SWAMP

***S**torm **Wa**ter prevention - **M**ethods to **P**redict damage from the water stream in and near road pavements in lowland areas*

Inception Report

January 2009

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Project Partner A: DRI, Danish Road Institute

Project Partner B: VTI, Swedish National Road and Transport Research Institute

This project was initiated by ERA-NET ROAD.

Project Nr. XYZ

Project acronym: SWAMP

Project title:

Storm Water prevention - Methods to Predict damage from the water stream in and near road pavements in lowland areas

Deliverable Nr 1 – Inception Report

Due date of deliverable: 31.01.2009

Actual submission date: 06.02.2009

Start date of project: 01.10.2009 End date of project: 31.05.2010

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Version: Final: 06-02-2009

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1 Introduction

"ERA-NET ROAD – Coordination and Implementation of Road Research in Europe" was a Coordination Action funded by the 6th Framework Programme of the EC. The partners in ERA-NET ROAD (ENR) were United Kingdom, Finland, Netherlands, Sweden, Germany, Norway, Switzerland, Austria, Poland, Slovenia and Denmark (www.road-era.net). Within the framework of ENR this joint research project was initiated. The funding National Road Administrations (NRA) in this joint research project are Danish Road Institute (DRI) and Swedish National Road and Transport Research Institute (VTI).

The project deals with drainage and drainage systems on or near the road network in lowland areas in e.g. The Netherlands, Sweden, Denmark, Germany and UK.

The result of the project is to provide guidelines for two scenarios: firstly, on an overall level, to identify places where frequent flooding occurs on the existing network which should obtain high priority in order to make best use of limited financial resources. Secondly, guidelines on a more detailed level after preliminary studies have been made and decisions should be taken, to determine which necessary initiatives should be undertaken in the chosen places to avoid or limit consequences of flooding.

The result of the project's first part will be an overall guideline on how to identify the places which create most problems on or near existing roads, called blue spots, i.e. places where flooding occurs in extreme precipitation events.

The result of the second part of the project will be a step-by-step guideline on inspection, maintenance and repair of the drainage system which is pointed out as a possible blue spot.

The project refers to two topics: 1) Climate Impact on Road Infrastructure and 2) Road Infrastructure Capacity for Climate Change.

2 Detailed Description of the Project

2.1 Background

For many years there has been a tendency that a large amount of precipitation has fallen in a short time. Næstved and Greve are examples of two Danish towns which have experienced heavy precipitation activity. The heavy precipitation has given problems, such as water in the basements of private homes and public institutions, but the road network has also been flooded, which has made pass ability difficult. In England, the motorways M5, M25 and M50 have been closed due to flooding, caused by extreme precipitation in the summer of 2007. In the worst case, M25 was closed on a warm summer day, where drivers could neither come backward nor forward. The British emergency services had to fly drinking water supplies to drivers in distress by helicopter. The last drivers could leave the M25 after being caught for twelve hours. The operation and help cost large amounts of money.

It is not only in summer that roads can become flooded due to heavy precipitation. Frequent and continuous precipitation in winter and spring periods can also cause flooding. In Denmark, there was flooding on the motorway towards Esbjerg in January 2007, where continuous rain put high pressure on the drainage systems. England experienced a similar situation in March 2008 on M25, where two lanes were closed.

The climatic changes which are predicted by the Intergovernmental Panel on Climate Change (IPCC) point towards more precipitation seen on average throughout the year as well as stronger and more intense shower activity in summer. This means that the drainage systems of the road network must be prepared to drain larger amounts of water and in extreme cases in relatively short periods of time. The existing drainage systems are designed and constructed on the basis of previous precipitation events (statistics). Similarly, more net precipitation leads to larger water stream flows, possibly causing problems with present culverts that are designed based on outdated statistics of high flow events. It is obvious that an upgrade must take place soon. But if this is done from "one end to the other" it becomes very comprehensive and expensive and presumably also unnecessary. In many places, additional capacity already exists.

2.2 Objectives

The project is of type application research and refers to two topics: 1) Climate Impact on Road Infrastructure and 2) Road Infrastructure Capacity for Climate Change.

The purpose of this project is to point towards a method of upgrading the drainage system in an optimum way, in other words to find the most exposed places, called "blue spots" (part 1) and deal with them first. When the exposed places have been identified it will be necessary to evaluate (part 2) how the upgrade is carried out in the best manner. In many cases only individual elements in the system are a weak link. How can they be identified and repaired? Much money can be saved by tailor-made solutions.

2.3 Project overview

The project will consist of five work packages (WP), each led by either DRI or VTI (Table 1). As shown in figure 1, WP1 and 2 are preparations for WP3 and 4; WP5 is for overall management

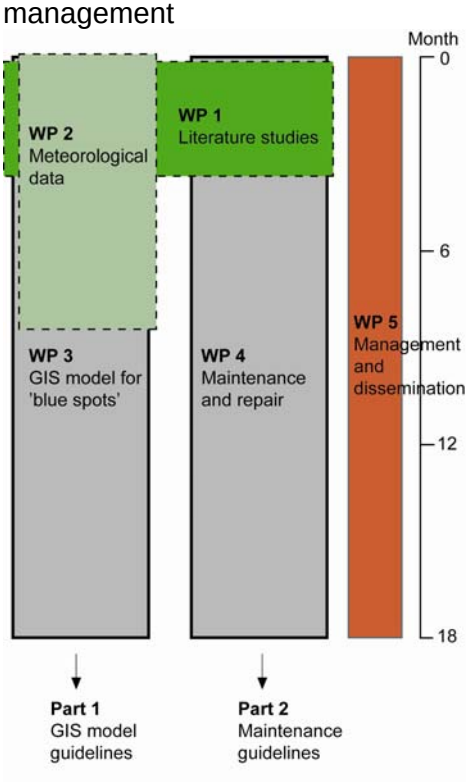

Figure 1 Project overview

Table 1 Work Package overview.

Work Package	1		2		3		4		5	
Title	Literature studies		Meteorological data		GIS model for blue spot		Maintenance and repair		Management and dissemination	
WP-leader	Marianne Grauert (DRI)		Klas Hansson (VTI)		Michael Larsen (DRI)		Fredrik Hellman (VTI)		Knud A. Pihl (DRI)	
Duration	Month 1-7		Month 1-12		Month 1-18		Month 1-18		Month 1-18	
Participants	DRI	VTI	DRI	VTI	DRI	VTI	DRI	VTI	DRI	VTI
Man-month	2	2	1,5	1,5	2,5	1	2	2	1	0,5

2.4 Detailed description of the Work Packages

Work Package 1

In the initial phase of the project it is important to seek already existing literature in the field.

WP1 will try to collect as much relevant knowledge for the project and ensure transfer and use of this specific knowledge throughout the entire project and for the use of future related projects. The collection of relevant literature will continue throughout the project period to ensure that everything relevant is included.

The results of the WP1 literature study will be presented as short summaries of the most important conclusions. All participants in the project will, based on these summaries, get basic knowledge of previous work and can get additional necessary relevant information for their part of the project. The study will be presented as a separate report that can be used by anyone interested.

Focus in the literature study will be on climate change in lowland areas, regional and local meteorological models, effects of climate change on hydrological systems and drainage design systems, design and hydraulic in retention ponds, experiences from storm water inundation and maintenance guidelines.

Project of more specific interest is e.g. the “WATMOVE” Water Movement in Road Pavement and Embankments, COST 351, which covers “Moisture content in base/subbase/ subgrade, water flows in these areas and in pavement drainage systems and water quality” and PIARC TC 4.5 focusing on “Earthwork, Drainage and Subgrade”. PEB member institutions, Vägverket in Sweden, Rijkswaterstaat in the Netherlands and other related institutions will be contacted for relevant projects.

WP1 will primarily be carried out in the first months of the project, as shown in Figure 2, but WP1 will be a continuous collection of knowledge throughout the duration of the project. In the beginning of the project, there will be an intensive collection of knowledge. The intensity will decrease towards the end of the project, where the final report from the work in WP1 will be documented.

WP1 will be the base for choosing different methodologies for the work in WP2-4.

Work Package 2

In recent years, predictions of our future climate on a regional scale have been reported by numerous institutes and agencies. Typically, meteorological institutes have prepared regional predictions of e.g. precipitation, evaporation and temperature during a certain time period, say 2070 to 2100, given a selected IPCC scenario. In addition, it is often possible to find data such as number of days with snow, number of days with extreme precipitation etc. The first step for WP2 is to find, and select, such regional predictions. Of relevance for this project is e.g. data regarding precipitation, evaporation, ground water levels, and water stream flow.

As an example, climate induced changes in rainfall is not only related to extreme shower activity in summer, but may also incude more rainfall throughout the year. This has especially great importance for the filling of rain water in retention ponds and penetration of water in the foundation and the road pavement.

WP2 should uncover the expected amount of net annual precipitation, in particular with respect to an evaluation of the amount of water that the retention ponds should be able to handle, but also in respect to an evaluation of whether water can penetrate into the subgrade and road pavement. Groundwater levels may be important here as well.

The work in WP2 will give contributions to the final report, including documentation/argumentation for the climatic scenarios used. The Consortium should be make a prioritisation of the importance of the climatic datasets obtained in the final report.

Work Package 3

In recent years, there have been several examples where the national road network has been blocked by large amounts of water - blue spots. Usually the same places are affected. The large amounts of water collect in low-lying areas on the road network and drainage systems do not have the capacity to remove them fast enough, so the water collects and floods the road.

These places can be identified on the basis of previous experience, but more places will appear on the road network, when precipitation increases. These places can be identified by Geographic Information Systems (GIS).

The data to be collected for the GIS model are:

- Digital maps of the road, road alignment, junctions, bridges, tunnels and viaducts.
- Topographical maps: Digital contour lines with a distance of 10-25 cm. The new digital topographical map made by The National Survey and Cadastre in Denmark will be used to identify elevation, hill slopes, areas with critical slopes, low lying areas and for measuring of the catchment area.
- Digital geological maps to identify the magnitude and the coverage of the geological layers and to establish the groundwater table and the pressure of the groundwater.
- Geotechnical maps which where made during the planning and the construction of the road. These maps give a more detailed picture of soil layers and soil types along the road.
- Topsoil maps to identify impermeable layers and to the calculate transmissivity of the soil.
- Digital maps of hydraulic, natural and man made aquifers.
- Maps of the sensitivity of the receiving habitats and water system. These maps can be collected from National Environment Research Institute (NERI, in Denmark).
- Road drainage systems, digital plans and calculations of the potential of maximum water flow through the drainage system.
- Collected and updated meteorological data from WP2
- Other relevant maps, found during the work in WP3.

In the GIS model, the dataset which has been obtained should be combined and connected to the meteorological data obtained in WP2. The GIS model will then be able to simulate potential

flooding points (blue spots). This means that the model not only can be used on exciting road construction, but also can be used to verify the capacity of the drainage system of planed future road constructions.

In the final report *Guidelines for development of a model for blue spot identification*, there should be an evaluation whether the SWAMP model can be used in other connections than in lowland areas, such as areas with a different geology, topography or in larger catchment areas. An evaluation should also be made whether the model can be used on roads other than motorways.

In the final report a prioritisation of the importance of the digital maps obtained, is made. It should be clearly specified what data one needs to have in order to run the model and which data is less important and would be nice to have.

Work Package 4

There are strong indications that more severe flooding situations will occur in the future. However, flooding has always taken place and in WP4 we will gather information from various sources on how flooding events have been handled before, obviously keeping our focus on the road environment. Experience from local authorities and how they acted during flooding events of the past decades is of fundamental importance. This knowledge will be assimilated through interviews and a couple of study visits in Sweden and Denmark. In addition, a complementing literature study will provide more suggestions, both theoretical and practical. Using this information we will attempt to identify and rank critical factors to consider in connection with flooding related road problems. This information, put into guidelines, can be used for pre-emptive measures, and in connection with flooding.

It is expected that the guidelines cover areas such as new demands for drainage, water retention ponds, protective barriers, and culverts, but may e.g. also include new practices for how to divert water from the road system, how to use television inspection, and how to clean the existing drainage structure.

WP4 intends to make these guidelines applicable for the kind of blue spot areas pinpointed by the model in WP3. The model will point out new areas where flooding did not occur in our past climate, and where the local authorities are not used to deal with these issues. The guidelines will be a valuable help when prioritizing future efforts

The final report *Guidelines for educing vulnerability to flooding in local places* includes a presentation of collected maintenance methods and interviews with field staff. The collection and interviews should be cross-border, including the countries represented by the Consortium and the Steering Group, but also other members of the ERA-NET Road network.

Work Package 5

The objectives for this work package are to manage and coordinate the work of the project and deliver the results. The project manager is responsible for the budget, financial control and scientific quality assurance. The manager is the link to ERA-NET Road administration.

Dissemination and co-ordination of knowledge sharing in accordance to the project schedule is also an important part of the work.

2.5 Deliverables

The Gantt diagram I figure 2 shows the work plan of the work packages. There will be three major deliverables (part 1-3) at the end of the project as described in the following.

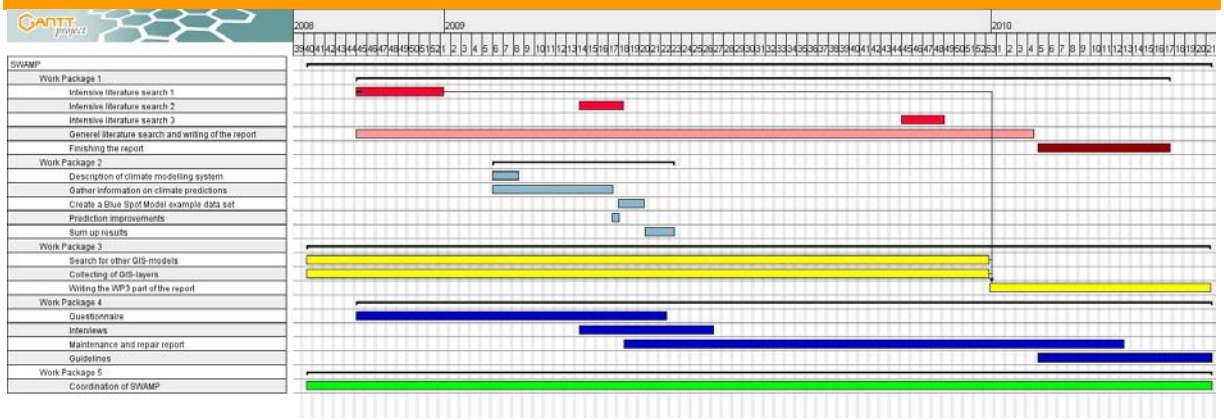

Figure 2 Gantt diagram of the work packages.

Part 1 Guidelines for development of a model for blue spot identification

By making systematic use of topographic and geological data combined with the detailed knowledge (plans, drawings etc.) of the existing drainage system, data can be collected, adapted and presented on maps, where blue spots areas can be pointed out – areas where flooding is expected to take place early in extreme weather. The purpose is to point out places on the road network where efforts should have a high priority to prevent negative effects from extreme weather conditions. With help from meteorological institutes, local rain data should be obtained.

The method described is based on use of “Geographic Information Systems (GIS)” (Figure 3). The model consists of several layers of information, gained from relevant authorities. The GIS model can, given a certain amount of rain (mm/hr) calculate supposed critical areas and plot them on a map as blue spots.

To actually program the GIS model to an operational level is not possible within this proposal, but the data collection and the guidelines made for the model will be the final step before having the model made. This will be the next step in the process.

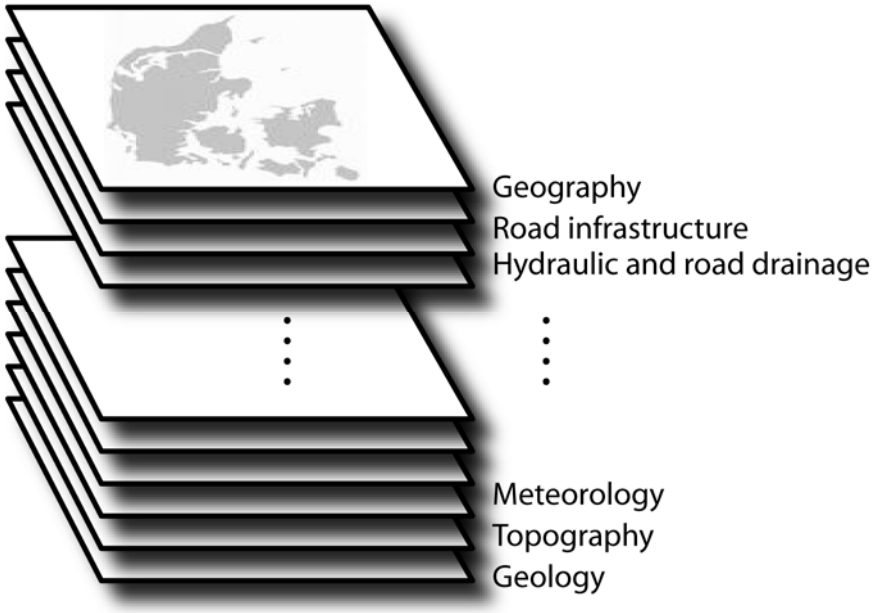

Figure 3 GIS modelling

Part 2 Guidelines for reducing vulnerability to flooding in local places

The second part of the project is to prepare guidelines on how to check the condition and maintenance of details of the drainage system and point towards improvements, extensions and renovations of places defined as blue spots.

The exposure of the problems is expected to be carried out by means of questionnaires and interviews with relevant road authorities and inspectors of road drainage, since it is assumed that the personnel often has good knowledge of “weak” points in the drainage system, e.g. too small dimensions of pipes and wells, merging of pipes, sludge in the pipes, filling of retention ponds, incorrect drainage from such basins, too small recipients, inadequate culverts, etc.

The results from these case-studies will be summarised in checklists and a step-by-step guideline that could be used generally.

A review of existing literature related to the SWAMP project will be produced as a separate report. This will ensure road-owners and other interested to benefit from the literature study.

Part 3 State of the art report from European literature.

The literature study will thus be report, where all relevant literature for the SWAMP project is collected in a reference list and also short summaries of some of articles, books and reports will be prepared, furthermore hearings of the ERA-NET Road partners – especially those who are Steering Committee members will be carried out. Literature found from the work throughout the entire project will be added and finally a collection of keywords may be collected. Such a ”stand alone” report would be of great help and should be able to be read by various road administrations.

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