AEC DISTRIBUTION FOR PART 50 DOCKET MATERIAL
(TEMPORARY FORM)

CONTROL NO: 8753

FILE:

FROM:	DATE OF DOC	DATE REC'D	LTR	TWX	RPT	OTHER
Iowa Electric Light & Power Co Cedar Rapids, IA GG Hunt	8-19-74	8-24-74	X			

TO:	ORIG	CC	OTHER	
AEC	1 signed			SENT AEC PDR XXX SENT LOCAL PDR XXX

CLASS	UNCLASS	PROP INFO	INPUT	NO CYS REC'D	DOCKET NO:
	XXX			1	50-331

DESCRIPTION:

Ltr furn suppl info...Abnormal occurrences #DPR-49/74-3A & DPR-49/74-4A of 4-26- & 4-28-74 re reactor water conductivity levels.......... w/att....

PLANT NAME: DUANE ARNOLD

ENCLOSURES:

DO NOT REMOVE

ACKNOWLEDGED

FOR ACTION/INFORMATION

BUTLER (L)	SCHWENCER (L)	ZIEMANN (L)	REGAN (E)
W/ CYS	W/ CYS	W/ CYS	W/ CYS
CLARK (L)	STOLZ (L)	DICKER (E)	✓LEAR
W/ CYS	W/ CYS	W/ CYS	W/7 CYS
~~PARR (L)~~	~~VASSALLO (L)~~	~~KNIGHTON (E)~~	
W/ CYS	W/ CYS	W/ CYS	W/ CYS
KNIEL (L)	PURPLE (L)	YOUNGBLOOD (E)	
W/ CYS	W/ CYS	W/ CYS	W/ CYS

INTERNAL DISTRIBUTION

✓REG FILE	TECH REVIEW	DENTON	LIC ASST	A/T IND
✓AEC PDR		GRIMES	DIGGS (L)	BRAITMAN
✓OGC	✓SCHROEDER	GAMMILL	GEARIN (L)	SALTZMAN
✓MUNTZING/STAFF	✓MACCARY	KASTNER	GOULBOURNE (L)	B. HURT
✓CASE	✓KNIGHT	BALLARD	KREUTZER (E)	
GIAMBUSSO	✓PAWLICKI	SPANGLER	LEE (L)	PLANS
BOYD	✓SHAO		MAIGRET (L)	MCDONALD
MOORE (L)(LWR-2)	✓STELLO	ENVIRO	REED (E)	CHAPMAN
✓DEYOUNG (L)(LWR-1)	✓HOUSTON	MULLER	SERVICE (L)	DUBE w/input
SKOVHOLT (L)	✓NOVAK	DICKER	SHEPPARD (L)	E. COUPE
GOLLER (L)	✓ROSS	KNIGHTON	SLATER (E)	
P. COLLINS	✓IPPOLITO	YOUNGBLOOD	SMITH (L)	✓D. THOMPSON (2)
DENISE	✓TEDESCO	REGAN	✓TEETS (L)	✓KLECKER
✓REG OPR	✓LONG	PROJECT MGR	WILLIAMS (E)	✓EISENHUT
FILE & REGION (2)	✓LAINAS		WILSON (L)	
✓MORRIS	✓BENAROYA	HARLESS		
✓STEELE	✓VOLLMER			

EXTERNAL DISTRIBUTION

✓1 - LOCAL PDR CEDAR RAPIDS, IA
✓1 - TIC (ABERNATHY)
✓1 - NSIC (BUCHANAN)
1 - ASLB
1 - Newton Anderson
✓5 - ACRS SENT TO LIC ASST TEETS 8-26-74

(1)(2)(10)-NATIONAL LABS
1-ASLBP(E/W Bldg, Rm 529)
1-W. PENNINGTON, Rm E-201 GT
1-B&M SWINEBROAD, Rm E-201 GT
1-CONSULTANTS
NEWMARK/BLUME/AGBABIAN

1-PDR-SAN/LA/NY
1-BROOKHAVEN NAT LAB
1-G. ULRIKSON, ORNL
1-AGMED (RUTH GUSSMAN)
Rm B-127 GT
1-RD..MUELLER, Rm F-3..
GT

IOWA ELECTRIC LIGHT AND POWER COMPANY

General Office
CEDAR RAPIDS, IOWA

50-331

Subject: Abnormal Occurrences (Supplementary Report)

Report Number: DPR-49/74-3A and DPR-49/74-4A

Report Date: August 13, 1974

Occurrence Dates: April 26, 1974 and April 28, 1974, respectively

Facility: Duane Arnold Energy Center, Unit #1, Palo, Iowa

Identification of Occurrences

Reactor water conductivity levels reportable in accordance with Appendix A to Operating License DPR-49, Specification 1.0.4.b.

Conditions Prior to Occurrences

DPR-49/74-3

1. Routine Startup Operation - nuclear heat was being used to raise reactor water temperature to 212°F. in preparation for Phase Four Startup Activities.

2. Reactor Vessel vented to atmosphere and reactor water temperature at inlet to Reactor Water Cleanup System 135°F..

3. Reactor Critical, thermal power <1%.

DPR-49/74-4

1. Nuclear heat (neutron flux) was being used to break down Reactor Water Cleanup System resins in the reactor water.

2. Reactor vessel vented to atmosphere and reactor water temperature at inlet to Reactor Water Cleanup System, 150°F..

3. Reactor Critical, thermal power <1%.

Description of Occurrence

DPR-49/74-3

April 26, 1974

1. 1300 hours, Control Room Operators observed increasing reactor water conductivity.

2. 1320, Reactor water conductivity exceeded Tech. Spec. limit of 5 micro mhos/cm. (Beginning of DPR-49/74-3.)

3. 1335, Operations requested reactor water sample analysis for conductivity, pH, and chlorides.

4. 1420, Chemistry Group implemented continuous monitoring of reactor water conductivity and pH at Reactor Water Cleanup Sample Station. Readings were to be logged at 1/2 hour intervals.

5. 1430, Shift Supervisor log entry indicates reactor water conductivity of 24 micro mhos/cm, reactor water temperature of 195°F. and a chemistry report that chlorides are within specifications.

6. 1620, Operations Supervisor directed that power and temperature be held constant (195°F.) and cleanup to continue until conductivity within Tech. Spec. limits.

7. 1700, Reactor water conductivity peaked at 33 micro mhos/cm and decreasing.

8. 1810, D. Boyd, Region III Reactor Inspector, USAEC, notified of Abnormal Occurrence, DPR-49/74-3.

9. 1822, Assistant Chief Engineer ordered commencement of orderly shutdown.

10. Control rod insertion began.

11. 2103, All control rods fully inserted.

12. 2112, Reactor mode switch placed in shutdown.

13. 2400, Reactor water conductivity approximately 22 micro mhos/cm.

April 27, 1974

14. 0454 hours, "B" RHR Loop placed in shutdown cooling mode to increase reactor water temperature with pump heat. (Reactor water temperature approximately 148°F.).

15. 1505, "A" RHR Loop placed in shutdown cooling mode to increase reactor water temperature with pump heat. (Reactor water temperature approximately 157°F.).

16. 1530, Reactor water conductivity below Tech. Spec. limitations of 5 micro mho per/cm. (End of DPR 49/74-3).

17. 1825, Reactor water temperature approximately 175°F..

18. 2021, RHR Loops "A" and "B" secured from shutdown cooling mode.

19. 2116, Reactor Mode Switch placed in "Startup" in preparation for heatup in accordance with instructions from the Assistant Chief Engineer and the Operations Supervisor. After each rod pull in the approach to criticality, reactor water conductivity is to be observed for five (5) minutes before pulling more rods. If at any time 4.5 micro mhos/cm reactor water conductivity is reached, rod motion is to stop, allowing Reactor Water Cleanup System to reduce conductivity.

20. 2136, Commenced rod pull for criticality.

DPR-49/74-4

April 28, 1974

21. 0155 hours, Reactor critical, reactor water temperature 160°F..

22. 0300-0500 hours, Although instrumentation indicated that conductivity exceeded Technical Specification limits, the actual conductivity was below Technical Specification limits when correctd for CO_2.

23. 0800, Reactor water conductivity exceeded Tech. Spec. limit of 5 micro mho./cm. (Beginning of DPR-49/74-4.)

24. 0845, Reactor water conductivity peaked at 7.8 micro mhos/cm.

25. 0916, Orderly reactor shutdown began. Reactor water conductivity began decreasing.

26. 1005, All control rods fully inserted.

27. 1012, Reactor Mode Switch placed in shutdown.

28. 1019, RHR Loop "B" placed in shutdown cooling mode in order to maintain reactor water temperature with pump heat.

29. 1023, RHR Loop "A" placed in shutdown cooling mode in order to maintain reactor water temperature with pump heat.

30. 1230, Reactor water conductivity below Tech. Spec. limits of 5 micro mhos/cm. (End of DPR 49/74-4.)

April 29, 1974

31. 0756, USAEC Region 5, Coordinating Office notified concerning DPR-49/74-4.

Designation of Apparent Cause of Occurrences

The cause of the occurrences was the breakdown of Reactor Water Cleanup System resins in the reactor water resulting from exposure to nuclear radiation.

Resins were introduced to the reactor water during the conduct of Preoperational Test No. 58.1 - Nuclear Steam Supply Shutoff System on April 3, 1974. (See Unusual Event Report No. DPR 49/74-UE-1.) During this test, the Reactor Water Cleanup System discharge valve to radwaste was open while the filter-demineralizers were in a "hold" mode of operation. It is believed the filter-demineralizer tanks may have partially drained allowing resins to drop off the septums. When the Reactor Water Cleanup System was restored to normal operations, resins could have passed through the septums and into the reactor vessel.

Investigation to determine other mechanisms by which large amounts of resin could have been introduced to the reactor water has been completed. Several potential design/operating deficiencies have been identified but it is not known whether they individually or collectively were the source of the resin in the reactor water. The potential design/operating deficiencies have been identified as follows:

1. Inadequate Pipe Venting - A high point exists on both filter-demineralizer loops where the precoat inlet and holding pump discharge piping are tied together. This condition could create an air pocket during the "backwash" mode, and the air pocket could be subsequently discharged during the "precoat" and "hold" modes. The ensuing air bubbles trapped in the precoat layer would collapse and destroy the integrity of the precoat layer.

2. No Automatic Isolation of Filter-Demineralizers - As designed, the filter demineralizer units do not automatically isolate on a low or no flow condition when there is a cleanup recirc. pump failure or closure of the main RWCU isolation valves. In certain modes of operation, it may be possible to either drop the filter-demineralizer bed or draw it down the bypass loop.

3. Improper Valve Lineups - Resin could have been introduced to the reactor water as the result of improper valve lineups during backwash and precoat cycles. As designed, there is no interlock between the manual backwash/precoat setup valves and the automatic backwash/precoat sequence.

4. No Loss of Holding Pump Alarm - The only indication of the loss of holding pump is a red light. If the red light is not observed by the operator with subsequent appropriate action, the resin cake will dislodge from the septum and subsequent resin injection into the reactor could result.

5. Diluted Precoats - A diluted precoat could result from misoperation of the precoat tank or leakage of demineralized water to the precoat tank.

Analysis of Occurrences

As indicated earlier in this report, the cause of the occurrences was the breakdown of reactor water cleanup resins resulting from exposure to nuclear radiation. This conclusion is supported by information contained in a Rohm and Haas bulletin Amber-Hi-Lites, No. 139 as follows, "When exposed to radiation, ion exchange resins are subject to degradation conditions in water treatment. High energy radiation, particularily gamma and X-ray radiation, will directly degrade many organic compounds, including all types of ion exchange resins. In addition, gamma radiation causes water to undergo radiolysis, resulting in the formation of hydrogen peroxide which in turn will cause all ion exchange resins to degrade." The Rohm and Haas report goes on to explain that such degradation of cation ion exchange resin will be evidenced by the formation of sulfuric acid. The formation of sulfuric acid will cause a reduction in solution pH and an increase in conductivity due to the presence of ionic material.

Following the subject occurrences, analysis of the reactor water indicated the presence of sulphates. The reaction of sulphates to form sulfuric acid would indicate degradation of cation resin and account for the observed low reactor coolant pH and high conductivity.

Corrective Actions

Reactor water pH and conductivity during the time of the occurrences and subsequent corrective actions are indicated in the attached Figure 1.

Following is a chronological summary of actions undertaken to control reactor water conductivity:

April 26 through April 28, 1974

Cleanup of the reactor water to reduce conductivity was attempted via the Reactor Cleanup System.

April 29, 1974

Special testing of the reactor water cleanup filter-demineralizer units was undertaken to ascertain if the use of solka-floc would reduce the traces of resins in the effluent of the units (the filter septums in current use are designed not to require the use of solka-floc). Results of the testing indicated that the use of solka-floc did not significantly reduce the traces of resin in the effluent of the units.

May 1, 1974

Actions were initiated to prepare the condensate-system filter-demineralizers for large volume cleanup of the reactor water. A procedure was prepared to provide for the following flow paths:

1. Removal of approximately 200 gpm of reactor water from the reactor vessel through the reactor water cleanup system bypass piping and discharge to the main condenser hot well.

2. Flow to the reactor vessel was to be through the Condensate-Feedwater System. The feedwater regulating valves would maintain reactor vessel level and flow to the condenser.

May 2, 1974

Cleanup of reactor water using the Condensate-Feedwater System commenced at 0200 hours.

May 3, 1974

Reactor water conductivity was reduced to less than 1 micro-mho/cm using the Condensate-Feedwater System. However, it was anticipated, reactor water conductivity would again increase and pH would decrease as resin breakdown occurred with radiation exposure. The Nuclear Steam Supply System supplier was contacted concerning the possibility of adding chemicals to the reactor water in order to maintain an acceptable pH during increases in neutron flux levels.

May 4, 1974

Based on recommendations of the Nuclear Steam Supply System supplier, titration of the reactor vessel with reagent grade trisodium phosphate commenced at 0100 hours. The trisodium phosphate was used to maintain a near neutral pH during neutron flux increases. (See attached Figure 2.) Cleanup of reactor water via the Condensate System was continued in parallel.

May 5 through May 8, 1974

Titration of the reactor vessel and cleanup of reactor water with the Condensate-Demineralizer System continued.

On May 8, 1974, the USAEC approved a change to the Duane Arnold Energy Center Technical Specifications providing for an increase in coolant conductivity limits for the purpose of facilitating demineralizer resin removal from the reactor vessel. The change raised the limit on coolant conductivity to 30 micro-mho/cm prior to the first occasion reactor coolant temperature reaches 375°F..

May 9, 1974

A procedure for increasing the rate of cleanup of the reactor water was reviewed and approved by the Operations Committee. The following items summarize the mechanism for increasing the rate of cleanup to 3000 gpm (See attached Figure 2).

1. Neutron flux levels were to be increased until a reactor coolant conductivity of 10 micro-mhos/cm was reached. Reactor water pH was to be controlled by continuing titration with trisodium phosphate.

2. When a conductivity of 10 micro-mho/cm is reached, the reactor would be taken subcritical.

3. Reactor water level would then be increased to a point just above the main steam line.

4. Recirculation of reactor coolant would be accomplished by flow through one main steam line, through the bypass and to the condenser.

5. Flow to the vessel to maintain reactor water level would be through the Condensate-Demineralizer System and one of the feedwater regulating valves.

6. Cleanup by recirculation through the Condensate-Demineralizer System would continue until reactor water conductivity reached acceptable levels as indicated by the IEL&P Chemistry Group. At which time, reactor vessel level would be lowered below the main steam lines and the reactor taken critical.

The above procedure was to continue alternately going critical and recirculating reactor water through the Condensate-Demineralizer Feedwater System.

IEL&P Engineering and nuclear steam supply vendor personnel had previously analyzed the above procedure and concluded that it would not have a deleterious effect on the main steam piping and isolation valves. All appropriate pipe hangers were pinned prior to commencement of the recirculation through the main steam lines.

Reactor water cleanup in accordance with the above procedure commenced at approximately 0500 horus.

May 10 and May 11, 1974

Reactor water cleanup via alternating nuclear heatup and recirculation of reactor coolant continued.

May 12, 1974

0930, cleanup of reactor water via recirculation through the main steam line was terminated. Reactor coolant conductivity leveled out well within acceptable levels (<2 micro-mho/cm) with the reactor critical, demonstrating resin breakdown from neutron flux exposure had ceased.

The reactor was returned to normal and the Startup Test Program continued.

As noted in the "Designation of Apparent Cause of Occurence" section of this report, several potential design/operating deficiencies have been identified as possible causes for the release of reactor water cleanup resins to the reactor water. The following items describe corrective actions initiated to eliminate the potential deficiencies and prevent repetition of the occurrences:

1. Inadequate pipe venting - a plant design change has been initiated to provide automatic venting of the high-point piping on the holding pump discharge lines.

2. No automatic isolation of filter-demineralizer - a plant design change has been initiated to provide automatic isolation of the reactor water cleanup filter-demineralizers in the event of low or no flow.

3. Improper valve lineups - a plant design change has been initiated to provide valve interlocks which prohibit initiation of backwash without the proper valve lineup.

4. No loss of holding pump alarm - a plant design change has been initiated to provide a holding pump status light and an alarm which is energized when the flow in the holding pump loop is less than the minimum required.

5. Diluted precoats - Operations personnel have been briefed concerning the importance of maintaining the proper mixture of water and resin in the resin precoat tank. A copy of the vendors reactor water cleanup operating procedures have been posted at the cleanup control panel to assist the operator.

This Supplemental Report was reviewed and approved by the Duane Arnold Energy Center Operations Committee on July 31, 1974.

G. G. Hunt
Chief Engineer
Duane Arnold Energy Center

DLW:GGH:bh
ATTACHMENTS (3)

DUANE ARNOLD ENERGY CENTER

NOTES

FIGURE 2

DATE	NOTES NO.	TIME	Na_3PO_4 Additions (in gms)	Reactor Startup	Reactor Shutdown	Reactor Vessel Flush Commenced (gpms)	Reactor Vessel Flush Secured
5-4-74	1	0059		x			
	2	1719	20				
	3	2152	200				
	4	2228	80				
	5	2305	50				
	6	2334	50				
	7	2359	50				
5-5-74	1	0020	50				
	2	0046	50				
	3	0210	50				
	4	0236	50				
	5	0250	50				
	6	1134	100				
	7	1155	100				
	8	1230	100				
	9	1257	100				
	10	1432	100				
	11	1501	100				
	12	1533	100				
	13	1603	100				
	14	1630	150				
	15	1700	100				
	16	1732	150				
	17	1800	150				
	18	1833	150				
	19	1917	100				
5-6-74	1	1049	200				
	2	1109	200				
	3	1121	200				
	4	1144	200				
	5	1158	200				
	6	1218	200				
	7	1227	200				
	8	1410	200				
	9	1542	200				
5-7-74							
5-8-74	1	2119	250				
	2	2157	250				
	3	2218	200				
	4	2348	200				
5-9-74	1	0020	200				
	2	0042	200				
	3	0225			x		
	4	0420		Raise Vessel Level			
	5	0530				3000	
	6	0540				2000	

DUANE ARNOLD ENERGY CENTER
NOTES
FIGURE 2

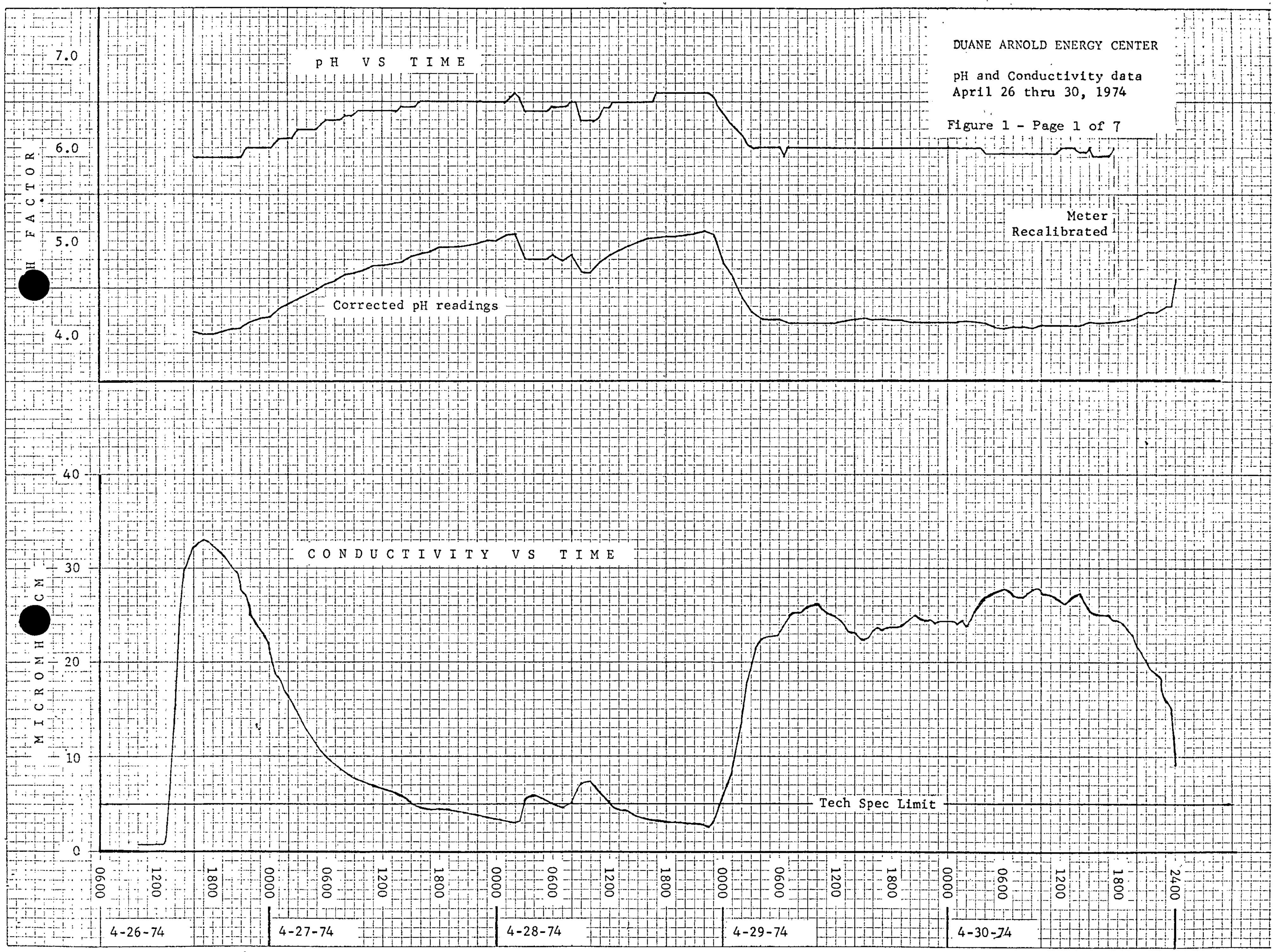
DATE	NOTES NO.	TIME	Na_3Po_4 Additions (in gms)	Reactor		Reactor Vessel Flush	
				Startup	Shutdown	Commenced (gpms)	Secured
5-9-74 Cont'd	7	0605					x
	8	0641		x			
	9	0717	200				
	10	0733	200				
	11	0745	200				
	12	0802	200				
	13	0817	200				
	14	0832	200				
	15	0847	200				
	16	0852			x		
	17	0915				2800	
	18	1012					x
	19	1029	200				
	20	1032		x			
	21	1117	200				
	22	1129	200				
	23	1142	200				
	24	1153	200				
	25	1204	200				
	26	1215	200				
	27	1228			x		
	28	1246				3000	
	29	1304				1700	
	30	1322					x
	31	1345		x			
	32	1404	200				
	33	1419	200				
	34	1428	200				
	35	1430	200				
	36	1457	200				
	37	1510			x		
	38	1540				3000	
	39	1645					x
	40	1657		x			
	41	1710	200				
	42	1727	200				
	43	1743	200				
	44	1800	200				
	45	1818	200				
	46	1840			x		
	47	1900				3000	
	48	2000					x
	49	2017		x			
	50	2025	200				
	51	2037	200				
	52	2055	200				
	53	2105	200				
	54	2120	200				
	55	2141	200				
	56	2213			x		

DUANE ARNOLD ENERGY CENTER

NOTES

FIGURE 2

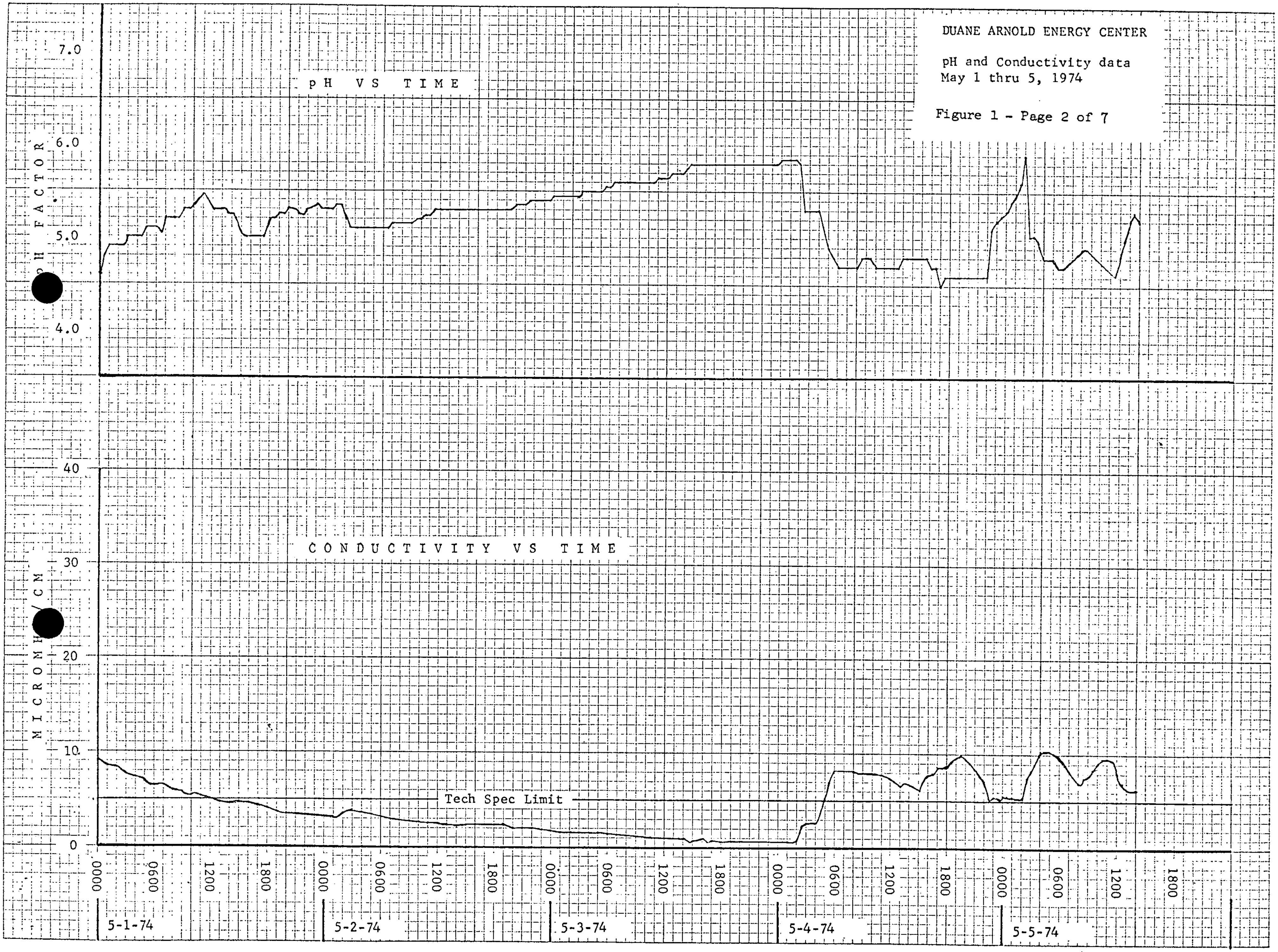
DATE	NOTES NO.	TIME	Na_4Po_4 Additions (in gms)	Reactor Startup	Reactor Shutdown	Reactor Vessel Flush Commenced	Reactor Vessel Flush Secured
5-10-74	1	0028		x			
	2	0101	200				
	3	0110	200				
	4	0131	200				
	5	0145	200				
	6	0238			x		
	7	0255				3000	
	8	0340					x
	9	0354		x			
	10	0438	200				
	11	0456	200				
	12	0543			x		
	13	0600				3000	
	14	0704					x
	15	0722		x			
	16	1059	50				
	17	1122	100				
	18	1146	100				
	19	1210	200		x		
	20	1241	200				
	21	1336				3000	
	22	1413					x
	23	1428		x			
	24	1758	200				
	25	1821	200				
	26	1840	200				
	27	1845			x		
	28	2325		x			
5-11-74	11	0024	200				
	2	1239			x		
5-12-74	1	0558				3000	
	2	0712					x
	3	0930	Main steam lineup returned to normal				
	4	1521		x			
		0530	Lowering Rx Vessel Level				
	5	1635			x		
	6	1644	200				
	7	1657	200				
	8	1720	200				
	9	1734					
	10	1800		x			
	11	1932	200				



DUANE ARNOLD ENERGY CENTER

pH and Conductivity data
April 26 thru 30, 1974

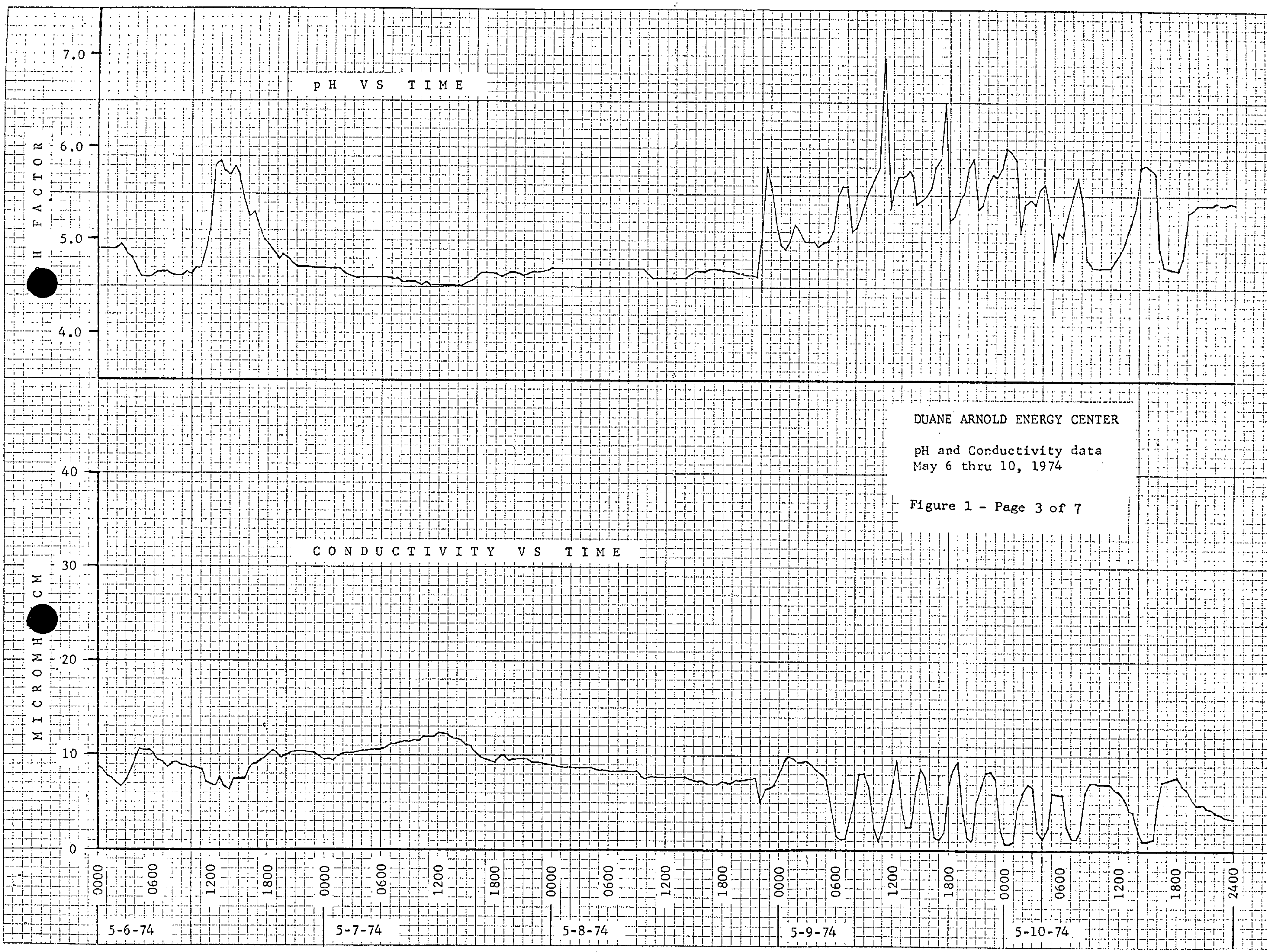
Figure 1 - Page 1 of 7



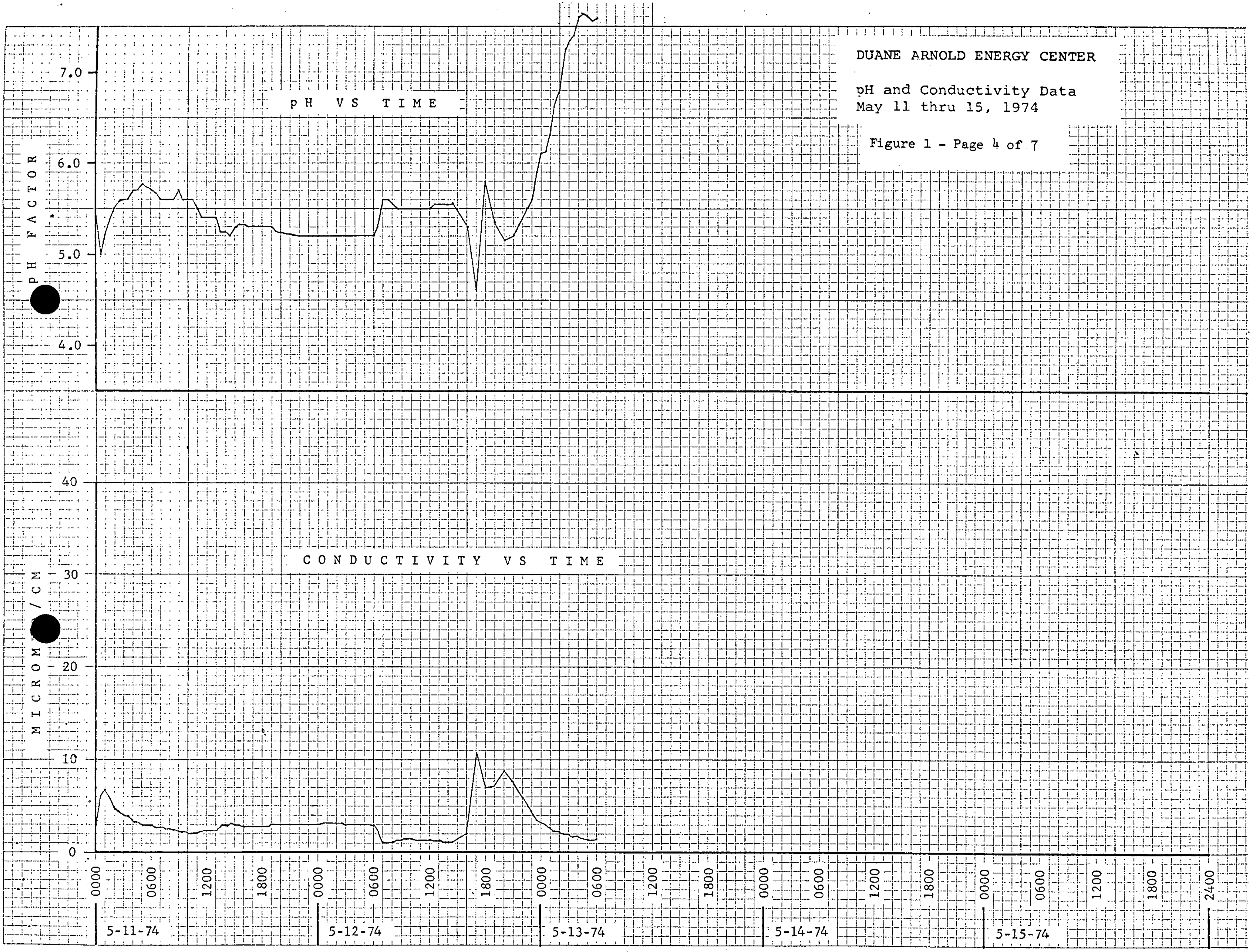
DUANE ARNOLD ENERGY CENTER

pH and Conductivity data
May 1 thru 5, 1974

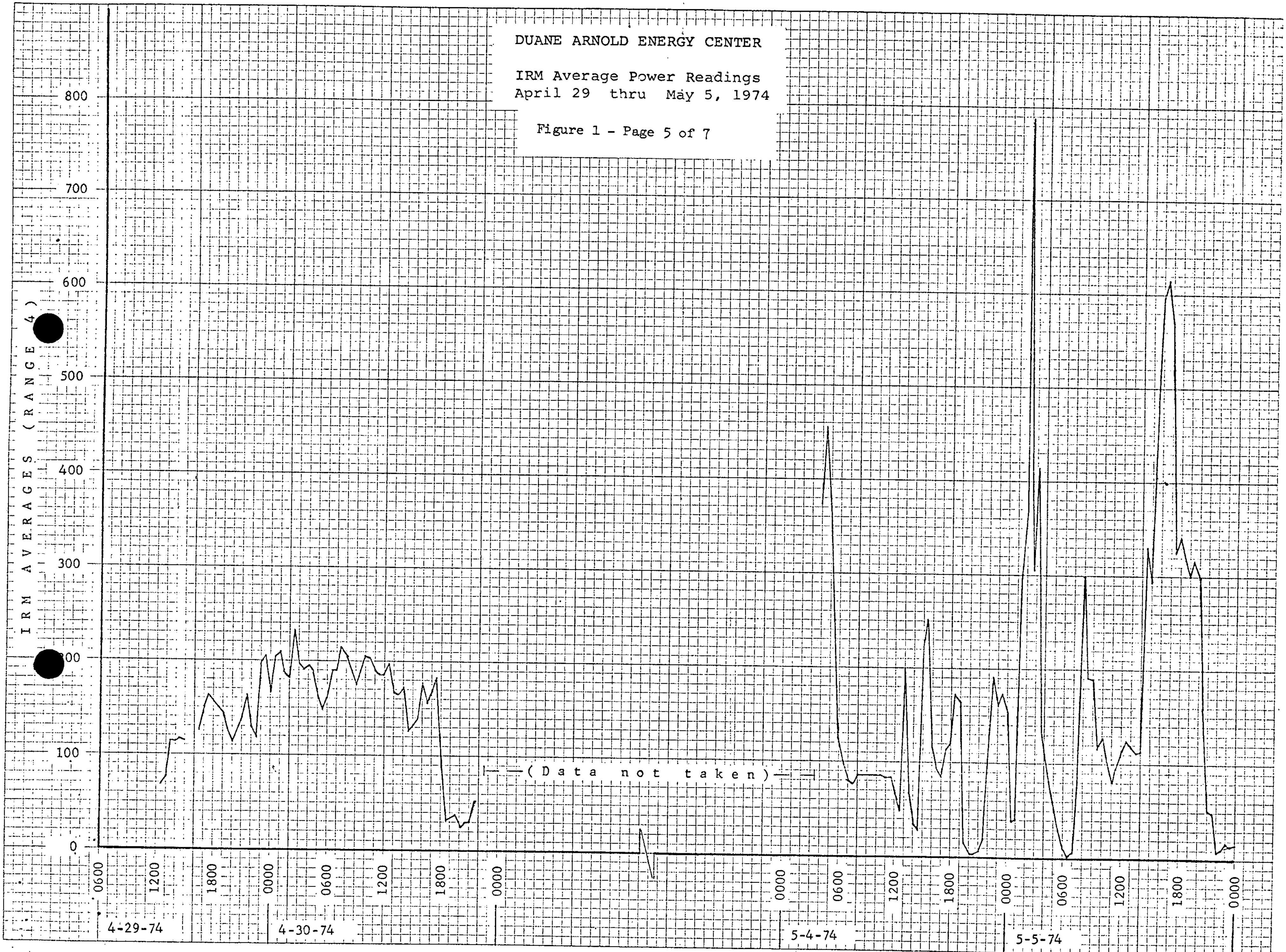
Figure 1 - Page 2 of 7



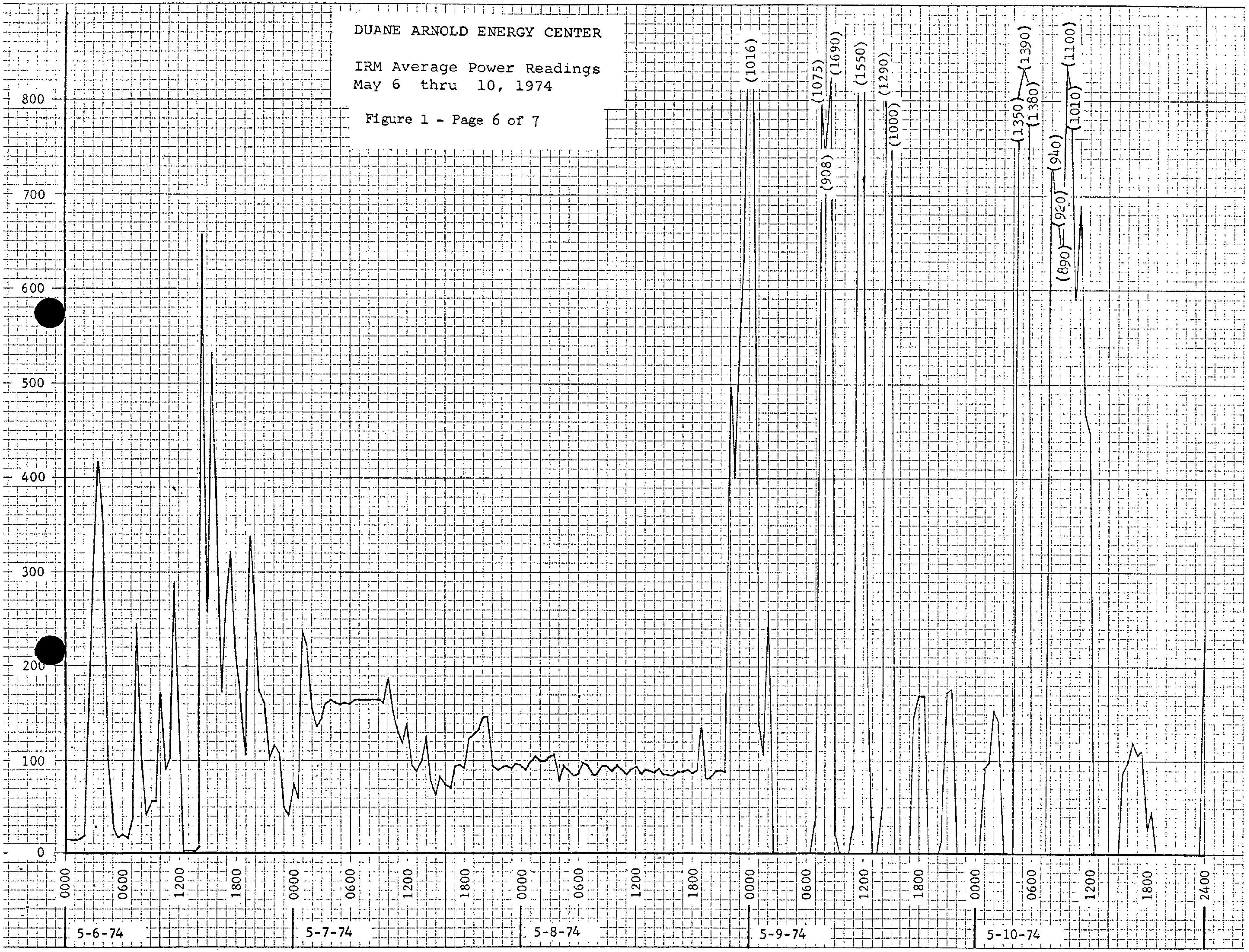
pH VS TIME
PH FACTOR
7.0
6.0
5.0
4.0
DUANE ARNOLD ENERGY CENTER
pH and Conductivity data
May 6 thru 10, 1974
Figure 1 - Page 3 of 7
CONDUCTIVITY VS TIME
MICROMHO CM
40
30
20
10
0
0000
0600
1200
1800
2400
5-6-74
5-7-74
5-8-74
5-9-74
5-10-74



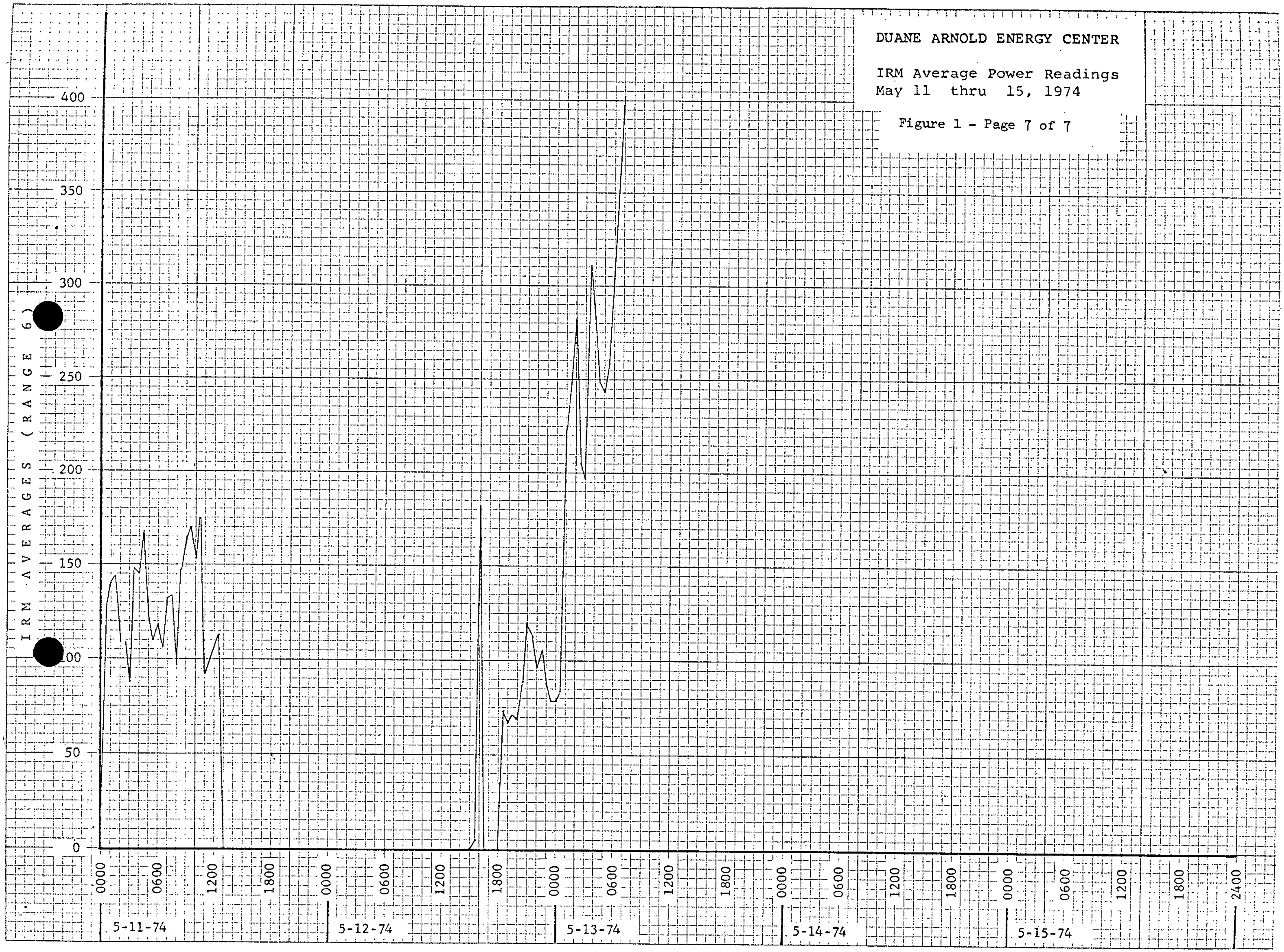
DUANE ARNOLD ENERGY CENTER
pH and Conductivity Data
May 11 thru 15, 1974
Figure 1 - Page 4 of 7
pH VS TIME
pH FACTOR
7.0
6.0
5.0
4.0
CONDUCTIVITY VS TIME
MICROMHOS/CM
40
30
20
10
0
0000
0600
1200
1800
2400
5-11-74
5-12-74
5-13-74
5-14-74
5-15-74



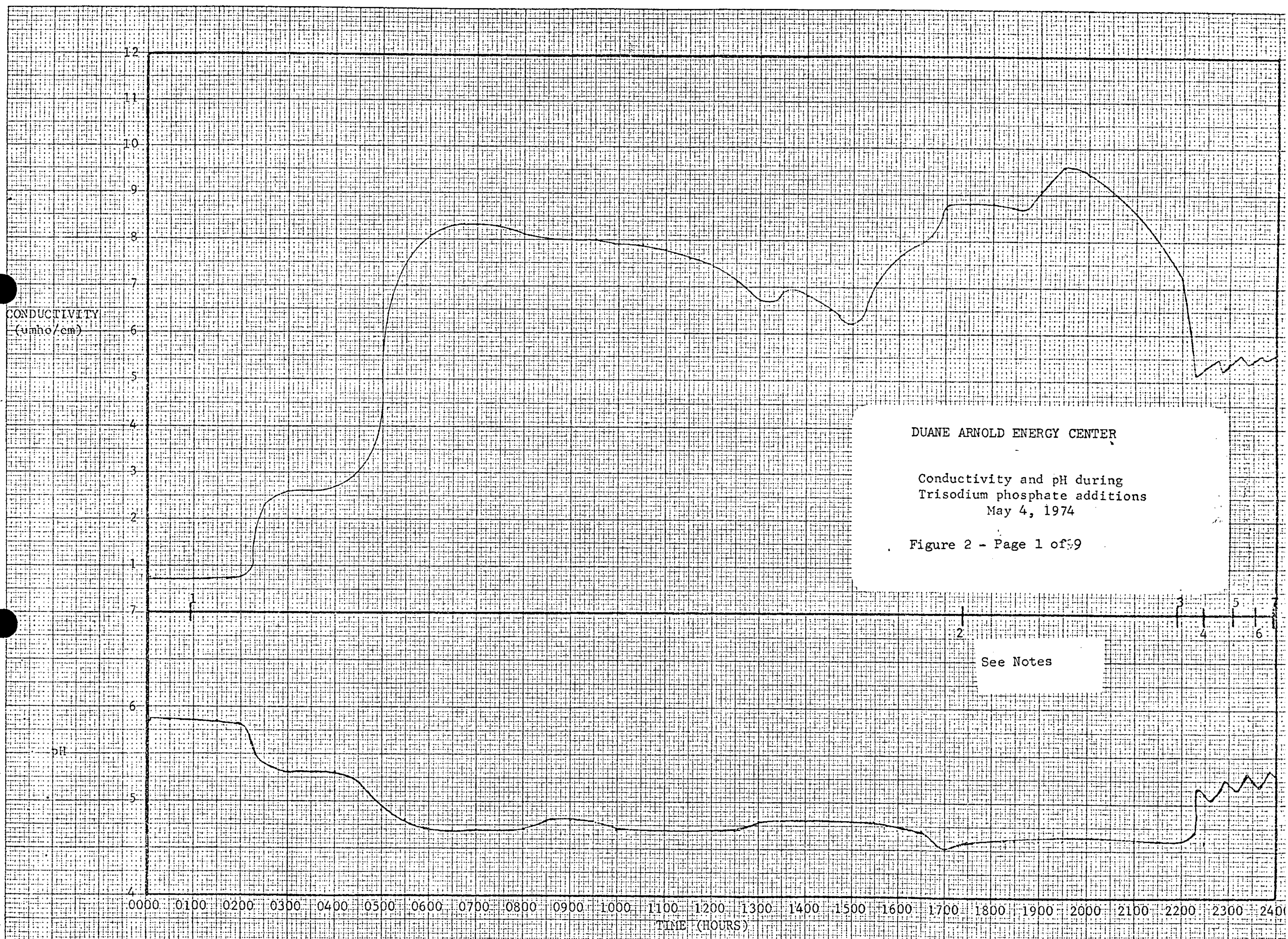
NOTE: 100 on IRM Range 4 corresponds to approximately .014% power



NOTE: 100 on IRM Range 6 corresponds to approximately .014% power.



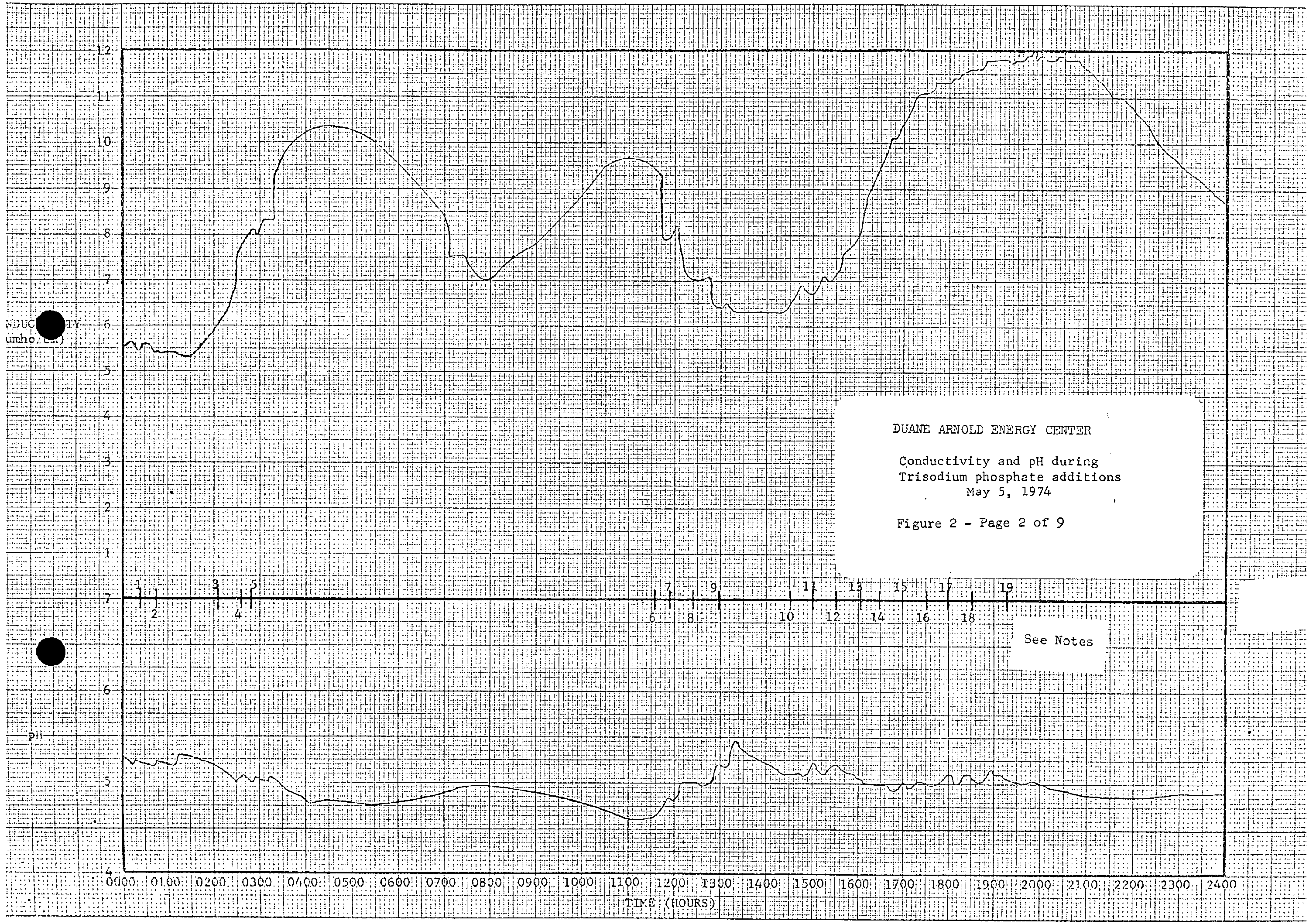
NOTE: 100 on IRM Range 6 corresponds to approximately .14% power.



DUANE ARNOLD ENERGY CENTER

Conductivity and pH during Trisodium phosphate additions
May 4, 1974

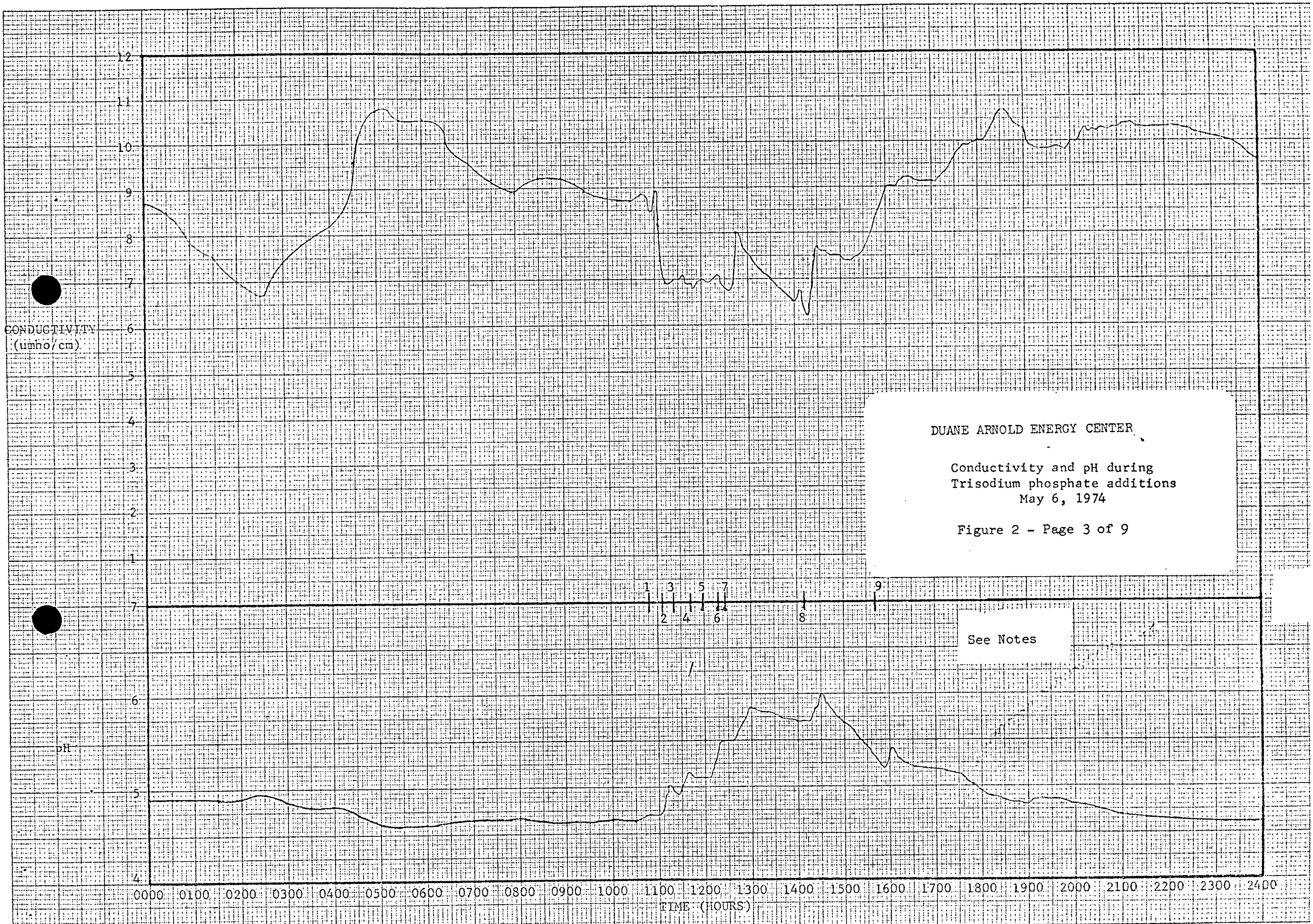
Figure 2 - Page 1 of 9



DUANE ARNOLD ENERGY CENTER

Conductivity and pH during Trisodium phosphate additions May 5, 1974

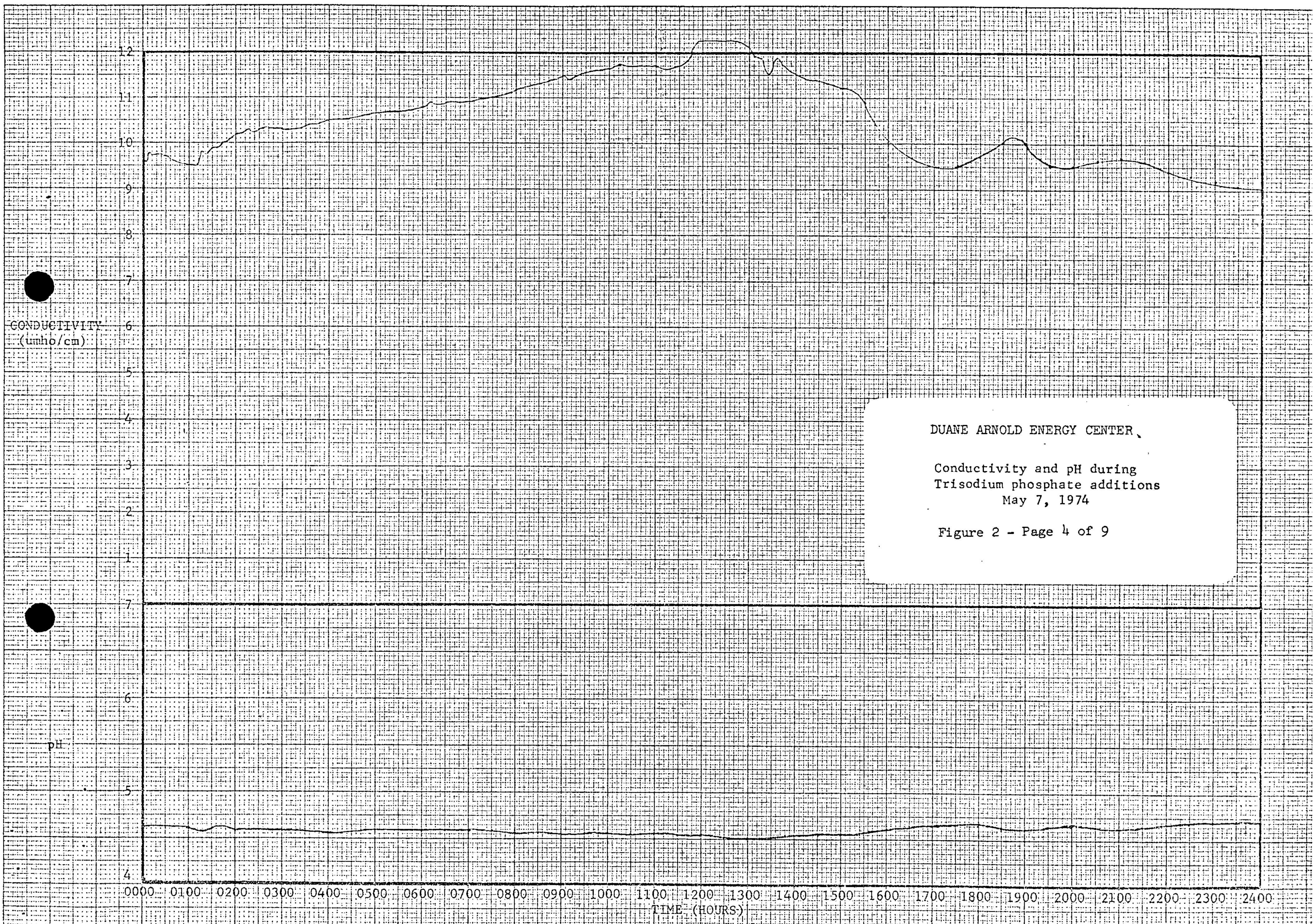
Figure 2 - Page 2 of 9



DUANE ARNOLD ENERGY CENTER

Conductivity and pH during
Trisodium phosphate additions
May 6, 1974

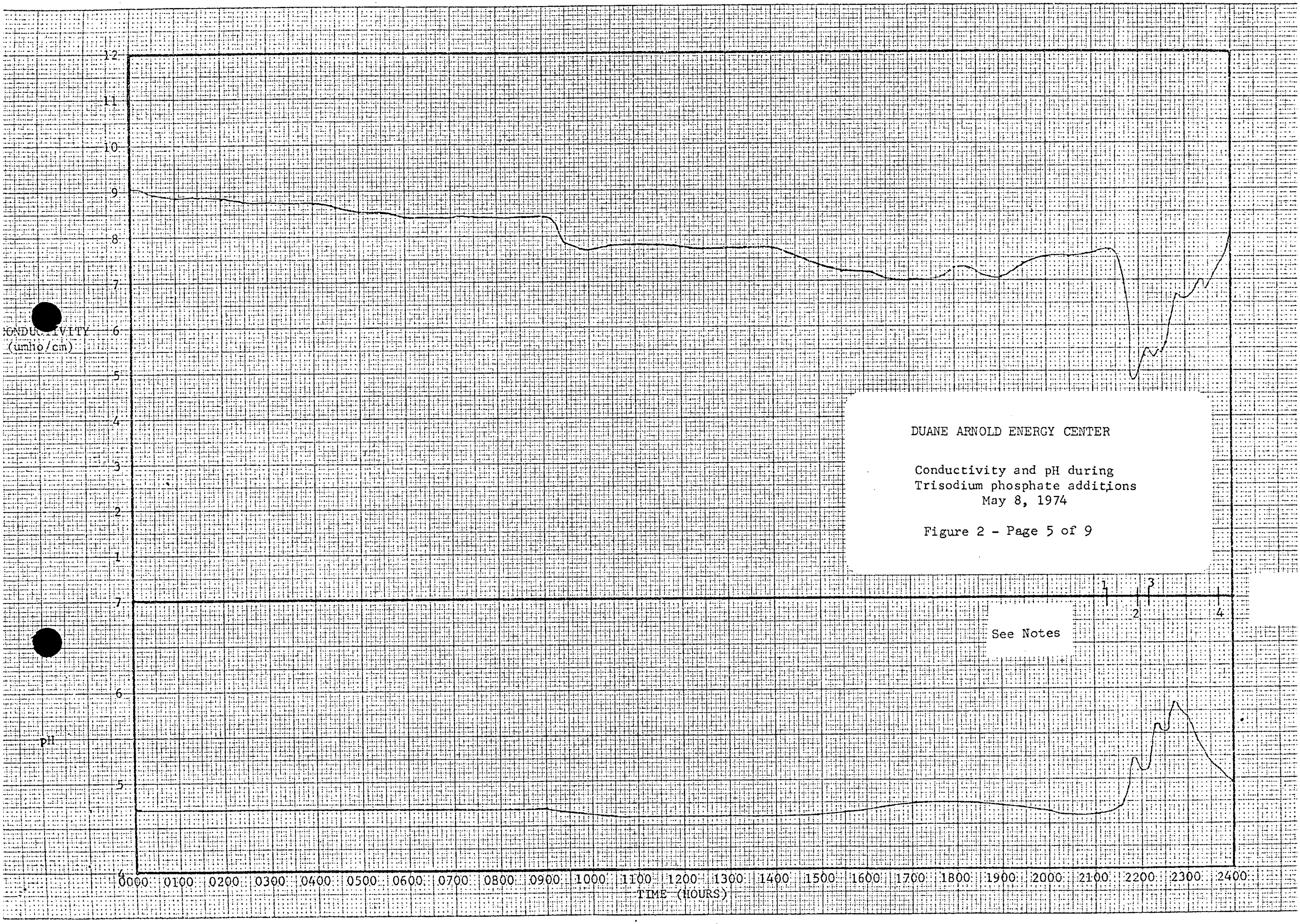
Figure 2 - Page 3 of 9

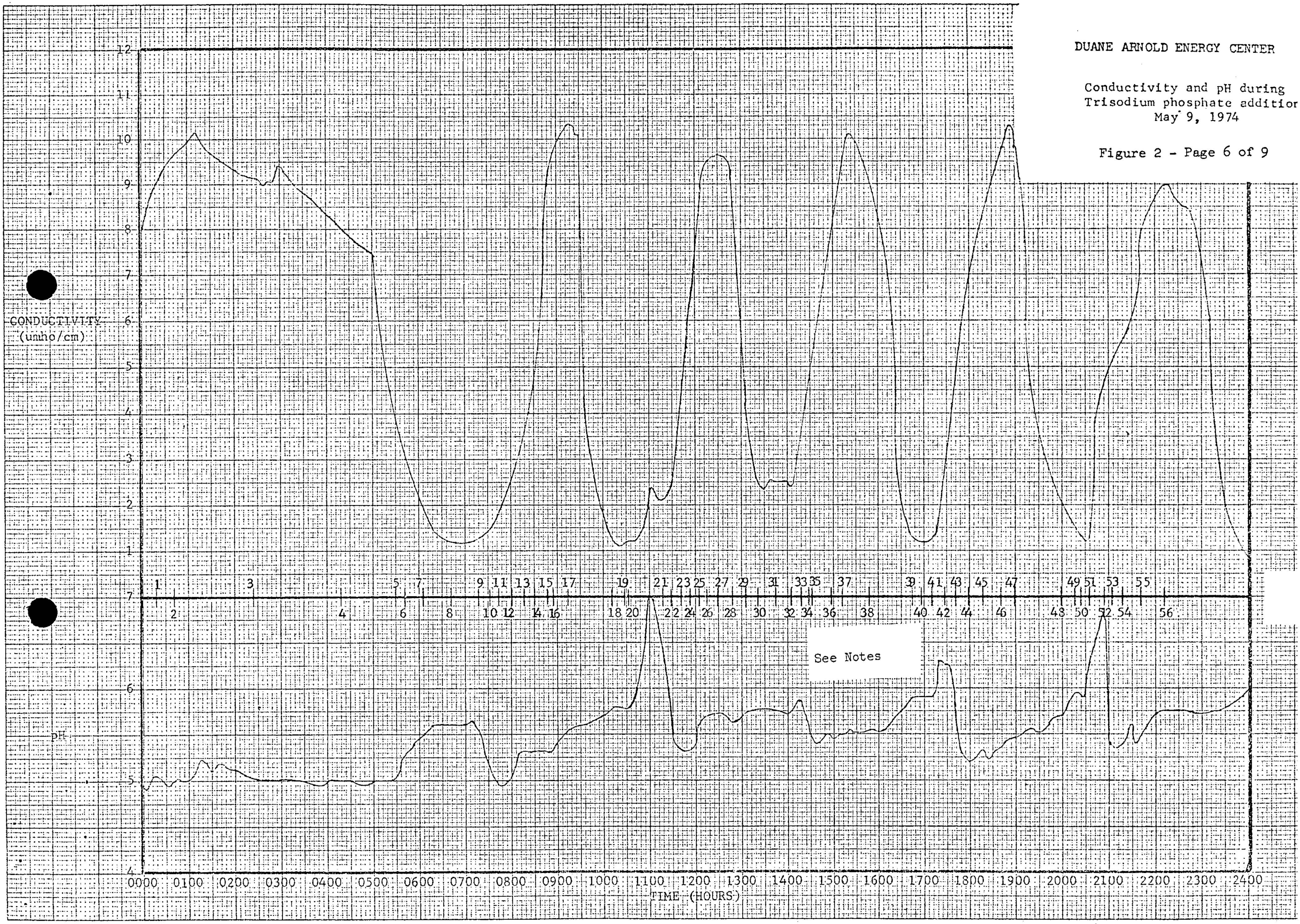


DUANE ARNOLD ENERGY CENTER

Conductivity and pH during
Trisodium phosphate additions
May 7, 1974

Figure 2 - Page 4 of 9

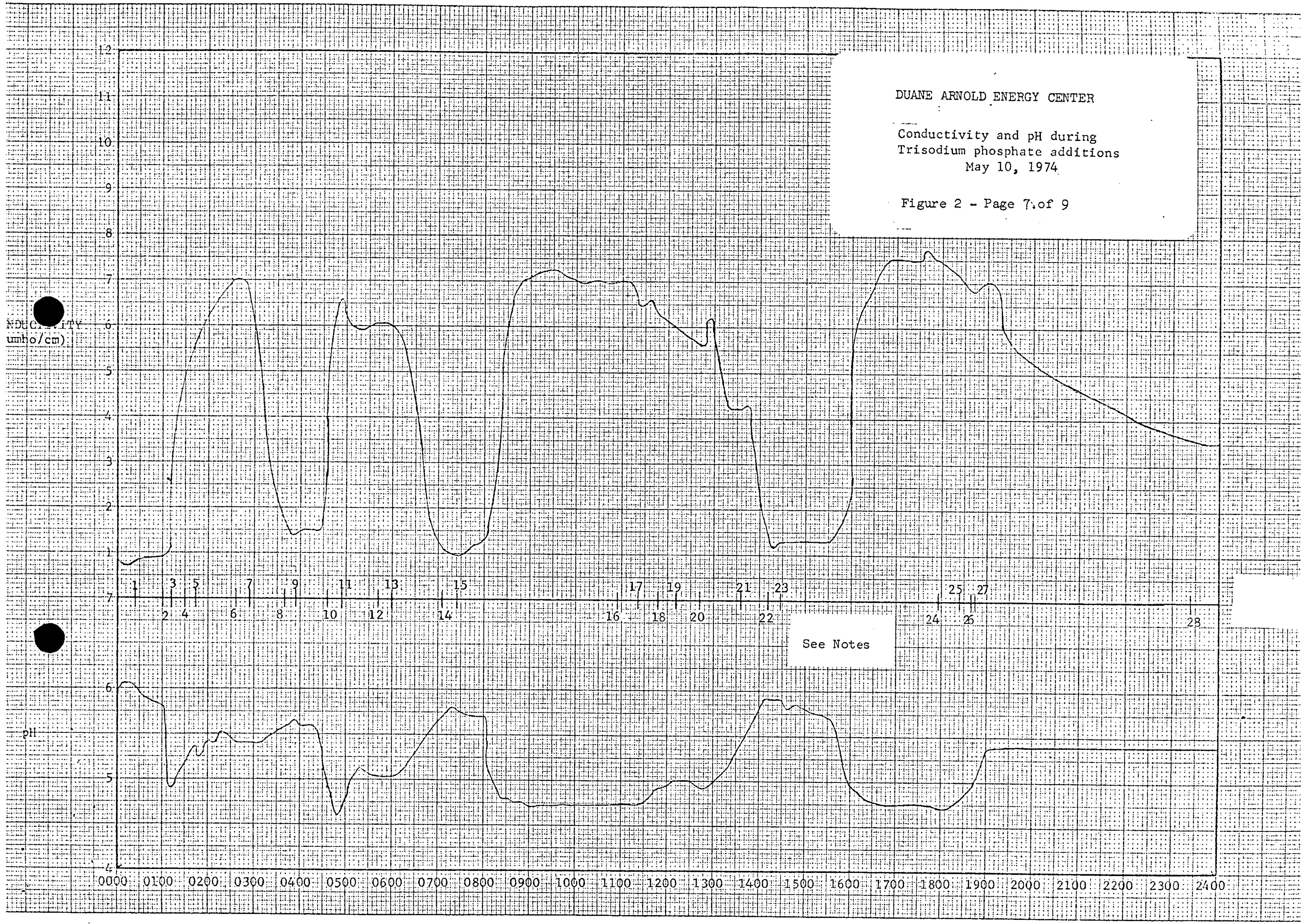

DUANE ARNOLD ENERGY CENTER
Conductivity and pH during
Trisodium phosphate additions
May 8, 1974
Figure 2 - Page 5 of 9
CONDUCTIVITY
(umho/cm)
pH
See Notes
TIME (HOURS)
0000 0100 0200 0300 0400 0500 0600 0700 0800 0900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400



DUANE ARNOLD ENERGY CENTER

Conductivity and pH during Trisodium phosphate addition
May 9, 1974

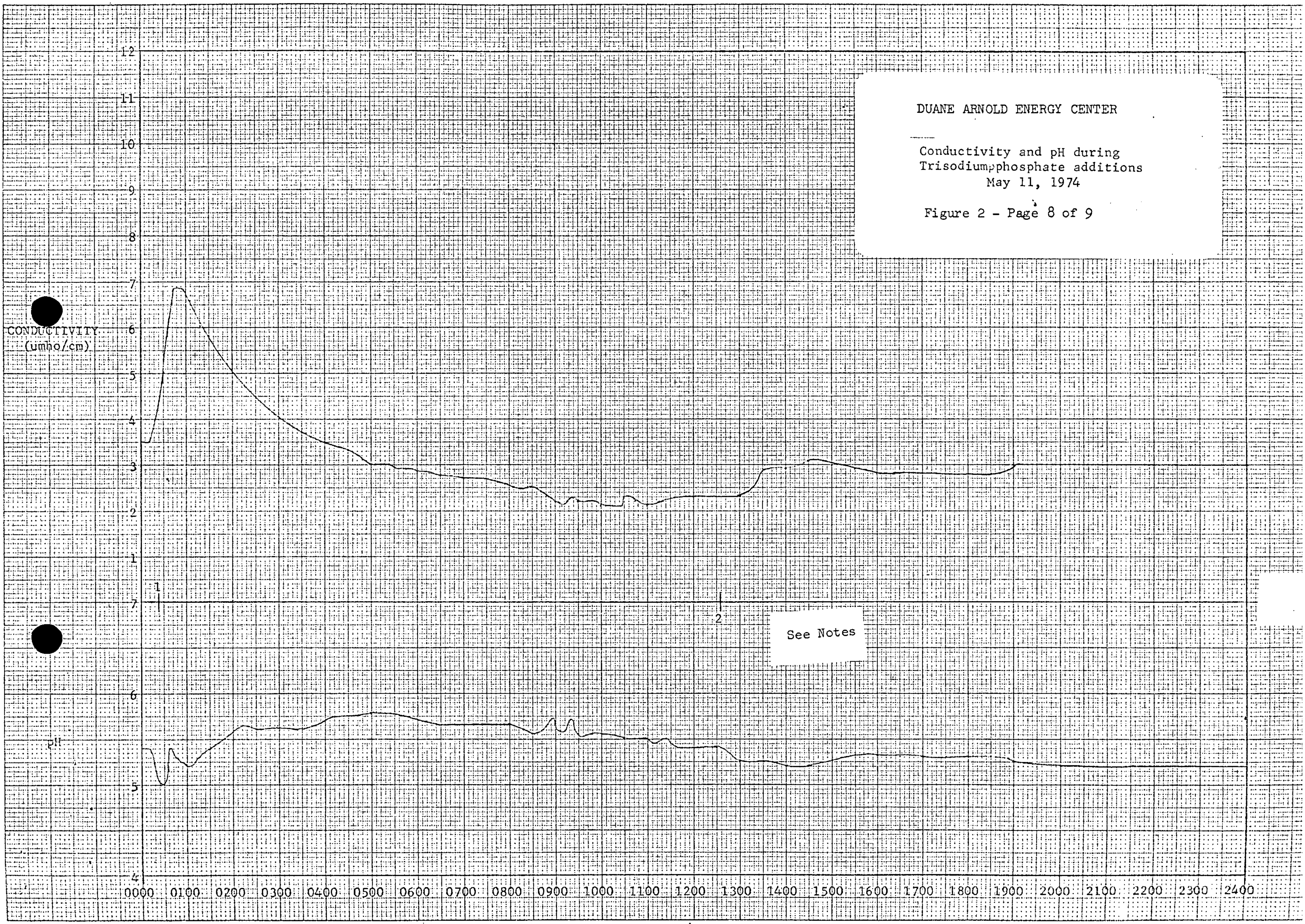
Figure 2 - Page 6 of 9

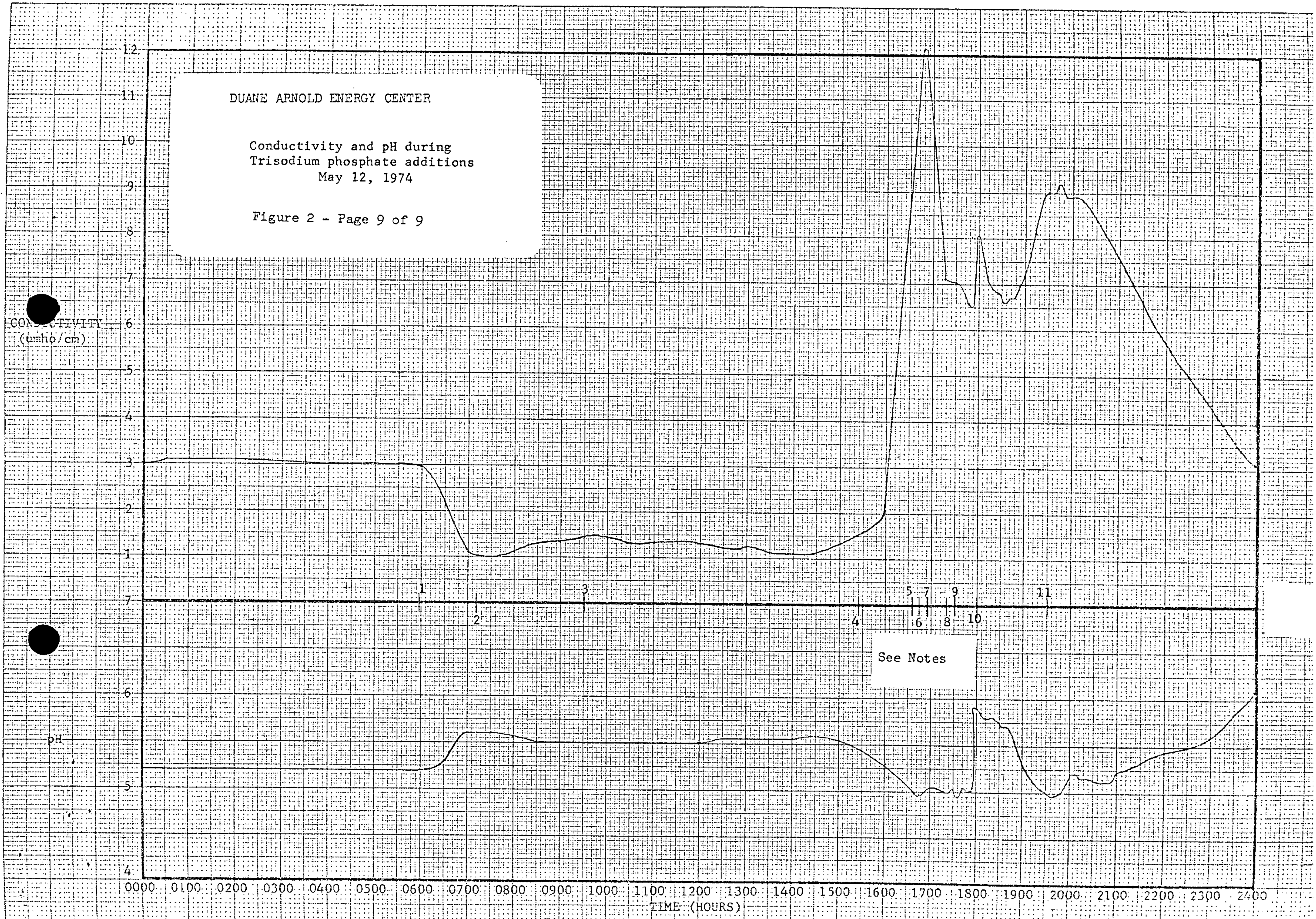


DUANE ARNOLD ENERGY CENTER

Conductivity and pH during
Trisodium phosphate additions
May 10, 1974

Figure 2 - Page 7 of 9


DUANE ARNOLD ENERGY CENTER
Conductivity and pH during
Trisodiumphosphate additions
May 11, 1974
Figure 2 - Page 8 of 9
CONDUCTIVITY
(umho/cm)
pH
See Notes
1
2
12
11
10
9
8
7
6
5
4
3
2
1
7
6
5
4
0000
0100
0200
0300
0400
0500
0600
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400


DUANE ARNOLD ENERGY CENTER
Conductivity and pH during
Trisodium phosphate additions
May 12, 1974
Figure 2 - Page 9 of 9
CONDUCTIVITY (umho/cm)
12
11
10
9
8
7
6
5
4
3
2
1
pH
7
6
5
4
1
2
3
4
5
6
7
8
9
10
11
See Notes
0000
0100
0200
0300
0400
0500
0600
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
TIME (HOURS)