CHAPTER VIII

SUMMARY AND CONCLUSIONS

GENERAL

The study area covering 1438 sq km is a part of the Saurashtra Peninsula of the Gujarat State and lies between 22°30' to 22°45' N and 71°00' to 71°30' E in one inch to a mile Survey of India Toposheet No. $41\frac{N}{2 \& 6}$. Within the area all roads and railways lead to Than which is an industrial town. The temperature variations and the average rainfall in this area, are 5.59° to 43.20°C and 500 mm respectively. The climate is semi-arid type. The natural vegetations are mostly thorny type and have stunted growth. Physiographically, this area is a part of inland plain of Saurashtra. Western Region of this area shows hilly and undulating ground while Eastern Region shows plain ground with few isolated hillocks. The rivers are mostly seasonal and influent type. This area has been broadly investigated in the past by geologists from Geological Survey of India, Department of Geology and Mining and Public Works Department, Government of Gujarat.

The main purpose of the present investigations is to classify the soils into soil/land irrigability classes and irrigability classes and to assess the available engineering and industrial resources. The soil samples from augerbores

were tested for their physical and chemical properties to classify the soil/land for the purpose of irrigation. The samples of soils taken from openpits, sands from river beds, crushed aggregates and rocks from quarries were tested for their engineering properties to find out their suitability as construction material. The industrial resources were examined for their industrial use. Groundwater conditions were studied to assess the potentialities of sub-surface water for irrigation and drinking purposes.

Methods of investigation used in this area include geological mapping, soil survey for irrigation and engineering purposes, survey for material resources and survey for ground water conditions.

GEOLOGY

Geologically, this area consists of rocks of Dhrangadhra Group, Wadhwan Group and Deccan Trap including lava flows and intrusives. The general geological sequence of this area based on field observations is as follows:

Soil	:	Sandy to loamy and medium black soils
Deccan Trap	:	Lavaflows and intrusives
----------		Unconformity ----------
Wadhwan Group	:	Upper - White and ferruginous sandstone having quartzite on top.
	:	Middle - Limestone and sandstone
	:	Lower - Dull brick red coloured sandstone
Dhrangadhra Group:		Ranipat Formation - Upper
	:	Surajdeval Formation - Middle
	:	Than Formation - Lower

---------- Base not exposed ----------

DHRANGADHRA GROUP: The rocks of this group are well exposed and cover greater part of the study area. The general dip varies from nearly horizontal to 5° except near the contact of dykes. Sandstones are medium to coarse grained and often gritty in texture. The grains are generally rounded to subrounded. They show current bedding, stratification and honey comb type weathering. The prominent joint directions are N-S and E-W. The river flowing through these rocks show dendritic drainage pattern. Sandstone of Ranipat Formation is harder than that of Than Formation.

WADHWAN GROUP: The rocks of this Group are exposed in the Eastern Region of this area. The general dip varies from 5° to 10°. In the river sections of Bhogavo-I the outcrops shows great variation in dip. It consists of dull, brick red coloured, friable sandstone with slightly calcareous matrix.

DECCAN TRAP: It includes lavaflows and intrusives. Basalt is hard and tough. It is fine to medium grained and porphyritic in texture. It shows spheroidal weathering and columnar joints. Fine to coarse grained doleritic dykes having 2 to 5 m width, show E-W trend. These dykes are similar to basalt in mineral composition but show the presence of olivine and ophitic texture. They are more concentrated in the Western Region than in the Eastern Region of this area.

SOIL/LAND IRRIGABILITY CLASSIFICATION

The rapid reconnaissance soil survey was carried out on a base map (one inch to a mile Toposheet No. $41\frac{N}{2 \& 6}$) to get comprehensive information about the soils for broad irrigation and land use planning of the study area. The soil samples were collected from 30 augerbores spaced at a distance of 6.9 km approximately. These soil samples were

tested in the field and laboratory for their physical and chemical properties.

The soil depth varies from moderately deep to deep (30 to 90 cm from surface). The soils are found in low-land to mid land areas. Their drainage capacity is moderately drained to well drained and the degree of erosion varies from slight to moderate. Soils found on Deccan trap are as fine to medium textured loamy soils and show the increment in lime content from surface downwards. Soils found on the rocks of Dhrangadhra and Wadhwan Groups are coarse textured sandy soils and coarse to fine textured loamy soils.

Soil colour of the surface soils is brown to greyish brown and that of the subsurface soils is brown to dark brown. The textural classes of surface soils vary from loamy sand to sandy loam and that of sub-surface soils vary from sandy loam to clay loam. The available water holding capacity of surface soils varies from 0 to 6 cm and that of sub-surface soils varies from 2 to 12 cm. The permeability of surface soils and sub-surface soils ranges from 0.5 to 13.0 cm/hr. The soil reaction for surface soils to sub-surface soils is mildly alkaline to moderately alkaline (pH - 7.4 to 8.4). The percentage of salts/alkalies

in surface soils and sub-surface soils varies from 0.25 to 0.50. The depth of groundwater level varies from 3 to 15 meters.

From the above results, the soil/land of this area is broadly divided into three divisions. Irrigable soil/land class including Classes II, III & IV, covers 80% area of the total land which may be utilized for agriculture under irrigation. Non-irrigable soil/land class includes the area covered by hills, gullies and rock exposures. Unclassified soil/land class includes the area covered by railways, roads and rivers with their tributaries.

Land use capability is indicated as Class-III and Class-IV which falls within the land suitable for cultivation, with major limitations from the results of inherent soil characteristics, viz. colour, texture, permeability, and soil reaction; external land features, viz. slope, erosion, drainage and depth to water table; and climatic conditions of the area.

ENGINEERING AND INDUSTRIAL RESOURCES

Engineering material resources include natural fine aggregate, crushed aggregate and buildingstones.

Natural fine aggregate consists of soils taken from openpits and sands from river beds. Soil samples from five openpits were tested for their index and engineering properties in the laboratory. Soils for general engineering purposes were classified from the grain size distribution curve and plasticity chart. SM and SC group symbols indicate silty sands and clayey sands respectively, while CI group symbol indicates inorganic clays with medium plasticity. The characteristic properties for these three soil types are given in the following table:

Characteristic properties	Soil Type		
	SM	SC	CI
Liquid limit (%)	Non plastic	27-38	41-43
Plastic limit (%)	Non plastic	14-22	23-25
Plasticity index (%)	Non plastic	10-16	18
Maximum Dry Density (lb/cft)	122 - 132	117.5-127.0	107.5-110.0
Optimum Moisture content (%)	7.5-8.6	11.5-16.2	14.6-18.0
Permeability (cm/sec)	9.4×10^{-4} - 6.0×10^{-5} (Pervious to semipervious)	2×10^{-6} - 8×10^{-6} (Semi-pervious to Impervious)	Impervious
Specific Gravity	2.76-2.81	2.64-2.66	2.58-2.60
Soaked CBR Value (%)	5-6	4-5.5	3.6-4.0
Shear Strength Cohesion (lb/sq in)	0.0	0.5	1.0
Internal friction	34°-35°	31°-33°	25°-25.5°

Petrographic study of fractions (+52 mesh BS sieve) of openpit soil samples indicated the presence of the constituents, viz. quartz, sandstone, calcareous sandstone, ferruginous sandstone, shale, clay lump, and trap. The heavy mineral study of fractions (between 80 and 120 mesh ASTM sieves) of openpit soil samples indicated the presence of augite and basaltine (hornblende basalt). The clay mineral study of fractions (0.002 mm or less in diameter) of openpit soil samples indicated the presence of illite, montomorillonite and beidellite.

The fineness modulii of six river sands range from 1.7 to 2.9. The deleterious materials present in these sands are cryptocrystalline silica and clay lump (upto 4 per cent).

The crushing values and abrasion values of crushed aggregates of trap and quartzitic sandstone are within the limits of specification for their use as construction materials.

The dry crushing strength of yellow and white sandstones indicates that they are weak to medium strong rocks.

Industrial material resources include industrial clay, silica sand, coal and raw materials for lime. Fire

clay is used in ceramics. Silica sand is used as in glass, foundary and ceramic industries. Coal is not used as fuel due to its poor quality. Cherty limestone and kankar are used locally to prepare lime.

HYDROGEOLOGY

The surface water is available from Machhu, Maha, Balal, Bambhan and Bhogavo-I rivers. Dyke cutting across a river course forms a barrier giving rise to natural reservoir for surface water. The artificial reservoirs by constructing dams across the river courses provide surface water.

Sub-surface water is available from open wells, dug-cum-bore wells and tube wells. The depth of water level in openwells varies from 3 to 15 meters from the surface during dry season. Many openwells located in sandstone near the contact of dykes act as barriers for groundwater movement. Sandstones are most productive aquifers for groundwater storage. Weathered trap as well as joints and openings in trap allow storage of groundwater.

The recharge of groundwater to the openwells is through joints, pores, bedding planes and weathered rock materials. The annual rainfall and artificial reservoirs

are the main sources for recharge of groundwater in this area. A contour map was prepared from the measured depths of static water levels in openwells and the groundwater potentialities for drinking and agricultural purposes were assessed.

CONCLUDING REMARKS

(1) White, light yellow and yellow coloured sandstones of lower Dhrangadhra Group are fine to medium grain in texture with argillaceous cement. They are easily dressable and carvable. They are weak to medium strong rock having 180 to 320 kg/cm^2 dry crushing strength. These rocks are quarried near Mahika and Songadh. They are suitable for the construction of buildings and temples.

The purplish brown coloured sandstone of Upper Dhrangadhra Group is very coarse to gritty in texture with ferruginous and siliceous cements. This sandstone is not easily dressable. They are mostly unsuitable for walls with fine finish. However it can be used in coarse rubble masonry work.

Greyish black to black coloured rock from Deccan trap lavaflows is fine to medium grain in texture. Due to the presence of columnar joints, 30 cm x 20 cm

blocks are available from quarry near Daldi. These blocks are used in the construction of culverts and as slabs and floor paving. In the old historical structures, these slabs have been used in fortwalls and other massive structures.

(2) The crushed aggregates of Deccan trap lavaflows from crusher plants located near Daldi and Muli having crushing values 16.66 and 19.30 per cent respectively and abrasion values 17.70 and 13.60 per cent respectively, are suitable for cement concrete work and as road aggregate and railway ballast.

The crushed aggregate of Upper Dhrangadhra sandstone quarried near Ranipat having crushing and abrasion values 30.64 and 29.00 per cent respectively, is not suitable as road aggregate, railway ballast, and for concrete work because of high crushing value.

The crushed aggregate of lower Dhrangadhra Group quarried near Sara having crushing and abrasion values 38.63 and 52.10 per cent respectively, is not suitable for any type of construction work because of its high crushing and abrasion values.

(3) White friable sandstone of Middle Dhrangadhra Group having high silica and low alumina and iron contents, is suitable for making silica sand for glass, foundry and ceramic industries.

(4) The river sands from Maha, Balal and Bambhan having fineness modulii from 1.7 to 2.3 and less than 3% deleterious materials, are suitable as fine aggregate for construction. The river sands from Bhogavo-I and Kharodia nala (Machhu river) having fineness modulii from 2.1 to 2.9 and more than 3 per cent deleterious materials are not suitable as fine aggregates. The deleterious materials is mostly clay. If this fine aggregate is properly washed to remove clay, it can be effectively used in construction work.

(5) The textural classification of surface soils (upto 15 cm) indicates that 2/3 of the study area is covered by loamy soil and has greater available water holding capacity than the remaining area covered by sandy soil. The irrigable soil/land classification indicates that 80% of the total area of soil/land is suitable for irrigation purposes.

(6) The land capability classification indicates that in general, the study area falls into class-III

and Class-IV categaries. The land is fairly good to moderately good for cultivation with major limitations. Careful selection of crop with intensive treatment is necessary to overcome soil limitations.

(7) The soil classification for general engineering purposes, of soils from five openpits indicates the presence of SM, SC and CI Soil types. SM and SC are silty sands and clayey sands respectively. SM Soil is non plastic and semipervious to pervious. It is moderately good for the construction of homogeneous embankment and for the semi pervious zone of earth dam. SC soil is medium plastic and semipervious to impervious. It is moderately good to good for the impervious zone of earth dam. CI is inorganic clays with medium plasticity. It is plastic and impervious. It is moderately good for impervious zone of earth dam.

The soaked CBR values for all the soil types rangs from 3 to 6 per cent which are much lower than 20 per cent. These soils cannot be used as subgrade or base material for road making without lime treatment.

The petrographic studies of these openpit soil samples giving the presence and nature of constituents and heavy minerals, indicate that soil near Sidsar and

Sayla comprising of angular grains of augite and basaltine with sharp edges and fracturing, though having Deccan trap as parent material, are of residual type. The soils near Sarsana, Than and Sudamda Nava comprising of rounded grains of augite and basaltine without sharp edges and fracturing, though having rocks of Dhrangadhra and Wadhwan groups as parent materials are of transported origin.

(8) Hydrogeological studies indicate that groundwater in the openwells is found at 3 to 15 meter depth. Rocks of Dhrangadhra Group yield both sweet and brackish water in openwells. The groundwater below the carbonaceous shale of Than formation is generally saline. The ground water obtained from weathered trap rock and from shallow aquifer in Wadhwan sandstone and Dhrangadhra sandstone is brackish while that from deep aquifer in Dhrangadhra sandstone is good for drinking and agricultural purposes.

(9) The studies indicate that the soil and rock types in Western Region investigated, can be further explored for material resources. On the other hand, the topography of Eastern Region indicates that there is considerable scope for developing agriculture through minor irrigation schemes and lift irrigation.