

FEBRUARY 23, 1993. NRC MEETING

PRESENTATION BY:

W. SMALLEY

XA Copy Has Been Sent to PDR

XA

8343314294

- TYPE 304 SS SLEEVES BRAZED TO INCONEL 718 GRID STRAPS AND HEAT TREATED AS PART OF GRID ASSEMBLY
 - BRAZED/SOLUTION TREATED AT []⁺ (a,c)
 - AGE HARDENED AT []⁺ (a,c)
- ZIRCALOY THIMBLE TUBES INSERTED INTO GRID SLEEVES, THEN EXPANDED VIA 4-LOBE BULGING TOOL
- TOP ENDS OF SS SLEEVES HELIARC WELDED TO TYPE 304 SS NOZZLE PLATE

HOT CELL EXAMINATIONS

- FRACTURES EXHIBIT LITTLE DUCTILITY (~10% OF SURFACE)
- BULGE JOINTS OF ~ NOMINAL DIMENSIONS (NO FABRICATION ANOMALY)
- SURFACES SHOW RUST COLORED FLOW PATTERNS ABOVE CRACKS
- FRACTOGRAPHY (SEM) SHOWS EXTENSIVE GRAIN BOUNDARY SEPARATION
- CRACKS APPEAR TO ORIGINATE ON OUTER SURFACE
- CORROSION PRODUCTS ON AND NEAR FRACTURE SURFACES
- EDX (SEM) INDICATES PARTICLES ON FRACTURE SURFACE HIGH IN SI, AL, CU AND CL
- CHEMICAL ANALYSIS OF SLEEVE INDICATES NORMAL CONSTITUENTS FOR TYPE 304 SS
- ADDITIONAL EVIDENCE OF STRESS CORROSION NEAR UPPER END OF SLEEVES AND NOZZLE/SLEEVE WELD AREA

INTERPRETATION OF HOT CELL RESULTS

- BULGE JOINT FRACTURE MODE IS IGSCC
- IGA AND TGSCC SEEN AWAY FROM BULGE JOINTS
- SCC RELATED TO RUST COLORED CORROSION PRODUCTS/FLOW PATTERNS
- SCC PRESENT PRIOR TO 12/16/81 INCIDENT
- SCC BELIEVED TO HAVE OCCURRED DURING STORAGE IN SFP
AFTER DISCHARGE FROM CORE

RELEVANT OPERATIONAL/FUEL HANDLING EXPERIENCE

- IN EXCESS OF 5,000 F/As IRRADIATED AND DISCHARGED W/O INCIDENT:
 - ~ 50 REGIONS W/3 CYCLES
 - > 200 F/As W/> 36,000 MWD/MTU

- EXTENSIVE EXPERIENCE W/O INCIDENT FOR LONG TERM STORAGE FOLLOWED BY HANDLING F/As:
 - ~ 2200 > 1 YR
 - ~ 600 > 3 YR
 - ~ 160 > 5 YR

- SIGNIFICANT EXPERIENCE WITH REIRRADIATION W/O INCIDENT FOLLOWING LONG TERM STORAGE

<u>STORAGE TIME</u>	<u># REINSERTED</u>	<u># DISCHARGED AFTER ADDITIONAL CYCLE</u>
> 1 YR	> 450	> 300
> 3 YR	> 250	> 200

REVIEW OF QC/TRACEABILITY RECORDS
RELATED TO PRAIRIE ISLAND FA D-34

- SLEEVE MATERIAL - CERTIFIED TEST REPORTS
- TOP GRID ASSEMBLY - HEAT TREATMENT FURNACE CHARTS
- BULGE JOINTS - DIMENSIONAL CHECK ON SAMPLES
 - VISUAL INSPECTION
- SLEEVE/NOZZLE PLATE WELDS - VISUAL INSPECTION
- MFG OPERATING PROCEDURES/REPORTS
 - DEVIATION NOTICES
 - REPAIRS
 - ROUTE CARDS
 - QC INSPECTION REPORTS

MATRIX OF FUEL ASSEMBLIES EXAMINED
AT PRAIRIE ISLAND AND OTHER PLANTS

PLANT	REGION	No. OF F/As	POOL LONG	STORAGE INT.	TIME SHORT	LOC. IN POOL CLOSE FAR	SLEEVE SAME	LOT OTHER	BRAZE SAME	RUN OTHER
PI	1	3	X					X		X
	2	2	X					X		X
	3	3		X		X		X		X
	4	6		X		X	X			X
	4	2		X		X		X		X
	4	3		X		X	X		X	
	4(U2)	2		X		X		X		X
	4(U2)	1		X				X		X
	5	1			X			X		X
	5(U2)	1			X			X		X
6	2			X			X		X	
A	3	2	X					X		X
	5	1		X			X			X
	6	2			X			X		X
B	1	1	X					X		X
	4	1		X			X			X
	6	1			X			X		X
C	1	3	X					X		X
	3	3		X				X		X
	5	2			X			X		X
D	1	5		X				X		X

PRAIRIE ISLAND TOP NOZZLE SEPARATION
-VISUAL EXAMINATIONS AT PLANT SITES-

- AT PRAIRIE ISLAND
 - 26 ADDITIONAL ASSEMBLIES EXAMINED
 - EVIDENCE OF CORROSION ON BULGE JOINTS OF 13 OTHER ASSEMBLIES, PRIMARILY FROM SAME REGION AS D-34
 - CORROSION NOT RELATED TO SLEEVE LOT, HEAT TREATMENT BATCH, OPERATING HISTORY IN CORE, NOR TO STORAGE LOCATION IN POOL
- AT OTHER SITES
 - PLANT A (3), PLANT B (5), PLANT C (5), PLANT D (8)
 - NO EVIDENCE OF CORROSION ON BULGE JOINTS AT OTHER PLANTS, INCLUDING THOSE MANUFACTURED IN SAME PERIOD AND CONTAINING SAME SLEEVE LOT AS D-34
 - SUCCESSFUL HANDLING OF ~5000 FAs AFTER DISCHARGE/STORAGE
- CONCLUSIONS
 - PROBLEM CONFINED TO THREE REGIONS FROM BOTH UNITS OF PRAIRIE ISLAND FUEL, I.E. W/COMMON FUEL POOL
 - SCC DOES NOT RESULT FROM DESIGN OR MFG ANOMALY
 - FUEL ASSEMBLIES WITH SAME DESIGN AND SAME SLEEVE LOT SHOWED NO SCC IN OTHER PLANTS

RELATED INDUSTRY OBSERVATIONS
SCC IN SENSITIZED 304 SS

- BWR PIPE CRACKING - EPRI/UTILITY BWR OG
 - OCCURS AT WELDED JOINTS
 - JOINTS DEVELOP STRESS AND BECOME SENSITIZED
 - CRACKING OCCURS AT OPERATING TEMPERATURE
 - STRONGLY SENSITIVE ~~TO~~ OXYGENATED ENVIRONMENT
(O₂ TOO LOW IN PWRs)
 - CONTAMINANTS, E.G. CL, IMPORTANT (SMALL IN PRIMARY COOLANT)
 - CRACKS TAKE TIME (SEVERAL YEARS) TO DEVELOP
- PWR - TMI-1 SPENT FUEL PIPING SYSTEM
 - FEATURES IDENTICAL TO ABOVE; EXCEPT
 - DEVELOPED AT POOL TEMPERATURES (~90°F)
 - DEVELOPED IN ~2,300 PPM B ENVIRONMENT
 - POOLS WILL TEND TO SATURATE WITH OXYGEN
 - RUST COLORED CORROSION - Fe₂O₃
 - CL, AL, CU ETC, DETECTED ON CRACK SURFACE (AS PRAIRIE ISLAND)
- PWR CONTAINMENT SPRAY AND SFP PIPING
 - AT ARKANSAS-1, CRYSTAL RIVER-3, SAN ONOFRE-1, SURRY-1 AND 2
 - CRACKS GENERALLY IN SENSITIZED ZONES NEAR WELDS
 - CHLORIDE AND/OR THIOSULFATE CONTAMINATION SUSPECTED

KEY RESULTS OF INVESTIGATION

- IGSCC IN BULGE JOINTS OF SS SLEEVES
- EVIDENCE OF SCC ALSO SEEN AWAY FROM BULGE JOINTS
- SCC APPARENTLY RELATED TO VISIBLE SURFACE CORROSION PRODUCTS
- VISUAL EXAM OF OTHER F/AS INDICATES PROBLEM CONFINED TO PRAIRIE ISLAND
- NO MATERIAL OR FABRICATION ANOMALIES IN REGION 4 (INCL D-34)

CONCLUSIONS

- FAILURE IN BULGE JOINTS DUE TO IGSCC DURING STORAGE IN POOL
- PROBLEM APPEARS TO BE CONFINED TO PRAIRIE ISLAND; IS NOT GENERIC

(a, c, q)

General View of Separated Nozzle and Remaining Sleeves

(a.c.g.)

Photomacrographs of Typical Sleeve Showing Corrosion Products
and Flow Patterns Adjacent to Fracture Plane

(a.c.g)

Composite of Photomacrograph and Photomicrographs Illustrating Intergranular Attack
of Inner Surface of Sleeve About 0.2 inch below Sleeve/Nozzle Weld Zone

(a.c.g.)

Photomicrographs Illustrating Intergranular Cracks in Typical Sleeve

(a.c.g.)

SEM Photomicrographs of Fracture Surface
Showing Grain Boundary Separation and Corrosion Products on Surface

FEBRUARY 23, 1983. NRC MEETING

PRESENTATION BY:

M. KLEE - NSP

BACKGROUND AND HISTORY

Fuel Assembly D-34

02-16-76 Unloaded from new fuel shipping container, receipt inspected and transfered to new fuel pit location A05

03-18-76 Thimble plugging device PD-70 placed in assembly

03-23-76 Transfered to spent fuel pool location D05

04-13-76 Transfered to Unit 1 core location J02 during cycle 1-2 core reload

Accumulated burnup after cycle 2: 6250 MWD/MTU

03-30-77 Transfered to Unit 1 core location H04 during cycle 2-3 core shuffle

Accumulated burnup after cycle 3: 18,230 MWD/MTU

04-05-78 Transfered to Unit 1 core location I04 during cycle 3-4 core shuffle

Accumulated burnup after cycle 4: 29,424 MWD/MTU

04-15-79 Transferred to spent fuel pool location J47
during cycle 4-5 core shuffle

12-27-79 Thimble plugging device PD-70 removed
from assembly

FAILURE AND RECOVERY

FUEL ASSEMBLY D-34

12-16-81	Assembly D-34 failed during tranfer to small pool
01-19-82	D-34 Uprighted
01-20-82	Replacement top nozzle installed and assembly stored in small pool location L17
08-24-82	Assembly transfered to large spent fuel location P22

UNIT 2



REFERENCE HOLE
ON FUEL ASSEMBLY

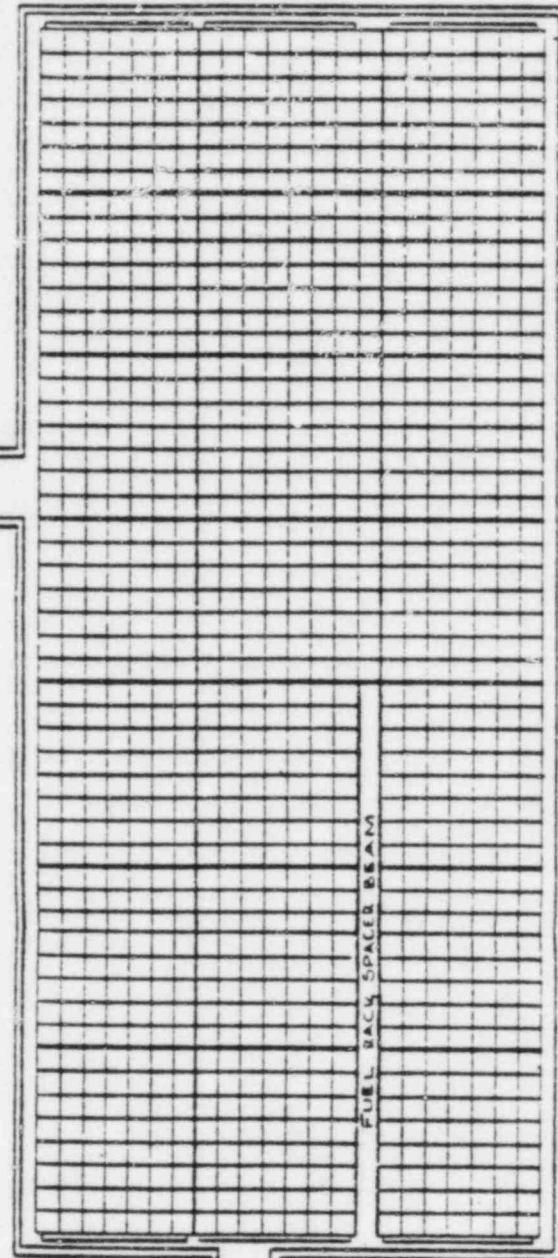
FUEL TRANSFER CANAL

REFERENCE HOLE
ON FUEL ASSEMBLY

UNIT 1



Y X W V U T S R Q P N M L K J H G F E D C B A



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73

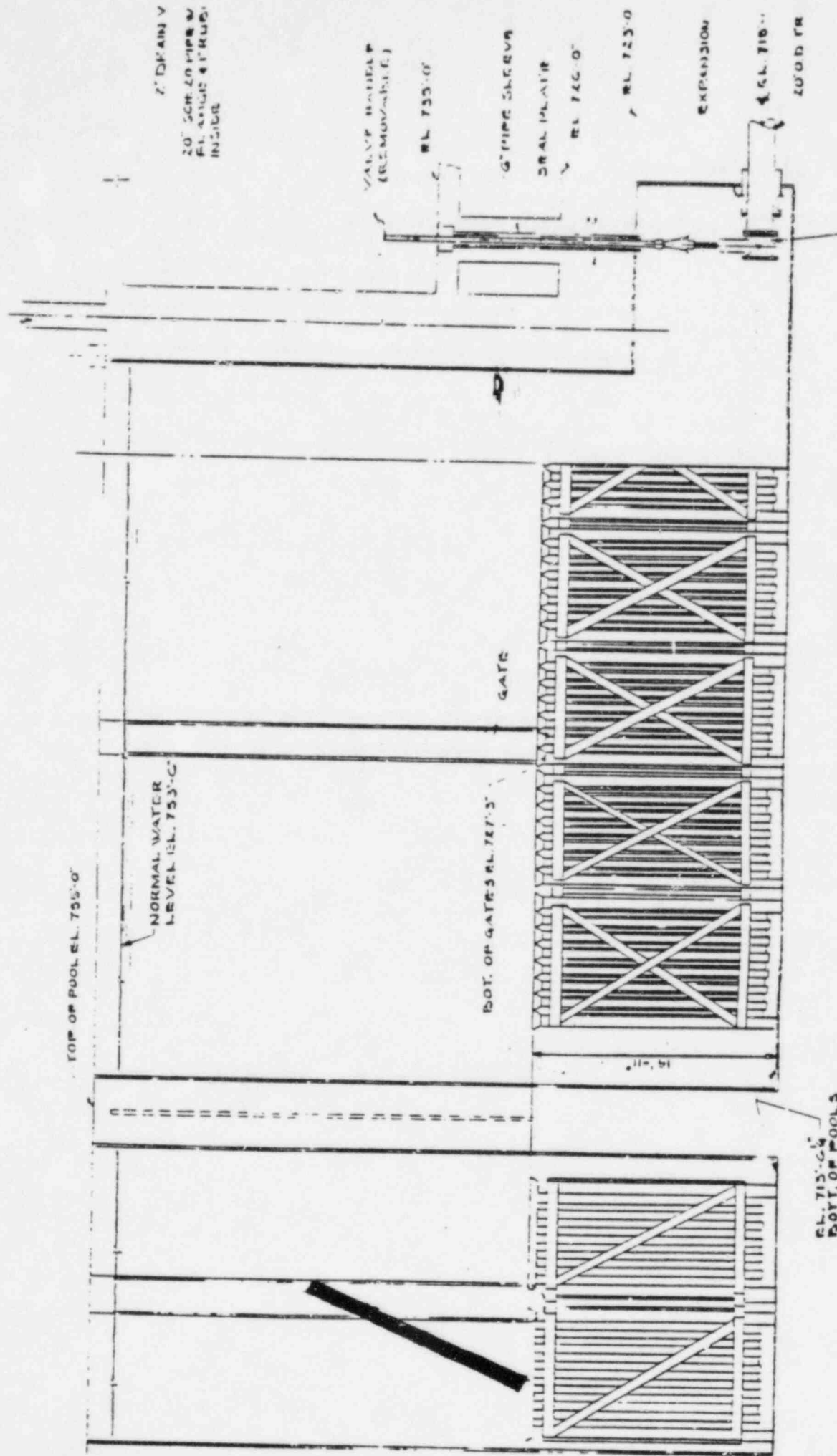
SPENT FUEL PIT #1

SPENT FUEL PIT #2

NORTH

POUR FOR AND NUCLEAR GENERATING PLANT
STORAGE AREA LOCATION
NUMBERS AND SYSTEM AND
FUEL ASSEMBLY IDENTIFICATION

THE POWER OF THE FUTURE



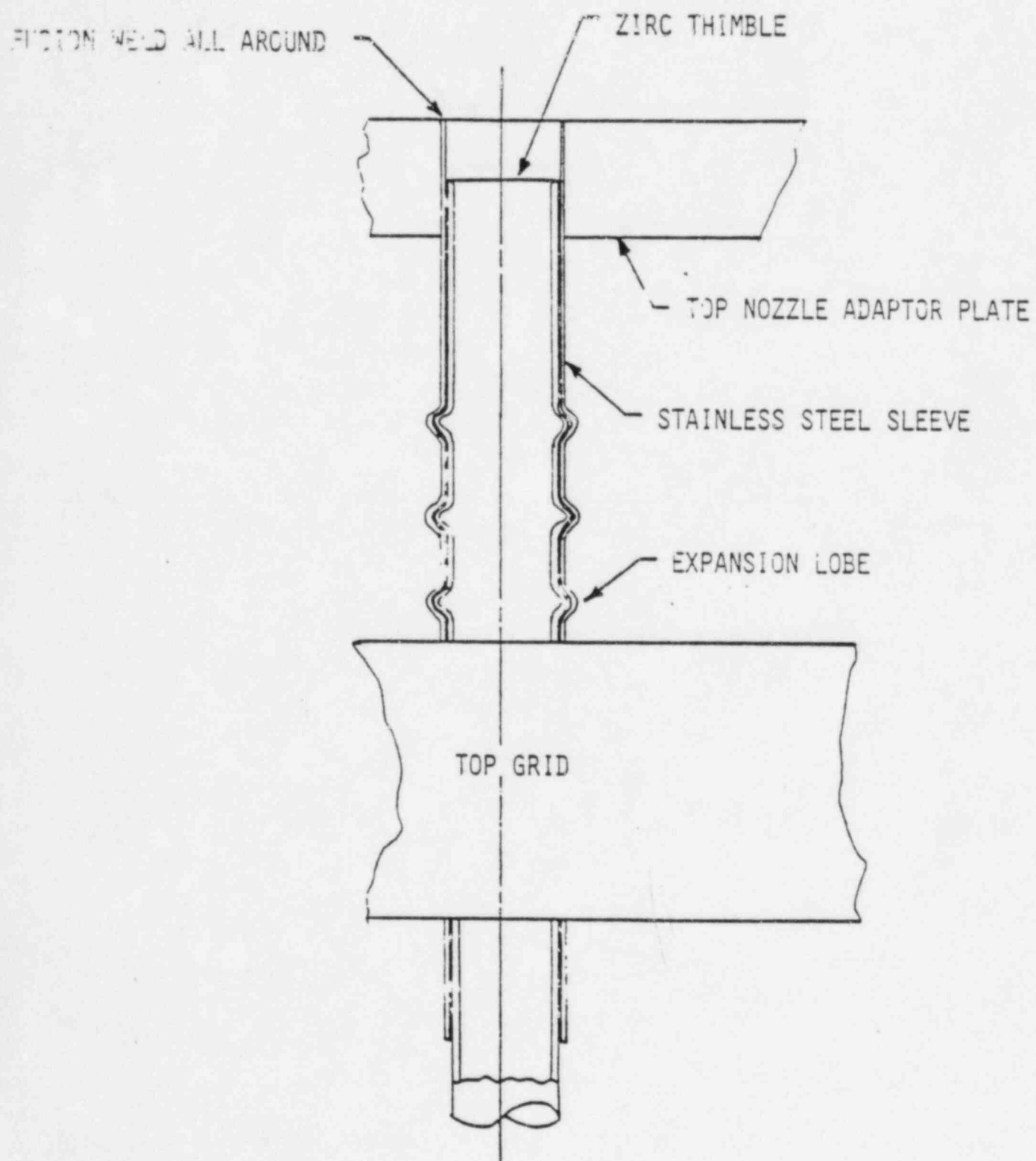
SECTION A-A

FEBRUARY 23, 1983, NRC MEETING

PRESENTATION BY:

L. STERN

TOP GRID TO NOZZLE ATTACHMENT



DESCRIPTION OF LOPAR F/A BULGE JOINT DESIGN

MECHANICAL JOINT APPROACH SELECTED FOR ZIRC TUBE-STAINLESS
SLEEVE ATTACHMENT (TYPE 304 SS)

INITIAL DEVELOPMENT/TESTING 1967-1969

- FORMABILITY
- STRENGTH
- THERMAL CYCLING
- CORROSION

PROCESS CONTROL AND INSPECTION METHODS DEVELOPED

RELEASED FOR PRODUCTION IN 1969

FOLLOW THROUGH EVALUATION WITH 1 CYCLE POINT BEACH SKELETON
PIE IN 1973 DEMONSTRATED EXCELLENT PERFORMANCE

POINT BEACH SKELETON PIE

- SAME DESIGN AS PRAIRIE ISLAND
- BURNUP OF 18,000 MWD/MTU
- MECHANICALLY SOUND (FAILURE LOADS UNIRRADIATED)
- STRUCTURALLY SOUND (NO EVIDENCE OF CRACKING)

FEBRUARY 23, 1983. NRC MEETING

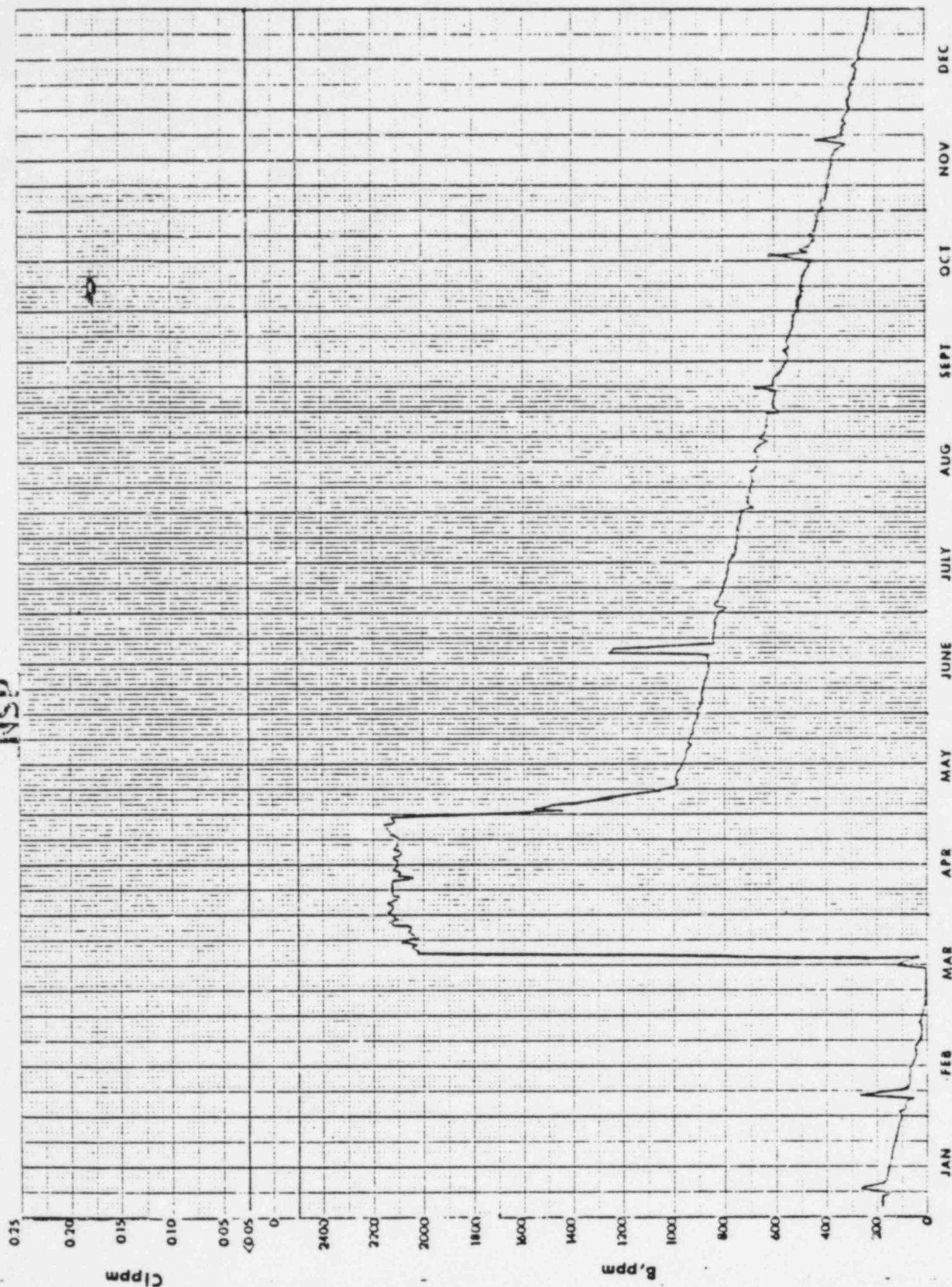
PRESENTATION BY:

M. W. ROTHAM

10 X 10 TO THE CENTIMETER
K_{0.5} PLUMFEL NUSSEN CO. 4000 954

461510

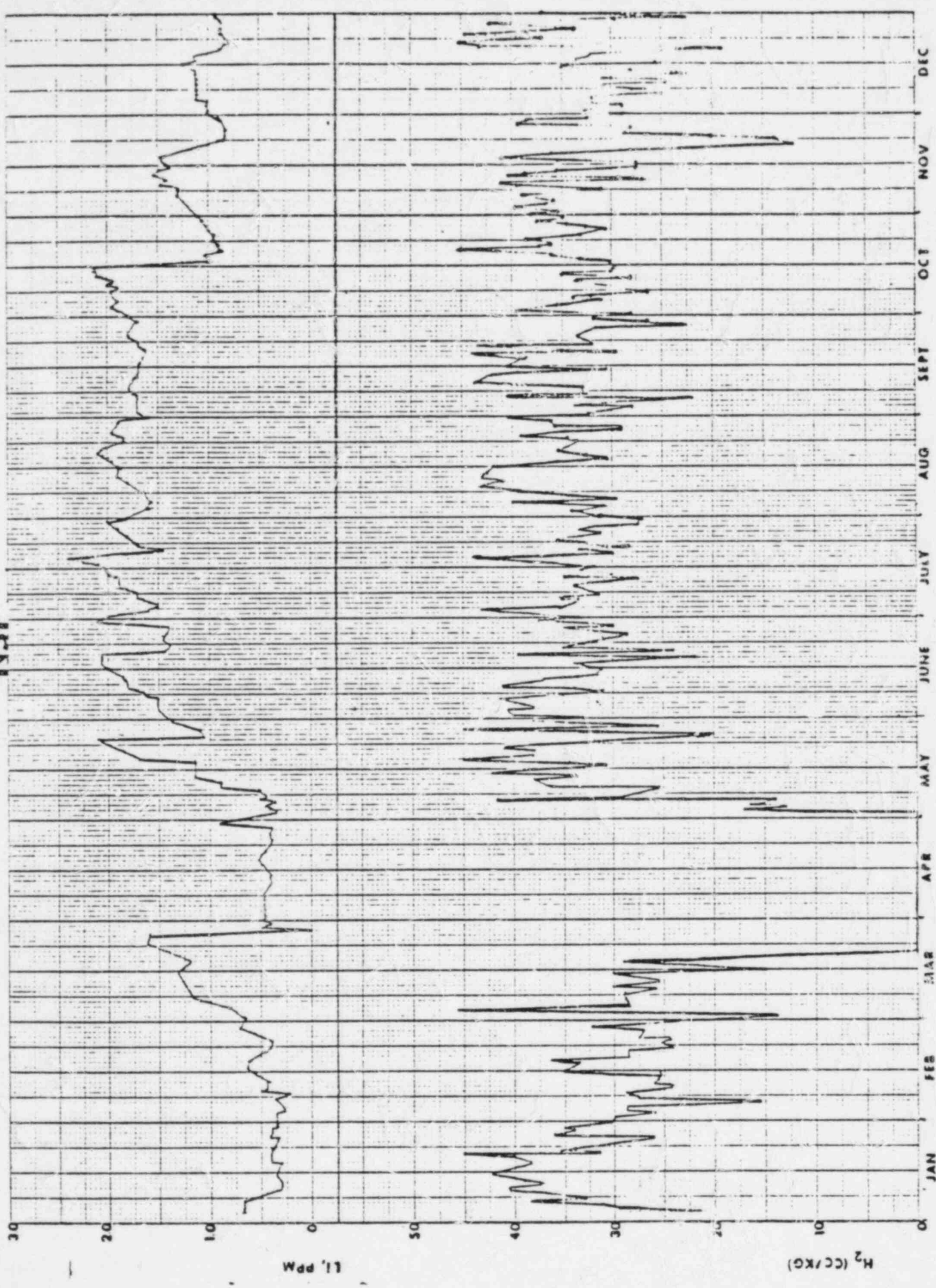
NSP



461510

16-2 10 X 10 TO 100 CENTIMETER IN X 20 CM
WOLFFEL & LUSSEN CO. MADE IN U.S.A.

NSP

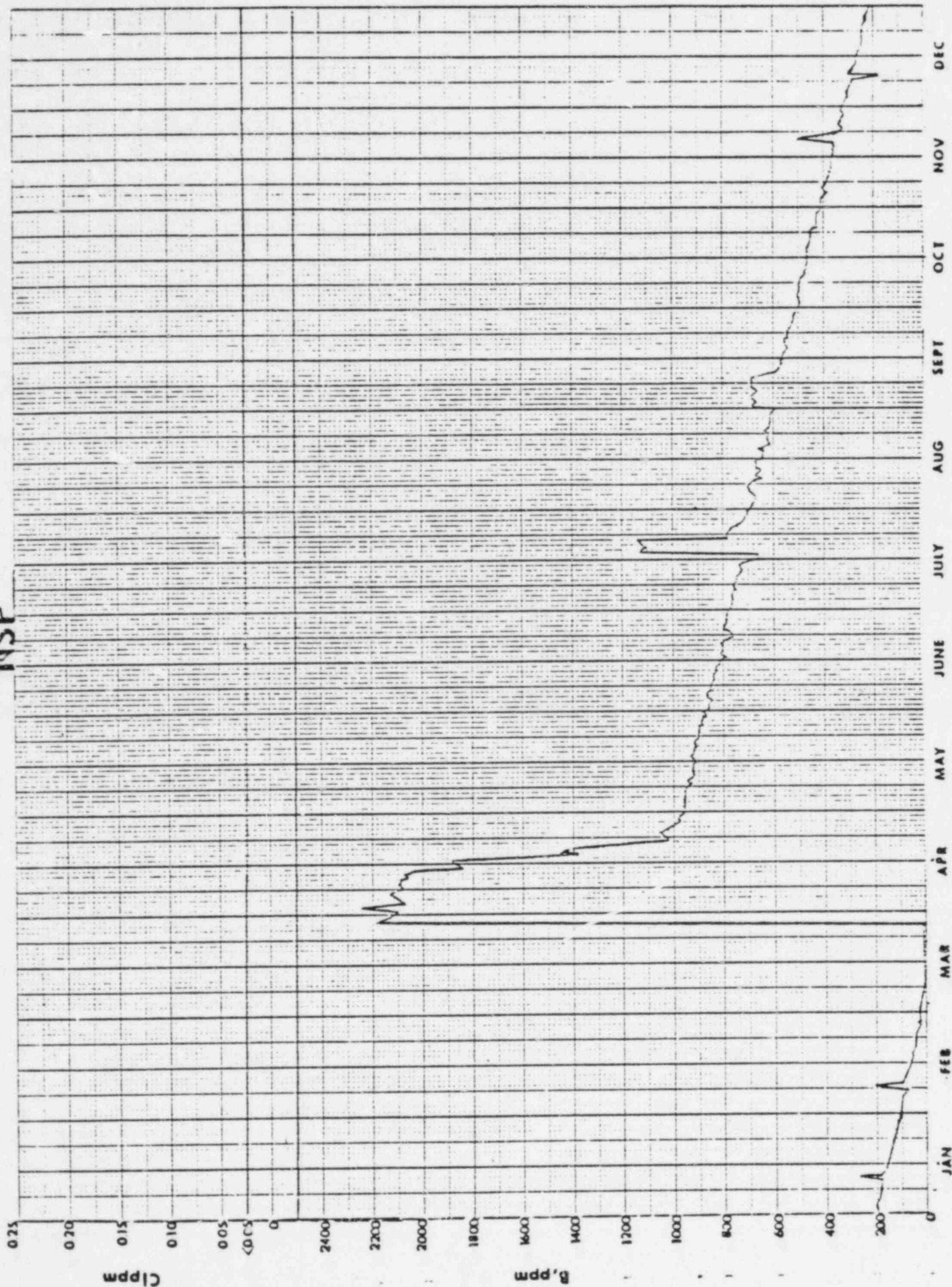


1977

461510

KE 10 X 10 TO THE CENTIMETER 10 X 10 CM
KIMTEL & ASSOCIATES MADE IN U.S.A.

NSP



DEC

NOV

OCT

SEP

AUG

JULY

JUNE

MAY

APR

MAR

FEB

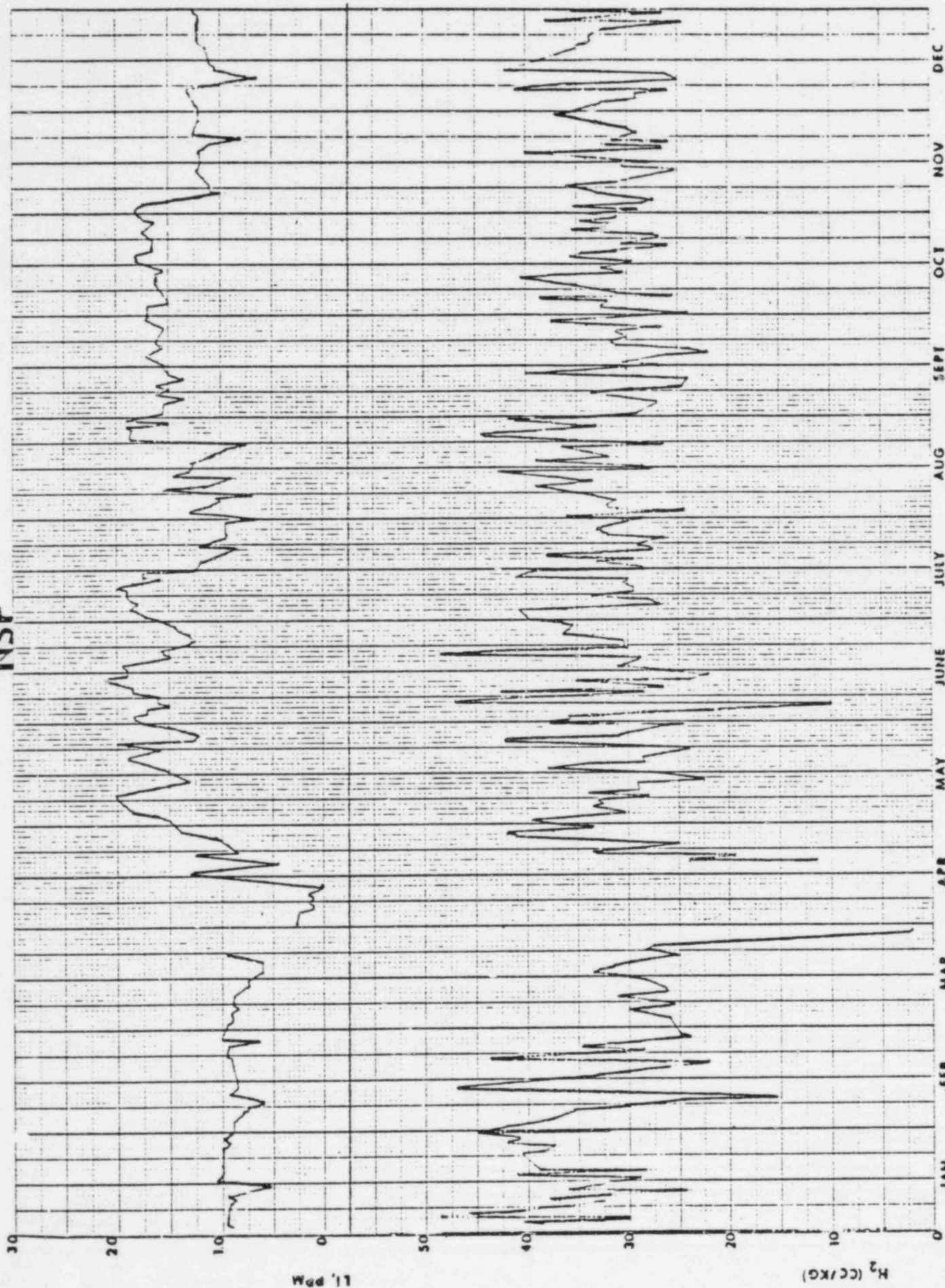
JAN

1978

16-Σ 10 X 10 TO THE CENTIMETER 10 X 25 CM
NEUFEL & EISEN CO. MADE IN U.S.A.

461510

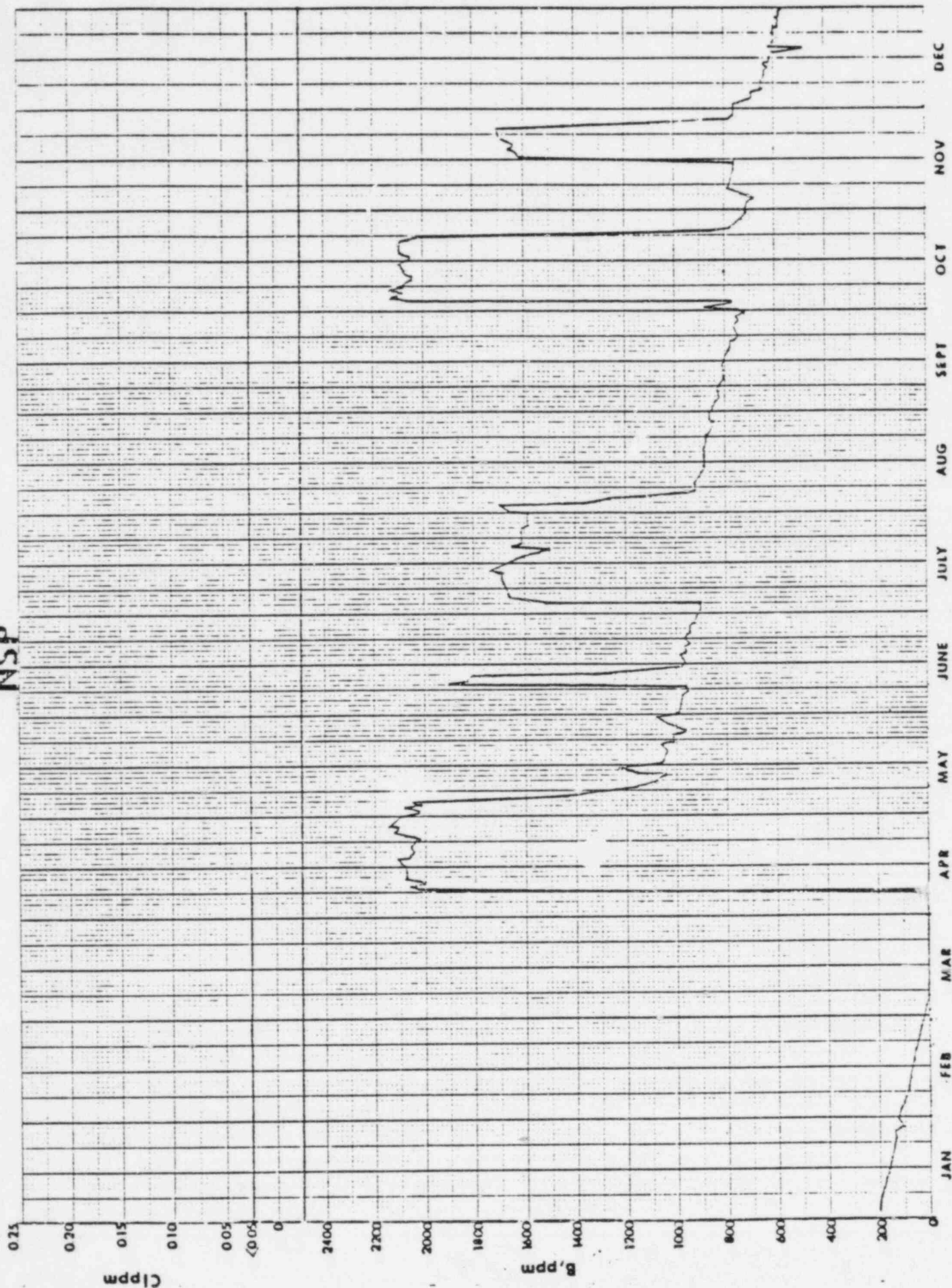
NSP



461510

REF ID: A61510
REF ID: A61510

NSP

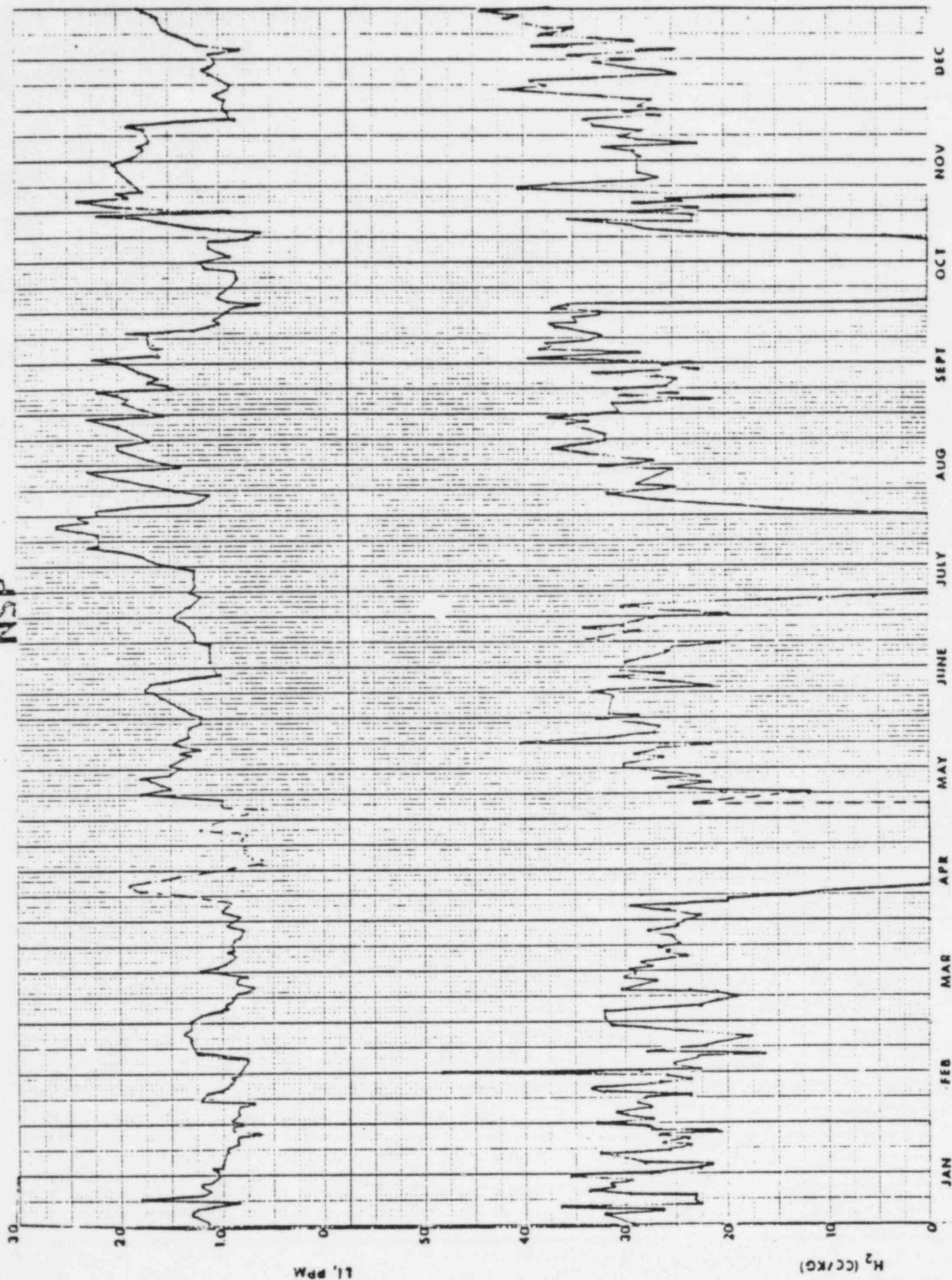


1979

461510

16-E 10 M TO THE CENTIMETER
KALFEL & CO. CO. MADE IN U.S.A.

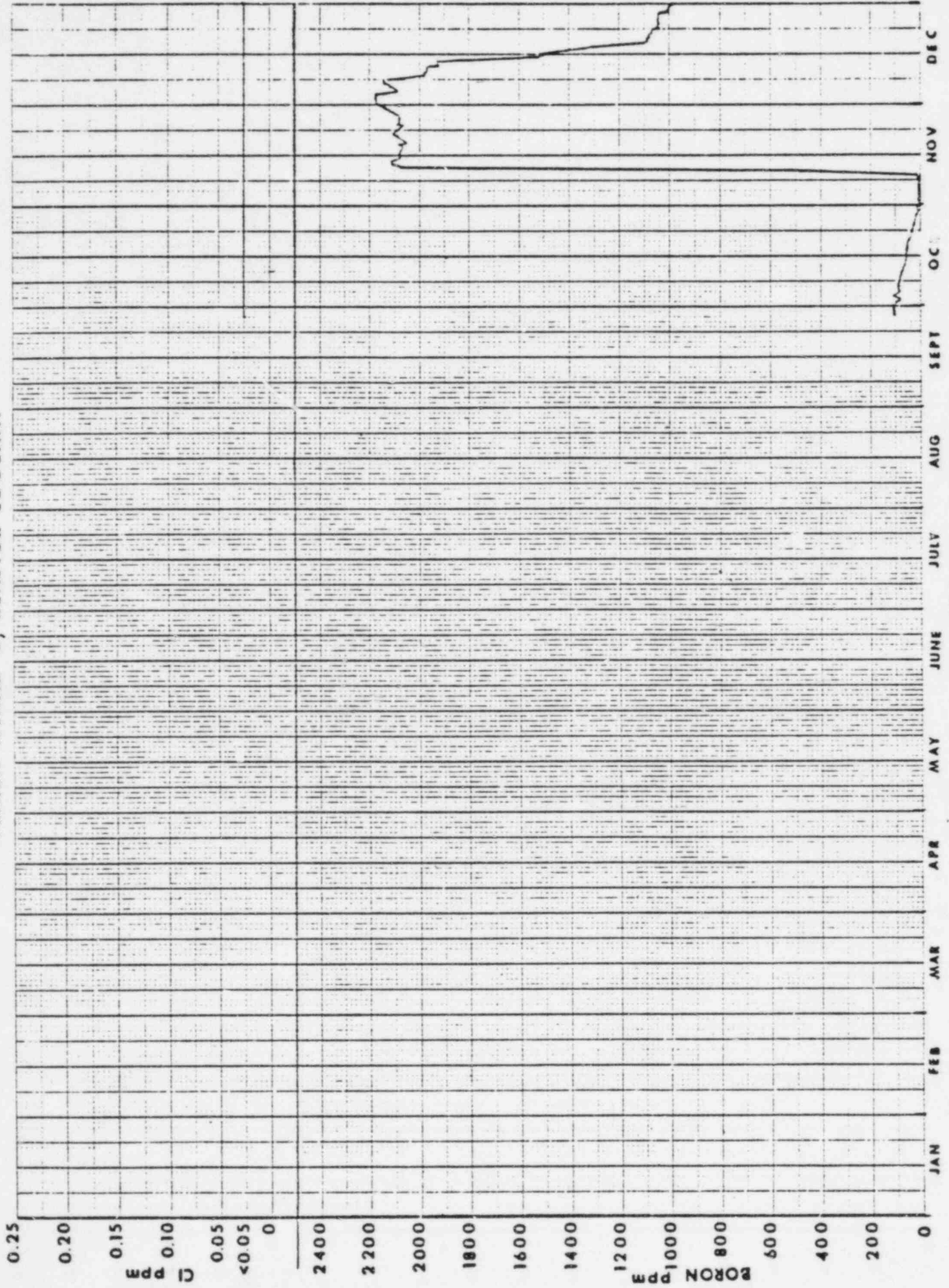
NSP



The figure consists of two vertically stacked line graphs sharing a common x-axis representing the months of the year (JAN to DEC). The top graph's y-axis is labeled 'H₂ cc/kg' and ranges from 0 to 50. The bottom graph's y-axis is labeled 'PPM' and ranges from 0 to 3.0. Both graphs show highly variable data series with multiple peaks and troughs throughout the year.

1978

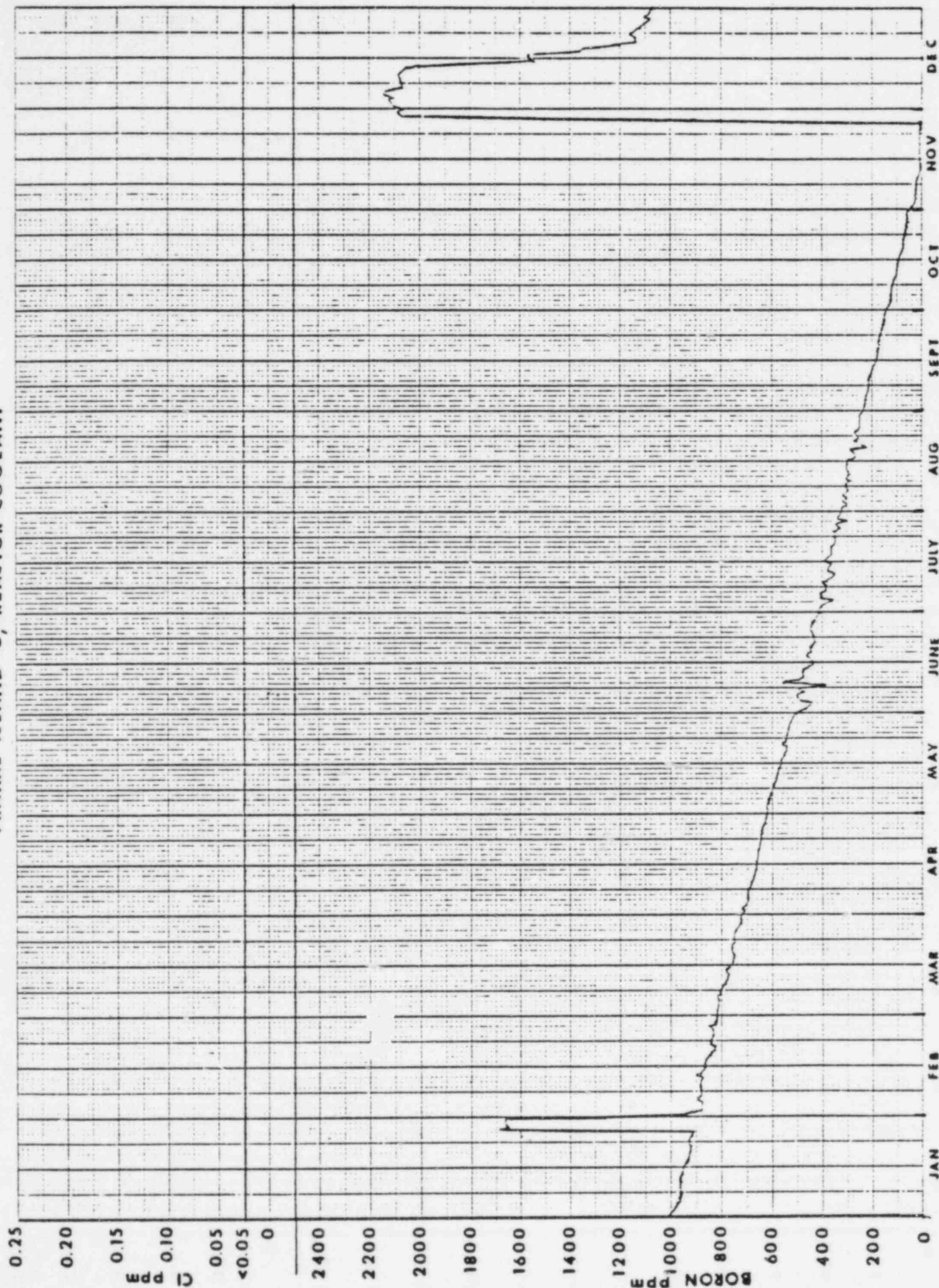
PRAIRIE ISLAND 2, REACTOR COOLANT



461510

10 X 10 TO THE CENTIMETER
KUMPFEL & ESSER CO. MADE IN U.S.A.

PRAIRIE ISLAND 2, REACTOR COOLANT

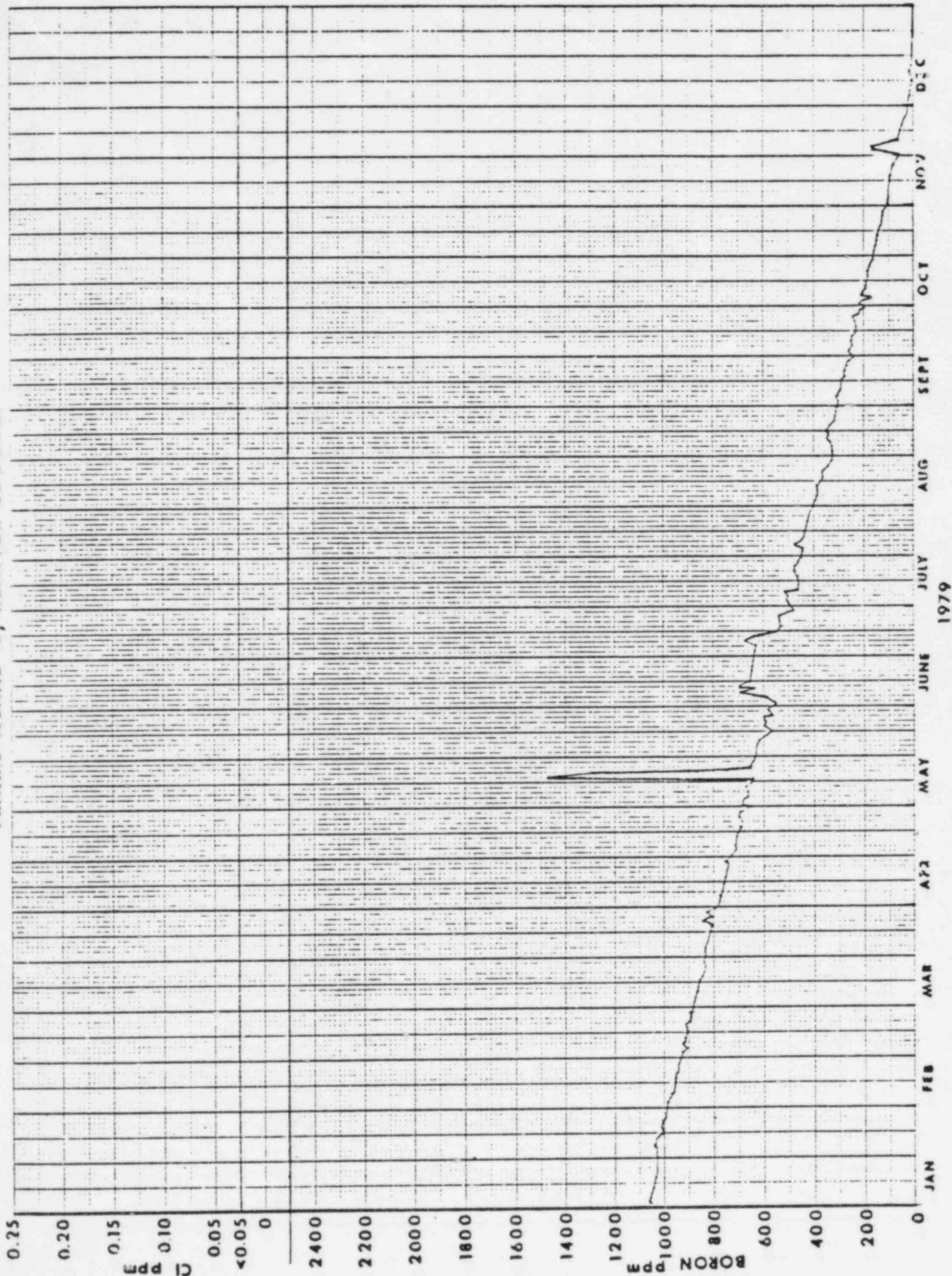


1978

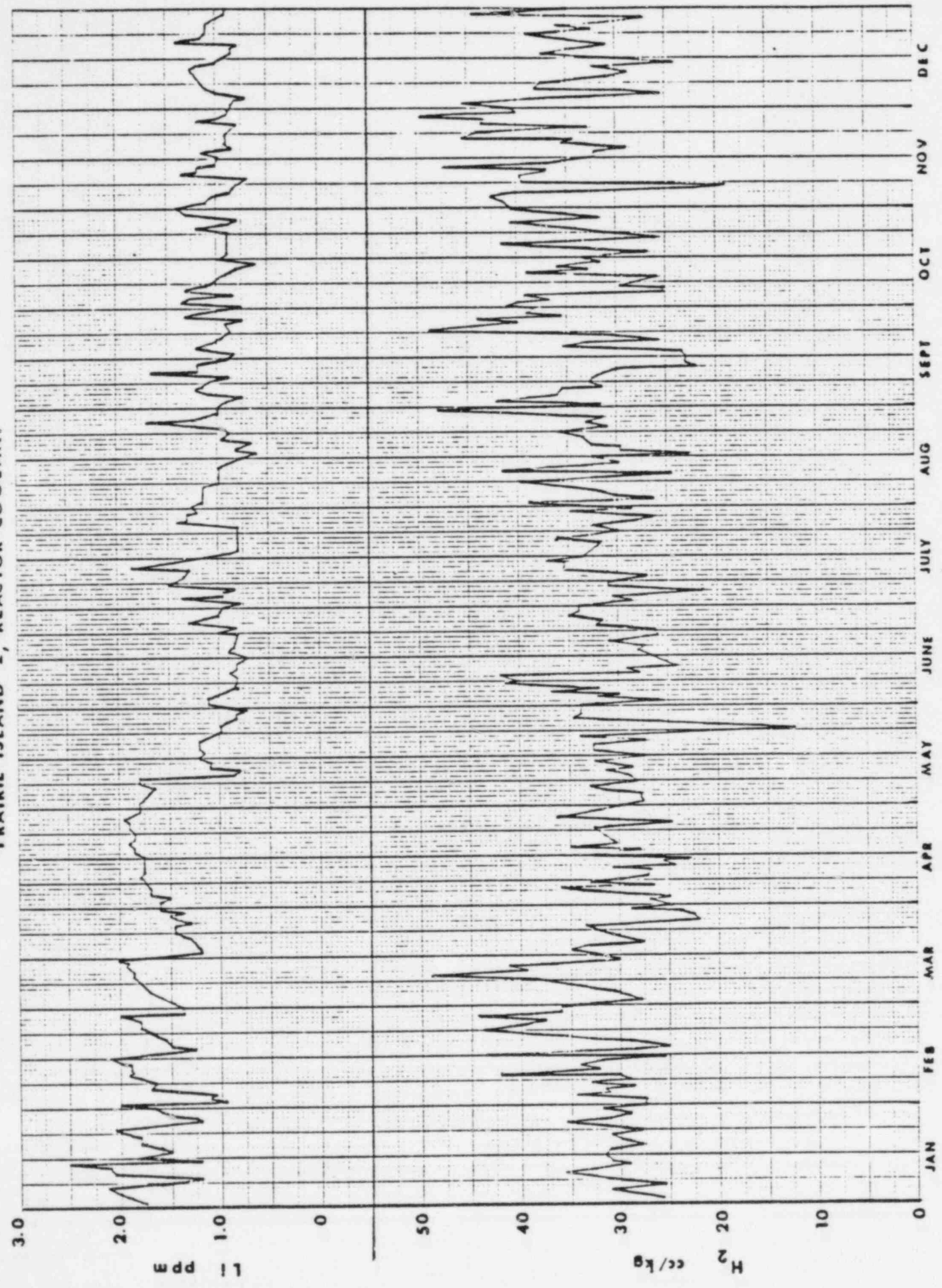
461510

16-2 10 X 10 TO THE CENTRAL ILL. IN S. 75.13
KIDFEL & ESSER CO. MAR. 20.74

PRAIRIE ISLAND 2, REACTOR COOLANT

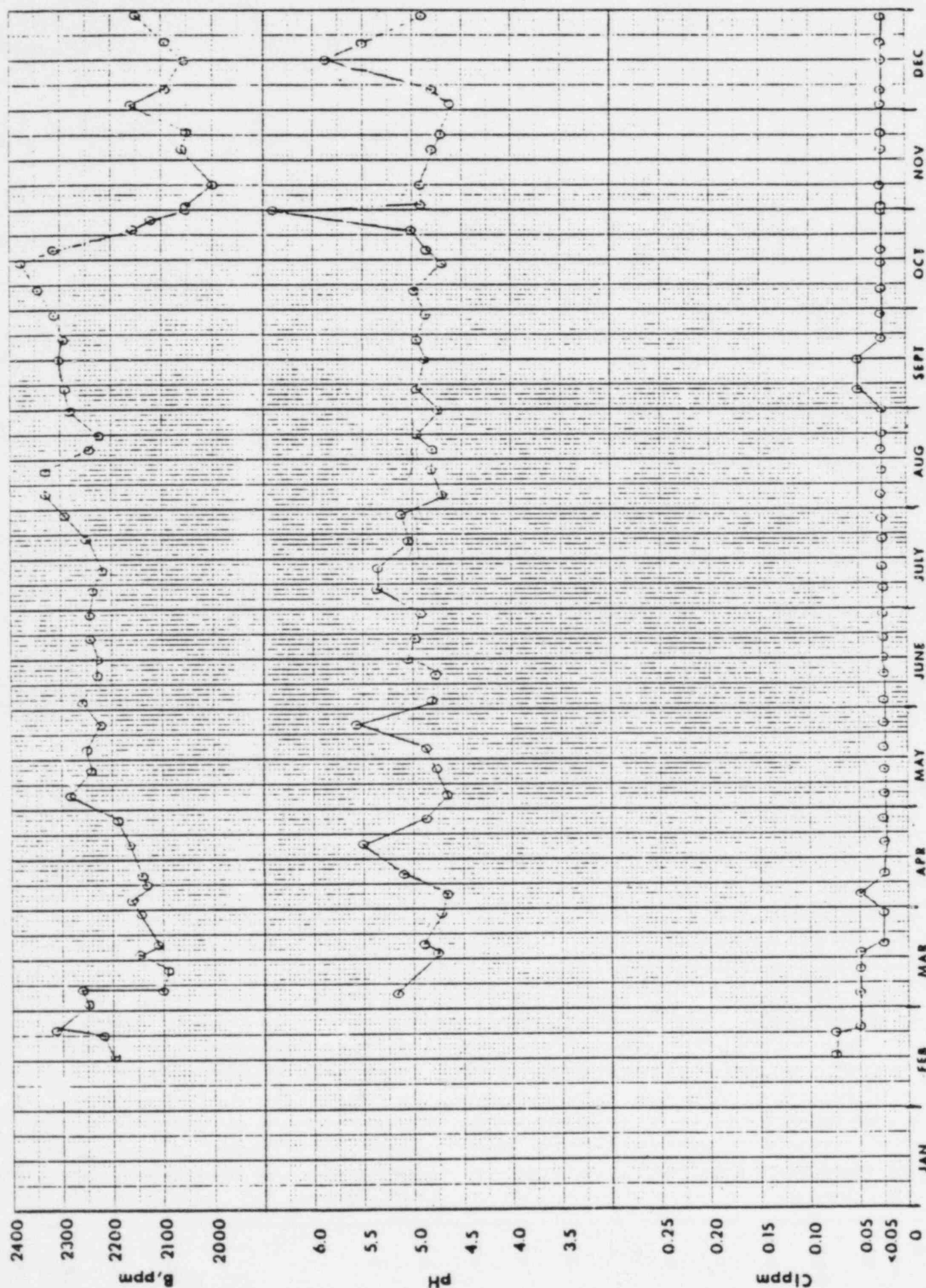


PRAIRIE ISLAND 2, REACTOR COOLANT



1979

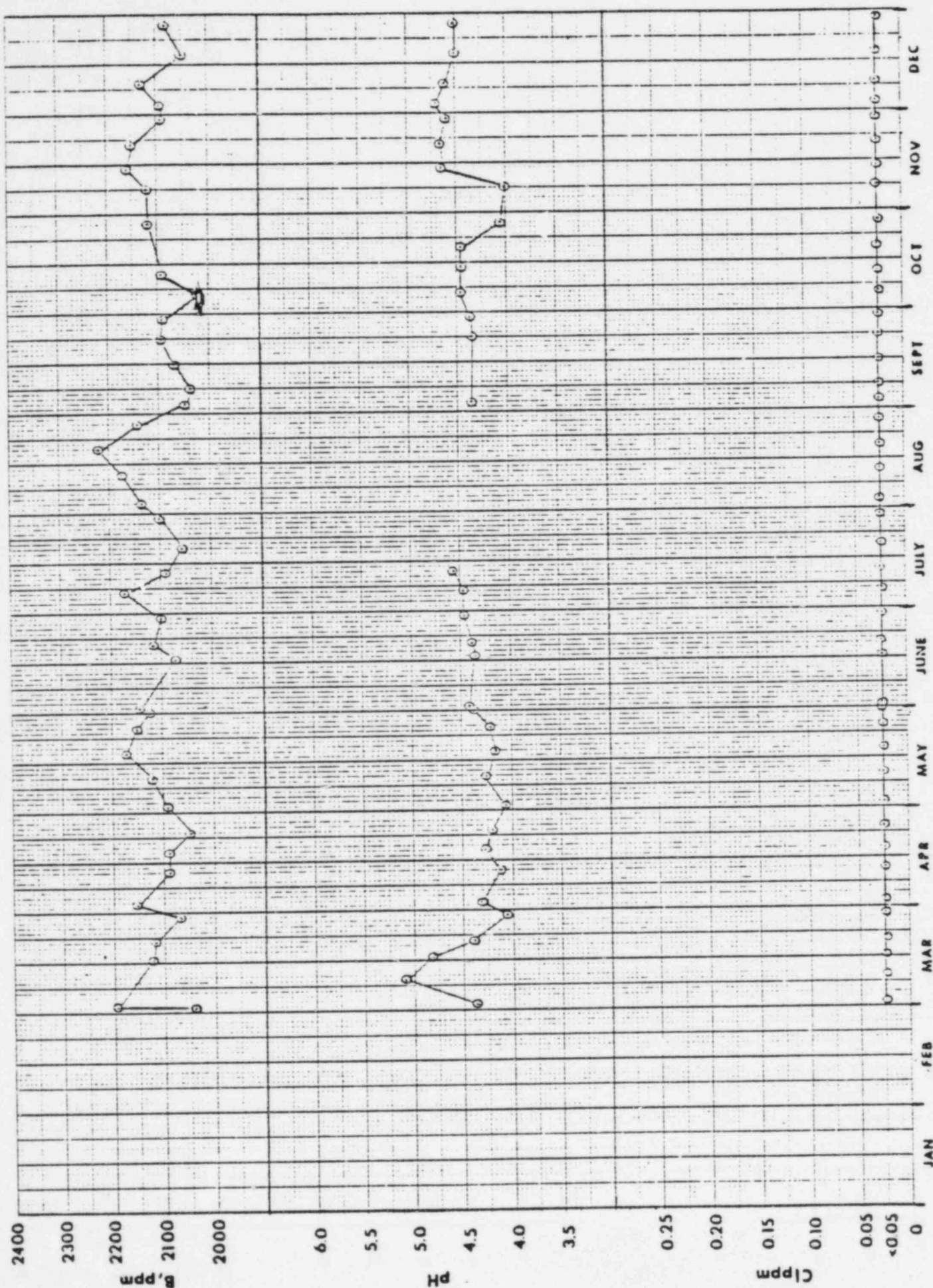
PRAIRIE ISLAND, SPENT FUEL PIT



461510

10 X 10 TO THE CENTIMETER
PAID FOR BY THE U.S. GOVERNMENT

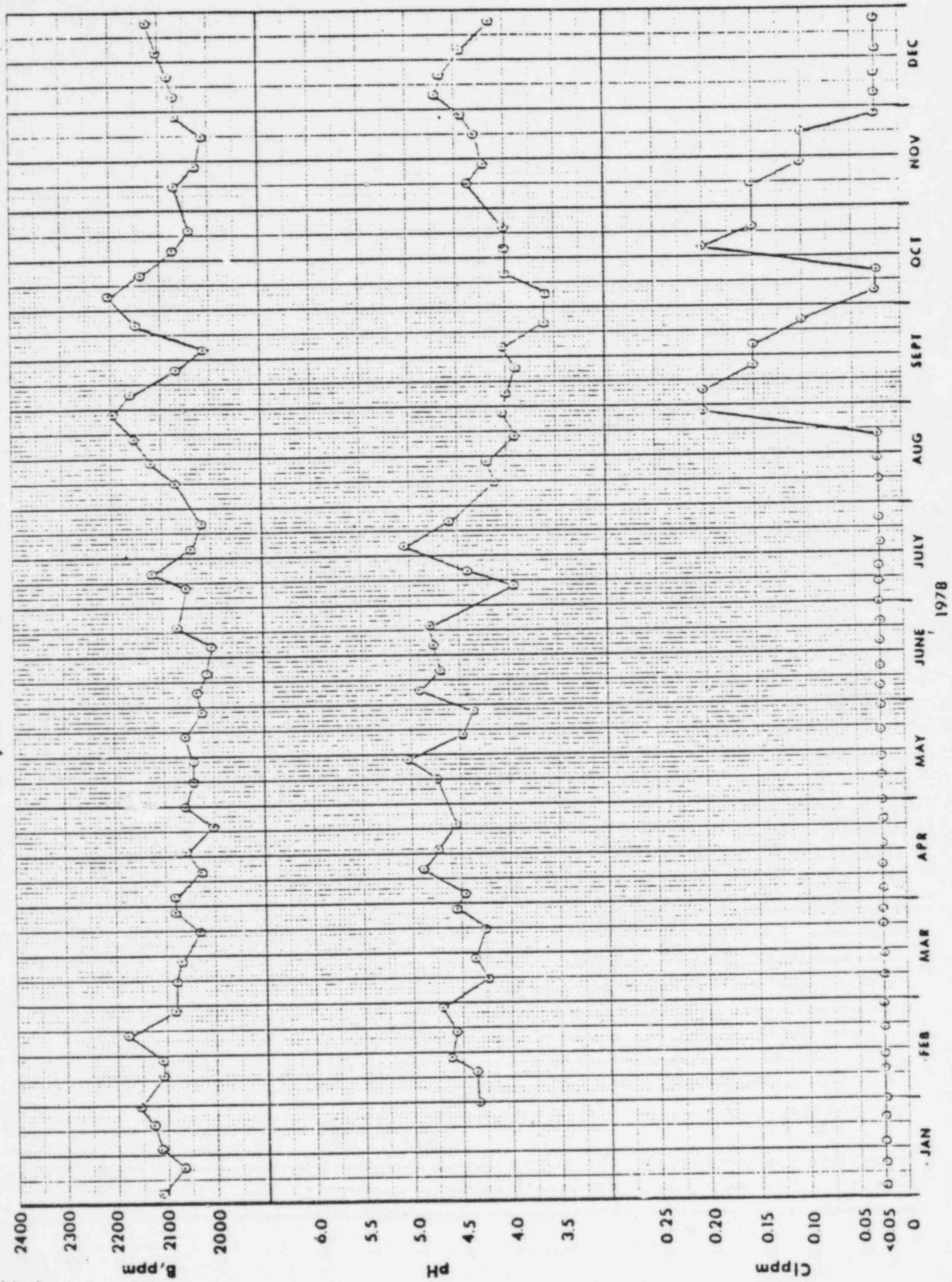
PRAIRIE ISLAND, SPENT FUEL PIT



461510

16-Σ 10 X 10 TO THE CENTIMETER
KOH-FEL & ESNEY CO. MADE IN U.S.A.

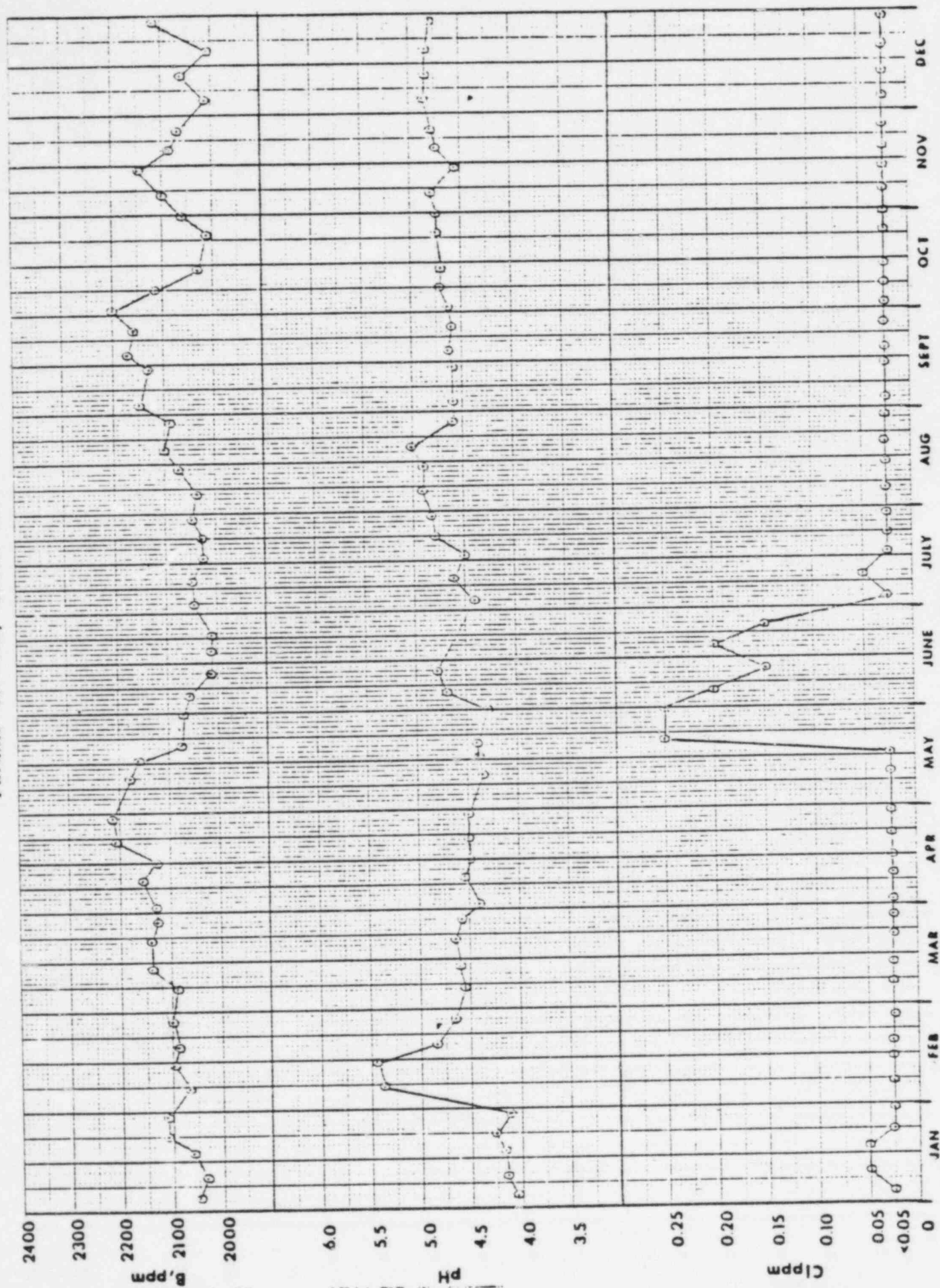
PRAIRIE ISLAND, SPENT FUEL PIT



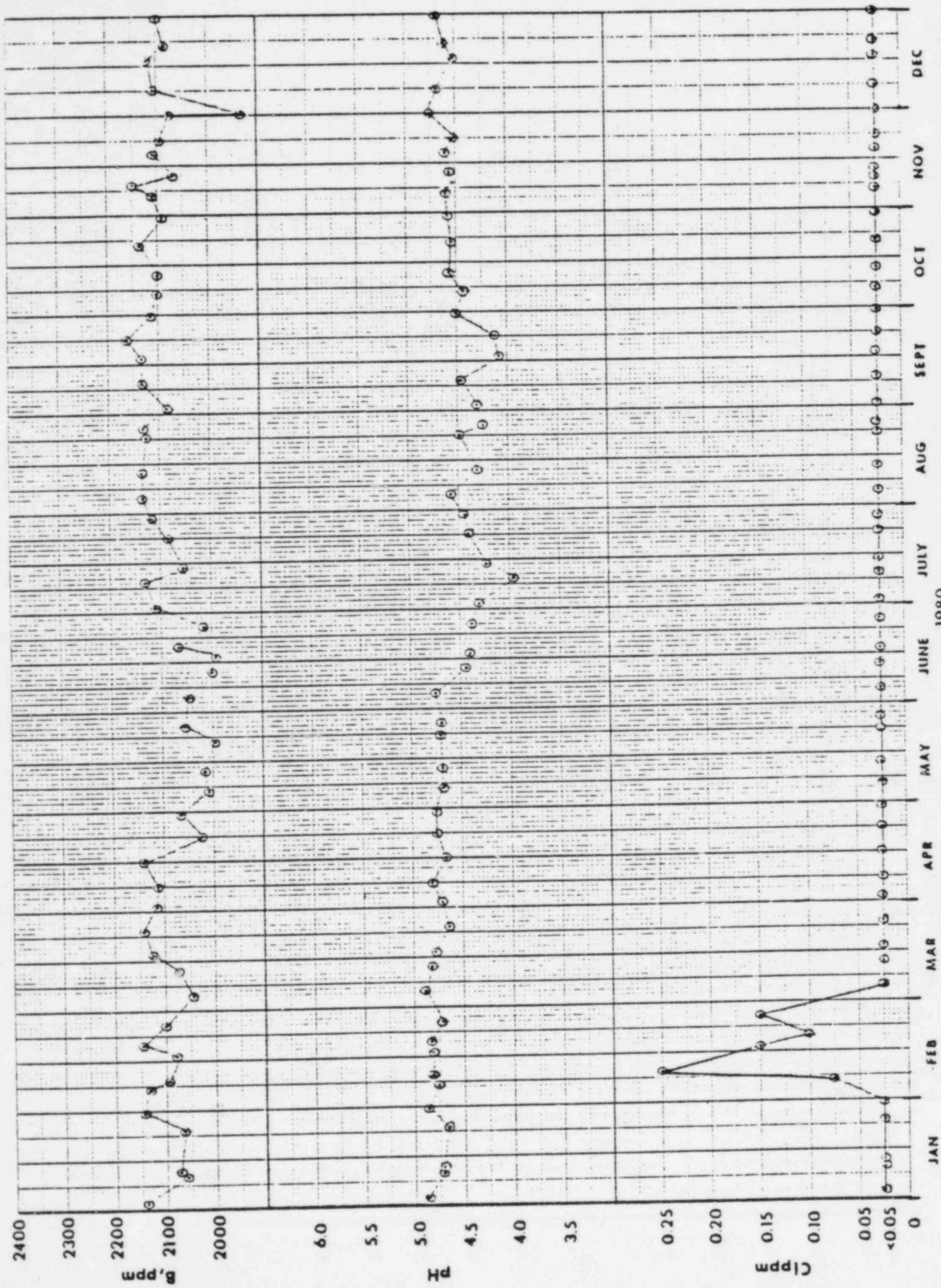
461510

16-2 10 X 10 TO THE CAPTAIN 1/12
ALBUQUERQUE 1/12/79

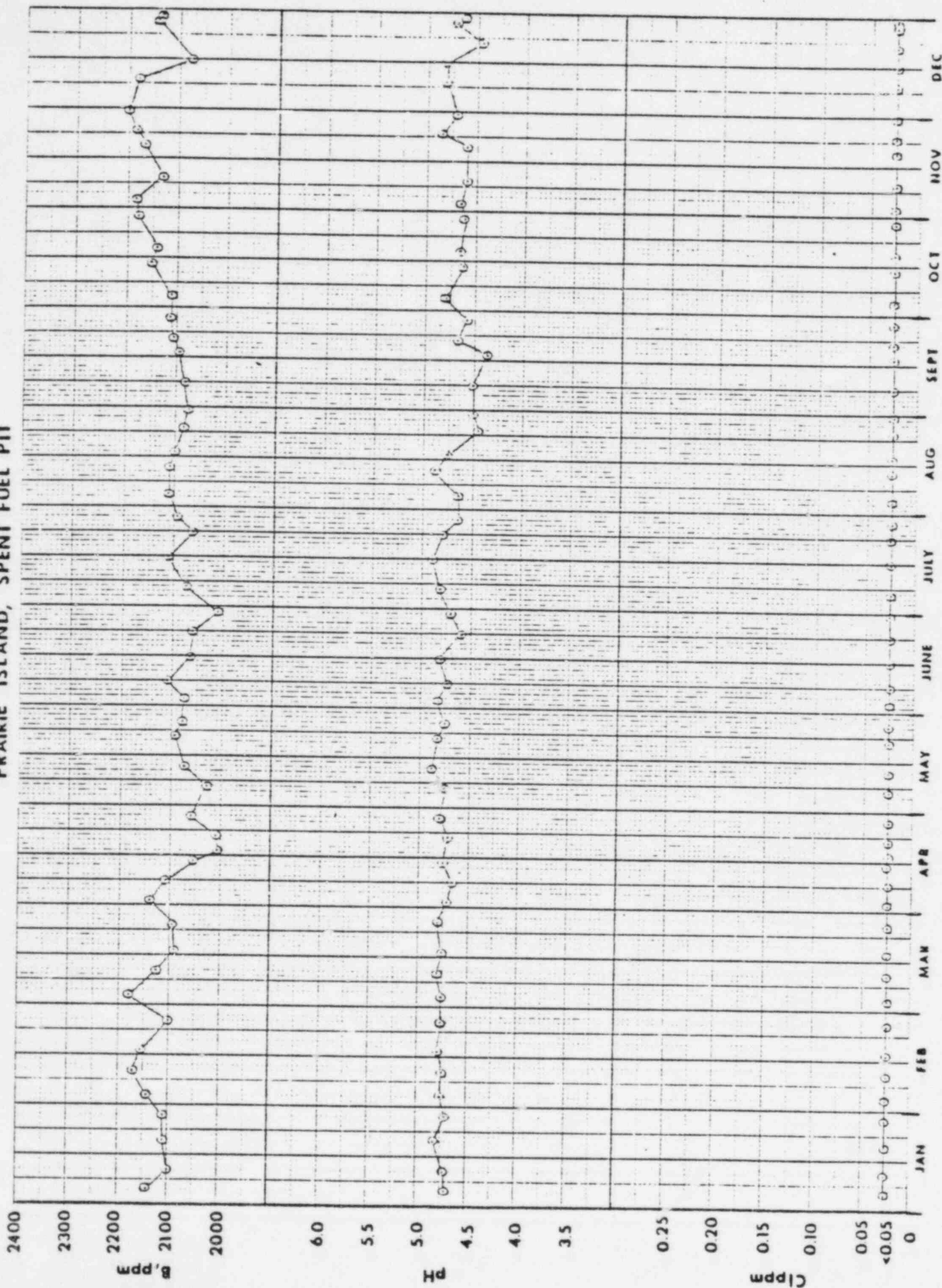
PRAIRIE ISLAND, SPENT FUEL PIT



PPAIRE ISLAND, SPENT FUEL PIT



PRAIRIE ISLAND, SPENT FUEL PIT





UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

MAR 31 1983

MEMORANDUM FOR: Richard H. Vollmer, Director
Division of Engineering, NRR

Edward Jordan, Director
Division of Emergency Preparedness
and Engineering Response, IE

FROM: Darrell G. Eisenhut, Director
Division of Licensing, NRR

SUBJECT: FUEL ASSEMBLY DEGRADATION WHILE IN THE
SPENT FUEL STORAGE POOL

The attached AEOD memorandum describes an event that involved degradation of fuel assemblies while in the Prairie Island spent fuel storage pool. The fuel assemblies apparently degraded via stress corrosion cracking. Degradation of fuel assemblies while in the spent fuel storage pool is new and it contradicts the NRC position on long-term storage of spent fuel assemblies.

We believe that this event may represent a potential safety concern and should be evaluated. Previous discussions with the Chemical Engineering Branch indicates a willingness to perform this evaluation. Therefore, we request that the Division of Engineering take the lead on this concern and pursue an appropriate NRR course of action.

We are also forwarding a copy of the Office of Inspection and Enforcement for information purposes. If further study indicates that this concern is generic we will pursue issuance of an IE Information Notice.

Darrell G. Eisenhut
Darrell G. Eisenhut, Director
Division of Licensing

Enclosure:
As Stated

cc: C. Michelson, AEOD
F. Miraglia
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8304140608
PDR/2 PDR

A/9