Cyfoeth Naturiol Cymru
Natural Resources Wales

Newborough Phase 3 Dune Rejuvenation Works Topographic Survey Report

Kenneth Pye & Simon J. Blott

Kenneth Pye Associates Ltd

Report No: 104

Date: March 2015

About Natural Resources Wales

Natural Resources Wales is the organisation responsible for the work carried out by the three former organisations, the Countryside Council for Wales, Environment Agency Wales and Forestry Commission Wales. It is also responsible for some functions previously undertaken by Welsh Government.

Our purpose is to ensure that the natural resources of Wales are sustainably maintained, used and enhanced, now and in the future.

We work for the communities of Wales to protect people and their homes as much as possible from environmental incidents like flooding and pollution. We provide opportunities for people to learn, use and benefit from Wales' natural resources.

We work to support Wales' economy by enabling the sustainable use of natural resources to support jobs and enterprise. We help businesses and developers to understand and consider environmental limits when they make important decisions.

We work to maintain and improve the quality of the environment for everyone and we work towards making the environment and our natural resources more resilient to climate change and other pressures.

Published by: Natural Resources Wales
Maes y Ffynnon
Penrhosgarnedd
Bangor
LL57 2DW

0300 065 3000

© Natural Resources Wales [2015]

All rights reserved. This document may be reproduced with prior permission of Natural Resources Wales

Further copies of this report are available from the library

Email: library@cyfoethnaturiolcymru.gov.uk

Evidence at Natural Resources Wales

Natural Resources Wales is an evidence based organisation. We seek to ensure that our strategy, decisions, operations and advice to Welsh Government and others are underpinned by sound and quality-assured evidence. We recognise that it is critically important to have a good understanding of our changing environment.

We will realise this vision by:

- Maintaining and developing the technical specialist skills of our staff;
- Securing our data and information;
- Having a well resourced proactive programme of evidence work;
- Continuing to review and add to our evidence to ensure it is fit for the challenges facing us; and
- Communicating our evidence in an open and transparent way.

This Evidence Report series serves as a record of work carried out or commissioned by Natural Resources Wales. It also helps us to share and promote use of our evidence by others and develop future collaborations. However, the views and recommendations presented in this report are not necessarily those of NRW and should, therefore, not be attributed to NRW.

Newborough Phase 3 Dune Rejuvenation Works Topographic Survey March 2015

Report series:	Evidence Report
Report number:	104
Publication date:	24 August 2015
Contract number:	2013835
Contractor:	Kenneth Pye Associates Ltd
Contract Manager:	Dr. Emmer Litt
Title:	**Newborough Phase 3 Dune Rejuvenation Works Topographic Survey March 2015**
Author(s):	**Prof. Kenneth Pye & Dr. Simon J. Blott**
Approved By:	Dr. Emmer Litt
Restrictions:	None

Distribution List (core)

NRW Library, Bangor

Recommended citation for this volume:

KPAL (2015f) Newborough Phase 3 Dune Rejuvenation Works Topographic Survey March 2015. NRW Evidence Report No. 104. Kenneth Pye Associates Ltd., Solihull.

Contents

1. Job Summary

KPAL Job No:	270315
Report Date:	24/08/2015
Client:	Natural Resources Wales
Client Job Title:	Newborough Dune Rejuvenation Works: Phase 3

Survey conducted:	25th to 26th March 2015
Instruments used:	Leica Viva NetRover controller and GS08 SmartAntenna mounted on GLS30 pole (2 m) Leica RX900 controller and ATX900 antenna mounted on GLS30 pole (2 m) Leica GX1230 RTK base station mounted on GST20-9 tripod Leica RX1210T Field Controller
No. of data points:	2056
RTK Control Station:	The site was too large to be covered with the base station situated in a single position. Most of the site was covered with the base station mounted over a wooden post (BM1) surveyed-in using Leica Smartnet GPRS on 25 March 2015, positioned on a high area of dune which had been stripped of vegetation and which was central and afforded a good line of site to most areas in Phase 3. A second wooden post (BM3) was surveyed-in using Leica Smartnet GPRS on 26 March 2015 and positioned on a high vegetated dune at the south-eastern end of the site; the base station was mounted over this benchmark to cover the area around Notch I: BM1: Easting: 241076.929 m Northing: 363096.357 m Height: 13.950 m OD BM3: Easting: 241451.667 m Northing: 362814.001 m Height: 17.301 m OD

RTK Backup Station:	Wooden post surveyed-in using Leica Smartnet GPRS on 25 March (BM2) (see Table 2).
Fixed profiles:	Twenty-one profile lines were surveyed, and compared with data surveyed before the restoration works using airborne LiDAR survey on 9 April 2014. Chainages along profile lines were interpolated at positions on a theoretical straight-line between the zero and end points of the profile. Note that Profile 9 also covers part of the Phase 2 ‘Zone 1 East’ site.

Survey undertaken by: S.J. Blott, A. Pye and K. Pye

2. Scope and purpose

Phase 1 dune rejuvenation trials at Newborough Warren commenced in January 2013 and involved (a) stripping of vegetation from the windward dune slopes, crests and parts of the arms and deflation corridors, (b) excavation of sand to deepen parts of the deflation corridors to encourage the development of wet slack habitat, and (c) placement of stripped turf blocks in areas on and behind the dune arms. Phase 2 works commenced in areas identified in the Newborough Forest Management Plan as Zone 1 West and Zone 1 East (see Figure 1) during 2014 and works on Newborough Warren (Phase III) were undertaken in February - early March 2015. The works on Newborough Warren involved (a) the creation / enlargement of six 'notches' (labelled D to I in Figures 2 & 3) in the frontal dunes to allow wind flow and sand movement from the beach into the back dune area, (b) turf stripping and shallow sand excavation to recreate a number of former parabolic dune and intra-dune slacks behind the frontal dunes, and (c) placement of piles of excavated sand in a series of hummocks around the inland perimeter of the working area. This report provides a summary of the results from the first ground topographic survey carried out in late March after completion of the works, and comparisons which have been made with a pre-works (April 201) aerial LiDAR survey.

3. Survey methods and error checking

In the March 2015 survey ground surface elevations were determined at 850 points using Leica RTK GPS SmartRover equipment listed in the Job Summary (Section 1.0) above. The distribution of survey points is shown in Figures 2 and 3. Many of the survey points were located on profile lines, chosen to measure elevations along the axes of the new notches, across the frontal dune between the notches, and along transects across the new notches. The limits of defined features, including areas stripped of vegetation, areas of windblown sand (where present), the main dune crest and base of slopes, any areas of standing water, and the position of the dune toe, were also mapped by survey points.

Average vertical and horizontal errors reported by the instrument during the March 2015 survey were well within the expected range (Table 1).

Measuring of the position and elevation of Benchmark 2 using the two instrumental set-ups (using Leica SmartNet corrections and using the base and rover set-up) showed a vertical difference of just 12 mm, which is within the errors expected for RTK GPS technique, due largely to atmospheric effects (Table 2).

Ground photographs were taken at a number of locations around the site; a selection is reproduced in Appendix 1.

4. Sediment particle size analysis

During the topographic survey a number of surface sand samples were collected for particle size analysis by dry sieving (sampling locations are shown on Figure 4). The particle size data were processed using Gradistat software (Blott & Pye, 2001) and the sediments classified using the statistical summary parameters and terminology proposed by Folk (1954), Folk & Ward (1957) and Blott & Pye (2012).

5. Results - particle size analysis

All of the dune sediment samples collected from with the Phase 3 area can be classified as very well sorted or well sorted fine sand (Tables 3 & 4). Some of the samples contained small quantities (0.1 to 0.5% of) silt. The median size showed a narrow range of variation (188 to 216 microns). Material of this size is easily moved by the wind.

6. Results - profile comparisons

Profiles 9 and 17 show that notches D and E represent pre-existing natural low points in the frontal dune ridge which were deepened by sand excavation. Much of the excavated sand was placed to create a mound behind the frontal dunes to the southeast (Figures 6a & 6i).

Profile 10 along the axis of notch D shows that a gentle rising, slightly convex profile was created during the excavation. By the time of survey (approximately a month after excavation) a lobe of windblown sand had been deposited across the turf stripped area behind the notch (Figure 6b).

Profile 11 shows that a flatter, lower long profile was created by excavation of notch E. By the time of survey a mound of windblown sand had formed at the landward end of the notch, with a thin veneer of blown sand extending as far as the forest boundary (Figure 6c).

Notch F was created with a relatively steeply rising seaward slope and a sharply dipping landward slope extending into an excavated area behind the frontal dune line (Profile 12, Figure 6d). This Notch was initially created with a deep and narrow cross-section (Figure 6j).

Notch G (Profile 13, Figure 6e) was created with a steeply rising seaward slope, a gently landward-sloping central section, and a steeply sloping landward section leading into a deep excavated depression with a flat bottom at c. 3.5 m OD (designed as a potential slack). The central part of the notch was crated with a deep and relatively narrow cross-section (Figure 6k). By the time of survey a windblown depositional sand lobe had formed at the landward end of the notch and the floor of the excavated depression had been covered by a 0.2 to 0.3 layer of blown sand.

Notches H and I (Profiles 14, 16, 19, 20, 21; Figures 6f, 6h, 6l & 6m) were created in a formerly continuous section of the frontal dune ridge. The axial profiles of these notches were created with steep seaward facing slope, a sharp crest and steep landward slopes leading into a deepened area (former intra-dune slack).

Profile 14 passes crosses the end of a dune ridge which projects into the excavated former deflation corridor of a parabolic dune. A significant quantity of sand was excavated from the former windward slope of this dune to create a steeper slope (Figure 6f).

Profile 15 crosses an area where excavated sand was deposited behind the frontal dune ridge (Figure 6g).

Profile 16 (Figure 6h) extends along the axis of notch I into a pre-existing low area behind the frontal dune, landward of which is a stabilised parabolic dune (left vegetated).

Profile 22, aligned parallel to the shore, crosses the are behind notches F, G and H, showing areas of sand excavation behind he notches and sand placement between notches F and G (Figure 6n).

Profiles 23 and 24 cross the large excavated parabolic dune and intra-dune slack behind notch H. The depth of sand excavation at profile 23 was c. 1 m and at profile 24 was approximately 4 m (Figures 6o and 6p).

Profile 25 (Figure 6q) extends from the centre of the newly excavated parabolic dune corridor, across the former dune crest which has been stripped of vegetation, and onto an area where excavated sand was deposited (surface relief in the form of a series of 2 m diameter mounds).

Profile 26 (Figure 6r) runs along the axis of another large intra-dune former deflation corridor from which the vegetation has been stripped and small dune features removed. The head of the deflation corridor has been steepened by excavation and sand placed in heaps on the dune crest to increase its height (with the intention of increasing wind speed-up over the dune).

Profile 27 runs along the axis of the adjoining parabolic dune corridor and over the dune crest (Figure 6s). The depth of sand excavation ranges from a few cm to c 2m where small dune features within the former deflation corridor have been removed to create a smooth surface and long ‘wind run’ towards the dune head. The up-wind face of the dune has been steepened through a combination of sand excavation at the base and sand deposition at the crest.

Profile 28 (Figure 6t) runs perpendicular to the two excavated dune deflation corridors and adjoining parabolic dune ‘arms’. The height of the ‘arm’ separating the two intended deflation corridors has been raised 2 m by placement of sand and turfs.

Profile 29 is aligned perpendicular the landward end of the eastern deflation corridor and also runs across the area of sand / turf placement behind the crest of the westernmost parabolic dune (Figure 6u).

At the time of survey (approximately two weeks after completion of the works) only relatively minor changes to the surface morphology were evident due to wind scour and deposition of blown sand. The total area of substantially bare sand, including deposited heaps of sand, was approximately 6.63 ha (Table 5).

7. References

Blott, S.J. and Pye, K. (2001) GRADISTAT: a grain size distribution and statistics package for the analysis of unconsolidated sediments. *Earth Surface Processes and Landforms*, 26, 1237-1248.

Blott, S.J. & Pye, K. (2012) Particle size scales and classification of sediment types based on particle size distributions: review and recommended procedures. *Sedimentology*, 59, 2071-2096.

Folk, R.L. (1954) The distinction between grain size and mineral composition in sedimentary-rock nomenclature. *Journal of Geology*, 62, 344-359.

Folk, R.L. and Ward, W.C. (1957) Brazos river bar: a study in the significance of grain size parameters. *Journal of Sedimentary Petrology*, 27, 3-26.

8. Tables

Table 1. Average error reported by the instrument for all 850 data points

	1-D quality control (height)	**2-D quality control (position)**	**3-D quality control (position and height)**
Average	9.3 mm	6.1 mm	11.2 mm
StDev	2.5 mm	1.6 mm	2.9 mm

Table 2. Measured location and height of Benchmark 2 (wooden post)

	Easting (m)	**Northing (m)**	**Height (m OD)**
Surveyed with Smartnet corrections (25 March 2013)	241080.456	363100.465	14.023
Surveyed with base & rover start of survey (25 March 2013)	214080.457	363100.470	14.011
Difference:	+1 mm	+5 mm	-12 mm

Table 3. Particle size characteristics of dune samples collected at the Phase 3 site on 25-26 March 2015. Statistics are calculated using GRADISTAT software (Blott & Pye, 2001), mean and sorting using the formulae of Folk & Ward (1957).

ID	Mean (µm & class)		D50 (µm)	Mode (µm)	Mean (phi)	Sorting (phi & description)		Gravel (%)	Sand (%)	Mud (%)
NW1	222	FS	216	215	2.17	0.46	WS	0.0	100.0	0.0
NW2	214	FS	213	215	2.23	0.42	WS	0.0	100.0	0.0
NW3	194	FS	200	215	2.37	0.37	WS	0.0	99.9	0.1
NW4	184	FS	188	215	2.44	0.36	WS	0.0	99.9	0.1
NW5	191	FS	198	215	2.39	0.34	VWS	0.0	99.6	0.4
NW6	196	FS	202	215	2.35	0.30	VWS	0.0	99.8	0.2
NW7	191	FS	197	215	2.39	0.35	VWS	0.0	99.5	0.5
NW8	188	FS	193	215	2.41	0.37	WS	0.0	99.8	0.2
NW9	194	FS	201	215	2.37	0.30	VWS	0.0	99.5	0.5
NW10	197	FS	203	215	2.35	0.36	WS	0.0	100.0	0.0
NW11	198	FS	204	215	2.34	0.35	VWS	0.0	99.9	0.1
NW12	205	FS	209	215	2.28	0.33	VWS	0.0	99.9	0.1
NW13	194	FS	201	215	2.36	0.33	VWS	0.0	100.0	0.0
NW14	34161	VCG	49591	54000	-5.09	1.76	PS	85.3	14.7	0.0
NW15	204	FS	206	215	2.29	0.48	WS	0.0	100.0	0.0
NW16	189	FS	194	215	2.41	0.36	WS	0.0	100.0	0.0
NW17	201	FS	205	215	2.31	0.26	VWS	0.0	100.0	0.0
NW18	222	FS	216	215	2.17	0.46	WS	0.0	100.0	0.0
NW19	208	FS	208	215	2.27	0.26	VWS	0.0	100.0	0.0
NW20	189	FS	196	215	2.41	0.32	VWS	0.0	99.8	0.2
NW32	193	FS	196	215	2.38	0.41	WS	0.0	100.0	0.0
NW34	198	FS	203	215	2.34	0.27	VWS	0.0	100.0	0.0

Mean Size Classification:

VCG (very coarse gravel)
CS (coarse sand)
MS (medium sand)
FS (fine sand)
VFS (very fine sand)

Sorting Descriptions:

VWS (very well sorted)
WS (well sorted)
MWS (moderately well sorted)
MS (moderately sorted)
PS (poorly sorted)
VPS (very poorly sorted)

Table 4. Sediment textural classifications, according to Folk (1954) and Blott & Pye (2012), from the samples collected on 25-26 March 2015.

ID	Easting	Northing	Folk (1954)	Blott & Pye (2012)
NW1	240966	363105	Sand	Sand
NW2	240995	363151	Sand	Sand
NW3	241097	363272	Sand	Sand
NW4	241169	363357	Sand	Sand
NW5	241185	363359	Sand	Sand
NW6	241288	363392	Sand	Sand
NW7	241281	363377	Sand	Sand
NW8	241248	363330	Sand	Sand
NW9	241226	363249	Sand	Sand
NW10	241037	363176	Sand	Sand
NW11	241161	363131	Sand	Sand
NW12	241146	362998	Sand	Sand
NW13	241563	362575	Sand	Sand
NW14	241542	362557	Gravel	Slightly sandy gravel
NW15	241511	362524	Sand	Sand
NW16	241133	362968	Sand	Sand
NW17	241169	363026	Sand	Sand
NW18	241262	362860	Sand	Sand
NW19	241380	363049	Sand	Sand
NW20	241295	362927	Sand	Sand
NW32	241079	363098	Sand	Sand
NW34	241316	362826	Sand	Sand

Table 5. Areas of bare sand in the Phase 3 area. Note that small areas of blown sand entering the forest were not surveyed due to the lack of GPS signal beneath the trees. Small remaining clumps of unstripped vegetation have also not been included, and many of the sand deposition areas contain blocks of turf which are partly vegetated.

Bare sand type	Area (ha)
Vegetation-stripped	5.30
Significant sand deposition in heaps	1.33
Blown sand	0.00
Total	6.63

9. Figures

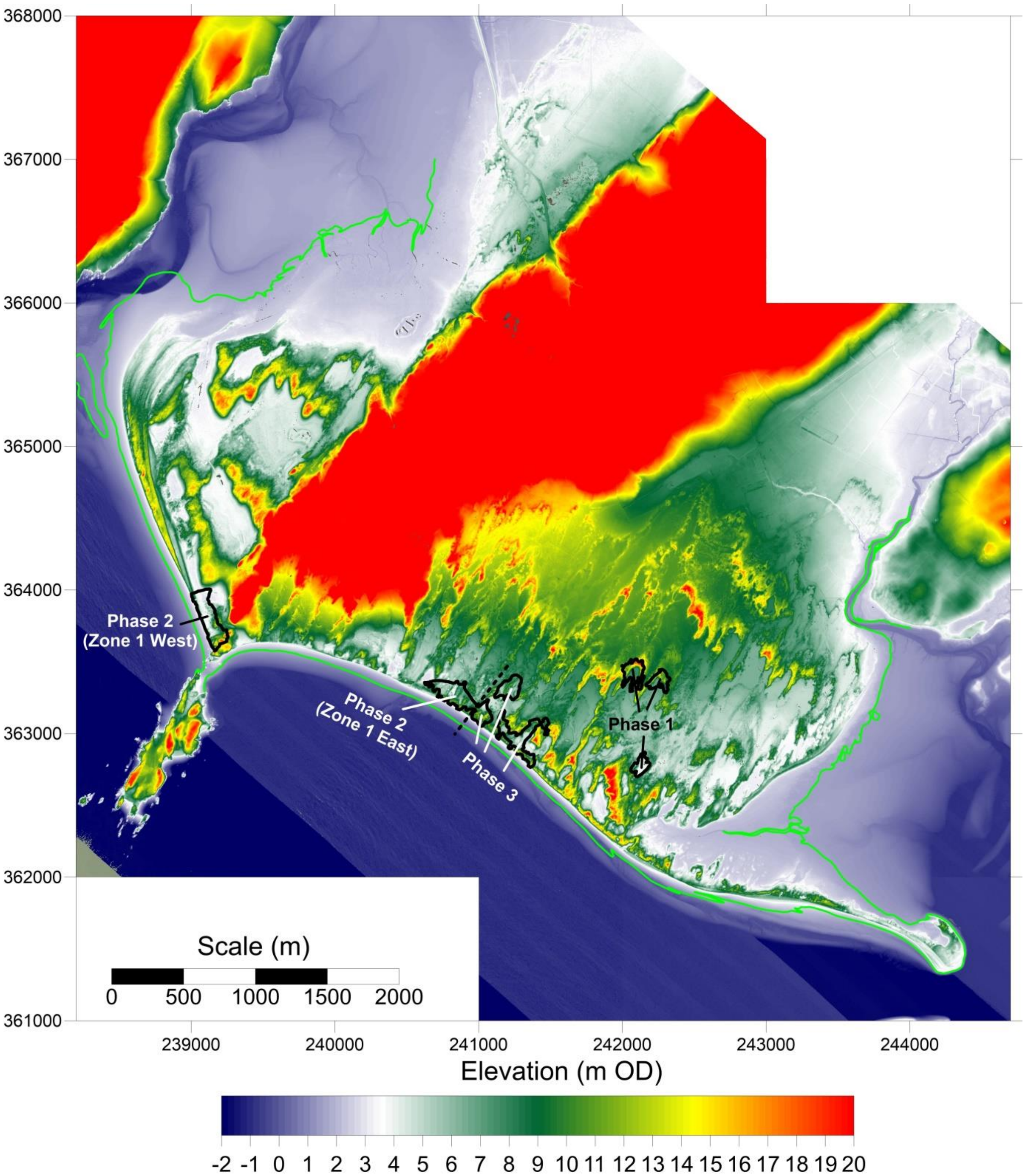


Figure 1. Locations of Phases 1, 2 and 3 dune restoration works at Newborough Warren, overlaid on LiDAR DEM flown on 9 April 2014.

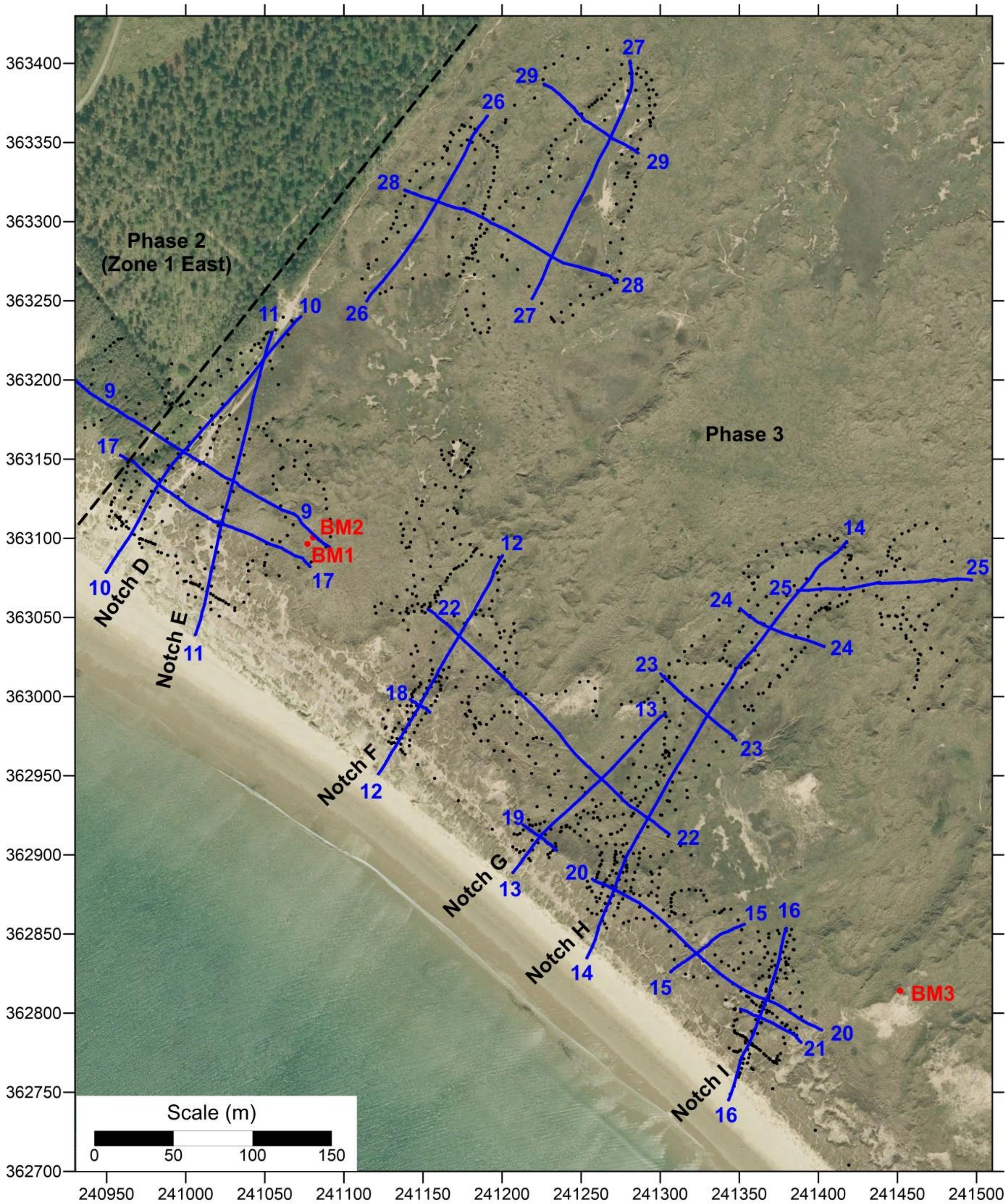


Figure 2. Locations of March 2015 data points (black dots), benchmarks (red dots) and cross-profiles (blue lines) in Phase 3, overlaid on air photographs flown 11 May 2009.

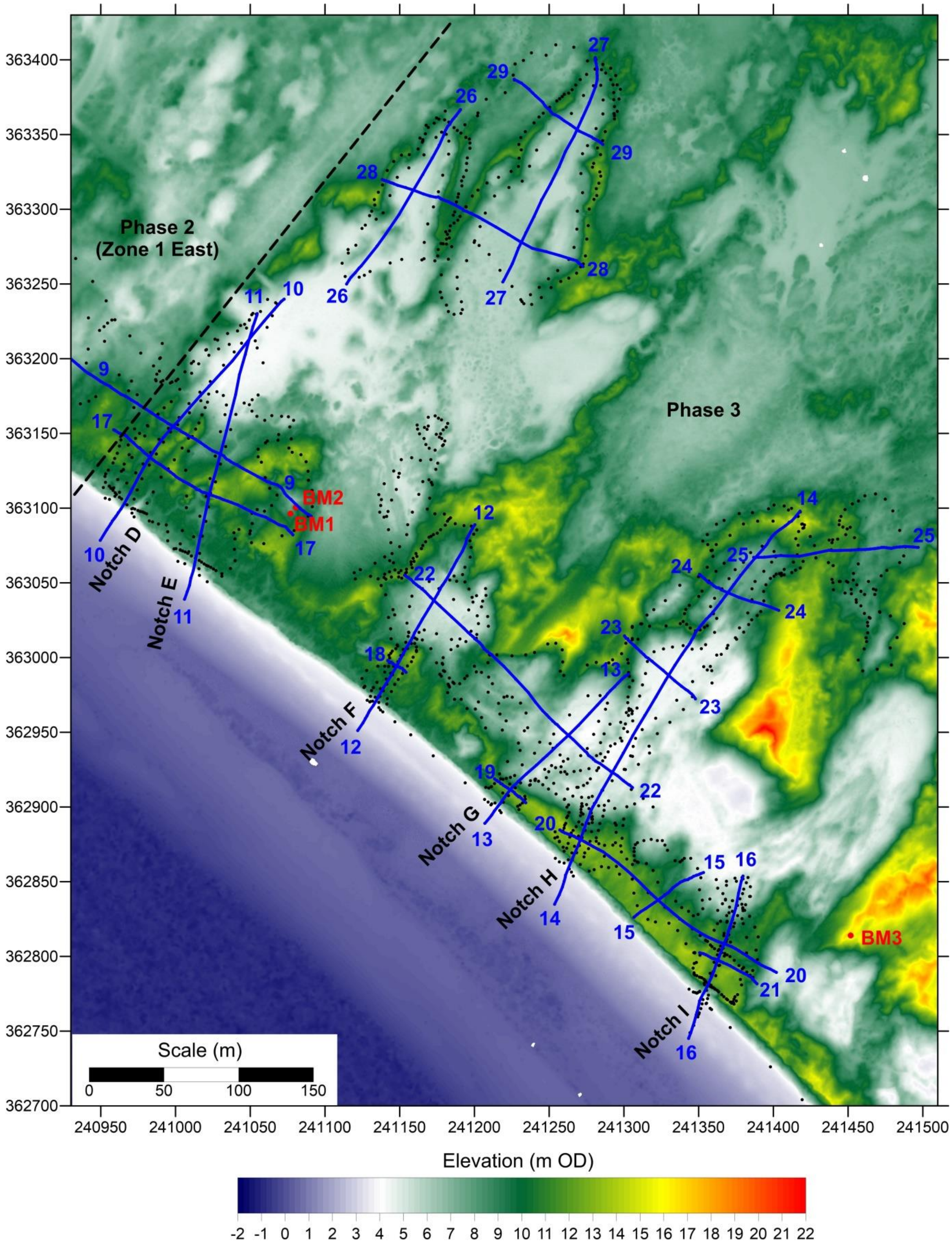


Figure 3. Locations of March 2015 data points (black dots), benchmarks (red dots) and cross-profiles (blue lines) in Phase 3, overlaid on LiDAR DEM flown on 9 April 2014.

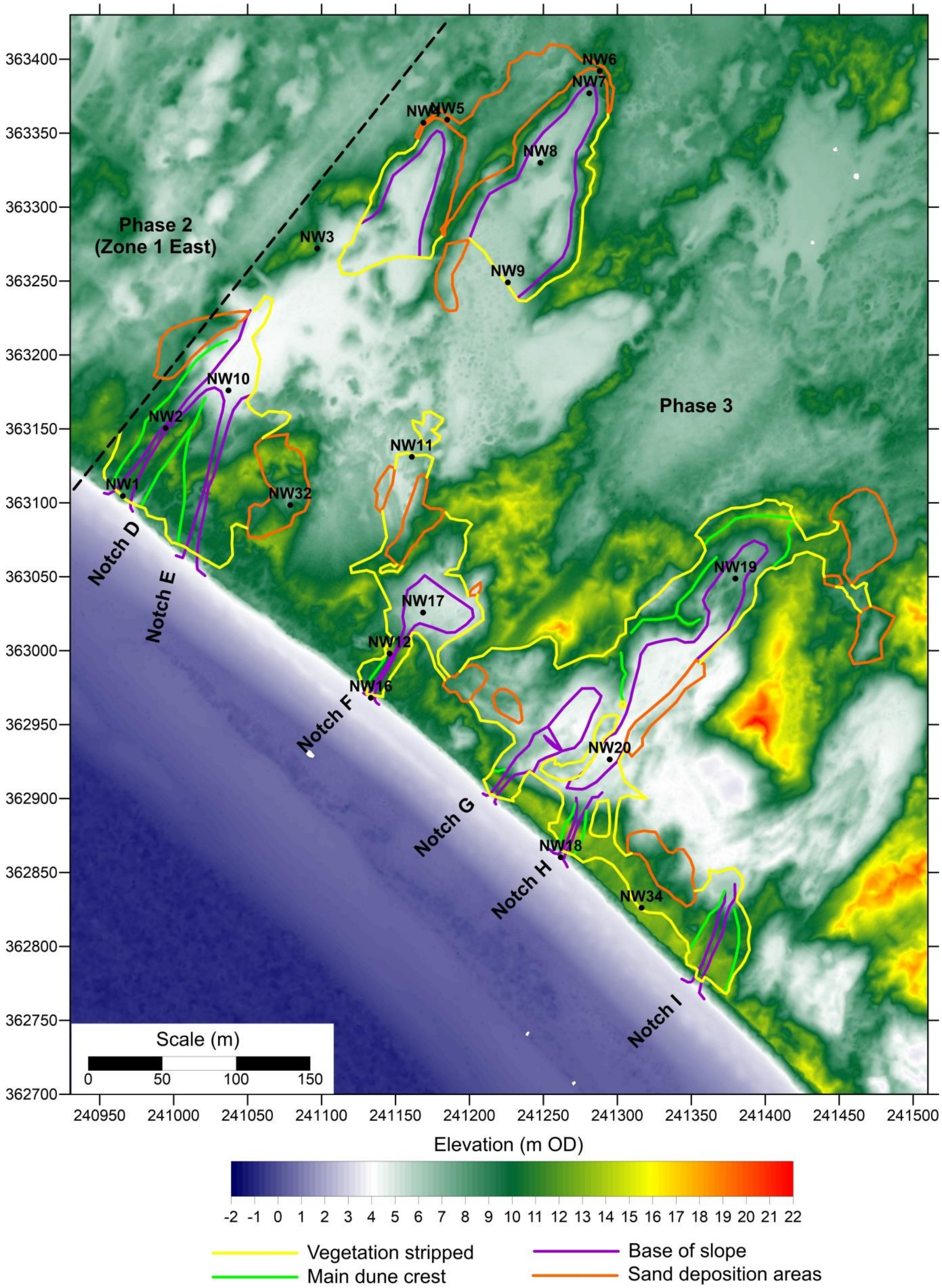


Figure 4. Locations of sediment samples collected in the Phase 3 area, overlaid on LiDAR DEM flown on 9 April 2014, with features mapped from Figure 5.

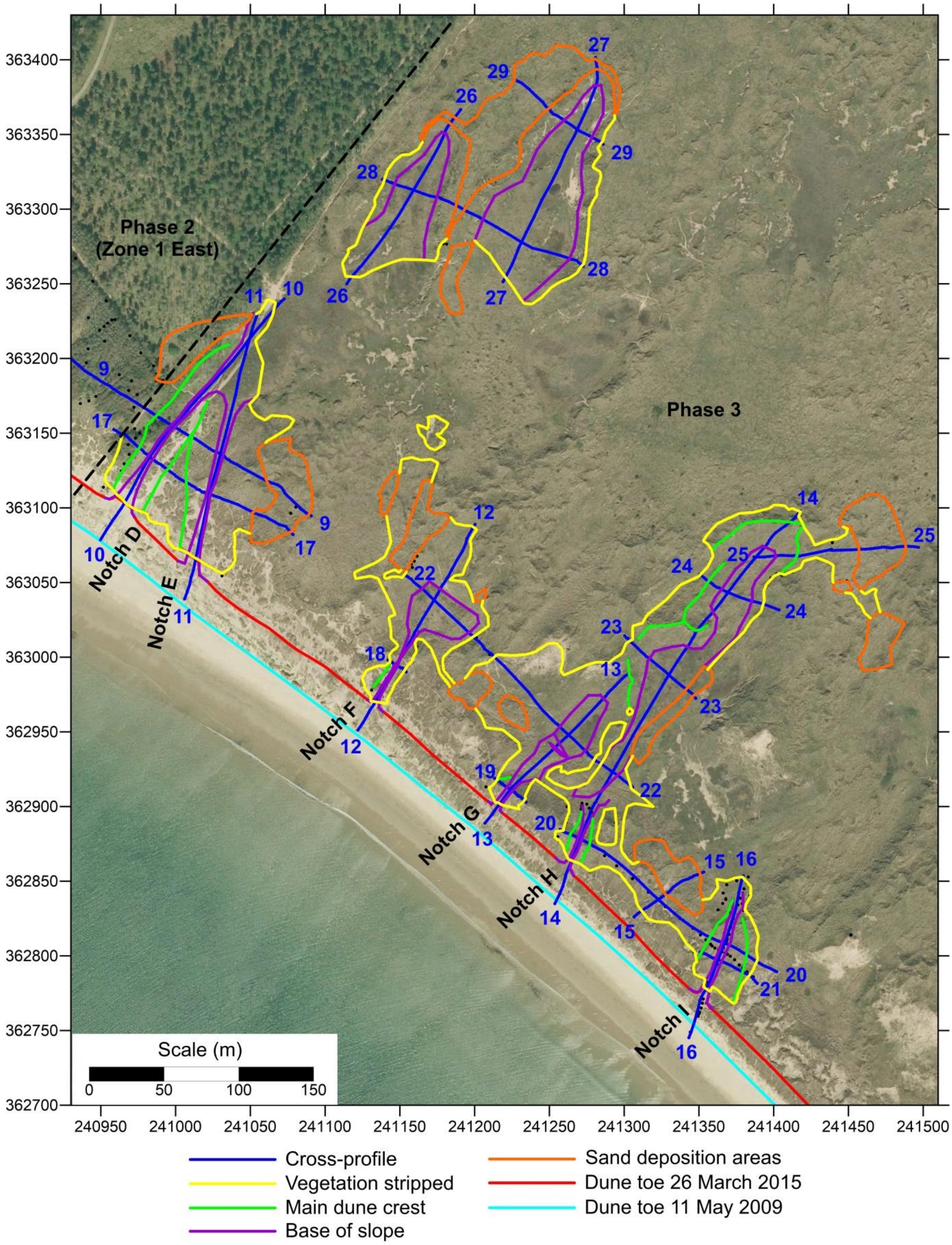


Figure 5. Locations of March 2015 data points (black dots) and cross-profiles (dark blue lines) in Phase 3, overlaid on May 2009 aerial photographs. The limit of vegetation stripping, areas of sand deposition (usually as sacrificial sand heaps), the main dune crests, base of slopes and positions of the dune toe surveyed in March 2015 are also shown. For comparison, the position of the dune toe from the 2009 air photographs is also shown.

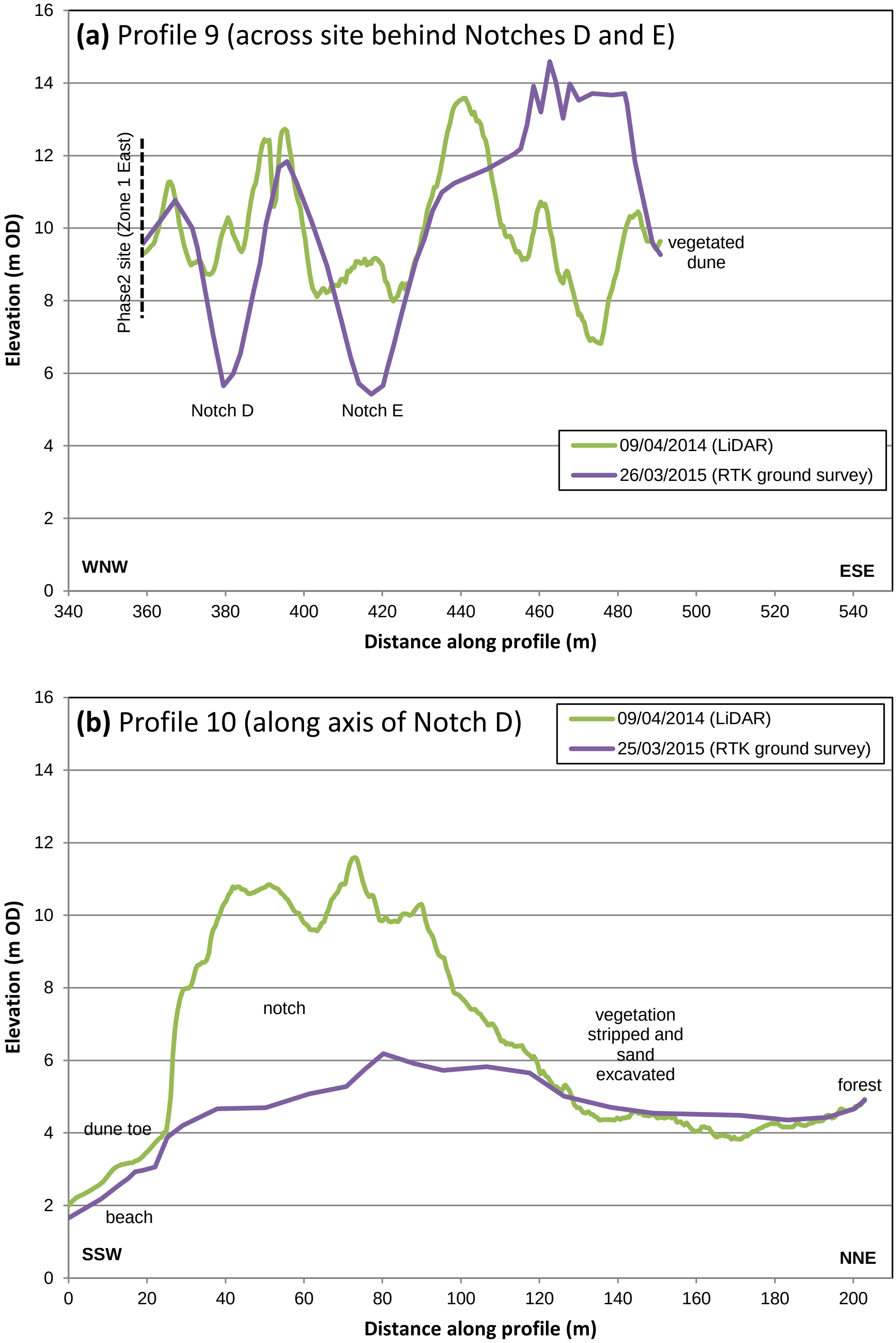
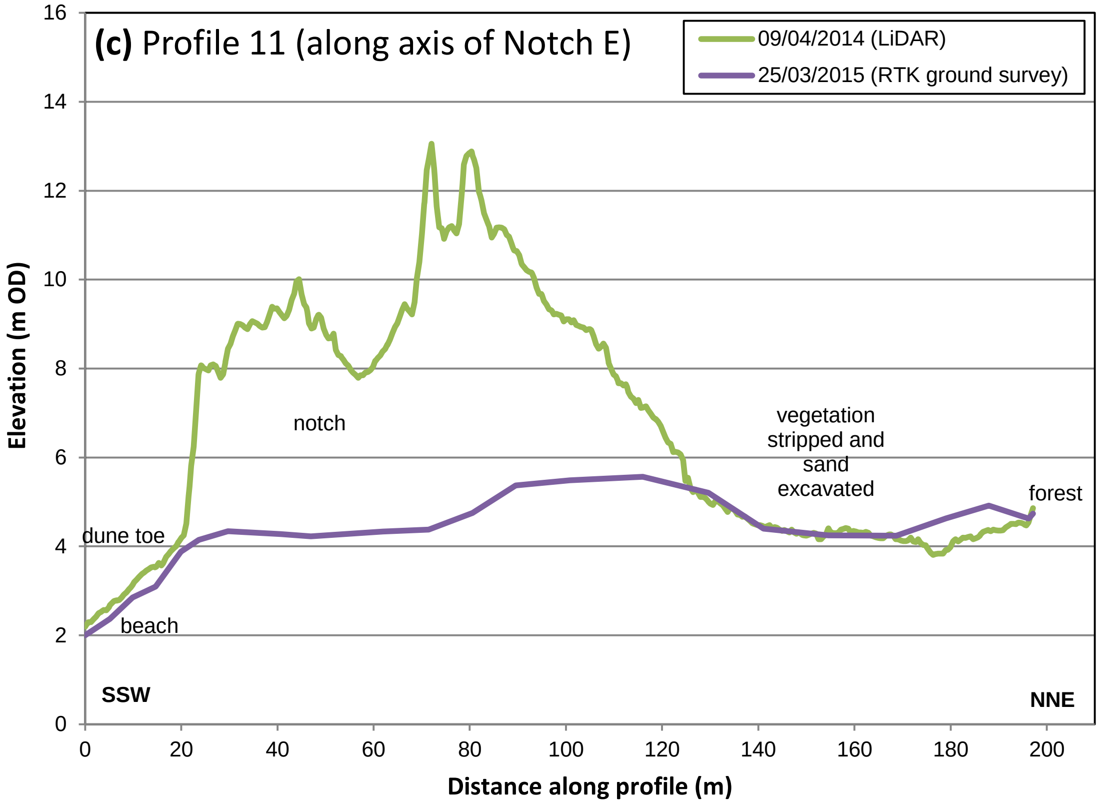


Figure 6. Comparison of surface levels at profiles 9 and 10, indicated by LiDAR survey on 9 April 2014 (pre-works) and ground survey on 25 March 2015.



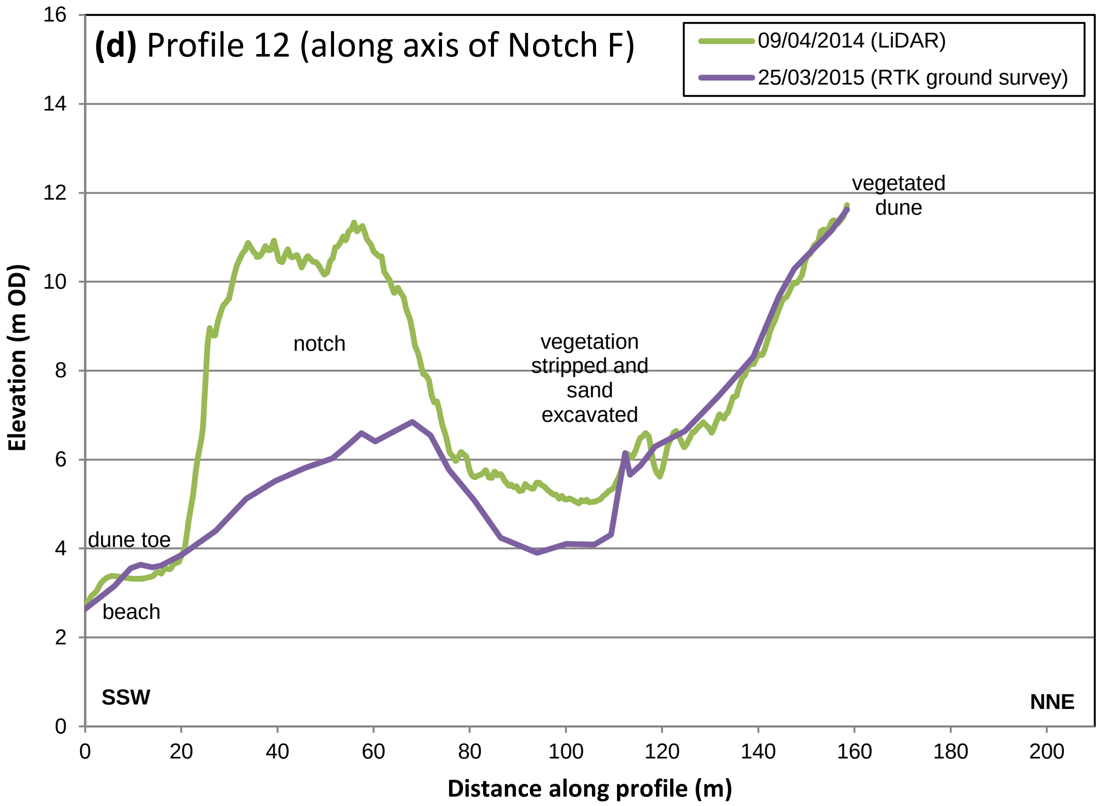
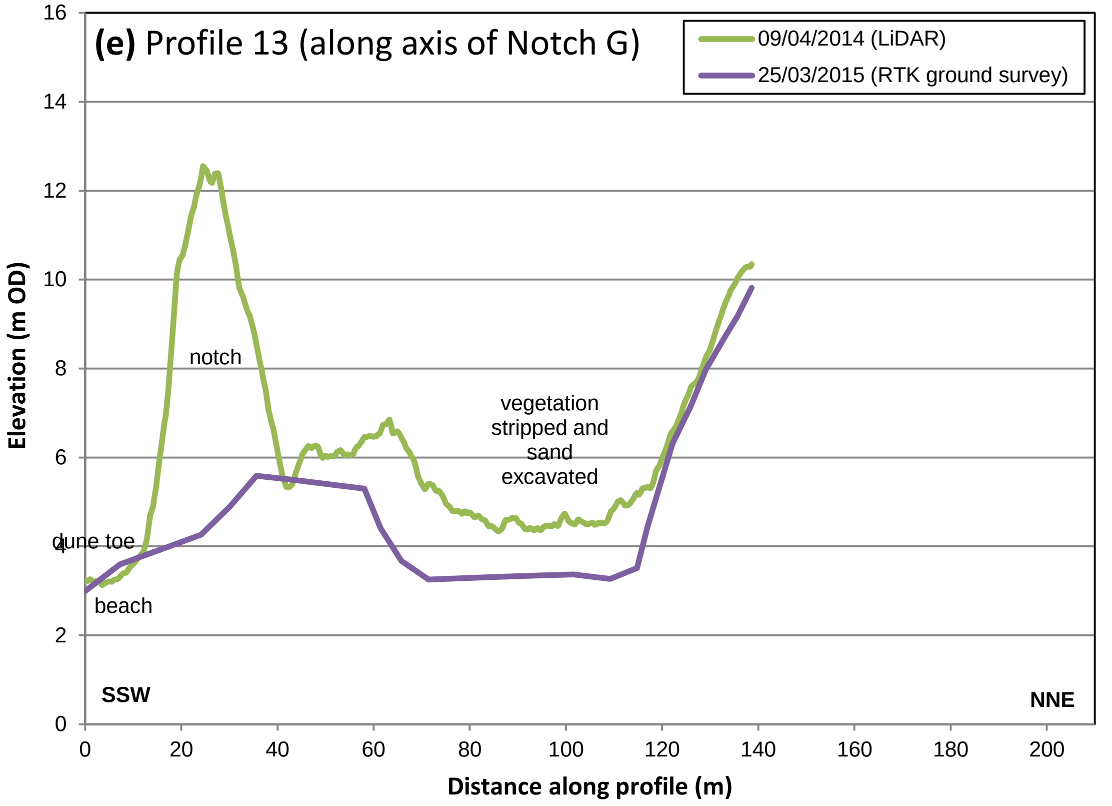


Figure 6 (continued). Comparison of surface levels at profiles 11 and 12, indicated by LiDAR survey on 9 April 2014 (pre-works) and ground survey on 25 March 2015.



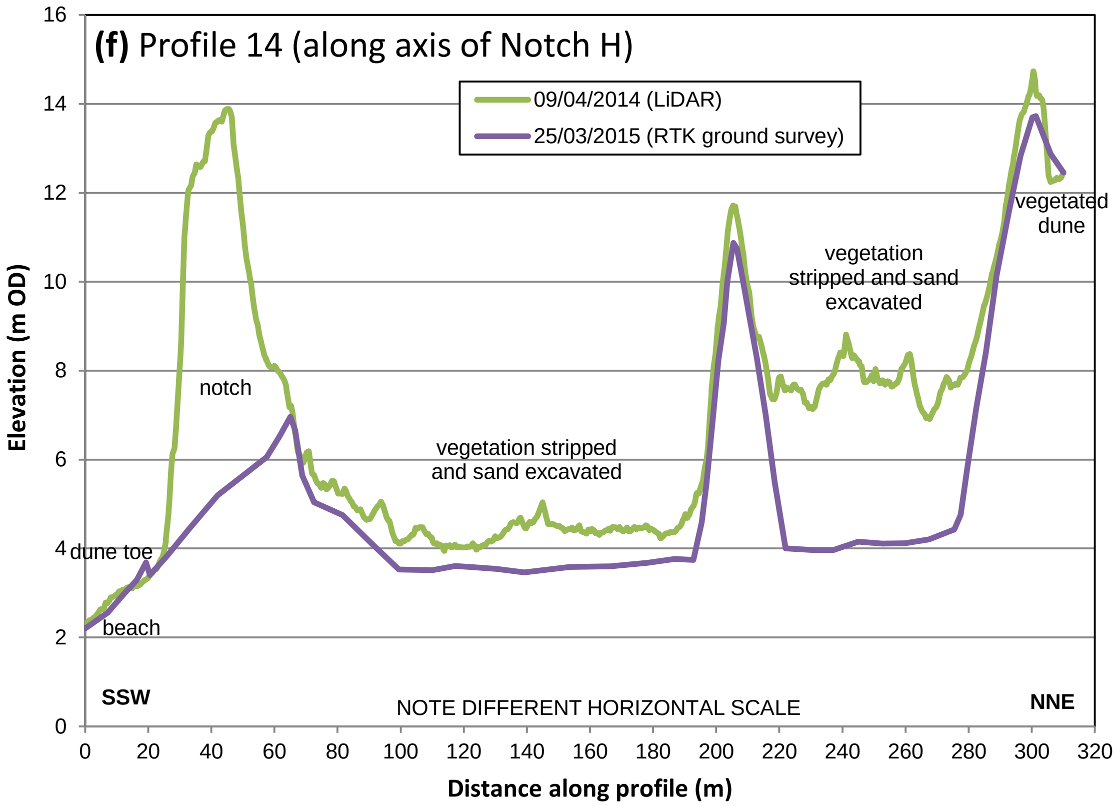
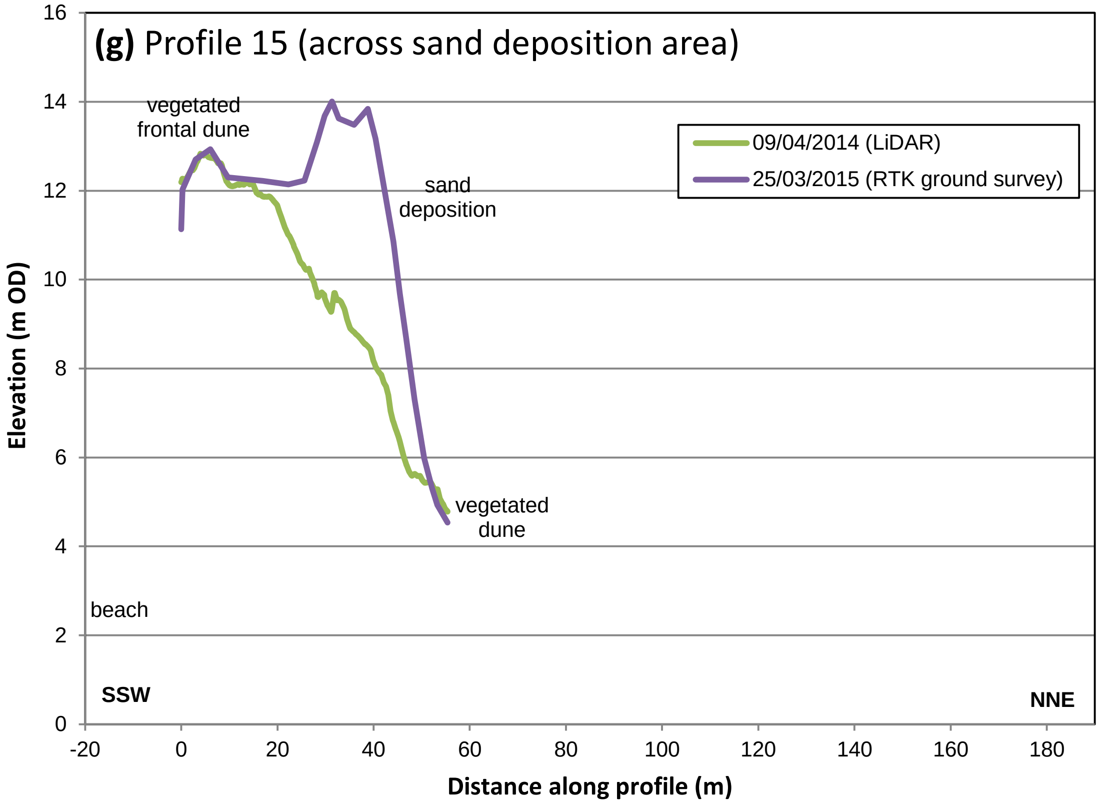


Figure 6 (continued). Comparison of surface levels at profiles 13 and 14, indicated by LiDAR survey on 9 April 2014 (pre-works) and ground survey on 25 March 2015.



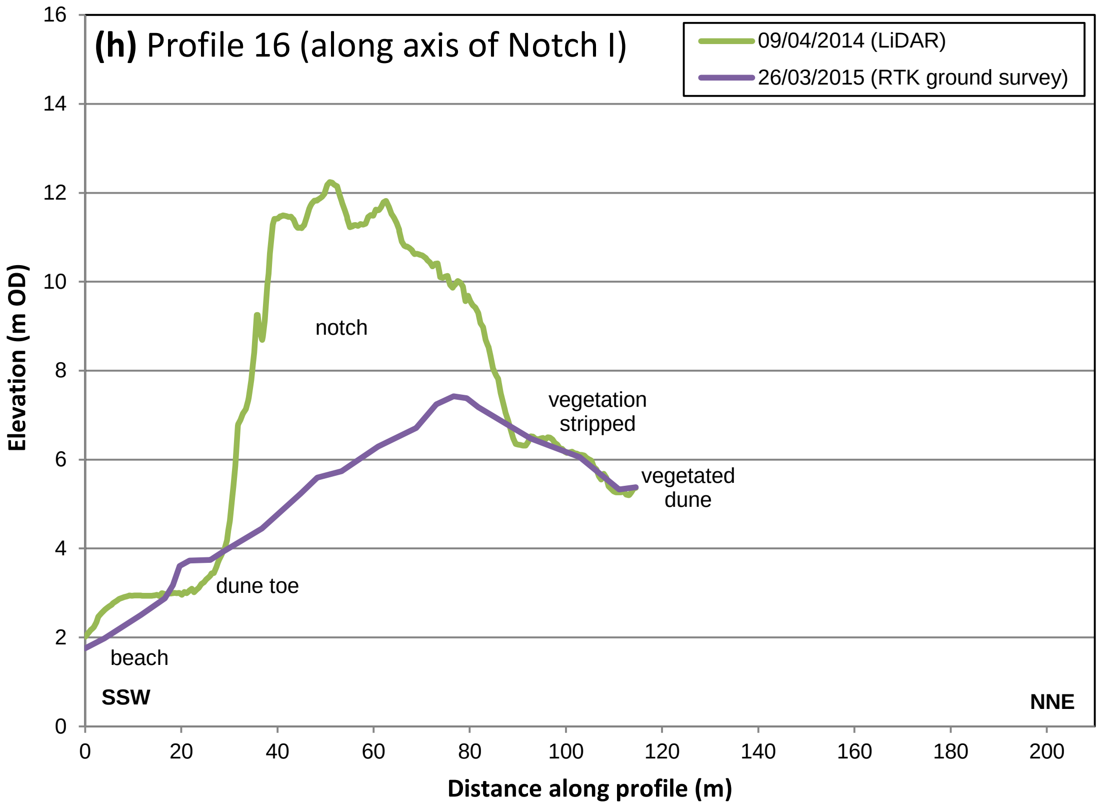
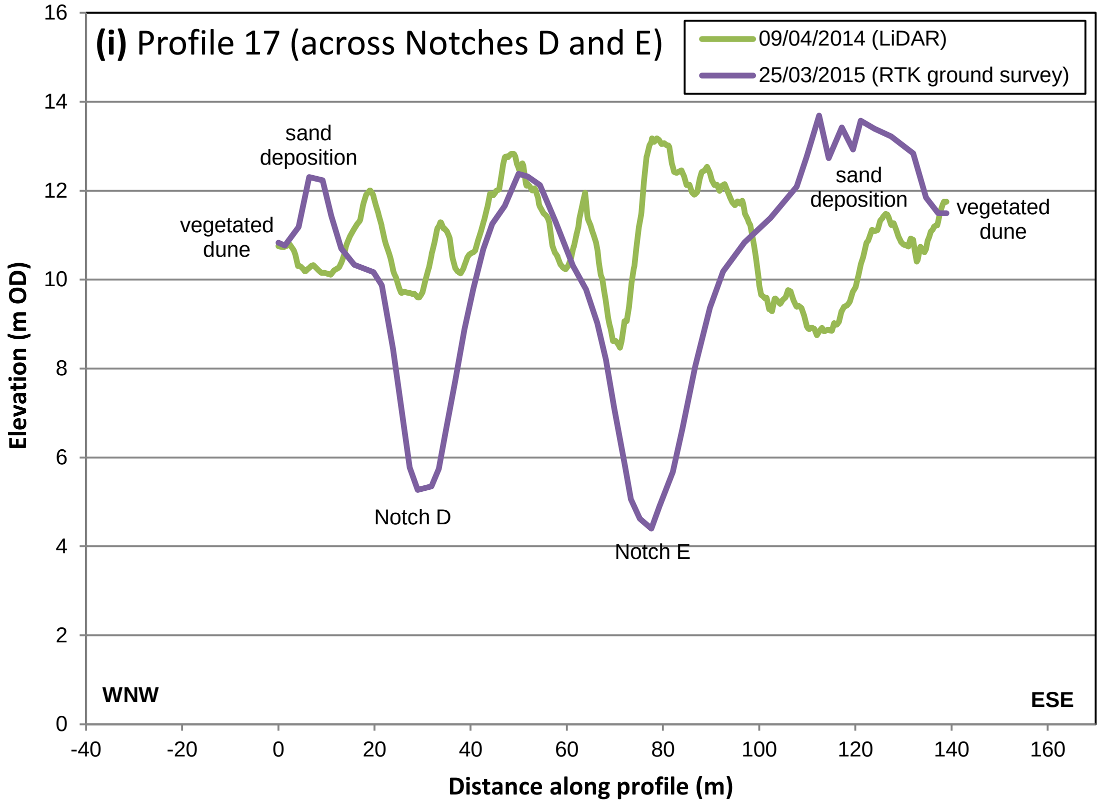


Figure 6 (continued). Comparison of surface levels at profiles 15 and 16, indicated by LiDAR survey on 9 April 2014 (pre-works) and ground survey on 25-26 March 2015.



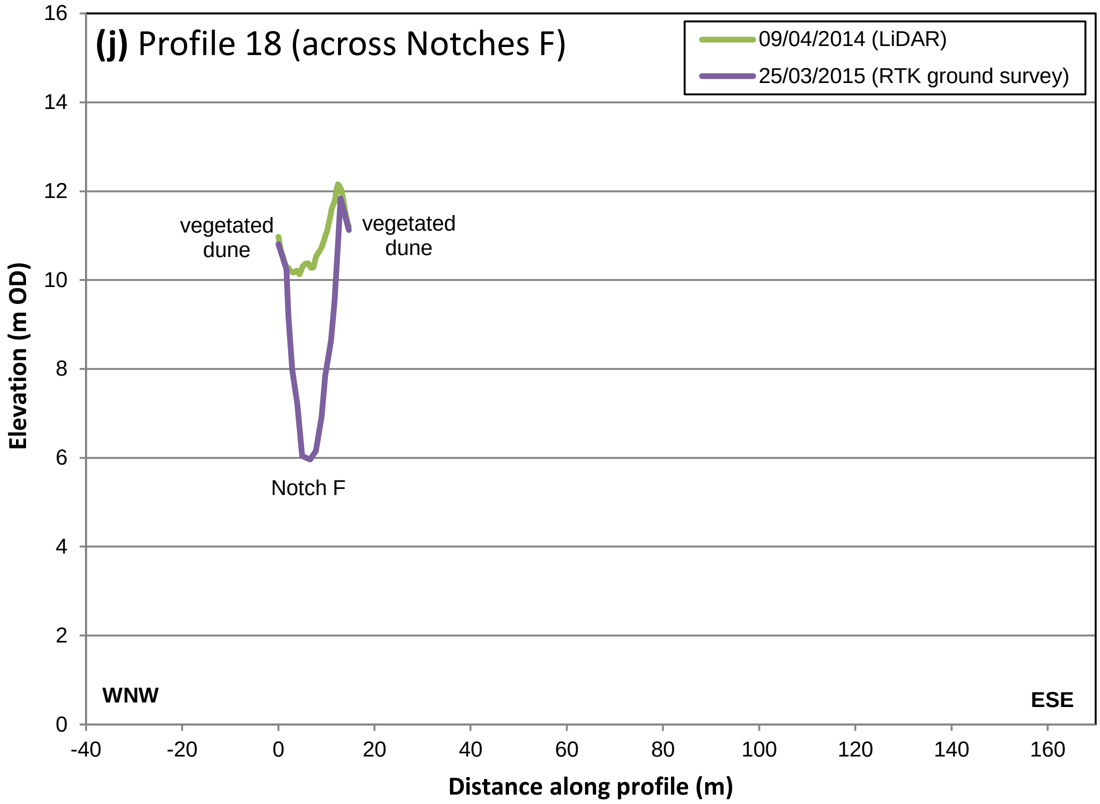
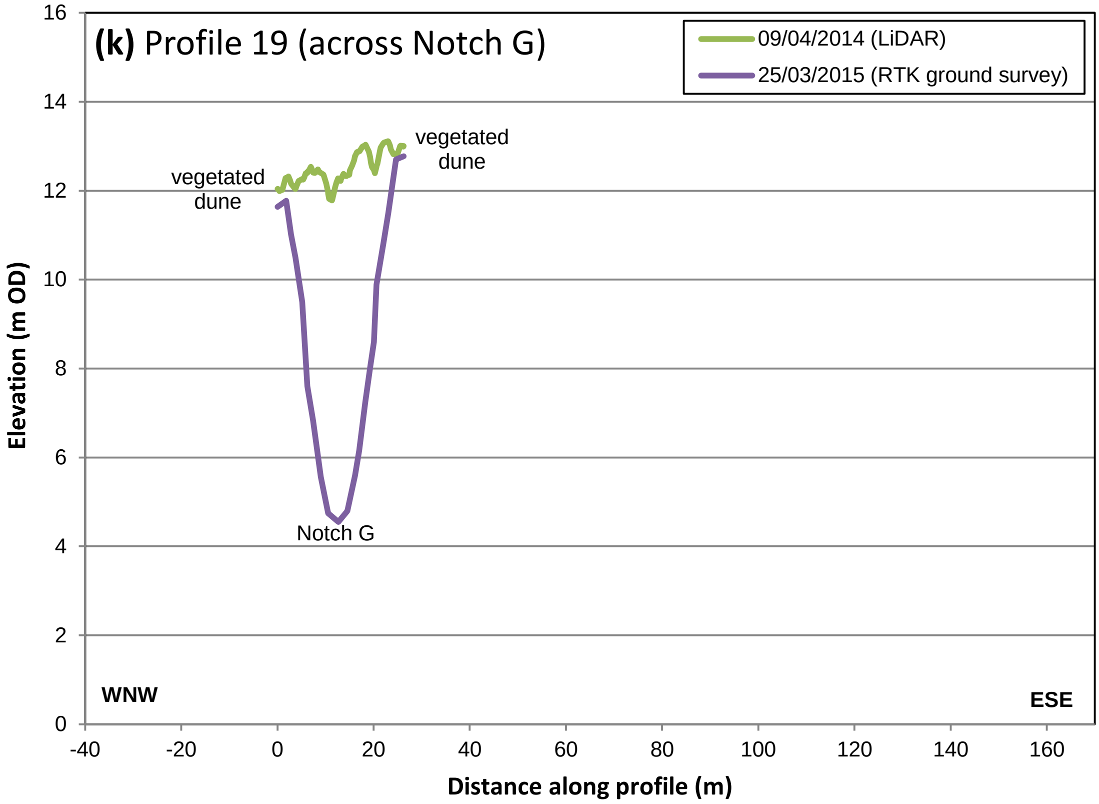


Figure 6 (continued). Comparison of surface levels at profiles 17 and 18, indicated by LiDAR survey on 9 April 2014 (pre-works) and ground survey on 25 March 2015.



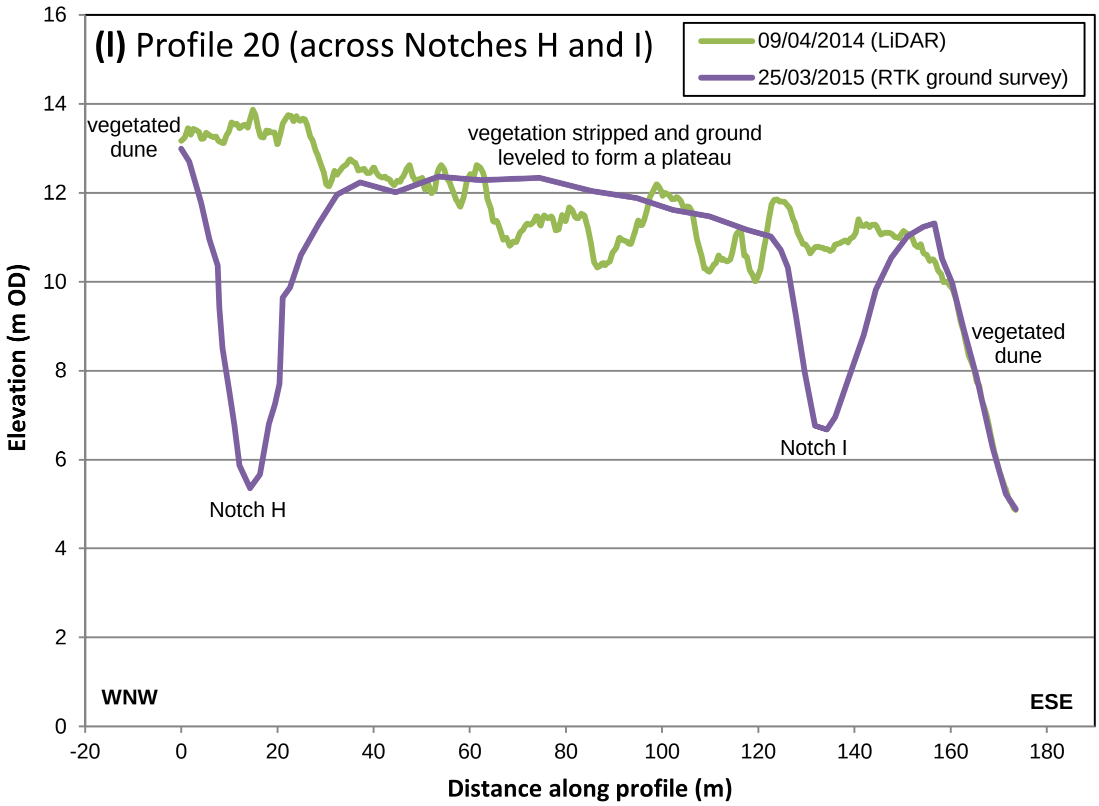


Figure 6 (continued). Comparison of surface levels at profiles 19 and 20, indicated by LiDAR survey on 9 April 2014 (pre-works) and ground survey on 25 March 2015.

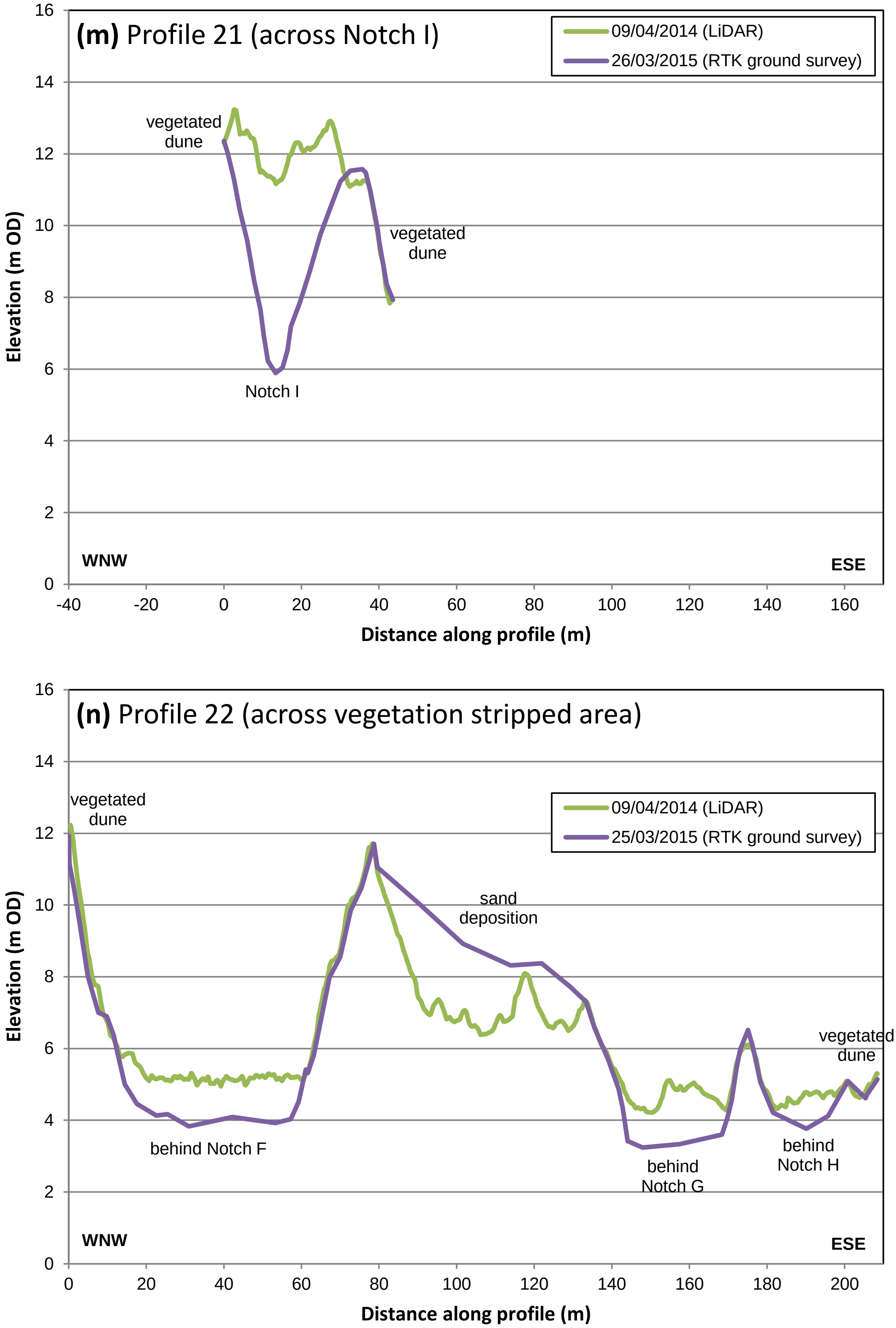
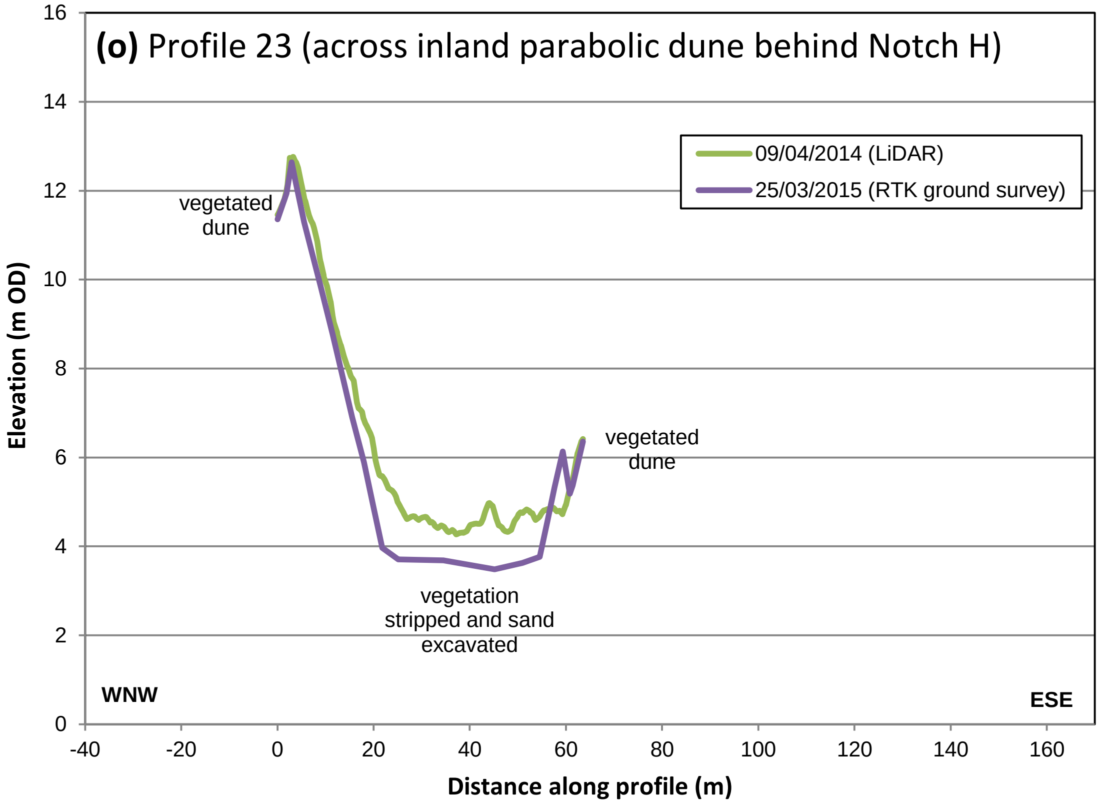


Figure 6 (continued). Comparison of surface levels at profiles 21 and 22, indicated by LiDAR survey on 9 April 2014 (pre-works) and ground survey on 25-26 March 2015.



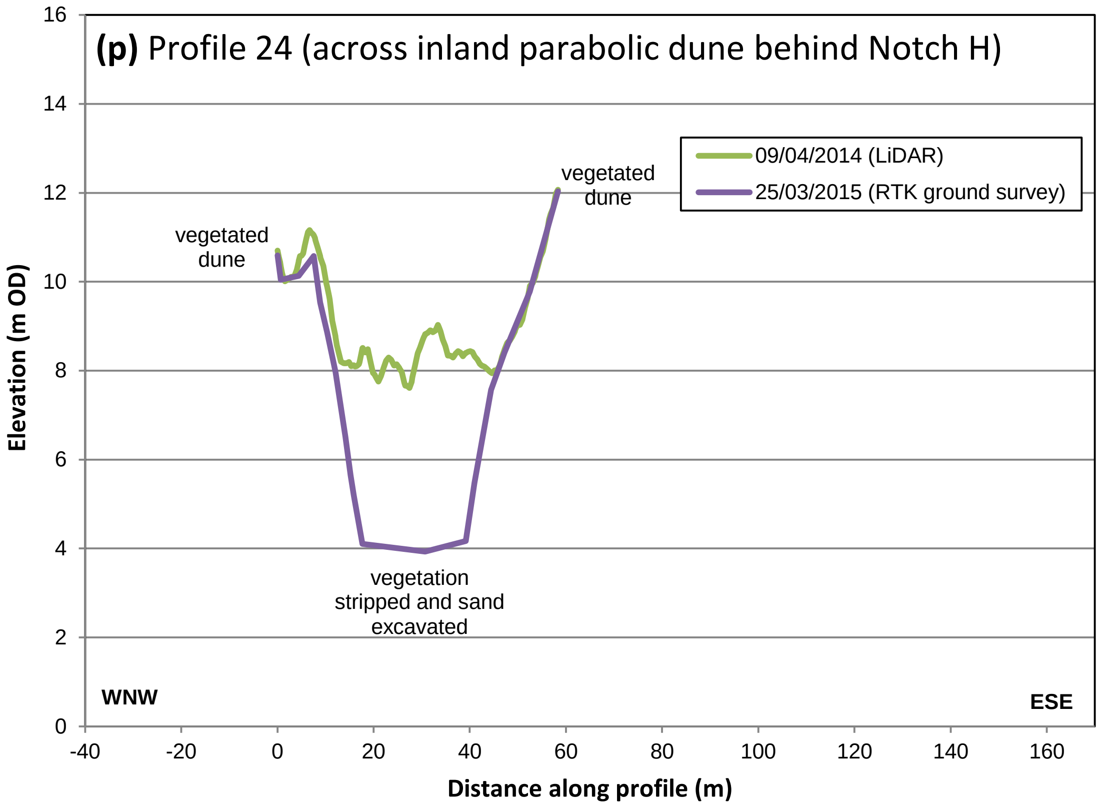
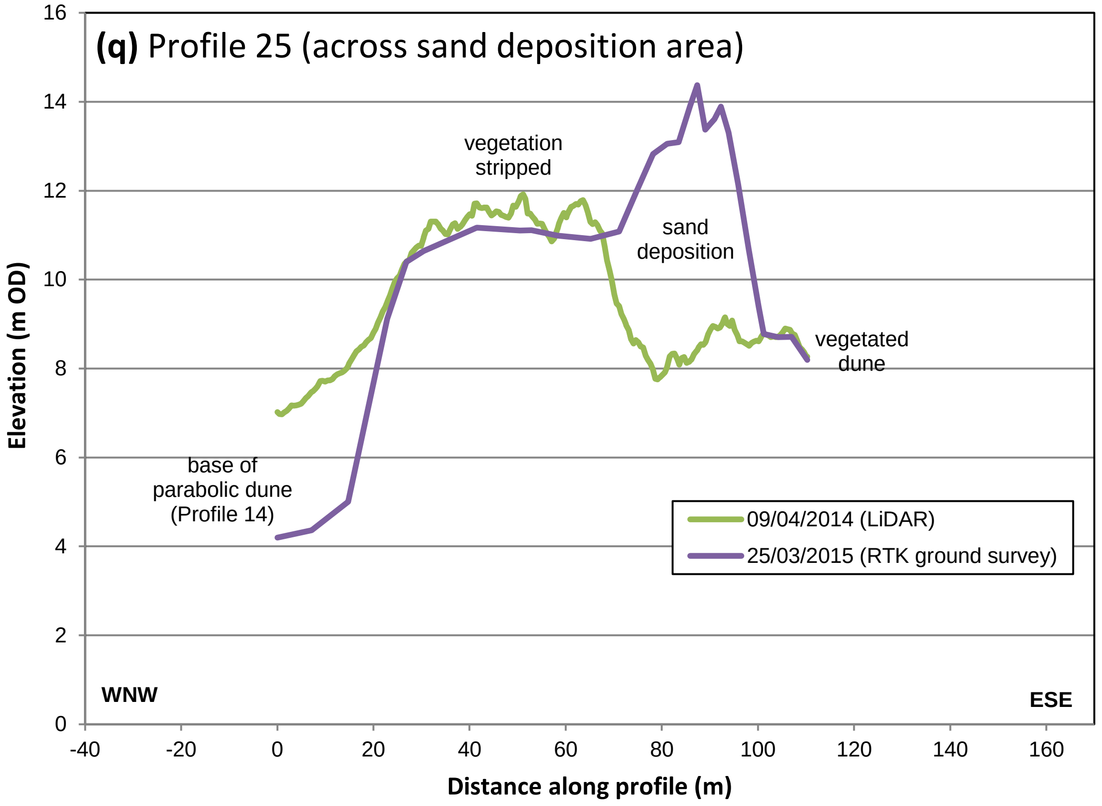


Figure 6 (continued). Comparison of surface levels at profiles 23 and 24, indicated by LiDAR survey on 9 April 2014 (pre-works) and ground survey on 25 March 2015.



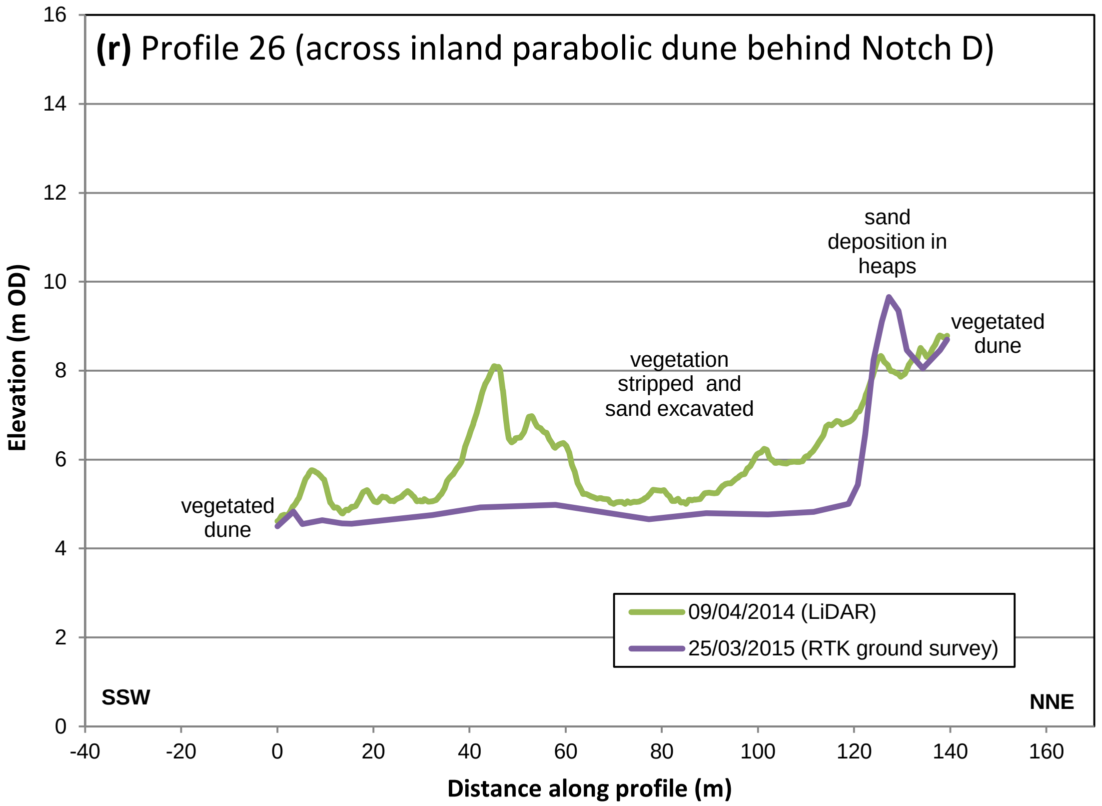
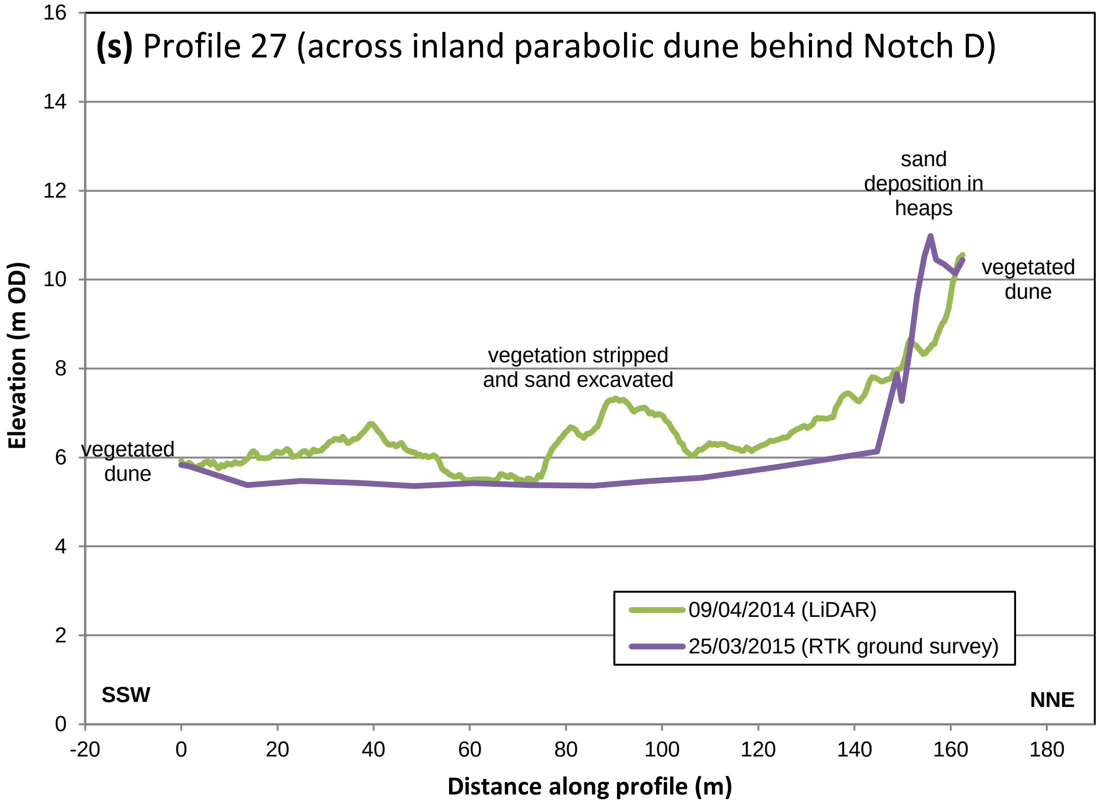


Figure 6 (continued). Comparison of surface levels at profiles 25 and 26, indicated by LiDAR survey on 9 April 2014 (pre-works) and ground survey on 25 March 2015.



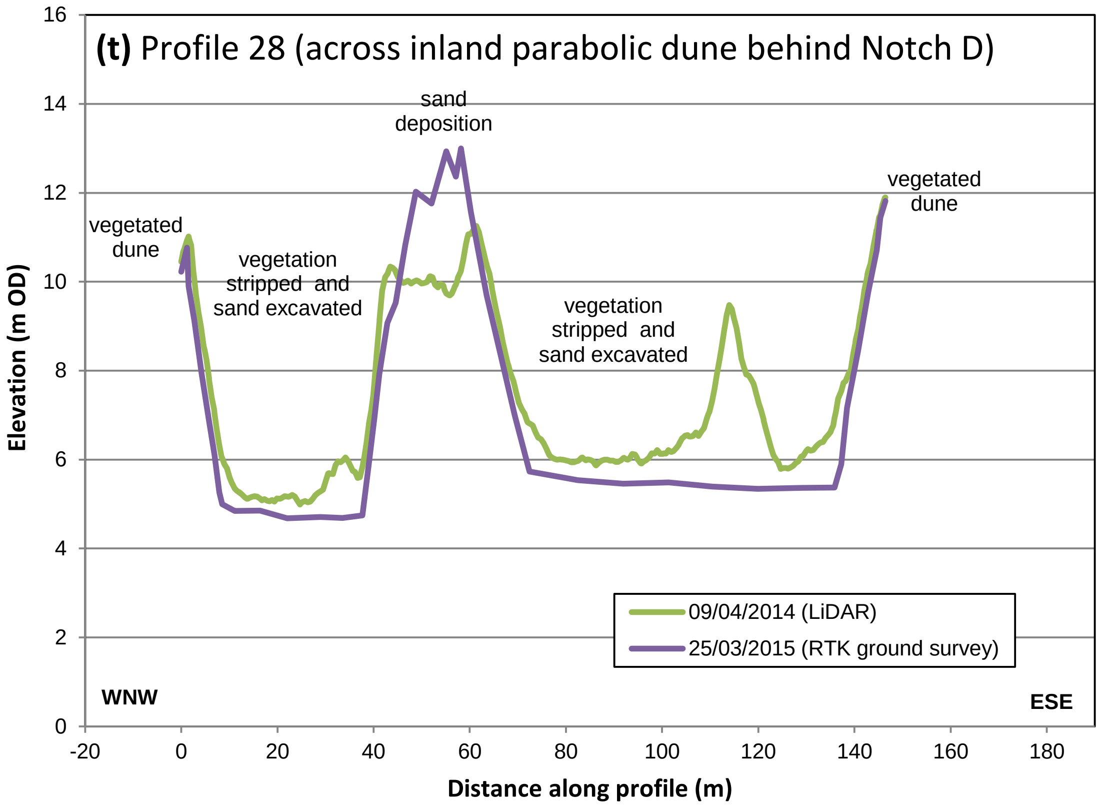


Figure 6 (continued). Comparison of surface levels at profiles 27 and 28, indicated by LiDAR survey on 9 April 2014 (pre-works) and ground survey on 25 March 2015.

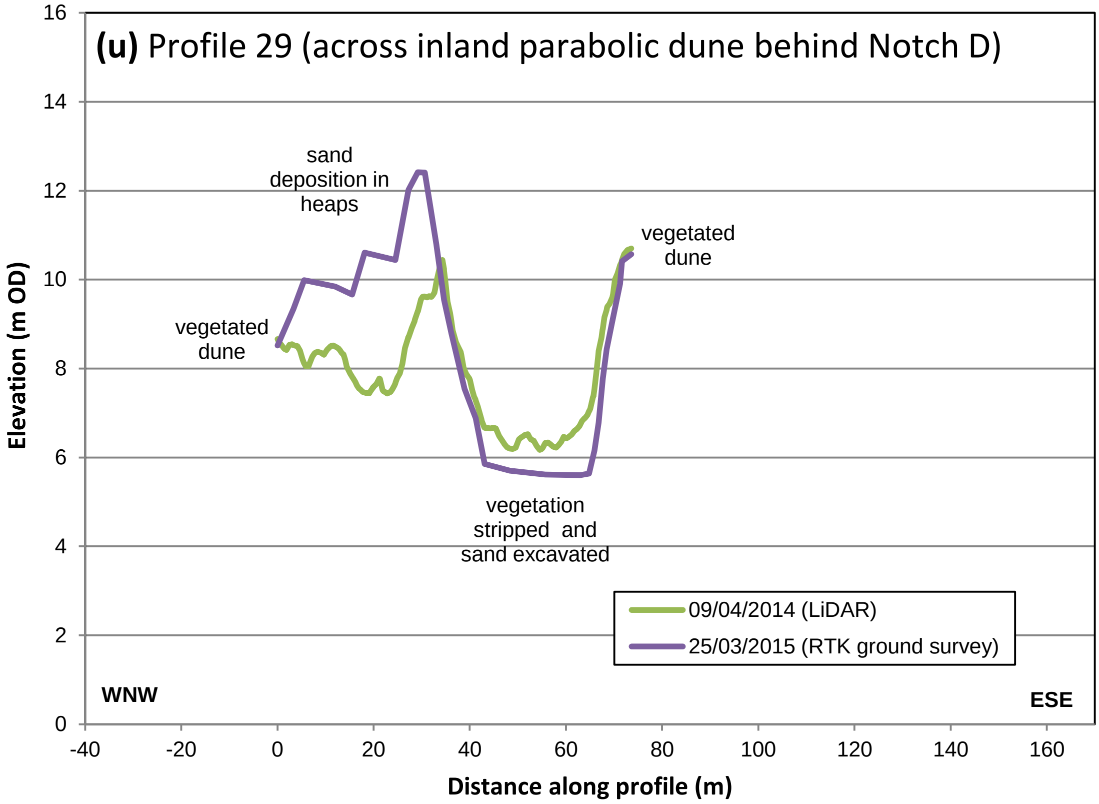


Figure 6 (continued). Comparison of surface levels at profile 29, indicated by LiDAR survey on 9 April 2014 (pre-works) and ground survey on 25 March 2015.

10. Field photographs

Taken 25 - 26 March 2015

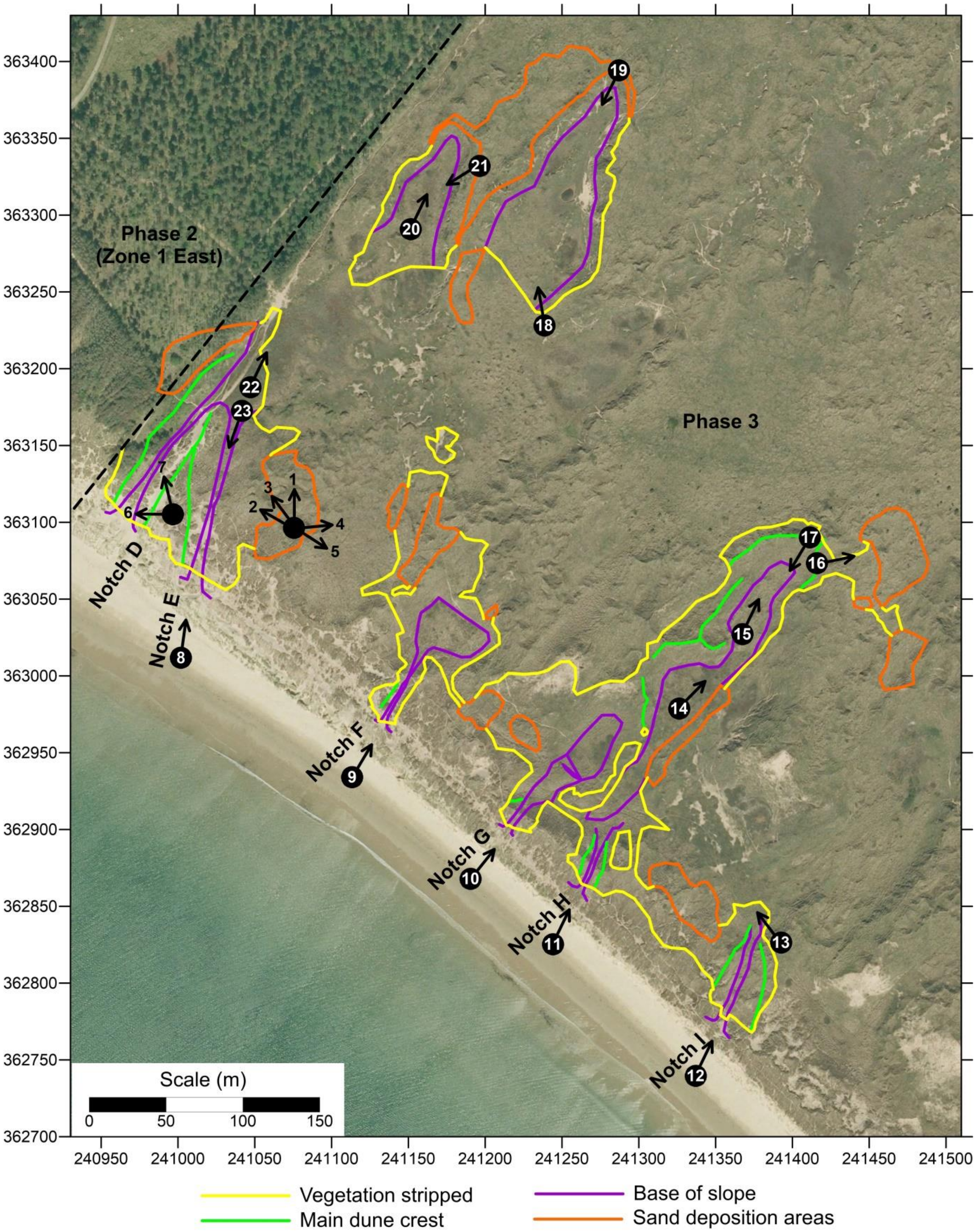
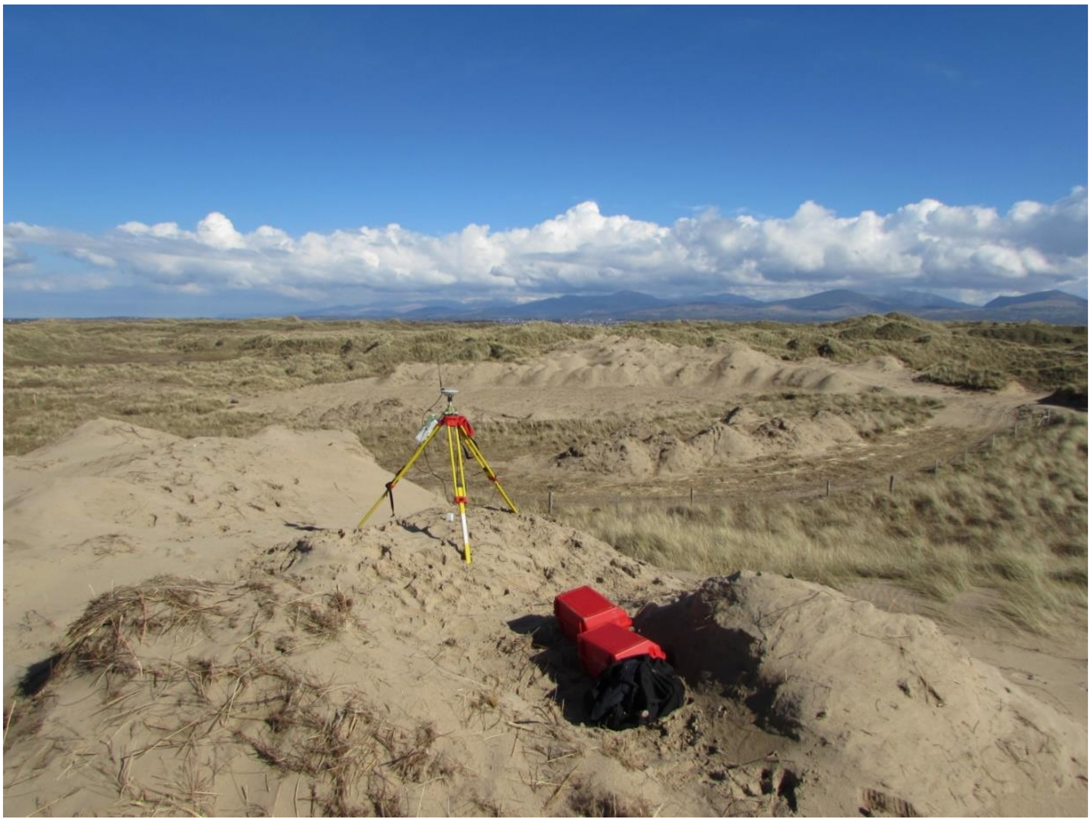


Figure A1. Locations of field photographs 1 to 23 in Phase 3. Arrows indicate direction of view; base 2009 aerial photography

Photograph 1. View across vegetation-stripped area, looking N

Photograph 2. View across vegetation-stripped area and Notch E, looking WNW

Photograph 3. View across vegetation-stripped area, looking NW



Photograph 4. View across vegetation-stripped area, RTK-GPS base station in the foreground, looking E

Photograph 5. View across vegetation-stripped area towards Notch F, looking SE

Photograph 6. View seawards along Notch D, looking W

Photograph 7. View landwards along Notch D, looking N

Photograph 8. View landwards from the beach along the axis of Notch E, looking NNE

Photograph 9. View landwards from the beach along the axis of Notch F, looking NE

Photograph 10. View landwards from the beach along the axis of Notch G, looking NE

Photograph 11. View landwards from the beach along the axis of Notch H, looking NE

Photograph 12. View landwards from the beach along the axis of Notch I, looking NE

Photograph 13. View across vegetation-stripped area behind Notch I, looking NW

Photograph 14. View along deflation trough inland of Notch H, looking NE

Photograph 15. View along deflation trough inland of Notch H, looking NE

Photograph 16. Sand deposition area at the eastern end of the site, looking E

Photograph 17. View seawards from the head of vegetation-stripped parabolic dune, inland of Notch H, looking SW

Photograph 18. View across deflation trough of inland vegetation-stripped parabolic dune, looking N

Photograph 19. View seawards from crest of inland parabolic dune, looking SSW

Photograph 20. View landwards along deflation through of inland parabolic dune, looking NNE


Photograph 21. View seawards from crest of inland parabolic dune, looking SW


Photograph 22. View landwards towards inland vegetation-stripped parabolic dune, looking NE

Photograph 23. View seawards along the axis of Notch E, looking SSW

Data Archive Appendix

Data outputs associated with this project are archived at ‘Topographical Survey of Newborough Dune Rejuvenation project 421, media 1535’ on server–based storage at Natural Resources Wales.

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] An Excel file named (Newborough Warren Survey Data 25-27 March 2015.xlsx) of data points (x,y,z)

[C] A zip file named (Newborough March 2015 profiles.zip) containing excel files of profile data contained within the report.

[D] A zip file named (Newborough March 2015 Phase 3 shapefiles.zip) containing a series of GIS layers on which the maps in the report are based.

Metadata for this project is publicly accessible through Natural Resources Wales’ Library Catalogue http://libcat.naturalresources.wales/webview/ (English Version) and http://libcat.naturalresources.wales/cnc/ (Welsh Version) by searching ‘Dataset Titles’. The metadata is held as record no [115840]

DO NOT DELETE THE SECTION BREAK BELOW

Published by: Natural Resources Wales
Maes y Ffynnon
Penrhosgarnedd
Bangor
LL57 2DW

0300 065 3000

© Natural Resources Wales [2015]

All rights reserved. This document may be reproduced with prior permission of Natural Resources Wales

Further copies of this report are available from the library

Email: library@cyfoethnaturiolcymru.gov.uk