Memorandum

To: Whom It May Concern

From: Jarrod D. Aden, P.E., C.F.M.
President
Lentz Engineering, LC
4710 Bellaire Blvd., Suite 250
Bellaire, Texas 77401
(713) 839-8900

Date: April 24, 2013

Re: Brazoria Drainage District No. 4 – Rules, Regulations, and Guidelines

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The enclosed is being provided electronically as a convenience to the end user.

It is the responsibility of the user to insure that this electronic version of the Rules, Regulations, and Guidelines contains all the latest information.

Sincerely,

Jarrod Aden, P.E., C.F.M.
President

# RULES, REGULATIONS & GUIDELINES

## BRAZORIA DRAINAGE DISTRICT NO. 4

## LENTZ ENGINEERING, L.C.

**Approved and adopted at a regular meeting on April 09, 2013**
**Effective date: May 01, 2013**

STATE OF TEXAS

COUNTY OF BRAZORIA

AFFIDAVIT OF AUTHENTICITY

BEFORE ME, the undersigned authority, on this day personally appeared MICHAEL D. YOST, Superintendent of BRAZORIA DRAINAGE DISTRICT NO. 4, known to me to be the person who subscribed his name below and who, after first having been duly sworn by me, on oath deposes and says that:

"The Board of Commissioners of Brazoria Drainage District No. 4 unanimously passed, approved and adopted the revised *Rules, Regulations & Guidelines* attached hereto on April 9, 2013, as evidenced by their signatures on the *Resolution No. 2013-002* and the *Statement of Authorization.*"

MICHAEL D. YOST, Superintendent

SUBSCRIBED AND SWORN TO BEFORE ME by Michael D. Yost on April 9, 2013.

KIMBERLEY S. WOODALL
MY COMMISSION EXPIRES
January 22, 2017

NOTARY PUBLIC in and
for the STATE OF TEXAS

STATE OF TEXAS §
§
COUNTY OF BRAZORIA §

RESOLUTION NO. 2013-02

A RESOLUTION OF THE BOARD OF COMMISSIONERS OF BRAZORIA DRAINAGE DISTRICT NO. 4 ("DISTRICT"), ADOPTING, AUTHORIZING AND APPROVING REVISED RULES, REGULATIONS AND GUIDELINES REGARDING DRAINAGE AND FLOOD CONTROL WITHIN ITS JURISDICTION

BE IT HEREBY RESOLVED BY THE BOARD OF COMMISSIONERS OF BRAZORIA DRAINAGE DISTRICT NO. 4:

SECTION 1: That the revised Rules, Regulations & Guidelines regarding drainage and flood control within its jurisdiction, attached hereto as Exhibit "A" and incorporated herein for all purposes, is hereby adopted, authorized and approved.

SECTION 2: That each Commissioner is hereby authorized to execute, and the Director of Administrative Services to attest, the attached Rules, Regulations & Guidelines, including the Statement of Authorization therein, for and on the behalf of the District.

PASSED AND APPROVED THIS 9th DAY OF April, 2013.

Brazoria Drainage District No. 4

Jeffrey H. Brennan, Chairman

Dan Keller, Secretary

Harrison Rogers, Commissioner

Attest:

Kimberley Woodall, Director of Administrative Services

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# PREFACE

BRAZORIA DRAINAGE DISTRICT NO. 4 is a political subdivision of the State of Texas. Its mission is to control and distribute the storm and floodwaters within its jurisdiction pursuant to Article XVI, Section 59 of the Texas Constitution, Chapters 49 and 56 of the Texas Water Code and all special legislation pertaining to the DISTRICT.

To achieve its mission, the Board of Commissioners has directed that the DISTRICT:

1. Develop sound fiscal procedures to protect taxpayer monies.

2. Design near-term and long-term goals and objectives.

3. Establish guidelines for land development that has the potential to impact the distribution of storm and floodwaters.

4. Schedule labor force and equipment to meet maximum efficiencies and use thereof.

5. Report plans and program progress to the public through appropriate entities.

## STATEMENT OF AUTHORIZATION

WHEREAS BRAZORIA DRAINAGE DISTRICT NO. 4, (the "DISTRICT") is lawfully and duly constituted, operates under applicable articles of the Texas Constitution, State Statutes, including but not limited to the Texas Water Code, special legislation, and rules and regulations duly adopted by the DISTRICT'S Board of Commissioners; and

WHEREAS a decided need exists for adoption, promulgation, application, and enforcement of uniform standards, Rules, Regulations & Guidelines affecting development within the boundaries of the DISTRICT; and

WHEREAS the aforementioned Rules, Regulations & Guidelines have been duly considered and adopted by the Board of Commissioners of the DISTRICT; and

WHEREAS said duly adopted Rules, Regulations & Guidelines are available at the DISTRICT'S offices at 4813 W. Broadway, Pearland, Texas 77581, and are entitled, Brazoria Drainage District No. 4 Rules, Regulations & Guidelines; and

WHEREAS said Rules, Regulations & Guidelines are readily available to the public and all persons who may be affected by the same; and

WHEREAS said Rules, Regulations & Guidelines are reasonably related to the provision of adequate drainage and flood control for the citizens of and property within the DISTRICT; and

WHEREAS said Rules, Regulations & Guidelines regulate the impact of man-made drainage from any private property into the DISTRICT'S facilities to insure that the DISTRICT'S facilities are capable of handling said artificial runoff and to avoid harm to the DISTRICT'S facilities and pre-existing property and/or persons; and

WHEREAS said Rules, Regulations & Guidelines use generally accepted engineering criteria; and

WHEREAS the DISTRICT seeks compliance with applicable statutes, articles, and rules of the State of Texas, and its agencies requiring notice, publication, and administrative compliance prior to certain enforcement of its Rules, Regulations & Guidelines; and

WHEREAS the DISTRICT called for a public hearing at their regular meeting of November 13, 2012, in accordance with Section 2007.042 of the Texas Government Code and held a public hearing on December 04, 2012 , at which time said Rules, Regulations & Guidelines were presented to the public for review and comment; now therefore,

BE IT RESOLVED that the facts and matters set forth in the preamble hereof are true and correct.

BE IT FURTHER RESOLVED that the DISTRICT, by and through its duly elected Board of Commissioners, having considered all of the facts attendant to adoption and enforcement of its Rules, Regulations & Guidelines, hereby adopts these Rules, Regulations & Guidelines as authorized by Section 49.211 of the Texas Water Code.

BE IT FURTHER RESOLVED that these Rules, Regulations & Guidelines and its appendices shall constitute a component part of the DISTRICT'S master drainage plan, entitled Flood Protection Plan for Brazoria Drainage District No. 4, as authorized by Section 49.211(c) of the Texas Water Code, and shall become effective and enforceable within the DISTRICT'S boundaries on the May 01, 2013

BE IT FURTHER RESOLVED that a certified copy of this STATEMENT OF AUTHORIZATION shall be filed in the official Public Records of Brazoria County, Texas.

PASSED, APPROVED and ADOPTED on this 9th day of April, 2013.

Jeffrey H. Brennan, Chairman

Dan Keller, Secretary

Harrison Rogers, Commissioner

Attest:

Kimberley Woodall, Administrative Assistant

# INTRODUCTION

The DISTRICT and its surrounding areas are drained by seven (7) major drainage arteries which run through the DISTRICT: CLEAR CREEK, HICKORY SLOUGH, MARY'S CREEK, COWARDS (aka COWARTS) CREEK, CHIGGER CREEK, MUSTANG BAYOU, and CHOCOLATE BAYOU. Subdivisions and other developments in the area, which are not located directly on one of these major drainage arteries, are generally drained by man-improved or man-made ditches and storm sewers, which convey the rainfall runoff to a major drainage artery.

Responsibility for provision and maintenance of drainage facilities is uniquely divided between the incorporated cities within the DISTRICT, Brazoria County, and the DISTRICT in the following manner:

1. Incorporated cities are responsible for underground storm sewers, open roadside ditches, and all roadside ditches that have been covered with the construction of various size pipes set at the roadside ditch grade, and regional detention facilities constructed and accepted by the City all within the boundaries of the city.

2. Brazoria County is responsible for underground storm sewers, open roadside ditches, and all roadside ditches that have been covered with the construction of various size pipes set at the roadside ditch grade, all outside the boundaries of a city.

3. The DISTRICT is responsible for the seven major drainage arteries listed above, all tributary drainage ditches, and all regional, sub-regional, and other detention reservoirs constructed in accordance with these criteria and accepted by the DISTRICT, all within the boundaries of the DISTRICT.

The DISTRICT is chartered by the State of Texas to manage these drainage arteries within its boundaries. The DISTRICT'S Board of Commissioners is charged with the responsibility of developing policies and enacting resolutions to facilitate the intent as well as implement the laws of the State of Texas and the DISTRICT'S master drainage plan, entitled Flood Protection Plan for Brazoria Drainage District No. 4, ("Flood Protection Plan") as authorized by Section 49.211(c) of the Texas Water Code.

The DISTRICT'S Flood Protection Plan for the area within its jurisdiction identifies easements and/or fee strips needed along its creeks, bayous, streams, gullies, and ditches, as well as channel design and size for the major drainage arteries and tributary drainage ditches as they are improved.

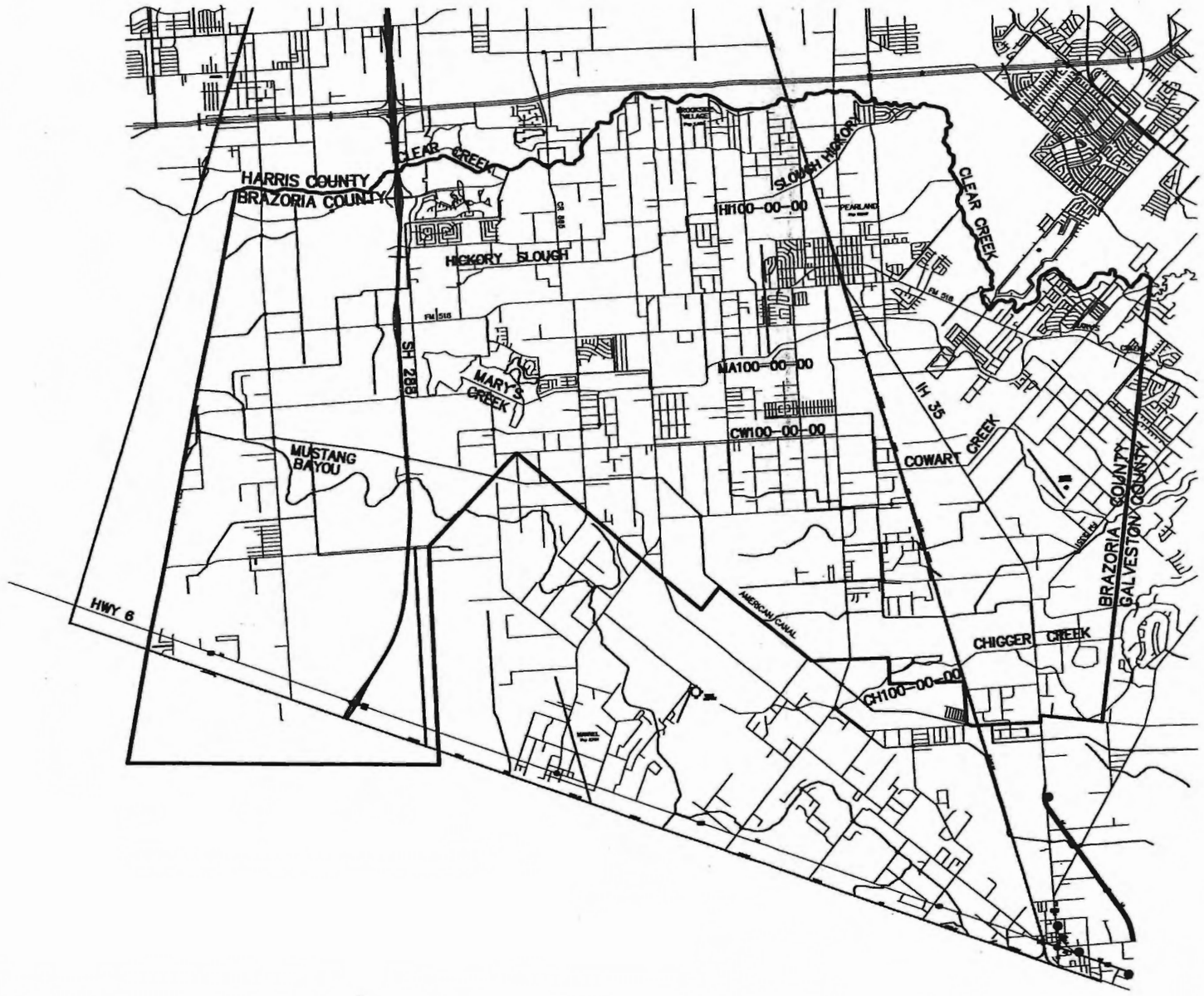
The following Rules, Regulations & Guidelines and its appendices shall constitute a component part of the DISTRICT'S Flood Protection Plan and the District's Flood Protection Plan shall constitute a component part of the DISTRICT'S Rules, Regulations & Guidelines. The following Rules, Regulations & Guidelines apply within the jurisdictional boundaries of the DISTRICT and address, among other subjects, the preparation of drainage plans for development within the DISTRICT'S jurisdiction, taking into consideration waters flowing from the property as a result of said development and the impact these waters have on the DISTRICT'S drainage facilities beyond what was experienced in the property's pre-development state.

The purpose of these Rules, Regulations & Guidelines is to a) provide for the efficient, consistent and orderly development of drainage facilities within the DISTRICT'S jurisdiction by applying generally accepted engineering criteria, and b) establish factual and scientific data required for planning and designing future drainage facilities, in order to achieve adequate retention, detention, and conveyance of storm and flood waters through the DISTRICT'S jurisdiction.

These Rules, Regulations & Guidelines, followed in conjunction with the rules, regulations, guidelines, ordinances, and criteria manuals concerning development of governmental entities which share concurrent jurisdiction with the DISTRICT, provide the developer and the developer's engineer information and instruction necessary for creating drainage plans that will promote the developer's interests and objectives while protecting the health and safety of citizens and property within the DISTRICT'S jurisdiction.

## MAP OF DISTRICT

# MAP OF DISTRICT



# SECTION 1
# OVERVIEW

## A. POLICY STATEMENT

The DISTRICT, by these Rules, Regulations & Guidelines, assumes and exercises its authority as provided by law and does not in anyway infringe upon the express or implied rights or obligations of any other governmental entity which shares concurrent jurisdiction with the DISTRICT. It is not the DISTRICT'S intent to usurp the powers or authority of any other governmental entity by exercising its own authority.

## B. DRAINAGE PLAN

It is the expressed intent of the DISTRICT to control flooding and detain excess runoff of orderly development. To that end, these Rules, Regulations & Guidelines serve to provide the means of zero downstream impact after development.

In order to control flooding and detain excess run off, the DISTRICT requires that developers prepare and submit to the DISTRICT a Preliminary and Final Drainage Plan, prior to development. A Final Drainage Plan must be filed and approved prior to commencement of construction. The DISTRICT also requires the following:

1. The Preliminary and Final Drainage Plans shall define the method of moving rainfall runoff from the development to the appropriate drainage artery and comply with the requirements and specifications as contained in these Rules, Regulations & Guidelines.

2. No person shall commence the development of any property within the jurisdiction of this DISTRICT without first securing the DISTRICT'S approval of a Final Drainage Plan as provided in Section 5 of these Rules, Regulations & Guidelines.

3. All drainage systems shall be constructed in strict compliance with the approved Final Drainage Plan.

4. The DISTRICT shall conduct periodic inspections of all projects being constructed within the DISTRICT. All outfalls into DISTRICT facilities must be inspected during installation.

5. A Texas Registered Professional Engineer shall submit to the DISTRICT a certification that the project has been constructed in accordance with the

approved Final Drainage Plan. The engineer shall submit the certificate in writing to the DISTRICT along with a CDROM of the 'As-Built' drawings within thirty (30) days after completion of the project which is subject to the Final Drainage Plan or the completion of all drainage structures on the Final Drainage Plan, whichever is earlier.

6. The DISTRICT shall conduct a formal inspection and notify the engineer in writing of any deficiencies. The engineer shall notify the DISTRICT when all deficiencies have been corrected and a subsequent inspection will be conducted. If all deficiencies have been corrected, a Certificate of Completion will be issued.

7. No drainage system or detention facility shall be placed in service until a certificate is issued.

## C. DATUM

The DISTRICT shall use its Flood Protection Plan, as amended, to determine which creeks, bayous, streams, gullies, and ditches are governed by the DISTRICT, and to determine the easements or fee strips required along such creeks, bayous, streams, gullies, and ditches for the DISTRICT'S access and maintenance of its drainage facilities. The developer's drainage plan elevations shall correspond with and be the datum used on the latest FEMA Floodplain Maps, as amended.

## D. REVIEW AND APPROVAL

Review and approval of Drainage Plans by the DISTRICT shall be accomplished in two phases as follows:

1. Preliminary Drainage Plan - The Preliminary Drainage Plan shall present the developer's overall approach to moving rainfall runoff from the development to the appropriate drainage artery. The rainfall distribution, loss rates, and hydrograph parameters used in the analysis shall be presented as described in Appendix A. The Preliminary Drainage Plan must also show the Detention System (where applicable), approximate volume, approximate sizes of any ditches, and the outfall with the proposed metering method.

2. Final Drainage Plan - The Final Drainage Plan shall contain the detailed design of all drainage improvements as specified in the following sections, the rainfall runoff impact information pertaining to the affected major drainage artery, and any special notes on the plat, including deed restrictions. A professional engineer registered in the State of Texas must seal the Final Drainage Plan.

Review and approval of all drainage plans by the DISTRICT will be performed coincident with other proper approval authorities, as nearly as possible to expedite approval of the development. Two (2) copies of the Preliminary Drainage Plan (and Preliminary Plat, if required as shown in SECTION 4.B. herein) of the proposed development along with the applicable filing fee shall be submitted to the DISTRICT for review. No review will be conducted or approval granted without the submittal of the applicable filing fee. Approval will be granted pursuant to the terms of Section 4.D.

One (1) copy of the Final Drainage Plan (and Final Plat, if required) shall be submitted to the DISTRICT and one (1) copy of the Final Drainage Plan (and Final Plat, if required) and any required resubmittals shall be submitted to the DISTRICT Engineer for review at least fourteen (14) days prior to the DISTRICT'S regular meeting in order for said plan to be placed on the agenda of the DISTRICT for approval, if warranted.

# SECTION 2
# DISTRICT MEETINGS

## A. SUBMITTAL

The Board of Commissioners shall hold such regular and special meetings at the DISTRICT'S office as deemed necessary for the proper conduct of the DISTRICT'S business. Plans (and plats if required) shall be submitted to the DISTRICT and the DISTRICT'S Engineer at least fourteen (14) days prior to the meeting will be reviewed by the DISTRICT'S Board of Commissioners at that time. The Developer must contact the DISTRICT at least fourteen (14) days in advance to be placed on the agenda.

The Preliminary Plan and Preliminary Plat (if required) shall be approved prior to the submittal of the Final Plan and Final Plat (if required).

## B. PROCEDURE

During the meeting of the Board of Commissioners of the DISTRICT, the DISTRICT'S Engineer will present the developer's Drainage Plan (and Plat if required) to the Commissioners for review and discussion, at which time the DISTRICT ENGINEER will make a recommendation to the Commissioners regarding acceptance or denial of the same. The developer may participate in the discussion and offer any additional information the developer deems necessary to assist the Board of Commissioners in making its decision.

## C. APPROVAL

An affirmative vote of two or more commissioners is required in order to approve any plans and/or plats submitted to the Board.

# SECTION 3
# FEE SCHEDULE

Plans (and plats if required) submitted to the DISTRICT for approval must be accompanied by a check made payable to the DISTRICT for an amount specified in the Schedule of Fees and as determined by resolution of the Board of Commissioners from time to time. Said fee schedule is kept on file at the DISTRICT'S office and copies are available upon request.

***Plans will not be reviewed until the required fee has been paid.***

# SECTION 4
# PRELIMINARY DRAINAGE PLAN & PLAT

The developer shall prepare or have prepared a Preliminary Drainage Plan for each development, which outlines the method proposed for, and impact resulting from the moving of rainfall runoff from the developed area to a drainage artery. This plan shall be submitted to the DISTRICT for review and approval to insure that adverse drainage or flooding conditions will not be created along any drainage artery or adjacent property as a result of the proposed development. The preliminary drainage plan must carry the interim seal of the engineer that prepared the plan.

## A. CONTENTS OF PRELIMINARY DRAINAGE PLAN

**Scale: Use standard engineering scales, properly identified on each drawing. Sheet size 22" X 34" is required.**

Preliminary Drainage Plans for all new construction or developments are required to show the following as a minimum:

1. Plan shall be titled "Preliminary Drainage Plan."

2. Firm name, address, phone number, and name of the of engineer that prepared the plan and the owner.

3. Date on all submittals and date of all revisions, including month, day, and year.

4. Scale of drawing with a minimum scale of 1" = 100'.

5. Location or vicinity map drawn to a scale.

6. Benchmark and reference benchmark with datum and year of adjustment. All projects must be tied vertically and horizontally to a City of Pearland or Brazoria Drainage District No. 4 benchmark.

7. DISTRICT notes in accordance with Section 5.H.

8. Copies of authorization documents, e.g., licenses, consent, etc., showing permission to cross privately held easements and fee strips.

9. Signature lines for the DISTRICT Superintendent and the DISTRICT Engineer in accordance with Section 4.D.

10. Contour lines at 0.5 foot intervals where slopes do not exceed 1.0% and 1 foot intervals for slopes exceeding 1.0% intervals covering the entire development and extended beyond the development boundaries at least two hundred (200) feet on all sides for development over five (5) acres, and fifty (50) feet on developments under five (5) acres. Two contours minimum are required.

11. Cross-section of existing and/or proposed detention facility, swales, and ditches.

12. Drainage area divides for the project area, including off-site areas, with peak runoff rates for each inlet, structure, or drainage area.

13. Location and dimensions of all existing and proposed drainage easements and fee strips. (See Section 9.)

14. Location of all drainage arteries adjacent to or crossing the development as determined by actual ground survey by the developer's surveyor including filing information and the DISTRICT Unit No. for the channel. Survey shall have been completed within the past year and shall show the stream alignment two hundred (200) feet upstream and downstream of development. This shall include identifying the static water level (if any).

15. Detention calculations in accordance with the applicable provisions of Appendix A, including volumetric calculations of detention provided. Calculations shall include the allowable release rate and restrictor sizing analysis. The detention service area, rate of detention, detention required, and detention provided shall be shown on the plans.

16. Drainage area map of receiving system if discharging to existing storm sewer system Drainage area of receiving channel if discharging to open ditch or stream. Provide calculations to prove available capacity.

17. Limits of the floodway and the 100-year floodplain scaled from the current FIRM. If none exists within the project limits, add a note stating that the entire project is outside of the floodplain.

18. Location of all existing and proposed buildings, structures, paving or other impermeable cover within the site or development.

19. Location of all planned drainage improvements proposed for moving runoff water from the development to the drainage artery and the point(s) of entry into the drainage artery.

20. Points at which structures or pipelines will cross any and all drainage ditches, streams, etc., within the development.

21. Location of structures or other physical features on the development area to provide orientation as required during field inspection of the site.

22. Location of all existing drainage structures, pipelines and other underground features on the property, and adjacent easements and fee strips.

23. Names of adjacent property owners.

24. Copy of application to Corps of Engineers requesting approval of discharge if connecting to one (1) of the seven (7) major drainage arteries.

25. Copy of request for a TxDOT Permit if applicable.

26. Plan shall contain Engineer's interim review stamp.

## B. CONTENTS OF PRELIMINARY PLAT (IF REQUIRED)

Certain governmental entities within the jurisdiction of the DISTRICT require signatures of the DISTRICT on plats certifying compliance with the DISTRICT'S Rules, Regulations & Guidelines before approval is granted. In these instances, a Preliminary Plat must be submitted to the DISTRICT simultaneously with the Preliminary Drainage Plan. In addition to the requirements of the governing entity, the following information must be on the plat:

1. Title plat "Preliminary Plat".

2. Name, address and phone number of the surveyor that prepared the plat and of the owner.

3. Date on all submittals and date of all revisions, including month, day, and year.

4. Location or vicinity map drawn to a scale.

5. Benchmark and reference benchmark with datum and year of adjustment.

6. DISTRICT notes in accordance with Section 5.H.

7. Signature lines for the DISTRICT Superintendent and the DISTRICT Engineer in accordance with Section 4.D.

8. Location and dimensions of all existing and proposed drainage easements and fee strips. (See Section 9.)

9. Location of all drainage arteries adjacent to or crossing the development as determined by actual ground survey by the developer's surveyor including recording information and the DISTRICT Unit Number. Survey shall have been completed within the past year and shall show stream alignment two hundred (200) feet upstream and downstream of development.

10. Limits of the floodway and 100-year floodplain scaled from the current FIRM. If none exists, add a note stating that the subject tract lies entirely outside the 100-year floodplain.

11. For all Preliminary Plat submittals requirements must conform to the Texas Board of Professional Land Surveying Rule 663.18.

12. Names of adjacent property owners or lot and block number if a platted subdivision.

## C. SUBMISSION

One copy of the Preliminary Drainage Plan (and Preliminary Plat if required) along with the applicable filing fee shall be submitted to the DISTRICT and one copy shall be submitted to the DISTRICT'S Engineer.

## D. SIGNATURE BLOCK – PRELIMINARY DRAINAGE PLAN AND PLAT

Approved by Brazoria Drainage District No. 4

_____ _____

District Superintendent Date

_____ _____

District Engineer Date

The above signatures are valid for three hundred sixty-five (365) calendar days from the date shown. The above signatures do not constitute authorization for any construction.

## E. APPROVAL

The DISTRICT will approve the proposed Preliminary Drainage Plan (and Preliminary Plat if required) if:

1. There is no increase in the 3-year, 10-year, and 100-year peak discharge from the site and no increase in the 3-year, 10-year and 100-year peak discharge or water levels in the affected drainage artery; or

2. Adequate provisions are made to detain the peak discharge to eliminate any increases in the 3-year, 10-year, and 100-year site runoff discharge rate, as well as the 3-year, 10-year and 100-year peak discharge or water levels in the affected drainage artery; or

3. Drainage artery deficiencies are corrected or improved, at the developer's expense, to carry the projected additional load resulting from the proposed development to a regional detention facility.

4. All required fees have been paid.

The approval of a Preliminary Drainage Plan (and Preliminary Plat if required) does not allow construction or development activities to begin. A Final Drainage Plan (and Final Plat if required) must be submitted and approved by the DISTRICT in accordance with Section 5. In the case of a single-family residential site (single ownership with one (1) dwelling unit), which is not being subdivided, the DISTRICT may at its discretion, waive the requirements for the Preliminary Drainage Plan, and allow the owner to proceed directly to a Final Drainage Plan.

## F. MASTER DRAINAGE PLANS OR DRAINAGE PLANS WITH VARIANCES

All Master Drainage Plans for any development submitted under these rules and regulations or any Preliminary Drainage Plan (and Preliminary Plat if required) submitted with a request for variance from these Rules, Regulations, and Guidelines must be approved by the Board of Commissioners. In each case, the signatory requirements must comply with Section 5.I.

## G. DENIAL

In the event the DISTRICT denies approval of the Preliminary Drainage Plan, the DISTRICT shall, within a reasonable time after said denial, but in no case later than ten (10) days from the date of said denial, prepare and provide to the developer requesting approval, a written report that identifies the area(s) not in compliance with the DISTRICT'S Flood Protection

Plan or Rules, Regulations & Guidelines, and shall not provide methodologies or technologies appropriate for correcting those areas not in compliance.

## H. APPEAL

In the event the DISTRICT denies approval of a Preliminary Drainage Plan, the developer may appeal such denial in accordance with the procedures set forth in Section 16 herein.

## I. REGIONAL DETENTION FACILITIES

The DISTRICT along with other governmental entities have constructed numerous regional detention facilities throughout the DISTRICT. These facilities may be utilized in lieu of on-site detention provided there is sufficient conveyance to the detention facility and/or DISTRICT channel. A meeting with the DISTRICT to discuss this possibility shall be held prior to assuming that these facilities will be allowed for the project.

# SECTION 5
# FINAL DRAINAGE PLAN & PLAT

A Final Drainage Plan for each development prepared by a Texas registered professional engineer and complying with the DISTRICT'S Rules, Regulations & Guidelines shall be presented to the DISTRICT for review and approval. The plan shall, in accordance with this section, consist of detailed design drawings for all drainage improvements and structures, rainfall runoff, impact data, and notes to be included, as applicable, including deed restrictions.

## A. CONTENTS OF FINAL DRAINAGE PLAN

**Scale: Use standard engineering scales, properly identified on each drawing. Sheet size 22" X 34" is required.**

Final Drainage Plans for all new construction or developments are required to show the following as a minimum:

1. Plan shall be titled "Final Drainage Plan".

2. Provide the name of the MUD and MUD engineer and the name of the surveyor including contact information. The contact information for the Homeowners Association shall be submitted to the DISTRICT upon being formed.

3. Date on all submittals and date of all revisions, including month, day, and year.

4. Scale of drawing with a minimum scale of 1" = 100'.

5. Location or vicinity map drawn to a scale.

6. Benchmark and reference benchmark with datum and year of adjustment. All projects must be tied vertically and horizontally to a City of Pearland or Brazoria Drainage District #4 benchmark.

7. DISTRICT notes in accordance with Section 5.H.

8. Copies of authorization documents, e.g., licenses, consents, etc., showing permission to cross privately held easements and fee strips.

9. Signature lines in accordance with Section 5.I.

10. Contour lines at 0.5 foot intervals where slopes do not exceed 1.0%, and 1 foot intervals for slopes exceeding 1.0% intervals covering the entire development and extended beyond the development boundaries at least two hundred (200) feet on all sides for developments over five (5) acres and fifty (50) feet on developments under five (5) acres. Two (2) contours minimum are required.

11. Cross-section of existing and/or proposed detention facility, swales, and ditches.

12. Drainage area divides for the project area, including off-site areas with peak runoff rates for each inlet, structure, or drainage area.

13. Location and dimensions of all existing and proposed drainage easements and fee strips. (See Section 9.)

14. True location of all drainage arteries adjacent to or crossing the development, as determined by actual ground survey by the developer's surveyor. Survey shall have been completed within one year of the date of approval of the Preliminary Drainage Plan and shall show stream alignment two hundred (200) feet upstream and downstream of development. This shall include identifying the static water level (if any).

15. Final detention calculation in accordance with the applicable provisions of Appendix A including volumetric calculations of detention provided. Calculations shall include the allowable release rate and restrictor sizing an analysis. The detention service area, rate of detention required, and detention provided shall be shown on the plans.

16. Drainage area map of receiving system if discharging to existing storm sewer system. Drainage area of receiving channel if discharging to open ditch or stream. Calculations to prove available capacity.

17. Limits of the floodway and the 100-year floodplain scaled from the current FIRM. If none exists within the project limits, add a note stating that the entire project is outside of the floodplain.

18. Location of all existing and proposed buildings, structures, pipelines, paving or other impermeable cover within the site or development and adjacent easements and fee strips.

19. Points at which structures or pipelines will cross any and all drainage ditches, streams, etc., within the development.

20. Provide a complete set of construction plans which include a lot grading plan that provides for the passage of sheet flow from adjacent property.

21. A 100-year sheet flow analysis that provides direct access to the detention facility or main outfall.

22. Details of all ditches, which are to convey rainfall runoff from a subdivision and/or through a subdivision to the appropriate DISTRICT drainage artery and location of that DISTRICT drainage artery. All ditches must comply with specifications herein.

23. Bridges, which span any creek, bayou, stream, gully, or ditch, specifying maintenance responsibility and/or ownership of such structures.

24. Culvert type and size shall be shown. No culvert shall be less than 18" in diameter without special permission by the DISTRICT'S engineer.

25. Seal of the Registered Professional Engineer that prepared the plan.

26. An erosion control plan and a permanent storm water quality plan acceptable to the DISTRICT and the Texas Commission on Environmental Quality (TCEQ). The DISTRICT shall receive copies of all submittals to the (TCEQ).

27. Any project that discharges into one (1) of the seven (7) major drainage arteries must have a permit or letter of no objection from the Corps of Engineers and a copy of that approval must be furnished the DISTRICT. A letter sealed by a Registered Professional Engineer certifying that a Nationwide Permit is applicable may be permitted.

28. A copy of the TxDOT permit, if applicable.

29. Provide a detention area service map.

30. CDROM containing the project boundary and plans tied to the State Plane Coordinate System NAD 83.

## B. RUNOFF AND IMPACT DATA

1. An analysis of the impact of the development must be submitted as outlined in Appendix A. The resultant impact, if any, must be mitigated in accordance with the provisions of Appendix A.

2. All fill in the 100-year floodplain, designated on the Flood Insurance Rate Map (FIRM) below the 100-year base flood elevation, must be mitigated by compensating cut from the floodplain in the vicinity of the fill. This compensating storage volume may be placed in an on-site or adjacent detention facility by adding the compensating storage to the detention volume required for impact mitigation.

3. A complete set of construction plans for the site must be submitted with the Final Drainage Plan.

## C. CONTENTS OF FINAL PLAT (IF REQUIRED)

Certain governmental entities within the jurisdiction of the DISTRICT require signatures of DISTRICT'S Board of Commissioners on plats certifying compliance with the DISTRICT'S Rules, Regulations & Guidelines before approval is granted. In these instances, a Final Plat must be submitted to the DISTRICT simultaneously with the Final Drainage Plan. In addition to the requirements of other governing entities, the following information must be on the plat:

1. Title plat "Final Plat".

2. Name, address and phone numbers of the surveyor that prepared the plat, owner, MUD, and Home Owners Association as applicable.

3. Location or vicinity map drawn to a scale.

4. Benchmark and reference benchmark with datum and year of adjustment. All projects must be tied vertically and horizontally to a City of Pearland or Brazoria Drainage District No.4 benchmark.

5. DISTRICT notes in accordance with Section 5.H.

6. Signature lines for the DISTRICT in accordance with Section 5.I.

7. Location and dimensions of all existing and proposed drainage easements and fee strips. (See Section 9.)

8. True location of all drainage arteries adjacent to or crossing the development as determined by actual ground survey by the developer's surveyor. Survey shall have been completed within the past year and shall show stream alignment two hundred (200) feet upstream and downstream of development.

9. Paper copies of the plat shall conform to Texas Board of Land Surveying Rule 663.18 (c).

10. Applicable signatures of all parties to the plat prior to Board approval.

11. CDROM containing the project boundary tied to the State Plane Coordinate System NAD 83.

## D. SUBMISSION

One copy of the Final Drainage Plan, Final Calculations, (and Final Plat if required) shall be submitted to the DISTRICT, and one copy shall be submitted to the DISTRICT Engineer for review at least fourteen (14) days prior to the scheduled request for final approval of the development by the DISTRICT'S Board of Commissioners.

## E. APPROVAL

The DISTRICT will approve the proposed Final Drainage Plan (and Final Plat if required) if:

1. There is no increase in the 3-year, 10-year, and 100-year peak discharge from the site and no increase in the 3-year, 10-year and 100-year water levels in the affected drainage artery;

2. Adequate provisions are made to detain the peak discharge to eliminate any increase in the 3-year, 10-year, and 100-year site runoff discharge rate, as well as the 3-year, 10-year and 100-year peak discharge or water levels in the affected drainage artery; or

3. Drainage artery deficiencies are corrected or improved, at developer's expense, to carry any projected additional load resulting from the proposed development to a regional detention facility.

## F. DENIAL

In the event the DISTRICT denies approval of the Final Drainage Plan, the DISTRICT shall, within a reasonable time after said denial, but in no case later than ten (10) days from the date

of said denial, prepare and provide to the developer requesting approval, a written report that identifies the area(s) not in compliance with the DISTRICT'S Flood Protection Plan or Rules, Regulations & Guidelines.

## G. APPEAL

In the event the DISTRICT denies approval of a Final Drainage Plan, the developer may appeal such denial in accordance with the procedures set forth in Section 16 herein.

## H. SPECIAL NOTES

Notes and clarifying statements shall be entered on the Drainage Plan (and Plat if required) including any deed restrictions to insure compliance with all drainage regulations and requirements. These notes and statements are:

1. Any governmental body for purposes of drainage work may use drainage easements and fee strips provided the DISTRICT is properly notified.

2. Permanent structures, including fences and permanent landscaping, shall not be erected in a drainage easement or fee strips.

3. Maintenance of detention facilities is the sole responsibility of the owner of the property. The DISTRICT will provide maintenance of regional facilities owned and constructed by the DISTRICT, or sub regional facilities constructed by developer(s) for which ownership has been transferred to the DISTRICT with the DISTRICT'S approval. The DISTRICT is responsible only for the maintenance of facilities owned by the DISTRICT unless the DISTRICT specifically contracts or agrees to maintain other facilities.

4. Contractor shall notify the DISTRICT in writing at least forty-eight (48) hours before placing any concrete for drainage structures.

5. The DISTRICT'S personnel shall have the right to enter upon the property for inspection at any time during construction or as may be warranted to ensure the detention facility and drainage system are operating properly.

6. Appropriate cover for the side slopes, bottom and maintenance berm shall be established prior to acceptance of the construction by the DISTRICT. At least 95% germination of the grass must be established prior to acceptance of construction by the DISTRICT.

7. No building permit shall be issued for any lot within this development until the detention facility has been constructed and approved by the DISTRICT.

8. The DISTRICT'S approval of the Final Drainage Plan (and Final Plat if required) does not affect the property rights of third parties. The developer is responsible for obtaining and maintaining any and all easements, fee strips and/or any other rights-of-way across third parties' properties for purposes of moving excess runoff to the DISTRICT'S drainage facilities as contemplated by the Final Drainage Plan and Final Plat.

## I. SIGNATURE BLOCK – FINAL DRAINAGE PLAN AND PLAT

APPROVED BY THE BOARD OF COMMISSIONERS ON _____.

_____
Brazoria Drainage District No. 4

_____
District Engineer

*(Add the following on the Final Drainage Plan Only)*

The above have signed these plans and/or plat based on the recommendation of the DISTRICT'S Engineer who has reviewed all sheets provided and found them to be in general compliance with the DISTRICT'S "Rules, Regulations, and Guidelines". This approval is only valid for three hundred sixty-five (365) calendar days. After that time re-approval is required. Please note, this does not necessarily mean that all the calculations provided in these plans and/or plats have been completely checked and verified. Plans submitted have been prepared, signed and sealed by a Professional Engineer licensed to practice engineering in the State of Texas and plat has been signed and sealed by a Registered Professional Land Surveyor licensed to practice in the State of Texas, which conveys the engineer's and/or surveyor's responsibility and accountability.

## J. SHORT FORM PLAT SUBMITTAL

A development consisting of no more than one single family residential lot may be submitted under the DISTRICT'S short form procedures provided that there are no existing or proposed DISTRICT facilities on or adjacent to the proposed lot. A final plat containing all applicable requirements of the Final Plat submittal section shall be submitted to the DISTRICT for approval. The plat will be reviewed in accordance with the DISTRICT'S review process and items needing to be addressed must be completed prior to the DISTRICT'S Board meeting.

No conditional approvals will be granted. This short form process addresses plats only and is not to be used for construction and drainage plans.

## K. PERMITS

The DISTRICT controls activities within the boundaries of DISTRICT drainage facilities. The DISTRICT grants permits and requires on-site availability of such permits. Permits granted for activity upon DISTRICT facilities shall list the specific activities for which the permit was issued. Activities shall be limited to those shown on the permit. Either the DISTRICT'S Superintendent or DISTRICT'S Engineer shall approve or deny the permit. Payment must be received before the permit will be issued.

This section does not apply to structures included in approved Final Drainage Plans or Final Plats.

## L. WORK WITHIN DISTRICT EASEMENTS AND/OR RIGHTS-OF-WAY

All concrete pours on detention systems require a minimum of forty-eight (48) hours written notice to the DISTRICT and an inspection appointment before the pour begins. Failure to properly coordinate an on-site inspection before concrete is poured will cause portions of the concrete to be broken out at the applicant's expense in order to prove to the DISTRICT'S inspector that construction complies with DISTRICT Rules, Regulations & Guidelines. The DISTRICT does not assume any liability or responsibility for damages occasioned by the exercise of its rights, obligations and powers stated herein.

# SECTION 6
# LIMITS OF APPROVALS

All approvals of the DISTRICT shall be valid for a period not to exceed three hundred sixty-five (365) calendar days beginning after the date of approval. Failure to commence construction of an approved project or to make full use of approvals granted within that time period shall make such approvals null and void. All fees shall be forfeited and will not be returned to the applicant. A request for a one-time extension, for a period not to exceed one hundred eighty (180) days, may be granted by the DISTRICT, at its discretion, provided good cause is shown and the request for the extension is made prior to the expiration of the original approval.

# SECTION 7
# BRIDGES

The following standards are for bridges constructed within DISTRICT easements or right-of-ways.

1. Construction and maintenance of bridges are the responsibility of the property owner.

2. Bridges shall not impede flow upstream or downstream of the bridge.

3. Bridges shall not increase the water surface elevation upstream or downstream of the bridge.

4. Plans for all bridges must be approved by the DISTRICT.

5. Piers may be placed in the bottom of the channel but no pier shall be placed in the center of the channel.

6. Guardrails shall not prevent access to the channel for maintenance. Additional access easements may be required.

7. The bottom of the low chord of the bridge should be two (2) feet above the 100-year water surface elevation.

# SECTION 8
# DITCHES

All ditches designed to convey rainfall runoff from the subdivision or development to a creek or stream shall meet the following minimum specifications:

1. Sides shall not exceed 4:1 side slope unless specifically approved by the DISTRICT.

2. Appropriate covering (hydromulch or approved equal) shall be established on side slopes and bottom of ditches and detention facilities to prevent erosion during periods of maximum water velocity. Germination must cover 95% of such area prior to the time of final inspection, weather permitting.

3. All ditches and storm sewers shall be aligned to point downstream approximately thirty (30) degrees to minimize water turbulence and reduce erosion, or provide drop-down structures at the junction of the outfall and drainage artery.

4. The use of backslope drains and swales is required wherever the property adjacent to detention facilities and drainage ditches slope toward the detention facility or ditch. These drainage systems collect overland peak discharge from channel or facility overbanks and other areas not draining to the storm sewer collection system. Their purpose is to prevent excessive overland peak discharge from eroding grass-lined channel side slopes as it enters the channel, and to prevent overland peak discharge from entering the detention facility or drainage ditch when it should not be included. In the latter case, the swale shall drain the peak discharge to another area where it should be included. If overland peak discharge will be included in a system being designed, the developer's engineer must provide computations for each backslope drain system, the pipe sizing, and swale sizing.

    a) General requirements for backslope drainage systems, including swales and drains are as follows:

    b) Backslope drain pipe shall be aluminized steel, pipe reinforced concrete pipe (RCP) or High Density Polyethylene pipe (HDPE).

    c) Maximum backslope inlet spacing is one thousand (1000) feet or five hundred (500) feet from the backslope inlet to the swale high point.

    d) The drain structure and swale centerline will be five (5) feet inside the channel ditch, easement, or fee strip.

    e) Minimum design depth in swale is 0.5 feet.

f) Maximum design depth in swale is 1.5 feet.

g) Minimum gradient for swale invert is 0.2%.

h) Swale will have a side slope of 3:1.

5. Access to a public right-of- way shall be provided at intervals not to exceed two thousand (2000) feet. This access shall be at least twenty (20) feet wide and shall not be obstructed.

## SECTION 9
## EASEMENTS & FEE STRIPS

The DISTRICT requires fee strips or easements in all developments within its boundaries for the purpose of allowing the DISTRICT access to and maintenance of the DISTRICT'S drainage facilities in accordance with the DISTRICT'S Flood Protection Plan.

1. Easements or fee strips shall be provided at the top of each ditch for unobstructed access by DISTRICT'S drainage crews pursuant to the requirement of Appendix A.

2. For major drainage arteries in the DISTRICT, as listed in the first paragraph of the INTRODUCTION herein, easement and fee strip width shall conform to the Flood Protection Plan.

3. Unobstructed access shall be provided every two thousand (2000) feet to all DISTRICT easements and fee strips from a public road or street. Access paths shall be at least twenty (20) feet wide.

4. Buildings, fences, other structures, and permanent landscaping shall not be erected in drainage easements, fee strips, or access paths.

5. Aerial overhang of a drainage fee strip or easement shall be prohibited unless specifically approved in writing by the DISTRICT.

6. Drainage easements and fee strips may be used by any governmental body for purposes of drainage work provided the DISTRICT is properly notified.

7. Drainage easements or fee strips shall be provided around privately maintained detention facilities pursuant to the requirements in Appendix A.

8. Instruments conveying easements and fee strips to the DISTRICT must be acceptable to the DISTRICT in form and content.

# SECTION 10
# OTHER REGULATIONS

The following are additional requirements:

1. All storm sewer pipes for outfalls shall be reinforced concrete pipe (RCP), aluminized steel pipe, or high density polyethylene pipe (HDPE).

2. If a subdivision (or development) is constructed in phases, in accordance with an approved Final Drainage Plan (and Final Plat if required) the outlet or metering pipe or device shall be designed so the allowable peak discharge from the first phase is the controlling factor for sizing the metering device. As phases are added, additional pipes may be added to the metering system, or the existing device may be altered to allow the peak discharge to be metered for both phases. All future phases must follow this design pattern.

3. In the event that any development within the DISTRICT increases the 3-year, 10-year, and 100-year runoff discharge rate or the 3-year, 10-year or 100-year peak discharge flow or water level in any drainage artery, the developer shall implement a drainage system to prevent any such increase. All drainage systems shall be designed to accumulate, detain, and release water so as to prevent any increase in the 3-year, 10-year, and 100-year peak discharge from the site, or any increase in the 3-year, 10-year or 100-year peak discharge flow or water level in the receiving stream or streams.

4. All detention facilities shall be properly labeled on all prints (DETENTION AREA, SITE, POND, RESERVE, RESERVOIR, etc.).

5. All detention facilities shall have a minimum unobstructed access easement of twenty (20) feet to a public road right-of-way.

# SECTION 11
# MAINTENANCE OF DETENTION FACILITIES

All detention facilities constructed by a property owner or developer shall be maintained by the property owner or developer, their legal heir(s), grantee(s), successor(s) or assignee(s). The DISTRICT shall not be responsible for any such facility maintenance. Ownership of detention facilities constructed adjacent to a DISTRICT drainage facility may be transferred to the DISTRICT with the DISTRICT'S approval. Maintenance of these facilities and other facilities owned by the DISTRICT shall be by the DISTRICT.

## A. NEWLY CONSTRUCTED DETENTION FACILITIES

The DISTRICT, at its option, may accept for maintenance all newly constructed detention facilities provided:

1. The developer/owner conveys the land area of the detention facility to the DISTRICT by General Warranty Deed, in a format acceptable to the DISTRICT. This conveyance shall include a minimum 20-foot wide unobstructed access way to the nearest public street.

2. The detention facility is constructed in accordance with Final Drainage Plans approved by the DISTRICT.

3. The DISTRICT is furnished a set of "As-Built" drawings, sealed by a surveyor registered in the State of Texas.

4. The detention facility has a concrete pilot channel.

5. The detention facility is designed to be a "dry" facility and not an amenity or private recreational facility. Amenity ponds shall be defined as any pond in which land area has been deeded to the Homeowners/Landowners. These ponds shall include "wet ponds" and ponds used for recreational purposes.

6. The developer/owner has paid to the DISTRICT the appropriate maintenance fee as reflected in the DISTRICT'S Fee Schedule.

7. The developer/owner provides to the DISTRICT 1) an owners title policy for the property conveyed based upon the fair market value as determined by an appraisal, including a tax search, 2) a Warranty, regarding the quality and performance of the facility, including but not limited to engineering, design, construction and operation, and, 3) an Indemnification and Hold Harmless

Agreement for any and all claims, actions and demands, including costs and attorneys' fees, the cause of which originated prior to conveyance. Each of these documents must be acceptable to the DISTRICT in form and content.

8. The pond shall have been constructed with adequate backslope drains and swales that were constructed to DISTRICT standards.

9. The detention facility, maintenance berms and access ways are not obstructed by any other easements or right-of-ways.

## B. PREVIOUSLY CONSTRUCTED DETENTION FACILITIES

The DISTRICT, at its option, may accept for maintenance previously constructed detention facilities provided that:

1. The facilities are returned to the standards of the DISTRICT that were in force at the time the DISTRICT approved the final drainage plan.

2. The DISTRICT is provided access to inspect the facility and provide the developer/owner/homeowners association with a list of items that must be corrected. The DISTRICT is allowed to inspect the facility after corrective measures are completed to ensure compliance.

3. A concrete pilot channel is constructed.

4. A minimum twenty (20) foot wide unobstructed access way to the nearest public street is provided.

5. Upon request, the DISTRICT will provide the developer/owner/homeowners association an estimated cost to correct the deficiencies and add the concrete pilot channel. Upon agreement by the parties, the DISTRICT will provide the necessary construction in exchange for a fee based upon the estimated cost of repairs or upgrades as determined by the DISTRICT.

6. The developer/owner conveys the land area of the detention facility to the DISTRICT by General Warranty Deed, in a format acceptable to the DISTRICT.

7. The developer has paid to the DISTRICT the appropriate maintenance fee as reflected in the DISTRICT'S Fee Schedule.

8. The developer/owner provides to the DISTRICT 1) an owners title policy for the property conveyed based upon the fair market value as determined by an appraisal, including a tax search, 2) a Warranty, regarding the quality and performance of the facility, including but not limited to engineering, design, construction, and operation, and, 3) an Indemnification and Hold Harmless Agreement for any and all claims, actions and demands, including costs and attorneys' fees, the cause of which originated prior to conveyance. Each of these documents must be acceptable to the DISTRICT in form and content.

9. The detention facility, maintenance berms and access ways are not obstructed by any other easements or rights-of-way.

10. The detention facility is designed to be a "dry" facility and not an amenity or private recreational facility. Amenity ponds shall be defined as any pond in which land area has been deeded to the Homeowners/Landowners. These ponds shall include "wet ponds" and ponds used for recreational purposes.

For newly constructed and previously constructed detention ponds, the following additional restrictions apply:

1. No detention pond under two (2) acres will be accepted.

2. Detention facilities must be located adjacent to an existing DISTRICT facility.

3. Side slopes must be greater than 3:1 or greater.

4. A note in the acceptance agreement will state that mowing will be only performed on the normal DISTRICT mowing schedule.

5. Hand maintenance must be minimal, and the extent should be identified in the agreement.

6. The acceptance fee may be waived only if accepting the maintenance responsibilities is of substantial benefit to the DISTRICT.

7. Any variance granted to the facility must be considered as part of the acceptance criteria.

8. The DISTRICT will not accept pumped detention systems.

## SECTION 12
## VARIANCES

The DISTRICT may grant a variance to these Rules, Regulations & Guidelines based upon written application by developer/owner, filed with the DISTRICT along with sealed engineering reports, drawings, etc., and presented during said meeting, showing substantial credible engineering evidence that:

1. There is no available alternative or option that would allow compliance with the Rules, Regulations & Guidelines in lieu of a variance; and

2. There are special circumstances or conditions affecting the applicant's land involved such that the strict application of the provisions of this chapter would deprive the applicant of all reasonable use of his land; and

3. The variance is necessary for the preservation and enjoyment of a substantial property right of the applicant; and

4. The granting of the variance will not be detrimental to the public health, safety, or welfare, or injurious to other property in the area; and

5. The granting of the variance will not increase the 100-year floodplain base flood elevations on private property upstream or downstream of the applicant's property; and

6. The granting of the variance will not have the effect of preventing the orderly development of other land in the area in accordance with the provisions of these Rules, Regulations & Guidelines.

The DISTRICT may grant a variance to the Rules, Regulations & Guidelines if it determines, based upon the evidence presented, that an undue hardship may result from strict compliance with said Rules, Regulations & Guidelines. Pecuniary hardship to the developer, standing alone, shall not be deemed to constitute undue hardship.

A variance may be granted so that substantial justice is done and the public interest secured, provided that such variance shall not have the effect of nullifying the intent and purpose of these Rules, Regulations & Guidelines.

Each variance shall be evidenced by an order adopted by the Board of Commissioners, setting forth specific facts upon which findings are made, and entered into the minutes of the meeting in its entirety.

## SECTION 13
## INSPECTIONS

The DISTRICT shall have the right to enter upon the property and inspect the installation of the storm drainage and detention facilities. Upon completion of said inspection the DISTRICT shall issue a letter noting deficiencies and/or that the facilities have been completed in accordance with the approved plans. Noted deficiencies must be rectified prior to acceptance.

Additionally, the DISTRICT shall have the authority to request an As-Built survey prepared and sealed by a Professional Land Surveyor registered in the State of Texas as deemed necessary by the DISTRICT to verify elevations and detention volumes.

The DISTRICT may also enter upon the property to inspect the facilities after acceptance, to ensure that the facilities are functioning and being maintained properly. If deficiencies are noted they must be rectified immediately.

All final inspections shall be performed by the DISTRICT engineer, and shall be in accordance with the "Policy and Procedures for Submittal Review and Construction Inspections" guidelines and checklists dated January 10, 2012, or as amended. Discrepancies in any document shall be governed by the most current regulation.

Once all deficiencies are corrected, the DISTRICT will issue a final certificate of acceptance.

## SECTION 14
## SAVINGS, REPEALER, SEVERABILITY & EFFECTIVE DATE

The saving, repealer, severability and effective date are as follows:

1. Savings:
   All rights and remedies that have accrued in favor of the DISTRICT under these Rules, Regulations & Guidelines and amendments thereto shall be and are preserved for the benefit of the DISTRICT.

2. Repealer:
   All resolutions, actions, policies, and procedures of the DISTRICT that are inconsistent herewith or in conflict with state laws and regulations are hereby repealed, but only to the extent of such inconsistency or conflict.

3. Severability:
   If any section, subsection, paragraph, sentence, clause, phrase, word, or portion of these Rules, Regulations & Guidelines or amendments thereto, is, for any reason, held invalid, unconstitutional, or otherwise unenforceable by any court of competent jurisdiction, such portion shall be deemed a separate, distinct, and independent provision, and such holding shall not affect the validity of the remaining portions thereof, which remaining portions shall continue in full force and effect and be binding upon all parties.

4. Effective Date:
   These Rules, Regulations & Guidelines shall become effective on April 1, 2013 and shall continue in force and effect until amended or repealed.

## SECTION 15
## ENFORCEMENT & COMPLIANCE

The enforcement and compliance requirements are as follows:

1. The developer of a tract of land within the DISTRICT shall submit a Preliminary Drainage Plan and Final Drainage Plan prepared by a Texas licensed professional engineer for any development within the DISTRICT as provided in Sections 4 and 5 of these Rules, Regulations & Guidelines.

2. If the property is being platted, the Drainage Plan must be submitted with a plat, as required, in accordance with Section 4B.

3. No person shall commence the development of any property within the jurisdiction of this DISTRICT without first securing the DISTRICT'S approval of a Preliminary Drainage Plan and Final Drainage Plan as provided in Sections 4 and 5 of these Rules, Regulations & Guidelines.

4. A developer who submits plans, which are approved by this DISTRICT, shall construct all drainage systems in strict compliance with said plans.

5. After construction of ditches and detention reservoirs, developer's engineer shall submit to the DISTRICT a set of "As-Built" drawings signed by the engineer along with verification that all drainage structures have been constructed to the specifications contained in the Final Drainage Plan approved by the DISTRICT. The engineer shall submit the verification in writing to the DISTRICT within thirty (30) days after the completion of the project which is the subject of the Final Drainage Plan or the completion of all drainage structures shown on the Final Drainage Plan, whichever is earlier.

6. In addition to the inspection set forth in Section 13 of these "Rules, Regulations and Guidelines" and pursuant to Section 49.221 of the Texas Water Code the Commissioners, engineers, attorneys, operators, agents, and employees of the DISTRICT have the right to enter real property within the jurisdiction of this DISTRICT to inspect, survey, or perform tests upon said property to determine the condition, value, or usability of the property with reference to the proposed location of flood control works, improvements, plants, facilities, equipment, or appliances.

7. In addition to the inspection set forth in Section 13 of these "Rules, Regulations and Guidelines" and pursuant to Section 49.221 of the Texas

Water Code the Commissioners, engineers, attorneys, operators, agents, or employees of the DISTRICT are entitled to enter any public or private property within the boundaries of the DISTRICT or adjacent to any reservoir or other property owned by the DISTRICT at any reasonable time for the purpose of inspecting and investigating conditions relating to the quality of water in the state or the compliance with any rule, regulation, permit, or other order of the DISTRICT.

8. Pursuant to Section 49.221 of the Texas Water Code the Commissioners, engineers, attorneys, operators, agents, or employees of this DISTRICT who enter private property shall observe the establishment's rules and regulations concerning safety, internal security and fire protection, and shall notify any occupant or management of their presence and exhibit proper credentials.

9. All requirements contained in these Rules, Regulations & Guidelines are mandatory unless specifically stated otherwise or unless a variance is granted by the DISTRICT. The use of the term "Guidelines" herein does not affect the mandatory nature of these Rules, Regulations & Guidelines.

10. For purposes of calculating any day or period of time under these rules, the day that the written notice is deposited into the United States mail or hand delivered to the person against whom penalties are to be assessed shall not be included in the period of time. The last day of the period so computed is to be included, unless it is a Saturday, Sunday, or legal holiday, in which event the period of time runs until the end of the next day which is not a Saturday, Sunday, or a legal holiday. Saturdays, Sundays, and legal holidays shall be counted when computing this time period. The period of time begins to run when written notice is placed in the United States mail or when said notice is hand delivered to the person to whom it is addressed.

# SECTION 16
# PENALTIES

## A. CIVIL PENALTIES

1. Pursuant to Section 49.004 of the Texas Water Code, the DISTRICT may assess reasonable civil penalties for the violation of the DISTRICT'S Rules, Regulations & Guidelines, not to exceed the jurisdiction of a Justice of the Peace Court.

2. A penalty under this section is in addition to any other penalty provided by law and may be enforced by filing complaints in an appropriate court having jurisdiction over the matter.

3. The DISTRICT may seek to recover reasonable attorneys' fees, reasonable expert witness fees, interest, and other reasonable costs incurred by the DISTRICT in conjunction with the prosecution of said penalties, in addition to the penalty assessed.

4. The DISTRICT may assess a separate penalty for each and every separate violation of its rules.

## B. HEARINGS ON CIVIL PENALTIES

Before assessing a civil penalty pursuant to this section, the DISTRICT shall meet the following procedural requirements:

1. Provide written notice to the person against whom penalties are sought by certified mail, return receipt requested. If the identity of the developer or owner of the property in question is not known, the DISTRICT may provide written notice by placing such a written notice on the property itself in a manner calculated to attract the attention of the owner or developer of the property.

2. The written notice shall be mailed or delivered to the owner or developer of the property in question at least fourteen days prior to the open meeting at which the assessment of civil penalties will be considered.

3. The written notice shall advise the person, against whom penalties are sought, of the following:

a) the date, place and time of the hearing;

b) The maximum amount of penalties, which may be assessed by the DISTRICT.

c) He/she has the right to appear at the hearing before the Board of Commissioners concerning the penalties in question either in person or through a duly authorized agent;

d) He/she has the right to address the Board of Commissioners on the subject of penalties in question either in person or through a duly authorized agent;

e) He/she has the right to have legal counsel present if he/she so desires;

f) He/she has the right to present witnesses at the hearing or written data relevant to the subject matter of the hearing.

4. Before assessing a civil penalty, the DISTRICT shall, in its written notice to the person against whom the penalties are sought, advise said person of the following:

a) The rule or regulation of the DISTRICT allegedly violated;

b) A general statement of the grounds for the civil penalty providing reasonable notice of the nature of the violation (e.g., failure to file a plan or failure to construct the plan approved by the Board of Commissioners).

5. All civil penalties assessed by the DISTRICT must be authorized by a majority vote of Commissioners present and voting.

6. In the event that the DISTRICT assesses any civil penalties against any person, the DISTRICT shall provide written notice by certified mail, return receipt requested, advising the person subject to civil penalties of the following:

a) The nature of the violation;

b) The amount of the civil penalties;

c) The date by which payment of the civil penalty is due.

7. Payment of all civil penalties assessed by the DISTRICT is due and owing thirty (30) days following written notice by certified mail, return receipt requested, that the civil penalty is due and payable.

## C. CUMULATIVE REMEDIES

Nothing in this Section shall or shall not be deemed to prevent, prohibit, or limit any other remedy at law or in equity otherwise available to the DISTRICT.

## D. APPEAL

Any person or entity against which civil penalties are such assessed may appeal such assessment in accordance with the procedures set forth in Section 16 herein.

## SECTION 17
## APPELLATE PROCEDURES

Appellate procedures are as follows:

1. In the event the DISTRICT makes an adverse ruling, the DISTRICT shall provide written notice of its adverse decision to the developer.

2. The developer may request an appellate hearing before the Board of Commissioners, provided that the developer requests such a hearing within fourteen (14) days of the date of receipt of the written communication from the DISTRICT. A request for an appellate hearing must be in writing.

3. The DISTRICT shall provide the developer with at least ten (10) days' notice in writing of the date of the appellate hearing. The DISTRICT shall schedule the hearing within thirty (30) days of the developer's written request, if practical.

4. The written notice of any adverse ruling made by the DISTRICT shall state that (a) the developer has the right to place an adverse decision on the agenda of a future open meeting as provided in this section, (b) the developer may appear in person or by an authorized agent at the hearing, and (c) the developer may submit additional relevant data, in either oral or written form, to the DISTRICT at the hearing.

5. During the appellate hearing, the Board of Commissioners shall receive any additional relevant data presented by developer or his/her authorized agent, after which time, a majority of the Commissioners present and voting may vote to change, modify, revise or uphold the DISTRICT'S earlier ruling. The ruling of the Board of Commissioners during the appellate hearing shall be the final ruling of the DISTRICT.

## SECTION 18
## AMENDMENTS

The DISTRICT'S Rules, Regulations & Guidelines may be amended from time to time pursuant to state law.

# APPENDIX A
# CRITERIA & METHODOLOGY

## 1. BACKGROUND

### 1.1. INTRODUCTION

Over the years a number of methods have been used in Brazoria County and adjacent counties for discharge determination in the design and analysis of flood control facilities. The methods included various forms of the Rational Method, U.S. Soils and Conservation Society synthetic unit hydrograph analysis using existing stream gauging records and computer programs developed by the Corps of Engineers, and U.S. Geological Survey generalized regression equations developed for the area.

In the mid-1960's, the Harris County Flood Control District (HCFCD) and the City of Houston commissioned a detailed hydrologic study of Harris County which resulted in the development of discharge versus drainage area relationships and unit graph methodologies used for the design of flood control and drainage facilities.

In June of 2001, Tropical Storm Allison came ashore on the Upper Texas Coast and produced record rainfall amounts and pervasive flooding in Harris and surrounding counties, including the Clear Creek Watershed. In October of 2001, through a joint effort between FEMA and HCFCD, Harris County began the Tropical Storm Allison Recovery Project (TSARP).

Since that time, a variety of updated models and FEMA maps have been released. Some of these models and maps are still preliminary while others have been officially adopted. It is required that the effective (current) FEMA map shall be used for any project within the DISTRICT. Furthermore, any new or updated analysis within the DISTRICT shall consider the tail water effects based upon potentially higher water surface elevations in the models or effective maps within neighboring counties. If the project involved requires the approval of FEMA, then the requirements of FEMA shall supersede any DISTRICT requirements.

In the case that FEMA approval is not required for the project, design engineers should use the methodology presented in this Appendix to design drainage facilities in the DISTRICT.

# 2. HYDROLOGIC ANALYSIS OVERVIEW

The selection of an appropriate hydrologic methodology for all projects shall be carried out in accordance with Figure 2-1. The design engineer shall contact the appropriate reviewing agencies prior to preparing his analysis to obtain approval of the selected methodology. This shall include a meeting with the DISTRICT'S Engineer.

HEC-HMS was created at the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC). HEC-HMS has replaced HEC-1 as the standard rainfall-runoff model. For this reason, the design engineer shall get approval from the DISTRICT'S Engineer prior to using HEC-1 models. This applies to existing, revised, and proposed models. Please note that a rainfall runoff analysis using HEC-1 or HEC-HMS should only be used in cases where it is required for FEMA submittals or where a reviewing agency has determined that the design engineer must investigate the downstream impacts of the proposed project. In any case, for projects requiring FEMA approval, design engineers should use the most current effective model of the study stream.

## 2.1. PEAK DISCHARGE DETERMINATION

### 2.1.1. APPLICATION OF RUNOFF CALCULATION MODELS

#### 2.1.1.1. ACCEPTABLE METHODOLOGY FOR AREAS LESS THAN TWO HUNDRED (200) ACRES

For areas up to two hundred (200) acres served by storm sewer or roadside ditch, peak discharges will be based on the Rational Method. If the modeling is associated with establishing a flood-prone area for purposes of a FEMA submittal, the models to be used must be acceptable to that agency.

#### 2.1.1.2. ACCEPTABLE METHODOLOGY FOR AREAS GREATER THAN TWO HUNDRED (200) ACRES

Rainfall runoff modeling will be applied to areas greater than two hundred (200) acres in size. Again, if the modeling is associated with establishing a flood-prone area for purposes of a FEMA submittal, the models to be used must be acceptable to that agency.

### 2.1.2. RAINFALL DURATIONS FOR HYDROLOGIC MODELING

For design using HEC-HMS, the 24-hour design storm isohyet graph will be used for rainfall data for drainage areas larger than two hundred (200) acres.

## 2.1.3. APPLICATION OF THE RATIONAL METHOD

Use of the Rational Method for calculating the peak pre- development and post development runoff for a storm drainage system involves applying the following formula to runoff:

$$Q = CIA$$

Where Q = peak discharge (cfs)
C = runoff coefficient
A = area (acres)
I = rainfall intensity (inches per hour)

### 2.1.3.1. CALCULATION OF RUNOFF COEFFICIENT

The runoff coefficient "C" values in the Rational Method formula will vary based on the land use. Land use types and "C" values which can be used are as follows:

| Land Use Type | Runoff Coefficient* |
|---|---|
| Paved Areas/Roofs | 1.0 |
| Residential Districts | |
| Lots more than ½ acre | 0.40 |
| Lots 1/4 - ½ acre | 0.50 |
| Lots 8,000 sf. – 1/4 acre | 0.55 |
| Lots 5,000 sf. – 8,000 sf. | 0.60 |
| Lots less than 5,000 sf. | 0.70 |
| Multi-Family areas | |
| Less than 20 DU/AC | 0.75 |
| 20 DU/AC or Greater | 0.85 |
| Business Developments | 0.95 |
| Industrial Developments | 0.95 |
| Railroad Yard Areas | 0.30 |
| Parks / Open Areas | 0.30 |

| | |
|---|---|
| Rice Fields/Pastures | 0.20 |
| Lakes / Detention Facilities*** | 1.0 |

** Includes concrete, asphalt, gravel, limestone, crushed stone, and lime stabilized surfaces.

*** Includes wet and dry detention facilities. Area will be computed from the top of slope.

Composite "C" values may be allowed in mixed-use drainage areas. These values are obtained by calculating the weighted average of the contributing sub-areas as follows:

$$C = \frac{(C_1A_1 + C_2A_2 + C_3A_3 \ldots C_nA_n)}{(A_1 + A_2 + A_3 \ldots A_n)}$$

The calculations and an exhibit of surface types for use of composite "C" values shall be included with the drainage calculations and provided on the plans.

### 2.1.3.2. DETERMINATION OF TIME OF CONCENTRATION

The following method shall be used for determining the time of concentration

$$Tc = D / (60*v) + Ti$$

Where Tc = time of concentration (minutes)
Ti = initial time (minutes)
use 10 minutes for developed flows
use 15 minutes for undeveloped flows
D = travel distance on flow path (feet)
V = velocity (ft / sec)

Time of concentration shall be based upon the actual travel time from the most remote point in the drainage area to the point of runoff. The design engineer shall provide a sketch of the travel path with the calculations.

The following minimum and maximum velocities shall be used when calculating the time of concentration.

| SURFACE TYPE | UNDEVELOPED FLOWS MIN V (fps) | DEVELOPED FLOWS MIN V (fps) |
|---|---|---|
| storm sewer | 3.00 | 3.00 |
| ditch / channel | 2.00 | 2.50 |
| paved area | 1.50 | 1.50 |
| bare ground | 0.50 | 1.00 |
| grass | 0.35 | 0.50 |
| thick vegetation | 0.25 | 0.35 |

### 2.1.3.3. RAINFALL INTENSITY

The rainfall intensity shall be computed as follows:

$$I = b / (Tc + d) ^ e$$

Where I = rainfall intensity (in / hr)
Tc = time of concentration (min)
b, d, e = coefficients per the table below

| COEFFICIENT | 100-YEAR | 50-YEAR | 25-YEAR | 10-YEAR | 5-YEAR | 3-YEAR |
|---|---|---|---|---|---|---|
| Tc <= 60 min | | | | | | |
| b | 90.8 | 107.0 | 98.5 | 107.9 | 92.9 | 90.6 |
| d | 16.5 | 21.1 | 24.0 | 23.6 | 19.7 | 19.5 |
| e | 0.685 | 0.734 | 0.729 | 0.781 | 0.788 | 0.803 |
| Tc > 60 min | | | | | | |
| b | 84.0 | 86.5 | 89.2 | 96.6 | 70.1 | 71.0 |
| d | 11.0 | 10.0 | 10.4 | 17.2 | 7.7 | 8.4 |
| e | 0.679 | 0.709 | 0.736 | 0.770 | 0.752 | 0.774 |

## 2.2. SMALL WATERSHED METHOD HYDROGRAPH METHODOLOGY

The small watershed method referred to in Figure 2-1 is the one developed by H.R. Malcolm and is described below.

## 2.2.1. INTRODUCTION

A technique for hydrograph development which is useful in the design of detention facilities serving relatively small watersheds has been presented by H.R. Malcolm. The methodology utilizes a pattern hydrograph which peaks at the design flow rate and which contains a runoff volume consistent with the design rainfall. The pattern hydrograph is a two-part function approximation to the dimensionless hydrograph proposed by the Bureau of Reclamation and the Soil Conservation Service.

This method shall be used for medium projects as defined in section 3.7.2. The minimum rate of detention shall be 0.65 ac-ft / ac when using this method.

## 2.2.2 EQUATIONS

The Small Watershed Hydrograph Method consists of the following equations:

$$T_p = \frac{V}{1.39 Q_p} \qquad (1)$$

$$q_i = \frac{Q_p}{2}\left[1 - \cos\left(\frac{\pi\, t_i}{T_p}\right)\right] \qquad \text{for } t_i \le 1.25T_p \quad (2)$$

$$q_i = 4.34 Q_p e^{-1.30 t_i / T_p} \qquad \text{for } t_i > 1.25T_p \quad (3)$$

* Calculator must be in radian mode.

Where $T_p$ is the time (in seconds) to $Q_p$, $Q_p$ is the peak design flow rate (in cubic feet per second) for the subject drainage area, $V$ is the total volume of runoff (in cubic feet) for the design storm, and $t_i$ and $q_i$ are the respective time (s) and flow rates (cfs) which determine the shape of the inflow hydrograph. All variables must be in consistent units.

## 2.2.3.1. APPLICATIONS

The peak flow rate, Qp, is obtained from the Rational Method Formula. For detention mitigation analyses the Rational Method should be applied in accordance with Section 2.1.3 of this Appendix, with the exception that all proposed developed runoff coefficients (C) given in that section should be inflated by 5%. The total volume of runoff (V) is the same as the rainfall excess. Table 2-1 below gives typical values for the rainfall excess based on percent

impervious cover. The actual values may be interpolated from the table. See Table 2-3, Section 2.3.3, for determination of percent impervious cover.

**Table 2-1. Typical Rainfall Excess Values To Be Used with Small Watershed Method**

| Impervious Cover | 100-Year Rainfall Excess (in.) | 10-Year Rainfall Excess (in) | 3-Year Rainfall Excess (in) |
|---|---|---|---|
| 100 % | 13.5 | 8.3 | 6.1 |
| 90% | 13.2 | 8.0 | 5.7 |
| 80% | 13.0 | 7.8 | 5.4 |
| 70% | 12.7 | 7.5 | 5.2 |
| 60% | 12.4 | 7.3 | 5.0 |
| 50% | 12.2 | 7.0 | 4.8 |
| 45% | 12.0 | 6.9 | 4.7 |
| 40% | 11.9 | 6.8 | 4.6 |
| 35% | 11.8 | 6.7 | 4.5 |
| 30% | 11.6 | 6.6 | 4.4 |

The Small Watershed Hydrograph Method should only be used where an impact analysis is not required for the total drainage system including the detention facility and outfall channel (as indicated in Figure 2-1). The Small Watershed Hydrograph Method cannot be used in conjunction with the HEC-HMS computer models of watersheds studied in the Flood Insurance Study. The time to peak of the Small Watershed Hydrograph Method is computed strictly to match volumes and has no relationship to the storm durations and rainfall distributions used in the Flood Insurance Study.

## 2.3. WATERSHED MODELING

In June of 2001, Tropical Storm Allison came ashore on the Upper Texas Coast and produced record rainfall amounts and pervasive flooding in Harris and surrounding counties, including the Clear Creek Watershed. In October of 2001, through a joint effort between FEMA and HCFCD, Harris County began the Tropical Storm Allison Recovery Project (TSARP). Since that time, a variety of updated models and FEMA maps have been released. Some of these models and maps are still preliminary while others have been officially adopted. It is required that the effective (current) FEMA map shall be used for any project within the DISTRICT. Furthermore, any new or updated analysis within the DISTRICT shall consider the tail water effects based upon potentially higher water surface elevations in the models or effective maps within neighboring counties. If the project involved requires the approval of FEMA, then the requirements of FEMA shall supersedes any DISTRICT requirements.

In the case that FEMA approval is not required for the project, design engineers should use the methodology presented in this Appendix to design drainage facilities in the DISTRICT.

### 2.3.1. RAINFALL FREQUENCY AND DURATION

The storm event used to establish regulatory flood plain and floodway limits in the Flood Insurance Study is the 100-year, 24-hour event. For planning purposes and establishing flood insurance rate zones the 10-, 50-, and 500-year events also require analysis. For projects requiring FEMA submittals, the rainfall depths in the most current effective model should be used. For all other projects requiring a rainfall runoff analysis, the depths should be based on Table 2-2, which includes the maximum values for each depth, duration and frequency from the TSARP, TP40 and Hydro 35 information.

Point rainfall amounts for various durations and frequencies for use in the DISTRICT are given in Table 2-2.

**Table 2-2. Point Rainfall Depth (Inches) Duration-Frequency Values[1]**

| | Depth (in) | | | | |
|---|---|---|---|---|---|
| | 100- | 25- | 10- | 5- | 3- |
| Duration | Year | Year | Year | Year | Year |
| 5 min. | 1.20 | 1.00 | 0.90 | 0.80 | 0.70 |
| 30 min. | 3.00 | 2.40 | 2.10 | 1.90 | 1.60 |
| 1 hr. | 4.30 | 3.40 | 2.90 | 2.50 | 2.20 |
| 2 hr. | 5.70 | 4.40 | 3.70 | 3.10 | 2.60 |
| 3 hr. | 6.80 | 5.10 | 4.20 | 3.50 | 2.80 |
| 6 hr. | 9.10 | 6.60 | 5.30 | 4.40 | 3.30 |
| 12 hr. | 11.10 | 8.00 | 6.40 | 5.30 | 4.00 |
| 24 hr. | 13.50 | 9.80 | 7.80 | 6.40 | 4.80 |

### 2.3.2. RAINFALL DEPTH-AREA RELATIONSHIP AND TEMPORAL DISTRIBUTION

In the initial stages of the TSARP it was necessary to address issues having to do with the use of the new USACE runoff model called HEC-HMS. HEC-HMS has replaced HEC-1 as the standard software for hydrologic analysis within the DISTRICT. Two important differences in between HEC-HMS and HEC-1 have to do with the use of depth-area indices to account for

[1] Source: TP-40, Hydro-35 and U.S.G.S.

point rainfall depths on large areas and the temporal distribution of rainfall (the rainfall hyetograph).

Furthermore, it is anticipated that HEC-1 will no longer be supported by the U.S. Army Corps of Engineers. For these reasons, the design engineer must get approval from the DISTRICT prior to using HEC-1 models. This applies to existing, revised, and proposed models. For projects requiring FEMA approval, the rainfall input of the most current effective model should be used. For projects not requiring FEMA submittals, the 67% duration peaking temporal rainfall distribution should be used.

### 2.3.3. LOSS RATES

Rainfall excess and runoff volume are dependent on factors such as rainfall volume, rainfall intensity, antecedent soil moisture, impervious cover, depression storage, interception, infiltration, and evaporation. The extent of impervious cover and depression storage is actually a measure of development and is discussed in the next section. The other factors are dependent on soil type, land use, vegetative cover, topography, time of year, temperature, etc.

For projects requiring FEMA approval, the loss input in the most current effective model should be used. For all other projects requiring a rainfall runoff analysis, the Green-Ampt loss function available in HEC-HMS shall be used. A detailed description of the Green-Ampt loss function can be found in USACE EM 1110-2-1417. The following parameters should be used to compute the Green-Ampt losses:

| | | |
|---|---|---|
| Initial Loss | = | 0.1 inches |
| Volume Moisture Deficit | = | 0.385 |
| Wetting Front Suction | = | 12.45 inches |
| Hydraulic Conductivity | = | 0.024 in/hr |

Additional development in the watershed is analyzed by increasing the value of the impervious cover parameter in the runoff model. Table 2-3 gives appropriate values of percent impervious based on land use types:

**Table 2-3. Percent Impervious Cover For Land Use Types**

| Land Use | % Impervious |
|---|---|
| High Density | 85% |
| Dry Detention Ponds | 85% |
| Undeveloped | 0% |
| Developed Green Areas | 15% |
| Residential Small Lot (<1/4 acre or schools) | 40% |
| Residential Large Lot (≥1/4 acre or older neighborhoods with limited roadside ditch capacity) | 20% |
| Residential Rural Lot (≥5 acre ranch or farm) | 5% |
| Isolated Transportation | 90% |
| Water | 100% |
| Light Industrial | 60% |
| Airport | 50% |
| | |

## 2.4. UNIT HYDROGRAPH METHODOLOGY

The model that the Clear Creek Watershed flood insurance study is based on is the Clark unit hydrograph. In cases where FEMA submittals are required, the design engineer should use the Clark unit hydrograph method. In other cases, where a downstream impact analysis is required, consult the appropriate reviewing agencies on the applicability of the Clark unit hydrograph. In some cases, other unit hydrograph methods may be applicable.

The watershed parameters for the Clark unit hydrograph may be developed using the Harris County methodology. Design engineers should refer to the most current effective model and the most recent version of the HCFCD hydrology manual.

## 2.5. FLOOD HYDROGRAPH ROUTING

Flood routing is used to simulate the runoff hydrograph movement through a channel or reservoir system. Flood routing techniques vary greatly between hydrologic computer models and caution should be used in selecting a routing method, which adequately represents the channel storage conditions present in areas with extremely flat slopes, such as within the DISTRICT.

The HEC-1 and HEC-HMS programs employ several flood routing methods for characterizing the transfer of the runoff hydrograph through the drainage system of a watershed. The models developed for the Flood Insurance Study for the Clear Creek watershed use the Modified Puls Method of routing. This flood routing method is based on the continuity equation and a relationship between flow and storage or stage. The routing is modeled on an independent-reach basis from upstream to downstream. A detailed discussion of the Modified Puls Method can be found in the user's manual for either HEC-1 or HEC-HMS.

### 2.5.1. STORAGE –ROUTING COMPUTATIONS USING HEC-2 OR HEC-RAS

All of the Flood Insurance Study data submitted for the Clear Creek Watershed have utilized the HEC-2 or HEC-RAS computer program to generate the storage-discharge relationship required for HEC-1 or HEC-HMS to utilize the Modified Puls flood routing. Listed below is a suggested procedure by which the HEC-2 or HEC-RAS program can best be formatted to provide the most effective input and output data necessary for hydrologic studies.

a) Determine which routing reaches of the subject channel will need to be evaluated. Routing reaches that are defined in the Flood Insurance Study usually represent an area between outfalls of two significant drainage areas.

b) Review all the available data for the routing reaches of the subject stream.

c) Run HEC-1 or HEC-HMS for the 100-year storm event using preliminary channel routing data or alternate methods (i.e. Muskingum or Lag).

d) Multiply the preliminary 100-year peak discharges determined above by 0.20, 0.40, 0.60, 0.80, 1.00, and 1.20 to obtain a series of six discharges for each storage routing reach.

e) The discharges that have been developed are then input to the HEC-2 or HEC-RAS program. The discharges should be held constant throughout the subject routing reach. Outflows through a routing reach should not vary.

HEC-RAS has replaced HEC-2 as the standard model for this type of analysis. Furthermore, it is expected that HEC-2 will no longer be supported by the U.S. Army Corps of Engineers. For these reasons, the design engineer must get the DISTRICT'S Engineer's approval prior to using HEC-2 models. This applies to existing, revised, and proposed models.

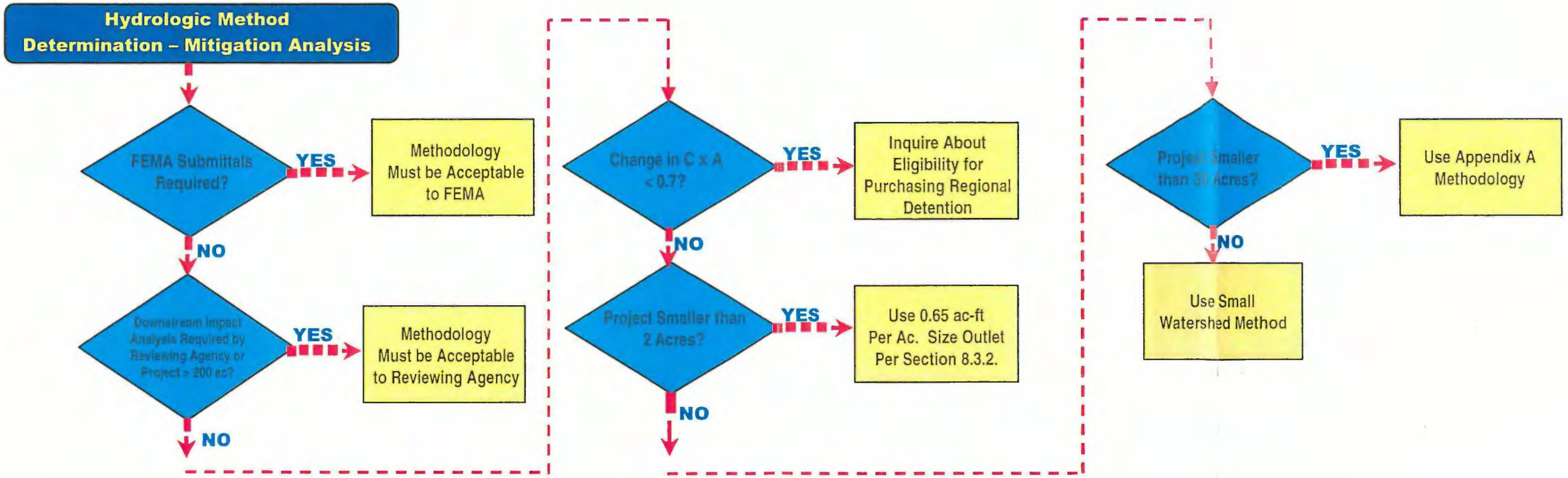
The HEC-2 or HEC-RAS model used in the storage-outflow analysis should be reviewed to ensure that the analysis is correctly determining the total storage volume. Make sure that the ineffective flow areas are modeled appropriately. Also, if using HEC-2 make sure that any ET

or X5 cards are removed from the input prior to running the storage-outflow multiple profile analysis.

**FIGURE 2.1**

# Brazoria Drainage District No. 4

Figure 2-1. Hydrologic Method Determination – Mitigation Analysis



## 3. DETENTION SYSTEM DESIGN

### 3.1. INTRODUCTION

In situations where on-site storage of storm water runoff is the most effective way to allow development of properties without increasing the flood potential downstream, detention systems will be permitted. This section of the Appendix presents background information on storm water storage techniques and detailed guidelines and criteria for the design of storm water storage facilities.

### 3.2. GEOTECHNICAL DESIGN

Before initiating final design of detention ponds over six (6) feet deep and two (2) acres in size, a detailed soils investigation by a geotechnical engineer shall be undertaken. Geotechnical investigation, at a minimum, the study should address:

a) The ground water conditions at the proposed site.

b) The type of material to be excavated from the pond site and its suitability for fill material.

c) If a dam is to be constructed, adequate investigation of potential seepage problems through the dam and attendant control requirements, the availability of suitable embankment material and the stability requirements for the dam itself the DISTRICT will not accept or be responsible for any said dams.

d) Potential for structural movement on areas adjacent to the pond due to the induced loads from existing or proposed structures and methods of control that may be required.

e) Stability of the pond side slopes.

### 3.3. PUMPED DETENTION SYTEMS

All storm water detention facilities requiring mechanical pumping systems are generally prohibited, with the exception of pumping of dead storage (maintenance or amenity water stored at or below the discharge pipe control level). However, pumped detention may be allowed under the following conditions and with the following stipulations:

a) A combination pump and gravity systems shall be constructed.

b) The minimum detention rate shall be 0.70 ac-ft/ac.

c) The selected outfall rate shall not increase the elevation or the flow within the receiving system.

d) No more than 75% of the total pond capacity shall be pumped.

e) The discharge delivery system shall not have peak discharge and / or peak stages that exceed the pre-developed values at any point in time for the 3-year, 10-year, and 100-year design storm events.

f) Two pumps minimum shall be required, each capable of providing the design discharge rate. If three pumps are provided, any two pumps in combination must be capable of providing the design discharge rate.

g) Pumping from detention ponds into an existing storm sewer is prohibited unless the pre-developed land already drains into that system and that system has capacity for those undeveloped flows.

h) Pumped detention shall not be allowed for detention basins that collect public storm water runoff, except for detention basins owned, operated and maintained by the DISTRICT or any other governmental entity. Public storm water runoff shall be defined as runoff water that originates from the property of two or more property owners.

i) For pumped detention basins collecting non-public storm water runoff outside of the City of Pearland and within the DISTRICT'S jurisdiction, a cash amount equal to the fair market value of the pumps and installation costs shall be provided to the DISTRICT and placed into an escrow account prior to the approval of the final plat, or prior to the issuance of a building permit if platting is not required. This deposit shall remain in a permanent interest bearing escrow account for the DISTRICT'S use to maintain the pumped system in the event that the Owner fails to maintain the pumped system in accordance with the requirements of the DISTRICT.

j) Fencing of the control panel must be provided to prevent unauthorized operation and vandalism pursuant to the Texas Commission on Environmental Quality Standards. The DISTRICT must be provided access.

k) Adequate assurance must be provided that flooding would not occur for those cases that loss of power occurred during a 100-year flood event.

l) Sensors must be placed so that the pumps would remain off during a rain event.

m) Sensors must be placed so that pumping will not occur when the level of water in the receiving system is at or above ¼ of its full depth.

n) The Operator shall provide the DISTRICT with a quarterly operational report that shall indicate the operational times, total hours of operation, and the amount pumped. Said report shall be delivered to the DISTRICT office on the 15th day of the month after the end of each quarter.

o) The DISTRICT shall have the right to enter the property and inspect the operation of the system at any time for any reason.

p) Failure to maintain the pump station in working order is a violation of these "Rules, Regulations and Guidelines" and is subject to the Penalty provisions of Section 16- "Penalties" and the forfeiture of funds paid in escrow to the DISTRICT for pumped detention facilities.

The use of a pumped detention system must be approved by the DISTRICT prior to the Preliminary Drainage Plan being submitted.

The structural design of detention facilities is very similar in many ways to wide bottom channels. Therefore, the design requirements concerning side slopes and berms are as outlined in Section 4.2.3 for channels. Design considerations addressed specifically in this section deal with the facility bottom and outfall structure.

## 3.4. STRUCTURAL AND GEOMETRIC PARAMETERS

### 3.4.1. GENERAL

Two types of detention facilities are acceptable in the DISTRICT. The first is a naturalized facility in which standing shallow pools of water and muddy areas are allowed to exist along the bottom of the facility and support natural or wetland vegetation. This type of facility is only maintained around the sides and perimeter and involves special design considerations at the outfall structure. Designing this type of facility must be approved by the DISTRICT prior to submittal of the Preliminary Drainage Plan and must consider the aesthetics of the surrounding area.

The second type of detention facility is a manicured or well-maintained facility, which is mowed regularly and is designed to stay dry between rainfall events. This type of facility may be more aesthetically pleasing in heavily populated areas and is more amenable to multiple uses such as parks or ball fields. The design considerations for each facility are outlined below.

The following parameters shall apply to all detention facilities.

a) Side slopes shall be 4:1 or greater.

b) Minimum maintenance berms shall be as follows:

| POND DEPTH | WIDTH OF BERM |
|---|---|
| 0' - 2' | 10' |
| >2' - 5' | 15' |
| >5' - 10' | 20' |
| > 10' | 30' |

c) When a detention facility is constructed adjacent to a street right-of-way or DISTRICT channel, a minimum 30 foot maintenance berm is required. This does not include the required channel maintenance berm of the DISTRICT channel or the distance from the street right-of-way line to the curb. The proposed maintenance berm shall not overlap into an adjacent DISTRICT easement, fee strip, or public right-of-way.

d) If the detention facility is to be dedicated to the DISTRICT, a minimum of 25 foot maintenance berm shall be required. Backslope swales and interceptor structures shall also be provided as per the DISTRICT details and requirements.

e) 95% turf germination shall be achieved on the maintenance berms, side slopes, and bottom to prevent erosion.

f) Maintenance berms shall not be encumbered by any other permanent improvements, easements, fee strips, or right-of-way.

### 3.4.1.2. WET DETENTION POND (STATIC WATER LEVEL)

Wet detention ponds must be approved by the DISTRICT prior to the design and preparation of construction plans. Any detention pond which is designed to hold water for any reason

shall be considered to be a wet detention pond. It will be the responsibility of the Developer, MUD or Homeowners Association to own and maintain any wet detention ponds. The DISTRICT will not accept wet detention ponds for maintenance.

### 3.4.2. BOTTOM DESIGN FOR NATURALIZED DETENTION FACILITIES

The bottom of a detention facility, which is intentionally meant to support natural vegetation, should be designed as flat as practical to still maintain positive drainage to the outfall structure. Side slopes should be designed to allow for regular maintenance and be grass-lined with a 4 to 1 side slope. The bottom should be graded toward the outfall structure at a minimum transverse slope of 0.002 feet per foot. The remainder of the pond bottom shall be graded toward the flowline of the pond at a minimum slope of 0.01 feet per foot. Selected vegetation may be introduced to the bottom of the facility to encourage a particular habitat. Other design requirements for channels should be followed, including backslope drains, and erosion protection measures. A maintenance plan to remove trash debris and excessive siltation must be provided to and approved by the DISTRICT. Additional storage volume may be required by the DISTRICT to offset predicted siltation based on experiences with nearby storage facilities.

### 3.4.3. BOTTOM DESIGN FOR MANICURED DETENTION FACILITY

The design of the detention facility bottom to remain dry and aesthetically manicured is very important from the standpoint of long term maintenance. A pilot channel is required to facilitate complete drainage of the basin following a runoff event. A lined concrete channel should have a minimum depth of 4 inches and a minimum flowline slope of 0.002 feet per foot (Standard District Details).

Bottom slopes of the detention basins should be graded towards the low-flow pilot channel or outfall. The transverse slope of the bottom should be a minimum slope of 1%.

Detention basins which make use of a channel section for detention storage may not be required to have pilot channels, but should be built in accordance with the requirements for channels, including side slopes, maintenance berms, back slope drains and erosion protection measures previously discussed.

### 3.4.4. OUTLET STRUCTURE

The outlet structure for a detention facility is subject to higher than normal headwater conditions and erosive velocities for prolonged periods of time. For this reason the erosion protection measures are very important.

Reinforced concrete pipe used in the outlet structure should conform to ASTM C-76 Class III with compression type rubber gasket joints conforming to ASTM C-443. HDPE or aluminized steel pipes may also be used. Pipes, culverts, and conduits used in the outlet structures should be carefully constructed with sufficient compaction of the backfill material around the pipe structure as recommended in the geotechnical analysis. Generally, compaction density should be the same as the rest of the structure. The use of pressure grouting around the outlet conduit should be considered where soil types or conditions may prevent satisfactory backfill compaction. Pressure grouting should also be used where headwater depths could cause backfill to wash out around the pipe. The use of seepage cutoff collars is not recommended since such collars are often inadequately installed and prevent satisfactory backfill compaction. A concrete control structure with a grate area equal to ten (10) times the outfall pipe area shall be constructed. Concrete or approved equal paving extending from the outfall area into the pond a distance of ten (10) feet shall be placed on the bottom of the facility for maintenance of the structure. Adequate steel grating around the outfall pipe intake must be designed to prevent clogging of the pipe from dead or displaced vegetation.

The concrete spillway for the 100-year discharge or greater flows shall extend down the bank to the bottom of the channel and up the far side as per the standard DISTRICT details.

### 3.4.5. EXTREME EVENT SPILLWAYS

The drainage system must be designed to adequately deal with an extreme rainfall event. The extreme event shall be defined as an event which includes or exceeds the 100-year flow. A sheet flow analysis shall be provided to show this extreme event will be conveyed to the detention pond and then to the receiving drainage system.

A concrete lined extreme event overflow swale shall be provided where this event enters and exits the detention pond. The swale shall be constructed as per the DISTRICT details.

Where providing this overflow swale between a detention pond and a DISTRICT maintained ditch or channel, the concrete lining shall extend into the bottom and up the far bank of that ditch or channel at a thirty (30) degree downstream angle in conformance with the standard DISTRICT details.

### 3.4.6. UNDERGROUND DETENTION SYSTEMS

With prior approval of the DISTRICT, underground detention systems may be utilized. All pipes must be at least forty-eight (48) inches in diameter.

For systems using buried arches or similar structures with rubble backfill, the void space in the rubble backfill shall not count as detention volume.

All underground detention systems must be accessible for inspection and cleaning. No such system may be used in conjunction with a pump system. Concrete overflow structures are required for all underground detention systems.

No underground detention system of any kind will be accepted by the DISTRICT for maintenance.

## 3.5. ADDITIONAL DESIGN CONSIDERATIONS

Ponds must have one (1) foot of freeboard. The following items describe additional design criteria associated with detention facilities.

### 3.5.1. EROSION CONTROL

Adequate erosion control and re-vegetation shall be accomplished during and following construction of the facility. The DISTRICT will not allow articulated block on filter fabric as an acceptable means of slope protection.

### 3.5.2. SAFETY, AESTHETIC CONSIDERATION, AND MULTI-PURPOSE USE

The use of a detention facility generally requires the commitment of a substantial land area. The DISTRICT recognizes that such a facility may be used for other purposes which are compatible with the primary intended purpose of providing flood control. Detention facilities may be utilized as parks and recreational facilities on a case-by-case basis as approved by the BOARD in advance. Also, a parking area may be used for a portion of the storage as long as the 100-year water depth is nine (9) inches or less at the inlets in areas where cars are parked. Street ponding is also allowed as long as the depth of water does not exceed nine (9) inches at the inlets as measured from the gutter. The proposed use and the facilities to be constructed within the facility area must be specifically approved by the DISTRICT. Any facilities constructed for a non-flood control use will not be maintained by the DISTRICT, nor will the DISTRICT be responsible for any damage to these facilities resulting from flooding. A note relieving the DISTRICT of any responsibility shall be provided on the construction plans.

### 3.5.3. STORM SEWER OUTFALLS

All storm sewer outfall structures should be constructed in accordance with the Standard District Details. Design criteria for outfall structures are as follows:

a) All storm sewer outfall pipes within the DISTRICT right-of-way must be reinforced concrete pipe, aluminized steel pipe, or HDPE with a minimum diameter of eighteen (18) inches.

b) All backslope drains shall be twenty-four (24) inch reinforced concrete pipe, aluminized steel pipe, or HDPE as shown in the Standard DISTRICT Details.

c) A standard manhole or junction box must be outside of the DISTRICT ultimate right-of-way. Where a road or railroad right-of-way is located adjacent to the channel, the manhole may be placed just inside the DISTRICT right-of-way.

d) The minimum radius of curvature for unlined and lined channel bends shall be as per the latest details. Bend losses and super elevation must be included in the hydraulic analysis of severe curves.

e) Erosion protection is required for all outfall pipes as per the Standard DISTRICT Details.

f) Wastewater Treatment plant outfalls shall have a paved invert and concrete slope paving in accordance with the Standard DISTRICT Details.

## 3.5.4. SPECIAL EROSION AND VELOCITY CONTROL STRUCTURES

### 3.5.4.1. GENERAL

Special erosion and velocity control structures will generally include stilling basins, baffled aprons, straight drop spillways, sloped drops and impact basins. Due to the hydraulic and earth loads encountered through these structures, the structural as well as the hydraulic design is very critical.

A geotechnical engineering investigation to determine the characteristics of the supporting soil is required for major hydraulic structures. For example, a two (2) foot sloped drop would not require a soils investigation, whereas a five (5) foot straight drop structure would.

### 3.5.4.2. STRAIGHT DROP SPILLWAY

Straight drop spillways are usually constructed of steel sheet piling with concrete aprons. Steel sheet pile drop structures can sometimes be considered a temporary structure. The Standard DISTRICT Details define the design features of a straight drop spillway.

The distance erosion protection aprons extend upstream and downstream of the drop is determined using hydraulic analysis. The DISTRICT recommends using concrete paving upstream and immediately downstream of the drop. This pavement must extend upstream and downstream to a point where the velocity is reduced to the levels contained in Table 4-2 and must also contain the hydraulic jump. Because of the additional impact load on the downstream slope paving, a six (6) inch thick pad is recommended. Concrete energy

dissipaters should be used at the ends of the concrete paving to decrease flow velocities and protect the concrete toe.

The drop structure should be designed for active and passive soil forces. Design calculations are required for each drop structure along with a copy of a geotechnical report defining soil characteristics of the site.

### 3.5.4.3. BAFFLE CHUTES

See Reference 15 for hydraulic and structural criteria regarding baffle block chutes.

### 3.5.4.4. SLOPED DROP STRUCTURES

Sloped drop structures can be made of monolithic poured-in-place reinforced concrete slope paving. The same design principles hold true for sloped drop structures as do for straight drop structures (i.e., the draw down curve and hydraulic jump must be contained within the structures).

The sloped drop structure shall have minimum forty eight (48) inch toe walls on the upstream and downstream ends. The sides of the structure shall have minimum eighteen (18) inch toe walls.

## 3.6. DETENTION – HYDROLOGIC DESIGN

The hydrologic methods for detention design should be in accordance with Section 2.0 of this Appendix. The hydrologic design criteria for the DISTRICT is divided into three design categories based on the size of the contributing drainage area.

| | |
|---|---|
| Small Projects | For drainage areas between zero (0) acre and two (2) acres |
| Medium Projects | For drainage areas between two (2) acres and two hundred (200) acres. |
| Large Projects | For drainage areas greater than two hundred (200) acres. |

When detention is proposed in any amount that is less than the amount required for ultimate build out, a note must be provided on the drainage plan stating that "future development on this site must be approved by Brazoria Drainage DISTRICT No. 4". Detention for that additional (future) development would be as per the current (potentially more stringent) requirements at the time that ultimate development is proposed.

## 3.7. ON-SITE FACILITIES

### 3.7.1. SMALL PROJECTS

Small Projects are defined as those projects that are two (2) acres or smaller. If a project causes change in runoff coefficient (existing vs. developed) times the area of the development equal to or less than 0.7, the project may be eligible for purchasing regional detention. Mitigation of such facilities will be incorporated within the DISTRICT regional detention facilities, provided capacity is available and the development is within the detention facility service area. If regional capacity is not possible, on-site detention will be required based 0.65 ac-ft. per acre and the outlet will be sized based on the procedure presented in Section 3.7.2 (below). In this case the volume that is calculated using 0.65 ac-ft. per acre will be considered to be the 100-year volume. The 10-year and 3-year volumes will be considered to be 57% and 39% of the 100-year volume, respectively. The generation of runoff hydrographs and the routing of flood flows are not required for Small Projects.

### 3.7.2. MEDIUM PROJECTS

Medium Projects in the DISTRICT shall include those more than two (2) acres to two hundred (200) acres in size. Medium projects will have their mitigation detention volumes calculated using the methodology presented in Section 2.2.1. All calculations shall be presented to the DISTRICT Engineer, including maps of suitable scale showing the flow paths used to calculate the existing and developed time of concentration. Hydrograph routing through the detention basin is not required. The outflow will be sized as follows:

a) Determine the storage elevation in the basin for the 3-year, 10-year, and 100-year storms.

b) Determine water surface elevation in the receiving system (if reasonably able to) for the 3-year, 10-year, and 100-year storms.

c) Use the orifice equation to compute the opening size(s) as follows:

$$Q = CA\sqrt{2gH}\ ,$$

Where:

| | | |
|---|---|---|
| Q | = | Basin Outflow (cfs) |
| C | = | Pipe Coefficient |
| A | = | Restrictor cross-sectional area |
| g | = | Acceleration due to gravity (32.2 ft/s$^2$) |
| H | = | The elevation difference between the water surface in the detention pond and the receiving system for a given storm. The design engineer shall assume two (2) feet unless the engineer can |

substantiate a known elevation in the receiving system.

Round up to the next half-foot diameter for restrictor pipes above eighteen (18) inch diameter. Some additional blockage of the pipe may be necessary to obtain the correct restrictor area. No restrictor pipes shall be less than six (6) inches in diameter. Restrictors shall always be placed at the upstream end of a pipe to enable cleaning.

For ponds discharging into creeks or ditches, the outfall structure shall be designed to ensure that the allowable flow is not exceeded during a 3-year, 10-year and 100-year event. This may be achieved using a combination of pipes and or weirs. The flowline of each pipe or weir level shall be set based upon the 3-year, 10-year, and 100-year water surface elevations in the detention pond.

Storm events in excess of the 100-year event must be considered in the design of detention facilities from the standpoint of overtopping. For a detention facility that is an excavated pond and has no dam associated with it, the outflow structure must be designed with an overflow structure or swale as per section 3.4.5. This will allow the passage of extreme events with no adverse impacts to adjacent structures. For detention facilities with a dam, the possibility of dam failure must be considered as part of the design. Specific dam criteria for storm events in excess of the 100-year design storm shall be established by the DISTRICT Engineer on a case-by-case basis.

The detention requirements shall never be less than 0.65 acre feet per acre.

### 3.7.3. LARGE PROJECTS

Large projects shall include those greater than two hundred (200) acres in size.

For projects in excess of two hundred (200) acres, HES-RAS HEC-HMS modeling shall be performed. The HEC-HMS modeling shall include analysis of existing and developed runoff. This analysis must demonstrate that no increase in runoff for the 3-year, 10-year, and 100-year event storms. Similarly a HEC-RAS model shall that no increase in the water surface elevation of the receiving system will occur during the 3-year, 10-year, and 100-year events. See section 2.0 for the specific requirements.

The minimum rate of detention for all large projects shall be 0.65 ac-ft/ac.

## 3.8. OFF-SITE FACILITIES

Off-site detention facilities will generally be regional in nature. The facility may be sized for one development, but will be designed to serve the entire watershed by reducing the flood

potential of a stream. Most of these facilities are envisioned to be adjacent to a channel to receive flood water from the main drainage artery through a system of multistage inlet pipes and high level weirs.

For the design of an off-site detention basin, the hydraulics of the stream and flood damage relationship of the watershed must be evaluated. This will be performed under the direction and advice of the DISTRICT Engineer. This evaluation will result in flood frequency/stage-damage estimates of the stream.

Upstream discharge of unmitigated runoff into a stream resulting in increases in flow or water surface elevation for the 3-year, 10-year, and 100-year events are not permitted. For this reason, careful planning must be used to insure that all property within a detention pond service area is able to discharge directly to the pond without causing these disallowed increases in flow or water surface elevation.

An off-site facility shall be considered a small, medium or large project based upon its service area.

Therefore, the appropriate part of Section 3.7 shall be used to determine the design parameters of the proposed off-site facility.

The construction plans for any proposed off-site facility shall include a detention service area map and a detention service table. The table shall specify the existing, proposed and future detention amount allocated to each sub area within the pond service area.

Subsequent plan submissions by others utilizing detention in these regional facilities shall include a current and updated version of the detention service table.

Any project proposing to utilize off site or regional detention must be accompanied by an analysis prepared by an Engineer which demonstrates how the 100-year developed flows will be conveyed to the detention area during an extreme event. This analysis must demonstrate that this can be achieved without adversely affecting property between the proposed development and the detention pond.

No property outside the approved service area for off-site facility will be allowed until a revised construction plan, service map, and service table is approved by the DISTRICT.

# 4. HYDRAULIC DESIGN CRITERIA

## 4.1. GENERAL

### 4.1.1. INTRODUCTION

The hydraulic design of a channel or structure is of primary importance to insure that flooding and erosion problems are not aggravated or created. This section summarizes methodologies, procedures, and criteria which should be used in the hydraulic analysis of the most common design problems in Brazoria County, Texas. In some instances, methodologies and parameters not discussed in this Appendix may be required. When an approach not presented herein is required, it should be first reviewed with the DISTRICT'S Engineer.

### 4.1.2. DESIGN FREQUENCIES

All of the DISTRICT'S open channels will be designed to contain the runoff from the 100-year frequency storm within the easement or fee strip, except where channel improvements are necessary to offset increased flows from a proposed development. In those cases, the 100-year flood profile under existing conditions of development should not be increased.

In areas served by closed systems, storm water runoff should be removed during the 100-year frequency storm without flooding of structures. This is accomplished through the design of the street system, the storm sewer system, and other drainage/detention systems.

### 4.1.3. REQUIRED ANALYSIS

In designing a facility for flood control purposes, a hydraulic analysis must be conducted which includes all the factors significantly affecting the water-surface profile or the hydraulic grade line of the proposed facility. For open channels, the primary factors are losses due to friction, constrictions, bridges, culverts, confluences, transitions and bends. The design of channels or conduits should generally minimize the energy losses caused by these factors which impede or disrupt the flow. Factors affecting the hydraulic grade line in closed conduits are entrance losses, friction losses, exit losses and bend losses.

### 4.1.4. ACCEPTABLE METHODOLOGIES

Several methods exist which can be used to compute water-surface profiles in open channels. The methodology selected depends on the complexity of the hydraulic design and the level of accuracy desired. Peak discharges and discharge hydrographs developed using one of the methodologies described in Section 2.0 of this Appendix must be incorporated into the existing effective HEC-RAS model in order to determine the impact of any proposed development flood control facility on the entire channel system.

For the design of proposed channel with flow confined to uniform cross-sections, either a hand calculated normal depth or direct step computation is sufficient. Manning's Equation should be used for computing normal depth. For designing a non-uniform proposed channel with flow in the overbanks, the use of HEC-RAS is recommended. Any proposed channel

improvements to an existing ditch or creek within the jurisdiction of the DISTRICT must be modeled using HEC-RAS and incorporated into the model used in the Flood Protection Plan (Reference 29). The DISTRICT'S Engineer shall approve the use of HEC-2 models. This applies to existing, revised and proposed models.

Bridges, culverts and expansion and contraction losses are taken into account in the HEC-RAS computer program. If these losses are significant and the normal depth or direct step method is employed, the losses must be included in the backwater calculations. Design criteria for bridges, culverts, transitions, bends and drop structures are presented in the remainder of this section.

## 4.2. OPEN CHANNEL DESIGN

### 4.2.1. LOCATION AND ALIGNMENT

The first step in designing or improving an open channel drainage system is to specify its location and alignment. Good engineering judgment must be incorporated to insure the proposed channel location provides maximum service to an area while minimizing construction and maintenance costs. General factors and the DISTRICT criteria which should be taken into account in locating improved channels are as follows:

a) Follow existing channels, ditches, swales or other low areas in undeveloped watersheds. This will minimize the cost of the channel itself and the underground storm sewer system, and will allow for overland flow to follow its natural drainage pattern.

b) For safety reasons, channels and roads must not be located adjacent to one another. Should such a conflict appear unavoidable, the design must be approved by the DISTRICT Engineer.

c) The angle at which two channels intersect must be ninety (90) degrees or less (angle measured between channel centerlines on upstream side of point of intersection).

d) The minimum radius of curvature for unlined and lined channel bends shall be as per the latest DISTRICT'S details. Bend losses and super elevation must be included in the hydraulic analysis of sever curves.

### 4.2.2. EXISTING CROSS SECTIONS

For determining existing flood profiles, both the channel section and overbank areas must be used in the hydraulic calculations. Channel sections must be based on a recent field survey.

In some cases, the DISTRICT may have recent survey information, which can be utilized. Plans of previous channel improvements should only be used for very preliminary analysis. Overbank areas are best defined by field surveys, but this is not always practical or economically justified. Elevations in the floodplain beyond the limits of the channel can be obtained from the best topographic information available for the study reach.

When designing a channel improvement, the channel sections used should extend beyond the DISTRICTS easement or fee strip a reasonable distance. The distance shall be determined and agreed upon by the DISTRICT Engineer and the developer on a case by case analysis. The purpose of including elevations beyond the easement and fee strip is to avoid a design which creates ponding adjacent to the easement or fee strip. A reasonable distance depends on the adjacent terrain, but in no case shall it be less than twenty (20) feet.

### 4.2.3. TYPICAL DESIGN SECTIONS

Typical channel sections have been established which should be used in designing improved channels. Minimum dimensions are based on experience of constructing and maintaining channels.

Four typical cross sections are given in the Standard DISTRICT Details. For some applications, other cross section configurations may be necessary. A proposed cross section different from the typical sections presented should be reviewed with the DISTRICT for approval before proceeding with design or analysis.

#### 4.2.3.1. EARTHEN CHANNELS

The most common flood control channel is a totally earthen channel. This is generally the most economical design except in the already developed areas where land costs are extremely high. The initial construction cost for a concrete lined channel is generally three to four times that of an earthen channel.

In the design of an earthen channel, consideration of long-term maintenance has a very strong influence on design parameters. The following are minimum requirements to be used in the design of all earthen channels:

a) Maximum earthen side slopes should be four (4) horizontal to one (1) vertical. Slopes flatter than four (4) to one (1) may be necessary in some areas due to local soil conditions. For channels and detention reservoirs six (6) feet deep or greater, side slopes selection shall be supported by geotechnical investigations and calculations.

b) Minimum bottom width is ten (10) feet unless approved by the DISTRICT Engineer.

c) A minimum maintenance berm is required on either side of the channel of between ten (10) to thirty (30) feet depending on channel size as follows:

**TABLE 4-1A**
**KEY TO EASEMENT AND FEE STRIP REQUIREMENTS**

| | | CHANNEL BOTTOM WIDTH | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **6** | **8** | **10** | **12** | **15** | **20** | **30** | **40** |
| **CHANNEL DEPTH** | **4** | A | A | B | B | B | B | C | C |
| | **6** | A | A | B | B | B | B | C | C |
| | **8** | B | B | B | C | C | C | C | C |
| | **10** | D | D | D | D | D | D | D | D |
| | **12** | D | D | D | D | D | D | D | D |
| | **14** | D | D | D | D | D | D | D | D |
| | **16** | D | D | D | D | D | D | D | D |
| | **18** | D | D | D | D | D | D | D | D |

**TABLE 4-1B**
**ULTIMATE MAINTENANCE REQUIREMENTS FOR CHANNELS**

| KEY VALUE | TOTAL | EACH SIDE | | |
|---|---|---|---|---|
| **A** | **30** | **15** | | |
| **B** | **40** | **20** | | |
| **C** | **50** | **25** | | |
| **D** | **60** | **30** | | |

Larger maintenance berms may be required due to the future needs of an ultimate channel. Easement and fee strip requirements for all main channels are included in the Flood Prevention Plan. (References 28 and 29).

d) Backslope drains or interceptor structures are necessary at a maximum of one thousand (1,000) feet intervals to prevent sheet flow over the ditch slopes. Refer to the Standard DISTRICT Details.

e) Channel slopes must be re-vegetated immediately after construction to minimize bank erosion.

f) Flow from roadside ditches must be conveyed to the channel through a roadside ditch interceptor and pipe. Refer to the Standard District Details.

g) Maintenance berm shall not be encumbered by any permanent improvements, easements or right-of-way.

### 4.2.3.2. CONCRETE-LINED TRAPEZOIDAL CHANNELS

In instances where flow velocities are excessive, channel confluences create a significant erosion potential or easements and fee strip is limited, fully or partially concrete lined channels may be necessary. The degree of structural analysis required varies significantly depending on the intended purpose and the steepness of the slope on which paving is being placed. Slope paving steeper than 3:1 shall be designed based on a geotechnical analysis that addresses slope stability and groundwater pressure behind the paving.

Following are minimum requirements for partially or fully concrete lined trapezoidal channels (Standard DISTRICT Details):

a) All slope paving shall include a minimum twenty-four (24) inch toe wall at the top and sides and a minimum forty eight (48) inch toe wall across or along the channel bottom for clay soils.

b) Fully lined cross-sections should have a minimum bottom width of eight (8) feet.

c) Concrete slope protection placed on 3:1 slopes should have a minimum thickness of four (4) inches and be reinforced with #3 bars on eighteen (18) inch centers both ways.

d) Concrete slope protection placed on 2:1 slopes should have a minimum thickness of five (5) inches and be reinforced with #3 bars on fifteen (15) inch centers both ways.

e) Concrete slope protection placed on 1.5:1 slopes should have a minimum thickness of six (6) inches and be reinforced with #4 bars on eighteen (18) inch

centers both ways. Poured in place concrete side slopes should not be steeper than 1.5:1.

f) In instances where the channel is fully lined, no backslope drainage structures are required. Partially lined channels will require backslope drainage structures as outlined in Item 4 of Section 4.2.3.1.

g) Weep holes should be used to relieve hydrostatic head behind lined channel sections. Refer to the Standard DISTRICT Details.

h) Where construction is to take place under conditions of mud and/or standing water, a seal slab of Class C concrete should be placed in channel bottom prior to placement of concrete slope paving. Refer to the Standard DISTRICT Details.

i) For bottom widths of twenty (20) feet and greater, transverse grade beams shall be installed at twenty (20) feet spacing on center. Grade beams shall be one (1) foot wide, one (1) foot-six inches deep, and run the width of the channel bottom. Refer to the Standard DISTRICT Details.

### 4.2.3.3. RECTANGULAR CONCRETE PILOT CHANNELS (LOW FLOW SECTIONS)

In limited easement and fee strip, it is sometimes necessary to have a vertical walled rectangular section. A standard section was developed some years ago in Harris County, which consists of four (4) foot vertical walls and variable bottom widths. Above the vertical walled section, a trapezoidal section is used varying from earthen to concrete lined depending on the design requirements. Most contractors in the area have had significant experience in the construction of this section.

Presented below are minimum requirements for rectangular concrete pilot channels:

a) Typical structural requirements are shown in the Standard DISTRICT Details. The structural steel design is based on Grade 60 steel. This should be confirmed by a design check based on local soil conditions.

b) Minimum bottom width should be eight (8) feet.

c) For bottom widths twelve (12) feet or greater, a center depression is required. Refer to the Standard DISTRICT Details.

d) For bottom widths twenty (20) feet or greater, transverse grade beams shall be installed at twenty (20) feet spacing on center. Grade beams shall be one (1) foot wide, one (1) foot six (6) inches deep, and run the width of the channel bottom. Refer to the Standard DISTRICT Details.

e) Minimum height of vertical walls should be four (4) feet. Heights above this shall be in two (2) foot increments. Exceptions shall be on a case by case basis.

f) Escape stairways shall be constructed in accordance with the Standard DISTRICT Details. Escape stairway shall be located at the upstream side of all street crossings, but not to exceed fourteen hundred (1400) feet intervals.

g) For rectangular concrete pilot channels with earthen side slopes, the top of the vertical wall should be constructed in accordance with the Standard DISTRICT Details to allow for future placement of concrete slope paving.

h) Weep holes should be used to relieve hydrostatic pressure as shown in the Standard DISTRICT Details.

i) Where construction is to take place under conditions of mud and/or standing water a seal slab of Class C concrete should be placed in channel bottom prior to placement of concrete slope paving. Refer to the Standard DISTRICT Details.

j) Concrete pilot channels may be used in combination with slope paving or a maintenance shelf as shown in the Standard DISTRICT Details. Horizontal paving sections should be analyzed as one way paving capable of supporting maintenance equipment.

k) A geotechnical investigation and report shall be performed. Soil boring shall be obtained at a minimum of every one thousand (1000) feet to a depth of 1.5 times the proposed channel depth.

## 4.3. WATER-SURFACE PROFILES

### 4.3.1. GENERAL

For steady, gradually varied flow conditions in natural or improved open channels, the computational procedure known as the standard step method is recommended for computing water-surface profiles. The one-dimensional energy equation is solved by using an iterative procedure to calculate a water-surface elevation at a cross section (References 5 and 10).

Manning's Equation is used to compute energy losses due to friction (Section 4.2.4.2), while losses due to obstructions and transitions are calculated using the appropriate equations discussed in this chapter. For cases where the flow is strictly uniform, as determined by the DISTRICT, the standard step method can be reduced to a direct step method or to a uniform flow computation.

The recommended computer program available for computing water-surface profiles when using the standard step method is the Corps of Engineers' program entitled HEC-RAS, Water Surface Profiles. As indicated previously the DISTRICT prefers this program primarily because it is widely accepted and the program readily facilitates the design of channel improvements.

Good judgment must be exercised when determining cross-section locations for water-surface profile calculations. Cross sections should divide the channel into reaches which approximate uniform flow conditions. For example, closely spaced cross sections are required at an abrupt transition such as a bridge, while relatively uniform channel reaches with no significant changes in conveyance require fewer cross sections. As a general guideline, the spacing should not exceed about one thousand (1000) feet.

### 4.3.2 MANNING'S EQUATION

Manning's Equation is an empirical formula used to evaluate the effects of friction and resistance in open channels. For uniform flow conditions where the channel bottom and energy line are essentially parallel, Manning's Equation should be used to compute the normal depth. For gradually varied flow conditions, the slope of the energy line at a given channel section should be computed using Manning's Equation.

The equation is:

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

| | | |
|---|---|---|
| where Q | = | total flow in cubic feet per second |
| n | = | coefficient of roughness |
| A | = | cross-sectional area of channel in square feet |
| R | = | hydraulic radius of channel in feet |
| and S | = | slope of energy line in feet per foot (same as channel bottom slope for uniform flow) |

Channel and overbank sections may have to be subdivided to represent differences in roughness across the section. Subdividing may also be helpful in computing Manning's Equation for natural, compound or non-prismatic sections (References 5 and 10).

### 4.3.3. MANNING'S "n" VALUES

Manning's "n" Values for design purposes should conform to Table 4-2. A "n" value of 0.045 for unlined channels represents a moderate vegetal growth. For unlined channels, with a design flow larger than ten thousand 10,000 cubic feet per second, "n" value of 0.040 may be used. For existing, unimproved channels and overbank areas, "n" values should be determined in accordance with References 10, 11, 12 and 13.

**TABLE 4-2**
**MANNING'S "n" VALUES AND ALLOWABLE 25-YEAR VELOCITIES FOR CHANNEL DESIGN**

| Channel Description | Roughness Coefficient or Manning's "n" Value | Average Velocity (Feet per Second) | Maximum Velocity (Feet per Second) |
|---|---|---|---|
| Unmaintained Earthen | 0.05 | 3.0 | 5.0 |
| Grass Lined | | | |
| Predominately Clay | 0.045 | 3.0 | 5.0 |
| Predominately Sand | 0.045 | 2.0 | 4.0 |
| Concrete Lined | 0.015 | 6.0 | 10.0 |
| Articulated Block | 0.045 | 5.0 | 8.0 |
| Overbanks and Existing Unimproved Channels | See References 3, 4 and 5 | Not Applicable | Not Applicable |

### 4.3.4 VELOCITIES

Average and maximum allowable velocities based on twenty-five (25) year flows are given in Table 4-2. In the portion of Brazoria County where sandy soils are known to exist, soils information may be needed to determine the predominant type of soil and the corresponding allowable velocities for unlined channels. Maximum velocities also apply to bridges, culverts,

transitions, etc. Where velocities exceed the maximum allowed, erosion protection must be provided.

### 4.3.5. FLOWLINE SLOPE

Maximum slopes are generally controlled by the maximum allowable velocity. Channel slopes shall not be less than 0.1%.

### 4.3.6. STARTING WATER-SURFACE ELEVATIONS

For design of open channels, starting water-surface elevations at the channel mouth will generally be based on the normal depth (slope-area method in HEC-RAS) in the design channel.

In determining actual flood profiles or flood plain delineation, the water-surface elevation from the outfall channel should be projected horizontally upstream until it intersects the flood profile on the design channel. An assumption that the peaks occur at the same time will generally produce a conservative flood profile. Otherwise, an analysis of coincident flow may be conducted to determine the flow in the outfall channel at the time the peak flow occurs on the design channel.

### 4.3.7. HEAD LOSSES

Manning's Equation is used to estimate energy or head losses due to channel friction and resistance. Other sources of losses in open channels include confluences, transitions, bends, bridges, culverts and drop structures. When computing water surface profiles either by hand or with the help of a computer program, the engineer must include the significant sources of head loss.

### 4.3.8. CONFLUENCES

The alignment of confluences is critical to channel erosion and energy losses caused by turbulence and eddies. The principle variables used in designing channel junctions are angle of intersection, shape and dimensions of the channel, flow rates and flow velocities. Definitions of the variables are given in the Standard DISTRICT Details.

The angle of intersection between the main channel and tributary channels or storm sewers shall be thirty (30) degrees as shown in the Standard DISTRICT Details. Outfalls or junctions perpendicular to the receiving channel will create severe hydraulic problems, and therefore will not be allowed without approval by the DISTRICT Engineer.

Any protective lining must extend far enough upstream and downstream on both channels to prevent serious erosion. The slope protection must be carried up to at least the ten (10) year flood level in both channels. A good grass cover must be established and maintained from the edge of the protection to the top of bank.

If the main channel flowline is lower than the side channel flowline, an erosion control structure must be used in the side channel.

### 4.3.9. TRANSITIONS

#### 4.3.9.1. DESIGN

Transitions in channels should be designed to create a minimum of flow disturbance and thus minimal energy loss. Transitions generally occur at bridges or culverts, and where cross-sections change due to hydraulic reasons or easements and fee strip restrictions. The transition can consist of either a change in cross-section size or geometry.

All angles of transition should be less than twelve (12) degrees twenty (20) feet in one hundred (100) feet. When connecting trapezoidal and rectangular channels, the warped or wedge type transition is recommended (Reference 10). If supercritical flow conditions are encountered, standing waves, superelevation and hydraulic jumps must be considered. See References 10 and 14 for discussions of transitions and supercritical flow.

#### 4.3.9.2. ANALYSIS

Expansion and contraction losses must be accounted for in backwater computations. Transition losses are usually computed using the energy equation and are expressed in terms of the change in velocity head from downstream to upstream of the transition. The head loss between cross sections is expressed by:

$$h_l = c \left[ \frac{(V_2^2 - V_1^2)}{2g} \right]$$

Where:

| | | |
|---|---|---|
| $h_L$ | = | head loss (feet) |
| c | = | expansion or contraction coefficient |
| $V_2$ | = | average channel velocity of downstream section (feet per second) |
| $V_1$ | = | average channel velocity of upstream section (feet per second) |
| g | = | acceleration of gravity (32.2 ft/sec$^2$) |

Typical transition loss coefficients are given below:

| Transition Type | Coefficient | |
|---|---|---|
| | Contraction | Expansion |
| Gradual or Warped | 0.10 | 0.30 |
| Bridge Sections, Wedge, or Straight Lined | 0.30 | 0.50 |
| Abrupt or Squared End | 0.60 | 0.80 |

When computing the backwater profile through a transition, engineering judgment must be used in selecting the reach lengths. As a guideline, the velocity should not change more than fifty (50) percent between two cross sections. Smooth transitions require fewer computation steps than the abrupt transitions.

If the HEC-2 or HEC-RAS computer program is used to compute the backwater profile, expansion and contraction losses are included in the energy equation. The user must incorporate the loss coefficients given above or as described in the user's manual (Reference 5).

## 4.4. BENDS

### 4.4.1. DESIGN

Channel bends or curves should be as gradual as possible to reduce erosion and deposition tendencies. For channel bends with a radius of curvature measured from the channel centerline of less than three (3) times the top width of the ultimate channel, slope protection is required. For both lined and unlined channels, a ninety (90) degree bend is the maximum curve allowed. Erosion protection on bends must extend at least along and twenty (20) feet downstream of the curved section on the outside bank. Additional protection may be required on the channel bottom and inside bank or further downstream than twenty 20 feet, if the channel geometry and velocities indicates a potential erosion problem.

### 4.4.2. ANALYSIS

Head losses should be incorporated into the backwater computations for bends with a radius of curvature less than three (3) times the channel top width. Energy loss due to curve resistance can be expressed as:

$$h_L = c_f V^2/2g$$

Where:

$h_L$ = head loss (feet)
$c_f$ = coefficient of resistance
V = average channel velocity (feet per second)
g = coefficient of gravity (32.3 feet/second)

Guidelines for selecting $c_f$ can be found in Reference 10.

The HEC-2 computer program does not incorporate a bend loss computation. Therefore the DISTRICT'S Engineer must approve the use of HEC-2.

## 4.5. UTILITY CROSSINGS

Approval must be obtained from the DISTRICT for all utility lines which cross a flood control facility. The utility crossing should be designed to minimize obstruction of the channel flow and conform with the channel cross-section. Contact the DISTRICT for information regarding the channel section and channel easement or fee strip at a proposed crossing prior to design.

All utility lines under channels should be constructed with the top portion of the conduit a minimum of five (5) feet below the projected flowline of the ultimate channel as shown in the Standard District Details. Pipelines shall have a minimum of ten (10) feet of cover depth. When appropriate, facilities may be constructed on special utility bridges or trestles in accordance with standard bridge design criteria. Pipes or conduits spanning the channel should be located above the top of banks for hydraulic and maintenance reasons. These overhead crossings shall be approved by the DISTRICT prior to design and construction. For utility crossings on street bridges, contact the appropriate government body for approval.

All manholes required for the utility conduit shall be located outside of the DISTRICT'S easement and fee strip. Backfill within the DISTRICT'S easement and fee strip shall be in accordance with the backfill requirements specified by the respective district, county, or utility company.

Crossings must be clearly marked in the field with a sign on either side of the DISTRICT facility, which shall be placed immediately outside the DISTRICT easement or right-of-way.

# 5. STORM SEWER DESIGN

Storm sewers shall be designed and constructed in accordance with the applicable City Ordinance and/or criteria. In locations within the DISTRICT where no City has jurisdiction, Brazoria County storm sewer regulations shall prevail.

# 6. SHEETFLOW DRAINAGE

The extreme event sheet flow drainage from all developed areas must be directed to the detention facility. The entrance of this drainage must be placed in a protected (slope paved) area. It cannot be discharged over an area that is unpaved or protected. See section 3.4.5 for additional requirements.

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# APPENDIX B
# GLOSSARY

| | |
|---|---|
| **10 YEAR DISCHARGE** | The annual peak discharge that has a ten percent chance of occurring or being exceeded in any given year. |
| **100 YEAR DISCHARGE** | The annual peak discharge that has a one percent chance of occurring or being exceeded in any given year. |
| **BACKSLOPE DRAIN** | A drain or swale that collects overland peak discharge from channel overbanks and other areas not draining into the storm sewer collection system. These may be designed to prevent unplanned runoff from entering a detention system or from entering a drainage ditch. They are also used to prevent excessive overland peak discharge from eroding the sides of a ditch or pond. |
| **BENCHMARK** | A point of known exact elevation set and used by surveyors to start from to obtain elevations on other points of unknown elevation. The known elevation is usually based on "mean sea level". |
| **BOARD** | The Board of Commissioners of Brazoria Drainage District No. 4 |
| **CFS** | Cubic feet per second |
| **CMP** | Corrugated metal pipe. |
| **COEFFICIENT OF ROUGHNESS** | A number used to measure and compare the roughness of pipe interior or open channel sides and bottom. |
| **COMMERCIAL** | Development of real estate for any purpose other than "residential" as defined herein. |
| **CONDUIT** | Any open or closed device for conveying flowing water. |
| **CONSTRUCTION COMMENCMENT** | The breaking ground of a planned or designed project. |

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| **CONSTRUCTION** | The building of a planned or designed project. |
| **CONTOUR LINE** | A line on a map, chart or plan that follows a continuous line of a certain known elevation. |
| **CULVERT** | One or more pipes that carry the discharge of water from one point in a ditch or channel to another point in a ditch or channel. |
| **GENERAL WARRANTY DEED** | An instrument that transfers legal title to real property from one to another in which grantor covenants to warrant and defend the title against all claims and demands. |
| **DESIGN STORM EVENT** | The rainfall intensity and/or depth upon which the drainage facility will be sized. |
| **DETENTION FACILITY** | A reservoir, dam, pond or other area, serving primarily as a collection device and not as a transmission system, where stormwater collects and is held. The collected stormwater is released at a calculated rate through a control structure. |
| **DETENTION RESERVOIR CONTROL STRUCTURE** | The low flow outlet pipe and high-level spillway that limits the discharge from a detention facility. |
| **DEVELOPER** | A person who engages in development as defined herein. |
| **DEVELOPMENT** | The improvement or subdivision of a tract of land exclusive of land being used for agricultural purposes. Improvement of land includes grading, paving, building structures, or otherwise changing the runoff characteristics of the land. |
| **DEVELOPER'S ENGINEER** | A Registered Professional Engineer licensed in the State of Texas who is performing work for a developer. |
| **DEVELOPER'S SURVEYOR** | A Registered Professional Land Surveyor or Licensed State Land Surveyor licensed in the State of Texas who is performing work for a developer. |
| **DISTRICT** | The Board of Commisioners and/or staff of Brazoria Drainage District No. 4 |

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| **DISTRICT DRAINAGE FACILITY** | Any and all drainage arteries, tributaries, channels, creeks, bayous, streams, gullies, ditches, lakes or ponds owned, operated, or controlled by the DISTRICT. |
| **DISTRICT ENGINEER** | A Registered Professional Engineer licensed in the State of Texas who is reviewing drainage plans or plats under the direction and authority of the DISTRICT. |
| **DRAINAGE AREA MAP** | Area map of watershed which is subdivided to show each area served by each storm drainage subsystem. |
| **DRAINAGE ARTERIES** | Natural or man made ditches or channels that intercept and carry storm water to a larger creek, bayou or stream. |
| **DRAINAGE PLAN** | An engineering representation of the peak discharge of rainfall runoff on or onto a particular area, and off of that same area. It may also include systems that will be used to detain or control runoff and provide flood control for a development, subdivision or structure. |
| **DRAINAGE SYSTEM** | A series of swales, storm sewers, ditches and creeks which function to collect and convey stormwater runoff in a watershed. |
| **EASEMENT** | A land area conveyed for a specific use, such as drainage, while the underlying fee title to the property remains the property of the owner out of which it is a part. |
| **FEMA** | Federal Emergency Management Agency which administers the National Flood Insurance Program. |
| **FEE STRIP** | A strip of land or real property in which legal title is conveyed to the DISTRICT by General Warranty Deed. |
| **FIRM** | Flood Insurance Rate Maps published by FEMA |
| **FIS** | Flood Insurance Study prepared for the Clear Creek Watershed by FEMA for purposes of developing the FIRM. |

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| **FLOOD PLAIN ADMINISTRATOR** | The person identified by the governing municipality or county who is responsible for administering the National Flood Insurance Program for the city or county in accordance with guidelines established by FEMA. Brazoria County and the incorporated cities within the DISTRICT administer the Flood Insurance Program in the DISTRICT and therefore, each has their own designated Flood Plan Administrator. |
| **FLOOD PROTECTION PLAN** | The DISTRICT'S master drainage plan, entitled Flood Protection Plan for Brazoria Drainage District No. 4, as authorized by Section 49.211(c) of the Texas Water Code. |
| **HDPE** | High Density Polyethylene pipe. |
| **HEC-HMS** | "Hydrologic Modeling System" computer program written by U.S. Army Corps of Engineers similar to HEC-1. Intended to replace HEC-1. |
| **HEC-RAS** | "River Analysis System" computer program written by U.S. Army Corps of Engineers similar to HEC-1. Intended to replace HEC-2. |
| **HYDRAULIC ANALYSIS** | The study and/or definition of the movement of stormwater through a drainage system. |
| **HYDRAULIC GRADE LINE** | A line representing the pressure head available at any given point within the drainage system. |
| **HYDROLOGIC ANALYSIS** | The study and/or definition of the properties, distribution and circulation of stormwater runoff over land or in the soil. |
| **HYDROMULCHING** | A process of spraying grass seeds on an exposed slope to seal the surface and seed it with vegetation to prevent or help prevent erosion of the soil. |
| **HYDROPAC** | A series of engineering computer programs designed by a private entity for computations and modeling of hydrology and hydraulics concerning storm water runoff and facilities. |

**ICPR**

Intercontinental Channel and Pond Routing computer program by Streamline Technologies, Inc. Computes unsteadygradually caried flow.

**IMPACT**

The effect of a proposed development on the hydrology or hydraulics of a subarea or watershed as defined by an increase or decrease in peak discharges or water surface elevations.

**IMPACT DATA**

Data required to support the Developer's Engineer in proving that the proposed development will not have a negative impact on the rainfall runoff rates, rainfall concentration times and the surface level of the affected creek, stream, gully or ditch into which proposed development runoff drains.

**IMPERVIOUS COVERS**

A land surface cover which does not allow the passage of storm water into the underlying soil. Used in hydrologic analysis to calculate the amount of storm water runoff from an area.

**IN-FILL DEVELOPMENT**

Development of open tracts of land in areas where the storm drainage infrastructure is already in place and takes advantage of the existing infrastructures as a drainage outlet.

**MANNING'S EQUATION**

$V = (K/n) R^{2/3} S_f^{1/2}$

Where K = 1.49 for English units, 1.00 for metric units
V = velocity (ft/sec or m/sec)
R = hydraulic radius (ft or m)
(area/wetted perimeter)
$S_f$ = friction slope (head loss/length)
N = 0.013 for concrete pipes
0.011 for HDPE pipes
0.028 for CMP
varies for earthen channels

**METERING DEVICE**

A device or structure containing pipe, V-notch weir, slots and other configurations designed to measure or regulate the outflow.

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|---|---|
| **MITIGATE** | To lessen or eliminate the impact of a proposed development on the hydrology or hyraulics of a subarea or watershed. |
| **MODIFIED RATIONAL FORMULA** | A modification of the Rational Formula (Q = CIA) used to compute the runoff rate from an area, either undeveloped or developed. |
| **MSL** | Mean Sea Level, pertaining to base elevations. |
| **MYLAR** | Used to mean a copy of a plat or plan made on Mylar, which is a polyester film resistant to tear, warp, curl, crack and peel. |
| **OUTFALL STRUCTURE** | A structure made to contain the outfall pipe or peak discharge, with necessary weir, slope paving or other methods to control velocity and prevent erosion, and may contain the metering device. |
| **OUTFALL** | The necessary conveyance from the development's drainage system into another or existing drainage system. |
| **OUTFLOW** | The total peak discharge from the development's drainage system into another or existing drainage system. |
| **OVERFLOW** | The peak discharge that will not pass through the design pipe or structure, and must go over a weir or some other relief structure. |
| **PEAK DISCHARGE** | The maximum rate of stormwater runoff from a tract of land or in a ditch or channel, as determined from the maximum point in cubic feet per second of the calculated hydrograph for the study area. |

**PLAT** A map of a piece of land with actual or proposed features and improvements which may be filed with the appropriate regulatory authority prior to the land being legally subdivided.

**RAINFALL DATA** Data pertaining to the amount of rainfall in a certain area and occurring over a certain specified period of time.

**RAINFALL FREQUENCY** The probability of a rainfall event of defined characteristics occurring in any given year. Information on rainfall frequency is published by the National Weather Service. For the purpose of storm drainage design, the following frequencies are applicable:

3-year frequency – a rainfall intensity having a 33% probability of being equaled or exceeded in any given year.

5-year frequency – a rainfall intensity having a 20% probability of being equaled or exceeded in any given year.

10-year frequency – a rainfall intensity having a 10% probability of being equaled or exceeded in any given year.

25-year frequency – a rainfall intensity having a 4% probability of being equaled or exceeded in any given year.

100-year frequency – a rainfall intensity having a 1% probability of being equaled or exceeded in any given year.

**RAINFALL RUNOFF** That portion of precipitation that does not soak into the land or evaporate and ultimately reaches the drainage system.

**RATIONAL FORMULA** A method for calculating the peak runoff for a storm drainage system.

**REDEVELOPMENT** A change in land use that alters the impervious cover from one type of development to either the same type or another type, and takes advantage of the existing infrastructure in place as a drainage outlet.

| | |
|---|---|
| **RCP** | Reinforced Concrete Pipe. |
| **REGIONAL DETENTION FACILITY** | A detention facility that collects and holds stormwater from more than one development or tract of land, or from one of the major drainage arteries in the DISTRICT. |
| **RESIDENTIAL** | Pertaining to single family detached dwelling(s) not including multi-family townhomes, condominiums, duplexes or apartments. |
| **RIGHT OF WAY** | A strip of land that is set aside and reserved for certain purposes including drainage and maintenance, and possibly future widening of a drainage channel. |
| **ROADSIDE DITCH** | A ditch made adjacent to and along the road to carry storm water from the road and adjacent land along the road rather than from other areas. |
| **RUNOFF** | That part of rainfall on property that does not soak in or evaporate, and ultimately reaches drainage arteries. |
| **RUNOFF COEFFICIENT** | A comparative measure of different soils, slopes and growths for their capability of allowing the peak discharge of water to move along and over them. |
| **SHEET FLOW** | Overland storm runoff that is not conveyed in a defined conduit, and is typically in excess of the capacity of the conduit. |
| **SITE** | A space of ground occupied or to be occupied by a building or development. |
| **SPILLWAY** | The part of the outfall structure that allows and controls the "overflow" that does not go through the structure. |
| **SUBDIVIDE** | To divide a tract of land into smaller tracts or building lots. |

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| **SUBDIVISION** | A tract of land which has been separated from surrounding tracts and has been defined into building lots and approved by the appropriate governmental entity. |
| **SWALE** | A very shallow ditch that usually has very long sloping sides, in some cases not much more than a small depression that allows water to flow in a somewhat controlled manner. |
| **TECHNICAL PAPER NO. 40** | Publication of the U.S. Weather Service. |
| **TRIBUTARY CHANNEL** | A smaller contributing channel or ditch to a larger channel or ditch. |
| **TSARP** | Tropical Storm Allison Recovery Project. |
| **UNDERGROUND STORM SEWER** | A continuous pipe sewer constructed underground with adequate grade and drainage for carrying storm water to a major drainage system. |
| **VARIANCE** | An exception granted by the DISTRICT to a developer or property owner, in limited instances, to allow departure from the literal requirements of the DISTRICT'S Rules, Regualtions & Guidelines. |
| **WATERSHED** | A region or area bounded peripherally by a ridge of higher elevation and draining ultimately to a particular watercourse or body of water. |
| **WSP2** | A software program developed by U.S. Soils Conservation Service, used to run backwater profiles on ditches, creeks and streams to determine the effects of various data changes such as quantity of peak discharge, restrictions, detention ponds, etc. |
| **WEIR** | A notch of regular form through which water flows. |

Illustrative items referenced but not included herein may be obtained at the DISTRICT'S office.