WAIKOLOA HIGHLANDS SUBDIVISION
PHASE 1

Waikoloa, Island of Hawaii
TMK: 6-8-02:16, 6-8-03:32
Subdivision No. 89-179
DPW Folder No. 6858

SEPTEMBER 2006

R. M. TOWILL CORPORATION
SINCE 1930

Prepared For:

Waikoloa Mauka, LLC

420 Waiakamilo Rd., Suite 411
Honolulu, Hawaii 96817-4941
(808) 842-1133 • Fax: (808) 842-1937
(RMTC Ref: 1-20580-0-E)

Exhibit "51"

R. M. TOWILL CORPORATION
SINCE 1930

DRAINAGE REPORT for the

WAIKOLOA HIGHLANDS SUBDIVISION, PHASE 1

September, 2006

Prepared for:

Waikoloa Mauka, LLC

Prepared by:

R. M. Towill Corporation
420 Waiakamilo Road, Suite 411
Honolulu, Hawaii 96817-4941

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1 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this study includes a brief description of the existing drainage patterns, proposed drainage improvements, and calculation for local subdivision drainage for the Phase 1 of Waikoloa Highlands Subdivision.

1.2 PROJECT LOCATION AND DESCRIPTION

The project site is located 22 miles northeast of Keahole International Airport in Waikoloa, District of South Kohala, Island of Hawaii (Tax Map Key: Third Division 6-8-02:16, 6-8-03:32). The project consists of 744.4 acres located south of Waikoloa Villages, north of Puu Hinai Cinder Cone between Auwaiakeakua Gulch and Waikoloa Road. Phase 1 is situated in the west portion of the Waikoloa Highlands Subdivision. It consists of grading, construction of roadways and utilities for the purpose of 149 single-family residential lots for Phase 1(Figures 1 and 2).

2 GENERAL AND METHODOLOGY

There is one (1) major stream identified in this study, which is Auwaiakeakua Gulch. The gulch and its sub-tributaries pass south of the project site. A previous drainage study conducted by R.M. Towill Corporation (RMTC, Reference 1) indicated that there were nine (9) Flood Routes within the project site (Auwaiakeakua Gulch and 8 tributaries). Figure 3, which is taken from Reference 1, shows the location of each Flood Route.

2.1 HYDROLOGIC CRITERIA AND METHODOLOGY

The RMTC report utilized the regression equation to calculate 100-year storm for the 9 flood routes. The regression equation was adopted in the 1995 Hawaii County Flood Insurance Study published by Federal Emergency Management Agency (FEMA, Reference 2). It was intended to incorporate basin and climatological characteristics to determine peak discharge-frequency relationships. Two groups of regression equations were established for windward and leeward areas. Waikoloa Highlands is located at leeward side (Figure 4).

For this study, the regression equation was mainly used to determine the 100-year peak discharges for culverts located at flood routes originated off-site. For culverts located at onsite flood routes and roadway drywells, the rational method was used to determine runoff quantities per County of Hawaii Storm Drainage Standard (Reference 3).

Hydrologic Criteria

- Culverts (off-site flood routes, area > 100acres):

Method	Regression Equation
Return Interval	100-year
Design Storm Duration	24-hour

- Culverts (onsite flood routes, area <100 acres):

Method	Rational Method
Return Interval	50-year
Design Storm Duration	1-hour

- Drywells:

Method	Rational Method
Return Interval	10-year
Design Storm Duration	1-hour
Maximum Capacity	6 cfs per drywell

Hydrologic Methodology

- Culverts (off-site flood routes):

$Q_{100} = 34.3\ (DA)^{0.77}\ (P24\text{-}2)^{2.26}$

where:

Q_{100}	=	Peak discharge with 100-year return interval (cfs)
DA	=	Drainage area (mi^2)
P24-2	=	2-year, 24-hour rainfall depth (inches)
	=	3" for Waikoloa Highlands area (Reference 1)

- Culverts (onsite flood routes) and Drywells:

$Q = C\ I\ A$

where:

Q	=	Flow rate (cfs)
C	=	Runoff coefficient (Reference 3 and Appendix B)
I	=	Rainfall intensity (in/hour) (Reference 3)
A	=	Drainage area (acres)

2.2 HYDRAULIC CRITERIA AND METHODOLOGY

Hydraulic Criteria and Methodology

- Culverts sizing

Method	CulvertMaster (Reference 5)
Entrance Type	Headwall
Max. HW/D	1.0 – 1.1
Material	CMP

3 EXISTING DRAINAGE CONDITIONS

The nine (9) Flood Routes stated in previous study (Reference 1) that impact the project site are Auwaiakeakua Gulch (Flood Route 5) and its tributaries (Flood Routes 1 to 4, 6 to 8) (see Figure 3). Auwaiakeakua Gulch, originating from the summit of Mauna Kea, flows in a northwest direction, ending up Pacific Ocean.

Auwaiakeakua Gulch passes south of project site and crosses Waikoloa Road further downstream of the project site. The existing topography consists of rolling terrain with flat to moderately steep slopes. Slopes are steep in the upper watershed areas and gradually reduce to flat through the project site. Ground cover primarily consists of low lying brush and scattered Kiawe trees. Flood Routes 1 and 3 originate off-site and enter the project site from east through culverts at Waikoloa Road. Flood Route 4 is located outside of the project site and is upstream of Auwaiakeakua Gulch. Other Flood Routes are minor tributaries originate onsite to eventually contribute to Auwaiakeakua Gulch.

4 PROPOSED DRAINAGE PLAN

For this study, the main focus is to size culverts at the proposed roadway crossing and determine the number of drywells required to be installed at Phase 1 of the project site. The onsite drainage area map was prepared and shown in Figure 5. The tabulated summaries of runoff quantities for culverts and drywells were presented in Appendices A and B. A brief description of the proposed drainage improvements is summarized as follows:

Culverts:

- Culvert A (2-84" CMP) is located at STA. 2+11.33 of Road "A" crossing. The drainage area is part of Flood Route 1, which originates off-site. The design peak discharge, (Q_{100}) calculated using the regression equation, is 567 cfs.

- Culvert B (30" CMP) is located at STA. 40+70.07 of Road "C" crossing. Culvert B is designed to pass onsite runoff generated by 50-year, 1-hour storm. The design peak discharge, calculated using the rational method, is 19.00 cfs.

- Culvert C (30" CMP) is located at STA. 4+96.19 of Road "B-3" crossing. Culvert C is designed to pass onsite runoff generated by 50-year, 1-hour storm. The design peak discharge, calculated using the rational method, is 16.34 cfs.

- Culvert D (30" CMP) is located at STA. 20+50.69 of Road "B" crossing. Culvert D is designed to pass onsite runoff generated by 50-year, 1-hour storm. The design peak discharge, calculated using the rational method, is 20.50 cfs.

- Culvert E (36" CMP) is located at STA. 2+30 of Road "B-1" crossing. Culvert E is designed to pass onsite runoff generated by 50-year, 1-hour storm. The design peak discharge, calculated using the rational method, is 35.05 cfs.

- Culvert F (60" CMP) is located at STA. 44+55.64 of Road "A" crossing. The drainage area is part of Flood Route 3, which originates off-site. The design peak discharge, (Q_{100}) calculated using the regression equation, is 125 cfs.

Drywells:

There are thirty-five (35) drywells proposed to be installed in road swales throughout the entire Phase 1 of the project site. The proposed will provide sufficient capacity foe the new development (Appendix B). They are designed for onsite runoff generated by 10-year, 1-year storm with maximum capacity of 6 cfs per drywell.

5 SUMMARY AND CONCLUSION

To protect the project site from flooding problems, drainage improvements are proposed in this study to accommodate the design flows. This will increase the developable lands in the Phase 1 of Waikoloa Highlands Subdivision development.

There are 6 culverts (Culvert A, B, C, D, E, and F) proposed at roadway crossing to pass the design flows to open area. Drywells will be installed in road swale s to take care of onsite runoff. Total number of drywells expected to be installed is 35. The proposed drainage improvements will decrease the risk of flooding problems in the Phase 1 of Waikoloa Highlands Subdivision development and are in compliance with current design standard.

6 REFERENCES

1. "Floodway Limits and Flood Control Plan for the Highlands Golf Estate at Waikoloa", R.M. Towill Corporation, 12/1992

2. "Flood Insurance Study for Hawaii County", Federal Emergency Management Agency, 6/2/1995

3. "Storm Drainage Standard", Department of Public Works, County of Hawaii, 10/1970

4. USGS Quadrangle (7.5 Minutes Series, 1:24K): Puu Hinai

5. CulvertMaster v3.1, Bentley Systems, Inc., 12/2005

Appendix A

Culverts

Culvert Calculator Report
90806 WH Culvert A Rd A (FR-1)

Solve For: Section Size

Culvert Summary			
Allowable HW Elevation	1,076.00 ft	Headwater Depth/Height	0.99
Computed Headwater Elevation	1,075.62 ft	Discharge	567.00 cfs
Inlet Control HW Elev.	1,075.15 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	1,075.62 ft	Control Type	Outlet Control

Grades			
Upstream Invert	1,068.68 ft	Downstream Invert	1,068.14 ft
Length	107.83 ft	Constructed Slope	0.005008 ft/ft

Hydraulic Profile			
Profile	M2	Depth, Downstream	4.43 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	4.43 ft
Velocity Downstream	11.06 ft/s	Critical Slope	0.012714 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	7.00 ft
Section Size	84 inch	Rise	7.00 ft
Number Sections	2		

Outlet Control Properties			
Outlet Control HW Elev.	1,075.62 ft	Upstream Velocity Head	1.17 ft
Ke	0.20	Entrance Loss	0.23 ft

Inlet Control Properties			
Inlet Control HW Elev.	1,075.15 ft	Flow Control	N/A
Inlet Type	Beveled ring, 33.7° (1.5:1) bevels	Area Full	77.0 ft²
K	0.00180	HDS 5 Chart	3
M	2.50000	HDS 5 Scale	B
C	0.02430	Equation Form	1
Y	0.83000		

Culvert Calculator Report
90806 WH Culvert B Rd C

Solve For: Section Size

Culvert Summary			
Allowable HW Elevation	1,098.50 ft	Headwater Depth/Height	0.98
Computed Headwater Elevation	1,098.15 ft	Discharge	19.00 cfs
Inlet Control HW Elev.	1,097.82 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	1,098.15 ft	Control Type	Outlet Control

Grades			
Upstream Invert	1,095.69 ft	Downstream Invert	1,095.29 ft
Length	80.75 ft	Constructed Slope	0.004954 ft/ft

Hydraulic Profile			
Profile	M2	Depth, Downstream	1.48 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.48 ft
Velocity Downstream	6.29 ft/s	Critical Slope	0.016948 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.50 ft
Section Size	30 inch	Rise	2.50 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	1,098.15 ft	Upstream Velocity Head	0.29 ft
Ke	0.20	Entrance Loss	0.06 ft

Inlet Control Properties			
Inlet Control HW Elev.	1,097.82 ft	Flow Control	Unsubmerged
Inlet Type	Beveled ring, 33.7° (1.5:1) bevels	Area Full	4.9 ft²
K	0.00180	HDS 5 Chart	3
M	2.50000	HDS 5 Scale	B
C	0.02430	Equation Form	1
Y	0.83000		

Culvert Calculator Report
90806 WH Culvert C Rd B-3

Solve For: Section Size

Culvert Summary			
Allowable HW Elevation	1,036.10 ft	Headwater Depth/Height	0.97
Computed Headwater Elevation	1,036.03 ft	Discharge	16.34 cfs
Inlet Control HW Elev.	1,035.77 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	1,036.03 ft	Control Type	Entrance Control

Grades			
Upstream Invert	1,033.62 ft	Downstream Invert	1,031.97 ft
Length	82.54 ft	Constructed Slope	0.019990 ft/ft

Hydraulic Profile			
Profile	S2	Depth, Downstream	1.28 ft
Slope Type	Steep	Normal Depth	1.28 ft
Flow Regime	Supercritical	Critical Depth	1.37 ft
Velocity Downstream	6.46 ft/s	Critical Slope	0.016114 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.50 ft
Section Size	30 inch	Rise	2.50 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	1,036.03 ft	Upstream Velocity Head	0.55 ft
Ke	0.90	Entrance Loss	0.50 ft

Inlet Control Properties			
Inlet Control HW Elev.	1,035.77 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	4.9 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Calculator Report
90806 WH Culvert D Rd B

Solve For: Section Size

Culvert Summary			
Allowable HW Elevation	1,015.70 ft	Headwater Depth/Height	0.93
Computed Headwater Elevation	1,015.57 ft	Discharge	20.50 cfs
Inlet Control HW Elev.	1,015.46 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	1,015.57 ft	Control Type	Entrance Control

Grades			
Upstream Invert	1,013.25 ft	Downstream Invert	1,011.17 ft
Length	104.04 ft	Constructed Slope	0.019992 ft/ft

Hydraulic Profile			
Profile	S2	Depth, Downstream	1.47 ft
Slope Type	Steep	Normal Depth	1.47 ft
Flow Regime	Supercritical	Critical Depth	1.54 ft
Velocity Downstream	6.82 ft/s	Critical Slope	0.017487 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.50 ft
Section Size	30 inch	Rise	2.50 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	1,015.57 ft	Upstream Velocity Head	0.65 ft
Ke	0.20	Entrance Loss	0.13 ft

Inlet Control Properties			
Inlet Control HW Elev.	1,015.46 ft	Flow Control	Unsubmerged
Inlet Type	Beveled ring, 33.7° (1.5:1) bevels	Area Full	4.9 ft²
K	0.00180	HDS 5 Chart	3
M	2.50000	HDS 5 Scale	B
C	0.02430	Equation Form	1
Y	0.83000		

Culvert Calculator Report
90806 WH Culvert E Rd B-1

Solve For: Section Size

Culvert Summary			
Allowable HW Elevation	986.00 ft	Headwater Depth/Height	1.00
Computed Headwater Elevation	985.78 ft	Discharge	35.05 cfs
Inlet Control HW Elev.	985.60 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	985.78 ft	Control Type	Outlet Control

Grades			
Upstream Invert	982.78 ft	Downstream Invert	981.75 ft
Length	102.73 ft	Constructed Slope	0.010026 ft/ft

Hydraulic Profile			
Profile	M2	Depth, Downstream	1.92 ft
Slope Type	Mild	Normal Depth	2.38 ft
Flow Regime	Subcritical	Critical Depth	1.92 ft
Velocity Downstream	7.32 ft/s	Critical Slope	0.017093 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	3.00 ft
Section Size	36 inch	Rise	3.00 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	985.78 ft	Upstream Velocity Head	0.54 ft
Ke	0.20	Entrance Loss	0.11 ft

Inlet Control Properties			
Inlet Control HW Elev.	985.60 ft	Flow Control	Unsubmerged
Inlet Type	Beveled ring, 33.7° (1.5:1) bevels	Area Full	7.1 ft²
K	0.00180	HDS 5 Chart	3
M	2.50000	HDS 5 Scale	B
C	0.02430	Equation Form	1
Y	0.83000		

Culvert Calculator Report
90806 WH Culvert F Rd A (FR-3)

Solve For: Section Size

Culvert Summary			
Allowable HW Elevation	1,106.30 ft	Headwater Depth/Height	1.03
Computed Headwater Elevation	1,106.09 ft	Discharge	125.00 cfs
Inlet Control HW Elev.	1,105.63 ft	Tailwater Elevation	0.00 ft
Outlet Control HW Elev.	1,106.09 ft	Control Type	Outlet Control

Grades			
Upstream Invert	1,100.94 ft	Downstream Invert	1,100.42 ft
Length	104.72 ft	Constructed Slope	0.004966 ft/ft

Hydraulic Profile			
Profile	M2	Depth, Downstream	3.20 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	3.20 ft
Velocity Downstream	9.43 ft/s	Critical Slope	0.014379 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	5.00 ft
Section Size	60 inch	Rise	5.00 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	1,106.09 ft	Upstream Velocity Head	0.78 ft
Ke	0.20	Entrance Loss	0.16 ft

Inlet Control Properties			
Inlet Control HW Elev.	1,105.63 ft	Flow Control	Unsubmerged
Inlet Type	Beveled ring, 33.7° (1.5:1) bevels	Area Full	19.6 ft²
K	0.00180	HDS 5 Chart	3
M	2.50000	HDS 5 Scale	B
C	0.02430	Equation Form	1
Y	0.83000		

Appendix B

Drywells

Roadway Drainage Calculations (10-year storm, Rational Method, Drywells): Post-Development

Roadway Basin ID	Total Area (ac)	Lot Area (ac)	Roadway Area (ac)	Existing Land Area (ac)	Weighted Lot C	Roadway C	Existing Land C	Final Weighted C	Original I (Plate 1) T_M (in/hr)	Length (ft)	Slope (ft/ft)	Gound Type	Tc (min)	Adjusted I (Plate 4) (in/hr)	Q_{10} (cfs)
1	0.30	0.00	0.30	0.00	0.39	0.95	0.28	0.95	1.5	360	7.2%	paved	5.0	3.90	1.12
2	1.16	0.06	1.10	0.00	0.39	0.95	0.28	0.92	1.5	1770	5.5%	paved	10.0	3.10	3.30
3	2.65	1.90	0.75	0.00	0.39	0.95	0.28	0.55	1.5	1015	7.6%	avg grass	24.0	2.29	3.33
4	4.70	4.59	0.11	0.00	0.39	0.95	0.28	0.40	1.5	1110	7.6%	avg grass	24.0	2.29	4.31
5	5.19	4.75	0.44	0.00	0.39	0.95	0.28	0.44	1.5	1375	6.3%	avg grass	30.0	2.05	4.68
6	4.59	4.28	0.31	0.00	0.39	0.95	0.28	0.43	1.5	920	8.4%	avg grass	30.0	2.29	4.52
7	0.53	0.08	0.45	0.00	0.39	0.95	0.28	0.87	1.5	645	2.9%	paved	7.5	3.50	1.60
8	10.66	10.30	0.28	0.08	0.39	0.95	0.28	0.40	1.5	1425	2.2%	avg grass	35.0	1.96	8.36
9	3.68	3.09	0.29	0.31	0.39	0.95	0.28	0.42	1.5	690	4.1%	avg grass	24.0	2.29	3.54
10	4.80	3.96	0.85	0.00	0.39	0.95	0.28	0.49	1.5	945	3.2%	avg grass	31.0	1.93	4.54
										440	5.7%	paved	5.5		
11	0.55	0.00	0.55	0.00	0.39	0.95	0.28	0.95	1.5	395	1.5%	paved	10.0	3.61	1.90
12	2.71	2.07	0.65	0.00	0.39	0.95	0.28	0.52	1.5	630	3.7%	avg grass	26.0	2.02	2.85
										275	2.5%	paved	5.5		
13	2.28	1.04	1.24	0.00	0.39	0.95	0.28	0.69	1.5	1275	5.1%	paved	9.0	3.26	5.13
14	2.38	0.56	1.83	0.00	0.39	0.95	0.28	0.82	1.5	1650	2.2%	paved	12.0	2.97	5.81
15	2.76	2.46	0.31	0.00	0.39	0.95	0.28	0.45	1.5	615	6.2%	avg grass	21.0	2.41	3.00
16	0.79	0.03	0.76	0.00	0.39	0.95	0.28	0.93	1.5	580	5.2%	paved	6.5	3.63	2.65
17	2.29	1.76	0.53	0.00	0.39	0.95	0.28	0.52	1.5	460	2.6%	paved	6.8	2.37	2.82
										170	2.4%	avg grass	15.5		
18	4.93	4.47	0.46	0.00	0.39	0.95	0.28	0.44	1.5	795	5.9%	avg grass	22.0	2.37	5.14
19	4.83	4.57	0.25	0.00	0.39	0.95	0.28	0.42	1.5	725	6.6%	avg grass	23.0	2.33	4.72
20	0.28	0.02	0.26	0.00	0.39	0.95	0.28	0.91	1.5	285	2.1%	paved	5.5	3.82	0.96
21	0.92	0.07	0.84	0.00	0.39	0.95	0.28	0.91	1.5	1130	6.3%	paved	8.0	3.42	2.85
22	5.11	4.94	0.17	0.00	0.39	0.95	0.28	0.41	1.5	800	4.4%	avg grass	27.0	2.01	4.21
										215	2.5%	paved	5.0		
23	11.05	9.90	1.15	0.00	0.39	0.95	0.28	0.45	1.5	1466	7.4%	avg grass	29.0	2.09	10.39
24	1.39	0.77	0.62	0.00	0.39	0.95	0.28	0.64	1.5	570	2.8%	paved	7.0	3.58	3.19
25	3.50	2.94	0.00	0.55	0.39	0.95	0.28	0.37	1.5	670	5.4%	avg grass	23.0	2.33	3.01
26	0.47	0.00	0.47	0.00	0.39	0.95	0.28	0.95	1.5	450	2.2%	paved	6.5	3.63	1.61
27	2.11	0.47	1.64	0.00	0.39	0.95	0.28	0.83	1.5	2265	5.3%	paved	12.0	2.97	5.20
28	0.34	0.00	0.34	0.00	0.39	0.95	0.28	0.95	1.5	350	6.6%	paved	5.0	3.90	1.25
29	1.32	0.07	1.25	0.00	0.39	0.95	0.28	0.92	1.5	1520	4.1%	paved	10.0	3.10	3.77
30	0.60	0.00	0.60	0.00	0.39	0.95	0.28	0.95	1.5	825	3.3%	paved	8.5	3.34	1.89
31	0.83	0.00	0.66	0.17	0.39	0.95	0.28	0.81	1.5	965	3.3%	paved	9.0	3.34	2.24
32	1.88	1.15	0.32	0.41	0.39	0.95	0.28	0.46	1.5	595	3.2%	avg grass	25.0	2.25	1.95
33	7.82	4.82	0.13	2.87	0.39	0.95	0.28	0.36	1.5	1400	8.3%	avg grass	29.0	2.09	5.89
34	0.86	0.40	0.21	0.25	0.39	0.95	0.28	0.49	1.5	510	2.4%	avg grass	24.0	2.29	0.96
35	0.08	0.00	0.08	0.00	0.39	0.95	0.28	0.95	1.5	100	2.0%	paved	5.0	3.90	0.29
															174.54

Maximum capacity per drywell = 6 cfs

Roadway Drainage Calculations (10-year storm, Rational Method, Drywells): Pre-Development

Roadway Basin ID	Total Area (ac)	Lot Area (ac)	*Roadway Area (ac)	Existing Land Area (ac)	*Weighted Lot C	*Roadway C	Existing Land C	*Final Weighted C	Original I (Plate 1) T_M (in/hr)	Length (ft)	Slope (ft/ft)	Gound Type	Tc (min)	Adjusted I (Plate 4) (in/hr)	Q_{10} (cfs)
1	0.30	0.00	0.30	0.00	0.28	0.28	0.28	0.28	1.5	360	7.2%	avg grass	16.0	2.71	0.23
2	1.16	0.06	1.10	0.00	0.28	0.28	0.28	0.28	1.5	1770	5.5%	avg grass	33.0	2.00	0.65
3	2.65	1.90	0.75	0.00	0.28	0.28	0.28	0.28	1.5	1015	7.6%	avg grass	24.0	2.29	1.70
4	4.70	4.59	0.11	0.00	0.28	0.28	0.28	0.28	1.5	1110	7.6%	avg grass	24.0	2.29	3.01
5	5.19	4.75	0.44	0.00	0.28	0.28	0.28	0.28	1.5	1375	6.3%	avg grass	30.0	2.05	2.98
6	4.59	4.28	0.31	0.00	0.28	0.28	0.28	0.28	1.5	920	8.4%	avg grass	30.0	2.29	2.94
7	0.53	0.08	0.45	0.00	0.28	0.28	0.28	0.28	1.5	645	2.9%	avg grass	26.0	2.21	0.33
8	10.66	10.30	0.28	0.08	0.28	0.28	0.28	0.28	1.5	1425	2.2%	avg grass	35.0	1.96	5.85
9	3.68	3.09	0.29	0.31	0.28	0.28	0.28	0.28	1.5	690	4.1%	avg grass	24.0	2.29	2.36
10	4.80	3.96	0.85	0.00	0.28	0.28	0.28	0.28	1.5	945	3.2%	avg grass	31.0	1.68	2.26
										440	5.7%	avg grass	19.0		
11	0.55	0.00	0.55	0.00	0.28	0.28	0.28	0.28	1.5	395	1.5%	avg grass	24.0	2.29	0.36
12	2.71	2.07	0.65	0.00	0.28	0.28	0.28	0.28	1.5	630	3.7%	avg grass	26.0	1.79	1.36
										275	2.5%	avg grass	18.0		
13	2.28	1.04	1.24	0.00	0.28	0.28	0.28	0.28	1.5	1275	5.1%	avg grass	30.0	2.05	1.31
14	2.38	0.56	1.83	0.00	0.28	0.28	0.28	0.28	1.5	1650	2.2%	avg grass	39.0	1.89	1.26
15	2.76	2.46	0.31	0.00	0.28	0.28	0.28	0.28	1.5	615	6.2%	avg grass	21.0	2.41	1.87
16	0.79	0.03	0.76	0.00	0.28	0.28	0.28	0.28	1.5	580	5.2%	avg grass	21.0	2.41	0.53
17	2.29	1.76	0.53	0.00	0.28	0.28	0.28	0.28	1.5	460	2.6%	avg grass	23.0	1.90	1.22
										170	2.4%	avg grass	15.5		
18	4.93	4.47	0.46	0.00	0.28	0.28	0.28	0.28	1.5	795	5.9%	avg grass	22.0	2.37	3.27
19	4.83	4.57	0.25	0.00	0.28	0.28	0.28	0.28	1.5	725	6.6%	avg grass	23.0	2.33	3.15
20	0.28	0.02	0.26	0.00	0.28	0.28	0.28	0.28	1.5	285	2.1%	avg grass	18.0	2.58	0.20
21	0.92	0.07	0.84	0.00	0.28	0.28	0.28	0.28	1.5	1130	6.3%	avg grass	27.0	2.17	0.56
22	5.11	4.94	0.17	0.00	0.28	0.28	0.28	0.28	1.5	800	4.4%	avg grass	27.0	1.79	2.56
										215	2.5%	avg grass	17.0		
23	11.05	9.90	1.15	0.00	0.28	0.28	0.28	0.28	1.5	1466	7.4%	avg grass	29.0	2.09	6.47
24	1.39	0.77	0.62	0.00	0.28	0.28	0.28	0.28	1.5	570	2.8%	avg grass	24.0	2.29	0.89
25	3.50	2.94	0.00	0.55	0.28	0.28	0.28	0.28	1.5	670	5.4%	avg grass	23.0	2.33	2.28
26	0.47	0.00	0.47	0.00	0.28	0.28	0.28	0.28	1.5	450	2.2%	avg grass	23.0	2.33	0.30
27	2.11	0.47	1.64	0.00	0.28	0.28	0.28	0.28	1.5	2265	5.3%	avg grass	39.0	1.89	1.12
28	0.34	0.00	0.34	0.00	0.28	0.28	0.28	0.28	1.5	350	6.6%	avg grass	17.0	2.65	0.25
29	1.32	0.07	1.25	0.00	0.28	0.28	0.28	0.28	1.5	1520	4.1%	avg grass	35.0	1.96	0.73
30	0.60	0.00	0.60	0.00	0.28	0.28	0.28	0.28	1.5	825	3.3%	avg grass	28.0	2.13	0.36
31	0.83	0.00	0.66	0.17	0.28	0.28	0.28	0.28	1.5	965	3.3%	avg grass	30.0	2.05	0.47
32	1.88	1.15	0.32	0.41	0.28	0.28	0.28	0.28	1.5	595	3.2%	avg grass	25.0	2.25	1.18
33	7.82	4.82	0.13	2.87	0.28	0.28	0.28	0.28	1.5	1400	8.3%	avg grass	29.0	2.09	4.58
34	0.86	0.40	0.21	0.25	0.28	0.28	0.28	0.28	1.5	510	2.4%	avg grass	24.0	2.29	0.55
35	0.08	0.00	0.08	0.00	0.28	0.28	0.28	0.28	1.5	100	2.0%	avg grass	12.5	2.94	0.07
															103.45

Maximum capacity per drywell = 6 cfs

* all roadway and lot areas are considered as existing condition since this is pre-development

Roadway Drainage Calculations (50-year storm, Rational Method, Culverts)

Roadway Basin ID	Total Area (ac)	Lot Area (ac)	Roadway Area (ac)	Existing Land Area (ac)	Weighted Lot C	Roadway C	Existing Land C	Final Weighted C	Original I (Plate 1) T_M (in/hr)	Length (ft)	Slope (ft/ft)	Gound Type	Tc (min)	Adjusted I (Plate 4) (in/hr)	Q_{50} (cfs)
*A (note 1)	15.18	15.18	0.00	0.00	0.39	0.95	0.28	0.39	2.0	2000	6.1%	avg grass	33.0	2.72	16.11
B	17.71	17.71	0.00	0.00	0.39	0.95	0.28	0.39	2.0	1535	4.3%	avg grass	32.0	2.75	19.00
C	18.75	9.37	0.00	9.38	0.39	0.95	0.28	0.33	2.0	1750	6.4%	avg grass	36.0	2.64	16.34
D	20.71	14.57	0.00	6.14	0.39	0.95	0.28	0.36	2.0	1950	6.7%	avg grass	32.0	2.75	20.50
*E (note 3)	14.59	9.06	0.00	5.53	0.39	0.95	0.28	0.35	2.0	1190	4.7%	avg grass	29.0	2.85	14.55
*F (note 2)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Note

* 1 Onsite Basin A is part of Flood Roue 1, which originates off-site. Thus, the runoff quantity is calculated using the regression equation for Q100 = 567 cfs, 2-84" CMP
Drainage area at Road "A" crossing = 975 ac

* 2 Onsite Basin F is part of Flood Roue 3, which originates off-site. Thus, the runoff quantity is calculated using the regression equation for Q100 = 125 cfs, 60" CMP
Drainage area before confluence point with Flood Route 5 = 136 ac

* 3 Upstram area of Basin E is Basin D. The final runoff quantity for Culvert E is 20.50+14.55 = 35.05 cfs

For a typical lot in this study, the land use types are consisted of house pad, landscale, and existing land.

Assumption:
1. Typical lot = 1 acre = 43560 sf
2. 50% of the lot remains as existing condition, 50% of the lot is used for mass grading
3. Maximum house pad = 4500 sf, remaining portion is used for landscape...etc
4. Runoff coefficient for various land use types:

Existing land runoff coefficient

Watershed Characteristics	Description	Values
Infiltration	Medium	0.07
Relief	Rolling (5-15%)	0.03
Vegetal Cover	Good (10-50%)	0.03
Development Type	Agricultural	0.15
Total		0.28

Land UseType	C
Existing Land	0.28
House Pad	0.90
Landscape	0.40
Paved Roadways	0.95

Weighted C for typical 1 acre lot

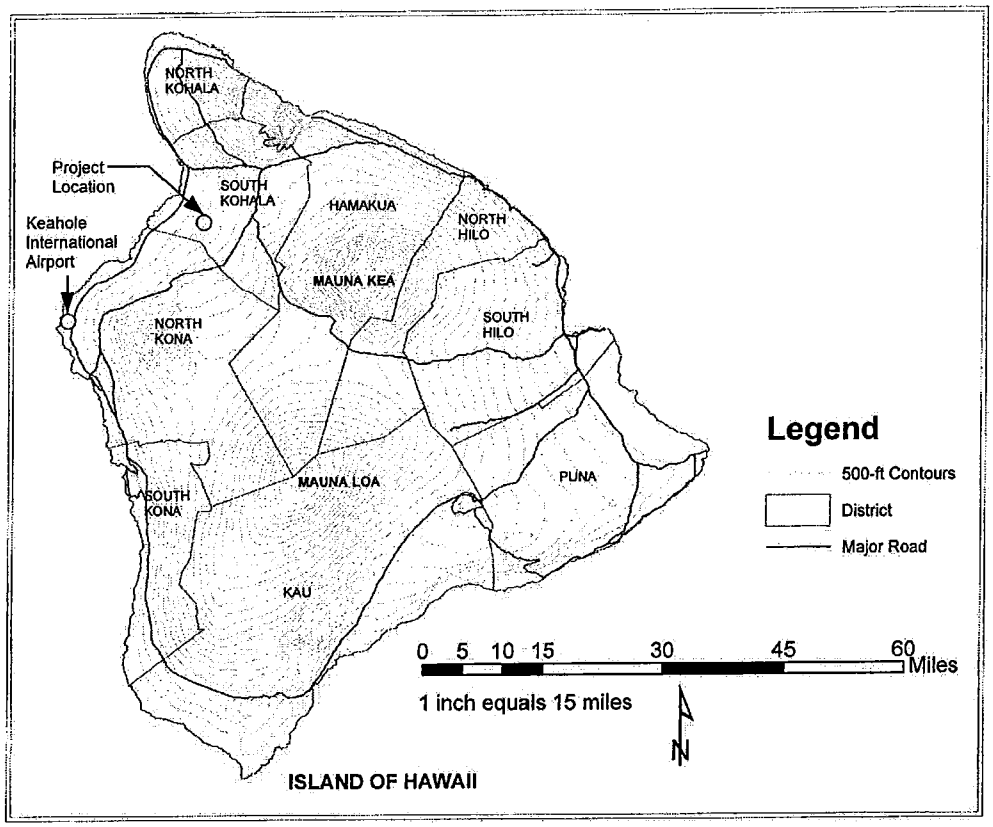
Total Lot Area =	43,560	sf	
Existing Land Area	21,780	sf	(50%)
House pad =	4,500	sf	(50%)
Landscape area =	17,280	sf	

$$\text{Weighted C} = \frac{(21780 \times 0.28) + (4500 \times 0.9) + (17280 \times 0.4)}{43560}$$

Weighted C= **0.39**

Appendix C

Figures



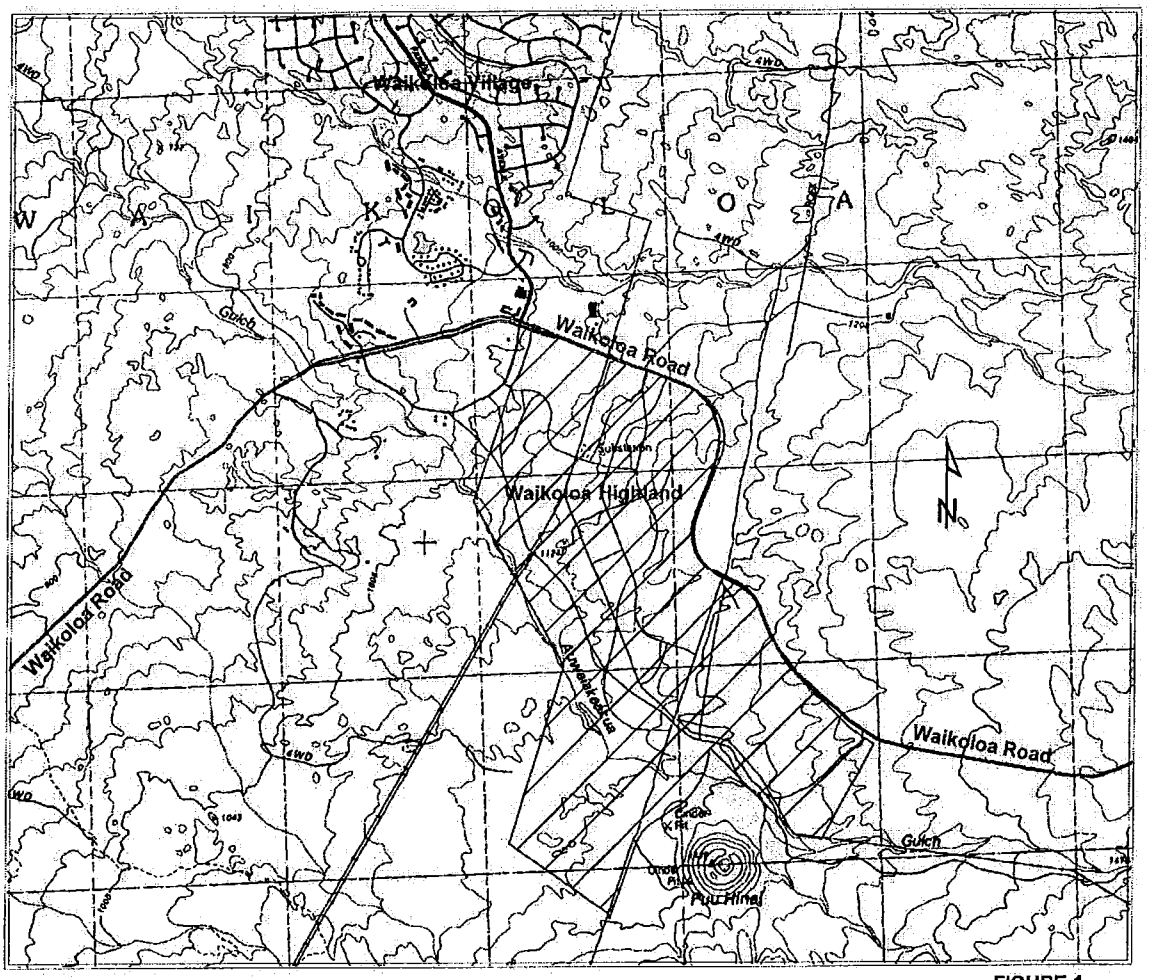
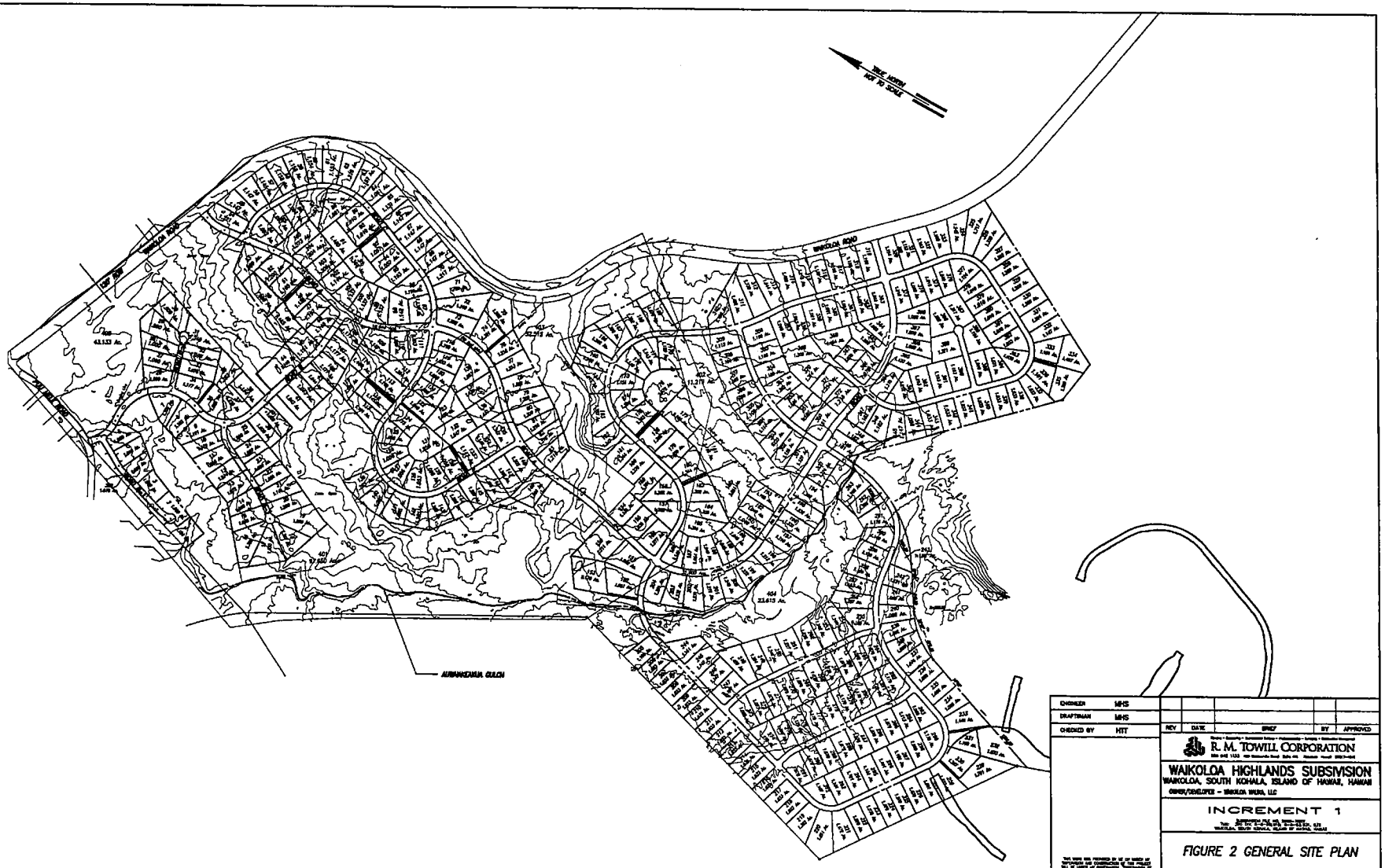


FIGURE 1
VICINITY MAP



GENERAL SITE PLAN
NOT TO SCALE

ENGINEER	MHS
DRAFTSMAN	MHS
CHECKED BY	HIT

REV	DATE	BRIEF	BY	APPROVED

R. M. TOWILL CORPORATION

WAIKOLOA HIGHLANDS SUBDIVISION
WAIKOLOA, SOUTH KOHALA, ISLAND OF HAWAII, HAWAII
OWNER/DEVELOPER – WAIKOLOA MAUKA, LLC

INCREMENT 1

FIGURE 2 GENERAL SITE PLAN

APPROVED ?

C-3 SHEET 5 OF XX SHEETS

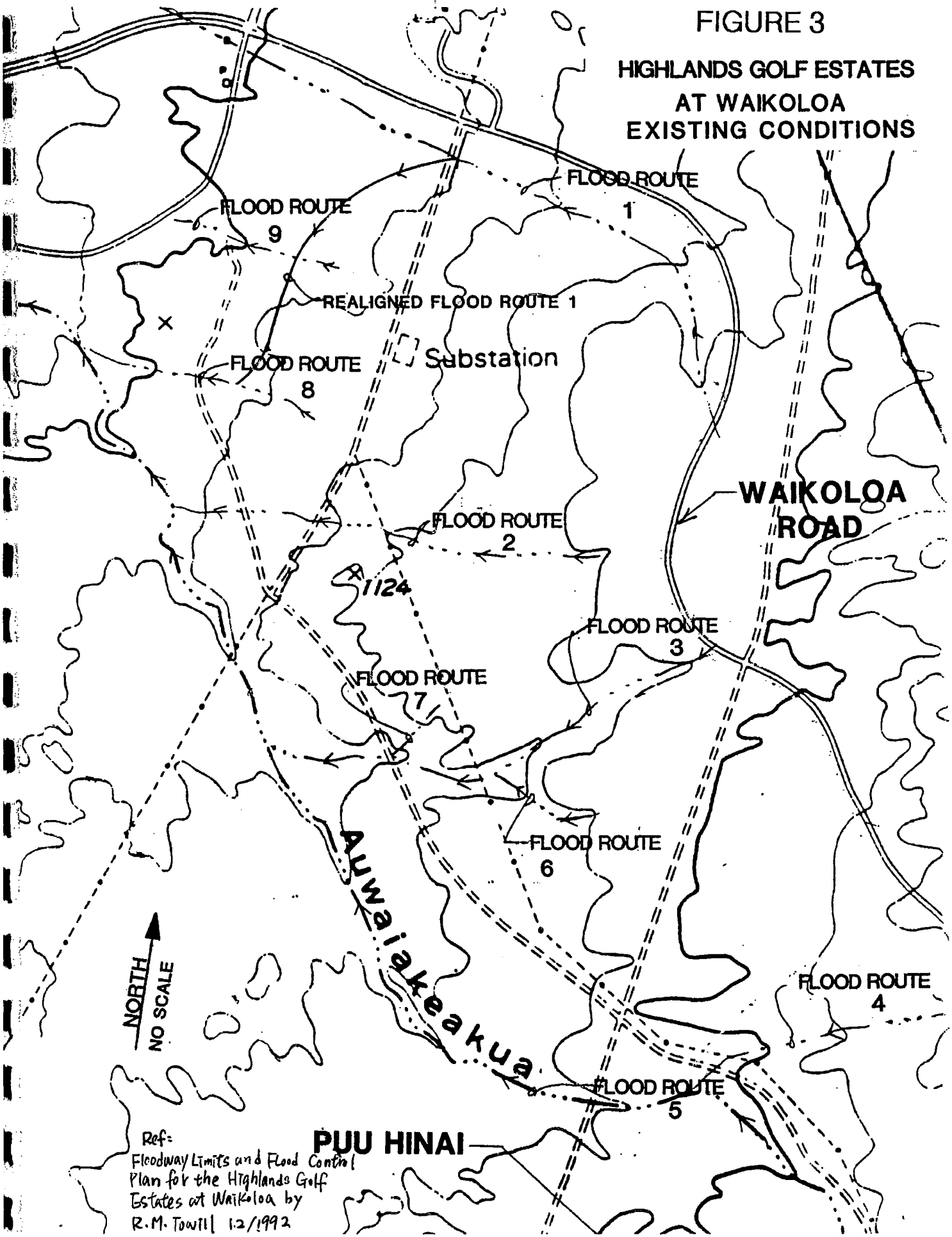


FIGURE 3
HIGHLANDS GOLF ESTATES
AT WAIKOLOA
EXISTING CONDITIONS
FLOOD ROUTE 1
FLOOD ROUTE 9
REALIGNED FLOOD ROUTE 1
Substation
FLOOD ROUTE 8
WAIKOLOA ROAD
FLOOD ROUTE 2
1124
FLOOD ROUTE 3
FLOOD ROUTE 7
FLOOD ROUTE 6
Auwaiakeakua
FLOOD ROUTE 4
FLOOD ROUTE 5
PUU HINAI
NORTH
NO SCALE
Ref:
Floodway Limits and Flood Control Plan for the Highlands Golf Estates at Waikoloa by R.M. Towill 12/1992

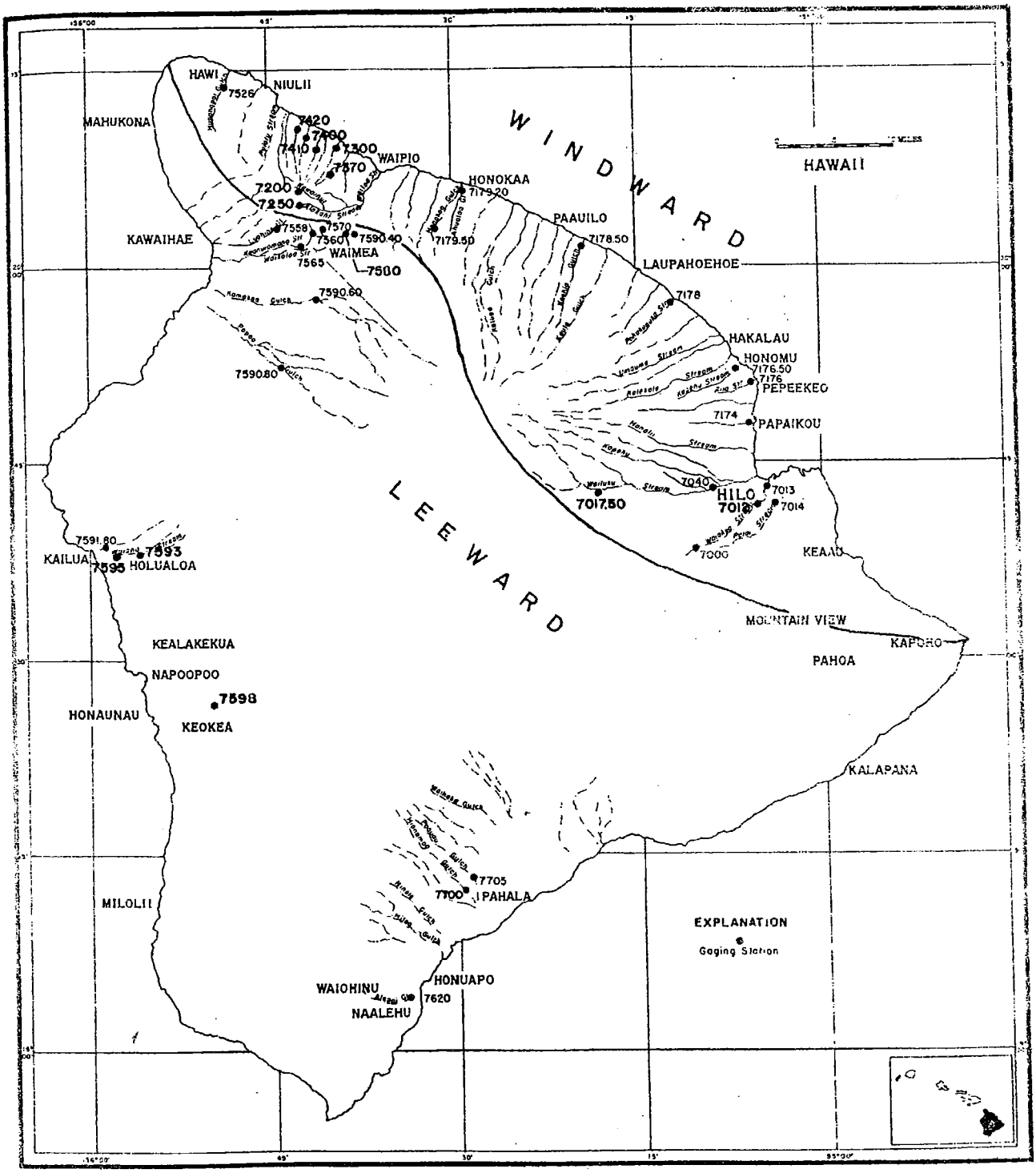


FIGURE 4 REGRESSION EQUATION GROUP

Source:
Hawaii County FIS 1995, FEMA

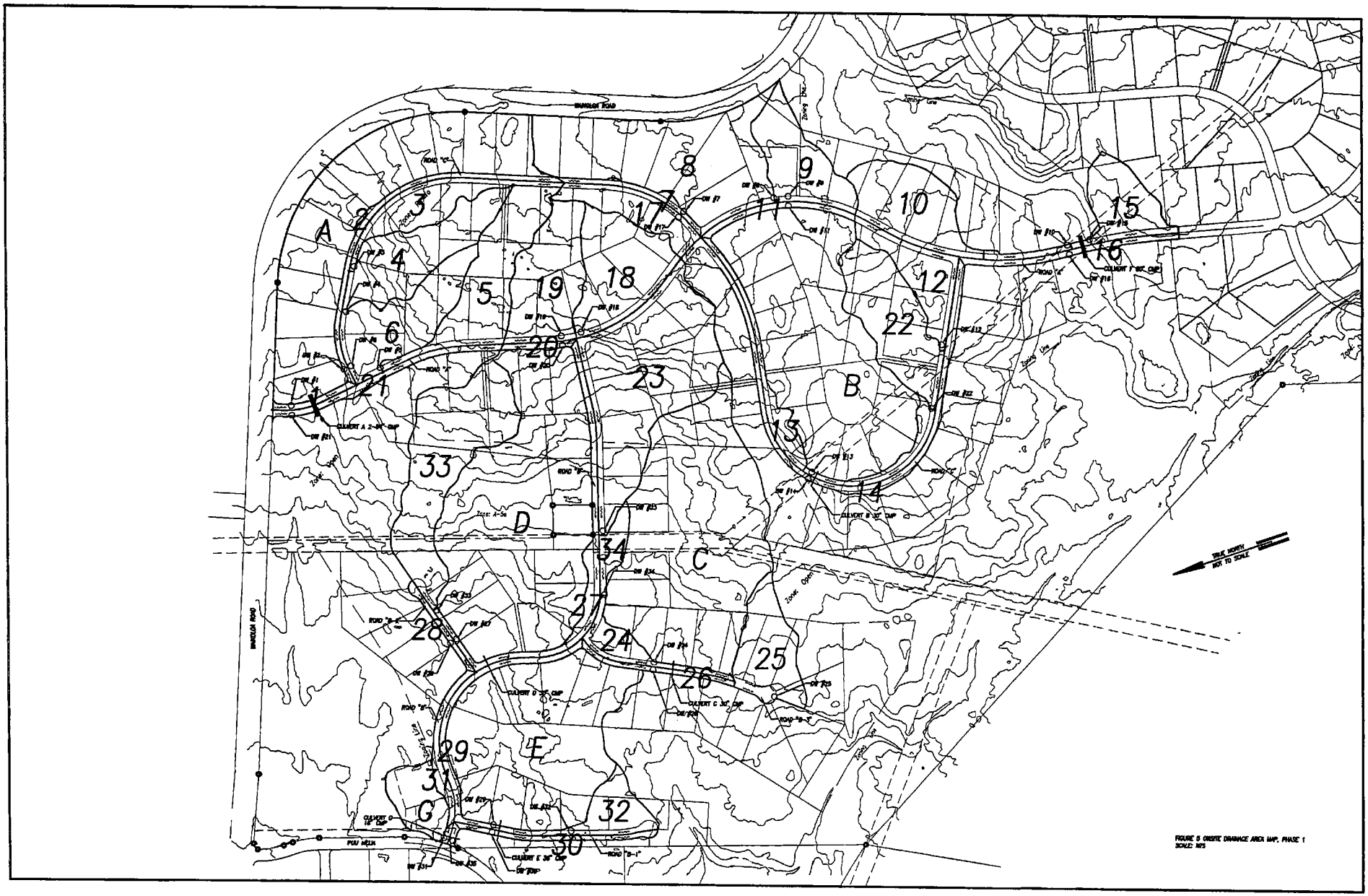


FIGURE 5 ONSITE DRAINAGE AREA MAP, PHASE 1
SCALE: NTS