



CITY OF EL CENTRO – EXTENSION OF IMPERIAL AVENUE SOUTH FROM I-8 TO McCABE ROAD

11/25/2015

PRELIMINARY DRAINAGE ANALYSIS REPORT



PREPARED BY:

THE HOLT GROUP, INC.
1601 N. IMPERIAL AVE.
EL CENTRO, CA 92243
P. 760.337.3883
F. 760.337.5997

THG Project No.:

135.033P

TABLE OF CONTENTS

I. INTRODUCTION.....	1
1. PROJECT DESCRIPTION	1
2. SCOPE OF WORK.....	2
II. SITE EVALUATION.....	2
1. FEMA FLOOD INSURANCE RATE MAP	2
2. GEOTECHNICAL REPORT FINDINGS	2
3. EXISTING SITE CONDITIONS AND FLOW PATTERN.....	3
4. PROPOSED SITE CONDITIONS AND FLOW PATTERN	6
III. METHODOLOGY	11
1. DESIGN STANDARDS.....	11
2. DESIGN ASSUMPTIONS.....	11
3. HYDROLOGIC ANALYSIS.....	12
4. HYDRAULIC ANALYSIS.....	15
IV. CALCULATIONS	15
1. EXISTING STORM RUNOFF VOLUMES.....	16
2. PHASE I IMPROVEMENTS.....	16
3. PHASE II IMPROVEMENTS.....	19
V. PRELIMINARY RESULTS AND RECOMMENDATIONS	22
1. DESIGN ASSUMPTIONS.....	23
2. EXISTING STORM DRAINAGE ISSUES	24
3. PROPOSED DRAINAGE FACILITIES.....	24

LIST OF EXHIBITS

- Exhibit A** - Vicinity Map
- Exhibit B** - Existing and Proposed Hydrologic Plans and Cross-Sections for Phase I & II Improvements
- Exhibit C** - FEMA FIRM
- Exhibit D** - Geotechnical Report
- Exhibit E** - IID Date Drain Plan
- Exhibit F** - City of El Centro Master Drainage Plan Deficiency Project Location Map
- Exhibit G** - Hydrologic and Hydraulic Calculations

LIST OF TABLES

- Table 1** - Existing Tributary Areas
- Table 2** - Proposed Tributary Areas
- Table 3** - Summary of Proposed Phases/Options
- Table 4** - Summary of Runoff Volumes and Retention Capacities of Existing Retention Basins for Existing Tributary Areas
- Table 5** - Summary of Runoff Volumes for Proposed Tributary Areas and Storage Capacities of Proposed Retention Basins/Swales for Phase I Improvements
- Table 6** - Summary of Full Flow Capacities of Proposed Swales/Retention Basins for Phase I Improvements
- Table 7** - Summary of Runoff Flow Rates for Proposed Ultimate Roadway Improvements (Phase II Improvements)
- Table 8** - Summary of Runoff Volumes for Proposed Ultimate Roadway Improvements (Phase II Improvements)

I. INTRODUCTION

1. PROJECT DESCRIPTION

The proposed project comprises of an extension of Imperial Avenue approximately 7,500 feet (1.42 miles) southerly from Interstate 8 (I-8) to McCabe Road in the City of El Centro, California. The project scope of work also includes an extension of Wake Avenue for an approximate length of 1,200 feet westerly from the existing Desert Estates South Subdivision boundary to Imperial Avenue and an extension of Danenberg Drive westerly for an approximate length of 700 feet from the existing Desert Village Subdivision boundary to Imperial Avenue. The project location is shown on the Exhibit A - Vicinity Map.

Presently, the existing access to and from I-8 from and to Imperial Avenue is limited to North of I-8 as Imperial Avenue South of I-8 is undeveloped and not open to public for access. State of California Transportation Department (Caltrans) is currently designing a new I-8/Imperial Avenue Interchange to provide an access to and from South Imperial Avenue.

The extension of Imperial Avenue will improve overall circulation within City of El Centro (City) and unincorporated Imperial County by connecting existing and future development south of I-8 and reduce congestion at the existing I-8 interchange within the City.

It was assumed that the project improvements will be developed in two (2) phases as described below:

Phase I Improvements will consist of the construction of a two (2) or three (3) traffic lanes roadway along Imperial Avenue between McCabe Road and I-8. Side street roadway sections along Wake Avenue and Danenberg Drive shall also be constructed, extended westerly from the existing pavement ends within the adjacent subdivisions to Imperial Avenue. The intersections at Manuel Ortiz Avenue and at Valleyview Avenue along Imperial Avenue shall also be completed to provide accesses to these two (2) side streets from Imperial Avenue.

Phase II Improvements will consist of the construction of the 110-foot wide (Right-of-Way width) full width roadway sections along Imperial Avenue. The Phase I Improvements will be incorporated as a part of the Phase II Improvements.

Refer to Cross-sections for Phase I and II Improvements included in Exhibit B.

2. SCOPE OF WORK

This Preliminary Drainage Analysis Report documents the existing and proposed project site hydrology and drainage characteristics. The existing and proposed flow patterns within the project vicinity are identified and analyzed to develop alternative solutions to manage increased runoff generated from the proposed improvements for both phases, Phase I and Phase II Improvements, as described in the previous section.

Drainage system proposed for the Phase I Improvements shall be temporary until the Phase II Improvements take place. Permanent infrastructures proposed to be installed at the Phase I Improvements shall be incorporated with the future infrastructures to be constructed in the Phase II Improvements.

II. SITE EVALUATION

1. FEMA FLOOD INSURANCE RATE MAP

Flood Insurance Rate Map (FIRM) was obtained for the project site to verify the Flood Zone. It was verified that the project site was located within Zone “X” of “Other Areas.” Zone “X” of “Other Areas” is defined as: “Areas determined to be outside the 0.2% annual chance floodplain.” Refer to Exhibit C – FEMA FIRM.

2. GEOTECHNICAL REPORT FINDINGS

Geotechnical Engineering report was prepared by Sierra Material Testing and Inspection (Sierra Project No. EC461) on November 25, 2015, included as Exhibit D of this report. Groundwater was not encountered in any of the borings completed.

3. EXISTING SITE CONDITIONS AND FLOW PATTERN

The majority of the project site is currently located within the undeveloped agricultural areas in the City of El Centro, partially in the County of Imperial Right-of-Ways and the privately owned properties. There are four (4) developed residential subdivisions located within the vicinity of the project site. Farmer Estates Subdivision and Buena Vista Park Subdivision are located along the project site. Desert Estates South Subdivision and Desert Village Subdivision Units 1-5 are located adjacent to the project site, along the west side of Eighth Street.

There are existing IID facilities located within the project site. Existing Date Drain (unlined open channel) is located along the west side of the project site between McCabe Road and I-8. Existing Dahlia Lateral (concrete lined open channel) is located within the east half of the project site from Danenberg Drive to McCabe Road. Refer to Existing Hydrology Plan as included in Exhibit B for the locations of the subdivisions and IID facilities relative to the project site location. Existing IID Date Drain Plan is also included in Exhibit E.

A. Existing Subdivisions

Farmer Estates Subdivision is located at the southwest corner of I-8 and Imperial Avenue. The main access road to the Farmer Estates Subdivision is Wake Avenue which is located along the south side of the Farmer Estates Subdivision and extended easterly to Imperial Avenue for the future intersection improvements at Imperial Avenue.

There is an existing retention basin at the northeast corner of the Farmer Estates Subdivision. The runoff generated from the Farmer Estates Subdivision is directed and discharged at the retention basin. There is an existing underground tile drain beneath the retention basin. The accumulated runoff from the retention basin is designed to be carried through the existing tile drain easterly to Date Drain. It is unknown if the retention basin was sized to also accept the future runoff generated from the Imperial Avenue Extension roadway sections abutting the east side of the Farmer Estates Subdivision.

Desert Estates South Subdivision is located at the southwest corner of Eighth Street and I-8. Desert Village Subdivision Units 1-5 is located immediately south of the Desert Estates South Subdivision. Danenberg Drive is located along the south side of the Desert Village Subdivision Units 1-5. It appears that Danenberg Drive was designated as the main

access road from Imperial Avenue to access the Desert Estates South Subdivision and the Desert Village Subdivision Units 1-5.

The main access road to Buena Vista Park Subdivision, Manuel Ortiz Avenue, is located approximately 3,900 feet South of I-8. When the Buena Vista Park Subdivision was developed, the east half roadway sections of Imperial Avenue was constructed as the frontage road along the west side of the Buena Vista Park Subdivision. The roadway sections consist of a 44-foot wide asphalt paved roadway section between Manuel Ortiz Avenue and Valleyview Avenue for an approximate length of 1,320 feet. Currently, this paved roadway segment is the only paved roadway constructed along Imperial Avenue. The runoff from the existing paved roadway section is designed to drain into the existing storm drainage infrastructure and to the retention basin within the Buena Vista Park Subdivision.

The runoff from the Buena Vista Park Subdivision, Desert Estates South Subdivision and Desert Village Subdivision Units 1-5 were designed to be conveyed through an existing underground storm drainage pipeline. The drainage pipeline extends northerly from the Buena Vista Park Subdivision and inter-connects the drainage pipeline network from the Desert Estates South Subdivision and Desert Village Subdivision Units 1-5. The accumulated runoff from all three (3) subdivisions are designed to be ultimately discharged at Date Drain located along the south side of I-8.

B. Existing IID Facilities

The entire length of the existing Date Drain is earthen lined open channel except for a small section undergrounded at the intersection of Wake Avenue and Imperial Avenue. The existing underground Date Drain pipeline diameter is 48-inch and made of concrete as illustrated on the IID Date Drain Plan as included in Exhibit E.

There are three (3) existing underground drainage pipelines connected to the existing Date Drain along the east side of Imperial Avenue. They are located near the intersections of Valleyview Avenue, Manuel Ortiz Avenue and Danenberg Drive. These pipelines are 6-inch to 12-inch in diameter and made of concrete. They were utilized as the drain pipes for the agricultural fields along the east side of Imperial Avenue.

There are also seven (7) existing underground drainage pipelines connected to the existing Date Drain along the west side of Imperial Avenue between McCabe Road and I-8. They

are spaced at an approximate distance of 1,300 feet along the west side of Imperial Avenue. They were/are the drain pipes for the existing agricultural fields and some of them are still in use to drain the agricultural irrigation water from the fields along the west side of Imperial Avenue. The existing IID pipelines were identified from the IID Drain Plan, as Included in Exhibit E, and also illustrated on the Existing Hydrologic Plan included in Exhibit B.

C. Existing Tributary Areas

The existing site has been divided into seven (7) tributary areas in accordance with the existing flow patterns and downstream concentration points. The existing tributary areas along with the current storm runoff flow patterns and the locations of the stormwater facilities are shown on Existing Hydrology Plan as included in Exhibit B.

Each of these existing seven (7) tributary areas includes a segment of half street width section of Imperial Avenue abutting the tributary area. A table below, Table 1, illustrates a list of the existing tributary areas.

Table 1 - Existing Tributary Areas

Area No.	Descriptions	Area (FT²)	Area (Acre)
AE 1	Existing Agricultural Area	13,907,602	319
AE 2	Existing Agricultural Area	3,492,464	80
AE 3	Farmer Estates Subdivision	2,342,332	54
AE 4	Existing Native Surface Area – Proposed Desert Village Subdivision Unit 6	2,182,803	50
AE 5	City of El Centro – Water Treatment Plant	3,513,534	81
AE 6	Buena Vista Park Subdivision	5,051,514	116
AE 7	Existing Native Surface Area – Proposed Linda Vista Subdivision	3,522,588	81

D. Existing Flow Pattern and Conditions

Majority of the existing native surface along Imperial Avenue flows easterly and northerly. If a straight line was projected along Imperial Avenue between McCabe Road and I-8, the native surface slopes down northerly at an approximate slope of 0.16 %. However, as the native surface terrain is uneven and there are countless depressed areas along Imperial Avenue, minor ponding occurs at numerous locations during major storm events.

As identified in the Master Drainage Plan prepared for the City of El Centro by Willdan Engineering dated April 2009, majority of the underground storm drainage pipelines, including the outlet pipeline to the existing Date Drain, installed with the development of the adjacent subdivisions are currently undersized and deficient to function properly during a 10-year storm. Refer to the Deficiency Project Location Map prepared by Willdan Engineering as included in Exhibit F.

4. PROPOSED SITE CONDITIONS AND FLOW PATTERN

The proposed site has been divided into nineteen (19) proposed tributary areas in accordance with the proposed flow patterns. Each of these nineteen (19) proposed tributary areas includes a segment of half street width section of Imperial Avenue abutting the proposed tributary area. A table below, Table 2, illustrates a list of the proposed tributary areas.

Table 2 – Proposed Tributary Areas

Area No.	Descriptions	Area	
		(FT ²)	(Acre)
AP 1	Existing Agricultural Area	13,616,828	312.60
AP 2	Existing Agricultural Area	3,419,395	78.50
AP 3	Farmer Estates Subdivision (Existing)	2,271,253	52.14
AP 4-1	Existing Native Surface Area – Proposed Desert Village Subdivision Unit 6	1,932,209	44.36
AP 4-2	North half of Proposed Danenberg Drive Improvements	31,541	0.72
AP 4-3	Existing Native Surface Area - South half of Proposed Wake Avenue Improvements	50,963	1.17

Area No.	Descriptions	Area (FT²)	Area (Acre)
AP 4-4	Existing Native Surface Area - North half of proposed Wake Avenue Improvements	50,883	1.17
AP 5	City of El Centro – Water Treatment Plant	3,413,464	78.36
AP 6	Buena Vista Park Subdivision (Existing)	4,986,907	114.48
AP 7	Existing Native Surface Area – Proposed Linda Vista Subdivision	3,362,163	77.18
AP 8	Existing Native Surface Area – West Half of Proposed Imperial Avenue Improvements from McCabe Road to Valleyview Avenue.	145,403	3.34
AP 9	Existing Native Surface Area – West Half of Proposed Imperial Avenue Improvements from Valleyview Avenue to Manuel Ortiz Avenue.	72,467	1.66
AP 10	Existing Native Surface Area – West Half of Proposed Imperial Avenue Improvements from Manuel Ortiz Avenue to Proposed High Point at Station 47+66.74.	37,110	0.85
AP 11	Existing Native Surface Area – West Half of Proposed Imperial Avenue Improvements from Proposed High Point at Station 47+66.74 to Danenberg Drive.	37,167	0.85
AP 12	Existing Native Surface Area – West Half of Proposed Imperial Avenue Improvements from Danenberg Drive to Wake Avenue.	71,279	1.64
AP 13	Existing Native Surface Area – West Half of Proposed Imperial Avenue Improvements from Wake Avenue to Interstate 8 South Right-of-Way.	73,981	1.70

Area No.	Descriptions	Area (FT ²)	Area (Acre)
AP 14	Existing Native Surface Area – East Half of Proposed Imperial Avenue Improvements from Wake Avenue to Interstate 8 South Right-of-Way.	30,119	0.69
AP 15	Existing Native Surface Area – East Half of Proposed Imperial Avenue Improvements from Danenberg Drive to Wake Avenue.	71,301	1.64
AP 16	Existing Native Surface Area – East Half of Proposed Imperial Avenue Improvements from Proposed High Point at Station 47+66.74 to Danenberg Drive.	37,110	0.85
AP 17	Existing Native Surface Area – East Half of Proposed Imperial Avenue Improvements from Manuel Ortiz Avenue to Proposed High Point at Station 47+66.74.	37,167	0.85
AP 18	Existing Native Surface Area – East Half of Proposed Imperial Avenue Improvements from Valleyview Avenue to Manuel Ortiz Avenue.	72,469	1.66
AP 19	Existing Native Surface Area – East Half of Proposed Imperial Avenue Improvements from McCabe Road to Valleyview Avenue.	145,406	3.34

The proposed site was analyzed for the two (2)/three (3) lanes roadway improvements on the east half width of Imperial Avenue – Phase I Improvements and the entire Imperial Avenue Extension Improvements – Phase II Improvements for the ultimately improved roadway width.

Two (2) options were developed for each phase, Phase I and Phase II Improvements.

A. Phase I Improvements – Option A – East Half Two (2) Lanes Roadway Improvements

Phase I Improvements – Option A consist of paved two (2) lane roadway sections within the east half of the Imperial Avenue Extension Project. The improved roadway section will consist of two (2) 12-foot asphalt paved traffic lanes with two (2) 8-foot wide Class 2 Base shoulders. The paved roadway surface shall be sloping toward the east edge of pavement (super-elevated) as these two (2) lane roadway sections will serve as the Imperial Avenue Extension Northbound lanes for the ultimate full width Imperial Avenue Improvements (Phase II Improvements).

The storm runoff from the paved surface will sheet-flow easterly to the native earthen swale/linear retention basin to be constructed along the east edge of pavement. The swale shall function as a retention basin to gradually percolate the runoff into the ground.

B. Phase I Improvements – Option B – East Half Three (3) Lanes Roadway Improvements

Phase I Improvements – Option B consist of three (3) 12-foot wide paved traffic lanes roadway sections within the east half of the Imperial Avenue Extension Project. The Improved roadway sections will also consist of one (1) 4-foot wide Class 2 Base shoulder. The storm runoff drainage system functions same as described in the Phase I – Improvements – Option A.

C. Phase II Improvements – Option A – Ultimate Imperial Avenue Extension Improvements – Drainage to East Side of Imperial Avenue Only

It was assumed that the adjacent property development was only completed on the east side of Imperial Avenue prior to the construction of the ultimate Imperial Avenue Extension Project, leaving the west side of Imperial Avenue undeveloped. It was also assumed that the entire storm runoff generated from the full built-out ultimate roadway sections will be drained into the retention basins within the future subdivisions to be developed on the east side of Imperial Avenue.

There are two (2) future subdivisions, Desert Village Subdivision Unit 6 (AP 4) and Linda Vista Subdivision (AP 7), tentatively proposed to be constructed along the east side of Imperial Avenue. They are designed to take in the storm runoff

generated from the east half roadway sections of the Imperial Avenue Extension Project in a similar fashion as the Buena Vista Subdivision.

The ultimate Imperial Avenue Extension roadway sections will consist of curb inlets/catch basins along proposed curb and gutter to be constructed along the west and east sides of Imperial Avenue. Storm runoff generated from the proposed Imperial Avenue Extension roadway sections will sheet-flow toward the nearest catch basins, travel through underground pipelines, be accumulated toward the east side of Imperial Avenue and conveyed to the subdivisions along the east side of Imperial Avenue. The storm runoff will ultimately be discharged at the retention basins within the subdivisions along the east side of Imperial Avenue.

D. Phase II Improvements – Option B - Ultimate Imperial Avenue Extension Improvements – Drainage to Both Sides of Imperial Avenue

It was assumed that the construction of the adjacent property development or subdivisions on both sides along Imperial Avenue will be completed prior to the construction of the ultimate Imperial Avenue Extension Improvements. It was also assumed that the storm runoff generated from the Imperial Avenue half width roadway section fronting each future subdivision on both sides of Imperial Avenue will be drained into the retention basin within the future subdivision.

The storm runoff generated from the ultimate full built-out roadways sections will be distributed and drained evenly to the west and east future development/subdivisions along Imperial Avenue. The runoff will surface-flow and drain into catch basins along proposed curb and gutters, flow through underground pipelines, then ultimately discharge at the future retention basins within the proposed subdivisions on the west and east sides of Imperial Avenue.

E. Summary of Proposed Phases/Options

The table below illustrates a summary of phases and options proposed for the project.

Table 3 – Summary of Proposed Phases/Options

Phases/Options	Descriptions
Phase I – Option A	Two (2) 12-foot traffic lanes with two (2) 8-foot Class 2 Base shoulders within the east half roadway sections
Phase I – Option B	Three (3) 12-foot traffic lanes with one (1) 4-foot Class 2 Base shoulder within the east half roadway sections
Phase II – Option A	Ultimate 110-foot ROW full built-out roadway improvements – drained to the future subdivisions along the east side of Imperial Avenue
Phase II – Option B	Ultimate 110-foot ROW full built-out roadway improvements – drained to the future subdivisions along the east and west sides of Imperial Avenue

III. METHODOLOGY

1. DESIGN STANDARDS

The storm runoff volume for the proposed improvements was estimated in conformance with the Section III Drainage Improvements of the County of Imperial Department of Public Works Engineering Design Guidelines Manual for the Preparation and Checking of Street Improvement, Drainage and Grading Plans within Imperial County (County of Imperial Design Manual). The storm runoff flow rates for 25-year and 100-year storms were also estimated utilizing the time of concentration calculated per the method from the Caltrans Highway Design Manual (HDM) and NOAA precipitation data.

2. DESIGN ASSUMPTIONS

It was assumed that the project site will be developed in two (2) phases, Phase I Improvements and Phase II Improvements as described in the previous sections.

It was proposed that the Phase I Improvements will consist of two (2) 12-foot wide paved traffic lanes with 8-foot wide Class 2 Base shoulders at the edge of both lanes for Option A or three (3) 12-foot wide paved traffic lanes with 4-foot wide Class Base shoulder on

one side along Imperial Avenue for Option B. The paved roadway sections will be super-elevated toward easterly. Native earthen swale/linear retention basin was proposed to be constructed along the east edge of roadway sections of Imperial Avenue. The native earthen swale was sized to retain the 3-inch rainfall per the County of Imperial Design Manual. The native earthen swale was designed to have 1V:3H side slopes.

It was proposed that the Phase II Improvements will consist of a full built-out 110-foot ROW roadway sections. It was assumed that the runoff generated from the roadway sections will be drained into the adjacent future development/subdivisions along the east side (Option A) or both sides (Option B) of Imperial Avenue.

Preliminary design grades along the proposed centerline of Imperial Avenue were established. All the calculations included in this report were based on the preliminary centerline design grades and the two (2) phases proposed. The design grades will be finalized during the preparation of the improvement plans. There may be additional phases between the Phase I and Phase II Improvements as the timing of the future development and the undergrounding of Date Drain is unknown.

It was assumed that the detention period required for the retention basin to be emptied was 72 hours.

3. HYDROLOGIC ANALYSIS

A. Design Storm Runoff Volume, V (cf)

The storm runoff volumes were estimated using the peak rainfall depth of 3-inches per the County of Imperial Design Manual.

The storm runoff volume for the Project was calculated by using the Rational Method Formula:

$$\text{Peak Runoff Volume, } V = C \times I \times A$$

Where:

C	=	Runoff coefficient	=	1.0
I	=	Rainfall depth (inches)	=	3-inches = 0.25 feet (Per County of

A = Drainage Area (ft²) = Area of each tributary area in ft²

The storm runoff volume was estimated for each existing and proposed tributary area.

The storm runoff volumes of the adjacent developed subdivisions were also calculated to evaluate if the existing retention basins have enough capacities to accept the 3-inch rainfall from the onsite improvements.

B. Design Storm Runoff Flow Rate, Q (cfs)

The times of concentration (T_c), intensities of rainfall in inches per hour (i), areas (A) and the peak runoff (Q) generated from a 25-year storm and a 100-year storm were calculated for the project as a reference and comparison with the design storm runoff volume estimated using the 3-inch rainfall.

a. Time of Concentration, T_c (min)

Time of Concentration for each proposed tributary area was calculated per Caltrans Highway Design Manual (HDM). Time of concentration for the watershed was determined by using the following equation.

T_c = T-sheet flow + T-shallow flow + T-concentrated flow.

Sheet flow travel time for the watershed was calculated by using the following simplified form of the Manning's kinematic equation:

$$T_t = \frac{0.42L^{4/5} * n^{4/5}}{P_2^{1/2} * S^{2/5}}$$

Where:

T_t = Travel time in minutes

L = Length of flow path in feet

S = Slope of flow in feet per feet

n = Manning's roughness coefficient for sheet flow (see Table 816.6A of Caltrans HDM)

P_2 = 2-year, 24-hour rainfall depth in inches (0.82-inch in this case per NOAA – See Exhibit G)

Shallow concentrated flow travel time for the watershed was calculated by using Upland Method stated in the Caltrans HDM.

$$V \text{ (ft/sec)} = (3.28) \cdot k \cdot S^{1/2}$$

$$T_t \text{ (min.)} = \frac{L}{60V}$$

Where:

T_t = Travel time in minutes
 L = Travel length in feet
 V = Velocity in feet/sec
 S = Slope in percent

Travel time for the channel flow was obtained by dividing the channel length by the channel flow velocity obtained by using Manning's equation assuming bankfull conditions.

$$V \text{ (ft/sec)} = \frac{1.486}{n} \cdot R^{2/3} \cdot S^{1/2}$$

$$T_t \text{ (min.)} = \frac{L}{60V}$$

Where:

V = Mean velocity in feet/sec
 n = Manning coefficient of roughness (See Table 864.3A of Caltrans HDM and Table B.3 of "Introduction to Highway Hydraulics" by FHWA included in Exhibit G).
 S = Channel slope, in feet per foot
 R = Hydraulic radius, in feet
= A/WP

- A = Cross sectional flow area, in square feet
- WP = Wetted perimeter, in feet

The time of concentration for each tributary area was calculated for several flow segments.

The calculation results of the time of concentration for the corresponding tributary areas are shown on the spreadsheets included in Exhibit G.

b. Rainfall Intensity, I (in/hr)

Using the time of concentration, intensity of rainfall (i) in inches per hour was calculated. In order to obtain specific rainfall intensity for the time of concentration calculated for each tributary area, Rainfall Intensity Equation Calculations were completed utilizing data from NOAA Precipitation Frequency (Refer to Exhibit G). Rainfall Intensity Equations were formulated for a 25-year and 100-year storm events.

4. HYDRAULIC ANALYSIS

Manning's equation was utilized for evaluating the existing storm drainage facilities and sizing the proposed storm drainage facilities. The Manning "n" value was determined from Caltrans HDM and "Introduction to Highway Hydraulics" by FHWA. Refer to Exhibit G for the FHWA roughness coefficients.

IV. CALCULATIONS

The existing and proposed storm runoff volumes from the Phase I and Phase II Improvements are estimated using the methods described in Section III above. The storm runoff volumes to be stored and flow rates to be considered for the design storm for the Phase I and Phase II Improvements were calculated, utilizing the preliminary design grades established along Imperial Avenue.

Existing storm runoff volumes were utilized to analyze the existing drainage facilities within the adjacent subdivisions along Imperial Avenue. Proposed storm runoff volume estimated for each tributary area was calculated and utilized to size the proposed storm

drainage facilities. Hydrologic and hydraulic calculations were included in Exhibit G. Summary of each calculation completed was illustrated in the tables below.

1. EXISTING STORM RUNOFF VOLUMES

Existing storm runoff volume of each existing tributary area was calculated. The capacities of the existing retention basins at the Farmer Estates Subdivision (AE3) and Buena Vista Park Subdivision (AE6) were also estimated as illustrated in the table below.

Table 4 – Summary of Runoff Volumes and Retention Capacities of Existing Retention Basins for Existing Tributary Areas

Area No.	Area		Runoff Volume (FT ³)	Existing Retention Basin Capacity
	(FT ²)	(ACRE)		(FT ³)
AE1	13,617,065.03	312.60	3,404,266.26	N/A
AE2	3,420,306.15	78.52	855,076.54	N/A
AE3	2,311,333.23	53.06	577,833.31	587,207.60
AE4	2,182,802.59	50.11	545,700.65	N/A
AE5	3,588,552.55	82.38	897,138.14	N/A
AE6	5,120,005.15	117.54	1,280,001.29	1,320,817.5
AE7	3,664,840.70	84.13	916,210.18	N/A

It appears that the existing retention basins at the existing subdivisions were adequately sized for a 3-inch rainfall storm event.

2. PHASE I IMPROVEMENTS

Native earthen swales/linear retention basins were sized to store the entire runoff volumes generated from two (2) 12-foot paved traffic lanes and two (2) 8-foot Class 2 Base shoulders (Option A) or three (3) 12-foot paved traffic lanes and one (1) 4-foot wide Class 2 Base shoulder (Option B) along Imperial Avenue, Wake Avenue and Danenberg Drive for the Phase I Improvements.

Table 5 – Summary of Runoff Volumes for Proposed Tributary Areas and Storage Capacities of Proposed Retention Basins/ Swales for Phase I Improvements

Street Name	Tributary Area	Swale/Strip Retention Basin No.	Runoff Volume	Swale/ Retention Basin Storage Capacity
			(FT ³)	(FT ³)
Danenberg Drive (North Half)	AP 4-2	Swale #6	7,885.33	7,990.72
Wake Avenue (South Half)	AP 4-3	Swale #9	6,000	9,640
Wake Avenue (North Half)	AP 4-4	Swale #10	6,000	9,640
Imperial Avenue (East Half)	AP 14*	N/A	7,529.77	N/A
	AP 15	Swale #7 & #8	17,825.17	18,902.80
	AP 16	Swale #4/WTP Central Retention Basin #1	9,277.51	62,577.23
	AP 17	Swale #5/WTP Central Retention Basin #1	9,291.84	
	AP 18**	N/A	18,117.18	N/A
AP 19	Swale #1, #2, and #3	36,351.40	37,697.38	

* Retention Basin/ Swale design for the Tributary Area will be determined based on the final Caltrans design of the Interchange at the intersection of Interstate 8 and S. Imperial Avenue.

** Tributary Area AP18 consists of the existing Imperial Avenue Roadway Section from Manuel Ortiz Avenue to Valleyview Avenue in the Buena Vista Park Subdivision (BVPS). Runoff from this area is drained via the existing storm drainage infrastructure into the existing BVPS Retention Basin.

The native earthen swales/linear retention basins along the roadway sections and the central retention basin, Retention Basin #1, at the City of El Centro Water Treatment Plant were adequately sized to store the design runoff volume based on a 3-inch rainfall storm event.

The full flow capacities of the proposed swales were calculated using the Manning's Equation as illustrated in the table below.

Table 6 – Summary of Full Flow Capacities of Proposed Swales /Retention Basins Capacities for Phase I Improvements

Street Name	Tributary Area	Retention Basin/ Swale No.	Full Flow Depth (FT)	Bottom Width (FT)	Top Width (FT)	Swale FL Slope (%)	Full Flow Capacity (CFS)	Swale/ Retention Basin Storage Capacity (FT ³)
Danenberg Drive (North Half)	AP 4-2	Swale #6	3	0	18	0.32	82.00	7,990.72
Wake Avenue (South Half)	AP 4-3	Swale #9	3	0	18.0	0.27	76.74	9,640
Wake Avenue (North Half)	AP 4-4	Swale #10	3	0	18.0	0.27	76.74	9,640
	AP 14*1				N/A			
	AP 15	Swale #7	3	0	18.0	0.10	45.86	18,902.80
		Swale #8	2.25	0	13.50	0.21	30.86	
	AP 16	Swale #4/WTP Central Retention Basin #1	1.50	0	9.0	0.42	14.80	
Imperial Avenue (East Half)	AP 17	Swale #5/WTP Central Retention Basin #1	1.50	0	9.0	0.21	10.47	62,577.23
		WTP Central Retention Basin #1	3	12	36	0.10	N/A	
	AP 18*2				N/A			
	AP 19	Swale #1	3.0	0	18.0	0.17	59.79	37,697.38

Street Name	Tributary Area	Retention Basin/ Swale No.	Full Flow Depth (FT)	Bottom Width (FT)	Top Width (FT)	Swale FL Slope (%)	Full Flow Capacity (CFS)	Swale/ Retention Basin Storage Capacity (FT ³)
		Swale #2	2.33	4	18.00	0.10	42.34	
		Swale #3* ³	2.0	4	16.0	0.10	30.34	

*¹ Retention Basin/ Swale design for the Tributary Area will be determined based on the final Caltrans design of the Interchange at the intersection of Interstate 8 and S. Imperial Avenue.

*² Tributary Area AP18 consists of the existing Imperial Avenue Roadway Section from Manuel Ortiz Avenue to Valleyview Avenue in the Buena Vista Park Subdivision (BVPS). Runoff from this area is drained via the existing Storm drainage Infrastructure into the existing BVPS Retention Basin.

*³ Swale #3 is located along the south half of Valleyview Avenue, extended easterly from Imperial Avenue.

Using a design percolation rate, including the safety factor, the storm runoff volume which can be percolated/dispersed within 72 hours detention period shall be estimated during the final design process for each future development to occur along Imperial Avenue.

3. PHASE II IMPROVEMENTS

Storm runoff flow rates for a 25-year, 24-hour storm and 100-year, 24-hour storm were estimated for the Phase II Improvements as illustrated in the table below.

Table 7 – Summary of Runoff Flow Rates for Proposed Ultimate Roadway Improvements (Phase II Improvements)

Area No.	Area		Coefficient of Runoff	T _c (HRS)	Storm Flow for a 25 year - 24 hour storm		Storm Flow for a 100 year - 24 hour storm	
	(FT ²)	(ACRE)			Intensity (INCH/HR)	Flowrate (CFS)	Intensity (INCH/HR)	Flowrate (CFS)
AP4-2	31,541	0.72	0.95	0.121	3.807	2.62	5.492	3.78
AP4-3	50,963	1.17	0.95	0.233	2.491	2.77	3.582	3.98
AP4-4	50,883	1.17	0.95	0.233	2.491	2.76	3.582	3.98

Area No.	Area		Coefficient of Runoff	Tc (HRS)	Storm Flow for a 25 year - 24 hour storm		Storm Flow for a 100 year - 24 hour storm	
	(FT ²)	(ACRE)			Intensity (INCH/HR)	Flowrate (CFS)	Intensity (INCH/HR)	Flowrate (CFS)
AP8	145,403	3.34	0.95	0.635	1.294	4.10	1.851	5.87
AP9	72,467	1.66	0.95	0.271	2.256	3.57	3.242	5.12
AP10	37,110	0.85	0.95	0.124	3.747	3.03	5.405	4.37
AP11	37,167	0.85	0.95	0.115	3.943	3.20	5.689	4.61
AP12	71,279	1.64	0.95	0.217	2.606	4.05	3.749	5.83
AP13	73,981	1.70	0.95	0.098	4.371	7.05	6.313	10.18
AP14	30,119	0.69	0.95	0.098	4.371	2.87	6.313	4.15
AP15	71,301	1.64	0.95	0.217	2.606	4.05	3.749	5.83
AP16	37,110	0.85	0.95	0.115	3.943	3.19	5.689	4.60
AP17	37,167	0.85	0.95	0.124	3.747	3.04	5.405	4.38
AP18	72,469	1.66	0.95	0.279	2.212	3.50	3.178	5.02
AP19	145,406	3.34	0.95	0.623	1.310	4.16	1.875	5.95

Design storm runoff volume for each proposed tributary area for the Phase II Improvements, consisting of a full built-out roadway sections within 110-foot right-of way, was calculated for a 3-inch rainfall storm event.

Table 8 – Summary of Runoff Volumes for Proposed Ultimate Roadway Improvements (Phase II Improvements)

Area No.	Area		Runoff Volume (FT ³)	Runoff Discharge Location
	(FT ²)	(ACRE)		
AP4-2	31,541	0.72	7,885.33	Proposed Desert Village Subdivision

Area No.	Area		Runoff Volume (FT ³)	Runoff Discharge Location
	(FT ²)	(ACRE)		
AP4-3	50,963	1.17	12,740.74	Unit 6
AP4-4	50,883	1.17	12,720.69	
AP8	145,403	3.34	36,350.87	
AP9	72,467	1.66	18,116.82	TBD Future Subdivisions along West Side of Imperial Avenue
AP10	37,110	0.85	9,277.51	
AP11	37,167	0.85	9,291.84	
AP12	71,279	1.64	17,819.74	
AP13	73,981	1.70	18,495.25	
AP14	30,119	0.69	7,529.77	Proposed Desert Village Subdivision Unit 6
AP15	71,301	1.64	17,825.17	
AP16	37,110	0.85	9,277.51	City of El Centro Water Treatment Plant
AP17	37,167	0.85	9,291.84	
AP18	72,469	1.66	18,117.18	Buena Vista Subdivision (Existing)
AP19	145,406	3.34	36,351.40	Proposed Linda Vista Subdivision

It was assumed that the design storm runoff generated from the proposed ultimate roadway improvements for the Phase II Improvements shall be stored at the future retention basins to be constructed with the development of the future subdivisions along the Imperial Avenue Extension Project. The onsite design storm runoff volume from AP 4-2, AP 4-3, and AP 4-4 from the future subdivisions and the off-site (Imperial Avenue half roadway sections) design storm runoff from AP 14 and AP 15 shall be conveyed through proposed storm drainage facilities and stored at the

future retention basin to be constructed at the proposed Desert Village Subdivision Unit 6.

The design storm runoff generated from the Imperial Avenue west half roadway sections along the east side of the Farmer Estates Subdivision (AP 3) and also from the east-half roadway sections of Imperial Avenue along the west side of the City of El Centro Water Treatment Plant (AP 16 and AP 17) shall be directed and stored at the Central Retention Basin, Retention Basin #1, proposed to be installed at the City of El Centro Water Treatment Plant.

The storm runoff generated from the existing east half paved roadway sections of Imperial Avenue along the west side of the Buena Vista Park Subdivision (AP 18) was designed to be stored at the existing retention basin within the Buena Vista Park Subdivision.

The design storm runoff generated from the east-half roadway sections of Imperial Avenue between Valleyview Avenue and McCabe Road (AP 19) shall be stored in the future retention basin to be constructed within the proposed Linda Vista Subdivision.

The design storm runoff generated from the west-half roadway sections of Imperial Avenue between Wake Avenue and McCabe Road shall be directed and stored at future retention basins to be constructed within the future subdivisions along the west side of Imperial Avenue.

V. PRELIMINARY RESULTS AND RECOMMENDATIONS

Hydrologic and hydraulic analyses were completed utilizing the methodologies presented in the County of Imperial Design Manual. A 3-inch rainfall with runoff coefficient with no soil absorption reduction factor ($C = 1$) was utilized to analyze the capacity of the proposed storm drainage facilities. A 100-year, 24-hour storm event was also evaluated whether a minimum two (2) 12-foot wide paved traffic lanes can be maintained at all times after the completion of the ultimate roadway improvements, Phase II Improvements, of the Imperial Avenue Extension Project.

1. DESIGN ASSUMPTIONS

A. Phase I and Phase II Improvements

The proposed improvements were assumed to be constructed in two (2) phases, Phase I and Phase II Improvements. Two (2) options were proposed for each phase. The City of El Centro shall select one (1) option for each phase or develop alternative options/phases. The phases/options proposed are as listed below:

Phase I Improvements will consist of the construction of two (2) lanes (Option A) or three (3) lanes (Option B) roadway along Imperial Avenue between McCabe Road and I-8. Side street roadway sections along Wake Avenue and Danenberg Drive shall also be constructed extending westerly from the existing pavement ends to Imperial Avenue. The intersections at Manuel Ortiz Avenue and at Valleyview Avenue shall also be completed to provide accesses to these two (2) existing side streets from Imperial Avenue.

Phase II Improvements will consist of the construction of the 110-foot wide (Right-of-Way) full width roadway sections along Imperial Avenue in addition to the Phase I Improvements. The storm runoff generated from the Phase II Improvements shall be drained into the proposed subdivisions along the east side only (Option A) or both sides (Option B) of Imperial Avenue.

B. IID Drainage Facilities

The entire length of Dahlia Lateral located along the east side of Imperial Avenue between McCabe Road and Danenberg Drive shall be undergrounded prior to the construction of the east two (2) or three (3) lanes roadway sections (Phase I Improvements).

A portion or the entire length of Date Drain shall be undergrounded prior to the construction of the west half of the Imperial Avenue Extension roadway sections (prior to the Phase II Improvements).

It was assumed that IID will allow the City of El Centro to utilize the existing underground irrigation/drain pipelines connected to Date Drain to drain the excess storm runoff generated from the Imperial Avenue Extension Project.

C. Caltrans Drainage Facilities

Caltrans is currently designing a new interchange at the intersection of I-8 and Imperial Avenue. Caltrans will extend a segment of Imperial Avenue southerly from the I-8 interchange to connect the new access ramp to the Imperial Avenue Extension Project. It was assumed that Caltrans undertake the storm runoff generated from the proposed interchange and extend the access ramp to Imperial Avenue up to the construction limits. It was assumed that the storm runoff generated from the Caltrans improvements shall not drain into the City of El Centro's proposed storm drainage system to be constructed with the Imperial Avenue Extension Project.

2. EXISTING STORM DRAINAGE ISSUES

Per our preliminary calculations, it seems that the existing retention basins constructed for the existing adjacent subdivisions were sized sufficiently for a 3-inch rainfall storm event. However, the existing storm drainage pipeline network system within the adjacent developed subdivisions are undersized and deficient in size as concluded in the Master Drainage Plan and as illustrated on the Deficiency Project Location Plan (Exhibit F). It is recommended that no additional storm runoff be directed toward or discharged at the existing subdivisions from the Imperial Avenue Extension Project Phase I and Phase II Improvements. The Imperial Avenue Extension Project Phase I and II Improvements will not change the existing flow patterns and conditions of the existing storm drainage system within the adjacent subdivisions. Flooding continues to occur at the locations identified in the Master Drainage Plan after the completion of the Phase I and II Improvements of the Imperial Avenue Extension Project.

3. PROPOSED DRAINAGE FACILITIES

A. Phase I Improvements

The proposed native earthen swale/retention basin was proposed to be constructed along the east side of the roadway sections and designed to store the design storm runoff during major storm events utilizing the County Method (3-inch rainfall with no reduction in "C" factor). The area, A, utilized to calculate the design storm runoff along Imperial Avenue and Wake Avenue were based on 40-foot wide roadway sections. The area, A, of the roadway sections along Danenberg Road was estimated by two (2) 12-foot wide paved traffic lanes with one (1) 8-foot wide Class 2 Base shoulder, totaling 32-foot wide roadway sections.

As the runoff coefficient is estimated to be 1.000 per the County of Imperial Design Manual, the design storm runoff volume will not increase even if the Class 2 Base shoulders were altered with paved shoulders. The finish design grades of the asphalt paved sections for the Phase I Improvements will be determined so that a minimum two (2) 12-foot wide traffic lanes will be above the 3-inch rainfall storm flooding zone at the most downstream locations along the entire length of Imperial Avenue.

An 18-foot wide triangular/trapezoidal swale/retention basin along the east pavement edge of Imperial Avenue will be required in order to retain the design storm runoff (3-inch rainfall). Similarly, 18-foot wide triangular native earthen swales shall be constructed along the both sides of Wake Avenue and on the south side of Danenberg Drive in order to retain the 3-inch rainfall for the Phase I Improvements. A 1,200-foot long x 36-foot wide x 3-foot deep retention basin will be required at the City of El Centro Water Treatment Plant. The retention basin will be sized to retain the storm runoff generated from the east half of Imperial Avenue roadway sections along the west side of Water Treatment Plant as well as the east half of Imperial Avenue roadway sections along the east side of the Farmer Estates Subdivision.

The proposed cross sections for the Phase I Improvements are illustrated on the drawing included in Exhibit B. The storm runoff volume from the Phase I Improvements will be stored within the proposed native earthen swale/retention basin.

B. Phase II Improvements

It was assumed that Phase II Improvements will consist of a full built-out roadway sections including four (4) traffic lanes, a center median and paved parkways/shoulders accommodated with P.C.C. curb and gutter and sidewalk along the both sides of Imperial Avenue within the proposed 110-foot Right-of-Way. There will be curb inlets to be installed at low grade break points and along the length of the curb and gutter at a constant interval, designed to maintain a minimum two (2) travel lanes dry at all times. The storm runoff generated from the proposed ultimate Imperial Avenue roadway improvement sections shall sheet flow toward the curb and gutter then continuously flow along the curb and gutter flowline to the nearest curb inlets. The accumulated runoff from the curb inlets shall

be conveyed through underground pipelines connected to the adjacent subdivisions to be ultimately discharged at the retention basins.

The preliminary locations and numbers of the curb inlets to be installed along the curb and gutters and the spacing required between the curb inlets were determined based on the preliminary design grades established along Imperial Avenue. The spacing required between curb inlets to drain a 100-year, 24-hour storm runoff estimated per the NOAA rainfall intensity data is 350 feet on center. Assuming that storage of the 100-year, 24-hour storm is allowed on the pavement sections, leaving two (2) dry lanes at all times, the spacing can be increased to 600 feet on center.

It is recommended that the City of El Centro require each proposed subdivision to be developed along the Imperial Avenue Extension to assure and verify that the onsite retention basin and all of the storm drainage facilities including the pipeline and the curb inlets are sufficiently sized in order to convey and retain/detain the storm runoff generated from the onsite improvements within the subdivision and also from the Imperial Avenue Extension Project. It is recommended that a project specific hydrology/hydraulic report be prepared by each developer for proposed development. Spread width calculations shall also be required to be included in the project specific hydrology/hydraulic report demonstrating that the number and the size of the curb opening of the curb inlets are accurately determined.

A central retention basin, Retention Basin #1, was proposed to be constructed, during the Phase I Improvements, within the City of El Centro Water Treatment Plant property for the ultimate Imperial Avenue Phase II Improvements. The retention basin may be expanded during the Phase II Improvements in order to take in any additional storm runoff volume which may need to be directed from the west half roadway improvements along Imperial Avenue.

C. Alternate Phases

There may be additional construction phases between the completion of the Phase I Improvements and Phase II Improvements as it is unknown when the adjacent properties will be developed or if Date Drain will be undergrounded prior to the commencement of the Phase II Improvements. If additional paved roadway sections be constructed prior to undergrounding of Date Drain, native earthen swale/

retention basin may be constructed between Date Drain and the proposed west pavement edge in a similar way as the Phase I Improvements were proposed to be developed. IID requires a minimum 12-foot wide access road reserved adjacent to Date Drain. In order to keep the 12-foot wide access road between the Date Drain and the proposed west roadway sections, additional 20-foot wide paved roadway area may be constructed from the west edge of pavement within the east half roadway section at the west half sections of Imperial Avenue.

D. Storm Drainage Facilities to be Provided by Future Subdivisions

Onsite storm drainage facilities including retention basins, underground pipelines, and catch basins within the proposed subdivisions shall be adequately sized and designed to retain and convey the design storm runoff generated from the proposed Imperial Avenue Extension Project as well as the onsite storm runoff.

E. Storm Runoff Detention

It is recommended that the existing IID drainage pipelines connected to the existing Date Drain be altered with new pipeline with a maximum allowable diameter designed with a slope to be utilized as discharge pipelines for the Phase I/II Improvements. The drainage pipelines shall function as alternate routes for the runoff to be eliminated from the proposed swales as the percolation rate of the swale may not be sufficient enough to disperse the stored runoff completely within 72 hours detention period.

As the existing Date Drain was assumed to be at its full capacity within 48 hours of a major storm event, the proposed discharge pipelines will be designed to discharge the stored storm runoff within 24 hours.

F. Maintenance of Storm Drainage Facilities

All the calculations completed for the preparation of this hydrology study were based under the assumption that the existing and proposed storm drainage facilities are maintained in good conditions. It is recommended that the City of El Centro maintain the existing and proposed storm drainage facilities in its original conditions for the facilities to function properly.

G. Mosquito Abatement Plan

If the standing water exists within the swales/retention basins or anywhere within the right-of-way of the Imperial Avenue Extension Project more than 72 hours retention period, the City of El Centro shall implement a Mosquito Abatement Plan to minimize/eliminate the propagation of mosquitos and other health concerning bacteria.