ROUTE SURVEY OF EVBHUKU COMMUNITY IN OREDO LOCAL GOVERNMENT AREA EDO STATE USING DGPS TECHNIQUE

BY

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PG/ENV2415151

DEPARTMENT OF GEOMATICS

UNIVERSITY OF BENIN

BENIN CITY, NIGERIA

P.M.B 1154

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF POST GRADUATE DIPLOMA {PGD GEOMATICS}, IN THE FACULTY OF ENVIRONMENTAL SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA.

DECEMBER, 2025

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CERTIFICATION

This is to certify that this project was carried out by OFEIMU, ANTHONY with Matriculation Number: PG/ENV2415151of the Department of Geomatics, Faculty of Environmental Sciences, University of Benin, Edo State, Nigeria.

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SUPERVISOR Date

Surv. Dr. S. O. Oladosu

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HEAD OF DEPARTMENT Date

Surv. Dr. S. O. Oladosu

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______________________ EXTERNAL EXAMINER

Date

DEDICATION

I dedicate this project work to God Almighty who gave me life to live, wisdom, and grace to stay all through this period of my academic pursuit and for the success of it, and also to my family members for their love and support.

ACKNOWLEDGEMENT

I thank Almighty God for his grace upon my life throughout the period of my post graduate program in University of Benin, Benin City, Edo State.

I heartedly appreciate the innumerable contributions and support from my parent Mrs Comfort Ofeimu, my brothers and sisters.

This project will be incomplete with appreciating and commending the efforts of project supervisor, Surv. Dr. S. O. Oladosu, for his meekness, and impactful method of knowledge into us throughout this program. His analytical feedback and guidance played a vital role in modeling this project to this standard.

I want to also appreciate the staff and management of the Department of Geomatics, the University of Benin for their encouragement, lovely nature and advice during the course of this program; Prof. Raphael Ehigiator-Irughe, (DEAN) Environmental Science, Surv. Dr. S.O. Oladosu (HOD) Geomatics, Surv. Dr Odumosu J. Olayemi, Surv. Dr. Nwodo O. Geoffrey, Surv. M. O. Ekun, Surv. Dr. Ojo E. Peter, also to the other staff of the department.

I say thank you and God bless you all, Amen.

ABTRACT

This project report presents the findings of a route survey conducted for the Evbhuku community road in Oredo Local Government Area, Edo State, Nigeria. The survey employed Differential Global Positioning System (DGPS) technology. The primary goal was to collect accurate topographic and cadastral data required for designing a new road and determining the necessary Right-of-Way.

Fieldwork was carried out using two Hi-Target V300 GNSS receivers operating in Real-Time Kinematic (RTK) mode. This setup was used to map a 2-kilometer proposed corridor connecting Obe, Evbhuku, and Amagba communities. Data collected included the road's centerline, ground elevations at 25-meter intervals, and the locations of all existing features and property encroachments. The collected data was processed using Autodesk Civil 3D software. This involved converting coordinates to the local map grid and creating a detailed digital model of the terrain. From this model, engineering drawings were produced, including road plans, elevation profiles, and cross-sections. The survey also calculated earthwork volumes, identifying a net requirement to excavate approximately 13,115 cubic meters of material.

The results confirm the survey achieved the necessary accuracy for road design. A major finding was the identification of significant land encroachment by buildings and a market along the first 350 meters of the route, which must be resolved before construction can begin. This project provides the essential mapped foundation for the subsequent stages of the road's development.

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INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Engineering surveying constitutes a specialized branch of surveying concerned with the planning, design, construction, operation, and maintenance of engineered infrastructure such as buildings, roads, bridges, pipelines, tunnels, and other civil works. It provides the accurate spatial measurements and geodetic control required to ensure that engineering projects are executed in strict conformity with design specifications, safety requirements, and regulatory standards (Kavanagh & Bird, 2000; Wolf & Ghilani, 2012).

Within the fields of engineering and environmental studies, surveying has long been recognized as a fundamental activity underpinning all meaningful physical development. It is widely regarded as the bedrock upon which infrastructure planning and implementation are built, as virtually every development project depends on precise spatial data for decision-making, design optimization, and construction control. The diverse branches of surveying collectively support the development of transportation routes, accessibility networks, land administration systems, and the spatial organization of both natural and human-modified environments (Punmia *et al.*, 2005).

Route surveying, as a key component of engineering surveying, is specifically concerned with the establishment of horizontal and vertical alignments for linear infrastructure such as highways, railways, pipelines, canals, and transmission corridors. It involves the planning, design, and setting out of routes, as well as the systematic assessment of terrain conditions, drainage characteristics, geological constraints, and existing natural and man-made features along the proposed corridor (Wolf & Ghilani, 2012). Route surveying is equally essential for the alignment improvement, expansion, or rehabilitation of existing transportation routes, particularly where increased traffic demand, safety considerations, or infrastructural deterioration necessitate redesign or upgrading.

The outputs of a route survey typically include detailed plans, longitudinal profiles, and cross-sectional information that collectively depict the geometric characteristics of the terrain along a defined strip of land. These survey products form the basis for engineering decisions related to route location, geometric design, earthwork estimation, drainage planning, and construction execution. Accurate route survey data therefore play a decisive role in ensuring the functionality, safety, and economic viability of transportation networks.

A well-developed road network is one of the most essential amenities required for societal and economic development. Human mobility, the movement of people, goods, and services, is a defining characteristic of organized societies, and efficient transportation infrastructure facilitates trade, access to education and healthcare, social interaction, and overall economic growth. Consequently, the availability of properly designed and constructed roads is indispensable for sustainable national and community development. Engineering route surveying, by providing the spatial foundation for road planning and construction, remains a critical driver of infrastructural advancement and regional connectivity.

1.2 STATEMENT OF THE PROBLEM

The Evbhuku Community at Oredo Local government area of Edo state, like many developing regions, faces critical challenges regarding connectivity and accessibility to essential social and economic services. Currently, the primary routes linking Evbhuku to neighbouring places, regional markets, and necessary infrastructure (such as hospitals and schools) are inadequate. These routes are characterized by two main deficiencies:

The paths are predominantly unpaved earth, severely degraded by seasonal rains, leading to washouts, deep erosion, and extensive flooding. This condition renders the route frequently impassable during the wet season, isolating the community.

The legal boundary of the existing access paths is undefined or poorly documented. This ambiguity has led to unauthorized encroachment by local structures, which complicates any future widening or formal infrastructure development and poses potential legal conflicts during construction.

1.3 AIM AND OBJECTIVES

The aim of this study is to conduct a route survey of the existing road network within Evbhuku Community, Oredo Local Government Area, Edo State, Nigeria, utilizing Differential Global Positioning System (DGPS) technology for easy access.

The objectives are to:

i. establish a precise network of horizontal and vertical control points georeferenced to a standard datum (WGS 84/UTM) along the proposed 2-kilometer corridor.

ii. execute a detailed topographic survey, capturing the centerline alignment, ground profile and transverse cross-sections at regular intervals.

iii. identify, map, and document all existing natural and man-made features, as well as cadastral boundaries and encroachments within the defined 20-meter project corridor.

iv. process the acquired field data to produce essential engineering outputs, plan and profile drawings, and a detailed earthwork volume calculation (cut and fill analysis).

1.4 SCOPE AND LIMITATIONS OF THE STUDY

This study is geographically limited to the proposed transportation corridor linking the communities of Obe, Evbhuku, and Amagba. The route begins near the Obe Community center, passes through Evbhuku, and terminates at a designated access point in the Amagba Community. The total length of the corridor is approximately 2 kilometers. Survey efforts will cover a lateral strip extending 10 meters to either side of the planned centerline, giving a total corridor width of 20 meters. This width ensures that all necessary topographic features, land boundaries, and potential Right-of-Way conflicts are captured, extending beyond the area required for construction.

The functional scope of the survey is defined by the project's objectives, which focus on obtaining the data required for designing an 11-metre-wide road with drainage canals measuring 1 meter by 1 meter by 0.15 meter on both sides. The survey involves establishing horizontal and vertical control points tied to a regional or national geodetic network to guarantee high positional accuracy for the route. High-precision leveling will be conducted to set bench marks for elevation reference, which is necessary for grading the road and drainage system.

Ground elevation data and feature locations within the 20-metre corridor will be collected in detail across the three communities. Cross-sectional profile data will be recorded at 25-metre intervals along the centerline, with additional detail in areas designated for drainage installation. All natural obstacles and man-made structures such as electric poles, fences, utilities, and community structures within the corridor will be documented. Property boundaries and ownership patterns will be traced and mapped, and any structures or improvements encroaching on the Right-of-Way for the road and drainage will be identified and marked.

Data processing will include the calculation and documentation of geometric elements necessary for the road alignment, including tangents, horizontal curves, and vertical curves. A Digital Terrain Model will be produced, along with final drawings including the plan, profile, and cross-sections for use by the design engineer, reflecting the specified road width and proposed drainage.

This study is strictly limited to the collection and processing of spatial data for the geometric and cadastral foundation of the project. It does not cover structural engineering design, soil testing or geotechnical investigation, detailed hydrological analysis beyond surface water features, environmental impact assessment or mitigation planning, or the physical construction and monitoring of the road.

1.5 JUSTIFICATION OF THE STUDY

The route survey of Evbhuku Road is not merely an academic exercise but a critical preliminary step necessitated by immediate socio-economic and engineering requirements. The justification for this study is multifaceted, addressing the need for improved infrastructure, enhanced safety, and efficient resource allocation for future construction.

Infrastructure Development and Design: Modern road construction and rehabilitation require centimetre-level accuracy to ensure structural integrity and longevity. The existing road profile is often poorly documented or outdated. This study provides the crucial, high-resolution Digital Elevation Model (DEM) and cross-sectional data required by civil engineers to design a stable, functional road alignment. Without this precise topographic data, accurate calculation of gradients, sight distances, and pavement thicknesses would be impossible, leading to potential design failures.

Safety and User Comfort: An accurate route survey directly contributes to public safety. The data collected identifies existing hazards, tight curves, and poor visibility zones. By establishing a true model of the terrain, the design phase can incorporate appropriate engineering solutions to improve safety features such as adequate super elevation on bends, effective drainage solutions to prevent flooding, and maximizing sight distance for vehicle operators.

Economic Feasibility and Cost Control: One of the most significant outputs of a route survey is the accurate quantification of earthwork volumes (cut and fill). This information is non-negotiable for the project's financial planning. The justification for this study lies in mitigating financial risk; accurate volume computation derived from the survey data prevents costly underestimates or overestimates of materials, ensuring that the budget allocated for the Evbhuku Road project is both realistic and responsibly managed.

Utility and Right-of-Way (ROW) Management: The survey precisely locates existing utilities (e.g., electric poles) and encroachment boundaries. This detailed mapping is essential to prevent costly and dangerous damage to infrastructure during construction and to legally define the road's Right-of-Way. The study, therefore, ensures smooth land acquisition processes and minimizes conflicts with local infrastructure.

CHAPTER TWO

LITERATURE REVIEW

2.1 FOUNDATIONAL PRINCIPLES OF ROUTE SURVEYING

The establishment of linear infrastructure, such as the proposed road segment in the Evbhuku Community, necessitates a rigorous route survey founded on established geomatic engineering principles. Route surveying is defined by foundational texts, including Elementary Surveying: An Introduction to Geomatics by Wolf and Ghilani (2012) and Surveying, Vol. 2 by Punmia *et al.* (2005), as the specialized process dedicated to determining the precise location, geometry, and cross-sections of transportation corridors. This process ensures the accurate establishment of horizontal and vertical curves, profile alignment, earthwork volumes, and drainage design necessary for a functional and durable road.

2.1.1 Definitional Framework and Classical Principles of Route Alignment

Engineering applications demand high-fidelity data acquisition to ensure strict adherence to design tolerances. Kavanagh and Bird (2000), in Engineering Surveying, emphasize that precision is non-negotiable for project integrity. Classical methodologies detailed by Duggal (2006) traditionally relied on rigorous traversing and leveling techniques to establish baseline horizontal and vertical controls. However, the increasing complexity of modern infrastructure projects has necessitated the adoption of advanced positioning technologies and compliance with regulatory and geodetic frameworks designed to support precise spatial referencing at both local and regional scales.

2.1.2 Geodetic Network as the Foundation

The success and longevity of any large-scale infrastructure project, including local road construction, depend heavily on its underlying geodetic reference framework. Adeyemi and

Emordi (2019) confirm that establishing an accurate and reliable geodetic control network is a critical prerequisite for road and railway construction projects in Nigeria. Such a network, composed of strategically positioned control points whose coordinates are determined with high precision, provides the fundamental reference for all subsequent surveying, mapping, and construction activities.

The contemporary reliance on differential positioning systems represents a significant paradigm shift from traditional surveying approaches. Conventional methods focused primarily on localized error minimization and traverse closure, whereas DGPS-based surveying situates projects within a unified global geodetic framework (Rizos, 2011). This approach ensures that spatial data acquired for the Evbhuku project possess global positioning integrity, enabling seamless integration with regional and national geospatial datasets while providing a stable and reliable reference datum.

Furthermore, geodetic networks facilitate construction tolerance management and quality control, both of which are essential for ensuring the structural integrity, safety, and durability of road infrastructure. The attainment of low Root Mean Square Error (RMSE) values,efficiently achieved using DGPS, serves as an objective metric for evaluating the technical soundness of the final road geometry (Abdi *et al.*, 2012; Tijani *et al.*, 2021). Consequently, the objective of the DGPS survey extends beyond simple mapping to fulfilling high-precision, construction-grade accuracy requirements.

2.2 STRATEGIC ROUTE ALIGNMENT AND OPTIMIZATION USING GEOINFORMATICS

Before field data acquisition begins, modern engineering practice mandates a comprehensive strategic evaluation of alternative corridor alignments. This ensures that the selected route is not only technically feasible but also environmentally sustainable, economically viable, and socially acceptable. Geoinformatics techniques, integrating Geographic Information Systems (GIS) and Remote Sensing, have therefore become indispensable at the pre-survey planning stage.

2.2.1 Role of Geoinformatics and Multi-Criteria Decision Analysis (MCDA)

Optimal route selection is inherently a complex decision-making process requiring the evaluation of multiple, often conflicting constraints. Mondal et al. (2021) demonstrated the effectiveness of integrating Geoinformatics with Multi-Criteria Decision Analysis (MCDA) for highway route delineation. Their approach assessed critical geoengineering parameters such as slope, aspect, geology, drainage patterns, soil characteristics, and land-use/land-cover conditions. The integration of these thematic datasets is typically achieved using the Weighted Linear Combination (WLC) technique within a GIS environment. Mondal *et al.* (2021) observed that the optimal alignment is generally the route associated with the lowest cumulative cost value, balancing economic considerations, such as land acquisition and demolition costs, with functional and environmental requirements.

2.2.2 Detailed Criteria for Alignment Optimization

The complexity of route alignment optimization arises from the need to simultaneously satisfy multiple project objectives. Mann and Ruiz (2019) identify the principal objectives of highway projects as minimizing environmental impact, optimizing operational functionality and safety, reducing construction cost and time, and maximizing economic returns. Spatial Multi-Criteria Evaluation (Spatial MCE) techniques are specifically designed to address this complexity by quantitatively evaluating alternative alignments against predefined criteria.

These criteria are commonly grouped into economic factors (e.g., slope and river crossing costs), environmental factors (e.g., protected areas and surface water bodies), and social factors (e.g., land cover and pollution sensitivity). Mann and Ruiz (2019) reported that economic considerations, particularly cost and construction duration, often receive the highest weighting during decision-making. The analytical process typically employs the Analytical Hierarchy Process (AHP) for pairwise comparison of criteria and the Weighted Sum method for aggregation, ultimately identifying the Least Accumulative Cost Distance path using algorithms derived from Dijkstra's shortest-path model.

Model robustness is essential to ensure scientific defensibility. As noted by Mann and Ruiz (2019), One-At-a-Time (OAT) Sensitivity Analysis is commonly used to evaluate the stability of MCE results by systematically varying individual criterion weights and assessing their influence on the final alignment.

Given that the Evbhuku community road follows an existing corridor, high-precision DGPS data serve a retrospective evaluative role rather than an initial planning function. The precise geometric, elevation, and slope data obtained through DGPS enable the development of detailed terrain models, which can be evaluated using contemporary MCDA principles (Mondal *et al.*, 2021; Mann and Ruiz, 2019) to assess whether the existing alignment approximates a least-cost path.

Additionally, high-quality spatial inputs derived from DGPS, such as detailed contour models and three-dimensional surface representations, are essential for future alignment optimization. Techniques involving three-dimensional laser scanning and advanced terrain modeling, as demonstrated by Shrestha *et al.* (1999) and Naseer et al. (2025), rely heavily on the geometric reliability of the underlying survey data. The demonstrated accuracy of DGPS thus guarantees dependable spatial inputs for subsequent road planning and corridor development within Oredo Local Government Area and similar terrains.

2.3 GLOBAL NAVIGATION SATELLITE SYSTEMS (GNSS) AND THE DGPS TECHNIQUE

The selection of Differential Global Positioning System (DGPS) surveying for the Evbhuku community road project is justified by its proven capability to deliver engineering-grade positional accuracy far superior to standalone GPS. This advantage is grounded in established geodetic theory and advanced error mitigation techniques.

2.3.1 Fundamentals of Satellite Positioning and Geodetic Theory

Modern satellite geodesy encompasses Global Navigation Satellite Systems (GNSS), including the United States GPS, Russia's GLONASS, and Europe's GALILEO, as comprehensively discussed by Leick (2004). Precise positioning is challenged by systematic errors arising from atmospheric effects, particularly ionospheric and tropospheric delays. To mitigate these errors, mathematical adjustment models, most notably least-squares estimation, are applied to observations derived from pseudorange and carrier-phase measurements. Headley (2010) emphasizes that understanding and managing these error sources is fundamental to achieving the accuracy required for highway mapping.

The maintenance of consistent geodetic accuracy over large spatial extents depends on robust ground infrastructure. Rizos (2011) highlights the critical role of GNSS Continuous Operating Reference Station (CORS) networks in modern geodesy, providing stable reference coordinates required for the generation and dissemination of differential corrections.

2.3.2 The Superior Mechanism of Differential GPS (DGPS)

DGPS enhances standard GPS accuracy through the application of differential correction techniques. The method employs a stationary reference receiver positioned over a point of precisely known coordinates and a mobile rover receiver operating along the project corridor. By comparing the satellite-derived position with its known coordinates, the reference station computes real-time correction values, which are transmitted to the rover receiver and applied to its raw observations.

Naseer *et al.* (2025) confirm that this differential correction process significantly improves positional reliability, reducing typical standalone GPS errors, often on the order of several decimeters, to centimeter or sub-centimeter levels. This improvement results from the effective elimination of common-mode errors associated with atmospheric delays and satellite orbit inaccuracies. Consequently, DGPS hardware selection for the Evbhuku project must prioritize robust differential functionality to meet construction-grade accuracy standards.

For continuous corridor mapping, kinematic DGPS, commonly implemented as Real-Time Kinematic (RTK) GPS, is particularly suitable. Roh *et al.* (2003) demonstrated the effectiveness of kinematic GPS/GLONASS integration for achieving high-accuracy horizontal road alignment, validating its suitability for rapid, high-density data collection along linear infrastructure. Operationally, DGPS offers superior data continuity and reduced dependence on intervisibility compared to conventional surveying methods, making it especially advantageous in environments characterized by vegetation cover or localized obstructions typical of community road settings in Edo State.

2.4 DGPS ACCURACY ASSESSMENT AND COMPARATIVE SUITABILITY IN GEOMATIC ENGINEERING

The justification for employing Differential Global Positioning System (DGPS) techniques in the Evbhuku route survey extends beyond theoretical suitability and is firmly supported by empirical accuracy assessments, particularly within the Nigerian surveying environment. Numerous comparative studies have consistently demonstrated that DGPS provides superior positional accuracy and operational efficiency when compared with conventional terrestrial surveying techniques, especially over extended linear corridors.

2.4.1 Empirical Validation of DGPS in the Nigerian Context

A pivotal comparative investigation by Tijani *et al.* (2021) in Oyo State, Nigeria, rigorously evaluated the coordinate accuracy obtained using DGPS and Total Station techniques on existing control points. Their findings conclusively revealed that DGPS achieved statistically superior positional accuracy. Notably, the vertical component—which is critical for engineering applications, showed a mean height difference of 0.2811 m for DGPS, compared to 0.5311 m for the Total Station. Given that vertical accuracy directly influences drainage design, cut-and-fill estimation, and pavement performance, this result provides strong empirical justification for prioritizing DGPS in the Evbhuku road project.

Further reinforcement is provided by Aliyu and Dahiru (2019), who confirmed the comparative suitability of DGPS for control extension over wide areas. Their study emphasized that DGPS outperforms Total Stations in establishing consistent geodetic control where line-of-sight limitations and cumulative traverse errors constrain conventional methods. This advantage is particularly relevant for community road projects traversing semi-urban and vegetated terrain such as Evbhuku.

2.4.2 Efficiency and Precision Gains

Beyond accuracy, DGPS offers measurable improvements in operational efficiency. Naseer *et al.* (2025) highlighted the dual benefit of DGPS technology, demonstrating its capacity to significantly enhance both precision and productivity. Their study reported a reduction in positional error from approximately 0.5 m to 0.02 m, representing a near-survey-grade accuracy improvement. Simultaneously, field survey duration was reduced from 10 hours to 4 hours, corresponding to a 60% reduction in field time.

These findings underscore the cost-effectiveness of DGPS for infrastructure development, where reduced survey duration directly translates to lower labor costs, faster project execution, and minimized exposure to field-related uncertainties. For the Evbhuku project, these efficiency gains are particularly advantageous in optimizing limited resources while maintaining engineering-grade data quality.

2.4.3 DGPS as the Ground Truth Benchmark

The technical standing of DGPS, particularly in its Real-Time Kinematic (RTK) configuration, is further reinforced by its widespread adoption as the ground truth reference for evaluating emerging geospatial technologies. In a comparative road corridor survey conducted in Ghana, Asamoah Asante *et al.* (2025) employed RTK GPS measurements as the benchmark for assessing UAV-derived spatial data. Their statistical evaluation yielded low Root Mean Square Error (RMSE) values of 0.025 m for Eastings and 0.041 m for Northings, confirming the high positional fidelity of RTK GPS observations.

The reliance on DGPS/RTK GPS as the reference standard in such studies validates its continued relevance and confirms that the Evbhuku survey methodology adheres to the highest contemporary accuracy standards required for road corridor topographic surveys.

2.5 FIELD APPLICATIONS AND CONTROL ESTABLISHMENT IN NIGERIA

The transition from theoretical accuracy validation to practical field implementation requires the adoption of methodologies proven under Nigerian terrain, climatic, and operational conditions.

2.5.1 Geodetic Control Network Establishment in Nigeria

The principal application of DGPS in the Evbhuku project lies in the establishment of a reliable geodetic control network. Adeyemi and Emordi (2019) emphasized that GNSS-based control points form the backbone of modern infrastructure projects in Nigeria, providing the reference framework for alignment, grading, and geometric consistency. Such control is indispensable for ensuring that roadway elements, curves, embankments, and drainage structures, conform strictly to design specifications.

In operational practice, geodetic network establishment typically follows a hybrid approach. GNSS-derived primary controls provide wide-area consistency, while densification using Total Stations and precise leveling supports detailed construction set-out. The initial positional integrity achieved through DGPS directly influences the long-term performance and safety of the road, as errors introduced at the control stage propagate throughout construction and maintenance phases.

2.5.2 Regional Route Survey Case Studies

Strong methodological support for the Evbhuku project is further provided by regional case studies. Amoo *et al.* (2022) documented a 4.7 km route survey from Awere Stream to Egbeda Loogun Village in Osun State, employing a hybrid strategy that combined GNSS traversing with Total Station observations. Their approach successfully generated three-dimensional positional data using a Tersus David GNSS receiver alongside a South Total Station.

This case study validates the strategic decision adopted in the Evbhuku project: DGPS is utilized for primary control extension and long-distance traversing, while Total Stations are applied for detailed cross-sectional measurements and obscured points. Such methodological integration reflects best practice within the Nigerian context and ensures both spatial consistency and local measurement precision.

2.5.3 Emerging Technologies as Future Context

Although DGPS remains central to high-precision surveying, its application exists within an evolving technological landscape. Early investigations into three-dimensional laser scanning for terrain and feature extraction by Shrestha et al. (1999) laid the foundation for modern spatial data acquisition techniques. More recently, UAV-based photogrammetry has gained prominence for highway and corridor mapping (Wilson & Rigby, 2020; Asamoah Asante *et al.*, 2025).

Despite these advancements, DGPS/RTK GPS continues to serve as the accuracy benchmark against which these emerging methods are validated. This sustained reliance confirms DGPS as the most dependable ground truth technique for establishing control networks in road corridor projects.

2.6 SYNTHESIS AND DIRECT RELEVANCE TO THE EVBHUKU COMMUNITY PROJECT

The reviewed geomatic literature provides a coherent and compelling justification for the selection of DGPS as the primary surveying technique for the Evbhuku community road. The methodology is grounded in established engineering surveying principles, reinforced by modern geospatial optimization strategies, and validated by empirical evidence from Nigeria and comparable regional contexts.

The DGPS approach satisfies three critical requirements for the Evbhuku project:

Accuracy Mandate: Empirical studies by Tijani *et al.* (2021) and Aliyu and Dahiru (2019) confirm DGPS's superior positional accuracy, particularly in the vertical component, ensuring suitability for drainage design, profile control, and earthwork computation.

Efficiency and Cost-Effectiveness: Quantitative findings from Naseer *et al.* (2025) demonstrate substantial reductions in survey time and positional error, supporting efficient resource utilization and timely project execution.

Geodetic Integrity: The establishment of GNSS-based primary control ensures alignment with Nigeria's geodetic framework, fulfilling the integrity requirements emphasized by Adeyemi and Emordi (2019).

Finally, the integration of DGPS-derived high-precision data with GIS-based Multi-Criteria Decision Analysis enables retrospective evaluation of the existing Evbhuku alignment against modern optimization principles articulated by Mondal *et al.* (2021). This synthesis bridges precise field data acquisition with advanced spatial planning methodologies, reinforcing the technical robustness and academic defensibility of the project.

Table 2.1: Literature Synthesis and Direct Relevance to Evbhuku Community Route Survey

Author(s) & Year	**Core Contribution**	**DGPS/Route Survey Relevance to Evbhuku Road**
Mondal, Garg, Pandey, and Kappas (2021)	GIS/MCDA for Optimal Alignment	Provides the analytical framework for retrospectively validating the existing route based on geoengineering parameters.
Leick (2004)	GNSS Theory and Adjustment	Defines the rigorous technical procedures (Least-Squares Adjustment) necessary for processing DGPS data to ensure high-quality output.
Tijani, Igbokwe, and Ono (2021)	DGPS vs. Total Station Accuracy (Nigeria)	Empirically justifies the choice of DGPS by proving its superior accuracy, particularly for height determination, crucial in road design.
Naseer *et al.* (2025)	DGPS Efficiency and Precision	Quantifies DGPS's operational performance and accuracy, supporting its suitability for route surveys.

CHAPTER THREE

METHODOLOGY

3.1 DESCRIPTION OF THE STUDY AREA

The route survey was carried out within the Evbhuku Community in Benin City, Edo State, Nigeria. The project focused on a 2-kilometre transportation corridor intended to improve accessibility between the neighboring communities of Obe, Evbhuku, and Amagba. The survey alignment begins close to the Obe Community centre, follows the proposed route across the Evbhuku axis, and terminates near the Amagba Community.

The geographical limits of the survey were defined using the Universal Transverse Mercator (UTM) system referenced to the World Geodetic System 1984 (WGS 84), Zone 31N. The starting point at Obe is located at UTM coordinates 791774.00 m E and 690452.00 m N, corresponding to approximate geographic coordinates of Latitude 6°12'00.12" N and Longitude 5°59'16.03" E. The end point at Amagba is positioned at UTM coordinates 789941.00 m E and 689856.00 m N, which converts to Latitude 6°11'40.54" N and Longitude 5°58'00.32" E. These coordinates served as the fixed reference for all engineering measurements and mapping operations within the project corridor.

A study area map of the project area provided the spatial context for understanding regional connectivity and the physical environment of the corridor. The survey methodology was developed to suit the terrain characteristics, settlement pattern, and accessibility conditions observed along the route.

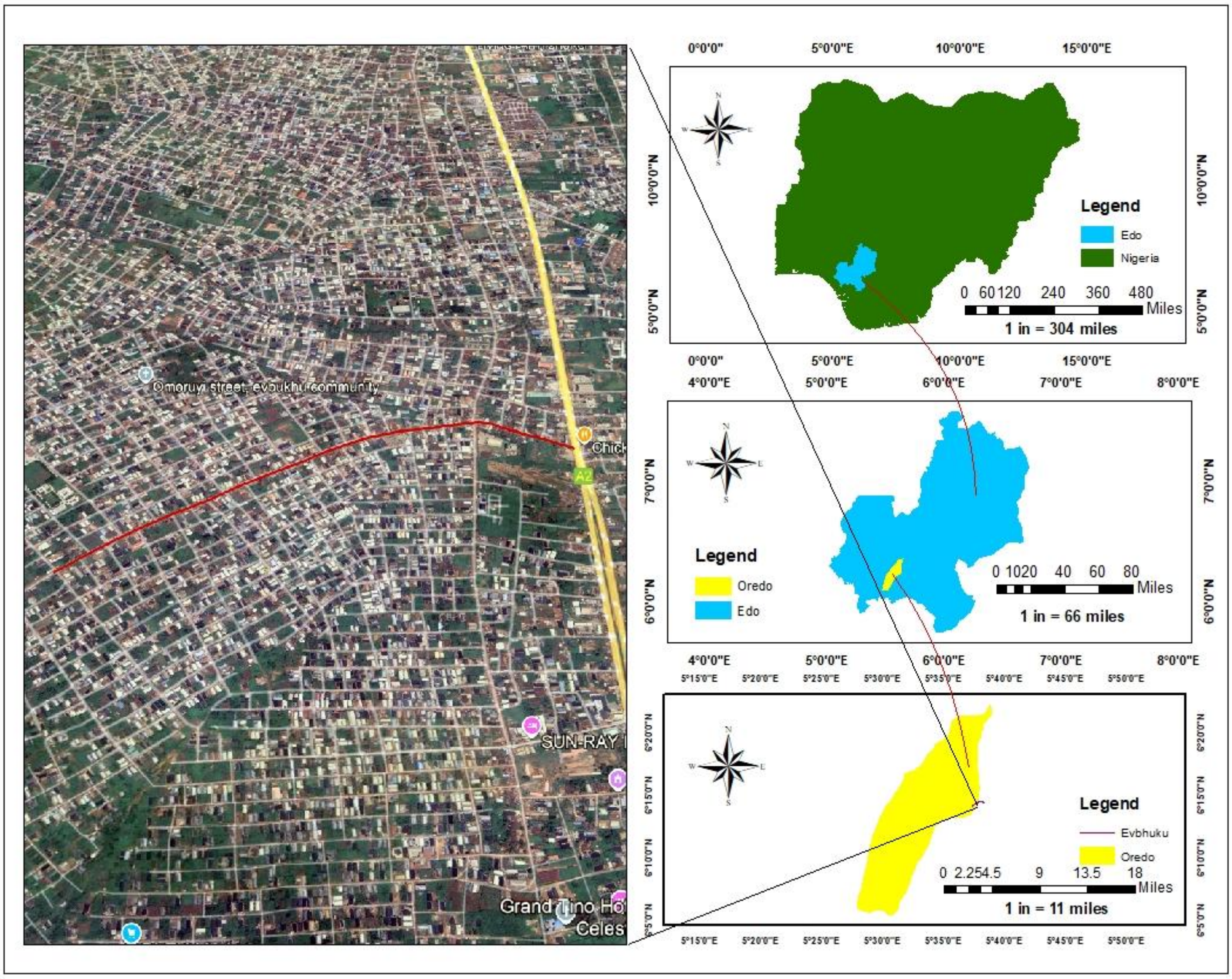

Figure 3.1: Study Area Map.

The workflow adopted for the execution of the route survey is summarised in the flow chart shown in Figure 3.2. It outlines the major stages from reconnaissance through data acquisition to processing and final outputs.

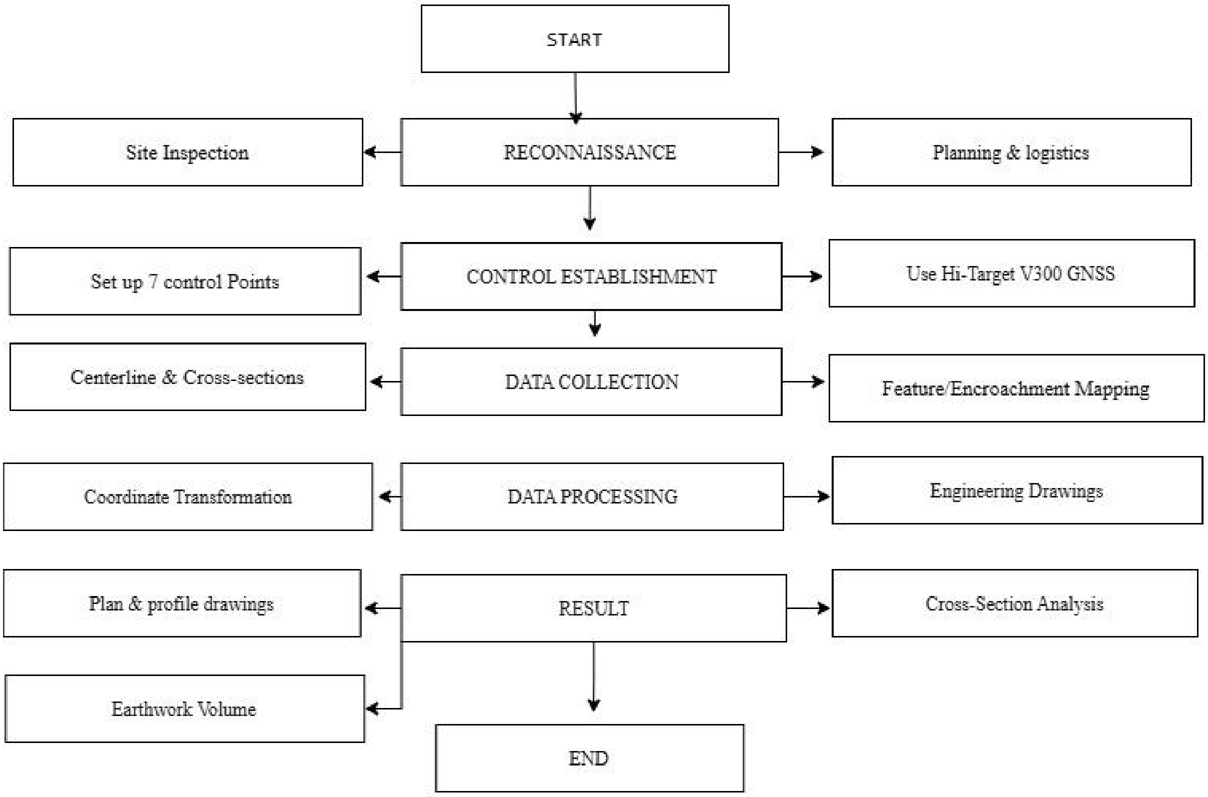

Figure 3.2: flow chart.

3.2 RECONNAISSANCE AND PLANING

A preliminary reconnaissance was carried out along the Evbhuku road corridor before the commencement of detailed fieldwork. This stage was essential for understanding the physical environment and for determining the most practical approach to the survey. The proposed alignment was first inspected on foot, allowing the team to observe existing features, assess terrain conditions, and identify locations that might present difficulties during data collection. Particular attention was given to sections with dense vegetation, irregular ground surfaces, and areas where obstructions could interfere with satellite visibility.

During the reconnaissance, an extensive search for existing geodetic control marks was undertaken. Although the corridor was checked for previously established survey pillars or reference monuments, none were found to be present or usable. This made it necessary to plan for the establishment of new control points that would serve as the reference framework for the route survey.

Logistical arrangements were also made at this stage. These included determining where the GNSS Base Station could be safely and efficiently positioned, organising the movement and deployment of the field crew, and addressing accessibility and safety concerns along the corridor. By the end of the reconnaissance exercise, the alignment had been properly evaluated and the information gathered provided a practical foundation for efficient field operations.

3.3 INSTRUMENTATION

The execution of the route survey relied on a combination of modern GNSS technology and professional survey software. The primary instruments used were two Hi-Target V300 GNSS receivers, which formed the core of the data acquisition workflow. The V300 is a robust, dual-frequency, multi-constellation receiver capable of tracking signals from GPS, GLONASS, Galileo, and BeiDou satellites. For this project, one unit functioned as the Base Station while the second served as the Rover. The base unit was positioned over a stable but previously unknown point within the survey corridor, where it continuously transmitted correction signals. The rover unit, operated by the field crew, received these corrections and recorded precise positional data along the centerline and cross-section points.

In addition to the GNSS receivers, standard field accessories, including measuring tapes, were used to verify offsets at cross-section stations and ensure that the perpendicular distances were accurately observed. These checks were necessary to maintain confidence in the positional integrity of the RTK measurements, especially in areas with partial obstructions or minor satellite geometry fluctuations.

For post-fieldwork processing, Autodesk Civil 3D (2024 edition) served as the main software environment. This platform made it possible to import, manage, and refine the raw GNSS observations. Civil 3D provided the tools required to develop the digital terrain model, generate profiles and cross-sections, and prepare the engineering drawings and analytical outputs associated with the project. Its integration of survey data handling and design functions ensured that the field observations were transformed into reliable, structured datasets suitable for planning and engineering interpretation.

3.4 CONTROL ESTABLISHMENT

Establishing reliable control points was a critical step in ensuring the accuracy of the route survey. Since no pre-existing geodetic control pillars were available within the corridor, temporary control stations were created to serve as reference points for the RTK survey.

A Hi-Target V300 receiver was set up over a stable but previously unknown location near the center of the survey area, serving as a temporary base station. Once the base station acquired satellite signals, it established coordinates referenced to the World Geodetic System 1984 (WGS 84), providing a geocentric reference framework for subsequent measurements. This configuration enabled the rover unit to perform real-time kinematic positioning along the proposed route.

Seven control points were established along the corridor, each precisely measured for Easting, Northing, and elevation. These control points anchored the survey and facilitated the accurate recording of centerline and cross-section points during the fieldwork. The coordinates of these stations were documented and used throughout the survey for both field guidance and post-processing verification. See Table 3.1.

Table 3.1: Coordinates of Controls Points

Control Stations	Northings	Eastings	height
ANT 1	690551.998	791260.447	47.348
ANT 2	690481.998	790980.695	45.845
ANT 2A	690483.910	790927.602	45.677
ANT 3A	690338.702	790674.517	41.316
ANT 3	690267.956	790592.208	40.322
ANT 4	690135.436	790375.456	38.956
ANT 4A	690133.478	790313.017	39.058

3.5 DATA ACQUISITION

Data collection for the route survey was carried out using the dual Hi-Target V300 GNSS system in Real-Time Kinematic (RTK) mode. This setup allowed for the rapid and accurate capture of topographic data along the survey corridor.

The Base Station receiver was placed over a temporary control point and configured to continuously transmit differential correction signals via its UHF radio or an external modem. The Rover unit, operated by the field team, received these corrections while tracking satellite signals, enabling precise real-time positioning. The field controller was used to monitor satellite geometry and confirm that the positional solution reached a fixed status before recording points. Survey points were collected along the corridor in two main categories:

I. **Centerline Points:** Recorded at regular intervals to define the horizontal alignment of the proposed road.

II. **Cross-Section Points:** Measured perpendicular to the centerline at predetermined stations, extending 20 meters to each side to capture the existing terrain. Measuring tapes were used where necessary to verify offsets.

This method ensured that all necessary horizontal and vertical features of the route were captured accurately for further processing and design.

3.6 DATA PROCESSING

The raw GNSS data collected in the field was transferred to the office for processing and analysis. The first step involved checking the data for errors, inconsistencies, and gaps. Positional Dilution of Precision (PDOP) values and residual errors were examined to ensure that the RTK measurements met the required accuracy thresholds of ±3 m horizontally and ±5 m vertically.

A dense three-dimensional point cloud was generated from the verified observations and used to create a Triangulated Irregular Network (TIN) surface, forming a detailed digital elevation model (DEM) of the survey corridor.

Using Autodesk Civil 3D, the DEM was further processed to produce the main engineering outputs:

i. Plan and Profile: The centerline coordinates were used to define the alignment of the road. The plan view was generated by overlaying the surface contours from the DEM onto the alignment, while the profile displayed the existing ground elevations along the centerline.
ii. Cross-Sections: Sample lines were created perpendicular to the alignment at specified intervals. Section views were extracted from the DEM to show terrain variations transversely to the road axis.
iii. Earthwork Volumes: A corridor model representing the proposed road surface, including its 11-meter width and 1-meter drainage, was created. The difference between the existing ground surface and the proposed design surface was calculated

using the Average End Area method, yielding the cut and fill volumes required for construction.

These processing steps produced accurate and comprehensive outputs that were used for detailed engineering analysis, design, and reporting.

3.6.1 Coordinate Transformation

Following the completion of field data collection, the raw GNSS observations, initially referenced to the temporary Base Station coordinates derived from the World Geodetic System 1984 (WGS 84), were transformed to the local datum applicable to the Evbhuku area. The entire point cloud was converted to the Universal Transverse Mercator (UTM) coordinate system relevant to the study area. This transformation ensured that all survey coordinates were horizontally aligned with the national grid and that elevations corresponded to the local geoid. Executing this step accurately was essential to maintain the geodetic integrity required for subsequent engineering analysis and construction activities.

3.6.2 Data Validation and Filtering

A thorough quality control check was performed on the transformed data to ensure accuracy and reliability. Field observation parameters, including Positional Dilution of Precision (PDOP), residual errors, and the number of satellites tracked, were examined for each recorded point. Observations with poor geometry or high residual errors were either filtered out or re-measured where possible. The remaining validated point cloud, representing the final terrain data, formed the basis for modelling and design. This process confirmed that the RTK methodology produced high-precision survey data suitable for engineering purposes.

3.7 PLAN PROFILE CROSS-SECTION AND EARTHWORK CALCULATIONS

The processed survey data was used to generate detailed engineering outputs necessary for the design and construction of the Evbhuku Road.

i. Plan Creation: The coordinates of the centerline points were used to define the alignment object in Civil 3D. Surface contours from the digital terrain model were overlaid onto the alignment, along with other feature points such as poles and boundaries, to produce the topographic plan view of the corridor.
ii. Profile Generation: The longitudinal profile of the road was obtained by sampling the DEM along the alignment. This profile shows elevation changes along the centerline and serves as a basis for vertical design and analysis.
iii. Cross-Section Development: Sample lines were placed perpendicular to the centerline at 20-meter intervals. Section views were extracted from the DEM to illustrate terrain variations across the corridor. These cross-sections provided detailed information on path asymmetry, slopes, and potential encroachments.
iv. Earthwork Volume Calculation: A corridor model representing the proposed finished road, including the 11-meter carriageway and 1-meter drainage, was created. Civil 3D's volume calculation tools were used to compare the existing ground surface with the design surface. Cut and fill volumes were determined using the Average End Area method, producing a report essential for material estimation and project budgeting.

These outputs collectively provided a comprehensive basis for the geometric design, planning, and construction of the proposed road.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 FINAL COORDINATES

The processed survey points, including the centerline stations, cross-section shots, and all relevant topographic features, were exported into a structured coordinate file in Easting, Northing, and Elevation format. These final coordinates form the primary dataset used for geometric design, earthwork computation, and other subsequent analyses. All values are presented in the local UTM coordinate system for direct compatibility with design software.

A detailed listing of the observed coordinates generated during the Evbhuku route survey is provided in Appendix A (Table A-1) for ease of reference and documentation.

4.2 PLAN AND PROFILE DRAWING

The entire set of processed coordinates and features were used to generate the Plan and Profile Drawings**,** which are the fundamental deliverables for geometric road design.

The Plan View (Topographic Map) clearly delineates contours (typically at 1.5-meter intervals), all existing man-made features (utilities, structures), and natural features (drainage paths, vegetation limits) within the defined 20-meter project corridor. As shown in Figure 4.1-4.7.

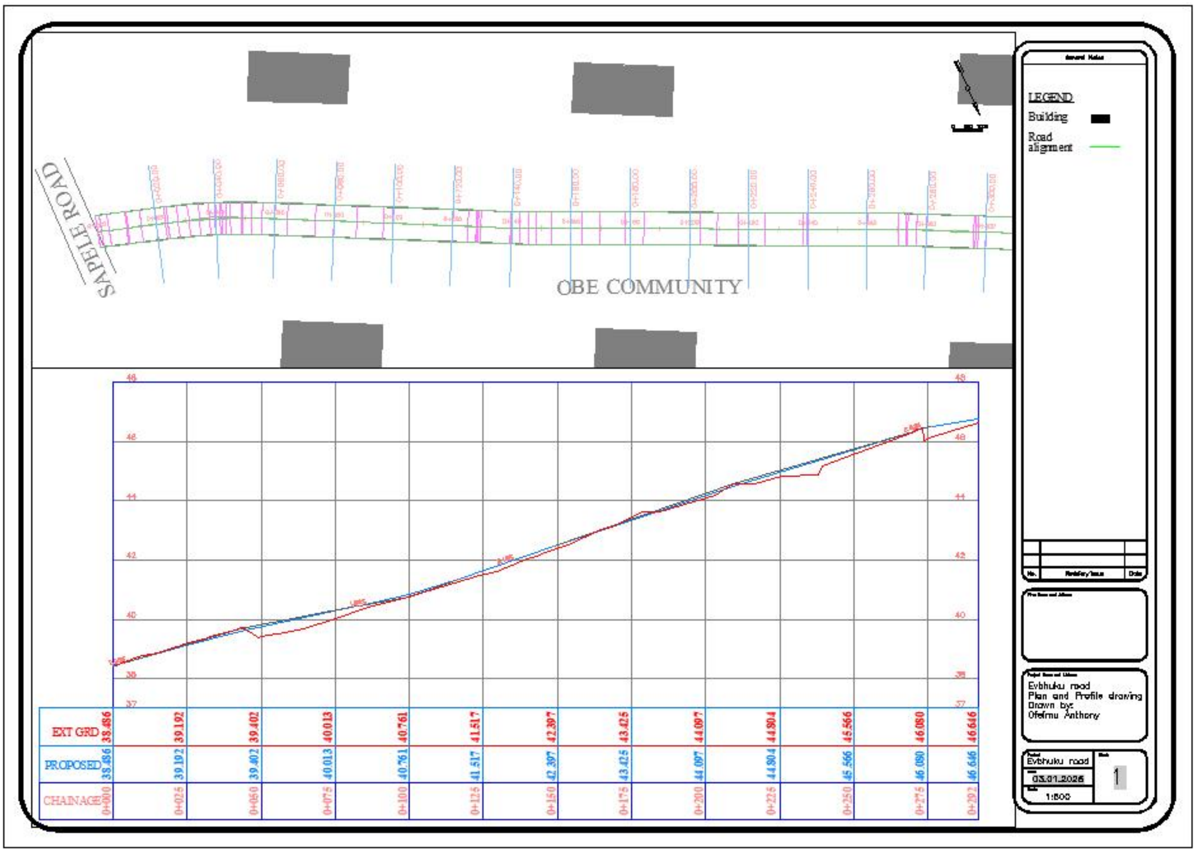

Figure 4.1: Plan and Profile Drawing (0+000 – 0+292)

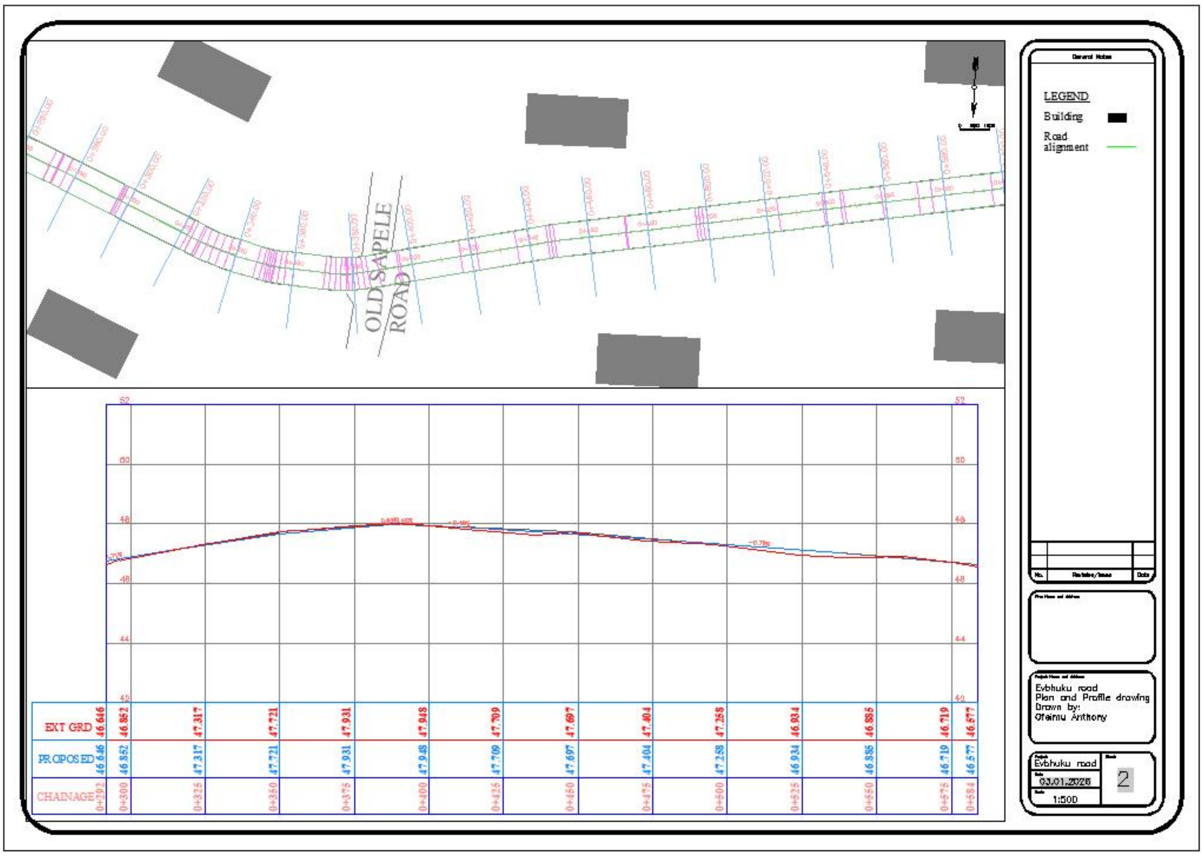

Figure 4.2: Plan and Profile Drawing (0+292– 0+554)

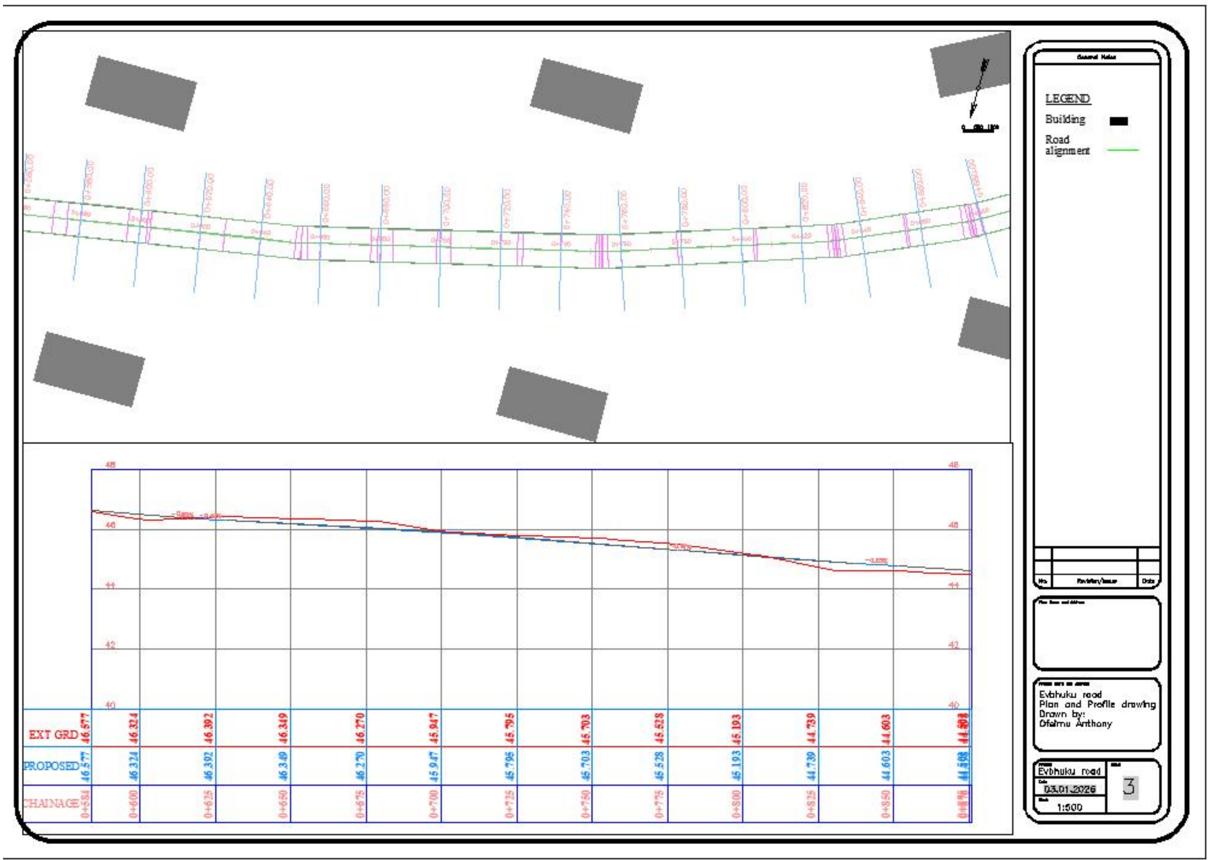

Figure 4.3: Plan and Profile Drawing (0+554 – 0+876)

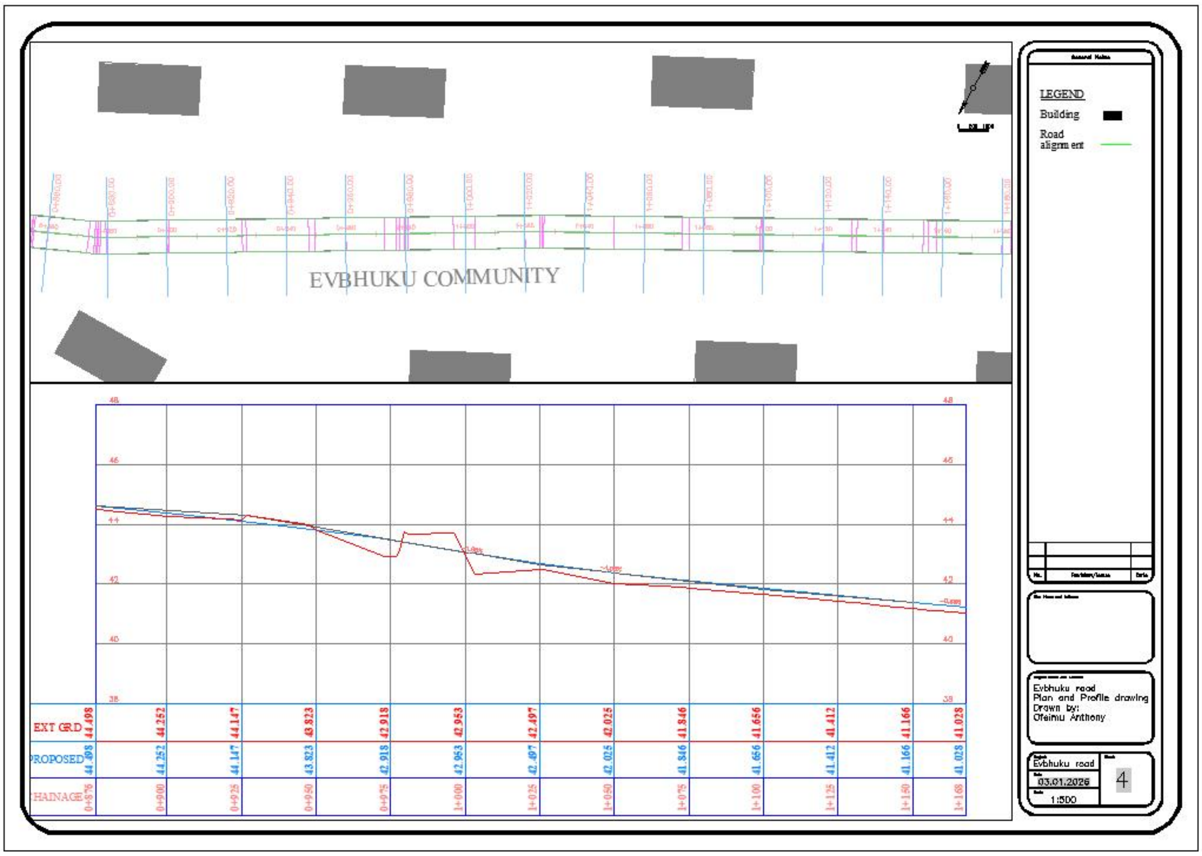

Figure 4.4: Plan and Profile Drawing (0+876 – 1+168)

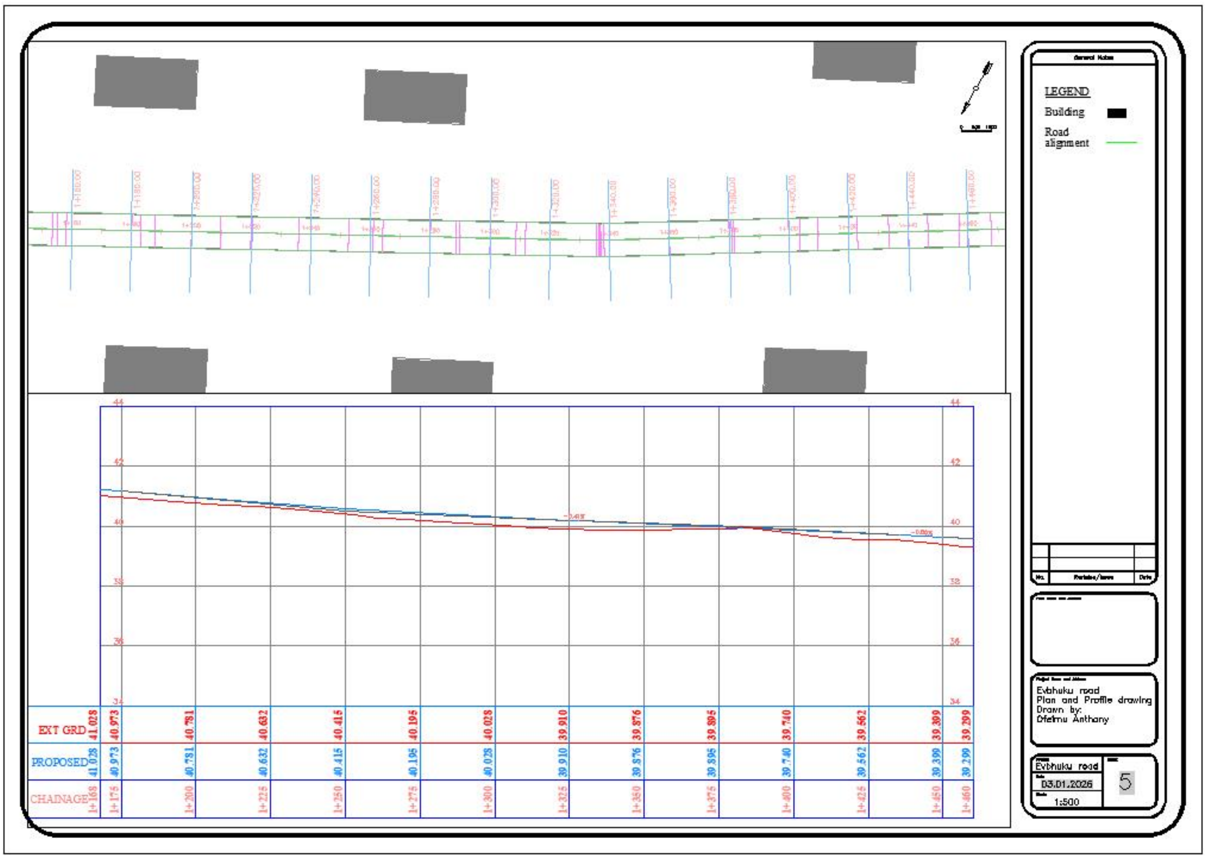

Figure 4.5: Plan and Profile Drawing (1+168 – 1+460)

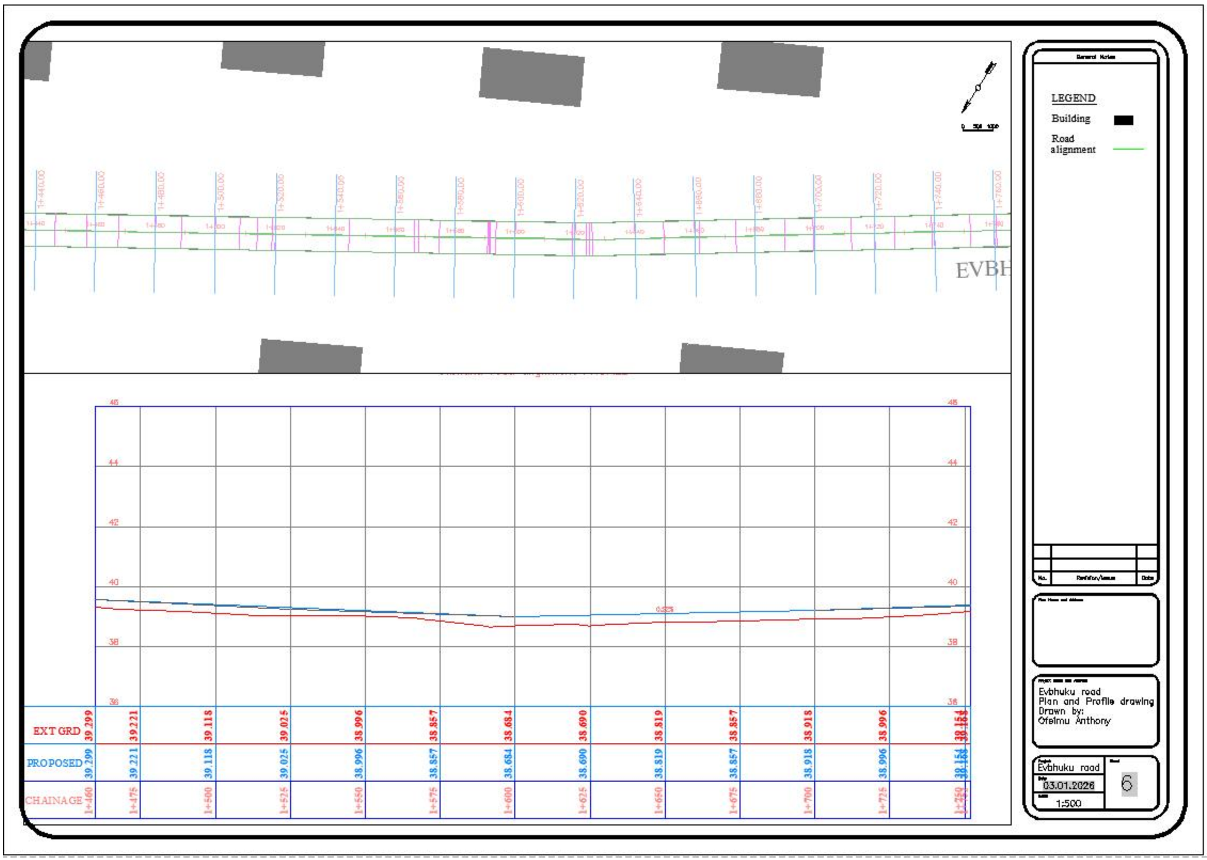

Figure 4.6: Plan and Profile Drawing (1+480 – 1+752)

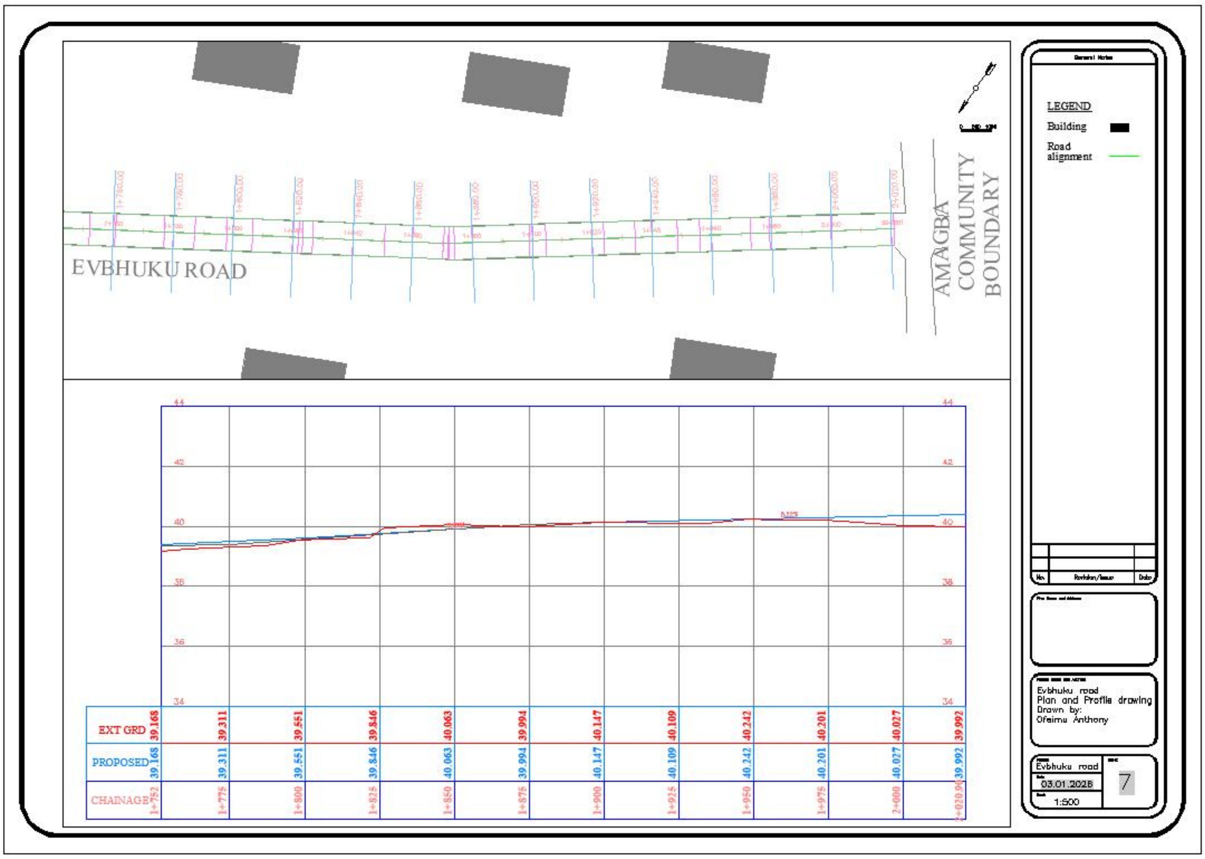

Figure 4.7: Plan and Profile Drawing (1+752 – 2+000)

4.2.1 Cross-Sectional Analysis

Analysis of the cross-sections, taken every 25 meters along the route, provided crucial transverse data for designing the 11m width of road surface with the proposed 1m wide, 1m deep, and 0.15m thick drainage canals on either side. The data revealed widespread path asymmetry, contributing to inconsistent natural drainage and localized ponding issues across the corridor. Crucially, the cross-sectional survey confirms that the initial segment of the project, from chainage 0+000 to 0+350**,** is fully and heavily encroached upon by existing permanent structures (buildings) and active market activities, rendering the required 20 Right-of-Way inaccessible in this segment as shown in Figure 4.8.

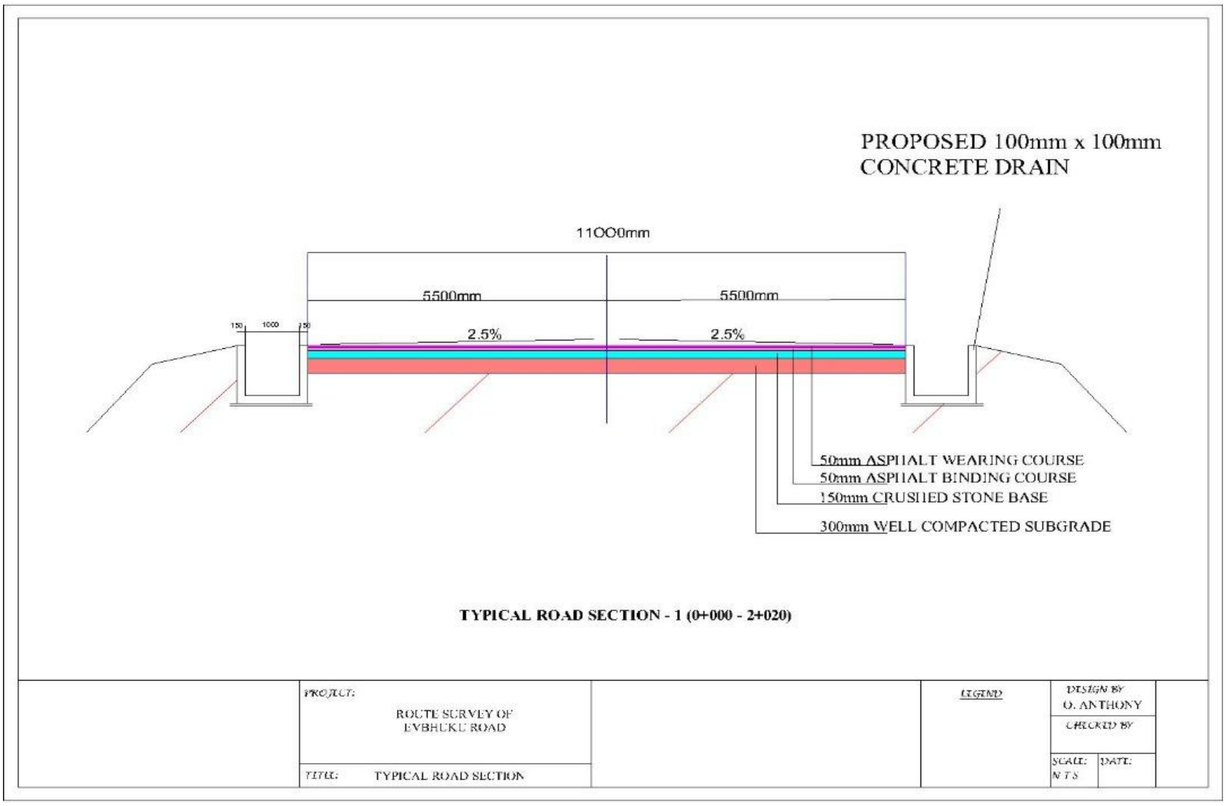

Figure 4.8: Typical Road Section

4.3 EARTHWORK VOLUME ANALYSIS

The earthwork volumes for the Evbhuku Road were computed by comparing a proposed finished grade model against the existing Digital Elevation Model (DEM). This analysis forms the basis for budgeting, construction planning, and material estimation.

The road alignment extends from Start Station 0+000.00 to End Station 2+020.90, covering a total length of 2.02 km. At each station, the cut and fill areas, volumes, and cumulative totals were calculated. See Table 4.1 and 4.2.

Table 4.1: Cut and Reusable Volumes

Station	Cut Area (Sq.M.)	Cut Volume (Cu.M.)	Reusable Volume (Cu.M.)	Cum. Cut Vol. (Cu.M.)	Cum. Reusable Vol. (Cu.M.)
0+020.00	6.34	0.00	0.00	0.00	0.00
0+040.00	5.61	119.64	119.64	119.64	0.00
0+060.00	8.60	142.57	142.57	262.21	0.00
0+080.00	8.75	173.49	173.49	435.70	0.00
0+100.00	8.98	177.26	177.26	612.95	0.00
0+120.00	8.69	176.71	176.71	789.66	0.00
0+140.00	7.22	159.16	159.16	948.82	0.00
0+160.00	5.27	124.77	124.77	1,073.59	0.00
0+180.00	3.64	89.12	89.12	1,162.71	0.00
0+200.00	3.89	75.28	75.28	1,237.99	0.00
0+220.00	5.26	91.44	91.44	1,329.44	0.00
0+240.00	4.80	100.54	100.54	1,429.97	0.00
0+260.00	4.60	93.95	93.95	1,523.93	0.63
0+280.00	6.60	112.07	112.07	1,636.00	1.25
0+300.00	3.87	104.63	104.63	1,740.63	2.49
0+320.00	5.14	90.04	90.04	1,830.67	3.83
0+340.00	14.24	185.69	185.69	2,016.35	3.93
0+360.00	14.56	269.03	269.03	2,285.38	3.93
0+380.00	14.96	276.28	276.28	2,561.67	3.93
0+400.00	10.46	247.74	247.74	2,809.40	3.93
0+420.00	6.43	168.93	168.93	2,978.33	3.93
0+440.00	6.15	125.85	125.85	3,104.19	3.93
0+460.00	5.89	120.33	120.33	3,224.51	3.93

Table 4.1: Cont'd

Station	Cut Area (Sq.M.)	Cut Volume (Cu.M.)	Reusable Volume (Cu.M.)	Cum. Cut Vol. (Cu.M.)	Cum. Reusable Vol. (Cu.M.)
0+480.00	6.11	119.92	119.92	3,344.44	3.93
0+500.00	6.09	121.94	121.94	3,466.38	3.93
0+520.00	6.39	124.82	124.82	3,591.20	3.93
0+540.00	6.54	129.32	129.32	3,720.51	3.93
0+560.00	5.78	123.21	123.21	3,843.72	3.93
0+580.00	6.51	122.90	122.90	3,966.63	3.93
0+600.00	7.50	140.04	140.04	4,106.67	3.93
0+620.00	6.25	137.51	137.51	4,244.18	3.93
0+640.00	5.68	119.38	119.38	4,363.57	3.93
0+660.00	5.56	112.54	112.54	4,476.11	3.93
0+680.00	5.34	109.03	109.03	4,585.14	3.93
0+700.00	6.29	116.32	116.32	4,701.46	3.93
0+720.00	5.82	121.17	121.17	4,822.63	3.93
0+740.00	5.55	113.71	113.71	4,936.34	3.93
0+760.00	5.09	106.36	106.36	5,042.70	3.93
0+780.00	4.95	100.43	100.43	5,143.12	3.93
0+800.00	5.63	105.78	105.78	5,248.91	3.93
0+820.00	7.08	127.13	127.13	5,376.04	3.93
0+840.00	8.95	160.22	160.22	5,536.26	3.93
0+860.00	7.28	162.27	162.27	5,698.52	3.93
0+880.00	7.76	150.86	150.86	5,849.39	3.93
0+900.00	6.69	144.47	144.47	5,993.85	3.93
0+920.00	6.45	131.37	131.37	6,125.22	3.93
0+940.00	7.15	135.97	135.97	6,261.19	3.93

Table 4.1: Cont'd

Station	Cut Area (Sq.M.)	Cut Volume (Cu.M.)	Reusable Volume (Cu.M.)	Cum. Cut Vol. (Cu.M.)	Cum. Reusable Vol. (Cu.M.)
0+960.00	7.13	142.80	142.80	6,403.99	3.93
0+980.00	4.29	114.23	114.23	6,518.23	3.93
1+000.00	8.94	132.27	132.27	6,650.50	3.93
1+020.00	10.18	191.14	191.14	6,841.63	3.93
1+040.00	7.60	177.74	177.74	7,019.38	3.93
1+060.00	7.85	154.46	154.46	7,173.84	3.93
1+080.00	6.82	146.66	146.66	7,320.51	3.93
1+100.00	6.52	133.42	133.42	7,453.93	3.93
1+120.00	6.71	132.38	132.38	7,586.30	3.93
1+140.00	7.03	137.44	137.44	7,723.74	3.93
1+160.00	6.91	139.41	139.41	7,863.16	3.93
1+180.00	6.96	138.71	138.71	8,001.87	3.93
1+200.00	6.47	134.34	134.34	8,136.20	3.93
1+220.00	6.25	127.20	127.20	8,263.40	3.93
1+240.00	6.24	124.90	124.90	8,388.30	3.93
1+260.00	6.24	124.88	124.88	8,513.18	3.93
1+280.00	6.38	126.19	126.19	8,639.37	3.93
1+300.00	6.62	129.94	129.94	8,769.31	3.93
1+320.00	6.87	134.91	134.91	8,904.22	3.93
1+340.00	6.94	138.15	138.15	9,042.37	3.93
1+360.00	6.41	133.45	133.45	9,175.81	3.93
1+380.00	5.85	122.53	122.53	9,298.35	3.93
1+400.00	4.84	106.89	106.89	9,405.23	3.93
1+420.00	4.34	91.79	91.79	9,497.02	3.93

Table 4.1: Cont'd

Station	Cut Area (Sq.M.)	Cut Volume (Cu.M.)	Reusable Volume (Cu.M.)	Cum. Cut Vol. (Cu.M.)	Cum. Reusable Vol. (Cu.M.)
1+440.00	4.71	90.47	90.47	9,587.49	3.93
1+460.00	5.74	104.47	104.47	9,691.96	3.93
1+480.00	5.83	115.66	115.66	9,807.62	3.93
1+500.00	6.23	120.59	120.59	9,928.21	3.93
1+520.00	6.14	123.74	123.74	10,051.95	3.93
1+540.00	6.20	123.45	123.45	10,175.40	3.93
1+560.00	6.17	123.70	123.70	10,299.10	3.93
1+580.00	5.96	121.31	121.31	10,420.42	3.93
1+600.00	6.11	120.70	120.70	10,541.12	3.93
1+620.00	6.26	123.64	123.64	10,664.76	3.93
1+640.00	6.38	126.39	126.39	10,791.15	3.93
1+660.00	6.36	127.38	127.38	10,918.54	3.93
1+680.00	6.35	127.04	127.04	11,045.57	3.93
1+700.00	6.36	127.08	127.08	11,172.65	3.93
1+720.00	6.48	128.43	128.43	11,301.08	3.93
1+740.00	6.35	128.34	128.34	11,429.43	3.93
1+760.00	6.16	125.10	125.10	11,554.53	3.93
1+780.00	6.28	124.37	124.37	11,678.90	3.93
1+800.00	6.23	125.13	125.13	11,804.04	3.93
1+820.00	6.20	124.30	124.30	11,928.34	3.93
1+840.00	6.21	124.06	124.06	12,052.40	3.93
1+860.00	6.48	126.95	126.95	12,179.34	3.93
1+880.00	6.83	133.03	133.03	12,312.38	3.93

Table 4.1 con'd

Station	Cut Area (Sq.M.)	Cut Volume (Cu.M.)	Reusable Volume (Cu.M.)	Cum. Cut Vol. (Cu.M.)	Cum. Reusable Vol. (Cu.M.)
1+900.00	6.30	131.25	131.25	12,443.63	3.93
1+920.00	6.29	125.88	125.88	12,569.51	3.93
1+940.00	5.96	122.56	122.56	12,692.07	3.93
1+960.00	5.37	113.31	113.31	12,805.37	3.93
1+980.00	5.27	106.37	106.37	12,911.74	3.93
2+000.00	5.29	105.63	105.63	13,017.38	3.93
2+020.00	4.83	101.25	101.25	13,118.62	3.93

Table 4.2: Fill Volumes

Station	Fill Area (Sq.M.)	Fill Volume (Cu.M.)	Cum. Fill Vol. (Cu.M.)	Cum. Net Vol. (Cu.M.)
0+020.00	0.00	0.00	0.00	0.00
0+040.00	0.00	0.00	0.00	119.64
0+060.00	0.00	0.00	0.00	262.21
0+080.00	0.00	0.00	0.00	435.70
0+100.00	0.00	0.00	0.00	612.95
0+120.00	0.00	0.00	0.00	789.66
0+140.00	0.00	0.00	0.00	948.82
0+160.00	0.00	0.00	0.00	1,073.59
0+180.00	0.00	0.00	0.00	1,162.71
0+200.00	0.00	0.00	0.00	1,237.99
0+220.00	0.00	0.00	0.00	1,329.44
0+240.00	0.00	0.00	0.00	1,429.97
0+260.00	0.06	0.63	0.63	1,523.30
0+280.00	0.00	0.62	1.25	1,634.75

Table 4.2 con'd

Station	Fill Area (Sq.M.)	Fill Volume (Cu.M.)	Cum. Fill Vol. (Cu.M.)	Cum. Net Vol. (Cu.M.)
0+300.00	0.12	1.24	2.49	1,738.13
0+320.00	0.01	1.34	3.83	1,826.84
0+340.00	0.00	0.10	3.93	2,012.43
0+360.00	0.00	0.00	3.93	2,281.46
0+380.00	0.00	0.00	3.93	2,557.74
0+400.00	0.00	0.00	3.93	2,805.48
0+420.00	0.00	0.00	3.93	2,974.41
0+440.00	0.00	0.00	3.93	3,100.26
0+460.00	0.00	0.00	3.93	3,220.59
0+480.00	0.00	0.00	3.93	3,340.51
0+500.00	0.00	0.00	3.93	3,462.45
0+520.00	0.00	0.00	3.93	3,587.27
0+540.00	0.00	0.00	3.93	3,716.59
0+560.00	0.00	0.00	3.93	3,839.80
0+580.00	0.00	0.00	3.93	3,962.70
0+600.00	0.00	0.00	3.93	4,102.74
0+620.00	0.00	0.00	3.93	4,240.26
0+640.00	0.00	0.00	3.93	4,359.64
0+660.00	0.00	0.00	3.93	4,472.18
0+680.00	0.00	0.00	3.93	4,581.21
0+700.00	0.00	0.00	3.93	4,697.53
0+720.00	0.00	0.00	3.93	4,818.70
0+740.00	0.00	0.00	3.93	4,932.41
0+760.00	0.00	0.00	3.93	5,038.77

Table 4.2 con’d

Station	Fill Area (Sq.M.)	Fill Volume (Cu.M.)	Cum. Fill Vol. (Cu.M.)	Cum. Net Vol. (Cu.M.)
0+780.00	0.00	0.00	3.93	5,139.20
0+800.00	0.00	0.00	3.93	5,244.98
0+820.00	0.00	0.00	3.93	5,372.11
0+840.00	0.00	0.00	3.93	5,532.33
0+860.00	0.00	0.00	3.93	5,694.60
0+880.00	0.00	0.00	3.93	5,845.46
0+900.00	0.00	0.00	3.93	5,989.93
0+920.00	0.00	0.00	3.93	6,121.30
0+940.00	0.00	0.00	3.93	6,257.27
0+960.00	0.00	0.00	3.93	6,400.07
0+980.00	0.00	0.00	3.93	6,514.30
1+000.00	0.00	0.00	3.93	6,646.57
1+020.00	0.00	0.00	3.93	6,837.71
1+040.00	0.00	0.00	3.93	7,015.45
1+060.00	0.00	0.00	3.93	7,169.92
1+080.00	0.00	0.00	3.93	7,316.58
1+100.00	0.00	0.00	3.93	7,450.00
1+120.00	0.00	0.00	3.93	7,582.38
1+140.00	0.00	0.00	3.93	7,719.82
1+160.00	0.00	0.00	3.93	7,859.23
1+180.00	0.00	0.00	3.93	7,997.94
1+200.00	0.00	0.00	3.93	8,132.28
1+220.00	0.00	0.00	3.93	8,259.47
1+240.00	0.00	0.00	3.93	8,384.38

Table 4.2 con'd

Station	Fill Area (Sq.M.)	Fill Volume (Cu.M.)	Cum. Fill Vol. (Cu.M.)	Cum. Net Vol. (Cu.M.)
1+260.00	0.00	0.00	3.93	8,509.25
1+280.00	0.00	0.00	3.93	8,635.44
1+300.00	0.00	0.00	3.93	8,765.38
1+320.00	0.00	0.00	3.93	8,900.29
1+340.00	0.00	0.00	3.93	9,038.44
1+360.00	0.00	0.00	3.93	9,171.89
1+380.00	0.00	0.00	3.93	9,294.42
1+400.00	0.00	0.00	3.93	9,401.31
1+420.00	0.00	0.00	3.93	9,493.09
1+440.00	0.00	0.00	3.93	9,583.56
1+460.00	0.00	0.00	3.93	9,688.04
1+480.00	0.00	0.00	3.93	9,803.69
1+500.00	0.00	0.00	3.93	9,924.29
1+520.00	0.00	0.00	3.93	10,048.03
1+540.00	0.00	0.00	3.93	10,171.48
1+560.00	0.00	0.00	3.93	10,295.18
1+580.00	0.00	0.00	3.93	10,416.49
1+600.00	0.00	0.00	3.93	10,537.19
1+620.00	0.00	0.00	3.93	10,660.84
1+640.00	0.00	0.00	3.93	10,787.23
1+660.00	0.00	0.00	3.93	10,914.61
1+680.00	0.00	0.00	3.93	11,041.65
1+700.00	0.00	0.00	3.93	11,168.73
1+720.00	0.00	0.00	3.93	11,297.16

Table 4.2 con’d

Station	Fill Area (Sq.M.)	Fill Volume (Cu.M.)	Cum. Fill Vol. (Cu.M.)	Cum. Net Vol. (Cu.M.)
1+740.00	0.00	0.00	3.93	11,425.50
1+760.00	0.00	0.00	3.93	11,550.60
1+780.00	0.00	0.00	3.93	11,674.98
1+800.00	0.00	0.00	3.93	11,800.11
1+820.00	0.00	0.00	3.93	11,924.41
1+840.00	0.00	0.00	3.93	12,048.47
1+860.00	0.00	0.00	3.93	12,175.42
1+880.00	0.00	0.00	3.93	12,308.45
1+900.00	0.00	0.00	3.93	12,439.70
1+920.00	0.00	0.00	3.93	12,565.58
1+940.00	0.00	0.00	3.93	12,688.14
1+960.00	0.00	0.00	3.93	12,801.45
1+980.00	0.00	0.00	3.93	12,907.82
2+000.00	0.00	0.00	3.93	13,013.45
2+020.00	0.00	0.00	3.93	13,114.70

From the computations, the total cut and fill volumes for the 2.02 km alignment are as follows:

i. Total Cut Volume: 13,118.62 m^3
ii. Total Fill Volume: 3.93 m^3 (cumulative incremental fills as per design)
iii. Net Earthwork Volume: 13,114.70 m^3

These results provide a quantitative basis for procurement of materials, cost estimation, and scheduling of earthworks during the construction of the road.

4.3.1 DISCUSSION

The project cantered on the crucial aspects of conducting a route survey and subsequently designing a road network in Evbhuku community. The discussion below elaborates on the traversing procedures employed during the survey and the Civil 3D design procedures used to create a comprehensive road design plan for the town.

4.4 VISUALIZATION AND PRESENTATION OF RESULTS

The processed survey data from the Evbhuku Road corridor was used to generate two key visualizations that clearly communicate the earthwork characteristics of the project: an Earthwork Volume Distribution Chart and a Mass Haul Diagram. These graphical representations provide immediate insight into the quantity and distribution of earthwork required for construction.

4.4.1 Earthwork Volume Distribution Analysis

Figure 4.9 presents the cumulative earthwork volumes at 200-meter intervals along the Evbhuku Road alignment. The visualization is presented in two parts to accurately display both cut and fill volumes despite their significant difference in magnitude.

The upper plot shows the cumulative cut volume progression from station 0+000 to 2+000. The cut volume increases steadily throughout the alignment, beginning at 0 m^3 at the starting point and reaching 13,118.62 m^3 at the final station. Notable increases occur between stations 0+340 and 0+400, where the cumulative cut volume rises from 1,830.67 m^3 to 2,978.33 m^3, an addition of 1,147.66 m^3 over just 60 meters. This section represents the steepest cut rate along the entire corridor.

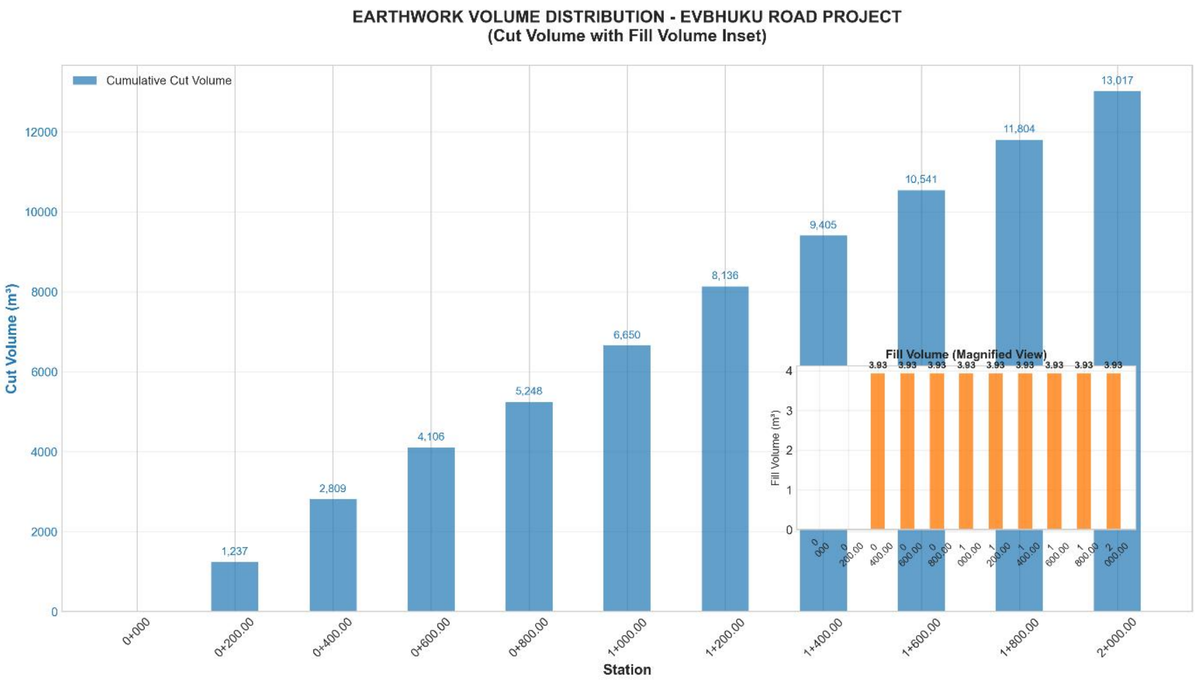

Figure 4.9: Cumulative Earthwork Volume Distribution (Cut Volume with Fill Volume)

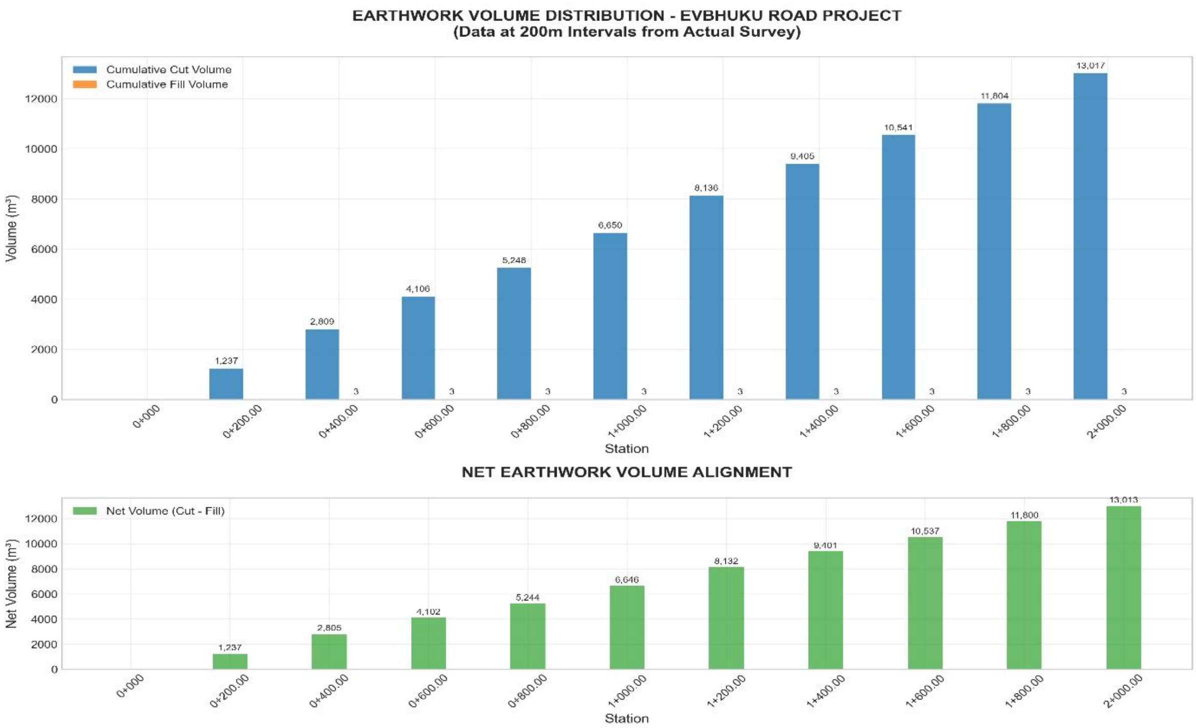

Figure 4.10: Earthwork Volume Distribution (200m Intervals)

The lower plot in Figure 4.10 displays the cumulative fill volume using an appropriate scale that makes the minimal fill quantities visible. The total fill volume across the entire 2.02 km alignment is only 3.93 m³, which accumulates primarily between stations 0+260 and 0+340. Beyond station 0+340, the fill volume remains constant at 3.93 m³, indicating no additional fill requirements for the remaining 1.68 km of the road.

The extreme disparity between cut and fill volumes is immediately apparent from these plots. The cut volume exceeds the fill volume by a factor of approximately 3,340:1, confirming that the Evbhuku Road project is essentially an excavation-only operation with negligible fill requirements.

4.4.2 Mass Haul Diagram Analysis

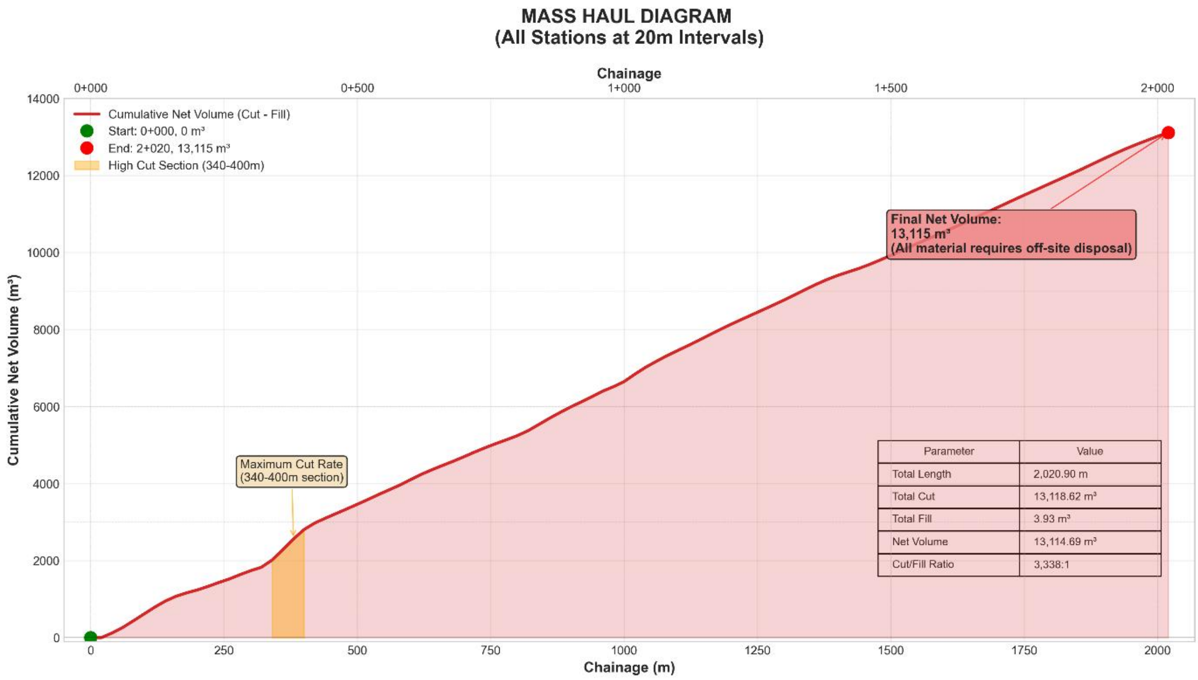

Figure 4.11: Mass Haul Diagram

Figure 4.11 presents the Mass Haul Diagram for the Evbhuku Road project, plotting cumulative net volume (cut minus fill) against chainage for all stations at 20-meter intervals.

The diagram shows a continuous upward curve from start to finish, beginning at 0 m³ at station 0+000 and ending at 13,114.70 m³ at station 2+020. The curve never returns to the baseline, indicating that there is no balance point where cut equals fill within the project limits. This continuous upward trend confirms the cut-dominant nature of the project observed in the volume distribution analysis.

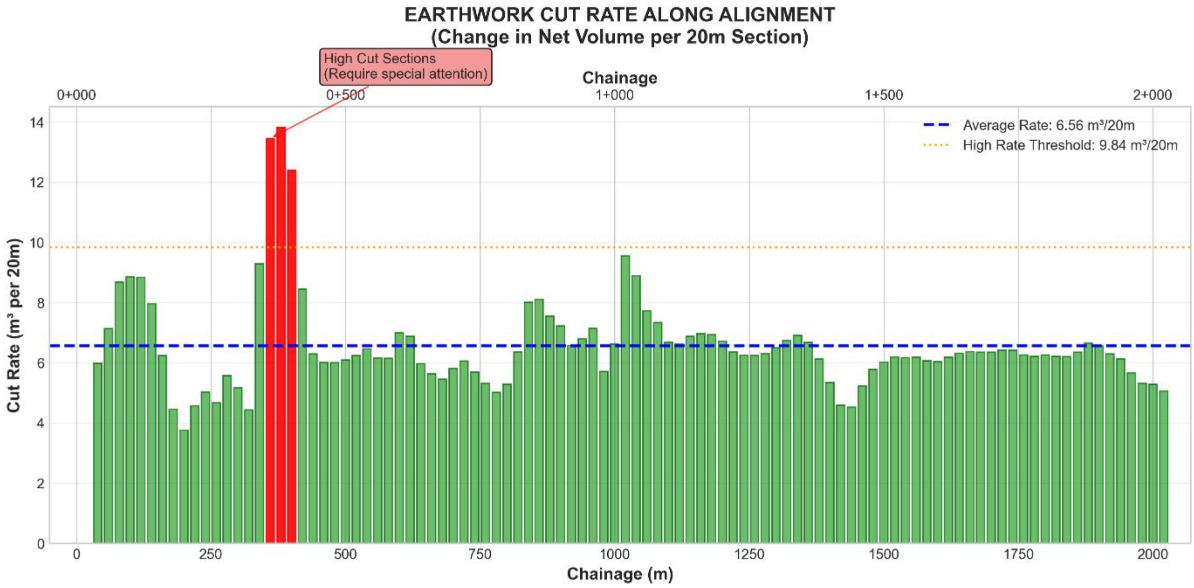

Figure 4.12: Earthwork Cut Rate Alignment

From Figure 4.12, a particularly steep section is evident between chainage 340 m and 400 m, highlighted in orange on the diagram. During this 60-meter segment, the cumulative net volume increases by approximately 1,147.66 m³, representing a cut rate of 19.13 m³ per meter. This section requires special attention during construction planning due to its high excavation intensity.

The final point of the mass haul curve at chainage 2,020 m shows a cumulative net volume of 13,114.70 m³. Since the curve does not close, all excavated material must be hauled off-site to designated spoil areas. The diagram clearly indicates that forward haul (in the direction of increasing chainage) is required throughout the project.

4.4.3 Engineering Implications

The visualizations confirm several critical engineering realities for the Evbhuku Road project:

i. Excavation-Only Operation: The negligible fill volume (3.93 m^3) compared to massive cut volume (13,118.62 m^3) means the project functions essentially as a large excavation operation.

ii. Spoil Management Requirement: The continuous upward trend of the mass haul diagram indicates that approximately 13,115 m^3 of material must be removed from site and properly disposed of.

iii. Construction Planning Impact: The high cut rate section between 340 m and 400 m chainage will require specialized equipment and possibly different construction sequencing compared to other sections.

iv. Cost Implications: The need to haul all excavated material off-site significantly impacts project costs, as hauling and disposal represent major expense items in earthwork operations.

These visualizations transform the numerical data from Tables 4.1 and 4.2 into actionable engineering information that directly informs construction planning, equipment selection, and cost estimation for the Evbhuku Road project.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The successful culmination of the route survey and road design project at Evbhuku community demonstrates the synergy between traditional surveying techniques and modern software solutions like Civil 3D. The project's emphasis on data precision, terrain understanding, and efficient design processes lays the groundwork for safer, more sustainable, and economically viable road infrastructure.

The impact of this project extends beyond the scope of Evbhuku community, it sets a precedent for future infrastructure projects, emphasizing the importance of accuracy, efficiency, and stakeholder communication. By embracing advanced technology and combining it with tried-and-true surveying methodologies, the project paves the way for a brighter and more connected future for Evbhuku community, showcasing the potential of modern civil engineering practices.

An initiative that bridges the gap between urban growth and infrastructure planning is the route survey and road design for Evbhuku community. We have not only built a safe and accessible road but also contributed to the general growth and prosperity of Evbhuku community by addressing the unique demands and concerns of the community. This undertaking highlights the value of sustainable, people-cantered infrastructure in the contemporary world and serves as an example of the power of intelligent and inclusive urban planning. I believe that the insights discovered through this study will encourage comparable initiatives in urban development around the world, resulting in more resilient, connected, and thriving communities.

5.2 RECOMMENDATIONS

Based on the detailed survey findings and the subsequent engineering analysis, the following recommendations are strongly put forward for the subsequent phases of the Evbhuku access road project:

1. Immediate Cadastral Intervention: Given the severe encroachment from chainage 0+000 to 0+350, it is recommended that the precise coordinates for this segment be immediately transferred to the land acquisition authority. Resolution of the Right-of-Way conflict, including property demarcation, compensation, and clearance, must be completed before any civil works commence in this initial section.
2. Integrated Drainage and Hydraulics Plan: A comprehensive drainage plan must be developed to ensure the durability of the road. This plan should include the uniform installation of the specified 1m x 1m drainage canals and the complete replacement of all non-functional culverts identified during the survey, preventing future washouts and subgrade failures.
3. Utility and Stakeholder Coordination: Before the commencement of construction, mandatory coordination with all relevant utility providers is required to plan for necessary relocations or height adjustments, mitigating risks of delays and ensuring safety during the construction phase.
4. Adherence to Standards: All subsequent design and construction activities must strictly adhere to the latest national and international highway engineering standards and specifications to guarantee the longevity, safety, and quality of the final Evbhuku Community access road infrastructure.

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APPENDIX A

COORDINATE DATA USED FOR THE EVBHUKU ROUTE SURVEY

Table A-1: Coordinates of the points observed during the route survey of Evbhuku road.

Eastings	Northings	Height
791418.4672m	690583.3502m	47.991m
791408.124m	690596.5160m	48.010m
791412.7940m	690617.9193m	48.187m
791423.5182m	690615.9406m	48.077m
791419.5541m	690602.1918m	48.218m
791419.3466m	690581.9710m	47.863m
791417.4843m	690556.4012m	47.763m
791407.4786m	690557.2463m	47.987m
791409.4146m	690580.6112m	47.941m
791409.5379m	690580.7512m	47.940m
791407.1723m	690585.7695m	47.965m
791405.1453m	690591.6458m	48.033m
791383.0809m	690576.4597m	47.773m
791381.6832m	690581.0240m	47.721m
791378.4157m	690587.2942m	47.764m
791358.4581m	690571.8980m	47.524m
791356.5776m	690576.7847m	47.731m
791354.1030m	690582.5764m	47.709m
791332.4621m	690567.3853m	47.320m
791331.3865m	690572.4725m	47.415m
791330.2450m	690578.1789m	47.428m
791305.8700m	690574.9468m	47.241m
791307.0240m	690568.1865m	47.290m
791308.8308m	690562.2802m	47.247m
791281.5193m	690559.3463m	46.973m
791280.9997m	690563.5933m	46.936m
791280.1071m	690570.9535m	46.957m
791260.4468m	690551.9984m	47.348m
791259.8030m	690555.1873m	47.039m
791258.8882m	690560.7517m	46.869m

791256.9046m	690566.2136m	46.784m
791235.0966m	690549.5433m	46.583m
791234.1980m	690555.4738m	46.737m
791235.2947m	690561.0420m	46.794m
791205.0707m	690545.4136m	46.500m
791203.5722m	690551.4858m	46.286m
791201.2668m	690556.6943m	46.557m
791179.0382m	690542.0044m	46.234m

Table A-1 con'd

Eastings	Northings	Height
791178.0110m	690547.5171m	46.425m
791176.9391m	690553.6377m	46.330m
791155.0113m	690534.2530m	46.195m
791152.8092m	690542.7862m	46.339m
791152.3055m	690549.5286m	46.258m
791128.9022m	690544.9099m	46.100m
791130.2901m	690537.9020m	46.287m
791131.2639m	690531.0480m	46.011m
791107.3042m	690525.5222m	45.972m
791105.2038m	690529.5756m	45.930m
791101.8009m	690538.4262m	45.829m
791078.5228m	690532.1737m	45.584m
791081.6183m	690524.7426m	45.789m
791082.5144m	690520.4432m	45.669m
791057.8058m	690513.8996m	45.556m
791055.9317m	690519.1421m	45.692m
791053.8062m	690525.3406m	45.355m
791034.0035m	690505.7381m	45.302m
791031.9124m	690511.8068m	45.516m
791029.2776m	690517.8069m	45.059m
791004.1070m	690509.6378m	45.026m
791007.0459m	690503.4545m	45.128m
791008.5453m	690498.0077m	45.131m
790984.6632m	690488.1774m	45.160m
790981.9726m	690495.1037m	44.616m
790980.6184m	690501.7395m	44.862m
790980.6949m	690481.9980m	45.845m
790963.4911m	690479.8364m	44.661m
790960.5455m	690485.8706m	44.581m
790960.0451m	690493.4559m	45.185m
790937.7353m	690483.1026m	44.985m
790940.5530m	690476.8908m	44.497m
790943.9711m	690471.2106m	44.328m

790927.6022m	690483.9100m	45.677m
790922.6821m	690459.6376m	43.991m
790919.5017m	690465.1423m	44.263m
790914.9013m	690473.3601m	44.933m
790893.5831m	690460.4734m	44.570m
790897.7166m	690453.7690m	44.212m
790901.6499m	690446.4595m	43.862m
790895.9006m	690441.5673m	44.722m

Table A-1 con'd

Eastings	Northings	Height
790880.5441m	690434.2551m	43.644m
790876.9398m	690441.1687m	43.874m
790872.6798m	690448.3183m	44.250m
790849.0988m	690435.8188m	43.730m
790852.3093m	690429.5271m	43.242m
790853.3817m	690427.4777m	42.799m
790855.6215m	690421.7701m	43.402m
790856.2295m	690420.8805m	44.401m
790850.0869m	690417.7443m	44.536m
790847.0298m	690415.3853m	44.431m
790833.7795m	690408.7866m	43.297m
790834.1490m	690408.1537m	44.238m
790831.3062m	690412.6523m	42.895m
790830.9768m	690413.0883m	42.322m
790828.6446m	690418.0420m	43.050m
790825.3376m	690420.6383m	44.076m
790807.8622m	690408.0053m	42.686m
790811.6947m	690401.8756m	42.502m
790814.3466m	690396.2904m	42.878m
790793.3614m	690385.7732m	42.296m
790790.4204m	690390.1299m	42.020m
790786.8382m	690395.6928m	42.523m
790765.0666m	690384.0588m	41.948m
790768.6208m	690377.4968m	41.832m
790770.9132m	690372.0139m	42.010m
790750.4078m	690360.3352m	41.762m
790746.9502m	690366.1842m	41.660m
790743.5043m	690371.4551m	41.680m
790714.7939m	690360.2869m	41.740m
790719.1662m	690350.7127m	41.348m
790721.9438m	690343.6254m	41.451m
790702.3988m	690332.8915m	41.273m
790697.8092m	690340.1419m	41.107m

790692.3458m	690349.8781m	41.542m
790674.5171m	690338.7019m	41.316m
790668.1065m	690336.4615m	40.939m
790673.1655m	690327.2320m	40.872m
790676.2012m	690321.3275m	41.087m
790652.7226m	690308.6867m	40.808m
790648.9020m	690315.7197m	40.668m

Table A-1 con'd

Eastings	Northings	Height
790646.5653m	690321.8410m	40.756m
790621.7919m	690311.6396m	40.550m
790625.8661m	690303.9356m	40.477m
790629.1543m	690297.1496m	40.656m
790609.9317m	690281.6784m	40.271m
790604.4368m	690290.5233m	40.255m
790601.1252m	690296.8322m	40.264m
790592.2084m	690267.9555m	40.322m
790584.2532m	690267.9077m	40.209m
790579.0433m	690276.7844m	40.069m
790575.3533m	690282.9594m	40.552m
790556.2433m	690273.0544m	40.175m
790560.9438m	690263.9390m	39.950m
790564.5752m	690258.0096m	40.112m
790544.0983m	690243.6634m	40.100m
790538.8317m	690252.2400m	39.866m
790533.8775m	690260.7267m	40.154m
790500.0014m	690231.8143m	40.100m
790503.3783m	690225.2809m	39.590m
790502.8319m	690219.6664m	39.571m
790482.5630m	690205.9371m	39.499m
790479.1625m	690210.7677m	39.453m
790475.1039m	690216.5252m	39.732m
790455.2398m	690204.6574m	39.658m
790458.4753m	690197.3957m	39.339m
790461.6077m	690192.5665m	39.442m
790442.0441m	690179.9288m	39.338m
790437.6260m	690187.3322m	39.267m
790433.9879m	690193.2626m	39.418m
790406.9933m	690177.0446m	39.201m
790411.0126m	690170.1346m	39.162m
790415.7741m	690161.9332m	39.218m
790393.6170m	690147.5424m	39.140m
790388.6143m	690158.4661m	39.038m
790384.7135m	690165.1590m	38.979m
790375.4559m	690135.4361m	38.956m
790369.6384m	690133.0513m	38.841m
790363.0793m	690141.4373m	39.027m
790358.2299m	690149.9230m	38.976m
790337.5883m	690140.9560m	38.815m
790342.0910m	690131.0166m	38.940m

Table A-1 con'd

Eastings	Northings	Height
790347.9364m	690120.5554m	38.940m
790338.9950m	690146.9977m	39.158m
790313.0170m	690133.4785m	39.057m
790315.4766m	690130.8203m	38.835m
790321.7005m	690120.4903m	38.672m
790326.7836m	690112.0749m	38.575m
790306.1363m	690098.9671m	38.651m
790287.0425m	690112.8187m	38.836m
790293.3801m	690101.7380m	38.689m
790298.2664m	690093.7862m	38.722m
790276.6991m	690083.0901m	38.901m
790270.3130m	690090.6967m	38.771m
790265.0485m	690099.0949m	38.842m
790243.7119m	690086.8919m	38.950m
790249.9343m	690077.9026m	38.827m
790255.0611m	690071.5370m	38.879m
790225.8678m	690069.8158m	38.895m
790230.0662m	690061.9529m	38.877m
790233.4240m	690056.9085m	38.990m
790210.0433m	690042.9750m	39.004m
790206.8309m	690047.9942m	39.004m
790203.1680m	690055.4875m	39.034m
790181.9136m	690041.0216m	39.216m
790186.5245m	690033.2308m	39.156m
790190.6865m	690025.4708m	39.195m
790169.8927m	690013.7768m	39.381m
790163.5746m	690020.6412m	39.256m
790159.0849m	690027.4240m	39.321m
790141.6244m	690016.0512m	39.633m
790147.7363m	690007.9942m	39.596m
790152.7035m	690001.0914m	39.464m
790128.7143m	689993.1670m	39.631m
790123.5076m	689999.1289m	39.710m
790133.1375m	689987.7798m	39.508m
790127.3728m	689981.9694m	40.155m
790093.2257m	689957.8573m	39.890m
790087.7894m	689964.0960m	39.976m
790083.0513m	689969.9069m	39.974m
790075.6607m	689966.9888m	40.210m
790061.9588m	689954.2207m	40.209m
790066.0287m	689948.3684m	40.153m

Table A-1 con'd

Eastings	Northings	Height
790070.2752m	689942.4206m	40.123m
790049.2910m	689930.0342m	40.090m
790044.7758m	689934.2052m	40.124m
790040.5828m	689939.2080m	40.170m
790022.8193m	689923.4948m	40.168m
790026.3662m	689918.7102m	40.312m
790029.8973m	689913.8817m	40.096m
790002.5158m	689907.3030m	40.169m
790007.3525m	689903.0805m	40.264m
790011.1697m	689899.2661m	40.057m
789982.4386m	689891.5101m	39.984m
789986.4748m	689886.4693m	40.071m
789989.3800m	689882.5072m	39.832m
789966.3134m	689877.4837m	39.720m
789970.3862m	689872.8097m	39.992m
789972.7360m	689868.3114m	39.815m
791424.1554m	690597.5370m	48.075m
791424.5720m	690591.4260m	47.953m
791426.2512m	690585.6900m	47.905m
791448.8593m	690585.8110m	47.619m
791449.9371m	690589.6850m	47.761m
791450.1871m	690594.1662m	47.705m
791476.5775m	690575.9430m	47.345m
791478.4648m	690580.2750m	47.282m
791480.5193m	690583.1324m	47.233m
791502.9841m	690574.1736m	45.953m
791501.8872m	690569.7964m	46.788m
791500.4755m	690565.3211m	46.903m
791522.1815m	690555.5380m	46.413m
791522.8416m	690560.4452m	46.035m
791524.2664m	690564.6322m	46.460m
791524.5276m	690565.2199m	45.487m
791564.9195m	690535.6195m	45.060m
791566.1857m	690540.5453m	44.667m
791568.8803m	690544.0240m	45.046m
791587.9275m	690535.7969m	44.400m
791587.3497m	690530.0938m	43.914m
791587.2438m	690526.1219m	44.157m
791617.1849m	690515.2010m	42.928m
791618.2583m	690518.6493m	42.953m
791619.8602m	690522.9878m	43.396m

Table A-1 con’d

Eastings	Northings	Height
791634.6797m	690517.4914m	42.998m
791633.6787m	690513.2742m	42.368m
791632.8892m	690510.9361m	42.829m
791657.7956m	690508.5060m	42.240m
791657.2153m	690504.4264m	41.541m
791655.6901m	690499.3329m	42.128m
791656.8954m	690504.2415m	41.577m
791683.5861m	690488.1060m	41.368m
791686.8262m	690492.8307m	40.259m
791688.5708m	690495.7631m	41.335m
791708.4631m	690487.0992m	40.566m
791704.8666m	690478.8821m	40.742m
791707.4033m	690483.1718m	39.549m
791729.7818m	690473.0773m	39.106m
791728.0008m	690468.6783m	39.871m
791731.3207m	690477.1778m	39.708m
791745.4093m	690471.1115m	39.406m
791749.8393m	690469.5656m	39.285m
791753.2319m	690468.5587m	39.158m
791759.1243m	690467.1013m	38.988m
791764.2463m	690466.0275m	38.845m
791771.1121m	690464.9164m	38.595m
791774.2073m	690464.7174m	38.484m
791774.1675m	690465.7654m	38.473m
791775.5111m	690472.3159m	38.535m
791776.7202m	690430.0449m	38.350m
791775.2301m	690428.2958m	38.316m
791787.3320m	690430.1007m	38.628m
790319.6324m	690104.8200m	38.298m
790323.9982m	690108.1413m	38.436m
790327.7830m	690109.5991m	38.953m