Attachment 2

CITY OF IMPERIAL BEACH

2010 Storm Drain Study

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Executive Summary

The purpose of the 2010 Storm Drain Study (Study) is to update the previous drainage study for Imperial Beach conducted in 1991 by BDS Engineering *(Bement-Dainwood-Sturgeon, August 1991)*. The results from this Study provide the preliminary analysis in the Storm Drain Master Planning process that will lead to the identification and prioritization of capital improvement projects that increase the capacity of the storm drain system. The scope of work for the Study consists of the following tasks:

- Review of Existing Data
- GIS Mapping and Field Verification
- Hydraulic and Hydrologic Modeling
- Identification of System Deficiencies

This Storm Drain Study is intended to be used as a planning tool for evaluating impacts to the storm drain system whether it is from new developments, capital improvement projects, or collection system improvements. The report provides hydraulic and hydrologic analysis for 7 large drainage areas and 15 smaller drainage areas in the City for the 2-year, 5-year, and 10-year storm flow conditions. This report identifies the existing capacity for each drainage area and provides preliminary recommendations on how to increase the capacity for the system.

The existing storm water conveyance system in the City is in need of capacity improvements to alleviate localized flooding. However, conveyance of storm water runoff in the City will always be a challenge due to the low elevations of drainage areas, flat gradient, and proximity of tidal areas. Possible improvements to address storm drain capacity issues include increased maintenance and cleaning, pipe replacement or construction of new conduits, pump stations, local storage, and low impact developments (LIDs). Any structural improvement to increase the capacity of the storm water conveyance system will need further analysis and modeling not provided in this study.

The table on the following page provides a summary of the hydrology and hydraulics for each of the drainage areas.

Table 1 Hydrology and Hydraulics Summary for Imperial Beach Drainage Basins

Drainage Basin	Drainage Area (Ac)	Runoff Flows (cfs) 2-yr, 5-yr, and 10-yr	Existing Capacity	Recommendations
A-1	65.1	24.1, 31.8, and 36.7	20 cfs	Additional inlets Date and Seacoast
A-2	72.1	30.8, 43.6, and 50.1	29 cfs	Improve timing at pump station
A-3	18.1	7.9, 11.2, and 12.8	2cfs - 18 cfs	Enhance pump station or detention pond on NRFF property
A-4	1.7	1.7, 2.4, and 2.7	> 2.7 cfs	No recommendations
B	27.8	12.2, 17.4, and 20	> 20 cfs	No recommendations
C	19.3	12.3, 17.2, and 19.6	> 17.2 cfs	Increase capacity of drain channel north of Cherry Ave
D	15.7	12.2, 17.3, and 20	20 cfs	Capture additional flows from Drainage Area E-1A
E-1A; E2	99.9	41, 59.4, and 68.8	33 - 39 cfs	Divert excess flow from E-1A north to Drainage Area D
E-1B	52.1	23.3, 33.6, and 39	< 23.3 cfs	Increase pipe size or install detention basin at MVSH
F-1	228	156.7, 257.4, and 292	< 156.7 cfs	Need additional modeling
F-2	28.7	10.2, 14.5, and 16.6	16.2 cfs	Enhance drainage between Grove Ave and Imperial Beach Blvd
F-3	21.7	20.2, 28, and 32	20.2 cfs	Improve drainage for F-1
F-4	39.5	19.9, 28.1, and 32.4	19.9 cfs	Improve drainage for F-1
F-5	19.1	14.8, 21, and 24.1	< 14.8 cfs	Detention or retention ponds at Veterans Park
G	39.5	19.8, 28, and 32.3	19.8 - 28 cfs	Construct additional drains to SD Bay between 7th and Cypress Ave
H	139.6	59.6, 88.7, and 103.7	< 59.6 cfs	Need additional modeling
J	35.1	17, 23.9, and 27.3	27.3 cfs	Maintain drainage channel on NOLF
K	111.3	51.1, 74.5, and 86.9	51.1 cfs	Construct drain pipe and inlets on Florence between Elder and Elm
K-12	9.1	7, 9.8, and 11.2	11.2 cfs	Maintain drain channel on 13th St
L	8.4	5.8, 8.2, and 9.3	9.3 cfs	No recommendations
M	48.1	23.4, 34, and 39.4	< 23.4 cfs	Increase capacity of V-channel between Grove and Holly
N	11.5	7.7, 10.8, and 12.4	12.4 cfs	No recommendations
O	5.7	7.9, 11.1, and 12.6	12.6 cfs	No recommendations
P; R	188.4	86, 125.4, and 145.3	< 86 cfs	Need additional modeling
Q	14.5	18, 25.4, and 29.2	29.2 cfs	No recommendations
S	50.4	29.4, 42.2, and 48.2	< 29.4 cfs	Need additional modeling
T	30.6	16.7, 23.3, and, 26.7	26.7 cfs	No recommendations
U	9	5.2, 7.3, and 8.4	8.4 cfs	No recommendations
V	8.3	5.4, 7.5, and 8.6	8.6 cfs	No recommendations
W	2.2	3.2, 4.4, and 5.0	4.4 cfs	No recommendations
X	20.1	26.5, 37.2, and 42.5	> 42.5 cfs	No recommendations

Chapter 1 Introduction

1.1 PROJECT PURPOSE

The purpose of the 2010 Storm Drain Study (2010 Study) is to update the previous drainage study for the City of Imperial Beach (City). The first storm drain study for the City was developed in 1960 and subsequently updated in 1991 *(Bement-Dainwood-Sturgeon, August 1991)*. The current study utilizes the most resent hydrologic and geospatial data for the region including the latest Land Use Map, the 2004 Light Detection & Ranging (LiDAR) technology topography mapping (Digital Mapping, inc), 2004 6-inch resolution aerial imagery, 2008 12-inch resolution aerial imagery, and the City's Geographic Information System (GIS) parcel boundaries, street center lines, and other data layers.

The existing drainage facility locations and pertinent information were collected by Michal Piasecki Consulting, Inc. (MPC). The information was collected from as-built plans, verified by extensive field reconnaissance, and put into the City's GIS. This information includes the location, elevation, slope, and dimensions of storm drain system main lines, catch basins and inlets, open channels, box conduits, and culverts etc that are publicly owned and maintained by the City.

The updated storm drain GIS data layers were used for the new hydrology and deficiency study. This information was used to delineate the drainage basin boundaries, and to calculate times of concentration, storm water runoff, and capacity of the existing storm drain system.

1.2 PROJECT AREA

The City of Imperial Beach is located in the south western portion of San Diego County. The drainage basin for the City's storm drain system is bordered on the south by Tijuana river valley and Estuary, on the north by the Otay River and San Diego Bay, on the west by the Pacific Ocean, and on the east by the City of San Diego.

The study area comprises 1,430 acres, including approximately 85 acres in the City of San Diego that contributes flow to the storm drain systems in Imperial Beach. Figure 1 presents the general location of the study area.

1.3 SCOPE OF WORK

The Scope of Work for the 2010 Storm Drainage Study includes the following tasks:

Review of Existing Data: MPC gathered and reviewed existing information including previous reports and as-built records, determining critical factors that influence hydrology and hydraulics modeling analyses, and identified local conditions that impact the performance of drainage system.

Mapping and Field Verification: MPC conducted field investigations to verify conditions of the existing storm drain system drainage structures. The majority of the catch basins and drain inlets were opened and photographed for future reference.

Hydrologic and Hydraulic Modeling: The storm drain system was modeled with CivilDesign Corporation software using hydrologic calculations based on the San Diego County Hydrology Manual (2003) Modified Rational Method.

Identification of System Deficiencies: From the modeling efforts hydraulic deficiencies within the storm drain system were identified. Each deficiency was evaluated to determine if the model results were realistic.

1.4 COMPARISON OF RESULTS

The current study has updated the City's 1991 Storm Drain Study (1991 Study) prepared by Bement-Dainwood-Sturgeon (BDS), and therefore it is important to compare the results of the current hydrology and hydraulics with the previous study and consider any variations and discrepancies.

The *2003 San Diego County Hydrology Manual (Manual)* was used as a basis of 2010 Study. The Modified Rational Method (MRM) outlined in this manual differs from method used in 1991 study. The major differences are:

1. San Diego County Hydrology Manual limits the size of initial area and initial time of concentration based on land use and slope, the method used in 1991 Study didn't have this limitation.
2. Ultimate land use and densities defined in the City's latest General Plan Land Use Map were used in this study, which differ from 1991 land use designations.
3. Runoff coefficient for this study was based on land use and density, which varies by sub drainage basins. The 1991 study by contrast assumed one relatively low runoff coefficient for the entire drainage area.
4. Latest topography, aerial imagery and updated storm drain system facilities have been utilized for the 2010 Study.
5. Hydraulic calculations used in 1991 Study assumed available Hydraulic Grade Line (HGL) based on evaluation of particular segment of storm drain pipeline, rather than the entire pipeline including outlet conditions, which led to overestimated capacity of the drain system.

Chapter 2. Drainage Area Characteristics and Study Methodology

2.1 STUDY AREA

Most of the study area is located within boundaries of City of Imperial Beach, with exception of the eastern boundary, where portions of tributary areas extend into the City of San Diego. The project area encompasses approximately 1,430 acres including 85 acres located within City of San Diego.

The study area was divided in 23 drainage basins, designated as A through X. Each drainage basin is served by a separate storm drain system. For this Storm Drain Study the drainage basins boundaries were determined based on the most current topographic map and drainage system.

Study area and general outline of drainage basins are presented in Figure 2.1.

2.2 SOIL AND TOPOGRAPHY

Soil properties influence the process of runoff from rain fall and are important to methods of runoff estimation. The soil type for Imperial Beach is based on the Soil Hydrologic Groups Map provided in the *City of San Diego Hydrology Manual (Appendix A)*. The dominant soil type is Soil Group D, which is characterized by clay soils having low infiltration and high runoff potential. The coastal area of Imperial Beach contains a narrow strip of Soil Group B of moderate to well-drained soils that are moderately fine to moderately coarse in texture and moderate permeability.

The study area is located on a gradually sloping plain with elevation ranging from 40 ft on the east to 0 ft along the coast.

Soils Map is presented in Figure 2.2.

2.3 LAND USE

The 2008 General Plan Land Use Map was used as the basis for the ultimate condition land use and land cover assumption for the hydrologic model. The Land Use Map is shown in Figure 2.3. The following Table 2.1 presents the land use designations, descriptions of those designations, and assumed effective percent impervious used for runoff factor. The percent impervious used for this study are from accepted values listed in the *2003 San Diego County Hydrology Manual (Table 3-1)*.

The subareas that are outside of the City of Imperial Beach boundary and drain into the City were assigned adjacent land uses from within the city and were then verified against the latest aerial photography for accuracy.

Table 2.1 Land Use Designation

Land Use	Designation	County Elements	% Impervious
Open Space	OS	Permanent Open Space	0
Medium Density Residential	R-2000, R-3000, R-1-6000,	Residential 7.3 DU/AC	40
Medium Density Residential	R-1-3800	Residential 11.5 DU/AC	45
Medium Density Residential	R-1500	Residential 14.5 DU/AC	50
Commercial	C-1, C-2, C-3	Neighborhood Commercial	80
Mixed Use	MU-1, MU-2	Neighborhood Commercial/High Density Residential	80
Public Facility	PF	School, Park	25
Public Facility	PF	City's Yard	80
Rail	Rail	Railroad Right-of-way	25
Road	Road	Roadway	95

2.4 SELECTION OF HYDROLOGIC METHOD

The runoff calculation methodology conforms to commonly accepted practices utilized in San Diego Region. The modified rational method as described in the *San Diego County Hydrology Manual (June 2003)* was used to obtain the runoff results.

Chapter 3 describes the rationale behind each of the parameters used in the storm water runoff calculations. The hydrology for this study was modeled using CivilDesign Software (RSB3). Detailed model input/output and supporting maps can be found in Appendix "D" (bound separately).

2.5 STORM FREQUENCY

Storm frequency is the reciprocal of return period. A frequency of 1/*T*, or one in *T* years, corresponds to return period of *T* years. For instance a 5-year storm is one of a magnitude that occurs on average every 5 years.

The design storm discharge for this study was calculated for 2-year, 5-year, and 10-year storm frequency.

2.6 DRAINAGE BASIN DELINEATION

Drainage basins provide the basis for all hydrologic calculations in this study. The drainage basins delineated in the 1991 Study, were verified and adjusted based on information obtained from field investigations, geospatial data, and changes in drainage patterns due to new improvements and facilities constructed in the study area.

The following rules were applied to drainage basin delineation:

- Runoff from the properties drains into the streets or alleys; there is no drainage flow across adjacent properties.
- Flow is perpendicular to contour lines and away from high points
- Flow paths do not cross over delineation lines that mark the drainage boundaries
- Runoff is contained in the streets or alleys
- Direction of the street/alley flow, high points and street inlets were used to determine basin's boundary.
- Direction of flow through street intersection was determined by location of cross-gutters, for intersections without cross-gutters, direction of drainage flow follows alignment of curb & gutter.
- Verify in field location of land use and physical obstacles such as walks, parking, landscaped areas, fencings, hardscape which may change general drain pattern.

2.7 FIELD INVESTIGATION

Drainage basins, sub drainage areas, and drainage facilities were identified and verified through filed investigations and through discussions with City staff. During field investigations information on the location, size, and elevation for each drainage facility was recorded and updated into the City's GIS database. Photos were also taken of manholes and catch basins and included in a digital photo library.

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2.8 DATA REVIEW

The 1991 Study and the City Utility Map was used as a starting point for analyzing the existing drainage facilities. Previous drainage studies and as-builts plans for some of the storm drain improvements were obtained from City staff.

Data review, field investigation, and input from the City operational staff were used to create hydrology model for this study.

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Chapter 3. Hydrologic and Hydraulic Methodology and Results

3.1 HYDROLOGY MODEL

3.1.1 General

The hydrology model predicts the volume of flow generated at any point in the watershed from a defined rainfall event, which in this study is the 2-year, 5-year, and 10-year storm event. Nodes were located at critical drainage facilities. A node represents a location where runoff rates were calculated. Usually node numbers are the same as cleanouts or inlet numbers.

3.1.2 Rational Method (RM) and Modified Rational Method (MRM)

The general computation process for the MRM is identical to the RM procedure with exception to calculating peak flow when combining independent drainage system at a junction. The calculation procedure is outlined in *Chapter 3.4* of the *San Diego County Hydrology Manual.* MRM procedure was used in this study. The copies of relevant supporting material from *San Diego County Hydrology Manual* used for this study are enclosed in Appendix "C".

The RM formula estimates the peak discharge rate Q at any location in the watershed as a function of the drainage area *A*, runoff coefficient *C*, and rainfall intensity *I*, for the duration equal to the time of concentration T_c, which is the time required for water to flow from the most remote point of the basin to the location analyzed:

$$Q=CIA$$

Where :

Q - peak discharge , in cubic feet per second (cfs)

C – runoff coefficient, dimensionless

I – average rainfall intensity for a duration of T_c, in inches per hour (in/hr)

A – drainage area contributing to the design location, in acres (AC)

3.1.3 Runoff Coefficient

Runoff coefficient *C* values are based on the land use designations described in the City of Imperial Beach General Plan and soil type. Runoff coefficients were selected from *Table 3-1 "Runoff Coefficients for Urban Areas"* of *San Diego County Drainage Manual*. Weighted *C* values were then calculated based on percentage of actual land use/soils types for each drainage area.

Runoff coefficients and drainage areas for individual drainage basins can be found in Appendix "B".

Table 3.1 Runoff Coefficients

Land Use	Designation	County Elements	Runoff Coefficient "C"	
			Soil "B"	Soil "D"
Open Space/Urban Res.	OS	Permanent open Space	0.25	0.35
Medium Density Residential	R-2000, R-3000, R-1-6000,	Residential 7.3 DU/AC	0.51	0.57
Medium Density Residential	R-1-3800	Residential 11.5 DU/AC	0.54	0.60
Medium Density Residential	R-1500	Residential 14.5 DU/AC	0.58	0.63
Commercial	C-1, C-2, C-3	Neighborhood Commercial	0.77	0.79
Mixed Use	MU-1, MU-2	Neighborhood Commercial/High Density Residential	0.77	0.79
Public Facility	PF	School, Park	0.41	0.50
Public Facility	PF	City's Yard	0.90	0.90
Rail	RAIL	Railroad Right-of-way	0.41	0.50
Road	Road	Roadway	0.85	0.85

3.1.4 Time of Concentration and Initial Time of Concentration

The Time of Concentration *Tc* is the time required for runoff to flow from the most remote part of the drainage area to the point of interest. The *Tc* is the sum of two components: initial time of concentration *Ti* and Travel Time *Tt.*

$$Tc = Ti + Tt$$

The *Ti* is the time required for runoff to travel across the surface of the most remote subarea in the study, or "initial subarea". The *Ti* depends on land use and slope of initial subarea. The *Ti* for this study was established based on *Table 3-2* of *San Diego County Drainage Manual.*

The Tt is the time required for the runoff to flow in the watercourse (i.e. pipe, channel) or series of watercourses from the initial subarea to the point of interest. Velocities of the flow in the watercourses were calculated based on Manning equations.

3.1.5 Rainfall Intensity and Duration

The rainfall intensity *I* is the rainfall in inches per hour for a duration equal to the T_c for a selected storm frequency.

The intensity is calculated using following formula :

$$I=7.44xP_6x\ D^{-0.645}$$

Where:

P_6 – *adjusted 6-hour storm rainfall*

D- duration in minutes

D= Tc

P_6 was determined based on Isopluvial Maps for San Diego County, and adjusted to be within 45% and 65% of 24-hour storm rainfall P_{24}.

Table 3.2 below summarizes Rainfall Intensity used in this study:

Table 3.2 Rainfall Intensity

Storm Frequency	P_6	P_{24}	P_6/P_{24}	Adjusted P_6
2-year	*1 in*	*1.7 in*	*59%*	*1 in*
5-year	*1.4 in*	*2.3 in*	*61%*	*1.4 in*
10-year	*1.6 in*	*2.6 in*	*62%*	*1.6 in*

3.1.6 Hydrologic Results

The results of hydrologic calculations are enclosed in Appendix “D”. Detailed CivilDesign model input/output reports are provided for 2-year storm events for each drainage area. Less detailed summary reports are provided for each drainage area for 5-year and 10-year storm events.

3.2 HYDRAULIC METHODOLOGY AND RESULTS

3.2.1 Hydraulic Models

The purpose of the hydraulic analysis was to evaluate the adequacy of the existing storm drain system and to determine design options for inadequately sized channels and conduits.

The CivilDesign software calculates velocities, hydraulic grade lines, and Time of Concentration Tc by analyzing each hydraulic segment (pipe or channel between nodes) individually. To calculate the capacity for the entire system, additional calculations were performed using Manning's Equation.

Manning's Equation was used to calculate the storm water conduit maximum discharge capacity. The calculation was based on available Hydraulic Grade Line (HGL), conduit size, and hydraulic roughness of the structure (Manning's n-factor). The Hydraulic Grade Line is a measure of flow energy and can be thought of as the line coinciding with the level of water flowing at any point along an open channel. The HGL will differ between an open channel and a closed conduit flowing under pressure. The HGL is determined by subtracting the velocity head from the energy gradient.

The results of the hydraulic calculations and evaluation of existing system are tabulated and combined with hydrologic results and presented in Appendix "A".

3.2.2 Flow Rates

The hydrology model calculates runoff rates at each node for 2-year, 5-year, and 10-year storm events.

The model assumes that drainage inlets serving closed conduits have 100% capture efficiency. The model does not evaluate the adequacy of drainage inlets.

It should be recognized that the rate of discharge carried by any particular section of drain conduit is not necessarily the sum of the inlet discharge rates for any of the inlets upstream of that section. This difference may be significant especially for larger drainage areas with large T_c and small subareas located at the downstream end of the drainage basin.

3.2.3 Conveyance System

The hydraulic model for this study uses Manning's equation to relate the depth of flow in the waterway to a number of factors including the flow rate (Q), cross sectional area of drainage facility (A), slope of the drainage facility (s), and hydraulic roughness of the structure (n). The following Manning's roughness coefficients "n" were used:

Table 3.3 Manning "n" Coefficient

Drainage Facility	"n" Factor
Drain Pipe (any material)	0.013
Concrete Lined Channel	0.015
Grassed Channel	0.020

3.2.4 Outlet Conditions

The hydraulic calculation to find the maximum capacity of the drainage conduit was simplified to assume that the HGL at the outlet for pressure flow is equal to the elevation at the top of the conduit. This assumption can affect the calculation for maximum discharge capacity for larger diameter pipes or drainage boxes; however, considering the small gradient of the pipes in the study area, and their relatively long length, this assumption will marginally affect the calculated discharge capacity.

The outfall elevations are a major factor to consider in the performance of the storm drain system. All of the storms drain outfalls in the City discharge into tidally affected water bodies (Pacific Ocean, San Diego Bay, Otay River, or Tijuana Estuary). The model high tide elevation used for evaluating the outfall conditions in the City is 5.72 feet. The model high tide is based on the mean higher-high water mark at the San Diego Tidal Station (9410170) and adjusted for the NAVD 88 vertical datum. The model high tide is an important benchmark to consider because when tidal conditions completely occlude the top crown of an outfall pipe, the conveyance of that pipe gets severely reduced.

Table 3.4 presents the storm drain outfall conditions and indicates whether the outfall pipe is impacted by the model high tide elevation of 5.72 feet. The outfall locations that are impacted include E-1A, G, and F. These outfalls can expect to have severely impacted conveyance when tidal conditions rise above the top of the conduit pipe elevation.

During winter months, coastal storm surges and spring tide events can generate temporary tidal conditions that exceed the model high tide event and lead to possible conveyance impacts on other outfalls. Lager tidal swings also increases the probability of peak storm discharges coinciding with high tide conditions.

The impact of sea level rise on the capacity of the storm drain system is another concern that needs to be factored into the long term planning in the City. According to the 2008 San Diego Foundation Regional Focus 2050 Study on climate change related impacts to the San Diego Region; Imperial Beach can expect to have 12-18 inches of coastal sea level rise by 2050. The City will need to continue to evaluate the climate change related impacts on storm drain system as the science on local sea level rise becomes more precise.

The table below depicts the elevation of each storm drain outfall systems and their outlet elevations. Since the top of the pipe or drain box was used to calculate maximum discharge, only system where elevation of the top of the storm drain conduit is less than the model high tide elevation of 5.72 feet will be affected.

Table 3.4 Storm Drain Conduits Outlet Condition

Drainage Area	Drainage Conduit	Node No.	Invert Elevation	Top of Conduit Elevation
A-1	6’x1.5’ RCB	190	7.62	9.12
D	24” Pipe	197	4.37	6.37
E-1A	36” Pipe	110	1.62	4.62 *)
E-1B	24” Pipe	109	4.59	6.59
G	24” Pipe	183	2.66	4.66 *)
H	48” Pipe	131	2.04	6.04
F	54” Pipe	124	0.00	4.50 *)
K	36” Pipe	285	4.09	7.09
P	48” Pipe	396	2.86	6.86
U	18” Pipe	112	4.69	6.18

*)Drain System affected by Model High Tide of 5.72 feet

Chapter 4. Existing Facilities and Conditions

4.1 GENERAL

The existing storm drain system was modeled as accurately as possible given the available information and resources. Some simplifications of the storm drain system were necessary for the purpose of modeling. Generally, pipes 18-inch and larger were modeled, with exception of few minor systems, where relatively small size of contributing areas and drainage facilities required considering smaller pipe sizes to sufficiently model the existing drainage scheme.

The hydrologic and hydraulic conditions of the storm drain system were then modeled using the defined 2-year, 5-year, and 10-year rainfall events. The final results of the model identify existing inadequacies in the storm drain system and serve as a baseline for future evaluation of existing and proposed drainage improvements.

The drainage basin boundaries are shown in Figure 2.1. Summary of capacity of the existing drainage facilities and comparisons to 2-year, 5-year, and 10-year runoff events are presented in Appendix "A". Existing Drainage System is shown in Figure 4.1.

The following is a short synopsis of the existing drainage systems, as well as general observations regarding performance, and possible mitigation of capacity deficiencies.

4.2 DRAINAGE AREA "A"

Area "A" has a drainage basin of 158 acres and generally drains toward the Pacific Ocean and to an area north of the City limits onto U.S. Navy property (Naval Radio Receiver Facility). The majority of Area "A" is located west of 5th Street. Area "A" consist of 4 subareas designated as "A-1", "A-2", "A-3" and "A-4". Area "A" also includes two storm drain diverters that capture low flow urban runoff and first flush rain water from subareas "A-1" and "A-2" and diverts the flow into the sanitary sewer.

Subarea "A-1"

The Subarea "A-1" has a drainage basin of 65.1 acres and generates 2-year, 5-year, and 10-year flows of 24.1 cfs, 31.8 cfs, and 36.7 cfs respectively. Runoff from Subarea "A-1" drains via surface flow into the lowest point located at the intersection of Date Ave and Seacoast Drive. During low flow conditions the water is diverted into the sanitary sewer at the Date Ave storm drain diverter. The storm drain diverter was designed to capture flows up to 0.5 ft^3/sec. Flows that exceed 0.5 ft^3/sec will cause a shut off valve to close to bypass the diversion system where it then enters a 6'x1.5' high box culvert. This box culvert is approximately 270 ft long and exits directly into the ocean.

The 6'x1.5' high by 270 ft long box culvert has a maximum capacity of 56 cfs; however, there are a three factors that significantly impact the drainage in this area. First, the slope of drainage culvert conveying runoff flow into the ocean is very shallow with a slope of 0.2%. The result is that during low flow conditions, the water velocities in the box culvert are not adequate to flush sand and other deposits, which reduces its hydraulic capacity. Also, during storm events and higher tides, waves periodically push water back into the box culvert decreasing or even temporarily stopping its capacity.

Another significant factor is the slope of the street which collects runoff. Subarea "A-1" drains onto Seacoast Dr and flows along the curb and gutter to the drain box inlet located at the intersection of Date Ave and Seacoast Dr. The slope of Seacoast Dr averages approximately 0.3%. The hydraulic capacity of the gutter and street is only 10-11 cfs (two sides, depth 0.5 ft at the curb), which creates

inundated condition for almost any storm, especially at the lower section (near Date Ave) of Subarea "A-1".

The last factor that impacts drainage is the capacity of the storm drain inlet at Date and Seacoast. Storm water from Area "A-1" enters the box culvert through a single inlet that is approximately 15 ft wide. The approximate capacity of this inlet is only 20 cfs (depth of flow 8-inch). During larger storms as the intersection of Date Ave and Seacoast Dr floods due to limited capacity of the box culvert, the water rises until it crests at the high point approximately 100 ft north of Date Ave, and runoff continues north on Seacoast Dr until it reaches another low point at Palm Ave, where runoff from Subarea "A-2" also drains.

Subarea "A-2"

Subarea "A-2" has a drainage basin of 72.1 acres and generates 2-year, 5-year, and 10-year flows of 30.8 cfs, 43.6 cfs, and 50.1 cfs respectively. Surface runoff drains to the Palm Ave street end where flows enter into a wet well that is part of the Palm Ave Storm Water Pump Station that was recently completed in January 2009. The pump station includes two 6,500 gpm pumps with a total design capacity of 13,000 gpm (29 cfs), which equates to a storm magnitude of 2-years. Palm Avenue Pump Station is also equipped with a smaller, 250 gpm storm drain diversion pump designed to divert polluted nuisance and first flush water to the sanitary sewer system. Additionally, the improvements at the Palm Ave street end included a 18" stub line that can be connected to the Carnation Ave street end at a later date to improve the drainage in Area "A-3". The Palm Ave diversion pump was not included in the drainage calculations.

The Palm Ave storm water pump station was designed to alleviate the flooding of water during storm events along Seacoast Drive. Although the storm water pumps are only designed for the 2-year storm, the capacity of the system is limited by the amount of flow that can be carried into the wet well through the existing storm drain pipes. The capacity is also limited by the operation of the storm water pumps that require a recovery time between each pumping cycle. As of publishing this report the City and Port of San Diego are still evaluating the optimal pumping cycle during storm events to convey the greatest amount of storm water flows.

When Palm Ave street end reaches capacity of the pump station, the runoff crest approximately 50 ft north of Palm Ave on Seacoast Dr, and then continues by surface flow to the concrete drainage ditch at the intersection of Seacoast Ave/Carnation Ave and onto the Naval Radio Receiver Facility (NRRF). This section of Seacoast Ave also receives runoff from Subarea "A-3".

Subarea "A-3"

Subarea "A-3" has a drainage basin of 18.1 acres and generates 2-year, 5-year, and 10-year storm flows of 7.9 cfs, 11.2 cfs, and 12.8 cfs respectively. Subarea "A-3" also receives overspill runoff from Subarea "A-2" and can generate combined flows of approximately 9.7 cfs, 25.8 cfs, and 33.9 cfs for 2-year, 5-year, and 10-year storm respectively. The actual flow may be larger because these flows do not take into consideration any additional overflow from Subarea "A-1" into Subarea "A-2".

Runoff from Subarea "A-3" flows into a concrete drainage ditch that has a capacity of 18 cfs. The drainage ditch flows off City limits and into a retention basin on NRRF property. The retention basin only has a limited capacity before water starts to back up into the City. The Navy operates a storm water pump (Gorman-Rupp T6A-B) located at the YMCA Camp Surf that pumps approximately 925 gpm (2 cfs) of water to the ocean. However, once the detention pond fills, the Gorman T6 storm water pump is undersized to prevent storm water from backing up into the City.

Approximate slope of Seacoast Dr in Subarea "A-3" is 0.5% with hydraulic capacity of gutter and street at 20 cfs (two sides, depth 0.5 ft at the curb).

Subarea "A-4"

Subarea "A-4" has a drainage basin of 1.7 acres and generates 2-year, 5-year, and 10-year storm flows of 1.7 cfs, 2.4 cfs, and 2.7 cfs respectively. Runoff from Subarea "A-4" drains directly to the NRRF. The existing storm drain system for this drainage area is adequate to carry all flows.

Conclusions and recommendation

Seacoast Dr is a collector for all surface runoff from area "A"; due to its flat slope and only there outlet points (with limited capacity) the current periodic flooding will be difficult to eliminate without extensive improvements.

Date Ave and Seacoast Dr

To alleviate the periodic flooding of the intersection of Date Ave and Seacoast Dr additional storm drain inlets should be constructed on the east side of the Seacoast Dr and south of the existing inlet to intercept incoming flow before it reaches the intersection. Periodic cleaning and maintenance of the box culvert is essential.

Another option will be to construct new drain pipe along 2nd Street between Date Ave and Imperial Beach Blvd. The new pipe approximately 1000 ft long would collect runoff from approximately 20 acres east of 2nd Street and discharge it into the Tijuana River National Estuarine Research Reserve (TRNERR), significantly reducing runoff to Seacoast Dr. If this option is selected, additional studies are required to determine the pipe size, optimal alignment, and possible environmental constraints.

Palm Ave and Seacoast Dr

The Palm Ave street end improvements have helped alleviate some of the drainage issues from this area and improvements are still being made in the operation and timing of the storm water pumps. The only valuable option to relieve the drainage problems at this location is the same alternative presented in 1991 Study, i.e. construction of a new storm drain inlet on 2nd Street between Dahlia Ave and Seacoast Drive. The installation of a new storm drain pipe can then direct flows to the north onto NRRF property and into a proposed new detention pond. This alternative relies on the proper sizing and construction for the detention pond. The pipe size and alignment could be determined after more data regarding location, size and elevations of the proposed detention pond is available.

4.3 DRAINAGE AREA "B"

Area "B" has a drainage basin of 27.8 acres and generally drains by street surface flow to the north City limits along 3rd Street and discharges into NRRF. Area "B" generates 2-year, 5-year, and 10-year storm flows of 12.2 cfs, 17.4 cfs, and 20.0 cfs respectively.

Conclusions and Recommendations

The 2-year, 5-year, and 10-year runoff is contained within the street and no improvements are required.

4.4 DRAINAGE AREA "C"

Area "C" has a drainage basin of 19.3 acres and drains by surface concrete channels to the north City limits where it enter an existing ditch within an existing drainage easement. Area "C" generates 2-year, 5-year, and 10-year storm flows of 12.3 cfs, 17.2 cfs, and 19.6 cfs respectively.

Conclusions and Recommendations

The 2-year and 5-year runoff events are contained within the street or concrete channel with exception of the 12-inch pipe between Cypress Ave and Cherry Ave. Considering minimal runoff volumes and small drainage area, possible flooding due to inadequate capacity of this pipe will be minimal. No additional improvements are required for this area.

To accommodate the 10-year runoff event, the capacity of concrete drain north of Cherry Ave will need to increase. This can be achieved by widening existing channel or increasing the high of channel walls allowing for greater flow depth.

4.5 DRAINAGE AREA "D"

Area "D" has a drainage basin of 15.7 acres and drains by street surface flow to an underground storm drain system at Rainbow Dr and Calla Ave. Flows enter a drainage ditch along Hwy 75 and outflows to the San Diego Bay through a culvert under Highway 75. Area "D" generates 2-year, 5-year, and 10-year storm flows of 12.2 cfs, 17.3 cfs, and 20.0 cfs respectively.

Conclusions and Recommendations

The existing storm drain system is adequate to convey runoff for up to the 10-year storm event and no improvements are required. Drain cleanouts located along SR-75 are located in the densely vegetated ditch and periodic removal of debris and outgrown weeds is required.

The 1991 Study proposed the extension of the existing storm drain system about 900 ft south to Citrus Ave where it would intercept additional flows from Subareas "E-1A-1" and "E-1A-2" totaling 8.8 cfs 12.5 cfs, and 14.3 cfs for 2-year, 5-year, and 10-year storms respectively. The improvement would address drainage deficiencies for Area "E" but may as a result reduce the capacity of area "D". This new system would increase total runoff from Area "D" to 21 cfs, 29.8 cfs, and 31.6 cfs for 2-year, 5-year, and 10-year respectively. The improvement will also improve drainage in the vicinity of Bonito Ave and Citrus Ave currently served by surface concrete channel. Since maximum capacity of the existing system is 21 cfs, the existing system will be adequate only for 2-year storm runoff. The benefits of construction of this drain pipe shall be considered together with improvements for Areas "E-1A" and "E-1B".

4.6 DRAINAGE AREA "E"

Area "E" (including subareas "E-1A", "E-1B", and "E2") has a drainage basin of 152 acres and drains by surface channels and by underground pipe to the south and discharges to the Tijuana River National Estuarine Research Reserve (TRNERR). From Elm Ave south to the discharge point, drainage pipes serving Areas "E-1A" and "E-1B" parallel each other. Area "E-1A" is served by a 36-inch pipe and Area "E-1B" by a 24-inch pipe. These parallel systems are connected at the storm drain inlet at Elm Ave where a slightly elevated 12-inch pipe allows for connectivity of storm water flows for both drainage systems. The outlet pipe for Area "E-1A" in the Tijuana Estuary gets partially to completely occluded by tidal water so the 12-inch connector pipe at Elm Ave allows for increase conveyance during storm events through the outlet pipe of Area "E-1B".

Area "E2" and "E-1A" generates 2-year, 5-year, and 10-year storm flows of 41.0 cfs, 59.4 cfs, and 68.8 cfs respectively.

Area "E-1B" has a drainage basin of 52.1 acres and drains by street flow and underground pipe to the south and discharges to the TRNERR where the outfall pipe is collocated with the outfall for Area "E-1A". The drainage area for this system is located south of Elm Avenue and north of Imperial Beach Blvd and encompasses Mar Vista High School and South Bay Union Elementary School.

Area "E-1B" generates 2-year, 5-year, and 10-year storm flows of 23.3 cfs, 33.6 cfs, and 39.0 cfs respectively.

Both areas have the lowest point located at Elm Ave in the vicinity of Corvina St and 5th Street. The combined capacity of drain pipes downstream of Elm Ave is approximately 39 cfs (33 cfs when high tide occurs). The combined runoff from Areas "E-1A" and "E-1B" contributes 49 cfs, 70 cfs, and 80 cfs for 2-year, 5-year, and 10-year storm respectively. Since the surrounding areas have much higher elevation, Elm Ave becomes inundated and floods when runoff exceeds capacity of the storm drain system.

Conclusions and Recommendations

The existing storm drain system is not adequate to convey runoff from even a 2-year storm. The most troublesome area – low point at Elm Ave – becomes inundated and floods even during small storms. To alleviate this periodic flooding the capacity of the existing storm drain system needs to increase. One option is the construction of new a parallel pipe that replaces one or both of the existing drain pipes with a larger diameter pipe and drain box.

The other option is to construct an underground retention system under the existing Mar Vista High School baseball fields. The open park field is a suitable location for a retention type storm water BMP that could increase the capacity of the storm drain system and provide storm water treatment.

Improvement to the drainage conveyance system recommended for drainage Area "D" would also improve the conveyance of runoff for Area "E". The extension of the existing storm drain pipe from Area "D" into subareas E-1A-1, E-1A-2, and E-1A-3 could intercept additional flows totaling 8.8 cfs, 12.5 cfs, and 14.3 cfs for 2-year, 5-year, and 10-year storm flows.

Additional studies are required to determine the most economical and feasible option to solve the drainage deficiency for this area.

4.7 DRAINAGE AREA "F"

Area "F" (including all subareas) has a drainage basin of 324.1 acres and drains towards the Tijuana River National Estuarine Research Reserve (TRNERR). Tidal water can completely inundate the outfall pipe for Area "F" and impact the conveyance of the system. The main conveyance system for Area "F" is the underground storm drain pipe that runs along Imperial Beach, Blvd. Area "F" consist of 4 subareas designated as "F-1", "F-2", "F-3", "F-4", and "F-5".

Subarea "F-1"

Subarea "F-1" drains the area west of 13th St along Imperial Beach Blvd. The backbone of the drainage system is the combination of drain pipes ranging from 24-inch to 54-inch following alignment of Imperial Beach Blvd, Connecticut St, and Grove Ave discharging to the TRNERR. This underground drain system also serves Subareas "F-2", "F-3", "F-4" and "F-5".

The total runoff from the entire Drainage Area "F" (including all subareas) for 2-year, 5-year, and 10-year storm flows is 156.7 cfs, 254.7 cfs, and 292.0 cfs respectively.

Conclusions and Recommendations

Majority of the drainage system for Area "F-1" is undersized, and not adequate to handle runoff from even a 2-year storm.

The entire Subarea "F-1" underground drainage system needs additional modeling to determine the optimal combination of new and existing pipes to increase the hydraulic capacity of the system to carry the select magnitude 2-year, 5-year, or 10-year storm event. The tidal condition at the outfall into the TRNERR presents an additional challenge because high tides can completely inundate the storm drain pipe.

Subarea "F-2"

Subarea "I-2" has a drainage basin of 28.7 acres and drains the areas south of Fern Ave, East of 9th St, and north of Holly Ave. The runoff from Subarea "F-2" for 2-year, 5-year, and 10-year storm flows is 10.2 cfs, 14.5 cfs and 16.6 cfs respectively.

The drainage system consists of surface flows and concrete rectangular channels located within drainage easements. At the street crossings of Essex St and Emory St, these channels transition into V-type concrete cross-gutters. The runoff from Subarea "F-2" ultimately discharges onto 9th St and from there flows on the surface towards the drain inlet located at the intersection of 9th St and Imperial Beach Blvd.

The existing drainage channel system is adequate to convey up to 10-year runoff flow event.

Conclusions and Recommendations

Although the existing drainage channels are adequate to carry runoff up to the 10-year storm event, flows at the street crossings create localized flooding and is a potential hazard for local traffic and pedestrians. Also, the magnitude of flow along 9th St exceeds street capacity for even a 2-year storm.

The 1991 Study proposed a new underground pipe and storm drain inlets between Grove Ave and Imperial Beach Blvd to replace the above ground ditches and to improve the drainage scheme for Subarea "F-2". This option remains feasible as a potential solution to eliminate some of the street flooding. The 1991 study also warned of high costs associated with this solution due to an additional easement that is required to construct and maintain the proposed storm drain.

Subarea "F-3"

Subarea "F-3" has a drainage basin of 21.7 acres and drains area north of Imperial Beach Blvd and south of Elder Ave. The runoff from Area "F-3" generates 2-year, 5-year, and 10-year storm flows of 20.2 cfs, 28.0 cfs, and 32.0 cfs respectively.

The drainage system consist of street flow and underground piping system ranging from 18-inch to 24-inch, which connects to the main drain pipe serving Area "F-1" within Imperial Beach Blvd.

The existing drain system is adequate to carry runoff from up to 2-year storm, with exception of the 24-inch pipe segment at 9th Street between Ebony Ave and Imperial Beach Blvd. The capacity of this segment is limited by the high Hydraulic Grade Line at the connection point to the "F-1" System.

Conclusions and Recommendations

The hydraulic capacity of the existing system depends on the hydraulic performance from Subarea "F-1". Currently, the storm water backs up in the pipes of Subarea"F-1" and drastically reduces the available hydraulic head for the drainage system in Subarea "F-3". Improvements to the drainage system at Subarea "F-1" will overcome the capacity constraints for the Subarea "F-3" system. Therefore, no improvements to the existing system are recommended.

Subarea"F-4"

Subarea "F-4" has a drainage basin of 35.9 acres and drains areas along 8th Street and Downing St between Grove Ave and Imperial Beach Blvd. The runoff from Subarea "F-4" generates 2-year, 5-year, and 10-year storm flows of 19.9 cfs, 28.1 cfs, and 32.4 cfs respectively.

The drainage system consist of street flow and underground storm drain pipes that range from 18-inches to 24-inches. The drainage system of Subarea "F-4" connects to the main drain pipe serving Area "F-1" at Imperial Beach Blvd. The existing drain system is adequate to carry runoff from up to a 2-year storm.

Conclusions and Recommendations

The existing drain system is adequate to carry runoff from up to a 2-year storm. Improvements to the "F-1" system will increase capacity of drainage serving "F-4". No improvements to the existing system are recommended.

Subarea "F-5"

Subarea "F-5" has a drainage basin of 19.1 acres and drains an area located along 8th Street between Imperial Beach Blvd and Encina Ave. The runoff from Subarea "F-5" generates 2-year, 5-year, and 10-year storm flows of 14.8 cfs, 21.0 cfs, and 24.1 cfs respectively. The drainage system consists of street flow and underground storm drain pipes.

Runoff from Veterans Park conveys through a 12-inch pipe and discharges to a catch basin and 24-inch pipe that connects downstream to the Subarea "F-1" system near intersection of Imperial Beach Blvd and 8th Street. This catch basin also drains street runoff from the remaining portion of Subarea "F-5".

The existing drain system is not adequate to carry runoff from 2-year storm.

Conclusions and Recommendations

The 12-inch drainage pipe system serving Veterans Park is undersized and water backs up onto a local residence located at the north end of the Park. Reconfiguring the drainage at Veterans Park can allow for excess storm water flows to be stored in local depressions along the grass. Excess water will percolate into the ground or get conveyed through the main drainage system once pipe capacity becomes available. In addition, the 24-inch pipe along 8th Street that connects to Imperial Beach Blvd needs to be upsized to carry larger flows. The size will depend on the desired capacity (2-year, 5-year, or 10-year storm runoff) as well as on future capacity improvements to the Subarea "F-1" drain system.

A second option for this drainage is to utilize the open space at Veterans Park for an underground detention basin or cistern that would capture runoff from area "F-5" to be stored and used for irrigation at a later date. The total drainage area is approximately 19.1 acres, average runoff factor C=0.53, average precipitation for Imperial Beach is 7.9-inch/year. Assuming that 50% of theoretical runoff will be captured and diverted to the underground reservoir, the approximate amount will be 145,150 CF/year which equals to 1,086,000gal/year.

4.8 DRAINAGE AREA "G"

Area "G" has a drainage basin of 39.5 acres and drains by street surface flow primarily along 7th Street, to a point where it outflows via 24-inch pipe to the San Diego Bay (FWS Pond 10A). Area "G" generates 2-year, 5-year, and 10-year storm flows of 19.8 cfs, 28.0 cfs, and 32.3 cfs respectively.

Improvements to Pond 10A by the FWS are proposed for winter 2010. Improvements include infill of the south end of San Diego Bay for enhanced tidal flat habitat and opening the Pond 10A to tidal flushing. The impacts from these improvements on Drainage Area "G" are undetermined at this time and will need to be monitored.

Conclusions and Recommendations

Existing 24-inch pipe is adequate to convey runoff from up to 10-year storm during low tide condition, and it is slightly undersized for 10-year storm during high tide condition. Considering low probability of these occurrences as well as magnitude of deficiency, no improvements to this pipe are required.

The slope along 7th Street between Cypress Ave and Basswood Ave is relatively flat (approximately 0.5%). The conveyance for this section is not adequate to carry 5-year and 10-year runoff flows and may periodically overtop the curb during storm conditions.

Construction of additional drain(s) into the San Diego Bay to mitigate these periodic flooding conditions should be considered.

4.9 DRAINAGE AREA "H"

Area "H" has a drainage basin of 139.6 acres and drains the areas north of Encina Ave between Delaware St and 11th St and to the outfall at the Otay River. This area drains by a combination of street surface flow, grass lined open ditches, and underground storm drain system. Area "H" is also affected by tidal waters, which may reduce the capacity of the system during storm events. Area "H" generates 2-year, 5-year, and 10-year storm flows of 59.6 cfs, 88.7 cfs and 103.7 cfs respectively.

Majority of the drainage system for Area "H" is undersized, and not adequate to handle the runoff from a 2-year storm.

Conclusions and Recommendations

The entire Area "H" underground drainage system should be modeled and studied to determine the optimal combination of new and existing pipes to increase its hydraulic capacity to carry selected magnitude of 2-year, 5-year, or 10-year storm runoff flows. The suggested improvements in the 1991 Study provide a starting point for evaluating possible solutions to increase conveyance.

The outfall channel that runs between the Bayshore Bike Path and the outfall pipe for Area "H" is also a critical spot that can potentially reduce the conveyance of the existing storm drain system. Because tidal conditions can impact the outfall for Area "H", it is important to ensure that any sediment or debris buildup in the outfall channel is removed. Debris and sediment in the channel will reduce the conveyance of the system and potentially block the culvert pipe underneath the Bayshore Bike Path.

4.10 DRAINAGE AREA "J"

Area "J" has a drainage basin of 35.1 acres and drains by street surface flow the area from Grove Ave south along 11th Street to the existing open concrete lined ditch that discharges onto the Naval

Outlaying Landing Field (NOLF). The runoff from Area "J" generates 2-year, 5-year, and 10-year storm flows of 17.0 cfs, 23.9 cfs, and 27.3 cfs respectively.

Conclusions and Recommendations

The street drainage and concrete ditch are of adequate size to accommodate runoff from up to a 10-year storm and no improvements are necessary. However, during storm events, the trash grates along the drainage channel on NOLF property can accumulate debris and result in water backing up into Area "J" and flooding the streets.

4.11 DRAINAGE AREA "K"

Area "K" has a drainage basin of 111.3 acres and collects runoff by surface flow and underground storm drains from approximately Ebony Ave north to the Otay River. The runoff from Area "K" generates 2-year, 5-year, and 10-year storm flows of 51.1 cfs, 74.5 cfs, and 86.9 cfs respectively. The existing storm drain system is adequate to convey runoff up to a 2-year storm.

Conclusions and Recommendations

As indicated in 1991 Study the significant drainage issue is on Florence St between Elder Ave and Elm Ave, where the street grade is technically flat and storm water hardly drains in any direction. Proposed drain pipe and drain inlets from Florence St to the existing drainage system in the vicinity of Florida St will improve drainage problem in Florence St, and would also reduce street surface flow along Elm Ave, which is near capacity for 2-year storm event.

The proposed pipe size shall be determined based on the desired capacity for a 2-year, 5-year, or 10-year storm event.

4.12 DRAINAGE AREA "K-12"

Area "K-12" has a drainage basin of 9.1 acres and drains by street surface flow from north of Palm Ave, west of Florence St along 13th St, and discharges to Otay River at a low spot on 13th Street between Calla and Cypress. The runoff from Area "K-12" generates 2-year, 5-year, and 10-year storm flows of 7.0 cfs, 9.8 cfs, and 11.2 cfs respectively.

Conclusions and Recommendations

The existing street drainage is adequate to carry runoff from 2-year, 5-year, and 10-year storms and no improvements are recommended. Routine maintenance of the drainage channel on 13th Street between Calla and Cypress is recommended because over grown vegetation, debris, or trash can obstruct the drainage flow and cause localized flooding in the street.

4.13 DRAINAGE AREA "L"

Area "L" has a drainage basin of 8.4 acres and drains by street surface flow the area between 3rd and 4th Streets along Imperial Beach Blvd and Caspian Ave and discharges to the Tijuana River National Estuarine Research. The runoff from Area "L" generates 2-year, 5-year, and 10-year storm flows of 5.8 cfs, 8.2 cfs, and 9.3 cfs respectively.

Conclusions and Recommendations

The existing street drainage is adequate to carry runoff from 2-year, 5-year and 10-year storm and no improvements are recommended.

4.14 DRAINAGE AREA "M"

Area "M" has a drainage basin of 48.1 acres and drains the area south of Fern Ave to NOLF between 10th and 13th Streets. The runoff from Area "M" generates 2-year, 5-year, and 10-year storm flows of 23.4 cfs, 34.0 cfs, and 39.4 cfs respectively. Managing runoff for this area is extremely challenging due to the relative flatness of the drainage area.

The runoff from areas north of Grove Ave is collected by street flow to the local low point located in the vicinity of Grove Ave and Florence St where it is then conveyed by a V-shaped concrete channel (2.5-ft wide) to Holly Ave. This channel is located within the existing 6 foot wide drainage easement between private properties. The drainage channel exits at Holly Ave where runoff flows continue on the surface along 12th St to Oneonta Ave where it ultimately flows into the underground storm drain system consisting of a combination of 20"x30" oval pipes and 48" pipe. At that location this system flows south off the City limits and empties into an open concrete channel that continues west and then south into the NOLF storm drain system.

The V-channel is not adequate to carry runoff from even a 2-year storm. The street capacity of 12th St and Oneonta Ave and the underground storm drain system is capable to convey runoff from up to a 2-year storm, assuming that the downstream conditions (concrete channel within NOLF) have adequate hydraulic capacity.

Conclusions and Recommendations

The combination of a flat slope and high elevation at the discharge point to the NOLF storm drain system creates difficult conditions for an efficient drainage system. Also, any system will be limited by the capacity of the drainage channel located downstream of the City's system. The 1991 Study and *"Feasibility Report for Construction of an Underground Storm Drainage System from Grove Ave to Ream Field Paralleling 12th Street" Bement-Dainwood-Sturgeon 1988*, indicates that the NOLF channel has capacity for 5-year storm runoff. Additional recommended improvements for Drainage Area "M"are also provided in these studies.

The underground drainage system is only adequate to handle up to a 2-year storm. It is recommended that the underground storm drain system discharging to the NOLF channel be modeled to determine the optimal combination new and existing pipes and drain inlets to accommodate the select magnitude storm runoff event (2-year, 5-year, or 10-years). In addition, the V-shaped concrete channel between Grove Ave and Holly Ave should be replaced with an underground pipe or rectangular box to provide drainage for up to a 5-year storm. Also, the existing underground storm drain system south of Holly Ave should be upgraded to receive runoff for up to a 5-year storm. For larger storms, a pump station will be required as recommended in 1991 Study.

4.15 DRAINAGE AREA "N"

Area "N" has a drainage basin of 11.5 acres and collets runoff from north of Cypress Ave between 10th Street and 11th Street. At the end of 10th Street, runoff continues through a grass lined ditch along an old railroad right of way toward its outlet to Otay River. The runoff from Area "N" generates 2-year, 5-year, and 10-year storm flows of 7.7 cfs, 10.8 cfs, and 12.4 cfs respectively.

Conclusions and Recommendations

The street drainage is adequate to convey runoff from up to 10-year storm. Therefore, no improvements for this area are recommended.

4.16 DRAINAGE AREA "O"

Area "O" (including all Subareas) has a drainage basin of 5.7 acres with the drainage area located between the old railroad right-of-way and San Diego Bay. Area "O" consists of four Subareas (O-1", "O-2", "O-3" and "O-4") that discharge through individual drainage pipes to the Otay River. The total runoff from the entire Area "O" generates 2-year, 5-year, and 10-year storm flows of 7.9 cfs, 11.1 cfs, and 12.6 cfs respectively.

Conclusions and Recommendations

The existing drainage system is adequate to convey runoff from up to 10-year storm for Subareas O-1, O-2, and O-3. The existing drain pipe carrying runoff from sub-area "O-4" (City's Public Works yard) is adequate only a 2-year storm; however, the relatively flat grade will cause runoff from this area, after reaching capacity of drain pipe, to flow toward the railroad right-of-way. No improvements for this area are recommended.

4.17 DRAINAGE AREA "P"

Area "P" (including runoff from Area R) has a drainage basin of 188.4 acres. The drainage area north of Grove Ave drains by street surface flow and via underground drain system to the Otay River. Approximately 2/3 of total acreage of Area "P" is located within the limits of the City of San Diego. The underground drainage system also collects runoff from Area "R". The total runoff from Area "P" (including runoff from Area "R") generates 2-year, 5-year, and 10-year storm flows of 86.0 cfs, 125.4 cfs, and 145.3 cfs respectively.

Conclusions and Recommendations

The entire Area "P" underground drainage system needs to be modeled and studied to determine the optimal combination new and existing pipes for adequate storm water drainage. The underground drainage system for Area "P" is undersized, and not adequate to handle runoff from even a 2-year storm.

Continuous maintenance of the storm drain conveyance system is also a concern for the City because the majority of the system falls under the City of San Diego jurisdiction. During storm events City staff members have reported flooding associated with debris clogged in the City of San Diego storm drain line. Maintenance needs to be coordinated with the City of San Diego because any obstructions in the line will reduce the already undersized capacity for the system.

4.18 DRAINAGE AREA "Q"

Area "Q" has a drainage basin of 14.5 acres and drains portions of Highway 75 and the privately owned Bernardo Shores RV Park and discharges to the San Diego Bay. The total runoff from Area "Q" generates 2-year, 5-year, and 10-year storm flows of 18.0 cfs, 25.4 cfs, and 29.2 cfs respectively.

The runoff is contained on Bernardo Shores RV Park within V-shaped concrete-lined access alleys, which are adequate to carry runoff from up to a 10-year storm. Runoff ultimately drains to a low spot where a14-inch discharge pipe discharges into the San Diego Bay (Pond 10A). The 14-inch pipe has insufficient capacity for even a 2-year flow; however, due to proximity of San Diego Bay, the excess runoff can easily bypass this pipe, and flow directly to the bay without causing major flooding issues.

Conclusions and Recommendations

The existing drainage system for Area "Q" is adequate and no improvements are recommended. However, approximately 3 acres located within SR-75 right of way, drains directly to the trailer park property. The runoff for this sub-area is relatively small (3 cfs for 2-year storm), but poses the potential for flooding at the entrance to the trailer park, especially during heavy storms. The runoff from SR-75 can be divert directly to the bay or diverted into the Area "D" drainage system to remediate flooding concerns for the trainer park entrance.

4.19 DRAINAGE AREA "R"

Area "R" has a drainage basin of 61.9 acres and drains the area east of 15th Street that is primarily in the City of San Diego. Runoff drains by street surface flow to an underground drain system that connects to the Area "P" drainage system. The total runoff from Area "R" generates 2-year, 5-year, and 10-year storm flows of 32.2 cfs, 45.5 cfs, and 52.0 cfs respectively. The underground drainage system for Area "R" is undersized, and not adequate to handle runoff from even a 2-year storm.

Conclusions and Recommendations

The drainage system for Area "R" needs to be evaluated together with Area "P" drainage system in order to determine the most economical approach to satisfy capacity requirements for both systems. The contribution of runoff from Area "R" impacts the capacity of the drainage system in Area "P" and leads to street flooding at inlet locations during storms.

4.20 DRAINAGE AREA "S"

Area "S" has a drainage basin of 50.4 acres and drains the area south of Grove Ave and east of 14th Street. The area drains by street surface flow and through an underground drainage system where it connects to the existing City of San Diego storm drain system and discharges to the Tijuana River. The runoff from Area "S" generates 2-year, 5-year, and 10-year, storm flows of 29.4 cfs, 42.2 cfs, and 48.2 cfs respectively.

The capacity of the underground drainage system for Area "S" is not adequate to handle runoff from even a 2-year storm.

Conclusions and Recommendations

The entire Area "S" underground drainage system needs to be evaluated to determine the optimal combination of new and existing pipes for select magnitude storm runoff flows for 2-year, 5-year, or 10-year storm events. The capacity of the existing City of San Diego drainage system for Area "S" is unknown and should be determined as part of further evaluations. The capacity of the City of San Diego system will determine the proposed improvements to the Area "S" drainage facilities.

4.21 DRAINAGE AREA "T"

Area "T" has a drainage basin of 30.6 acres and drains the area bordered by Grove Ave and Iris Ave and Connecticut St and 5th St. Runoff drains by street surface flow to the TRNERR. The runoff from Area "T" generates 2-year, 5-year, and 10-year storm flows of 16.7 cfs, 23.3 cfs, and 26.7 cfs respectively.

Conclusions and Recommendations

The capacity of street drainage is adequate to carry runoff up to a 10-year storm. Therefore, no improvements are necessary.

4.22 DRAINAGE AREA "U"

Area "U" has a drainage basin of 9.0 acres and drains the area north of Imperial Beach Ave, between Seacoast Dr and 2nd Street. Runoff drains by street surface flow and underground drainage system to the TRNERR. The runoff from Area "U" generates 2-year, 5-year, and 10-year storm flows of 5.2 cfs, 7.3 cfs, and 8.4 cfs respectively.

Conclusions and Recommendations

The capacity of street drainage and underground system of Area "U" is adequate to carry runoff up to a 10-year storm. Therefore, no improvements are necessary.

4.23 DRAINAGE AREA "V"

Subareas "V-1" and "V-2" have a combined drainage basin of 8.3 acres and drain the area along the City's southern boundary by street surface flow onto NOLF. Subarea "V-1" drains the area along 9th Street via street surface flow onto NOLF. Subarea "V-2" drains runoff through a concrete lined circular brow ditch located at the intersection of Iris Ave and 9th St before flowing onto NOLF. The runoff from Area "V" generates 2-year, 5-year, and 10-year storm flows of 5.4 cfs, 7.5 cfs, and 8.6 cfs respectively.

Conclusions and Recommendations

The capacity of street drainage and brow ditch for this drainage area is adequate to carry runoff up to a 10-year storm. Therefore, no improvements are necessary.

4.24 DRAINAGE AREA "W"

Area "W" has a drainage basin of 2.2 acres and drains the area along Ebony Ave to 2nd Street. Area "W" drains via underground drainage system and discharges to the Pacific Ocean. The runoff from Area "W" generates 2-year, 5-year, and 10-year, storm flows of 3.2 cfs, 4.4 cfs, and 5.0 cfs respectively.

Conclusions and Recommendations

The capacity of street drainage for this drainage area is adequate to carry runoff up to a 5-year storm. Therefore, no improvements are necessary.

4.25 DRAINAGE AREA "X-1" AND "X-2"

Area "X" has a combined drainage basin of 20.1 acres with the drainage area located on the narrow peninsula along south Seacoast Dr in the southwestern corner of the City. This narrow drainage area is bordered by the Pacific Ocean from west and TRNERR from east. Runoff is collected and conveyed along Seacoast Ave and discharges via a number of short culverts, drain ditches, and gutters into the TRNERR. The total runoff from Area "X" generates 2-year, 5-year, and 10-year storm flows of 26.5 cfs, 37.2 cfs, and 42.5 cfs respectively.

Conclusions and Recommendations

The capacity of street drainage and culverts is adequate to handle relatively large flows; however, low street elevation, especially in the southern end of drainage area “V” where street elevation is only slightly higher than high tide elevation, prevents proper drainage during high tide conditions. Considering that these sporadic flooding conditions are inherent to this drainage area, no improvements are recommended. Periodic maintenance and removal of sand and silt accumulated during rain is essential.

Chapter 5. Summary

5.1 EXISTING SYSTEM DESCRIPTION AND CONSTRAINTS

The City of Imperial Beach storm drain collection system collects storm water runoff from an approximately 1,430 acres including approximately 85 acres located outside of City's administrative boundary. The existing storm drain system is comprised of underground pipes, open drainage channels, box culverts, manholes, catch basins, and pump stations. The watershed area consist of 7 larger basins (Areas: "A", "E", "F", 'H', 'K', 'P' and 'R' and 15 smaller basins (Areas: "B', "C", "D", "G", "J", "L", "M", "N", "O","S", "T","U", "V", "W", "X"). Runoff directly discharges to the Pacific Ocean, San Diego Bay, Otay River, or the Tijuana River National Estuarine Research Reserve.

The watershed area drained by the City's storm water conveyance system periodically experiences localized flooding during the wet weather season due to capacity constraints throughout the system. This drainage study indicated that many parts of the storm drain system do not have adequate capacity to accommodate even rainfall runoff from the 2-year storm event. Flooding is a public safety concern that causes traffic issues, and can potentially cause road and property damage.

The 2-year storm event was used as the baseline to evaluate the current performance of the storm drain system. Future analyses associated with storm drain master planning should evaluate the improvements to the storm water conveyance system necessary to achieve the desired level of protection.

Figure 5 depicts existing storm drain system deficiencies.

5.2 IMPROVEMENTS TO ADDRESS STORM DRAIN CAPACITY ISSUES

The existing storm water conveyance system is in need of capacity improvements to alleviate localized flooding in the several parts of the City. However, it should be recognized that the low elevations of drainage areas, flat gradient and proximity of tidal areas will always challenge any mitigation efforts.

Following are possible alternatives to address system capacity issues:

5.2.1 Pipe replacement or construction of new conduits.

Pipe replacement is an option utilized when the capacity of an existing pipe is inadequate or when a pipe is in poor condition. Proposed improvements can be assessed through storm water modeling to achieve the desired hydraulic performance for the system.

5.2.2 Pump Stations

Pump stations can aid in the management of storm water by facilitating the movement and timing of storm water conveyance through the system. Pump stations are used to mechanically control flow through a storm drain system and alleviate-localized flooding. The limitations of pump stations include high capital and maintenance costs, space constraints, and permitting.

5.2.3 Local Storage

Detention/retention basins are local storage options for runoff in lieu of conveyance system improvements. Local detention storage is designed to store excess runoff, treat pollutants, and reduces size upgrades to storm drain system.

The use of detention basins is somehow limited for use in City's boundary due to difficulty to site such facilities in developed areas. There is some potential to locate underground detention basins under school's ball fields and public parks. Feasibility of construction of such facilities shall be conducted during planning process.

5.2.4 Runoff reducing practices

Runoff to storm drains can be reduced community-wide through innovative re-development planning and implementation of low impact development practices (LID). Utilizing runoff reduction approach maximizes storm water locally by managing its movement with structures that allow more storm water to be captured on-site. Structures that off-set the storm water impacts from impervious surfaces include strategically-placed vegetated buffers, grassy strips and swales, and permeable pavement. The implementation runoff reduction structures can have additional benefit of slowing and reducing the volume runoff to storm drains, and allowing water to infiltrate into the ground, promoting groundwater recharge. However, implementation of LID's in an already developed area such as City of Imperial Beach can be expensive and is generally done over a long period of time as redevelopment occurs.

5.3 STORM DRAIN MASTER PLANNING

In order to implement storm drain improvements and alleviate capacity deficiencies, the City will need to conduct a formal storm drain master planning process. This process will ultimately identify and prioritize capital improvements projects necessary to provide capacity to convey the design storm event throughout the storm drain system. This preliminary analysis was based on the 2-year storm event; however, the actual level of protection to be used in the development of a storm drain master plan would be determined as part of future analyses associated with storm drain master planning.

Depending on a community's specific needs, storm drain master planning steps and tasks may vary. The City has already begun a key component of the master planning process by developing a model of the storm drain system that includes all major pipes within the drainage basin. The primary phases of a storm drain master planning process include data collection and verification, modeling, conceptual alternatives development, and alternatives analysis and development of a capital improvement program. The phases, and a description of the steps required in each phase are described below.

5.3.1 Phase I — Data Collection and Verification

Infrastructure review and field verification: This step has been already completed during this study. Extensive field investigation verified location and size of existing facilities. The elevations were surveyed using Zip Level PRO2000, major facilities were photographed and pictures are integrated with City's GIS.

Next Steps :

Design standards: Select the desired level of protection – 2-year, 5-year, or 10-year storm event, and use it to evaluate the storm drain facilities.

Rainfall and flow monitoring: This step requires collection of data for multiple storm events at multiple locations throughout the storm drain system. Based on the size of the storm drain system, flow monitoring should be conducted at approximately 8 locations in the system for major subasins.

5.3.2 Phase II — Modeling and Conceptual Alternatives Development

Model calibration: The flow and rainfall data collected as part of Phase 1 would be used to calibrate the existing model to a selected storm event.

Design flow simulation: Stormwater modeling will then be conducted for a number of design events to identify system deficiencies and correlate them with areas of known flooding.

Improvements analysis and alternatives development: This step will include modeling conceptual improvements to assess potential benefits to the system and developing a suite of conceptual alternatives.

5.3.3 Phase III — Detailed Alternative Analyses

Evaluate alternative feasibility: Once alternatives are developed in Phase 2, a feasibility analyses will be conducted based on evaluation criteria such as performance criteria, preliminary cost estimates, contractility assessment, community impacts, and maintenance issues.

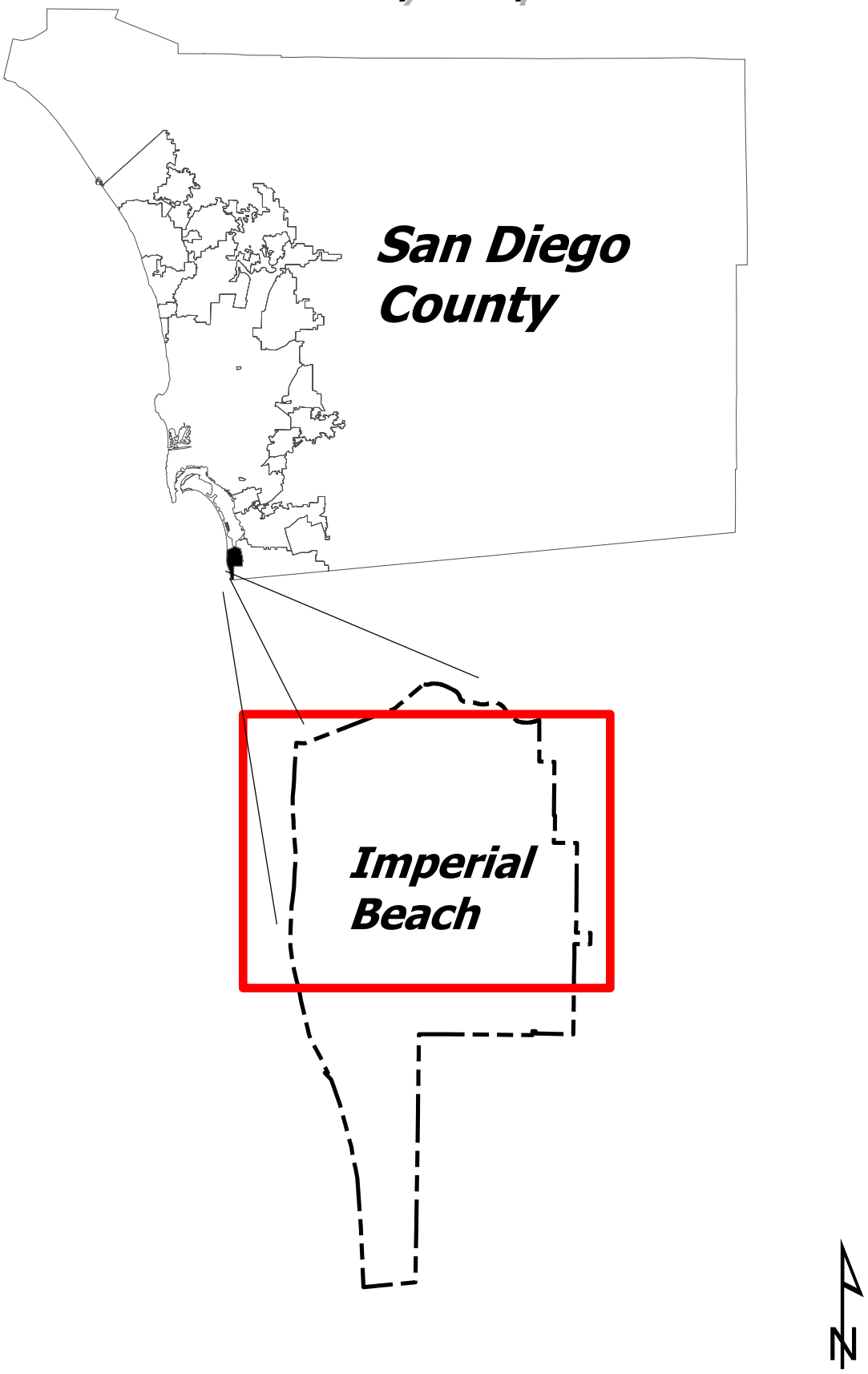
5.3.4 Phase IV — Development of Capital Improvement Program

Prioritization of recommendations: This step includes prioritizing and phasing recommended improvements against a set of evaluation criteria.

Capital Improvement Program Development:: This step includes preliminary cost estimating of the recommended improvements and development of a schedule for program implementation. Additionally, funding options for the recommended program improvements should be identified.

Conducting a storm drain master planning process, as outlined above would identify deficient infrastructure and provide solutions to alleviate localized flooding and overflows for a selected rainfall event, assess the validity of proposed recommendations, prioritize the most feasible recommendations, and provide a capital improvement program for storm drain improvements.

Vicinity Map



City of Imperial Beach Storm drain Study August 2010

Location Map

Figure 1

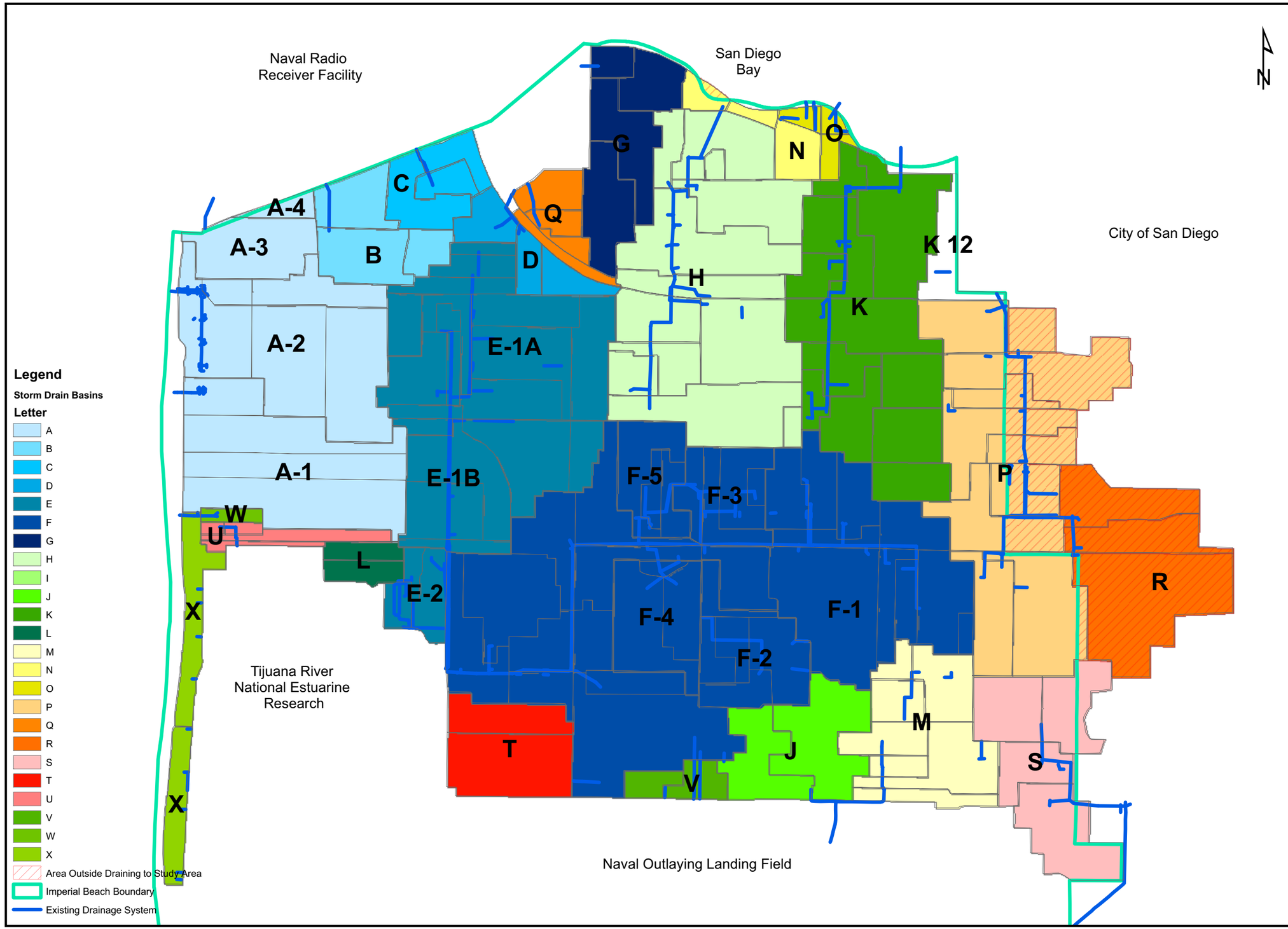


Figure 2.1

City of Imperial Beach
Storm Drain Study August 2010

Study Area Drainange Basins

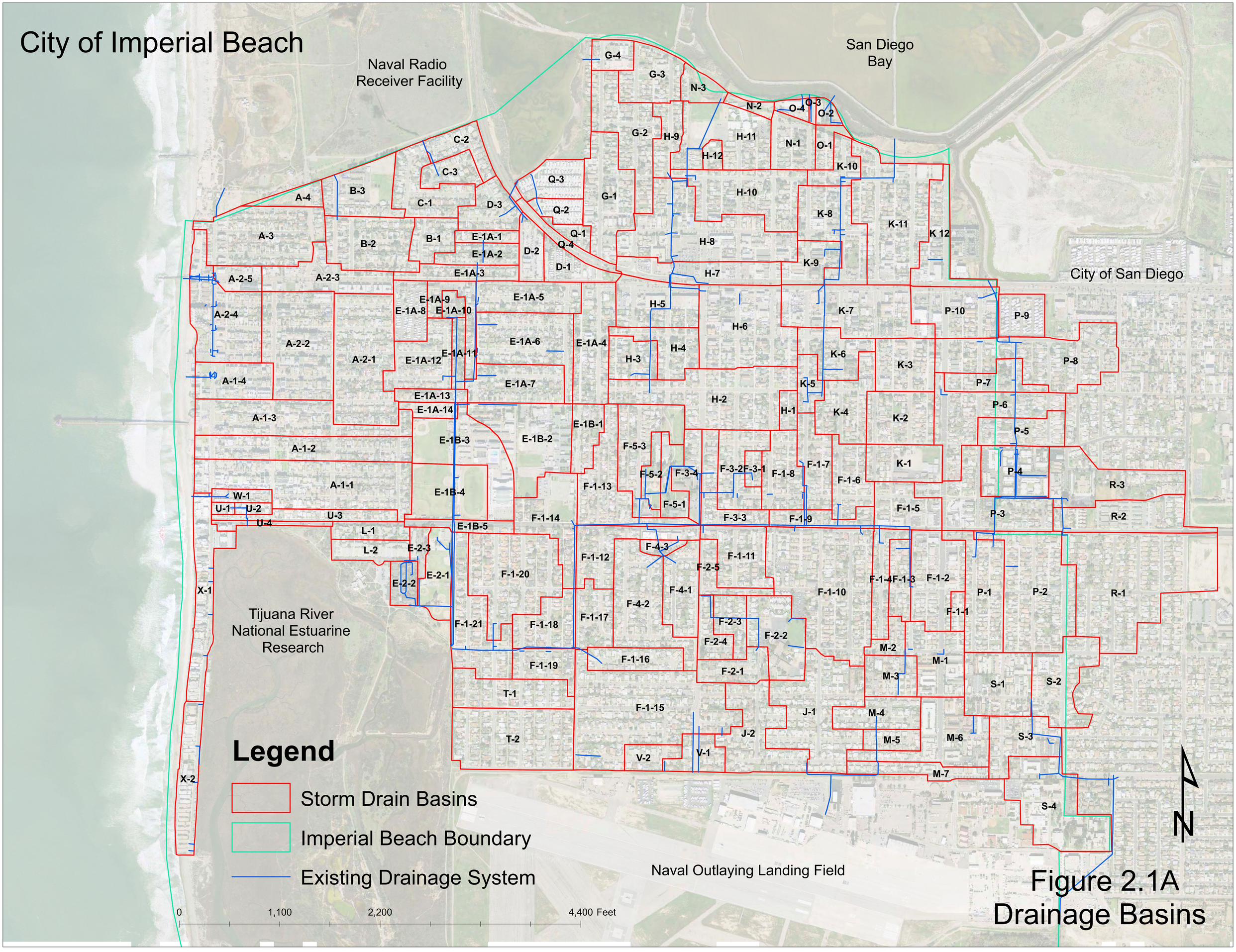
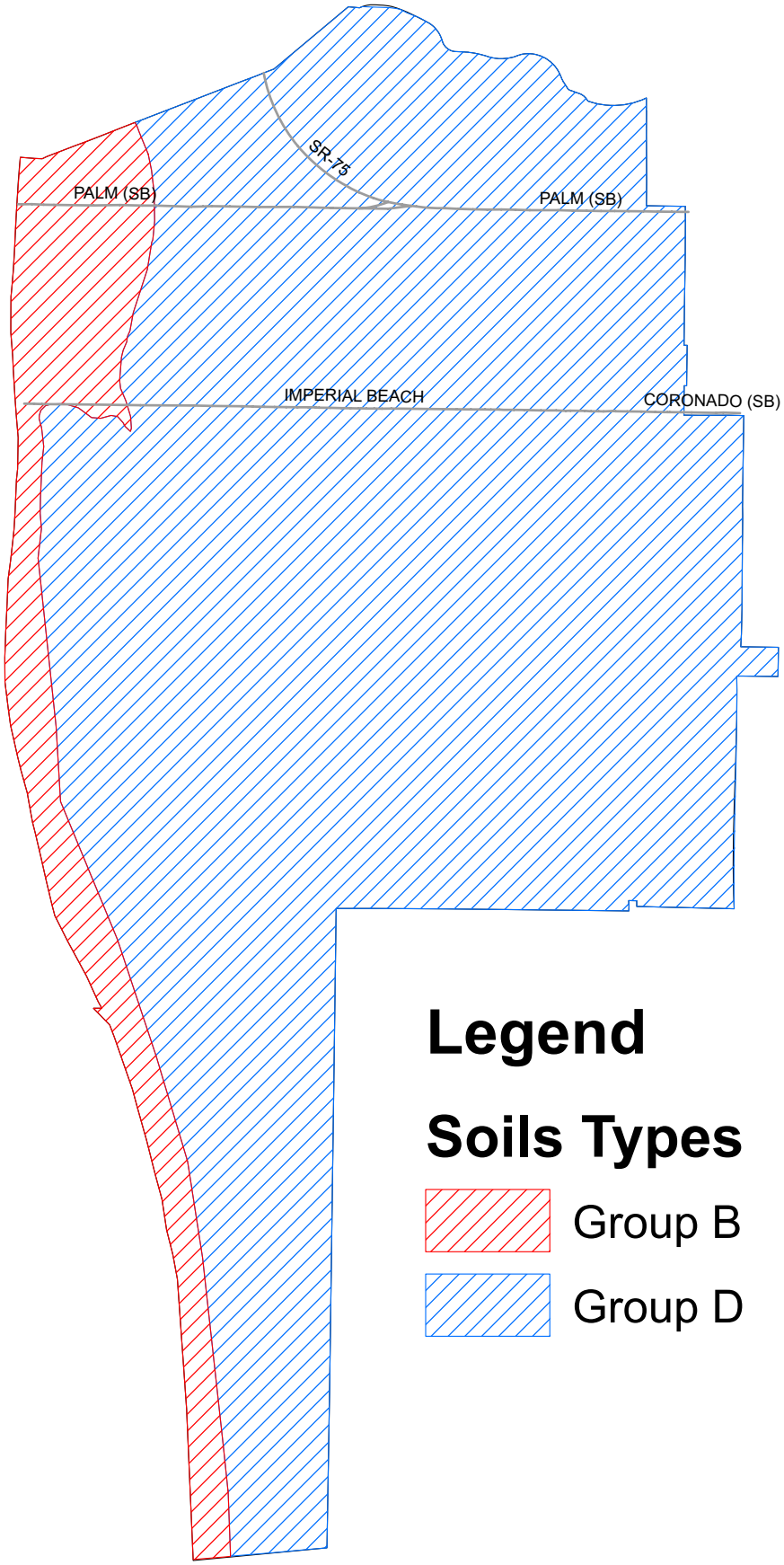


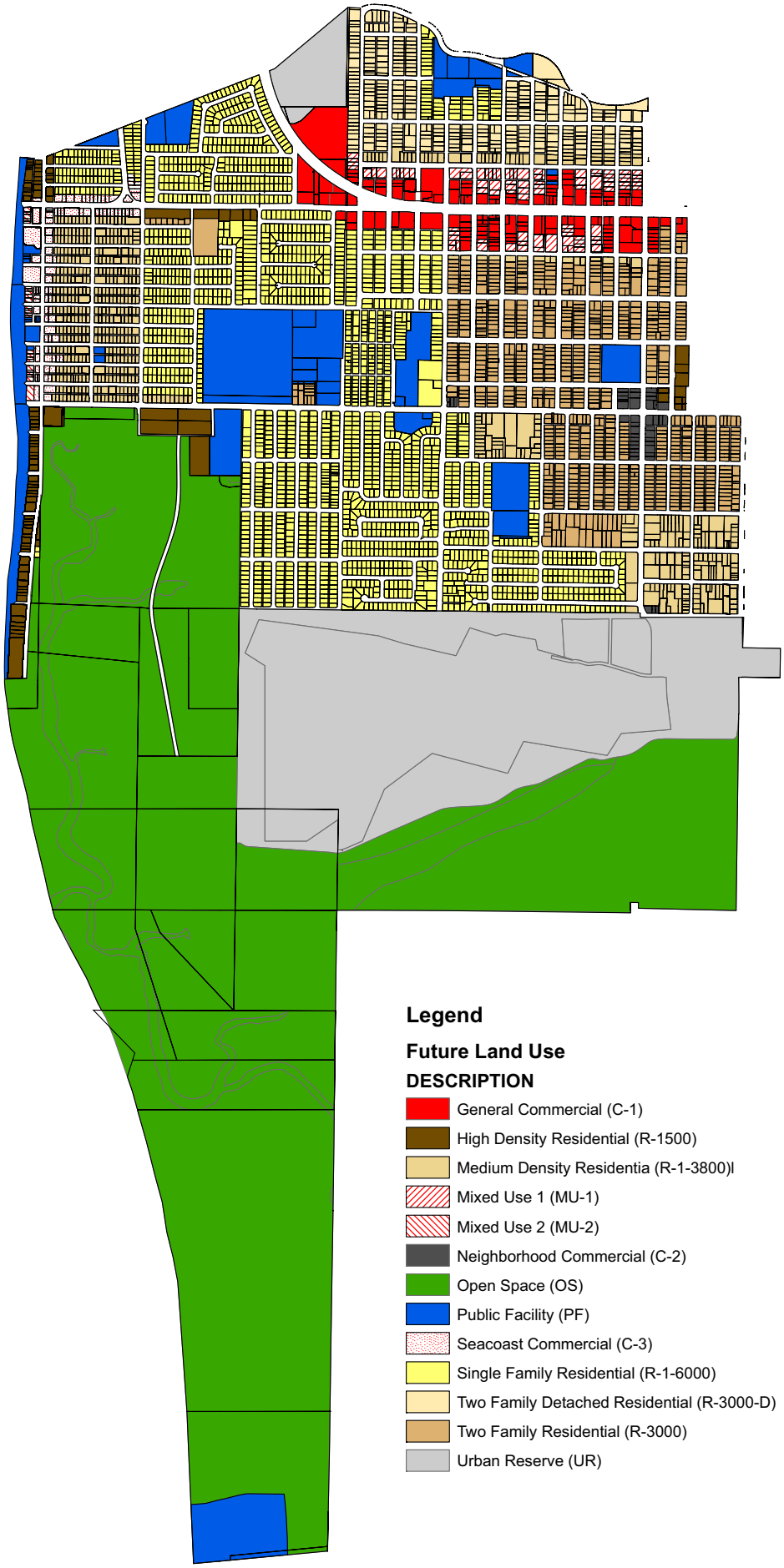
Figure 2.1A
Drainage Basins



City of Imperial Beach Storm drain Study August 2010

Soils Map

Figure 2.2



City of Imperial Beach Storm drain Study August 2010

Ultimate Land Use

Figure 2.3

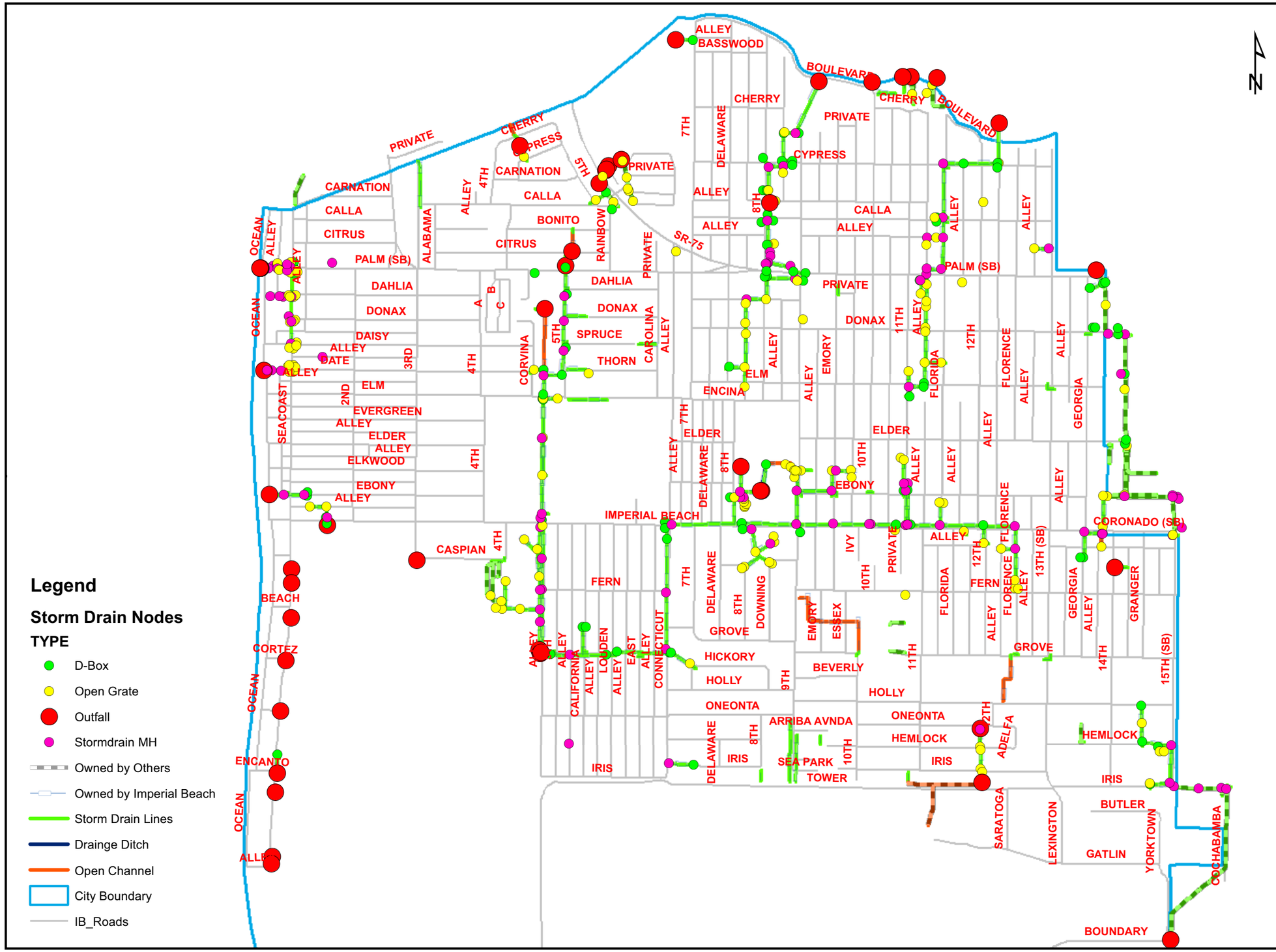
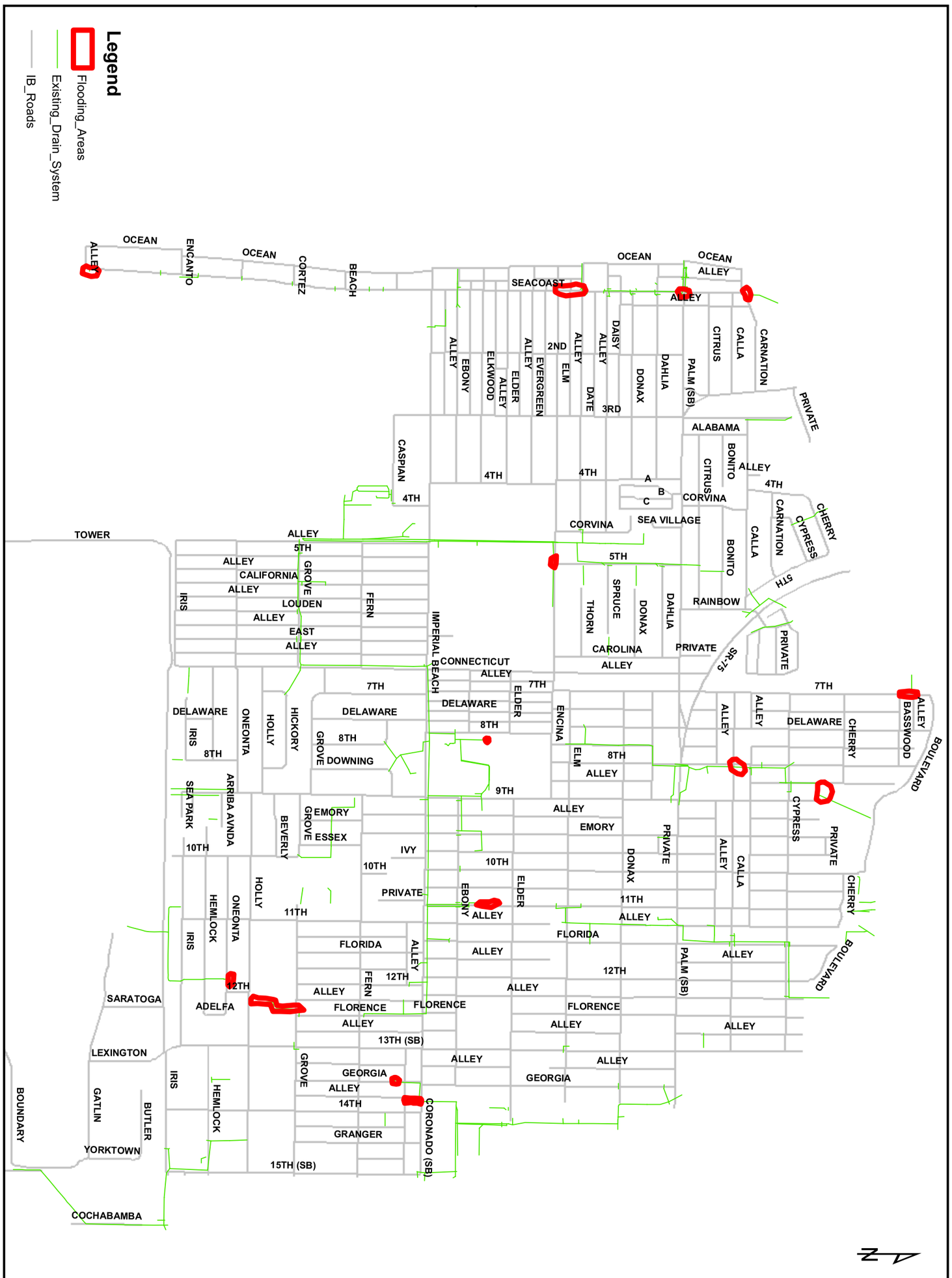


Figure 4.1

City of Imperial Beach
Storm Drain Study August 2010

Existing Storm Drain System



City of Imperial Beach
Storm Drain Study August 2010

Flooding Areas

Figure 5.0

City of Imperial Beach Storm Drain Study

Appendix A

Hydraulic Capacity Analysis of Existing Storm Drain System

Drainage Area - Area "A"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
A-1	190 - 34	Seacoast/Date	1.5' x 6' Box	0.59	56.2	24.1	31.8	36.7

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
A-2	192 - 330	Seacoast/Palm Pump Station	30" Pipe	0.76	35.7	30.7	43.6	50.1
	330 - 414	Seacoast/Palm Pump Station	42" Pipe	0.76	87.7	30.7	43.6	50.1

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Channel Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
A-3	16 - 16.2	Seacoast/ Carnation	Trapez. Conn. Channel 4' wide	0.25	18 *)	7.9	11.2	12.8

**) depth=1 ft*

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
A-4	1 -2	Silver Strand	Street Flow	0.82	22**)	1.7	2.4	2.7

***) depth=0.5 ft*

Drainage Area - Area "B"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
B	2-3	Calla	Street Flow	0.62	20.5*)	7.0	9.8	11.3
	3-4	3-rd	Street Flow	0.60	19.5*)	12.2	17.4	20.0

**) depth=0.5 ft*

Drainage Area - Area "C"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
C	184 - 399	Cypress	12" Pipe	0.28	1.9	3.6	5.0	5.7
	399 - 400	Cherry	28"- wide Conc Channel, 7" max depth	0.99	7.1	3.6	5.0	5.7
	400 - 401	Cherry	V-Gutter, 10' wide , 6" max depth	0.61	7.7	3.6	5.0	5.7
	401 - 402	Cherry/Earth Channel	28"- wide Conc Channel, 12" max depth	0.90	14.5	12.3	17.2	19.6

Drainage Area - Area "D"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
D	182 - 196	Calla/SR 75	24" Pipe	5.20	51.6	8.1	11.5	13.3
	158 - 196	5-th/SR 75	18" Pipe	0.86	9.7	5.2	7.2	8.3
	196 - 197	SR 75	24" Pipe	0.86	21.0	12.2	17.3	20.0
	197 - 382	Outlet @ SR 75	24" Pipe	0.86	21.0	12.2	17.3	20.0

Drainage Area - Area "E"

Existing Conditions and Estimated Drainage Flows -Free Outfall

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
E	412 - 198	Bonito/Citrus	4' wide Conc Channel, 8"max depth	0.53	12.2	5.3	7.4	8.5
	198 - 338	Citrus	Cross-gutter, 8' wide, 4" max depth	2.83	5.6	5.3	7.4	8.5
	338 - 179	Citrus/Palm	4' wide Conc Channel, 8"max depth	0.72	14.2	8.8	12.5	14.3
	179 - 199	5-th @ Dahlia	24" Pipe	0.54	16.6	8.8	12.5	14.3
	199 - 58	5-th	24" Pipe	0.54	16.6	16.2	23.0	26.5
	58 - 200	5-th @ Spruce	30" Pipe	0.19	17.9	16.2	23.0	26.5
	200 - 57	5-th	30" Pipe	0.19	17.9	21.8	31.2	36.1
	57 - 368	off 9-th	30" Pipe	0.19	17.9	31.1	44.7	51.7
	368 -201	Elm	30" Pipe	0.19	17.9	37.1	53.5	61.9
	201 - 63	Elm	36" Pipe	0.19	29.1	37.8	54.7	63.3
	63 - 146	Imperial Beach	36" Pipe	0.19	29.1	38.6	55.8	64.6
	146 - 208	Alley @Fern	36" Pipe	0.19	29.1	38.6	55.8	64.6
	208 - 209	Alley Fern/Grove	36" Pipe	0.19	29.1	38.6	55.8	64.6
	209 - 110	Outfall @ Grove	36" Pipe	0.19	29.1	41.0	59.4	68.8

Existing Conditions and Estimated Drainage Flows - Submerged Outfall - High Tide=5.5' MSL

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
E	412 - 198	Bonito/Citrus	4' wide Conc Channel, 8"max depth	0.53	12.2	5.3	7.4	8.5
	198 - 338	Citrus	Cross-gutter, 8' wide, 4" max depth	2.83	5.6	5.3	7.4	8.5
	338 - 179	Citrus/Palm	4' wide Conc Channel, 8"max depth	0.72	14.2	8.8	12.5	14.3
	199 - 58	5-th	24" Pipe	0.18	9.6	16.2	23.0	26.5
	58 - 200	5-th @ Spruce	30" Pipe	0.12	14.2	16.2	23.0	26.5
	200 - 57	5-th	30" Pipe	0.12	14.2	21.8	31.2	36.1
	57 - 368	off 9-th	30" Pipe	0.12	14.2	31.1	44.7	51.7
	368 -201	Elm	30" Pipe	0.12	14.2	37.1	53.5	61.9
	201 - 63	Elm	36" Pipe	0.12	23.1	37.8	54.7	63.3
	63 - 146	Imperial Beach	36" Pipe	0.12	23.1	38.6	55.8	64.6
	146 - 208	Alley @Fern	36" Pipe	0.12	23.1	38.6	55.8	64.6
	208 - 209	Alley Fern/Grove	36" Pipe	0.12	23.1	38.6	55.8	64.6
	209 - 110	Outfall @ Grove	36" Pipe	0.12	23.1	41.0	59.4	68.8

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
E	66 - 67	Elm/5-th	12" Pipe	0.18	1.5	10.9	15.5	17.8
	67 - 202	Off 5-th	24" Pipe	0.18	9.6	10.9	15.5	17.8
	202 - 204	Off 5-th	24" Pipe	0.18	9.6	17.6	25.0	18.9
	204 - 64	Imperial Beach	24" Pipe	0.18	9.6	22.2	32.0	37.0
	64 - 147	Imperial Beach	24" Pipe	0.18	9.6	22.2	32.0	37.0
	147 - 145	Alley @Fern	24" Pipe	0.18	9.6	23.2	33.6	39.0
	145 - 109	Outfall @Grove	24" Pipe	0.18	9.6	23.2	33.6	39.0

Drainage Area - Area "G"

Existing Conditions and Estimated Drainage Flows -Free Outfall

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
G	183 - 369	Alley @7-th	24" Pipe	2.75	31.8	19.8	28.0	32.2

Existing Conditions and Estimated Drainage Flows - Submerged Outfall - High Tide=5.5' MSL

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
G	183 - 369	Alley @7-th	24" Pipe	1.20	27.4	19.8	28.0	32.2

Drainage Area - Area "H"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
	82 - 69	Elm/ Donax	18" Pipe	0.40	6.6	11.4	16.3	18.8
	69 - 314	Alley @ Donax	18" Pipe	0.40	6.6	13.8	19.8	22.8
	314 - 313	Alley @ Donax	18 " Pipe	0.22	5.0	16.7	24.1	27.8
	313 - 3	SR 75	24" Pipe	0.22	10.6	16.7	24.1	27.8
	75 - 3	SR 75	12" Pipe	1.00	3.6	12.2	17.0	19.5
	3 - 306	SR 75	36" Pipe	0.22	31.3	30.7	44.7	51.9
H	306 -300	Calla/8th	36" Pipe	0.22	31.3	36.3	52.9	61.4
	300 - 176	Alley@ Calla/Cypress	36" Pipe	0.22	31.3	48	70.5	82.1
	176 - 167	Cypress	42" Pipe	0.22	47.2	48.8	72.2	84.2
	167 - 295	Alley @ Cypress	42" Pipe	0.22	47.2	55.3	81.7	95.3
	295 - 393	End of 9th	42" Pipe	0.25	50.3	59.4	88.2	103.1
	393 - 131	9th to Outlet	48" Pipe	0.25	76.5	59.6	88.7	103.8

Drainage Area - Area "F"

Existing Conditions and Estimated Drainage Flows -Free Outfall

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
	31 - 30	Fern/Florence	15" Pipe	0.32	3.7	11.9	16.8	19.3
	30 - 386	Florence	15" Pipe	0.32	3.7	15.3	21.7	24.9
	386 - 98	Florence/Imp. Beach	18" Pipe	0.32	5.9	15.3	21.7	24.9
	98 - 97	Imp. Beach/12- th	24" Pipe	0.32	12.8	15.3	21.7	24.9
	97 - 247	Imp. Beach/Florida	24" Pipe	0.32	12.8	22.6	32.5	37.4
	247 - 323	Imp. Beach/11-th	24" Pipe	0.32	12.8	27.6	39.8	45.9
	323 - 86	Imp. Beach	36" Pipe	0.25	12.8	38.5	55.7	64.2
	86 - 85	Imp. Beach/Emory	36" Pipe	0.25	33.3	51.2	73.6	84.9
F- 1	85 - 236	Imp. Beach/9-th	36" Pipe	0.25	33.3	51.2	73.6	84.9
	236 - 84	Imp. Beach	36" Pipe	0.25	33.3	80.1	119.6	139.5
	84 - 84.1	Imp. Beach/8-th	54" Pipe	0.12	68.1	107.6	155.9	180.3
	84.1 - 217	Imp. Beach/Connecticut	54" Pipe	0.12	68.1	118.2	171.8	198.9
	217 - 154	Connecticut/Grove	54" Pipe	0.12	68.1	126.1	192.4	226.5
	165 - 153	Grove	54" Pipe	0.12	68.1	146.4	223.7	262.3
	153 - 151	Grove/Louden	54" Pipe	0.12	68.1	146.4	223.7	262.3
	151 - 151.1	Grove/California	54" Pipe	0.12	68.1	146.4	224.5	266.3
	151.1 - 143	Grove/5-th	54" Pipe	0.12	68.1	156.3	238.9	281.9
	143 - 124	Outfall	54" Pipe	0.12	68.1	156.7	245.7	292.0

Existing Conditions and Estimated Drainage Flows - Submerged Outfall - High Tide=5.5' MSL

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
	31 - 30	Fern/Florence	15" Pipe	0.32	3.7	11.9	16.8	19.3
	30 - 386	Florence	15" Pipe	0.32	3.7	15.3	21.7	24.9
	386 - 98	Florence/Imp. Beach	18" Pipe	0.32	5.9	15.3	21.7	24.9
	98 - 97	Imp. Beach/12- th	24" Pipe	0.32	12.8	15.3	21.7	24.9
	97 - 247	Imp. Beach/Florida	24" Pipe	0.32	12.8	22.6	32.5	37.4
	247 - 323	Imp. Beach/11-th	24" Pipe	0.32	12.8	27.6	39.8	45.9
	323 - 86	Imp. Beach	36" Pipe	0.25	12.8	38.5	55.7	64.2
	86 - 85	Imp. Beach/Emory	36" Pipe	0.25	33.3	51.2	73.6	84.9
F - 1	85 - 236	Imp. Beach/9-th	36" Pipe	0.25	33.3	51.2	73.6	84.9
	236 - 84	Imp. Beach	36" Pipe	0.25	33.3	80.1	119.6	139.5
	84 - 84.1	Imp. Beach/8-th	54" Pipe	0.10	62.2	107.6	155.9	180.3
	84.1 - 217	Imp. Beach/Connecti	54" Pipe	0.10	62.2	118.2	171.8	198.9
	217 - 154	Connecticut/Grove	54" Pipe	0.10	62.2	126.1	192.4	226.5
	165 - 153	Grove	54" Pipe	0.10	62.2	146.4	223.7	262.3
	153 - 151	Grove/Louden	54" Pipe	0.10	62.2	146.4	223.7	262.3
	151 - 151.1	Grove/California	54" Pipe	0.10	62.2	146.4	224.5	266.3
	151.1 - 143	Grove/5-th	54" Pipe	0.10	62.2	156.3	238.9	281.9
	143 - 124	Outfall	54" Pipe	0.10	62.2	156.7	245.7	292.0

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
	406 - 407	Bevery	4' Conc. Channel, max depth 1 ft	0.21	10.6	6.5	9.2	10.6
F - 2	407 - 409	Emory	4' Conc. Channel, max depth 1 ft	0.63	18.4	8.3	11.7	13.5
	409 - 411	9-th/Ferm	4' Conc. Channel, max depth 1 ft	0.53	16.9	9.6	13.7	15.7
	411 - 236	Imp. Beach/9-th	Street Flow , 1 side, max depth 0.5 ft	0.41	8.0	10.2	14.5	16.6

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
F - 3	88 - 80	Emory	18" Pipe	0.77	9.2	1.9	2.6	3.0
	80 - 77	Ebony/9-th	18" Pipe	1.00	10.5	10.4	14.7	16.8
	77 - 236	Imp. Beach/9-th	24" Pipe	0.30	12.4	20.2	28.0	32.0

Table 2 - Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
F - 4	16 - 240	8-th	18" Pipe	1.20	11.5	5.2	7.3	8.4
	17 - 240	Downing	18" Pipe	1.20	11.5	9.4	13.1	15.0
	240 - 238	Imp. Beach/8-th	18" Pipe	1.20	11.5	15.1	21.2	24.3
	238 - 84	Imp. Beach/8-th	24" Pipe	1.20	24.8	19.9	28.1	32.4

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
F - 5	230 - 227	City Park	12" Pipe	0.50	2.5	3.5	4.9	5.6
	227 - 226	8-th	12" Pipe	0.50	2.5	5.6	7.9	9.1
	226 - 84.1	Imp. Beach/8-th	18" Pipe	0.50	7.4	14.8	21.0	24.1

Drainage Area - Area "J"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
J	3 - 4	Iris/Tower	4'- wide Conc Channel, 1.5' max depth	0.90	51.0	17.0	23.6	27.3

Drainage Area - Area "K"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
K	102 - 101	Elm/11 th	16" Pipe	7.90	22	3.3	4.6	5.3
	101 - 95	Alley @ Donax	24" Pipe	0.46	15.3	19.4	27.7	31.8
	95 - 1	Palm	30" Pipe	0.52	29.6	22.4	32.2	37.1
	1 - 287	Florida	36" Pipe	0.30	38.3	33.1	47.5	55.0
	287 - 286	Florida/Calla	36" Pipe	0.30	38.3	35.2	50.9	59.1
	286 - 134	Cypress	36" Pipe	0.30	38.3	40.9	59.5	69.1
	134 - 133	Alley @ Cypress	36" Pipe	0.30	38.3	41.1	60.0	69.9
	133 - 285	Outfall	36" Pipe	1.00	66.7	51.0	74.5	86.9

Drainage Area - Area "M"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
M	404 -403	Grove/Holly	V-channel *)	0.47	3.9	12.8	15.7	20.8
	403 - 339	Holly/Oneonta	Street flow **)	0.30	12.0	13.1	18.8	21.8
	339 - 19	Oneonta/Hemlock	20"x30" Oval Pi	0.23	10.8	13.1	18.8	21.8
	19 - 20	Hemlock/Iris	48" Pipe	0.23	68.9	14.5	21.0	24.3
	20 - 21	Iris	2-20"x30" Oval Pipes	0.23	21.6	21.1	30.5	35.4
	21 - 252	Iris/Navy	48" Pipe	0.23	68.9	23.4	33.9	39.4

*) 10" depth
**) 6"depth

Drainage Area - Area "N"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
N	2-3	Channel off Cherry/ Boulevard	Irregular Earth Channel	-	-	7.7	10.8	12.4

Drainage Area - Area "O"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
O-1	1-2	Florida	Street/Earth Channel Flow	-	-	1.8	2.6	2.9

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
O-2	130-391	off Boulevard	14" Pipe	14.50	20.5	2.6	3.6	4.1

Existing Conditions and Estimated Drainage Flows - High Tide = 5.5'

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
O-2	130-391	off Boulevard	14" Pipe	8.19	15.4	2.6	3.6	4.1

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
O-3	128-129	City Yard	12" Pipe	5.10	8.1	1.1	1.6	1.8

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
O-4	389-390	City Yard	6" Pipe	13.00	2.0	2.4	3.3	3.8

Drainage Area - Area "P"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
P	26-25	Georgia	18" Pipe	0.28	5.6	7.6	10.6	12.2
	25-24	Georgia/ Coronado	24" Pipe	0.28	12	7.6	10.6	12.2
	24 - 266	Imp. Beach@14-th	24" Pipe	0.32	12.8	19.8	27.6	36.6
	266 - 269	Off Georgia	30" Pipe	0.32	23.2	27.9	39.1	44.7
	269 - 376	Off Eboe	30" Pipe	0.32	23.2	27.9	39.1	44.7
	376 - 271	Elder/14-th	42" Pipe	0.32	56.9	58.9	82.7	94.7
	271 - 272	Elder/14-th	42" Pipe	0.32	56.9	60.1	85.9	98.8
	272 - 274	Elm/14-th	42" Pipe	0.32	56.9	63.2	90.4	104.0
	274 - 275	14-th	42" Pipe	0.32	56.9	68.0	98.0	113.0
	275 - 276	Donax/14-th	42" Pipe	0.30	55.1	70.2	101.1	116.6
	276 - 282	Palm	42" Pipe	0.30	55.1	78.2	113.1	130.8
	282 - 396	Palm/Outfall	48" Pipe	0.30	78.7	86.0	125.4	145.3

Drainage Area - Area "Q"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
Q	380-381	Trailer Park	14" Pipe	4.30	11.2	18.0	25.4	29.2

Drainage Area - Area "R"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
R	318 - 41	Imp. Beach@15-th	21" Pipe	0.96	15.5	18.6	25.5	29.7
	41 - 317	Off Eboe	21" Pipe	0.96	15.5	24.9	34.9	39.9
	317 - 376	Off Eboe	30" Pipe	0.96	40.2	32.3	45.5	52.0

Drainage Area - Area "T"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
T	1-2	Oneonta	Street Flow	0.60	10 *)	5.7	7.9	9.1
	3-2	Oneonta	Street Flow	0.60	10 *)	11.1	15.6	17.8

*) max depth 6", 1 side only

Drainage Area - Area "U"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
U	54 - 48	Alley @ Ebony/Imp.B	12" Pipe	2.48	5.6	0.7	0.9	1.5
	48 -53	Alley/Imp. Beach	12" Pipe	2.48	5.6	1.6	2.3	2.6
	53 - 354	Imp. Beach	18" Pipe	1.40	12.4	4.3	6.0	6.9
	354 - 149	Imp. Beach	18" Pipe	1.40	12.4	4.3	6.0	6.9
	149 - 112	Outfall @Imp. Beach	18" Pipe	1.40	12.4	5.2	7.3	6.9

Drainage Area - Area "V"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
V1	1 -2	9-th	Street Flow	0.30	13.0	2.9	4.1	4.7
V2	4 - 5	8-th/Iris	2'-wide Circ Concrete Channel , 8" max depth	1.10	4.7	2.5	3.4	3.9

Drainage Area - Area "W"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
W	52-113	Ebony/Outfall	12" Pipe	1.53	4.4	3.2	4.4	5.0

Drainage Area - Area "X"

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
X-1	117.1-117	Seacoast	Street Flow	-	-	15.6	21.7	24.8

Existing Conditions and Estimated Drainage Flows

Drainage Basin	Section /Node Number	Location	Existing Condition	Hydraulic Slope	Existing Capacity	Estimated Storm Flow		
						2-yr	5-yr	10-yr
				%	*cfs*	*cfs*	*cfs*	*cfs*
X-2	119.1-119	Seacoast	Street Flow	-	-	11.0	15.5	17.7

City of Imperial Beach Storm Drain Study

Appendix B

Drainage Areas and Runoff Coefficients

Table A - 1

Drainage Areas and Runoff "C" Coefficients

Drainage Area "A"		
Subarea	Area (ac)	Composite "C" Factor
A1-1	25.49	0.54
A1-2	14.76	0.53
A1-3	16.91	0.54
Total drainage area "A1"	***57.16***	
A1-4	7.93	0.60
A2-1	21.58	0.51
A2-2	20.41	0.51
A2-3	10.09	0.68
A2-4	16.82	0.63
A2-5	3.20	0.75
Total drainage area "A2"	***80.03***	
A3	18.08	0.52
A4	3.15	0.50
Total drainage area "A"	***158.42***	

Drainage Area "B"		
Subarea	Area (ac)	Composite "C" Factor
B1	4.93	0.57
B2	12.77	0.57
B3	10.11	0.52
Total drainage area "B"	***27.80***	

Drainage Area "C"		
Subarea	Area (ac)	Composite "C" Factor
C1	9.78	0.57
C2	5.20	0.57
C3	4.31	0.57
Total drainage area "C"	***19.29***	

Drainage Area "D"		
Subarea	Area (ac)	Composite "C" Factor
D1	5.01	0.79
D2	4.18	0.79
D3	6.49	0.57
Total drainage area "D"	***15.68***	

Drainage Area "E-1A" and "E-2"		
Subarea	Area (ac)	Composite "C" Factor
E-A1-1	2.22	0.57
E-A1-2	4.59	0.57
E-A1-3	5.07	0.57
E-A1-4	12.11	0.61
E-A1-5	9.10	0.58
E-A1-6	14.82	0.57
E-A1-7	10.07	0.57
E-A1-8	5.60	0.58
E-A1-9	5.22	0.59
E-A1-10	1.61	0.58
E-A1-11	2.62	0.57
E-A1-12	9.78	0.57
E-A1-13	2.67	0.57
E-A1-14	2.25	0.50
E-2-1	6.77	0.48
E-2-2	3.32	0.61
E-2-3	2.10	0.55
Total drainage area "E-1A" and "E-2"	***99.93***	

Drainage Area "E-1B"		
Subarea	Area (ac)	Composite "C" Factor
E-1B-1	5.06	0.57
E-1B-2	16.74	0.50
E-1B-3	15.45	0.50
E-1B-4	11.63	0.50
E-1B-5	3.23	0.56
Total drainage area "E-1B"	***52.11***	

Drainage Area "G"		
Subarea	Area (ac)	Composite "C" Factor
G1	13.73	0.61
G2	13.72	0.57
G3	8.48	0.57
G4	3.53	0.57
Total drainage area "G"	***39.46***	

Drainage Area "H"		
Subarea	Area (ac)	Composite "C" Factor
H1	1.94	0.57
H2	22.65	0.57
H3	5.52	0.57
H4	7.06	0.57
H5	10.73	0.69
H6	20.57	0.69
H7	9.98	0.79
H8	24.41	0.71
H9	4.76	0.57
H10	15.98	0.57
H11	14.43	0.53
H12	1.52	0.55
Total drainage area "H"	***139.55***	

Drainage Area "F"		
Subarea	Area (ac)	Composite "C" Factor
F1-1	1.53	0.57
F1-2	12.59	0.66
F1-3	4.74	0.57
F1-4	5.76	0.57
F1-5	7.73	0.64
F1-6	7.47	0.57
F1-7	7.47	0.57
F1-8	8.11	0.57
F1-9	4.72	0.57
F1-10	31.60	0.57
F1-11	9.22	0.57
F1-12	9.55	0.56
F1-13	12.47	0.59
F1-14	11.53	0.53
F1-15	33.89	0.57
F1-16	6.03	0.57
F1-17	6.42	0.57
F1-18	7.89	0.57
F1-19	5.67	0.57
F1-20	19.84	0.57
F1-21	13.77	0.56
Total drainage area "F1"	***228.00***	
F2-1	5.31	0.56
F2-2	10.85	0.51
F2-3	4.48	0.57
F2-4	4.13	0.57
F2-5	3.92	0.56
Total drainage area "F2"	***28.71***	
F3-1	1.70	0.57
F3-2	8.43	0.57
F3-3	6.69	0.59
F3-4	4.90	0.57

Total drainage area "F3"	***21.73***	
F4-1	8.63	0.57
F4-2	16.07	0.57
F4-3	1.62	0.50
Total drainage area "F4"	***26.32***	
F5-1	4.48	0.53
F5-2	3.03	0.51
F5-3	11.62	0.56
Total drainage area "F5"	***19.14***	
Total drainage area "F"	***323.88***	

Drainage Area "J"		
Subarea	Area (ac)	Composite "C" Factor
J1	21.41	0.57
J2	13.73	0.57
Total drainage area "J"	***35.14***	

Drainage Area "K"		
Subarea	Area (ac)	Composite "C" Factor
K1	7.88	0.52
K2	9.89	0.57
K3	8.73	0.57
K4	9.53	0.57
K5	3.55	0.57
K6	7.50	0.60
K7	18.35	0.79
K8	12.82	0.65
K9	5.54	0.77
K10	4.24	0.50
K11	23.29	0.63
K12	9.10	0.71
Total drainage area "K"	***120.42***	

Drainage Area "L"		
Subarea	Area (ac)	Composite "C" Factor
L1	3.85	0.63
L2	4.59	0.61
Total drainage area "L"	***8.44***	

Drainage Area "M"		
Subarea	Area (ac)	Composite "C" Factor
M1	9.92	0.57
M2	2.69	0.57
M3	5.96	0.57
M4	7.01	0.57
M5	3.34	0.57
M6	13.97	0.57
M7	5.18	0.55
Total drainage area "M"	***48.08***	

Drainage Area "N"		
Subarea	Area (ac)	Composite "C" Factor
N1	6.46	0.58
N2	1.64	0.50
N3	3.38	0.53
Total drainage area "N"	***11.48***	

Drainage Area "O"		
Subarea	Area (ac)	Composite "C" Factor
O1	2.61	0.57
O2	1.55	0.57
O3	0.51	0.57
O4	1.58	0.79
Total drainage area "O"	***6.25***	

Drainage Area "P"		
Subarea	Area (ac)	Composite "C" Factor
P1	12.88	0.58
P2	23.04	0.57
P3	15.29	0.62
P4	9.55	0.63
P5	7.09	0.57
P6	14.68	0.57
P7	5.65	0.57
P8	21.33	0.57
P9	5.43	0.79
P10	11.55	0.73
Total drainage area "P"	***126.48***	

Drainage Area "Q"		
Subarea	Area (ac)	Composite "C" Factor
O1	2.03	0.79
O2	3.16	0.79
O3	6.25	0.79
O4	3.09	0.85
Total drainage area "Q"	***14.53***	

Drainage Area "R"		
Subarea	Area (ac)	Composite "C" Factor
R1	35.76	0.85
R2	11.85	0.63
R3	14.32	0.63
Total drainage area "R"	***61.92***	

Drainage Area "S"		
Subarea	Area (ac)	Composite "C" Factor
S1	11.78	0.57
S2	11.78	0.57
S3	8.88	0.57
S4	17.98	0.39
Total drainage area "S"	***50.42***	

Drainage Area "T"		
Subarea	Area (ac)	Composite "C" Factor
T1	10.19	0.57
T2	20.39	0.57
Total drainage area "T"	***30.58***	

Drainage Area "U"		
Subarea	Area (ac)	Composite "C" Factor
U1	0.77	0.69
U2	1.20	0.57
U3	5.25	0.57
U4	1.82	0.51
Total drainage area "U"	***9.04***	

Drainage Area "V"		
Subarea	Area (ac)	Composite "C" Factor
V1	4.84	0.56
V2	3.48	0.57
Total drainage area "V"	***8.32***	

Drainage Area "W"		
Subarea	Area (ac)	Composite "C" Factor
W1	2.23	0.62
Total drainage area "W"	***2.23***	

Drainage Area "X"		
Subarea	Area (ac)	Composite "C" Factor
X1-	11.65	0.59
X2-	8.38	0.56
Total drainage area "X"	***20.03***	

City of Imperial Beach Storm Drain Study

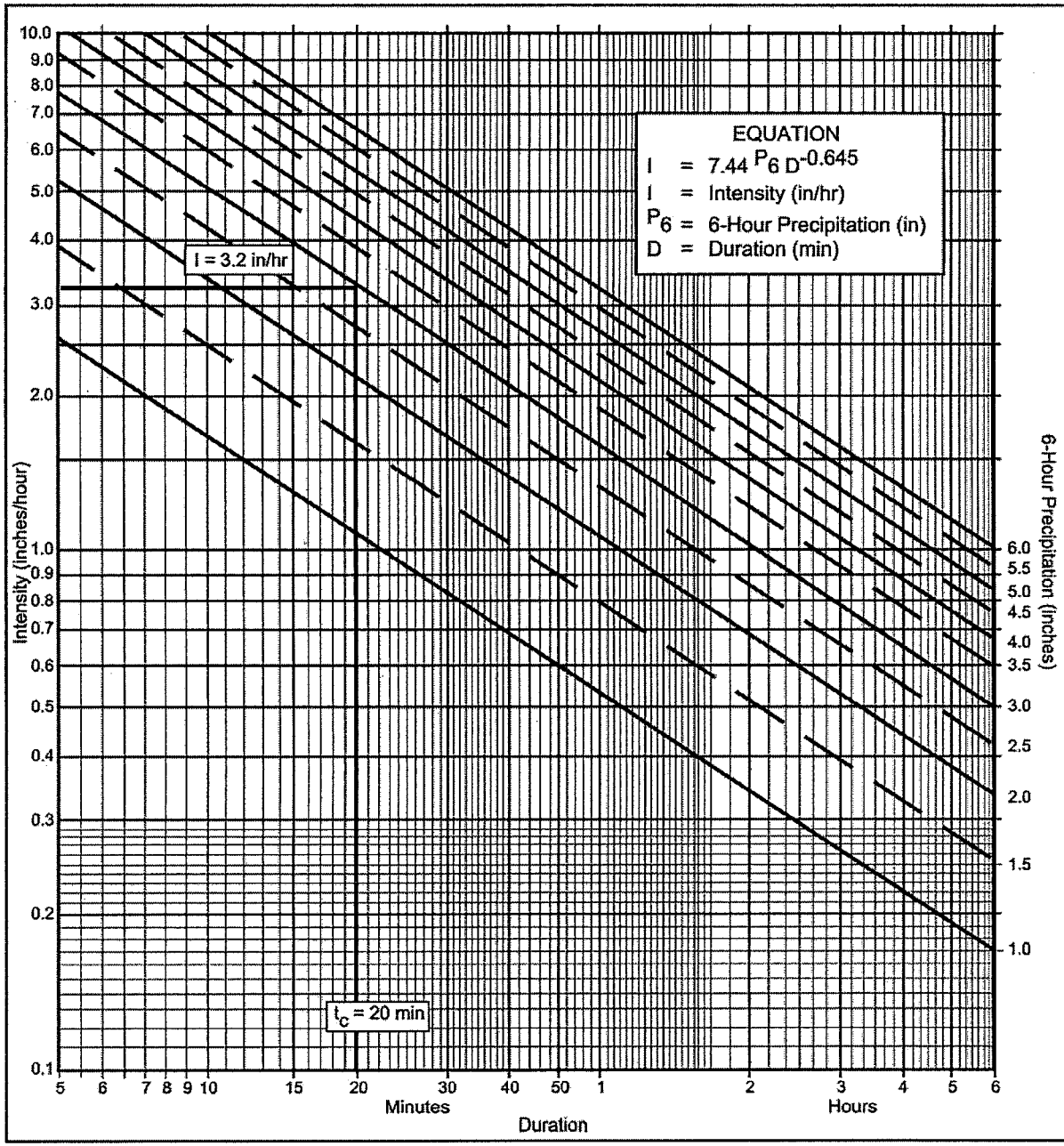
Appendix C

Hydrology Maps and Charts

Table 3-1
RUNOFF COEFFICIENTS FOR URBAN AREAS

Land Use		Runoff Coefficient "C"				
			Soil Type			
NRCS Elements	County Elements	% IMPER.	A	B	C	D
Undisturbed Natural Terrain (Natural)	Permanent Open Space	0*	0.20	0.25	0.30	0.35
Low Density Residential (LDR)	Residential, 1.0 DU/A or less	10	0.27	0.32	0.36	0.41
Low Density Residential (LDR)	Residential, 2.0 DU/A or less	20	0.34	0.38	0.42	0.46
Low Density Residential (LDR)	Residential, 2.9 DU/A or less	25	0.38	0.41	0.45	0.49
Medium Density Residential (MDR)	Residential, 4.3 DU/A or less	30	0.41	0.45	0.48	0.52
Medium Density Residential (MDR)	Residential, 7.3 DU/A or less	40	0.48	0.51	0.54	0.57
Medium Density Residential (MDR)	Residential, 10.9 DU/A or less	45	0.52	0.54	0.57	0.60
Medium Density Residential (MDR)	Residential, 14.5 DU/A or less	50	0.55	0.58	0.60	0.63
High Density Residential (HDR)	Residential, 24.0 DU/A or less	65	0.66	0.67	0.69	0.71
High Density Residential (HDR)	Residential, 43.0 DU/A or less	80	0.76	0.77	0.78	0.79
Commercial/Industrial (N. Com)	Neighborhood Commercial	80	0.76	0.77	0.78	0.79
Commercial/Industrial (G. Com)	General Commercial	85	0.80	0.80	0.81	0.82
Commercial/Industrial (O.P. Com)	Office Professional/Commercial	90	0.83	0.84	0.84	0.85
Commercial/Industrial (Limited I.)	Limited Industrial	90	0.83	0.84	0.84	0.85
Commercial/Industrial (General I.)	General Industrial	95	0.87	0.87	0.87	0.87

*The values associated with 0% impervious may be used for direct calculation of the runoff coefficient as described in Section 3.1.2 (representing the pervious runoff coefficient, Cp, for the soil type), or for areas that will remain undisturbed in perpetuity. Justification must be given that the area will remain natural forever (e.g., the area is located in Cleveland National Forest).
DU/A = dwelling units per acre
NRCS = National Resources Conservation Service



Directions for Application:

(1) From precipitation maps determine 6 hr and 24 hr amounts for the selected frequency. These maps are included in the County Hydrology Manual (10, 50, and 100 yr maps included in the Design and Procedure Manual).

(2) Adjust 6 hr precipitation (if necessary) so that it is within the range of 45% to 65% of the 24 hr precipitation (not applicaple to Desert).

(3) Plot 6 hr precipitation on the right side of the chart.

(4) Draw a line through the point parallel to the plotted lines.

(5) This line is the intensity-duration curve for the location being analyzed.

Application Form:

(a) Selected frequency 50 year

(b) P_6 = 3 in., P_{24} = 5.5, $\frac{P_6}{P_{24}}$ = 54.5 %(2)

(c) Adjusted P_6(2) = 3 in.

(d) t_x = 20 min.

(e) I = 3.2 in./hr.

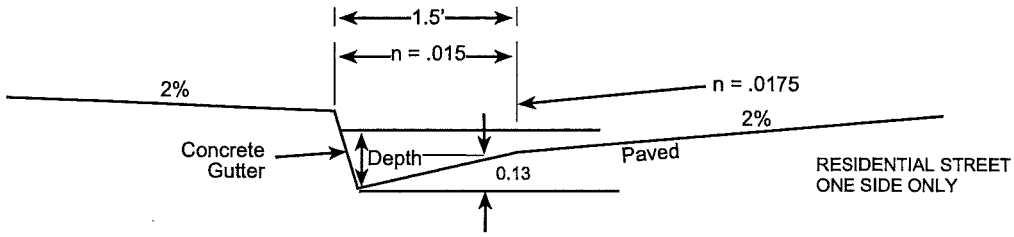
Note: This chart replaces the Intensity-Duration-Frequency curves used since 1965.

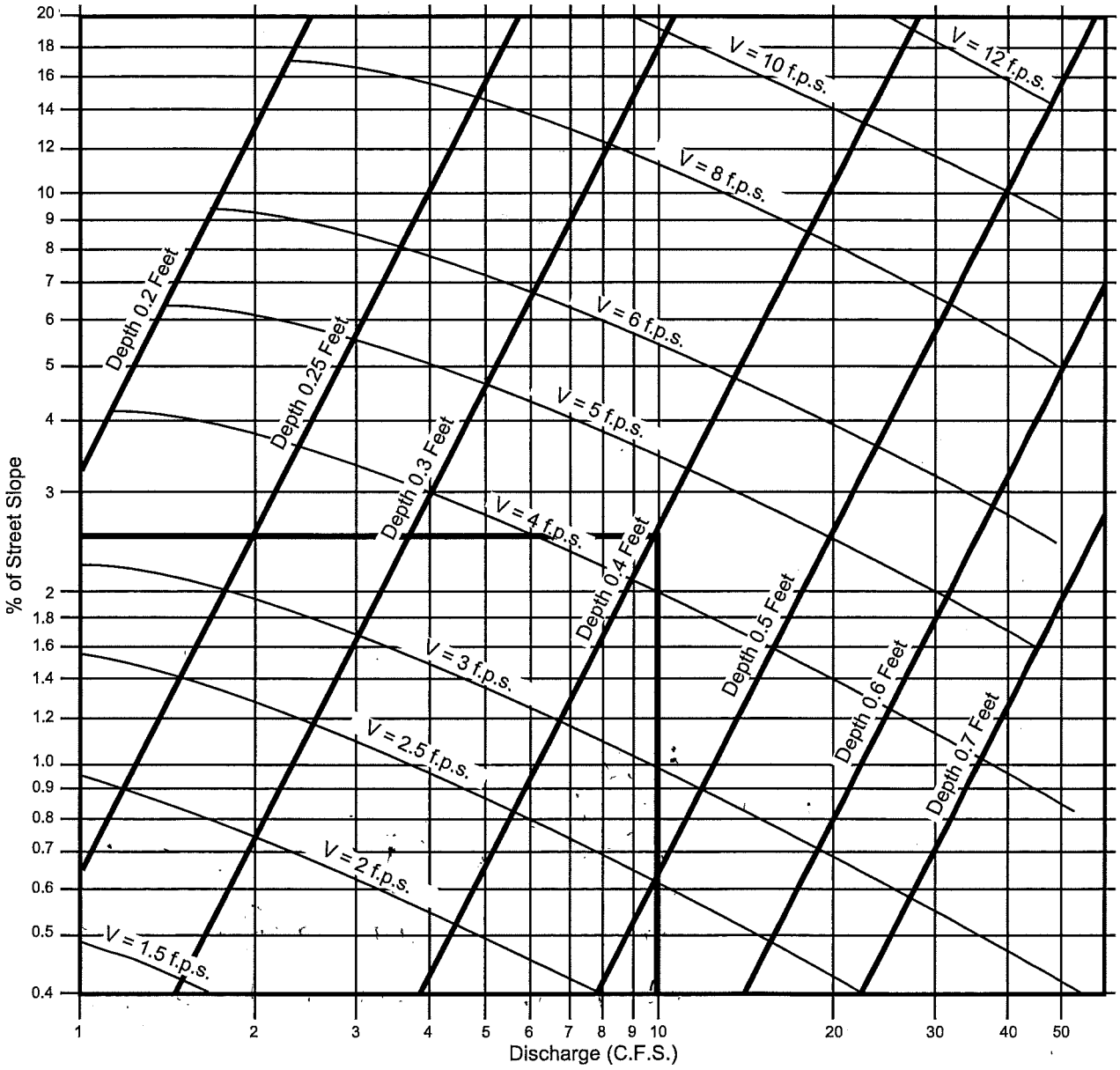
P6	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6
Duration	I	I	I	I	I	I	I	I	I	I	I
5	2.63	3.95	5.27	6.59	7.90	9.22	10.54	11.86	13.17	14.49	15.81
7	2.12	3.18	4.24	5.30	6.36	7.42	8.48	9.54	10.60	11.66	12.72
10	1.68	2.53	3.37	4.21	5.05	5.90	6.74	7.58	8.42	9.27	10.11
15	1.30	1.95	2.59	3.24	3.89	4.54	5.19	5.84	6.49	7.13	7.78
20	1.08	1.62	2.15	2.69	3.23	3.77	4.31	4.85	5.39	5.93	6.46
25	0.93	1.40	1.87	2.33	2.80	3.27	3.73	4.20	4.67	5.13	5.60
30	0.83	1.24	1.66	2.07	2.49	2.90	3.32	3.73	4.15	4.56	4.98
40	0.69	1.03	1.38	1.72	2.07	2.41	2.76	3.10	3.45	3.79	4.13
50	0.60	0.90	1.19	1.49	1.79	2.09	2.39	2.69	2.98	3.28	3.58
60	0.53	0.80	1.06	1.33	1.59	1.86	2.12	2.39	2.65	2.92	3.18
90	0.41	0.61	0.82	1.02	1.23	1.43	1.63	1.84	2.04	2.25	2.45
120	0.34	0.51	0.68	0.85	1.02	1.19	1.36	1.53	1.70	1.87	2.04
150	0.29	0.44	0.59	0.73	0.88	1.03	1.18	1.32	1.47	1.62	1.76
180	0.26	0.39	0.52	0.65	0.78	0.91	1.04	1.18	1.31	1.44	1.57
240	0.22	0.33	0.43	0.54	0.65	0.76	0.87	0.98	1.08	1.19	1.30
300	0.19	0.28	0.38	0.47	0.56	0.66	0.75	0.85	0.94	1.03	1.13
360	0.17	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.84	0.92	1.00

Intensity-Duration Design Chart - Example

FIGURE

3-2





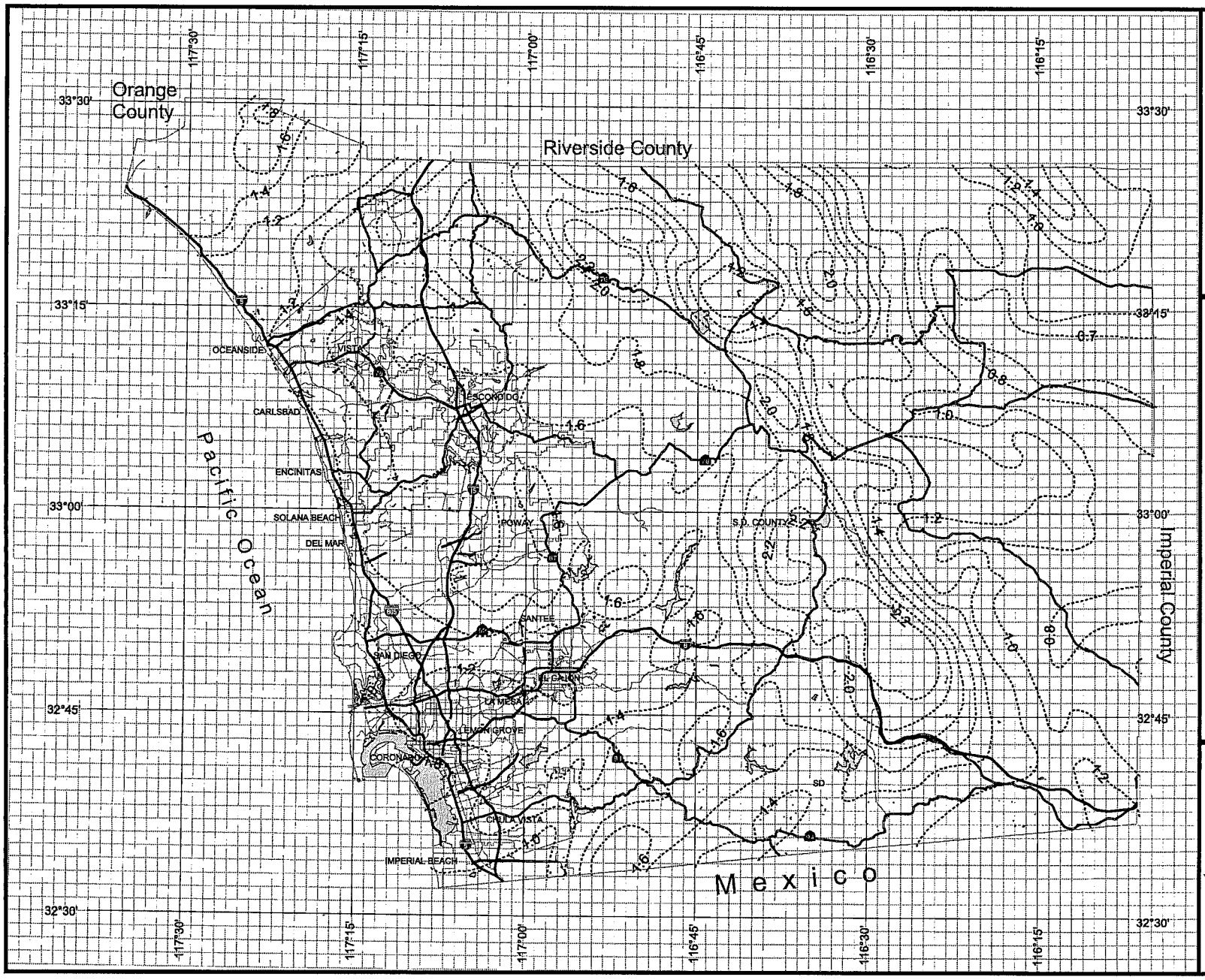
EXAMPLE:
Given: Q = 10 S = 2.5%
Chart gives: Depth = 0.4, Velocity = 4.4 f.p.s.

SOURCE: San Diego County Department of Special District Services Design Manual

FIGURE

Gutter and Roadway Discharge - Velocity Chart

3-6



County of San Diego Hydrology Manual

Rainfall Isopluvials

2 Year Rainfall Event - 6 Hours

Isopluvial (inches)

DPW GIS
Department of Public Works Geographic Information Services

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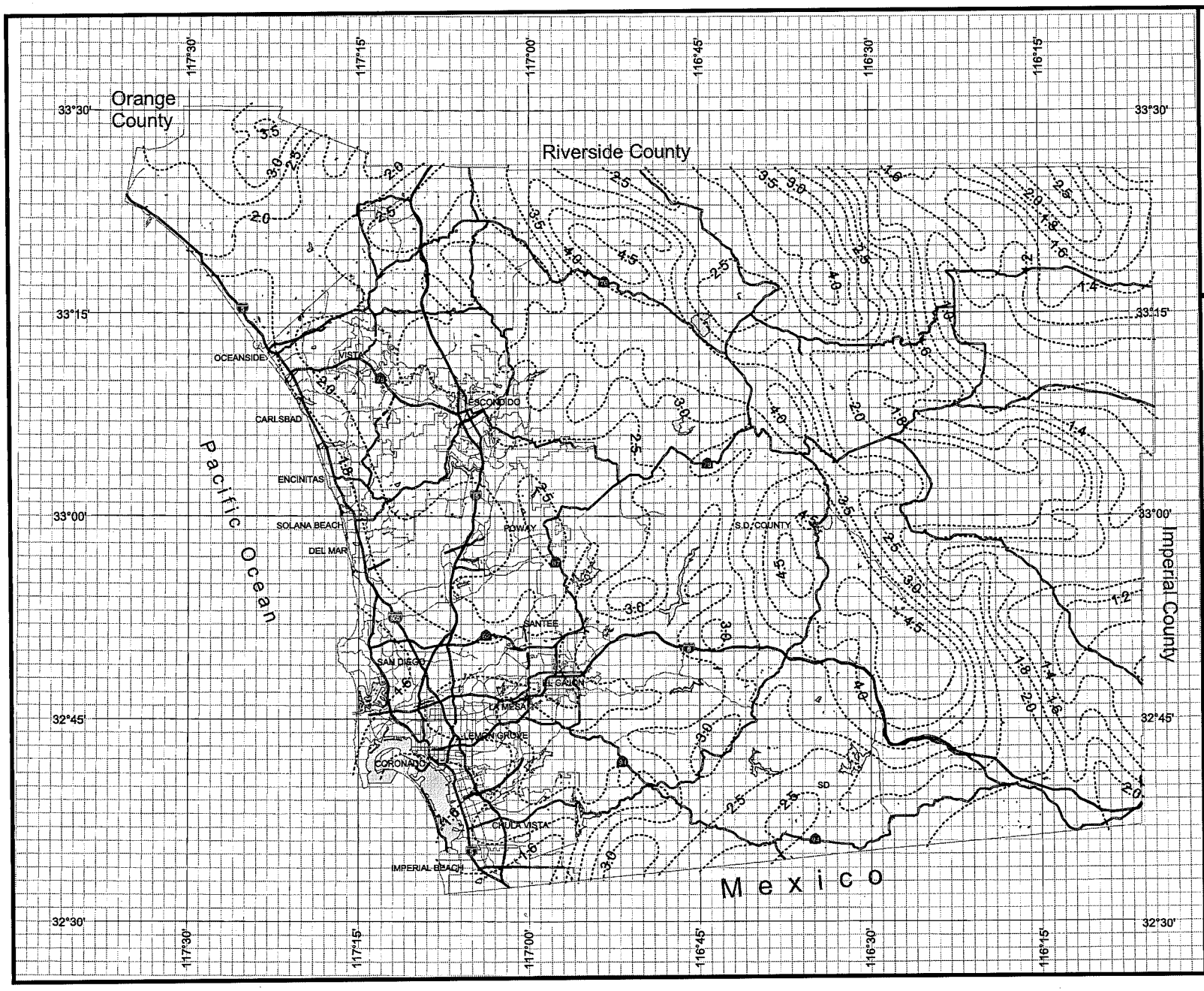

County of San Diego Hydrology Manual

Rainfall Isopluvials

2 Year Rainfall Event - 24 Hours

Isopluvial (inches)

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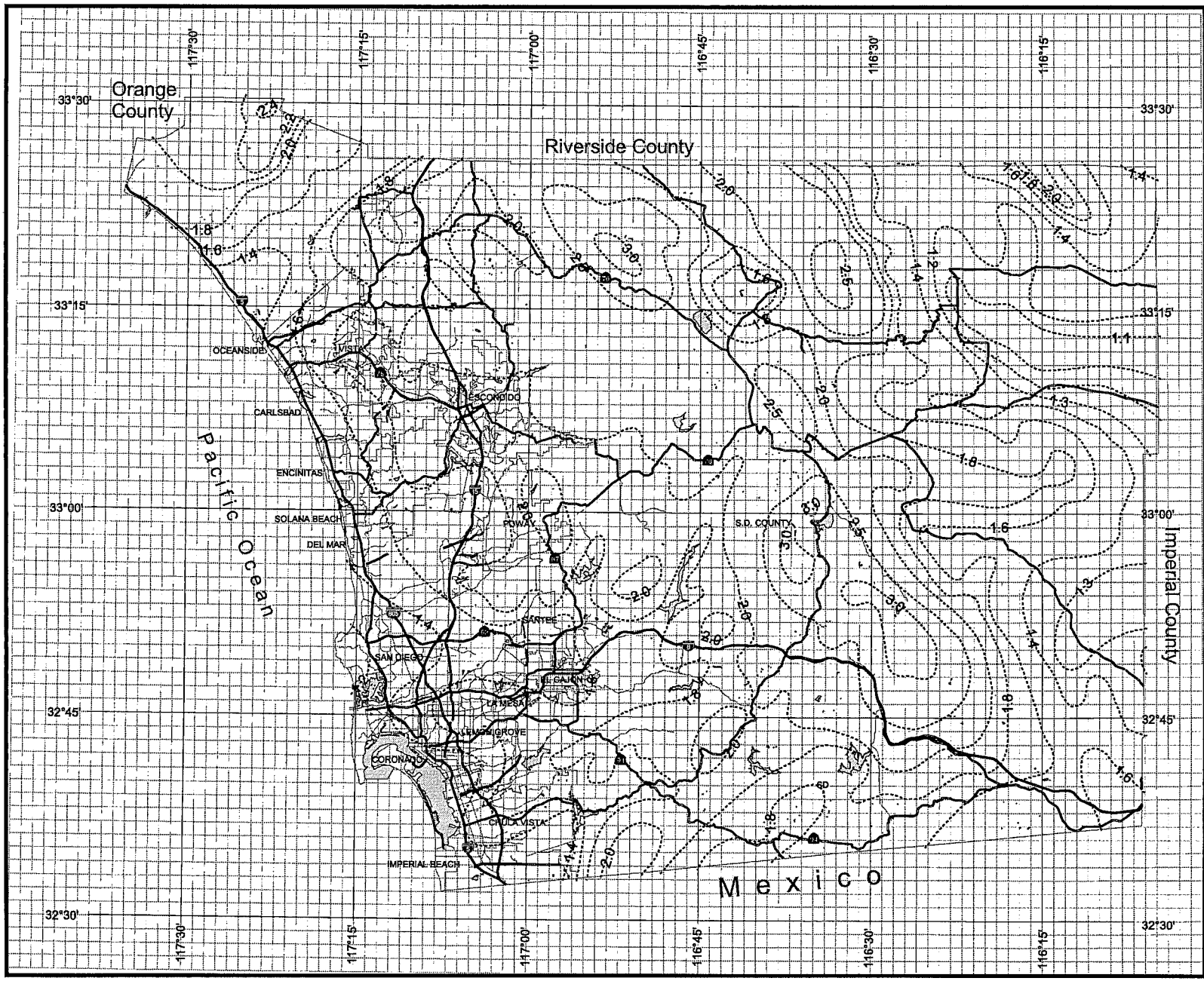

County of San Diego Hydrology Manual

Rainfall Isopluvials

5 Year Rainfall Event - 6 Hours

-------- Isopluvial (inches)

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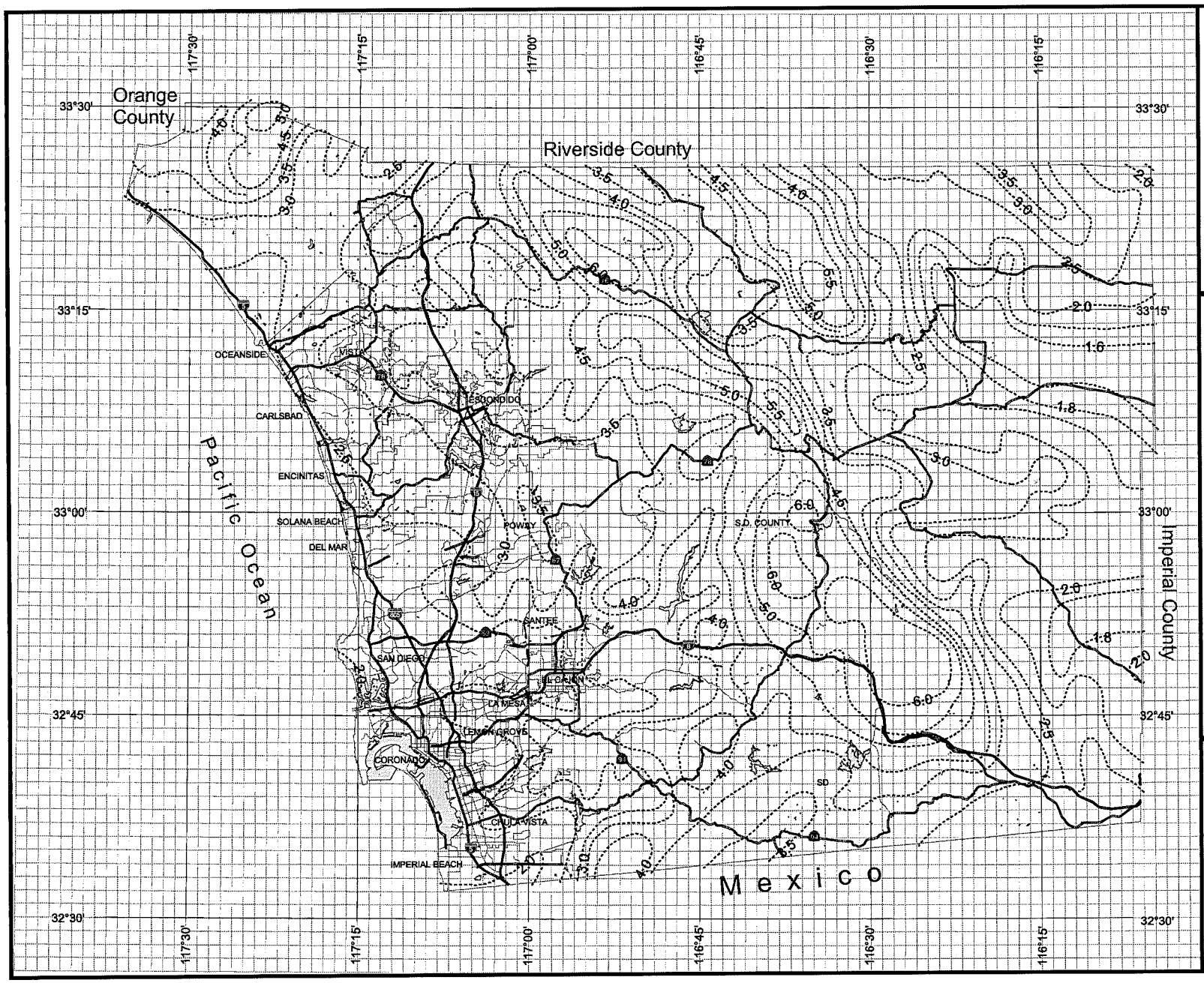

County of San Diego Hydrology Manual

Rainfall Isopluvials

5 Year Rainfall Event - 24 Hours

Isopluvial (inches)

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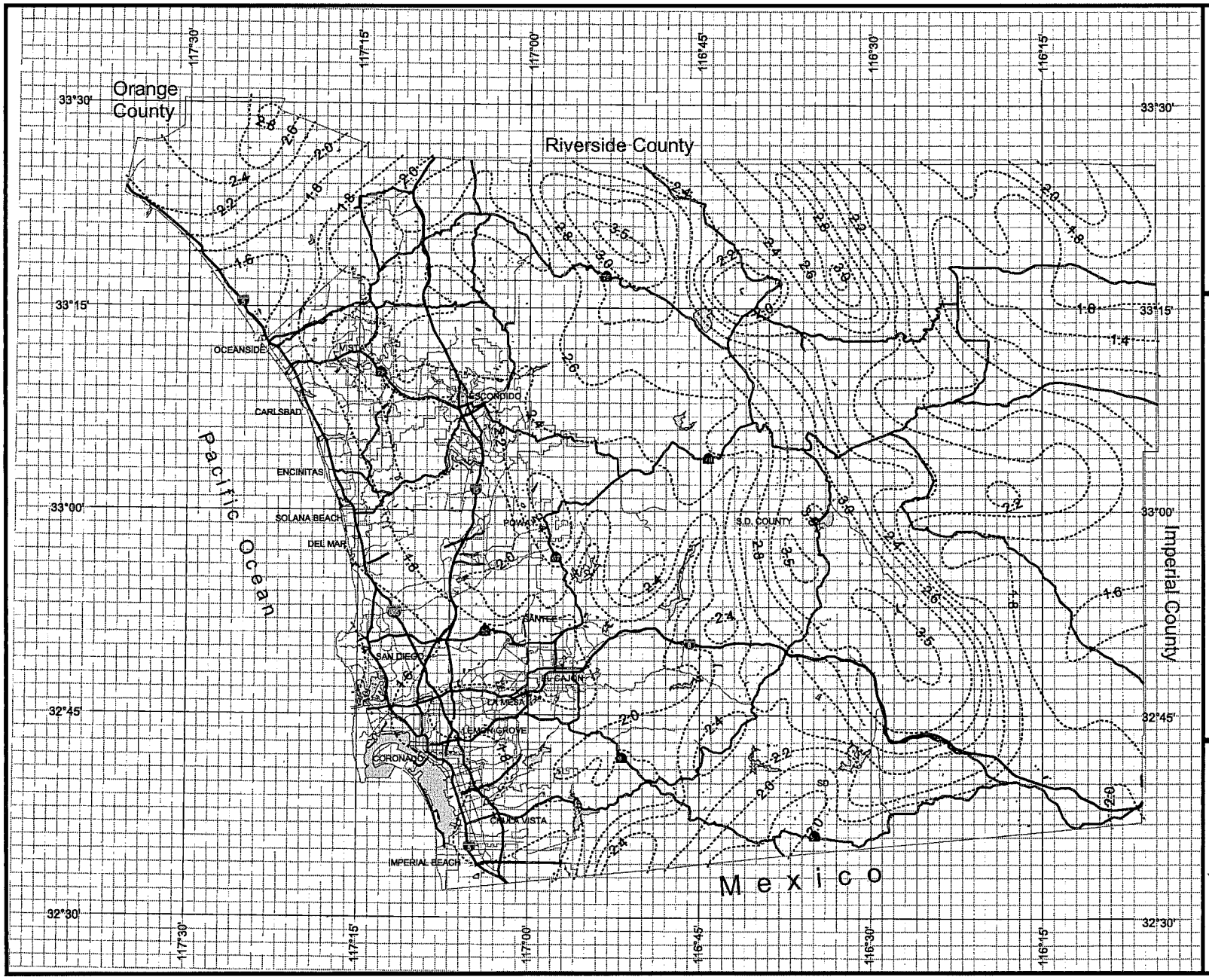

County of San Diego Hydrology Manual

Rainfall Isopluvials

10 Year Rainfall Event - 6 Hours

Isopluvial (inches)

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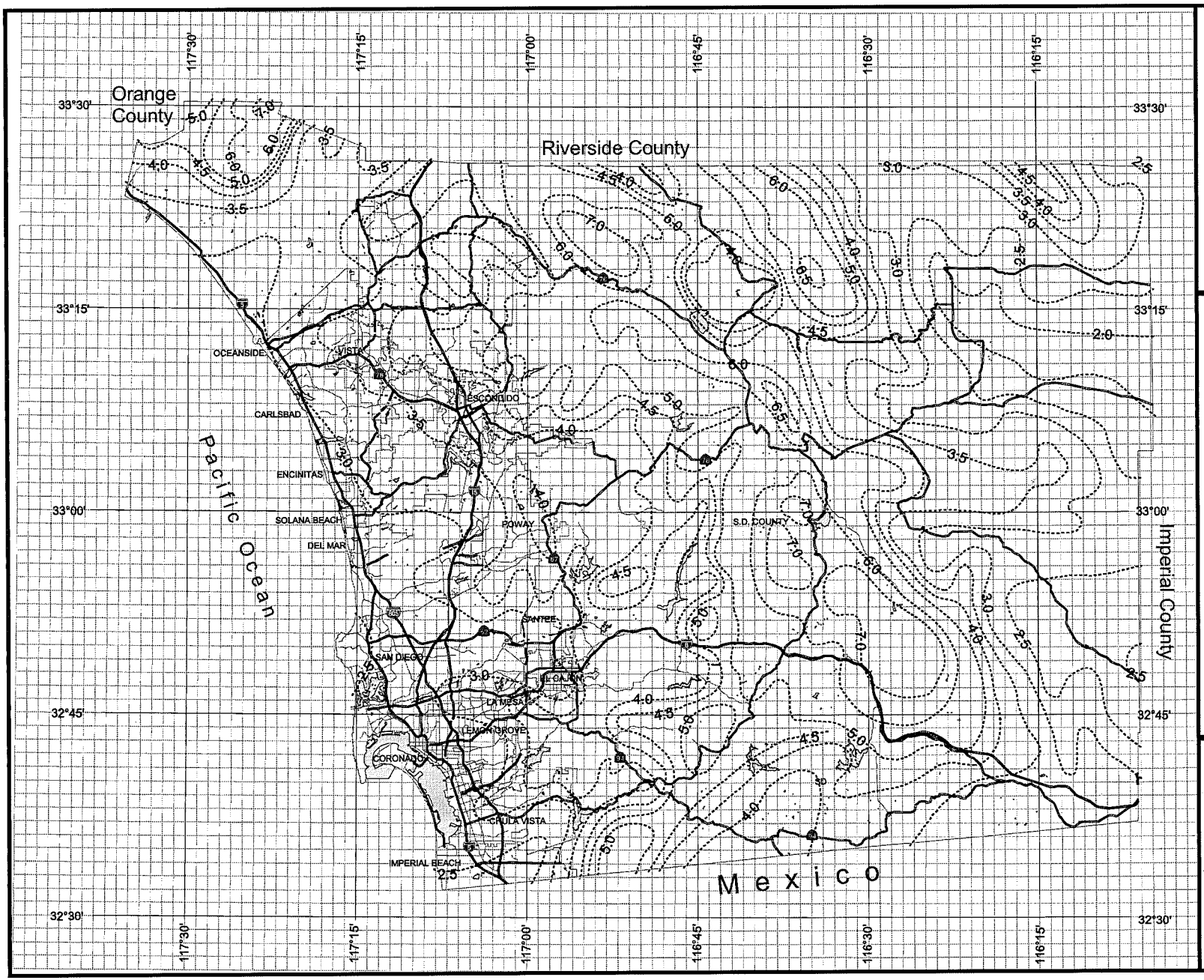
County of San Diego Hydrology Manual

Rainfall Isopluvials

10 Year Rainfall Event - 24 Hours

Isopluvial (inches)



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