MORIHARA LAU & FONG LLP

MICHAEL H. LAU 4551
LIANNA L. FIGUEROA 9173
400 Davies Pacific Center
841 Bishop Street
Honolulu, Hawai'i 96813
Telephone: (808) 526-2888
Facsimile : (808) 566-0800

IMANAKA ASATO LLLC

STEVEN K.S. CHUNG 1751
Topa Financial Center
Fort Street Tower
745 Fort Street Mall, 17th Floor
Honolulu, Hawai'i 96813
Telephone: (808) 521-9500
Facsimile: (808) 541-9050

Attorneys for HASEKO ROYAL KUNIA, LLC

BEFORE THE LAND USE COMMISSION

OF THE STATE OF HAWAI'I

In the Matter of the Petition of HALEKUA DEVELOPMENT CORPORATION, a Hawai'i corporation To Amend the Agricultural Land Use District Boundary into the Urban Land Use District for Approximately 503.886 Acres at Waikele and Ho'ae'ae, 'Ewa, O'ahu, City and County of Honolulu, State of Hawai'i, Tax Map Key No. 9-4-02: 1, portion 52, 70 and 71	DOCKET NO. A92-683 DECLARATION OF MICHAEL H. LAU; EXHIBIT 5; AND CERTIFICATE OF SERVICE

DECLARATION OF MICHAEL H. LAU

STATE OF HAWAI'I)
) SS.
CITY AND COUNTY OF HONOLULU)

MICHAEL H. LAU, being first sworn on oath, deposes and says that:

1. I am an attorney at the firm of Morihara Lau & Fong LLP, located at Davies Pacific Center, 841 Bishop Street, Suite 400, Honolulu, Hawai'i, 96813, am duly admitted to practice law in the State of Hawai'i and am one of the attorneys for Haseko Royal Kunia, LLC, a Hawai'i limited liability company, owner of Parcels 71, 70 and 78 (collectively, "**Haseko**").

2. I have personal knowledge of the matters set forth herein and am qualified and competent to make this Declaration.

3. Haseko's Exhibits 1-4 were filed with the Declaration of Sharene S. Tam, filed with the State of Hawai'i Land Use Commission ("**Commission**") on October 1, 2020.

4. Attached hereto as Haseko's **Exhibit 5** is a true and correct copy of the Drainage Master Plan for the Royal Kunia Development, Phase II, Hoaeae and Waikele, Ewa, Oahu, Hawaii TMK 9-4-02: 1 and 52; and 9-4-03: 1, dated September 1996, prepared by ParEn, Inc., dba Park Engineering for Halekua Development Corporation and accepted by the Department of Public Works of the City and County of Honolulu on October 3, 1996.

I make this Declaration under Hawai'i Administrative Rules §15-15-39(c).

Further affiant sayeth naught.

DATED: Honolulu, Hawai'i, October 5, 2020.

MICHAEL H. LAU

The foregoing document, Declaration of Michael H. Lau dated this 5th day of October, 2020, which consists of 110 pages (including this page), was executed by Michael H. Lau who was subscribed and sworn to before me this 5th day of October, 2020 in the First Judicial Circuit of the State of Hawai'i.

[Notary Signature]

Printed Name: Annabelle Ignacio
My commission expires: 6/8/2022

ANNABELLE IGNACIO NOTARY PUBLIC 14-188 STATE OF HAWAII

TC 78

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

JEREMY HARRIS
MAYOR

KENNETH E. SPRAGUE
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO:
96-12-0677

October 3, 1996

Mr. Russell M. Arakaki
ParEn, Inc. dba Park Engineering
Suite 300, Kawaiahao Plaza
567 South King Street
Honolulu, Hawaii 96813

Dear Mr. Arakaki:

Subject: Royal Kunia Development, Phase II, Drainage Master Plan
TMK: 9-4-02: 1 and 52, and 9-4-03: 1

We have reviewed your revised drainage master plan dated September 1996 and find it acceptable. We will retain a copy of the drainage master plan for our files.

If you have any questions, please contact Dennis Toyama of the Division of Engineering at 523-4756.

Very truly yours,

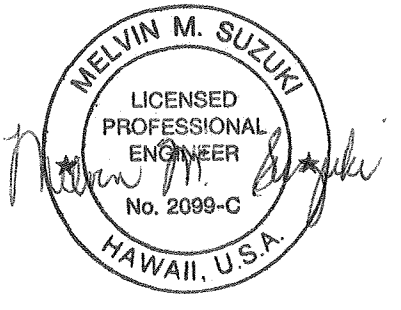
KENNETH E. SPRAGUE
Director and Chief Engineer

EXHIBIT 5

DRAINAGE MASTER PLAN
for the
ROYAL KUNIA DEVELOPMENT, PHASE II

Hoaeae and Waikele, Ewa, Oahu, Hawaii
T.M.K.: 9-4-02: 1 and 52; and 9-4-03: 1

Prepared For:
Halekua Development Corporation
2024 North King Street
Honolulu, Hawaii 96819



Prepared By:
ParEn, Inc.
dba PARK ENGINEERING
567 South King Street, Suite 300
Honolulu, Hawaii 96813

September 1996

EXHIBIT 5

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1. INTRODUCTION

1.1 General

This drainage master plan presents the drainage concept and the proposed drainage improvements for the Royal Kunia Phase II development. The concept and drainage improvements presented herein are based on the latest development master plan and land use plan for Phase II. The information contained in this drainage master plan updates and supersedes the information presented in the ***Drainage Master Plan for the Royal Kunia Development, Phase II***, dated September 1995 and the ***Preliminary Drainage Master Plan for the Royal Kunia Development, Phase I and II***, dated January 1991, prepared by ParEn, Inc. A copy of the January 1991 preliminary drainage master plan has been included in Appendix A for reference purposes.

1.2 Project Description

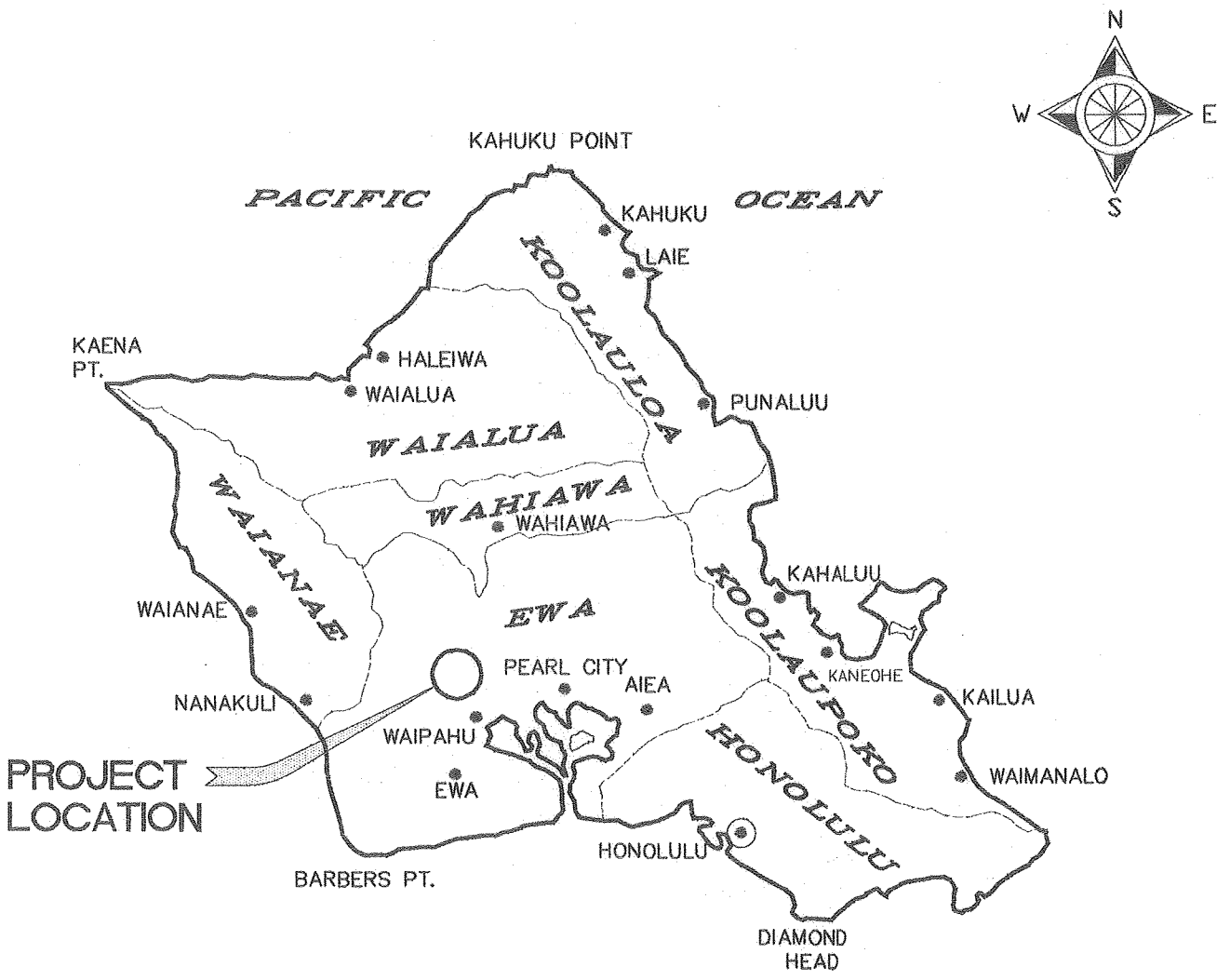
Halekua Development Corporation proposes to develop approximately 655-acres of abandoned sugarcane land located within Hoaeae and Waikele in the Ewa District on the Island of Oahu. See Figure 1 - Location Map. The project site is situated to the north of the Royal Kunia - Phase I development, which is currently in various stages of planning, design and construction. Several residential and commercial sites within the Phase I development have been occupied.

The development plan for Royal Kunia Phase II consists of single-family dwellings, low density apartments, a light industrial area, an agricultural park, recreational parks and a school. See Figure 2 - Royal Kunia Phase II Master Plan. Onsite and offsite utilities (drainage, sewer and water), roadway improvements and landscaping will also be provided. As Figure 2 indicates, development of Phase II will be completed in three (3) increments. Increment I has been zoned for its proposed land use. The remaining increments are presently zoned AG-1, Restricted Agriculture.

1.3 Drainage Concerns

Royal Kunia Golf Course No. 1, which is centrally located within the Phase I development, is master planned as a major drainageway for stormwater runoff. When Royal Kunia is fully developed, approximately 670-acres of the upstream tributary drainage area will flow through the golf course site. To date, the golf course site remains undeveloped. Temporary drainage improvements were constructed within the golf course site to accommodate stormwater runoff from adjacent developments.

Royal Kunia Phase II will be constructed in three (3) increments. The proposed sequence of development shall not jeopardize the integrity of the downstream drainage improvements and subject the existing developments to potential flood related damages. In general, the impact of the increased stormwater runoff rate and volume associated with development of Phase II must be addressed. Mitigative measures for flood, erosion and sedimentation control should be investigated.



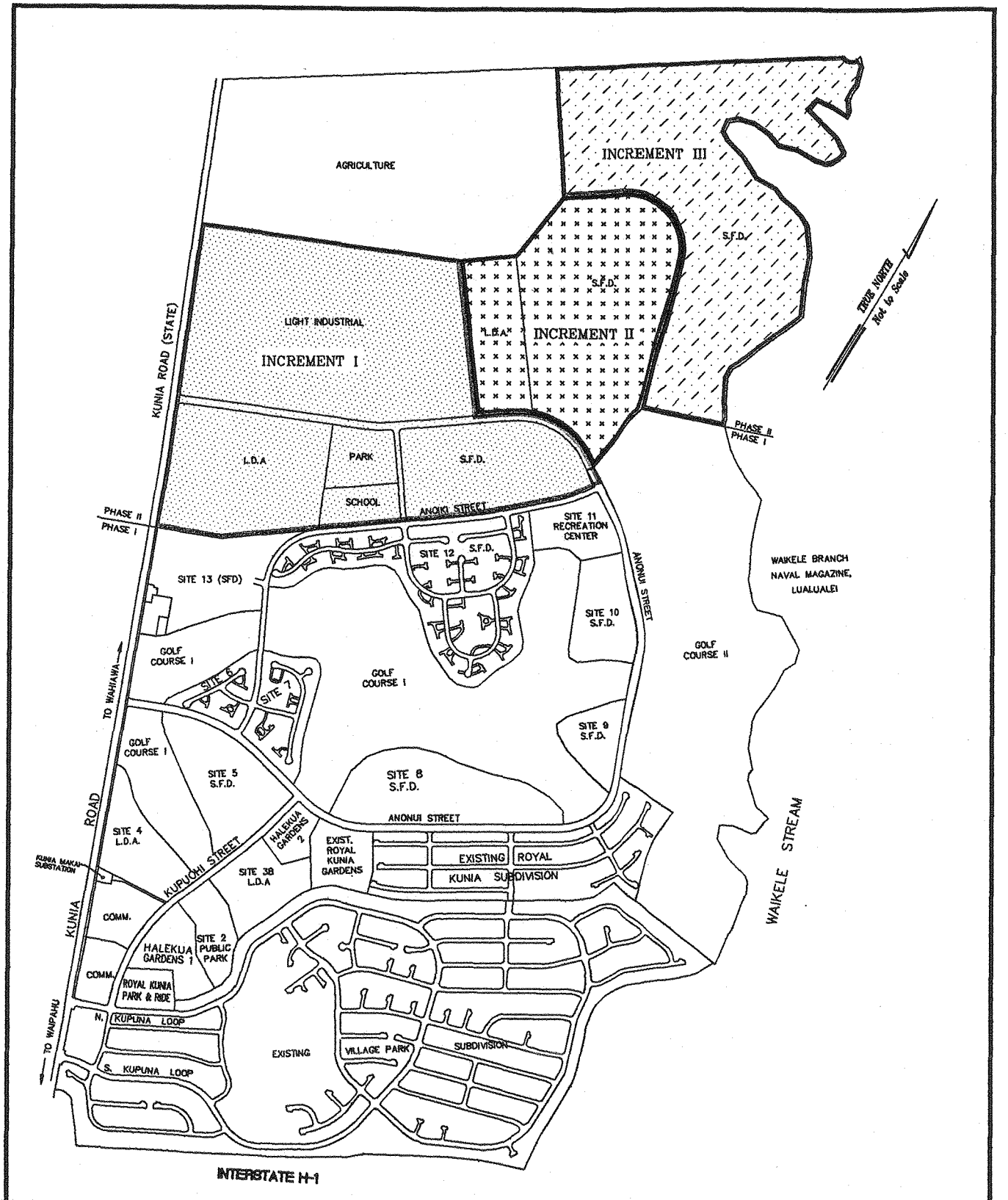
ISLAND OF OAHU

NOT TO SCALE

RK2-LOC 6-28-96 RMA

Prepared for: HALEKUA DEVELOPMENT CORPORATION	ROYAL KUNIA - PHASE II DRAINAGE MASTER PLAN LOCATION MAP	ParEn, Inc. dba Park Engineering Engineers, Surveyors, Planners Figure 1

EXHIBIT 5



Prepared for: *Halekua Development Corporation*	**ROYAL KUNIA - PHASE II** **Drainage Master Plan** **AT HOAEAE & WAIKELE, EWA, OAHU, HAWAII**	**ParEn, Inc.** **dba Park Engineering** Engineers, Surveyors, Planners
	Royal Kunia - Phase II Master Plan	**FIGURE 2**

EXHIBIT 5

2. PURPOSE AND SCOPE

The purpose of this drainage master plan is to present a drainage concept for the Royal Kunia Phase II development. The concept proposes to implement a drainage plan consistent with the drainage master plan for Royal Kunia Phase I and outline the drainage improvements for the Phase II development.

In view of the drainage concerns mentioned above, this drainage master plan will examine the existing drainage conditions, investigate the impact of stormwater runoff generated from the Phase II development, then propose drainage improvements to mitigate flooding, erosion and sedimentation of the surrounding areas.

3. SITE DESCRIPTION

3.1 Location

The development site is located within Hoaeae and Waikele in the Ewa District on the Island of Oahu. See Figure 1 - Location Map. The Tax Map Key for the project is 9-4-02: 1 and 52, and 9-4-03: 1. The project site is situated approximately 14-miles northwest of the Primary Urban Center (Honolulu) and 1.2-miles north of the Interstate Highway H-1 at Kunia Junction. Kunia Road and Waikele Gulch abuts the project along its western and eastern property boundaries, respectively. The Hawaiian Electric Company (HECo.) easement for their overhead transmission lines is located to the north. Phase 1 of the Royal Kunia development is located along the southern boundary.

3.2 Topography

Based on aerial photo contour maps, the topographic conditions of the site are generally uniform with ground slopes ranging from 2-percent to 7-percent, sloping in the southeasterly direction. Steeper slopes may be found in gully areas. Existing ground elevations range from 450-feet Mean Sea Level (MSL) at the Phase I - Phase II boundary to 575-feet MSL at the upper boundary.

3.3 Soil Types

Soil survey maps prepared by the U.S. Department of Agriculture, Soil Conservation Service (U.S. Department of Agriculture, SCS, 1972) indicate that the predominant soil types in the Phase II development are the Lahaina silty clay (LaA and LaB) and Molokai silty clay loam (MuD) . The SCS describes these soils as well-drained soils commonly found in areas of agricultural cultivation. Some general drainage characteristics of these soils are moderate permeability and slow to medium runoff. The Soil Conservation Service has classified these soil types in Hydrologic Soil Group (HSG) B.

3.4 Climate

As with most of the Hawaiian Islands, the prevailing northeasterly trade winds dictate the climate throughout the year. Orographic effects from the Koolau Mountain Range often produce "light showers" which extends onto the central plateau.

Heating of the central plateau may also produce rain clouds by orthographic effects. The heated land causes convection of the air mass which still contains moisture. Precipitation is generated as the air mass rises, cools, then forms rain clouds. The development site generally receives a fair amount of rainfall during "Kona" storms. These storm fronts which move into the island from the southwesterly direction often produce intense rainfall rates over a short duration.

The mean annual rainfall is approximately 32 to 40-inches. The estimated minimum and maximum average annual temperatures at the project site are 64-degrees and 79-degrees Fahrenheit.

3.5 Existing Drainage Conditions

Based on aerial photo contour maps, the Royal Kunia Phase II development is generally located within four (4) drainage basins. See Figure 3 - Drainage Map, Existing Conditions. The onsite and offsite tributary drainage areas for each basin are given below in Table 1.

Area No.	Onsite Area acs.	Offsite Area acs.	Total Area acs.
1	300	170	470
2	0	0	0
3	304	2	306
4	Located within the Phase I Development		
5	37	234	271
6	14	26	40
Total	655	432	1,087

TABLE 1 - Royal Kunia Phase II, Onsite and Offsite Tributary Drainage Areas
Existing Conditions

Under existing drainage conditions, Area No. 1 drains an area which extends from the Phase I - Phase II boundary to the Waiahole Ditch Irrigation system. Two (2) abandoned earth reservoirs are located within a well-defined drainageway. Under sugarcane cultivation, these reservoirs served to collect and store runoff for irrigation purposes. These uncontrolled reservoirs are still capable of containing runoff from the upstream onsite and offsite tributary drainage area.

TRUE NORTH
1" = 800'

TO WAHIAWA

PHASE 2

A=165 ACS.
Q=1050 CFS

A=2 ACS.
Q=10 CFS

A=234 ACS.
Q=1400 CFS

A=26 ACS.
Q=130 CFS

PHASE 2

DRAINAGE AREA 6
(14 ACS.)

DRAINAGE AREA 5
(37 ACS.)

550

525

500

(147 ACS.)

EXISTING EARTH RESERVOIR

(255 ACS.)

(143 ACS.)

KUNIA ROAD (5 ACS.)

WAIKELE BRANCH NAVAL MAGAZINE, LUALUALEI

475

PHASE 2
PHASE 1

450

EXISTING 60" PIPE CULVERT

425

EXISTING 48" PIPE CULVERT

WAIKELE STREAM

DRAINAGE AREA 1

(45 ACS.)

(14 ACS.)

EXISTING TEMP. DITCH & 2-60"
A = 143 AC
Q = 470 CFS

EXISTING TEMP. DITCH & 48"
A = 14 AC
Q = 86 CFS

EXISTING 54" PIPE CULVERT

INTERCEPTOR DITCH

DRAINAGE AREA 3

400

EXISTING. TEMP. DITCH
A = 45 AC
Q = 250 CFS

KUNIA ROAD (STATE)

SITE 11 RECREATION CENTER

ANONUI STREET (ROAD "D")

375

EXISTING 12'x10' BOX CULVERT
A = 470 AC
Q = 2290 CFS

EXISTING TEMPORARY ROAD

EXISTING ANOIKI STREET (ROAD "R")

350

EXISTING 8'x8' BOX CULVERT
A = 160 AC
Q = 570 CFS

EXISTING 96" PIPE CULVERT
A = 204 AC
Q = 720 CFS

GOLF COURSE II

PHASE 2
PHASE 1

S.F.D. SITE 12

SITE 10 S.F.D.

EXISTING STORMWATER DETENTION BASIN
A = 8.3 AC.
V = 70.6 AC.-FT

SITE 13 (SFD)

EXISTING RETENTION BASIN
A = 8.2 AC
V = 55.6 AC-FT

EXISTING 12' x 12' BOX CULVERT

STORM WATER RETENTION BASIN

EXISTING 72" PIPE CULVERT
A = 48.5 AC
Q = 149.1 CFS

GOLF COURSE I

SITE 9 S.F.D.

EXISTING 30" PIPE CULVERT
A = 11.8 AC
Q = 42.7 CFS

325

EXISTING 20'x10' BOX CULVERT
A = 531 AC
Q = 2500 CFS

SITE 6

SITE 7

DRAINAGE AREA 2

EXISTING 14'x 8' BOX CULVERT
A = 138 AC
Q = 920 CFS

EXISTING 54" PIPE CULVERT
A = 16 AC
Q = 80 CFS

EXISTING 2-60" PIPE CULVERT

OUTLET

SITE 8 S.F.D.

DRAINAGE AREA 4

ANONUI STREET (ROAD "D")

EXISTING ROYAL KUNIA SUBDIVISION

EXISTING 30" PIPE CULVERT

SITE 5 S.F.D.

GOLF COURSE I

HALEKUA GARDENS 2

EXIST. ROYAL KUNIA GARDENS

SITE 4 L.D.A.

KUNIA ROAD (STATE)

STREET

SITE 3B L.D.A

EXISTING 14'x 10' BOX CULVERT

KUPUOHI

KUNIA MAKAI SUBSTATION

EXISTING 48" PIPE CULVERT

COMM.

SITE 2 PUBLIC PARK

HALEKUA GARDENS 1

EXISTING 144" MPCM PIPE CULVERT

SUBDIVISION

EXISTING 162" MPCM PIPE CULVERT

VILLAGE PARK

COMM.

ROYAL KUNIA PARK & RIDE

KUPUNA LOOP N.

EXISTING

S. KUPUNA LOOP

TO WAIPAHU

INTERSTATE H-1

EXISTING 3-168" MPCM PIPE CULVERTS

LEGEND:

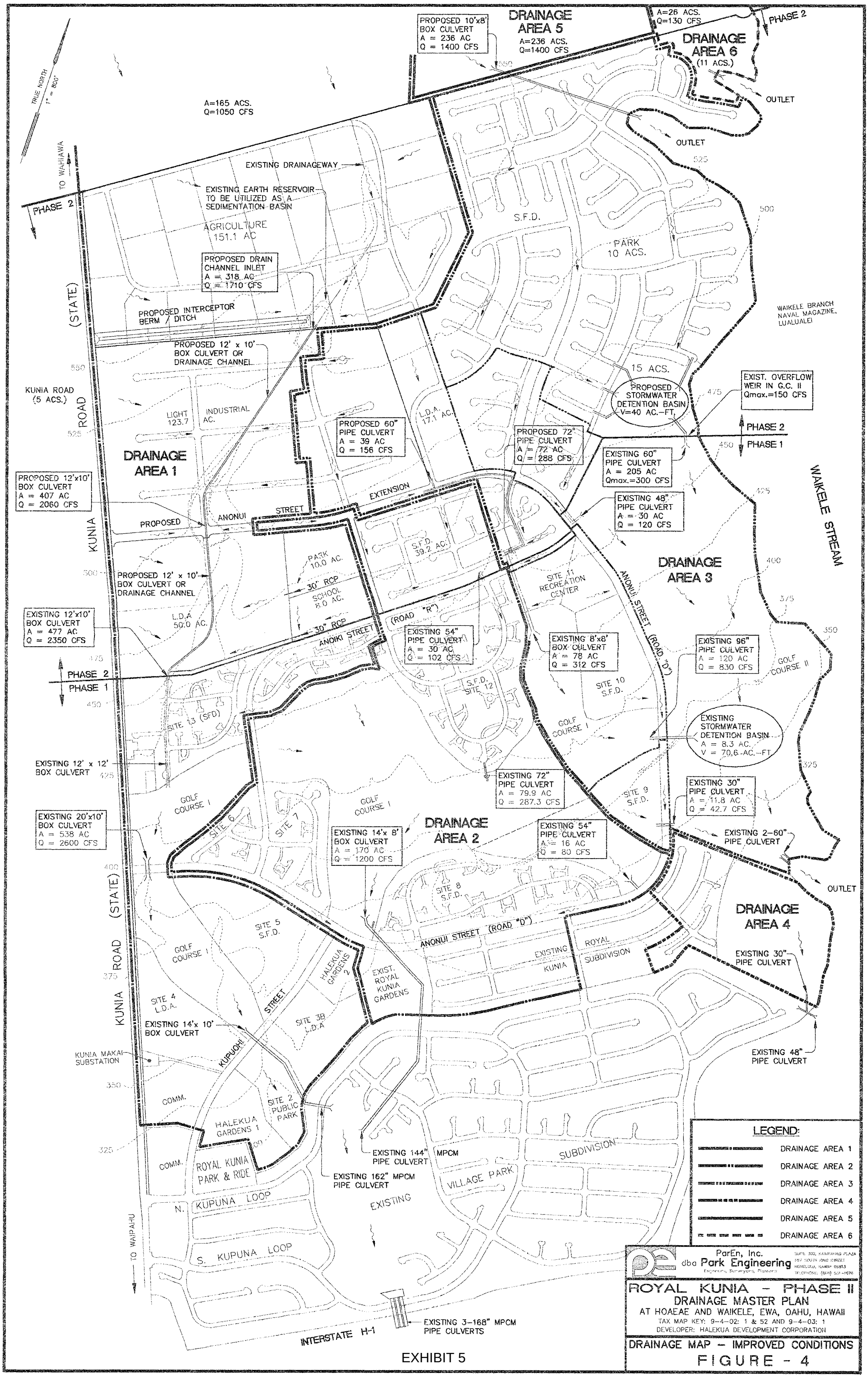
- DRAINAGE AREA 1
- DRAINAGE AREA 2
- DRAINAGE AREA 3
- DRAINAGE AREA 4
- DRAINAGE AREA 5
- DRAINAGE AREA 6

ParEn, Inc.
dba Park Engineering
Engineers, Surveyors, Planners
SUITE 300, KAWAIAHAO PLAZA
567 SOUTH KING STREET
HONOLULU, HAWAII 96813
TELEPHONE: (808) 531-1675

ROYAL KUNIA - PHASE II
DRAINAGE MASTER PLAN
AT HOAEAE AND WAIKELE, EWA, OAHU, HAWAII
TAX MAP KEY: 9-4-02: 1 & 52 AND 9-4-03: 1
DEVELOPER: HALEKUA DEVELOPMENT CORPORATION

DRAINAGE MAP - EXISTING CONDITIONS
FIGURE - 3

EXHIBIT 5



ParEn, Inc.
dba Park Engineering
Engineers, Surveyors, Planners
SUITE 300, KAMAHAO PLAZA
667 SOUTH KING STREET
HONOLULU, HAWAII 96813
TELEPHONE: (808) 521-1678

ROYAL KUNIA - PHASE II
DRAINAGE MASTER PLAN
AT HOAEAE AND WAIKELE, EWA, OAHU, HAWAII
TAX MAP KEY: 9-4-02: 1 & 52 AND 9-4-03: 1
DEVELOPER: HALEKUA DEVELOPMENT CORPORATION

DRAINAGE MAP - IMPROVED CONDITIONS

FIGURE - 4

EXHIBIT 5

An existing 12-feet x 10-feet concrete box culvert has been constructed in conjunction with the construction of Royal Kunia Site 13 (A). An inlet structure was constructed at the interface of the Phase I - Phase II property line. The outlet structure was constructed within the Royal Kunia Golf Course No. 1 site. Approximately 470-acres of undeveloped scrub sugarcane land from Area No. 1 drains into this drainage facility.

A temporary interceptor ditch has been constructed within the Phase II development site to divert runoff around Anoiki Street, previously labeled Road "R". The interceptor ditch, located to the north of the Phase I - Phase II property line, drains an area of approximately 202-acres. Stormwater runoff from 45-acres of scrub sugarcane land is being diverted into the drainageway located within Area No. 1.

Within Drainage Area No. 3, the interceptor ditch drains approximately 157-acres of scrub sugarcane land. Two (2) existing 60-inch pipe culverts and an existing 48-inch pipe culvert are temporarily being used to convey runoff from the ditch into an existing 8-feet x 8-feet concrete box culvert. Stormwater runoff is being discharged into the Royal Kunia Golf Course No. 1 site. An additional 147-acres of undeveloped land sheet flows into the existing Royal Kunia Golf Course No. 2 site and also into U.S. Navy land.

Stormwater runoff from Drainage Areas No. 5 and 6 is presently being conveyed by overland flow into two gullies located in the extreme northeast end of the development site. The runoff passes through U.S. Navy land then enters Waikele stream approximately 1.2-miles upstream of the confluence with the Kipapa Stream.

Five (5) - drainage stubouts were installed during the construction of Phase I drainage improvements. They are the: 1) 12-feet x 10-feet box culvert from Site 13; 2) 54-inch reinforced concrete pipe (RCP) culvert, located in the northeastern corner of Site 12; 3) 8-feet x 8-feet concrete box culvert, installed along the western property boundary of Site 11; 4) 48-inch pipe culvert, which is part of the Road "D" drainage system discharging into the Royal Kunia Golf Course No. 2; and 5) 60-inch pipe culvert, located along the northeastern property boundary of Golf Course No. 2. Except for the 12-feet x 10-feet box culvert, all of these drainage stubouts are temporarily plugged.

Royal Kunia Golf Course No. 1, which is centrally located within the Phase I development, has been master planned as a major drainageway for stormwater runoff. To date, the golf course site remains undeveloped. However, the surrounding sites are currently under construction or are currently being occupied. Several temporary drainage improvements were constructed to accommodate the runoff from adjacent developments. They include a stormwater retention basin and an inlet structure for the 96-inch pipe culvert crossing Road "D". The retention basin has been sized to contain the 100-year 24-hour stormwater runoff from a portion of Site 12 including adjacent tributary areas. See ***Drainage Calculations for Royal Kunia Site 12, Interim Offsite Drainage Plan***, ParEn, Inc. dated Feb. 1995. The temporary inlet structure for the 96" pipe culvert, including temporary interceptor berms, were constructed to divert and collect runoff from the 8-feet x 8-feet box culvert, and the undeveloped sites of Golf Course 1, Site 10 and Site 11.

4. PROPOSED DRAINAGE IMPROVEMENTS

4.1 General

The proposed drainage improvements for the Phase II development will not drastically alter the existing drainage pattern of the site. However, adjustments to the drainage areas will be required to accommodate the proposed land use plan for the Phase II development. See Figure 4 - Royal Kunia Phase II, Drainage Master Plan.

The proposed drainage improvements for the Phase II development consists of underground and surface drainage systems, which includes catch basins, drain intakes, drain manholes, pipe and box culverts, drainage channels, ditches and swales. Detention basins are also being proposed in Drainage Area No. 1 and Drainage Area No. 3 for sediment containment and a reduction of the peak stormwater runoff rates. Similar to the existing detention basin within the Royal Kunia Golf Course No. 2 site, the proposed detention basins will be privately owned, operated and maintained.

The drainage improvements for the Phase II development will be designed and constructed in accordance with the City and County of Honolulu, Department of Public Works, Storm Drainage Standards, dated May 1988, and applicable Standard Specifications and Standard Details, as amended. Except for the detention basins, the drainage improvements are proposed to be dedicated to the City and County of Honolulu. For each development site, hydraulic computations and a drainage map shall be submitted to the City and County of Honolulu, Department of Public Works for approval.

In consideration of the City and County of Honolulu Ordinance No. 96-34, Amendment to Chapter 14 of the Revised Ordinances of Honolulu 1990, as amended, relating to "Drainage, Flood and Pollution Control", best management practices (BMP's) and engineering control facilities shall be implemented for stormwater quality improvements and to reduce the peak stormwater runoff rates.

Based on the proposed land use plan for the Phase II development and the drainage pattern of the site, it may be feasible to construct a detention (sedimentation) basin within the agricultural park site located within Drainage Area No. 1. Another detention basin is being proposed in an open space area located above the Golf Course No. 2 site. This detention basin will be designed to accommodate the increase in runoff associated with development of Drainage Area No. 3.

In general, the basins should provide an adequate storage capacity to detain the 2-year 24-hour stormwater runoff. In addition, the outlet works should be designed to release the runoff at the pre-developed 2-year 24-hour rate and also be capable of conveying the 100-year peak discharge. The detention basin located in Drainage Area No. 3 shall be designed to detain the 100-year stormwater runoff from its tributary drainage area. Additional discussion regarding the design criteria are provided in the following section.

4.2 Proposed Onsite Drainage Improvements - Phase II

The cumulative onsite and offsite drainage areas tributary to the existing drainage improvements at the interface of the Phase I - Phase II boundary are given below in Table 2. As compared to the areas listed above in Table 1, the total onsite and offsite areas remains the same. However, the onsite area have been adjusted.

Preliminary computations indicate that the Royal Kunia Phase II site will contribute approximately 382 cfs to the existing 2-year 24-hour stormwater runoff rate of 141 cfs. See Appendix C, Hydrologic Computations for Royal Kunia Phase II Development, 2-year 24-hour Stormwater Runoff Rate. A detention basin is being proposed within Drainage Area No. 1 and 3 to address this increase in runoff.

Area No.	Onsite Area acs.	Offsite Area acs.	Total Area acs.
1	307	170	477
2	30	0	30
3	307	0	307
4	Located within the Phase I Development		
5	0	236	236
6	11	26	37
Total	655	432	1,087

TABLE 2 - Royal Kunia Phase II, Onsite and Offsite Tributary Drainage Areas

Drainage Area No. 1

A 12-feet wide by 10-feet high concrete box culvert (or drainage channel) is being proposed to collect and convey stormwater runoff generated from Drainage Area No. 1. Under developed conditions, the proposed box culvert will replace the existing drainageway. The box culvert will extend from the existing 12-feet x 10-feet box culvert at the Phase I - Phase II boundary and continue through the proposed Low Density Apartment site and Light Industrial site.

The 12-feet x 10-feet box culvert may terminate at the Light Industrial/Agricultural Park property line, where an existing earth reservoir is located. Due to the proposed agricultural land use of the upstream tributary drainage area, the existing reservoir should be utilized as a sedimentation (detention) basin. The inlet structure for the 12-feet x 10-feet box culvert shall be designed to pass the 100-year peak flow rate of 1,710 cfs and should include debris barriers.

Preliminary computations indicate that the sedimentation basin should have a volume of storage of approximately 25 acre-feet. The low flow outlet works should be designed to pass a peak 2-year 24-hour runoff rate of approximately 15 cfs from the agriculture park and offsite tributary drainage area. See Appendix D for computations.

The natural drainageway through the proposed agricultural park site may be used to convey stormwater runoff generated from the upstream drainage area. During the subdivision process of the 151.1-acre agricultural park site, a drainage study should be conducted to determine the limits of flooding along the existing drainageway. With this information, building setback lines may then be established. No structures will be allowed to be constructed within the flood plain as indicated by the setback lines.

As an alternative and where appropriate, a box culvert of equivalent size may replace the concrete lined open channel. Provisions for access, maintenance and security of these drainage structures shall be provided in accordance with City standards.

Additional drainage systems will be required to collect stormwater runoff from the Low Density Apartment, Light Industrial, and Agricultural Park sites and convey the runoff into the proposed box culvert and/or drainage channel. These drainage improvements will be identified as each site is subdivided and when detailed layouts become available.

Drainage Area No. 2

Within the Phase II development, Drainage Area No. 2 will consists mostly of single family dwellings. Approximately 102 cfs of stormwater runoff (30-acres) may drain into the existing 54-inch stubout, which was constructed with the roadway improvements for Anoiki Street . The drainage system for Anoiki Street was also designed to collect approximately 7.4-acres of lot and roadway area from the single family dwelling site in Phase II.

Prior to connection to the existing 54-inch stubout, additional drainage improvements may be required within the Golf Course No. 1 site to accommodate the increase in stormwater runoff associated with development of Phase II - Increment 1. To date, the golf course site remains undeveloped. As a result, a stormwater retention basin was designed and constructed within the golf course to contain runoff generated from a portion of Site 12 and Anoiki Street. The basin was sized for a 100-year 24-hour storm. (ParEn, Inc., Feb. 1995)

The stormwater retention basin does not have the capacity for the increase in runoff. If the golf course is not developed before development of Increment 1, then the retention basin may be enlarged. Approximately 33 acre-feet of additional storage will be required.

An alternative is to provide a temporary relief drain for the basin. This will reduce the storage capacity of the detention basin due to the continual and gradual release of stormwater runoff. The relief drain may consist of a low flow outlet works and a temporary ditch to convey the runoff into the existing 14-feet x 8-feet box culvert. Flood routing computations shall be submitted to the City for review and approval.

Drainage Area No. 3

Within the Phase II development, Drainage Area No. 3 will be divided into three (3) subareas. Stormwater runoff generated from these subareas will be drained by an existing 8-feet x 8-feet concrete box culvert, an existing 48-inch pipe culvert and an existing 60-inch pipe culvert.

A 72-inch reinforced concrete pipe (RCP) culvert is being proposed as an extension to the existing 8-feet x 8-feet concrete box culvert. The 72-inch RCP will collect stormwater runoff from approximately 72-acres of land from the Phase II development. The runoff will be discharged into the Royal Kunia Golf Course No. 1 site.

The existing 48-inch pipe culvert will discharge approximately 30-acres of single family dwelling and roadway area into Royal Kunia Golf Course No. 2. The existing 60-inch pipe culvert will drain approximately 205-acres into Golf Course No. 2. The 205-acres of land includes the onsite area of Drainage Area No. 5 and a portion of Drainage Area No. 6. A detention basin is being proposed to reduce the 100-year peak stormwater runoff rate to pre-developed conditions.

Hydraulic computations indicate that the 60-inch drain line has the capacity to convey approximately 300 cfs. In addition, a relief drainageway, which has been graded into the golf course, may provide additional conveyance for approximately 150 cfs of runoff.

Preliminary hydrologic and hydraulic computations indicate that the detention basin should have approximately 40 acre-feet of storage to contain the 100-year 24-hour stormwater runoff. See Appendix D. Using the Soil Conservation Service (SCS) Curve Number (CN) Method, computations indicate that the 100-year peak flow rate from the 205-acre subarea will be approximately 760 cfs. Computations were performed for a 205-acre, fully developed residential subdivision. Based on a maximum outflow rate of 300 cfs, preliminary computations indicate that a volume of 40 acre-feet would be required.

The low flow outlet works may consist of an inlet or intake structure connected to the existing 60-inch pipe culvert. The outlet works should be designed to pass a 2-year 24-hour peak discharge of 45 cfs, at which time the detention basin should contain approximately 15 acre-feet of runoff. See Appendix D.

As an added measure of safety, an emergency overflow spillway should be graded along the golf course property line to pass a maximum flow rate of approximately 150 cfs into the drainageway. The maximum 100-year 24-hour outflow rate from the outlet works and emergency spillway would then be 450 cfs.

To the maximum extent practicable, stormwater runoff from Drainage Area No. 3 will be contained onsite. No outlets will be constructed along the eastern property line of the Phase II development. Discharge into U.S. Navy land along this property line is not permitted.

Drainage Area No. 5

As Figure 4 indicates, Drainage Area No. 5 consists of the offsite area above the Royal Kunia Phase II development. Approximately 236-acres of agricultural lands will drain into the project site. A 10-feet x 8-feet concrete box culvert is being proposed to convey the runoff through the single family dwelling site. Based on Plate 6 of the City and County of Honolulu, Storm Drainage Standards, the box culvert should be designed for 1,400 cfs of runoff. No onsite runoff will contribute into this drainage facility.

Stormwater runoff collected in the 10-feet x 8-feet box culvert will be discharged into a gully located on U.S. Navy lands. The runoff will flow via overland flow along the gully, then cross a U.S. Navy access road prior to entering Waikele Stream.

Drainage Area No. 6

Drainage Area No. 6 will drain approximately 11-acres of land from the Phase II development and 26-acres of offsite tributary area into another gully along Waikele Gulch. A park site is being proposed at this location. The increase in runoff generated from the proposed park and upstream agricultural lands is anticipated to be minimal.

4.3 Offsite Drainage Improvements

An offsite drainage improvement for the proposed Phase II development may include increasing the storage capacity of the existing stormwater retention basin, located within the Royal Kunia Golf Course I site. Development of the single family dwelling site (Phase II, Increment I) will increase the stormwater runoff contributing into the existing 54-inch pipe culvert located at the Phase I - Phase II property line within Drainage Area No. 2.

As discussed in Section 4.2, an additional 33 acre-feet of retention storage will be required. An alternative would be to construct a temporary relief drain for the basin. Stormwater runoff may be conveyed by a temporary drainage system through the Royal Kunia Golf Course I site and drain into the existing 14-feet x 8-feet concrete box culvert.

An interceptor berm or swale may be constructed along the northern most property line of the Phase II development. The berm or swale would divert runoff into an existing drainageway, as in Drainage Area No. 1, or to a specific point of collection.

At this time, there are no other offsite drainage improvements being proposed.

5. SUMMARY OF FINDINGS, RESULTS AND CONCLUSION

The proposed drainage system for the Phase II development consists of underground and surface drainage systems, which includes catch basins, drain intakes, drain manholes, pipe and box culverts, drainage channels, ditches, swales and detention basins. The drainage improvements will be designed and constructed in accordance with the City and County of Honolulu, Department of Public Works, Storm Drainage Standards, dated May 1988, and applicable Standard Specifications and Standard Details, as amended. Except for the stormwater detention basins, the drainage improvements are proposed to be dedicated to the City and County of Honolulu.

In consideration of the City and County of Honolulu, Ordinance No. 96-34, Amendment to Chapter 14 of the Revised Ordinances of Honolulu, 1990, relating to "Drainage, Flood and Pollution Control", best management practices (BMP's) and engineering controls shall be implemented for stormwater quality improvements and to reduce the peak stormwater runoff rates.

When fully developed, the Royal Kunia Phase II development site will be located within four (4) drainage basins. The following paragraphs will summarize the drainage improvements being proposed for each drainage basin.

Drainage Area No. 1:

A 12-feet x 10-feet concrete box culvert or drainage channel is being proposed for Drainage Area No. 1. The culvert or drainage channel will extend from the existing 12-feet x 10-feet box culvert, at the Phase I - Phase II boundary and continue through the low density apartment site and light industrial site. The drainage improvement may terminate at the property line of the proposed agricultural park site and light industrial site, where an earth reservoir is located.

The existing earth reservoir may be utilized as a sedimentation (detention) basin to contain silt and debris from the upstream tributary drainage area and also to reduce to 2-year 24-hour peak runoff rate. To detain the 2-year 24-hour stormwater runoff, the basin should have a storage capacity of approximately 25 acre-feet, at which time the outlet should pass a peak discharge of 15 cfs. The outlet works shall also be designed to pass the 100-year runoff rate of 1,710 cfs.

The natural drainageway through the agricultural park site may be used to convey stormwater runoff from the upstream area. A detailed hydraulic study should be conducted to determine the 100-year limits of flooding and establish building setback lines to prevent development within the flood plain.

Drainage Area No. 2:

Prior to connection to the existing 54-inch stubout, additional drainage improvements may be required within the Golf Course No. 1 site to accommodate the increase in stormwater runoff associated with development of Phase II - Increment 1. The existing stormwater retention basin may be expanded to provide approximately 33 acre-feet of additional storage volume. An alternative solution would be to provide a temporary relief drain for continual and gradual release of runoff from the basin. A temporary ditch may be constructed from the outlet of the relief drain to the existing 14-feet x 8-feet box culvert.

Drainage Area No. 3:

Within the Phase II development, Drainage Area No. 3 will be divided into three (3) subareas. Stormwater runoff generated from these subareas will be served by an existing 8-feet x 8-feet concrete box culvert, an existing 48-inch pipe culvert and an existing 60-inch pipe culvert.

A 72-inch, 48-inch and 60-inch pipe culvert, respectively, are being proposed as extensions to each of the existing drainage structures. A stormwater detention basin is being proposed upstream of the 60-inch pipe culvert. Preliminary hydrologic and hydraulic computations indicate that the detention basin should have a storage capacity of 40 acre-feet to contain the 100-year 24-hour stormwater runoff.

Hydraulic computations indicate that the existing 60-inch drain line within the Royal Kunia Golf Course No. 2 has the capacity to convey approximately 300 cfs. In addition, a emergency overflow weir may be graded along the property line to pass a maximum flow rate of 150 cfs. As a result, the maximum outflow rate from the basin was determined to be approximately 450 cfs.

The low flow outlet works should also be designed to pass a peak 2-year 24-hour flow rate of approximately 45 cfs, at which time the detention basin should contain approximately 15 acre-feet of runoff.

A 10-feet x 8-feet concrete box culvert is being proposed to convey the offsite runoff from Drainage Area No. 5 through the single family dwelling site. No. onsite runoff will contribute into this drainage facility. The runoff will be discharged into a gully located on U.S. Navy lands.

Drainage Area No. 6:

Drainage improvements within Drainage Area No. 6 will consist of open swales, catch basins, drain intakes and drain pipes. The drainage system will drain the proposed 11-acre park site, located in the Phase II development, and 26-acres of agricultural lands above Phase II. The runoff will be discharged into another gully also located on U.S. Navy lands.

6. REFERENCES

1. City and County of Honolulu, Department of Public Works, May 1988, ***Storm Drainage Standards***, Honolulu, Hawaii.

2. Department of Land and Natural Resources, Division of Water and Land Development, State of Hawaii, 1984, ***Rainfall Frequency Study for Oahu***, Report R-73, prepared by Giambelluca, T.W., et. al., Honolulu, Hawaii.

3. Haestad Methods, 1989, ***Hydrology for Small Watersheds***, Quick TR-55 User's Manual, Michael Glazner, Waterbury, CT.

4. Haestad Methods, 1989, ***Detention Pond Design and Analysis, POND-2 User's Manual***, Michael Glazner, Waterbury, CT.

5. ParEn, Inc., March 1991, ***Preliminary Drainage Master Plan for the Royal Kunia Development, Phases I and II, Hoaeae, Ewa, Oahu, Hawaii***, prepared for Halekua Development Corporation, Honolulu, Hawaii.

6. ParEn, Inc., January 1992, ***Drainage Report for Royal Kunia Golf Course II,*** prepared for Royal Oahu Resort, Inc. and Hazama Corporation, Honolulu, Hawaii.

7. ParEn, Inc., ***Royal Kunia Golf Course II, Grading and Drainage Plan, T.M.K.: 9-4-02: 46***, prepared for Royal Oahu Resort, Inc. and Hazama Corporation, Honolulu, Hawaii.

8. ParEn, Inc., ***Construction Plans for Royal Kunia Increment "C", Road "R" Phase 2, at Hoaeae, Ewa, Oahu, Hawaii, T.M.K.: 9-4-02:51***, prepared for Kunia Residential Partners, Inc., Honolulu, Hawaii.

9. ParEn, Inc., ***Construction Plans for Royal Kunia Increment "E", Road "D" Phase III, at Hoaeae, Ewa, Oahu, Hawaii, T.M.K.: 9-4-02:51***, prepared for Kunia Residential Partners, Inc., Honolulu, Hawaii.

10. ParEn, Inc., February 1995, ***Drainage Calculations for Royal Kunia Site 12, Interim Offsite Drainage Plan, Hoaeae, Ewa, Oahu, Hawaii***, prepared for Kunia Residential Partners, Honolulu, Hawaii.

11. U.S. Department of Agriculture, Soil Conservation Service, 1972, ***Soil Survey of Island of Kauai, Oahu, Maui, MoloKai, and Lanai, State of Hawaii,*** prepared in cooperation with the University of Hawaii, Agricultural Experiment Station, Honolulu, Hawaii.

12. U.S. Department of Agriculture, Soil Conservation Service, 1986, ***Urban Hydrology for Small Watersheds***, Technical Release No. 55, Second Edition.

APPENDIX A

Preliminary Drainage Master Plan

DEPARTMENT OF PUBLIC WORKS
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET
HONOLULU, HAWAII 96813

FRANK F. FASI
MAYOR

SAM CALLEJO
DIRECTOR AND CHIEF ENGINEER

IN REPLY REFER TO:
91-12-0027

January 16, 1991

Park Engineering
567 South King Street, Suite 300
Honolulu, Hawaii 96813

Gentlemen:

Subject: Your Letter of January 3, 1991 Regarding the Preliminary Drainage Master Plan Report for the Royal Kunia Development, Phases I & II, TMK: 9-4-02: Por. 1, 46, 49, 50, 51, & 52

The preliminary drainage master plan report dated January 1991 is acceptable. We will retain the report for our files.

Very truly yours,

C. Michael Street
for SAM CALLEJO
Director and Chief Engineer

EXHIBIT 5

PRELIMINARY
DRAINAGE MASTER PLAN
FOR THE
ROYAL KUNIA DEVELOPMENT
PHASES I and II

AT

HOAEAE, EWA, OAHU, HAWAII

TAX MAP KEY: 9-4-02: POR. 1, 46, 49, 50, 51, & 52

PREPARED BY:

ParEn, Inc. dba Park Engineering
Kawaiahao Plaza, Hale Mauka
567 South King Street, Suite 300
Honolulu, Hawaii 96813-3036

JANUARY 1991

EXHIBIT 5

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LIST OF APPENDICES

1 PURPOSE

A drainage investigation will herein be conducted for the proposed Royal Kunia Development. The purpose of this study will be to examine the present drainage patterns, outline the future drainage of the Royal Kunia Development and investigate the effects of the development on the surrounding areas. This report will also establish the basic hydrologic criteria to be used in the engineering design of the development's storm drainage network.

2 SITE DESCRIPTION

2.1 LOCATION

The project site is located in Hoaeae, Ewa, Oahu, Hawaii. The Tax Map Key designation for this project is 9-4-02: Por. 1, 46, 49, 50, 51, 52.

The Royal Kunia Development is situated approximately 1900 feet north of the H-1 overpass on Kunia Road. This site extends between Kunia Road at its west property boundary, and Waikele Gulch at its east property boundary. Sugarcane crop land and Village Park Subdivision encompasses the project site at its north and south property boundaries, respectively. See Figure 1 - Project Location Map.

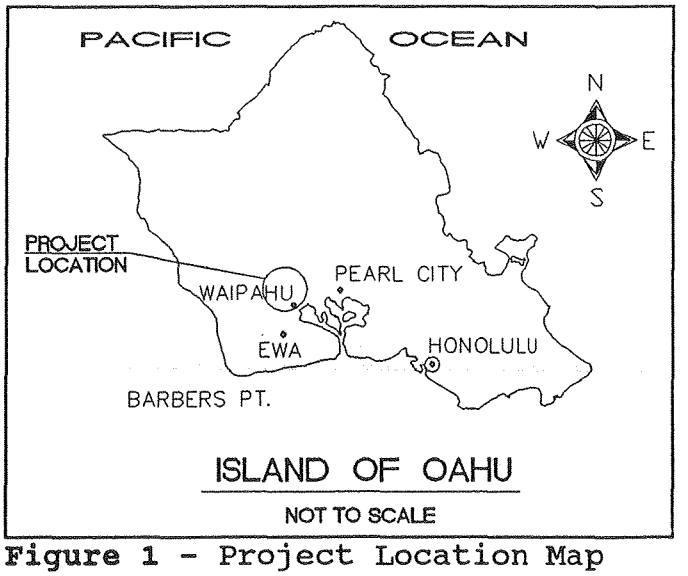


Figure 1 - Project Location Map

EXHIBIT 5

2.2 TOPOGRAPHY

Based on the aerial photo contour maps, ground slopes in the project site generally range from 2 to 7 percent, sloping in the northwesterly to southeasterly direction. Steeper slopes may be found in gully areas.

2.3 SOIL TYPE

The soil types found in the area of the development are predominantly of the Molokai and Lahaina Series, which are well drained soils commonly used for agricultural purposes. Slow to medium runoff, with a moderate rate of permeability are some of the general drainage characteristics of these soils (Hydrologic Soil Group B).

2.4 LAND USE

The proposed Phases I and II of the Royal Kunia Development will convert approximately 1,313.5 acres of cultivated sugarcane land, into a community consisting of residential, apartment, commercial, and industrial use, as well as public parks and golf courses. See Figure 2 - Royal Kunia Master Plan.

3 EXISTING DRAINAGE

Due to the intricate network of surface irrigating systems and cane haul roads, including the seasonal variations in land conditions associated with the cultivation of sugarcane, the drainage areas are not well defined. However, based on aerial photo contour maps, the area of the proposed development is located within three drainage basins, shown on Exhibit No. 1. Drainage areas 1 and 2, which consists of approximately 70 percent of the total drainage area, flows towards the existing Village Park Subdivision. Drainage area 3, which makes up the remaining 30 percent, flows into Waikele Stream.

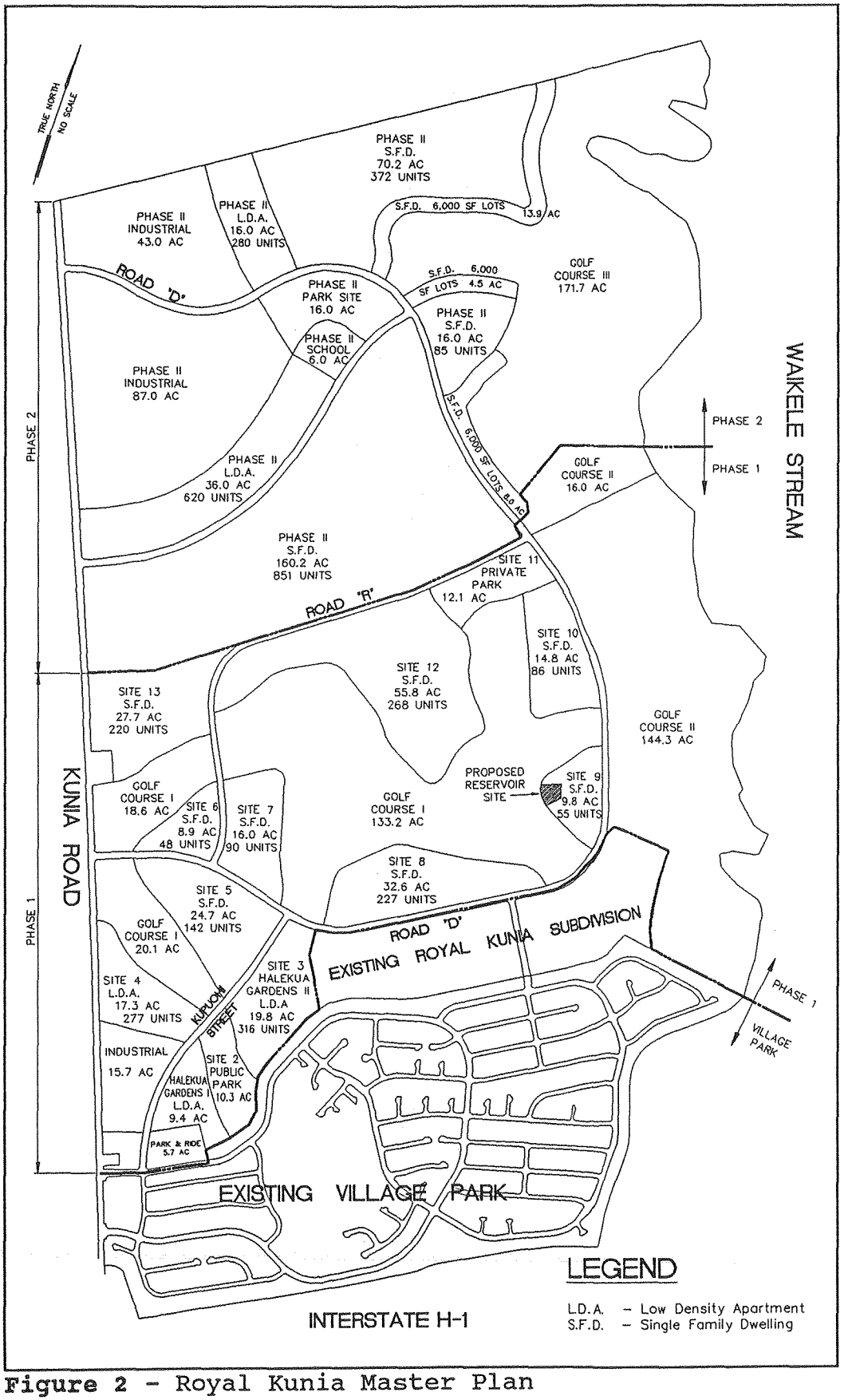


Figure 2 - Royal Kunia Master Plan

EXHIBIT 5

Stormwater from drainage areas 1 and 2, flows towards the existing Village Park Subdivision and into two existing drainage systems. The runoff in drainage area 1 is conveyed by an existing 162-inch multi-plated corrugated metal (MPCM) pipe culvert. Runoff within drainage area 2 is conveyed by a drainage system which incorporates a 14-feet x 8-feet concrete box culvert, a 144-inch multi-plated corrugated metal pipe culvert, and a concrete-lined trapezoidal channel. The two systems were constructed concurrently with the Village Park Subdivision and discharge the off-site stormwater runoff into an existing gulch within the Village Park subdivision. The systems from drainage areas 1 and 2, along with the drainage systems from Village Park, discharge into three existing 168" MPCM culverts located at the south end of the Village Park Subdivision (See Exhibit 1). Since the quantity of runoff has changed slightly, an investigation of the adequacy of the culverts will be conducted later in this report.

Runoff from drainage area 3, which discharges into the Waikele Stream, is conveyed predominantly by overland flow to steep gullies in the side slopes of the valley.

Among the surface irrigation systems mentioned above are a series of ponding earth reservoirs being used for storage. A reservoir of this type currently exists within the proposed development and will be relocated to a permanent site shown on Exhibit No. 1.

4 PROPOSED DRAINAGE

The overall drainage pattern of the proposed development will correlate closely with the existing drainage patterns. However, this pattern will be modified slightly prior to the construction of Phase II. Both underground and surface drainage systems, which includes roadway drainage, channels, ditches and swales, will be used to transport stormwater runoff through the development. Drainage structures found within each drainage area will be

designed based on the hydrologic criteria in the City and County of Honolulu, Department of Public Works, Storm Drainage Standards, dated May 1988. Drainage networks within the individual drainage sites will also be analyzed based on City and County of Honolulu Standards and submitted for approval at a later date.

Since the existing runoff pattern may be adjusted slightly following the completion of Phase I, it becomes necessary to analyze the runoff pattern both prior to and following the development of Phase II. The following paragraphs will summarize the overall drainage for each drainage area according to phases.

4.1 PHASE I

4.1.1 Drainage Area 1

Several drainage structures will be required to convey the stormwater runoff of drainage area no. 1 through the proposed development. Essentially, the major drainage channels will follow the course of the existing gully adjacent to Kunia Road. A preliminary investigation yields the use of the following:

a) Temporary earth ditches and a silting basin will be constructed at the boundary of phase 1 to channelize the off-site runoff of drainage area 1 and a portion of drainage area 2 into a 12-feet x 12-feet (Horiz. x Vert.) concrete-lined open channel. An energy dissipator will be required to minimize the exit velocity of the open channel, discharging into the proposed golf course;
b) 16-feet x 10-feet and 20-feet x 10 feet box culverts will be installed at Road "D" and Kupuohi Street crossings respectively.

Drainage area 1 discharges into the existing 162" MPCM culvert at Kupuna Loop. Based on the current Storm Drainage Standards, the

peak discharge from drainage area 1 exceeds the original design discharge of the existing 162" MPCM culvert. However, the existing 162" culvert at Village Park conforms with the Storm Drainage Standards, Department of Public Works, City and County of Honolulu, March 1969 using the peak discharge curves for areas over 100 acres. Since the peak discharge curves were adjusted upwards in the later Storm Drainage Standards, and the 162" MPCM culvert was designed to handle a discharge of 1900 cfs over approximately 426 acres, the area that the culvert drains will essentially remain the same regardless of the change in runoff. To check the adequacy of the existing 162" MPCM culvert under this new discharge, a hydraulic analysis shall be conducted later in this report.

4.1.2 Drainage Area 2

Temporary earth ditches at the upper boundary of Phase I will be used to divert approximately 92 acres of off-site stormwater runoff from drainage area no. 2 into a temporary silting basin in drainage area 3. This off-site water will be routed through a culvert and discharged into drainage area 3. The on-site runoff from site 12 will be transported through the roadway drainage systems and discharged into Golf Course I. Grass lined channels will be utilized to convey the runoff through the golf course and an underground drainage system will be installed where the flow velocity significantly exceeds the maximum permissible velocity for grass-lined channels.

The runoff from drainage area 2 will enter a realigned 14 feet x 8 feet box culvert crossing Road "D". This culvert is connected to the existing 144" MPCM culvert at Village Park. Similar to the existing 162" MPCM culvert at Kupuna Loop, the 144" MPCM was also originally designed using the Storm Drainage Standards, dated March 1969. It was sized to handle a capacity of 1400 cfs over approximately 295.5 acres. The area draining into the 144" culvert will remain at 295.5 acres.

4.1.3 Drainage Area 3

Prior to the development of Phase II, the off-site runoff above Road "R" from drainage area 2 will be diverted into drainage area 3. Stormwater runoff from drainage area no. 3 will be contained within the Golf Course II property line and discharged into Waikele Stream at a gully located in the lower limits of the golf course. Due to development of the drainage area, a detention basin will be used to contain the increased stormwater runoff rate. The detention basin will be designed in conjunction with the design of Golf Course II, and will limit the outflow rate to pre-developed conditions based on a 100 year storm of 24 hour duration. Detailed computations of the basin will accompany the drainage report for Golf Course II.

4.2 PHASE II

4.2.1 Drainage Area 1

With the development of Phase II, additional drainage structures need to be installed to discharge both the off-site and on-site runoff through the development. Because the layout of Phase II is preliminary, it can be assumed that the bulk of the stormwater will be carried by either 12 feet x 10 feet or 12 feet x 12 feet channels, or 12 feet x 10 feet to 12 feet x 12 feet box culverts at roadway crossings. The discharge through Phase II will enter Phase I at the 12 feet x 12 feet lined channel at site 13. Approximately 2,400 cfs over 477 acres will pass the boundary between Phases I and II.

4.2.2 Drainage Area 2

Once Phase II is developed, 40 of the original 92 acres north of Road "R" will be rerouted into site 12. This will adjust the

tributary area of the 144" MPCM culvert back to its design area of 295.5 acres.

4.2.3 Drainage Area 3

The proposed detention basin within the Golf Course II site will be required to serve 475 acres for a peak discharge of 2,450 cfs. As mentioned earlier in this report, a detailed analysis of the basin will accompany the drainage report for Golf Course II.

5 TENTATIVE DESIGN OF MAJOR DRAINAGE STRUCTURES

Since the road and lot grades have not been finalized, slopes for drainage structures shall be based upon reasonable assumptions to aid in sizing the structures. For convenience, the major structures are designated by nodes on Exhibit 1. Each node is designated by a capital letter followed by either 1, 2, or 3 to represent which drainage area the node falls in.

5.1 STRUCTURES IN DRAINAGE AREA 1

5.1.1 Phase I

5.1.1.1 14' x 10' Box Culvert at Public Park Site 2.

For:

Q= 3,000 cfs n= 0.015 slope= .0220 ft/ft
A= 645 acres

Computed:

normal:	depth= 6.49 ft	velocity= 33.01 fps	
critical:	depth=11.26 ft	velocity= 19.12 fps	slope=.0053
capacity:	depth=10.00 ft	velocity= 37.75 fps	Q= 5285 cfs

EXHIBIT 5

5.1.1.2 16' x 10' Box Culvert at Kupuohi Street. (Node A1)

For:

Q= 2,800 cfs n= 0.015 slope= .0280 ft/ft
A= 600 acres

Computed:

normal: depth= 4.99 ft velocity= 35.05 fps
critical: depth= 9.83 ft velocity= 17.87 fps slope=.0045
capacity: depth=10.00 ft velocity= 44.81 fps Q= 7170 cfs

Freeboard= 5.00 ft

Therefore, stormwater from the golf course shall be channelized into the inlet structure to attain normal depth at the entrance.

A transition shall be provided to channelize the 16'x 10' box into the 14' x 10' box at the park site.

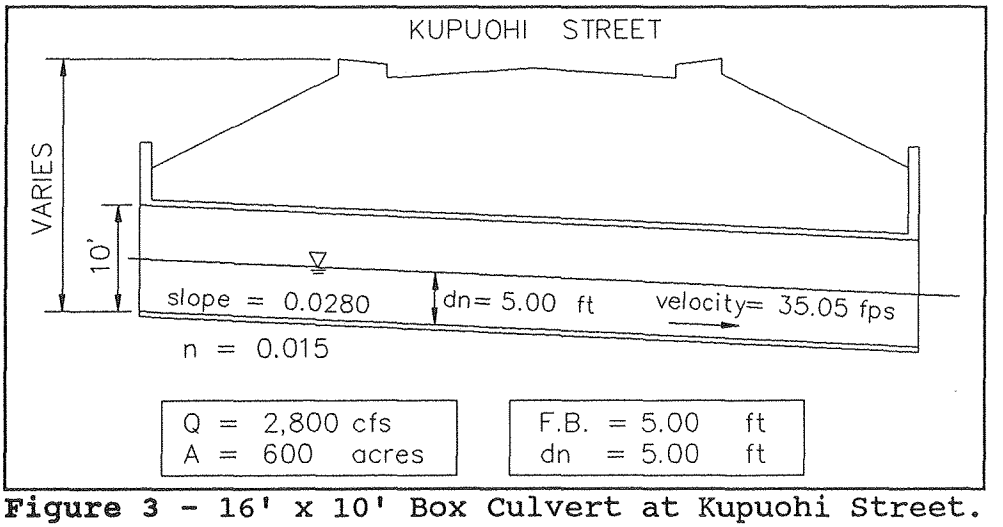


Figure 3 - 16' x 10' Box Culvert at Kupuohi Street.

5.1.1.3 20' x 10' Box Culvert at Road "D". (Node B1)

For:

Q= 2,600 cfs n= 0.015 slope= .0250 ft/ft
A= 538 acres

Computed:

normal: depth= 4.08 ft velocity= 31.85 fps
critical: depth= 8.07 ft velocity= 16.12 fps slope=.0036
capacity: depth=10.00 ft velocity= 45.80 fps Q= 9160 cfs

Freeboard= 5.00 ft

Therefore, stormwater from the golf course shall be channelized into the inlet structure to attain normal depth at the entrance.

Velocity breakers will be provided at the outlet in the final design.

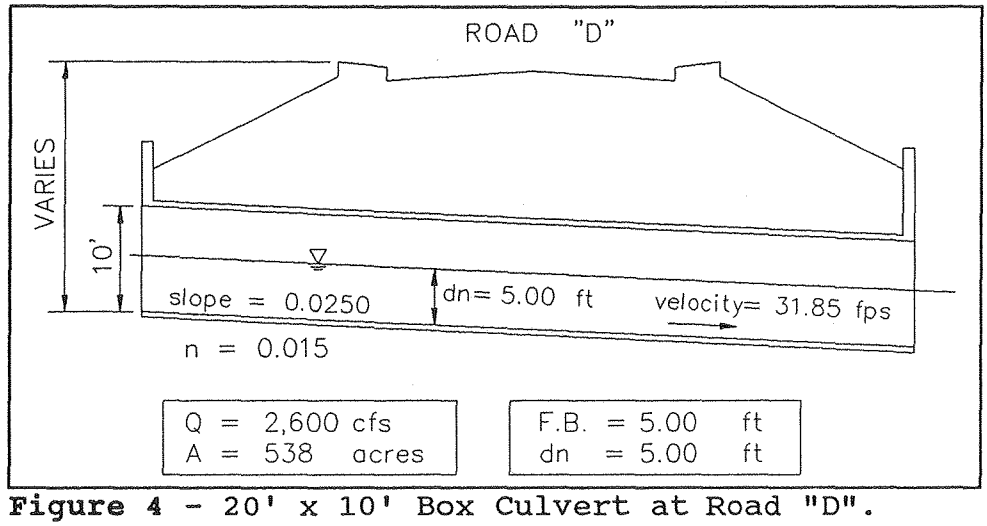


Figure 4 - 20' x 10' Box Culvert at Road "D".

5.1.1.4 14' x 12' Rectangular Channel at Site 13 (Between Nodes C1 and D1)

For:

Q= 2,500 cfs n= 0.015 slope= .0180 ft/ft
A= 517 acres

Computed:

normal: depth= 6.11 ft velocity= 29.23 fps
critical: depth= 9.97 ft velocity= 17.98 fps slope=.0050
capacity: depth=12.00 ft velocity= 35.80 fps Q= 6015 cfs

Freeboard= 5.00 ft

Velocity breakers will be provided at the channel outlet in the final design.

5.1.1.5 Temporary 14' x 12' Inlet Structure at Site 13 near Phase I border. (Node D1)

For:

Q= 2,400 cfs n= 0.015 slope= .0180 ft/ft
A= 477 acres

Computed:

normal: depth= 5.93 ft velocity= 28.92 fps
critical: depth= 9.70 ft velocity= 17.67 fps slope=.0049
capacity: depth=12.00 ft velocity= 35.80 fps Q=6,015 cfs

Freeboard= 5.00 ft

Therefore, stormwater from the golf course shall be channelized into the inlet structure to attain normal depth at the entrance.

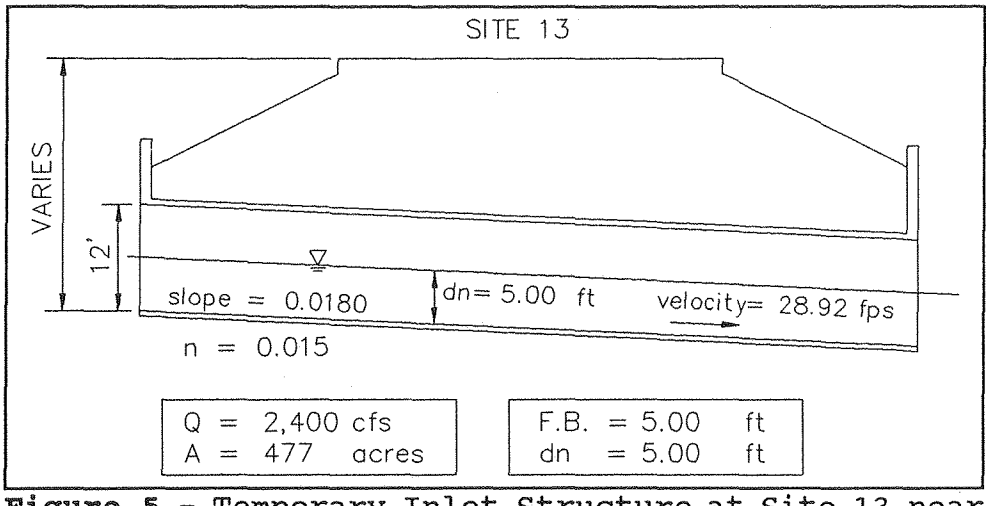


Figure 5 - Temporary Inlet Structure at Site 13 near Phase I border.

5.1.1.6 Temporary Interceptor Ditch at Phase I and II Border. (Node D1)

For:

Q= 250 cfs n= 0.035 slope= .0100 ft/ft
A= 60 acres B= 10 ft z1= 2:1
z2= 4:1

Computed:

normal: depth= 2.43 ft velocity= 5.94 fps
critical: depth= 2.15 ft velocity= 7.07 fps slope=.0161
flow top width = 24.61 Froude No= 0.80 (Subcritical)

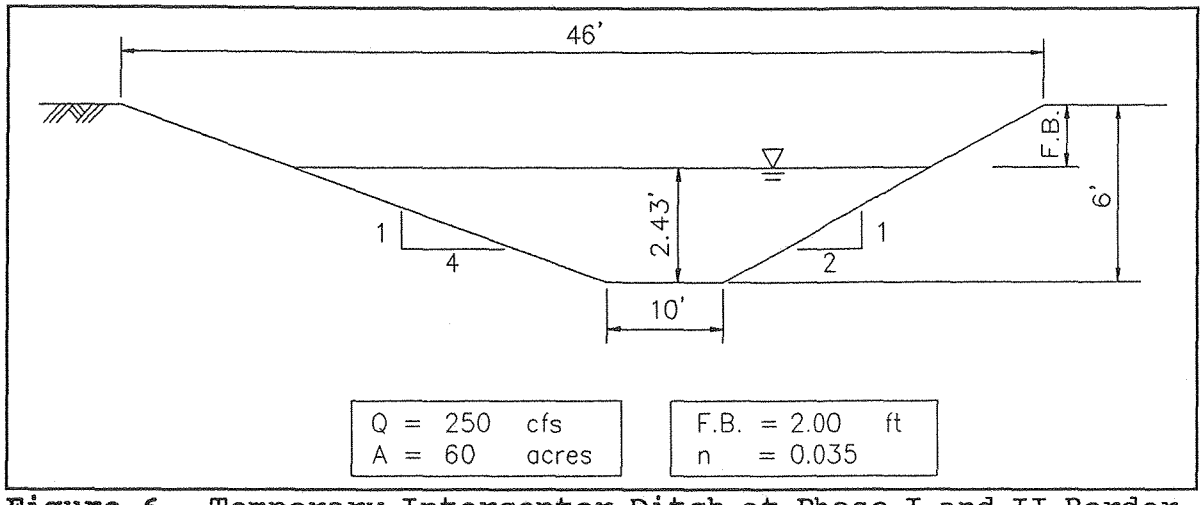


Figure 6 - Temporary Interceptor Ditch at Phase I and II Border.

5.1.2 Phase II

5.1.2.1 12' x 12' Rectangular Channel. (Between Nodes D1 and E1)

For:

Q= 2,400 cfs n= 0.015 slope= .0175 ft/ft
A= 477 acres

Computed:

normal: depth= 6.99 ft velocity= 28.62 fps
critical: depth=10.75 ft velocity= 18.60 fps slope=.0058
capacity: depth=12.00 ft velocity= 33.02 fps Q=4,755 cfs

Freeboard= 5.00 ft

Neglect entrance control and assume that the flow is channelized into the box.

** Alternate Trapezoidal Channel [8' bottom by 10' depth]. (Between nodes D1 and E1)

For:

Q= 2,400 cfs n= 0.015 slope= .0125 ft/ft
A= 477 acres B= 8 ft z1= 1:1
z2= 1:1

Computed:

normal: depth= 6.45 ft velocity= 25.77 fps
critical: depth= 9.62 ft velocity= 14.12 fps slope=.0025
flow top width =20.89 ft Froude No= 2.15 (Supercritical)
Freeboard = 3.20 ft

Neglect entrance control and assume that the flow is channelized into the box.

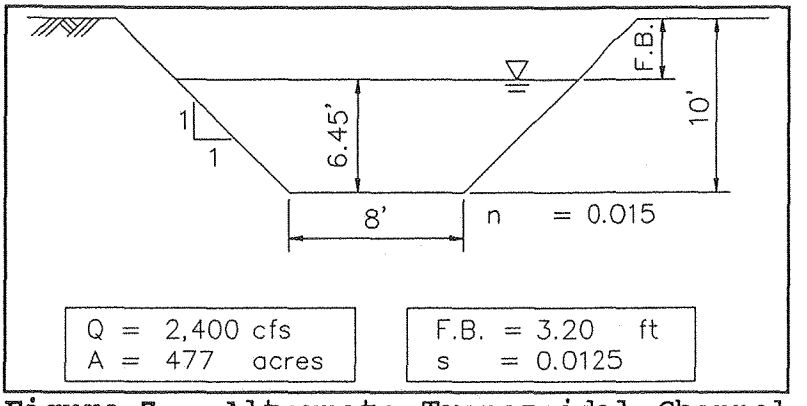


Figure 7 - Alternate Trapezoidal Channel (8' Bottom by 10' Depth)

5.1.2.2 12' x 12' Box Culvert through typical roadway (Node E1)

For:

Q= 2,150 cfs n= 0.015 slope= .0170 ft/ft
A= 400 acres

Computed:

normal: depth= 6.50 ft velocity= 27.58 fps
critical: depth= 9.99 ft velocity= 17.93 fps slope=.0056
capacity: depth=12.00 ft velocity= 32.55 fps Q=4,687 cfs

Freeboard= 5.00 ft

Assume the flow is channelized from either a 12' x 12' rectangular channel, or an alternate 8' x 10' trapezoidal channel into the box.

** Alternate Trapezoidal Channel [8' bottom by 10' depth]. (Between Nodes E1 and F1)

For:

Q= 2,150 cfs n= 0.015 slope= .0100 ft/ft
A= 400 acres B= 8 ft z1= 1:1
z2= 1:1

Computed:

normal: depth= 6.45 ft velocity= 23.06 fps
critical: depth= 9.10 ft velocity= 13.72 fps slope=.0025
flow top width =20.90 ft Froude No= 1.92 (Supercritical)
Freeboard = 3.07 ft

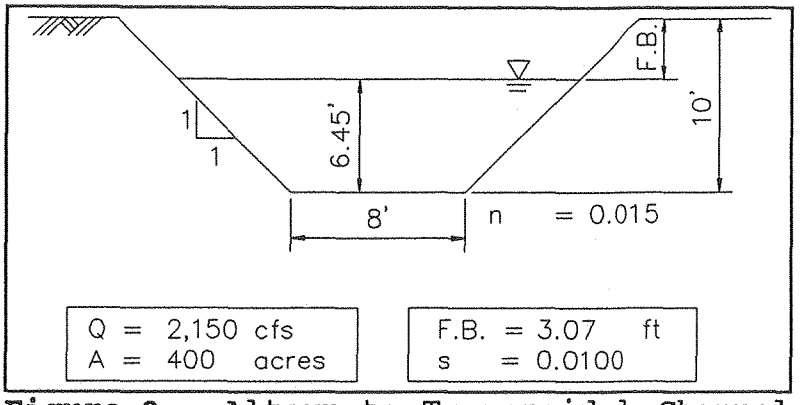


Figure 8 - Alternate Trapezoidal Channel (8' Bottom by 10' Depth).

5.1.2.3 12' x 10' Box Culvert at Road "D". (Node F1)

For:

Q= 1,500 cfs n= 0.015 slope= .0190 ft/ft
A= 250 acres

Computed:

normal: depth= 4.77 ft velocity= 26.20 fps
critical: depth= 7.86 ft velocity= 15.85 fps slope=.0050
capacity: depth=10.00 ft velocity= 32.96 fps Q= 3955 cfs

Freeboard= 5.00 ft

Therefore, neglect entrance control and assume that the flow is channelized into the box to attain normal depth at entrance.

5.1.2.4 12' x 10' Rectangular Channel. (Between Nodes F1 and G1)

For:

Q= 1,500 cfs n= 0.015 slope= .0190 ft/ft
A= 250 acres

Computed:

normal: depth= 4.77 ft velocity= 26.20 fps
critical: depth= 7.86 ft velocity= 15.85 fps slope=.0050
capacity: depth=10.00 ft velocity= 32.96 fps Q= 3955 cfs

Freeboard= 5.00 ft

Therefore, neglect entrance control and assume that the flow is channelized into the box to attain normal depth at entrance.

** Alternate Trapezoidal Channel [8' bottom by 8' depth]. (Between nodes F1 and G1)

For:

Q= 1,500 cfs	n= 0.015	slope= .0130 ft/ft
A= 250 acres	B= 8 ft	z1= 1:1
		z2= 1:1

Computed:

normal: depth= 4.99 ft velocity= 23.14 fps
critical: depth= 7.54 ft velocity= 12.72 fps slope=.0026
flow top width =17.98 ft Froude No= 2.15 (Supercritical)

Freeboard = 2.99 ft

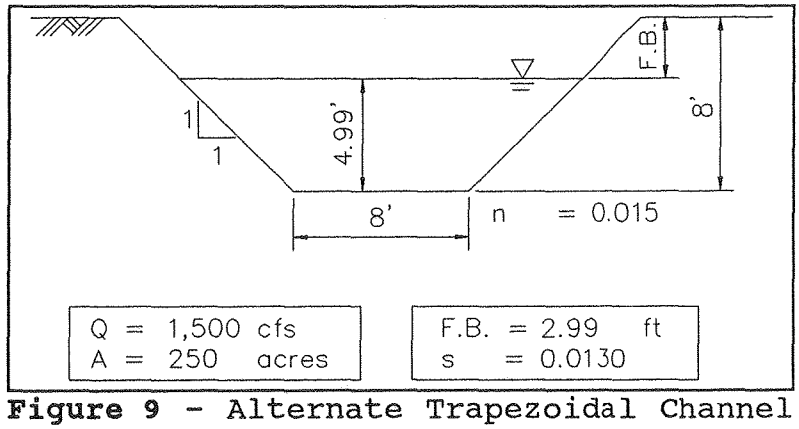


Figure 9 - Alternate Trapezoidal Channel (8' Bottom by 8' Depth).

5.2 STRUCTURES IN DRAINAGE AREA 2

5.2.1 Phase I

5.2.1.1 14' x 10' Box Culvert at Road "D" in Golf Course I. (Node A2)

For:

Q= 1,200 cfs	n= 0.015	slope= .0070 ft/ft
A= 170 acres		

Computed:

normal: depth= 5.05 ft velocity= 16.98 fps
critical: depth= 6.11 ft velocity= 13.95 fps slope=.0041
capacity: depth=10.00 ft velocity= 21.29 fps Q= 2981 cfs

Freeboard= 5.00 ft Entrance Control= 9.60 ft

Therefore, neglect entrance control and assume that the flow is channelized into the box to attain normal depth at entrance.

A transition shall be provided to channelize the 14' x 10' box into the 14' x 8' box at Site 8.

5.2.1.2 72" Pipe Culvert in Road "D" along Site 8. (From Node B2)

For:

Q= 200 cfs n= 0.015 slope= 0.0050 ft/ft
A= 50 acres

Computed:

normal:	depth= 3.95 ft	velocity= 10.13 fps	
maximum :	depth= 5.64 ft	velocity= 10.12 fps	Q= 279 cfs
capacity:	depth= 6.00 ft	velocity= 9.18 fps	Q= 260 cfs

Freeboard= 2.40 ft Entrance Control= 5.58 ft

5.2.1.3 48" Pipe Culvert in Road "D" from Road "R". (Node C2)

For:

Q= 120 cfs n= 0.015 slope= 0.0350 ft/ft
A= 30 acres

Computed:

normal:	depth= 2.04 ft	velocity= 18.67 fps	
maximum :	depth= 3.76 ft	velocity= 20.44 fps	Q= 251 cfs
capacity:	depth= 4.00 ft	velocity= 18.53 fps	Q= 233 cfs

Freeboard= 2.59 ft Entrance Control= 5.60 ft

5.2.1.4 90" Pipe Culvert from Site 12 discharging into Golf Course I. (Node D2)

For:

Q= 625 cfs n= 0.015 slope= 0.0100 ft/ft
A= 91 acres

Computed:

normal:	depth= 5.77 ft	velocity= 17.13 fps	
maximum :	depth= 7.05 ft	velocity= 16.61 fps	Q= 716 cfs
capacity:	depth= 7.50 ft	velocity= 15.06 fps	Q= 665 cfs

Freeboard= 2.77 ft Entrance Control= 10.88 ft

** Alternate 8' x 8' Box Culvert from Site 12 discharging into Golf Course I

For:

Q=	625 cfs	n= 0.015	slope= .0250 ft/ft
A=	91 acres		

Computed:

normal:	depth= 3.34 ft	velocity= 23.36 fps	
critical:	depth= 5.74 ft	velocity= 13.61 fps	slope=.0060
capacity:	depth= 8.00 ft	velocity= 30.12 fps	Q=1,927 cfs

Freeboard= 5.00 ft

Therefore, neglect entrance control and assume that the flow is channelized into the box to attain normal depth at entrance.

Velocity breakers will be provided for each of the channel outlets in the final design.

5.2.2 Phase II

5.2.2.1 60" Pipe Culvert from Phase II into Site 12. (Node E2)

For:

Q=	190 cfs	n= 0.015	slope= 0.0100 ft/ft
A=	45 acres		

Computed:

normal:	depth= 3.51 ft	velocity= 12.88 fps	
maximum :	depth= 4.70 ft	velocity= 12.68 fps	Q= 243 cfs
capacity:	depth= 5.00 ft	velocity= 11.50 fps	Q= 226 cfs

Freeboard= 2.49 ft Entrance Control= 6.25 ft

** Alternate 6' x 6' Box Culvert from Site 12 discharging into Site 12.

For:

Q=	190 cfs	n= 0.015	slope= 0.0100 ft/ft
A=	45 acres		

Computed:

normal:	depth= 2.57 ft	velocity= 12.31 fps	
critical:	depth= 3.15 ft	velocity= 10.05 fps	slope=.0058
capacity:	depth= 6.00 ft	velocity= 15.73 fps	Q= 566 cfs

Freeboard= 2.42 ft Entrance Control= 4.75 ft

Therefore, invert of the box should be about 8 feet below the finished road grade.

5.3 STRUCTURES IN DRAINAGE AREA 3

5.3.1 Phase I

5.3.1.1 Detention Basin in Golf Course II (Node A3)

A detention basin will be constructed within the Golf Course II area. It will be sized to serve approximately 475 acres based on a 100 year storm of 24 hour duration. Detailed calculations will accompany the drainage report for Golf Course II.

5.3.1.2 42" Outlet from Site 10 into Golf Course II. (Node B3)

For:

Q= 60 cfs n= 0.015 slope= 0.0100 ft/ft
A= 15 acres

Computed:

normal:	depth= 2.13 ft	velocity= 9.77 fps	
maximum :	depth= 3.29 ft	velocity= 9.99 fps	Q= 94 cfs
capacity:	depth= 3.50 ft	velocity= 9.06 fps	Q= 87 cfs

Freeboard= 2.31 ft Entrance Control= 3.68 ft

Velocity breakers will be provided at the channel outlet in the final design.

5.3.1.3 10' x 10' Box Culvert at Road "D" near Site 9. (Node C3)

For:

Q= 825 cfs n= 0.015 slope= .0150 ft/ft
A= 120 acres

Computed:

normal:	depth= 3.99 ft	velocity= 20.65 fps	
critical:	depth= 5.96 ft	velocity= 13.92 fps	slope=.0052
capacity:	depth=10.00 ft	velocity= 27.07 fps	Q=2,707 cfs

Freeboard= 5.00 ft

Therefore, neglect entrance control and assume that the flow is channelized into the box to attain normal depth at entrance.

Velocity breakers will be provided at the channel outlet in the final design.

5.3.1.4 8' x 8' Box Culvert at Road "R" near Private Park Site 11. (Node D3)

For:

Q= 480 cfs n= 0.015 slope= .0200 ft/ft
A= 70 acres

Computed:

normal: depth= 3.00 ft velocity= 20.07 fps
critical: depth= 4.82 ft velocity= 12.49 fps slope=.0056
capacity: depth= 8.00 ft velocity= 26.94 fps Q=1,724 cfs

Freeboard= 5.00 ft

Therefore, neglect entrance control and assume that the flow is channelized into the box to attain normal depth at entrance.

Velocity breakers will be provided at the outlet in the final design.

5.3.1.5 Temporary Interceptor Ditch at Phase I and II Boundary. (Node E3)

For:

Q= 250 cfs n= 0.035 slope= .0100 ft/ft
A= 60 acres B= 10 ft z1= 2:1
z2= 4:1

Computed:

normal: depth= 2.43 ft velocity= 5.94 fps
critical: depth= 2.15 ft velocity= 7.07 fps slope=.0161
flow top width = 24.61 Froude No= 0.80 (Subcritical)

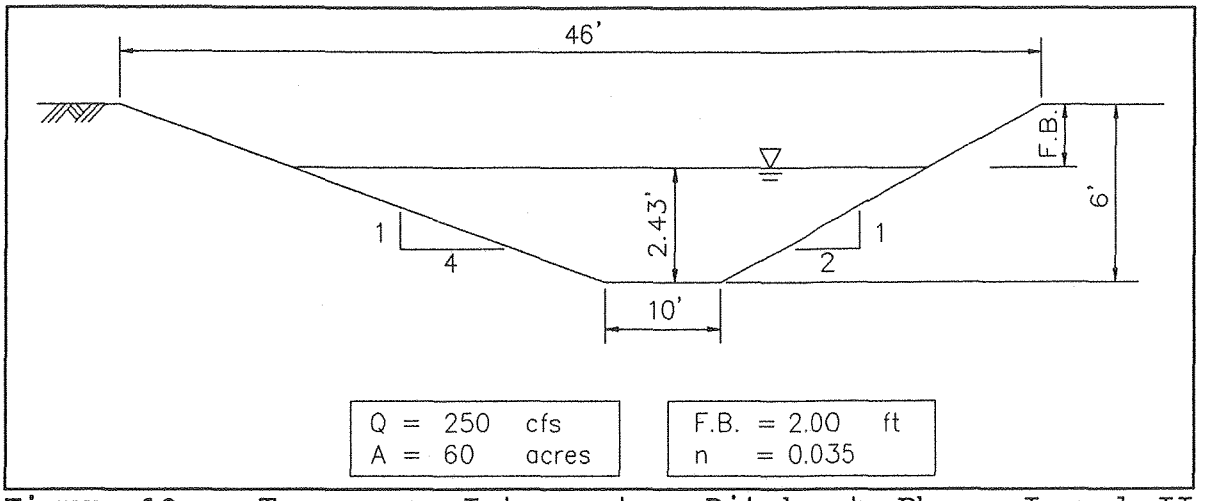


Figure 10 - Temporary Interceptor Ditch at Phase I and II Boundary.

5.3.2 Phase II

5.3.2.1 54" Outlet from Phase II into Golf Course II. (Node F3)

For:

Q= 120 cfs n= 0.015 slope= 0.0100 ft/ft
A= 30 acres

Computed:

normal: depth= 2.79 ft velocity= 11.61 fps
maximum : depth= 4.23 ft velocity= 11.82 fps Q= 183 cfs
capacity: depth= 4.50 ft velocity= 10.72 fps Q= 170 cfs

Freeboard= 2.41 ft Entrance Control= 5.04 ft

5.3.2.2 Detention Basin in Golf Course III. (Node G3)

A second detention basin may be required within the Golf Course III area to reduce the size of the detention basin in Golf Course II. The size of the basin shall be determined with the drainage report for Golf Course II.

6 INVESTIGATION OF EXISTING OUTLET STRUCTURES

Since the drainage area for Drainage Area 1 has increased from the original design, an investigation of the adequacy of the existing drainage structures needs to be conducted. The runoff from Drainage Area 1 discharges into an existing 162" MPCM culvert at the northern part of Kupuna Loop. At the southern part of Kupuna Loop, an existing triple-barrel 168" MPCM culvert intercepts the runoff from the existing Village Park Subdivision and Drainage Areas 1 and 2. The check for adequacy for the 162" MPCM and the triple-barrel 168" MPCM culverts follow.

6.1 162" Pipe Culvert from Phase I into Village Park.

From Exhibit 3 of the Revised Drainage Master Plan for Village Park Subdivision, by Park Engineering, dated November 1978, the design data for the 162" culvert is as follows:

A = 426 Acres
Q = 1,900 cfs

For:
Q= 3,000 cfs n= 0.024 slope= 0.0450 ft/ft
A= 645 acres

Computed:

normal:	depth= 8.40 ft	velocity= 32.06 fps	
maximum :	depth=12.69 ft	velocity= 32.59 fps	Q= 4550 cfs
capacity:	depth=13.50 ft	velocity= 29.55 fps	Q= 4230 cfs

Freeboard= 3.63 ft Entrance Control= 21.33 ft

Flow from the proposed 14' x 10' box will be channelized into the existing 162" culvert and entrance control can be neglected.

Therefore, based on the criteria from the Storm Drainage Standards, Department of Public Works, dated May 1988, the existing 162" MPCM culvert is adequate to convey the stormwater runoff after Royal Kunia Phases 1 and 2 are fully developed.

6.2 3-168" Pipe Culverts at Kupuna Loop in Village Park

From the "Drainage Map, Kunia to Waikele, Project No. I-H1-1(32):5, Unit 1" by the Department of Transportation, State of Hawaii, dated September 1966, the design data for the triple-barrel 168" culvert is as follows:

A = 1,497 Acres
Q = 3,580 cfs

For:
Qtot= 6,300 cfs n= 0.024 slope = 0.0415 ft/ft
Atot= 1,759 acres

Therefore, for one culvert:

Q= 2,100 cfs n= 0.024 slope = 0.0415 ft/ft
A= 586 acres

Computed:

normal: depth= 6.74 ft velocity= 28.61 fps
maximum : depth=13.16 ft velocity= 32.06 fps Q= 4815 cfs
capacity: depth=14.00 ft velocity= 29.08 fps Q= 4476 cfs

Freeboard= 3.35 ft Entrance Control= 15.60 ft

Therefore, based on the criteria from the Storm Drainage Standards, Department of Public Works, dated May 1988, the existing triple-barrel 168" MPCM culvert is adequate to convey the stormwater runoff after Royal Kunia Phases 1 and 2 are fully developed.

A P P E N D I X A

References

City and County of Honolulu, Department of Public Works, Storm Drainage Standards, May 1988.

PARK ENGINEERING, Nov. 1978, "Village Park Drainage Master Plan".

ParEn, Inc., Feb. 1988, "Royal Kunia Subdivision, Off-Site Drainage Master Plan".

State of Hawaii, Department of Transportation, "Drainage Map, Kunia to Waikele, Project No. I-H1-1(32):5, Unit 1," September 1966.

TRUE NORTH
SCALE: 1 in. = 800 Ft.

PROPOSED 12' x 10'
BOX CULVERT
A = 165 AC
Q = 1,150 CFS

PROPOSED 12' x 10'
RECT. CHANNEL
OR ALT. TRAPEZOIDAL
CHANNEL

A = 234 AC
Q = 1,400 CFS

Q = 110 CFS

B5

B6

DRAINAGE
AREA 6

A = 45 AC
Q = 170 CFS

A6

G1

DRAINAGE
AREA 5

A5

A = 290 AC
Q = 1,650 CFS

PHASE II
S.F.D.
70.2 AC
372 UNITS

PHASE II
INDUSTRIAL
43.0 AC

PHASE II
L.D.A.
16.0 AC
280 UNITS

S.F.D. 6,000 SF LOTS 13.9 AC

GOLF
COURSE III
171.7 AC

ROAD "D"

F1

PHASE II
PARK SITE
16.0 AC

S.F.D. 6,000
SF LOTS 4.5 AC

PROPOSED 12' x 10'
BOX CULVERT
A = 200 AC
Q = 1,500 CFS

PHASE II
SCHOOL
6.0 AC

PHASE II
S.F.D.
16.0 AC
85 UNITS

PHASE II
INDUSTRIAL
87.0 AC

PROPOSED 12' x 12'
RECT. CHANNEL
OR ALT. TRAPEZOIDAL
CHANNEL
A = 340 AC
Q = 1,900 CFS

PROPOSED
DETENTION BASIN
A = 180 AC
Q = 1,250 CFS

G3

S.F.D. 6,000 SF LOTS 8.0 AC

PHASE 2
PHASE 1

PROPOSED 12' x 12'
RECT. CHANNEL
OR ALT. TRAPEZOIDAL
CHANNEL
A = 340 AC
Q = 1,900 CFS

PHASE II
L.D.A.
36.0 AC
620 UNITS

GOLF
COURSE II
16.0 AC

WAIKELE STREAM

PROPOSED 8' x 8'
BOX CULVERT
A = 65 AC
Q = 470 CFS

PROPOSED 12' x 12'
BOX CULVERT
A = 400 AC
Q = 2,150 CFS

PROPOSED 54"
PIPE CULVERT
A = 35 AC
Q = 140 CFS

F3

PROPOSED 48"
PIPE CULVERT
A = 30 AC
Q = 120 CFS

E1

E2

E3

PHASE II
S.F.D.
160.2 AC
851 UNITS

TEMP. INTERCEPTOR
DITCH and SILT BASIN
A = 60 AC
Q = 250 CFS

SITE 11
PRIVATE
PARK
12.1 AC

PROPOSED 12' x 12'
RECT. CHANNEL
OR ALT. TRAPEZOIDAL
CHANNEL
A = 477 AC
Q = 2,400 CFS

DRAINAGE
AREA 3

PROPOSED
8' x 8'
BOX CULVERT
A = 70 AC
Q = 480 CFS

ROAD "F"

TEMP. INTERCEPTOR
DITCH and SILT BASIN
A = 60 AC
Q = 250 CFS

D3

PHASE 2
PHASE 1

D1

SITE 10
S.F.D.
14.8 AC
86 UNITS

B3

PROPOSED 36"
PIPE CULVERT
A = 15 AC
Q = 60 CFS

SITE 12
S.F.D.
55.8 AC
266 UNITS

PROPOSED 14' x 12'
RECT. CHANNEL and
TEMP. INLET STRUCT.
A = 477 AC
Q = 2,400 CFS

SITE 13
S.F.D.
27.7 AC
220 UNITS

DRAINAGE
AREA 2

PROPOSED 10' x 10'
BOX CULVERT
A = 120 AC
Q = 825 CFS

C3

GOLF
COURSE II
144.3 AC

PROPOSED 14' x 12'
RECT. CHANNEL
A = 517 AC
Q = 2,500 CFS

C1

D2

GOLF
COURSE I
18.6 AC

SITE 7
S.F.D.
16.0 AC
90 UNITS

PROPOSED 90"
PIPE CULVERT
A = 91 AC
Q = 625 CFS

GOLF
COURSE I
133.2 AC

PROPOSED
OAHU SUGAR
RESERVOIR
SITE

SITE 9
S.F.D.
9.8 AC
55 UNITS

PROPOSED
DETENTION BASIN
A = 450 AC
Q = 2,450 CFS

SITE 6
S.F.D.
8.9 AC
48 UNITS

PROPOSED 20' x 10'
BOX CULVERT
A = 538 AC
Q = 2,600 CFS

PROPOSED 48"
PIPE CULVERT
A = 30 AC
Q = 120 CFS

PROPOSED 72"
PIPE CULVERT
A = 50 AC
Q = 200 CFS

A3

PROPOSED 14' x 10'
BOX CULVERT
A = 170 AC
Q = 1,200 CFS

B1

C2

B2

A2

SITE 8
S.F.D.
32.6 AC
227 UNITS

GOLF
COURSE I
20.1 AC

SITE 5
S.F.D.
24.7 AC
142 UNITS

ROAD "D"

DRAINAGE
AREA 1

DRAINAGE
AREA 4

PROPOSED 14' x 8'
BOX CULVERT
A = 255 AC
Q = 2,550 CFS

EXISTING ROYAL KUNIA SUBDIVISION

PROPOSED 16' x 10'
BOX CULVERT
A = 600 AC
Q = 2,800 CFS

EXISTING 144"
MPCM CULVERT
A = 295.5 AC
Q = 2,700 CFS

SITE 4
L.D.A.
17.3 AC
277 UNITS

SITE 3
HALEKUA
GARDENS II
L.D.A
19.8 AC
316 UNITS

A1

A4

KUNIA ROAD

KUALOKA STREET

EXISTING 48"
PIPE CULVERT
A = 40 AC
Q = 110 CFS

INDUSTRIAL
15.7 AC

SITE 1
HALEKUA
GARDENS I
L.D.A.
9.4 AC

SITE 2
PUBLIC
PARK
10.3 AC

EXISTING VILLAGE PARK

PARK & RIDE
5.7 AC

EXISTING 162"
MPCM CULVERT
A_{des} = 426 AC
Q_{des} = 1,900 CFS
Q_{1985} = 2,250 CFS

A_{tot} = 645 AC
Q_{tot} = 3,000 CFS

DATE: FEBRUARY, 1991 JTS

LEGEND:

S.F.D. SINGLE FAMILY DWELLING
L.D.A. LOW-DENSITY APARTMENT
DRAINAGE AREA 1
DRAINAGE AREA 2
DRAINAGE AREA 3
DRAINAGE AREA 4
DRAINAGE AREA 5
DRAINAGE AREA 6

EXISTING 3-168"
MPCM CULVERTS
A_{des} = 1,497 AC
Q_{des} = 3,580 CFS

A_{tot-3} = 1,759 AC
Q_{tot-3} = 6,300 CFS
A_{tot-1} = 586.3 AC
Q_{tot-1} = 2,100 CFS

INTERSTATE H-1

EXHIBIT 1
ROYAL KUNIA DRAINAGE MASTER PLAN
PHASES I and II

EXHIBIT 5

TRUE NORTH

SCALE: 1 In. = 800 Ft.

DRAINAGE AREA 1

DRAINAGE AREA 2

DRAINAGE AREA 3

DRAINAGE AREA 4

DRAINAGE AREA 5

DRAINAGE AREA 6

DATE: FEBRUARY, 1991 JTS

LEGEND:

S.F.D.	SINGLE FAMILY DWELLING
L.D.A.	LOW-DENSITY APARTMENT
	DRAINAGE AREA 1
	DRAINAGE AREA 2
	DRAINAGE AREA 3
	DRAINAGE AREA 4
	DRAINAGE AREA 5
	DRAINAGE AREA 6

EXHIBIT 2
ROYAL KUNIA DRAINAGE MASTER PLAN
PHASES I and II

EXHIBIT 5

APPENDIX B

Hydrologic Computations
Royal Kunia Phase II Development
2-year 24-hour Stormwater Runoff Rates

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 09-11-1995 13:27:49
Watershed file: --> c:\rkii\PRE-DEV .WSD
Hydrograph file: --> c:\rkii\PRE-DEV .HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR 24-HOUR STORMWATER RUNOFF RATE - EXISTING CONDITIONS

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
ONSITE	655.00	61.0	1.00	0.00	4.50	1.08	.28	.30

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 655.00 acres or 1.0234 sq.mi
Peak discharge = 141 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
ONSITE	1.00	0.00	**	**	No	--

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

$$q = \frac{Q}{A} = \frac{141 \text{ cfs}}{655 \text{ acs.}} = 0.215 \frac{\text{cfs}}{\text{ac.}}$$

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 09-11-1995 13:27:49
Watershed file: --> c:\rkii\PRE-DEV .WSD
Hydrograph file: --> c:\rkii\PRE-DEV .HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR 24-HOUR STORMWATER RUNOFF RATE - EXISTING CONDITIONS

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
ONSITE	141	11.0
Composite Watershed	141	11.0

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 09-11-1995 13:27:49
Watershed file: --> c:\rkii\PRE-DEV .WSD
Hydrograph file: --> c:\rkii\PRE-DEV .HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR 24-HOUR STORMWATER RUNOFF RATE - EXISTING CONDITIONS

Composite Hydrograph Summary (cfs)

Subarea Description	9.0 hr	9.3 hr	9.6 hr	9.9 hr	10.0 hr	10.1 hr	10.2 hr	10.3 hr	10.4 hr
ONSITE	0	0	0	0	1	2	8	19	38
Total (cfs)	0	0	0	0	1	2	8	19	38

Subarea Description	10.5 hr	10.6 hr	10.7 hr	10.8 hr	11.0 hr	11.2 hr	11.4 hr	11.6 hr	11.8 hr
ONSITE	61	87	109	126	141	126	111	98	88
Total (cfs)	61	87	109	126	141	126	111	98	88

Subarea Description	12.0 hr	12.3 hr	12.6 hr	13.0 hr	13.5 hr	14.0 hr	14.5 hr	15.0 hr	15.5 hr
ONSITE	82	75	70	65	60	56	51	48	45
Total (cfs)	82	75	70	65	60	56	51	48	45

Subarea Description	16.0 hr	17.0 hr	18.0 hr	20.0 hr	24.0 hr
ONSITE	44	43	41	36	25
Total (cfs)	44	43	41	36	25

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 09-11-1995 13:27:49
Watershed file: --> c:\rkii\PRE-DEV .WSD
Hydrograph file: --> c:\rkii\PRE-DEV .HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR 24-HOUR STORMWATER RUNOFF RATE - EXISTING CONDITIONS

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
9.0	0	12.8	68
9.1	0	12.9	66
9.2	0	13.0	65
9.3	0	13.1	64
9.4	0	13.2	63
9.5	0	13.3	62
9.6	0	13.4	61
9.7	0	13.5	60
9.8	0	13.6	59
9.9	0	13.7	58
10.0	1	13.8	58
10.1	2	13.9	57
10.2	8	14.0	56
10.3	19	14.1	55
10.4	38	14.2	54
10.5	61	14.3	53
10.6	87	14.4	52
10.7	109	14.5	51
10.8	126	14.6	50
10.9	134	14.7	50
11.0	141	14.8	49
11.1	134	14.9	49
11.2	126	15.0	48
11.3	118	15.1	47
11.4	111	15.2	47
11.5	105	15.3	46
11.6	98	15.4	46
11.7	93	15.5	45
11.8	88	15.6	45
11.9	85	15.7	45
12.0	82	15.8	44
12.1	80	15.9	44
12.2	77	16.0	44
12.3	75	16.1	44
12.4	73	16.2	44
12.5	72	16.3	44
12.6	70	16.4	44
12.7	69	16.5	44

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 09-11-1995 13:27:49
Watershed file: --> c:\rkii\PRE-DEV .WSD
Hydrograph file: --> c:\rkii\PRE-DEV .HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR 24-HOUR STORMWATER RUNOFF RATE - EXISTING CONDITIONS

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
16.6	43	20.4	35
16.7	43	20.5	35
16.8	43	20.6	34
16.9	43	20.7	34
17.0	43	20.8	34
17.1	43	20.9	34
17.2	43	21.0	33
17.3	42	21.1	33
17.4	42	21.2	33
17.5	42	21.3	32
17.6	42	21.4	32
17.7	42	21.5	32
17.8	41	21.6	32
17.9	41	21.7	31
18.0	41	21.8	31
18.1	41	21.9	31
18.2	41	22.0	31
18.3	40	22.1	30
18.4	40	22.2	30
18.5	40	22.3	30
18.6	40	22.4	29
18.7	39	22.5	29
18.8	39	22.6	29
18.9	39	22.7	29
19.0	39	22.8	28
19.1	38	22.9	28
19.2	38	23.0	28
19.3	38	23.1	27
19.4	38	23.2	27
19.5	37	23.3	27
19.6	37	23.4	27
19.7	37	23.5	26
19.8	37	23.6	26
19.9	36	23.7	26
20.0	36	23.8	26
20.1	36	23.9	25
20.2	35		
20.3	35		

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 08:34:42
Watershed file: --> c:\rkii\POST-DEV.WSD
Hydrograph file: --> c:\rkii\POST-DEV.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
AGRICULTURE	151.10	65.0	1.00	0.00	4.50	1.33	.24	.30
LT. INDUSTRIAL	123.70	88.0	0.75	0.00	4.50	3.20	.06	.10
LDA	50.00	85.0	0.50	0.00	4.50	2.91	.08	.10
PARK & SCHOOL	18.00	65.0	0.50	0.00	4.50	1.33	.24	.30
SFD	39.20	85.0	0.50	0.00	4.50	2.91	.08	.10
LDA	17.10	85.0	0.75	0.00	4.50	2.91	.08	.10
SFD	210.10	85.0	0.75	0.00	4.50	2.91	.08	.10
PARKS, OPEN	36.00	65.0	1.00	0.00	4.50	1.33	.24	.30
ROADS	9.80	95.0	0.50	0.00	4.50	3.92	.02	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 655.00 acres or 1.0234 sq.mi
Peak discharge = 523 cfs

WARNING: Drainage areas of two or more subareas differ by a factor of 5 or greater.

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
AGRICULTURE	1.00	0.00	**	**	No	--
LT. INDUSTRIAL	0.75	0.00	**	**	No	Computed Ia/p < .1
LDA	0.50	0.00	**	**	No	Computed Ia/p < .1
PARK & SCHOOL	0.50	0.00	**	**	No	--
SFD	0.50	0.00	**	**	No	Computed Ia/p < .1
LDA	0.75	0.00	**	**	No	Computed Ia/p < .1
SFD	0.75	0.00	**	**	No	Computed Ia/p < .1
PARKS, OPEN	1.00	0.00	**	**	No	--
ROADS	0.50	0.00	**	**	No	Computed Ia/p < .1

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 08:34:42
Watershed file: --> c:\rkii\POST-DEV.WSD
Hydrograph file: --> c:\rkii\POST-DEV.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
AGRICULTURE	40	11.0
LT. INDUSTRIAL	144	10.7
LDA	64	10.4
PARK & SCHOOL	7	10.5
SFD	50	10.4
LDA	18	10.6
SFD	223	10.7
PARKS, OPEN	10	11.0
ROADS	17	10.4
Composite Watershed	523	10.6

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 08:34:42
Watershed file: --> c:\rkii\POST-DEV.WSD
Hydrograph file: --> c:\rkii\POST-DEV.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

Composite Hydrograph Summary (cfs)

Subarea Description	9.0 hr	9.3 hr	9.6 hr	9.9 hr	10.0 hr	10.1 hr	10.2 hr	10.3 hr	10.4 hr
AGRICULTURE	0	0	0	0	0	1	2	5	11
LT. INDUSTRIAL	10	14	19	25	29	36	51	74	103
LDA	5	6	9	13	17	25	40	56	64
PARK & SCHOOL	0	0	0	0	0	1	2	5	6
SFD	4	5	7	10	13	20	31	44	50
LDA	1	2	2	3	4	5	6	9	13
SFD	15	21	29	39	45	56	78	114	160
PARKS, OPEN	0	0	0	0	0	0	1	1	3
ROADS	1	2	2	3	4	7	11	15	17
Total (cfs)	36	50	68	93	112	151	222	323	427

Subarea Description	10.5 hr	10.6 hr	10.7 hr	10.8 hr	11.0 hr	11.2 hr	11.4 hr	11.6 hr	11.8 hr
AGRICULTURE	17	25	31	36	40	36	31	28	25
LT. INDUSTRIAL	129	142	144	131	100	75	60	49	43
LDA	62	52	42	35	25	19	16	14	13
PARK & SCHOOL	7	6	5	5	4	3	3	3	2
SFD	48	41	33	27	19	15	13	11	10
LDA	16	18	18	16	13	9	8	6	5
SFD	200	219	223	203	154	117	93	76	66
PARKS, OPEN	4	6	7	9	10	9	7	7	6
ROADS	16	14	11	9	6	5	4	4	3
Total (cfs)	499	523	514	471	371	288	235	198	173

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 08:34:42
Watershed file: --> c:\rkii\POST-DEV.WSD
Hydrograph file: --> c:\rkii\POST-DEV.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

Composite Hydrograph Summary (cfs)

Subarea Description	12.0 hr	12.3 hr	12.6 hr	13.0 hr	13.5 hr	14.0 hr	14.5 hr	15.0 hr	15.5 hr
AGRICULTURE	23	21	20	19	17	16	14	14	13
LT. INDUSTRIAL	38	35	32	28	26	24	20	19	18
LDA	13	12	11	10	9	8	7	7	7
PARK & SCHOOL	2	2	2	2	2	2	2	1	1
SFD	10	9	8	8	7	6	6	5	5
LDA	5	4	4	4	3	3	3	2	2
SFD	59	53	49	44	40	36	32	30	28
PARKS, OPEN	6	5	5	4	4	4	3	3	3
ROADS	3	3	3	3	2	2	2	2	2
Total (cfs)	159	144	134	122	110	101	89	83	79

Subarea Description	16.0 hr	17.0 hr	18.0 hr	20.0 hr	24.0 hr
AGRICULTURE	13	12	12	10	7
LT. INDUSTRIAL	17	17	15	14	9
LDA	6	6	6	5	3
PARK & SCHOOL	1	1	1	1	1
SFD	5	5	4	4	2
LDA	2	2	2	2	1
SFD	27	26	24	21	13
PARKS, OPEN	3	3	3	2	2
ROADS	2	2	2	1	1
Total (cfs)	76	74	69	60	39

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 08:34:42
Watershed file: --> c:\rkii\POST-DEV.WSD
Hydrograph file: --> c:\rkii\POST-DEV.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
9.0	36	12.8	128
9.1	41	12.9	125
9.2	45	13.0	122
9.3	50	13.1	120
9.4	56	13.2	117
9.5	62	13.3	115
9.6	68	13.4	112
9.7	76	13.5	110
9.8	85	13.6	108
9.9	93	13.7	106
10.0	112	13.8	105
10.1	151	13.9	103
10.2	222	14.0	101
10.3	323	14.1	99
10.4	427	14.2	96
10.5	499	14.3	94
10.6	523	14.4	91
10.7	514	14.5	89
10.8	471	14.6	88
10.9	421	14.7	87
11.0	371	14.8	85
11.1	329	14.9	84
11.2	288	15.0	83
11.3	261	15.1	82
11.4	235	15.2	81
11.5	217	15.3	81
11.6	198	15.4	80
11.7	185	15.5	79
11.8	173	15.6	78
11.9	166	15.7	78
12.0	159	15.8	77
12.1	154	15.9	77
12.2	149	16.0	76
12.3	144	16.1	76
12.4	141	16.2	76
12.5	137	16.3	75
12.6	134	16.4	75
12.7	131	16.5	75

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 08:34:42
Watershed file: --> c:\rkii\POST-DEV.WSD
Hydrograph file: --> c:\rkii\POST-DEV.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
16.6	75	20.4	58
16.7	75	20.5	57
16.8	74	20.6	57
16.9	74	20.7	56
17.0	74	20.8	56
17.1	74	20.9	55
17.2	73	21.0	55
17.3	73	21.1	54
17.4	72	21.2	54
17.5	72	21.3	53
17.6	71	21.4	53
17.7	71	21.5	52
17.8	70	21.6	52
17.9	70	21.7	51
18.0	69	21.8	51
18.1	69	21.9	50
18.2	68	22.0	50
18.3	68	22.1	49
18.4	67	22.2	48
18.5	67	22.3	48
18.6	66	22.4	47
18.7	66	22.5	47
18.8	65	22.6	46
18.9	65	22.7	46
19.0	65	22.8	45
19.1	64	22.9	45
19.2	64	23.0	44
19.3	63	23.1	44
19.4	63	23.2	43
19.5	62	23.3	43
19.6	62	23.4	42
19.7	61	23.5	42
19.8	61	23.6	41
19.9	60	23.7	41
20.0	60	23.8	40
20.1	59	23.9	40
20.2	59		
20.3	58		

APPENDIX C

Hydrologic and Hydraulic Computations
Proposed Stormwater Detention Basin

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 09-12-1995 15:18:42
Watershed file: --> c:\rkii\POST-DA1.WSD
Hydrograph file: --> c:\rkii\POST-DA1.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN - DRAINAGE AREA NO. 1
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
OFFSITE	165.00	61.0	1.00	0.00	4.50	1.08	.28	.30
AGRICULTURE	151.10	65.0	1.00	0.00	4.50	1.33	.24	.30

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 316.10 acres or 0.4939 sq.mi
Peak discharge = 76 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
OFFSITE	1.00	0.00	**	**	No	--
AGRICULTURE	1.00	0.00	**	**	No	--

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 09-12-1995 15:18:42
Watershed file: --> c:\rkii\POST-DA1.WSD
Hydrograph file: --> c:\rkii\POST-DA1.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN - DRAINAGE AREA NO. 1
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
OFFSITE	36	11.0
AGRICULTURE	40	11.0
Composite Watershed	76	11.0

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 09-12-1995 15:18:42
Watershed file: --> c:\rkii\POST-DA1.WSD
Hydrograph file: --> c:\rkii\POST-DA1.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN - DRAINAGE AREA NO. 1
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

Composite Hydrograph Summary (cfs)

Subarea Description	9.0 hr	9.3 hr	9.6 hr	9.9 hr	10.0 hr	10.1 hr	10.2 hr	10.3 hr	10.4 hr
OFFSITE	0	0	0	0	0	1	2	5	9
AGRICULTURE	0	0	0	0	0	1	2	5	11
Total (cfs)	0	0	0	0	0	2	4	10	20

Subarea Description	10.5 hr	10.6 hr	10.7 hr	10.8 hr	11.0 hr	11.2 hr	11.4 hr	11.6 hr	11.8 hr
OFFSITE	15	22	28	32	36	32	28	25	22
AGRICULTURE	17	25	31	36	40	36	31	28	25
Total (cfs)	32	47	59	68	76	68	59	53	47

Subarea Description	12.0 hr	12.3 hr	12.6 hr	13.0 hr	13.5 hr	14.0 hr	14.5 hr	15.0 hr	15.5 hr
OFFSITE	21	19	18	16	15	14	13	12	11
AGRICULTURE	23	21	20	19	17	16	14	14	13
Total (cfs)	44	40	38	35	32	30	27	26	24

Subarea Description	16.0 hr	17.0 hr	18.0 hr	20.0 hr	24.0 hr
OFFSITE	11	11	10	9	6
AGRICULTURE	13	12	12	10	7
Total (cfs)	24	23	22	19	13

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 09-12-1995 15:18:42
Watershed file: --> c:\rkii\POST-DA1.WSD
Hydrograph file: --> c:\rkii\POST-DA1.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN - DRAINAGE AREA NO. 1
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
9.0	0	12.8	37
9.1	0	12.9	36
9.2	0	13.0	35
9.3	0	13.1	34
9.4	0	13.2	34
9.5	0	13.3	33
9.6	0	13.4	33
9.7	0	13.5	32
9.8	0	13.6	32
9.9	0	13.7	31
10.0	0	13.8	31
10.1	2	13.9	30
10.2	4	14.0	30
10.3	10	14.1	29
10.4	20	14.2	29
10.5	32	14.3	28
10.6	47	14.4	28
10.7	59	14.5	27
10.8	68	14.6	27
10.9	72	14.7	27
11.0	76	14.8	26
11.1	72	14.9	26
11.2	68	15.0	26
11.3	63	15.1	26
11.4	59	15.2	25
11.5	56	15.3	25
11.6	53	15.4	24
11.7	50	15.5	24
11.8	47	15.6	24
11.9	46	15.7	24
12.0	44	15.8	24
12.1	43	15.9	24
12.2	41	16.0	24
12.3	40	16.1	24
12.4	39	16.2	24
12.5	39	16.3	24
12.6	38	16.4	24
12.7	37	16.5	24

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 09-12-1995 15:18:42
Watershed file: --> c:\rkii\POST-DA1.WSD
Hydrograph file: --> c:\rkii\POST-DA1.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN - DRAINAGE AREA NO. 1
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
16.6	23	20.4	18
16.7	23	20.5	18
16.8	23	20.6	18
16.9	23	20.7	18
17.0	23	20.8	18
17.1	23	20.9	18
17.2	23	21.0	18
17.3	23	21.1	17
17.4	23	21.2	17
17.5	23	21.3	17
17.6	22	21.4	17
17.7	22	21.5	17
17.8	22	21.6	17
17.9	22	21.7	16
18.0	22	21.8	16
18.1	22	21.9	16
18.2	22	22.0	16
18.3	22	22.1	16
18.4	21	22.2	16
18.5	21	22.3	16
18.6	21	22.4	15
18.7	21	22.5	15
18.8	21	22.6	15
18.9	21	22.7	15
19.0	21	22.8	15
19.1	20	22.9	15
19.2	20	23.0	15
19.3	20	23.1	14
19.4	20	23.2	14
19.5	20	23.3	14
19.6	20	23.4	14
19.7	19	23.5	14
19.8	19	23.6	14
19.9	19	23.7	13
20.0	19	23.8	13
20.1	19	23.9	13
20.2	19		
20.3	19		

POND-2 Version: 5.17 S/N:

>>>>> OUTFLOW HYDROGRAPH ESTIMATOR <<<<<

Inflow Hydrograph: c:\rkii\POST-DA1.HYD
Qpeak = 76.0 cfs

Estimated Outflow: c:\rkii\ESTIMATE.EST
Qpeak = 15.0 cfs

Approximate Storage Volume
(computed from t= 10.00 to 22.90 hrs)

21.1 acre-ft

say 25 acre-feet

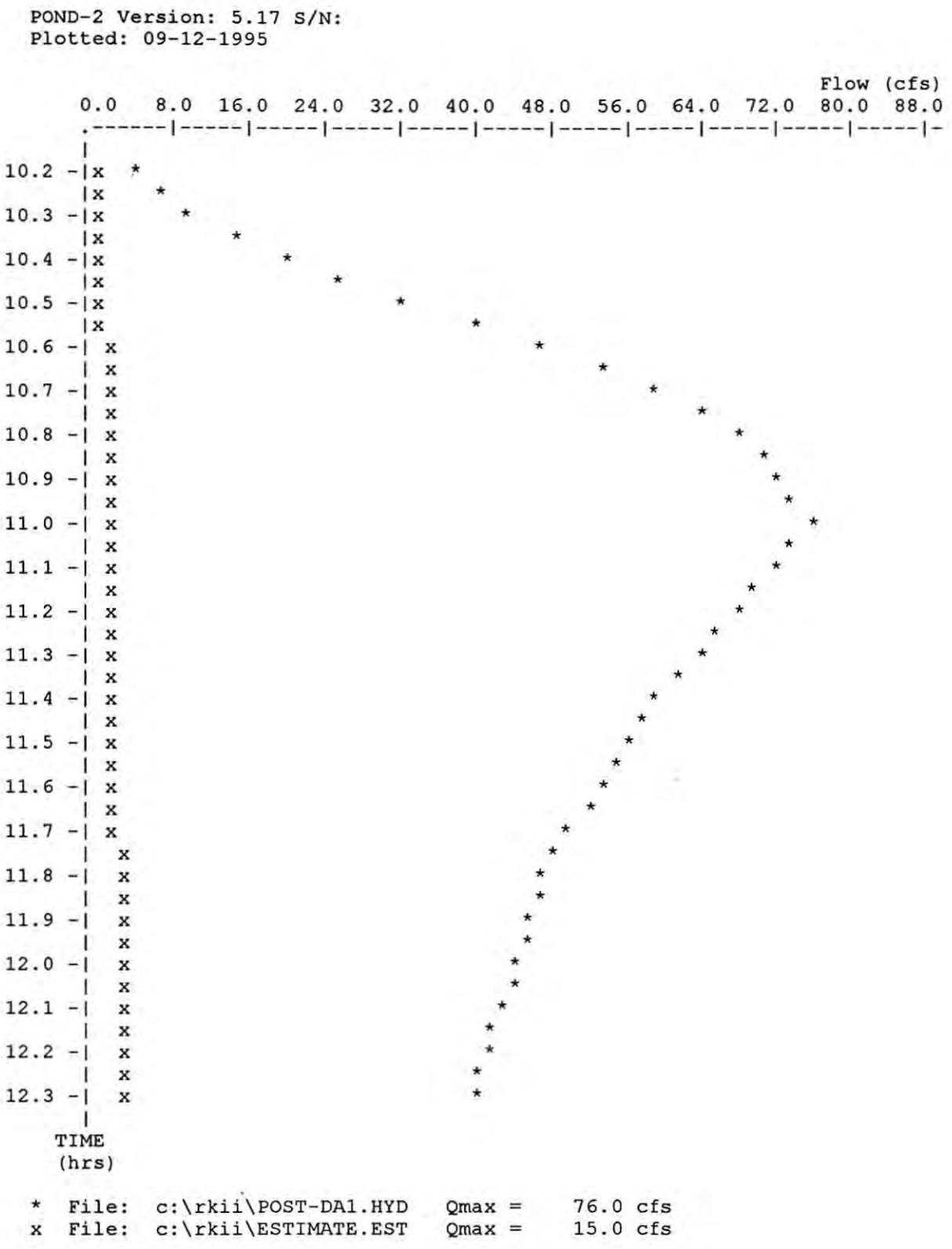

POND-2 Version: 5.17 S/N:
Plotted: 09-12-1995
Flow (cfs)
0.0 8.0 16.0 24.0 32.0 40.0 48.0 56.0 64.0 72.0 80.0 88.0
10.2
10.3
10.4
10.5
10.6
10.7
10.8
10.9
11.0
11.1
11.2
11.3
11.4
11.5
11.6
11.7
11.8
11.9
12.0
12.1
12.2
12.3
TIME
(hrs)
* File: c:\rkii\POST-DA1.HYD Qmax = 76.0 cfs
x File: c:\rkii\ESTIMATE.EST Qmax = 15.0 cfs

EXHIBIT 5

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 09:11:54
Watershed file: --> c:\rkii\POST-DA3.WSD
Hydrograph file: --> c:\rkii\POST-DA3.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN - DRAINAGE AREA NO. 3
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
SFD	180.10	85.0	0.75	0.00	4.50	2.91	.08	.10
PARK	10.00	61.0	1.00	0.00	4.50	1.08	.28	.30
OPEN SPACE	15.00	61.0	0.50	0.00	4.50	1.08	.28	.30

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 205.10 acres or 0.3205 sq.mi
Peak discharge = 197 cfs

WARNING: Drainage areas of two or more subareas differ by a factor of 5 or greater.

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
SFD	0.75	0.00	**	**	No	Computed Ia/p < .1
PARK	1.00	0.00	**	**	No	--
OPEN SPACE	0.50	0.00	**	**	No	--

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 09:11:54
Watershed file: --> c:\rkii\POST-DA3.WSD
Hydrograph file: --> c:\rkii\POST-DA3.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN - DRAINAGE AREA NO. 3
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
SFD	191	10.7
PARK	2	10.7
OPEN SPACE	4	10.4
Composite Watershed	197	10.7

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 09:11:54
Watershed file: --> c:\rkii\POST-DA3.WSD
Hydrograph file: --> c:\rkii\POST-DA3.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN - DRAINAGE AREA NO. 3
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

Composite Hydrograph Summary (cfs)

Subarea Description	9.0 hr	9.3 hr	9.6 hr	9.9 hr	10.0 hr	10.1 hr	10.2 hr	10.3 hr	10.4 hr
SFD	13	18	25	34	38	48	67	97	137
PARK	0	0	0	0	0	0	0	0	1
OPEN SPACE	0	0	0	0	0	1	2	3	4
Total (cfs)	13	18	25	34	38	49	69	100	142

Subarea Description	10.5 hr	10.6 hr	10.7 hr	10.8 hr	11.0 hr	11.2 hr	11.4 hr	11.6 hr	11.8 hr
SFD	171	188	191	174	132	100	79	66	57
PARK	1	1	2	2	2	2	2	2	1
OPEN SPACE	4	4	4	3	3	2	2	2	2
Total (cfs)	176	193	197	179	137	104	83	70	60

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 09:11:54
Watershed file: --> c:\rkii\POST-DA3.WSD
Hydrograph file: --> c:\rkii\POST-DA3.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN - DRAINAGE AREA NO. 3
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

Composite Hydrograph Summary (cfs)

Subarea Description	12.0 hr	12.3 hr	12.6 hr	13.0 hr	13.5 hr	14.0 hr	14.5 hr	15.0 hr	15.5 hr
SFD	51	46	42	38	34	31	27	25	24
PARK	1	1	1	1	1	1	1	1	1
OPEN SPACE	2	2	1	1	1	1	1	1	1
Total (cfs)	54	49	44	40	36	33	29	27	26

Subarea Description	16.0 hr	17.0 hr	18.0 hr	20.0 hr	24.0 hr
SFD	23	22	20	18	11
PARK	1	1	1	1	0
OPEN SPACE	1	1	1	1	1
Total (cfs)	25	24	22	20	12

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 09:11:54
Watershed file: --> c:\rkii\POST-DA3.WSD
Hydrograph file: --> c:\rkii\POST-DA3.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN - DRAINAGE AREA NO. 3
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
9.0	13	12.8	42
9.1	15	12.9	41
9.2	16	13.0	40
9.3	18	13.1	39
9.4	20	13.2	38
9.5	23	13.3	38
9.6	25	13.4	37
9.7	28	13.5	36
9.8	31	13.6	35
9.9	34	13.7	35
10.0	38	13.8	34
10.1	49	13.9	34
10.2	69	14.0	33
10.3	100	14.1	32
10.4	142	14.2	31
10.5	176	14.3	31
10.6	193	14.4	30
10.7	197	14.5	29
10.8	179	14.6	29
10.9	158	14.7	28
11.0	137	14.8	28
11.1	120	14.9	27
11.2	104	15.0	27
11.3	93	15.1	27
11.4	83	15.2	27
11.5	77	15.3	26
11.6	70	15.4	26
11.7	65	15.5	26
11.8	60	15.6	26
11.9	57	15.7	26
12.0	54	15.8	25
12.1	52	15.9	25
12.2	51	16.0	25
12.3	49	16.1	25
12.4	47	16.2	25
12.5	46	16.3	25
12.6	44	16.4	25
12.7	43	16.5	25

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 09:11:54
Watershed file: --> c:\rkii\POST-DA3.WSD
Hydrograph file: --> c:\rkii\POST-DA3.HYD

ROYAL KUNIA DEVELOPMENT, PHASE II
DRAINAGE MASTER PLAN - DRAINAGE AREA NO. 3
HOAEAE & WAIKELE, EWA, OAHU, HAWAII
2-YEAR, 24-HOUR STORMWATER RUNOFF - POST DEVELOPMENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
16.6	24	20.4	19
16.7	24	20.5	19
16.8	24	20.6	19
16.9	24	20.7	19
17.0	24	20.8	18
17.1	24	20.9	18
17.2	24	21.0	18
17.3	23	21.1	18
17.4	23	21.2	18
17.5	23	21.3	17
17.6	23	21.4	17
17.7	23	21.5	17
17.8	22	21.6	17
17.9	22	21.7	17
18.0	22	21.8	16
18.1	22	21.9	16
18.2	22	22.0	16
18.3	22	22.1	16
18.4	22	22.2	16
18.5	22	22.3	15
18.6	21	22.4	15
18.7	21	22.5	15
18.8	21	22.6	15
18.9	21	22.7	15
19.0	21	22.8	14
19.1	21	22.9	14
19.2	21	23.0	14
19.3	21	23.1	14
19.4	21	23.2	14
19.5	21	23.3	13
19.6	20	23.4	13
19.7	20	23.5	13
19.8	20	23.6	13
19.9	20	23.7	13
20.0	20	23.8	12
20.1	20	23.9	12
20.2	20		
20.3	19		

POND-2 Version: 5.17 S/N:

>>>>> OUTFLOW HYDROGRAPH ESTIMATOR <<<<<

Inflow Hydrograph: C:\RKII\POST-DA3.HYD
Qpeak = 197.0 cfs

Estimated Outflow: C:\RKII\ESTIMATE.EST
Qpeak = 45.0 cfs

Approximate Storage Volume
(computed from t= 9.00 to 12.55 hrs)

13.7 acre-ft

say 15 acre-feet

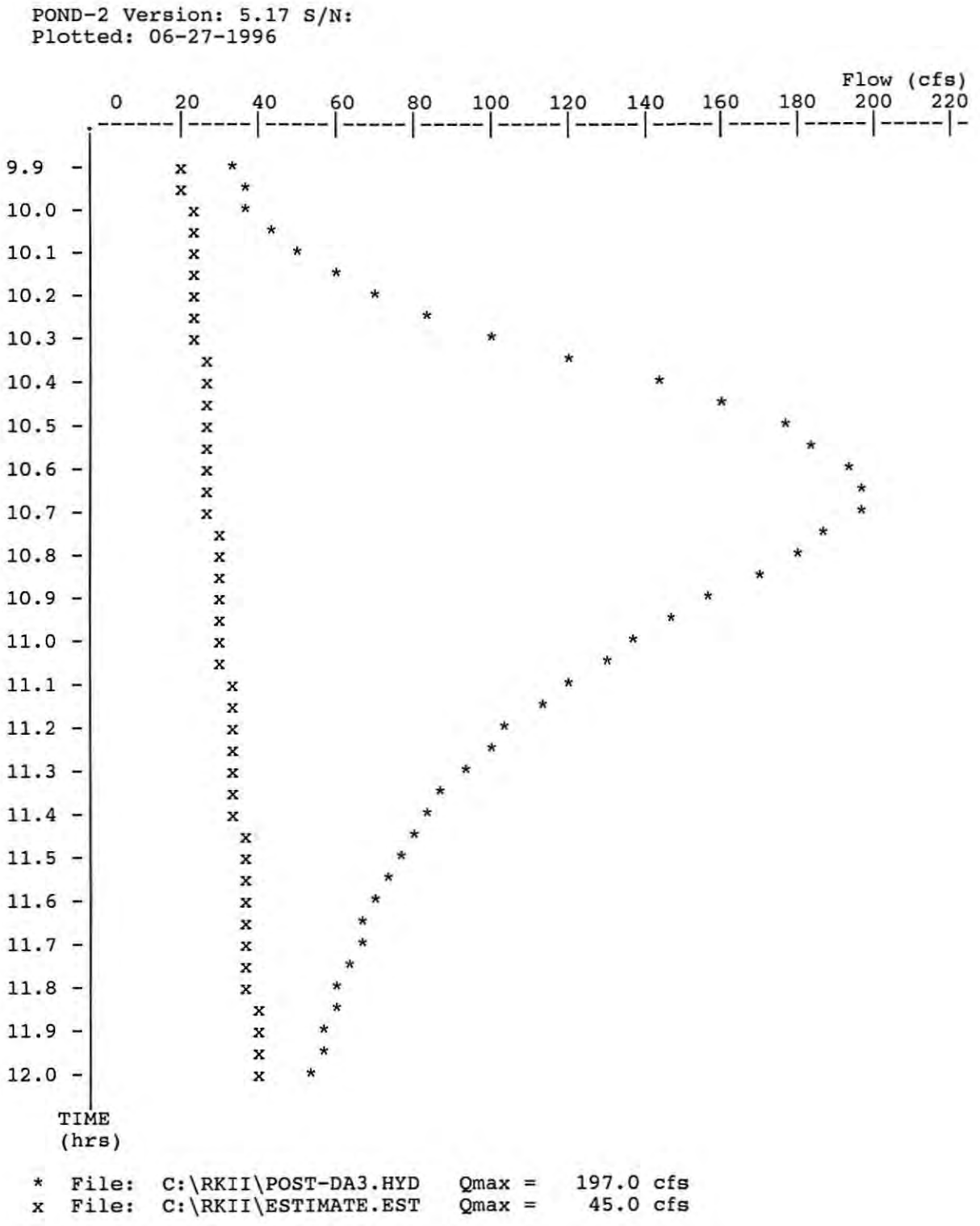

POND-2 Version: 5.17 S/N:
Plotted: 06-27-1996
Flow (cfs)
0 20 40 60 80 100 120 140 160 180 200 220
9.9
10.0
10.1
10.2
10.3
10.4
10.5
10.6
10.7
10.8
10.9
11.0
11.1
11.2
11.3
11.4
11.5
11.6
11.7
11.8
11.9
12.0
TIME
(hrs)
* File: C:\RKII\POST-DA3.HYD Qmax = 197.0 cfs
x File: C:\RKII\ESTIMATE.EST Qmax = 45.0 cfs

EXHIBIT 5

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 09:50:02
Watershed file: --> c:\rkii\RK2-DA3 .WSD
Hydrograph file: --> c:\rkii\RK2-DA3 .HYD

ROYAL KUNIA - PHASE II, DRAINAGE MASTER PLAN
HOAEAE AND WAIKELE, EWA, OAHU, HAWAII
PRELIMINARY SIZING OF STORMWATER DETENTION BASIN IN AREA NO. 3
100-YEAR 24-HOUR STORM EVENT

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
Single Family	180.10	85.0	0.75	0.00	12.70	10.80	.03	.10
Park	10.00	61.0	1.00	0.00	12.70	7.32	.1	.10
Open Space	15.00	61.0	0.50	0.00	12.70	7.32	.1	.10

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 205.10 acres or 0.3205 sq.mi
Peak discharge = 761 cfs

WARNING: Drainage areas of two or more subareas
differ by a factor of 5 or greater.

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
Single Family	0.65	0.00	0.75	0.00	No	Computed Ia/p < .1
Park	1.00	0.00	**	**	No	--
Open Space	0.50	0.00	**	**	No	--

* Travel time from subarea outfall to composite watershed outfall point.
** Tc & Tt are available in the hydrograph tables.

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 09:50:02
Watershed file: --> c:\rkii\RK2-DA3 .WSD
Hydrograph file: --> c:\rkii\RK2-DA3 .HYD

ROYAL KUNIA - PHASE II, DRAINAGE MASTER PLAN
HOAEAE AND WAIKELE, EWA, OAHU, HAWAII
PRELIMINARY SIZING OF STORMWATER DETENTION BASIN IN AREA NO. 3
100-YEAR 24-HOUR STORM EVENT

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
Single Family	708	10.7
Park	23	10.8
Open Space	48	10.4
Composite Watershed	761	10.7

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 09:50:02
Watershed file: --> c:\rkii\RK2-DA3 .WSD
Hydrograph file: --> c:\rkii\RK2-DA3 .HYD

ROYAL KUNIA - PHASE II, DRAINAGE MASTER PLAN
HOAEAE AND WAIKELE, EWA, OAHU, HAWAII
PRELIMINARY SIZING OF STORMWATER DETENTION BASIN IN AREA NO. 3
100-YEAR 24-HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	9.0 hr	9.3 hr	9.6 hr	9.9 hr	10.0 hr	10.1 hr	10.2 hr	10.3 hr	10.4 hr
Single Family	49	67	91	125	143	179	249	362	508
Park	2	2	3	4	4	5	7	9	12
Open Space	4	5	7	10	13	19	30	42	48
Total (cfs)	55	74	101	139	160	203	286	413	568

Subarea Description	10.5 hr	10.6 hr	10.7 hr	10.8 hr	11.0 hr	11.2 hr	11.4 hr	11.6 hr	11.8 hr
Single Family	635	696	708	644	489	371	295	243	210
Park	16	19	21	23	21	17	14	12	10
Open Space	46	39	32	26	19	14	12	11	10
Total (cfs)	697	754	761	693	529	402	321	266	230

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 09:50:02
Watershed file: --> c:\rkii\RK2-DA3 .WSD
Hydrograph file: --> c:\rkii\RK2-DA3 .HYD

ROYAL KUNIA - PHASE II, DRAINAGE MASTER PLAN
HOAEAE AND WAIKELE, EWA, OAHU, HAWAII
PRELIMINARY SIZING OF STORMWATER DETENTION BASIN IN AREA NO. 3
100-YEAR 24-HOUR STORM EVENT

Composite Hydrograph Summary (cfs)

Subarea Description	12.0 hr	12.3 hr	12.6 hr	13.0 hr	13.5 hr	14.0 hr	14.5 hr	15.0 hr	15.5 hr
Single Family	188	170	155	140	128	115	100	94	88
Park	8	7	6	6	5	5	4	4	3
Open Space	9	9	8	8	7	6	5	5	5
Total (cfs)	205	186	169	154	140	126	109	103	96

Subarea Description	16.0 hr	17.0 hr	18.0 hr	20.0 hr	24.0 hr
Single Family	85	82	76	67	43
Park	3	3	3	3	2
Open Space	5	4	4	4	2
Total (cfs)	93	89	83	74	47

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 09:50:02
Watershed file: --> c:\rkii\RK2-DA3 .WSD
Hydrograph file: --> c:\rkii\RK2-DA3 .HYD

ROYAL KUNIA - PHASE II, DRAINAGE MASTER PLAN
HOAEAE AND WAIKELE, EWA, OAHU, HAWAII
PRELIMINARY SIZING OF STORMWATER DETENTION BASIN IN AREA NO. 3
100-YEAR 24-HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
9.0	55	12.8	162
9.1	61	12.9	158
9.2	68	13.0	154
9.3	74	13.1	151
9.4	83	13.2	148
9.5	92	13.3	146
9.6	101	13.4	143
9.7	114	13.5	140
9.8	126	13.6	137
9.9	139	13.7	134
10.0	160	13.8	132
10.1	203	13.9	129
10.2	286	14.0	126
10.3	413	14.1	123
10.4	568	14.2	119
10.5	697	14.3	116
10.6	754	14.4	112
10.7	761	14.5	109
10.8	693	14.6	108
10.9	611	14.7	107
11.0	529	14.8	105
11.1	465	14.9	104
11.2	402	15.0	103
11.3	361	15.1	102
11.4	321	15.2	100
11.5	294	15.3	99
11.6	266	15.4	97
11.7	248	15.5	96
11.8	230	15.6	95
11.9	217	15.7	95
12.0	205	15.8	94
12.1	199	15.9	94
12.2	192	16.0	93
12.3	186	16.1	93
12.4	180	16.2	92
12.5	175	16.3	92
12.6	169	16.4	91
12.7	165	16.5	91

TR-55 TABULAR HYDROGRAPH METHOD
Type I Distribution
(24 hr. Duration Storm)

Executed: 06-27-1996 09:50:02
Watershed file: --> c:\rkii\RK2-DA3 .WSD
Hydrograph file: --> c:\rkii\RK2-DA3 .HYD

ROYAL KUNIA - PHASE II, DRAINAGE MASTER PLAN
HOAEAE AND WAIKELE, EWA, OAHU, HAWAII
PRELIMINARY SIZING OF STORMWATER DETENTION BASIN IN AREA NO. 3
100-YEAR 24-HOUR STORM EVENT

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
16.6	91	20.4	71
16.7	90	20.5	71
16.8	90	20.6	70
16.9	89	20.7	69
17.0	89	20.8	69
17.1	88	20.9	68
17.2	88	21.0	67
17.3	87	21.1	67
17.4	87	21.2	66
17.5	86	21.3	65
17.6	85	21.4	65
17.7	85	21.5	64
17.8	84	21.6	63
17.9	84	21.7	63
18.0	83	21.8	62
18.1	83	21.9	61
18.2	82	22.0	61
18.3	82	22.1	60
18.4	81	22.2	59
18.5	81	22.3	58
18.6	80	22.4	58
18.7	80	22.5	57
18.8	79	22.6	56
18.9	79	22.7	56
19.0	79	22.8	55
19.1	78	22.9	54
19.2	78	23.0	54
19.3	77	23.1	53
19.4	77	23.2	52
19.5	76	23.3	52
19.6	76	23.4	51
19.7	75	23.5	50
19.8	75	23.6	50
19.9	74	23.7	49
20.0	74	23.8	48
20.1	73	23.9	48
20.2	73		
20.3	72		

POND-2 Version: 5.17 S/N:

>>>>> OUTFLOW HYDROGRAPH ESTIMATOR <<<<<

Inflow Hydrograph: C:\RKII\RK2-DA3 .HYD
Qpeak = 761.0 cfs

Estimated Outflow: C:\RKII\ESTIMATE.EST
Qpeak = 300.0 cfs

Approximate Storage Volume
(computed from t= 9.60 to 11.48 hrs)

32.8 acre-ft

say 40 acre-feet

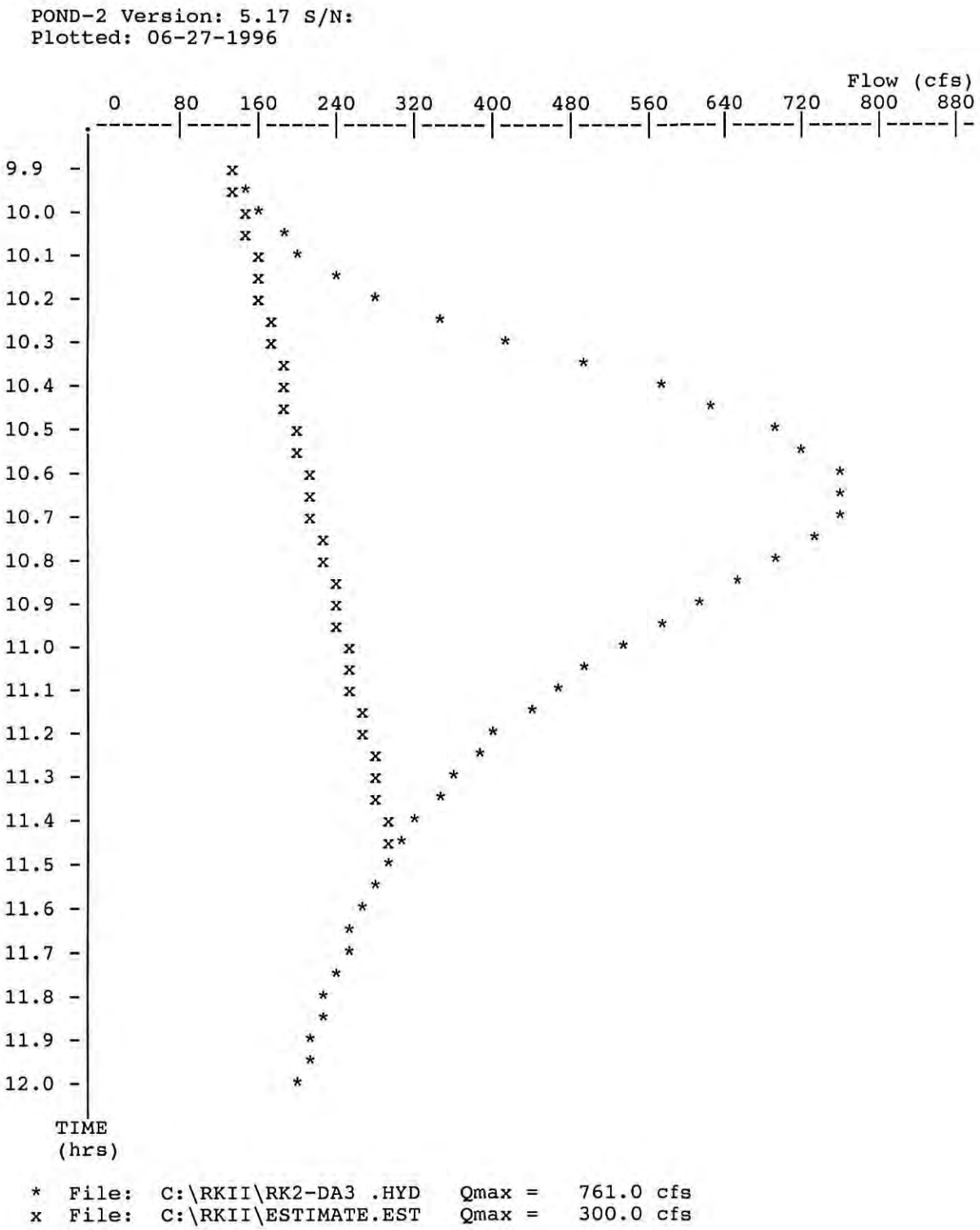

POND-2 Version: 5.17 S/N:
Plotted: 06-27-1996
Flow (cfs)
0 80 160 240 320 400 480 560 640 720 800 880
9.9
10.0
10.1
10.2
10.3
10.4
10.5
10.6
10.7
10.8
10.9
11.0
11.1
11.2
11.3
11.4
11.5
11.6
11.7
11.8
11.9
12.0
TIME
(hrs)
* File: C:\RKII\RK2-DA3 .HYD Qmax = 761.0 cfs
x File: C:\RKII\ESTIMATE.EST Qmax = 300.0 cfs

EXHIBIT 5

APPENDIX D

Hydraulic Computations
Proposed Drainage Improvements

12-ft. x 10-ft. B.C. in L.D.A.
Worksheet for Rectangular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Drainage Channel/Box within Area No. 1
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.015	
Channel Slope	0.040000	ft/ft
Bottom Width	12.00	ft
Discharge	2400.00	ft^3/s

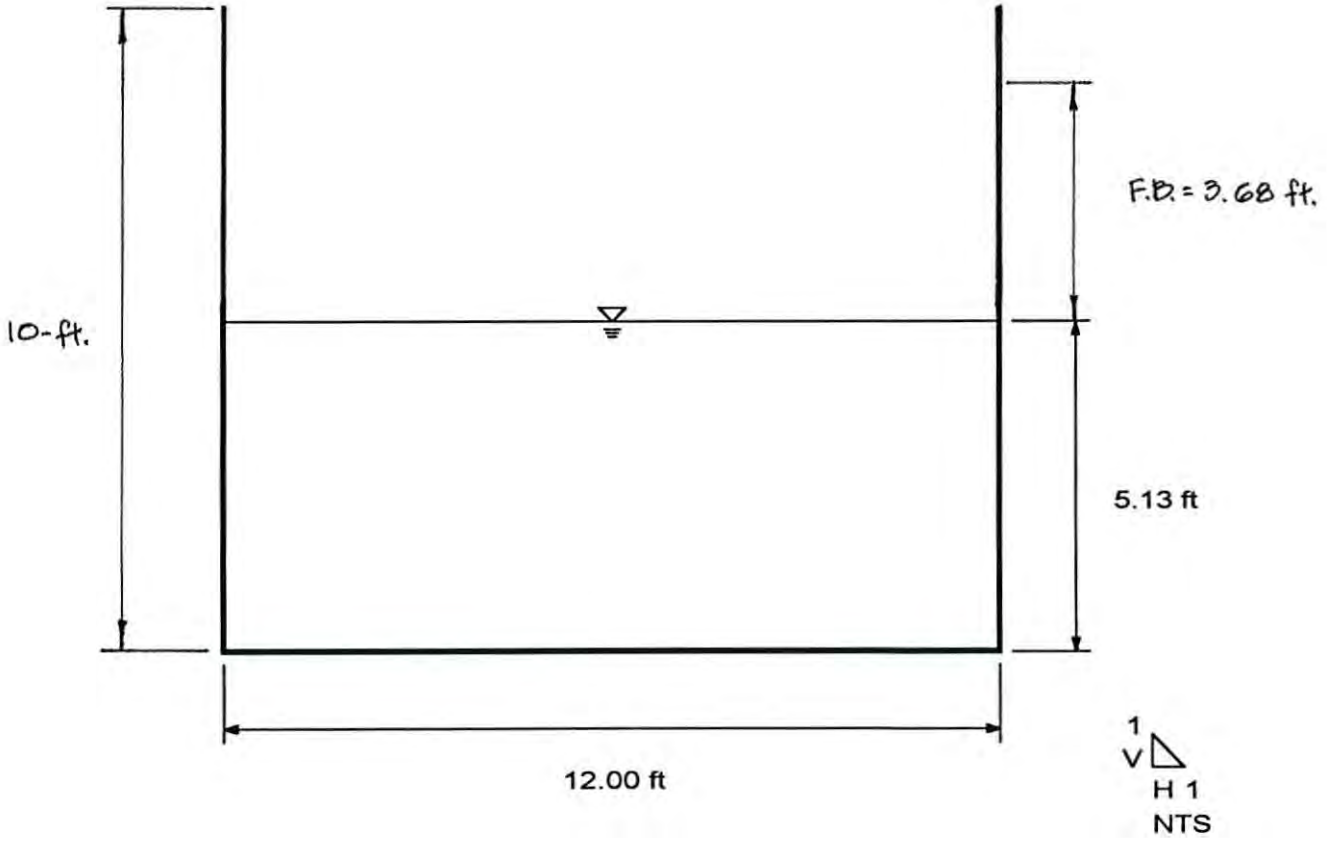
Results		
Depth	5.13	ft
Flow Area	61.50	ft^2
Wetted Perimeter	22.25	ft
Top Width	12.00	ft
Critical Depth	10.75	ft
Critical Slope	0.005840	ft/ft
Velocity	39.02	ft/s
Velocity Head	23.66	ft
Specific Energy	28.79	ft
Froude Number	3.04	
Flow is supercritical.		

$$F.B. = 2.0 + 0.025 V\sqrt[3]{d}$$
$$= 2.0 + 0.025 (39.02) \sqrt[3]{5.13}$$
$$= 3.68 - ft.$$

12-ft. x 10-ft. B.C. in L.D.A.
Cross Section for Rectangular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Drainage Channel/Box within Area No. 1
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.015	
Channel Slope	0.040000	ft/ft
Depth	5.13	ft
Bottom Width	12.00	ft
Discharge	2400.00	ft^3/s



12-ft. x 10-ft. B.C. in Light Industrial
Worksheet for Rectangular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Drainage Channel/Box within Area No. 1
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.015	
Channel Slope	0.017000	ft/ft
Bottom Width	12.00	ft
Discharge	2060.00	ft^3/s

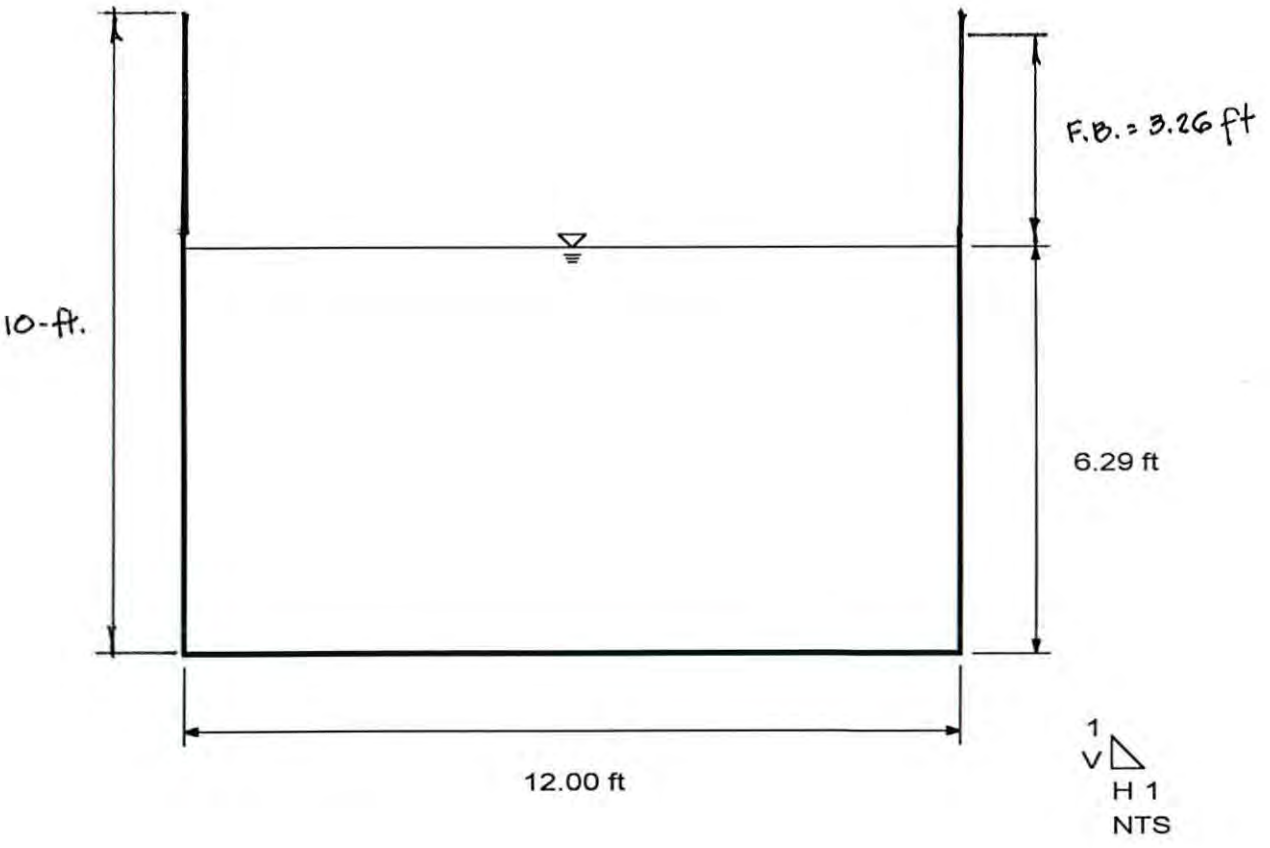
Results		
Depth	6.29	ft
Flow Area	75.49	ft^2
Wetted Perimeter	24.58	ft
Top Width	12.00	ft
Critical Depth	9.71	ft
Critical Slope	0.005547	ft/ft
Velocity	27.29	ft/s
Velocity Head	11.57	ft
Specific Energy	17.86	ft
Froude Number	1.92	
Flow is supercritical.		

$$F.B. = 2.0 + 0.025 v \sqrt[3]{d}$$
$$= 2.0 + 0.025 (27.29) \sqrt[3]{6.29}$$
$$= 3.26 \text{ ft.}$$

12-ft. x 10-ft. B.C. in Light Industrial
Cross Section for Rectangular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Drainage Channel/Box within Area No. 1
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.015	
Channel Slope	0.017000	ft/ft
Depth	6.29	ft
Bottom Width	12.00	ft
Discharge	2060.00	ft^3/s



10-ft. x 10-ft. B.C. in Agriculture Park
Worksheet for Rectangular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Drainage Channel/Box within Area No. 1
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.015	
Channel Slope	0.018000	ft/ft
Bottom Width	10.00	ft
Discharge	1710.00	ft^3/s

Results		
Depth	6.45	ft
Flow Area	64.51	ft^2
Wetted Perimeter	22.90	ft
Top Width	10.00	ft
Critical Depth	9.69	ft
Critical Slope	0.006470	ft/ft
Velocity	26.51	ft/s
Velocity Head	10.92	ft
Specific Energy	17.37	ft
Froude Number	1.84	
Flow is supercritical.		

$$F.B. = 2.0 + 0.025 v \sqrt[3]{d}$$
$$= 2.0 + 0.025 (26.51) \sqrt[3]{6.45}$$
$$= 3.23 \text{ ft.}$$

EXHIBIT 5

10-ft. x 10-ft. B.C. in Agriculture Park
Cross Section for Rectangular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Drainage Channel/Box within Area No. 1
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.015	
Channel Slope	0.018000	ft/ft
Depth	6.45	ft
Bottom Width	10.00	ft
Discharge	1710.00	ft^3/s

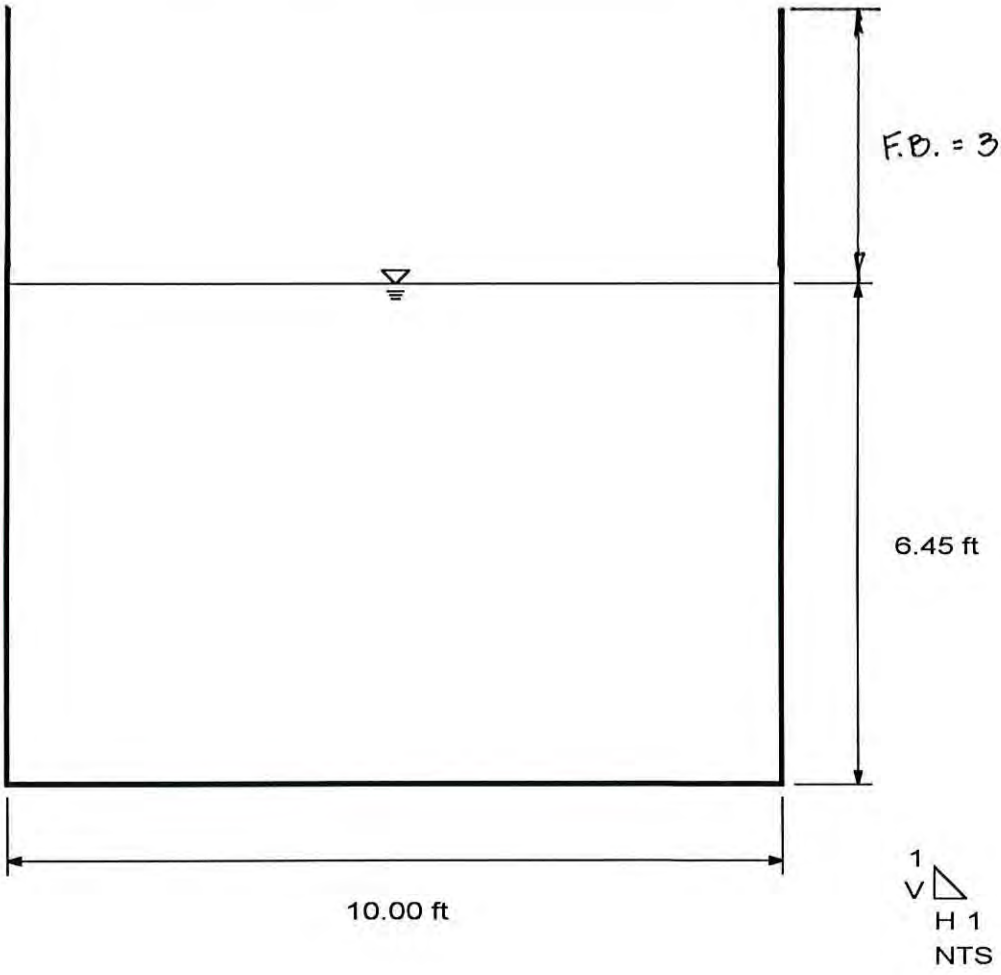


EXHIBIT 5

Connection to Existing 54" Pipe Culvert
Worksheet for Circular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Pipe Culvert in Area No. 2
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Channel Slope	0.010000	ft/ft
Diameter	4.50	ft
Discharge	102.00	ft^3/s

Results		
Depth	2.30	ft
Flow Area	8.17	ft^2
Wetted Perimeter	7.17	ft
Top Width	4.50	ft
Critical Depth	2.97	ft
Percent Full	51.10	%
Critical Slope	0.004509	ft/ft
Velocity	12.48	ft/s
Velocity Head	2.42	ft
Specific Energy	4.72	ft
Froude Number	1.63	
Maximum Discharge	211.53	ft^3/s
Full Flow Capacity	196.64	ft^3/s
Full Flow Slope	0.002691	ft/ft
Flow is supercritical.		

ENTRANCE CONTROL:

D = 54"

Q = 102cfs

H/D = 1.0

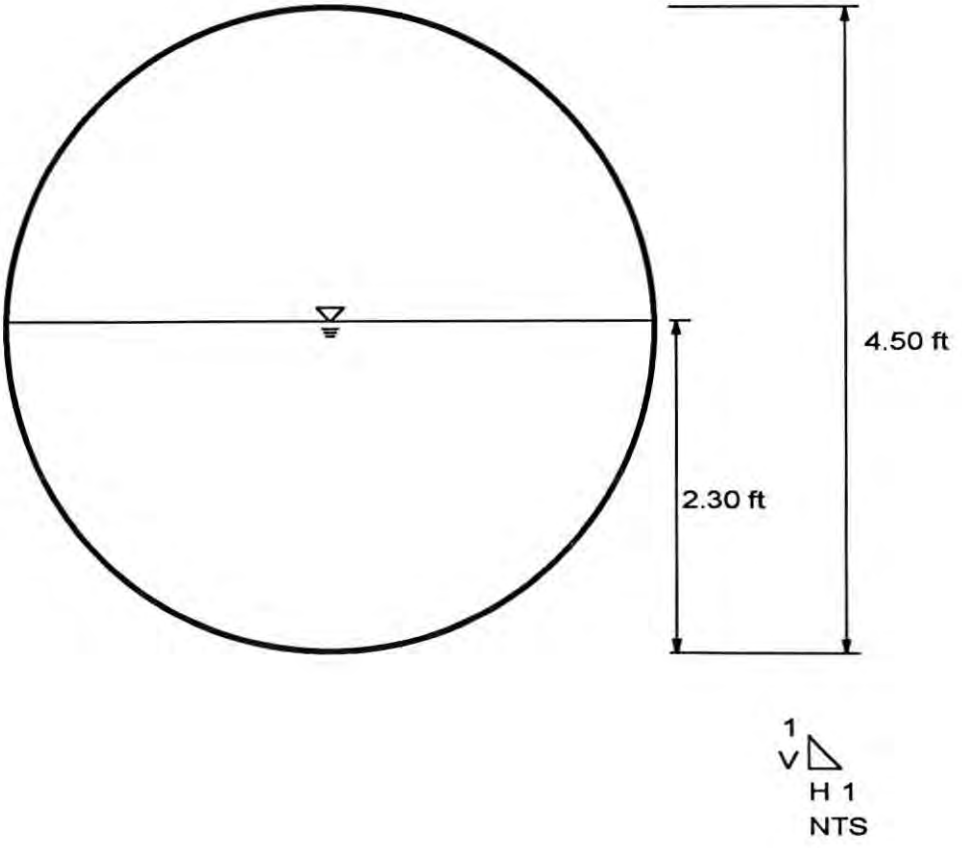
H = 4.5 ft. OK

EXHIBIT 5

Connection to Existing 54" Pipe Culvert
Cross Section for Circular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Pipe Culvert in Area No. 2
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.013	
Channel Slope	0.010000	ft/ft
Depth	2.30	ft
Diameter	4.50	ft
Discharge	102.00	ft^3/s



48" Pipe Culvert Extension
Worksheet for Circular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Pipe Culvert in Area No. 2
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Channel Slope	0.010000	ft/ft
Diameter	4.00	ft
Discharge	102.00	ft^3/s

Results		
Depth	2.49	ft
Flow Area	8.22	ft^2
Wetted Perimeter	7.27	ft
Top Width	3.88	ft
Critical Depth	3.06	ft
Percent Full	62.25	%
Critical Slope	0.005800	ft/ft
Velocity	12.40	ft/s
Velocity Head	2.39	ft
Specific Energy	4.88	ft
Froude Number	1.50	
Maximum Discharge	154.51	ft^3/s
Full Flow Capacity	143.64	ft^3/s
Full Flow Slope	0.005043	ft/ft
Flow is supercritical.		

ENTRANCE CONTROL:

D = 48"

Q = 102 CFS

H/D = 1.2

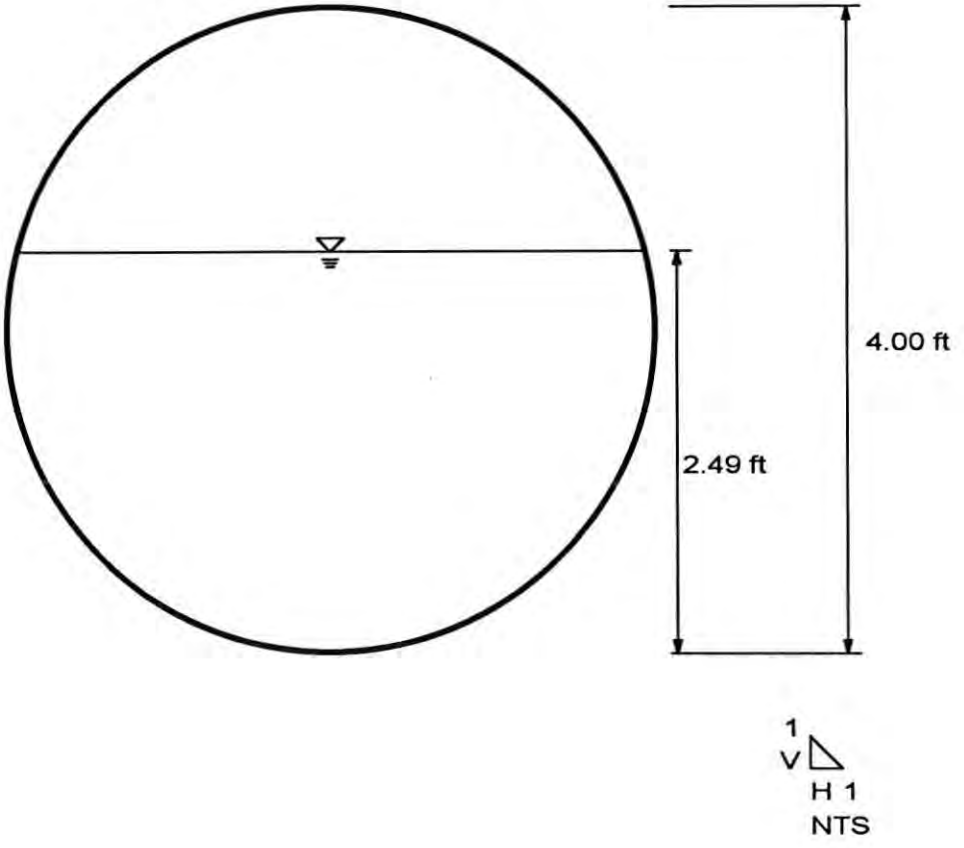
H = 4.8 ft. OK

EXHIBIT 5

48" Pipe Culvert Extension
Cross Section for Circular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Pipe Culvert in Area No. 2
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.013	
Channel Slope	0.010000	ft/ft
Depth	2.49	ft
Diameter	4.00	ft
Discharge	102.00	ft^3/s



72" Pipe Culvert in S.F.D.
Worksheet for Circular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Pipe Culverts in Area No. 3
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

TO EXIST. 8'x8' B.C.

Input Data		
Mannings Coefficient	0.013	
Channel Slope	0.015000	ft/ft
Diameter	6.00	ft
Discharge	280.00	ft^3/s

Results		
Depth	3.14	ft
Flow Area	14.98	ft^2
Wetted Perimeter	9.71	ft
Top Width	5.99	ft
Critical Depth	4.58	ft
Percent Full	52.33	%
Critical Slope	0.005048	ft/ft
Velocity	18.69	ft/s
Velocity Head	5.43	ft
Specific Energy	8.57	ft
Froude Number	2.08	
Maximum Discharge	557.93	ft^3/s
Full Flow Capacity	518.66	ft^3/s
Full Flow Slope	0.004372	ft/ft
Flow is supercritical.		

ENTRANCE CONTROL:

D = 72"

Q = 280 cfs

H/D = 1.2

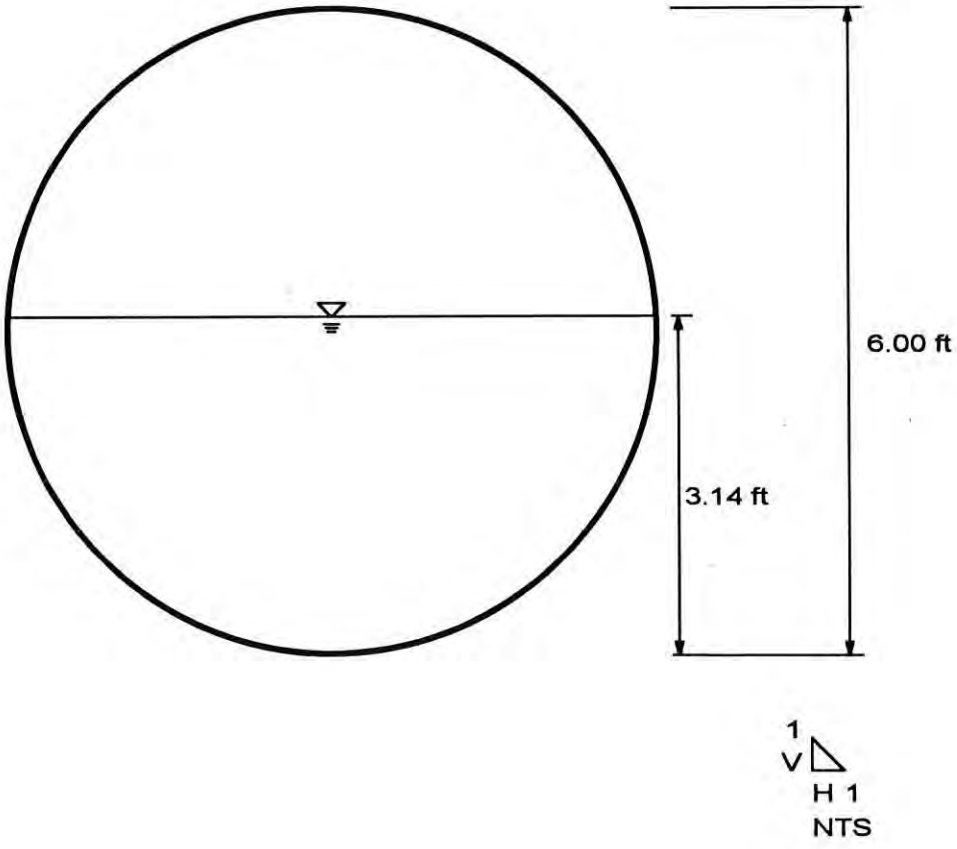
H = 7.2 ft.

EXHIBIT 5

72" Pipe Culvert in S.F.D.
Cross Section for Circular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Pipe Culverts in Area No. 3
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.013	
Channel Slope	0.015000	ft/ft
Depth	3.14	ft
Diameter	6.00	ft
Discharge	280.00	ft^3/s



48" Pipe Culvert Extension
Worksheet for Circular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Pipe Culverts in Area No. 3
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Channel Slope	0.037500	ft/ft
Diameter	4.00	ft
Discharge	120.00	ft^3/s

Results		
Depth	1.84	ft
Flow Area	5.63	ft^2
Wetted Perimeter	5.96	ft
Top Width	3.99	ft
Critical Depth	3.30	ft
Percent Full	45.91	%
Critical Slope	0.006906	ft/ft
Velocity	21.32	ft/s
Velocity Head	7.06	ft
Specific Energy	8.90	ft
Froude Number	3.16	
Maximum Discharge	299.21	ft^3/s
Full Flow Capacity	278.15	ft^3/s
Full Flow Slope	0.006980	ft/ft
Flow is supercritical.		

ENTRANCE CONTROL:

D = 48"

Q = 120 cfs

H/D = 1.5

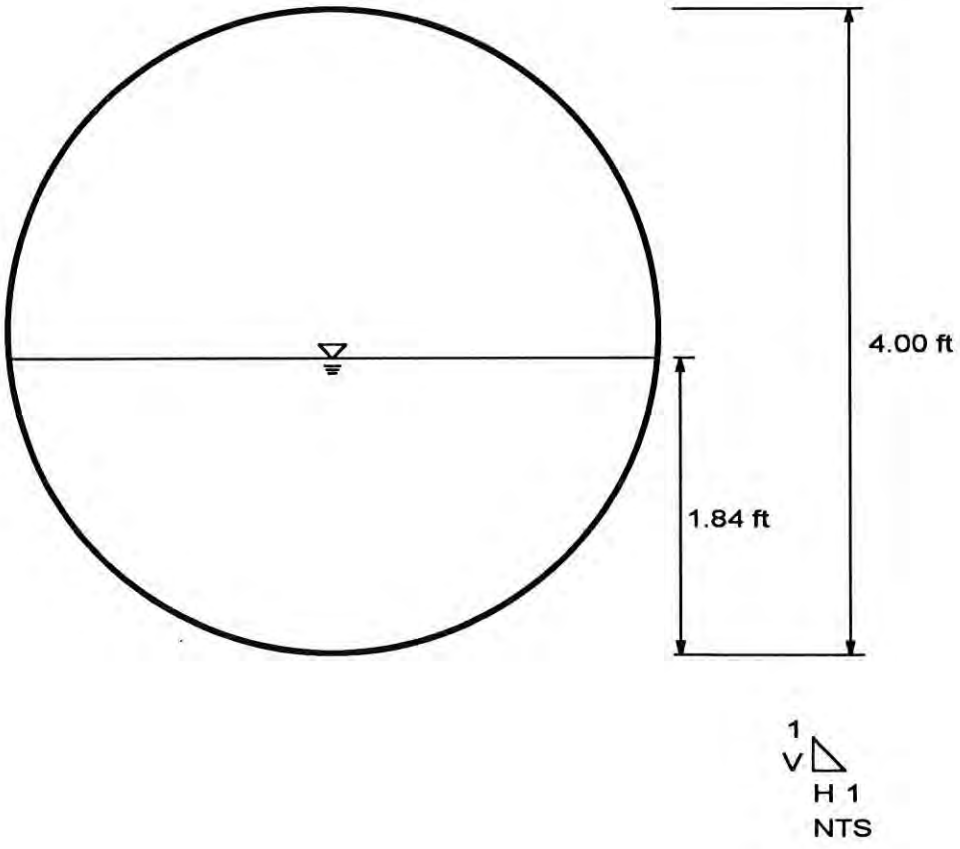
H = 6.0 ft.

EXHIBIT 5

48" Pipe Culvert Extension
Cross Section for Circular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Pipe Culverts in Area No. 3
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.013	
Channel Slope	0.037500	ft/ft
Depth	1.84	ft
Diameter	4.00	ft
Discharge	120.00	ft^3/s



60" Pipe Culvert to G.C. #2
Worksheet for Circular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Pipe Culverts in Area No. 3
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Channel Slope	0.025000	ft/ft
Diameter	5.00	ft
Discharge	300.00	ft^3/s

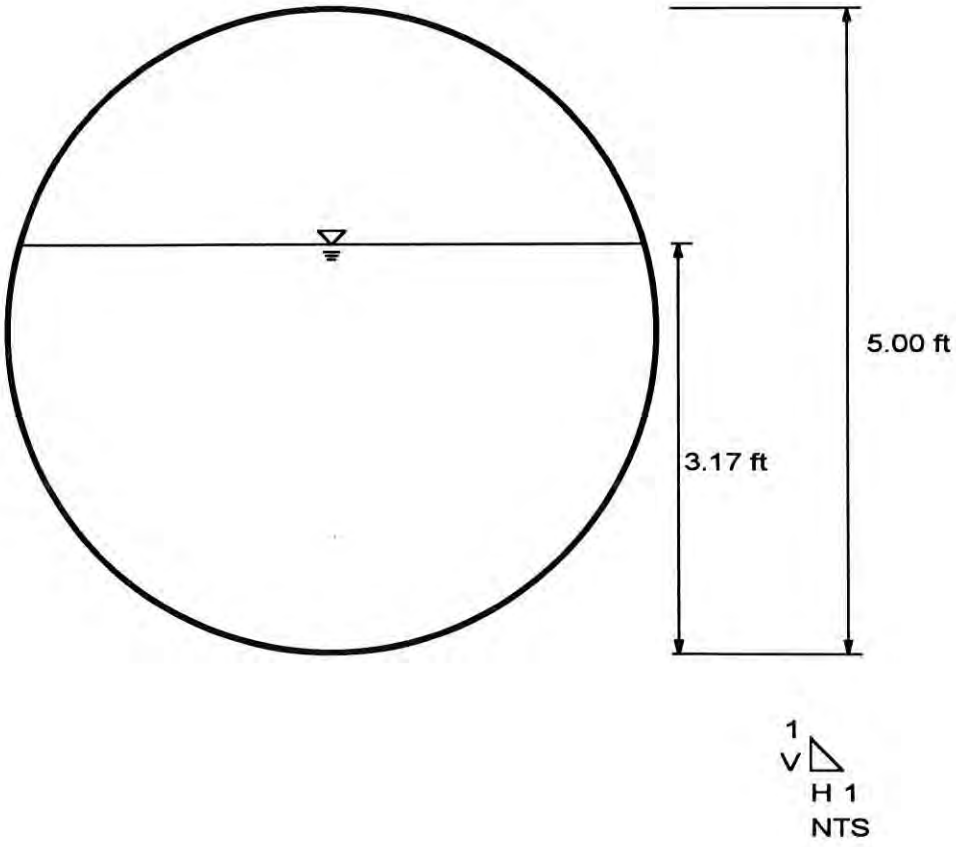
Results		
Depth	3.17	ft
Flow Area	13.11	ft^2
Wetted Perimeter	9.20	ft
Top Width	4.82	ft
Critical Depth	4.67	ft
Percent Full	63.34	%
Critical Slope	0.011471	ft/ft
Velocity	22.88	ft/s
Velocity Head	8.14	ft
Specific Energy	11.30	ft
Froude Number	2.45	
Maximum Discharge	442.95	ft^3/s
Full Flow Capacity	411.77	ft^3/s
Full Flow Slope	0.013270	ft/ft
Flow is supercritical.		

ENTRANCE CONTROL:
D = 60"
Q = 300 cfs
H/D = 2.0
H = 10 ft. (APPROX. HEIGHT OF EXIST. INTAKE STRUCTURES WITHIN GOLF COURSE NO.2)

60" Pipe Culvert to G.C. #2
Cross Section for Circular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Pipe Culverts in Area No. 3
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.013	
Channel Slope	0.025000	ft/ft
Depth	3.17	ft
Diameter	5.00	ft
Discharge	300.00	ft^3/s



10' x 8' Box Culvert for Area No. 5
Worksheet for Rectangular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Drainage Channel/Box in Area No. 3
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.015	
Channel Slope	0.025000	ft/ft
Bottom Width	10.00	ft
Discharge	1400.00	ft^3/s

Results		
Depth	4.89	ft
Flow Area	48.89	ft^2
Wetted Perimeter	19.78	ft
Top Width	10.00	ft
Critical Depth	8.48	ft
Critical Slope	0.006032	ft/ft
Velocity	28.64	ft/s
Velocity Head	12.74	ft
Specific Energy	17.63	ft
Froude Number	2.28	
Flow is supercritical.		

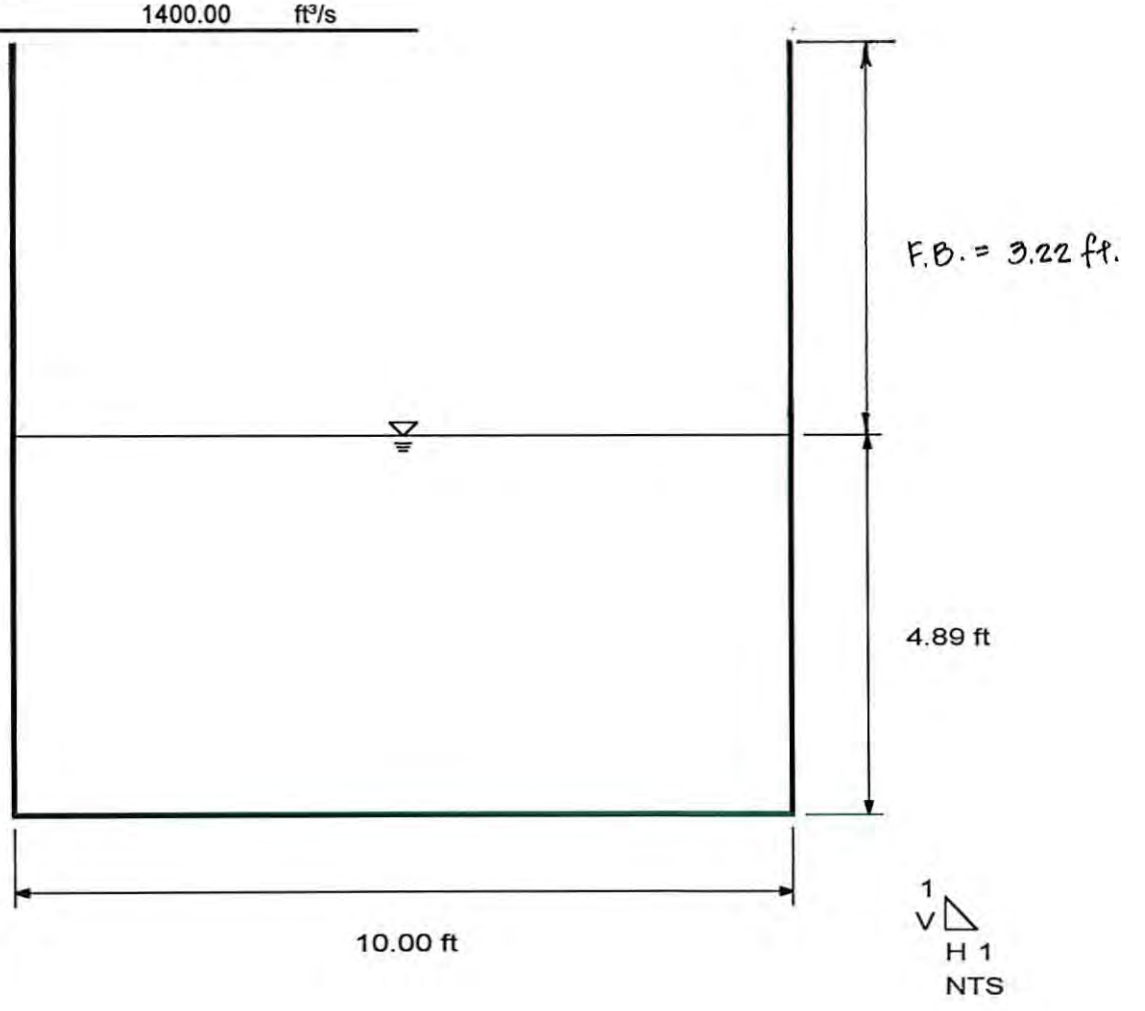
$$F.B. = 2.0 + 0.025\sqrt[3]{d}$$
$$= 2.0 + 0.025\,(28.64)\sqrt[3]{4.89}$$
$$= 3.22 \text{ ft.}$$

EXHIBIT 5

10' x 8' B.C. for Area No. 5
Cross Section for Rectangular Channel

Project Description	
Project File	c:\flow\rk-ii.fm2
Worksheet	Drainage Channel/Box in Area No. 3
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.015	
Channel Slope	0.025000	ft/ft
Depth	4.89	ft
Bottom Width	10.00	ft
Discharge	1400.00	ft^3/s



BEFORE THE LAND USE COMMISSION

OF THE STATE OF HAWAI'I

In the Matter of the Petition of HALEKUA DEVELOPMENT CORPORATION, a Hawai'i corporation To Amend the Agricultural Land Use District Boundary into the Urban Land Use District for Approximately 503.886 Acres at Waikele and Ho'ae'ae, 'Ewa, O'ahu, City and County of Honolulu, State of Hawai'i, Tax Map Key No. 9-4-02: 1, portion 52, 70 and 71	)	DOCKET NO. A92-683 CERTIFICATE OF SERVICE

CERTIFICATE OF SERVICE

The undersigned hereby certifies that on this date a copy of the foregoing document was served upon the following parties via U.S. mail, postage prepaid:

Mary Alice Evans, Director State of Hawai'i Office of Planning Leiopapa A Kamehameha Building 235 South Beretania Street, 6th Floor Honolulu, HI 96813	U.S. MAIL, POSTAGE PREPAID
Clare E. Connors, Esq. Attorney General Dawn T. Apuna, Esq. Deputy Attorney General Hale Auhau, Third Floor 425 Queen Street Honolulu, HI 96813 Attorneys for State of Hawai'i Office of Planning	U.S. MAIL, POSTAGE PREPAID

Kathy K. Sokugawa, Acting Director
Department of Planning and Permitting
City and County of Honolulu
Frank F. Fasi Municipal Building
650 South King Street
Honolulu, HI 96813

U.S. MAIL, POSTAGE PREPAID

Paul S. Aoki, Esq.
Acting Corporation Counsel
Duane Pang, Esq.
Deputy Corporation Counsel
Department of Corporation Counsel
530 South King Street, Room 110
Honolulu, HI 96813

Attorneys for Department of Planning and Permitting, City and County of Honolulu

U.S. MAIL, POSTAGE PREPAID

Rush Moore LLP
Attn: Stephen K.C. Mau
1100 Alakea Street, Suite 600
Honolulu, HI 96813

Attorneys for Robinson Kunia Land LLC

U.S. MAIL, POSTAGE PREPAID

HRT Realty, LLC
Attn: Giorgio Caldarone
3660 Waialae Avenue, Suite 400
Honolulu, HI 96816

U.S. MAIL, POSTAGE PREPAID

RKES, LLC
Patrick K. Kobayashi
1288 Ala Moana Blvd., Suite 201
Honolulu, HI 96814

U.S. MAIL, POSTAGE PREPAID

Kunia Residential Partners
Troy T. Fukuhara
680 Iwilei Road, Suite 510
Honolulu, HI 96817

U.S. MAIL, POSTAGE PREPAID

Hawaiian Electric Company, Inc.
Susan A. Li
1001 Bishop Street, Suite 2500
Honolulu, HI 96813

Carlsmith Ball LLP
Jennifer A. Lim
Derek B. Simon
ASB Tower
1001 Bishop Street, Suite 2100
Honolulu, HI 96813

U.S. MAIL, POSTAGE PREPAID

Attorneys for Successor Petitioner Ho'ohana Solar 1, LLC

Jupiter Investors II LLC
Norm Tatch
24 Corporate Plaza, Suite 100
Newport Beach, CA 92660

U.S. MAIL, POSTAGE PREPAID

DATED: Honolulu, Hawai'i, October 5, 2020.

MICHAEL H. LAU
LIANNA L. FIGUEROA
STEVEN K.S. CHUNG

Attorneys for HASEKO ROYAL KUNIA, LLC