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Geospatial Techniques in Water Distribution Network Mapping and Modelling in Warri Port Complex (Nigeria)
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FIG WORKING WEEK 2015
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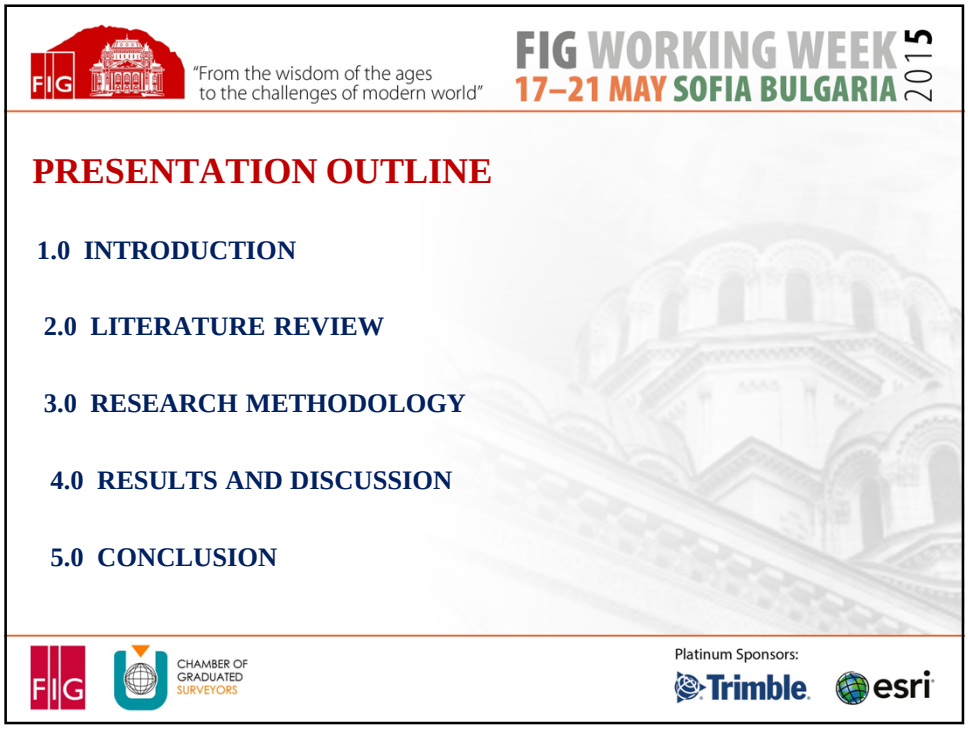
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PRESENTATION OUTLINE
1.0 INTRODUCTION
2.0 LITERATURE REVIEW
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INTRODUCTION

❑Water, a vital resource to man's existence and any nation should be well planned, developed, conserved, distributed and managed.

❑ Its *infrastructure* should be properly maintained to avoid future water problems.

❑A well planned and adequately mapped water distribution network plays an immense role in the provision of potable water supply.

❑ A good water distribution system is fundamental to environmentally sustainable development in any country and is also important in the control of water borne diseases (Al- layla et al, 1978; Audu and Anyata, 2010; Audu and Ehiorobo, 2010; Audu and Edokpia,2010)

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INTRODUCTION CONTD

❑The aim and objectives of this study are to:

- **examine the location of NPA water distribution pipeline routes;**
- **determine the geo-spatial information required for the planning and design of a omprehensive NPA water distribution network**
- **produce the vector models of the water infrastructure.**

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2.0 LITERATURE REVIEW

- The distribution components form a large proportion of total investment in any water supply system (Rao, 2002).
- These components include water reservoir, water pipes, water pumps, storage tanks, junctions and valves
- Water distribution system account for 40-70% of the total cost of water supply scheme (Sarbu and Borza, 1997; Nathanson, 1997 and Izinyon, 2007), hence its proper planning, design, operation and layout is of great importance

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2.0 LITERATURE REVIEW CONTD

Table 1- Components of Water Distribution System and Modelling purposes (Walski et al, 2003)

Component	Type of Network Modelling Element	Primary modelling purpose
Reservoir	Node	Provides water to the system
Pipe	Link	Conveys water from one node to another
Pump	Node	Raises the hydraulic grade to overcome elevation differences and friction losses.
Storage Tank	Node	Stores excess water within the system and releases that water at times of high usage.
Junction	Node	Removes (demand) or adds (inflow) water from/to the system.
Valve	Node or Link	Controls flow or pressure in the system based on specified criteria

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3.0 RESEARCH METHODOLOGY

3.1 The Study Area

- The study area is situated at Warri Ports Complex of the Nigerian Ports Authority, Warri, in Warri South Local Government Area of Delta State, Nigeria.
- It lies within the tropical rainforest zone and is bounded by National Coordinates 16700mN to 16850mN and 361500mE to 367000mE
- The Satellite Imagery of the Study Area is shown in Fig. 1 below

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Fig. 1. Satellite imagery of NPA Warri Ports Complex (Source: Google Earth)

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3.2 Data Collection, processing and modelling of Water pipeline Distribution Network

- Since there were no control points existing within the port area, three (3) control points, viz: NPA 1, NPA 1A, NPA 1B, were established at the port site in the vicinity of the water headworks using SHELL GPS Control Station (CBLI) at NPA-DSC Express way as a *reference station*, Global Positioning System (GPS) receivers and the method of Differential GPS (DGPS);
- These control points were used in running secondary total station traverses through the proposed water distribution pipeline routes;
- The total station survey was carried out at millimetre (mm) level accuracy to capture break in slopes while support levels were run between the total station traverse routes in order to prepare ground profiles of the proposed water pipeline routes.
- During the survey, all details within the pipeline routes were recorded. Profile levelling was carried out with the aid of an automatic levelling instrument with the levels taken.

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3.2 Data Collection, processing and modelling of Water pipeline Distribution Network Contd

- The geo-spatial data of all the components of the water distribution pipelines were acquired using the established GPS controls and Geomatics techniques and instruments.
- The post processing of the GPS data was carried out using the THALES GNSS Solution software. The computation and adjustment of the traverse survey of the proposed pipeline routes were also carried out using the inbuilt software in the Total station instrument.
- The acquired elevation data of the components of the water distribution system were reduced using the height of instrument method.
- The accuracy of the traversing and the levelling operations were within the permissible accuracy. The processed geo-spatial information of the NPA water distribution scheme was input into Microsoft Excel software and script files were created.

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3.2 Data Collection, processing and modelling of Water pipeline Distribution Network Contd

- The script files were exported into AutoCAD 3D Civil software and the geo-spatial information of the various components of WDN were modelled in the CAD software as vector models.
- The distribution layout vector plan was exported into the topographical model generated from the satellite imagery. The ground elevations were obtained from DEM generated from the topo-map and from ground levelling.
- The geospatial database, which was designed and created, was exported into Haestad Water CAD environment for the water distribution network analysis and it was based on traverse lines representing length of pipes, intersection points;
- Analysis of DEM database with the Haedstad CAD was used to determine where pressures are low and head losses high. These were used to identify if pipe sizes were adequate or not for delivering the required flow rates to various section of the port.

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4.0 RESULTS AND DISCUSSION

Table 2: WGS 84 Coordinates of the GPS Reference stations in Minna Datum and Established Controls at NPA site

Station ID	East (m)	North (m)	Height (orthometric) (m)
CBL 1	376 194.180	166 859.940	4.270
NPA 1	366 330.062	168 055.404	3.008
NPA 1A	366 238.369	168 133.840	2.589
NPA 1B	366 441.071	168 058.694	2.440

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Table 3 Geo-spatial Information and the Estimated Borehole Capacity in the Study Area

Borehole (BH)	Service Area	Coordinates		Status/ Proposed work	Proposed Yield (m^3/hr)	Proposed Yield (m^3/day)
		Easting (m)	Northing (m)			
BH1	New Port	366 097.259	168050.883	NF/Reactivation	70 m^3/hr	1400 m^3/day
BH2	New Port	366 033.392	168029.223	NF/Reactivation	70 m^3/hr	1400 m^3/day
BH3	New Port	366 455.782	167 992.213	NF/Reactivation	70 m^3/hr	1400 m^3/day
BH4	New Port (Standby)	366 027.041	168139.879	New Construction	70 m^3/hr	1400 m^3/day
BH5	Old Port (Standby)	366 767.493	167 493.883	New Construction	70 m^3/hr	1400 m^3/day

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Table 4 Attribute information of the components of NPA Water Transmission and Distribution pipelines

System Component	Pipe Material	Pipe Diameter	Hazen – Williams factor (C)	Deign Period (years)
Transmission pipes	uPVC	200mm	140-150	30
Distribution Pipes	uPVC	250mm (Mains 200mm (Sub- mains)	140-150	30
Distribution system Appurtenance	Gate valves, End cap, Washout valves, Air relief valves, Water metres and Hydrants			

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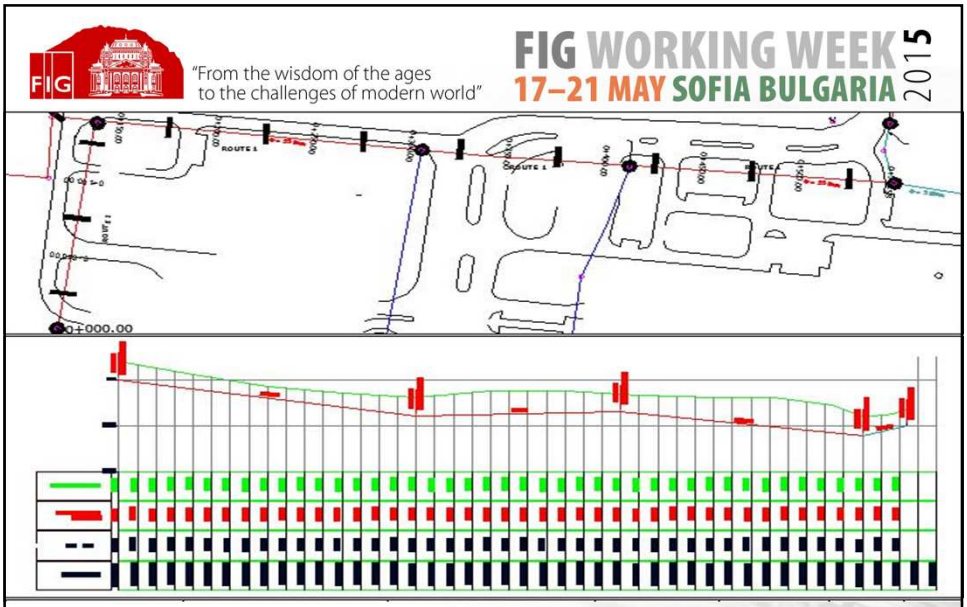

Fig. 2 Vector plan and profile of water pipeline Route 1

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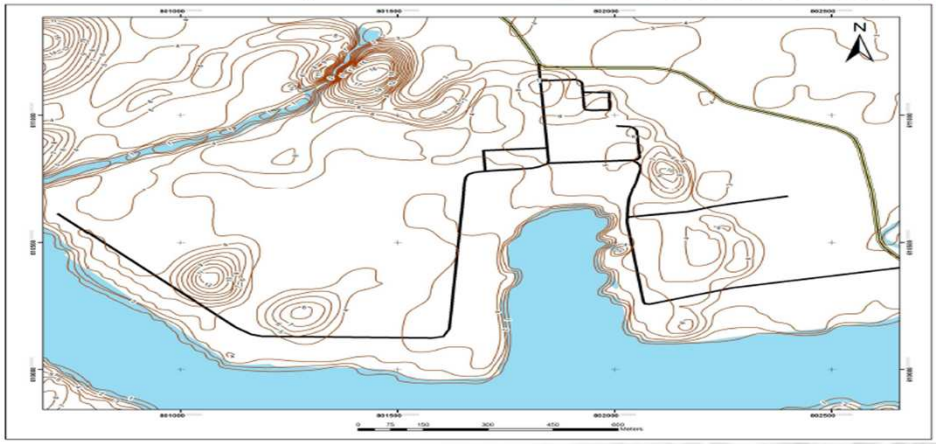

Fig. 3 The contour map of the Nigerian Port Authority(NPA) site, Warri

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- DISCUSSION
- The established GPS controls (NPA1, NPA IA, NPA IB) (Table 2) in the study area provided the needed control stations for the traverse and detailed survey of the water pipeline routes at Warri NPA site.
- **Establishment of controls, where none exists, is in accordance with survey principles when carrying out any survey work.**
- **Besides, they shall be used as reliable control points for future survey works within the study area and its environs.**
- **The practice of using control framework as a basis for further survey operations, often called 'working from whole to the part', prevents the accumulation of errors in any survey work.**
- **The commonest system of control is by coordinates- *planimetric coordinates for the horizontal* controls and height recording from an adopted datum for the vertical controls (Scofield and Breach, 2007).**

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- **The rectangular coordinates, shown in Table 2, played significant roles in the location and geo-spatially positioning of the entire water distribution network of the study area.**
- **Besides, the various components of NPA water distribution system can be planned, designed, constructed and maintained on the basis of the computerised information, which includes coordinates as well as other information concerning topography, geology, drainage, population inter alia.**
- **According to Audu and Ehiorobo (2010), most engineering infrastructure such as waterlines, railways, highways, buildings, dams and powerlines located on, beneath or above the surface of the earth are spatial objects. The most convenient and most used method of describing their positions is by their rectangular coordinates (McCormac, 2004).**
- **The remotely sensed data, the digital satellite imagery (Fig.1) has provided reliable, up-to-date information of the study area and aided in determining the most desirable and economic location of the NPA water distribution pipelines.**

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DISCUSSION CONTD

- **The Geomatics techniques and equipment were used to provide the geospatial information needed for the location and positioning of the existing and newly, proposed boreholes in the study area in order to boost hourly and daily yields.**
- **The additional boreholes (BH4 and BH5) are to serve as buffer and standby for the existing boreholes. The estimated borehole capacities are given in Table 3.**

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- The design period, the pipe materials, pipe carrying capacity and the pipe diameter for both the transmission and distribution pipelines are presented in Table 4.
- Unplasticised Polyvinyl Chloride (uPVC) pipes were proposed for the transmission and distribution pipelines because:
  - they are nowadays not only most preferred pipe materials for water supply piping;
  - of their strength and resistance to internal pressure;
  - they are not subject to corrosion or deterioration by electrolysis, chemicals or biological activities;
  - They are exceptionally smooth, minimizing friction losses in water flow.
- Furthermore, they are lightweight, very smooth surface finish, ease of installation and repair, and *up to 150mm in diameter of the pipes may be site-bent slightly* to accommodate *ground contours or changes in direction(*Rao, 2002).

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- The vector plans and profiles for the NPA water pipeline routes (Fig.2) were used in the preparation of the estimates for the construction of the water distribution system and the tender for the contractors.
- They are part of the tender documents that provide valuable information for the bidders as well as form a reference manual for use during the execution of the project.
- The plans are the drawings that contain all details necessary for proper construction of the water distribution network, while the vertical alignment sometimes referred to as profile indicate the natural ground surface and the centre line of the water infrastructure with details of the vertical curves.
- The profile also helps in computing the estimated earthwork quantities. Nicholas and Lester (1999) noted that "plans, profiles and specifications are part of the contract documents for the construction of water distribution system, highways, railways etc.

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DISCUSSION Contd

- They are therefore considered as legal documents in the construction industry. Furthermore, they are used for the preparation of the construction's estimates and the contractor's bids."
- Terrain elevations, shown in Fig.3, play major roles in the distribution and flow of water in the natural landscape of the study area.
- Moreover, they contribute immensely in the determination of the actual location of NPA ground level storage reservoir and the elevated storage tank.
- The ground elevations are very useful when evaluating the hydraulic grades and operating elevations within the pressure systems.
- The produced contour map and the profile levels were used for the pipeline network design.

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CONCLUSION

- The importance of accurate and up-to-date geo-spatial information in the planning, location, design and development of water distribution infrastructure has been highlighted.
- This study has examined the use of a modern technology, Geo-spatial information and Geomatics techniques in the planning and development of water distribution system of the Nigerian Ports Authority.
- The results of the study revealed that with the provision of accurate, up-to- date geo-spatial information, the physical location of NPA water infrastructure on or beneath the earth's surface can be determined.
- Moreover, with the help of the modern Geomatics techniques and state-of –the art instruments regular updating of the geo-spatial information of the components of the water systems in the study area can be carried out.

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CONCLUSION CONTD

- Since we live in a dynamic world with increasing population, urbanization and industrialization, the geo-spatial information (the water distribution systems maps)should be regularly updated using Geomatics technology and equipment including Electronic Total Station (ETS), GNSS receivers, or satellite remote sensors.

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