Shear-Wave Velocity and Site-Amplification Factors for 50 Australian Sites Determined by the Spectral Analysis of Surface Waves Method

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Contents

Figures

Table

Conversion Factors

International System of Units to Inch/Pound

Multiply	By	To obtain
Length		
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
Flow rate		
meter per second (m/s)	3.281	foot per second (ft/s)

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Abstract

One-dimensional shear-wave velocity (V_S) profiles are presented at 50 strong motion sites in New South Wales and Victoria, Australia. The V_S profiles are estimated with the spectral analysis of surface waves (SASW) method. The SASW method is a noninvasive method that indirectly estimates the V_S at depth from variations in the Rayleigh wave phase velocity at the surface.

Introduction

This project focuses on the measurement of shear-wave velocity (V_S) of the near-surface materials at strong motion recording stations in Australia. During two measurement periods, data were collected in the states of Western Australia, South Australia, Victoria, and New South Wales. These states are only regionally instrumented with permanent seismometer recording stations, although these stations have been supplemented with more closely spaced temporary aftershock recorders in response to local seismic activity. The V_S profiles presented in this report are useful for calibration of site-amplification models based on direct measurement of velocity, by topography, or by surface geologic unit. Data presented here were collected using the continuous sine wave source spectral analysis of surface waves (CSS-SASW) test presented by Kayen and others (2004), which is a stepped-sine wave notch-filtered methodology that improves on the approach of Satoh and others (1991). CSS-SASW is an inexpensive and efficient means of non-invasively estimating the near-surface V_S of the ground. Although it is possible to measure V_S in cased boreholes or during penetration tests, these approaches tend not to be useful for evaluation of Australian strong motion sites as they can not reach the meaningful depths required for seismic site response analysis without expensive drilling and casing. Because many of the Australian sites are stiff saprolitic profiles of in-place weathered rock, penetration methods are not useful.

Study Sites

The V_S profiles presented in this report are for local site conditions in regions within four States in Australia (table 1). Between June 9 and June 13, 2006, testing was done in Western Australia at the Cadoux seismic zone and at Perth. We tested in South Australia at sites in and near the Flinders Range, at Adelaide, and in the Clare Valley (June 15–18, 2006). Testing was done near Albury in Victoria and in the Blue Mountains in New South Wales (June 21–23, 2006). Finally, we tested in the greater Sydney-Bowral region at four Hawkesbury sandstone sites (June 24–27, 2006). In 2010, a second measurement period focused primarily on specific geologic settings of the Gippsland Basin, Latrobe Valley, and Melbourne Basin regions of Victoria (May 24–29, 2010). A dense urban microzonation of units beneath Newcastle, New South Wales, was collected from May 20 to May 22, 2010, and a similarly dense suite of sites was tested at Botany Bay south of Sydney, New South Wales, from May 15 to May 19, 2010.

Table 1. Sites tested in Australia in 2006 and 2010.

[Columns (left to right) record (1) the U.S. Geological Survey (USGS) station name; (2) Geosciences Australia seismometer station; (3) region and State; (4) date of data collection; (5) latitude (LAT); (6) longitude (LONG); (7) site parameter V_{S30}, defined as 30 meters divided by the shear-wave travel time to 30 meters depth, in meter per second (m/s); and (8) National Earthquake Hazards Reduction Program (NEHRP) site classifications. **Abbreviations:** NSW, New South Wales; SA, South Australia; WA, Western Australia]

USGS site	Australia site ID	Location	Date tested	LAT	LONG	V_{S30} (m/s)	NEHRP code
236CMC	CMC	Cadoux, WA	June 10, 2006	-30.79102	117.0963	474	C
237BK5	BK5	Burakin, WA	June 11, 2006	-30.5194	117.12187	565	C
238PIG2	PIG2	Macardy Hill, WA	June 11, 2006	-30.84753	116.79184	1232	B
239PIG3	PIG3	Bolgart, WA	June 12, 2006	-31.31517	116.48366	1101	B
240CARL	CARL	Carlisle WA	June 13, 2006	-31.977	115.916	338	D
241SDN	SDN	Sedan, SA	June 15, 2006	-34.5093	139.3374	1026	B
242FR14	FR14	Flinders Ranges, SA	June 16, 2006	-33.4709	138.5757	725	B
243FR13	FR13	Flinders Ranges, SA	June 16, 2006	-33.1249	138.5683	1652	A
244NAP	NAP	Napperby, SA	June 17, 2006	-33.184	138.145	893	B
245GHS	GHS	Adelaide, SA	June 18, 2006	-34.92077	138.6001	257	D
246DTM	DTM	Dartmouth Dam, Victoria	June 21, 2006	-36.5293	147.469	659	C
247LGT	LGT	Lightning Creek, Victoria	June 21, 2006	-36.7633	147.464	458	C
248DRA	DRA	Dora Dora, NSW	June 22, 2006	-35.9654	147.375	1148	B
249BJE	BJE	Burrinjuck Dam, NSW	June 23, 2006	-34.9505	148.646	1194	B
250TAL	TAL	Tallowa, NSW	June 24, 2006	-34.7709	150.381	643	C
251NAT	NAT	Nattai, NSW	June 24, 2006	-34.2061	150.427	804	B
252KAT	KAT	Katoomba, NSW	June 25, 2006	-33.8531	150.4076	536	C
253LUC	LUC	Lucas Heights, NSW	June 27, 2006	-34.05181	150.97958	728	B

USGS site	Australia site ID	Location	Date tested	LAT	LONG	V_{s30} (m/s)	NEHRP code
355BOT	Botany microtrem 305006	Latham Park, Sydney, NSW	April 15, 2010	-33.93479	151.25119	543	C
356BOT	Botany microtrem 301016	Snape Park, Sydney, NSW	April 16, 2010	-33.93572	151.2332	289	D
357BOT	Botany microtrem 301027	David Phillips Sports Field, Daceyville, NSW	April 16, 2010	-33.9313	151.2247	274	D
358BOT	Botany microtrem 301035	Kimberley Grove sidewalk, Sydney, NSW	April 16, 2010	-33.91608	151.208491	314	D
359RIV	Riverview ANSN (Geol. Unit Rh)	Saint Ignatius' College, Riverview, NSW	April 17, 2010	-33.8277	151.1591	768	B
360BOT	Botany microtrem 305054	Booralee Park, Botany, NSW	April 17, 2010	-33.93928	151.20146	253	D
361BOT	Botany microtrem 304052	Sir Joseph Banks Park, Botany, NSW	April 17, 2010	-33.9556	151.20241	250	D
362BOT	Botany microtrem 30036	Botany Golf Club, Botany, NSW	April 19, 2010	-33.9585	151.20706	314	D
363NEW	Wik-01 SCPT-36.0 m	Wickham Park, Newcastle, NSW	April 20, 2010	-32.9189	151.7556	177	E
364NEW	Iso-01 SCPT-15.0 m	Islington Park, Newcastle, NSW	April 20, 2010	-32.91053	151.74651	246	D
365NEW	North Lambton Depot-JUMP ES&S	North Lambton, Newcastle, NSW	April 20, 2010	-32.90133	151.70391	302	D
366NEW	Brd-04 SCPT site-26.7 m	Smith Park, Broadmeadow, Newcastle, NSW	April 20, 2010	-32.91661	151.73515	188	D
367NEW	Brd-09 SCPT site-11.5 m	Beaumont Park, Broadmeadow, Newcastle, NSW	April 21, 2010	-32.9343	151.7402	270	D
368NEW	Mer-05 SCPT site-6.8 m	Henderson Park, Merewether, Newcastle, NSW	April 21, 2010	-32.93837	151.73731	360	D
369MNG	Mangrove Creek ANSN	Mangrove Creek Dam, NSW	April 21, 2010	-33.2094	151.1093	970	B
370LYG	Latrobe HHF-Loy Yang	Loy Yang, Gippsland, Victoria	April 23, 2010	-38.26627	146.50835	290	D
371RSD	Latrobe alluvium-Rosedale	Rosedale, Gippsland, Victoria	April 24, 2010	-38.14317	146.79073	273	D
372TGS	Latrobe HHF-Toongabbie South	Toongabbie, Gippsland, Victoria	April 24, 2010	-38.11883	146.63242	274	D
373TGB	Latrobe HHF-Toongabbie	Toongabbie, Gippsland, Victoria	April 24, 2010	-38.02631	146.66515	282	D
374NAM	Latrobe HHF-Nambrok West	Nambrok, Gippsland, Victoria	April 24, 2010	-38.05449	146.83669	273	D
375GFW	Pleistocene dunes Giffard West	Giffard West, Victoria	April 25, 2010	-38.37931	146.99754	310	D
376LNF	Latrobe HHF-Kilmany	Kilmany/Sale, Victoria	April 25, 2010	-38.10309	146.95038	323	D
377LNF	Latrobe alluvium-Longford	Longford, Gipsland, Victoria	April 25, 2010	-38.16047	147.05964	218	D
378YLN	Latrobe alluvium-Yallourn North	Maryvale, Gippsland, Victoria	April 26, 2010	-38.16361	146.4067	134	E
379GLG	Latrobe alluvium-Glengarry	Glengarry, Gippsland, Victoria	April 26, 2010	-38.16161	146.5567	270	D
380HYF	Thomson alluvium-Heyfield	Heyfield, Gippsland, Victoria	April 26, 2010	-37.99	146.7758	229	D
381WLS	Willung South ES&S	Willung South, Victoria	April 26, 2010	-38.3406	146.74089	852	B
382THD	Thomson Dam ES&S	Thomson Dam, Victoria	April 27, 2010	-37.80987	146.35046	710	C
383GMD	Glenmaggie ES&S	Glenmaggie Dam, Gippsland, Victoria	April 27, 2010	-37.90206	146.7986	948	B
384TLG	Toolangi ANSN	Toolangi, Victoria	April 28, 2010	-37.56952	145.49085	981	B
385GRV	Greenvale ES&S	Greenvale, Victoria	April 28, 2010	-37.61685	144.90262	1265	B
386FCR	Fish Creek ES&S	Fish Creek, Victoria	April 29, 2010	-38.75622	146.0001	865	B

The sites tested in 2006 and 2010 are plotted on the regional maps shown as figures 1 through 8. The National Earthquake Hazards Reduction Program (NEHRP) A-E site classification is as follows: (1) blue square-A, (2) green circle-B, (3) yellow diamond-C, (4) red triangle-D, and (5) purple triangle-E.
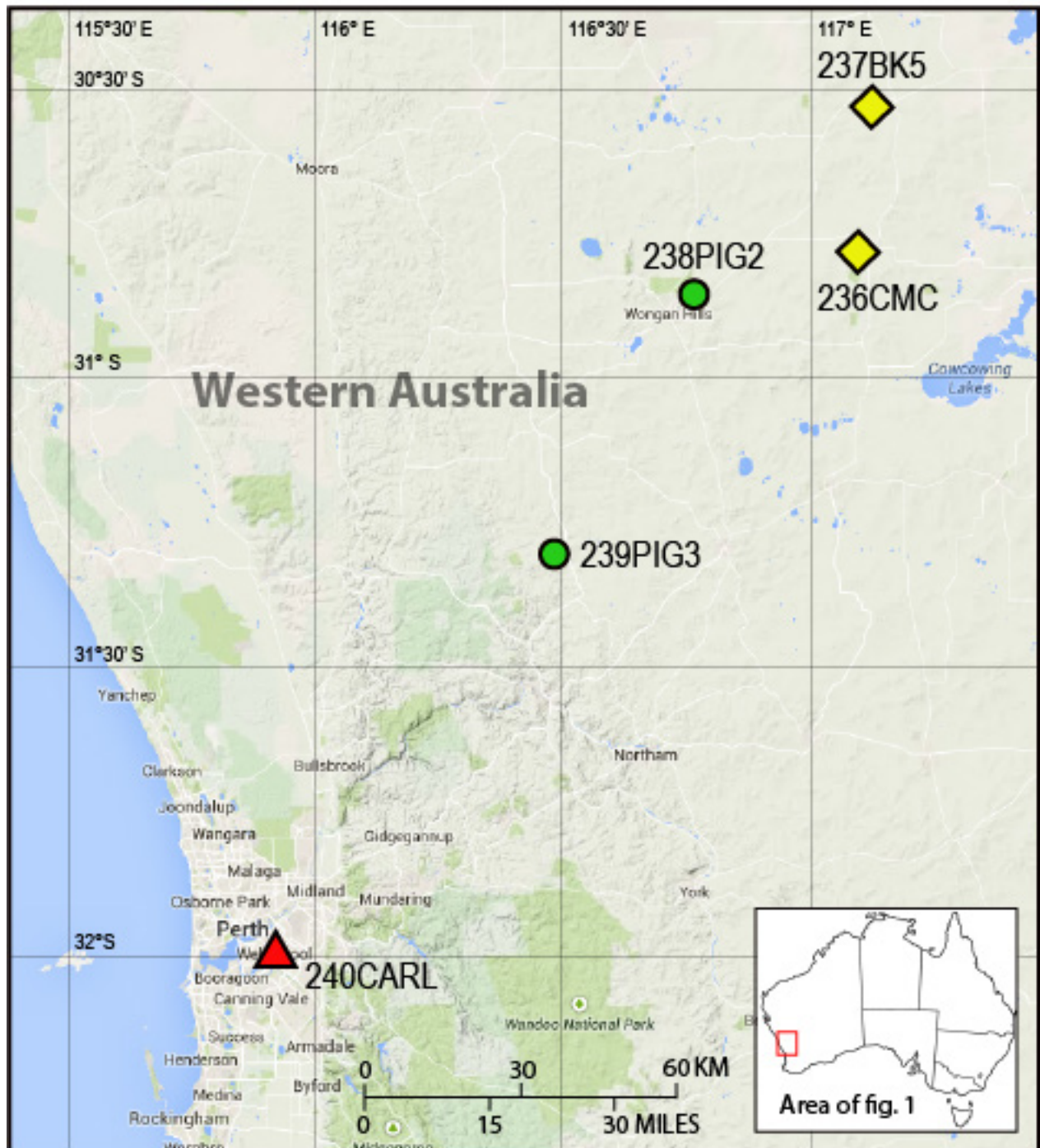
Figure 1. Spectral analysis of surface waves test sites visited in Perth and eastern rangeland, Western Australia, 2006. Symbols indicate National Earthquake Hazards Reduction Program site classifications, where green circles are B sites, yellow diamonds are C sites, and red triangle is a D site.

Figure 2. Spectral analysis of surface waves test sites visited in the Adelaide area and Flinders Range, South Australia, 2006. Symbols indicate National Earthquake Hazards Reduction Program site classifications, where blue square is an A site, green circles are B sites, and red triangle is a D site.

Figure 3. Spectral analysis of surface waves test sites visited in south central Victoria, 2010. Symbols indicate National Earthquake Hazards Reduction Program site classifications, where green circles are B sites, yellow diamond is a C site, and red triangle is a D site.
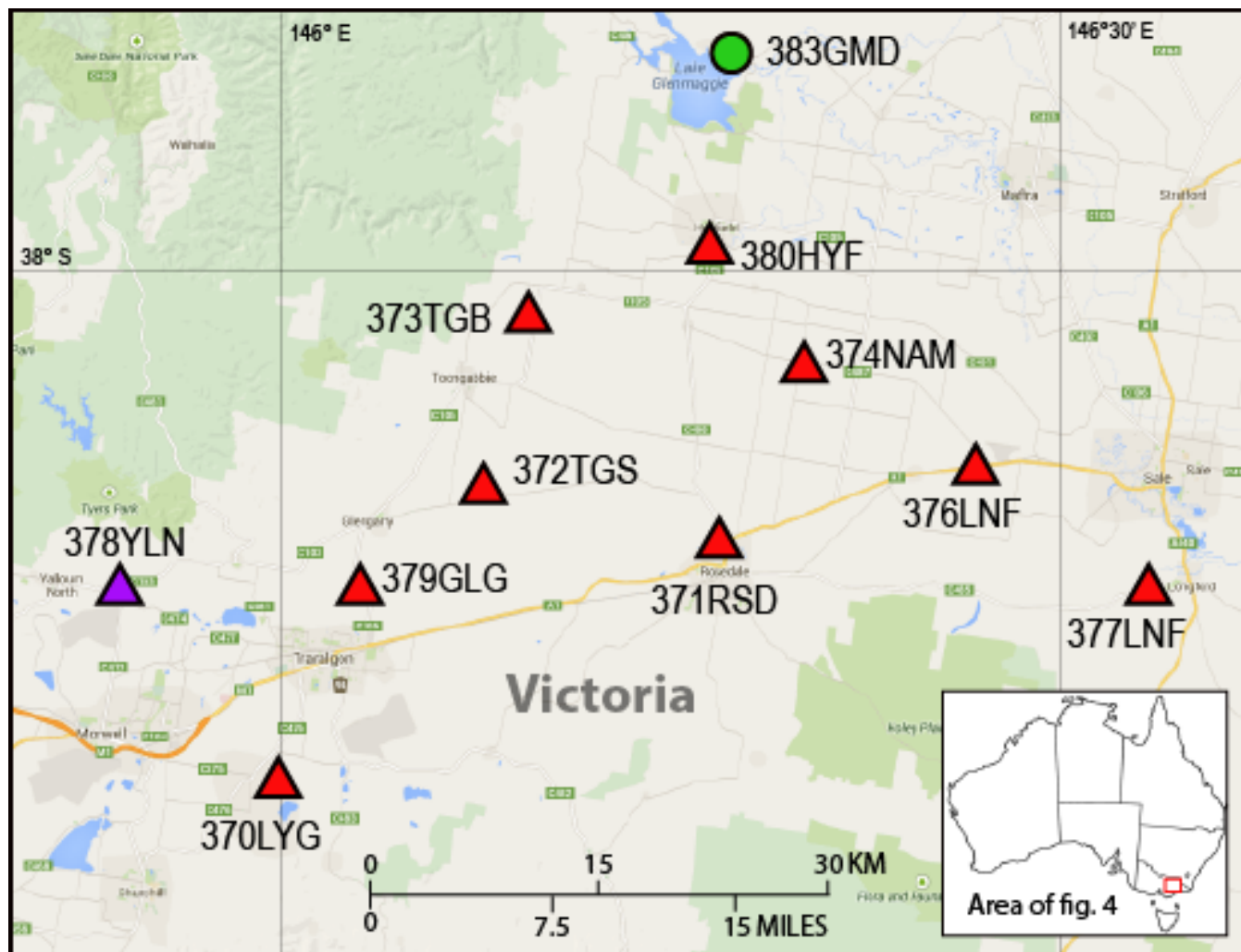
Figure 4. Spectral analysis of surface waves test sites visited in the Gippsland Basin, and Latrobe Valley, Victoria, 2010. Symbols indicate National Earthquake Hazards Reduction Program site classifications, where green circle is a B site, red triangles are D sites, and purple triangle is an E site.

Figure 5. Spectral analysis of surface waves test sites visited in southern New South Wales and northern Victoria, 2006. Symbols indicate National Earthquake Hazards Reduction Program site classifications, where yellow diamonds are C sites, and green circles are B sites.

Figure 6. Spectral analysis of surface waves test sites visited in the greater Sydney region, New South Wales, 2006 and 2010. Symbols indicate National Earthquake Hazards Reduction Program site classifications, where green circles are B sites, and yellow diamonds are C sites.
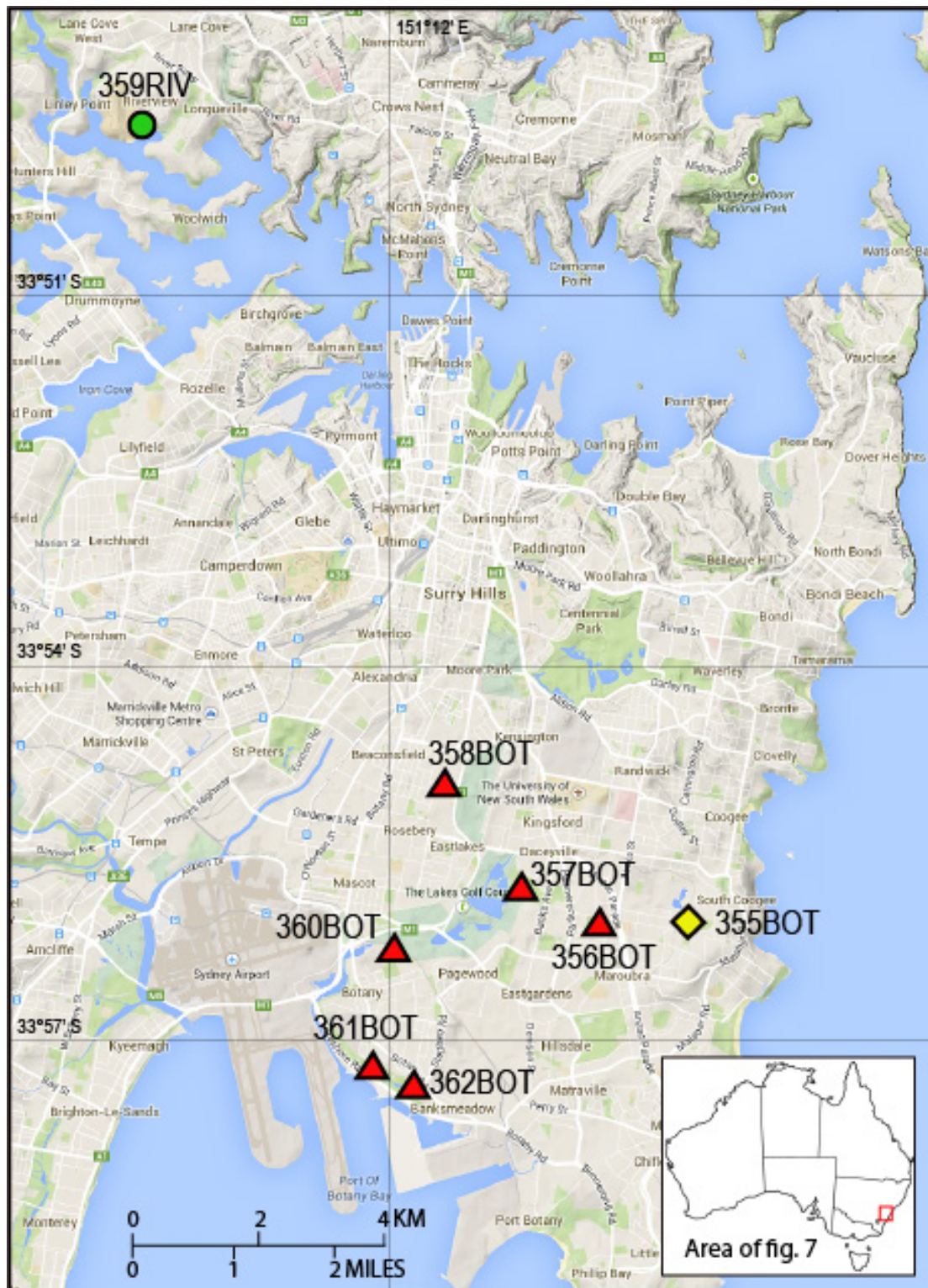
Figure 7. Spectral analysis of surface waves test sites visited in Sydney and suburbs, New South Wales, 2010. Symbols indicate National Earthquake Hazards Reduction Program site classifications, where green circle is a B site, yellow diamond is a C site, and red triangles are D sites.
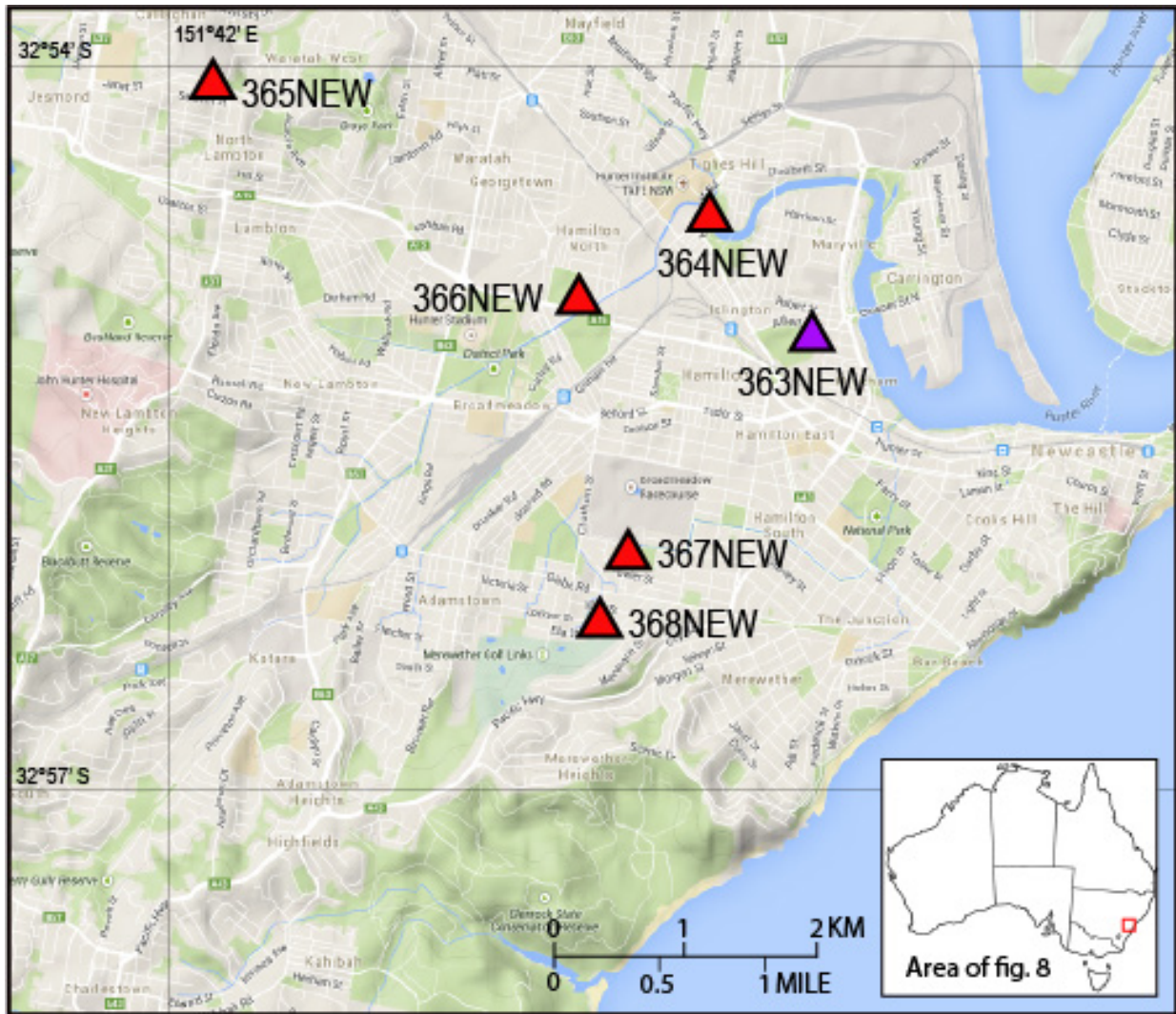
Figure 8. Spectral analysis of surface waves test sites visited in the Newcastle area, New South Wales, 2010. Symbols indicate National Earthquake Hazards Reduction Program site classifications, where red triangles are D sites, and purple triangle is an E site.

Analysis of Rayleigh Wave Spectrum

For this project, we use the noninvasive and nondestructive method referred to as the spectral analysis of surface waves (SASW). The general approach is to measure the phase velocity of Rayleigh surface waves, which then can be used to infer the V_S profile. The SASW method focuses on the fundamental mode of Rayleigh waves that are actively controlled by vertically loading the ground surface with a parallel array of mass shakers. The shakers used have a long-stroke capable of cycling as low as 1 Hz, well below the normal cut-off frequency of a Vibroseis™ truck at 7 Hz. The output signal from the spectral analyzer is split into a parallel circuit and sent to the separate amplifiers. The amplifiers power the shakers to produce a coherent phase continuous harmonic-wave that vertically loads the ground. Most of this energy produces Rayleigh surface waves. We sweep across frequencies from 1 to 100 Hz.

11

Active-source surface wave analysis testing typically profiles the upper tens of meters of the ground using drop weights or harmonic sources. The upper 30 m is needed to compute the widely used site parameter V_{S30}, defined as 30 m divided by the shear-wave travel time to 30 m depth. Deeper shear-wave profiles require lower frequencies and longer wavelengths that normally can not be collected unless a large drop weight (such as massive construction machinery) is used. For example, Kayen and others (2004) profiled the shear-wave structure of both sides of the Denali Fault using a 49-ton Caterpillar D9N™ bulldozer as an active source. Drop weights and heavy track-mounted machinery are useful tools for generating surface waves where the physical ground and landowners will support their presence. The two major drawbacks to this approach are that (1) these devices tend to be damaging to the ground surface, and (2) many sites of scientific importance are not easily accessible with such equipment.

The SASW method used by the U.S. Geological Survey Pacific Science Center is an alternative technique that uses a parallel array of mass shakers. This method allows for profiling to depths as much as 100 m without the use of massive drop weights or heavy track-mounted machinery. In this method, an array of many low frequency, 100–1Hertz (Hz) range, electro-mechanical shakers are substituted for what traditionally would be a large Vibroseis™ truck. Surface waves are generated with an array APS Dynamics Model 400 shaker and amplifier units, powered by a generator and controlled by a spectral analyzer (fig. 9).

The shakers have a long-stroke capable of cycling as low as 1 Hz, much lower than the normal cut-off frequency of a Vibroseis™ truck at 7 Hz. The output signal from the spectral analyzer is split into a parallel circuit and sent to the separate amplifiers. The amplifiers power the shakers to produce a continuously vibrating coherent in-phase harmonic-wave that vertically loads the ground. Most of this energy produces Rayleigh retrograde elliptical surface waves that propagate away from the source in a vertical cylindrical wavefront perpendicular to the ground surface. The amplitude of the surface waves decays exponentially with depth, such that the energy of the wavefront is centered at a depth of about one-third to one-half the wavelength.

Figure 9. Brad Carkin, U.S. Geological Survey (left), and David Love, South Australia (right), testing surface waves with two parallel-arrayed electromechanical shakers (left), and 1-Hertz sensor arrays, at USGS site 244NAP, Napperby, South Australia.

Frequency domain analyses are made on two or more signals received by sensors placed in the field in the linear array some distance from the source. First, all channels of time domain data are transformed into their equivalent linear spectrum in the frequency domain using a Fourier transform. One of the sensor signals (typically from the sensor closest to the source) is used for a reference input signal, and the other sensor signals are used to compute the linear spectrums of the output. The separation of the reference seismometer and output seismometer (d_s–d_{ref}) radially from the source later is used to compute the wave velocity. The cross power spectrum $G_{xy}(\omega)$ is determined by multiplying the complex conjugate of the linear spectrum of the input signal $S_x^*(\omega)$, and the real portion of the linear spectrum of the output signal $S_y(\omega)$. The cross power spectrum is defined as

$$G_{xy}(\omega) = S_x^*(\omega) \times S_y(\omega) \tag{1}$$

The autopower spectrum, a measure of the energy at each frequency of the sweep, can be used to determine the strength of individual frequencies, and is equal to the linear spectrum of a given sensor times its complex conjugate pair:

$$G_{xx}(\omega) = S_x(\omega) \times S_x^*(\omega), \text{ and} \tag{2}$$

$$G_{yy}(\omega) = S_y(\omega) \times S_y^*(\omega). \tag{3}$$

A cross power spectrum can be represented by its real and imaginary components to determine phase θ, and magnitude m. The phase θ is the relative lag between the signals at each frequency, and the magnitude is a measure of the power between the two signals at each frequency. Because the phases are relative, they can be stacked to enhance signal-to-noise ratio of the phase lag at each frequency.

The phase of the cross power spectrum is computed as the inverse tangent of the ratio of the imaginary and real portions of the cross power spectrum:

$$\theta_{xy}(\omega) = tan^{-1}\frac{Im(G_{xy}(\omega))}{Re(G_{xy}(\omega))} \tag{4}$$

The travel time t(f) of one cycle of a wave of frequency (f) is computed as,

$$t(f) = \theta(\omega)/\omega \tag{5}$$

and the wavelength, λ, at each frequency is

$$\lambda(\theta) = (d_s - d_{ref})/\theta(f) \tag{6}$$

The Rayleigh wave velocity, V_r, is computed as

$$V_r(f) = (d_s - d_{ref})/t(f)$$
$$= f(d_s - d_{ref})\, 360°/\theta \text{ (degrees)}$$
$$= f(d_s - d_{ref})\, 2\pi/\theta(f) \text{ (radians)}$$
$$= f\lambda(f) \tag{7}$$

The SASW procedure maps the change in θ across the frequency spectrum, and merges these phase lags with the sensor array geometry to measure velocity. With the shaker source, the discrete frequencies typically are cycled in a swept (stepped)-sine fashion across a range of low frequencies (1–200 Hz). Rayleigh-wave phase velocity then is mapped in frequency or wavelength space. This velocity map or profile is referred to as a dispersion curve and characterizes changes in the frequency-dependent Rayleigh wave velocity. The evaluation of velocities is constrained to the wavelength zone where $\lambda(f)/3$ < $(d_s–d_{ref})$ < 2 $\lambda(f)$ for typical data and $\lambda(f)/3$ < $(d_s–d_{ref})$ < 3 $\lambda(f)$ for excellent data, corresponding to phase lags of 180°–1080° (typical data) and 120°–1080° (excellent data). At longer and shorter wavelengths, the data become unreliable for computing velocities.

As the useable wavelengths are constrained by the seismometer separation, the array is expanded to capture Rayleigh wave dispersion representative of a specific range of wavelengths. The near surface is characterized by short wavelengths and high frequencies, whereas the deeper part of the profile is characterized by long wavelengths and low frequencies. Each wavelength range requires a separate independent test that is merged together with other wavelength ranges to determine an average dispersion curve for the site.

At the largest seismometer separations, the increasing area of the wavefront causes the wave amplitude to diminish because of geometric damping, and the overall quality of the data diminishes. Two measures of data quality are used to evaluate the field measurements in the frequency domain. Coherence, $\gamma^2(\omega)$, is a normalized real function with values between 0 and 1 corresponding to the ratio of the power of the cross power spectrum, $G_{yx}(\omega) \bullet G_{yx}^{*}(\omega)$, to the autopower spectrum of the outboard seismometer, $G_{xx}(\omega) \bullet G_{yy}(\omega)$. Values close to 1 indicate high correlation between the reference and outboard seismometers across narrow frequency bands. This is a useful data quality parameter for hammer impact data.

$$\gamma_{xy}^2(\omega) = \frac{G_{yx}(\omega) \bullet G_{yx}^*(\omega)}{G_{xx}(\omega) \bullet G_{yy}(\omega)} \qquad (8)$$

For swept sine data where discrete frequencies are used to compute phase rather than narrow frequency bands, the frequency response function, FRF, is a complex measure of the data quality of the output (outboard) seismometer, and is sometimes referred to as the Transfer Function:

$$\text{FRF}(\omega) = \frac{G_{yx}(\omega)}{G_{xx}(\omega)} \qquad (9)$$

where

x is the input (reference) signal, and
y is the response (output) signal.

The Frequency Response Function is a two-sided complex parameter. To convert to the frequency response gain (magnitude) that is used to evaluate the amplitude of the output response to the input stimulus, a rectangular-to-polar coordinate conversion is used.

Inversion of the V_S Profile

The relation between Rayleigh wave (V_R), shear wave (V_S) and compression wave (V_P) velocities can be formulated through Navier's equations for dynamic equilibrium. At the ground surface in the case of plane strain, the following characteristic equation is:

$$\frac{V_r^6}{V_S} - 8 \frac{V_r^4}{V_S} + \left(24 - 16\left[\frac{1-2\nu}{2(1-\nu)}\right]\right)\frac{V_r^2}{V_S} + 16\left[\left[\frac{1-2\nu}{2(1-\nu)}\right] - 1\right] = 0 \tag{10}$$

where

ν is the Poisson ratio and

$$\frac{V_S}{V_P} = \gamma = \sqrt{\left[\frac{1-2\nu}{2(1-\nu)}\right]} \tag{11}$$

For reasonable values of Poisson Ratio for earth materials, between 0.20 and 0.49, Viktorov (1967) shows that the shear wave velocity ranges from 105 to 115 percent of the measured Rayleigh wave velocity

$$\frac{V_R}{V_S} = K = \frac{0.87 + 1.12\nu}{1+\nu} \tag{12}$$

such that across the range $0.2 < \nu < 0.49$, the range of K is $0.87 < K < 0.96$.

The inversion method seeks to infer an acceptable best-fit *model* of seismic shear wave velocity, V_S, of the ground given the *measured* dispersive characteristics of Rayleigh waves observed in the frequency domain, and the estimated profile of Poisson ratio and material density. The inversion attempts to build a model from observations, as compared to the normal prediction of behavior based on a model. If the inversion model is simple and linear, it will result in a unique and stable solution. The French mathematician Hadamard defined mathematical problems that have solutions, are unique, and are stable as "well-posed" (Zhdanov, 2002). By contrast, surface wave inversion is an "ill-posed" inverse problem, as solutions are not unique, the solutions may become unstable, and multiple shear wave velocity profiles can result in approximately the same dispersion curve (Zhdanov, 2002).

The dispersive characteristic of Rayleigh wave propagation allows us to infer the V_S at depth based on measurements at the free surface. The forward model computes the Rayleigh wave phase velocity (V_R) from laterally constant layers of an infinite half space. For each of these layers, the shear modulus, Poisson ratio, density, and thickness are unknown. Displacements for a vertically acting harmonic point load can be computed as follows in the far field if body wave components are disregarded:

$$u_\beta(r,z,\omega) = F_z \cdot G_\beta \cdot (r,z,\omega) \cdot e^{i[\omega t - \psi_\beta(r,z,\omega)]} \tag{13}$$

where

        β stands for the generic component either vertical or radial,
  $G_\beta(r,z,\omega)$ is the Rayleigh geometrical spreading function, and
  $\Psi_\beta(r,z,\omega)$ is the composite phase function (Lai and Rix, 1998; Foti, 2000).

Regularization methods have been developed for solving the ill-posed problem if inversion of stiffness from surface wave dispersion data. The Levenberg-Marquardt method, also referred to as damped least squares, is one example of a regularization method. These and other techniques, such as artificial neural networks and genetic algorithms, are discussed by Santamarina and Fratta (1998). One cost of these stochastic methods is that they often require many more iterations, and so they are much more computationally intensive.

The parameters of the forward problem can be selected so that the difference between the observational dispersion data and the output of the forward problem are minimized. Such a constraint is insufficient for ill-posed problems because many solutions can fit the data equally well, and some of these solutions will be physically unrealistic. The most common approach is to constrain the inversion solution space by selecting the smoothest solution from a suite of solutions that all indicate a sufficient goodness-of-fit to the observed data, as indicated by a root mean square error minimum

An empirical approach serves as a counterpoint to the forward inversion methods with the forward model method used in this report. Pelekis and Athanosopoulos (2011) advanced the work of Satoh and others (1991) in a technique termed the Simplified Inversion Method that computes the shear wave velocity profile as a function of the incremental slope of the Rayleigh wave dispersion curve where:

$$V_{Sn,normal\ dispersion} = 1.1 \cdot \frac{\bar{V}_{Rn}D_n - \bar{V}_{Rn-1}D_{n-1}}{D_n - D_{n-1}} \qquad (14)$$

$$V_{Sn,inverted\ dispersion} = 1.1 \cdot \frac{D_n - D_{n-1}}{D_n/\bar{V}_{Rn} - D_{n-1}/\bar{V}_{Rn-1}} \qquad (15)$$

The dispersion curve V_R plotted against λ_R is converted into an apparent velocity ($\bar{V}_R$) and depth (z) by converting λ_R to an estimated depth of $z_{eq} = a_R \cdot \lambda_R \approx 0.635\lambda_R$. The parameter a_R is a penetration depth coefficient optimized to achieve a minimum weighted average difference between the simplified velocity profile and that computed through the more advanced forward inversion of Pelekis and Athansopoulos (2011). The apparent phase velocity, $\overline{V_R}$, is approximated as the velocity at each segment node (layer interface) of a multi-linear curve fit to the dispersion curve. A positive slope of a segment indicates normal dispersion; a negative slope indicates inverted dispersion. The value of V_S for each individual layer is calculated using equations 14 and 15 for the cases of normal dispersion or inverted dispersion, respectively. The approach of Pelekis and Athansopoulos (2011) improves on method of Satoh and others (1991), notably by optimizing the penetration depth coefficient, a_R.

Results

Two profile solutions are provided at each site (Forward Inversion and Simplified Inversion Method model). We varied the assumptions about the layer thicknesses and the threshold root mean square error that determines if the inversion has converged to best characterize the site. Whether or not the more complex model is warranted by the fit of the theoretical dispersion curve to the empirical dispersion curve is a subjective decision.

Profile results are summarized in table 1, including the following information provided: SASW site ID, site location, date of data collection, site latitude and longitude, and site parameter V_{S30}.

Plots of the two model profiles and the empirical dispersion curve and theoretical dispersion curves for each site are included in appendix A. Site photographs and a vicinity map for each site also are included in appendix A. Where possible, we have indicated the location of the strong motion station in the site photographs and vicinity maps to assess the distance between the SASW survey and the strong motion station.

Resources

We have used the SWAMI Fortran routines that are freely available at *http://geosystems.ce.gatech.edu/soil_dynamics/research/surfacewavesanalysis/* (distributed under the terms of the GNU General Public License).

Acknowledgments

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Appendix A. Site Summaries Ordered by USGS Site Identifier

Figure A1-1. Surface wave test site 236CMC located 2.3 km SW of Cadoux, Western Australia (lat -30.79102, long 117.0963). Tested on June 10, 2006. (A) view towards the east from shakers; (B) view NE from seismometer and borehole toward the shakers behind vehicle; (C) view SW from shakers; (D) view to the west along seismometer array; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Western Australia.

19

Geosciences Australia (GA) SMR Stations

Site ID   **236CMC**
NEHRP CLASS   **C**
Vs30   **474 (m/s)**
SUB-CLASS   **C-**
Vs100   **785 (m/s)**
Location

SMR Station	CMC
State	WEST AUSTRALIA
Description	Archean Granite
POSITION	Cadoux, WA
LAT (S)	-30.791
LON (E)	117.0963

Data Type	SWEPT-SINE SASW
Investigators	KAYEN, CARKIN
Date collected	10-Jun-2006
TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW; 3D AMBIENT MICROTREMOR ANALYSIS
PROJECT NAME	GA-SMR CHARACTERIZATION
SPONSOR	GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   < 180 m/s
F   Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats >3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(A) Merged Field-LAMBDA Dispersion Curves

(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(D) Shear Wave Velocity SASW

Figure A1-2. Site ID, location, and shear wave velocity for surface wave test site 236CMC. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

Figure A1-3. Surface wave test site 237BK5 located about 5 km west of Burakin, Western Australia (lat -30.5194, long 117.12187). Tested on June 11, 2006. (A) view looking eastward toward shakers; (B) view westward from shakers; (C) shakers at the east end of array; (D) landmark near the west end of seismometer array; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Western Australia.

Geosciences Australia (GA) SMR Stations

Site ID	**237BK5**
NEHRP CLASS	**C**
Vs30	**565 (m/s)**
SUB-CLASS	**C+**
Vs100	**928 (m/s)**
Location	

SMR Station	BK5
State	WEST AUSTRALIA
Description	Archean Granite
POSITION	Burakin, WA
LAT (S)	-30.5194
LON (E)	117.1219

Data Type	SWEPT-SINE SASW
Investigators	KAYEN, CARKIN
Date collected	11-Jun-2006
TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW; 3D AMBIENT MICROTREMOR ANALYSIS

PROJECT NAME	GA-SMR CHARACTERIZATION
SPONSOR	GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)

A	>1500 m/s
B+	1080 < Vs30 ≤ 1500 m/s
B-	720 < Vs30 ≤ 1080 m/s
C+	540 < Vs30 ≤ 720 m/s
C-	360 < Vs30 ≤ 540 m/s
D+	270 < Vs30 ≤ 360 m/s
D-	180 < Vs30 ≤ 270 m/s
E	<180 m/s
F	Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(A) Merged Field-LAMBDA Dispersion Curves

(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(D) Shear Wave Velocity SASW

Figure A1-4. Site ID, location and shear wave velocity for surface wave test site 237BK5. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

22

Figure A1-5. Surface wave test site 238PIG2 located 8.5 km NE of Wongan Hills, Western Australia (lat -30.84753, long 116.79184). Tested on June 11, 2006. (A) view looking southwards to the shakers; (B) view north to the seismometer array; (C) view towards the NE from shakers; (D) view of local bedrock exposure near the seismometer array, about 100 m to the east; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Western Australia.
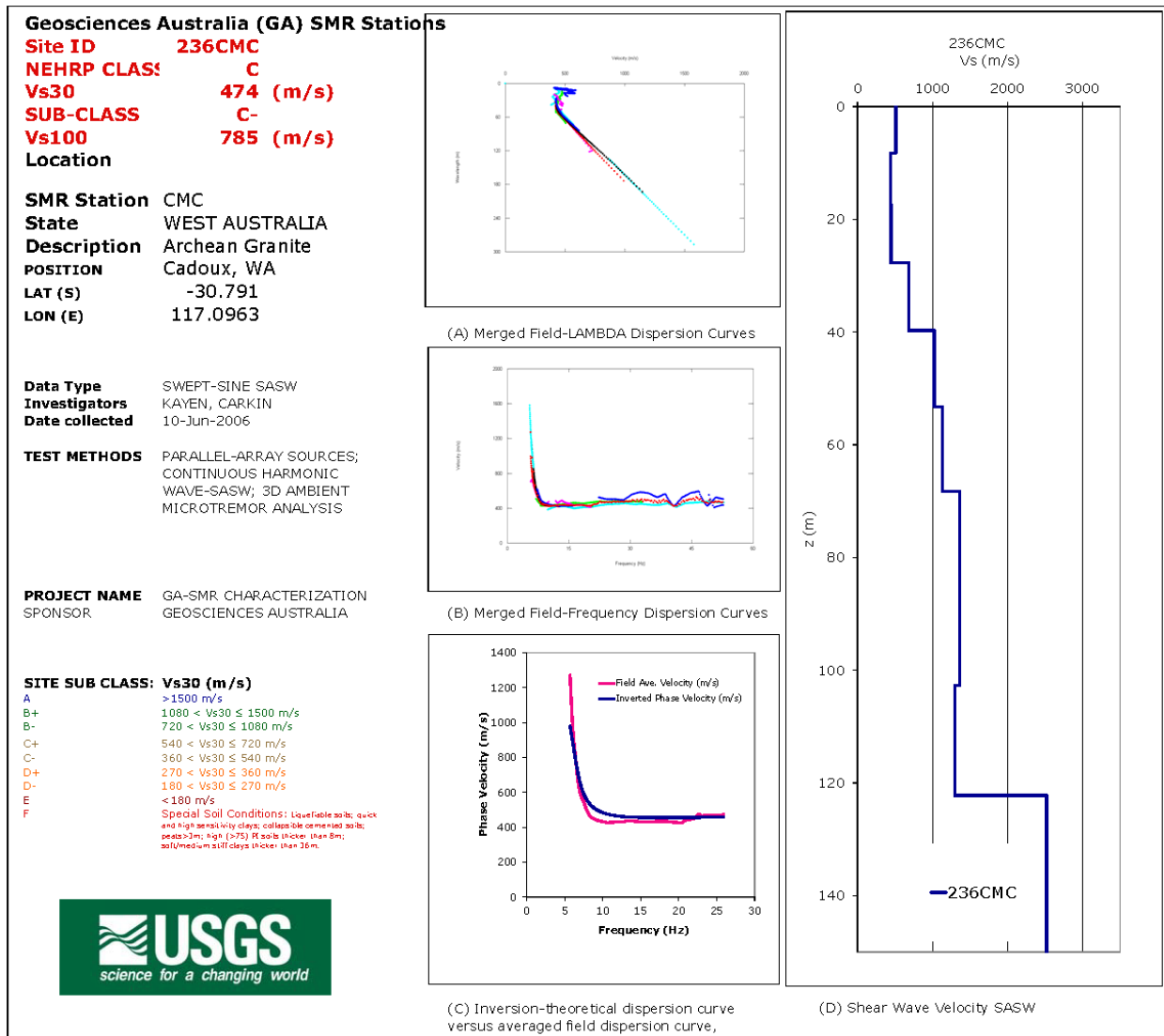
Geosciences Australia (GA) SMR Stations

Site ID	**238PIG2**
NEHRP CLASS	**B**
Vs30	**1232 (m/s)**
SUB-CLASS	**B+**
Vs100	**2196 (m/s)**
Location	

SMR Station	PIG2
State	WEST AUSTRALIA
Description	Archean Granite
POSITION	WONGAN HILLS
LAT (S)	-30.8475
LON (E)	116.7918

Data Type	SWEPT-SINE SASW
Investigators	KAYEN, CARKIN
Date collected	11-Jun-2006
TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW; 3D AMBIENT MICROTREMOR ANALYSIS

PROJECT NAME	GA-SMR CHARACTERIZATION
SPONSOR	GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)

A	>1500 m/s
B+	1080 < Vs30 ≤ 1500 m/s
B-	720 < Vs30 ≤ 1080 m/s
C+	540 < Vs30 ≤ 720 m/s
C-	360 < Vs30 ≤ 540 m/s
D+	270 < Vs30 ≤ 360 m/s
D-	180 < Vs30 ≤ 270 m/s
E	<180 m/s
F	Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

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(A) Merged Field-LAMBDA Dispersion Curves

(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(D) Shear Wave Velocity SASW

Figure A1-6. Site ID, location, and shear wave velocity for surface wave test site 238PIG2. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.
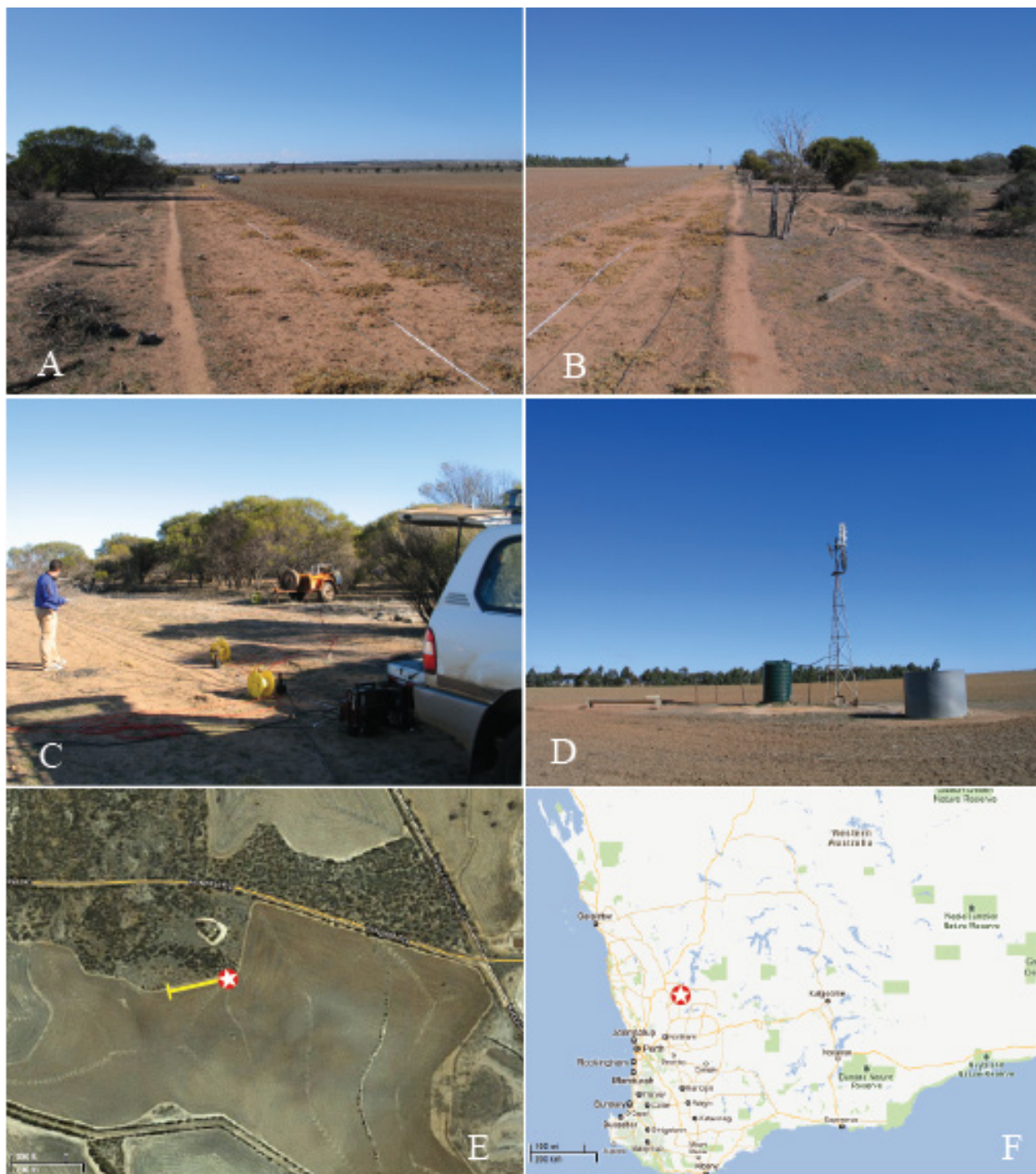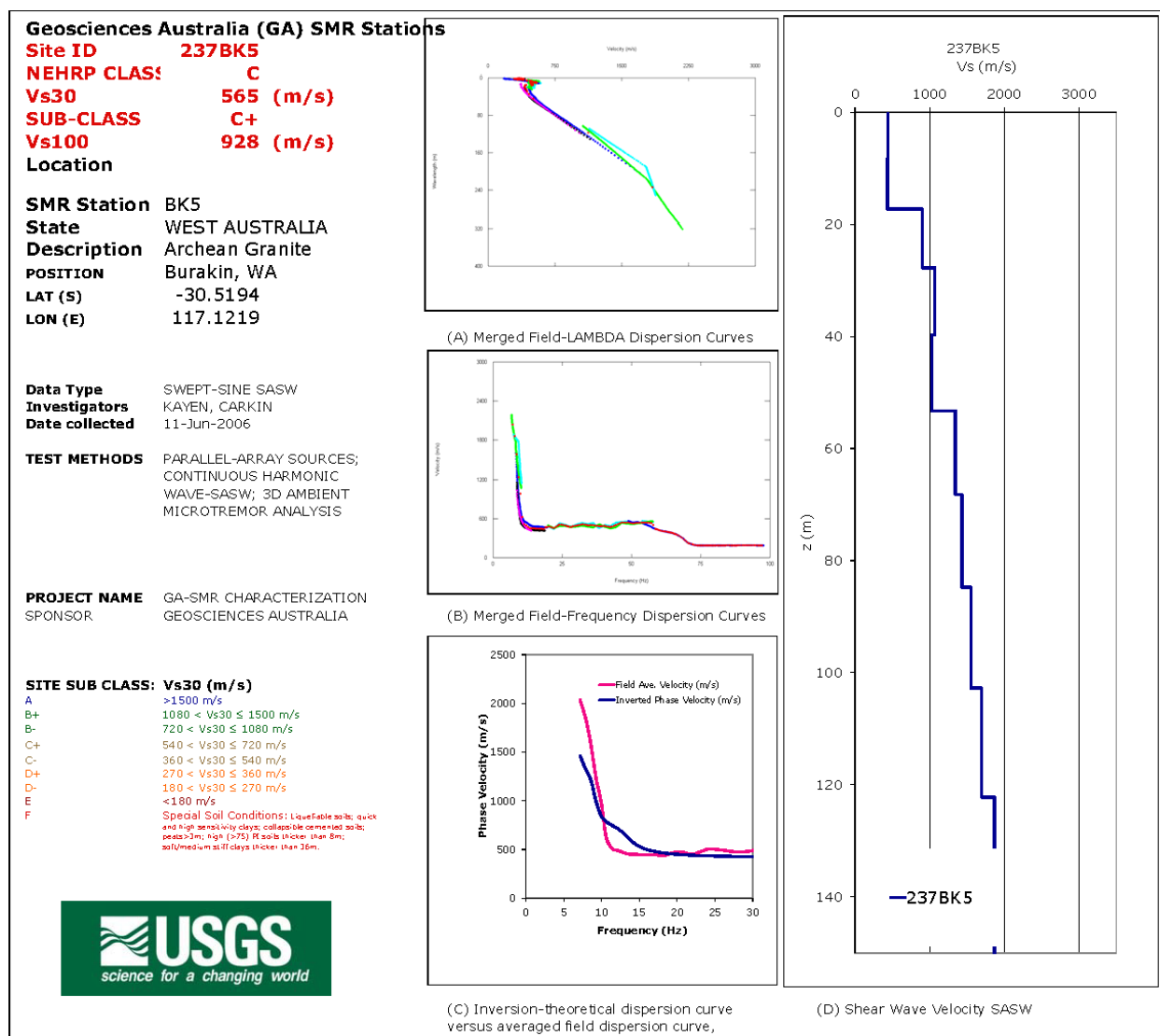
Figure A1-7. Surface wave test site 239PIG3 located 5.4 km SW of Bolgart, Western Australia (lat -31.31517, long 116.48366). Tested on June 12, 2006. (A) view looking southeastwards from the shakers; (B) view looking NW toward shakers; (C) view to the east at the shakers; (D) seismometer, battery and solar panel on rock knob, behind the vehicle in B; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Western Australia.
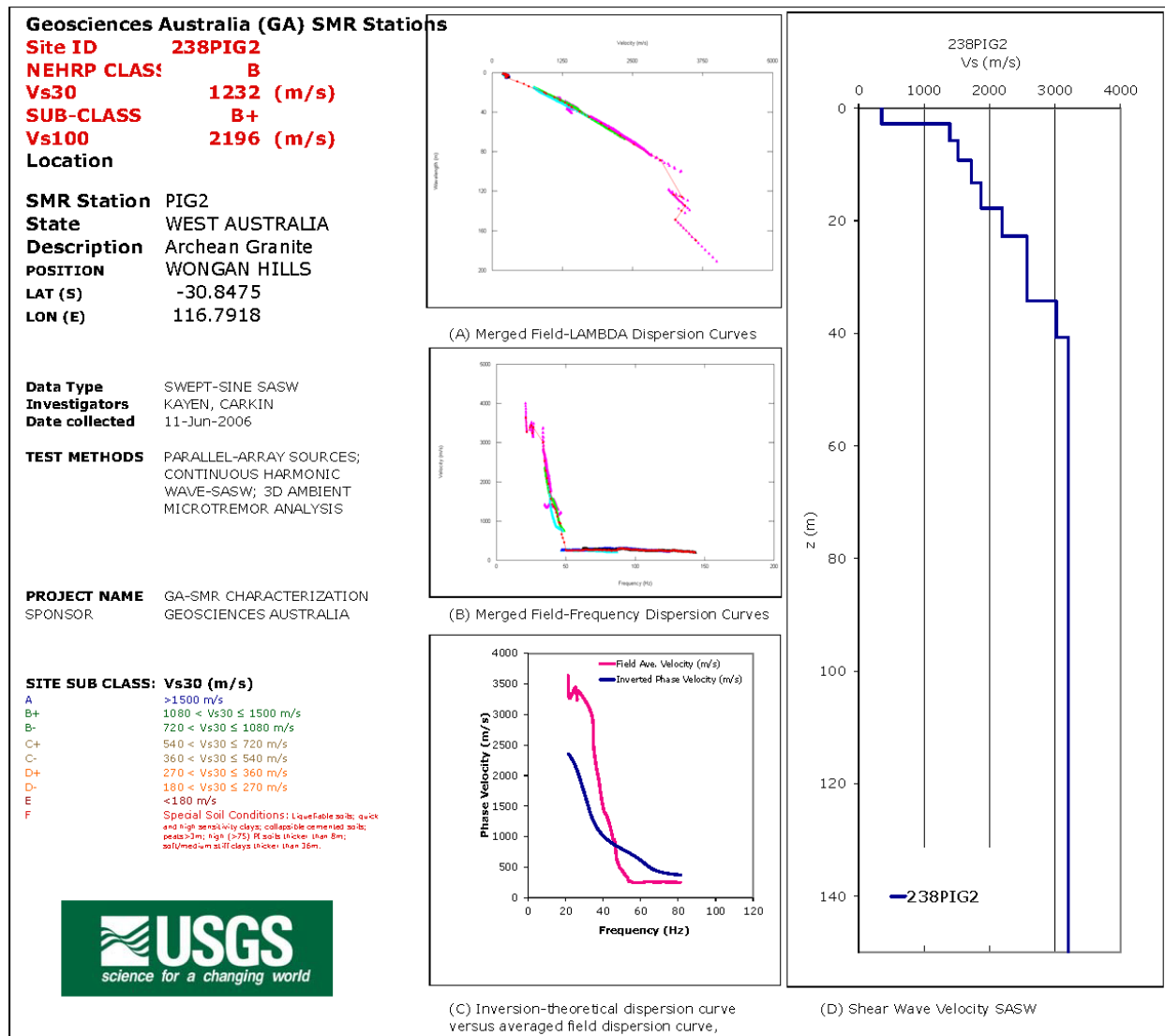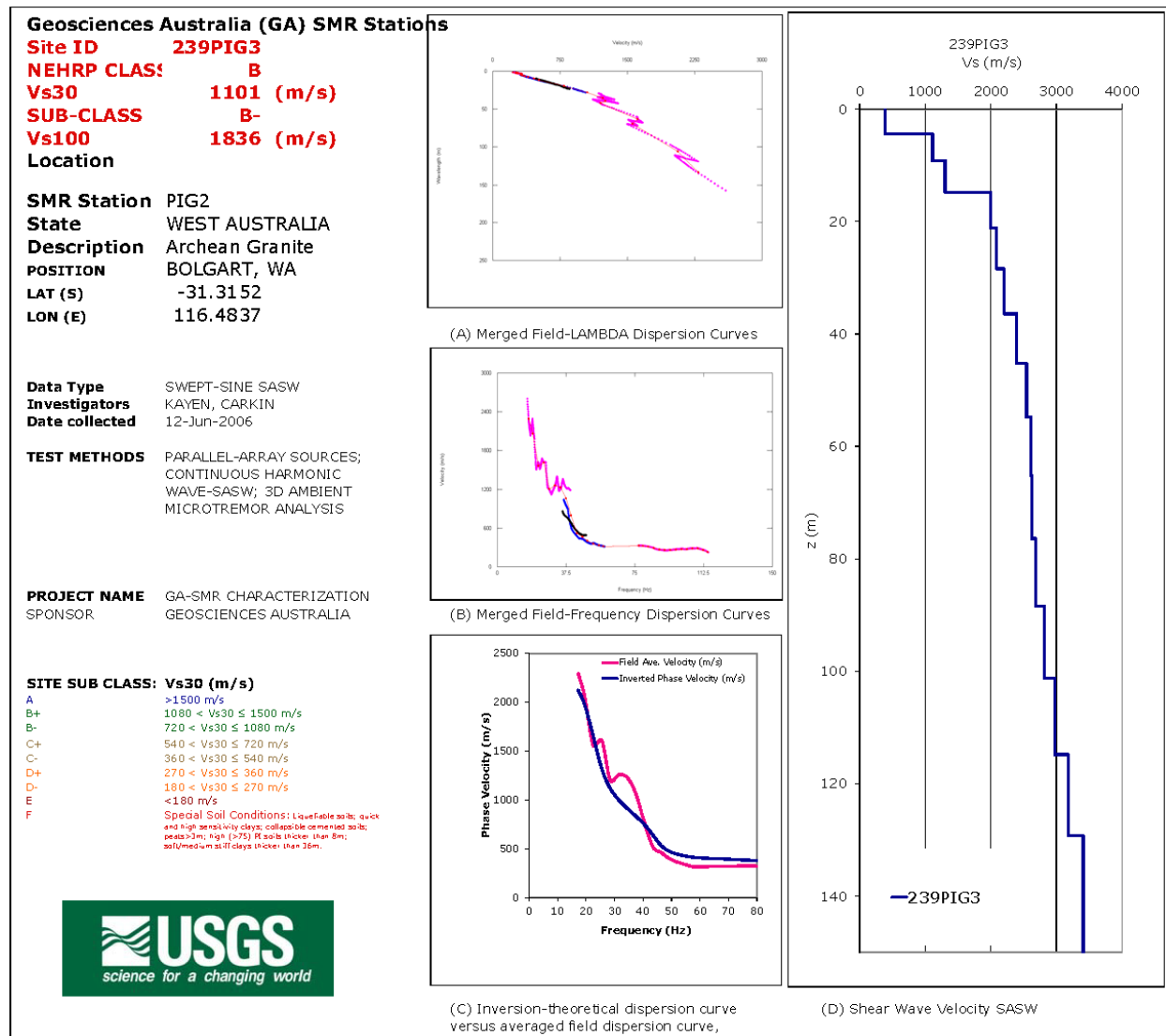
Geosciences Australia (GA) SMR Stations

Site ID	**239PIG3**
NEHRP CLASS	**B**
Vs30	**1101 (m/s)**
SUB-CLASS	**B-**
Vs100	**1836 (m/s)**
Location	

SMR Station	PIG2
State	WEST AUSTRALIA
Description	Archean Granite
POSITION	BOLGART, WA
LAT (S)	-31.3152
LON (E)	116.4837

Data Type	SWEPT-SINE SASW
Investigators	KAYEN, CARKIN
Date collected	12-Jun-2006
TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW; 3D AMBIENT MICROTREMOR ANALYSIS
PROJECT NAME	GA-SMR CHARACTERIZATION
SPONSOR	GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)

A	>1500 m/s
B+	1080 < Vs30 ≤ 1500 m/s
B-	720 < Vs30 ≤ 1080 m/s
C+	540 < Vs30 ≤ 720 m/s
C-	360 < Vs30 ≤ 540 m/s
D+	270 < Vs30 ≤ 360 m/s
D-	180 < Vs30 ≤ 270 m/s
E	<180 m/s
F	Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(A) Merged Field-LAMBDA Dispersion Curves

(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(D) Shear Wave Velocity SASW

Figure A1-8. Site ID, location, and shear wave velocity for surface wave test site 239PIG3. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.
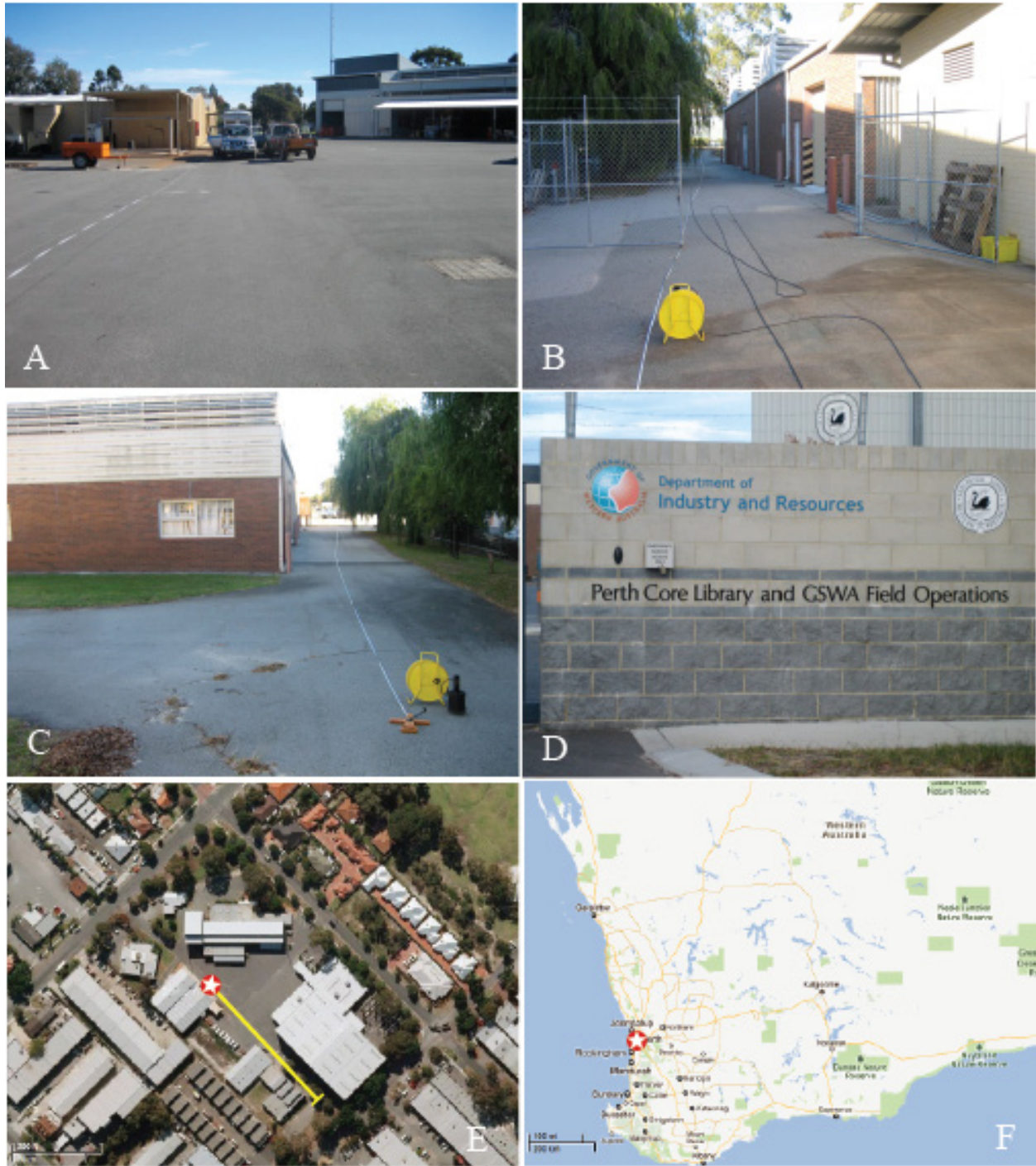
26

Figure A1-9. Surface wave test site 240CAR located in Carlisle, suburb of Perth, Western Australia (lat -31.983031, long 115.926921). Tested on June 13, 2006. (A) view looking NW towards the shaker location; (B) view looking SE along seismometer array; (C) SE end of the seismometer array looking NW; (D) entrance to facility on Harris Street; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Western Australia.
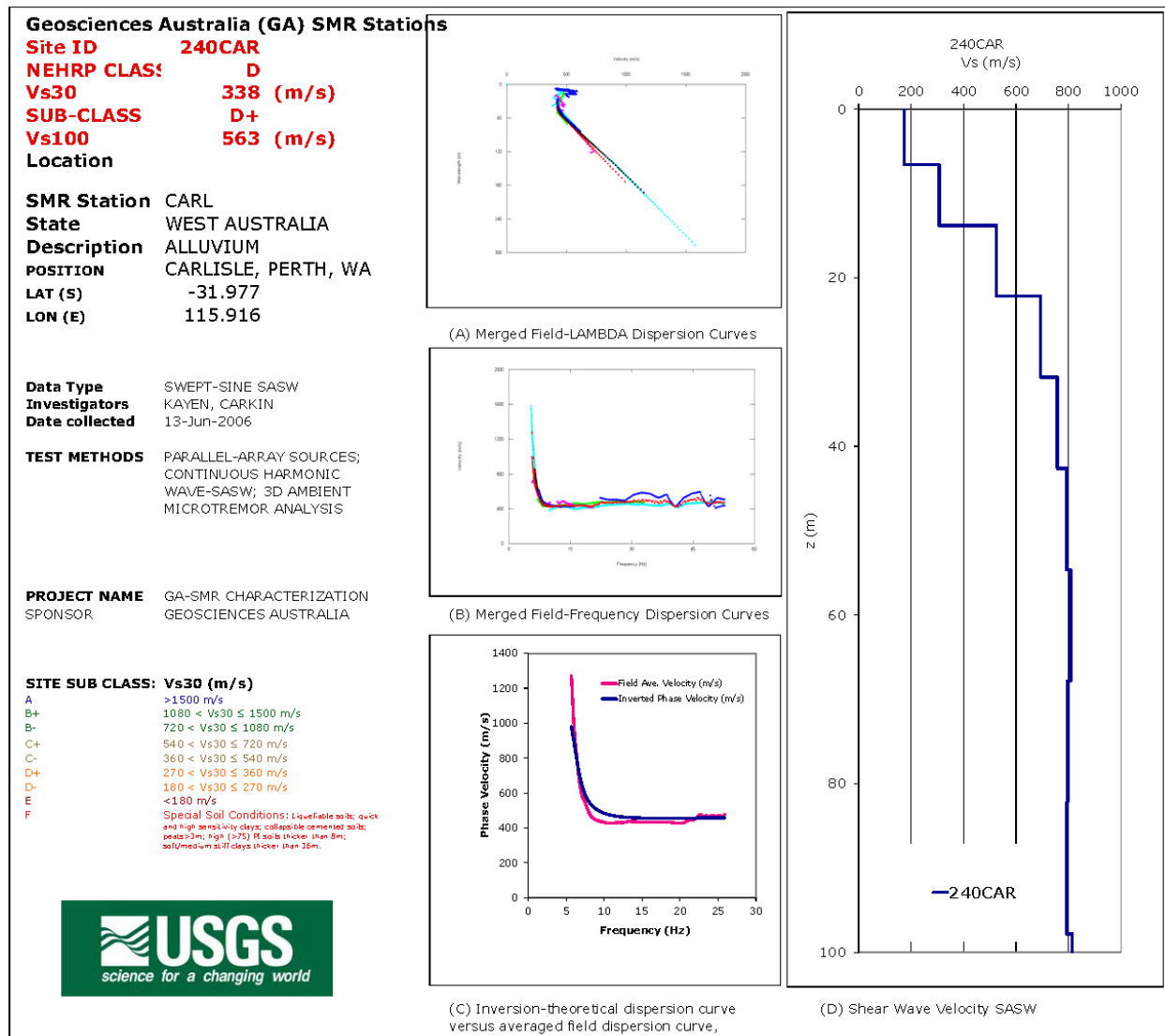
Geosciences Australia (GA) SMR Stations

Site ID	**240CAR**
NEHRP CLASS	**D**
Vs30	**338 (m/s)**
SUB-CLASS	**D+**
Vs100	**563 (m/s)**
Location	

SMR Station	CARL
State	WEST AUSTRALIA
Description	ALLUVIUM
POSITION	CARLISLE, PERTH, WA
LAT (S)	-31.977
LON (E)	115.916

Data Type	SWEPT-SINE SASW
Investigators	KAYEN, CARKIN
Date collected	13-Jun-2006
TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW; 3D AMBIENT MICROTREMOR ANALYSIS
PROJECT NAME	GA-SMR CHARACTERIZATION
SPONSOR	GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)

A	>1500 m/s
B+	1080 < Vs30 ≤ 1500 m/s
B-	720 < Vs30 ≤ 1080 m/s
C+	540 < Vs30 ≤ 720 m/s
C-	360 < Vs30 ≤ 540 m/s
D+	270 < Vs30 ≤ 360 m/s
D-	180 < Vs30 ≤ 270 m/s
E	<180 m/s
F	Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(A) Merged Field-LAMBDA Dispersion Curves

(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(D) Shear Wave Velocity SASW

Figure A1-10. Site ID, location, and shear wave velocity for surface wave test site 240CAR. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.
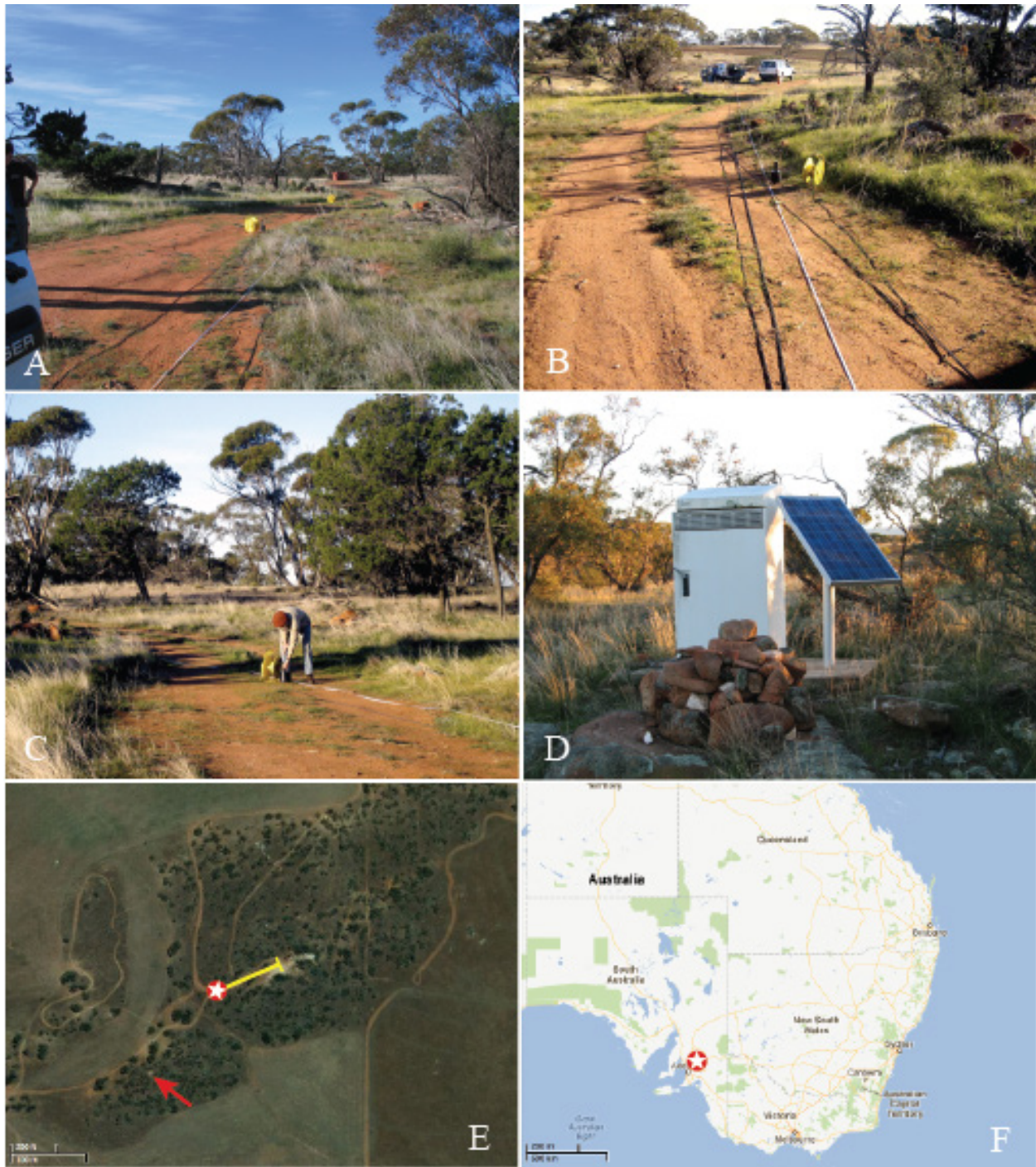
Figure A1-11. Surface wave test site 241SDN located 8 km NE of Sedan, South Australia (lat -34.5093, long 139.3374). Tested on June 15, 2006. (A) view looking towards the northeast from shakers; (B) view SW toward the shakers; (C) view looking east at a seismometer on array; (D) seismometer shelter and solar panel located at the red arrow in E; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in South Australia.
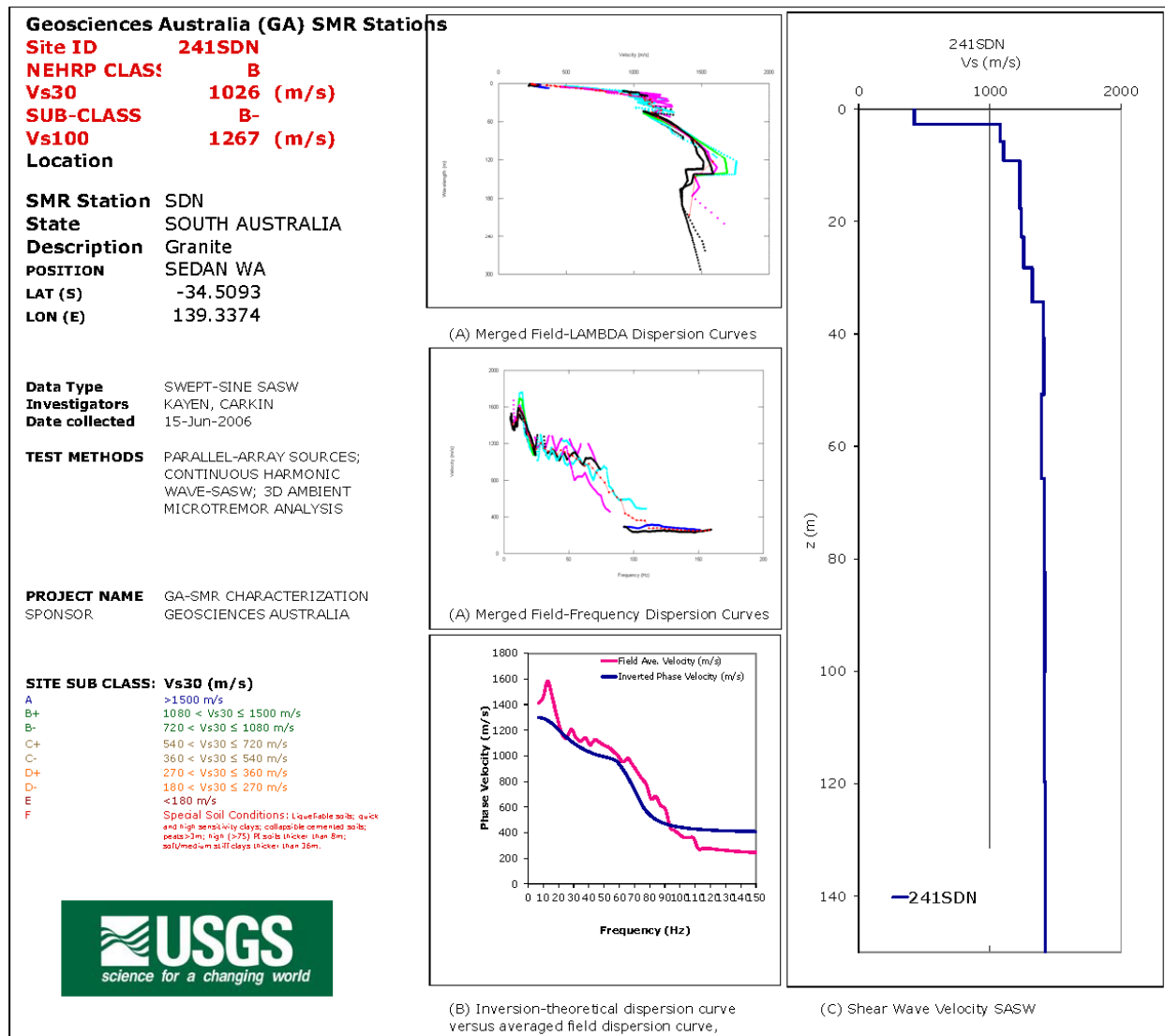
Figure A1-12. Site ID, location, and shear wave velocity for surface wave test site 241SDN. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

Figure A1-13. Surface wave test site 242FR14 located 4.2 km NW of Spalding, South Australia (lat -33.4709, long 138.5757). Tested on June 16, 2006. (A) view looking towards the SW down ridge line from shakers; (B) view looking SW down ridge line; (C) view SW from shakers, 2 m seismometer separation; (D) view looking NE uphill toward shakers; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in South Australia.
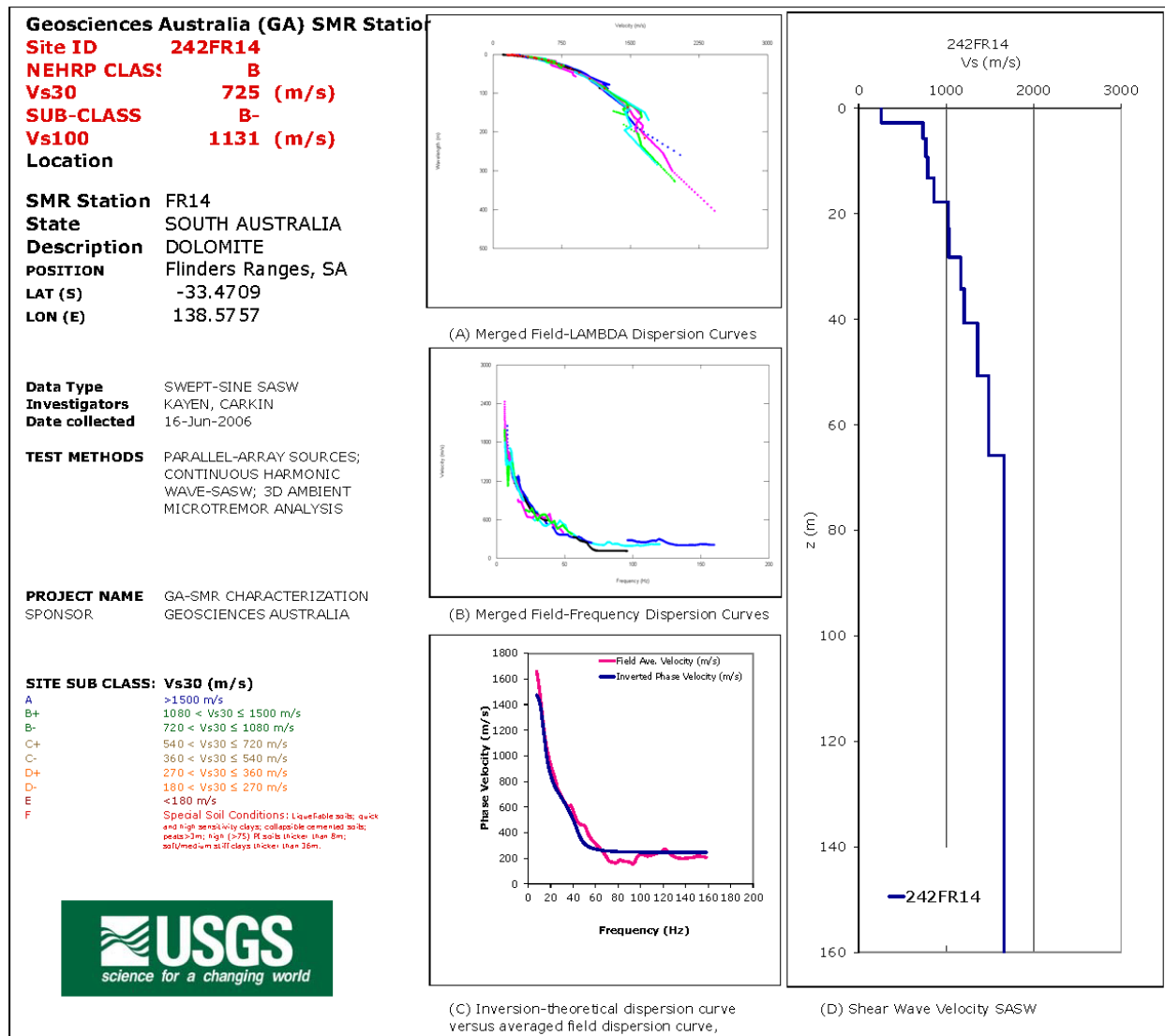
Geosciences Australia (GA) SMR Station

Site ID	242FR14
NEHRP CLASS	B
Vs30	725 (m/s)
SUB-CLASS	B-
Vs100	1131 (m/s)
Location	

SMR Station	FR14
State	SOUTH AUSTRALIA
Description	DOLOMITE
POSITION	Flinders Ranges, SA
LAT (S)	-33.4709
LON (E)	138.5757

Data Type	SWEPT-SINE SASW
Investigators	KAYEN, CARKIN
Date collected	16-Jun-2006

TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW; 3D AMBIENT MICROTREMOR ANALYSIS

PROJECT NAME	GA-SMR CHARACTERIZATION
SPONSOR	GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 16m.

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(A) Merged Field-LAMBDA Dispersion Curves

(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(D) Shear Wave Velocity SASW

Figure A1-14. Site ID, location, and shear wave velocity for surface wave test site 242FR14. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

Figure A1-15. Surface wave test site 243FR13 located about 9 km NW of Jamestown, South Australia (lat -33.1249, long 138.5683). Tested on June 16, 2006. (A) view looking westward from the shakers; (B) view looking SW above test site; (C) view NE from the shakers; (D) view to the west along seismometer array; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; F) site location in South Australia.
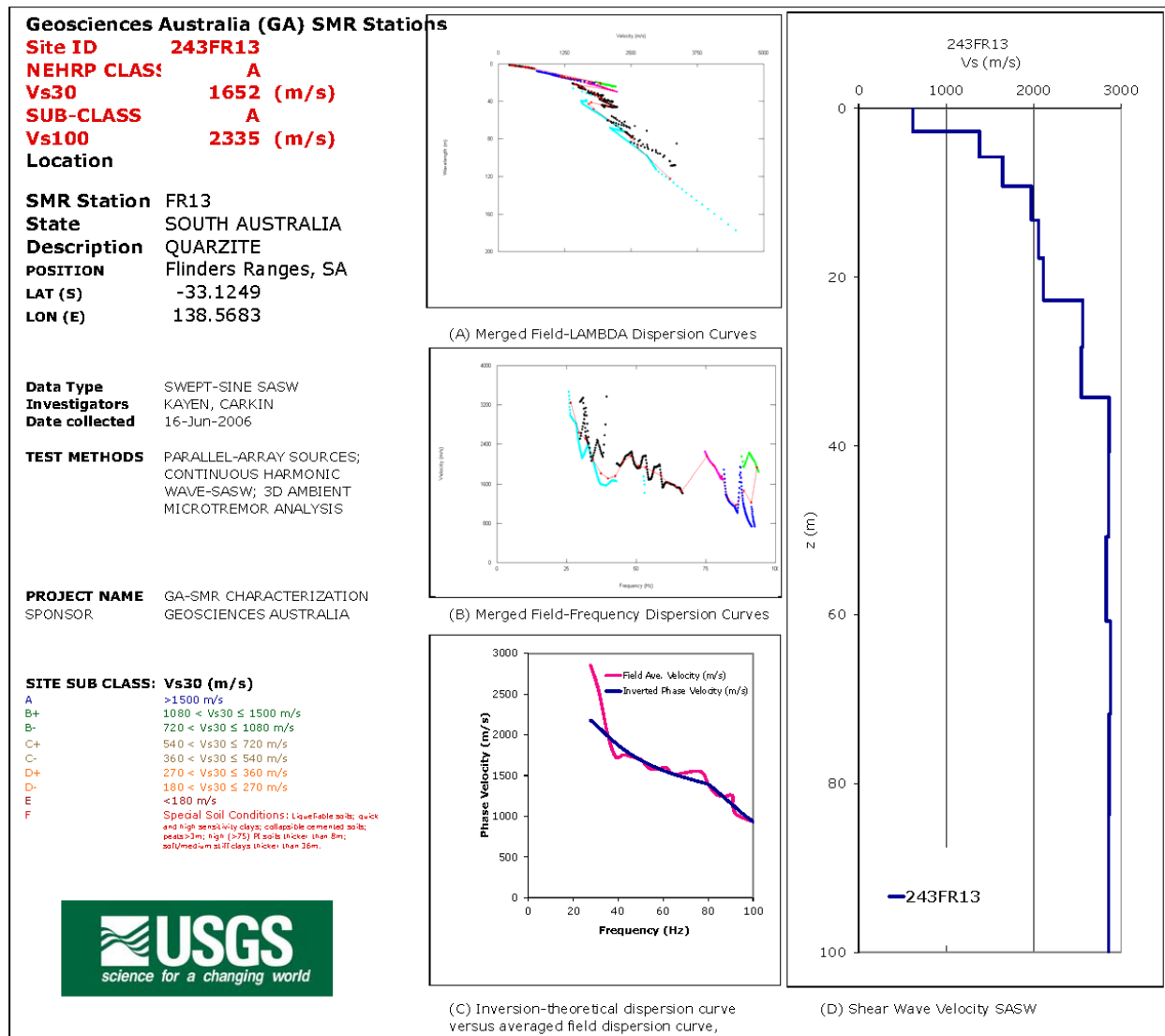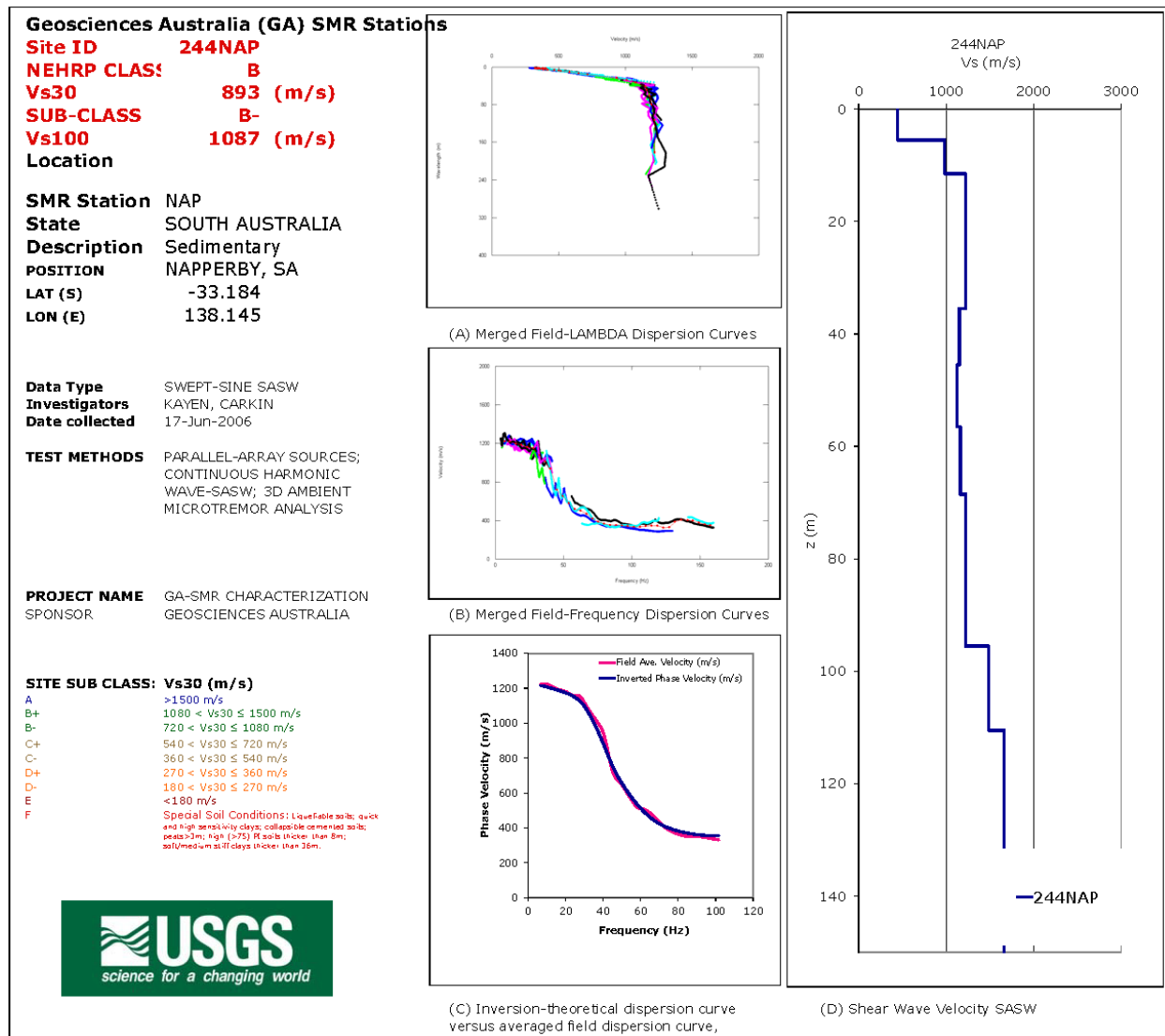
Figure A1-16. Site ID, location, and shear wave velocity for surface wave test site 243FR13. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

Figure A1-17. Surface wave test site 244NAP located 4 km SE of Napperby, South Australia (lat -33.184, long 138.145). Tested on June 17, 2006. (A) view looking towards the west from shakers; (B) view to the SE up the gulley along seismometer array; (C) view northward from shakers; (D) seismometer shelter located at the red arrow in E; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in South Australia.
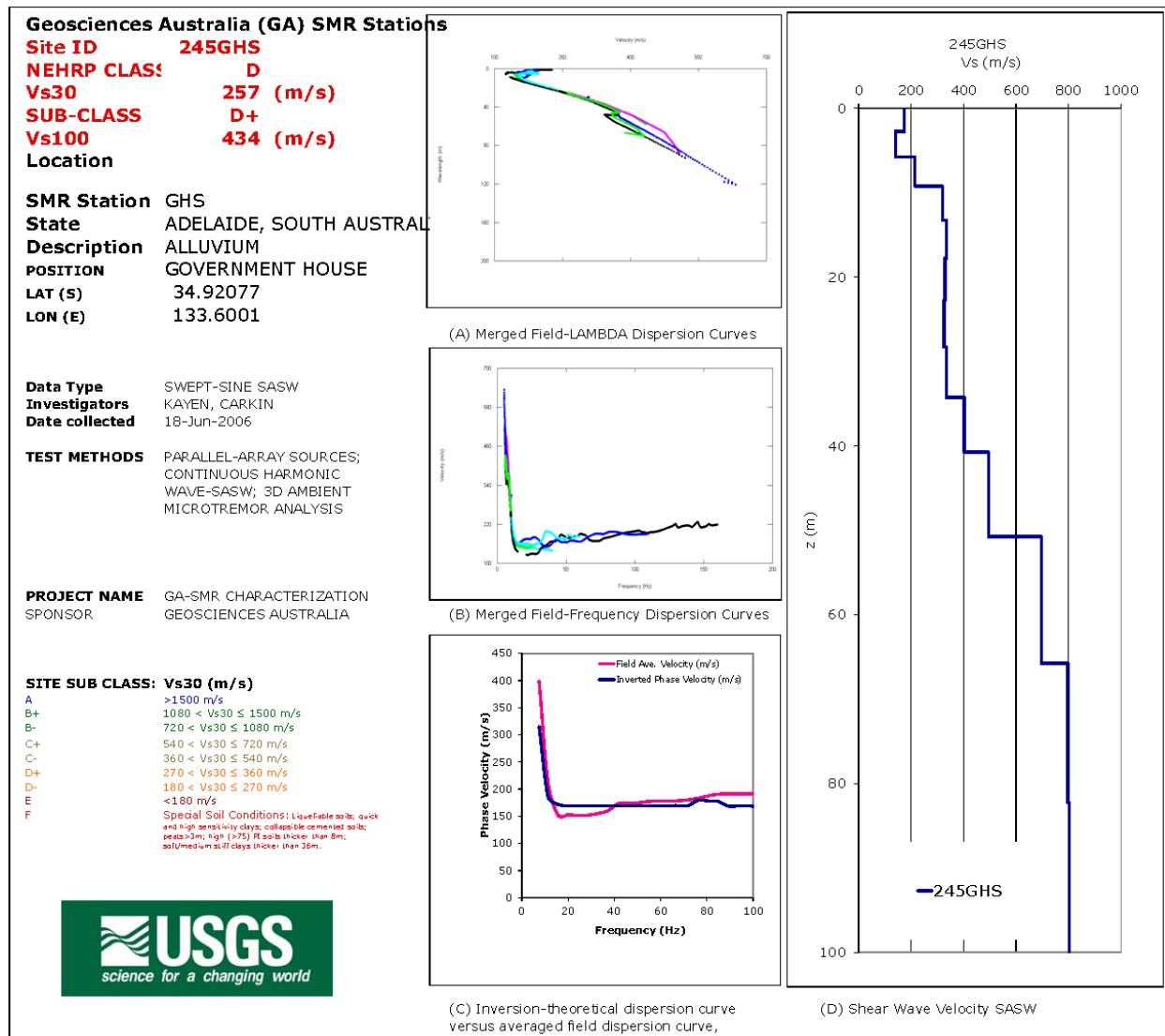
Geosciences Australia (GA) SMR Stations

Site ID	244NAP
NEHRP CLASS	B
Vs30	893 (m/s)
SUB-CLASS	B-
Vs100	1087 (m/s)
Location	

SMR Station	NAP
State	SOUTH AUSTRALIA
Description	Sedimentary
POSITION	NAPPERBY, SA
LAT (S)	-33.184
LON (E)	138.145

Data Type	SWEPT-SINE SASW
Investigators	KAYEN, CARKIN
Date collected	17-Jun-2006
TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW; 3D AMBIENT MICROTREMOR ANALYSIS
PROJECT NAME	GA-SMR CHARACTERIZATION
SPONSOR	GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)

A	>1500 m/s
B+	1080 < Vs30 ≤ 1500 m/s
B-	720 < Vs30 ≤ 1080 m/s
C+	540 < Vs30 ≤ 720 m/s
C-	360 < Vs30 ≤ 540 m/s
D+	270 < Vs30 ≤ 360 m/s
D-	180 < Vs30 ≤ 270 m/s
E	<180 m/s
F	Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 16m.

(A) Merged Field-LAMBDA Dispersion Curves

(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

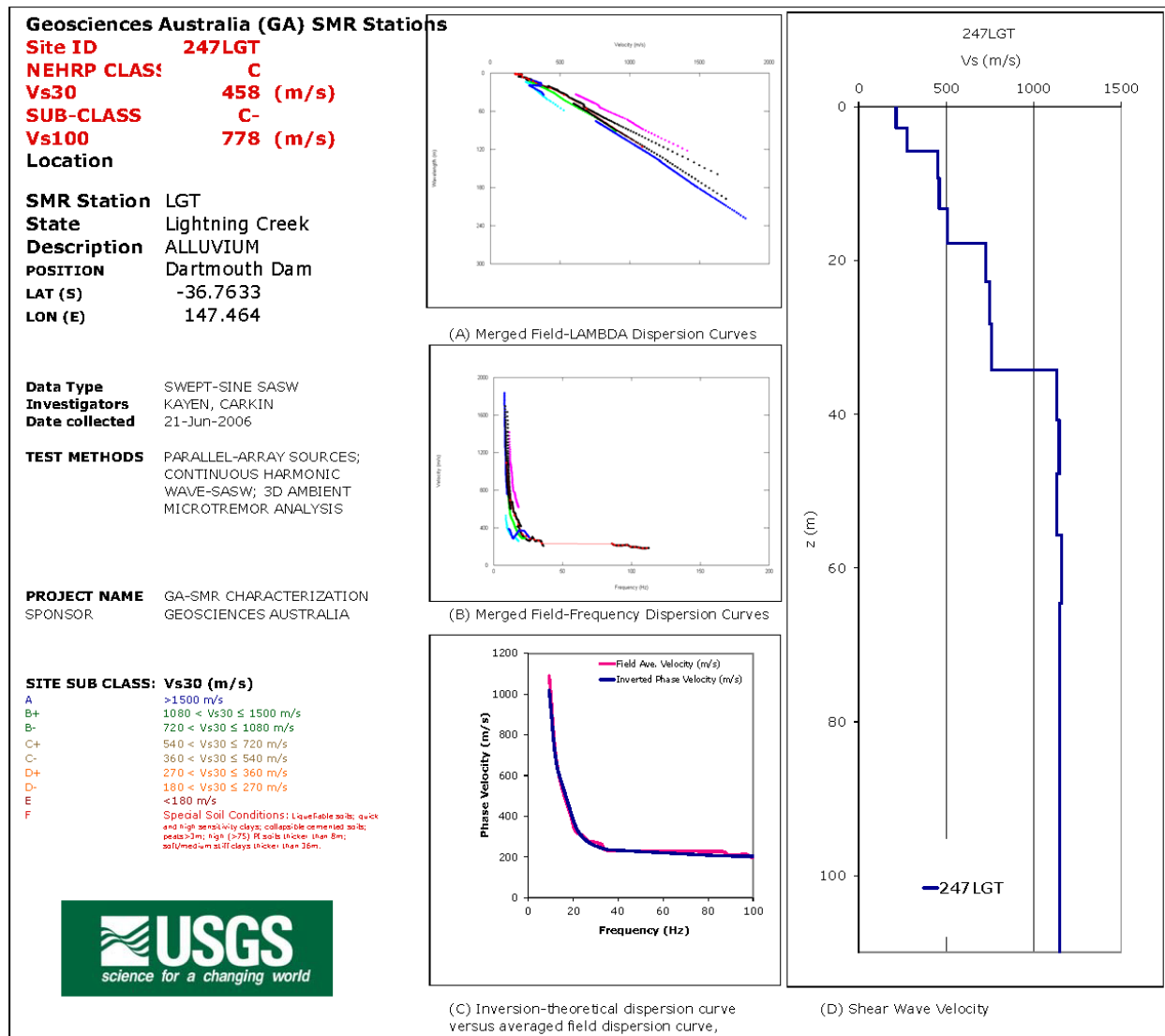(D) Shear Wave Velocity SASW

Figure A1-18. Site ID, location, and shear wave velocity for surface wave test site 244NAP. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

Figure A1-19. Surface wave test site 245GHS located at Government House, Adelaide, South Australia (lat -34.92077, long 138.6001). Tested on June 18, 2006. (A) view looking toward the NE from shakers; (B) view SW toward the shakers; (C) view south to the shakers; (D) view to the SW along seismometer array; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in South Australia.

Geosciences Australia (GA) SMR Stations

Site ID — 245GHS
NEHRP CLASS — D
Vs30 — 257 (m/s)
SUB-CLASS — D+
Vs100 — 434 (m/s)
Location

SMR Station	GHS
State	ADELAIDE, SOUTH AUSTRALIA
Description	ALLUVIUM
POSITION	GOVERNMENT HOUSE
LAT (S)	34.92077
LON (E)	133.6001

Data Type	SWEPT-SINE SASW
Investigators	KAYEN, CARKIN
Date collected	18-Jun-2006
TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW; 3D AMBIENT MICROTREMOR ANALYSIS
PROJECT NAME	GA-SMR CHARACTERIZATION
SPONSOR	GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)

A	>1500 m/s
B+	1080 < Vs30 ≤ 1500 m/s
B-	720 < Vs30 ≤ 1080 m/s
C+	540 < Vs30 ≤ 720 m/s
C-	360 < Vs30 ≤ 540 m/s
D+	270 < Vs30 ≤ 360 m/s
D-	180 < Vs30 ≤ 270 m/s
E	<180 m/s
F	Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(A) Merged Field-LAMBDA Dispersion Curves

(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(D) Shear Wave Velocity SASW

Figure A1-20. Site ID, location, and shear wave velocity for surface wave test site 245GHS. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

38

Figure A1-21. Surface wave test site 246DTM located on ridge top about 70 km SW of Wodonga, Victoria (lat -36.5293, long 147.469). Tested on June 21, 2006. (A) photo view towards the SE at the shakers; (B) view Sw from the shakers; (C) view SE along seismometer array; (D) seismometer shelter on south-facing side of ridge; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Victoria.
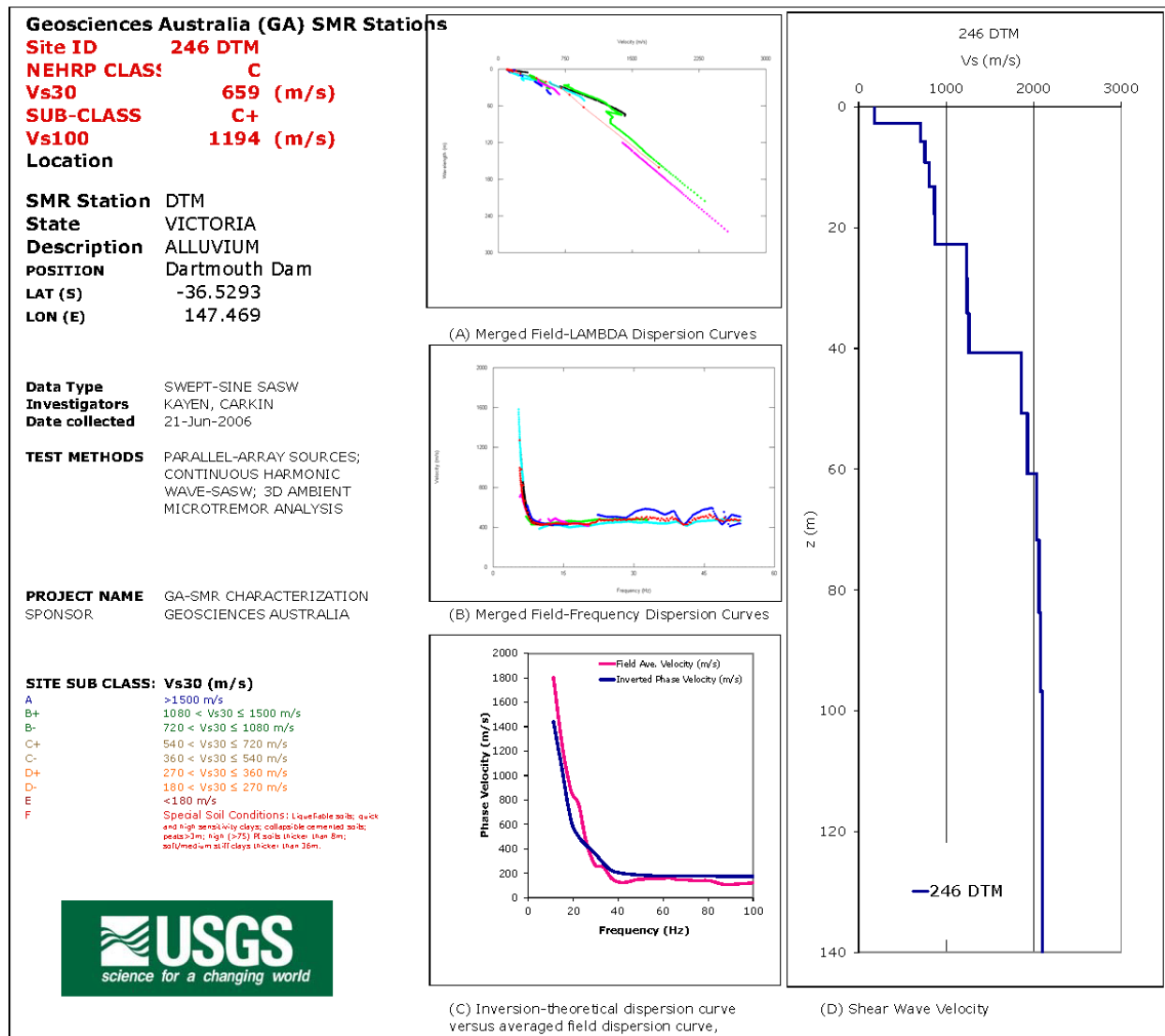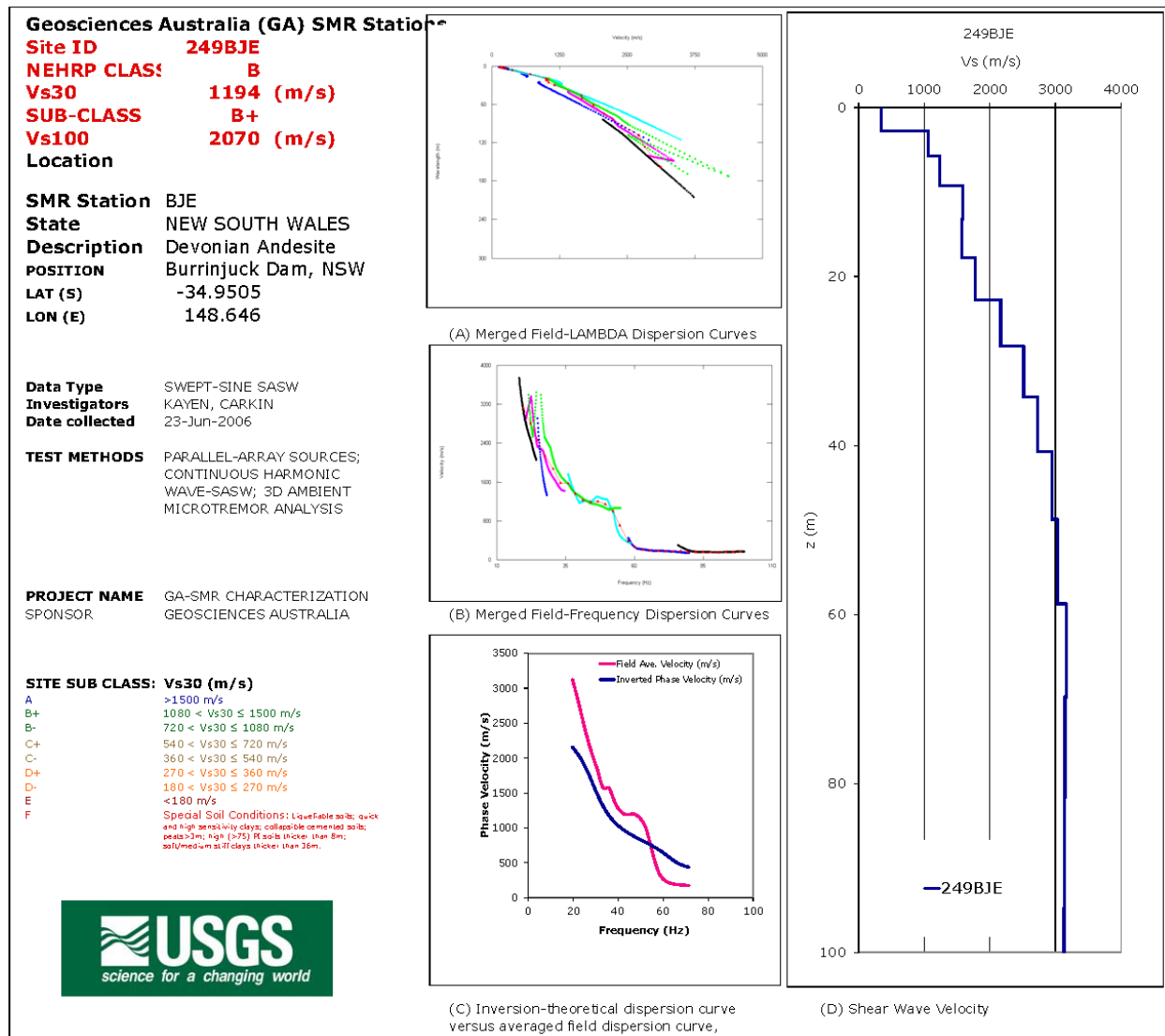
Figure A1-22. Site ID, location, and shear wave velocity for surface wave test site 246DTM. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

Figure A1-23. Surface wave test site 247LGT located about 88 km SE of Wodonga, Victoria (lat -36.7633, long 147.464). Tested on June 21, 2006. (A) view of shakers and seismometers; (B) view NW or SE along seismometer array; (C) view of shakers and seismometers, 2 m spacing; (D) seismometer shelter; (E) satellite view of the local site, red and white symbol is the location of the shakers based on GPS, trend of the seismometer array is uncertain on irregular forest road; (F) site location in Victoria.

Geosciences Australia (GA) SMR Stations

Site ID	247LGT
NEHRP CLASS	C
Vs30	458 (m/s)
SUB-CLASS	C-
Vs100	778 (m/s)
Location	

SMR Station	LGT
State	Lightning Creek
Description	ALLUVIUM
POSITION	Dartmouth Dam
LAT (S)	-36.7633
LON (E)	147.464

Data Type	SWEPT-SINE SASW
Investigators	KAYEN, CARKIN
Date collected	21-Jun-2006
TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW; 3D AMBIENT MICROTREMOR ANALYSIS
PROJECT NAME	GA-SMR CHARACTERIZATION
SPONSOR	GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)

A	>1500 m/s
B+	1080 < Vs30 ≤ 1500 m/s
B-	720 < Vs30 ≤ 1080 m/s
C+	540 < Vs30 ≤ 720 m/s
C-	360 < Vs30 ≤ 540 m/s
D+	270 < Vs30 ≤ 360 m/s
D-	180 < Vs30 ≤ 270 m/s
E	<180 m/s
F	Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats >3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

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(A) Merged Field-LAMBDA Dispersion Curves

(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(D) Shear Wave Velocity

Figure A1-24. Site ID, location, and shear wave velocity for surface wave test site 247LGT. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

42

Figure A1-25. Surface wave test site 248DRA located 42 km NE of Albury, New South Wales (lat -35.9654, long 147.375). Tested on June 22, 2006. (A) view of the test site looking towards the east; (B) view west toward seismometers; (C) view east along seismometer array; (D) view to the west; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.
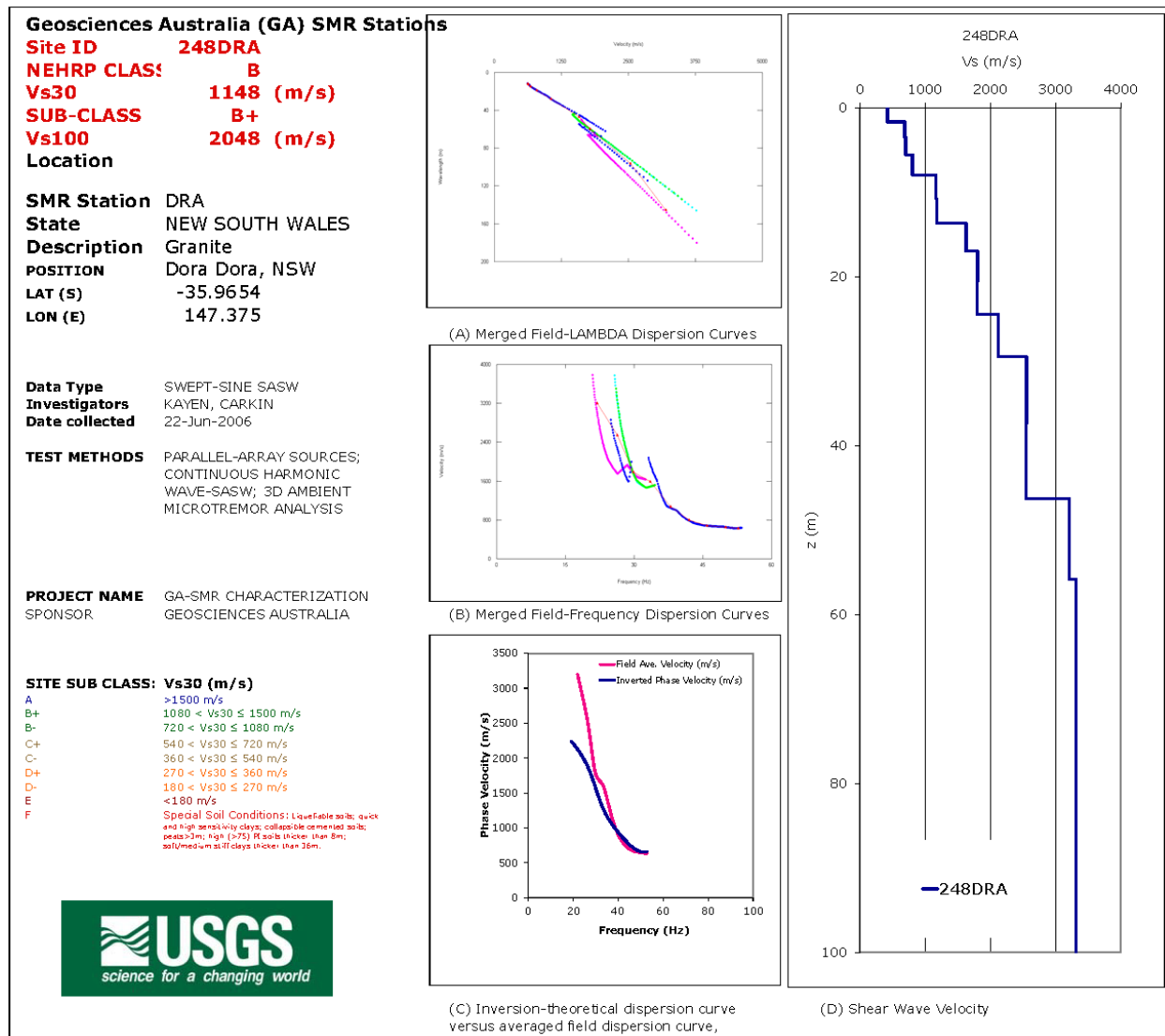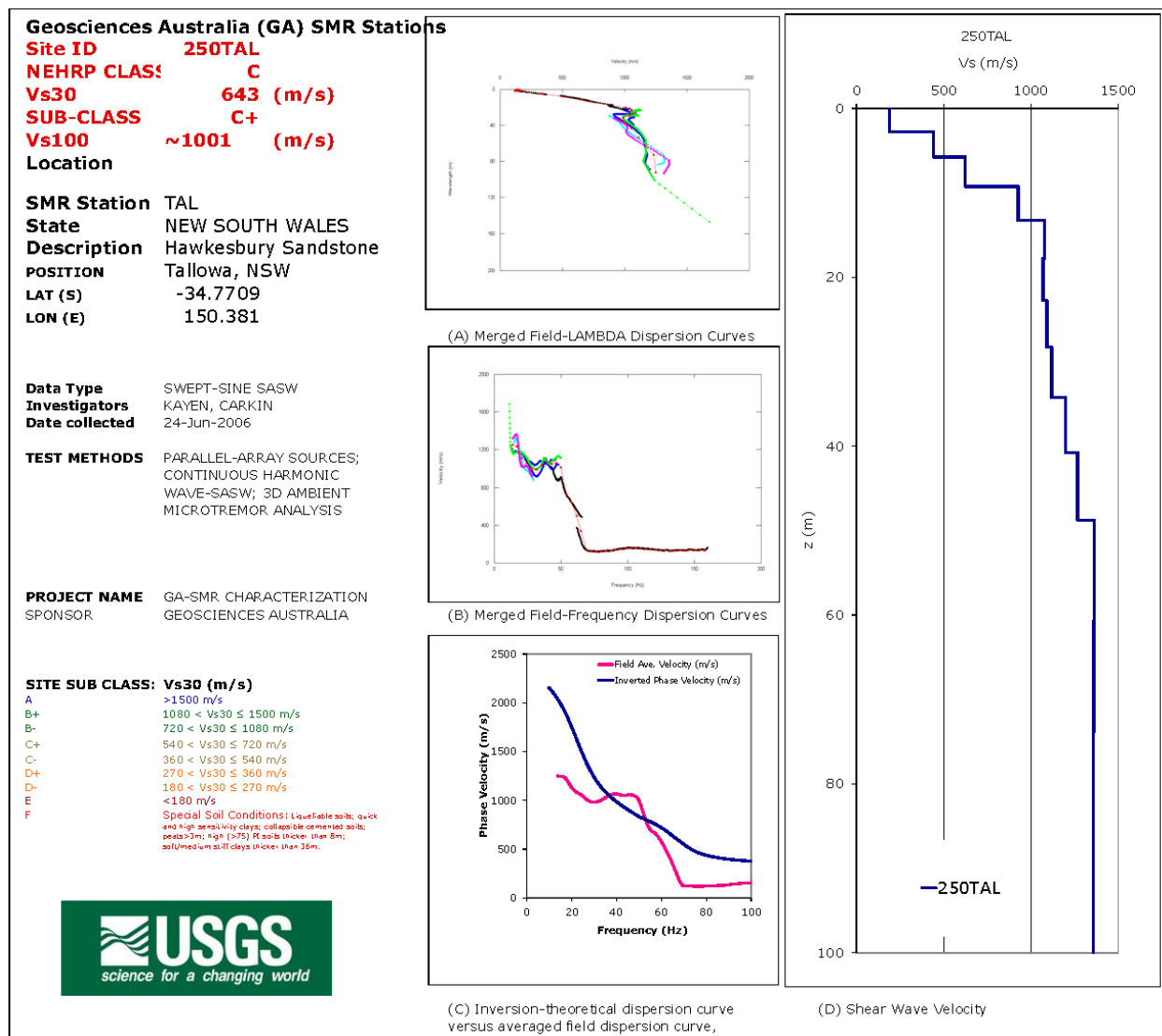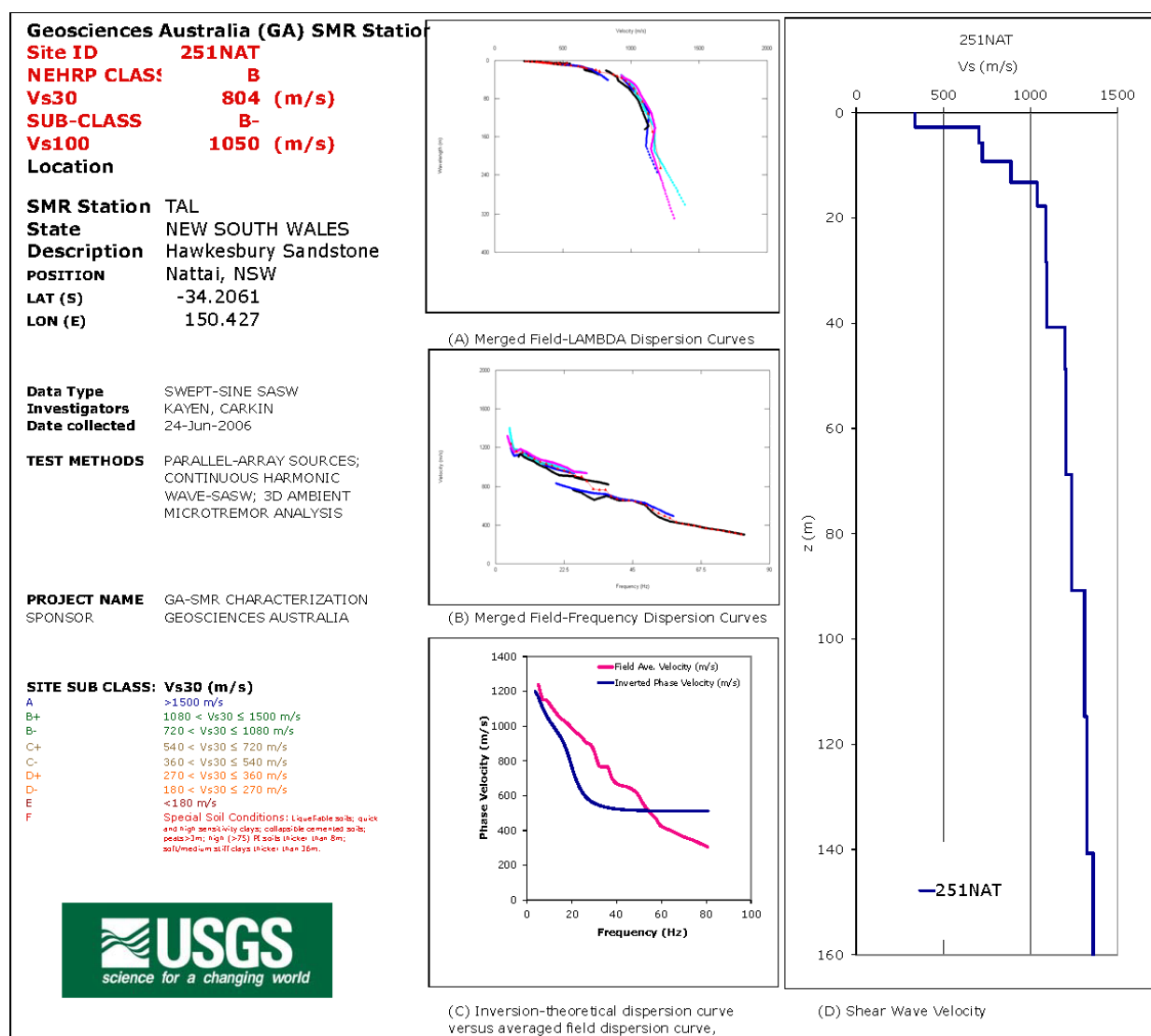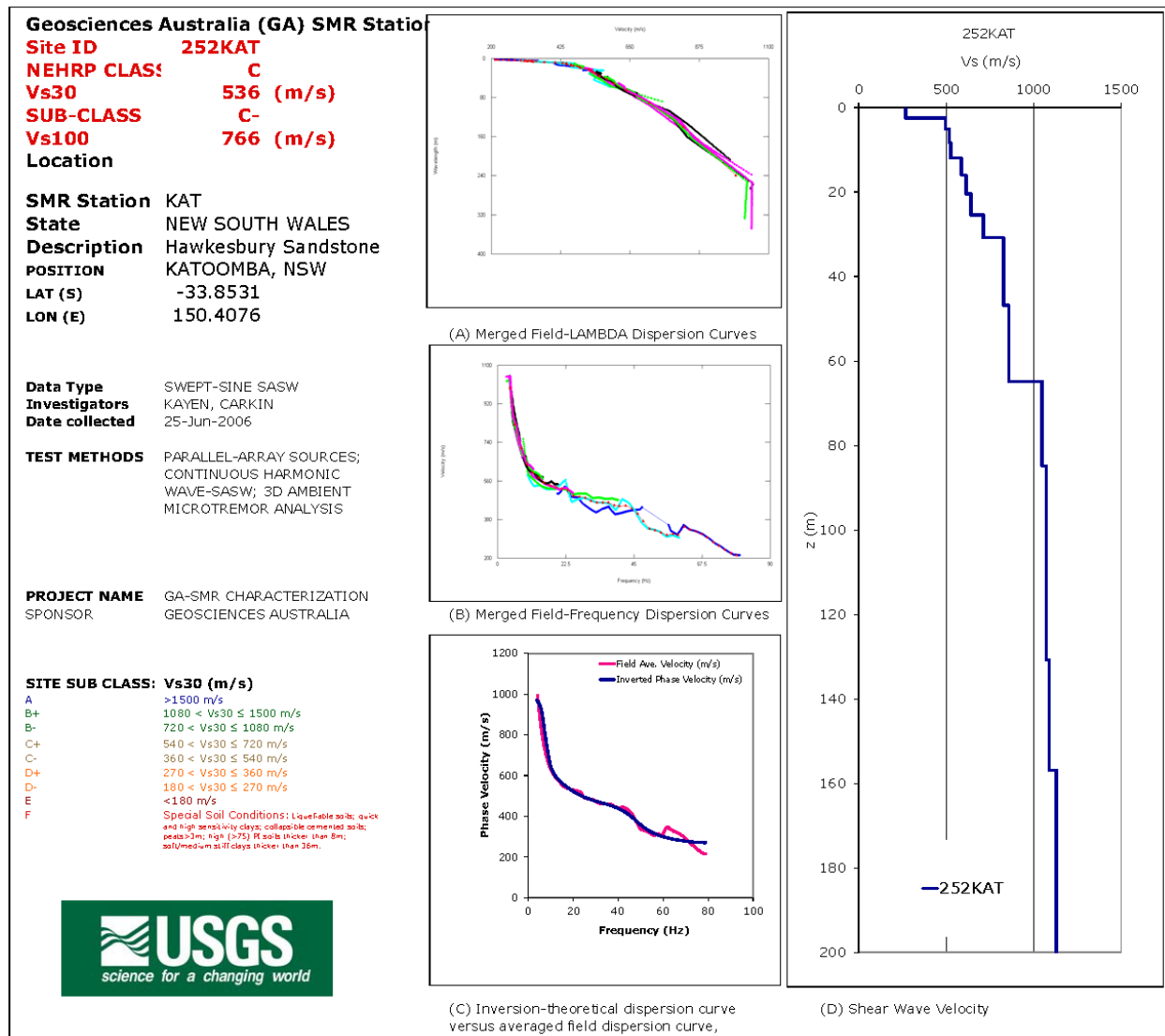
Figure A1-26. Site ID, location, and shear wave velocity for surface wave test site 248DRA. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

44
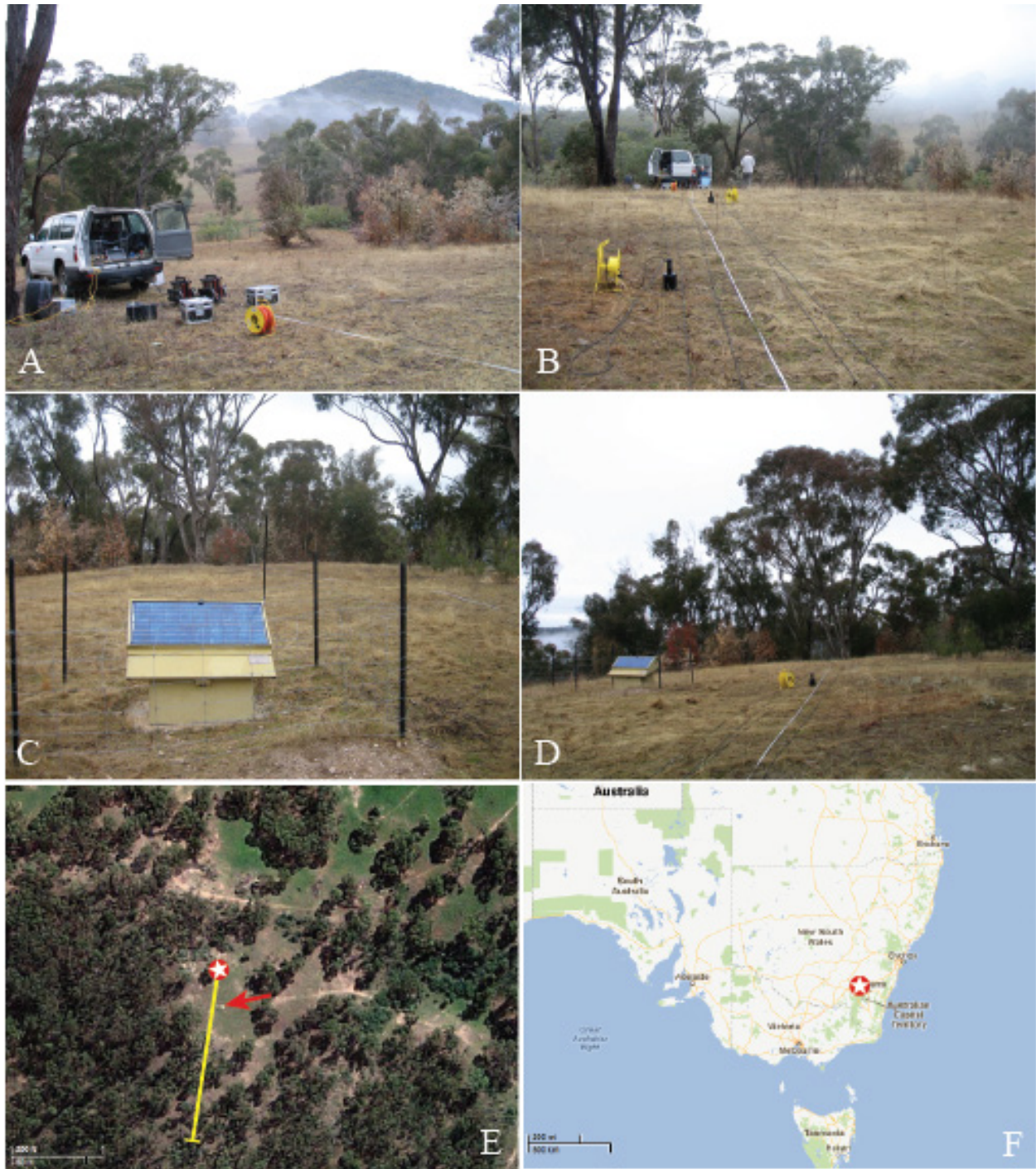
Figure A1-27. Surface wave test site 249BJE located 27 km SW of Yass, New South Wales (lat -34.9505, long 148.646). Tested on June 23, 2006. (A) view looking NE towards the shakers; (B) view looking north to the shakers; (C) seismometer shelter; (D) view to the south along seismometer array; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array, seismometer shelter located at the red arrow; (F) site location in New South Wales.
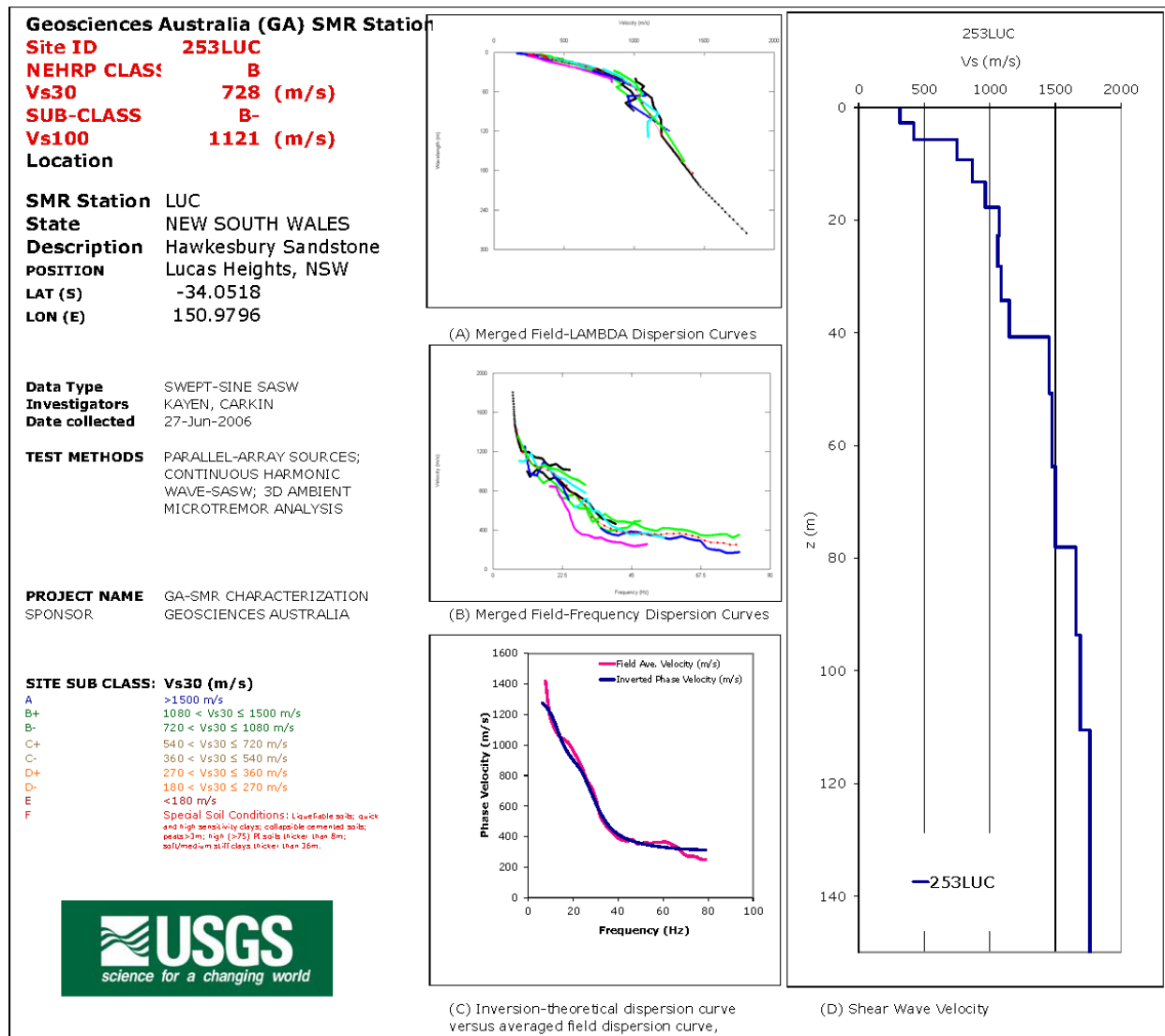
45

Figure A1-28. Site ID, location, and shear wave velocity for surface wave test site 249BJE. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

Figure A1-29. Surface wave test site 250TAL located about 14 km W-SW of Kangaroo Valley, New South Wales (lat -34.7709, long 150.381). Tested on June 24, 2006. (A) view looking towards the SE from shakers; (B) view SE along the seismometer array; (C) the seismometer shelter west of the road near the shakers; (D) shakers at the NW end of the seismometer array; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.

Geosciences Australia (GA) SMR Stations

Site ID   **250TAL**
NEHRP CLASS   **C**
Vs30   **643 (m/s)**
SUB-CLASS   **C+**
Vs100   **~1001 (m/s)**
Location

SMR Station	TAL
State	NEW SOUTH WALES
Description	Hawkesbury Sandstone
POSITION	Tallowa, NSW
LAT (S)	-34.7709
LON (E)	150.381

Data Type	SWEPT-SINE SASW
Investigators	KAYEN, CARKIN
Date collected	24-Jun-2006

TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW; 3D AMBIENT MICROTREMOR ANALYSIS

PROJECT NAME	GA-SMR CHARACTERIZATION
SPONSOR	GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.
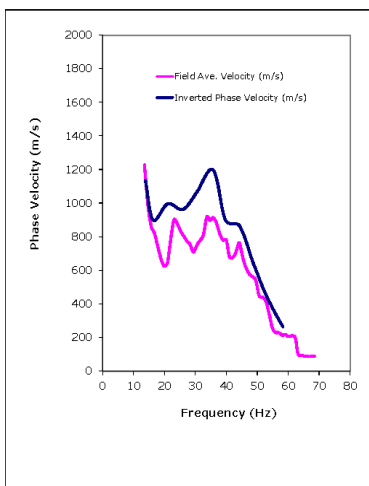
(A) Merged Field-LAMBDA Dispersion Curves

(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(D) Shear Wave Velocity

Figure A1-30. Site ID, location, and shear wave velocity for surface wave test site 250TAL. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

48

Figure A1-31. Surface wave test site 251NAT located about 5 km N-NW of Hill Top, New South Wales (lat -34.31846, long 150.46255). Tested on June 24, 2006. (A) view looking towards the SW from near the shakers; (B) view SW along the seismometer array; (C) view NE along seismometer array; (D) view eastward of the shaker location on Wattle Ridge Road; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.

Geosciences Australia (GA) SMR Station

Site ID   **251NAT**
NEHRP CLASS   **B**
Vs30   **804 (m/s)**
SUB-CLASS   **B-**
Vs100   **1050 (m/s)**
Location

SMR Station	TAL
State	NEW SOUTH WALES
Description	Hawkesbury Sandstone
POSITION	Nattai, NSW
LAT (S)	-34.2061
LON (E)	150.427

Data Type	SWEPT-SINE SASW
Investigators	KAYEN, CARKIN
Date collected	24-Jun-2006

TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW; 3D AMBIENT MICROTREMOR ANALYSIS

PROJECT NAME	GA-SMR CHARACTERIZATION
SPONSOR	GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats >3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

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(A) Merged Field-LAMBDA Dispersion Curves

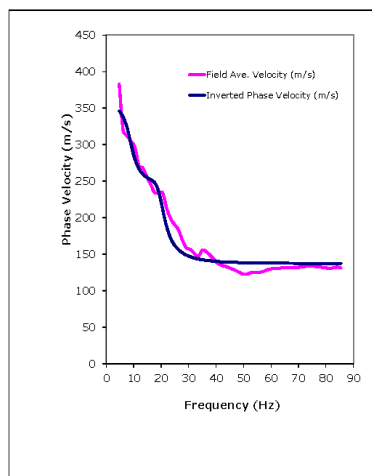(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(D) Shear Wave Velocity

Figure A1-32. Site ID, location, and shear wave velocity for surface wave test site 251NAT. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

50

Figure A1-33. Surface wave test site 252KAT located 17 km SE of Katoomba, New South Wales (lat -33.8531, long 150.40755). (A) view looking S-SE towards the seismometer array; (B) view looking S-SE towards the seismometer array; (C) view northward to the shaker location; (D) the shakers sitting directly on bedrock at road junction; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.

Geosciences Australia (GA) SMR Station

Site ID	**252KAT**
NEHRP CLASS	**C**
Vs30	**536 (m/s)**
SUB-CLASS	**C-**
Vs100	**766 (m/s)**
Location	

SMR Station	KAT
State	NEW SOUTH WALES
Description	Hawkesbury Sandstone
POSITION	KATOOMBA, NSW
LAT (S)	-33.8531
LON (E)	150.4076

Data Type	SWEPT-SINE SASW
Investigators	KAYEN, CARKIN
Date collected	25-Jun-2006
TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW; 3D AMBIENT MICROTREMOR ANALYSIS
PROJECT NAME	GA-SMR CHARACTERIZATION
SPONSOR	GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)

A	>1500 m/s
B+	1080 < Vs30 ≤ 1500 m/s
B-	720 < Vs30 ≤ 1080 m/s
C+	540 < Vs30 ≤ 720 m/s
C-	360 < Vs30 ≤ 540 m/s
D+	270 < Vs30 ≤ 360 m/s
D-	180 < Vs30 ≤ 270 m/s
E	<180 m/s
F	Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(A) Merged Field-LAMBDA Dispersion Curves

(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(D) Shear Wave Velocity

Figure A1-34. Site ID, location, and shear wave velocity for surface wave test site 252KAT. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

Figure A1-35. Surface wave test site 253LUC located at the High Flux Australian Reactor site, Lucas Heights, New South Wales (lat -34.05181, long 150.97958). Tested on June 27, 2006. (A) satellite view of the reactor and test site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (B) wider satellite view of reactor site and shaker location; (C) site location in New South Wales.

Geosciences Australia (GA) SMR Station

Site ID   **253LUC**
NEHRP CLASS   **B**
Vs30   **728 (m/s)**
SUB-CLASS   **B-**
Vs100   **1121 (m/s)**
Location

SMR Station   LUC
State   NEW SOUTH WALES
Description   Hawkesbury Sandstone
POSITION   Lucas Heights, NSW
LAT (S)   -34.0518
LON (E)   150.9796

Data Type   SWEPT-SINE SASW
Investigators   KAYEN, CARKIN
Date collected   27-Jun-2006

TEST METHODS   PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW; 3D AMBIENT
MICROTREMOR ANALYSIS

PROJECT NAME   GA-SMR CHARACTERIZATION
SPONSOR   GEOSCIENCES AUSTRALIA

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
soft/medium stiff clays thicker than 36m.

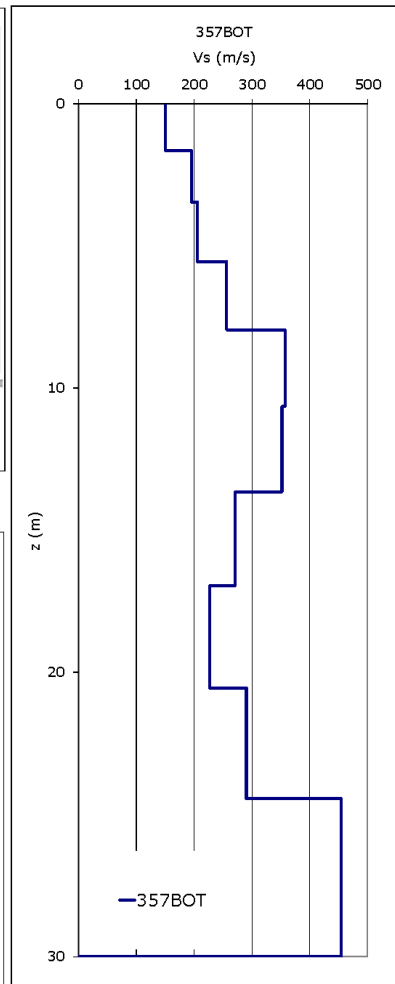(A) Merged Field-LAMBDA Dispersion Curves

(B) Merged Field-Frequency Dispersion Curves

(C) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(D) Shear Wave Velocity

Figure A1-36. Site ID, location, and shear wave velocity for surface wave test site 253LUC. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Phase velocity versus frequency for individual empirical dispersion curves; (C) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (D) Shear wave velocity versus depth.

Figure A1-37. Surface wave test site 355BOT, Latham Park, eastern suburbs, Sydney, New South Wales (lat -33.93479, long 151.25119). Botany microtremor site 305006, tested on April 15, 2010. (A) view southward to the seismometer array from the shakers; (B) view northward to the shakers; (C) view north to the seismometers and shakers; (D) view west at the shakers; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.

Geoscience Australia (GA) Site Response

Site ID	**355BOT**
NEHRP CLASS	**C**
Vs30	**543 (m/s)**
SUB-CLASS	**C+**

Location Latham Park, Sydney

SMR Station Botany microtrem 305006
State New South Wales

POSITION
LAT (N) -33.93479
LON (E) 151.25119

Data Type SWEPT-SINE SASW
Investigators Kayen, Carkin, Minasian, Allen, Collins
Date collected 15 April, 2010

TEST METHODS PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW.

PROJECT NAME New South Wales, Victoria SASW SMR CHARACTERIZATION
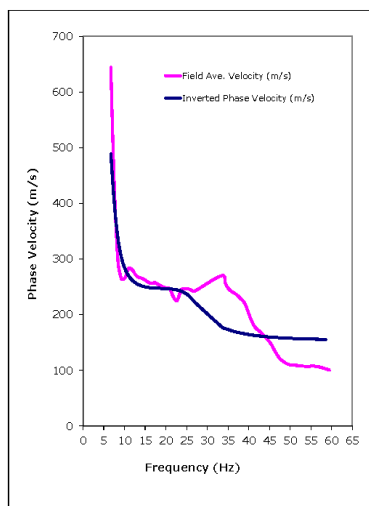**SPONSOR** GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A > 1500 m/s
B+ 1080 < Vs30 ≤ 1500 m/s
B- 720 < Vs30 ≤ 1080 m/s
C+ 540 < Vs30 ≤ 720 m/s
C- 360 < Vs30 ≤ 540 m/s
D+ 270 < Vs30 ≤ 360 m/s
D- 180 < Vs30 ≤ 270 m/s
E < 180 m/s
F Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.
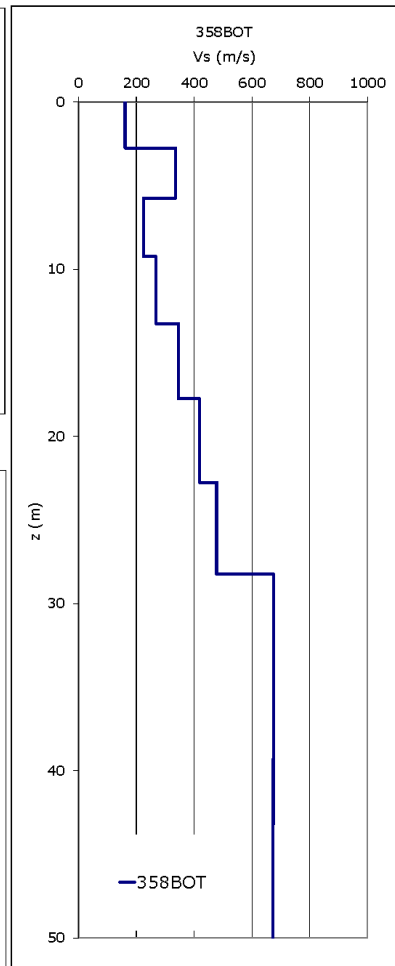
(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-38. Site ID, location, and shear wave velocity for surface wave test site 355BOT. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-39. Surface wave test site 356BOT, Snape Park, Maroubra, eastern suburbs, Sydney (lat -33.93572, long 151.2332). Botany microtremor site 301016, tested on April 16, 2010. (A) view westward from the shakers; (B) view east at the seismometers and shakers; (C) view NE from the shakers into playing field; (D) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (E) site location in New South Wales.

Geoscience Australia (GA) Site Response

Site ID 356BOT
NEHRP CLASS D
Vs30 289 (m/s)
SUB-CLASS D-

Location Snape Park, Sydney

SMR Station Botany microtrem 301016
State New South Wales

POSITION
LAT (N) -33.93572
LON (E) 151.2332

Data Type SWEPT-SINE SASW
Investigators Kayen, Carkin, Minasian, Allen, Collins
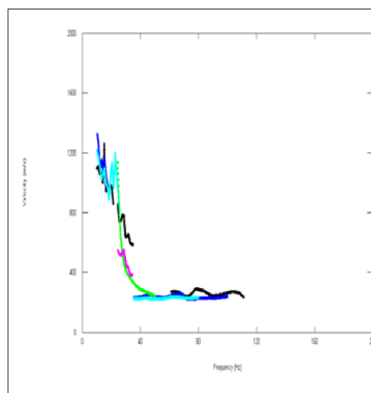**Date collected** 16 April, 2010

TEST METHODS PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME New South Wales, Victoria SASW
SMR CHARACTERIZATION
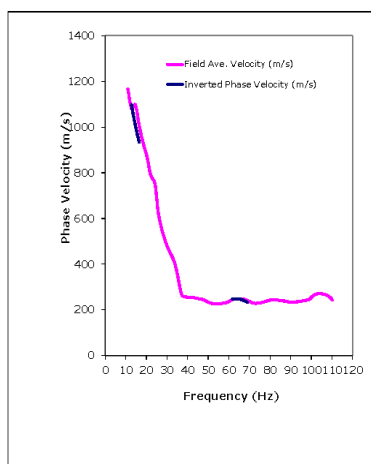**SPONSOR** GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A > 1500 m/s
B+ 1080 < Vs30 ≤ 1500 m/s
B- 720 < Vs30 ≤ 1080 m/s
C+ 540 < Vs30 ≤ 720 m/s
C- 360 < Vs30 ≤ 540 m/s
D+ 270 < Vs30 ≤ 360 m/s
D- 180 < Vs30 ≤ 270 m/s
E < 180 m/s
F Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
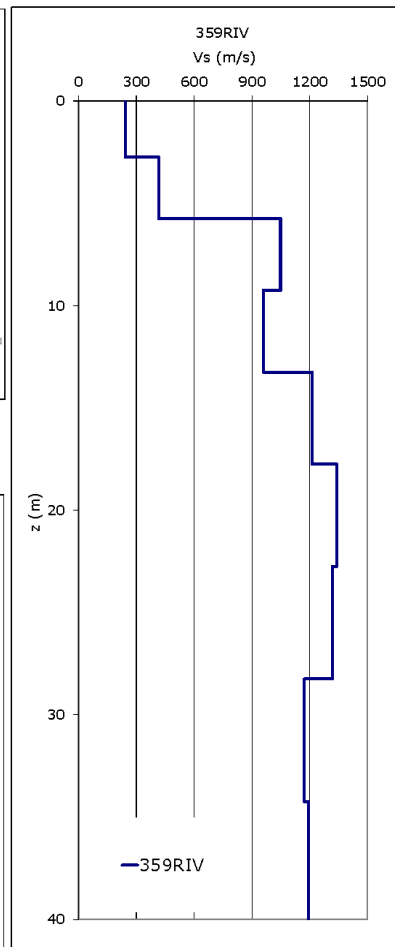soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-40. Site ID, location, and shear wave velocity for surface wave test site 356BOT. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-41. Surface wave test site 357BOT located at David Phillips Sports Field, Daceyville, eastern suburbs, Sydney (lat -33.9313, long 151.2247). Tested on April 16, 2010. (A) view looking NE from the shakers; (B) view looking south toward the shakers; (C) view NE showing the shakers and analyzer; (D) view to the east of part of the seismometer array; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.

Geoscience Australia (GA) Site Response

Site ID   **357BOT**
NEHRP CLASS   **D**
Vs30   **274 (m/s)**
SUB-CLASS   **D+**

Location   David Phillips Sports Field, Daceyville

SMR Station   Botany microtrem 301027
State   New South Wales

POSITION
LAT (N)   -33.9313
LON (E)   151.2247

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
Date collected   16 April, 2010

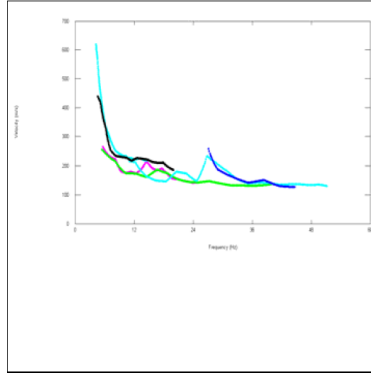**TEST METHODS**   PARALLEL-ARRAY SOURCES;
                CONTINUOUS HARMONIC
                WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW
                SMR CHARACTERIZATION
SPONSOR   GA, USGS
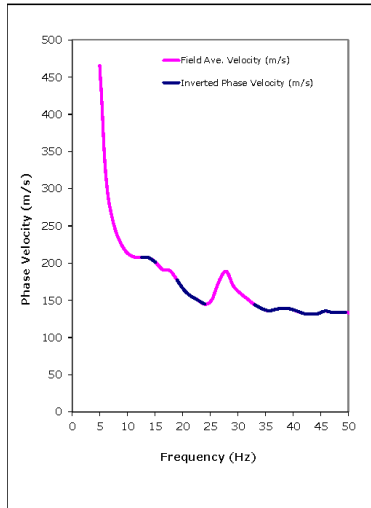
SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
           and high sensitivity clays; collapsible cemented soils;
           peats>3m; high (>75) PI soils thicker than 8m;
           soft/medium stiff clays thicker than 36m.

(B) Merged Field-Frequency Dispersion Curves

(b) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(c) Shear Wave Velocity SASW

Figure A1-42. Site ID, location, and shear wave velocity for surface wave test site 357BOT. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-43. Surface wave test site 358BOT located in Rosebery, southeastern suburbs, Sydney, New South Wales (lat -33.91608, long 151.208491). Botany microtremor site 301035, tested on April 16, 2010. (A) view looking east from shakers along Kimbereley Grove; (B) view west along seismometer array; (C) view of the shakers looking NE; (D) view to the west to the shakers; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.
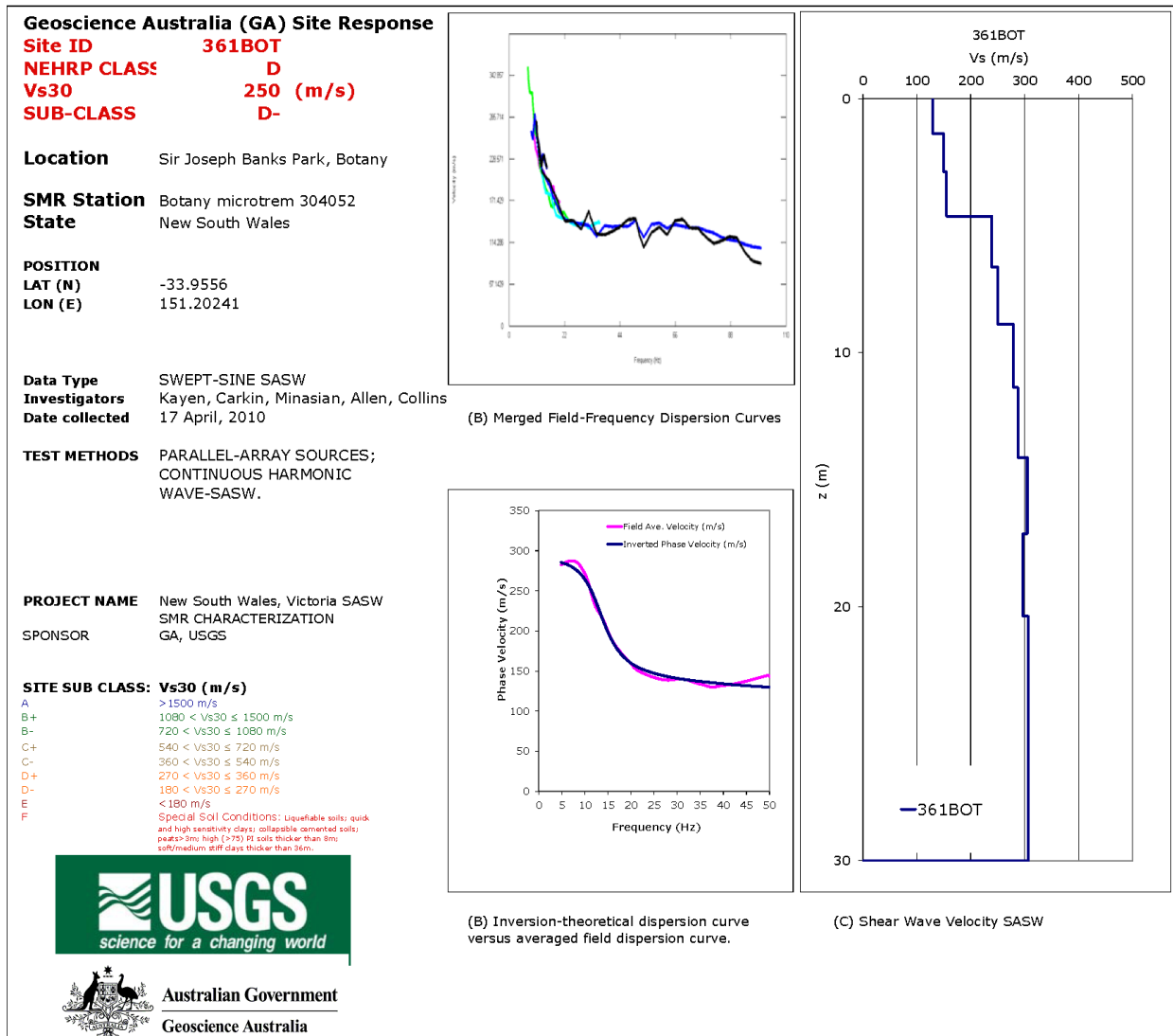
Geoscience Australia (GA) Site Response

Site ID   **358BOT**
NEHRP CLASS   **D**
Vs30   **314 (m/s)**
SUB-CLASS   **D+**

Location   Kimberley Grove sidewalk, Sydney

SMR Station   Botany microtrem 301035
State   New South Wales

POSITION
LAT (N)   -33.91608
LON (E)   151.208491

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
Date collected   16 April, 2010

TEST METHODS   PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW SMR CHARACTERIZATION
SPONSOR   GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-44. Site ID, location, and shear wave velocity for surface wave test site 358BOT. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-45. Surface wave test site 359RIV located at Saint Ignatius' College, Riverview, northeastern suburbs, Sydney, New South Wales (lat -33.8277, long 151.1591). Tested on April 17, 2010. (A) view looking west from the shakers; (B) another view looking west from the shakers; (C) view east to the shakers; (D) view to the NW into play field adjacent to the test area; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.

Geoscience Australia (GA) Site Response

Site ID   **359RIV**
NEHRP CLASS   **B**
Vs30   **768 (m/s)**
SUB-CLASS   **B-**

Location   Saint Ignatius' College, Riverview

SMR Station   Riverview ANSN (Geol. Unit Rh)
State   New South Wales

POSITION
LAT (N)   -33.8277
LON (E)   151.1591

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
Date collected   17 April, 2010

TEST METHODS   PARALLEL-ARRAY SOURCES;
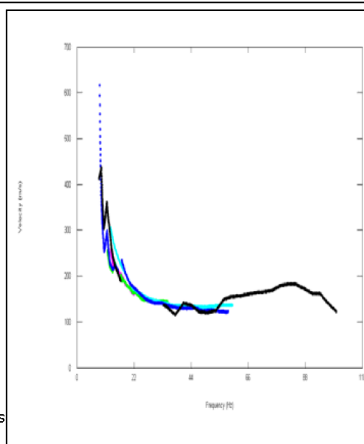CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR   GA, USGS

SITE SUB CLASS: Vs30 (m/s)
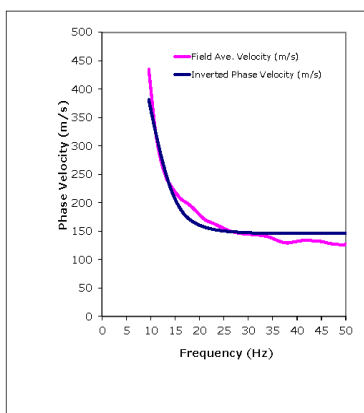A   > 1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   < 180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
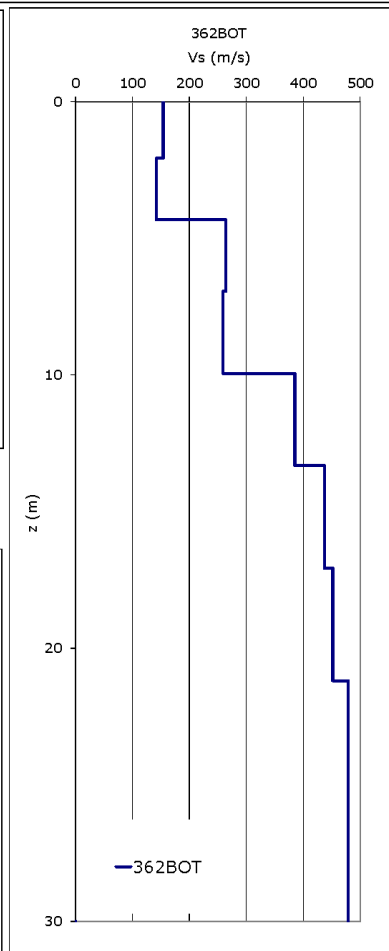soft/medium stiff clays thicker than 36m.

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(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-46. Site ID, location, and shear wave velocity for surface wave test site 359RIV. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-47. Surface wave test site 360BOT, Botany, southern suburbs, Sydney, New South Wales (lat -33.93928, long 151.20146). Botany microtremor site 305054, tested on April 17, 2010. (A) view looking southward from the shakers; (B) view northwards to the shakers; (C) view SW from shakers; (D) view southward along the seismometer array; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.
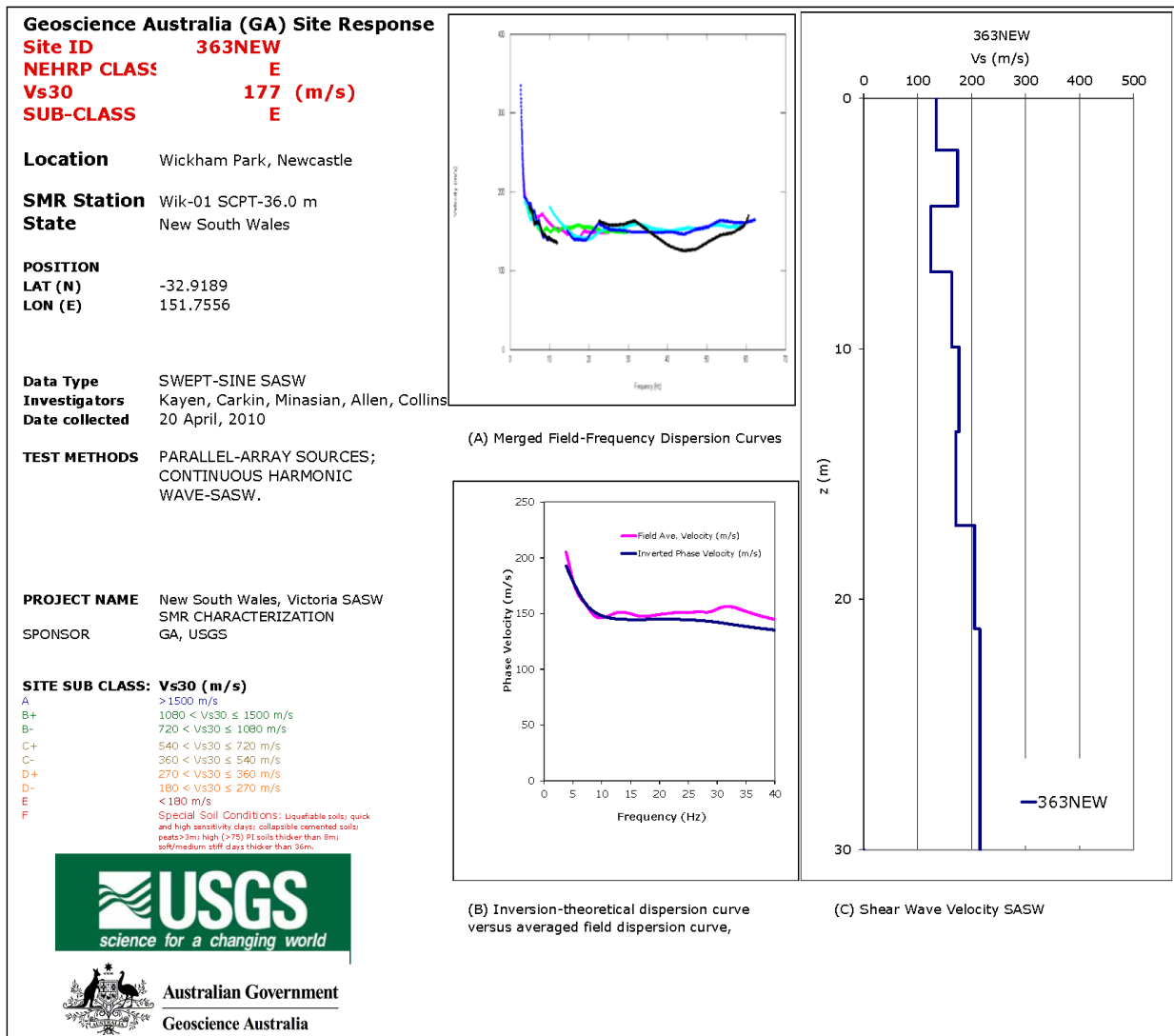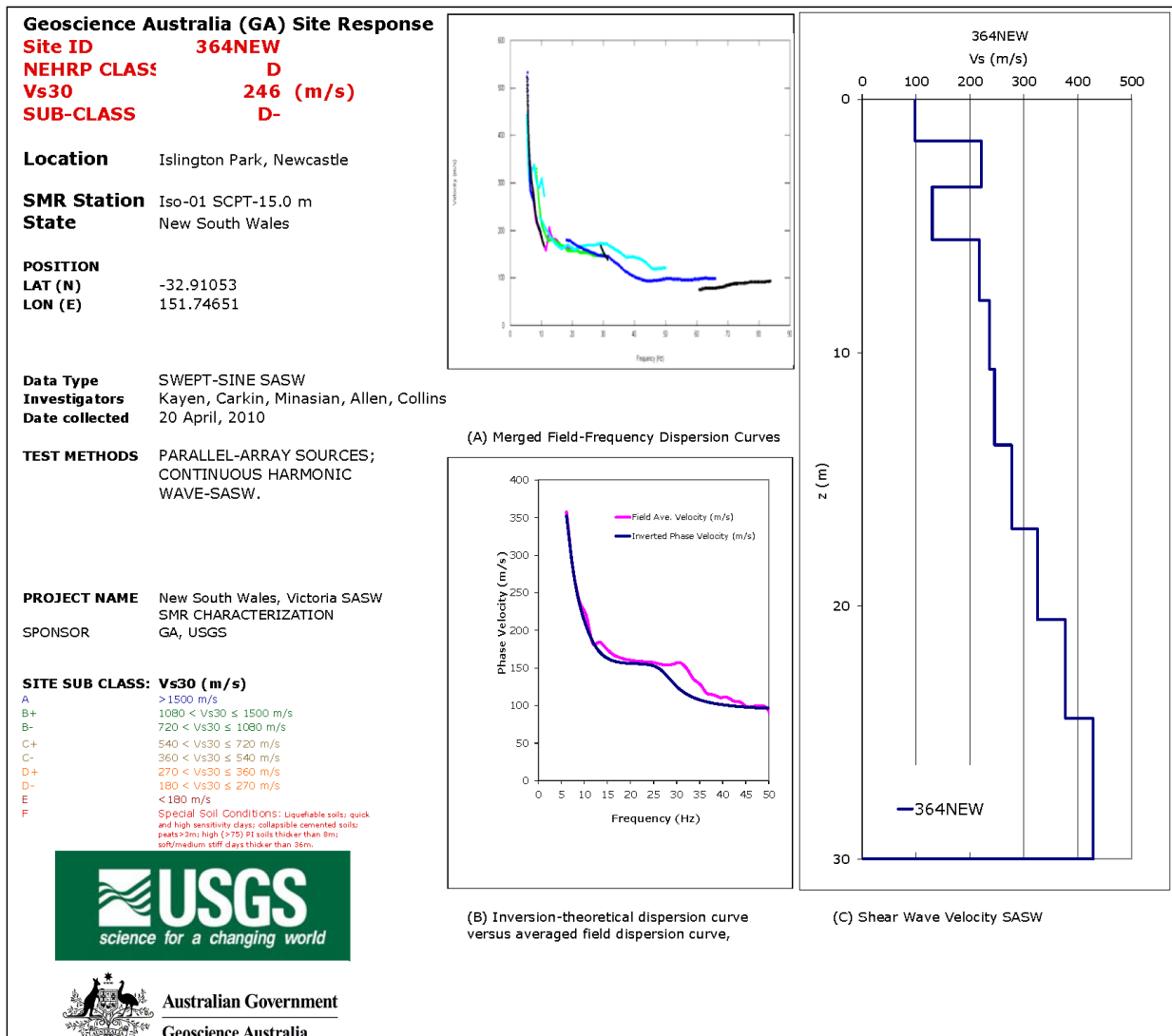
Geoscience Australia (GA) Site Response

Site ID 360BOT
NEHRP CLASS D
Vs30 253 (m/s)
SUB-CLASS D-

Location Booralee Park, Botany

SMR Station Botany microtrem 305054
State New South Wales

POSITION
LAT (N) -33.93928
LON (E) 151.20146

Data Type SWEPT-SINE SASW
Investigators Kayen, Carkin, Minasian, Allen, Collins
Date collected 17 April, 2010

TEST METHODS PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
         and high senstivity clays; collapsible cemented soils;
         peats>3m; high (>75) PI soils thicker than 8m;
         soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-48. Site ID, location, and shear wave velocity for surface wave test site 360BOT. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

66

Figure A1-49. Surface wave test site 361BOT located at Sir Joseph Banks Park, Banksmeadow, southern suburbs, Sydney, New South Wales (lat -33.9556, long 151.20241). Botany microtremor site 304052, tested on April 17, 2010. (A) view to the SE from the shakers; (B) view NW along the seismometer array; (C) view SE from near the shakers; (D) view to the NE near the shakers; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.
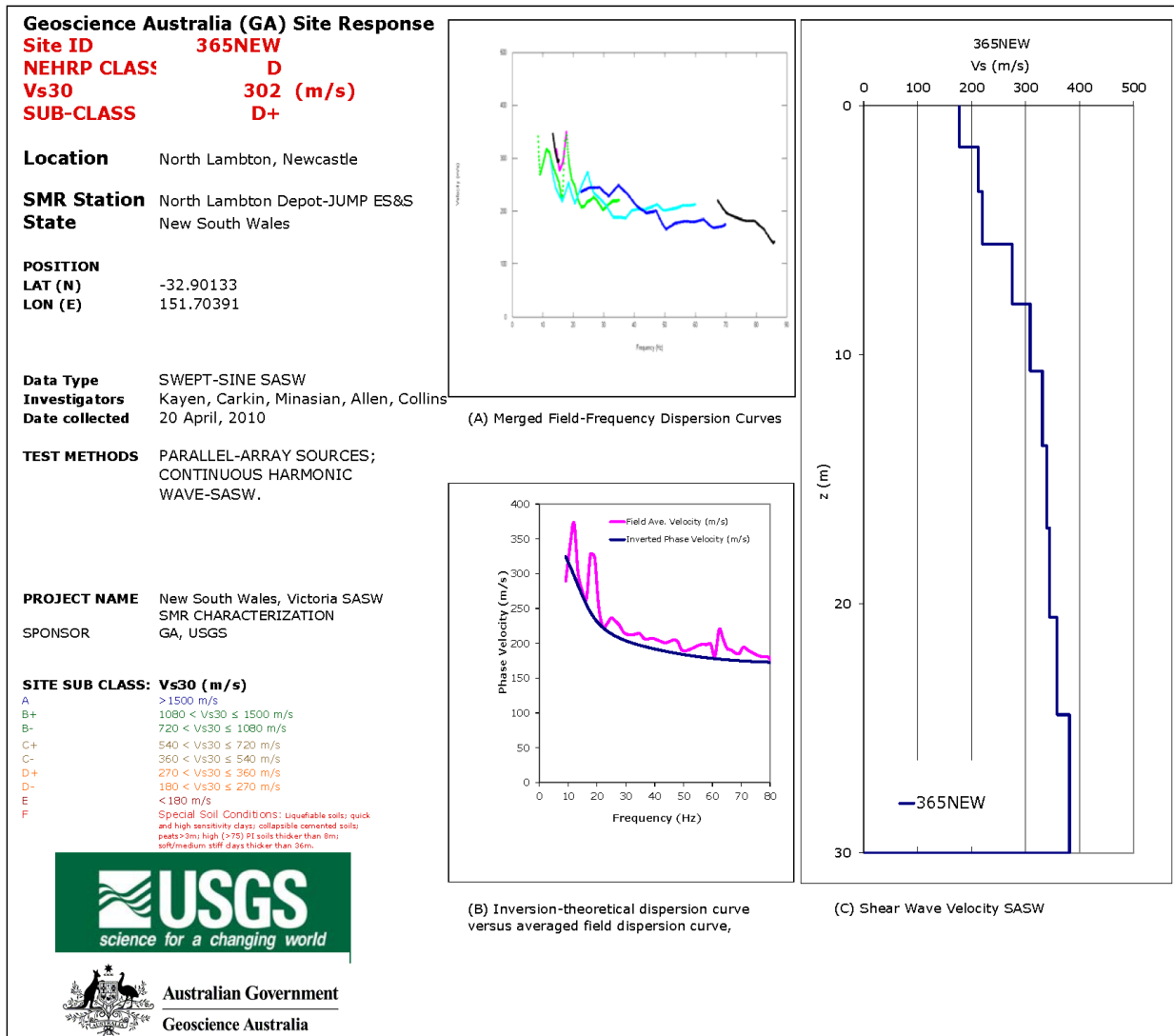
Geoscience Australia (GA) Site Response

Site ID   361BOT
NEHRP CLASS   D
Vs30   250 (m/s)
SUB-CLASS   D-

Location   Sir Joseph Banks Park, Botany

SMR Station   Botany microtrem 304052
State   New South Wales

POSITION
LAT (N)   -33.9556
LON (E)   151.20241

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
Date collected   17 April, 2010

TEST METHODS   PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR   GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
soft/medium stiff clays thicker than 36m.

(B) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve.

(C) Shear Wave Velocity SASW

Figure A1-50. Site ID, location, and shear wave velocity for surface wave test site 361BOT. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-51. Surface wave test site 362BOT located at Botany Golf Club, Banksmeadow, southern suburbs, Sydney, New South Wales (lat -33.9585, long 151.20706). Botany microtremor site 30036, tested on April 19, 2010. (A) view looking NW along the seismometer array from the shakers; (B) another view NW from near the shakers; (C) view SE toward the shakers; (D) view NW to the shakers and seismometer array; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.

Geoscience Australia (GA) Site Response

Site ID 362BOT
NEHRP CLASS D
Vs30 314 (m/s)
SUB-CLASS D+

Location Botany Golf Club, Botany

SMR Station Botany microtrem 30036
State New South Wales

POSITION
LAT (N) -33.9585
LON (E) 151.20706

Data Type SWEPT-SINE SASW
Investigators Kayen, Carkin, Minasian, Allen, Collins
Date collected 19 April, 2010

TEST METHODS PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A >1500 m/s
B+ 1080 < Vs30 ≤ 1500 m/s
B- 720 < Vs30 ≤ 1080 m/s
C+ 540 < Vs30 ≤ 720 m/s
C- 360 < Vs30 ≤ 540 m/s
D+ 270 < Vs30 ≤ 360 m/s
D- 180 < Vs30 ≤ 270 m/s
E <180 m/s
F Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.
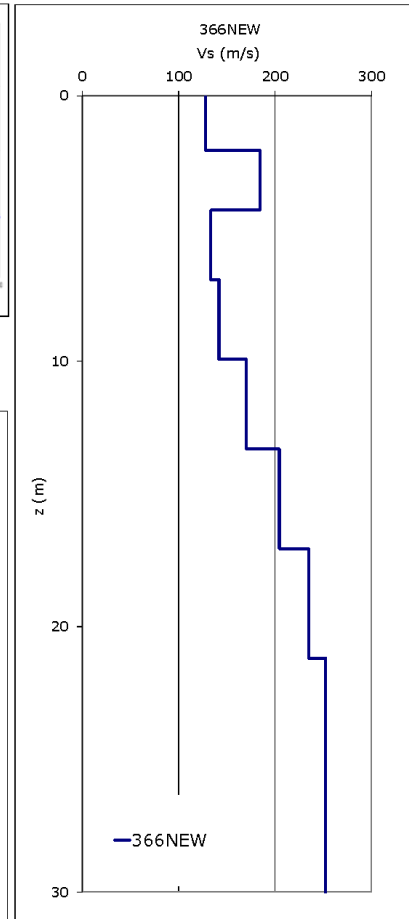
(B) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-52. Site ID, location, and shear wave velocity for surface wave test site 362BOT. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-53. Surface wave test site 363NEW located at Wickham Park, Wickham district, Newcastle, New South Wales (lat -32.9189, long 151.7556). Wik-01 SCPT-36.0 m site, tested on April 20, 2010. (A) view to the north from the shakers; (B) view SW from the shakers; (C) another view SW from the shakers; (D) view to the NW along the seismometer array; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.
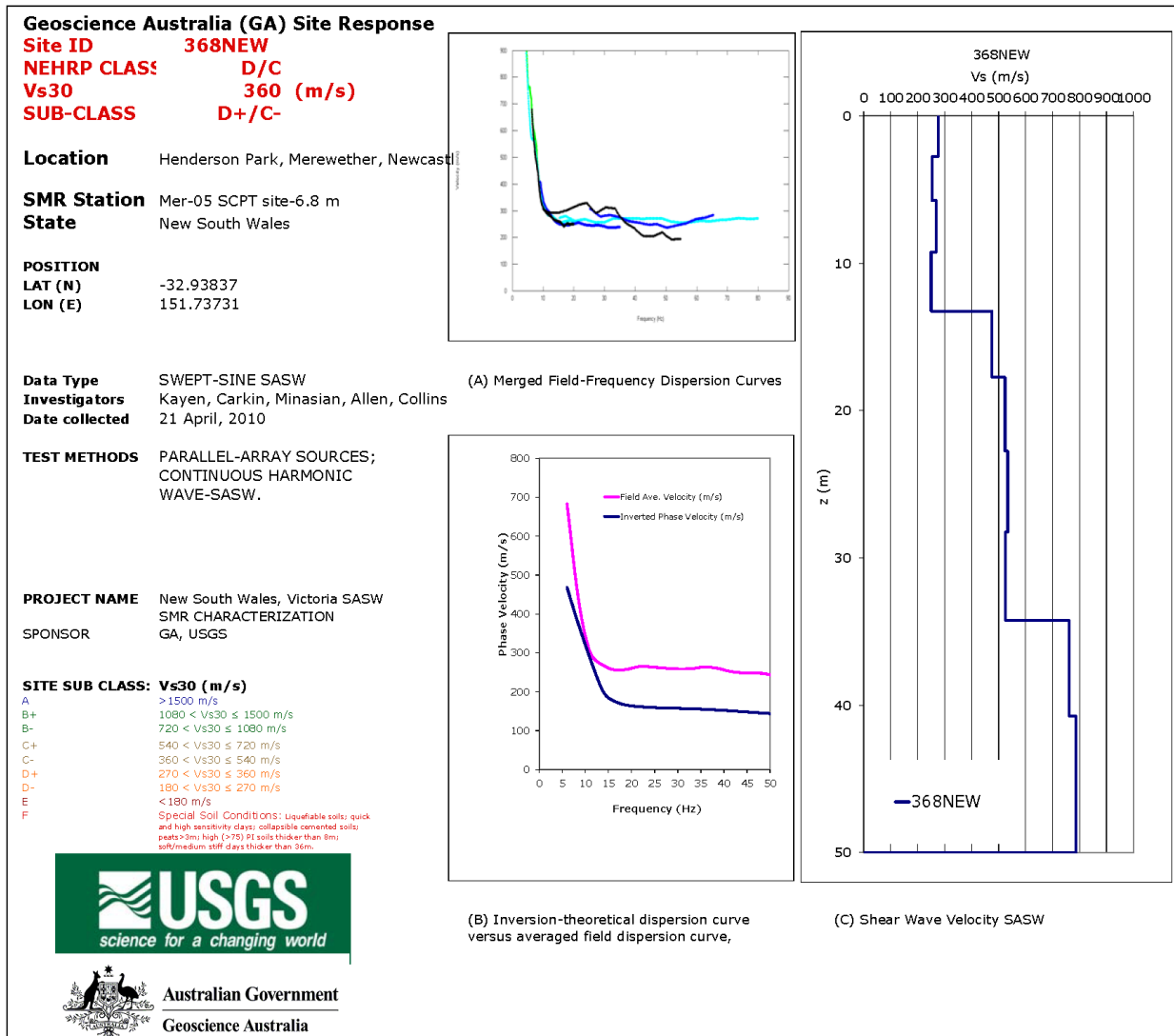
Geoscience Australia (GA) Site Response

Site ID	**363NEW**
NEHRP CLASS	**E**
Vs30	**177 (m/s)**
SUB-CLASS	**E**

Location Wickham Park, Newcastle

SMR Station Wik-01 SCPT-36.0 m
State New South Wales

POSITION
LAT (N) -32.9189
LON (E) 151.7556

Data Type SWEPT-SINE SASW
Investigators Kayen, Carkin, Minasian, Allen, Collins
Date collected 20 April, 2010

TEST METHODS PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A >1500 m/s
B+ 1080 < Vs30 ≤ 1500 m/s
B- 720 < Vs30 ≤ 1080 m/s
C+ 540 < Vs30 ≤ 720 m/s
C- 360 < Vs30 ≤ 540 m/s
D+ 270 < Vs30 ≤ 360 m/s
D- 180 < Vs30 ≤ 270 m/s
E <180 m/s
F Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-54. Site ID, location, and shear wave velocity for surface wave test site 363NEW. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

72

Figure A1-55. Surface wave test site 364NEW located at Islington Park, Islington district, Newcastle, New South Wales (lat -32.91053, long 151.74651). Iso-01 SCPT-15.0 m site, tested on April 20, 2010. (A) view looking southward along seismometer array from the shakers; (B) view northward to the shakers; (C) view SE across seismometer array toward Styx Creek; (D) view to the west near the shakers; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.

73

Geoscience Australia (GA) Site Response

Site ID 364NEW
NEHRP CLASS D
Vs30 246 (m/s)
SUB-CLASS D-

Location Islington Park, Newcastle

SMR Station Iso-01 SCPT-15.0 m
State New South Wales

POSITION
LAT (N) -32.91053
LON (E) 151.74651

Data Type SWEPT-SINE SASW
Investigators Kayen, Carkin, Minasian, Allen, Collins
Date collected 20 April, 2010

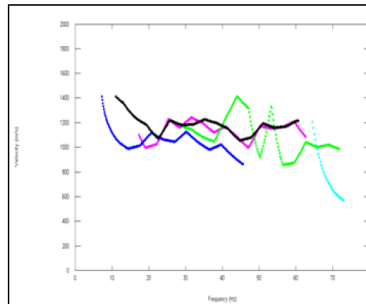**TEST METHODS** PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME New South Wales, Victoria SASW
SMR CHARACTERIZATION
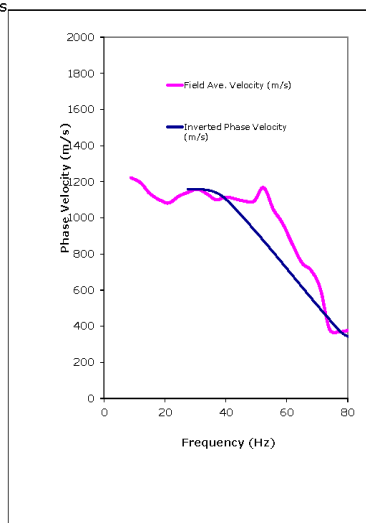**SPONSOR** GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A >1500 m/s
B+ 1080 < Vs30 ≤ 1500 m/s
B- 720 < Vs30 ≤ 1080 m/s
C+ 540 < Vs30 ≤ 720 m/s
C- 360 < Vs30 ≤ 540 m/s
D+ 270 < Vs30 ≤ 360 m/s
D- 180 < Vs30 ≤ 270 m/s
E < 180 m/s
F Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
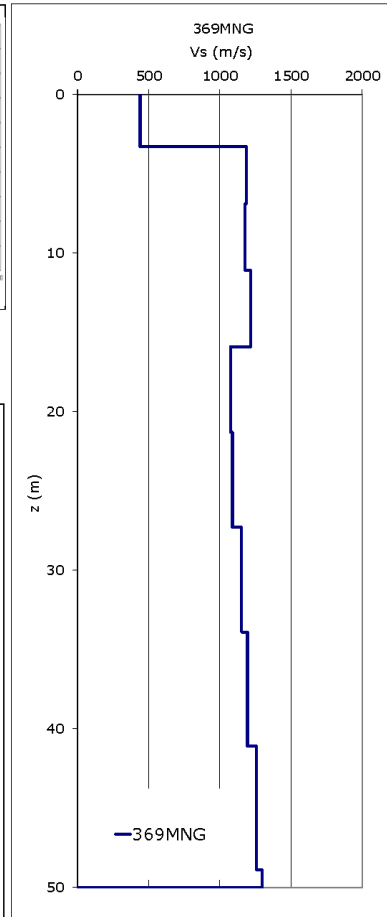soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-56. Site ID, location, and shear wave velocity for surface wave test site 364NEW. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

74

Figure A1-57. Surface wave test site 365NEW, North Lambton district, Newcastle, New South Wales (lat -32.90133, long 151.70391). North Lambton Depot-JUMP ES&S site, tested on April 20,2010. (A) view westward from the shakers; (B) view SE from the shakers; (C) view to the NE from across Compton Street toward the shakers; (D) view to the west along Compton Street; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.

Geoscience Australia (GA) Site Response

Site ID	**365NEW**
NEHRP CLASS	**D**
Vs30	**302 (m/s)**
SUB-CLASS	**D+**

Location North Lambton, Newcastle

SMR Station North Lambton Depot-JUMP ES&S
State New South Wales

POSITION
LAT (N) -32.90133
LON (E) 151.70391

Data Type SWEPT-SINE SASW
Investigators Kayen, Carkin, Minasian, Allen, Collins
Date collected 20 April, 2010

TEST METHODS PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A >1500 m/s
B+ 1080 < Vs30 ≤ 1500 m/s
B- 720 < Vs30 ≤ 1080 m/s
C+ 540 < Vs30 ≤ 720 m/s
C- 360 < Vs30 ≤ 540 m/s
D+ 270 < Vs30 ≤ 360 m/s
D- 180 < Vs30 ≤ 270 m/s
E <180 m/s
F Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-58. Site ID, location, and shear wave velocity for surface wave test site 365NEW. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.
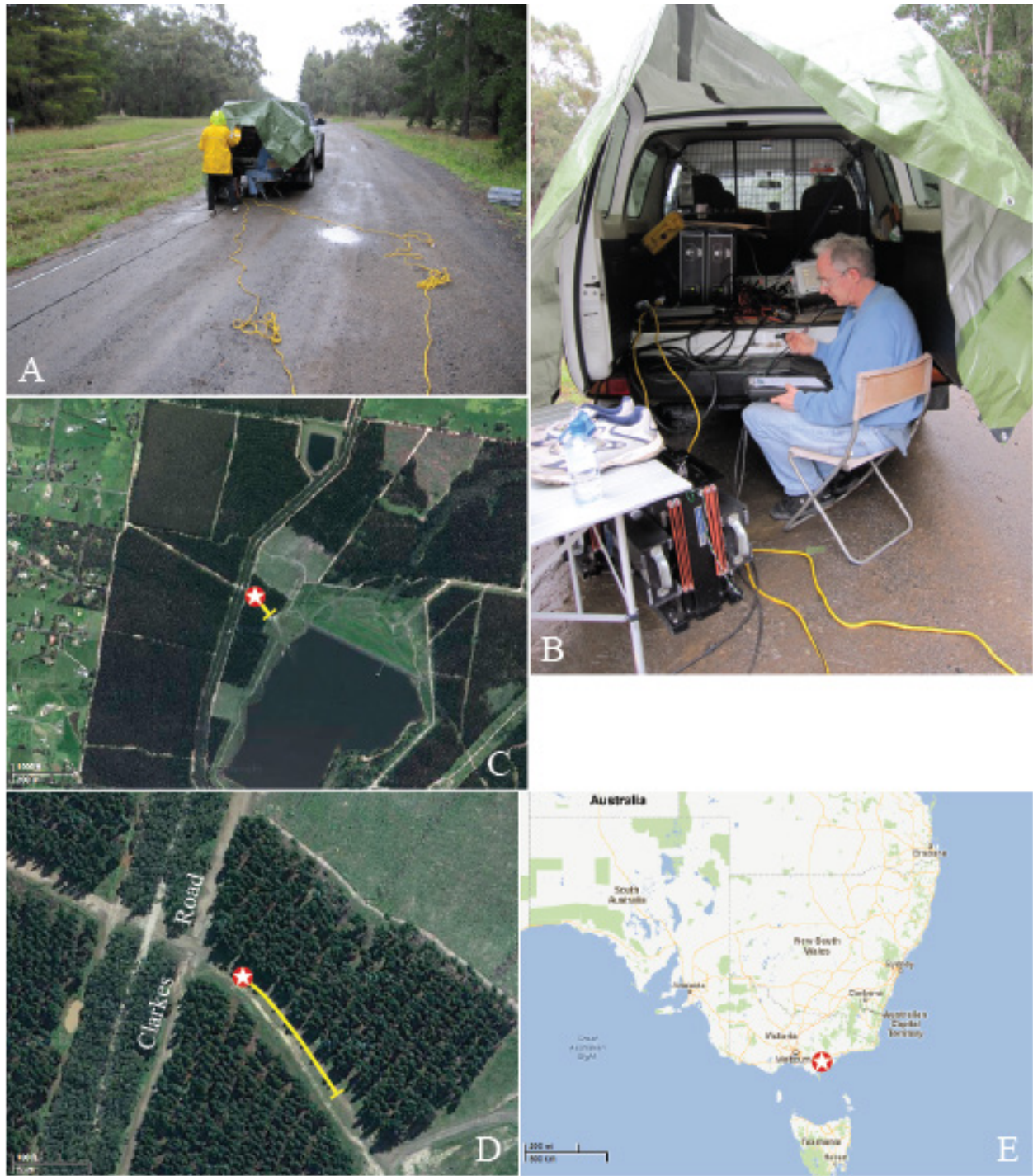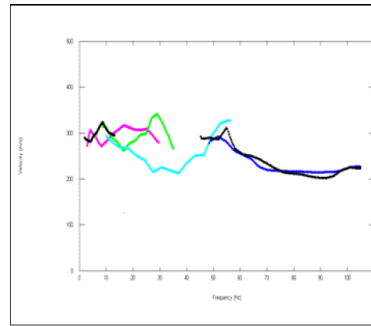
Figure A1-59. Surface wave test site 366NEW located at Smith Park, Broadmeadow district, Newcastle, New South Wales (lat -32.91661, long 151.73515). Brd-04 SCPT-26.7 m site, tested on April 20, 2010. (A) view looking northward from shakers; (B) view SE from the shakers; (C) view north across Smith Park; (D) view to the NE from near the shakers; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.

Geoscience Australia (GA) Site Response

Site ID   **366NEW**
NEHRP CLASS   **E/D**
Vs30   **188 (m/s)**
SUB-CLASS   **D-**

Location   Smith Park, Broadmeadow, Newcastle

SMR Station   Brd-04 SCPT site-26.7 m
State   New South Wales

POSITION
LAT (N)   -32.91661
LON (E)   151.73515

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
Date collected   20 April, 2010

TEST METHODS   PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR   GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
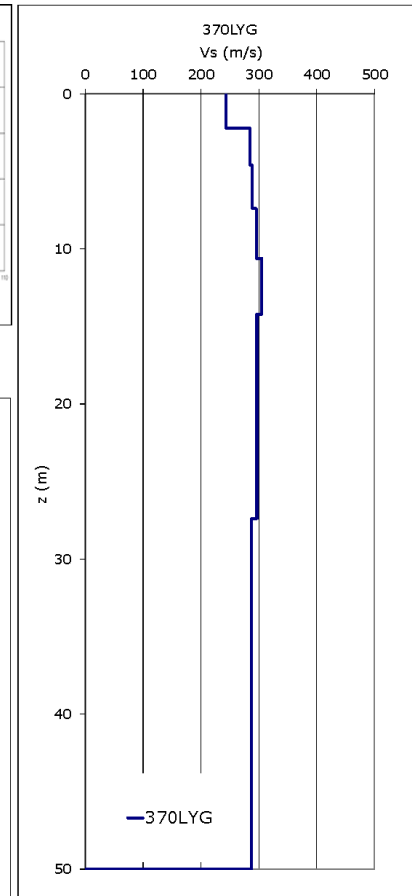soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-60. Site ID, location, and shear wave velocity for surface wave test site 366NEW. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-61. Surface wave test site 367NEW located at Darling Street Oval, Broadmeadow district, Newcastle, New South Wales (lat -32.9343, long 151.7402). Brd-09 SCPT site-11.5 m, tested on April 21, 2010. (A) view looking north from shakers; (B) view south toward the shakers; (C) view SE toward shakers; (D) view to the SW toward the shakers; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.
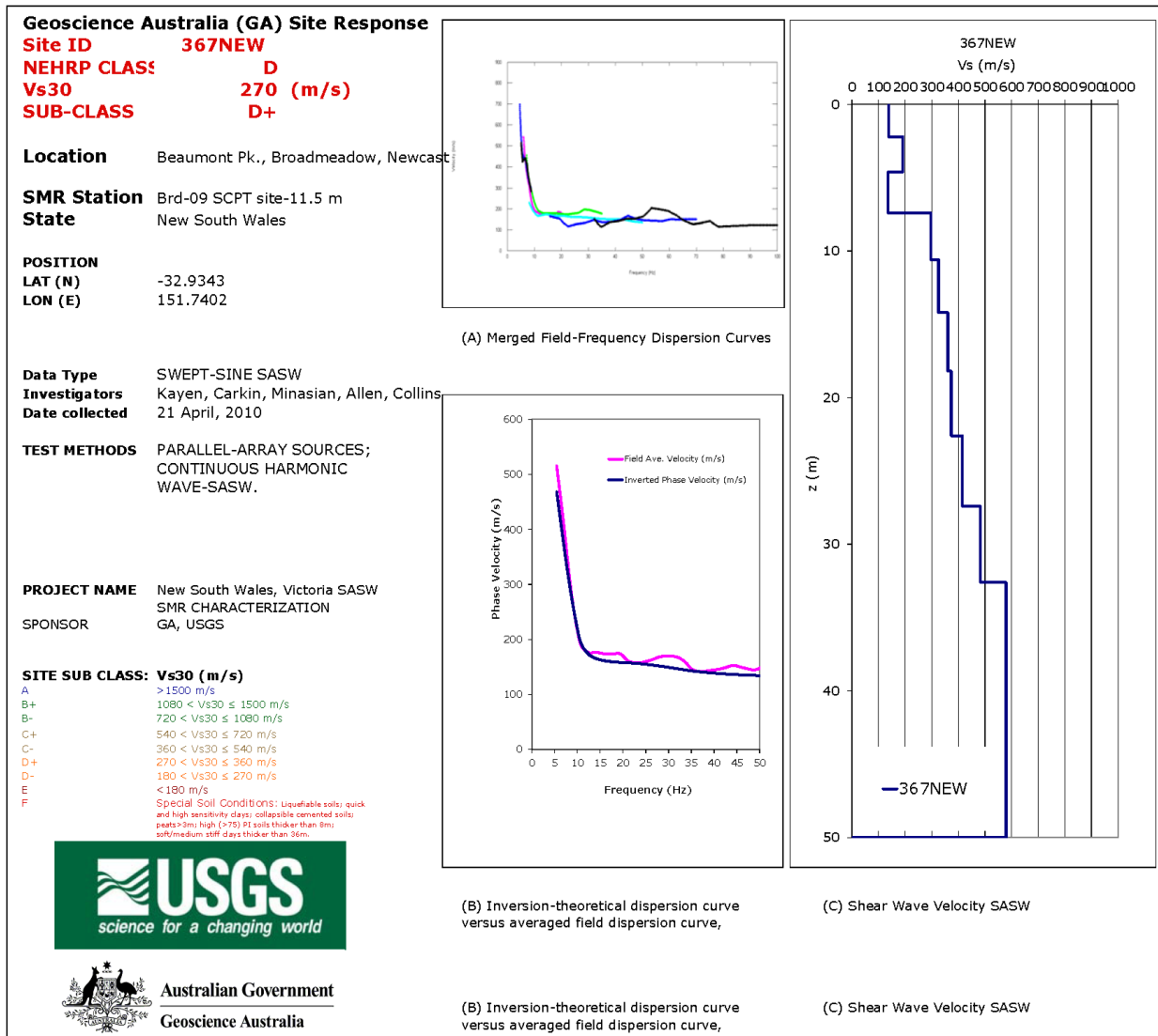
Figure A1-62. Site ID, location, and shear wave velocity for surface wave test site 367NEW. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-63. Surface wave test site 368NEW located at Henderson Park, Merewether district, Newcastle, New South Wales (lat -32.93837, long 151.73731). Mer-05 SCPT-6.8 m site, tested on April 21, 2010. (A) view looking NE from the shakers; (B) another view to the NE down the seismometer array; (C) view SE to the shakers; (D) view to the SE across the park toward the shakers; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.

Geoscience Australia (GA) Site Response

Site ID   **368NEW**
NEHRP CLASS   **D/C**
Vs30   **360 (m/s)**
SUB-CLASS   **D+/C-**

Location   Henderson Park, Merewether, Newcastl

SMR Station   Mer-05 SCPT site-6.8 m
State   New South Wales

POSITION
LAT (N)   -32.93837
LON (E)   151.73731

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
Date collected   21 April, 2010

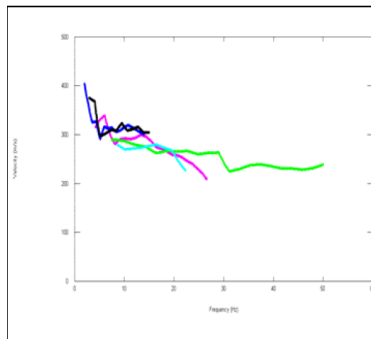**TEST METHODS**   PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR   GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-64. Site ID, location, and shear wave velocity for surface wave test site 368NEW. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-65. Surface wave test site 369MNG located 1.3 km NW of Mangrove Creek Dam, New South Wales (lat -33.2094, long 151.1093). Mangrove Creek ANSN site, tested on April 21, 2010. (A) view looking W-NW from the dam towards the shaker location (red circle) on the ridgetop; (B) view southward on the ridgetop toward the shakers; (C) view eastward from near the shakers toward the ANSN seismometer location; (D) ANSN seismometer and solar panels on ridgetop; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in New South Wales.

Geoscience Australia (GA) Site Response

Site ID	**369MNG**
NEHRP CLASS	**B**
Vs30	**970 (m/s)**
SUB-CLASS	**B-**

Location	Mangrove Creek Dam
SMR Station	Mangrove Creek ANSN
State	New South Wales

POSITION
LAT (N)   -33.2094
LON (E)   151.1093

Data Type	SWEPT-SINE SASW
Investigators	Kayen, Carkin, Minasian, Allen, Collins
Date collected	21 April, 2010

TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW.

PROJECT NAME	New South Wales, Victoria SASW SMR CHARACTERIZATION
SPONSOR	GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   > 1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   < 180 m/s
F   Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsable cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.
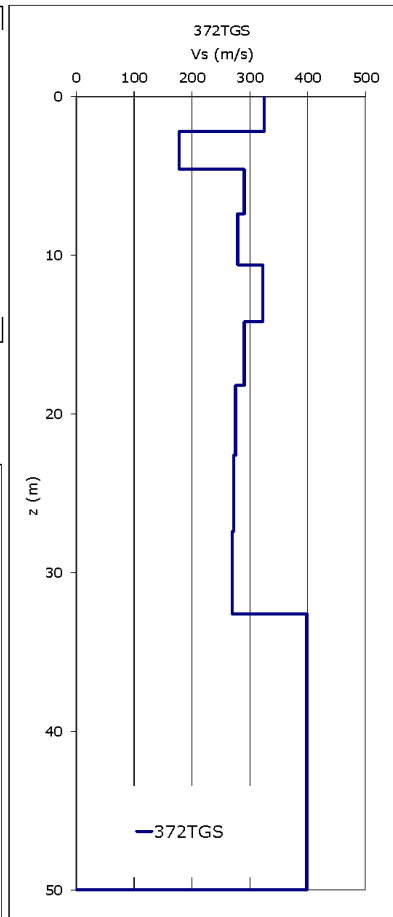
(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-66. Site ID, location, and shear wave velocity for surface wave test site 369MNG. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-67. Surface wave test site 370LYG, Loy Yang, located about 7 km S-SW of Traralgon, Victoria (lat -38.26627, long 146.50835). Latrobe HHF Loy Yang site, tested on April 23, 2010. (A) view to the NW toward the shakers; (B) two shakers in operation at the test site; (C) satellite view of the surrounding region; (D) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (E) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID 370LYG
NEHRP CLASS D
Vs30 290 (m/s)
SUB-CLASS D+

Location Loy Yang, Gippsland, Victoria

SMR Station Latrobe HHF-Loy Yang
State Victoria

POSITION
LAT (N) -38.26627
LON (E) 146.50835

Data Type SWEPT-SINE SASW
Investigators Kayen, Carkin, Minasian, Allen, Collins
Date collected 23 April, 2010

TEST METHODS PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME New South Wales, Victoria SASW
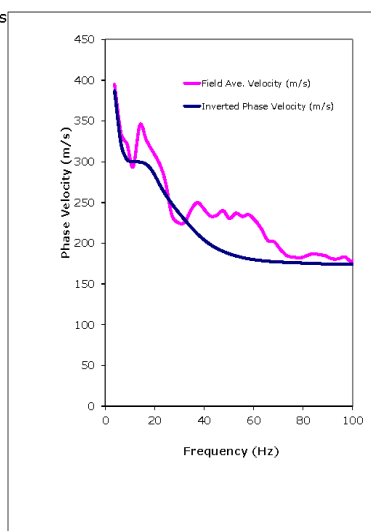SMR CHARACTERIZATION
SPONSOR GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils: quick
      and high sensitivity clays; collapsible cemented soils;
      peats>3m; high (>75) PI soils thicker than 8m;
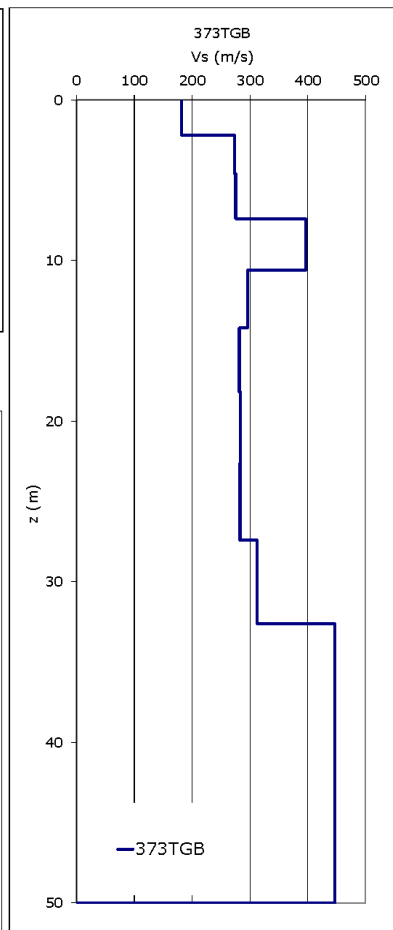   soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-68. Site ID, location, and shear wave velocity for surface wave test site 370LYG. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-69. Surface wave test site 371RSD located 1 km northeast of Rosedale, Gippsland, Victoria (lat -38.14317, long 146.79073). Latrobe alluvium-Rosedale site, tested on April 24, 2010. (A) view looking north at the shakers; (B) another view looking north to the shakers; (C) view south from the shakers down the seismometer array; (D) another view to the south to the site location; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID   **371RSD**
NEHRP CLASS   **D**
Vs30   **273 (m/s)**
SUB-CLASS   **D+**

Location   Rosedale, Gippsland, Victoria

SMR Station   Latrobe alluvium-Rosedale
State   Victoria

POSITION
LAT (N)   -38.14317
LON (E)   146.79073

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
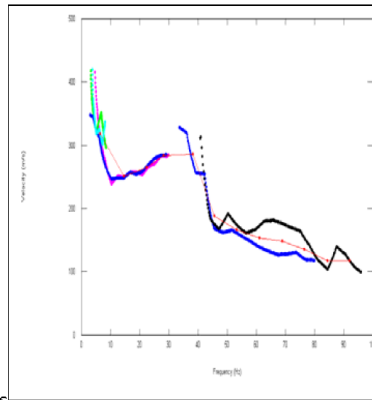**Date collected**   24 April, 2010

TEST METHODS   PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR   GA, USGS
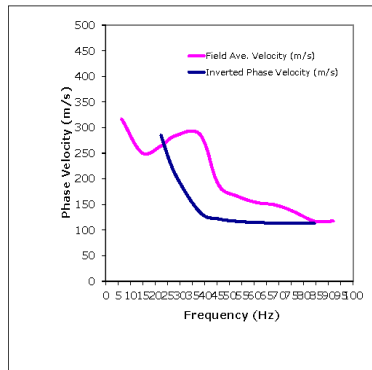
SITE SUB CLASS: Vs30 (m/s)
A   > 1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   < 180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
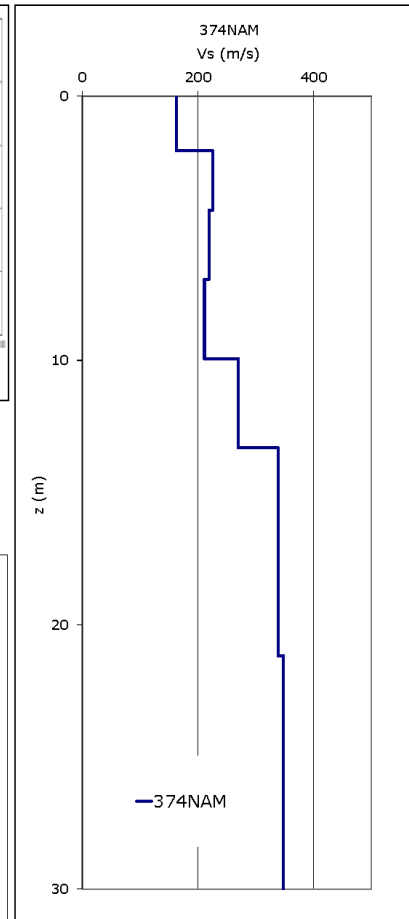soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-70. Site ID, location, and shear wave velocity for surface wave test site 371RSD. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-71. Surface wave test site 372TGS located about 6 km south of Toongabbie, Gippsland, Victoria (lat -38.11883, long 146.63242). Latrobe HHF Toongabbie South site, tested on April 24, 2010. (A) view looking southward from the shakers; (B) view northward along seismometer array toward the shakers; (C) another view southward from the shakers; (D) view to the south toward the shakers, behind vehicle; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID   **372TGS**
NEHRP CLASS   **D**
Vs30   **274 (m/s)**
SUB-CLASS   **D+**

Location   Toongabbie, Gippsland, Victoria

SMR Station   Latrobe HHF-Toongabbie South
State   Victoria

POSITION
LAT (N)   -38.11883
LON (E)   146.63242

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
Date collected   24 April, 2010

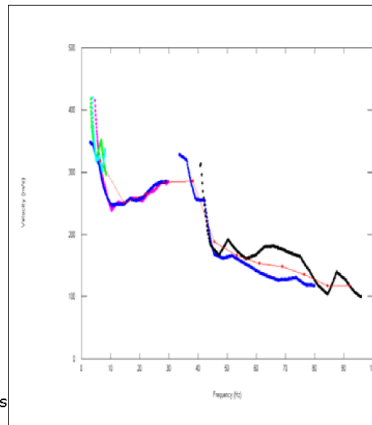**TEST METHODS**   PARALLEL-ARRAY SOURCES;
                    CONTINUOUS HARMONIC
                    WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW
                    SMR CHARACTERIZATION
SPONSOR   GA, USGS
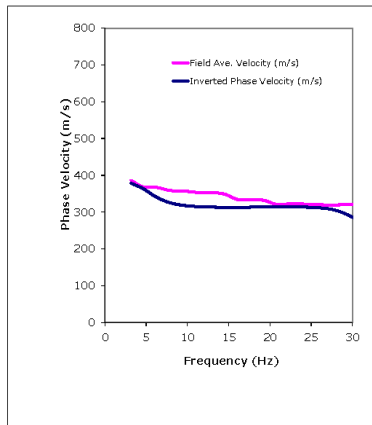
SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   < 180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
           and high sensitivity clays; collapsible cemented soils;
           peats>3m; high (>75) PI soils thicker than 8m;
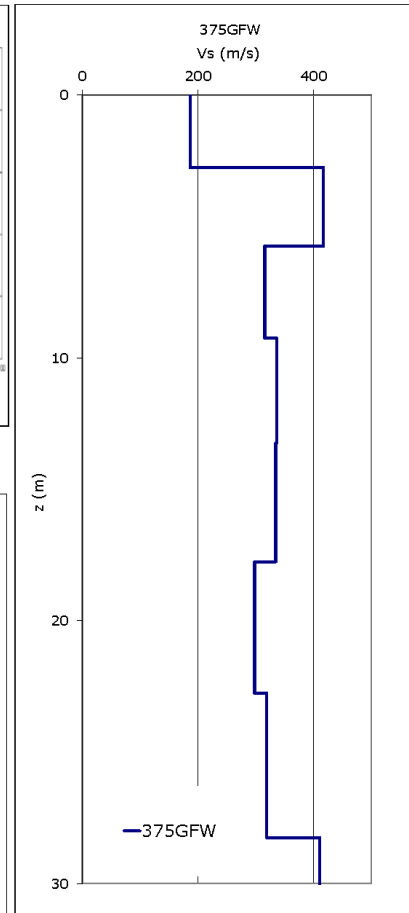   soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-72. Site ID, location, and shear wave velocity for surface wave test site 372TGS. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

90

Figure A1-73. Surface wave test site 373TGB located 5 km NE of Toongabbie, Gippsland, Victoria (lat -38.02631, long 146.66515). Latrobe HHF Toongabbie site, tested on April 24, 2010. (A) view looking eastward down the seismometer array from the shakers; (B) view westward from from the shakers; (C) another view westward from shakers; (D) view NE from the shakers; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Victoria.

91

Geoscience Australia (GA) Site Response

Site ID 373TGB
NEHRP CLASS D
Vs30 282 (m/s)
SUB-CLASS D+

Location Toongabbie, Gippsland, Victoria

SMR Station Latrobe HHF-Toongabbie
State Victoria

POSITION
LAT (N) -38.02631
LON (E) 146.66515

Data Type SWEPT-SINE SASW
Investigators Kayen, Carkin, Minasian, Allen, Collins
Date collected 24 April, 2010

TEST METHODS PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

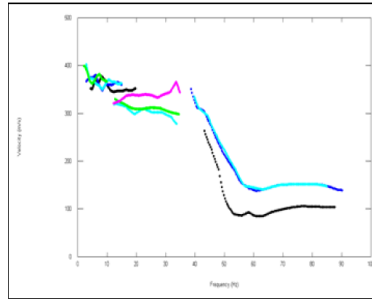**PROJECT NAME** New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR GA, USGS
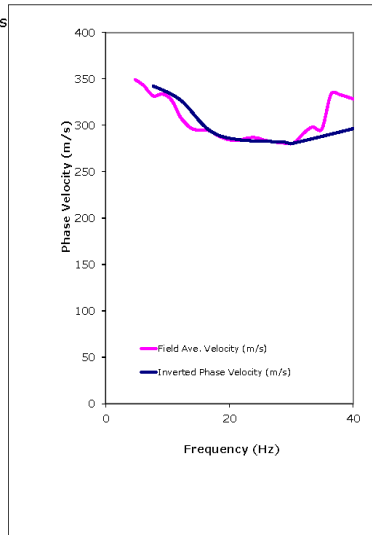
SITE SUB CLASS: Vs30 (m/s)
A > 1500 m/s
B+ 1080 < Vs30 ≤ 1500 m/s
B- 720 < Vs30 ≤ 1080 m/s
C+ 540 < Vs30 ≤ 720 m/s
C- 360 < Vs30 ≤ 540 m/s
D+ 270 < Vs30 ≤ 360 m/s
D- 180 < Vs30 ≤ 270 m/s
E < 180 m/s
F Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-74. Site ID, location, and shear wave velocity for surface wave test site 373TGB. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

92

Figure A1-75. Surface wave test site 374NAM located about 3 km west of Nambrok, Victoria (lat -38.05449, long 146.83669). Latrobe HHF-Nambrok West site, tested on April 24, 2010. (A) view looking southward from the shakers; (B) view northward from the shakers to the seismometer array along Nambrok Road; (C) satellite view of the surrounding area; (D) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (E) site location in Victoria.

93

Geoscience Australia (GA) Site Response

Site ID   **374NAM**
NEHRP CLASS   **D**
Vs30   **273 (m/s)**
SUB-CLASS   **D+**

Location   Nambrok, Gippsland, Victoria

SMR Station   Latrobe HHF-Nambrok West
State   Victoria
Description
POSITION
LAT (N)   -38.05449
LON (E)   146.83669

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
Date collected   24 April, 2010

TEST METHODS   PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR   GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.
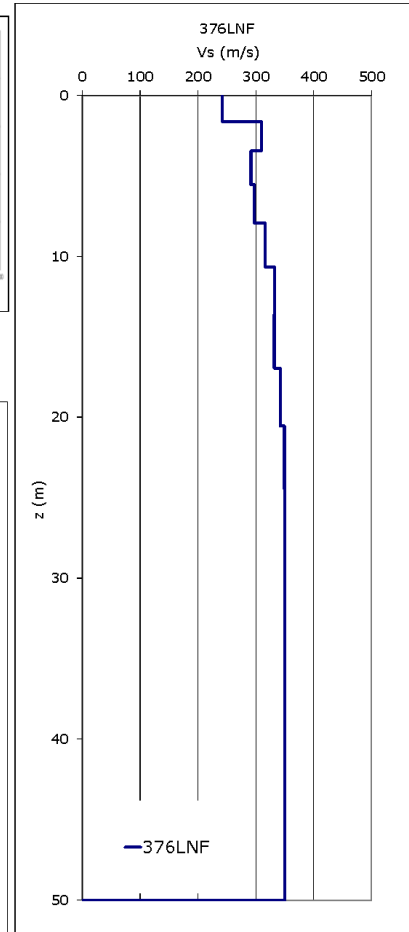
(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-76. Site ID, location, and shear wave velocity for surface wave test site 374NAM. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.
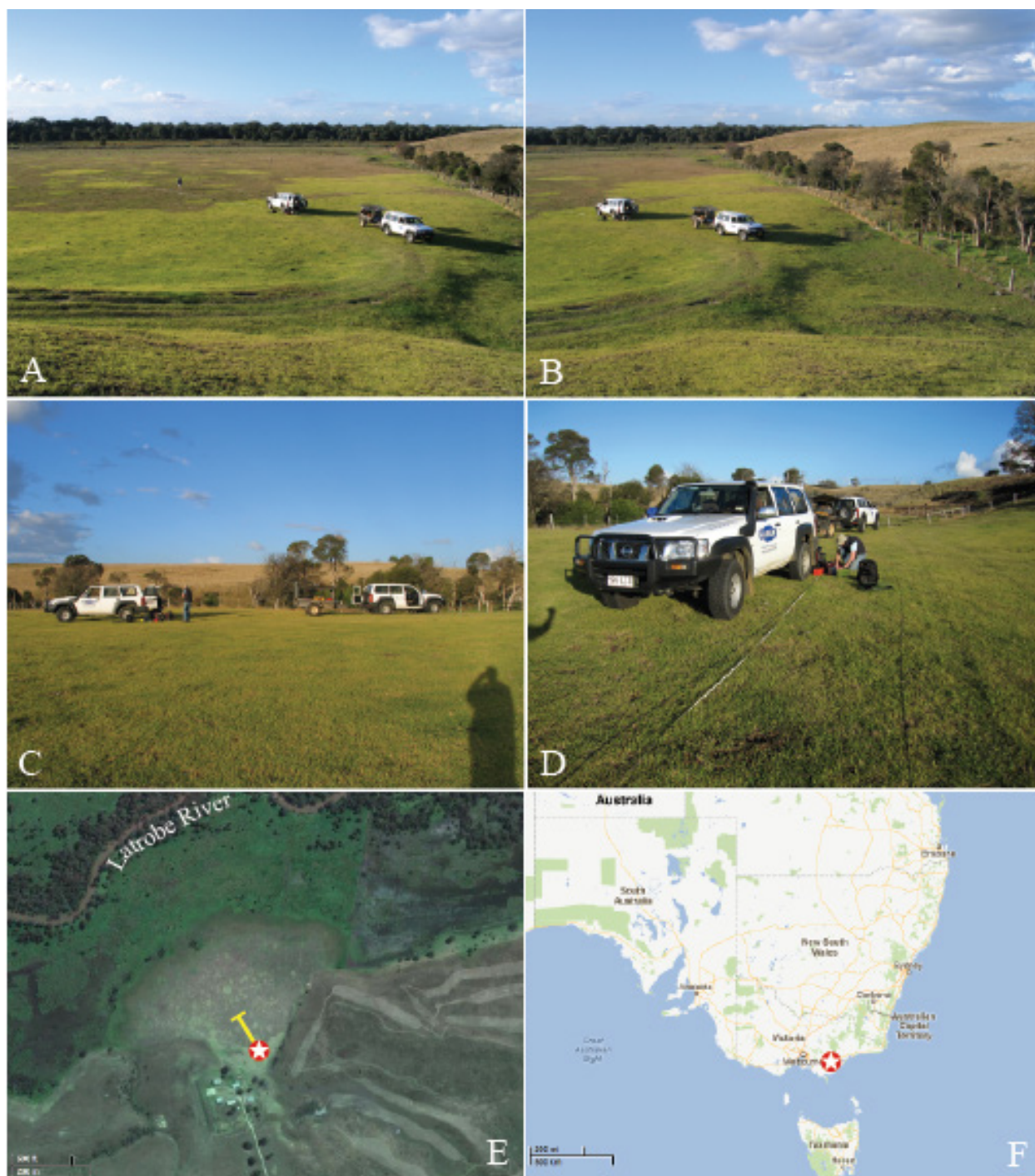
Figure A1-77. Surface wave test site 375GFW, Giffard West, located 8.4 km NW of Giffard, Victoria (lat -38.37931, long 146.99754). Pleistocene dunes Giffard West site, tested on April 25, 2010. (A) view looking westward in the direction of the seismometer array; (B) view eastward from the shakers; (C) another view eastward from the shakers; (D) view to the SW from the shakers; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID   **375GFW**
NEHRP CLASS   **D**
Vs30   **310 (m/s)**
SUB-CLASS   **D+**

Location   Giffard West, Victoria

SMR Station Pleistocene dunes Giffard West
State   Victoria

POSITION
LAT (N)   -38.37931
LON (E)   146.99754

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
Date collected   25 April, 2010

TEST METHODS   PARALLEL-ARRAY SOURCES;
                     CONTINUOUS HARMONIC
                     WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW
                     SMR CHARACTERIZATION
SPONSOR   GA, USGS
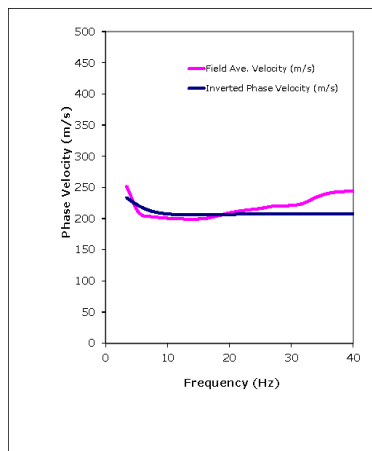
SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils: quick
           and high senstivity clays; collapsible cemented soils;
           peats>3m; high (>75) PI soils thicker than 8m;
           soft/medium stiff clays thicker than 36m.
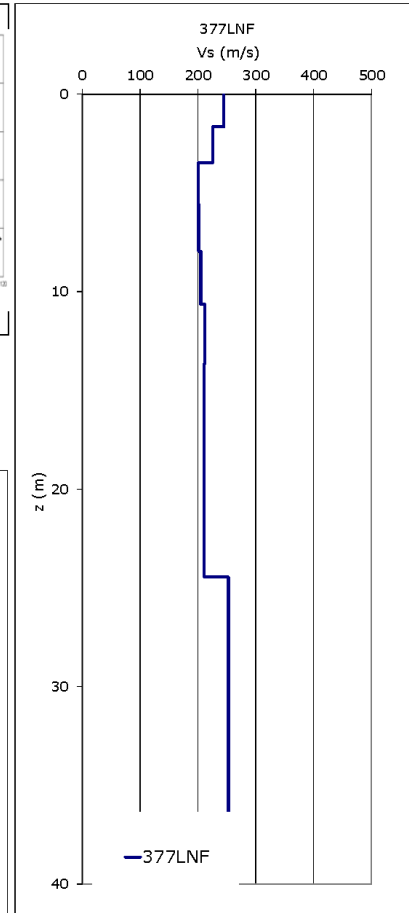

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-78. Site ID, location, and shear wave velocity for surface wave test site 375GFW. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-79. Surface wave test site 376LNF located about 10 km west of Sale, Victoria (lat -38.10309, long 146.95038). Latrobe HHF Kilmany site, tested on April 25, 2010. (A) view looking west from the shakers; (B) view SW to the shakers; (C) view SE to the shakers; (D) view southward to the shakers; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bars are the seismometer arrays, spacings up to 50 meters oriented E-W, 87-meter spacing oriented N-NE; (F) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID	**376LNF**
NEHRP CLASS	**D**
Vs30	**323 (m/s)**
SUB-CLASS	**D+**
Vs100	
Location	Kilmany/Sale, Victoria
SMR Station	Latrobe HHF-Kilmany
State	Victoria
Description	
POSITION	
LAT (N)	-38.10309
LON (E)	146.95038

(A) Merged Field-Frequency Dispersion Curves

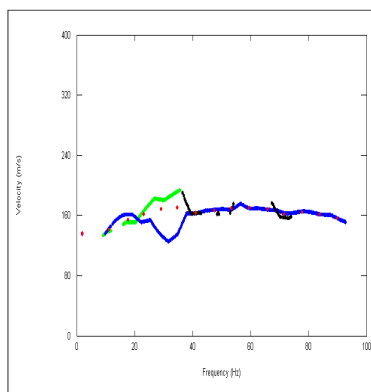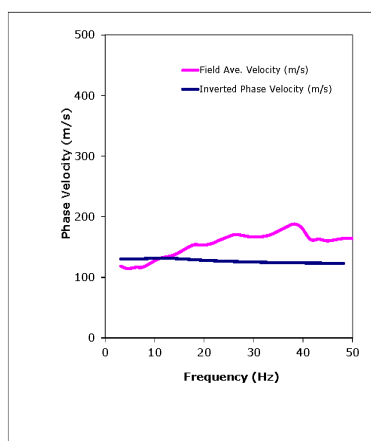|	
Data Type	SWEPT-SINE SASW
Investigators	Kayen, Carkin, Minasian, Allen, Collins
Date collected	25 April, 2010
TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW.
PROJECT NAME	New South Wales, Victoria SASW SMR CHARACTERIZATION
SPONSOR	GA, USGS

SITE SUB CLASS: Vs30 (m/s)

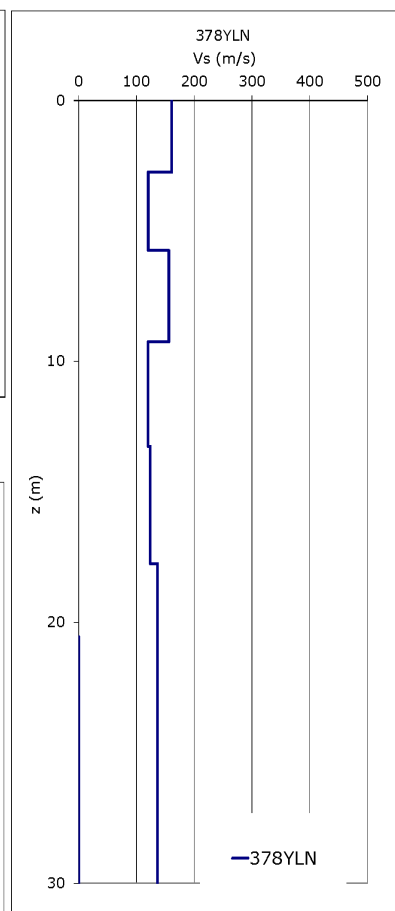|	
A	> 1500 m/s
B+	1080 < Vs30 ≤ 1500 m/s
B-	720 < Vs30 ≤ 1080 m/s
C+	540 < Vs30 ≤ 720 m/s
C-	360 < Vs30 ≤ 540 m/s
D+	270 < Vs30 ≤ 360 m/s
D-	180 < Vs30 ≤ 270 m/s
E	< 180 m/s
F	Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(B) Inversion-theoretical dispersion curve versus averaged field dispersion curve.

(C) Shear Wave Velocity SASW

Figure A1-80. Site ID, location, and shear wave velocity for surface wave test site 376LNF. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-81. Surface wave test site 377LNF located 2 km NW of Longford, Gippsland, Victoria (lat -38.16047, long 147.05964). Latrobe alluvium-Longford site, tested on April 25, 2010. (A) view looking north towards the test site, shakers situated next to the vehicle on left; (B) another view looking north; (C) view SE to the shakers; (D) view to the south to the shakers behind the vehicle; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID 377LNF
NEHRP CLASS D
Vs30 218 (m/s)
SUB-CLASS D-
Vs100
Location Longford, Gipsland, Victoria

SMR Station Latrobe alluvium-Longford
State Victoria

POSITION
LAT (N) -38.16047
LON (E) 147.05964

Data Type SWEPT-SINE SASW
Investigators Kayen, Carkin, Minasian, Allen, Collins
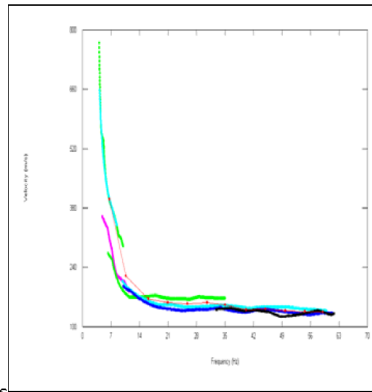**Date collected** 25 April, 2010

TEST METHODS PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR GA, USGS
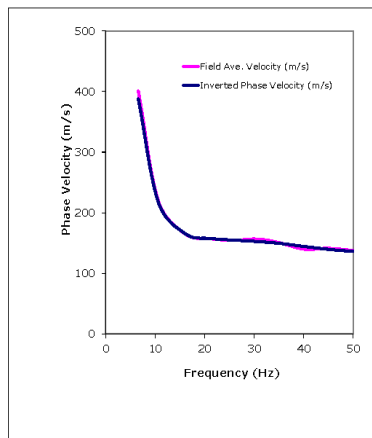
SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.
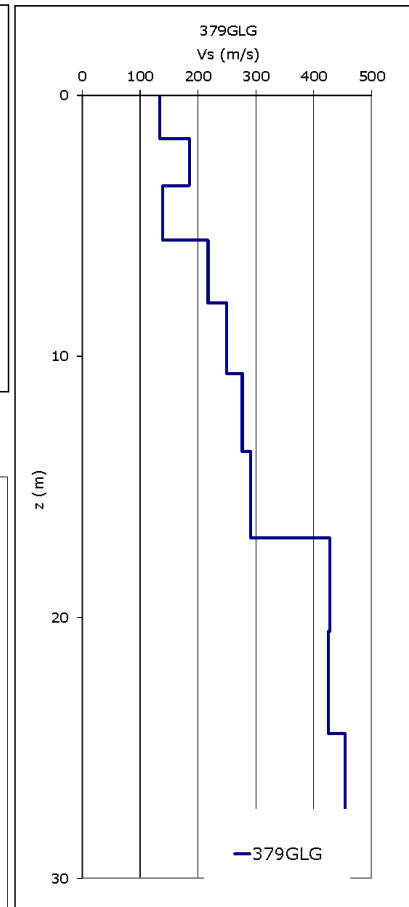
USGS
science for a changing world

Australian Government
Geoscience Australia

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve versus averaged field dispersion curve.

(C) Shear Wave Velocity SASW

Figure A1-82. Site ID, location, and shear wave velocity for surface wave test site 377LNF. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-83. Surface wave test site 378LYN located 3.5 km east of Yallurn North, Gippsland, Victoria (lat -38.16361, long 146.4067). Latrobe alluvium Yallourn North site, tested on April 26, 2010. (A) view looking south towards the shakers behind the vehicle; (B) view north to the shaker location; (C) view south along the seismometer array on Toms Bridge Road; (D) another view to the south; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID	**378YLN**
NEHRP CLASS	**E**
Vs30	**134 (m/s)**
SUB-CLASS	**E**

Location Maryvale, Gippsland, Victoria

SMR Station Latrobe alluvium-Yallourn North
State Victoria

POSITION
LAT (N) -38.16361
LON (E) 146.4067

Data Type SWEPT-SINE SASW
Investigators Kayen, Carkin, Minasian, Allen, Collins
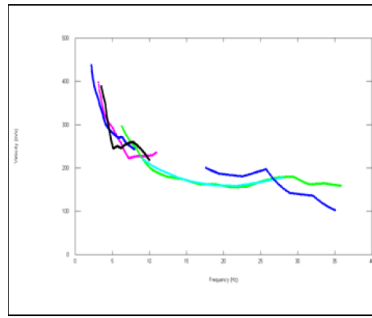Date collected 26 April, 2010

TEST METHODS PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME New South Wales, Victoria SASW
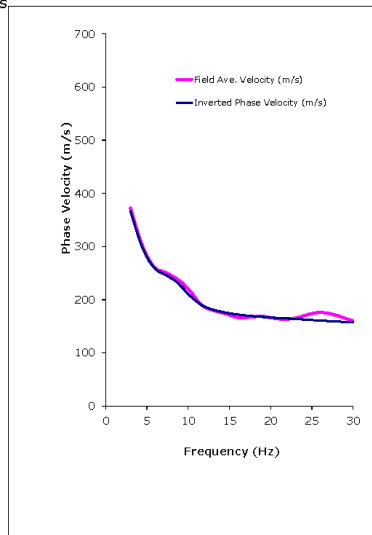SMR CHARACTERIZATION
SPONSOR GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+ 1080 < Vs30 ≤ 1500 m/s
B- 720 < Vs30 ≤ 1080 m/s
C+ 540 < Vs30 ≤ 720 m/s
C- 360 < Vs30 ≤ 540 m/s
D+ 270 < Vs30 ≤ 360 m/s
D- 180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-84. Site ID, location, and shear wave velocity for surface wave test site 378YLN. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-85. Surface wave test site 379GLG located 3.5 km S-SW of Glengarry, Gippsland, Victoria (lat -38.16161, long 146.5567). Latrobe alluvium-Glengarry site, tested on April 26, 2010. (A) view looking SE towards the shakers behind the vehicles; (B) view to the east to the shaker location; (C) view SE from shakers down the seismometer array; (D) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (E) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID	**379GLG**
NEHRP CLASS	**D**
Vs30	**270 (m/s)**
SUB-CLASS	**D**

Location   Glengarry, Gippsland, Victoria

SMR Station   Latrobe alluvium-Glengarry
State   Victoria

POSITION
LAT (N)   -38.16161
LON (E)   146.5567

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
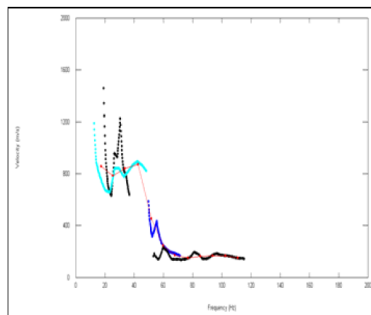**Date collected**   26 April, 2010

TEST METHODS   PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR   GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve.

(C) Shear Wave Velocity SASW

Figure A1-86. Site ID, location, and shear wave velocity for surface wave test site 379GLG. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-87. Surface wave test site 380HYF located about 1 km SW of Heyfield, Gippsland, Victoria (lat -37.9900, long 146.7758). Thomson alluvium Heyfield site, tested on April 26, 2010. (A) view looking west from the shakers; (B) another view looking westward; (C) view west down the dirt road and seismometer array; (D) view of the site looking west from the Traralgon-Maffra Road; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID	**380HYF**
NEHRP CLASS	**D**
Vs30	**229 (m/s)**
SUB-CLASS	**D-**

Location	Heyfield, Gippsland, Victoria
SMR Station	Thomson alluvium-Heyfield
State	Victoria

POSITION
LAT (N)	-37.99
LON (E)	146.7758

Data Type	SWEPT-SINE SASW
Investigators	Kayen, Carkin, Minasian, Allen, Collins
Date collected	26 April, 2010
TEST METHODS	PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW.

PROJECT NAME	New South Wales, Victoria SASW SMR CHARACTERIZATION
SPONSOR	GA, USGS

SITE SUB CLASS: Vs30 (m/s)
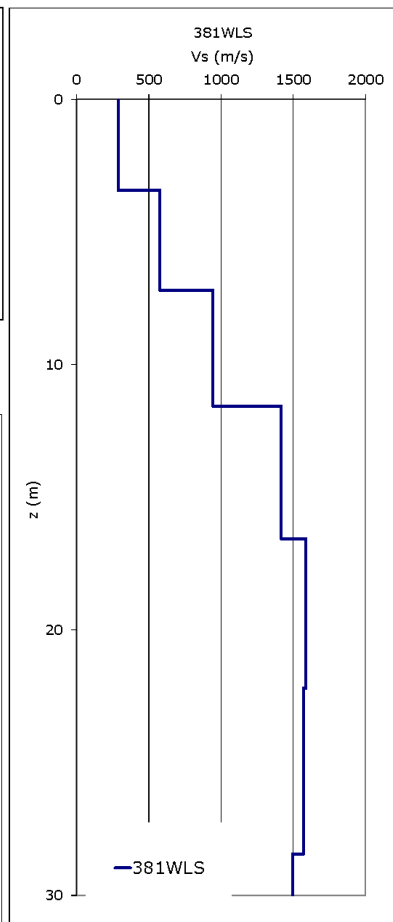|	
A	>1500 m/s
B+	1080 < Vs30 ≤ 1500 m/s
B-	720 < Vs30 ≤ 1080 m/s
C+	540 < Vs30 ≤ 720 m/s
C-	360 < Vs30 ≤ 540 m/s
D+	270 < Vs30 ≤ 360 m/s
D-	180 < Vs30 ≤ 270 m/s
E	<180 m/s
F	Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve versus averaged field dispersion curve.

(C) Shear Wave Velocity SASW

Figure A1-88. Site ID, location, and shear wave velocity for surface wave test site 380HYF. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-89. Surface wave test site 381WLS located about 1 km E-NE of Willung South, Victoria (lat -38.3406, long 146.74089). Willung South ES&S site, tested on April 26, 2010. (A) view looking SW from near the shakers; (B) view eastward to the shaker location; (C) another view looking SW on Willung South Road; (D) seismometer on road pavement; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID	**381WLS**
NEHRP CLASS	**B**
Vs30	**852 (m/s)**
SUB-CLASS	**B-**

Location Willung South, Victoria

SMR Station Willung South ES&S
State Victoria

POSITION
LAT (N) -38.3406
LON (E) 146.74089

Data Type SWEPT-SINE SASW
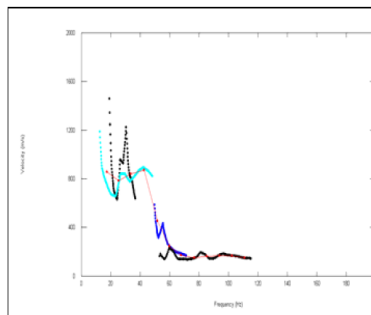**Investigators** Kayen, Carkin, Minasian, Allen, Collins
Date collected 26 April, 2010

TEST METHODS PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW.

PROJECT NAME New South Wales, Victoria SASW SMR CHARACTERIZATION
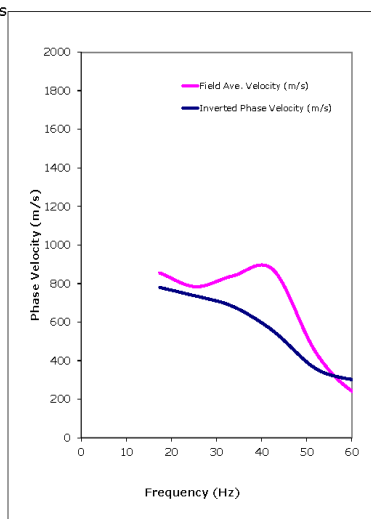**SPONSOR** GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   > 1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   < 180 m/s
F   Special Soil Conditions: Liquefiable soils; quick and high sensitivity clays; collapsible cemented soils; peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.
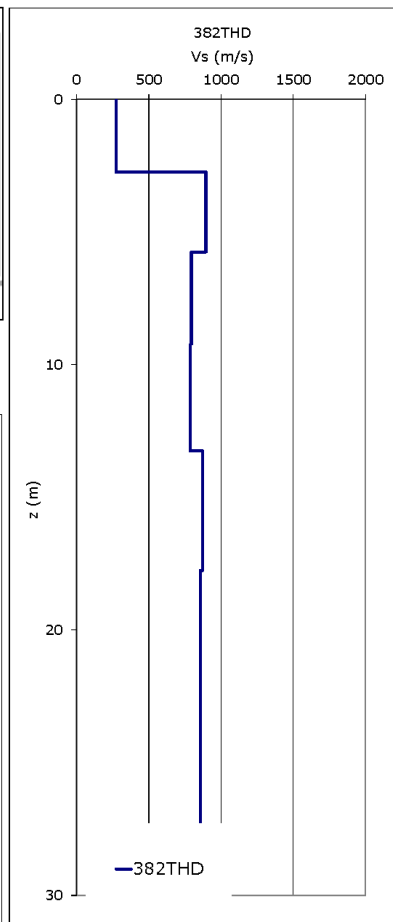
(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-90. Site ID, location, and shear wave velocity for surface wave test site 381WLS. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-91. Surface wave test site 382THD located 5.5 km NW of Thomson Dam, Victoria (lat -37.80987, long 146.35046). Thomson Dam ES&S site, tested on April 27, 2010. (A) view towards the north from shakers; (B) view south to the shakers and ES&S seismometer shed beyond vehicle; (C) another view south to the ES&S seismometer shed beyond vehicle; (D) view to the north from the ES&S seismometer shed; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID　　　　**382THD**
NEHRP CLASS　　**C/B**
Vs30　　　　　**710 (m/s)**
SUB-CLASS　　**C+/B-**

Location　　Thomson Dam, Victoria

SMR Station　Thomson Dam ES&S
State　　　Victoria

POSITION
LAT (N)　　-37.80987
LON (E)　　146.35046

Data Type　　SWEPT-SINE SASW
Investigators　Kayen, Carkin, Minasian, Allen, Collins
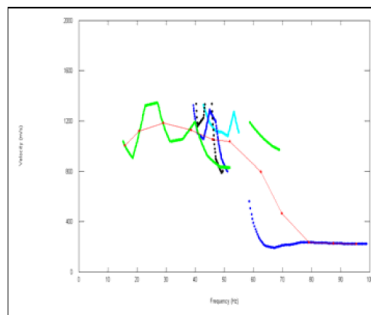**Date collected**　27 April, 2010

TEST METHODS　PARALLEL-ARRAY SOURCES;
　　　　　　CONTINUOUS HARMONIC
　　　　　　WAVE-SASW.

PROJECT NAME　New South Wales, Victoria SASW
　　　　　　SMR CHARACTERIZATION
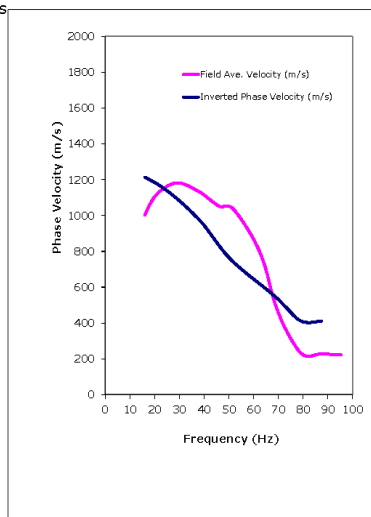**SPONSOR**　　GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A　　　　> 1500 m/s
B+　　　　1080 < Vs30 ≤ 1500 m/s
B-　　　　720 < Vs30 ≤ 1080 m/s
C+　　　　540 < Vs30 ≤ 720 m/s
C-　　　　360 < Vs30 ≤ 540 m/s
D+　　　　270 < Vs30 ≤ 360 m/s
D-　　　　180 < Vs30 ≤ 270 m/s
E　　　　< 180 m/s
F　　　　Special Soil Conditions: Liquefiable soils; quick
　　　　　and high sensitivity clays; collapsible cemented soils;
　　　　　peats>3m; high (>75) PI soils thicker than 8m;
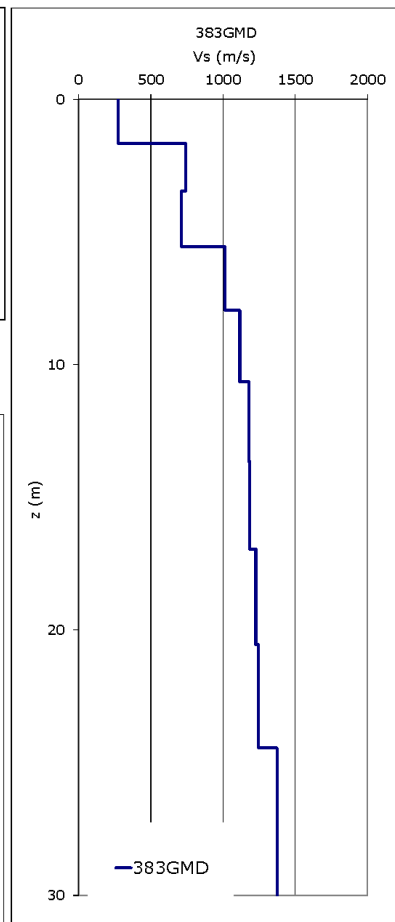　　　　　soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve.

(C) Shear Wave Velocity SASW

Figure A1-92. Site ID, location, and shear wave velocity for surface wave test site 382THD. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

110

Figure A1-93. Surface wave test site 383GMD, Glenmaggie Dam, located 9 km north of Heyfield, Victoria (lat -37.90206, long 146.7986). Glenmaggie ES&S site, tested on April 27, 2010. (A) view looking NE towards the shaker location beyond the vehicles; (B) view NE from the shakers and downhill to the seismometer array; (C) view SW from shakers; (D) view to the SE to the dam; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID   **383GMD**
NEHRP CLASS   **B**
Vs30   **948 (m/s)**
SUB-CLASS   **B-**

Location   Glenmaggie Dam, Gippsland, Victoria

SMR Station   Glenmaggie ES&S
State   Victoria

POSITION
LAT (N)   -37.90206
LON (E)   146.7986

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
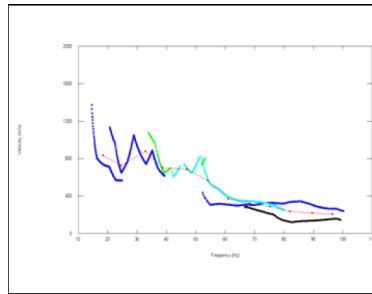**Date collected**   27 April, 2010

TEST METHODS   PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW
SMR CHARACTERIZATION
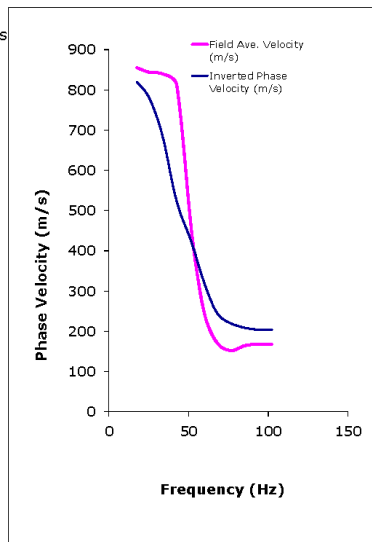**SPONSOR**   GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve.

(C) Shear Wave Velocity SASW

Figure A1-94. Site ID, location, and shear wave velocity for surface wave test site 383GMD. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical averaged phase velocity (blue) versus frequency; (C) Shear wave velocity versus depth.

Figure A1-95. Surface wave test site 384TLG located 4 km S-SE of Toolangi, Victoria (lat -37.56952, long 145.49085). Toolangi ANSN site, tested on April 28, 2010. (A) view looking east toward the shakers and seismometer array; (B) view westward toward the shakers; (C) view westward to shakers and ANSN seismometer station within fenced area; (D) sign on fence; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (F) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID	**384TLG**
NEHRP CLASS	**B**
Vs30	**710 (m/s)**
SUB-CLASS	**B-**

Location — Toolangi, Victoria

SMR Station — Toolangi ANSN
State — Victoria

POSITION
LAT (N) — -37.56952
LON (E) — 145.49085

Data Type — SWEPT-SINE SASW
Investigators — Kayen, Carkin, Minasian, Allen, Collins
Date collected — 28 April, 2010

TEST METHODS — PARALLEL-ARRAY SOURCES; CONTINUOUS HARMONIC WAVE-SASW.

PROJECT NAME — New South Wales, Victoria SASW SMR CHARACTERIZATION
SPONSOR — GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A — >1500 m/s
B+ — 1080 < Vs30 ≤ 1500 m/s
B- — 720 < Vs30 ≤ 1080 m/s
C+ — 540 < Vs30 ≤ 720 m/s
C- — 360 < Vs30 ≤ 540 m/s
D+ — 270 < Vs30 ≤ 360 m/s
D- — 180 < Vs30 ≤ 270 m/s
E — <180 m/s
F — Special Soil Conditions: Liquefiable soils: quick and high sensitivity clays: collapsible cemented soils: peats>3m; high (>75) PI soils thicker than 8m; soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve versus averaged field dispersion curve,

(D) Shear Wave Velocity SASW

Figure A1-96. Site ID, location, and shear wave velocity for surface wave test site 384TLG. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.

Figure A1-97. Surface wave test site 385GRV located at Greenvale, Victoria (lat -37.61685, long 144.90262). Greenvale ES&S site, tested on April 28, 2010. (A) view looking NW towards the shakers and the seismometer array; (B) another view NW to the seismometer array; (C) view southward from the shakers toward the green ES&S seismometer shelter (red arrow); (D) view to the SE to the shakers; (E) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array, red arrow indicates the location of the ES&S seismometer; (F) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID   **385GRV**
NEHRP CLASS   **B**
Vs30   **1265 (m/s)**
SUB-CLASS   **B+**

Location   Greenvale, Victoria

SMR Station Greenvale ES&S
State   Victoria
Description
POSITION
LAT (N)   -37.61685
LON (E)   144.90262

Data Type   SWEPT-SINE SASW
Investigators Kayen, Carkin, Minasian, Allen, Collins
Date collected 28 April, 2010

TEST METHODS PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR   GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
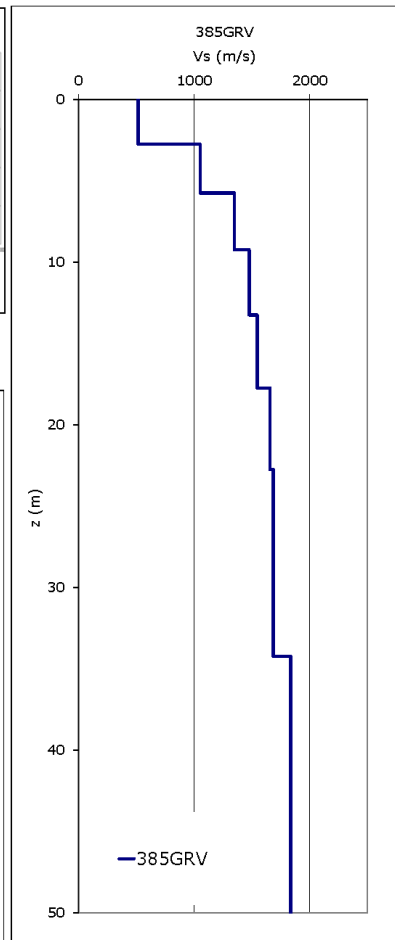soft/medium stiff clays thicker than 36m.

(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-98. Site ID, location, and shear wave velocity for surface wave test site 385GRV. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth

Figure A1-99. Surface wave test site 386FCR located about 10 km SW of Fish Creek, Victoria (lat -38.75622, long 146.0001). Fish Creek ES&S site, tested on April 29, 2010. (A) view looking NE from the shakers uphill toward the seismometer array; (B) view SW toward the shakers; (C) view SE from the shakers; (D) satellite view of the local site, red and white symbol is the location of the shakers, the yellow bar is the seismometer array; (E) site location in Victoria.

Geoscience Australia (GA) Site Response

Site ID   **386FCR**
NEHRP CLASS   **B**
Vs30   **865 (m/s)**
SUB-CLASS   **B-**

Location   Fish Creek, Victoria

SMR Station   Fish Creek ES&S
State   Victoria

POSITION
LAT (N)   -38.75622
LON (E)   146.0001

Data Type   SWEPT-SINE SASW
Investigators   Kayen, Carkin, Minasian, Allen, Collins
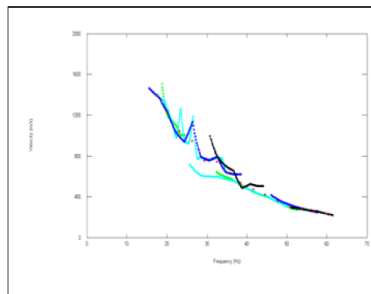**Date collected**   29 April, 2010

TEST METHODS   PARALLEL-ARRAY SOURCES;
CONTINUOUS HARMONIC
WAVE-SASW.

PROJECT NAME   New South Wales, Victoria SASW
SMR CHARACTERIZATION
SPONSOR   GA, USGS

SITE SUB CLASS: Vs30 (m/s)
A   >1500 m/s
B+   1080 < Vs30 ≤ 1500 m/s
B-   720 < Vs30 ≤ 1080 m/s
C+   540 < Vs30 ≤ 720 m/s
C-   360 < Vs30 ≤ 540 m/s
D+   270 < Vs30 ≤ 360 m/s
D-   180 < Vs30 ≤ 270 m/s
E   <180 m/s
F   Special Soil Conditions: Liquefiable soils; quick
and high sensitivity clays; collapsible cemented soils;
peats>3m; high (>75) PI soils thicker than 8m;
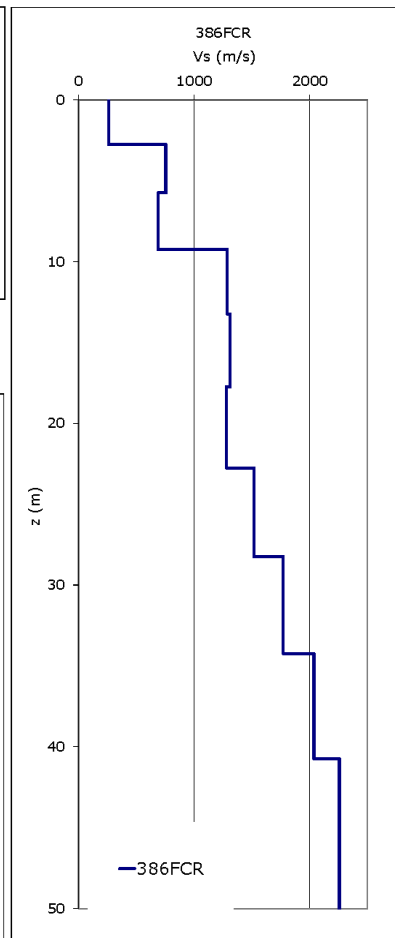soft/medium stiff clays thicker than 36m.

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(A) Merged Field-Frequency Dispersion Curves

(B) Inversion-theoretical dispersion curve
versus averaged field dispersion curve,

(C) Shear Wave Velocity SASW

Figure A1-100. Site ID, location, and shear wave velocity for surface wave test site 386FCR. (A) Phase velocity versus wavelength for individual empirical dispersion curves; (B) Empirical (red) and theoretical (blue) averaged phase velocity versus frequency; (C) Shear wave velocity versus depth.