6312 U-003-307 .14

A STUDY TO DETERMINE A METHOD FOR FILLING CHEMICAL WASTE PIT NUMBER 3 - (USED AS A REFERENCE IN THE OU1 RI)

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REPORT

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A STUDY TO DETERMINE A METHOD FOR FILLING CHEMICAL WASTE PIT NO. 3

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NATIONAL LEAD COMPANY OF OHIO

February 1, 1971

1. Introduction

Wet Chemical Waste Pit No. 3 was placed in service in December, 1958. This pit was used as a settling basin until Pit No. 5 was completed and placed in service in October, 1968. At the time Pit No. 5 was placed in service, Pit No. 3 was abandoned as a settling basin and a process residue receiving facility. When abandoned, Pit No. 3 was filled with a water/solids mixture virtually to the point of overflowing. Since being abandoned, and with essentially continuous removal of the supernatant liquids, the contents of the pit have undergone a degree of consolidation. The surface of the pit's contents is now some three to four feet lower than it was during the latter stages of the pit's useful life.

Economic studies have shown that the value of the materials in the pit will not justify a recovery effort. These materials are, therefore, destined to remain in their present location in permanent storage, and a manageable, long-term storage facility must be established. The provision of an earth cover for the pit and the creation of a logical drainage pattern are essential to this effort. If these physical characteristics can be properly provided, the long-term storage of these waste materials should not cause environmental problems.

Even though there has been a significant consolidation of the stored materials in the two years that Pit No. 3 has been inactive, the strength and consequent ability of these materials to support loads is subject to question. This strength deficiency was recently made quite evident. During an attempt to utilize a bulldozer to push fly ash into the northeast corner of the pit, a sudden and severe lateral flow occurred as a result of the imposed load. The bulldozer and the fly ash fill beneath the vehicle dropped seven or eight feet as the underlying materials flowed radially outward from the point of load. No damage resulted and the bulldozer was easily retrieved; however, this incident emphasizes the need for care in attempting to cover the pit.

This study has been undertaken in order to develop a safe and workable method for establishing a manageable, long-term, storage facility.

2. Earthwork Placement Technique

In 1969, the Technical Division made a rather extensive investigation that studied the possibility of dewatering Pit No. 3. This investigation did not develop a dewatering technique that appears adaptable to a plan for providing an earth cover for the pit. However, some of the data assembled in that investigation has been useful in this current study.

2: Earthwork Placement Technique (cont'd)

The present study was initiated by engaging a soils consultant, Mr. C. K. Hoffmeyer, in an attempt to establish the load bearing capabilities of the pit materials. Mr. Hoffmeyer's study was not extensive, but a more detailed investigation is not believed to be justified at this time. The report on this work is included in this study as Appendix A. In summary, it can be stated that Mr. Hoffmeyer concluded that the pit sludges would support no more than 2 to 4 feet of earth fill and would not support heavy earthmoving equipment.

Several ideas for stabilizing the pit sludges and several methods for placing the fill material have been considered in this study. A listing and a discussion of these ideas and/or methods follows:

a. Injection Stabilization - It is doubtful that this approach would be effective. Pressure injection of cement and water suspensions, certain chemicals, or bituminous compounds has proven to be a successful stabilizing technique under certain conditions and in some soils. The effectiveness of this technique is dependent upon being able to force the stabilizing medium through the pores of the material being stabilized. It is unlikely that the pore structure of the pit sludges would be suitable for such treatment. It would also be quite difficult to place the injection pipes due to the configuration of the pit.

b. Dewatering - It would seem that some means of removing at least some of the water from the sludges will be necessary before an earth cover for the entire pit can be completed. Attempting this dewatering effort with a system of well points does not seem to offer much hope for success. The permeability of the sludges and their consequent ability to sustain a meaningful flow is doubtful. If the flow is induced only by the difference in head created by the drawdown at the well point, it would seem that the flow would be virtually negligible. This would require close spacing of the well points and placement of this equipment would be just as difficult as the placement of injection tubes.

An attempt has been made to think of some procedure which would cause the sludge to want to give up water more rapidly than it seems inclined to do under natural forces. Since the material shows a strong tendency to release water upon handling, it seems likely that vibration would be beneficial; however, there does not seem to be any practical way to apply this technique in the field and take advantage of this tendency. Consequently, there is no current plan to attempt to establish the effectiveness of vibration dewatering through a test program.

b. Dewatering (cont'd)

It is known that some soils show a tendency to release water and to consolidate by electrochemical action when exposed to a direct current passing between electrodes. Since it seems possible that such a technique could be field applied at Pit No. 3, this idea will be investigated in the laboratory. Even if successful, it is likely that the energy cost involved in applying this procedure would be high. For this reason, more conventional techniques should be applied first and the planning should not be delayed awaiting the results of this test work.

The use of sand drains is another dewatering technique that has been considered. This system has been employed with success in dewatering and consolidating some marshlands. In this approach, a plugged mandrel is driven into the ground and as the mandrel is withdrawn the void is filled with sand. The sand core then serves as a wick and dewatering takes place by evaporation. Low permeability of the pit sludges and the difficulty of placing the sand drains make it doubtful that this technique could be successfully employed.

c. Fill Placement - The fill material could be placed with a bucket and cable system that would span the width of the pit. The difficulty of installing a cable system that would have enough mobility to cover the entire pit seems to eliminate this method from consideration. Also, it seems likely that it would eventually be necessary to place earth moving equipment on the cable placed fill in order to establish a drainage pattern, and this reduces the advantage of such a system.

A cable type system has not been studied in enough detail to determine the exact feasibility and cost of such a system; however, it is believed that this study should be delayed until it is known that the following procedure cannot be successfully adopted.

After consideration of all of these techniques and methods, it is recommended that a simple, conventional approach be attempted before a more sophisticated stabilization, dewatering or fill placement procedure is undertaken. This recommendation, to a large degree, ignores the conclusion of the soils consultant that was engaged to assist in this study. The initial fill placement attempt should be made in the vicinity of the northeast corner of the pit. Maximum dewatering and crust formation has occurred in this area and this location should offer the greatest hope for initial success. The placement of the fill should be advanced ely as shown in Figure No. I. The precise place- ule will be determined by field developments as dvances with an aim toward establishing the final attern shown in Figure No. II.

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The lightest available equipment should be used to work near the face of the advancing fill. The small Case tractor that was recently acquired should be most suitable for this task. The loads that must be applied, even using light equipment, will probably cause some crust failures. It is believed that these failures will be localized and that they will occur ahead of the operating equipment if reasonable care is exercised in working near the face of the fill. Nevertheless, during the early stages of the program a man should be stationed near the work in the event a failure occurs where the operator would need assistance.

As the fill is placed, the loads that are imposed will cause the sludges to dewater and consolidate. Pumping facilities should be maintained to remove this water. The pumping facilities must be relocated as the work advances to maintain dewatering capabilities. The present pump location should be suitable for the initial work. The fill placement should be advanced slowly over a rather wide working face in order to take maximum advantage of the consolidation and dewatering that will be realized from the applied loads.

The establishment of the drainage pattern shown in Figure No. II will require the placement of approximately 75,000 cubic yards of fill. This quantity is based on the assumption that the fill will embed into the sludges to an average depth of one foot. The depth of fill required over the existing sludge surface varies from a maximum of 10 to 11 feet to a minimum of approximately 4 feet. Typical cross sections showing the fill in place are shown in Figure III. The location of these sections has been indicated on Figure II.

3. Work Performance

The initial placement of fill should be by NLO forces and with equipment now on hand. If experience shows that the work can be performed more rapidly than is now predicted and there is a need for applying the cover quickly, consideration can be given to a subcontracting effort.

Two borrow areas have been proposed for supplying the required fill material. The location of these areas is shown in Figure IV. Borrow Area No. 1 is west of Pit 5 and is the area where the excavated material was wasted during the construction of that pit. It has been estimated that an eight foot cut can be made in this area before encountering brush and debris that would cause the borrowed material to be unsuitable for placement as fill. On the basis of this assumption, 30,000 cubic yards of fill is available in this area.

A second borrow area has been designated as Borrow Area No. 2. This area is located 600 to 800 feet north of the railroad connecting spur. A mound, rising approximately

3. Work Performance (cont'd)

15 feet above the surrounding terrain, now exists in this area. Approximately 60,000 cubic yards of fill is available at this location without creating a depressed area and drainage problems. Utilization of Borrow Area No. 2 will create a need for a temporary access and two drainage structures where this road crosses the railroad spur.

The equipment usage contemplated in the placement of this fill is: excavation in the borrow area with a backhoe, haul to the placement area with two dump trucks, and placement at the working face with the Case tractor. If the feasibility of this work plan can be firmly established, the equipment requirements should be evaluated again to determine if a scraper could be used to advantage. If this evaluation shows that some economies are possible with improved equipment, the surplus lists can be examined for equipment availability. It would be premature to acquire any additional equipment until the feasibility of the filling technique is firmly established.

4. Estimated Cost and Schedule

The following cost estimate is based on performing the work with NLO forces utilizing the equipment array outlined above. The labor portion of the cost includes only out-of-pocket costs (wages + 13% fringe benefits), and does not include any allowance for supervision, engineering, or such incidental costs as pumping, relocation of pumping facilities, etc.

Estimated Cost

Fill pit (75,000 C.Y. @ $.80)	$60,000
Access road to borrow pit	1,700
Drainage structures at railroad	2,300
Finish grade pit surface	1,000
	$65,000
20% contingency allowance	13,000
	$78,000

It is estimated that 300, full crew, working days will be required to complete the program. The calendar time that would be consumed will depend upon the plant's routine demands for the services of a limited heavy equipment crew.

FILL PLACEMENT SEQUENCE

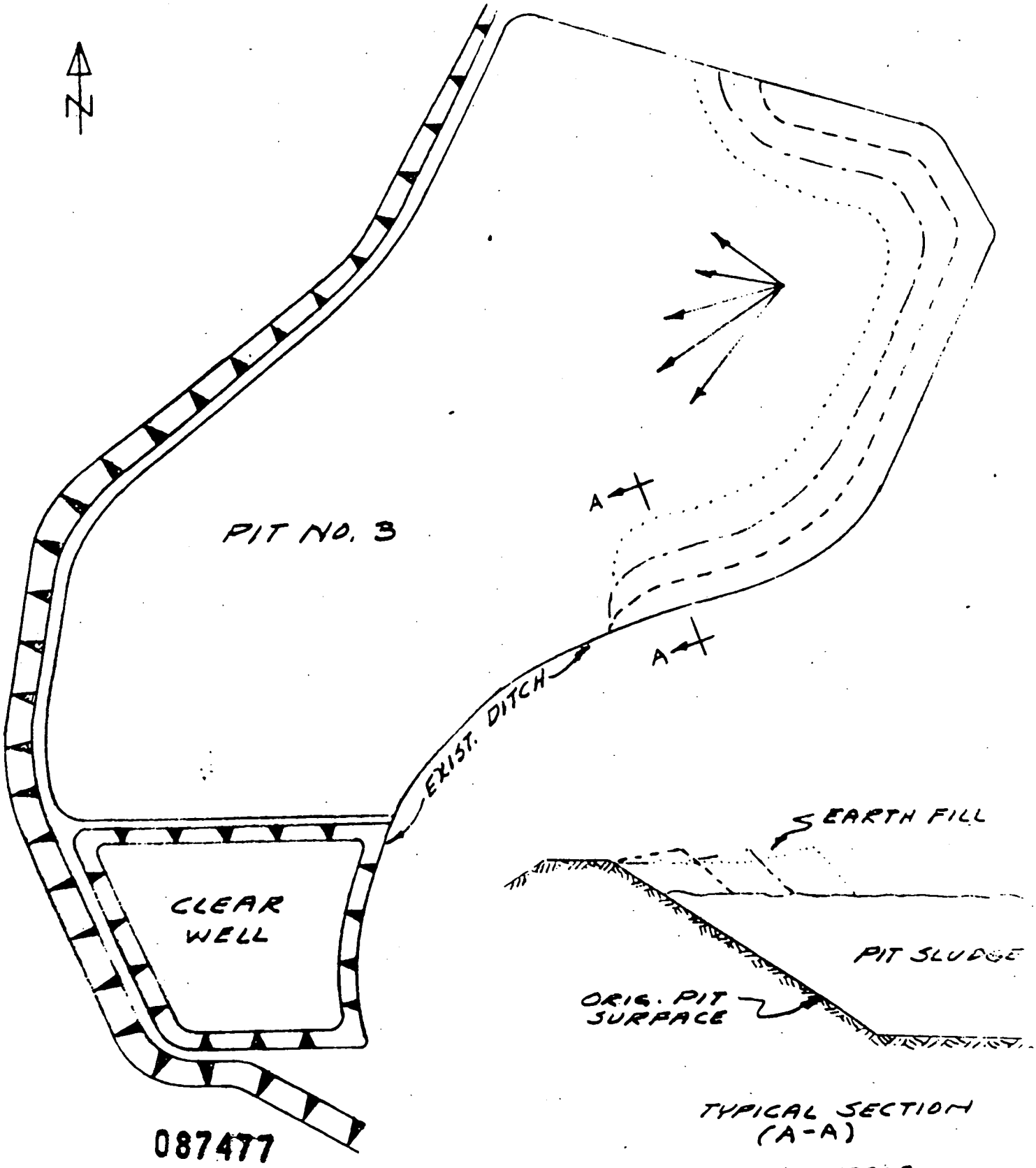

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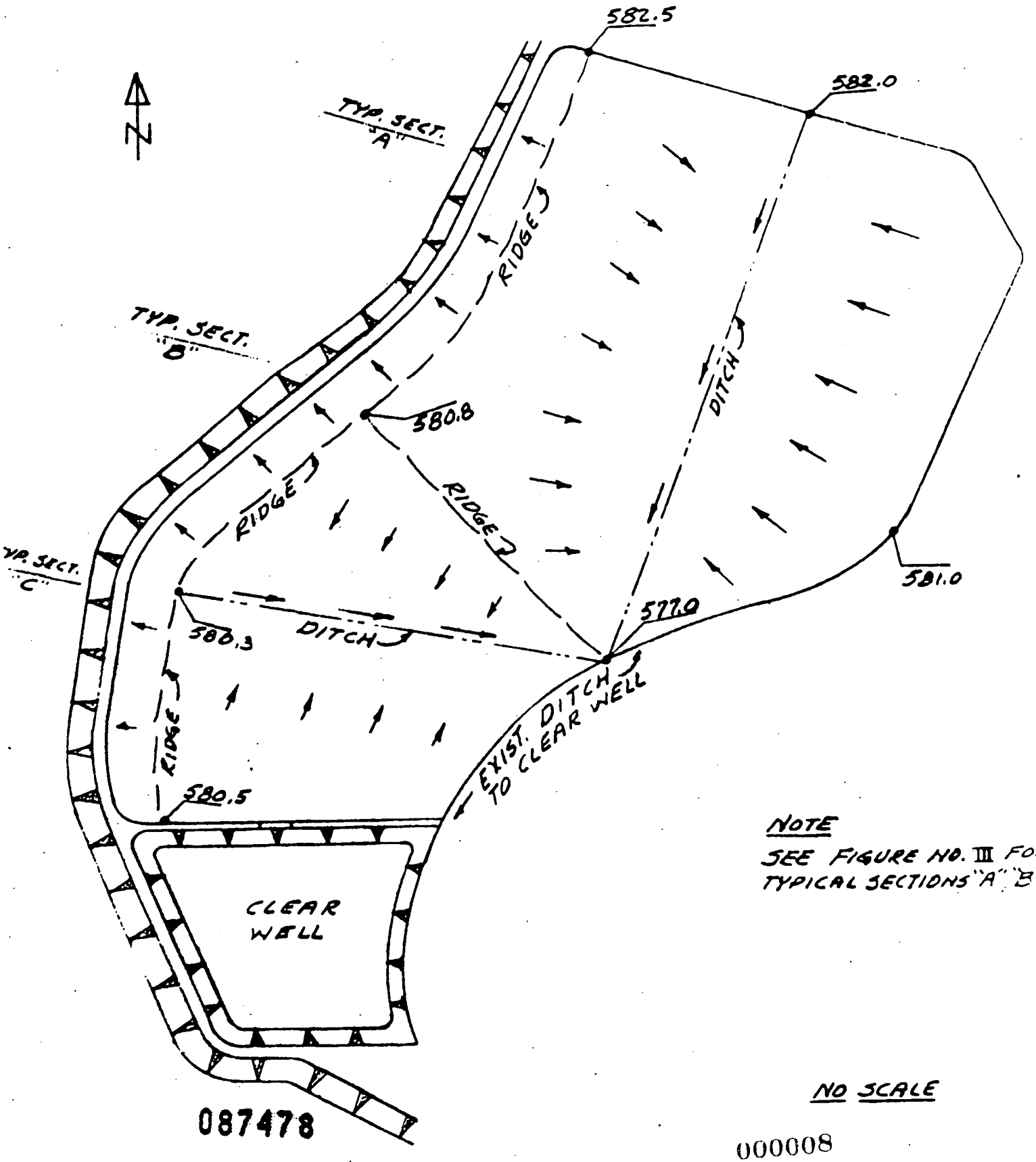
FIGURE NO. 1

PROPOSED FINAL DRAINAGE PATTERN



NOTE
SEE FIGURE NO. III FOR TYPICAL SECTIONS "A" "B"

NO SCALE

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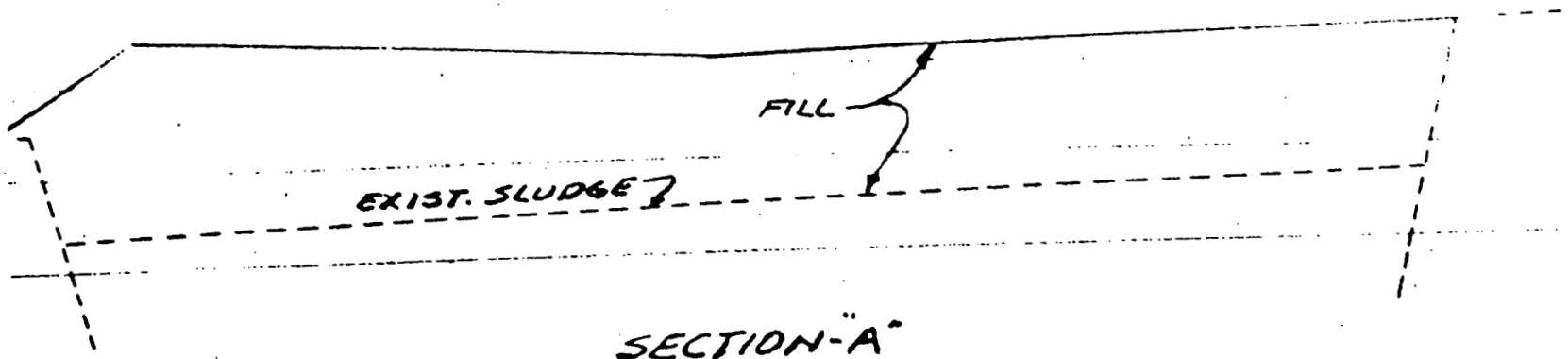
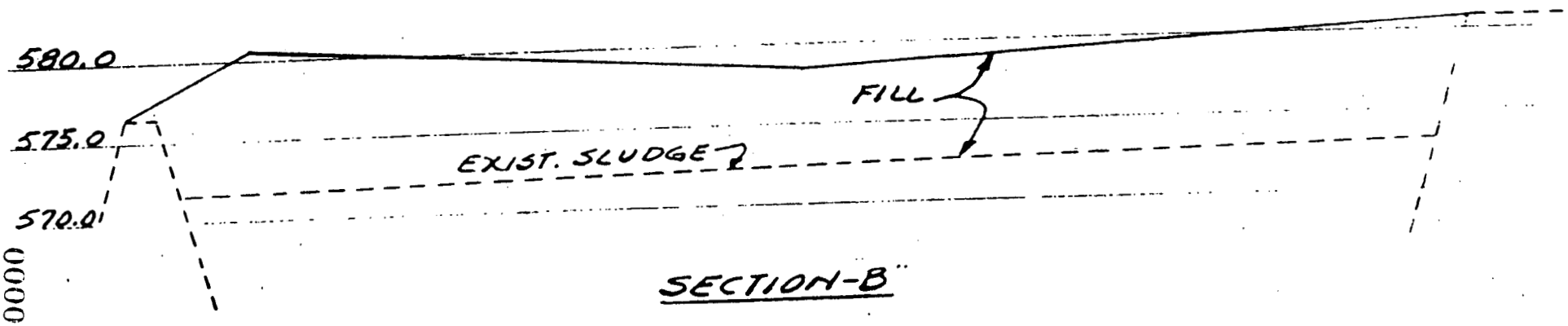
FIGURE NO. II

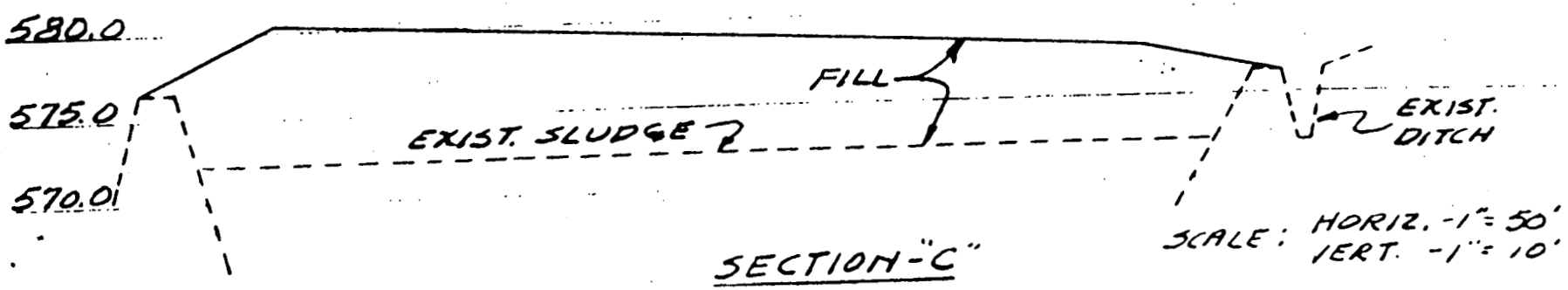
TYPICAL SECTIONS



SECTION-"A"



SECTION-"B"



SCALE: HORIZ. -1" = 50'
VERT. -1" = 10'

SECTION-"C"

FIGURE NO. III

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PROPOSED BORROW AREAS

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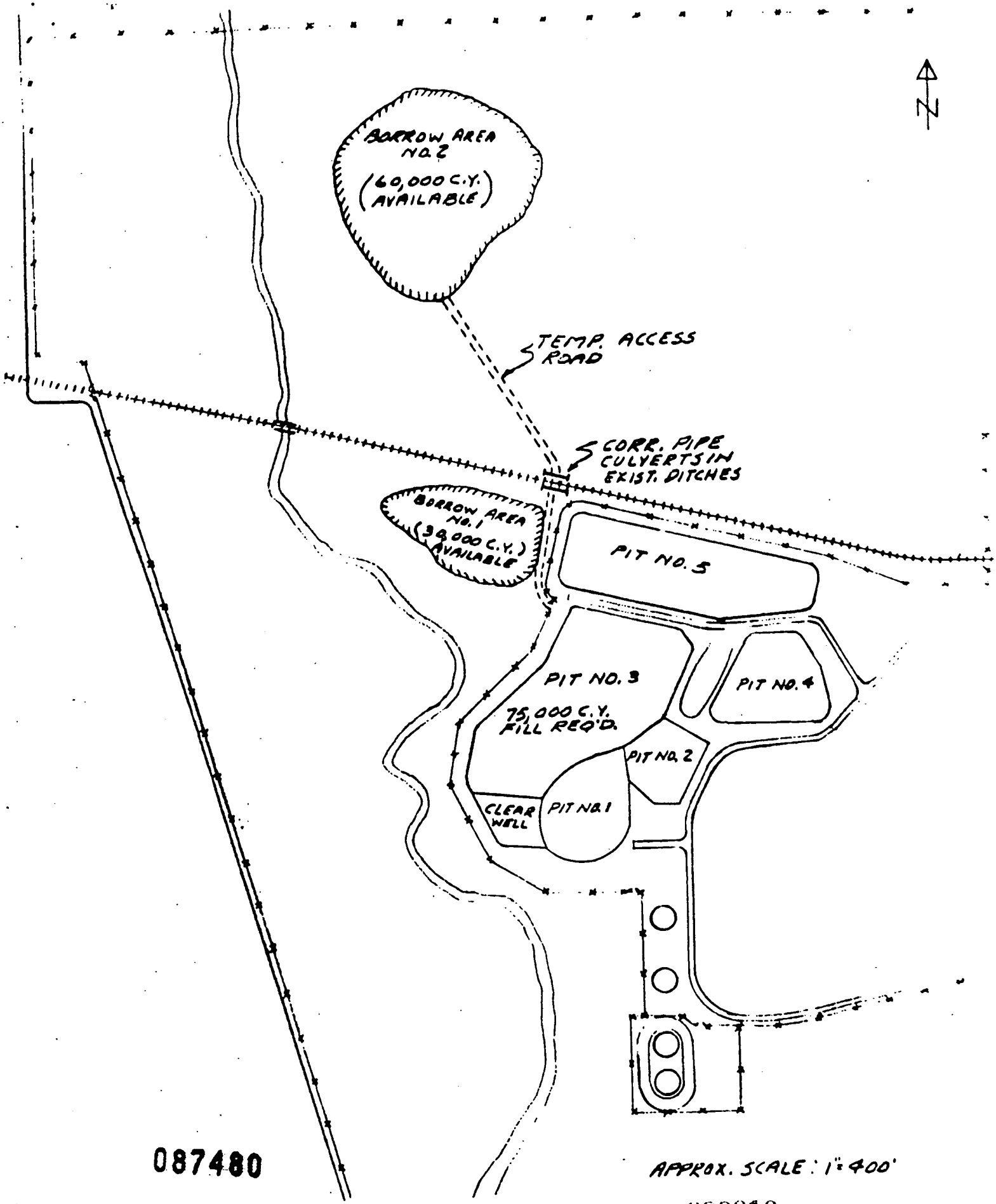

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APPROX. SCALE: 1" = 400'

FIGURE NO. IV

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CONSULTING ENGINEER
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CINCINNATI, OHIO 45227

STUDY OF SCRAP PIT NO. 3, K-65 AREA
National Lead Company of Ohio
Feed Materials Production Center
Fernald, Ohio

Introduction:

1. This report describes the results of studies the writer has made on methods for covering the contents of Chemical Waste Pit No. 3 at Fernald. Request for these studies was made by your Purchase Order No. R93163, dated 11 December 1970.

2. The report describes and presents the results of field studies, laboratory tests, and stability analyses, and presents conclusions and recommendations regarding covering the chemical waste pit with soil.

Field Conditions:

3. The writer met with Mr. J. R. Stevenson at the site on 17 December 1970. Points of interest noted in the vicinity of Scrap Pit No. 3 included the retaining earth dike along the west side of the pit, the separating dike and weir between the pit and clear well, the ditch carrying water along east side of pit, the dumped cinders along north and north east rim of pit, and the new membrane-lined pit to north of the pit.

4. During the visit, copies of Dwg. No. 8-4151 and excerpts of Monthly Progress Reports dealing with studies of the waste Materials in Pit No. 3 were obtained. These documents will be referred to later in this report. In addition, a one-gallon sample of the chemical waste was dug from the pit with a hand auger for testing.

Tests on Chemical Waste

5. The following tests were run on the sample obtained from the pit:

a. Water content in percent; defined as the weight of water divided by the dry weight of the solids.

b. Absolute specific gravity of the solids.

c. Unit weight test. This test was made by placing the waste material into a graduated hydrometer jar in as undisturbed state as possible and noting the volume and weight of the specimen.

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6. Results of the 2 water content tests were 217 and 170% respectively. Inasmuch as the percentage of solids for the chemical waste is reported to be in the range of 20 to 30 (as shown in the above mentioned monthly progress reports), the following table showing relationship of moisture content versus percent solids is shown:

Percent solids by weight	Water Content percent
20	400.
25	300.
30	233.
33	200.
40	150.

It appears that the chemical waste tested has slightly less water content than was found in the tests of July 1969. This will be discussed further in this report.

7. The specific gravity test gave a value of 2.92 . The corresponding value for most soils is in the range of 2.65 to 2.75.

8. The unit weight test gave values of:

87.5 lbs/cu.ft.(wet weights)
29.2 lbs/cu.ft.(dry weight)*

*assuming a water content of 200%.

When the same sample was agitated and completely dispersed in a surplus of water and allowed to settle it reached a dry density of only 16 lbs./cu.ft. and a total density of 77 lbs./cu.ft.

This later condition approximates the density at which the sludge is in when it first settles-out after pouring into the waste pit. Any later increase in density is caused by the weight of additional solids settling out on top of it. The present top layer of sludge is drier and more dense due to shrinkage caused by drying.

Stability Analyses.

9. In order to arrive at some estimate of the stability and strength of the chemical sludge, the failure that occurred in the north west corner of the pit was analyzed. Figure 1 is a typical section showing the levee fill, cut slope on the pit side of the levee, and elevations of pit bottom and top of sludge fill. On Fig. 2 this section is repeated and in addition a cinder fill similar to that placed in north west corner is added. The failure analysis was made using the method of active and passive wedges, with location of failure planes assumed as shown on the sketch. Unit weights of dry cinders and saturated sludge are shown, and a Ø angle of 25 degrees was assumed for

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the cinders and top crust of sludge. The graphic analysis shown on Figure 2 indicates that the mass of sludge would have to have a Ø angle of approximately 12 degrees for a safety factor of 1.0 against failure. The same analysis indicates a required unit cohesion strength of .125 Kips/sq.ft. for the sludge to prevent failure (for the Ø = zero case).

10. Both of the above required shear parameters are greatly in excess of what the sludge possesses or can mobilize. The location of the cinders with respect to the center of the levee influences the stability to a large amount. If the center of mass of cinders had been closer to center of levee, then the driving forces would be less and the required shear strength of sludge lower. It is not known where the face of cinders was with respect to the pit side slope of levee when failure occurred. However, the sketch on Figure 2 indicates the condition that would prevail as the new fill was moved further out in the pit. The computations accompanying Figure 2 are shown on computation sheet No. 1.

11. Another stability analysis is shown on Figure 3. This illustrates the condition in the pit away from the levee. 8 feet of fill is placed on top of crust. The sludge would require an average cohesive strength of 0.144 Kips/sq.ft. to prevent failure such as pictured. The numerical analysis is also shown on computation Sheet No. 1. It indicates that the strength required varies directly with the height of fill.

Discussion

a. Condition of the Chemical Sludge.

12. Due to the extremely high water content of the sludge it is hard to get representative samples for water content tests, as water separates from the solid mass upon handling. It is noted that the material today appears to be somewhat dryer than was reported in the 12 June 1969 progress report (percent solids in the 32 to 35 range today versus 18 to 25 range in 1969). This gradual densification is to be expected due to consolidation of the mass and gradual withdrawal of water by pumping (see. par. 6 above).

13. From inspection of the material and knowledge of its water content, the sludge is considered to act as a heavy liquid with high viscosity and possess almost zero shear strength.

14. The sludge is slowly densifying due to the process of consolidation. This process is retarded by the inability of the squeezed-out water to escape.

15. The upper crust is much stronger than the underlying sludge, but its shear strength is unknown and of limited help in supporting superimposed loads.

b. Stability Studies

16. Indications are that the upper crust layer would supply most of the shear resistance when loads are placed on the surface of the pit. The action would be very similar to a pond of water covered with a layer of ice. When the strength of the ice is exceeded due to concentrations of load, it will break suddenly and all load support will disappear. If the ice is thick enough or the load small enough no failure will occur.

17. The retaining levee along the west side of the pit appears in excellent shape. Its effective height for sludge retention varies from 1 or 2 feet at the north to 15 feet at the south. The amount of seepage through its clay embankment should be very small.

Conclusions and Recommendations

18. Based upon inspection of the site and the studies described above the following conclusions can be drawn:

a. The sludge deposit will not support fill loads of the height tried at the north end of the pit.

b. The upper crust will support a minimum fill load (something on the order of 2 to 4 feet,) but not heavy earthmoving equipment.

c. The mass of sludge in its present condition cannot be counted on to mobilize any shear resistance.

d. The shear strength of the upper crust will be dependent on the water content in that material. It will be a maximum during hot summer months or when the surface is frozen, and a minimum when it becomes saturated.

19. It is recommended that:

a. Any fill be placed in a thin layer (2 to 4 feet) and that the method of hauling and spreading avoid the use of any heavy equipment.

b. Due to the uncertainties of the action of the upper sludge crust, any filling activities should be done on an experimental basis, with due care taken regarding safety of personnel against failures.

c. As filling on the surface is done, adequate provision for pumping of water from sumps should be made for removing the water that will be squeezed out of the sludge.

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20. This concludes my studies on the project. If I can be of further assistance on this problem please call on me.

C. Kenneth Hoffmeyer

C. Kenneth Hoffmeyer

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	COMPUTATION SHEET	PAGE / OF PAGES
[redacted]	SUBJECT Fernald - Scrap Pit #3	DATE 3 Jan. 1971
INSTALLATION	COMPUTATION	
COMPUTED BY HOFFMEYER		
CHECKED BY		6312

Stability near dike (Refer to fig. #2)

Horz. load from segment ① $= \frac{.4 \times .10 \times 18^2}{2} = 6.5^K$

Wt. segment ② $\frac{19 \times 28}{2} \times .100 = 27$ (Cinders & crust, dry)

$\frac{29 \times 20}{2} \times .026 = 7$ (submerged sludge)

Total $= 34^K$

Wt. segment ③ $4 \times 38 \times .100 = 15^K$ (crust)

$\frac{29 \times 20}{2} \times .026 = 7$ (submerged sludge)

Total $= 22^K$

Sliding analysis with above wts. and $\phi = 25°$ for cinders & crust requires $\phi = 12°$ for sludge for stability. (see fig. #2)

Cohesion req'd, when $\phi = 0$, $= .125^{K/\square'}$

Stability away from dike (Refer to Fig. #3)

Assume surcharge fill of 8'

Use Taylors Stability number, $\phi = 0$ case)

$N = .18 = \frac{Cd}{\gamma H}$ $\quad Cd = .100 \times 8 \times .18 = .144^{K/\square'}$

If height of fill is reduced to 4', then required cohesion is $4/8 \times .144 = .072^{K/\square'}$

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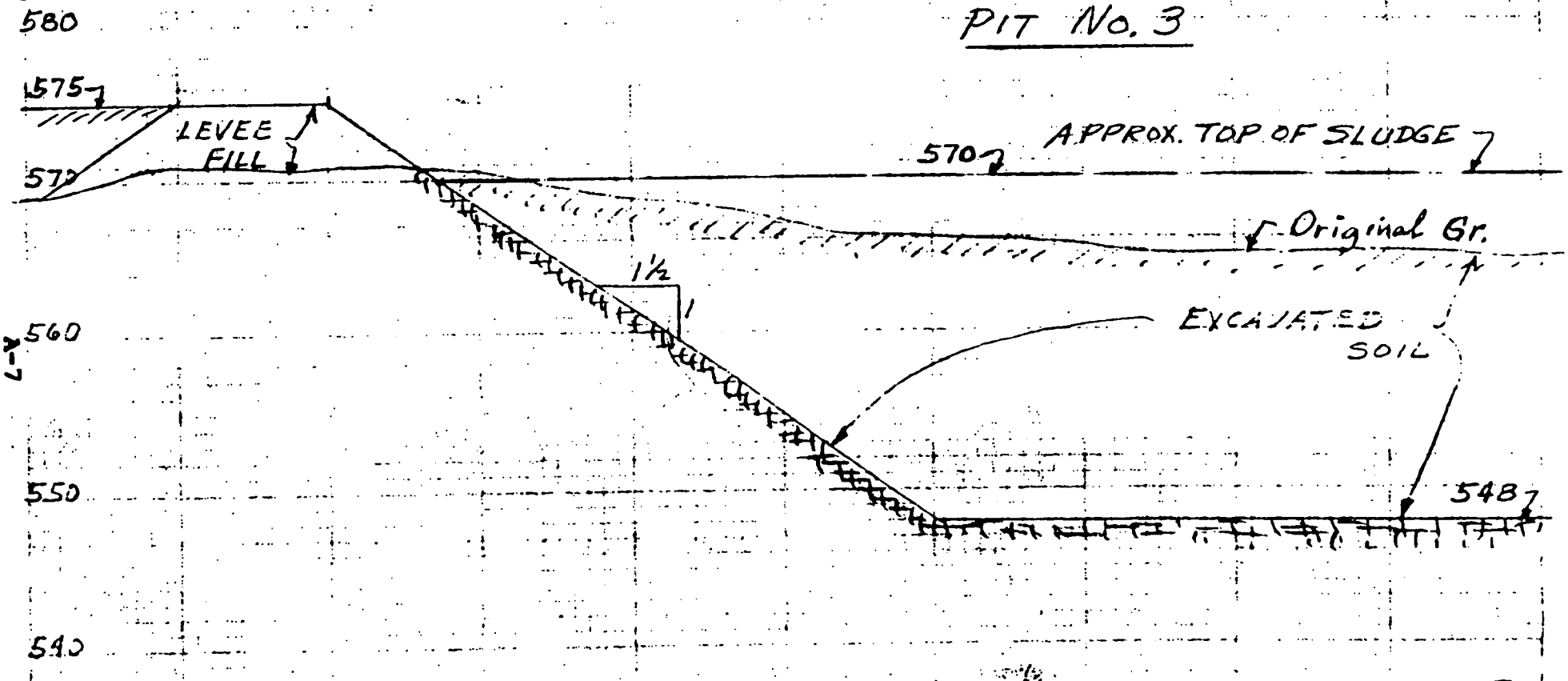

Scale: 1" = 10'

FIG. 1

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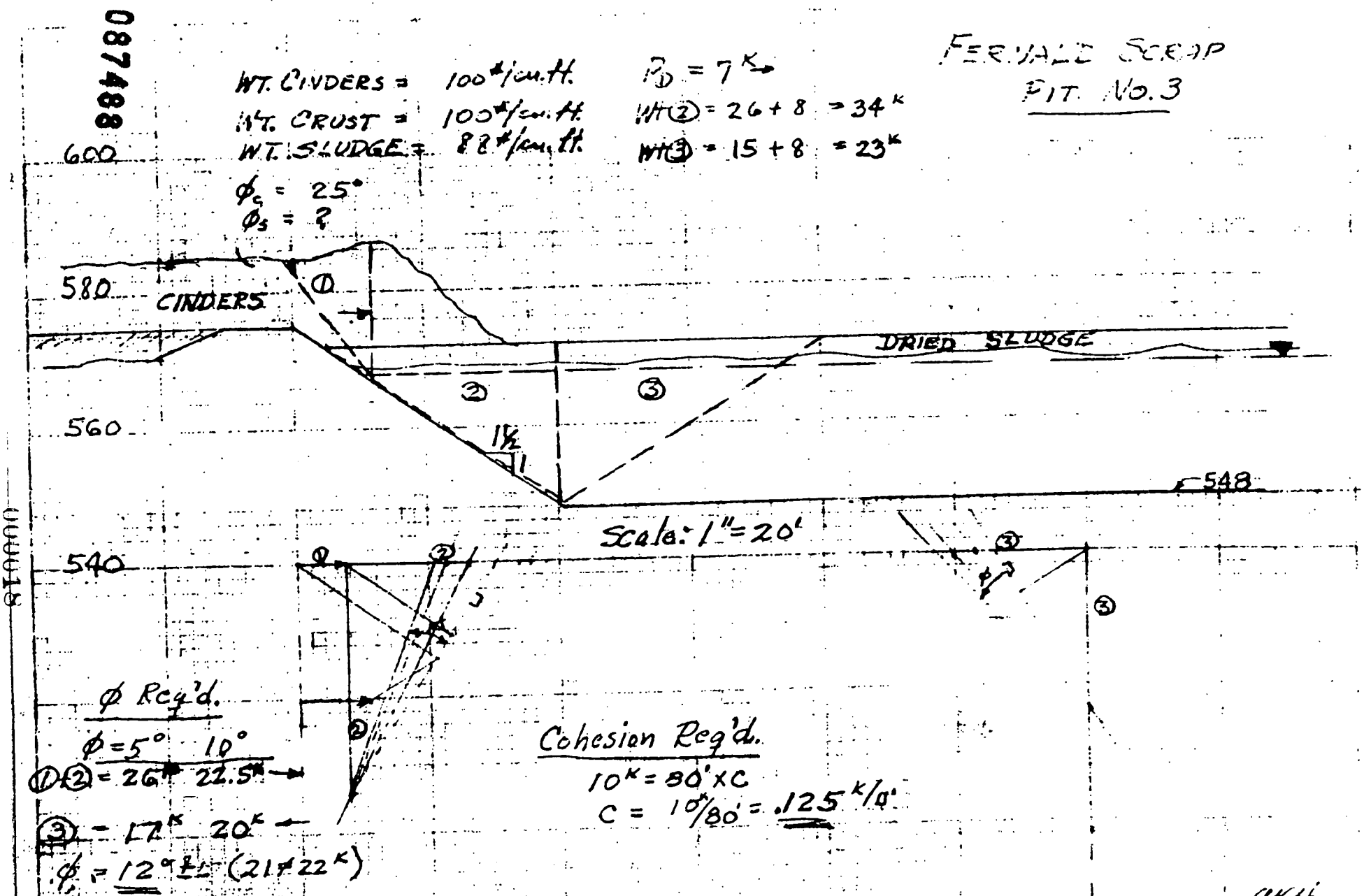
FERNALD SCRAP
PIT No. 3
WT. CINDERS = 100#/cu.ft.
WT. CRUST = 100#/cu.ft.
WT. SLUDGE = 88#/cu.ft.
ϕ_c = 25°
ϕ_s = ?
P_D = 7K
Wt② = 26 + 8 = 34K
Wt③ = 15 + 8 = 23K
600
580
560
540
548
CINDERS
DRIED SLUDGE
①
②
③
1½
1
Scale: 1" = 20'
φ Req'd.
φ = 5° 10°
①②= 26# 22.5K
③ = 17K 20K
φ = 12° ± (21# 22K)
Cohesion Req'd.
10K = 80' x C
C = 10K/80' = .125 K/□'

FIG. 2

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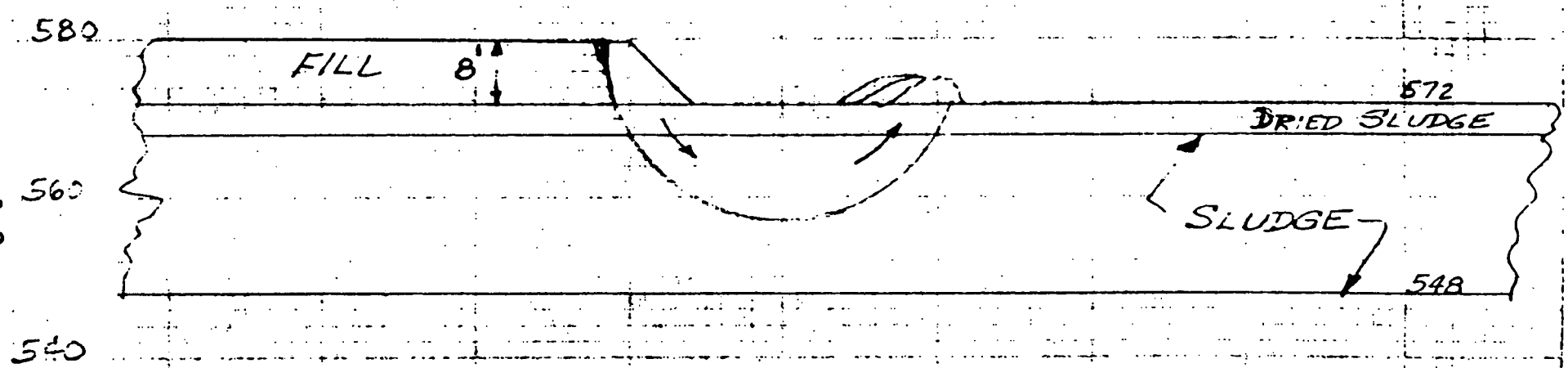
FERNALD SCRAP
PIT No. 3



SCALE: 1" = 20'

Required cohesion strength for safety factor of 1.0 is 0.14 K/□'

Fig. 3

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CAH.