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Water Engineering & Technology, Inc
Report

Geomorphical and Sedimentological
Characteristics of Sink Valley, Kane County
Utah

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GEOMORPHOLOGICAL AND SEDIMENTOLOGICAL CHARACTERISTICS OF SINK VALLEY, KANE COUNTY, UTAH

Report Prepared for

NEVADA ELECTRIC INVESTMENT COMPANY

Water Engineering & Technology, Inc.

Consultants in
Applied Geomorphology,
Hydrology and
Water Resources
Engineering

GEOMORPHOLOGICAL AND SEDIMENTOLOGICAL CHARACTERISTICS OF SINK VALLEY, KANE COUNTY, UTAH

Report Prepared for

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1. INTRODUCTION

Sink Valley is located in west-central Kane County, Utah, in the West Block of the proposed Alton Coal Project. The hydrologic behavior of the valley has been significantly modified by the capture of the upper part of the drainage basin (Dry Fork and Water Canyon) by Lower Robinson Creek. The surficial discharges passing through Sink Valley are now derived primarily from the unnamed tributary in Section 21 and from Swapp Hollow drainage basin. Within Sink Valley there is no continuous channel, but a continuous and deeply incised channel (Sink Valley Wash) exists downstream of the culvert on County Road 136 (Alton-Skutumpah).

The incision of Sink Valley Wash downstream of the road culvert post-dates the General Land Office Survey (Burrill, 1876). At the time of the survey, Sink Creek (his term for Sink Valley Wash) was 5 links (~ 3 feet) wide and 6 inches deep. In contrast, the present channel is about 69 feet wide and 23 feet deep. The diminutive size of the pre-incision channel in the comparatively narrow valley, about 2 miles downstream of the County Road 136 culvert, suggests that sheetflow, rather than confined channel flow, was the primary discharge mode. This observation tends to be supported by Gregory (1935), who described the area within Sink Valley as being swampy, and this is corroborated by the accounts of early settlers (Carroll, 1960).

1.1. Alluvial Valley Floor Definition

The regulatory definition of an alluvial valley floor is outlined in the Office of Surface Mining's (OSM, 1983), Alluvial Valley Floor Identification Guidelines, in which are laid down two sets of criteria (1) Geologic and (2) Water Availability. The geologic criteria are:

(a) a topographic valley with a continuous perennial, intermittent, or ephemeral stream channel running through it; and

(b) within that valley, those surface landforms that are either flood plains or terraces if these landforms are underlain by unconsolidated deposits (streamlaid); and

(c) within that valley, those side-slope areas that can reasonably be shown to be underlain by alluvium and which are adjacent to flood plain or terrace landform areas.

Specifically excluded from the OSM definition of alluvial valley floors are upland areas, which are defined as those geomorphic features located outside the flood plain and terrace complex, such as isolated higher terraces, alluvial fans, pediment surfaces, landslide deposits, and surfaces covered with residuum, mud flows or debris flows, as well as highland areas underlain by bedrock and covered by residual weathered material or debris deposited by sheetwash, rillwash, or windblown material.

On the basis of the geologic criteria it is apparent, therefore, that the requirement for an Alluvial Valley Floor determination is the presence of a continuous channel within a topographic valley, the floor

of which contains floodplain and terrace features that are underlain by unconsolidated streamlaid deposits that were deposited by the continuous channel. The flow regime of the channel may be perennial, intermittent or discontinuous. By the same criteria alluvial fans, areas underlain by bedrock and covered by residuum or colluvial deposits and surfaces covered by mud flows, debris flows or sheetwash deposits are not considered to meet the geologic criteria for alluvial valley floors.

Current regulations of the Utah Division of Oil, Gas and Mining (UDOGM) state that unconsolidated streamlaid deposits holding streams means, with respect to alluvial valley floors, all floodplains and terraces located in the lower portions of topographic valleys which contain perennial or other streams with channels that are greater than 3 feet in bankfull width and greater than 0.5 feet in bankfull depth.

1.2. Background

The results of previous investigations of Sink Valley reported in July 1987 (C.D.M., 1987) concluded that Sink Valley did not meet the regulatory definition of an alluvial valley floor for two reasons. First, there is no continuous stream channel through the valley. Second, the valley fill in Sink Valley is not streamlaid but rather was deposited by various processes including mudflows, debris flows, and sheetfloods that formed alluvial fans.

This information was presented to Utah Division of Oil, Gas and Mining (UDOGM) for their consideration. UDOGM concluded that further information was necessary before Sink Valley could be determined not to

be an AVF. UDOGM proposed that man's activities may have eliminated the continuous stream through Sink Valley. They suggested that further work be performed to identify whether there are continuous streamlaid deposits through the valley.

Second, they suggested that, while streamlaid deposits did not appear to be present on the surface, exploration drill holes have indicated the possible presence of streamlaid deposits at depth. They suggested that further information be submitted to determine whether the surface expression of possible streamlaid deposits has been obscured by recent development of alluvial fans or man's activities. Under this scenario careful subsurface investigations would identify the presence of streamlaid deposits at a shallow depth that have been overlain by more recent deposits.

Therefore, the objectives of this investigation of Sink Valley, that was conducted for the Nevada Electric Investment Company, under the supervision of Mr. Dean Williams of BHP-Utah International were: (1) to determine whether there were streamlaid deposits beneath the surface of the valley floor, and (2) to determine whether the alluvial fans, or man's activities had obscured a previously existing continuous channel that traversed the length of Sink Valley.

1.3. Methods of Investigation

This field investigation of Sink Valley was conducted between July 7, 1988 and July 17, 1988. Nine topographic cross sections (I to IX) were surveyed across the valley and two tributaries with an EDM-coupled

theodolite such that they were oriented perpendicular to the depositional axis of the valleys. The cross sections were tied to a common datum and fiducial point (10,000, 10,000): the section corner between Sections 19, 20, 29 and 30, T. 39S. R. 5W, where there is a monumented brass cap (EL. 6914 feet). The up-valley cross section (No. I) is located in Section 21, T. 39S., R. 5W and the down-valley cross section (No. IX) is located in Sections 5 and 6, T. 40S., R. 5W. The cross sections were surveyed in order to characterize the valley floor topography, and to provide ground surface elevations for the stratigraphic investigation (Drawings No. 1 to 9).

Stratigraphic data for the valley floor were obtained from bank exposures in the incised channels of Lower Robinson Creek and Sink Valley Wash, and from 28 backhoe pits. A total of 37 stratigraphic sections were measured and described in the pits and incised-channel banks. All of the pit and channel bank exposures were photographed.

In addition to the above, a debris flow lobe on the valley floor was roughly surveyed with a hip chain and Brunton compass. The axes of coarse clastic sediments on one of the debris flow levees were measured and recorded. A field reconnaissance of the Sunset Cliffs in Water Canyon was conducted to document the up-valley sediment source. These deposits and the source rocks were photographed. During the field investigation previously mapped discontinuous channel segments within Sink Valley (Harvey and Schumm, 1987) were field checked to determine their origin and continuity.

1.4. Geology

Sedimentary rocks associated with the Pausaugunt Plateau range in age from Jurassic to Recent (Fig. 1.1). In the Sink Valley area, sandstones and coal seams of the Cretaceous Dakota Formation are overlain by the slope forming Tropic Shale. The Tropic Shale consists of grey to brown argillaceous shale, which commonly erodes into badlands topography (Gregory, 1951). The Tropic Shale is approximately 750 feet thick in central Kane County (Doelling, 1972). Overlying the Tropic Shale, the Upper Cretaceous Straight Cliffs, Wahweap, and Kaiparowits Formations are composed of weakly cemented sandstones and minor arenaceous shales which reach a cumulative thickness of 1700 feet in the study area.

The Upper Cretaceous Kaiparowits Formation is unconformably overlain by the Eocene Wasatch (Claron) Formation, a sequence of basal conglomerate and pink and white limestone which is approximately 500 feet thick in the Sunset Cliffs above Sink Valley. The basal portion of the Wasatch Formation consists of a conglomeratic unit which ranges in thickness from 20 to 100 feet (Gregory, 1951). The unit contains rounded quartzite, chert, limestone, and volcanic clasts in a calcareous matrix. Clasts reach 3 feet in diameter on the rim of the Paunsaugunt Plateau (Gregory, 1951). The Wasatch Formation becomes sandy upsection (Doelling, 1972). Quaternary basalt flows are present south of Sink Valley, in the Bald Knoll and Buck Knoll areas.

Pre-Quaternary sediments of the Sink Valley area dip gently northeastward. Along strike, the lateral continuity of these units is

System	Series	Stratigraphic Unit			Thickness (Feet)	Description
Tertiary	Eocene	Claron Formation (Wasatch)			1000-1300	Pink, white, and varicolored limestone, cliff former eroding into picturesque slopes and forms, basal conglomerate of exotic quartzite and limestone cobbles and pebbles.
						Unconformity
Cretaceous	Campanian	Kaiparowits Formation			265-700	Dark gray to gray-green arkosic sandstone, friable with weak calcareous cementation.
						Unconformity
	Santonian ? Coniacian ? Turonian	Wahweap Formation *Minor Coal*			500-1300	Alternating sandy shale and thin- to thick-bedded resistant sandstone, ledge and slope topography.
		Straight Cliffs Formation *Minor Coal*			80-500	Yellow-gray to brown, thick-bedded to massive cliff-forming sandstone with subordinate intervening gray shale, shaley sandstone, *coal* and carbonaceous shale.
		Tropic Shale			700-1000	Drab gray shale with subordinate thin brown fine-grained sandstone, slope former.
	Cenomanian	Dakota Formation *Major Coal Seams*			150-450	Yellow-gray to brown fine- to medium-grained sandstone alternating with gray shale, sandy shale, carbonaceous shale and *coal*, ledge and slope former creating Gray Cliffs; best *coal* near bottom and top of unit.
						Angular Unconformity
Jurassic	Upper	Entrada Sandstone		Cannonville Member	0-300	White and reddish banded fine-grained sandstone and siltstone, friable and earthy weathering, massive.
				Gunsight Butte Member	0-300	Red-brown and light green siltstone; also red cross-bedded sandstone of the "slickrock" type.
		Carmel Formation		Wiggler Wash Member	0-60	Limestone, red siltstone, white and greenish gypsum.
				Winsor Member	180-250	White, pink, brown sandstone alternating with thin red siltstone and mudstone.
				Paria River Member	55-200	Interbedded light gray and red sandstone, limestone, siltstone, shale, and gypsum.
			Judd Hollow Tongue of Carmel	Thousand Pockets Tongue of Navajo Sandstone	0-60	Yellowish cross-bedded friable but resistant sandstone.
				Crystal Peak Member	120-190	Dark reddish brown and white to light gray fine-grained sandstone, medium-bedded with minor thin gypsiferous or calcareous shales and conglomerate.
				Kolob Limestone	122-350	Gray and tan dense limestone with some thin sandy red shale near the base and thin gypsum near top.
						Unconformity
	Lower	Navajo Sandstone			1000+	Light gray to tan, locally red fine-grained sandstone, massive, exhibiting large-scale aeolian cross-bedding, calcareous and cliff forming.

Figure 1.1. Generalized Section of Rock Formations in the Alton Coal Field (Doelling and Graham, 1972).

disrupted by two major northeasterly trending faults which bound the Paunsaugunt Plateau (Fig. 1.2). The Paunsaugunt fault marks the eastern boundary of the plateau and is located approximately 13 miles east of Sink Valley. The fault is generally normal and downthrown to the west. Offset along the Paunsaugunt fault ranges from 100 to 500 feet (Doelling and Graham, 1972).

The Sevier fault lies 3 miles west of Sink Valley, marking the boundary of both the Pausaugunt Plateau and the Alton coal field. The fault extends approximately 300 miles from south of the Grand Canyon to central Utah. The fault is normal and downthrown to the west. Total displacement on the Sevier fault ranges from 1000 to 2000 feet (Doelling and Graham, 1972).

The Bald Knoll fault runs parallel to the Sevier and Paunsaugunt faults, passing approximately 1 mile east of Sink Valley. The fault is normal and downthrown to the east. Total offset on the Bald Knoll fault may be as much as 500 feet (Doelling and Graham, 1972).

A topographic gradient which averages 600 ft/mile extends from the head of Sink Valley, up Water Canyon, to the top of the Paunsaugunt Plateau. The edge of the plateau consists of a steep 400 feet escarpment of Eocene Wasatch Formation known as the Sunset Cliffs. The cliffs have weathered into a large amphitheatre as a result of mass wasting of the Wasatch Formation. Massive debris flow and landslide deposits are present at the base of the cliffs. As a result, a large amount of debris which has eroded from the Sunset Cliffs has concentrated at the head of Water Canyon in a large debris flow-

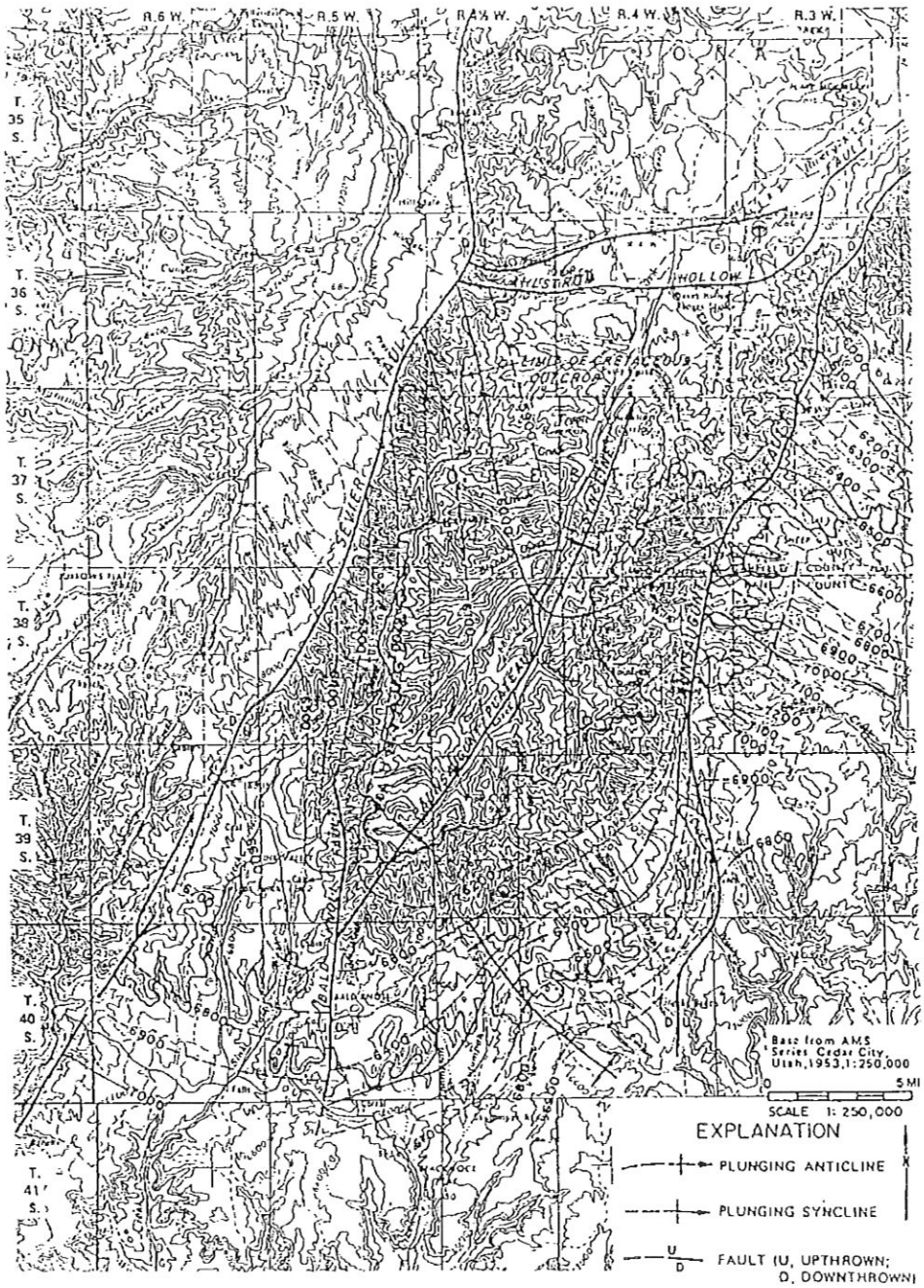

Figure 1.2. Generalized structure map, Alton coal field. (Doelling and Graham, 1972).

dominated fan. Subsequent events have remobilized and transported this material into Sink Valley, as evidenced by Sink Valley stratigraphic data presented in this report. Erosion as a result of mass wasting processes is characteristic of the Tropic Shale on the margins of Sink Valley.

Sink Valley lies on an erosional surface of Tropic Shale which, due to its lithologic character, has manifested itself into a relatively wide topographic depression in a region dominated physiographically by steep canyons in indurated sandstones. The margins of Sink Valley consist of laterally retreating Tropic Shale and a pediment. The pediment surface consists primarily of limestone, quartzite, and basalt clasts derived from the Wasatch Formation. Rounded clasts of quartzite and basalt on the pediments are derived from the basal conglomerate of the Wasatch Formation. The pediment gravels have provided a local source of coarse clastics during the most recent phase of Sink Valley deposition.

1.5. Alluvial Fan Literature Review

Previous studies of Sink Valley (Harvey and Schumm, 1987) indicated that the floor of Sink Valley was composed of alluvial fan sediments. Therefore, it is appropriate that a review of the alluvial fan literature be undertaken.

Numerous investigators have studied the sedimentology of alluvial fans. Although most research has been carried out on fans of arid regions, general controls on fan development may be extended to a range of climatic systems.

Reading (1978) described how alluvial fans develop in areas of high relief where an abundance of sediment exists. Deposition takes place when infrequent violent rainfall induces rapid erosion. Bull (1977) defines an alluvial fan as "a deposit whose surface forms a segment of a cone that radiates downslope from the point where the stream leaves the source area".

Climate plays a large role in alluvial fan development and sedimentation. Kochel and Johnson (1984) delineated four different fan types based on climate. Arid fans are characterized by periods of rapid deposition followed by long periods of inactivity. Humid-glacial fans consist of constantly shifting braided streams on an aggrading outwash plain. Humid-tropical fans reflect seasonal deposition by braided streams and debris flows, and humid-temperate fans are characterized by infrequent debris avalanching initiated by large rainstorms.

In general, alluvial fans form at the margins of steep basins due to a decreased confinement of streamflow (Bull, 1977). Deposition, is therefore, not due to a change in slope, but is the result of a rapid lateral expansion of sediment onto a fan surface (Reading, 1978). The reduction in lateral confinement which induces alluvial fan deposition is generally the result of base level lowering (Bull, 1977). An erosional base level reduction will generally produce a temporary thin fan, whereas tectonic base level lowering results in the development of a prolonged thick fan sequence (Bull, 1977).

High sediment supply is characteristic of alluvial fans. Therefore, the initiation of an alluvial fan may result from a climatic change

which increases rates of erosion. In addition, coarse unconsolidated materials on a fan surface will reduce downvalley surface discharges and promote deposition.

Three types of deposits are commonly found in small steep basins characteristic of alluvial fans: water floods, hyperconcentrated flows, and debris flows (Costa, 1988). Water floods behave as Newtonian fluids and, therefore, have no yield or shear strength. Waterflood deposits contain primary channels with width:depth ratios in excess of 12:1.

Sheetfloods are waterfloods on an alluvial fan surface. Sheetfloods are characterized by low viscosity flows which expand laterally at the downstream end of a confined channel onto a fan surface (Reading, 1978). They generally reflect upper flow regime conditions, and deteriorate into patterns of braided channels and bars which dissect the upper surface of the sediment sheet (Reading, 1978). Bull (1977) described sheetfloods as surges of sediment laden water which range in depth from 0.5 to 1.5 feet. The resultant deposit is a sheetlike unit of sand and gravel which may be traversed by shallow discontinuous channels which repeatedly divide and rejoin.

Hyperconcentrated flows are generally defined to begin at 40% sediment concentration by weight (Costa, 1988). Shear strength within hyperconcentrated flows is small but measurable (100-400 dynes/cm^2). The amount of fine material present in hyperconcentrated flows greatly affects fluid characteristics of the material, because shear stress is acquired very rapidly by clay rich deposits. Hyperconcentrated flows, also called noncohesive mudflows, mudfloods, and intermediate flows,

have a much higher sediment transport rate than waterfloods, because the increased sediment concentration increases fluid viscosity, thereby decreasing sediment fall velocities and enabling sediment to remain in suspension for longer periods of time (Costa, 1988).

The third primary mode of deposition on alluvial fans is that of debris flows, where solid particles and water move together as a single viscoplastic body (Costa, 1988). Debris flow cohesion is controlled by clay content. Debris flows occur when large quantities of water enter a basin over a short period of time; when steep slopes contain insufficient stabilizing vegetation, and when a proximal source contains both coarse detritus and a fine mud matrix.

Debris flow deposits are generally characterized by the following features (Reading, 1978): a) a steep lobate snout with large boulders concentrated at the front; b) lateral levees of coarse deposits; c) a tendency to flow in pulses or surges; d) a concentration of the largest particles towards the surface and edges of the flow, and 3) the formation of a rigid plug at the center of the flow. The presence of wood fragments is good evidence for debris flow deposition, as water rich floods would remove buoyant materials from the sediment. Debris flows lack stratification and sedimentary structures, and they are distinctly chaotic.

Kochel and Johnson (1984) described alluvial fans in humid-temperate regions, and identified debris flows based on the following evidence: a) very poor sorting and coarse textures, b) indistinct stratification, c) sharp basal contacts; d) an absence of current structures; 3) inverse graded bedding, and f) the preservation of ripups.

longitudinal profile found on many fans could be generated by both fluvial and mixed-mode (i.e., mudflow dominated) processes. Harvey (1984b) suggested that debris flow dominated fans are more likely to have numerous disconnected channel segments because of the greater irregularity of the fan surface. From the above discussion it is clear that fan sedimentology has important implications for understanding fan morphology, and this is especially true with respect to areas of local aggradation and degradation.

Experimental (Schumm et al., 1987) and field studies (Rust and Koster, 1984) of alluvial fans have shown that grain size generally diminishes in the down-fan direction such that the distal portion of the fan at any time is composed of the finest sediments (i.e., silts and clays). Schumm et al. (1987) suggested that a sharp break in the slope profile near the toe of the fan marks the point at which the silts and clays are deposited. Deposition of the fines forms a clay-rich basal layer over which the fan progrades through time. Progradation of the fan results in coarser sediments being deposited over the basal layer and therefore, at a given location on the fan the grain-size coarsens upwards. The net result of this type of sedimentation pattern would be confined or semi-confined flow within the fan. Because of the nature of depositional processes on alluvial fans, depositional units are more continuous longitudinally than they are laterally (Schumm et al., 1987) and, therefore, it is likely that subsurface flows will tend to follow the depositional axis of the fan. Galloway et al. (1979) showed that on alluvial fans groundwater recharge on the upper fan surface takes place

as a result of direct precipitation or infiltration of stream discharge. Groundwater discharge occurs in the lower fan region.

In contrast to laterally unconfined fans, the floors of valleys in the semi-arid regions of the western U.S. can be comprised of semi-confined valley alluvial fans that prograde down-valley (Patton, 1973; Patton and Schumm, 1975; Bergstrom and Schumm, 1981; Harvey, 1980; Schumm and Hadley, 1957; Laird and Harvey, 1986). In these valleys the flat-appearing alluvial-valley floors are irregular in the downstream direction. The processes that operate on the valley fans are very similar to those that have been described for the classical alluvial fans in semi-arid areas (Bull, 1964a, b; Denny, 1965; Hooke, 1967, 1968a; Lustig, 1965).

2. SINK VALLEY GEOMORPHOLOGY

The geomorphological characteristics of Sink Valley can be divided into three areas of concern: (1) the morphological characteristics of the valley itself, (2) the morphological characteristics of the valley floor, and (3) the spatial distribution and continuity of channels within Sink Valley.

2.1. Morphologic Characteristics of Sink Valley

The shape of Sink Valley is atypical of that of a valley formed in a uniform lithologic setting by fluvial processes. It is very evident that the resistance to erosion of the rock formations (Fig. 1.1) that comprise the margins of the valley has affected the shape of the valley. The rock formations bordering the valley margins are shown in Figure 2.1. From up-valley to down-valley the valley margins are composed of rock formations that get progressively older (Fig. 1.1). The upper reach of Sink Valley at the confluence of Dry Fork and Water Canyon (Fig. 2.1) is narrow and the valley margins at the elevation of the valley floor are composed of resistant sandstones of the Straight Cliffs Formation. Valley width is about 300 feet. Tropic shale forms the basin boundary for almost the remainder of Sink Valley in the down-valley direction. Valley width within the confines of the Tropic Shale, increases from 900 feet at cross section I (Fig. 3.1) to 3200 feet at cross section IV (Fig. 3.1) and then decreases to about 700 feet at cross section VIII (Fig. 3.1). The Dakota Fm. crops out down-valley from cross section VIII, and the valley width at cross section IX

(Fig. 3.1) is about 500 feet. The reduced valley width at this location is due to the resistance of Dakota Fm.

Field observation and aerial photograph analysis indicates that the shape of Sink Valley within the area whose margins are composed of Tropic Shale is strongly influenced by mass failure of the Tropic Shale. The distribution of mass failures in the Tropic Shale is shown in Figure 2.1. The mass failures are probably related to the distribution of faults (Fig. 1.2). The presence of mass failures on the perimeter of Sink Valley explains why the valley shape is atypical, but it also suggests that mass failure-derived deposits should make up a high proportion of the valley fill of Sink Valley.

The western margin of Sink Valley from where Lower Robinson Creek traverses the low relief outcrop of Tropic Shale to the area to the west of Swapp ranch (Fig. 2.1) is very subdued topographically. The Tropic Shale ridge and isolated remnants of Tropic Shale at the mouth of Swapp Hollow indicate that badland topography had formed on the Tropic Shale in Sink Valley and in the Lower Robinson Creek drainage basin. The eastern flank of the Tropic Shale ridge between Lower Robinson Creek and Swapp ranch has been buried by down-valley progradation of a valley fan. The western flank of this ridge, which is located in the Lower Robinson Creek drainage basin, forms a fairly steep and well defined escarpment. The southern extremity of the ridge is completely buried by sediments, and no Tropic Shale outcrop is visible at the ground surface. In fact at this location sheetfloods that are generated up-valley bifurcate into both lower Sink Valley and Lower Robinson Creek drainage basin. The

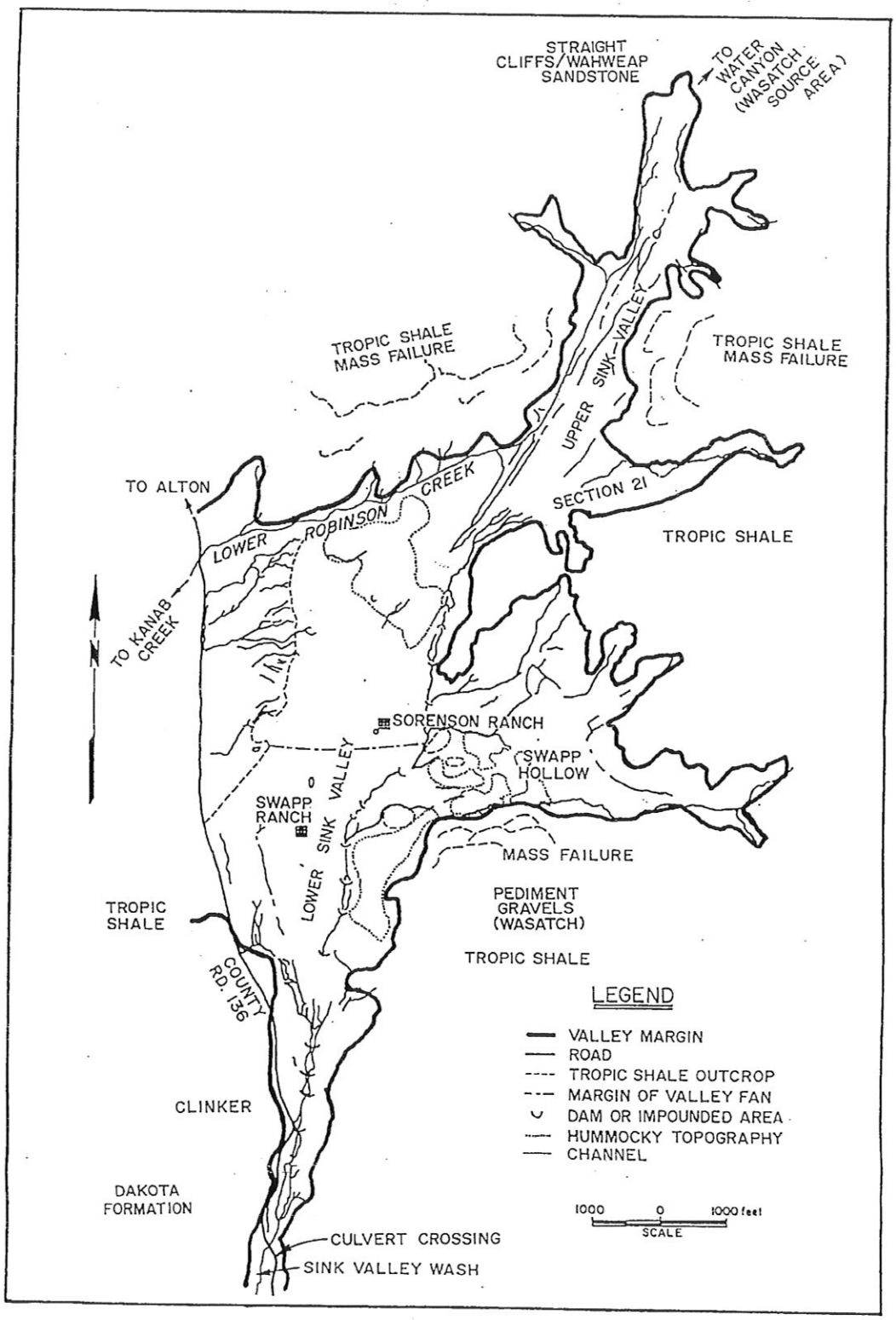

Figure 2.1. Map of significant features in Sink Valley.

western margin of Sink Valley has, therefore, been significantly modified by sedimentation in Sink Valley. The progradation of sediments onto the Tropic Shale outcrop has significantly affected the elevation of the water table within Sink Valley.

One further feature of the valley margin of Sink Valley has significant implications in terms of the valley fill sediments. A pediment surface is located on the south side of Swapp Hollow and it forms the eastern boundary of Sink Valley down-valley from the confluence with Swapp Hollow (Fig 2.1). The pediment was formed on Tropic Shale and it is capped by coarse-grained clasts that were originally derived from the Wasatch Formation. Mass failure of the Tropic Shale underlying the pediment and scarp retreat have introduced the coarse-grained Wasatch-derived clasts into Swapp Hollow and lower Sink Valley. Hillslope erosion processes and gullying of the valley walls are also introducing significant quantities of the coarse clasts to the floor of Sink Valley.

2.2. Valley Floor Morphology

The first indication that the floor of Sink Valley might be composed of a valley fan is seen on the Alton 7.5 min. Quadrangle (USGS, 1966). The 40-foot contour-interval map suggests that a fan-shaped body has prograded down valley from the confluence of Dry Fork and Water Canyon. Bull (1964) and Kochel and Johnson (1984) have demonstrated that there is a relationship between the size of the drainage basin and the surface area of the fan (Fig. 2.2). The fan area-drainage basin area

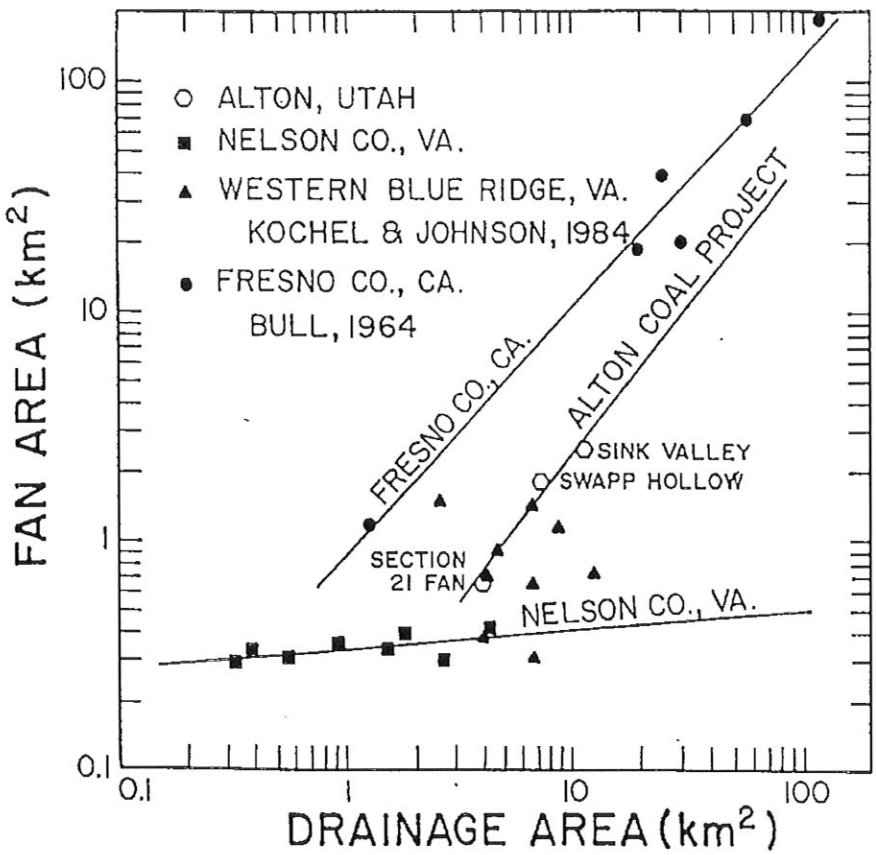

Figure 2.2. Plot of fan area versus drainage basin area for data sets from Fresno, CA, Nelson County, VA, and Sink Valley, Utah. (Figure modified from Kochel and Johnson, 1984).

relationships for three fans in the location of Sink Valley were determined from the USGS topographic map: (1) Sink Valley fan, (2) Section 21 fan, and (3) Swapp Hollow fan. These data were then plotted with the data from Bull (1964a) and Kochel and Johnson (1984) on Figure 2.2. The best-fit line for the Sink Valley data is sub-parallel to Bull's curve (Fresno, CA) and lies above the curve that fits the data for Nelson County, VA.

Two conclusions can be drawn from the data in Figure 2.2. First, there is a systematic relationship between fan and drainage basin areas in Sink Valley, which provides strong evidence that the floor of Sink Valley does contain a valley fan. The down-valley margin of the valley fan was determined from topographic and sedimentologic (Fig. 3.5) data (Fig. 2.1). It is evident that the valley fan is different morphologically from alluvial fans that were studied by previous investigators. The primary difference is one of shape. The conventional fan has a shape that is best described as a segment of a cone that radiates downslope from the point where the stream leaves the source area (Bull, 1977). The fan owes its existence to reduced confinement of the sediment and water discharges from the source area (Reading, 1978). However, the basic requirements for reduced confinement and a high supply of sediment are met in Sink Valley. Dry Fork and Water Canyon confluence in a reach of the valley whose width is narrow (~ 300 feet) and is controlled by outcrop of sandstones. Tropic Shale forms the valley margin down-valley from this location and the valley widens. The high sediment supply is derived primarily from the

Wasatch Formation in the Sunset Cliffs. The floor of Water Canyon is composed of numerous over-lapping debris flow deposits. Therefore, the confinement caused by the gradually widening valley has caused the fan to prograde down valley, but the fan area-drainage area relationship has been maintained. The rate of down-valley progradation of the fan must have been lower in the down-valley direction because the valley width increases significantly from about 300 feet at the head of the fan to about 3000 feet at the location of the fan toe at cross section V (Fig. 3.1).

The second conclusion that can be drawn from Figure 2.2 is that for a given drainage area the Sink Valley fans are larger than those in Nelson County, VA, but they are smaller than the ones in Fresno, CA. This may be due to differences in lithology of the source areas (Hadley and Schumm, 1961) but it may also be due to climatic differences. Mean annual precipitation at Alton, Utah is 16.56 ins. (CDM., 1987), which is intermediate between those in California and Virginia.

Longitudinal and cross-section profiles of Sink Valley were constructed from surveyed data to characterize the morphology of the valley floor. The longitudinal profile (Fig. 2.3) of the valley floor was constructed from the surveyed cross sections and the Alton Quadrangle. The profile extends from the base of the Sunset Cliffs in Water Canyon to cross section IX (Fig. 3.1). The irregular topography that is the result of the presence of over-lapping debris flow lobes in Water Canyon can be seen on the upper part of the profile. The profile of the valley floor shows clearly that the toe of the fan is located in

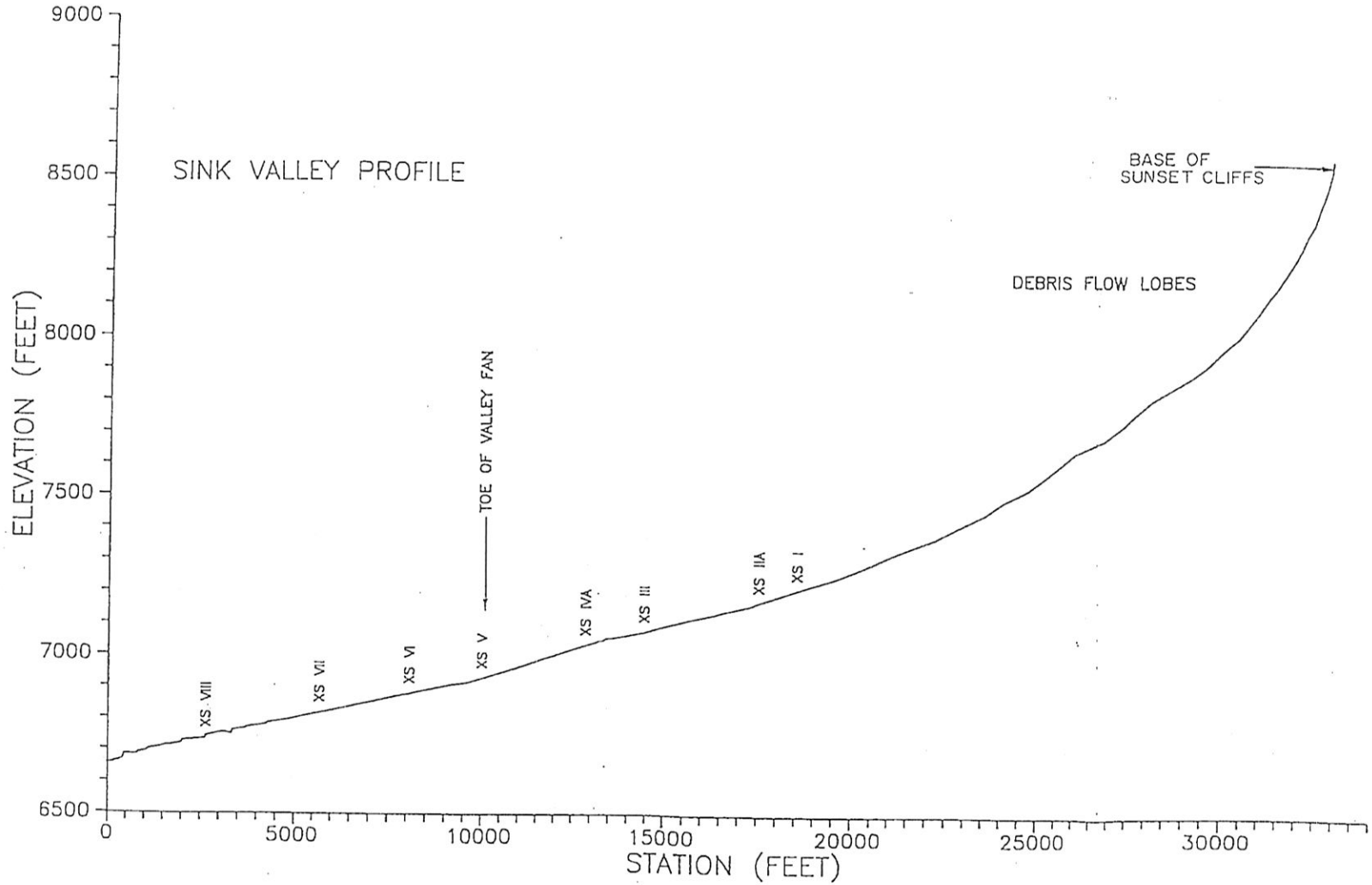

Figure 2.3. Longitudinal profile of Sink Valley showing the locations of surveyed cross sections.

the vicinity of cross section V, where there is a significant change in slope (Schumm et al., 1987). The crest of the fan is located between cross sections III and IVA.

The Sink Valley cross-section profiles (Fig. 2.4) further confirm the presence of a valley fan, and the effects on cross-section morphology of sediment contribution to the valley floor from valley margin hillslopes and tributary alluvial fans. The details of the cross-section morphology are more clearly seen on Drawings No. 1 to 9. Cross sections I and IIA show the irregularity of the valley floor in the upper fan region. Cross section III shows the cross-fan convexity very well, as does cross section IVA. Cross sections V and VI demonstrate that Swapp Hollow fan has prograded out onto the floor of Sink Valley. Valley wall contribution of sediment to the valley floor is clearly demonstrated in cross sections VII, VIII and IX.

2.3. Channels in Sink Valley

The locations of all the channels in Sink Valley are shown in Figure 2.1. With the exception of Lower Robinson Creek, Sink Valley Wash downstream of the culvert on County Road 136, and the incised former wagon road on the western margin of the lower reaches of the valley, the channels within Sink Valley are discontinuous. The majority of these channels have been either constructed, or modified, by local landowners. A number of the discontinuous channel segments are located on the eastern side of the valley between Section 21 tributary and the mouth of Swapp Hollow. These channel segments are located in areas that have

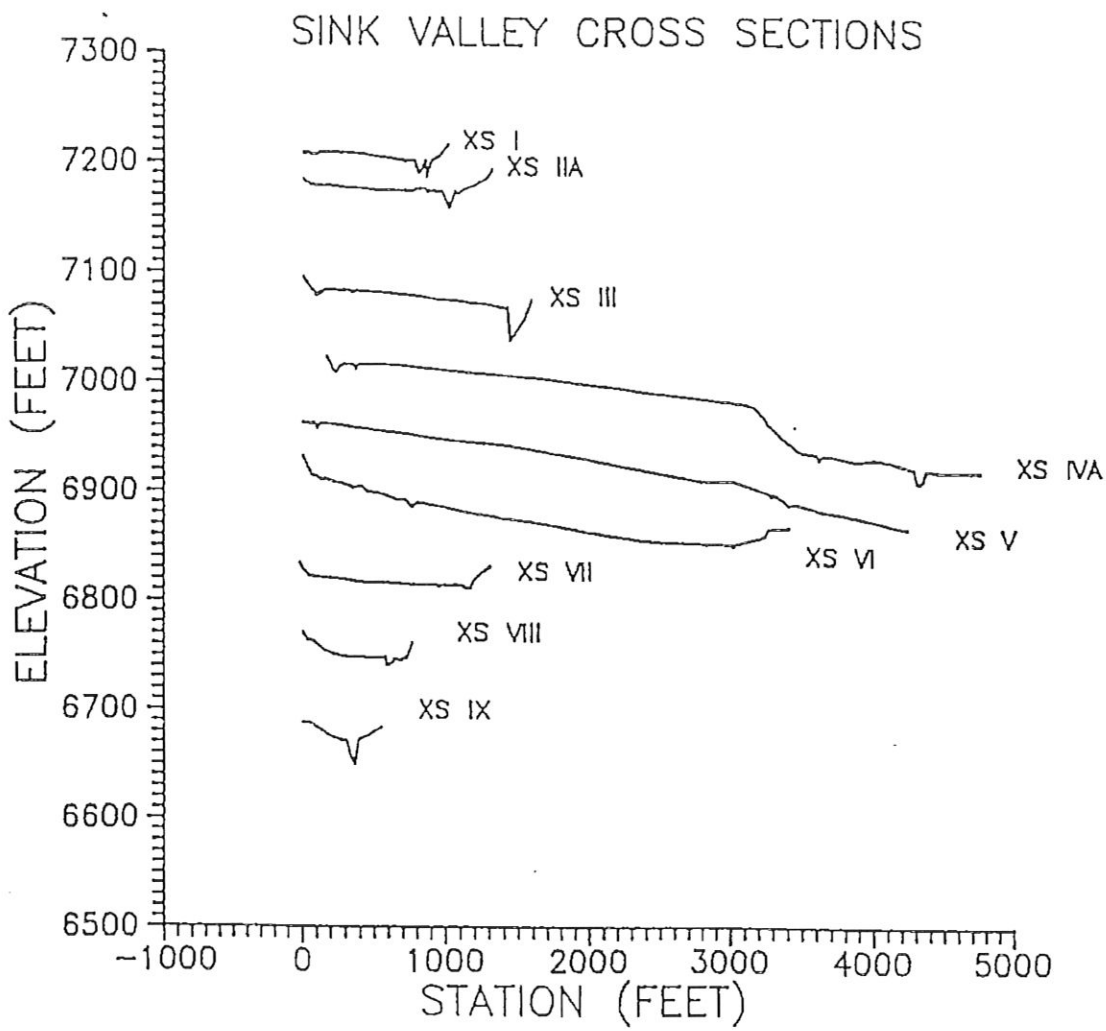

Figure 2.4. Cross-section profiles of Sink Valley.

been affected by localized sediment deposition on the medial part of the valley fan where aggradation and local oversteepening of the valley floor are to be expected (Harvey, 1987; Schumm et al., 1987). The presence of debris flow and mudflow deposits on the medial part of the fan can be expected to produce topographic irregularities on the valley floor which can lead to sheetflood concentration and, hence, the development of discontinuous gullies (Harvey 1984b). The absence of a continuous channel through Sink Valley is, therefore, further evidence that the valley floor is composed of a valley fan. The cross section profiles (Fig. 2.4: Drawings No. 1 to 9) show a strong cross-valley gradient to the west, and, therefore, if a channel was to be located through Sink Valley, it would be logical to find it towards the western part of the valley. Figure 2.1 shows that no such channel exists. Discontinuous channel segments are located on the valley floor south of the Swapp ranch where the valley narrows (Cross Section VI).

The incision of Kanab Creek (c. 1865) has significantly effected both Lower Robinson Creek and Sink Valley Wash by lowering their base levels which in turn has caused them to incise. The magnitude of the changes in these channels that was due to base level lowering can be seen by the changes that have taken place in Sink Valley Wash since 1876. Burrill (1876) states that Sink Creek, at a location that was down-valley from the culvert on County Road 136 (Fig. 2.1), was about 3 feet wide and 6 inches deep. In contrast the channel today is about 69 feet wide and 23 feet deep (see cross section IX, Fig. 2.4). There is little doubt that the culvert has prevented the bulk of the degradation

from migrating farther up-valley. However, the valley floor is being eroded by headcuts upstream of the culvert. Most of the headcut retreat appears to be related to sapping processes because of the high groundwater table. Undoubtedly when sheetfloods occur there is an element of surficial erosion of the gully headwalls.

The incision of Lower Robinson Creek has had a significant effect on both the sedimentology and morphology of Sink Valley, because Lower Robinson Creek has captured the headwaters of Sink Valley (Dry Fork and Water Canyon). Prior to capture the discharge from Sink Valley was delivered to Kanab Creek by Sink Valley Wash. Explicit evidence for the capture is provided by the sedimentological data.

There is no source of Wasatch-derived sediments in the pre-capture drainage basin of Lower Robinson Creek. Therefore, the Wasatch-derived sediments that were observed in the stratigraphic sections on the western end of cross section IVA (Figs. 2.4, 3.1) must have originated in Sink Valley. For these sediments to have been transported to Lower Robinson Creek drainage basin the divide between the two basins must have been overtopped. The intermittent presence of the Wasatch-derived sediments in the upper parts of the stratigraphic sections (measured sections #20, 14 , Fig. 3.1) indicates that this was not a continuous process, but rather it was related to discrete large magnitude events on the valley fan in Sink Valley. The fine-grained nature of the Wasatch-derived sediments indicates that they were fan margin sediments. Following incision of Lower Robinson Creek, and the burial of the eastern flank of the divide between the two basins by fan progradation,

floodflows that overtopped the divide would have been confined to the incised channel of Lower Robinson Creek. Flow confinement when coupled with the elevation difference between the top of the divide and the bed of the channel (approximately 60 feet; Fig. 2.4, cross section IVA) would have caused the channel to headcut through the divide, thereby initiating the capture of the Sink Valley headwaters.

The capture of the upper part of Sink Valley by Lower Robinson Creek has had significant effects on Sink Valley. First, following capture the discharge from the upper part of Sink Valley is now transported to Kanab Creek through Lower Robinson Creek which has reduced the discharge passing through Sink Valley. Second, the primary sediment source area for Sink Valley was Water Canyon. Capture has removed this source of sediments because the incised channel of Lower Robinson Creek at the confluence of Dry Fork and Water Canyon is now about 20 feet deep and 80 feet wide, and it is highly unlikely that there will be overbank discharge and sedimentation.

2.4. Summary of Geomorphological Characteristics of Sink Valley

The shape of Sink Valley and the valley widths are controlled by the resistance to erosion of the valley margin rock formations (Fig. 2.1). Where resistant formations (Straight Cliffs Fm., Dakota Fm.) crop out the valley is narrow (300 to 500 feet). Where the Tropic Shale crops out the valley is wide (700 to 3200 feet). Progradation of the valley fan has significantly modified the low relief western margin of Sink Valley. Mass failure of the Tropic Shale has contributed to the valley widening.

The presence of a valley fan within the floor of Sink Valley is confirmed by the valley floor topography. The longitudinal profile of the valley floor shows the presence of a fan-shaped body (Fig. 2.3), and the cross-sectional profiles show typical cross-fan shapes (Fig. 2.4). Confinement of the water and sediment discharges from upper Sink Valley has led to the down-valley progradation of a fan. The drainage area-fan area relationship developed by other investigators is supported by the Sink Valley data (Fig. 2.2).

No continuous channel that traverses the length of Sink Valley is present on the valley floor (Fig. 2.1). Discontinuous channel segments on the medial part of the fan are related to fan sedimentation. Base level lowering by the incision of Kanab Creek (c. 1865) has caused incision of both Sink Valley Wash and Lower Robinson Creek. Capture of the headwaters of Sink Valley by Lower Robinson Creek is attributable to both valley fan progradation in Sink Valley and incision of Lower Robinson Creek. The former eliminated the pre-existing drainage divide, and the latter caused sheetflood confinement into a single channel.

3. SINK VALLEY SEDIMENTOLOGY

In order to determine the sedimentologic characteristics of the valley fill deposits of Sink Valley, 9 cross sections (I to IX) were surveyed across the valley in orientations that are perpendicular to depositional strike (Fig. 3.1). Two cross sections (IIA, IVB) were surveyed across the mouths of tributary fans (Fig. 3.1). A total of 37 stratigraphic sections were measured and described along these cross sections; 5 on the banks of Lower Robinson Creek, 1 on the bank of Sink Valley Wash, and 31 in a total of 28 backhoe pits. The locations of the cross sections and measured stratigraphic sections are shown in Figure 3.1. Stratigraphic sections are compiled in Appendix I.

Measured stratigraphic sections are shown in relation to cross-sectional topography on the accompanying drawings, Nos. 1 to 9. All of the cross sections are oriented looking in a downvalley direction. Because the Cretaceous Tropic Formation weathers to dark brown silt and clay (10 YR 3/2 to 10 YR 4/4) whereas sediments derived from the Eocene Wasatch Formation are orange-red-brown in color (10 YR 5/4 to 10 YR 5/8) the two source areas were readily discernable in the valley fill stratigraphy. The Cretaceous sandstones are weakly cemented and hence do not resist chemical weathering as do the Wasatch sediments; as a result, the input of Cretaceous sandstone into Sink Valley generally consists of sands which are yellowish-grey in color (2.5Y 6/4).

The ability to delineate between Wasatch-derived, Tropic-derived, and Cretaceous sandstone-derived sediments is critical to the determination of sedimentation processes in Sink Valley. The Wasatch-

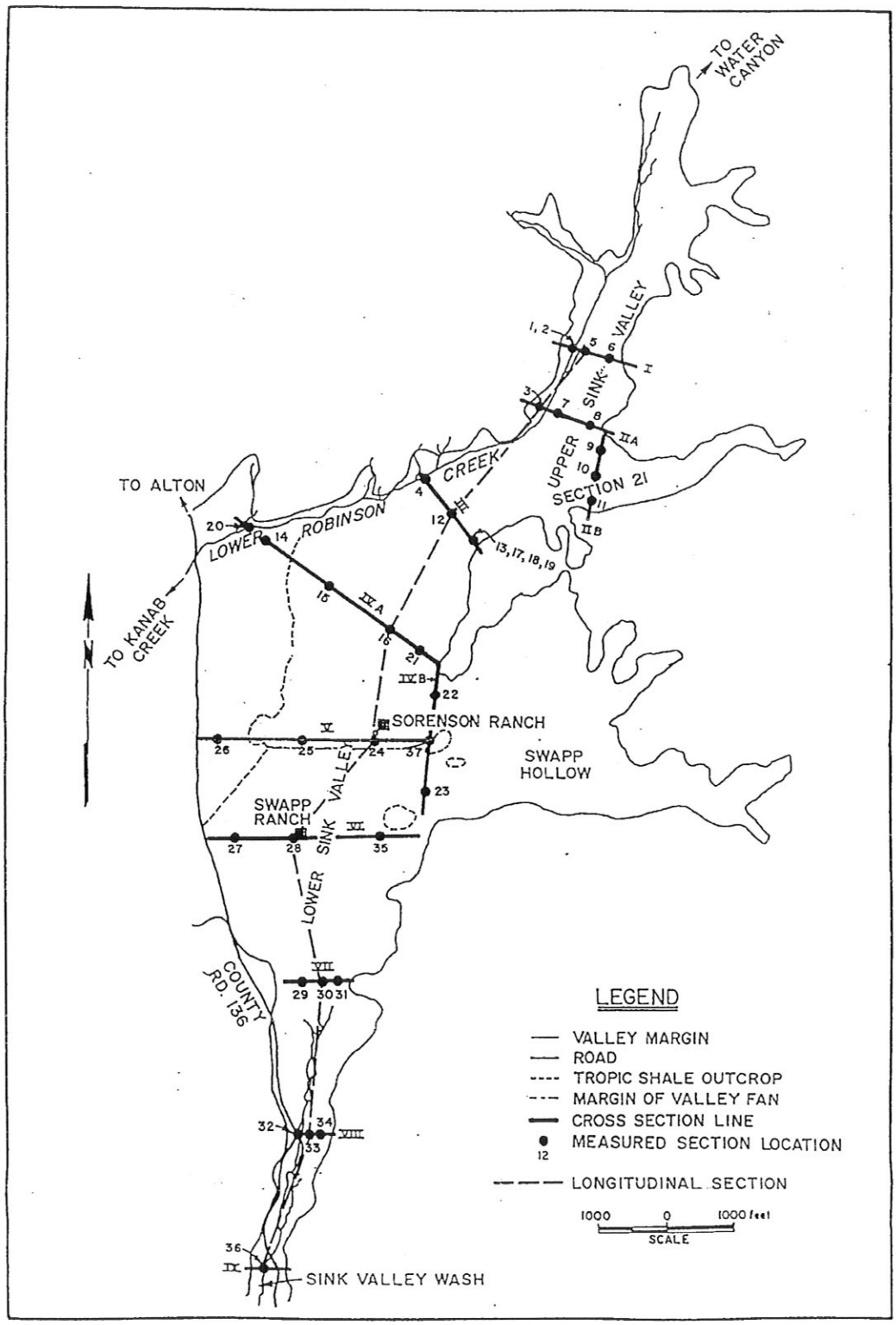

Figure 3.1. Locations of surveyed cross sections and measured stratigraphic sections in Sink Valley. Also shown is the longitudinal profile that was used to construct Figure 3.5.

derived sediments in Sink Valley have been transported downvalley, whereas Tropic-derived sediments reflect a lateral component of deposition from the valley margins and tributary fans. The intermixing of the two types of sediment in a single depositional unit is indicative of surficial reworking of the valley fill. Cretaceous sandstone-derived sediments are primarily introduced to the valley floor of Sink Valley by the tributary fans and by hillslope processes.

3.1. Cross Section I (Drawing No. 1)

Cross section (XS) I is located in the upper portion of Sink Valley, where the valley is less than 1000 feet wide (Fig. 3.1). The two stratigraphic sections measured along Lower Robinson Creek are shown on the west side of the valley. Lower Robinson Creek consists of two channels along XS I. The bifurcation point of the channel is located approximately 100 feet upstream of the cross-section line. The thalweg of the east channel, at measured section (MS) #2, is located approximately 4 feet higher than the thalweg of the channel at MS #1. Where the main channel bifurcates upstream, the abandoned east channel contains a high concentration of boulders which consist of Wasatch-derived limestone, quartzite and conglomerate, which represent the leading edge of a debris flow. The boulders probably influenced the re-routing of the channel into the relatively erodible fine-grained deposits to the west. Subsequent incision of the west channel has perched the channel to the east.

Although several boulders present in the perched east channel are rounded, there is no evidence of reworking via conventional fluvial

transport. The rounded clasts are derived from the basal conglomerate of the Wasatch Formation, hence rounding occurred prior to this depositional cycle.

Measured section #1, on the west channel of Lower Robinson Creek, contains Wasatch-derived sand and minor gravel at its base which is overlain by a thick sequence of Tropic-derived silt and clay. Minor amounts of Wasatch-derived clasts are present within the Tropic sediments. The section is capped by Wasatch-derived silty sand. The thick sequence of Tropic-derived sediments is not present in MS #1, 78 feet to the east. The lateral thinning to the east of the unit as well as a high concentration of charcoal and dispersed pebbles suggests that the unit is a mudflow deposit from the western valley margin. Similar deposits exposed on the valley margins have been described by Harvey and Schumm (1987). The incorporation of Wasatch-derived pebbles reflects transport of the silt and clay over Wasatch-derived sediments. The valley margin is evident on the west side of XS I (Drawing No. 1); at station 9+00 the ground surface rises on Tropic Shale. The break in slope at station 9+50 probably represents a contact between intact Tropic shale to the west and mass wasted material to the east.

The lateral transport of sediment into Sink Valley from the valley walls is evident on the east end of XS I in MS #6. The base of the section is composed of both Tropic Shale and clasts of Cretaceous-age sandstone. The size of the sandstone boulder in MS #6 is striking (800 mm), because the poorly cemented nature of the sandstones generally favors chemical versus mechanical weathering (i.e., the sandstones break

down close to their source). Thus the association of Tropic-derived silt and clay with large clasts of Cretaceous age sandstone is indicative of rapid transport from a proximal source. The mass wasting of a sandstone block onto a Tropic Shale slope followed by transport of weathered shale by mudflow processes into the valley, provides a likely scenario for the observed deposit. Alternatively, the sequence represents two events; the deposition of a mudflow carrying sandstone boulders followed by a rockfall of Cretaceous age sandstone. The top of MS #6 contains thinly interbedded sands and clays of local derivation. These units represent lateral slopewash from the eastern bounding topographic high.

The mid-valley area of XS I consists primarily of Wasatch-derived sediments that reflect a transport direction oriented downvalley. MS #5 contains two Wasatch-derived coarse-grained horizons. The upper unit consists of a chaotic assemblage of matrix supported sand to boulder sized sediments which reach 170 mm in diameter. The unit pinches out to the west. Similar deposits are present in the lower portions of MS #1, #2, and #5. The matrix supported, chaotic nature of these units indicate downvalley deposition of Wasatch-derived sediments via debris flows. The absence of internal stratification, normally-graded bedding, and sorting indicates that deposition was not the result of fluvial processes.

The remainder of the sediments depicted on XS I consist of thinly bedded, structureless sands, horizontally laminated sands, and silt/clay drapes; these units are commonly separated by mud (silt/clay) drapes,

and the sand-mud couplets reflect deposition by shallow flow depth discrete events. The Wasatch-derived sands represent deposition during shallow sheetfloods on the fan surface, whereas the drapes document sediment deposition during recessional flows. Due to the narrowness of Sink Valley, a result of the presence of bounding Tropic Shale outcrops, distinct fan-margin facies were not present in the stratigraphic sections of XS I. The primary axis of deposition may be located generally at midvalley, where thick Wasatch-derived debris flow deposits are present (MS #5). This tends to be confirmed by the absence of Tropic-derived sediments in MS #5.

Cross section I (Fig. 3.1) effectively shows the complexity of Sink Valley sedimentation. Wasatch-derived sediments record downvalley transport directions, whereas deposits of Tropic Shale-derived sediments indicate mass wasting, and possibly sheetflow, from the valley margins. The sedimentary sequences described indicate deposition on an alluvial fan which, in the vicinity of XS I, is laterally confined by bounding topographic highs. Sedimentation at XS I has been dominated by down-valley transport of Wasatch-derived sediments by debris flow and sheetflood processes. The ubiquity of charcoal in the sediments indicates that fire has been a significant morphogenetic agent in this drainage basin. Fires followed by significant precipitation frequently result in the occurrence of debris and mud flows (Laird and Harvey, 1986).

3.2. Cross Section IIA (Drawing No. 2)

Cross section IIA (Fig. 3.1) is characterized by a predominance of Wasatch-derived sediments which range from thin clay/silt drapes to thick coarse gravels. The coarsest material observed in XS IIA is located on the west side of the valley in the left bank of Lower Robinson Creek. There, MS #3 contains 18 continuous feet of Wasatch-derived sediments. The section contains a basal gravel which consists of very poorly sorted gravel in a sandy silt matrix which displays faint inverse grading. The unit is overlain by interbedded gravels, sands, and silt drapes. Thirty-two individual events are distinguishable from the drapes in the section. The sand layers commonly contain trough crossbeds or coarse/fine couplets. These units are indicative of deposition by sheetflood; the sands containing coarse/fine couplets reflect shallow water flooding over the fan surface (Blair, 1986) and small-scale cross bedded sands are suggestive of deposition within an array of small braided channels on the fan surface during flood events. Silt drapes record the recession of discrete flow events. The distinctly bedded, cyclic nature of the sediments in MS #3, coupled with the presence of debris flow and sheetflood deposits reflect a typical vertical sequence of alluvial fan sediments.

The sediments of XS IIA fine eastward from Lower Robinson Creek, and at MS #8, only fine grained thinly bedded units are present. The eastward thinning and fining of individual units is coupled with an increase in Tropic-derived sediments. This relationship is due to the off-axis location of the section, where Tropic-derived sediments from

the valley slopes have been incorporated into the fan margin. A substantial portion of the units in MS #7 and MS #8 contain intermixed Wasatch- and Tropic-derived sediments, that reflect downfan reworking of the deposits on the fan margin.

The increase in Tropic-derived sediment on the east side of XS IIA is also due to the convergence of an alluvial fan from the east side of Sink Valley (Fig. 3.1), just downvalley from XS IIA in the vicinity of Section 21 (herewith referred to as the Section 21 fan). The Section 21 fan sediments are derived primarily from Tropic Shale and Cretaceous sandstones (see XS IIB), and deposition due to progradation of the fan has modified the depositional environment at XS IIA. The coalescence of the two fans has produced a topographically low area in the vicinity of MS #8 where slack-water sedimentation has produced the multiple-event deposits that are seen at the top of the section.

At MS #7, the upper 36 inches of the section document the presence of a mudflow deposit that was probably generated from the Tropic Shale outcrops on the margins of the valley. The mudflow travelled to at least the center of the valley.

The depositional axis of the Sink Valley fan in the vicinity of XS IIA is located on the west side of the valley, at the present location of Lower Robinson Creek. Displacement of the axis towards the west valley margin is due probably to the coalesence of the valley fan with the Section 21 fan. The convergence of the fans on the eastern side of the valley has produced a topographically low area on XS IIB that has resulted in considerable slack-water sedimentation. Mudflows generated

from the valley walls have the ability to travel a considerable distance into the valley (Costa, 1988).

3.3. Cross Section IIB (Drawing No. 3)

The absence of Wasatch-derived sediments is strikingly evident in XS IIB (Fig. 3.1), which traverses the distal margin of the Section 21 fan. As the drainage basin of the Section 21 fan does not include outcrop of Wasatch Formation, the deposits are relatively fine grained and are composed of Tropic Shale and Cretaceous age sandstone-derived sediment.

Small discontinuous channel segments are shown on XS IIA. They are located in the medial and distal parts of the fan, where discontinuous channels are to be expected (Harvey, 1984b; Schumm et al., 1987). The stratigraphic evidence in MS #9, 10, and 11, support the presence of the small scale discontinuous channels. One channel fill is present in MS #9, 3 are present in MS #10, and one is present in MS #11. The greater number of small-scale channel deposits in MS #10 tends to suggest that MS #10 is located along the depositional axis of Section 21 fan. Mudflow deposits are present in each of the measured sections, with higher frequency near the fan margins (MS #9, 11). Sheetflood deposits that consist of horizontally laminated and structureless sands that are separated by fine-grained silt/clay drapes are present in the three vertical sequences along XS IIB. The presence of ripup clasts and mudballs in all three sections argue for widespread reworking of surficial sediments that dry and crack between events.

3.4. Cross Section III (Drawing No. 3)

Cross section III (Fig. 3.1), located just downvalley from Section 21 fan, displays the effect of detrital input from Section 21 on Sink Valley sediments. The amount of Tropic-derived sediment increases markedly from XS IIA. In addition, coarse debris flow deposits are distinctly bimodal, with Wasatch-derived clasts included in a Tropic-derived silt/clay matrix (MS #12). The increased availability of silt and clay-sized sediments increases the viscosity of debris flows and thereby increases rates of sediment transport for a given event (Costa, 1988). The 4 measured sections on the east side of XS III represent 4 different localities in a single backhoe pit. In this pit, a paleotopographic surface that had formed on Tropic-derived mass wasted or sheetwash sediments is documented in the basal portions of MS #13 and MS #17. Sediments to the west of this surface are in tangential contact (i.e., lap onto) the Tropic-derived deposit. MS #17, MS #18, and MS #19 depict a convex paraconglomeratic unit which has eroded out a Tropic derived drape in MS #18. Sheetflood and minor channel features are common in the sand units in the four sections.

Measured sections #13, 17, 18 and 19 characterize the environment of deposition at this valley fan margin locality which is influenced by sediments that are derived from three sources; the valley wall, Section 21 fan and the valley fan. Sediments derived from the valley wall are characterized predominantly by fine-grained, Tropic-derived hillslope sheetwash and mudflow deposits. Mudflow and debris flow deposits that are derived from both the Wasatch source area and Section 21 fan make

up a significant portion of the sediments. Sheetflood deposits that include minor small-scale channel fills are generated by unconfined flood flows that are generated in the headwaters of both the valley fan and Section 21 fan drainage basins. Discontinuous channels are present on the eastern margin of XS III, and their presence is related to the relatively high rates of sedimentation at this locale, the result of sediment deposition from multiple source areas. The cross section demonstrates that the area around MS #13, 17, 18, 19, where the discontinuous channels are present, is a topographic high which indicates that the local valley slope is oversteepened and, it is, therefore, a logical location to find discontinuous gullies on a fan (Schumm, 1977; Schumm et al., 1987; Harvey, 1987).

The depositional axis of the valley fan at XS III is represented by MS #12. The stratigraphic column is dominated by debris flow and mudflow deposits that are separated by sheetflood deposits. The mudflow deposits can be subdivided on the basis of their sources. Where Wasatch-derived clasts are present, it is probable that the source area for the mudflow was Section 21 fan area, because the Wasatch-derived sediments were probably incorporated into the mudflow during the event. The source area for the Wasatch-derived clasts would have been the valley fan surface. In contrast, the mudflow deposits that do not contain appreciable quantities of Wasatch-derived clasts were probably generated on the eastern valley margin. Debris flow deposits contain sediments that were derived from both the Tropic Shale and the Wasatch Fm.

Both debris flows and mudflows produce irregular, hummocky terrain, and it is highly likely that this irregular terrain is responsible for producing some of the minor channel fills in the predominantly unconfined sheetflood deposits that cover the debris flow and mudflow deposits (Harvey, 1984b). Significant areas of hummocky terrain are located on the valley fan south of XS III. The spatial distribution of the coarser debris flow deposits is highlighted by the distribution of Gambol's oak (scrub oak) which has a preference for coarser grained deposits (Ed. Mogren, Forestry Department, Colorado State University, pers. comm).

During this field investigation one of the debris flow lobes that was located in the vicinity of XS III was mapped with a hip-chain and Brunton compass (Fig. 3.2). Raised ridges within the mapped lobe represent debris flow levees, and it was on the levees that very coarse grained cobble to boulder-size clasts were observed. Nineteen of the larger clasts were measured (Table 3.1), so that critical bottom velocity values (U.S.B.R., 1978) for initiation of motion under fluvial transport conditions could be calculated. For the range of clasts (b axis) in Table 3.1, the required bottom velocities ranged from 6.0 to 11.8 ft/sec. These velocities, which are conservative, are extreme for fluvial channels and therefore, it is unlikely that the clasts were deposited under fluvial conditions.

On the west side of XS III, the upper left bank of Lower Robinson Creek (MS #4) is characterized by thinly inter-bedded fine grained Wasatch- and Tropic-derived sediments which are indicative of a fan

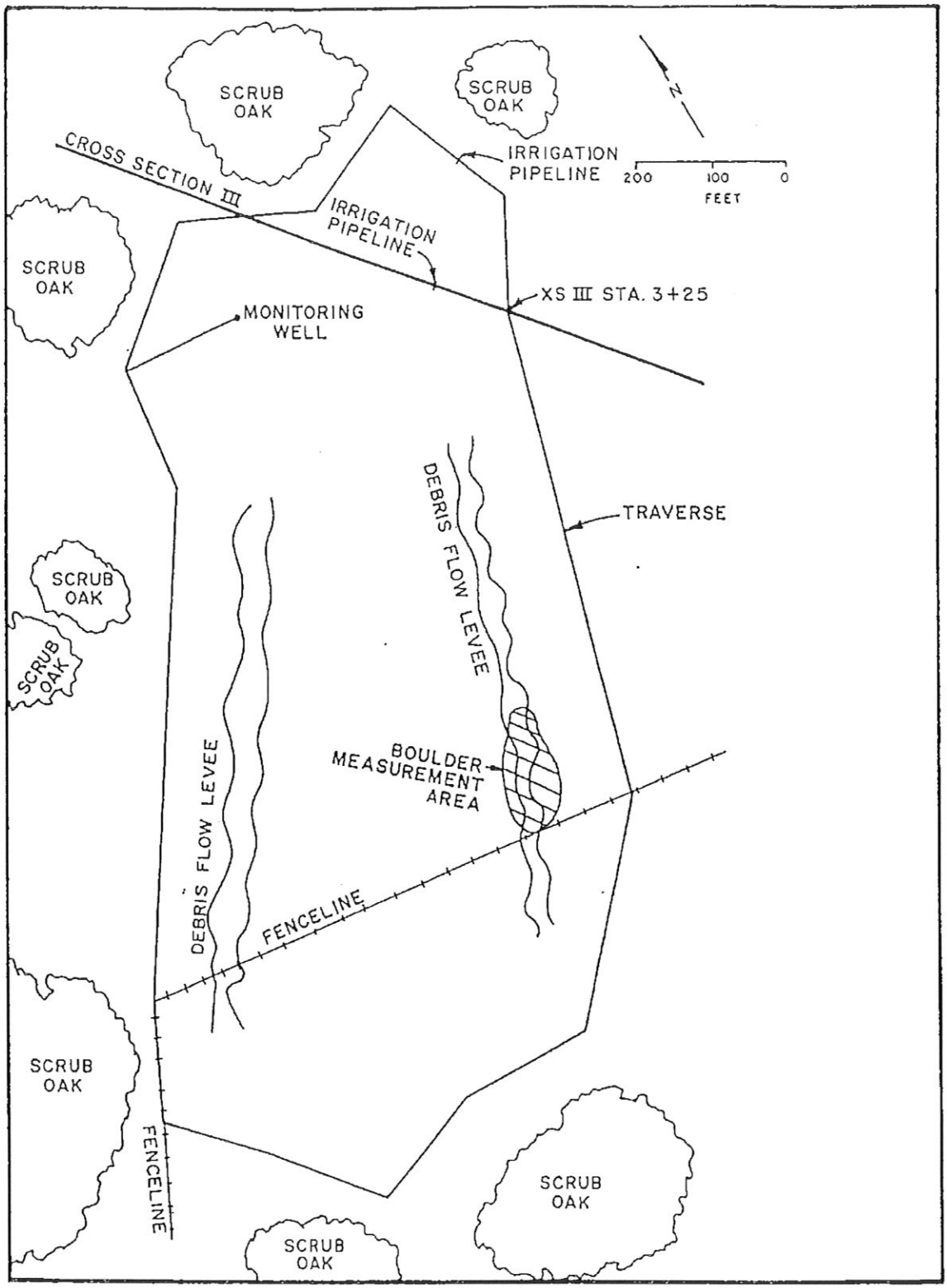

Figure 3.2. Map constructed from a Hip-Chain and Brunton compass survey of a debris flow lobe on the surface of Sink Valley.

Table 3.1. Boulder measurements on Sink Valley fan south of Cross Section III.

Sample No.	Clast Axes Dimensions (mm) A	B	C	Bottom[1] Velocity (ft/sec.)	Clast Lithology
1	320	160	90	6.7	sandstone
2	240	150	130	6.5	limestone
3	320	250	160	8.5	sandstone
4	230	190	150	7.3	sandstone
5	300	150	100	6.5	limestone
6	240	130	95	6.0	conglomerate
7	430	170	buried	7.0	sandstone
8	220	160	130	6.7	limestone
9	290	250	170	8.5	conglomerate
10	230	190	170	7.3	limestone
11	280	220	110	7.8	sandstone
12	290	170	130	7.0	conglomerate
13	330	190	130	7.3	limestone
14	400	260	200	8.6	sandstone
15	500	350	buried	9.8	sandstone
16	420	240	170	8.4	sandstone
17	330	210	180	7.6	limestone
18	480	310	260	9.4	conglomerate
19	700	500	240	11.8	sandstone

[1] Calculated from USBR (1978) using b axis diameter.

margin environment of deposition. A distinct cyclicity in the column reflects repeated relatively low energy deposition far off the axis of valley fan deposition (MS #12). The Wasatch-derived sediments of MS #4 are present only in the left bank of the channel; the right bank consists of only Tropic-derived sediments. Consequently, MS #4 is located at the extreme western margin of the Sink Valley Fan. This is supported by both topographic and sedimentologic evidence. Cross section III profile shows that the top of MS #4 represents the lowest elevation on the pre-incision cross section. This is consistent with a fan margin location because the cross profile of a fan in the medial location generally is convex (Bull, 1964b; Schumm et al., 1987). Sedimentologically, the evidence for a fan margin environment of deposition at MS #4 is fourfold. First, a comparison of grain size between MS #12 (depositional axis) and MS #4 shows that the sediments in MS #4 are much finer grained which can be expected in a fan margin environment (Rust and Koster, 1984). Second, a comparison of the grain sizes in MS #3 (XS II2A) and MS #4 also shows that the sediments in MS #4 are finer, which can be expected as one proceeds down-fan, (Blissenbach, 1954; Bull, 1964b; Rust and Koster, 1984). The third line of evidence for a fan margin environment of deposition at MS #4 is provided by the interbedding of Tropic Shale-derived and Wasatch-derived sediments. Sediments from both sources are fine grained and, therefore, it is unlikely that the Tropic-derived sediments originated from the eastern valley margin in the form of mudflows (c.f. MS #12).

The final piece of evidence that the sediments in MS #4 represent a valley margin environment of deposition is provided by the nature of the

contact between the Tropic-derived basal sediments and the overlying interbedded Tropic-derived and Wasatch-derived sediments that comprise the upper 6 feet of the section. Without doubt the Tropic Shale outcrop that forms the valley wall on the north side of Lower Robinson Creek is retreating today as a result of both mass wasting and sheet erosion processes, and there is no reason to believe that these processes were not active historically. Prior to the incision of Lower Robinson Creek, and progradation of the valley fan, channelized flow occurred from the Tropic Shale outcrop, across what is now Lower Robinson Creek, and southward into Sink Valley. Evidence for this is channel-shaped scour surfaces within the Tropic-derived basal sediments exposed in the banks of the left bank of Lower Robinson Creek (Fig. 3.3). The scour surfaces are oriented perpendicular to the present channel of lower Robinson Creek and prior to filling by the fan margin sediments it is likely that badland topography was present. The scoured channels have been filled by sediments derived from both the Tropic Shale and the Wasatch Formation. The interbedding of Tropic-derived and Wasatch-derived sediments in the upper part of MS #4 argues for discrete valley slope and valley fan events. On the slopes sheetwash was the transport mechanism whereas sheetfloods transported the sediments on the valley fan. Since there is no source of Wasatch Formation sediments on the north side of Lower Robinson Creek, the paleo-flow direction of the Wasatch-derived sediments must have been parallel or sub-parallel to the present course of Lower Robinson Creek, which makes the flow direction and, therefore, the direction of valley fan progradation sub-parallel to the depositional axis of the valley fan (MS #12).

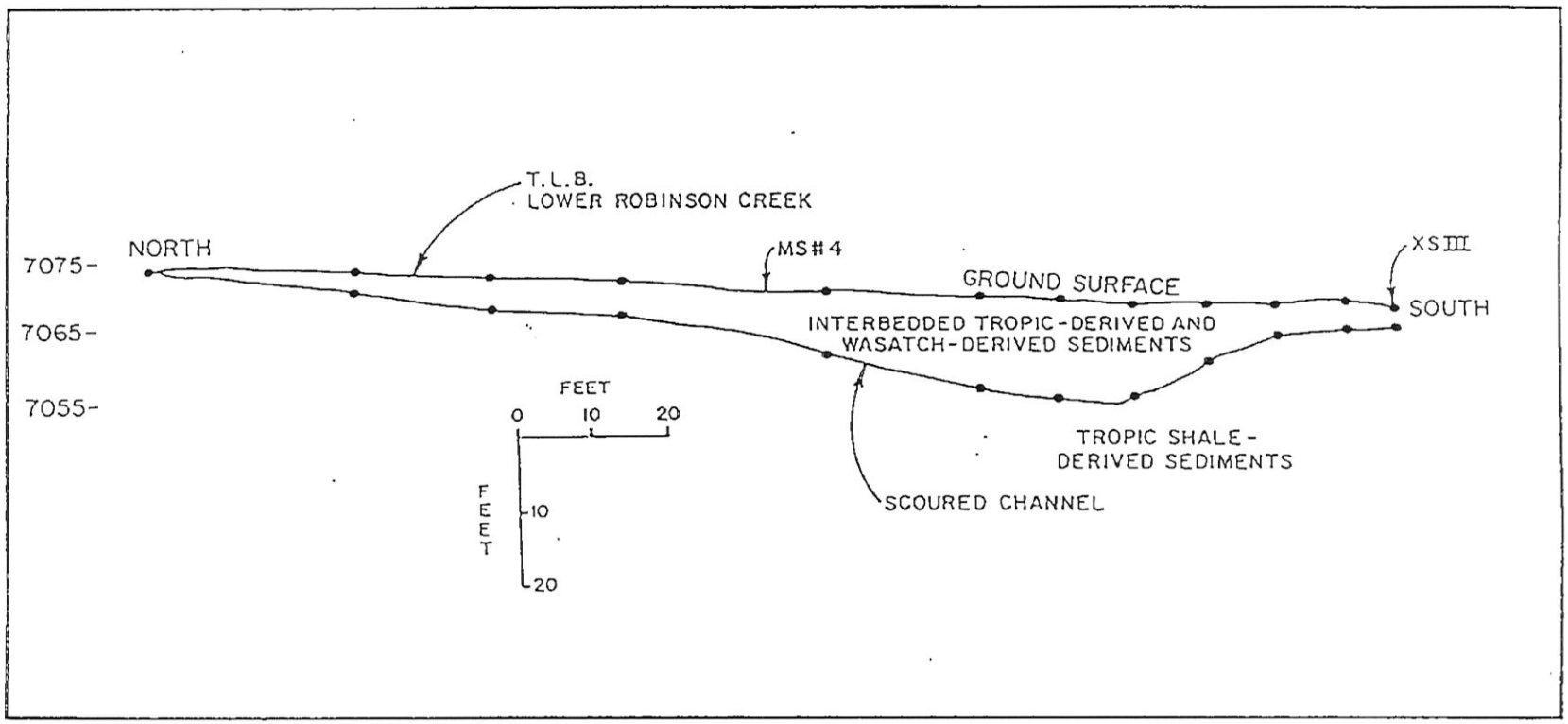

Figure 3.3. Cross section profile of a filled paleo-channel in the bank of Lower Robinson Creek in the vicinity of cross section III.

The measured sections along XS III provide very strong evidence to support the presence of a valley fan in Sink Valley. Sheetwash or mudflow deposits from the valley slopes contribute significantly to the valley fill on both the western (MS #4) and eastern (MS #13, 17, 18, 19) margins of the fan. The depositional axis of the valley fan contains significant mudflow and debris flow deposits which are characteristic of semi-arid fan sediments (Beaty, 1970). Sheetflood deposits and minor channel fills are deposited as a result of relatively shallow and unconfined flows. The absence of any laterally continuous channel deposits argues against the presence of a single major channel on the fan. Instead, it is highly likely that small discontinuous channels typical of the medial fan environment were present. The channels could originate as a result of local oversteepening of the valley floor due to high rates of local deposition (i.e., discontinuous gullies) or they could be the result of topographic irregularities caused by debris flow and mudflow deposits. The presence of a badland paleo-topography draining south into Sink Valley from the area to the north of the present location of the incised channel of Lower Robinson Creek is strong evidence that the valley fan prograded down valley and smoothed the topography. The presence on the fan surface of large cobble to boulder size clasts (Table 3.1) further argues for a non-fluvial transport mechanism.

3.5. Cross Section IVA (Drawing No. 4)

Cross Section IVA crosses the Tropic Shale ridge as shown in Figure 3.1. Due to the infilling of Sink Valley as a result of valley fan progradation, the ridge is characterized topographically by an escarpment which separates Sink Valley to the east and the lower Robinson Creek drainage to the west. The escarpment is approximately 50 feet high on XS IVA. The incision of Lower Robinson Creek through the north end of the ridge occurred just upvalley from XS IVA.

The two measured sections on the west side of XS IVA, MS #14 and MS #20, document the predominance of sheetwash transported, Tropic Shale-derived sediments in the Lower Robinson Creek drainage basin prior to capture of the upper drainage basin of Sink Valley. The presence of Wasatch-derived sediments records the overtopping by the Sink Valley fan of the Tropic ridge. Thus, two distinct sedimentologic phases are depicted within these sections. One is the initial overtopping of the Tropic ridge by the prograding valley fan, marked by the lowermost horizon of Wasatch-derived sand in MS #20. The second event recorded is the incision of Lower Robinson Creek and capture of a portion of the Sink Valley drainage basin. Following capture, the source of the Wasatch-derived sediments was removed from the valley fan as materials were transported down the new drainage. This event is stratigraphically located at the top of the section, because following capture by the incised channel of Lower Robinson Creek, it is highly unlikely that Wasatch-derived sediments could be deposited at the top of the section because of the depth of incision.

At the center of XS IVA, approximately 600 feet to the east of the Tropic ridge escarpment, the hydrologic complexity of Sink Valley becomes evident as the level of the water table is higher than the bottom of the backhoe pit. This emergence of groundwater is related to the impingement of the prograding valley fan sediments onto relatively impermeable Tropic Shale. In addition, the fine grained nature of the sediments overlying the water saturated horizon are indicative of both the down-fan fining of grain size and the fact that MS #15 is located off the major axis of fan deposition (MS #16) at the fan margin.

Measured Section #16 of XS IVA which is located towards the eastern side of the fan contains an excellent example of a debris flow deposit which was exposed in 3 dimensions in the backhoe pit. The coarse unit consists entirely of Wasatch-derived sediments which include boulders which reach 400 mm in diameter. The unit is matrix supported, very poorly sorted, and chaotic. The monolithologic nature of the unit suggests that it records a very large event which traversed a great deal of Sink Valley without being reworked and subsequently diluted by the inclusion of Tropic-derived silts and clays. The high frequency of debris flow and mudflow deposits in MS #16 indicates that the measured section represents the depositional axis of the valley fan. The vertical sequence is typical of a prograding fan in that it initially coarsens upwards and then fines upwards. The lowermost sediments probably represent fine grained fan toe deposits (Schumm et al., 1987). The debris flow and mudflow sediments represent progradation of a medial fan environment, and the upper sheetflood deposits represent deposition

on the back-slope of the fan crest. The mudflow deposits were probably generated from the Tropic Shale on the eastern valley margin. Minor channel fills within the section are located above and below debris flow deposits which tends to indicate that the debris flow deposits caused some channelization of the sheetfloods.

The east side of XS IVA consists of a section (MS #21) that contains laterally continuous, thinly bedded, fine grained deposits which are very similar to those of MS #8 on the east side of XS IIA. The two stratigraphic sections represent similar depositional sub-environments as they are both located up-valley of the point of coalescence between two alluvial fans. Both sections contain deposits indicative of low energy slackwater sedimentation. Consequently, each of the two alluvial fans which enter Sink Valley from the east (Section 21 and Swapp Hollow) must have produced sufficient sediment to prograde out onto the floor of Sink Valley, thereby creating a topographic depression which favored slackwater sedimentation.

The sedimentologic record preserved in the measured sections on XS IVA documents the down-valley progradation of the valley fan and it also highlights the role of the tributary fans. Progradation of the valley fan onto the Tropic Shale ridge, and the subsequent overtopping of the ridge are documented in MS #20 and MS #14. Both of these sections provide stratigraphic evidence that constrains the time of capture by Lower Robinson Creek of the upper drainage basin of Sink Valley, to within the period of time that Kanab Creek degraded (i.e., 1865). The fine grained and saturated sediments in MS #15 document the progradation

of the valley fan margin onto the Tropic Shale ridge and its effects on the elevation of the water table. MS #16 is located on the crest of the valley fan and it represents the axis of deposition which is characterized by a high frequency of debris flow and mudflow deposits. Progradation of Swapp Hollow fan onto the floor of Sink Valley created a topographically low area on the eastern margin of the valley fan that favored fine grained slackwater sedimentation (MS #21).

Cross section IVA (Fig. 3.1) shows an overall increase in the ratio of Tropic- to Wasatch-derived sediments relative to sections up-valley. Deposits are generally finer grained, although coarser horizons record large debris flow events. The combination of the down-valley transition towards the fan toe deposits with the onlapping of these fine sediments onto an impermeable bedrock ridge has induced the emergence of groundwater high in the stratigraphic section.

3.6. Cross Section IVB (Drawing No. 5)

Cross Section IVB (Fig. 3.1) traverses the mouth of Swapp Hollow fan from north (MS #22) to south (MS #23). Tropic-derived silts and clays constitute the majority of the sediments observed, however significant quantities of Wasatch-derived and Cretaceous sandstone-derived sediments are present as well. The Wasatch-derived sediments may have been emplaced from two sources. The finer grained sediments may represent sheetflood deposits formed as a result of large floods on the valley fan overtopping the toe of Swapp Hollow fan. The coarser grained sediments are derived from the pediment gravels that cap the Tropic Shale outcrop

to the east. Retreat of the Tropic Shale valley margins due to mass failure and gullying is delivering significant quantities of Wasatch-derived clasts to the valley floor.

An erosional remnant of Tropic Shale is present in the center of XS IVB. This outcrop is representative of the subsurface configuration of Sink Valley; the deposition of alluvial fan sediments has occurred on a surface of significant pre-existing relief. This shale is capped by pediment gravels which provide a local source of coarse rounded clasts, primarily limestone and quartzite of the Wasatch Formation.

In general the sediments exposed in the measured sections on XS IVB are fine grained and probably reflect the fine-grained nature of the proximal source rocks. Charcoal is abundantly distributed throughout the sections which indicates that fires have significantly affected fan sedimentation. The deposits in MS #22 reflect the predominance of local slope processes. The basal portion of MS #37 is composed of significant sheetflood deposits, but the upper portion contains significant mudflow deposits that include locally derived Wasatch clasts. MS #23 reflects mass failures of the Tropic Shale sediment on the south side of Swapp Hollow. The frequency of debris flow and mudflow deposits is higher in the upper portion of MS #37 and this probably correlates with the observed fairly recent mass failure deposits that are located up-fan from MS #23.

3.7. Cross Section V (Drawing No. 6)

Cross section V extends from the Lower Robinson Creek drainage basin in the west to the mouth of Swapp Hollow in the east (Fig. 3.1). The eastern end of the cross section is tied into MS #37 on XS IVB. This cross section provides further evidence for progradation of the valley fan and its effects on modifying pre-existing relief and drainage basin divides. Further, the effects of Swapp Hollow fan on the topography and sedimentologic characteristics of the valley floor are evident on this cross section. The sedimentologic evidence indicates that the toe of the valley fan is located in the vicinity of XS V, and this is supported by the valley slope and profile data (Fig. 2.3).

Measured section #26 documents the overtopping of the Tropic Shale ridge that formerly was the drainage divide between the Lower Robinson Creek drainage basin and Sink Valley drainage basin. The basal portion of MS #26 contains sediments that were primarily derived from the Lower Robinson Creek drainage basin prior to overtopping of the Tropic Shale divide. The coarser sandstone clasts were probably derived from local outcrops of the Dakota Formation. Wasatch-derived sediments document the down valley progradation of the valley fan. The upper portion of MS #26 is composed primarily of locally derived Tropic Shale sediments (sheetwash and mudflows), but the presence of Wasatch-derived sediments indicates that sheetfloods still transport valley fan sediments into this location. The sheetfloods that are generated up-valley split at a location between MS #26 and MS #27 because sedimentation has removed the divide between Sink Valley and Robinson Creek drainage basins. Part of

the flow and sediment travels down Sink Valley and the remainder enters the Lower Robinson Creek basin and is delivered to MS #26.

Measured section #25 is comprised mainly of finer-grained sediments that were deposited by sheetfloods in the distal portion of the valley fan (i.e., fan toe). The stratigraphic section shows an initial coarsening upwards trend followed by a fining upwards trend in the grain size. The sediments are dominantly Cretaceous sandstone-derived which suggests that Swapp Hollow was the source area. This tends to be supported by the cross section profile which dips fairly steeply to the west. The basal section of MS #25 is water saturated and this probably reflects the fact that sediments have prograded onto the Tropic Shale ridge at this location, a situation which is analogous to that at MS #15 (XS IVA).

Measured section #24 represents the depositional axis of the valley fan in a distal location. The sediments were transported down the valley fan and from Swapp Hollow fan. The basal portion of MS #24 contains mudflow deposits that appear to have originated from Swapp Hollow because they contain almost no Wasatch-derived sediments. Farther up section Cretaceous sandstone-derived sediments became more common and they consist of alternating horizontally laminated sand and drape units which are typical of discrete sheetflood events. The drapes tend to be composed of Wasatch-derived sediments. The interbedding of the sediments from the two source areas suggests that the mid section sediments represent events on both the valley fan and Swapp Hollow fan. The upper part of the section appears to be dominated by sheetflood and

mudflow sediments from Swapp Hollow, and this may be due to two causes. First, Swapp Hollow is proximally located with respect to the location of MS #24 and, therefore, it can be expected to exert considerable influence. Second, the relatively minor contribution of Wasatch-derived sediments may reflect the capture of the upper Sink Valley drainage basin by Lower Robinson Creek, thereby removing the source area.

The basal portion of MS #24 was water saturated. The reasons for the relatively high water table in MS #24 may be somewhat different from those responsible for the high water table in MS #25 and MS# 15. The high water table at the latter locations appear to be the result of fan margin sediments lapping onto impermeable Tropic Shale outcrop. The situation at MS #24 can probably be explained in terms of the fan dynamics and possibly by the geomorphic history of Sink Valley. The finest sediments on a prograding alluvial fan are located in the distal portion of the fan (Schumm et al., 1987). As the fan progrades coarser sediments are laid down over the silt-clay basal layer and, therefore, a perched water table can be formed. Groundwater tends to follow the depositional axis of the fan (Galloway et al., 1979) because depositional units are more continuous longitudinally than they are laterally (Schumm et al., 1987). Groundwater recharge takes place up-fan and discharge takes place in the lower fan region.

The high water table in MS #24 may also be related to the retreat of the valley margins. Isolated Tropic Shale remnants are located at the mouth of Swapp Hollow and there is little doubt that the Tropic Shale underlain pediment on the south side of Swapp Hollow is retreating

today. It is, therefore, conceivable that paleo-topography exists beneath the valley floor in the general location of MS # 24, and it is this relief that is causing the high water table. In this case the situations at MS #15, MS # 25 and MS #24 would be similar.

The eastern end of XS V is marked by MS #37 which has already been described (XS IVB). The basal part of the section is dominated by sheetflood deposits and the upper portion by mudflow deposits.

Cross section V (Fig. 3.1) is important as it documents the location of the toe of the valley fan and the progradation of the fan which resulted in elimination of the low-relief divide between Lower Robinson Creek drainage basin and Sink Valley drainage basin. The cross section profile, which dips to the west, indicates that significant cross-valley sediment transport has occurred from the Swapp Hollow drainage basin. All of the measured sections document the diminishing amount of Wasatch-derived sediments and the corresponding increase in the amount of Tropic-derived and Cretaceous sandstone-derived sediment. Further, the Wasatch-derived sediments are much finer than those encountered farther up-fan. The rather rapid dimunition of the size of the Wasatch-derived sediments and their reduced volumes in the stratigraphic sections argue very strongly for a non-channelized flow origin for the sediments along XS V. The coarse Wasatch-derived clasts in MS #37 were locally derived from pediment gravels that cap the Tropic Shale.

3.8. Cross Section VI (Drawing No. 7)

Cross section VI trends in an east-west direction across Swapp Ranch, and it is located where Sink Valley begins to narrow (Fig. 3.1). The western valley margin intersects outcrop of Tropic Shale, hence XS VI lies completely within the Sink Valley drainage basin. The narrowing of Sink Valley in the location of XS VI means that the valley slopes are contributing significant quantities of sediment to the valley floor and this is expressed in the stratigraphic sections.

Measured section #27 is located on the western margin of the cross section in the topographically lowest part of the cross section. Small discontinuous gullies are present on the valley floor and this probably reflects the confinement of the sheetfloods by the narrower valley. The sediments in MS #27 are fine grained and they reflect sheetwash deposition from the Tropic Shale outcrop to the west and sheetflood deposition from a down-valley direction. MS #27 is located south of the area where sheetfloods bifurcate into Lower Robinson Creek drainage basin and into Sink Valley. The interbedding of fine-grained Tropic-derived and predominantly Wasatch-derived sediments can probably be related to hillslope and valley events. Saturation of the basal part of MS #27 is probably due to the emergence of valley fan groundwater down valley from the toe of the fan and to the fact that sediments in MS #27 lap onto the Tropic Shale basin boundary.

Measured section #28 is located in the approximate center of the valley, and, therefore, it probably is representative of the depositional axis of the valley. Although it is located in the center

of the valley it is apparent that sediments derived from the eastern valley margin have significantly affected the sedimentological characteristics of the valley fill. The topographic cross section which dips to the west strongly confirms the observation. The basal part of the section is composed of horizontally laminated sands derived from Cretaceous sandstones in Swapp Hollow. The most noticeable depositional unit in MS #28 is the large, matrix supported debris flow deposit. The relatively coarse-grained Wasatch-derived sediments originated from the pediment gravels on the eastern valley margin. The generally coarser sediments in MS #28 probably can be attributed to the progradation of a lobe of Swapp Hollow fan onto the valley floor. This is supported by the cross section profile which shows a relatively steep (0.03) cross-valley gradient between MS #28 and MS #35. A relatively high water table was observed in MS #28, and it appeared to be perched on top of a mudflow deposit. Flow rates into the pit were very high.

Measured section #35 appears to be located on a former lobe of Swapp Hollow fan. Abandonment of this lobe may be related to the presence of the mass failure debris that is located up-fan on the southern margin of Swapp Hollow fan. The basal part of the section contains a mudflow deposit that is overlain by numerous sheetflood deposits that contain minor small-scale channel fills. Debris flow and mudflow deposits predominate in the upper part of the section. The coarse Wasatch-derived clasts must have been derived from the eroding hillslopes that form the eastern valley margin of this cross section. Field observation of the valley margin hillslopes showed that considerable quantities of

Wasatch-derived pediment gravels mantle the hillslope and they are also concentrated in hillslope gullies that are discharging to the valley floor.

Comparison of the size of the Wasatch-derived sediments across XS VI shows a marked fining in the westward direction. The coarsest sediments are located in MS #35 and the finest are found in MS #27. However, the ground surface elevation at MS #35 is 6903 feet, whereas that at MS #27 is 6851.9 feet, a difference of about 51 feet. It is highly unlikely that a channel, if one ever existed, would be located at the higher elevation on the valley cross profile. The cross-valley gradient would argue for a channel location in the lowest part of the valley where flows would be most confined. The fine grained nature of the Wasatch-derived sediments at MS #27 does not provide evidence of channelized flow, but rather it argues for unconfined sheetflows.

3.9. Cross Section VII (Drawing No. 8)

The valley width at XS VII (~ 1200 feet) is about half of that at XS VI, and the narrowing is an expression of the changing lithology at the basin margins (Fig. 3.1). The Dakota Fm, which is more erosion resistant than the Tropic Shale controls the width of the valley. Because of the topographic confinement, flow confinement occurs at this location and, therefore, the probability of having confined channel flow is high. However, only minor discontinuous channels are present on the valley floor. The larger channel on the western margin of the valley is at the location of the old Alton-Skutumpah wagon road which appears to

have incised relatively recently, probably as a result of flow concentration in the wagon wheel ruts.

Morphologically and stratigraphically XS VII is heavily influenced by valley margin contribution of sediments. On the eastern margin (MS #31), a detrital cone extends from the base of the hillslope for a distance of about 500 feet onto the valley floor. The basal sediments in MS #31 are sandy and they are water saturated. The absence of any sedimentary structures, other than horizontal laminations, in a relatively thick interval of well sorted sand indicates that these are sheetflood deposits. The remainder of MS #31 is comprised of hillslope derived sediments that encompass debris flow deposits, mudflow deposits and sheetwash deposits. The coarse Wasatch-derived sediments in the debris flow deposit are derived from the local pediment gravels.

MS #30 is located at the toe of the detrital cone. It reflects some valley margin sediment contribution, especially in the upper part of the section, which documents the progradation into the valley of the detrital cone. The lower part of the section appears to be composed of sheetflood deposits, as the sand units do not have structures other than horizontal laminations. The absence of cross-bedded structures in the relatively thick sand units argues for unchannelized flow conditions. The yellowish color of the sands in both MS #31 and MS #30 suggests that they were derived from the Cretaceous age sandstones that crop out in Swapp Hollow drainage basin rather than from an up-valley source such as the Wasatch Formation. The basal portion of MS #30 was water saturated.

Measured section #29 is located in the middle of the non-hillslope-modified part of the valley floor. The sediments in the base of the

section are similar to those in the basal portions of MS #31 and MS #30. The sands are water saturated. A mudflow deposit overlies the basal sand unit (Cretaceous Sandstone-derived). It could have been derived from either valley wall, but the presence of minor amounts of Wasatch-derived sediments in the mudflow deposit argues for an eastern source area. The remainder of the sediments in MS #29 are comprised primarily of fine grained Wasatch-derived silts and sands that are sheetflood deposits. The section appears to be capped by hillslope-sourced Tropic Shale-derived sheetwash deposits.

The stratigraphic data from XS VII indicate that the valley margins are significant source areas for the sediments. The relatively minor amounts of Wasatch-derived sediments and their fine grained nature in the stratigraphic sections further indicates that these sediments were not transported by channels that were continuously linked to their source area. The Wasatch-derived sediments were delivered to this lower valley location by periodic sheetflood events and their greater frequency in the upper parts of the stratigraphic sections provides evidence for valley fan progradation. The coarser Wasatch-derived clasts that are located in the eastern measured section (MS #31) were derived from a local source, the pediment. The yellow basal sands sections of the three measured sections indicate that Swapp Hollow drainage basin was probably the major source of sediments prior to valley fan progradation down Sink Valley, because the yellowish sands were derived from Cretaceous age sandstones. The absence of cross-bedding in the sands indicates strongly that the sands were transported by unconfined sheetfloods.

3.10. Cross Section VIII (Drawing No. 9)

The valley width at XS VIII (Fig. 3.1) is about 700 feet, but a detrital cone at the base of the hillslope on the eastern valley margin extends about 200 feet onto the valley floor. Sediments derived from the Dakota Formation on the western valley margin have been transported into the valley floor by slopewash processes. They include fragments of reddish colored clinker, the result of coal seam burns within the Dakota Formation.

Measured Section #34 is located at the toe of the detrial cone on the eastern side of the valley. MS #34 reflects considerable valley margin contribution of sediment in the form of both Tropic-derived and locally Wasatch-derived sediments. Coarse locally derived Wasatch clasts were observed on the surface of the detrital cone to the east of MS #34.

Measured section #33 is located in the middle of the valley. The basal part of the section contains numerous sheetflood deposits that contain clasts that were locally derived (i.e. Dakota SS and clinker chips) and those that may have been transported down valley (Wasatch), or from a local source such as the pediment (Wasatch). The base of the section was water saturated. The remainder of the section consists of interbedded sheetflood and locally derived sheetwash and mudflow deposits.

Measured section #32 is located to the east of a major incised channel on the western margin of the valley. The incised channel is in the former location of the Alton-Skutumpah wagon road, and it is

currently dammed. The basal portion of MS #32 contains a number of Wasatch-derived silt drapes which may reflect unusually large sheetfloods on the prograding valley fan. The remainder of the sediments in MS #32 are very fine grained and they contain abundant locally derived clinker and sandstone clasts. The coarser units were probably derived from the local hillslopes in the form of mudflows and debris flows. The base of the section was water saturated.

The small fraction of the total sediments that are exposed in the measured sections along XS VIII that were derived from Wasatch sources argues against channelized delivery of Wasatch-derived sediments to the lower valley region. Sediments in the valley fill appear to be strongly influenced by local sources.

3.11. Cross Section IX (Drawing No. 9)

The valley width at XS IX (Fig. 3.1) is about 500 feet. A small alluvial fan on the eastern valley margin has prograded out onto the valley floor for a distance of about 250 feet. Another small alluvial fan has prograded onto the valley floor from the western valley margin about 300 feet upstream of MS #36. Therefore, it is evident that sedimentation on the valley floor is very strongly influenced by valley margin sources. On the eastern valley margin coarse clastic sediments derived from the pediment gravels and outcrops of Dakota sandstone are being introduced to the valley floor. On the western valley margin the coarse clastics are derived from the Dakota sandstone.

Measured section #36 is located on the true right bank of the incised channel of Sink Valley Wash. The lowermost 14 feet of the

section is composed of shale-derived sediments, which include minor clinker chips. The frequency of occurrence of Wasatch-derived sediments increases up-section which suggests that the Wasatch-derived sediments were not available for deposition until late in the valley aggradation cycle which preceeded the incision of Sink Valley Wash, the result of base level lowering due to the incision of Kanab Creek. The upper part of MS #36 is dominated by interbedding of locally and down-valley-derived fine grained sediments.

There is no doubt that the bed of the currently incised channel of Sink Valley Wash contains significant quantities of coarse-grained clasts. It might be argued that they represent part of the valley fill. However, the field evidence indicates that the coarse clasts were locally derived and concentrated in the bed of the channel as a result of the processes of channel incision and incision-induced channel widening. The absence of coarse Wasatch-derived clasts in the measured sections up-valley (i.e., MS #32, MS #33, MS #27) indicates that the coarse clasts in the bed of the incised channel must have been locally derived. The majority of the coarser clasts were derived from the Dakota sandstone, but the quartzite, basalt and limestone clasts were derived from the pediment gravels on the eastern margin of the valley.

3.12. Summary of Sink Valley Sedimentology

The surveyed cross sections (9) and measured stratigraphic sections (37) in Sink Valley document a very complex valley fill. However, the very distinctive nature of the three principal sediment source

lithologies enable the sedimentology to be interpreted with a relatively high degree of confidence. Sedimentation in Sink Valley has significantly modified pre-existing relief in the basin and it has had a significant effect on flow distribution between Sink Valley drainage basin and the drainage basin of Lower Robinson Creek. A pre-existing drainage divide between Sink Valley and Lower Robinson Creek has been eliminated by stream capture and by burial of the divide. Sedimentation in the upper portion of Sink Valley has been the result of the down-valley progradation of a valley fan. This fan differs from more conventional alluvial fans in terms of its shape, but it has similar sedimentologic characteristics (Beaty, 1970; Costa, 1988).

The sedimentologic and morphologic characteristics of the valley fan have been in essence frozen by the capture of the Wasatch Formation source area by Lower Robinson Creek, which is deeply incised. Currently, sediments eroded from the Sunset Cliffs in Water Canyon are transported down-valley in this incised channel. An incised channel exists to the base of the Sunset Cliffs in Water Canyon, but the sediments eroded from the cliffs are being transported down Water Canyon principally as very coarse-grained debris flows. The debris flows, however, currently are unable to reach the valley fan in Sink Valley because of the presence of the incised channel. Channelized debris flow deposits were observed in the bed of the abandoned channel segment (east) of Lower Robinson Creek at XS I. It is reasonably certain that the capture by Lower Robinson Creek was related to the incision of Kanab Creek (c. 1865) and, therefore, it is likely that the morphologic and

sedimentologic characteristics of the valley fan represent events prior to the time of capture.

The dominant source rocks that contribute sediment to Sink Valley change along its length (Fig. 3.4). Cross section I (Fig. 3.1) sediments are predominantly Wasatch-derived and reasonably coarse grained. Sheetflood deposits with minor channel fills and debris flow deposits dominate the valley fill (MS #5). Valley margin influences are seen in MS #6 and MS #1 where sheetwash, mudflow and possibly gravity processes contribute sediment from the Tropic Shale and Cretaceous age sandstones. Cross Section II (Fig. 3.1) sediments are predominantly Wasatch-derived and consist of sheetflood and debris flow deposits (MS #3). Lateral contribution from the Tropic Shale is documented by a mudflow deposit in MS #7. The interbedded Wasatch-derived and Tropic-derived fine grained slackwater sediments at the top of MS #8 document the progradation of Section 21 fan onto the floor of Sink Valley and the displacement westward of the depositional axis of the valley fan (MS #3). Cross Section IIB (Fig. 3.1) across the mouth of Section 21 fan documents the delivery of both fine-grained (silt/clay) Tropic-derived sediments to the valley fan and yellowish-grey sands derived from the Cretaceous age sandstones.

Cross Section III (Fig. 3.1) documents the influence of Tropic-derived sediments on the character of the deposits along the depositional axis of the valley fan (MS #12). Mudflow and debris flow deposits dominate this cross section. Valley margin contribution of sediment to Sink Valley is evident in the eastern margin of the fan (MS

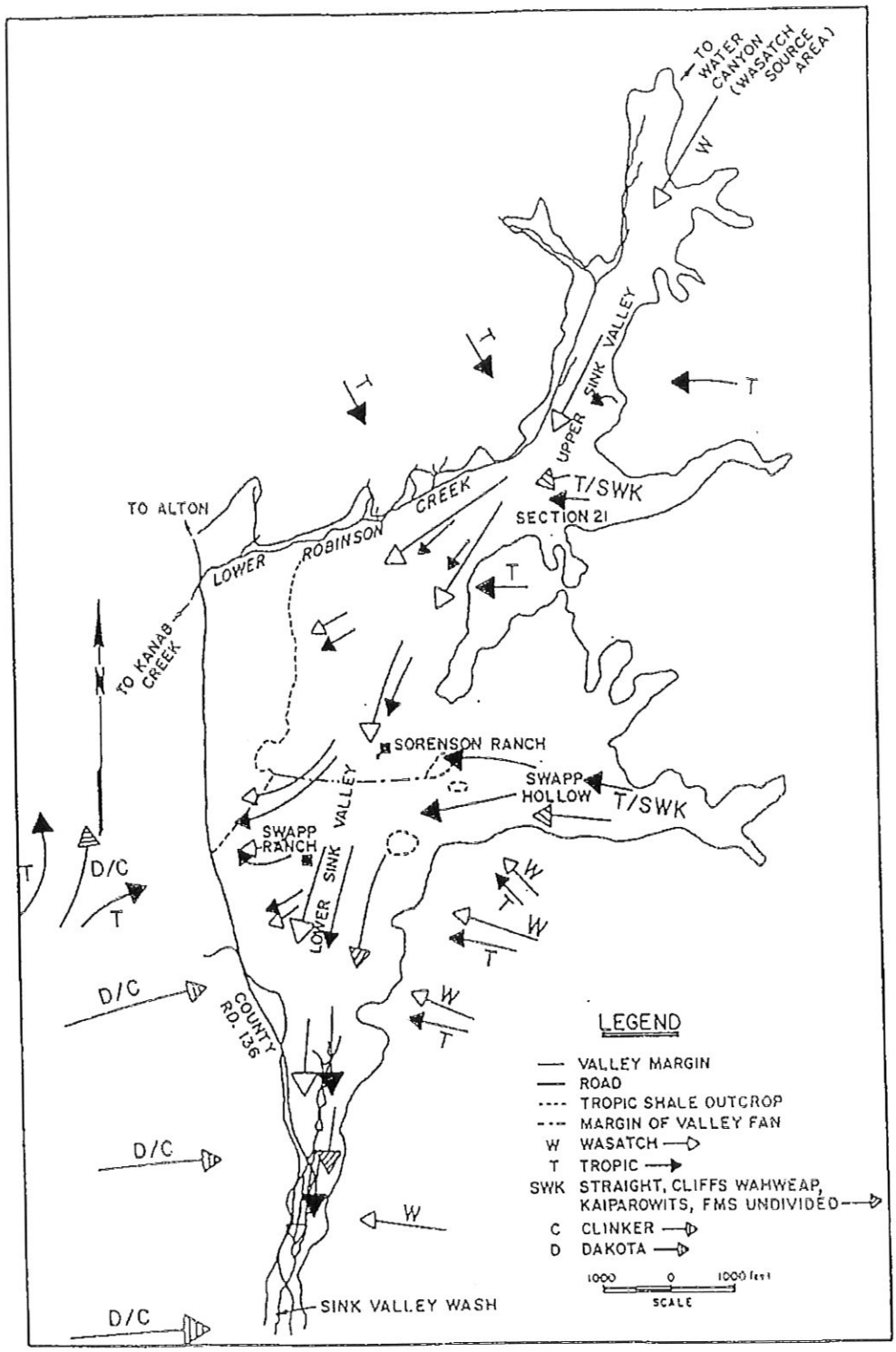

Figure 3.4. Source area lithologies for sediments in Sink Valley.

#13, 17, 18, 19). Localized deposition has created locally oversteepened topography and this has resulted in the formation of discontinuous gullies. Fan progradation towards the valley margin is documented in MS #4, where the Wasatch-derived sediments (sands and silts) have infilled a pre-existing badland topography (Fig. 3.3) that drained the area to the north of the presently incised channel of Lower Robinson Creek. The surveyed XS profile confirms that MS #4 is located on a fan margin.

Cross Section IVA extends from the drainage basin of Lower Robinson Creek on the west to the eastern margin of Sink Valley just up-valley from the junction with Swapp Hollow fan (Fig. 3.1). Progradation of the valley fan to the point where sheetfloods overtopped the Tropic Shale ridge which was the drainage divide between Lower Robinson Creek and Sink Valley is documented in MS #14 and MS #20. Since there is no outcrop of Wasatch Formation in the pre-capture drainage basin of lower Robinson Creek, then the Wasatch-derived sediments in MS #14 and MS #20 must have been derived from Sink Valley. The low frequency of the Wasatch-derived sediments in MS #14 and MS #20 and the fact that they are located in the upper portions of the stratigraphic sections indicates that the sediments were transported by extreme events on the valley fan. Deposition of the Wasatch-derived sediments must have pre-dated the incision of Lower Robinson Creek (c. 1865) and the capture of Upper Sink Valley because the Wasatch-derived sediments are interbedded with Tropic-derived sediments.

The on-lap of the valley fan onto the eastern side of the Tropic Shale ridge, and its effects on the water table are shown in MS #15,

which is composed of primarily fine grained fan-margin sediments. The depositional axis of the fan is located at MS #16 and it reflects the contribution of sediments from both the Wasatch Formation and the Tropic Shale. Progradation of Swapp Hollow fan into Sink Valley and its effects on slackwater sedimentation can be seen in MS #22 where fine-grained sediments from the Wasatch Formation and the Tropic Shale are interbedded. Cross Section IVA is located near the crest of the valley fan.

Cross Section IVB (Fig. 3.1) extends across the mouth of Swapp Hollow and it documents a number of important factors with respect to Sink Valley sedimentology. First, a considerable volume of Cretaceous age sandstone-derived sand-sized sediments are being introduced to Sink Valley (MS #37). Second, significant quantities of Tropic-derived sediment is also being introduced to Sink Valley. Finally, erosion of the pediment on the south side of Swapp Hollow is introducing coarse Wasatch-derived pediment gravels to Sink Valley.

Cross Section V extends from the Lower Robinson Creek drainage basin on the west to the mouth of Swapp Hollow on the east (Fig. 3.1). The cross section is located within Sink Valley at the approximate location of the down-valley terminus of the valley fan. The depositional axis of the valley fan is located at MS #24 and the sediments reflect different source lithologies; Wasatch Formation, Tropic Shale, and the Cretaceous age sandstones. The Wasatch-derived sediments have been diluted considerably in comparison to the sections that are located up-fan. MS #25 shows the effects on the water table of fan margin on-lap to the

impermeable Tropic Shale ridge. Sediment delivery from Swapp Hollow may have been responsible for displacing valley fan margin sedimentation towards the west, thereby eliminating the pre-existing drainage divide between Sink Valley and Lower Robinson Creek drainage basins. The coarse-grained basal sediments in MS #26 were derived from local Dakota Formation outcrops in the Lower Robinson Creek basin. Wasatch-derived sediments constitute a minor portion of MS #26. Elimination of the drainage divide as a result of sedimentation just south of XS V permits present day sheetfloods to bifurcate into both Sink Valley and Lower Robinson Creek. Groundwater discharge in the distal portion of the valley fan is confirmed in MS #24 and MS #25.

Cross Section VI lies completely within the margins of Sink Valley (Fig. 3.1). Pediment-derived Wasatch Formation clasts, Tropic-derived finer-grained sediments and Cretaceous age sandstone-derived sands were transported on a formerly active lobe of Swapp Hollow fan to the valley floor (MS #35, MS #28). This lobe formed a significant cross gradient across Sink Valley which must displace the sheetfloods to the west (MS #27). Very little Wasatch-derived sediment is present in MS #27, and the sediments in the section are dominated by sands derived from the Cretaceous age sandstones in Swapp Hollow and by local contributions of Tropic-derived sediments from the western valley margin. A shallow water table is present in both MS #28 and MS #27.

Cross Section VII (Fig. 3.1) demonstrates the importance to the valley fill of local sediment sources. A detrital cone has prograded from the eastern valley margin onto the valley floor. The coarse-

grained Wasatch-derived sediments in MS #31 and MS #30 originated from the pediment gravels. The basal portions of all the measured sections along XS VII are composed of yellowish-grey sands that were derived from Cretaceous age sandstones in Swapp Hollow. It is significant to note that Wasatch-derived finer grained sheetflood deposits are located in the upper part of MS #29. This tends to confirm that the delivery of Wasatch-derived sediments down-valley to this location was dependent on valley fan progradation rather than as the result of channelized flow.

The paucity of Wasatch-derived sediments other than silt/clay drapes in the measured sections (MS #32, 33, 34) along XS VIII (Fig. 3.1) indicates that it is highly unlikely that a continuous channel has been in existance through the length of Sink Valley during the time that the observed valley fill was deposited. The sediments in the measured sections are dominated by yellowish-grey sands that were derived from Swapp Hollow. Lateral contribution of sediments from the valley margins is documented by clasts of Dakota sandstone and clinker chips. Coarser-grained Wasatch-derived clasts and fine-grained Tropic-derived sediments are present in the detrital cone on the eastern valley margin (MS #34).

The absence of a continuous channel through Sink Valley in the time period represented by the valley fill is further confirmed by MS #36 on XS IX (Fig. 3.1). The coarse clasts in the bed of the incised channel of Sink Valley Wash have been derived from local sources. Dakota sandstone clasts were derived from both valley margins, and the Wasatch-derived clasts were transported by slope transport processes on the eastern valley margin.

The sedimentology of Sink Valley can be summarized in a longitudinal profile that follows the depositional axis (Fig 3.5). The measured sections that represent the depositional axis of the valley at each of the surveyed cross sections were arranged in a down-valley sequence (Fig. 3.1). The elevation of the top of each measured section was used to construct the longitudinal profile of the valley floor. The distances between the measured sections are to scale.

The valley fan extends from XS I (MS #5) to XS V (MS #24). The proximal (up-valley) part of the valley fan (MS #5, MS #3) is composed of predominantly Wasatch-derived, relatively coarse-grained sediments that were deposited by debris flows and sheetfloods. Minor channel fills are located within the horizontally laminated sheetflood deposits. The channels were probably small-scale and ephemeral, and they probably represent a braided pattern during sheetflood events (Reading, 1978; Bull, 1977; Blair, 1986). The coarse-fine couplets within the sheetflood deposits represent the down-fan passage of low relief sheets of sands and fine gravels (Bull, 1977; Blair, 1986).

The medial portion of the valley fan is represented by MS #12 (XS III) and MS #16 (XS IVA). The sediments were deposited by mudflows, debris flows and sheetfloods. However, there is a dilution of the Wasatch-derived sediments by Tropic-derived and Cretaceous sandstone-derived sediments. The Tropic-derived sediments probably originated from Section 21 tributary and the Tropic Shale eastern valley margin. Cross Section V marks the approximate location of the distal portion of the fan (MS #24). Both the volume and caliber of the Wasatch-derived

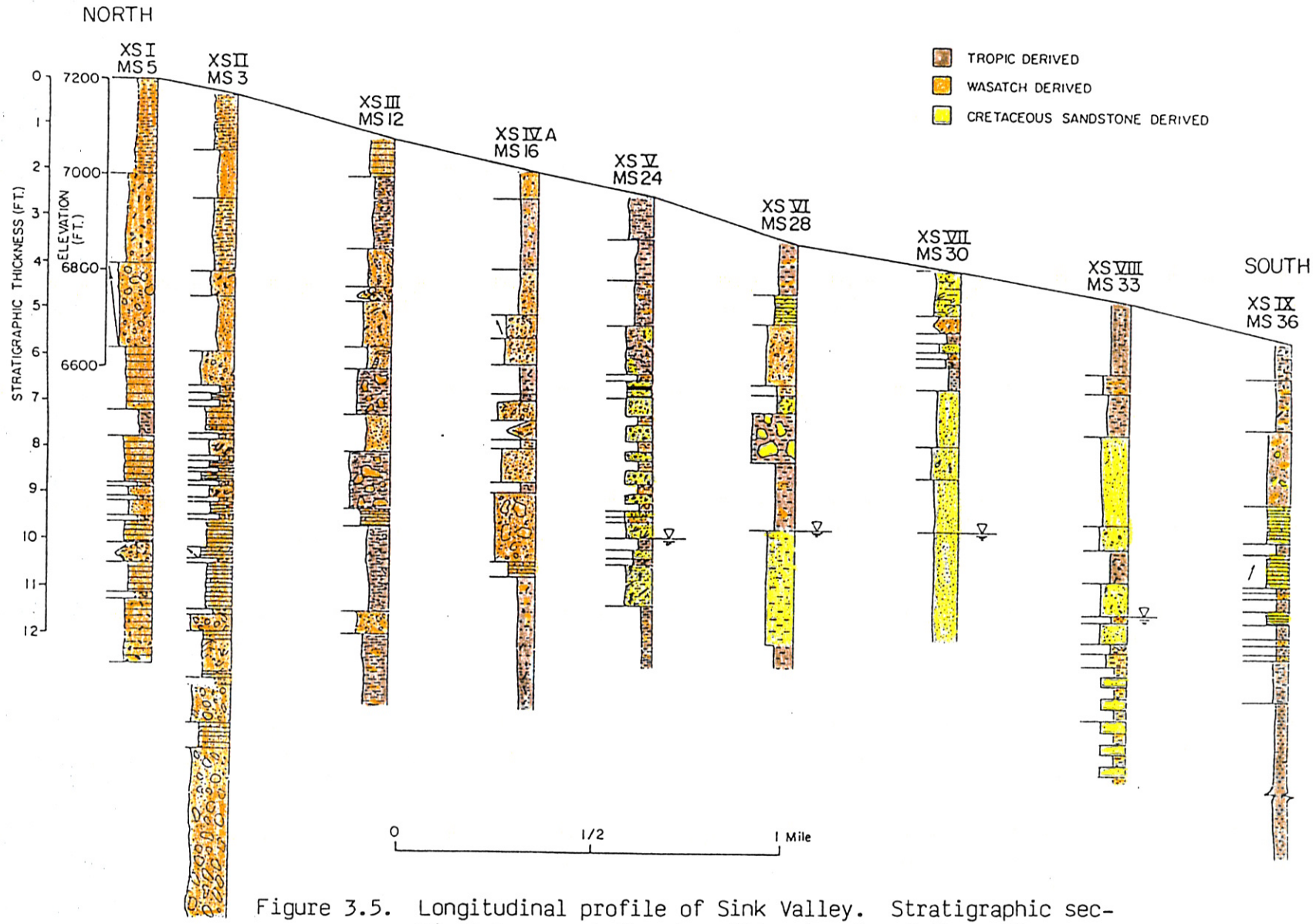

Figure 3.5. Longitudinal profile of Sink Valley. Stratigraphic sections represent the depositional axis of the valley.

sediments have declined significantly in MS #24 (XS V). The Wasatch-derived sediments are fine-grained and they represent drapes which document discrete down-valley flood events. The sediments in MS #24 also reflect a significant increase in the volume of sands that were derived from Cretaceous age sandstones in the Swapp Hollow drainage basin. The presence of groundwater at shallow depth in MS #24 also argues that this section represents the toe of the valley fan (Galloway et al., 1979).

Cross section VI is contained completely within Sink Valley, but the sediments in MS #28 are heavily influenced by Swapp Hollow fan, a lobe of which had prograded onto the floor of Sink Valley, thereby displacing the depositional axis to the west. The basal portion of MS #28 is dominated by Cretaceous sandstone-derived sands. Debris flow and mudflow deposits contain relatively coarse-grained Wasatch-derived sediments that originated from the pediment gravels on the south side of Swapp Hollow (Fig. 2.1).

Sink Valley narrows considerably at XS VII and the sediments in MS #30 are dominated by Cretaceous age sandstone-derived sands. The upper portion of MS #30 reflects progradation of a small detrital cone onto the valley floor. The sediments originated from the valley side slopes and they contain coarser clasts of both sandstone and the Wasatch-derived pediment gravels. The absence of fine-grained Wasatch-derived sediments (silt/clay drapes) in the basal parts of MS #30 and MS #28 may be the result of the relatively shallow depth of the pits. Very high rates of groundwater flow were encountered in the pits and wall caving

occurred rapidly and frequently. The Wasatch-derived fine-grained sediments (drapes) were prominent in the basal portion of MS #33 (XS VIII), which is a deeper section.

The bulk of the sediment in MS #33 were derived from the Cretaceous age sandstones in the Swapp Hollow drainage basin. The increasing dominance of these sands in MS #28, MS #30, and MS #33, and the concomittant reduction in the amount of Wasatch-derived sediments, may be related to the elimination of the Wasatch Formation source area due to its capture by Lower Robinson Creek. Conversely, the change in the character of the sediments may merely reflect the fact that the valley fan had not prograded far enough down-valley to deliver significant volumes of sediment to the lower valley. The presence of the multiple Wasatch-derived drapes in the basal portion of MS #33 indicates that sheetflood events that originated up-valley from XS VIII were more frequent in the earlier part of the valley fill cycle. It is also conceivable that the relative abundance of the sandstone-derived sediments is related to the dynamics of Swapp Hollow fan. Fan trenching (Schumm 1977; Schumm et al, 1987) may have delivered large quantities of fan sediments to the valley floor. The absence of sedimentary structures other than horizontal laminations in the sand units argues for unconfined flow conditions on the valley floor.

Minor amounts of fine-grained Wasatch-derived sediments are interbedded with Tropic-derived and Cretaceous age sandstone-derived sediments in MS #36 (XS IX). Coarser Wasatch-derived clasts interbedded with Tropic-derived sediments in the upper part of MS #36 were derived

from the pediment gravels on the eastern margin of the valley. Detrital cones and small scale fans at the base of both valley margins have significantly affected sedimentation in this narrow reach of the valley.

The morphological (Figs. 2.1, 2.3, 2.4) and sedimentological data (Fig. 3.5) strongly confirm that a valley fan exists in Sink Valley between XS I and XS V. Tributary fans (Section 21 and Swapp Hollow) have significantly affected the sedimentology and morphology of the valley floor (Fig. 3.3). Lateral inflow of sediments from the valley margins has introduced coarser grained sediments to the valley floor that interrupt the down-valley fining trends of the grain size (Fig. 3.4). The presence of a shallow groundwater table down-valley from XS V is consistent with the valley fan interpretation.

4. CONCLUSIONS

This investigation of Sink Valley was conducted to determine: (1) whether there were streamlaid deposits beneath the surface of the valley floor and (2) whether alluvial fans, or man's activities had obscurred a previously existing continuous channel that traversed the length of Sink Valley. Both of these factors are important with respect to determining whether Sink Valley meets the regulatory geologic criteria for an Alluvial Valley Floor (AVF). On the basis of these criteria, the requirement for an AVF determination is the presence of a continuous channel within a topographic valley, the floor of which contains floodplain and terrace features that are underlain by unconsolidated streamlaid deposits that were deposited by the continuous channel. Alluvial fans are specifically excluded from determination as AVF's

The results of this investigation have demonstrated that:

(1) there are no streamlaid deposits within the sediments that were observed in the backhoe pits and exposed banks of Lower Robinson Creek and Sink Valley Wash. The sediments were deposited by unconfined sheetfloods, debris flows and mudflows. Minor channel fill sediments were observed in the stratigraphic sections, but they are related to the presence of small ephemeral channels during sheetflood events and to topographic irregularities caused by the presence of mudflow and debris flow deposits.

(2) no continuous channel has traversed the length of Sink Valley within the time interval that is represented by the valley fill

that was observed in this investigation. The valley fan that prograded down-valley from the confluence of Dry Fork and Water Canyon is composed primarily of Wasatch-derived sediments. Capture of the upper part of the Sink Valley drainage basin by Lower Robinson Creek was due to base level lowering, the result of incision of Kanab Creek (c. 1865), and progradation of the valley fan that eliminated a pre-existing drainage divide between the basins. Capture of the source area for the Wasatch-derived sediments has in essence frozen the valley fan morphology into the pre-capture configuration, and therefore, the valley fan must pre-date the time of capture. Therefore, it cannot be argued that the valley fan is a recent feature that has obscurred the presence of a pre-existing continuous channel. Further, the absence of any sedimentary evidence for channelized flow in the investigated stratigraphic fill indicates that surface modifications of the valley floor by man's activities has not obscurred the presence of a continuous channel. This is further reinforced by the rapid down-valley fining of the size of the Wasatch-derived sediments, and by the relative paucity of Wasatch-derived sediments in the stratigraphic sections down-valley from the toe of the valley fan.

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APPENDIX I

SINK VALLEY STRATIGRAPHIC SECTIONS

LEGEND

- SILT/CLAY
- SAND
- GRAVEL
- CHARCOAL
- ROOT CASTS
- RIPUP CLASTS
- FINING UPWARD SEQUENCE
- COARSENING UPWARD SEQUENCE
- W — WASATCH DERIVED
- T — TROPIC DERIVED
- SW — SHEETWASH
- CH — CHANNEL FILL
- MF — MUDFLOW
- DF — DEBRIS FLOW
- HORIZONTAL STRATIFICATION
- RIPPLE CROSS STRATIFICATION
- TROUGH CROSS STRATIFICATION
- COARSE / FINE COUPLETS
- SILT/CLAY DRAPE
- PEDOGENIC STRUCTURE
- LENTICULAR BEDDING
- EROSIONAL CONTACT
- SWK — STRAIGHT CLIFFS/WAHWEAP DERIVED
- RF — ROCKFALL
- SF — SHEETFLOOD
- D — DRAPE
- WATER TABLE

MEASURED SECTION NO. 1
LOCALITY XS 1 WEST CHANNEL
SETTING TLB LOWER ROBINSON CREEK
STATION 8+56

DATE 7/11/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7202.4

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	22			W	WASATCH DERIVED SILT TO MEDIUM SAND LATERALLY CONTINUOUS SHARP LOWER CONTACT
2	13			T	TROPIC DERIVED SILT/CLAY DENSE
3	6			W/T	WASATCH/TROPIC DERIVED SILT TO MEDIUM SAND INCREASE IN WASATCH DERIVED MATERIAL UPSECTION LATERALLY CONTINUOUS
4 5 6 7 8 9	67			W/T	PRIMARILY TROPIC DERIVED SILT AND CLAY WITH MINOR WASATCH DERIVED SAND-PEBBLE SIZE CLASTS HIGH CHARCOAL CONTENT
10 11 12	35			T	TROPIC DERIVED SILT AND CLAY WITH MINOR ANGULAR GRIT HIGH CHARCOAL CONTENT
					CONTINUED

MEASURED SECTION NO. 1 (CONT.)
LOCALITY XS 1 WEST CHANNEL
SETTING TLB LOWER ROBINSON CREEK
STATION 8+56

DATE 7/11/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7202.4

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					CONTINUED SECTION
-13	20			W/T	TROPIC DERIVED SILT AND CLAY WASATCH DERIVED FINE GRAVEL AND SAND MASSIVE
	3			W	GRAVEL TO COBBLES; LIMESTONE/QUARTZITE/BASALT CLAST B-AXIS = 55-100 MM MATRIX SUPPORTED CHAOTIC ⇒ DEB FLO
-14	8			W/T	INTERBEDDED WASATCH DERIVED MEDIUM SAND AND TROPIC DERIVED SILT/CLAY DRAPES
	5			T	TROPIC DERIVED SILT TO FINE SAND
-15	5			W	WASATCH DERIVED MEDIUM SAND
	4			W/T	TROPIC DERIVED SILT/CLAY DRAPE UNDERLAIN BY WASATCH DERIVED MEDIUM SAND
				W	SILT/CLAY DRAPE
-16	6			W	WASATCH DERIVED MEDIUM SAND MASSIVE
					BASE OF SECTION

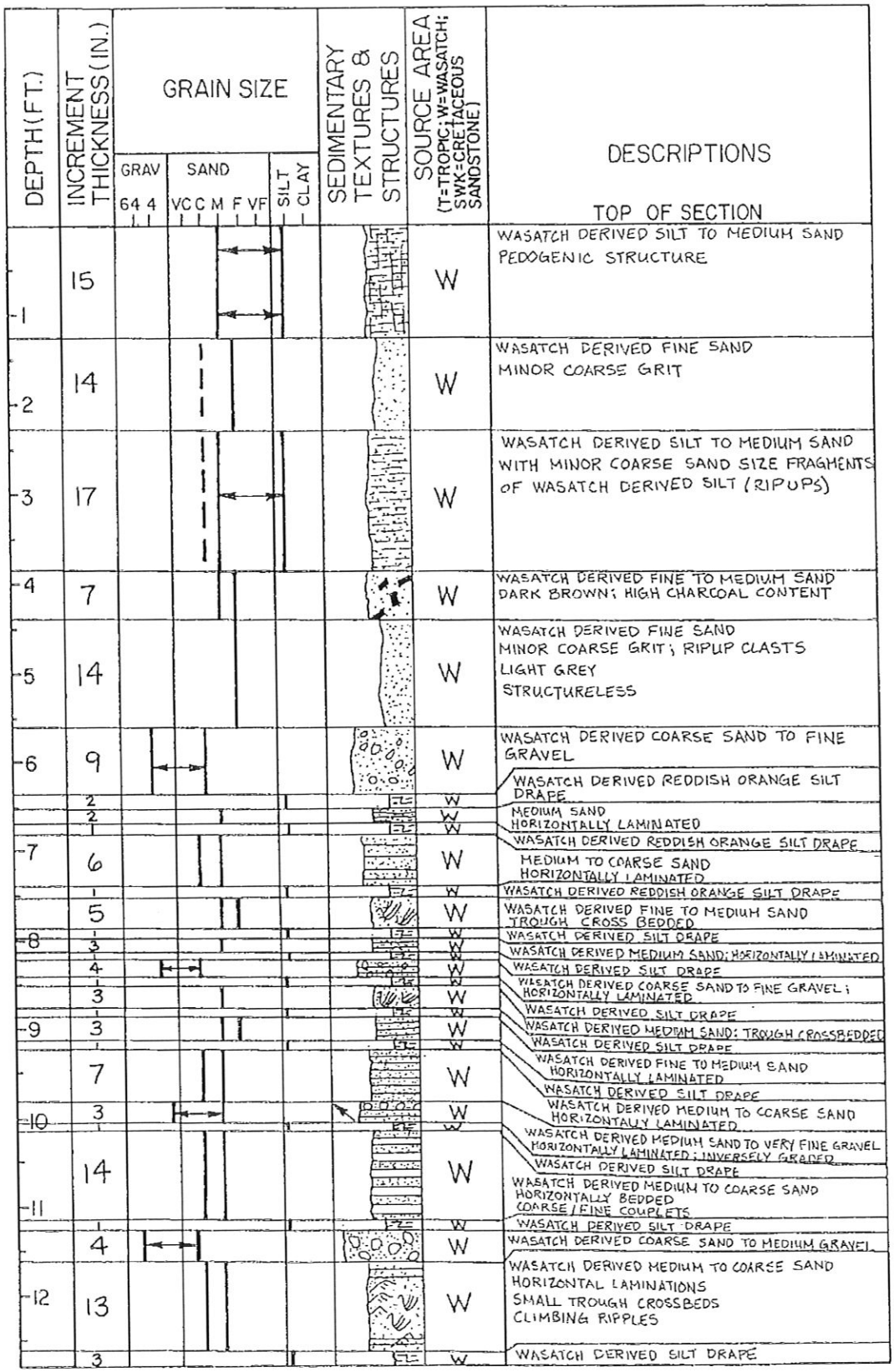
MEASURED SECTION NO. 2
LOCALITY XS 1 EAST CHANNEL
SETTING TLB LOWER ROBINSON CREEK
STATION 7+78

DATE 7/11/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7202.2

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	13			W	WASATCH DERIVED SILT TO FINE SAND
	10			W	WASATCH DERIVED FINE SAND
2	10			W	WASATCH DERIVED MEDIUM TO COARSE SAND
	1			W	WASATCH DERIVED REDDISH FINE GRAVEL
3–4	17			W	WASATCH DERIVED FINE TO MEDIUM SAND HIGH CHARCOAL CONTENT DENSE
	3			W	WASATCH DERIVED REDDISH FINE GRAVEL
	5			W	WASATCH DERIVED FINE TO MEDIUM SAND MASSIVE
5	7			W	GRAY VERY FINE TO MEDIUM SAND MINOR PINK WASATCH DERIVED COARSE SAND HORIZONTALLY LAMINATED
6	5			W	WASATCH DERIVED MEDIUM SAND UNDERLAIN BY 1/4" PINK SILT DRAPE
7	20			W	DARK BROWN FINE SAND MINOR COARSE SAND TO PEBBLE CLASTS MASSIVE HIGH CHARCOAL CONTENT FINE GRAINED DENSE BASE WITH WELL DEVELOPED ROOT CASTS
8	8			W	WASATCH DERIVED MEDIUM TO COARSE SAND MASSIVE
	5			W	WASATCH DERIVED GRAVEL MAXIMUM B-AXIS = 70 MM QUARTZITE, LIMESTONE, BASALT CLASTS
9	12			W	MEDIUM SAND WELL SORTED
10–12					MODERN STREAM GRAVELS BASE OF SECTION

MEASURED SECTION NO. 3
LOCALITY XS 2 A
SETTING TLB LOWER ROBINSON CREEK
STATION 9+79

DATE 7/12/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7174.8



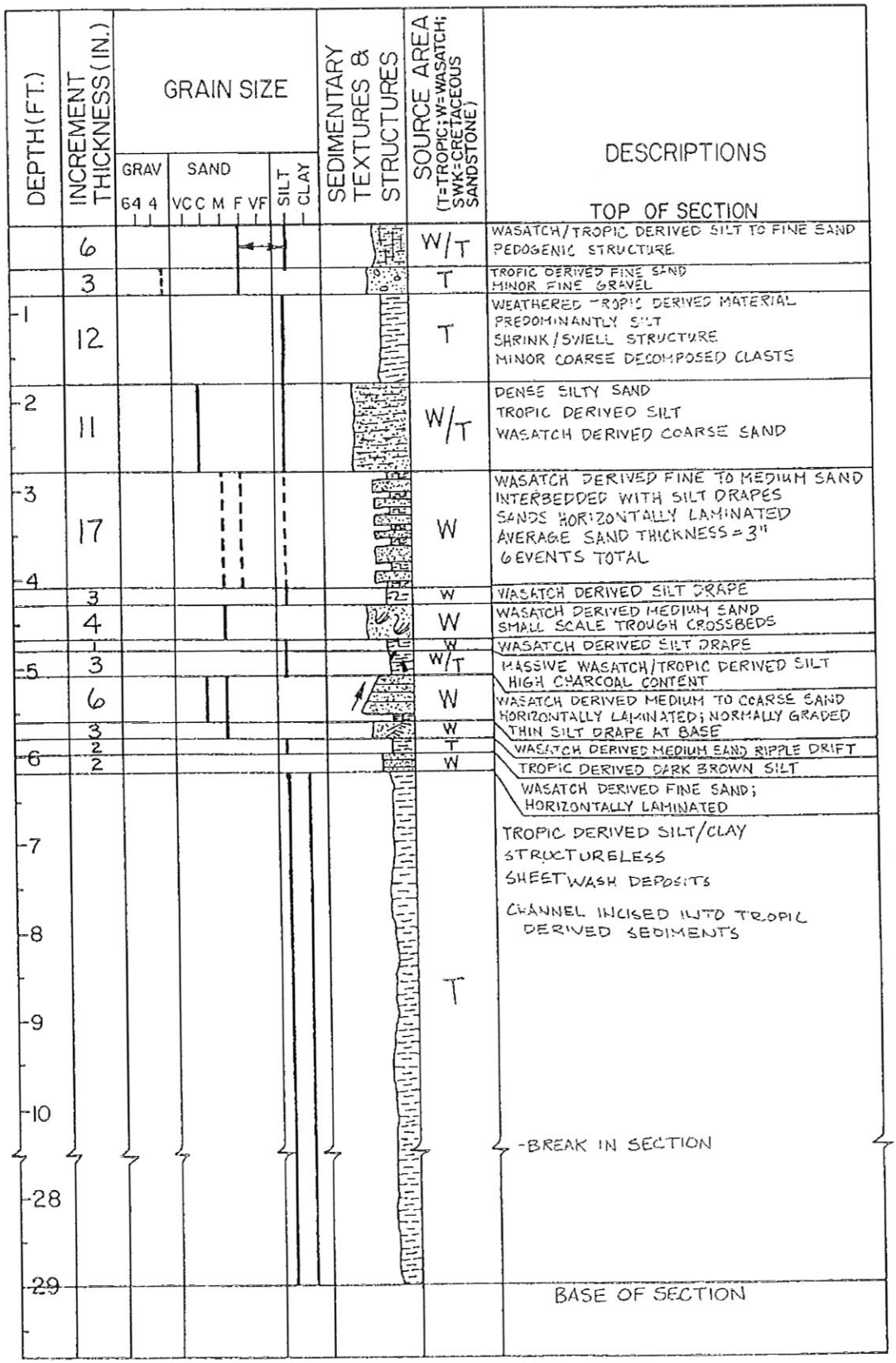
MEASURED SECTION NO 3(CONT.)
LOCALITY XS 2 A
SETTING TLB LOWER ROBINSON CREEK
STATION 9+79

DATE 7/12/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7174.8

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE: GRAV (64 4)	SAND (VC C M F VF)	SILT CLAY	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
							CONTINUED SECTION
13	10					W	WASATCH DERIVED VERY POORLY SORTED GRAVEL TO COBBLES MATRIX SUPPORTED SANDY MUD MATRIX MAXIMUM CLAST B-AXIS = 150 MM
14	6					W	WASATCH DERIVED MEDIUM TO COARSE SAND HORIZONTALLY LAMINATED
15 16 17	45					W	WASATCH DERIVED GRAVEL TO COBBLES VERY POORLY SORTED MINOR INVERSE GRADING
18							BASE OF SECTION

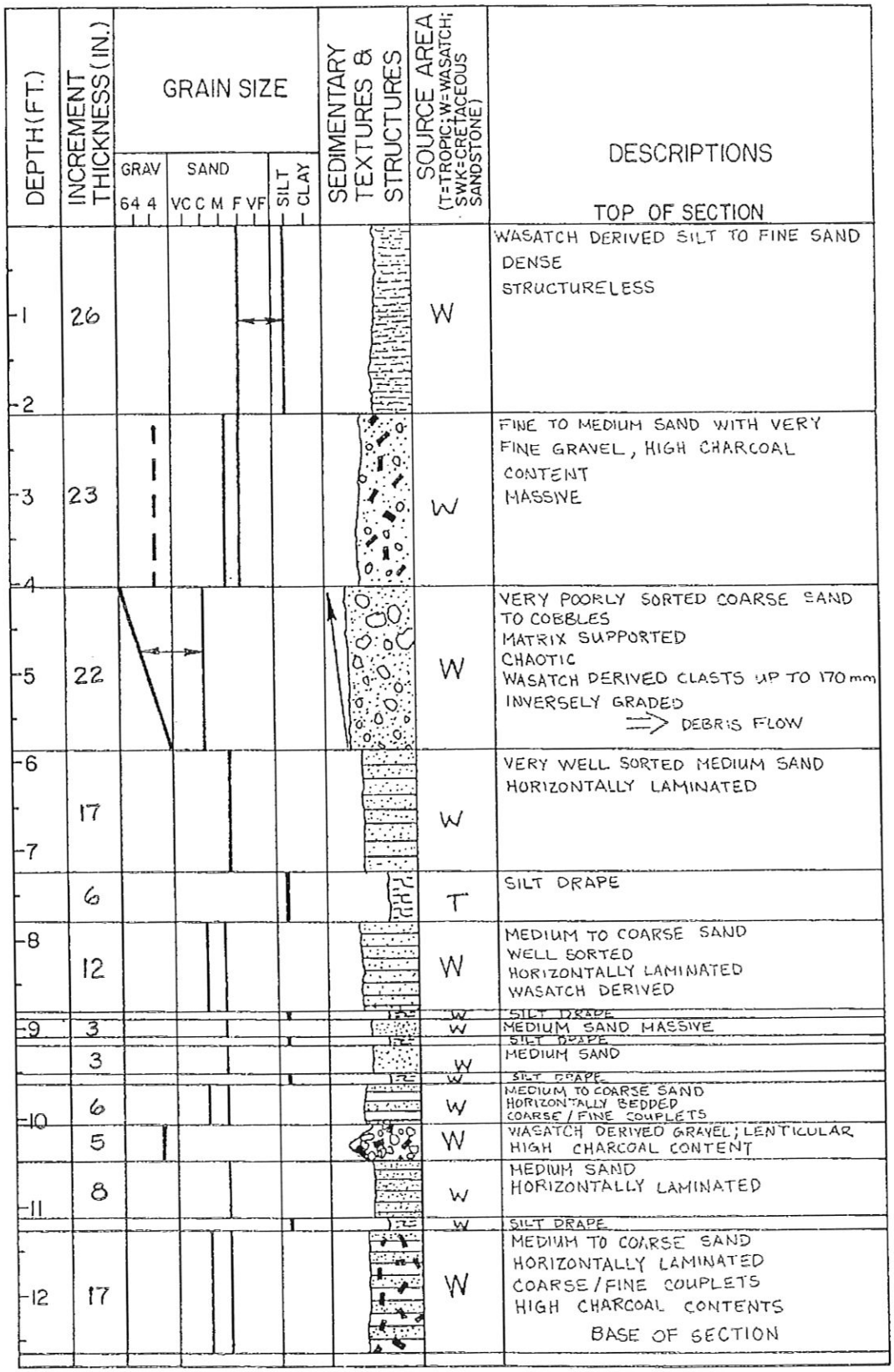
MEASURED SECTION NO 4
LOCALITY XS 3
SETTING TLB LOWER ROBINSON CREEK
STATION 15+22

DATE 7/12/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7068.2



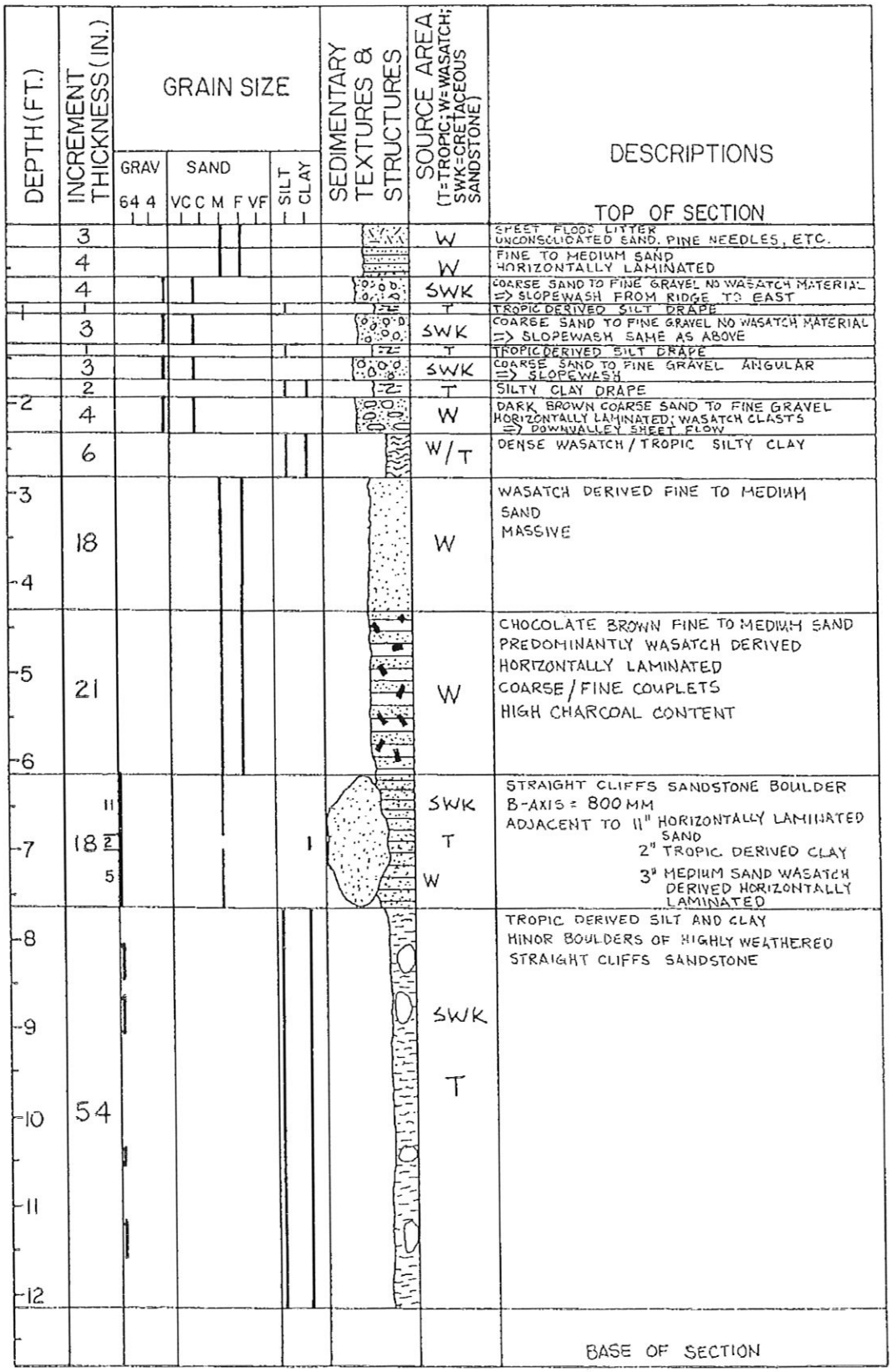
MEASURED SECTION NO. 5
LOCALITY XS 1
SETTING MIDVALLEY
STATION 5+14

DATE 7/12/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7204.9



MEASURED SECTION NO 6
LOCALITY XS 1
SETTING EAST SIDE VALLEY
STATION 0+00

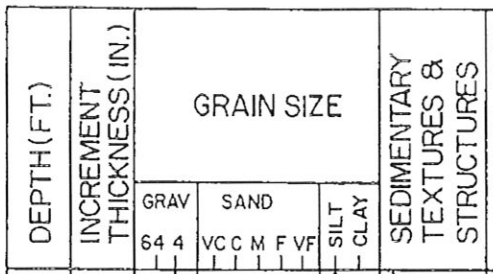
DATE 7/12/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 7208.9



DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	3			W	SHEET FLOOD LITTER UNCONSOLIDATED SAND, PINE NEEDLES, ETC.
	4			W	FINE TO MEDIUM SAND HORIZONTALLY LAMINATED
	4			SWK	COARSE SAND TO FINE GRAVEL NO WASATCH MATERIAL => SLOPEWASH FROM RIDGE TO EAST
1	1			T	TROPIC DERIVED SILT DRAPE
	3			SWK	COARSE SAND TO FINE GRAVEL NO WASATCH MATERIAL => SLOPEWASH SAME AS ABOVE
	1			T	TROPIC DERIVED SILT DRAPE
	3			SWK	COARSE SAND TO FINE GRAVEL ANGULAR => SLOPEWASH
	2			T	SILTY CLAY DRAPE
2	4			W	DARK BROWN COARSE SAND TO FINE GRAVEL HORIZONTALLY LAMINATED; WASATCH CLASTS => DOWNVALLEY SHEET FLOW
	6			W/T	DENSE WASATCH / TROPIC SILTY CLAY
3 – 4	18			W	WASATCH DERIVED FINE TO MEDIUM SAND MASSIVE
5 – 6	21			W	CHOCOLATE BROWN FINE TO MEDIUM SAND PREDOMINANTLY WASATCH DERIVED HORIZONTALLY LAMINATED COARSE / FINE COUPLETS HIGH CHARCOAL CONTENT
7	11 / 18 / 2 / 5			SWK / T / W	STRAIGHT CLIFFS SANDSTONE BOULDER B-AXIS = 800 MM ADJACENT TO 11" HORIZONTALLY LAMINATED SAND; 2" TROPIC DERIVED CLAY; 3" MEDIUM SAND WASATCH DERIVED HORIZONTALLY LAMINATED
8 – 12	54			SWK / T	TROPIC DERIVED SILT AND CLAY MINOR BOULDERS OF HIGHLY WEATHERED STRAIGHT CLIFFS SANDSTONE
					BASE OF SECTION

MEASURED SECTION NO. 7
LOCALITY XS 2A
SETTING MID VALLEY
STATION 7+14

DATE 7/12/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7174.5



DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1–2	36			W/T	VERY POORLY SORTED SILT, SAND, & FINE GRAVEL DENSE CHAOTIC U-SHAPED SOME TROPIC DERIVED CLASTS HIGH CHARCOAL CONTENT ⇒ MUDFLOW
3–4	17			W	MEDIUM SAND TO MEDIUM GRAVEL MASSIVE CONTAINS RIPUPS OF WASATCH DERIVED SILT DRAPES
	2			W	WASATCH DERIVED SILT DRAPE
	2			W	WASATCH DERIVED MEDIUM-COARSE SAND; RIPPLES
5	6			W/T	DARK BROWN TROPIC DERIVED SILT WITH MINOR WASATCH COMPONENT, DENSE HIGH CHARCOAL CONTENT
	6			W	PINK WASATCH DERIVED FINE TO MEDIUM SAND LATERALLY CONTINUOUS; COARSE/FINE COUPLETS HIGH CHARCOAL CONTENT
6	11			W/T	WASATCH/TROPIC DERIVED SILT TO FINE SAND DENSE RIPUPS OF WASATCH SILT
7	9			W	MEDIUM TO COARSE SAND COARSE/FINE COUPLETS RIPUPS ⇒ SHEETFLOW
	3			W	WASATCH DERIVED COARSE SAND LATERALLY CONTINUOUS ⇒ SHEETFLOW COARSE/FINE COUPLETS; COARSENS TO GRAVEL EASTWARD
8	10			W	WASATCH DERIVED MEDIUM SAND SMALL SCALE TROUGH CROSSBEDS LATERALLY CONTINUOUS HIGH CHARCOAL CONTENT
	3			T	TROPIC DERIVED SILT DRAPE LATERALLY CONTINUOUS
9	4			W	WASATCH DERIVED FINE TO MEDIUM SAND; SMALL SCALE TROUGH CROSSBEDS; CHANNEL FILL 18" WIDE X 14" DEEP
	1			T	TROPIC DERIVED SILT DRAPE
	9			W	WASATCH DERIVED COARSE SAND SMALL SCALL THROUGH CROSSBEDS
10	3			W/T	WASATCH/TROPIC DERIVED SILT DRAPE
	3			W	WASATCH DERIVED FINE SAND
	4			W	WASATCH DERIVED SILT DRAPE
11	6			W	WASATCH DERIVED MEDIUM TO COARSE SAND HORIZONTALLY LAMINATED OVERLYING SILT DRAPE
12					BASE OF SECTION

MEASURED SECTION NO 8 DATE 7/12/88
LOCALITY XS 2A STRATIGRAPHIC UNIT VALLEY FILL
SETTING EAST SIDE VALLEY MEASURED BY MH/KF/JS/DW
STATION 1+58 ELEVATION 7108.0

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	16			T/W	COARSE SAND INTERBEDDED WITH SILT DRAPES. 11 DISTINGUISHABLE EVENTS ⇒ MULTIPLE SLACK WATER DEPOSITIONAL EVENTS ⇒ LOW TOPOGRAPHIC SPOT AT EASTERN SLOPE BREAK
2 3	22			T	BLACK-BROWN TROPIC DERIVED SILTY CLAY MINOR FINE SAND LATERALLY CONTINUOUS ⇒ SHEETWASH
4	18			W/T	WASATCH/TROPIC DERIVED SILT TO VERY FINE SAND DENSE NO STRUCTURE
5	6			W	WASATCH DERIVED MEDIUM SAND CONTAINS RIPUPS OF WASATCH DERIVED SILT
	3			W	WASATCH DERIVED SILT DRAPE; LATERALLY VERY CONTINUOUS
6	16			W	WASATCH DERIVED MEDIUM SAND INTERBEDDED WITH WASATCH DERIVED SILT DRAPES. 7 CYCLES DISTINGUISHABLE.
7	2			W	WASATCH DERIVED VERY COARSE SAND; LATERALLY CONTINUOUS COARSE/FINE COUPLETS
	4			T	TROPIC DERIVED SILT DRAPE
	3			W	WASATCH DERIVED FINE SAND; MASSIVE
	3			T	TROPIC DERIVED SILT DRAPE; LATERALLY CONTINUOUS
8	2			W	WASATCH DERIVED COARSE SAND; HORIZONTALLY LAMINATED; COARSE/FINE COUPLETS
	1			W	WASATCH DERIVED SILT DRAPE
	7			W/T	WASATCH DERIVED MEDIUM SAND RIPUP CLASTS OF TROPIC & WASATCH MATERIAL
	2			W/T	TROPIC/WASATCH DERIVED SILT DRAPE
9	4			T	TROPIC DERIVED MEDIUM SAND HORIZONTAL & TROUGH CROSS STRATIFICATION
	9			W/T	TROPIC DERIVED SILT DRAPE HIGH CHARCOAL CONTENT MINOR WASATCH COMPONENT
10	12			W/T	WASATCH DERIVED FINE TO MEDIUM SAND TROPIC RIPUPS
11 12					BASE OF SECTION

MEASURED SECTION NO _____ DATE _____

LOCALITY XS 2B

SETTING NORTH SIDE VALLEY

STATION 1+59

STRATIGRAPHIC UNIT SEC. 21 V. FILL

MEASURED BY MH/KF/JS/DW

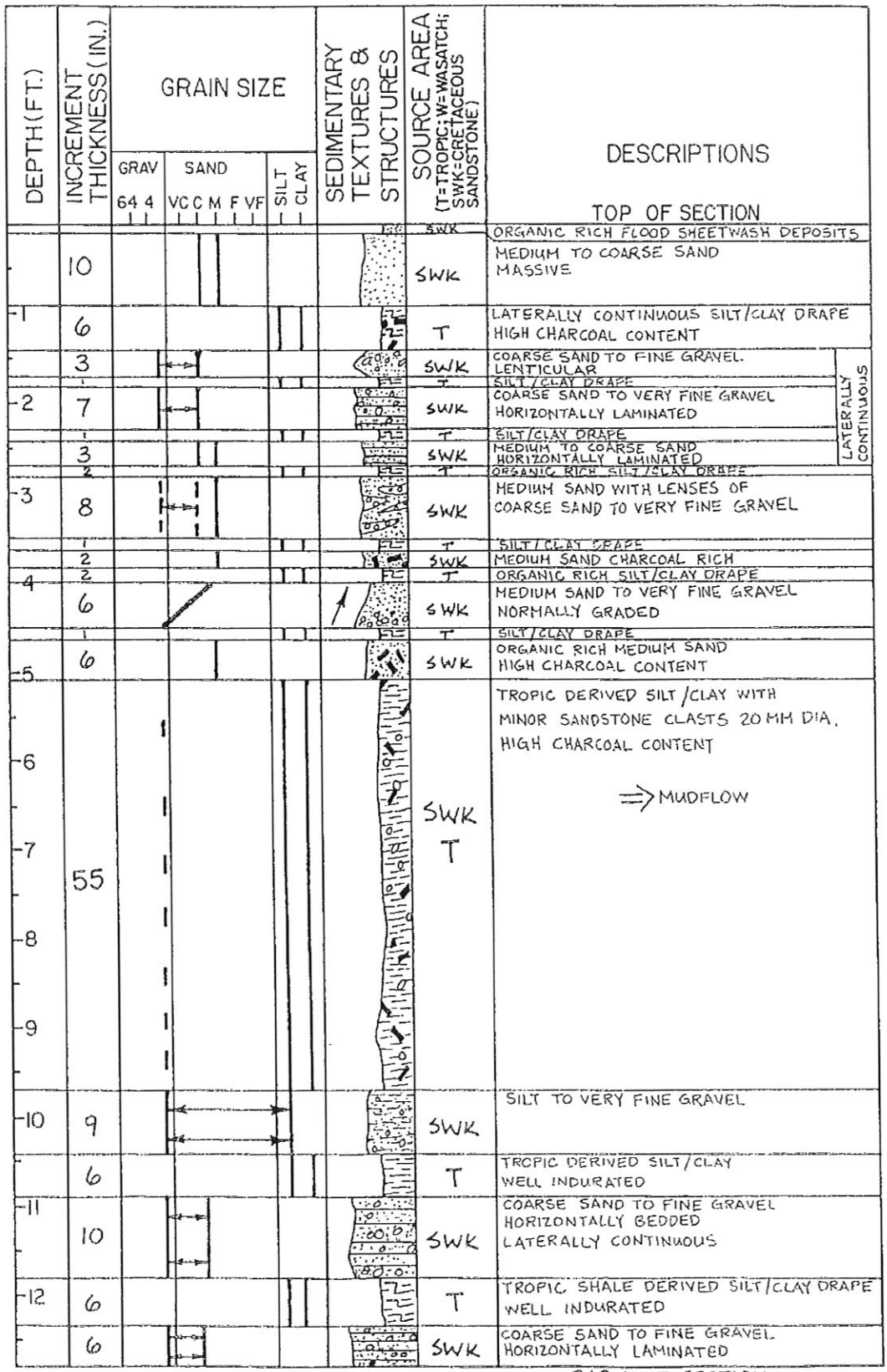
ELEVATION 7174.0

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS (TOP OF SECTION)
	3			SWK	ORGANIC RICH SHEETFLOOD MATERIAL
	5			SWK	STRAIGHT CLIFFS DERIVED VERY WELL SORTED MEDIUM SAND; GREYISH
				T	SILT DRAPE
-1	10			SWK	MEDIUM SAND COARSE/FINE COUPLETS
	4			T	ORGANIC RICH SILT DRAPE
-2	3			SWK	MEDIUM SAND; HORIZONTALLY LAMINATED (COARSE/FINE COUPLETS
				T	SILT DRAPE
	3			SWK	MEDIUM SAND; HORIZONTALLY LAMINATED COARSE/FINE COUPLETS
				T	SILT DRAPE
-3	7			SWK	COARSE SAND TO FINE GRAVEL
				T	SILT DRAPE
-4	9			SWK	MEDIUM SAND HIGH ORGANIC CONTENT
				T	SILT / CLAY DRAPE
-5	9			SWK	COARSE SAND TO FINE GRAVEL RIPUPS, MUDBALLS
	4			SWK	FINE SAND HORIZONTALLY LAMINATED
				T	ORGANIC RICH SILT/CLAY DRAPE
	5			SWK	MEDIUM SAND MASSIVE
-6	2			T	SILT / CLAY DRAPE
	4			SWK	MEDIUM SAND MASSIVE
				T	SILT / CLAY DRAPE
-7	8			SWK	MEDIUM SAND COARSE / FINE COUPLETS
				T	SILT/CLAY DRAPE
	6			SWK	COARSE SAND ABUNDANT RIPUPS
				T	SILT / CLAY DRAPE
-8	5			SWK	MEDIUM SAND HORIZONTALLY LAMINATED COARSE / FINE COUPLETS
	2			T	SILT / CLAY DRAPE
	2			SWK	COARSE SAND HORIZONTALLY LAMINATED
	2			T	ORGANIC RICH SILT/CLAY DRAPE
	2			SWK	COARSE SAND
-9	7			T	TROPIC DERIVED CLAY/SILT DARK BROWN TO BLACK; FRIABLE
-10 -11	29			T	TROPIC DERIVED SILT/CLAY BLOCKY MASSIVE DENSE
-12	5			SWK	COARSE SAND TO FINE GRAVEL IN BLOCKY MASSIVE TROPIC DERIVED SILT AND CLAY

LATERALLY CONTINUOUS DIP 5° WESTWARD (DOWNFAN)

MEASURED SECTION NO. 10
LOCALITY XS 2B
SETTING MIDVALLEY
STATION 5+36

DATE 7/12/88
STRATIGRAPHIC UNIT SEC. 21 V. FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7168.2

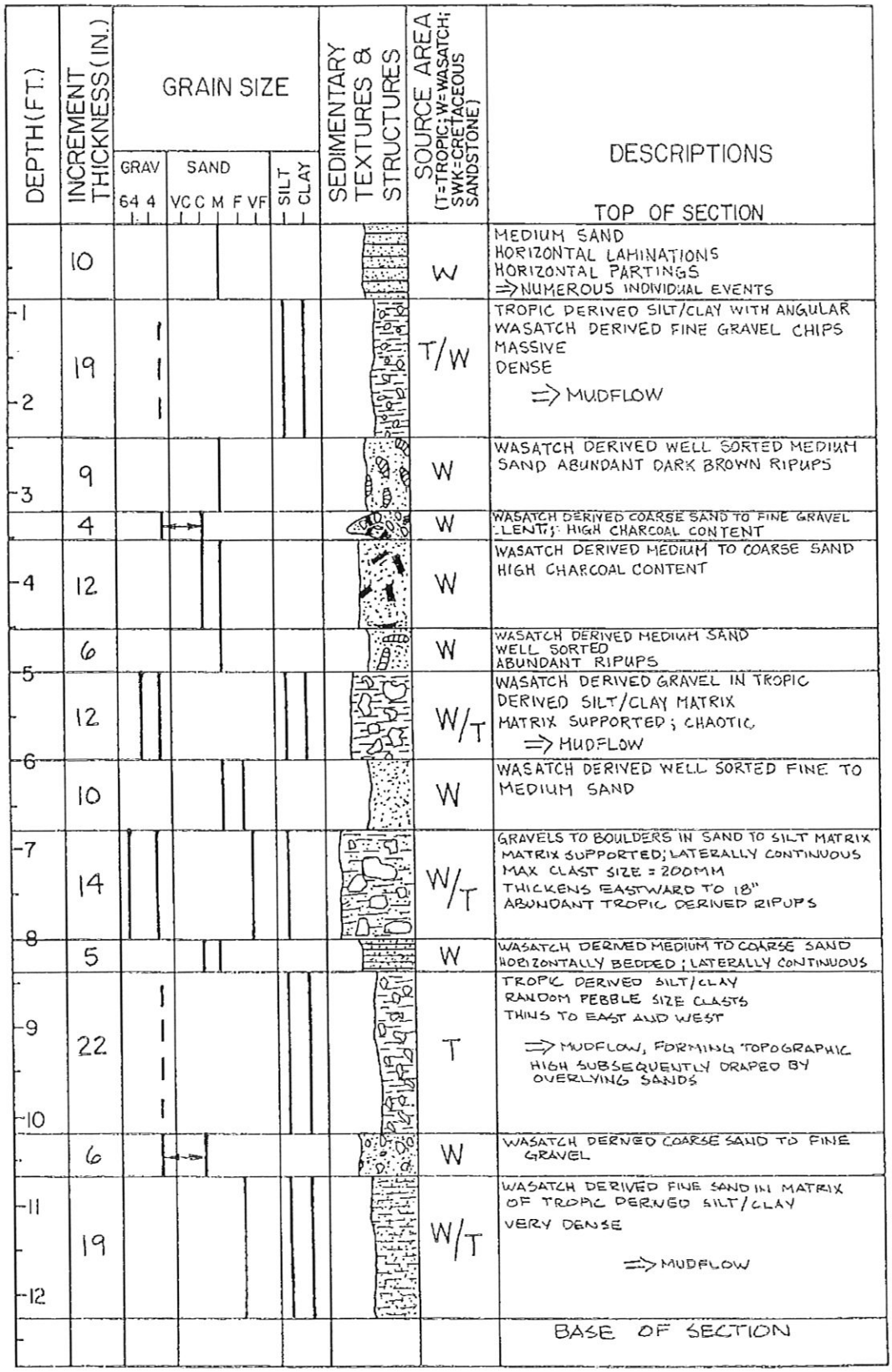


MEASURED SECTION NO. 11 DATE 7/12/88
LOCALITY XS 2B STRATIGRAPHIC UNIT SEC. 21 V. FILL
SETTING SOUTH SIDE VALLEY MEASURED BY MH/KF/JS/DW
STATION 11+39 ELEVATION 7159.5

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT; CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	19			T	TROPIC DERIVED SILT AND CLAY DARK BROWN TO BLACK BLOCKY ; DENSE
	3			T/SWK	GRAVEL IN MUD MATRIX ; CHAOTIC MAX GRAVEL = 20MM ⇒ MUDFLOW
2 3	22			T	TROPIC DERIVED DENSE SILT AND CLAY ⇒ LOWER PORTION OF OVERLYING MUDFLOW?
4	14			SWK T	FINE GRAVEL IN SANDY MUD MATRIX ⇒ MUDFLOW
5	8			SWK	WELL SORTED MEDIUM SAND HIGH CHARCOAL CONTENT
	1			T	SILT/CLAY DRAPE
6	10			SWK	MEDIUM SAND HORIZONTAL LAMINATIONS MUD RIPUPS
	3			SWK	COARSE SAND TO FINE GRAVEL LENTICULAR
7	9			SWK	VERY POORLY SORTED FINE TO MEDIUM SANDS ABUNDANT CHARCOAL, RIPUPS, ORGANICS CHAOTIC
	2			T	SILT/CLAY DRAPE
8	5			SWK	MEDIUM TO COARSE SAND HORIZONTAL LAMINATIONS COARSE/FINE COUPLETS
	5			T	SILT/CLAY DRAPE
9	9			SWK	MEDIUM TO COARSE SAND HORIZONTALLY BEDDED LENTICULAR TOTAL UNIT 33" WIDE x 9" THICK
	6			T	TROPIC DERIVED SILT/CLAY DRAPE HIGH CHARCOAL CONTENT
	3			SWK	MEDIUM SAND
10	9			T	TROPIC DERIVED SILT/CLAY
11	5			SWK	MEDIUM SAND HORIZONTAL LAMINATIONS
12					BASE OF SECTION

MEASURED SECTION NO. 12
LOCALITY XS 3
SETTING MIDVALLEY
STATION 8+59

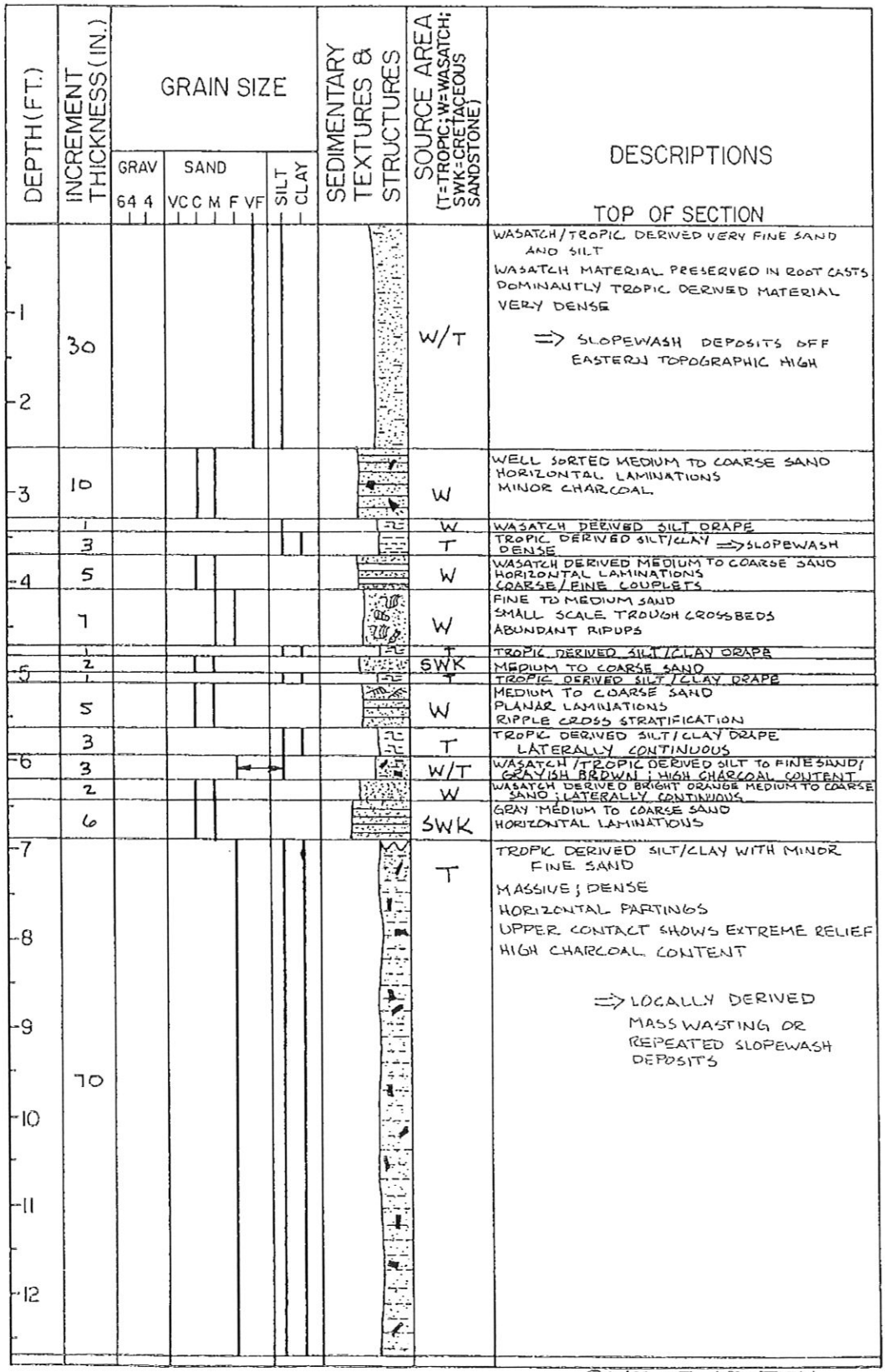
DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7078.1



DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	10			W	MEDIUM SAND HORIZONTAL LAMINATIONS HORIZONTAL PARTINGS ⇒ NUMEROUS INDIVIDUAL EVENTS
1–2	19			T/W	TROPIC DERIVED SILT/CLAY WITH ANGULAR WASATCH DERIVED FINE GRAVEL CHIPS MASSIVE DENSE ⇒ MUDFLOW
3	9			W	WASATCH DERIVED WELL SORTED MEDIUM SAND ABUNDANT DARK BROWN RIPUPS
	4			W	WASATCH DERIVED COARSE SAND TO FINE GRAVEL LENTI; HIGH CHARCOAL CONTENT
4	12			W	WASATCH DERIVED MEDIUM TO COARSE SAND HIGH CHARCOAL CONTENT
5	6			W	WASATCH DERIVED MEDIUM SAND WELL SORTED ABUNDANT RIPUPS
6	12			W/T	WASATCH DERIVED GRAVEL IN TROPIC DERIVED SILT/CLAY MATRIX MATRIX SUPPORTED; CHAOTIC ⇒ MUDFLOW
7	10			W	WASATCH DERIVED WELL SORTED FINE TO MEDIUM SAND
8	14			W/T	GRAVELS TO BOULDERS IN SAND TO SILT MATRIX MATRIX SUPPORTED; LATERALLY CONTINUOUS MAX CLAST SIZE = 200MM THICKENS EASTWARD TO 18" ABUNDANT TROPIC DERIVED RIPUPS
	5			W	WASATCH DERIVED MEDIUM TO COARSE SAND HORIZONTALLY BEDDED; LATERALLY CONTINUOUS
9–10	22			T	TROPIC DERIVED SILT/CLAY RANDOM PEBBLE SIZE CLASTS THINS TO EAST AND WEST ⇒ MUDFLOW, FORMING TOPOGRAPHIC HIGH SUBSEQUENTLY DRAPED BY OVERLYING SANDS
	6			W	WASATCH DERIVED COARSE SAND TO FINE GRAVEL
11–12	19			W/T	WASATCH DERIVED FINE SAND IN MATRIX OF TROPIC DERIVED SILT/CLAY VERY DENSE ⇒ MUDFLOW
					BASE OF SECTION

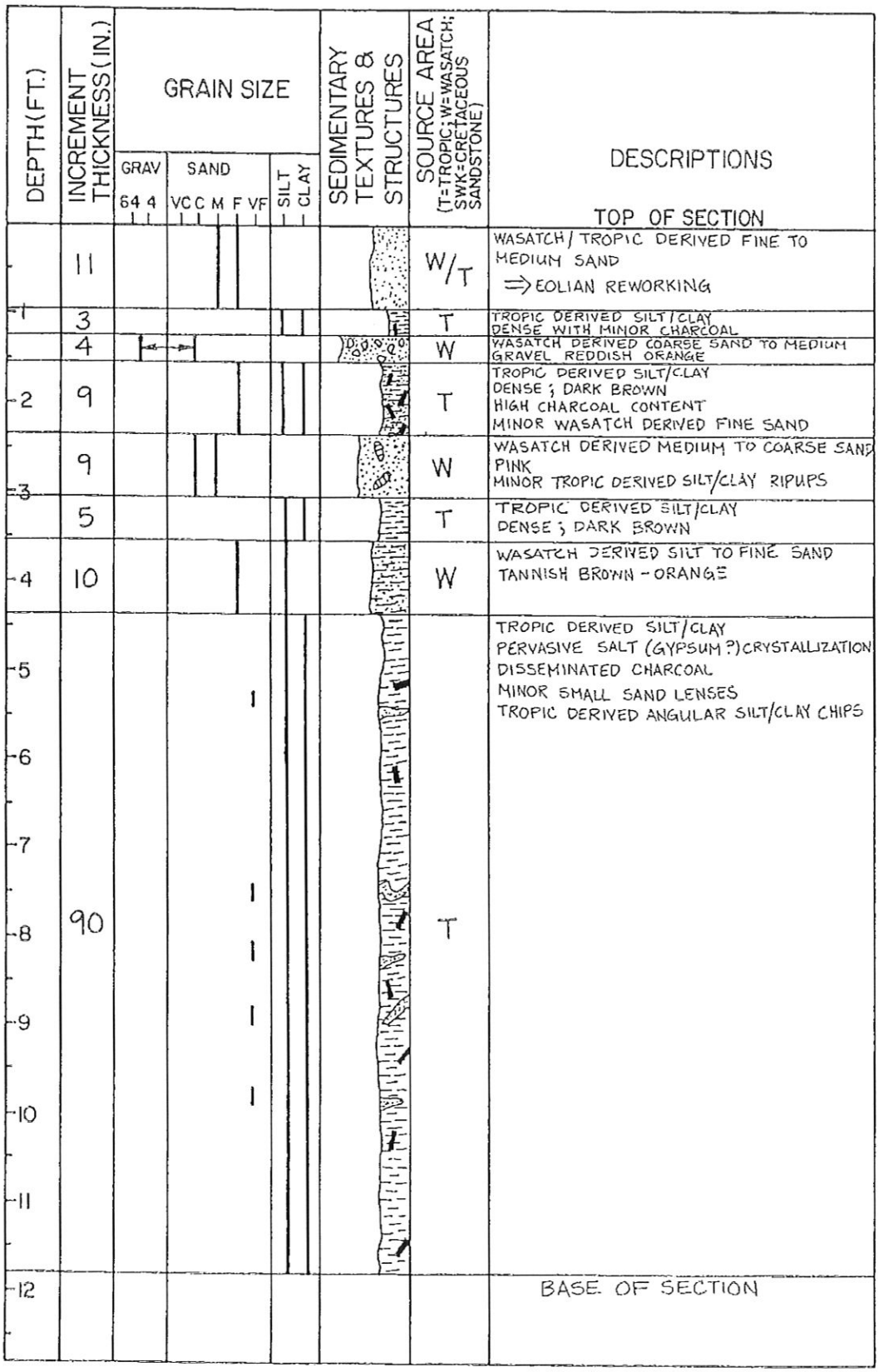
MEASURED SECTION NO. 13
LOCALITY XS 3
SETTING EAST SIDE VALLEY
STATION 1+79

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 7084.0



MEASURED SECTION NO. 14
LOCALITY XS 4A
SETTING WEST SIDE VALLEY
STATION 39+88

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 6931.3



DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	11			W/T	WASATCH / TROPIC DERIVED FINE TO MEDIUM SAND ⇒ EOLIAN REWORKING
1	3			T	TROPIC DERIVED SILT/CLAY DENSE WITH MINOR CHARCOAL
	4			W	WASATCH DERIVED COARSE SAND TO MEDIUM GRAVEL REDDISH ORANGE
2	9			T	TROPIC DERIVED SILT/CLAY DENSE ; DARK BROWN HIGH CHARCOAL CONTENT MINOR WASATCH DERIVED FINE SAND
3	9			W	WASATCH DERIVED MEDIUM TO COARSE SAND PINK MINOR TROPIC DERIVED SILT/CLAY RIPUPS
	5			T	TROPIC DERIVED SILT/CLAY DENSE ; DARK BROWN
4	10			W	WASATCH DERIVED SILT TO FINE SAND TANNISH BROWN - ORANGE
5	90			T	TROPIC DERIVED SILT/CLAY PERVASIVE SALT (GYPSUM ?) CRYSTALLIZATION DISSEMINATED CHARCOAL MINOR SMALL SAND LENSES TROPIC DERIVED ANGULAR SILT/CLAY CHIPS
6					
7					
8					
9					
10					
11					
12					BASE OF SECTION

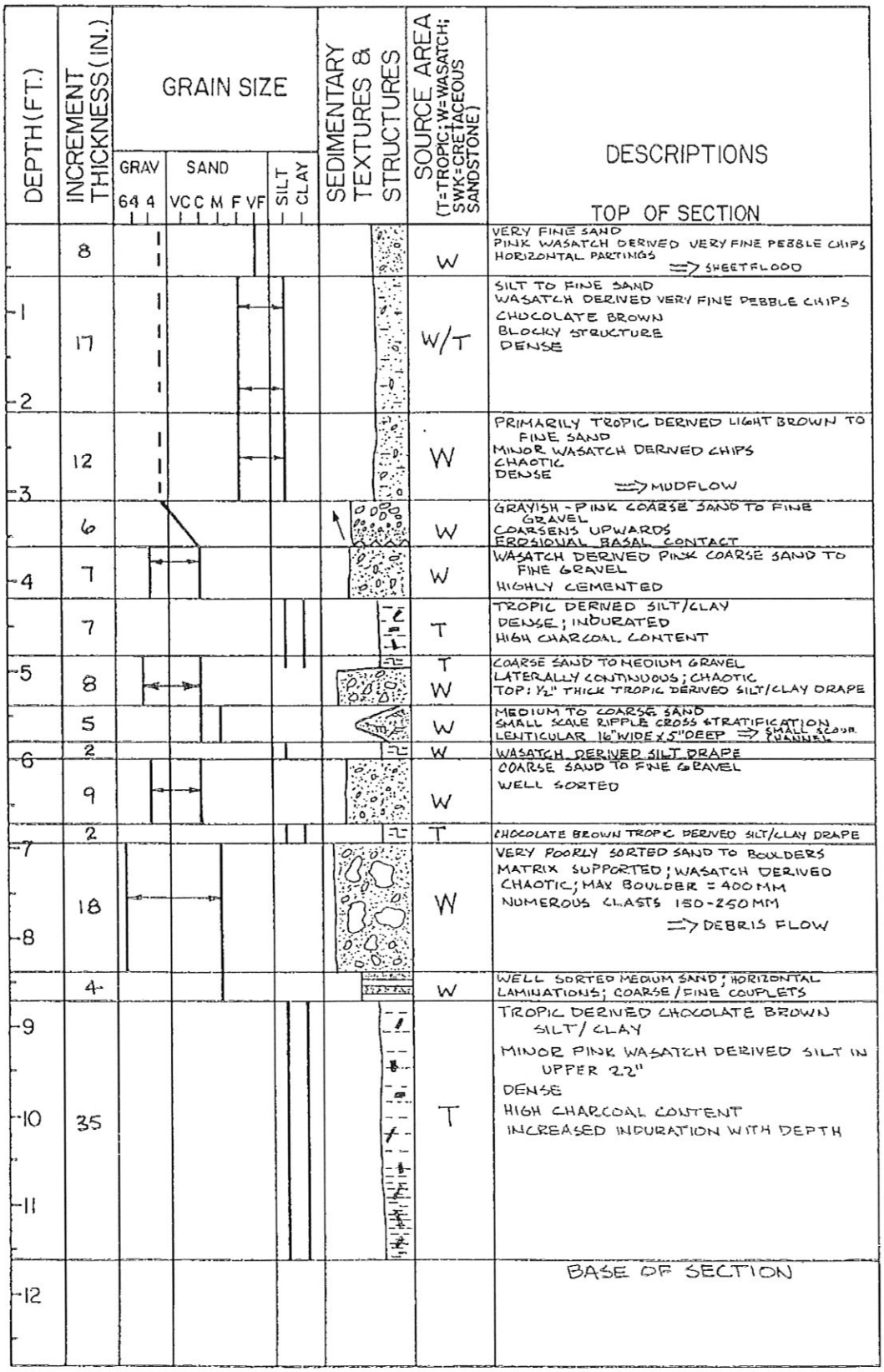
MEASURED SECTION NO 15
LOCALITY XS 4A
SETTING MIDVALLEY
STATION 26+00

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS/DW
ELEVATION 6988.2

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	20			T/W	DARK GRAY SILT TO FINE SAND MINOR WASATCH DERIVED PINK FINE PEBBLE CHIPS ROOTING ZONE
2	15			W	WASATCH DERIVED FINE SAND TO SILT WELL SORTED WELL INDURATED
3–4	16			T/W	CLAY TO MEDIUM SAND WASATCH DERIVED FINE PEBBLE CHIPS VERY DENSE
	6			T/W	ORGANIC RICH HORIZON (ROOTS) PEAT TYPE DEPOSIT => MAXIMUM DEPTH OF OPTIMUM ROOTING; SEASONALLY HIGH POINT OF WATER TABLE
5–6	23			T	GLEY HORIZON WATER SATURATED SILT =▽=
7–9	37				BASE OF SECTION-WATER LEVEL STANDING WATER
10–12					BASE OF HOLE

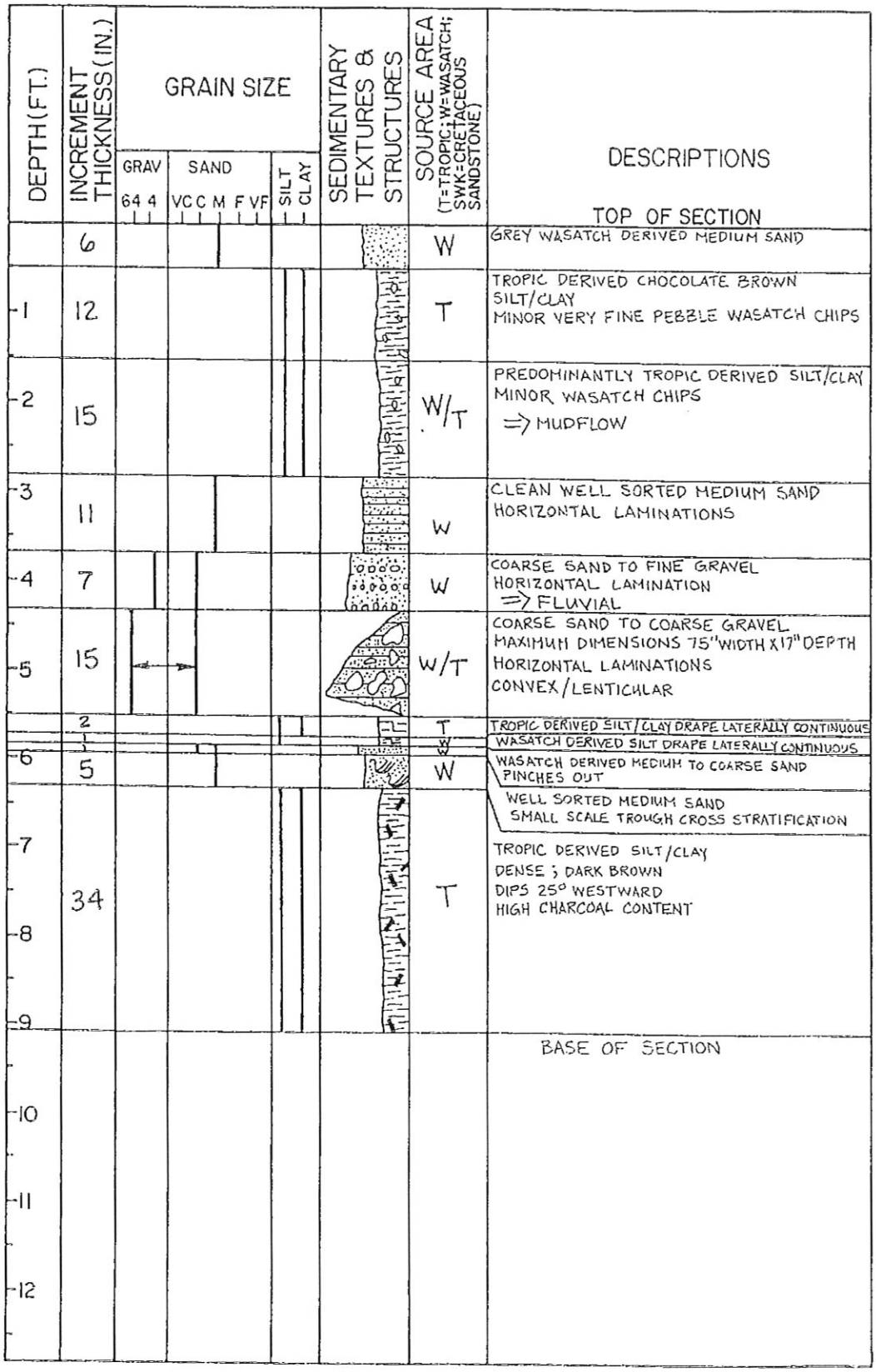
MEASURED SECTION NO. 16
LOCALITY XS 4A
SETTING MIDVALLEY
STATION 11+82

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 7008.7



MEASURED SECTION NO 17
LOCALITY XS 3
SETTING EAST SIDE; 9' WEST OF M.S. 13
STATION 1+79

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 7084.0

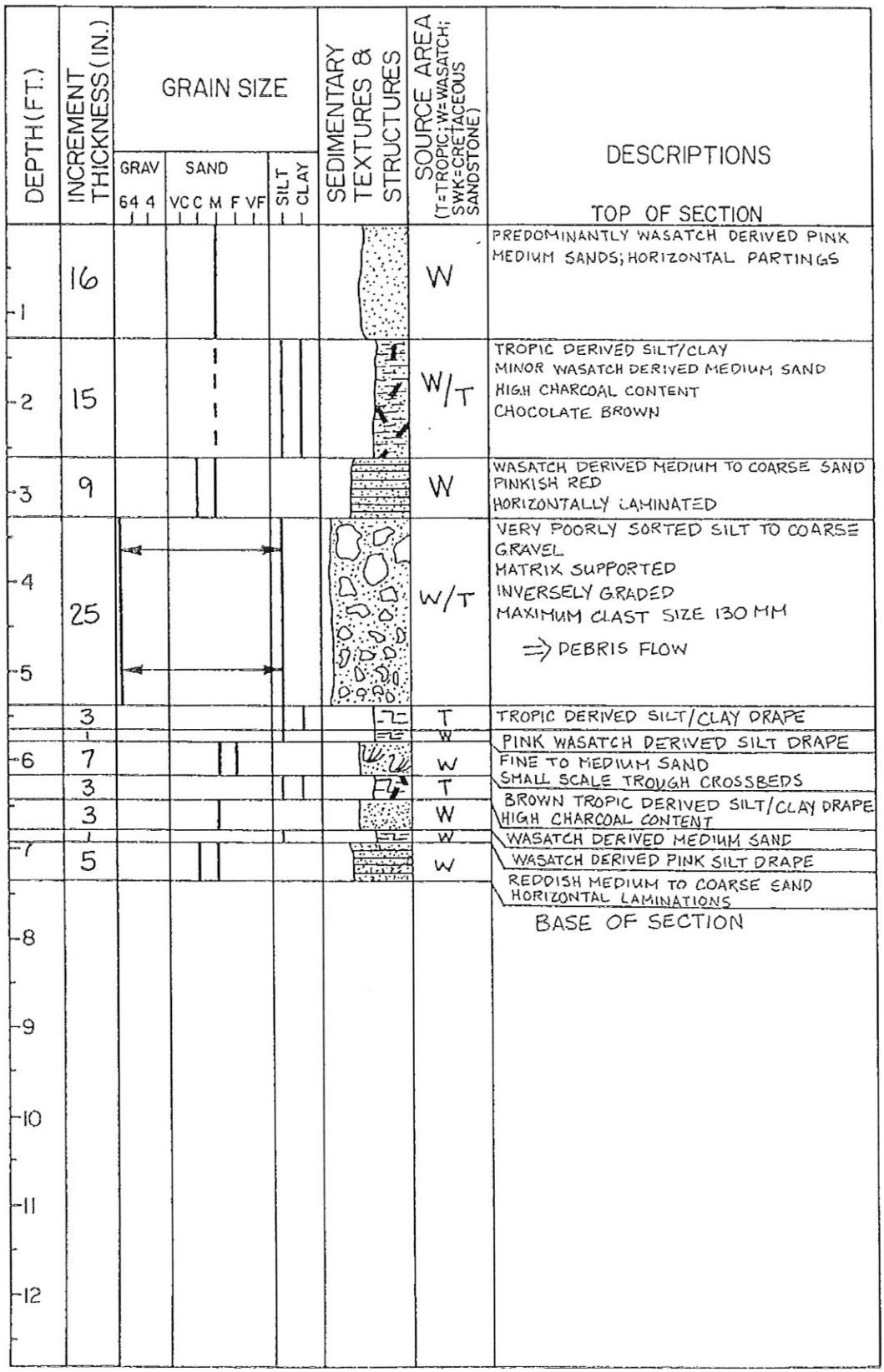


MEASURED SECTION NO 18 DATE 7/13/88
LOCALITY XS 3 STRATIGRAPHIC UNIT VALLEY FILL
SETTING EAST SIDE; 16' WEST OF M.S. 13 MEASURED BY MH/KF
STATION 1+79 ELEVATION 7048.0

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	7			W/T	FINE TO MEDIUM SAND HORIZONTALLY LAMINATED MINOR WASATCH DERIVED VERY FINE PEBBLE CHIPS
1	15			T	TROPIC DERIVED SILT/CLAY CHOCOLATE BROWN MINOR ANGULAR WASATCH DERIVED VERY FINE PEBBLE CLASTS
2	10			W/T	MEDIUM SAND TROPIC DERIVED RIPUPS HIGH CHARCOAL CONTENT CHAOTIC
3	12			W/T	WELL SORTED MEDIUM SAND MINOR TROPIC/WASATCH SILT RIPUPS HORIZONTALLY LAMINATED
4 5	26			W/T	MATRIX SUPPORTED VERY POORLY SORTED SAND TO COBBLES CLASTS UP TO 100 MM CURVILINEAR BASAL CONTACT INVERSELY GRADED / CHAOTIC ⇒ DEBRIS FLOW INFILLING TOPOGRAPHIC LOW
				W	WASATCH DERIVED SILT DRAPE
6	6			W	MEDIUM TO COARSE SAND SMALL SCALE TROUGH CROSSBEDS
				W	WASATCH DERIVED PINK SILT DRAPE
7 8	25			W	SERIES OF ALTERNATING SILT DRAPES AND MEDIUM TO COARSE SANDS DRAPES 1" THICK SAND 2-3" THICK ALL WASATCH DERIVED
9 10 11 12					BASE OF SECTION

MEASURED SECTION NO 19
LOCALITY XS 3
SETTING EAST SIDE; 25' WEST OF M.S. 13
STATION 1+79

DATE 7/13/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 7084.0



MEASURED SECTION NO. 20
LOCALITY XS 4A
SETTING TLB LOWER ROBINSON CREEK
STATION 42+80

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6921.4

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT, CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	15			W/T	WASATCH/TROPIC DERIVED SILT TO FINE SAND MASSIVE; FRIABLE
2 3	31			T	TROPIC DERIVED SILT/CLAY DENSE; BLOCKY
4				W	WASATCH DERIVED SILT DRAPE DISCONTINUOUS
5	25			T	TROPIC DERIVED SILT/CLAY MASSIVE MINOR WASATCH DERIVED ROOT COATINGS
6	3			W	WASATCH DERIVED FINE TO MEDIUM SAND MASSIVE; DISCONTINUOUS
7 8 9 10 11 12	71			T SWK	TROPIC DERIVED SILT/CLAY PERVASIVE SALT CRYSTALLIZATION 22" FROM TOP, MINOR STRAIGHT CLIFFS DERIVED PEBBLES, UP TO 20MM NO WASATCH MATERIAL
					BASE OF SECTION

MEASURED SECTION NO. 21
LOCALITY XS 4A
SETTING EAST SIDE VALLEY
STATION 4+42

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 7017.6

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT; CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	8			T	TROPIC DERIVED SILT TO FINE SAND DESSICATED; FRIABLE; MASSIVE MINOR WASATCH INPUT
1	12			W T W	TROPIC DERIVED SILT/CLAY DISCONTINUOUS LENSES OF WASATCH DERIVED SILTS
2	15			T	TROPIC DERIVED SILT/CLAY DENSE
3	6			T	TROPIC DERIVED SILT TO FINE SAND HORIZONTAL LAMINATION
	3			T	TROPIC DERIVED SILT, HIGH CHARCOAL CONTENT
	1			W	WASATCH DERIVED SILT DRAPE
4	2			T	TROPIC DERIVED SILT, SOME CHARCOAL, WASATCH CHIPS
	1			W	WASATCH DERIVED SILT DRAPE
	3			W/T	WASATCH/TROPIC DERIVED SILT TO MEDIUM SAND
	2			W	WASATCH DERIVED SILT DRAPE
	3			W/T	ALTERNATING T/W/T/W SILT DRAPE
	2			W	WASATCH DERIVED SILT TO FINE SAND
5	2			W/T	W/T MED. SAND TROUGH CROSSBEDS C/F COUPLETS
	1			W	WASATCH DERIVED SILT DRAPE
	1			W	WASATCH DERIVED SAND TROUGH CROSSBEDS
	2			W	WASATCH DERIVED SILT TO FINE SAND
	2			W/T	W/T DERIVED SILT TO MED. SAND; TROUGH CROSSBEDS
	1			W	WASATCH DERIVED SILT DRAPE
6	5			W/T	WASATCH/TROPIC DERIVED SILT TO MEDIUM SAND POORLY SORTED, MINOR TROUGH CROSS STRATIFICATION
	2			W/T	ALTERNATING W/T DERIVED SILT/CLAY DRAPES
	3			SWK	SILT TO MEDIUM SAND LIGHT BROWN MINOR TROUGH CROSSBEDS
	1			W	WASATCH DERIVED SILT DRAPE
	2			W	WASATCH DERIVED SILT TO FINE SAND
7	2			W/T	ALTERNATING W/T DERIVED SILT/CLAY DRAPES
	3			W	WASATCH DERIVED SILT TO MEDIUM SAND HORIZONTAL LAMINATIONS
	4			W/T	ALTERNATING W/T DERIVED SILT/CLAY DRAPES
	3			SWK	COARSE SAND TO FINE GRAVEL; INVERSELY GRADED EROSIONAL BASE
8	2			T	TROPIC DERIVED SILT
	4			SWK	FINE TO MEDIUM SAND COURSE / FINE COUPLETS
	1			W	WASATCH DERIVED SILT DRAPE
	5			SWK/W	SILT TO COARSE SAND TROUGH CROSSBEDS HIGH CHARCOAL CONTENT
9	7			T	TROPIC DERIVED CLAY TO FINE SAND; CHARCOAL MINOR WASATCH CHIPS
	1			W	WASATCH DERIVED SILT TO MEDIUM SAND
10	13			W/T	INTERBEDDED MEDIUM SAND AND SILT/CLAY DRAPES SAND 2-4", DRAPES 1" LIGHT TO DARK BROWN PRIMARILY TROPIC DERIVED, WITH SOME WASATCH MATERIAL IN DRAPES
11	6			W/T	ALTERNATING WASATCH/TROPIC DERIVED SILT/CLAY MINOR VF SAND
	5			W/T	WASATCH/TROPIC DERIVED SILT/CLAY
	2			W	WASATCH DERIVED SILT TO COARSE SAND LENTICULAR; HORIZONTAL LAMINATIONS
	4			W/T/SWK	ALTERNATING W/T DERIVED SILT/CLAY PINK-BROWN-GRAY HIGH CHARCOAL CONTENT
12	2			SWK	LIGHT BROWN FINE TO MEDIUM SAND; MASSIVE
	6			T/SWK	SILT TO FINE SAND LIGHT BROWN; MASSIVE
					BASE OF SECTION

MEASURED SECTION NO. 22
LOCALITY XS 4B
SETTING NORTH SWAPP HOLLOW
STATION 7+86

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6988.7

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT; CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	23			T/W	DENSE PRIMARILY TROPIC DERIVED SILT/CLAY WITH MINOR WASATCH DERIVED COARSE SAND POORLY SORTED; BROWN HIGH CHARCOAL CONTENT
2, 3, 4	32			T/W	DENSE TROPIC DERIVED SILT/CLAY WITH MINOR FLOATING FRAGMENTS OF WASATCH DERIVED COARSE SAND TO FINE GRAVEL.
	4			W	WASATCH DERIVED CLAY TO MEDIUM SAND; DENSE; PINK LATERALLY CONTINUOUS; DIPS 4° SOUTHWARD
5, 6, 7, 8	43			T/W	TROPIC DERIVED SILT/CLAY VERY DENSE; HIGH CHARCOAL CONTENT DISCRETE POCKETS OF WASATCH DERIVED SILT TO FINE SAND - BRIGHT ORANGE IN DARK BROWN MATRIX => CRACK INFILLING? PERVASIVE SALT CRYSTALLIZATION
9, 10	25			T/W	TROPIC DERIVED SILT/CLAY SALT CRYSTALLIZATION MINOR WASATCH SILT TO FINE SAND
11, 12					BASE OF SECTION

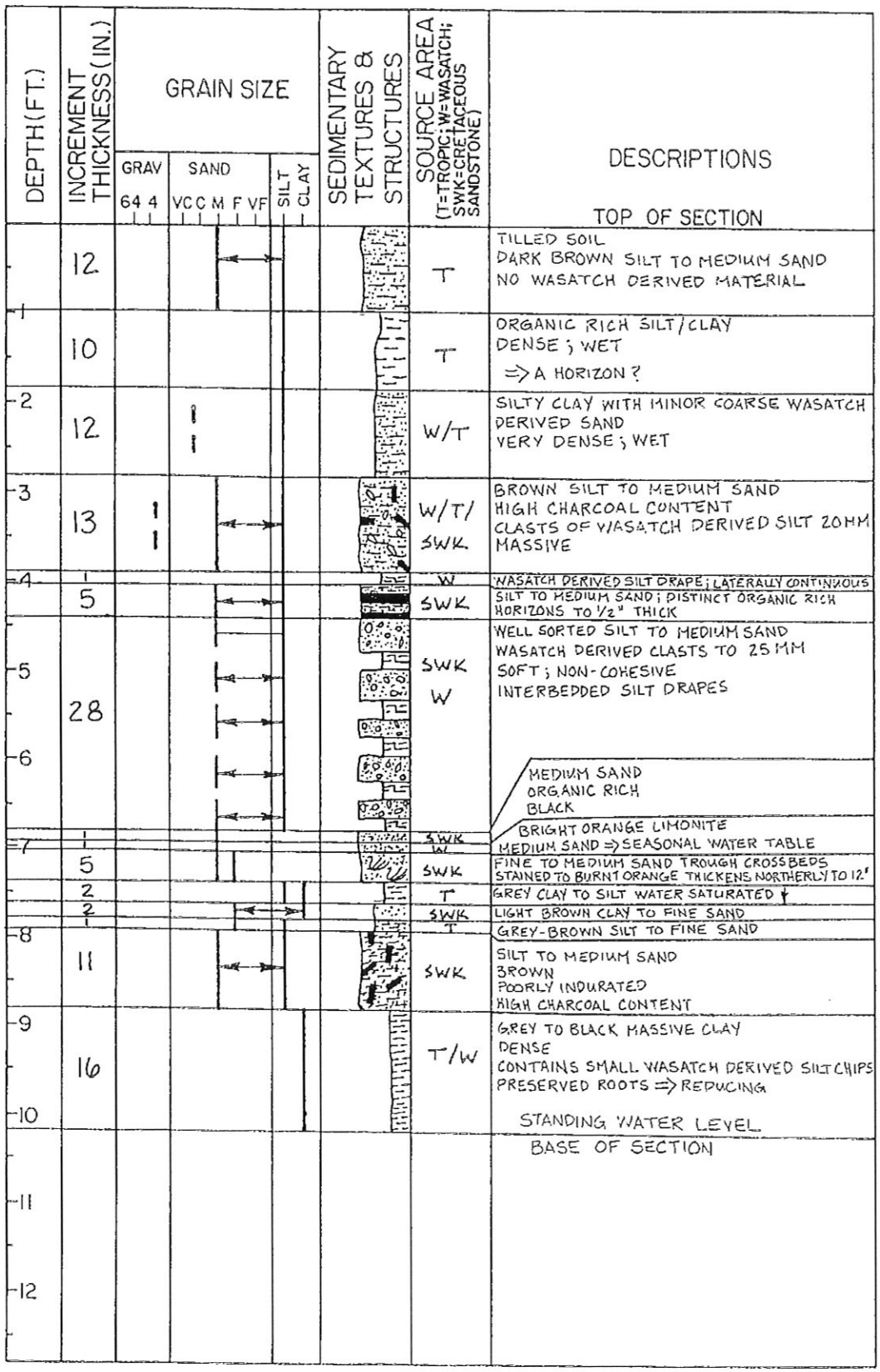
MEASURED SECTION NO. 23
LOCALITY XS 4B
SETTING SOUTH SIDE SWAPP HOLLOW
STATION 23+67

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6952.3

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT; CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	15			W/T	TROPIC DERIVED SILT/CLAY MINOR WASATCH CLASTS UP TO 15 MM CHAOTIC
2 3 4	42			W/T	TROPIC DERIVED SILT/CLAY FRIABLE; VERY DENSE RANDOM WASATCH CLASTS UP TO 35MM CHAOTIC => MUDFLOW
5	9			T/W/SWK	MED. SAND TO COARSE GRAVEL UP TO 130MM CHAOTIC; CONVEX; LENTICULAR FAINT INVERSE GRADING; HIGH CHARCOAL CONTENT; MINOR WASATCH DERIVED MATERIAL
	2			W	WASATCH DERIVED PINK SILT DRAPE
6	4			W/T	TROPIC DERIVED SILT/CLAY W/ MINOR WASATCH DERIVED CHIPS UP TO 10MM
	1			W	WASATCH DERIVED PINK SILT DRAPE
	2			T	TROPIC DERIVED SILT/CLAY; CHARCOAL; MASSIVE
	1			W	WASATCH DERIVED PINK SILT DRAPE
7	10			T	TROPIC DERIVED SILT/CLAY BROWN RIPUPS OF WASATCH DERIVED SILT DRAPES
	2			T	SILT TO FINE SAND; TROPIC/STRAIGHT CLIFFS; CHARCOAL
8	9			W/T	TROPIC DERIVED SILT/CLAY WITH RANDOMLY ORIENTED WASATCH DERIVED FINE GRAVEL
	2			W	WASATCH DERIVED SILT/CLAY; PINK
9 10	25			SWK	SILT TO FINE SAND; MOTTLED; BROWN TROPIC/STRAIGHT CLIFFS DERIVED
11	6			T/W/SWK	TROPIC DERIVED CLAY TO FINE SAND HIGH CHARCOAL CONTENT MINOR WASATCH COARSE SAND
	5			SWK/W	SILT TO FINE SAND; GREY TO LIGHT BROWN; CHARCOAL; COARSE SAND SIZE WASATCH DERIVED FRAGMENTS
12					BASE OF SECTION

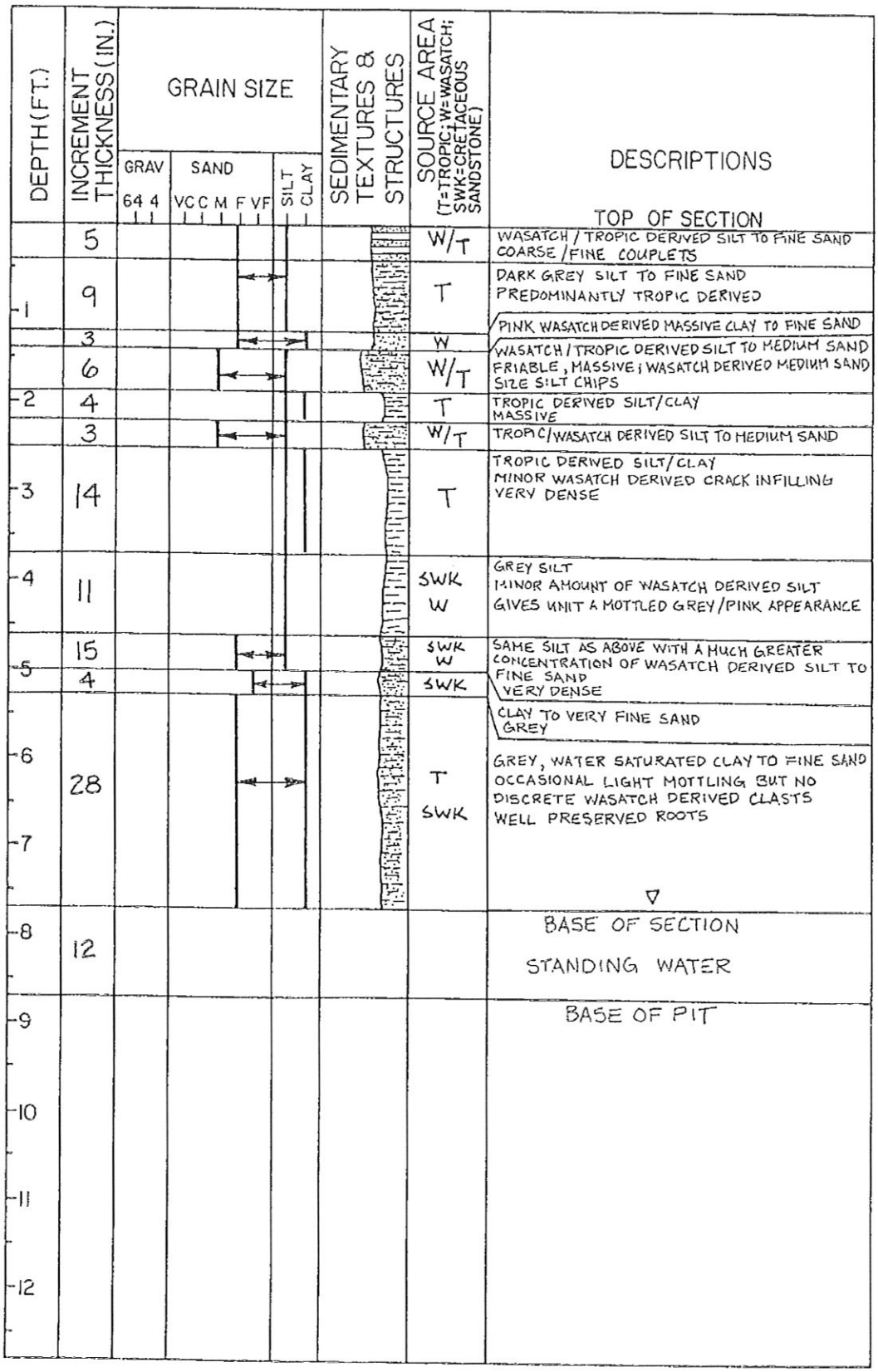
MEASURED SECTION NO. 24
LOCALITY XS 5
SETTING WEST EDGE SORENSON'S GARDEN
STATION 10+14

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6946.9



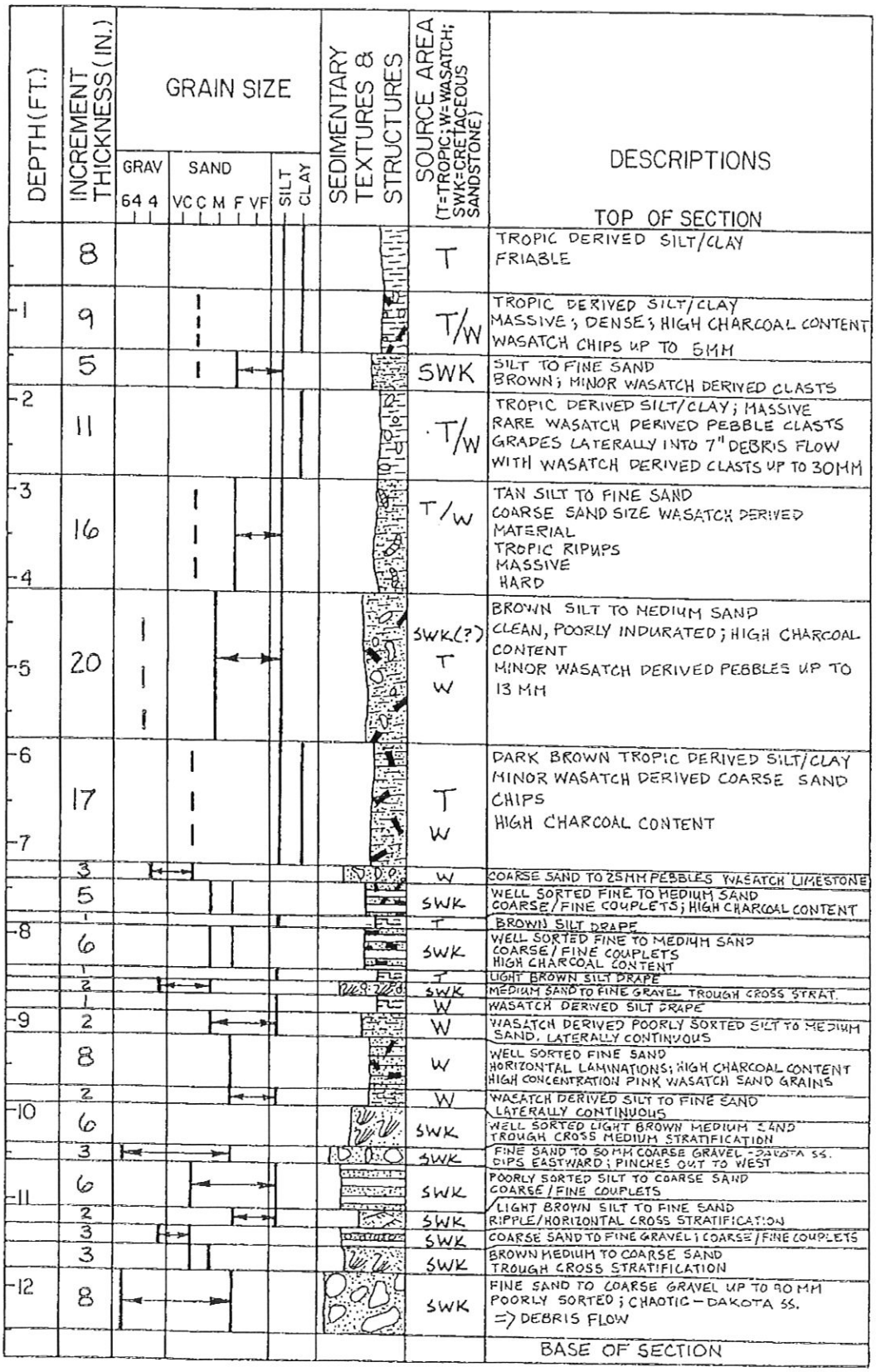
MEASURED SECTION NO. 25
LOCALITY XS 5
SETTING MIDVALLEY
STATION 24+29

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6917.5



MEASURED SECTION NO 26
LOCALITY XS 5
SETTING WEST SIDE VALLEY
STATION 40+02

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6871.1



DEPTH (FT.)	INCREMENT THICKNESS (IN.)	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
			TOP OF SECTION
	8	T	TROPIC DERIVED SILT/CLAY FRIABLE
1	9	T/W	TROPIC DERIVED SILT/CLAY MASSIVE; DENSE; HIGH CHARCOAL CONTENT WASATCH CHIPS UP TO 5MM
	5	SWK	SILT TO FINE SAND BROWN; MINOR WASATCH DERIVED CLASTS
2	11	T/W	TROPIC DERIVED SILT/CLAY; MASSIVE RARE WASATCH DERIVED PEBBLE CLASTS GRADES LATERALLY INTO 7" DEBRIS FLOW WITH WASATCH DERIVED CLASTS UP TO 30MM
3 4	16	T/W	TAN SILT TO FINE SAND COARSE SAND SIZE WASATCH DERIVED MATERIAL TROPIC RIPUPS MASSIVE HARD
5	20	SWK(?) T W	BROWN SILT TO MEDIUM SAND CLEAN, POORLY INDURATED; HIGH CHARCOAL CONTENT MINOR WASATCH DERIVED PEBBLES UP TO 13 MM
6 7	17	T W	DARK BROWN TROPIC DERIVED SILT/CLAY MINOR WASATCH DERIVED COARSE SAND CHIPS HIGH CHARCOAL CONTENT
	3	W	COARSE SAND TO 25MM PEBBLES WASATCH LIMESTONE
	5	SWK	WELL SORTED FINE TO MEDIUM SAND COARSE/FINE COUPLETS; HIGH CHARCOAL CONTENT
	1	T	BROWN SILT DRAPE
8	6	SWK	WELL SORTED FINE TO MEDIUM SAND COARSE/FINE COUPLETS HIGH CHARCOAL CONTENT
	1	T	LIGHT BROWN SILT DRAPE
	2	SWK	MEDIUM SAND TO FINE GRAVEL TROUGH CROSS STRAT.
	1	W	WASATCH DERIVED SILT DRAPE
9	2	W	WASATCH DERIVED POORLY SORTED SILT TO MEDIUM SAND, LATERALLY CONTINUOUS
	8	W	WELL SORTED FINE SAND HORIZONTAL LAMINATIONS; HIGH CHARCOAL CONTENT HIGH CONCENTRATION PINK WASATCH SAND GRAINS
	2	W	WASATCH DERIVED SILT TO FINE SAND LATERALLY CONTINUOUS
10	6	SWK	WELL SORTED LIGHT BROWN MEDIUM SAND TROUGH CROSS MEDIUM STRATIFICATION
	3	SWK	FINE SAND TO 50 MM COARSE GRAVEL - DAKOTA SS. DIPS EASTWARD; PINCHES OUT TO WEST
11	6	SWK	POORLY SORTED SILT TO COARSE SAND COARSE/FINE COUPLETS
	2	SWK	LIGHT BROWN SILT TO FINE SAND RIPPLE/HORIZONTAL CROSS STRATIFICATION
	3	SWK	COARSE SAND TO FINE GRAVEL; COARSE/FINE COUPLETS
	3	SWK	BROWN MEDIUM TO COARSE SAND TROUGH CROSS STRATIFICATION
12	8	SWK	FINE SAND TO COARSE GRAVEL UP TO 90 MM POORLY SORTED; CHAOTIC – DAKOTA SS. => DEBRIS FLOW
			BASE OF SECTION

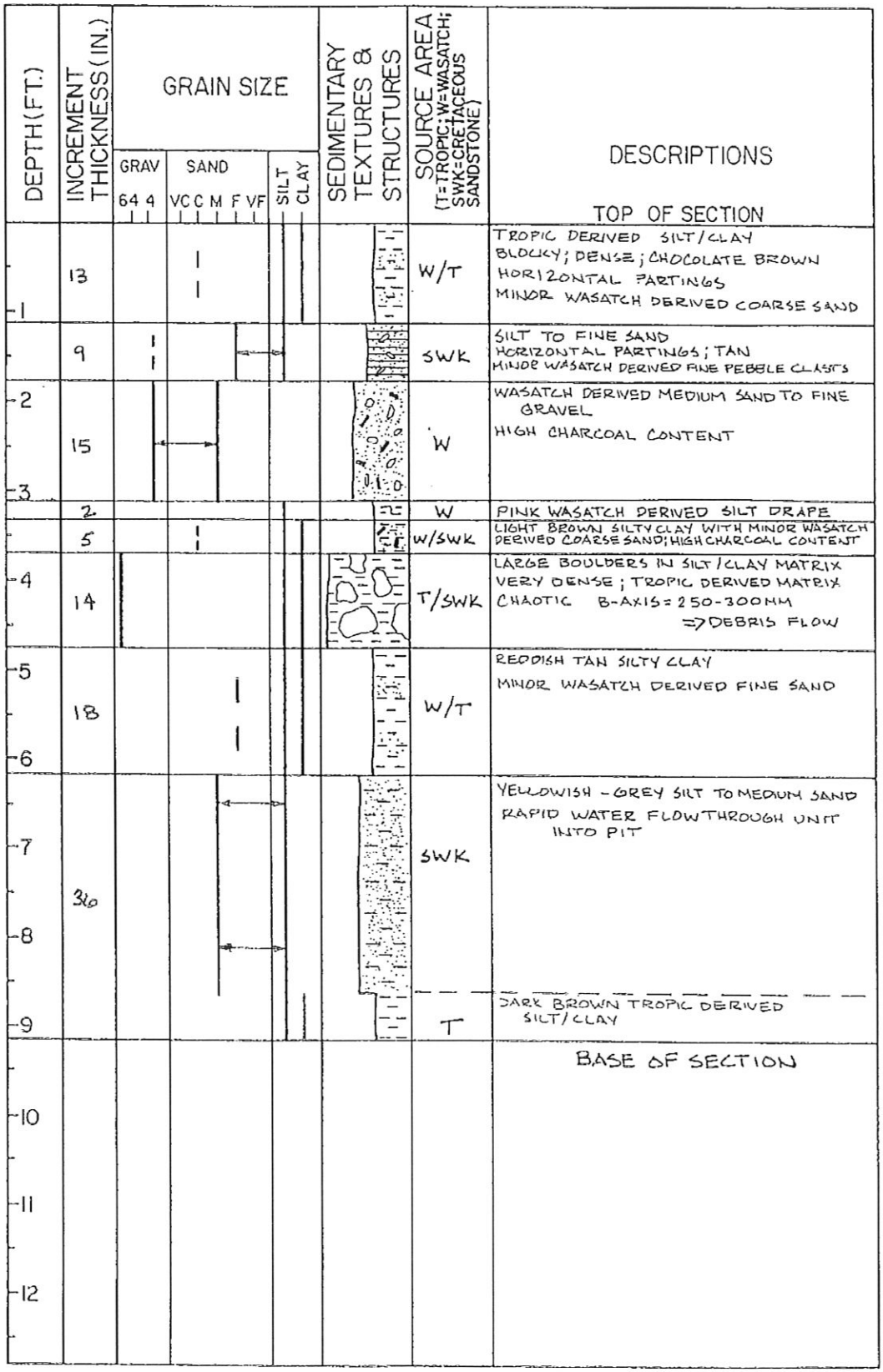
MEASURED SECTION NO. 27
LOCALITY XS 6
SETTING WEST SIDE VALLEY
STATION 29+92

DATE 7/14/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY KF/JS
ELEVATION 6851.9

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT; CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	11			W	WASATCH DERIVED SILT TO FINE SAND HORIZONTAL PARTINGS ⇒ SHEETFLOW
1	2			T	TROPIC DERIVED SILT/CLAY; MASSIVE; HIGH CHARCOAL CONTENT
	7			W/T	WASATCH/TROPIC DERIVED SILT
2 3	20			T	TROPIC DERIVED SILT/CLAY HIGH CHARCOAL CONTENT MASSIVE
	5			SWK	SILT TO MED. SAND LIGHT BROWN HIGH CHARCOAL CONTENT
4 5	16			W/T	TROPIC DERIVED SILT/CLAY WITH WASATCH DERIVED FINE SAND
6 7	31			T	GREY CLAY WATER SATURATED ORANGE MOTTLING ▽
8 9					BASE OF SECTION STANDING WATER
10 11 12					BASE OF PIT

MEASURED SECTION NO 28
LOCALITY XS 6
SETTING SWAPP RANCH
STATION 18+91

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF
ELEVATION 6866.8



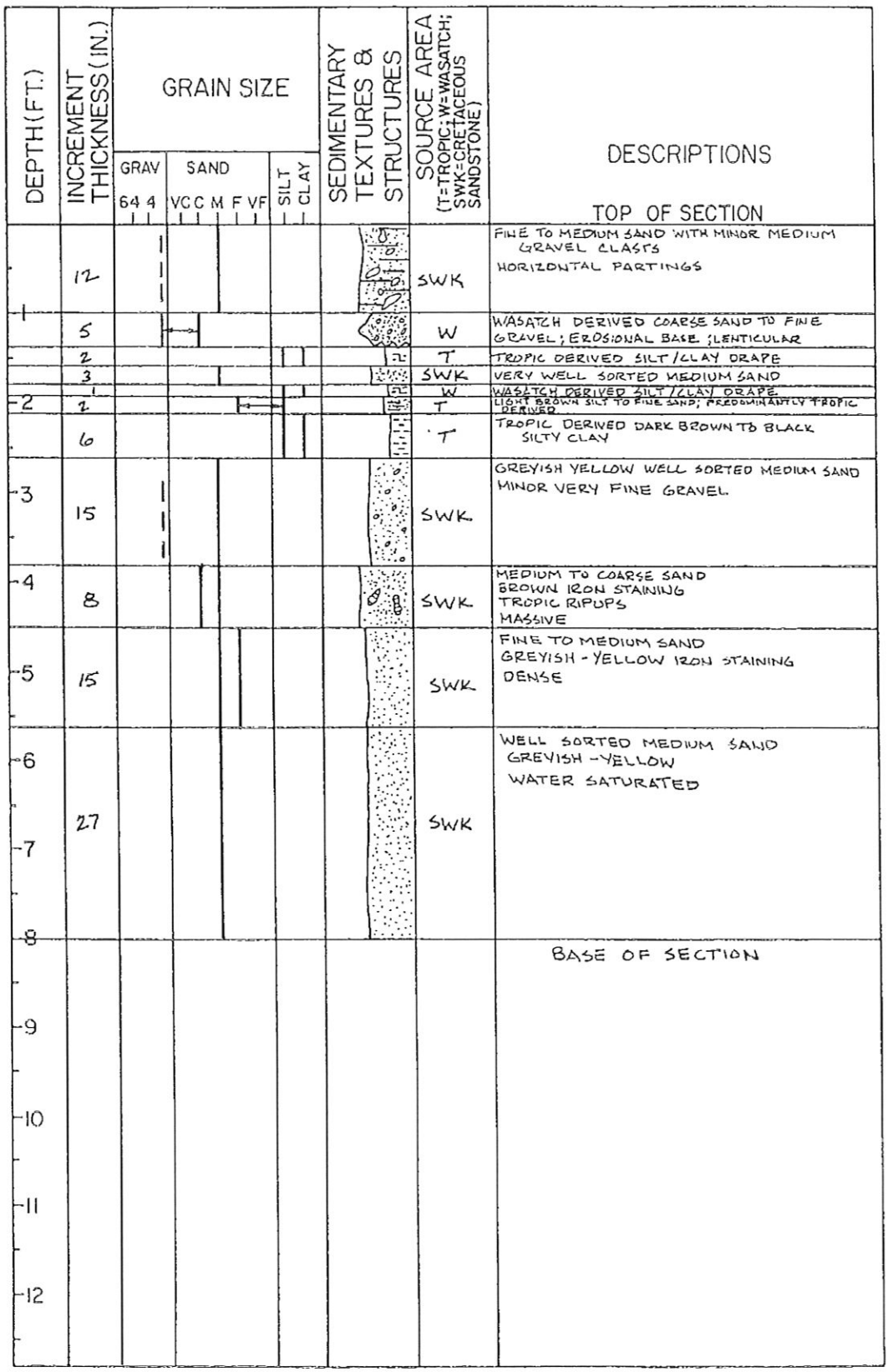
MEASURED SECTION NO. 29
LOCALITY XS 7
SETTING WEST SIDE VALLEY
STATION 8+99

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS
ELEVATION 6814.2

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	8			T	DARK BROWN TROPIC DERIVED SILT/CLAY PEDOGENIC STRUCTURE
1	9			W	PREDOMINANTLY WASATCH DERIVED SILT TO FINE SAND MINOR SMALL PEBBLE SIZE WASATCH SILT FRAGMENTS
2	8			T	DARK BROWN TROPIC DERIVED SILT/CLAY HIGH CHARCOAL CONTENT
3	14			W/T	PINK-TAN WASATCH DERIVED SILT TO FINE SAND TROPIC SHALE RIPUPS
	1			W	PINK WASATCH DERIVED SILT DRAPE
4	10			SWK	VERY WELL SORTED MEDIUM SAND TAINNISH, WITH MINOR PINK WASATCH DERIVED SILT FRAGMENTS
5	15			T/W	DARK BROWN TROPIC DERIVED SILT/CLAY VERY DENSE MINOR WASATCH DERIVED PINK SILT FRAGMENTS
6 7 8 9	42			SWK	YELLOWISH-GREY VERY WELL SORTED FINE TO MEDIUM SAND WATER SATURATED; CONSTANT SEEPAGE INTO PIT FROM UNIT
10 11 12					BASE OF SECTION

MEASURED SECTION NO. 30
LOCALITY XS 7
SETTING MIDVALLEY
STATION 5+17

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/JS/KF
ELEVATION 6815.6



MEASURED SECTION NO 31
LOCALITY XS 7
SETTING EAST SIDE VALLEY
STATION 1+72

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/JS/KF
ELEVATION 6820.3

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE: GRAV (64 4)	SAND (VC C M F VF)	SILT CLAY	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
							TOP OF SECTION
	9					SWK	MEDIUM TO COARSE SAND ⇒ SHEETFLOW
1	10					T	TROPIC DERIVED DARK BROWN TO BLACK SILT/CLAY WITH ABUNDANT FINE GRAVEL BLOCKY; CHAOTIC ⇒ MUDFLOW
2	8					SWK	MEDIUM SAND TO FINE GRAVEL WASATCH COLORATION
3 4	28					T/W	WASATCH DERIVED BOULDERS IN SAND/MUD MATRIX CHAOTIC; MATRIX SUPPORTED BOULDERS REACH 200MM LENTICULAR; PINCHES OUT WESTWARD ⇒ DEBRIS FLOW FROM EAST
5 6 7	36					SWK	VERY WELL SORTED MEDIUM SAND GREYISH-YELLOW IRON STAINING SATURATED - HEAVY WATER FLOW
8 9 10 11 12							BASE OF SECTION

MEASURED SECTION NO. 32
LOCALITY XS 8
SETTING WEST SIDE VALLEY
STATION 5+50

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS
ELEVATION 6747.7

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	13			SWK	FINE TO MEDIUM SAND HORIZONTAL LAMINATION, PARTINGS GREY MINOR CLINKER CHIPS
2	15			T	TROPIC DERIVED SILT/CLAY DARK BROWN BLOCKY DENSE
3	9			SWK	LIGHT BROWN TO GREY SILT TO FINE SAND MINOR CLINKER CHIPS MASSIVE DENSE
	11			SWK/W	SILT TO VERY FINE SAND VERY WELL SORTED MINOR WASATCH DERIVED SILT CHIPS
4	1			T	TROPIC DERIVED CHOCOLATE BROWN SILT/CLAY DRAPE
5	13			SWK	VERY WELL SORTED FINE SAND MASSIVE MINOR CLINKER CHIPS
	7			SWK	MEDIUM SAND TO FINE GRAVEL GRAVEL IS REDDISH-ORANGE AND CONTAINS CLINKER MATERIAL
6	4			SWK	SILT TO FINE SAND GREYISH BROWN; MASSIVE; DENSE
	1			W	WASATCH DERIVED PINK SILT DRAPE
	3			SWK	WELL SORTED FINE SAND; HIGH CHARCOAL CONTENT
	1			W	WASATCH DERIVED SILT DRAPE
7	6			SWK	SILT TO VERY FINE SAND TAN; ABUNDANT CLINKER CHIPS
	1			W	WASATCH DERIVED SILT DRAPE
	5			T	BROWN SILT/CLAY ABUNDANT WASATCH DERIVED CHIPS; CHARCOAL
	2			W	TANNISH PINK SILT TO VERY FINE SAND CLINKER CHIPS
	1			W	PINK SILT DRAPE
8	8			T/W	ORANGE-BROWN SILT/CLAY ABUNDANT CLINKER CHIPS
	6			SWK	VERY FINE SAND WATER SATURATED ▽
9	13				BASE OF SECTION STANDING WATER
10					BASE OF PIT
11					
12					

MEASURED SECTION NO. 33
LOCALITY XS 8
SETTING MIDVALLEY
STATION 3+82

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS
ELEVATION 6747.8

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
1	19			T	TROPIC DERIVED SILT/CLAY HEAVILY ROOTED THIN SAND STRINGERS TOP 12" PEDOGENIC
2	5			W/T	WASATCH DERIVED ORANGE FINE TO MEDIUM SAND WITH TROPIC DERIVED SILT/CLAY; DENSE; BLOCKY
	11			T	TROPIC DERIVED CLAY TO VERY FINE SAND DARK BROWN MINOR CLINKER CHIPS
3 4	23			SWK	TAN FINE TO MEDIUM SAND ABUNDANT ORGANICS, TROPIC CHIPS, CLINKER CHIPS IRON STAINING PRODUCES YELLOW MOTTLING
5	5			SWK	MEDIUM SAND TO VERY FINE GRAVEL GRAVEL CONSISTS OF SANDSTONE, CLINKER CHIPS ⇒ LOCAL SOURCE
6	9			T	CHOCOLATE BROWN TROPIC DERIVED SILT/CLAY DENSE HIGH CHARCOAL CONTENT
	8			SWK	WELL SORTED MEDIUM SAND MINOR AMOUNT OF FINE CLINKER, SANDSTONE CLASTS HIGH CHARCOAL CONTENT MASSIVE
	2			W	TANNISH-YELLOW SILT/CLAY DRAPE
7	5			SWK	WELL SORTED MEDIUM VERY WET; HIGH WATER FLOW
	3			W	PINKISH-ORANGE SILT DRAPE; HIGH CHARCOAL CONTENT
	3			W	BROWNISH-ORANGE SILT TO FINE SAND; DENSE ABUNDANT CLINKER OR WASATCH DERIVED CLASTS
8 9	15			W/SWK	ALTERNATING PINKISH ORANGE SILT AND GREY MEDIUM SAND. SAND - 2" SILT - 1". CONTINUES BELOW WATER LEVEL TO T.D. ▽
10	16			W/SWK	STANDING WATER LEVEL
11 12					BASE OF SECTION

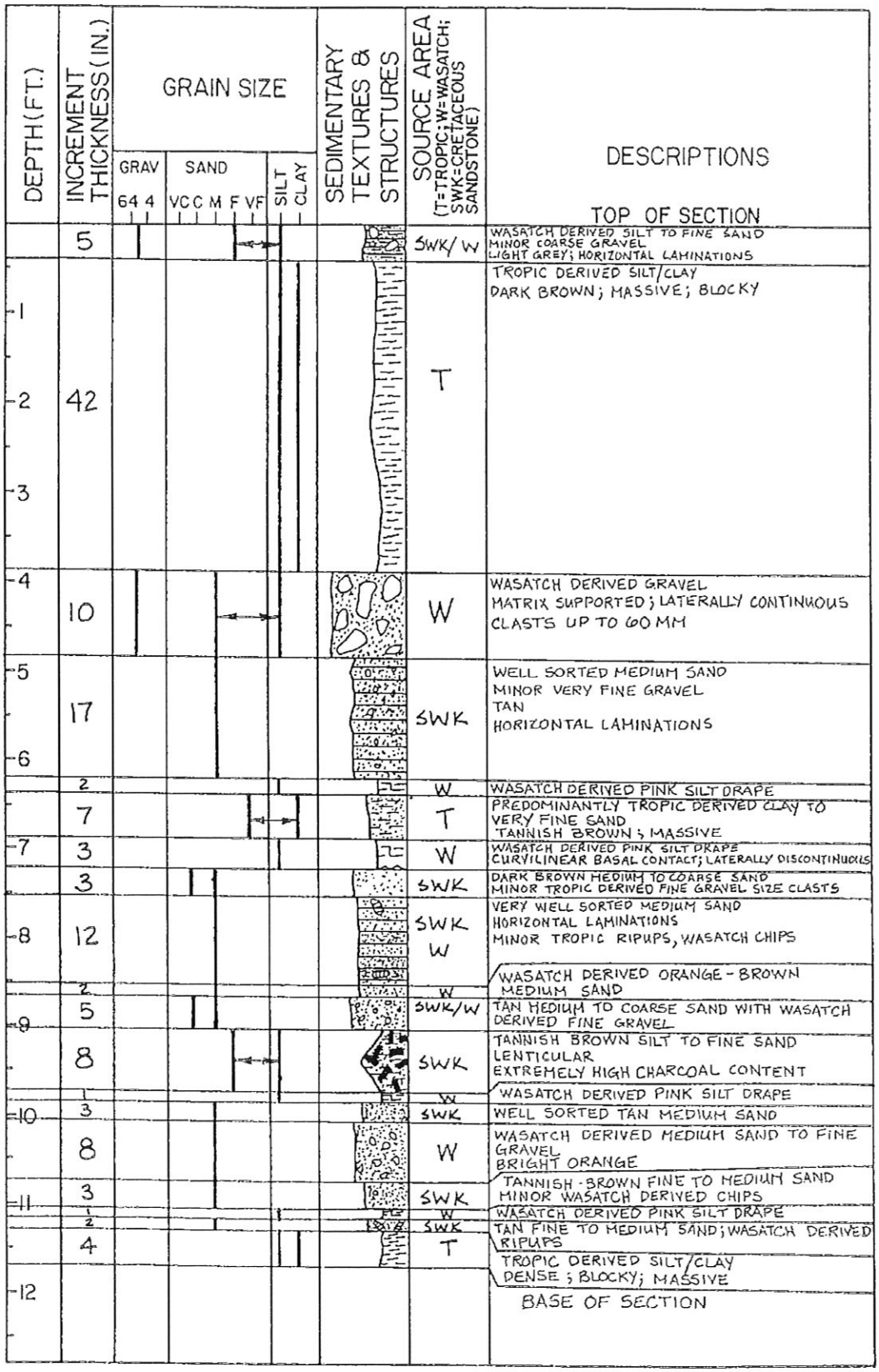
MEASURED SECTION NO. 34
LOCALITY XS 8
SETTING EAST SIDE VALLEY
STATION 2+33

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS
ELEVATION 6750.0

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV: 64 4; SAND: VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	7			T	TROPIC DERIVED SILT/CLAY BLOCKY PEDOGENIC STRUCTURE MINOR PINK FINE CLASTS
1 2 3	32			W/T	DARK BROWN TROPIC DERIVED SILT/CLAY BLOCKY; DENSE; MASSIVE SOME WASATCH DERIVED FINE TO MEDIUM GRAVEL
4 5	23			SWK W/T	TAN MEDIUM SAND MINOR WASATCH DERIVED FINE GRAVEL LARGE TROPIC DERIVED RIPUPS MASSIVE; DENSE; WET
	6			SWK	WELL SORTED LENTICULAR MEDIUM SAND
6	7			W	WASATCH DERIVED MEDIUM TO COARSE SAND VERY WELL SORTED; PINK DIPS WESTWARD 4°
	1			W	SILT DRAPE
	4			SWK	WELL SORTED MEDIUM SAND MINOR WASATCH DERIVED RIPUPS
7 8	18			T W	TROPIC DERIVED SILT/CLAY HIGH CHARCOAL CONTENT DIP WESTWARD 4° LARGE RIPUP CLASTS OF WEATHERED WASATCH DERIVED MATERIAL
	2			W	PINK-GRAY WASATCH DERIVED SILT DRAPE; LATERALLY CONTINUOUS
	5			T	BROWN SILT/CLAY DENSE
	1			W	PINK WASATCH DERIVED SILT DRAPE
9	12			W SWK	WELL SORTED MEDIUM TO COARSE SAND HORIZONTAL LAMINATIONS; COARSE / FINE COUPLETS PEBBLES AT TOP; WASATCH DERIVED LIMESTONE, QUARTZITE BASAL SURFACE - HIGH WATER FLOW
10	4			W/T	WASATCH DERIVED SILT THINLY INTERBEDDED WITH TROPIC DERIVED SILT/CLAY
	6			T	TROPIC DERIVED SILT/CLAY - CONTINUES TO BASE OF SECTION
11	6			T	STANDING WATER LEVEL
12					BASE OF SECTION

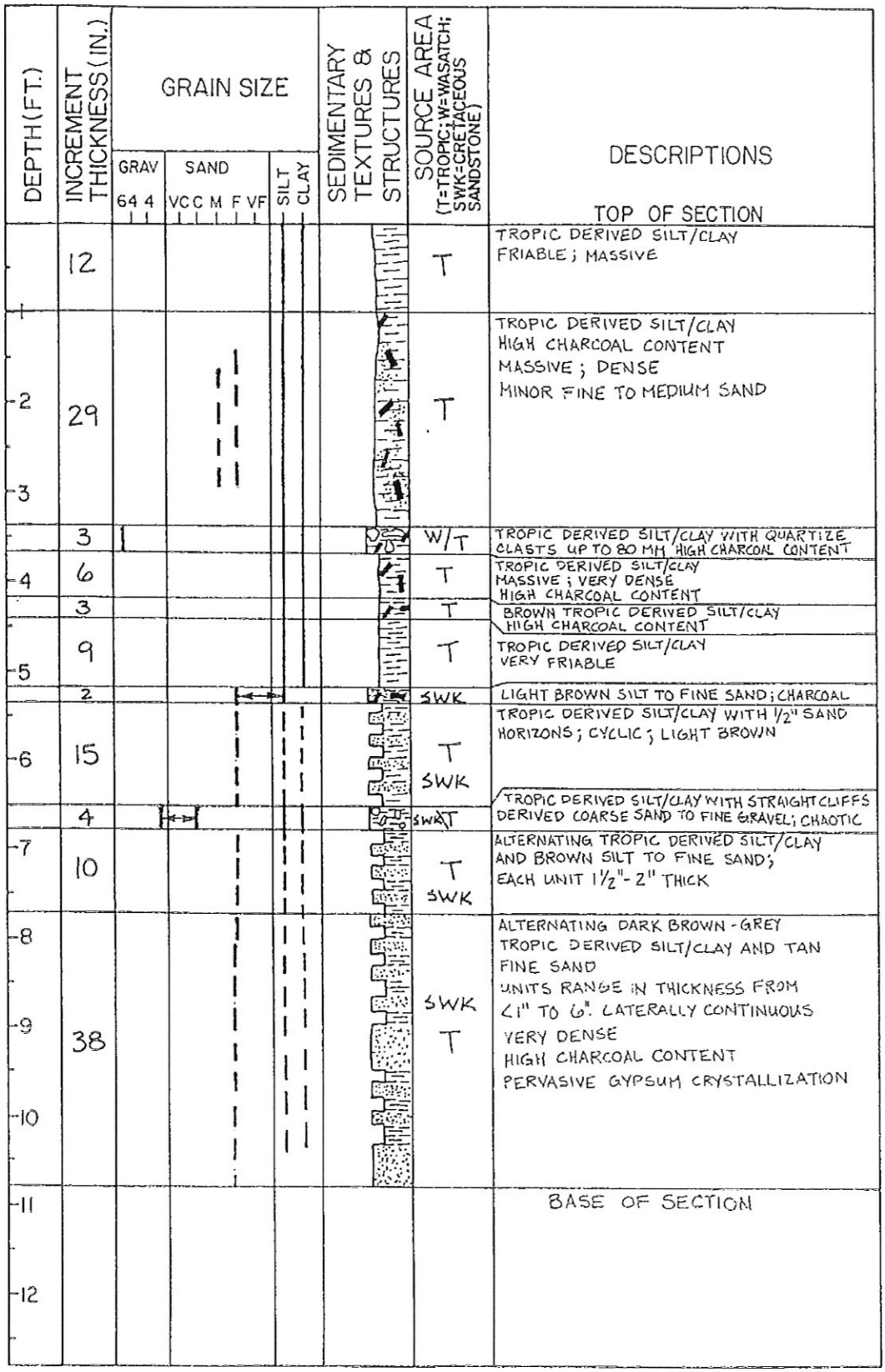
MEASURED SECTION NO. 35
LOCALITY XS 6
SETTING EAST SIDE VALLEY
STATION 3+84

DATE 7/15/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/KF/JS
ELEVATION 6903.0



MEASURED SECTION NO 36
LOCALITY XS 9
SETTING TRB SINK VALLEY WASH
STATION 3+13

DATE 7/16/88
STRATIGRAPHIC UNIT VALLEY FILL
MEASURED BY MH/JS/KF
ELEVATION 6670.4

DEPTH (FT.)	INCREMENT THICKNESS (IN.)	GRAIN SIZE (GRAV 64 4; SAND VC C M F VF; SILT CLAY)	SEDIMENTARY TEXTURES & STRUCTURES	SOURCE AREA (T=TROPIC; W=WASATCH; SWK=CRETACEOUS SANDSTONE)	DESCRIPTIONS
					TOP OF SECTION
	9			T	TROPIC DERIVED SILT TO FINE SAND WITH MINOR DISSEMINATED VERY FINE GRAVEL AND CLINKER CHIPS; ALL LOCALLY DERIVED CRUMB STRUCTURE => PEDOGENIC A HORIZON WITH SLOPE WASH
-1	14			W/T	WASATCH/TROPIC DERIVED SILT TO FINE SAND MINOR TROPIC DERIVED RIPUPS BLOCKY MASSIVE DENSE
-2 -3	19			W/T	WASATCH/TROPIC DERIVED MEDIUM SAND MINOR ANGULAR SANDSTONE CLASTS UP TO 20 MM DENSE; MASSIVE
-4	10			SWK	FINE TO MEDIUM WELL SORTED SAND HORIZONTAL LAMINATIONS COARSE/FINE COUPLETS
	2			T	DARK BROWN TROPIC DERIVED SILT/CLAY DRAPE
-5	8			SWK	TAN FINE TO MEDIUM SAND WELL SORTED; FINES UPWARDS HORIZONTAL LAMINATIONS; COARSE FINE COUPLETS
	1			T	TROPIC DERIVED DARK BROWN SILT/CLAY DRAPE
				W	WASATCH DERIVED PINK SILT DRAPE
	4			T	TROPIC DERIVED DARK BROWN SILT/CLAY DRAPE HORIZONTAL LAMINATIONS
-6	4			SWK	FINE TO MEDIUM SAND; LATERALLY CONTINUOUS HORIZONTAL LAMINATIONS; COARSE/FINE COUPLETS
	3			T	TROPIC DERIVED DARK BROWN SILT/CLAY DRAPE
	1			W	WASATCH DERIVED ORANGE SILT DRAPE
	2			T	TROPIC DERIVED DARK BROWN SILT/CLAY DRAPE
	1			W	WASATCH DERIVED ORANGE SILT DRAPE
-7	6			T	REDDISH BROWN CLAY TO FINE SAND PREDOMINANTLY TROPIC DERIVED MATERIAL ABUNDANT RIPUPS; CRACK PENETRATION OF WASATCH DERIVED MATERIAL
-8 -9 -20 -21	170			T T	TROPIC DERIVED DARK BROWN SILT/CLAY MINOR DISSEMINATED CLINKER CHIPS BLOCKY LOWER SECTION COUPLED WITH A HIGH CONCENTRATION OF RECRYSTALLIZED SALTS BREAK IN SECTION
-22					BASE OF SECTION

MEASURED SECTION NO. 37 | DATE 7/14/88
LOCALITY XS 4B; XS 5 | STRATIGRAPHIC UNIT VALLEY FILL
SETTING CENTER SWAPP HOLLOW | MEASURED BY KF/MH/JS
STATION 14+59(4B); 0+00(5) | ELEVATION 6963.3