ROADEX
Implementing Accessibility

Northern Periphery Programme 2007–2013
Innovatively investing in Europe's Northern Periphery for a sustainable and prosperous future

European Union
European Regional Development Fund

Alan Drake

GLEN FIDDICH FOREST ROAD
MORAY, SCOTLAND

A Report on a demonstration of the ROADEX method for assessing forest roads on the Glen Fiddich forest road in the Moray & Aberdeenshire Forest District, Moray, Scotland

ABSTRACT

The European Union ROADEX Project 1998 – 2012 was a trans-national roads co-operation that aimed at developing ways for interactive and innovative management of low volume roads across the European Northern Periphery. Its main goals were to facilitate co-operation and research into the common problems of constructing and maintaining low volume roads in harsh climates.

This report gives a summary of a local demonstration of ROADEX methods for assessing forest roads for heavy timber traffic. The work was carried out by the road condition survey team of the Forestry Commission's Civil Engineering Central Services on the Glen Fiddich forest road in the Moray & Aberdeenshire Forest District, Moray, Scotland in October 2010. The assessment was carried out as part of the preparation for an upgrading and strengthening of the road and informed the specification for the planned rehabilitation.

The road was surveyed using the modern non-destructive road survey techniques of video, ground penetrating radar (GPR) and falling weight deflectometer (FWD). Following this an integrated analysis was carried out using Road Doctor software to produce a metre by metre strength assessment of the road. The results were then further analysed by the Forestry Commission by means of a suite of spreadsheets to identify the amount of additional stone required for the road to bring it up to the required strength.

The paper discusses the methods of survey involved, the interpretation of the collected data, the development of assessment methods and the presentation of the resulting information to managers. It includes:

- The initial surveys in October 2010 and their interpretation
- The assessment method
- A design of strengthening works to bring the road up to a standard suitable for harvesting traffic

KEYWORDS

ROADEX, forest roads, assessment, strengthening

PREFACE

This is a final report from Task D3 of the ROADEX "Implementing Accessibility" project, a technical trans-national cooperation project between The Highland Council, Forestry Commission Scotland and the Western Isles Council from Scotland; The Northern Region of The Norwegian Public Roads Administration; The Northern Region of The Swedish Transport Administration and the Swedish Forest Agency; The Centre of Economic Development, Transport and the Environment of Finland; The Government of Greenland; The Icelandic Road Administration; and The National Roads Authority and The Department of Transport of Ireland.

The lead partner of the ROADEX "Implementing Accessibility" project was The Northern Region of The Swedish Transport Administration and the project consultant was Roadscanners Oy from Finland.

This report records a demonstration of the use of ROADEX methods to assess a forest road for heavy timber traffic. The works includes the initial survey, interpretation and assessment, recommendation for strengthening measures, and a follow-up survey with lessons learned. The report was prepared by Alan Drake of the Forestry Commission's Civil Engineering Central Services. Mika Pyhähuhta of Laboratorio Uleåborg designed the graphic layout.

The author would like to express his gratitude to the following persons for their assistance in the work:

- David Killer (Head of Civil Engineering - retired) who inaugurated and steered the Forestry Commission project through the first formative years,
- Timo Saarenketo of Roadscanners who supported David Killer throughout the development of the project and continues to support the author,
- Pekka Maijala of Roadscanners who devised the software modifications for stiffness moduli calculation,
- Gordon McCheyne formerly of Civil Engineering Central Services who devised the Stone Depth analysis spreadsheet procedure,
- Frank MacCulloch, former Head of Civil Engineering and Director Forestry Business Units Forestry Commission, who was an enthusiastic advocate of the project throughout.

ROADEX "Implementing Accessibility" Lead Partner: The Swedish Transport Administration, Northern Region, Box 809, S-971 25 Luleå. Project co-ordinator: Mr. Krister Palo.

CONTENTS

1. INTRODUCTION

1.1. THE ROADEX PROJECT

The ROADEX Project was a technical co-operation between road organisations across northern Europe that aimed to share road related information and research between the partners. The project was started in 1998 as a 3 year pilot co-operation between the districts of Finnish Lapland, Troms County of Norway, the Northern Region of Sweden and The Highland Council of Scotland and was subsequently followed and extended with a second project, ROADEX II, from 2002 to 2005, a third, ROADEX III from 2006 to 2007 and a fourth, ROADEX "Implementing Accessibility" from 2009 to 2012.

Figure 1.1 The Northern Periphery Area and ROADEX Partners

The Partners in the ROADEX "Implementing Accessibility" project comprised public road administrations and forestry organisations from across the European Northern Periphery. These were The Highland Council, The Forestry Commission and the Western Isles Council from Scotland, The Northern Region of The Norwegian Public Roads Administration, The Northern Region of The Swedish Transport Administration and the Swedish Forest Agency, The Centre of Economic Development, Transport and the Environment of Finland, The Government of Greenland, The Icelandic Road Administration, and The National Roads Authority and The Department of Transport of Ireland

The aim of the project was to implement the road technologies developed by ROADEX on to the partner road networks to improve operational efficiency and save money. The lead partner for the project was The Swedish Transport Administration and the main project consultant was Roadscanners Oy of Finland.

The project was awarded NPP funding in September 2009 and held its first steering Committee meeting in Luleå, November 2009.

A main part of the project was a programme of 23 demonstration projects showcasing the ROADEX methods in the Local Partner areas supported by a new pan-regional "ROADEX Consultancy Service" and "Knowledge Centre". Three research tasks were also pursued as part of the project: D1 "Climate change and its consequences on the maintenance of low volume roads", D2 "Road Widening" and D3 "Vibration in vehicles and humans due to road condition".

All reports are available on the ROADEX website at www.ROADEX.org.

1.2. ROADEX DEMONSTRATION PROJECTS

The aim of the ROADEX demonstration projects was to demonstrate the use of ROADEX strategies and technologies locally in the Partner areas to encourage their general use in the Partner offices. Projects were funded and executed by the local Partner offices with design and management support from the ROADEX consultancy service. The demonstration groups were:

- D1 Drainage maintenance guidelines (7 projects planned)
- D2 Road friendly vehicles and tyre pressure control (3 projects planned)
- D3 Forest road policies and maintenance (3 projects planned)
- D4 Rutting, from theory to practice (5 projects planned)
- D5 Roads on Peat (2 projects planned)
- D6 Health and vibration (3 projects planned)

In the event, a greater number of demonstration projects were carried out than planned in the 6 groups. All were delivered within the project timescale and their project reports are available on the ROADEX website at www.roadex.org.

1.3. TASK D3 FOREST ROADS POLICIES AND MAINTENANCE

The aim of the Task D3 projects, "Forest Roads Policies and Maintenance"" was to demonstrate the ROADEX methods of using integrated survey and analysis for assessing of public and forest roads. These forms of integrated methods did not exist before being introduced in the ROADEX pilot project in 1998 but since then have gained increasing popularity in roads districts across the Northern Periphery.

The Forestry Commission had been a Partner in the ROADEX Project since 2002 and had invested heavily in personnel and resources to manage their forest road networks to their maximum potential. A relatively recent innovation has been the introduction of GIS tools to enable improved recording of road data, including usage, construction and maintenance details. This information is needed to create up-to-date databases, improve road planning and justify infrastructure investments on the 30,000 km Forestry Commission forest road network in the UK.

The ROADEX methodologies for assessing forest roads, and the development of new rehabilitation strategies, were a key component in achieving the new direction. As part of its investment in modern technologies, the Forestry Commission established a dedicated 2-man road condition survey team and developed a survey vehicle equipped with state-of-the-art GPR, GPS and video systems following discussions within ROADEX.

Using the new equipment, a full range of GPR interpretation, FWD analysis, stiffness modulus estimation, California Bearing Ratio (CBR) calculation and stone depth analysis techniques were developed over time.

The survey and assessment of the Glen Fiddich Forest Road that follows is a demonstration of the work produced by the Forestry Commission survey team using the ROADEX methods.

2. GENERAL DESCRIPTION OF THE ROAD

2.1. LOCATION

The Glen Fiddich forest block is located some 9 kilometres south of Dufftown in the Moray & Aberdeenshire Forest District of Forest Enterprise, Scotland. The forest road running from east to west through the block was identified as the required timber extraction route for the next felling operation, Figure 2-1

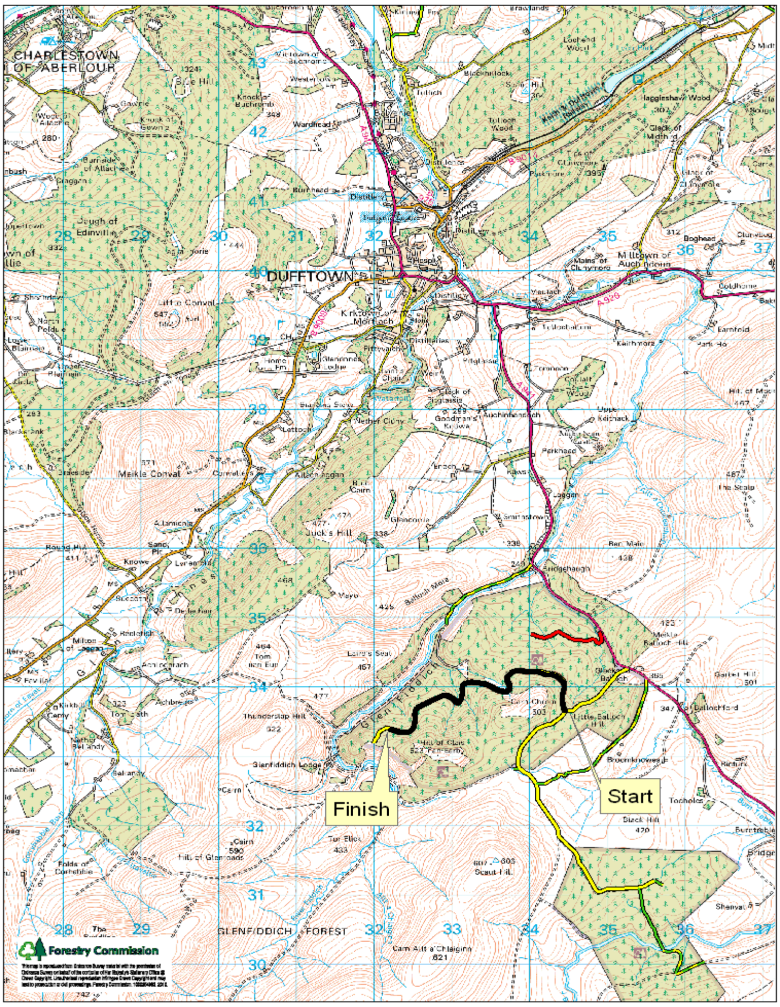


Figure 2-1 Location of the Glen Fiddich forest road

The road was 3622 metres long and is single track throughout its length starting at a Y junction and ending at a turning head. The road centre, edges and roadside drains were overgrown with heather - only the wheel tracks were clear of vegetation.

2.2. THE IMPORTANCE OF THE ROAD

The Glen Fiddich forest road is defined as a Class C forest “other” road within the Forestry Commission’s forest road classification. The full forest road classification comprises:

1. Class A - main roads
2. Class B - spur roads
3. Class C - other roads
4. Unclassified roads

A road is classified as Class C when it is:

- Maintained dependent on usage.
- Not normally used by timber haulage lorries.
- Subject to an individual engineering assessment before each usage.

The surveys and assessments that follow were commissioned to inform the planning of the upgrade and the preparation of the specification.

The local civil engineer was reasonably confident that the Glenfiddich forest road had been constructed purely as a road formation, i.e that it had not had structural layers laid on it. The road was therefore an interesting application of the newly developed stone depth analysis procedure and was expected to show that the entire length would require upgrading. This result would give further confidence in the ROADEX/FC procedure.

2.3. TYPE OF ROAD STRUCTURE

As mentioned above, the road was expected to comprise a simple excavated or graded road formation with a running width of between 3.0m and 3.5m. No formal records existed of the construction details before the surveys but the subgrade was thought to be firm enough to withstand the loads imposed on it by the GPR and FWD tests.

2.4. LANDSCAPE AND TERRAIN

The road was cut into generally sidelong ground with mature forest on both sides as shown in Figure 2-2.

Figure 2-2 Typical photograph of the landscape of the Glen Fiddich forest road

2.5. GROUND CONDITIONS & GEOLOGY ON A GENERAL LEVEL

The geology associated with the road is as shown in Figure 2-3 from the Forestry Commission's in-house record system.

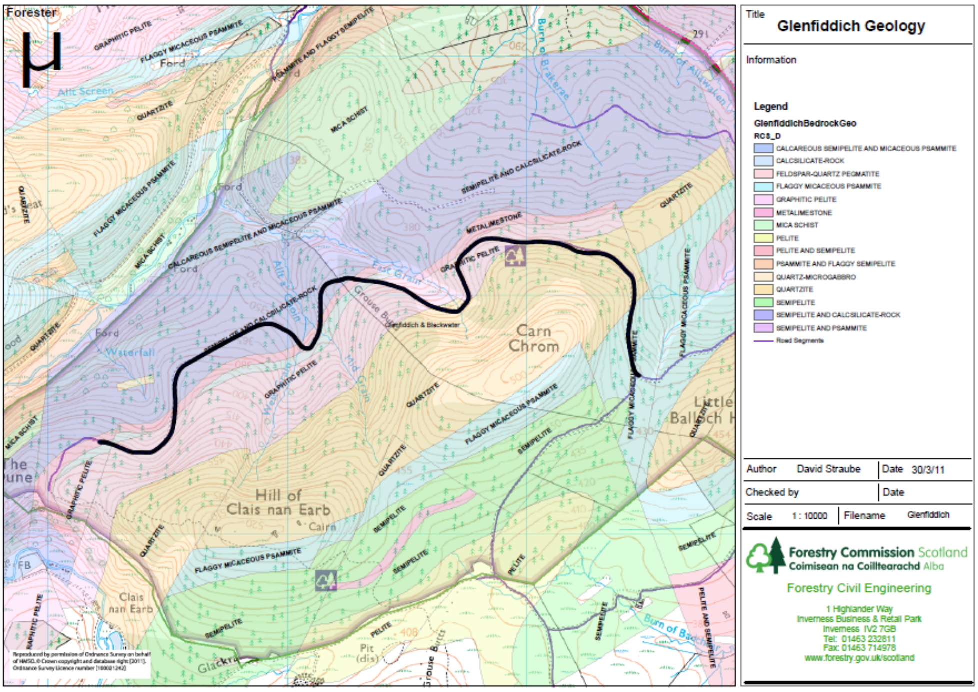


Figure 2-3 Map showing the general geology of the Glen Fiddich forest road

2.6. TYPICAL PROBLEMS OF THE ROAD

There were no significant gradient or geometry issues on the route but as it had never been used for timber haulage (Figure 2-4). The objectives of the surveys were to

1. Establish CBR values for the formation
2. Determine the required depths and total volume of stone to form a suitable pavement
3. Minimise stone production and associated costs

Figure 2-4 Photograph showing typical conditions on the Glen Fiddich forest road in October 2010

3. SURVEYS AND TESTS

3.1. GENERAL

The following surveys of the road were carried out in October 2010 during periods of dry weather.

- a GPR survey using a GSSI SIR-20 unit with a 2GHz air-coupled antenna and a 400 MHz ground-coupled antenna
- a video to record the condition of the surface and the roadside drainage
- an FWD survey

All surveys were linked to GPS to ensure a common base for measurement, and repeatability.

3.2. GROUND PENETRATING RADAR SURVEY, 12 OCTOBER 2010

The GPR and video surveys of the road were carried out by the Forestry Commission's in-house survey team (Fig.3-1).

Figure 3-1 The Forestry Commission Road Condition Survey vehicle

GPR is a non-destructive ground survey method that transmits short pulses of electromagnetic energy through the road structural layers and subgrade soils to determine layer thicknesses. Its main advantage is the continuous profile of layers that it provides along the road section being surveyed. As a result of this GPR is becoming an increasingly important survey tool for the structural assessment of roads.

Once collected, GPR data must be processed with appropriate computer software in order to achieve understandable results. These results can be interpreted in a number of ways in road surveys, e.g. the calculation of the thickness of the pavement and road structure in general, the estimation of subgrade soil types, or the presence of peat or bedrock.

A range of different electromagnetic wavelengths and antenna frequencies can be used in GPR surveys depending on which layers are being surveyed. The 400 MHz antenna has good signal penetration and provides good information on the subgrade soils, whilst the higher frequency of the 2 GHz antenna provides a better resolution of the surface layers. A trained interpreter can generally achieve an accuracy of +/- 10% in thickness surveys provided that the materials in the layers and their respective dielectric values differ to the extent that identifiable reflections are generated. This can be improved to +/- 5 % with reference drill cores or test pits.

A secondary output of a GPR survey is the indication of the roughness of the road. This can be obtained by measuring the "bounce" in the GPR signal time of the air-coupled antenna as it passes along the road. This gives the change in the distance between the antenna and the pavement surface. This "bounce" is shown in the panel for Antenna Elevation in the Road Doctor screen outputs in Section 4.2.

3.3. FALLING WEIGHT DEFLECTOMETER SURVEY, 28 OCTOBER 2010

The falling weight deflectometer (FWD) survey on the road was carried out by URS Scott Wilson Ltd on 28 October 2010 (Fig.2).

Figure 3-2 The Falling Weight Deflectometer Equipment

The FWD is an automated impulse load device that measures deflections in the road surface. These deflections, in the case of a road formation such as with the Glenfiddich road, can give an indication of the bearing capacity along the road as part of the general road assessment. The FWD device consists of a weight that drops from a pre-specified height on to a plate supported by rubber dampers on a circular plate on the road. The drop of the weight is designed to simulate the load produced by a passing heavy vehicle. The system is fully automated and the operator does not need to leave the vehicle in order to carry out the measurements. However, the vehicle does have to stop for each test. The FWD survey for the Glen Fiddich forest road used the standard load of 50 kN falling on to a 300 mm diameter loading plate.

4. PROCESSING AND INTERPRETATION

4.1. METHOD

All GPR, FWD and video data collected in the surveys was synchronised, processed and interpreted by the Forestry Commission team with Road Doctor Pro® software. Map data was imported from ArcGIS using GPS co-ordinates.

The GPR results confirmed that there were no road construction layers on the alignment and that the District Engineer's "formation-only" assumption had proved to be correct.

Road Doctor software calculated the stiffness modulus of the subgrade at 50 metre intervals (the spacing of the FWD tests) by analysing the FWD deflection bowls. The modulus values were then exported into the spreadsheet and converted into CBR values using the formula $E = 17.6 \times CBR^{0.64}$ MPa. ("*Interim Advice Note 73/06, Revision 1 (2009) - Design Guidance for Road Pavement Foundations*"). This formula has been found to be particularly relevant to UK soil conditions however in the rest of Europe, an alternative, and commonly used, relationship for the subgrade modulus is $E_{sg} = 10.3 \times CBR$)

The required total depth of roadstone for each CBR value was then found by reference to the undernoted Table 3.1 abstracted from the Forestry Commission's Civil Engineering Handbook.

Table 3.1 Forestry Commission Design Thickness Table
"An indication of required total pavement thickness for given CBR values"

CBR	Design Thickness	CBR	Design Thickness
0	850 min	11	240
1	850 min	12	230
2	700	13	220
3	550	14	210
4	475	15	200
5	425	16	190
6	375	17	180
7	325	18	170
8	300	19	160
9	275	20	150
10	250	>20	150

These depths were then inserted into Table 3.2 "Glen Fiddich forest road, design of structural layers" prior to moving on to the next stage of determining the amount of stone required for the rehabilitation.

Unlike other analyses carried out by the Forestry Commission, the Glenfiddich forest road was a formation road only and as a result road aggregates were required throughout its length to bring it up to a standard suitable for harvesting operations.

Table 3.2 Glen Fiddich forest road, design of structural layers

Distance (m)	X-coord (m)	Y-coord (m)	Z-coord (m)	Formation Stiffness (MPa)	CBR	CBR Rounding	Design Aggregate Depth (mm)		**CBR**	**Design Thickness**
0	334471.312	833661.904	433.639	76	9.83	10.0	250		0	850
1	334470.925	833662.127	433.639	76	9.83	10.0	250		1	850
2	334470.134	833662.675	433.639	76	9.83	10.0	250		2	700
3	334469.334	833663.26	433.639	76	9.83	10.0	250		3	550
4	334468.513	833663.815	433.639	76	9.83	10.0	250		4	475
5	334467.694	833664.372	433.639	76	9.83	10.0	250		5	425
6	334466.908	833664.975	433.639	76	9.83	10.0	250		6	375
7	334466.121	833665.577	433.639	76	9.83	10.0	250		7	325
8	334465.381	833666.232	433.639	76	9.83	10.0	250		8	300
9	334464.681	833666.933	433.639	76	9.83	10.0	250		9	275
10	334463.981	833667.634	433.639	76	9.83	10.0	250		10	250
11	334463.306	833668.359	433.639	76	9.83	10.0	250		11	240
12	334462.65	833669.101	433.639	76	9.83	10.0	250		12	230
13	334461.994	833669.843	433.639	76	9.83	10.0	250		13	220
14	334461.347	833670.593	433.639	76	9.83	10.0	250		14	210
15	334460.728	833671.366	433.639	76	9.83	10.0	250		15	200
16	334460.108	833672.139	433.639	76	9.83	10.0	250		16	190
17	334459.489	833672.912	433.639	76	9.83	10.0	250		17	180
18	334458.924	833673.725	433.639	76	9.83	10.0	250		18	170
19	334458.392	833674.56	433.639	76	9.83	10.0	250		19	160
20	334457.86	833675.396	433.639	76	9.83	10.0	250		20	150
21	334457.327	833676.231	433.639	76	9.83	10.0	250		>20	150
22	334456.795	833677.066	433.639	76	9.83	10.0	250			
23	334456.263	833677.902	433.639	76	9.83	10.0	250			
24	334455.73	833678.737	433.639	76	9.83	10.0	250			
25	334455.198	833679.573	433.639	76	9.83	10.0	250			
26	334454.727	833680.442	433.639	7	0.24	0.0	850			
27	334454.306	833681.339	433.639	7	0.24	0.0	850			
28	334453.886	833682.236	433.639	7	0.24	0.0	850			
29	334453.465	833683.133	433.639	7	0.24	0.0	850			
30	334453.052	833684.033	433.639	7	0.24	0.0	850			
31	334452.674	833684.949	433.639	7	0.24	0.0	850			
32	334452.296	833685.864	433.639	7	0.24	0.0	850			
33	334451.917	833686.78	433.639	7	0.24	0.0	850			
34	334451.541	833687.696	433.639	7	0.24	0.0	850			
35	334451.184	833688.62	433.639	7	0.24	0.0	850			
36	334450.827	833689.544	433.639	7	0.24	0.0	850			
37	334450.47	833690.468	433.639	7	0.24	0.0	850			
38	334450.115	833691.393	433.639	7	0.24	0.0	850			
39	334449.802	833692.333	433.639	7	0.24	0.0	850			
40	334449.489	833693.273	433.639	7	0.24	0.0	850			
41	334449.176	833694.213	433.639	7	0.24	0.0	850			
42	334448.864	833695.153	433.639	7	0.24	0.0	850			
43	334448.565	833696.098	433.639	7	0.24	0.0	850			
44	334448.266	833697.042	433.639	7	0.24	0.0	850			
45	334447.967	833697.986	433.639	7	0.24	0.0	850			
46	334447.668	833698.931	433.639	7	0.24	0.0	850			
47	334447.431	833699.893	433.639	7	0.24	0.0	850			
48	334447.199	833700.856	433.639	7	0.24	0.0	850			
49	334446.967	833701.819	433.639	7	0.24	0.0	850			
50	334446.735	833702.782	433.639	7	0.24	0.0	850			
51	334446.492	833703.742	433.639	7	0.24	0.0	850			
52	334446.239	833704.7	433.639	7	0.24	0.0	850			
53	334445.986	833705.658	433.639	7	0.24	0.0	850			
54	334445.732	833706.615	433.639	7	0.24	0.0	850			
55	334445.479	833707.573	433.639	7	0.24	0.0	850			
56	334445.257	833708.538	433.639	7	0.24	0.0	850			
57	334445.034	833709.504	433.639	7	0.24	0.0	850			
58	334444.812	833710.469	433.639	7	0.24	0.0	850			
59	334444.589	833711.434	433.639	7	0.24	0.0	850			
60	334444.377	833712.402	433.639	7	0.24	0.0	850			
61	334444.184	833713.374	433.639	7	0.24	0.0	850			
62	334443.99	833714.345	433.639	7	0.24	0.0	850			
63	334443.797	833715.317	433.639	7	0.24	0.0	850			
64	334443.603	833716.288	433.639	7	0.24	0.0	850			
65	334443.422	833717.262	433.639	7	0.24	0.0	850			
66	334443.25	833718.238	433.639	7	0.24	0.0	850			
67	334443.078	833719.213	433.639	7	0.24	0.0	850			
68	334442.906	833720.189	433.639	7	0.24	0.0	850			
69	334442.734	833721.165	433.639	7	0.24	0.0	850			
70	334442.564	833722.14	433.639	7	0.24	0.0	850			
71	334442.398	833723.117	433.639	7	0.24	0.0	850			
72	334442.233	833724.094	433.639	7	0.24	0.0	850			
73	334442.067	833725.071	433.639	7	0.24	0.0	850			
74	334441.901	833726.047	433.639	7	0.24	0.0	850			
75	334441.736	833727.024	433.639	7	0.24	0.0	850			
76	334441.562	833727.999	433.639	9	0.35	0.0	850			
77	334441.385	833728.974	433.639	9	0.35	0.0	850			
78	334441.208	833729.949	433.639	9	0.35	0.0	850			
79	334441.032	833730.923	433.639	9	0.35	0.0	850			
80	334440.855	833731.898	433.639	9	0.35	0.0	850			

4.2 DEPTHS & TOTAL VOLUME CALCULATION

This stage of the process normally identifies those sections of the road which need additional stone and thereafter calculate the average depth of surfacing required for each section of road.

In the case of the Glenfiddich road however, the whole road required upgrading to bring it up to an acceptable standard for trafficking by heavy haulage. The following Stone Depth Analysis sets out the procedure followed:

Table 4-1 Summary of sections requiring upgrading

Total road length surveyed	3622	m
Total road length requiring additional stone	3622	m
Total volume of stone needed	7622	m³

Table 4-2 Summary of the Stone Depth Analysis

Distance (m)		Length (m)	Design depth (mm)	Depth of Stone required (mm)	Volume (m³)
Start	End				
0	25	25	250	250	21.9
25	125	100	850	850	297.5
125	175	50	300	300	52.5
175	325	150	850	850	446.3
325	375	50	300	300	52.5
375	425	50	850	850	148.8
425	475	50	275	275	48.1
475	675	200	850	850	595.0
675	725	50	375	375	65.6
725	775	50	850	850	148.8
775	875	100	250	250	87.5
875	1025	150	850	850	446.3
1025	1075	50	425	425	74.4
1075	1125	50	325	325	56.9
1125	1175	50	300	300	52.5
1175	1225	50	550	550	96.3
1225	1275	50	850	850	148.8
1275	1325	50	550	550	96.3
1325	1375	50	250	250	43.8
1375	1425	50	200	200	35.0
1425	1475	50	250	250	43.8
1475	1525	50	230	230	40.3
1525	1625	100	850	850	297.5
1625	1675	50	325	325	56.9
1675	1725	50	300	300	52.5
1725	1775	50	375	375	65.6
1775	1825	50	275	275	48.1
1825	1875	50	475	475	83.1
1875	1925	50	550	550	96.3
1925	1975	50	150	150	26.3
1975	2225	250	850	850	743.8
2225	2275	50	325	325	56.9
2275	2335	60	850	850	178.5

2335	2425	90	550	550	173.3
2425	2575	150	850	850	446.3
2575	2628	53	700	700	129.9
2628	2703	75	425	425	111.6
2703	2775	72	550	550	138.6
2775	2975	200	850	850	595.0
2975	3025	50	550	550	96.3
3025	3085	60	850	850	178.5
3085	3135	50	250	250	35.0
3125	3175	50	850	850	148.8
3175	3225	50	425	425	74.4
3225	3275	50	325	325	56.9
3275	3325	50	550	550	96.3
3325	3375	50	275	275	48.1
3375	3425	50	425	425	74.4
3425	3475	50	300	300	52.5
3475	3525	50	425	425	74.4
3525	3622	97	850	850	288.6
Totals		**3622**			**7622.2**

Table 4-2 has been prepared using the following “rules”:

1. Additional stone depths of less than 10 mm have been disregarded.
2. Additional stone depths of between 10 and 50 mm have been rounded up to 50 mm.
3. Road width used for volume calculation = 3.5 m

4.3 MAP REPRESENTATION OF RESULTS

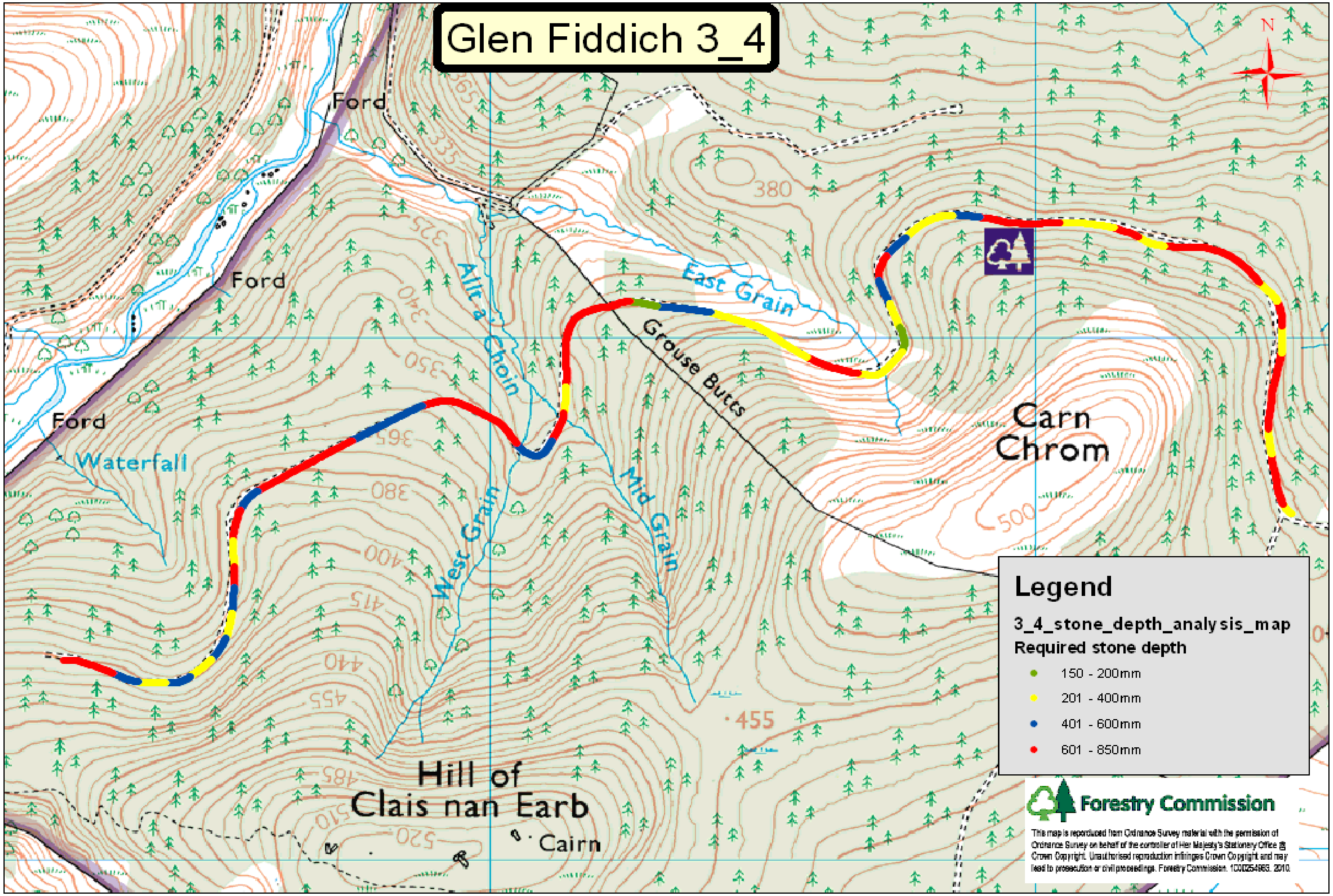
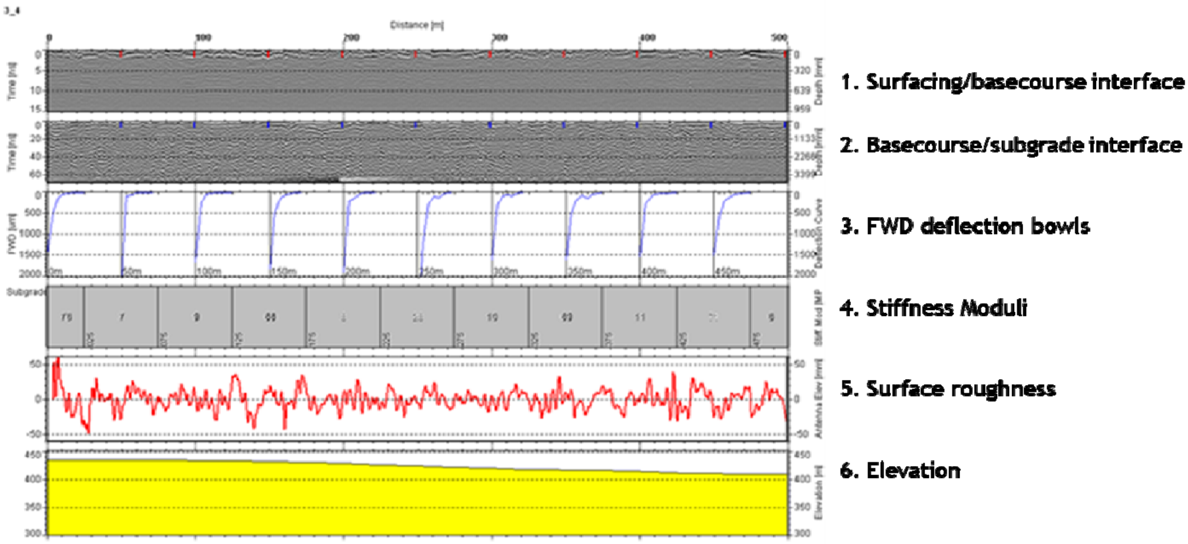


Figure 4-1 Map of Glen Fiddich forest road showing the survey route and the depths of additional stone required

4.4 INTERPRETATION AND SCREEN OUTPUTS

The screen outputs that follow on pages 18-21 are pictorial representations of the Road Doctor outputs for each consecutive 500m length of road. From the top, the panels in the screen are as follows:

1. 2GHz GPR data – no evidence of surfacing
2. 400MHz data – no evidence of a pavement/subgrade interface
3. Falling weight deflectometer deflection bowls
4. Calculated subgrade stiffness moduli
5. Surface roughness
6. Elevation above sea level from GPS

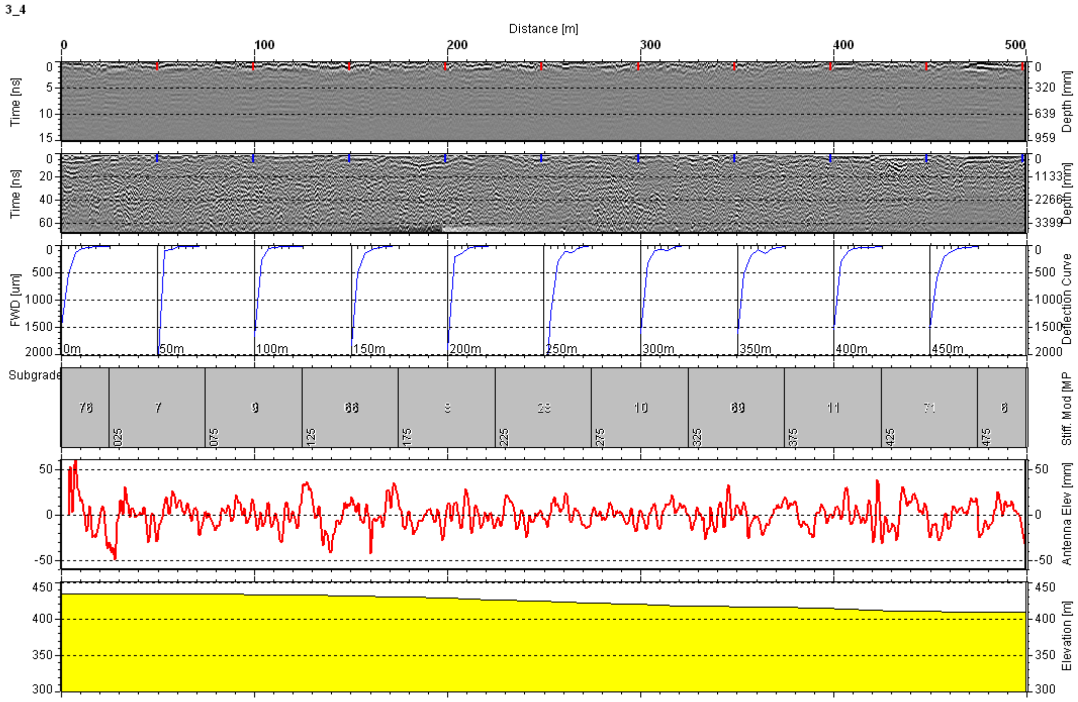


Road Doctor screen output

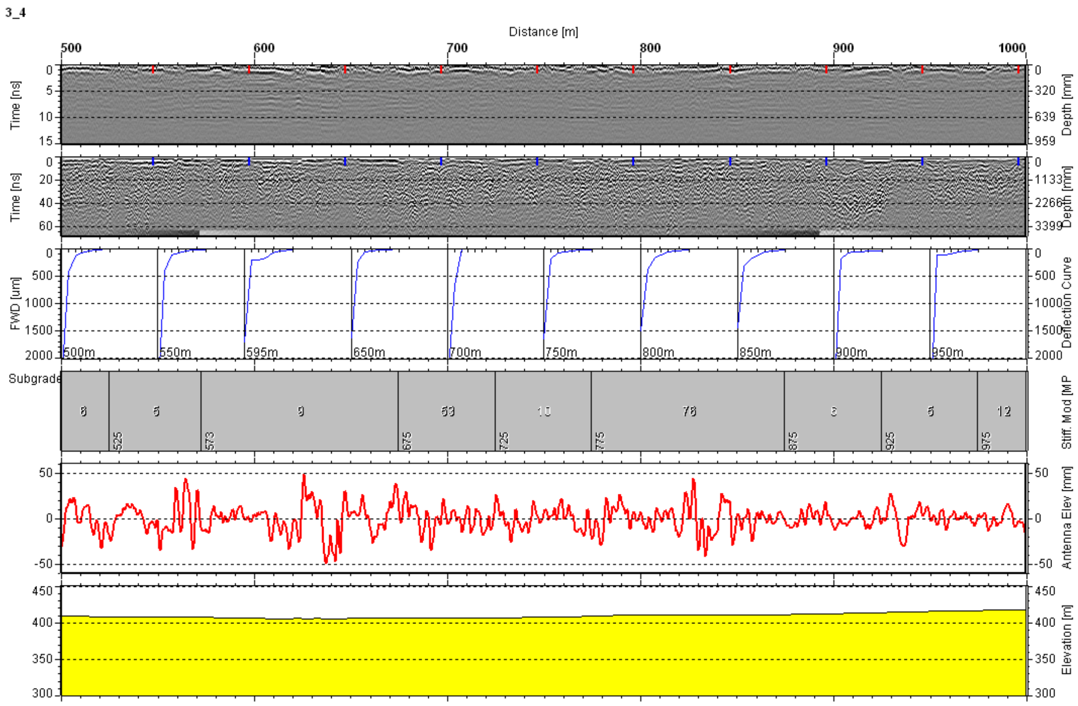
Panel 5, “surface roughness” data is the record of the “bounce” of the 2 GHz antenna as the survey vehicle passes along the road. This equates reasonably well to values established by the International Roughness Index. This can identify those areas of the surface in need of grading.

Panel 6, the elevation above sea level is the GPS “z” co-ordinate and gives an indication of the longitudinal profile of the road.

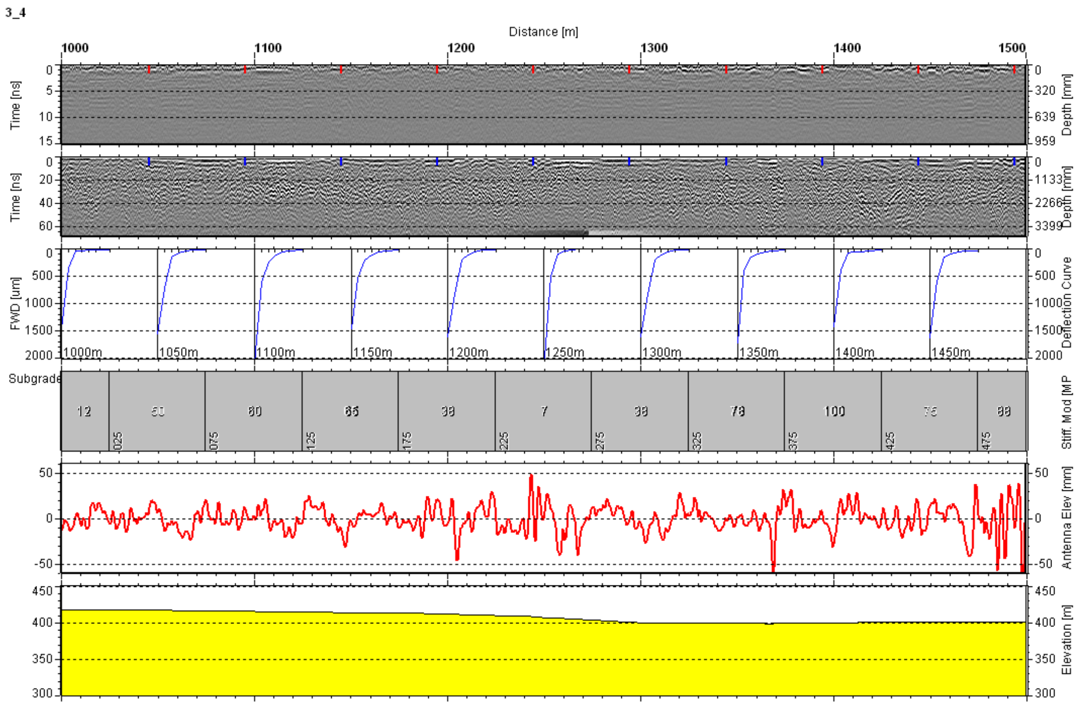
Road Doctor screen outputs for the Glen Fiddich forest road:



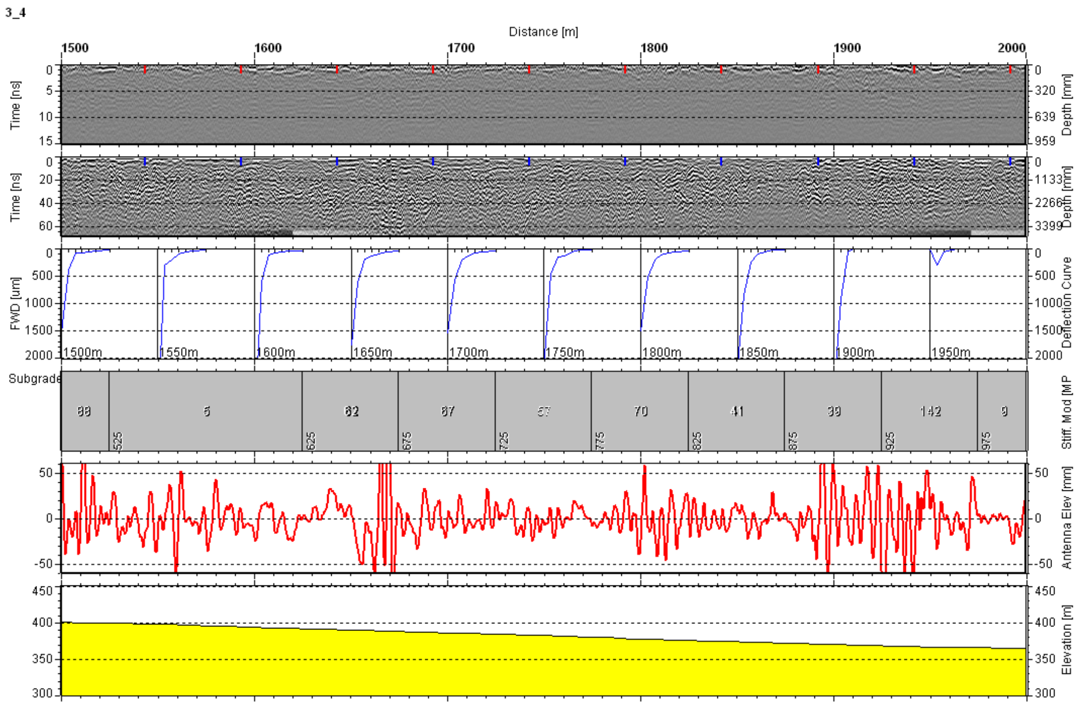
0 – 500m



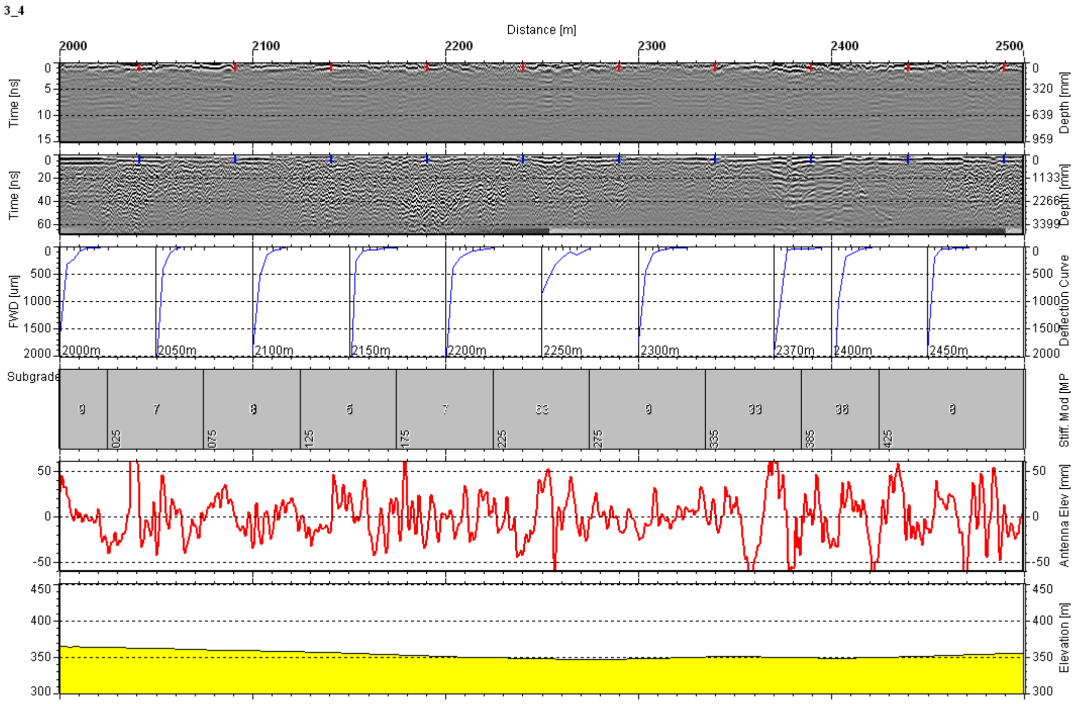
500 – 1000m



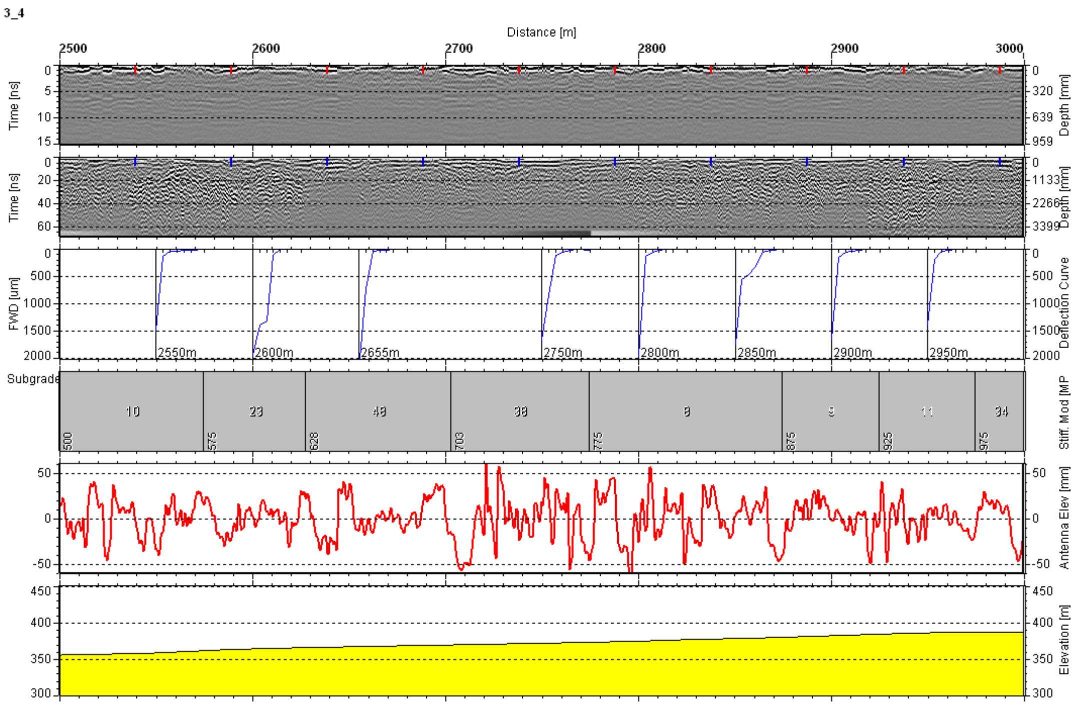
1000 – 1500m



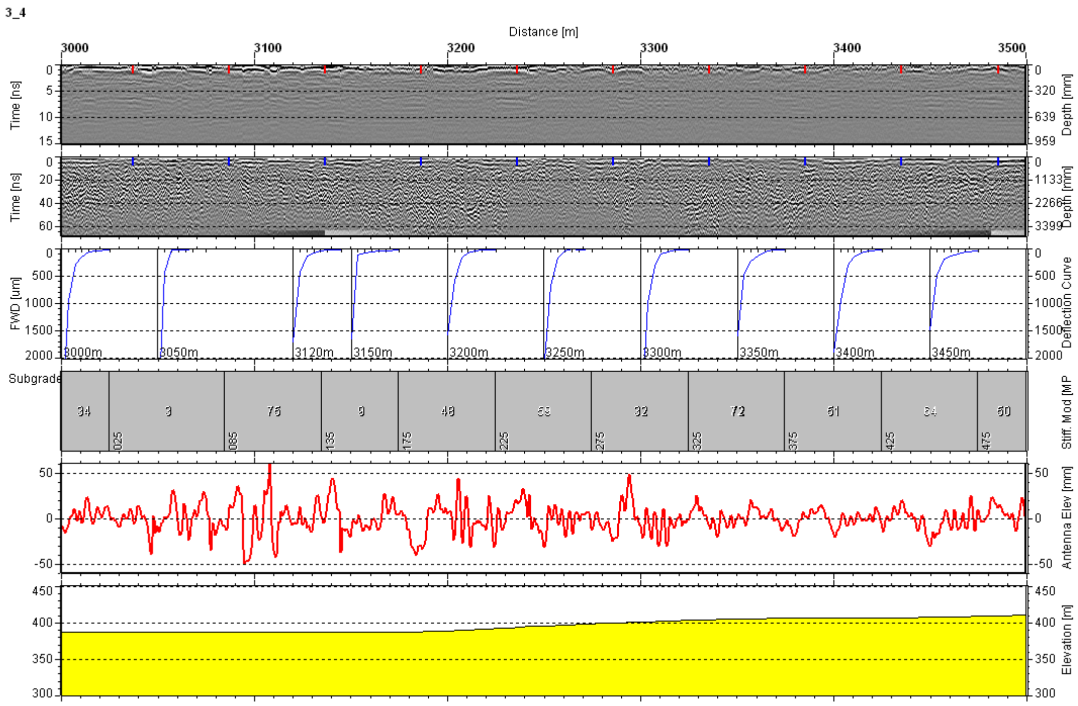
1500 – 2000m



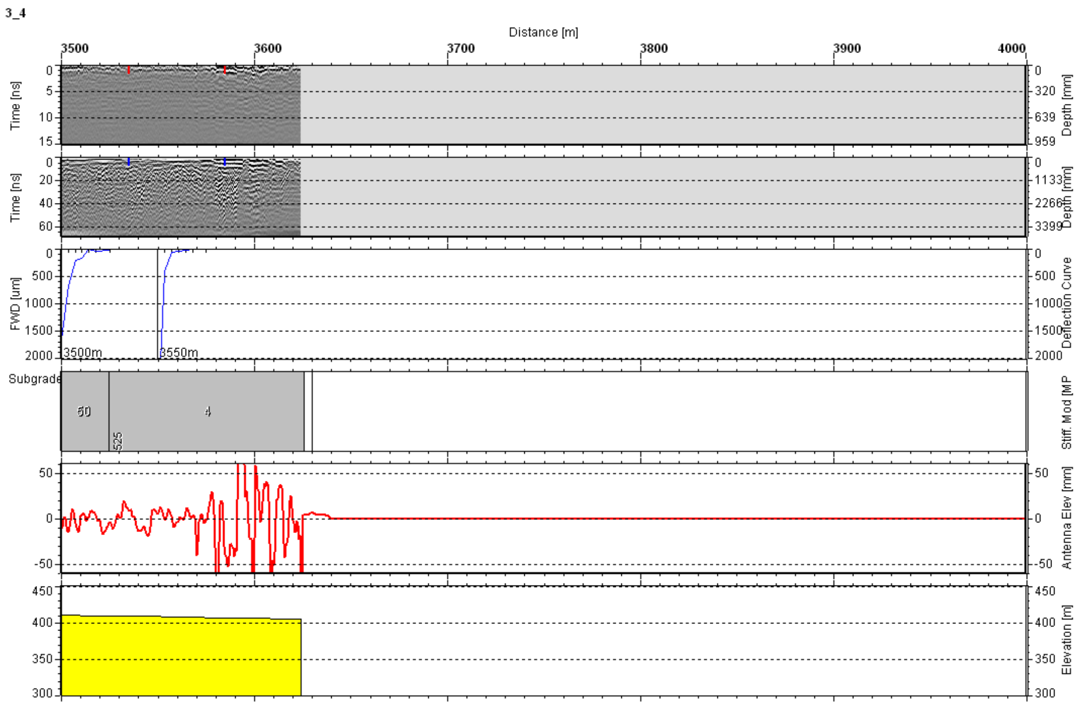
2000 – 2500m



2500 – 3000m



3000 – 3500m



3500 – 3622m

5. CONCLUSIONS

The Stone Depth analysis procedure developed by ROASDEX and the Forestry Commission has been proven to work on existing forest roads over a number of previous projects. A typical example of the use of the method was published by ROADEX in 2011 under the title of "The Gleann Mor Forest Road". The ROADEX report on the project is available on the ROADEX website at www.roadex.org.

The method first uses the ROADEX method of assessing roads to identify the locations of weak sections of road and thereafter uses an in-house Forestry Commission spreadsheet to calculate the volumes of additional stone required based on measured subgrade CBR values.

The Glen Fiddich forest road comprised an old road formation that had not yet had structural layers laid. It was considered to offer a suitable opportunity for evaluating if the ROADEX method could be used as a design tool for a simple road formation.

The ROADEX method of road risk assessment and the Forestry Commission stone depth analysis procedure were applied to the Glenfiddich forest road in the standard fashion. This identified that the formation CBR values required additional stone along the entire length of the road to bring it up to a standard suitable for heavy haulage operations.

It can be concluded that the ROADEX road assessment method and the Forestry Commission stone depth analysis can be a useful tool in assessing the bearing capacity of an existing formation and identifying the additional stone layers required. This assumes that the formation is stiff enough to be tested by FWD.

ROADEX
Implementing Accessibility

ROADEX PROJECT REPORTS (1998–2012)

This report is one of a suite of reports and case studies on the management of low volume roads produced by the ROADEX project over the period 1998-2012. These reports cover a wide range of topics as below.

- Climate change adaptation
- Cost savings and benefits accruing to ROADEX technologies
- Dealing with bearing capacity problems on low volume roads constructed on peat
- Design and repair of roads suffering from spring thaw weakening
- Drainage guidelines
- Environmental guidelines & checklist
- Forest road policies
- Generation of 'snow smoke' behind heavy vehicles
- Health issues raised by poorly maintained road networks
- Managing drainage on low volume roads
- Managing peat related problems on low volume roads
- Managing permanent deformation in low volume roads
- Managing spring thaw weakening on low volume roads
- Monitoring low volume roads
- New survey techniques in drainage evaluation
- Permanent deformation, from theory to practice
- Risk analyses on low volume roads
- Road condition management of low volume roads
- Road friendly vehicles & tyre pressure control
- Road widening guidelines
- Socio-economic impacts of road conditions on low volume roads
- Structural innovations for low volume roads
- Treatment of moisture susceptible materials
- Tyre pressure control on timber haulage vehicles
- Understanding low volume pavement response to heavy traffic loading
- User perspectives on the road service level in ROADEX areas
- Vehicle and human vibration due to road condition
- Winter maintenance practice in the Northern Periphery

All of these reports, and others, are available for download free of charge from the ROADEX website at www.ROADEX.org.