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Texas General Land Office, Austin, Texas
U.S. Fish & Wildlife Service, Anahuac, Texas

McFaddin National Wildlife Refuge
Dune Restoration Project

Texas General Land Office
for
Internal Use Only

Conceptual Design Report

Coastal Tech

August 29, 2000

COASTAL TECH

COASTAL TECH
COASTAL TECHNOLOGY CORPORATION

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TRANSMITTAL LETTER

20240

August 29, 2000

To: Matthew Mahoney, Project Manager
Texas General Land Office
1700 North Congress Avenue
Austin, Texas 78701-1495

Via: FedEx Priority

Re: **McFaddin National Wildlife Refuge**

Transmitted:

Item	Description
1)	Six (6) copies of the report titled *"McFaddin National Wildlife Refuge Dune Restoration Project - Conceptual Design Report"*

Remarks:

As required by the Texas GLO Work Order No. 1003-00-001, enclosed are six copies of the *"Conceptual Design Report"* for McFaddin National Wildlife Refuge. If you have any questions, please do not hesitate to call me, or Peter Ravella in Austin at (512)236-9494.

Sincerely,
COASTAL TECH

Michael P. Walther, P.E.
Principal Engineer

cc: Peter Ravella - Coastal Tech
Larry Wise - Coastal Tech

Executive Summary

The McFaddin National Wildlife Refuge (NWR) is a unique coastal preserve covering more than 56,000 acres, including beach property fronting the Gulf of Mexico. The NWR is managed by the United States Fish and Wildlife Service (USFWS). For many years, the beach/dune system in the NWR has suffered from chronic and episodic erosion events, resulting in damage to the beach/dune system and associated natural resources. This document identifies recommended immediate measures for partial restoration of the beach/dune system.

In September 1998, Tropical Storm Frances impacted the north Texas coast causing extensive beach and dune erosion in the NWR. In its current condition, the dune/beach system provides only a modest level of protection from storm surge and wave attack for refuge lands and Texas State Highway 87. Since the storm, natural recovery of vegetation within the NWR has been sporadic and insubstantial, apparently due to vehicular traffic and beach cleaning activities within the foredune terrace area. In contrast, the beach/dune system within the adjoining Sea Rim State Park has recovered more extensively, where the wide foredune terrace has colonized with vegetation. Vehicular access and beach cleaning are conducted over a more limited area within Sea Rim State Park; this appears to account for the more extensive recovery.

To the extent possible, given available funds, the USFWS's general project goal is to restore the dune system within the refuge to pre-storm conditions and to promote natural recovery of the dunes lost during Tropical Storm Frances. In the Project Goal Summary, the USFWS identified dune restoration and re-vegetation of the dune and foredune areas as the preferred means of accomplishing the project goals. This report identifies and evaluates four alternative approaches to meet the project goal. For each alternative, Coastal Tech (1) assessed the expected project performance; (2) identified permitting requirements; (3) provided an opinion of probable costs; and (4) estimated the schedule for completion of design, permitting, and construction.

Coastal Tech recommends that the GLO and USFWS proceed with a project entailing:

(1) dune restoration with sand and vegetation,
(2) banded vegetation within the foredune terrace.

At an estimated cost of approximately $249,000, this is a cost-effective means to partially restore the beach/dune system to pre-storm conditions while providing a reasonable level of protection to upland improvements and habitat. The use of a banded dune planting in the foredune area will reduce the project cost per linear foot and allow the project length to be extended by natural vegetation recovery in protected areas. With proper monitoring, the project will allow NWR managers and biologists to gather qualitative and quantitative information on the rate of natural propagation of dune plants within protected areas within the NWR. Coastal Tech recommends that pre-project and post-project monitoring by aerial photography and beach profiles be performed to assess current conditions and project performance.

After selection of the preferred alternative by the USFWS and GLO. Coastal Tech is prepared to immediately proceed with final design plans and specifications, under a separate work order.

Table of Contents

List of Figures

List of Tables

Appendices

1.0 INTRODUCTION

The McFaddin National Wildlife Refuge (NWR) is located approximately 12 miles west of Sabine Pass along the Texas Gulf Coast in Jefferson County. Sea Rim State Park borders the refuge to the east and Texas State Highway 87 transects the refuge just north of the shoreline. At Sea Rim State Park, the foredune terrace is vegetated where beach cleaning and vehicular traffic are limited. The Gulf shoreline at the refuge is characterized by a wide, relatively unvegetated foredune terrace consisting of fine grained sand backed by a low dune system. The interior portions of the refuge consist of freshwater and tidal marshes.

Approximately two and one-half (2.5) miles of the Gulf shore on the eastern portion of the refuge has experienced recession of the existing dunes. According to Morton (1997), the chronic erosion rate for the Gulf shore within the refuge has been as high as 12.2 feet/year. Primary causes of the erosion are believed to include: a deficit of available sand both onshore and in the littoral zone, subsidence, and the effect of Hurricane Frances. Hurricane Frances (September 12, 1997) produced a storm surge of approximately 5.3 feet and eroded the primary dune by approximately 35 feet in the project area (PGS). Beach erosion along the shoreline west of the project site has resulted in the partial destruction of Texas State Highway 87.

Continued shoreline recession within the refuge will likely result in loss of important coastal natural resource areas, damage infrastructure, and reduce access and use of the beach. Even in its degraded and eroded condition, the dune/beach system within the refuge continues to serve important functions such as providing public recreation area, wildlife habitat, and protection for upland areas from storm surge and wave attack.

Comparison of beach conditions at the refuge with conditions at Sea Rim State Park indicate an opportunity for habitat restoration at the refuge. Consistent with its management philosophy and mission, the USFWS seeks to use natural means to restore and enhance the beach/dune system within the refuge.

1.1 Scope and Objective

As required by Work Order 1003-00-01, this report identifies and evaluates several alternatives to mitigate the erosion of the Gulf shoreline and restore dune habitat within the McFaddin NWR. The scope of alternatives chosen for evaluation has been determined by several parameters:

1. Location: The alternatives considered in the report begin at the eastern-most boundary of the refuge on the Gulf of Mexico shoreline and extend westward up to 7,100 feet, depending on the alternative restoration technique selected.
2. Law/Policy: Consistent with the GLO Beach and Dune rules (31 TAC Chapter15), this report does not include any alternatives for construction of structures on the shoreline or off-shore.
3. Materials: All alternatives contemplate use of beach quality sand and native vegetation for restoration and/or enhancement of the beach/dune system.

4. Budget: Project alternatives have been selected to provide the maximum level of restoration and enhancement of the beach/dune system within the expected budget of $267,500.
5. Permit Feasibility: Alternative approaches have been selected to minimize permitting requirements.

The objective of this report is to provide information and analysis sufficient for the USFWS and the GLO to evaluate and select the best alternative approach to mitigate erosion and restore the beach/dune system within the refuge. The project objective is to identify the most cost-effective means to optimally restore the beach/dune system to pre-storm conditions, protect upland wildlife habitat and infrastructure, maintain suitable public access and use of the beach, and, to the extent possible, reduce the scope and cost of future post-storm recovery efforts.

2.0 SITE CONDITIONS

2.1 General Description and Erosion History

The shoreline at the McFaddin NWR is characterized as having low primary dunes fronted by a wide foredune terrace. In contrast, chenier beaches to the east and west are relatively narrow and steep. The beach sands within the refuge are believed to be locally derived from underlying fluvial deposits (Morton, 1997). The shoreline at the adjacent Sea Rim State Park has been relatively stable and even slightly accretional over the period of 1974 to 1996, possibly due to the release of sediments when updrift groins (the Hatfield structures) were lowered (Morton, 1997). In contrast, the shoreline at McFaddin NWR has been eroding at a rate of up to 12.2 feet/year (Morton, 1997).

Shoreline erosion is typically characterized by strong, episodic erosion events. In late August and early September of 1998 the southeast Texas coast was impacted by three (3) tropical storms (NCDC, 2000). On August 21 minor coastal erosion was experienced in Jefferson County due to high tides and winds associated with Tropical Storm Charley. On September 1 minor flooding was caused by a 3.5 foot storm surge from Hurricane Earl. Finally, on September 9 Tropical Storm Frances hit the area. Wind gusts in excess of 50 miles per hour (mph) were reported along the coast on September 11. Extensive flooding and coastal erosion was caused by a storm surge of 5.3 feet. At Sea Rim State Park water reportedly reached to dune crests at an elevation of 8 to 9 feet above mean sea level. McFaddin NWR staff reported that the dunes in the refuge were eroded a lateral distance of approximately thirty five (35) feet. This dune erosion resulted in the formation of a broad foredune terrace as shown in Figure 1. (Note that the vegetated foredune terrace in the foreground is part of Sea Rim State Park, while the denuded foredune terrace is part of McFaddin NWR.)

Figure 1: Typical Present Dune/Foredune

As seen in the foreground of Figure 1, the seaward portion of the foredune terrace within Sea Rim State Park has been colonized by vegetation since the 1998 storms. Within the refuge (background of Figure 1), natural re-vegetation of the dunes and foredune terrace has been hindered for two reasons. First, vehicular traffic on the beach has been heavy along the foredune terrace seaward of the primary dunes preventing natural re-vegetation and formation of coppice mounds and foredunes. Second, Jefferson County periodically cleans the beach seaward of the primary dunes to remove debris, further detering re-vegetation or dune formation. In contrast, the beaches within Sea Rim State Park show clear evidence of natural dune recovery and re-vegetation. Without the disturbance of vehicular traffic and beach cleaning it is likely that vegetation and some dunes would have recovered on the foredune terrace within the refuge. This conclusion is supported by the natural re-vegetation of the foredune terrace that has occurred on the beaches immediately adjacent to the project site within Sea Rim State Park.

2.2 Surveys and Aerial Photography

In concert with this project, the US Army Corps of Engineers (USACE), Texas Department of Transportation (TXDOT), University of Texas Bureau of Economic Geology (BEG), Texas GLO, and Dr. Billy Edge of Texas A&M University College Station were contacted to obtain available survey data and aerial photography.

Aerial photographs were obtained from the BEG, TXDOT, and the GLO. The BEG and GLO aerial photographs were included in the Texas Natural Resource Information Network (TNRIS) digital orthographic quarter quadrangle (DOQQ) data set. These aerials have a resolution of 2.5 meter (per pixel) and are geo-referenced. The photographs were taken in 1995 (prior to Hurricane Frances). Figure 2 shows the project site located on the Southeast and Southwest Clam Lake DOQQ's.

Survey data for the proposed project site was obtained from Dr. Billy Edge, Texas A&M University. These surveys, conducted in conjunction with the Highway 87 realignment study for TXDOT, consisted of upland profiles approximately every 200 meters.

Figure 2 Project Site on SE and SW Clam Lake DOQQ's

In addition to the DOQQ's, aerial photographs were available from TXDOT for the project area. The TXDOT aerial photographs were taken in 1995 at a scale of approximately one inch to two hundred fifty feet (1"=250'). These photographs give a closer view of the project area and are contained in Appendix A. However, these photographs were also taken prior to Hurricane Frances. Post Tropical

Storm Frances aerial photographs of the project site were not available for preparation of this report and should be obtained and analyzed prior to final design.

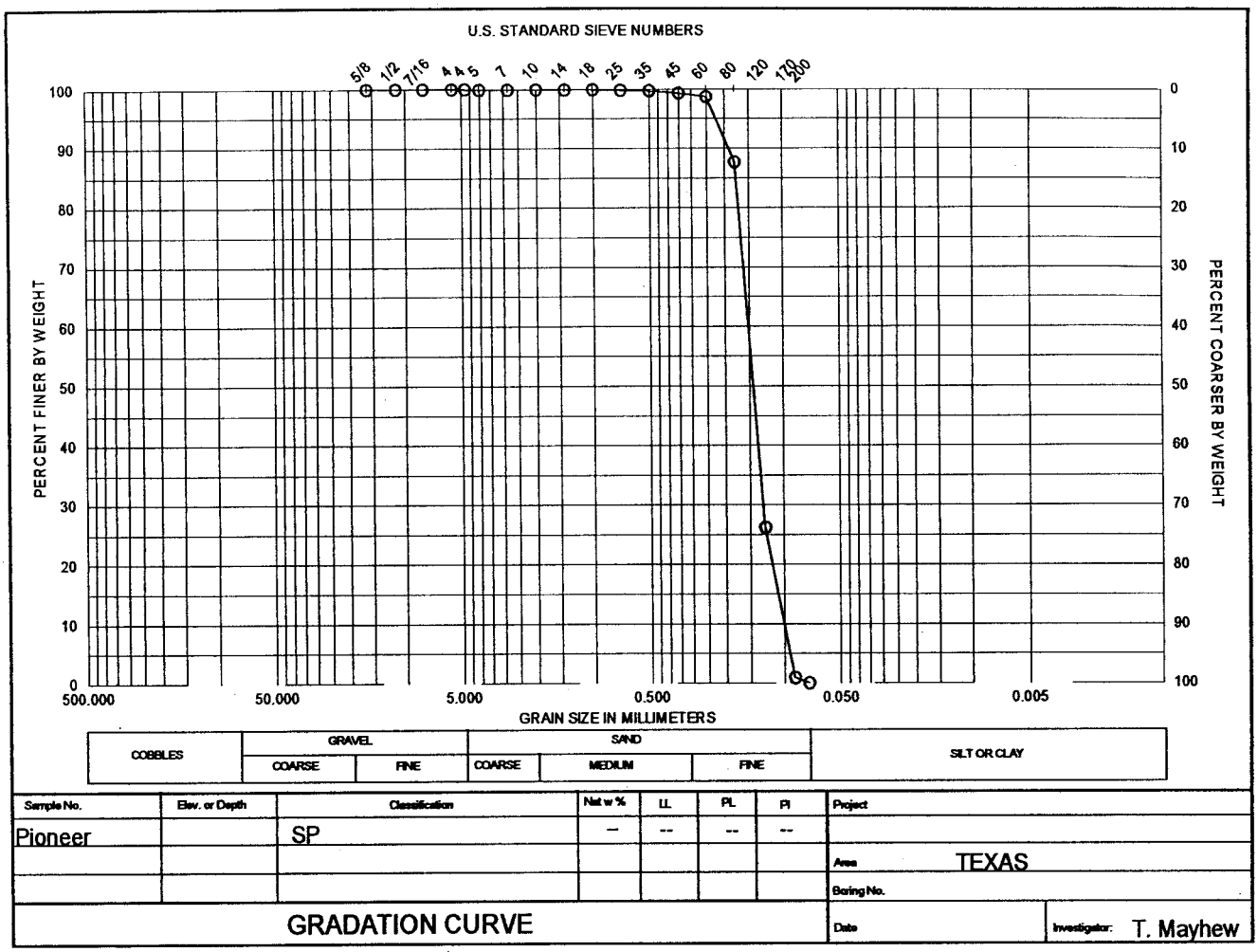
In 1999, BEG conducted LIDAR flights of the upper coast, including the project area. LIDAR provides high accuracy digital elevation data of shoreline and upland areas. LIDAR technology is also capable of determining bathymetric depths; however, this capability is highly sensitive to water turbidity and was not utilized for the BEG flights. The LIDAR flight data is currently being processed by BEG and is not expected to be available until late 2000.

2.3 Sediment Information

During the July 18, 2000 kick-off meeting at the site, Coastal Tech collected two (2) sediment samples from the seaward face of the primary dune and from the pioneer zone seaward of the dunes. The samples were analyzed and classified by Dr. Randall W. Parkinson, PH.D., P.G., coastal geologist, for grain size, color, and composition. The analysis found that the beach sediments are well-sorted, very fine quartz sand containing some organic content. The results of the analysis are contained in Table 1 and the sieve analysis curves are contained in Figures 3 and 4.

Table 1: Soil Sample Analysis Results

Sample	Seaward Face of Primary Dune	Pioneer Zone
Color	Beige	Beige
Sorting	Well Sorted (Poorly Graded)	Well Sorted (Poorly Graded)
Composition	Quartz sand Trace (<1%) organic matter and fines (<#200 sieve) 1-3% (by volume) thin, delicate, and angular fine-grained skeletal sand fragments	Quartz sand Trace (<1%) fines (<#200 sieve)
Size (General Description)	Very Fine Grained	Very Fine Grained
Unified Soil Classification System (USCS) Classification	SP	SP



G.E.O. Consulting, Inc.

Figure 3: Sieve Analysis Results for Primary Dune Sample

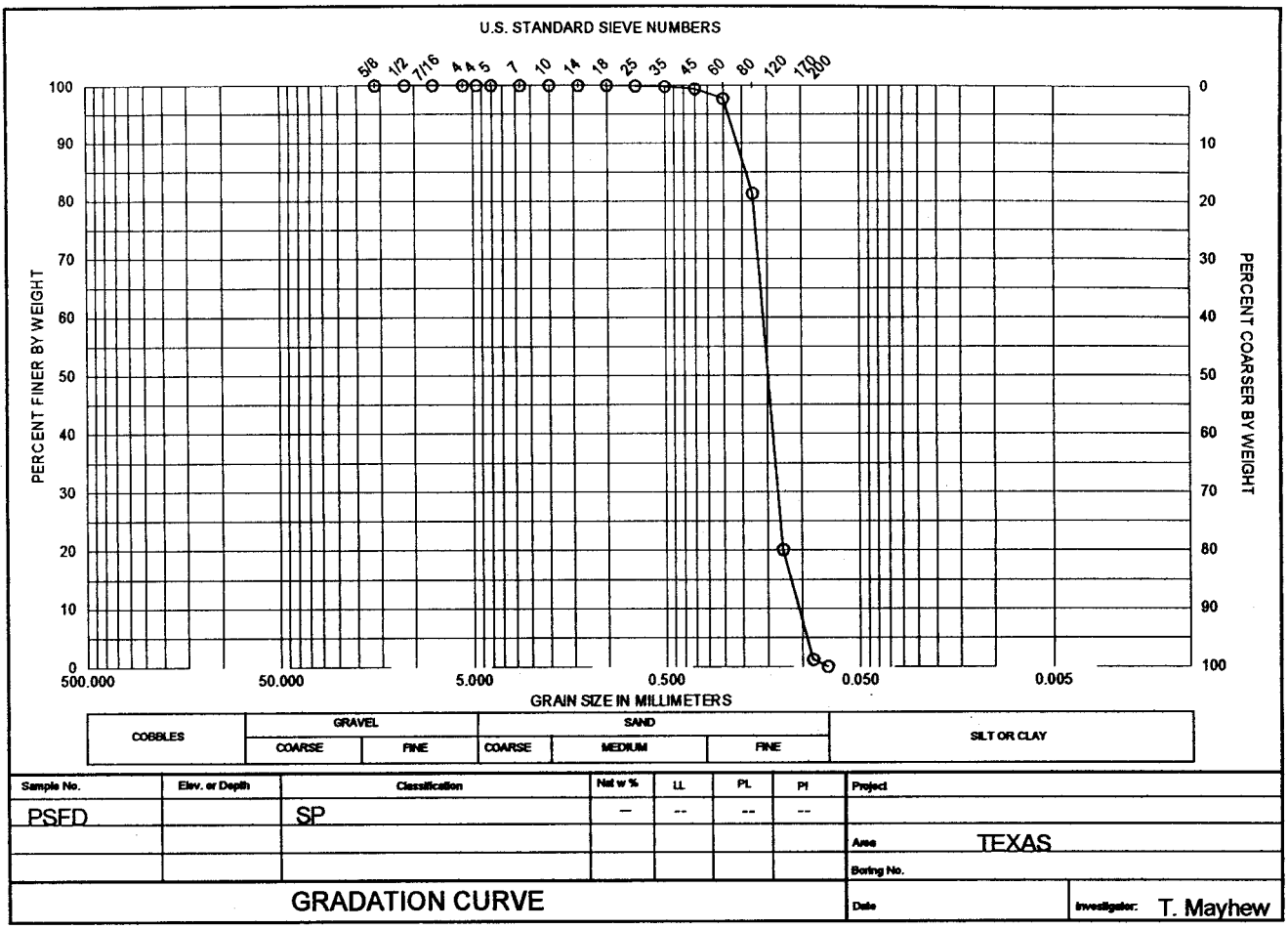


Figure 4: Sieve Analysis Results for Pioneer Zone Sample

2.4 Environmental Conditions

The southeast Texas coast is generally considered to be a low wave energy environment. Appendix B contains a summary of wave and wind information hindcast by the USACE for Wave Information Study (WIS) Gulf Station 79 (in a water depth of 6 m or 20 ft) from 1976 to 1995. According to the WIS study, the average significant wave height was 0.8 m (2.6 ft) with more than two-thirds of all waves being under 1 m (3.3 ft). Smaller wave heights dominate during the summer and fall months with somewhat larger waves in the winter months; however, the largest waves, associated with tropical storms, occurred during the late summer and early fall months. The largest hindcast wave height during the study period was 5.7 m (19 ft). On average, slightly larger waves occur during the winter and spring months. The mean wave period was reported as 5 seconds. Short wave periods predominate the summer months, but the longest wave periods were associated with tropical storms in summer and fall months. The predominant wave direction at is from the southeast and south-southeast, particularly during spring and summer. During the late fall through early spring waves from the east become more prevalent.

Wind hindcasts for WIS Gulf Station 79 are also contained in Appendix B. Most wind velocities for the station occurred within the band of 2.5 to 7.5 meters per second (m/s) (5.6 to 16.8 miles per hour (mph)). Slightly higher wind speeds predominate during in the winter and spring with lighter winds being common during the summer. However, the highest wind speeds occurred during late summer and early fall, associated with tropical storms. The highest hindcast wind speed was 29 m/s (65 mph). The dominant wind direction is southeast to south, particularly in the summer and fall, with more northerly and northeasterly winds occurring during the winter and spring.

The elevation of water levels associated with storms, particularly tropical storms, is referred to as storm surge. Storm surge is an important factor controlling the morphology of the southeast Texas coastline. Washover terraces are formed relatively frequently where the storm surge exceeds the dune height. Upland damage associated with tropical storms is generally less extensive where the backing dune crest exceeds the storm surge elevation. However, dunes are typically eroded during periods of elevated water levels, reducing the dune's capacity resist wave attack. Hurricane storm surges experienced at Sabine Pass since 1886 are found in Table 2 (Tuttle, 2000).

Table 2: Hurricane Storm Surge Levels at Sabine Pass since 1883

Date	Name	Surge (ft)
8/12/1886	Not Named	1.3
8/27/00	Not Named	7.5
7/13/09	Not Named	3.3
8/5/15	Not Named	11.8
8/1/18	Not Named	4.6
6/27/29	Not Named	1.3
7/25/33	Not Named	1.6
8/2/40	Not Named	4.9
9/16/41	Not Named	7.5

Date	Name	Surge (ft)
8/24/45	Not Named	3.6
6/27/57	Audrey	8.5
7/25/59	Debra	3.3
9/11/61	Carla	7.2
8/3/70	Celia	2.6
9/16/71	Edith	3.0
9/9/71	Fern	1.6
9/4/73	Delia	5.9
9/8/74	Carmen	2.0
9/11/82	Chris	5.6
8/18/83	Alicia	7.9
8/15/85	Danny	1.0
6/26/86	Bonnie	4.3
8/1/89	Chantal	5.2
10/15/89	Jerry	4.3

3.0 DEVELOPMENT OF DESIGN CONSIDERATIONS

Proper design of shore protection or restoration projects invariably requires an evaluation and understanding of the physical site conditions, the use and value of the upland areas to be protected, and specific design goals and considerations that define success for the project. Generally, the level of protection or restoration warranted is a function of the value of the upland areas examined in light of environmental, regulatory or budgetary constraints that may exist.
In this case, the specific design goal is to restore the dune system within the refuge to pre-storm conditions and to promote natural recovery of the dunes and dune vegetation communities lost during Tropical Storm Frances, to the extent possible given available funds. Restoration and enhancement of the dune system with beach-quality sand and natural vegetation is expected to yield several benefits:

- partial restoration of dune system and habitat to pre-storm conditions
- reduce the threat of erosion to refuge property and access road

In addition to the design goal, other important secondary considerations have been identified that must be considered in the selection of the final project design approach. These considerations require that the final design alternative:

- be readily permittable and implementable
- utilize compatible beach-quality sand and native plants for restoration efforts
- include management of vehicle traffic to protect the project from damage
- include a program to monitor the effectiveness of the overall dune restoration efforts and specific dune restoration methodologies; and
- incorporate public education signage to increase public understanding and appreciation of the functions and values of dunes.

All alternatives identified in this report have been developed in light of the design goal and secondary considerations set forth above.

3.1 Applicable Regulations and Considerations

Projects to restore and enhance the beach/dune system are subject to regulation by multiple agencies and under several separate programs. In this case, some regulatory considerations are applicable because the project is within the National Wildlife Refuge and the project sponsor is a federal agency. As required by the Work Order, this section identifies the expected permitting requirements for the conceptual project designs set forth below.

Depending on the alternative design selected by the USFWS and the GLO, compliance with some or all of the following regulatory programs and requirements will be required:

3.1.1 Applicable Local Regulations

No local permitting requirements are known to apply to the proposed project alternatives

3.1.2 Applicable State Regulations

a. **Open Beaches Act**. The final design should be reviewed to ensure compliance with the Open Beaches Act (OBA), Sections 61.001-61.025 of the Texas Natural Resources Code. Passed by the Texas Legislature in 1959, the OBA guarantees the public's right of free and unrestricted access to the "public beach," which extends from the line of mean low tide to the line of permanent vegetation on the shoreline bordering the Gulf of Mexico. The act makes it unlawful to prevent or impede access to or use of the public beach by erecting barriers or by posting signs declaring a beach closed to the public.

As a federal project within the refuge, a local Beach/Dune permit will not be required for this project, however, the project will be required to comply with the substantive standards in the Open Beaches Act and the GLO Beach and Dune rules (31 TAC § 15.01 et seq.) governing dune restoration projects. In general, regulation under the Open Beaches Act will mandate that the project be constructed in a manner that does not diminish or interfere with public use and access to the beach.

b. **Dune Protection Act.** The final design should be reviewed to ensure compliance with the Dune Protection Act which prescribes standards for local regulation. While a local dune protection permit will not be required (because the project is on federal lands), restoration of the dunes in the McFaddin NWR must nonetheless be undertaken in accordance with the Dune Protection Act (Sections 63.001-63.181 of the Texas Natural Resources Code), as amended by the Texas Legislature in 1991. The Act requires the counties bordering the Gulf of Mexico to establish a dune protection line (DPL) on the gulf shoreline. This applies to mainland shoreline fronting the open gulf as well as to the gulf shoreline of islands and peninsulas. The DPL may lie up to 1,000 feet landward of the mean high tide line. A permit from the county or municipality with jurisdiction is generally required for any activity seaward of the DPL. However, because this is a federal project undertaken within the refuge, a local Beach Dune permit will not be required. Nonetheless, the standards in the Dune Protection Act and GLO's Beach/Dune rules will apply and compliance will be required.

In general, the Dune Protection Act establishes the proper materials and methods that can be employed to restore dunes within the refuge. These requirements are expressed in the GLO Beach/Dune rules and are set forth below.

c. **GLO Beach and Dune Rules, 31 TAC Chapter 15.** The final design should be reviewed to ensure compliance with regulations governing restoration of dunes and dune vegetation on the public beach found in the GLO Beach/Dune rules, 31 TAC Chapter 15. As applied to dune restoration projects, the rules are intended to ensure compliance with both the Open Beaches Act and the Dune Protection Act. While an extensive analysis of the GLO Beach/dune rules will be undertaken in the final design report, the following excerpts from the rules provide guidance on the regulatory compliance requirements that will be encountered in restoration of dunes and dune vegetation in the McFaddin NWR.

> 15.4. DUNE PROTECTION STANDARDS
>
> §15.4(f)(3)(A) Mitigation Standards for Dunes. Local governments may allow a permittee to mitigate adverse effects on dunes using vegetative or mechanical means. Local governments shall require that a permittee proposing to restore dunes use the following techniques:
>
> > (i) restore dunes to approximate the naturally formed dune position or location, contour, volume, elevation, vegetative cover, and sediment content in the area;
> >
> > (ii) allow for the natural dynamics and migration of dunes;
> >
> > (iii) use discontinuous or continuous temporary sand fences or an approved method of dune restoration, where appropriate, considering the characteristics of the site; and
> >
> > (iv) restore or repair dunes using indigenous vegetation that will achieve the same protective capability or greater capability as the surrounding natural dunes.
>
> 15.7. LOCAL GOVERNMENT MANAGEMENT OF THE PUBLIC BEACH.
>
> §15.7(e) Restored Dunes on Public Beaches. Sand dunes, either naturally created or restored, may aid in the preservation of the common law public beach rights by slowing beach erosion processes. Except as otherwise provided, local governments shall allow restoration of dunes on the public beach only under the following conditions. Restored dunes may be located farther seaward than the 20-foot restoration area only upon an affirmative demonstration by the permit applicant that substantial dunes would likely form farther seaward naturally. Such seaward extension past the 20-foot area must first receive prior written approval of the General Land Office and the attorney general's office. In the absence of such an affirmative demonstration by the applicant, a local government shall require the applicant to meet the following standards relating to the location of restored dunes.

(1) Local governments shall require persons to locate restored dunes in the area extending no more than 20 feet seaward of the landward boundary of the public beach. Local governments shall ensure that the 20-foot restoration area follows the natural migration of the vegetation line.

(2) Local governments shall not allow any person to restore dunes, even within the 20-foot corridor, if such dunes would restrict or interfere with the public use of the beach at normal high tide.

(3) Local governments shall require persons to restore dunes to be continuous with any surrounding naturally formed dunes and shall approximate the natural position, contour, volume, elevation, vegetative cover, and sediment content of any naturally formed dunes in the proposed dune restoration area.

(4) Local governments shall require persons restoring dunes to use indigenous vegetation that will achieve the same protective capability as the surrounding natural dunes.

(5) Local governments shall not allow any person to restore dunes using any of the following methods or materials:

(A) hard or engineered structures;

(B) materials such as bulkheads, riprap, concrete, or asphalt rubble, building construction materials, and any nonbiodegradable items;

(C) fine, clayey, or silty sediments;

(D) sediments containing the toxic materials listed in Volume 40 of the Code of Federal Regulations, Part 302.4 in concentrations which are harmful to people, flora, and fauna as determined by applicable, relevant, and appropriate requirements for toxicity standards established by the local, state, and federal governments; and

(E) sand obtained by scraping or grading dunes or the beach.

(6) Local governments may allow persons to use the following dune restoration methods or materials:

(A) piles of sand having similar grain size and mineralogy as the surrounding beach;

(B) temporary sand fences conforming to General Land Office guidelines;

(C) organic brushy materials such as used Christmas trees; and

(D) sand obtained by scraping accreting beaches only if the scraping is approved by the local government and the project is monitored to determine any changes that may increase erosion of the public beach.

The GLO Beach and Dune Rules also include a special provision that allows for demonstration of innovative approaches and scientific research in association with beach and dune restoration projects. This provision -- Section 15.7(f) – may be relevant and important to the extent that the USFWS and GLO elect to consider the use of Eco-Dune technology described later in this report. Section 15.7(f), Scientific Research Projects, provides as follows:

> Local governments may exempt a scientific research project from the requirements of 15.4(c) or 15.7(e) provided the research is conducted by an academic institution or state, federal, or local government. Prior to conducting the research, the project manager shall submit a detailed work plan and monitoring plan for approval by the General Land Office and the Office of the Attorney General. The research activities shall not materially weaken existing dunes or dune vegetation, or increase erosion of adjacent properties

d. **CEPRA State Boundary Survey.** The final design should be reviewed to ensure compliance with regulations governing boundary surveys for erosion response projects. The Coastal Erosion Planning and Response Act requires that prior to state funding for any erosion response project that may alter the shoreline, a boundary survey must be conducted and approved by the General Land Office. The CEPRA boundary requirement is further discussed in 31 TAC §15.23 addresses the coastal boundary survey requirement from the CEPRA. No boundary survey was required or conducted in conjunction with this conceptual design report. Upon selection of the alternative best suited for the McFaddin NWR and if directed by the GLO, Coastal Tech is prepared to conduct and file a coastal boundary survey, as required by law.

Section 33.136(a)-(e), Texas Natural Resources Code, addresses this requirement as follows:

i. Notwithstanding any law to the contrary, a person may not undertake an action on or immediately landward of a public beach or submerged land, including state mineral lands, relating to erosion response that will cause or contribute to shoreline alteration before

the person has conducted and filed a coastal boundary survey in the same manner as the survey of public land required by Chapter 21 and any applicable rule of the commissioner and has obtained any required lease or other instrument from the commissioner or board, as applicable. A person is not required to obtain a lease or other instrument from the commissioner or board if the action is confined to land owned by a navigation district or municipality. On filing of the survey, the shoreline depicted on the survey is a fixed line for the purpose of locating a shoreline boundary, subject to movement landward of that line. A coastal boundary survey conducted under this section may not be filed until the commissioner gives notice of approval under Subsection (c).

ii. The survey must contain the following statement: "NOTICE: This survey was performed in accordance with Section 33.136, Natural Resources Code, for the purpose of evidencing the location of the shoreline in the area depicted in this survey as that shoreline existed before commencement of erosion response activity, as required by Chapter 33, Natural Resources Code. The line depicted on this survey fixes the shoreline for the purpose of locating a shoreline boundary, subject to movement landward as provided by Section 33.136, Natural Resources Code."

iii. Within 30 days after the date the commissioner approves a coastal boundary survey under this section, the commissioner shall provide notice of that approval by:

(1) publication in the Texas Register;

(2) publication for two consecutive weeks in a newspaper of general circulation in the county or counties in which the land depicted in the survey is located; and

(3) filing a copy of the approval in the archives and records division of the land office.

e. **CMP Consistency Review**. The final design should be reviewed to ensure compliance with regulations governing consistency of actions and activities under the Texas Coastal Management Program. In 1989, the Texas Legislature designated the Texas General Land Office as the lead agency for development of a comprehensive, long-term management plan for state-owned coastal public lands. Erosion control and beach management projects were included in the Texas Coastal Management Plan and incorporated into coastal management legislation passed by the 72nd Texas Legislature in 1991.

Section 33.205(b) of the Coastal Coordination Act requires that agencies and subdivisions proposing an action subject to the program affirm that

the action is consistent with the goals and policies of the TCMP. This determination must be in writing in the order, permit, or other document approving or authorizing the action. Therefore, rules, orders, permits, or authorizations must contain the conditions, restrictions or limitations necessary to justify the determination of consistency.

There is only one exception to the requirement that an action be consistent with the goals and policies of the TCMP. Under 31 TAC 501.30, consistency is not required if an agency determines that adverse effects from an action will be neither direct nor significant. A finding of no direct and significant adverse effect is a form of the consistency determination under 33.205(b) of the Act and is therefore subject to administrative and judicial challenges in the same manner as an agency consistency determination.

The Coastal Zone Management Act requires federal agencies to act consistently with federally approved state coastal management programs. Federal consistency review is the process by which the state can review an action undertaken, licensed, permitted, or funded by a federal agency to ensure the consistency of the action with the enforceable policies of its program. If the state finds a given action to be inconsistent with the enforceable policies, with few exceptions, the action cannot be undertaken.

In addition to requiring all Texas coastal cities and counties to establish dune protection lines on the gulf beach, amendments to the Texas Natural Resources Code require each coastal local government to adopt a plan for preserving and enhancing access to and use of public beaches within its jurisdiction. The Texas Coastal Management Plan recommend beach traffic lanes, off-beach parking, and dune walkovers as ways to minimize vehicle and pedestrian impact on dunes and to promote dune re-vegetation and restoration.

Specific governmental actions and rules subject to the Coastal Management Program are found in Title 31 Texas Administrative Code, Chapter 505. Section 505.11 of that chapter includes an exclusive list of state agency actions and rules that are subject to the program. If construction of an erosion response project entails a state agency action included in Section 505.11 or local government action included in Section 505.60, that action must be consistent with the Coastal Management Program. Federal actions subject to the Coastal Management Program are found in Title 31 Texas Administrative Code, Chapter 506.

f. Historical and Archeological Site Survey. The final design should be reviewed to ensure compliance with regulations governing activities that may impact historical or archeological sites. The enabling legislation of the Texas

Historical Commission directs the agency to protect and preserve the cultural resources of Texas. Cultural resources include archaeological sites, historical sites, and shipwrecks on land or underwater. For projects strictly on private property, the agency offers historic preservation advice. If the project requires a federal permit or involves federal funding, regardless of the land ownership, THC applies federal guidelines and rules under 106 of the National Historic Preservation Act (16 U.S.C.A. 470 et seq.). A permit is required for the taking, altering, or destruction of cultural resources on public land.

If historical or archeological resources exist in the project area, a permit will be required for the taking, altering, damaging, destroying, salvaging, or excavating of state archeological landmarks. Permits are also required for site-assessment-related activities, such as surveys, testing, excavation, and preservation activities and for specially designated archeological landmarks and Native American sites. (THC - Permit for Destruction, Alteration, or Taking of a Coastal Historic Area, TEX. NAT. RES. CODE ANN. 33.2053(E)(1) and 13 TAC 41.20 and 41.2).

The Texas Historical Commission also has the authority and responsibility to review federal activities affecting coastal historical areas. (THC - Review of a Federal Undertaking Affecting a Coastal Historic Area (TEX. NAT. RES. CODE ANN. 33.2053(E)(2)). Federal undertakings affecting property listed in the National Register or affecting property eligible for inclusion in the National Register. Such properties are nationally significant for their illustration or commemoration of the history or prehistory of the United States (36 CFR Part 800 and 36 CFR Part 60).

g. **TNRCC §401 certification.** The final design should be reviewed to ensure compliance with regulations governing dredge and fill activities. (TNRCC - Certification of a Federal Permit for the Discharge of Dredge or Fill Material, (TEX. NAT. RES. CODE ANN. 33.2053(f)(6)). The chief state authority for regulation of coastal wetlands is water-quality certification under 401 of the Clean Water Act (CWA). This process essentially allows the state to determine whether federal permits for discharges into the surface waters of the state will be granted, denied, or conditionally granted. Section 401 certification authority covers all Corps permits under 404 of the CWA, permits or licenses issued by the Federal Energy Regulatory Commission, and NPDES permits under 402 of the CWA. Section 401 certifications are also required for activities requiring Corps 9 and 10 of the Rivers and Harbors Act if the activity may lead to a discharge.

To the extent that an individual 404 permit is required for the project alternative selected by the USFWS and GLO, a state §401 Certification would also be required. However, Coastal tech has determined, after consultation with the Galveston District-Corps of Engineers and a review of applicable law and regulations, that a 404 permit will not be required for any of the alternatives proposed for consideration in this report. This matter is discussed further below.

h. **Sand Mining & Regulation of Borrow Sites**. The final design should be reviewed to ensure compliance with regulations governing sand mining at the borrow site. Sections 61.211 through 61.227 of the Texas Natural Resources Code regulate the removal of sand, marl, gravel, and shell from islands, peninsulas, and land within 1500 feet of mainland public beaches outside corporate limits. A permit must be obtained from the relevant county commissioners' court for the excavation of any of these materials unless the material is to be moved by a landowner, or with a landowner's consent, from one location to another on the same piece of property. No permit is required if the removal is officially undertaken by a federal, state, or local governmental entity. An incorporated city, town, or village may not authorize the removal of sand, marl, gravel, or shell from a public beach within its boundaries for any purpose other than the construction of a public recreational facility or a shoreline protection structure.

The Texas Parks and Wildlife Department, under Sections 86.001 through 86.019 of the Parks and Wildlife Code regulates the disturbance and removal of marl, sand, gravel, shell, or mudshell located within tidewater areas for any purpose other than that necessary or incidental to navigation or dredging under state or federal authority.

3.1.3 Applicable Federal Regulations

a. **NEPA**. The final design should be reviewed to ensure compliance with the National Environmental Policy Act and its implementing regulations. To the extent that the USFWS determines that the McFaddin Dune Restoration Project constitutes a "major federal action significantly affecting the human environment," review of the project under NEPA will be required. USFWS staff have indicated that they are currently reviewing how the project will be addressed under NEPA and are committed to taking all actions necessary to comply with NEPA, including possibly preparing an Environmental Assessment (EA) for the project.

b. **Section 404 Dredge and Fill Permit**. The final design should be reviewed to ensure compliance with regulations governing dredge and fill activities. In 1989, the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, and the U.S. Department of Agriculture, Soil Conservation Service, issued the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands*. Federal permits must be obtained from the Corps of Engineers for activities in these areas. Jurisdictional wetlands are identified on the basis of plant type, soils, and local hydrology.

Section 404 dredge and fill permits are required for the discharge of dredged or fill material into waters of the United States, including jurisdictional wetlands. In most cases, activities in coastal sand dunes will not affect jurisdictional wetlands and no federal permit will be required; however, seasonally wet swales between dunes can be considered wetlands. In this case, all fill material proposed for placement is on the seaward face of the existing primary dune system and are unlikely to impact dune swale wetlands. Based on a preliminary inspection of the project site, no jurisdictional wetlands appear to be impacted under any of the alternatives proposed in this report. A separate determination of the potential application of Section 404 to the borrow area for the project must also be made.

The Corps also asserts 404 regulatory jurisdiction up to the "High Tide Line" on the beach. This line is described as the highest non-storm tide line extending landward on the beach and is typically referred to as the Spring tide. Coastal Tech has reviewed tide gauge data for the upper Texas coast for the period of January to June 2000. This review revealed that the highest recorded tide in the project area is approximately 2.5 feet NGVD. As reflected in the Profile View for each alternative, the lowest elevation impacted for all proposed alternatives proposed in this report is approximately 3.3 feet NGVD.

Therefore, because no proposed alternative is expected to impact jurisdictional wetlands and all alternatives are at an elevation greater than the "High Tide Line," Coastal Tech has determined that no 404 permit is likely to be required for any of the alternatives proposed of consideration in this report. Coastal Tech recommends that prior to completing the final design that confirmation of this determination be obtained from the Galveston District-Army Corps of Engineers, particularly with respect to the potential borrow area for the project.

c. **Review of a Federal "Undertaking" - Affecting a Coastal Historic Area.** The final design should be reviewed to ensure compliance with the National Historic Preservation Act (NHPA). The NHPA calls for federal agencies to take historic properties into account in their undertakings, and allows state consultation (through the THC) and public involvement in historic preservation matters. The term "undertaking" takes on a specific and important meaning in the NHPA, and applies only to federal agencies.

"Undertaking" means any project, activity, or program that can result in changes in the character or use of historic properties. The project, activity, or program must be under the direct or indirect jurisdiction of a federal agency or licensed or assisted by a federal agency. Undertakings include new and continuing projects, activities, or programs and any of their elements not previously considered under 106 of the NHPA (36 CFR, Part 800).

The restoration of dunes and dune vegetation in the McFaddin NWR is clearly a direct federal activity or project and thus considered an undertaking that would

change the historic use of the beach foredune terrace. In addition to compliance with the NHPA, the McFaddin NWR will be required to consult with the State Historic Preservation Officer (SHPO) to the extent that historic or cultural sites exist in the project area.

3.2 Dune Restoration Sand Supply

Implementation of any dune restoration option will require a source of sand that is compatible in grain size, color, and composition with the existing native sand in the project area. The characteristics of the native sand are summarized in Table 1 and Figures 3 and 4. In general, sand beach and dune restoration projects can be obtained from either terrestrial or subaqueous (wetland or off-shore) sources.

One subaqueous sand source is dredge material from adjacent waterways. The USACE is expected to perform maintenance dredging of the Sabine-Neches waterway during the Fall of 2000 and a beneficial use of dredged material is expected to occur. However, the material is expected to be placed on the critically eroding section of Texas Point approximately ten (10) miles east of the McFaddin NWR. No other subaqueous sand sources are known to exist that would not require an USACE "dredge and fill" permit.

Sand from a terrestrial source can be delivered to the project site via truck. Coastal Tech has contacted several sand suppliers in the southeast Texas region to determine the availability, quality, and cost of beach compatible sand. Sand sources which were derived from a littoral environment generally provide material which is most compatible with the native sand. The cost of sand depends in large part on the distance from the sand source to the project site. Table 3 summarizes the quality and cost of sand from the most reasonable sand sources which Coastal Tech has identified. The cost in Table 3 does not include placement of the sand. Once placed on-site, standard earth working equipment can be used to work the sand material into the construction template. A foredune slope of between one to one (45 degrees) and one on three (18.5 degrees) is recommended for the construction template. For the engineer's opinion of probable costs, Coastal Tech has used a cost of $15/c.y. for sand placed according to the design template. This cost is consistent with costs Coastal Tech has seen on similar jobs which have been constructed where delivery trucks have not been able to operate on the beach. If delivery trucks can operate on the beach without difficulty, Coastal Tech believes that the placement cost may be lowered to $12/c.y.

Table 3: Potential Terrestrial Sand Sources

Sand Supplier	Source Location	Source Quality	Cost
Bailey's Construction	Johnson Bayou, LA (drive time= approx. 1 hour)	Undetermined	Approx. $10/c.y.
White Hole, Inc.	Crystal Beach (drive time approx. = 1.5 hours)	<4% fines	Approx. $10/c.y.
Kerr Materials	Nederland (drive time= approx. 20 minutes)	<10% fines	Approx. $6.50/c.y.
Davis's Sand	Vidor (drive time = approx. 45 minutes)	Undetermined	Approx. $6.50/c.y.
Trinity Aggregate	Port Arthur (drive time = approx. 30 minutes)	<1% fines	Approx. $7/c.y.
Barry Industrial Sand	Vidor (drive time = approx. 45 minutes)	Undetermined	Approx. $15/c.y.

In concert with preliminary design, Coastal Tech will assess potential sand sources and develop pre-qualification criteria for grain size distribution, color, and composition. The grain size distribution will be analyzed based on a sieve analysis and the color will be evaluated using the Munsell color system.

ECO-DUNE. The Eco-Dune product, produced by Novus Wood Group of Houston, Texas has been identified by GLO staff as a potential method of increasing the effectiveness of the dune restoration project. The Eco-Dune product is a wood chip and fiber material that can be placed in wind rows along the beach to induce and augment dune formation by aeolian transport. The product could alternatively be mixed with the dune Restoration sand to augment the volume of the fill material. The product increases the organic material content in the dunes formed, and is believed to increase the water retention capacity of the dune, thus promoting reestablishment of dune vegetation. In April 2000, Novus Wood Group, in cooperation with the Texas Department of Parks and Wildlife, installed an Eco-Dune project in Galveston Island State Park. Dr. Jim Webb of Texas A&M University at Galveston is currently monitoring the project. A final report on the effectiveness of this dune restoration method is not currently available.

Coastal Tech is continuing to explore the suitability and potential use of Eco-Dune as a means of augmenting the dune restoration project in the NWR. Based on preliminary discussions with USFWS, it appears incorporating Eco-Dune into the project as a limited experiment or demonstration element may be acceptable.

It should be emphasized that the use of Eco-Dune materials in the restoration project will require an affirmative determination by GLO staff that the material complies with the GLO Beach and Dune Rules governing dune restoration projects. No such determination of compliance has been made at

this time.

Coastal Tech has initiated discussions with Novus Wood Group to determine: (1) the availability of Eco-Dune materials in the project area; (2) the cost of incorporating Eco-Dune materials into a portion of the project; (3) the specific composition of the available wood fiber, if any; (4) the specifications for the material and its installation; and (4) whether Novus is willing to offer the product at a reduced or no cost as a demonstration of the method. Coastal Tech will forward to the GLO additional information about Eco-Dune as soon as it is available. If the USFWS and GLO are interested, specific guidance on means and methods to use Eco-Dune will be covered in the preliminary design report.

3.3 Dune Re-vegetation

Re-vegetation is an integral part of a dune restoration project. Dune plants hold existing sediment in place through their root system and also help trap windblown sand to aid in the natural formation of sand dunes. It is appropriate, particularly in the case of a wildlife refuge, to use native species for the re-vegetation. The species used for re-vegetation, especially those on the used seaward of the dune crest, must be salt resistant and able to survive burial by shifting sands. Three types of grasses have been identified as appropriate for re-vegetation projects along the Texas coast (GLO, 1997): bitter panicum (Panicum amarum), sea oats (Uniola paniculata), and marshhay cordgrass (Spartina patens). All of these species are either commercially available or have previously be cultivated specifically for re-vegetation projects in Texas. Of these, marshhay cordgrass is susceptible to burial by shifting sands and is, therefore, not well suited to use seaward of the dune crest. Other plants which are native to Southeast Texas dunes include beach morning glory and seagrape vines; however, these species are not currently commercially available.

The optimum time for dune re-vegetation in Southeast Texas is between February and April. During this time period there is generally enough rainfall to increase the chance of survival of the plants. Survival rates are also increased if the planting area is watered prior to planting. Dune re-vegetation is typically done by hand, but large, relatively level planting areas may make mechanical planting devices economically feasible. Fertilization during the first year also increases the survival rates, with three or four applications of 12-6-6 fertilizer, 90 to 100 pounds per acre, recommended.
Bitter Panicum (Figure 5) has been used most successfully in Texas due to its high salt tolerance and rapid growth rate. The plant propagates from tillers, shoots that grow from nodes on the roots. A plant spacing of two (2) feet on center is recommended for Bitter Panicum with closer spacing on slopes. Bitter Panicum can become well established in one year. Sea oats (Figure 6) have also been successfully used in Texas. They are less salt resistant, but have a rapid growth rate. A plant spacing of eighteen (18) inches on center is recommended for sea oats, and the plants can become well established within two years. If mixed plantings are conducted, a ratio of one to one is recommended. Coastal Tech has identified Dr. Jim Webb of Texas A&M Galveston as a potential source for native dune plants and is actively searching for other sources in the area. Table 4 contains the approximate unit costs of bitter panicum, sea oats, and mixed plant re-vegetations.

Figure 5: Bitter Panicum (GLO, 1997)

Figure 6: Sea Oats (GLO, 1997)

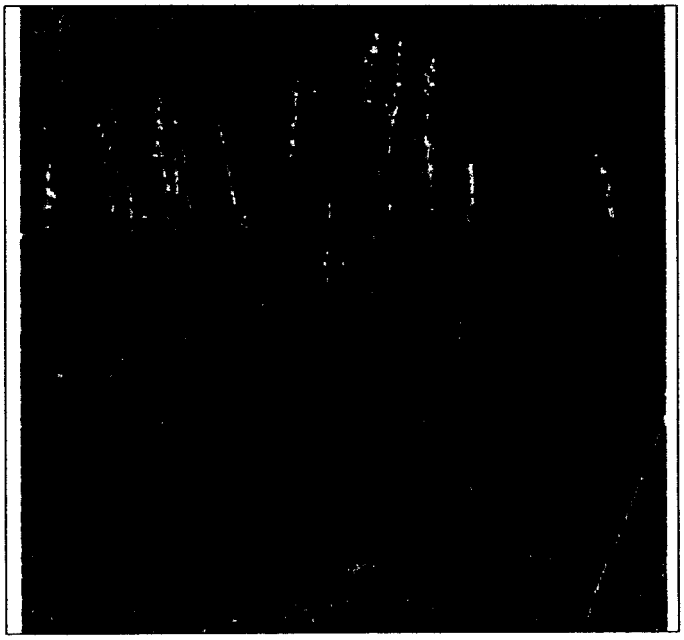


Table 4: Approximate Re-vegetation Unit Costs

Re-vegetation Scheme	**Approximate Installed Cost Per Plant**	**Approximate Installed Cost Per Acre**
Bitter Panicum	$1.50	$16,350
Sea Oats	$1.50	$16,350
Mixed Planting	$1.50	$16,350

3.4 Sand Fencing and Public Awareness Signs

Sand fencing is often used to protect replenished dunes from foot and vehicular traffic and help the dunes rebuild by natural aeolian sand transport. A typical height of four (4) feet is used with wooden or metal posts at a ten (10) foot spacing. A lower fence height may improve natural dune building in sand starved areas (GLO, 1997). Elevating the bottom of the sand fence four (4) to six (6) inches above the ground prevents the fence from being buried in the sand dune that forms in the vicinity, thus allowing the fence to be recovered and reused (GLO, 1997). The material cost for sand fencing is approximately $3.50 per foot with the installed cost being approximately $5 per foot.

Consistent with the design considerations set forth in Section 3.0 of this report, Coastal Tech recommends that signs be erected to educate the public about the restoration project and the benefits of the dune system. The awareness signs would be placed at the vehicular access points to the beach and along the restoration project's seaward boundary. Coastal Tech has identified the cost of signs and mounting hardware at approximately $100 each. The design and wording of the signs will be addressed under the preliminary design phase.

4.0 DESIGN ALTERNATIVES

Four design alternatives, in addition to the "do nothing" alternative, have been identified to address the erosion at the McFaddin NWR site. These alternatives are:

Alternative A: Dune Restoration/Re-vegetation with Uniform Re-vegetation of Foredune Terrace
Alternative B: Uniform Re-vegetation of the Foredune Terrace
Alternative C: Dune Restoration/Re-vegetation with Banded Re-vegetation of Foredune Terrace
Alternative D: Banded Re-vegetation of the Foredune Terrace

For each of the three designs an evaluation has been performed to:

- assess the expected performance;
- identify the expected permitting requirements;
- provide an opinion of probable cost; and,
- provide a schedule for completion of design, permitting, and construction.

In general, all alternatives are expected to minimally affect the rate of erosion at McFaddin but, will offer varying degrees of protection of upland infrastructure and habitat restoration. The project length for each alternative has been determined based on the available construction budget, estimated to be, after engineering and surveying expenses, approximately $267,500. The actual available budget will be better defined and the chosen alternative appropriately refined during the preliminary design process.

4.1 Alternative A - Dune Restoration/Re-vegetation and Foredune Terrace Re-vegetation

The proposed dune restoration/re-vegetation and foredune terrace re-vegetation alternative is illustrated in Figures 7, 8, and 9. Under this alternative, sand would be placed to move the dune face twenty (20) feet seaward. Sand fence would be placed at the seaward limits of existing vegetation, approximately thirty (30) feet landward of the wrack line with the re-vegetation extending from the sand fence to the dune Restoration. Re-vegetation would be accomplished through the planting of a one to one mixture of bitter panicum and sea oats. Dune restoration would require a volume of 6 cubic yards per foot (cy/ft). The project length is approximately 1675 feet, with a total of 10,050 cubic yards of fill material. The dune face and crest would also be planted with a one to one mixture of bitter panicum and sea oats. Vehicular access along the beach would be maintained seaward of the sand fence, and vehicular access to the beach would be maintained at existing locations. Permanent signs would be posted to raise public awareness of the project and educate the public on the importance of dunes and vegetation. These signs would be placed at each vehicular access and along the seaward edge of the project.

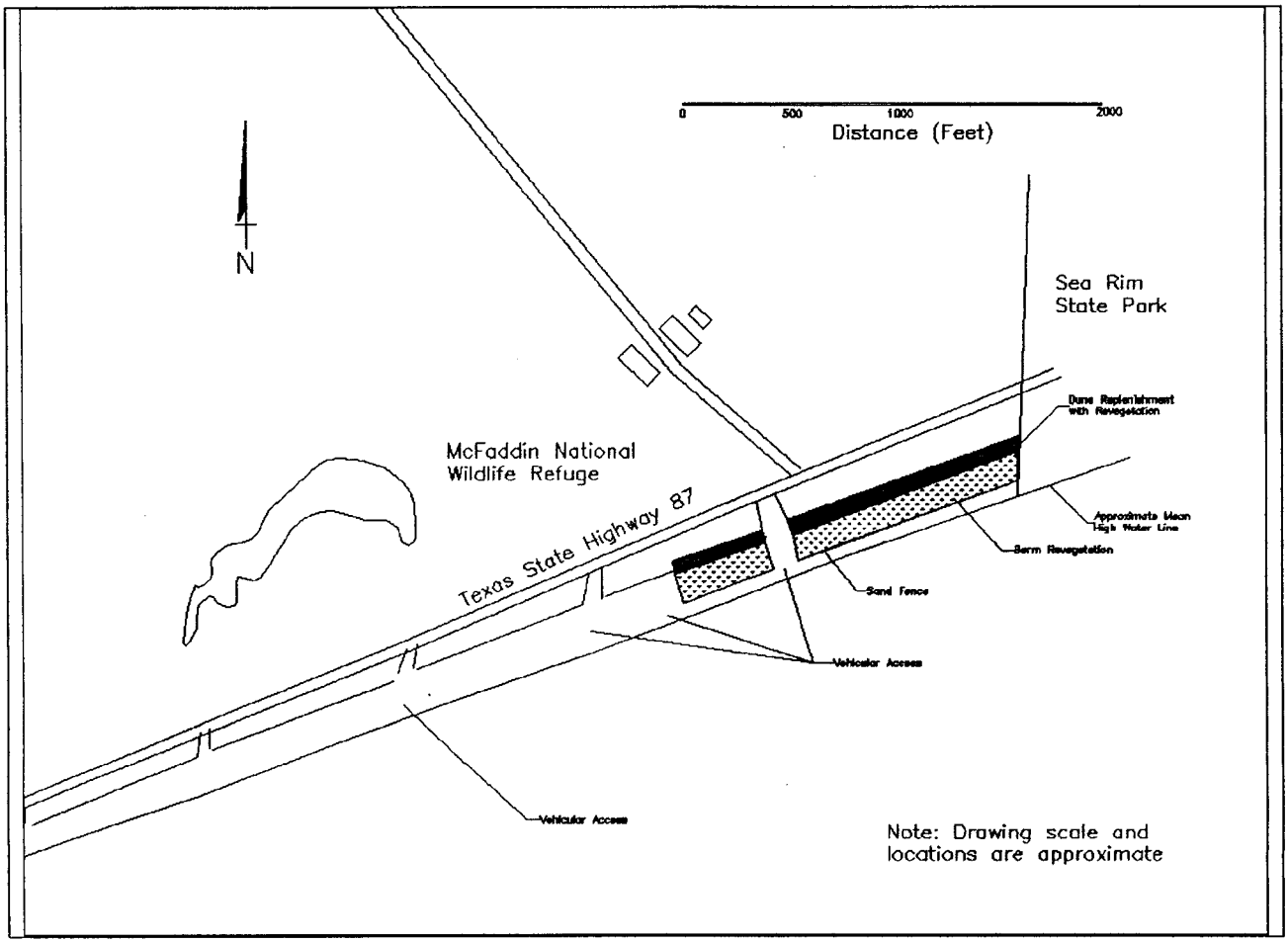


Figure 7: Plan View of Alternative A

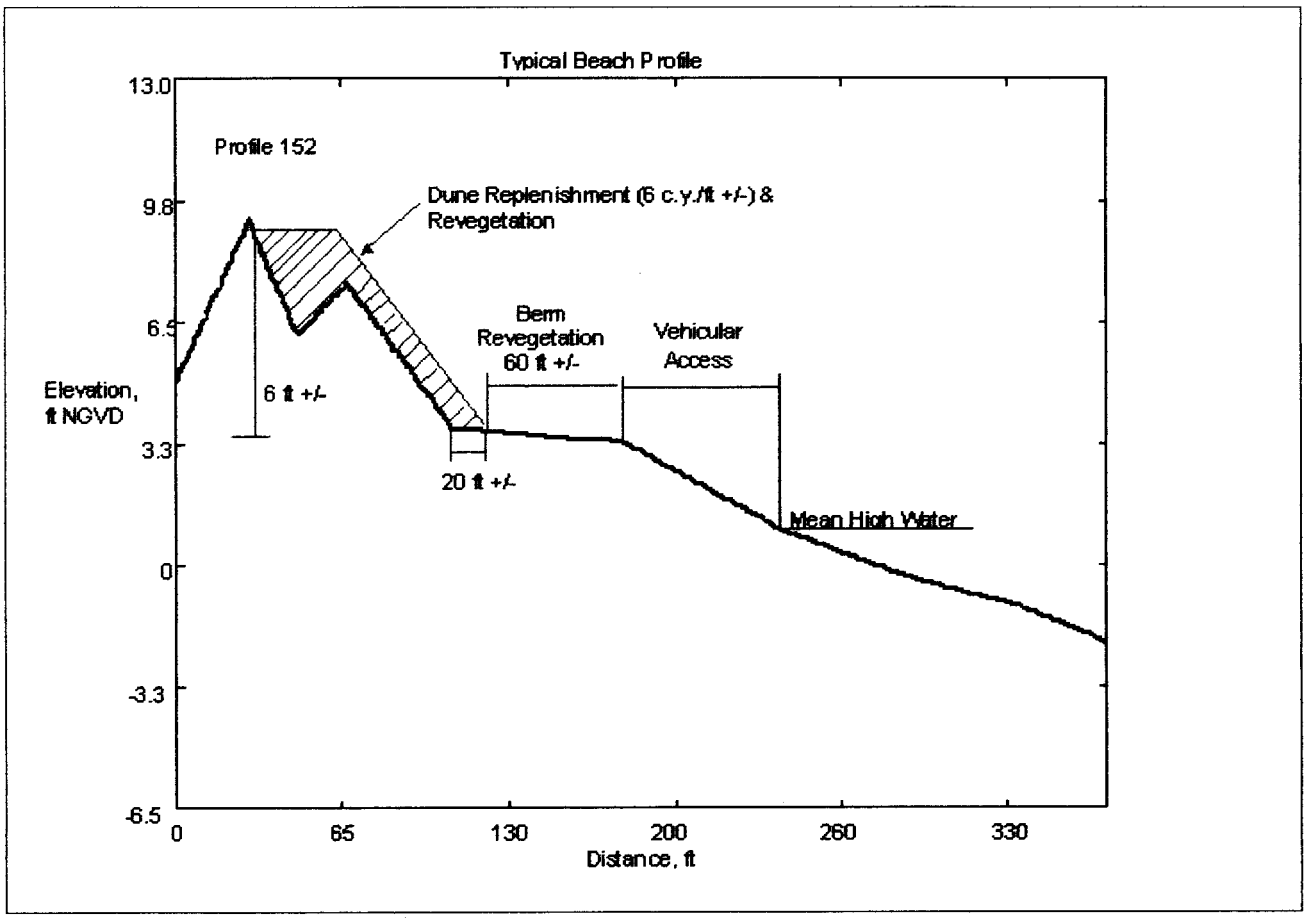


Figure 8: Profile View of Alternative A

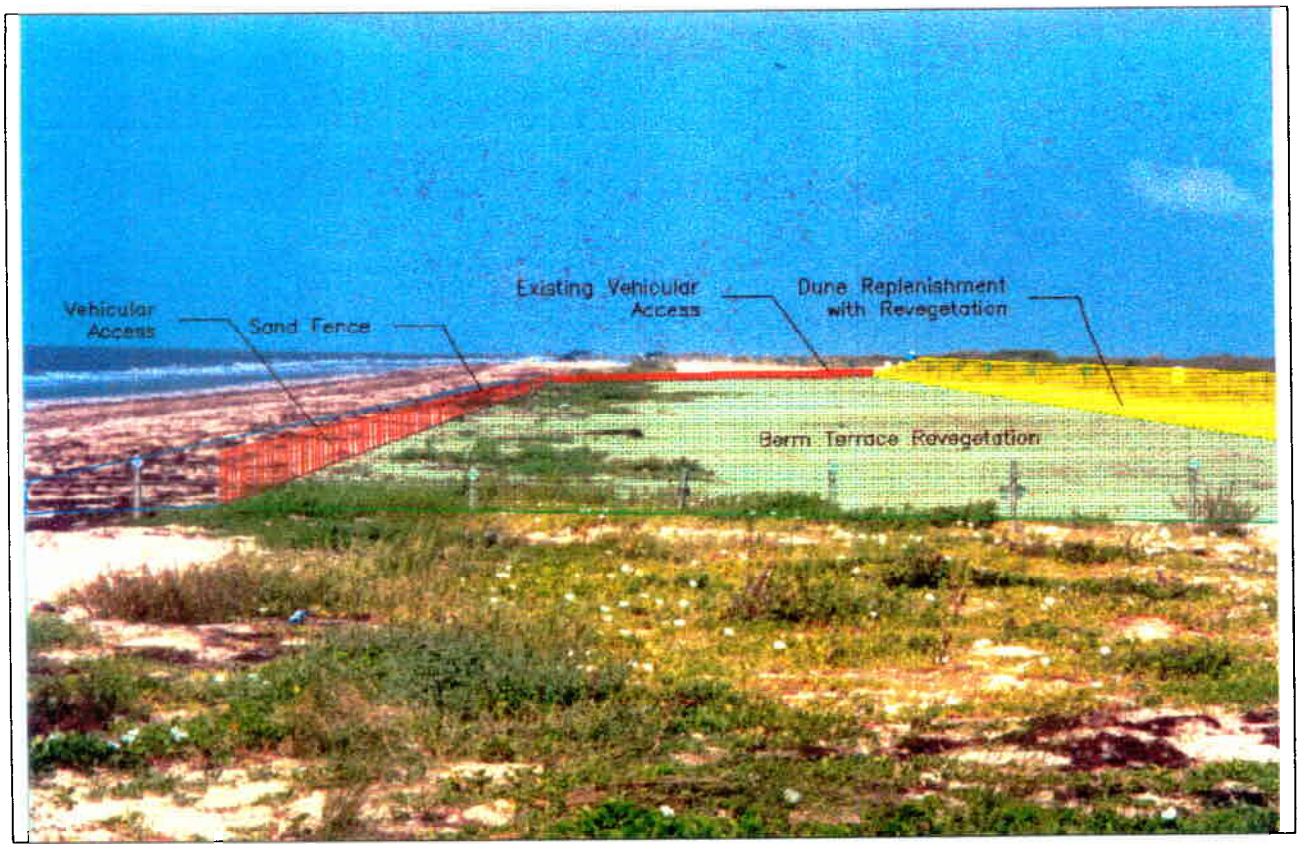


Figure 9: Photographic View of Alternative A

Performance Assessment

Alternative A is expected to provide a reasonable level of protection to the upland infrastructure and reasonably restore habitat. The dune restoration would increase the effectiveness of the dune system as a protective feature and thereby reduce the likelihood of damage to upland improvements and habitats. However, the length of the project is limited by the available funds. Re-vegetation is expected to stabilize the existing foredune terrace and aid in the natural dune building process. The sand fence would also aid in the natural creation of new dunes on the foredune terrace.

Permit Requirements

The permit requirements for Alternative A are consistent with Work Order 1003-00-01 and the criteria described in Section 3.1 of this Report.

Project Cost and Schedule

An engineer's opinion of probable costs for Alternative A is outlined in Table 5. The project design length is based on the available construction funds. The project length has been specifically chosen to meet the construction budget. This project length is approximate and would be affected by the number of actual vehicular beach accesses through the existing dune. An approximate schedule for the completion of the design, permitting, and construction of the project is contained in Table 6. The schedule assumes reasonable permitting and construction periods and would be affected by any delays in these project elements.

Table 5: Engineer's Opinion of Probable Cost for Alternative A

Element	**Unit Cost**	**Project Length**	**Total Cost**
Dune Restoration (6 cy/ft)	$90/ft	1675	$150,750
Dune Re-vegetation (1-to-1 ratio of bitter panicum & sea oats, 18" on centers)	$30/ft	1675	$50,250
Foredune Revegation (1-to-1 ratio of bitter panicum & sea oats, 18" on centers)	$22.50/ft	1675	$37,687.50
Sand Fence	$5.50/ft	1675	$9,212.50
Public Awareness Signs	$1,500		$1,500
Mobilization/Demobilization	$5,000		$5,000
Total			$254,400

Table 6: Approximate Project Schedule for Alternative A

Element	**Expected Start and Completion Dates**
Design	September 1, 2000 to October 31, 2000
Permitting	October 15, 2000 to November 30, 2000
Construction	December 1, 2000 to February 28, 2001

4.2 Alternative B - Foredune Terrace Re-vegetation

Re The proposed foredune terrace re-vegetation alternative is illustrated in Figures 10, 11, and 12. Under this alternative, sand fence would be placed at the seaward limits of existing vegetation - approximately thirty (30) feet landward of the wrack line with the re-vegetation extending from the sand fence to the toe of the existing dune. The project length is approximately 7100 feet. Re-

vegetation would be accomplished through the planting of a one to one mixture of bitter panicum and sea oats. Vehicular traffic on the beach would be maintained between the line of mean high water up to the sand fence; vehicular access to the beach would be maintained at existing accessways off of Highway 87. Permanent signs would be posted to identify the project and increase public awareness of the importance of dunes and vegetation. These signs would be placed at each vehicular access and along the seaward edge of the project.

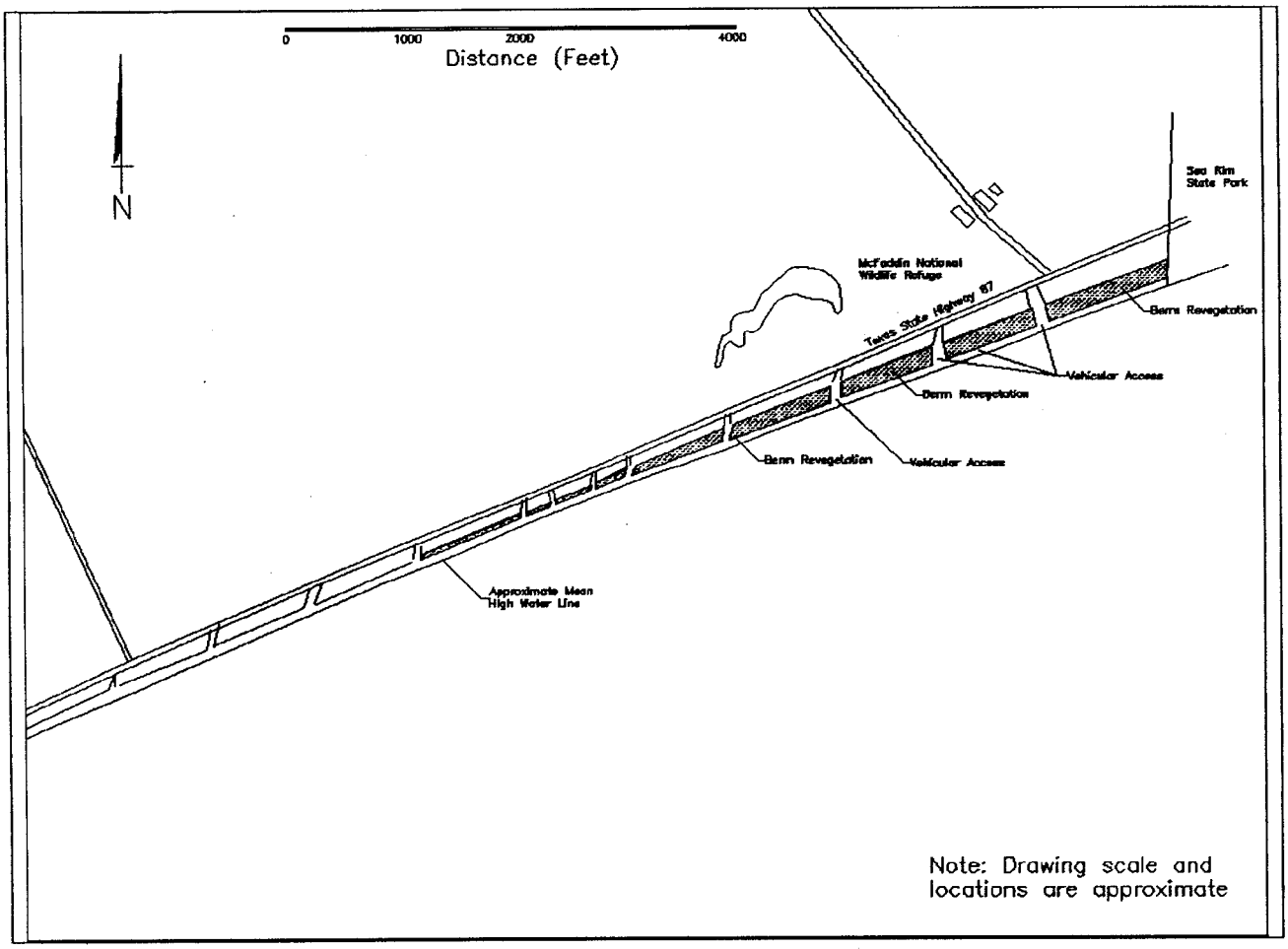


Figure 10: Plan View of Alternative B

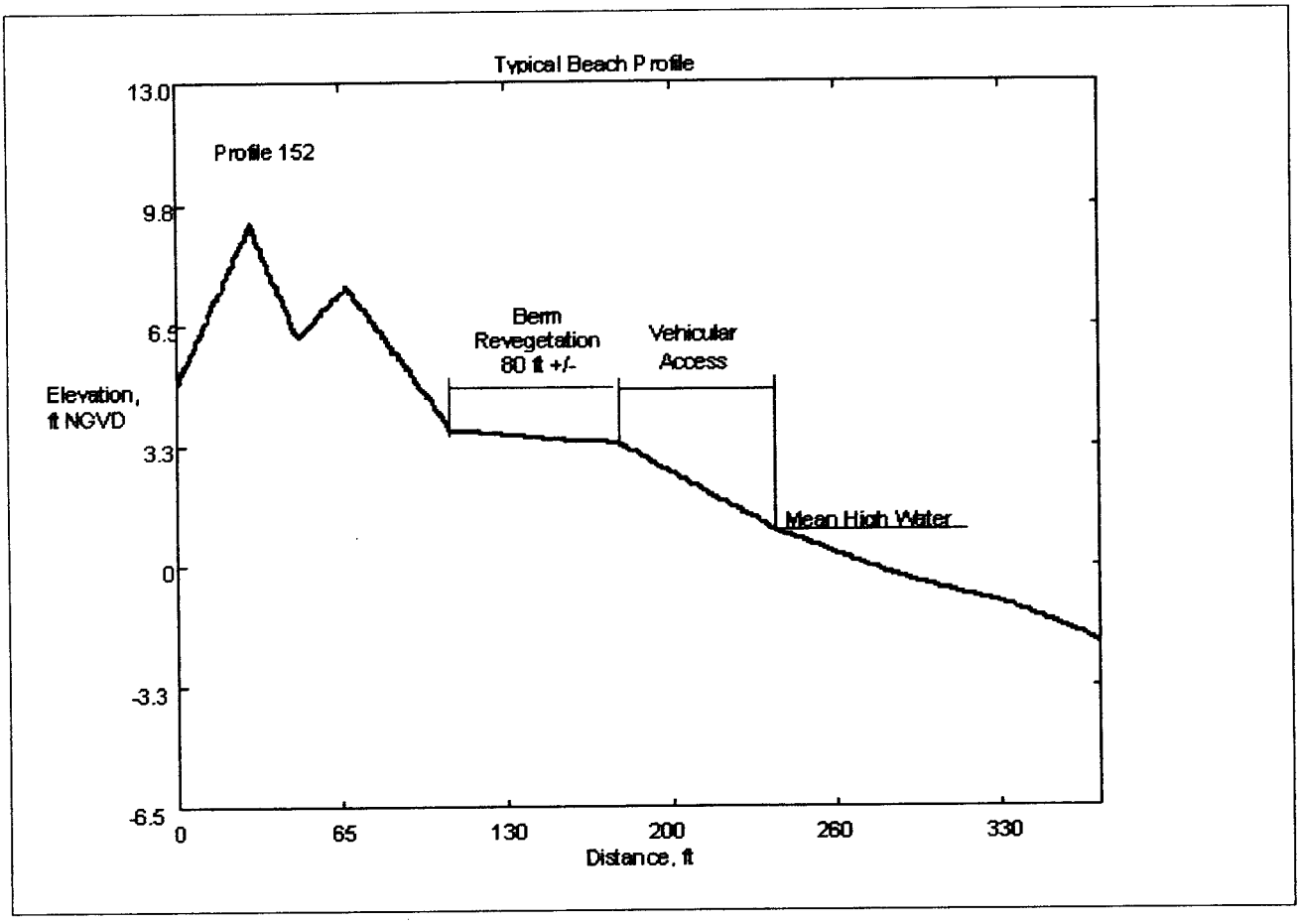


Figure 11: Profile View of Alternative B

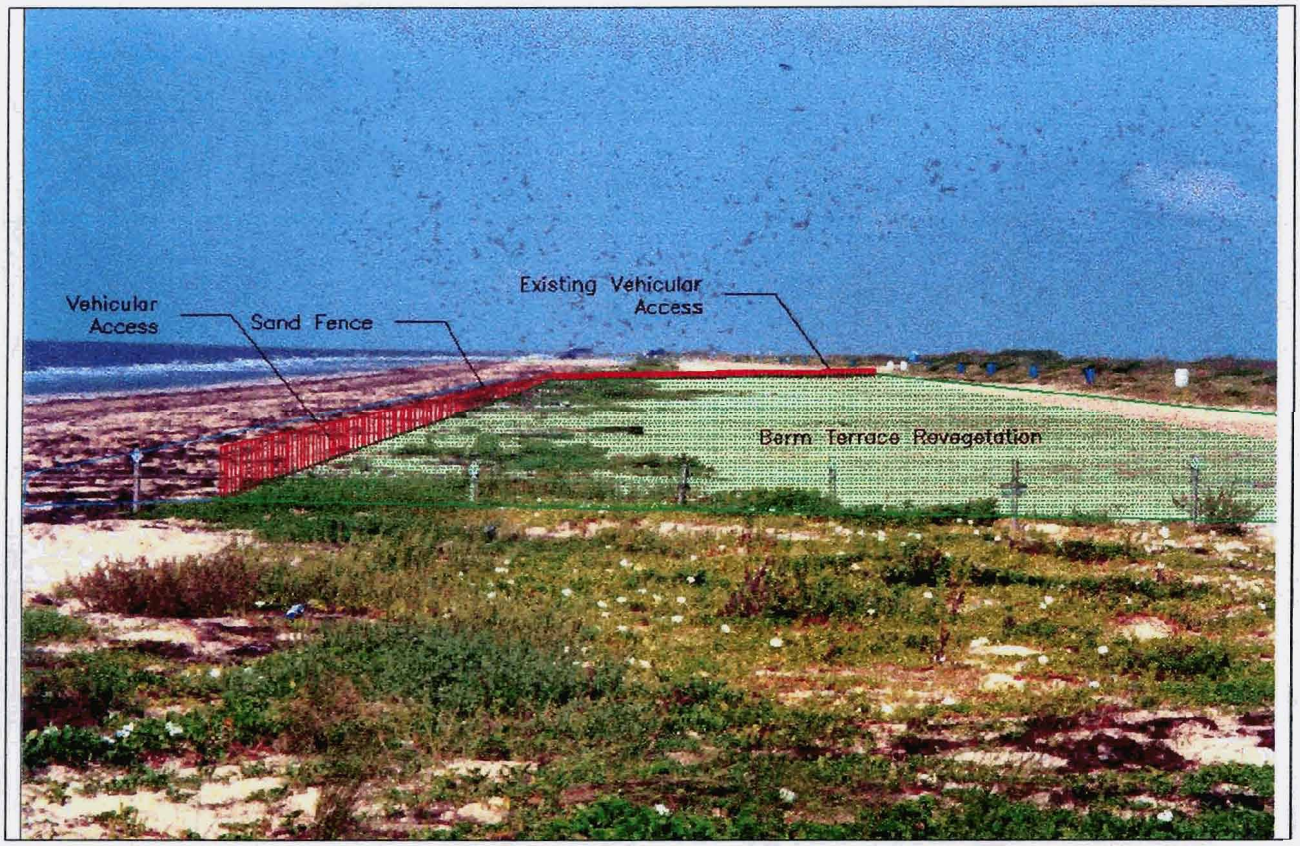


Figure 12: Photographic View of Alternative B

Performance Assessment

Because Alternative B does not include restoration of the dunes, it would not result in the restoration of the beach/dune system to pre-storm conditions. Alternative B is also expected to provide only a moderate level of protection to upland infrastructure and only partially restore habitat. However, because it has a lower cost per liner foot, the Alternative B project length is increased significantly. The re-vegetation is expected to stabilize the exiting foredune terrace and aid in the natural dune building processes. The sand fence would also aid in the natural creation of new dunes on the foredune terrace. However, as noted in the GLO "Dune Protection and Improvement Manual for the Texas Gulf Coast," natural restoration of dunes on the upper Texas coast does not readily occur due to erosion attributable to the deficit of sand in the littoral system. Without placement of additional sand on the primary dunes, very little natural restoration of the dune is likely and protection for uplands areas will be minimal.

Permit Requirements

The permit requirements for Alternative B are consistent with Work Order 1003-00-01 and the criteria described in Section 3.1 of this Report.

Project Cost and Schedule

An engineer's opinion of probable costs for Alternative B is outlined in Table 7. The total project cost is limited by the available construction budget. The project length has been specifically chosen to meet the construction budget. Because no sand is placed under Alternative B, the project length is longer than Alternatives A or C. This project length is approximate and would be affected by the actual number of vehicular beach accesses through the existing dune. An approximate schedule for the completion of the design, permitting, and construction of the project is contained in Table 8. The schedule assumes reasonable permitting and construction periods and would be affected by any delays in these project elements.

Table 7: Engineer's Opinion of Probable Cost for Alternative B

Element	**Unit Cost**	**Project Length**	**Total Cost**
Foredune Revegation (1-to-1 ratio of bitter panicum & sea oats, 18" on centers)	$30/ft	7100	$213,000
Sand Fence	$5.50/ft	7100	$39,050
Public Awareness Signs	$3,000		$3,000
Mobilization/Demobilization	$2,500		$2,500
Total			$257,550

Table 8: Approximate Project Schedule for Alternative B

Element	**Expected Start and Completion Dates**
Design	September 1, 2000 to October 15, 2000
Permitting	October 15, 2000 to November 15, 2000
Construction	November 16, 2000 to January 31, 2001

4.3 Alternative C - Dune Restoration/Re-vegetation and Banded Re-vegetation of the Foredune Terrace

The proposed dune restoration/re-vegetation and banded foredune terrace re-vegetation alternative is illustrated in Figures 13, 14, and 15. Under this alternative, sand would be placed to move the dune

face twenty (20) feet seaward. Sand fence would be placed at the seaward limits of existing vegetation - approximately thirty (30) feet landward of the wrack line with the re-vegetation extending from the sand fence to the dune Restoration. Unlike Alternative A, under Alternative C, the re-vegetation planting would be performed in bands, allowing the plants to propagate by natural means into the unvegetated bands. The planted and unplanted bands would be fifty (50) feet wide each, running perpendicular to the shoreline. Re-vegetation will be accomplished through the planting of a one to one mixture of bitter panicum and sea oats. Dune restoration would require a volume of 6 cy/ft. The project length is approximately 1775 feet, with a total of 10,650 cubic yards of fill material. The dune face and crest would also be planted with a one to one mixture of bitter panicum and sea oats. Vehicular access to the along beach would be maintained along the beach up to the sand fence, and vehicular access to the beach would be maintained at existing locations. Permanent signs would be posted to raise public awareness of the project and educate the public about the importance of dunes and vegetation. Signs would be placed at each vehicular access and along the seaward edge of the project.

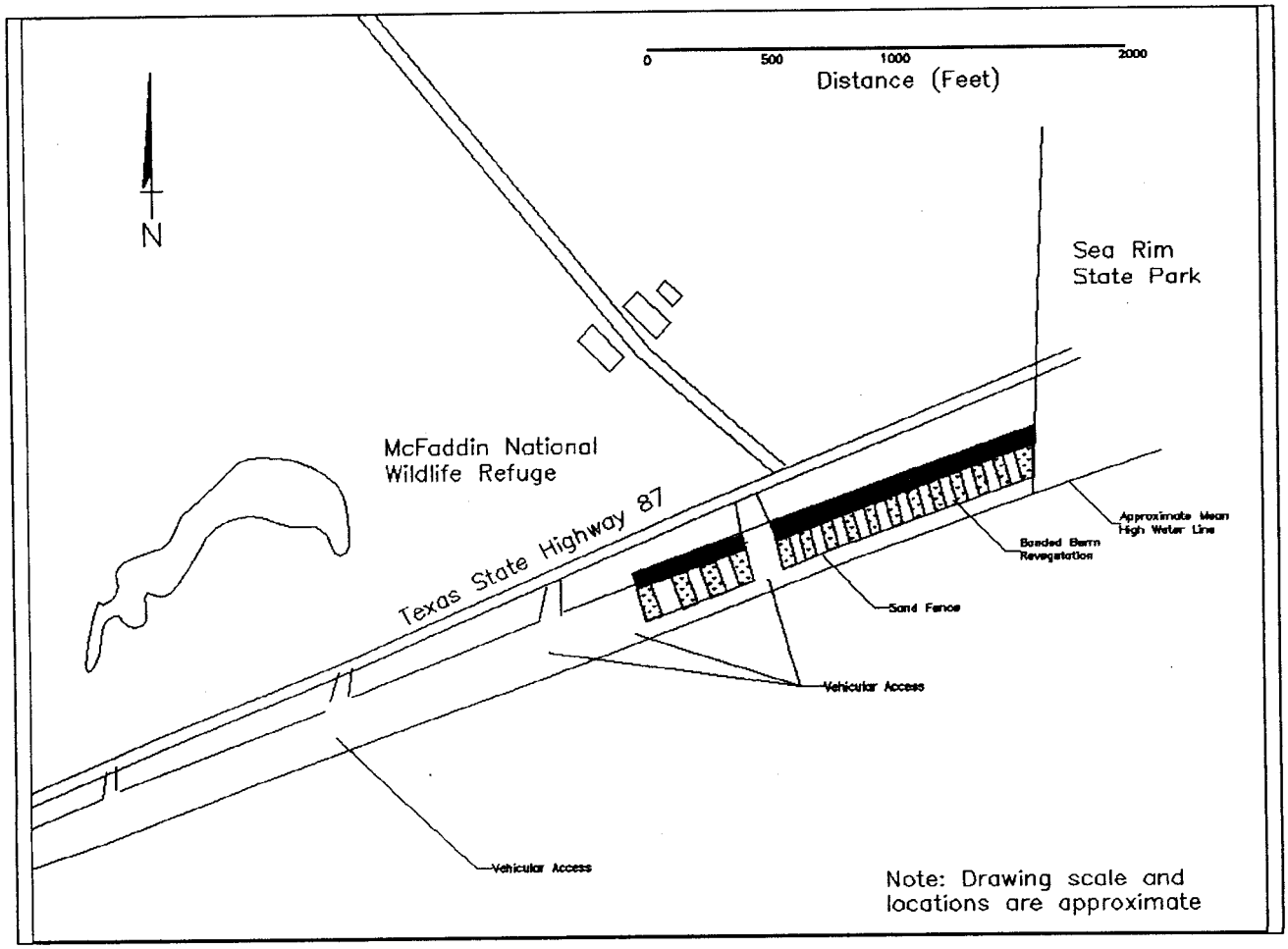


Figure 13: Plan View of Alternative C

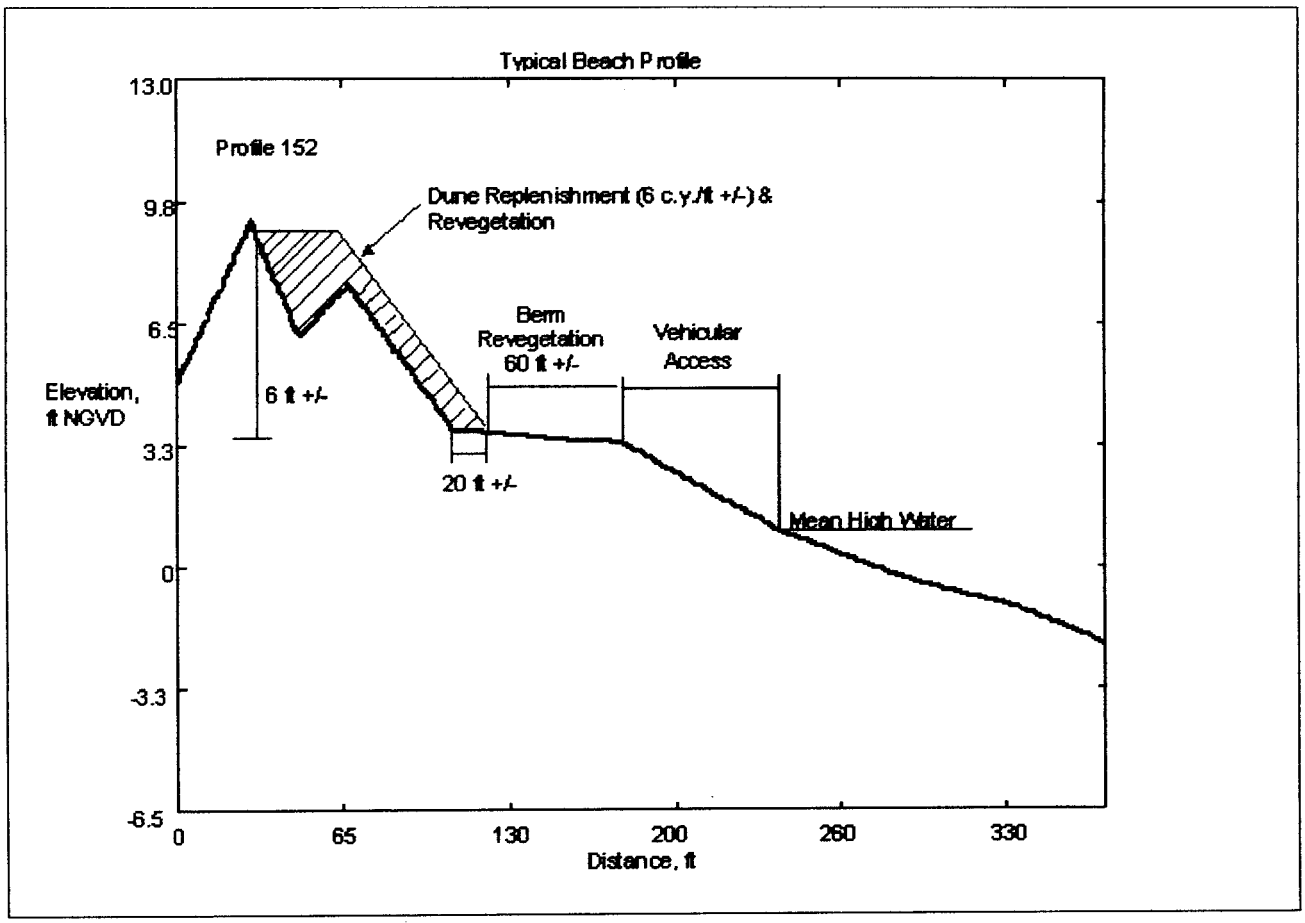


Figure 14: Profile View of Alternative C

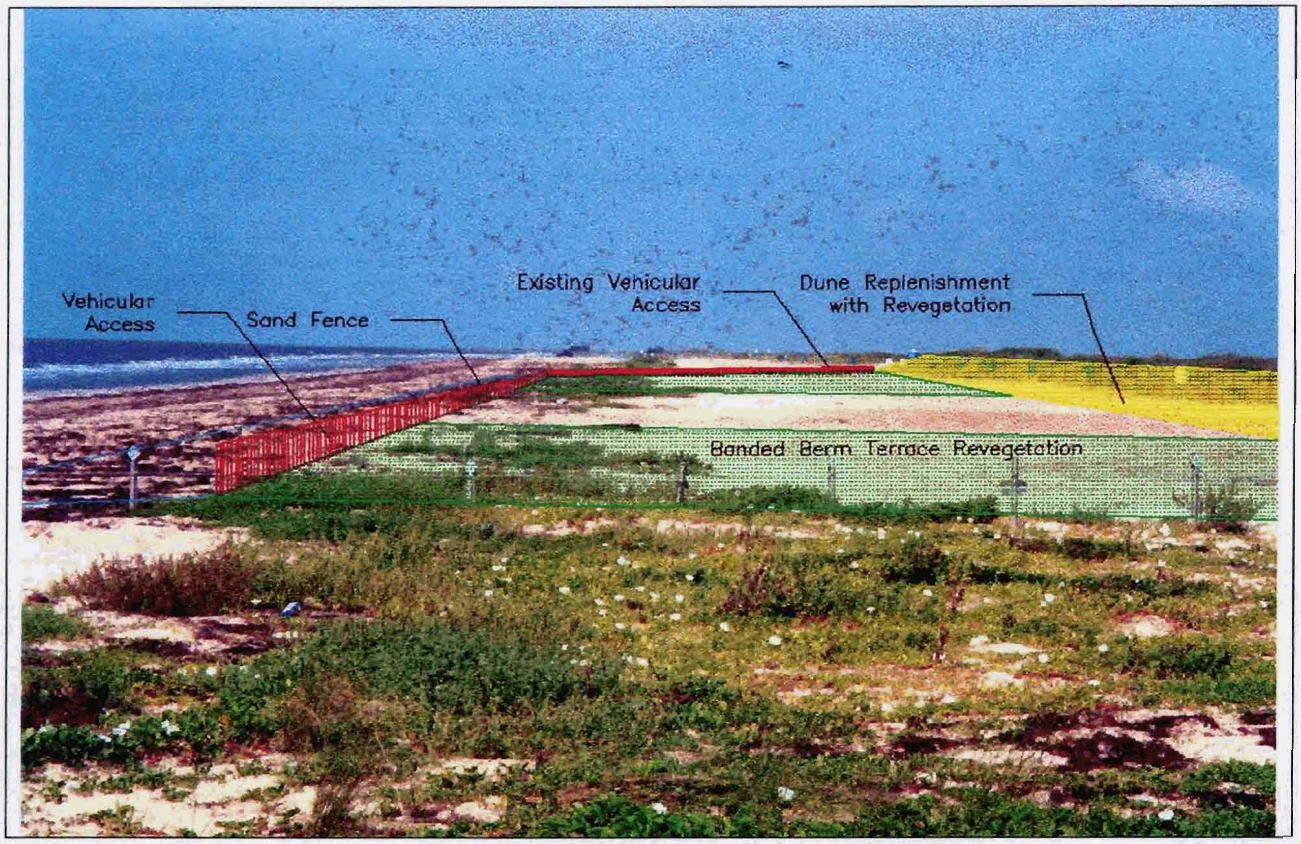


Figure 15: Photographic View of Alternative C

Performance Assessment

Alternative C is consistent with the design goal to restore the beach/dune system to pre-storm condition. Vegetation is expected to naturally reestablish in the unvegetated band areas within two years, creating a uniform vegetated foredune terrace. Because restoration of the dune volume is included, this alternative is expected to provide a reasonably good level of protection for upland infrastructure and habitats relative to other alternatives. Dune restoration would increase the effectiveness of the dune system as a protective feature and thereby reduce the likelihood of damage to upland improvements and restore habitat. By leaving unvegetated areas, the length of the project is increased over Alternative A by 100 feet (6.7%). The re-vegetation is expected to stabilize the existing foredune terrace and aid in the natural dune building process. The sand fence would also aid in the natural creation of new dunes on the foredune terrace.
criteria described in Section 3.1 of this Report.

Permit Requirements

The permit requirements for Alternative C are consistent with Work Order 1003-00-01 and the criteria described in Section 3.1 of this Report.

Project Cost and Schedule

An engineer's opinion of probable costs for Alternative C is outlined in Table 9. The total project cost is based on an estimate of the available construction budget. The project length has been specifically chosen to meet the construction budget. Because the foredune re-vegetation is banded, Alternative C allows for a longer project length than Alternative A. This project length is approximate and would be affected by the actual number of vehicular beach accesses through the existing dune. An approximate schedule for the completion of the design, permitting, and construction of the project is contained in Table 10. The schedule assumes reasonable permitting and construction periods and would be affected by any delays in these project elements.

Table 9: Engineer's Opinion of Probable Cost for Alternative C

Element	**Unit Cost**	**Project Length**	**Total Cost**
Dune Restoration (6 cy/ft)	$90/ft	1775	$159,750
Dune Re-vegetation (1-to-1 ratio of bitter panicum & sea oats, 18" on centers)	$30/ft	1775	$53,250
Banded Foredune Revegation (1-to-1 ratio of bitter panicum & sea oats, 18" on centers)	$11.25/ft	1775	$19,968.75
Sand Fence	$5.50/ft	1775	$9,762.50
Public Awareness Signs	$1,500		$1,500
Mobilization/Demobilization	$5,000		$5,000
Total			$249,231.75

Table 10: Approximate Project Schedule for Alternative C

Element	**Expected Completion Date**
Design	September 1, 2000 to October 31, 2000
Permitting	October 15, 2000 to November 30, 2000
Construction	November 16, 2000 to January 31, 2001

4.4 Alternative D - Banded Re-vegetation of the Foredune Terrace

The proposed banded foredune terrace re-vegetation alternative is illustrated in Figures 16, 17, and 18. Under this alternative, sand fence would be placed at the seaward limits approximately thirty (30) feet landward of the wrack line with the re-vegetation extending from the sand fence to the dune restoration. Re-vegetation would be accomplished through the planting of a one to one mixture of bitter panicum and sea oats. Unlike Alternative B, under Alternative D, the re-vegetation planting would be performed in bands, allowing the plants to propagate by natural means into the unvegetated bands. The planted and unplanted bands would be fifty (50) feet wide each, running perpendicular to the shoreline. The project length is approximately 12,000 feet. Vehicular access to the along beach would be maintained along the beach seaward of the sand fence, and vehicular access to the beach will be maintained at existing locations. Permanent signs would be posted to raise public awareness of the project and educate the public on the importance of dunes and vegetation. These signs would be placed at each vehicular access and along the seaward edge of the project.

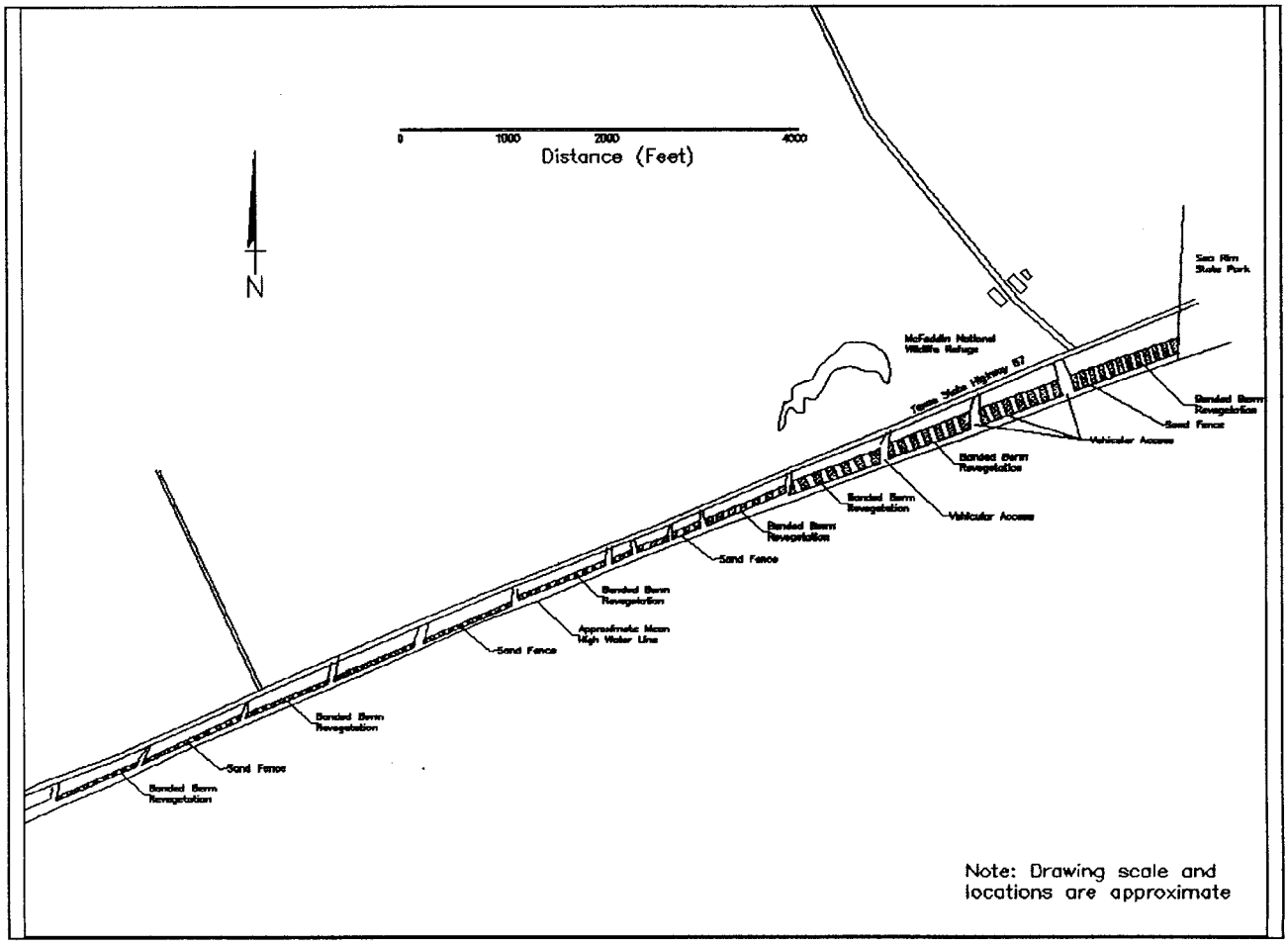


Figure 16: Plan View of Alternative D

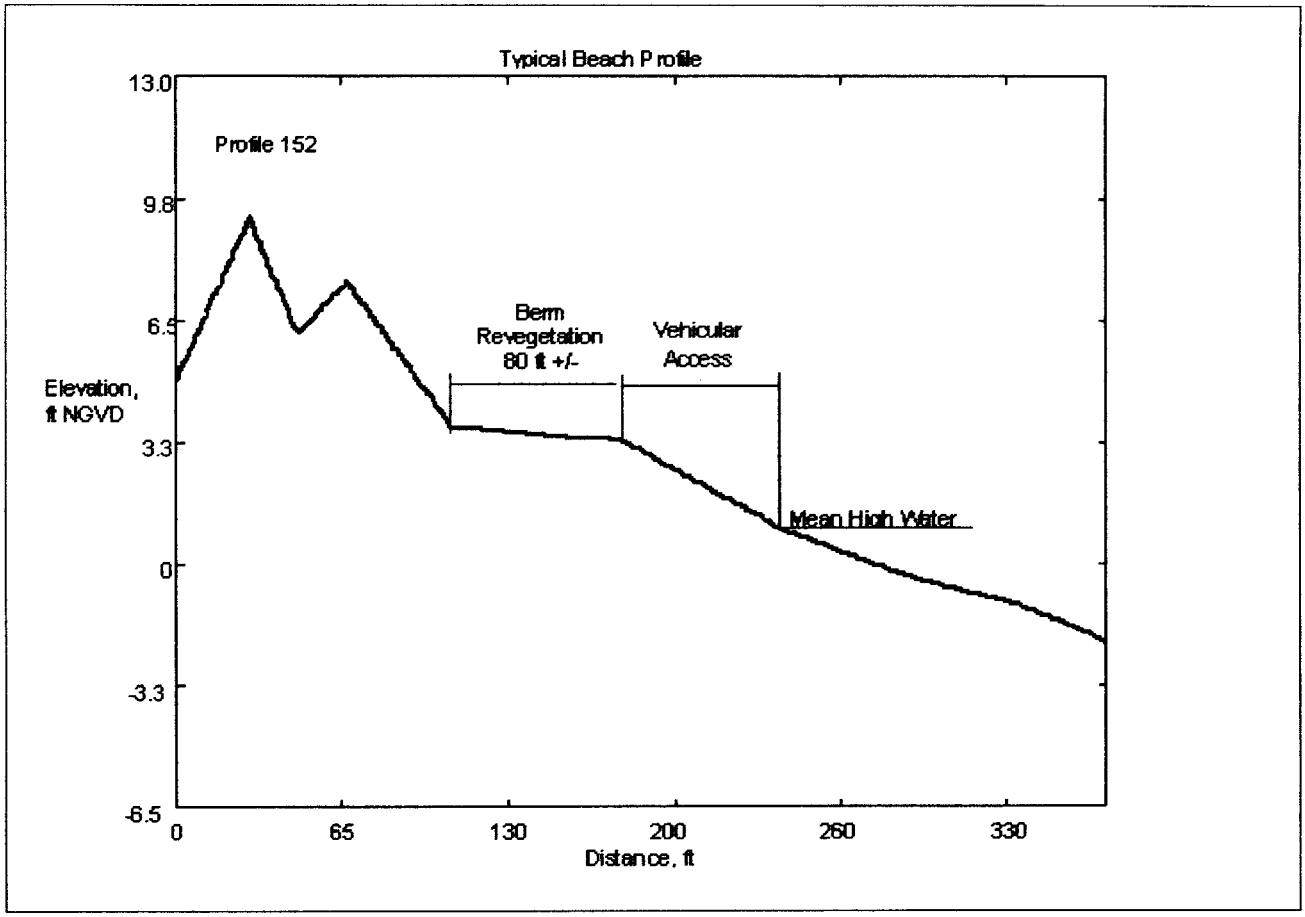


Figure 17: Profile View of Alternative D

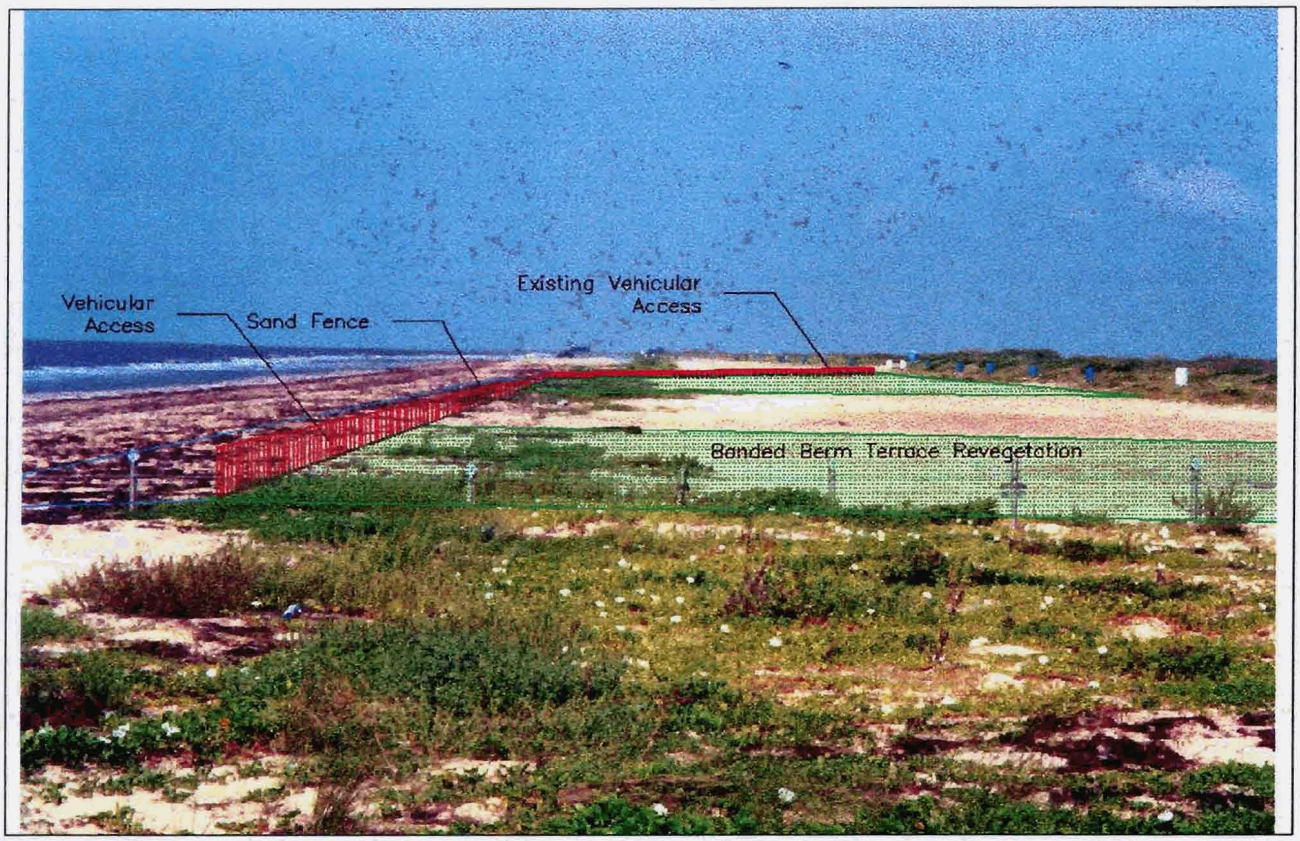


Figure 18: Photographic **View** of **Alternative D**

Performance Assessment

Relative to other alternatives, Alternative D is least **likely** to **result in** restoration of **the beach/dune** system to pre-storm conditions. In addition, this **alternative** is expected to provide **the** least **protection** to upland **infrastructure** and **habitats. However,** because **this alternative is the** least expensive cost **per** linear foot, **the** project length is the greatest of all the alternatives. **Natural** colonization of **vegetation is** expected to *occur* within the **unvegetated** bands of **the foredune** terrace **within** two years and, to **some** *extent,* aid in the natural dune building processes. **The** *sand* **fence would** also aid **m the natural** creation of **new dunes** on **the foredune** terrace. **However,** without the placement of additional sand on **the** primary **dunes, very little additional** protection would be provided to uplands until **new dunes** form by **natural** processes.

Permit Requirements

The permit requirements for **Alternative** D **are** consistent with **Work** Order **1003-00-01 and the criteria described m** Section 3.1 of this Report.

Project Cost and Schedule

An engineer's opinion of probable costs for Alternative D is outlined in Table 11. The total project cost is based on an estimate of the available construction budget. The project length has been specifically chosen to meet the construction budget. Because the foredune re-vegetation is banded and no sand would be placed, Alternative D allows for the longest project length to be restored. This project length is approximate and would be affected by the number of vehicular beach accesses through the existing dune. An approximate schedule for the completion of the design, permitting, and construction of the project is contained in Table 12. The schedule assumes reasonable permitting and construction periods and would be affected by any delays in these project elements.

Table 11: Engineer's Opinion of Probable Cost for Alternative D

Element	**Unit Cost**	**Project Length**	**Total Cost**
Foredune Revegation (1-to-1 ratio of bitter panicum & sea oats, 18" on centers)	$15/ft	12,000	$180,000
Sand Fence	$5.50/ft	12,000	$66,000
Public Awareness Signs	$6,000		$6,000
Mobilization/Demobilization	$2,500		$2,500
Total			$254,500

Table 12: Approximate Project Schedule for Alternative D

Element	**Expected Completion Date**
Design	September 1, 2000 to October 15, 2000
Permitting	October 15, 2000 to November 15, 2000
Construction	February 28, 2001

5.0 CONCLUSIONS AND RECOMMENDATIONS

The dune system at McFaddin NWR is threatened by chronic and episodic erosion events, thus threatening damage to upland improvements and habitats. Tropical Storm Frances, in 1998, caused extensive loss of the dune and dune vegetation. Since the storm, vegetation has naturally reestablished on the foredune terrace on the adjacent beach within Sea Rim State Park; however, vehicular traffic and beach cleaning have prevented the dune terrace from being colonized by dune plants within the refuge. Restoration of the dune system through sand placement and re-vegetation would add a level of protection to the uplands, restore habitat, and aid the natural dune building processes.

After evaluating each of the four design alternatives presented, Coastal Tech recommends that design Alternative C, dune Restoration and re-vegetation with banded foredune terrace re-vegetation, be pursued by the Texas GLO and USFWS. Alternative C is consistent with the design goal to restore the beach/dune system to pre-storm conditions. Because the cost per linear foot is less compared to Alternative A, Alternative C allows the GLO and USFWS to restore a greater length of shoreline. With the restoration of the dune, Alternative C also provides a reasonable level of protection for upland improvements and habitat, given the budget available for the project. Finally, the banded dune planting scheme will also allow engineers and biologists to gather information on the natural colonization of dune plants into unvegetated areas.

In order to move forward with any of the alternatives outlines in this report, certain regulatory compliance steps must be undertaken. It should be assumed that all four alternatives could trigger the necessity for the steps outlined below. Should the GLO and USFWS elect to proceed to preliminary and final design, a definitive determination of the regulatory requirement steps will provided, based on the design option selected. The following regulatory steps and requirements must be taken:

1. Establish Compliance with the Open Beach Act. The OBA prohibits construction of projects that interfere with public use and enjoyment of the public beach. With respect to dune restoration projects specifically, the dune restoration project is limited to an area 20 feet seaward of the existing line of vegetation, unless the applicant can establish that dunes would naturally form seaward of that limit. In this case, based on comparison the Sea Rim State Park beach immediately adjacent to the project area, dunes and dune vegetation will naturally reestablish, barring interference from vehicles and beach maintenance activities, in an area substantially greater than 20 feet seaward of the current line of vegetation. Documentation supporting this preliminary determination should be compiled in the preliminary permitting stage. In addition, the applicant must further establish that once constructed, public access to the beach has not been hindered and that vehicle access along the beach seaward of the project remains adequate.

2. Establish Compliance with the Dune Protection Act. The DPA and accompanying GLO Beach/Dune rules establish clear standards governing restoration of dunes on the public beach. These standards generally govern dune building materials, acceptable re-vegetation species, construction and location of sand fences and traffic management barriers, and sand quality. The Preliminary Design report must include adequate documentation and analysis to

establish that the preferred alternative complies with the DPA and accompanying GLO Beach/Dune rules.

3. Establish Compliance with CEPRA Boundary Survey Requirements. A CEPRA Boundary survey by a State Licensed Land Surveyor will be required if the project will "will cause or contribute to shoreline alteration." Because the volume of sand proposed in the alternatives evaluated in this report is limited, it is unlikely that the project will result in the "alteration of the shoreline" as that requirement is intended under the CEPRA. Nonetheless, documentation and analysis of this preliminary finding must be compiled and analyzed during the Preliminary Design phase. If necessary, a boundary survey must be conducted as required by law.

4. Establish Compliance with Historical and Cultural Resources Survey and Protection Requirements. Federal and state law will require protection of any historic and cultural resources that may exist in the project area. During the Preliminary Design Phase, the State Historic Preservation officer should be consulted to determine whether any historic and/or cultural sites exist in the project area, or whether a site survey will be required to identify and document any sites that are believed to exist. In historic/cultural sites are identified in the project area, consultation with the SHPO should be undertaken immediately to ensure protection of the sites as required by law.

5. NEPA. It is likely that the McFaddin Dune Restoration Project will requires preparation of and Environmental Assessment (EA) under the National Environmental Policy Act. A "Categorical Exclusion" of the project from the EA requirement is unlikely and may not be preferred by the McFaddin NWR. Preparation of the EA should be commenced in conjunction with the Preliminary Design phase of the project.

6. Section 404 Permit/401 Certification. It is unlikely that a §404 permit/401 certification will be required for the project for three reasons: (1) Based on a preliminary site visit, it does not appear that any jurisdictional wetlands exist in the project area for any of the alternatives evaluated; (2) sand will be obtained from a commercial sand supplier, and no wetland disturbance is anticipated and (3) under any alternative proposed, the project will be will be installed above the high tide line on the beach, avoiding the requirement for the 404 permit/401 certificate.

Coastal Tech recommends that aerial photography be taken of the project site to serve as the basis for final design of the project. This will allow for a more accurate determination of beach access locations and allow for assessment of the existing vegetation conditions as needed for the final design. The pre-project aerial photography can also be compared with post-project photography or monitoring surveying data to determine how well the project is performing. Coastal Tech also recommends that the project be monitored, preferably through aerial photography and beach profiles, at one (1), two (2), and five (5) years after completion to assess performance. On going monitoring of the propagation of dune plants by refuge personnel would also help in assessing the performance of the project and optimizing future designs.

6.0 REFERENCES

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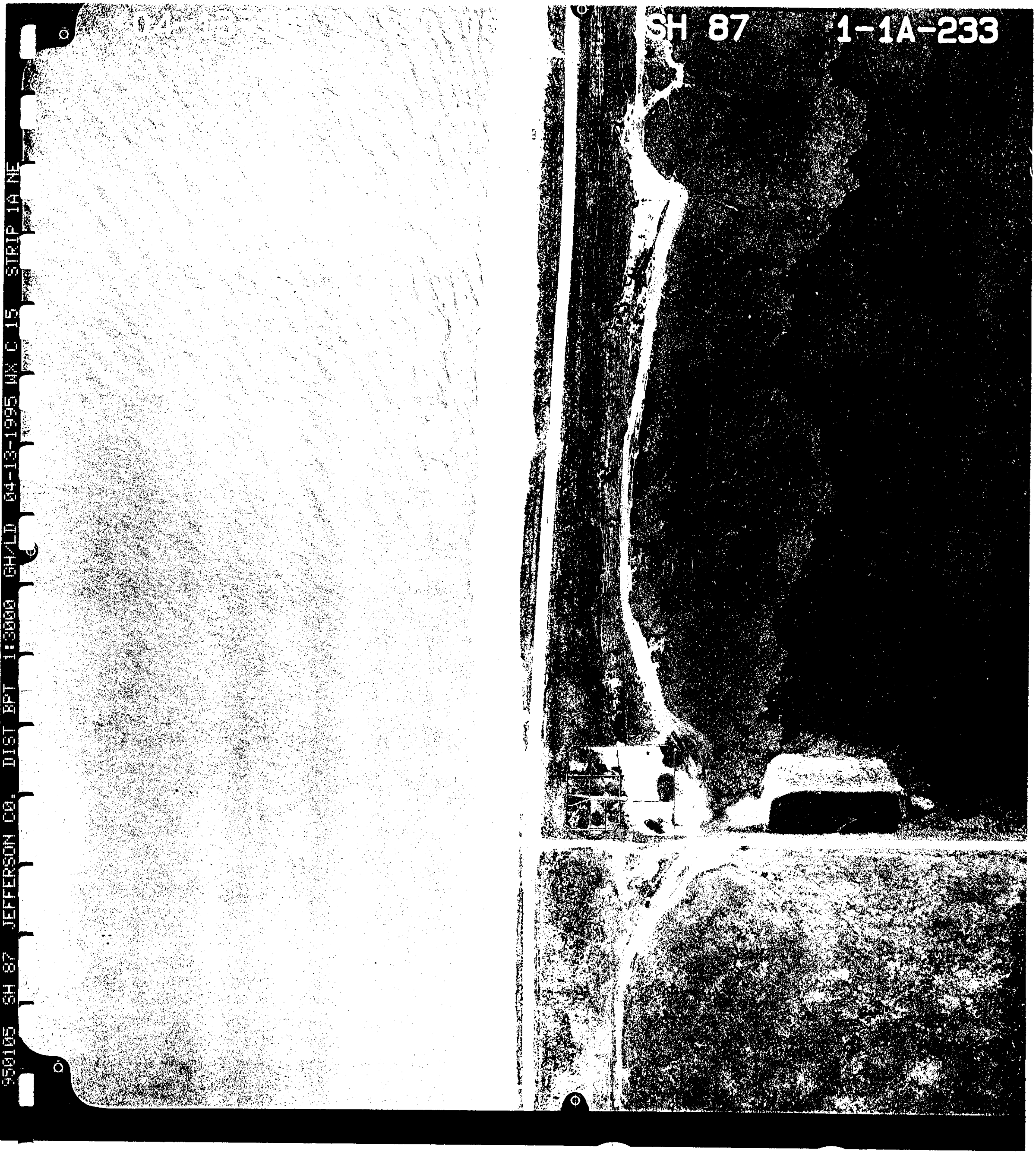
National Climatic Data Center (NCDC) (2000), "Storm Details", NOAA, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?events~Storms

Texas GLO (1997) "Dune Protection and Improvement Manual for the Texas Gulf Coast," Texas General Land Office, Austin, Texas

Tuttle, Meghan (2000) *Master's Thesis,* In progress, Texas A&M University, College Station, Texas

Appendix A

TXDOT Aerial Photographs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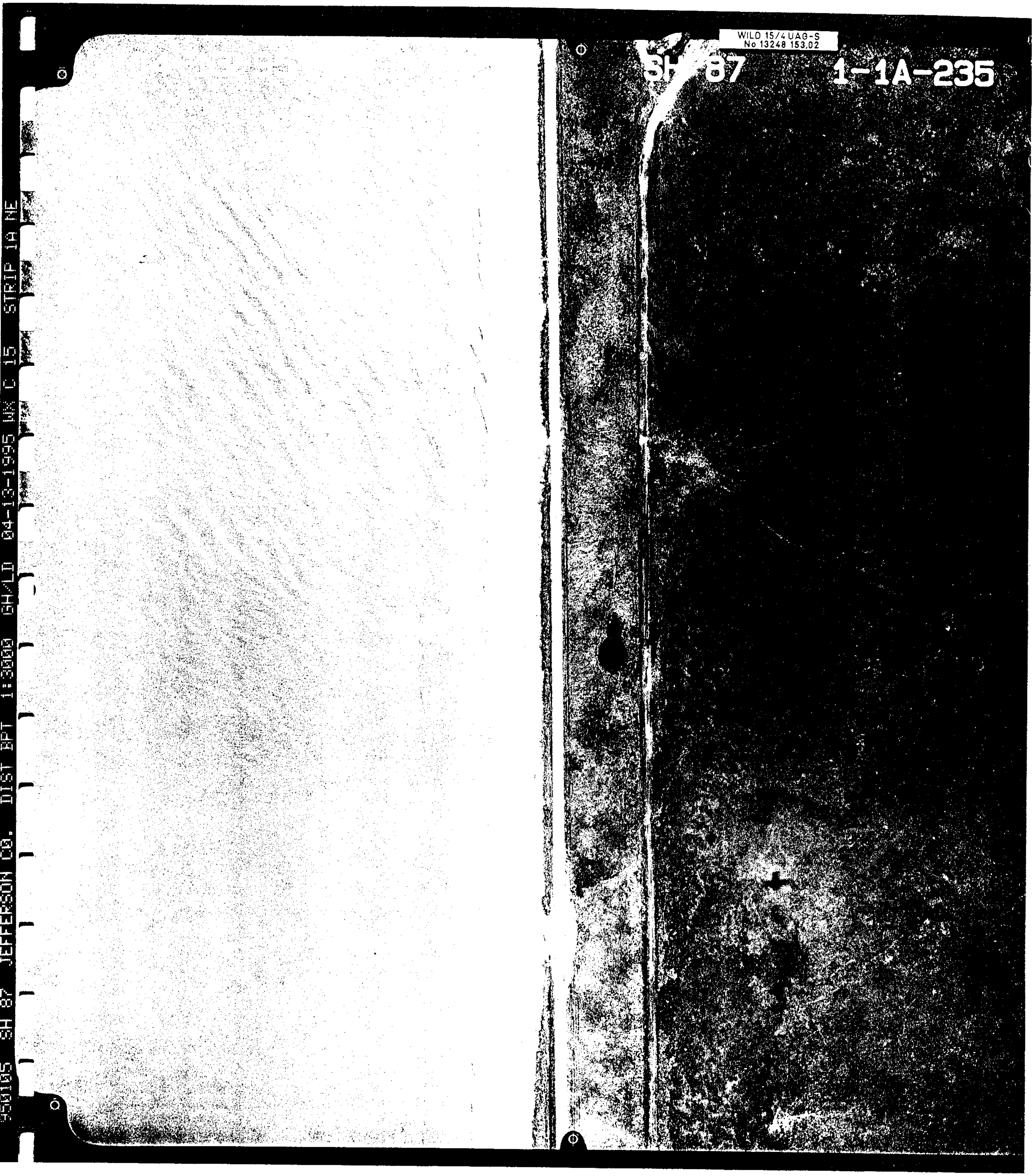
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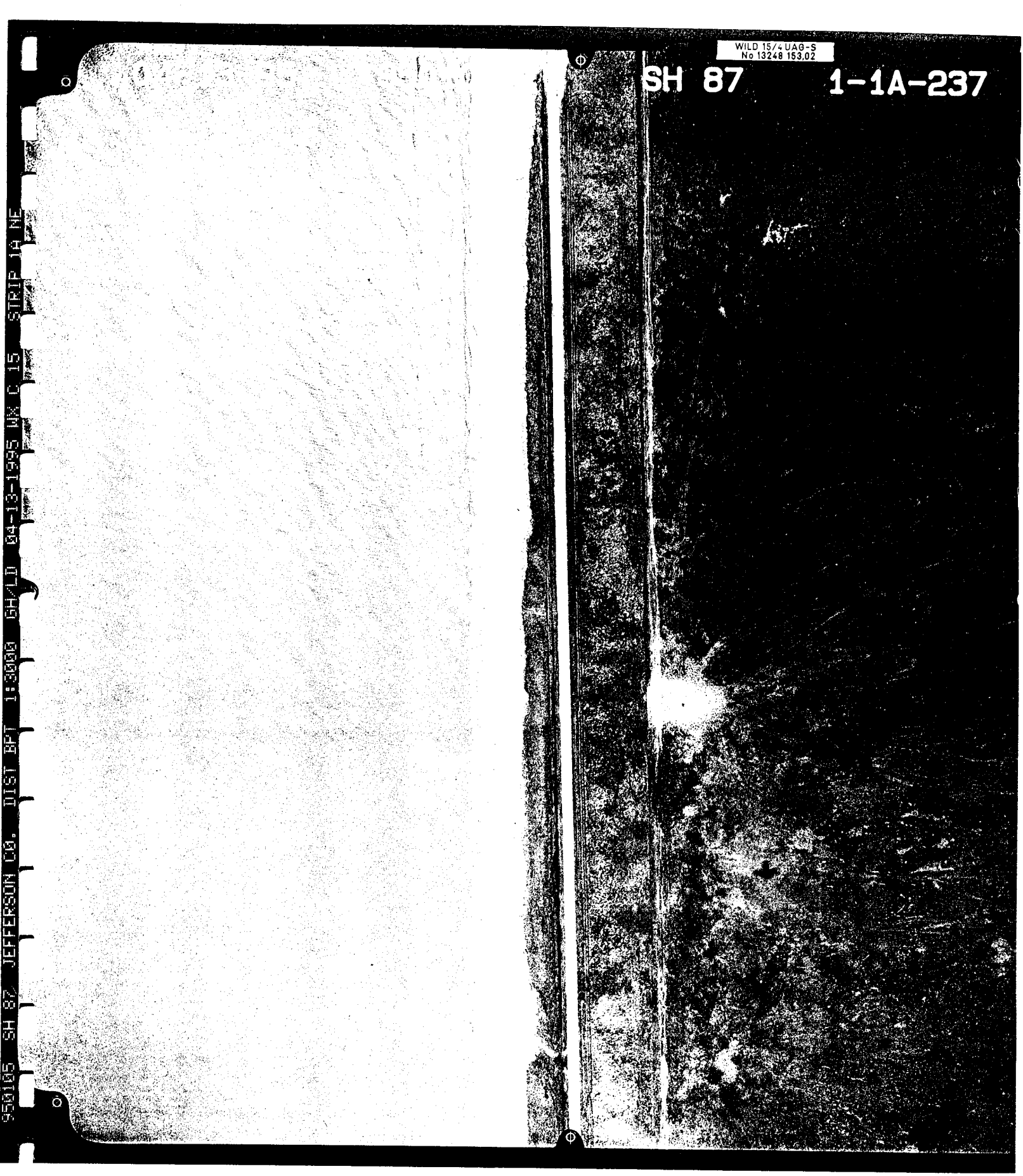
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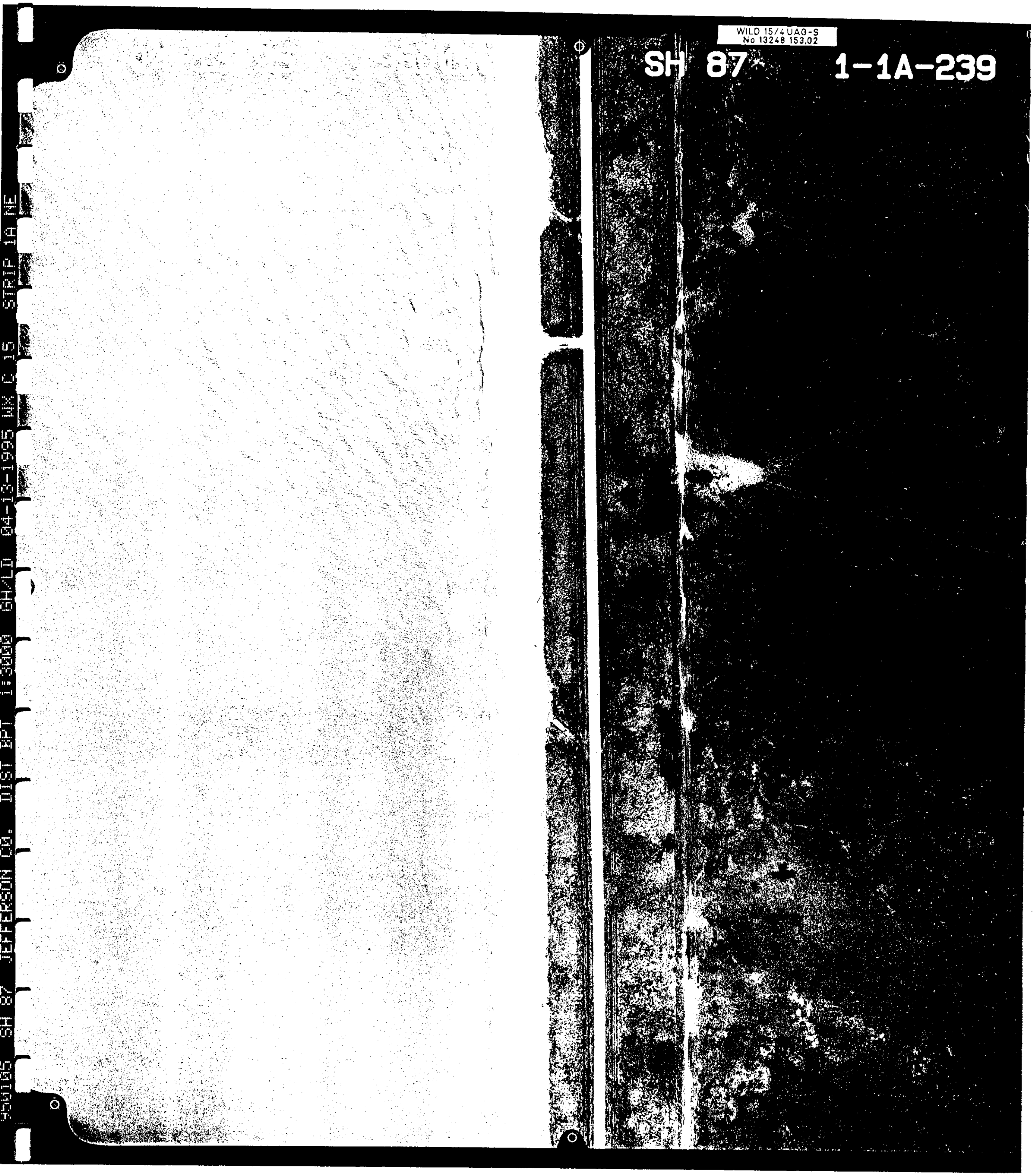
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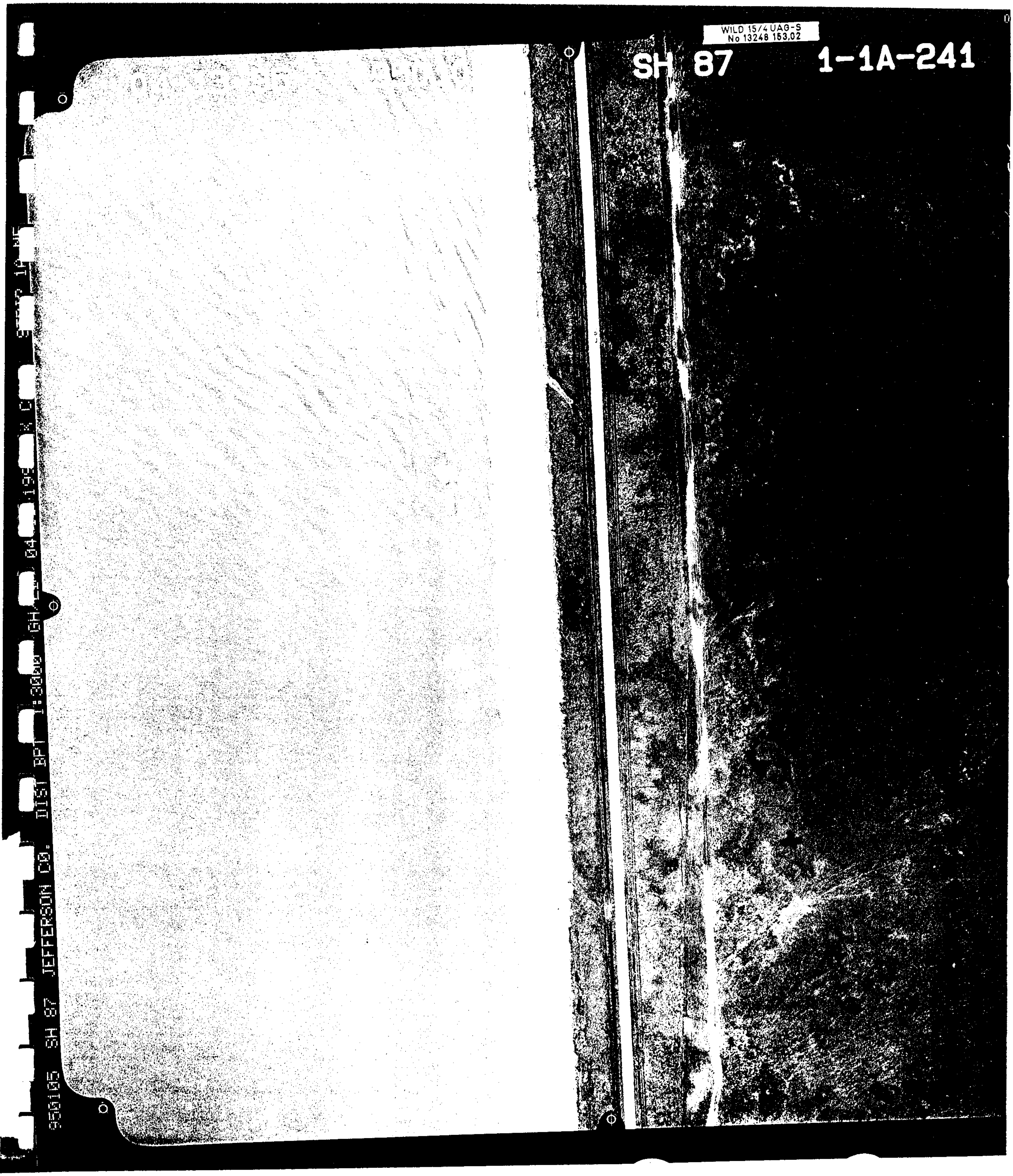
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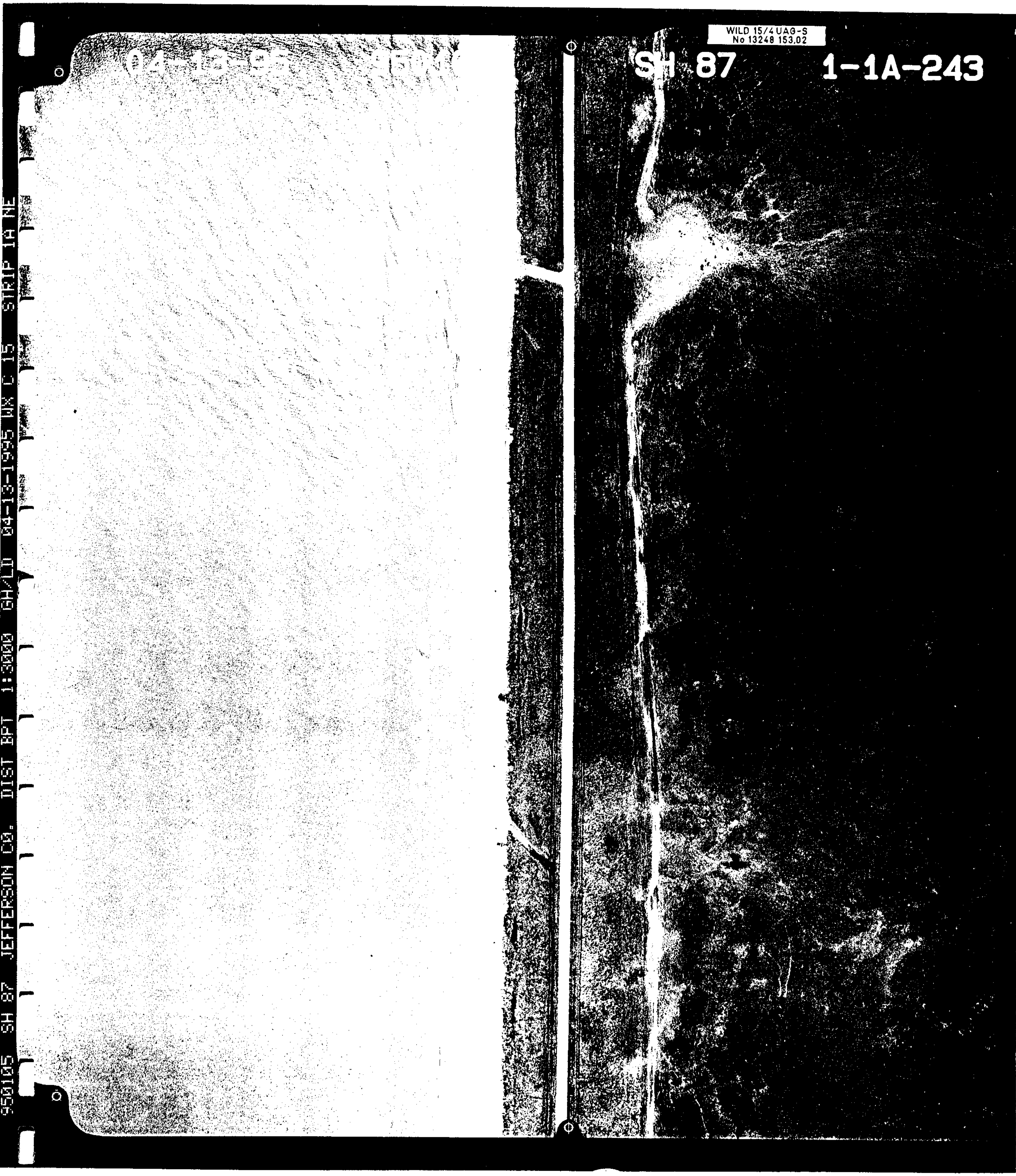
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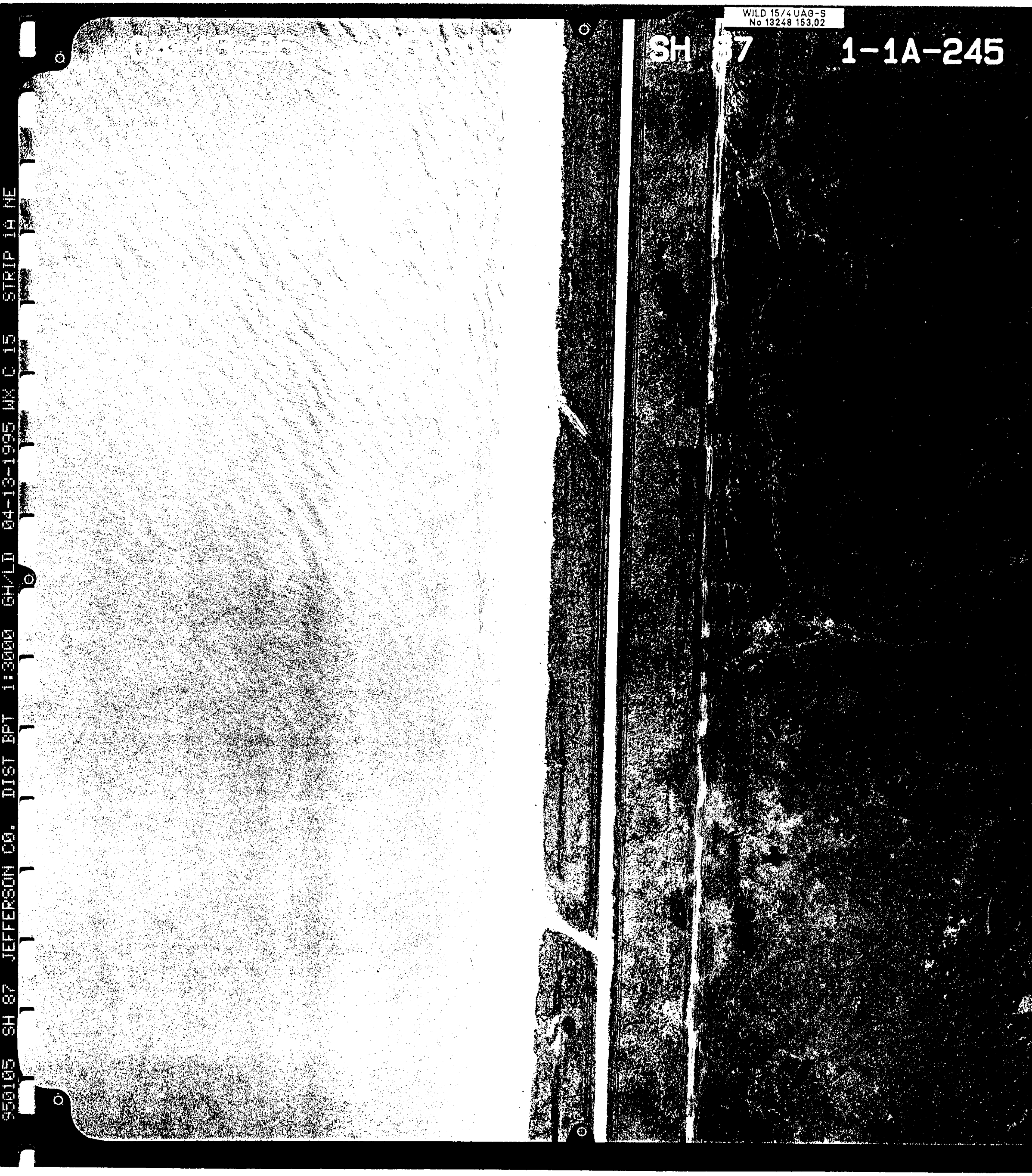
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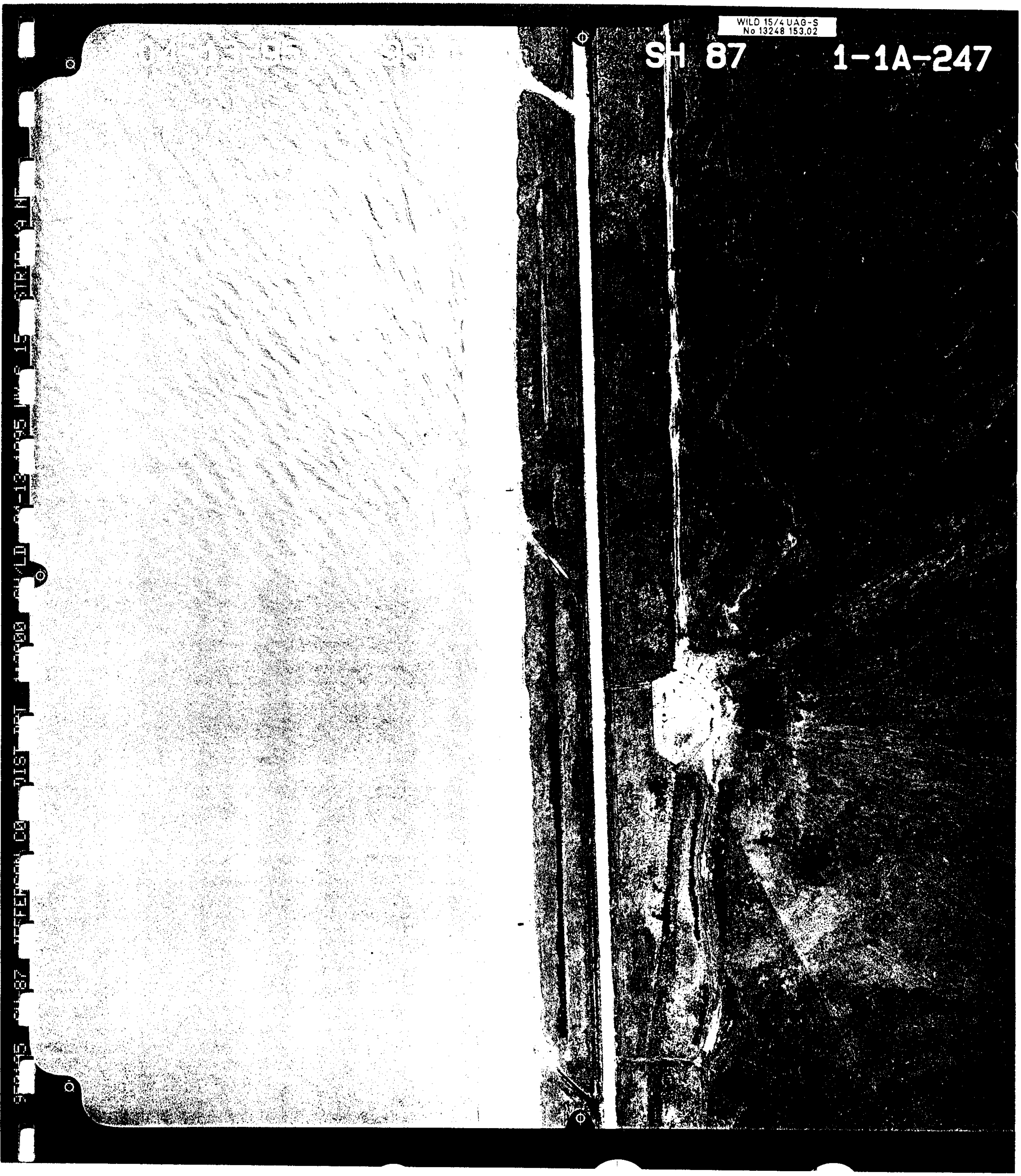
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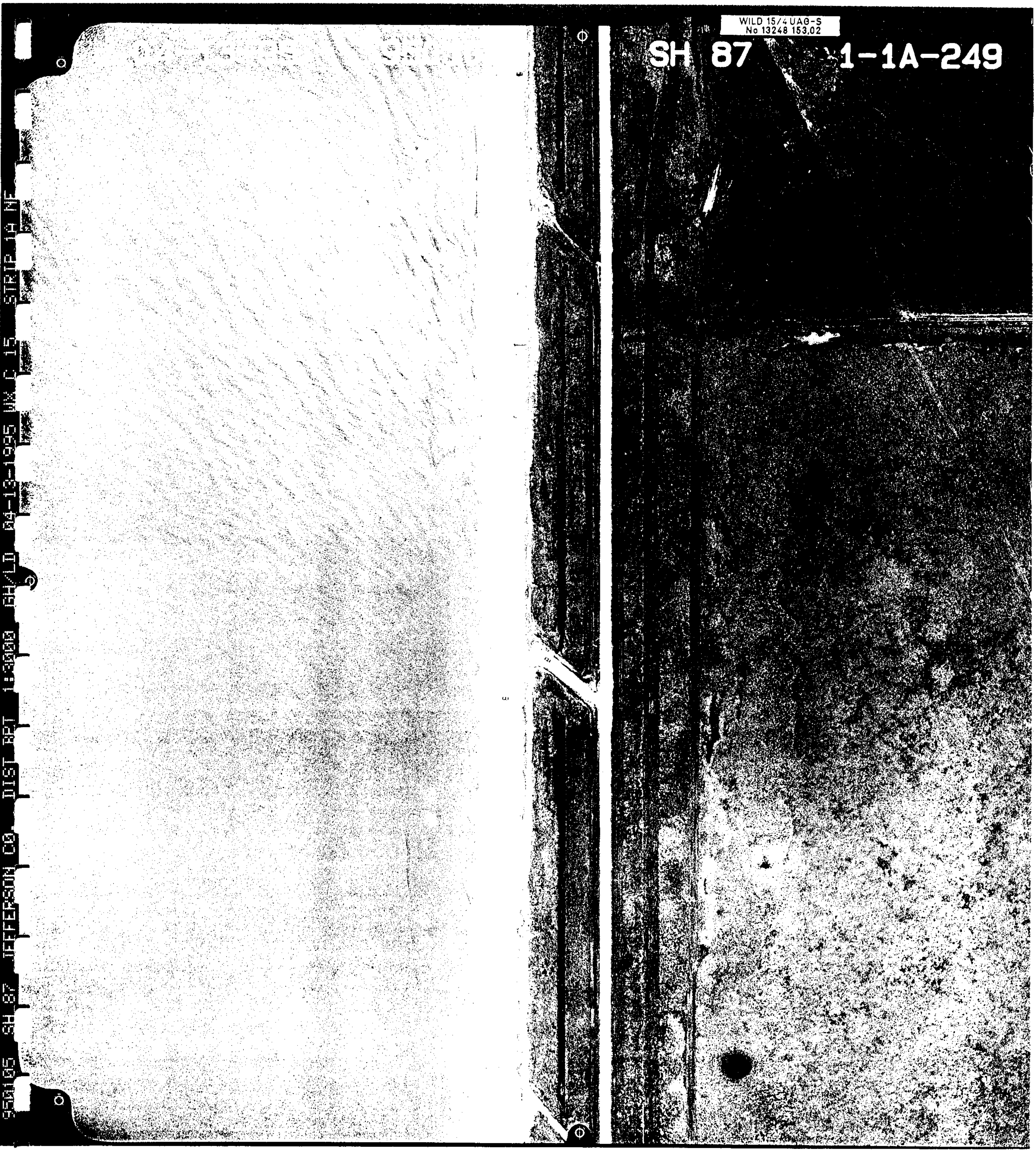
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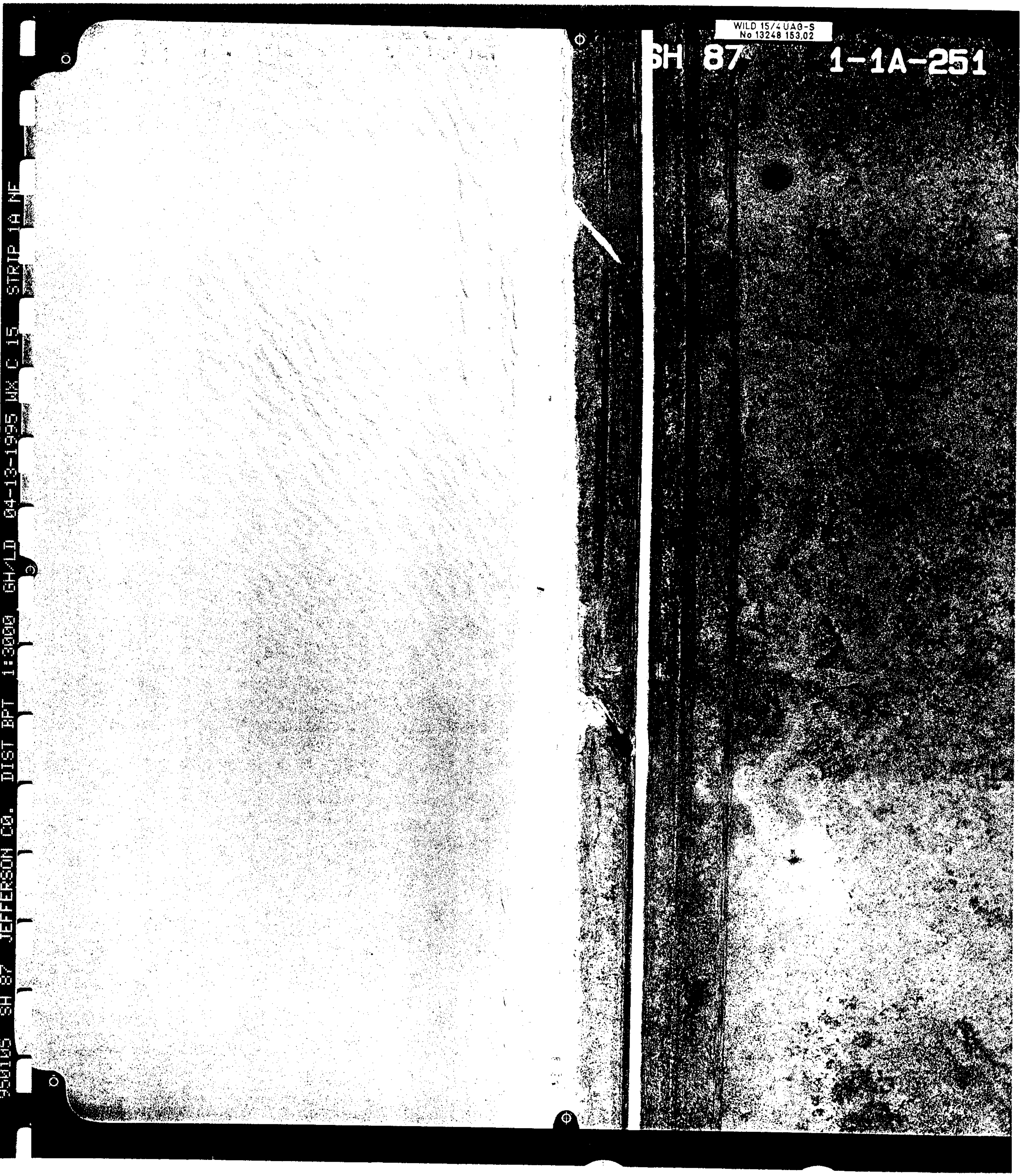
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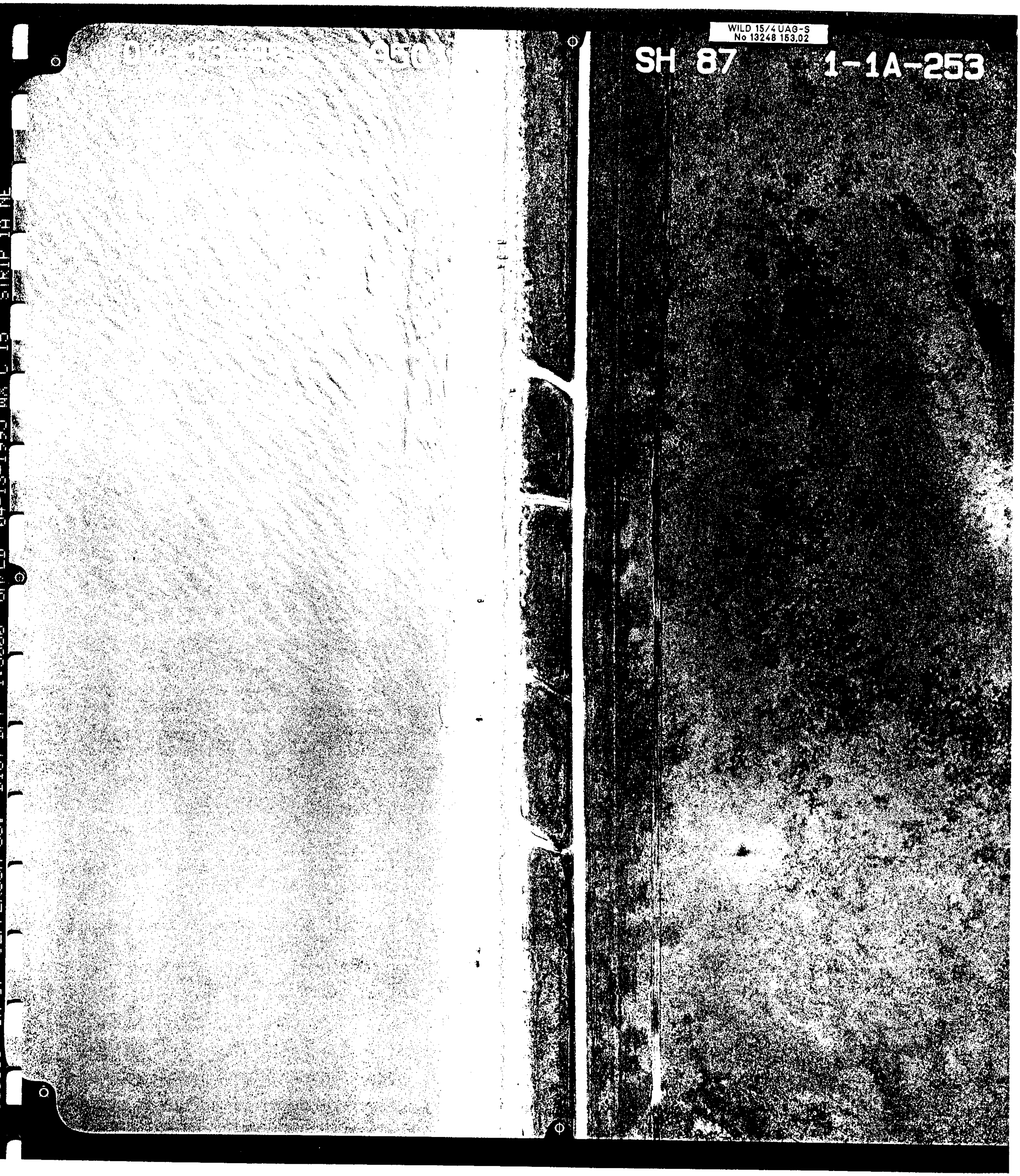
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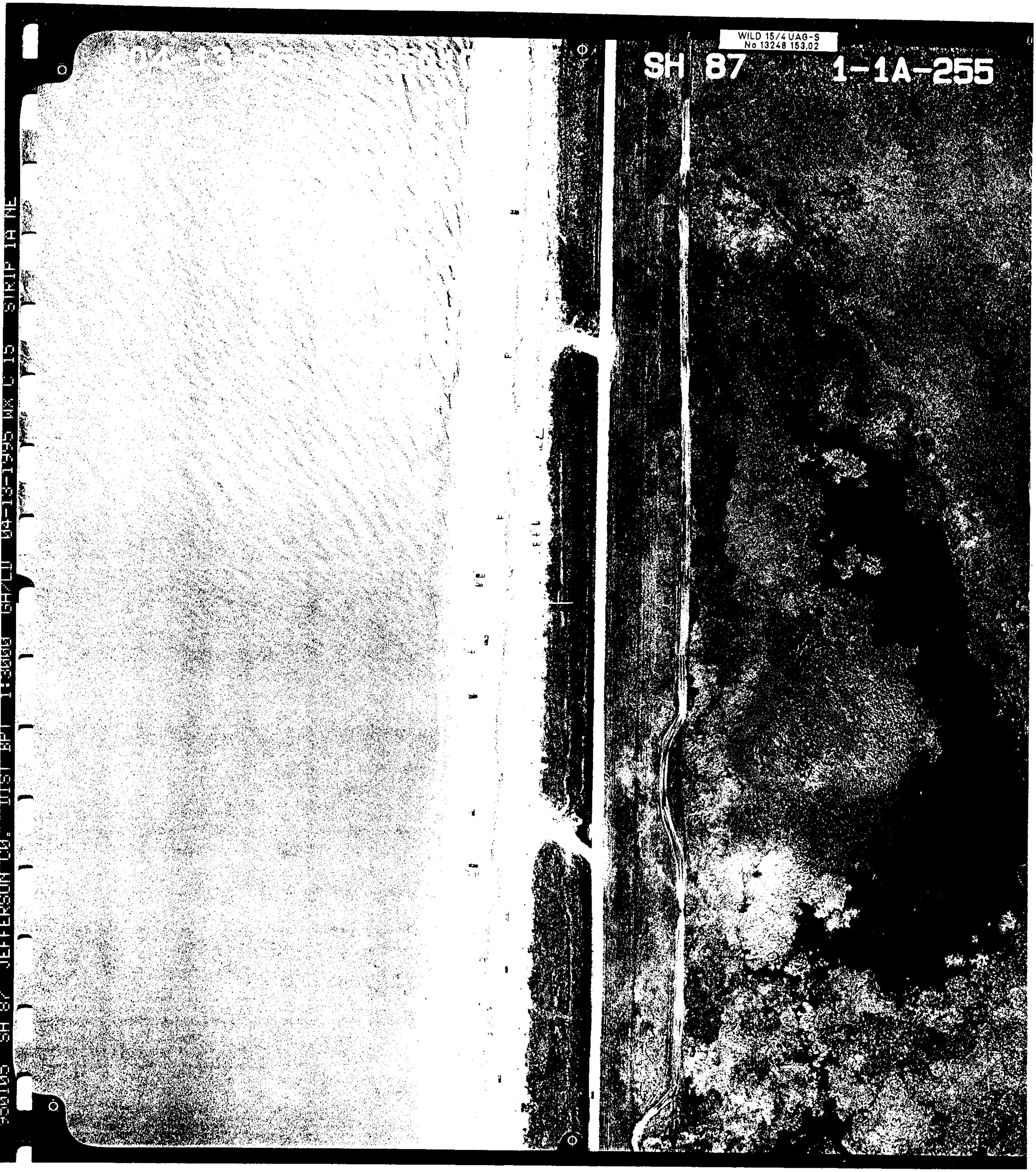
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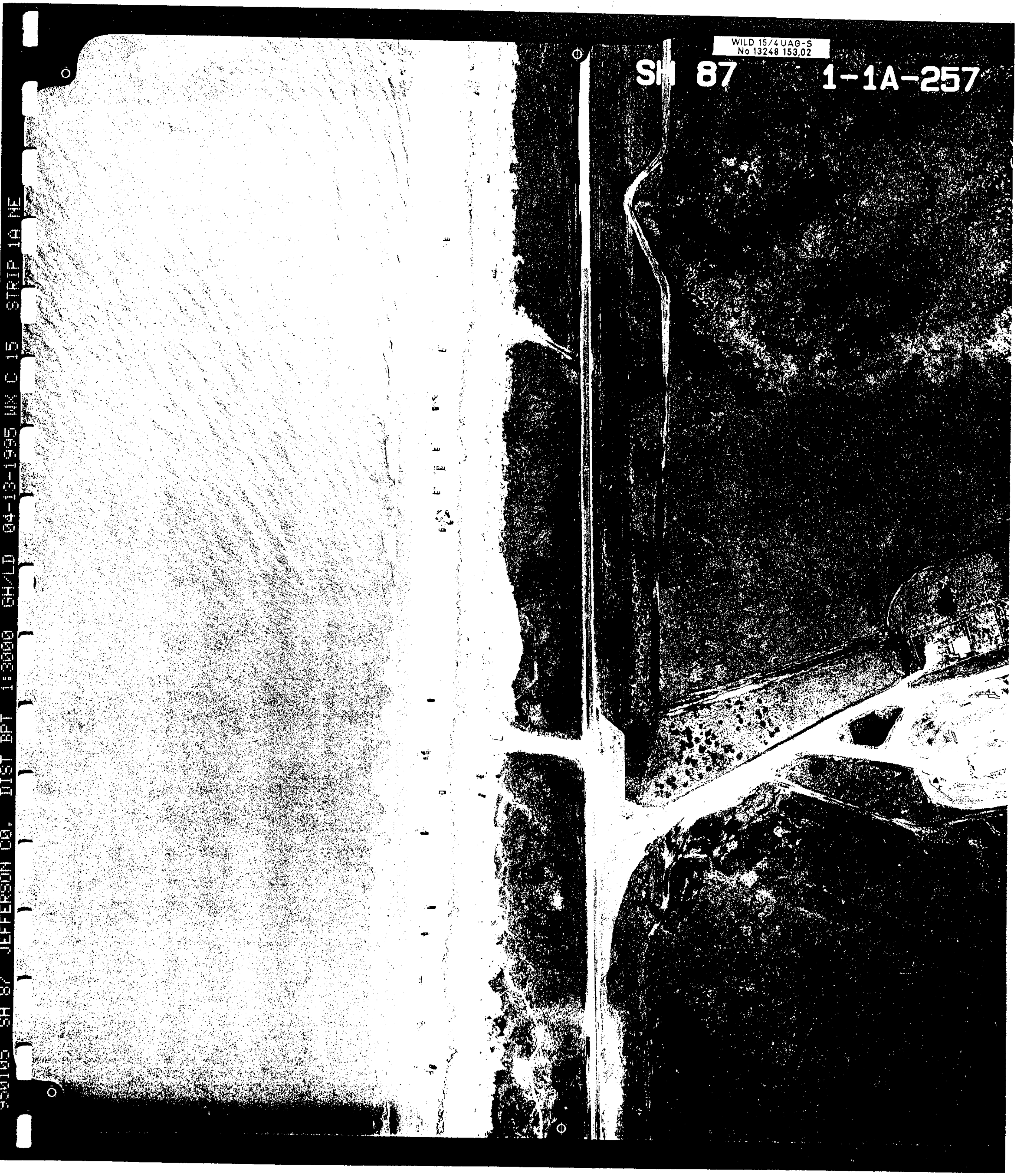
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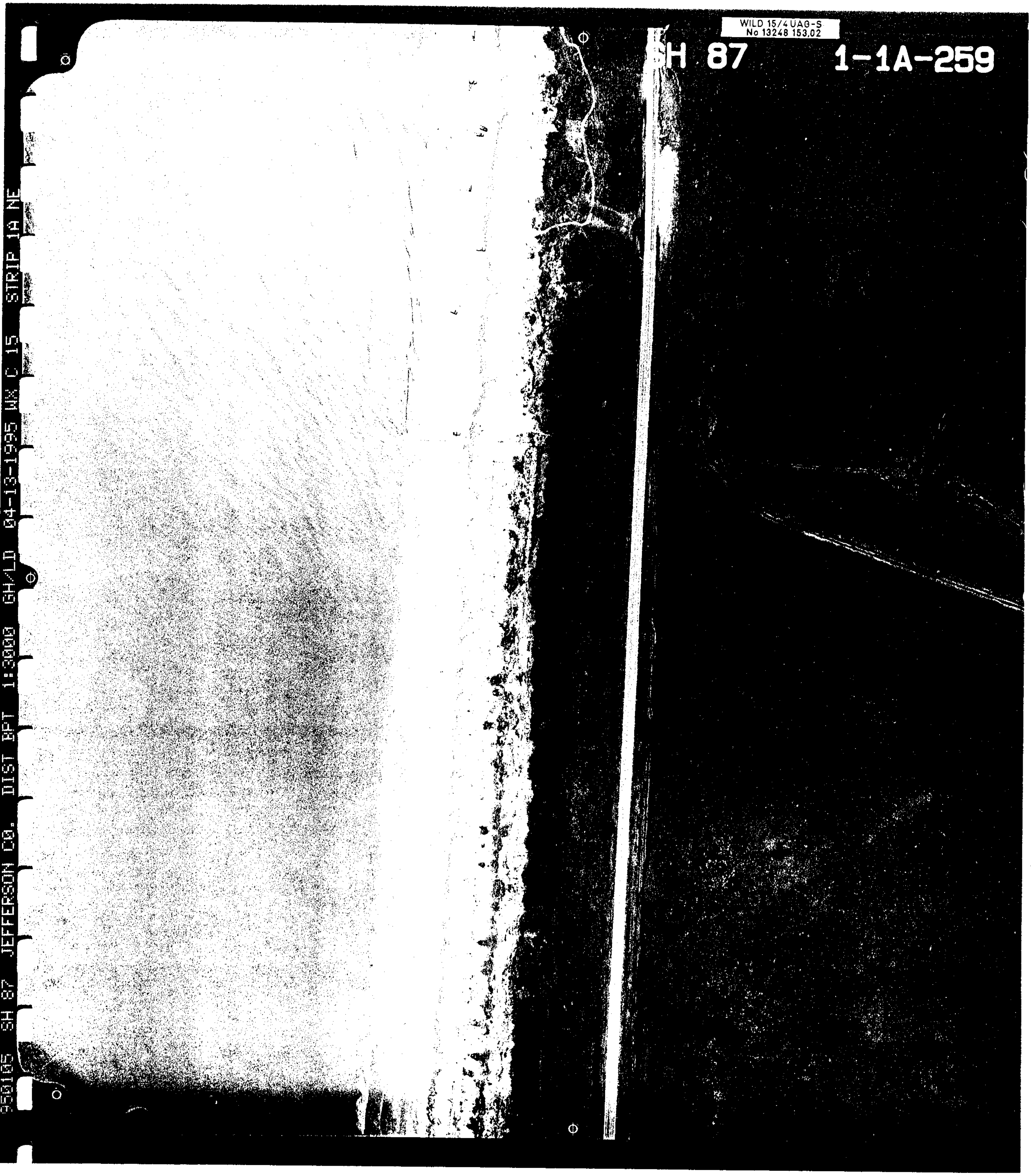
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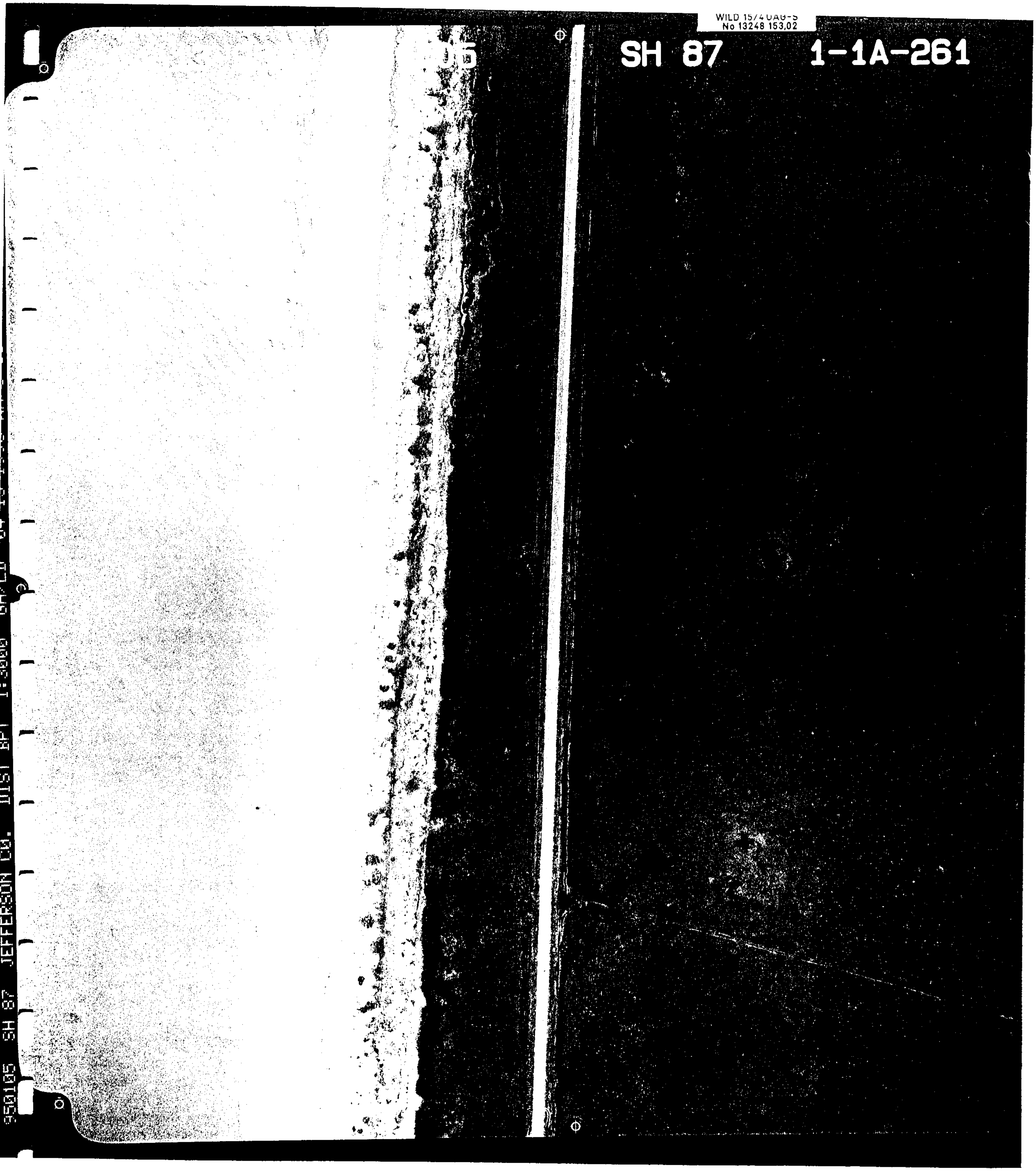
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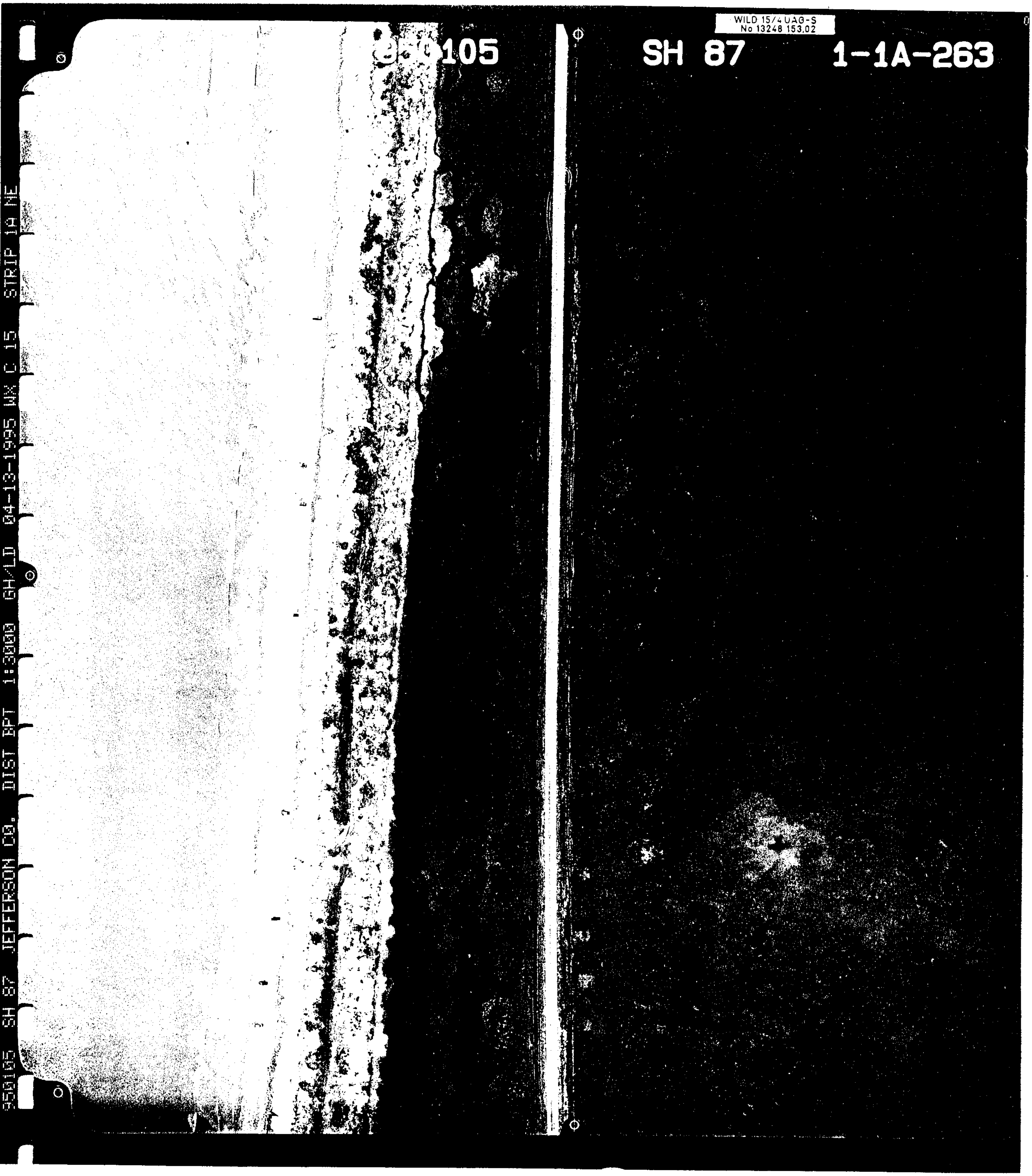
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Appendix B

WIS Gulf Station 79 Summary Data

WIS GULF OF MEXICO UPDATE - WITH HURRICANES 1976 - 1995
LAT: 29.00 N, LONG: 95.00 W, DEPTH: 15 M
SUMMARY OF WAVE INFORMATION BY MONTH

STATION: 79

OCCURRENCES OF WAVE HEIGHT BY MONTH FOR ALL YEARS

Hs (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
0.00 - 0.49	911	643	595	565	599	849	1682	2467	1636	1320	798	816	12881
0.50 - 0.99	2056	1961	1779	1800	2330	3001	2804	2137	2503	2621	2205	2069	27266
1.00 - 1.49	1461	1249	1548	1609	1508	808	383	255	527	751	1222	1469	12790
1.50 - 1.99	428	501	739	579	419	100	71	28	71	190	413	402	3941
2.00 - 2.49	86	125	238	177	86	27	10	21	27	38	99	128	1062
2.50 - 2.99	14	41	52	65	18	10	7	18	7	27	53	69	381
3.00 - 3.49	4	.	9	5	.	5	3	8	7	7	10	7	65
3.50 - 3.99	.	.	.	.	.	.	.	4	6	1	.	.	11
4.00 - 4.49	.	.	.	.	.	.	.	5	14	2	.	.	21
4.50 - 4.99	.	.	.	.	.	.	.	3	2	1	.	.	6
5.00 - 5.49	.	.	.	.	.	.	.	8	.	.	.	.	8
5.50 - 5.99	.	.	.	.	.	.	.	6	.	2	.	.	8
6.00 - 6.49	.	.	.	.	.	.	.	.	.	.	.	.	0
6.50 - 6.99	.	.	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.49	.	.	.	.	.	.	.	.	.	.	.	.	0
7.50 - 7.99	.	.	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.49	.	.	.	.	.	.	.	.	.	.	.	.	0
8.50 - 8.99	.	.	.	.	.	.	.	.	.	.	.	.	0
9.00 - 9.49	.	.	.	.	.	.	.	.	.	.	.	.	0
9.50 - 9.99	.	.	.	.	.	.	.	.	.	.	.	.	0
10.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

STATION: 79

OCCURRENCES OF PEAK PERIOD BY MONTH FOR ALL YEARS

Tp(sec)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
3.0 - 3.9	843	579	478	353	258	342	760	1095	864	1016	703	780	8071
4.0 - 4.9	1148	988	724	601	672	895	1469	1606	1339	1283	1093	1127	12945
5.0 - 5.9	862	826	743	972	1337	1732	1682	1474	1371	1164	874	913	13950
6.0 - 6.9	859	770	985	1128	1522	1252	819	467	695	769	855	962	11083
7.0 - 7.9	715	733	950	1019	836	457	169	169	243	415	702	647	7055
8.0 - 8.9	331	418	656	506	281	89	41	61	110	140	345	340	3318
9.0 - 9.9	165	161	330	203	48	28	12	19	56	60	141	163	1386
10.0 - 10.9	35	31	74	18	6	4	8	9	22	28	33	28	296
11.0 - 11.9	2	9	18	.	.	1	.	29	12	26	10	.	107
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19.0 - 19.9	.	.	.	.	.	.	.	.	.	.	.	.	0
20.0 - LONGER	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

STATION: 79

OCCURRENCES OF PEAK DIRECTION BY MONTH FOR ALL YEARS

Dm(deg) DIRECTION BAND & CENTER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
348.75 - 11.24 (0.0)	402	265	102	40	16	29	5	2	127	259	277	394	1918
11.25 - 33.74 (22.5)	366	243	111	46	28	25	2	8	153	261	273	303	1819
33.75 - 56.24 (45.0)	260	206	140	99	54	35	11	48	185	261	243	273	1815
56.25 - 78.74 (67.5)	334	283	173	147	69	63	29	138	353	437	326	377	2729
78.75 - 101.24 (90.0)	373	335	216	196	150	157	101	327	565	608	372	365	3765
101.25 - 123.74 (112.5)	466	427	448	588	706	642	716	912	1040	994	611	467	8017
123.75 - 146.24 (135.0)	997	1031	1943	2186	2491	2345	1540	1509	1261	1121	1088	933	18445
146.25 - 168.74 (157.5)	996	1074	1407	1166	1292	1222	1779	1262	818	722	1045	1046	13829
168.75 - 191.24 (180.0)	431	371	246	228	125	274	718	674	267	171	366	533	4404
191.25 - 213.74 (202.5)	46	36	35	21	16	6	55	70	17	28	15	15	360

213.75 - 236.24 (225.0)	21	21	12	8	4	1	3	6	.	16	1	3	96
236.25 - 258.74 (247.5)	11	19	11	2	.	1	.	1	.	5	15	11	76
258.75 - 281.24 (270.0)	11	10	4	.	.	.	.	1	.	1	7	8	42
281.25 - 303.74 (292.5)	25	21	6	5	2	.	.	1	.	3	22	21	106
303.75 - 326.24 (315.0)	62	50	43	31	5	.	.	1	1	18	26	59	296
326.25 - 348.74 (337.5)	159	128	63	37	2	.	1	.	13	55	113	152	723
TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

WIS GULF OF MEXICO UPDATE - WITH HURRICANES 1976 - 1995
LAT: 29.00 N, LONG: 95.00 W, DEPTH: 15 M
OCCURRENCES OF WAVE HEIGHT AND PEAK PERIOD FOR 22.5-DEG DIRECTION BANDS

STATION: 79 (348.75 - 11.24) 0.0 DEG

Hs(m) \ Tp(sec)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	1090	374	.	.	.	.	.	.	.	.	1464
1.00 - 1.99	.	420	28	.	.	.	.	.	.	.	448
2.00 - 2.99	.	.	3	3	.	.	.	.	.	.	6
3.00 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	1090	794	31	3	0	0	0	0	0	0	1918

STATION: 79 (11.25 - 33.74) 22.5 DEG

Hs(m) \ Tp(sec)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	1085	414	.	.	.	.	.	.	.	.	1499
1.00 - 1.99	.	314	6	.	.	.	.	.	.	.	320
2.00 - 2.99	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	1085	728	6	0	0	0	0	0	0	0	1819

STATION: 79 (33.75 - 56.24) 45.0 DEG
Tp(sec)

Hs (m)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	658	724	194	13	.	.	.	.	.	.	1589
1.00 - 1.99	.	107	21	90	6	.	.	.	.	.	224
2.00 - 2.99	.	.	.	.	1	1	.	.	.	.	2
3.00 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	658	831	215	103	7	1	0	0	0	0	1815

STATION: 79 (56.25 - 78.74) 67.5 DEG

Tp (sec)

Hs (m)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	593	1021	674	93	.	.	.	.	.	.	2381
1.00 - 1.99	.	44	79	178	28	.	.	.	.	.	329
2.00 - 2.99	.	.	.	1	15	2	.	.	.	.	18
3.00 - 3.99	.	.	.	.	.	1	.	.	.	.	1
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	593	1065	753	272	43	3	0	0	0	0	2729

STATION: 79 (78.75 - 101.24) 90.0 DEG

Tp (sec)

Hs (m)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	801	1474	936	58	1	.	.	.	.	.	3270
1.00 - 1.99	.	13	199	203	35	2	.	.	.	.	452
2.00 - 2.99	.	.	.	5	11	11	7	.	.	.	34

3.00 - 3.99	.	.	.	.	3	5	.	.	.	.	8
4.00 - 4.99	.	.	.	.	.	.	1	.	.	.	1
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	801	1487	1135	266	50	18	8	0	0	0	3765

WIS GULF OF MEXICO UPDATE - WITH HURRICANES 1976 - 1995
LAT: 29.00 N, LONG: 95.00 W, DEPTH: 15 M
OCCURRENCES OF WAVE HEIGHT AND PEAK PERIOD FOR 22.5-DEG DIRECTION BANDS

STATION: 79 (101.25 - 123.74) 112.5 DEG

Hs(m) \ Tp(sec)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	796	1442	2208	1530	868	110	8	.	.	.	6962
1.00 - 1.99	.	17	302	461	193	36	3	.	.	.	1012
2.00 - 2.99	.	.	.	3	16	11	4	.	.	.	34
3.00 - 3.99	.	.	.	.	.	1	2	1	.	.	4
4.00 - 4.99	.	.	.	.	.	.	1	.	.	.	1
5.00 - 5.99	.	.	.	.	.	.	.	.	.	4	4
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	796	1459	2510	1994	1077	158	18	1	0	4	8017

STATION: 79 (123.75 - 146.24) 135.0 DEG

Hs(m) \ Tp(sec)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	847	2395	3854	2375	1047	716	392	93	35	46	11800
1.00 - 1.99	.	66	818	2379	1993	732	242	69	24	45	6368
2.00 - 2.99	.	.	.	5	26	90	87	18	7	10	243
3.00 - 3.99	.	.	.	.	.	.	3	.	4	6	13
4.00 - 4.99	.	.	.	.	.	.	.	1	2	9	12
5.00 - 5.99	.	.	.	.	.	.	.	.	.	9	9
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	847	2461	4672	4759	3066	1538	724	181	72	125	18445

STATION: 79 (146.25 - 168.74) 157.5 DEG
Tp(sec)

Hs (m)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	675	2084	2797	863	220	103	41	3	6	20	6812
1.00 - 1.99	.	36	689	2130	1996	884	151	18	12	18	5934
2.00 - 2.99	.	.	.	14	94	446	389	65	2	14	1024
3.00 - 3.99	.	.	.	.	.	1	9	20	6	8	44
4.00 - 4.99	.	.	.	.	.	.	.	.	.	12	12
5.00 - 5.99	.	.	.	.	.	.	.	.	.	3	3
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	675	2120	3486	3007	2310	1434	590	106	26	75	13829

STATION: 79 (168.75 - 191.24) 180.0 DEG

Tp (sec)

Hs (m)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	686	1239	807	223	100	58	11	1	.	4	3129
1.00 - 1.99	.	24	234	438	381	81	15	6	7	12	1198
2.00 - 2.99	.	.	.	5	21	24	14	.	2	6	72
3.00 - 3.99	.	.	.	.	.	1	1	.	.	3	5
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	686	1263	1041	666	502	164	41	7	9	25	4404

STATION: 79 (191.25 - 213.74) 202.5 DEG

Tp (sec)

Hs (m)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	235	90	11	.	.	.	.	.	.	.	336
1.00 - 1.99	.	2	13	3	.	.	.	.	.	.	18
2.00 - 2.99	.	.	.	5	.	.	.	.	.	.	5

3.00 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.99	.	.	.	.	.	1	.	.	.	.	1
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	235	92	24	8	0	1	0	0	0	0	360

WIS GULF OF MEXICO UPDATE - WITH HURRICANES 1976 - 1995
LAT: 29.00 N, LONG: 95.00 W, DEPTH: 15 M
OCCURRENCES OF WAVE HEIGHT AND PEAK PERIOD FOR 22.5-DEG DIRECTION BANDS

STATION: 79 (213.75 - 236.24) 225.0 DEG

Hs(m) \ Tp(sec)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	62	23	.	.	.	.	4	1	.	.	90
1.00 - 1.99	.	1	1	1	.	.	.	.	.	.	3
2.00 - 2.99	.	.	.	2	.	.	.	.	.	.	2
3.00 - 3.99	.	.	.	1	.	.	.	.	.	.	1
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	62	24	1	4	0	0	4	1	0	0	96

STATION: 79 (236.25 - 258.74) 247.5 DEG

Hs(m) \ Tp(sec)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	64	8	.	.	.	1	1	.	.	.	74
1.00 - 1.99	.	.	1	1	.	.	.	.	.	.	2
2.00 - 2.99	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	64	8	1	1	0	1	1	0	0	0	76

STATION: 79 (258.75 - 281.24) 270.0 DEG
Tp(sec)

Hs (m) \ Tp (sec)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	33	4	.	.	.	.	.	.	.	.	37
1.00 - 1.99	.	2	3	.	.	.	.	.	.	.	5
2.00 - 2.99	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	33	6	3	0	0	0	0	0	0	0	42

STATION: 79 (281.25 - 303.74) 292.5 DEG

Hs (m) \ Tp (sec)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	46	22	.	.	.	.	.	.	.	.	68
1.00 - 1.99	.	26	12	.	.	.	.	.	.	.	38
2.00 - 2.99	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	46	48	12	0	0	0	0	0	0	0	106

STATION: 79 (303.75 - 326.24) 315.0 DEG

Hs (m) \ Tp (sec)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	96	68	.	.	.	.	.	.	.	.	164
1.00 - 1.99	.	111	20	.	.	.	.	.	.	.	131
2.00 - 2.99	.	.	1	.	.	.	.	.	.	.	1

3.00 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	96	179	21	0	0	0	0	0	0	0	296

WIS GULF OF MEXICO UPDATE - WITH HURRICANES 1976 - 1995
LAT: 29.00 N, LONG: 95.00 W, DEPTH: 15 M
OCCURRENCES OF WAVE HEIGHT AND PEAK PERIOD FOR 22.5-DEG DIRECTION BANDS

STATION: 79 (326.25 - 348.74) 337.5 DEG

Hs(m) \ Tp(sec)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	304	168	.	.	.	.	.	.	.	.	472
1.00 - 1.99	.	212	37	.	.	.	.	.	.	.	249
2.00 - 2.99	.	.	2	.	.	.	.	.	.	.	2
3.00 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	304	380	39	0	0	0	0	0	0	0	723

STATION: 79

OCCURRENCES OF WAVE HEIGHT AND PEAK PERIOD FOR ALL DIRECTIONS

Hs(m) \ Tp(sec)	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-LONGER	TOTAL
0.00 - 0.99	8071	11550	11481	5155	2236	988	457	98	41	70	40147
1.00 - 1.99	.	1395	2463	5884	4632	1735	411	93	43	75	16731
2.00 - 2.99	.	.	6	43	184	585	501	83	11	30	1443
3.00 - 3.99	.	.	.	1	3	9	15	21	10	17	76
4.00 - 4.99	.	.	.	.	.	1	2	1	2	21	27
5.00 - 5.99	.	.	.	.	.	.	.	.	.	16	16
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0

8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	8071	12945	13950	11083	7055	3318	1386	296	107	229	58440

STATION: 79

OCCURRENCES OF WIND SPEED BY MONTH FOR ALL YEARS

WS(m/sec)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
0.00 - 2.49	513	427	445	563	807	1100	1471	1860	1244	799	467	491	10187
2.50 - 4.99	1263	1062	1424	1482	1852	2218	2493	2497	2286	2041	1498	1323	21439
5.00 - 7.49	2188	2152	2283	2193	2019	1430	958	526	1162	1808	2096	2213	21028
7.50 - 9.99	708	700	644	470	260	30	18	3	62	234	554	655	4338
10.00 - 12.49	274	172	155	92	22	14	10	33	29	38	171	263	1273
12.50 - 14.99	11	7	8	.	.	8	6	12	10	13	14	15	104
15.00 - 17.49	3	.	1	.	.	.	2	16	7	15	.	.	44
17.50 - 19.99	.	.	.	.	.	.	1	4	.	4	.	.	9
20.00 - GREATER	.	.	.	.	.	.	1	9	.	8	.	.	18
TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

STATION: 79

OCCURRENCES OF WIND DIRECTION BY MONTH FOR ALL YEARS

WD(deg) DIRECTION BAND & CENTER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
337.50 - 22.49 (0.0)	1275	911	626	404	293	156	104	148	533	862	1029	1202	7543
22.50 - 67.49 (45.0)	839	743	681	588	486	355	223	528	1021	941	785	768	7958
67.50 - 112.49 (90.0)	573	554	534	693	774	704	531	875	1132	944	608	548	8470
112.50 - 157.49 (135.0)	787	799	1561	1883	2361	1985	1614	1507	1228	1320	1055	927	17027
157.50 - 202.49 (180.0)	631	762	854	777	748	1259	1963	1346	645	549	760	799	11093
202.50 - 247.49 (225.0)	195	202	199	117	115	207	372	348	103	119	122	194	2293
247.50 - 292.49 (270.0)	150	166	127	103	60	76	89	114	55	63	112	136	1251
292.50 - 337.49 (315.0)	510	383	378	235	123	58	64	94	83	162	329	386	2805

TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

WIS GULF OF MEXICO UPDATE - WITH HURRICANES 1976 - 1995
LAT: 29.00 N, LONG: 95.00 W, DEPTH: 15 M
OCCURRENCES OF WAVE HEIGHT AND PEAK PERIOD FOR 22.5-DEG DIRECTION BANDS

STATION: 79

SUMMARY OF MEAN Hs(m) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1976	1.02	1.01	1.24	1.05	0.80	0.71	0.58	0.35	0.45	0.68	0.73	0.84	0.79
1977	0.85	1.08	1.31	0.94	0.80	0.70	0.50	0.68	0.84	0.63	0.85	1.12	0.86
1978	1.03	0.82	0.90	0.96	0.94	0.61	0.53	0.61	0.72	0.51	0.77	1.04	0.79
1979	1.08	0.93	1.07	1.11	0.84	0.62	0.78	0.42	0.69	0.72	0.83	0.68	0.81
1980	0.84	0.89	1.16	0.83	0.91	0.71	0.44	1.08	0.60	0.62	0.78	0.71	0.80
1981	0.63	0.90	0.87	1.00	0.97	0.92	0.60	0.47	0.54	0.77	0.84	1.00	0.79
1982	1.06	0.82	1.03	1.11	0.96	0.72	0.54	0.46	0.62	0.76	0.88	1.26	0.85
1983	0.71	0.97	1.09	1.20	1.16	0.63	0.66	0.74	0.72	0.55	1.08	0.93	0.87
1984	0.77	0.94	0.96	1.35	1.01	0.74	0.51	0.55	0.84	1.01	0.95	1.09	0.89
1985	0.74	0.97	1.11	1.11	0.66	0.83	0.54	0.55	0.78	0.93	0.91	0.81	0.83
1986	0.80	0.94	0.90	1.00	0.93	0.58	0.57	0.48	0.71	0.70	0.82	0.72	0.76
1987	0.80	0.94	0.87	0.52	0.74	0.71	0.58	0.52	0.47	0.60	0.87	1.08	0.73
1988	0.98	0.99	1.10	0.88	0.73	0.57	0.57	0.50	0.88	0.57	1.17	0.88	0.82
1989	0.93	1.12	1.03	0.87	1.04	1.07	0.59	0.53	0.46	0.79	0.83	0.75	0.83
1990	0.87	1.10	1.06	1.08	1.14	0.75	0.50	0.47	0.39	0.54	0.89	1.03	0.82
1991	0.87	0.89	1.31	1.21	1.03	0.73	0.55	0.44	0.63	0.66	0.92	1.01	0.85
1992	0.75	0.81	0.97	0.77	0.70	0.58	0.77	0.40	0.68	0.64	0.91	0.93	0.74
1993	0.74	0.90	0.93	1.14	0.87	1.06	0.68	0.51	0.68	0.71	0.85	0.84	0.83
1994	1.16	0.89	0.86	1.00	0.73	0.77	0.72	0.51	0.47	0.79	0.97	0.73	0.80
1995	0.90	0.81	1.04	1.11	1.16	0.65	0.65	0.52	0.44	0.96	0.93	0.87	0.84
MEAN	0.88	0.94	1.04	1.01	0.91	0.73	0.59	0.54	0.63	0.71	0.89	0.92	

STATION: 79

MAX Hs(m)*10 WITH ASSOCIATED Tp(sec) AND Dm(deg/10) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1976	21 816	22 816	24 815	30 914	18 714	13 615	15 714	7 5 9	9 4 3	22 913	19 717	21 816	30 914
1977	19 814	271016	311015	20 815	14 614	14 714	9 514	291214	441315	14 6 8	19 816	25 816	441315
1978	27 916	26 916	23 915	18 815	21 815	10 612	10 617	14 713	19 816	11 4 2	17 817	28 916	28 916
1979	21 816	16 717	22 815	271015	17 816	11 514	30 818	11 612	24 712	311016	17 717	19 816	311016
1980	19 717	25 915	24 917	22 816	23 815	11 414	9 615	571414	17 517	25 916	341314	19 715	571414
1981	16 6 5	21 816	22 814	26 916	26 915	23 914	15 715	15 717	15 717	15 714	27 917	321016	321016
1982	311016	15 716	17 7 7	21 817	27 914	15 615	10 415	8 514	25 913	16 717	20 717	311015	311015
1983	23 816	23 816	30 916	25 915	22 915	11 416	14 614	531212	14 435	12 613	30 917	18 816	531212
1984	22 815	25 916	20 816	311016	21 815	16 714	9 713	12 813	17 712	25 916	21 817	29 916	311016
1985	19 5 1	23 814	25 816	28 916	17 715	21 815	10 515	21 7 6	14 614	30 8 6	29 9 9	17 817	30 8 6
1986	21 7 7	23 816	23 816	26 915	18 714	16 524	15 717	13 714	13 615	15 715	17 913	16 713	26 915
1987	21 817	19 817	331015	17 815	16 714	14 714	11 715	10 714	9 617	14 6 6	271015	26 916	331015
1988	23 915	21 817	27 914	20 815	16 715	12 713	12 616	11 616	451113	9 516	301016	25 916	451113
1989	22 916	26 916	28 915	20 917	23 815	26 717	20 6 7	301113	8 6 5	561214	17 913	18 817	561214
1990	20 816	21 916	23 916	22 814	27 915	19 815	11 613	121017	9 5 5	15 717	26 916	24 917	27 915
1991	24 916	26 917	23 916	251015	17 716	14 714	11 616	7 517	12 4 3	16 715	25 916	291014	291014
1992	20 814	19 815	21 916	16 713	15 714	11 617	17 815	121113	13 6 5	13 5 8	18 816	26 915	26 915
1993	15 715	26 917	29 915	21 816	18 714	31 810	13 616	11 617	21 816	18 916	21 816	25 816	31 810
1994	26 816	19 717	221015	20 613	16 715	12 614	11 615	13 716	12 716	17 714	301016	15 716	301016
1995	21 817	17 718	20 814	27 914	24 915	14 614	32 810	161318	11 813	271316	23 917	19 816	32 810
MAX	311016	271016	331015	311016	27 915	31 810	32 810	571414	451113	561214	341314	321016	

MAX Hs(m): 5.7 MAX Tp(sec): 14. MAX Dm(deg): 144. DATE(gmt): 1980081000

MAX WIND SPEED(m/sec): 29. MAX WIND DIRECTION(deg): 60. DATE(gmt): 1983081803

MEAN Hmo(m): 0.8 MEAN Tp(sec): 5.

STANDARD DEVIATION Hmo(m): 0.5 STANDARD DEVIATION Tp(sec): 1.6