Shallow Shear Wave Velocity Profiling Of Poorly Characterized Earthquake Site-Response Units In Urban Utah, Davis, And Weber Counties, Utah

Final Report

USGS-NEHRP Award # 05HQGR0088

March 2008

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CHAPTER 1
INTRODUCTION

The Wasatch Fault in Utah, is one of the most active normal strike-slip faults in the world. The 343 km long fault parallels the most heavily populated areas in the State of Utah as it winds along the base of the Wasatch mountain range (Solomon et al. 2002). The Wasatch Front contains approximately two-thirds of the population and economy found in Utah. Population in the Greater Wasatch Area (Ogden to Provo) was at 1.6 million in 1995 and is expected to reach 2.3 million by 2010 (QGET 2003). The predicted earthquake magnitude for the Wasatch Fault is on the order of $M_w = 7.0$ (Wong et al. 2002), with a recurrence interval of 1350 ± 200 with the latest event occurring approximately 1300 years ago (Black and Lund 1995). A large earthquake on the Wasatch fault poses a significant hazard to human life and property.

The magnitude of earthquake induced ground shaking at a particular location is heavily dependant upon the characteristics of the near surface soils. In a seismically active region such as the Wasatch Front, characterization of the near surface soils and understanding the influence of the soil on ground shaking is extremely important. In building codes, such as the 2006 International Building Code, the contributing soil properties are quantified by the mean shear wave velocity of the upper 30 meters of soil (V_{S30}). This near surface soil parameter is used in building codes as well as other engineering efforts to account for the near surface soil effects on ground shaking, on a site by site basis.

Geologic site response maps have been developed for the Greater Wasatch Front to group similar geographic areas that will respond similar during an earthquake.

These maps are based on surficial geology and V_{S30} data (Ashland and Rollins 1999, Ashland 2001). The mapped units can be used to better predict significant earthquake hazards, and improve seismic building code implementation along the Wasatch Front, as well as supplement other earthquake mitigation efforts. The Davis, Weber, and Utah Counties lacked sufficient shear wave velocity data to verify these previously mapped units. Prior to this work, there were 4 existing V_{S30} sites in Weber County, 6 existing V_{S30} sites in Davis County, and 7 existing V_{S30} sites in Utah County.

During the summer of 2005, a team from Utah State University, in cooperation with the University of Utah Seismograph Stations, the Utah Geologic Survey, and the National Earthquake Hazards Reduction Program, used geophysical methods to add 42 new shear wave velocity profiles to poorly defined urban areas of Davis, Weber, and Utah Counties, Utah. Testing was performed by Utah State University, utilizing the Spectral Analysis of Surface Waves method (SASW). There were 18 V_{S30} sites added to Weber County, 9 V_{S30} sites added to Davis County, and 15 V_{S30} sites added to Utah County. SASW testing was also performed at the Fire Training Tower in Salt Lake County, and two rock sites located on opposite sides of the Salt Lake Valley. Of these 45 sites, 20 were located near seismic stations that are monitored by the University of Utah Seismograph Stations.

The shear wave velocity data that was obtained during this study will be used to verify and/or justify a reworking of the previously mapped site response units. Based on preliminary observations, the mapped geologic units in the Davis, Weber, and Utah Counties exhibit softer near surface soils than those found in the Salt Lake Valley. There are also noticeable outliers and anomalies in the measured data which will most

likely lead to modifications of the existing site response maps.

CHAPTER 2

SASW TESTING RESULTS

This chapter presents the results of the SASW testing that was performed by Utah State University during the summer of 2005. Field work was performed throughout the summer and into early fall of 2005. Laboratory work followed and proceeded throughout the winter.

The data will be presented in four different sections: Weber and Northern Davis counties, Davis County, Salt Lake County, and Utah County. A map will be included at the beginning of each section to show the spatial distribution of the test locations, the locations of previously identified V_{S30} sites, and the geologic units as described in Ashland et al. (2005).

For each of the test sites, the following figures will be included: A map showing the center of the SASW testing array, a photograph of the test setup, the experimental dispersion curve measured at the site, comparison of the experimental and theoretical dispersion curve determined from forward modeling, a graphical representation of the shear wave velocity profile, and tabulated values of the shear wave velocity profile and soil properties.

The test setup and location will be described for each site such that the location and test orientation could easily be replicated. If the site is also home to a strong motion sensor, its location will be described.

2.1. WEBER AND NORTHERN DAVIS COUNTIES

Weber and Northern Davis counties are bounded on the east by the Wasatch Mountains and on the west by the shores of the Great Salt Lake. The northernmost city in Weber County is Pleasant View, and the southern boundary of this study region falls between Layton and Kaysville. The reason for this arbitrary boundary will be discussed in the following paragraph.

The surficial geologic features and origins of the Weber County and northern portion of Davis County are similar. This area is dominated by a river delta that was formed along the east side of the Late Pleistocene Lake Bonneville. This prehistoric delta is referred to as the Weber-Ogden Rivers delta (Bay et al. 2005). There are significant differences in the types of sediment that is deposited in this basin when compared to others. The major drainages in this region tend to erode Tertiary sedimentary rocks and Precambrian metamorphic rocks, which tend to exhibit a finer grain size than those in the Salt Lake Valley (Ashland et al. 2005).

Figure 2.1 shows the site condition map from Ashland and McDonald (2003) and Ashland et al (2005). The figure also shows the spatial distribution of new V_{S30} sites, and the locations of existing V_{S30} sites. During this study, 18 new sites were tested, quadrupling the existing database. The distribution of the sites in the different Quaternary units is: (Q01) 6 new sites were tested, there were no existing sites in the unit. (Q02) 6 new sites were tested, there were 4 existing sites in the unit. (Q03) 6 new sites were tested, there were no existing sites in the unit.

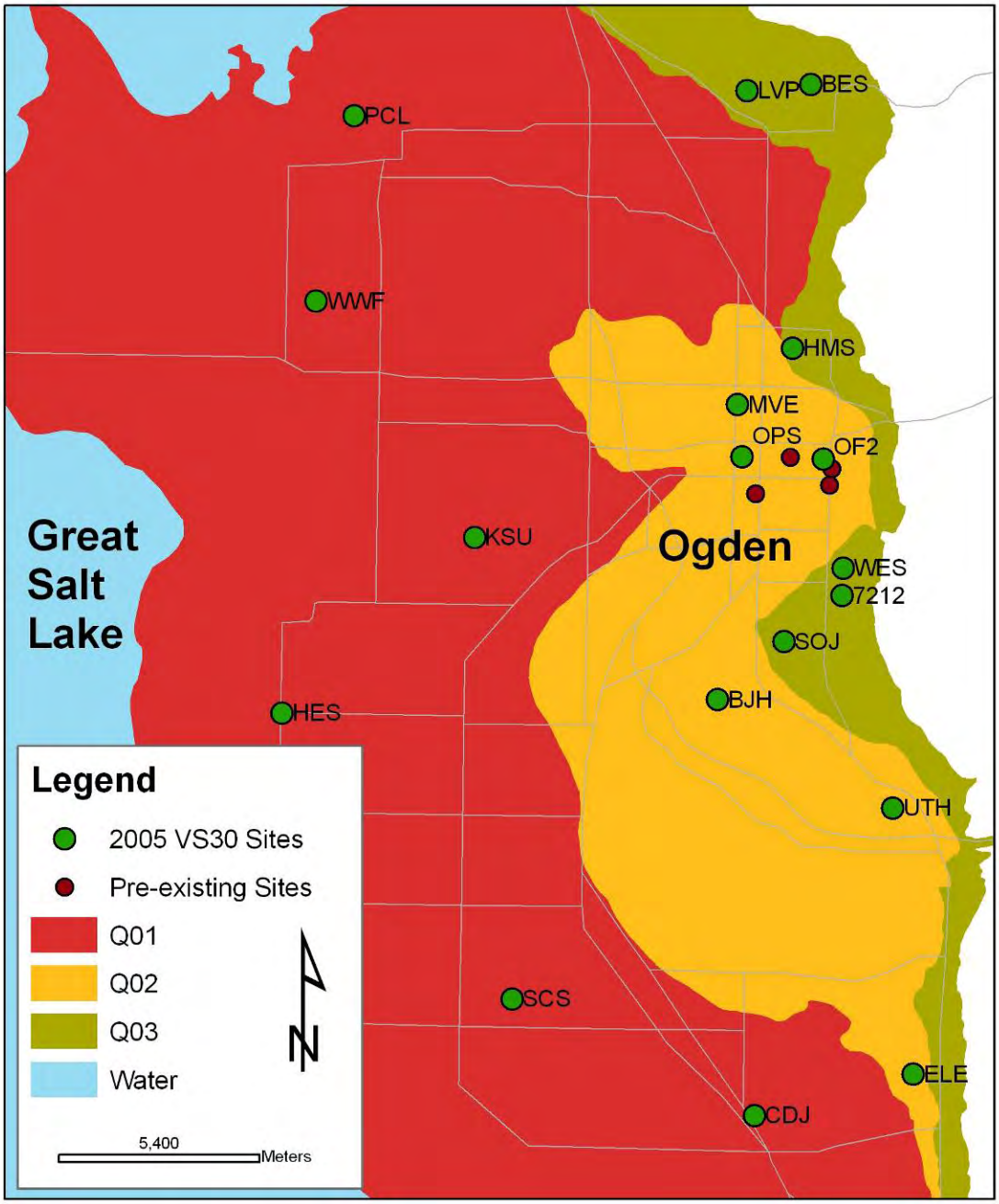

Fig. 2.1 Map showing spatial distribution of V_{S30} sites in Weber and Northern Davis Counties, Utah.

2.1.1. Plain City Landfill

SASW testing was performed at the Plain City landfill, designated as PCL in this report, located in North-Western Weber County at 2700 N. 500 W., Plain City, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are

41.30979 North and 112.10013 East, with an elevation of approximately 1284 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.2. The site was of particular interest because a strong motion sensor monitored by the University of Utah Seismograph Stations is located adjacent to the SASW array.

Testing was performed the morning of June 30, 2005. The SASW array was located on an access road running east-west along the north side of the landfill. A photograph of the site is shown in Fig. 2.3. The strong motion sensor is located in the masonry outbuilding that can be seen in Fig. 2.3. Standing water at the site indicated a shallow water table and a fully saturated zone was assumed to exist at 2 m below the ground surface. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.3 m.

Figure 2.4 shows the experimental dispersion curve measured at the Plain City landfill. Figure 2.5 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.6 shows the calculated shear wave velocity profile for the site. Table 2.1 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.2 Site map showing the location of the centerline of the SASW array at the Plain City Landfill (PCL), Weber County, Utah (from Google Earth 2006).

Fig. 2.3 Photograph of SASW testing at the Plain City Landfill (PCL), Weber County, Utah.

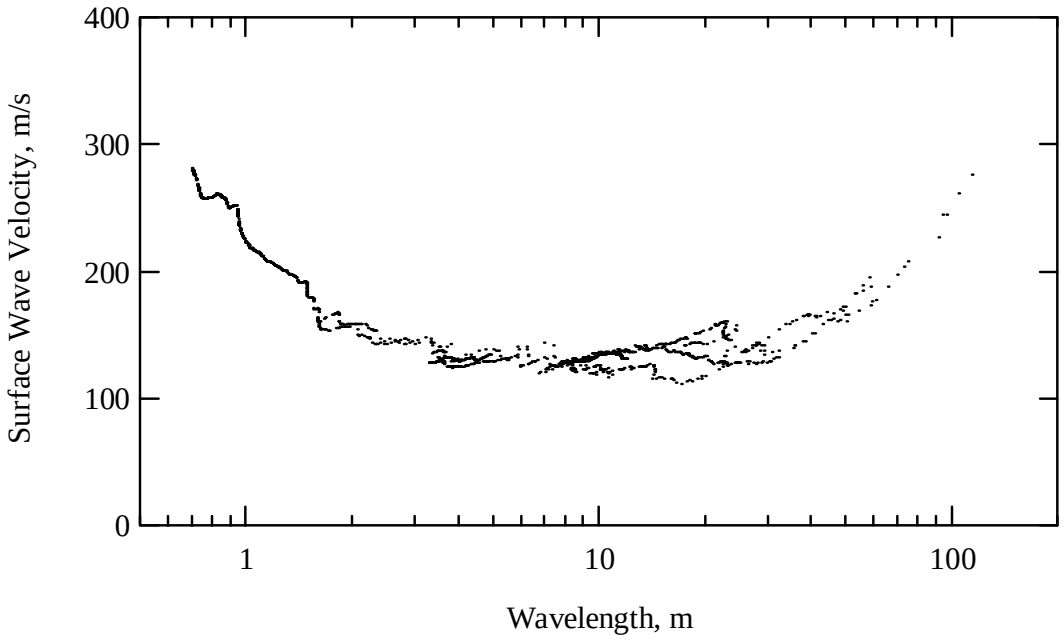

Fig. 2.4 Experimental dispersion curve measured at the Plain City Landfill (PCL), Weber County, Utah.

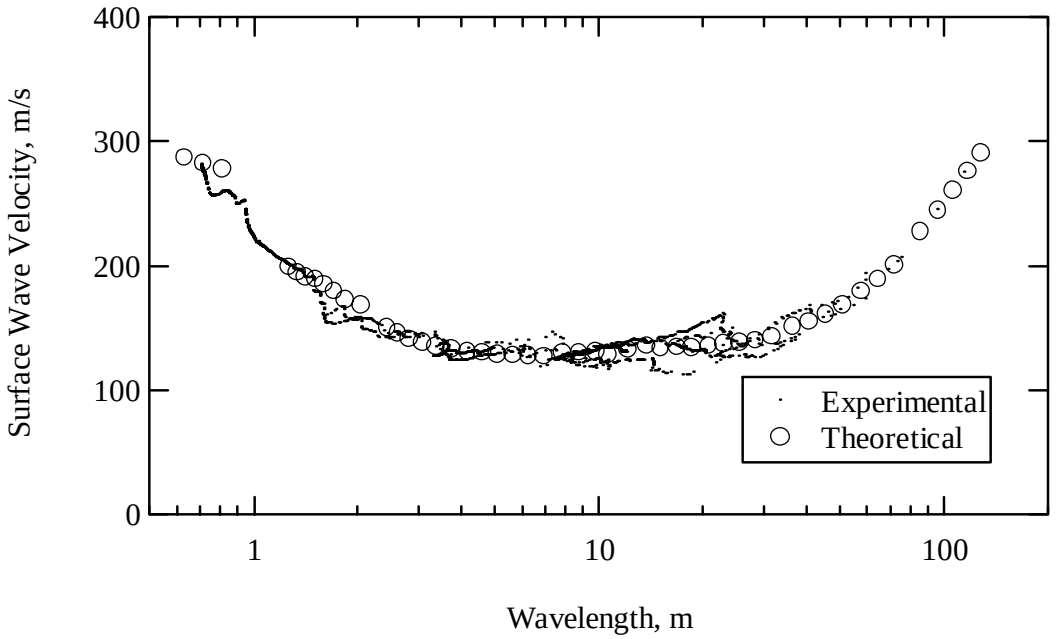

Fig. 2.5 Comparison of experimental and theoretical dispersion curves from the Plain City Landfill (PCL), Weber County, Utah.

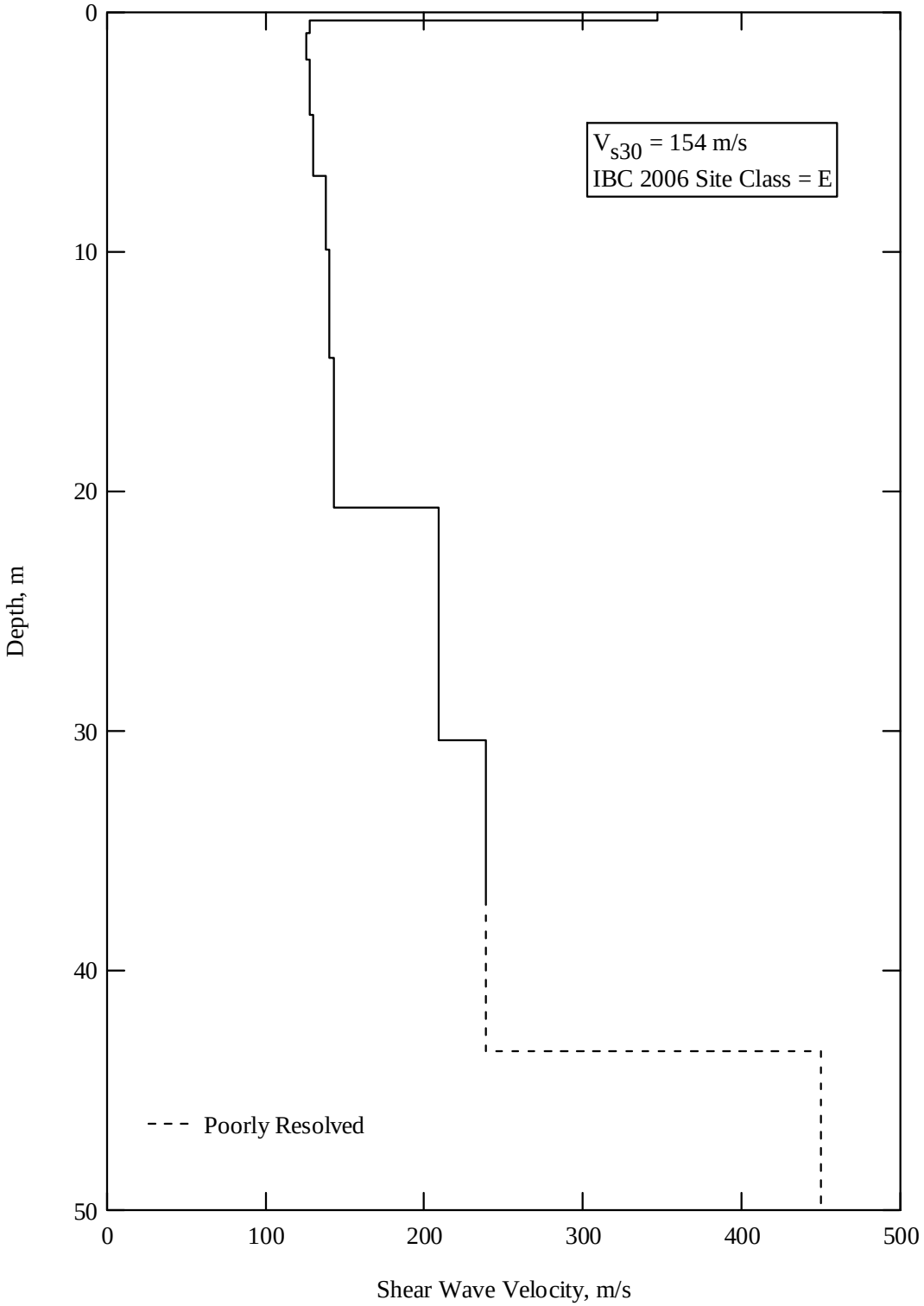

Fig. 2.6 Shear wave velocity profile determined from SASW testing at the Plain City Landfill (PCL), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 154 m/s, which corresponds to an IBC 2006 site class E. The shear wave velocity profile is well resolved to a depth of 37 m and poorly resolved from 37 m to 50 m.

Table 2.1 Tabulated measured and assumed layer properties at the Plain City Landfill (PCL), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	347	649	0.30	1.92
0.4	0.5	128	240	0.30	1.89
0.9	1.1	126	236	0.30	1.89
2.0	2.3	128	1500	0.49	1.89
4.3	2.6	130	1500	0.49	1.89
6.8	3.1	138	1500	0.49	1.89
9.9	4.5	140	1500	0.49	1.89
14.4	6.2	143	1500	0.49	1.89
20.7	9.7	209	1500	0.49	1.92
30.4	6.7	239	1500	0.49	1.92

2.1.2. Syracuse Cemetery

SASW testing was performed at the Syracuse Cemetery, designated as SCS in this report, located in Davis County at 1100 S. 1000 W., Syracuse. The GPS derived latitude and longitude of the center of the SASW testing array are 41.09705 North and 112.04621 East, with an elevation of approximately 1332 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.7. The site was of particular interest because a strong motion sensor monitored by the University of Utah Seismograph Stations is located adjacent to the SASW array.

Testing was performed at 10:00 a.m. on June 30, 2005. The SASW array was located north of the cemetery in a field. A photograph of the site is shown in Fig. 2.8 where the cemetery can be seen in the distant background. The strong motion sensor is

located in a utility shed on the south side of the cemetery. A fully saturated zone was assumed to exist at 5.4 m. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 1.0 m and pads were used for leveling purposes only.

Figure 2.9 shows the experimental dispersion curve measured at the Syracuse Cemetery. Figure 2.10 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.12 shows the calculated shear wave velocity profile for the site. Table 2.2 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.7 Site map showing the location of the centerline of the SASW array at the Syracuse Cemetery (SCS), Davis County, Utah (from Google Earth 2006).

Fig. 2.8 Photograph of SASW testing at the Syracuse Cemetery (SCS), Davis County, Utah.

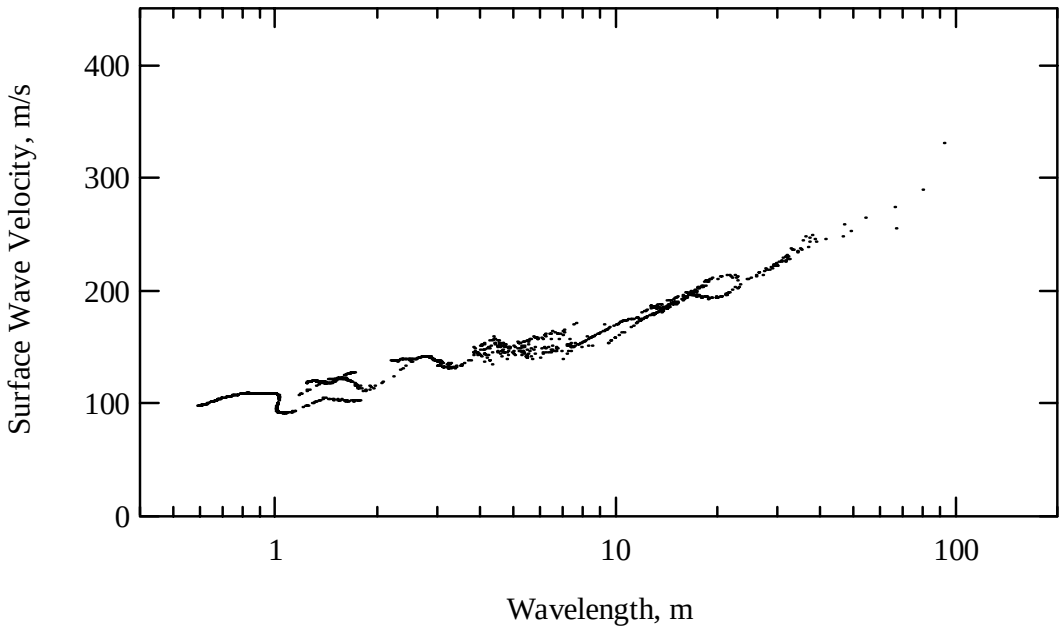

Fig. 2.9 Experimental dispersion curve measured at the Syracuse Cemetery (SCS), Davis County, Utah.

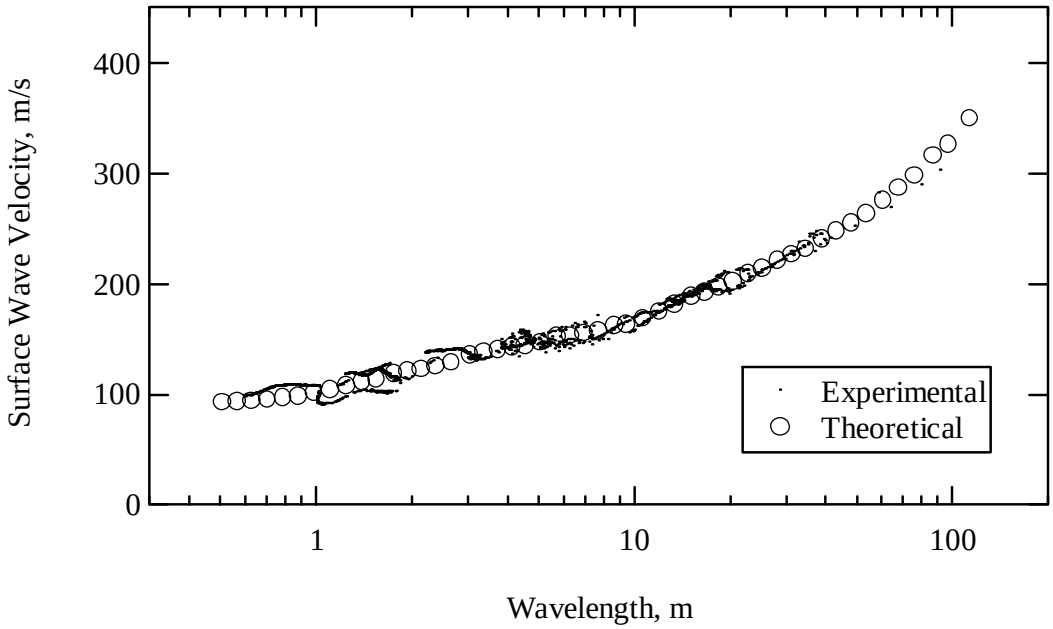

Fig. 2.10 Comparison of experimental and theoretical dispersion curves from the Syracuse Cemetery (SCS), Davis County, Utah.

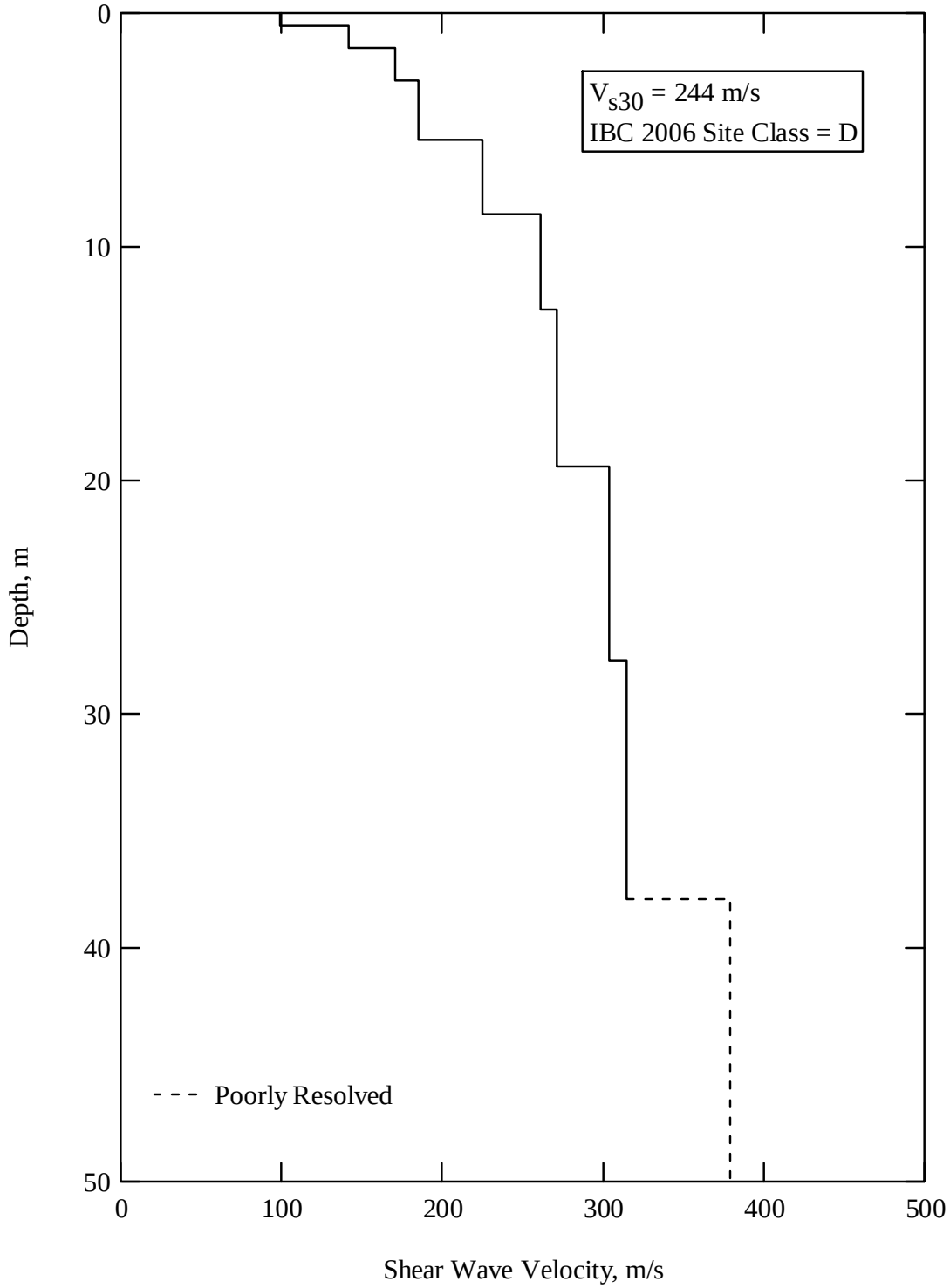

Fig. 2.11 Shear wave velocity profile determined from SASW testing at the Syracuse Cemetery (SCS), Davis County, Utah.

The average shear wave velocity in the upper 30 m of soil is 244 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 37.9 m and poorly resolved from 37.9 m to 50 m.

Table 2.2 Tabulated measured and assumed layer properties at the Syracuse Cemetery (SCS), Davis County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.5	99	185	0.30	1.89
0.5	1.0	142	266	0.30	1.89
1.5	1.4	171	320	0.30	1.92
2.9	2.5	185	346	0.30	1.92
5.4	3.2	225	1500	0.48	1.92
8.6	4.1	261	1500	0.48	1.92
12.7	6.7	271	1500	0.48	1.92
19.4	8.3	304	1500	0.48	1.96
27.7	10.2	315	1500	0.48	1.96

2.1.3. Central Davis Junior High School

SASW testing was performed at Central Davis Junior High School, designated as CDJ in this report, located in northern Davis County at 633 Church Street, Layton. The GPS derived latitude and longitude of the center of the SASW testing array are 41.0696 North and 111.96839 East, with an elevation of approximately 1497 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.12.

Testing was performed at 4:00 p.m. on September 9, 2005. The SASW array was located west of the school in a playing field and the array was oriented in the north-south direction. A photograph of the site is shown in Fig. 2.13 where the Junior, High School can be seen in the background. A fully saturated zone was assumed to exist at 5.2 m. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.3 m with 13 cm of padding.

Figure 2.14 shows the experimental dispersion curve measured at Central Davis Junior High School. Figure 2.15 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.16 shows the calculated shear wave velocity profile for the site. Table 2.3 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.12 Site map showing the location of the centerline of the SASW array at Central Davis Junior High School (CDJ), Davis County, Utah (from Google Earth 2006).

Fig. 2.13 Photograph of SASW testing at Central Davis Junior High School (CDJ), Davis County, Utah.

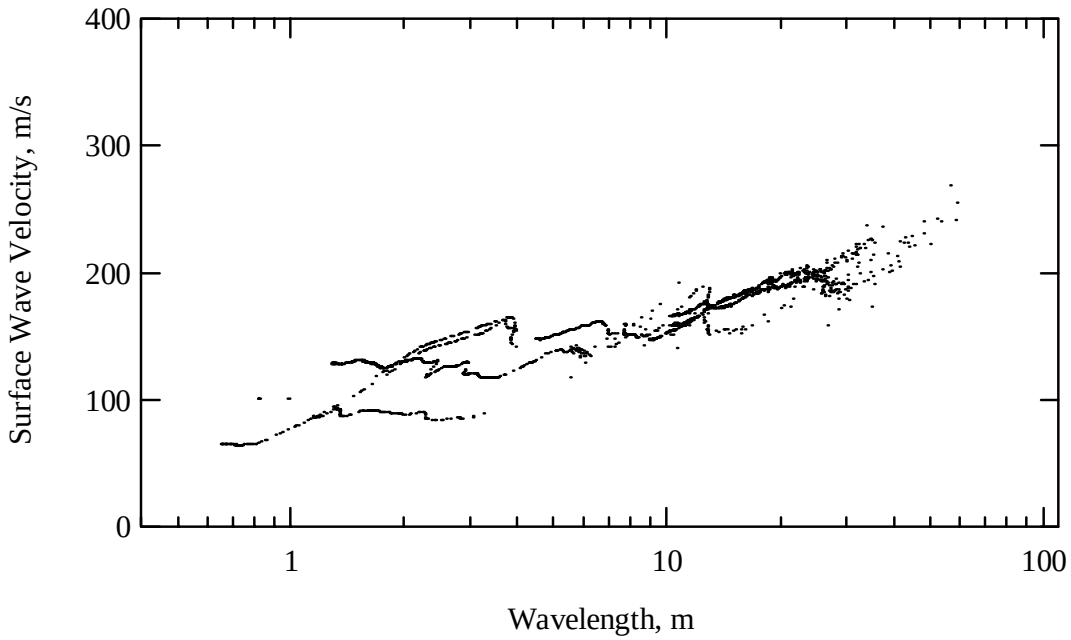

Fig. 2.14 Experimental dispersion curve measured at Central Davis Junior High School (CDJ), Davis County, Utah.

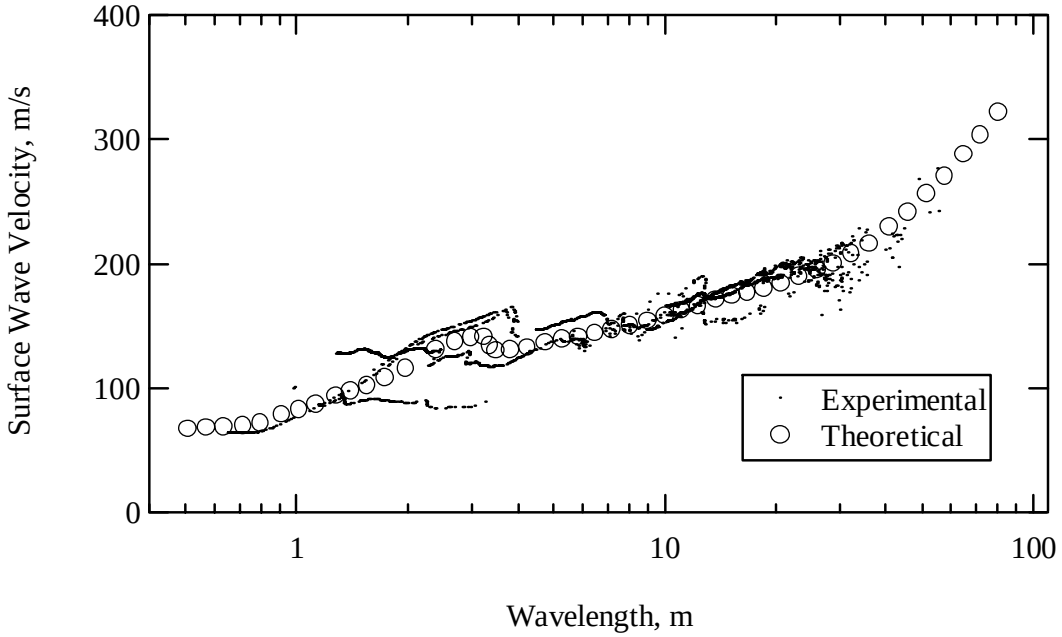

Fig. 2.15 Comparison of experimental and theoretical dispersion curves from Central Davis Junior High School (CDJ), Davis County, Utah.

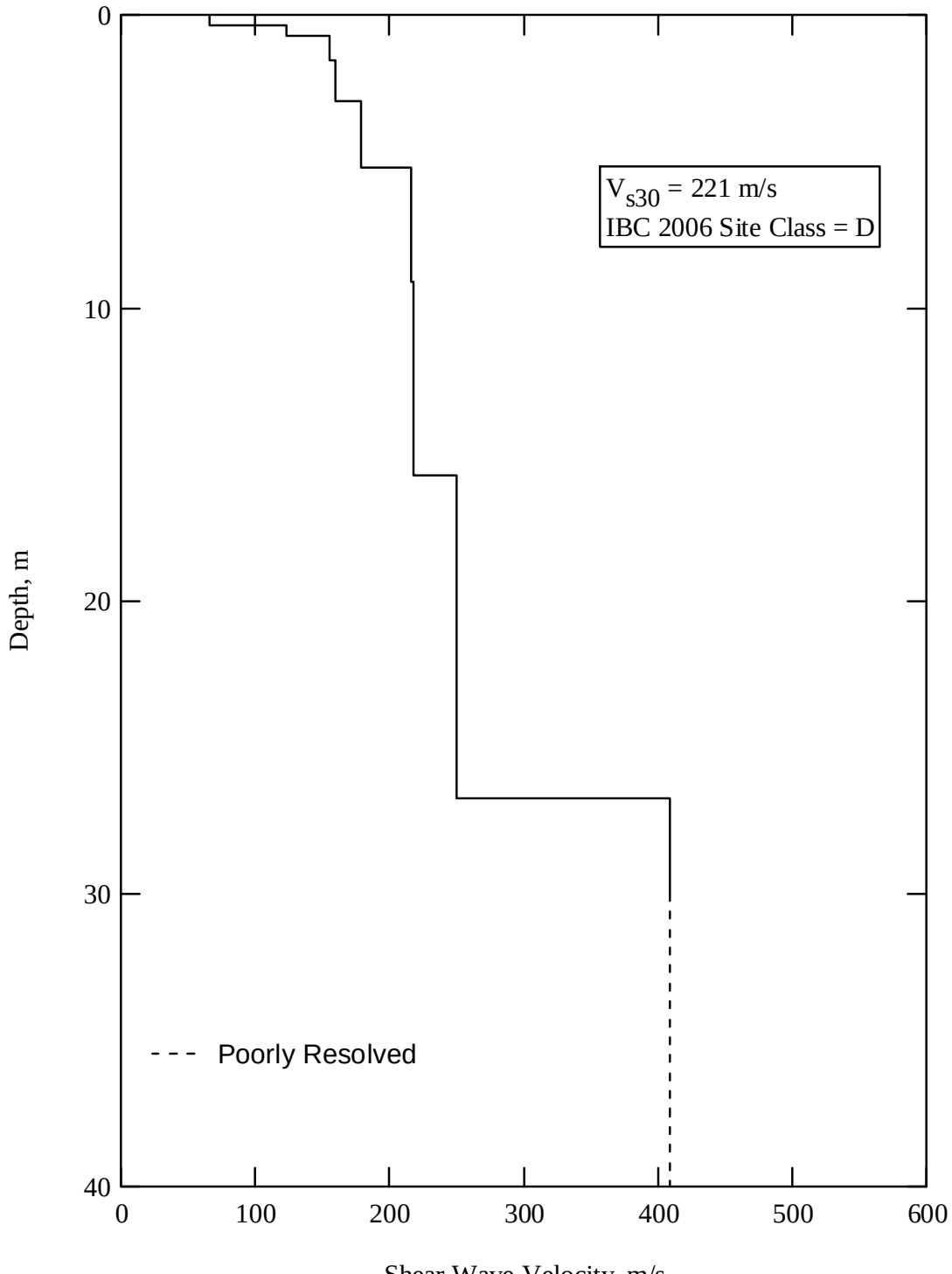

Fig. 2.17 Shear wave velocity profile determined from SASW testing at Central Davis Junior High School (CDJ), Davis County, Utah.

The average shear wave velocity in the upper 30 m of soil is 221 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 30 m and poorly resolved from 30 m to 40 m.

Table 2.3 Tabulated measured and assumed layer properties at Central Davis Junior High School (CDJ), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	66	124	0.3	1.89
0.3	0.4	123	231	0.3	1.89
0.7	0.8	155	290	0.3	1.89
1.5	1.4	160	299	0.3	1.90
2.9	2.3	179	335	0.3	1.92
5.2	3.9	217	1500	0.49	1.92
9.1	6.6	218	1500	0.49	1.92
15.7	11.0	250	1500	0.48	1.92
26.7	3.3	408	1500	0.46	1.96

2.1.4. Kanesville Elementary School

SASW testing was performed at Kanesville Elementary School, designated as KSU in this report, located in Weber County at 3112 S. 3500 W., West Haven, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.20838 North and 112.05997 East, with an elevation of approximately 1303 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.17.

Testing was performed at 10:00 a.m. on September 30, 2005. The SASW array was located along the east side of the school property in a north-south orientation. A photograph of the site is shown in Fig. 2.18 where the school can be seen in the background. A fully saturated zone was assumed to exist at 4.9 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.3 m with 19 cm of padding.

Figure 2.19 shows the experimental dispersion curve measured at Kanesville Elementary School. Figure 2.20 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.21 shows the calculated shear wave velocity profile for the site. Table 2.4 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

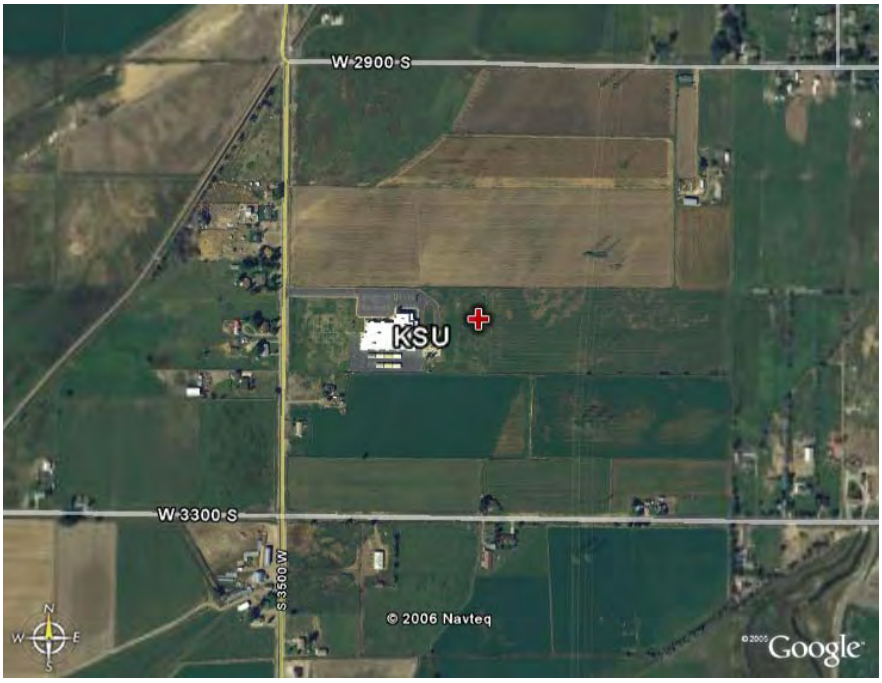

Fig. 2.17 Site map showing the location of the centerline of the SASW array at Kanesville Elementary School (KSU), Weber County, Utah (from Google Earth 2006).

Fig. 2.18 Photograph of SASW testing at Kanesville Elementary School (KSU), Weber County, Utah.

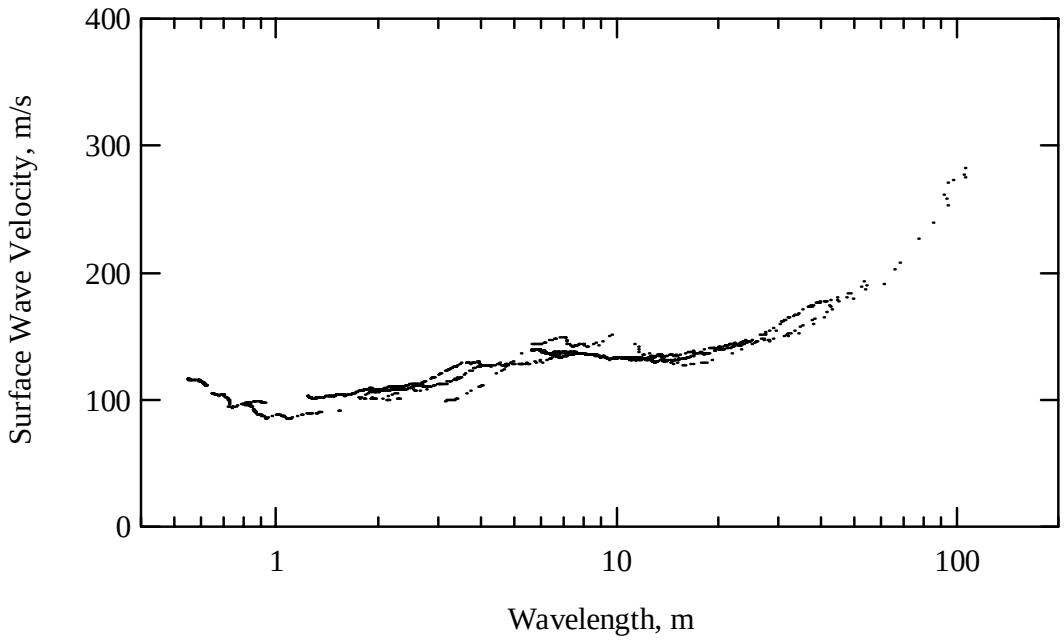

Fig. 2.19 Experimental dispersion curve measured at Kanesville Elementary School (KSU), Weber County, Utah.

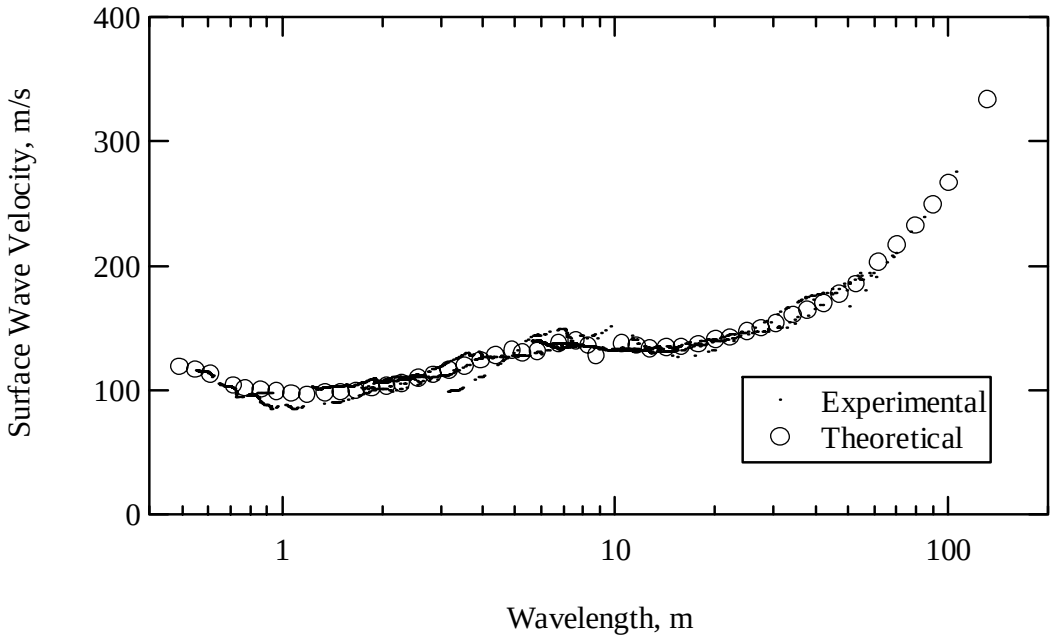

Fig. 2.20 Comparison of experimental and theoretical dispersion curves from Kanesville Elementary School (KSU), Weber County, Utah.

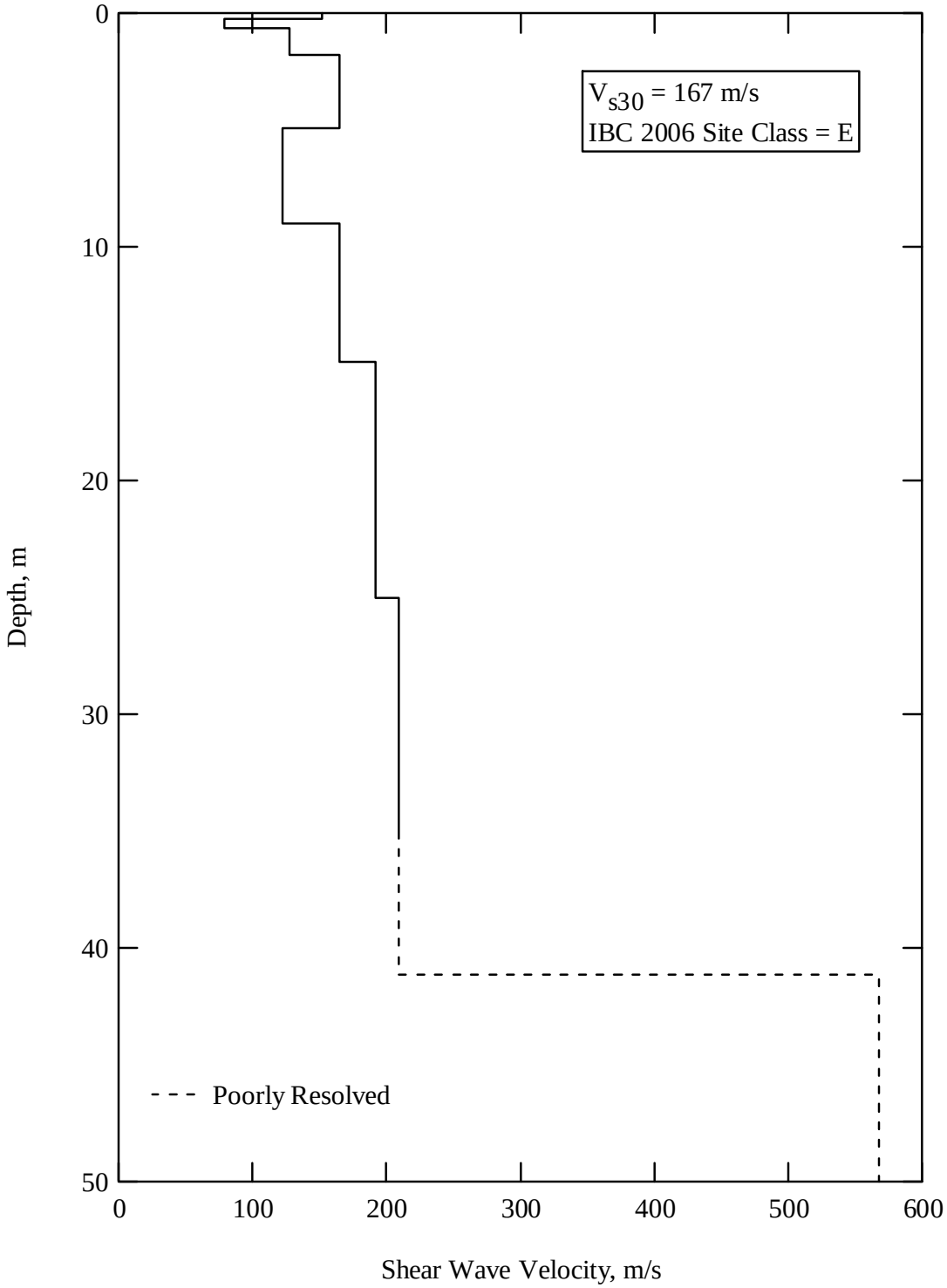

Fig. 2.21 Shear wave velocity profile determined from SASW testing at Kanesville Elementary School (KSU), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 167 m/s, which corresponds to an IBC 2006 site class E. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 50 m.

Table 2.4 Tabulated measured and assumed layer properties at Kanesville Elementary School (KSU), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.2	152	284	0.3	1.89
0.2	0.4	79	148	0.3	1.89
0.7	1.1	128	240	0.3	1.89
1.8	3.2	165	309	0.3	1.89
4.9	4.1	123	1500	0.49	1.92
9.0	5.9	166	1500	0.49	1.92
14.9	10.1	192	1500	0.49	1.92
25.0	10.0	209	1500	0.49	1.92

2.1.5. West Weber Field

SASW testing was performed in a field in West Weber, designated as WWF in this report, located in northwestern Weber County, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.26491 North and 112.11155 East, with an elevation of approximately 1295 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.22.

Testing was performed at 11:00 a.m. on September 10, 2005. The SASW array was located in a hay field in western Weber County, oriented in an east-west direction. A photograph of the site is shown in Fig. 2.23. A fully saturated zone was assumed to exist at 4.2 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.6 m with no padding.

Figure 2.24 shows the experimental dispersion curve measured at the site. Figure 2.25 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.26 shows the calculated shear wave velocity profile for the site. Table 2.5 contains the tabulated layer properties

including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.22 Site map showing the location of the centerline of the SASW array at the West Weber Field (WWF), Weber County, Utah (from Google Earth 2006).

Fig. 2.23 Photograph of SASW testing at the West Weber Field (WWF), Weber County, Utah.

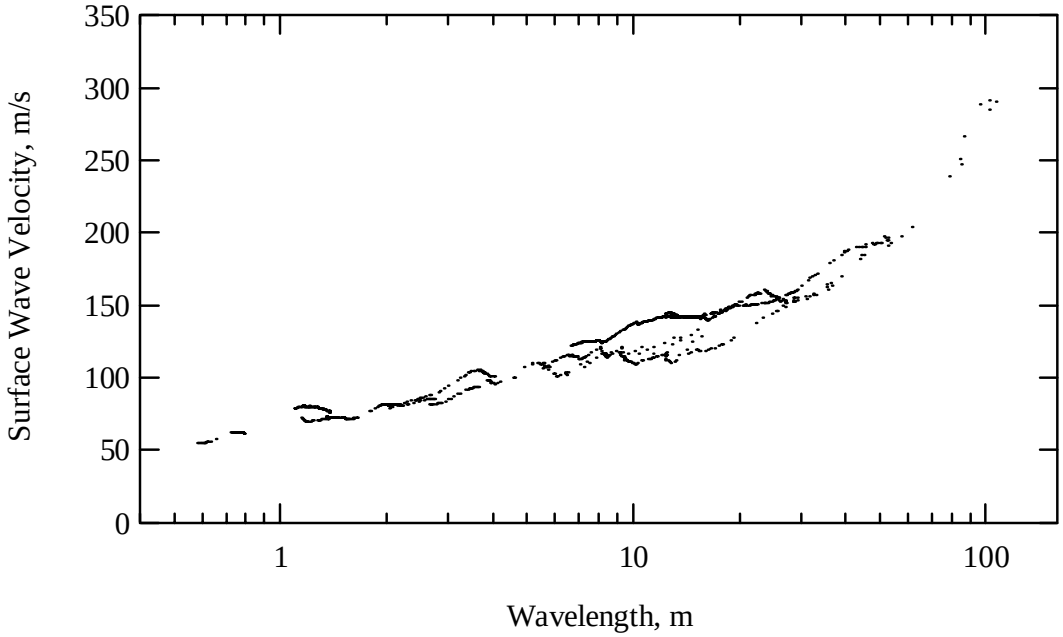

Fig. 2.24 Experimental dispersion curve measured at the West Weber Field (WWF), Weber County, Utah.

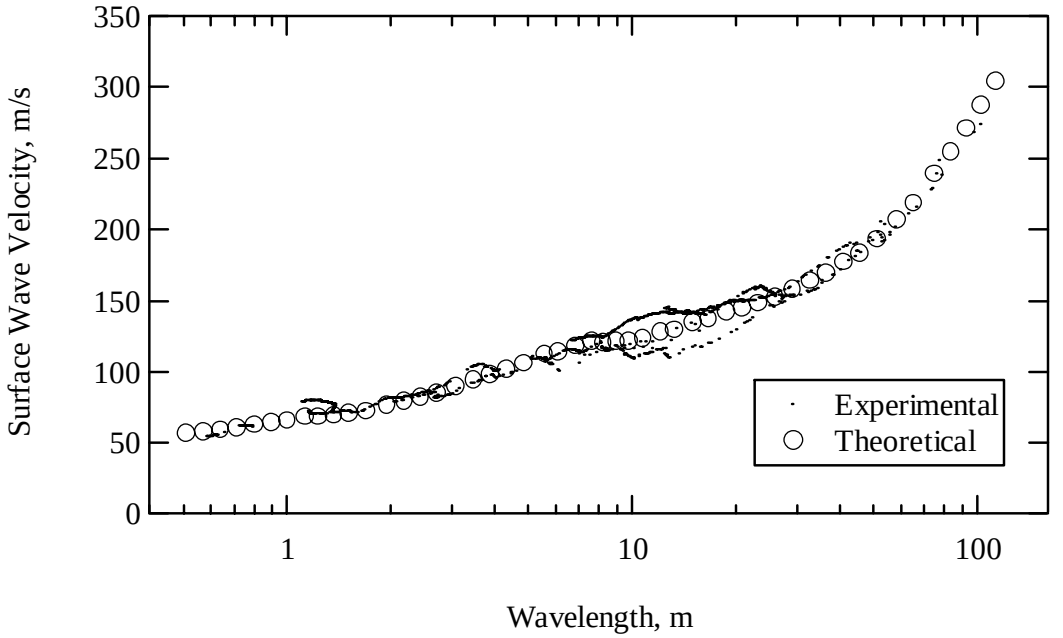

Fig. 2.25 Comparison of experimental and theoretical dispersion curves from the West Weber Field (WWF), Weber County, Utah.

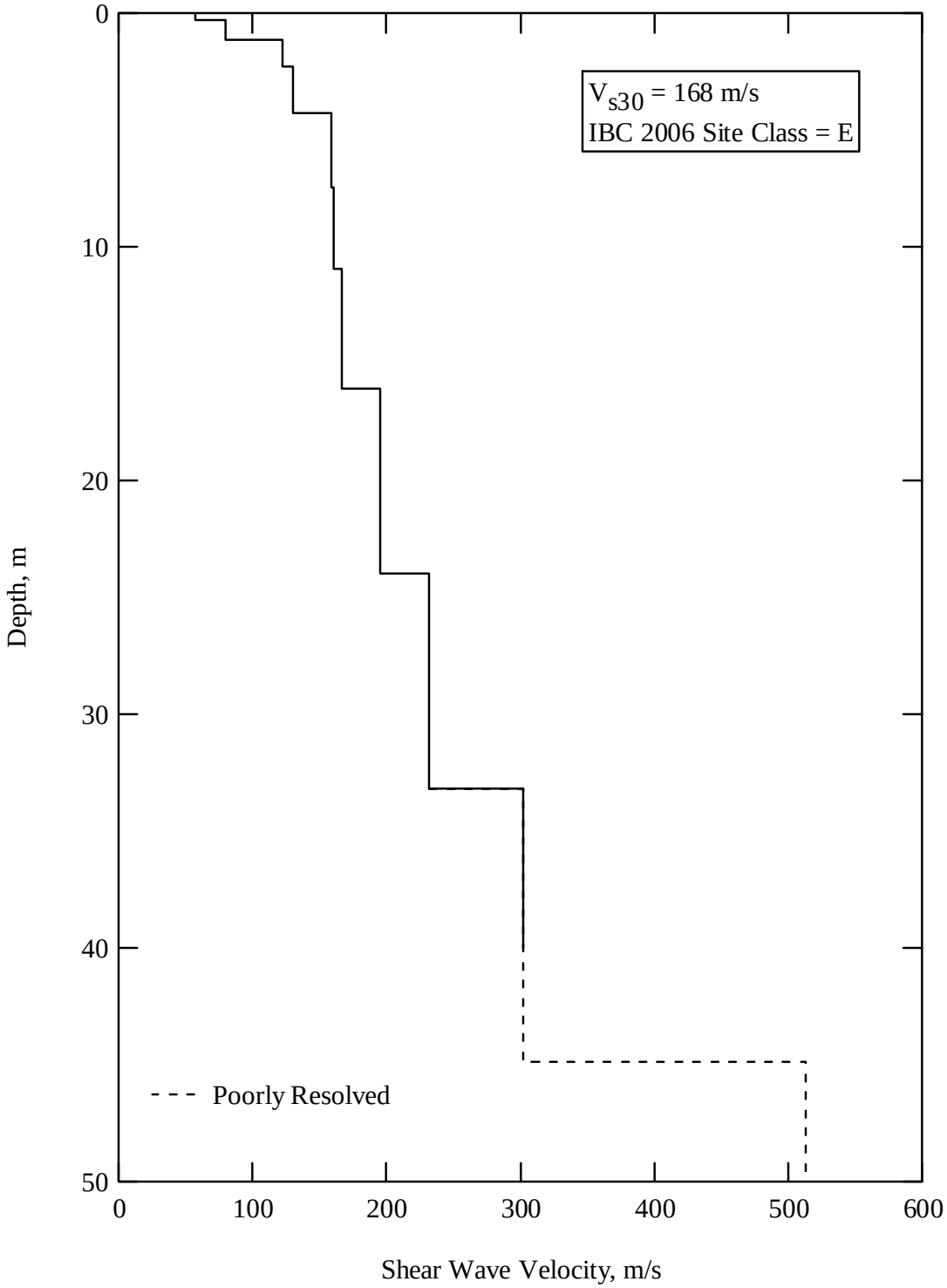

Fig. 2.26 Shear wave velocity profile determined from SASW testing at the West Weber Field (WWF), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 168 m/s, which corresponds to an IBC 2006 site class E. The shear wave velocity profile is well resolved to a depth of 40 m and poorly resolved from 40 m to 50 m.

Table 2.5 Tabulated measured and assumed layer properties at the West Weber Field (WWF), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	58	108	0.3	1.89
0.3	0.8	80	150	0.3	1.89
1.1	1.1	123	230	0.3	1.89
2.2	2.0	130	244	0.3	1.89
4.2	3.2	160	1500	0.49	1.92
7.4	3.5	161	1500	0.49	1.92
10.9	5.1	167	1500	0.49	1.92
16.0	7.9	195	1500	0.49	1.92
23.9	9.2	232	1500	0.49	1.92
33.2	6.9	302	1500	0.48	1.96

2.1.6. Hooper Elementary School

SASW testing was performed at Hooper Elementary School, designated as HES in this report, located in Weber County at 5900 W. 5500 S., Hooper, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.16538 North and 112.1207 East, with an elevation of approximately 1293 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.27. The site was of particular interest because a strong motion sensor monitored by the University of Utah Seismograph Stations is also located on the school grounds.

Testing was performed at 7:30 a.m. on October 30, 2005. The SASW array was located north of the school in the soccer playing fields. A photograph of the site is shown in Fig. 2.28. The strong motion sensor is located near the north-west corner of the

school, approximately 120 m southeast of the center of the SASW array near the school outbuildings. A fully saturated zone was assumed to exist at 4.9 m below the ground surface. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.3 m.

Figure 2.29 shows the experimental dispersion curve measured at Hooper Elementary School. Figure 2.30 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.31 shows the calculated shear wave velocity profile for the site. Table 2.6 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

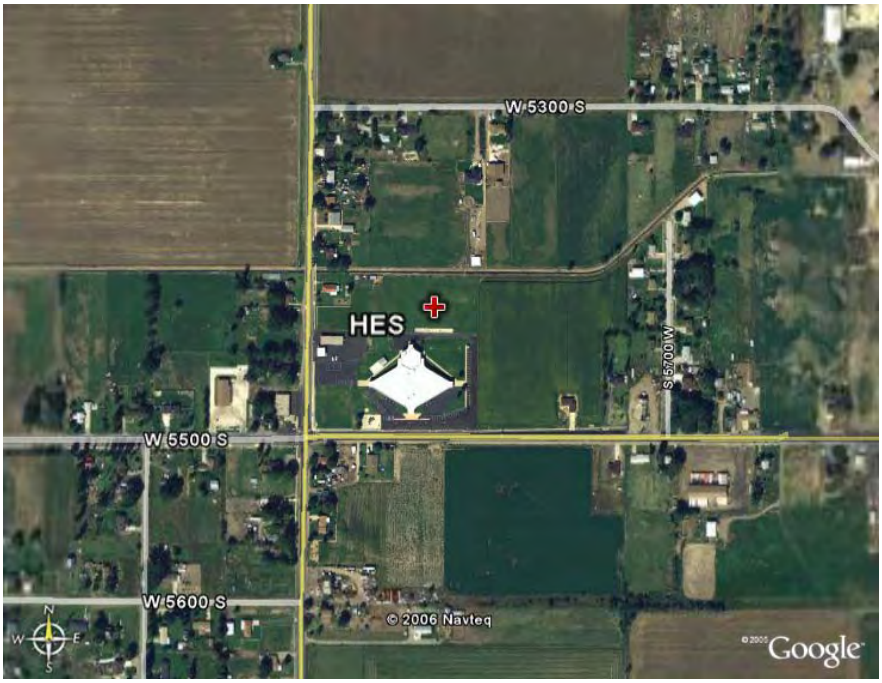

Fig. 2.27 Site map showing the location of the centerline of the SASW array at Hooper Elementary School (HES), Weber County, Utah (from Google Earth 2006).

Fig. 2.28 Photograph of SASW testing at Hooper Elementary School (HES), Weber County, Utah.

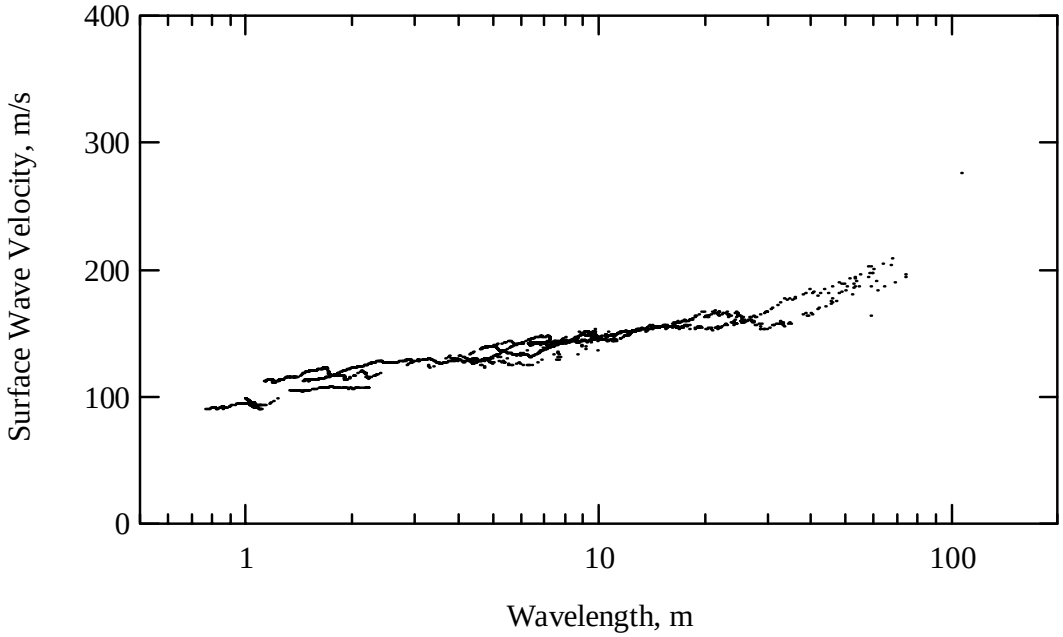

Fig. 2.29 Experimental dispersion curve measured at Hooper Elementary School (HES), Weber County, Utah.

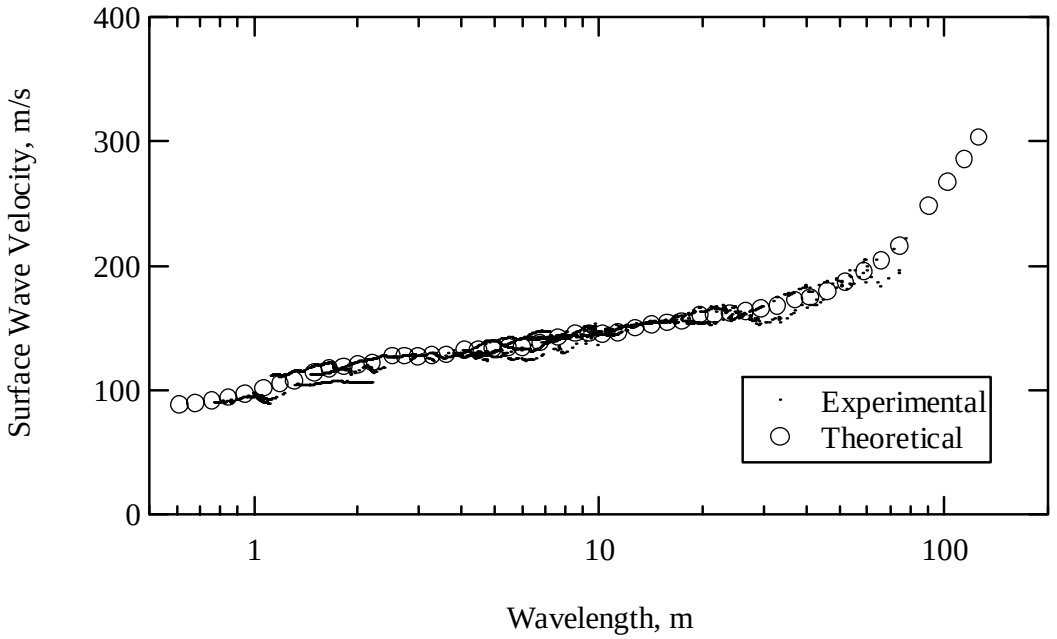

Fig. 2.30 Comparison of experimental and theoretical dispersion curves from Hooper Elementary School (HES), Weber County, Utah.

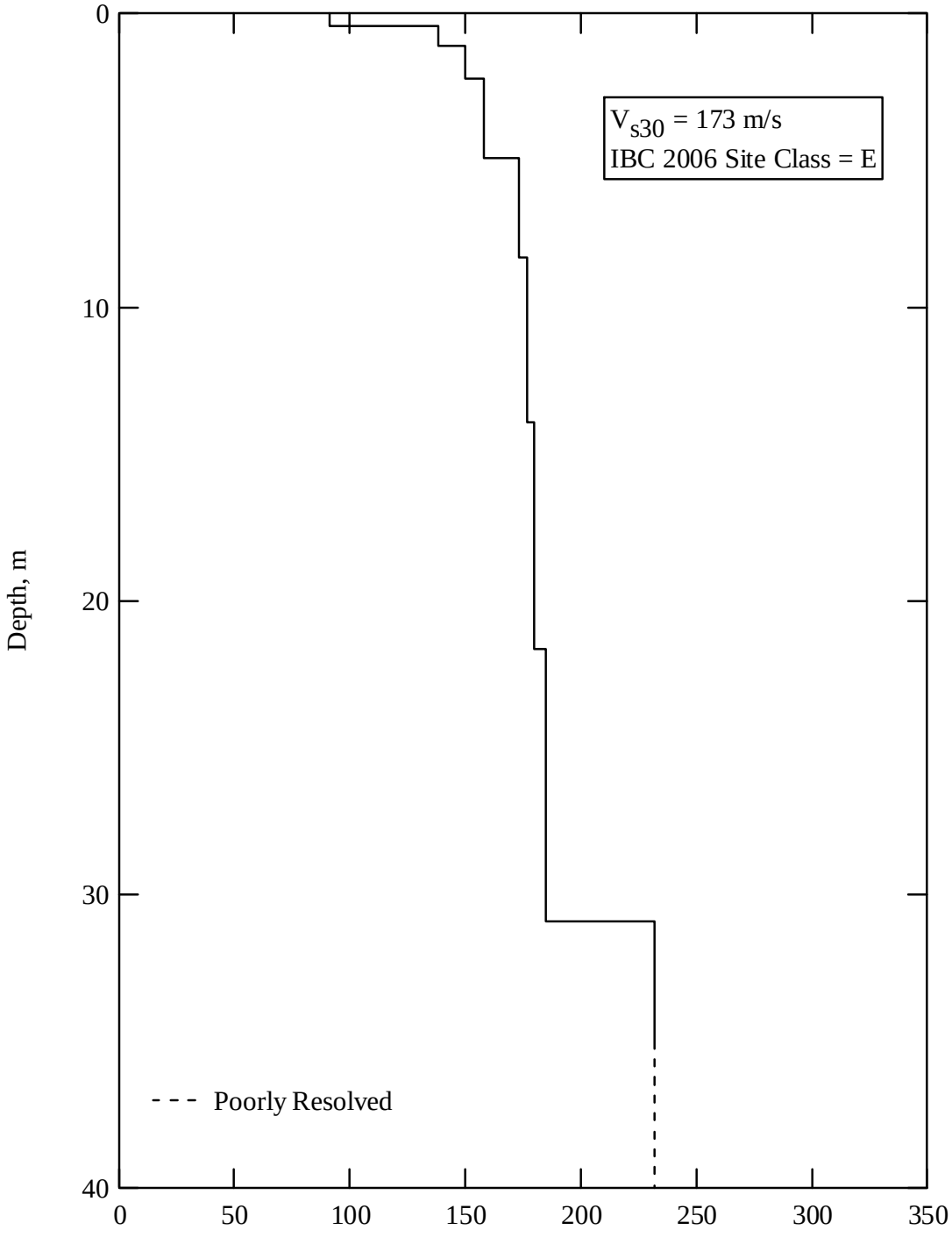

Fig. 2.31 Shear wave velocity profile determined from SASW testing at Hooper Elementary School (HES), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 173 m/s, which corresponds to an IBC 2006 site class E. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 40 m.

Table 2.6 Tabulated measured and assumed layer properties at Hooper Elementary School (HES), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	91	170	0.3	1.89
0.4	0.7	138	258	0.3	1.89
1.1	1.1	150	280	0.3	1.89
2.2	2.7	158	296	0.3	1.89
4.9	3.4	173	1500	0.49	1.89
8.3	5.6	177	1500	0.49	1.92
13.9	7.7	180	1500	0.49	1.92
21.6	9.3	185	1500	0.49	1.96
30.9	4.1	232	1500	0.49	1.96

2.1.7. East Layton Elementary School

SASW testing was performed at East Layton Elementary School, designated as ELE in this report, located in Davis County at 2470 E. Cherry Lane,. Layton, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.07993 North and 111.9179 East, with an elevation of approximately 1459 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.32. The site was of particular interest because a strong motion sensor monitored by the University of Utah Seismograph stations is located adjacent to the SASW array.

Testing was performed at 2:30 p.m. on June 30, 2005. The SASW array was located along the east side of the school adjacent to a chain-link fence. A photograph of the site is shown in Fig. 2.33. The strong motion sensor is located in the north-east corner of the property and can be seen in Fig. 2.33 near the center of the photograph. A

fully saturated zone was assumed to exist at 9.8 m below the ground surface. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.25 m with 15 cm of padding.

Figure 2.34 shows the experimental dispersion curve measured at East Layton Elementary School. Figure 2.35 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.36 shows the calculated shear wave velocity profile for the site. Table 2.7 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.32 Site map showing the location of the centerline of the SASW array at East Layton Elementary School (ELE), Davis County, Utah (from Google Earth 2006).

Fig. 2.33 Photograph of SASW testing at East Layton Elementary School (ELE), Davis County, Utah.

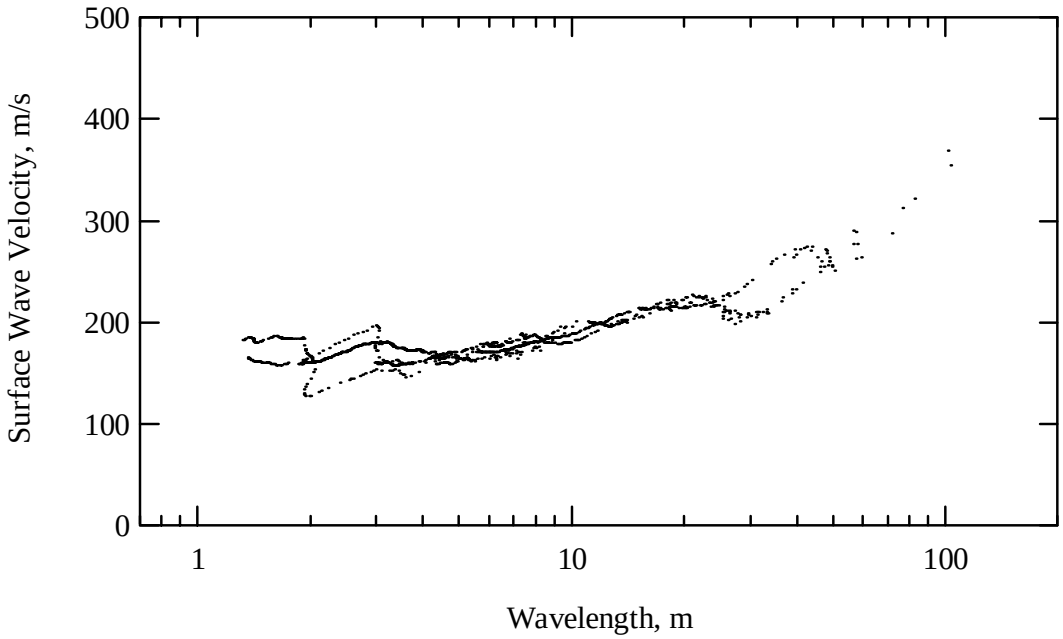

Fig. 2.34 Experimental dispersion curve measured at East Layton Elementary School (ELE), Davis County, Utah.

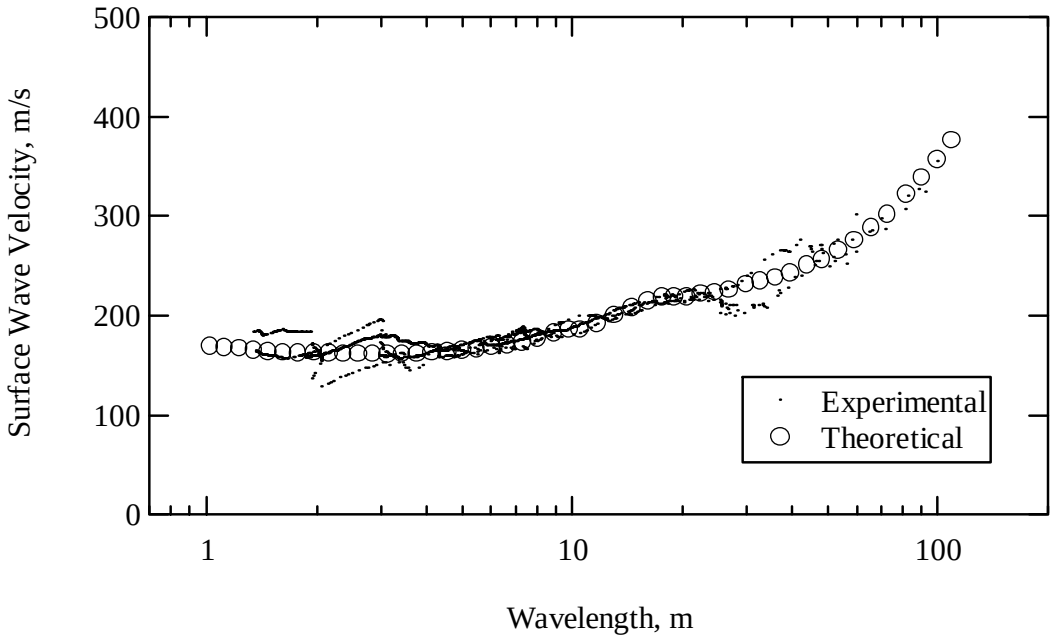

Fig. 2.35 Comparison of experimental and theoretical dispersion curves from East Layton Elementary School (ELE), Davis County, Utah.

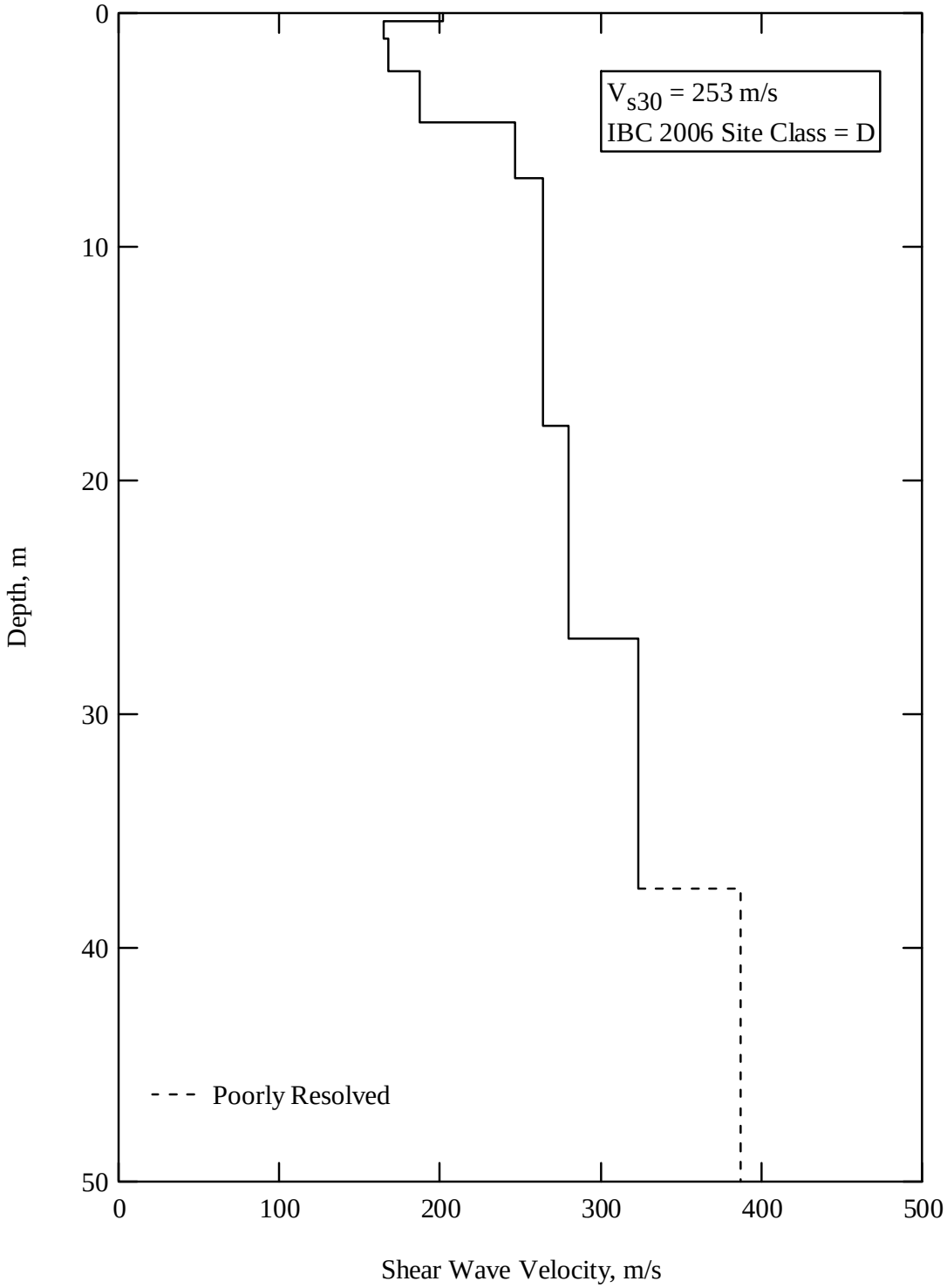

Fig. 2.36 Shear wave velocity profile determined from SASW testing at East Layton Elementary School (ELE), Davis County, Utah.

The average shear wave velocity in the upper 30 m of soil is 253 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 37.5 m and poorly resolved from 37.5 m to 50 m.

Table 2.7 Tabulated measured and assumed layer properties at East Layton Elementary School (ELE), Davis County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	202	378	0.3	1.89
0.3	0.7	165	309	0.3	1.89
1.1	1.4	168	314	0.3	1.89
2.5	2.2	187	350	0.3	1.89
4.7	2.4	247	462	0.3	1.92
7.1	2.7	264	494	0.3	1.92
9.8	7.9	264	1500	0.48	1.92
17.7	9.1	280	1500	0.48	1.96
26.8	10.7	323	1500	0.48	1.96

2.1.8. Ogden Fire Station #2

SASW testing was performed at the Ogden Fire Station #2, designated as OF2 in this report, located in Weber County at 21st and Harrison, Ogden, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.22821 North and 111.948838 East, with an elevation of approximately 1370 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.37. The site was of particular interest because a strong motion sensor monitored by the University of Utah Seismograph Stations is located adjacent to the SASW array.

Testing was performed at 8:30 a.m. on July 1, 2005. The SASW array was located in an unpaved alley directly behind the Fire Station. A photograph of the site is shown in Fig. 2.38 where the Fire Station can be seen in the background. The strong motion sensor is located in Fire Station. A fully saturated zone was assumed to exist at a depth of 13 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.19 cm with 19 cm of padding.

Figure 2.39 shows the experimental dispersion curve measured at the Fire Station. Figure 2.40 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.41 shows the calculated shear wave velocity profile for the site. Table 2.8 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

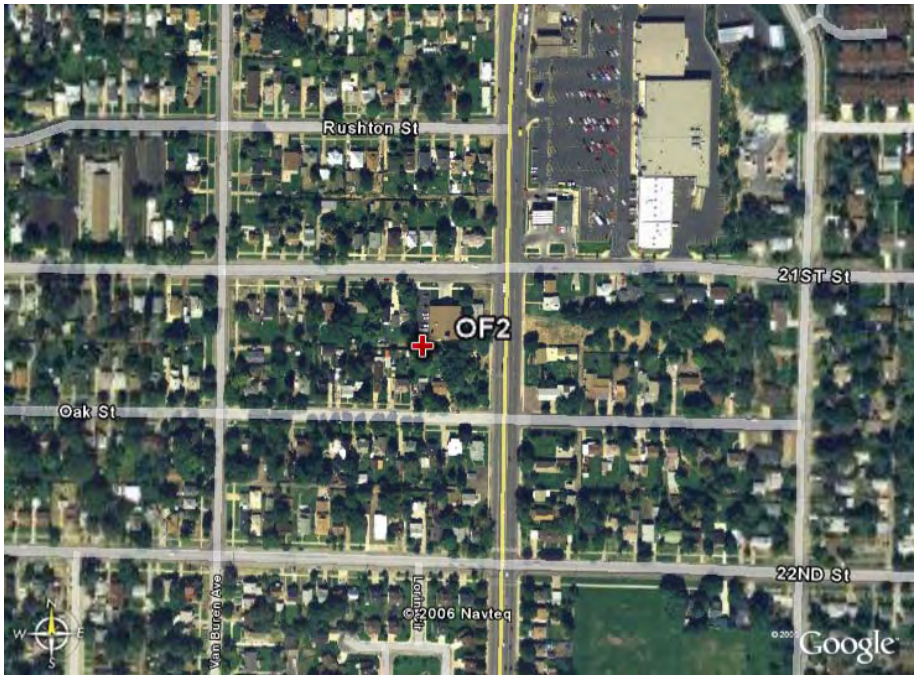

Fig. 2.37 Site map showing the location of the centerline of the SASW array at the Ogden Fire Station #2 (OF2), Weber County, Utah (from Google Earth 2006).

Fig. 2.38 Photograph of SASW testing at the Ogden Fire Station #2 (OF2), Weber County, Utah.

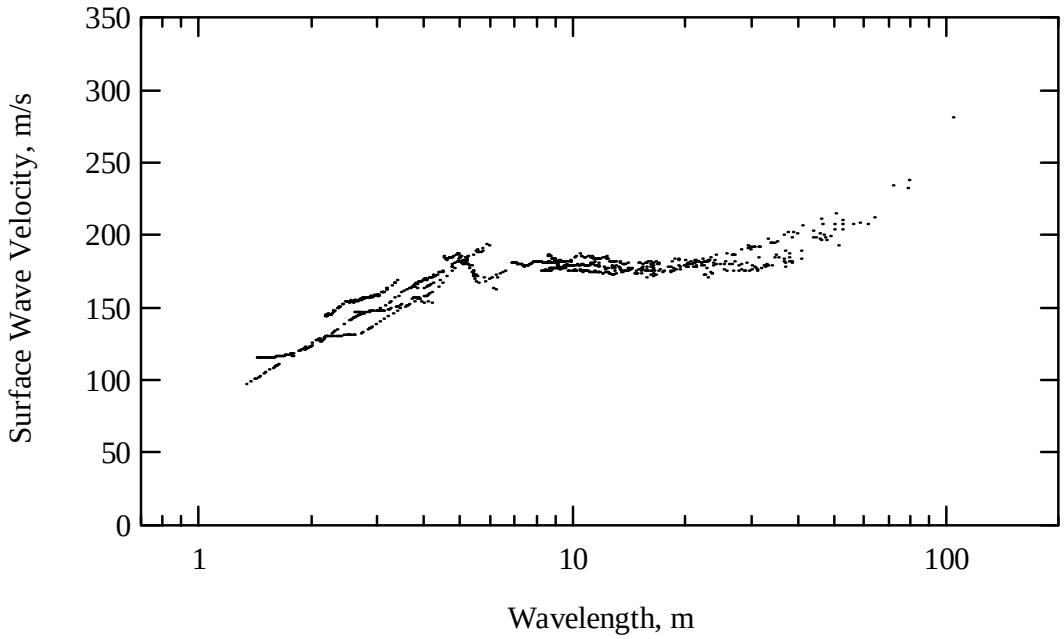

Fig. 2.39 Experimental dispersion curve measured at the Ogden Fire Station #2 (OF2), Weber County, Utah.

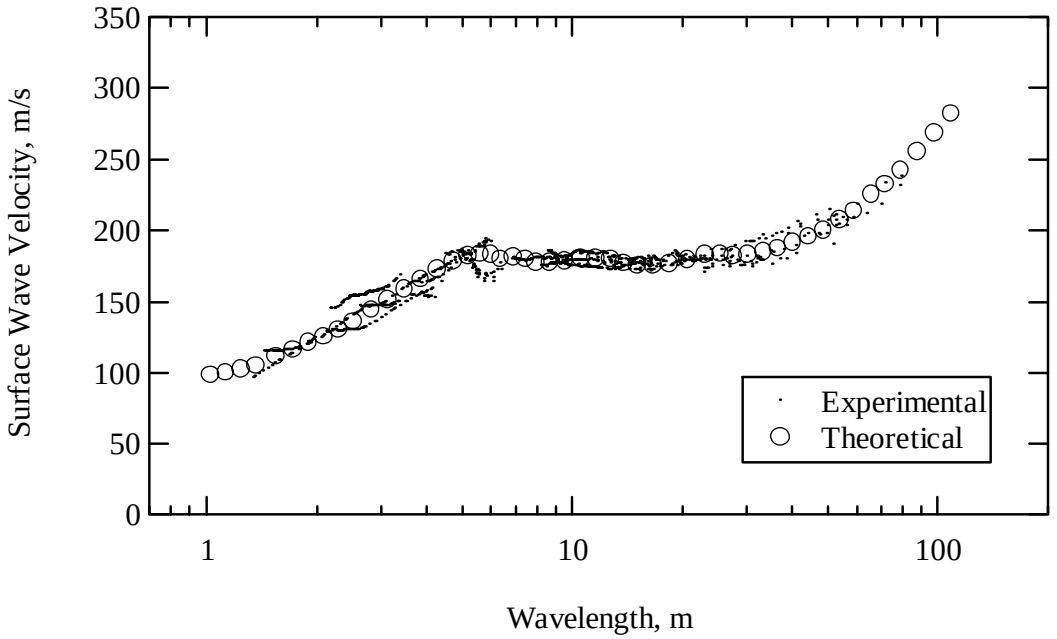

Fig. 2.40 Comparison of experimental and theoretical dispersion curves from the Ogden Fire Station #2 (OF2), Weber County, Utah.

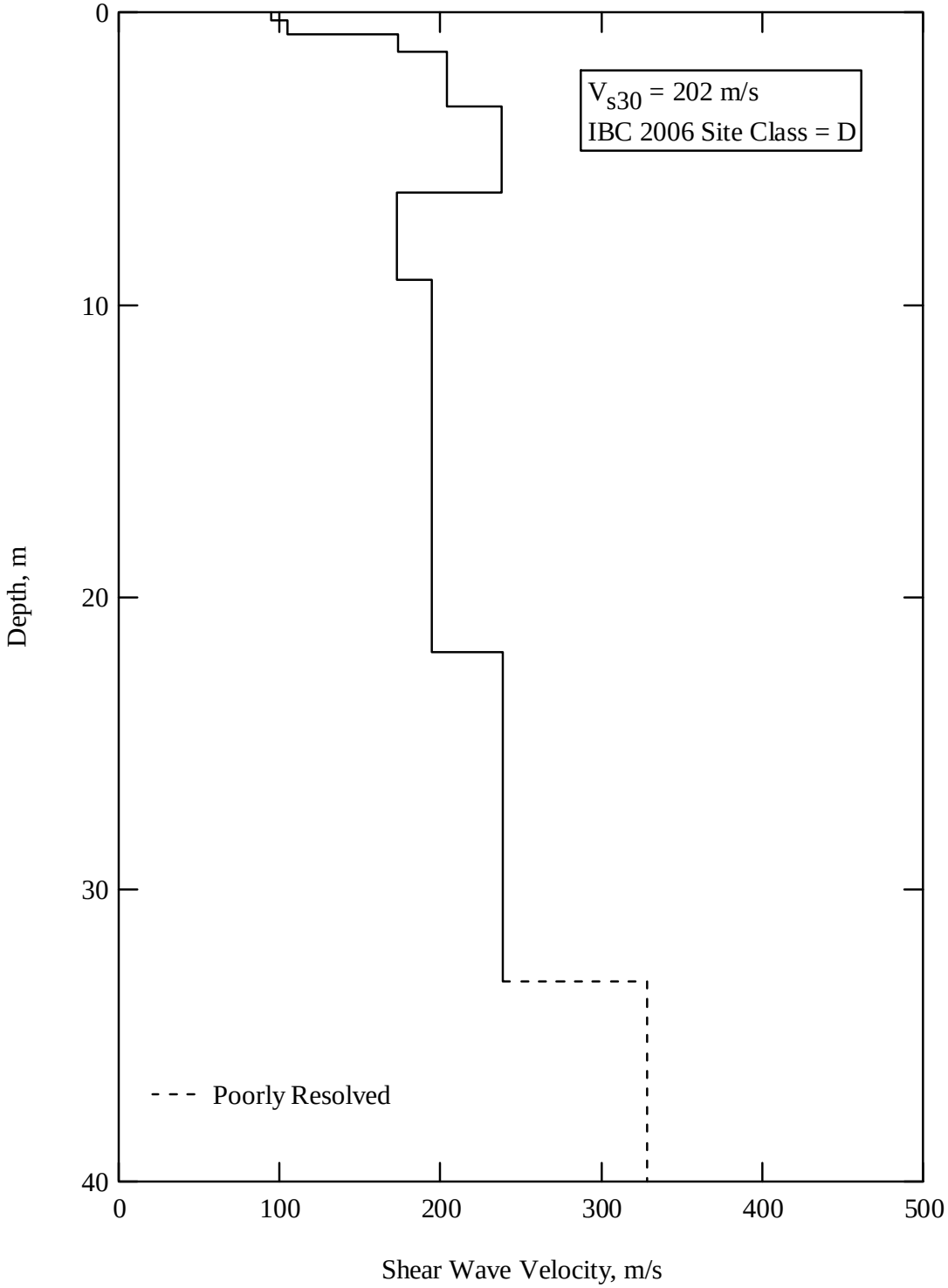

Fig. 2.41 Shear wave velocity profile determined from SASW testing at the Ogden Fire Station #2 (OF2), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 202 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 33.2 m and poorly resolved from 33.2 m to 40 m.

Table 2.8 Tabulated measured and assumed layer properties at the Ogden Fire Station #2 (OF2), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	95	178	0.3	1.89
0.3	0.5	105	196	0.3	1.89
0.7	0.6	174	326	0.3	1.92
1.3	1.9	204	382	0.3	1.92
3.2	2.9	238	445	0.3	1.92
6.2	3.0	173	324	0.3	1.92
9.2	3.8	195	365	0.3	1.92
13.0	8.9	195	1500	0.49	1.92
21.9	11.3	239	1500	0.49	1.92

2.1.9. Ogden Public Safety Building

SASW testing was performed at the Ogden Public Safety Building, designated as OPS in this report, located in Weber County at 21st and Lincoln Ave., Ogden, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.2286 North and 111.97481 East, with an elevation of approximately 1318 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.42. The site was of particular interest because a strong motion sensor monitored by the University of Utah Seismograph is located adjacent to the SASW array.

Testing was performed at 12:00 p.m. on June 30, 2005. The SASW array was located in a private parking lot to the north of the Ogden Public Safety Building, in an east-west orientation. A photograph of the site is shown in Fig. 2.43, the array extended beyond the Ogden Public Safety Building property and into the neighboring hotel which can be seen in the background of the photograph. Figure 2.44 shows the location of the strong motion sensor relative to the trailer. The strong motion sensor is located in the

green box on the far side of the fence and directly behind the source trailer. A fully saturated zone was assumed to exist at a depth of 15.7 m below the ground. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.25 m with 19 cm of padding.

Unusual spacings were used at this site due to vehicle and curbing obstructions. Rather than the typical 15-30 m setup, a 15-24 m spacing configuration was used. The hammer spacings were also restricted to a single direction because of the difficult terrain.

Figure 2.45 shows the experimental dispersion curve measured at the Fire Station. Figure 2.46 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. The dispersion curve exhibits a velocity inversion due to the stiff asphalt and base layers that are found in the parking lot. Figure 2.47 shows the calculated shear wave velocity profile for the site. Table 2.9 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.42 Site map showing the location of the centerline of the SASW array at the Ogden Public Safety Building (OPS), Weber County, Utah (from Google Earth 2006).

Fig. 2.43 Photograph of SASW testing at the Ogden Public Safety Building (OPS), Weber County, Utah.

Fig. 2.44 Photograph of the strong motion sensor near the Ogden Public Safety Building (OPS), Weber County, Utah.

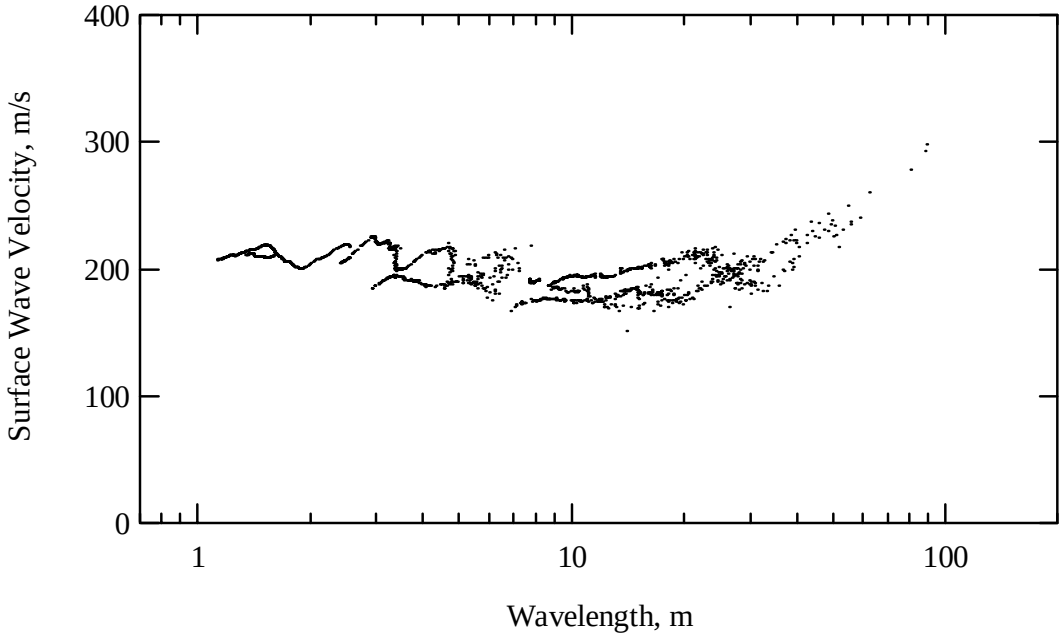

Fig. 2.45 Experimental dispersion curve measured at the Ogden Public Safety Building (OPS), Weber County, Utah.

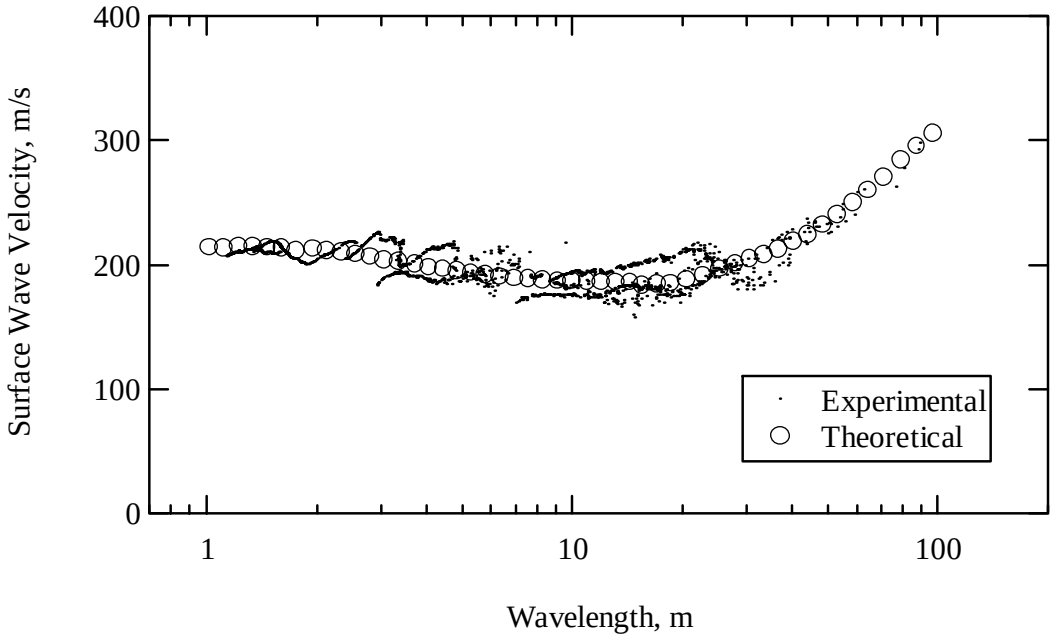

Fig. 2.46 Comparison of experimental and theoretical dispersion curves from the Ogden Public Safety Building (OPS), Weber County, Utah.

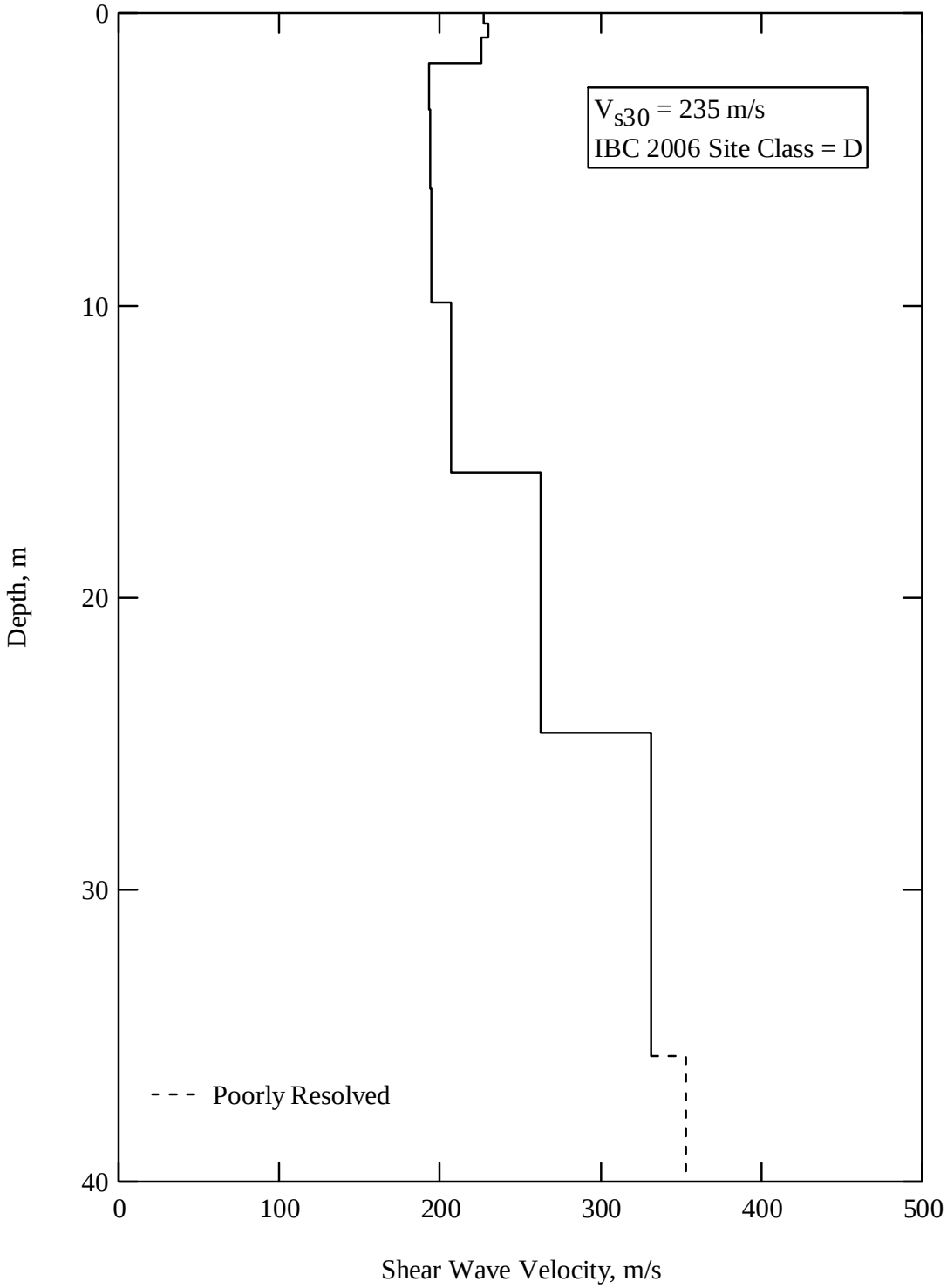

Fig. 2.47 Shear wave velocity profile determined from SASW testing at the Ogden Public Safety Building (OPS), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 235 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 35.7 m and poorly resolved from 35.7 m to 40 m.

Table 2.9 Tabulated measured and assumed layer properties at the Ogden Public Safety Building (OPS), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	227	425	0.3	1.92
0.4	0.5	230	430	0.3	1.92
0.8	0.9	226	423	0.3	1.92
1.7	1.6	193	361	0.3	1.92
3.3	2.7	194	363	0.3	1.92
6.0	3.9	195	365	0.3	1.92
9.9	5.8	207	387	0.3	1.92
15.7	8.9	263	1500	0.48	1.92
24.6	11.1	331	1500	0.47	1.96

2.1.10. Bell Junior High School

SASW testing was performed at Bell Junior High School, designated as BJH in this report, located at 165 W. 5100 S., Ogden, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.16987 North and 111.9817 East, with an elevation of approximately 1408 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.48.

Testing was performed at 7:30 a.m. on August 12, 2005. The SASW array ran across the baseball playing fields to the west of the school. A photograph of the site is shown in Fig. 2.49. Due to soft ground, the source location remained constant and the centerline of the array was shifted. A fully saturated zone was assumed to exist at 19.2 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.25 m with 19 cm of padding.

Figure 2.50 shows the experimental dispersion curve measured at Bell Junior High School. Figure 2.51 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.52 shows the calculated shear wave velocity profile for the site. Table 2.10 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.48 Site map showing the location of the centerline of the SASW array at Bell Junior High School (BJH), Weber County, Utah (from Google Earth 2006).

Fig. 2.49 Photograph of SASW testing at Bell Junior High School (BJH), Weber County, Utah.

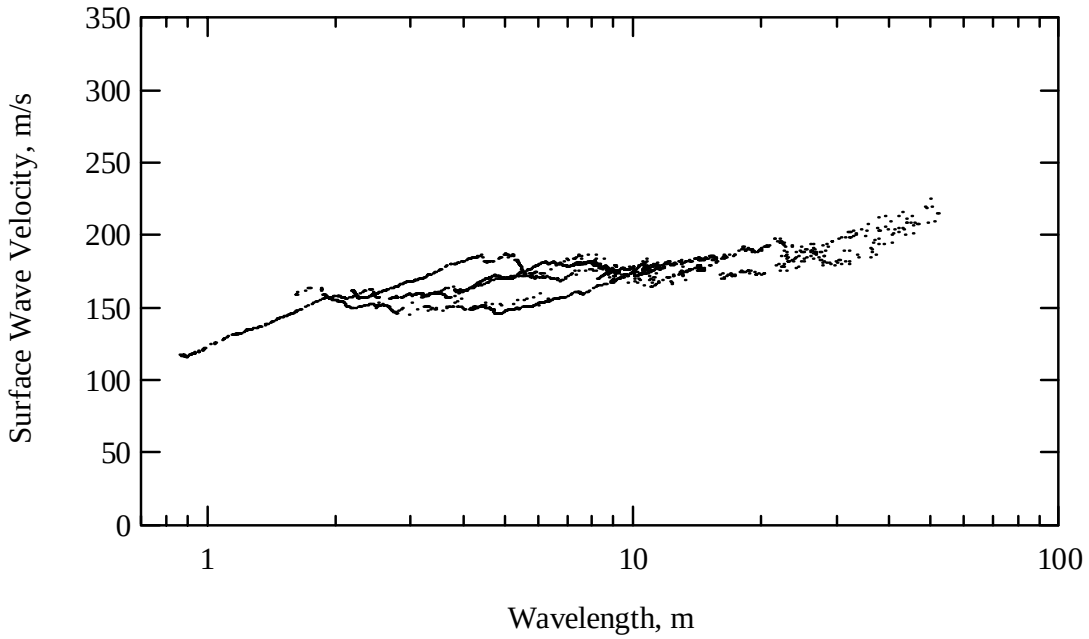

Fig. 2.50 Experimental dispersion curve measured at Bell Junior High School (BJH), Weber County, Utah.

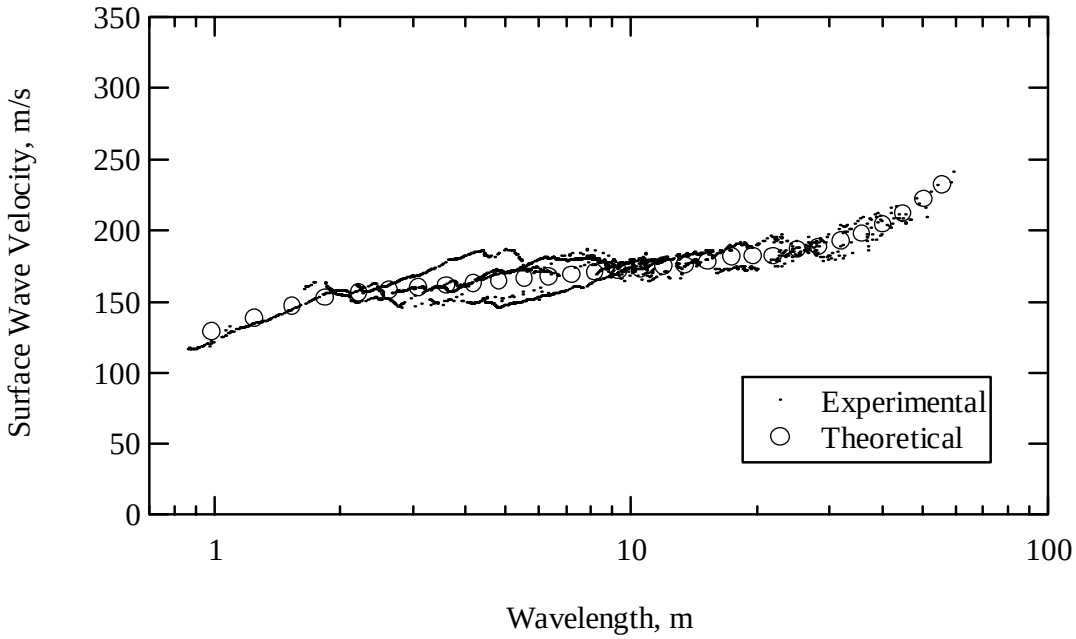

Fig. 2.51 Comparison of experimental and theoretical dispersion curves from Bell Junior High School (BJH), Weber County, Utah.

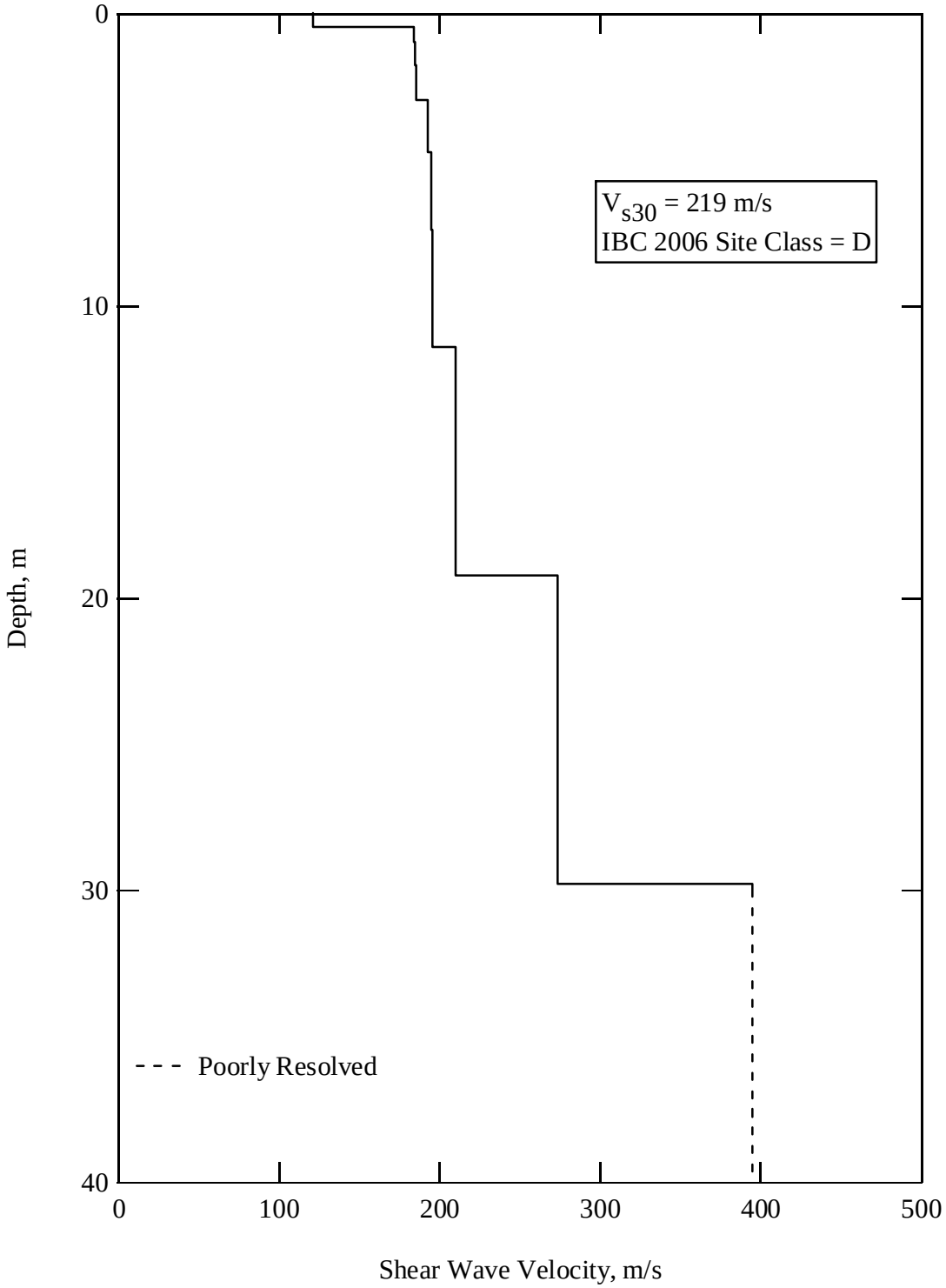

Fig. 2.52 Shear wave velocity profile determined from SASW testing at Bell Junior High School (BJH), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 219 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 40 m.

Table 2.10 Tabulated measured and assumed layer at Bell Junior High School (BJH), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.5	122	227	0.3	1.87
0.5	0.5	184	345	0.3	1.90
1.0	0.8	185	346	0.3	1.90
1.8	1.2	185	347	0.3	1.90
3.0	1.8	193	360	0.3	1.90
4.7	2.7	195	365	0.3	1.90
7.4	4.0	196	367	0.3	1.90
11.4	7.8	210	393	0.3	1.90
19.2	10.6	273	1500	0.49	1.95
29.8	2.0	395	1500	0.46	2.00

2.1.11. Uintah Town Hall

SASW testing was performed at the Uintah Town Hall, designated as UTH in this report, located at 2105 E. 6550 S., Uintah, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.14416 North and 111.9253 East, with an elevation of approximately 1480 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.53. The site was of particular interest because a strong motion sensor monitored by the University of Utah Seismograph stations is located adjacent to the SASW array in the County Building.

Testing was performed at 10:00 a.m. on October 30, 2005. The SASW array ran diagonal across the baseball playing field. A photograph of the site is shown in Fig. 2.54. Due to wet weather, the source location remained constant and the centerline of the array

was shifted. A fully saturated zone was not assumed at this site. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.2 m with 19 cm of padding.

Figure 2.55 shows the experimental dispersion curve measured at the Town Hall. Figure 2.56 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.57 shows the calculated shear wave velocity profile for the site. Table 2.11 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

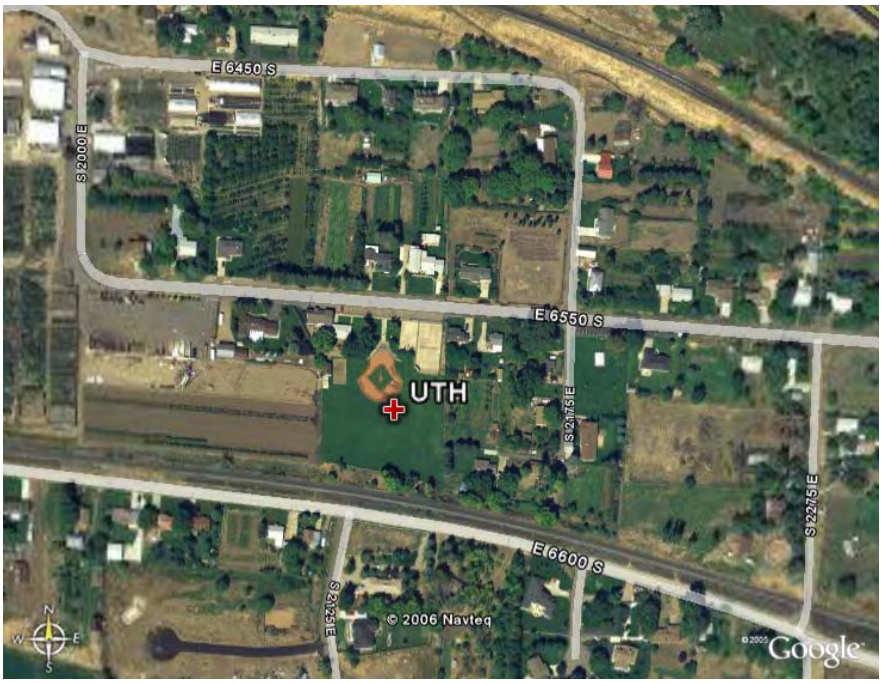

Fig. 2.53 Site map showing the location of the centerline of the SASW array at the Uintah Town Hall (UTH), Weber County, Utah (from Google Earth 2006).

Fig. 2.54 Photograph of SASW testing at the Uintah Town Hall (UTH), Weber County, Utah.

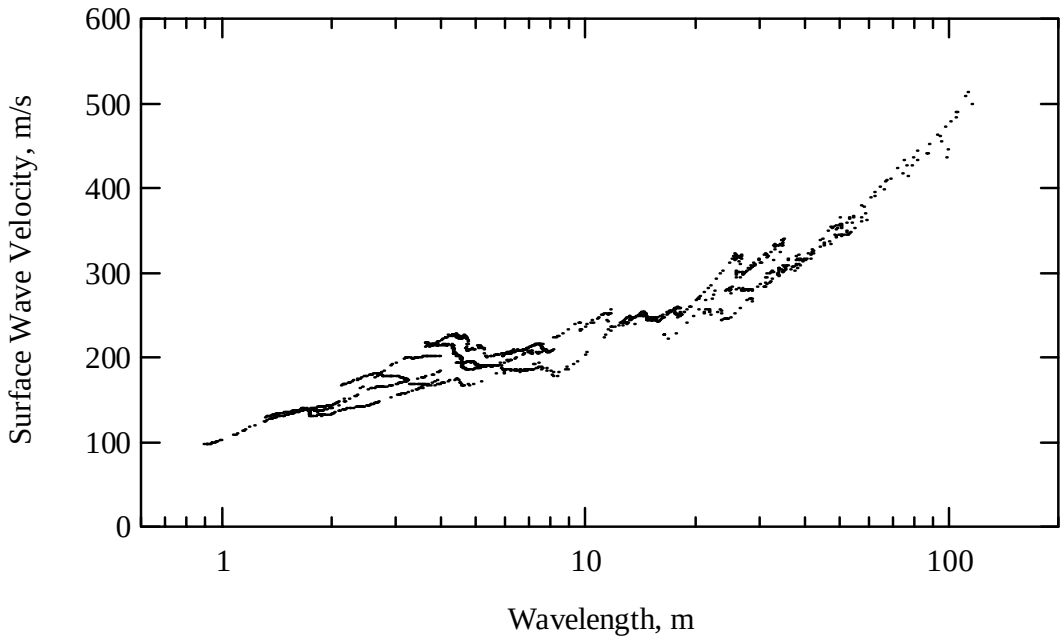

Fig. 2.55 Experimental dispersion curve measured at the Uintah Town Hall (UTH), Weber County, Utah.

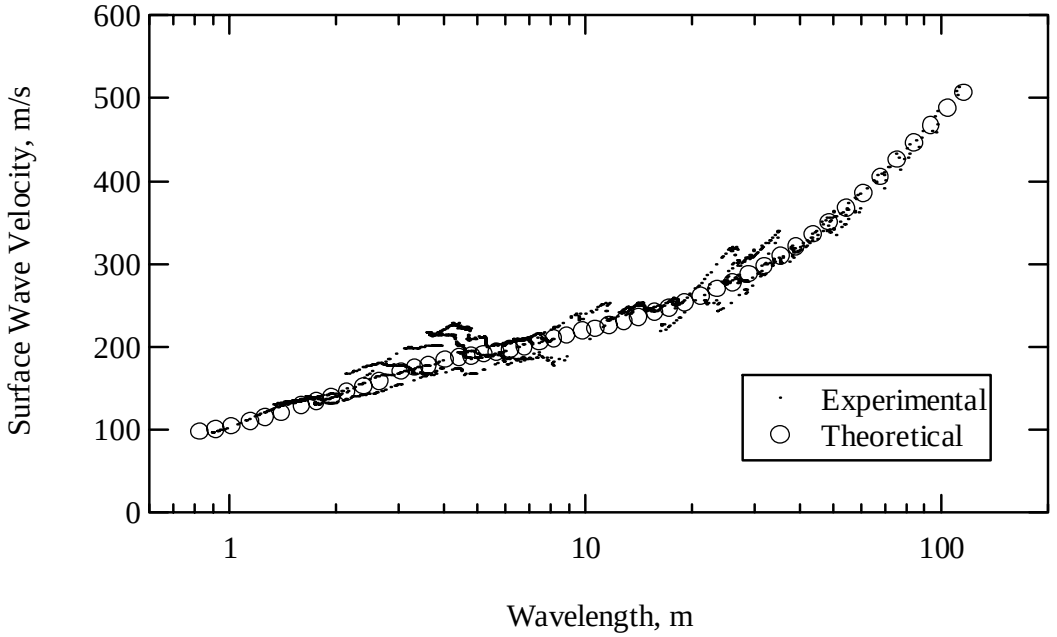

Fig. 2.56 Comparison of experimental and theoretical dispersion curves from the Uintah Town Hall (UTH), Weber County, Utah.

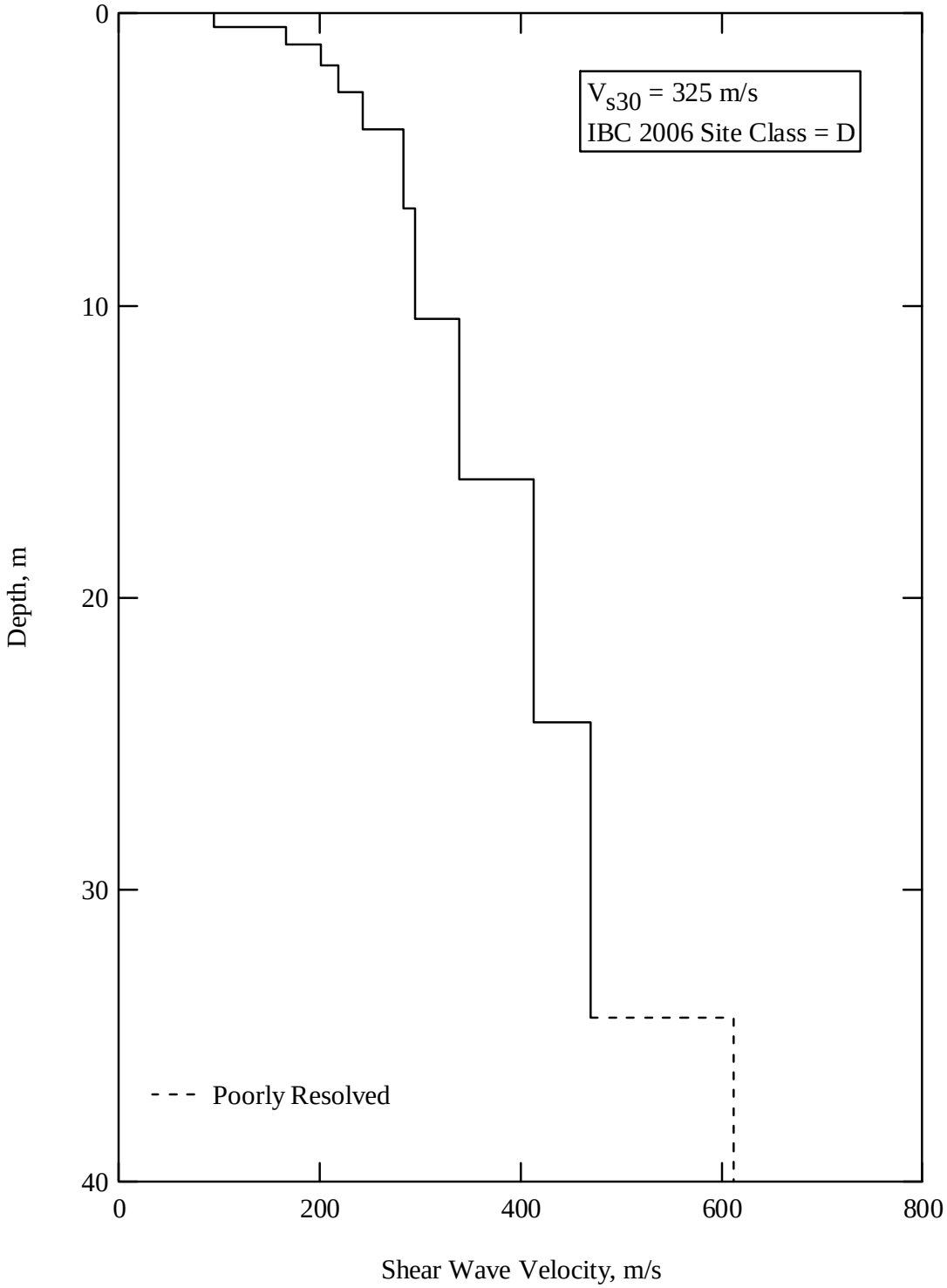

Fig. 2.57 Shear wave velocity profile determined from SASW testing at the Uintah Town Hall (UTH), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 325 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 34.4 m and poorly resolved from 34.4 m to 40 m.

Table 2.11 Tabulated measured and assumed layer at the Uintah Town Hall (UTH), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.5	95	177	0.3	1.89
0.5	0.6	167	312	0.3	1.89
1.1	0.7	201	376	0.3	1.89
1.8	0.9	219	410	0.3	1.90
2.7	1.3	243	454	0.3	1.90
4.0	2.7	284	531	0.3	1.90
6.7	3.8	295	552	0.3	1.92
10.5	5.5	339	634	0.3	2.00
16.0	8.3	413	773	0.3	2.00
24.3	10.1	470	879	0.3	2.00

2.1.12. Mountain View Elementary School

SASW testing was performed at Mountain View Elementary School, designated as MVE in this report, located at 14th St. and Lincoln Ave., Ogden, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.24116 North and 111.97634 East, with an elevation of approximately 1312 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.58.

Testing was performed at 1:00 p.m. on September 24, 2006. The SASW array was located to the north of the school in the soccer playing fields. A photograph of the site is shown in Fig. 2.59 with Mountain View Elementary School visible in the background. A fully saturated zone was assumed to exist at a depth of 17.5 m below the

ground surface. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.25 m with 15 cm of padding.

Figure 2.60 shows the experimental dispersion curve measured at Mountain View Elementary School. Figure 2.61 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.62 shows the calculated shear wave velocity profile for the site. Table 2.12 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.58 Site map showing the location of the centerline of the SASW array at Mountain View Elementary (MVE), Weber County, Utah (from Google Earth 2006).

Fig. 2.59 Photograph of SASW testing at Mountain View Elementary (MVE), Weber County, Utah.

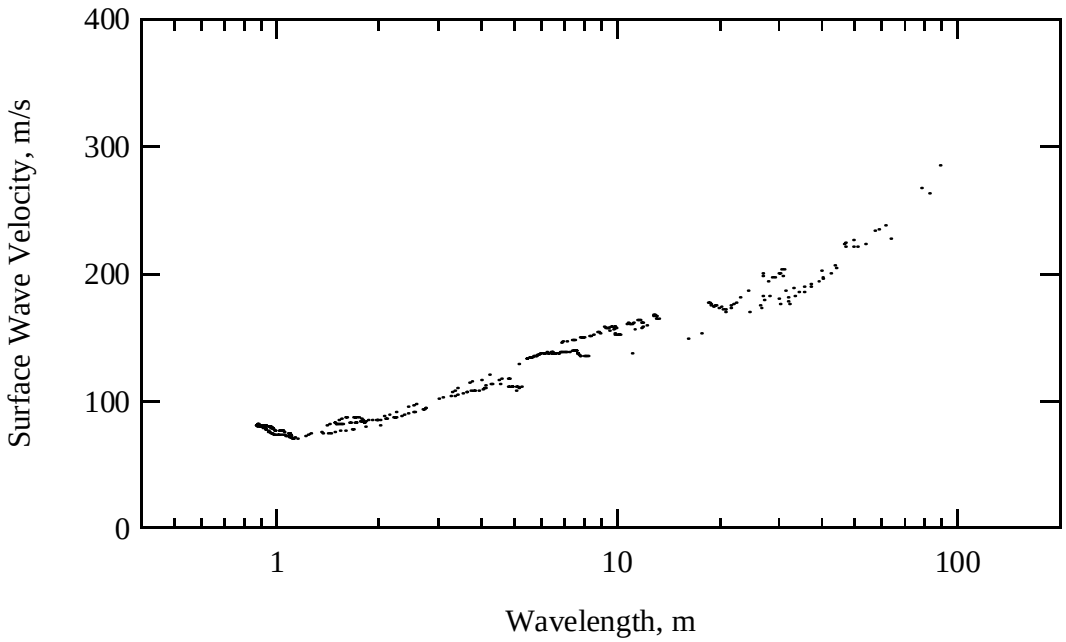

Fig. 2.60 Experimental dispersion curve measured at Mountain View Elementary (MVE), Weber County, Utah.

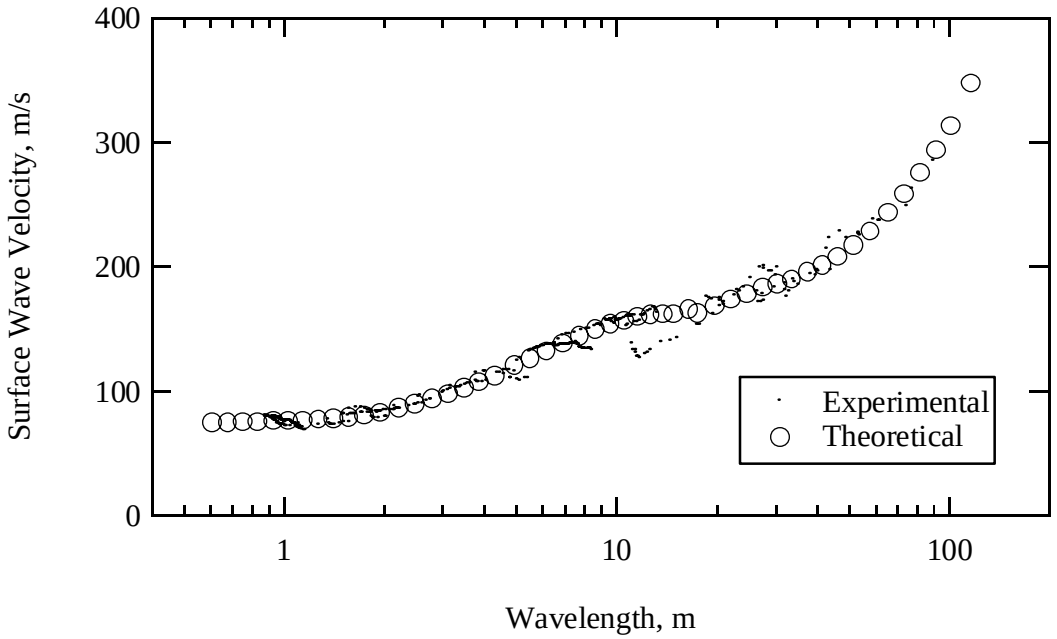

Fig. 2.61 Comparison of experimental and theoretical dispersion curves from Mountain View Elementary (MVE), Weber County, Utah.

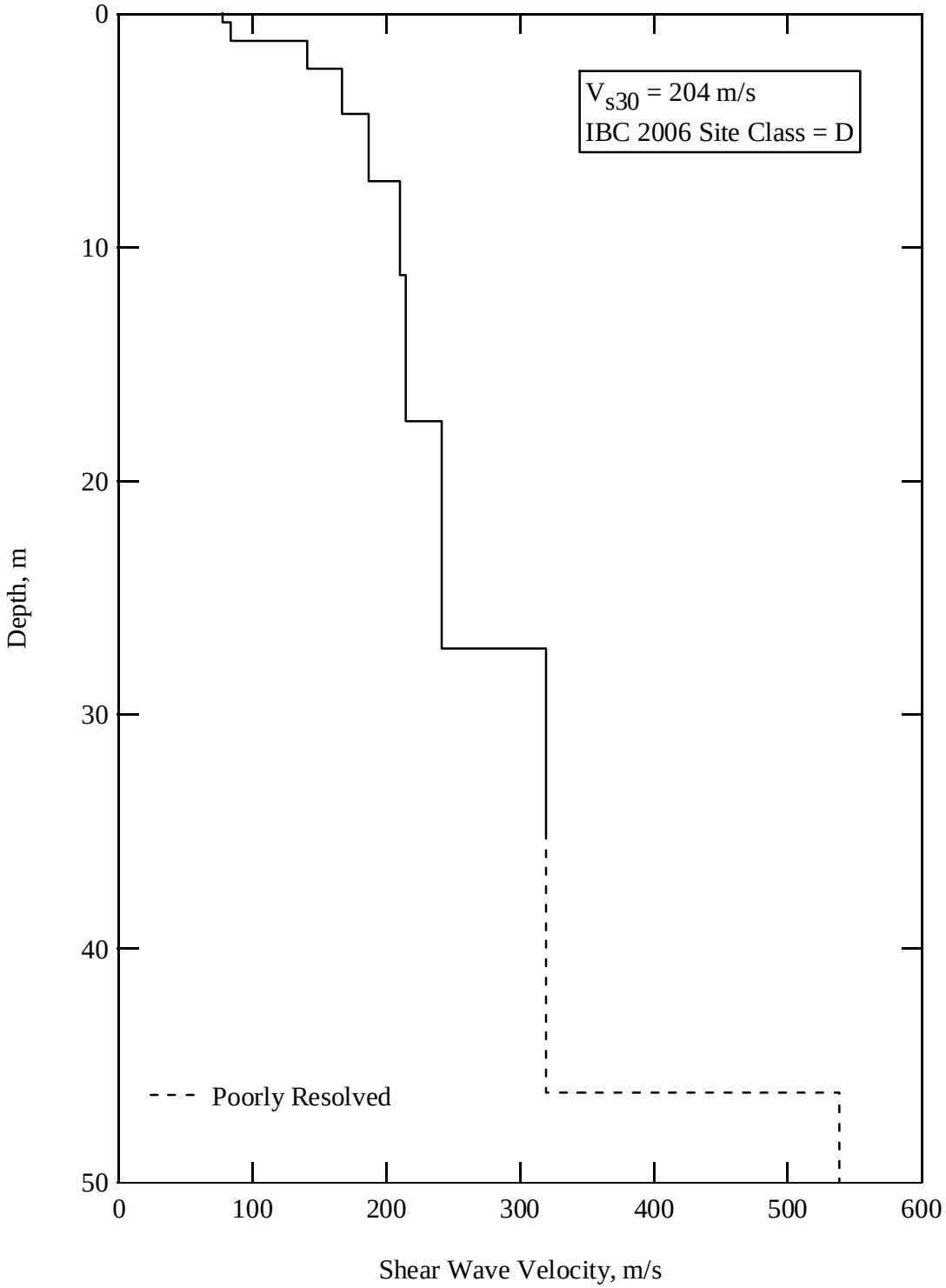

Fig. 2.62 Shear wave velocity profile determined from SASW testing at Mountain View Elementary (MVE), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 204 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 50 m.

Table 2.12 Tabulated measured and assumed layer at Mountain View Elementary (MVE), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	78	146	0.3	1.89
0.4	0.8	84	157	0.3	1.89
1.2	1.2	141	264	0.3	1.89
2.4	1.9	167	312	0.3	1.89
4.3	2.9	187	350	0.3	1.92
7.2	4.0	211	395	0.3	1.92
11.2	6.3	215	402	0.3	1.92
17.5	9.7	242	1500	0.49	1.92
27.2	7.8	320	1500	0.48	1.96

2.1.13. Bates Elementary School

SASW testing was performed at Bates Elementary School, designated as BES in this report, located at 850 E. 3100 N., Ogden, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.31876 North and 111.95402 East, with an elevation of approximately 1463 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.63. The site was of particular interest because a strong motion sensor monitored by the University of Utah Seismograph Stations is located adjacent to the SASW array.

Testing was performed on June 17, 2005. The SASW array was located along the fence line on the north side of the school running in the east-west direction. A photograph of the site is shown in Fig. 2.64. The strong motion station is located approximately 50 m to the west of the SASW array next to the school building. A fully saturated zone was not assumed at this site. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.25 m with 19 cm of padding.

Figure 2.65 shows the experimental dispersion curve measured at Bates Elementary School. Figure 2.66 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.67 shows the calculated shear wave velocity profile for the site. Table 2.13 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.63 Site map showing the location of the centerline of the SASW array at Bates Elementary School (BES), Weber County, Utah (from Google Earth 2006).

Fig. 2.64 Photograph of SASW testing at Bates Elementary School (BES), Weber County, Utah.

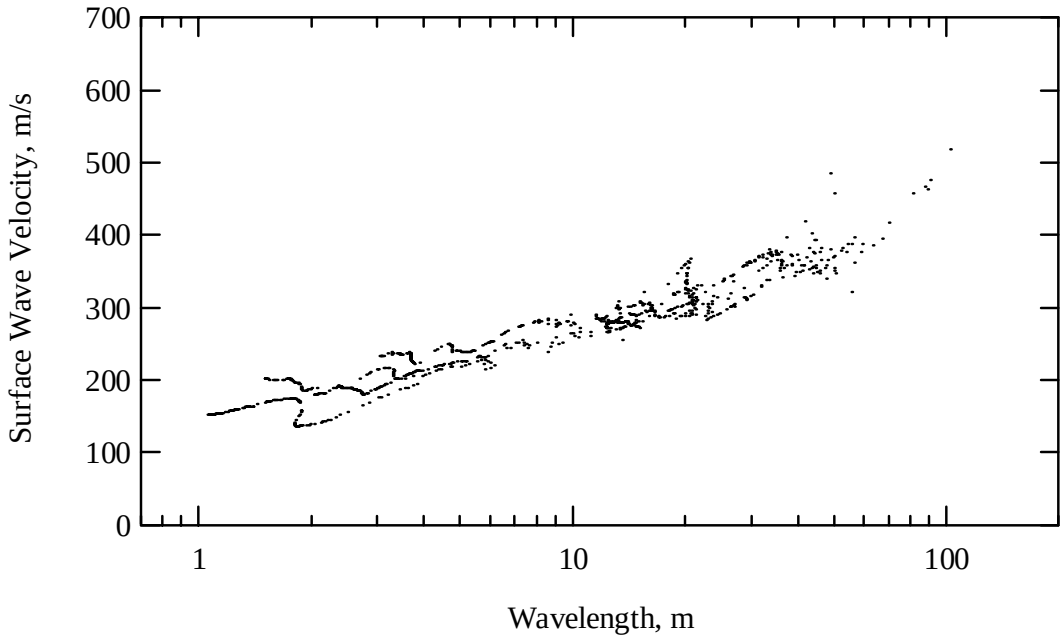

Fig. 2.65 Experimental dispersion curve measured at Bates Elementary School (BES), Weber County, Utah.

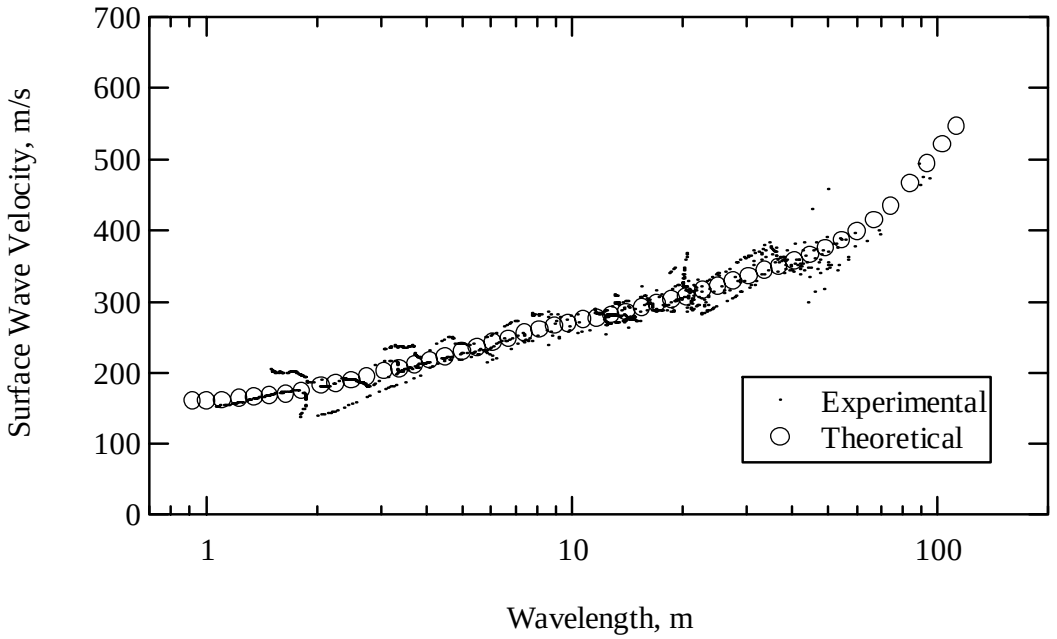

Fig. 2.66 Comparison of experimental and theoretical dispersion curves from Bates Elementary School (BES), Weber County, Utah.

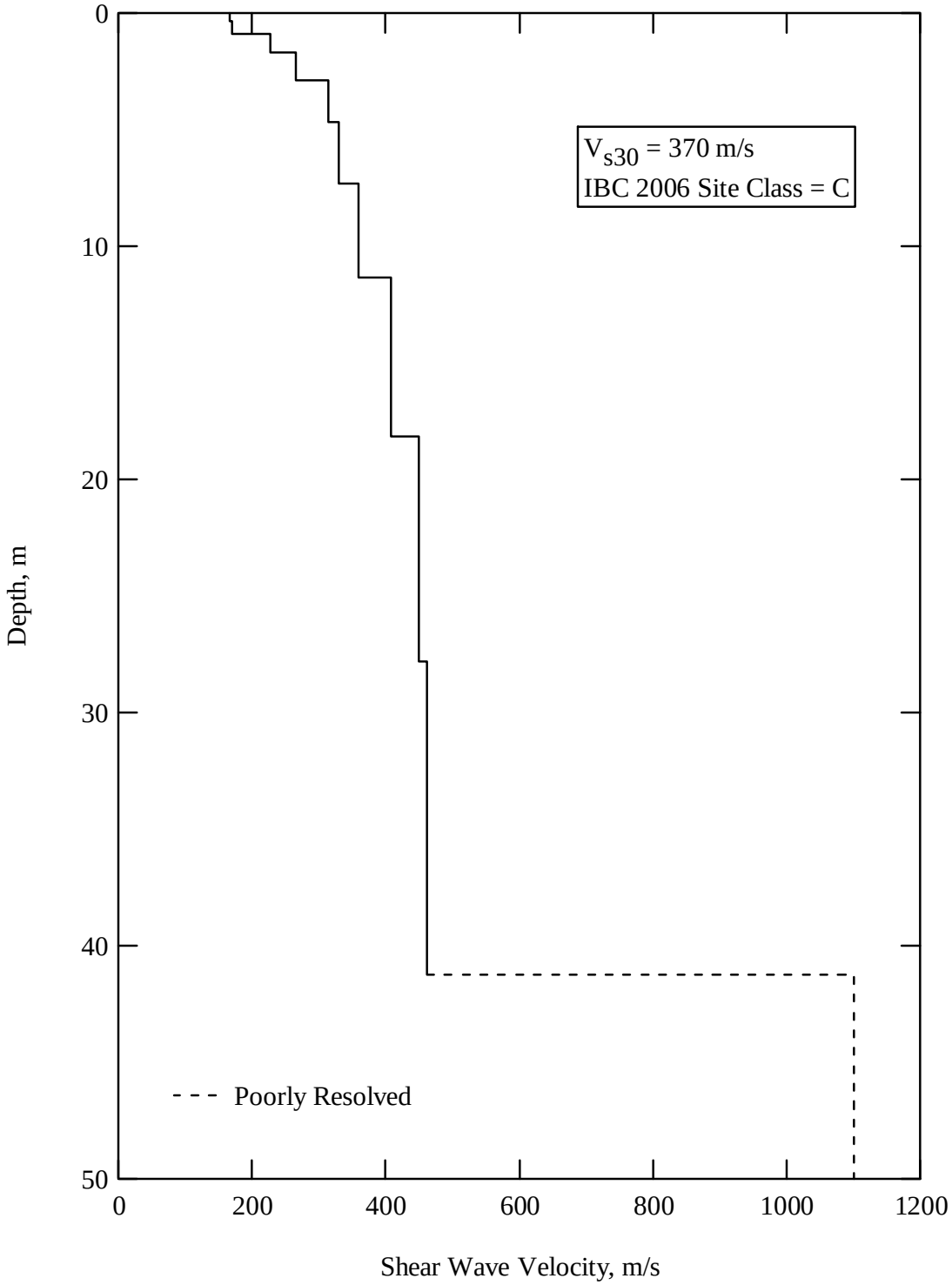

Fig. 2.67 Shear wave velocity profile determined from SASW testing at Bates Elementary School (BES), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 370 m/s, which corresponds to an IBC 2006 site class C. The V_{S30} for the site is near the site class B transition. The shear wave velocity profile is well resolved to a depth of 41.2 m and poorly resolved from 41.2 m to 50 m.

Table 2.13 Tabulated measured and assumed layer at Bates Elementary School (BES), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	168	314	0.3	1.89
0.4	0.5	171	320	0.3	1.92
0.9	0.8	228	427	0.3	1.92
1.7	1.2	265	496	0.3	1.92
2.9	1.8	314	587	0.3	1.92
4.7	2.7	330	617	0.3	2.00
7.3	4.0	359	672	0.3	2.00
11.3	6.8	409	765	0.3	2.00
18.1	9.7	449	840	0.3	2.00
27.8	13.4	461	863	0.3	2.00

2.1.14. Weber State University

SASW testing was performed at Weber State University, designated as 7212 in this report, located at 37th St. and Birch Ave., Ogden, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.19533 North and 111.94234 East, with an elevation of approximately 1429 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.68. The site was of particular interest because a strong motion sensor monitored by the University of Utah Seismograph Stations is located near the site.

Testing was performed on July 1, 2005. The SASW array was located in a parking lot on campus. A photograph of the site is shown in Fig. 2.69. The strong motion sensor is located in the Annex 2 English building that can be seen at the distant end of the SASW array in Fig. 2.69. A fully saturated zone was not assumed at this site.

Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.2 m with 15 cm of padding.

Figure 2.70 shows the experimental dispersion curve measured at the Weber State University site. Figure 2.71 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.72 shows the calculated shear wave velocity profile for the site. Table 2.14 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.68 Site map showing the location of the centerline of the SASW array at Weber State University (7212), Weber County, Utah (from Google Earth 2006).

Fig. 2.69 Photograph of SASW testing at Weber State University (7212), Weber County, Utah.

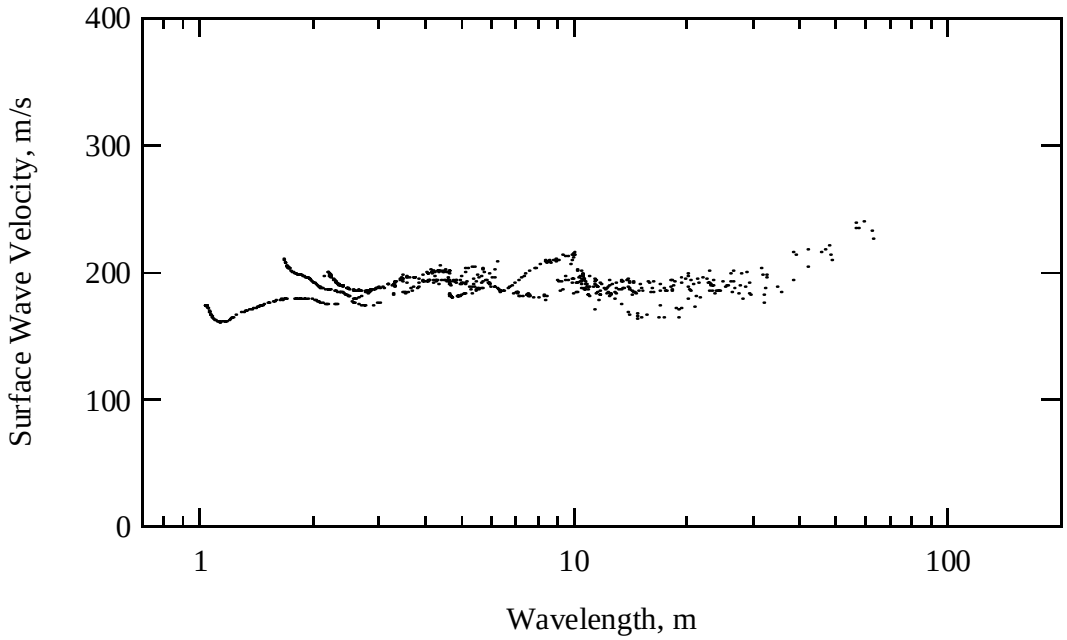

Fig. 2.70 Experimental dispersion curve measured at Weber State University (7212), Weber County, Utah.

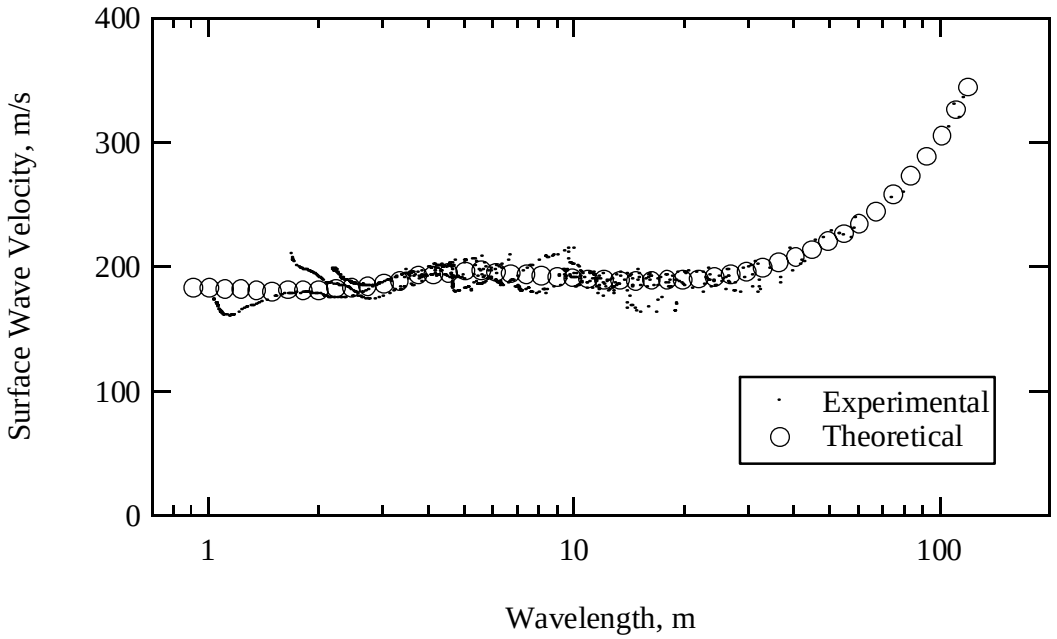

Fig. 2.71 Comparison of experimental and theoretical dispersion curves from Weber State University (7212), Weber County, Utah.

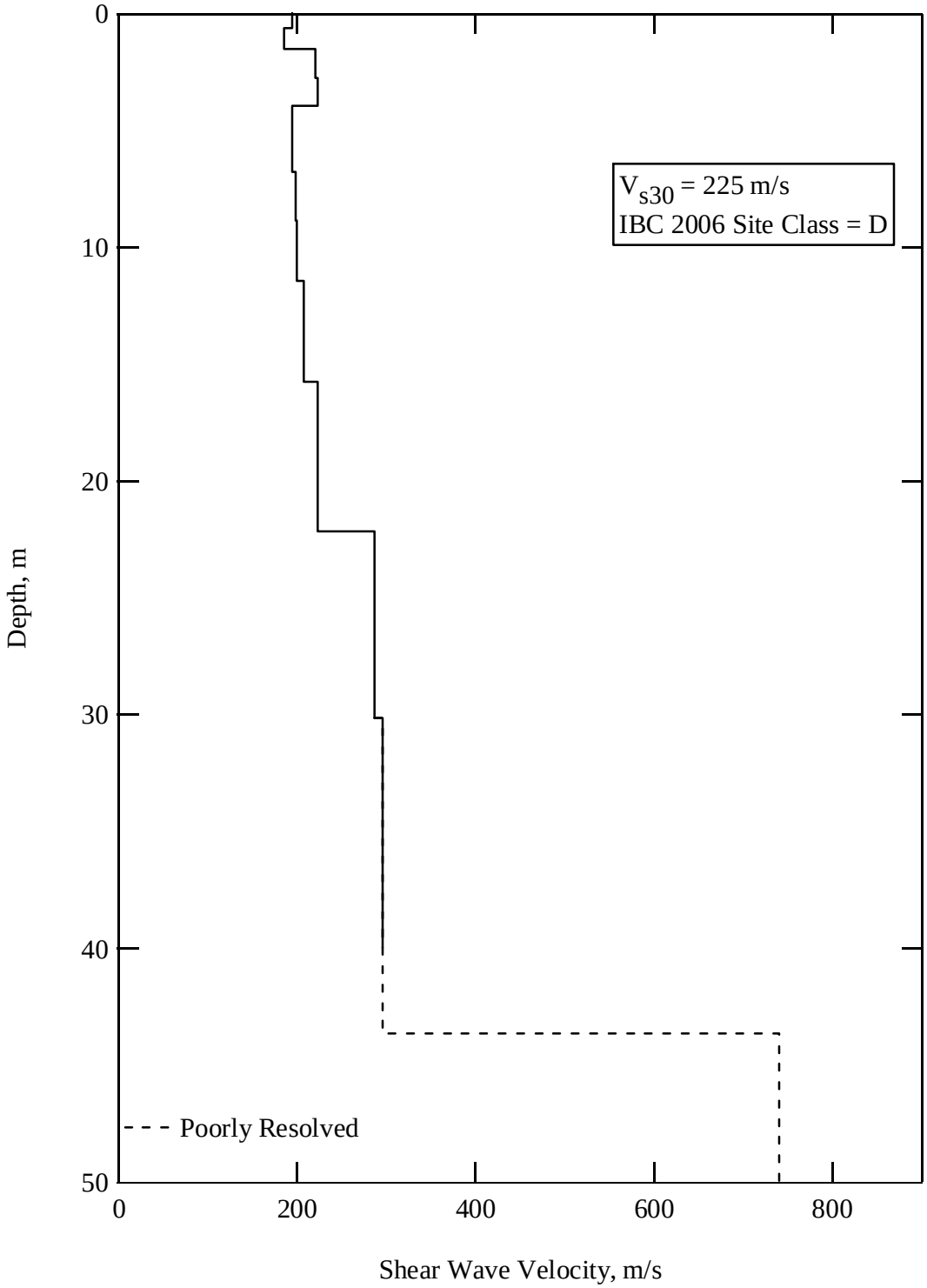

Fig. 2.72 Shear wave velocity profile determined from SASW testing at Weber State University (7212), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 225 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 40 m and poorly resolved from 40 m to 50 m.

Table 2.14 Tabulated measured and assumed layer at Weber State University (7212), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.7	195	365	0.30	1.92
0.7	0.9	186	349	0.30	1.92
1.5	1.3	222	415	0.30	1.92
2.8	1.2	223	418	0.30	1.92
3.9	2.9	195	365	0.30	1.92
6.8	2.1	199	373	0.30	1.92
8.9	2.6	201	375	0.30	1.92
11.4	4.3	208	388	0.30	1.92
15.8	6.4	223	418	0.30	1.92
22.1	8.0	287	537	0.30	1.92
30.2	9.8	296	554	0.30	1.92

2.1.15. South Ogden Junior High School

SASW testing was performed at South Ogden Junior High School, designated as SOJ in this report, located at 4300 Madison Ave., Ogden, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.18406 North and 111.96069 East, with an elevation of approximately 1401 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.73.

Testing was performed at 9:30 a.m. on August 12, 2005. The SASW array ran across the baseball playing field to the east of the school. A photograph of the site is shown in Fig. 2.74. Due to soft ground, the source location remained constant and the

centerline of the array was shifted. A fully saturated zone was not assumed. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.2 m with 15 cm of padding.

Figure 2.75 shows the experimental dispersion curve measured at South Ogden Junior High School. Figure 2.76 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.77 shows the calculated shear wave velocity profile for the site. Table 2.15 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.73 Site map showing the location of the centerline of the SASW array at South Ogden Junior High School (SOJ), Weber County, Utah (from Google Earth 2006).

Fig. 2.74 Photograph of SASW testing at South Ogden Junior High School (SOJ), Weber County, Utah.

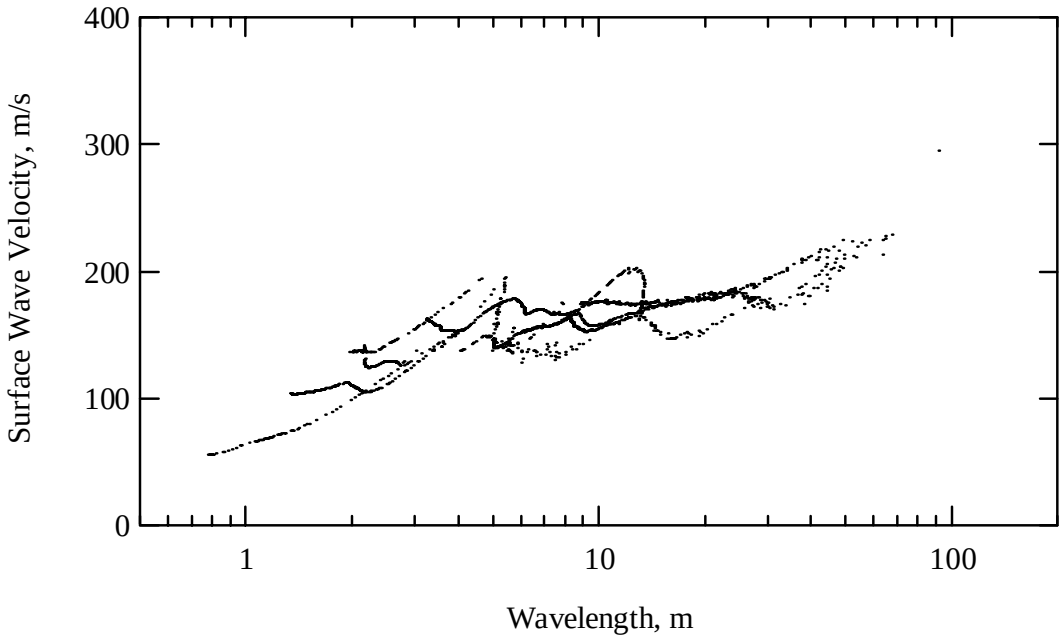

Fig. 2.75 Experimental dispersion curve measured at South Ogden Junior High School (SOJ), Weber County, Utah.

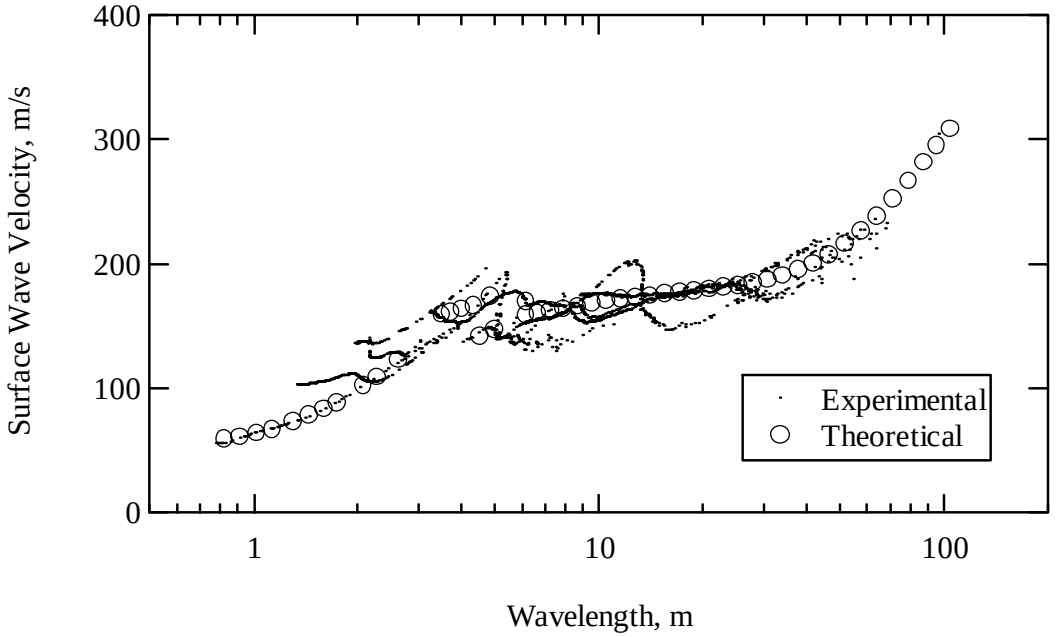

Fig. 2.76 Comparison of experimental and theoretical dispersion curves from South Ogden Junior High School (SOJ), Weber County, Utah.

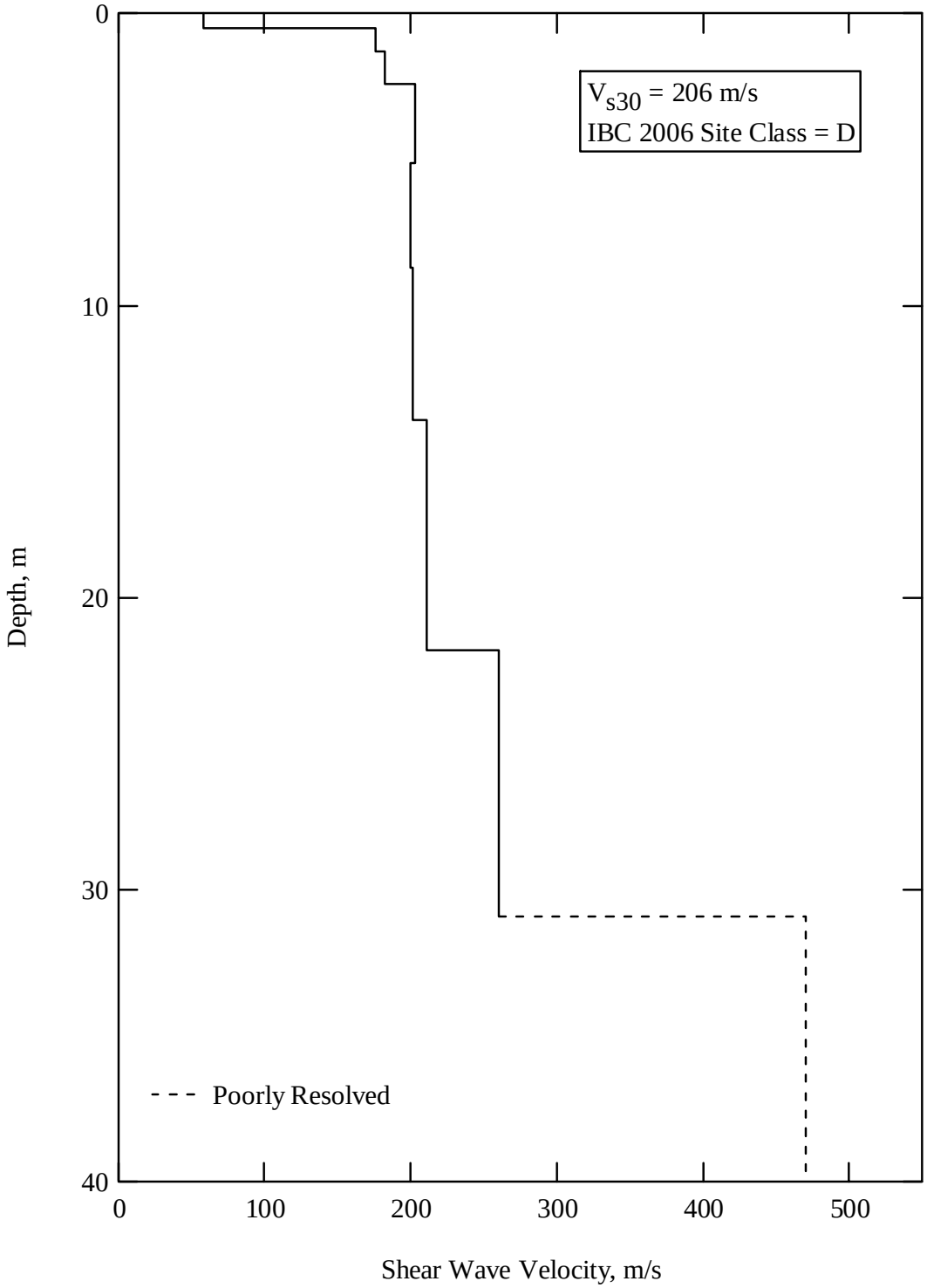

Fig. 2.77 Shear wave velocity profile determined from SASW testing at South Ogden Junior High School (SOJ), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 206 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 30.9 m and poorly resolved from 30.9 m to 40 m.

Table 2.15 Tabulated measured and assumed layer at South Ogden Junior High School (SOJ), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.5	58	109	0.3	1.92
0.5	0.8	176	329	0.3	1.92
1.3	1.1	182	341	0.3	1.92
2.4	2.7	203	380	0.3	1.92
5.1	3.6	200	374	0.3	1.92
8.7	5.2	201	376	0.3	1.92
13.9	7.9	211	395	0.3	1.92
21.8	9.1	260	486	0.3	1.92

2.1.16. Wasatch Elementary School

SASW testing was performed at Wasatch Elementary School, designated as WES in this report, located at 3370 Polk Ave., Ogden, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.20198 North and 111.94201 East, with an elevation of approximately 1412 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.78.

Testing was performed at 1:00 p.m. on August 12, 2005. The SASW array was located on a small bluff to the east of the school with a north-south orientation. A photograph of the site is shown in Fig. 2.79 where the school can be seen in the background. A fully saturated zone was not assumed at this site. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.2 m with 15 cm of padding.

Figure 2.80 shows the experimental dispersion curve measured at Wasatch Elementary School. Figure 2.81 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.82 shows the calculated shear wave velocity profile for the site. Table 2.16 contains the

tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.78 Site map showing the location of the centerline of the SASW array at Wasatch Elementary School (WES), Weber County, Utah (from Google Earth 2006).

Fig. 2.79 Photograph of SASW testing at Wasatch Elementary School (WES), Weber County, Utah.

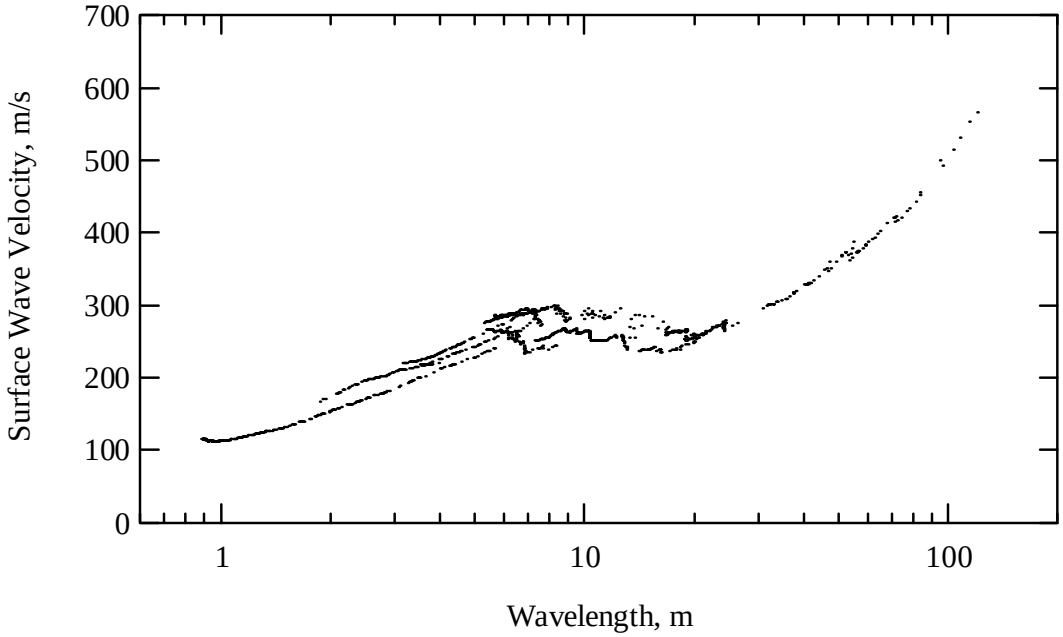

Fig. 2.80 Experimental dispersion curve measured at Wasatch Elementary School (WES), Weber County, Utah.

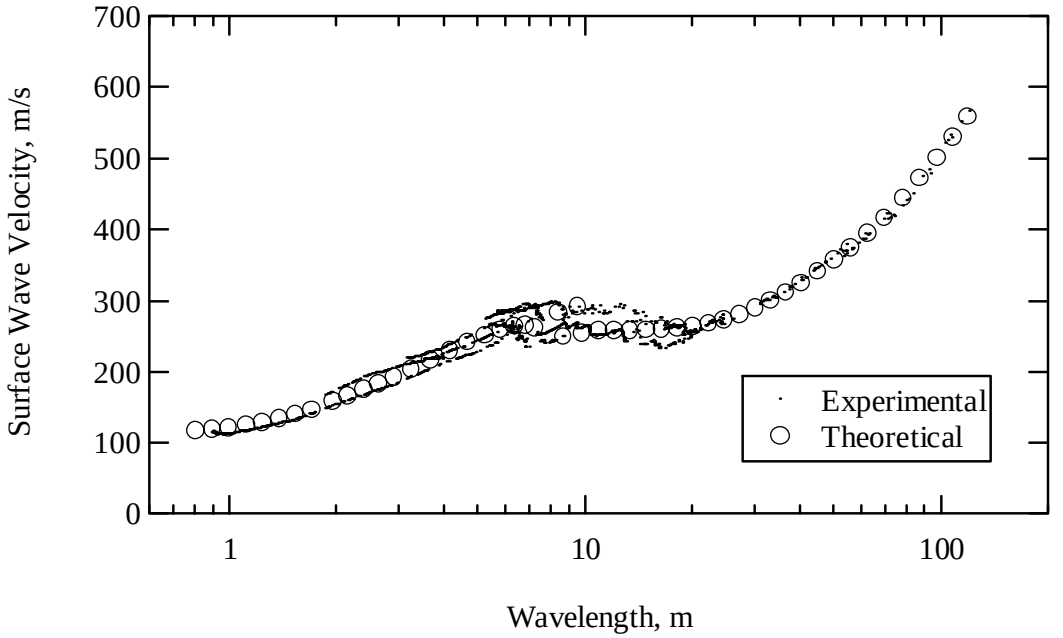

Fig. 2.81 Comparison of experimental and theoretical dispersion curves from Wasatch Elementary School (WES), Weber County, Utah.

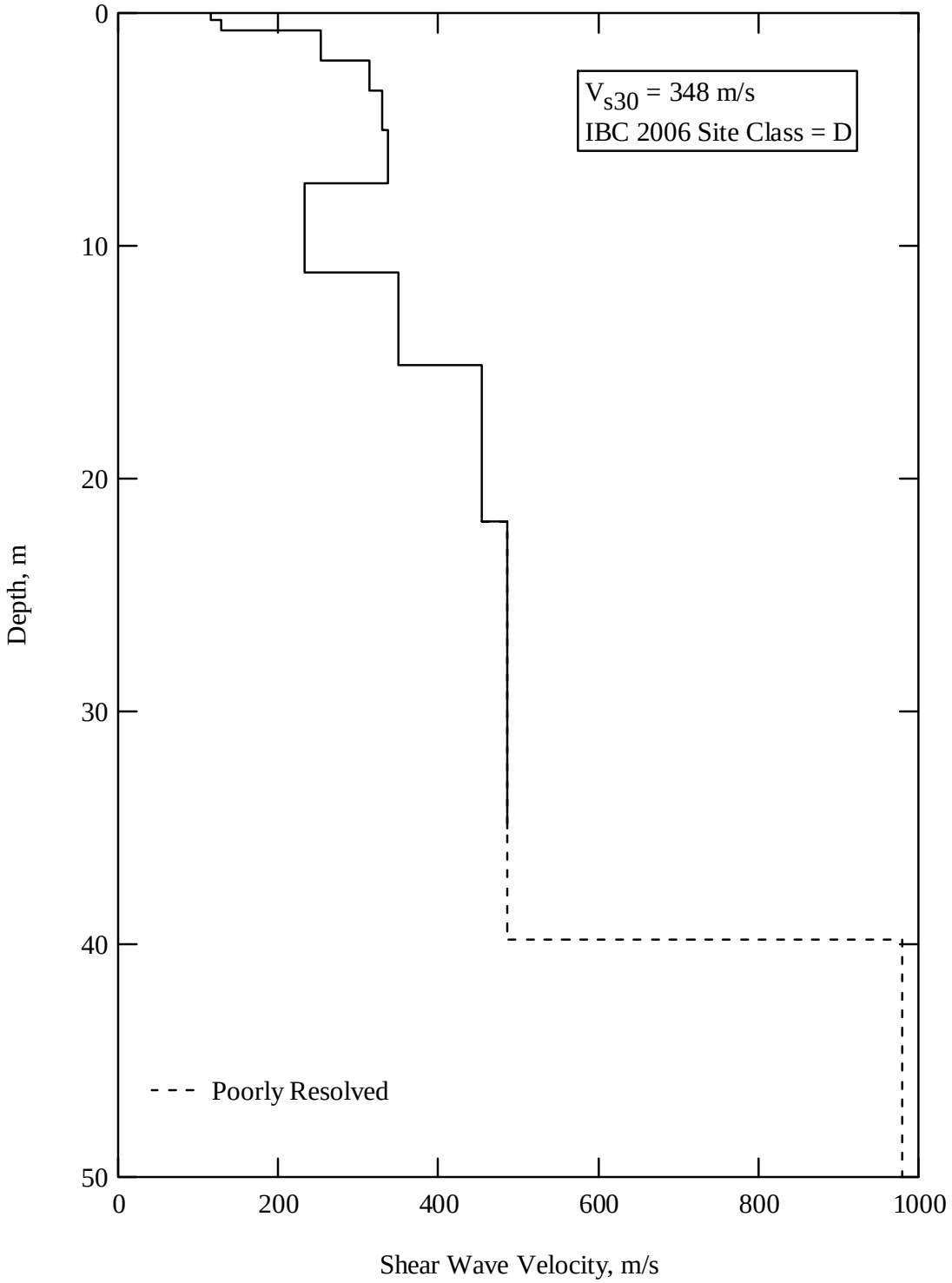

Fig. 2.82 Shear wave velocity profile determined from SASW testing at Wasatch Elementary School (WES), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 348 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 50 m.

Table 2.16 Tabulated measured and assumed layer at Wasatch Elementary School (WES), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	116	218	0.30	1.89
0.3	0.4	129	241	0.30	1.89
0.7	1.3	254	475	0.30	1.92
2.0	1.3	314	588	0.30	1.96
3.3	1.7	330	616	0.30	1.96
5.0	2.3	337	631	0.30	1.96
7.3	3.8	233	436	0.30	1.92
11.1	4.0	351	657	0.30	1.96
15.1	6.7	455	851	0.30	1.96
21.8	8.2	486	909	0.30	1.96

2.1.17. Highland Middle School

SASW testing was performed at Highland Middle School, designated as HMS in this report, located at 325 Gramercy Ave., Ogden, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.25496 North and 111.95897 East, with an elevation of approximately 1335 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.83.

Testing was performed at 8:00 a.m. on August 24, 2005. The SASW array was located to the south of the school in an east-west orientation along the fence line. A photograph of the site is shown in Fig. 2.84. A fully saturated zone was not assumed at this site. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.3 m with 19 cm of padding.

Figure 2.85 shows the experimental dispersion curve measured at Highland Middle School. Figure 2.86 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.87 shows the calculated shear wave velocity profile for the site. Table 2.17 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.83 Site map showing the location of the centerline of the SASW array at Highland Middle School (HMS), Weber County, Utah (from Google Earth 2006)

Fig. 2.84 Photograph of SASW testing at Highland Middle School (HMS), Weber County, Utah.

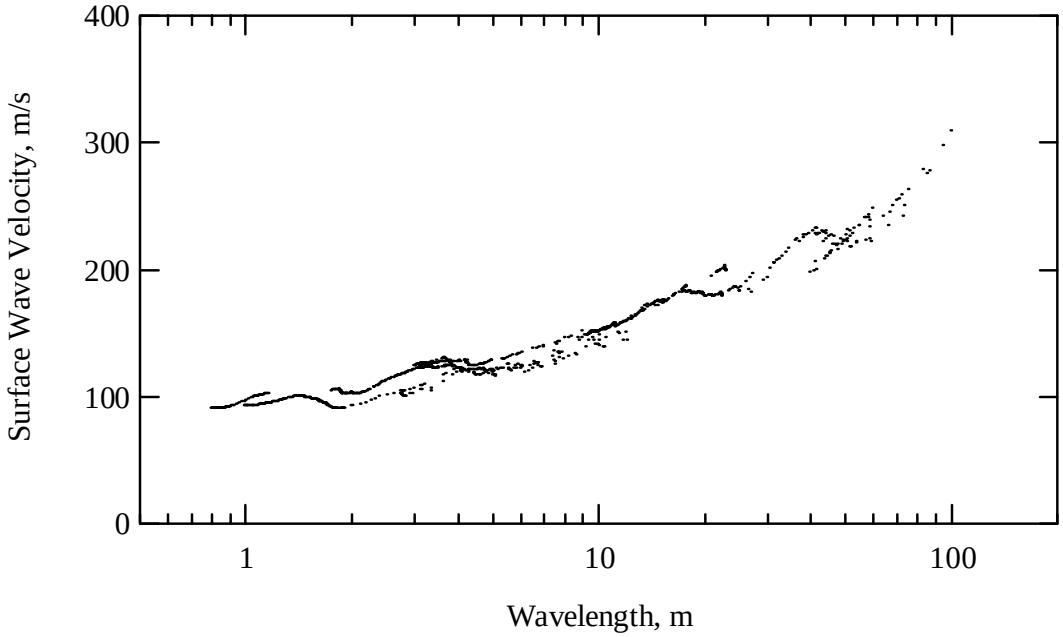

Fig. 2.85 Experimental dispersion curve measured at Highland Middle School (HMS), Weber County, Utah.

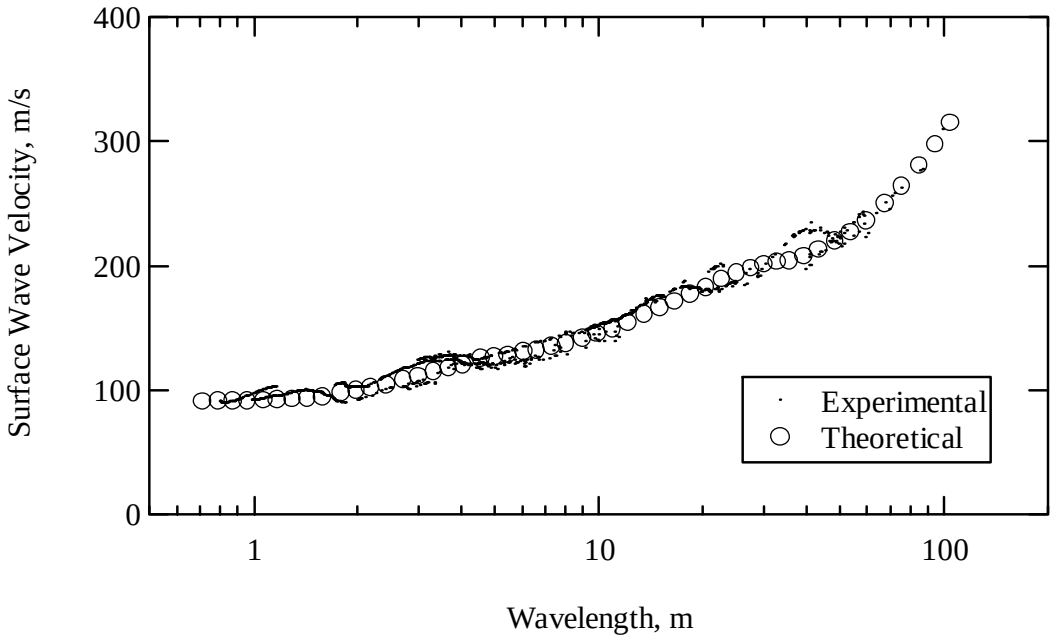

Fig. 2.86 Comparison of experimental and theoretical dispersion curves from Highland Middle School (HMS), Weber County, Utah.

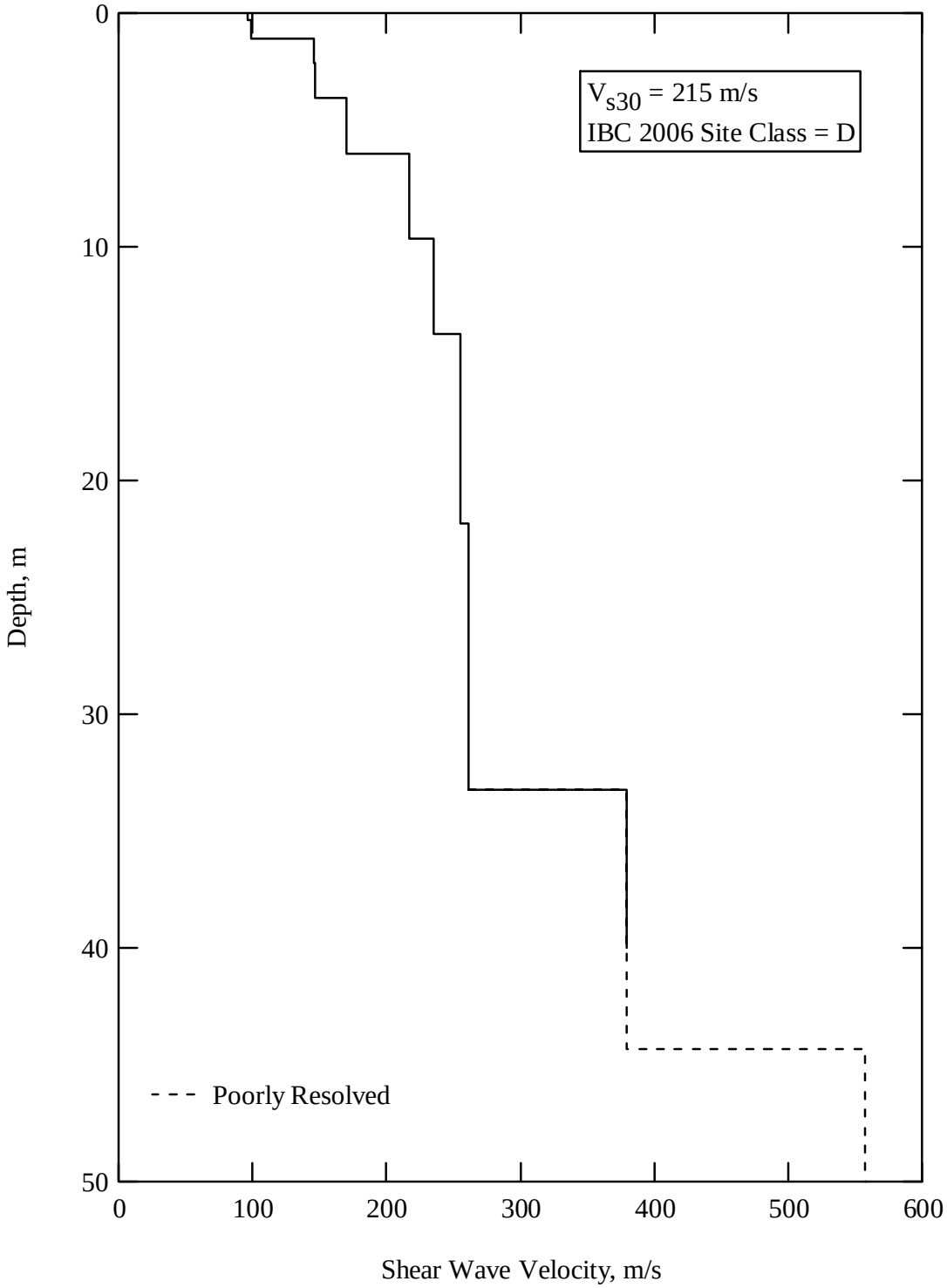

Fig. 2.87 Shear wave velocity profile determined from SASW testing at Highland Middle School (HMS), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 215 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 40 m and poorly resolved from 40 m to 50 m.

Table 2.17 Tabulated measured and assumed layer at Highland Middle School (HMS), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	96	180	0.3	1.89
0.3	0.8	99	185	0.3	1.89
1.1	1.0	146	273	0.3	1.89
2.1	1.5	147	275	0.3	1.89
3.6	2.4	170	318	0.3	1.92
6.0	3.6	217	406	0.3	1.92
9.6	4.1	235	440	0.3	1.92
13.7	8.1	255	477	0.3	1.92
21.8	11.4	261	488	0.3	1.92
33.2	6.8	379	709	0.3	1.96

2.1.18. Lomond View Park

SASW testing was performed at Lomond View Park, designated as LVP in this report, located at 3000 N. Elberta Dr., North Ogden, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.31706 North and 111.97437 East, with an elevation of approximately 1356 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.88.

Testing was performed at 10:30 a.m. on September 24, 2005. The SASW array was located on a baseball playing field below the bluff. The source remained constant so as to accommodate a baseball game. A photograph of the site is shown in Fig. 2.89. A fully saturated zone was not assumed at this site. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.6 m with no padding.

Figure 2.90 shows the experimental dispersion curve measured at Lomond View Park. Figure 2.91 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.92 shows the calculated shear wave velocity profile for the site. Table 2.18 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.88 Site map showing the location of the centerline of the SASW array at Lomond View Park (LVP), Weber County, Utah (from Google Earth 2006).

Fig. 2.89 Photograph of SASW testing at Lomond View Park (LVP), Weber County, Utah.

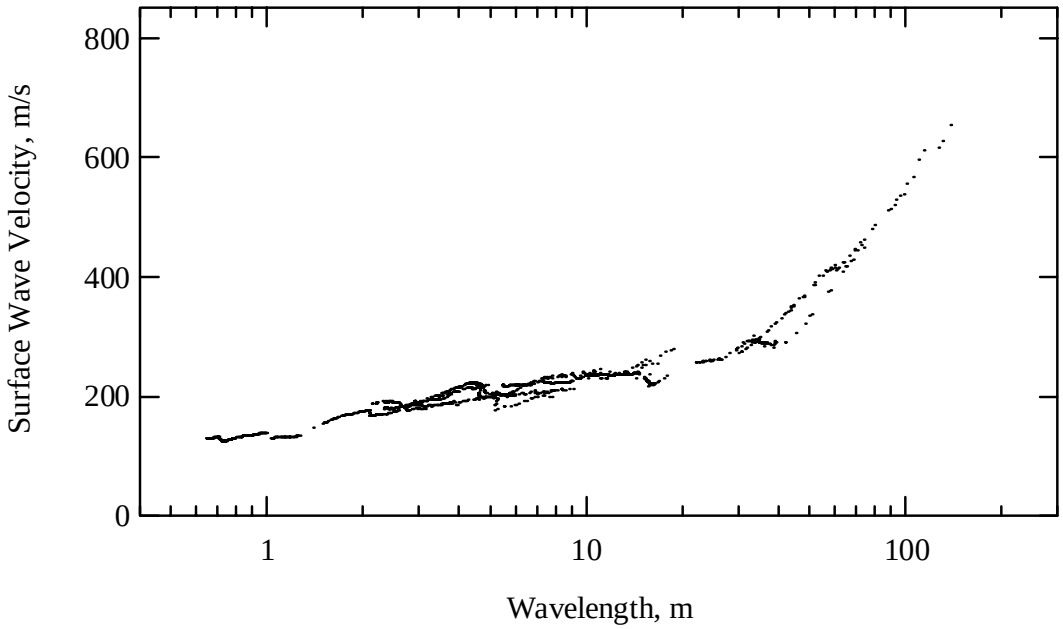

Fig. 2.90 Experimental dispersion curve measured at Lomond View Park (LVP), Weber County, Utah.

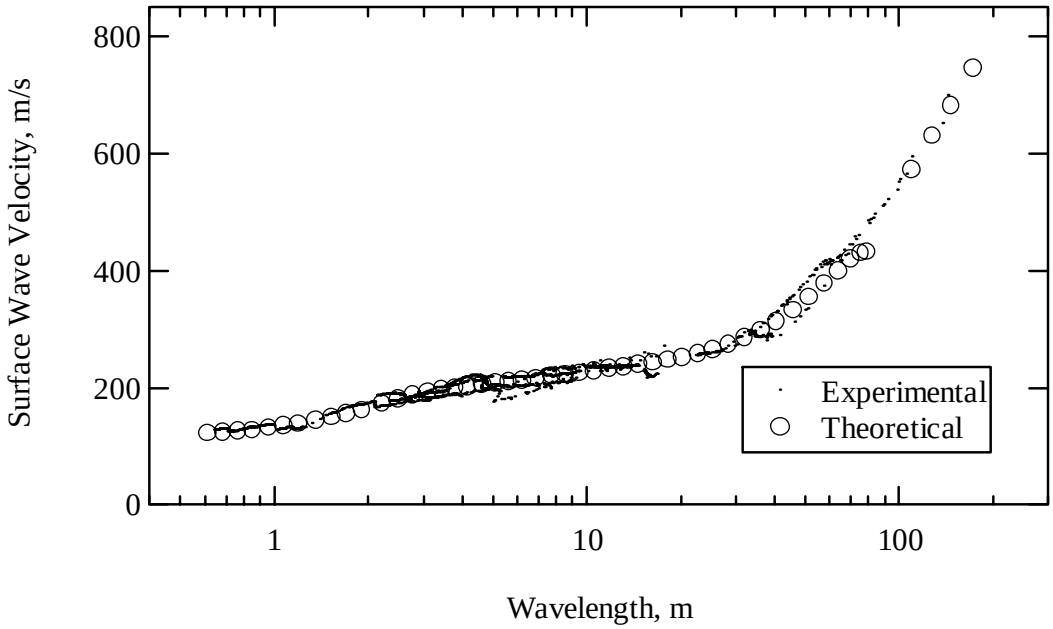

Fig. 2.91 Comparison of experimental and theoretical dispersion curves from Lomond View Park (LVP), Weber County, Utah.

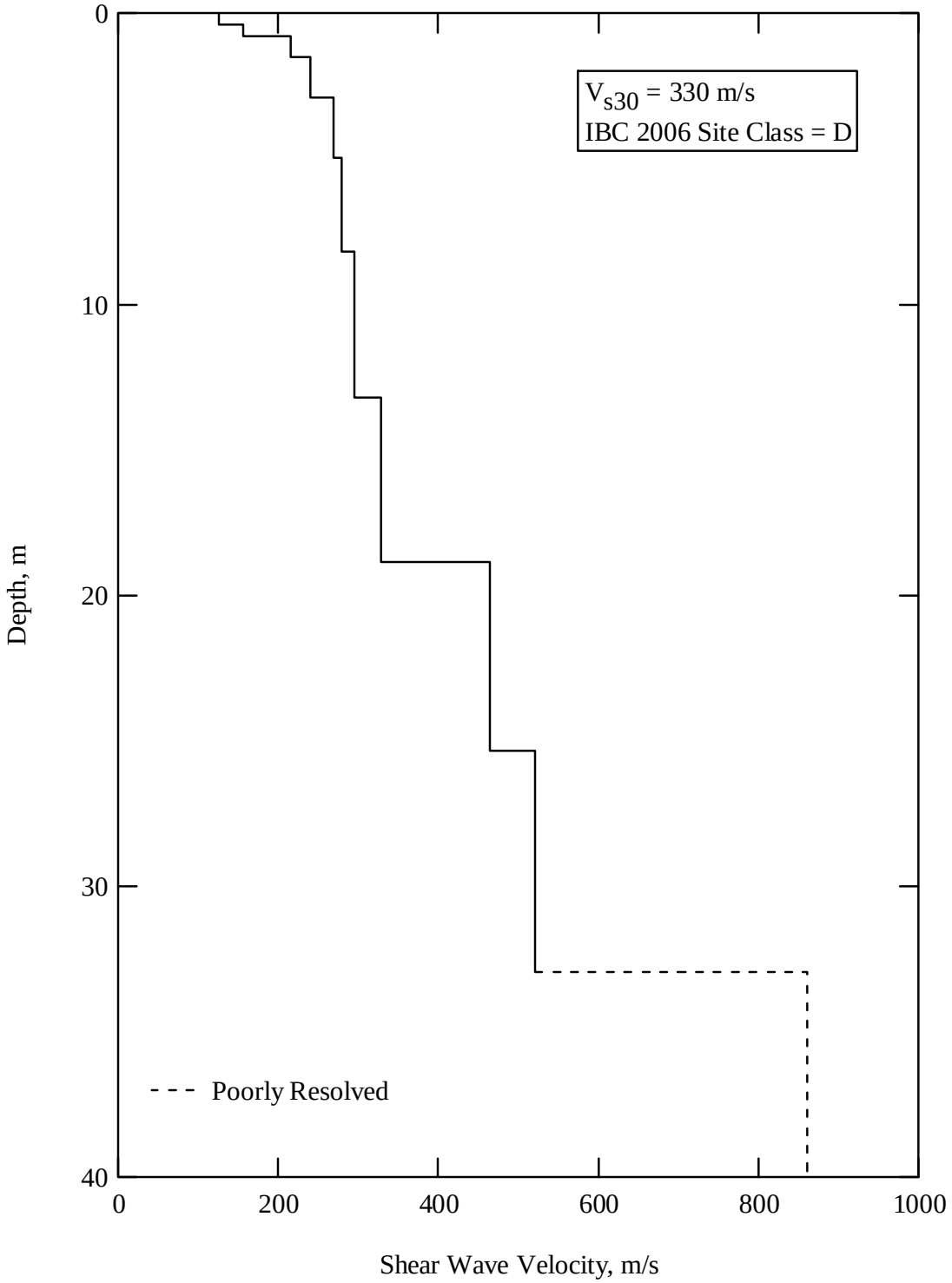

Fig. 2.92 Shear wave velocity profile determined from SASW testing at Lomond View Park (LVP), Weber County, Utah.

The average shear wave velocity in the upper 30 m of soil is 330 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 32.9 m and poorly resolved from 32.9 m to 50 m.

Table 2.18 Tabulated measured and assumed layer at Lomond View Park (LVP), Weber County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	126	236	0.30	1.89
0.4	0.4	157	294	0.30	1.89
0.8	0.7	216	404	0.30	1.92
1.5	1.4	240	449	0.30	1.92
2.9	2.1	269	503	0.30	1.92
5.0	3.2	279	522	0.30	1.92
8.2	5.0	295	552	0.30	1.92
13.2	5.7	329	616	0.30	1.96
18.8	6.5	464	868	0.30	1.96
25.3	7.6	521	975	0.30	2.00

2.2. DAVIS COUNTY

Davis County is bounded on the east by the Wasatch Mountains and on the west by the Great Salt Lake. The area will be referred to as Davis County in this report but perhaps it would better be described as Central and Southern Davis County as the northern most city considered is Kaysville. The southern boundary is near where Interstate 15 meets Interstate 215 in North Salt Lake, Utah. This narrow strip of land is less than 3.5 kilom wide at the narrowest point (Bay et al. 2005).

The geologic origins of Davis County consist of a narrow band of lacustrine deposits of Late Pleistocene Lake Bonneville. The deposit consists of relatively fine grained sediments in the west and a gravel dominated shoreline along the base of the

Wasatch Mountains that is locally overlain by the latest Pleistocene to Holocene alluvium and alluvial fan deposits (Bay et al. 2005). Local landslides and earthquake induced lateral spreading have also worked to shape the area, including the supposed largest lateral spread in the world, called the Farmington Siding Landslide (Hylland et al. 1997).

Figure 2.93 shows the site condition map from Ashland and McDonald (2003) and Ashland et al. (2005). The figure also shows the spatial distribution of new V_{S30} sites and the locations of existing V_{S30} sites. During this study, 9 new sites were tested, tripling the existing database. The distribution of the sites in the different Quaternary units is as follows: (Q01) 4 new sites were tested, there were 3 existing sites in the unit. (Q02) 3 new sites were tested, there were 2 existing sites in the unit. (Q03) 2 new sites were tested, there was 1 existing site in the unit.

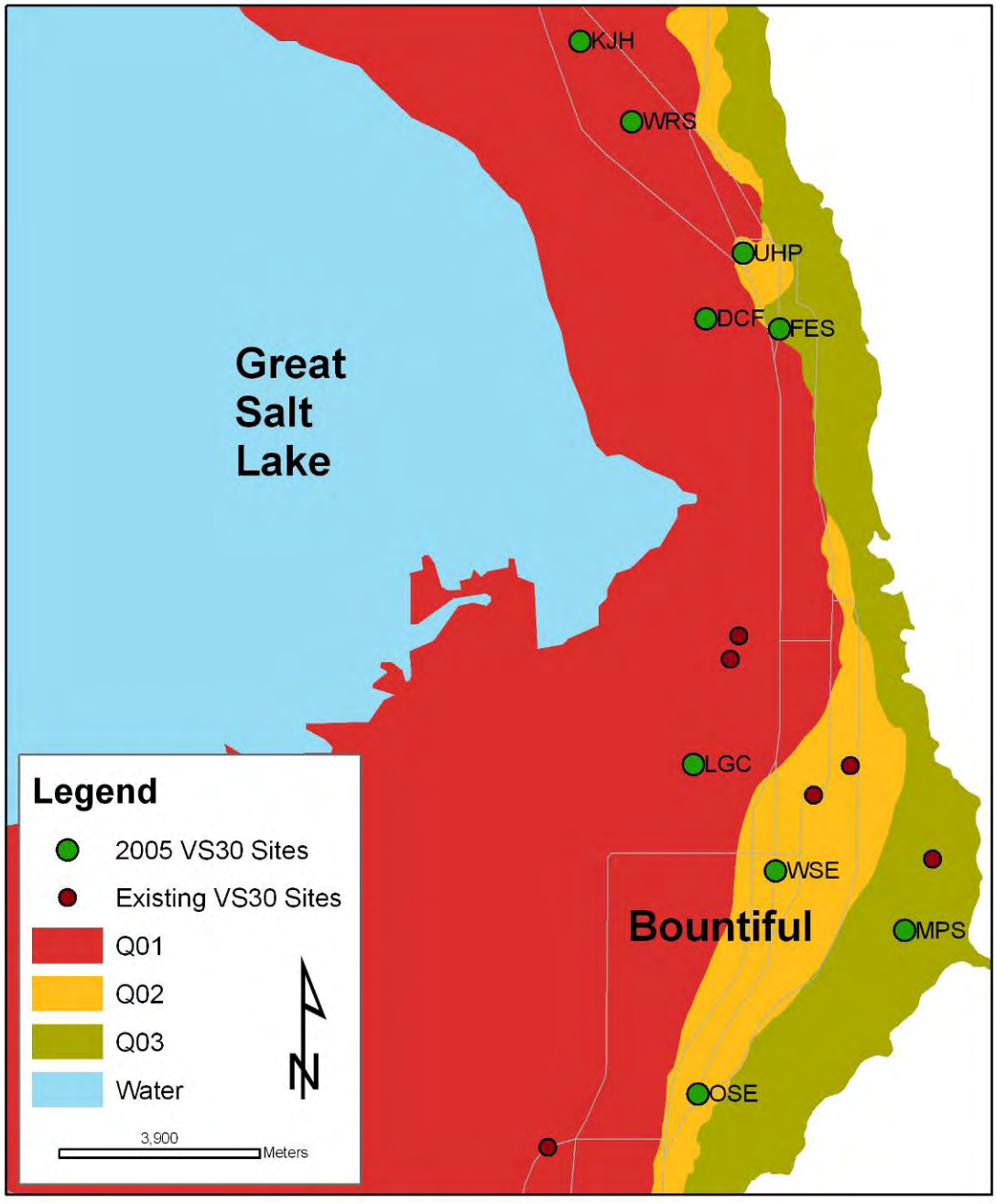

Fig. 2.93 Map showing spatial distribution of V_{S30} sites in Davis County, Utah.

2.2.1. Lakeside Golf Course

SASW testing was performed at the Lakeside Golf Course, designated as LGC in this report, located at 1200 N. Howard St., Bountiful, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.90091 North and 111.9092 East, with an elevation of approximately 1291 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.94. The site was of particular interest because a strong motion sensor monitored by the University of Utah Seismograph Stations is located adjacent to the SASW array.

Testing was performed at 10:30 a.m. on August 10, 2005. The SASW array was located on a bad weather cart path along the north side of the golf Course outbuildings; the array was oriented in the east-west direction. A photograph of the site is shown in Fig. 2.95. The strong motion sensor is located in the golf course storage shed on the other side of the trees seen in Fig. 2.95. A fully saturated zone was assumed to exist at a depth of 5 m below the ground surface. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.25 m with no padding.

Figure 2.96 shows the experimental dispersion curve measured at the Lakeside Golf Course. Figure 2.97 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.98 shows the calculated shear wave velocity profile for the site. Table 2.19 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

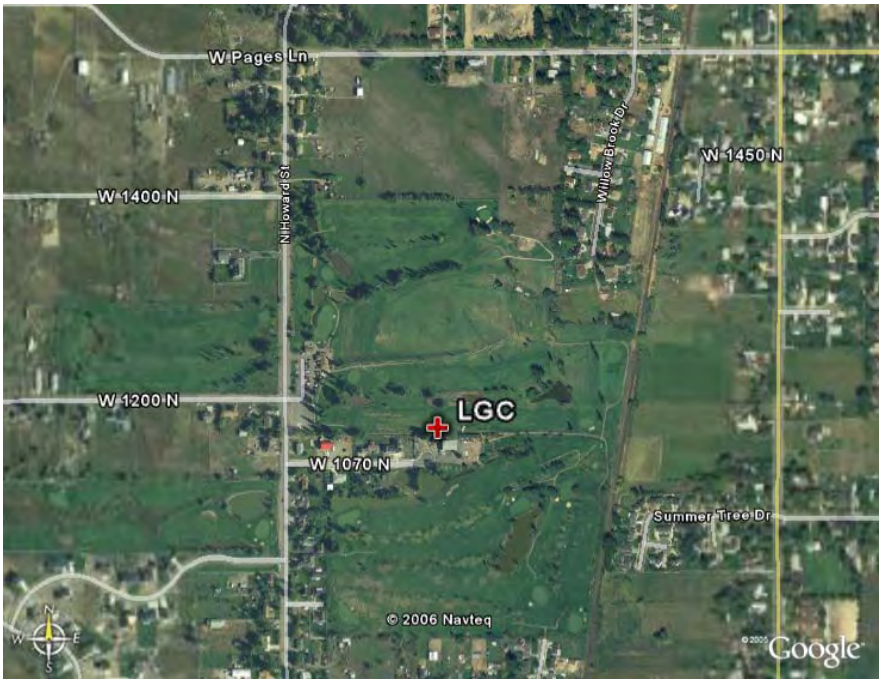

Fig. 2.94 Site map showing the location of the centerline of the SASW array at the Lakeside Golf Course (LGC), Davis County, Utah (from Google Earth 2006).

Fig. 2.95 Photograph of SASW testing at the Lakeside Golf Course (LGC), Davis County, Utah.

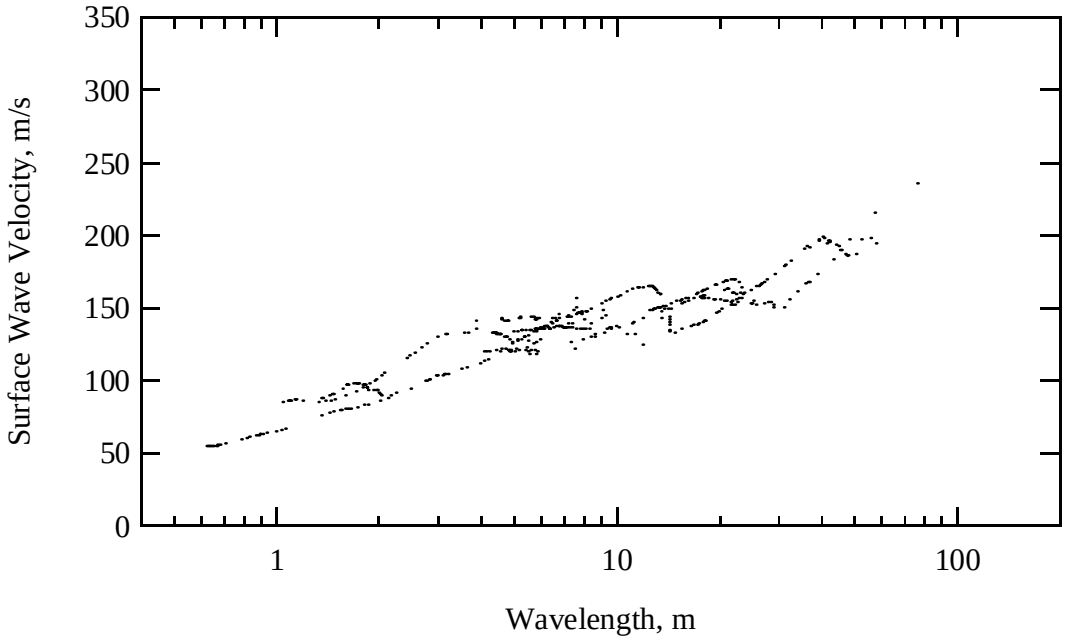

Fig. 2.96 Experimental dispersion curve measured at the Lakeside Golf Course (LGC), Davis County, Utah.

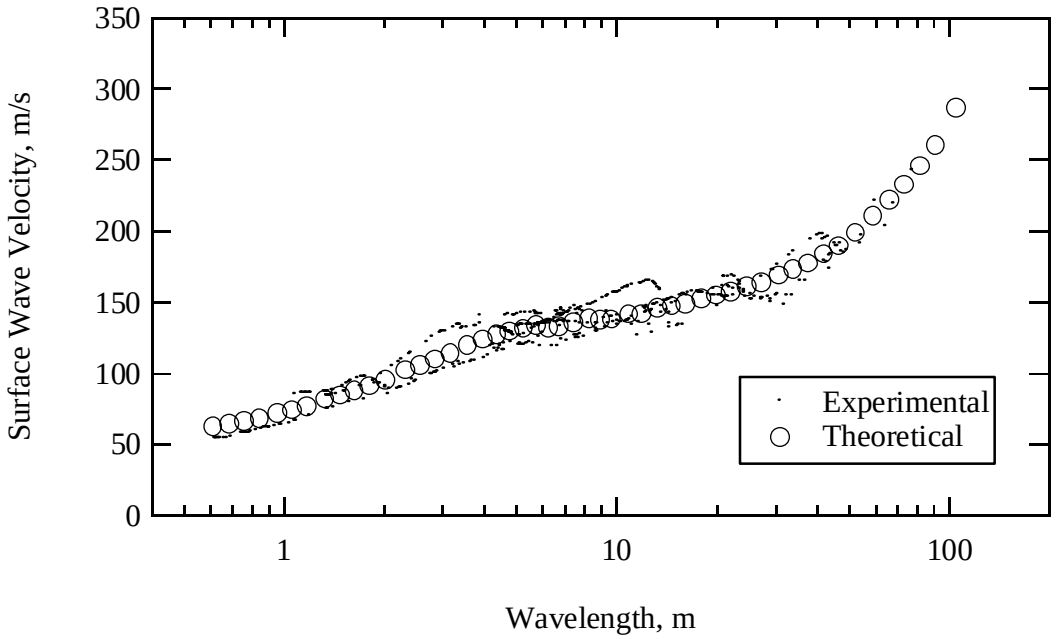

Fig. 2.97 Comparison of experimental and theoretical dispersion curves from the Lakeside Golf Course (LGC), Davis County, Utah.

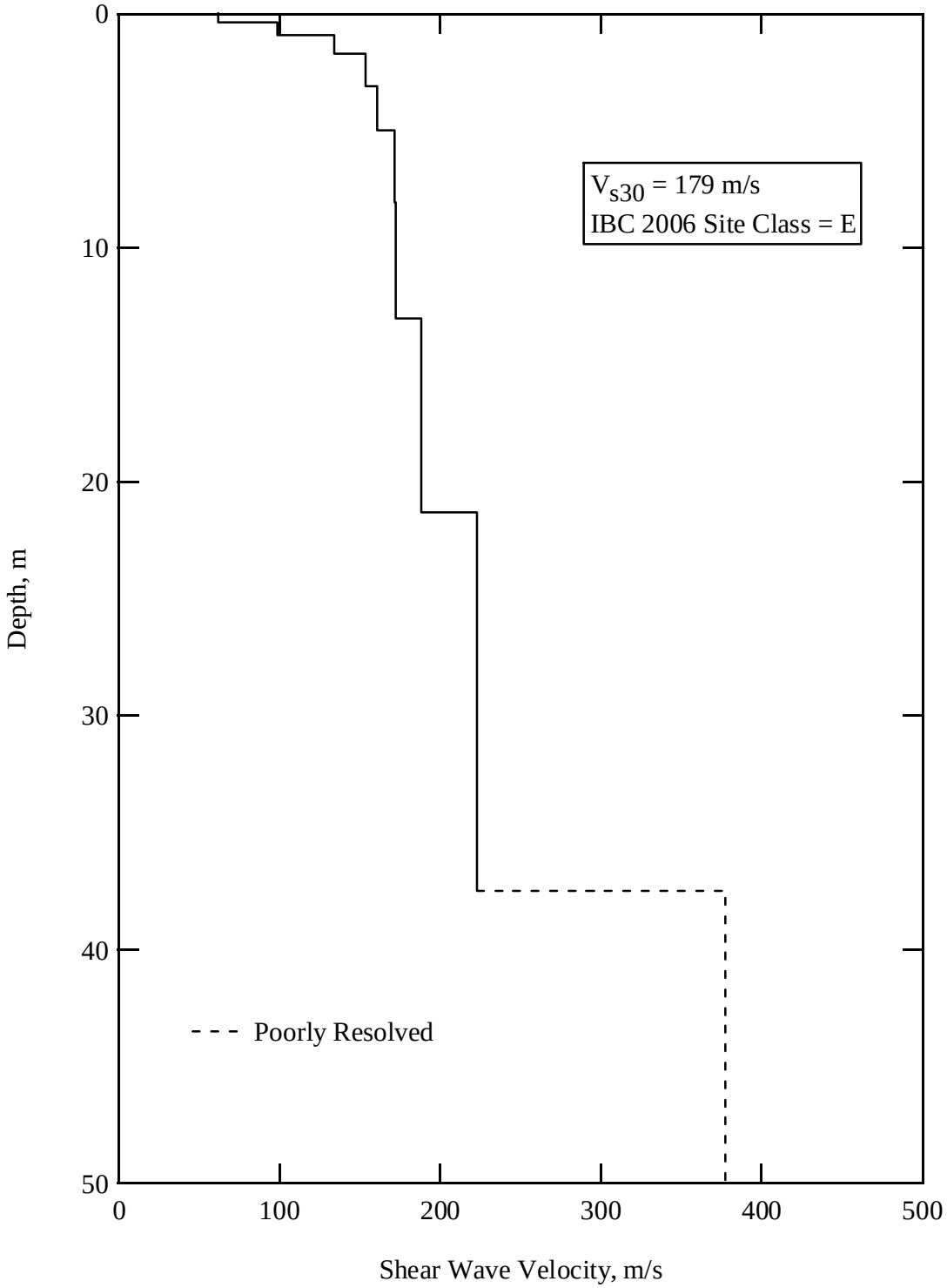

Fig. 2.98 Shear wave velocity profile determined from SASW at the Lakeside Golf Course (LGC), Davis County, Utah.

The average shear wave velocity in the upper 30 m of soil is 179 m/s, which corresponds to an IBC 2006 site class E. The average shear wave velocity is within 1 m/s of site class D. The shear wave velocity profile is well resolved to a depth of 37.5 m and poorly resolved from 37.5 m to 50 m.

Table 2.19 Tabulated measured and assumed layer properties at the Lakeside Golf Course (LGC), Davis County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	63	117	0.3	1.89
0.4	0.6	99	186	0.3	1.89
0.9	0.8	134	251	0.3	1.89
1.7	1.4	154	288	0.3	1.89
3.1	1.9	161	301	0.3	1.89
5.0	3.1	172	1500	0.49	1.90
8.1	5.0	173	1500	0.49	1.90
13.0	8.3	189	1500	0.49	1.90
21.3	16.2	223	1500	0.49	1.92

2.2.2. Davis County Fairgrounds

SASW testing was performed at the Davis County Fairgrounds, designated as DCF in this report, located at 175 S. 1100 W., Farmington, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.97893 North and 111.90742 East, with an elevation of approximately 1294 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.99.

Testing was performed at 8:00 a.m. on August 11, 2005. The SASW array was located along the inside rail of the horse track at the fairgrounds. A photograph of the site is shown in Fig. 2.100. A fully saturated zone was assumed to exist at a depth of 2.5 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.5 m with no padding.

Figure 2.101 shows the experimental dispersion curve measured at the Davis County Fairgrounds. There is significant scatter due to heavy construction in the area at

the time of testing. Figure 2.102 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.103 shows the calculated shear wave velocity profile for the site. Table 2.20 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.99 Site map showing the location of the centerline of the SASW array at the Davis County Fairgrounds (DCF), Davis County, Utah (from Google Earth 2006).

Fig. 2.100 Photograph of SASW testing at the Davis County Fairgrounds (DCF), Davis County, Utah.

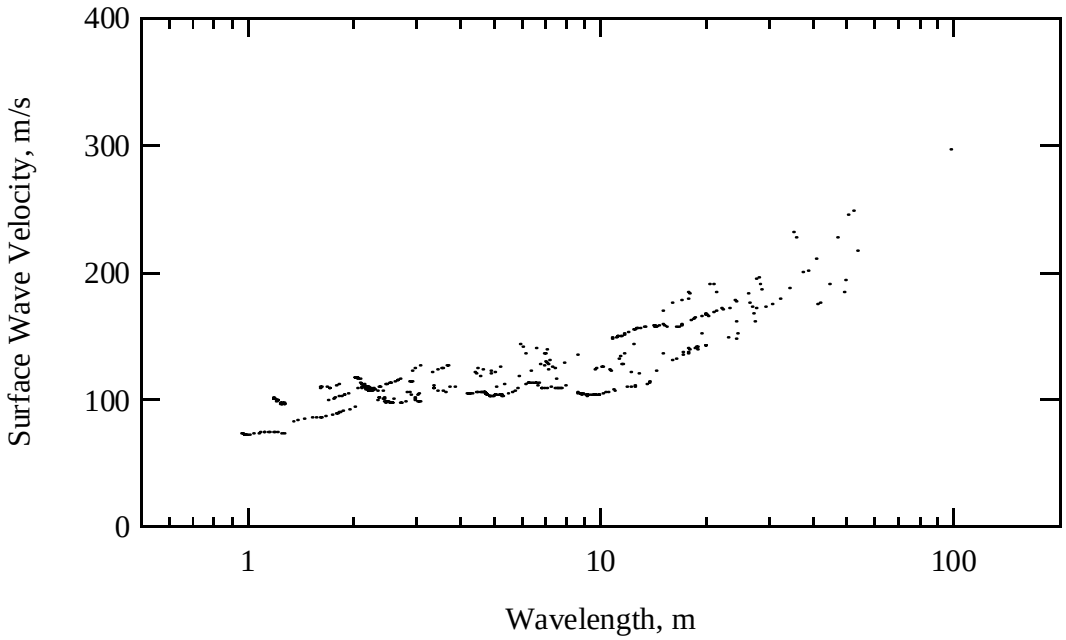

Fig. 2.101 Experimental dispersion curve measured at the Davis County Fairgrounds (DCF), Davis County, Utah.

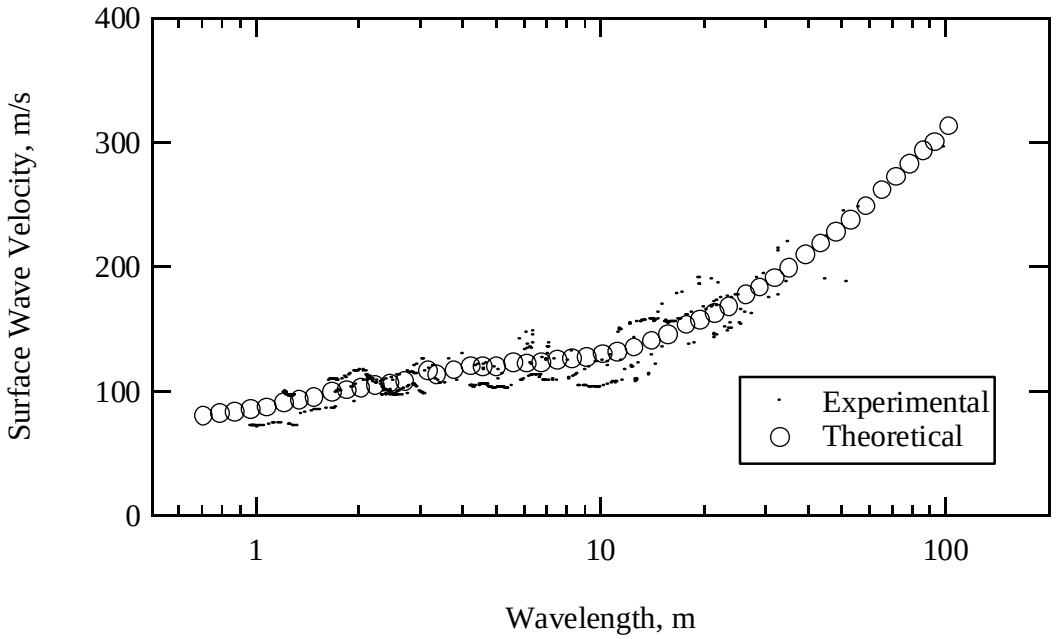

Fig. 2.102 Comparison of experimental and theoretical dispersion curves from the Davis County Fairgrounds (DCF), Davis County, Utah.

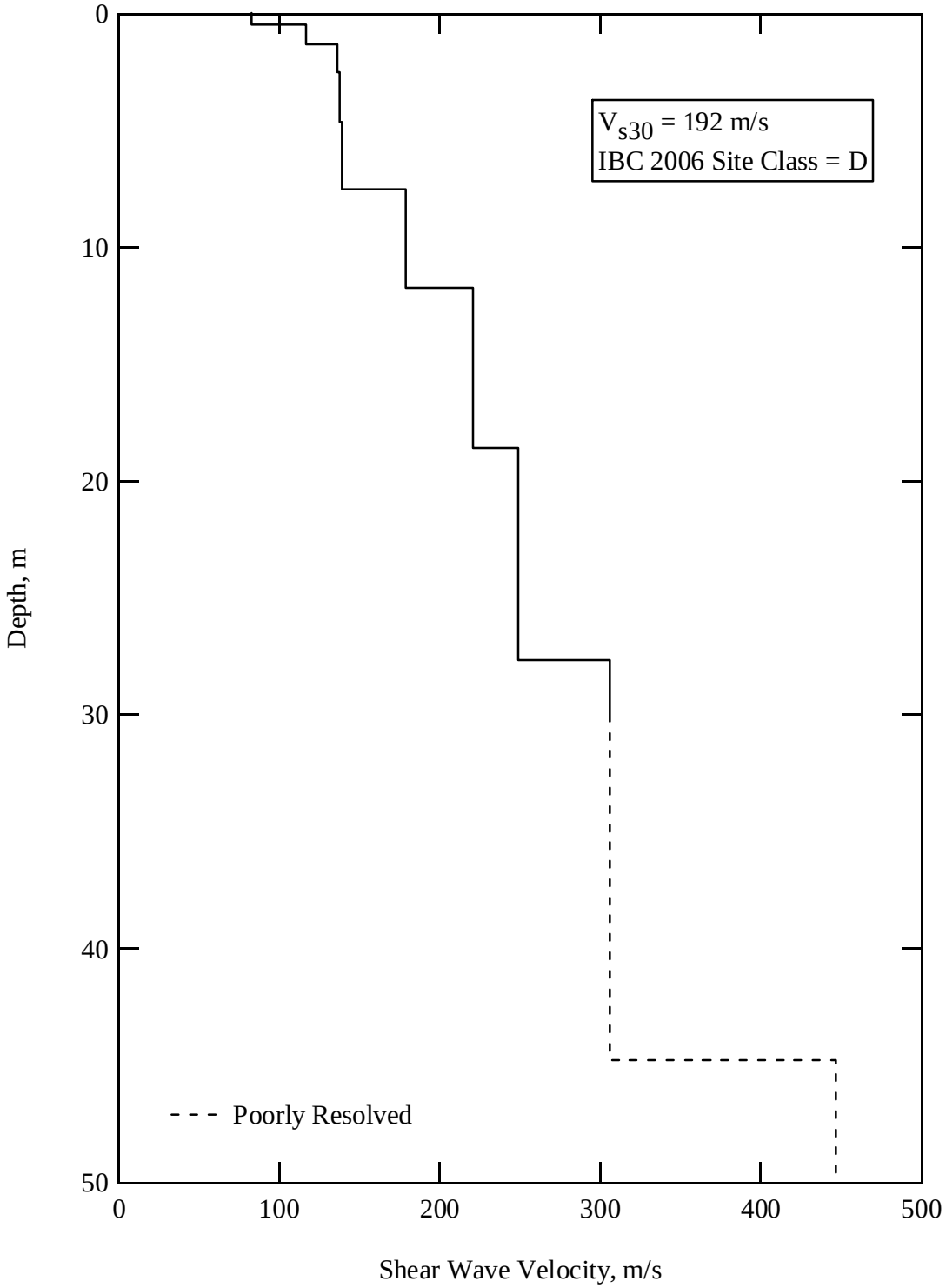

Fig. 2.103 Shear wave velocity profile determined from SASW at the Davis County Fairgrounds (DCF), Davis County, Utah.

The average shear wave velocity in the upper 30 m of soil is 192 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 30 m and poorly resolved from 30 m to 50 m.

Table 2.20 Tabulated measured and assumed layer properties at the Davis County Fairgrounds (DCF), Davis County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.5	83	156	0.3	1.89
0.5	0.8	117	219	0.3	1.89
1.3	1.2	137	256	0.3	1.89
2.5	2.1	138	1500	0.49	1.89
4.6	2.9	139	1500	0.49	1.90
7.5	4.2	179	1500	0.49	1.90
11.7	6.9	221	1500	0.49	1.90
18.6	9.1	249	1500	0.49	2.00
27.7	2.3	306	1500	0.48	2.00

2.2.3. Kaysville Junior High School

SASW testing was performed at Kaysville Junior High School, designated as KJH in this report, located at 100 E. 350 S., Kaysville, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.02726 North and 111.93713 East, with an elevation of approximately 1330 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.104.

Testing was performed at 3:00 p.m. on August 11, 2005. The SASW array was located on the west side of the school running in a parallel direction with the structure. A photograph of the site is shown in Fig. 2.105. A fully saturated zone was assumed to exist at a depth of 2.6 m below the ground surface. Maximum drop heights of the 2.04 x 10^3 kg drop weight 0.2 m with 15 cm of padding.

Figure 2.106 shows the experimental dispersion curve measured at Kaysville Junior High School. Figure 2.107 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure

2.108 shows the calculated shear wave velocity profile for the site. Table 2.21 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

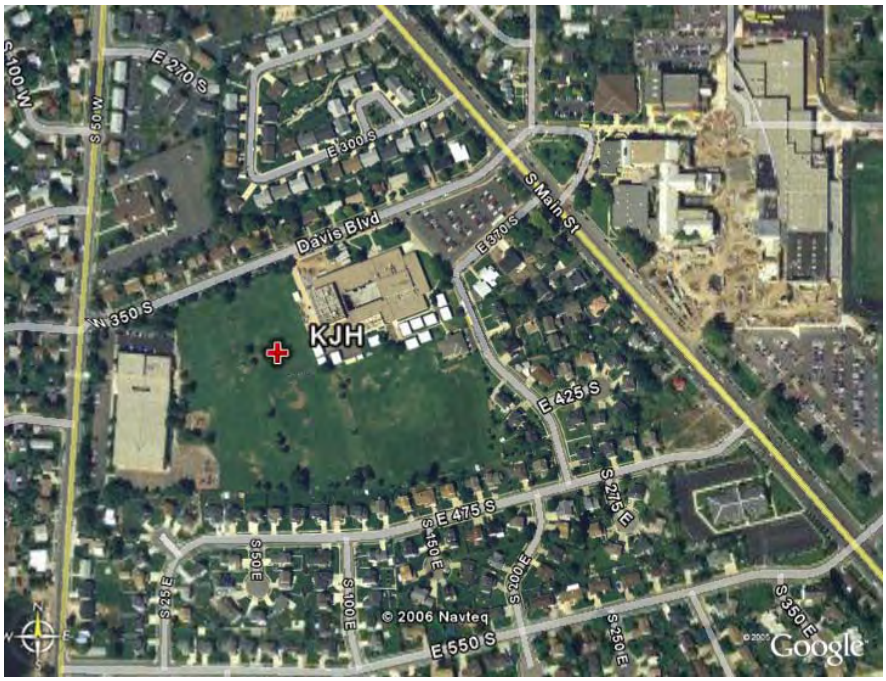

Fig. 2.104 Site map showing the location of the centerline of the SASW array at Kaysville Junior High (KJH), Davis County, Utah (from Google Earth 2006).

Fig. 2.105 Photograph of SASW testing at Kaysville Junior High (KJH), Davis County, Utah.

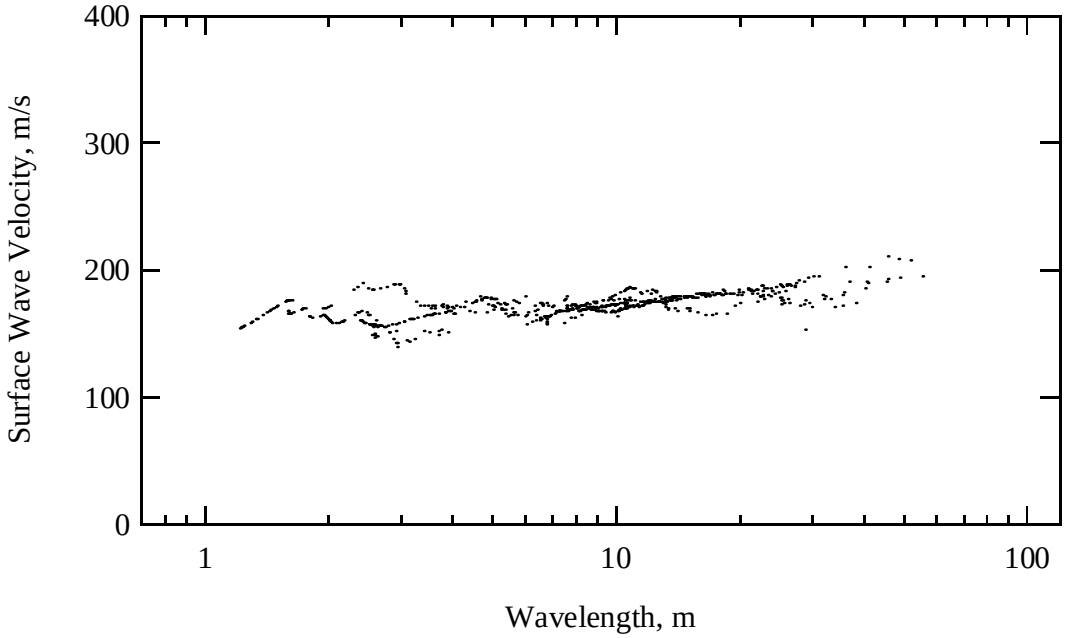

Fig. 2.106 Experimental dispersion curve measured at Kaysville Junior High (KJH), Davis County, Utah.

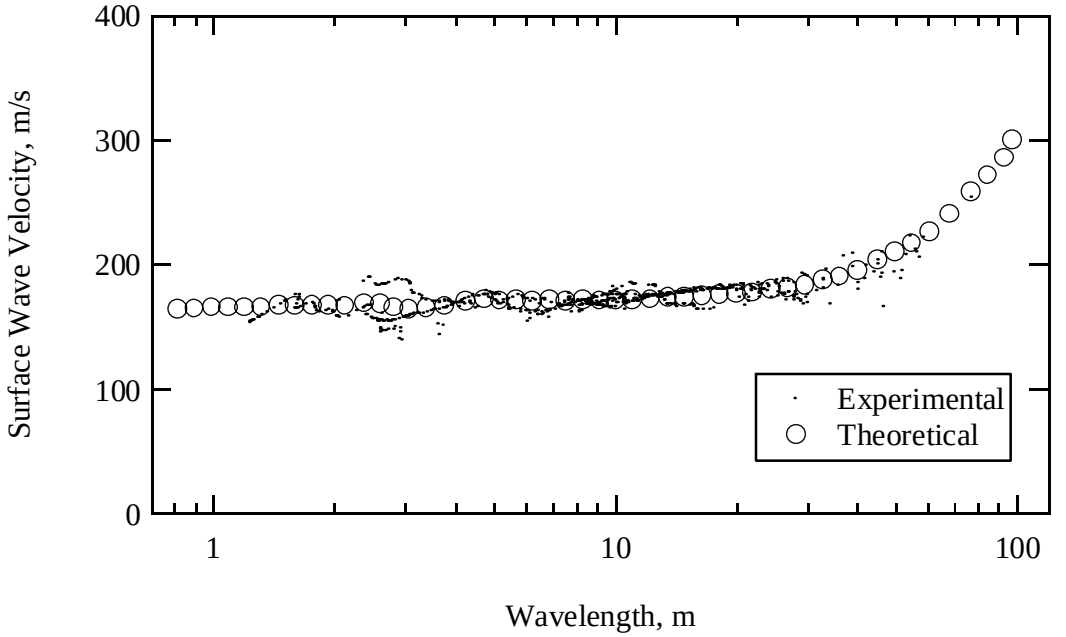

Fig. 2.107 Comparison of experimental and theoretical dispersion curves from Kaysville Junior High (KJH), Davis County, Utah.

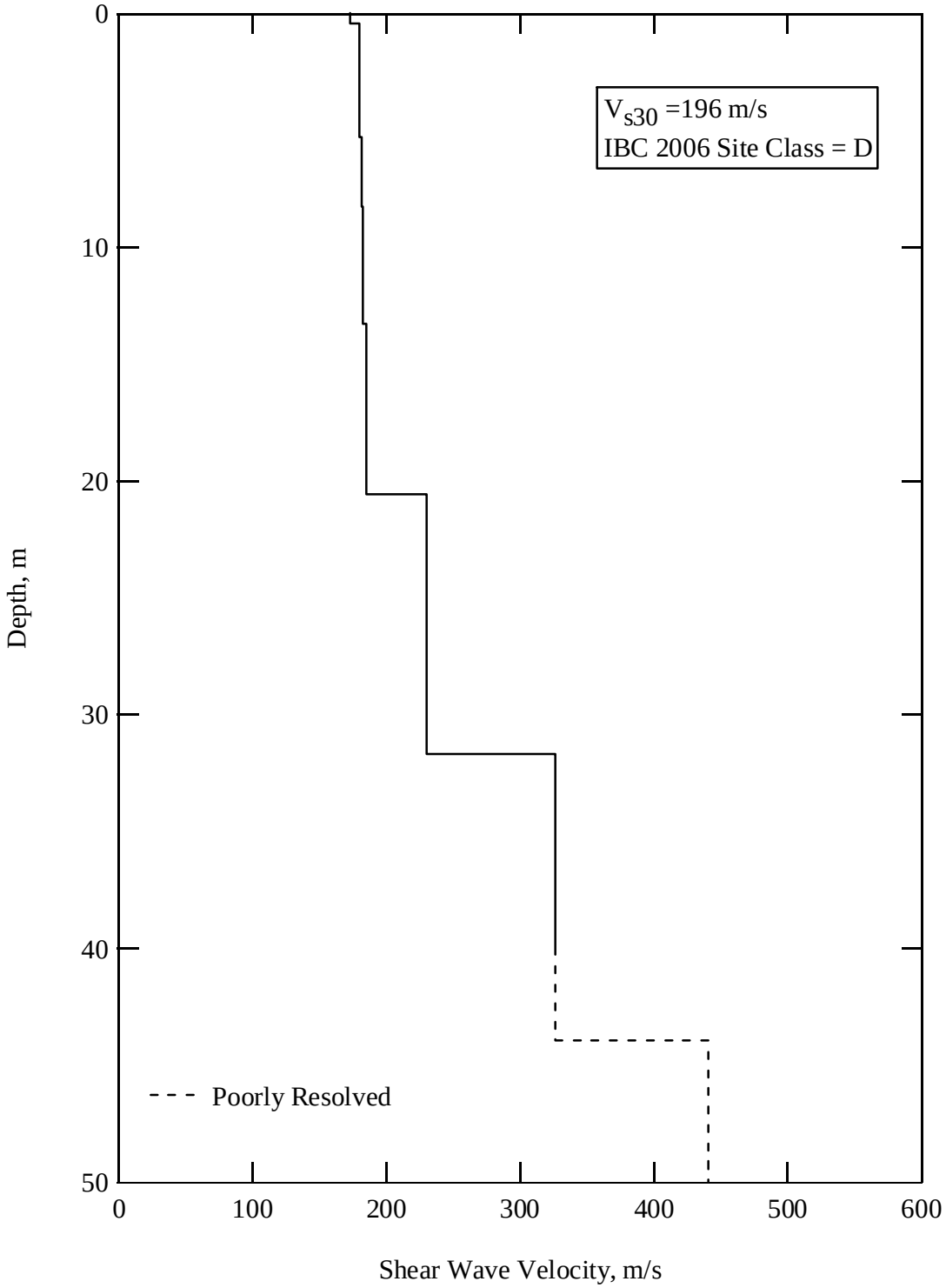

Fig. 2.108 Shear wave velocity profile determined from SASW at Kaysville Junior High (KJH), Davis County, Utah.

The average shear wave velocity in the upper 30 m of soil is 196 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 40 m and poorly resolved from 40 m to 50 m.

Table 2.21 Tabulated measured and assumed layer properties at Kaysville Junior High (KJH), Davis County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	173	324	0.3	1.92
0.4	0.8	180	337	0.3	1.92
1.2	1.4	180	338	0.3	1.92
2.6	2.7	181	1500	0.49	1.92
5.3	3.0	182	1500	0.49	1.92
8.3	5.0	183	1500	0.49	1.92
13.3	7.3	186	1500	0.49	1.92
20.6	11.1	230	1500	0.49	1.92
31.7	8.3	327	1500	0.48	1.96

2.2.4. Windridge Elementary School

SASW testing was performed at Windridge Elementary School, designated as WRS in this report, located 1300 S. 700 E., Kaysville, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.01331 North and 111.92502 East, with an elevation of approximately 1333 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.109.

Testing was performed at 1:00 p.m. on August 11, 2005. The SASW array was located on the west side of the school in the baseball playing fields. A photograph of the site is shown in Fig. 2.110. A fully saturated zone was assumed to exist at a depth of 2.7 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.2 m with 15 cm of padding

Figure 2.111 shows the experimental dispersion curve measured at Windridge Elementary School. Figure 2.112 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure

2.113 shows the calculated shear wave velocity profile for the site. Table 2.22 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

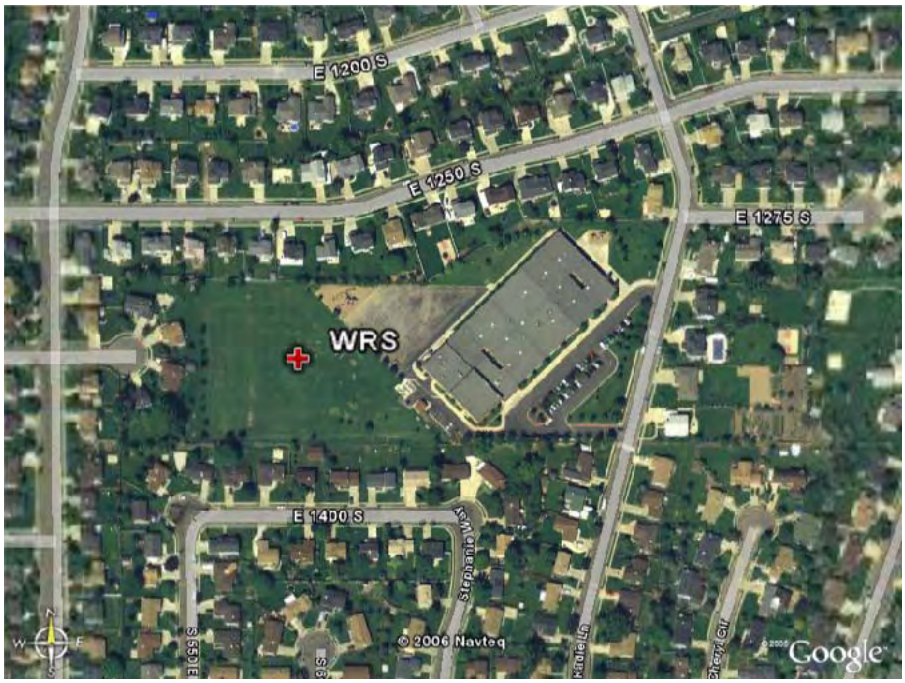

Fig. 2.109 Site map showing the location of the centerline of the SASW array at Windridge Elementary School (WRS), Davis County, Utah (from Google Earth 2006).

Fig. 2.110 Photograph of SASW testing at Windridge Elementary School (WRS), Davis County, Utah.

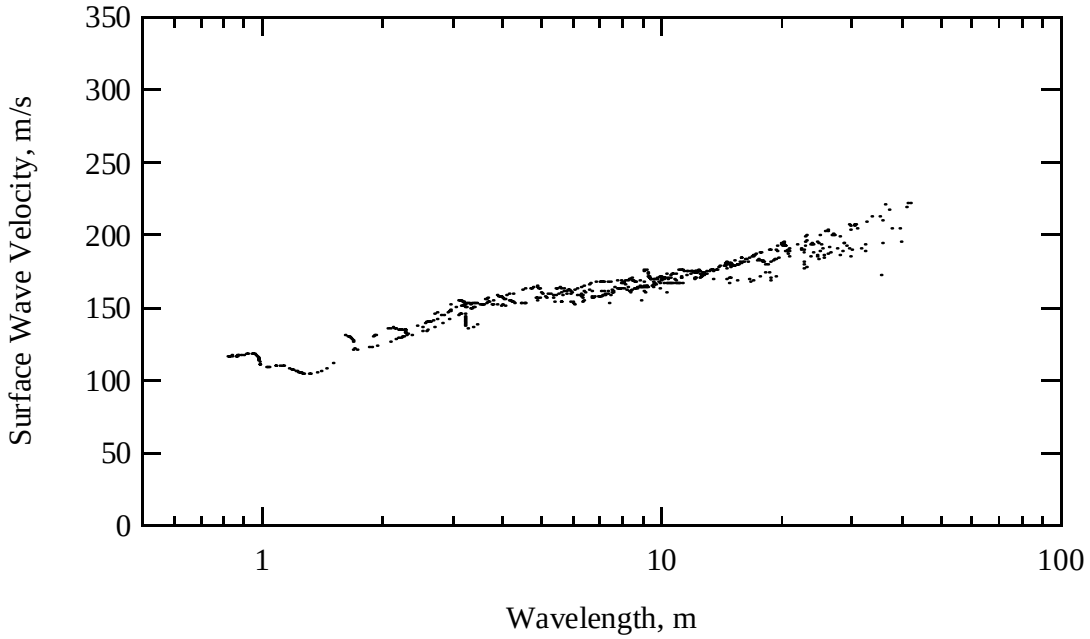

Fig. 2.111 Experimental dispersion curve measured at Windridge Elementary School (WRS), Davis County, Utah.

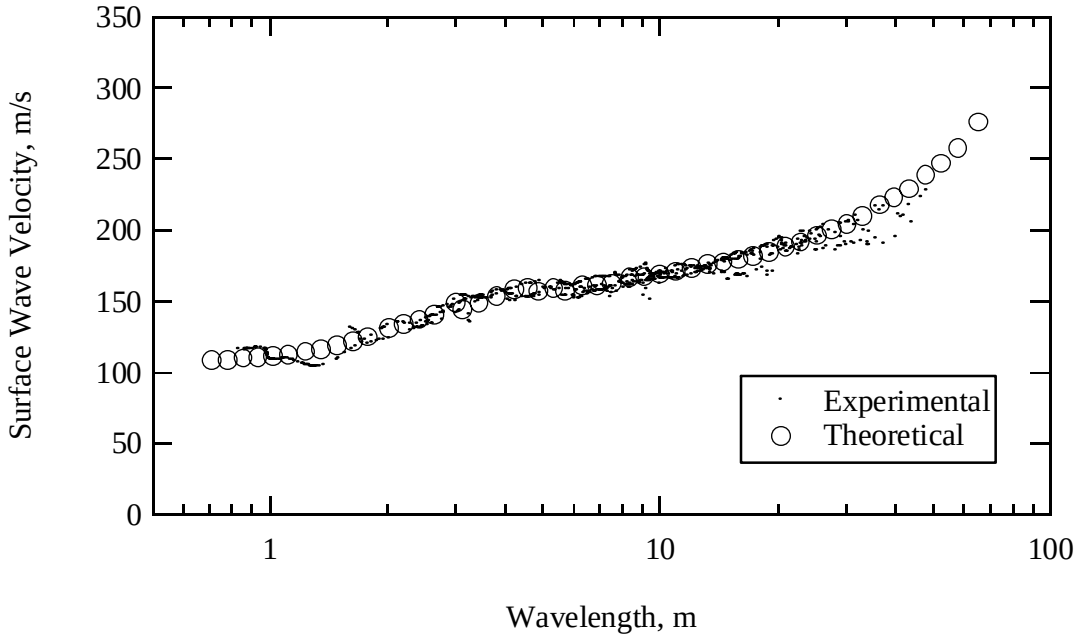

Fig. 2.112 Comparison of experimental and theoretical dispersion curves from Windridge Elementary School (WRS), Davis County, Utah.

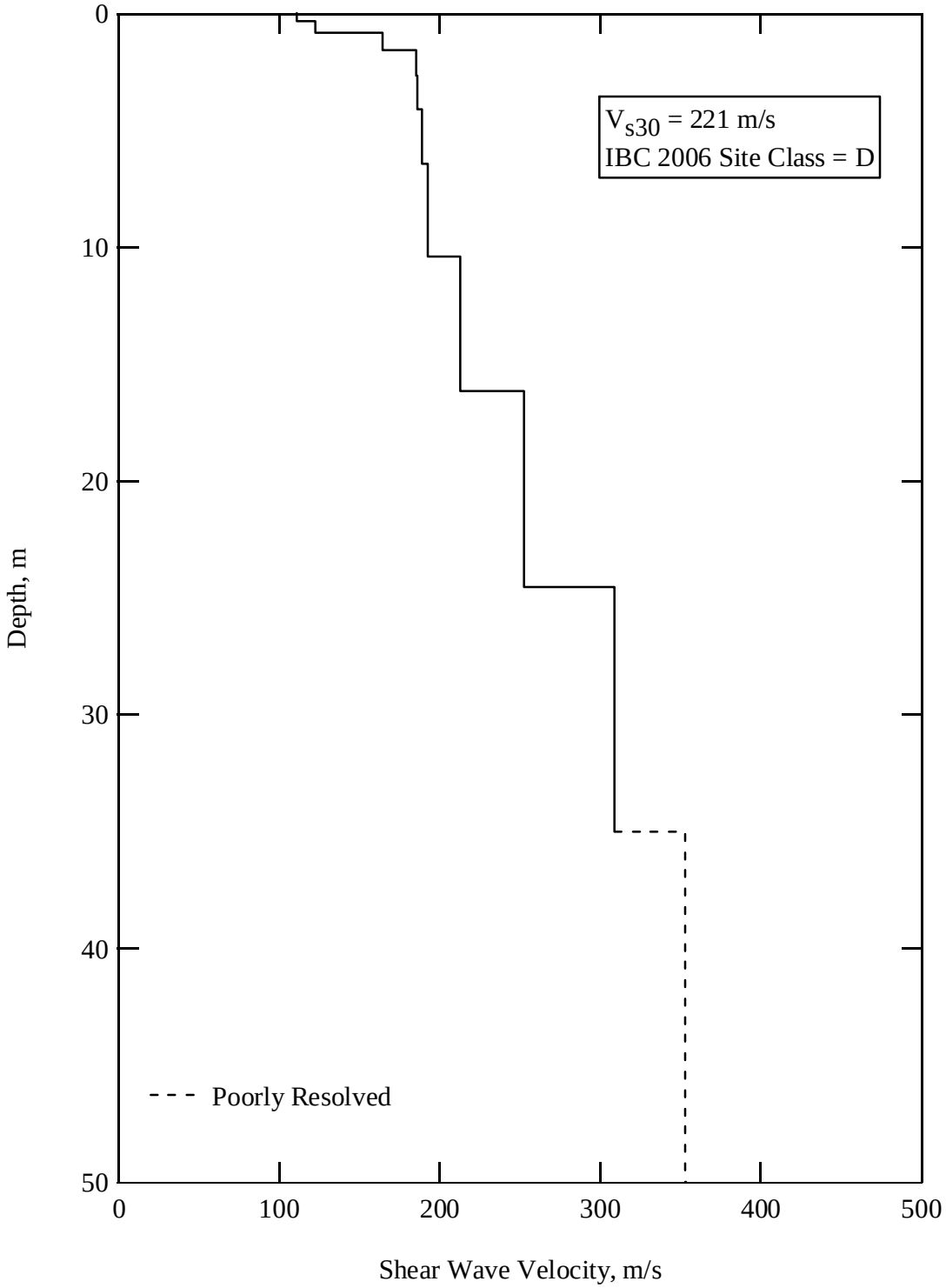

Fig. 2.113 Shear wave velocity profile determined from SASW at Windridge Elementary School (WRS), Davis County, Utah.

The average shear wave velocity in the upper 30 m of soil is 221 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 50 m.

Table 2.22 Tabulated measured and assumed layer properties at Windridge Elementary School (WRS), Davis County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	111	208	0.3	1.89
0.4	0.5	123	230	0.3	1.89
0.8	0.7	165	309	0.3	1.89
1.6	1.1	186	348	0.3	1.89
2.7	1.5	186	1500	0.49	1.89
4.1	2.3	189	1500	0.49	1.92
6.4	4.0	193	1500	0.49	1.92
10.4	5.8	213	1500	0.49	1.92
16.2	8.4	253	1500	0.49	1.92
24.5	10.5	309	1500	0.48	1.96

2.2.5. Washington Elementary School

SASW testing was performed at Washington Elementary School, designated as WSE in this report, located 340 W. 650 S., Bountiful, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.88242 North and 111.89001 East, with an elevation of approximately 1335 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.114.

Testing was performed at 2:00 p.m. on August 10, 2005. The SASW array was located along the west side of the school in the baseball playing fields oriented in a north-south direction. A photograph of the site is shown in Fig. 2.115. A fully saturated zone was assumed to exist at a depth of 10.3 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.3 m with 15 cm of padding.

Figure 2.116 shows the experimental dispersion curve measured at Washington Elementary School. Figure 2.117 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.118 shows the calculated shear wave velocity profile for the site. Table 2.23 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.114 Site map showing the location of the centerline of the SASW array at Washington Elementary School (WSE), Davis County, Utah (from Google Earth 2006).

Fig. 2.115 Photograph of SASW testing at Washington Elementary School (WSE), Davis County, Utah.

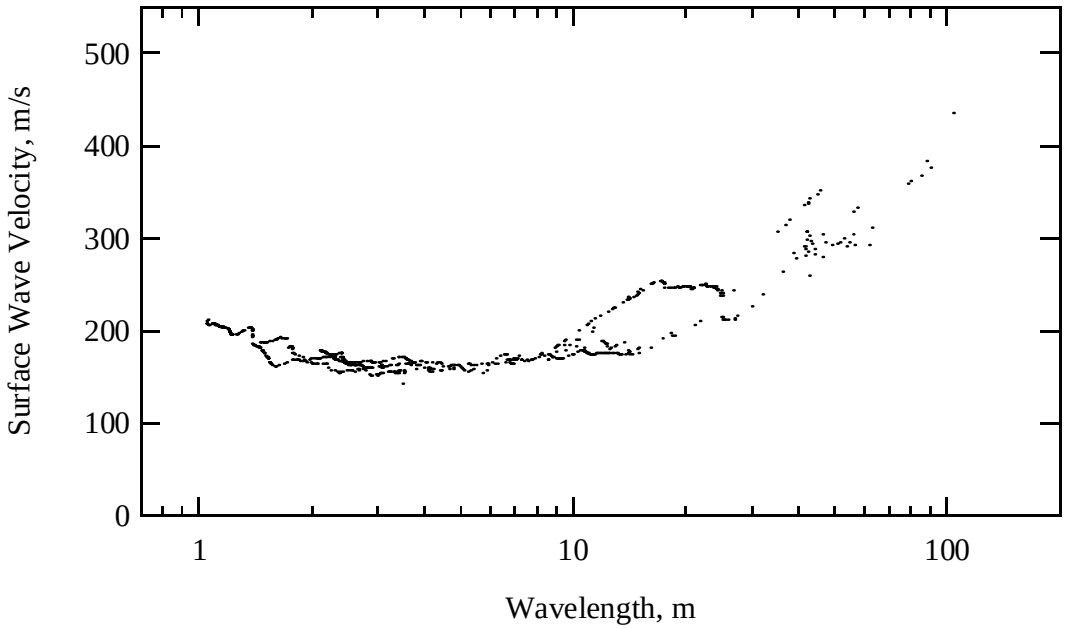

Fig. 2.116 Experimental dispersion curve measured at Washington Elementary School (WSE), Davis County, Utah.

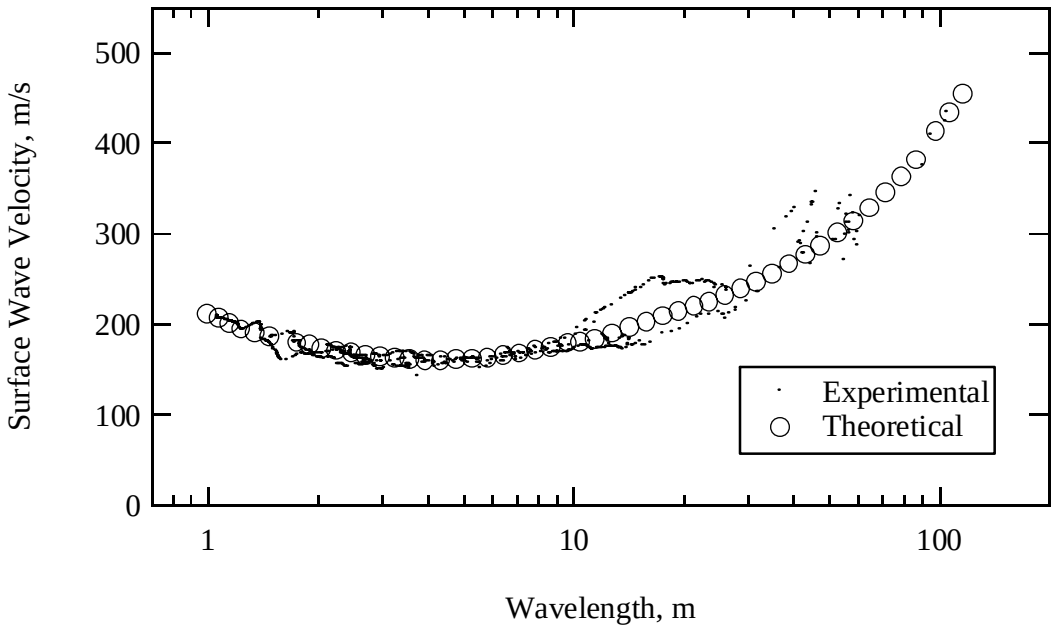

Fig. 2.117 Comparison of experimental and theoretical dispersion curves from Washington Elementary School (WSE), Davis County, Utah.

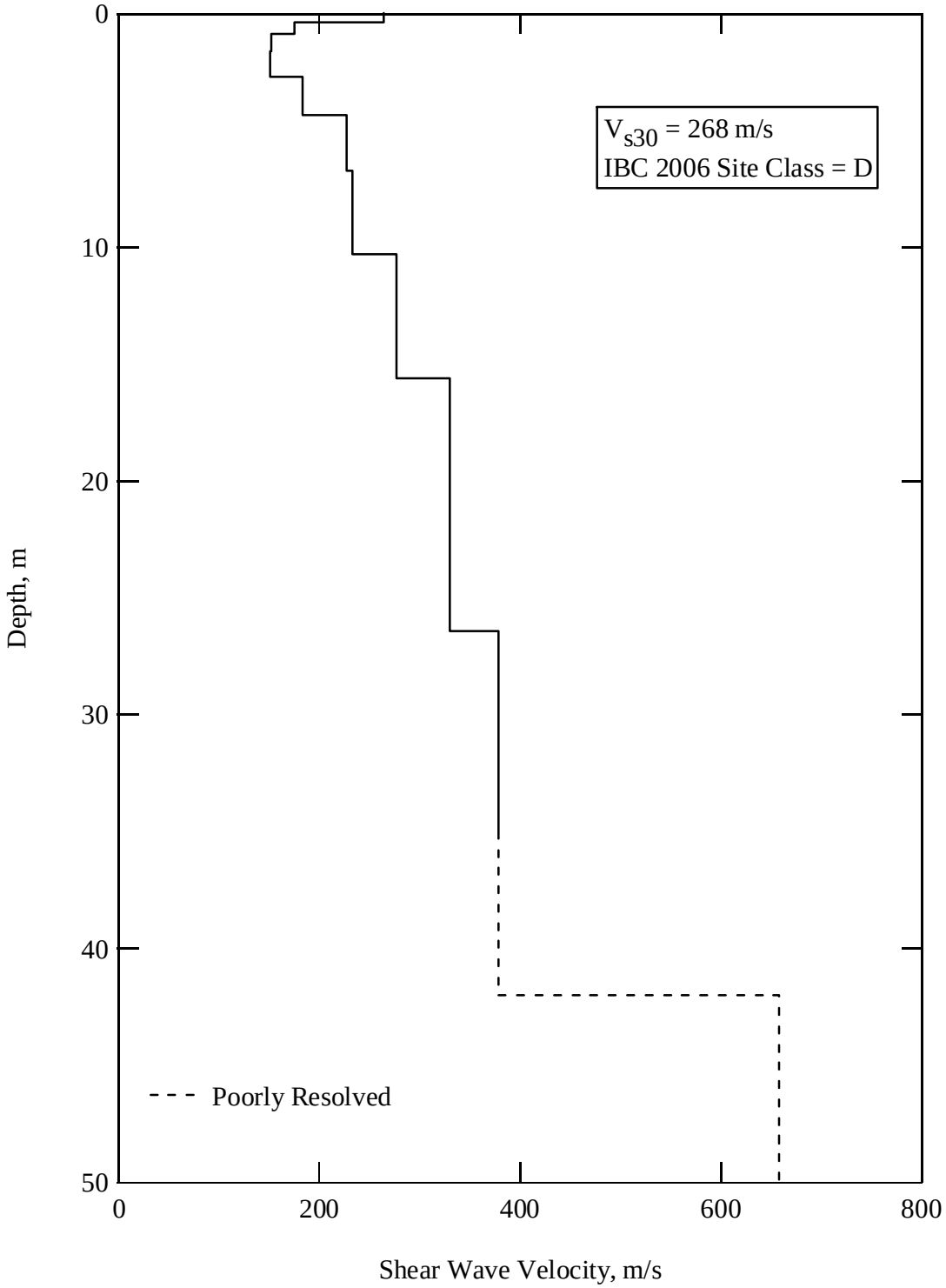

Fig. 2.118 Shear wave velocity profile determined from SASW at Washington Elementary School (WSE), Davis County, Utah.

The average shear wave velocity in the upper 30 m of soil is 268 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 50 m.

Table 2.23 Tabulated measured and assumed layer properties at Washington Elementary School (WSE), Davis County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	265	496	0.3	1.90
0.4	0.5	176	329	0.3	1.90
0.9	0.7	153	286	0.3	1.90
1.6	1.1	151	283	0.3	1.90
2.7	1.6	184	344	0.3	1.90
4.3	2.4	228	427	0.3	1.90
6.7	3.6	234	438	0.3	1.90
10.3	5.3	277	1500	0.48	1.92
15.6	10.8	331	1500	0.47	1.96
26.4	8.6	379	1500	0.47	1.96

2.2.6. Utah Highway Patrol Building

SASW testing was performed at the Utah Highway Patrol Building, designated as UHP in this report, located at 631 N. 200 W., Farmington, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.99046 North and 111.89903 East, with an elevation of approximately 1303 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.119. A strong motion sensor monitored by the University of Utah Seismograph Stations is located on the north side of the Highway Patrol Building in a green containment box on the lawn.

Testing was performed at 8:00 a.m. on August 11, 2005. The SASW array was located in a field to the west of the Highway Patrol Building, oriented in an east-west direction. A photograph of the site is shown in Fig. 2.120 where Interstate 15 can be seen

in the background. Standing water indicated a shallow water table such that a fully saturated zone was assumed to exist at a depth of 3 m below the ground surface. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.5 m with no padding.

Figure 2.121 shows the experimental dispersion curve measured at the Utah Highway Patrol Building. Figure 2.122 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.123 shows the calculated shear wave velocity profile for the site. Table 2.24 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.119 Site map showing the location of the centerline of the SASW array at the Utah Highway Patrol Building (UHP), Davis County, Utah (from Google Earth 2006).

Fig. 2.120 Photograph of SASW testing at the Utah Highway Patrol Building (UHP), Davis County, Utah.

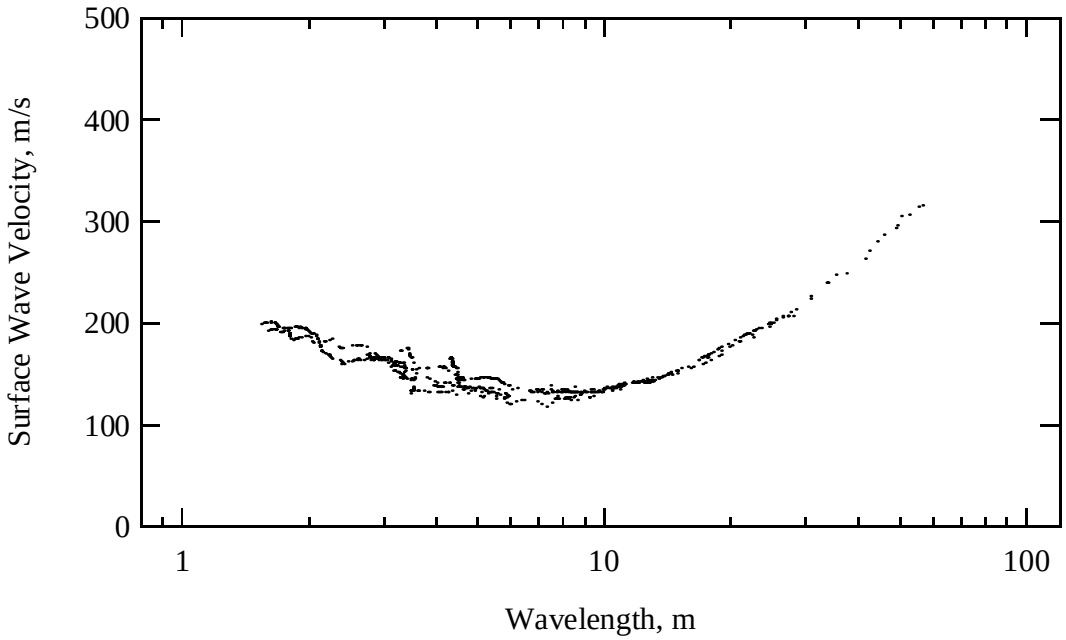

Fig. 2.121 Experimental dispersion curve measured at the Utah Highway Patrol Building (UHP), Davis County, Utah.

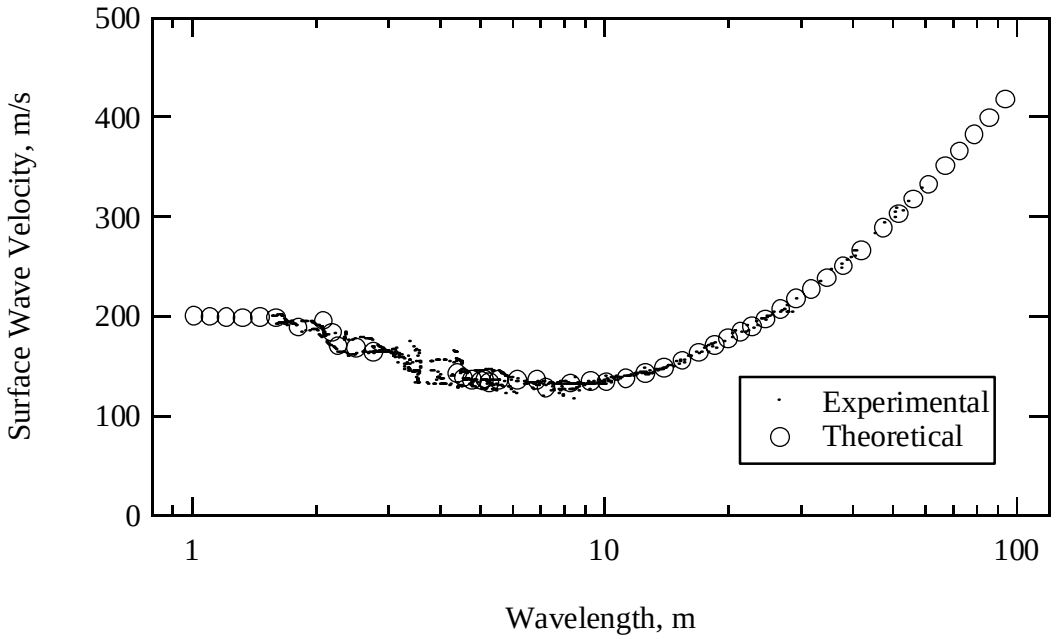

Fig. 2.122 Comparison of experimental and theoretical dispersion curves from the Utah Highway Patrol Building (UHP), Davis County, Utah.

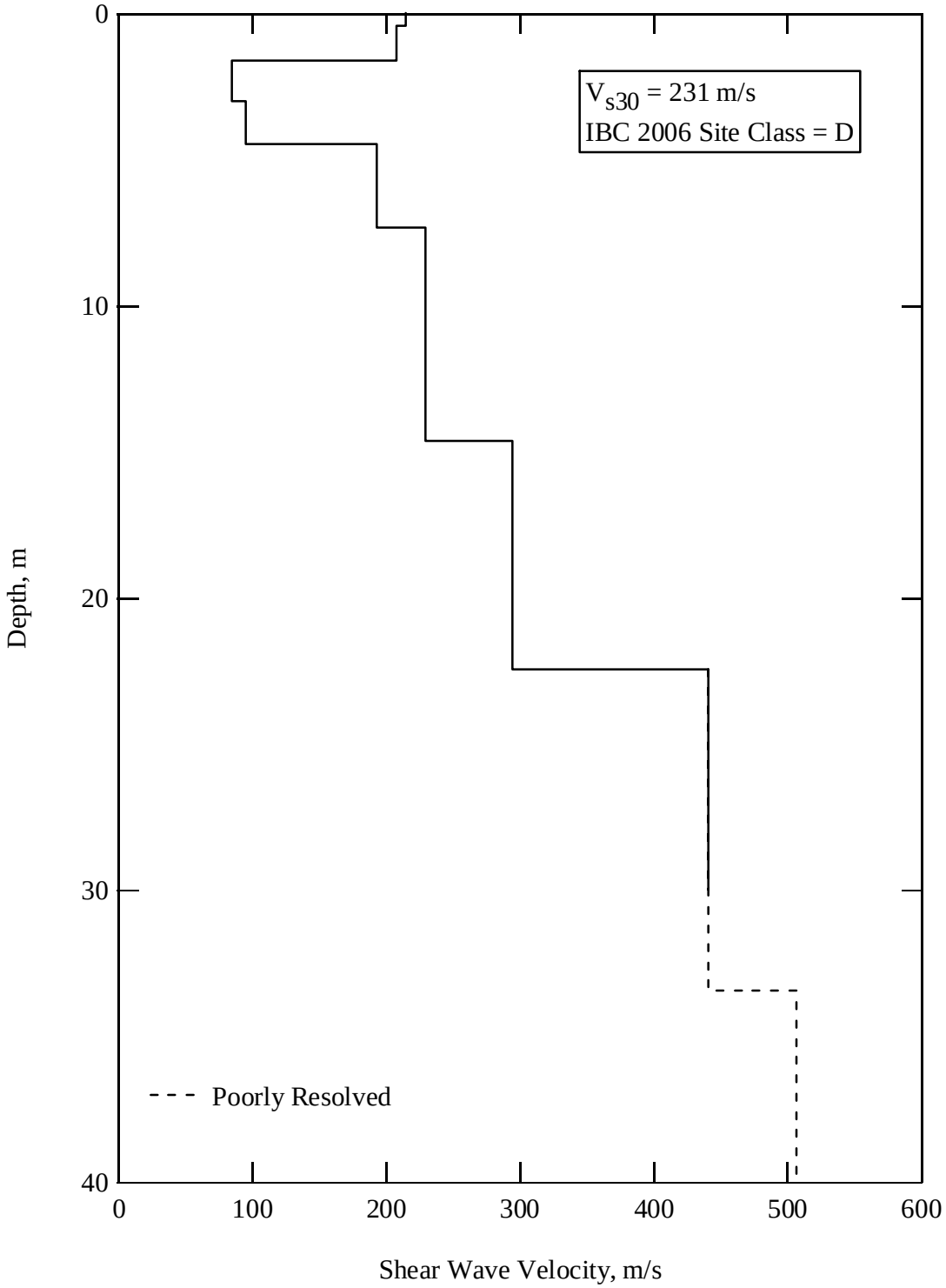

Fig. 2.123 Shear wave velocity profile determined from SASW at the Utah Highway Patrol Building (UHP), Davis County, Utah.

The average shear wave velocity in the upper 30 m of soil is 231 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 30 m and poorly resolved from 30 m to 40 m.

Table 2.24 Tabulated measured and assumed layer properties at the Utah Highway Patrol Building (UHP), Davis County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	215	402	0.3	1.90
0.4	1.2	209	390	0.3	1.90
1.6	1.4	85	159	0.3	1.90
3.0	1.5	95	1500	0.49	1.90
4.5	2.9	193	1500	0.49	1.90
7.3	7.3	230	1500	0.49	1.92
14.6	7.8	295	1500	0.48	1.92
22.5	7.5	441	1500	0.45	1.96

2.2.7. Orchard Elementary School

SASW testing was performed at Orchard Elementary School, designated as OSE in this report, located at 205 E Center St., North Salt Lake, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.84319 North and 111.90739 East, with an elevation of approximately 1340 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.124.

Testing was performed at 10:30 a.m. on October 15, 2005. The SASW array was located along the west side of the school building, running parallel to the structure. A photograph of the site is shown in Fig. 2.125 which shows the layout of the soccer fields and the orientation of the SASW array. A fully saturated zone was assumed to exist at a depth of 10.7 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.25 m with 10 cm of padding used.

Figure 2.126 shows the experimental dispersion curve measured at Orchard Elementary School. Figure 2.127 shows the comparison of the experimental dispersion

curve and the theoretical dispersion curve determined from forward modeling. Figure 2.128 shows the calculated shear wave velocity profile for the site. Table 2.25 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

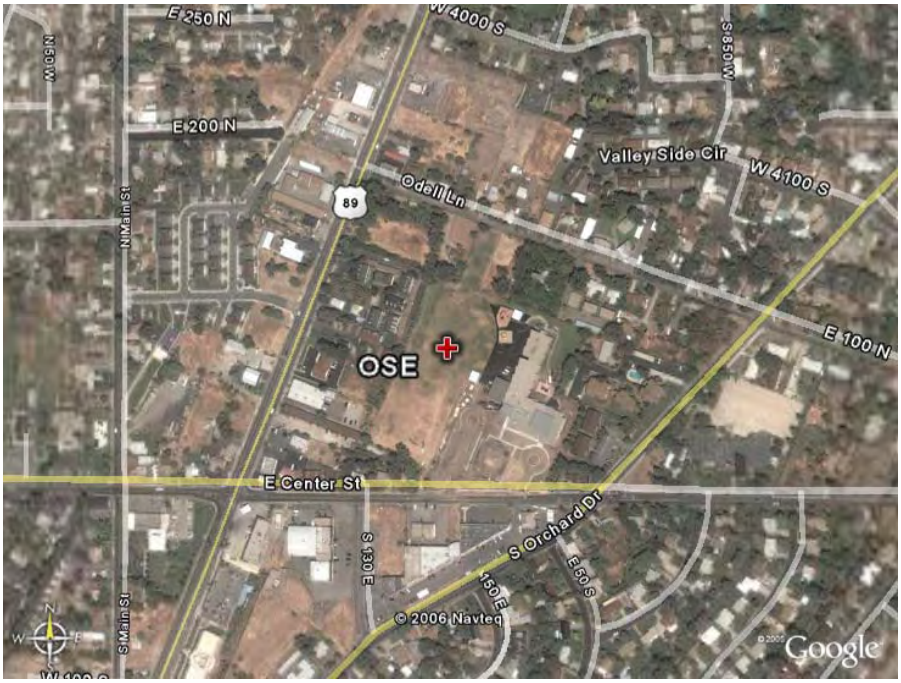

Fig. 2.124 Site map showing the location of the centerline of the SASW array at Orchard Elementary School (OSE), Davis County, Utah (from Google Earth 2006).

Fig. 2.125 Photograph of SASW testing at Orchard Elementary School (OSE), Davis County, Utah.

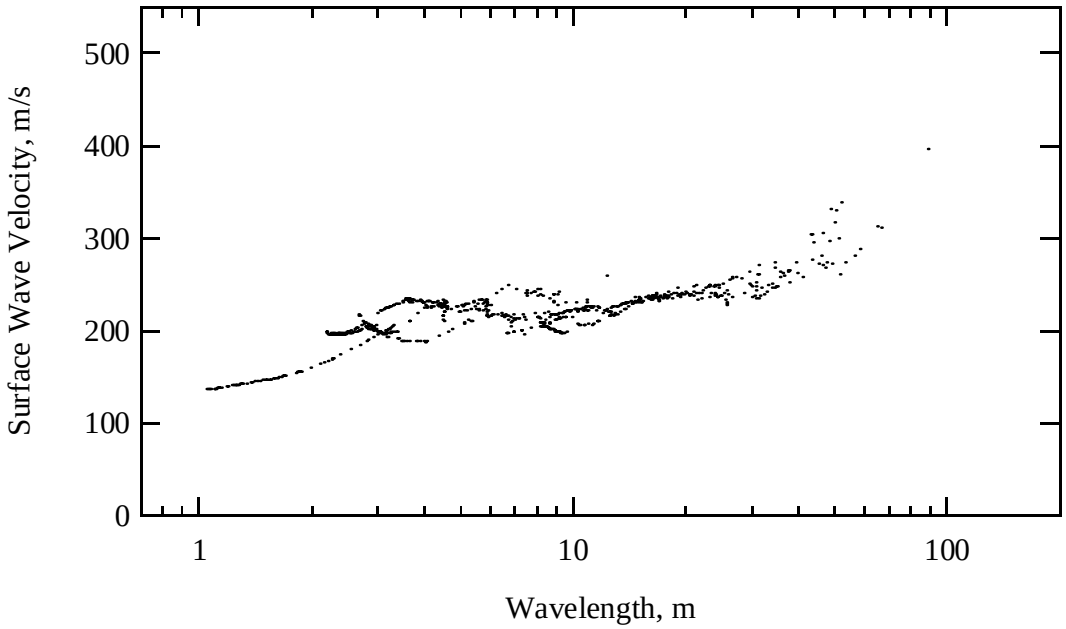

Fig. 2.126 Experimental dispersion curve measured at Orchard Elementary School (OSE), Davis County, Utah.

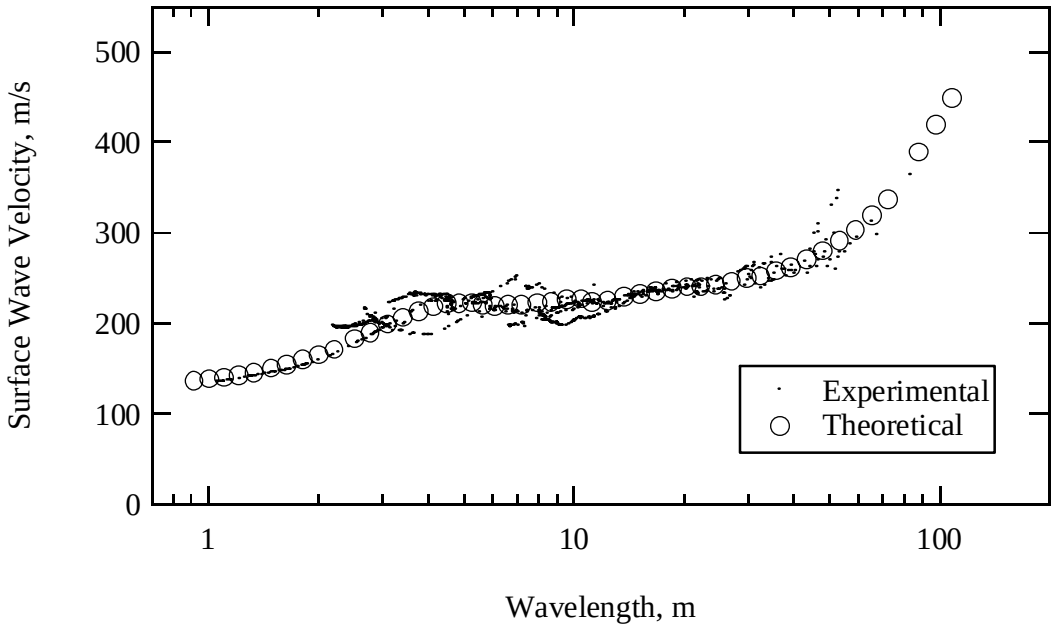

Fig. 2.127 Comparison of experimental and theoretical dispersion curves from the Orchard Elementary School (OSE), Davis County, Utah.

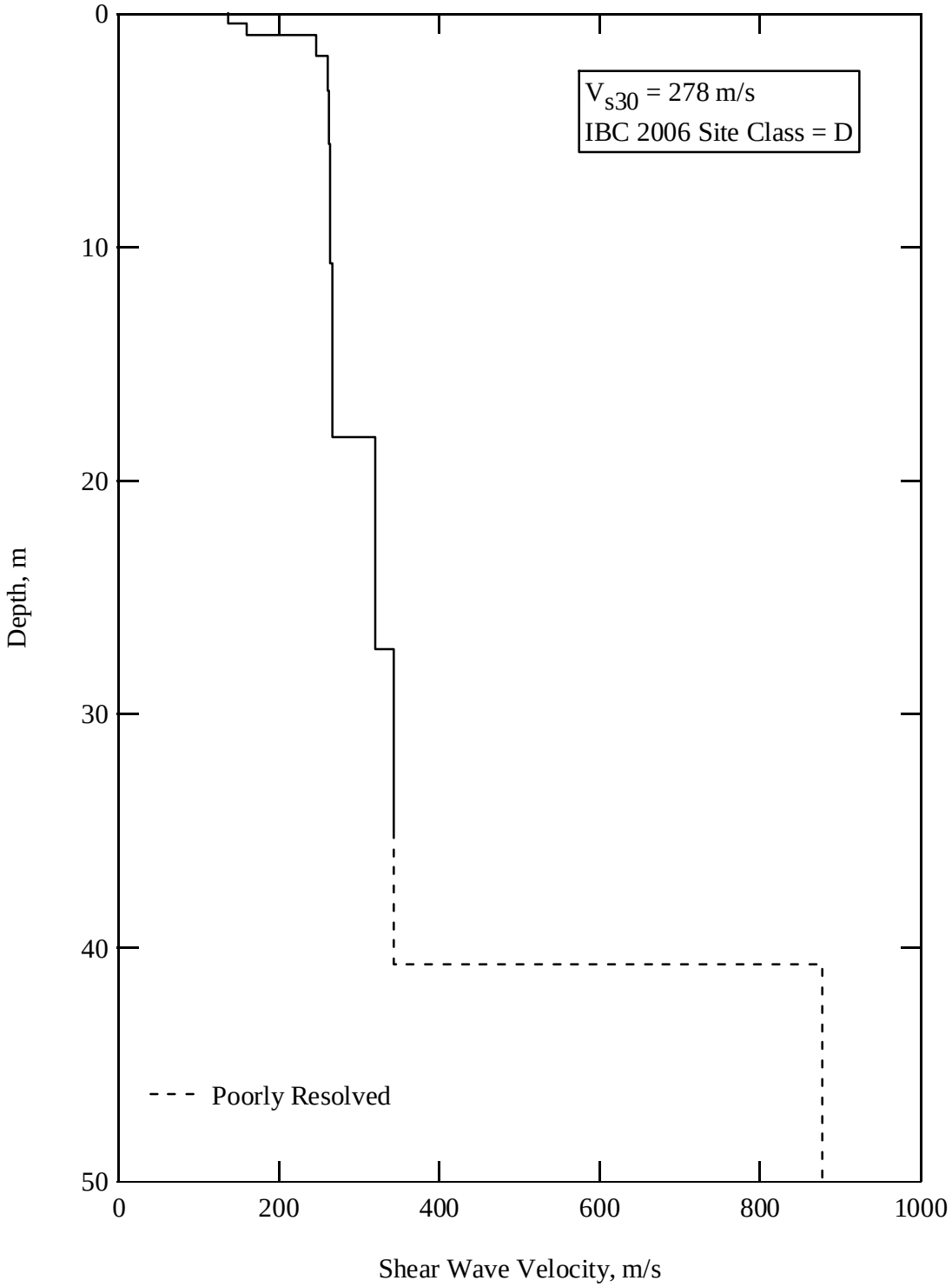

Fig. 2.128 Shear wave velocity profile determined from SASW at Orchard Elementary School (OSE), Davis County, Utah.

The average shear wave velocity in the upper 30 m of soil is 278 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 50 m.

Table 2.25 Tabulated measured and assumed layer properties at Orchard Elementary School (OSE), Davis County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	137	256	0.3	1.90
0.4	0.5	160	299	0.3	1.90
0.9	0.9	247	462	0.3	1.90
1.8	1.5	261	488	0.3	1.90
3.3	2.3	263	492	0.3	1.90
5.6	5.1	264	494	0.3	1.92
10.7	7.4	267	1500	0.48	1.92
18.1	9.1	321	1500	0.48	1.96
27.2	7.8	344	1500	0.47	1.96

2.2.8. Farmington Elementary School

SASW testing was performed at Farmington Elementary School, designated as FES in this report, located at 50 W. 200 S., Farmington, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.97725 North and 111.89048 East, with an elevation of approximately 1308 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.129.

Testing was performed at 8:30 a.m. on October 15, 2005. The SASW array was located on the west side of the school in an east-west orientation. A photograph of the site is shown in Fig. 2.130 which shows the layout of the geophones through a baseball field. A fully saturated zone was not assumed at this site. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.2 m with 15 cm of padding used

Figure 2.131 shows the experimental dispersion curve measured at Farmington Elementary School. Figure 2.132 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure

2.133 shows the calculated shear wave velocity profile for the site. Table 2.26 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.129 Site map showing the location of the centerline of the SASW array at Farmington Elementary School (FES), Davis County, Utah (from Google Earth 2006).

Fig. 2.130 Photograph of SASW testing at Farmington Elementary School (FES), Davis County, Utah.

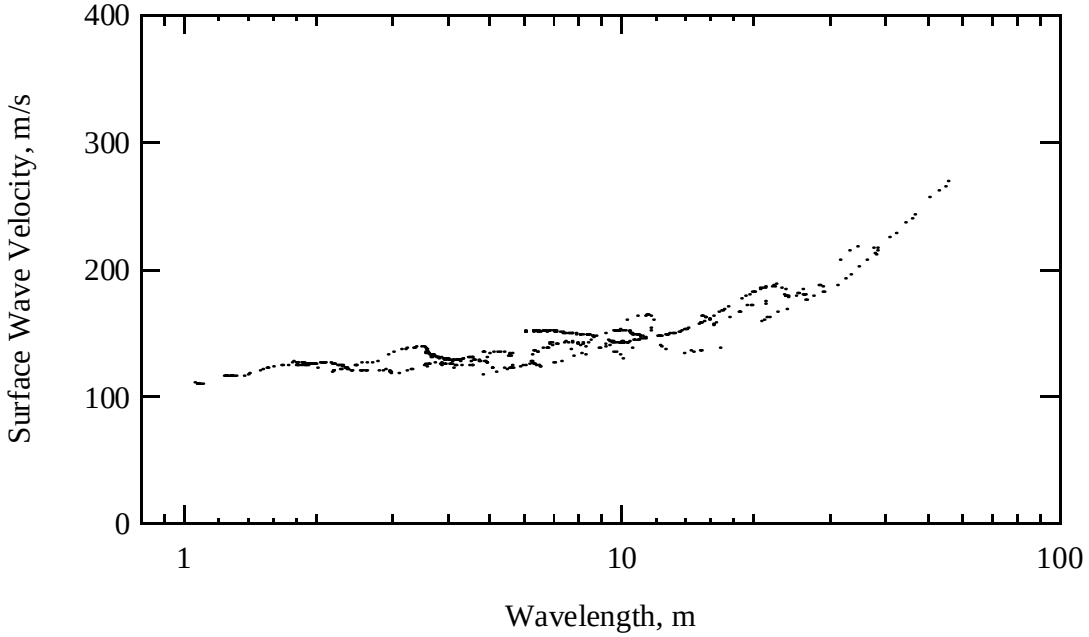

Fig. 2.131 Experimental dispersion curve measured at Farmington Elementary School (FES), Davis County, Utah.

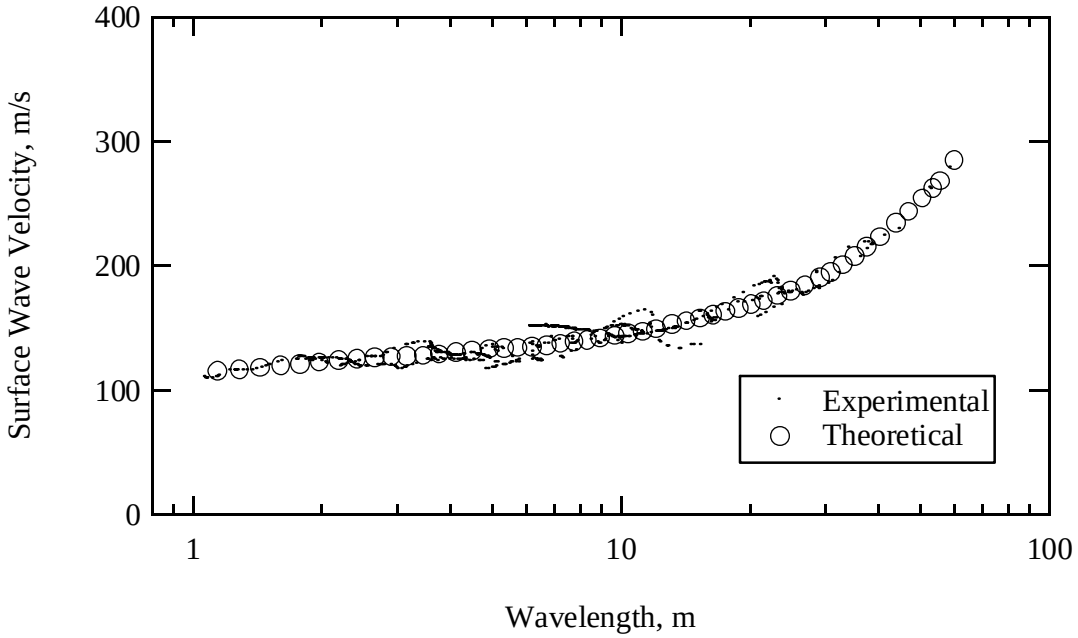

Fig. 2.132 Comparison of experimental and theoretical dispersion curves from Farmington Elementary School (FES), Davis County, Utah.

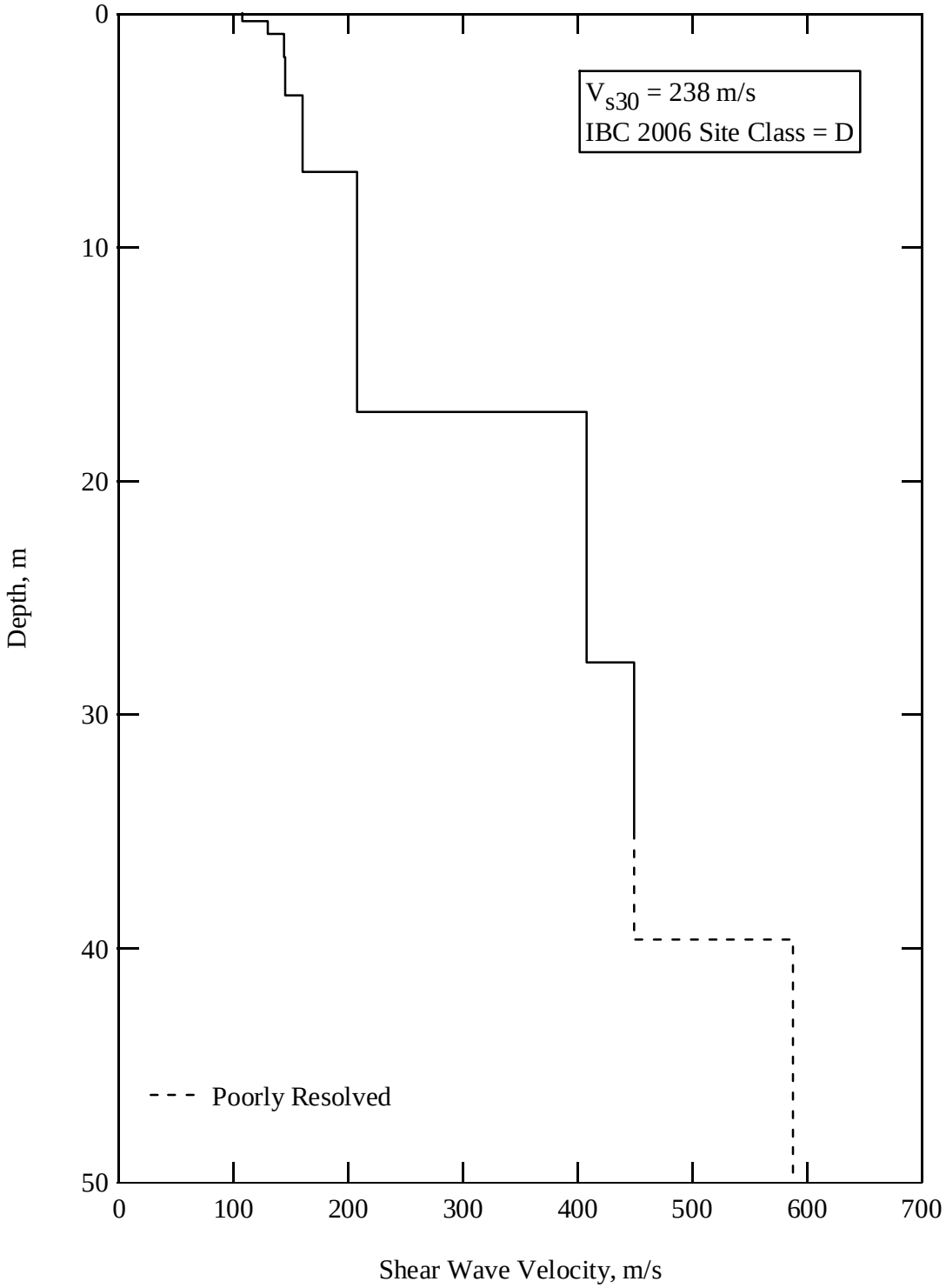

Fig. 2.133 Shear wave velocity profile determined from SASW at Farmington Elementary School (FES), Davis County, Utah.

The average shear wave velocity in the upper 30 m of soil is 238 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 50 m.

Table 2.26 Tabulated measured and assumed layer properties at Farmington Elementary School (FES), Davis County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	108	202	0.3	1.89
0.3	0.6	131	245	0.3	1.89
0.9	1.0	144	270	0.3	1.89
1.9	1.6	146	273	0.3	1.89
3.5	3.3	161	301	0.3	1.90
6.8	10.3	208	389	0.3	1.90
17.1	10.7	408	764	0.3	1.90
27.8	7.3	450	841	0.3	1.92

2.2.9. Mueller Park Junior High School

SASW testing was performed at Mueller Park Junior High School, designated as MPS in this report, located at 955 Mueller Park Rd., Bountiful, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.87215 North and 111.86018 East, with an elevation of approximately 1481 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.134.

Testing was at 10:45 a.m. on October 15, 2005. The SASW array was located on the east side of the school in a north-south orientation parallel to the running track. The source trailer remained at a constant location while the centerline was adjusted. A photograph of the site is shown in Fig. 2.135. A fully saturated zone was not assumed at this site. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.2 m with 15 cm of padding.

Figure 2.136 shows the experimental dispersion curve measured at Mueller Park Junior High School. Figure 2.137 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.138 shows the calculated shear wave velocity profile for the site. Table 2.27 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

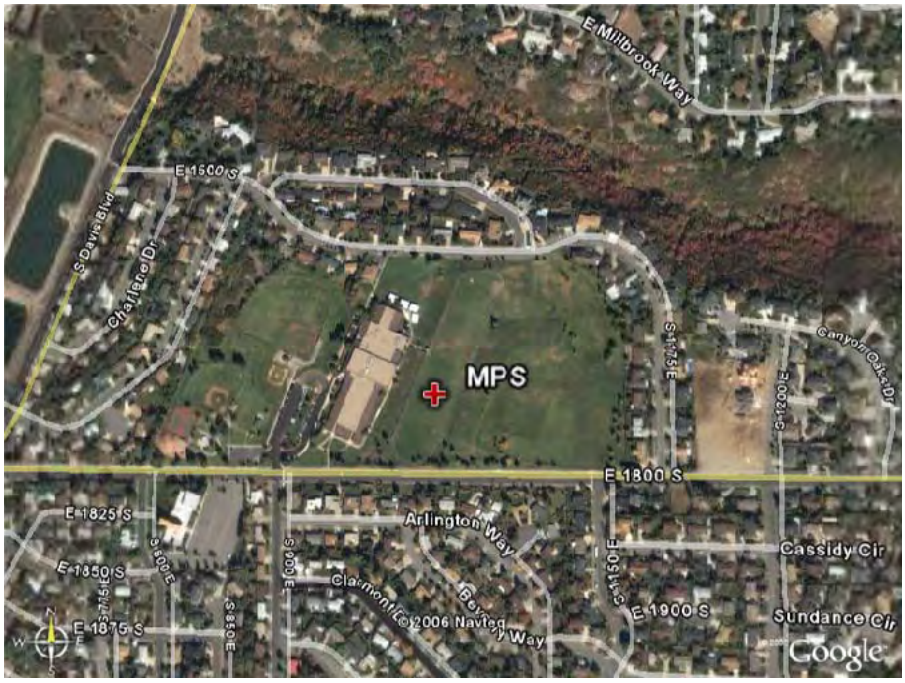

Fig. 2.134 Site map showing the location of the centerline of the SASW array at Mueller Park Junior High School (MPS), Davis County, Utah (from Google Earth 2006).

Fig. 2.135 Photograph of SASW testing at Mueller Park Junior High School (MPS), Davis County, Utah.

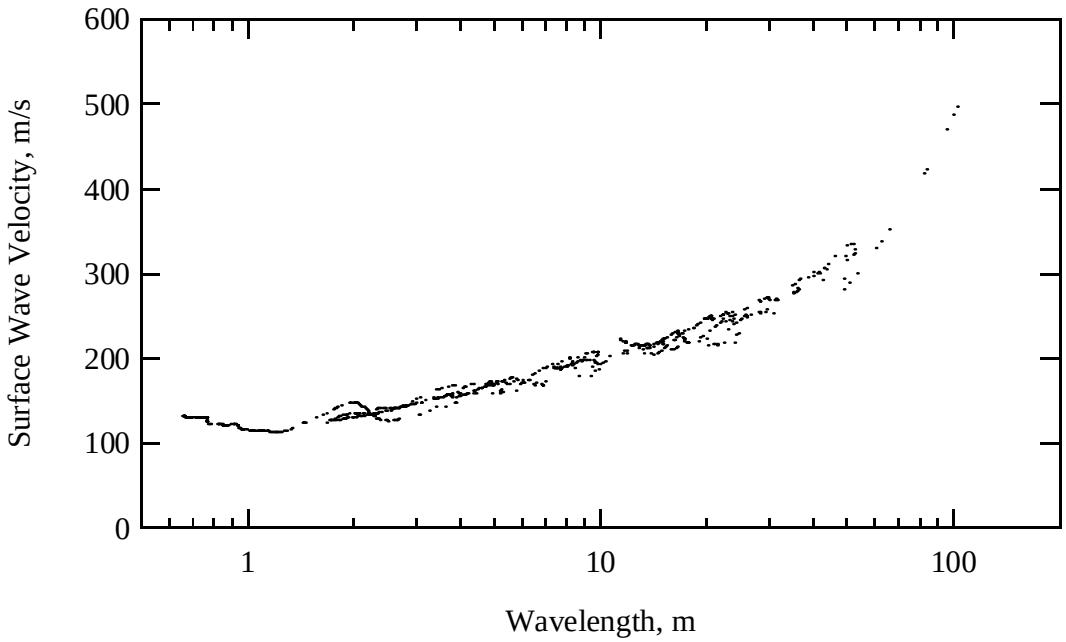

Fig. 2.136 Experimental dispersion curve measured at Mueller Park Junior High School (MPS), Davis County, Utah.

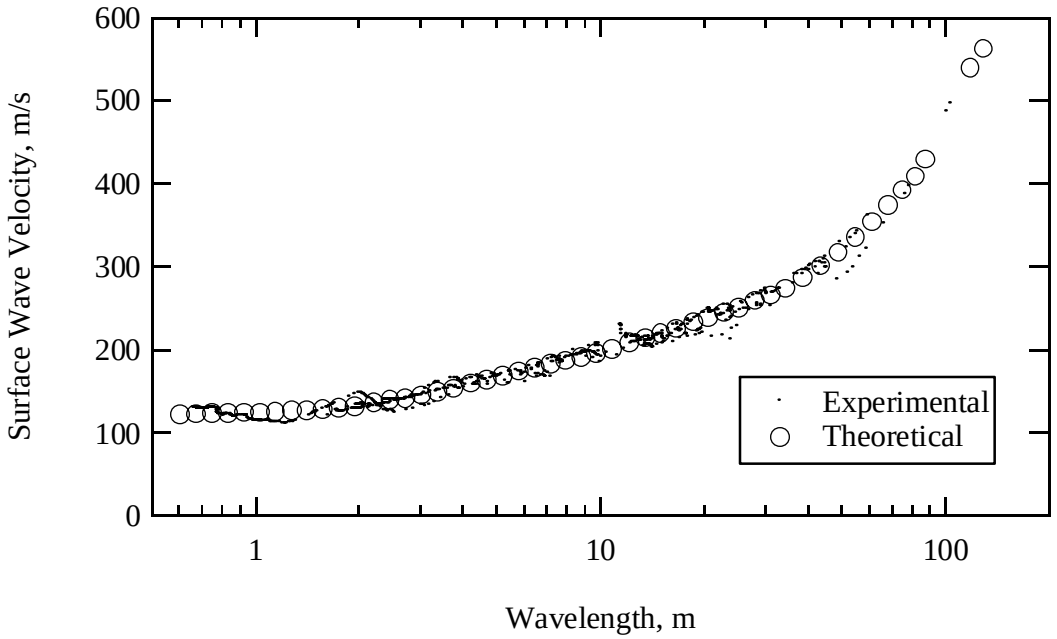

Fig. 2.137 Comparison of experimental and theoretical dispersion curves from Mueller Park Junior High School (MPS), Davis County, Utah.

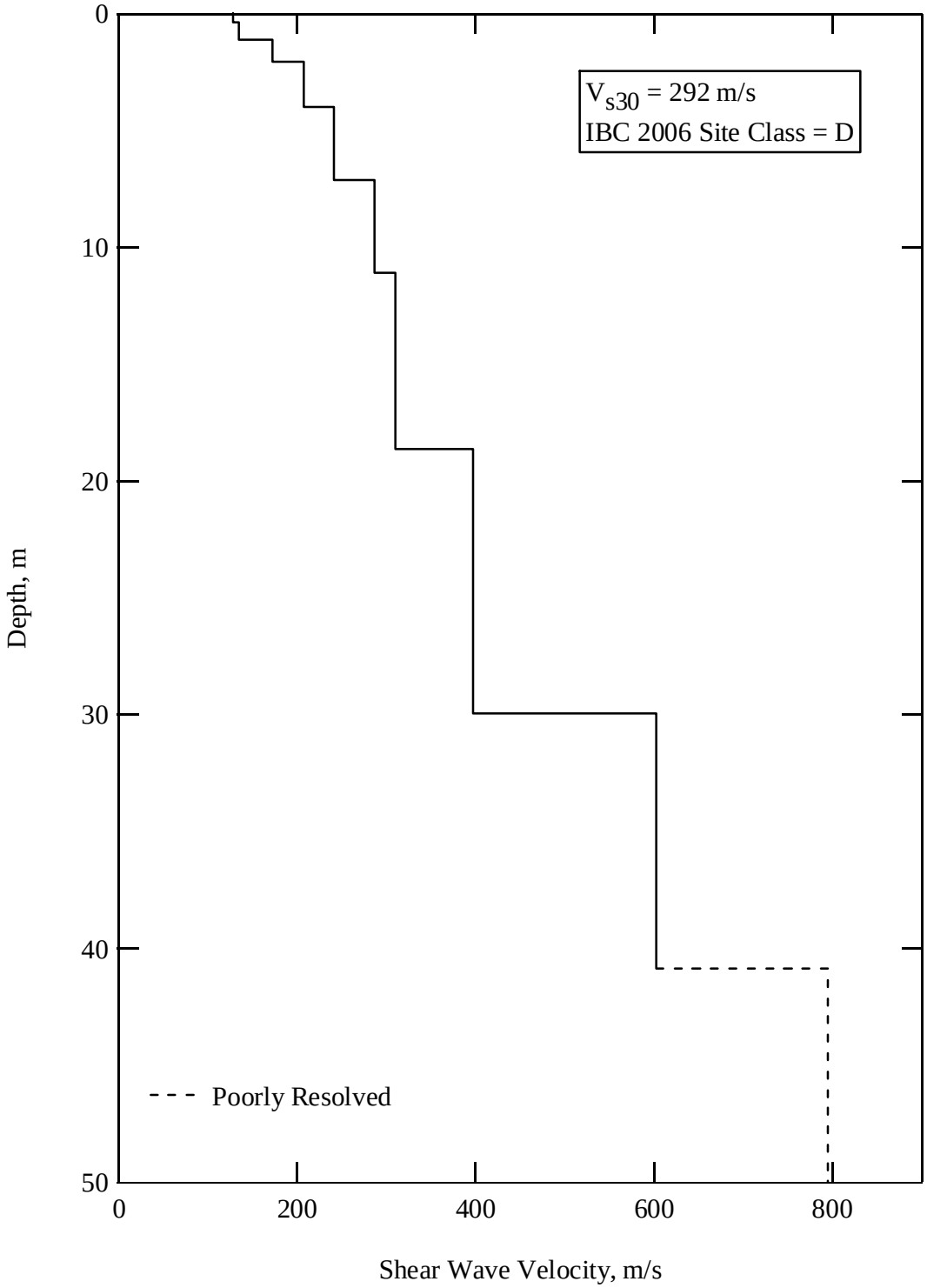

Fig. 2.138 Shear wave velocity profile determined from SASW at Mueller Park Junior High School (MPS), Davis County, Utah.

The average shear wave velocity in the upper 30 m of soil is 292 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 40.9 m and poorly resolved from 40.9 m to 50 m.

Table 2.27 Tabulated measured and assumed layer properties at Mueller Park Junior High School (MPS), Davis County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	129	241	0.3	1.89
0.4	0.7	135	252	0.3	1.89
1.1	1.0	173	324	0.3	1.90
2.1	1.9	208	389	0.3	1.90
4.0	3.1	241	451	0.3	1.90
7.1	4.0	287	537	0.3	1.92
11.1	7.6	311	582	0.3	1.96
18.7	11.3	398	745	0.3	1.96
30.0	10.9	603	1128	0.3	2.00

2.3. SALT LAKE COUNTY

The Salt Lake County does not fall in the study region for this report. The Salt Lake Valley was the location of prime interest in the 2003 Utah State University SASW study funded by the National Earthquake Hazard Reduction Program (NEHRP). Results from this study can be found in Gilbert (2004) or Bay et al. (2005).

At the request of the University of Utah Seismograph Stations, 3 sites were tested within the Salt Lake County. Figure 2.139 shows the locations of the sites that were tested, and the dense spatial distribution of existing data. There are approximately 131 existing V_{S30} sites in the Salt Lake County (Bay et al. 2005). The Quaternary units shown are those of Ashland et al. (2005).

Of the 3 sites that were tested, only one profile was resolved to a depth of 30 m. This site was located in Magna, Utah near the Fire Training Tower. The test was requested to verify the results of a test that was performed during the summer of 2003. The remaining 2 sites were located in mountainous terrain, and the intent was to measure the shear wave velocity of the shallow bedrock. In these tests, the source trailer was not used. The following section presents the results of the three tests that were performed in Salt Lake County.

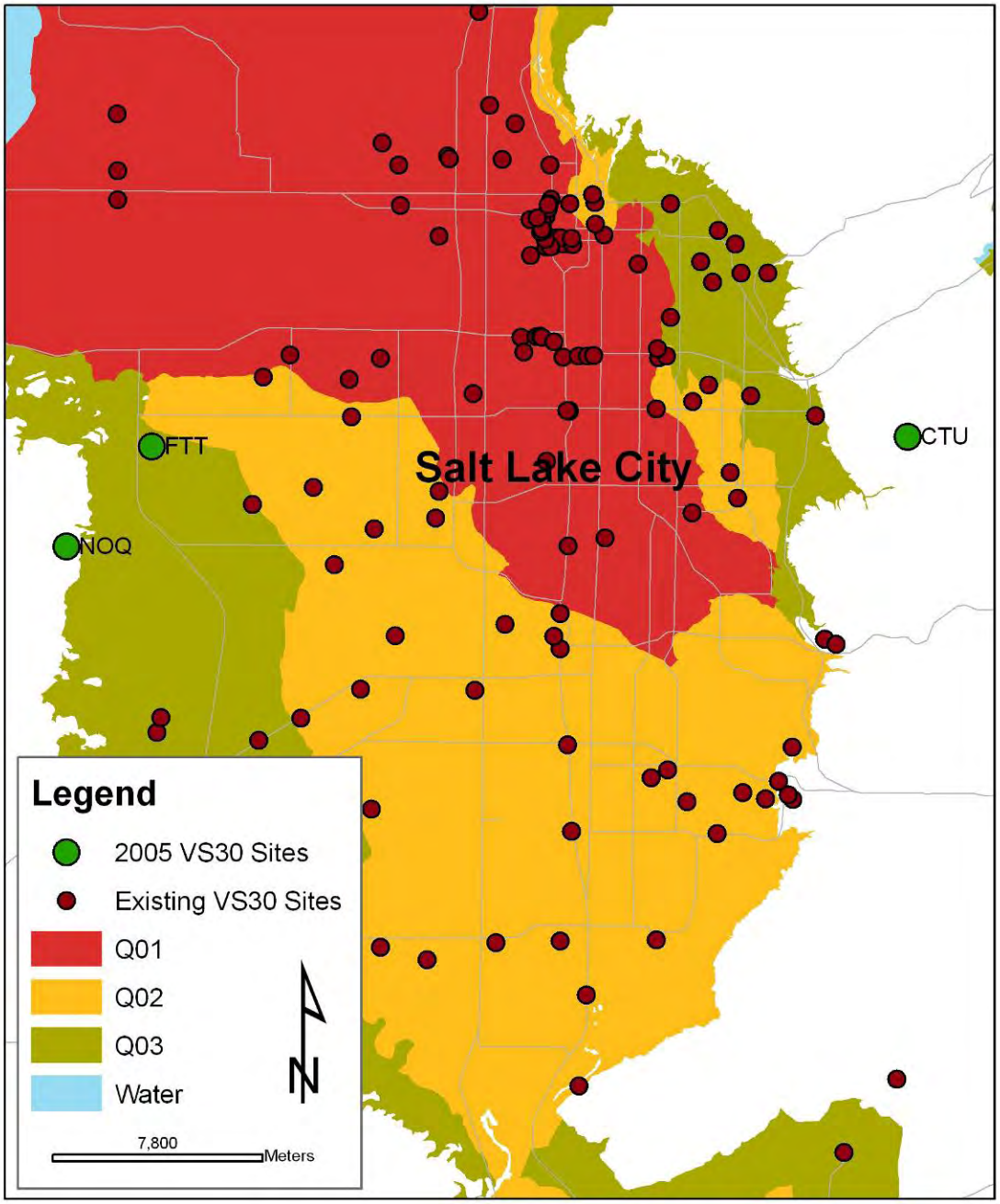

Fig. 2.139 Map showing spatial distribution of V_{S30} sites Salt Lake County, Utah.

2.3.1. Fire Training Tower

SASW testing was performed at the Fire Training Tower in Magna, designated as FTT in this report, located at 3950 S. 8000 W., Magna, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.68657 North and 112.08395 East, with an elevation of approximately 1382 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.140. The test was performed at the request of the University of Utah Seismograph Stations to verify the profile that was measured in the 2003 Utah State University SASW study at the same location found in Gilbert (2004).

Testing was performed at 9:00 a.m. on August 25, 2005. The SASW array was located along a gravel and dirt road that runs along the north side of the Fire Training Tower. A photograph of the site is shown in Fig. 2.141 where the Fire Training Tower can be seen. The strong motion sensor is located on the adjacent property near the Fire Training Tower. A fully saturated zone was not assumed at this site. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.25 m with no padding.

Figure 2.142 shows the experimental dispersion curve measured at the Fire Training Tower. Figure 2.143 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.144 shows the calculated shear wave velocity profile for the site. Table 2.28 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.140 Site map showing the location of the centerline of the SASW array at the Fire Training Tower (FTT), Salt Lake County, Utah (from Google Earth 2006).

Fig. 2.141 Photograph of SASW testing at the Fire Training Tower (FTT), Salt Lake County, Utah.

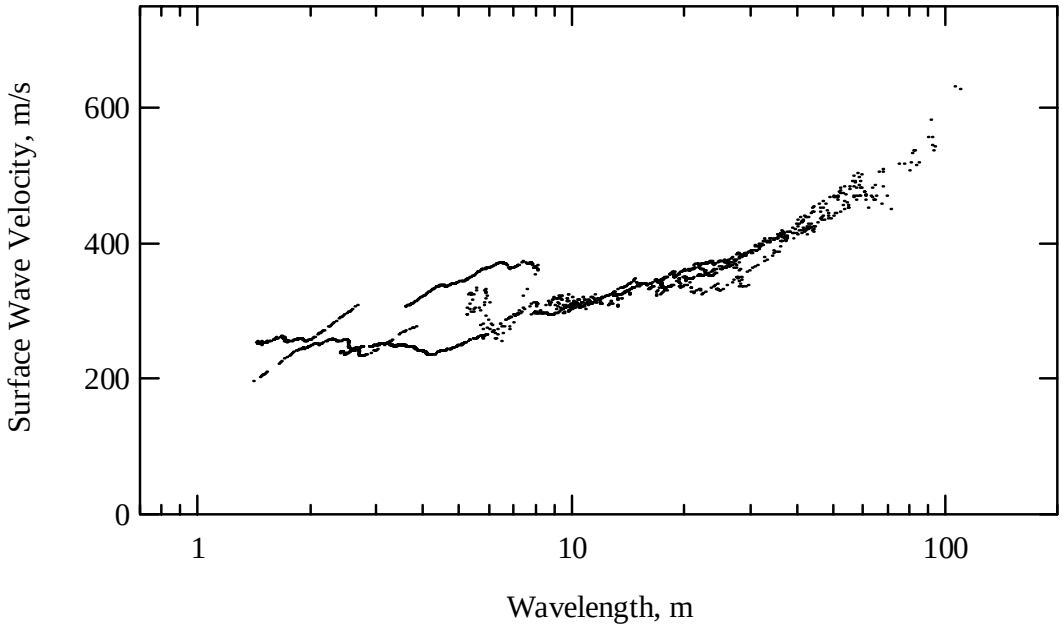

Fig. 2.142 Experimental dispersion curve measured at the Fire Training Tower (FTT), Salt Lake County, Utah.

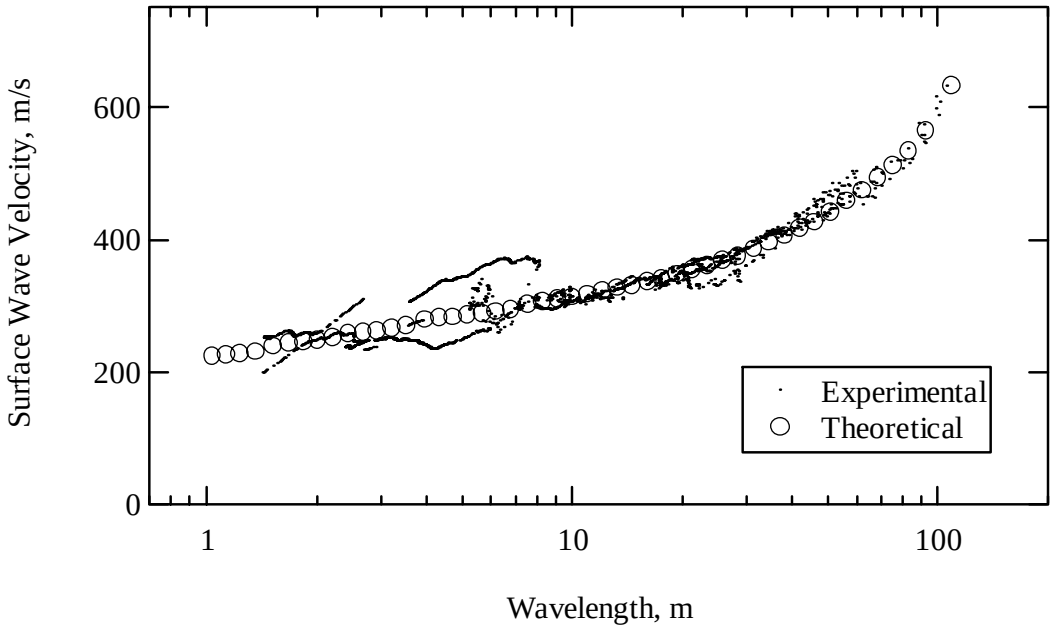

Fig. 2.143 Comparison of experimental and theoretical dispersion curves from the Fire Training Tower (FTT), Salt Lake County, Utah.

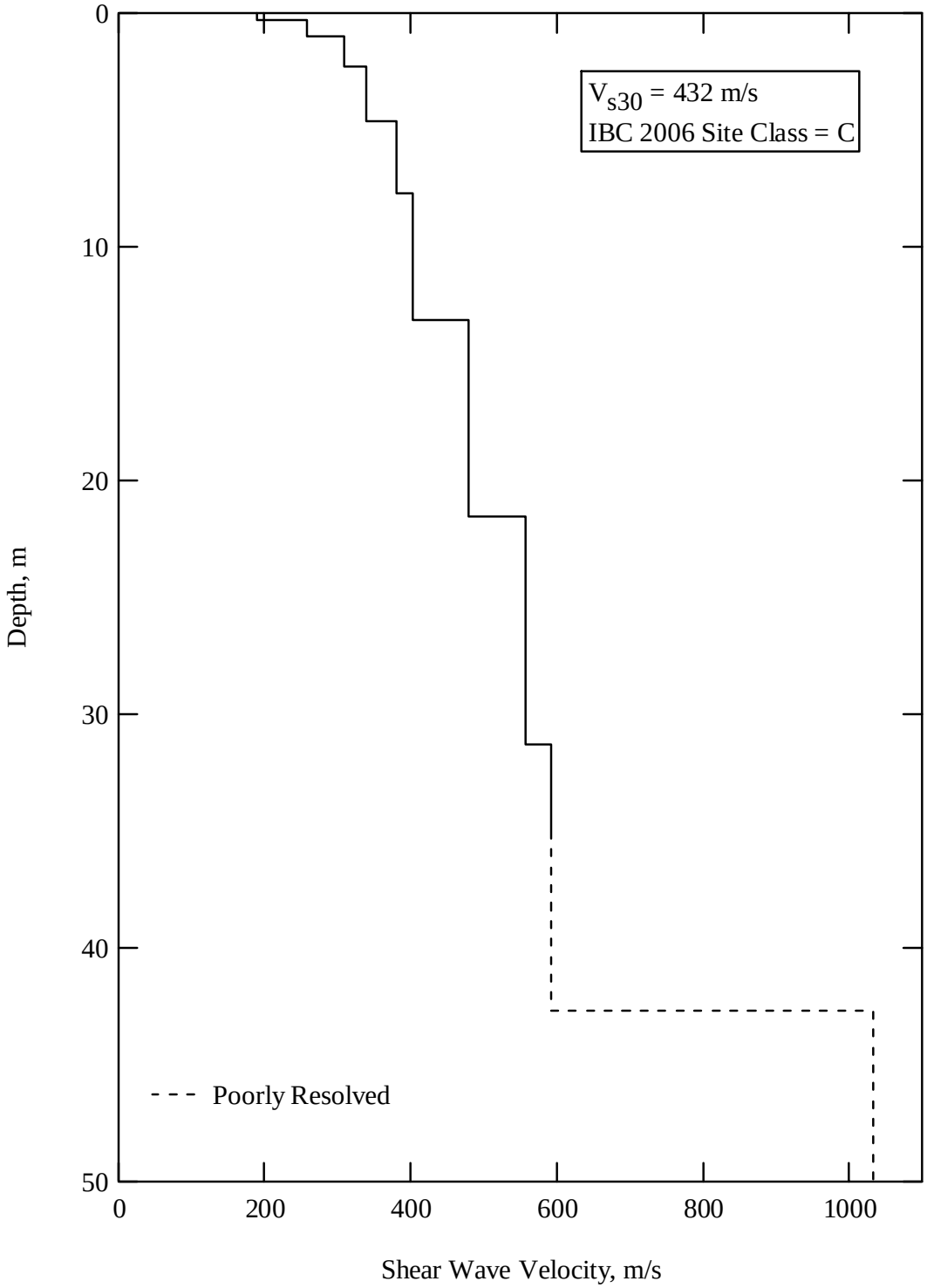

Fig. 2.144 Shear wave velocity profile determined from SASW at the Fire Training Tower (FTT), Salt Lake County, Utah.

The average shear wave velocity in the upper 30 m of soil is 432 m/s, which corresponds to an IBC 2006 site class C. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 50 m.

Table 2.28 Tabulated measured and assumed layer properties at the Fire Training Tower (FTT), Salt Lake County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	190	356	0.3	1.90
0.3	0.7	259	485	0.3	1.92
0.9	1.3	309	578	0.3	2.00
2.2	2.4	339	634	0.3	2.00
4.6	3.1	380	711	0.3	2.00
7.7	5.4	403	754	0.3	2.00
13.1	8.4	479	896	0.3	2.00
21.5	9.8	557	1042	0.3	2.00
31.3	3.7	592	1108	0.3	2.00

Figure 2.145 shows the shear wave velocity profile from the 2003 SASW study of the Salt Lake Valley by Gilbert (2004) compared to the 2005 profile. The SASW array from the previous study was located in a field to the south of the Fire Training Tower, on the opposite side of the Tower relative to the location of the 2005 array. The two profiles are very similar and have V_{S30} values that are nearly identical. The slight differences are likely due to geologic variability at the site. The comparison is a good demonstration of the repeatability of the SASW method.

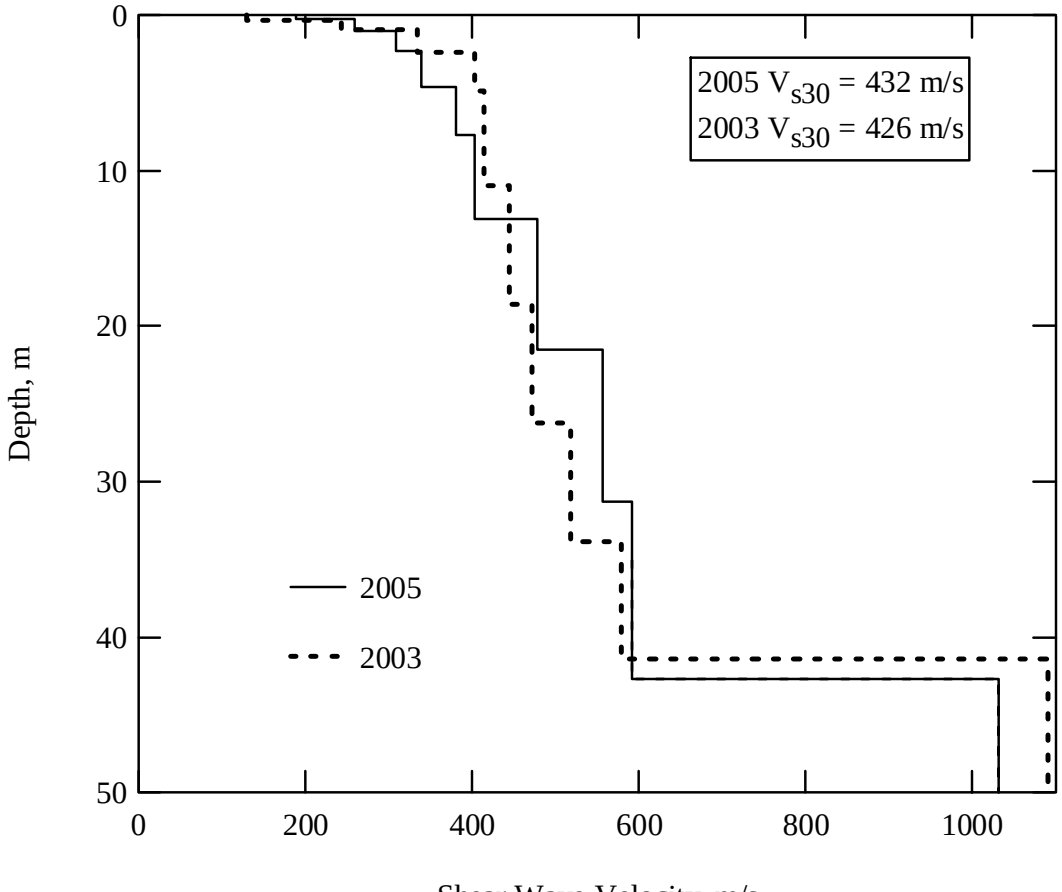

Fig. 2.145 Comparison of shear wave velocity profiles determined from SASW at the Fire Training Tower (FTT), Salt Lake County, Utah.

2.3.2. North Oquirrh Seismic Station

SASW testing was performed at the North Oquirrh Seismic Station which is monitored by the University of Utah Seismograph Stations. In this report, the site will be referred to as NOQ which is the same reference name as the strong motion station. The GPS derived latitude and longitude of the center of the SASW testing array are 40.65262 North and 112.12094 East, with an elevation of approximately 1624 m above sea level using the NAD83 datum. A site map showing the general location of the SASW array is shown in Fig. 2.146. Two SASW tests were performed at the site; one on a rock outcrop directly above the NOQ strong motion sensor, and the second was on soil near the outcrop. Testing was performed at 12:00 p.m. on August 25, 2005.

A photograph of the soil site is shown in Fig. 2.147 where the outcrop can be seen in the background. The array was located along the ridge starting near the rock outcrop, and heading up the slope. Only hammer spacings were used at this site because of the remote location. The spacings for the soil site were: 20 m, 10 m, 5 m, 4 m, and 2 m. All of the listed spacings were measured in the forward and reverse direction to accommodate a good average.

A photograph of the rock outcrop site is shown in Figure 2.148. The photograph shows the orientation of the SASW array, and the hammer that is used to create the seismic waves. The spacings that were used on the rock outcrop were 2 m and 4 m. Both were tested in the forward and reverse direction. A photograph of the strong motion sensor is shown in Figure 2.149, which is located directly below and to the west of the rock outcrop. Most likely it rests on bedrock with properties similar to the tested material.

Figure 2.150 shows the experimental dispersion curve measured at the soil site. Figure 2.151 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.152 shows the calculated shear wave velocity profile for the soil site. The shear wave velocity profile is well resolved to a depth of 7.1 m after which the half-space velocity is 651 m/s. Table 2.29 contains the tabulated layer properties for the soil site including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities.

Figure 2.153 shows the experimental dispersion curve measured at the rock site. Figure 2.154 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.155 shows the calculated shear wave velocity profile for the rock site. The shear wave velocity profile is well resolved to a depth of 0.46 m after which the half-space velocity is 1220 m/s. The shear wave velocity for the upper 0.46 m of rock is approximately 658 m/s.

Table 2.30 contains the tabulated layer properties for the rock site including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities.

Fig. 2.146 Site map showing the location of the SASW array at The North Oquirrh Seismic Station (NOQ), Salt Lake County, Utah (from Google Earth 2006).

Fig. 2.147 Photograph of SASW testing at the North Oquirrh Seismic Station soil site (NOQ), Salt Lake County, Utah.

Fig. 2.148 Photograph of SASW testing on the rock site at the North Oquirrh Seismic Station (NOQ), Salt Lake County, Utah.

Fig. 2.149 Photograph of the strong motion station container located at the North Oquirrh Seismic Station site (NOQ), Salt Lake County, Utah.

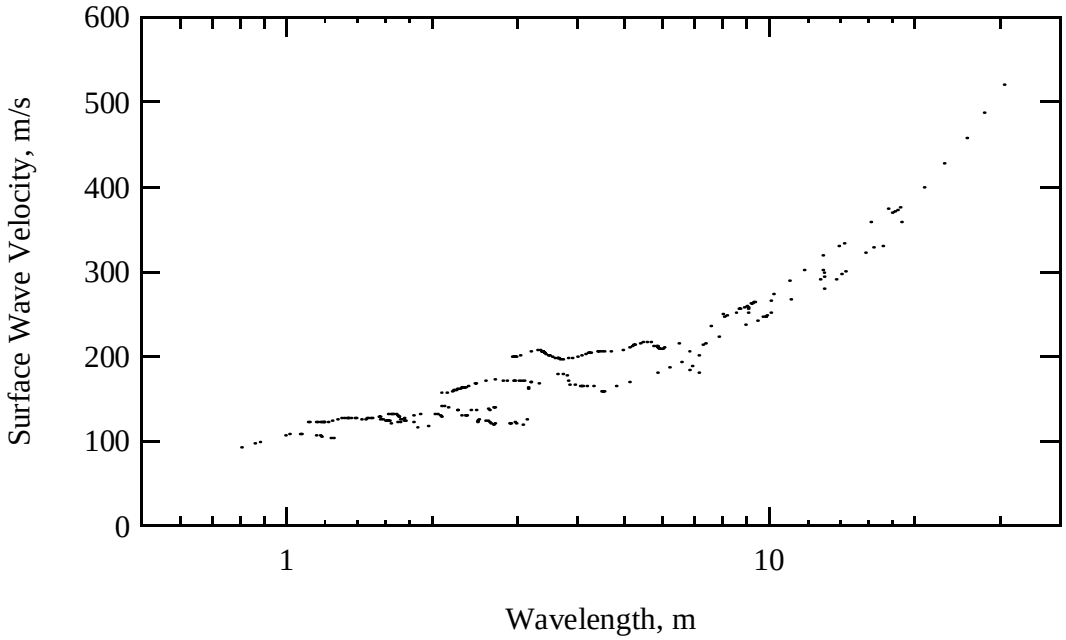

Fig. 2.150 Experimental dispersion curve measured at the North Oquirrh Seismic Station soil site (NOQ), Salt Lake County, Utah.

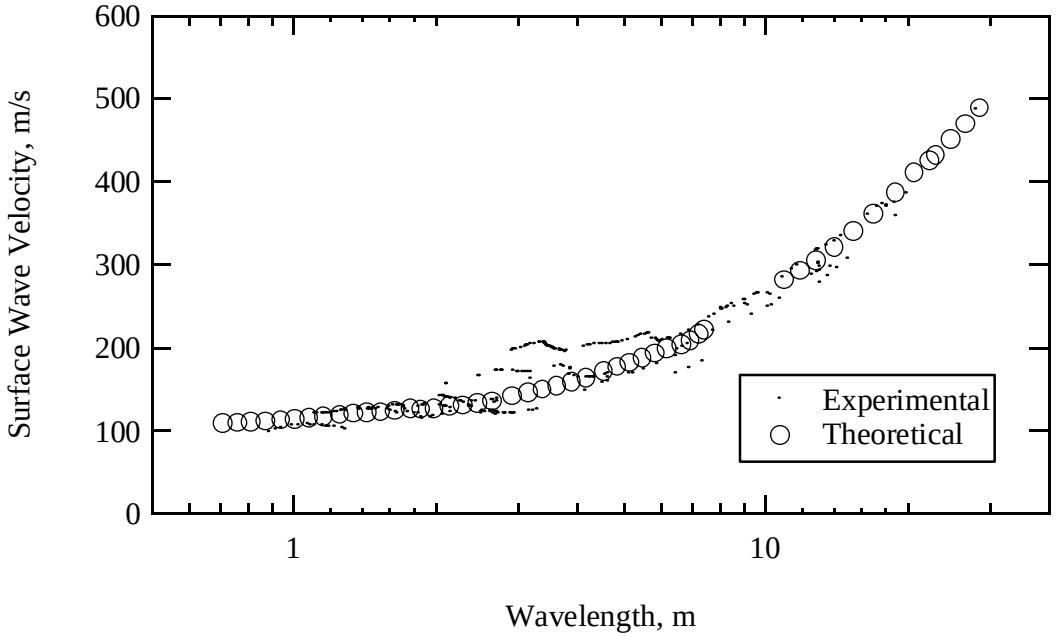

Fig. 2.151 Comparison of experimental and theoretical dispersion curves from the North Oquirrh Seismic Station soil site (NOQ), Salt Lake County, Utah.

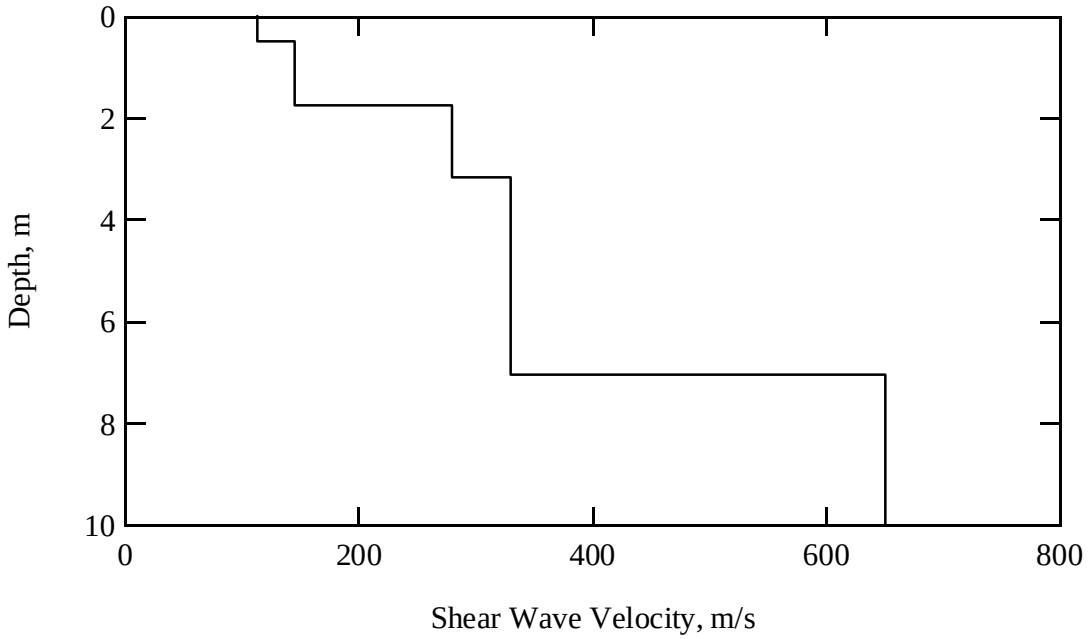

Fig. 2.152 Shear wave velocity profile determined from SASW at the North Oquirrh Seismic Station soil site (NOQ), Salt Lake County, Utah.

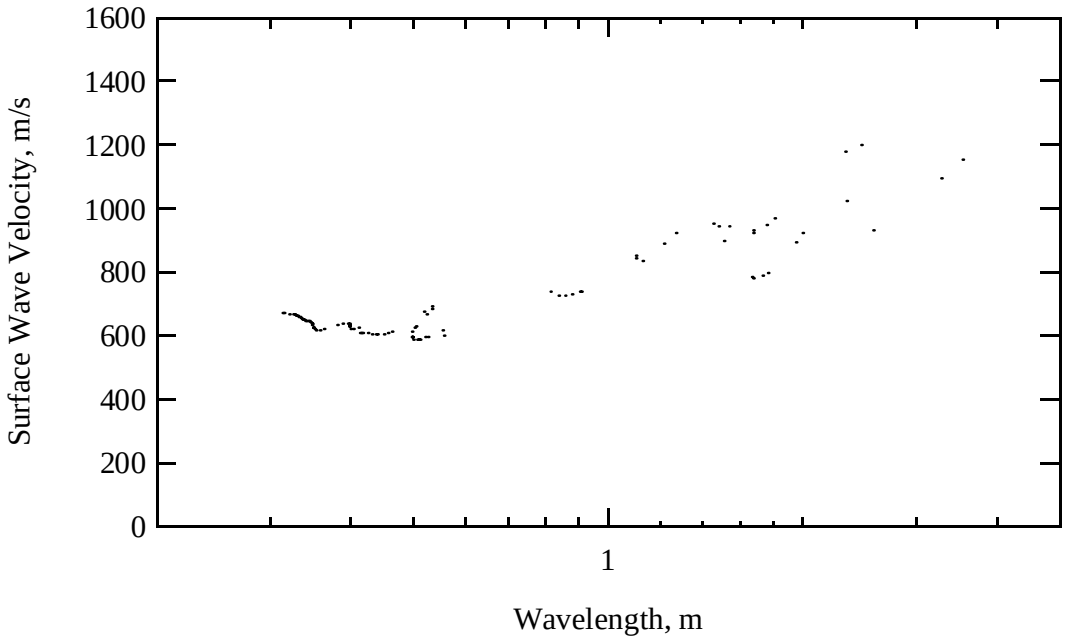

Fig. 2.153 Experimental dispersion curve measured at the North Oquirrh Seismic Station rock site (NOQ), Salt Lake County, Utah.

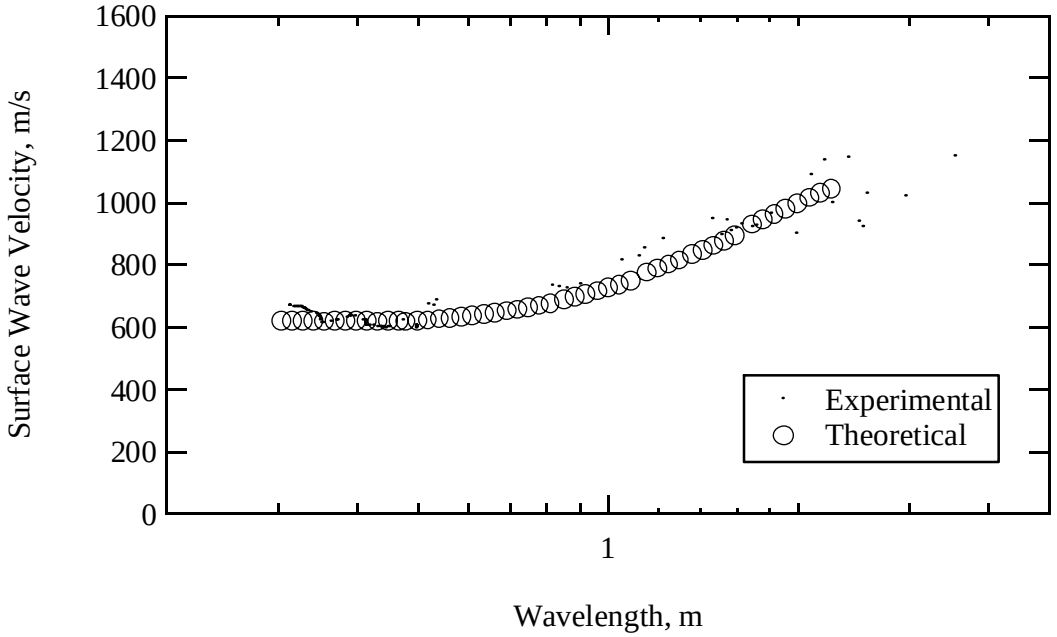

Fig. 2.154 Comparison of experimental and theoretical dispersion curves from the North Oquirrh Seismic Station rock site (NOQ), Salt Lake County, Utah.

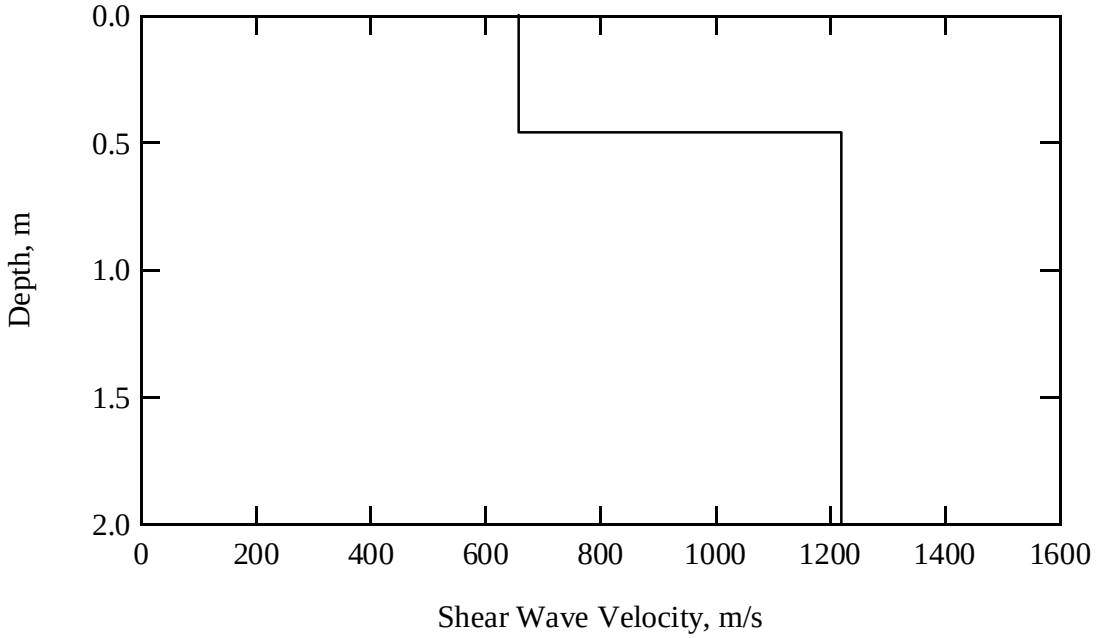

Fig. 2.155 Shear wave velocity profile determined from SASW at the North Oquirrh Seismic Station rock site (NOQ), Salt Lake County, Utah.

Table 2.29 Tabulated measured and assumed layer properties at the North Oquirrh Seismic Station soil site (NOQ), Salt Lake County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.5	113	211	0.30	1.92
0.5	1.3	145	271	0.30	1.92
1.8	1.4	280	524	0.30	2.00
3.2	3.9	330	617	0.30	2.00

Table 2.30 Tabulated measured and assumed layer properties at the North Oquirrh Seismic Station rock site (NOQ), Salt Lake County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer	Layer Thickness (m)	Shear Wave Velocity	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)

(m)		(m/s)			
0.0	0.46	658	1231	0.30	2.06
0.46	0.54	1220	2282	0.30	2.06

2.3.3. Camp Tracy

SASW testing was performed at Camp Tracy on the east side of the salt lake valley, designated as CTU in this report. The GPS derived latitude and longitude of the center of the SASW testing array are 40.6925 North and 111.7511 East, with an elevation of approximately 1732 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.156.

Testing was performed at 4:00 p.m. on August 25, 2005. The SASW array was located on a hiking trail just above a broadband seismometer monitored by the University of Utah Seismograph Stations, also known as CTU. A photograph of the site is shown in Fig. 2.157 that was taken next to the seismometer looking up at the hiking trail and SASW array. The hammer spacings used at the site were: 2 m, 3 m, 4 m, and 6 m. Both forward and reverse directions were tested.

Figure 2.158 shows the experimental dispersion curve measured at Camp Tracy. Figure 2.159 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.160 shows the calculated shear wave velocity profile for the site. Table 2.31 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

The shear wave velocity profile is well resolved to a depth of 3 m showing velocities of approximately 1000 m/s for the near surface rock.

Fig. 2.156 Site map showing the location of the centerline of the SASW array at Camp Tracy (CTU), Salt Lake County, Utah (from Google Earth 2006).

Fig. 2.157 Photograph of SASW testing at Camp Tracy (CTU), Salt Lake County, Utah.

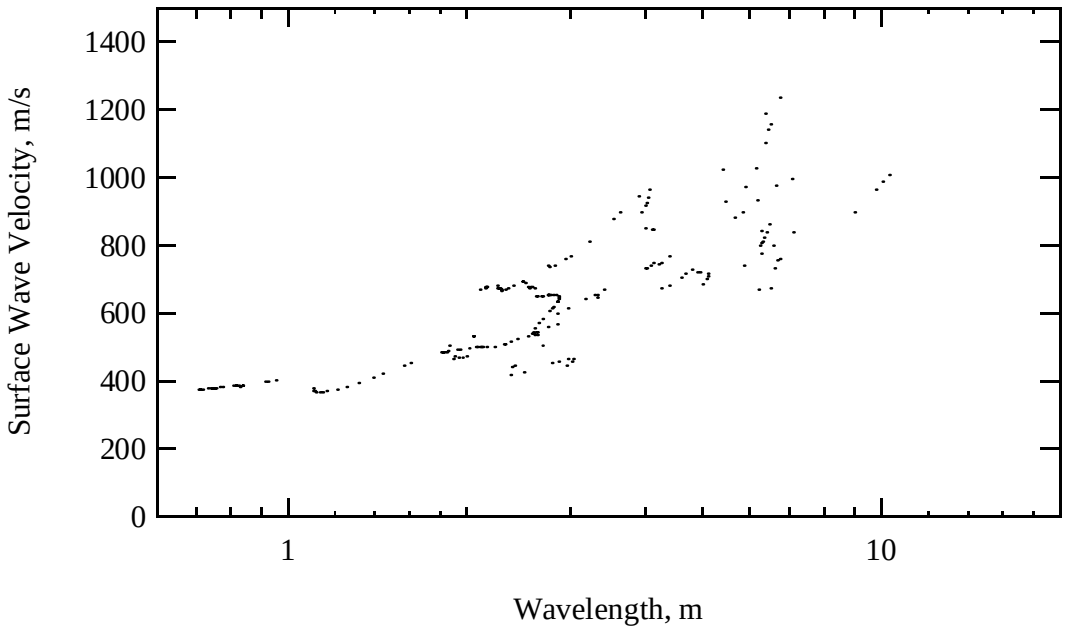

Fig. 2.158 Experimental dispersion curve measured at Camp Tracy (CTU), Salt Lake County, Utah.

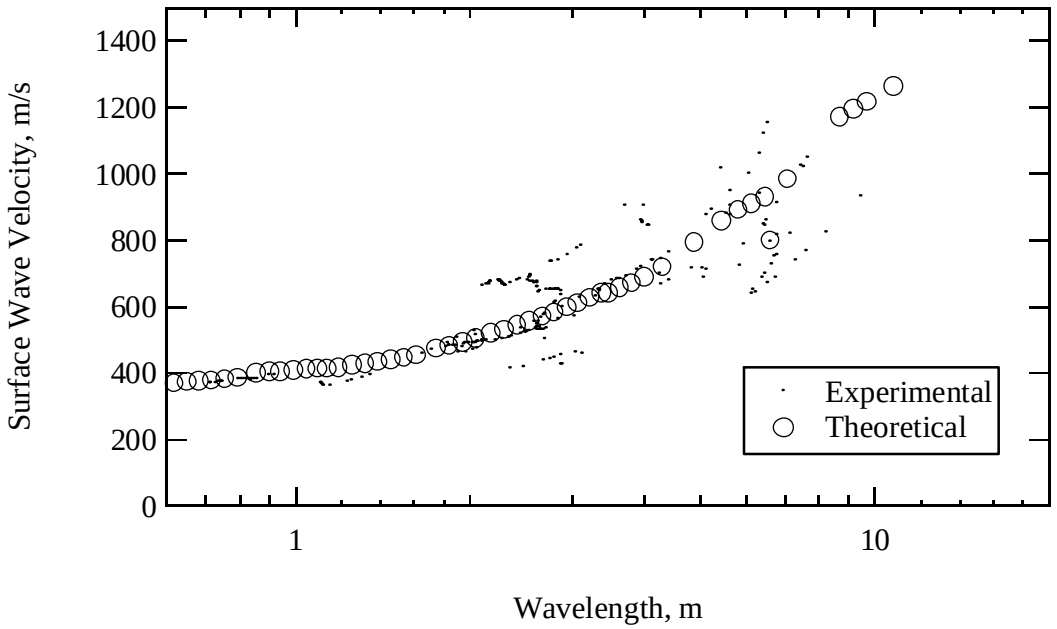

Fig. 2.159 Comparison of experimental and theoretical dispersion curves from Camp Tracy (CTU), Salt Lake County, Utah.

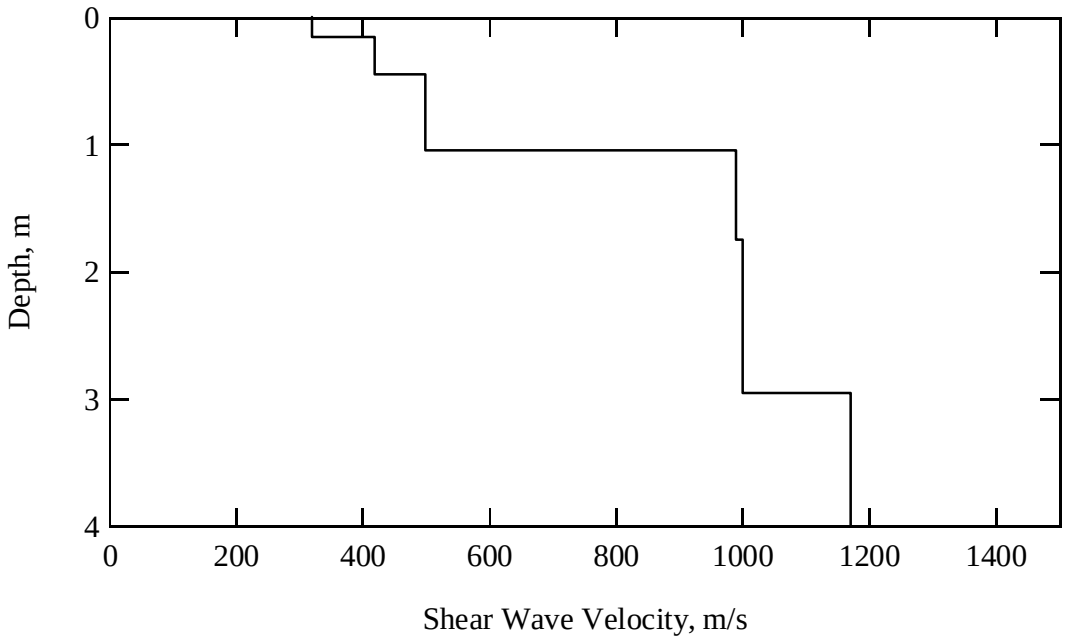

Fig. 2.160 Shear wave velocity profile determined from SASW at Camp Tracy (CTU), Salt Lake County, Utah.

Table 2.31 Tabulated measured and assumed layer properties at Camp Tracy (CTU), Salt Lake County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.2	320	599	0.30	2.00
0.2	0.3	420	786	0.30	2.00
0.5	0.6	500	935	0.30	2.06
1.1	0.7	990	1852	0.30	2.06
1.8	1.2	1000	1871	0.30	2.06
3.0	1.0	1170	2189	0.30	2.06

2.4. UTAH COUNTY

The study region was heavily focused on Northern Utah County. Testing was not performed any further south of Salem, Utah. The northern portion of the County can be subdivided into two distinct parts: the eastern Utah Valley, and the Cedar Valley to the west. The Utah valley is bounded by the Wasatch Mountains on the east and partially by Utah Lake on the west. The northern most city in Utah County is Lehi, near the point of the mountain. The Cedar Valley is located to the west of Utah Lake, surrounded by mountains.

The surficial geologic units in the eastern Utah Valley consist mostly of lacustrine deposits of Late Pleistocene Lake Bonneville overlain be the latest Pleistocene to Halocene alluvium and alluvial fan deposits (Bay et al. 2005). The surficial geologic units in the Cedar Valley consist of pre-Bonneville alluvial fan deposits and lacustrine deposits of Late Pleistocene Lake Bonneville, Local latest Pleistocene to Holocene alluvium, alluvial fan deposits, and loess overlain by lacustrine deposits (Bay et al. 2005).

Our testing focused on the urban corridor of Utah County. Only a single SASW test was performed in the Cedar Valley area. A total of 15 new sites were tested during this study, more than doubling the existing number of profiles. Figure 2.161 shows the site condition map from Ashland and McDonald (2003) and Ashland et al. (2005). The figure also shows the spatial distribution of new V_{S30} sites, and the locations of existing V_{S30} sites. The distribution of the new sites in the different Quaternary units is: (Q01) 5 new sites were tested, there were 2 existing sites in the unit. (Q02) 5 new sites were tested, there were 2 existing sites in the unit. (Q03) 5 new sites were tested, there was 3 existing sites in the unit (2 of which are located in the Cedar Valley area).

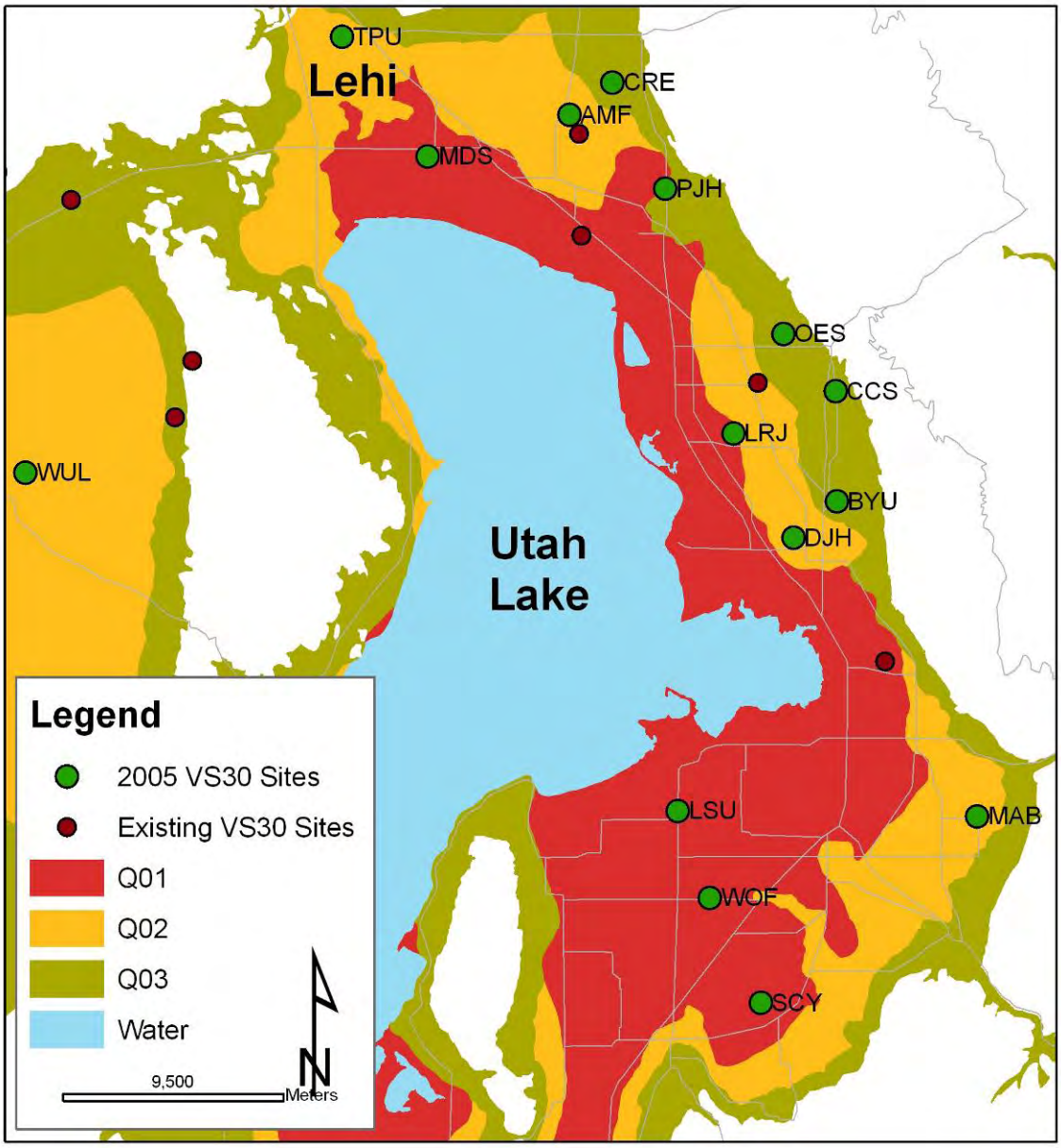

Fig. 2.161 Map showing spatial distribution of V_{S30} sites Utah County, Utah.

2.4.1. Meadow School

SASW testing was performed at Meadow School, designated as MDS in this report, located at 176 S. 500 W., Lehi, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.38494 North and 111.85898 East, with an elevation of approximately 1389 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.162.

Testing was performed at 10:30 a.m. on August 17, 2005. The SASW array was located to the south of the school building oriented in the north-south direction. A photograph of the site is shown in Fig. 2.163. A fully saturated zone was assumed to

exist at a depth of 3.3 m below the ground surface. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.25 m with 15 cm of padding.

Figure 2.164 shows the experimental dispersion curve measured at Meadow School. Figure 2.165 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.166 shows the calculated shear wave velocity profile for the site. Table 2.32 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

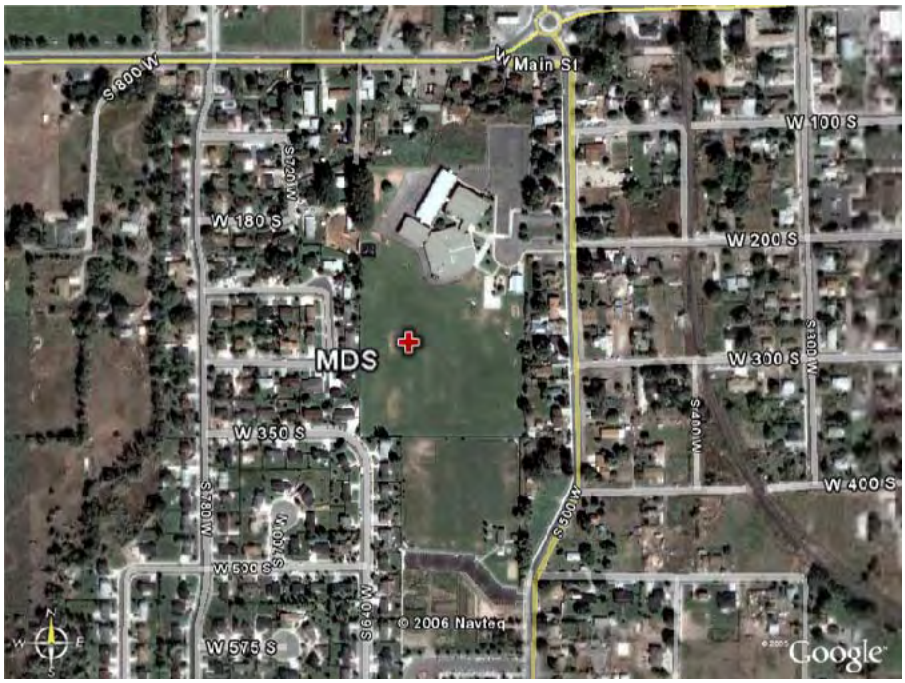

Fig. 2.162 Site map showing the location of the centerline of the SASW array at the Meadow School (MDS), Utah County, Utah (from Google Earth 2006).

Fig. 2.163 Photograph of SASW testing at the Meadow School (MDS), Utah County, Utah.

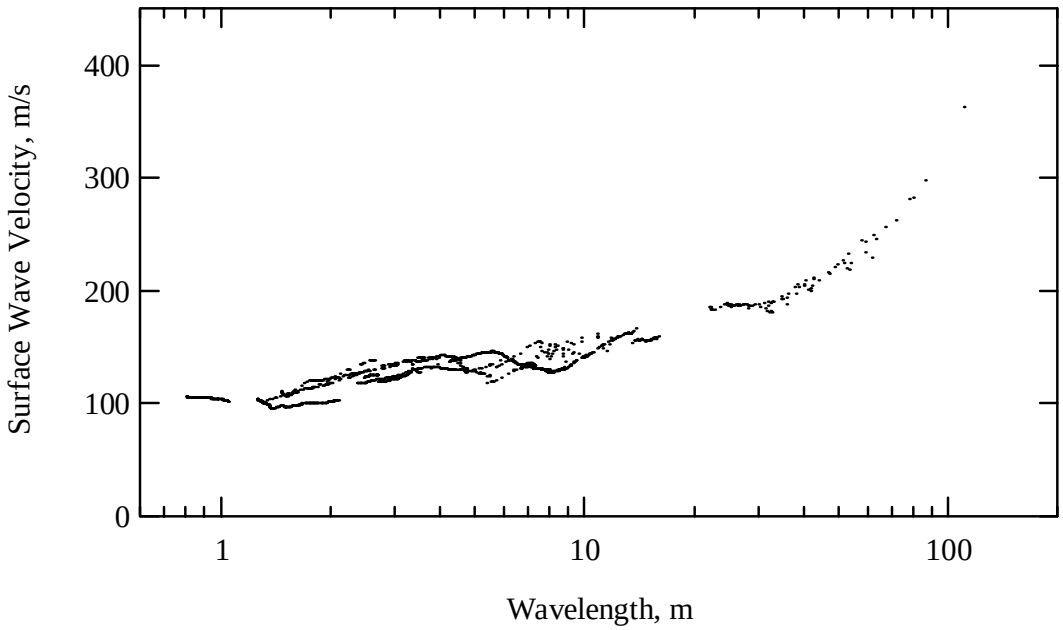

Fig. 2.164 Experimental dispersion curve measured at the Meadow School (MDS), Utah County, Utah.

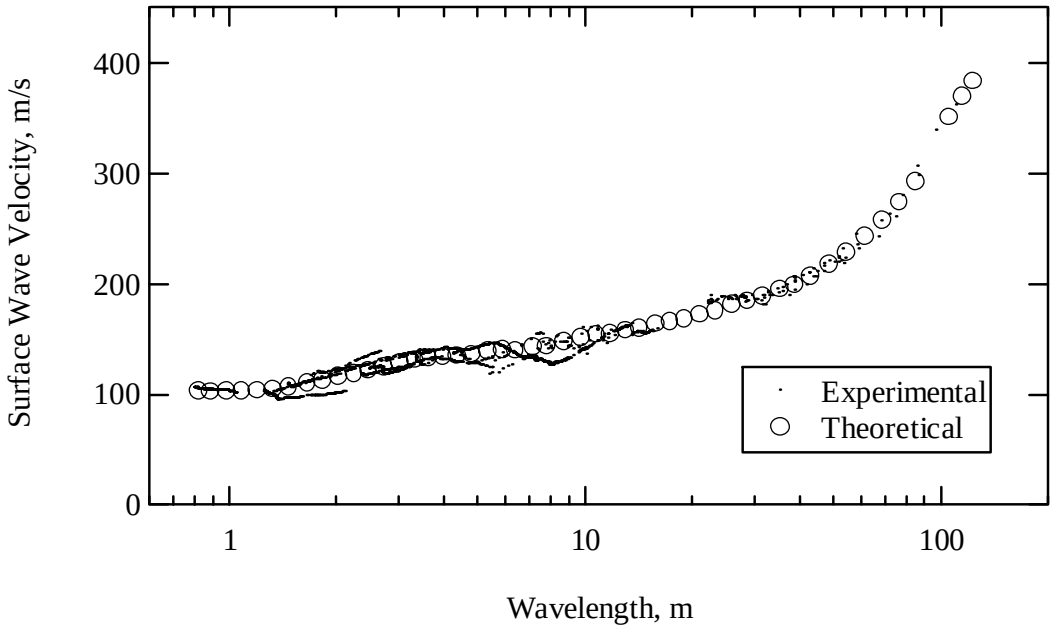

Fig. 2.165 Comparison of experimental and theoretical dispersion curves from the Meadow School (MDS), Utah County, Utah.

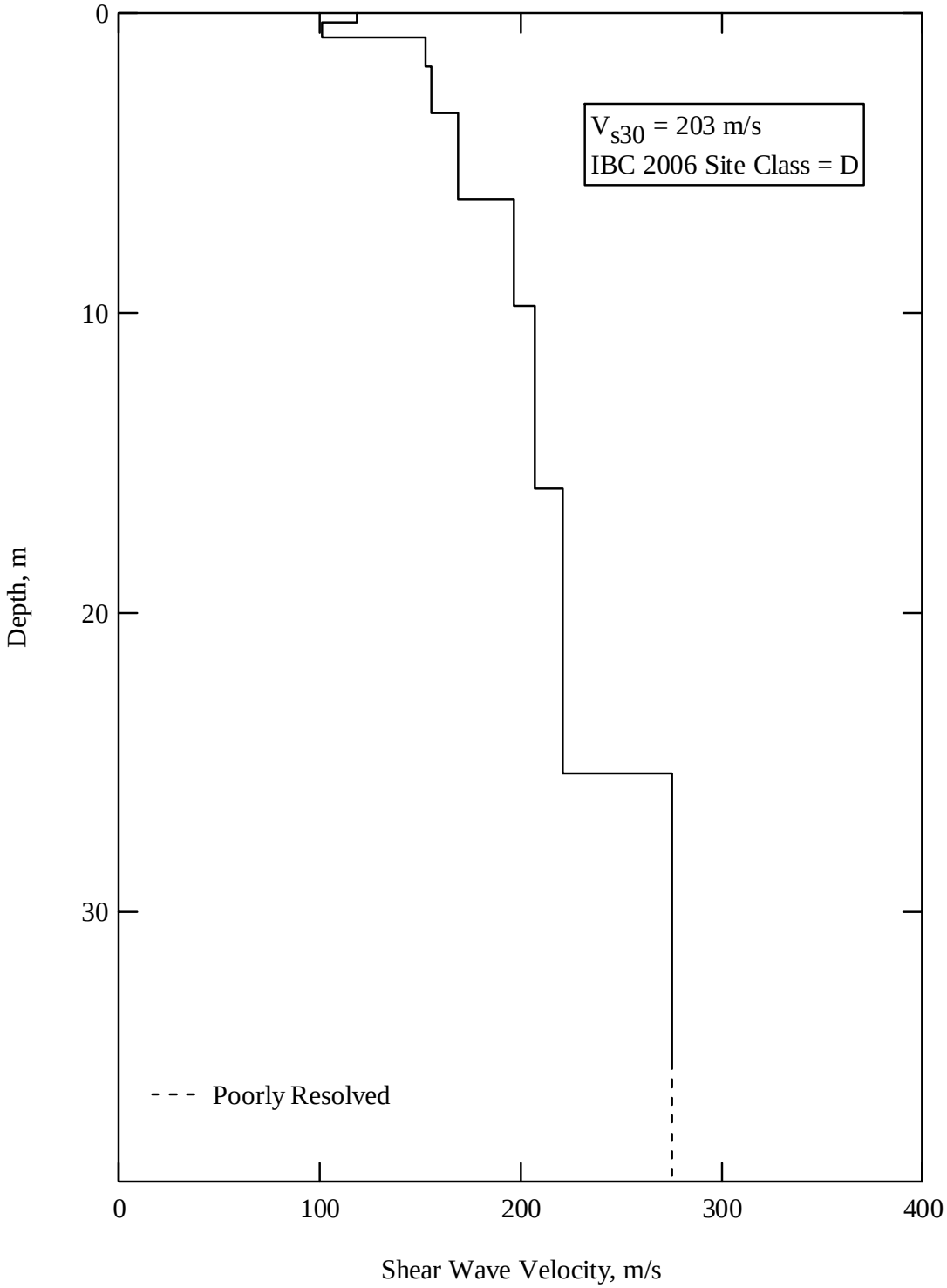

Fig. 2.166 Shear wave velocity profile determined from SASW at the Meadow School (MDS), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 203 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 40 m.

Table 2.32 Tabulated measured and assumed layer properties at the Meadow School (MDS), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.00	0.29	119	223	0.3	1.89
0.29	0.51	101	189	0.3	1.89
0.80	0.97	153	286	0.3	1.92
1.77	1.56	156	292	0.3	1.92
3.33	2.87	169	1500	0.49	1.92
6.20	3.56	197	1500	0.49	1.92
9.76	6.12	207	1500	0.49	1.92
15.88	9.50	221	1500	0.49	1.92
25.38	9.62	275	1500	0.48	1.92

2.4.2. Lakeridge Junior High School

SASW testing was performed at the Lakeridge Junior High School, designated as LRJ in this report, located 951 S. 400 W., Orem, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.27874 North and 111.70277 East, with an elevation of approximately 1420 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.167.

Testing was performed at 11:00 a.m. on August 18, 2005. The SASW array was located to the south of the school building oriented in the east-west direction. A photograph of the site is shown in Fig. 2.168 where the school building can be seen in the background. A fully saturated zone was assumed to exist at a depth of 3.8 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.2 m with 19 cm of padding.

Figure 2.169 shows the experimental dispersion curve measured at Lakeridge Junior High School. Figure 2.170 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure

2.171 shows the calculated shear wave velocity profile for the site. Table 2.33 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.167 Site map showing the location of the centerline of the SASW array at Lakeridge Junior High School (LRJ), Utah County, Utah (from Google Earth 2006).

Fig. 2.168 Photograph of SASW testing at Lakeridge Junior High School (LRJ), Utah County, Utah.

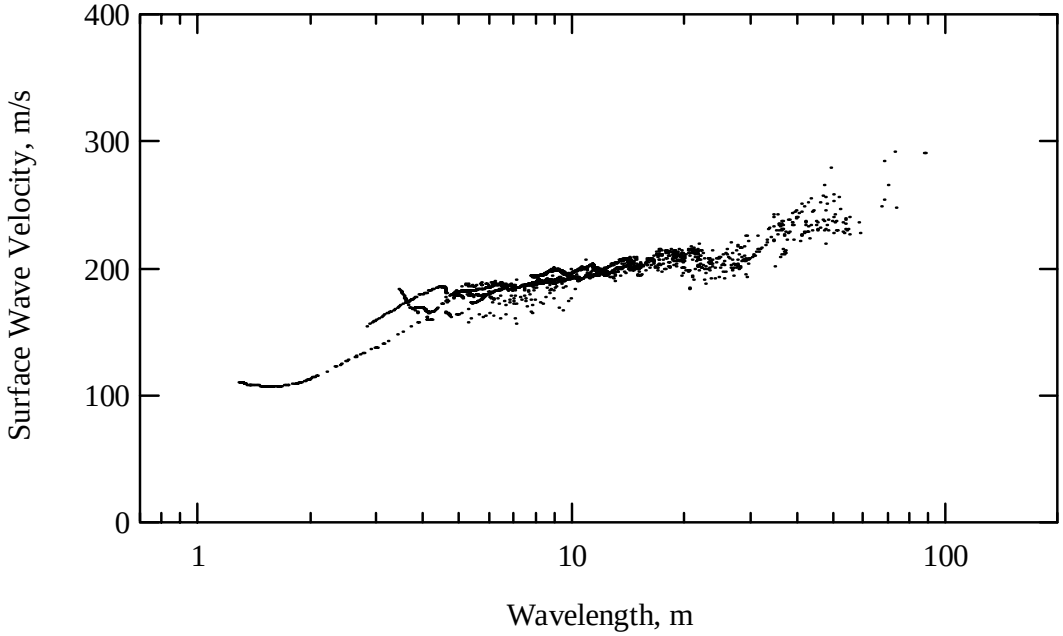

Fig. 2.169 Experimental dispersion curve measured at Lakeridge Junior High School (LRJ), Utah County, Utah.

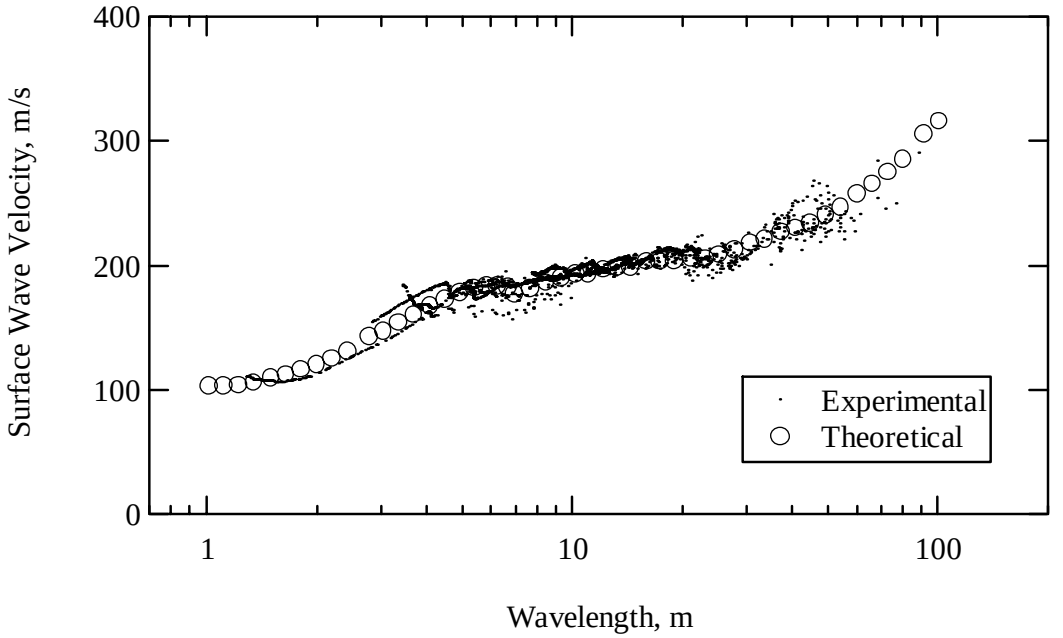

Fig. 2.170 Comparison of experimental and theoretical dispersion curves from Lakeridge Junior High School (LRJ), Utah County, Utah.

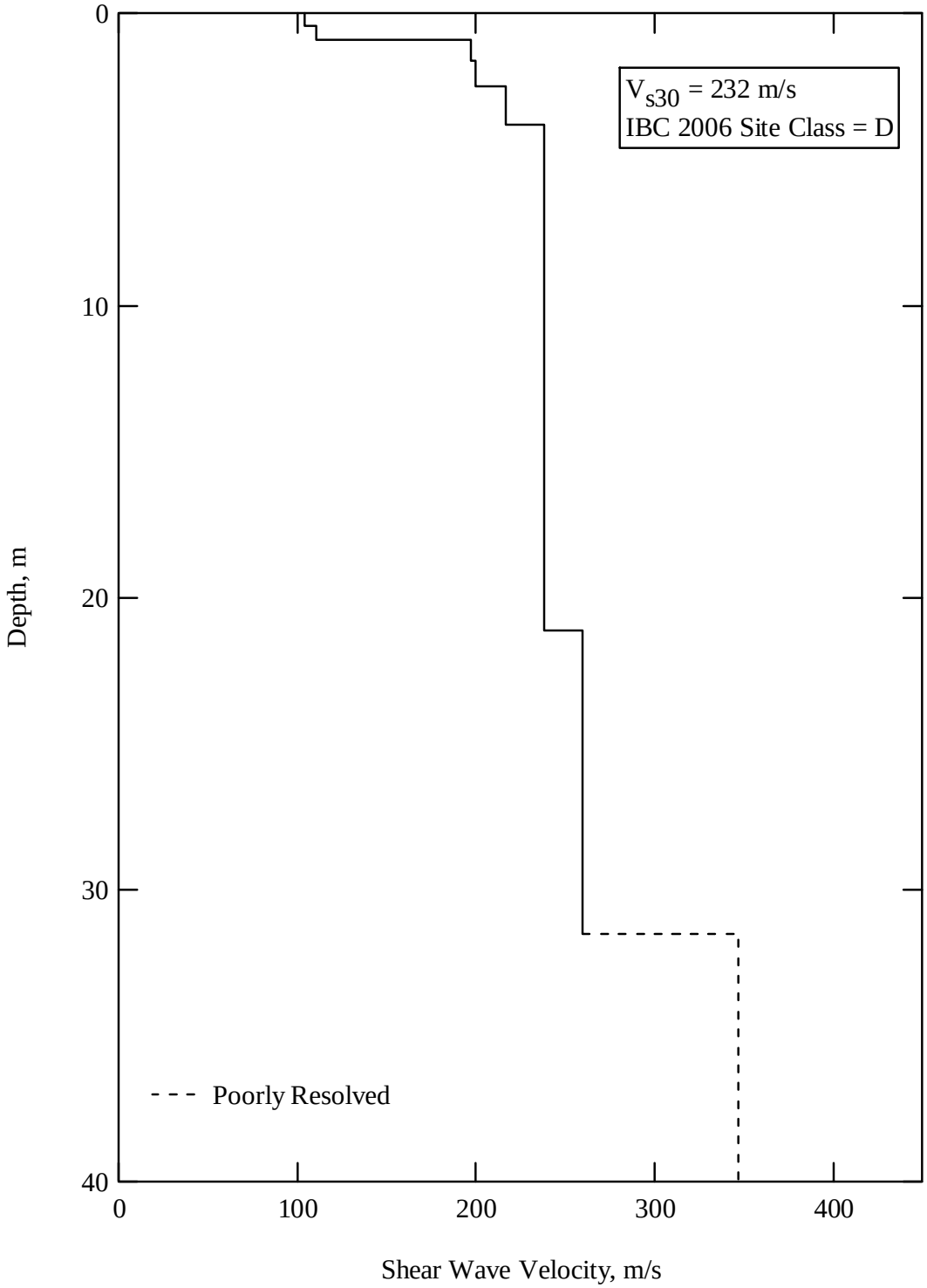

Fig. 2.171 Shear wave velocity profile determined from SASW at Lakeridge Junior High School (LRJ), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 232 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 31.5 m and poorly resolved from 31.5 m to 40 m.

Table 2.33 Tabulated measured and assumed layer properties at Lakeridge Junior High School (LRJ), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	104	195	0.3	1.89
0.4	0.5	111	208	0.3	1.89
0.9	0.7	197	369	0.3	1.89
1.6	0.9	200	374	0.3	1.90
2.5	1.3	217	405	0.3	1.90
3.8	2.8	238	1500	0.49	1.90
6.6	5.5	238	1500	0.49	1.90
12.1	9.0	238	1500	0.49	1.90
21.2	10.4	260	1500	0.48	1.90

2.4.3. Youd Home

SASW testing was performed at the Youd Family Home, designated as LSU in this report, located at 5400 S. 3200 W., Lakeshore, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.13253 North and 111.72926 East, with an elevation of approximately 1380 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.172. This site is of particular interest because a strong motion sensor is located adjacent to the SASW array in a masonry storage building.

Testing was performed at 2:00 p.m. on August 23, 2005. The SASW array was located along a dirt access road oriented in the east-west direction. A photograph of the site is shown in Fig. 2.173 where the masonry building containing the strong motion sensor can also be seen. Standing water indicated a shallow water table such that a fully saturated zone was assumed to exist at a depth of 1.4 m below the ground surface.

Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.2 m with 1.5 cm of padding used for dust control purposes.

Figure 2.174 shows the experimental dispersion curve measured at the Youd home. Figure 2.175 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.176 shows the calculated shear wave velocity profile for the site. Table 2.34 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.172 Site map showing the location of the centerline of the SASW array at the Youd Home (LSU), Utah County, Utah (from Google Earth 2006).

Fig. 2.173 Photograph of SASW testing at the Youd Home (LSU), Utah County, Utah.

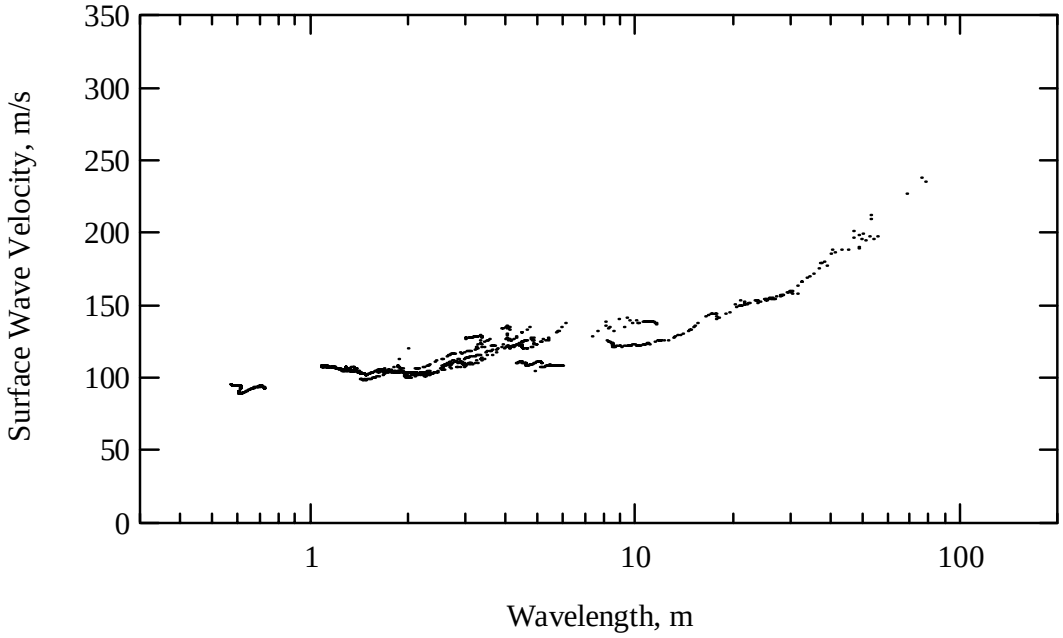

Fig. 2.174 Experimental dispersion curve measured at the Youd Home (LSU), Utah County, Utah.

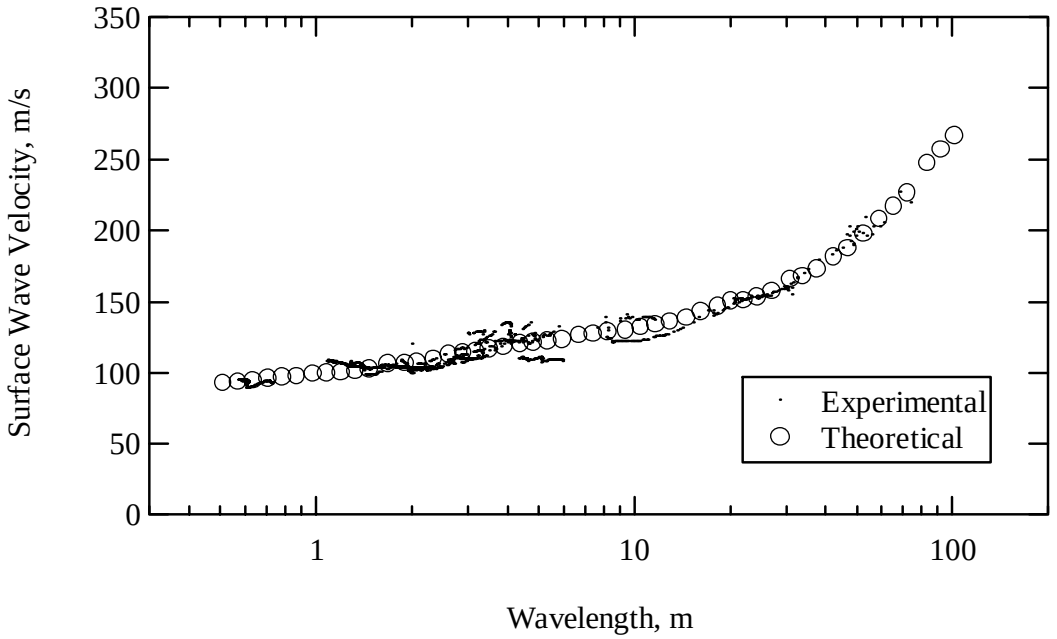

Fig. 2.175 Comparison of experimental and theoretical dispersion curves from Lakeshore (LSU), Utah County, Utah.

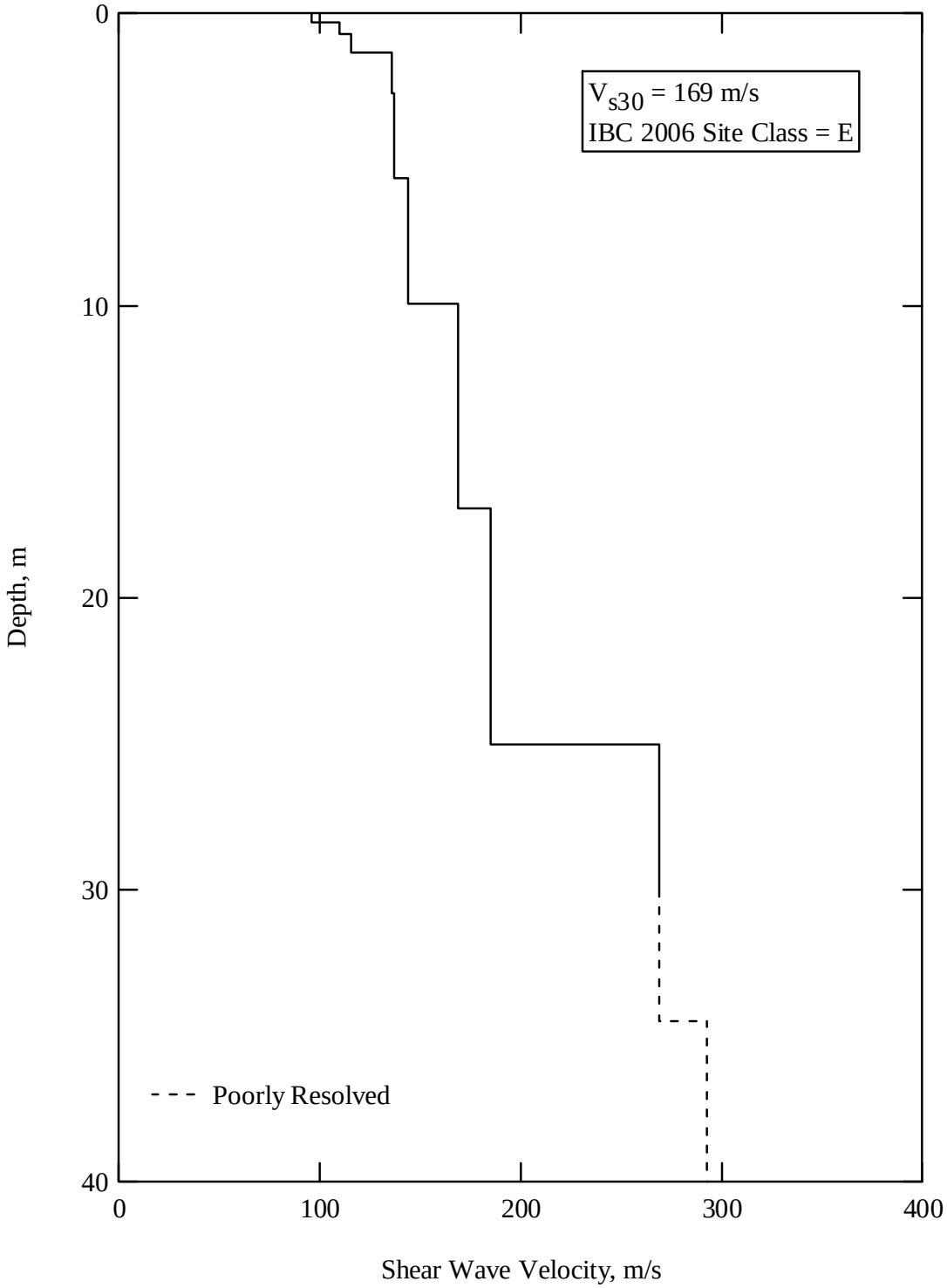

Fig. 2.176 Shear wave velocity profile determined from SASW at the Youd Home (LSU), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 169 m/s, which corresponds to an IBC 2006 site class E. The shear wave velocity profile is well resolved to a depth of 30 m and poorly resolved from 30 m to 40 m.

Table 2.34 Tabulated measured and assumed layer properties at the Youd Home (LSU), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	96	180	0.30	1.89
0.3	0.4	110	206	0.30	1.89
0.7	0.7	116	217	0.30	1.89
1.4	1.4	136	1500	0.50	1.89
2.7	2.9	137	1500	0.50	1.89
5.6	4.3	144	1500	0.50	1.89
10.0	7.0	169	1500	0.49	1.92
16.9	8.1	185	1500	0.49	1.92
25.0	5.0	269	1500	0.48	1.92

2.4.4. Salem City Yard

SASW testing was performed at the Salem City Yard, designated as SCY in this report, located at 200 N 500 W., Salem, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.05857 North and 111.68673 East, with an elevation of approximately 1393 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.177. This site is of particular interest because a strong motion sensor is located near the SASW array in the City Yard.

Testing was performed at 4:30 p.m. on August 23, 2005. The SASW array was located along a dirt road to the west of the City Yard. A photograph of the site is shown in Fig. 2.178. The strong motion station is located approximately 100 m from the centerline of the SASW array. Standing water indicated a shallow water table such that a fully saturated zone was assumed to exist at a depth of 2.6 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.5 m with no padding.

Figure 2.179 shows the experimental dispersion curve measured at the Salem City Yard. Figure 2.180 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.181 shows the calculated shear wave velocity profile for the site. Table 2.35 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.177 Site map showing the location of the centerline of the SASW array at the Salem City Yard (SCY), Utah County, Utah (from Google Earth 2006).

Fig. 2.178 Photograph of SASW testing at the Salem City Yard (SCY), Utah County, Utah.

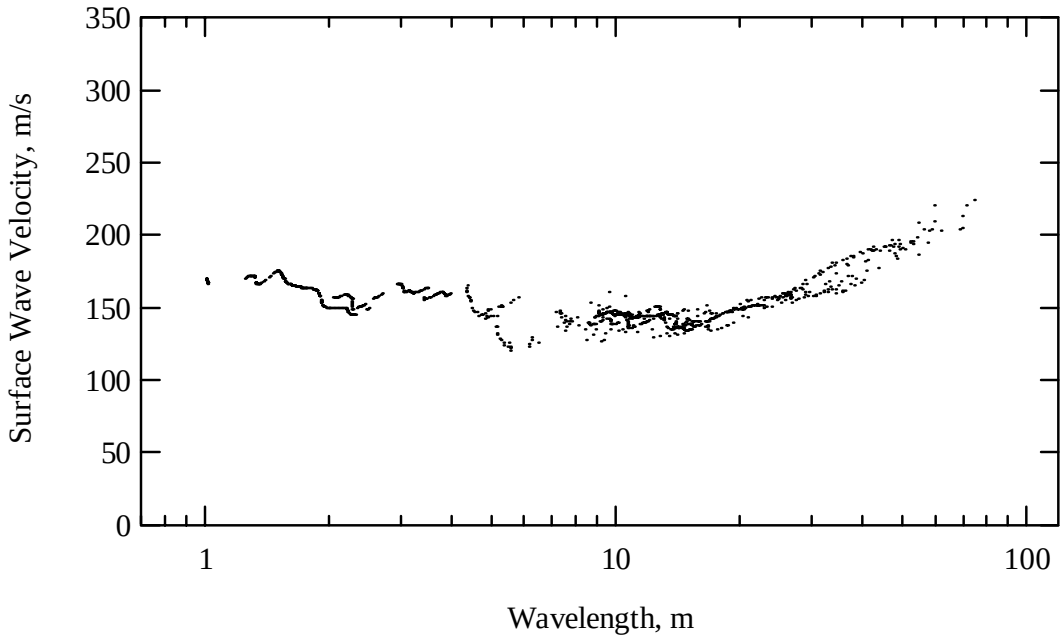

Fig. 2.179 Experimental dispersion curve measured at the Salem City Yard (SCY), Utah County, Utah.

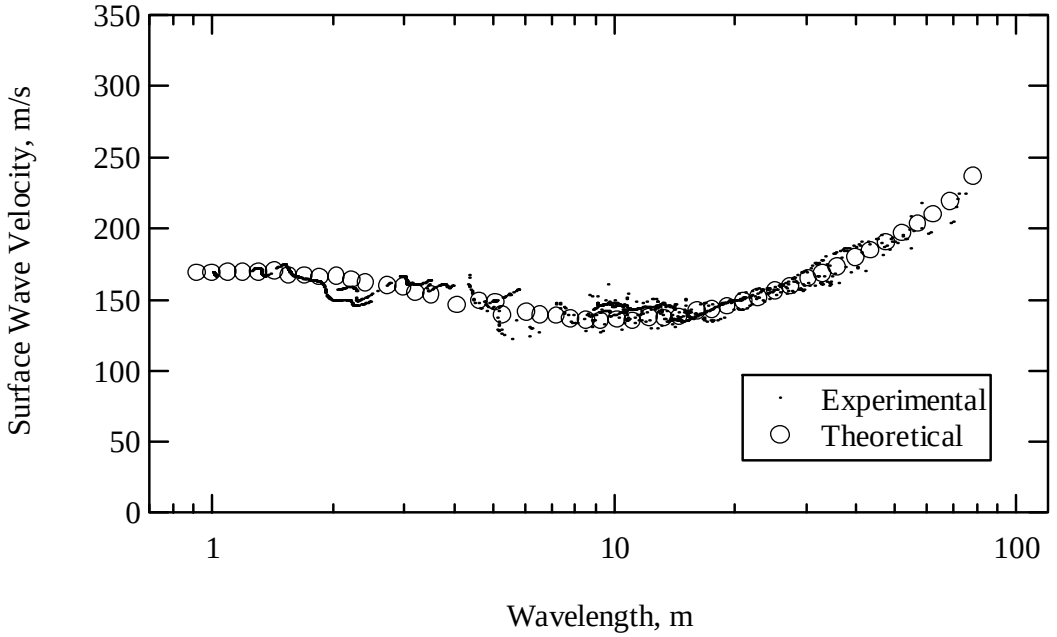

Fig. 2.180 Comparison of experimental and theoretical dispersion curves from the Salem City Yard (SCY), Utah County, Utah.

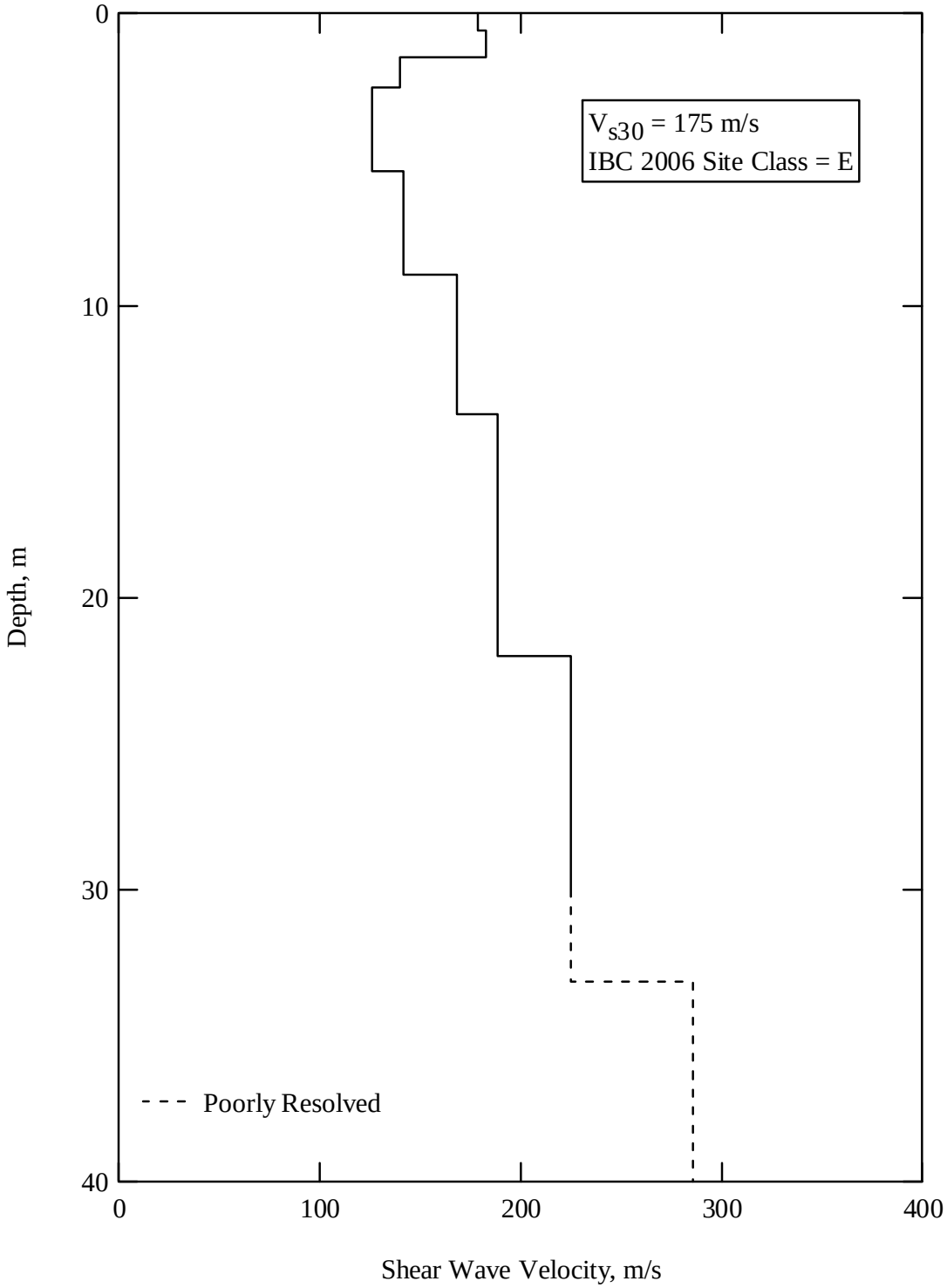

Fig. 2.181 Shear wave velocity profile determined from SASW at the Salem City Yard (SCY), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 175 m/s, which corresponds to an IBC 2006 site class E. The V_{S30} is near the transition between site class D and site class E. The shear wave velocity profile is well resolved to a depth of 30 m and poorly resolved from 30 m to 40 m.

Table 2.35 Tabulated measured and assumed layer properties at the Salem City Yard (SCY), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.6	179	335	0.3	1.92
0.6	0.9	183	342	0.3	1.92
1.5	1.1	140	263	0.3	1.89
2.6	2.9	127	1500	0.49	1.89
5.4	3.6	142	1500	0.49	1.89
9.0	4.8	169	1500	0.49	1.92
13.7	8.3	189	1500	0.49	1.92
22.0	8.0	225	1500	0.49	1.92

2.4.5. Woffinden Home

SASW testing was performed in Benjamin Utah, at the Woffinden Home, designated as WOF in this report, located at 7204 S. 2400 W., Benjamin, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.09905 North and 111.71274 East, with an elevation of approximately 1389 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.182.

Testing was performed at 7:00 a.m. on August 24, 2005. The SASW array was located in a hay field, oriented in a north-south direction. A photograph of the site is shown in Fig. 2.183. A fully saturated zone was assumed to exist at a depth of 2.3 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.75 m with no padding.

Figure 2.184 shows the experimental dispersion curve measured at the Woffinden Home. Figure 2.185 shows the comparison of the experimental dispersion curve and the

theoretical dispersion curve determined from forward modeling. Figure 2.186 shows the calculated shear wave velocity profile for the site. Table 2.36 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.182 Site map showing the location of the centerline of the SASW array at the Woffinden Home (WOF), Utah County, Utah (from Google Earth 2006).

Fig. 2.183 Photograph of SASW testing at the Woffinden Home (WOF), Utah County, Utah.

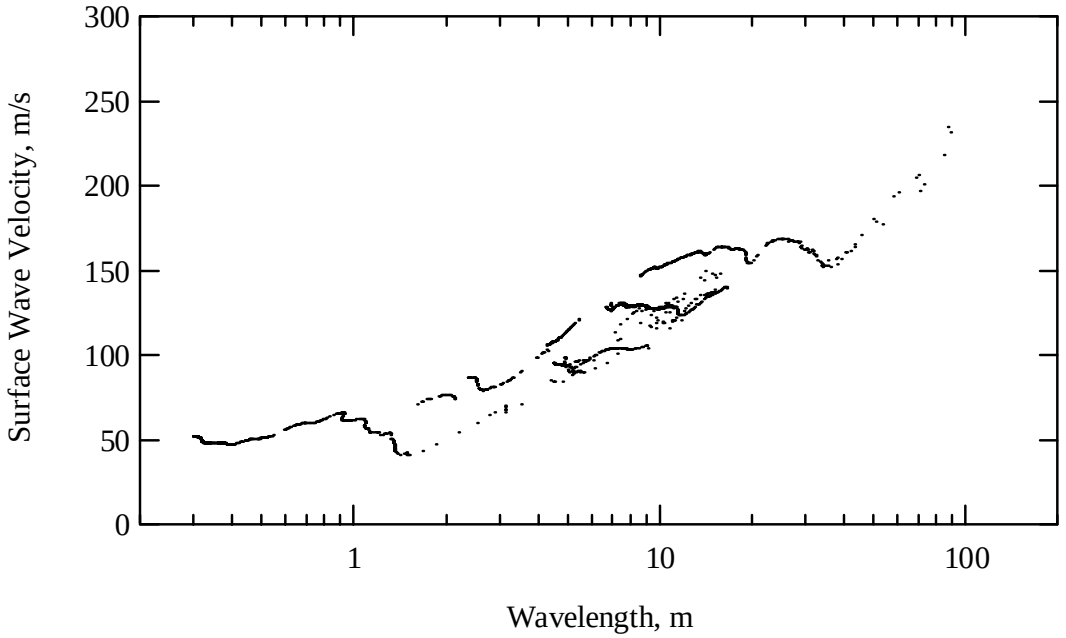

Fig. 2.184 Experimental dispersion curve measured at the Woffinden Home (WOF), Utah County, Utah.

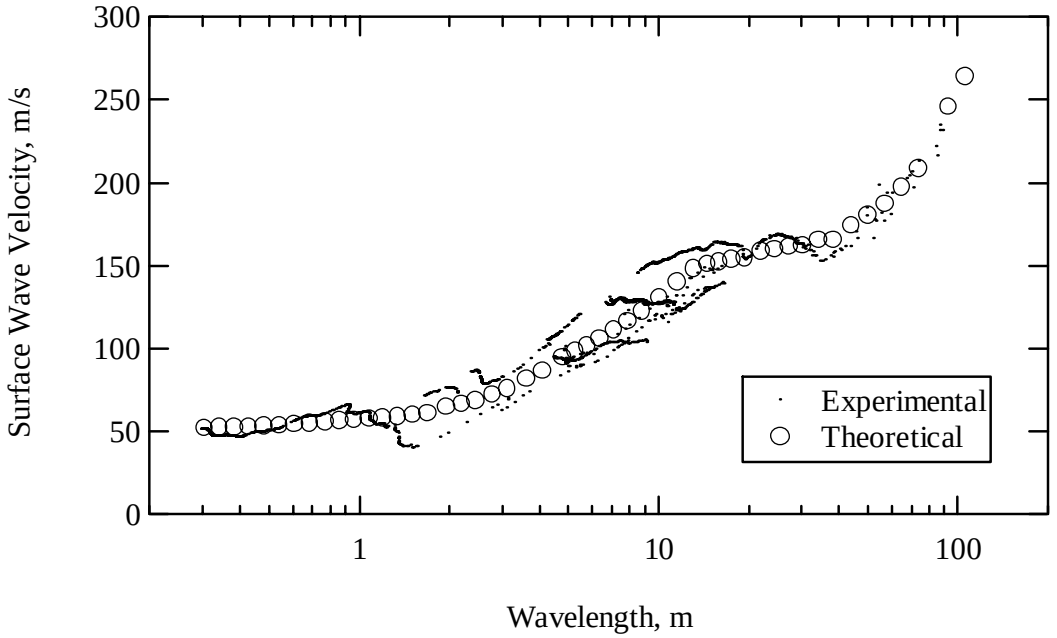

Fig. 2.185 Comparison of experimental and theoretical dispersion curves at the Woffinden Home (WOF), Utah County, Utah.

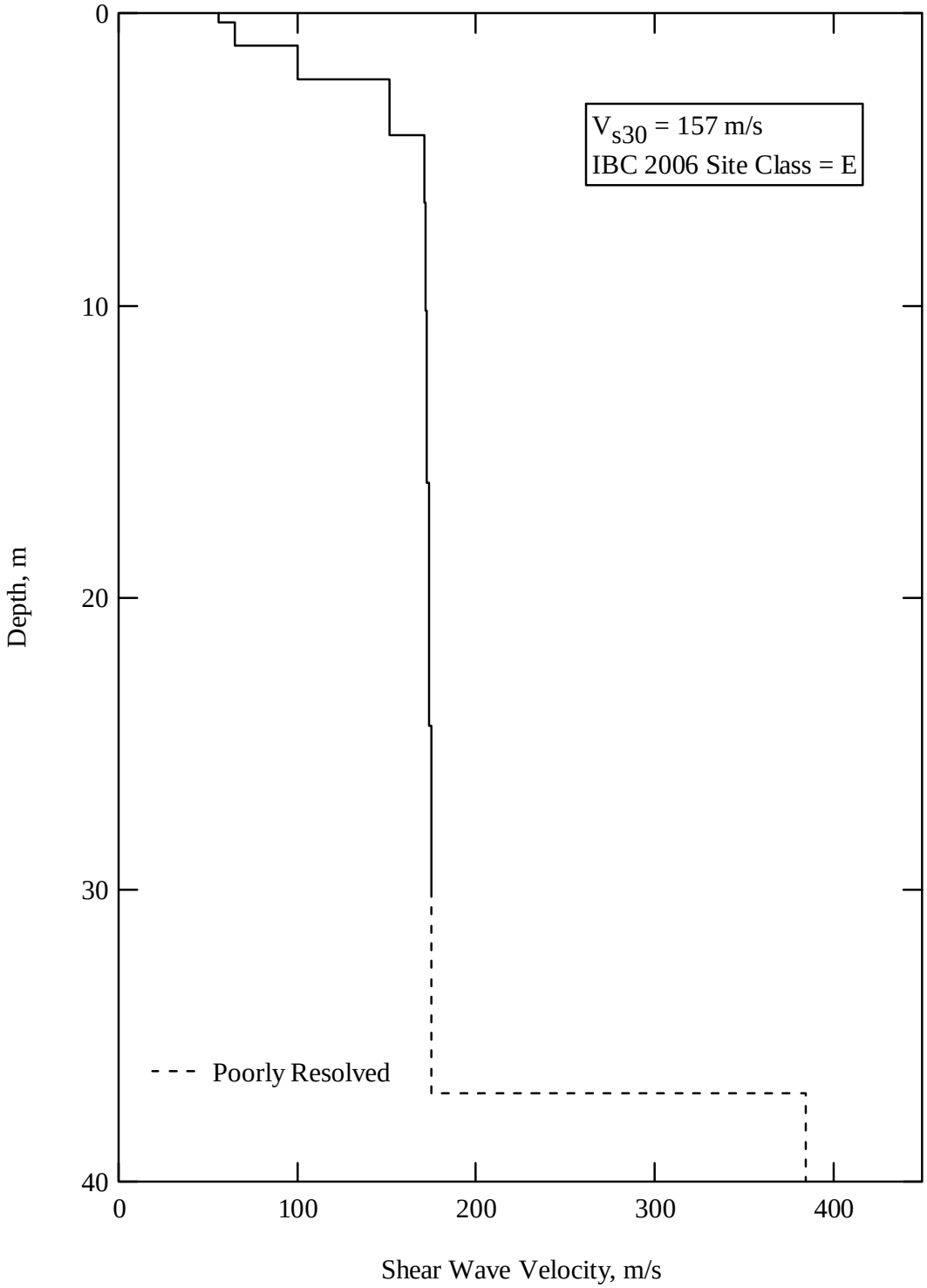

Fig. 2.186 Shear wave velocity profile determined from SASW at the Woffinden Home (WOF), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 157 m/s, which corresponds to an IBC 2006 site class E. The shear wave velocity profile is well resolved to a depth of 30 m and poorly resolved from 30 m to 40 m.

Table 2.36 Tabulated measured and assumed layer properties at the Woffinden Home (WOF), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	56	105	0.3	1.87
0.3	0.8	65	122	0.3	1.87
1.1	1.2	101	188	0.3	1.87
2.3	1.9	152	1500	0.49	1.87
4.2	2.3	171	1500	0.49	1.87
6.5	3.7	172	1500	0.49	1.87
10.2	5.9	173	1500	0.49	1.87
16.1	8.3	174	1500	0.49	1.90
24.4	5.6	175	1500	0.49	1.90

2.4.6. Tri City Golf Course

SASW testing was performed at the Tri City Golf Course, designated as AMF in this report, located at 1400 N. 200 E., American Fork, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.40137 North and 111.78722 East, with an elevation of approximately 1451 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.187. This site is of particular interest because a strong motion sensor is also located at the golf Course in the main groundskeeper office.

Testing was performed at 2:30 p.m. on July 27, 2005. The SASW array was located along a maintenance path on the south end of the golf course. A photograph of the site is shown in Fig. 2.188. The strong motion station is located approximately 90 m to the north-east of the SASW centerline. A nearby canal indicated a somewhat shallow water table such that a fully saturated zone was assumed to exist at a depth of 5.8 m

below the ground surface. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.3 m with minimal padding used for leveling purposes.

Figure 2.189 shows the experimental dispersion curve measured at the Tri City Golf Course. Figure 2.190 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.191 shows the calculated shear wave velocity profile for the site. Table 2.37 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.187 Site map showing the location of the centerline of the SASW array at the Tri City Golf Course (AMF), Utah County, Utah (from Google Earth 2006).

Fig. 2.188 Photograph of SASW testing at the Tri City Golf Course (AMF), Utah County, Utah.

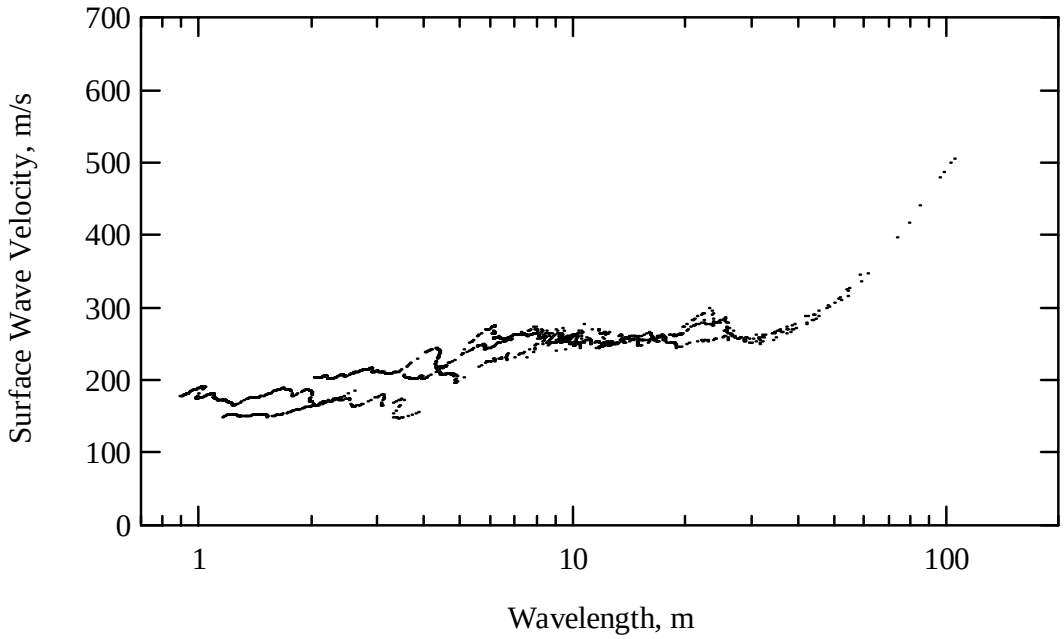

Fig. 2.189 Experimental dispersion curve measured at the Tri City Golf Course (AMF), Utah County, Utah.

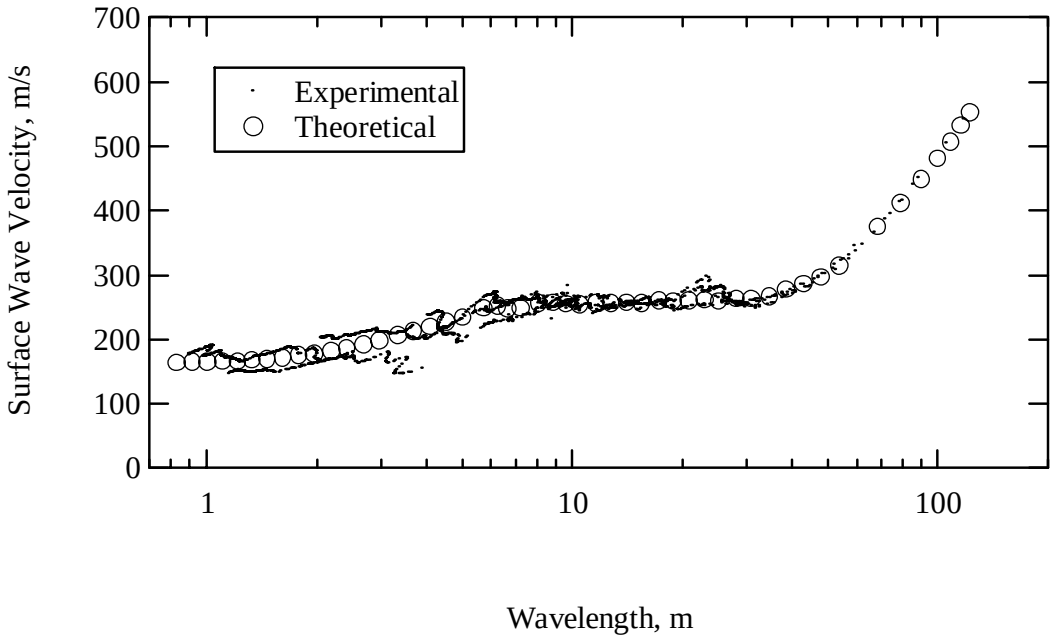

Fig. 2.190 Comparison of experimental and theoretical dispersion curves at the Tri City Golf Course (AMF), Utah County, Utah.

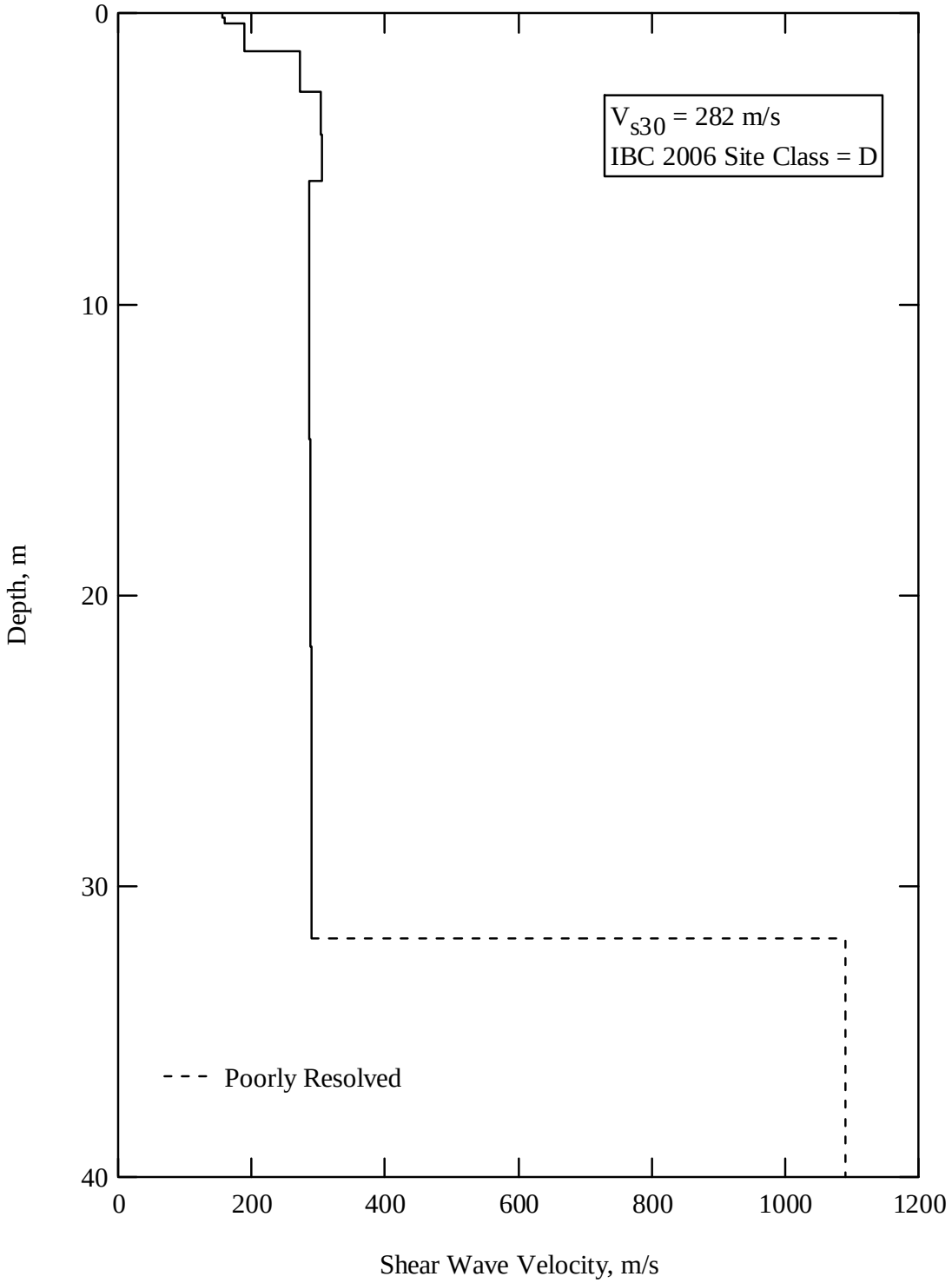

Fig. 2.191 Shear wave velocity profile determined from SASW at the Tri City Golf Course (AMF), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 282 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 31.8 m and poorly resolved from 31.8 m to 40 m.

Table 2.37 Tabulated measured and assumed layer properties at the Tri City Golf Course (AMF), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.1	157	295	0.30	1.92
0.1	0.2	160	300	0.30	1.92
0.3	0.9	189	354	0.30	1.92
1.3	1.4	274	512	0.30	1.92
2.7	1.5	305	571	0.30	1.96
4.2	1.6	306	573	0.30	1.96
5.8	3.0	286	1500	0.48	1.92
8.8	5.9	287	1500	0.48	1.92
14.7	7.1	288	1500	0.48	1.92
21.8	10.0	290	1500	0.48	1.92

2.4.7. Thanksgiving Point

SASW testing was performed at the Thanksgiving Point Golf Course, designated as TPU in this report, located at 2095 N., Frontage Rd. Lehi, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.4307 North and 111.90282 East, with an elevation of approximately 1398 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.192. A strong motion sensor monitored by the University of Utah Seismograph stations is located near the SASW array.

Testing was performed at 10:00 a.m. on July 27, 2005. The SASW array was located along the south side of Frontage road on the golf course lawn. A photograph of the site is shown in Fig. 2.193. The strong motion sensor is located approximately 50 m to the north of the centerline of the SASW array by a utility shed. A fully saturated zone

was assumed to exist at a depth of 9 m below the ground surface. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.15 m with 19 cm of padding.

Figure 2.194 shows the experimental dispersion curve measured at the Thanksgiving Point Golf Course. Figure 2.195 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.196 shows the calculated shear wave velocity profile for the site. Table 2.38 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.192 Site map showing the location of the centerline of the SASW array at Thanksgiving Point (TPU), Utah County, Utah (from Google Earth 2006).

Fig. 2.193 Photograph of SASW testing at Thanksgiving Point (TPU), Utah County, Utah.

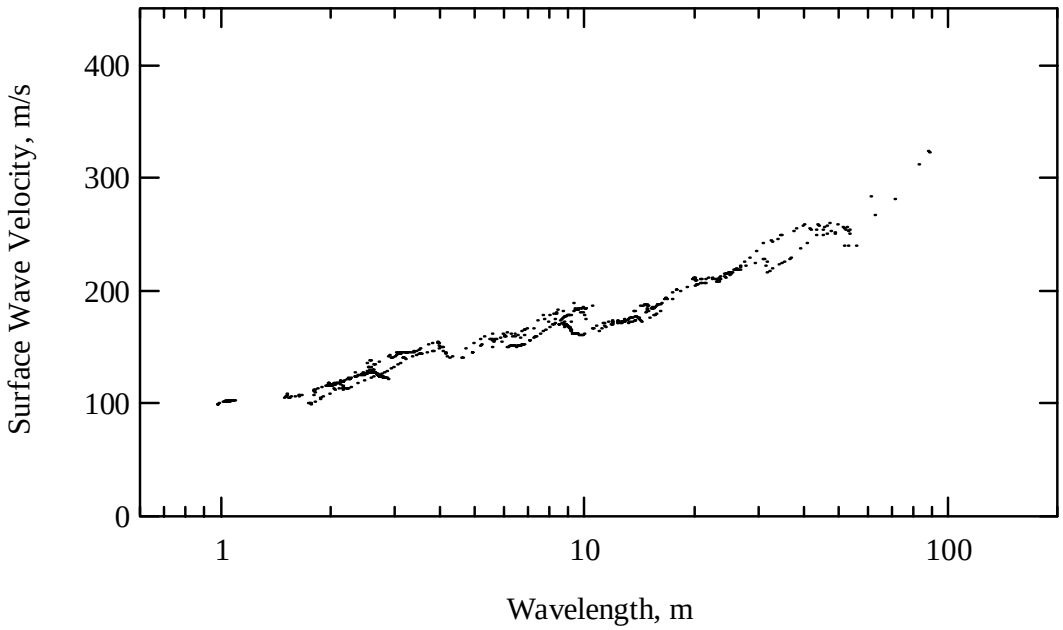

Fig. 2.194 Experimental dispersion curve measured at Thanksgiving Point (TPU), Utah County, Utah.

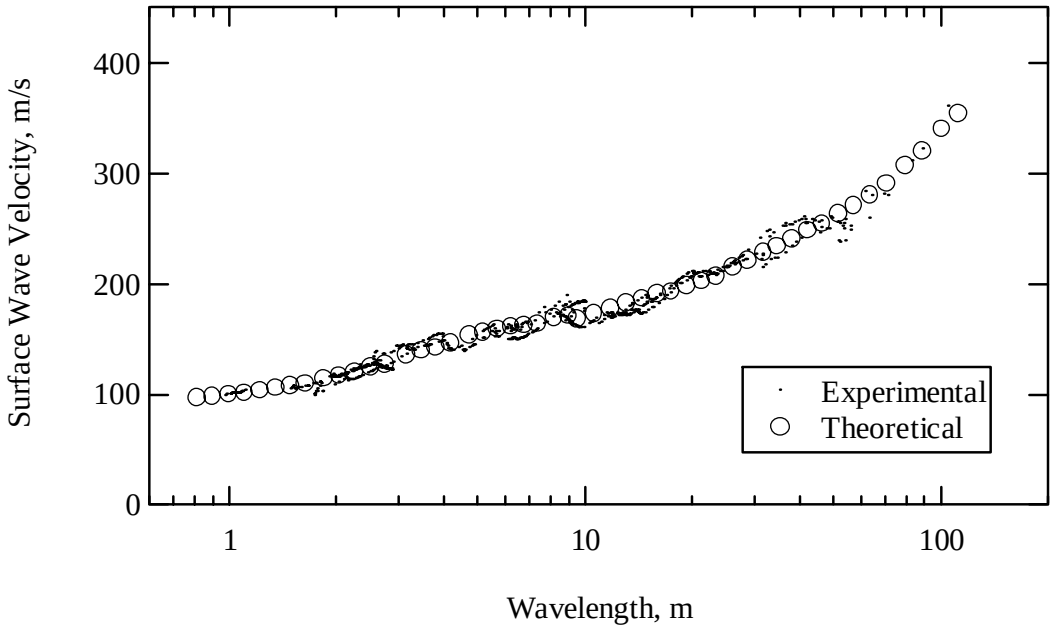

Fig. 2.195 Comparison of experimental and theoretical dispersion curves at Thanksgiving Point (TPU), Utah County, Utah.

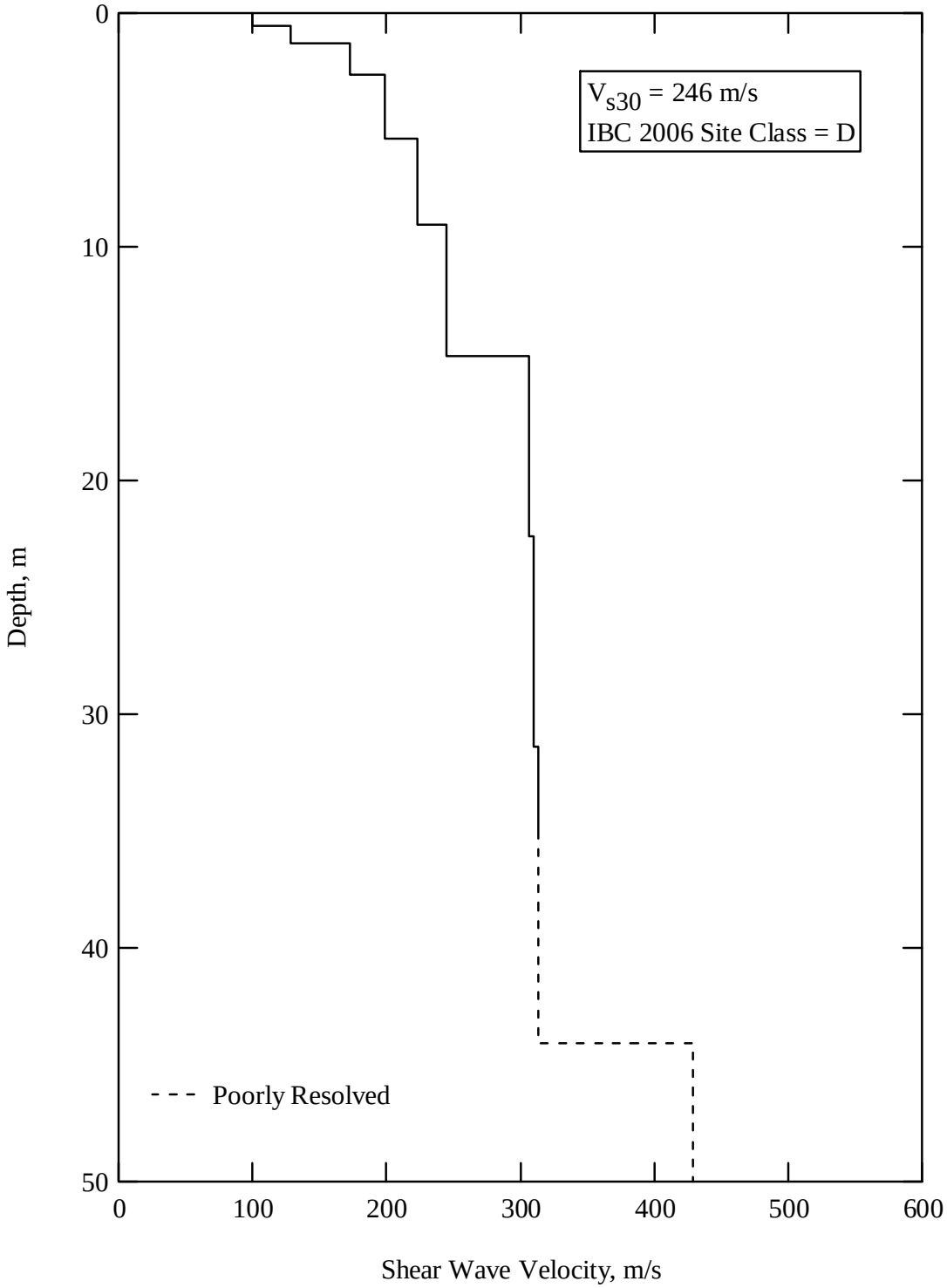

Fig. 2.196 Shear wave velocity profile determined from SASW at Thanksgiving Point (TPU), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 246 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 50 m.

Table 2.38 Tabulated measured and assumed layer properties at Thanksgiving Point (TPU), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.5	100	187	0.30	1.89
0.5	0.7	129	241	0.30	1.89
1.3	1.4	173	324	0.30	1.92
2.6	2.7	199	372	0.30	1.92
5.3	3.7	223	417	0.30	1.92
9.0	5.6	245	1500	0.49	1.92
14.7	7.8	306	1500	0.48	1.96
22.4	9.0	310	1500	0.48	1.96
31.4	3.6	313	1500	0.48	1.96

2.4.8. Dixon Junior High School

SASW testing was performed at Dixon Junior High School, designated as DJH in this report, located in Utah County at 300 N. 700 W., Provo, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.23853 North and 111.67184 East, with an elevation of approximately 1401 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.197.

Testing was performed at 3:00 p.m. on August 18, 2005. The SASW array was located in the playing fields to the north of the school. A photograph of the site is shown in Fig. 2.198. A fully saturated zone was assumed to exist at 12.6 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.2 m with 19 cm of padding.

Figure 2.199 shows the experimental dispersion curve measured at Dixon Junior High School. Figure 2.200 shows the comparison of the experimental dispersion curve

and the theoretical dispersion curve determined from forward modeling. Figure 2.201 shows the calculated shear wave velocity profile for the site. Table 2.39 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.197 Site map showing the location of the centerline of the SASW array at Dixon Junior High School (DJH), Utah County, Utah (from Google Earth 2006).

Fig. 2.198 Photograph of SASW testing at Dixon Junior High School (DJH), Utah County, Utah.

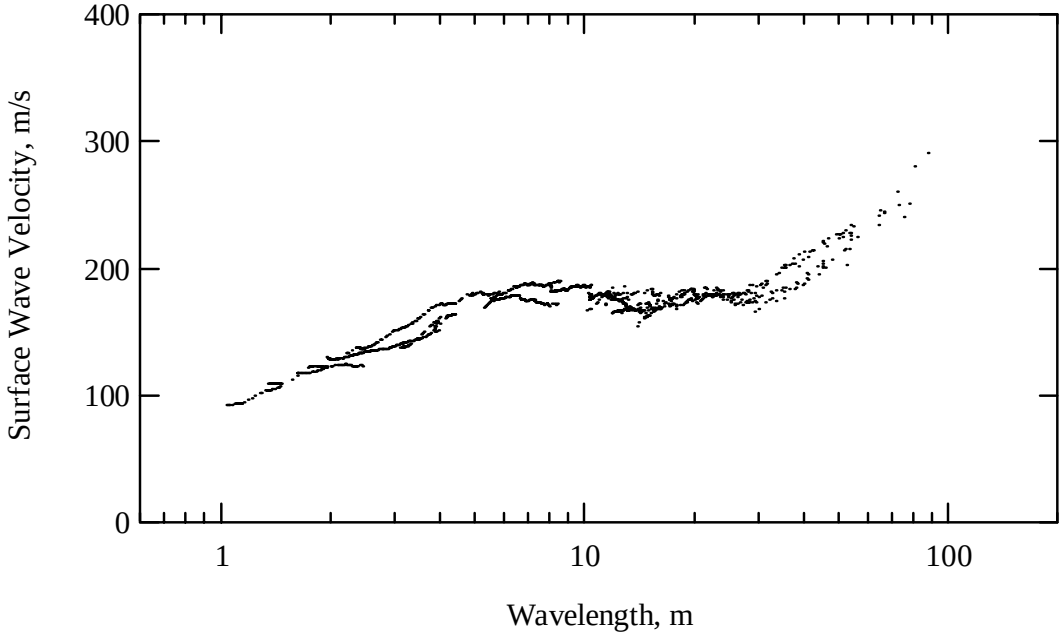

Fig. 2.199 Experimental dispersion curve measured at Dixon Junior High School (DJH), Utah County, Utah.

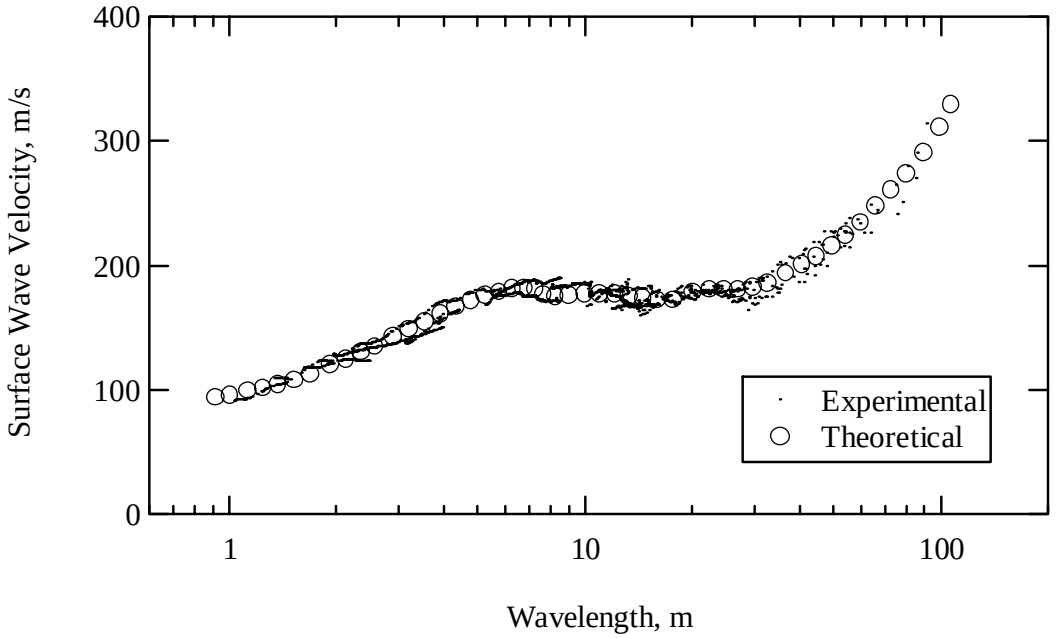

Fig. 2.200 Comparison of experimental and theoretical dispersion curves from Dixon Junior High School (DJH), Utah County, Utah.

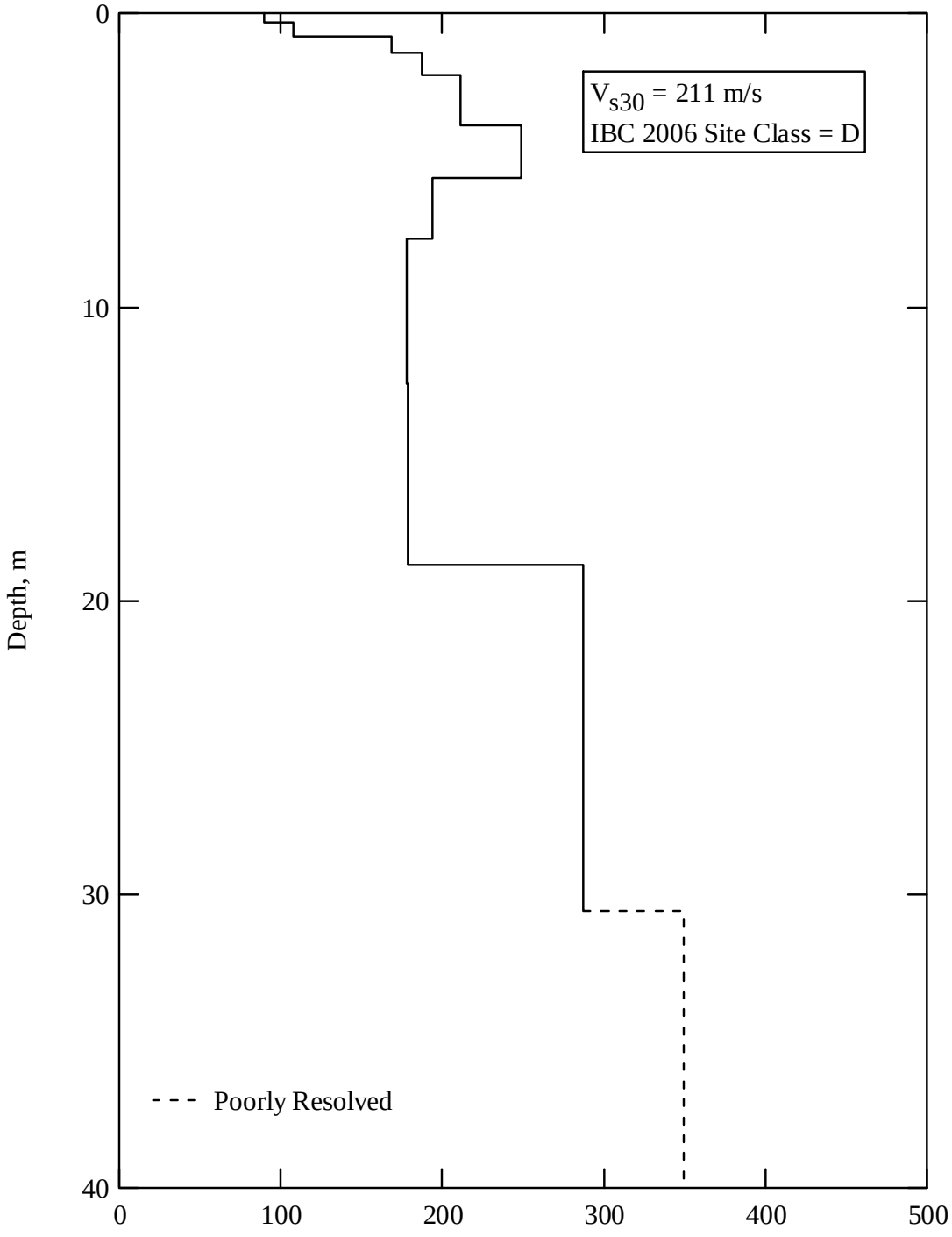

Fig. 2.201 Shear wave velocity profile determined from SASW testing at Dixon Junior High School (DJH), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 211 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 30.6 m and poorly resolved from 30.6 m to 40 m.

Table 2.39 Tabulated measured and assumed layer properties at Dixon Junior High School (DJH), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	90	168	0.3	1.89
0.3	0.5	108	202	0.3	1.89
0.8	0.6	169	316	0.3	1.92
1.4	0.7	187	350	0.3	1.92
2.1	1.7	211	395	0.3	1.92
3.8	1.8	249	466	0.3	1.92
5.6	2.1	194	363	0.3	1.92
7.7	4.9	178	333	0.3	1.92
12.6	6.2	179	1500	0.49	1.92
18.8	11.8	287	1500	0.48	1.92

2.4.9. West of Utah Lake

SASW testing was performed in the Cedar Valley, on the west side of Utah Lake, designated as WUL in this report, located in Utah County. The GPS derived latitude and longitude of the center of the SASW testing array are 40.26082 North and 112.06094 East, with an elevation of approximately 1484 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.202.

Testing was performed on August 23, 2005. The SASW array was located on a farm access road in the middle of the valley near 1600 North. A photograph of the site is shown in Fig. 2.203. A fully saturated zone was assumed to exist at 13 m below the ground surface. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.65 m with minimal padding used for dust control.

Figure 2.204 shows the experimental dispersion curve measured at the site. Figure 2.205 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.206 shows the calculated shear wave velocity profile for the site. Table 2.40 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.202 Site map showing the location of the centerline of the SASW array West of Utah Lake (WUL), Utah County, Utah (from Google Earth 2006).

Fig. 2.203 Photograph of SASW testing West of Utah Lake (WUL), Utah County, Utah.

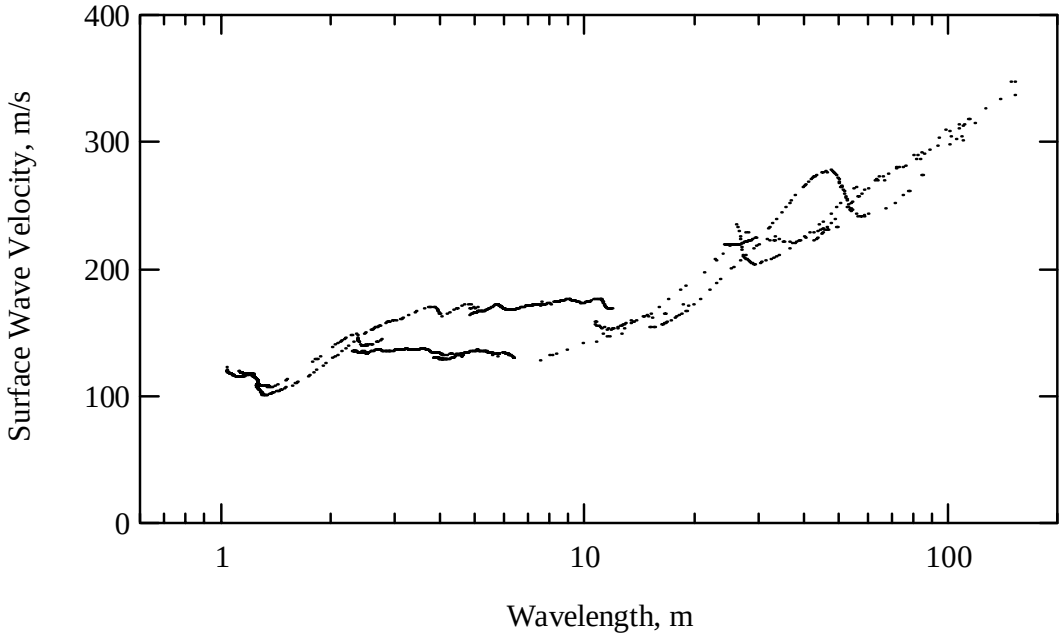

Fig. 2.204 Experimental dispersion curve measured West of Utah Lake (WUL), Utah County, Utah.

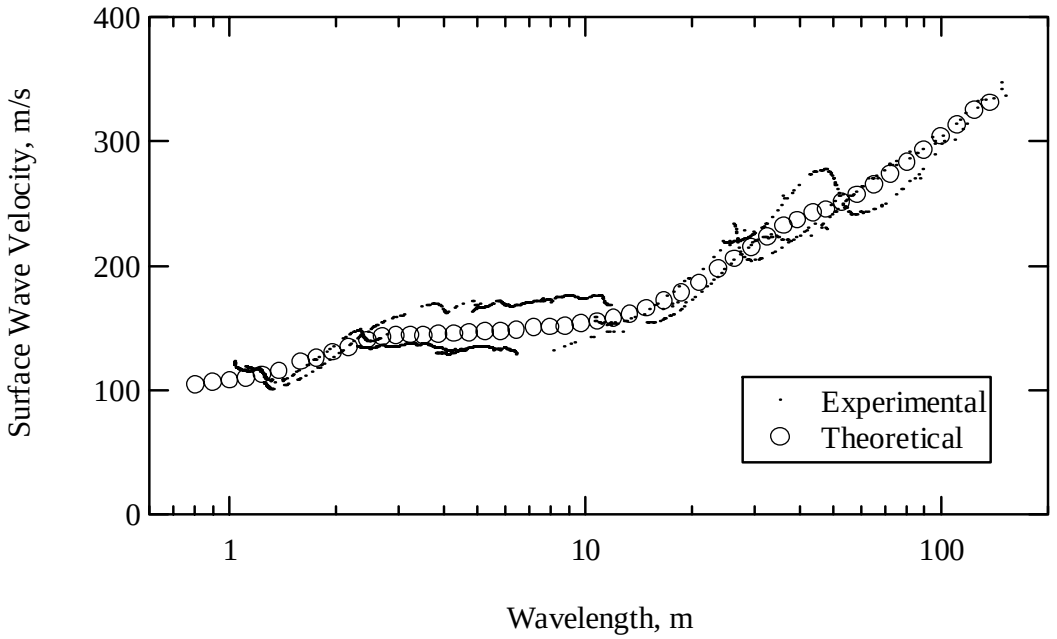

Fig. 2.205 Comparison of experimental and theoretical dispersion curves from West of Utah Lake (WUL), Utah County, Utah.

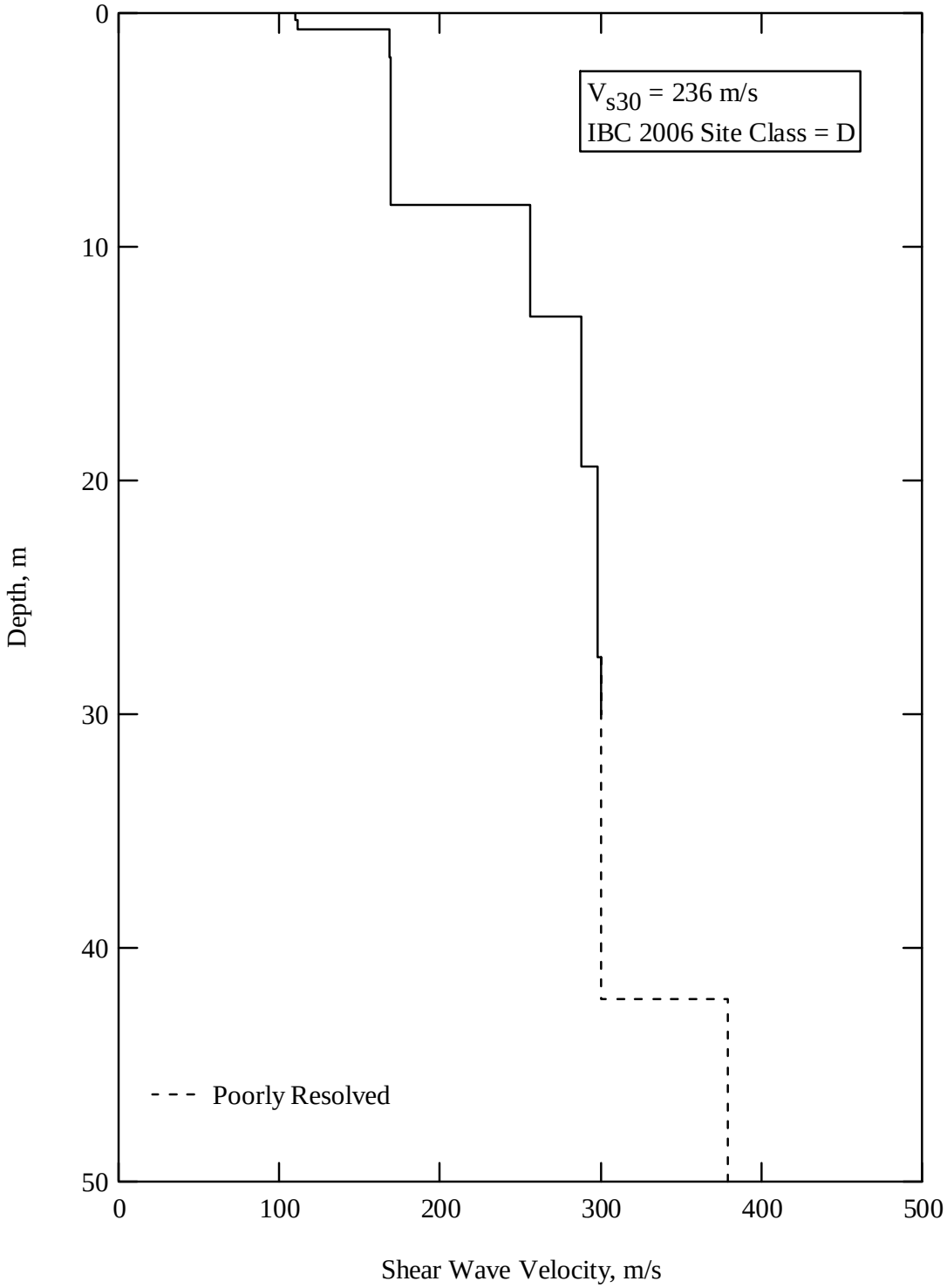

Fig. 2.206 Shear wave velocity profile determined from SASW testing West of Utah Lake (WUL), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 236 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 30 m and poorly resolved from 30 m to 50 m.

Table 2.40 Tabulated measured and assumed layer properties West of Utah Lake (WUL), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	110	206	0.30	1.89
0.3	0.4	111	208	0.30	1.89
0.7	1.2	169	315	0.30	1.89
1.9	2.4	169	317	0.30	1.92
4.3	3.9	170	318	0.30	1.92
8.2	4.8	256	479	0.30	1.92
13.0	6.4	288	1500	0.48	1.92
19.4	8.2	298	1500	0.48	1.92
27.6	2.4	300	1500	0.48	1.96

2.4.10. Mapleton Ambulance Building

SASW testing was performed near the Mapleton Ambulance Building, designated as MAB in this report, located at 35 Maple St., Mapleton, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.13129 North and 111.57794 East, with an elevation of approximately 1452 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.207. The site was of particular interest because a strong motion sensor monitored by the University of Utah Seismograph Stations is located near the SASW array in the Mapleton Ambulance Building.

Testing was performed at 9:00 a.m. on August 24, 2005. The SASW array was located in a vacant lot to the north of the Ambulance Building, oriented in the east-west direction. A photograph of the site is shown in Fig. 2.208 looking to the west. The strong motion sensor is located approximately 30 m to the south of the SASW centerline.

A fully saturated zone was not assumed at this site. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 13 cm with 19 cm of padding used.

Figure 2.209 shows the experimental dispersion curve measured at the Mapleton Ambulance Building. Figure 2.210 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.211 shows the calculated shear wave velocity profile for the site. Table 2.41 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.207 Site map showing the location of the centerline of the SASW array at the Mapleton Ambulance Building (MAB), Utah County, Utah (from Google Earth 2006).

Fig. 2.208 Photograph of SASW testing at the Mapleton Ambulance Building (MAB), Utah County, Utah.

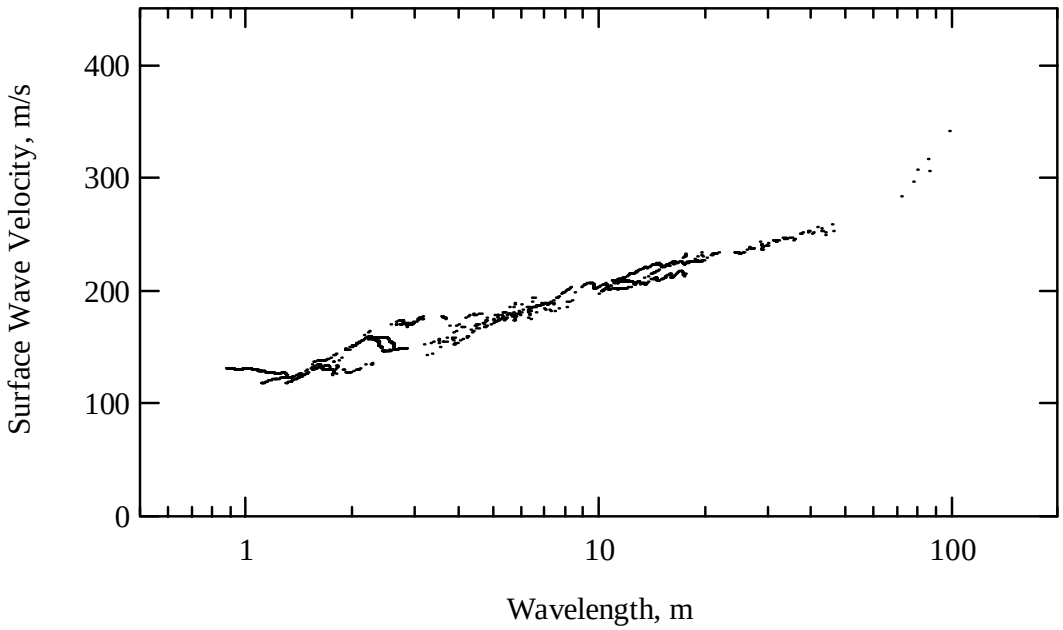

Fig. 2.209 Experimental dispersion curve measured at the Mapleton Ambulance Building (MAB), Utah County, Utah.

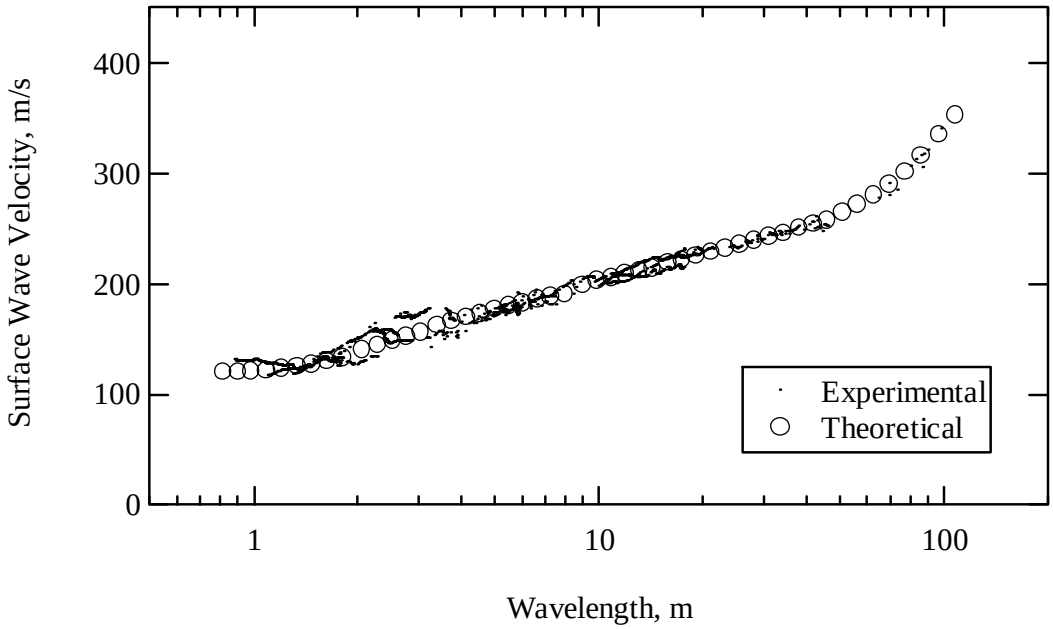

Fig. 2.210 Comparison of experimental and theoretical dispersion curves from the Mapleton Ambulance Building (MAB), Utah County, Utah.

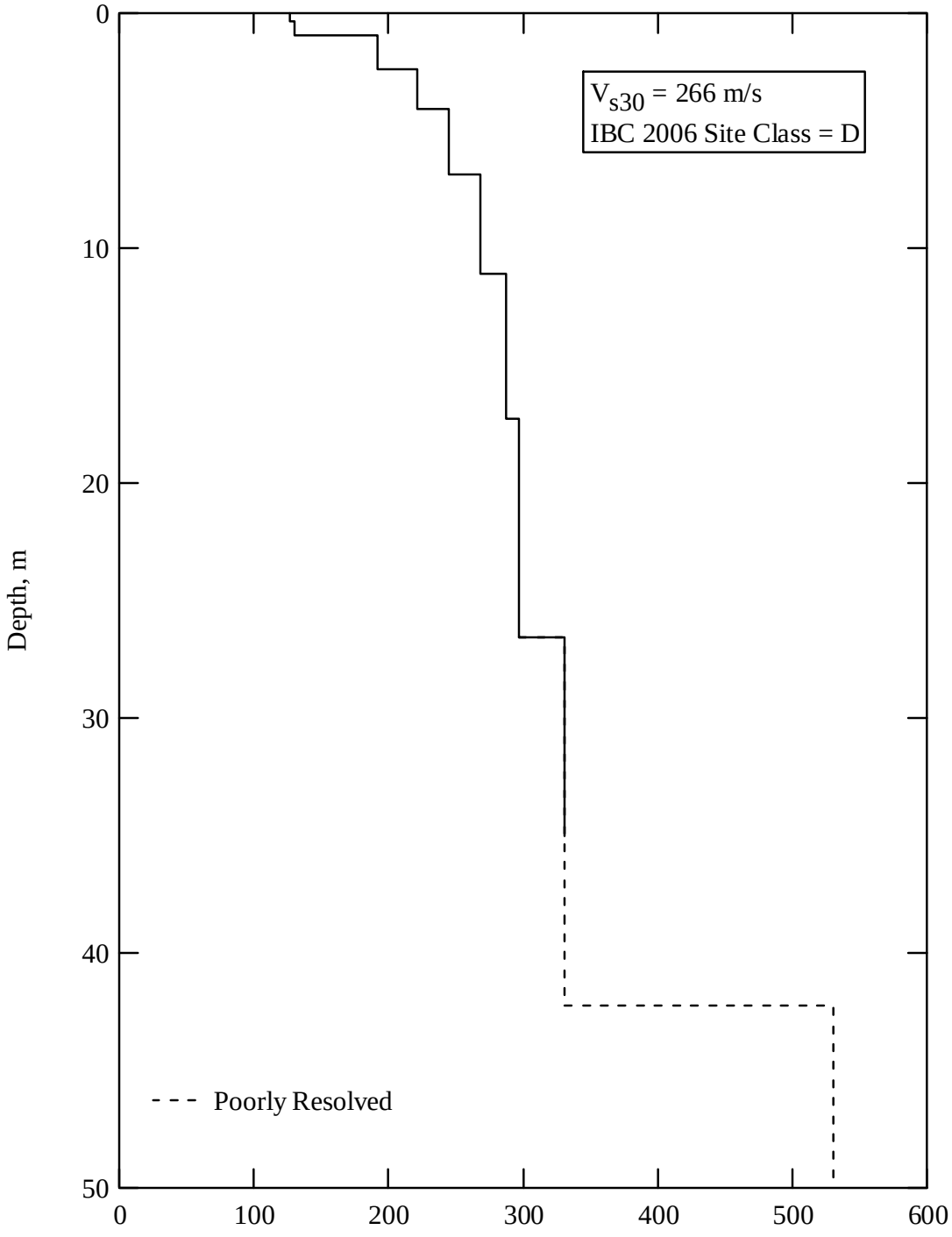

Fig. 2.211 Shear wave velocity profile determined from SASW testing at the Mapleton Ambulance Building (MAB), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 266 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 35 m and poorly resolved from 35 m to 50 m.

Table 2.41 Tabulated measured and assumed layer properties at the Mapleton Ambulance Building (MAB), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	127	238	0.3	1.89
0.3	0.6	130	243	0.3	1.89
0.9	1.5	192	359	0.3	1.92
2.4	1.7	221	414	0.3	1.92
4.1	2.8	245	457	0.3	1.92
6.9	4.2	268	502	0.3	1.92
11.1	6.2	287	537	0.3	1.92
17.3	9.3	297	556	0.3	1.92
26.6	8.4	331	619	0.3	1.96

2.4.11. Cedar Ridge Elementary School

SASW testing was performed at Cedar Ridge Elementary School, designated as CRE in this report, located at 4501 Cedar Hills Dr., Pleasant Grove, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.4141 North and 111.76559 East, with an elevation of approximately 1497 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.212.

Testing was performed at 3:00 p.m. on August 17, 2005. The SASW array was located on the south end of the school in an east-west orientation. A photograph of the site is shown in Fig. 2.213. A fully saturated zone was not assumed at this site. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.2 m with 13 cm of padding.

Figure 2.214 shows the experimental dispersion curve measured at Cedar Ridge Elementary School. Figure 2.215 shows the comparison of the experimental dispersion

curve and the theoretical dispersion curve determined from forward modeling. Figure 2.216 shows the calculated shear wave velocity profile for the site. Table 2.42 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.212 Site map showing the location of the centerline of the SASW array at Cedar Ridge Elementary School (CRE), Utah County, Utah (from Google Earth 2006).

Fig. 2.213 Photograph of SASW testing at Cedar Ridge Elementary School (CRE), Utah County, Utah.

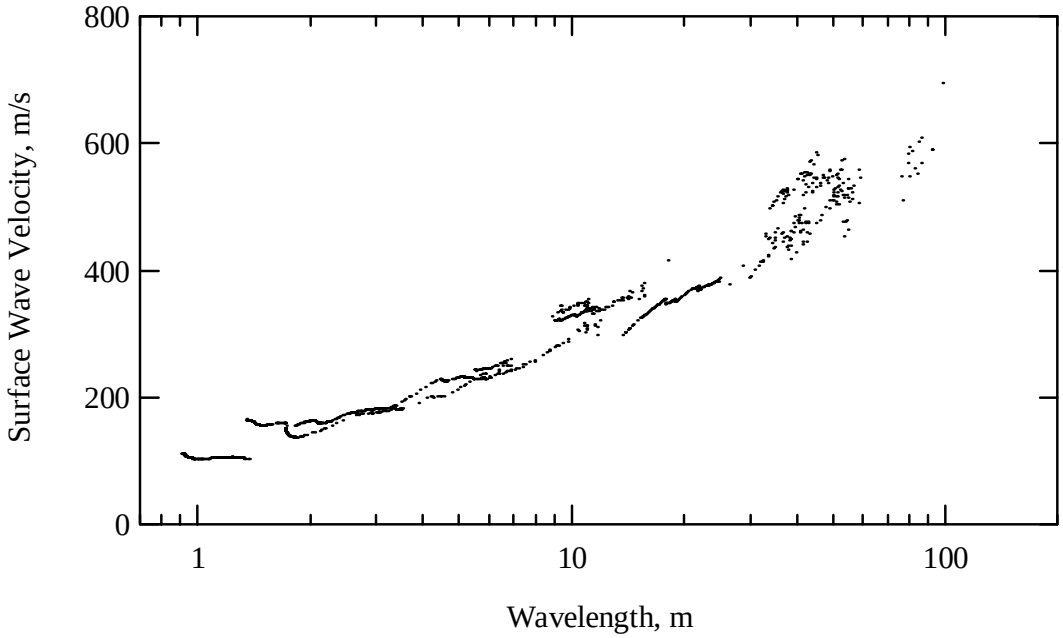

Fig. 2.214 Experimental dispersion curve measured at Cedar Ridge Elementary School (CRE), Utah County, Utah.

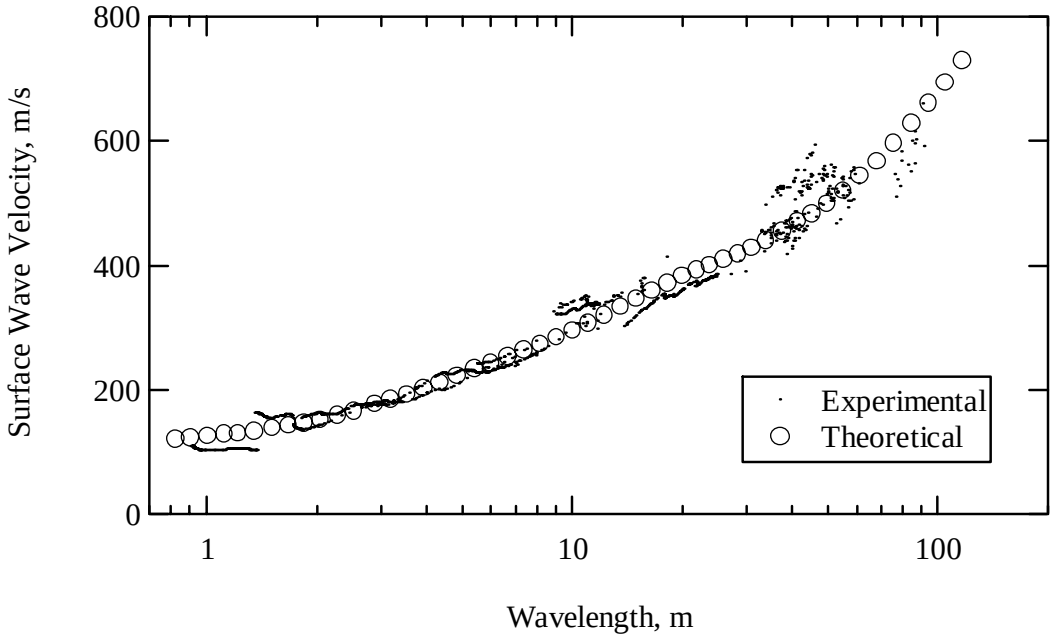

Fig. 2.215 Comparison of experimental and theoretical dispersion curves from Cedar Ridge Elementary School (CRE), Utah County, Utah.

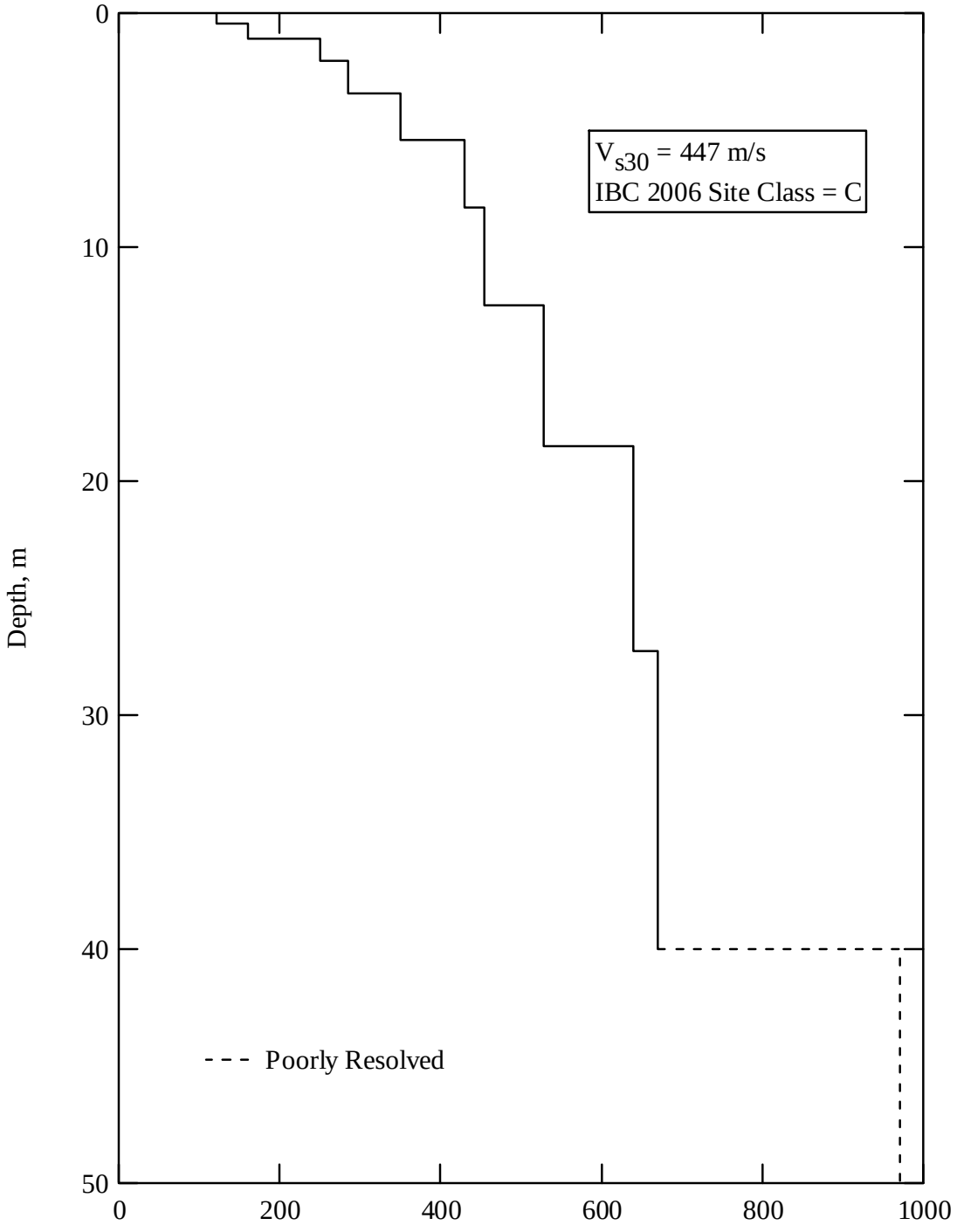

Fig. 2.216 Shear wave velocity profile determined from SASW testing at Cedar Ridge Elementary School (CRE), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 447 m/s, which corresponds to an IBC 2006 site class C. The shear wave velocity profile is well resolved to a depth of 40 m and poorly resolved from 40 m to 50 m.

Table 2.42 Tabulated measured and assumed layer at Cedar Ridge Elementary School (CRE), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.5	122	228	0.3	1.89
0.5	0.7	160	299	0.3	1.89
1.1	1.0	250	468	0.3	1.92
2.1	1.4	285	533	0.3	1.92
3.4	2.0	350	655	0.3	1.92
5.4	2.9	430	805	0.3	2.00
8.3	4.2	455	851	0.3	2.00
12.5	6.1	528	988	0.3	2.00
18.5	8.8	640	1197	0.3	2.00
27.3	12.7	670	1254	0.3	2.00

2.4.12. Canyon Crest School

SASW testing was performed at Canyon Crest School, designated as CCS in this report, located at 4664 N. Canyon Rd., Provo, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.29531 North and 111.6512 East, with an elevation of approximately 1478 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.217.

Testing was performed at 7:00 a.m. on August 18, 2005. The SASW array was located on the playing fields to the east of the school, oriented in a north-south direction. A photograph of the site is shown in Fig. 2.218 where the school can be seen in the background. A fully saturated zone was not assumed at this site. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.2 m with 13 cm of padding.

Figure 2.219 shows the experimental dispersion curve measured at Canyon Crest School. Figure 2.220 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.221 shows the calculated shear wave velocity profile for the site. Table 2.43 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.217 Site map showing the location of the centerline of the SASW array at Canyon Crest School (CCS), Utah County, Utah (from Google Earth 2006).

Fig. 2.218 Photograph of SASW testing at Canyon Crest School (CCS), Utah County, Utah.

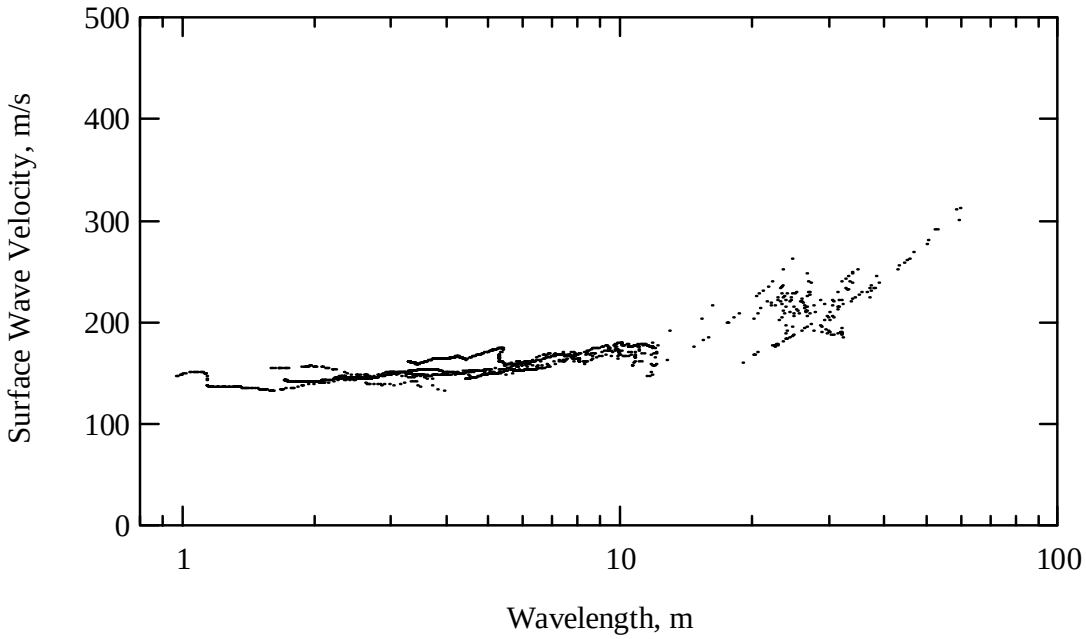

Fig. 2.219 Experimental dispersion curve measured at Canyon Crest School (CCS), Utah County, Utah.

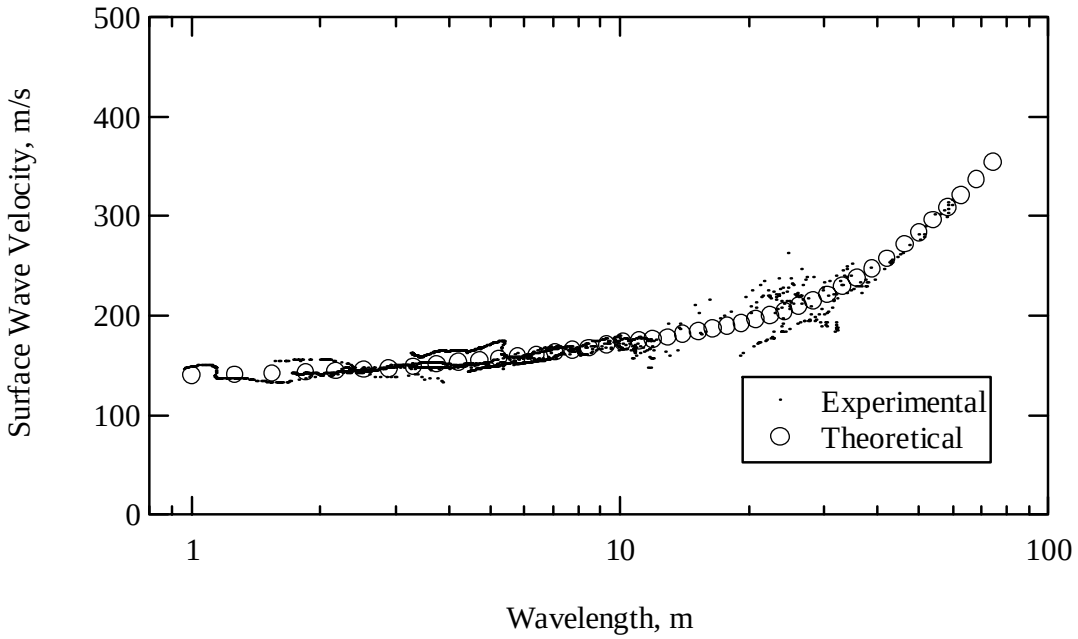

Fig. 2.220 Comparison of experimental and theoretical dispersion curves from Canyon Crest School (CCS), Utah County, Utah.

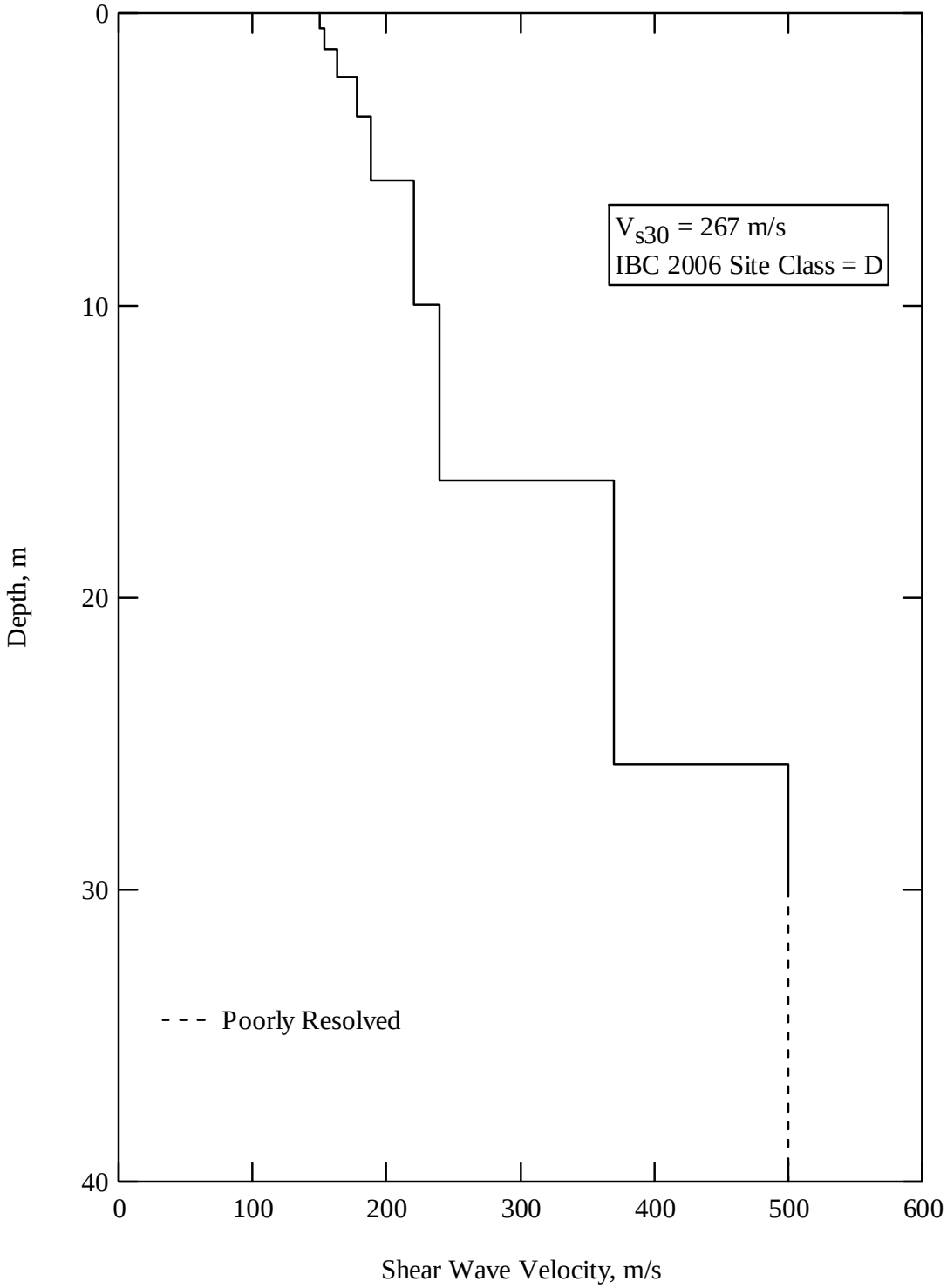

Fig. 2.221 Shear wave velocity profile determined from SASW testing at Canyon Crest School (CCS), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 267 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 30 m and poorly resolved from 30 m to 40 m.

Table 2.43 Tabulated measured and assumed layer at Canyon Crest School (CCS), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.5	150	281	0.3	1.89
0.5	0.7	154	288	0.3	1.92
1.2	1.0	163	305	0.3	1.92
2.2	1.4	178	333	0.3	1.92
3.6	2.2	188	352	0.3	1.92
5.7	4.3	220	412	0.3	1.92
10.0	6.0	239	447	0.3	1.96
16.0	9.7	370	692	0.3	2.00
25.7	4.3	500	935	0.3	2.00

2.4.13. Orchard Elementary School

SASW testing was performed at Orchard Elementary School, designated as OES in this report, located at 1035 N. 800 E., Orem, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.31738 North and 111.67788 East, with an elevation of approximately 1474 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.222.

Testing was performed at 9:00 a.m. on August 18, 2005. The SASW array was located along the east property line of the school, in a north-south orientation. A photograph of the site is shown in Fig. 2.223 where an LDS Church can be seen in the distant background. A fully saturated zone was not assumed at this site. Maximum drop heights of the 2.04×10^3 kg drop weight were 0.25 m with 13 cm of padding. Due to moist ground, the far source location remained in a single location and the centerline was adjusted.

Figure 2.224 shows the experimental dispersion curve measured at Orchard Elementary School. Figure 2.225 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.226 shows the calculated shear wave velocity profile for the site. Table 2.44 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.222 Site map showing the location of the centerline of the SASW array at Orchard Elementary School (OES), Utah County, Utah (from Google Earth 2006).

Fig. 2.223 Photograph of SASW testing at Orchard Elementary School (OES), Utah County, Utah.

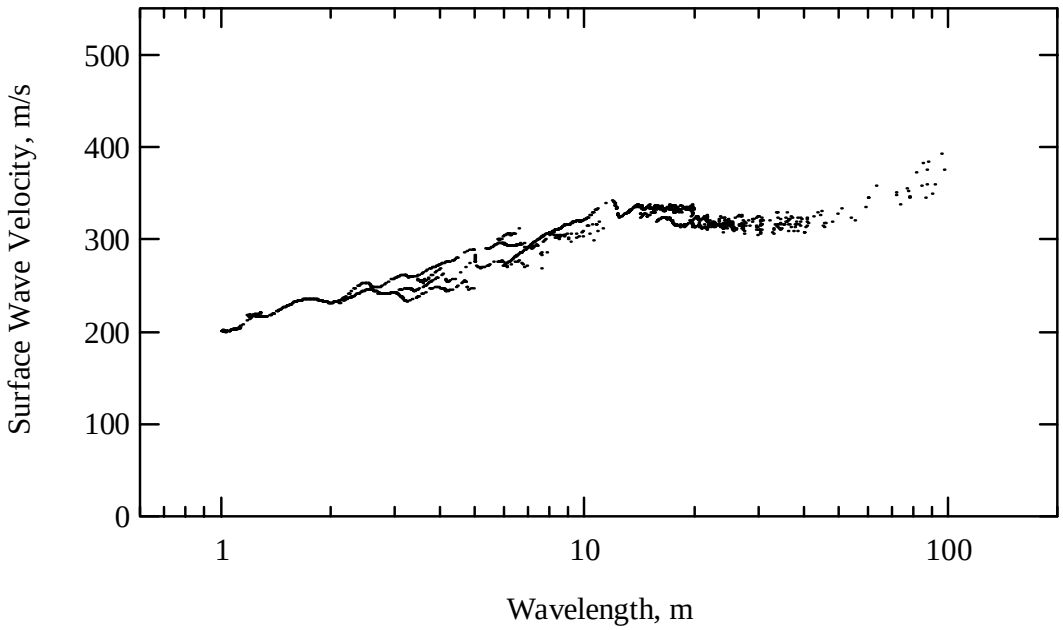

Fig. 2.224 Experimental dispersion curve measured at Orchard Elementary School (OES), Utah County, Utah.

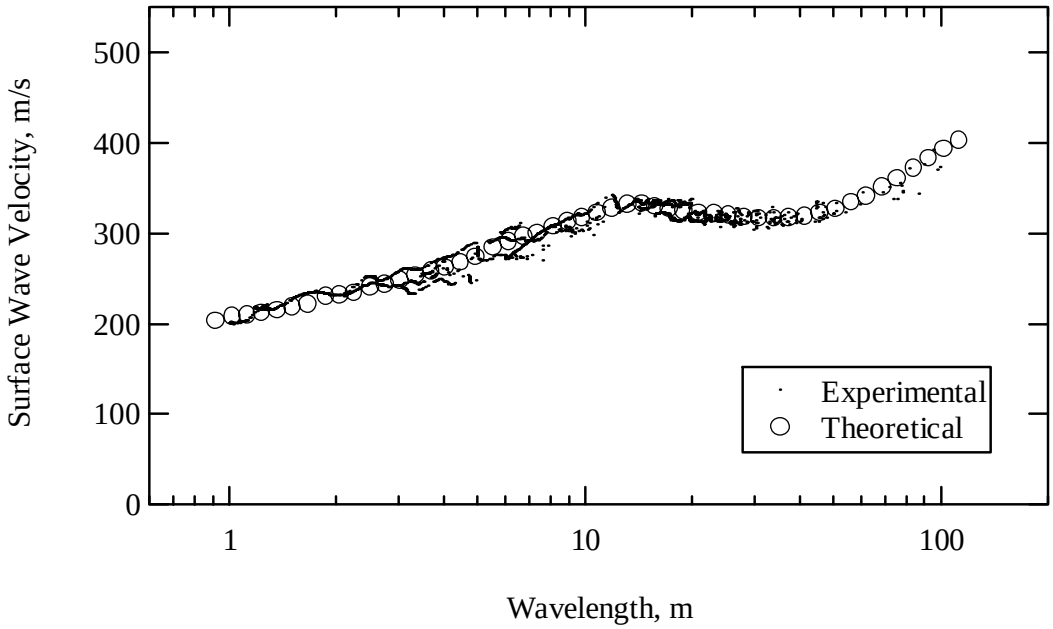

Fig. 2.225 Comparison of experimental and theoretical dispersion curves from Orchard Elementary School (OES), Utah County, Utah.

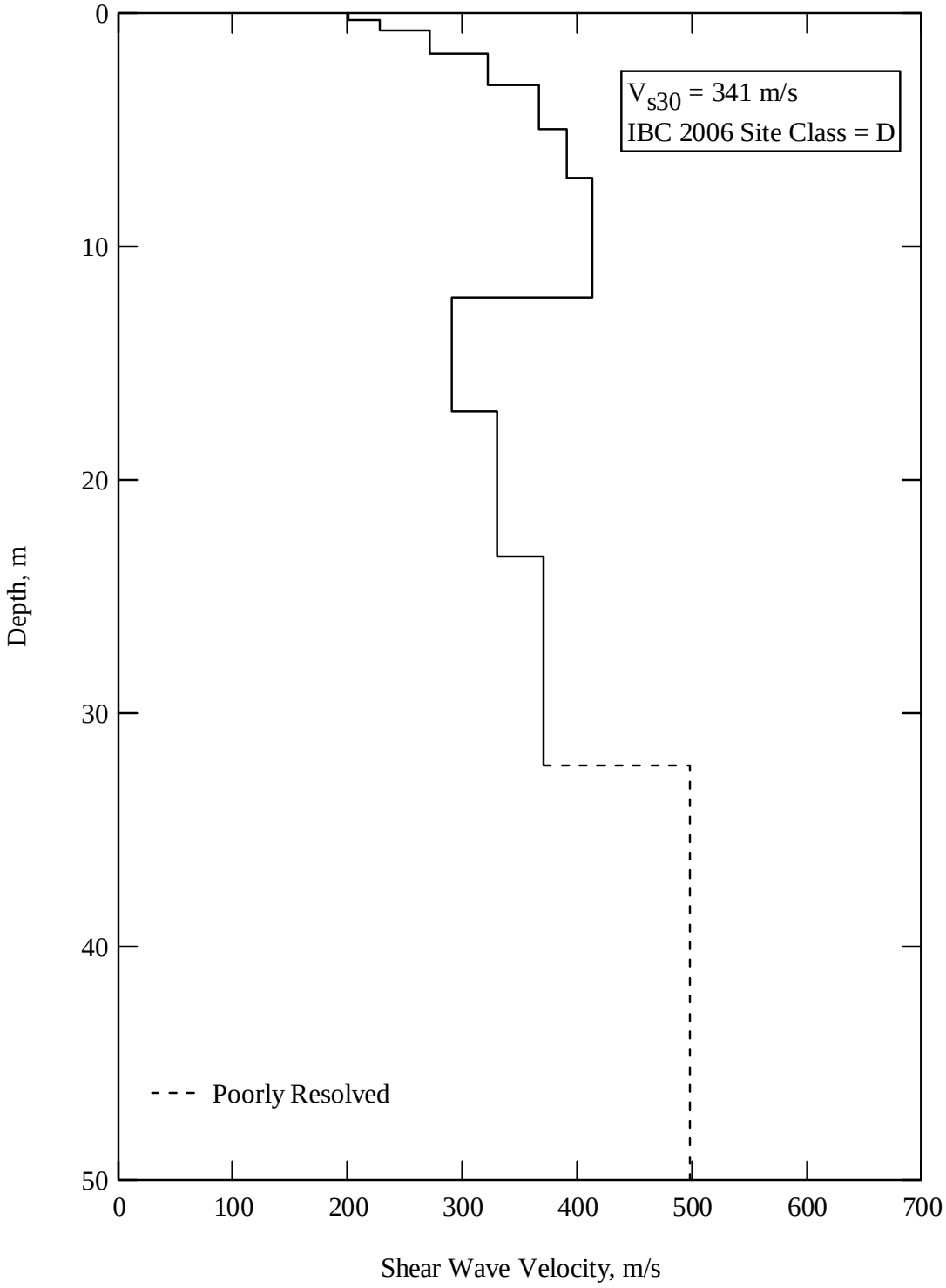

Fig. 2.226 Shear wave velocity profile determined from SASW testing at Orchard Elementary School (OES), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 341 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 32.3 m and poorly resolved from 32.3 m to 50 m.

Table 2.44 Tabulated measured and assumed layer at Orchard Elementary School (OES), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	201	376	0.30	1.92
0.3	0.4	228	427	0.30	1.92
0.7	1.0	271	507	0.30	1.92
1.7	1.4	322	602	0.30	2.00
3.1	1.9	366	685	0.30	2.00
5.0	2.1	391	732	0.30	2.00
7.1	5.1	413	773	0.30	2.00
12.2	4.9	291	544	0.30	1.96
17.1	6.2	330	617	0.30	2.00
23.3	9.0	371	694	0.30	2.00

2.4.14. Pleasant Grove Junior High School

SASW testing was performed at Pleasant Grove Junior High School, designated as PJH in this report, located at 810 N 100 E., Pleasant Grove, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 40.37312 North and 111.73836 East, with an elevation of approximately 1423 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.227.

Testing was performed at 4:00 p.m. on August 24, 2005. The SASW array was located between the Junior High School and an Elementary School on the soccer playing fields, in a north-south orientation. A photograph of the site is shown in Fig. 2.228 where Pleasant Grove Junior High School can be seen in the background. A fully saturated

zone was not assumed at this site. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.2 m with 19 cm of padding.

Figure 2.229 shows the experimental dispersion curve measured Pleasant Grove Junior High School. Figure 2.230 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.231 shows the calculated shear wave velocity profile for the site. Table 2.45 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.227 Site map showing the location of the centerline of the SASW array at Pleasant Grove Junior High School (PJH), Utah County, Utah (from Google Earth 2006).

Fig. 2.228 Photograph of SASW testing at Pleasant Grove Junior High School (PJH), Utah County, Utah.

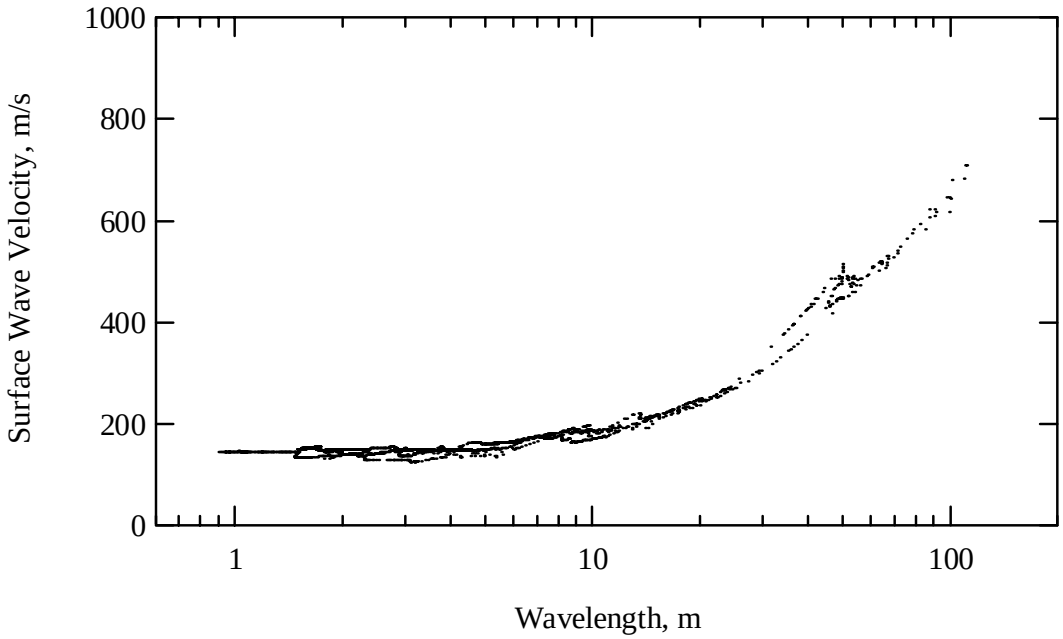

Fig. 2.229 Experimental dispersion curve measured at Pleasant Grove Junior High School (PJH), Utah County, Utah.

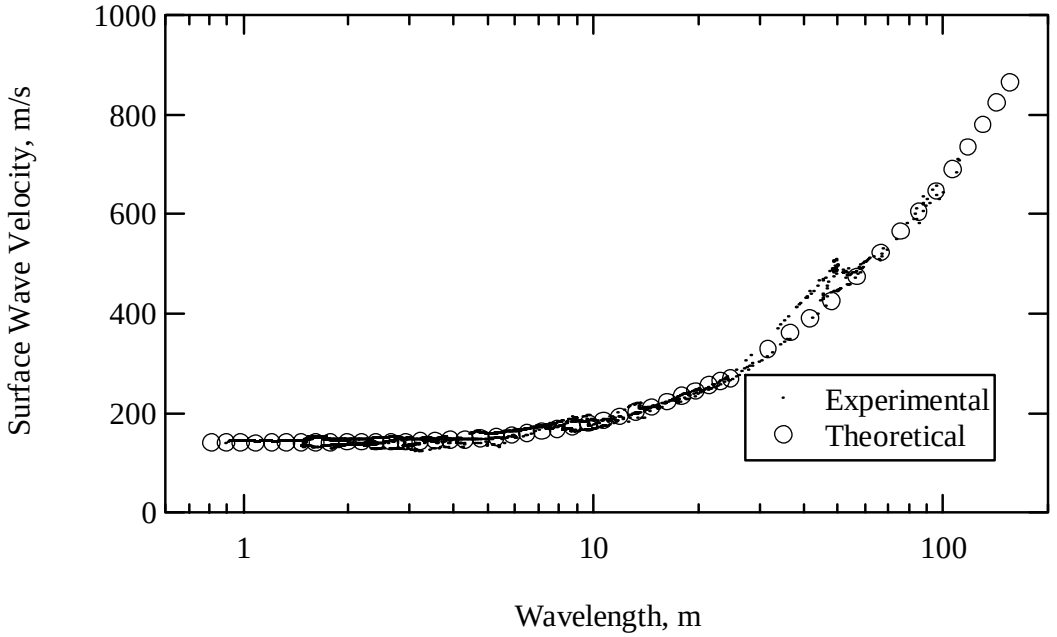

Fig. 2.230 Comparison of experimental and theoretical dispersion curves from Pleasant Grove Junior High School (PJH), Utah County, Utah.

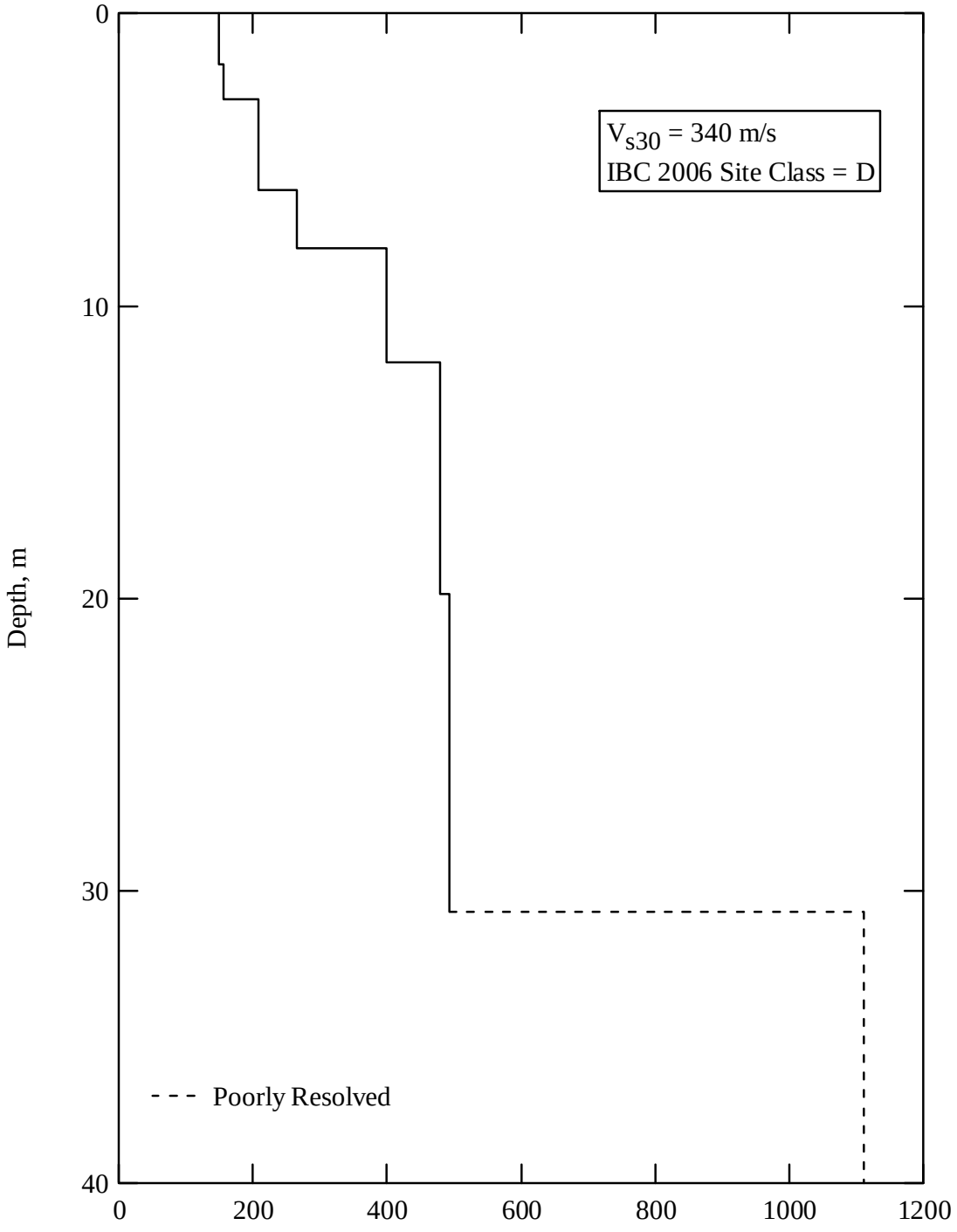

Fig. 2.231 Shear wave velocity profile determined from SASW testing at Pleasant Grove Junior High School (PJH), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 340 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 30.7 m and poorly resolved from 30.7 m to 40 m.

Table 2.45 Tabulated measured and assumed layer at Pleasant Grove Junior High School (PJH), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.3	149	279	0.3	1.89
0.3	0.5	150	281	0.3	1.89
0.9	0.9	150	281	0.3	1.89
1.8	1.2	157	294	0.3	1.92
2.9	1.4	209	391	0.3	1.92
4.3	1.8	210	392	0.3	1.92
6.0	2.0	266	497	0.3	1.92
8.0	3.9	400	748	0.3	1.96
11.9	7.9	480	898	0.3	1.96
19.9	10.9	493	922	0.3	1.96

2.4.15. Brigham Young University

SASW testing was performed at Brigham Young University, designated as BYU in this report, and located at 1430 N. 500 E., Provo, Utah. The GPS derived latitude and longitude of the center of the SASW testing array are 41.25237 North and 111.65019 East, with an elevation of approximately 1440 m above sea level using the NAD83 datum. A site map showing the location of the SASW centerline is shown in Fig. 2.232. The site was of particular interest because a strong motion sensor monitored by the University of Utah Seismograph is located near the SASW test location.

Testing was performed at 1:00 p.m. on August 24, 2005. The SASW array was located on the north side of North Campus Drive in an east-west orientation. A photograph of the site is shown in Fig. 2.233. The strong motion sensor is located on the bluff to the north of the SASW array behind the public safety building, roughly 30 m

north of the centerline. A fully saturated zone was not assumed. Maximum drop heights of the 2.04 x 10^3 kg drop weight were 0.25 cm with 19 cm of padding. Due to moist conditions, the far source remained constant, located on the oversized sidewalk.

Figure 2.234 shows the experimental dispersion curve measured at Brigham Young University. Figure 2.235 shows the comparison of the experimental dispersion curve and the theoretical dispersion curve determined from forward modeling. Figure 2.236 shows the calculated shear wave velocity profile for the site. Table 2.46 contains the tabulated layer properties including shear wave velocities determined from forward modeling, layer thicknesses, and the assumed unit weights, Poisson's ratio, and p-wave velocities for the site.

Fig. 2.232 Site map showing the location of the centerline of the SASW array at Brigham Young University (BYU), Utah County, Utah (from Google Earth 2006).

Fig. 2.233 Photograph of SASW testing at Brigham Young University (BYU), Utah County, Utah.

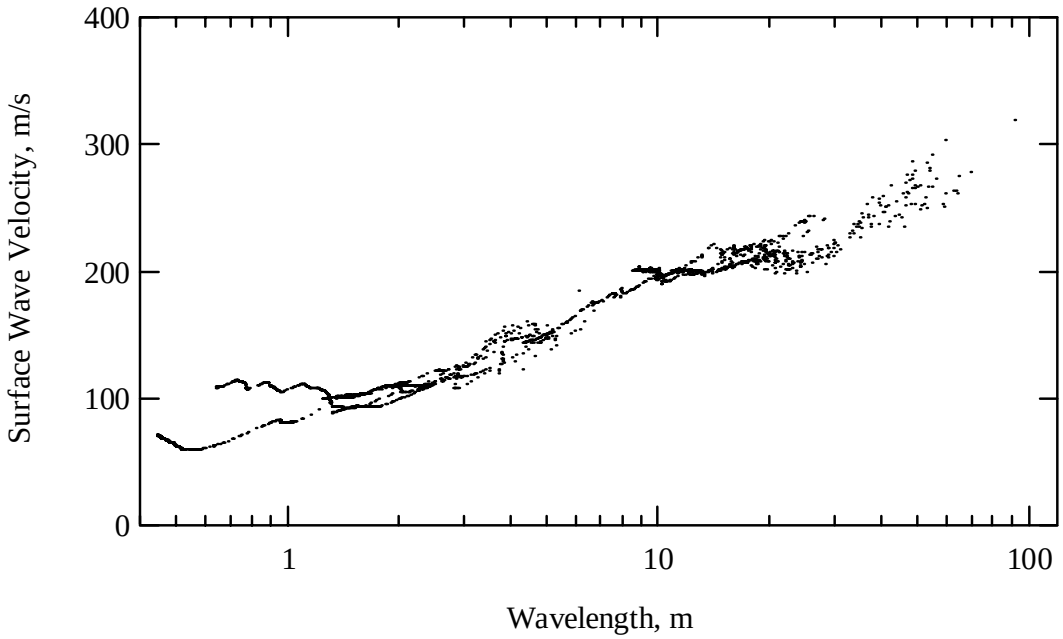

Fig. 2.234 Experimental dispersion curve measured at Brigham Young University (BYU), Utah County, Utah.

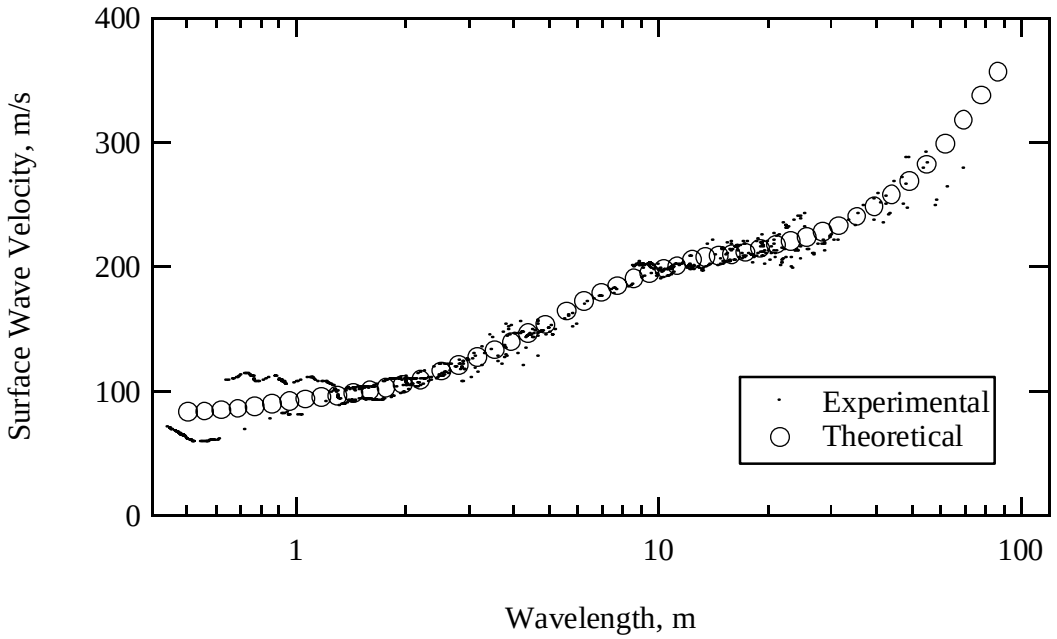

Fig. 2.235 Comparison of experimental and theoretical dispersion curves from Brigham Young University (BYU), Utah County, Utah.

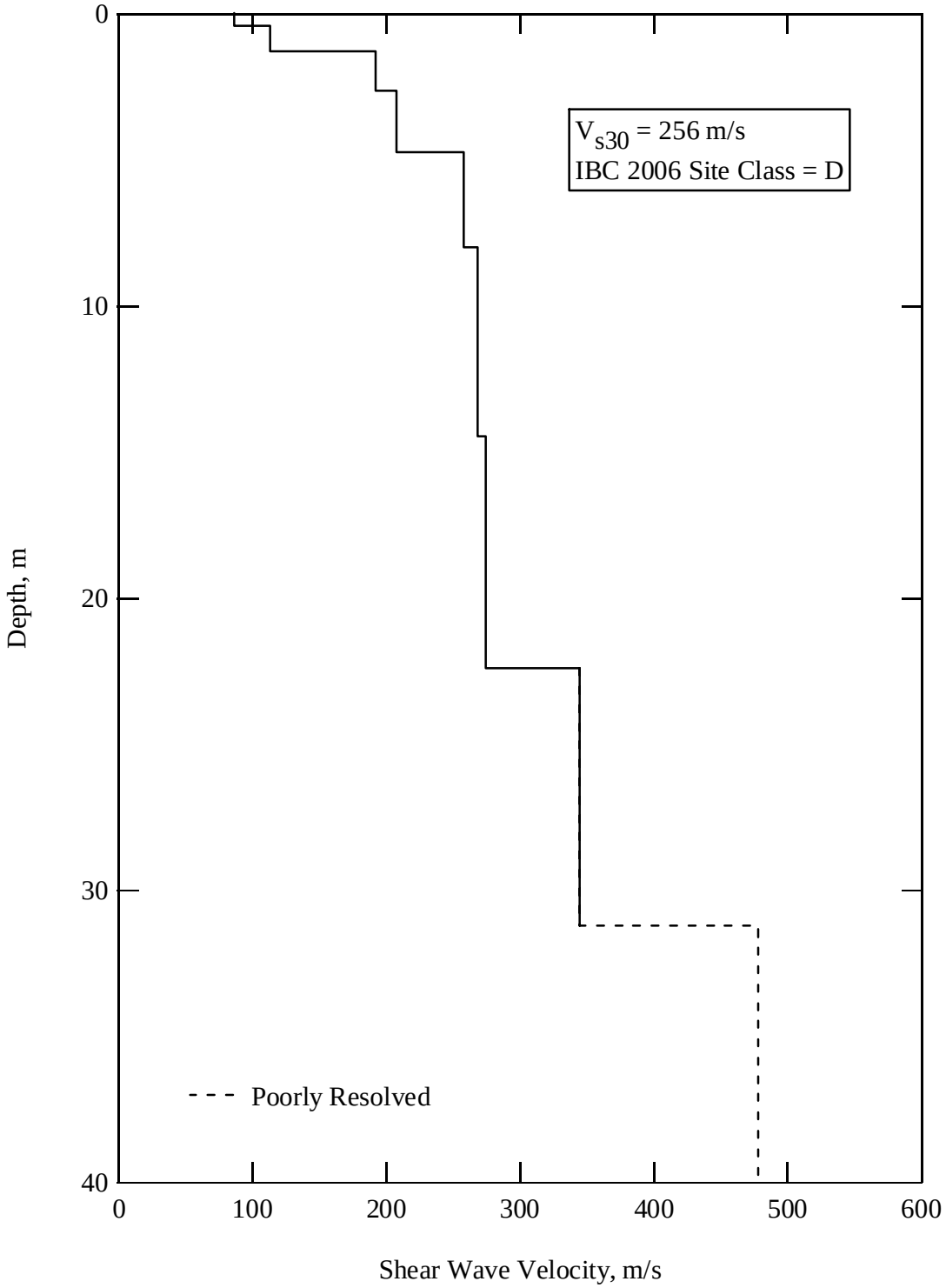

Fig. 2.236 Shear wave velocity profile determined from SASW testing at Brigham Young University (BYU), Utah County, Utah.

The average shear wave velocity in the upper 30 m of soil is 256 m/s, which corresponds to an IBC 2006 site class D. The shear wave velocity profile is well resolved to a depth of 31.2 m and poorly resolved from 31.2 m to 40 m.

Table 2.46 Tabulated measured and assumed layer properties at Brigham Young University (BYU), Utah County, Utah.

Measured Values			Assumed Values		
Depth to Top of Layer (m)	Layer Thickness (m)	Shear Wave Velocity (m/s)	P-Wave Velocity (m/s)	Poisson's Ratio	Unit Weight (t/m^3)
0.0	0.4	87	163	0.3	1.89
0.4	0.9	114	213	0.3	1.89
1.3	1.4	192	359	0.3	1.92
2.7	2.1	208	389	0.3	1.92
4.7	3.3	258	483	0.3	1.92
8.0	6.5	269	503	0.3	1.92
14.5	8.0	275	515	0.3	1.92
22.4	8.8	345	645	0.3	1.96

CHAPTER 3

SASW DATA SUMMARY

During the summer of 2005, 45 SASW tests were performed along the Wasatch Front as part of a cooperative research project funded by the National Earthquake Hazard Reduction Program (NEHRP). Of these 45 sites, 18 were located in Weber and Northern Davis Counties, 9 were located in Davis County, 3 were located in Salt Lake County, and 15 were located in Utah County. The individual result for each test was presented in Chapter 2.

The geologic site response units presented in this section are the most current prior to this study, from Ashland et al. (2005). The results of this study are currently being evaluated by Greg McDonald and Francis Ashland of the Utah Geologic Survey. The revised site response units are not included in this document because the work had not yet been completed as of June, 2006.

The following sections will summarize the results of the SASW tests for Weber and Northern Davis County, Davis County, Salt Lake County, and Utah County. The mean V_{S30} for each unit will be compared to that of the other Counties. A map will be presented for Davis, Weber, and Utah Counties that shows the distribution of shear wave velocities in the previously defined site response units. This map can be used to visually identify trends and anomalies in the data.

WEBER AND NORTHERN DAVIS COUNTIES

Weber County and the Northern portion of Davis County were severely lacking shear wave velocity data prior to this study. There were 4 existing V_{S30} sites, all located in the Ogden area within the previously defined Q02 unit. During the 2005 study, 18 new shear wave velocity profiles were developed in this region. Of the 18 sites that were tested, 9 were co-location to strong motion sensors monitored by the University of Utah Seismograph Stations.

Table 3.1 shows the comparison of average shear wave velocities in each of the 3 units tested compared to the existing average. Existing averages are not listed for the Q01 and Q03 units because none were available in Weber or Northern Davis County. The table also shows that 6 sites were tested in each of the 3 Quaternary site response units. Figure 3.1 shows the spatial distribution of the measured shear wave velocities, both existing and new. The following sections will present the results for each of the individual Quaternary units and suggest further work that might be beneficial.

Table 3.1 Comparison of existing V_{S30} profiles with 2005 V_{S30} profiles in Weber and Northern Davis Counties.

	2005 V_{S30} Profiles		**Existing V_{S30} Profiles**	
Geologic Unit	No. of Profiles	Mean V_{S30} m/s	No. of Profiles	Mean V_{S30} m/s
Q01	6	188	0	-
Q02	6	240	4	212
Q03	6	282	0	-

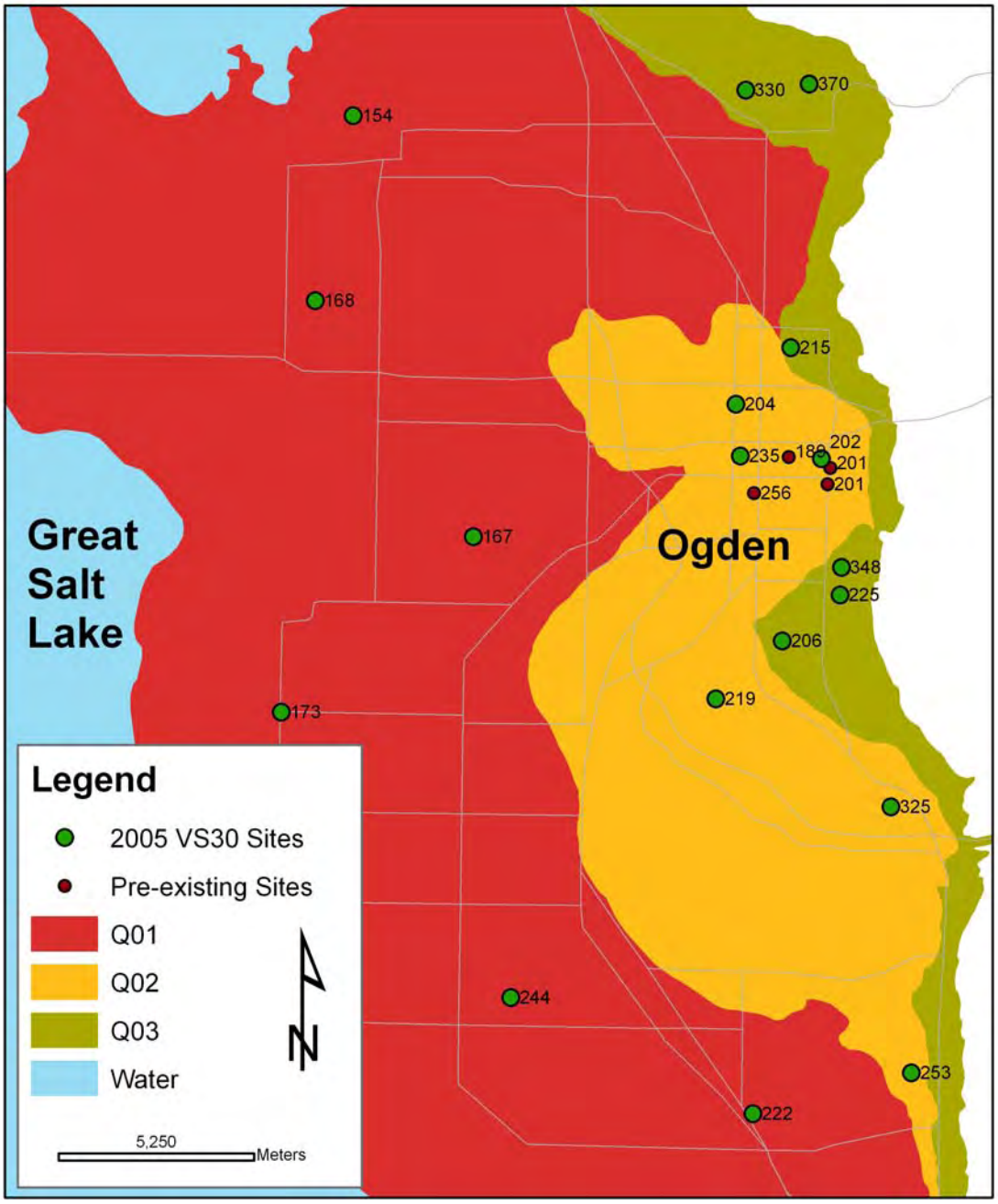

Fig. 3.1 Map showing the shear wave velocity distribution in Weber and Northern Davis Counties, Utah.

2005 Results for the Weber and Northern Davis Q01 Unit

Of the 6 sites that were tested in the Weber and Northern Davis Counties Q01 unit, 4 fell into the 2006 IBC site class E, and 2 were site class D. The 4 sites that fell into site class E are located in Weber County, and the 2 sites in site class D are located in

Davis County. There is a significant difference in V_{S30} between these 2 groups of sites. The shear wave velocities in Northern Davis County that were grouped with the Weber County sites tend to more closely resemble the shear wave velocities measured in Davis County, being a little higher. This preliminary observation suggests that more data is needed between Hooper and Syracuse so as to better detail the transition from site class E to site class D.

Three of the sites are co-location to strong motion sensors: Plain City Landfill (PCL), Syracuse Cemetery (SCS), and Hooper Elementary School (HES). Syracuse Cemetery is located in Davis County, while Hooper Elementary School and Plain City Landfill are located in Weber County.

Figure 3.2 shows all of the profiles on the same plot. Central Davis Jr. High School (CDJ), and Syracuse Cemetery (SCS) are the 2 sites located in Davis County that fall into site class D. In Fig. 3.2, these 2 sites can be seen to exhibit stiffer profiles than the rest. The mean V_{S30} for the 6 sites shown in Fig. 3.2 is 188 m/s. The minimum V_{S30} was measured at PCL as 154 m/s, and the maximum V_{S30} was measured at SCS as 242 m/s.

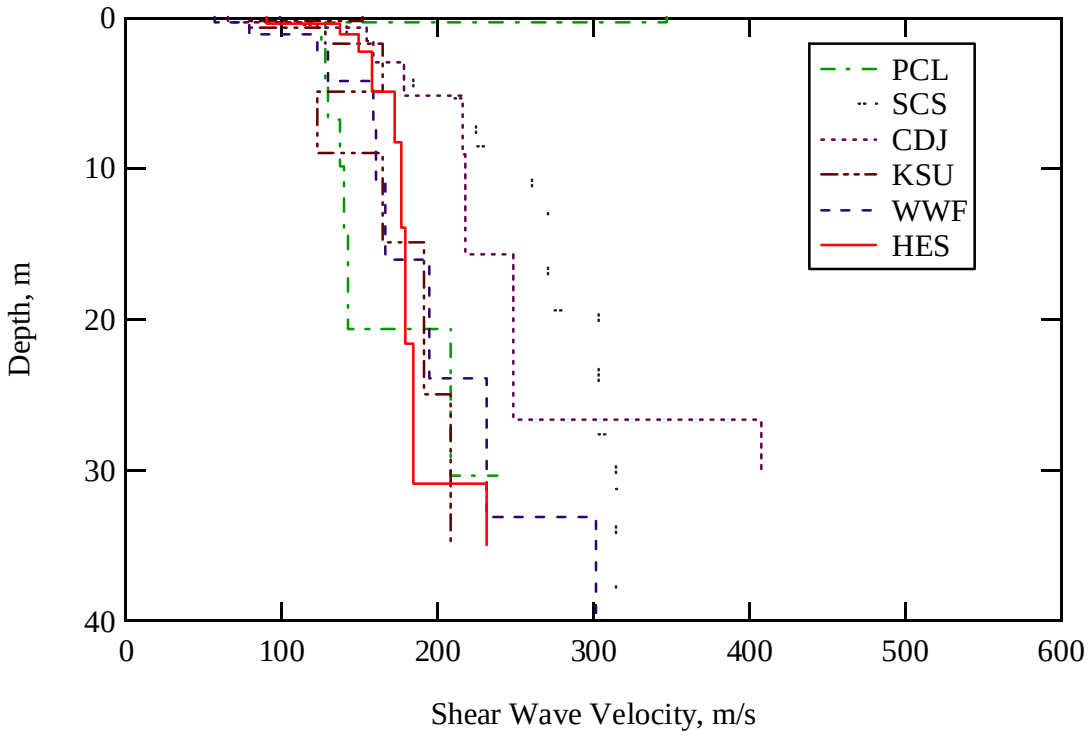

Fig. 3.2 Measured shear wave velocity profiles in the Q01 site response unit of Weber and Northern Davis Counties, Utah.

2005 Results for the Weber and Northern Davis Q02 Unit

Six sites were tested in the Weber and Northern Davis Counties Q02 unit. The V_{S30} ranged from a minimum of 202 m/s measured in Ogden (OPS), to 325 m/s measured in Uintah (UTH). All of the sites are classified as IBC 2006 site class D. Four of the sites are co-location to strong motion sensors: East Layton Elementary School (ELE), the

Ogden Fire Station #2 (OF2), the Ogden Public Safety Building (OPS), and the Uintah Town Hall (UTH).

Although all of the sites fall within site class D, UTH has a distinctively higher shear wave velocity than the other sites. This can be seen in Fig. 3.3 which shows the shear wave velocity profiles measured in the Davis County Q02 unit.

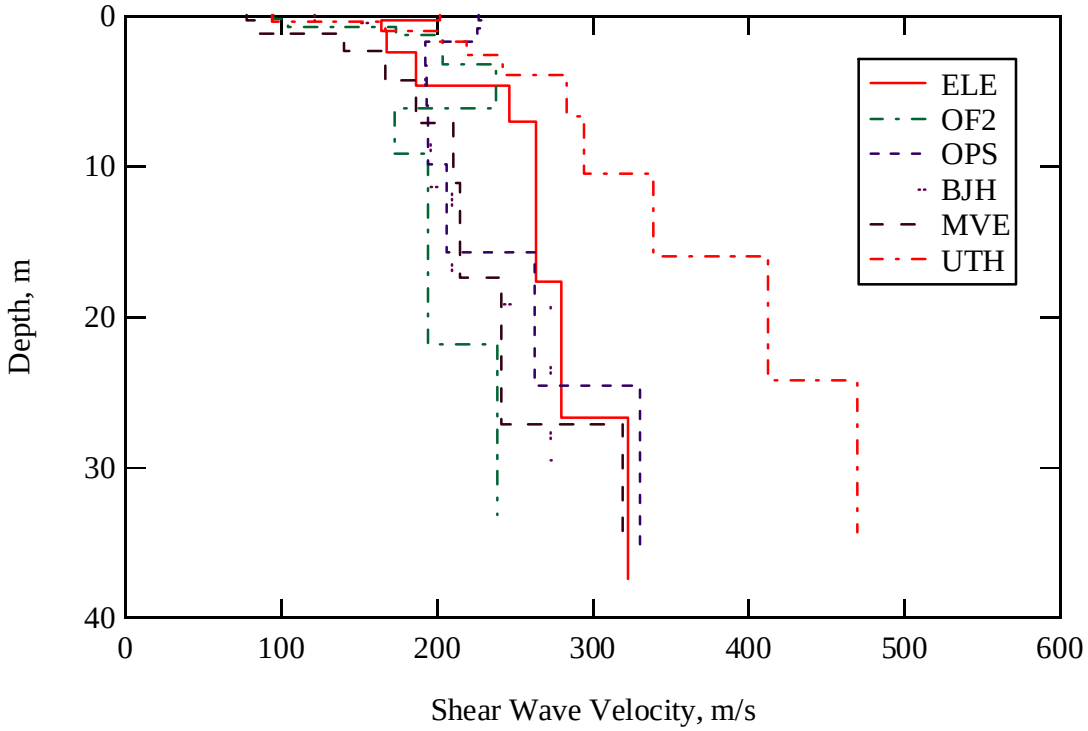

Fig. 3.3 Measured shear wave velocity profiles in the Q02 site response unit of Weber and Northern Davis Counties, Utah.

The spatial distribution of V_{S30} sites in the previously defined Q02 site response unit is not very good. More data is needed in the western Ogden area, South Ogden, and in the Clearfield area near Hill Air force Base. The high V_{S30} measured at the Uintah Town Hall (UTH) might also justify a reworking of the Q02/Q03 boundary.

2005 Results for the Weber and Northern Davis Q03 Unit

Six sites were tested in the Weber and Northern Davis Counties Q03 unit. The V_{S30} ranged from a minimum of 206 m/s measured at South Ogden Jr. High School (SOJ), to 370 m/s measured at Bates Elementary School (BES). All of the sites are classified as IBC 2006 site class D except for BES which falls into a site class C. Two of the sites are co-location to strong motion sensors: Weber State University (7212) and Bates Elementary School (BES).

The V_{S30} measured at the 6 sites in the Weber and Northern Davis Counties Q03 unit are not statistically distinct. There is a large variation in the profiles as can be seen in Fig. 3.4. It appears that LVP, BES, and WES exhibit similar shear wave velocity profiles while SOJ, HMS, and 7212 are very similar with significantly softer profiles.

BES and LVP are located near each other in northern Weber County, but WES exhibits an unusual profile when compared to 7212 and SOJ which are located nearby.

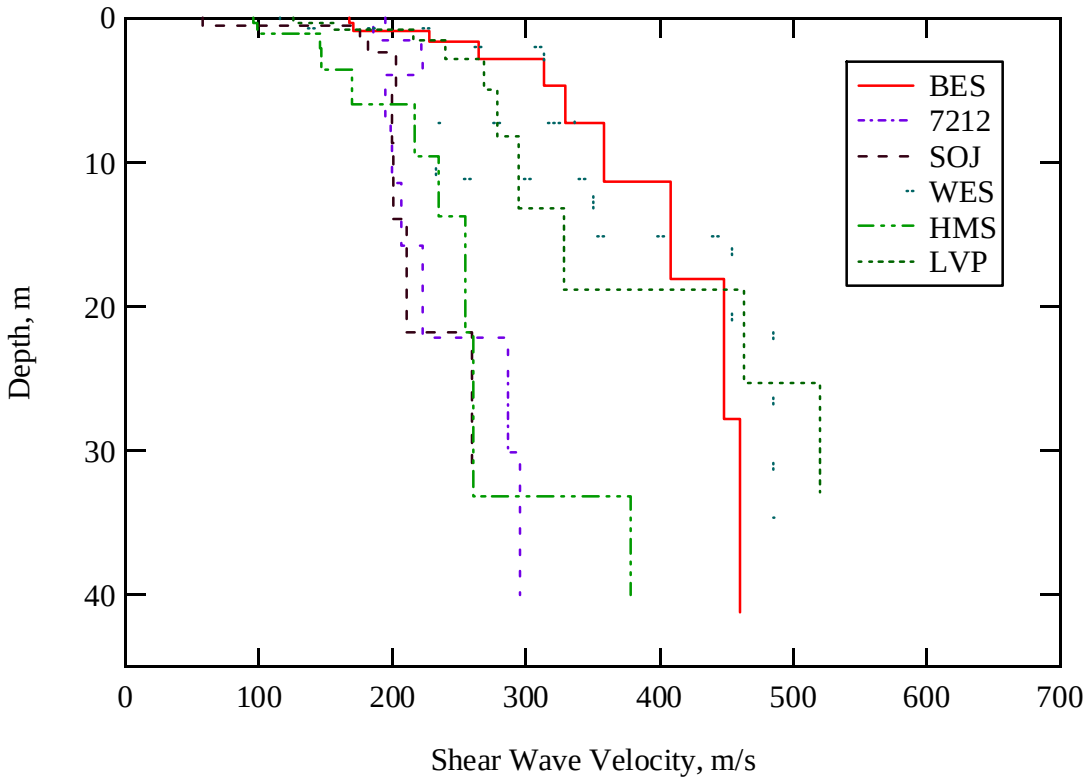

Fig. 3.4 Measured shear wave velocity profiles in the Q03 site response unit of Weber and Northern Davis Counties, Utah.

A preliminary observation that can be made is the distinct difference between the Wasatch Elementary School (WES) measurement and the measurement taken at Weber State University (7212). The V_{S30} for 7212 is 225 m/s and the V_{S30} at WES is 348 m/s. The sites are located just kilometers from each other and exhibit extremely different geologic characteristics.

More data along the eastern strip of the Weber County Q03 unit would be beneficial, yet it was found to be extremely difficult to find an adequate location due to the mountainous terrain.

DAVIS COUNTY

There were 6 existing V_{S30} sites located in the Davis County. During the 2005 study, 9 new shear wave velocity profiles were developed in this region and added to the existing 6. Of the 9 sites that were tested, 2 were co-location to strong motion sensors monitored by the University of Utah Seismograph Stations. Figure 3.5 shows the spatial distribution of the measured shear wave velocities for both the existing and the new sites.

Table 3.2 shows the comparison of average shear wave velocities in each of the 3 units tested compared to the existing average. The table also shows the distribution of the 9 tests in each site response unit. The following sections will present the results for each of the individual Quaternary units and suggest further work that might be beneficial.

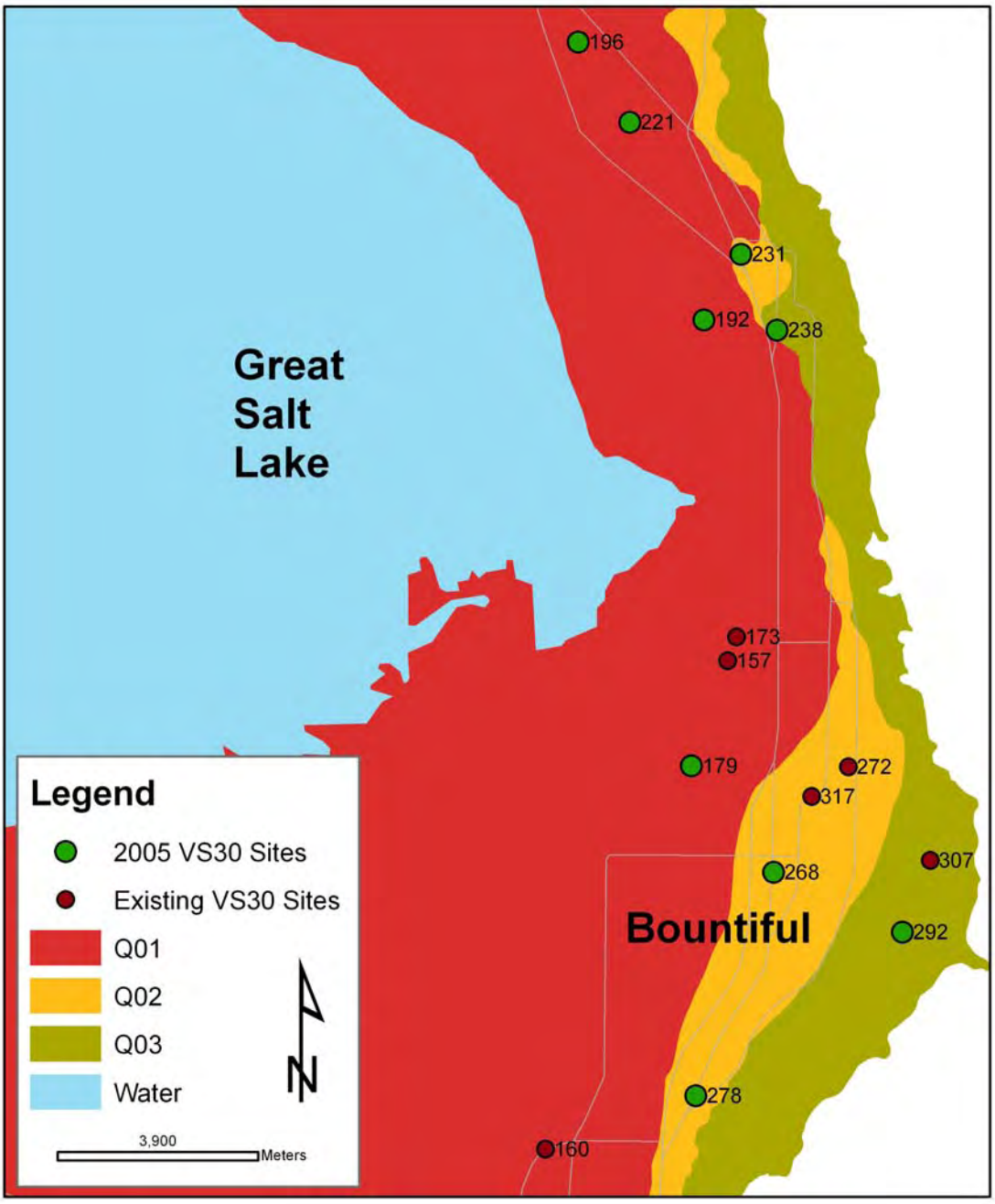

Fig. 3.5 Map showing the shear wave velocity distribution in Davis County, Utah.

Table 3.2 Comparison of existing V_{S30} profiles with 2005 V_{S30} profiles in Davis County.

	2005 V_{S30} Profiles		**Existing V_{S30} Profiles**	
Geologic Unit	No. of Profiles	Mean V_{S30} m/s	No. of Profiles	Mean V_{S30} m/s
Q01	4	197	3	163
Q02	3	259	2	294
Q03	2	265	1	307

2005 Results for the Davis County Q01 Unit

Of the 4 sites that were tested in the Davis Counties Q01 unit, 1 fell into the 2006 IBC site class E, and 3 were site class D. The 1 site that fell into site class E is the Lakeside Golf Course (LGC) which is also the only Q01 site that is co-location to a strong motion sensor. It should also be noted that the V_{S30} for LGC was measured to be 179 m/s, and the cutoff between site class D and site class E is 180 m/s. The minimum V_{S30} for the Q01 unit was measured at LGC as 179 m/s and the maximum V_{S30} was measured at WRS as 221 m/s. The mean V_{S30} for the unit is 183 m/s.

Figure 3.6 shows the 4 new profiles on the same plot. The profiles show fairly good agreement, however the limited number of test sites in Davis County presents a problem when trying to perform a statistical analysis. More data is needed, especially in the in central and southern Davis County area.

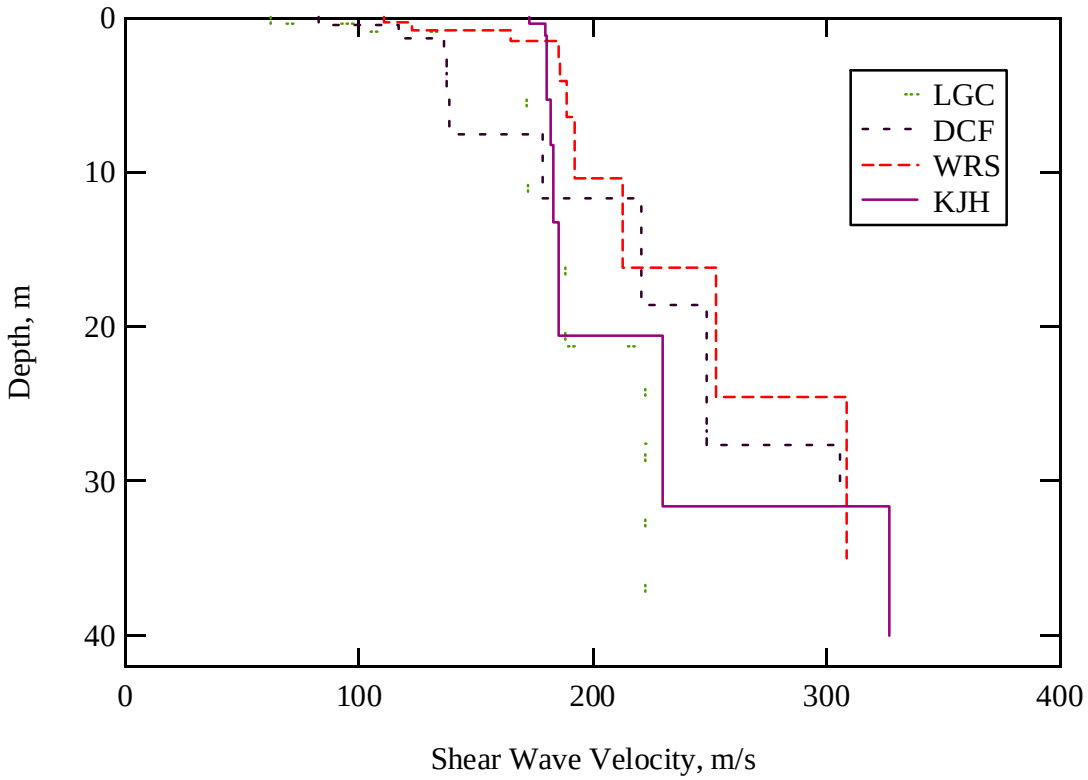

Fig. 3.6 Measured shear wave velocity profiles in the Q01 site response unit in Davis County, Utah.

2005 Results for the Davis County Q02 Unit

Three sites were tested in the Davis County Q02 unit. The V_{S30} ranged from a minimum of 231 m/s measured at the Utah Highway Patrol Building (UHP) in Farmington, to 278 m/s measured at Orchard Elementary School (OES) in Bountiful. All of the sites are classified as IBC 2006 site class D according to the shear wave velocity criteria. UHP is the only site that is also co-location to a strong motion sensor.

Figure 3.7 shows the 3 new shear wave velocity profiles in the Davis County Q02 site response unit. The profiles exhibit a very similar trend with similar V_{S30} values. The mean V_{S30} for the unit is 273 m/s.

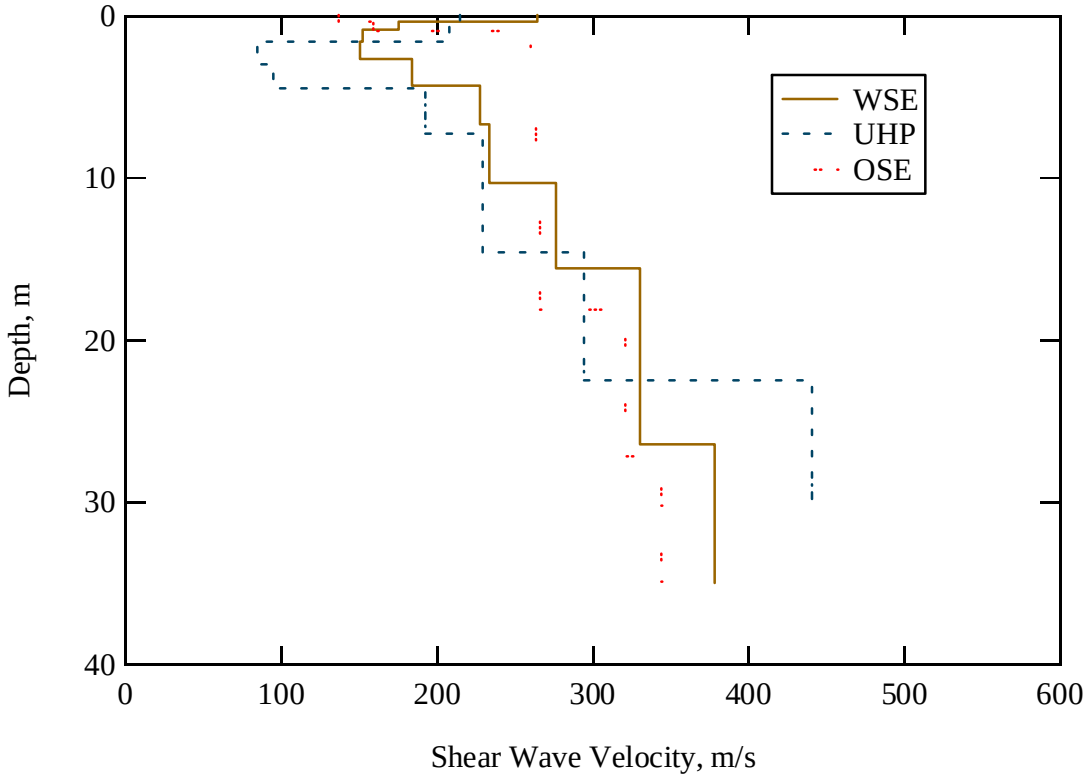

Fig. 3.7 Measured shear wave velocity profiles in the Q02 site response unit of Davis County, Utah.

2005 Results for the Davis County Q03 Unit

Two sites were tested in the Weber and Northern Davis Counties Q03 unit. The V_{S30} values were 292 m/s and 238 m/s for Mueller Park Jr. High School (MPS) and Farmington Elementary School (FES) respectively. Neither of the two sites are co-location with strong motion sensors. The mean V_{S30} for the unit is 279 m/s.

There is a definite need for more data in the Davis County Q03 unit. The challenge in performing SASW testing in this area is the difficult terrain. The Q03 unit lies in the highlands where it is difficult to find flat roads, parks, schools, or other properties with the required free space.

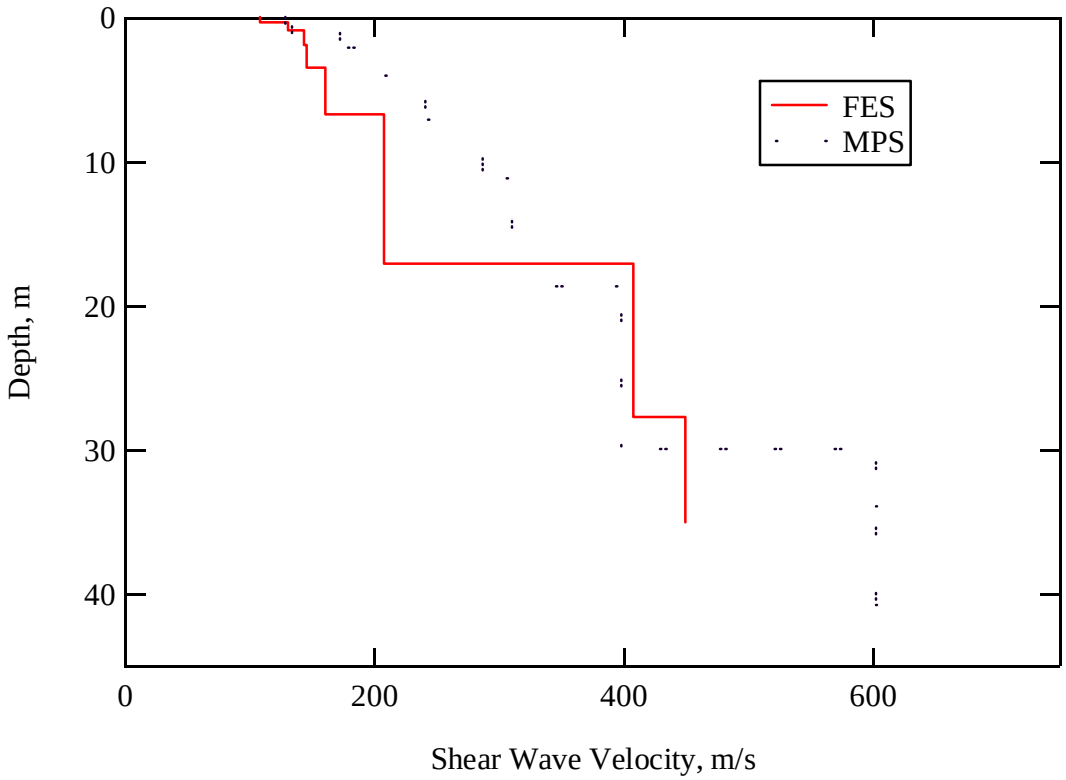

Fig. 3.8 Measured shear wave velocity profiles in the Q03 site response unit of Davis County, Utah.

SALT LAKE COUNTY

The Salt Lake County has 131 existing shear wave velocity profiles (Ashland et al. 2005). The County has been fairly well characterized, and was the topic of a similar study by Gilbert (2004) where 30 new profiles were added to the database. A map showing the revised site response units and the spatial distribution of the profiles is shown in Fig. 3.9. The map also shows the location of 3 tests that were performed in the Salt Lake County during the 2005 study. The following sections will summarize the results of the 3 tests that were performed in 2005.

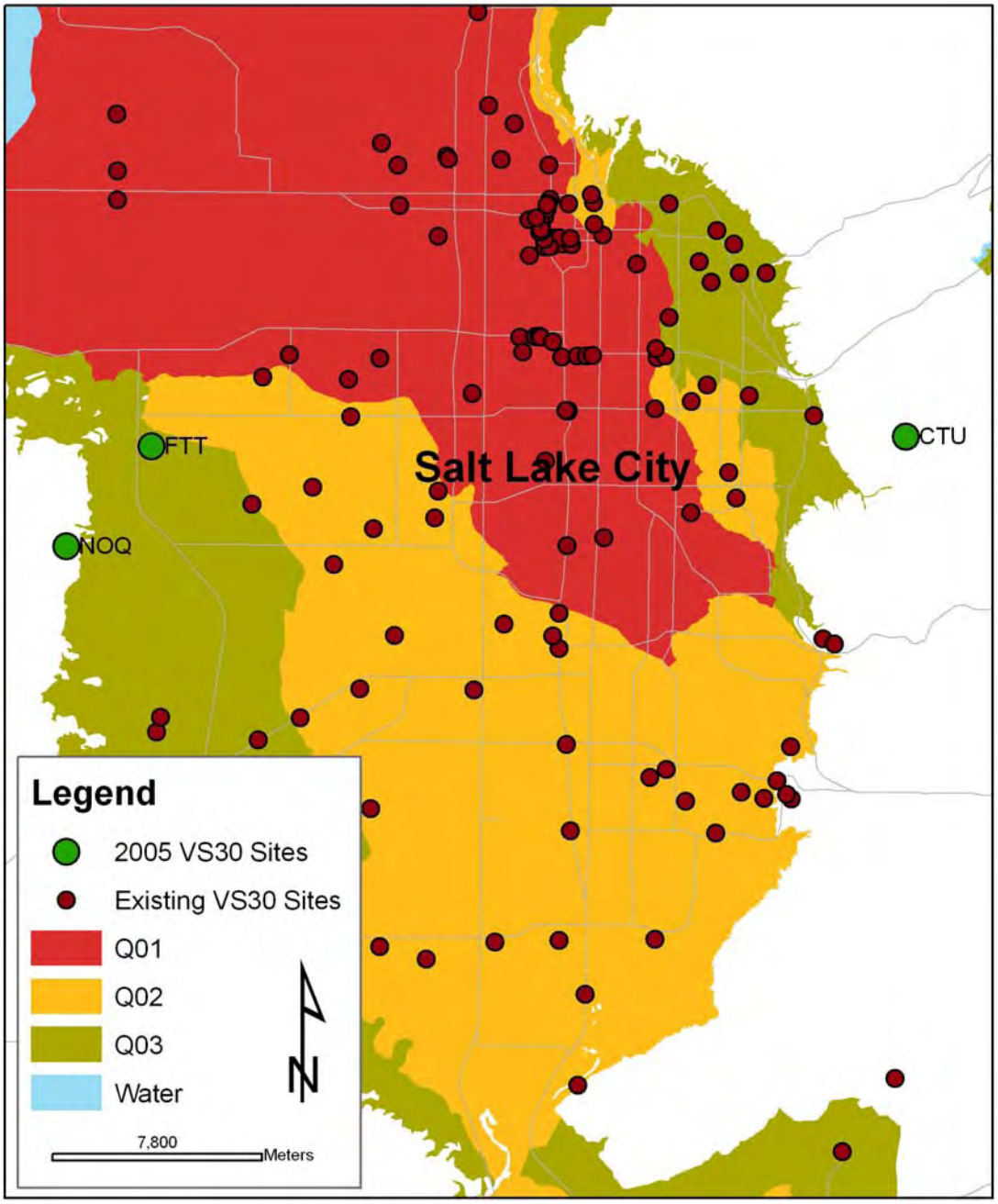

Fig. 3.9 Map showing the shear wave velocity distribution, revised site response units, and location of 3 new test sites in Salt Lake County, Utah.

Fire Training Tower

The Fire Training Tower in Magna, Utah is the location of a strong motion sensor that is monitored by the University of Utah Seismograph Stations. During the summer of 2003 an SASW test was performed by Jeff Gilbert and Dr. James Bay of Utah State University (Gilbert 2004). A previous geophysical test showed disagreement with the

2003 test, so the 2005 objective was to verify the profile. The results of this study and a comparison of the measured profiles can be found in Chapter 4.

Camp Tracy

A Broadband Seismometer is located at Camp Tracy in the Wasatch Mountains on the East side of the Salt Lake County. SASW testing at the site indicated shallow bedrock shear wave velocities of approximately 1000 m/s. The detailed shear wave velocity profile was previously shown in Chapter 4.

Northern Oquirrh Seismic Station

A strong motion sensor is located on Kennecott property on the western boundary of the Salt Lake County in the Oquirrh Mountains. SASW testing at the site indicated shallow bedrock shear wave velocities to be approximately 650 m/s. The detailed shear wave velocity profile was previously shown in Chapter 4.

UTAH COUNTY

During the 2005 study, 15 new shear wave velocity profiles were developed in Utah County. Of the 15 sites that were tested, 6 were co-location to strong motion sensors monitored by the University of Utah Seismograph Stations.

Table 3.3 shows the comparison of average shear wave velocities in each of the 3 units tested compared to the existing average. The table also shows that 5 sites were tested in each of the 3 Quaternary site response units. Figure 3.10 shows the spatial distribution of the measured shear wave velocities, both existing and new. The following sections will present the results for each of the individual Quaternary units and suggest further work that might be beneficial.

Table 3.3 Comparison of existing V_{S30} profiles with 2005 V_{S30} profiles in Utah County, Utah.

	2005 V_{S30} Profiles		**Existing V_{S30} Profiles**	
Geologic Unit	No. of Profiles	Mean V_{S30} m/s	No. of Profiles	Mean V_{S30} m/s
Q01	5	197	2	171
Q02	5	259	2	328
Q03	5	265	1	480

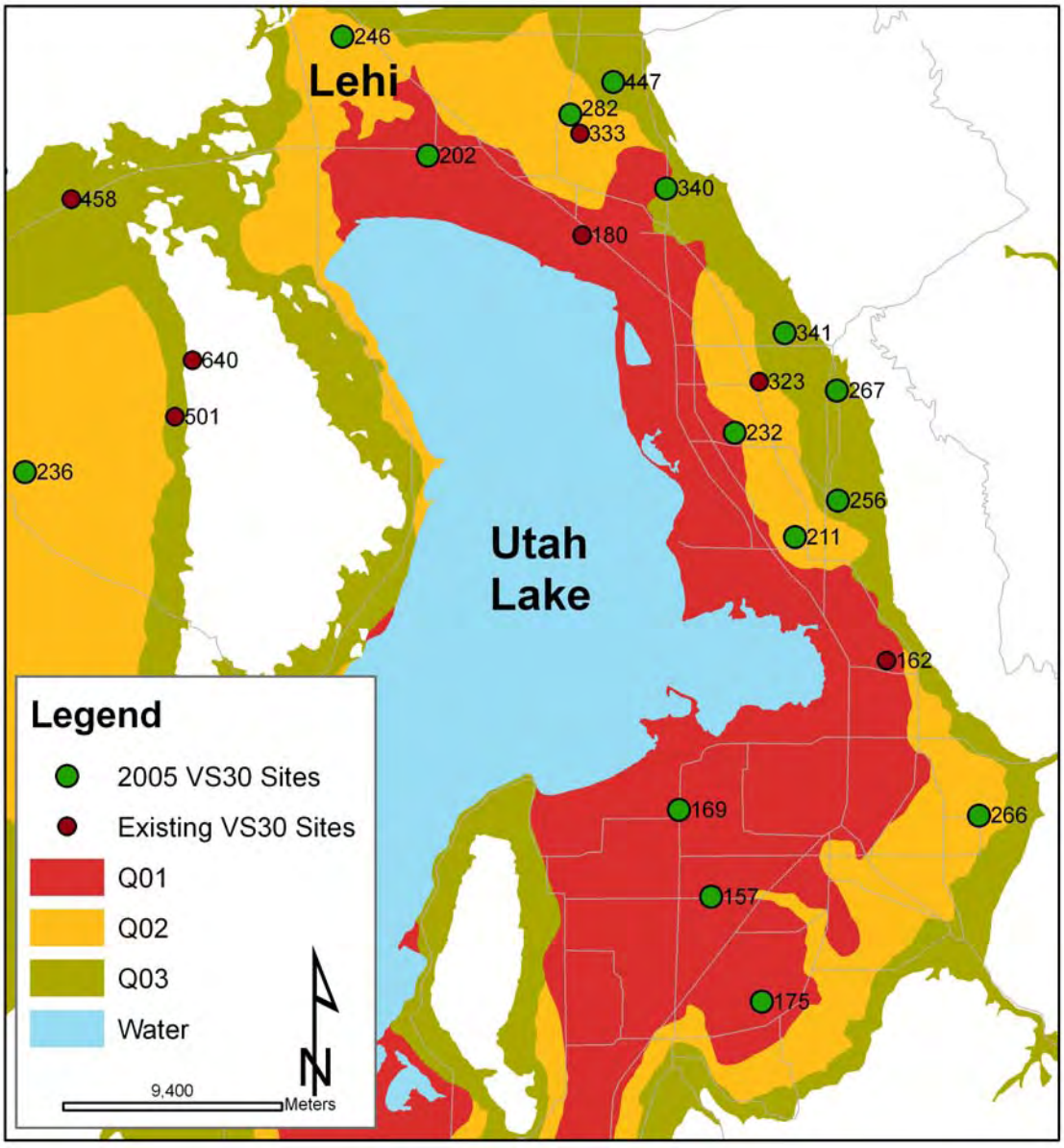

Fig. 3.10 Map showing the shear wave velocity distribution in Utah County, Utah.

2005 Results for the Utah County Q01 Unit

Of the 5 sites that were tested in the Utah County Q01 unit, 3 fell into the 2006 IBC site class E, and 2 were site class D. The 3 sites that fell into site class E are located in the southern portion of the County. Two of the sites are co-location to strong motion sensors: Salem City Yard (SCY), and Lakeshore (LSU).

A total of 7 shear wave velocity profiles exist in the Utah County Q01 unit. Lakeridge Jr. High School (LRJ) has the highest V_{S30} of 232 m/s. The site is located in the Q01 unit but near the mapped Q01/Q02 boundary. The lowest V_{S30} for the entire study was measured in Benjamin, Utah at the Woffinden Home (WOF) as 157 m/s. The maximum V_{S30} was measured at LRJ as 232 m/s. The mean V_{S30} for the unit is 186 m/s. Figure 3.11 shows the shear wave velocity profiles for each of the 5 sites.

Because of the size of Utah County and the limited number of V_{S30} sites, the data is sparsely distributed. Residential developments are becoming common on the west side of Interstate 15 along the east coast of Utah Lake. Data in this area and others such as Spanish Fork and western Provo would fill important gaps and provide a more representative mean V_{S30}.

2005 Results for the Utah County Q02 Unit

Each of the 5 sites that were tested in the Utah County Q02 unit fall into the 2006 IBC site class D. The minimum V_{S30} was measured at Dixon Jr. High School (DJH) as 211 m/s, and the maximum was measured at the Tri Cities Golf Course (AMF) as 282 m/s. Three of the 5 sites are co-location to strong motion stations: Tri Cities Golf Course (AMF), Thanksgiving Point (TPU), and the Mapleton Ambulance Building (MAB).

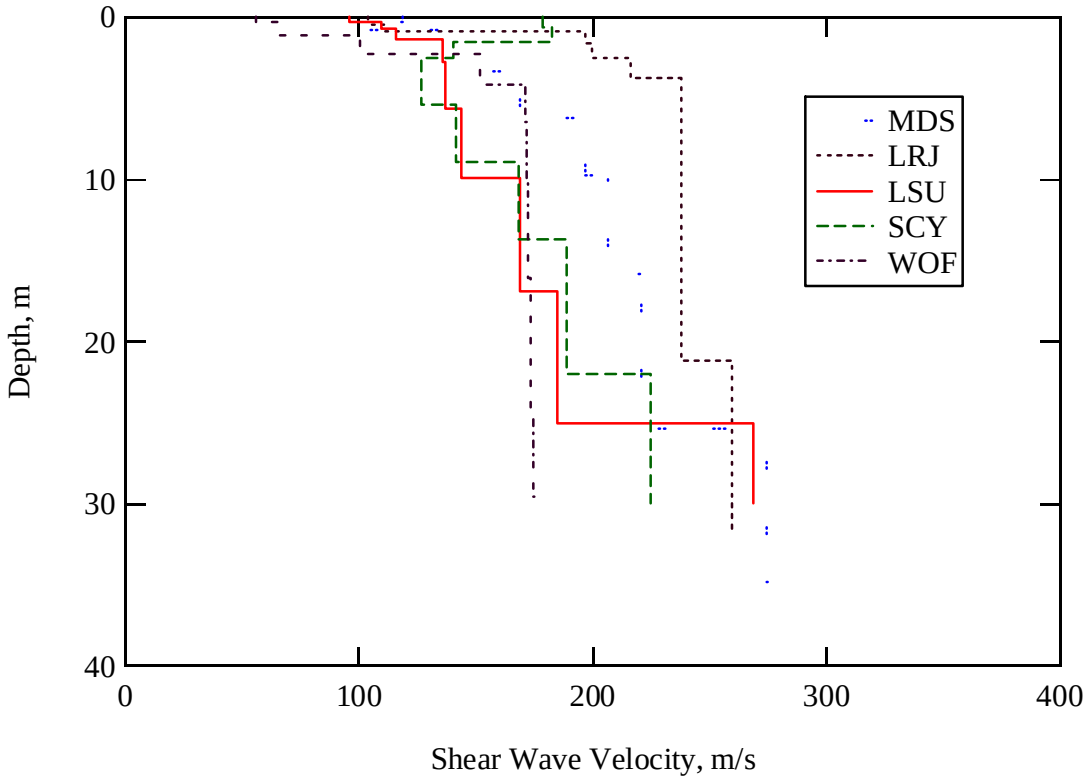

Fig. 3.11 Measured shear wave velocity profiles in the Q01 site response unit in Utah County, Utah.

Figure 3.12 shows the shear wave velocity profiles for the 5 new sites in the Utah County Q02 unit. All of the sites have similar profiles to depths of 30 meters with the exception of AMF, which exhibits a stiffer profile at shallow depths and encounters a stiff layer at about 30 meters below the ground surface.

More V_{S30} profiles in the Spanish Fork Q02 area and western Lehi would fill gaps in the data and provide a better representation of the mean V_{S30}. The two existing sites

located in the Utah County Q02 unit have higher V_{S30} values which increase the mean from 248 m/s to 271 m/s.

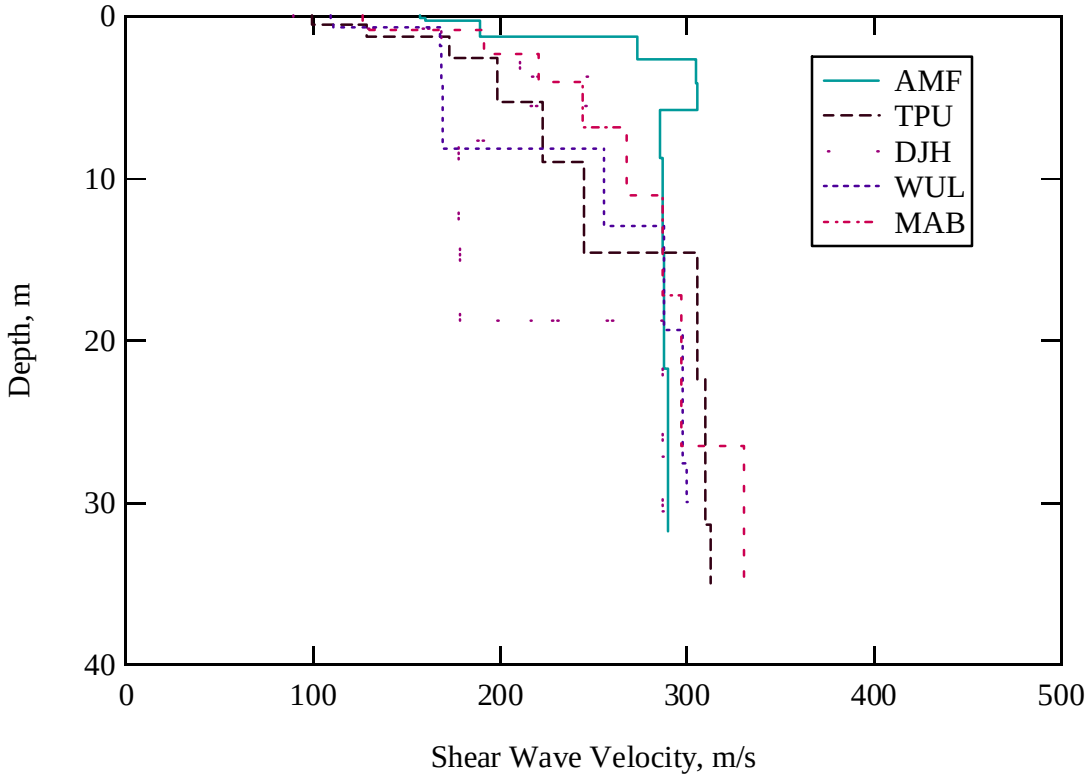

Fig. 3.12 Measured shear wave velocity profiles in the Q02 site response unit in Utah County, Utah.

2005 Results for the Utah County Q03 Unit

Of the 5 sites that were tested in the Utah County Q03 unit, 4 fall into the IBC 2006 site class D, and 1 in site class C. The minimum V_{S30} was measured at BYU as 256 m/s, and the maximum was measured at the CRE as 447 m/s. BYU was the only site located near a strong motion sensor.

Figure 3.13 shows the shear wave velocity profiles for the 5 new sites in the Utah County Q03 unit. From this figure it is obvious that there is a significant geologic difference in the Cedar Valley area, where CRE is located. The mean V_{S30} for the unit is 373 m/s. Without consideration of Cedar Valley sites, the mean V_{S30} is 301 m/s.

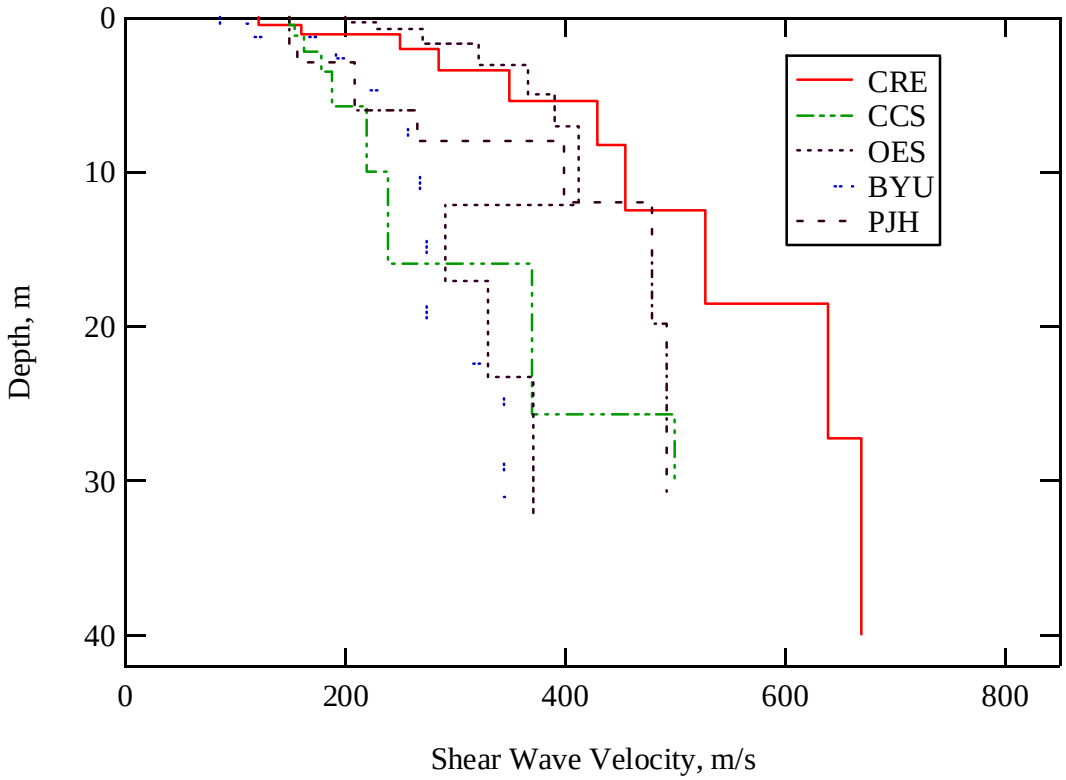

Fig. 3.13 Measured shear wave velocity profiles in the Q03 site response unit in Utah County, Utah.

COMBINED DATA SUMMARY

The statistical data is summarized in Table 3.4 for the three combined Counties by Quaternary site response unit. The Q01 sites fall between 154 m/s and 244 m/s with a standard deviation of 28.3. Two-thirds of the data falls below 200 m/s; however, there do not seem to be any significant outliers. The Q02 sites fall between 201 m/s and 325 m/s with a standard deviation of 34.7. The Uintah Town Hall (UTH) with a V_{S30} of 325 m/s seems to be an outlier, and with this data point excluded, the standard deviation is 27.4. The Q03 sites range in V_{S30} from 206 m/s to 447 m/s. This unit exhibits the largest standard deviation and most significant scatter in the data. The standard deviation for the Q03 data is 71.6.

Table 3.5 presents the results for Weber and Northern Davis, Davis, and Utah Counties. The table presents the number of SASW tests performed during the course of this study, the mean V_{S30} for each unit, the median V_{S30}, maximum V_{S30}, minimum V_{S30}, and standard deviation.

Table 3.6 lists the site name, site description, county, site response unit, and calculated V_{S30} for each of the 45 sites. Figure 3.14 shows the V_{S30} for each of the 2005 sites located in the Weber and Northern Davis, Davis, and Utah Counties, where the number of occurrences of V_{S30} for each Quaternary unit are plotted against V_{S30}. The data for each if the different counties are combined in the figure.

Weber and Davis Counties exhibit a much lower mean V_{S30} in the Q03 unit than Slat Lake and Utah County. This preliminary observation might suggest either a major reworking of the Q02/Q03 boundary in the Davis and Weber area, or a method of uniquely identifying the Quaternary units in Weber and Davis Counties. More data in the Weber and Davis Q03 unit would be beneficial and provide more statistically significant results.

Table 3.4 Statistical data for combined counties.

Geologic Unit	No. of Profiles	Mean V_{S30} m/s	Median V_{S30} m/s	Maximum V_{S30} m/s	Minimum V_{S30} m/s	Standard Deviation	Salt Lake County Mean V_{S30} m/s
Q01	15	190	179	244	154	28.3	198
Q02	14	246	241	325	201	34.7	297
Q03	13	298	292	447	206	71.6	398

Table 3.5 Statistical data for Weber, Davis, and Utah Counties, Utah.

Geologic Unit	County	No. of Profiles	Mean V_{S30} m/s	Median V_{S30} m/s	Max V_{S30} m/s	Min V_{S30} m/s	Standard Deviation
Q01	Weber	6	188	170	243	154	36.0
	Davis	4	197	194	221	179	17.5
	Utah	5	187	175	232	157	30.0
Q02	Weber	6	240	240	325	202	46.1
	Davis	3	259	268	278	231	24.7
	Utah	5	248	246	282	210	27.4

Q03	Weber	6	282	277	370	206	74.6
	Davis	2	265	N/A	292	238	38.2
	Utah	5	330	340	447	256	76.4

Table 3.6 Summary of SASW tests performed by USU in 2005.

SITE	Description	County	Q0_	V_{S30} (m/s)
LGC	Lakeside Golf Coarse	Davis	1	179
DCF	Davis County Fairgrounds	Davis	1	192
KJH	Kayseville Jr High School	Davis	1	196
WRS	Windridge Elementary School	Davis	1	221
WSE	Washington Elementary School	Davis	2	268
UHP	Utah Highway Patrol	Davis	2	231
OSE	Orchard Elementary School	Davis	2	278
FES	Farmington Elementary School	Davis	3	238
MPS	Mueller Park Jr High School	Davis	3	292
MDS	Meadow School	Utah	1	202
LRJ	Lakeridge Elementary School	Utah	1	232
LSU	Lakeshore	Utah	1	169
SCY	Salem City Yard	Utah	1	175
WOF	Woffinden home	Utah	1	157
AMF	Tri City Golf Coarse	Utah	2	282
TPU	Thanksgiving Point	Utah	2	246
DJH	Dixon Jr High	Utah	2	211
WUL	Eagle valley area	Utah	2	236
MAB	Mapleton Ambulance Bldg	Utah	2	266
CRE	Cedar Ridge ES	Utah	3	447
CCS	Canyon Crest School	Utah	3	267
OES	Orchard Elementary School	Utah	3	341
BYU	BYU	Utah	3	256
PJH	Pleasant Grove Jr High School	Utah	3	340
PCL	Plain City Landfill	Weber	1	154
SCS	Syracuse Cemetery	Weber/Davis	1	244
CDJ	Central Davis Jr High School	Weber/Davis	1	222
KSU	Kanesville Elementary School	Weber	1	167
WWF	West Weber Hay Field	Weber	1	168
HES	Hooper Elementary School	Weber	1	173
ELE	East Layton Elementary	Weber/Davis	2	253
OF2	Ogden Fire Station 2	Weber	2	202
OPS	Ogden Public Safety Building	Weber	2	235
BJH	Bell JR High School	Weber	2	219
MVE	Mountain View Elementary	Weber	2	204
UTH	Uintah Town Hall	Weber	2	325
BES	Bates Elementary School	Weber	3	370
7212	Weber State Annex 2 (parking lot)	Weber	3	225
SOJ	South Ogden Jr High School	Weber	3	206
WES	Wasatch Elementary School	Weber	3	348
HMS	Highland Middle School	Weber	3	215
LVP	Lemond View Park	Weber	3	330
FTT	Fire Training Tower Redo	Salt Lake	3	432

NOQ	Kennecott Rock site for UUSS	Salt Lake	N/A	N/A
CTU	Camp Tracy Rock Site for UUSS	Salt Lake	N/A	N/A

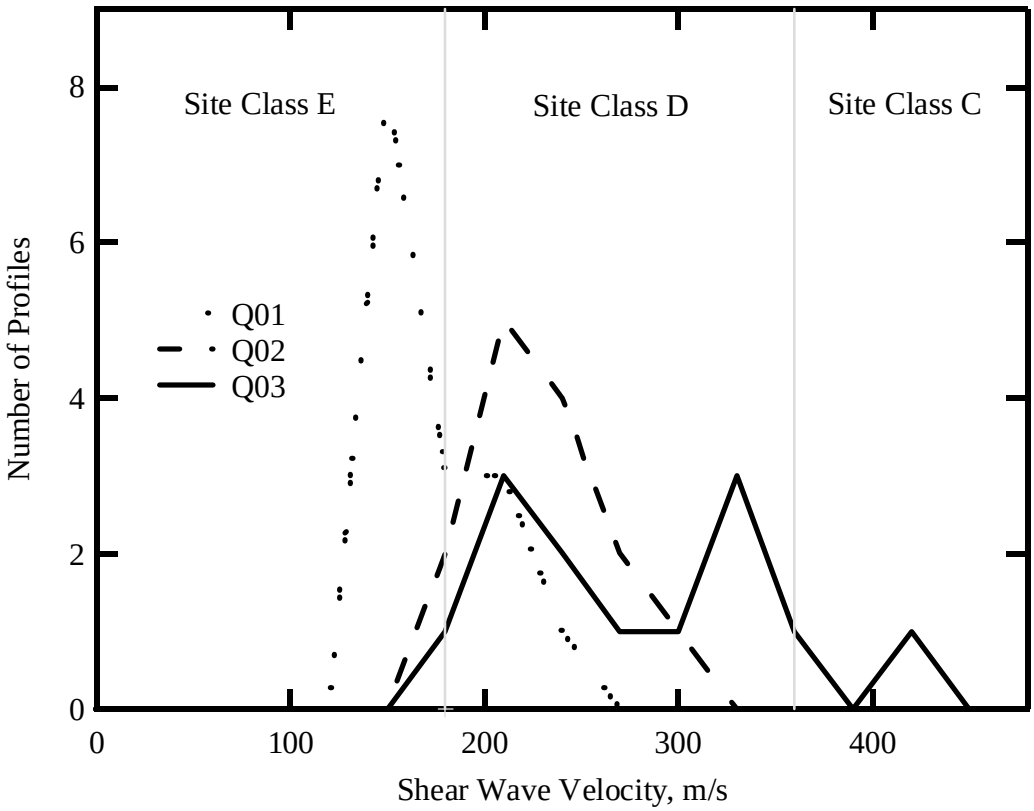

Fig. 3.14 Plot showing the combined County V_{S30} distribution for each of the previously defined Quaternary site response units.

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