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Location Optimization of Wastewater Treatment Plants Using GIS: A Case Study in Umm Durman/Karary

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Abstract: Spatially-referenced and up-to-date information system is one of the most useful tools for effective wastewater planning, management and environmental protection. Therefore, it is necessary to have a system which provides facilities through geo-spatial relationships. The River Nile catchment is one of the most important watersheds in the Sudan in terms of providing for domestic, agricultural, and industrial purposes and for electricity generation. Thus, protection of this important water source is crucial in national development. But, only very few point source treatment plants are currently in operation and non-point source treatment plants are required to be established to protect the catchment from pollution. Locating wastewater treatment systems is one of the essential components, and that needs spatially-oriented data gathering, analyzing and visualizing. Further, GIS-BASED decision support systems for available treatment plants are well suited for informing improved analysis and understanding of the problems of available treatment plants to perform a reliability to improve analysis and understand of the existing situation to choose the appropriate location of treatment through a GIS MODEL BASE using ARCGIS. This study-plan solve the issues and undertaken logics of GIS to identify the critical socio-economic and environmental factors, and find a more comprehensive and convenient way to optimize the locations for wastewater treatment facilities that are suitable for different local conditions in Karary.

Keywords: *Location Optimization; Geographical Information System (GIS); Wastewater Treatment (WWT) Systems.*

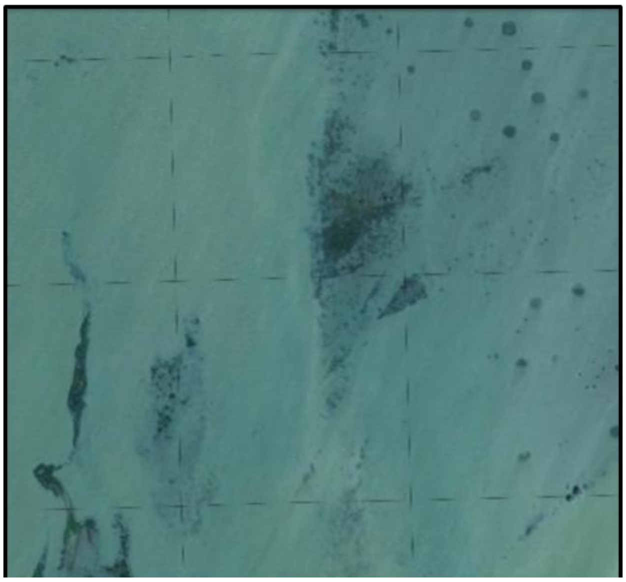
1. INTRODUCTION

A case study in Karary county/Omdurman requires extensive modeling using GIS due to the increase of urban and sub-urban agglomeration along water bodies, wastes disposal by local authorities, soil erosion. Even though, every new building requirement includes on-site wastewater disposal systems. As a result, partially-treated sewage directly is disposed to streams and canals. On the other hand, medium and small-scale industries such as service stations and agricultural waste (pesticides, fertilizers and herbicides) contribute significantly to deteriorate river water quality. (See SPOT5 image and classification details/fig &fig2). Therefore, widespread demand for improved water quality requires implementation of Catchment- based Wastewater Management System (CWMS) for in North Omdurman/Karary catchment. Other than the city of Khartoum were wastewater plant are covered by sub-urban and rural settlements, where resources and technical capacities required for operation and maintenance of conventional mechanical systems are limited and GIS in practical not in use for monitoring, modeling, geoprocesssing and solving the issues are relevant to the matters. Simple and low-cost but relatively high land consuming natural systems basically either belong to soil-based land treatment systems or aquatic plant-based wetlands are more appropriate to such a conditions that will definitely use and been supported by advanced GIS Object- Oriented application. Therefore, locating wastewater treatment system by analyzing socio-economical, environmental and technical aspects is vital in wastewater management process in the catchment area. With recent development of information technology, there has been an enormous change in the way information is collected, stored, analyzed and visualized. Geographic Information System Technology (GIST) has made easier to develop computer application to handle volume of data related to water resource management. “GIS systems have been used for more than 30 decades in the West in the field of wastewater management” (Paulson and Eitz, USA wastewater system using GIS/ARCGIS/ARC HYDRO 2010).

Therefore, the main objective of this study is to optimize the location of wastewater treatment systems in the study area by integrating GIS with related local factors. Selection criteria were based on technical, environmental and economical factors and topography.

2. Material and methods

The waste water treatment plant in Khartoum state KALAKLA(South of Khartoum) area is a bad example of water treatment.
The spill over is quite notable from aerial and satellites images: see image below
Taken by SPOT5 Thermal Infrared Sensor(TIRS)



Fig(1). SPOT5 image: South of Khartoum/wastewater spillover/Eutrophication occur to tackle against nitrogen and phosphorus.

Image classification using (ENVI 4.8)

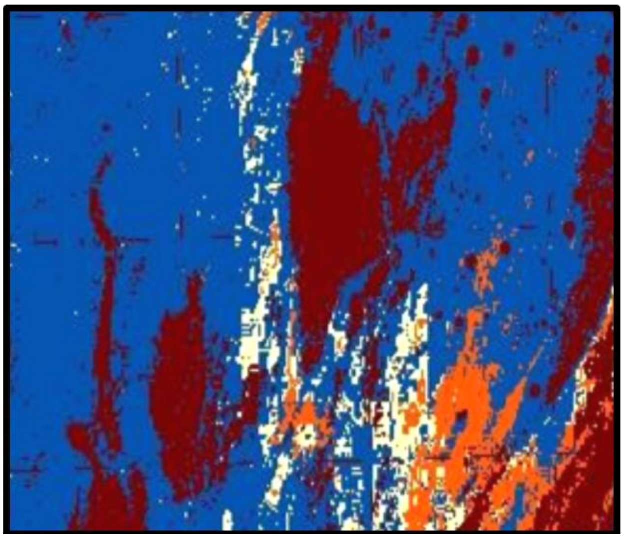


Fig (2). The supervised classification method delineate the Eutrophication plant (dark brown) nitrogen (orange), phosphorus (yellow)

To avoid such results it is obvious to use GIS; the system requires the preparation of necessary spatial data in GIS namely:

a) Residential area
b) The course of the River Nile.
c) Areas likely to be flooded (below contour 382)
d) The military area.
e) Roads.

Then analyzing the layers for each criteria using GIS tools

Preparation of spatial data in GIS

The optimum site selection in GIS has got a clear procedure. To choose a site for a specific project, "Optimum site for waste water in the County of Karari, North of Umm Durman".

Questions will be asked which indicate the basic data needed for the site for the project in hand. These questions will be:
a-The site should be on a low land to help materials driving into it.
b- It shouldn't be in an area likely to be flooded
c- It should be outside the dwelling zone and military areas by such and such distance
d- Total area should not be less than 1km*1km.
e- Should be within a certain distance from major roads in the area.

So site selection of (WWT) can be done with thematic vector layer analyzing in ArcGIS (10). Low land area were obtained from a digital elevation model (DEM) of the area using ArcGIS 10(see fig. 2.7)
Then area likely to be flooded was excluded from the test as it will not be chosen.(see fig. 2.3)
The rest of low lands were included in choice test.
Areas covered by human settlements were obtained from satellite images. (See fig. 2.2)

Analysis of Boolean maps

The analysis of the thematic maps was performed by using overlaying, union, and intersects operators. Areas likely to be flooded were buffered to isolate them from the test; also a buffer of 0.3 km around the dwelling area was made. The rest of the area where all criteria's were satisfied and feasible for WWT systems constructions were included.

Water Services and wastewater treatment (sanitation) services for Karari

Umm Durman and immediate region's sustainable water supply are being threatened by a combination of population growth and urban development. This requires alternatives strategies: i.e. bulk wastewater management infrastructure, specialized equipment investment needs. Growing wastewater volumes are directly linked to population growth, industrial development and increase in visitors from neighboring countries. A new multipurpose, replacement landfill and a system of transfer stations must be established as the existing landfills are filling up and will not be able to cope with increasing waste volume during the next years. Water management is the efficient and effective use of water resource available by minimizing wastage, promoting recycling and improving water quality.

In order to manage water better it is crucial to have an inventory of the water available, how it is being managed, the drainage area, the demand and supply of water. GIS has been very beneficial in mapping and data analysis, thus greatly aiding in the understanding and decision making in water resource management.

The initiative is application-oriented with two scientific and technical domains to be jointly activated: in general the services to demonstrate the catalyst role of GIS as integration tools for Water treatment and Environment, to assess how geographical knowledge can be transferred to potential water management users, to implement the proposed approach in the design of sustainable development.

The final goal is to offer our services, where water treatment plant operators will co-operate with GIS analysts. Moreover the technology is intended to give particular emphasis to enlarge the market of GIS application in water treatment and management and the awareness on the potentiality of these tools, with the benefits for all technical operators working in the water environment fields.

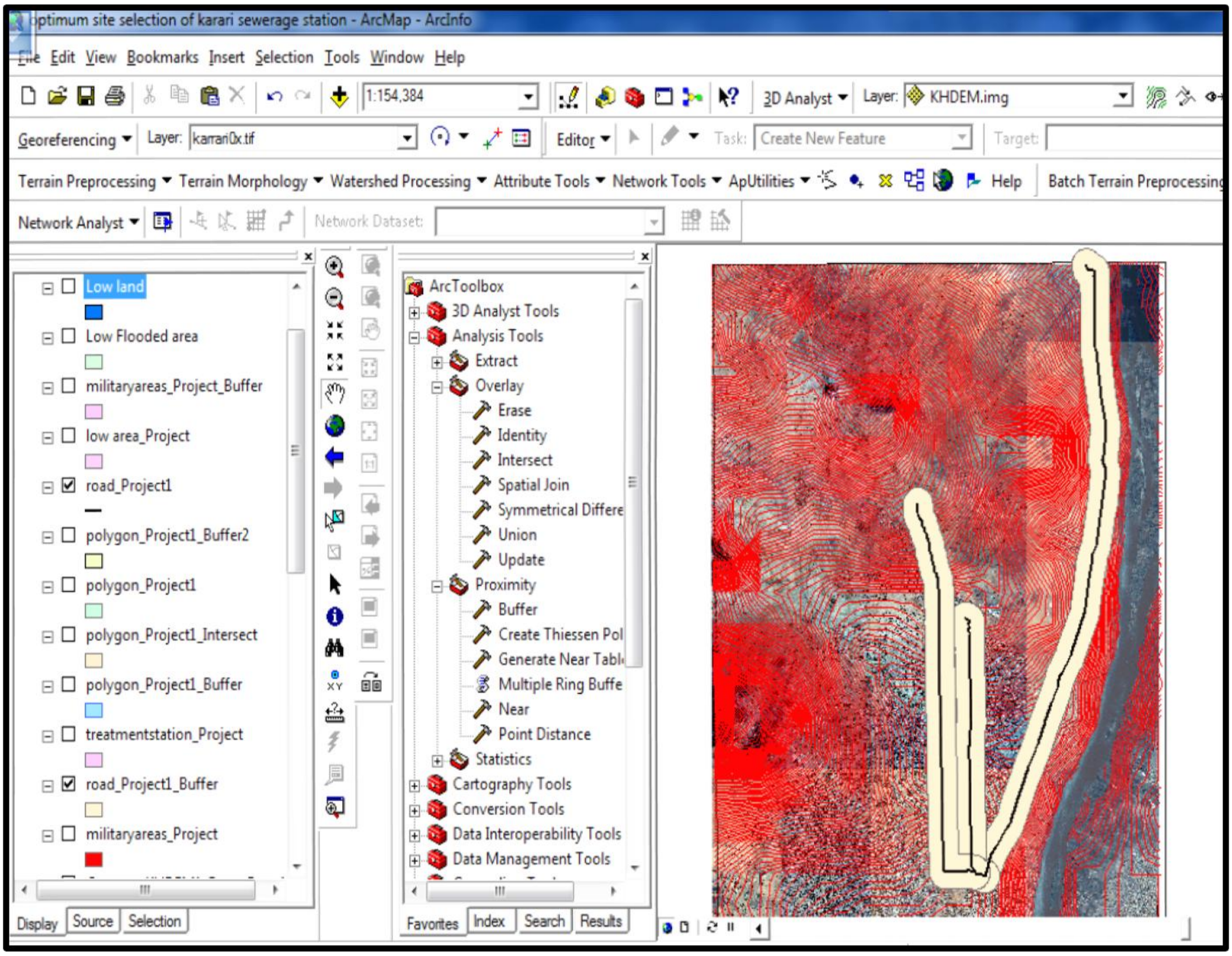
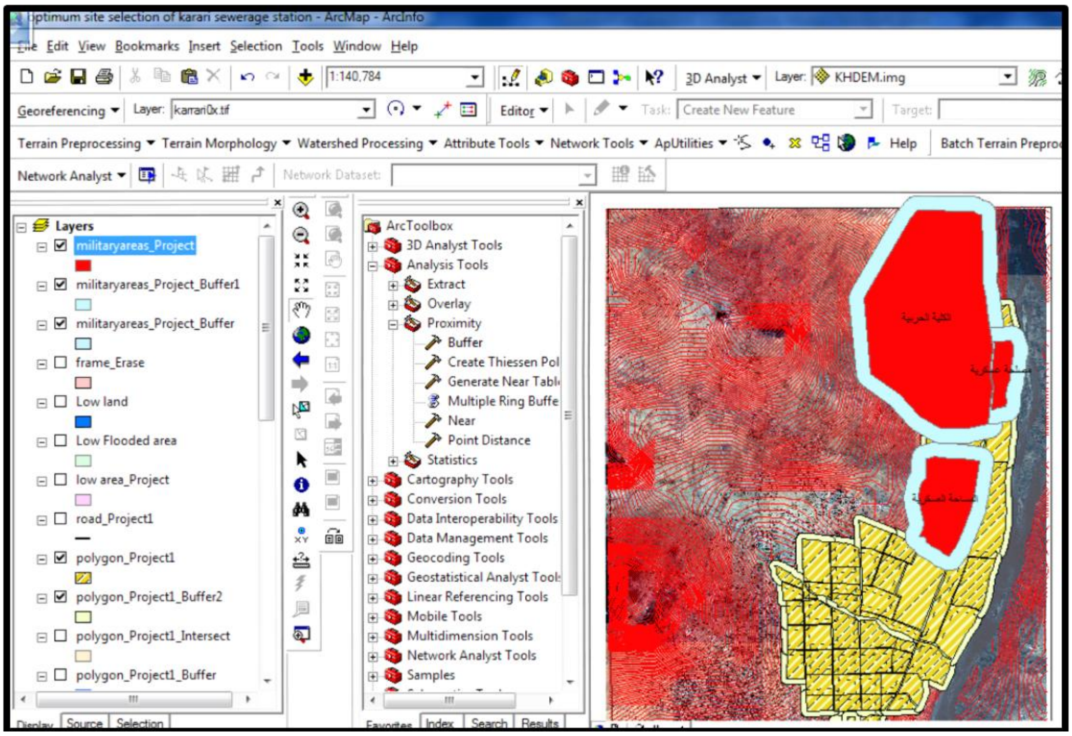


Figure (2.1). 500 m –road buffer



Figure(2.2). 500 m –buffer around residential area and military area

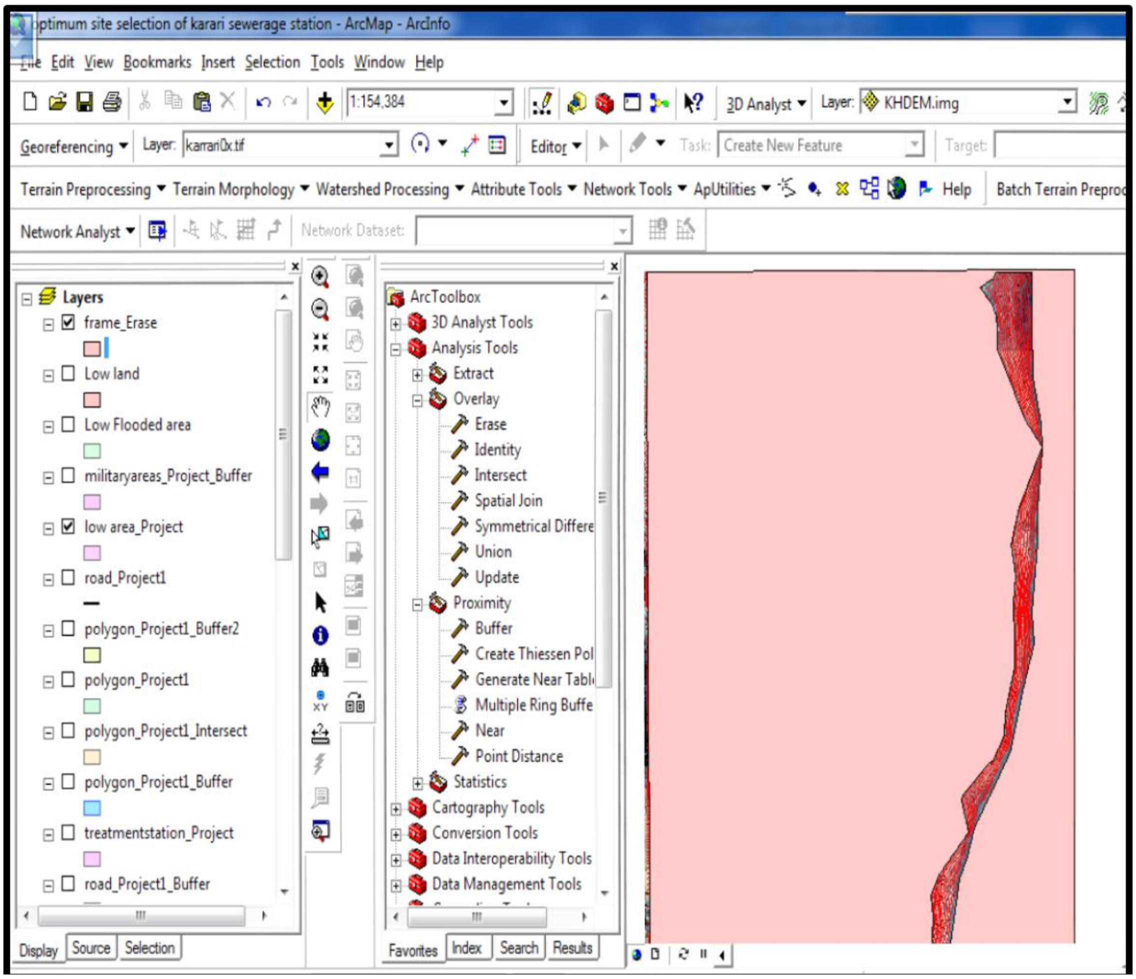
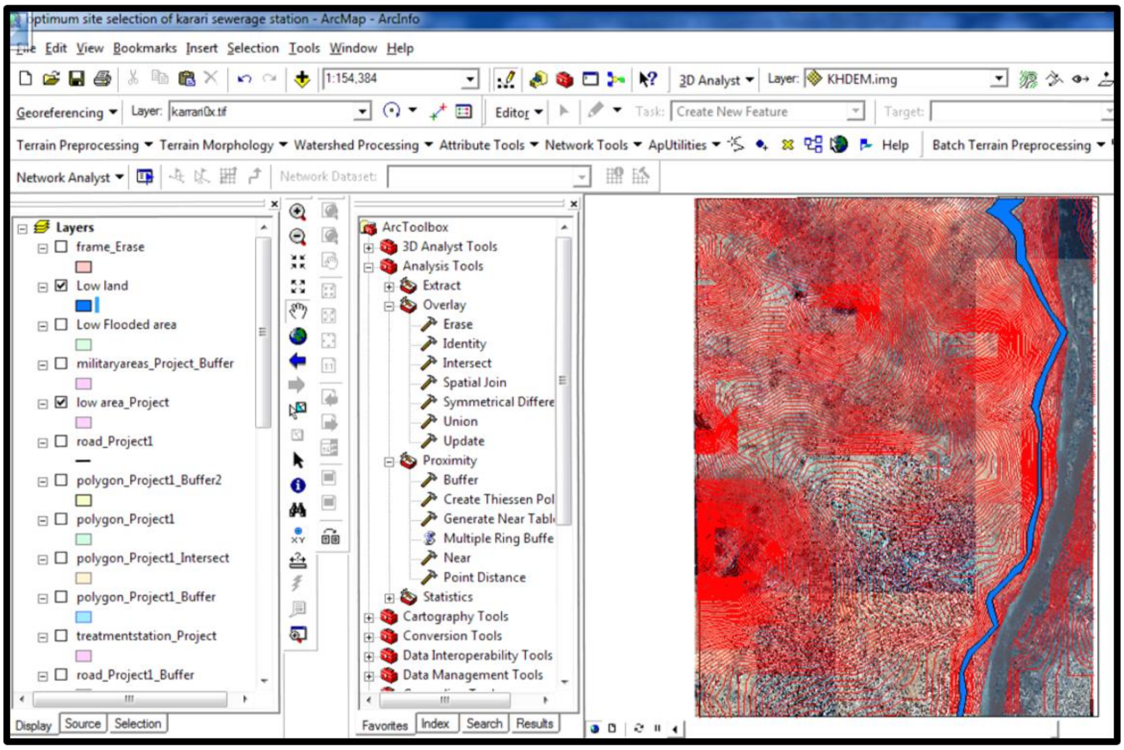


figure (2.3). Erase of Flooded area (less than or equal 382m)



figure(2.4). Low land area between contour (382-384 m)

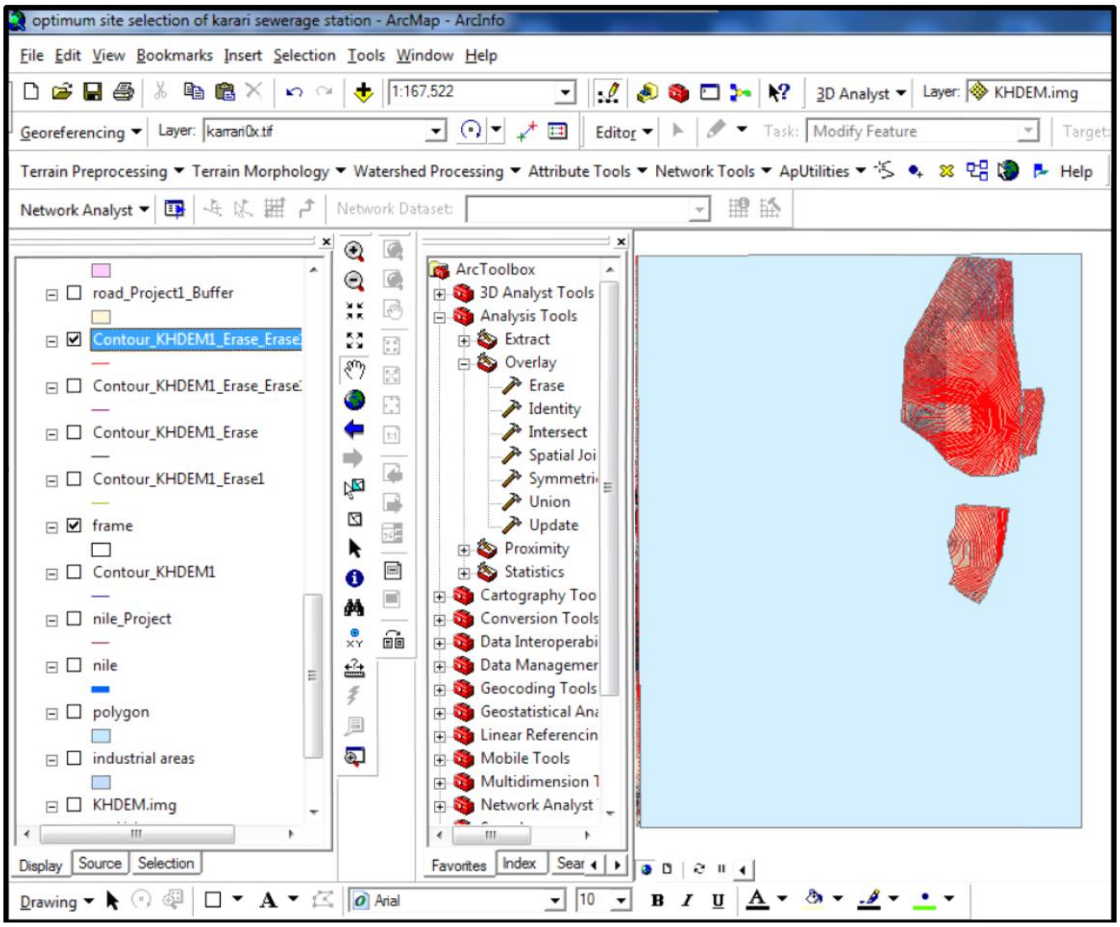
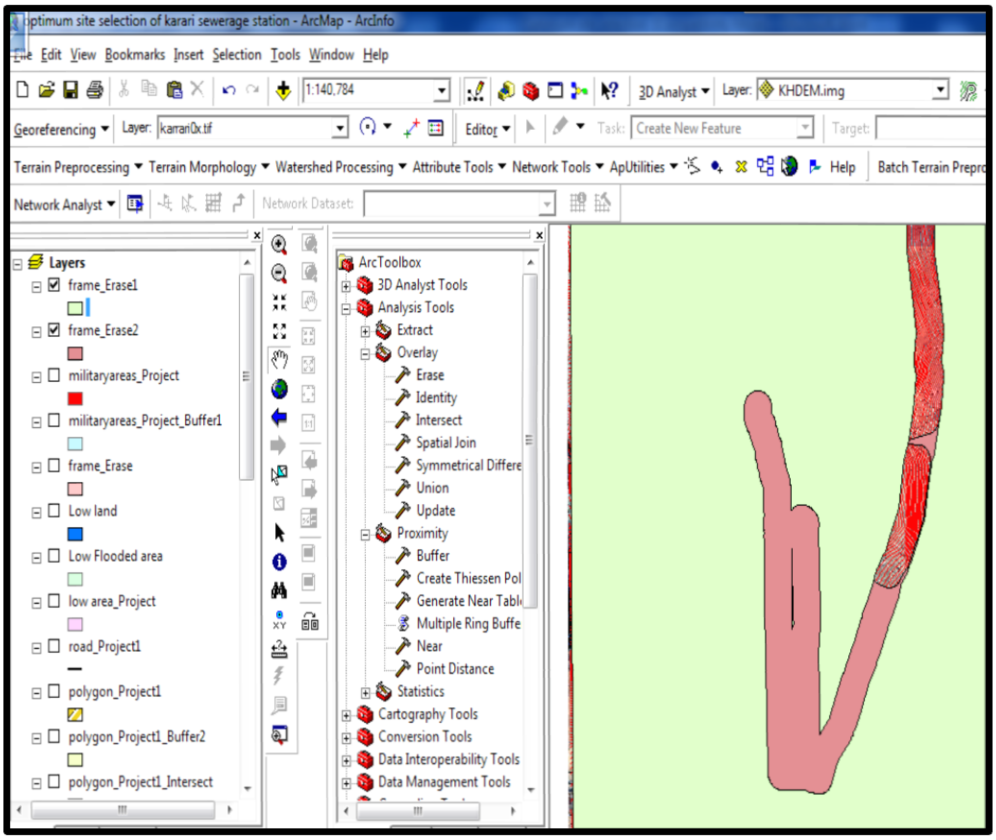


Figure (2.5). Erase military area



figure(2.6). Erase road buffer area

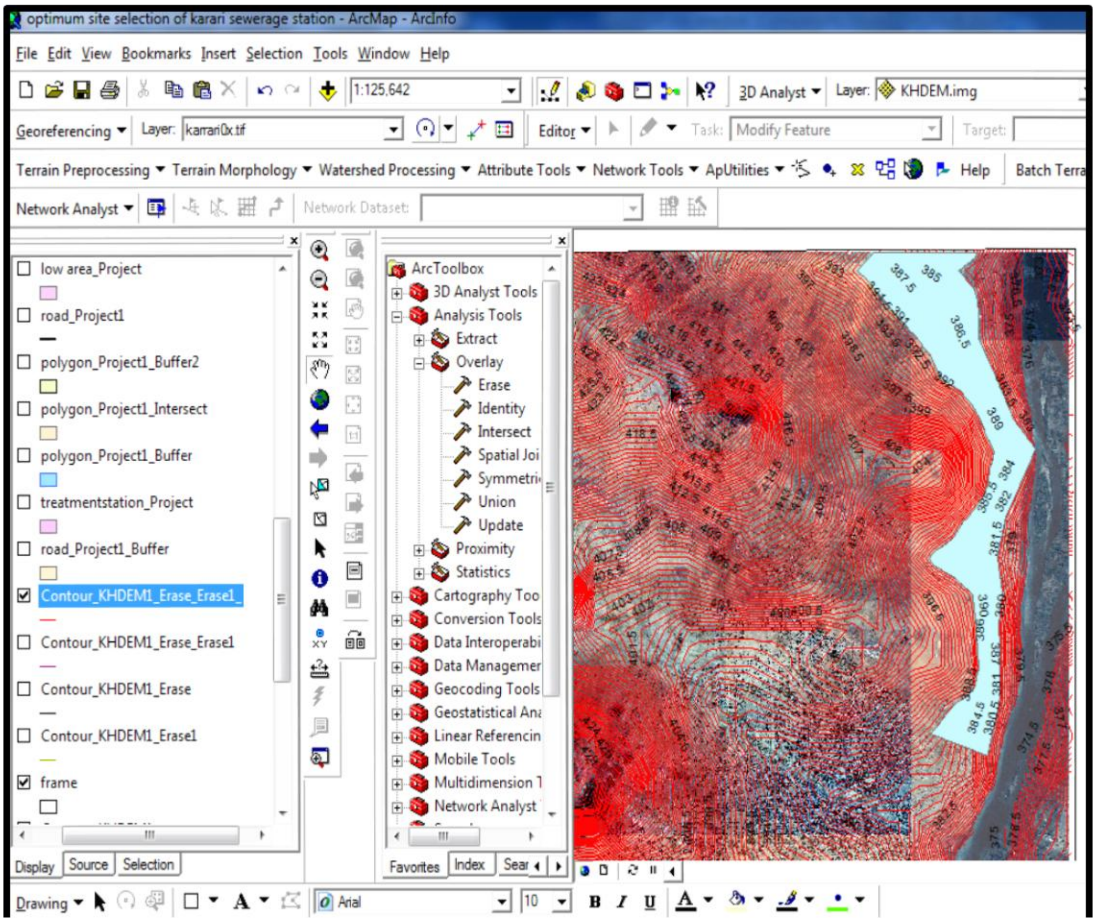


Fig.(2.7). Recommended area between contour 384-390 m

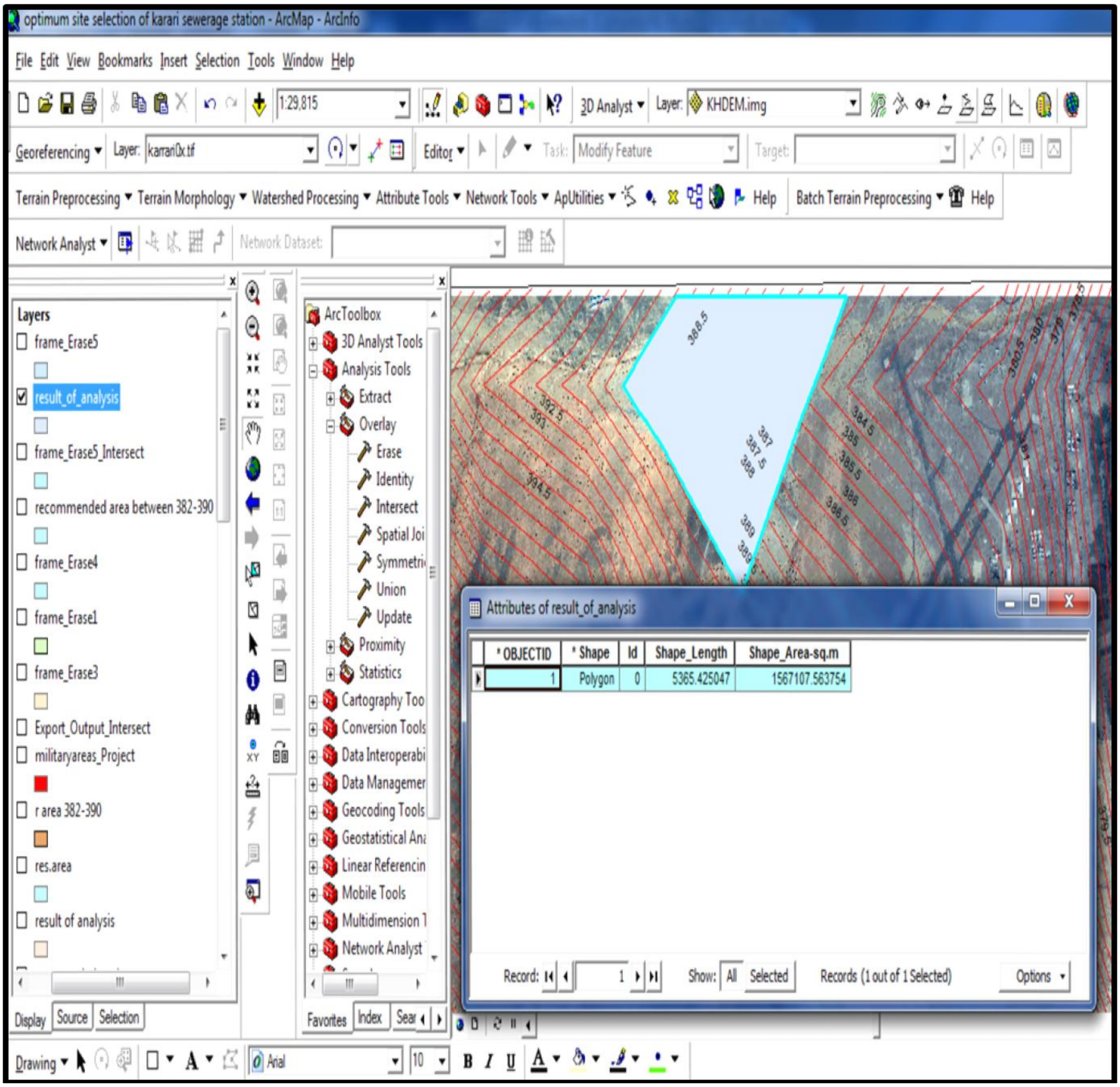


Fig. (2.8). FINAL RESULT OF OPTIMUM SITE SELECTION OF WASTE WATER PLANT

3. Discussion and Results

The final map resulting from the multi-criteria analysis gave a total area suitable for wastewater plant of more than 2km of the total area examined.

Some areas were obviously unsuitable for their excessive elevation and steep slopes. The suitable location which satisfied all the criteria of choice was EAST of the main road and close to the River Nile. This area is suitable for the collection post and the disposal of Excess Treated Wastewater.

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