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An Investigation of Brain and Lymphopoietic Cancer at a Union Carbide Plant in Seadrift, Texas

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16. Abstract (Limit: 200 words) A possible excess of brain and lymphopoietic cancer mortality occurring among employees of a petrochemical facility in Texas was investigated. One brain cancer death and a possible cluster of five lymphopoietic cancer deaths had been reported at the facility. The facility was a diversified chemical production site. No brain or lymphopoietic cancer deaths were identified other than those initially reported. The results of a proportionate mortality study and a preliminary sample based cohort mortality study suggested that there were excesses in the number of lymphopoietic cancer deaths among this employee population. For lymphopoietic cancer the proportionate mortality ratio was 666 and the preliminary estimate of the standardized mortality ratio was 291. A case/control study of facility employees indicated that there was evidence of an association between lymphopoietic cancer mortality, particularly Hodgkin's disease, and the assignment of the worker to areas in the facility where low density polyethylene was produced. The low density polyethylene production was started in 1954. However, any conclusion that the excess of lymphopoietic deaths may have been to employment in this area of the facility was weakened by the long term employment of one case at a different chemical facility, the limited number of cases and the calendar distribution of the Hodgkin's Disease deaths.

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An Investigation of Brain and Lymphopoietic Cancer at a Union Carbide Plant in Seadrift, Texas

SUMMARY

A series of epidemiologic studies was conducted to investigate possible excess brain and lymphopoietic cancer mortality among employees of a petrochemical plant in Texas. Regional case ascertainment did not identify any brain or lymphopoietic cancer deaths other than those initially reported: one brain and 5 lymphopoietic cancer deaths. A proportionate mortality study and a preliminary sample-based cohort mortality study indicated excesses of lymphopoietic cancer mortality among the employee population at the plant. The PMR for lymphopoietic cancer was 666, and the preliminary estimate of the SMR was 291. A case-control study of plant employees indicated associations between lymphoietic cancer mortality, specifically Hodgkin's disease, and assignment to low-density polyethylene production areas. However, the long-term employment of one case at a different chemical plant, the limited number of cases and the calendar distribution of Hodgkin's Disease deaths (last occurrence in 1966) substantially weakened any conclusions that the excess of lymphopoietic deaths may be causally linked to employment at the plant or in the low-density polyethylene area.

INTRODUCTION

While investigating a cluster of brain tumor deaths at a Union Carbide chemical plant in Texas City, Texas,[1] NIOSH was informed of a brain cancer death and a possible cluster of lymphopoietic cancer deaths at a Union Carbide chemical plant located in Seadrift, Texas. Because 18 brain tumors deaths had already been documented at the Texas City plant,[1] which is similar to but older than the Seadrift plant, there was concern that this newly reported brain cancer death might be the first of many at Seadrift.

Plant Description

The facility at Seadrift, Texas is a diversified chemical production plant. It is located on the Gulf Coast approximately 150 miles southwest of Houston. In its current configuration, production units and related structures cover 1,450 acres of the 2,500 acre compound. As of October 1978, there were 1,303 company employees and an estimated 250 contract laborers at the facility. Following the plant's start-up, the number of company employees has grown steadily from 126 in 1954, to approximately 800 in the 1960's, and exceeded 1,000 in 1974.

When the facility began operations in 1954, its production was limited to ethylene oxide, olefins and low-density polyethylene. An ethylene oxide derivative unit came into production in 1956 and a high-density polyethylene unit in 1957. Expansion in the 1960's included the addition of an alcohol unit in 1960, a styrene unit in 1964, and

expansion of the olefins and ethylene oxide units, in 1961 and 1969, respectively. In the mid-1970's, production facilities of both high-and low-density polyethylene were expanded, but styrene production was curtailed in 1978 (See Figures 1-3).

Objectives

Confronted with a small number of cases arising from a population of modest size, the NIOSH investigators limited the scope of their initial investigation to the following activities:

- Verifying reported brain cancer and lymphopoietic cancer deaths;
- Ascertaining additional deaths;
- Computing preliminary estimates of risk; and
- Investigating associations of selected causes of death and particular chemical processes.

The results of these activities were only expected to serve as a basis for future investigations at this or other chemical plants.

METHODS

Case Ascertainment and Verification

Information concerning all deaths of Seadrift employees known to the company was made available by the plant medical director. The precise mechanism for the company knowing of these deaths was not determined.

Ascertainment of additional deaths due to brain or lymphopoietic cancer was based on a computer search of state vital statistics records of all Texas cancer deaths from 1949 through 1977. This search was conducted by the University of Texas System Cancer Center using computer data tapes provided them by the Texas Department of Health Resources. All deaths meeting the following criteria were selected and printed on listings:

- Death occurred during the period from January 1, 1954 through December 31, 1977;
- Age at death was greater than 19 years
- Decedent was a white male;
- ICDA Seventh Revision Code for underlying cause of death was 193, 200-203,205 or revision equivalents; and
- County of residence at time of death was Calhoun, Jackson, Refugio or Victoria.

These listings were then manually matched by NIOSH investigators against personnel records at the Seadrift plant.

Preliminary Risk Estimation

Additional activities were focused on the lymphopoietic cancer deaths because the brain cancer death initially reported was the only confirmed case. The protocol consisted of three short-term epidemiologic studies to be conducted using only readily available information. The designs chosen were a proportionate mortality study, a preliminary sample-based cohort study, and a case-control study.

Proportionate Mortality Study: The study was conducted to determine whether or not the proportions of deaths due to lymphopoietic cancers among those deaths known to the company were unusual. Separate proportionate mortality ratios (PMR's) were calculated for Hodgkin's Disease (ICDA Seventh Revision, Code 201) and other selected lymphopoietic malignancies (ICDA Seventh Revision, Code 200-203,205, leukemia excluded). Certificates for all reported deaths known to the company were obtained by NIOSH and coded by a nosologist. The five year age- and calendar-specific distributions of deaths by cause for the U.S. white male population were used to generate expected deaths.[2] The PMRs are reported in terms of observed deaths divided by expected deaths and multiplied by 100.

Statistical significance of the PMRs was determined by computing p values assuming the observed deaths followed a Poisson distribution with the mean equal to the expected number of deaths. The level of statistical significance was set at the 0.05 level, two-tailed.

Preliminary Sample-Based Cohort Study: This study was conducted to determine whether or not the number of deaths due to lymphoma appeared to be in excess.

This study was called a sample-based cohort study primarily because a sample of the total study population was used to estimate the number of expected lymphopoietic cancer deaths. Further, the observed deaths consisted of those ascertained by the previously described methods

used to ascertain the lymphopoietic deaths. These deaths included those known to the company and ascertained among former workers who died while a resident of the 4-county area proximate to the plant. Hence, the observed deaths of the study constituted a sample of the total number of lymphoma deaths of the study population. This study design is also referred to as "preliminary" because the design of the sample-based cohort study has subsequently been expanded and improved.[3,4]

A ten percent sample of all former and current employees was collected using a random process to select one of the first 10 records in the alphabetically-ordered personnel file; then every tenth folder thereafter was selected for the sample. Selected information (name, social security number, sex, race, birthdate, first and last date employed and death date, if reported to be deceased by the company) was collected from company personnel records for each member of the sample. All employees whose vital status was unknown to the company were assumed alive until the end of the study period, December 31, 1979. Females and nonwhites were subsequently excluded from the sample because they constituted a small percentage of the employee population.

Each white male sample member was allowed to accumulate person years at risk (PYARs) from his date of hire through the end of the study period (December 31, 1977) or his date of death, if prior to the end of the study period. The accumulated age- and calendar-specific PYARs

were multiplied by the corresponding U.S. death rates for the selected lymphopoietic malignancies in order to obtain the expected number of deaths of the sample.(2) These expected deaths of the 10% sample were then multiplied by 10 (the reciprocal of the sampling fraction) to obtain an estimate of the total number of expected lymphopoietic cancer deaths of all white males of the total plant population.

A sample-based standardized mortality ratio (SMR) was computed by dividing the observed lymphopoietic cancer deaths known to the company and/or among employee residents in the four-county area by the total number of expected deaths derived from the sample and then multiplying that ratio by 100.

As noted in a previous report in which the sample-based method was used,(3) significance testing of the sample-based SMRs was considered inappropriate due to the developmental nature of the method. One problem involves the variability incorporated in the expected deaths by deriving them from a sample of the total population at risk. This variability could produce an estimate of the expected deaths which is either more or less than the actual number of expected deaths thus possibly producing an inaccurate estimate of the actual SMR. In addition, an underascertainment bias for the observed deaths should be anticipated. These deaths were limited to those known to the company or ascertained in the four-county area when the expected deaths should have approximated all lymphopoietic cancer deaths of the entire plant population. Therefore, these preliminary sample-based

SMRs should underestimate the actual SMR. Sample-based SMRs less than or equal to 100 would be difficult to interpret since one could not be certain whether the result was due to underascertainment of observed deaths or due to an actual deficit or lack of an excess in mortality. However, if a sample-based SMR was greatly elevated in spite of the underascertainment bias, the primary problem of interpretation would be to what extent might the actual SMR be higher than the sample-based SMR. To provide a degree of perspective, the observed and expected deaths of each sample-based SMR are reported.

Case-Control Study: A matched case-control study was conducted to determine if any associations existed between specific work area assignments and the lymphopoietic cancer cases. Six matched controls were chosen for each case. Using a company hiring log ordered by hire date, a pool of potential controls was identified from individuals hired within five months of each case. Potential controls were randomly chosen from this pool and the first six persons were selected as controls if they met the following criteria:

- Birth date was within seven years of case;
- Sex and race same as case; and
- Duration of work at least as long as the case.

Detailed work history information and interpretations were provided by Union Carbide. These work history summaries were such that each job assignment of a case or control could be characterized by involvement

in one or a limited number of production processes areas of the plant. If an individual job assignment involved more than one production process area, the time spent in the assignment was divided and equally allocated to each production process. For example, if an employee was assigned as a pipefitter to Area I from January, 1955 to January, 1956, he would have had an opportunity to be involved in both the low-density polyethylene and olefins areas (See Figure 1). Since more detailed information was unavailable, 6 months of employment in the olefins area and 6 months in the low-density polyethylene area would be allocated to that particular employee's work history. The various configurations of the plant by production areas used for such determinations are presented as Figures 1 - 3.

Only the work area assignments of the cases prior to the date of diagnosis of the malignancy were considered in the case-control analysis. Similarly, only the assignments of the matched controls were considered in the analysis if the assignments were held during the period from the first day of plant employment to the date of diagnosis of the respective case.

Associations between particular job assignments and death due to lymphopoietic cancers were quantified by computing the maximum likelihood estimate of the odds-ratio.(5) The statistical significance of the odds-ratios were determined by computing the associated Mantel-Haenszel X^2s and was also presented in terms of 95% confidence intervals. An odds-ratio was considered statistically

significant if the X^2 (1 d.f.) exceeded 3.84, i.e. p 0.05, two-tailed.

RESULTS

Case Ascertainment and Verification

The 4-county vital statistics search did not identify any brain or lymphopoietic cancer deaths not already known to the company medical department. The one worker who died of a brain tumor had worked for the company 25 years and died at the age of 46. The pertinent characteristics of the five workers who died of hematopoietic malignancies are summarized in Table 1. All had worked at least 6 years in the industry and 3 years at the plant, and died before age 50. All but one of the Hodgkin's Disease deaths occurred while the decedent had resided in the same county in which the plant was located, Victoria County. The most recent lymphopoietic cancer death occurred in 1977, and of the three Hodgkin's Disease deaths, the last occurred in 1966.

Review of medical records of the three cases reported to have died of Hodgkin's Disease documented that the diagnosis was based upon tissue examination. The medical records of the other two cases also supported the cause of death reported on the respective death certificates, namely, lymphoma (not otherwise specified) and multiple myeloma.

Preliminary Risk Estimation

Proportionate Mortality Study: The PMR for all lymphopoietic cancer, excluding leukemia, of 666 (based on 5 observed deaths and 0.75 expected) was statistically significant, p = 0.012. The PMR for Hodgkin's Disease of 1200 (based on 3 observed deaths and 0.25 expected) was statistically significant, p = 0.006. A PMR for death due to brain tumors was not calculated for the single confirmed case.

Preliminary Sample-Based Cohort Study: The sample-based SMR for all lymphopoietic cancer, excluding leukemia, was 291, based on 5 observed deaths and 1.72 expected. The greatest contribution to this excess was attributable to the Hodgkin's Disease deaths. For Hodgkin's Disease, the SMR was 484, based on 3 observed deaths and 0.62 expected. The sample-based SMR for other lymphopoietic malignancies, excluding leukemia, was 182, based on 2 observed deaths and 1.10 expected.

Despite the limited number of observed deaths, trends by duration of employment and time since first employment at the plant, and by calendar period of death were examined for all five lymphopoietic cancer deaths and for the three Hodgkin's Disease deaths (Tables, 2, 3,4). For the evaluations of duration and time since first plant employment, several excesses were seen. These excesses, which ranged from twice to more than five times the expected, did not demonstrate any marked trends. The excesses were somewhat similar in magnitude

for the 0 through 9 year and 10 through 19 year strata, but no deaths were observed for the 20 or more year strata for either duration or time since first employment. For the evaluation by calendar period of death, there was an apparent decrease in risk of lymphopoietic cancer, excluding leukemia, over time although the observed deaths exceeded the expected in four of the five calendar periods examined. For Hodgkin's Disease, no deaths occurred after 1966.

Case Control Study: The case-control study demonstrated associations between deaths due to lymphopoietic cancer and 2 of the 10 particular work area assignments examined. See Table 5 for details of analyses where 3 or more of the cases were exposed. On the basis of all five deaths, a strong association was demonstrated for assignment to either the high- or low-density polyethylene areas and lymphopoietic cancer. Since all five cases had at one time been assigned to either of the areas, the odds-ratio was infinite. Despite the limited number of cases, the X^2 of 6.06 was statistically significant. Associations, though not statisticaly significant, were seen for assignments to the oxide derivatives, alcohol, amines area (odds-ratio = 4.86, X^2 = 3.27), the ethylene oxides area (odds-ratio = 3.69, X^2 = 2.07), and the low-density polyethylene area (odds-ratio = 2.83, X^2 = 1.23).

Further analyses (Table 6), counting work experience of one year or more in an area prior to diagnosis of the case, further substantiated associations of lymphopoietic cancer with employment in the polyethylene areas. The odds-ratio for assignment to either high or

low-density polyethylene was 7.06 and was statistically significant, $X^2 = 4.00$. For low-density polyethylene assignments only, the odds-ratio was 4.01, but was not statistically significant ($X^2 = 2.53$). The odds-ratios for other work area assignments were not reported because no more than 2 of the 5 cases were assigned to any of the other areas for a sufficient time to be allocated one or more years of exposure to the given production processes.

When the work area assignments were evaluated on the basis of the three Hodgkin's Disease deaths, there was a strong association between the cases and assignment to the low-density polyethylene area. All three of the cases had been assigned to areas which included low-density polyethylene production and stayed long enough to be allocated a year or more of exposure. The association was statistically significant, $X^2 = 7.00$. No more than 1 of the 3 Hodgkin's Disease deaths had ever been assigned to any of the other areas prior to date of diagnosis.

DISCUSSION AND CONCLUSIONS

The report of a potential brain cancer cluster was not substantiated. Although the reported death due to brain tumor was confirmed, no additional cases were identified. The studies which comprised the investigation of the lymphopoietic cancer deaths documented an excess by proportional and cohort mortality analyses. More specifically,

these excesses were primarily attributable to Hodgkin's Disease deaths among this population. The PMR for lymphopoietic cancer was significantly elevated at 666 and for the subset of Hodgkin's Disease deaths it was significantly elevated at 1200. The sample-based SMRs were also elevated. For lymphopoietic cancer, excluding leukemia, the sample-based SMR was 291 and for the subset of Hodgkin's Disease deaths, it was 484. Although the set of deaths on which the proportionate mortality study was based may not have been representative of all employee deaths and the observed deaths of the sample-based SMR probably did not include all lymphopoietic deaths of the employee population, one must conclude that five lymphopoietic cancer deaths, three of which were due to Hodgkin's Disease, constituted an excess.

The case-control study linked the lymphopoietic cancer excess to assignments in the polyethylene areas of the plant. For the heterogeneous case definition which included all 5 lymphopoietic cancers, assignment for a year or more to a polyethylene area was significantly associated with a 7 fold risk of lymphoma. For a comparable assignment to one of the low-density polyethylene areas, there was a 4 fold risk. This latter risk association was not statistically significant.

For the more specific case definition of Hodgkin's Disease, there was a significant association between the disease and an assignment of a year or more to a low-density polyethylene area. The odds-ratio was

infinite because all three of the cases had been assigned to low-density polyethylene areas.

Despite the results of the aforementioned studies, a conclusion that polyethylene exposure caused or contributed to the observed excesses would be very tenuous, given the limitations of the case-control studies. They were based on an extremely small number of cases, five. When the case definition was restricted to Hodgkin's Disease, only three cases remained.

The definition of exposure was based on two assumptions. First, if not otherwise specified by the company, it was assumed that the time an employee was assigned to an area where several different production units were operated was equally divided among all production units. Second, it was assumed that time spent (or assumed to be spent) in a particular production unit entailed exposure to the primary production product of the unit. Although these are reasonable assumptions and were equally applied to both cases and controls, they could lead to erroneous results for such a limited number of study subjects .

It should be noted that one of the Hodgkin's Disease deaths of the investigation spent most of his 18 year tenure with the company, not at Seadrift, but at another Union Carbide plant. Although he actually worked in a low-density polyethylene area at the other location, his inclusion in the Seadrift investigation served to confuse the interpretations of the case-control studies, especially in terms of

duration and time since first exposure, and in the appropriateness of his matched controls.

Of particular interest is the fact that the last Hodgkin's Disease death occurred in 1966. Since polyethylene production at the plant has continued and has even been expanded since the last of these cases was first exposed, one would have expected additional Hodgkin's Disease deaths. The lack of additional deaths weakens an argument of a causal association between polyethylene exposure and Hodgkin's Disease.

Examination of potential chemical exposures in the low-density polyethylene production area failed to produce any support for a causal association. From start-up in 1954 through the present, the plant produced low-density polyethylene. From published descriptions of this process, ethylene is charged into the reactor at high pressures, 15,000 - 50,000 psi. Polymerization is initiated by molecular oxygen or other free radical generators, such as caprylyl peroxide or lauroyl peroxide.(6) Ethylene is regulated as a simple asphyxiant.(7) The organic peroxides used as initiators are considered mild skin irritants by the NIOSH Registry of Toxic Effects without any indication of carcinogenic potential from either human or animal studies.(8) Furthermore, an extended walk-through survey of the production areas found them well ventilated with no noticable odors. Although the end product, polyethylene, is considered carcinogenic in animals, this conclusion is based entirely on implant

studies,[9] which are hardly comparable to the routes of exposure encountered by occupationally exposed individuals.[10]

The findings of this investigation also lack consistency with comparable reports in the literature. Other epidemiologic studies of Hodgkin's Disease do suggest an occupational association, but the implicated exposure is to wood dust, not chemical exposures.[11] Finally, the results of a recently completed cohort mortality study of the Union Carbide plant in Texas City, Texas[12] were compared to the Seadrift results. The Texas City plant had been in operation longer and had produced polyethylene four years before Seadrift. The SMR for Hodgkin's Disease for male hourly workers was 30, based on one observed death; the individual who transferred to the Seadrift plant.

On the basis of the information presented here, an excess of lymphopoietic cancer deaths did occur among this plant population. This information, however, does not support a conclusion of a causal association between these deaths and employment at the plant or any specific production area.

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Table 1

LYMPHOMA DEATHS AMONG THE WORKERS
OF A PETROCHEMICAL PLANT IN SEADRIFT, TEXAS

ICD Code	Cause of Death	Month & Year of Death	Age at Death	Time from Diagnosis to Death[b]	Duration of Employment at Plant	Time Since First Employment to Death	Usual Job Title
201	Hodgkin's	01/59	46	0:9	3:0[c]	3:1	Process Operator
201	Hodgkin's	01/65	34	2:9	10:2	10:7	Pipe Fitter
201	Hodgkin's	02/66	31	3:4	6:6	6:6	Process Operator
202.2	Malignant Lymphoma	04/72	49	11.10	16:8	17:10	Pipe Fitter
203	Multiple Myeloma	12/77	47	1:9	11.1	11:7	Rigger

a) Seventh Revision of the International Classification of Disease
b) Reported as years; months
c) The case worked 18 years with the company; his last 3 years were at the Seadrift plant

Table 2

DISTRIBUTION OF OBSERVED AND EXPECTED DEATHS
BY DURATION OF EMPLOYMENT AT THE PLANT

Hodgkin's Disease (ICD-7 201)

Duration of Employment in Years	Observed	Expected
0 - 9	2[a]	0.40
10 - 19	1	0.18
20+	0	0.04
Total	3	0.62

All Diseases of the Lymphatic and Hematopoietic Systems
Excluding Leukemia (ICD-7 200-203.205)

Duration of Employment in Years	Observed	Expected
0 - 9	2[a]	0.84
10 - 19	3	0.63
20+	0	0.25
Total	5	1.72

a) One of these cases worked 18 years with the company, but only 3 years at the Seadrift plant.

Table 3

DISTRIBUTION OF OBSERVED AND EXPECTED DEATHS BY TIME SINCE FIRST EMPLOYMENT AT THE PLANT

Hodgkin's Disease (ICD-7 201)

Time Since First Employment in Years	Observed	Expected
0 - 9	2[a]	0.35
10 - 19	1	0.21
20+	0	0.06
Total	3	0.62

All Diseases of the Lymphatic and Hematopoietic Systems Excluding Leukemia (ICD-7 200-203,205)

Time Since First Employment in Years	Observed	Expected
0 - 9	2[a]	0.61
10 - 19	3	0.69
20+	0	0.42
Total	5	1.72

a) One of these cases worked 18 years with the company, but only 3 years at the Seadrift plant.

Table 4

DISTRIBUTION OF OBSERVED
AND EXPECTED DEATHS BY CALENDAR PERIOD

	Hodgkin's Disease (201 only)		All Lymphatic and Hemopoietic Cancer (200-203,205)	
Calendar Period	Obs.	Exp.	Obs.	Exp.
1955-1959	1	0.08	1	0.12
1960-1964	0	0.12	0	0.23
1965-1969	2	0.14	2	0.33
1970-1974	0	0.14	1	0.43
1975-1979	0	0.14	1	0.61
Total	3	0.62	5	1.72

Table 5

RESULTS OF CASE-CONTROL ANALYSES BY PROCESS AREA
IF EVER ASSIGNED TO AREA PRIOR TO DATE OF DIAGNOSIS OF CASE

Process Area	No. of Cases Exposed	Odds Ratio	Chi Squared	Statistically Significant*	95 Per Cent CI for Odds Ratio
Low or High Density Polyethylene	5/5		6.06	Yes	Not Calculated[b]
Alcohol, Amine and Oxide Derivatives	3/5	4.86	3.27	No	0.88 to 26.93
Oxides (Ethylene)	3/5	3.69	2.07	No	0.63 to 21.72
Low-Density Polyethylene	3/5	2.83	1.23	No	0.45 to 17.72

a X^2 (1 d.f.) exceeded 3.84, therefore, p 0.05, two-tailed.
b All of the cases were exposed producing an infinite odds-ratio, therefore, it was not possible to calculate 95% confidence intervals.

Table 6

RESULTS OF CASE-CONTROL ANALYSES
BY PRODUCTION AREA

Duration of Work in Area 1 Year or More and
Prior to Date of Diagnosis of Case

Production Process	No. of Cases Assigned to Area	Odds Ratio	Chi Squared	Statistically Significant*	95 Per Cent of for Odds Ratio
Low or High Density Polyethylene	4/5	7.06	4.00	Yes	1.04 to 47.68
Low Density Polyethylene	3[b]/5	4.01	2.53	No	0.72 to 23.32

a) X^2 (1d.f.) exceeded 3.84, therefore, p 0.05, two-tailed.

b) The exposed cases consisted of the 3 Hodgkins Disease deaths.

FIGURE I

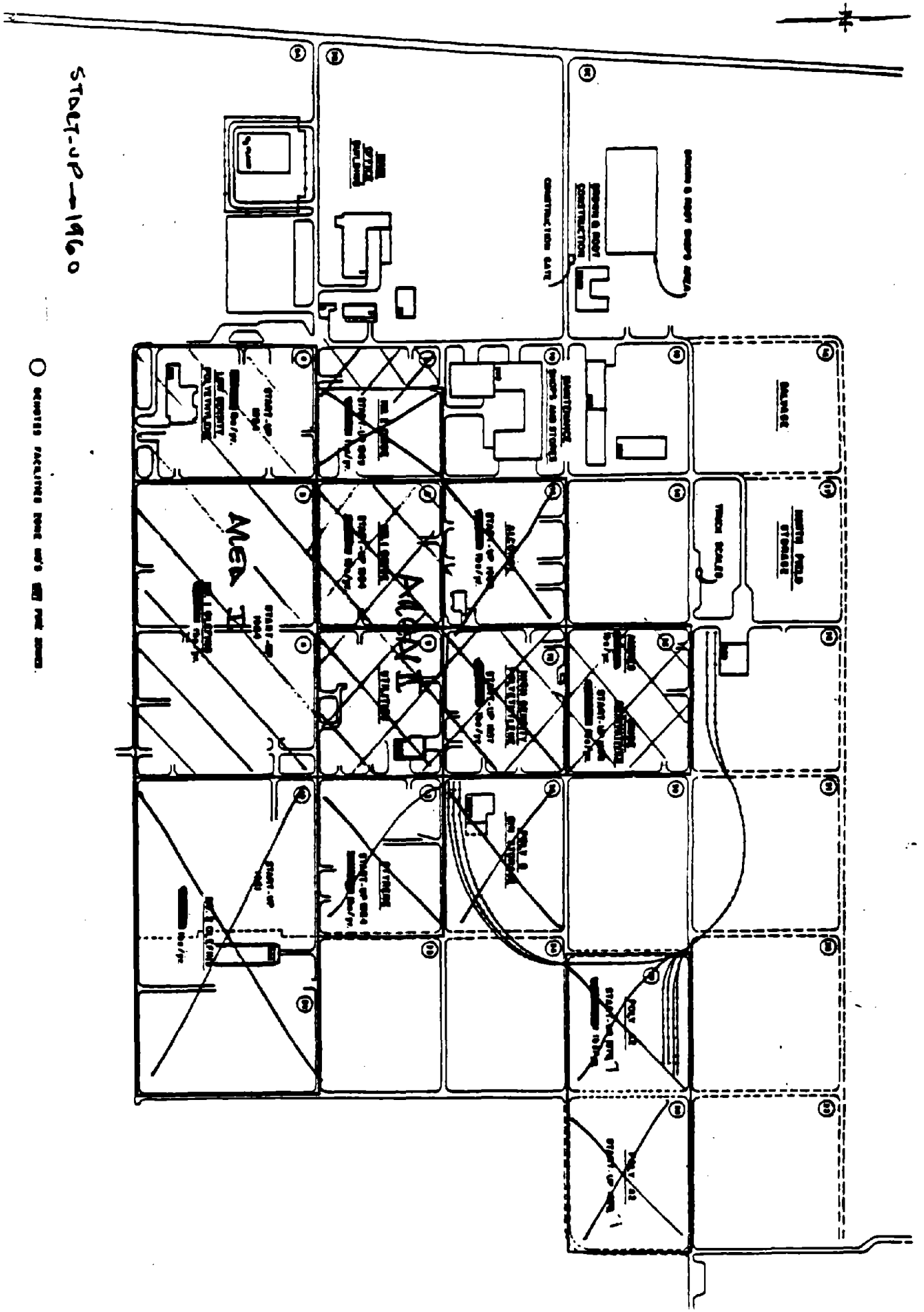


FIGURE 2

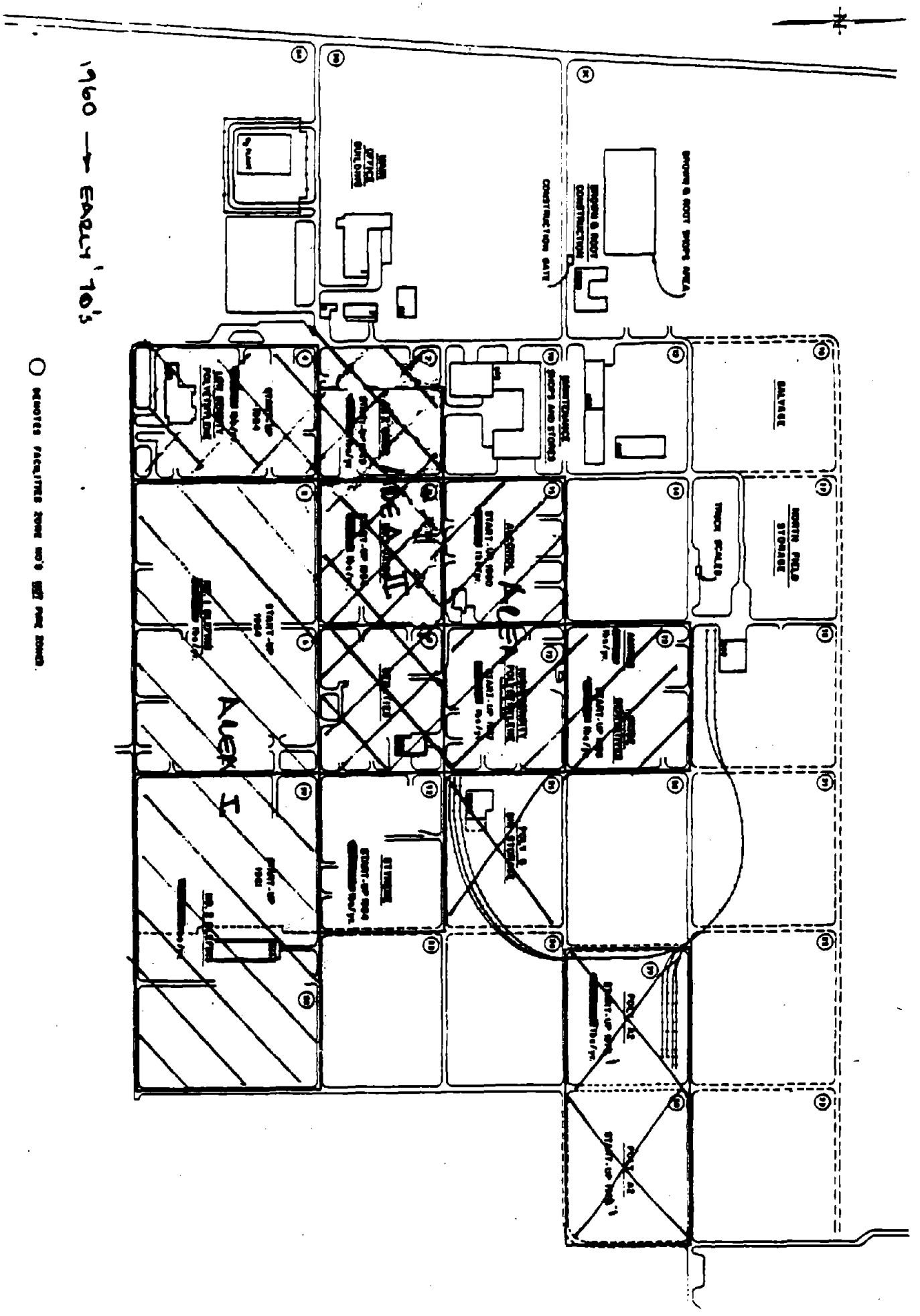
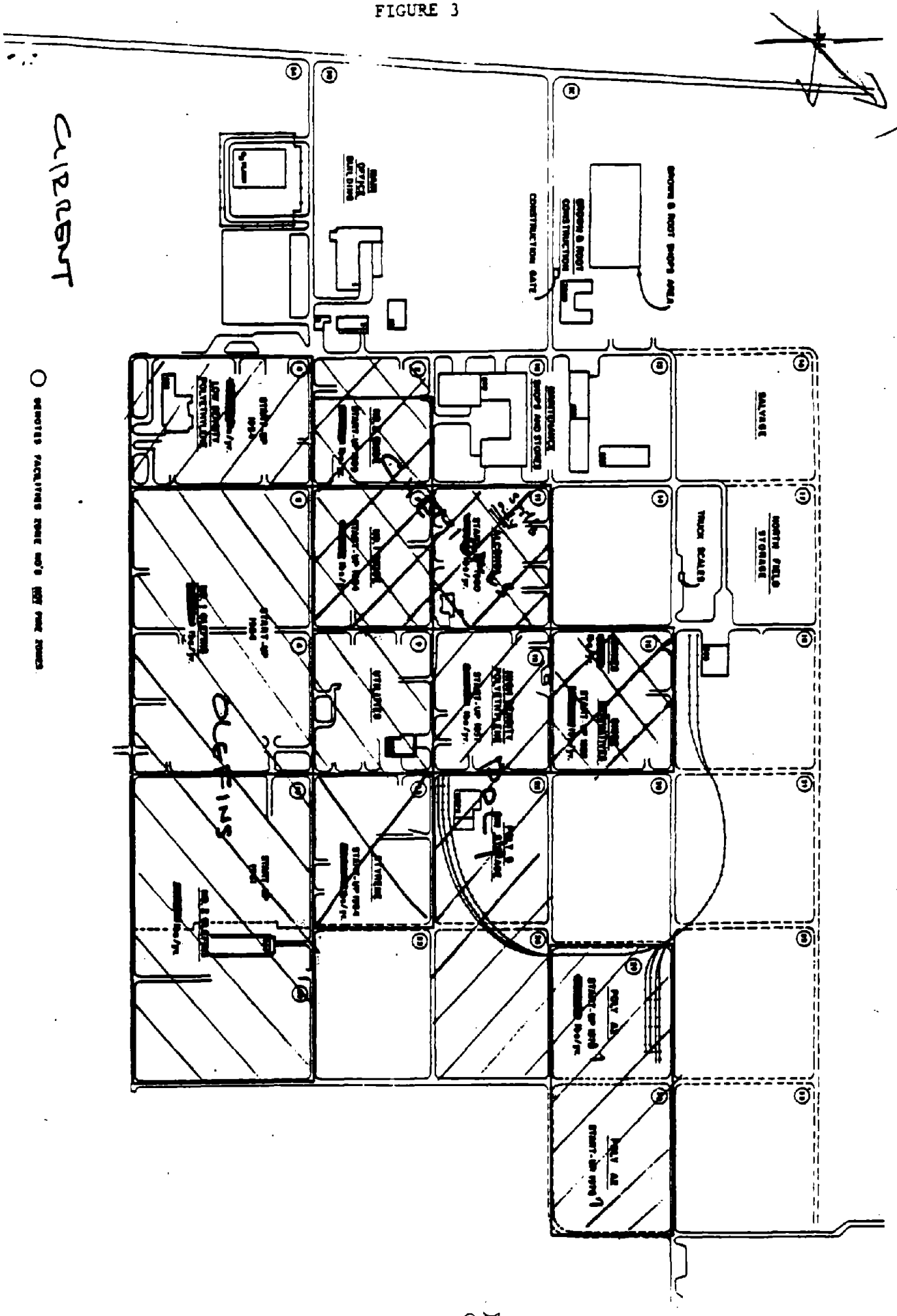

1960 — EARLY '70's
SALVAGE
TRUCK SCALES
NORTH FIELD STORAGE
ALEX T.

FIGURE 3


CURRENT
CONSTRUCTION GATE
SALVAGE
TRUCK SCALES
NORTH FIELD STORAGE
PROPOSED