Annele Matintupa, Seppo Tuisku

SUMMARY OF DRAINAGE ANALYSIS IN IRELAND, ROADS N56 AND N59

Demonstration Project Report

ABSTRACT

Drainage is one of the most important factors to be kept in mind in road design and maintenance projects. It is accepted generally that road structures work well and last longer in dry conditions. Researches have shown that that poor drainage is often the main cause of road damages and problems with long term road serviceability. This knowledge however has not always been applied in practice with the result that the general drainage condition of the road networks is not good. Previous ROADEX projects have reported that poor drainage is the one of the biggest problems for Northern European rural roads, and parts of the main road network. Drainage improvement, and maintaining the drainage in a good condition has therefore a major effect in reducing the rate of deterioration of roads and ROADEX research has shown that drainage improvement measures can increase pavement lifetimes by 1.5-2.0 times. Drainage measures are thus very profitable and offer major savings in annual paving costs.

A drainage analysis methodology has been developed in ROADEX to locate those critical road sections needing drainage improvement and regular maintenance. In the analysis, data is collected from all of the important factors that affect the road drainage condition. After this data has been analysed, classified and reported, the critical road sections can be awarded a special drainage maintenance class for use in maintenance contracts. Drainage analysis can be carried out on both paved and gravel road networks. The survey results are reliable and repeatable and allow the current drainage condition of the road network to be monitored.

Demonstrations of the ROADEX drainage analysis were carried out on roads N56 and N59 in Ireland. The total length of the roads analysed was approximately 438km. The demonstrations showed that, compared to Nordic countries, Ireland has different drainage features, such as grass verges and a lack of traditional open ditches. These make the improvement of drainage more difficult. In renewed road sections however the existing drainage works well and usually open ditches have been provided. In general the drainage condition of road N56 is in slightly better condition than in road N59. The drainage classes and verge classes correlate very well with roughness (IRI) and rut depth values. It was found that the poorer the drainage or verge class, the bigger the IRI and rut depth values. Rut depths were found to be almost two times higher in road sections with drainage Class 3 than in road sections with drainage Class 1. The biggest problems were found to be located in road cuttings but their relative length was small.

KEYWORDS
Drainage, analysis, verge, pavement, life time, rutting, IRI

PREFACE

In September 2010 Roadscanners Oy carried out drainage analysis field surveys on roads N56 and N59 in western Ireland. The goal was to demonstrate the ROADEX drainage analysis technique and guidelines on the Irish road network.

The field measurements were performed by Seppo Tuisku with the help of PMS Pavement Management Services Ltd. Stephen Craven from PMS Ltd assisted in the field surveys. The drainage analysis technique was also demonstrated to Eoin Greaney and Michael Jordan of PMS Ltd. Vincent O'Boyle from Mayo County Council accompanied the road surveys in County Mayo.

The processing and analysis of the measured data was carried out by Seppo Tuisku. This report was jointly written by Seppo Tuisku and Annele Matintupa. Timo Saarenpää and Pekka Maijala from Roadscanners Oy helped with the handling of the roughness and rutting data supplied by the clients. Timo Saarenketo steered the demonstrations as lead manager of the ROADEX D1 “Drainage Maintenance Guidelines” group. Ron Munro helped with the demonstration arrangements and also checked the language. Mika Pyhähuhta from Laboratorio Uleåborg designed the report layout.

All of the work carried out in this project was made in close cooperation with personnel from Donegal and Mayo County Councils. The authors would specially like to thank and acknowledge the assistance given by Michael Mongan and Michael Lyons of Mayo CC, and James Boyle and Brian Burke of Donegal CC. Without their help and support it would not have been possible to complete the work.

Finally the authors would like to thank the ROADEX IV Project Steering Committee for their guidance and encouragement in the work.

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CONTENTS

1. INTRODUCTION

1.1 THE ROADEX PROJECT

The ROADEX Project is a technical co-operation between road organisations across northern Europe that aims 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 Finland 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 IV from 2009 to 2013.

Figure 1: The Northern Periphery Area and ROADEX IV partners.

The Partners in ROADEX IV “Implementing Accessibility” comprised public road administrations and forestry organisations from across the European Northern Periphery. These were The Highland Council, Forestry Commission Scotland and Comhairle Nan Eilean Siar 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.

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 pursued as part of the project: “Climate change and its consequences on the maintenance of low volume roads”, “Road Widening” and “Vibration in vehicles and humans due to road condition”.

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

1.2 THE DEMONSTRATION PROJECTS

Twenty three demonstration projects were planned within the ROADEX IV project. Their goal was to take selected technologies developed by ROADEX out on to the local road networks to have them physically used in practice to show what they could achieve. The projects were funded locally by the local Partners, designed and supervised by local staff, and supported by experts from the ROADEX consultancy.

The demonstrations were managed in 6 groups by a nominated lead manager from ROADEX:

D1 - “Drainage Maintenance Guidelines”

D2 - “Road friendly vehicles and Tyre Pressure Control”

D3 - “Forest Road policies”

D4 - “Rutting, from theory to practice”

D5 - “Roads on Peat”

D6 - “Health and Vibration”

This report deals with the two demonstrations projects in the D1 “Drainage Maintenance Guidelines” group carried out in the Counties of Donegal and Mayo in Ireland.

2. ROADS SURVEYED

Drainage analysis surveys were carried out on the national secondary roads N56 and N59 on the west coast of Ireland. The sections of roads surveyed are shown in the maps in Figures 2 and 3.

- Road N56 runs from Donegal town to Letterkenny and is 156 km long. This road was selected for a demonstration of a full drainage survey and a rehabilitation plan.
- Road N59 commences in County Sligo, south of Sligo Town and circles around the west of Ireland, passing west from Sligo into County Mayo. The road then continues on to Westport and then through Maam Cross to Oughterard, from where it proceeds southeast to Galway city, a total length of 297 km. This road was selected for a full field survey and statistical analysis.

Figure 2: Surveyed road N56.

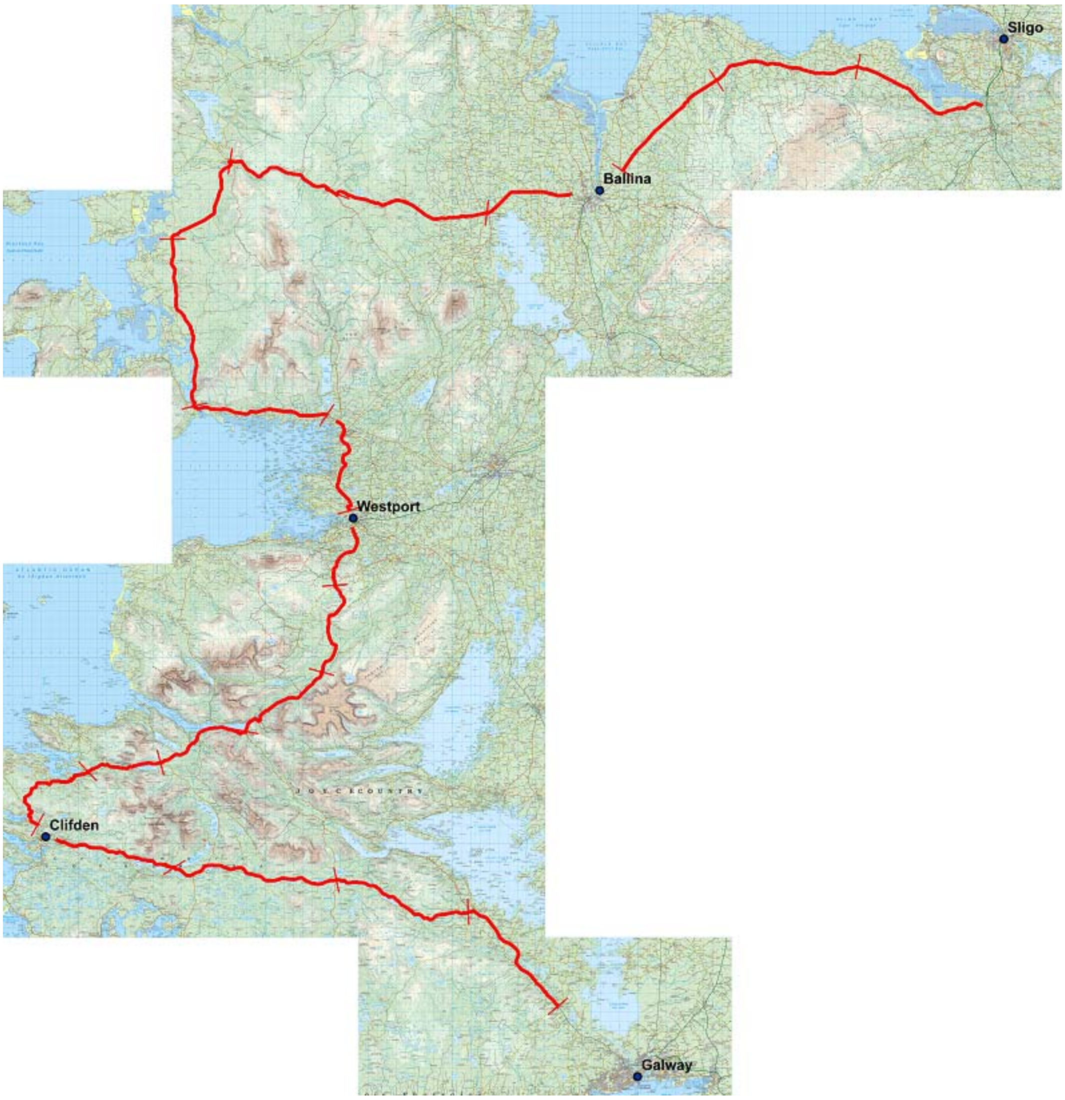

Figure 3: Surveyed road N59.

The N56 and N59 are fairly busy roads, with some sections having noticeably less traffic. The landscape and terrain along the roads is very variable. Generally the roads are coastal on side sloping ground. The subgrade soil type varies along both routes and there is substantial amount of peat soils.

3. DATA COLLECTION, FIELD SURVEYS

The data collection for the two demonstration projects was carried out in September 2010. Surveys started from Galway on the N59 road to County Sligo and then continued on road N56 from Donegal to Letterkenny. The total length of the survey in N59 was 285,950 m from a bridge in Ballysadare to the Forest Hills intersection near Galway. The N56 road was surveyed from the N15 roundabout in Donegal to the “Mountain Top” roundabout in Letterkenny. The total length surveyed on the N56 was 151,770 m.

The weather during the surveys varied from heavy rain to sunshine. Only two days were rain free, but overall only one day was abandoned because of heavy rain.

Prior to the commencement of the surveys both roads were divided into sub sections. The section lengths varied between 10-20 kilometres, with a couple of sections less than 10 km. Junctions and bridges were used as section break points as they were easy to locate during measurements.

Drainage analysis in the field was carried out on one road section at a time and both sides of the road were analysed separately. PMS Pavement Management Services Ltd office at Athenry provided the vehicle for the survey and a CamLink video-logging system by Roadscanners Oy was installed on the van roof (Figure 4). The driving speed during the data collection was about 30 km/h and the van was driven close to road shoulder so that the video cameras had the best possible view of the ditch and roadside. An APD Communications INCA 2 GPS device was used for GPS positioning. All data was linked to GPS coordinates using Road Doctor CamLink software.

Figure 4: The PMS survey vehicle used in the project. Video cameras were placed in the orange CamLink box for shelter from the rain and dust. .

Two digital video cameras were used in the survey, one camera for the road view and the second camera to record the ditch. The system has also an option to use a third camera to record the condition of outlet ditches but it was decided not to use this as the vegetation was blocking the view. The road camera view proved very useful in the surveys, especially where roadside vegetation blocked the view of the ditch camera.

A Panasonic Toughbook laptop was used to record the video data from the cameras and the classification of the drainage data. Preliminary classifications were directly recorded using the pc keyboard. Audio comments in the vehicle were also recorded to assist data interpretation in the office. These audio comments were mainly about soil type, presence of ditches and their condition, and to correct any mistakes in classifications made with the keyboard.

Figure 5: The laptop used in the drainage analysis project. The coloured pieces of paper helped to choose the right keys during the survey.

4. DRAINAGE ANALYSIS

4.1. GENERAL

Road drainage systems in Ireland differ fairly significantly from Nordic countries where the ROADEX drainage survey method was originally developed. The main difference is that in the older sections open ditches are quite rare. This makes improvement of drainage that more difficult. In the most demanding sections French drains, or storm water piped drains, are used to take care of the drainage. In most parts these arrangements are still working well, but in some cases they were blocked or just inadequate. The drainage in upgraded sections of road appeared to be working well. Usually these had open ditches.

4.2. TYPICAL DRAINAGE PROBLEMS

The majority of the severe drainage problems in Ireland appear to occur in the same kind of circumstances as in Nordic countries. A good example of this is the road section located on side sloping ground. If the ditch is not in good condition in the upper side of the road problems will most likely occur. A few “local” drainage problems were noticed on the N56 and N59 that are not so common in Nordic countries but are quite common in Ireland, and Scotland. Descriptions of some of these are described in the following.

4.2.1. Verges

Verges are very common on the N56 and N59, and there use is widespread on the Irish road network. An example of an extremely high verge is shown in Figure 6. Verges prevent the water flowing away from the roadway, forcing any surface water to drain through the pavement structure instead of flowing away from the road. Water also runs along the road surface causing a risk for aquaplaning and splash problems.

Figure 6: A high verge on the Irish road network, photo taken on road N59.

Verges can cause a number of problems to roads. The greatest is that of reduced bearing capacity, as seen as large deformations in the pavement. Where drainage has been improved, the drainage through the verges has usually been handled by adding or opening offlets. In cases, where the road has been upgraded or repaved some verges have been removed. However in those sections where the drainage through the verges was not improved problems have reappeared soon afterwards. A few examples of the types of problems caused by high verges are presented in Figure 7.

Figure 7: Examples of road sections suffering from problems due to verges.

4.2.2. Stone walls

Another typical feature on the Irish roads surveyed was the presence of stone boundary walls. An example of a stone wall is shown in Figure 8. These were very common along both roads N56 and N59. Usually these walls were located along old sections of roads that had not been upgraded. Where road improvements had been carried out these walls appear to have been removed. Usually the walls are very old and in many cases not visible due to vegetation growth.

Figure 8: A typical stone walls on road N59.

Typically these walls blocked the flow of surface water away from the road unless water outlets had been provided. This caused problems to the road similar to those caused by high verges, i.e.

reduced bearing capacity and deformations. Examples of typical problems caused by stone walls without water outlets are shown in Figures 9.

Figure 9: Examples of road sections suffering problems due to stone walls.

4.2.3. Road cut related problems

A very special feature on the roads surveyed was the narrow road cutting. A typical example of an Irish “road cut” as seen in Figure 10 shows sharply inclined side slopes that start immediately at the pavement edge leaving very little room for drainage structures. A high proportion of these steep slopes appear to consist of stone walls obscured by vegetation and soil.

Figure 10: An example of a road cut on road N59.

In many cases there is a complete absence of ditches or any other drainage structure within these types of road cuts. This means that water generally flows along the road as there is no possibility for it to get off the road, and this in turn causes erosion, bearing capacity and deformation problems to the road. Examples of typical problems that can occur in such road cuts are shown in Figures 11.

Figure 11: Examples of road sections located in road cuts.

4.3. DRAINAGE CLASSIFICATION

The drainage classification of the surveyed roads was carried out using the principles that will be presented in this chapter. A complete description of the ROADEX drainage analysis classification is given in the ROADEX report "Drainage Survey Method Description".

4.3.1. Class 1; Drainage in Good Condition

Drainage Class 1 means that the drainage condition is faultless. The cross-section of the road has preserved its form well and water flows unrestricted from the pavement to the ditch. Water has also a clear passage in the ditches. Where a verge is present it has enough offlets to let the water flow to the ditch.

Figure 12: Examples of road sections with drainage Class 1 in Ireland.

4.3.2. Drainage Class 2; Drainage in Adequate Condition

In drainage Class 2 there can be some visible changes to the road cross-section. The road shoulder has narrow verges or vegetation growth that is preventing the free flow of surface water from the road surface into the ditch. There is some vegetation in the ditch that restricts water flow and creates damages. Some soil is sliding from the road sideslope into the ditches and raising the bottom of the ditch. This hinders water flow and raises the ground water level.

Figure 13: Examples of road sections with drainage Class 2 in Ireland.

4.3.3. Drainage class 3; Drainage in Poor Condition

Drainage Class 3 covers those road sections with severe drainage problems. The road shoulder has a high verge and/or dense vegetation that is causing ponding on the traffic lane or on the shoulder. Vegetation is growing in the ditches and restraining the flow of water creating dams in the ditches. Unstable soil is flowing from ditch slopes into the bottoms of ditches and blocking the flow of water. Clogged culverts or outlet ditches is preventing the flow of water in the ditch. All of these situations lead to the development of deformation and damage in the road cross-section.

Figure 14: Examples of road sections with drainage Class 3 in Ireland.

4.4. VERGE CLASSIFICATION

Earlier research in the ROADEX project indicated that verges can have a substantial negative impact on road drainage. Hard statistical data was not available to support this assumption however, so it was decided that in the Irish drainage demonstration projects the verges would be classified into three classes according to their existence and condition. The classification was made according to the principles below:

4.4.1. Class 1; No verges

Class 1 verges cover those road sections where there is no verge and water can flow freely from road surface. Figure 15 presents a few examples of verge Class 1 road sections.

Figure 15: Two examples of verge Class 1, i.e. road sections without verges. The photo on the left is from road N56 at point 15,222m, the photo on the right is from road N59 at point 40,996m.

4.4.2. Class 2; Minor verges

Class 2 verges cover all road sections with minor verges and adequate offlets. The number of offlets is enough to ensure proper drainage and they are in good condition. The water can flow freely from the road surface. Verges do not restrict the water flow or the workings of the road drainage system. Figure 16 shows a few examples of road sections with verge Class 2.

Figure 16: Two examples of verge Class 2, roads with a verge which has minor effect on the workings of the road drainage system. The photo on the left is from road N56 at point 27,591m, the photo on the right is from road N59 at point 91,163m.

4.4.3. Class 3; Significant verges

Class 3 verges cover those road sections with significant verges restricting the water flow away from the pavement causing ponding and other problems. There are no offlets or they are in poor condition. Figure 17 shows a few examples of road sections belonging to verge Class 3.

Figure 17: Two examples of verge Class 3, roads with a verge that has a significant negative impact on the workings of the road drainage system. Both photographs are from road N56. The photo on the left is at point 2,777m, the photo on the right is at point 20,685m.

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5. DRAINAGE ANALYSIS RESULT

5.1. STATISTICAL RESULTS OF THE SURVEY

5.1.1. Summary of Drainage and Verge classes

As already mentioned the drainage condition on the surveyed roads was divided into three different classes: Class 1 Good condition, Class 2 Adequate condition and Class 3 Poor condition. The verges were also classified into three classes: Class 1 No verges, Class 2 Minor verges and Class 3 Significant verges.

Interestingly, nearly all of the road sections surveyed passed through villages or even little towns. These urban lengths can make the overall results look very favourable, when compared to other ROADEX test areas, as the road drainage in these sections is usually well handled with piped storm water systems, and so classified as Class 1 drainage.

The overall survey statistics in Table 1 show that, in general, the drainage in road N56 seems to be in better condition than in road N59. The main part (68.4%) of the drainage system in road N56 is rated as drainage Class 1. Also the majority of the verges are rated as Class 1. Only 8.1% of the drainage in road N56 is Class 3.

The N59 road is in slightly worse condition. Only 23,7% of the N59 is rated as drainage Class 1 and 33.7% of verges are rated as Class 1. The two urban sections in Ballina and Clifden are excluded from the analysis of the N59.

Table 1: Distribution of drainage class and verge class (roads N56 and N59).

	Drainage class			Verge class		
Road	**Class 1**	**Class 2**	**Class 3**	**Class 1**	**Class 2**	**Class 3**
N56	68,4 %	22,8 %	8,1 %	55,3 %	19,8 %	24,1 %
N59	43,7 %	27,4 %	24,3 %	33,7 %	19,9 %	41,8 %

A more detailed description of the drainage systems of the N56 and N59 is given in the following chapters.

5.1.2. Road N56

The first surveyed section of the N56 was from Donegal to Dungloe. The drainage in this section is mainly in good condition. The best section is located at the end of the road from the R252 crossroads to Dungloe (71,290 – 75,240m). The section with the worst drainage is from the R263 crossroads to the R261 crossroads (25,570 – 39,030m). A map of the drainage statistics for this section is presented in Figure 18.

The second surveyed section of the N56 was from Dungloe to the Mountaintop Roundabout in Letterkenny. This part is in generally good condition. The best section is from the R249 crossroads to the Mountaintop Roundabout in Letterkenny (144,500 – 151,770m). The worst part is from the R257 crossroads to Dunfanaghy (103,220 – 119,700m). A map of the drainage statistics for this section is presented in Figure 19.

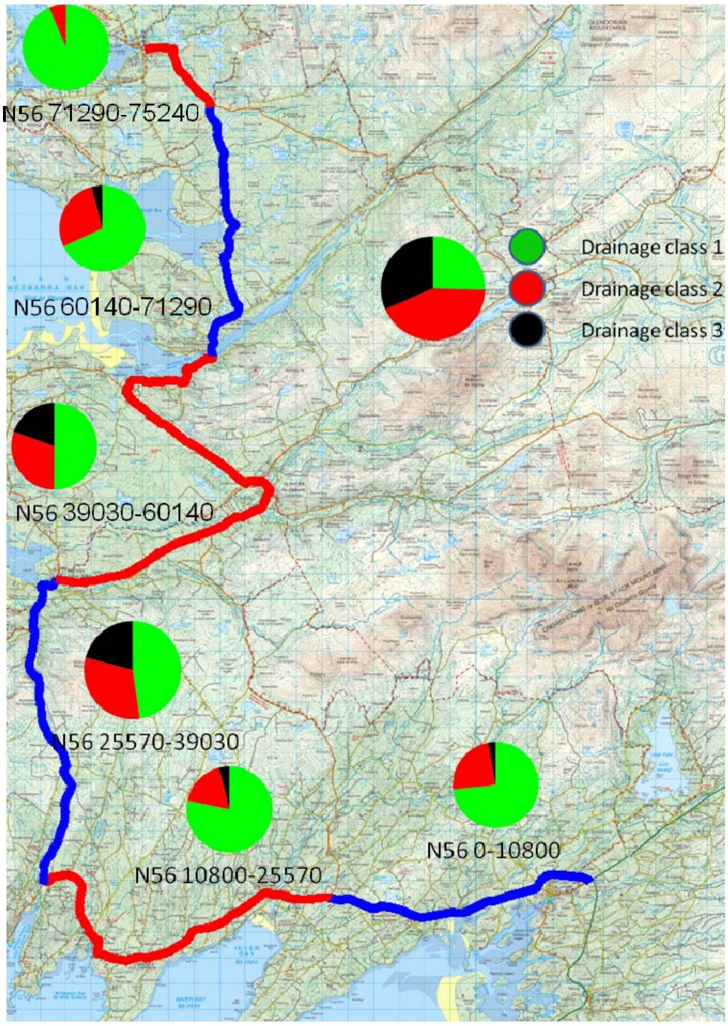

Figure 18: Drainage condition in the first part of road N56 from Donegal to Dungloe.

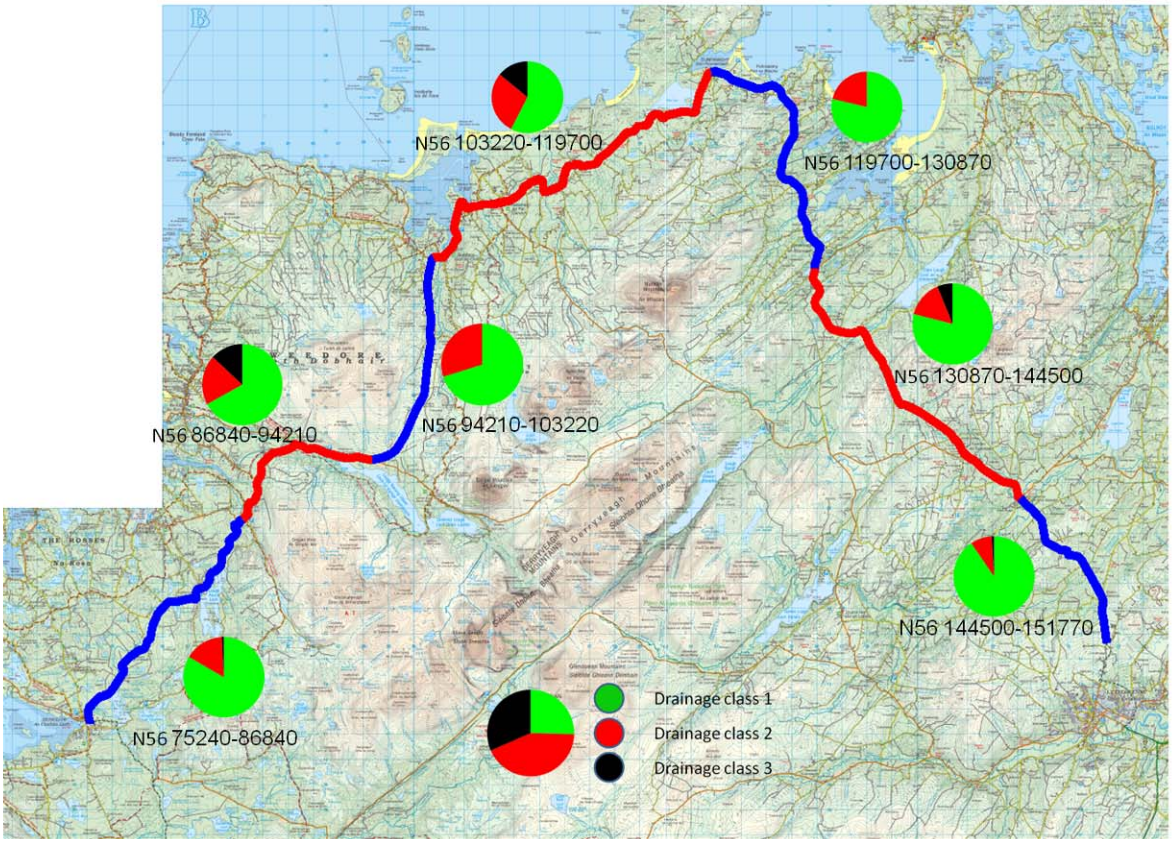

Figure 19: Drainage condition in the second part of road N56 from Dungloe to Mountaintop Roundabout in Letterkenny.

Verge classes follow the same trends as drainage classes in the first section of the N56. The road section with the fewest verges on the N56 is the section from the R252 intersection to Dungloe (71,290 – 75,240). The map of verge class along this road section is presented in Figure 20.

The second section of N56, from Dungloe to the Mountaintop Roundabout in Letterkenny, has a greater quantity of verges. The section from Dunfanaghy to the R245 intersection (119,700 – 130,870) has the least verges, while the most verges could be found on the section from the R257 intersection to Dunfanaghy (103,220 – 119,700). The map of verge class along this part of road is presented in Figure 21.

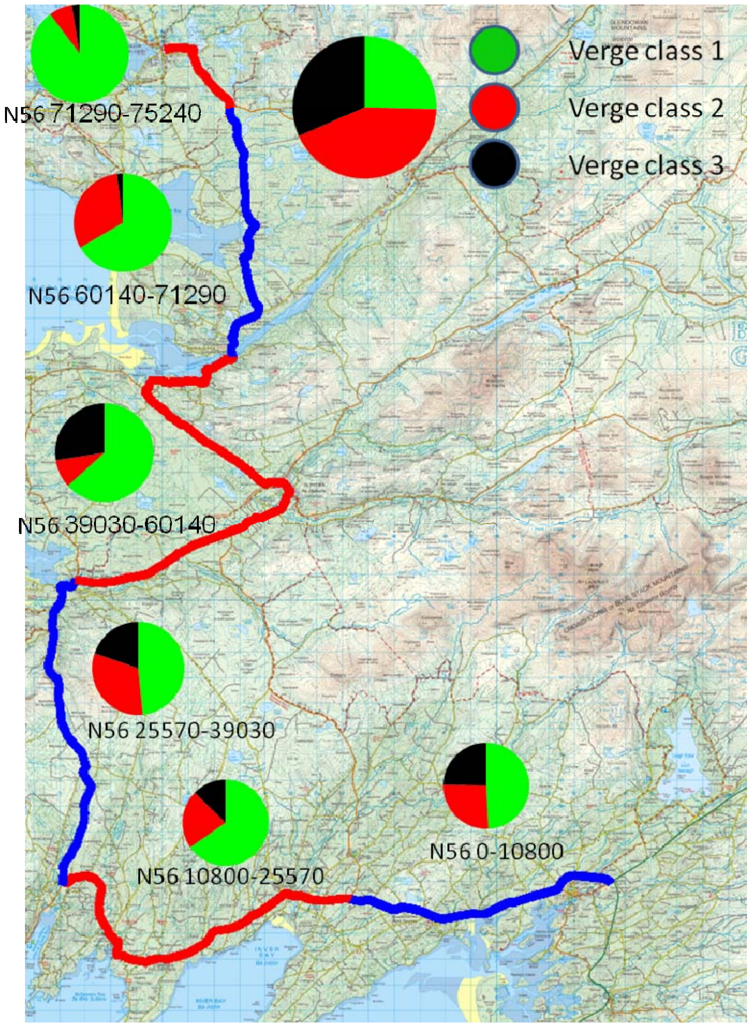

Figure 20: Verge class in the first part of road N56 from Donegal to Dungloe.

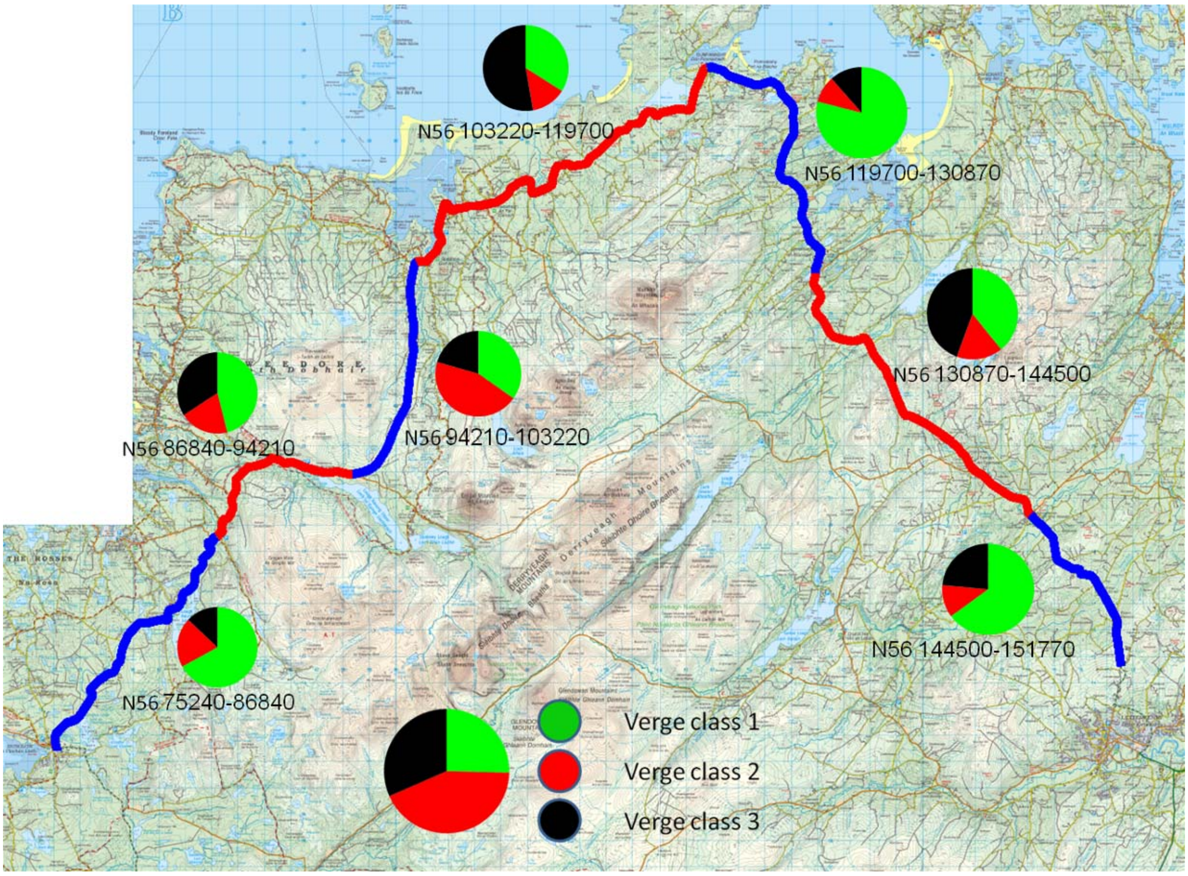

Figure 21: Verge class in second part of the road N56 from Dungloe to Mountaintop Roundabout in Letterkenny.

5.1.3. Road N59

Road N59 was divided into four parts to make the analysis easier. The two urban road sections in Ballina and Clifden have been excluded from the analysis.

The first section of road N59 was from Ballisodare to the R312 intersection. The drainage in this section is mainly in good condition. The section with the best condition is the section from Owenberg to the R297 crossroads (33,570 – 47,680m), just before the village of Ballina. The section with the worst condition is the section from the R297 crossroads to Crossmolina (55,270 – 65,320m) after the village of Ballina. A map showing the drainage statistics of this section is presented in Figure 22.

The second section of road N59 was from the R312 intersection to Westport. The drainage of this section is slightly worse than that of the first section. The worst section is from Achill Road R257 to Bridge (108,180 – 127,390m). A map showing the drainage statistics of this section is presented in Figure 23.

The third section was from Westport to Letterfrack. The best drainage condition was found to be from the R344 crossroads to the R336 crossroads (188,500 – 199,710m). The worst section is at the end, from the R344 crossroads to Letterfrack (199,710 – 208,110m), where more than 50 % of the road was classified as drainage Class 3. A map showing the drainage statistics of this section is presented in Figure 24.

The fourth section was from Letterfrack to Galway (Forest Hills intersection). The end part of this section, from Oughterard to Forest Hills (272,900 – 287,960m has the best drainage condition with more than half of the road section classified as drainage Class 1. A map showing the drainage statistics of this section is presented in Figure 25.

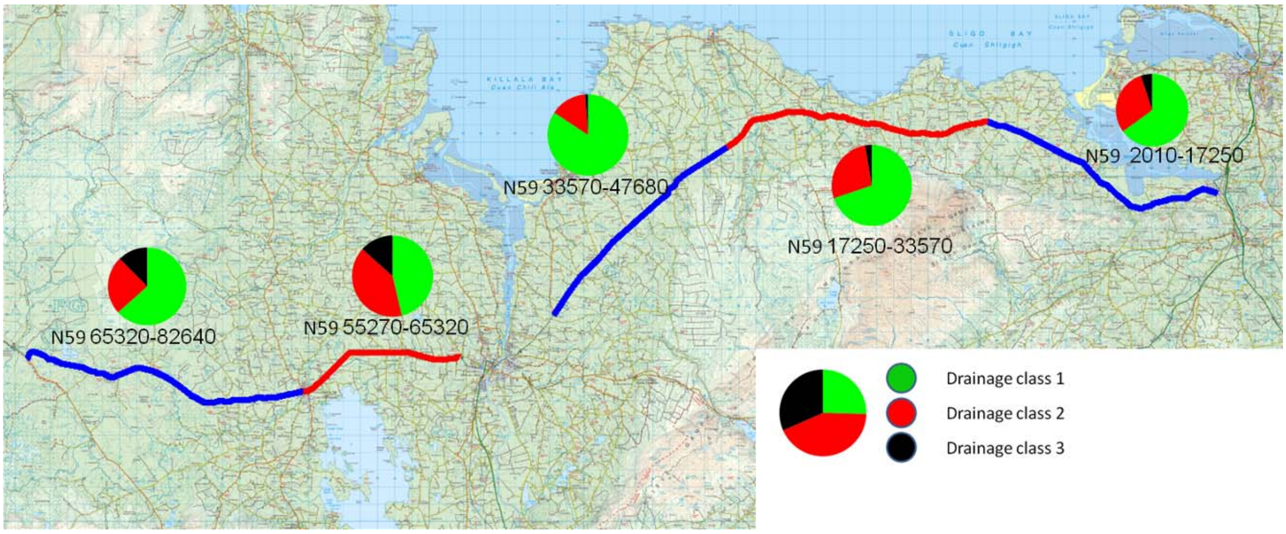

Figure 22: Drainage condition in the first part of road N59 from Ballisodare to the R312 intersection.

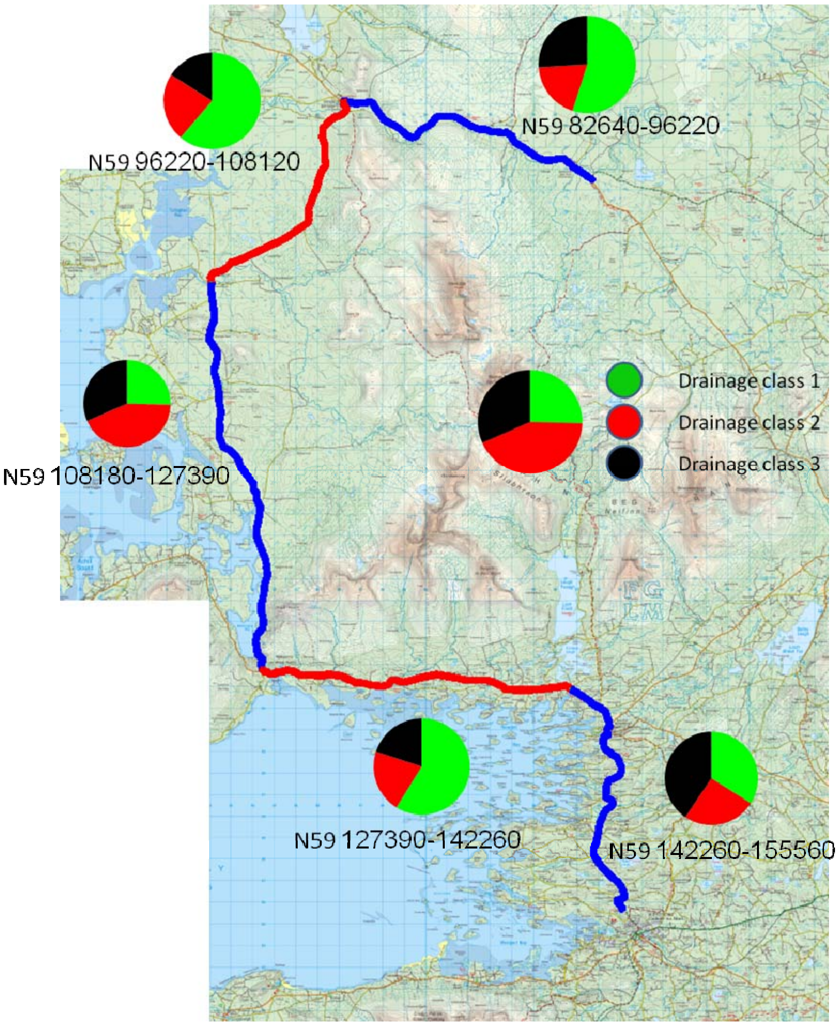

Figure 23: Drainage condition in the second part of road N59 from the R312 intersection to Westport.

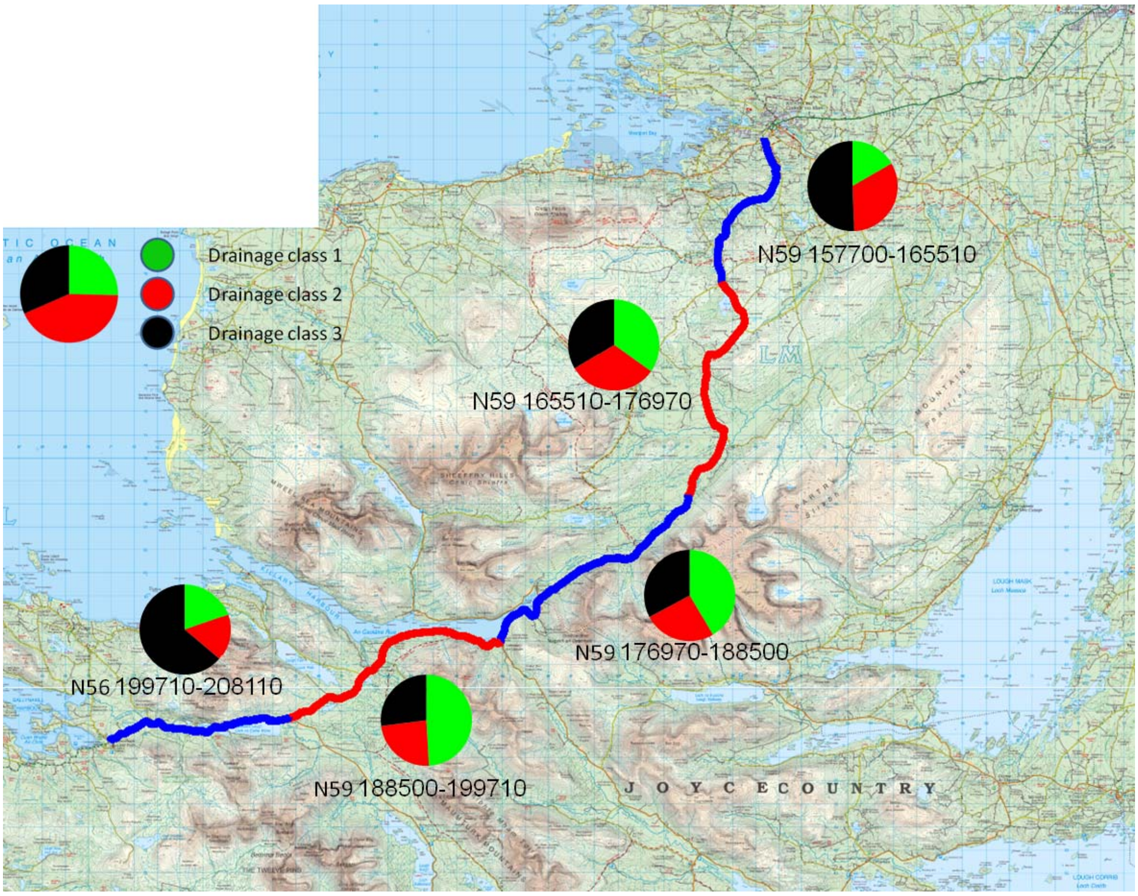

Figure 24: Drainage condition in the third part of road N59 from Westport to Letterfrack.

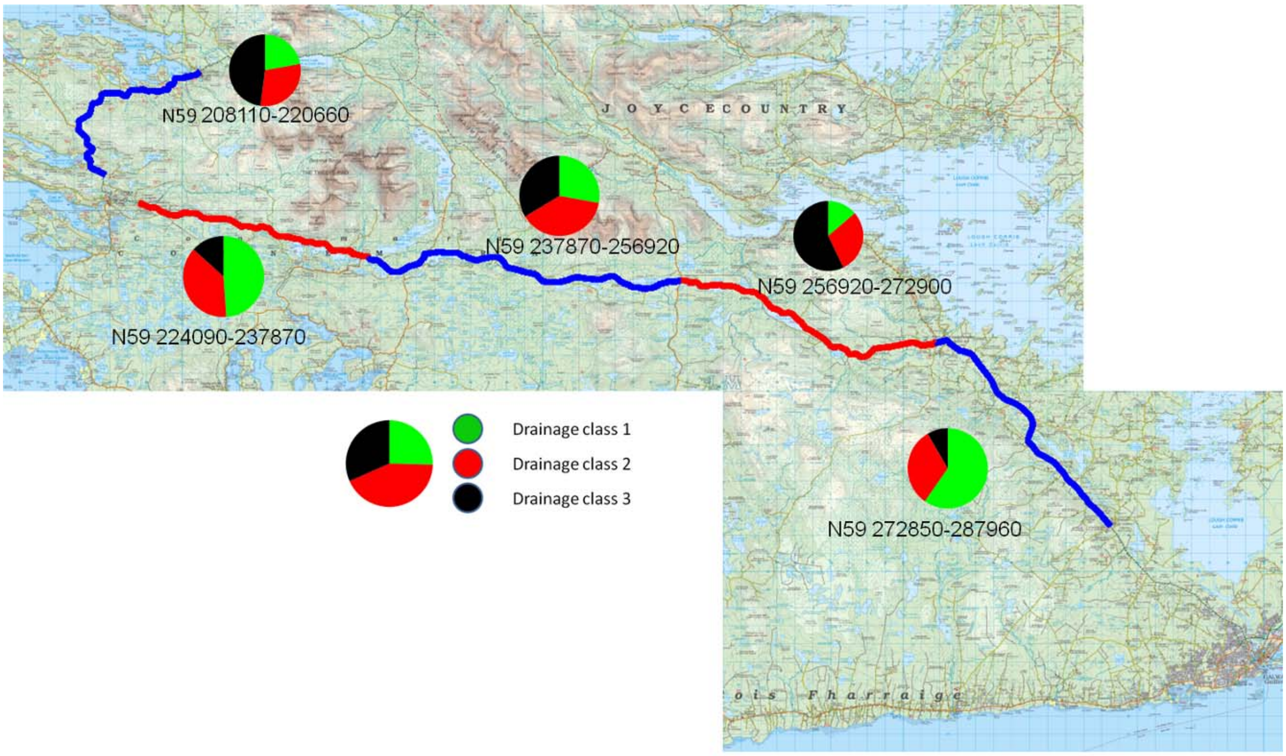

Figure 25: Drainage condition last part of road N59 from Letterfrack to Galway (Forest Hills intersection).

The class of verge varies significantly on the N59. The majority of the verges were rated as Class 1 on the following sections: from the Masreagh intersection to Owenberg (17,250 – 33,570), from the Burrishoole Bridge to Westport (142,260 – 155,560), from Erriff Bridge to the R336 (176,970 – 188,500) and from the bridge after Clifden to the R341 (224,090 – 237,870). The majority of the verges were rated as Class 3 on the section from Westport to Lischarney (157,700 – 165,510). Almost 80% of the verges are Class 3 in this section. Maps of verge class along the N59 are given in Figures 26 – 29.

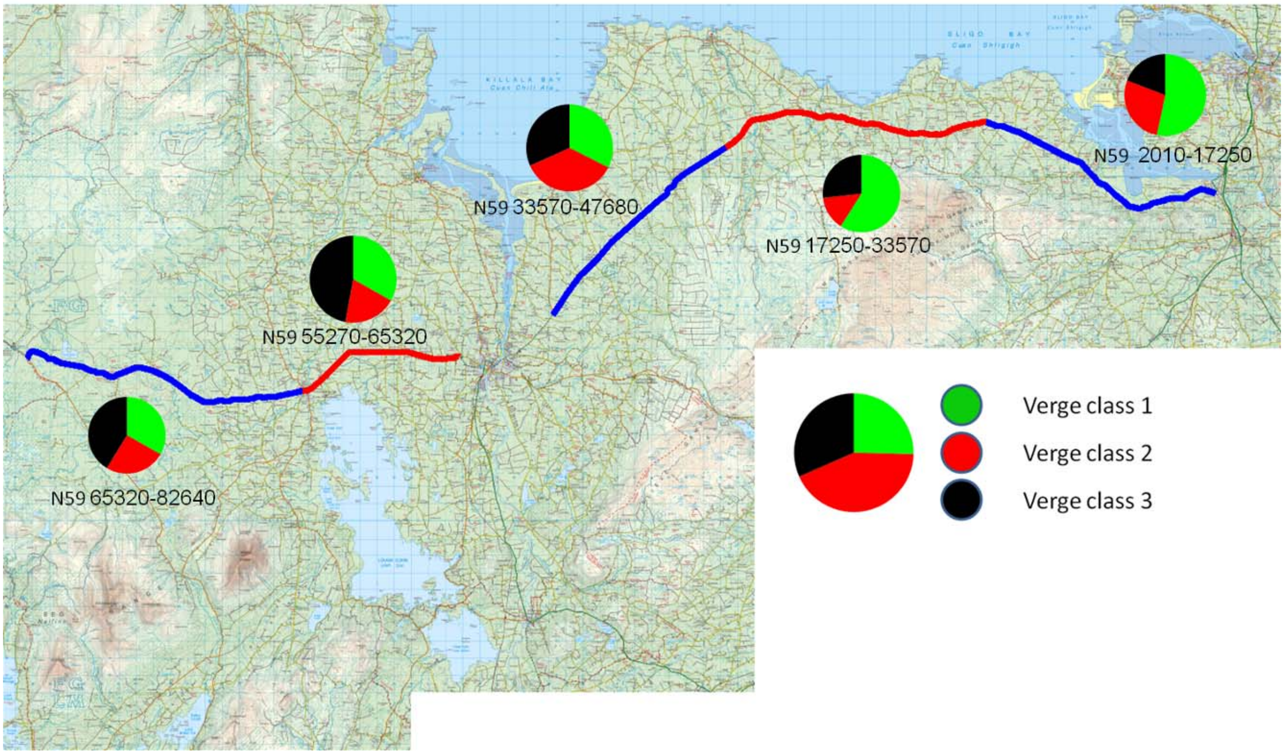

Figure 26: Verge class in the first part of road N59 from Ballisodare to the R312b intersection.

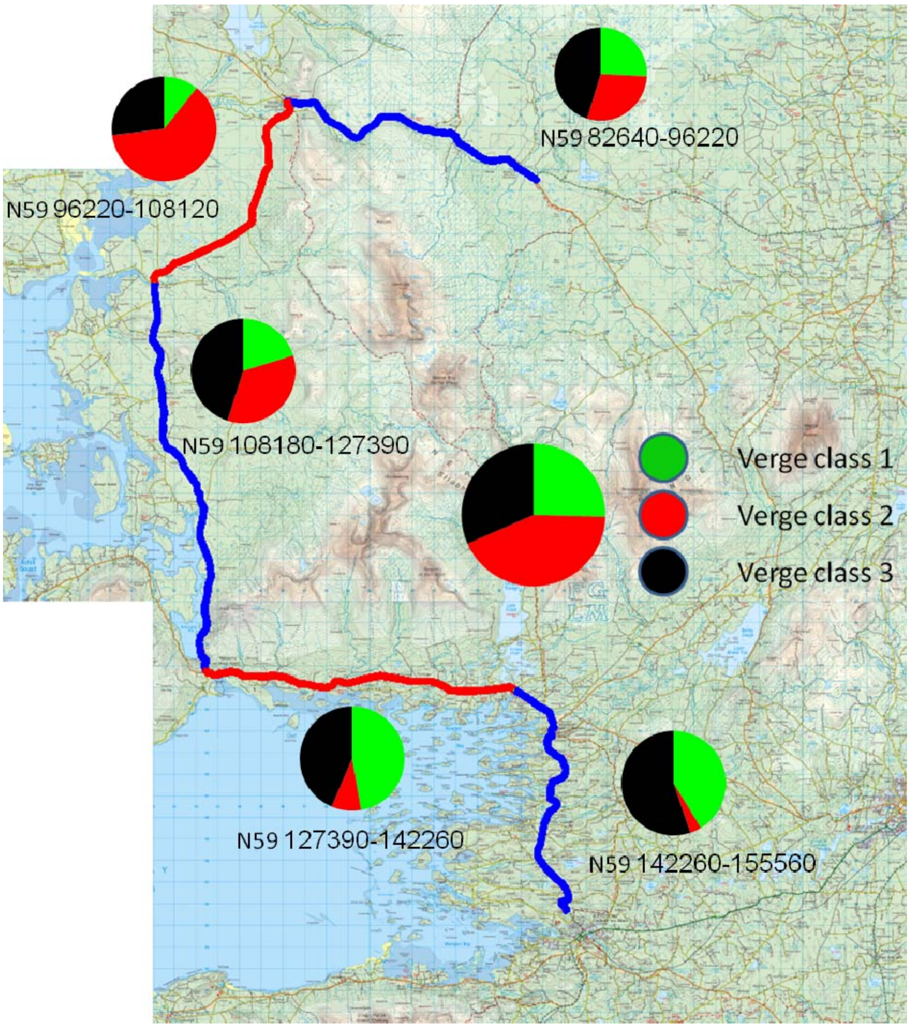

Figure 27: Verge class in the second part of road N59 from the R312 crossroads to Westport.

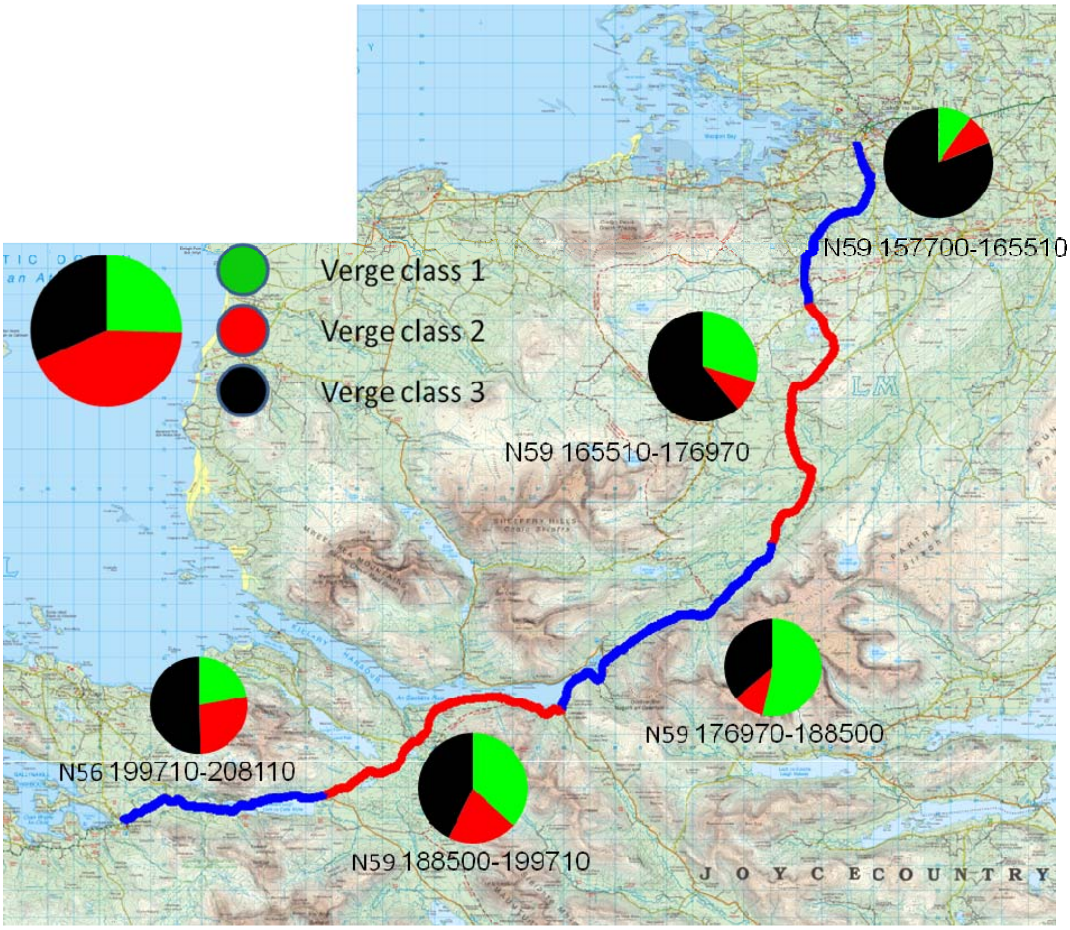

Figure 28: Verge class in the third part of road N59 from Westport to Letterfrack.

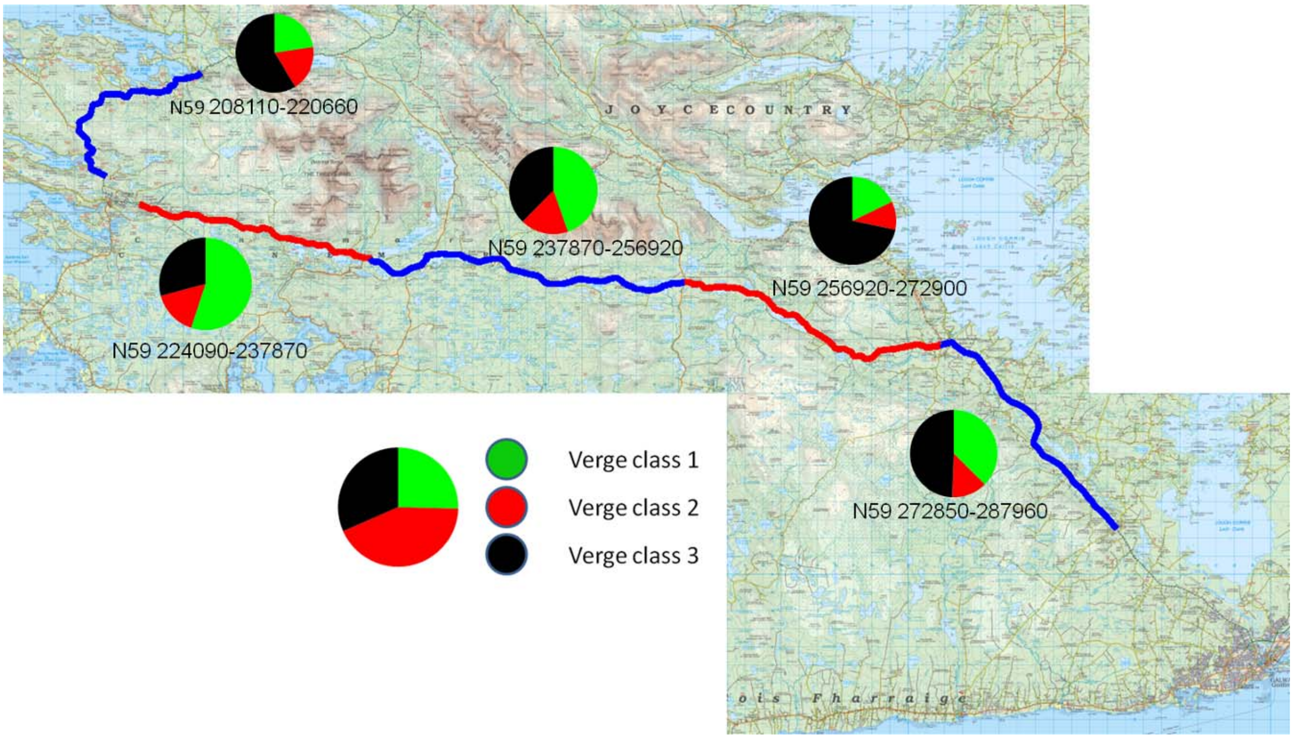

Figure 29: Verge class in the fourth part of road N59 from Letterfrack to Forest Hills.

5.2. DRAINAGE AND ROAD PERFORMANCE

5.2.1. Effect of drainage on roughness and rutting

The average roughness (IRI) value for each drainage class on roads N56 and N59 is summarised in Figures 30 and 31. This clearly shows the impact of poor drainage on road roughness (IRI). In drainage Class 1 the average IRI was 4.2, i.e. an adequate level of comfort for driving. In drainage Class 3 the average IRI was 6.9, which equates to an uneven and uncomfortable road surface. Figure 31 also shows that the N56 is more sensitive to poor drainage.

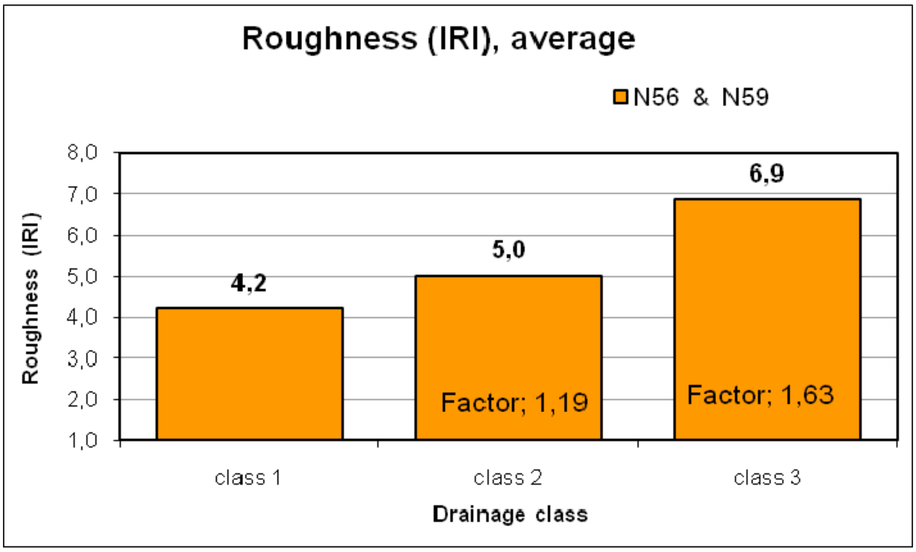

Figure 30: The average roughness value for each drainage class in roads N56 and N59. The value on the top of the column presents the average IRI value for each drainge class. The factor inside the column shows how many times bigger the value is compared to the value for Class 1.

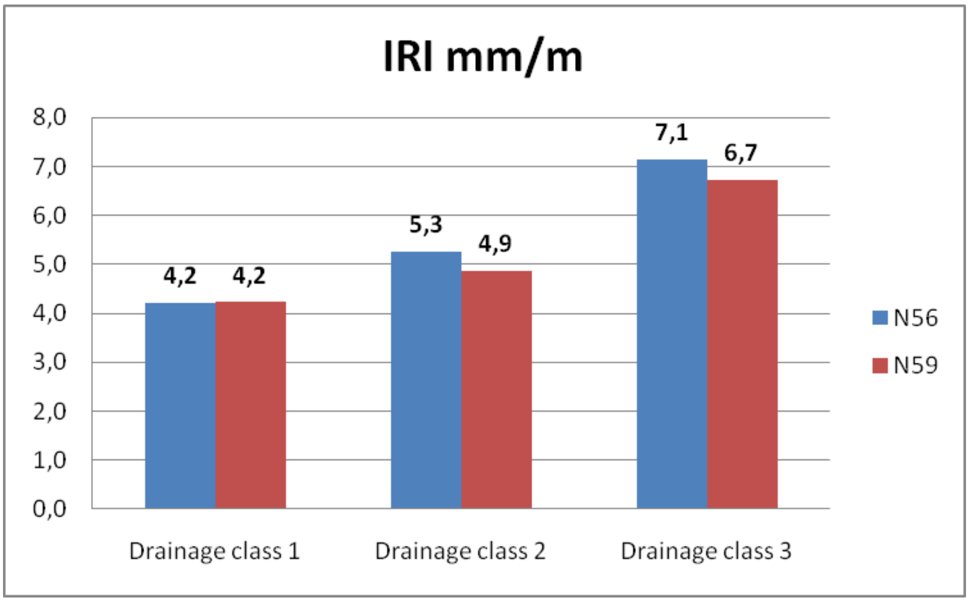

Figure 31: The mean roughness values for each drainage class in roads N56 and N59.

Figures 32 and 33 show that the impact of poor drainage on rutting is even higher when compared to roughness. The average rut depth in drainage Class 2 is 43 % higher than in Class 1, and in drainage Class 3 the rut depths are almost two times higher than in drainage Class 1.

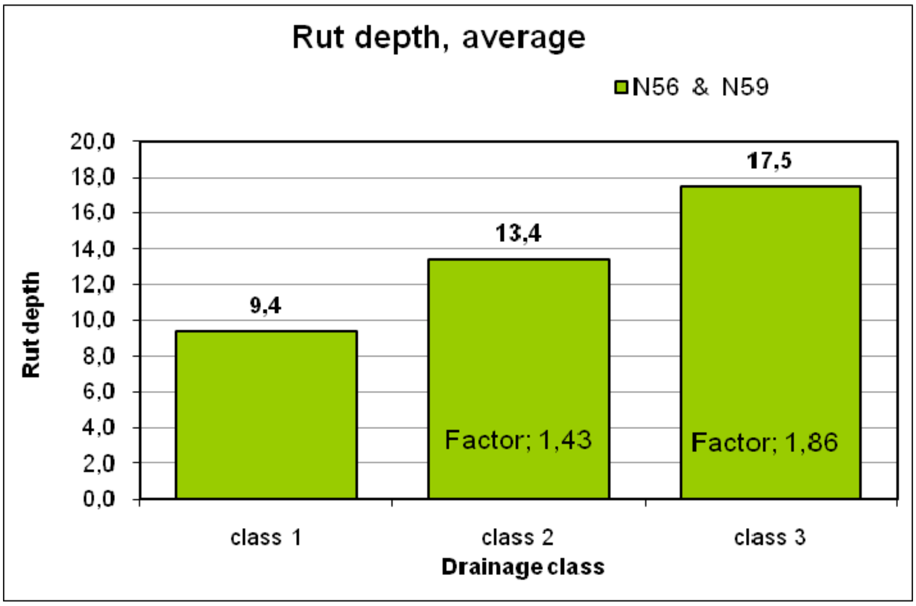

Figure 32: The average rut depth value for each drainage class in roads N56 and N59. The value on the top of the column shows the average rut depth value on each drainge class. The factor shows inside the column shows how many times bigger the value is compared to the value for Class 1.

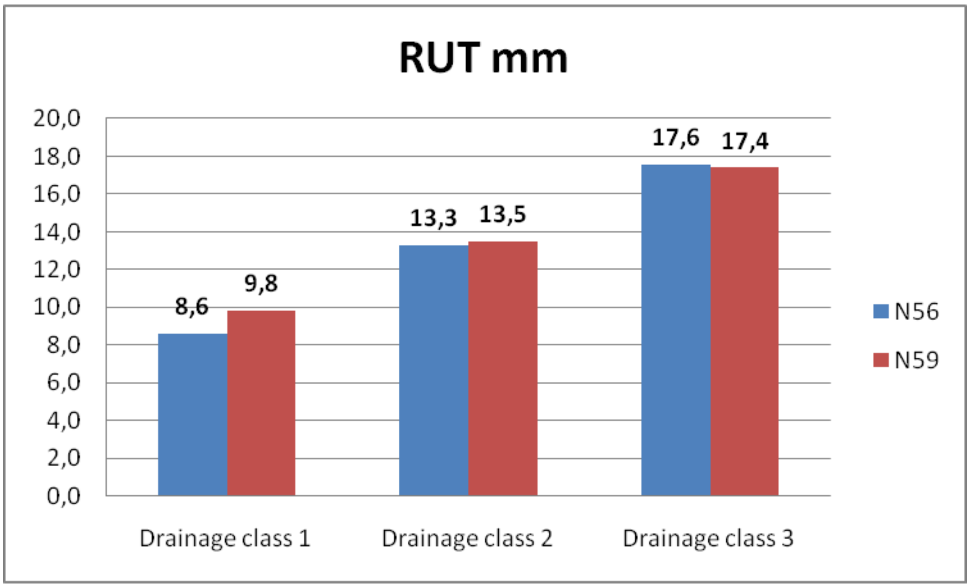

Figure 33: The mean rut depth values for each drainage class in roads N56 and N59.

5.2.2. Effect of verges on roughness and rutting

Verges also have an effect on roughness and rutting but not so great as average drainage class. Figure 34 shows that small verges with well maintained offlets do not affect roughness, but that IRI values are 1.24 times higher in verge Class 3 compared to verge Class 1 (no verges).

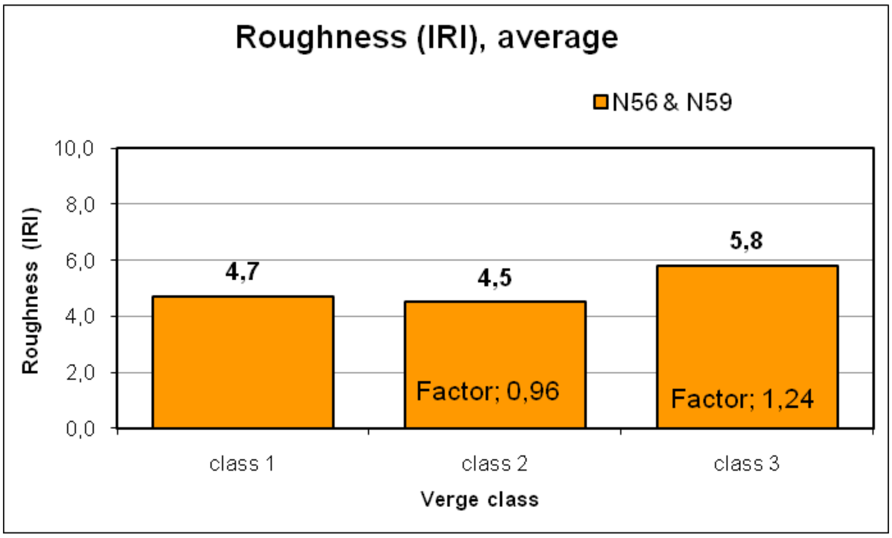

Figure 34: The average roughness value compared to verge class on roads N56 and N59. The value on the top of the column shows the average IRI value in each drainge class. The factor shows inside the column shows how many times bigger the value is compared to the value for Class 1.

The correlation between average rut depths and verge class (Figure 35) is clearer than with roughness values. The average rut depth is 1.45 times greater in Class 3 compared to Class 1.

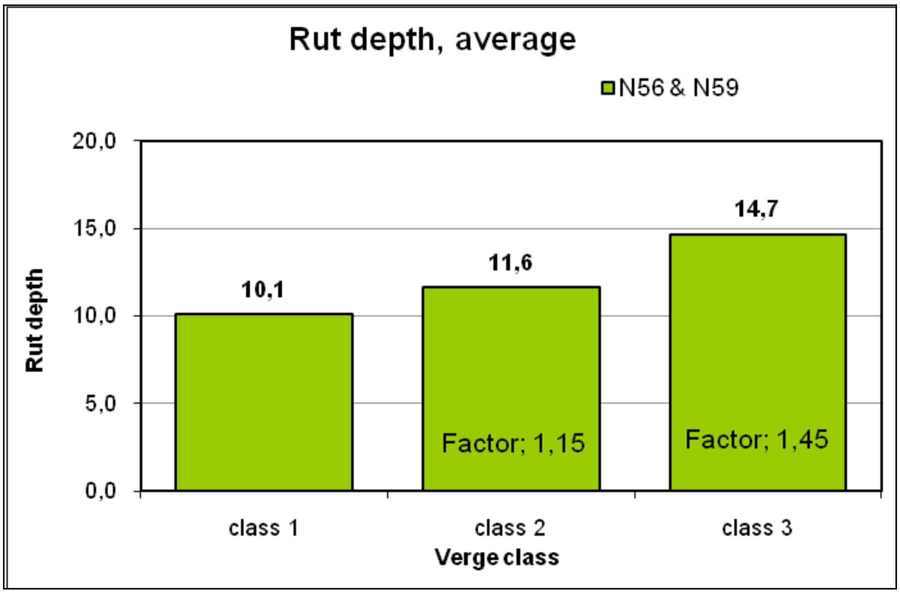

Figure 35: The average roughness value compared to verge class on roads N56 and N59. The value on the top of the column shows the average rut depth value for each drainge class. The factor inside the column shows how many times bigger the value is compared to the value for Class 1.

5.3. DRAINAGE AND ROAD PROFILE

The majority of the road sections surveyed were on side sloping ground (52%), and only a limited length were in road cuts (only 3%). The distribution of road profile types is presented in Figure 36.

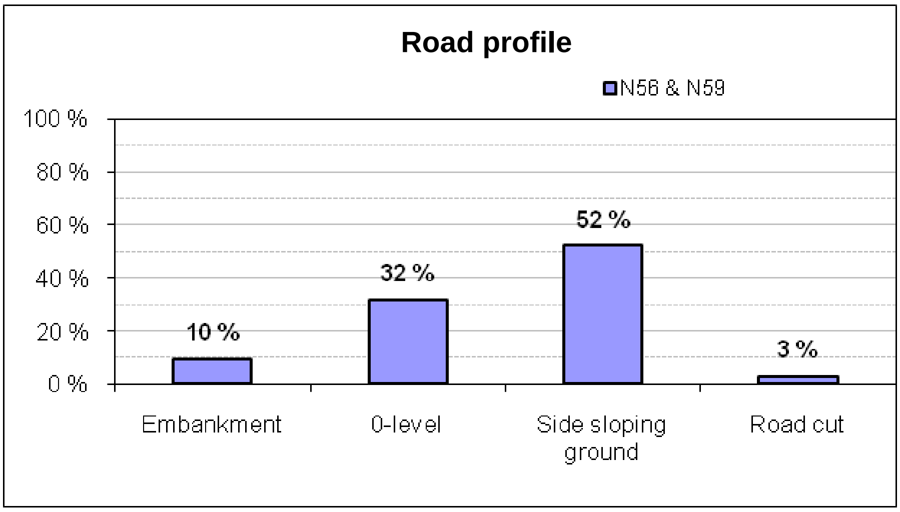

Figure 36: The distribution of road profile on roads N56 and N59.

Figure 37 shows that the average drainage class was the best in road sections classified as "0-level" (i.e. the road was approximately at the level of the adjacent ground). The average drainage class in these sections was 1.2. The drainage was the worst condition in road cuts, but quite surprisingly the drainage condition in embankments was almost as bad.

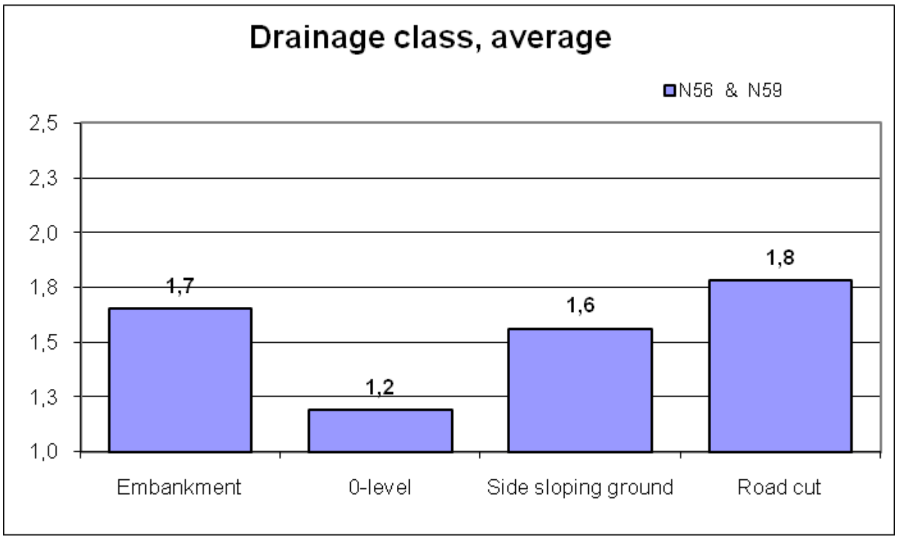

Figure 37: The average drainage class for each type of road profile.

When roughness and rutting values were compared to road profile, the average values were about the same, except for 0-level where the values were slightly worse (Figures 38 and 39). The worst cases were always in road cuts.

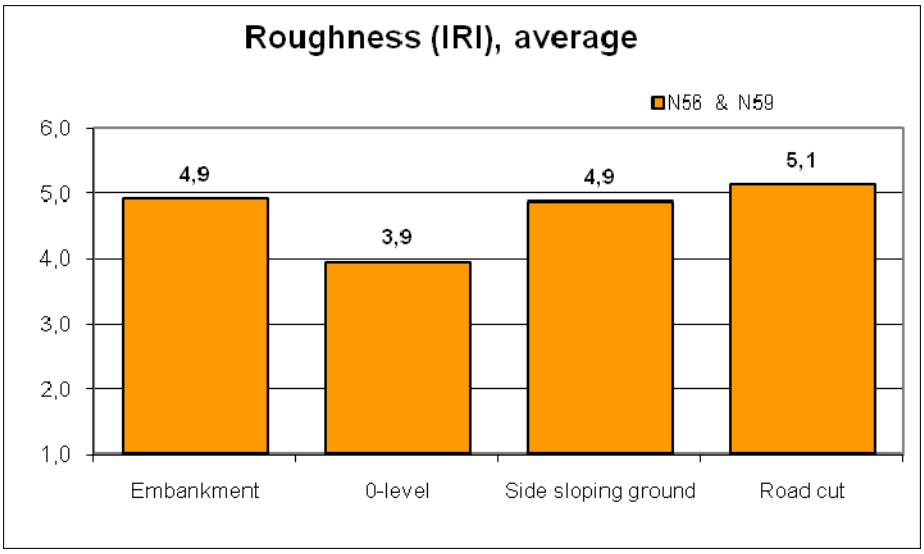

Figure 38: The average IRI-value for each type of road profile.

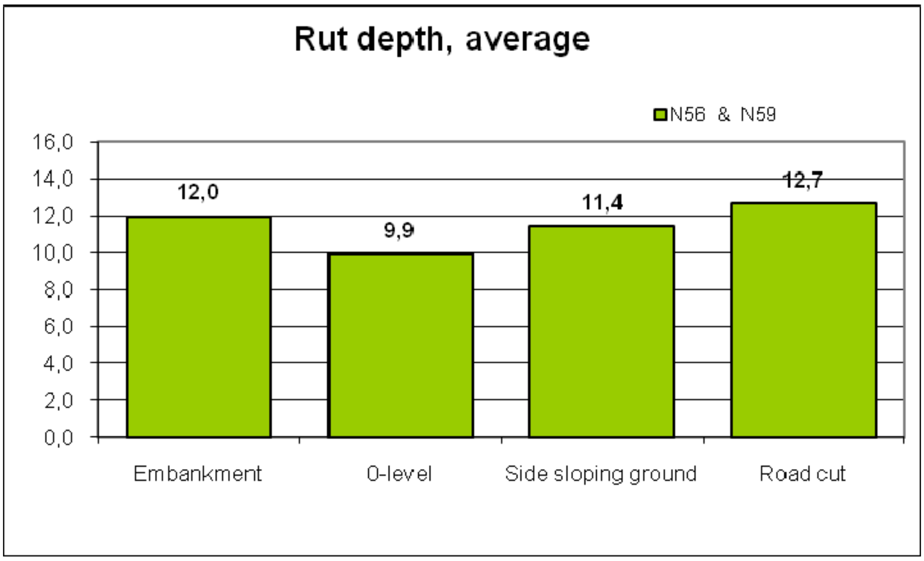

Figure 39: The average rut depth for each type of road profile.

6. DRAINAGE AND PAVEMENT LIFE TIME

The lifetime of a road section is controlled by its worst 10 % sub sections. The results of the drainage analysis in Ireland confirm the findings from other ROADEX partner countries that improving the drainage condition in critical sections, and maintaining it in good condition, will increase the pavement lifetime by 1.5 - 2.0 times. In the Irish surveys of this report there were even sections where the lifetime improvement factor reached almost 3. The conclusion was that if drainage maintenance and rehabilitation can be carried out in an economic fashion, they can lead to major savings in the annual paved road network costs.

In order to calculate how much a well-functioning drainage can affect the life cycle costs of a pavement, it is important to know the costs for improving the drainage. Normally the costs of drainage maintenance are much smaller than repaving. It this regard it is likely that the drainage solutions for roads N56 and N59 roads will be challenging, and in some places expensive, due to the local constraints involved but the pay-back time is expected to be short. If the drainage can be improved, the potential savings in annual paving costs could be up to 30% according to calculations made in earlier ROADEX projects.

From Figure 40, the pavement lifetime factor (the ratio of the worst 10% rutting class) on road N56 is mostly >1.5, and so it is highly economic to improve the drainage on this road. Only on one section, from 119,700 to 130,870, was the pavement lifetime factor less than 1.05.

Road N59, on the other hand, has slightly better (but still not good) pavement lifetime factors, even though in general the drainage condition is worse than the N56. This indicates that the N59 has thicker road structures, or the amount of heavy traffic on the N59 is less than on the N56.

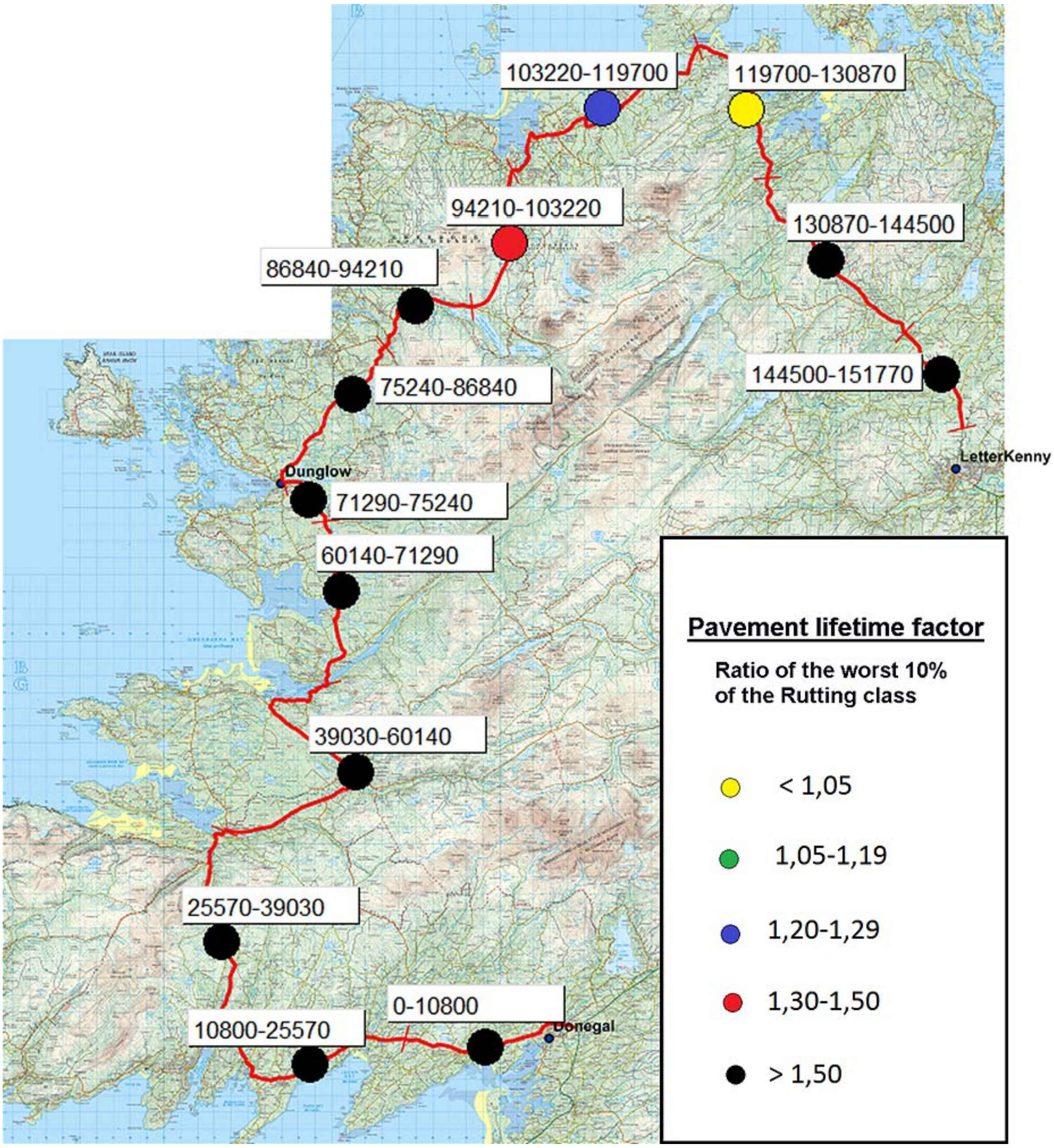

Figure 40: Pavement lifetime factor N56

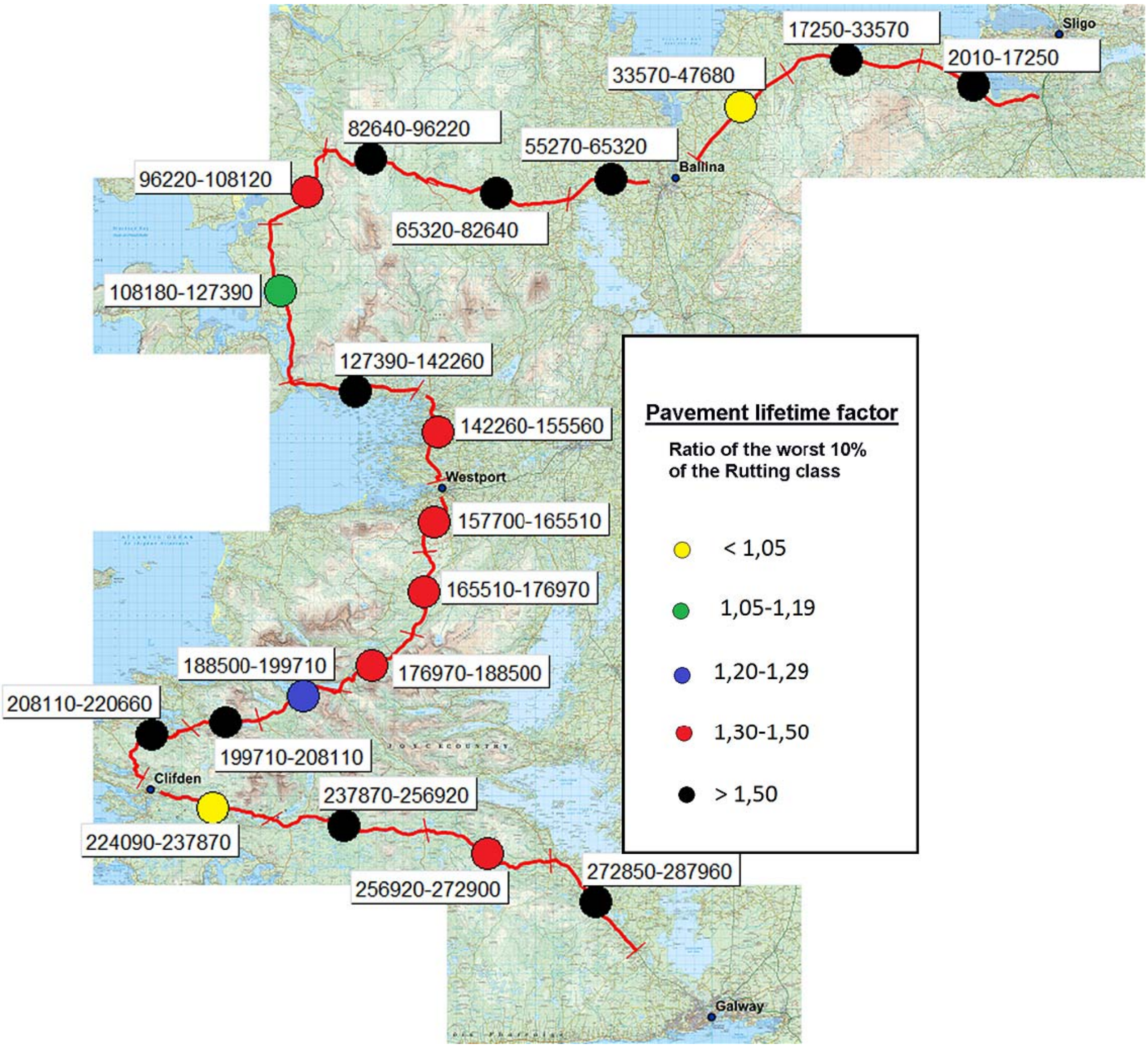

Figure 41: Pavement lifetime factor N59

7. DRAINAGE IMPROVEMENT DESIGN

In many ROADEX countries drainage, and drainage improvement, has a low priority despite research proving that it is important that road drainage should be kept in a good condition. Nowadays a number of issues have to be considered when planning drainage work. What is the best way to organise it? Should the work be the responsibility of the maintenance or pavement contractor? Etc.

It is not just enough that problematic sites are improved, it is vital that the improved sections are also kept in a good condition. Constant monitoring and maintenance of the improved drainage is vital to ensure that good drainage work remains effective.

When a drainage improvement is carried out the work should be done carefully. It is more important pay attention to the longitudinal gradient of the ditch and the removal of obstacles blocking the water flow (big stones, flowing soil, etc.), than to dig the ditch deeper. Ditches that are dug too deep increase the risk of sideslope erosion. It is recommended that the bottom of the ditch should be 20-30cm deeper than the bottom of the road structure and that the longitudinal gradient of the side ditch should be at least 4 ‰ (4 mm/m).

If the ditch has steep side slopes, it is better to carry out the improvement works in the early summer so that the local vegetation has enough time to grow back before winter to reduce the risk of erosion.

The most noteworthy feature of the surveyed sections of the N56 and N59 in Ireland is the lack of traditional open ditches. This will cause difficulties in the improvement of the road drainage, as will the presence of verges. The solution for road sections where verges are producing problems is to remove the verge or make more offlets.

8. CONCLUSIONS

Two ROADEX drainage demonstration projects were carried out on roads N56 and N59 on the west coast of Ireland. It was found that the road network in Ireland has a number of different features to those of the Nordic countries. The main difference is that open ditches are quite rare, especially in older Irish road sections. New and upgraded roads now have open ditches and these are working well. In the most demanding sections French drains or piped storm water systems are used to take care of the drainage. These arrangements mostly work well, but in some cases the drainage is blocked, or just inadequate. Verges and stone walls are also very typical for roads in Ireland.

Considering the condition of drainage of the surveyed roads, road N56 seems to be in slightly better condition than road N59. In general nearly all of the sections surveyed included one or more villages or little towns. These urban sections make the drainage analysis results look overly good as the drainage in these sections is usually well taken care of with piped drains that are classified as Class 1. Overall drainage classes and verge classes correlate very well with roughness (IRI) and rut depth values. The poorer the drainage or verge class, the greater the IRI and rut depth value. Rut depths in road sections with drainage Class 3 were almost two times higher than in sections with drainage Class 1. The worst sections were located in road cuts but these accounted for only a small proportion of the sections surveyed.

The lack of traditional open ditches will pose problems for the design and improvement of road drainage on roads in Ireland. The demonstration project for road N56 involved a drainage analysis and a design for special drainage maintenance sections. The demonstration project for the N59 involved a drainage analysis and a statistical analysis. Even though the drainage on road N56 was in fairly good condition there was still a substantial need for improvements. A number of sections were identified for special maintenance measures and the information has been sent separately to the respective County. A “special maintenance section” means that measures are needed for both ditches and verges. If the design only mentions the verge, it means that only the verge will need some operations (e.g. removal of verges or making more offlets).

The demonstrations on the N56 and N59 have confirmed that poor drainage has a major effect on pavement condition and pavement lifetime. If the existing drainage on the poorest road sections can be improved, the potential savings can be up to 30 %. The drainage solutions for these cases may be challenging and expensive but the pay-back time will be short. The challenges in the drainage design will be the lack of open ditches, the presence of adjacent stone boundary walls and stone retaining walls supporting slopes, and what can be done with them. It is recommended that a policy is developed on what should be done with verges. Possible options could be removing them completely, or building more offlets and accepting the increased maintenance costs for them.

The ROADEX drainage analysis guidelines have been proven to be suitable for use on Irish roads. It is however important that verges should be analysed also in the counties where they are typical as they will have a major impact on the efficient working of the road drainage system.

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.