1. INTRODUCTION

The Department of Plant Production and Soil Science of the University of Pretoria has been conducting extensive research on the use of mine water for irrigation of agricultural crops. As part of this research, the Department has also undertaken to study the use of mine water for the irrigation of crops grown on rehabilitated mine surfaces.

A pilot trial to irrigate virgin and rehabilitated land *(Annandale et al., 2000)* was conducted at Kleinkopjé Colliery, Witbank, South Africa. Three centre pivots, identified as Major, Jacuzzi and Tweefontein, within the colliery boundaries, irrigated different tracts of land. Of these, Jacuzzi and Tweefontein were set up on rehabilitated mine dumps whilst Major is on virgin land.

The Kleinkopjé Colliery, belonging to Anglo Coal, is located close to Witbank, in Mpumalanga (26 00' S, 29 21' E, altitude 1570 m), in the summer rainfall region, with an average rainfall of about 690 mm a^{-1}. The soils irrigated by the pivots are predominantly, a medium-textured Ferralsol (FAO, 1998). For Major, an underlying layer of weathered sandstone limits free percolation of water with occasional plinthic formations (generally at 1.1 m depth). Contouring and building of waterways was therefore indispensable, to facilitate drainage of excess surface water.

The effluent generated by this mine has high concentrations of Ca^{2+} and SO_4^{2-} associated with a moderate to high presence of Mg^{2+}. The water used to irrigate at Pivot Major originates in old underground workings and needs to be pumped to the surface and utilised in order to enable mining operations to continue. The water used to irrigate at Pivot Jacuzzi and Tweefontein is predominantly runoff water. The effects of the chemistry of the mine water can be masked or even enhanced by the condition of the soil and of the sub-soil. These specific conditions can range from irregular compaction across the field, resulting in an uneven depth to spoil, up to a marked variability in the characteristics of the soils themselves because of

the irregular mixing of the dumped heaps that are later flattened. Slumping of spoil layers can also take place.

The study concentrated on two of the centre pivots, specifically Major and Tweefontein. Both are irrigated with mine water, but, as stated above, Pivot Major, has been undermined, but has a virgin soil profile, whilst Tweefontein is a rehabilitated open cast section.

The object of this study was to observe, measure, analyse this variability with an emphasis on the tools and instruments that can be used for such a process. It is crucial to the whole methodology of the study that all matters causing spatial variability are taken into consideration and, conscious of this, the Department of Plant Production and Soil Science decided to explore and apply remote sensing and GIS technology to their studies.

In this framework, Mr. Giovanni Narciso, the experiment researcher with the Institute for Soil, Climate and Water of the Agricultural Research Council (ARC-ISCW), was appointed to carry out a study on the determination of the cause/effect relationships of spatial variability on crop canopies irrigated with mine water on virgin and rehabilitated landscapes using remote sensing.

In the course of normal everyday farm management practices, the eye of the farmer and his experience are the most used, and at times, the best available 'instrument' for gauging crop conditions. However, electronic instrumentation and various other technical devices are increasingly enhancing our observation capacity. Nevertheless, the ground level observation of crops, whether 'human' or 'electronic', provides a spatially distorted observation point of the fields and the awareness of any spatial alteration is limited.

A vertical, downward view allows a more effective examination of the spatial variability of a cultivated field and the identification of the correct significance, size and shape of anomalies over the crop canopy. This is the

basic requirement addressed by remote sensing technology, which literally means collecting information from a distance and possibly, vertically, from above.

Just as relevant as the assessment of crop conditions though, is the study of farming systems, which calls for a detailed analysis of the complex interactions between crop, soil and management practices. Remote sensing technology and Geographic Information Systems (GIS) can play a significant role also in these studies *(Goddard et al, 1996).*

The use of remote sensing and GIS addresses the observation and measurement component of the study. The analysis, also conducted utilising GIS technology, focuses on the links between soil variability and crop performance (as well as the different suitability of crops to irrigation with mine water). The aim is ultimately, to explain the reason for the existence of the poorer-performing parts of the two fields. Furthermore, knowing that the comparison is carried out between a 'virgin' and a rehabilitated site, the study also aims at understanding why they differ, and to provide helpful hints to further studies on how rehabilitation works and land preparation over former open cast sites should be carried out.

Finally, the main objective of the research is to contribute to the specific knowledge addressed at recommending sustainable cropping and irrigation management practices in the specific environment of the mines using wastewaters on virgin and rehabilitated sites.