REVISED DRAINAGE MANAGEMENT PLAN

HOMER, ALASKA

drainage investigations for the west hill, sterling south, and beluga lake areas

February 1982

QUADRA
ENGINEERING, INC.

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DRAINAGE INVESTIGATIONS FOR THE WEST HILL,
STERLING SOUTH, AND BELUGA LAKE AREAS

PREPARED FOR
CITY OF HOMER

PREPARED BY
QUADRA ENGINEERING, INC.

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I. INTRODUCTION

This report provides revisions and additional information for the City of Homer's Drainage Management Plan. The original plan did not address certain areas of the City, and did not cover other areas in sufficient detail for planning drainage systems. Three major areas, each with distinctive geomorphic and hydrologic characteristics, are addressed in this report. The Sterling South Area is located between the coastal bluffs along Kachemak Bay and the Sterling Highway, bounded on the east by Main Street and extending west to the city limits. The second location, the Beluga Lake Area, includes that area draining into Beluga Lake from the north, roughly bounded by Lake Street to the west and East End Road to the north. The West Hill Area lies north of the Sterling Highway, is bounded on the east by a major drainage-way, on the west by the Bidarki Creek drainage divide, and extends north nearly to the city limits.

This report provides recommendations for the City of Homer to use in developing a sound and effective drainage policy, and in implementing a management plan for the drainage of surface waters in the three study areas. The purpose of such a policy and plan is to help correct existing problems and to prevent future damages to real and personal property from surface runoff and stream flows. This study contains a description of drainage-ways and drainage patterns in the study areas, and also contains general evaluation guidelines that should be used to plan, design and review proposed development in these areas.

The first section of this study provides planning background information, including a general discussion of soils and topography, land use and development, and constraints to development caused by drainage and erosion problems in the area. The next three sections describe each area's drainage characteristics, provide drainage control recommendations, and discuss development constraints for each area. In addition, the section devoted to the West Hill Area provides recommendations on culvert sizes in the basin, and recommends a corridor for the proposed extension of Fairview Avenue.

The information in this study is of a general nature; surveying is required to precisely locate and delineate drainage-ways. Nonetheless, this report is a valuable guideline for planning streets, residential, and commercial development, and for designing and reviewing proposed development projects.

II. PLANNING BACKGROUND

The background information presented in this section provides a general understanding of the characteristics and processes of drainage and erosion in the study areas. Soils and topography, land use and development, and constraints to development imposed by drainage and erosion are discussed. While soils and landforms in the area are the major long-term influence in the development of drainage patterns, development of roads and residential areas can cause rapid major changes in drainage characteristics. It is therefore necessary to gain an overview understanding of the natural processes of drainage and erosion and the way these processes are affected by human activities, in order to properly plan and evaluate development projects in the area. In general, four types of drainage features have been identified: major drainage-ways; minor drainage-ways; poorly drained areas; and areas dominated by overland or sheet-flow processes. Each drainage feature is typically associated with characteristic soils and topographic conditions, and each feature requires different management techniques.

Soils and Topography

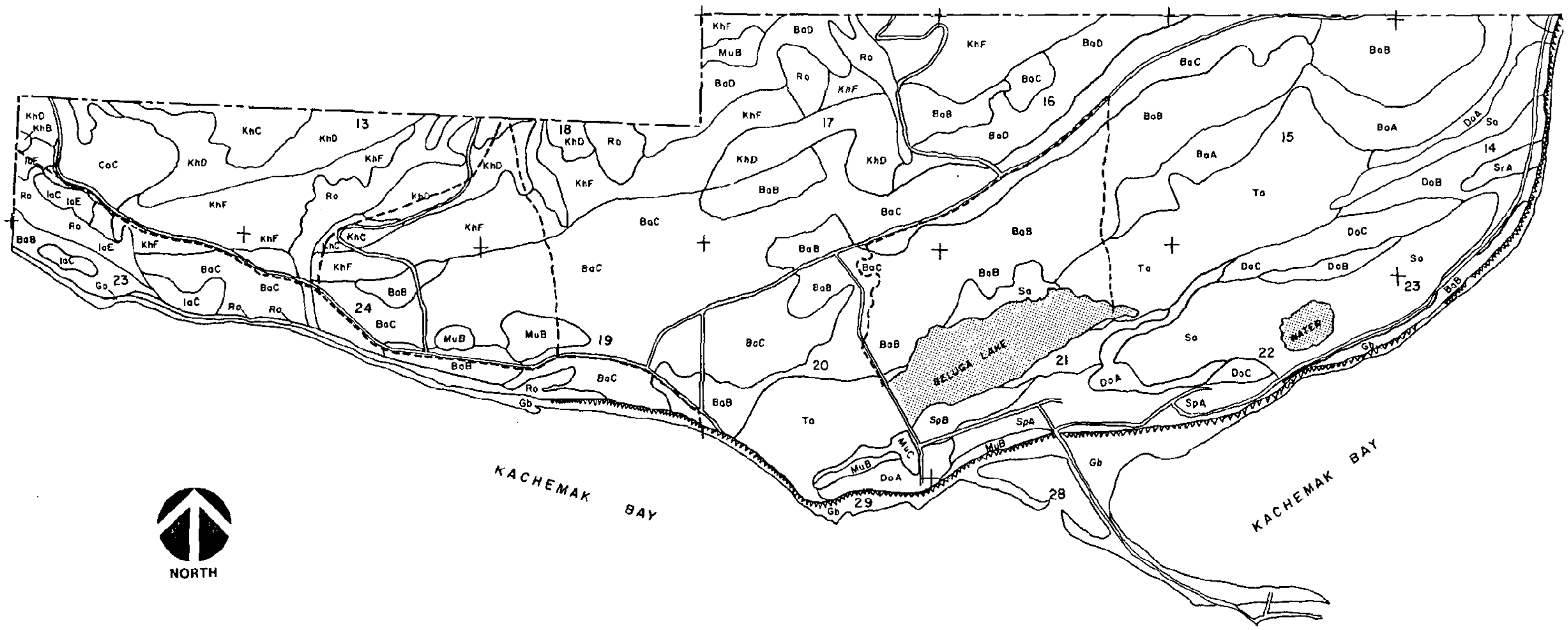
Topography varies widely within the study area. A steep escarpment runs along the northern boundary of Homer's city limits, and occupies a major portion of the West Hill Area. This escarpment is approximately 300 feet high, with its upper most elevation lying at 675 feet. There is a bench area at the base of this steep slope, which drops gradually and terminates at coastal bluffs or at the shoreline. This bench feature is found in all three basins. Coastal bluffs occur in the Sterling South area, ranging from heights of 20 feet to 300 feet.

Soils in the study areas reflect the topography. Four major associations are found in these basins: Beluga silt loam; Kachemak silt loam; Mutnala silt loam; and Island silt loam. Salamatof peat, rough broken land, gravelly beach, and tidal flats are also found. Soil conditions are mapped in Figure 1. In general, Kachemak silt loams are found in the escarpment area, while Beluga and Mutnala silt loams are found along the lower bench. Island silt loams are found near the coastal bluffs. Table 1 summarizes characteristics of the various soils found in the area.

Kachemak silt loams tend to be well drained, but have a moderate to high degree of erosion hazard depending on the amount of slope. Beluga silt loams are generally poorly drained, with a slight to moderate erosion hazard.

TABLE 1 - SOIL CHARACTERISTICS IN THE WEST HILL, STERLING SOUTH, AND BELUGA LAKE AREAS

Soil Type	Rate of Runoff	Erosion Hazard	Drainage	Slope	Comments
BaB - Beluga Silt Loam, Gently sloping	Slow	Slight	Poor	3-7%	Subject to seepage from higher areas; drainage measures needed
BaC - Beluga Silt Loam Moderately Sloping	Medium	Moderate	Poor	7-12%	Areas near high escarpments dissected by drainage-ways; erosion control measures needed
Gb - Gravelly Beach	--	--	--	--	Subject to tidal action
IaC - Island Silt Loam, Moderately Sloping	Medium	Moderate	Good	7-12%	Susceptible to wind erosion
IaE - Island Silt Loam, Moderately Steep	Medium-Rapid	Severe	Good	20-30%	Very susceptible to wind erosion
KhC - Kachemak Silt Loam, Moderately Sloping	Medium	Moderate	Good	7-12%	Erosion hazard greatest during spring break-up while subsoils are still frozen; erosion control measures needed
KhD - Kachemak Silt Loam, Strongly Sloping	Medium-Rapid	Moderate-High	Good	12-20%	Erosion hazard greatest during spring break-up while subsoils are still frozen; erosion control measures needed
KhF - Kachemak Silt Loam, Steep	Rapid	Severe	Good	30-45%	Erosion control measures needed
Ro - Rough Broken Land	Rapid	Severe	N/A	Steep	-----
Sa - Salamatof Peat	Very Slow	None	Very Poor	Level	High water table and ponding common
Ta - Tidal Flats	--	--	--	--	Subject to tidal action
MuB - Mutnala Silt Loam, Gently Sloping	Slow	Slight	Good	3-7%	-----



KEY TO SOILS TYPES

BaA - Beluga silt loam, nearly level.
BaB - Beluga silt loam, gently sloping.
BaC - Beluga silt loam, moderately sloping.
BaD - Beluga silt loam, strongly sloping
CoC - Cohoe silt loam, moderately sloping.
DoA - Doroshin peat,nearly level.
DoB - Doroshin peat, gently sloping.
DoC - Doroshin peat, moderately sloping.
Gb - Gravelly beach.
IaC - Island silt loam, moderately sloping.
IaE - Island silt loam, moderately steep.
KhC - Kachemak silt loam, moderately sloping.
KhD - Kachemak silt loam, strongly sloping.
KhF - Kachemak silt loam, steep.
MuB - Mutnala silt loam, gently sloping.
MuC - Mutnala silt loam, moderately sloping.
Ro - Rough broken land.
SpA - Spenard silt loam, nearly level.
SpB - Spenard silt loam, gently sloping.
SpC - Spenard silt loam, moderately sloping
SrA - Starichof peat, nearly level.
Ta - Tidal flats.
WW- Escarpment.

SOURCE: Soil Conservation Service,1971

---- DRAINAGE BASIN BOUNDARIES

Soils Map
West Hill, Sterling South, And Beluga Lake Area

PREPARED BY, QUADRA ENGINEERING INC.

FIGURE 1

Island silt loams are well drained, with a moderate to severe erosion hazard, again varying with the degree of slope. Mutnala silt loams are the most suitable for development, with only a slight erosion hazard and good drainage characteristics.

Topography and soils are the major determinants of drainage patterns in the study areas. Steeply sloping escarpments and coastal bluffs with erodible soils are typically dissected by numerous, well-defined channels, several of which are deeply cut. There is a marked change in both soil type and drainage characteristics at the base of the escarpment. Few well-defined channels are found; the predominant drainage process is sheet or overland flow. Most runoff carried down the bluff either infiltrates the soil and enters the groundwater, or becomes sheetflow, depending on the amount of moisture in the soil and the intensity of rainfall. Poorly drained areas are found in both the Sterling South and Beluga Lake drainage basins. These poorly drained areas usually correspond with gently sloping Beluga silt loams.

Land Use and Development

The major land use in all three basins is residential, with low-density development patterns. In the Sterling South Area, residential and commercial development is concentrated in the highway corridor. There is also one subdivision that has been developed south of the highway. The West Hill Area is mostly undeveloped. Again, development in this basin is concentrated along the Sterling Highway and West Hill Road. The Beluga Lake Area is the most densely developed basin, with several subdivisions, a school, and some commercial uses.

Although the West Hill Area is now mostly undeveloped, future growth is anticipated. The proposed Fairview Avenue extension would not only provide an alternate east/west route through town, but would undoubtedly stimulate residential development in the central portion of this drainage basin. Because of the highly erodible soils predominating in this part of the West Hill basin, great care must be taken in planning, designing, and constructing new development projects or serious drainage and erosion problems will result.

Development Considerations

The natural processes of drainage and erosion impose some constraints on development in the study areas. The majority of these constraints are not severe, and appropriate mitigation techniques can be used to prevent anticipated drainage and erosion problems. In some areas, however, soils, topography and drainage characteristics severely limit development suitability.

Steeply sloping sites in the West Hill and Sterling South Areas are extremely susceptible to accelerated erosion. Soils in such areas are typically highly erodible, and this charateristic, coupled with the steepness of the slope, poses severe development limitations. Development in these areas must be carefully designed and planned in order to avoid problems. In general, new development should be located away from the edges of bluffs or streambanks to avoid decreasing slope stability, and to allow an erosion buffer zone. Major drainage channels should be maintained in their natural condition to the greatest possible extent, as routing discharge to a new area may result in rapid gully erosion. Channels may be lined or otherwise altered to increase their discharge capacity, providing that erosion control measures are incorporated into the design. Easements should be established to protect these drainage-ways. Sound construction practices will reduce the potential for erosion problems. The vegetative cover should be maintained to the greatest possible extent, and exposed soils should be re-vegetated as soon as possible. Catch basins, berms, or other devices will reduce the amount of downstream sedimentation. Culverts should be provided for both major and minor drainages; extensive channel routing of drainage should be avoided because of the erosion hazard. Culverts should be designed to avoid increasing flow velocities and downstream erosion.

Less steeply-sloping sites are more suitable for development. The major consideration in these locations is to provide or maintain channels with adequate hydraulic capacity to contain discharge from the area. Major drainage-ways should be maintained in their natural channels, and minor drainages may be routed as convenient. When areas dominated by sheet-flow processes or poorly drained sites are developed, great care must be taken to ensure that adequate channels are provided for these flows.

In summary, the simplest method of avoiding drainage and erosion problems is to carefully site and plan development in accordance with the natural characteristics of the site. Where this approach is not desireable or feasible, the development must be designed in order to accommodate site limitations and problems.

III. WEST HILL DRAINAGE INVESTIGATION

The West Hill Area is bounded on the south by the Sterling Highway, on the west by Bidarki Creek, on the east by another major drainage-way, and extends north nearly to the city limits. This area is not a true drainage basin, but is rather a region characterized by numerous small drainage basins. Aproximately 415 acres are contained in the study area. This section discusses the general drainage characteristics of the West Hill basin, provides recommendations for drainage system improvements, and provides a conceptual plan and design criteria for the proposed Fairview Avenue extension.

Two maps are provided with this report: an uncontrolled Aerial Photographic Map (Figure 2); and a Drainage Features Map (Figure 3). Neither of these maps are precisely accurate or drawn to scale; their major function is to show the general location of major drainage-ways, and minor drainage features are not shown on either map. The Aerial Photographic Map is best used as a guide for stereoscopic interpretation of the drainage basin. Table 2 lists recent aerial photography that can be used in analyzing the West Hill Area. Detailed, accurate representation of drainage characteristics in the basin is provided in five Drainage Systems Maps. Four of these maps are 1 inch = 100 feet scale orthophototopographic maps with 2 foot contour intervals. A small portion of the basin is mapped on a 1968 topographic base, with a 1 inch = 200 feet scale and 5 foot contour intervals. Major and minor drainage-ways, sheet-flow areas, sub-basin boundaries and existing and recommended culvert locations are shown on these Drainage System Maps. The size of these maps prevents their inclusion into this report. The City of Homer maintains copies for review, and additional copies may be obtained for the cost of reproduction from QUADRA Engineering, 401 E. Fireweed, Anchorage, Alaska 99503.

Drainage Characteristics

The methodology used to determine drainage features in the West Hill Area combined aerial photographic interpretation and analysis of topographic maps. Field checks were made as necessary. The purpose of this effort was to identify drainage features and to perform a hydrologic analysis in order to update Homer's Drainage Management Plan.

As discussed in Section II, the major determinant of drainage features in the Homer area is soils and topography. The northern half of this basin is characterized by steep

TABLE 2

RECENT AERIAL PHOTOGRAPHY IN THE HOMER AREA

North Pacific Aerial Surveys flew the Homer area on April 28,1981. The following aerial photography is available:

FLIGHT LINE	SCALE	PHOTO NUMBERS	COVERAGE
1	1" = 750'	1-5	-eastern portion Sterling South Area
		5-8	-Beluga Lake Area
	1" = 1000'	1-7	-Sterling South Area
		7-11	-Beluga Lake Area
		4-6	-southern portion West Hill Area
2	1" = 750'	1-9	-eastern portion Sterling South Area
		9-12	-Beluga Lake Area
		1-7	-southern portion West Hill Area
	1" = 1000'	2-7	-western portion Sterling South Area
		10-14	-Beluga Lake Area
		6-10	-West Hill Area
3	1" = 750'	9-11	-Beluga Lake Area
		1-7	-West Hill Area

Photography may be ordered from:

NORTH PACIFIC AERIAL SURVEYS, INC.
4241 "B" STREET
ANCHORAGE, ALASKA 99503
(907) 274-3548

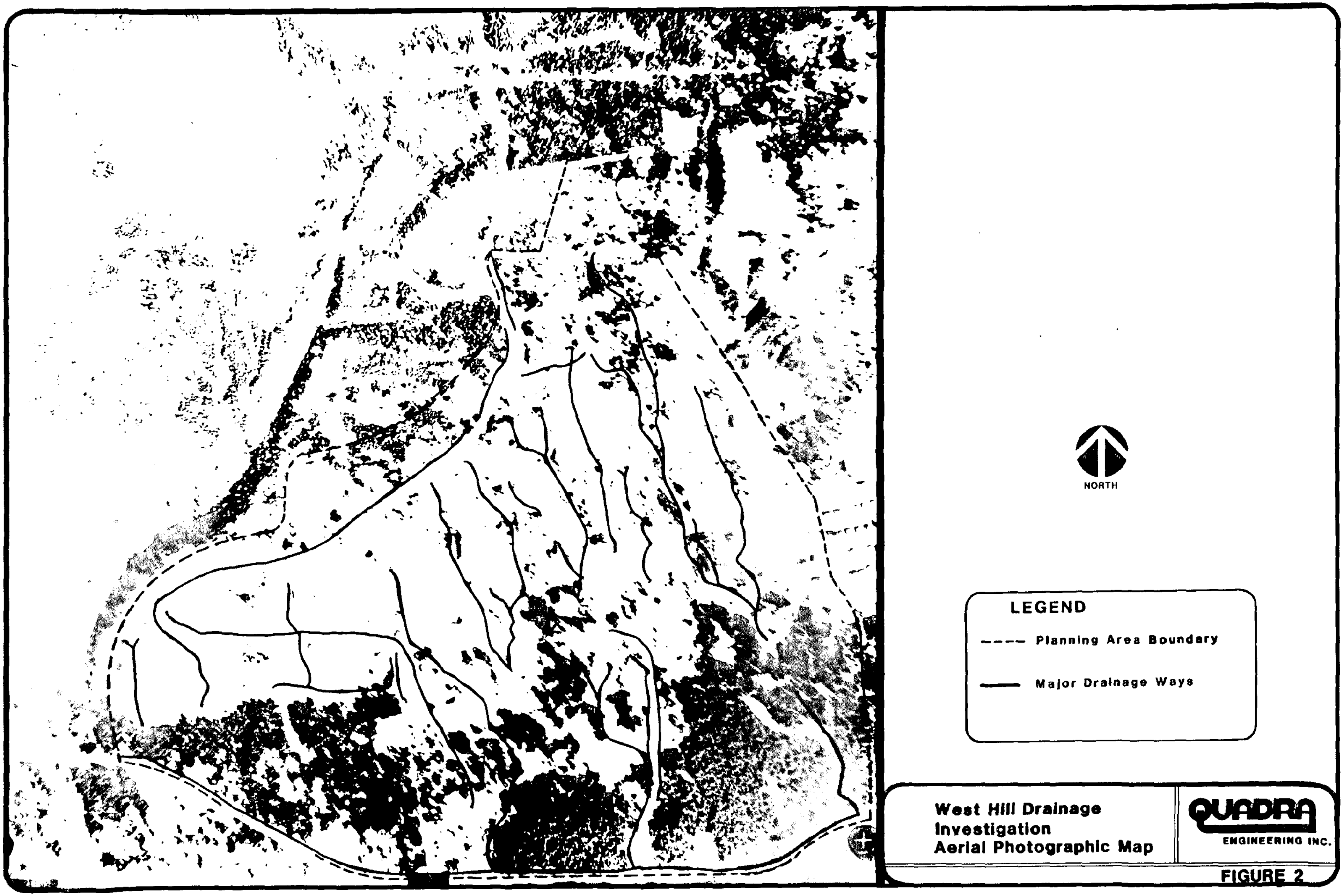
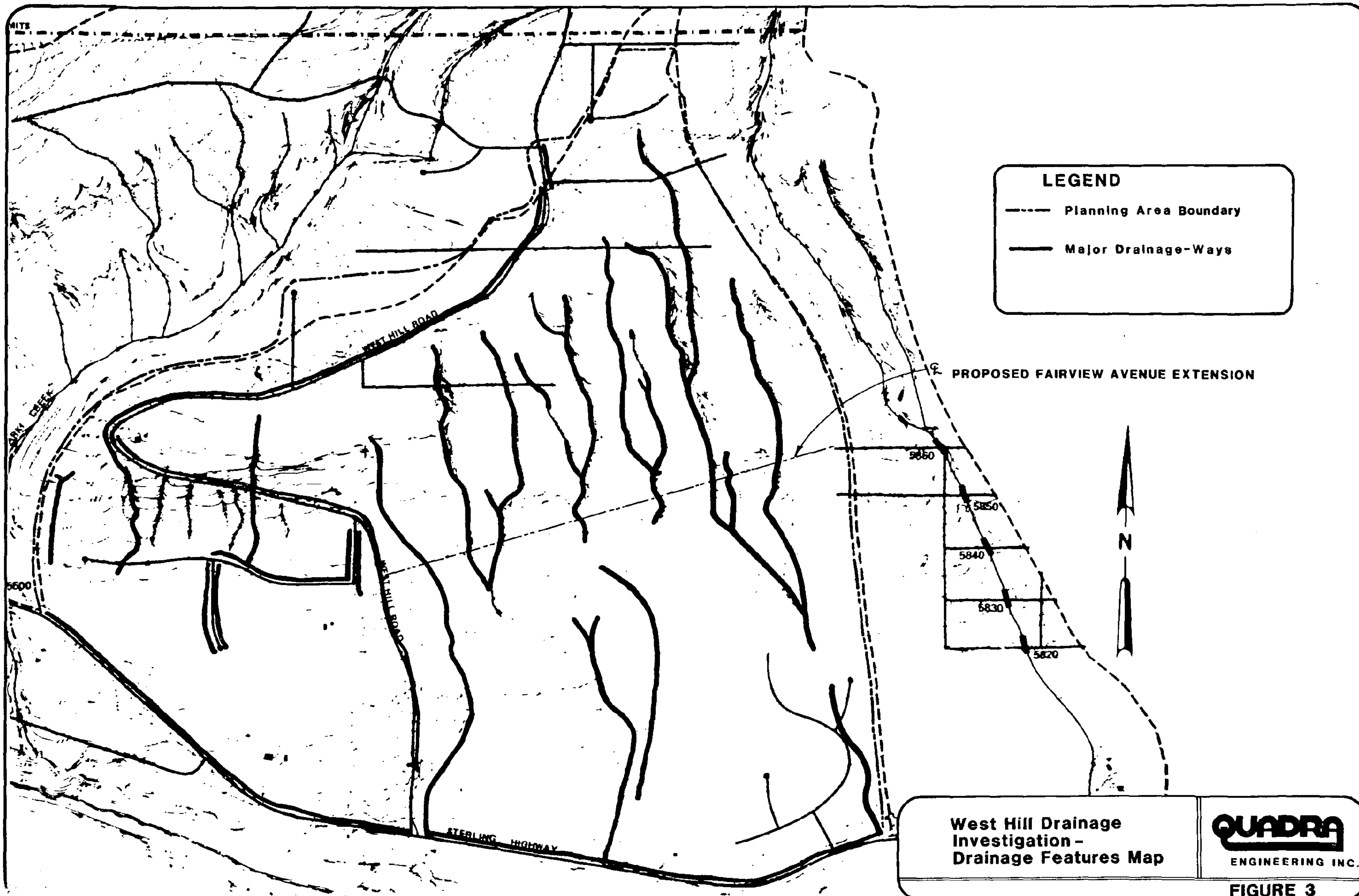

NORTH
LEGEND
Planning Area Boundary
Major Drainage Ways
West Hill Drainage
Investigation
Aerial Photographic Map
QUADRA
ENGINEERING INC.

FIGURE 2



West Hill Drainage Investigation - Drainage Features Map

FIGURE 3

slopes and erodible soils. A series of major drainage-ways have developed in this area. While many of these appear to be only intermittent streams, carrying surface runoff from intense storms, and discharging seasonal flows in the spring, they are classified as major drainage-ways due to the severe erosion hazard and rapid rate and large quantities of peak runoff in the area. Many of these channels are deeply cut; some have formed ravines. At the point where the topography changes from the steeply sloping escarpment area to the moderately sloping bench, drainage characteristics also change. Channels generally become poorly-defined and frequently disappear. Much discharge reaching these areas apparently infiltrates the soil or becomes sheet-flow, depending on the amount of soil moisture and the intensity of rainfall. Sheet-flow processes tend to dominate in grassed areas, while wooded sites tend to be cut by small, ill-defined channels. Roadside ditches are well established in both the upper and lower portions of the basin.

Drainage features for the entire West Hill basin are shown on the Drainage System Maps. The nine sub-basins in the West Hill Area have been delineated and numbered; boundaries of tributary drainages to each of these sub-basins are also delineated and numbered. The numbering system is keyed to that system used in Potential Flooding, City of Homer, prepared by the Soil Conservation Service, June 1978. That report assigned 4 as the West Hill Area Sub-watershed boundary number. Thus, each of the nine major sub-basins and their tributaries is preceded by the number 4.

The methodology developed for Homer's Drainage Management Plan was also used in analyzing discharge in the West Hill Area. The acreage of each tributary basin was measured, and quantities of discharge were then determined from Figure 4, "Relationship of Peak Discharge and Drainage Area for Average Recurrence Intervals".

Table 3 lists drainage basins, acreage, and discharge in the West Hill Area. In determining quantities of discharge, it is important to understand that, for downstrema sub-basins, it is accumulated acreage that determines discharge. Runoff is not calculated by adding discharge from upstream basins to quantities from the downstream basin. For example, from Table 3, sub-basins 4-1-112 and 4-1-111 contribute to sub-basin 4-1-11. The acreage of 4-1-112 and 4-1-111 is 14.00 acres and 2.40 acres respectively. The combined acreage of 4-1-112 and 4-1-111 is added to the 21.15 acres of 4-1-11 to a total of 37.55 acres contributing to create a peak discharge of 18 cfs out of sub-basin 4-1-11. If runoff had been calculated separately for the 21.15 acres

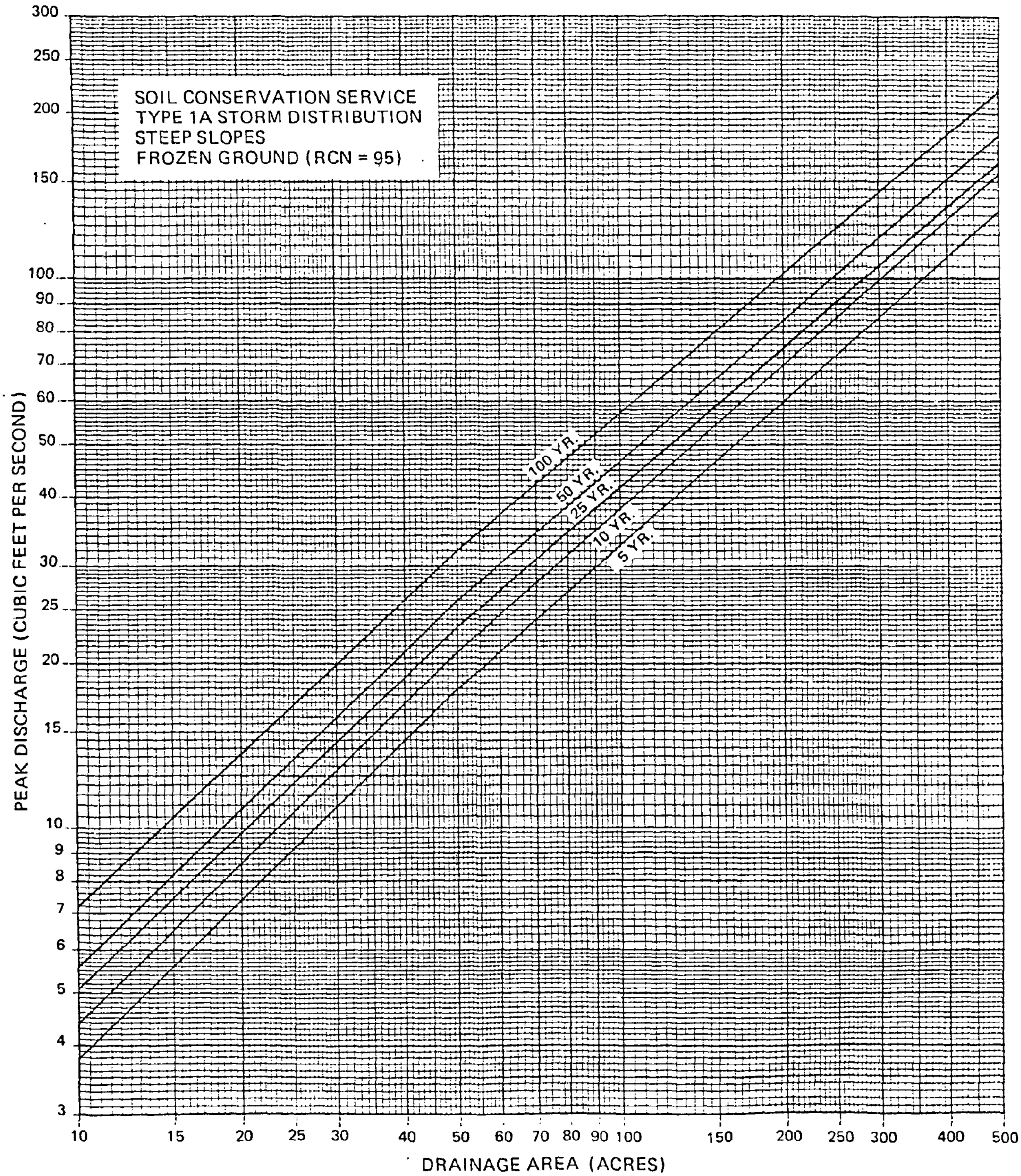


FIGURE 4
RELATIONSHIP OF PEAK
DISCHARGE AND DRAINAGE AREA
FOR AVERAGE RECURRENCE INTERVALS

TABLE 3

WEST HILL AREA SUB-BASINS: ACREAGE AND DISCHARGE*

Sub-Basin #	Contributing Sub-Basins	Contributing Area (Acres)	Discharge (CFS)
4-1-112		14.00	7
4-1-111		2.40	5
4-1-11	(4-1-112,4-1-111)	37.55	18
4-1-12		17.71	9
4-1-2		.18	5
4-1-1	(4-1-11,4-1-12)	71.92	32
4-1	(4-1-1,4-1-2)	91.95	39
4-2-3		7.72	5
4-2-23		2.72	5
4-2-22		.09	5
4-2-21		4.02	5
4-2-2	(4-2-21,4-2-22,4-2-23)	15.45	8
4-2-1		.46	5
4-2	(4-2-1,4-2-2,4-2-3)	80.38	35
4-3-3		1.93	5
4-3-21		2.98	5
4-3-2	(4-3-21)	21.41	11
4-3-1		4.07	5
4-3	(4-3-1,4-3-2,4-3-3)	45.08	22
4-4		13.26	7
4-5-51		3.59	5
4-5-5	(4-5-51)	12.44	7
4-5-41		3.37	5
4-5-4	(4-5-41)	6.54	5
4-5-3		8.89	5
4-5-2		4.98	5
4-5-13		3.38	5
4-5-12		6.77	5
4-5-111		.10	5
4-5-11		10.43	6
4-5-1	(4-5-111,4-5-11,4-5-12, 4-5-13)	22.27	11
4-5	(4-5-1,4-5-2,4-5-3, 4-5-4,4-5-5)	86.52	37
4-6-21		4.86	5
4-6-2	(4-6-21)	3.55	5
4-6-12		1.81	5
4-6-11		8.30	5
4-6-1	(4-6-11,4-6-12)	16.46	9
4-6	(4-6-1,4-6-2)	62.81	30

TABLE 3 (cont'd)

Sub-Basin #	Contributing Sub-Basins	Contributing Area (Acres)	Discharge (CFS)
4-7		14.83	8
4-8-3		.18	5
4-8-2	(4-8-3)	1.13	5
4-8-13		3.20	5
4-8-12	(4-8-13)	7.22	5
4-8-11	(4-8-12)	7.43	5
4-8-1	(4-8-2,4-8-11)	10.30	6
4-8	(4-8-1)	12.58	7
4-9		6.61	5

*Calculated for 25 year recurrence interval.

of sub-basin 4-1-11, and added to runoff from the two upstream basins, an erroneous total of 22 cfs would be reached.

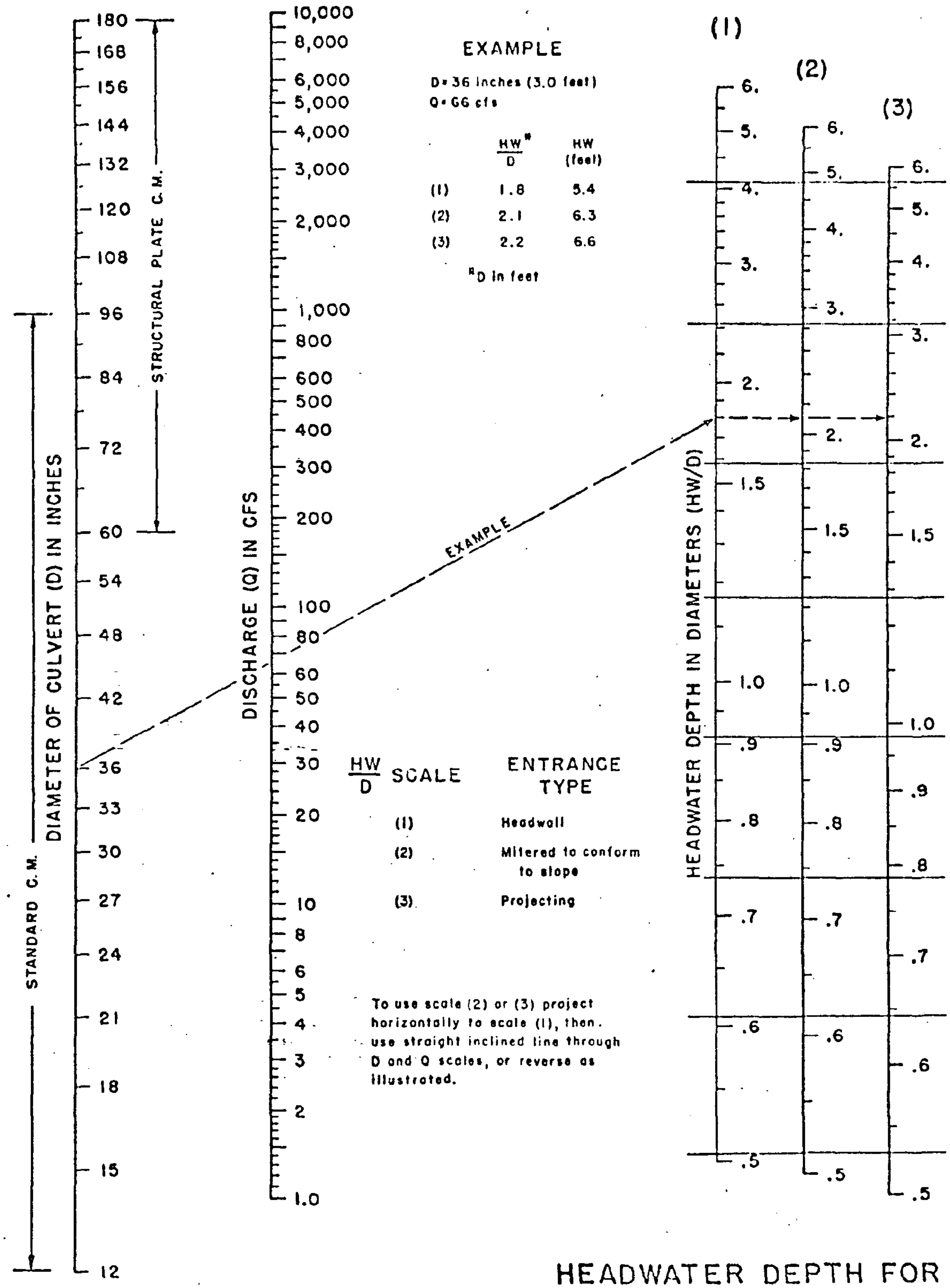
The next step in the analysis was to select the appropriate size of culverts, where these are needed. Sizes were selected only for CMP (corrugated metal pipe) culverts with projecting entrance. Inlet-controlled design was used to determine culvert sizing. Inlet-controlled culverts tend to be of larger diameter, and quantities of flow and headwater depth (HW/D) are factors influencing the required culvert diameter. For the purposes of this study, a headwater depth of 1.0 was assumed. In other words, the depth of water ponded at the culvert inlet must be no greater than the diameter of the culvert. The nomograph used for sizing culverts is included as Figure 5. Sizes selected were limited to standard 18, 24 and 36 inch diameters. When culvert sizes greater than 36 inches were indicated, hydrograph analysis techniques were used to recheck basin discharage. These techniques indicated that no sizes greater than 36 inches are required. It should be noted that the installation of a culvert not recommended in this report, or the development of new roads other than Fairview Avenue, might change drainage basin boundaries and therefore change acreage, discharge, and required culvert sizes downstream.

Recommendations

Based on analysis of the West Hill Area, the following recommendations for improving the basin drainage system are made:

A. Those major drainage-ways indicated on the Drainage System Maps should be protected by establishing easements or rights-of-way. The boundaries of these easements should be adequate to protect real and personal property from flood and/or erosion damages. The recommended protection is for one percent probability (or 100 year) flood flows. This degree of protection should also be adequate to provide an erosion buffer zone. In most cases, the easement should contain the drainage-way and its ravine or valley, plus a strip along the banks. The bank area easement would provide the needed erosion buffer zone.

B. In order to establish the boundaries of these easements, a controlled instrument survey must be performed. Encroachment limits and permissible activities in drainage-ways should be defined to ensure that flows are not constricted and that erosion rates are not accelerated. In this way, properties up and downstream will not be damaged by flooding. For example,



HEADWATER DEPTH FOR
C. M. PIPE CULVERTS
WITH INLET CONTROL

FIGURE 5
NOMOGRAPH

prohibiting fill of drainage-ways will ensure that flow is not constructed or backwater pools formed.

C. Alteration of major drainage-ways should be avoided. Drainage-ways should be kept in their natural condition as much as possible. Potential for accelerated erosion is greatly increased when the natural regime of the channel is altered. Where alteration is necessary, engineering design and review is required. With careful design, however, channels may be widened, deepened or lined when necessary.

D. Those areas with poor drainage or overland flow processes, as shown on the Drainage Features Maps, do not require the establishment of drainage easements. It is important that when new development or construction occurs, channels with hydraulic capacity adequate to contain surface runoff from the area are provided. Development will concentrate flows that previously were dispersed; measures are required to accommodate this newly concentrated runoff or serious drainage problems will result. Quantities of discharge indicated in Table 3 should be the basis for design of these channels.

E. Most of the soils in the area are highly erodible. In order to prevent increased rates of erosion, construction activities near drainage-ways and steeply sloping sites should incorporate soil erosion control measures. Proper grading, detention basins, and limiting the length of time soils are open and exposed are all means of reducing soil erosion. Removal of vegetation should be kept to a minimum and avoided where possible.

F. Culverts should be installed as indicated in Table 4, which lists basin number, discharge, existing culvert size, and recommended culvert size. This table also includes sizes for culverts crossing the proposed Fairview Avenue extension. Figure 6 shows locations and numbers of all existing and recommended culverts in the basin. It must be stressed that these recommended sizes are not a complete design; an engineering analysis of the appropriate slope for each culvert and the required erosion control and energy dissipation devices must be performed prior to installing new culverts. Erosion control at the outlet end of each culvert is an extremely important consideration in the West Hill Area due to the nature of the soils and topography. For the same reasons, vegetative cover should be established in channels up and downstream of each culvert. Thaw wires should be installed in culverts with diameters of 36 inches or greater in order to avoid icing problems.

Proposed Fairview Avenue Extension

Homer's Master Plan for Roads and Streets recommends extending Fairview Avenue west to an intersection with West Hill Road. Once extended, Fairview Avenue would serve as a major arterial thoroughfare. The recommended corridor for this extension is shown on Figure 3, and on the Drainage System Maps. A plan and centerline profile of the Fairview Avenue extension is enclosed; this shows culvert crossings, road grade, existing surface elevation, and the road corridor. A typical culvert crossing detail is also shown on these sheets.

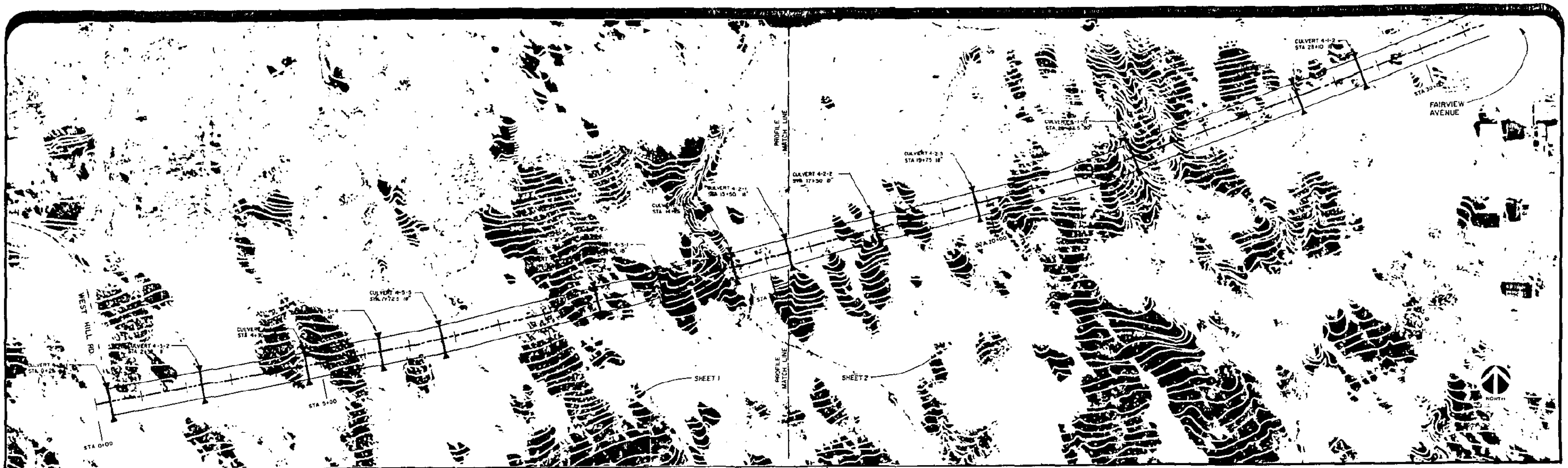
While the extension of Fairview Avenue will improve traffic circulation in the Homer area, it will cause severe drainage and erosion problems unless it is carefully designed and constructed. The road corridor crosses many major and minor drainages in steeply sloping and erodible terrain. The location of the corridor itself follows the contour of the hillside to the greatest possible extent. Culvert crossings for all drainages are strongly recommended for several reasons. By allowing each drainage to cross the road, location of downstream channels will be maintained. This approach would avoid increasing the rate of erosion by concentrating runoff in a new channel on the downstream side of Fairview Avenue. Furthermore, if more development in the area causes increased rates of runoff, these numerous crossings should be sufficient to accommodate these additional flows. Finally, if development alters drainage basin boundaries, there should be fewer problems with inadequate culvert sizes with numerous drainage crossings.

In summary, the extension of Fairview Avenue must be carefully designed in order to prevent causing erosion and drainage problems. Culvert crossings should be provided for nearly all major and minor drainage-ways. Erosion control should be provided at culvert outfalls. Standard erosion and sedimentation control measures should be used throughout the construction period for the proposed extension.

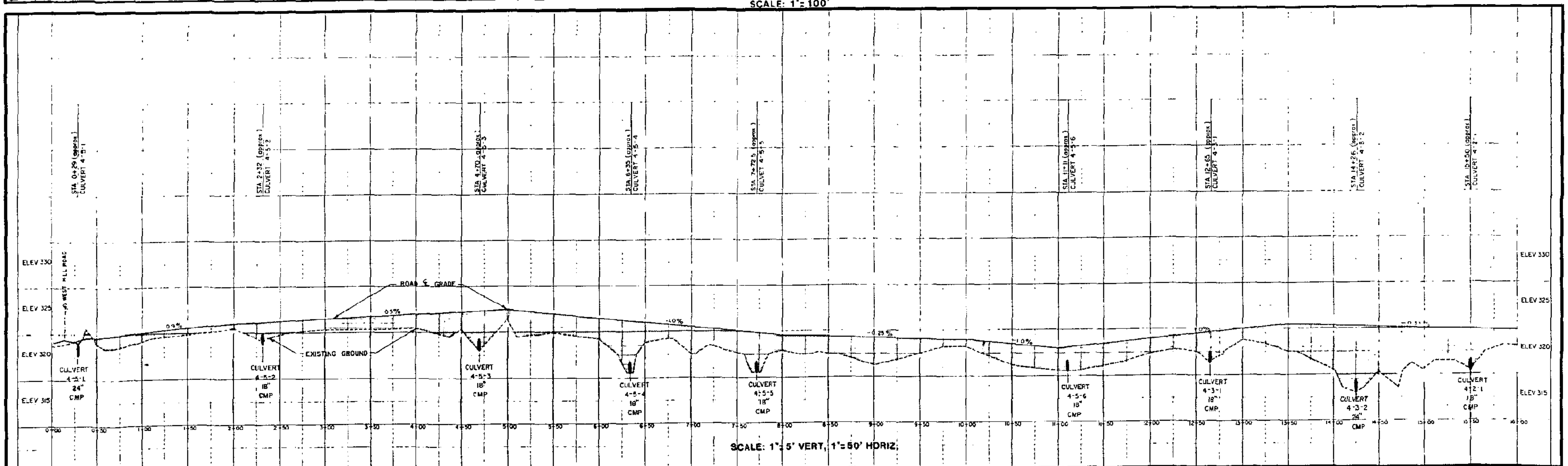
TABLE 4

CULVERT SIZES - WEST HILL AREA

Sub-Basin # Drained By Culvert	Discharge (CFS)	Existing Size (Inches)	Recommended Size (Inches)
4-1-2	5	--	18
4-1-12	9	--	24
4-1-112	7	18	24
4-1-111	5	18	18
4-1-11	18	--	36
4-2-3	5	--	18
4-2-23	5	18	18
4-2-22	5	16	18
4-2-21	5	18	18
4-2-2	8	--	24
4-2-1	5	--	18
4-2 (also drains 4-1, 4-3, and 4-4)	68	--	36
4-3-3	5	5	18
4-3-21	5	18	18
4-3-2	11	--	24
4-3-1	5	--	18
4-5-5	5	--	18
4-5-41	5	36	18
4-5-4	5	--	18
4-5-3	5	--	18
4-5-2	5	--	18
4-5-13	5	18	18
4-5-12	5	18	18
4-5-111	5	16	18
4-5-11	6	16	24
4-5-1	11	--	24
4-5 (also drains 4-6, 4-7,4-8, and 4-9)	38	26	36
4-6-21	5	16	18
4-6-12	5	16	18
4-6-11a	5	20	18
4-6-11b	5	16	18
4-6-1	10	--	18
4-6 (also drains 4-7,4-8, and 4-9)	42	36	36
4-8-3	5	18	18
4-8-2	5	16	18
4-8-13	5	16	18
4-8-12	5	18	18
4-8-11	5	16	18
4-8-1	6	18	24



SCALE: 1"=100'



SCALE: 1"=5' VERT, 1"=50' HORIZ.

STATUS	DATE PRINTED
No. DATE	REVISIONS BY

West Hill Sub-basin Investigation

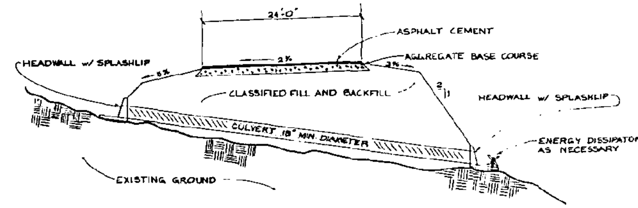
DRAWN J D U. DESIGNED J D M & K S W CHECKED J D M.

QUADRA ENGINEERING, INC.

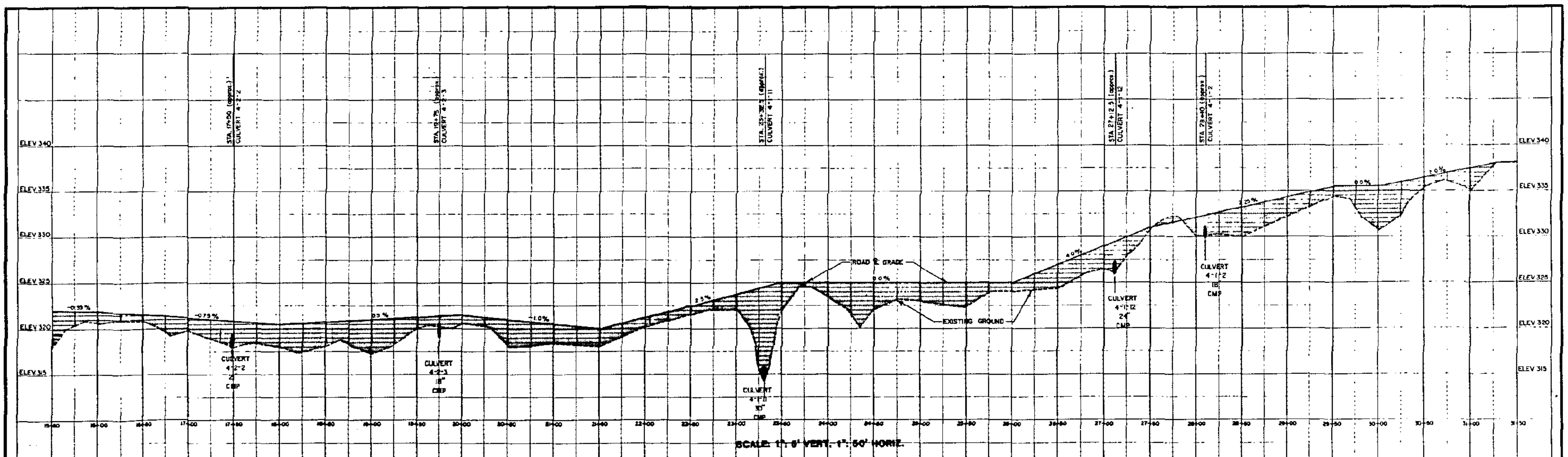
PROPOSED ALIGNMENT AND ROAD GRADE
FOR FAIRVIEW AVENUE
RIDGEVIEW ACRES TO WEST HILL ROAD

DATE | JOB No. 1-15 | SCALE AS SHOWN

SHEET 1 OF 2



① / ② **TYPICAL CULVERT CROSSING**
N.T.S.



STATUS	DATE PRINTED

No	DATE	REVISIONS	BY

West Hill Sub-basin Investigation

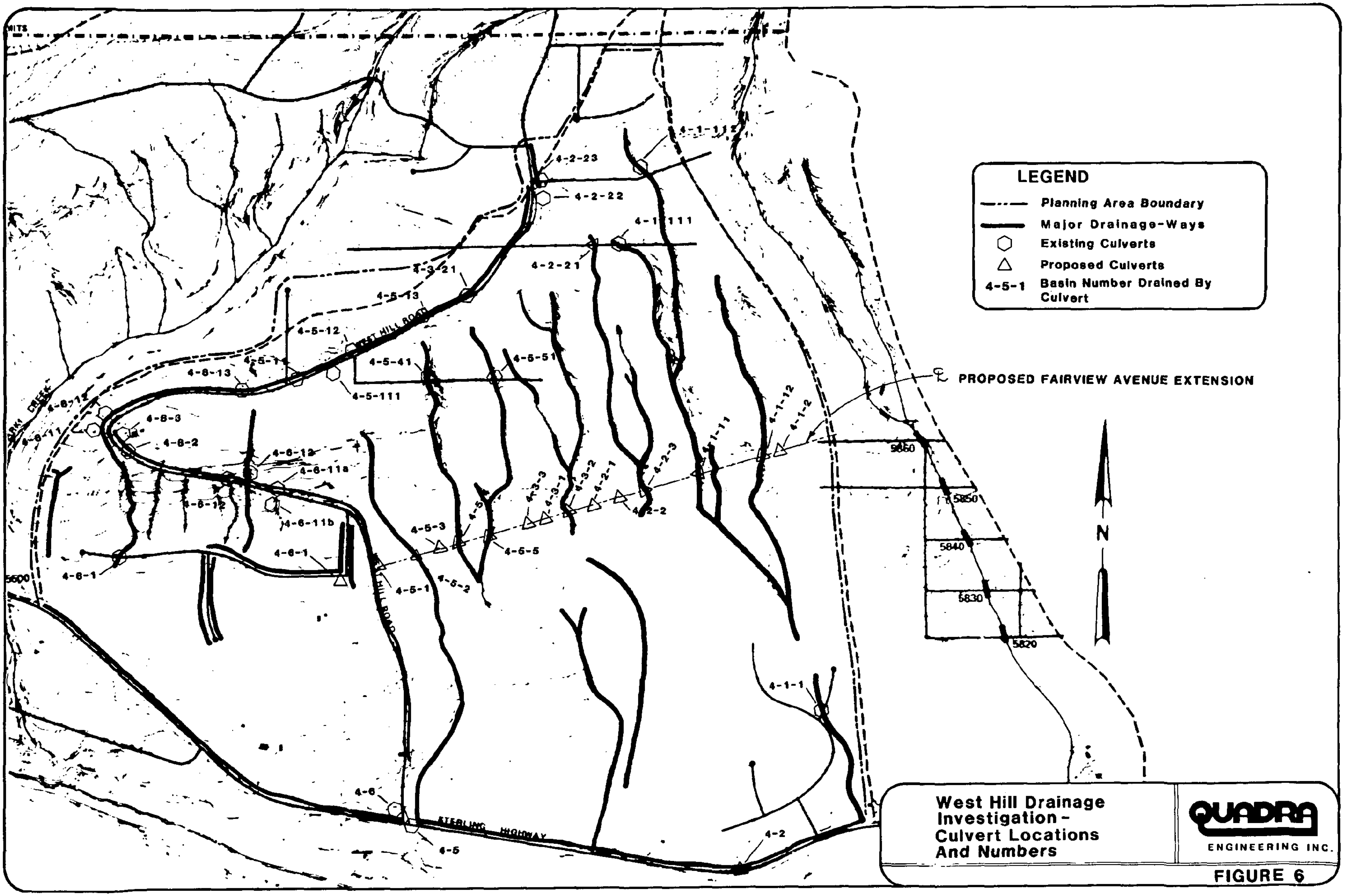
DRAWN J.O.U. | DESIGNED JPM & KSW | CHECKED JPM

QUADRA ENGINEERING, INC.

PROPOSED ALIGNMENT AND ROAD GRADE
FOR FAIRVIEW AVENUE
RIDGEVIEW ACRES TO WEST HILL ROAD

DATE | JOB No. 1-15 | SCALE AS SHOWN

SHEET 2 OF 2



West Hill Drainage Investigation - Culvert Locations And Numbers

FIGURE 6

IV. STERLING SOUTH DRAINAGE INVESTIGATION

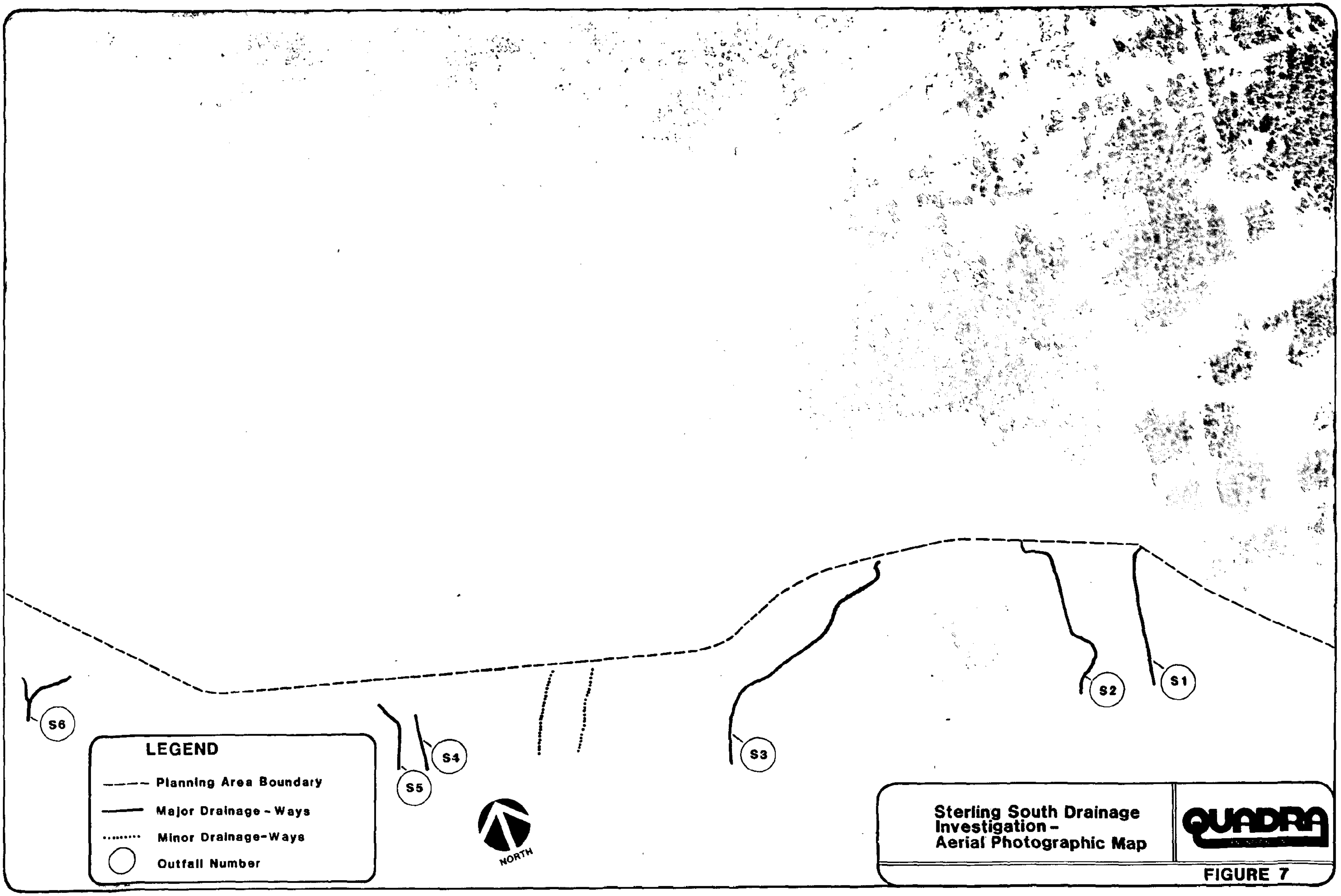
The Sterling South Area is bounded on the north by the Sterling Highway, on the east by Main Street and extends west to the City limits; the entire area drains into Kachemak Bay. In this area, drainage-ways and drainage outfalls to the beach were inventoried. The methodology used to identify these features combined field surveys and the interpretation of aerial photography. An overview of the study area was gained by reviewing air photos which were flown in late April 1981. Drainage features were subsequently verified in late June 1981.

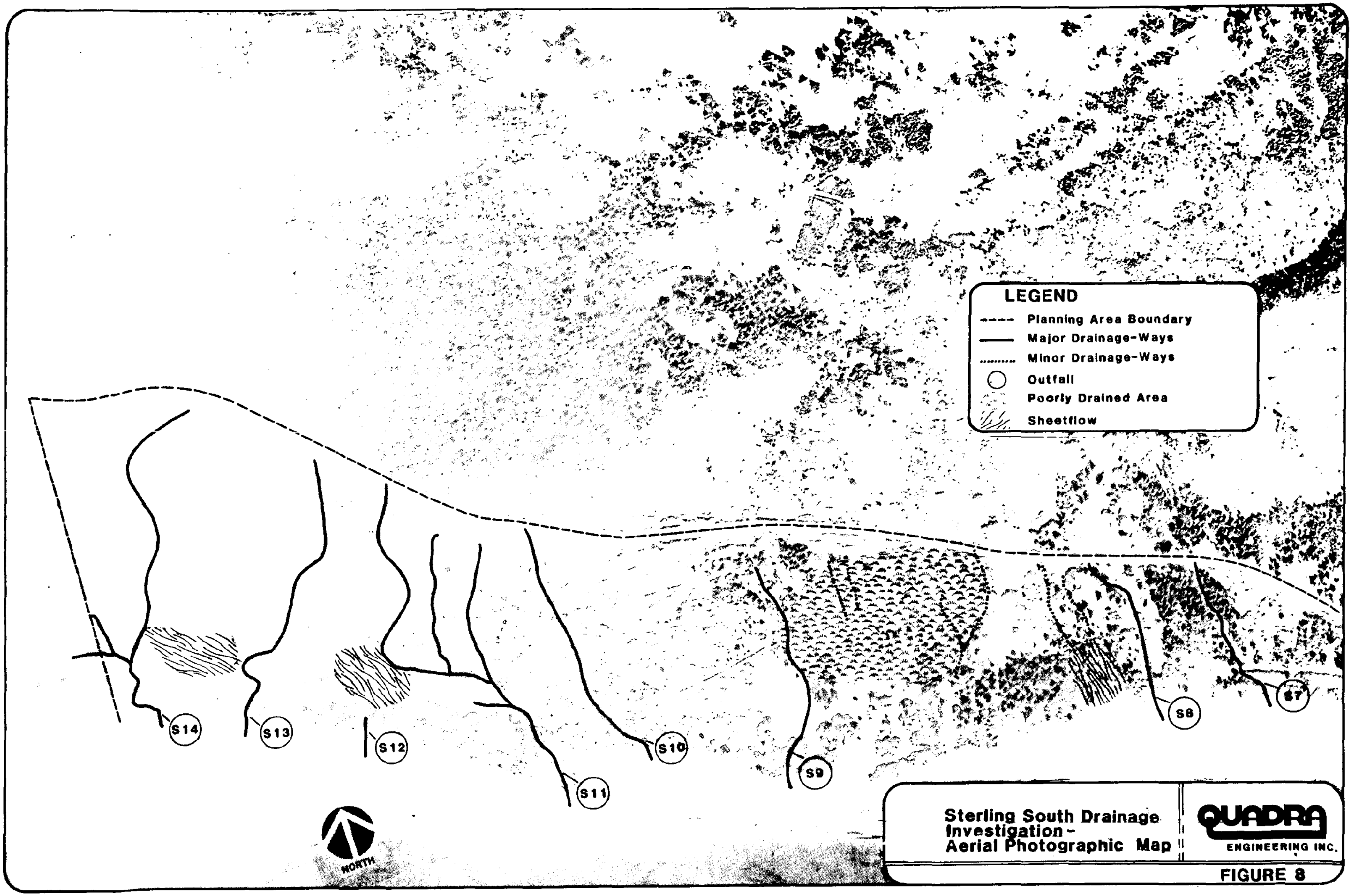
Two types of maps are used to illustrate drainage patterns in the Sterling South Area. Uncontrolled Aerial Photographic Maps (Figures 7 and 8) are used to provide a general, visual representation of the area. These maps can also be used as a guide in air-photo interpretation, referencing major drainage-ways for stereoscopic identification. Table 2 lists recent aerial photography that can be used in analyzing the Sterling South Area.

Drainage features are most accurately represented in Figure 9, the Drainage Features Map. Unfortunately, these topographic maps are out-dated; topography in several locations has been altered through natural processes or construction activities. Heavy lines indicate the location of major drainage-ways. Poorly drained areas and areas where overland flow is the dominant process are also shown. Following is a descriptive inventory of drainage features. Those major drainage-ways outfalling to the beach are numbered, ordered from east to west; others are not numbered. It must be noted that the location of these features is approximate and for general planning purposes only. A controlled cadastral survey is required to determine the exact location of these drainage features.

Starting at Main Street and traveling west along the beach, the first major channel encountered was Woodward Creek (Outfall #S1). This stream, as it approaches Kachemak Bay, is large with a well estabished channel and with unstable banks. Any easement established for this stream should be fairly wide. The stream banks should be stabilized by regrading them to a more gentle slope and then planting appropriate vegetation to prevent erosion (see Core Area Report for recommended species).

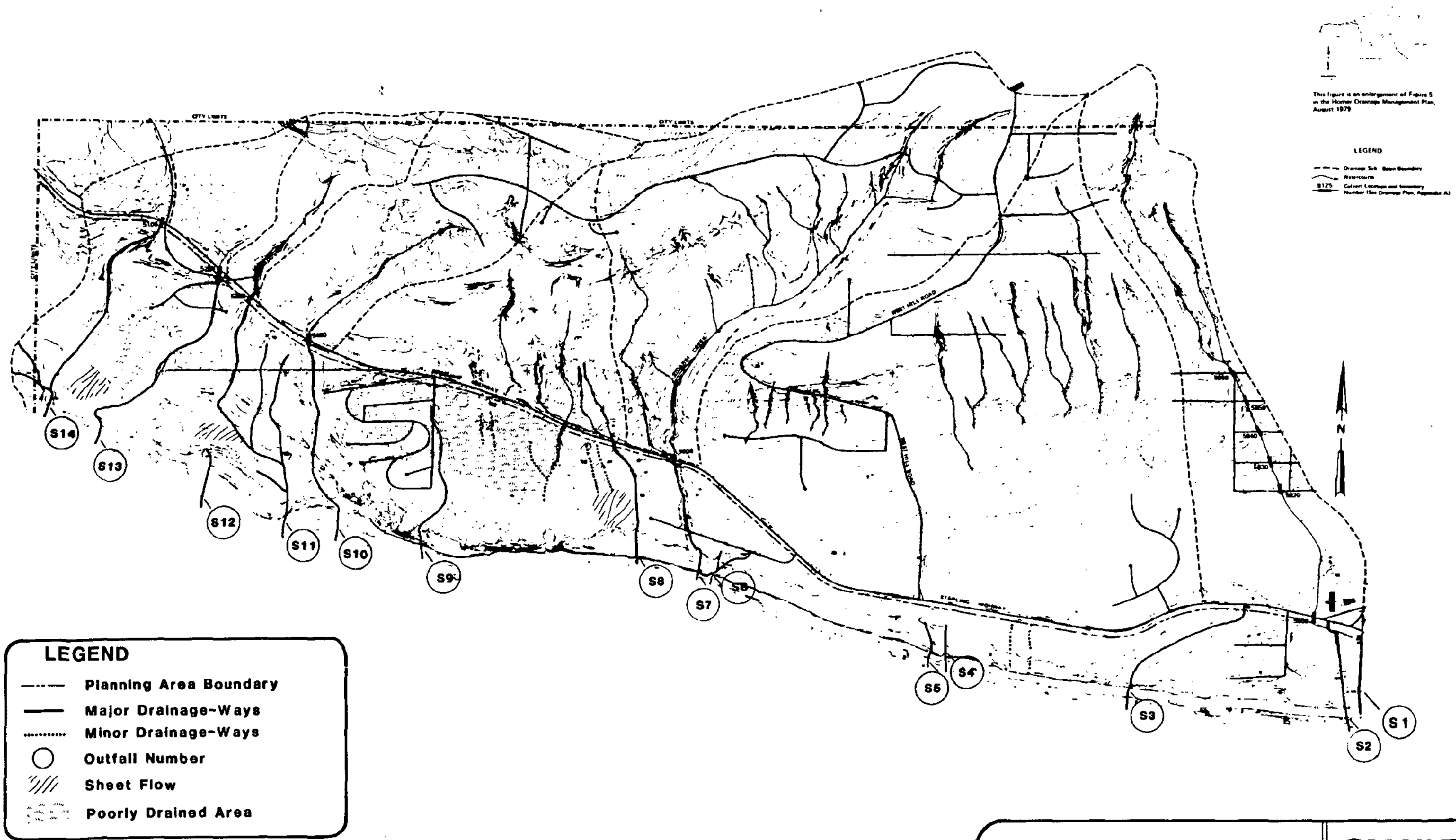
The next drainage feature found occurred where two streams joined above the bluff line and formed a single channel down the face of the bluff (Outfall #S2). This channel has eroded a semi-circular cut into the top of the bluff.


S1
S2
S3
S4
S5
S6
NORTH
LEGEND
Planning Area Boundary
Major Drainage - Ways
Minor Drainage-Ways
Outfall Number
Sterling South Drainage
Investigation -
Aerial Photographic Map
QUADRA
FIGURE 7



Sterling South Drainage Investigation - Aerial Photographic Map

FIGURE 8



Sterling South Drainage Investigation - Drainage Features Map

FIGURE 9

Further west along the beach a large area of the bluff has slumped. It appeared as if vegetation in the area above this slump had been recently cleared. Aerial photographs of this site show a manmade channel extending from near the Sterling Highway east of the Bidarka Inn road to the bluff line just east of the slumped area.

The next major drainage into Kachemak Bay is a natural stream (Outfall #S3). This stream originates at the Sterling Highway just west of the Bidarka Inn and flows southwest through a well vegetated, shallowly cut valley high on the bluff's edge, where it then falls directly down the sandy face. This stream channel and its banks are well established and stable.

For quite a distance after this stream there were no major drainage-ways, only small groundwater seep zones and slump areas. The next outfall (# S4) is located east of West Hill Road. In late June, at the time of this survey, there was little discharge; but the size of this outfall indicates greater quantities of discharge in the spring and after heavy rains. Just to the west of this outfall is another channel (Outfall #S5). Heavy seasonal flows are indicated by the small, sharply-cut ravine at the top of the bluff. The area above the bluff in this vicinity is relatively flat with no defined channels.

Further west along the beach are two drainage-ways which intersect as they flow down the bluff (Outfall # S6). Gravel and cobbles have been deposited at the toe of the bluff by their action. The next feature is Bidarki Creek (Outfall # S7), which forms a waterfall over the bluff. The next outfall (# S8) is also a waterfall.

In the northwest quarter of Section 23, south of the Sterling Highway, are several fairly well-defined channels. These become less well-defined and eventually disappear, with water either infiltrating or becoming sheet flow. In the reach between the waterfall (Outfall # S8) and the rounded point on the beach are several poorly-defined, shifting intermittent channels. This area lies mainly in the north-east corner of Section 14. Due to the impermeable soils in this area, the upland area is poorly drained and wet after periods of precipitation. Between the rounded point and the more angular point to the west, two flowing streams were found. Numerous bluff slumps, however, indicated the erosive action of water. Examination of aerial photographs revealed many shallow streams, which discharge significant amounts of runoff to the beach during the spring. Outfall # S9 discharges to the west of the rounded point. The next drainage feature (Outfall #S10) is a waterfall located just east of the sharp, angular point on the beach. This point was formed by slumped material originating from higher on the bluff's face. The stream forming the waterfall originates landward of the Sterling Highway, with the actual outfall approaching the beach from the west.

There is a small bench and near the foot of the bluff from this area west to the city limits. Runoff flows down the bluff's face, and then sheet-flow becomes the dominant process on the bench. There is a fairly well-defined channel flowing down a ravine from the Sterling Highway, then east along the bench to an outfall at the previously described sharp point on the beach. The outfall (#S11) is a medium sized stream which flows down through the center of the slumped material and rocks.

Again, for a distance along the beach, there are no outfalls, only several groundwater seep zones. Sheet flow occurs along the bench. The next discharge point found was a small drainage-way flowing from a high ravine cut into the bluff (Outfall # S12). A deep ravine (Outfall # S13) which appears to discharge large amounts of seasonal runoff, is located near the western limits of the City. The last channel within the City limits (Outfall # S14) originates landward of the Sterling Highway and crosses it near the Baycrest Inn. This stream approaches the beach from the eastern side of a large slumped area. This outfall has three tributaies and has a fairly large drainage basin, only part of which lies within the City limits. It discharges a large amount of water and probably flows the entire year. This stream is the only one in the Sterling South area to discharge into Kachemak Bay on a gentle gradient; all others flowed steeply down the bluff.

In summary, the majority of the drainage-ways in the study area are natural channels. They are generally well established, but have unstable banks. The frequent occurrence of groundwater seepage in the bluff face indicates a combination of both perched water tables and permeable soils. There are several locations that are either poorly drained or dominated by overland flow processes. Rock formations and soil types vary considerably in this area, with the eastern portion being the more stable and resistant to erosion. For instance, in the sandstone bluff formation, waterfalls caused very little erosion at the edge of the bluff, while elsewhere drainage caused severe erosion.

Based on investigation and analysis, the following recommendations are made:

A. Those major drainage-ways indicated on the Drainage Features Maps should be protected by establishing easements or rights-of-way. The boundaries of these ease-

In general, the most cost-effective and least complicated method of drainage control in the undeveloped portions of the Sterling South Area is to avoid interfering with natural drainage processes. Maintaining drainage-ways in their natural channels and siting development so as to avoid drainage-ways is an effective means of preventing drainage problems.

V. BELUGA LAKE DRAINAGE INVESTIGATION

The Beluga Lake Area includes that area draining into Beluga Lake from the north. It is bounded by Beluga Lake to the south, Lake Street to the west, East End Road to the north and a line drawn north from the eastern edge of Beluga Lake forms the eastern boundary. Drainage patterns and outfalls to Beluga Lake were identified within the study boundaries. The methodology used to identify these features combined field surveys and the interpretation of aerial photography. Photography from late April 1981 was used, and a field survey performed in August 1981 was used to verify the air-photo interpretation.

The same types of maps as used in the Sterling South Area are used to show drainage areas in the Beluga Lake Area, e.g.; uncontrolled aerial photographs (Figures 10 and 11), and the Drainage Features Maps (Figures 12 and 13) on topographic bases. Again, the most accurate representation is on the Drainage Features Maps. The aerial photographs are intended for use as overall visual references and guides for stereoscopic interpretation of the area. An index of appropriate aerial photography is listed in Table 2. Again, if the precise location of drainage-ways is to be established, a controlled instrument survey is required.

Following is a descriptive inventory of drainage features in the Beluga Lake Area. Drainage-ways are numbered, ordered from west to east. Other drainage features are shown but not numbered.

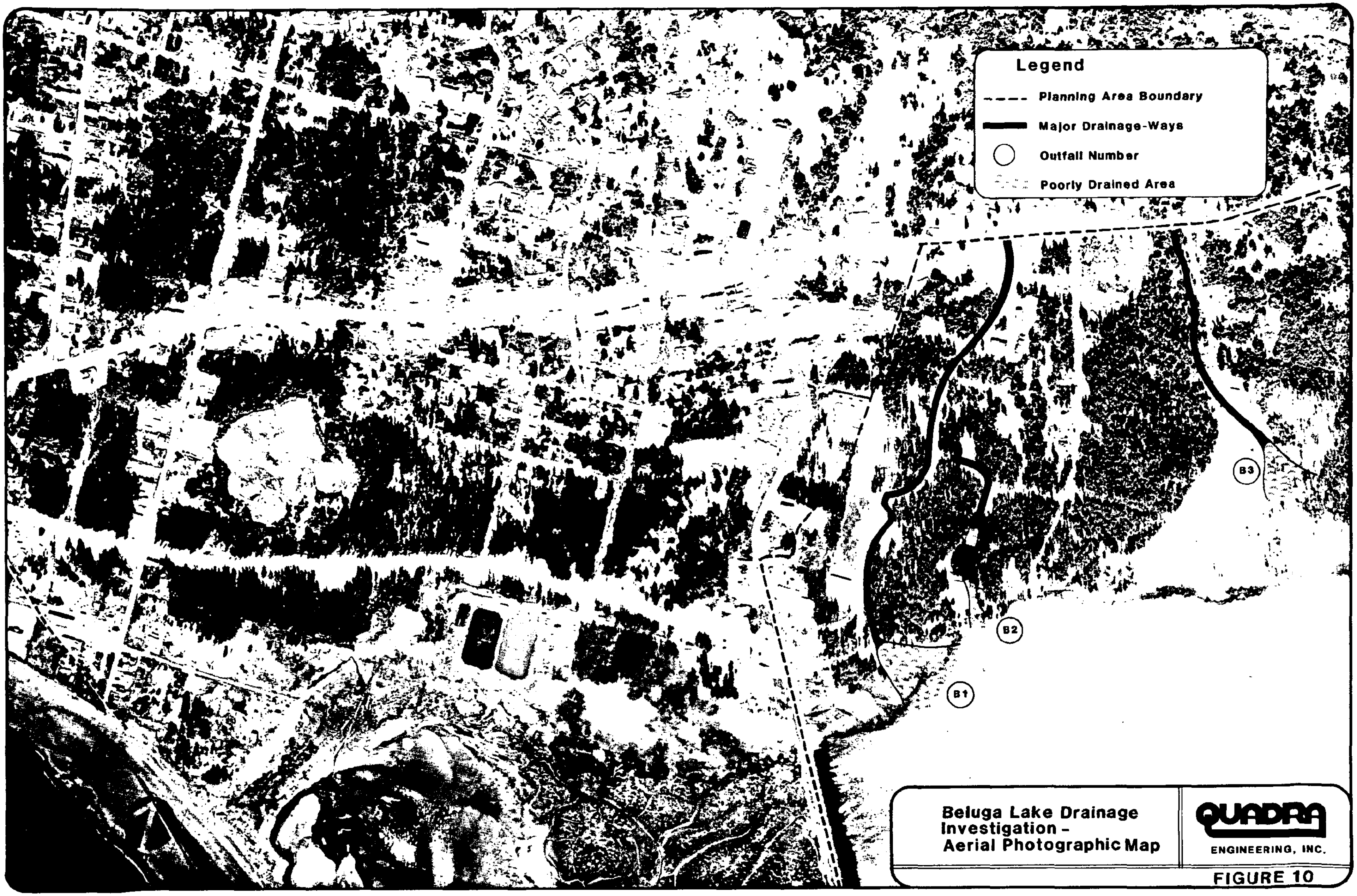
A well-defined drainage system comprised of two separate channels has been developed in the Lakeside Village Subdivision. The first (Outfall # B1) flows along the west side of Ben Walters Lane. The channel has been eroded in places but otherwise the channel pattern and culvert sizes are adequate to contain the expected discharge. Flow from this ditch system is routed to Beluga Lake over a "cat trail" road. With no channel or culvert provided for the drainage to bypass this road, water travels west along the "cat trail" for about 100-feet, and then forms small ponds which overflow to the south and outfall to Beluga Lake.

The other channel in the Lakeside Village Subdivision (Outfall # B2) collects surface runoff from areas east of Ben Walters Lane, and then flows under an old wooden bridge/culvert structure. The channel then spreads out and the stream flows over a wide area east of the residence in Lot 1-A of the A.A. Mattox Subdivision. It finally discharges to the wetland area along the shore of Beluga Lake.

Beluga Lake Drainage Investigation - Aerial Photographic Map

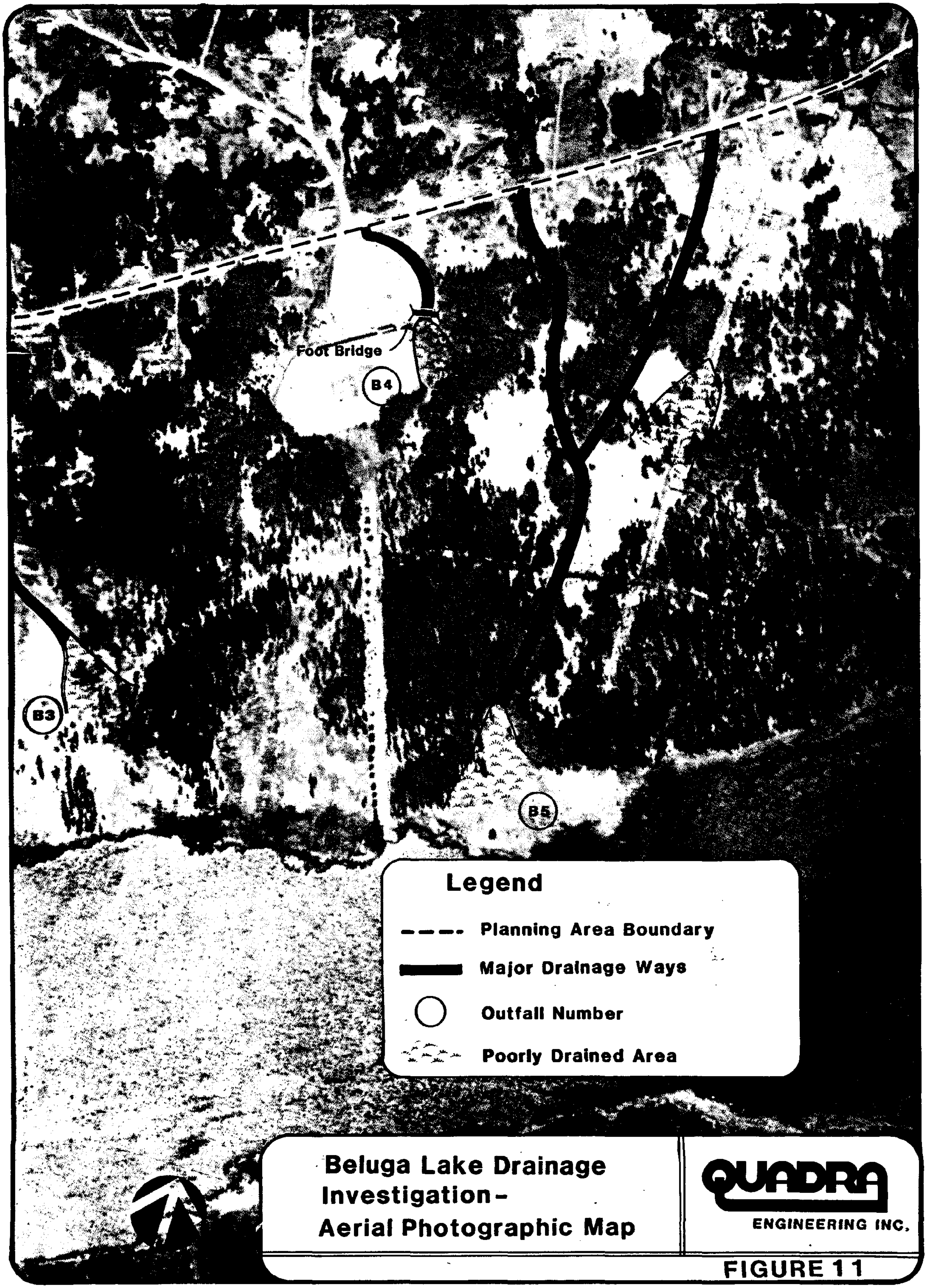
QUADRA ENGINEERING, INC.

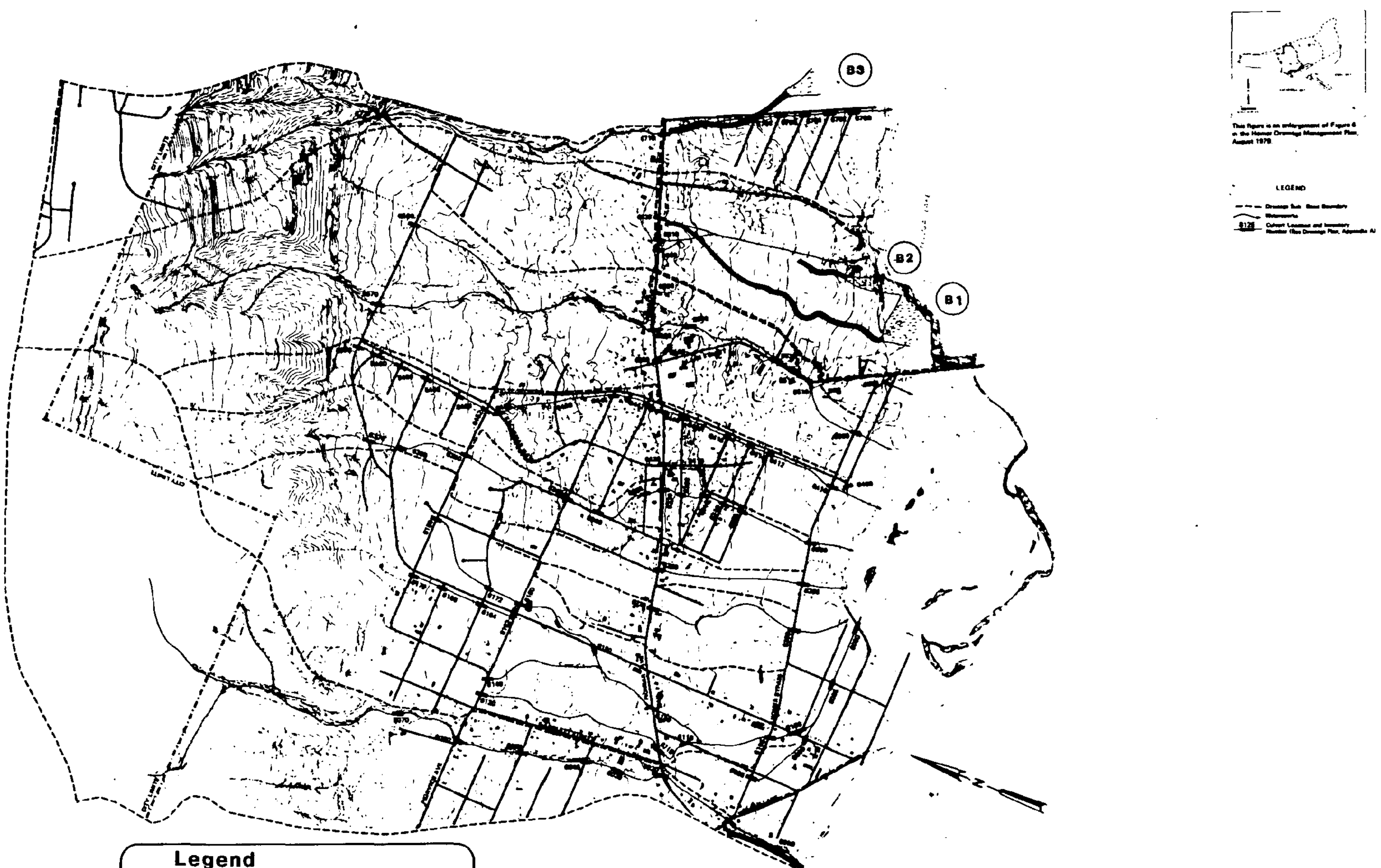
FIGURE 10



Beluga Lake Drainage Investigation - Aerial Photographic Map

FIGURE 10


Foot Bridge
B4
B3
B5
Legend
Planning Area Boundary
Major Drainage Ways
Outfall Number
Poorly Drained Area
Beluga Lake Drainage Investigation - Aerial Photographic Map
QUADRA ENGINEERING INC.
FIGURE 11



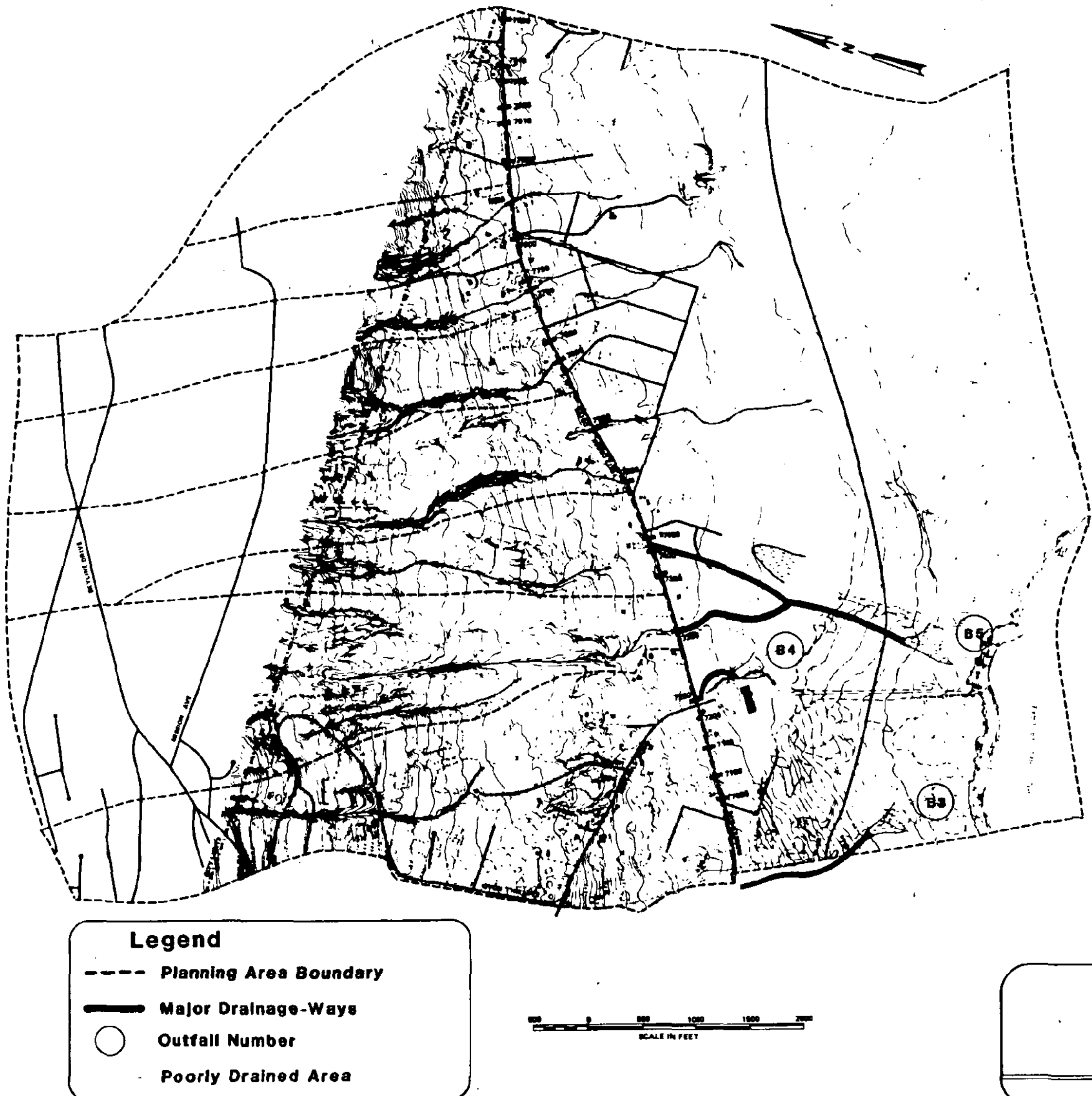
Legend

- Planning Area Boundary
- Major Drainage-Ways
- Poorly Drained Areas
- Outfall Numbers

Beluga Lake Drainage Investigation - Drainage Features Map

QUADRA ENGINEERING, INC.

FIGURE 12



Beluga Lake Drainage Investigation– Drainage Features Map

QUADRA ENGINEERING, INC.

FIGURE 13

A drainage area originating upstream of East End Road forms the next outfall system (Outfall # B3). From East End Road, water flows in a channel west of Mattox Road. The channel then heads to the east and emerges from a wooded area just south of the last residence on Mattox Road. From there, it meanders through an old field downhill from this residence. While flowing through the field, the stream divides itself into two smaller channels. One flows east toward the wooded area, while the other runs first through an old corral in the field, and then east to a boggy area in the woods.

To the east, the next drainage system (Outfall # B4) collects drainage from above and around the elementary school. Flow is channelized as it passes the school yard, and then drains into a marshy area. Any channel that may once have existed has since been disturbed by the construction of sewer lines. These lines lie both parallel and perpendicular to the direction of natural drainage to Beluga Lake. The largest quantity of drainage now flows down this utility clearing behind the school, primarily as sheet flow. There are, however, several areas where water forms pools as it flows to the lake.

The last major drainage-way (Outfall # B5) in the Beluga Lake Area originates upland of East End Road. Two small streams with defined channels cross East End Road, and then merge into a single stream. This stream flows into the wetland area bordering the shore of Beluga Lake. The utility right-of-way east of this stream and south of the Mariner Subdivision is also quite swampy, and drains to the northeast end of Beluga Lake. There is no defined channel for this system; drainage is transported by sheet and subsurface flow.

The wetland bordering the northern shore of Beluga Lake is the ultimate catchment for drainage in this area. Water then filters through the wetland to the lake itself. Drainage in the Beluga Lake basin is, in general, not well-developed. Only a few drainage areas have defined channels; the majority are shallow and intermittent with sheet flow frequently the dominant process. There are no distinct outfalls into Beluga Lake. Instead, all drainage systems discharge to the wetland area on the shore.

Most of the drainage-ways originate and flow through undeveloped properties. Vegetation is established in most of these areas and erosion is not a problem. Due to impermeable soils in the area and the large drainage basin supplying Beluga Lake, there are large quantities of runoff.

Based on investigation and analysis, the following recommendations are made:

A. The few channels that are currently well-established (e.g., channels of Outfalls B1, B2, and the upper part of channels B3, B4 and B5) should be protected with drainage easements or rights-of-way.

B. As development proceeds in sites dominated by overland flow or sheet-flow, it is essential that drainage-ways or channels be established to contain the runoff currently flowing through these areas. If underground conduits or culverts are used, design must prevent piping through of the surrounding backfill. If open channel drainage systems are chosen, they must be vegetated or otherwise lined to prevent erosion. It is of primary importance that sufficient hydraulic capacity to collect and discharge both channel and sheet flow in the Beluga Lake Area be maintained and developed or improved as necessary.

APPENDIX A

APPENDIX A
RECOMMENDATIONS FOR A DRAINAGE ORDINANCE

This Appendix provides recommendations to be used by the City of Homer in developing a drainage ordinance. The purpose of such an ordinance is to:

1. Protect existing development from damages to real and personal property caused by flooding and erosion.
2. Provide for orderly new development in such a manner that flood and erosion damages are prevented.
3. Protect the environment.
4. Provide for the general public health, safety, and welfare.

In order to achieve these objectives, the City of Homer should enact a drainage ordinance containing the following provisions*:

1. Definitions

   a. Drainage System - The combination of natural drainage features and ditches, culverts, channels and the like designed to convey surface water drainage to a designated outfall.

   b. Major Drainage-Way - A natural or man-made channel or stream that requires protection by easements and that conveys significant quantities of water, as delineated on Drainage System Maps.

   c. Minor Drainage-Way - A natural or manmade channel or stream discharging small and/or intermittent quantities of water, as delineated on Drainage System Maps.

   d. Peak Discharge - The maximum rate of surface water discharge (in cfs) from a specified drainage basin expected with a certain annual probability of occurrence.

   e. Sheet Flow - Surface water runoff that flows in a thin sheet over a large area before it discharges into a channel or infiltrates the soil.

   f. Thread of a Stream - That line defining the center of the primary channel of a stream, generally corresponding with the deepest portion of the channel.

*Legal review and advice is required to ensure the accuracy and legality of these drainage provisions.

2. Major Drainage-Ways

Because many of the major drainage-ways in the city are in a natural, unaltered condition, these major natural drainage-ways may not be altered in any way, such alterations including, but not limited to, deepening, widening, relocating, filling, encroaching, and removing vegetation. Variances may be granted in unusual circumstances and only when alterations are designed by a professional engineer.

Where a subdivision or lot is traversed by or is adjacent to a major drainage-way, a dedicated stream maintenance easement shall be established. All easements shall be a minimum of 20 feet wide centered on the thread of the stream and adequate to contain peak discharge expected to occur with a one percent annual probability (100 year flood), whichever is greater. When a major drainage-way flows through a ravine, the easement shall include a 10 foot wide strip beyond both edges of the stream bank.

When a road or driveway crosses a major drainage-way, a culvert or other drainage appurtenance adequate to convey 25 year peak discharge shall be provided.

3. Minor Drainage-Ways

Alteration of minor drainage-ways should be avoided. A drainage system adequate to contain 25 year peak discharge from minor drainage-ways or sheet flow areas must be provided. A drainage system contains but is not limited to natural channels, constructed channels, culverts and ditches. This drainage system shall conform to the natural system to the maximum possible extent. Culvert outfalls and ditches shall be designed to minimize the potential for erosion.

4. Construction Practices

Erosion of the soil with subsequent downstream sedimentation shall be avoided. Removal of vegetation shall be kept to a minimum and vegetation shall be replanted as soon as possible after completion of construction. In areas with slopes greater than 10% or in projects involving construction and disturbance of the soil in areas of 2 acres or greater, erosion control devices shall be utilized. Such devices might include settling basins, diversion berms, hay bales, or other standard controls.

APPENDIX B

APPENDIX B
FACTORS AFFECTING BLUFF STABILITY

This Appendix briefly identifies and discusses the factors affecting bluff stability, and offers planning guidelines and other recommendations for avoiding bluff erosion problems. While this discussion focusses on the coastal bluffs of the Sterling South Area, much is also applicable to steep slopes, bluffs, and escarpments throughout Homer.

Bluff erosion is a continuous, natural process. While the rate of erosion may be reduced, the process of erosion cannot be entirely halted. Recognizing this fact, the most practical and effective approach to reducing the potential for property damages or losses from erosion is to avoid the situations where erosion may become a problem. In other words, rather than building a home on the edge of a rapidly eroding or unstable bluff, and then taking corrective actions as problems arise the more practical approach would be to site the structure a safe distance from the bluff's edge.

Both the population and the rate of development in Homer are expected to increase in the near future. Because coastal bluff front property offers desireable views and other amenities, there will undoubtedly be pressure to rapidly develop these areas regardless of any constraints these sites impose. With an understanding of the processes of erosion, planning guidelines and development controls may be designed to reduce the potential for erosion damages.

Erosion Processes

In several areas, the rate of bluff erosion has already been accelerated by human activities. Alteration of the natural drainage regime can cause a marked effect on the processes of bluff erosion. Creating new, artificial channels conveying runoff to the bluff's edge can initiate rill gully erosion. This occurs when the concentration of runoff cuts grooves or rills into the soil. With increased velocity of flow, gullies develop, cutting into the face of the bluff.

The action of ground-water within the bluff is often the most important factor affecting its stability. Water added to the bluff naturally by rainfall or artificially by septic systems, affects the bluff in three ways.

1. Water added to the bluff may saturate the more permeable layers until it encounters a less permeable layer such as coal and often flows out toward the bluff face. Seep zones develop along the bluff face causing materials to be removed and increasing surface erosion.

2. Water added to the bluff may saturate the more permeable unconsolidated layers at the top increasing the weight and creating an unstable situation.

3. Added water increases the water pressure within the bluff materials. This increased pressure decreases the natural strength (cohesion) of the bluff materials and this in turn decreases stability or resistance to slumping and sliding.

Other factors in addition to the presence of water in the bluff can contribute to internal failure of the bluff materials. Weight added to the top of the bluff close to the edge in the form of buildings, roads, or other structures decreases the stability of the bluff. Materials removed from the toe of the bluff by wave action or by human excavation steepen the slope and remove the support at the base. With sufficient addition of water to the bluff, the internal strength of the bluff materials will decrease and an unstable situation is created which nature will seek to correct.

Natural readjustment of the bluff slope is accomplished by slumping and sliding. These processes vary according to the bluff composition; unconsolidated layers tend to slough off in shallow segments near the face of the bluff whereas cohesive materials tend to slide along deeper zones in the bluff.

In the case of a bluff composed of layers of several different materials, the overall failure and retreat of the bluff will reflect the differential erosion processes associated with each layer of material in the bluff. In the case of a bluff composed of one massive unit of sandstone, large slump blocks tend to fail along deep-seated zones of weakness and establish a more stable slope by sliding downward, seeking a natural angle of repose.

One other factor involved in bluff erosion is wave action. High tides combined with wind-generated waves reach the toe of the bluff, eroding this area away. Erosion of the toe generally will result in decreasing the stability of the remainder of the bluff's face, eventually causing it to slump or slide into a more stable angle.

Figures 14 through 16 summarize and illustrate several of the factors affecting bluff erosion. This has been an oversimplified explanation of a set of processes which can be very complex depending on the specific section of bluff. All of these factors contribute to the overall instability of a bluff but their relative degree of importance depends on the particular bluff in question.

<u>Recommendations</u>

1. The rate of bluff erosion can be reduced by not locating development close to the bluff's edge, where the weight of the structure will make the slope less stable.

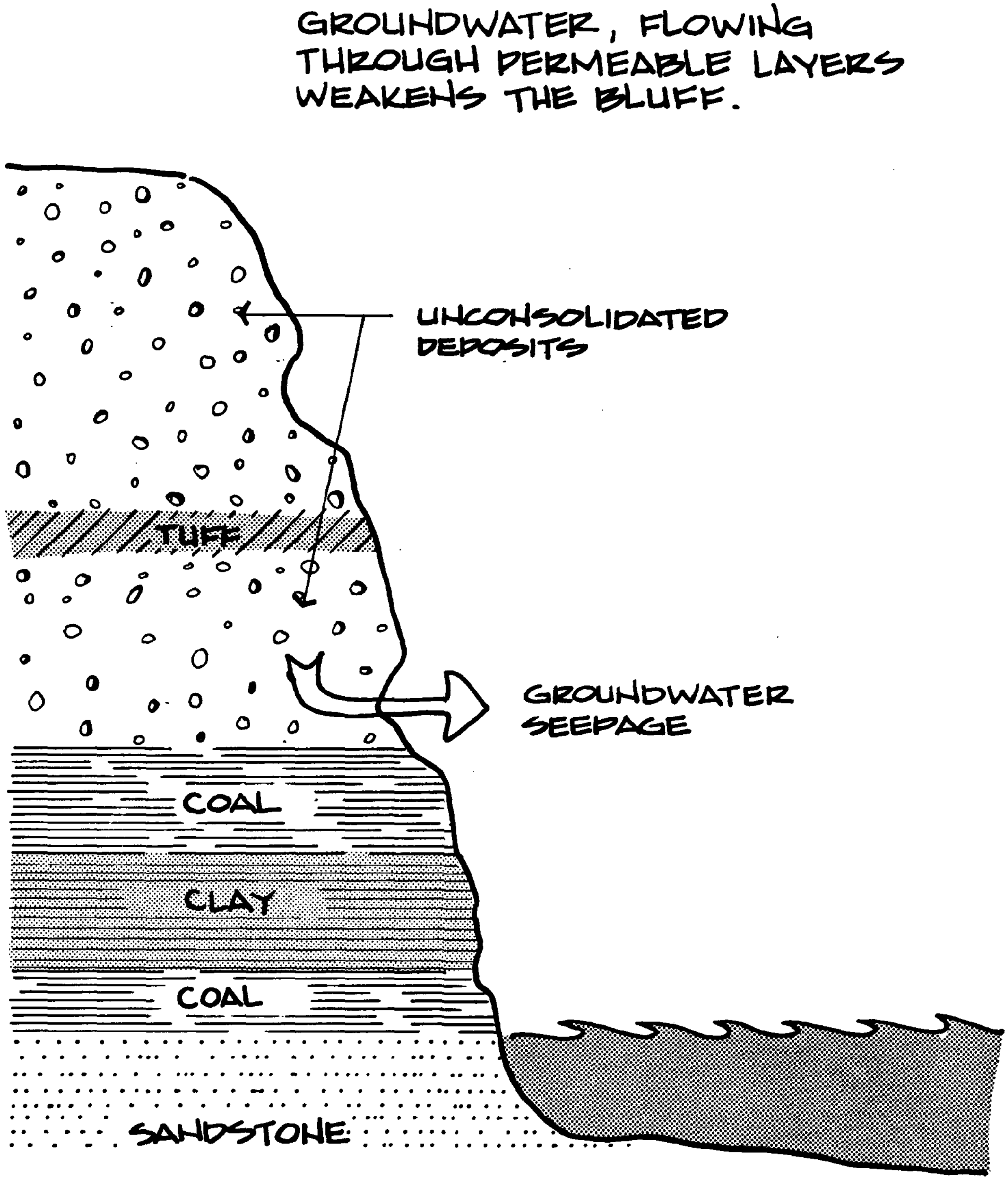


FIGURE 14
Factors Affecting Bluff Stability - Bluff Composition

QUADRA ENGINEERING, INC.

SURFACE RUNOFF

__RAINDROP EROSION__ - THE SPLASHING OF SOIL FROM THE DIRECT IMPACT OF RAIN ON SOIL.

__RILL AND GULLY EROSION__ - OCCURS WHEN THE CONCENTRATION OF RUNOFF CUTS GROOVES OR RILLS INTO THE SOIL. WITH INCREASED FLOW, GULLIES DEVELOP.

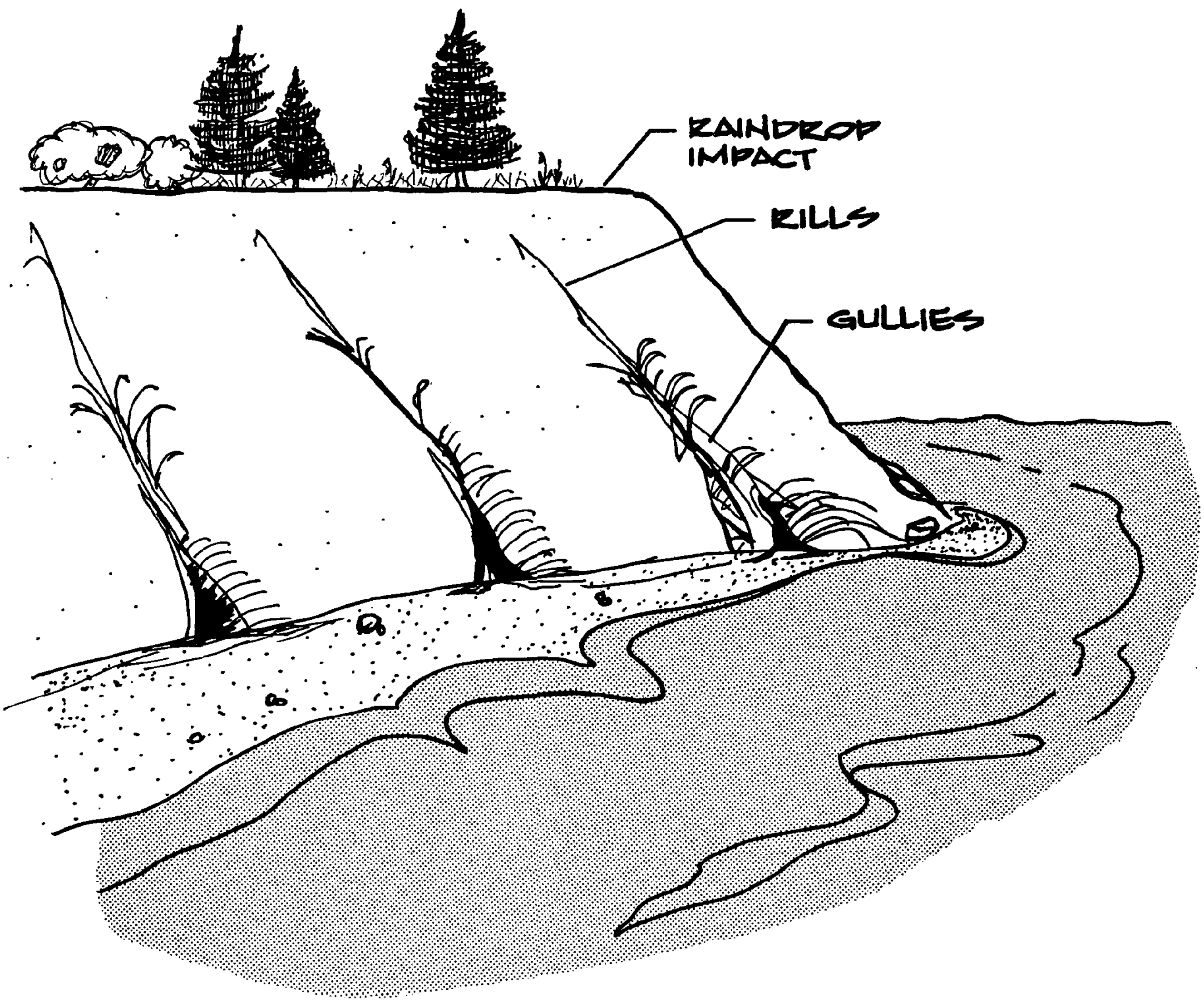


FIGURE 15
Factors Affecting Bluff Stability - Surface Runoff

QUADRA ENGINEERING, INC.

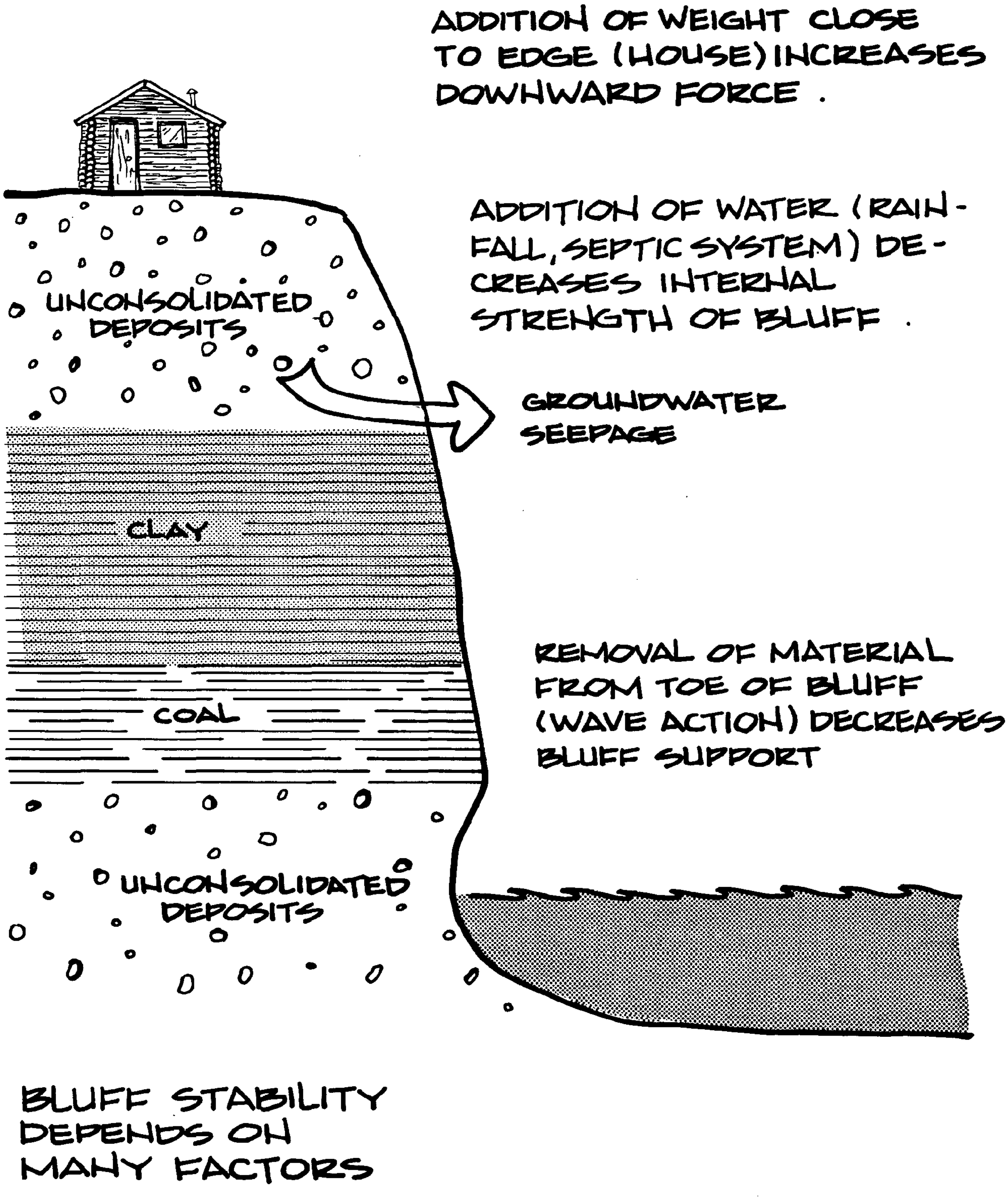


FIGURE 16

Factors Affecting Bluff Stability - Summary

QUADRA ENGINEERING, INC.

2. Septic tilefields should be installed in such a manner so that subsurface drainage is routed away from the bluff edge or face rather than towards it. Increased wetness in soils tends to decrease stability of the bluff.

3. Channelization and routing of surface runoff and storm water directly over the bluff should be avoided. This practice tends to promote the development of gully erosion and significantly decreases stability. A better practice is to route surface water runoff to a drainage system or natural drainageway.

4. Structures should be set back a suitable distance from the bluff's edge. Thus, as erosion of the bluff continues, the struture will be protected from damage or destruction by a buffer zone.

APPENDIX C

APPENDIX C
GENERAL STORM DRAINAGE CRITERIA

Article 1.1 General

All developments being constructed within the City of Homer shall be protected from drainage problems by use of proven engineering techniques as set forth and described hereinafter. Problems resulting from natural waters such as creeks, springs, and groundwater; from storm water runoff; from winter icing accumulations; and from spring breakup waters; will be considered in determining the necessary drainage improvements that will be required for any specific project.

Article 1.2 Types of Required Improvements

The following improvements, if based on or designed in accordance with proven engineering techniques, are viable alternatives which may be used in solving drainage problems: Placement of proper drainage easements or reserves, construction of subsurface storm drains, construction of open channels, placement of culverts, construction of temporary storage areas, construction of subdrains, construction of dry wells, construction of metering basins, placement of staggered culverts, and other methods or combinations of the above if the situation warrants such use.

Article 1.3 Basis for Required Improvements

The need for drainage improvements may be based on one or more of the following items: topographic maps, field inspections, historical information, soils tests, existing floodplain studies, existing storm drainage improvements studies, and any future drainage related studies, reports, or ordinances as may be adopted for use by the City.

Article 1.4 Design of Improvements: General

A. Capacity.

Provisions shall be made within the drainage system to insure that the inlet flow line elevations and the capacity of the drainage system is such that it may be extended to properly serve the entire drainage basin at the time of ultimate development. This shall include the entire upstream portion and the portion of the basin outside the development, regardless of existing conditions.

B. Alignment.

The alignment for storm drainage conduits shall:

1. Avoid meandering, offsetting and unnecessary angular changes.

2. Not have angular changes greater than necessary and none to exceed ninety degrees (90°).

3. Maintain as nearly as possible in their existing alignment natural streams, paved channels, and swale flows.

4. Have the vertical alignment designed so as to preclude any ponding.

C. Required Easements.

Easements are required in the following situations and shall be as specified:

1. Creek maintenance easements are required.

2. A drainage easement reserve needs to be placed on such features as depressions, sinkholes, low spots, or bogs. Such an easement is also required where icing accumulations are known, or are expected to develop unless icing control or prevention techniques are used to curtail the icing's development.

3. Drainage easements are needed for existing drainage facilities if no easement exists or if the present easement is inadequate when the facilities lie outside of public rights-of-way. They are also needed on new drainage facilities proposed for construction in areas lying outside of public rights-of-way.

   a. Easements for closed conduits shall have a minimum width of twenty feet. Large pipes and deep trenches may require additional width to provide ample working space as required by the City.

   b. Easements for open channels shall have sufficient width to contain the open channel, side slopes, erosion buffer zone, and a twelve-foot service road with available turnaround at end if needed.

A drainage system should outfall into a natural drainage way or an established drainage easement, which has been determined to be of adequate hydraulic capacity to carry the new outfall flows.

D. Structural Elements.

The structural design and construction of storm drain improvements shall conform to the following:

1. Closed Conduits.

   a. Materials used shall be either cast-in-place or precast reinforced concrete pipe or corrugated metal pipe of the proper class or guage.

b. Minimum depth of cover shall be four feet, measured from the top of the pipe to finish grade. If this requirement cannot be met at some point for any reason, icing prevention or control measures must be taken to curtail icing development at that point.

c. Minimum diameter on any storm drain shall be twelve inches.

2. Outfalls.

a. When the outfall is from a pipe or paved ditch to a natural unprotected channel, an energy dissipator shall be provided for protection against erosion. If the natural channel is subject to flooding, headwalls, gabions or other suitable means of protecting the outfall from damage shall be provided.

b. The outfall invert of a drainage system should be a minimum of two feet above the water surface of the natural drainage feature in order to provide storage for icing accumulations.

c. All outfalls should have icing control devices.

3. Culverts.

a. Culverts under driveway entrances shall have a minimum inside diameter of fifteen inches and shall be either corrugated metal pipe, approved plastic, or reinforced concrete pipe. Installation of icing control devices may be necessary.

b. Cross culverts may be reinforced concrete box type, corrugated metal pipe, reinforced concrete pipe or structural plate arch.

1) Minimum inside diameter shall be eighteen inches.

2) Trash racks, metal beam guardrails and headwalls may be required where necessary.

3) Icing control devices may be necessary in the culvert.

4. Open Channels.

a. Minimum side slope ratio shall be 2:1 (horizontal to vertical) with a minimum invert width of two feet.

b. Maximum flow velocity allowed in a channel shall be such that no erosion or scouring will occur to the channel sides or bottom during normal flow or design storm flow. This scour velocity will be determined by soil conditions of the channel.

c. Side slopes of open channels will be seeded from the top of bank down to the normal channel flow depth to help in preventing erosion.

5. Roadside Ditches.

Where gutters and storm drains do not exist, roadside ditches shall be provided to carry the drainage from the road and tributary lands without damage to the road bed and abutting property. Ditch sections shall be properly designed as to location, size, shape, lining, and gradient, and shall have the required hydraulic capacity.

Article 1.5 Miscellaneous

A. Driveways.

Driveways within the right-of-way shall have a minimum width of 12 feet and shall not exceed a 40-foot width maximum. Minimum spacing between driveways shall be 22 feet. Driveways within State right-of-way shall be in accordance with regulations as promulgated by the Alaska Department of Highways.

B. Recurrence Interval.

Design of storm drainage systems shall be based on a 25-year recurrence interval.

C. Hydraulic Design.

The use of established engineering principals shall be used for hydraulic design of storm drainage facilities.