Sewer condition assessment using ground penetrating radar and multitemporal thermal infrared imagery

Introduction

Reduction in the monitoring frequency and aging of the sewer system lead to the generation of cracks or failures in the sewer pipe. Such failures can lead to water leaking out of the sewer pipe into the surrounding soil or underground soil erosion developing into underground voids.
These underground voids usually go undetected, and may cause the surface above them to collapse thereby developing sinkholes. In this research it is proposed to use ground penetrating radar (GPR) (Figure 1) and thermal infrared (TIR) imagery (Figure 2) to observe the environment surrounding the pipe.

Data acquisition setup

At the current stage of the study, measurements are being taken in Waalstraat, Enschede, The Netherlands. The test site was selected in collaboration with the municipality of Enschede who have run a CCTV inside the sewer system and identified sediment entering into the pipe (Figure 3a) and causing deformation in the road surface (Figure 3b).

Figure 1. Sensors and software GPR Pulse EKKO Pro mounted with 500MHz transducers, and possibility to mount 100MHz antennas. GPR lines are collected perpendicular and parallel to the direction of the rad.

Figure 2. FLIR x6570sc equipped with 50mm lens, with a precision of ±1°C. Currently is collecting 1 frame every 5 minutes since January 15 2020. Attached in the mounting frame is also mounted and optical game camera Moultrie m-series, collection 1 frame every 30 minutes. The images collected by the optical camera are only used for observation purposes to aid in the interpretation of the thermal images.

Figure 3. a) CCTV image acquired by the Municipality of Enschede, it can be clearly seen infiltration of sediment from the road into the sewer pipe. b) Optical image acquired with optical game camera Moultrie m-series showing the test sit in Waalstraat. Notice the deformation on the road (red circle) caused by infiltration of sediment into the sewer pipe. c) Thermal infrared image acquired on February 15 2020 at 16:15 hours.

Preliminary results

The proposed setup will allow us to observe changes in diurnal surface temperature cycles through time with the use of TIR images (Figure 3c & Figure 4). GPR data will show differences in return time of emitted electromagnetic waves travelling in the underground layer (Figure 5).
By combining these two techniques it may be possible to localize increase in soil moisture (due to water outflow from the pipe), or areas with voids.

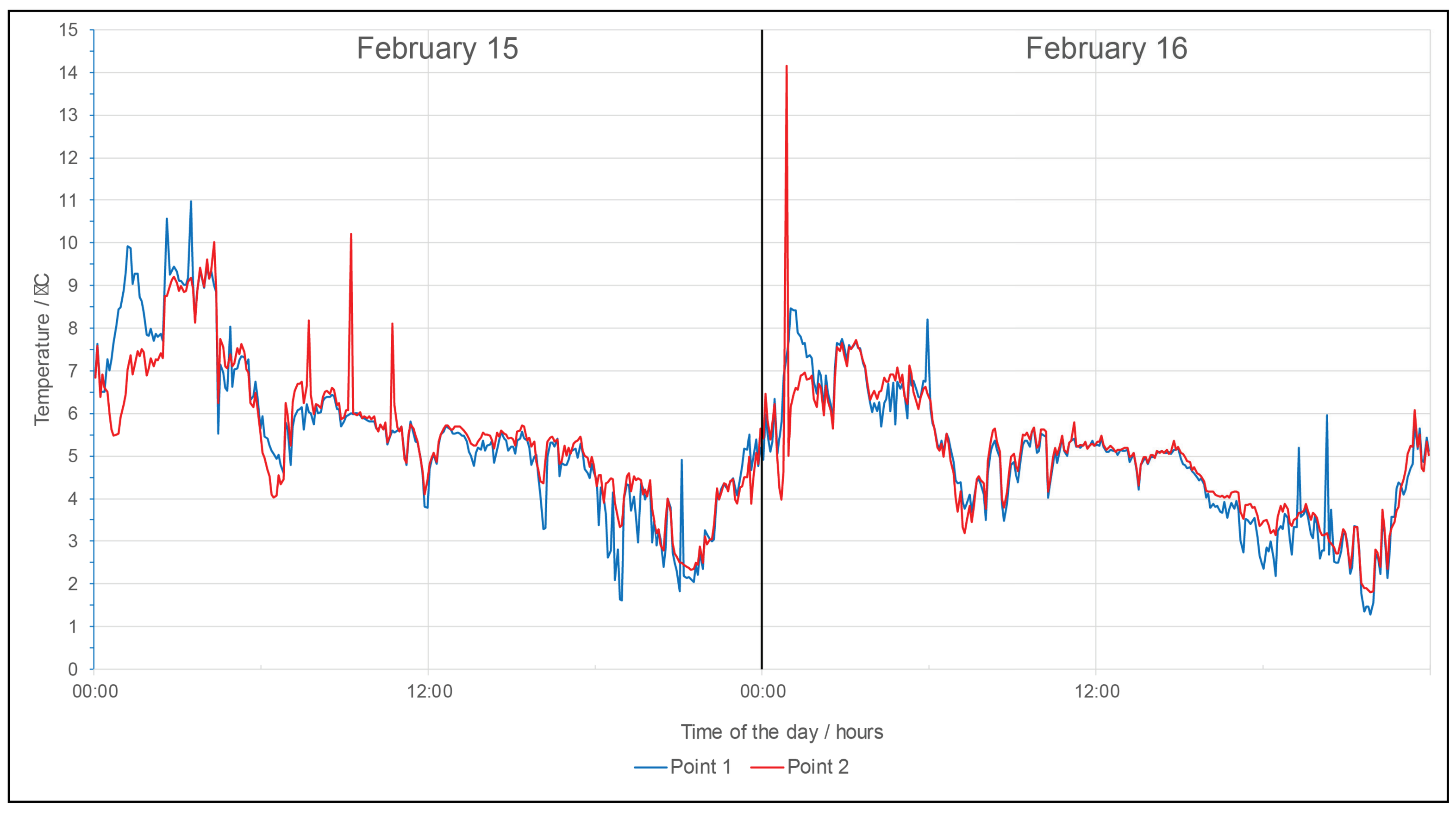

Figure 4. Surface temperatures of 2 different points on Waalstraat road. Temperature taken from thermal infrared imagery acquired every 5 minutes between 15 and 16 February 2020. The abrupt changes in temperature are due to turbulence in the Convective boundary layer that presented high turbulence due to the effect of Storm Dennis.

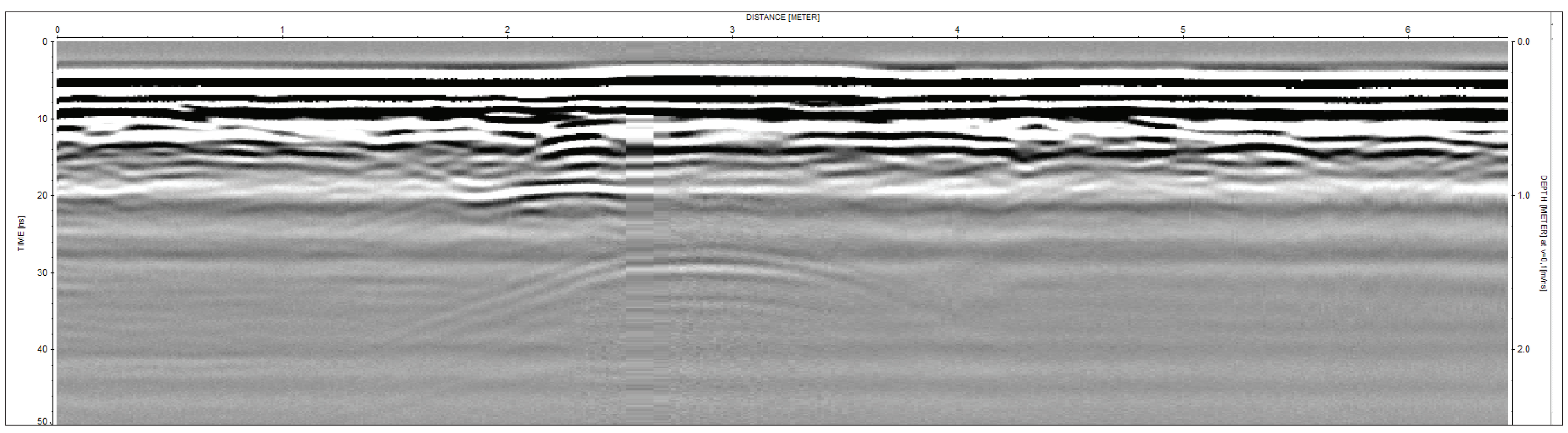

Figure 5. Radargram of Line 25, perpendicular to the direction of the road. The first 1m of depth (20ns) corresponds to base of the road, which generates various reflection from the different layers of the road. At 1.5m depth and a distance of approximately 3m it can be seen the apex of the parabola. This parabola corresponds to reflection of the EM waves from the top part of the sewer pipe.

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