COMPILATION OF CADASTRAL CONTROLS OF KATSINA TOWNSHIP

BY

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ZARIA.

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DECLARATION

I hereby declare that this thesis has been compiled by myself, Ehoche Peter A. OINU, under the supervision of Prof. N. J. Field, and that it is a record of my own research work. It has not been accepted in any previous application for a higher degree. All quotations are distinguished by quotation marks and indentures and the sources of information are specifically acknowledged by means of references.

Eoinu

OINU, Ehoche Peter A.

CERTIFICATION

This thesis entitled:

COMPILATION OF CADASTRAL CONTROLS OF KATSINA TOWNSHIP by EHOCHE PETER A. OINU meets the regulations governing the award of the degree of Master of Science (M.SC.) of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Chairman, Supervisory Committee Date:.....

Member, Supervisory Committee Date:.....

Member, Supervisory Committee Date:.....

Head of Department Date: 26th June 1987

Dean, Postgraduate School Date:.....

Dedicated to my

Wife: Amina Ehoche

Brother: Ada Egli Oinu

Son: Eka Ehoche.

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ABSTRACT

Land is an essential non-renewable resource of mankind with a growing and disorderly use due to increased population pressure and demand for more space per inhabitant leading to scarcity especially in the urban centres. Basic to all other land data and helpful in describing it is its location which is fixed. The location helps in the coordination and effective use of land and monuments (controls) are used to describe the location.

Cadastral controls form township framework providing references on which future surveys are tied and basic information on which township maps are made. They give information on resources available and insight into how best they can be used. Katsina township framework is an isolated framework surveyed, coordinated and freighted between 1959 and 1962.

This compilation brings the history of Katsina framework into the limelights with the stark realities of the gross inadequacy of the controls. Most of the controls established have been lost and also the township has outgrown the framework in some sections. Many of the controls were lost due to lack of coordination in execution of urban public works projects. There are no up to date township maps. The preparation of any map requires adequate controls and the coordinates of these controls must be derived from ground surveys involving physical measurement of directions and distances.

The picture is the same for most urban centres in Nigeria. Most plans for the urban centres are still based on out of date fragmentary information and this is partly responsible for the wastes and inefficiencies in the administration of the urban centres.

The revelations of the compilation is used in designing a new framework for Katsina incorporating the existing controls that can be used. The same could be done for most Nigerian townships. The new framework will provide the necessary information for efficient planning, execution, coordination and administration of the township. It will provide adequate statistics which is essential for modern economic development of the township.

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ABBREVIATIONS

FATC - Federal Advanced Teachers College

Ft - Feet

GRA - Government Residential Area

KCSP - Katsina Cadastral Control Survey, Primary Control

KCSS - Katsina Cadastral Control Survey, Secondary Control

KCST - Katsina Cadastral Control Survey, Tertiary Control

M - Metre

MSL - Mean Sea Level

WTC - Women Teachers College

Conversion Factors:

$$\frac{^{o}F \quad \text{to} \quad ^{o}C}{(^{o}F \quad - \quad 32) \times \frac{5}{9}}$$

Ft to Metre

1m = 3.28086933ft

1ft = 0.304797265m

Dec. = December

Feb. = February

Sept. = September

RO = Reference Object

HMSO = Her Majesty's Stationary Office

FL = Face Left

FR = Face Right

CM = Central Meridian

CHAPTER 1 INTRODUCTION

Controls form the basis of all surveying and are usually points of origin of surveys. They measure the overall limits of a project to an accuracy greater than the probable limits of subsequent surveys. According to Wood, 1962,"the accuracies of the surveys can be improved by tying them into networks. They provide information vital to the development of an area such as

i. Coordinates of points
ii. Reduced levels of points physically established
iii. Control diagrams showing location of the controls
iv. Register of traverse and triangulation stations
v. Data for production of topographical maps
vi. Information for the determination of the area covered
vii. Physical features of the area covered".

The accurate and precise location of points on the surface of the earth is important to man.

Controls are classified as horizontal and vertical. Horizontal controls are the planimetric positions of points either in latitude and longitude fixed through astronomic observations or in coordinates of points in horizontal planes. Vertical controls are the elevations of points above an adopted surface reference (datum).

All human measurements are liable to error. All measurements made are computed and then adjusted. The controls are also classified according to the achieved precision and accuracy as geodetic, secondary, tertiary,

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minor and cadastral. The most precise controls are the geodetic controls which form the national framework. They are further broken down (interspersed by) secondary controls, then tertiary controls, minor controls and cadastral controls so as to make them readily available, chart 1.1.

The monuments marking the positions are usually put in and allowed to settle before the observations are made.

Geodetic Controls

(Determining shape of earth and spheroidal relations, fixing the correct shape of the area on the surface of the earth).

Accuracy 1:300,000

↓

Secondary Controls

(First breakdown of primary controls)

Accuracy 1:150,000

↓

Tertiary Controls

(Breakdown from primary or secondary controls)

Accuracy 1:100,000

↓

Minor Controls

(Control for minor traverses and topographical surveys etc)

Accuracy 1:75,000

↓

Cadastral Controls

(Breakdown from national framework or isolated surveys. They form township framework and information for township mapping)

Accuracy 1:15,000

Chart 1.1: Control Classification

The survey techniques of triangulation, traversing trillateration and levelling could be used to determine these positions which are monumented before hand.

Cadastral controls form the township framework and the basis for mapping urban centres. "For any proper development, planning and efficiently executed urban public works project, full information concerning land and the boundaries of real property ownership is required" (Bauer, 1963). There is therefore the need for an integrated and continuously updated information system of all urban resources, including positional and geometrical information on topography, infrastructure and land parcels. This is especially so for urban centres because of the present rapid growth being experienced by the urban centres. Base maps of required accuracy and precision providing the necessary inventory of physical facts relating to the land and cultural information of the land are necessary. This can be achieved through the establishment of cadastral controls. The establishment of cadastral controls can therefore be seen as the first step towards the creation of modern land

data system. Cadastral controls to be useful must be readily available.

Cadastral controls are the controls for a township usually referred to a system of plane coordinates. They could be primary, secondary or tertiary, table 1.1. The primary cadastral controls form the perimeter controls (outer circuit) of a township marking the forseable limits of the township established by either triangulation or traversing. They are then broken down to secondary and tertiary controls so as to make them readily available. The secondary and tertiary controls are usually established by traversing since triangulation will be virtually impossible within the town environment, and they usually run along main streets within the township. "These controls must permit the accurate correlation of property boundary line information monumented on the ground so that lines on the map may be accurately re-established in the field when planned public projects reach the construction stage" (Bauer, 1963). Cadastral controls could be break downs from national control network or are isolated surveys with a local origin, assumed coordinates and heights; and precisely determined geographical coordinates.

In Nigeria, the establishment of cadastral controls is the responsibility of state governments while the Federal Surveys is responsible for the national framework. According to Adutwum, 1969:

> Due partly to the enormous size of the country partly to the urgent need for maps and plan for urban development, and partly to lack of funds

Table 1.1 : Classification of Cadastral Traverse Controls

Criteria	Primary Cadastral	Secondary Cadastral	Tertiary Cadastral	Topographical Traverse, Minor Cadastral
Maximum closing error	1/15,000	1/8,000	1/3,000	1/3,000
Instrument	Second order or 1" Theodolite e.g. Wild T2, Kern DKM-2	2nd order Theodolite	Third order Theodolite e.g. Wild T1A	Third order Theodolite
Horizontal Angles	Two FL Two FR Two Zeros	Two FL Two FR Two Zeros	One FR One FL One Zero	One FR One FL One Zero
Horizontal mean to agree within	10"	10"	20"	20"
Minimum No. of Pairs in Azimuth Observation	3	Not applicable	Not applicable	Not applicable
Maximum Range of Azimuth Pairs	10"	Not applicable	Not applicable	Not applicable
Tape :	100m, (300'x1/8")	100m (300'x1/8")	100m (300'x¼")	100m (300'x¼")
Taping Method:	Catenary	Catenary	Flat	Flat
Temperature corrections	Yes	No	No	No

Table 1.1 Contd.

Criteria	Primary	Secondary	Tertiary	Topo traverse
Slope Angle by	Theodolite	Theodolite	Abney	Abney
Final bearings to the nearest	Second	Second	10"	10"
Final Coordinates Computed to	3 decimal places of metre (2 decimal places of a foot)	3 decimal places of a meter (2 decimal places of a foot)	2 decimal places of a meter (1 decimal place of a foot)	Nearest foot or 1 decimal place of a meter
Principal Uses	To provide main framework of the township	First break-down from primary cadastral control	Further break-down of secondary or primary cadastral controls. They are controls for details	Controls for details further breakdown of higher order controls.

> and technical personnel, it has been the practice of the various Regional Survey Department of the country to undeftake isolated local surveys in the big towns. Some of these surveys start from one of the national framework pillars as origin with assumed coordinates expressed on the plane. Without an effort to define the projectional relationship of this point in terms of the national grid system, an azimuth is observed at this point for use as bearing. The assumed plane coordinates and azimuth from this point then define the survey system for that town. This has resulted in producing as many local survey systems as there are large towns in Nigeria.

Most township frameworks in Nigeria are based on isolated surveys with local origins not tied to the national framework. According to Federal Surveys specification: Pamphlet No. 3, 1954.

> In all townships where a good value for latitude and longitude exists the survey will be carried out on the colony projection but no scale corrections will be applied as it is essential to preserve agreement between distances shown on the plan and the distances shown on the ground. Similarly distances will not be reduced to mean sea level. Where a sound value for the latitude and longitude does not exist, the survey will be carried out on the local meridian. Transference to the colony projection in future years will be made when the area can be connected to the colony framework.

The perimeter controls could be established by either triangulation or traversing depending on the topography. The secondary and tertiary controls are then establised by traversing along main roads starting and closing on points of the perimeter controls., The Katsina township framework is an isolated survey put in before national controls were extended to the area.

Katsina, a traditional moslem - Hausa settlement on the northern plains of Hausa land is the focus of this study. The aim of this study is to look into the history of the establishment of the cadastral controls,

their achieved accuracies and show the density of the controls. An attempt is made at explaining how to link up this isolated survey with the national network. It is a known fact that controls are lost at high rates, an attempt is also made to show whether this is true of Katsina framework or not. Based on the findings of the field inspection the existing controls will be related to the level of development of the township. The adequacy or other wise of the existing controls will be shown along with the density. The problems faced by the controls are also looked into and suggestions on how they can be overcomed. In short, cadastral controls of Katsina are brought into the limelight with their problems and suggestions on how to safeguard the controls and the need to provide new controls for the growing town so as to meet the present day needs of the township. A new township control framework is designed for the township incorporating the existing controls.

It is an open secret that township controls in Nigeria are grossly inadequate with practically no town at all having adequate controls. Because of the inadequacy and at times total absence of cadastral controls, base maps of required accuracy and precision, providing the necessary inventory of physical facts relating to land and its ownership are lacking for most if not all the nation's urban centres. Thus alot of decisions made about our urban centres are based on out of date, fragmentary and inconsistent land-use information which is courting disaster. Urban public

works projects cannot therefore be soundly conceived and effectively planned and executed. Executing one urban public works project in Nigeria today involves damaging others previously executed which amounts to waste. Public works projects must be coordinated if such damages as are being done to previously executed projects as is being experienced now are to be avoided.

Sources of Data:

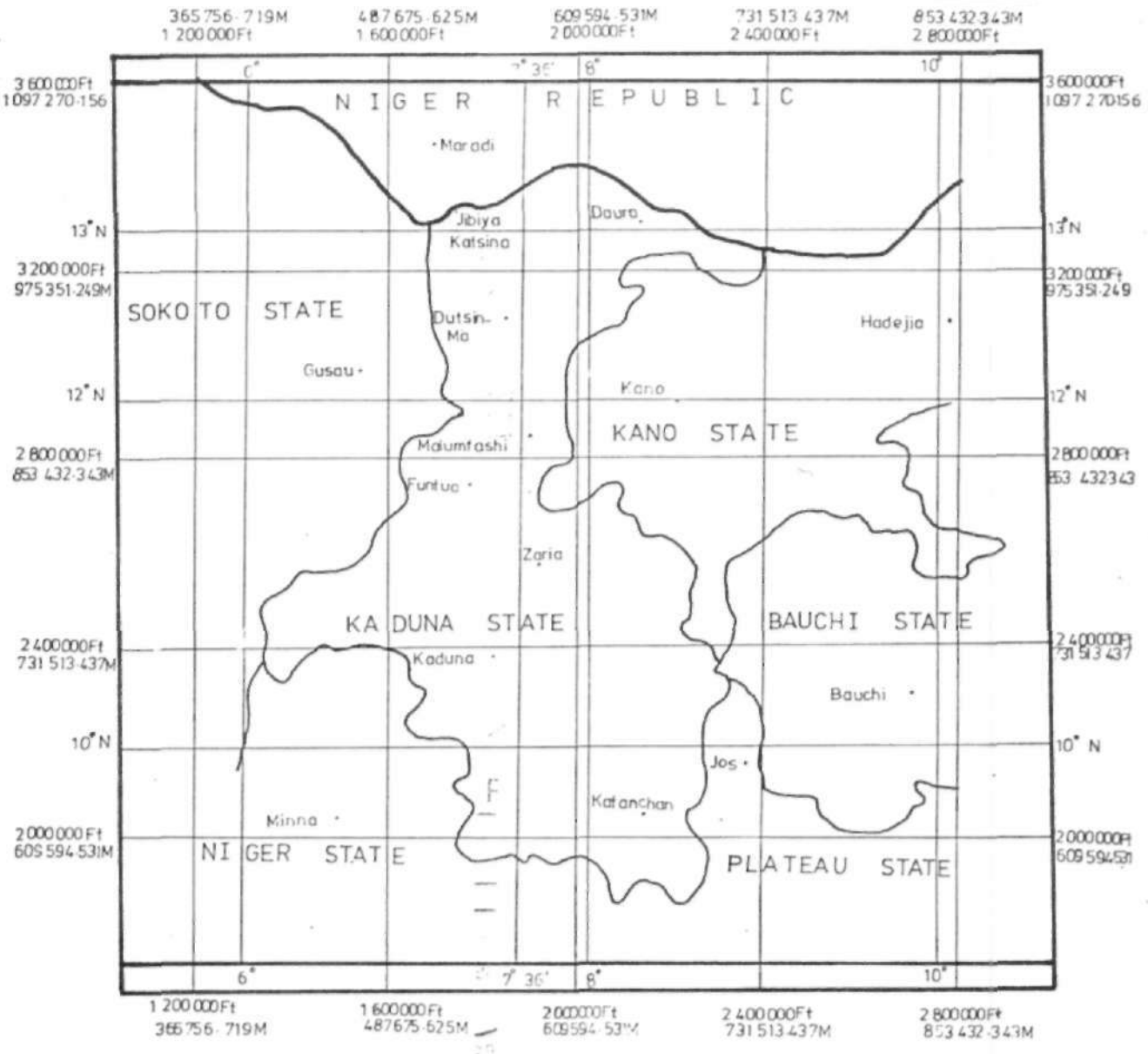
For the purpose of this work, alot of information was gathered from box files 526 and 843 in the Ministry of Land and Surveys, Kaduna. Coordinates and heights of all the Katsina township framework are abstracted from the Kaduna State Coordinate Register, Ministry of Land and Surveys, Kaduna. Township maps and plans though outdated found at the Ministry were also found useful. Field inspection of some of the controls in Katsina town was carried out and notes were made on their conditions. A few photographs were also taken of some of the controls. Some information was also gathered through personal communication. The data so collected was analysed and interpreted to form the write up.

CHAPTER 2: LOCATION AND SIZE OF KATSINA

2.1 LOCATION

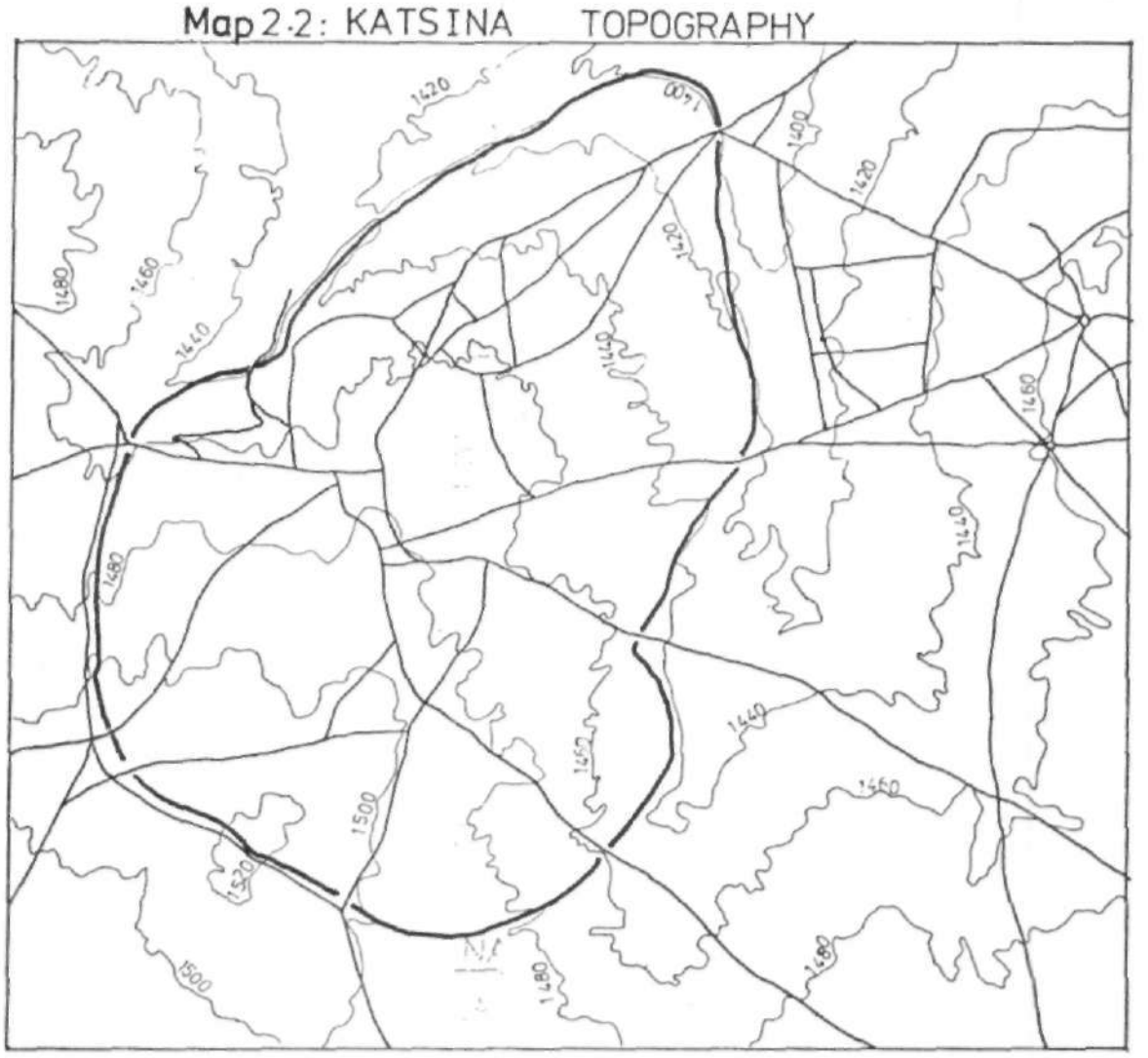
Katsina is an old moslem traditional city of Hausa-speaking people. The population is predominantly Hausa-Fulani in ethnic composition. The centre of the city lies on approximately latitude 13°N and longitude 7°36' E(Map 2.1). Located on the Hausa plains with a general north-easterly slope (Map 2.2), it has an elevation of over 518m (1700 ft.) above mean sea level. It is one of the major towns in Kaduna State, in fact third after Kaduna and Zaria. It is located in the extreme north, very close to the Nigeria-Niger border (Map 2.3), at the southern fringes of sahara desert. It is a walled city enclosing an area of about eight square kilometers and the present city wall spans about twelve kilometers (max lock, 1977). Development has spread out of the city walls and the new layouts outside the city wall are growing rapidly. The township is traversed by two streams, the Koraman Tilla and Koraman Gisu and the river Tagwai system, about sixteen kilometers to the east which flows northwards into a swamp (oasis) in the sahara desert is the main source of water supply (Map 2.4). Katsina was one of the important termini of the Trans-saharan Caravan from North Africa (Max lock, 1977; Udo, 1978). Katsina was the capital of the then Katsina Kingdom (under Habe rule) which metermorphosed into Katsina Emirate and then Katsina Province. It is the head quarters of Katsina Local Government and the proposed Capital of the proposed Katsina State.

Map 2.1: THE GRID OF RECTANGULAR COORDINATES



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AHMADU BELLO UNIVERSITY
ZARIA, NIGERIA.

Map 2.2: KATSINA TOPOGRAPHY



Source: Max Lock 1977

City Walls

Roads and Streets

1460 Contours at Intervals of 20Ft

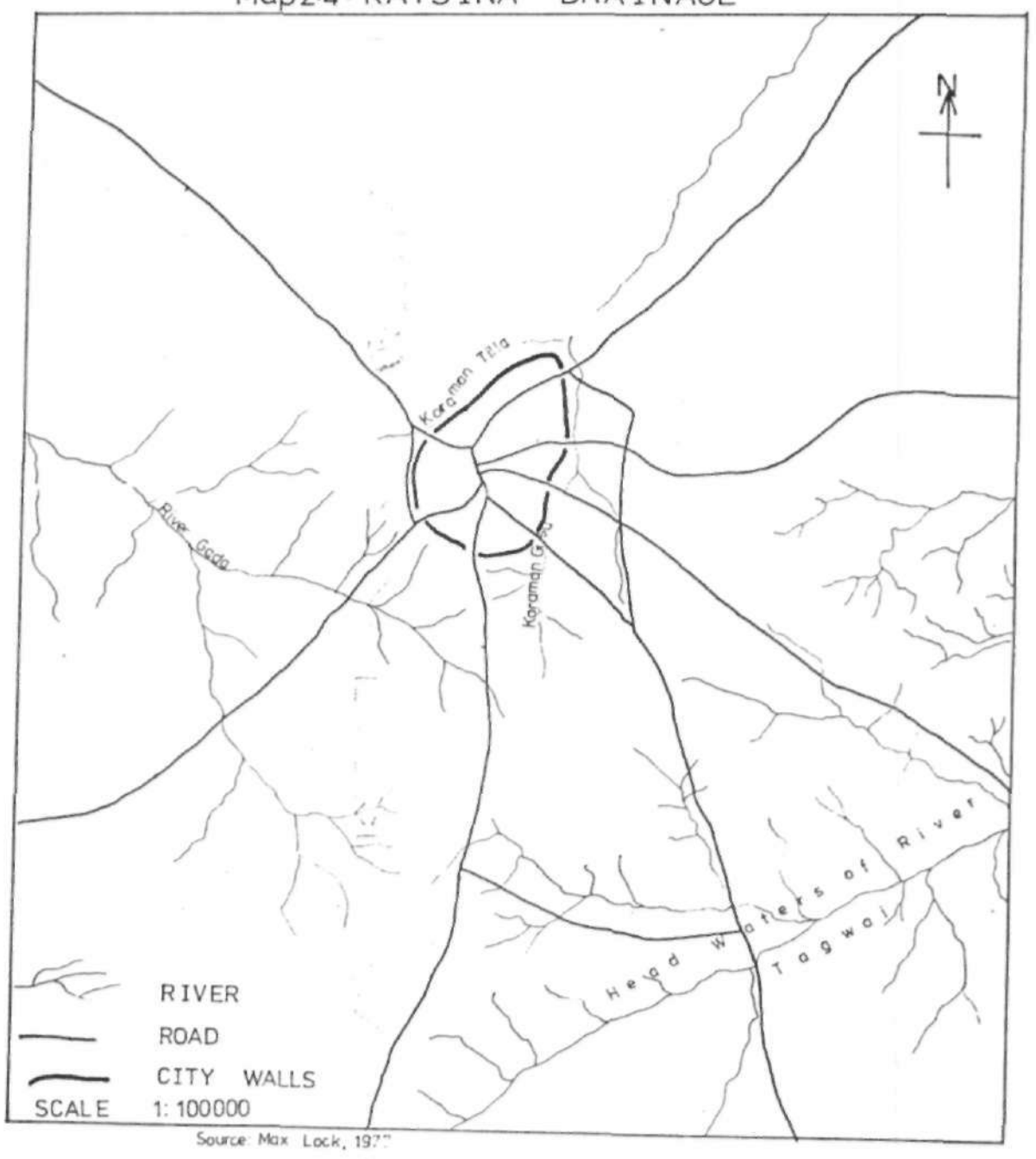
Scale 1: 25,000

MAP 2.3: LOCATION OF KATSINA



Source: Max Lock, 1977

Map 2.4: KATSINA DRAINAGE



Source: Max Lock, 197?

2.2 PHYSICAL ENVIRONMENT

The topography is generally gently undulating, dissected by Koraman Tilla and Koraman Gisu and their tributaries. The soil comprises of transported sandy or loamy materials overlying rounded quartz pebbles and clays derived mainly from weathering of cretaceous conglomerates. The soils are quite suitable for groundnut cultivation. Rain water soaks easily into the ground thereby affording the town a good drainage system. The soil is underlain by sedimentary rocks of cretaceous age, comprising the Gundumi formation. Lithologically, they consist chiefly of coarse purple and mottled, feldspathic grits. Impersistent intercalations of blueish and purplish clays are occassionaly present in the grits, while bands or horizons of quartz pebbles are common at certain levels. The sediments rest on an even floor of pre-cambrian Basement complex rocks although in general they dip at a low angle to the north-west. Inliers of Basement complex rocks can be seen at several localities in the valley of the Koraman Gisu. (Max lock, 1977).

There are no permanent/perennial streams in the area immediately surrounding Katsina. The Koraman Gisu only carries surface run-off during the rains; permanent pools are, however, present in the Koraman Tilla stream bed. Groundwater occurs under water table conditions and is held mainly in the sediments of the cretaceous Gundumi formation. The most important feature controlling the distribution and

circulation of groundwater in this area is the existence of a buried granite ridge in the valley of the Koraman Gisu. Two subterranean valleys flanking this basement ridge are filled with cretaceous sediments which reach a considerable thickness and are copiously water bearing. The Tagwai Dam scheme which incorporates the daming of the northward flowing Tagwai River is now supplying all the water needs of Katsina with potential for increment in the future (Max lock, 1977).

The climate is a prolonged dry season in the semi-arid region. It is hot arid type with characteristic rapid changes in temperature and humidity. The highest mean monthly temperature is approximately 40^{o}c in April and the lowest is approximately 15^{o}c between December and January. Serious diurnal temperature changes are experienced. Relative humidity is generally quite low throughout the year (Udo, 1978) ranging from 10% in February to 90% in August (Iloeje 1976). The usual wind velocities range from one to twenty (1-20) knots, but sometimes with sudden gusts may read up to forty (40) knots. The climate varies considerably according to month and season and is dependent on the movement of the Tropical Maritime air mass (South West Trade Winds) and Tropical continental air mass (North East Trade Winds). There are three marked seasons with one less marked season as follows.

i. Cool-Dry season (Dec-Feb.) with very low temperature and humidities. Temperatures may fall to as low

as 12.78°c (55°F) accompanied by harmattan winds with haze and dust in the air reducing visibility. During this period, the whole of Northern Nigeria is brought under the influence of the North East Trade Winds - a dry dust laden wind originating in the Arabian desert and blowing across the Sahara desert. The relative humidity usually becomes so low about 10% in February, that human skins and lips in particular crack.

ii. Hot-Dry season (March-May). This follows the harmattan. Temperatures are generally high, going over 37.2°C (99°F) with April averages being about 40°C. Dust storms occur in May hampering outdoor activities.

iii. Warm-Wet Season (June - Sept). During this period Katsina is brought under the influence of the South West Trade Winds which is moisture laden having blown across the Atlantic Ocean Picking up moisture. Thick clouds, lightning and thunder and rain with a single peak in August are characteristic of this season. Dust storms are frequent in early June. During the rainfall peak in August, total of 200mm may be recorded in the month with relative humidity being as high as 90%.

iv. Finally, there is the less marked season after the rains (October - November). It is characterised by gradual lowering of temperatures. The South West Trade Winds will be retreating while the North East Trade Winds will be advancing to take its place.

The vegetation is Sahel Savanna with short grass, thorny bushes, staunted acacia trees and neem trees (dogon yaro) dominating the scene. Natural bush vegetation is almost completely out and several trees especially neem have been planted to provide shade within the township. Forest plantations of neem trees are found to serve mostly as fuel and also to check winds and modify the climate. There is a belt of neem tree forest round the city walls.(Max lock, 1977)

2.3 POPULATION

Like most other Nigerian towns, accurate and up to date census figures are not available and so actual population figures are not available. The country has not succeeded in conducting any acceptable population head count yet. Whatever is given here is an estimation. Estimations based on the 1952 and 1963 censuses which were fairly accurate give a population of about 100,000 for the town in 1977; 144,895 in 1985 and projected to 288,158 for the year 2000 A.D. The population growth rate is about 5% per annum (Max lock, 1977). Population determinants like migration, death and birth rates are not known precisely. The establishment of Iron and Steel Rolling Mills led to an unprecedented migration to the town.

2.4 SIZE

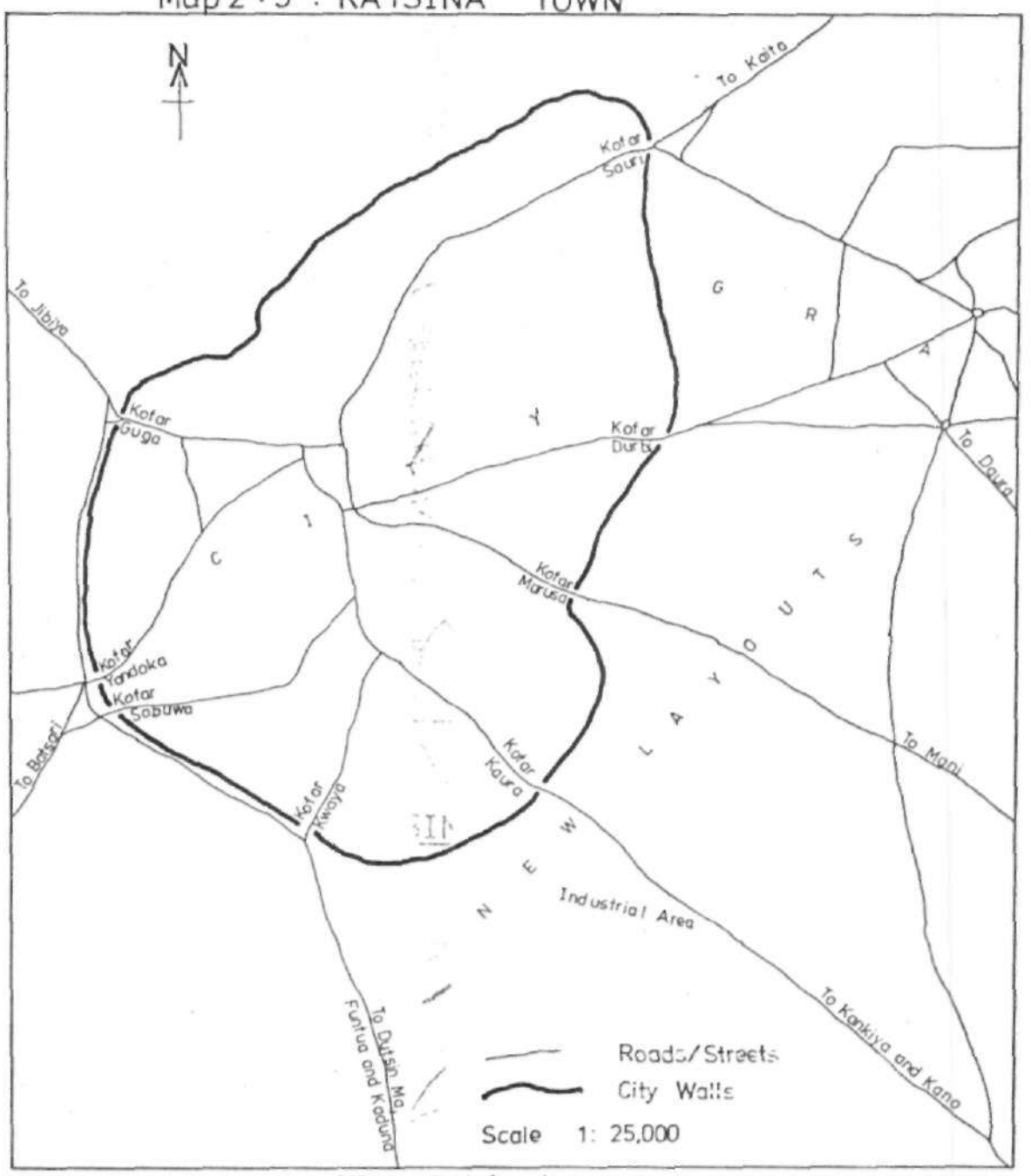
"Katsina is a traditional urban centre founded on surplus agricultural wealth which sustain the non-agricultural population and provide the basis for

interregional trade"(sada, 1972). Katsina used to play more important roles in the past. Its growth was accounted for by immigration from neighbouring states due to relative peace enjoyed by the city. It however, did not attain any importance with the British Administration because of its distance from the administrative and economic centres. "It thus experienced at least relative decline"(Urquhart, 1977). It however, picked up with the creation of the North Central State, now Kaduna State and is growing now.

In terms of size, according to Max lock, 1977, Katsina sprawls over an area of about 496 hectares with a total of about 15,809 compounds out of which 1,741 are vacant. There are about thirty two compounds per hectare, 6.80 people per compound and 201 people per hectare. About 1,133 compounds were under construction. After 1977, further land allocations include 600 hectares for Katsina College of Arts, Science and Technology later reallocated to Katsina Polytechnic. Allocations were also made to Federal Advanced Teachers College (FATC), the New Army Barracks, Verterinary Centre, new residential plots (1600 plots), Polo Grounds and Teaching Hospital. About 3,094 compounds were expected to be added by 1985. The town is growing at the rate of about 5% per annum.

The walled city has nine gates each linked to the centre by a street (Map 2.5). The traditional radial pattern of major roads still feature strongly within the city walls. The roads passing through the gates

Map 2 · 5 : KATSINA TOWN



Source: Max Lock, 1977 and Field Inspection

converge on the central area of the city where the Emir's Palace, Central Mosque, City Square (Dandali) and a number of public offices are located. The minor access spaces (streets) feature mainly in the form of tight incidental spaces between compounds and compound clusters. The buildings generally have poor access passageways winding through the maze of incoherent spaces, most of which are too narrow for motor vehicles. Along these narrow winding spaces run un-channelled and channelled drains within the city. No attempts are being made to interfere with this pattern yet. The city has close links with the surrounding rural areas. The comppund is the physical basis of residential unit - a group linked through male line. All compounds follow the same basic physical pattern of Zaure, forecourt and inner compound though wide variations exist in size. The compound is further partitioned into sections containing separate though closely related households. The separate household is usually nuclear type. There is the tendency for compounds to fragment. Customary land tenure is prevalent. Infilling is still going on covering areas which until recent were farmlands, thus development of residential houses is not fast spreading out of the walls. Unlike most other Hausa-moslem traditional cities the walled city is still accepting and accommodating strangers (Max lock, 1977).

Development of settlement outside the walls include the Government Residential Area (GRA) - a creation of the British colonial administration; the new layouts

in the East and South including the Industrial Zone; the Army Barracks; Verterinary Clinic; Katsina Polytechnic, Federal Advanced Teachers College and some institutions along Dutsin Ma road. They unlike the city are well planned and laid out. Within the G.R.A. there are well laid streets providing good passageways with iron grid systems, houses are not jammed together, each compound is isolated from the others. It is a low density zone. Most of the growth of the city now is accounted for in the New Layouts especially in the industrial zone. Land tenure is by statutory Right of Occupancy and most occupants are tenants.

2.5 ECONOMY

Katsina was one of the termini of the Trans-Saharan Caravan from North Africa. It has been a centre of commerce of long standing. The market is still an international market with goods and people from the neighbouring Niger Republic. It speciallised in the production of leather goods, exportation of hides and skins and dried meat. The prolonged drought in this part of the country has decimated the animal population and hence reduced the once burgeoning exportation of hides and skins and meat business to North Africa to nothingness. Apart from the drought, the establishment of tannery in Katsina has provided another use for the hides and skins (raw material for the tannery). In fact hides and skins are presently being brought from other parts of the North to feed the factory. The Katsina/Kano brown goat form the main source of hides and skins. The tannery has helped to retain the importance of Katsina as a centre

specialised in the production of leather goods. Finished and semi-finished leather goods find their ways from here to other parts of the country and the neighbouring Niger Republic. Katsina also suffered from relative decline because of the creation of the modern transportation superstructure which by-passed Katsina there by shunting her to the back water of economic decadence, losing many of her virile young men to centres better favoured locationally. Imported manufactured wares drove locally manufactured goods out of market and led to the decline of traditional craft industry on which the glory of the city depended.

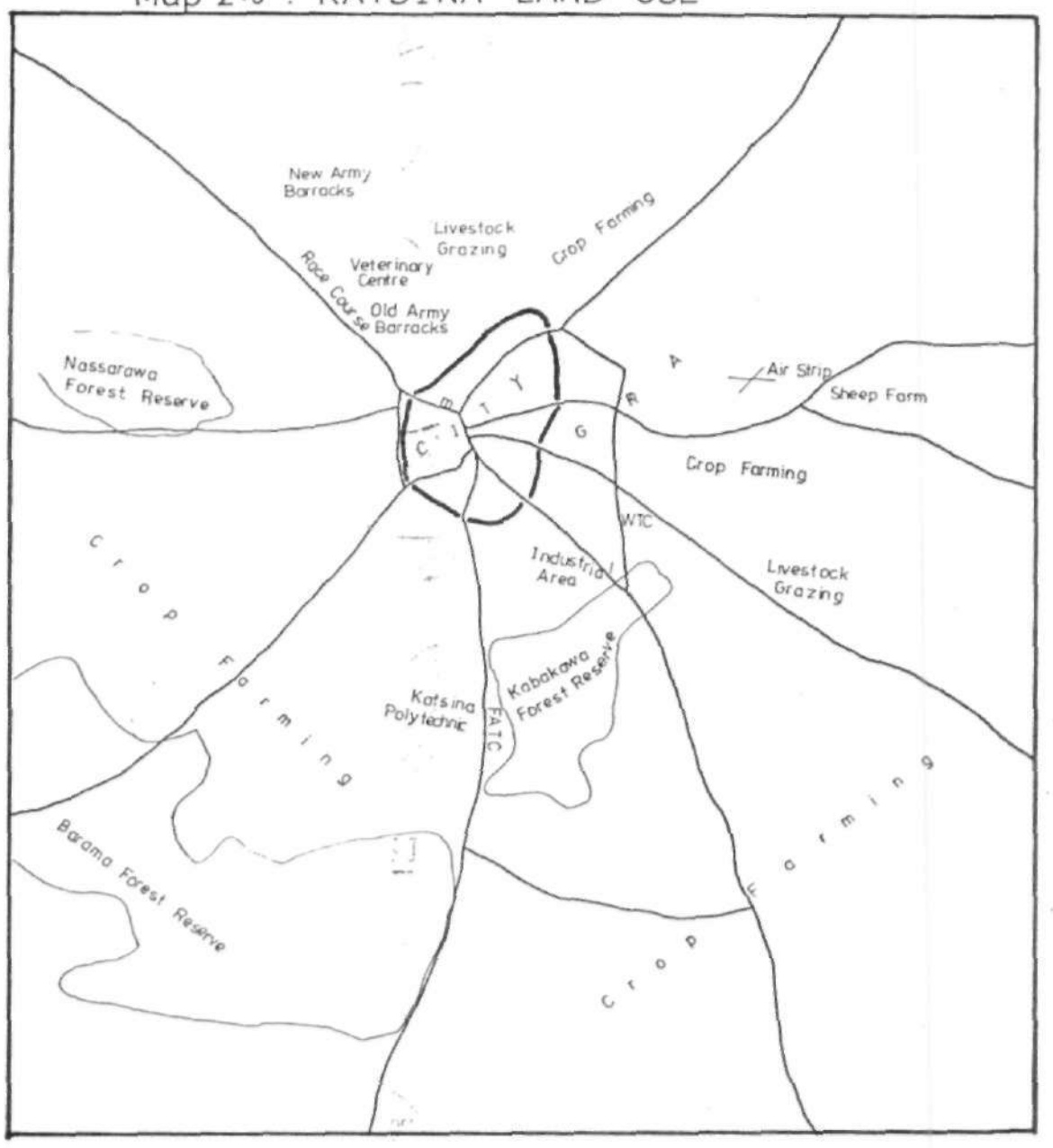
Agriculture too plays an important role in the life of the people. In the past, agriculture used to provide more than 50% of the population employment, but this has reduced to about 9.3% (Max lock, 1977) and likely smaller now. There is a general move towards secondary and tertiary sectors of the economy. Animal rearing is an important aspect of the economy. Cattle, goats, sheep, donkeys, carmels, horses and poultry are specially favoured. Despite the harsh climatic conditions, crops like groundnuts, millet, guineacorn, cotton, sugar cane, onions, pepper and tomatoes are grown. Irrigation is being embarked upon seriously now and rice and wheat may soon enter into the list of crops grown. Fadama cultivation is important. Planting of crops is done with the coming of the rains and harvested in September/ October. Only annual crops could be grown due to the vagaries of weather. Mixed farming is also practised

with animal droppings adding fertility to the soil and the corn stalks and other vegetable matter are stored as hays to feed animals. Map 2.6 shows agricultural land use.

Presently, there are many industries in Katsina and those of note include the Steel Rolling Mills, Oil Mills, Tannery, Garment Manufacturing, Chipboard Manufacturing utilising groundnut husks and carpet manufacturing. The Steel Rolling Mills is attracting many more factories already. There are also many service industries including Banking, Hotels, Repair Shops, Insurance, Tailoring, Carpentry and Furniture manufacture. Many employment opportunities are found here and this sector now accounts for a high percentage of the population of working age in the township.

There are many schools in the township including koranic, primary, secondary and higher institutions meeting the educational needs of the township and its surroundings. There is a good road network system connecting Katsina with other towns in Northern Nigeria especially Kano and Funtua (a road nodal centre), Map 2.7. There is also a direct road link through Jibiya to Maradi and Daura to Zinder all in Niger Republic as parts of the Trans African Trade Routes of modern times Map 2.8, and this may help to bring Katsina to its former position as a terminus of the Trans Saharan Trade Route. Already groundnuts, hides and skins, cattle, sheep and goats from Niger Republic pass through the major markets of Sokoto, Katsina and Kano for distribution to the rest of Nigeria

Map 2·6 : KATSINA LAND USE



FATC Federal Advanced Teachers College

GRA Goverment Residential Area

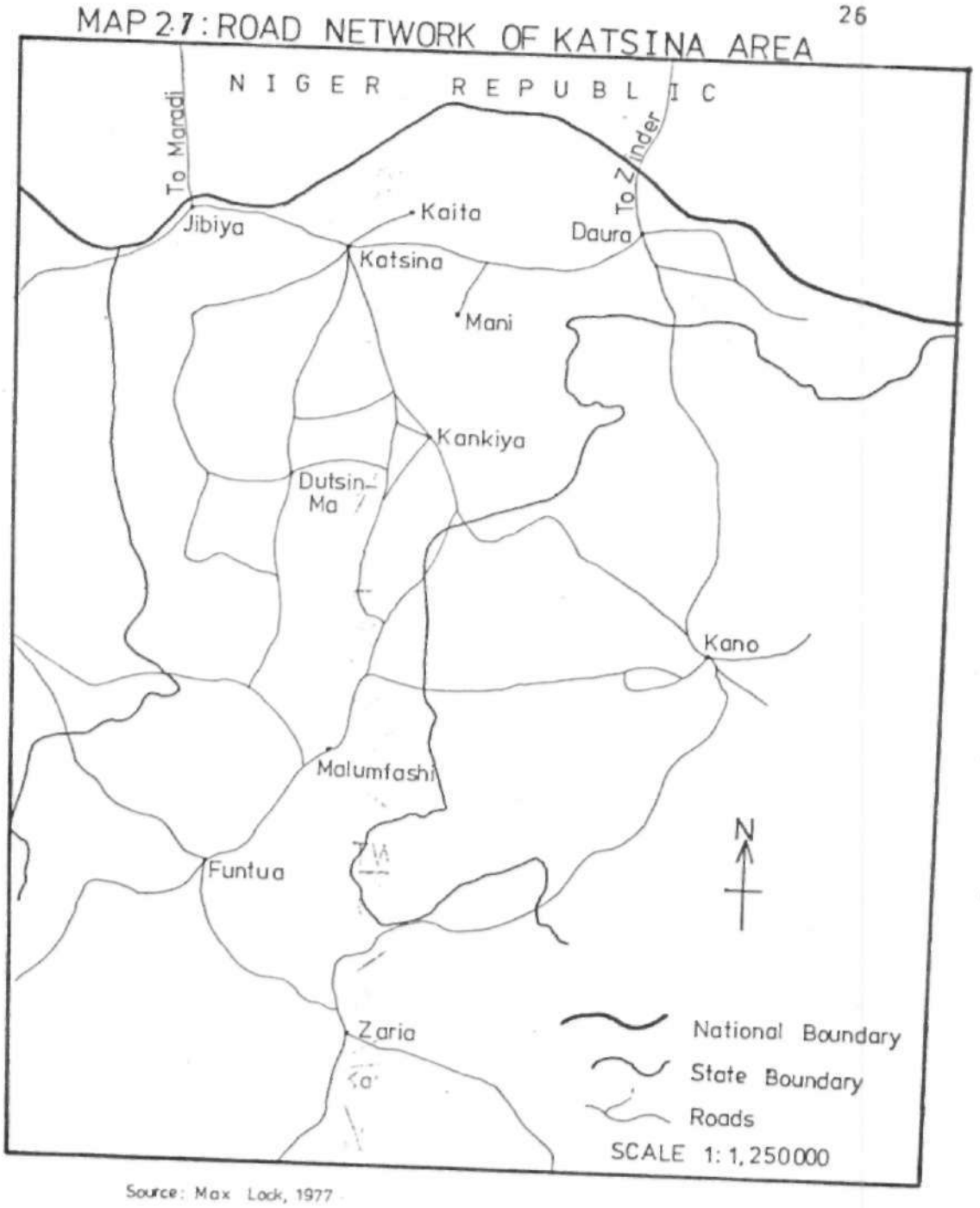
m Market

WTC Women Teachers College

Scale 1:100000

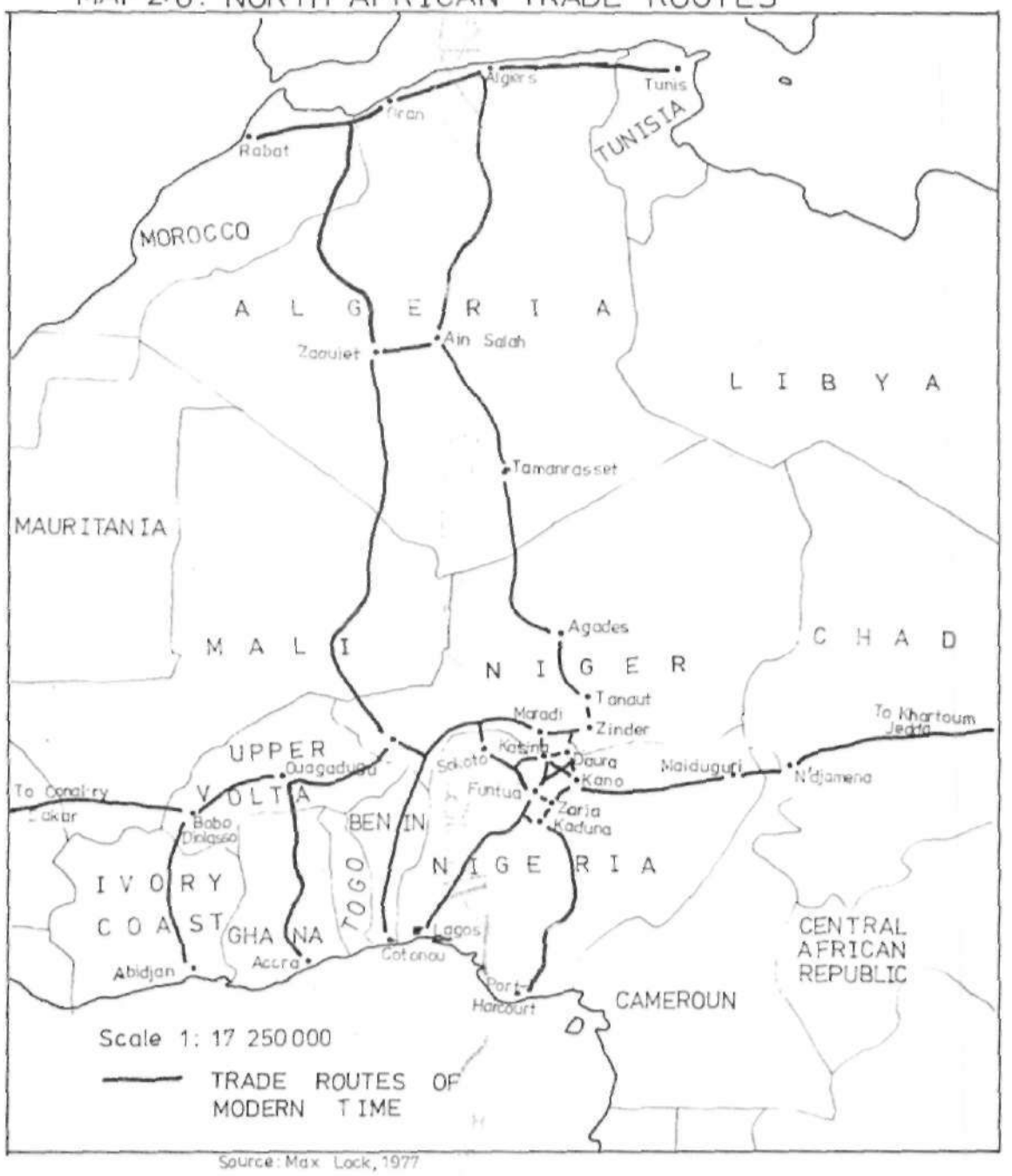
Source: Max Lock, 1977 and Field Inspection

MAP 2.7: ROAD NETWORK OF KATSINA AREA



Source: Max Lock, 1977

MAP 2.8: NORTH AFRICAN TRADE ROUTES



Source: Max Lock, 1977

and exportation. Katsina also has an airstrip which is being upgraded to handle more traffic. The township is supplied electricity by the Nigerian National Electric Power Authority (NEPA). It also has good and constant water supply throughout the year by the Kaduna State Water Board from the Tagwai Dam scheme.

CHAPTER 3: HISTORY OF CADASTRAL CONTROLS IN KATSINA

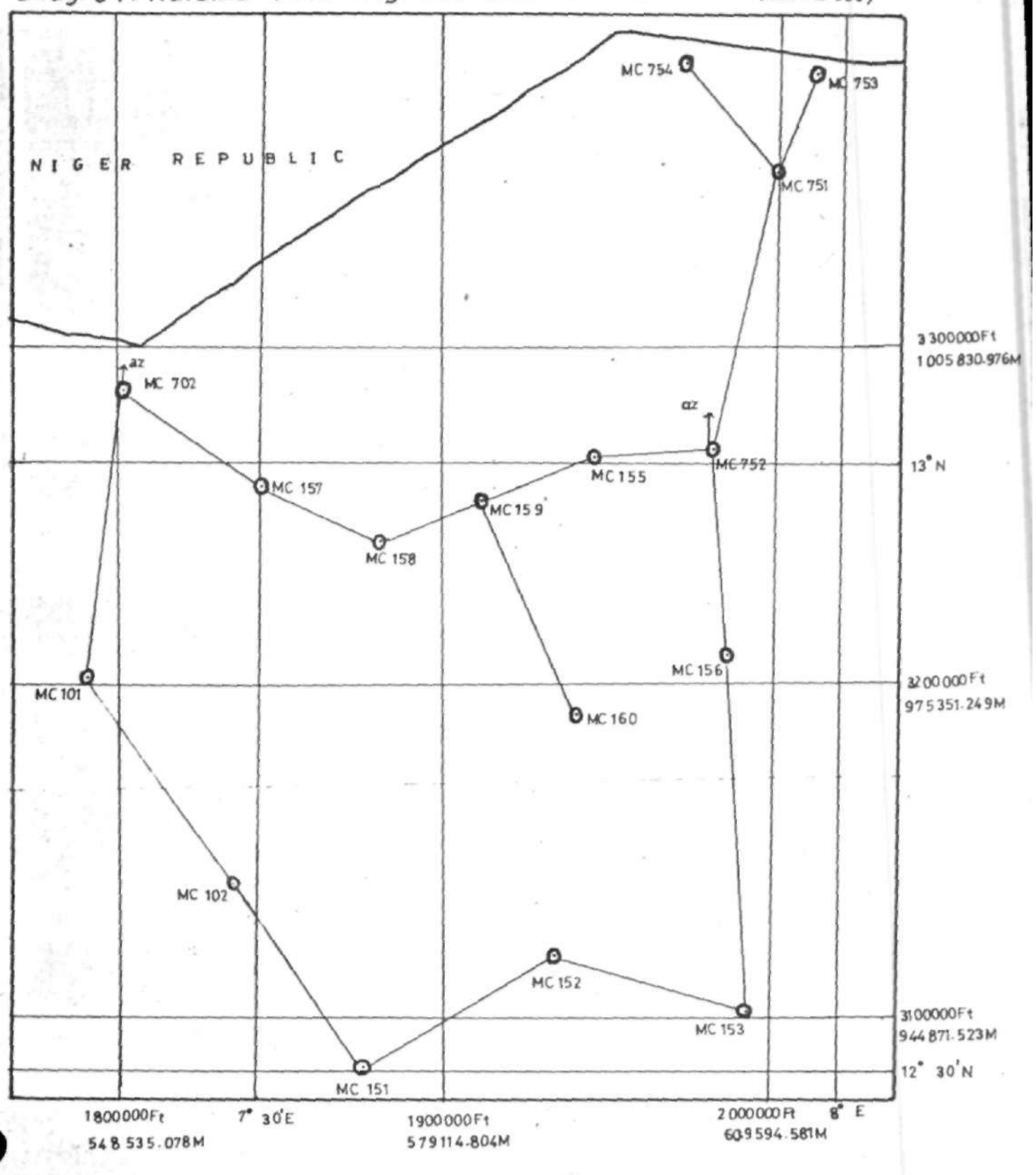
3.1 NATIONAL CONTROLS

Katsina area has not been covered by either primary triangulation or traversing partly due to the topography and partly due to shortage of manpower and capital. There is therefore no single primary control of the national network within the vicinity of Katsina. However, some secondary controls of the national framework have been established in the area meant for mapping, tying in township frameworks and engineering surveys. The survey was carried out between 1966 and 1967 by Tellurometer Traverse but the accuracies are not specified. It was adjusted by least squares technique. Some of the controls are shown on table 3.1 and map 3.1.

Table 3.1: Secondary Controls in Katsina Area.

Station No.	N	E	H
MC 151	3,084,109.1ft	1,875,445.4ft	2,029.6ft
	940,028.02m	571,630.630m	618.617m
MC 152	3,117,711.9ft	1,933,506.5ft	1,854.7ft
	950,270.062m	589,327.494m	565.307m
MC 153	3,100,133.2ft	1,992,776.9ft	1,874.0ft
	944.912.122m	607,392.950m	571.190m
MC 155	3,267,035.5ft	1,946,387.0ft	1,622.7ft
	995,783.487m	593,253.435m	495.595m
MC 156	3,206,399.5ft	1,986,373.9ft	1,765.5ft
	977,301.800m	605,441.333m	538.120m
MC 157	3,259,426.6ft	1,844,645.8ft	1,681.8ft
	993.464.315m	562,242.996m	512.608m

Diag. 3.1: Katsina Area Trig. and Traverse Framework (Box File 526)



MC 159	3,253,998.9ft	1,911,715.2ft	1,705.2ft
	991,809.966m	582,685.565m	519.740m
MC 160	3,189,395.2ft	1,935,063.1ft	1,744.3ft
	972,118.935m	589,801.941m	531.658m
MC 751	3,269,054.8ft	1,982,395.9ft	1,709.3ft
	996,398.954m	604,228.849m	520.990m

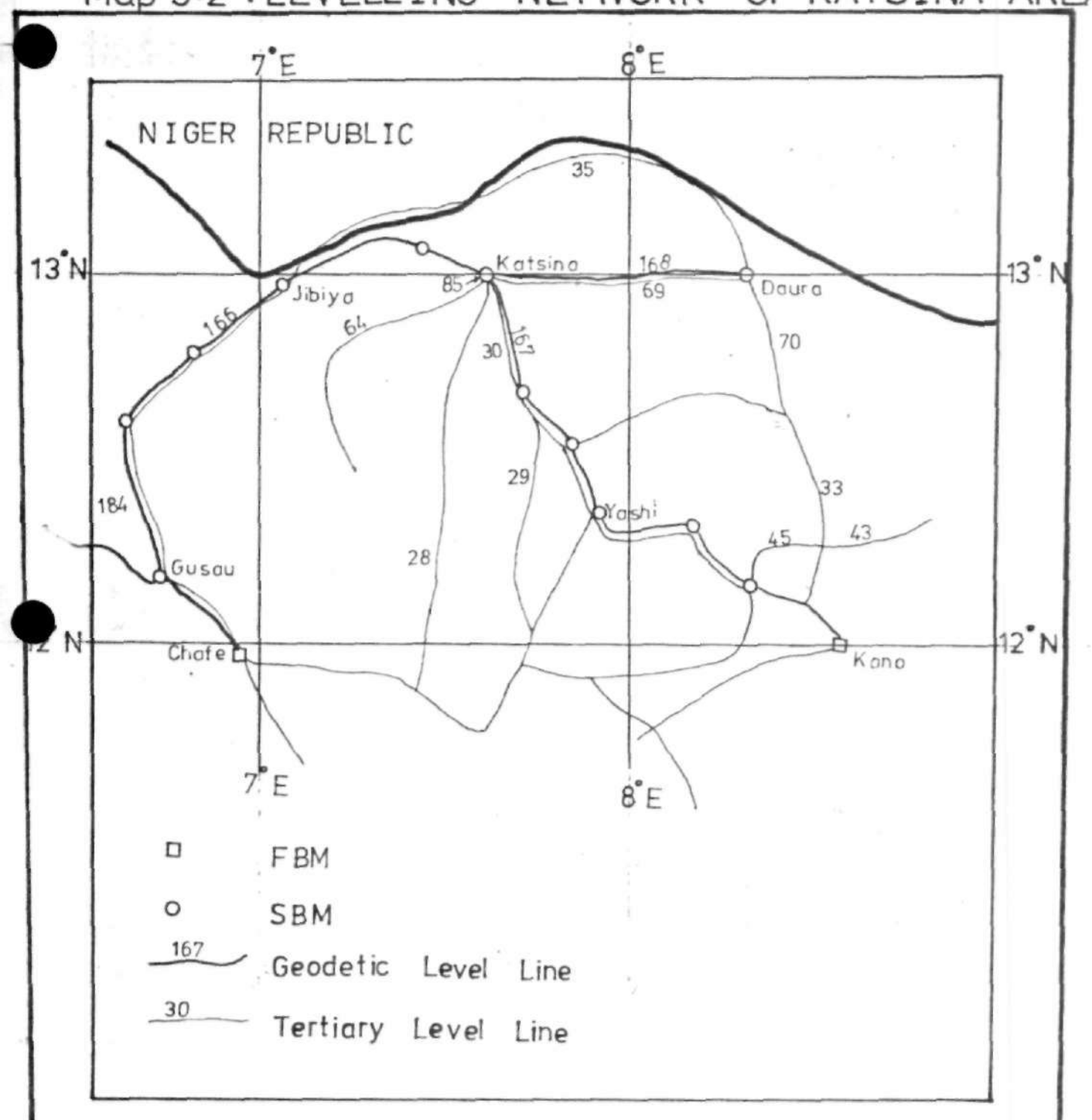
Geodetic levelling of the national levelling network was carried out passing through the township in 1960 (Field, 1986 personal communication). The town has benchmark 85 on level line 82. Third order levelling was also carried out linking up the township with nearby stations. The Geodetic level line runs from Chafe through Jibiya to Katsina then to Kano. There is also a level line run from Katsina to Daura. Map 3.2 shows all the level lines run in Katsina area.

3.2 CADASTRAL CONTROLS IN KATSINA TOWNSHIP

For a township, there are usually three orders of cadastral controls - primary, secondary and tertiary. The cadastral controls could be a break down from national framework or they are isolated surveys. In the case of isolated surveys, they should be tied to the national framework later, and usually the geographical coordinates of the origin are accurately determined.

The Katsina township framework was established by an isolated survey in three stages - primary cadastral control survey, secondary cadastral control survey and tertiary cadastral control survey. The first set of

Map 3.2 : LEVELLING NETWORK OF KATSINA AREA



primary controls were put in and coordinated before 1950 for the Rex Cinema Plot was surveyed and tied to the $KCSP_2$ and $KCSP_3$ in 1950. This was followed by putting in and coordinating secondary cadastral controls in 1950/51 which were also referenced to primary cadastral controls. Finally, tertiary cadastral controls were put in and coordinated by 1957. However, there are no records as to the observations made or coordinates and heights determined with the exception of those of the Tertiary Cadastral Controls. There are also no records as to who carried out these surveys, but it can be assumed that the primary and secondary cadastral controls were at least carried out by the Nigerian Surveys. The Tertiary cadastral controls were carried out likely on the instructions of the Survey Department of Northern Region. There are also no records of the accuracies attained of both the primary and secondary cadastral controls. These observations were later discarded and fresh observations made between 1959 and 1961 (Ashton, 1986 personal communication). New controls were also presumably put in. Why the first set of observations were discarded is not stated. These new observations were computed and adjusted between 1961 and 1962. There are no records as to how these observations were carried out and who carried them out. They were presumably carried out by the Northern Nigeria Survey Department. The computation sheets are well preserved showing all the computations and accuracies necessary. There are no station description records. There are

also no records as to whether the geographical coordinates of at least one of the controls has been determined.

In the township framework, $KCSP_1$ was chosen as the local origin with assumed coordinates 15,239.86mN, 15,239.86mE (50,000ftN, 50,000ftE). The township framework covered an area of about 4,060 hectares of land, a great part of this land is outside the present settled areas. The areas immediately outside the built up zone is given to agriculture and forestry. A summary of the present land use is presented on map 2.6. Present settlement development is concentrated mainly in the East between Kofar Sauri and Kofar Sabuwa outside the city walls. Between Kofar Sauri and Kofar Kaura are the Government Residential Area (GRA a creation of the British colonial administration) and Government Low Cost Houses. Between Kofar Kaura and Kofar Kwaya are the industrial and commercial areas, while between Kofar Kwaya and Kofar Sabuwa are institutions of learning. Along Jibiya Road are the Army barracks, verterinary office and the Race Course. The rest of the area is given to agriculture and forests. There is green belt round the city walls.

With $KCSP_1$ as origin and oriented with $KCSP_2$ and $KCSP_3$, the perimeter control survey was carried out transferring coordinates to all the primary cadastral controls. The coordinates of $KCSP_1$ were chosen in such a way that all coordinates of Katsina are positive. Because of the nature of the topography, the perimeter controls were observed by traverse technique of cadastral

control survey, table 1.1. The computations were completed by November, 1961 (Box file 843) and the final coordinates were arrived at. The perimeter control is made up of 186 controls out of which two have no coordinates in the coordinate Register and these are KCSP647 and KCSP650. $KCSP_2$ was destroyed by road construction and $KCSP_3$ was isolated by buildings (Box file 843). The controls were then heighted by differential levelling using the booking method of rise and fall (Box file 843) and heights of the controls were arrived at by February 1962. KCSP601 was chosen as the local datum with an assumed height of 426.716m (1400ft) and from here heights were transferred to the other primary cadastral controls. The coordinates and heights of all primary cadastral controls are shown in the Apendix, Table 1.

The second stage of the project is the interspersing of the primary cadastral controls with secondary cadastral controls - break down of primary cadastral controls. The secondary cadastral controls are found along the main streets and city walls. The observations were completed and computations carried out and adjusted by November, 1962. A total of forty four controls were thus established out of which only eight were heighted. There are no records as to how the eight were heighted, but since there are no records of spirit levelling, it can be assumed that the method of trigonomethic heighting was used. The coordinates and heights of the secondary cadastral controls are shown in the

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Apendix, Table 2. The coordinates were transferred from primary cadastral controls as well as the heights. The stipulated minimum linear misclosure of secondary cadastral control is 1/8,000, but the Katsina secondary cadastral controls has limear misclosure of 1/15,785. The controls were established by traverse technique, in some instances radial traverses being used. These controls were greatly used along with the primary cadastral controls in the Air Survey of Katsina in 1962. The Air Survey was carried out by Fairey Air Surveys by photopointing at a scale of 1:2,400 and vertical interval of five foot (Box file 843). Apart from the permanent controls, the auxiliary points established for this Air Survey have long since dissappeared.

The third and final stage is the further interspersing of the controls with tertiary cadastral constrols. The observations were made by tertiary cadastral control traverse of mostly radial and closed loop traverses transferring coordinates from the higher order controls. The coordinates were computed by November, 1962. Heights were not determined for these controls. A total of thirty six controls were established out of which three have no coordinates (T242, T243, T244), Apendix, Table 3. Table 1.1 gives the stipulations of tertiary cadastral controls traverse survey with minimum linear misclosure of 1/3,000.

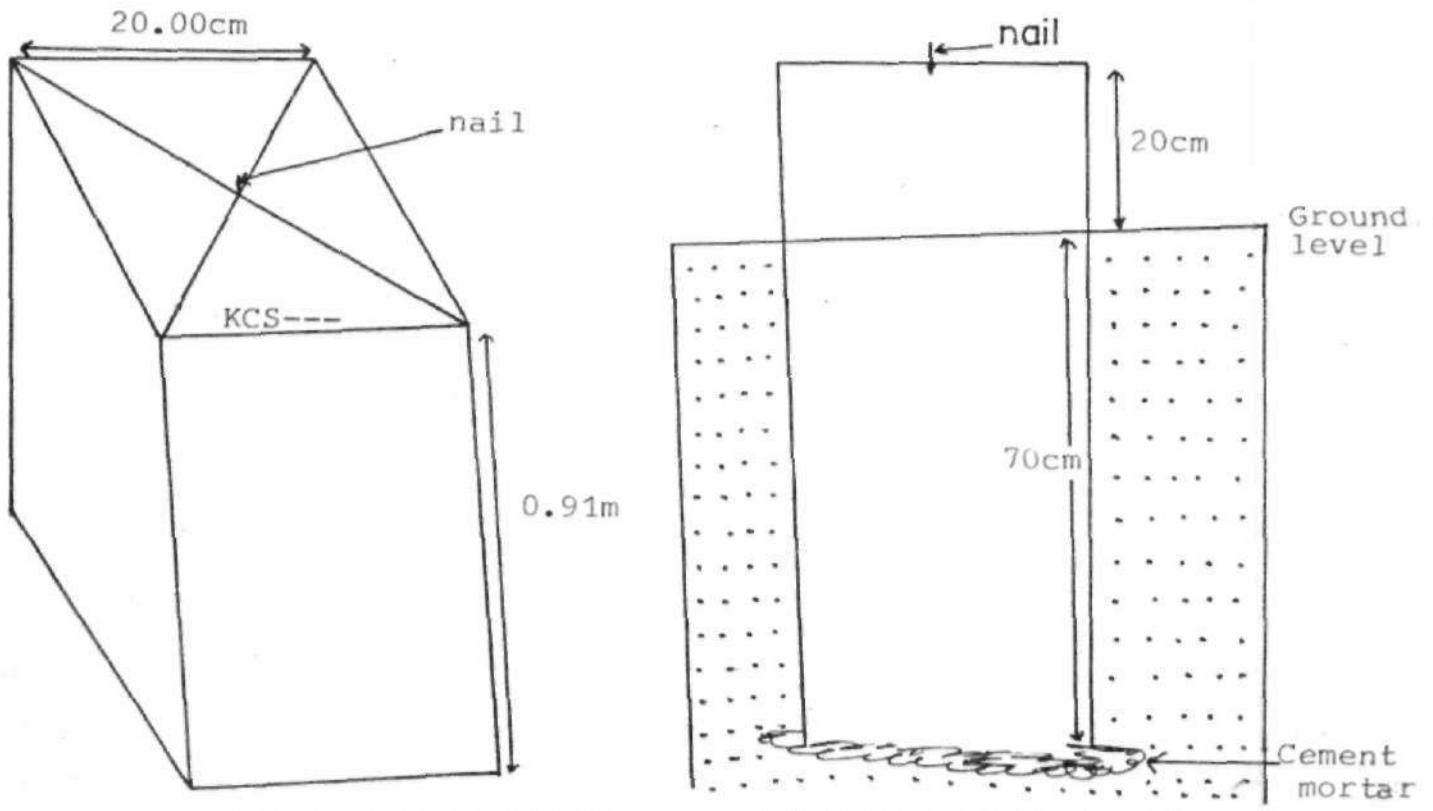
Azimuths were also observed by the method of polaris using the mean of six observations. They were observed and computed by October, 1961 (Box file 843). Table 3.2

shows the observed and computed azimuths.

Table 3.2: Azimuths, October, 1961.

Station	RO	Azimuth of station	Range	Azimuth of R.O.	Observed Latitude	Assumed Longitude
P673	P656	329°43'28"	5"	30°16'32"	12°29'08"	07°37'
P666	P585	44 57 36	7	315 02 04	13 00 01	07 37
P645	P646	260 21 38	5	99 38 22	12 59 19	07 37
57	P702	166 39 54	4	193 20 06	12 59 02	07 37
P547	P548	357 21 39	10	02 38 21	13 00 30	07 37
P707	P569	77 46 54	4	77 46 54	13 01 23	07 37
P711	P601	125 57 54	3	234 02 06	13 00 54	07 37
P688	P687	241 43 07	5	118 16 53	12 58 34	07 37

The monuments marking the stations are pre-cast concrete blocks about 0.91m (3ft) long with the top being 20cm (8 inches) square and buried to a depth of about 0.70m (2'3") leaving 0.20m (9") above ground, diag. 3.1.



a) Pre-cast concrete

b) Cross section of a buried beacon.

Diag. 3.1 : CONTROL MONUMENTS

The controls are usually made massive above ground, but a few are buried to just above the ground level with the upper surface on the same level with the ground level. The station mark is at the intersection of two diagonal lines on the upper surface of the beacon marked by a 10.2cm (4 inch) nail. They are bedded in a layer of weak cement mortar and the hole is rammed with earth and water to prevent movement. A few of the pillars do not have cappings. Numbers are stamped on the upper sufface of the pillars. The beacons carry the initials of the town survey followed by numbers of the stations, KCS...(Katsina Control Survey). The letters P,S and T following KCS indicates the order of survey,

P = Primary cadastral control

S = Secondary cadastral control

T = Tertiary cadastral control.

The station number then follows e.g. $KCSP_1$ implies Katsina Control Survey, Primary Cadastral Control Station one.

3.3 ACHIEVED ACCURACIES

Every measurement has a degree of uncertainty and inspite of the greatest care all measurements yield only approximate values. A sound network of control points allows the surveyor to assess the reliability of his measurements by allowing a ready means of checking his work and thus ensuring that it is not substandard. In control survey the position of beacons is of primary interest rather than distance between the beacons, but

the position of the beacons (coordinates) can only be determined by measuring distances and angles between the controls. Reliability of a survey could thus be expressed in terms of positional error of each or any coordinate point or linear misclosures.

The executed traverse and level networks of Katsina are shown on diags 3.2 and 3.3 and tables 3.3, 3.4, 3.5 and 3.6 (box file 843). The achieved accuracies are quite high and the control survey could therefore be said to be precise - a sound network of control points have been established. When compared with the expected accuracies of cadastral control surveys in table 1.1 the surveyors that carried out the Katsina township cadastral control survey should be given credit for a job well done.

3.3.1 TRAVERSE ACCURACY.

The achieved accuracies are shown on diag. 3.2 and tables 3.3, 3.4 and 3.5. The linear misclosures are quite low. The traverse is made up of seven loops with eighteen lines with some of the lines common to more than one loop. The traverse length is 54,075.302m (177,414ft). The secondary cadastral control survey has an accuracy of 1/15,785. The individual loop misclosures of the secondary cadastral controls are not shown, neither is there any information on the accuracies or even the breaking down of the secondary cadastral controls into loops. Presumably, the secondary cadastral controls form just one loop. The primary cadastral

Diag. 3.2 : SKETCH DIAGRAM OF KATSINA TRAVERSE NETWORK

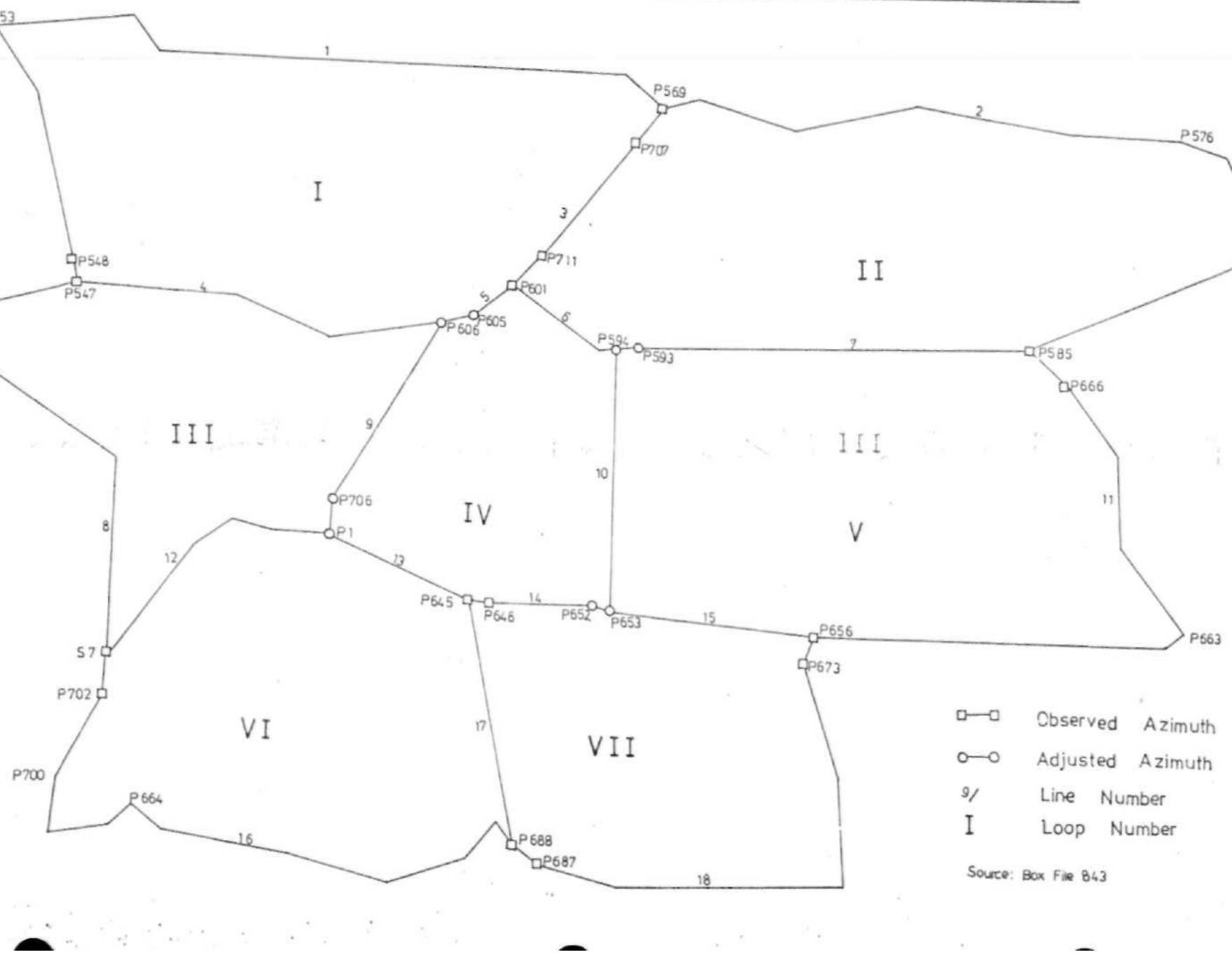


Table 3.3 : Traverse Loop Misclosures (Box File 843 No. 3)

Loop No	Lines	dN	dE	Length	Linear-Misclosure
1	1,3,5,4	-0026	-1.114	44.864ft (13,674.425m)	1/40,000
II	2,7,6,3	+0.258	-0.199	43,370ft (13,219.057m)	1/111,000
III	4,9,12,8	+0.227	-0.934	32.049ft (9,768.448m)	1/34,000
IV	5,6,10,14,13,9	+0.079	-1.32	32,846ft (10,011.371m)	1/214,000
V	7,11,15,10	-0.013	-0.782	32,833ft (10,007.409m)	1/42,000
VI	12,13,17,17	-0.401	-0.414	33,071ft (10,079.950m)	1/58,000
VII	14,15,18,17	+0.588	-0.449	32,629ft (9,945.230m)	1/414,000

Table 3.4 : Traverse Net (Box file 843, No. 3)

Line No.		dN	dE	feet	metres
1.	P547 - P569	4,725.514	17,226.625	25,054	7,636.391
2.	P569 - P585	-7,163.746	6,495.182	21,330	6,501.326
3.	P569 - P601	-4,329.129	-6,409.823	7,803	2,378.333
4.	P606 - P547	1,344.960	-7,043.143	7,837	2,388.696
5.	P601 - P606	-1,741.371	-3,77.773	4,179	1,271.005
6.	P601 - P594	-1,931.525	4,688.425	5,167	1,574.887
7.	P585 - P594	903.350	-8,216.779	9,070	2,764.511
8.	P S7 - P547	9,273.007	- 832.848	12,088	3,684.389
9.	P606 - P1	-4,750.934	-1,665.309	5,264	1,604.453
10.	P594 - P653	-6,305.534	-359.123	7,081	2,188.269
11.	P585 - P565	-5,703.367	-5,480.332	13,450	4,099.523
12.	P1 - S7	-3,176.886	-4,545.920	6,860	2,090.909
13.	P1 - P645	1,534.462	4,088.091	4,494	1,369.759
14.	P645 - P653	- 210.371	5,681.425	6,670	2,032.998
15.	P653 - P656	- 301.170	3,096.352	3,232	985.105
16.	P688 - S7	3,214.492	-9,705.345	15,117	4,607.620
17.	P645 - P688	-4,857.317	1,070.920	6,600	2,011.662
18.	P656 - P688	-4,345.188	-7,707.306	16,127	4,915.466
				177,414	50,075.302

Table 3.5: Tertiary Control Traverse (Report, Revision of the 1,4800 Plans of Katsina Town).

Numbers	Name	Length		No. of Station	Bg. Misclosure	Linear Misclosure
		Feet	Metres			
1.	Kofar Dunbi	3,890	1,185.661	6	44"(7.3per station	1/5,985
2.	Kofar Guga	4,936	1,504.479	8	37(4.6 ")	1/3,144
3.	Kofar Marusa	4,485	1,367.016	7	52(7.4 ")	1/2,324
4a		4,683	1,427.366	7	15(2.1 ")	1/22,300
5a		2,433	741.572	5	10(2.0 ")	1/32,012
6	Kofar Kaura	6,659	2,029.645	9	70(7.7 ")	1/6,282
6a		5,952	1,814.153	10	05(0.5 ")	1/17,005

controls have no separate loop misclosures shown and it too has not been broken down into loops separetely. However, the combination of the primary and secondary cadastral controls are broken into loops and their linear misclosures are shown on diag 3.2 and tables 3.3 and 3.4. The tertiary cadastral control traverse is not integrated into the primary and secondary cadastral control traverse. The tertiary cadastral control traverse is made up of seven loops as shown in table 3.5 with the linear misclosures of each of the loops shown as well as bearing misclosures.

Table 3.4 gives the worst traverse linear misclosure as 1/34,000 in loop III, but this is still better than double the minimum required for primary cadastral controls. The accuracies attained for loops II and Iv are of geodetic standards. The overall accuracy of the secondary cadastral controls achieved is as good as the required minimum for primary cadastral controls. In the Tertiary Cadastral Control traverse shown in Table 3.5, numbers 4a,5a and 6a have linear misclosures better than the stipulated minimum for primary cadastral control traverse; and number 1,2 and 6 have linear misclosures better than the stipulated minimum for tertiary cadastral controls. There is one of the traverses of the tertiary control with an achieved accuracy of 1/2,324 which is worse than the required minimum - this is the only traverse in the Katsina traverses that fall short of the required minimum stipulations.

Some lines are common to more than one loop and in coordinate computations all controls along such lines are coordinated separately and averages of the different results from the different routes are found and used as the coordinates of such controls. Generally, the differences in coordinates of such controls arrived at through the different loops are very small. Tables 3.3 and 3.4 show such lines common to more than one loop and computations carried out. Coordinates of all junction points are computed based on lines meeting at such juctions and averages are also used to determine the final coordinates of such points.

3.3.2 LEVEL ACCURACY

A levelling network is considered accurate if:

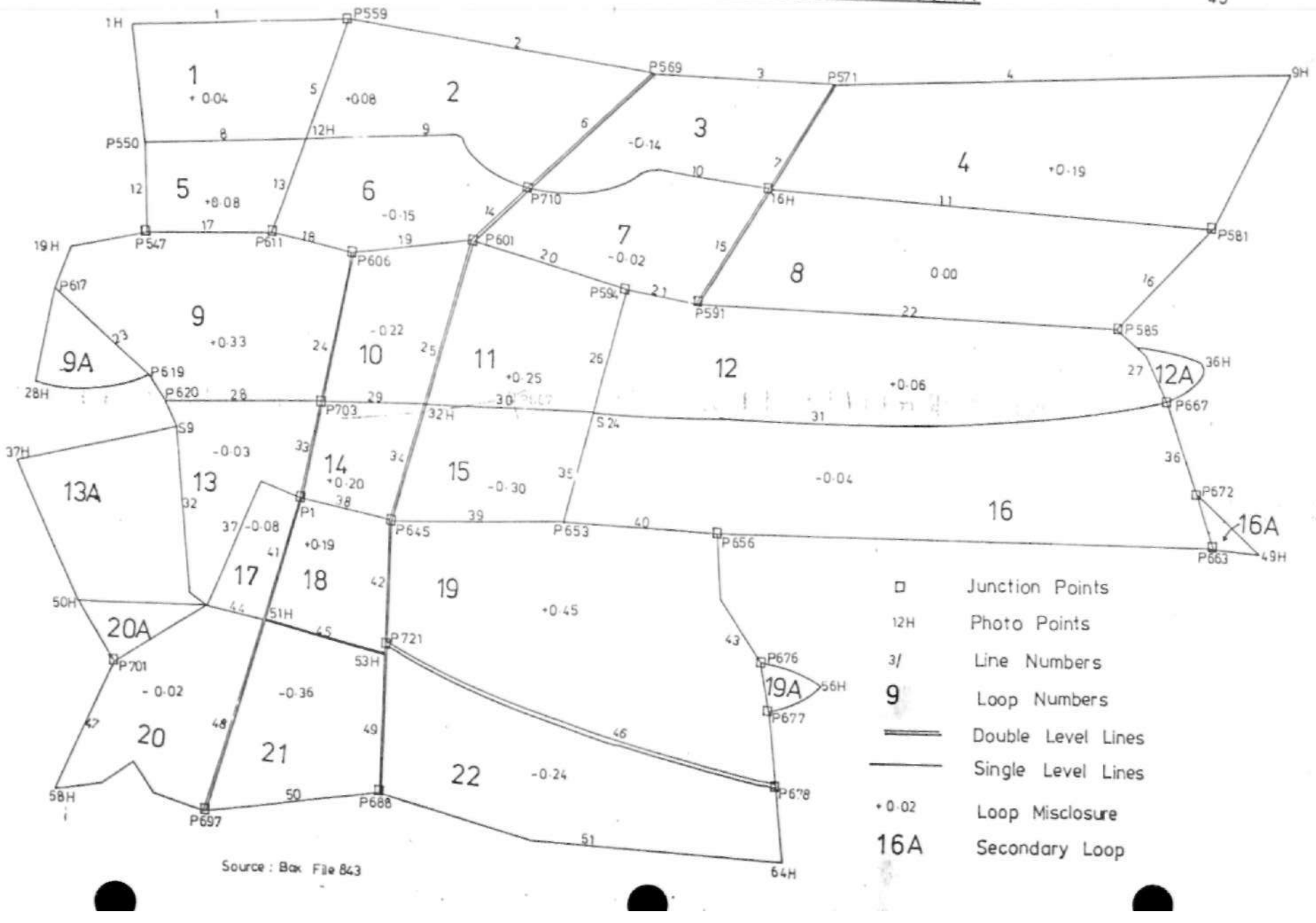
i. there is a good agreement between forward and backward levelling between adjacent benchmarks.

ii. the misclosure around the circuits should be close to zero.

iii. the survey starts and ends on two published heights from a survey of equal or higher order, there should be good agreement.

The first and second criteria may indicate that the levelling is precise, but do not assure of accuracy. A measurement is accurate if it closes to the true value. The true value here refers to the published heights of existing benchmarks. For an area not previously levelled, there is no true value. Backward and forward levellings are usually done close together

Diag 3·3 : SKETCH OF KATSINA LEVEL NETWORK



Source : Box File 843

in time, thus will contain similar refraction errors. However, refraction correction will not present any serious problem in flat countries, they could be neglected in flat areas.

Generally, for any levelling figures to be accepted in practice, there has to be good agreement between forward and backward levelling between adjacent bench-marks. Secondly, Katsina is a gently undulating country, map 2.2, thus refraction is neglected and therefore the misclosures around the circuits are good indications of the accuracy of the work. The township was divided into twenty two main loops and six secondary loops, diag. 3.3 and table 3.6. The sum of the circuit misclosures is 0.079m (o.28ft) which is quite close to zero. This is quite good even for a national network. In computing the level network, photo points which were established in 1962 for the Air Survey of the township were also used, though the points have since dissapeared, but they at least help in establishing heights which were used in mapping the township. The topographical map produced is largely based on this. The ideal situation is when the sum of level net loop misclosure sum up to zero. This is difficult to come by even in geodetic work for in the real life situation imperfect human beings use imperfect instruments to make measurements on the surface of the earth. Table 3.6 shows that loop 8 has no misclosure at all. The worst loop misclosure is on loop 19 with a misclosure of 0.45. Many of the loop

Table 3.6: Level net loop misclosures
(Box file 843, No. 3)

Loop Number	Misclosure
1	+0.04
2	+0.08
3	-0.14
4	+0.19
5	+0.08
6	-0.15
7	-0.02
8	0.00
9	+0.33
10	-0.22
11	+0.25
12	+0.06
13	-0.03
14	+0.20
15	-0.30
16	-0.04
17	-0.08
18	+0.19
19	+0.45
20	-0.02
21	-0.36
22	-0.24
9A	+0.04
12A	+0.04
13A	-0.01

16A	-0.02
19A	-0.02
20A	-0.02
	0.28

misclosures are infact small which show that the work was done to a high degree of accuracy, it is quite precise. Distances of the circuit levelling loops are not given, therefore the misclosures cannot be expressed in linear form.

3.3.3 ADJUSTEMENTS

After computations, the next stage is the adjustment of the computations. For cadastral controls, the non-rigorous technique of adjustment is favoured since it produces consistent figures and is simpler to compute. There are no records as to what method of adjustment was used in determining the final coordinates. Since Transit Method is the standard method for cadastral control surveys in Nigeria, it can be assumed. Presumably, the final coordinates in the appendix were arrived at after the adjustments. The semi-rigorous and rigorous methods were not resorted to because the differences that will result will not be worth the efforts used. Non of the methods will improve the observations, but to make them consistent.

3.4 DENSITY OF CONTROLS

The density of controls vary from place to place depending on population and buildings. The ideal situation is to spread out the controls evenly, but this is not economical nor even practicable in an area previously settled. Rather, the controls should be spaced so as to allow surveyors tie in their surveys with ease. With Electromagnetic Distance Measuring Devices (EDM), long range direct measurements could be made, but city

traffic and other obstacles in the commercial and densely populated areas limit the sights to 100-200m. The maximum distance between two controls should not exceed 400m and due to influence of centring errors on error propagation in traverses with short sights, the distance should not be less than 100m. According to Dale (1976), there should be a hundred people to a control. Based on the estimated 1985 population, Katsina should then have at least 1,449 controls. This is however not practicable in our crowded urban centres with houses/compounds jammed together. In well planned and laid out low density townships, this method could be practicable, but not for a crowded city like Katsina. According to Federal Government stipulations (Township surveys and lay outs, pamphlet No. 3, 1954), no detail point should be more than 1000ft (305m) from a framework point (control), and this density is much lower in the undeveloped areas. This implies that two adjacent controls in a developed area should not be more than 2000ft (610m) apart. This stipulated density is too low for any meaningful survey work in an urban centre now.

Katsina township framework covers an area of approximately 4,060 hectares (40,546,804m^2). The total number of controls established was 266 (186 primary, 44 secondary and 36 tertiary). This gives a control density of one control per 152,432m^2 that is about 390m between two adjacent controls. This is much higher than the Federal stipulations. However, the controls are not spaced evenly throughout the framework.

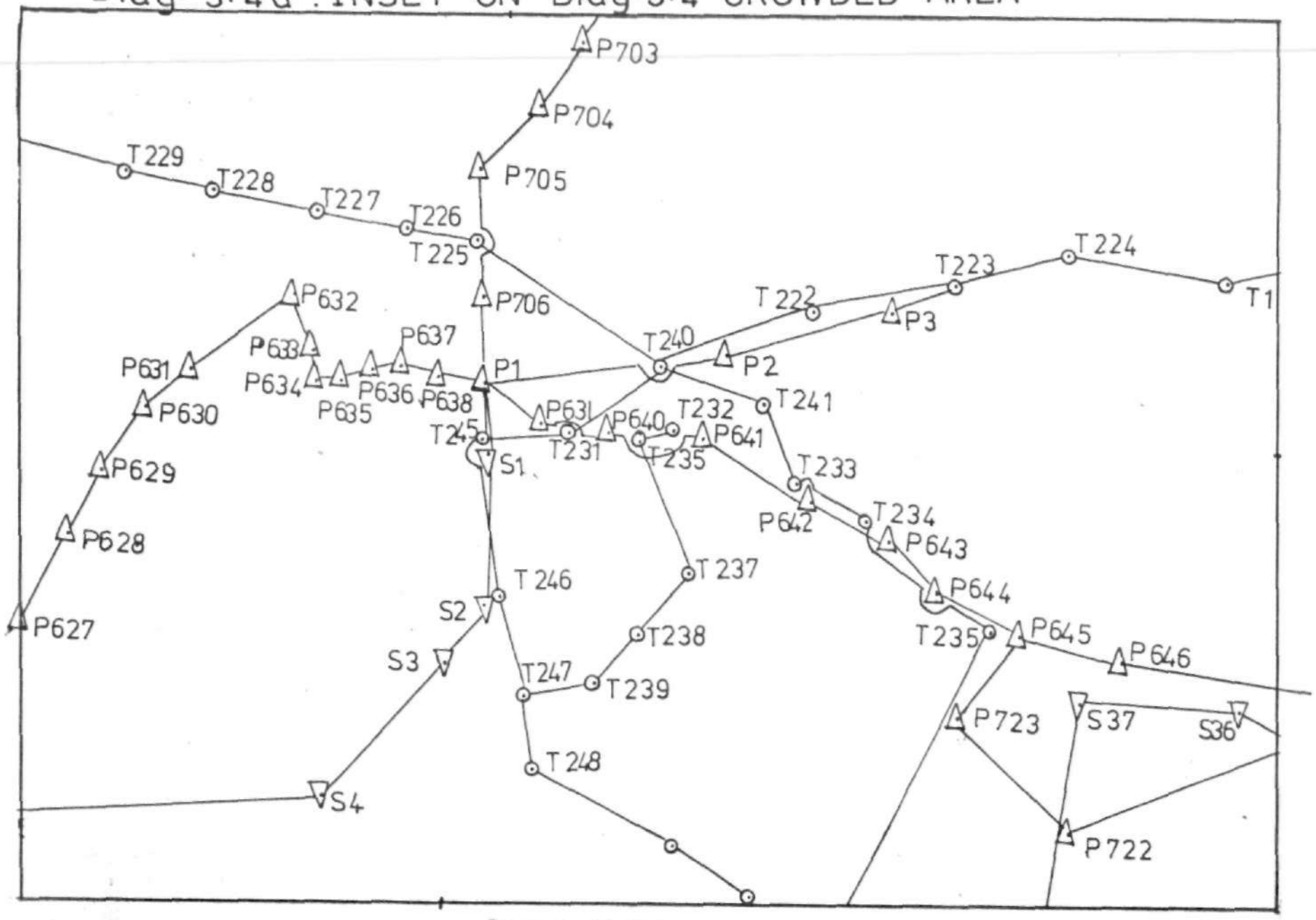
Apart from the outer cricuit and lines linking it to the origin, no other controls are found in the outskirts diag. 3.4. Most of the controls were located in the settled areas (city, G.R.A. and the new layouts). Serious development is going on in the new layouts and infilling is taking place within the city walls on land previously given to farming. The total area settled now is in excess of 600 hectares and control density within this zone is quite high. Within the city, controls are found mainly along the main streets and city walls leaving huge chunks of land without controls. Along the roads, the controls are crowded as opposed to near complete absence in wards within the city. In the GRA, controls are found along the major streets and tend to be more evenly distributed. There is a high concentration of controls in the GRA and the new layouts. Thus most of the area to the north between Kofar Guga and Kofar Sauri have no extra controls apart from the outer circuit controls. The area to the west between Kofar Yandoka and Kofar Guga too has no controls apart from the outer circuit contools. Areas to the east on the other hand where GRA is located with plans for expansion (new layouts) has many controls other than the outer circuit controls.

The expansion of the settlement so far is within the township framework with the exceptions of Federal Advanced Teachers College and Katsina Polytechnic along Dutsin Ma road. A serious problem with the control density is the issue of controls still in existence and this is looked into in chapter five.

DIAG 3.4 : KATSINA CONTROL DIAGRAM



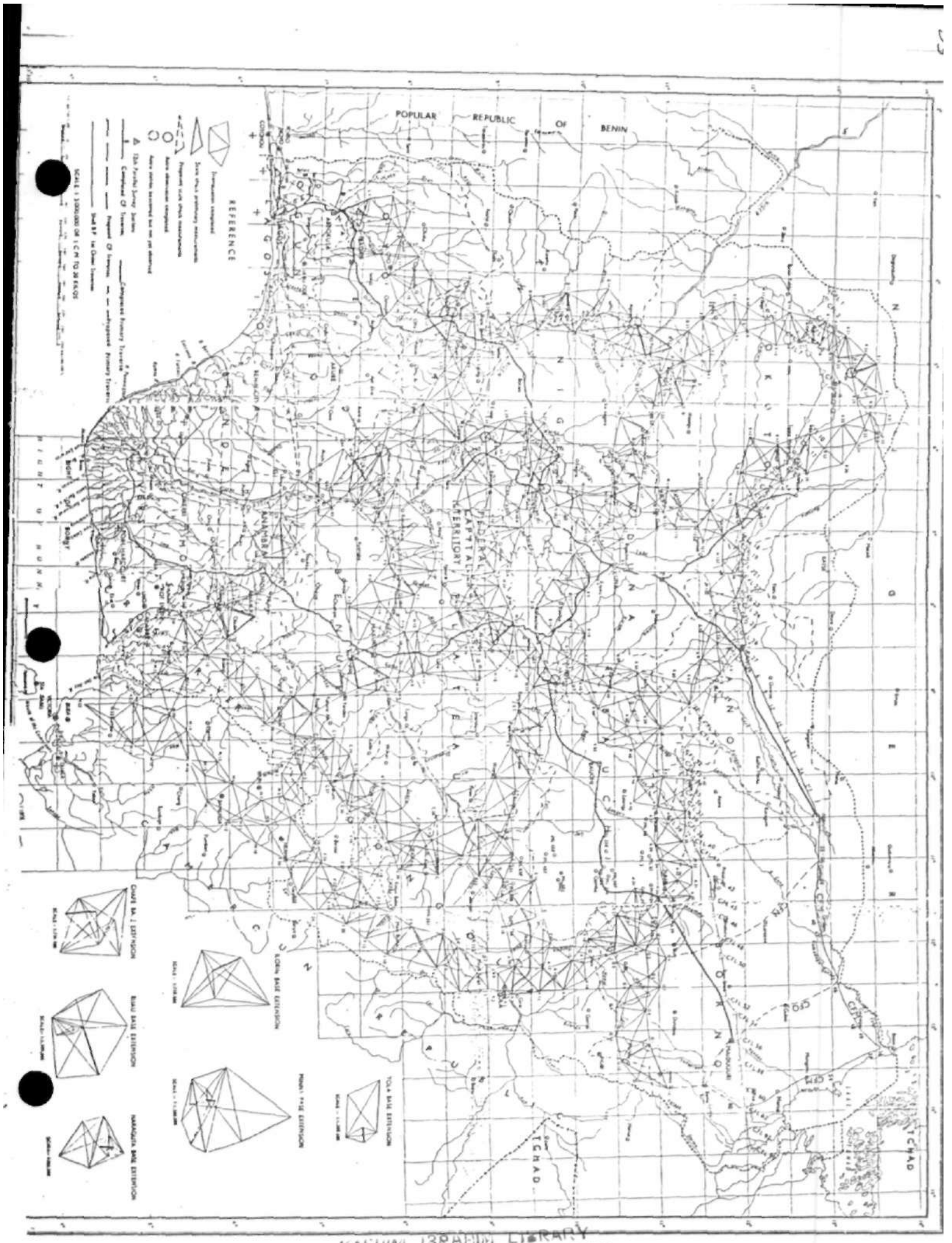
Diag. 3.4a : INSET ON Diag.3.4 CROWDED AREA



CHAPTER 4: CONVERSIONS TO PROJECTION COORDINATES

Township framework surveys in Nigeria are mostly isolated local surveys. This is due partly to shortage of skilled manpower and capital and also inadequacy of national control networks. National controls are generally inadequate and are not readily available near urban centres for cadastral controls to be tied on to them. The national control network has not been sufficiently densified to meet the needs of township frameworks (map 4.1). Some of the township framework surveys start from one of the national control network pillars as origin with assumed coordinates or coordinates of the pillar expressed on the plane. Most however, start from local origins with assumed coordinates and height. Efforts are not made to define the projectional relationship of this point in terms of national grid system. Azimuth is observed at the point for use as a bearing. The assumed plane coordinates from this point define the survey system for the township (Adutwum, 1969). There is the need to integrate these local surveys into the national framework though the local surveys should not be used in the adjustment of the national framework. In the conversion of local surveys into projection framework, the local framework is converted/tied to national framework through coordinate and height conversions.

The township framework of Katsina is an isolated framework established by an isolated survey which has not been tied and or converted to the national framework.



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ZARIA, NIGERIA.

The lack of this conversion is partly due to the absence of national controls within the vicinity of Katsina when the local survey was carried out and partly due to negligence. The Tellurometer Traverse extending secondary national controls was extended to Katsina area in 1966-68 and secondary controls MC 157, MC 158 and MC 159 are established quite close to Katsina town. To link up the Katsina isolated survey to any of these will not take time, but it has not been done. The Geographical coordinates of Katsina origin or any of the controls in the township framework are not known and could therefore not be converted to rectangular coordinates. The township framework has a local origin and a local datum and all cadastral surveys within the township are based on these.

4.1 *LOCAL ORIGIN AND LOCAL DATUM*

Katsina township framework has $KCSP_1$ as the local origin with assumed plane coordinates 15,239.860m 15,239.860mE. The Geographical Coordinates of this points are not known. This point was located at about the central part of the city just to the south of the (central) Friday mosque. P601 was chosen as the local datum with an assumed height of 426.716m (1400ft). It is located just outside the city wall off Kofar Sauri (Sauri Gate) in the north-eastern corner of the township.

4.2 CONVERSION OF LOCAL COORDINATES TO PROJECTION COORDINATES

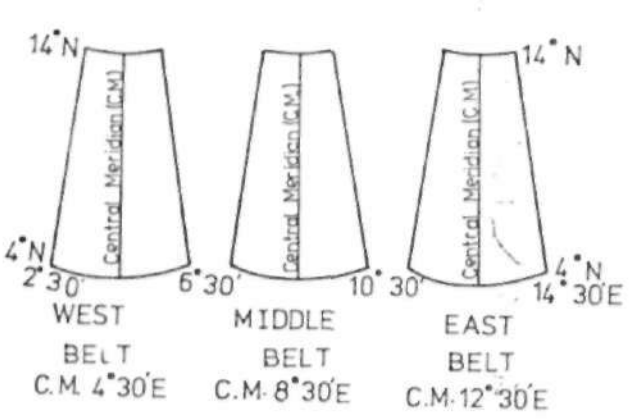
The Nigerian Coordinate System is based on the Nigerian Modified Transverse Mercator Projection (NTM)

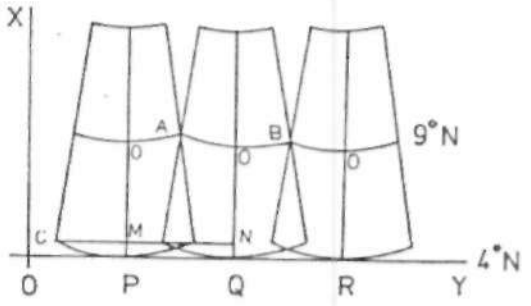
with 4^{o}N and 757,022.1ft (230,738.288m) west of the West Belt in the south-western most corner of the country as the origin (Diag. 4.1). All controls of the national framework are extended from this origin. The clarke relation of the metre to the Yard is used, 1 metre = 1.0936211 yards. The township frameworks are not directly linked to the national framework. The local origins chosen for the townships generally have local coordinates which are expected to be tied to the national framework later. The Geographical Cooordinates of the local origins are expected to be determined to a high level of precision so that they could be converted to rectangular coordinates.

4.2.1 TYING TOWNSHIP SURVEYS ONTO NATIONAL CONTROLS

The local origin of the township framework is carefully tied onto a nearby national control and coordinated from it. The new coordinates so determined for the township origin become the projection coordinates of the township origin. The coordinates of all the other controls in the township framework are converted to projection coordinates by subtracting the assumed coordinates of the local origin from the coordinates of each control in the framework and adding what is left to the coordinates of the projection coordinates of the origin(Diag. 4.1). Apart from the local origin, any other control could be carefully tied to the national control, coordinated from the national control and its local coordinates are subtracted from the local coordinates

Diag.4.1: THE NIGERIAN 3-BELT SYSTEM





BELT	MERIDIAN			Y-COORDINATE OF CENTRAL MERIDIAN	
	WEST	CENTRAL	EAST	METRE	FEET
WEST	2°30'E	4°30'E	6°30'E	230 738·266	757 022·1
MIDDLE	6°30'E	8°30'E	10°30'E	670 553·984	2 200 000·0
EAST	10°30'E	12°30'E	14°30'E	- 1 110 369·702	3 642 977·9

Latitude of Origin: 4°N
Longitude of Origin: Central Meridian (C.M) of Each Zone
False Northing: 0 Metres

Chart 4.1: Tying Local Origin to National Control

Select a National control with known coordinates near the township.

↓

Carefully tye the local origin to the National Control

↓

Coordinate the local origin from the National Control Producing Projection Coordinates of the Origin.

↓

Subtract the assumed coordinates of the origin from the local coordinates of all controls in the township framework.

↓

Add what is left for each control to the Projection Coordinates of the origin.

↓

The resulting coordinates are the projection coordinates of the township framework.

Chart 4.2: Tying a Reference Control to National Control

Select a National Control with known coordinates near the township.

↓

Select a township control (Reference Control) that can be tied to the National Control.

↓

Carefully tie the Reference Control to the National Control.

↓

Coordinate the Reference Control from the National Control producing the projection coordinates for the Reference Control.

↓

Subtract the local coordinates of the Reference Control from the local coordinates of each of the controls in the network/framework.

↓

Add what is left for each control to the projection coordinates of the Reference Control.

↓

The resulting coordinates are the projection coordinates of the township framework.

of each of the other controls in the framework and add whatever is left to the projection coordinates of this reference control and thereby the projection coordinates of the township controls are arrived at (chart 4.2).

The Katsina township framework could easily be tied to any of MC 157, MC 158 and MC 159 and coordinated, but this has not been done yet. Considering the rate at which controls are lost, if these national controls are still in existence, the tying in could be done with ease especially to MC 158 which is quite close to Katsina.

4.2.2 CONVERSION OF GEOGRAPHICAL COORDINATES TO RECTANGULAR COORDINATES

For this method to be used, latitudes and longitudes in particular must be accurately determined. A small error in the longitude could lead to serious shifts of the framework. The Geographical Coordinates of a control are precisely determined and then converted to rectangular coordinates. Projection tables and closed formulae can be used. For ease of calculations, projection tables are preferred and will be described here. The Transverse Mercator Projection Tables for Transformation of coordinates ..... (1961) is used as follows

$$N = I + IIP^2 + IIIP^4 + A_6$$

$$E^1 = IVP + VP^3 + B_5$$

P and E^1 are always taken as positive.

E = Grid Easting = E^1 + easting of central meridian (CM) when point is east of CM;

= easting CM - E^1 when point is west of CM.

P = $\Delta\lambda$ x (0.0001) = 0.000$\Delta\lambda$

= difference in longitude between CM and the control point.

The Roman numeral functions are tabulated in the Transverse Mercator Projection Tables.

After determining the Rectangular Coordinates of the control from its Geographical Coordinates, the Rectanglar Coordinates of the rest of the controls is determined by subtracting the local coordinates of the reference control from the local coordinates of each of the other controls and adding what is left to the rectangular coordinates of the reference control and this produce the projection coordinates of the township framework (Chart 4.3).

Chart 4.3: Conversion of Local Coordinates to Projection Coordinates through Geographical Coordinates.

Chose a local control of the township framework (Reference Control).

↓

Precisely determine its Geographical Coordinates

↓

Convert the Geographical Coordinates to rectangular coordinates through Projection Tables.

↓

Subtract local coordinates of the Reference

Control from the Local Coordinates of each of the controls in the township framework.

↓

Add what is left for each control to the Rectangular Coordinates of the Reference Control.

↓

The resulting Rectangular Coordinates give the projection coordinates of the township.

For Katsina, the Geograhical Coordinates of any of the controls has not been determined or is at least known, therefore, this simple conversion method cannot be applied.

4.3 CONVERSION OF LOCAL HEIGHTS TO NATIONAL HEIGHTS

Usually in a township framework, a local datum is chosen with assumed height from which all points within the framework are heighted either through spirit levelling or trigonometric heighting. The local heights so determined could be converted to national heights. To make this conversion possible, precise spirit levelling is carried out from any of the heighted township controls to a national control (with known height or to a nearby Benchmark (Geodtic levelling). In this way, the Geodetic Height (Height of the Benchmark or National Control) is transferred to the township control. The local height of the township reference control is then subtracted from each of the heighted control within the framework and whatever is left is added to the

national height of the reference control thereby converting all local heights to national heights (Chart 4.4).

Chart 4.4: Conversion of local heights to National Heights

Select a local control with a published height (reference control)

↓

Carefully tye the reference control to either a national control with published height or Benchmark by spirit levelling. This produces the geodetic height of the reference control

↓

Subtract the local height of the reference control from each of the local controls with published heights.

↓

Add whatever is left for each control to the geodetic height of the reference control.

↓

The resulting heights are the national heights of the township framework.

For Katsina, Geodetic levelling was extended to the area and through the township in 1966 establishing Benchmark 85 (SBM) in the township (Field, 1986, personal communication) along level lines 68 from Kaura Namoda to Katsina, 69 Katsina to Daura and 30 Katsina to Kano (map 3.2). There are a number of tertiary level lines from Katsina to neighbouring benchmarks. The heights of

MC 157, MC 158 and MC 159 are all known. This implies that the height of a control in the Katsina township could easily be tied to Benchmark 85 (SBM) or to any of MC 157, MC 158 and MC 159 and the national heights of all Katsina controls determined. This has not been done yet. All topographical maps produced based on the local heights show that the township is generally over 1400ft (426.716m) and not more than 1520ft (463.918m), but the actual height of Katsina is over 1700ft (518m).

4.4 CONVERGENCE, SCALE CORRECTION AND MEAN SEA LEVEL

For cadastral control surveys, convergence is not required and therefore not calculated. The area dealt with is always very small and is thus assumed to be flat without converging. Scale corrections are usually applied to geodetic surveys and cadastral controls are only adjusted to fit into the geodetic network as if the system were in plane rectangulars. Scale corrections are not applied to township frameworks because it is essential to preserve agreement between distances on plan and actual distances on the ground. Similarly distances will not be reduced to mean sea level (Township surveys and layouts, Pamphlet No. 3).

Thus with the aid of the above formulae and techniques local coordinates and heights could be converted to projection coordinates and national heights paving the way for an integrated land data system nationally.

CHAPTER 5: FIELD INSPECTION OF KATSINA CADASTRAL CONTROLS

After describing the controls as shown in the records, it is necesaary to ascertain the availability or otherwise of these controlson the field. For controls to be of use, they must be established and maintained in enduring form and suitably distributed. According to (Wright C.1956),"it is more important to be certain of finding the marks after thirty years,than to be able to find them easily at any time". The controls were made massive and strong enough to make removal or destruction too difficult to be worth anyone's while; made of reinforced concrete they are thus cheap, unattractive and of no local value. The controls are not sited on made up ground, crustal disturbances are least expected and the soil is not acidic so as to corrode the pillars. With the drainage pattern, one least expects destruction of pillars through soil erosion. The pillars themselves are buried to a depth of about 0.69m with the bottom bedded in weak cement mortar. They are regularly spaced in lines (Dig. 3.4) so as to make tracing and identification easy. Despite all these precautions, beacons are still lost at high rates. They may be lost owing to road construction, buildings, laying of pipes and cables, ignorance or willfully. Of the 266 cadastral controls established and coordinated by 1959/62, many have been lost and others seriously tampered with and damaged beyond the stage where they can be used as they are.

To ascertain the availability of cadastral control

in Katsina township and describe their conditions, field inspection of the controls was carried out on 28th - 29th April, 1986. To achieve this the assistance of township plans, a survey assistant and headchainman in the State Area Survey Office at Katsina were used. Positions of some of the controls within the township were looked up. Due to transportation constraints not all controls at the outskirts could be visited. The head chainman has been at the Katsina Area Office since 1971 as chainman and knows the locations of virtually all the controls in the settled area. The controls in the outskirts in the undeveloped areas are not in use and are therefore presumed to be in tact with may be a few uprooted or damaged by farmers. Most of the controls found within the settled areas are in bad shapes and cannot be used for any survey work as they are.

The first control visited is KCS T225, located in front of the Emir's Palace in the city square (Dandali), plate 1. It is buried to the ground level with the capping at the same level with the ground. It was covered by sand and some time was taken scooping out the sand to make the top visible. There are no witness marks to help locate this pillar despite the fact that it is not massive above ground level. Without the aid of people who know the location of such pillars, they cannot easily be located. One corner of the capping is already broken. The centre mark is shown at the meeting of two diagonal lines and there is a nail on it. There is a metal pipe



Plate 1 : KCS T225

towards the centre which helps to protect the nail. The control is in good condition and can be used for any cadastral survey.

The next pillar visited is KCS T227 on a road Kerb opposite the market by a culvert. This is shown on plate 2. It is buried with its capping just on ground level. It is not witnessed, The centre dot is marked by a nail at the intersection of two diagonal lines. The nail goes through a metal disc around the centre. Part of the capping is already broken and the break extends right to near the nail. If this is not



Plate 2: KCS T227

repaired, soon the break will extend to the nail making it vulnerable. The break is new/fresh.

The next pillar is KCS S9, just outside Kofar Guga. It is about an inch (2.5cm) above ground level. The centre dot is marked by a nail at the intersection of two diagonal lines and there is a metal pipe around the nail. Both the metal pipe and the nail have been bent so that centring on the centre dot is not possible neither can it be bissected precisely. Part of the capping too is broken. It is near a mechanic's workshop and seem to have been battered by metals and scraps used in the workshop. The number on the capping is no longer legible, plate 3.

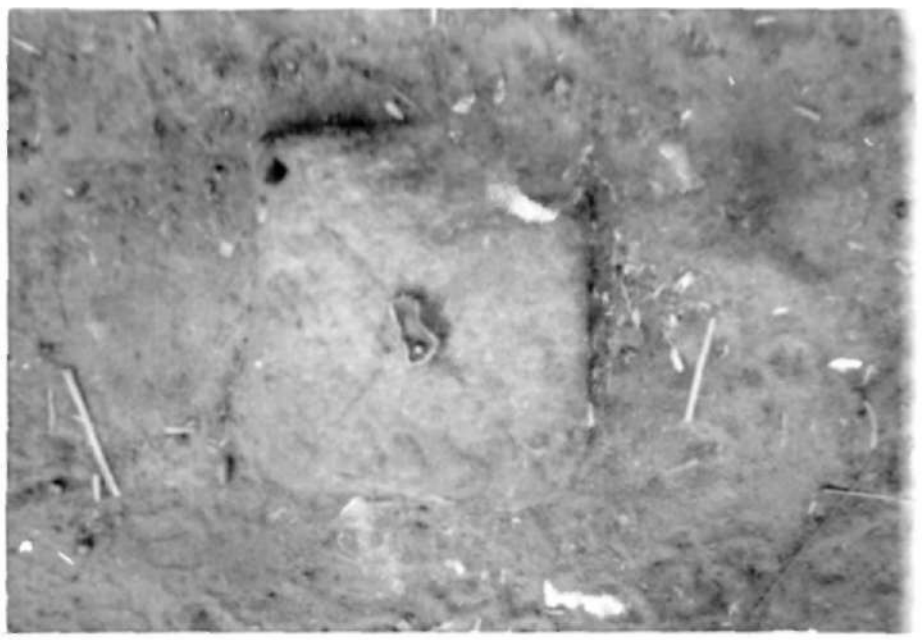


Plate 3 · KCS S9

KCS P_1, the town origin was next checked. A massive roundabout now stands in the place formerly occupied by KCS P_1 and no trace of the control could be found. It was revealed that the control was lost to road construction and in particular round-about construction. Several appeals were made to the area ministry of works by the Area Survey Office as regards the importance of KCS P_1 and therefore its safety/preservation. Assurances were given by the Ministry of Works that the town origin would be preserved, but when the project was completed, the town origin had dissappeared.

KCS P_2 was destroyed long ago so no use looking for it. KCS P_3 isolated by buildings earlier on could not be traced. A few more controls were found within the city. The stump of KCS P605 was found still massive

above ground, but the capping has been broken and the nail marking the centre dot is bent, thus cannot be used for surveying as it is. KCS P606 is also still massive above ground with the capping broken and the centre dot nail bent. These controls can only be identified by reference to maps and diagram as well as information from survey office. KCS P604 seen of recent has been destroyed, located near a public water tap, only fragments of the cement concrete could be found in the vicinity, no stump whatsoever was found.

Just outside Sauri gate (Kofar Sauri) is KCS P601, the local datum. Half of the capping is already broken and the nail marking the centre is seriously damaged, plate 4.

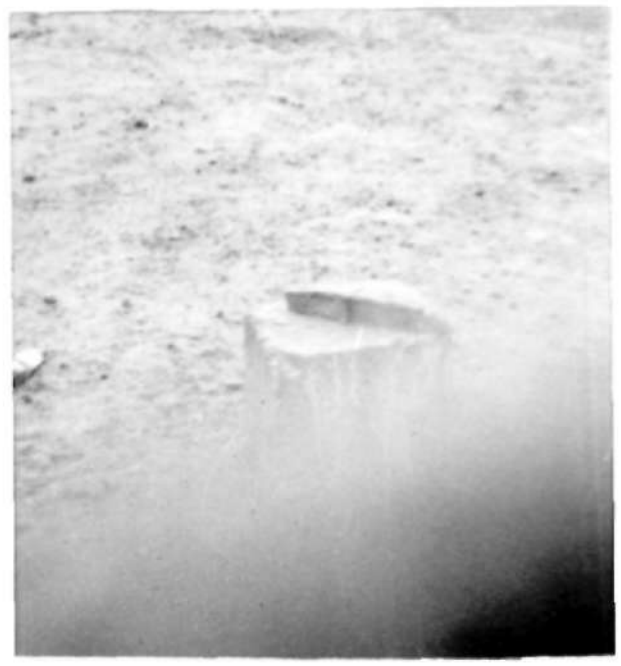


Plate 4 : KCS P601

It is massive above ground.

KCS S17 is along the city wall with no capping and there is no nail on it. It has no number either.

The top is worn out and looks as if it is being used for sharpening metallic objects like knives and hoes.

Many pillars were traced along Sauri road and most of them are in good conditions KCS S22 for example is in good condition with concrete poured on its surface and this had to be removed to show the number. KCS S23 was lost of recent to another roundabout near the Rest House. Table 5.1 is a summary of the controls traced and their conditions. KCSP 636 and KCSP 637 are covered by metal scraps within the city but could not be looked up.

The break down of controls traced from the table is: two tertiary controls, fifteen secondary controls and twenty six primary controls. A total of forty three cadastral controls were traced within the settled part of the township. The existing controls are not evenly distributed throughout the township. Most of the existing controls are found in the GRA and along the city walls. The existing controls are grossly inadequate for the existing and rapidly growing settlement. The only controls not inspected are those between the road to Jibiya and the road to Kaita and outskirts of GRA from the road to Kaita to the Catering Rest House. If these controls are all in tact, they cannot be very useful for cadastral surveys for they are located in areas not subject to development.

Attempt was made at finding out reasons for the destruction of the controls. As can be seen from above,

TABLE 5.1: FIELD INSPECTION

Control Station	Remarks
KCS T225	Buried with capping at ground level, not witnessed. Located in front of the Emir's Palace on city square (Dandali) covered by sand. Nail marking center dot of two diagonal lines intersecting plate 1.
KCS T227	Buried with capping at ground level, not witnessed, It is along road kerb on a culvert opposite main market. Part of Cap is broken, pipe near centre is exposed. Centre dot is marked by nail at intersection of two diagonal lines, plate 2.
KCS S9	Buried with capping about 2.5cm (1 inch) above ground. Nail and pipe marking centre are bent. Found just outside Guga gate (Kofar Guga), plate 3.
KCS P606	Massive above ground, nail at the centre is bent. Capping is broken and number is missing.
KCS P605	Massive above ground, it has no capping and number.
KCS P601	Massive above ground, just outside Kofar Sauri (Sauri gate). Part of the cap is broken and the number is missing. It is by the road side.

KCS S17 Along city wall. It is massive above ground The top is worn, probably used for sharpening metals. The number is missing.

KCS P596 Massive above ground level along Sauri road. It is in tact.

KCS S22 Cement concrete, poured on top, massive above ground. The cement concrete had to be removed to show the number. It is intact.

KCS P600 Massive above ground level, intact.

KCS S19 " " " " "

KCS P599 " " " " "

KCS P598 " " " " "

KCS S21 " " " " "

KCS P596 " " " " "

KCS P595 " " " " "

KCS P683 Capping is broken, massive above ground level, found on farm behind the new carpet factory.

KCS P681 Massive above ground, capping broken, located on farm.

KCS S10 Massive above ground, along city walls, intact.

KCS S11 " " " " " " "

KCS S13 " " " " " " "

KCS S14 " " " " " " "

KCS S15 " " " " " " "

KCS S16 " " " " " " "

KCS P637 Buried under scrap. Could not be seen

KCS P638 " " " " " " "

KCS S42 Inside the city, near Kwaya gate. Capping

above ground, nail at the centre is missing.

KCS S 56 Outside Kofa Sabuwa, capping is broken leaving a stump of the concrete behind, massive above ground.

KCS P702 Massive above ground, capping is broken

KCS P625 " " " " " "

KCS P656 " " " " " "

KCS P673 " " " " " "

KCS P674 " " " " " "

KCS P710 " " " " " "

KCS P587 " " " " " "

KCS P718 Massive above ground level intact

KCS P719 Massive above ground level intact

KCS P692 Massive above ground level, capping is broken

KCS P619 Massive above ground level, capping is broken

KCS S 38 Capping is worn out, number is missing

KCS P690 Massive above ground, capping is broken.

road construction, widening and round-about renovation seem to have done very serious damages. Almost all controls close to roads have been lost with the exception of those along Sauri road. Buildings too have either destroyed or isolated controls which are eventually lost. Places supposedly occupied by controls are taken up by buildings especially in the new layouts, including the low income housing areas, the industial zone, and commercial zone, as well as areas developing within the city. The laying of pipes and cables along main streets help to destroy controls especially secondary and tertiary cadastral controls which were established along main streets. Most pillars on farm have lost their cappings presumably due to hitting of the cappings with hoes and hard objects leading to development of cracks on the controls and eventual disintegration of the cap. The cap falls off leaving the pre-cast concrete alone as a stump with nail sticking out. The nail becomes the next target of hitting and will eventually bend under pressure Some farmers due to ignorance uproot the controls on their property seeing the controls as threats to their ownership and thus have to get rid of the threat. Some of the pillars are also used for sharpening knives, hoes and axes from the way they appear worn out. The role of natural factors cannot be assessed yet because apart from KCS T225 which was temporarily covered by sand deposits, no other control seemed to have suffered from harsh conditions imposed by natural factors. It is too early

to say whether other controls are similarly covered by sand deposits or not. Carelessness on the part of people is another factor, the two controls covered by metal scraps within the city walls bear this out as well as the pysical damages done to KCS T227 and KCS S9.

In view of the conditions and number of existing controls and the nature of the settlement especially within the city, one wonders how surveys are tied to the controls. It was learnt that most cadastral surveys within the city are tied to property beacons which themselves are rare to come by partly because land tenure system within the city is predominantly by customary right of occupancy and partly because most property beacons established have been presumably destroyed. Within the city, walls of adjacent compounds are joined with apparently no ends, thereby making it extremely difficult to demarcate boundaries of individual parcels. With the disintegration of the large compounds, individuals in trying to secure their tenures are moving away from customary rights of occupancy to statutory rights of occupancy and application for statutory right of occupancy must be accompanied by a plan of the parcel surveyed. To get into a compound, one may pass through as many as three zaures, therefore, instrument stations have to be close to each other bringing about centring errors and invariably accuracy is lost. At times up to twenty stations may have to be occupied in order to fix some property beacons within compounds. All these help to make cadastral surveys within the city tedious.

In summary, only seven cadastral controls could be found within the city and out of these seven only two KCS T225 and KCS T227 can be occupied and used as they are. These are inadequate for the cadastral survey needs of the township. Cadastral surveys in the city are tied to property beacons which are not too easy to find either.

Along the city walls, most controls established are still in position though the conditions of some of them are bad. Many of the controls in the GRA especially along the Sauri Road are in good conditions. The controls in the new layouts have been lost to either road construction or buildings. The perimeter survey controls in the north are presumably intact but were not inspected and most of those on farms and bush in the east of the GRA and the new layouts are available, though not all of them were inspected.

Generally many of the controls inspected have lost their cappings and cannot be used as they are. Most of the controls destroyed have their postion taken over by other structures thus cannot be emplaced in their previous exact positions and even if emplaced will not be stable and or convinient or readily available to surveyors.

The controls established were not enough to meet the present cadastral survey needs of the township, even then not all of them are in postion. The township is growing fast, at the rate of about 5% per annum and

the density of the existing controls is quite low. There are no controls near the sites given to FATC and Katsina Polytechnic and the Industrial Area is growing beyond the township framework. Some new developments have been earmarked for the west of the city walls and there are no controls there either. All these help to make cadastral surveying in Katsina difficult. The existing controls can safely be said to be grossly inadequate and cannot meet the present cadastral survey needs of Katsina. A new cadastral survey control network incorporating the existing controls in good condition should be designed and executed for the township so as to meet the present cadastral survey needs of the township. The cadastral controls should be made readily available to surveyors so that they can tie their works to.

CHAPTER 6 : PROBLEMS AND SUGGESTIONS

In the earlier chapters of this thesis, the problems facing cadastral controls in Katsina have been touched upon. These problems will be briefly highlighted here and suggestions as to how to tackle these problems are made leading to the design of a new cadastral control for the township.

6.1 PROBLEMS OF KATSINA CADASTRAL CONTROLS

The problems facing the township framework are many and varied ranging from finance to manpower, ignorance, destruction of controls and inadequacy of the controls.

6.1.1 ADEQUACY OF THE CONTROLS

The controls originally established could meet the cadastral survey needs of the township as well as providing enough framework for the production of Base Maps for the township. However, the existing controls are grossly inadequate for the needs of the township and this will still be true even if all the controls originally established were still in position. The controls were established along main streets and city wall to the detriment of the wards thereby making it very difficult to connect objects far removed from the main streets to the controls especially along the winding streets. Many of the controls established have been lost and areas of new development like FATC and Katsina Polytechnic have no controls at all. Most of the existing controls have been physically damaged and cannot be occupied as they are for any precise work.

6.1.2 DESTRUCTION OF CONTROLS

Established controls have been destroyed or damaged by the execution of other urban works projects like construction and renovation of roads, building of houses, laying of pipes and cables, uprooted or cappings damaged by farmers. The town origin has been destroyed.

6.1.3 RECORDS

Proper records are not kept of all surveys executed in laying the township framework. Detailed description of procedures of surveys, station descriptions and sketches are not available. The only available records are the computation sheets. There are no records of observations made, dates they were made and the surveyors who made them. Field observation booklets are not available either. A file is missing from Box File 843.

6.1.4 ENLIGHTENMENT

The inhabitants were not and have not been enlightened on the uses and costs of the controls, thus they tamper with the controls and destroy some of them because they do not know how much they cost and what they stand for. It is also the lack of enlightenment that has led some to see the controls as threats to their properties.

6.1.5 PROTECTIONS

The controls do not have physical protections like guard posts and flags hoisted on them to keep people off and also warn them of the existence of the controls. There are legal protections for the controls, but these

have not been enforced so that one can say there are no laws which work to deter people from tampering with the controls.

6.1.6 ISOLATION OF CONTROLS

New constructions are often found along survey lines leading to isolation and eventual loss of the control. Intervisibility between the ground monuments is lost.

6.1.7 NATIONAL CONTROLS

National controls were not extended to the area early enough and this is partly responsible for the framework not been tied to national framework. National controls were extended to the area after the township framework had been established, thus the township framework was and still is an isolated framework.

6.1.8 THE GEOGRAPHICAL COORDINATES

The geographical coordinates of at least one of the controls has not been determined which would have provided an easy means of converting the township framework to projection coordinates.

6.1.9 CONVERSION TO NATIONAL CONTROLS

The township framework has not been converted to national heights so that any topographical maps made based on the township surveys give a false impression of the height of the township. Unless one is quick to detect the differences between these maps and heights determined by geodetic levelling and shown on Nigerian

maps, one will be confused as what the height of Katsina is.

6.1.10 OBSTRUCTIONS

Sand deposits covering controls as well as scraps heaped on controls make location of such controls difficult and do not lend such controls readily available for survey work without some serious searching and uncovering them.

6.1.11 WITNESS MARKS

Absence of witness marks for controls at ground level.

6.1.12 INACCURATE TOWNSHIP MAPS

The township plan is inaccurate for it does not agree with the ground positions of the township controls.

6.2 SUGGESTIONS

In view of the above problems, the Katsina township framework is no longer adequate and cannot meet the present needs of Katsina Cadastral Surveys. The framework resulted from an isolated survey and has not been connected to the national framework though National Controls were extended to the vicinity of the township in 1966/67.

To make the controls readily available for surveyors densification of controls should be carried out, see section 6.3. A completely new framework may be too costly, but the new design incorporating all existing

and useable controls will help reduce the costs. Most of the roads have been widened and positions of cables and pipes laid are known, thus new controls carefully established in the light of the above information will not be easily destroyed by the execution of these other public works projects. More controls should be established in the city and towards the south beyond the present out-skirts of the township framework.

The Geographical Coordinates of at least one of the controls should be precisely determined and this will help to check on the accuracy of the results of connections of the framework to the national framework. It will also help to convert the local coordinates to Rectangular Coordinates.

The township framework should be carefully and precisely tied to the national framework. A careful traverse from any of the controls to any of the National Controls within the vicinity of Katsina should be carried out so as to connect the township framework to National Framework and convert the township's local coordinates to projection coordinates. The local heights should also be converted to the Geodetic height determined on the National Height System by tying one of the township controls with height to SBM85.

All efforts to trace records other than the computations of the township framework proved abortive. In the new township control network, information like procedures and observations made, station descriptions,

sketches, dates of the surveys, field books and the name of the surveyor should be properly kept. Very good accurate records and details of jobs carried out, station descriptions and computations should be stored in files and computers and the computer information should have room for up dating. The records should be made as permanent as possible. Methods of field surveys, drawings and computings should be made as clear as possible for easy reading. Everything should be so clear that anybody other than the original surveyor, computor, or draughtsman, who has to work with the records will not only be able to obtain any desired information readily, but will also be able easily to understand exactly what has been done throughout the whole course of the field work and its subsequent stages. In pursuance of this, a control booklet of the survey should also be published and filed in the state survey office, Ministry of Justice and State Library though not meant for public consumption. The control booklet should contain:

(a) Coordinates of all stations

(b) Location, description and references of all control stations.

(c) Description of how the survey was run, the starting and ending stations, azimuths and distance closures, and grid scale factors.

(d) Ties to other controls in the area and their evaluations.

(e) Local origin and datum.

(f) Reference coordinates.

(g) Geographical coordinates.

This booklet if properly kept will ensure that all details are safely stored preventing the issue of files missing or contents of a file being misplaced.

Public enlightenment campaign on the uses and costs of controls should be carried out through the Emir. The Emir will either directly warn the people or talk to ward heads who will then warn the people. This will work for the people have high regards for the Emir and will obey him.

Protection of the controls. Laws protecting the controls should be enforced strictly through the Emir and his ward heads. The ward heads or their agents should be made overseers over controls in their domains and be made to report any damages or tamperings with the controls along with the culprits. Any ward head who fails to report tampering with or destruction of controls should be made to pay more than twice what it costs to replace such a control(s) with the accompanying surveys. Anyone caught tampering with or destroying a control should be made to pay double what it will cost to replace the control(s) with the accompanying surveys. The controls should be checked from time to time to make sure that they are not tampered with.

The controls should also be given physical protection by setting up guard posts about one and half metres tall and painted (plate 5) with barb wire around them. Flags hoisted on long poles could also



Plate 5 : Guard Posts Painted.

be used to warn people of the location of the control.

There is the tendency for the cappings to break easily rendering the nail marking the centre dot vulnerable instead of a nail, a small hole should be made at the intersection of two diagonal lines marking the centre and a small nail is used to mark its centre. Alternatively, the nail marking the centre should not protrude above the surface of the concrete so that it will not be readily exposed. The nail is built into the concrete and can only be damaged if the control itself is seriously damaged. Also the control could be made more massive and prefarably made on site so as to take advantage of local conditions. The control could be made about one metre above ground, plate 6.



Plate 6 : Very Massive Control.

Laws banning buildings along survey lines should be strickly enforced. Any building so erected should be demolished and the owner prosecuted.

There should be cooperation between the Ministry of Works and Ministry of Land and Surveys towards the establishment and maintainance of controls so that during road renovation or repairs and or cables and pipes, controls established are not tampered with. Joint efforts should be made by all government ministries in planning, executing and coordination of development projects for the development of the township.

The execution of any public works project in Nigeria requires the attention, approval and financial support of the government. The importance of cadastral controls in effective land administration for the development of the township should be emphasised to the

Government so that she could give the go ahead order and provide the finances for the densification (execution of the new township control design) and the maintain :nce of the controls.

6.3 DESIGN OF NEW CADASTRAL CONTROL NETWORK FOR KATSINA

Both the population and size of Katsina are growing at the rate of about 5% per annum (Max Lock, 1977). The growth rate implies that the urban centre and its urbanising areas need more work in terms of planning. The growth is generating an unprecedented demand for both land and new urban public work facilities (roads, pipe borne water, electricity etc) of all types. For a properly planned and executed urban public works projects, information on the land itself and the boundaries of real property ownership must be known. Base maps of required accuracy and precision, providing the necessary inventory of the physical facts relating to the land and its ownership must be available. It is the lack of these that partly led to the contracting out of Katsina township for the production of master plan to Max Lock in 1976.

According to Bauer, 1963.

> It is axiomatic that any accurate mapping project requires the establishment of a basic system of survey control. This control consists of a framework of points whose horizontal and vertical positions and interrelationships have been accurately established by field surveys and to which the map details are adjusted. The control system used should be carefully designed to fit the specific needs of the particular mapping project being undertaken.

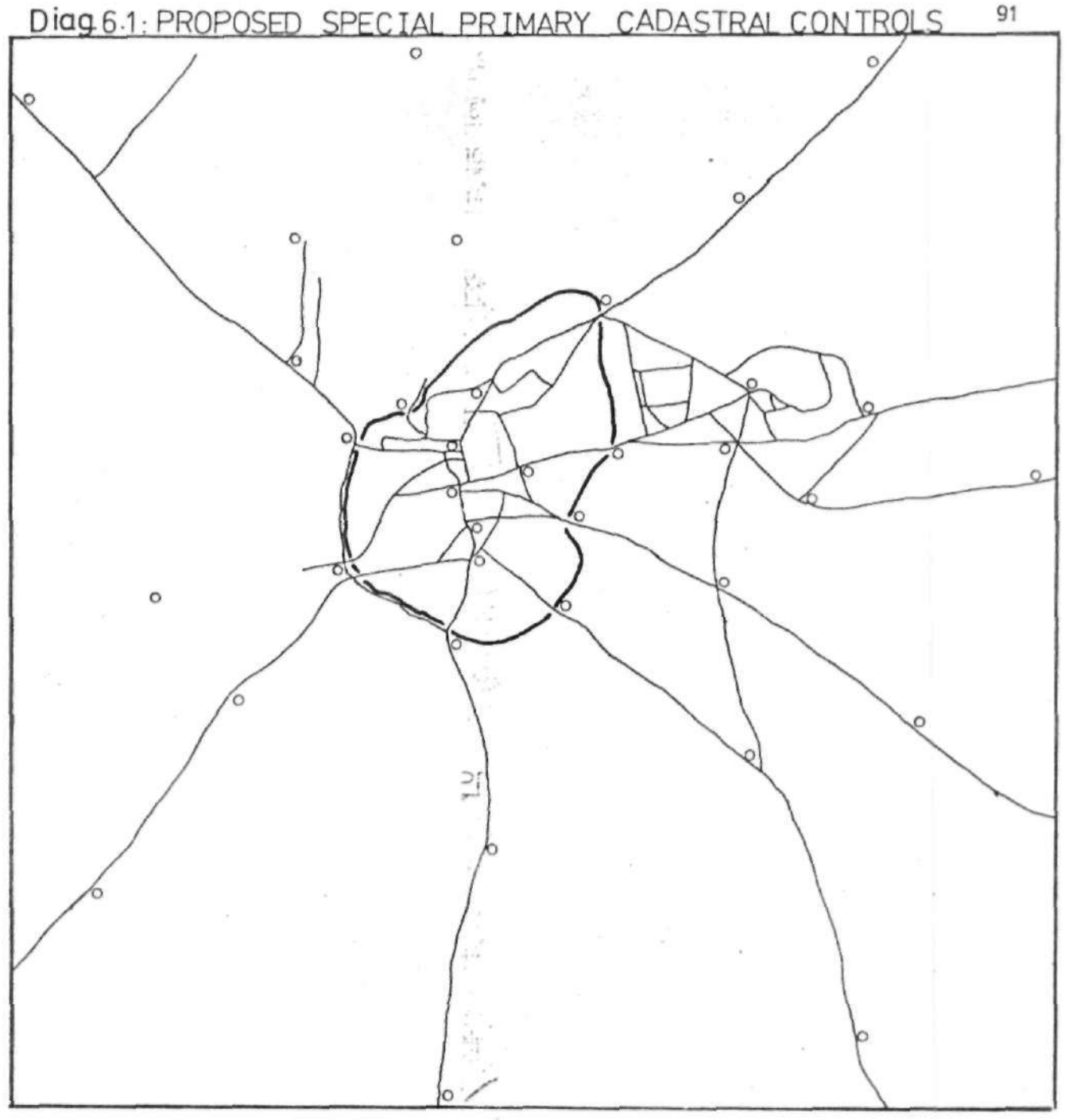
Thus in urban centres, the controls must permit accurate correlation of property boundary line information with topographic data and must be permanently monumented on the ground. Adequate control availability is the basis for all surveying. With control network established, any point within the area can be relocated any time in future with fairly high degree of accuracy.

In view of the inadequacy of the present controls for Katsina township, it is necessary to design a new control network for the township, but so as to cut down on costs, the existing controls should be incorporated. A lot of changes have taken place in the city structure and the urban centre has grown. Also many of the controls established have been destroyed. There are also no up to date township plans of Katsina which implies that accurate up to date land information is not available. The existing framework has not been tied to the national network. The basic principle of this new township framework is to correct the shortcomings of the existing controls. A systematically arranged files of sketches, computation records, and lists of coordinates must be maintained. All the information to be collected should also be safely stored in a computer and control booklets must be kept. The control network and the Geographical Coordinates of at least one of the controls should be accurately determined. Changes should be constantly surveyed and recorded.

The new design should therefore be based on permanently

monumented cadastral control tied to the National Geodetic Datum with at least the Geographical Coordinates of a control established. The network is made up of primary, secondary and tertiary cadastral controls. With the help of large scale township maps all street junctions and corners are marked. A field inspection of all the street corners, city gates and the forseable township limits is next carried out. Primary cadastral controls are then put in at the outskirts of the township and along the streets. At the turning points of the outskirts the street corners and city gates specially made primary cadastral controls preferably built on the site with a height of about one metre above the surface of the ground should be used(Diag 6.1). These constrols are designed and built so as to withstand malicious shocks over long periods of time. There should be no cappings on these controls instead the centre dot should be marked by a nail not protruding above the surface of the concrete at the intersection of two diagonal lines from the corners of the upper surface of the control. The rest of the primary cadastral controls could be made of pre-cast concretes previously used, but without cappings. All existing primary cadastral controls that are useable should be incorporated. The specially built primary cadastral controls should be put in with the advice of geologists as regards the stability of such sites and the depth to which the controls should be built. Necessary cadastral observations are then made carefully determining the coordinates of all the controls in the primary cadastral network. Heights are next transferred from SBM 85 by differential spirit levelling to all these controls thereby providing national heights for these controls. Azimuth observations should also be made for the orientation of the network

Diag. 6.1: PROPOSED SPECIAL PRIMARY CADASTRAL CONTROLS



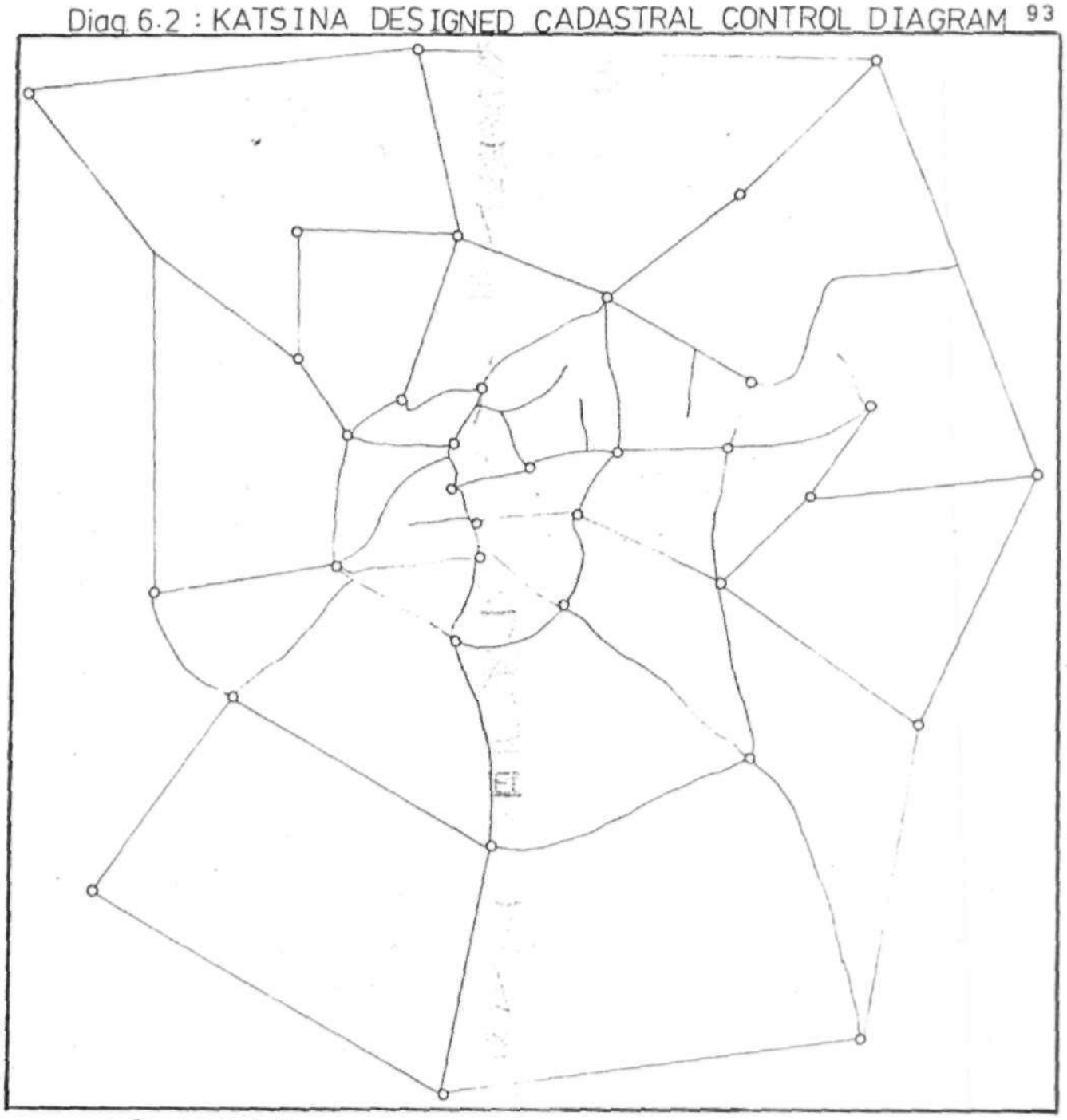
o Primary Cadastral Controls

Scale 1: 50,000

Geographical Coordinates of at least one of these controls should also be determined. Next the framework should be connected to one of the national controls within the vicinity and the local coordinates that resulted are converted to projection coordinates. The framework is made up of loops as shown on diag. 6.2.

The primary cadastral controls used must be able to withstand malicious shocks over long periods of time. The specially built primary cadastral controls should be such that with the help of one more control, it can be used to relocate all lost controls within its vicinity with ease. The primary controls are then densified by secondary cadastral controls along minor streets and into the city wards thereby making the controls readily available. In their surveys, they should run from one primary control to another. Finally, tertiary cadastral controls are put in to further densify the controls running from one control of higher order to another and at times left unclosed especially within the city where narrow winding passage ways make the closure of the circuits extremely difficult. Radial traverses, intersection and resection methods could all be used. Heights should be transferred from primary cadastral controls to both the secondary and tertiary controls by trigonometric heighting. All existing secondary and tertiary controls should be incorporated into the new network as well. In the computations, each traverse loop (Diag 6.2) is first computed and the coordinates of controls on

Diag. 6.2 : KATSINA DESIGNED CADASTRAL CONTROL DIAGRAM



o Special Controls
Scale 1 50,000

lines common to several loops are severally computed with each loop and the average found. Because of the nature of the environment, method of traversing is favourved.

After the observations and computations, the following records must be kept properly and neatly in files, computers and control booklet.

(a) Coordinates (projection) of each control.

(b) Height of each control.

(c) Horizontal and vertical control accuracies.

(d) Geographical coordinates of at least one control.

(e) Sketches of controls in relation to salient features within the immediate vicinity.

(f) Detailed description of the controls. Dossier on each control station to permit its easy recovery.

(g) Control Diagram for all the controls in the network.

(h) Dates of survey.

(i) Name of surveyor and his declaration.

(j) Field observation records.

(k) Computations (all).

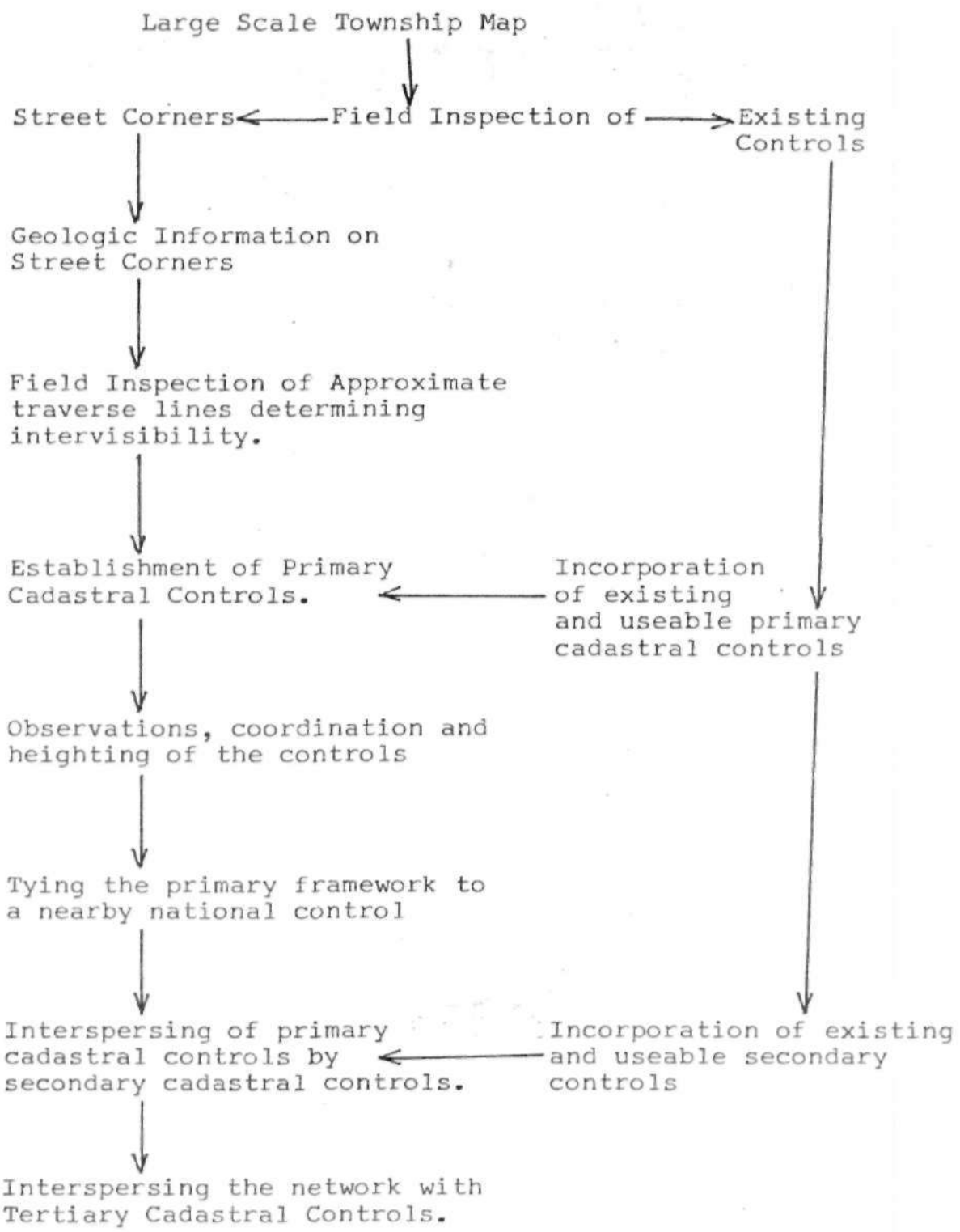
(l) Report of the survey,

This will then produce a consistent and accurate system of control of real property boundary line information and for topographic mapping. A new and up to date topographic map and township plans will be produced which can readily be up dated with the development of the township. All these will help to make the development of modern land data system possible which can easily be integrated into the national land data system.

In designing this new network, specifications for horizontal and vertical controls made by the Federal Surveys for urban centres (Table 2.1) are borne in mind and should be followed in execution. In terms of density controls along traverse lines should not be more than 300m apart and two adjacent controls must be intervisible. If building lines regulations are strictly followed, the ideal places to locate the controls will be along the major streets and roads. The new town plans and proposals for future development are also taken into consideration.

The new design can be executed easily through the techniques of traversing, levelling, intersection resection and trigonometric heighting. To execute the plan, a large scale township map of Katsina is contacted to identify all possible street corners and gates. Next a field inspection of all existing control and the street corners is carried out. Geologic information on the stability of the street corners is supplied. The controls are then put in along the roads and densified, Chart 6.1.

Chart 6.1 : Procedures in Executing the New Control Design.



Controls should be located on both sides of any busy roads so that heavy traffic will not hinder observations. Physical protections should be provided

for each of the controls in the form of guard posts about one and half metres above ground with barb wire wound round the posts. The legal protections should be strickly enforced. The Emir should be involved in warning the inhabitants and also putting the controls under proper supervision. Public enlightenment on the costs and uses of the controls are thus given to the inhabitants and watches are set over the controls. Survey line regulations should also be strictly enforced without fear or favour.

The completed survey should be accompanied by control diagrams showing locations of the control stations with identifying names, routes of traverse (survey) and level lines with distinguishing symbols and where space permits, the names of the traverse stations.

Controls should not be sited on buildings because re-occupation may be inconvinient or, after a period of time, impossible. Such sites can also be the sources of observational difficulties because of vibration or abnormal refraction caused by heat radiation and exhausts from ventilating systems. The walls may also fall.

If executed, this new network will be able to take care of all the survey and mapping needs of Katsina township for a long time. This will in turn make possible for effective planning and execution of all urban public works projects without unnecessary wastages. It will also lead to effective and better administration of the township

and its resources. All these will lead to economic development of the township for the good of all.

Street patterns are generally irregular, thus there can be no uniform spacing of controls. In this new township design, maps showing street patterns and all man-made features should be shown on a planimetric setting. Contours and spot heights will then be added to complete the Topographic set. As far as possible, contours should be at uniform intervals. The maps and controls should be made available to the public by the survey department.

CHAPTER 7 : SUMMARY AND CONCLUSION

Katsina is a traditional Hausa-moslem city on a gently undulating plain. It is the headquarters of Katsina Local Government and the proposed capital of the proposed Katsina State. It is the third largest urban centre in Kaduna State. It lies on latitude 13°N and longitude 7°36'E with an elevation of about 518m (1700ft) above mean sea level. A walled city spanning about twelve kilometers and enclosing an area of about eight square kilometers, the settlement has grown out of the walls especially in the East. The soil is porous affording good natural drainage The climate is hot-arid with characteristic rapid changes in temperature and humidity. Rainy season lasts from May to September. Relative humidity is generally low. Vegetation is sahel Savanna.

It is a commercial centre of long standing, declined in importance for the most of the twentieth century, but is picking up now. It is growing in/a-to serious industiral centre with the siting of the steel Rolling Mills. Agriculture too plays an important role. Animal rearing is very important and the skins of the animals that used to provide materials for the once burgeoning Trans-Saharan Caravan now provides the basic raw material for the Tannery. Crops like millet, groundnut, guineacorn and onions are grown.

The accurate and precise location of points on the

surface of the earth is of prime importance to man. To be able to locate objects precisely, a reference system has to be resorted to. The reference system usually forms the framework onto which all other details are tied. The survey reference system is the control network. Controls form the basis of all surveying and are the foundations of an integrated land data system. Controls measure the overall limits of a project to an accuracy greater than the probable limits of subsequent surveys. The controls could be horizontal or vertical and the orders range from geodetic to secondary, tertiary, minor and cadastral depending on the aim and precision.

Cadastral controls provide township frameworks which then form the basis for mapping urban centres and provide references for tying in property surveys. Cadastral controls could be break downs from the national framework or they are isolated networks established by isolated surveys as is the case for most Nigerian townships. The cadastral controls could be primary, secondary or tertiary. The primary cadastral controls form the perimeter control network marking the forseable township limits. They are then interspersed by secondary and then tertiary cadastral controls. The Katsina township framework is an isolated framework and has not been tied to the national network. This framework has $KCSP_1$ as the local origin with assumed coordinates (15,239.86mN, 15239.86mE) chosen in such a way that all the township controls have positive coordinates. The framework also has a local datum with an assumed height. Work on

the township framework started before 1950 for cadastral surveys carried out in 1950 to fix Rex Cinema were referenced to $KCSP_2$ and $KCSP_3$. Secondary cadastral controls were put in and computed between 1950 and 1951 with reference to the primary cadastral controls. The tertiary cadastral controls were put in in 1957 and coordinated. All these observations and computations were discarded and from 1959 to 1962 fresh surveys were carried out providing the coordinates and heights of the controls in use presently. The linear misclosures attained for these surveys are quite high, infact some of them approach geodetic accuracies. The surveyor who carried out this job should be commended for a job well done. One of the traveses in the tertiary traverse fail to meet the required accuracy.

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The spacing of the controls was fair with the average distance of about 395m between two adjacent controls. The controls are however, not spread evenly. There is a concentration of the controls in the settled part of the township along main streets and roads. Most development is concentrated on the city the GRA and the adjoining new layouts. The price of development in the city and the new layouts is the loss of controls. In the GRA, controls were put in mainly after development. There is very little by way of development in the North and West of the city. The town is growing in both population and size and the settlement has sprawled over the township limits in the East and South. There are

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AHMADU

no controls near the sites for FATC AND Katsina Polytechnic

The township framework has not been connected to the National Framework. The connection could be done by carefully tying one of the township controls to a nearby national control and coordinated from it. The new coordinates of the township framework control form the projection coordinates of the control. All the local controls could then be converted to projection coordinates. The Geographical coordinates could also be converted to Rectangular coordinates, but unfortunately, the geographical coordinates of none of the controls is known. Height conversion is also simple, but has not been done either. SBM 85 is in the town and the conversion is a question of tying one of the controls to it by spirit levelling, thereby transferring height from the benchmark to the control. The heights of all the other controls are then converted with reference to this control.

Field inspection was carried out to determine the availability of the controls on the field. The result of the field inspection confirmed that many of the controls have been destroyed and out of those left many are in bad conditions. The factors responsible for the destruction and damaging of control include road construction and renovation, laying of pipes and cables, isolation of controls by buildings and ignorance especially of farmers. There is dearth shortage of controls for the township especially within the city and the new layouts. Due to shortage of controls, cadastral surveys are being tied to property beacons

which are themselves not very common in the city because customary tenure prevails and in the new layouts because they have been destroyed. Other problems facing the controls are lack of physical protection like guard posts and enforcement of legal protections. Lack of purpose and coordination of Government Development projects for the township are also important. The existing controls are yet to be tied to national framework and geographical coordinates of at least one of the controls is yet to be determined. There are no records of observations and station descriptions.

It is suggested that:

(a) A new control network incorporating the existing controls should be established. The new framework should be laid taking note of the present trend of development and making some forecast into the future.

(b) The Geographical Coordinates of at least one of the controls should be determined and the township framework should be tied to the national network.

(c) Records of all the new surveys must be properly kept in recoverable manner. Computer, control booklet and files should be used to store the information. Details of the procedures, station descriptions and computations carried out with illustrative sketches and diagrams must be kept.

(d) Public enlightenment through the Emir should be embarked upon so as to reduce tamperings with the controls.

(e) Physical protections should be provided and legal protections enforced for the controls. There is also the need for cooperation in planning and executing of development projects for the township by all government ministries and parastatals concerned.

Because of the inadequacy of the controls a new township framework has been designed incorporating the existing controls. If executed, it will provide controls for mapping the township and tying in cadastral surveys. Enough controls will be made available for the township. Taken into consideration in making this design is the proposed township plan. The resulting framework must be tied to the national framework immediately and the geographical coordinates of at least one of the controls must be determined. Specially monumented primary cadastral controls should be set up at street corners, city gates and the turning points of the outer circuit. These special controls with one more control can be used to relocate many other controls since they are more durable. Thirty six of these special primary cadastral controls are suggested for the township. The controls when put in must be given physical and legal protection including regulations on survey lines, if they are to be of use in the future. The completed survey should be well documented. Records must be appropriately kept. Files must be well kept containing details of all observations, dates, surveyors, sketches, computations and diagrams. Control diagram showing the location of all controls must also be shown. the file should also be

made into control booklet with copies in the state survey office, Kaduna; Ministry of Justice and State Library Kaduna strictly meant for security and not public consumption. The information should also be stored in computers. In these ways, the information will be well preserved and can be traced easily and fresh information can be added from time to time. With the execution of this design, adequate land data information for planning, execution and effective administration of the township results leading to the development of the town. Base maps of the township could also be produced.

The problems discussed above are not peculiar to Katsina. The picture is the same for most townships in Nigeria. There is therefore the need to carry out field inspection for most Nigerian township frameworks and design new networks which will enhance the development of the township. This is especially true because of the rate at which urban centres are growing spontaneously in Nigeria without proper planning. Most of the urban centres have outgrown their limits in at least one direction and many new projects are sited outside township frameworks. For effective planning, execution and administration of urban public works projects, there is the need to provide adequate cadastral controls. Presently the execution of one project leads to damage of another project which is an unecessary waste and this results from lack of coordination. Repairing what has been damaged takes time and money which should be used for other projects. It is suggested that a trained

graduate surveyor should be made to lay a township frame-work in two years at the most and with some incentives the time taken will be less. The savings that this will bring about will more than compensate the waste that is being experienced now.

REFERENCES

1. ADUTWUM, J.B. (1969). Isolated Survey System. Surveying and Mapping, Vol. 29:273-279

2. ALEXANDER TARICS, Dr (1950). The New City Survey of Budapest. Surveying and Mapping, Vol. 10 (4): 265-273.

3. ASHTON J.B. (1986). Personal communication

4. BAUER W. KURT (1963). A proposed System of Control for Urban Surveying and Mapping Operations. Surveying and Mapping, Vol. 23 pp 291-302.

5. BLACHUT T.J. (1969). Technical and Organisational Problems in Urban Surveying and Mapping. Canadian Surveyor, Vol. 23 pp 409-419

6. Box File 526 : Katsina Block, Tellurometer Traverse Ministry of Land and Surveys, Kaduna.

7. Box File 843 : Katsina. Ministry of Land and Surveys, Kaduna.

8. Coordinate Register; Ministry of Land and Surveys, Kaduna.

9. DALE P. F. (1976). Cadastral Surveys Within the Commonwealth, London: HMSO.

10. DRACUP F. JOSEPH (1969). Control Surveys for Akron, Ohio. Surveying and Mapping, Vol. 29: 243-249.

11. FIELD N.J. PROFESSOR (1986). Personal Communication.

12. GALE A. LOUIS (1969). Control Surveys for Urban Areas in Canada. Surveying and Mapping, Vol. 29 : 669-672.

13. GOTTFREID KONENCY (1969). Control Surveys as a Foundation for an Integrated Data System. Canadian Surveyor, Vol. 23: 34-39

14. GROVE A.T. (1970). Africa South of the Sahara. Oxford University Press.

15. ILOEJE N.P. (1976). A New Geography of Nigeria: Metricated Edition. Longman Nigeria.

16. JARRETT H. R. (1977).Africa. The New Certificate Geography Series. Advanced Level. Macdonald and Evans. pp 278.

17. LARRABEE M. BRUCE (1954). The Role of Monuments in Surveying. Surveying and Mapping, Vol. 14 (2).pp 196-200.

18. MAX LOCK, NIGERIA (1978). Katsina: Kaduna State Government, Federal Republic of Nigeria. Surveys and Development Plans Produced by Max lock Group Nigeria.

19. McCAW G. T. (1944). The Keeping of Survey Records. Empire Survey Review, Vol. 7 pp 331-332.

20. MORLEY J.D. (1969). Files and Data Banks. Canadian Surveyor, Vol. 23: 116-119

21. PELTON L. E. (1966). Survey Control for Cities. Canadian Surveyor, Vol. 20 (4).

22. REID D.L. and MELDRUM D.R. (capt); D.S.O: (1934). Surveying and Setting out of Townships and Town Planning Layout. Empire Survey Review, Vol. 2, pp 395-400.

23. SADA P.O. (1972). Urbanisation Trends and Problems of Urban Administration in Nigeria. In: Adebayo Adedeji and Rowland, L. (Edited). Management Problems of Rapid Urbanisation - University of Ife Press, Ile Ife, Nigeria.

24. SULEIMAN ABUBAKAR (1981). Katsina Master Plan: A Programme for Implementation of the Second Phase of the Plan 1980-85. Unpublished M.Sc. (U.R.P.) Thesis, A.B.U., Zaria.

25. Technical Instructions for Field Parties. Kaduna Polytechnic, College of Environmental Studies.

26. Township Surveys and Layout (1954). Pamphlet No. 3, Survey Department, Nigeria.

27. Transvers Mercator Projection. Tables for Transformation of Coordinates from:

(a) Geographical to Grid.

(b) Grid to Geographical

Clarke 1980 Speroid. 1961. Published by Army Map Survice, Washington D.C.

28. UDO, R.K. (1978). Geographical Regions of Nigeria. Heineman Educational Books Ltd., London pp. 178-187.

29. URQUHART A.W.(1977). Planned Urban Landscapes of Northern Nigeria: A Case Study of Zaria. Ahmadu Bello University Press.

30. WOOD B. KENDALL (1962). On Control Surveys. Surveying and Mapping, Vol. 22. pp.581 - 584.

31. WRIGHT J.W. (1956). Reference Marks in Land Settlement. Journal of African Administration, Vol. 8, pp.38-45.

APENDIX : KATSINA COORDINATE REGISTER

The original coordinates and heights were given in the imperial system, feet, and have all been converted to the metric system using the Clarke Metre to the yard relationship:

1m = 1.093 623 11 yard

or 1ft = 0.304797265m

The total number of coordinates is 266, broken down as follows:

Primary Cadastral Controls	: 186
Secondary " "	: 44
Tertiary " "	: 36
Total	266

All coordinates are with reference to National North (Colony North). Not all these controls, however, can be found on the ground now.

	FEET			METRES		
	N	E	H	N	E	H
P582	55,590.80	72,044.28	1429.93	16,943.924	21,958.900	435.839
P583	54,691.49	71,146.54	1434.49	16,669.817	21,685.280	437.229
P584	54,276.62	69,645.81	1443.29	16,543.365	21,227.852	439.911
P585	53,659.41	68,346.50	1452.86	16,355.241	20,831.826	442.828
P586	54,042.96	67,267.22	1454.80	16,472.146	20,502.865	443.419
P587	53,601.69	66,592.34	1456.77	16,337.649	20,297.163	444.020
P588	53,822.02	64,758.05	1479.37	16,404.805	19,738.077	450.908
P589	54,595.96	64,575.74	1468.83	16,640.699	19,682.509	447.695
P590	54,438.90	63,566.15	1466.39	16,592.828	19,374.789	446.952
P591	54,584.73	62,904.32	1464.31	16,637.276	19,173.065	446.318
P592	54,650.77	61,837.27	1461.96	16,657.405	18,847.831	445.601
P593	54,624.90	60,785.38	1457.93	16,649.520	18,527.218	444.373
P594	54,561.52	60,128.71	1452.53	16,630.202	18,327.066	442.727
P595	54,479.11	59,606.30	1447.02	16,605.084	18,167.837	441.048
P596	54,682.85	58,955.79	1440.33	16,667.183	17,969.564	439.009
P597	55,016.44	58,192.26	1429.34	16,768.860	17,736.842	435.659
P598	55,384.93	57,440.68	1417.03	16,881.175	17,507.762	431.907
P599	55,765.05	56,646.70	1404.44	16,997.035	17,265.759	428.069
P600	56,102.23	56,069.35	1396.01	17,099.806	17,089.785	425.500

	N	E	H	N	E	H
P601	56,492.66	55,440.01	1400.00	17,218.808	16,897.963	426.716
P602	56,320.30	54,843.03	1410.35	17,166.273	16,716.006	429.871
P603	55,981.67	54,152.86	1419.49	17,063.060	16,505.644	432.657
P604	55,577.48	53,370.50	1427.92	16,939.864	16,267.182	435.226
P605	55,007.93	52,370.03	1435.94	16,766.267	15,962.242	437.671
P606	54,751.06	51,665.25	1441.33	16,687.973	15,747.427	439.313
P607	54,291.59	51,306.81	1447.05	16,547.928	15,638.175	441.057
P608	54,619.48	50,964.02	1441.37	16,647.868	15,533.694	439.326
P609	54,588.91	50,386.16	1438.41	16,638.550	15,357.564	438.423
P610	55.099.03	50.084.14	1439.49	16,794.034	15,265.509	438.753
P611	55.926.84	47.862.90	1454.03	17,046.348	14,588.481	443.184
P612	55,526.98	46,664.78	1478.18	16,924.472	14,223.297	450.545
P613	55,928.20	46,023.32	1479.16	17,046.762	14,027.782	450.844
P614	56,019.82	45,319.50	1479.54	17,074.688	13,813.260	450.960
P615	56,191.42	43,828.09	1488.11	17,126.991	13,358.682	453.572
P616	56,051.31	43,258.46	1489.43	17,084.286	13,185.060	453.974
P617	54,196.28	43,768.89	1478.63	16,518.878	13,340.638	450.682
P618	53,458.66	44,551.57	1465.95	16,294.053	13,579.197	446.818
P619	52,800.03	45,228.81	1455.31	16,093.305	13,785.618	443.575

	N	E	H	N	E	H
P620	52,222.42	45,814.42	1453.52	15,917.251	13,964.110	443.029
P621	49,687.56	45,506.98	1477.95	15,144.632	13,870.403	450.475
P622	48,905.75	54,465.86	1486.36	14.906.339	13,857.870	453.038
P623	48,056.40	45,487.29	1496.60	14,647.459	13,864.402	456.160
P624	47,288.36	45,548.13	1503.76	14,413.363	13,882.945	458.342
P625	47,010.63	45,912.23	1506.83	14,328.711	13,993.922	459.278
P626	47,457.31	46,344.15	1503.50	14,464.858	14,125.570	458.263
P627	47,966.01	46,767.11	1500.87	14,619.909	14,254.487	457.461
P628	46,621.77	47,035.93	1496.40	14,210.188	14,336.423	456.099
P629	49,131,33	47,267.12	1492.38	14,975.095	14,406.889	454.873
P630	49,635,69	47,523.72	1487.45	15,128.823	14,485.100	453.371
P631	49,919,56	47,823.17	1482.48	15,215.345	14,576.371	451.856
P632	50,512.14	48,535.10	1477.41	15,395.962	14,793.366	450.311
P633	50,138.36	48,715.88	1460.51	15,282.035	14,848.467	445.159
P634	49,920.23	48,757.48	1481.05	15,215.550	14,861.147	451.420
P635	49,962.70	48,920.49	1481.53	15,228.494	14,910.832	451.566
P636	50,006.84	49,164.82	1480.48	15,241.948	14,985.303	451.246
P637	50,092.48	49,392.51	1481.63	15,268.051	15,054.702	451.597

	N	E	H	N	E	H
P656	47,954.73	62,866.88	1478.90	14,616.471	19,161.653	450.765
P657	48,178.82	63,656,46	1492.35	14,684.773	19,402.315	454.864
P658	48,345.90	64,362.36	1498.32	14,735.698	19,617.471	456.684
P659	48,208.44	65,578.68	1515.71	14,693.801	19,988.202	461.984
P660	47,552.72	67,111.71	1509.90	14,493.939	20,455.466	460.213
P661	47,793,72	68,274.64	1496.05	14,567.395	20,809.924	455.992
P662	47,787.43	68,860.95	1498.63	14,565.478	20,988.629	456.778
P663	48,060.78	69,736.85	1489.55	14,648.794	21,255.601	454.011
P664	44,625.97	45,902.78	1498.37	13,601.874	13,991.042	456.699
P665	47,871.62	56,195.47	1431.50	14,591.139	17,128.226	436.317
P666	53,199.43	68,802.86	1456.02	16,215.041	20,970.924	443.791
P667	52,322.73	68,928.58	1463.10	15,947.825	21,009,243	445.949
P668	51,710.14	69,244.76	1464.18	15,761.109	21,105.613	446.278
P669	50,963.33	69,103.65	1471.76	15,533.484	21,062.604	448.588
P670	49,715.29	68,767.10	1480.78	15,153.084	20,960.024	451.338
P671	49,268.06	69,273.15	1477.15	15,016.770	21,114.267	450.231
P672	48,692.84	69,410.02	1482.38	14,841.444	21,155.984	451.825
P673	47,244.50	62,449.11	1481.97	14,399.994	19,034.318	451.700

	N	E	H	N	E	H
P674	46,419.08	62,769.29	1489.77	14,148.409	19,131.908	454.078
P675	45,621.41	63,323.21	1499.14	13,905.281	19,300.741	456.934
P676	44,715.21	63,850.05	1503.17	13,629.074	19,461.321	458.162
P677	43,684.88	64,176.44	1507.96	13,315.032	19,560.803	459.622
P678	42,759.67	64,215.26	1513.05	13,033.030	19,572.636	461.174
P679	41,764.36	63,985.39	1522.87	12,479.663	19,502.572	464.167
P680	42,049.09	62,172.27	1515.57	12,816.448	18,949.938	461.942
P681	42,383.51	61,346.08	1498.86	12,918.378	18,698.117	456.848
P682	42,592.68	60,623.66	1498.62	12,982.132	18,477.926	456.775
P683	42,669.71	59,927.67	1485.34	13,005.611	18,265.790	452.728
P684	42,531.59	58,897.26	1458.40	12,963.512	17,951.724	452.746
P685	42,245.40	57,329.22	1490.13	12,876.282	17,473.789	454.188
P686	42,768.40	56.502.24	1479.90	13,035.691	17,221.728	451.069
P687	43,191.32	55,928.17	1471.46	13,164.596	17,046.753	448.497
P688	43,608.19	55,159.60	1464.75	13,291.657	16,812.495	446.452
P689	43,731.77	54,336.69	1452.66	13,329.324	16,561.675	442.767
P690	43,102.53	53,704.18	1464.90	13,137.533	16,368.887	446.498
P691	42,750.59	52,909.75	1477.65	13,030.263	16,126.747	450.384

	N	E	H	N	E	H
P692	43,062.91	52,330.52	1483.48	13,125.457	15,950.199	452.161
P693	43,608.71	51,470.28	1491.20	13,291.816	15,688.001	454.514
P694	43,434.51	50,522.01	1497.90	13,238.720	15,398.970	456.556
P695	43,180.04	49,772.27	1502.76	13,161.158	15,170.452	458.037
P696	43,373.78	48,407.26	1522.04	13,220.210	14,754.400	463.914
P697	43,736.96	47,231.56	1508.69	13,330.906	14,396.050	459.845
P698	44,170.51	45,475.42	1498.59	13,463.051	13,860.784	456.766
P699	43,889.27	44,553.64	1498.86	13,377.329	13,579.829	456.848
P700	44,790.23	44,444.09	1493.57	13,651.940	13,546.437	455.236
P701	45,647.31	44,957.81	1504.62	13,913.175	13,703.018	458.604
P702	46,162.16	45,294.65	1507.44	14,070.100	13,805.685	459.464
P703	52,642.32	50,524.28	1464.27	16.045.235	15,399.662	446.305
P704	52,085.37	50,271.19	1469.71	15,875.478	15,322.521	447.964
P705	51,572.03	49,844.51	1467.46	15,719.014	15,192.470	447.278
P706	50,630.40	49,930.11	1479.57	15,432.007	15,218.561	450.969
P707	60,649.23	61,035.33	1424.17	18,489.719	18,603.402	434.083
P708	59,684.94	59,867.98	1404.41	18,222.286	18,247.597	428.060
P709	58,902.02	58,681.88	1406.78	17,953.175	17,886.077	428.783

	N	E	H	N	E	H
P710	58,180.77	57,673.43	1405.19	17,733.340	17,578.704	428.298
P711	57,247.26	56,487.40	1398.23	17,448.808	17,217.205	426.177
P712	51,550.83	60,464.98	1461.65	15,712.552	18,429.561	445.507
P713	50,233.32	60,001.78	1446.66	15,310.979	18,288.378	440.938
P714	49,004.89	59,673.92	1449.83	14,936.556	18,188.448	441.902
P715	53,478.99	50,916.59	1456.18	16,300.250	15,519.237	443.840
P716	53,716.33	65,634.83	1468.11	16,372.590	20,005.317	447.476
P717	42,350.66	57,942.39	1492.88	12,908.365	17,660.682	455.026
P718	44,479.15	54,496.72	1450.73	13,557.123	16,610.451	442.179
P719	44,895.22	53,435.12	1478.97	13,683.940	16,286.878	450.786
P720	45,646.50	53,723.67	1450.25	13,912.928	16.374.828	442.032
P720A	60,661.94	65,856.34	1430.36	18,489.593	20,072.832	435.970
P721	46,395.59	54,133.07	1450.75	14,141.249	16,499.612	442.185
P722	47,052.95	54,571.35	1450.81	14,341.610	16,633.198	442.203
P723	47,823.31	53,695.05	1457.98	14,576.414	16,366.104	444.333
P724	44,146.76	46,562.40	1506.85	13,455.812	14,192.092	459.284

	N	E	H	N	E	H
P725	54,747.55	42,958.85	1490.31	16,686.904	13,093.740	454.242
P726	55,361.61	43,229.12	1493.98	16,874.067	13,176.118	455.361
P727	55,122.53	48,775.13	1493.98	16,801.196	14,866.526	455.361
P728	47,603.43	66,348.46	1594.77	14,509.395	20,222.829	486.082

All the coordinates are with reference to colony North (CN), now National North.

P_0 is the origin and P601 is the assumed local datum.

APENDIX A, TABLE 2: SECONDARY CADASTRAL CONTROLS

Pillar NO.	N (ft)	E (ft)	H (ft)	N (m)	E (m)	H (m)
S1	49,486.64	50,085.45	-	15,083.393	15,265.908	Origin cs P1
S2	48,467.40	50,254.51	-	14,772.731	15,317.437	-
S3	47,916.03	49,863.79	-	14,604.675	15,198.347	-
S4	46,826.23	49,078.75	-	14,272.507	14,959.069	-
S5	46,527.44	46,657.26	-	14,181.436	14,221.005	-
S6	46,352.27	45,717.60	-	14,128.045	13,934.599	-
S7	46,823.02	45,453.76	1505.90	14,271.528	13,854.182	458.994
S8	50,440.34	45,691.10	1469.39	15,374.078	13,926.522	447.866
S9	51,643.60	46,042.09	1457.81	15,740.828	14,033.503	444.337
S10	52,252.95	46,371.56	-	15,926.556	14,133.925	-
S11	53,161.28	48,448.75	-	16,203.413	14,767.047	-
S12	53,508.85	48,413.52	-	16,309.351	14,756.309	-
S13	56,221.16	51,424.89	-	17,136.056	15,674.166	-
S14	56,467.06	51,977.44	-	17,211.005	15,842.582	-
S15	56,672.48	52,598.77	-	17,273.617	16,031.961	-
S16	57,406.87	54,519.61	-	17,497.457	16,617.428	-
S17	57,213.90	54,984.50	-	17,438.640	16,759.125	-
S18	56,273.20	55,844.57	-	17,151.917	17,021.272	-

APENDIX A, TABLE 2: SECONDARY CADASTRAL CONTROLS

Pillar No.	N (ft)	E (ft)	H (ft)	N (m)	E (m)	H (m)
S19	56,000.36	56,215.24	-	17,068.757	17,553.162	-
S20	55,299.47	57,589.63	-	16,855.127	17,553.162	-
S21	54,832.28	58,632.26	-	16,712.729	17,870.953	-
S22	54,105.52	60,018.28	1452.15	16,491.215	18,293.408	442.611
S23	53,514.13	61,001.71	1465.83	16,310.960	18,593.154	446.781
S24	52,245.48	60,750.23	1464.98	15,924.279	18,516.504	446.522
S25	51,547.48	60,468.82	-	15,711.531	18,430.731	-
S26	50,564.96	60,100.62	-	15,412.062	18,318.505	-
S27	49,428.42	59,766.78	1446.16	15,065.647	18,216.751	440.786
S28	48,570.12	59,612.97	-	14,804.040	18,169.870	-
S29	47,828.02	59,610.33	-	14,577.850	18,169.066	-
S30	46,884.15	59,582.69	-	14,290.161	18,160.641	-
S31	45,822.58	59,782.42	-	13,966.597	18,221.518	-
S32	46,107.87	59,294.74	-	14,053.552	18,072.872	-
S33	46,563.62	58,359.99	-	14,192.464	17,787.965	-
S34	47,067.64	57,568.17	-	14,346.088	17,546.621	-

APENDIX A, TABLE 2: SECONDARY CADASTRAL CONTROLS

Pillar No.	N (ft)	E (ft)	H (ft)	N (m)	E (m)	H (m)
S35	47,652.50	56,657.46	-	14,524.352	17,269.039	-
S36	48,072.92	55,741.04	1427.98	14,652.495	16,989.717	435.244
S37	48,508.25	54,076.46	-	14,785.182	16,482.357	-
S38	46,034.33	54,379.40	-	14,031.138	16,574.692	-
S39	45,008.31	53,584.69	-	13,718.410	16,332.467	-
S40	44,462.37	53,074.28	-	13,552.009	16,176.895	-
S41	43,729.18	50,148.15	-	13,328.534	15,285,019	-
S42	44,270.47	49,456.35	-	13,493.518	15,074.160	-
S43	45,016.84	47,970.17	-	13,721.010	14,621.177	-
S44	46,067.52	46,251.48	-	14,041.254	14.097.325	-

All these are with reference to colony North (CN), now National North values without heights are recomputed onto CN between first pillars, values with heights were reobserved with the new Primary Cadastral Controls.

APENDIX A TABLE 3: TERTIARY CADASTRA CONTROS.

Pillar No.	N (ft)	E (ft)	N (m)	E (m)	Origin is KCS P1
T1	51,210.35	55,420.95	15,608.775	16,892.154	
T2	51,565.40	56,473.19	15,716.993	17,212.874	
T3	51,511.63	57,507.53	15,700.604	17,528.138	
T4	38,674.05	39,364.34	11,787.745	11,998.143	
T5	38,044.27	38,619.17	11,595.789	11,771.017	
T6	37,277.84	38,082.74	11,362.184	11,607.515	
T222	50,744.02	52,392.05	15,466.639	15,968.954	
T223	51,025.83	53,404.73	15,552.533	16,277.616	
T224	51,307.27	54,213.86	15,638.316	16,524.236	
T225	51,043.89	49,858.01	15,558.039	15,196.585	
T226	51,098.97	49,311.31	15,574.826	15,029.952	
T227	51,178.68	48,663.79	15,599.122	14,832.590	
T228	51,236.11	47,900.38	15,616.626	14,599.905	
T229	51,326.83	47,245.89	15,644.277	14,400.418	
T230	51,506.09	46,306.59	15,598.915	14,114.122	
T231	49,695.76	50,651.96	15,147.132	15,438.579	
T232	49,781.06	51.418.00	15,173.131	15,672.066	
T233	49,452.07	52,342.65	15,072.856	15,933.897	
T234	49,206.79	52,887.15	14,998.095	16,119.859	
T235	48,497.29	53,887.39	14,781.841	16,424.729	

	N	E	N	E
T236	49,683.19	51,677.85	15,143.300	15,751.267
T237	48,737.10	51,605.81	14,854.935	15,729.310
T238	48,244.80	51,262.89	14,704.883	15,624.789
T239	47,858.80	50,989.50	14,587.231	15,541.460
T240	50,240.16	51,300.30	15,313.063	15,636.191
T241	50,012.07	52,079.97	15,243.542	15,873.832
T242	-	-	-	-
T243	-	-	-	-
T244	-	-	-	-
T245	49,581.28	50,017.73	15,112.239	15,245.267
T246	48,478.96	50,256.33	14,776.254	15,317.992
T247	47,720.98	50,458.60	14,545.224	15,379.643
T248	47,197.24	50,582.28	14,385.590	15,417.341
T249	46,703.04	51,640.98	14,234.959	15,740.029
T250	46,385.70	52,243.76	14,138.235	15,923.755
T251	45,711.72	52,746.71	13,932.807	16,077.053

Coordinates are with reference to colony north