THE PHYSICAL ENVIRONMENT AS A FACTOR IN THE ULTIMATE CONFIGURATION OF THE BUILT-UP AREA OF THE VAAL TRIANGLE

A. NIEUWOUDT AND A.B. DE VILLIERS
Department of Geography, Potchefstroom University for C.H.E.

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The importance of integrating physical parameters with social and economic variables when discussing urban growth and development is crucial. The physical factors have not always been appreciated or properly documented. Sites for urban settlements were in the past determined largely by physical factors rather than economic attributes.

In more recent times economic considerations played a more dominant role. In both instances however, the role of the physical environment in the ultimate configuration of the built-up area, once the place of settlement had been decided upon, tended to be neglected. In the past this was mainly due to ignorance – leading in many instances to damage to buildings and loss of lives. In more recent years it arose mainly from the prevailing philosophy that nature represented a passive force, easily subdued by man and his sophisticated technology. Because of this notion the alteration of the landscape and blatant ignoring of natural processes, to fit man's urban needs (both residential and economic), has in many instances led to an increase in environmental hazards.

In this article, the problem and process of the physical environment on the city will be examined with reference to the Vaal Triangle.

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Die belangrikheid van die integrasie van fisiese parameters by sosiale en ekonomiese veranderlikes tydens die bespreking van stedelike groei en ontwikkeling, is onbetwisbaar. Die fisiese faktore is nie altyd gewaardeer en behoorlik gedokumenteer nie. Ruimtes vir stedelike vestiging is in die verlede grootliks bepaal deur fisiese faktore eerder as ekonomiese eienskappe.

Ekonomiese oorwegings speel tans 'n groter rol. Nadat die plek van vestiging gekies is, word die rol van die fisiese omgewing in die uiteindelike vorm van die beboude gebied, dikwels verwaarloos. In die verlede was dit hoofsaaklik te wydte aan onkunde wat in baie gevalle gelei het tot die beskadiging van geboue en lewensverlies. Die afgelope paar jaar, het dit hoofsaaklik gespruit uit die heersende filosofie, naamlik dat die natuur 'n passiewe krag verteenwoordig, wat maklik deur die mens en sy gesofistikeerde tegnologie oorwin kan word. As gevolg van hierdie opvatting, die verandering van die landskap en die blatante ignorering van die natuurlike bevrediging van die mens se stedelike behoeftes (beide residensiël en ekonomies), het dit in baie gevalle gelei tot 'n toename in omgewingsrisikos.

In hierdie artikel, sal die probleme en die wisselwerking tussen die omgewing en die stad ondersoek word, met verwysing na die Vaaldriehoek.

INTRODUCTION

The Vaal Triangle forms the southernmost section of the Pretoria-Witwatersrand-Vereeniging Complex (PWV Complex) which constitutes the economic heartland of the Republic of South Africa. The Vaal Triangle consists of the closely spaced towns of Vereeniging, Vanderbijlpark, Sasolburg, Sebokeng and Meyerton. This urban agglomeration spans the Vaal River, with Sasolburg situated in the Orange Free State, and the other towns in the Transvaal (Figure 1)

The Vaal Triangle has a present population of approximately 500 000. The area plays an extremely important role in regional and national context, especially in respect of the basic iron and steel industry and the petrochemical industry. The development of the area over the past 100 years and the attraction of industry can mainly be attributed to three natural factors. These factors are the occurrence and exploitation of coal and clay deposits, and the availability of water. However, strange as it may seem, it is these positive natural factors which also place the greatest limitations to urban growth in the Vaal Triangle.

GEOLOGY

Figure 2 is a generalized geological map of the area. This area is underlain by a variety of sediments, metamorphosed sediments as well as igneous rock of different ages. The oldest deposits consists of the quartzites of the Black Reef. These quartzites however have only limited outcrops and are therefore not shown on the map. The next important rock group, with a rather limited outcrop area, is the dolomite of the Chuniespoort group, while the Hekpoort andesite and Daspoort quartzite (also with rather limited outcrops) form, together with the Black Reef quartzites, the rocks of the Transvaal Sequence. These older rocks are overlain by the younger sedimentary strata of the Ecca group of the Karoo Sequence. These rocks have been intruded by dolerite (also of Karoo age).

Unconsolidated materials of Tertiary to recent age cover the rest of the area. These occurrences are mainly in the west of the area along the banks of the major drainage routes.

Although only a relatively small section of the study area is underlain by dolomite, a few sinkholes and subsidences do occur (Figure 3). There is no assurance that the rest of the dolomite sections will be permanently safe if further development were to take place thereon, or if the underground water resources in these rocks were over exploited.

As far as all the other rocks underlying

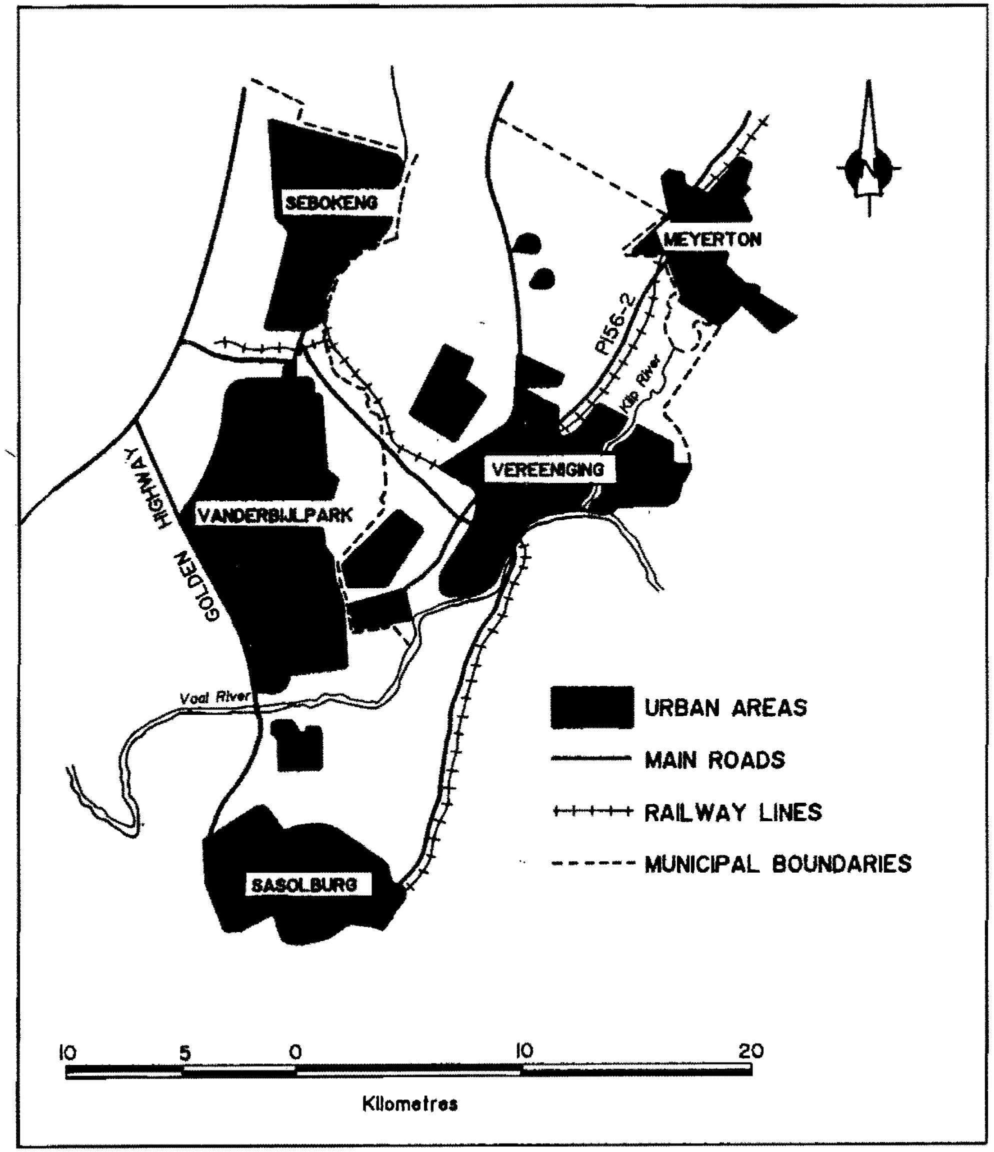

FIGURE 1 THE VAAL TRIANGLE

SOURCE: Office of the Prime Minister, 1982

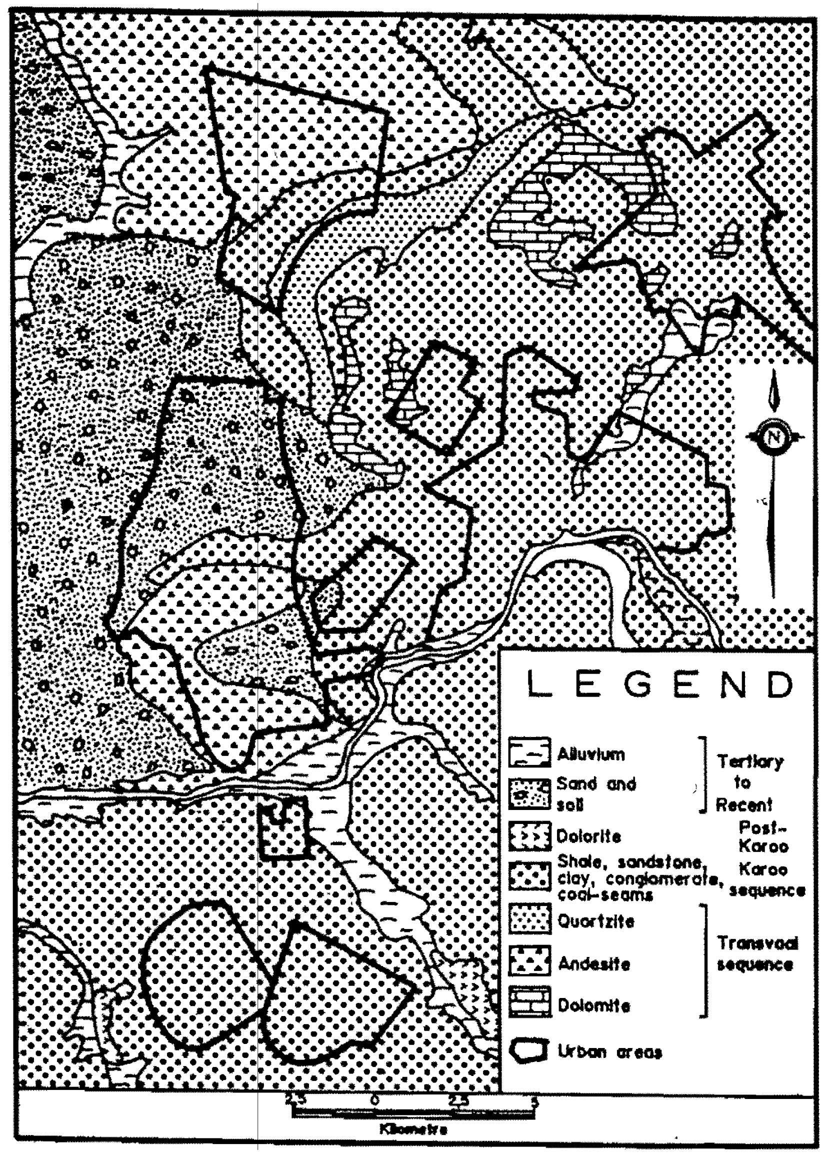

FIGURE 2 GENERALIZED GEOLOGICAL MAP OF THE VAAL TRIANGLE

SOURCE: R.S.A., Geological series, 1967

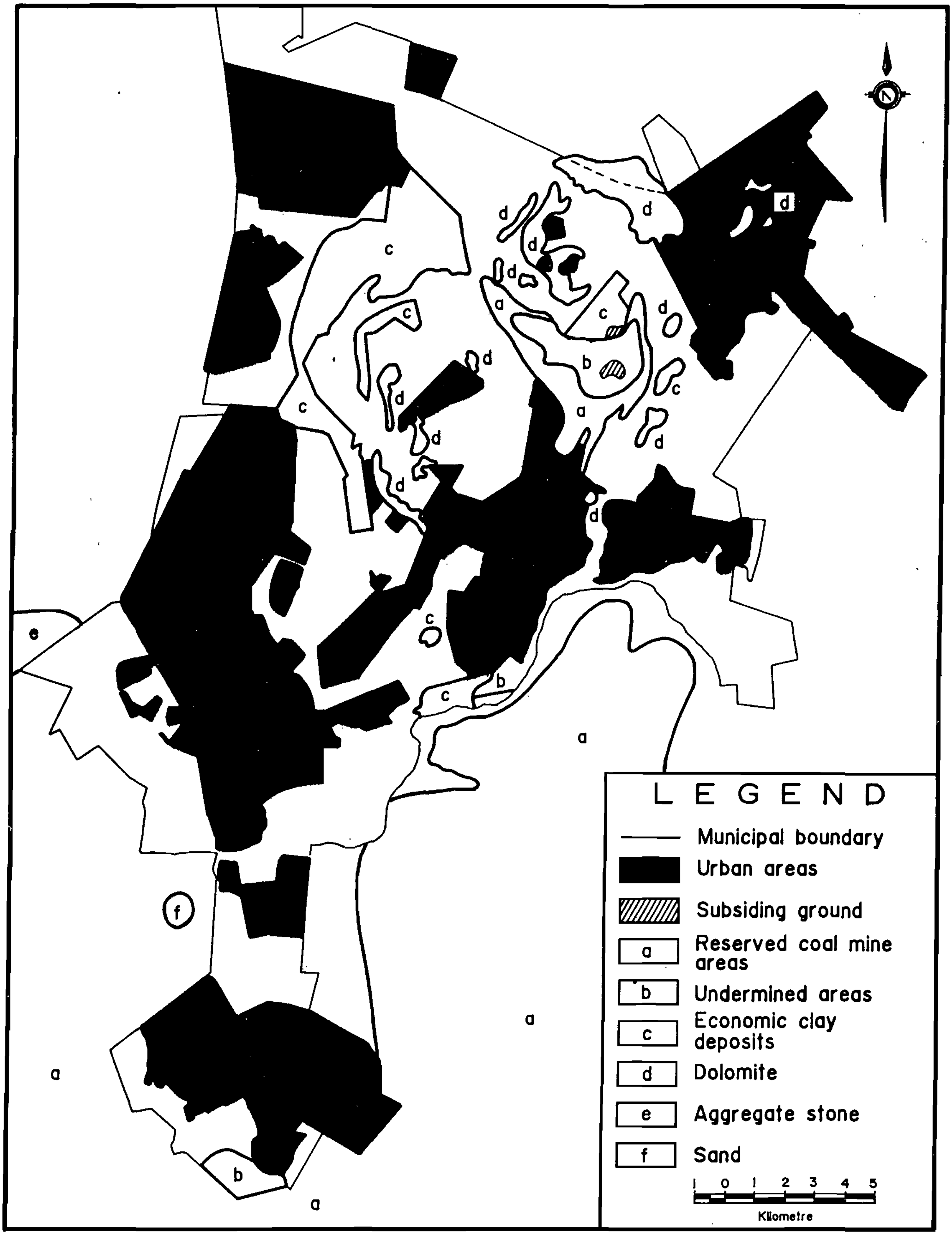

FIGURE 3 GEOLOGICAL LIMITATIONS TO URBAN DEVELOPMENT

SOURCE: Nieuwoudt, 1983, Office of the Prime Minister, 1982 the area is concerned there is no apparent reason why development should not take place on these rock types if due regard is paid to the heaving clays which cause cracking of all types of structures, particularly houses (see also Brink, 1985:241–247). However, as will be shown, the economic mineral deposits in the Ecca group of rocks do pose a problem for development.

MINERAL RESOURCES

The mining industry, and especially the influence which the availability of coal had on the location of industries, played an important role in the structural development of the Vaal Triangle. The coal which is produced in the area is generally of a quality which, due to its relatively low calorific value, is used mainly for the production of electricity (the presence of coal has resulted in several power stations being erected in the area), for the production of synthetic oil from coal, and as a source of power for the iron and steel industry. As the coal forms an important part of the resources that are utilized in the development of the Vaal Triangle, the distribution of this commodity is of vital importance to the area. Thus the coal deposits in the area have been reserved for present and future mining operations by the Guide Plan for the Vaal Triangle. This restricts development on the affected areas.
Economic coal deposits are found over an extensive area to the east, south and south-west of Sasolburg and over a more restricted area to the north of Vereeniging (Figure 3).

The layers of coal are covered by thick layers of sand, clay, weathered shale and sandstone. As the areas underlain by coal are relatively flat the drainage of rain-water and surface-water is often inadequate. This has seriously hampered the exploitation of coal. As a result of possible roof collapse and the danger of strong water resources (especially in the dolomite) being opened by blasting, special techniques often have to be applied in these mines. Because of the water hazard mining operations to the north of Vereeniging had to be abandoned. Subsequently subsidence already occurred in this undermined area (see Figure 3).

The sections to the east and south of Sasolburg have already been extensively undermined and no buildings are allowed there. The areas to the south-west of the town as well as certain areas to the east and south where mining operations have not as yet occurred, have been reserved for future mining. The reserved areas should also be treated as potentially hazardous in future years (when the coal has been extracted).

The growing demand for coal and more advanced mining methods will result in low-grade coal, which could previously not be exploited economically, being mined profitably. The economically exploitable reserves will therefore increase in the future, which may lead to bigger areas being used for mining purposes, especially in the vicinity of Sasolburg. It is also expected that increased use will in future be made of open cast mining methods: to exploit a much larger percentage of coal than that at present mined by conventional methods. In both instances urban development will to a large degree be restricted in the vicinity of Sasolburg. In the event of the open cast method being used the surface can be restored and in future be used for agricultural purposes.

It needs also to be mentioned that the dolomite is considered as a mineral resource, because it is already utilized as a flux in the blast-furnaces of the iron and steel industries of the Vaal Triangle.

Several types of clay which are used in the ceramics industry are excavated to the south, west, north-west and north of Vereeniging, and to the north and east of Meyerton (Figure 3).

Stone for construction purposes is found over extensive areas on the northern boundary of Sebokeng and to the west of Vanderbijlpark. With a view to the needs of the area itself, as well as those of the East Rand and the Far East Rand, where the sources of stone for construction purposes are fast being depleted, provision has been made in the Guide Plan for the Vaal Triangle for the reservation of the areas where the stone is found.

Sand deposits which are up to three meters thick are generally found along the Vaal River. The sand is generally suitable for construction. Apart from local needs these deposits will also have to provide for the broader regional needs, including the southern parts of the Witwatersrand. Special attention will thus have to be paid to the reservation of these areas.

TOPOGRAPHY

This area falls within the so called Karoo-Highveld. The area possesses a slightly undulating to flat topography. The only exception to this general rule is to be found in the north-western corner of the area to the south-east of Sebokeng. Here a low ridge has developed on quartzite with a relative relief at maximum of about 100 meters above the rest of the area. This ridge has a roughly north-south trend in its southern portion, while it takes a roughly north-east to south-west trend in its northern extremity.

The towns in the area have in general been built on relatively flat terrain. Meyerton has slopes that vary between 1:50 and 1:20; Vanderbijlpark has slopes that are at maximum approximately 1:80 while Sasolburg's slopes are approximately 1:110 and Sebokeng, with a maximum slope of approximately 1:125, was built on the flattest terrain available in the area. It needs to be mentioned however, that these slopes were measured on a scale of 1:50 000 with a contour interval of 20m. Microrelief (that is any feature of a height of less than 20m that falls between any two contours) may present problems. This is especially true in the vicinity of the major drainage routes, where step-like features along the river banks are present.

The steep slopes along the ridge described above are shown in Figure 4. This area is the only one that presents problems to development from a topographical point of view.

DRAINAGE

The whole area is drained by the Vaal River and its tributaries. The main tributaries are shown in Figure 4. Table 1 lists the approximate slopes of the tributaries of the Vaal River and the subtributaries of some of the Vaal's major feeders.

The Vaal River's gradient however, is even lower. It is approximately 1:4 000 in the Vaal Triangle vicinity. These gradients reflect the general flatness of the area. This leads to one of the problems that can be expected in the sense that due to this low gradients, flooding presents a hazard that needs to be taken into consideration. The floodline of the 1975 flood is also shown in Figure 4.

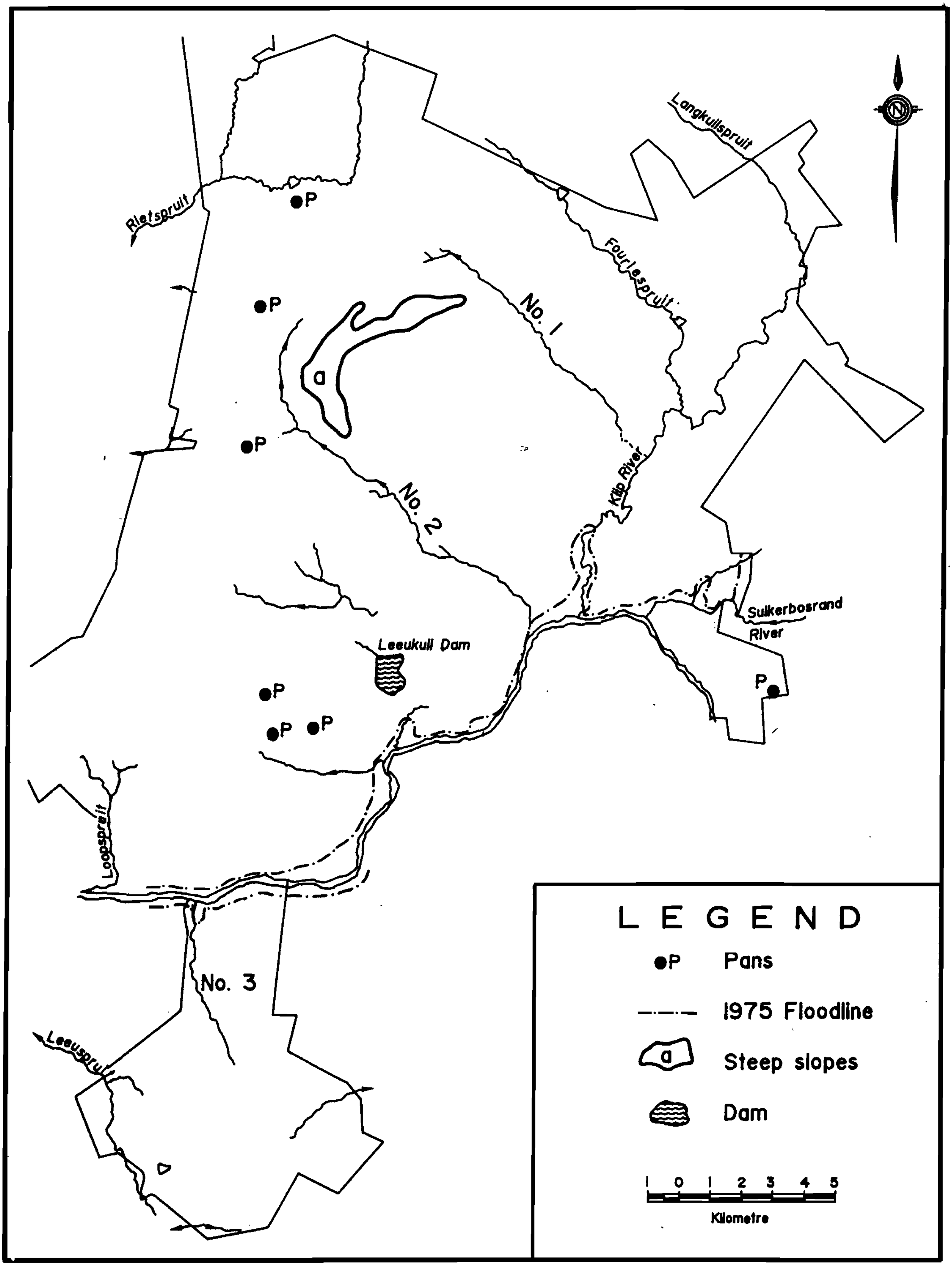

FIGURE 4 TOPOGRAPHY OF THE VAAL TRIANGLE

SOURCE: Nieuwoudt, 1983

TABLE 1 APPROXIMATE SLOPES OF SOME TRIBUTARIES.*

TRIBUTARY	APPROXIMATE SLOPE
Klip River (north-eastern section)	1:975
Klip River (lower section)	1:1 583
Langkuilspruit	1:200
Fouriespruit	1:175
Spruit 1	1:150
Suikerbosrand River	1:2 000
Spruit 2	1:157
Spruit 3	1:500
Leeuspruit	1:300
Rietspruit	1:273
Loopspruit	1:115

* Calculated from data on 1:50 000 topographic maps.

Serious floods occurred in 1958 and again in 1975 – especially around the area to the south of Vereeniging, where the Klip River flows into the Vaal River. Parts of the residential areas of Three Rivers and Vosloo Park, the Zoological Gardens, the Riviera recreational resort, and the municipal caravan park along the northern bank of the Vaal River and to the south of Vereeniging were inundated. The occupants of the houses had to evacuate their homes and in both instances the animals in the Zoological Gardens had to be rescued.

Another problem that is generally found where rivers have low gradients is that of marshiness. Fortunately only small portions of marshland are found in the lower region of both the Klip and Suikerbosrand Rivers. A large marshy area does however exist to the south of the Vaal River at Makouvlei. This marsh falls outside the main study area.

A few pans are also found in the area. They are rather small and do not represent a large proportion of the study area.

SOILS

One of the main foundation problems in the whole Vaal Triangle area, affecting both light structures, like houses and businesses, and major construction, like power stations, is that of heaving clay.

As early as 1952 tests were undertaken in the suburb of Leeuhof in Vereeniging by the National Building Research Institute (N.B.R.I., 1952:7–24) to find solutions for the cracking problems which were being reported (see also Brink, 1985: 243–247; Steyn and Collins, 1952:14–23; Collins, 1953:219–237; and Collins, 1957:273–285 for more information on the test programme). In brief it was eventually established that on clay soils:

* the heaving pattern of a building in the area is cumulative and is directly related to rainfall;
* while the general movement will tend to an equilibrium after several years, with a probable domed final shape, distortions due to local effects are sufficient to damage a building and will be greatly aggravated by such influences as broken drains, shrubs and trees, and garden watering;
* 80 per cent of all movement occur at depths between 1,8 and 5,5 metres;
* the movement of piled foundations generally decrease with depth of founding;
* piled foundations isolate buildings from the heaving soil and rigid reinforced brickwork structures ride out the movement without enough distortion to cause cracking;
* a relatively cheaper approach is the use of expansion joints to divide brickwork buildings into a number of separate reinforced rigid units which can move relative to each other but remain intact in themselves;
* where severe heave is experienced, the latter method can only be used in association with a stiffened raft foundation that damps out the severest differential movements (Brink, 1985: 246).

As no engineering geology map is at present available for the study area as a whole, the agricultural soils map by Loxton, Hunting Associated (1970) and the classification of soils by MacVicar et, al. (1977) have been used in the description of this physical parameter. Proper evaluation of specific building sites should however be based on the engineering geology of the area to be developed in any detail. This takes into account the deep soil profile as far as bedrock and the influence of the water table on any form of construction. Thus it is clear that in developing such areas, an engineering geologist should be part of the planning team from the conceptual stage onwards.

Five major agricultural soil associations occur within the confines of the study area. The Lindley and Gelykvlakte association (see Figure 5) that occurs in the south-western portion of the study area, imposes some restrictions on building activities in these areas. The reason for this is that the Gelykvlakte series has a clay percentage of between 30% and 60% in the A-horizon. Any construction on this soil should be built on pile foundations. The Lindley soil series, with a clay content of between 30% and 35% (in the B-horizon) needs certain elementary precautions such as foundations that make provision for differential movement in the soil (Institute for Pedological Research, PU for CHE, 1986).

According to Schmitt (1979:27) the Westleigh series imposes some restriction on building activities due to the plasticity index of between 11% and 43% of the B-horizon, however, if the same precautions are taken as with the Lindley soil series, buildings could be erected on this soil series. The other soil series namely the Kroonstad series that was mapped in association with the Westleigh series poses serious problems to any urban development. The reason being that these soils possess a sandy E-horizon with a collapsible grain structure that will consolidate if pressure is applied to the horizon. The 'collapse settlement' of the soil is associated with differential wetting of the E-horizon. It is suggested that this saturation of the sandy E-horizon is associated with the clayey material underneath the E-horizon (Schmitt, 1979:28).

The soils mapped as the Shorrocks association, as a rule exhibit few problems as far as urban development is concerned. It needs to be mentioned however, that some of the subdominant soil series that are included in this mapping unit do pose some restriction on building activities. The soils referred to are the so-called Rietvlei en Soetmelk series. If buildings are to be erected on soils of these two subdominant series, it would be advisable to have a careful investigation of the underlying parent material. If the parent material consists of clayey sediments, the best probable founding method would likely be piling (especially for larger constructions). The Soetmelk series would. as in all probability, need

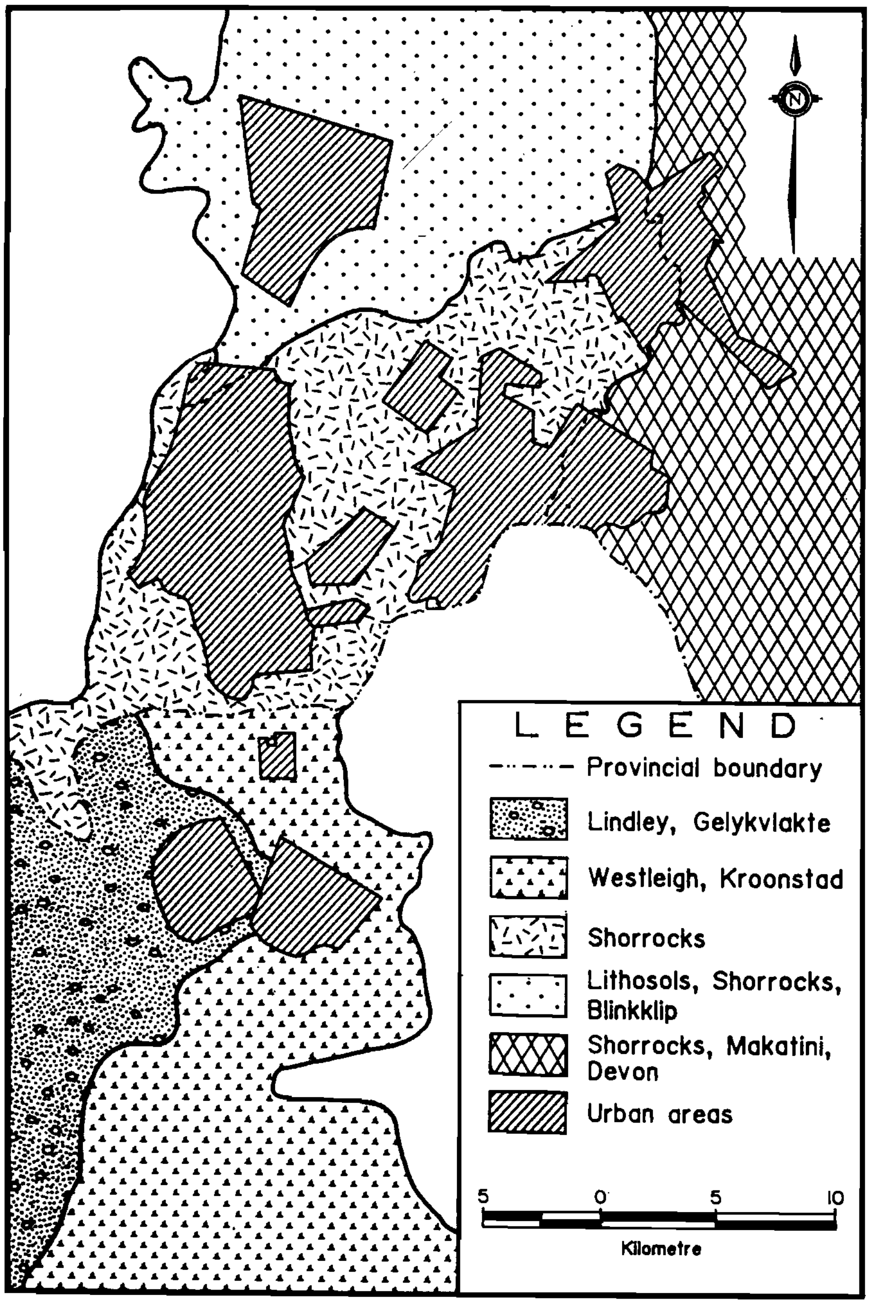

FIGURE 5 SOILS OF THE VAAL TRIANGLE

SOURCE: Loxton - Hunting, 1970

a special foundation.

The northern portion of the study area is underlain by a soil association characterized by lithosols, as well as Shorrocks- and Blinkklip series. These dominant series pose no problems to building. One of the subdominant soil series found within this mapping unit namely the Makatini series, poses some problems due to the high percentage of clay in the B-horizon. However, if precautions regarding foundation construction are taken which allow for differential movement, this soil series can also be utilized for the building of certain structures.

The last major soil association found in the study area is that of the Shorrocks-, Makatini- and Devon series. The first two series have already been discussed under the other associations. The Devon series does not pose unsurmountable problems to urban development. If the underlying parent material however consists of clayey sediments, the same precautions as suggested with the Rietvlei series should be adopted.

It can be concluded that most of the soils that occur in the study area will cause certain problems for urban development. Most problems can however be overcome by using the right method of construction. It is only in the case of soils that belong to the Kroonstad series that really serious problems will be encountered when normal urban development occurs.

INFLUENCE ON THE DIRECTION OF URBAN DEVELOPMENT

The importance of the above-mentioned physical limitations to urban development have also been accepted by the Guide Plan Committee, which was established by the Central Government in 1978 to formulate a guide plan for the Vaal Triangle. The Guide Plan was completed in 1982. The plan is statutorily binding and serves as the framework within which physical planning must take place on urban and regional levels. The recommendations of the guide plan are illustrated in Figure 6.
As can be seen on the map, dolomite and economic coal deposits to the north of Vereeniging, where subsidence has already occurred, forms an obstruction to the convergence of Vereeniging and Meyerton.

Economic clay deposits are found over a substantial area to the south-east of Sebokeng. The clay deposits and the adjoining hilly range, where slopes greater than 10 percent are general, form a natural boundary between the urban areas of Vereeniging and Sebokeng.

The flood area along both banks of the Vaal River and along the lower parts of the Klip River restrict the development along these banks to open spaces, natural areas, and recreation. The same applies to the river bank to the north of Sasolburg. The sandy E-horizon of the soils along the river bank to the north of Sasolburg, poses further restrictions to urban development in this area.

Economic coal deposits and existing mining operations to the east and south of Sasolburg make these areas unutilizable for urban development. Possible economic coal deposits and the high clay potential of the Gelykvlakte series to the south-west of Sasolburg, make urban development in this area undesirable. Urban development in Sasolburg has therefore no option but to extend in a northerly direction. Development to the north will however, eventually be checked by the Vaal River.

To the west and north of Meyerton outcrops of dolomite confine development to agriculture and natural areas.

The great demand for aggregate stone and sand for the construction industry led to certain areas in the Vaal Triangle being reserved for current and future use thus making them unutilizable for urban development.

CONCLUSION

From the previous description and Figure 6 it is abundantly clear that present urban development in the Vaal Triangle had been shaped in no small way by physical factors, both inside and surrounding the built-up area. Man's utilization of some of the physical attributes in the Vaal Triangle and his disregard for others in urban development has led to an increase in environmental hazards as illustrated by subsiding ground and flood damage that has occurred. From the Guide Plan indications are that economic considerations, with reference to the physical attributes of the area, will be a major force in the ultimate configuration of the built-up area of the Vaal Triangle. However, the Guide Plan also indicated an awareness that preserving an adequate environment is part of a greater scenario relating to urban growth and planning in the area.

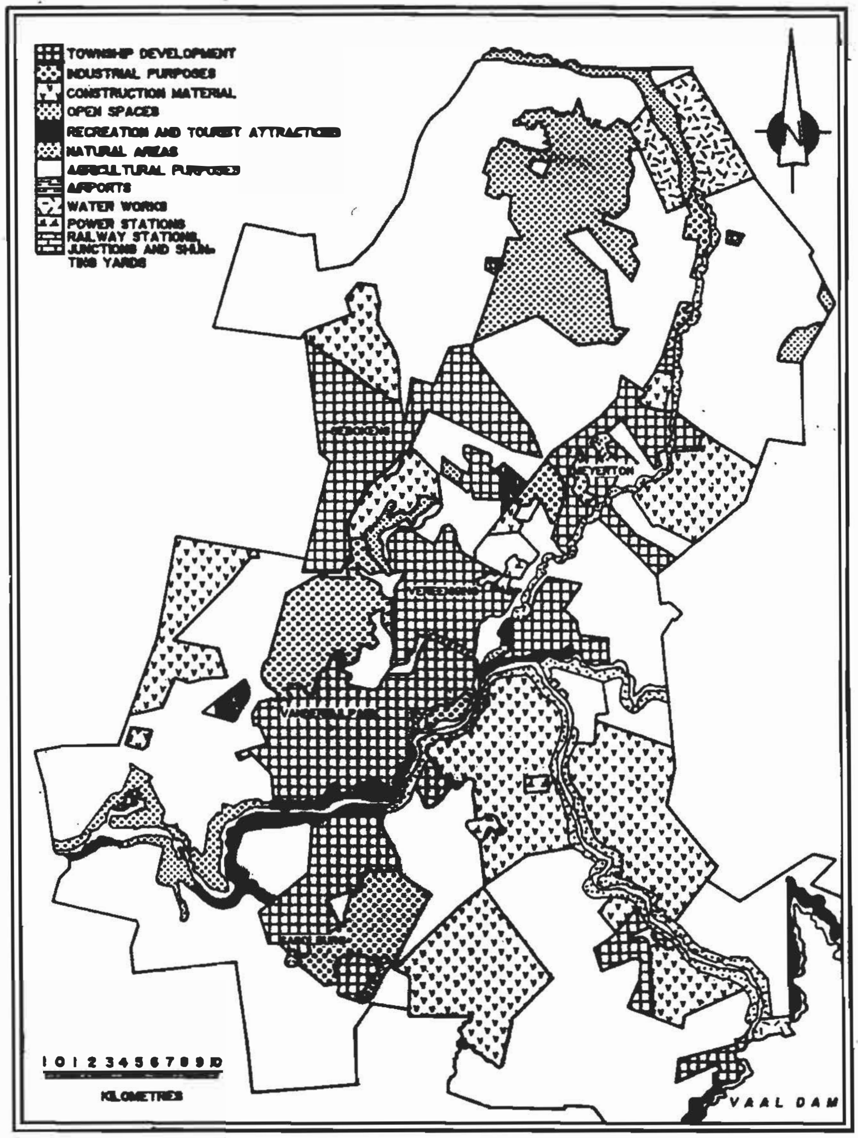

FIGURE 6 VAAL TRIANGLE GUIDE PLAN

SOURCE: Office of the Prime Minister, 1982

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