2.3 Result of Field Investigation

2.3.1 Existing Conditions along Batinah Highway

Reconnaissance surveys were conducted along the project area. This field investigations revealed the following situations:

(1) A rehabilitation project for the old carriageway of Batinah Highway between Bait Al Barakah R/A and Al Khaburah R/A is currently underway. The rehabilitation works are being carried out in various stretches along the highway. Adequate traffic control measures are being taken with the other carriageway along the affected stretches operating as a two way road.

(2) A pedestrian underpass facility is being constructed at Al Bidayah Junction, at around 8 km before the Al Khaburah R/A. Construction commenced around October 1995 on the new carriageway side. Similar traffic control measures as in (1) are being taken.

(3) Civil works for a roundabout at Al Muladdah R/A is being carried out to replace the old T junction. The works currently affect the new carriageway side of the highway.

(4) A new monument is now under construction at Sohar R/A. Except for a few construction trucks a day entering and exiting the roundabout, there is no significant effect on traffic flow at this roundabout.

(5) The highway beyond Al Khaburah R/A is not affected by any road works and is in excellent condition.

(6) Improvement of Route No.11 to a dual carriageway two-lane road from Rustaq to Al Hamza has been completed. The remaining stretch from Al Hamza to Al Muladdah R/A is still in process.

(7) Although not directly affecting the project area, the road improvement work along Route No.15 Rusayl-Nizwa road for the section from Rusayl to Fanjah has been completed. This section of Route No.15 is now upgraded to a dual carriageway road with interchanges at Fanjah and junction to Bidbid.

(8) Development along the Batinah Highway such as construction of houses, shops are more noticeable along the stretch nearer to Muscat up to Al Khaburah R/A.

(9) Some debris are observed at curb sides and median at Irish crossing sections of the Batinah Highway. This is judged to be due to recent heavy rains along the region.

Except for the Pertial temporary closure of some stretches of the Batinah Highway for the rehabilitation work on the old carriageway and construction of a pedestrian underpass as well as a roundabout at Al Mulladah, the traffic flow of Batinah Highway is smooth with no noticeable congestion. Works to upgrade the junctions and adjoining roads such as Route No. 11 are continuously being carried out. All the roundabouts and their respective monuments or landscaping are also well maintained and in excellent conditions.

2.3.2 Natural Conditions

(1) Physiography

(a) The Major Physiographic Features of Oman

The Sultanate of Oman is located in the eastern part of the Arabian Peninsula. Oman covers an area of approximate 310,000 sq. km, the greater part of which is a hot, tropical desert. Oman has a contrasting landscape characterized by two deeply dissected narrow mountains areas, one in the north of the country (Oman mountains) and the others in the south (Dhofar Mountains) with elevations up to 3,000 m, and vast, generally flat, central plains, between 50 and 250 m above sea level.

Oman constitutes a major part of the coastline of the Arabian Peninsula that borders the Indian Ocean. The coast of Oman is washed by the waters of the Gulf of Oman in the northeast, and by the Arabian Sea in the southeast. Oceanic depths of 3,000 m or more occur not far from the coast, as is the case, for example, about 50 km off Muscat and Sur in the Gulf of Oman. The coastal mountains thus have a spectacular difference in altitude of more than 6,000 m between the peaks of the Oman Mountains and the oceanic depths of the Gulf of Oman.

(b) The Mountains in the North

The northern coastal region of Oman is formed respectively by the Oman mountain chain (Oman Mountains).

The Oman Mountains (also known as the Al-Hajar mountain range), extend about 700 km along the edge of the Gulf of Oman from Musandam in the north, to Ras Jibsh in the south. The chain is arcuate in form, narrow (30-40 km) at its extremities, and 100-150 km wide in its central part.

The mountains comprise the greatest variety of sedimentary and crystalline rocks in Oman. The higher peaks are made up of hard, resistant Mesozoic sedimentary rocks (260-90 million years [Ma]) which have been folded and buried, then subsequently uplifted since the Miocene, 16 Ma ago. These highlands constitute the main massifs of the axial zone of the Oman Mountains and are composed essentially of limestone in thick slabs. This axial zone culminates in three massifs; Jabal Akhdar which includes the highest peak in the country, Jabal Shams, at 3009 m, the Saih Hatat massif and the Musandam massif. In the heart of Jabal Akhdar, erosion has cut deeply into the ridge of the fold, creating large depressions such as the Ghubrah Bowl and the Wadin Sahtan or Amq Bowl.

In contrast, the softer sedimentary rocks, which are more thinly bedded and intensely folded, form smaller, dissected mountain chains and elongated hills, characteristic of the southern side of the Oman Mountains. Crystalline rocks, essentially from the Cretaceous Samail Ophiolite (about 90 Ma old), form large, deeply dissected massifs along the axial zone and at the foot of higher limestone massifs.

Along the coast, the Oman Mountains descend steeply into the Gulf of Oman between Muscat and Ras al Hadd, and into the Arabian Gulf and the Gulf of Oman in Musandam. The narrow Batinah coastal plain lines the northern flank of the mountains. In contrast, on the southern and western flanks, a vast piedmont zone with gentle slope characterizes the forehand of the mountain chain. Since Miocene-Pliocene times (about 5 Ma), enormous alluvial fans have been accumulating in this area, made up of sand and gravel derived from erosion of the mountains. The only striking topography in this area is that of ancient alluvial terraces incised by the more recent wadis, along with dune fields of the major deserts, the Rub al Khali and Wahibah Sands. Moving progressively southward from the highlands, the land surface becomes gradually flatter towards the great desert plain of Interior Oman.

(c) From the Coast to the Depths of the Ocean

1) Variations in sea level

The configuration of the present-day Oman coastline along the Gulf of Oman and the Arabian Sea reflects fluctuations of both climate and sea level during the Quaternary, i.e. the last 1.8 million years.

Although Oman and the middle East as a whole were not influenced directly by the great Quaternary glaciations, effects of related major falls in sea level are observed. Thus, 15,000 year ago at the end of the most recent glaciation, the mean global sea level was 100 m lower that of the present-day. The coastline at the this time, for example, was several tens of kilometers off the current coastline. A significant part of the present-day, shallow and fairy flat continental shelf was at this time dry land; aeolian sand dunes developed as a southward extension of the Wahibah Sands, and river channels which can still be discerned.

In contrast, during the Late Tertiary about 5 to 2 millions years ago, sea level was higher than at present. Marine coastal erosion cut into the Eocene limestone forming flat terraces and coastal cliffs along the eastern slopes of the Oman Mountains bordering the Gulf of Oman. Such features are clearly visible between Quryat and Ras al Had inland form the present-day coastline where five main stepped levels exist, with increasing altitudes of 15 m, 50 m, 110 m, 150 m and 190 m respectively. These levels represent the successive coastline positions from the end-Tertiary (Pliocene) to the recent Quaternary. However, the highest eustatic sea level known for this period was about 50 m during the Pliocene (Haq et al., 1987). Therefore, these marine palaeoterraces at current elevations of 110-190 m clearly indicate that they have been uplifted 60-140 m during the Pliocene-Quaternary period. This is the result of recent phase of movement following uplift and creation of the Oman Mountains which began in the Miocene, some 16 million years ago.

2) The submarine profile

Beneath the sea, a strip of shallow shelf is delimited by the 200 m bathymetric contour around the coast of Oman. This corresponds to the classic, continental shelf which borders the oceanic domain of the earth's surface. Around Oman, the width of the shelf varies significantly from one area to another. It is best developed along the southeast coast between Ras al Hadd and Hasik where it reaches a width of 100 km locally. The islands of Masirah and Al Halaaniyaat protruding from this shelf edge line of the Arabian Sea do not follow the irregular coastline pattern of large bays and promontories. Between Ras al Haad and Ras Sawqirah it is practically linear, orientated NNE-SSW. Further along the coast, the shelf runs essentially E-W towards Hasik in Dhofar, incorporating the Al Halaaniyaat Islands.

Around the Musandam promontory the sea floor is less than 200 m deep and forms a vast shelf zone in the Gulf of Oman and the Arabian Gulf.

Elsewhere, the continental shelf is very narrow, approximately 25 km wide along the Batinah Coast between Sohar and Muscat, and only about 10 km wide between Muscat and Ras al Hadd in the north, and off Dhofar in the south. In these areas the shelf limit mirrors almost perfectly the present-day outline of the coast. Narrow shelves are located at the foot of the two mountain ranges in the north and south of Oman, whereas the shelf is considerably wider the length of the central plains.

The continental shelf of Oman is narrow along the Gulf of Oman and the Arabian Sea, bounded by a relatively steep continental slope which descend towards the abyssal plain at a depth of 3,000 m or more. Recent sediments on such steep continental slopes, off Muscat in the Gulf of Oman for example, are commonly unstable and subject to gigantic submarine slides known as slumps (White and Ross, 1979).

The deep ocean floor is made up of abyssal plains. Several well-defined oceanic domains border the north, the south east and the south of Oman. To the north is the Oman Basin and the Gulf of Oman, bounded to the north by the gentle continental slope of Makran. To the southeast is the Owen Fracture Zone. To the south is the northeastern part of the Gulf of Aden, bounded to the south by another submarine mountain chain, the East Sheba Ridge, a relatively young segment of mid-oceanic ridge.

(2) Geology

(a) Geology of Oman

The geology of south and central Oman consists of predominantly Mesozoic and Cainozoic sediments overlying a pre-Permian basement. This continental shelf facies includes limestones, marls, sandstones, and evaporates. Bedding is essentially horizontal. Structural features include sporadic NE-SW faulting and a number of salt diapers which act as minor oil traps (Ghaba, Sahma, Qarn Alam). The oil pay zones are located in the Mesozoic sediments, and it is consequently extremely difficult to collect existing geological data on formations older than the early Tertiary. Rocks outcropping in the central desert platform are predominantly Oligocene/Miocene. Older formations including the basement are exposed in the core of the Huqf anticline on the east coast, and the southern escarpment of the Qara mountains.

The northern Oman mountains are the topographical expression of a narrow elongated complex fold belt. The Mesozoic Hajar group, which consists of a thick sequence of shallow marine limestones and dolomites with minor quartz sandstones, rests with unconformity on a pre-Permian basement of conglomerates, quartzites, slates and granite. These basal metamorphic form the core of the Oman mountains. The Hajar group is overlain unconformably by the tubidites and limestones of the Muti formation. The typical continental shelf deposits of the Hajar group are overthrust by the Mesozoic Hawasina nappe; a thick pipe of thrust sheets of intensely sheared and folded charts, turbidites and deep water limestaones which may be attributed to continental slope and deepwater sedimentation.

The Hawasina itself has been overthrust by a thick nappe of serpentines peridoties, gabbros, dolerites and volcanic thought to be a slice of Cretaceous oceanic crust. The Hawasina and Semail nappes were emplaced during the late Cretaceous. Following nappe emplacement there was a period of marine transgression with deposition of the lower Tertiary and Mastrichtian limestones marls conglomerates and sandstone's on an eroded basement of the Hawasina, Semail Hajar and pre-Permian formations. Mid Tertiary tectonic movements, possibly related to the crustal instability induced by overthrusting of a heavy Semail ultrabasic sheet, culminated in uplift of the Oman mountains.

Late Pliocene and early Pleistocene deposits include extensive sheets of cemented conglomerate, cemented wadi gravels, and the fossil Seif dunes of the Wahiba and the United Arab Emirates. Continual emergence of the Oman mountains and eustatic change in sea level during the Pleistocene has resulted in exhumation of a number of marine and wadi terraces. Spectacular examples can be seen along the coast between Sur and Quryat and behind Medinat Qaboos where there is a marine platform 160 m above present day sea level. Examples of Pleistocene (late Pliocene?) sheet conglomerates can be seen in the Sur basin and Wadi Sumail.

Recent sediments are predominately wadi gravels in the form of coalescing alluvial fans on both side of the mountains. Along the coast carbonate dunes, sabkhas and lagoonal sediments are common. Much of the desert forehand is under active deflation but extensive sand dunes occur along the Saudi/Oman border and in the Wahiba. Inland sabkhas include the Umm Al Sammin SW of Fahud, and the Sabkha Suaidat.

(b) The Quaternary Surficial Deposits

The unit of Quaternary surficial Deposits is particularly well represented in Oman, both in the mountain piedmont zone in northern and southern Oman, and in the sand deserts of the Rub' al Kharl and the Wahiba Sands. The deposit form a surficial, discontinuous cover of very irregular thickness, made up of unconsolidated continental material that is differentiated from the substratum, commonly termed <solid geology>.

The surficial sediments have great lithological diversity reflecting their different continental depositional environments. The environments range from coastal (littoral) marine, such as along the Batinah and Batain coasts, through alluvial wadi system, piedmont zones, sabkhahs and concretion zone of travertine limestone, to the aeolian, sand- dominated Rub' al Khali environment. The predominant constituents of the surficial deposits are derived from subaerial weathering and erosion of the Oman and Dhofar mountains. Transport to the area of deposition is mainly by either surface water or by wind; the dominant method of transport is related directly to the climatic conditions which prevailed at that epoch, i. e. either more humid or more arid conditions respectively. The surficial deposits were laid down during the Pliocene-Quaternary, a period that was strongly influenced by alternating humid and arid climatic phases and that was characterized by an increase in aridity over the last five thousand years or so.

The Quaternary Surficial Deposits unit constitutes a discontinuous cover of unconsolidated continental sediment that partially masks the older, underlying rocks.

(3) Climate

The climate differs from one area to another, it is hot and humid in the coastal areas in summer, hot and dry in the interior with the exception of higher mountains, which enjoy a moderate climate throughout the year. The climate of Dhofar Region is also moderate. Generally, the Sultanate of Oman has little and irregular rains, though heavy rains fall at times with the exception of Dhofar Region where heavy and regular rains fall between June and October because of monsoons.

Air circulation over Oman during the winter month is dominantly Northwesterly (the Shamal wind) bringing remnants of European cyclonic storms down the Gulf and widespread, though sporadic, precipitation to the Northern Oman Mountains. During the summer months, the Inter Tropical Convergence Zone and the southeast Trade winds are down northwards by a low pressure area over the India-Pakistan landmass. The resultant Southwest monsoon generates heavy precipitation in the Asir Mountains of Saudi Arabia where the annual average rainfall reaches 1,000 mm in places and brings summer rain to the Qara Mountains of Dhofar. The Southwest monsoon is deflected by the Oman Mountains resulting in occasional storms on their southern flanks. Approximately 40 % of the rain at Nizwa falls during the summer months, whereas at Muscat and along the Batinah coast, which is effectively in the rain shadow of the SW monsoon, summer rain is negligible.

Cyclones and cyclonic storms generate over the Indian Ocean and Arabian Sea during the months of May, June, October and November. Some of these cyclones track over the eastern seaboard and occasionally up the Gulf of Oman. These storms hit the Arabian coast on average once every three years and occasionally result in very heavy precipitation. 300 mm of rain fell at Muscat in one day from a cyclone on the fifth of June, 1980.

Variations in annual rainfall are considerable everywhere in Oman, but the most unreliable as well as the lowest, occurs in the desert forehand (Bidiyah). An estimated 200 mm fell in 2 days at Haima in July, 1980, where the last occurrence was reputed to be eight years ago. The variability can be seen by considering the data records at Muscat between 1893 and 1976 where the mean annual precipitation is 116 mm yet the minimum recorded value is 5 mm and the maximum value is 265 mm. One of the reasons for this unpredictability of rainfall is that Oman lies at the boundary between two meteorological regions (the Sahara Arabian Desert and The Indian Ocean Monsoon).

The hottest months are June and July where the average maximum daily temperature in any one month may reach 40 centigrade. The coldest month is January with an average daily minimum temperature of 19 centigrade. Evaporation is high and annual pan evaporation is commonly in excess of 2,500 mm. Humidity is higher in coastal regions than inland and there is a noticeable change when crossing the mountains from Muscat where the average maximum relative humidity in any month is in excess of 80 %.

Maximum and minimum temperatures from 1987 to 1994 and monthly maximum and minimum temperature in 1994 are given in Table 2.14 and Table 2.15 respectively.

Table 2.14: Maximum and Minimum Temperature, 1987 - 1994

(Unit: centigrade)

Location of the Station		1987	1988	1989	1990	1991	1992	1993	1994
Muscat	Maximum	47	47	47	49	47	48	47	49
	Minimum	12	15	13	15	10	13	13	14
Salalah	Maximum	44	40	38	42	41	35	43	45
	Minimum	14	15	13	15	16	14	15	15
Masirah	Maximum	42	45	42	41	40	45	42	44
	Minimum	15	12	12	14	15	12	12	14
Sur	Maximum	47	48	47	48	49	47	50	48
	Minimum	13	13	11	14	11	14	13	14
Sohar	Maximum	50	48	46	48	47	46	47	45
	Minimum	9	8	8	11	7	8	6	9
Thumrit	Maximum	45	44	43	46	45	44	44	45
	Minimum	7	4	2	7	7	4	4	7
Khasab	Maximum	45	44	45	46	43	44	46	46
	Minimum	14	11	12	14	14	11	12	13
Saiq	Maximum	33	34	33	34	36	33	34	35
	Minimum	-1	1	-3	-2	-1	-2	-4	-2
Al Buraimi	Maximum	50	49	49	51	49	46	-	-
	Minimum	7	6	4	6	4	3	-	-

Table 2.15: Monthly Maximum and Minimum Temperature, 1994

(Unit: centigrade)

Location of the Station		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Muscat	Maximum	33	29	35	42	44	49	43	43	43	40	33	33
	Minimum	14	14	17	20	24	25	26	26	23	20	19	14
Salalah	Maximum	30	32	36	32	35	45	31	30	30	34	35	30
	Minimum	18	20	21	19	23	24	25	26	23	20	15	17
Masirah	Maximum	29	31	35	37	43	44	36	36	33	36	32	31
	Minimum	14	14	19	22	24	24	23	22	21	22	21	17
Sur	Maximum	32	33	40	44	44	48	46	44	43	39	36	35
	Minimum	14	15	17	19	27	26	27	26	24	20	19	14
Sohar	Maximum	29	32	33	39	44	45	39	38	37	34	33	31
	Minimum	12	9	13	18	21	24	28	27	19	18	17	12
Thumrit	Maximum	32	34	37	41	43	45	43	43	42	39	34	33
	Minimum	9	8	13	20	22	24	24	23	17	17	15	7
Khasab	Maximum	29	28	30	39	42	46	42	44	40	37	34	32
	Minimum	15	16	18	21	23	29	31	31	26	24	21	13
Saiq	Maximum	22	21	26	29	32	35	32	32	32	27	23	23
	Minimum	-2	-1	2	9	12	16	15	16	11	9	6	1
Al Buraimi	Maximum	-	-	-	-	-	-	-	-	-	-	-	-
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-

Maximum and minimum humidity from 1987 to 1994 and monthly maximum and minimum humidity in 1994 are given in Table 2.16 and Table 2.17 respectively.

Table 2.16: Maximum and Minimum Humidity, 1987 - 1994

(Unit: %)

Location of the Station		1987	1988	1989	1990	1991	1992	1993	1994
Muscat	Maximum	100	99	99	100	100	100	100	98
	Minimum	5	7	5	4	9	5	5	11
Salalah	Maximum	100	100	99	99	100	99	100	100
	Minimum	6	5	5	5	4	1	4	4
Masirah	Maximum	100	100	100	100	100	100	100	100
	Minimum	13	12	11	15	12	12	21	22
Sur	Maximum	100	100	100	100	94	100	100	100
	Minimum	10	6	7	11	8	8	13	7
Sohar	Maximum	100	100	100	100	100	100	100	100
	Minimum	6	7	7	8	8	10	9	6
Thumrit	Maximum	98	100	100	100	96	99	98	95
	Minimum	1	3	5	4	2	4	3	2
Khasab	Maximum	100	96	98	100	98	100	100	98
	Minimum	1	8	5	3	7	7	6	9
Saiq	Maximum	100	100	100	100	100	100	100	100
	Minimum	1	1	1	1	1	1	1	1
Al Buraimi	Maximum	100	100	100	100	100	100	100	-
	Minimum	5	1	1	1	1	3	-	-

Table 2.17: Monthly Maximum and Minimum Humidity, 1994

(Unit: %)

Location of the Station		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Muscat	Maximum	95	95	98	93	91	89	96	95	96	93	93	91
	Minimum	28	15	16	12	11	9	17	26	16	18	29	31
Salalah	Maximum	85	90	89	86	96	96	100	100	100	94	86	82
	Minimum	13	4	7	50	49	7	70	69	24	18	21	9
Masirah	Maximum	100	99	100	98	100	100	98	98	100	95	100	100
	Minimum	47	22	26	26	23	31	32	45	46	31	49	46
Sur	Maximum	100	100	100	95	82	91	92	94	97	92	97	95
	Minimum	26	33	8	13	13	7	21	25	14	18	26	32
Sohar	Maximum	100	100	100	100	98	92	96	96	96	100	94	94
	Minimum	28	18	23	21	8	6	26	52	30	20	33	28
Thumrit	Maximum	95	84	90	85	83	78	83	91	84	85	91	93
	Minimum	14	4	6	9	4	2	3	6	4	11	16	15
Khasab	Maximum	95	91	96	96	98	93	94	94	94	88	87	91
	Minimum	27	18	19	11	17	9	27	26	19	22	30	28
Saiq	Maximum	100	83	89	95	90	89	100	95	94	89	97	100
	Minimum	1	1	1	1	1	1	10	15	4	7	1	1
Al Buraimi	Maximum	-	-	-	-	-	-	-	-	-	-	-	-
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-

Total annual precipitation from 1985 to 1994 and monthly total annual precipitation in 1994 are given in Table 2.18 and Table 2.19 respectively.

Table 2.18: Total Annual Precipitation, 1985 - 1994

(Unit: mm)

Location	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Muscat	1	94	194	63	70	79	45	101	31	44
Salalah	55	73	66	145	120	83	72	97	45	62
Masirah	-	7	83	28	16	47	8	185	23	17
Sur	11	120	110	30	67	164	5	145	42	129
Sohar	-	95	143	261	143	121	77	103	53	76
Thumrit	3	30	53	43	227	6	-	132	2	14
Khasab	27	118	144	152	251	177	280	321	239	22
Saiq	128	294	324	420	246	441	267	497	320	429
Al Buraimi	-	24	97	92	110	98	19	12	-	-

Table 2.19: Monthly Total Precipitation, 1994

(Unit: mm)

Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep	Oct.	Nov.	Dec.
Muscat	9	-	-	1	-	-	4	27	-	-	-	4
Salalah	-	-	-	-	-	1	30	24	7	-	-	-
Masirah	16	-	-	-	-	2	TR	TR	-	-	-	TR
Sur	99	-	-	22	-	4	-	4	-	-	TR	-
Sohar	40	-	31	-	-	-	-	5	-	TR	1	-
Thumrit	-	-	-	-	-	-	-	12	-	2	-	-
Khasab	21	-	TR	-	1	-	-	-	-	-	TR	TR
Saiq	TR	-	-	23	95	TR	178	52	49	32	-	-
Al Buraimi	-	-	-	-	-	-	-	-	-	-	-	-

(4) Geotechnical Properties of Stratigraphy

1) Pre-Tertiary Formations

The pre-Tertiary formations including the Hajar limestones, basement metamorphics, Semail ultrabasics and Hawasina charts, generally form areas of high relief with consequently little superimposed development. Exceptions can be found around Muscat, Muttrah and Ruwi. These rocks though jointed are competent and generally form sound foundations. Fairly steep rock slopes are possible though benching is often required as a precaution against minor rock falls. Joint orientations may locally be unfavorable, especially in the ultrabasics, and joint surveys are recommended as a precursor to slope design.

The curious small potholes ubiquitous to the peridotite outcrops around Muscat appear to be superficial features and not seen in excavations.

Karstification is limited in the limestone of the Hajar group. The surface of outcrops are fairy rich in residual clay and the rock tends to be more fractured (probably by insulation).

Although the author knows of no geotechnical problems associated with these older formations, it must be appreciated that to date there is very little available data. Thin red/brown hard lateritic clays are locally present at the junction between the basal Tertiary deposits and the underlying peridotite. These are characteristically slickensided and are possibly expansive.

2) Tertiary Clays

The Tertiary formation consists of alternating beds of shallow marine limestone, clay and conglomerate. Clays make up a significant proportion of the succession; probably about 30% in the eastern Batinah though slightly higher in the interior (Fahud, Adam). The individual clay beds, which may be more than 50m thick, are easily eroded and not usually exposed, having been covered in collegial or wadi deposits. This alternation of hard and soft beds gives rise to the dendritic drainage pattern characteristic of the Tertiary outcrop. The water table in this formation is usually at some considerable depth and the clay above the water table, slightly undersaturated. This clay has proved to be highly expansive and where close to the ground surface a serious foundation problem.

Within and around the Tertiary foothills to the west of the capital area the alluvial overburden is thin and the clay is commonly found at shallow depths. Wetting up the clay as a result of garden watering, leaking sewers and septic tanks, and burst water mains, can and has resulted in ground heave with subsequent damage to buildings. Double odometer tests on typical clay samples predicted swelling pressures could be as great as 400 kN/sq. m and that heave under an isolated footing sitting on clay could be as much as 200 mm. In practice ground movements of this magnitude have been observed, but their pattern suggests wetting up has only taken place at shallow depth and that deeper moisture content change could result in greater total heave. The effect of ground heave on the superimposed structure is closely related to overburden thickness. Structures sitting directly on clay suffer much greater damage as wetting up is more localized.

With increasing overburden thickness, ground heave is both reduced and more widespread. Limited observations suggest that where the alluvial cover is greater than 5 to 10 m, differential movement under small structures is tolerable though total heave may still be quite large. Excessive information of water into the ground may result in the formation of a perched water table. Buildings some distance from the point of recharge could then be affected by ground heave.

The clays are characteristically rich in sulfates and, where they outcrop or are covered by thin wadi grovels, evaporation has resulted in the upward migration of Calcium Sulfate salts and their precipitation near the surface. Gypsum is not usually found in high concentrations where the depth of alluvial grovels exceeds 3 to 4 m.

Expansive Tertiary clays have also been encountered in the central desert and Dhofar where they have reportedly caused borehole caving and stuck tools during well drilling. The importance of site investigation in areas possibly underlain by expansive clay cannot be over-emphasized. Closely spaced boreholes and trial pits, possibly combined with receptivity surveying, are essential. Where the clay is at or close to the surface foundations designed to accommodate heave such as bellied piers and suspended floor slabs are likely to be expensive and for small single storey buildings, prohibitive. Where the overburden is thicker (greater than 7 to 8 m) differential heave is likely to be small and structures could be designed to accommodate any movements. Where possible, construction on these soils should be avoided and alternative site found.

The other tertiary lithologies are generally should and high allowable bearing pressures can usually be adopted. Karstification in some of the limestone beds seems to be fairly wall developed and small sink holes can occasionally be found. Joints are locally filled with red/brown residual soil which is commonly rich in sulfates.

3) Alluvial Silts and Clays

Deposits of light brown and gray clayey silt underlay many of the villages of the interior. These soils are closely associated with the cultivated areas and, with few exceptions, are not found in the surrounding gravel plains and wades. The problem as to how the silts accumulated is comparable with the chicken-and-the-egg dilemma. The material is obviously a better agricultural soil than the wadi grovels, but the village come after the falaj, and the location of the falaj was primarily determined by the groundwater regime. The silts contain trace of sand, gravel, Gastropod shell, and, at Nizwa, pottery fragments can be seen exposed in the sides of terraces. The deposits can reach thickness of 4 to 5 m. Assuming the older villages to be over two million years old, then the rate of accumulation of the silt is approximately 2 mm per year. The palm groves have probably acted as sediment traps for wind blown loess deflated from the surrounding gravel plain and material brought down by the falaj during wadi flood. The Omani have been known to divert flood water into the falaj under the mistaken impression that this will line the tunnel invert with sediment and so prevent leakage. These silty clays often extend for a little distance outside the village perimeter suggesting that the palm groves were more extensive in the past.

The deposits are predominantly composed of Kaolinite and Calcium and Magnesium Carbonate. They characteristically have a low to moderate plasticity and a low dry density. The soil structure is metastable and exhibits limited collapse on saturation.

Extensive deposits of silt and silty clay can be found along the Batinah coast from Barka to Sohar extending from the littoral zone some 3 to 4 km inland. The silts, which can be up to 3 to 4 m thick are generally underlain by coarser grained outwash deposits. The material close to the ground surface is dry and porous with a very low dry density. Traces of sand and fine gravel in thin impersistent layers are common especially near active wadi channels. The soil, though not a true loess, has very similar geotechnical properties. Dry densities as low as 1 mg/cu. cm and porosity's as high as 65 % have been recorded. The soil structure is metastable and when preloaded, can and does collapse upon wetting up.

Very little investigation has been done into the geotechnical properties of these soils. Site investigations, including insitu density determinations double odometer tests, are essential for all but the smaller structures. Certainly low bearing pressures should be adopted and in some cases it may be necessary to pipe through to a denser formation. Measures should be taken to prevent ingress of water into the ground around buildings. The soil density may have to be increased below rafts by compaction. Flooding without preloading is unlikely to work as the soil, unlike loess was deposited in water.

4) Alluvial Gravels

The predominant component of the alluvial deposits of the Piedmont is coarse bouldery gravel. Thin impersistent sands and silts are occasionally found in the wider wadis. The deposits are characteristically poorly sorted. Early cementation is common. Gravels composed essentially of limestone tend to have a higher degree of cementation than their contemporaries in wadis with no limestone outcrops in their catchments. Good examples of selective cementation can be seen at Nizwa where the gravels in the Wadi Abayad are cemented while those in the wadis draining the peridotite outcrops are at least superficially uncemented. The thinness of the deposits, which seldom exceed 20 to 30 m, and the many wadi terraces indicate continual uplift of the land during the Pleistocene. The thickness of the wadi gravels out towards the desert forehand is unknown. Active deflation probably removes much of the deposited material. Late Tertiary/early Quaternary conglomerate found as far south as Ghaba suggest that the wadis at one time penetrated much further into the bidiyah than they do at present.

The alluvial deposits of the coastal plans (e.g. Batinah, Quryat) thicken away from the mountain foothills. Over 175 m have been found at Sohar. Drilling in the Gulf of Oman has proved upon 4 km of late Tertiary and Quaternary conglomerates, sandstones and shells. The alluvium of the Batinah is fairly well sorted and becomes finer grained away from the mountains. Sands and silts form a significant proportion of the near surface deposits along the coast. The predominant component of the Batinah gravels is Peridotite. Exploratory drilling has shown that this material has partially decayed to the Montmorilonite clay mineral, Smectite, because of slightly alkaline groundwater.

The alluvial gravels in general form a sound foundation. Moderately high bearing pressure (150 - 400 kN/sq. m) can usually be adopted. The deposits are generally cemented and/or slight claycy a few feet below the surface. The sulfate content is closely related to particle size, frequency of flooding, and overburden thickness. Gravels in active wadi channels tend to have very low total sulfate contents. The gravels of the wadi terraces, though cemented, are normally low in soluble sulfates, but traces of Gypsum can sometimes be found just below surface. Where the gravels overlying a low permeability bedrock are thin, soluble sulfates are usually high. Gypsum is ubiquitous in the surface gravels of the outer bajada and desert forehand.

5) Coastal Dunes and Associated Sediments

The most extensive tract of coastal dunes along the eastern Batinah occur in the area between Qurum and Azaiba to the west of the capital. Most of the development over the next five years is likely to be concentrated in this area.

The dune sand is predominantly uniform fine to medium grained and angular. The prevailing wind direction, as indicated by the orientation of the small Bachran dunes, is easterly. The thickness of the dunes vary from a few meters near the coast to over 60 m around Baushar. Between Al Khuwair and Saruq the dune sands are underlain by up to 40 m of alluvium of which the upper 5 to 10 m is essentially reworked aeolian sand. These sands are weakly cemented a few feet below the surface, have low relative densities, and are characteristically metastable exhibiting limited collapse when saturated under a preloaded condition. The effect of the weal binding cement is to significantly increase the observed SPT values. A sharp decrease in the N number is sometimes seen on penetration through the water table. The anomaly between the relative densities and the N value questions the value of carrying out Standard Penetration Tests in these soils.
It may be possible to determine a correction factor to take into account the effect of cementation, but because of the variable nature of the soil and the degree of cementation, a particular factor determined for one site or bed may not be applicable to another. Limited data for two sites at Al Khuwair suggest that a correction factor of 0.5 applied to the recorded N value will given results more compatible with the observed relative densities.

Minor silts with a variable organic content and moderately high porosity are locally interceded with the alluvial sands. Dry densities of 1.3 to 1.4 mg/cu. cm are common. Further east towards Quorum, black organic sediments up to 4 m thick have been encountered in shallow boreholes. These may be swamp deposits similar to those forming in the lagoons at the mouth of Wadi Abay, and where probably responsible for the failure at the foundations of the Muscat International Hotel. A good example of differential settlement caused by collapse of metastable sands can be seen at Ras Al Hamra where the western blockwork wall of the PDO school house is badly cracked.

6) Batinah Coastal Sediments

The geology of Batinah coastal plain consists of sedimentary formation of tertiary and quaternary age as shown in Table 2.20.

Table 2.20: Explanation of Sedimentary Rocks

Geological Time		Formation	Description
Quaternary	Holocene	Alluvium	Fluviatile deposit recent fans coastal deposit
	Pleistocene	Diluvium	Fluviatile deposit old fans terrace deposit
Tertiary	Neocene	Mudstone	Mudstone, Gravity mudstone and marlymudstone, marlystone
	Paleocene	Limestone	Limestone, marlystone

2.3.3 Condition of Eight Roundabouts

The following are the results of observation of eight roundabouts involved in the study, compiled from the field reconnaissance surveys and analyses of other collected data:

(1) The existing geographical condition such as landuse,public facilities, type of buildings etc., around the eight roundabouts are summarized in Table 2.21 and are illustrated in Figure 2.9 (a) to (d).

(2) The Batinah Highway with the shape of embankment runs over plains along the Gulf of Oman, into where many wadi flow. Therefore, the highway crosses these wadi by Irish Bridges, Irish Crossings and culverts. The drainage structures in the vicinity of the eight roundabouts are listed in Table 2.22.

Table 2.21: Existing Geographical Condition

No.of R/A	Name of R/A	Main Landuse				Public Facilities and Building				Bus Stop
		Seaside Area		Inland Area		Seaside Area		Inland Area		
		Aqr Side	Muscat Side	Aqr Side	Muscat Side	Aqr Side	Muscat Side	Aqr Side	Muscat Side	Location
R/A -2	A'Naseem Garden	Agricultural areas	Agricultural areas	Agricultural areas	Agricultural areas	Nil	Filling Station Public Park	Nil	Mosque	Nil
R/A-3	Barka	Commercial areas	Commercial areas	Agricultural areas	Commercial areas	Mosque	Filling Station Bank	Nil	Filling Station,Mosque Municipality	Both directions at Agr side
R/A-5	Al Muladdah	Agricultural areas	Residential areas	Residential areas	Commercial areas	Nil	Hospital Post office	Mosque(2Nos)	Filling Station Graveyard	Both sides at Secondary lane
R/A-8	Al Khaburah	Commercial areas	Commercial areas	Residential areas	Agricultural areas	GTO office Post office	Filling Station Mosque	Clinic	Nil	Aqr side at old lane Muscat side at secondary lane
R/A-10	Saham	Commercial areas	Commercial areas	Commercial areas	Commercial areas	Filling Station Bank	Ministry office	Filling Station,Mosque GTO Towar Station	Ministry office Bank	Aqr side at old lane Muscat side at secondary lane
R/A-12	Sohar	Residential areas	Political office areas	Agricultural areas	Agricultural areas	Nil	Ministry office Filling Station	Nil	Mosque	Both sides at secondary lane
R/A-14	Falaj Al Qabail	Residential areas	Residential and Commercial area	Residential areas	Commercial areas	Mosque	Mosque Bank	Nil	Filling Station Cemetry,Mosque	Aqr side at old lane
R/A-18	Aqr	Residential areas	Residential areas	Agricultural areas	Commercial areas	Nil	Mosque	Nil	Filling Station Mosque(2Nos)	Dubai side at crossroad

Notes: Commercial areas include Workshops

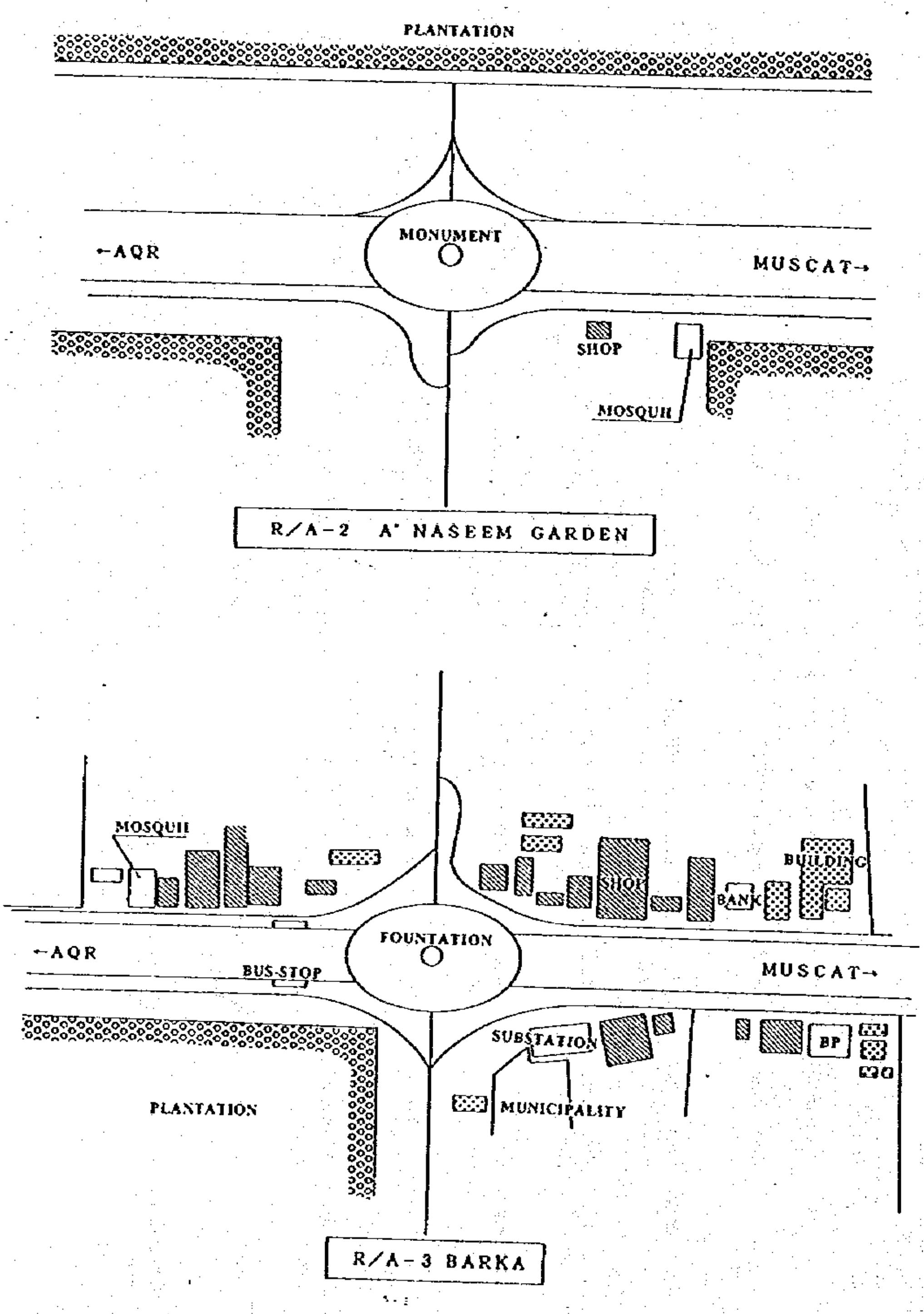


Figure 2.9(a): Location of Roudabout

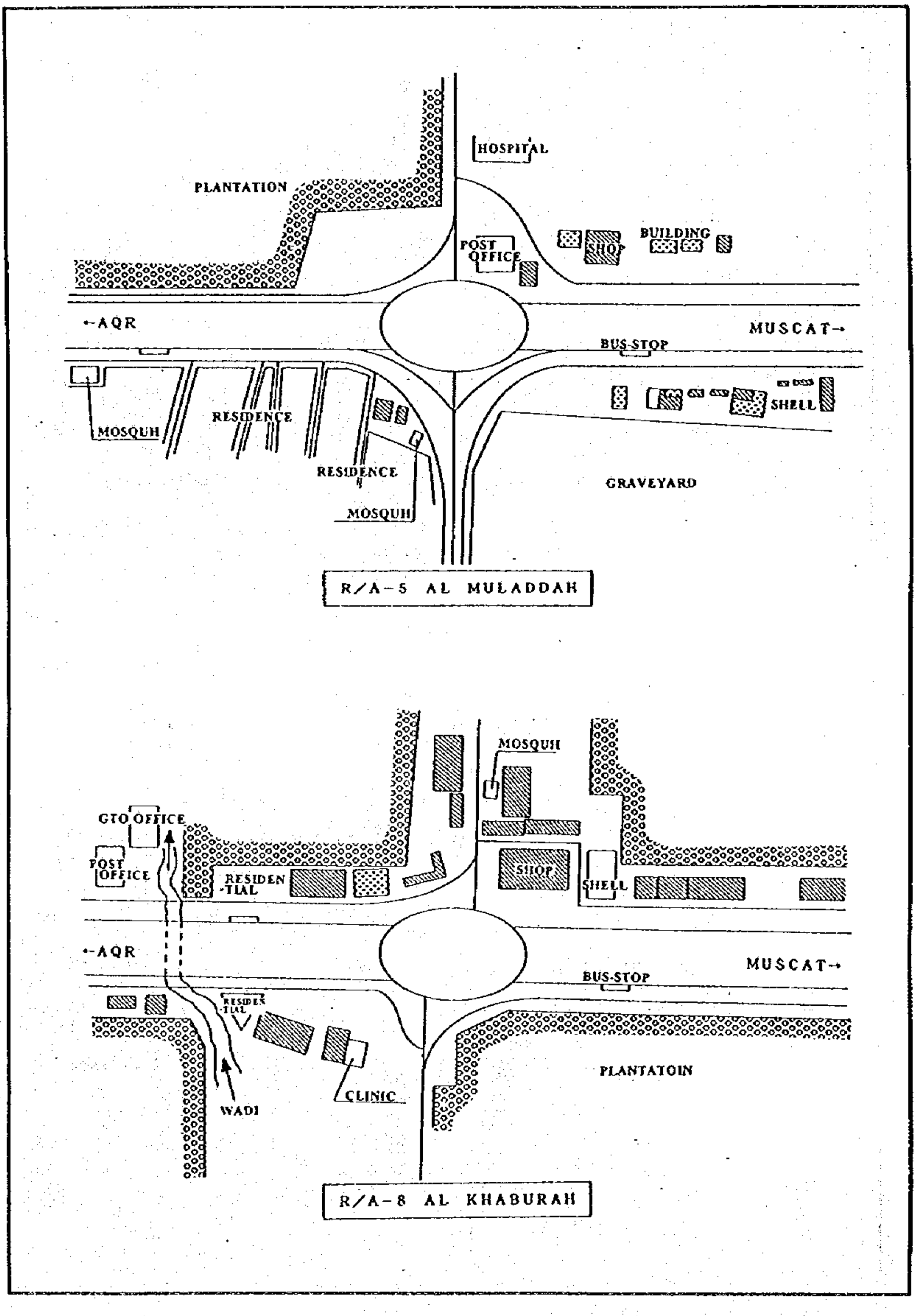
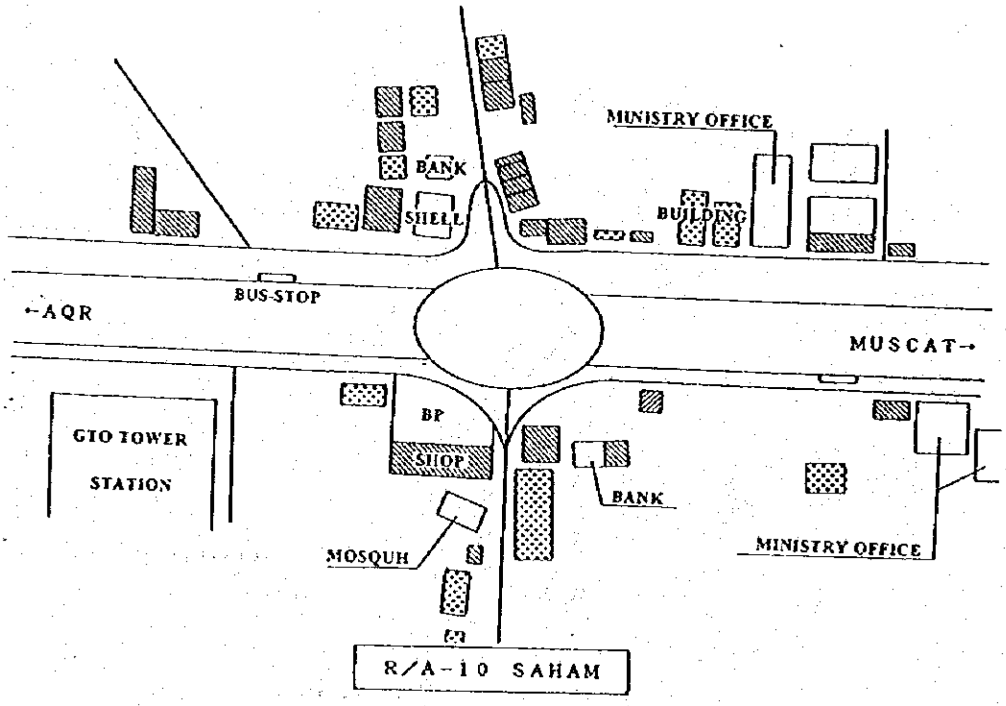


Figure 2.9(b): Location of Roudabout



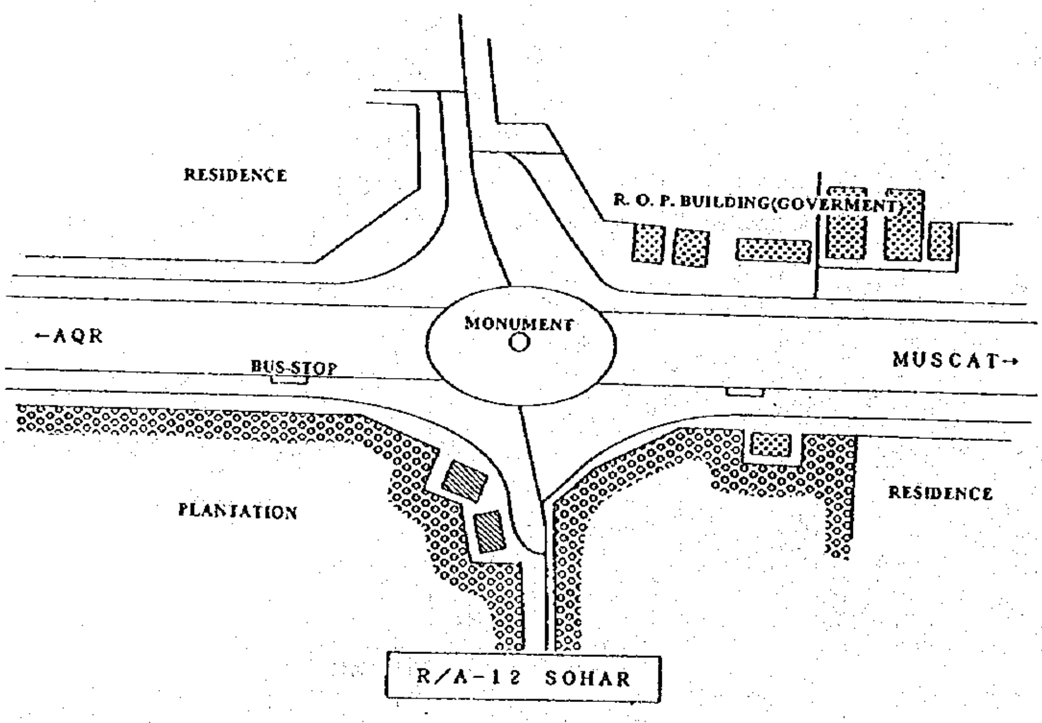


Figure 2.9(c): Location of Roudabout

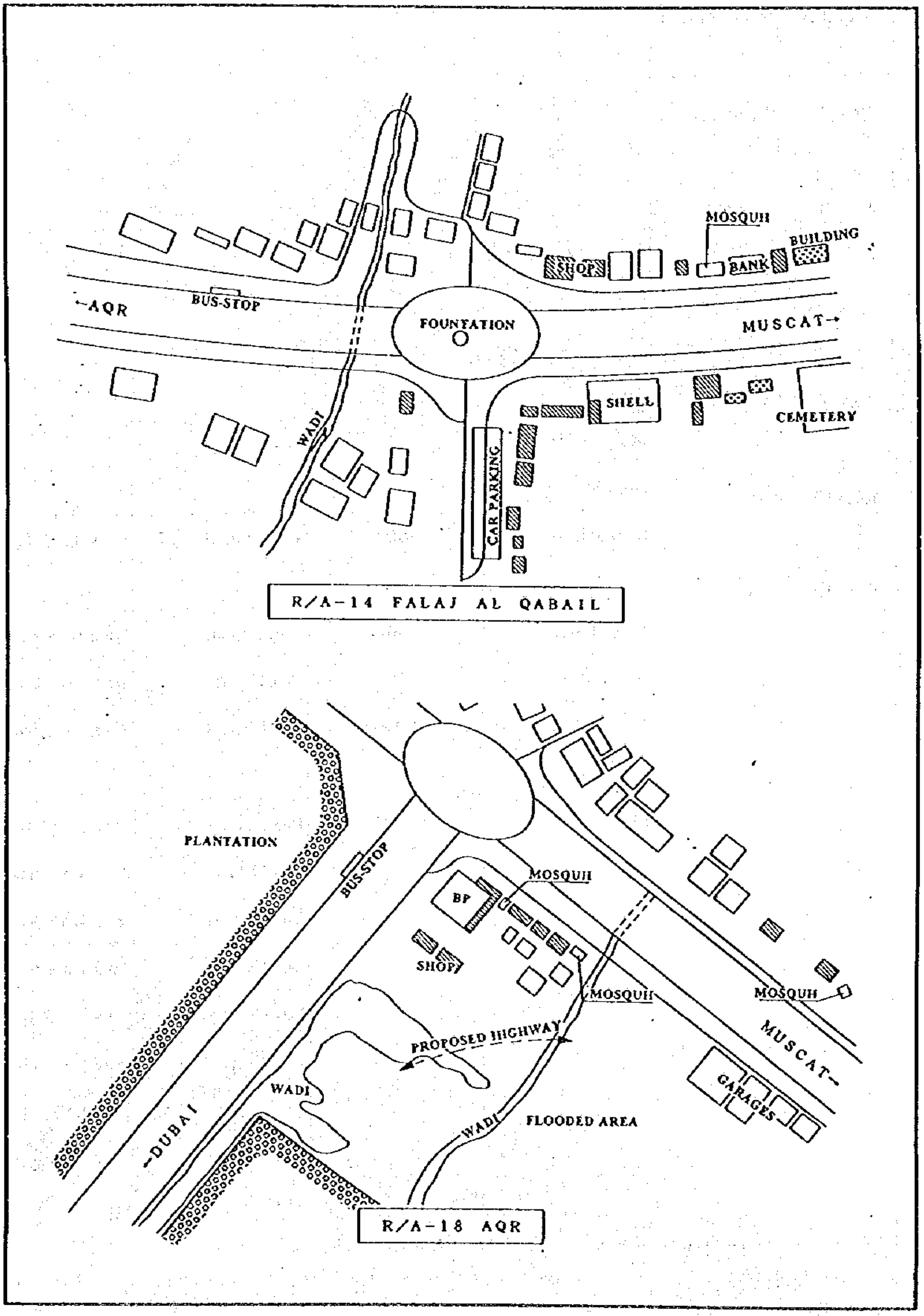


Figure 2.9(d): Location of Roudabout

Table 2.22 Existing Drainage Structure at Wadi

No.of R/A	Name of R/A	Location of Wadi		Drainage Structure	
		Direction	Distance FromR/A	Type	Dimension
R/A -2	A'Naseem Garden	Aqr Side	–	–	–
		Muscat Side	–	–	–
R/A-3	Barka	Aqr Side	–	–	–
		Muscat Side	780m	Box Culvert	2m x 1m x 12cells
R/A-5	Al Muladdah	Aqr Side	1050m	Box Culvert	2m x 1m x 2cells
		Muscat Side	–	–	–
R/A-8	Al Khaburah	Aqr Side	320m	Box Culvert	2m x 1m x 3cells
		Muscat Side	–	–	–
R/A-10	Saham	Aqr Side	–	–	–
		Muscat Side	890m	Box Culvert	2m x 1m x 3cells
R/A-12	Sohar	Aqr Side	–	–	–
		Muscat Side	580m	Box Culvert	2m x 1m x 2cells
R/A-14	Falaj Al Qabail	Aqr Side	150m	Box Culvert	2m x 1m x 2cells
		Muscat Side	690m	Box Culvert	2m x 1m x 3cells
R/A-18	Aqr	Aqr Side	–	–	–
		Muscat Side	130m ~ 1800m	Box Culvert	2m x 1m x 2cells
				Box Culvert	2m x 1m x 3cells
				Box Culvert	2m x 1m x 2cells
				Box Culvert	2m x 1m x 2cells
				Box Culvert	2m x 1m x 1cell
				Pipe Culvert	0.80m x 1cell
				Box Culvert	2m x 1m x 3cells
				Box Culvert	2m x 1m x 2cells
				Irish Crossing	300m

Notes: 1)The listed wadi is located at the stretch of about 1Km at both sides of a roundabout.

2)The listed wadi has a clear stream bed at the both sides of upstream and downstream except in the case of Aqr Roundabout

3)The drainage structure at Barka Roundabout (R/A-3) is Irish Bridge.

4)The Muscat side of Aqr Roundabout is flooded area (Wadi Hatta).

(3) The curve radius surrounding the eight roundabouts are presented in Table 2.23. On the other hand, the vertical alignment of Batinah Highway is fairly flat. From the viewpoint of alignment consideration, there may be no problems in making the grade separation.

Table 2.23: Relation of Roundabout Site Horizontal radius

NO.of R/A	Name of R/A	Curve Radius(m)
R/A-2	A'Naseem Garden	R=∞
R/A-3	Barka	R=∞
R/A-5	Al Muladdah	R=∞
R/A-8	Al Khaburah	R=∞
R/A-10	Saham	R=4,800
R/A-12	Sohar	R=1,500
R/A-14	Falaj Al Qabail	R=1,250
R/A-18	Aqr	R=∞

(4) The Batinah Highway is a dual two lane carriageway from Bait Al Barakah R/A to Aqr R/A, but becomes an undivided two lane road beyond Aqr R/A towards Al Malahah. Most of the cross roads at the roundabouts are an undivided two lane roads except the inland crossroads at Aqr R/A and Al Muladdah R/A. The above mentioned crossroads are Route No.5 and Route No.11 respectively, and are dual two lane carriageways same as the Batinah Highway.

(5) All the eight roundabouts are of an elliptical shape with a longer radius of approximately 150 m along the alignment of the highway and a shorter radius of approximately 90m in the other direction. This design is to accommodate smoother flow of traffic on the Batinah Highway. However, the carriageway width including both shoulders around the roundabouts and at the entry and exit points of these roundabouts are different at different construction periods.

(6) The following six roundabouts, R/A-3: Barka Roundabout, R/A-8: Al Khaburah Roundabout, R/A-10: Saham Roundabout, R/A-12: Sohar Roundabout, R/A-14: Falaj Al Qabail Roundabout and R/A-18: Aqr Roundabout were constructed in June 1984 together with the new carriageway from Bait Al Barakah R/A to Aqr R/A. The old carriageway was constructed in 1974. These roundabouts are in good condition.

(7) A'Naseem Garden Roundabout (R/A-2) was constructed on February 1994. The alignment of this roundabout is slightly skewed to the inland side because of the narrow space between the old carriageway and the seaside service road parallel to the highway. With this condition, two exclusive right-turn lanes from and to the seaside service road are provided at this roundabout. On the other hand, the inland crossroads ends abruptly after a distance of about 50m.

(8) Al Muladdah Roundabout (R/A-5) is currently under construction to replace the existing T-junction and will be completed by May 1996. The roundabout has two

exclusive right-turn lanes between the inland crossroads and the highway.

(9) Since the completion of the Feasibility Study in 1994, some changes to the landscaping efforts at two of the eight study roundabouts have occurred.

- At R/A-2 : A'Naseem Garden Roundabout, a new cultural monument was erected in the roundabout in 1995.
- At R/A-12 : Sohar Roundabout, the old cultural monument was demolished and a new one is under construction. At the same time, the existing open channels inside the roundabout are being replaced by box culverts. The construction at this roundabout will be completed by June 1996.

(10) Another road infrastructure improvement project by the Ministry of Regional Municipalities and Environment along the Batinah Highway is the "Entrance to Batinah Towns from Barka Wilayat to Saham Wilayat" and approved by DGR on January 1996. The project involves :

-Improvement of service roads and provision of parking lots for a distance of about 1 km on both sides of three roundabouts at R/A-3: Barka, R/A-8: Al Khaburah and R/A-10: Saham.

-Improvement of exits from Batinah Highway to service roads and crossroads at roundabouts.

2.3.4 Conditions of Twelve Pedestrian Underpass Locations

As discussed in progress meeting 2.3.1, twelve locations for the construction of pedestrian underpasses were identified in the previous Feasibility Study. A reconnaissance survey was carried out at the beginning of this study to observe the present conditions at these locations and to determine the final exact position.

At one of the twelve recommended location from the F/S study, namely Al Bidayah, a pedestrian underpass has been under construction since September 1995. The implementation of this underpass was regarded very urgent due to high frequency of accidents hazards. The study team and DGR have agreed to replace this location with another.

As a result of the field observation survey, the twelve new study locations for pedestrian underpasses are as follows:

Code	Name	Wilayat
P/U-1	Barka	Barka
P/U-2	Al Billah	Barka
P/U-3	A'Tareef	Masna'ah
P/U-4	Al Qarat	Masna'ah
P/U-5	A'Tharmad	A'Suweiq
P/U-6	A'Suweiq	A'Suweiq
P/U-7	Al Khadra	A'Suweiq
P/U-8	Qarih	A'Suweiq
P/U-9	Majaz A'Sughra	Saham
P/U-10	Khor A'Siyabi	Sohar
P/U-11	Liwa	Liwa
P/U-12	Asrar Bani Sa'd	Shinas

Figures 2.10 (a) to (c) show the land use condition and type of buildings and facilities around these twelve locations. The exact locations of three underpasses at Barka, A'Tareef and Al Khadra are finally adjusted to their final proposed locations. These fine adjustments are based on actual pedestrian traffic crossing observation survey on site for 12 hours discussed in Appendix I, where the line of crossing by most pedestrians are noted.

Below are brief descriptions of these proposed pedestrian underpass locations.

P/U-1: Barka

This location has dense development on both sides of the highway. Being very close to the Barka Roundabout, pedestrian activities are conspicuously heavy. There are many sundry shops on both sides of the highway, including petrol stations. Two mosques are located close to the service road on the coastal side.

At the proposed underpass location, there are access streets on both sides leading to the coastal and inland settlement. The highway reserve on the coastal side is considerably wider than the inland side.

At a distance of 550 m from the roundabout, this underpass will be fairly close to head of the flyover bridge if the latter is constructed.

P/U-2: Al Billah

The location of the primary school at this point was the main reason for its selection. The school is situated on the coastal side with gravel path leading to the village behind. Sundry shops are present on both sides of the highway. A bus shelter is located very close to the entrance to the school.

P/U-3: A'Tareef

Situated at about 2.5 km from Masna'ah Roundabout towards Aqr, this proposed location has heavy pedestrian traffic. Access roads to both the coastal and inland settlements directly connect to the highway. There is a dense cluster of sundry shops, utility shops, vehicle repair workshops on both sides of the location. Mosques and banks are among them. Elderly persons crossing the highway are frequently observed.

P/U-4: Al Qarat

This location is situated at about 5.5 km from Muladdah Junction towards Aqr. The proposed underpass is to be located close to the access to the coastal village and a bus shelter. There are several sundry shops on the coastal side, but a mosque is located across the highway.

P/U-5: A'Tharmad

A'Tharmad is very close to the Wudan A'Sahil roundabout. This location is densely built-up with facilities on both sides of the highway. Direct accesses from the highway with weaving lengths are present. Large clusters of shops, restaurants, banks, including petrol stations are present. Both the service roads at this location are paved roads. Access road leads to the coastal village is partially paved. Settlement just behind the shop rows are dense.

P/U-6: A'Suweiq

A'Suweiq is also located very close to the roundabout of A'Suweiq. There is heavy activity at the proposed site. There are 2 secondary schools on the coastal side of the highway. Close to the proposed underpass is the Social Welfare Office of Suweiq wilayat. About 1 km from the site towards the inland side is the general hospital. Dense rows of sundry shops, petrol station are present on the coastal side of this location. There are two bus shelters, one on each side of the highway flanking the proposed underpass.

P/U-7: Al Khadra

There is an 800-student school located at this site towards the coast. Bus shelter is present across the highway from the school. Students are sometimes seen disembarking from buses on the opposite side and having to cross the road to school. Some sundry shops are also present on the coastal side near to the gravel path to villages.

P/U-8: Qarih

The pedestrian underpass proposed at Qarih is aimed at providing safe crossing for the students attending the school situated on the coastal side of the highway. Besides, there are also two mosques located very close to the highway on the same side as the school.

Paved access road and service road are present on this side of the highway, including a bus shelter.

P/U-9: Majaz A'Sughra

The proposed underpass is at a location where there is a junction providing access to both the coastal and inland villages. Many sundry shops and restaurants are located at this site. There are two mosques, one on each side, located close to the highway. The proposed location for the underpass is in between the access roads to the coastal and inland villages.

P/U-10: Khor A'Siyabi

The teachers training college on the coastal side and villages to the inland side call for the construction of a pedestrian underpass at this site. Students were seen crossing the highway to patronize shops opposite the college. In the morning, students will get off the bus and cross the highway to attend classes. Besides shops, there is a mosque on the inland side of the highway.

P/U-11: Liwa

This location is situated very close to the roundabout of Liwa. At 200m, pedestrian could actually cross under the flyover bridge structure. However, since the construction of a flyover at this roundabout is considered as low priority, for the time being a pedestrian underpass is deemed necessary. On the coastal side, dense rows of sundry shops, restaurants, vehicle repair workshops lined the paved service road. Across the highway is the municipal building. Bus shelters are present on both sides of the highway.

P/U-12: Asrar Bani Sa'd

At this proposed location, there are many shops and workshops, including a school on the coastal side of the highway. It also has a gravel access road leading to the coastal villages but a direct access opening to the highway. Across the highway are more rows of sundry shops. Two bus shelters are present.

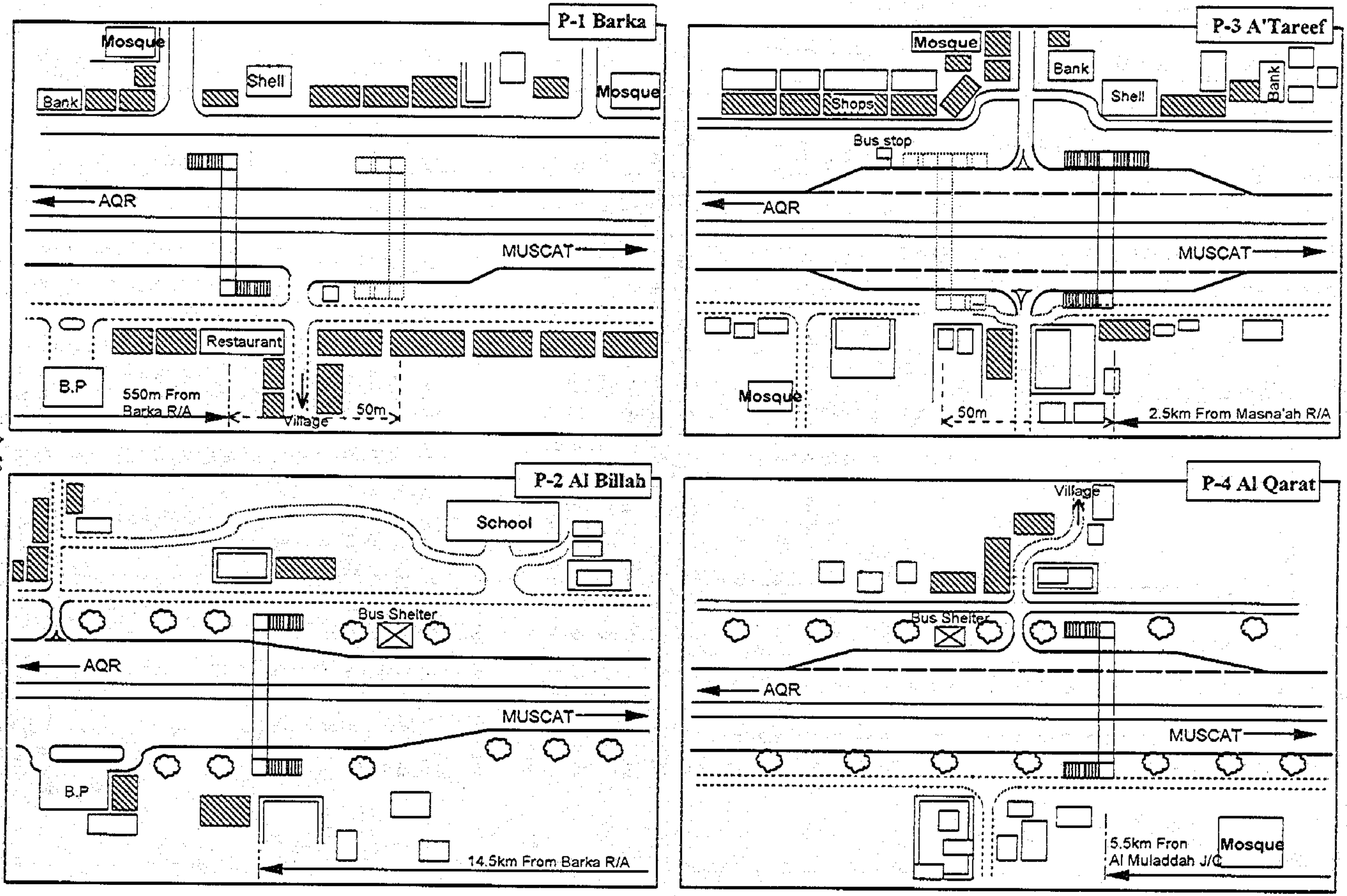


Figure 2.10 (a):Location of Pedestrian Underpass(P-1 to P-4) (Not to Scale)

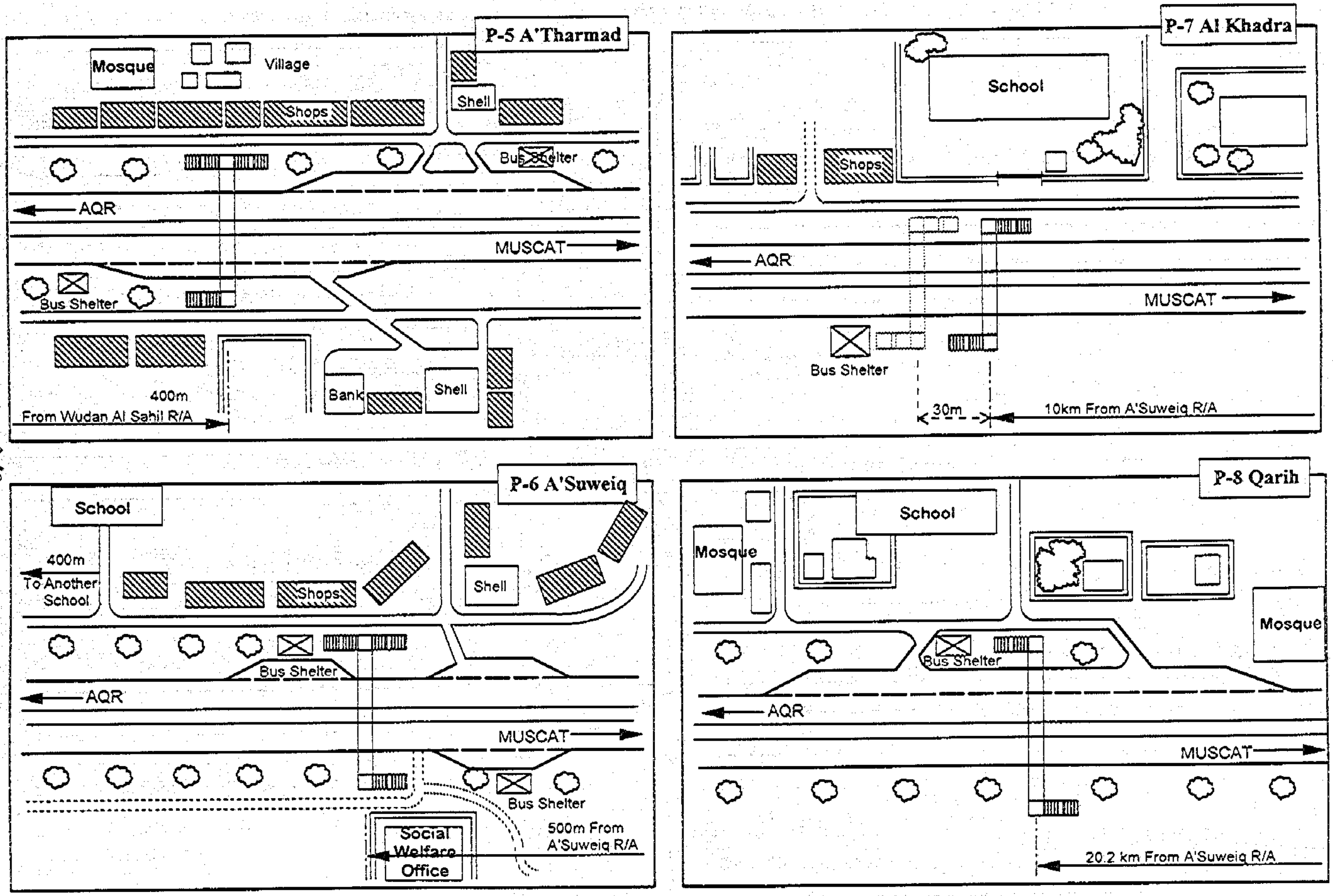


Figure 2.10(b): Location of Pedestrian Underpass(P-5 to P-8) (Not to Scale)

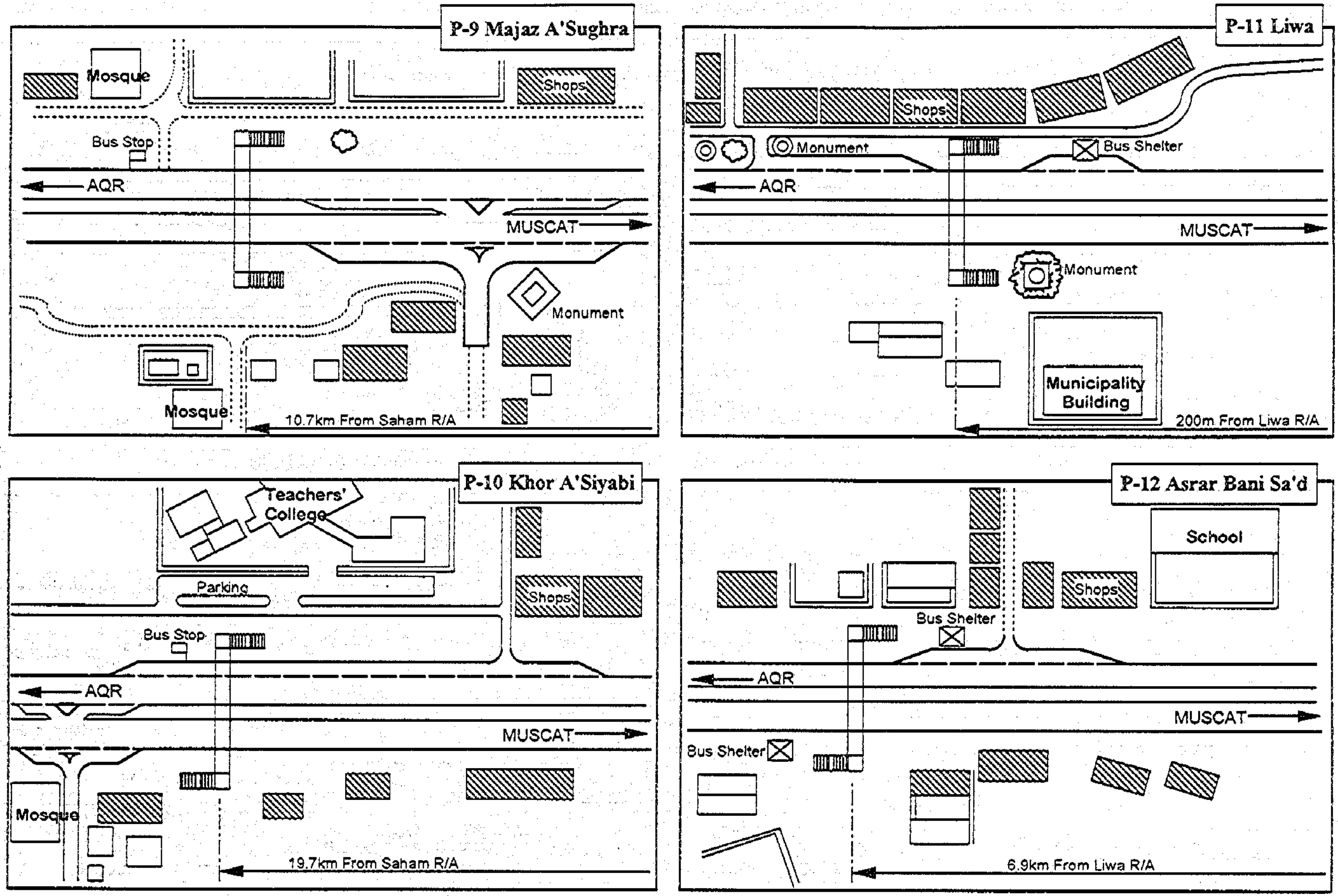


Figure 2.10(c): Location of Pedestrian Underpass(P-9 to P-12) (Not to Scale)

2.3.5 Road Facilities, Utilities and Land Acquisition

(1) Road Facilities

The present road facilities along Batinah Highway consist of safety barriers, street lighting, traffic control and safety devices, and landscaping.

a) Safety barriers

The safety barriers are in the form of galvanized guard rails installed at both external edges of the highway and in the medians. Along the external edges, guard rails are provided at the sharp curves sections near roundabouts or junctions without a sidewalk, at high embankment areas, and at section with large crossing culverts. On the other hand, the barriers in the medians are provided from Bait Al Barakah R/A to Aqr R/A, except the short sections just before and after roundabout where there are paved sidewalks with curbs.

b) Street lighting

There are two types of street lighting provided along Batinah Highway depending on their locations. One of these is an approximate 10m high galvanized iron pole with one or two sodium lamps and installed at intervals of approximately 30m on both sides of the median. The other type is an approximate 20m high pole with four sodium lamps and installed in the triangular spaces formed by intersections between the approach roads and a roundabout.

The first type is provided in the following stretches; from Bait Al Barakah R/A to A'Naseem Garden R/A, and from Suweihrah R/A to Majees R/A. The street lighting is also installed at crossroads where there are houses and shops along these roads.

c) Traffic Control Devices

Traffic control and safety devices installed along Batinah Highway include traffic signs and road markings. Traffic signs consist of information signs, warning signs, regulatory signs and supplementary signs for warning or regulatory signs. Basically, many traffic safety devices at approaches to a roundabout due to the need to warn road users and to induce slowing of travel speed for turning and entering a roundabout. Road studs are also used to supplement road markings near junctions and roundabouts.

d) Landscaping

Soft landscaping using plants such as grass, shrubs, flowers and trees is provided along Batinah Highway by Muscat Municipality or the Ministry of Regional Municipalities and Environment. In addition there are also impressive monuments erected in some of the roundabouts.

(2) Utilities

The present utilities consist of water supply, electricity and telephone lines along the highway. These service lines are located in the soft area within the road's right of way, that is in verges and other unpaved areas. In the case of Batinah Highway, the above areas are generally the open space between the main highway carriageways and the service roads as well as the outer verge of service roads. Lighting cables or irrigation pipes exist, where street lighting or soft landscaping is provided in the median. At any rate, it is seldom that these service lines cross the Batinah Highway.

The lateral layout of the above services is shown in Figure 2.11. Additionally, the electricity and telephone services have an underground line and an overhead line.

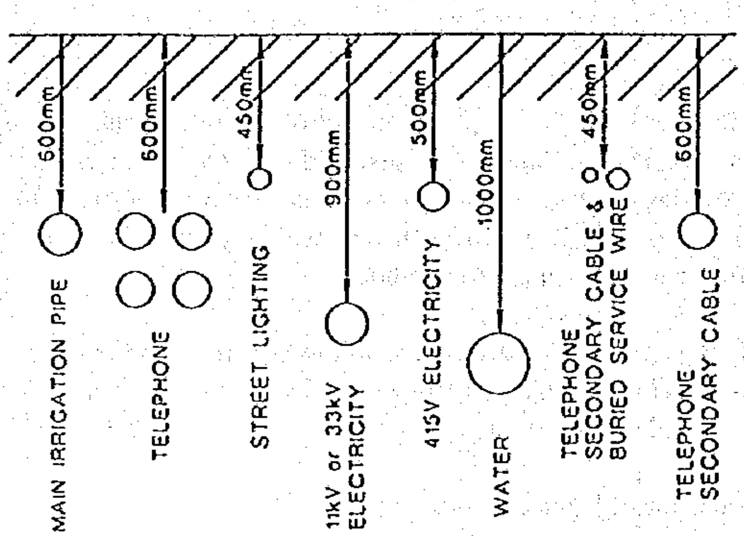


Figure 2.11: Lateral Layout of Utility Lines

In the event that temporary removal of these service lines is required, the respective authorities concerned shown in Table 2.24 must be contacted.

Table 2.24: Authorities Concerned of Each Utilities

Type of Utilities	Authority Concerned
Water Supply	Ministry of Electricity and Water Directorate General of Water
Electricity	Ministry of Electricity and Water Directorate General of Electricity (Head of Drawing Section) Directorate of Transmission and Control
Telephone	Ministry of Post, Telegraphs and Telephones General Telecommunications Organizations (Head of Technical Support Section) Director General of Network (Section Head, Junction Cable)

Note : The authority concerned with water supply has branch offices at the following regions; Muscat(Muscat - A'Naseem Garden), South Batinah (A'Naseem Garden - Sohar), Sohar(Sohar), North Batinah (Sohar - Aqr).

(3) Land Acquisition

The right-of-way for the following primary roads; Route No.1(Batinah Highway), Route No.5(Agr to United Arab Emirates), Route No.7(Sohar to Al Buraimi) and Route No.9(Al Kaburah to Miskin) is basically 120m wide but reduced in existing towns. The ROW for secondary roads such as the other crossroads at junctions or roundabouts range from 30m to 50m.

For the existing landaus and type of buildings around the eight roundabout whose vicinity area will be affected by the proposed grade separation project, refer to Chapter 2.3.3.

When land acquisition is required for improvement of roads, the procedure to be carried is as follows:

1) The scheme has to be approved first by the client; Ministry of Communications(MOC).
2) "Land Reference" drawings showing land acquisition including buildings are prepared with coordinating efforts from all the concerned Ministries, particularly the Ministry of Housing (MOH), the Ministry of Interior, Muscat Municipality, the Ministry of Regional Municipalities and Environment, the Ministry of Electricity and Water, and the General Telecommunications Organization.
3) MOC submits its plans to the Ministry of Housing (MOH).
4) MOH reviews and issues a no objection letter, if the plans are acceptable.
5) The plans are then submitted to the office of the Ministry of State for Legal Affaires

which prepares a Royal Decree.

6) When the Royal Decree is made, the amount of compensation that the land owner will receive is fixed in accordance with standard scales. The details are agreed between the owner and the compensation committee of either Muscat Municipality or the Ministry of Regional Municipalities and Environment. The scales of compensation to be followed are set by the Supreme Committee for Town Planning (SCTP).

CHAPTER 3

BASIC DESIGN POLICY FOR FLYOVERS AND PEDESTRIAN UNDERPASS

CHAPTER 3 PLANNING OF FLYOVERS AND PEDESTRIAN UNDERPASSES

3.1 Determination of Locations of Flyovers and Pedestrian Underpass

3.1.1 Location of the Proposed Flyovers at eight Roundabouts

The location of the proposed flyovers at eight roundabouts for this Detailed Design Study has already been determined and agreed upon by both JICA and DGR in the previous Feasibility Study. The selection of the eight proposed flyovers was carried out based on the results of a systematic evaluation process considering such factors as the future traffic volumes on Batinah Highway at these locations, the estimated V/C ratios in the roundabout, the relative importance to the overall road network, the potential for promoting community integration and relevance to industrial development along the highway corridor.

A weighed scoring system was devised and the eight flyovers were selected with additional to considerations of abstract (e.g. Aqr Roundabout's position as gateway to the Sultanate). The final eight locations selected for the detailed design study are:

R/A-2:	A'Naseem Garden Roundabout	R/A-10:	Saham Roundabout
R/A-3:	Barka Roundabout	R/A-12:	Sohar Roundabout
R/A-5:	Al Muladdah Roundabout	R/A-14:	Falaj Al Qabail Roundabout
R/A-8:	Al Khaburah Roundabout	R/A-18:	Aqr Roundabout

3.1.2 Location of Proposed Twelve Pedestrian Underpasses

The location of the proposed twelve pedestrian underpasses has also been roughly determined in the previous Feasibility Study. However, the exact locations need to be further examined especially in relation to the directions in the provision of access entrances and their relative distances to public facilties like schools, bus shelters and others on site.

At the commencement of this study, a pedestrian underpass at one of the proposed candidate locations, i.e. Al Bidayah, is already in the process of construction. At the first technical committee meeting, it was agreed by both JICA Study Team and DGR that this location be replaced by another, but the exact location shall be selected after a site observation survey.

Other considerations to determine the exact location of these underpasses were the actual pedestrian crossing paths to be observed through the pedestrian traffic volume survey which has been planned in this study.

Figure 3.1 summarizes the steps taken to finalize the selection of the proposed 12 pedestrian underpasses and fine adjustments as to their final exact locations on topographic maps at a scale of 1:500.

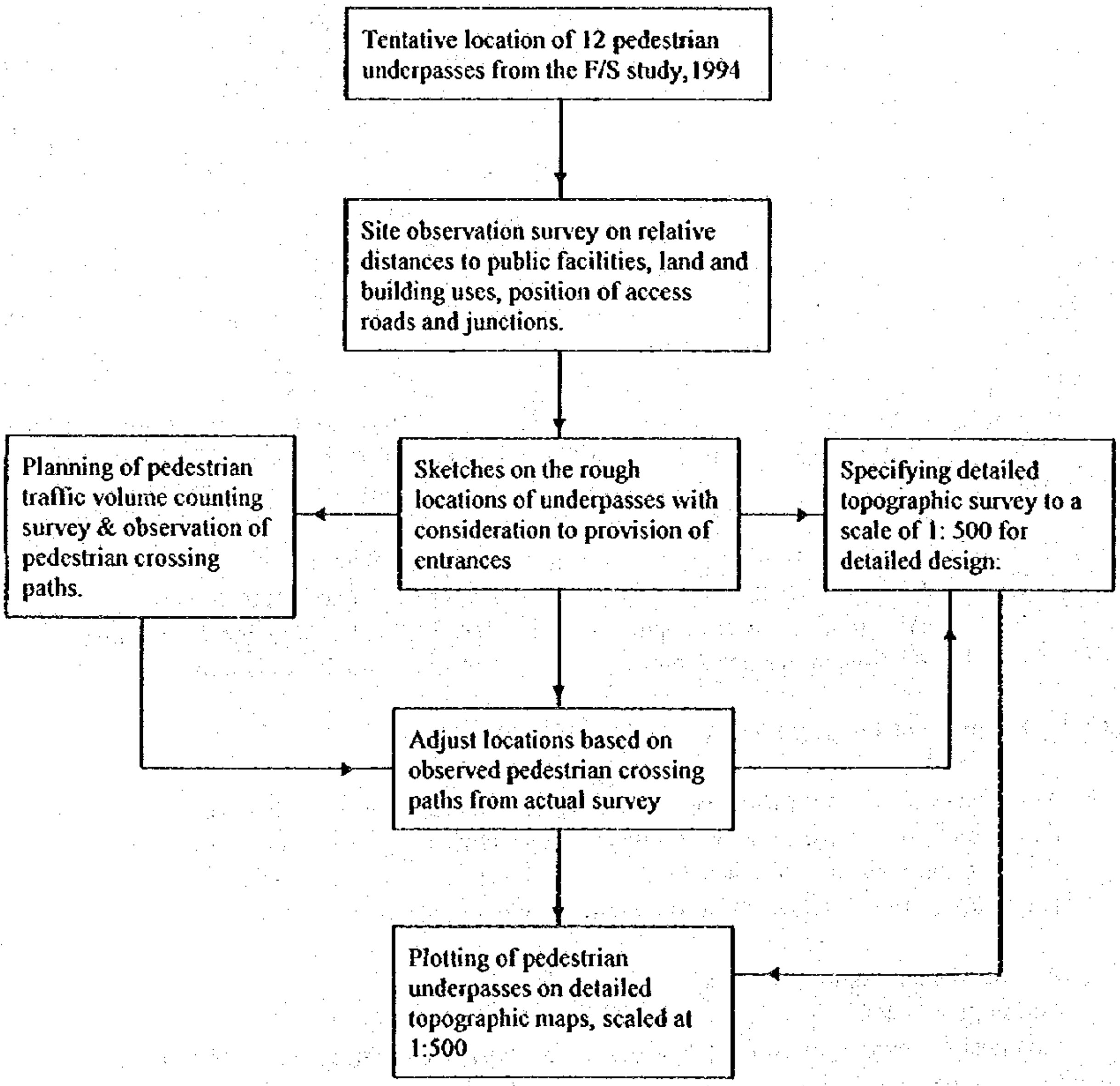


Figure 3.1: Procedure in Determining the Pedestrian Underpass Locations

In place of the initially proposed underpass for Al Bidayah , a new location at about 600 meters before Barka R/A was selected. The locations of A'Tharmad, Bataha Hilal (renamed A'Suweiq), Al Khadra, Majaz A'Sughra, Liwa, Liwa 3 (renamed Asrar Bani Sa'd) as described by the Feasibility Study were adjusted from the site observation survey conducted jointly by JICA study team and DGR counterpart engineers (Mr.Hamad Bin Saud Al Ramadhani and Mr.Saif Bin Abdullah Al Sa'adi) on the 25th and 26th of December 1996. The adjustments were made to reflect the land and building uses, the relative distances to the underpasses to public facilities such as schools, bus shelters, etc.

The underpass at Dhiyan-2 in the F/S was renamed Qarih and that at Hilat Al Rawashid was re-adjusted to a new location , Khor A'Siyabi.

The final selected twelve pedestrian underpasses and their tentative km posts are given below:

P/U-1	Barka (20.3 km)	P/U-7	Al Khadra (82.40 km)
P/U-2	Al Billah (35.40 km)	P/U-8	Qarih (92.40 km)
P/U-3	A'Tareef (49.20 km)	P/U-9	Majaz A'Sughra (150.20 km)
P/U-4	Al Qarat (59.60 km)	P/U-10	Khor A'Siyabi (159.20 km)
P/U-5	A'Tharmad (61.20 km)	P/U-11	Liwa (195.80 km)
P/U-6	A'Suweiq (72.40 km)	P/U-12	Asrar Bani Sa'd (202.50 km)

Sketches showing the relative position and type of buildings and facilities around these 12 locations are produced with information gathered from the observation survey. These sketches of the pedestrian underpass locations and their surrounding conditions can be seen in section 2.3. The exact locations of three underpasses at Barka, A'Tareef and Al Khadra were finally determined at their final proposed locations (shifted slightly from the dotted line in the figures). These fine adjustments were based on actual pedestrian traffic crossing observation survey on site over a period of 12 hours, where the line of crossing by most pedestrians was noted.

The Location Map in Figure 3.2 shows the location of the finally selected eight flyovers and twelve pedestrian underpasses on the Batinah Highway.

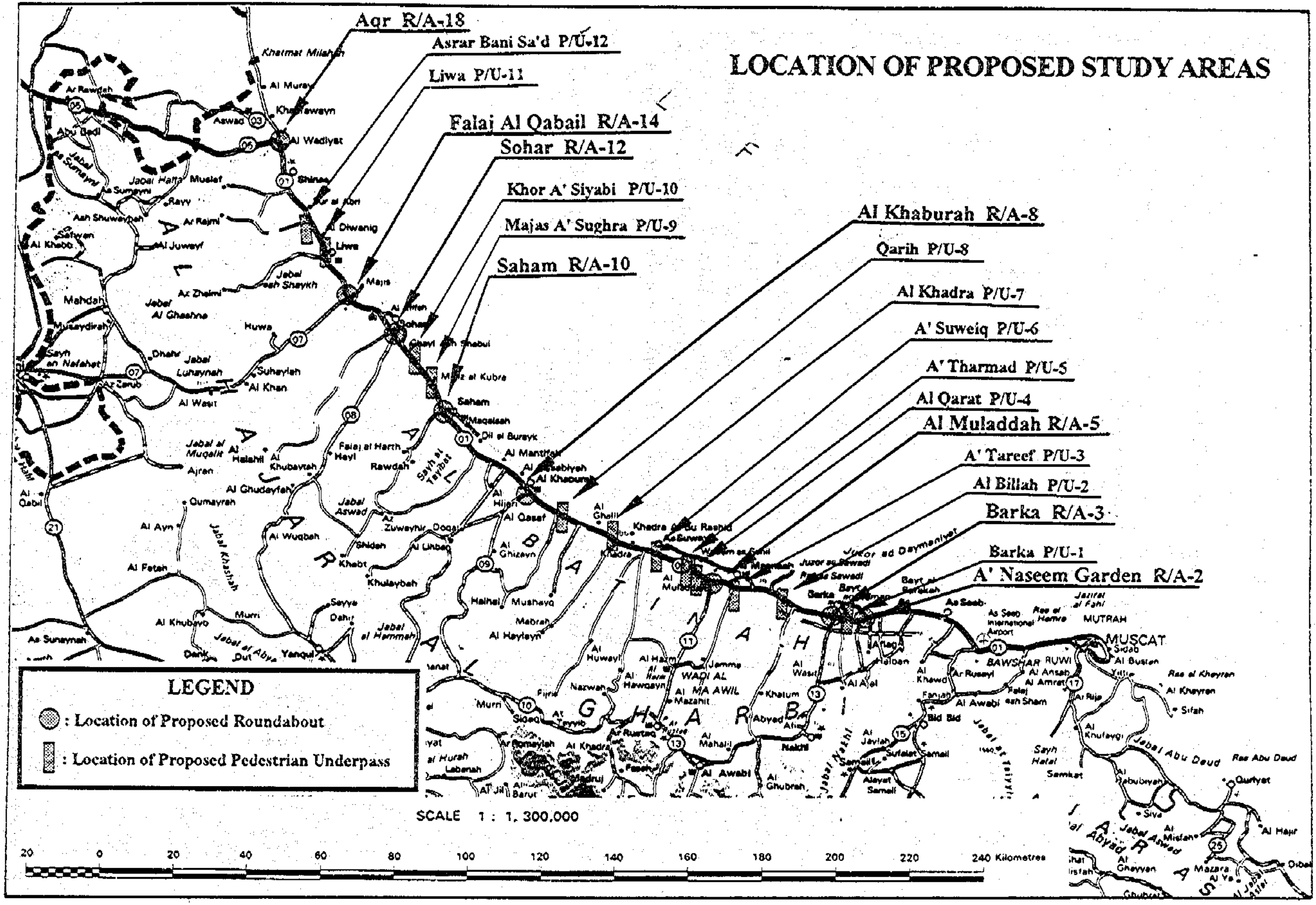


Figure 3.2: Location of Selected 8 Flyovers and 12 Pedestrian Underpasses

3.1.3 Priority Ranking of Flyovers

At this stage of the study, priority ranking of the eight proposed flyovers is carried out for the following two purposes:

(1) As a guideline for consideration in implementation priority,
(2) As a priority sequence in carrying out the detailed design of these flyovers for the subsequent stages of the study.

As set forth in Step 3 in Section 1.4 of this report, detailed design of the first set of four flyovers and six pedestrian underpasses with higher priorities are to be carried out first

Priority ranking of the study eight roundabouts for the construction of flyovers is conducted in this study using the same methodology as in the Feasibility Study. The factors considered are:

(1) Future Traffic Volume on the Batinah Highway
(2) V/C ratio in roundabout if flyovers are not constructed,
(3) Relation to road network,
(4) Local community integration
(5) Industrial development.

The future daily traffic volume was forecasted in the Feasibility Study and reviewed in this study in Appendix. The V/C ratios at the study roundabouts are reviewed as traffic on the cross-roads has been forecasted in this study to increase slightly from the F/S's forecasts. Using the same method as in the F/S study, the V/C ratios are computed and shown in Table 3.1.

Table 3.1: Forecasted V/C Ratios at Study Roundabouts in 2010

Name of R/A	To Aqr Batinah (Q1)	To Aqr R/A (Q2)	To Muscat Batinah (Q1)	To Muscat R/A (Q2)	V/C Ratios (Q3) To Aqr	V/C Ratios (Q3) To Muscat	V/C Ratios (Q3) Average
A'Naseem Gar.	31,368	1,646	29,384	2,624	1.253	1.247	1.250
Barka	29,390	2,634	20,115	15,551	1.247	4.820	3.033
Al Muladdah	22,877	5,950	9,024	17,266	1.232	1.236	1.234
Al Khaburah	14,917	8,010	15,688	7,323	0.963	0.950	0.957
Saham	15,485	13,427	14,351	14,631	2.104	2.584	2.344
Sohar	16,172	26,287	20,983	13,599	2.497	2,955	2.726
Falaj Al Qabail	16,294	1,413	10,493	6,221	0.642	0.578	0.610
Aqr	9,528	1,026	5,042	5,507	0.367	0.262	0.315

Q3 = (Q1 x 0.08)/(2,200 - 1.5 (Q2 x 0.08))
0.08 = Ave. peak hr. traffic ratio

Barka R/A, Sohar R/A and Saham R/A will probably face very critical traffic congestion problems within the roundabouts due to heavy weaving traffic problems. A'Naseem Garden and Al Muladdah Roundabouts will also face congestion problems, but to a lesser extent. Al Khaburah R/A will have a V/C ratio approaching the value of 1.0, a situation where traffic congestion is likely to occur during peak hours.

The factor of relation to road network takes into account the relative importance of the flyover location to regional road network.

Local community integration measures the relative level of needs in integrating the communities on both sides of the highway at the flyover location. This is taken to be the relative density of urban development of land on both sides of the highway. Lastly, industrial development takes into account the proposed future industrial development near the proposed flyover.

Weights are given to these 5 factors, similar to those used in the Feasibility Study for a scoring evaluation.

(1) Forecasted V/C ratios in R/A	-	50%
(2) Relation to Regional Road Network	-	20%
(3) Future Traffic Volume on Batinah Highway	-	10%
(4) Local Community Integration	-	10%
(5) Industrial development	-	10%

The scores of each roundabout for the above 5 factors are given as 10,9,8,7,6,5,4,3 in descending order of importance. 0 is given if it is not applicable. Consequently, the total weighted scores of each proposed flyover location are summed up as in Table 3.2.

Traffic accident data of 1993 were collected in the F/S. The exact location of the accidents are not clear due to the manner these data were kept. Accident data can be used for reference only.

Roundabout/Jn	No.of Accident	No.of Injuries	No.of Fatallities
A'Naseem Garden R/A	25	26	0
Barka R/A	12	2	0
Al Muladdah R/A	13	9	0
Al Khaburah R/A	7	1	0
Saham R/A	23	5	1
Sohar R/A	29	4	0
Falaj Al Qabail R/A	7	1	0
Aqr R/A	1	0	0

1993 accident data from ROP

Table 3.2 :Summation of Weighted Scores and Priority Ranking of Flyovers

Name of R/A	V/C ratio	Future Traffic Vol.	Road Network	Local Comm.	Industrial Devt.	Total Wt.scores/Rank
A'Naseem Gar.	7	10	0	4	10	
	(3.5)	(1.0)	(0.0)	(0.4)	(1.0)	(5.9) <3>
Barka	10	9	7	8	0	
	(5.0)	(0.9)	(1.4)	(0.8)	(0.0)	(8.1) <1>
Al Muladdah	6	8	8	3	0	
	(3.0)	(1.0)	(1.6)	(0.3)	(0.0)	(5.7) <4>
Al Khaburah	5	6	6	7	0	
	(2.5)	(0.6)	(1.2)	(0.7)	(0.0)	(5.0) <6>
Saham	8	7	0	9	0	
	(4.0)	(0.7)	(0.0)	(0.9)	(0.0)	(5.6) <5>
Sohar	9	5	5	10	0	
	(4.5)	(0.5)	(1.0)	(1.0)	(0.0)	(7.0) <2>
Falaj al Qabail	4	4	10	6	0	
	(2.0)	(0.4)	(2.0)	(0.6)	(0.0)	(5.0) <7>
Aqr	3	3	9	5	0	
	(1.5)	(0.3)	(1.8)	(0.5)	(0.0)	(4.1) <8>

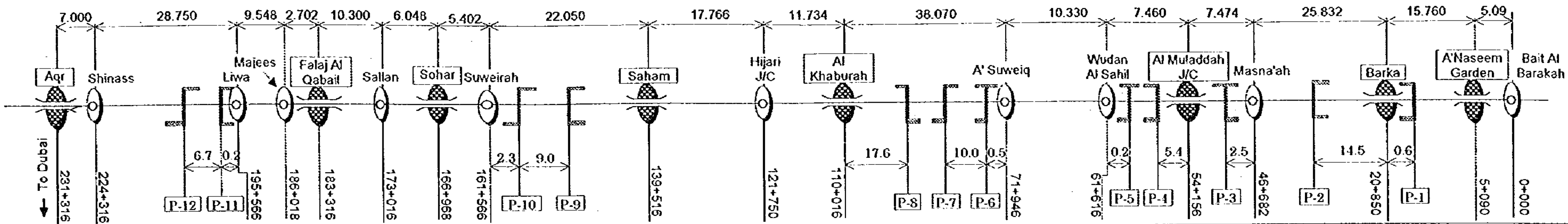
<2> Ranking, ( ) weighted scores

Based on the above evaluation, the relative order of priority for constructing the flyovers at the 8 roundabouts are

Rank 1 - Barka Roundabout
Rank 2 - Sohar Roundabout
Rank 3 - A'Naseem Gar. R/A
Rank 4 - Al Muladdah Roundabout
Rank 5 - Saham Roundabout
Rank 6 - Al Khaburah R/A
Rank 7 - Falaj Al Qabail R/A
Rank 8 - Aqr Roundabout

Figure 3.3(a) shows the summary of priority ranking of the proposed eight flyovers with reference to that done for the 18 flyovers in the Feasibility Study in 1994. Based on this ranking, the detailed design for the first four higher priority flyovers carried out in this study for reporting in the coming Interim Report in August 1996.

Figure 3.3(a): PRIORITY RANKING OF FLYOVERS ON ROUNDABOUTS AND JUNCTION



Result of Feasibility Study																DETAILED DESIGN STUDY										
Roundabout(R/A) and Junction(J/C)						Criteria for Evaluation				Evaluation Ranking					Priority	Result of Field Reconnaissance	Criteria for Evaluation				Evaluation Ranking					Priority
No.	Station No.	Name	Cross Road	Access: To Coastal Town	Access: To Interior Town	Traffic Volume: Batinah Highway 1994	Traffic Volume: Batinah Highway 2010	Traffic Volume: Cross Road 2010	Volume/Capacity (V/C) 2010	Batinah Highway 2010	V/C Ratio 2010	Relation with Road Network	Local Community Integration	Relation with Industrial Development			Traffic Volume: Batinah Highway 1996	Traffic Volume: Batinah Highway 2010	Traffic Volume: Cross Road 2010	Volume/Capacity (V/C) 2010	Batinah Highway 2010	V/C Ratio 2010	Relation with Road Network	Local Community Integration	Relation with Industrial Development	
1	No. 0 + 000	Bait Al Barakah R/A		Bait Al Barakah		20,100	59,700	1,300	1.13	1	5				8											
2	No. 5 + 090	A'Naseem Garden R/A		Naseem Garden Park		18,300	58,700	2,900	1.16	2	4			2	3	New Monument Constructed	21,210	61,280	6,600	1.25	1	4		7	1	3
3	No. 20 + 850	Barka R/A	N.R 13	Barka	Rustaq	16,200	51,800	21,700	2.76	3	1	3	3		1		15,570	58,000	21,800	3.03	2	1	4	3		1
4	No. 46 + 682	Masna'ah R/A		Masna'ah		13,900	44,300	2,700	0.87	4	7				10											
5	No. 54 + 156	Al Muladdah R/A	N.R 11		Rustaq	11,700	37,700	12,100	1.05	5	6	4			4	R/A under Construction	15,643	14,600	25,000	1.23	3	5	3	8		4
6	No. 61 + 616	Wudan A'Sahil R/A		Wudan A'Sahil		11,500	30,600	2,500	0.60	6	11		5		11											
7	No. 71 + 946	A'Suweiq R/A		A'Suweiq		11,600	29,200	4,500	0.61	8	10				13											
8	No. 110 + 016	Al Kaburah R/A	N.R 9	Al Kaburah	Rustaq	9,600	27,900	11,300	0.74	10	8	5			6		11,178	30,850	18,800	0.96	5	6	5	4		6
9	No. 121 + 750	Hijari J/C		Al Muntenfah	Al Hijari	8,600	26,800	1,600	0.51	11	13	7	4	3	7											
10	No. 139 + 516	Saham R/A		Saham	Rawdah	10,200	28,700	23,200	1.45	9	3		2		5		12,382	32,060	29,500	2.34	4	3		2		5
11	No. 161 + 566	Suweirah R/A		Suweirah		11,000	29,700	7,400	0.68	7	9				12											
12	No. 166 + 968	Sohar R/A	N.R 8	Sohar	Wadi Hibi	11,700	26,400	27,200	1.93	12	2	6	1		2	New Monument under Contruction	10,566	29,700	39,800	2.73	6	2	6	1		2
13	No. 173 + 016	Sallan R/A		Sallan		9,800	25,200	7,300	0.57	13	12			1	15											
14	No. 183 + 316	Falaj Al Qabail R/A	N.R 7	Majas	Al Burami	7,700	22,100	17,200	0.61	14	14	1	6		9		11,457	28,770	11,500	0.61	7	7	1	5		7
15	No. 186 + 018	Majees R/A		Khawr As Sammi		6,600	17,200	1,000	0.32	15	15				14											
16	No. 195 + 566	Liwa R/A		Sahi Hammul		6,500	16,600	2,100	0.32	16	16		7		17											
17	No. 224 + 316	Shinas R/A		Shinas		6,200	16,100	2,300	0.31	17	17				18											
18	No. 231 + 316	Aqr R/A	N.R 5		Dubai	4,500	13,600	5,400	0.29	18	18	2			16		5,790	19,030	10,000	0.32	8	8	2	6		8

3.1.4 Priority Ranking of Pedestrian Underpasses

The priority ranking of pedestrian underpasses is also done with the same purposes as those for the flyovers and carried out using a similar factor-scoring method. The factors considered here are:

	Factors	Scores	Weightage
(1)	12-hour total pedestrian volumes	1 to 12	60%
(2)	Existence of public facilities	2 or 1	20%
(3)	12-hour cross sectional traffic volumes on Batinah Highway	1 to 12	20%

The scores for 12-hour pedestrian volume and cross-sectional traffic volumes are set at 1-12 for the pedestrian underpasses with the highest pedestrian volume or traffic volume scoring 12. For the existence of public facilities, either 1 or 2 scores are given according to whether there are 1 or more than 1 major public facilities. The weights are given as 60% for the pedestrian volumes since it is the most important factor that determine its usage and needs, 20% for the public facilities and 20% for the traffic volumes.

Similar to the reason discussed for flyovers, traffic accident data are not used as a factor here. The 1993 traffic accident data at locations near to the proposed pedestrian underpasses are given as a reference information below.

Location	No.of Accidents*	No.of Injuries	No.of Fatalities	Proposed P/U near location**
Barka R/A	12	2	0	P/U-1:Barka
Al Muladdah R/A	13	9	0	P/U-3:A'Tareef
A'Suweiq R/A	13	6	0	P/U-6:A'Suweiq
Diyan Al Jahawer Jn	2	3	0	P/U-7: Qarih
Al Khaburah R/A	7	1	0	
Saham R/A	23	5	1	
Majaz A'Sughra Jn	4	0	0	P/U-9:Majaz A'Sughra
Khor A'Siyabi	11	4	0	P/U-10:Khor A'Siyabi

Note: * 1993 data,
** Exact location of accident is unclear

Table 3.3 shows the scores and weighted scores of each of the proposed pedestrian underpasses. Based on the results of this evaluation, the 12 proposed pedestrian underpasses are given the following rankings:

Rank 1 - P/U-1: Barka
Rank 2 - P/U-3: A'Tareef
Rank 3 - P/U-5: A'Tharmad
Rank 4 - P/U-6: A'Suweiq
Rank 5 - P/U-2: Al Billah
Rank 6 - P/U-7: Al Khadra
Rank 7 - P/U-9: Majaz A'Sughra
Rank 8 - P/U-8: Qarih
Rank 9 - P/U-4: Al Qarat
Rank10 - P/U-12:Asrar Bani Sa'd
Rank 11 - P/U-11:Liwa
Rank 12 - P/U-10:Khor A'Siyabi

Figure 3.3(b) shows the summary results of priority ranking for the twelve proposed pedestrian underpasses.

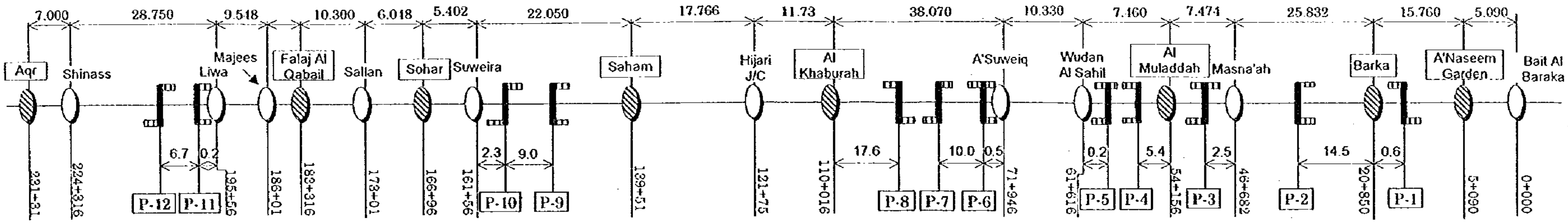
Based on this priority ranking, detailed design of the first set of six pedestrian underpasses at Barka, A'Tareef, A'Tharmad, A'Suweiq, Al Billah and Al Khadra, will be carried out first in the next stage of study and the results to be reported in the coming Interim Report in August 1996.

Table 3.3: Summation of Weighted Scores and Ranking of Pedestrian Underpasses

Name of P/U	Name of Wilayat	12 hours Pedestrian	Public facilities	12 -hours Traffic vol.	Total Scores	Total Rank
P/U-1:	Barka	12	2	12		
Barka		(7.2)	(0.4)	(2.4)	(10.0)	< 1 >
P/U-2:	Barka	7	2	8		
Al Billah		(4.2)	(0.4)	(1.6)	(6.2)	< 5 >
P/U-3:	Masna'ah	11	2	10		
A'Tareef		(6.6)	(0.4)	(2.0)	(9.0)	< 2 >
P/U -4:	Masna'ah	2	1	9		
Al Qarat		(1.2)	(0.2)	(1.8)	(3.2)	< 9 >
P/U-5:	A'Suweiq	9	2	11		
A'Tharmad		(5.4)	(0.4)	(2.2)	(8.0)	<3 >
P/U-6:	A'Suweiq	10	2	6		
A'Suweiq		(6.0)	(0.4)	(1.2)	(7.6)	< 4 >
P/U-7:	A'Suweiq	8	2	4		
Al Khadra		(4.8)	(0.4)	(0.8)	(6.0)	< 6 >
P/U -8:	A'Suweiq	5	2	3		
Qarih		(3.0)	(0.4)	(0.6)	(4.0)	< 8 >
P/U-9:	Saham	6	2	5		
Majaz A'Sughra		(3.6)	(0.4)	(1.0)	(5.0)	< 7 >
P/U -10:	Sohar	1	1	7		
Khor A'Siyabi		(0.6)	(0.2)	(1.4)	(2.2)	< 12 >
P/U-11:	Liwa	3	2	2		
Liwa		(1.8)	(0.4)	(0.4)	(2.6)	< 11 >
P/U -12:	Shinass	4	2	1		
Asrar Bani Sa'd		(2.4)	(0.4)	(0.2)	(3.0)	< 10 >

< > Ranking, (   ) weighted score

Figure 3.3(b): **PRIORITY RANKING OF PEDESTRIAN UNDERPASSES**



Result of Feasibility Study					DETAILED DESIGN STUDY							
Candidates of Selection			Recommendation		Result of Field Reconnaissance	Adjusted Location			Criteria-1 Pedestrian Volume(12hrs)	Criteria-2 School,Mosque, Public Facility	Criteria-3 Traffic Volume(12hrs)	Priority
Location		Name of Settlement				Location		Name of Location				
No.	Station No.		No.	●		No.	Station No.					
1	No. 20 + 400	As Somhan			Replaced	P- 1	No. 20 + 300	Barka	2,603	2-Mosques, Souq	11,289	1
2	No. 35 + 400	Al Billah	1	●	→	P- 2	No. 35 + 400	Al Billah	772	School, Bus shelter	8,850	5
3	No. 49 + 200	A'Tareef	2	●	→	P- 3	No. 49 + 200	A'Tareef	2,345	2-Mosques, Banks	9,590	2
4	No. 55 + 150	Al Muladdah										
5	No. 59 + 600	Al Qarat	3	●	→	P- 4	No. 59 + 600	Al Qarat	459	Mosque, Bus shelter	9,124	9
6	No. 61 + 416	A'Tharmad	4	●	Adjusted	P- 5	No. 61 + 200	A'Tharmad	1,133	Mosque, Bus shelter, Bank	9,647	3
7	No. 63 + 150	Al Manfash										
8	No. 72 + 900	Bataha Hilal	5	●	Adjusted	P- 6	No. 72 + 400	A'Suweiq	2,074	2-Schools, Hospital, Welfare, Bus shelter	8,215	4
9	No. 79 + 200	Sur Al Hilal										
10	No. 81 + 0	Al Uriq										
11	No. 82 + 350	Al Khadra	6	●	Adjusted	P- 7	No. 82 + 400	Al Khadra	1,110	School, Bus shelter	7,229	6
12	No. 91 + 700	Dhiyan-1										
13	No. 92 + 400	Dhiyan-2	7	●	Change Name	P- 8	No. 92 + 400	Qarih	593	School, Mosque, Bus shelter	6,987	8
14	No. 93 + 0	Dhiyan-3										
15	No. 100 + 100	Al Bidayah	8	●	Under Construction							
16	No. 110 + 16	Sur Al Duwahnah										
17	No. 115 + 550	Qasbyat Al Hawashnah										
18	No. 139 + 516	Saham										
19	No. 141 + 350	Al Badi										
20	No. 142 + 400	Al Ghuwaisah										
21	No. 143 + 400	Al Hadheeb										
22	No. 147 + 500	Hilat Al Rawashid										
23	No. 148 + 600	Hilat Al Rawashid	9	●	To be replaced							
24	No. 150 + 250	Majaz A'Sughra	10	●	Adjusted	P- 9	No. 150 + 200	Majaz A'Sughra	764	2-Mosques	7,999	7
25	No. 159 + 0	Khor A'Siyabi			Replaced	P- 10	No. 159 + 200	Khor A'Siyabi	431	College	8,701	12
26	No. 159 + 900	Otab										
27	No. 166 + 968	Al Waqaybah										
28	No. 170 + 200	Sallan										
29	No. 174 + 200	Al Gushbah-1										
30	No. 175 + 400	Al Gushbah-2										
31	No. 176 + 900	Falaj Al Quhi										
32	No. 183 + 316	Falaj Al Qabail										
33	No. 195 + 766	Liwa	11	●	Adjusted	P- 11	No. 195 + 800	Liwa	531	Municipal building, Bus shelter	4,581	11
34	No. 200 + 850	Liwa-1										
35	No. 201 + 750	Liwa-2										
36	No. 202 + 900	Liwa-3	12	●	Adjusted	P- 12	No. 202 + 500	Asrar Bani Sa'd	577	School, Bus shelter	4,214	10
37	No. 212 + 500	Al Hazari										
38	No. 212 + 700	Sur Al Abril										
39	No. 213 + 800	Sur Bani Gizmah										
40	No. 215 + 100	Tari Hajih										