Enclosure 5

Attachment B to SAR Chapter 2 (Partial) associated with Response to RAI NP-2.4-1

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CENTRALIZED INTERIM STORAGE FACILITY DRAINAGE EVALUATION AND FLOODPLAIN ANALYSIS

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REVISED FEBRUARY 2019

Prepared for:

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This report is issued for permitting or licensing purposes. It is not intended for bidding or construction purposes.

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06 February 2019

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1.0 INTRODUCTION

This report presents the results of a hydrologic and hydraulic analysis of the proposed conditions in and around the area of the Centralized Interim Storage Facility (CISF) proposed to be licensed by the Nuclear Regulatory Commission at the Waste Control Specialists, LLC (WCS) site located in Andrews County, Texas. This report is prepared in support of the Safety Analysis Report (SAR) as described at 10 CFR 72.24 and addresses items contained in the "Standard Review Plan for Spent Fuel Dry Storage Facilities", NUREG-1567, dated March 2000, Section 2.4.4 Surface Hydrology.

1.1 HYDROLOGIC DESCRIPTION

The CISF site is located in western Andrews County, Texas nearly at the Texas – New Mexico border, just north of Texas Highway 176 approximately 31 miles west of Andrews, Texas and 5 miles east of Eunice, New Mexico. There are no maps of special flood hazard areas for this location published by the Federal Emergency Management Agency (FEMA). The Site Location and Surrounding Topography Map, Figure 1.1-1, shows the CISF site location with respect to the surrounding topography and drainage features and the WCS property boundary.

1.1.1 Hydrosphere

From a surface water perspective, the general area is characterized by ephemeral drainages, sheet flow, minor gullies and rills, internally-drained playas, and a salt lake basin (identified on Figure 1.1-1 as the Depression Pond). The salt lake basin is the only naturally-occurring, perennial (year-round) water body located near the CISF site; the internally-drained salt lake basin is located approximately 5 miles from the eastern boundary of the CISF site and rarely has more than a few inches of water at scattered locations within the bottom footprint. Surface drainage from the CISF site does not flow into this basin. Other perennial surface water features are man-made, including various stock tanks (often replenished by shallow windmill wells) located across the area and the feature denoted as the Fish Pond on Figure 1.1-1, which is located at the existing Permian Basin Materials quarry west of the CISF site and is also replenished by well water. In addition, Sundance Services, LLC operates the Parabo Disposal Facility for oil and gas waste on portions of the Permian Basin Materials quarry property. Water collects periodically in excavated and/or diked areas at this disposal facility and in the active quarry areas at this property adjacent to and west of the WCS property in New Mexico.

Baker Spring, another man-made feature, is located at a historic quarry on WCS property about 2,150 ft west of the CISF site in Lea County, New Mexico. This feature was formed by excavation of the caliche caprock to the top of the underlying red bed clays. After periods of rainfall, the depression holds water for some period until it evaporates. During wet cycles, the depression may hold water for an extended period; during dry cycles, the depression may be dry for extended periods.

The National Oceanic and Atmospheric Administration's National Weather Service Office for Hobbs, New Mexico indicates that the minimum average annual precipitation recorded is 2.01 inches in 2011 and the maximum average annual precipitation recorded is 32.19 inches in 1941. The annual precipitation on average is approximately 14 inches.

The CISF site is located on the southwest-facing slope that transitions from the Southern High Plains to the Pecos Valley physiographic section. The Southern High Plains is an elevated area of undulating plains with low relief encompassing a large area of west Texas and eastern New Mexico. In Andrews County, the southwestern boundary of the Southern High Plains is poorly defined, but in this report is considered to be where the caprock caliche is at or relatively close to surface, such as on and near the CISF site.

The main surface water drainage in the area is Monument Draw, an ephemeral stream about 3 miles west of the WCS site in New Mexico. Ephemeral streams or drainage ways flow briefly only in direct response to precipitation in the immediate locality. Monument Draw is a reasonably well-defined, southward-draining feature (although not through-going) that is identified on the USGS topographic maps that serve as the base map source for Figure 1.1-1.

An ephemeral drainage feature, referred to as the Ranch House Draw crosses the WCS property from east to west, generally to the south of the CISF site, as shown on Figure 1.1-1. This feature is discernible from the topographic relief depicted on Figure 1.1-1, although it is much less pronounced than Monument Draw. This drainage feature is a relict drainage way that is choked with windblown sand and is not through-going to Monument Draw. Most of the drainage from the area of the CISF site is down slope toward the Ranch House Draw, with a small portion of the drainage from this area toward the southwest. Surface water eventually infiltrates into the windblown sands and dune fields to the south and southwest of the CISF site.

There are no ephemeral drainages that cross the CISF site. Most of the immediate area of the CISF site is drained from northwest to southeast by sheet flow. Sheet flow is a term describing overland flow or down slope movement of water taking the form of a thin, continuous film.

Playas, or small, internally-drained basins, occur on the WCS property. The playas are dry most of the time. Some of the playas occasionally hold water after relatively large precipitation events; however, the ponded water rapidly dissipates through infiltration, evaporation, and plant uptake. An established playa basin is present on the eastern edge of the CISF site. Surface topography maps indicate approximately 10 ft of relief in the playa.

The combination of low annual precipitation, relatively high potential evapotranspiration, permeable surficial soils down gradient of the CISF site, and topographic relief results in well-drained conditions. The engineering design and construction of the CISF site will eliminate areas that might promote ponding. Diversion berms and a collection ditch will direct stormwater from upstream drainage areas around the CISF.

There are no public or private surface water drinking-water supplies in the site vicinity. Potable water supply for the WCS facility is provided by the City of Eunice, which gets its water from wells in the Hobbs area. There are scattered windmills in the general area that take water from isolated pockets of groundwater perched on top of the red bed clay. This water is utilized primarily for livestock watering.

1.1.2 Site and Structures

The CISF site is defined as the area within the owner controlled fence and is approximately 320 acres as depicted on the Developed Drainage Plan, Figure 1.1.2-1. The CISF site is undeveloped and the existing land surface is fairly flat with an average slope of 0.8 percent (%). The existing maximum and minimum elevations of the site are about 3520 ft and 3482 ft msl, respectively. The cover type is desert shrub. The existing WCS railroad is generally aligned parallel with and south of the proposed southern CISF site boundary.

The CISF storage area, which is within the CISF site, is defined as the area within the protected area fence whose boundary is defined by a rectangle 2360 feet by 2430 feet, as indicated on the Developed Drainage Plan, Figure 1.1.2-1. Included in the storage area are the security/administration building, the cask handling building, the storage pads and a portion of the

CISF rail side track. The CISF storage area is approximately 132 acres and is graded for surface drainage with slopes of approximately 0.8 % from the northwest to the southeast. Developed elevations across the CISF storage area range from 3506 ft msl at the northwest corner to 3486 ft msl near the southeast corner.

All of the surface water runoff from the storage area will drain into the large playa southeast of the site. Flow arrows on Figure 1.1.2-2, Developed Drainage Area Map provide the detailed drainage patterns for the CISF site.

2.0 FLOODS

There is no evidence that the CISF site area has experienced flooding in the past. The ranch house drainage within the WCS property was evaluated as part of a Flood Plain Study conducted in February 2004 (Revised December 2004 and March 2006) for the Application for License to Authorize New-Surface Land Disposal of Low-Level Radioactive Waste (LLRW) that was approved by the Texas Commission on Environmental Quality (TCEQ) in 2009 as Radioactive Material License No. R04100. The 2004 Flood Plain Study as revised through March 2006 is provided as Appendix A and includes maps depicting the drainage areas within the WCS property and the location of the 100-year, 500-year and Probable Maximum Precipitation (PMP) flood plain. The 100-year flood plain extends across the southern portion of the WCS property area along the ranch house drainage. The northernmost limit of the 100-year floodplain is approximately 4,000 ft southeast of the CISF site while the northernmost limits of the 500-year and PMP floodplains are 3965 feet and 3895 feet southeast of the CISF site respectively.

The prior floodplain analysis indicated that the PMP elevation of the large playa located mostly east of the CISF site is 3488 ft msl. A portion of the CISF site is located over the large playa. Elevations of the storage pads, security/administration building, and the transfer facility are above 3490 ft msl.

An analysis of the drainage features around the CISF site is performed for the PMP to ensure that the structures important to safety are safe from flooding.

2.1 FLOOD HISTORY

The climate of the area is classified as semiarid, characterized by dry summers and mild, dry winters. Annual precipitation on average is approximately 14 inches and annual evaporation exceeds annual precipitation by nearly five times. The area is subject to occasionally winter storms, which produce brief snowfall events of short duration.

Rainfall records from July 2009 through December 2015, provided by WCS from a weather station near the CISF site, indicate an average annual rainfall of 12.6 inches and a maximum twenty-four hour rainfall total of 3.62 inches. According to WCS personnel, surface water runoff has not overflowed roads or existing drainage features at the WCS facility during this time frame.

2.2 FLOODPLAIN ANALYSIS DEVELOPED CONDITIONS

This analysis identifies the limits of the watershed in which the CISF site is proposed to be located and determines the local peak flow rates and water elevations at the watershed analysis points resulting from the 100-year and 500-year frequency storm events and the Probable Maximum Precipitation event (PMP) after the CISF site is fully developed. This analysis also identifies the location of the local PMP floodplain associated with a large playa/depression located within the subject watershed.

2.2.1 Description of Watershed

The contributing watershed that crosses the CISF site contains about 869 acres (1.4 square miles). For the most part, the CISF site is located on top of a hill and will be graded to allow drainage away from the site. Fully developed conditions result in four distinct drainage areas that predominantly slope away from the CISF site. The Developed Drainage Area Map, Figure 1.1.2-2, identifies the developed drainage area boundaries in relation to the CISF site and the associated analysis points described below.

Drainage Area P DA 1 contains 100.9 acres and drains the northwest portion of the site outside of the storage area. Analysis Point P AP 1 is located where surface water runoff from P DA 1 flows across State Line Road. Drainage Area P DA 2 contains 46.1 acres and drains the southwest portion of the CISF site contained between the existing WCS railroad and the CISF rail side track outside of the storage area. Analysis Point P AP 2 is located at the western intersection of the CISF rail side track and the existing WCS railroad. Drainage Area P DA 3 contains 42.8 acres and drains the southeast portion of the CISF site bounded by the existing WCS railroad and the CISF rail side track. Surface water runoff from P DA 3 discharges into the large playa located east of the facility. Drainage Area P DA 4 contains 679.3 acres encompassing the large playa and the majority of the CISF site; surface water from this portion of the CISF site also discharges into the large playa. Analysis Point P AP 3 refers to the location where surface water runoff in the large playa will overtop the existing ground to the south.

The watershed is located in Andrews County, Texas. The *Custom Soil Resource Report for Andrews County, Texas, and Lea County, New Mexico*, prepared by the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), located in Appendix B, shows the watershed contains soils from the Blakeney and Conger, Jalmar-Penwell, Ratliff, and Triomas and Wickett series. These soils are classified with the hydrologic groups A, B and D. Group A soils have high infiltration and transmission rates. Group B soils have moderate infiltration and transmission rates. Group D soils have very low infiltration and transmission rates. The Soils Boundary Map with the CISF site location, topographic information and drainage area boundaries is included as Figure 2.2.1-1.

2.2.2 Description of Hydrologic Analysis Methodology

Surface water runoff from the watershed in which the CISF site is located is modeled using the U.S. Army Corps of Engineers Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS), version 4.0. The rainfall amount for the 100-year frequency storm event is taken from the *USDA Soil Conservation Service (SCS) Texas Engineering Technical Note No. 210-18-TX5, October 1990 (TETN 210).* A 24-hour storm duration is used. The 100-year 24-hour rainfall amount from *TETN 210* for the CISF site is six (6) inches and is the same rainfall amount used in the floodplain study in Appendix A. The 500-year, 24-hour and PMP, 72-hour rainfall amounts are taken from the floodplain study in Appendix A and are 8.71 inches and 40.5 inches, respectively. The precipitation amounts used as input for the HEC-HMS model are as follows:

Return Period	Rainfall (In.)
100-Year, 24 Hour	6.0
500-Year, 24 Hour	8.71
PMP, 72 Hour	40.5

Peak discharges from small watersheds are usually caused by intense, brief rainfalls. Utilizing synthetic rainfall distribution as taken from *TETN 210* in this case is common practice instead of using actual storm events. The synthetic Type II, 24-hour rainfall distribution for Andrews County, Texas, as shown on Figure 1 of *TETN 210,* and the SCS dimensionless unit hydrograph method are used for the model. The method requires curve numbers to indicate the runoff potential of a hydrologic soil-cover complex and watershed lag to model watershed response. The development of these values is described in the following paragraphs.

The curve number (CN) is computed based on land use, cover type, hydrologic condition and soil group. A December 16, 2015 site visit supported determination of land use, cover types and hydrologic condition. Hydrologic condition indicates the effects of cover type and treatment on infiltration and runoff. The hydrologic condition of the cover at the site is considered poor. The soil group information is taken from the Soil Report in Appendix B. The variability of the CN from rainfall intensity and duration, total rainfall, soil moisture conditions, cover density, stage of growth, and temperature are collectively accounted for in the Antecedent Runoff Condition (ARC). The three classes of ARC are as follows: I for dry conditions, II for average conditions, and III for wetter conditions. Figure 5 of *TETN 210* indicates that the ARC across the state of Texas varies greatly and Andrews County is ARC I. In order to be conservative and check the sensitivity of the model to the various ARC conditions, all three classes are used in the CN determinations and the model.

The *USDA NRCS, Part 630 Hydrology, National Engineering Handbook (NEH)* explains that lag is the delay between the time runoff from a rainfall event over a watershed begins until runoff reaches its maximum peak. Lag is empirically estimated as six-tenths (0.6) of the time of concentration, (USDA NRCS, Part 630, NEH, Equation 15-3). The time of concentration is the time it takes for runoff to travel from the hydraulically most remote part of a watershed to a point of consideration. In hydrograph analysis it represents the time from the end of "excess rainfall" to the point of inflection of an SCS unit hydrograph.

Time of concentration is computed by determining the travel times for different segments of the flow path. The segments consist of sheet flow, shallow concentrated flow and concentrated flow. The sheet flow and shallow concentrated flow components are calculated for all of the drainage areas using the equations from USDA SCS *Technical Release 55*, *Urban Hydrology for Small Watersheds*. Drainage Areas P DA 1 and P DA 2, as shown on Figure 1.1.2-2, also exhibit channelized flow. Broad channelized flow occurs in P DA 1 as the surface water flows southwest out of the CISF site and crosses State Line Road. Channelized flow occurs in P DA 2 as the surface water flows southwest in the existing ditch along the northern side of the existing WCS railroad. Concentrated flow is calculated based on the flow velocity for the channel being analyzed. Channel velocities are calculated using Manning's Equation or they are estimated based on the results of the HEC-HMS model. All time of concentration parameters for the various drainage areas are included in Appendix C, Calculations.

Elevation, storage and cross-section data are developed for P DA 2, P DA 3 and the playa/depression located within the subject watershed to determine their effect on the runoff from these areas and are included in Appendix C. All watershed parameters that are topography dependent are based on the WCS provided aerial survey dated May 29, 2014 flown by Dallas Aerial Surveys, Inc and the WCS provided proposed CISF elevations.

2.2.3 Site Drainage and Model Strategy

The CISF site drainage features consist of a collection ditch and four culverts through the CISF rail side track that are located as shown on the Developed Drainage Plan, Figure 1.1.2-1. The design criterion for the site drainage features are the 100-Year, 24 Hour, ARC I, peak flow rates as determined by HEC-HMS. Whenever possible, surface water runoff will be maintained as sheet flow. Conservative input parameters and strategies are used in the HEC-HMS modeling of the peak flow rates.

2.2.3.1 Site Drainage

Surface water runoff from the up gradient area north of the storage area will be diverted by a collection ditch located just north of the storage area boundary as shown on Figure 1.1.2-1. Onsite surface water runoff will be mainly sheet flow off of the sloped storage pads and the sloped areas in between the pads. The land surface adjacent to the eastern and western perimeters of the storage pads will be sloped to drain as sheet flow toward the protected area fence and beyond through the owner controlled area fence. Surface water runoff between the collection ditch and the northern storage pads within the storage area will sheet flow to the southeast. Surface water runoff south of Phase 1 storage pad will drain southeast into Culvert 2 under the CISF rail side track just west of the cask handling building. Surface water runoff south of the Phase 5 storage pad and the CISF rail side track will sheet flow to the east.

The cask handling building roof drains half to the north and half to the south. The western portion of the area between the CISF rail side track and the existing railroad outside of the storage area will drain to the west with some of the surface water runoff flowing through the existing culvert under the WCS railroad crossing at State Line Road and the rest of it flowing through Culvert 1 into existing surroundings. The eastern portion of the area between the CISF rail side track and existing railroad will drain to the east and empty into the large playa through Culverts 3 and 4.

2.2.3.2 Model Strategy

Conservative parameters are input into the HEC-HMS model to determine peak runoff rates and overflow elevations. Conservative assumptions include the following: (1) all areas inside the storage area are assumed to be impervious for the CN calculation; (2) all three ARC conditions are used for the CN calculation even though Andrews County exhibits ARC I conditions; (3) no consideration is given to initial losses or infiltration rates of the precipitation; (4) all culverts are presumed clogged and do not allow any flow through them; and (5) the collection ditch and berms are not in place in order to model the greatest possible area contributing runoff into the playa. Surface water runoff at the clogged culverts in P DA 2 and P DA 3 and at the outflow of the large playa are modeled as reservoir elements in HEC-HMS. To stimulate flow out of these areas the non-level dam top routine is used with a discharge coefficient of 2.6. The probable maximum flood (PMF) flow is modeled over the existing railroad and the proposed CISF rail side track.

3.0 SUMMARY OF RESULTS

The Developed Drainage Area Map, Figure 1.1.2-2 delineates the subject watershed including drainage areas and analysis points. The 100-year, 500-year, and PMP peak discharges for each drainage area and ARC condition as determined by the HEC-HMS model are shown in Table 1, Post-Development Drainage Areas – Peak Flow. The 100-year, 500-year, and PMP runoff volumes for each drainage area and ARC condition as determined by the HEC-HMS model are shown in Table 2, Post-Development Drainage Areas – Runoff Volumes.

The 100-year, 500-year, and PMP water surface elevations at analysis points as determined by HEC-HMS for every ARC condition are shown in Table 3, Post-Development Analysis Points - Peak Elevation.

At Analysis Point 1, the peak discharge resulting from all modeled storm events flows over State Line Road. The peak discharge (during the PMP and ARC III conditions) is 424 cubic feet per second (CFS). The maximum depth of flow over the road (during the PMP and ARC III conditions) is approximately 0.8 ft. which is equivalent to elevation 3487.3 ft. msl.

The peak discharge resulting from all modeled storm events flows over the railroad tracks at Analysis Point 2. The peak discharge (during the 500-year and ARC III conditions) is 284 CFS. The maximum depth of water over the rail (during the 500-year and ARC III) is approximately 1.4 ft. which is equivalent to elevation 3466.4 ft. msl.

The playa/depression contains all the runoff from drainage areas P DA 3 and P DA 4. The limit of the PMP, ARC III condition, water surface elevation of the playa/depression based on the topographic information provided by WCS is 3488.9 ft. msl and is shown on Figure 1.1.2-2, Developed Drainage Area Map. The results indicate that the playa/depression does not discharge during the 100-year frequency event but does discharge at Analysis Point 3 during the other modeled events. The peak discharge (during the PMP and ARC III conditions) flowing out of the playa is 3005 CFS. The depth of the PMP, ARC III, peak discharge flow over the railroad tracks at Analysis Point 3 is approximately 1.5 ft. which is equivalent to elevation 3488.9 ft. msl.

4.0 CONCLUSIONS

The local PMP floodplain analysis yields the PMF elevation near the CISF site of 3488.9 ft msl. Elevations of the storage pads vary from 3490 ft msl to 3504 ft msl. Elevations of the foundations of the security/administration building and the transfer facility are 3496 ft msl and 3493 ft msl, respectively.

5.0 OTHER CONSIDERATIONS

The naturally occurring playa/depression will reach its maximum elevation for a brief time as the surface water flows out over the rail and the natural ground and infiltrates into the existing ground. At the peak elevation the area of the water surface in the playa/ depression is approximately 280 acres which is too small to produce any wind wave activity.

No PMP analysis of perennial streams or rivers is considered since they do not exist in the vicinity of the CISF site.

There are no dams on any upgradient areas from the site; therefore, no analysis is required.

Since no large bodies of water exist near the site, no surge, seiche, or ice flooding is possible.

The site is located 480 miles from the Gulf of Mexico, which is the nearest coastal area; therefore, no tsunami sea waves are possible.

There are no liquid releases that result from the normal operation of the CISF.

The local short-term overland flow depth of surface water runoff and velocity on the CISF Phase 1 pad for the 500-year rainfall event are calculated using Manning's Equation. The maximum rainfall intensity for all analyzed storms is used which is the 500-year rainfall event and is taken from the HEC-HMS output. Calculations are found in Appendix C and the results are as follows:

Maximum depth: 1.1 inches

Maximum velocity: 1.7 feet/second

Berms and ditches upgradient of the storage area will be constructed of on-site available compacted red bed clay and armored with on-site available caliche in order to minimize erosion and seepage. Inspection of the berms for erosion and ditches for sediment buildup will be part of the routine inspection operations for the site. Areas of the site impacted by erosion and sediment buildup will be repaired to original grades. Inspection and maintenance will occur after normal and extreme precipitation events and through all phases of the facility.

6.0 REFERENCES

Waste Control Specialists LLC, Application for License to Authorize Near-Surface Land Disposal of Low-Level Radioactive Waste, Appendix 2.4.1: Flood Plain Study, March 2006.

United States Department of Agriculture, Natural Resources Conservation Service. *Custom Soil Resource Report for Andrews, County, Texas, and Lea County, New Mexico,* December 2015.

United States Department of Agriculture, Soil Conservation Service. *Texas Engineering Technical Note No. 210-18-TX5*, October 1990 (TETN 210).

United States Department of Agriculture, Natural Resources Conservation Service. *Part 630 Hydrology,* National Engineering Handbook (NEH), Chapter 15, Time of Concentration, May 2010.

United States Department of Agriculture, Natural Resources Conservation Service Technical Release 55. June 1986. Urban Hydrology for Small Watersheds.

TABLES

TABLE 1
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT DRAINAGE AREAS - PEAK FLOW

ARC I

Drainage Area	100 YR Peak Flow (CFS)	500 YR Peak Flow (CFS)	PMP Peak Flow (CFS)
P DA 1	118.3	245.4	410.7
P DA 2	118.1	209.2	191.1
P DA 3	127.5	218.2	178.4
P DA 4	803.6	1523.1	2786.9

ARC II

Drainage Area	100 YR Peak Flow (CFS)	500 YR Peak Flow (CFS)	PMP Peak Flow (CFS)
P DA 1	223.4	373.1	421.5
P DA 2	170.8	264.8	193.1
P DA 3	173.8	265.4	179.8
P DA 4	1324.0	2113.8	2839.4

ARC III

Drainage Area	100 YR Peak Flow (CFS)	500 YR Peak Flow (CFS)	PMP Peak Flow (CFS)
P DA 1	292.0	440.6	424.2
P DA 2	193.2	284.4	193.5
P DA 3	191.1	279.9	180.1
P DA 4	1574.7	2346.9	2849.7

TABLE 2
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT DRAINAGE AREAS - RUNOFF VOLUMES

ARC I

Drainage Area	100 YR Runoff Volume (IN)	500 YR Runoff Volume (IN)	PMP Runoff Volume (IN)
P DA 1	2.09	4.11	33.97
P DA 2	3.09	5.44	36.38
P DA 3	3.38	5.81	36.94
P DA 4	2.62	4.84	35.35

ARC II

Drainage Area	100 YR Runoff Volume (IN)	500 YR Runoff Volume (IN)	PMP Runoff Volume (IN)
P DA 1	3.68	6.17	37.48
P DA 2	4.52	7.14	38.76
P DA 3	4.74	7.38	39.05
P DA 4	4.20	6.78	38.30

ARC III

Drainage Area	100 YR Runoff Volume (IN)	500 YR Runoff Volume (IN)	PMP Runoff Volume (IN)
P DA 1	4.96	7.63	39.34
P DA 2	5.41	8.11	39.88
P DA 3	5.53	8.23	40.00
P DA 4	5.18	7.87	39.61

TABLE 3
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT ANALYSIS POINTS - PEAK ELEVATION

ARC I

Analysis Point	100 YR MAX WSE (FT)	500 YR MAX WSE (FT)	PMP MAX WSE (FT)
P AP 1	3486.9	3487.1	3487.2
P AP 2	3466.0	3466.3	3466.2
P AP 3	3484.4	3485.8	3488.8

ARC II

Analysis Point	100 YR MAX WSE (FT)	500 YR MAX WSE (FT)	PMP MAX WSE (FT)
P AP 1	3487.0	3487.2	3487.3
P AP 2	3466.2	3466.4	3466.2
P AP 3	3485.4	3486.5	3488.9

ARC III

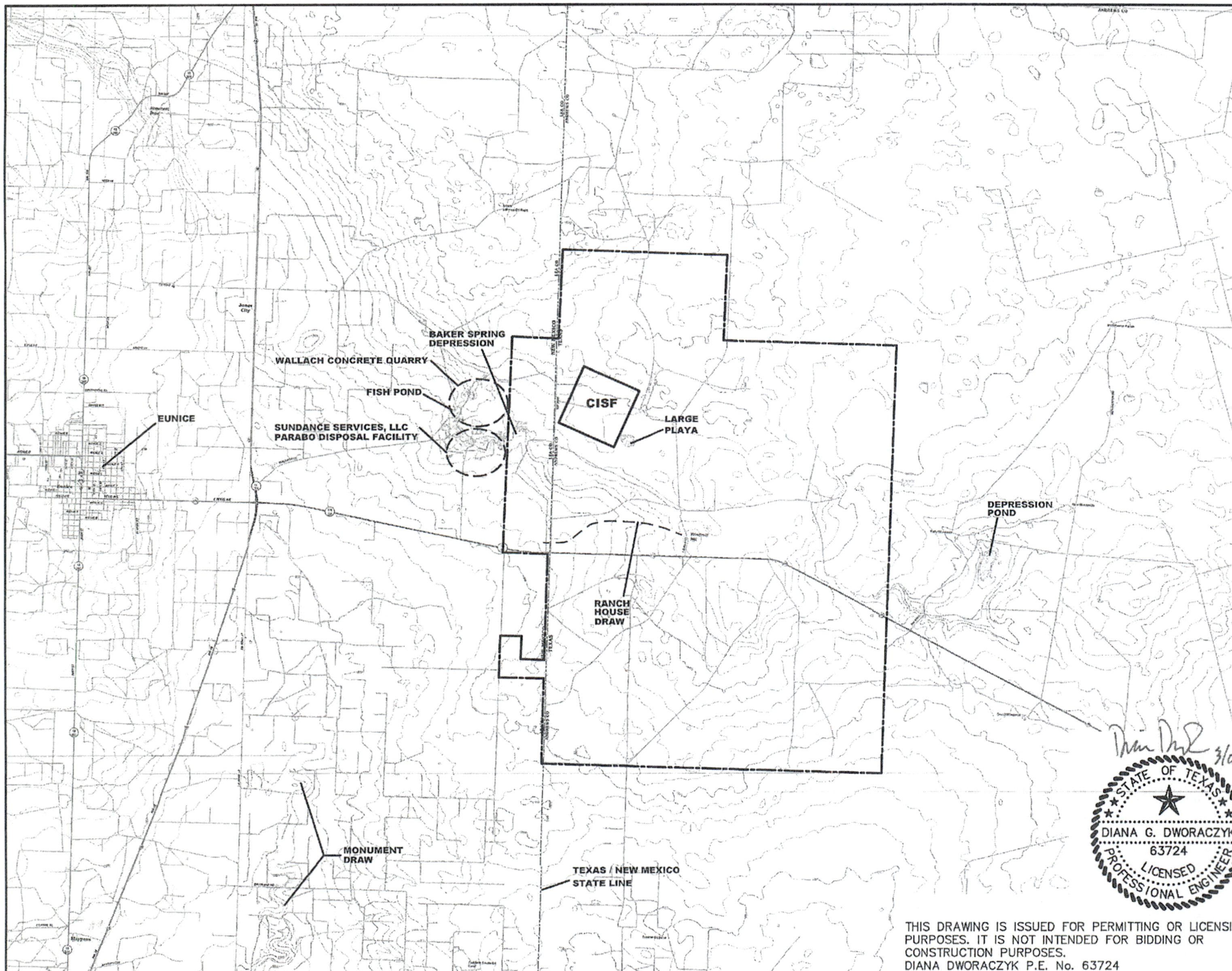
Analysis Point	100 YR MAX WSE (FT)	500 YR MAX WSE (FT)	PMP MAX WSE (FT)
P AP 1	3487.1	3487.3	3487.3
P AP 2	3466.2	3466.4	3466.2
P AP 3	3486.0	3486.8	3488.9

NOTES:

1. Water surface elevation (WSE) represent elevation above mean sea level (AMSL).

2. Elevations are taken from topographic aerial survey provided by Dallas Aerial Surveys, Inc., flown 5-29-2014. 10220 Forest Lane, Dallas, Texas 214-349-2190, 800-862-2190, Fax 214-349-2193.

FIGURES



N

6000 3000 0 6000

(SCALE IN FEET)

LEGEND

CISF OWNER CONTROLLED FENCE (site)

WCS PROPERTY BOUNDARY

NOTE: CISF LOACTION PROVIDED BY WCS.

BASE MAP SOURCE: WWW.USGS.GOV

USGS 7.5 MIN. TOPOGRAPHIC QUADRANGLE:
EUNICE NE, 2012
FRANKEL CITY SW, 2012
JUMBO HILL, 2012
BRINSON RANCH, 2012
HOBBS SE, 2012
HOBBS SW, 2012
EUNICE, 2012
RATTLESNAKE CANYON, 2012
EUNICE SE, 2012

REV.	DATE	DESCRIPTION	DR BY	APP BY

WCS THE TEXAS SOLUTION

COOK-JOYCE INC.
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812 WEST ELEVENTH 512-474-9097
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TEXAS REGISTERED ENGINEERING FIRM F-883

STATE OF TEXAS
DIANA G. DWORACZYK
63724
LICENSED
PROFESSIONAL ENGINEER

3/08/16

PROJECT:
CENTRALIZED INTERIM STORAGE FACILITY
ANDREWS COUNTY, TEXAS

SHEET TITLE:
SITE LOCATION AND SURROUNDING TOPOGRAPHY MAP

DES BY	DD	SCALE:	SEE BAR SCALE
DR BY	SDB	PROJECT NO.	15052.01
CHK BY	DD	CJI NO.	15052003
APP BY	DD	SHEET	1 OF 1 SHEETS
DATE ISSUED: 03-08-2016		FIGURE NO.	1.1-1
PURPOSE:			

THIS DRAWING IS ISSUED FOR PERMITTING OR LICENSING PURPOSES. IT IS NOT INTENDED FOR BIDDING OR CONSTRUCTION PURPOSES.
DIANA DWORACZYK P.E. No. 63724

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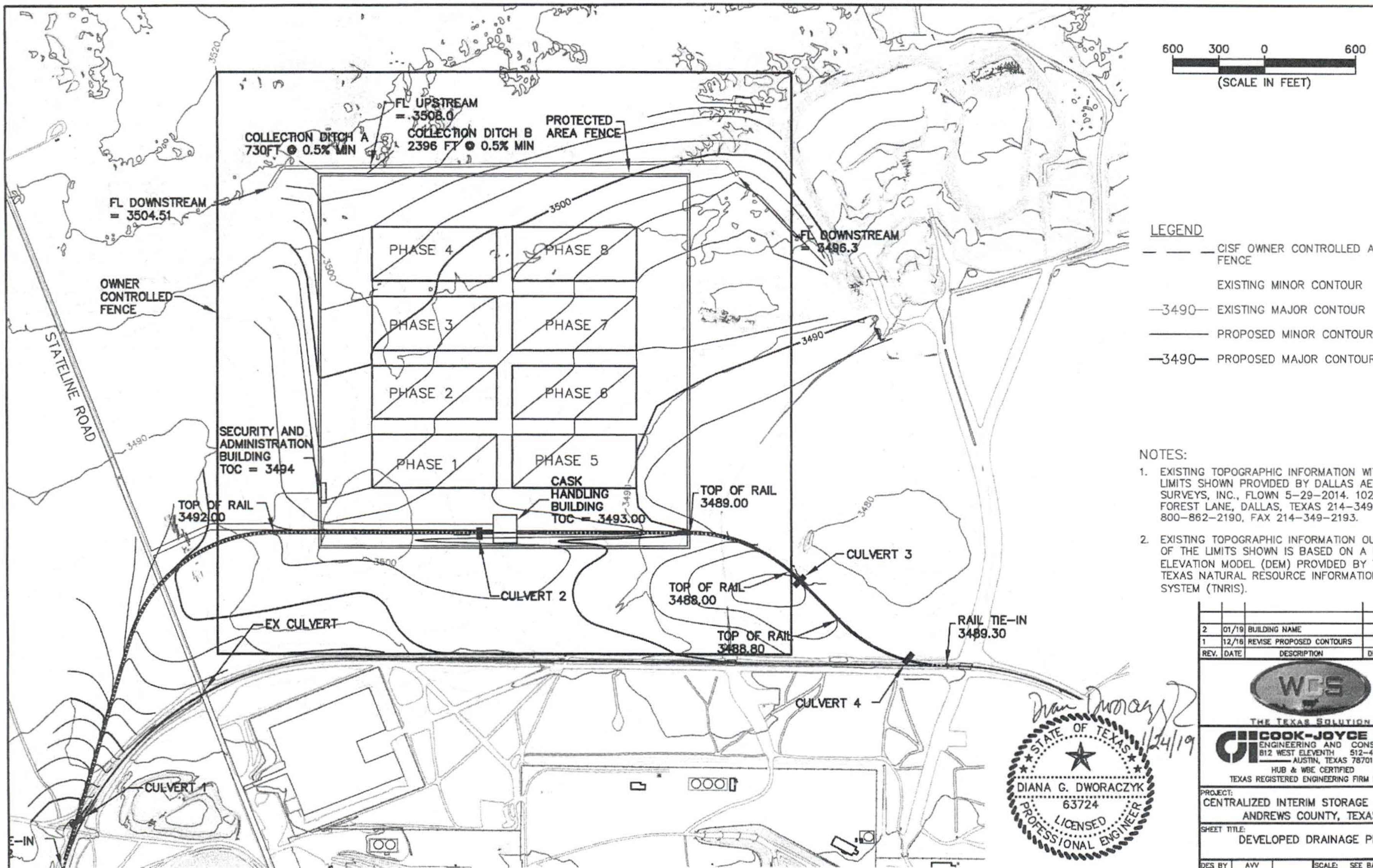

LEGEND

- CISF OWNER CONTROLLED AREA FENCE
- EXISTING MINOR CONTOUR
- 3490 EXISTING MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- 3490 PROPOSED MAJOR CONTOUR

NOTES:

1. EXISTING TOPOGRAPHIC INFORMATION WITHIN LIMITS SHOWN PROVIDED BY DALLAS AERIAL SURVEYS, INC., FLOWN 5-29-2014. 10220 FOREST LANE, DALLAS, TEXAS 214-349-2190, 800-862-2190, FAX 214-349-2193.
2. EXISTING TOPOGRAPHIC INFORMATION OUTSIDE OF THE LIMITS SHOWN IS BASED ON A DIGITAL ELEVATION MODEL (DEM) PROVIDED BY THE TEXAS NATURAL RESOURCE INFORMATION SYSTEM (TNRIS).

REV.	DATE	DESCRIPTION	DR BY	APP BY
2	01/19	BUILDING NAME		
1	12/16	REVISE PROPOSED CONTOURS		

WCS
THE TEXAS SOLUTION

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ENGINEERING AND CONSULTING
812 WEST ELEVENTH 512-474-9097
AUSTIN, TEXAS 78701
HUB & WBE CERTIFIED
TEXAS REGISTERED ENGINEERING FIRM F-883

PROJECT:
CENTRALIZED INTERIM STORAGE FACILITY
ANDREWS COUNTY, TEXAS

SHEET TITLE:
DEVELOPED DRAINAGE PLAN

DES BY	AVV		SCALE: SEE BAR SCALE
DR BY	AVV		PROJECT NO. 15052.01
CHK BY	DD		CJI NO. 15052007R2
APP BY	DD		SHEET 1 OF 1 SHEETS
DATE ISSUED: 02-15-2016			FIGURE NO. 1.1.2-1
CLIENT REVIEW			

STATE OF TEXAS
DIANA G. DWORACZYK
63724
LICENSED
PROFESSIONAL ENGINEER

Diana Dworaczyk 1/24/19

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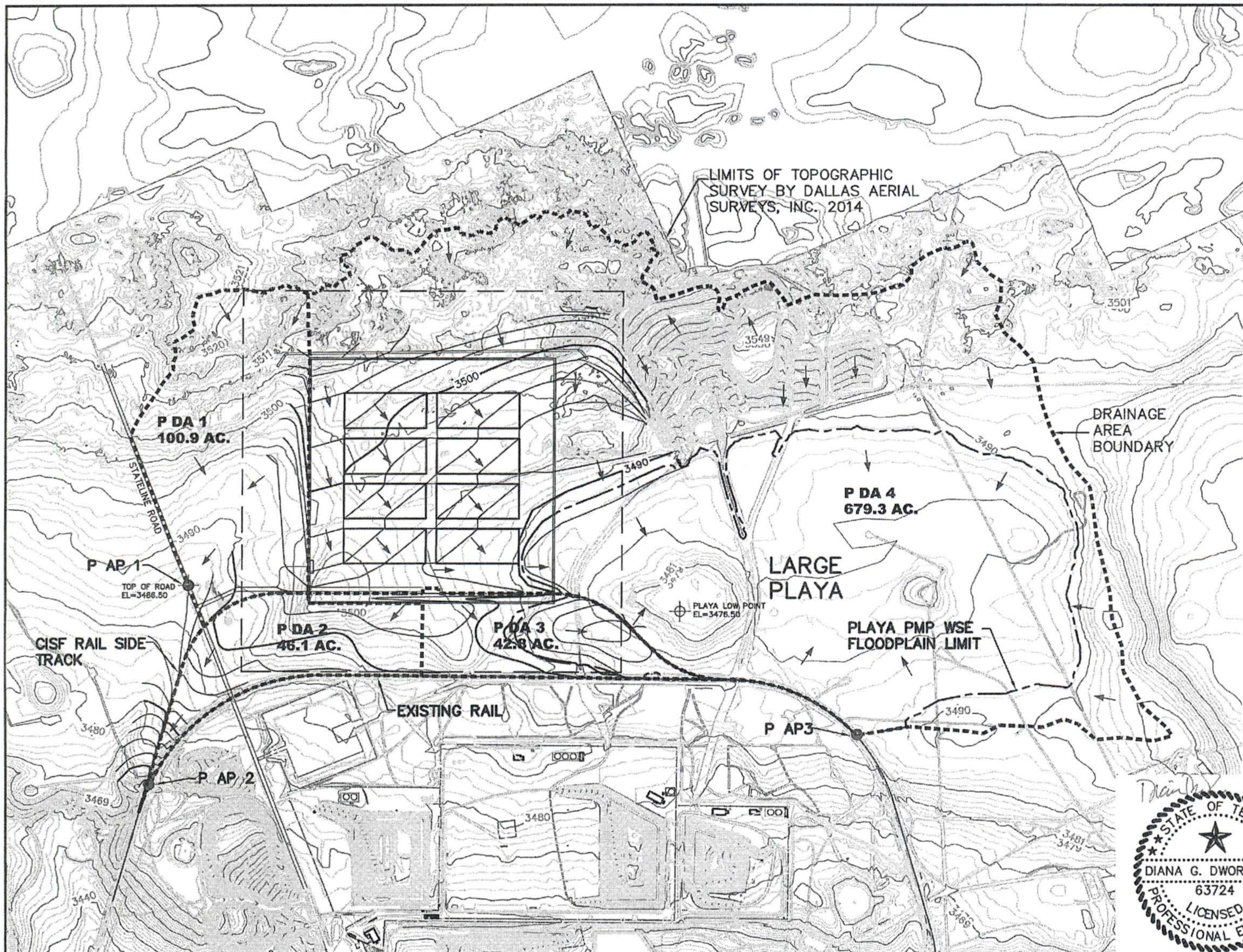
S:\CAD\WCS\15052 CISF Floodplain\15052007R2 - DEVELOPED DRAINAGE PLAN.dwg, 1/22/2019 2:25:12 PM



LEGEND

- DRAINAGE AREA BOUNDARY
- LIMITS OF TOPOGRAPHIC SURVEY BY DALLAS AERIAL SURVEY 5-29-2014
- ANALYSIS POINT
- DIRECTION OF FLOW
- APPROXIMATE PLAYA PMP WSE FLOODPLAIN LIMIT
- CISF OWNER CONTROLLED AREA FENCE
- EXISTING MINOR CONTOUR
- 3490 EXISTING MAJOR CONTOUR
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3. DEVELOPED DRAINAGE AREAS REPRESENT THE ABSENCE OF PROPOSED BERMS OR DITCHES.

REV.	DATE	DESCRIPTION	DR BY	APP BY
2	12/16	REMOVE FLOW PATH INFO, REVISE DRAINAGE AREAS, PROPOSED CONTOURS, PLAYA LIMIT	DD	DD
1	11/16	FIX FLOW ARROWS & ADD FLOW PATH INFO	DD	DD

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TEXAS REGISTERED ENGINEERING FIRM F-883

PROJECT: CENTRAL INTERIM STORAGE FACILITY ANDREWS COUNTY, TEXAS

SHEET TITLE: DEVELOPED DRAINAGE AREA MAP

DES BY	AVV	SCALE: SEE BAR SCALE
DR BY	AVV	PROJECT NO. 15052.01
CHK BY	DD	CJI NO. 15052005R2
APP BY	DD	SHEET 1 OF 1 SHEETS
DATE ISSUED: 03-08-2016		FIGURE NO. 1.1.2-2

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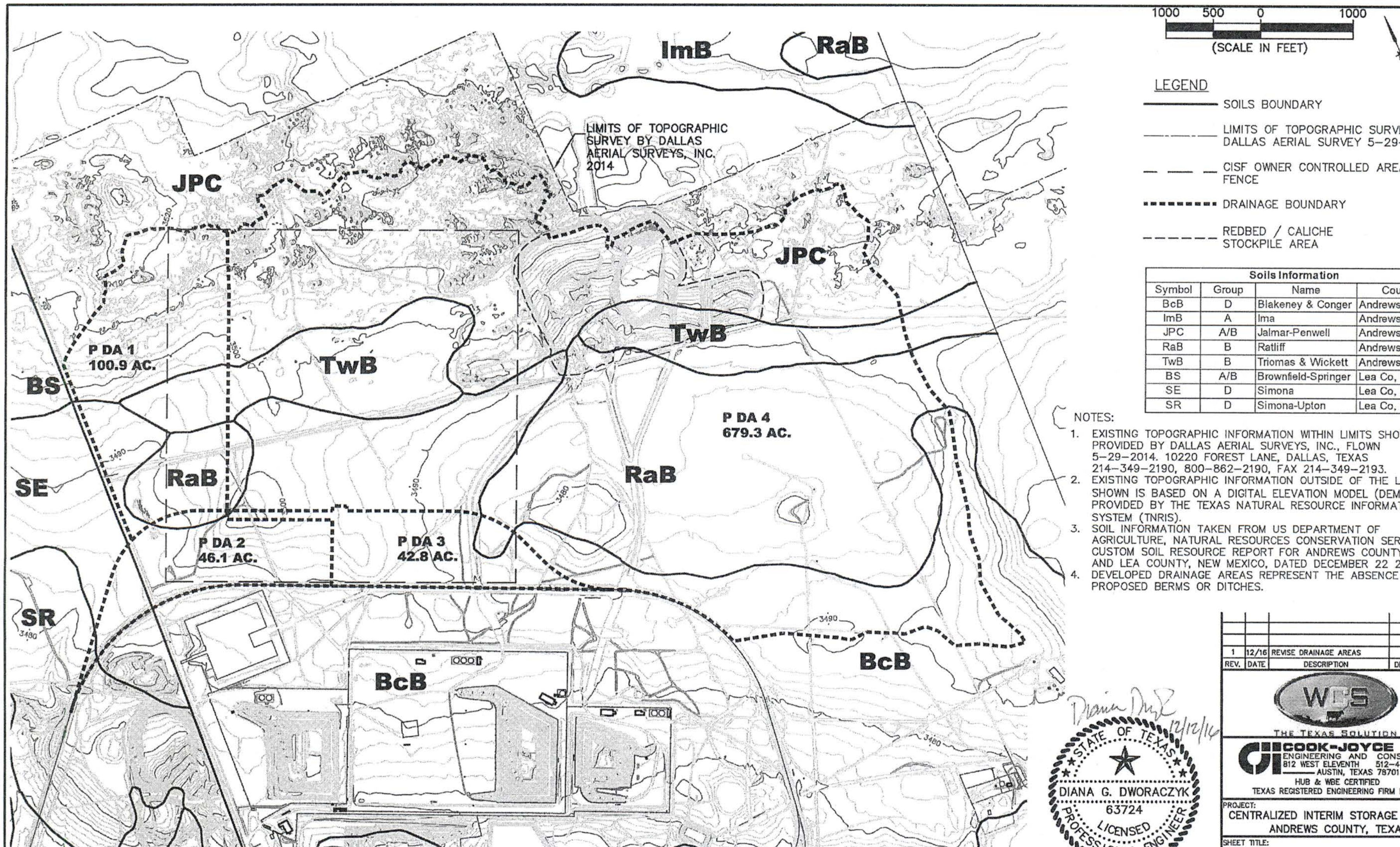

LEGEND

- SOILS BOUNDARY
- LIMITS OF TOPOGRAPHIC SURVEY BY DALLAS AERIAL SURVEY 5-29-2014
- CISF OWNER CONTROLLED AREA FENCE
- DRAINAGE BOUNDARY
- REDBED / CALICHE STOCKPILE AREA

Soils Information			
Symbol	Group	Name	County
BcB	D	Blakeney & Conger	Andrews Co, TX
ImB	A	Ima	Andrews Co, TX
JPC	A/B	Jalmar-Penwell	Andrews Co, TX
RaB	B	Ratliff	Andrews Co, TX
TwB	B	Triomas & Wickett	Andrews Co, TX
BS	A/B	Brownfield-Springer	Lea Co, N.M.
SE	D	Simona	Lea Co, N.M.
SR	D	Simona-Upton	Lea Co, N.M.

NOTES:

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2. EXISTING TOPOGRAPHIC INFORMATION OUTSIDE OF THE LIMITS SHOWN IS BASED ON A DIGITAL ELEVATION MODEL (DEM) PROVIDED BY THE TEXAS NATURAL RESOURCE INFORMATION SYSTEM (TNRIS).
3. SOIL INFORMATION TAKEN FROM US DEPARTMENT OF AGRICULTURE, NATURAL RESOURCES CONSERVATION SERVICE CUSTOM SOIL RESOURCE REPORT FOR ANDREWS COUNTY, TEXAS, AND LEA COUNTY, NEW MEXICO, DATED DECEMBER 22 2015
4. DEVELOPED DRAINAGE AREAS REPRESENT THE ABSENCE OF PROPOSED BERMS OR DITCHES.

REV.	DATE	DESCRIPTION	DR BY	APP BY
1	12/16	REVISE DRAINAGE AREAS		

Diana Dworaczyk 12/12/16

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PROJECT:
CENTRALIZED INTERIM STORAGE FACILITY
ANDREWS COUNTY, TEXAS

SHEET TITLE:
SOILS BOUNDARY MAP

DES BY	AVV		SCALE: SEE BAR SCALE
DR BY	AVV		PROJECT NO. 15052.01
CHK BY	DD		CJI NO. 15052006R1
APP BY	DD		SHEET 1 OF 1 SHEETS
DATE ISSUED: 03-08-2016			FIGURE NO. 2.2.1-1

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ADDENDUM A
BERM BREACH ANALYSIS

COOK-JOYCE INC.
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AUSTIN, TEXAS 78701

ADDENDUM A
BERM BREACH ANALYSIS

FEBRUARY 2019

Prepared for:

Waste Control Specialists LLC
P.O. Box 1129
Andrews, Texas 78714

Prepared by:

Cook-Joyce, Inc.
812 West 11th Street, Suite 205
Austin, Texas 78701

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STATE OF TEXAS
DIANA G. DWORACZYK
63724
REGISTERED
PROFESSIONAL ENGINEER

Diana Dworaczyk P.E. No. 63724
06 February 2019

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LIST OF FIGURES

FIGURE

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APPENDIX

1.0 INTRODUCTION

This addendum presents the results of a hydrologic and hydraulic analysis for an unlikely berm breach of the proposed berm and ditch located just north of the protected area fence for the Centralized Interim Storage Facility (CISF). The same analysis methods, strategies and references that are found in the main part of the flood report are used in this analysis.

The diversion berms and collection ditches, A and B as shown on Figure A-1, will divert surface water runoff from the area north and upgradient of the CISF. Collection ditches A and B drainage areas that will contribute runoff to the ditches and berms are delineated on Figure A-1. Collection Ditch A drainage area is 4.3 acres and Collection Ditch B drainage area is 62.2 acres. Collection Ditch B has the largest drainage area contributing surface water runoff to it by a substantial amount and will carry the largest flow. Therefore, only a berm breach in Collection Ditch B is analyzed since it will yield the greatest potential surface water flow to the storage pads.

2.0 WATERSHED DESCRIPTION AND MODEL

Drainage Area Ditch B DA contains 62.2 acres and drains southeast toward the collection ditch and berm. Collection Ditch B drains to the east and ends several hundred feet past the northeast corner of the protected area fence. The soils in the area draining to Ditch B DA are the Jalmar-Pehnwell series and are classified as hydrologic group A/B as shown on Figure 2.2.1-1, Soils Boundary Map. Curve number (CN) and time of concentration parameters are found in Addendum A, Appendix A, Calculations.

The Ditch B DA parameters are input into the HEC-HMS model to determine peak runoff rates for Collection Ditch B. The 100-year, 500-year and PMP peak discharges for Collection Ditch B are 60 cubic feet per second (CFS), 129 CFS and 251 CFS, respectively. HEC-HMS model setup and inputs are found on the CD in Appendix E of the main part of the report. Results of the HEC-HMS modeling for Collection Ditch B are found in Addendum A, Appendix B, HEC-HMS Output.

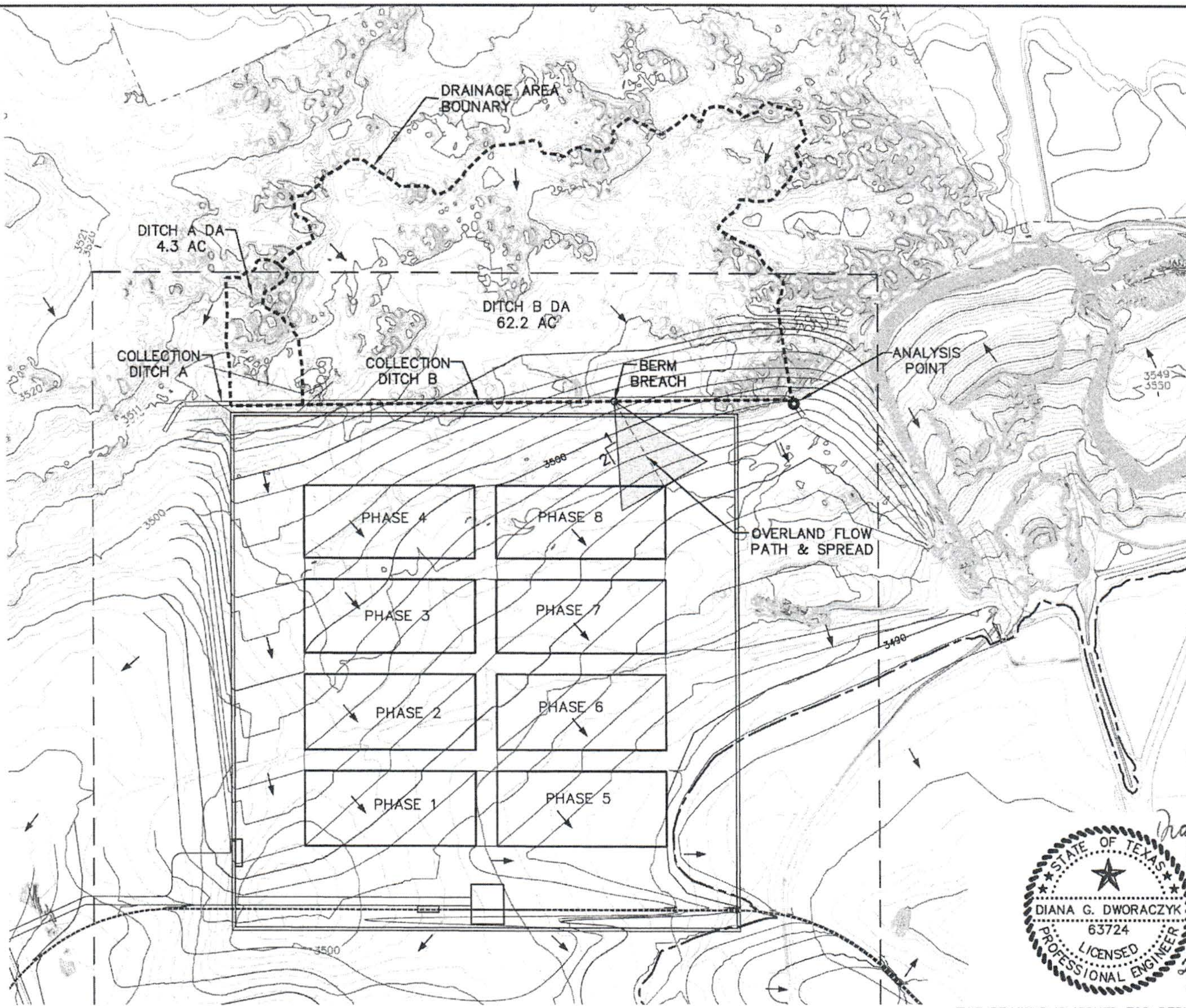
3.0 BERM BREACH

Onsite surface water runoff will be mainly sheet flow off the sloped storage pads and the sloped areas in between the pads. The Collection Ditch B berm is 2.6 feet high and approximately 470 feet from the nearest storage pad at the northern side of the CISF as surface water flows, which is the Phase 8 storage pad. The worst-case for a berm breach will be when Collection Ditch B has the greatest amount of surface water flowing in it and will be at the location where breach flow can still reach a storage pad. The peak flow, 251 CFS, in Collection Ditch B is calculated by HEC-HMS at the analysis point depicted on Figure A-1. The analyzed berm breach location is approximately 800 feet upstream from the analysis point, yet the peak flow is conservatively assumed to flow in Collection Ditch B at that location. The berm breach location is depicted on Figure A-1.

Assumptions for the overland depth of flow adjacent to the Phase 8 storage pad from a berm breach include the following: the berm breach is large enough to release the entire PMP flow, even though Ditch B will still be flowing to the southeast; all of the breach flow will reach the storage pad, even though the pads sit above the surrounding area; and the berm breach flow will spread out from the breach at approximately 2:1 angles from the breach area as it returns to overland flow over the approximately 470 feet to the nearest pad.

The estimated depth of flow adjacent to the pad is approximately 3 inches. Overland depth of flow calculations are found in Addendum A, Appendix A, Calculations.

FIGURE



500 0 500

(SCALE IN FEET)

LEGEND

- DRAINAGE AREA BOUNDARY
- LIMITS OF TOPOGRAPHIC SURVEY BY DALLAS AERIAL SURVEY 5-29-2014
- ANALYSIS POINT
- DIRECTION OF FLOW
- APPROXIMATE PLAYA PMP WSE FLOODPLAIN LIMIT
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PROJECT:
CENTRAL INTERIM STORAGE FACILITY
ANDREWS COUNTY, TEXAS

SHEET TITLE:
DEVELOPED DRAINAGE AREA DITCHES

DES BY	DD	SCALE: SEE BAR SCALE
DR BY	DD	PROJECT NO. 15052.01
CHK BY	DD	CJI NO. 15052016
APP BY	DD	SHEET 1 OF 1 SHEETS
DATE ISSUED: 02-06-2019		FIGURE NO. A-1

S:\CAD\WCS\15052 CISF Floodplain\15052016 Fig A-1 Developed Drainage Area Ditches.dwg, 2/6/2019 1:22:35 PM, 1:1

APPENDICES

APPENDIX A
CALCULATIONS

ADDENDUM A
WCS - CISF DITCH B
POST-DEVELOPMENT DRAINAGE AREA TIME OF CONCENTRATION

Diana Dworaczyk (signature)

STATE OF TEXAS ★ DIANA G. DWORACZYK 63724 REGISTERED PROFESSIONAL ENGINEER

02/06/19
Calculations
4 Pages

	DES		CHK	
WCS	DD	1/31/2019	SC	2/5/2019

Reference: 1. United States Department of Agriculture, Urban Hydrology for Small Watersheds TR-55, 1986
2. Reference Drawing: S:\CAD\WCS\15052 CISF Floodplain\Engineering\15052 - P Hydraulic Calcs DD.dwg

		DITCH B	
Drainage Area	A	**62.2**	(acres)
		0.097	(sqmi)
Sheet Flow			
Manning's roughness coef.[1]	n	0.15	n/a
Flow Length	L	408	feet
2-year, 24-hour rainfall	P2	2.5	inches
Slope	s	0.0098	ft/ft
Travel time[2]	Tt	**0.76**	hours
		45.4	min.
Shallow Concentrated Flow			
Flow Length	L	1060	feet
Slope	s	0.00710	ft/ft
Surface (1=paved or 2=unpaved)		2	n/a
Velocity[3]	V	1.36	ft/sec
Travel time	Tt	**0.22**	hours
		12.99	min.
Manning's Equation			
Flow Length	L	1383	feet
Slope	S	0.00500	ft/ft
roughness[4]	n	0.028	n/a
Open Channel			
Bottom Width	BW	4	feet
Side Slopes (ft/ft, H:V) Rt.	H:V	3	feet
Side Slopes (ft/ft, H:V) Lt.	H:V	3	feet
Depth	d	2	feet
Flow Rate	Q	111	cfs
Velocity	V	4.2	ft/sec
Travel time	Tt	**0.09**	hours
		5.49	min.
Total Travel Time	T	**1.06**	hours
	T	63.90	min.
Lag Time (Tc*0.6)	Tlag	**0.64**	hours
	Tlag	38.34	min.

Notes:
1. Manning's roughness coefficient taken from 'Table 3-1 Roughness coefficients (Manning's n) for sheet flow' - United States Department of Agriculture, Urban Hydrology for Small Watersheds TR-55, 1986
2. Equation 3-3, United States Department of Agriculture, *Urban Hydrology for Small Watersheds TR-55*, 1986
3. Figure 3-1, United States Department of Agriculture, *Urban Hydrology for Small Watersheds TR-55*, 1986
4. Reference Manning's 'n' calculations in APPDX C: POST-DEVELOPMENT HYDRAULIC CALCULATIONS

S:\Projects\W - Z\WCS (Waste Control Specialists)\draft\18059 ISP - NRC Responses\Engineering Checks\Ditch B HEC\R190204_TC.xls

ADDENDUM A
WCS - CISF DITCH B
POST-DEVELOPMENT CURVE NUMBER CALCULATIONS

	DES		CHK	
WCS Job No. 18059	DD	2/4/2019	SC	2/5/2019
File: R190204_CURVE NO				

CURVE NUMBER

Reference: 1. CISF Drainage Evaluation and Floodplain Analysis Fig. No. 2.2.1-1, Soils Boundary Map

2. Soil information taken from US Department Of Agriculture, Natural Resources Conservation Service Custom Soil Resource Report For Andrews County, Texas, And Lea County, New Mexico, dated December 22, 2015

3. Texas Engineering Technical Note, No. 210-18-TX5, *Estimating Runoff for Conservation Practices,* 1990

Drainage Area - Ditch B	A=	**62.2** Acres	**0.097** sq mi	ARC I Adjustment**	ARC III Adjustment**
Cover Type & Hydrologic Condition	Soil Type	Hyd. Soil Group	CN*	(60 Min.)	(60 Min.)
Desert Shrub Poor	JPC	B/A***	77	60	89

*Taken from Table 2c of Texas Engineering Technical Note, Hydrology, No. 210-18-TX5, Estimating Runoff for Conservation Practices

**Taken from Table 3 of Texas Engineering Technical Note, Hydrology, No. 210-18-TX5, Estimating Runoff for Conservation Practices

***USDA Soil Survey indicates 46% A and 50% B. CN is conservatively calculated to be 100% B

ADDENDUM A
WCS - CISF BERM BREACH
POST-DEVELOPMENT BERM BREACH OVERLAND DEPTH OF FLOW

	DES		CHK	
WCS	DD	1/16/2019	SC	2/5/2019

Reference:

1. Reference Drawing: S:\CAD\WCS\15052 CISF Floodplain\Engineering\15052 - P Hydraulic Calcs PMP.dwg

Dich B carries the largest flow.
Use the PMP peak flow in Ditch B to calculate the pad depth of flow.

Manning Equation

$$v = 1.49/n * R_h^{2/3} * s^{1/2}$$

Where,

v= velocity (ft/s)
n= Manning's n
R_h= hydraulic radius
s= slope (ft/ft)

Manning Equation for Sheet Flow

$$q = v*y = 1.49/n * y^{5/3} * s^{1/2}$$

Therefore

$$y = (q/(1.49/n * s^{1/2}))^{3/5}$$
$$v = q/y$$

Where,

q= unit discharge (ft^2/s)
v= velocity (ft/s)
n= Manning's n
y= depth
s= slope (ft/ft)

Max flow

$$q_{Max} = I*L$$

Where,

q_{Max}= maximum unit discharge (ft^2/s)
I= Rainfaill Intensity
L= Length of flow

Max depth at edge of pad

$$y_{max} = (q_{max}/(1.49/n * s^{1/2}))^{3/5}$$

Where,

y_{max}= Maximum depth of flow (ft)
q_{Max}= Maximum unit discharge
n= Manning's n
s= slope (ft/ft)

Max velocity

$v_{max}= q_{max}/y_{max}$

Where,

$q_{Max}=$ maximum unit discharge (ft^2/s)

$y_{max}=$ Maximum depth of flow (ft)

Inputs

$Q_{max} =$ 251 cfs From HEC-HMS Ditch B

Assumptions: Berm breach is large enough to release Ditch B PMP peak flow
The flow spreads out at approx. 1:2 on each side from center of berm breach,
Length of flow from berm breach to phase 8 pad = 470 ft., See Fig. A-1
Width of flow at phase 8 pad = 470 ft
The peak flow reaches a pad and flows onto a pad.

$q_{Max}=$ 0.534043 ft^2/s

$I= q_{max}/L$

s=	0.011	ft/ft	flow slope
L=	470	ft	length of flow from berm breach to phase 8 pad, see Fig. A-1
n=	0.025		Manning's n for gravel

Calculation

I= 0.001136 ft/sec

Max y=	**0.228549**	**ft**
	2.7	**in**
Max v=	**2.3**	**ft/s**

APPENDIX B
HEC-HMS OUTPUT

Project: 15052 - CISF Design Simulation Run: Collection Ditch B R

Start of Run:	01Jan2016, 00:00	Basin Model:	Collection Ditch B revised
End of Run:	02Jan2016, 12:00	Meteorologic Model:	100 yr
Compute Time:	04Feb2019, 16:25:04	Control Specifications:	Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Collection Ditch B R	0.097	59.7	01Jan2016, 12:34	1.92

Project: 15052 - CISF Design   Simulation Run: Collection Ditch B R 500 Yr

Start of Run:	01Jan2016, 00:00	Basin Model:	Collection Ditch B revised
End of Run:	02Jan2016, 12:00	Meteorologic Model:	500 yr
Compute Time:	04Feb2019, 16:26:45	Control Specifications:	Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Collection Ditch B R	0.097	128.5	01Jan2016, 12:33	3.87

Project: 15052 - CISF Design Simulation Run: Collection Ditch B R PMP

Start of Run: 01Jan2016, 00:00
End of Run: 05Jan2016, 00:00
Compute Time: 04Feb2019, 16:26:51

Basin Model: Collection Ditch B revised
Meteorologic Model: PMP Distribution A
Control Specifications: Control PMP

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Collection Ditch B R	0.097	250.6	03Jan2016, 06:01	33.47