. Limnocythere ceriotuberosa was a common ostracode in most of the deep lakes that resided in the greater Great Salt Lake Basin
DK93-23E	Peat and organic-rich silt with shell-hash layers	0-100		Physocypira *Limnocythere ~ Itasca* *Cyclocypris* *Candona distincta* *Candona renoensis* *Candona acuminata* *Potamocypris* *Candona* sp. (caudatid?)		
DK93-23D	Dark gray, fine and medium sand; layers of snails	100-170	6750 ± 60	Physocypira *Limnocythere ~ Itasca* *Cyclocypris* *Cypridopsis vidua* *Potamocypris* *Candona renoensis* *Candona ~ candida* *Candona* n. sp. 1 and 2	*Carinifex, Lymnaea* snails	*Candona* n. sp. 1 and 2 are the two most common Bear Lake endemics. Also, possibly modified versions of *Candona* n. sp. 3 and 4 from Bear Lake
DK93-23C	Organic-rich silt and peat with silty sand layers; snail shells and shell hash	170-190		No adult ostracodes, few juveniles		

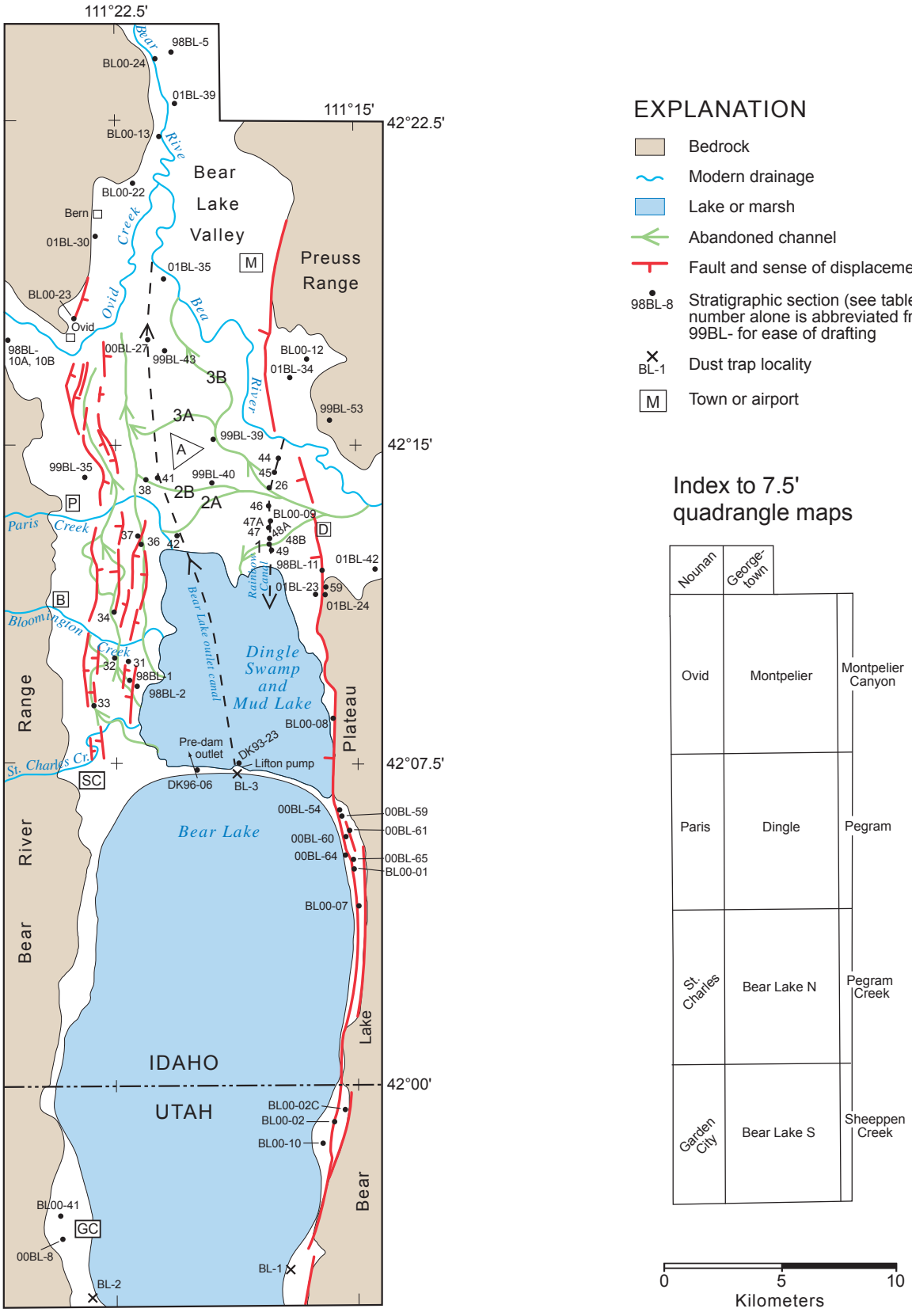
Table 3. Ostracodes in sediment samples from outcrops in the Bear Lake drainage basin, 1998-2001—Continued.

Site and sample number	Description of unit (see table 1)	Depth below top of section (cm unless noted)	Age (if dated; see table 2)	Ostracode taxa	Other taxa	Comments
DK93-23B	Laminated marl, rhythmically bedded gray silt and white silt-clay; abundant snails	190-270		Cypridopsis vidua *Physocypria* *Limnocythere ~ Itasca* *Candona compressa* *Candona* n. sp. 2		*Candona* n. sp. 2 is the most common endemic in Bear Lake. Few valves
DK93-23A	Sedge peat	270-280		Cypridopsis vidua Physocypria *Candona ~ candida* Limnocythere ~ itasca		Very few valves
DK96-06	Brown mud; top of tube driven below ~150 cm in section at Fish Ladder	0-10 in tube	≥8550	Physocypria *Cypridopsis vidua* *Cyclocypris ampla* *Candona* sp.? (caudatid) *Limnocythere itasca or itascoid* *Limnocythere* sp.?	*Valvata, Gyraulis* snails	
DK96-06	Deformed, pasty gray marl	11 in tube	≥8550	Physocypria *Candona* sp.? (caudatid) *Limnocythere ~ Itasca* *Candona compressa* *Candona acuminata* Cypridopsis vidua	*Lymnaea*, some *Valvata* snails	
DK96-06	Dark gray mud	21 in tube	≥8550	*Candona* sp.? (caudatid) *Physocypria* *Cypridopsis vidua* *Cyclocypris* Limnocythere ~ itasca	*Valvata, Gyraulus* snails; *Pisidium* or *Sphaerium* clams	
DK96-06	Laminated, gray to light tan mud	26 in tube	≥8550	Limnocythere ~ itasca *Physocypria* *Candona* sp.? (caudatid) Cypridopsis vidua	*Gyraulus, Valvata* snails; *Pisidium* or *Sphaerium* clams; charophytes	
DK96-06	Black, gritty, stiff mud; base of tube driven below ~150 cm in section at Fish Ladder	31 in tube	≥8550	None	None	Sieve residue is charcoal and burned seeds
DK99-28 (same as BL00-14)	Gray, massive marl	50-200	>45,000	None	Stagnicola	

Table 3. Ostracodes in sediment samples from outcrops in the Bear Lake drainage basin, 1998-2001—Continued.

Site and sample number	Description of unit (see table 1)	Depth below top of section (cm unless noted)	Age (if dated; see table 2)	Ostracode taxa	Other taxa	Comments
DK99-32A (same as 99BL-53)	Well-sorted well-bedded fine-medium sand and silt	~16 m		None	*None*	
BL00-13	Multiple marl beds	115-260		*Candona* sp.?	Sphaerium	
BL00-17	Yellow, massive, slightly weathered marl with *Stagnicola* shells	90-355		None	*Stagnicola, Gyraulus, Discus,* and *Valvata*	
BL00-18	Gray, massive marl	240-250		*Strandesia meadensis* *Cavernocypris* *Cypridopsis*	None	
BL00-19	Green, massive marl with *Stagnicola* shells	175-250		None	*Stagnicola*	

Figure 1. Map of Bear Lake Valley showing site locations and generalized traces of Quaternary faults and modern and abandoned stream courses. Site numbers beginning with year (for example, 99BL-35) were described and sampled by Reheis; prefixes for some sites were omitted for ease of drafting, but all the omitted prefixes are for sites described in 1998 (for example, site 98BL-47 is abbreviated to 47). Site numbers beginning with BL- were described and sampled by Laabs; those beginning with DK- were described and sampled by Kaufman. A, airport; B, Bloomington; D, Dingle; GC, Garden City; M, Montpelier; P, Paris; SC, St. Charles.



EXPLANATION

- Bedrock
- Modern drainage
- Lake or marsh
- Abandoned channel
- Fault and sense of displacement
- 98BL-8 — Stratigraphic section (see table 1); number alone is abbreviated from 99BL- for ease of drafting
- BL-1 — Dust trap locality
- M — Town or airport

Index to 7.5' quadrangle maps

EXPLANATION FOR BEAR LAKE SECTIONS

Site number (type of exposure)
Surface altitude (in meters and feet;
annotated if measured using GPS)


Mud or clay


Marl


Interbedded mud and sand


Silt and sand, well sorted and bedded


Fine sand and silt, well sorted, massive (loess)


Sand and gravel, well rounded clasts (beach and nearshore deposits)


Crossbedded gravel and sand, rounded clasts (fluvial deposits)


Crossbedded sand and fine pebble gravel (fluvial deposits)


Clay, silt, sand, and minor pebbles, moderately sorted (fluvial and overbank deposits)


Peat and organic-rich deposits


Clay, silt, sand, and gravel, poorly sorted and bedded (alluvial fan deposits)


Steep dips (foreset beds)


Calcareous cement, locally tufa


Buried soil

Erosional contact

Btk — Soil horizon

←A 2445 ^{14}C yr B.P. — Sample letter or depth in centimeters and ^{14}C age (if dated)

01BL42 — Tephra layer and sample number

Figure 2. Stratigraphic sections measured by Reheis from outcrops and auger holes in Bear Lake valley. Site locations are in figure 1 and table 1. Sections are shown in rough order from north to south on the following four pages. Column to right of lithology gives descriptive information such as color, sample data, and soil horizons. On some sections, leaders group depositional layers into different types of deposits (e.g., loess) as interpreted from sedimentary characteristics.

Figure 2. Continued.

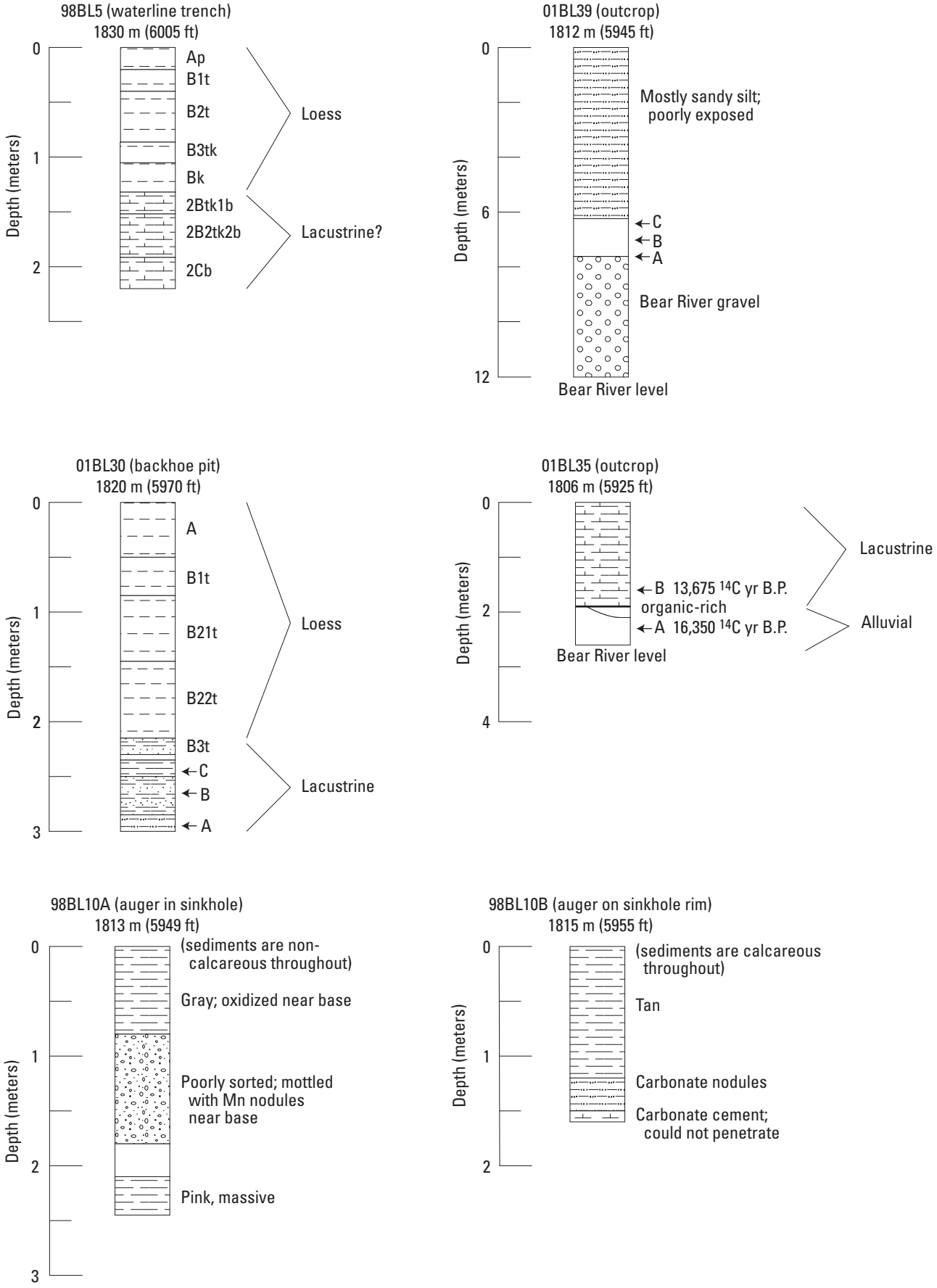


Figure 2. Continued.

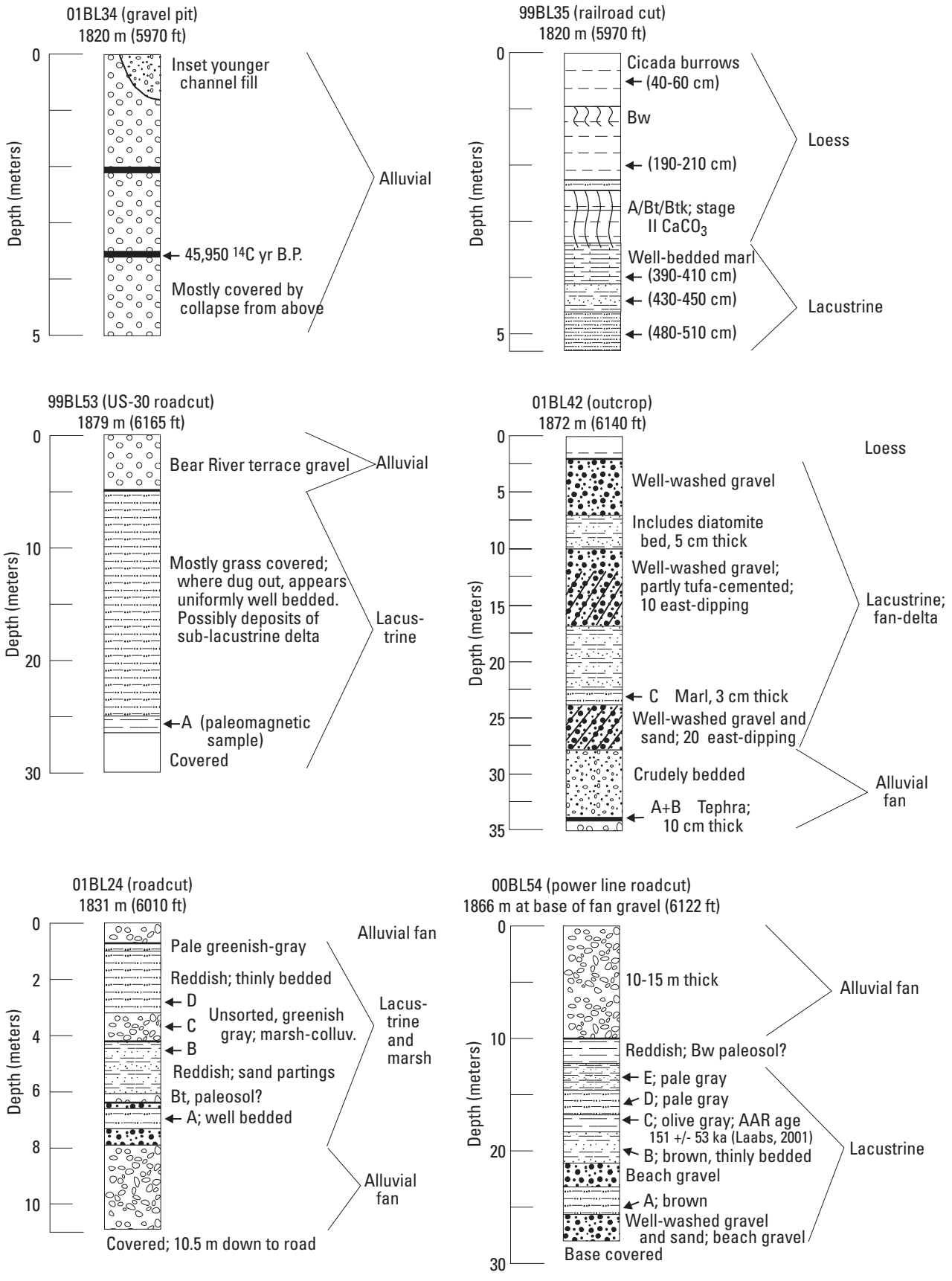


Figure 2. Continued.

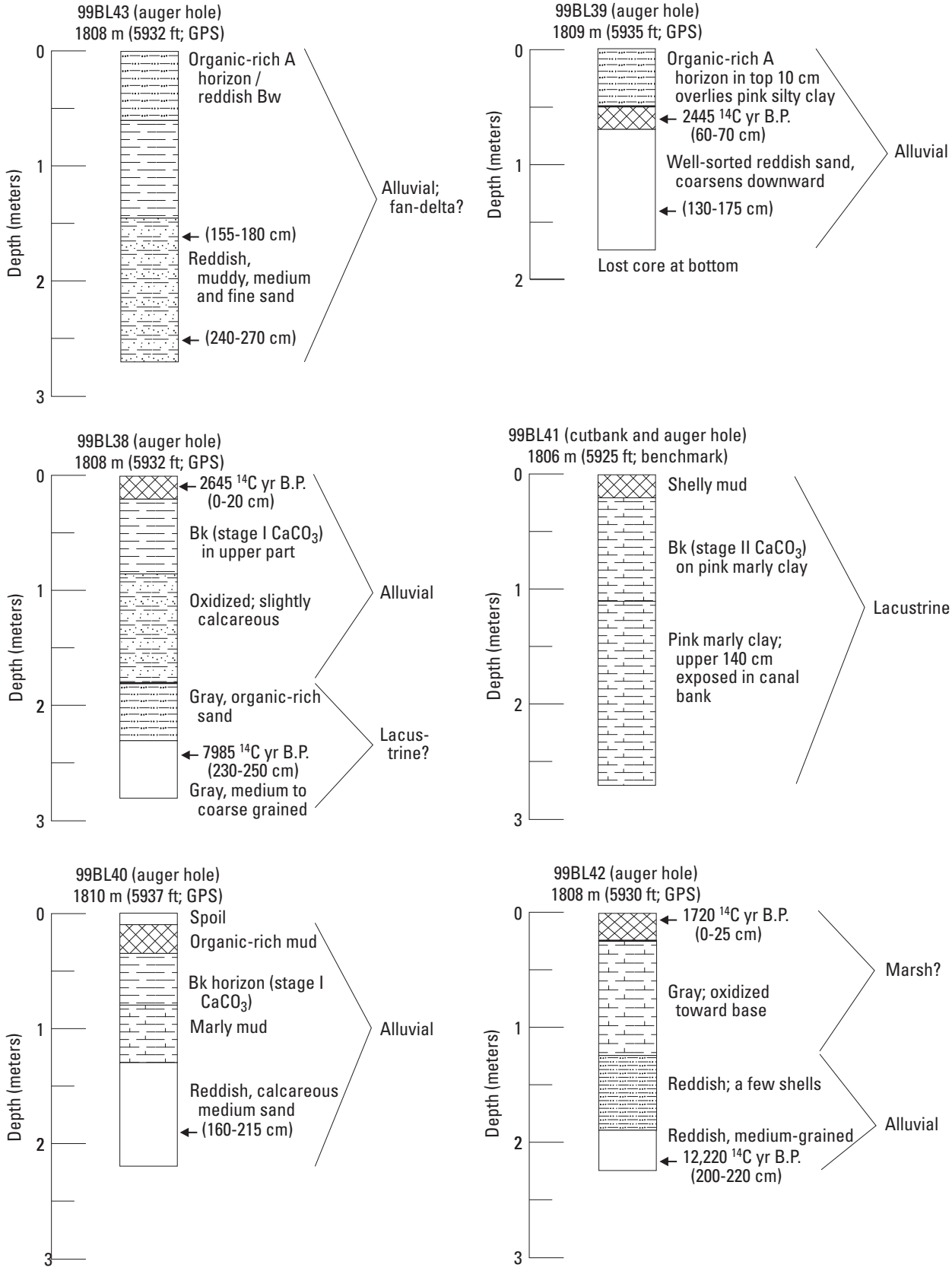
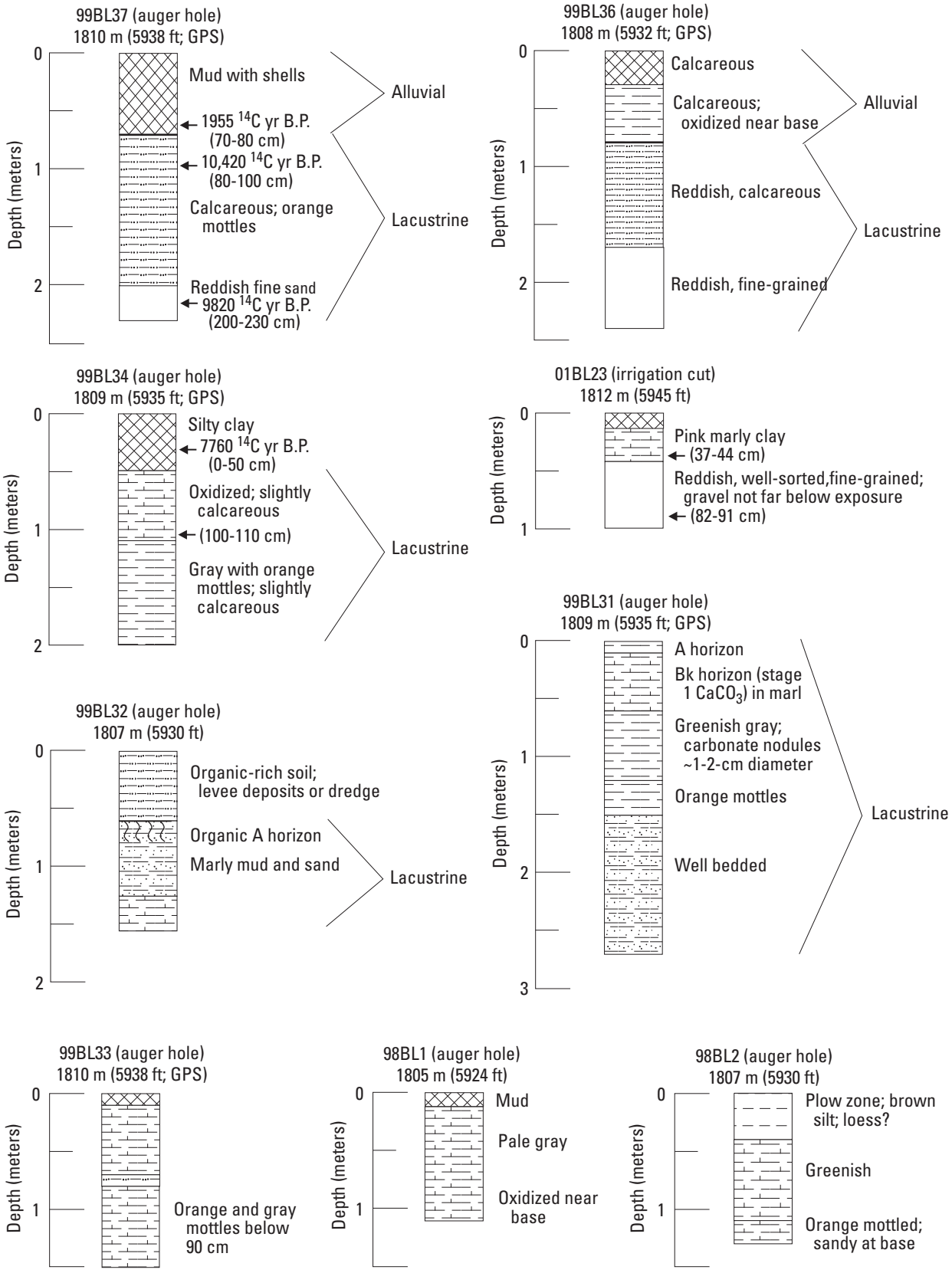


Figure 2. Continued.



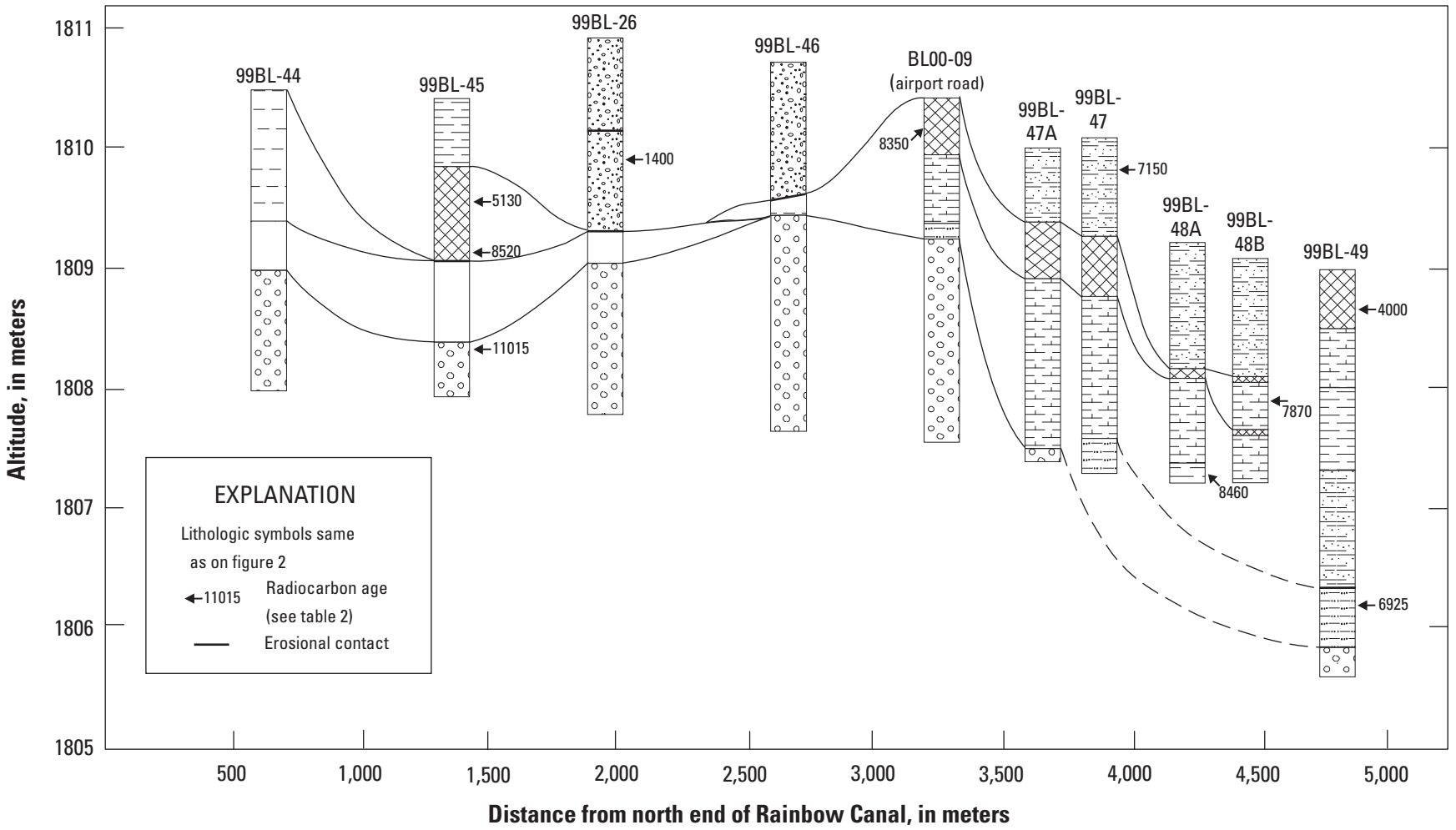


Figure 3. Stratigraphic sections of exposures along the Rainbow Canal (see table 1). Most sections are outcrops and correlation lines are physically traced, except that BL99-49 is an auger hole within a channel fill cut into older sediment and correlations are uncertain. Surface altitudes were measured using a Trimble GPS and differentially corrected in the office. The base of the outcrop sections is the water level, thus the section bases essentially reflect the water gradient in the canal over a two-day period when flow rate in the canal remained relatively constant. Measured sections were then plotted and their altitudes slightly adjusted to yield a smoothly sloping water level at the base of the outcrop sections.