Adams Township, MI

R E P O R T

on the

W H I T E   P I N E   M I N E

covering

Development, Stoping and Equipment

for Producing 10,000 tons of Ore

per day.

By

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copy to F.A.A.
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1. <u>General.</u>

In February of this year I made a report and estimate for equipping and developing the White Pine Mine for a production of 2500 tons per shift, or 5,000 tons per day, making two shifts. Increasing this production to 7,200 tons per day with a possibility of a further increase to 10,000 tons per day makes necessary a number of changes in the original plans.

The mining system remains unchanged, but provision must be made for double the number of production units, and this in turn increases the number of levels on which stoping will be done.

It is proposed to sink the shaft to the 900 ft. level at this time, turning off levels at -400, -500, -600, -700 and -800 ft. At first ore will be stoped on the three top levels only, while development of the 700 ft. level is being finished. Development of the 800 ft. level can be carried on at the same time.

Transportation is a serious problem. To haul 5,000 tons per shift to the shaft on one level is not easy, and it is therefore advisable to haul to the shaft on each level as large a proportion as is feasible of the ore produced on that level.

In order to facilitate this program a series of ore-passes and another of waste-passes near the shaft is proposed, so that ore or waste can be dumped on any level without delay. The skips will be loaded at one point only, a little below the 800 ft. level.

Another series of ore- and waste-passes will be put up from the 700 ft. level on each side about 5000 ft. from the shaft, and ore and waste from these passes will be trammed on the 700 ft. level, at least half of the production of the mine being trammed on this level.

In order to facilitate loading, the ore will be crushed underground. It is proposed to erect the crusher near the shaft below the 700 ft. level, where it will serve the four upper levels.

2. Shafts.

It is proposed to sink a vertical hoisting shaft on Sec. 10 near the south line about 1800 ft. west of the southeast corner and about halfway between D.D.H.'s 7 E 2 and 7 E 4. This location is opposite the deepest part of the lode, and drifts on both sides of the shaft will have approximately the same length. This location also gives ready access to the flat ore to the north, the limits of which have not yet been disclosed.

The long axis of the shaft has tentatively been placed at S65°E, but this bearing can be changed if it does not fit into the surface lay-out. If the axis of the shaft is changed, the plats and pockets underground must be moved to correspond, but the direction of the main crosscuts should remain unchanged.

The plan of the shaft is shown on drawing No. 1. The dimensions have been increased slightly from those previously recommended, and are 20ft. by 14 ft. 6 in. outside. The shaft is of the "square" type, having two skip-roads, each 6 ft. 6 in by 6 ft. 6 in. in cross-section across the S.E.

end, a cage-road 8 ft wide and 13 ft. 6 in. long in the middle, and three compartments for pipes, ladders and counterweight respectively across the N.W. end. The sets are made of 6 in. H-beams, weighing28 lbs. per ft. and are hung on 6 ft. centers. Lagging can be either 3 in. plank or pre-cast concrete slabs. If, on account of the shortage of steel, sets are made of timber, the over-all dimensions will be increased.

The larger cross-sectional area of the skip compartments not only makes possible a shorter skip, which will require less time to load and dump, but also makes it possible to use a larger skip, if it should be found to be advisable at some later date.

The larger cage permits more men to be carried per trip, and permits the passage of 10-ton cars and locomotives and all parts for a 36-in. crusher. The cage has four guides instead of the two usually used in U.S.A. This is common practice abroad, and it is to be recommended for a cage as large as this. (On account of the large number of men carried, the cage should have safety catches for each pair of guides. A special drawhead will be necessary.)

For ventilation and second outlet old No. 4 shaft will serve at the north-west end of the mine. It is 600 ft. deep. At the south-east end of the mine another shaft is needed for ventilation and outlet. It needs to be only 600 ft. deep at this time. Both shafts are inclines.

3. Plats and Pockets.

The cage-road and ladderway will be connected to each level, but there will be no opening into the skipways except at the loading-pocket below the 800 ft. level and at the spill pocket on the 900 ft. level. Plans for the plats at the various levels are shown on drawings Nos. 7, 8 and 9. The design of the 600 ft. level plat is tentative only, because the exact distance from the lode to the shaft is not known.

The ore and waste passes connecting the upper levels with the crusher and measuring-pocket are shown on drawing No. 10. Above the 700 ft. level they are given a slope of 55°, because this inclination allows free movement of dry material with little packing. The ore-passes lead to the crusher, and the waste-passes lead directly to the measuring pocket.

The crusher is below the 700 ft. level. Below the crusher there is a 400-ton storage-pocket for ore, and the measuring pocket is below this, 25 ft. below the 800 ft. level. This measuring pocket will handle either ore or waste, and will load either skip.

Provision for catching spilled dirt in loading the skips will be made on the 900 ft. level, as shown in drawing No. 4.

4. Crusher.

The crusher recommended in a 36-in. gyratory.

5000 tons of ore per shift is 714 tons per hour for seven hours of operation. By using a scalping grizzly above the crusher at least 15% of the ore can be bi-passed, leaving 600 tons an hour to be crushed. The smallest crusher that has a rated capacity of this amount is a 36-in. gyratory, set at 7 in. discharge. This crusher will take any piece of orethat is likely to be broken in the stopes, so that secondary blasting will be reduced to a minimum. A gyratory crusher is recommended, because it is almost trouble-free, will run under a choke-feed, and costs less to build, operate or maintain than a jaw-crusher and feeder of equal capacity.

It is proposed to erect the crusher below the 700-ft. level, as shown on drawings 4, 5, 6 and 10. The ore from the 700 ft. level will be dumped directly into the crusher, and that from the upper levels will be drawn from the ore-passes, and will pass over the same grizzly. Undercutting arc chutes operated by compressed air, as shown on drawing No. 14, are recommended for the chutes in both the ore-and waste-passes.

The crusher will be driven by a 250 H.P. motor through a short V-belt drive.

The largest part of a 36-in. gyratory crusher is 13 ft. 4 in. in diam., and can be taken down the shaft through the cage-road. It will be taken off on the 700 ft. level on the northeast side, the drift at this point being enlarged to permit its passage.

Capacity, horse-power required, and dimensions have been taken from Traylor Eng. and Mfg. Co., Bulletin No. 3100.

The grizzly should be of the open-end type, which is self-clearing, and should have bars spaced 7 in. apart at the lower end.

5. Level Development.

The approximate outlines of the levels are shown on drawing No. 11, which is based on the contours of the ore-body as shown by diamond-drilling.

The 400 ft. level will be opened by a long cross cut due north from the shaft. The ore here is nearly flat, and there is consequently considerable leeway in laying out the level. The existence of ore to the west is proven by diamond drilling, but its extent to the north and east has not been determined. Three or four diamond-drill holes put down from surface in the N.E.¼ of the S.E.¼ and the S.E.¼ of the N.E.¼ of Sec. 10 and in the two adjacent forties in Sec. 11 on the east would aid substantially in planning development on the 400 ft. and 500 ft. levels.

The west drift on the 400 ft. level should be driven north-west to the old workings, connecting with the north transfer raises at about 5000 ft. The ore is so flat that it should be easy to keep this drift open until the stopes on the 500 ft. and 600 ft. levels are pulled back to the transfer raises.

A large pillar will have to be left under the plant, and most of the ore tied up in it will be on the 400 and 500 ft. levels.

The ore on the 500 ft. level is also on the north side of the shaft at a distance of about 800 ft. It will be opened by a cross-cut driven N 25' E, and by drifts driven east and north-west on the vein. Here again the ore to the west has been proven by diamond drilling, but that to the east has not. It is, however, very probably nearly flat, so that there will be much leeway in laying out the level.

The west drift will follow the ore as far as the old workings, approximately 8000 ft., connecting with the north transfer raises at about 5000 ft.

The ore on the 600 ft. level is near the shaft on the north side. Its continuity to the east is reasonably assured, but D.D.H's. 9 E 4 and 9 E 6 should be drilled in order to obtain definite information on this point.

On this level drifts should follow the ore south-east and north-west to its limits, connecting with No. 4 shaft and the North transfer raises on the north west and with the south transfer raises and the air shaft at the S.E. end of the mine.

The 700 ft. level is south of the shaft. This is a main haulage level, and it should be opened as rapidly as possible. Drifts should be driven in the ore south-east and north-west from the cross-cut south of the shaft, connecting by raises with the workings east of No. 4 shaft and with the air-shaft at the other end of the mine.

About 6000 ft. from the shaft on each side a cross-cut will be driven into the foot wall, and from these cross-cuts raises will be put up to the 600, 500 and 400 ft.

levels on the north-west and to the 600 and 500 ft. levels on the south-east, as shown in drawings Nos. 12 and 13.

The 800 ft. level will follow the lines of the 700 ft. level, but may be developed at a more leisurely rate. This level is below the crusher, and ore and waste cannot be dumped into the regular system of passes. A short separate chute has been provided, however, as shown on drawings Nos. 4,5,6 and 9, leading directly to the measuring pocket. This chute must have a grizzly over it, because the ore is not crushed, and is intended to handle only material from development.

Drifting should be done rapidly. White Pine ore and rock drill readily and stand well. Each heading should be advanced at least 500 ft. per month. Work should be concentrated at first on the levels between No. 4 shaft and the main shaft, as this is where stoping will start.

When No. 4 shaft has been reopened and equipped, drifting can be started from workings in this shaft to connect with the 600 and 500 ft. levels from the main shaft. By drifting, raising and experimental stoping ore can be produced up to the capacity of the shaft, possibly enough for one unit of the mill.

6. Stoping.

In order to maintain a production of 10,000 tons a day all mining operations, and especially stoping, must be carried out systematically and with precision. It would be almost impossible to obtain such an output from a large number of working places, each of which produces a relatively small amount, as is customary in places where loading is done by hand, and the cost of collecting the ore from so many places and the tremendous amount of development that would have to be done before full production was possible would be prohibitive. The only feasible scheme is to work a smaller number of stopes intensely, obtaining a relatively large production from each. This is possible with modern loading machinery, if stoping operations are so arranged that frequent movement of the loading equipment is unnecessary.

The mode of occurrence of the copper in the White Pine ore is so different from that in other parts of the Michigan Copper Country that an entirely different control of stoping is indicated. At the other mines the native copper is visible to the naked eye, and is impossible to sample satisfactorily in small lots. Control of stoping operations is largely a matter of eye, and depends on the judgment of the miner and his bosses. At White Pine, however, although some of the copper in the sandstone is visible, the most important copper content is in the shale between the upper and lower sandstones, and cannot be distinguished by eye from the enclosing rock. Control of stoping widths and ore limits must therefore depend on sampling and analysis.

To be effective the sampling and analysis must be done in advance of stoping as much as possible. In the method of mining proposed the importance of this procedure is recognized.

Except close to the main fault the ore dips at too flat an angle for broken ore to run by gravity. In some places it may be flat enough to be loaded directly into cars by machines of the Conway or Finlay type, but in most places it will apparently be best to do the loading with scrapers, using short chutes or slides to get it into the cars.

Taking into account the dip and thickness of the ore, the closest parallel to White Pine conditions that I know in the United States is the iron ore at Birmingham, Alabama. A very successful technique, using large scrapers for moving the ore, has been developed in the Birmingham District, and a modification of this system should work well at White Pine. Not all the companies operating in the Birmingham District follow the same details of practice, but the essentials are the same at all mines.

1. The ore is mined by breast stoping with rooms and pillars.
2. The rooms are turned off from a drift driven along the foot-wall, and are driven up the dip for 250 to 300 ft.
3. The ore is moved by large, box-type scrapers, hauled by 50-H.P. electric hoists, which are mounted on trucks. One hoist serves three to five rooms.

4. Because the loading capacity of one scraper crew is greater than the drilling and blasting capacity of one stope, two or three crews of miners are employed to each crew of loaders. For example, in a three-room unit two mining crews, each using two drills, drill and blast in two rooms, while the loading crew cleans out the third room room with the scraper. By working the rooms in rotation, each breast is blasted twice before it is cleaned out. 125 tons of ore is broken at each blast, and the scraper has 250 tons to work on, when it starts to clean out a stope. In the five-room groups the discrepancy between drilling and loading capacity is even greater.

5. The ore is loaded into 5-ton cars hauled by electric locomotives. At the foot of the room, a simple ramp, or slide, built out of timber and channel-irons, has a lip that extends over the side of the car. The truck on which the hoist is mounted, runs on a track parallel to and behind the main haulage track, and is moved along this track from room to room as required. Usually, however, the scraper is not moved from room to room, each room having its own scraper, which is left in the slide, when not in use.

6. Variations in practice are mainly in the manner of leaving pillars. At some mines long narrow pillars with few break-throughs separate the rooms. At others large pillars are left around each group of rooms, and small random pillars are left in and between the rooms. At some mines narrow rooms are driven upgrade, and are then

widened by stripping the pillar on each side. At others the rooms are driven full width on the advance, or three breasts may be carried up almost as one stope, being separated only by small random pillars.

In Birmingham there is a water-bearing stratum in the hanging-wall, and it is considered to be unsafe to allow the hanging-wall to cave, until ultimate depth has been reached. Only 60% of the ore is therefore mined on the advance, and it is planned to recover part of the pillars later, retreating from the bottom upwards. At White Pine the Freda Sandstone, overlying the Nono-Such Shales, at the base of which the ore occurs, is water-bearing, but it can probably be drained, and the shale below it is thick enough to act as an effective seal. Consequently it will be safe to remove 75% to 80% of the ore, mining the ore on the retreat. By reducing the size of the pillars just before the stope is abandoned, they will be crushed and the hanging-wall will not be badly shattered, when subsidence takes place; and the weight of the capping will be taken off the adjoining rooms, thereby preventing a general squeeze.

The plan that I have in mind for White Pine contemplate s following Birmingham practice to a large extent. I would drive the levels 100 ft. apart vertically, which over a large part of the mine will permit rooms about 300 ft. long on the dip. In the flatter ore of the upper levels it may be expedient to drive intermediate levels rather than to lengthen the rooms. If experience at White Pine is the same as at Birmingham, however, rooms 500 ft. long can be mined economically.

In somewhat similar shale in Rhodesia long, narrow, continuous pillars were better than shorter and wider pillars with break-throughs between them, and I think that the same thing would be true at White Pine. My recommendation is to lay out the stopes on 45-ft. centers, rooms being 33 ft. wide and pillars 12 ft. The pillars can finally be stripped to an average width of 8 ft. or less.

In starting a stope the first thing will be to drive a raise 12 ft. wide from level to level following the center-line of the stope and taking out the full thickness of the ore, if the ore is not over 12 ft. thick. In thicker ore a thickness of 8 ft. to 10 ft. would be mined, and the raise would follow the hanging-wall. Ore left on the foot-wall would be mined by ring-drilling from the raise, when the stope was widened. By using a burn-out cut 12 ft. rounds can be pulled, and the raise is so large thatthe ore can be broken economically. When the raise is up about 20 ft., a ramp or chute will be built at the bottom, and thereafter the broken ore will be loaded directly into cars by a scraper. In this ground a 12-ft. round should be pulled in two shifts.

When the raise has been holed through to the level above , it will be widened 11 ft. on each side just above the chute so as to form a hopper. The ore above will then be broken by successive rows of horizontal holes drilled into the rib on each side of the raise, each row being in a plane normal to the dip. A little experimenting will soon determine the most economical distance between holes and the proper burden. I think that holes can be spaced 3 ft. apart in the row and can carry a 4-ft. burden. Drilling will be kept well ahead of blasting, and the whole raise can be drilled on both sides for its full length, if desired, before blasting starts. Enough holes can be blasted every day to keep the scraper supplied with ore, and the hoist will not have to be moved until the stope is finished.

If the drills are mounted on columns with universal arms, and the columns are set up normal to the dip, reaching from foot to hanging, two rows of holes can be drilled from each set-up, and not more than two set-ups in a shift will be needed for each machine. Since the holes are all parallel, and the spacing and burden are determined in advance, miners can be paid on contract or bonus according to footage drilled without loss of efficiency in blasting, and all holes can be measured before they are fired. The holes can be laid out in advance, and their position marked on the rib, so that there will be no mistake.

White Pine ore drills very readily, and should break well. In this ground a reasonably good miner should be able to drill well over 100 ft. of hole in a shift, and a very good man might drill as much as 200 ft. An everage burden of .7 ton of ore per foot of hole can be reasonably expected. This would make the tonnage broken per machine in this part of the work anywhere from 75 to 150 tons per shift. The lower efficiency of the raise work would reduce the avergge to possibly 50 or 60 tons per machine shift.

If there are enough working places available, it is proposed to drill and load ore on the day and afternoon shifts, and to blast and trim back on the "grave-yard" shift, using a special crew for this work. By this arrangement the miners can drill for the full shift without delay for trimming and blasting.

Another advantage of having the raise put through to the level above is that the men drilling the side-holes will always be working in a narrow place that is safe from falls of ground. When the stope is widened, if the back shows signs of weakness, single props or batteries of stulls can be set up on the center-line without interfering with either drilling or blasting.

By using the center raise, control of stoping width, i.e. the thickness of ore that should be mined, will be greatly facilitated, for the rest of the stope. While the raise is being put up, sectional samples should be taken from every cut to determine the commercial limit of the ore, and the top and bottom of the ore should be marked clearly on both ribs for the guidance of the miners, who will later widen the stope. If the center raise is carefully sampled, the ribs will not need to be sampled again.

Although the ore at White Pine is in general unusually regular in its occurrence, as indicated by the drilling, small cross faults were found in the old mine, which dislocated the lode for a few feet. These may be connected with the formation of the ore, and are to be expected in the vicinity of the main fault. The presence of such a fault in a stope will be shown by the center raise, and this advance knowledge will be helpful in mining the rest of the stope.

The number of crews that will work as a unit depends on the loading capacity of the scraper. A scraper large enough to load 300 tons a shift will prove economical. Each unit will then produce 600 tons a day. Depending on the skill of the miners, three machines should drill the necessary side holes to produce this tonnage. Three or possibly four more machines are needed to drive two raises fast enough to keep pace with the side-hole work, and these will produce 200 tons more per day, if they are provided with separate loading equipment. A 12-ft. advance should be made in each raise every day. Theoreticallly therefore we should be able to get 800 tons a day from each stoping unit, but it will be safer to count on only 600 tons.

In normal procedure it would be good practice to have one stoping unit on each side of the shaft on each level, and to retreat towards the shaft from each end of the level. The drifts at White Pine, however, will be so long that it will be possible, by having a transfer raise 5000 ft. or more from the shaft, to work as many as 6 units on one level, two retreating towards each transfer raise and two retreating towards the shaft. From current development and sixteen stoping units it should be quite feasible to produce 5,000 tons per shift. If there are six units on each oftwo levels and four on a third level, while a fourth level is being developed, production and development will be in balance.

Because White Pine ground drills so easily, I think that as good speed can be attained with 3-in. machines as with 3½-in. machines, and the smaller machines would be preferable, because they are really one-man machines, and are easy to set up. All drifters should have automatic feed, and 36-in. shells.

Each unit would require six or seven machines in regula r use, and there should be three spares. We should therefore count on 10 machines for each unit. Each unit will require seven saddle-clamps and seven 3-in. universal arms, and at least 12 3-in. columns of various lengths. One 50-ft. air-hose and one 50-ft. water-hose will be needed for each machine.

For loading ore from the raises each unit will require one 25 H.P. double-drum electric hoist, mounted on a small truck, and a 48-in. hoe-type scraper with cheek-plates, which will weigh about 1000 lb. Rope-speed should be 250 f.p.m. For the stopes I recommend a 60-in. or 72-in. hoe-scraper with cheek-plates about 2 ft. long, weighing about 2500 lb. The hoist should preferably have three drums and a rope speed of 250 to 300 f.p.m. It would be driven by a 50-H.P. motor, and would be mounted on a truck that can run on the main track. Each unit would have one hoist of each kind, and there should be two spares of each kind for the mine.

When the development program has been completed, it will be possible to work stoping units as follows:

Level.	Dumping Point			Total
	Main Shaft Units	N.Transfer Units	S.Transfer Units	Units
400	3	1		4
500	2	2	2	6
600	2	2	2	6
700	2			2
Total	9	5	4	18

16 units at 300 tons each is 4,800 tons per shift. Probably 15 units in production, one in process of development and level development will be sufficient to maintain a production of 10,000 tons a day.

For a production of 7,200 tons a day, or 3,600 tons a shift, 11 stoping units and level development should produce the requisite tonnage. These units can all start between No.4 shaft and the main shaft on the 400, 500 and 600 ft. levels, the men working on the 600 ft. level being transferred to the 400 and 500 ft. levels, when development on the east side has advanced far enough.

7. Transportation.

The cage in the main shaft is large enough to carry 10-ton cars. These would be either Granby or Differential drop-door type. The latter is preferred. They should be equipped with roller-bearing wheels and automatic couplers. They can be dumped automatically by an inclined ramp, placed opposite the chute, without stopping the train. If the train is moving 3 m.p.h. about 20 ft. along the track is required for dumping, and the opening into the chute at the dump must be about this length, as shown on drawings Nos. 6, 7, 8 and 9. All of the waste dumps and the ore-dumps on the 400, 500 and 600 ft. levels should have ramps for dumping. The ore dumps at the shaft on the 700 and 800 ft. levels may be equipped with air-cylinders for dumping the cars, as dumping at these points will not be done as rapidly as at the others.

Cars will weigh 7 to 8 tons each empty, and will have rolling friction of not more than 15 lb. per ton. On a level track therefore a loaded car, weighing 18 tons, will have rolling friction of 270 lb. and an empty car weighing 8 tons will have 120 lb. It is planned to use a track of 36-in. guage laid with 50 lb. rails on a grade of 0.4% in favor of the load. A 6½-ton locomotive can haul 9 loaded cars on a level track or push 6 loaded cars up a 0.4% grade. A locomotive of this size is large enough to serve the stopes, but on the 700 ft.level larger locomotives are required for the main-line haul to the shaft. The main-line locomotives should weigh 10 tons each.

Because the hauls are so long, trolley locomotives should be used.

Each stoping unit is planned to produce 300 tons a shift and 100 tons from the raises, 30 cars in all.

A 60-in. scraper in a stope should load a 10-ton car easily in 10 to 15 minutes, under average conditions. If we assume a capacity of 4 cars, or 40 tons, per hour, it will take only 5 hours to load 200 tons, leaving 2 hrs. for switching and delays.

A 42-in. scraper in a 12-ft. raise will have no difficulty in loading 2 10-ton cars an hour, and will therefore load its quota of 100 tons in 5 hours.

If one car is spotted at the raise and two at the stope, they can be loaded in half an hour, the cars being shifted by a small air-hoist. A locomotive can then pick up the three cars, take them to the shaft or transfer, and dump them, leaving three empties in their places.

The maximum haul is 3000 ft., except on the 400 ft. and 700 ft. levels. At 6 m.p.h. it will take a train 6 mins. to make the run to the shaft. Allowing 2 minutes for dumping and 6 for switching, a round trip should be made in 20 minutes. Allowing for all delays half an hour should be the maximum. On this schedule one locomotive and six cars should handle 300 tons easily in 5 hours.

On the 700 ft. level a much larger tonnage must be hauled to the shaft than on any other level. At the maximum production there will be 300 tons from a stoping unit at each end of the level with a maximum haul of 3000 ft. to a siding near the transfer raises. In addition there will be 1200 tons from each pair of transfer raises. If the ore from each stoping unit is hauled to a siding near the transfer raises, these cars can be picked up by the locomotive that hauls to and from the shaft.

Each pair of transfer raises will discharge 1200 tons a shift on the 700 ft. level. There should be a siding 250 ft. long on the main line near the end of the cross-cut on the side nearest the shaft. The haul from the inside chute to this siding is roughly 1000 ft. and from the siding to the shaft 6500 ft.

A 6½-ton locomotive will handle cars in trains of six from the siding to and from the transfer chutes, or an 8-ton locomotive can haul 12 at a time. It should be possible to load a car comfortably at the chute in 1 min. If the main line trains are made up of 15 cars each, there will be 3 from the stope and 12 from the chutes. The 3 cars from the stope will be set out by the stope locomotive, and 3 empties will be taken inside, leaving 12 empties to be loaded at the chutes. The chutes locomotive will take 6 cars to the chute, load them, return to the siding with the loads and take back 6 more empties, working on a schedule as follows:

Switching and coupling	3 mins.
Haul in	2 "
Load 6 cars	6 "
Haul out	2 "
Delays	2 "
Total	15 "

Making 2 trips in half an hour, there will be a train of 15 cars ready on the siding every 30 mins.

An 8-ton locomotive ~~will~~ can take the 12 empty cars to the chutes and fill them and return to the siding on the following schedule:

Switching	3 mins.
Haul in	2 "
Load 12 cars	12 "
Haul out	2 "
Delays	1 "
Total	20 "

Three trips per hour is 36 cars per hour, or 180 cars in 5 hours.

The crusher has a rated capacity of 600 tons per hour, and more than 100 tons per hour will pass through the grizzly. A trainload of 15 cars, or 150 tons, can be dumped at the crusher in 12 mins.

If the main-line locomotive has a speed of 8 m.p.h., the 6500 haul to the shaft can be made comfortably in 10 mins. The time required for a train to go through the cross-cut to or from the shaft is 2 mins. To go through the cross-cut, dump, and return to the main line is therefore 16 mins. The schedule for a train is as follows:

Switching	3 mins.
Siding to shaft	10 "
Dumping	12 "
Shaft to siding	10
Total	35 "
Time in cross-cut and at shaft	16 "
Time on main line	19 "

As soon as a train from the north-west has dumped and gone back, a train from the south-east will enter the cross-cut to the shaft, dump and return. Since the time inside is 19 mins. we can expect one trainload to be dumped every 20 mins., or 3 trainloads of 15 cars each per hour. This is 2700 tons in 6 hours, and is ample for a production of 7200 tons of ore in two shifts, or 10,000 tons of ore in 20 hours of hoisting.

On the schedule as outlined there will be required 2 10-ton locomotives for main line work and 2 6½-ton, or 2 8-ton locomotives for switching at the transfer raises, one 6½-ton locomotive for each active stoping unit, four 6½-ton locomotives for development, and four more for supplies. Spares should be 10% more.

The 700-ft. level will require 24 cars for tramming ore from the transfer raises to the shaft, and each stoping unit will require six cars. Development will require at least 12 more, and there should be 10% spares. Each stoping unit will have a man car.

8. Hoisting.

General. In making plans for hoisting equipment calculations must be based on maximum requirements. The following calculations have been based, therefore, on a production of 10,000 tons of ore and 1000 tons of waste per day.

It is feasible to use 10-ton skips, even for maximum production. With them 8,000 tons can be hoisted in 2 shifts and 11,000 tons in 20 hours. The ore-passes at the shaft and the storage pocket below the crusher have a combined capacity of 1150 tons, and the ore-passes at the transfer raises have a capacity of 1750 tons, a totalof 2900 tons. The waste-passes at the shaft have a capacity of 1000 tons, and those at the transfer raises have a capacity of 1500 tons, a total of 2500 tons. The combined total is 5400 tons. It is not to be supposed that this will be left full at the end of the second shift every day, but it is reasonable to suppose that 3,000 tons might be available each day from this source, so that hoisting could be continued for 4 hrs. on the third shift with only tramming from transfer raises to shaft being necessary. If desired, storage capacity at the shaft can be increased, making tramming from the transfer raises unnecessary on the third shift.

The headframe should be made of steel or concrete, and should contain equipment for disposal of waste. The coarse crusher will be underground, and the secondary crusher, preferably a 7-ft. Symons, may be placed in the shaft-house, or in a separate building, from which the product will be elevated to the mill bins by a belt conveyor.

Two hoists are required, one for the skips and one for the cage and counterweight. Both hoists should be driven electrically through herringbone gears. The lift is so short that a first motion hoist is not necessary.

Skip-Hoist.

If 16-ton skips are used, 7200 tons of ore and 800 tons of waste can be hoisted from the 800 ft. level in two 8-hr. shifts, and10,000 tons of ore and 1000 tons of waste can be hoisted in 20 hours, if the hoisting speed is 1800 ft. per min.

Hoisting Cycle.

		800 ft. level	
		Secs.	Ft.
Load		8	
Accelerate	(25 ft. per sec.) per sec.	12	150
Full Speed		22	660
Decelerate		15	225
Dump		5	
Total		62	1035
Trips per hour			58
Tons per hour			580
Tons per shift (7 hrs.)			4,060
Tons per day (2 shifts)			8,120
Tons per day (20 hours)			11,600

The skip-hoist should have a cylindrical drum 10 ft. in diameter with 9 ft. face keyed to the shaft, driven through herringbone gearszat 54 r. p.m. by two 750 H.P. motors with Ward-Leonard control

Calculation of Horse Power:

$$\frac{.7 \times 2 \times 20{,}000 \times 1800}{33{,}000} = 1530 \text{ H.P.}$$

If the acceleration is increased to 3 ft. per sec., this hoist will have ample capacity for the bottom level also.

This calculation is empirical but is close enough for estimating purposes.

Cage-Hoist.

It is highly desirable that all men be lowered into the mine in not more than half an hour and that they be hoisted out in the same length of time.

The number of men that will have to be hoisted will be between 600 and 800 per shift, 800 probably being the maximum.

If a cage holding 50 men were used, 16 trips would be required, and this would take an hour. Two cages in balance would not double the capacity. In order to get the men down in half an hour a double-decked cage, holding 50 men on each deck, is indicated. Double-deck platforms for loading and unloading men both underground and on surface must be provided, and men must go on and off the cage two abreast. In this way a cage can be loaded or unloaded in 30 to 40 secs. At change of shifts men will be coming on and going off shifts at the same time. This will cause little delay, if provision is made for them to go on the cage on one side and off on the other.

A hoisting speed of 900 ft. per min. or 15 ft. per sec. is permissible.

The hoisting cycle will therefore be as follows:

	Time Secs.	Distance Ft.
Load cage	30	–
Signals	5	–
Accelerate	10	75
Full speed	42	635
Decelerate	12	90
Signals	3	
Unload	30	
Signals	3	
Accelerate	10	
Full speed	42	
Decelerate	12	
Signals	3	
Total, round trip –	202	800
	– 3 m. 22 secs.	

It should be easy to make 8 trips in half an hour.

The load on the rope will be as follows:

100 men @ 180 lbs.	–	18,000 lb.
Double-decked cage	–	20,000 "
Weight of rope	–	4,000 "
Total weight on rope	–	42,000 "

With a factor of safety of 5, a 6 x 19 rope $1\frac{1}{8}$ in.diam. of extra plow steel will be satisfactory.

If the counterweight weighs as much as the cage, plus 40% of the live load, the unbalanced load, when the cage is loaded, will be 60% of 18,000 lb. or 10,800 lb. Assuming a rope speed of 900 f.p.m., the horse-power required is calculated as follows:

$$\frac{10,800 \text{ lb.} \times 900 \times 2}{33,000} = 600 \text{ H.P.}$$

The hoist should be a duplicate of the skip-hoist, except that it should be driven by a 600 H.P. A.C. wound rotor motor, and should have a rope-speed of 900 ft. per min.

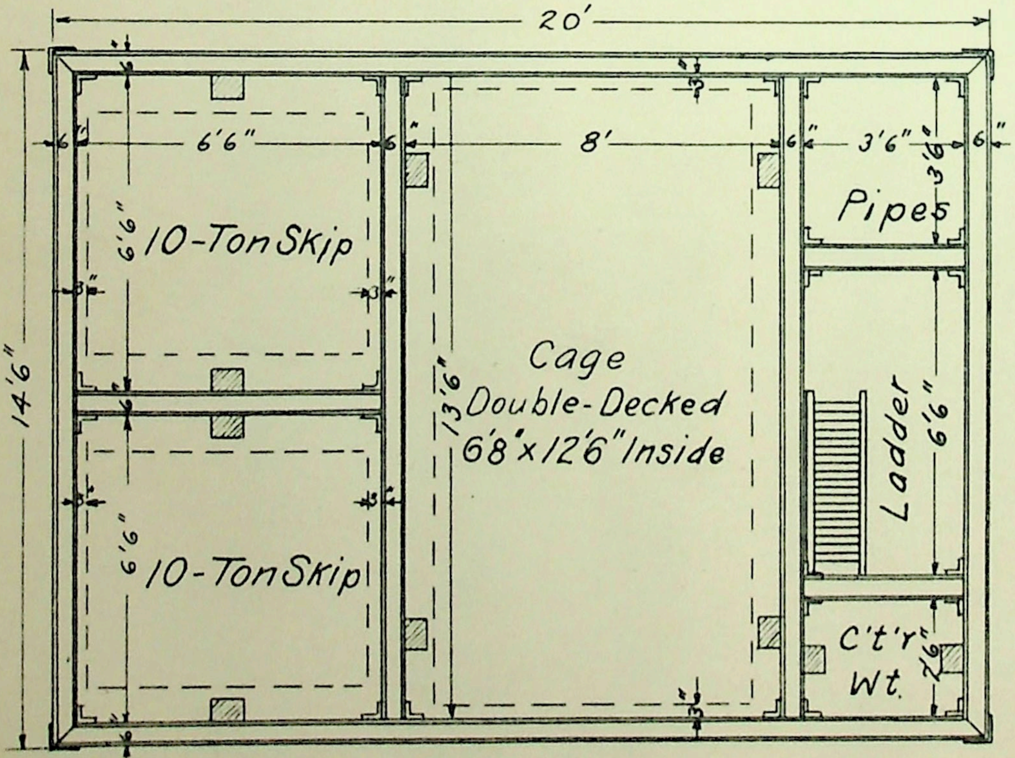
Pumping.

Although the sandstones are water-bearing, I do not anticipate a large flow of water under normal conditions. The pump-house should, however, be designed in such a way that additional pumping units can be added without disturbing those already installed. The design shown on drawing No. 15 meets these requirements, and is recommended.

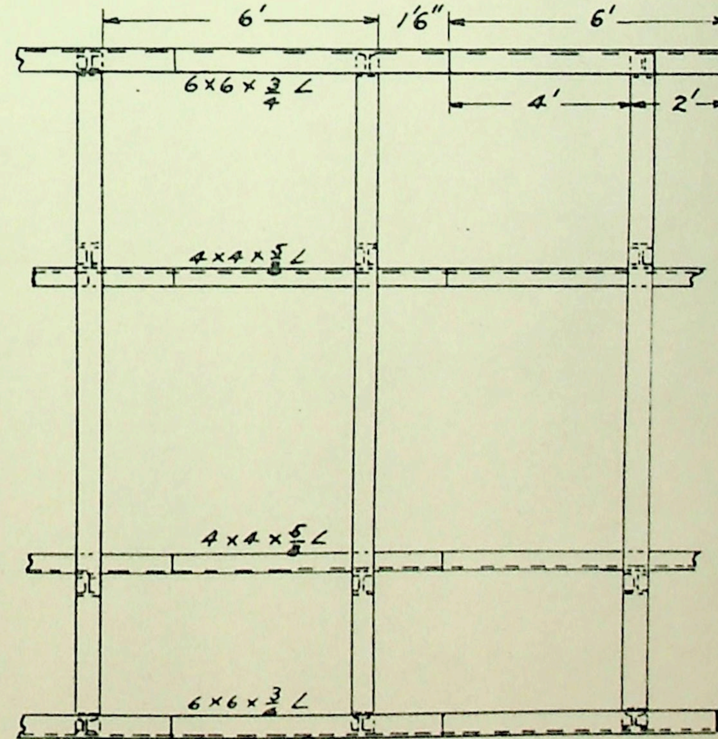
The logical place for the pump-house appears to be the 700 ft. level west of the shaft with connections to the cross-cut to the cage road.

Water from the 800-ft. and 900-ft. levels would be handled by motor-pumps with automatic control, discharging into the sump on the 700-ft. level.

Sets are 6" H-Sections 28 lb. All steel copper-bearing.
Corner studdles are 6"×6"×$\frac{3}{4}$" ∠s All members dipped in asphalt.
All guides 5$\frac{1}{2}$"×7$\frac{1}{2}$" S4S Oak or Fir.



PLAN



ELEVATION

WHITE PINE MINE SHAFT SETS

SCALE: 1"=4'

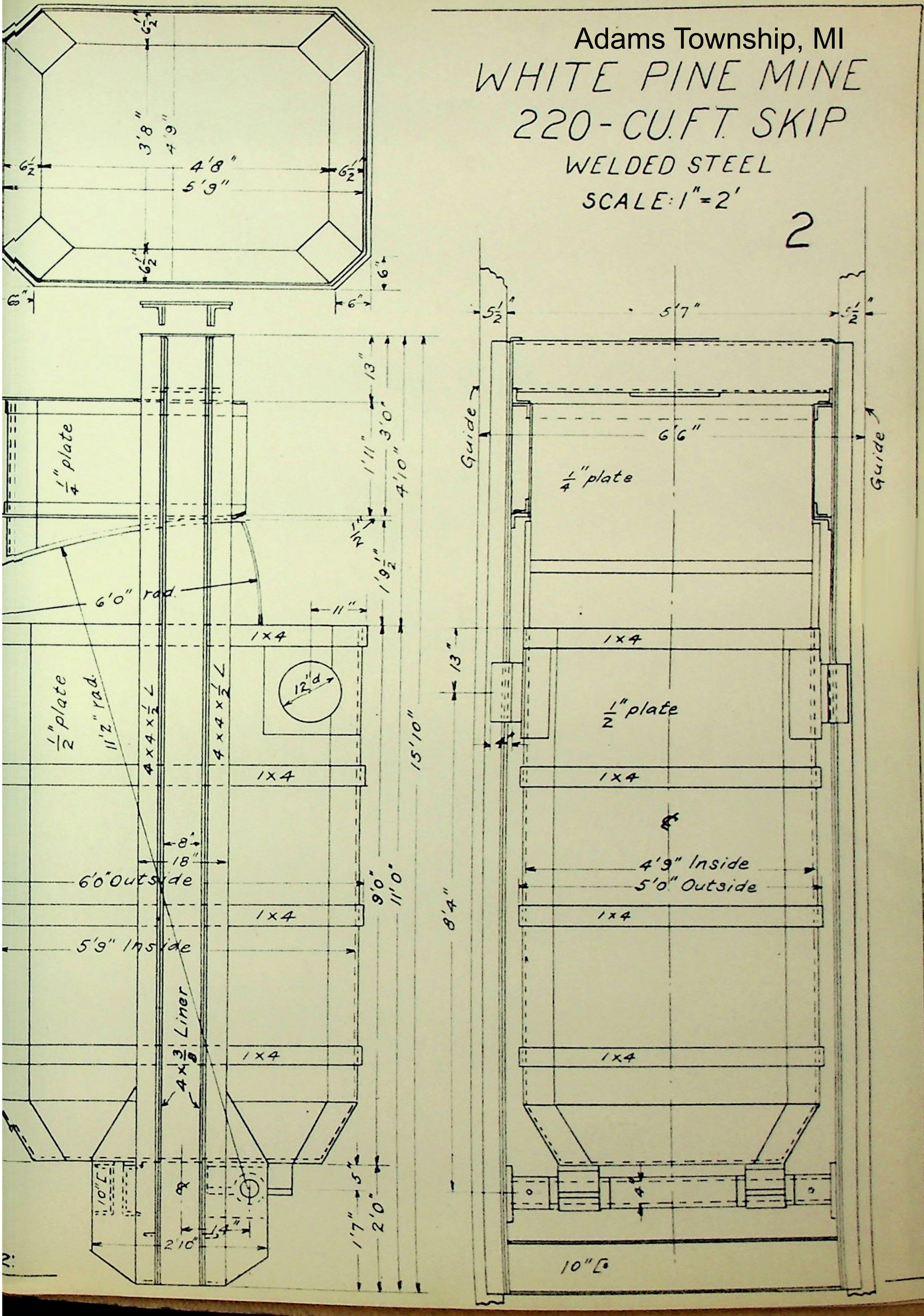
Adams Township, MI

WHITE PINE MINE
220-CU.FT. SKIP

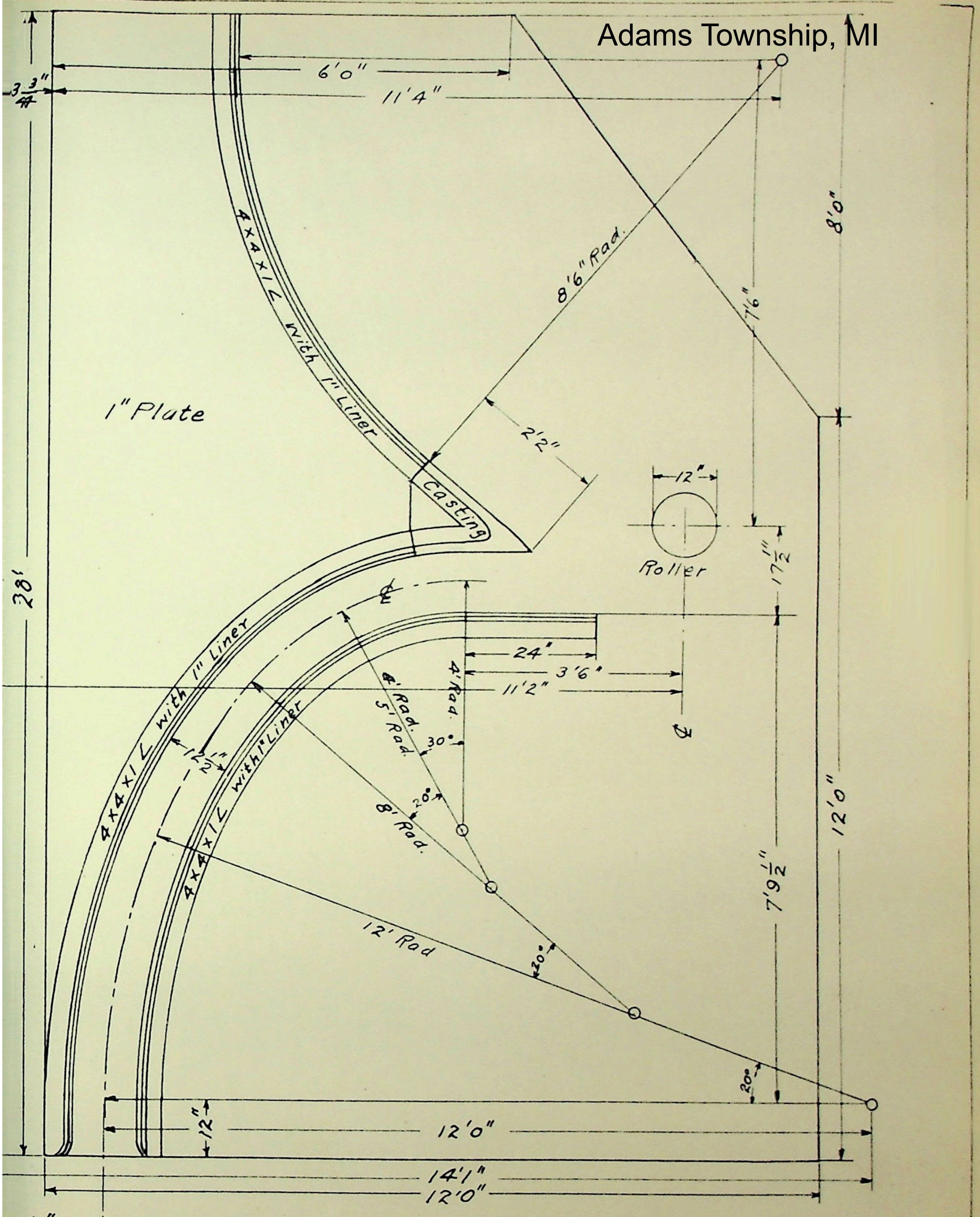
WELDED STEEL

SCALE: 1" = 2'

2



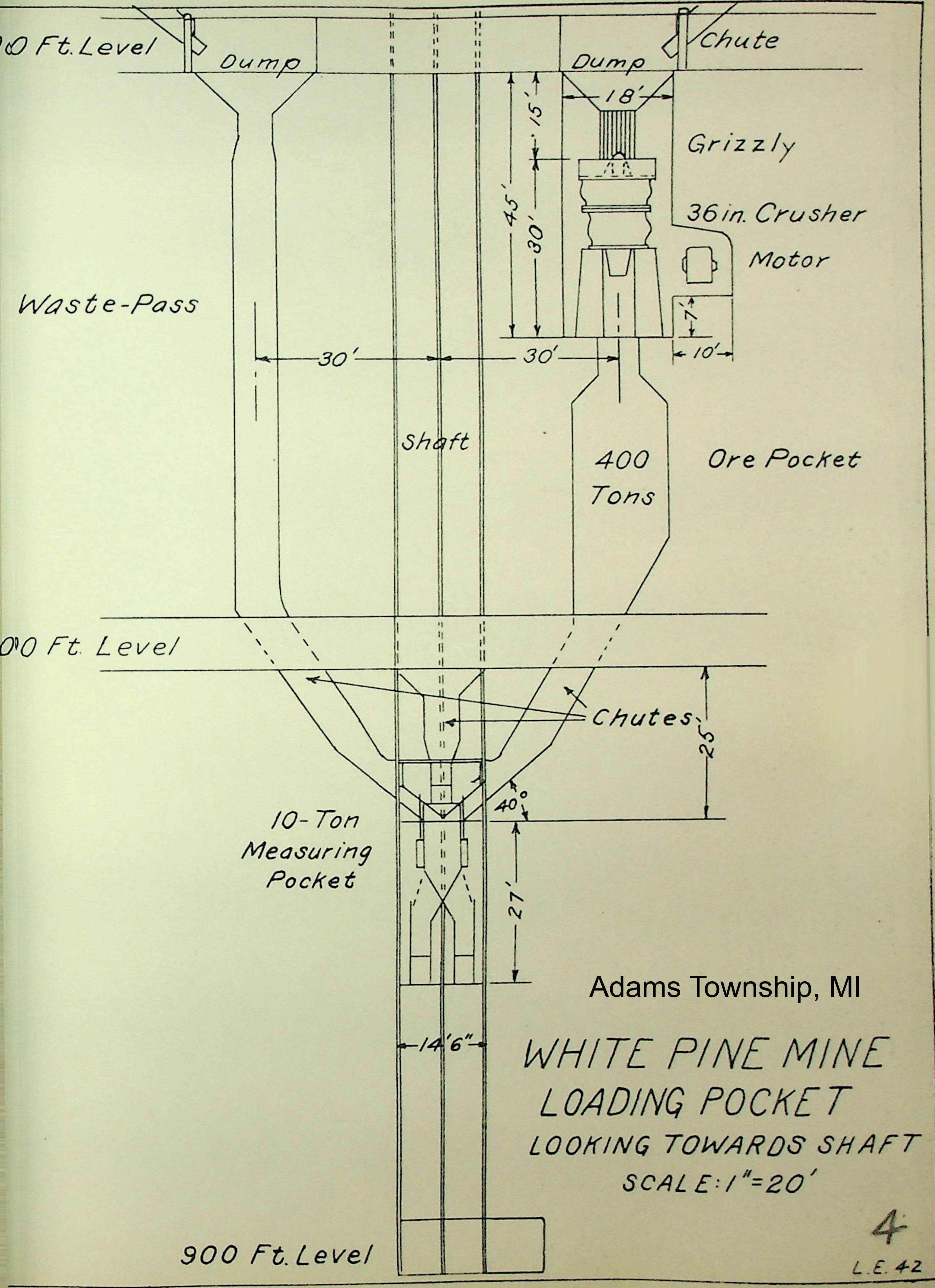
Adams Township, MI



WHITE PINE MINE
SKIP DUMP

3

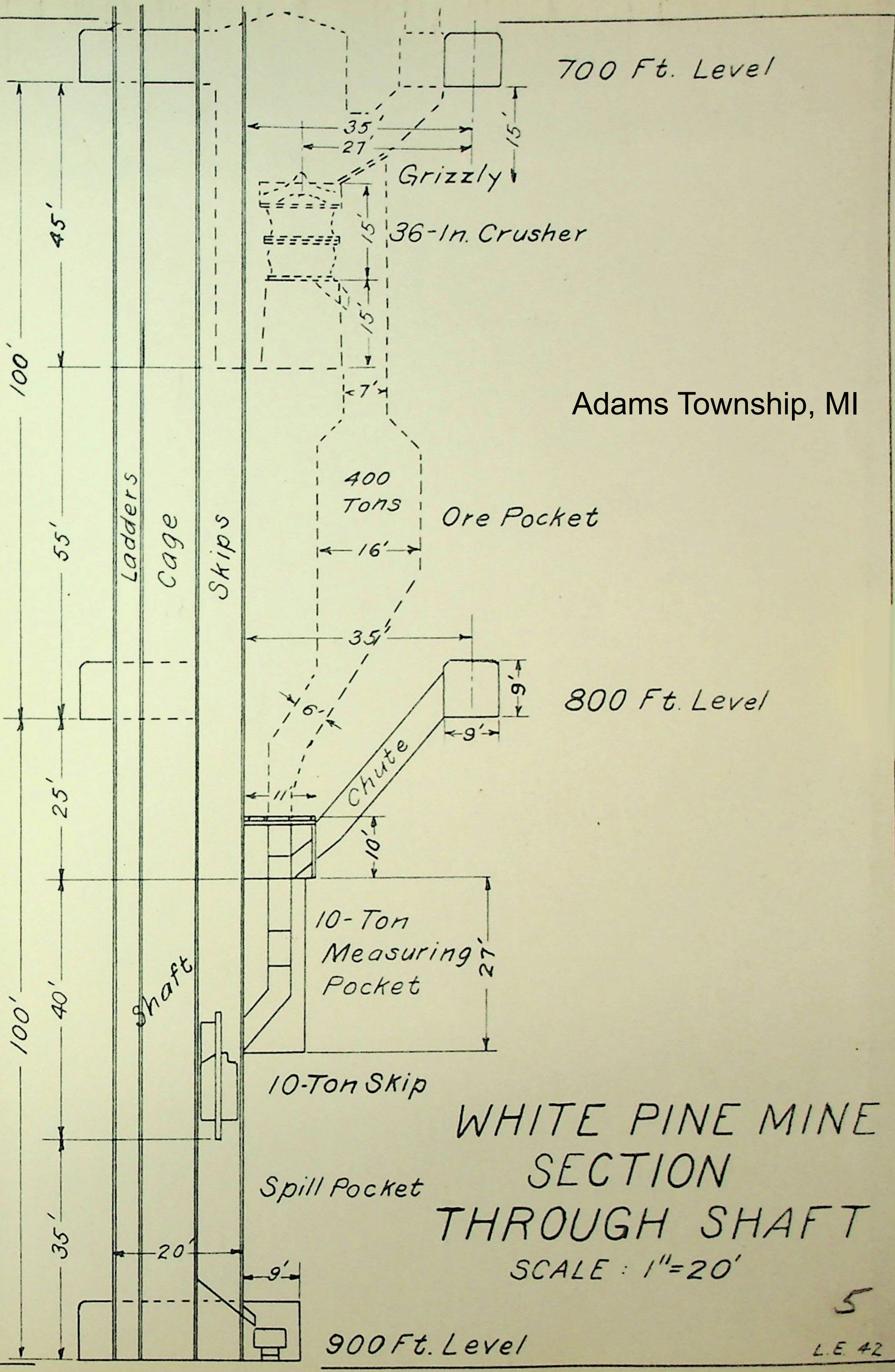
IR IL SCALE: 1"=2' LE 42



WHITE PINE MINE
LOADING POCKET
LOOKING TOWARDS SHAFT
SCALE: 1" = 20'

4

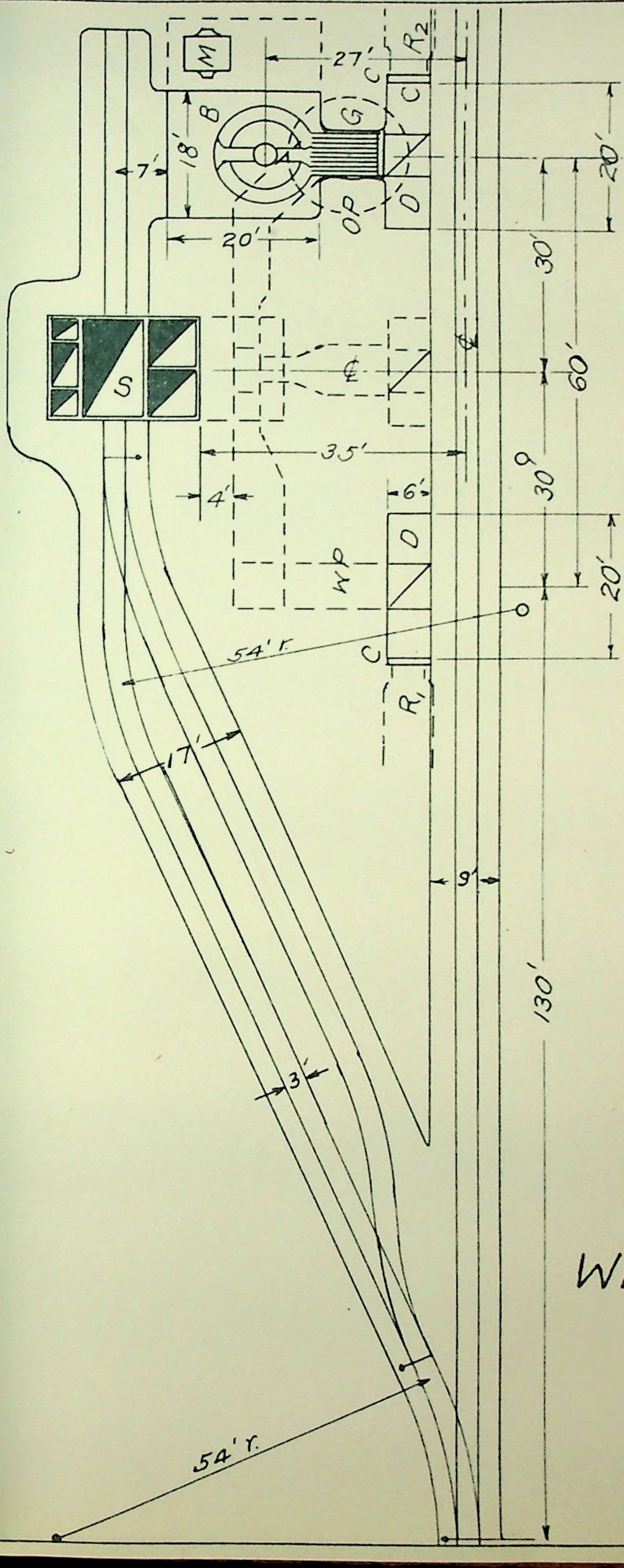
L.E. 42



Adams Township, MI

WHITE PINE MINE
SECTION
THROUGH SHAFT
SCALE: 1"=20'

Adams Township, MI



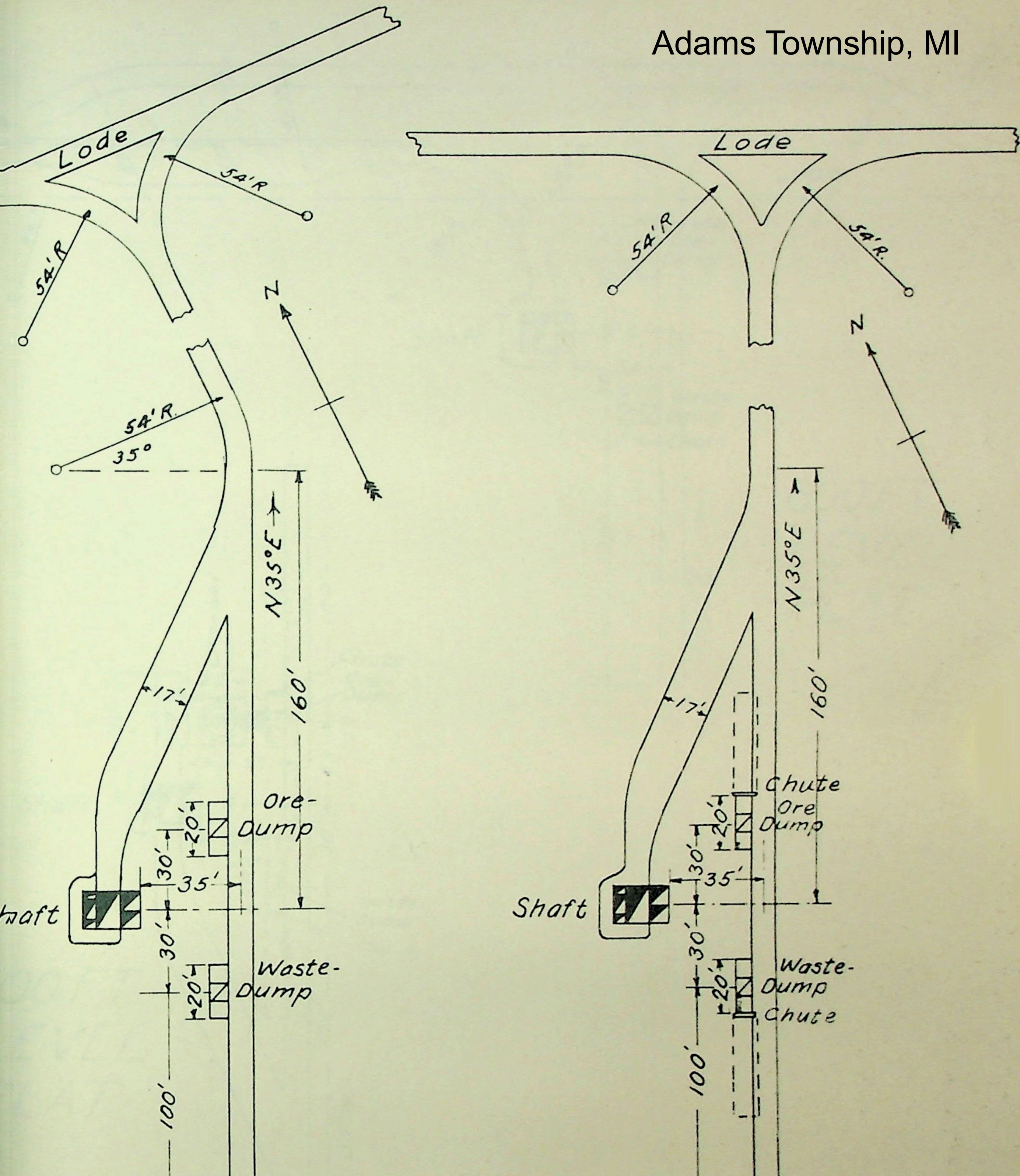
B= 36" Crusher
C= Chute
D= Dump
G= Grizzly
M= Motor
R_1= Waste-Pass
R_2= Ore-Pass
S= Shaft
OP= Ore Pocket
WP= Waste Pocket

WHITE PINE MINE 700 FT. LEVEL PLAT

SCALE: 1" = 20'

L.E.42

Adams Township, MI

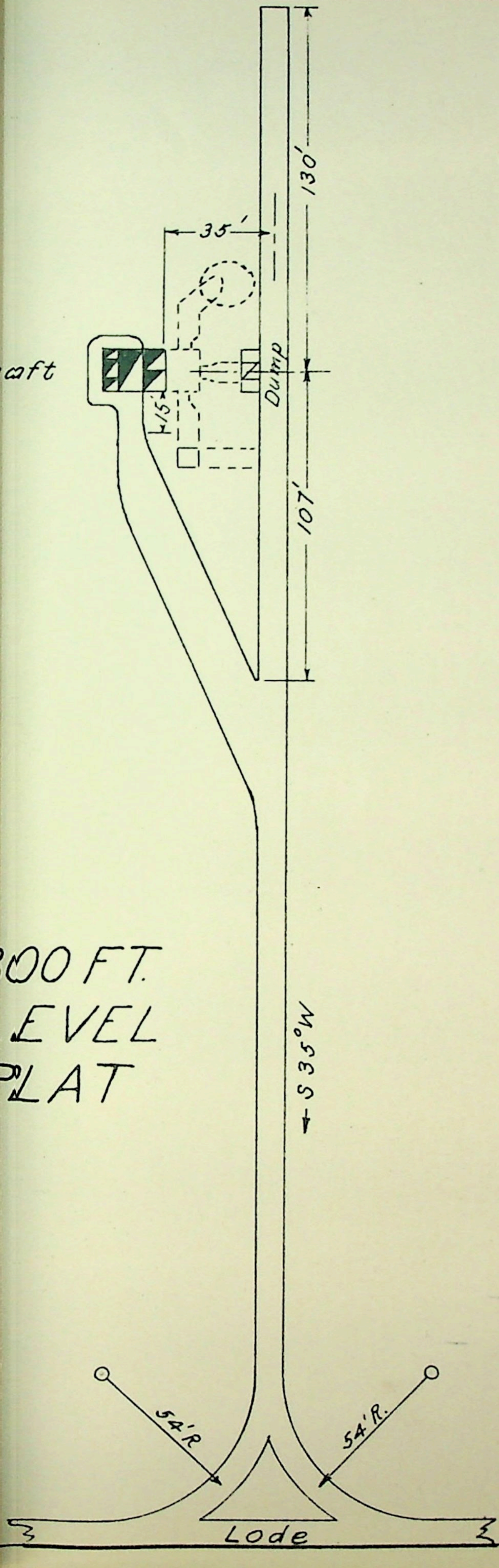


WHITE PINE MINE

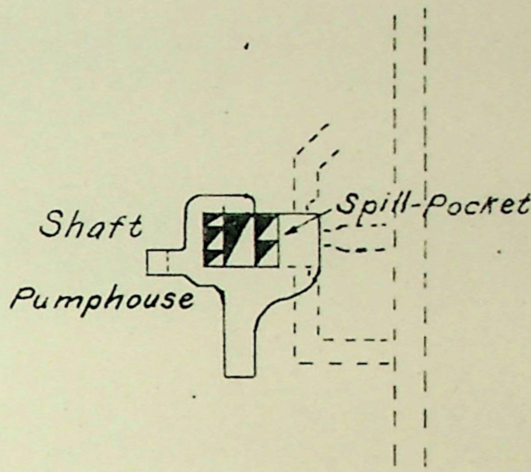
OO FT. LEVEL PLAT   500 FT. LEVEL PLAT

SCALE: 1" = 50'

Adams Township, MI



800 FT. LEVEL PLAT



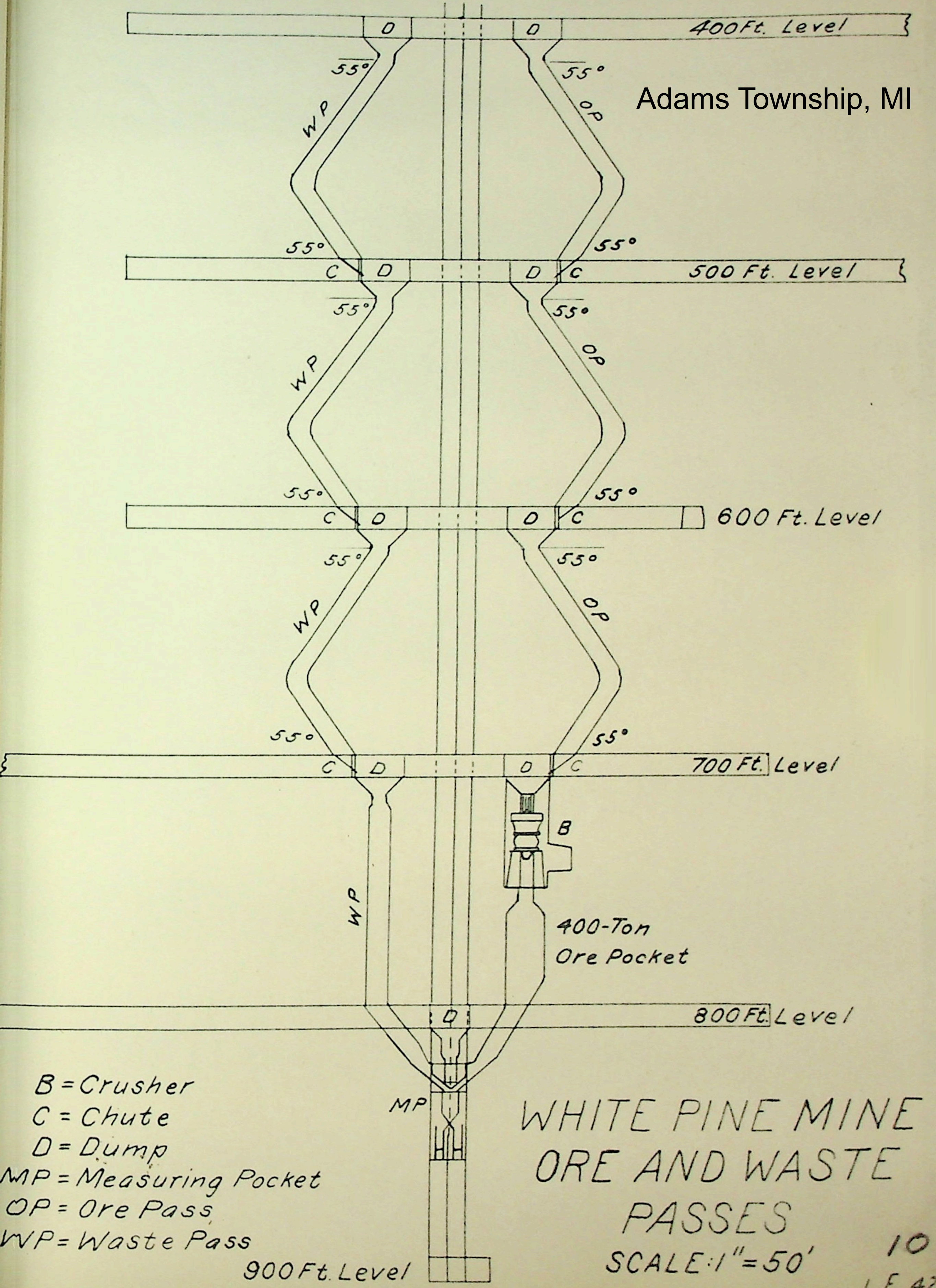
900 FT. LEVEL PLAT

WHITE PINE MINE

SCALE: 1"=50'

L.E. 42

Adams Township, MI

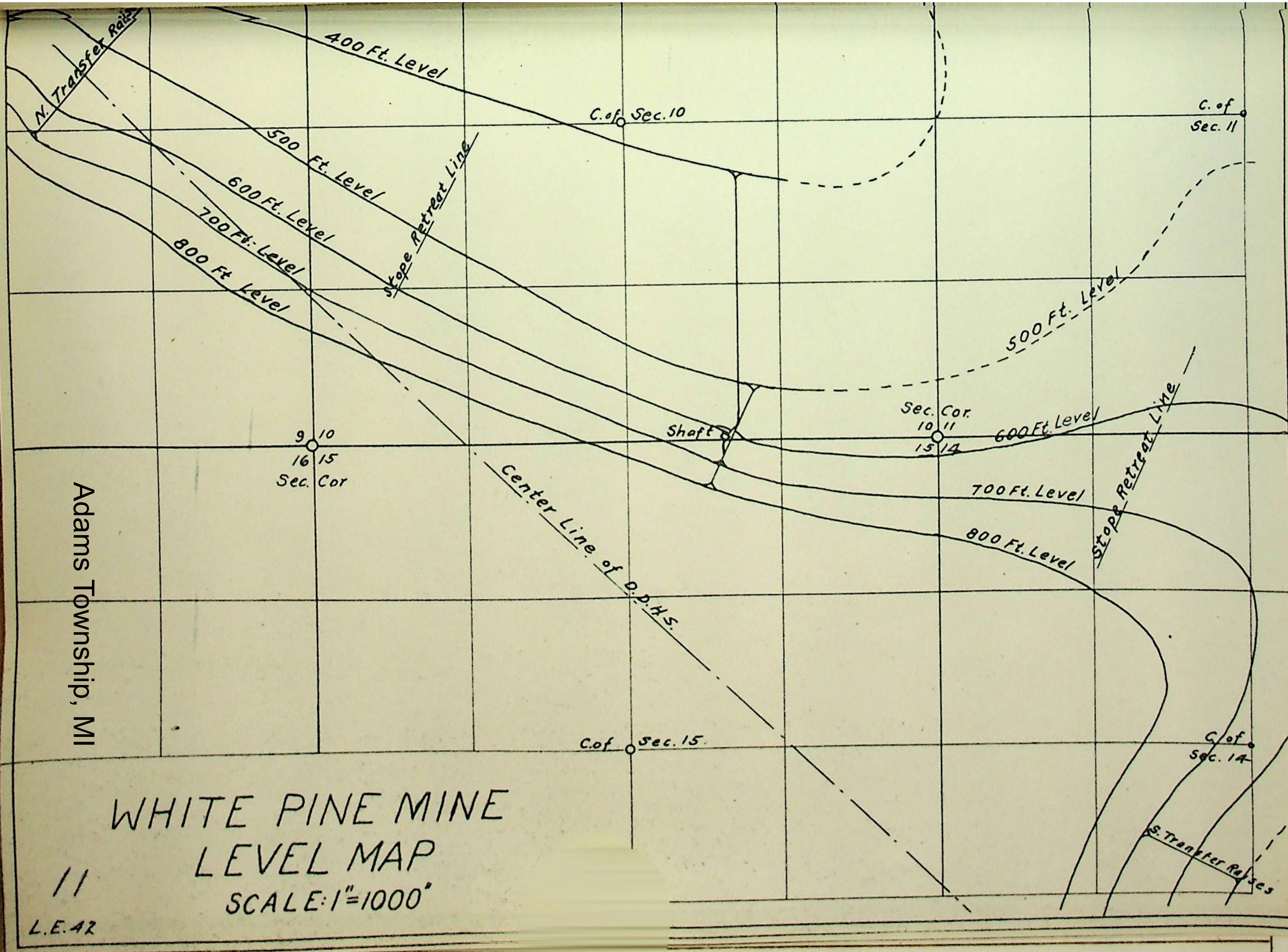


WHITE PINE MINE
ORE AND WASTE
PASSES

SCALE: 1" = 50'

10

L.E. 42



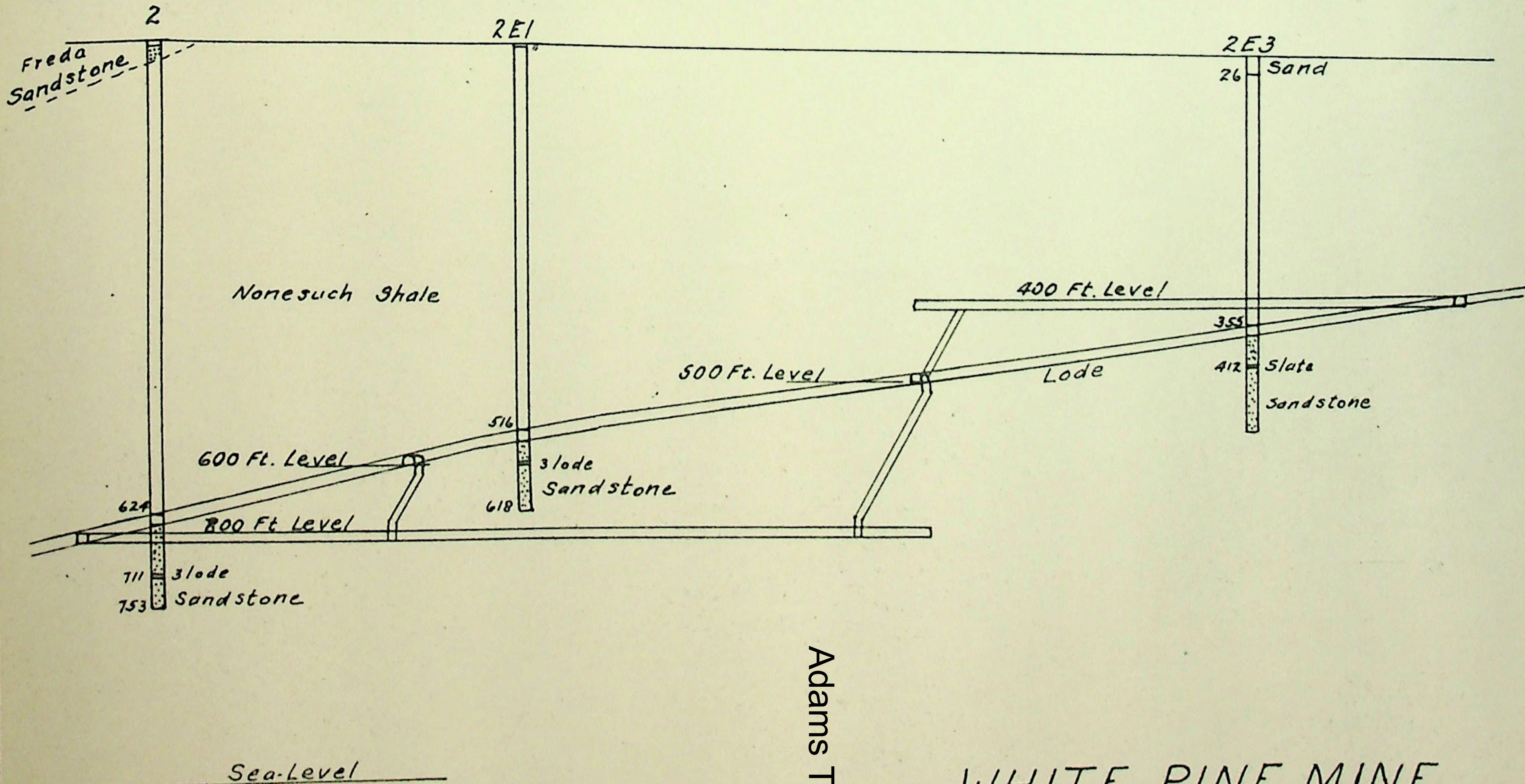
WHITE PINE MINE
LEVEL MAP

SCALE: 1" = 1000'

11

L.E. 42

Adams Township, MI



Adams Township, MI

WHITE PINE MINE

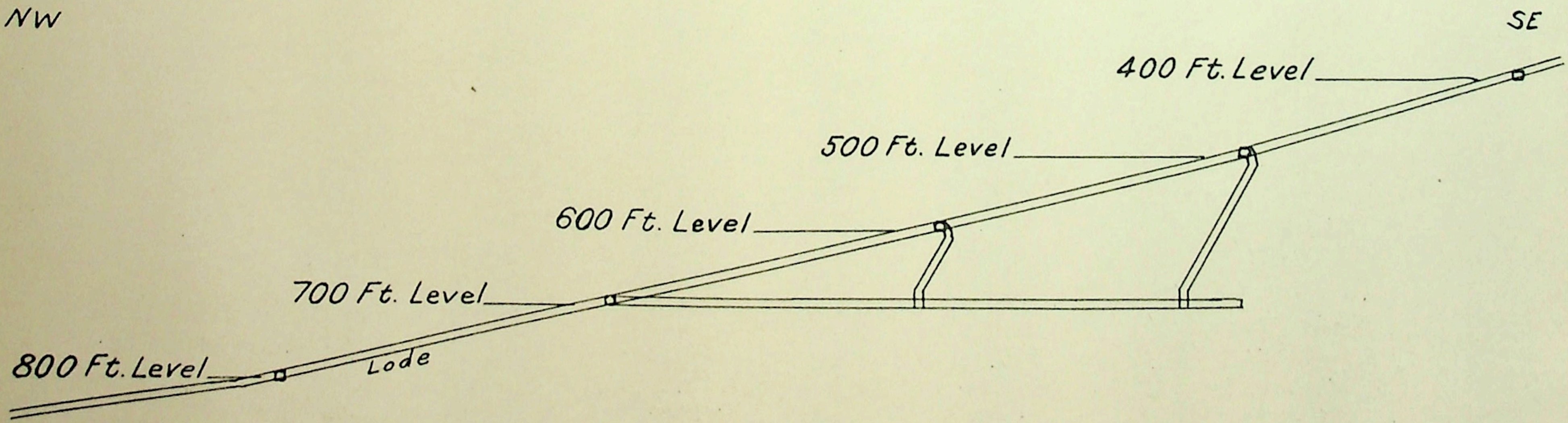
NORTH TRANSFER RAISES

ON LINE OF D.D.H. 2 & 2E1

SCALE: 1" = 200'

12

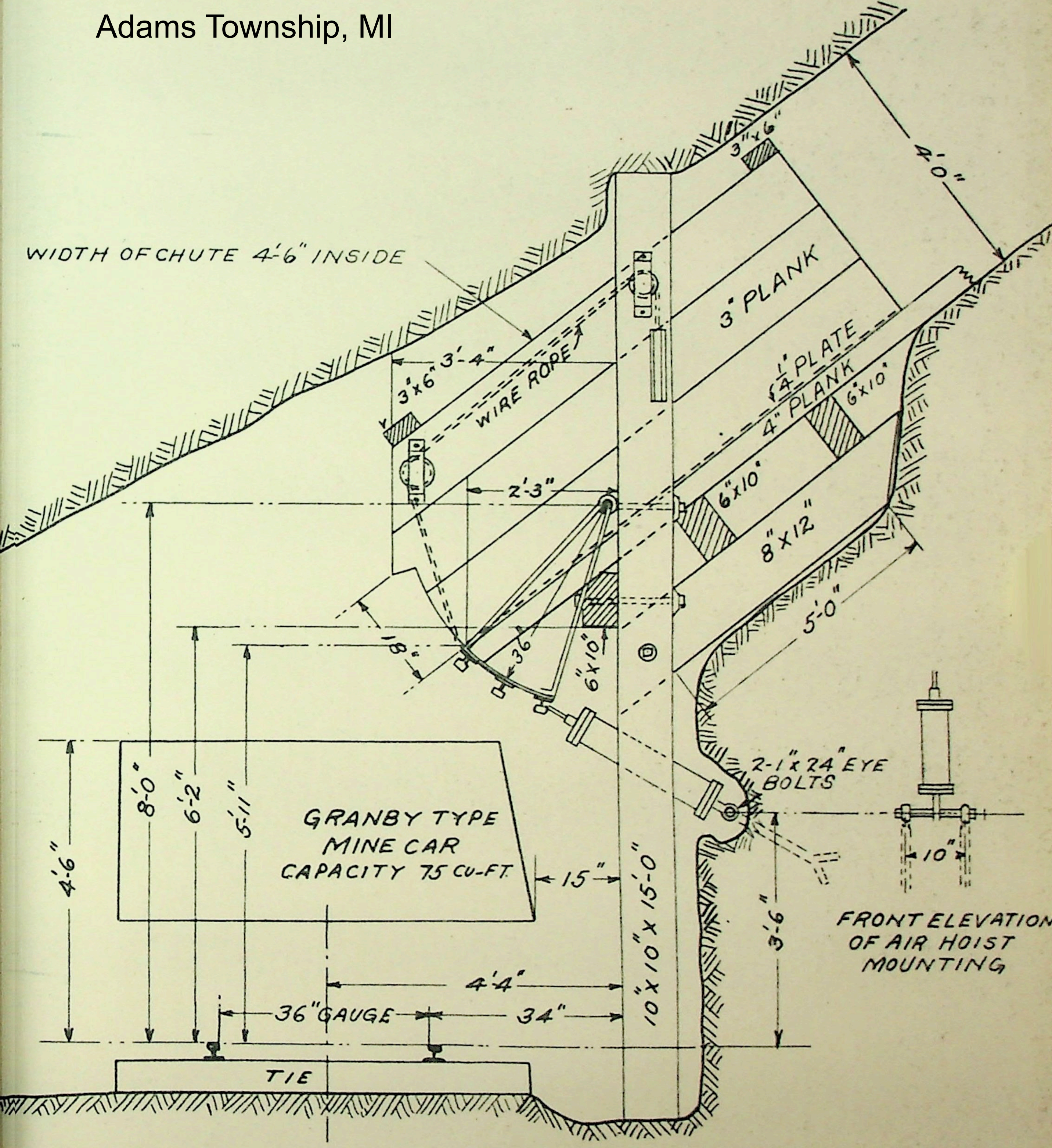
L.E. 42



WHITE PINE MINE
SOUTH TRANSFER RAISES
500 FT. N.E. OF D.D.H. 11E2
SCALE: 1" = 200'

L.E. 42

Adams Township, MI

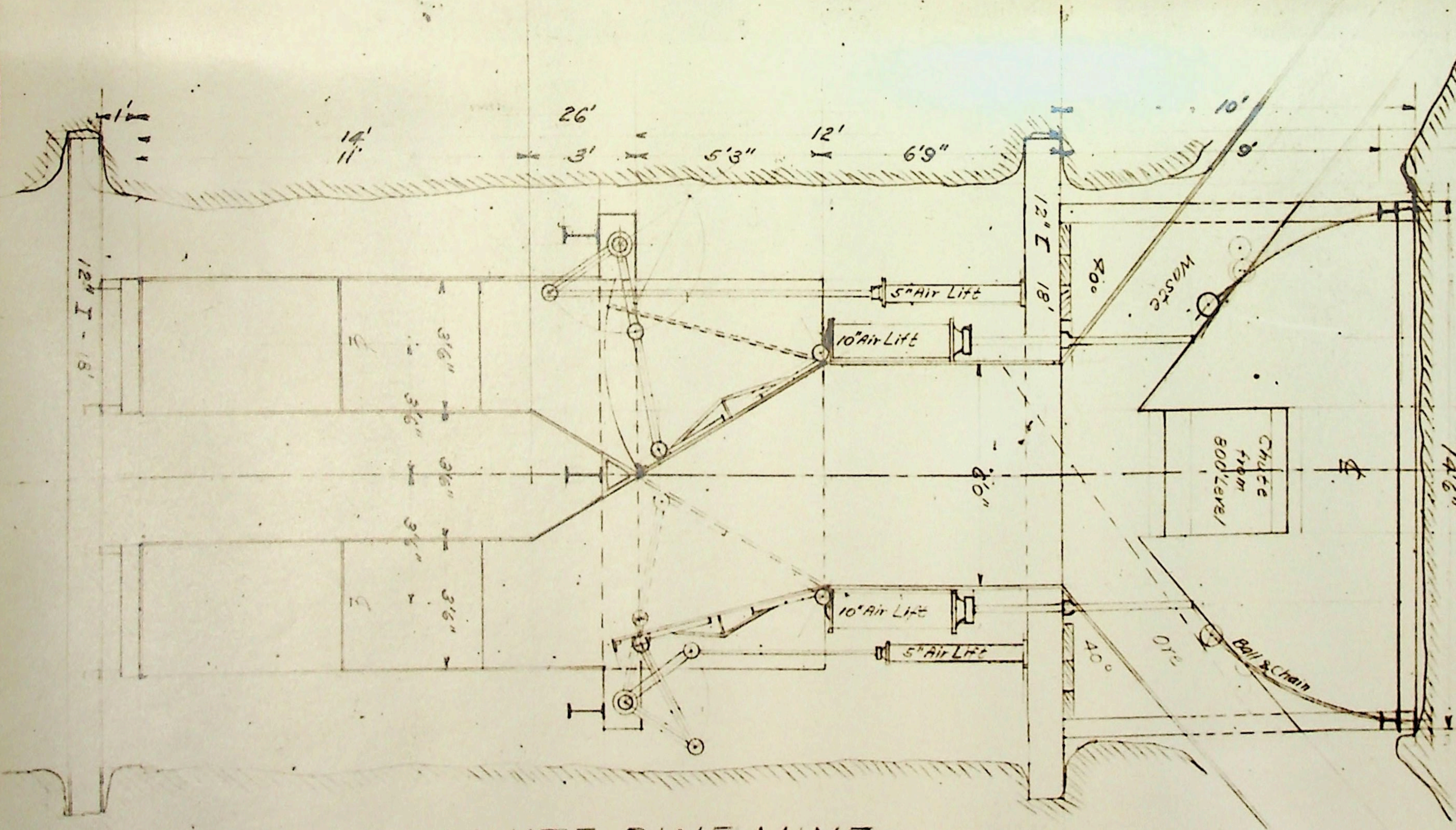


CHUTE
WITH
UNDERCUTTING ARC GATE
SCRUB OAKS MINE

SCALE: 1/2" = 1 FT.

14

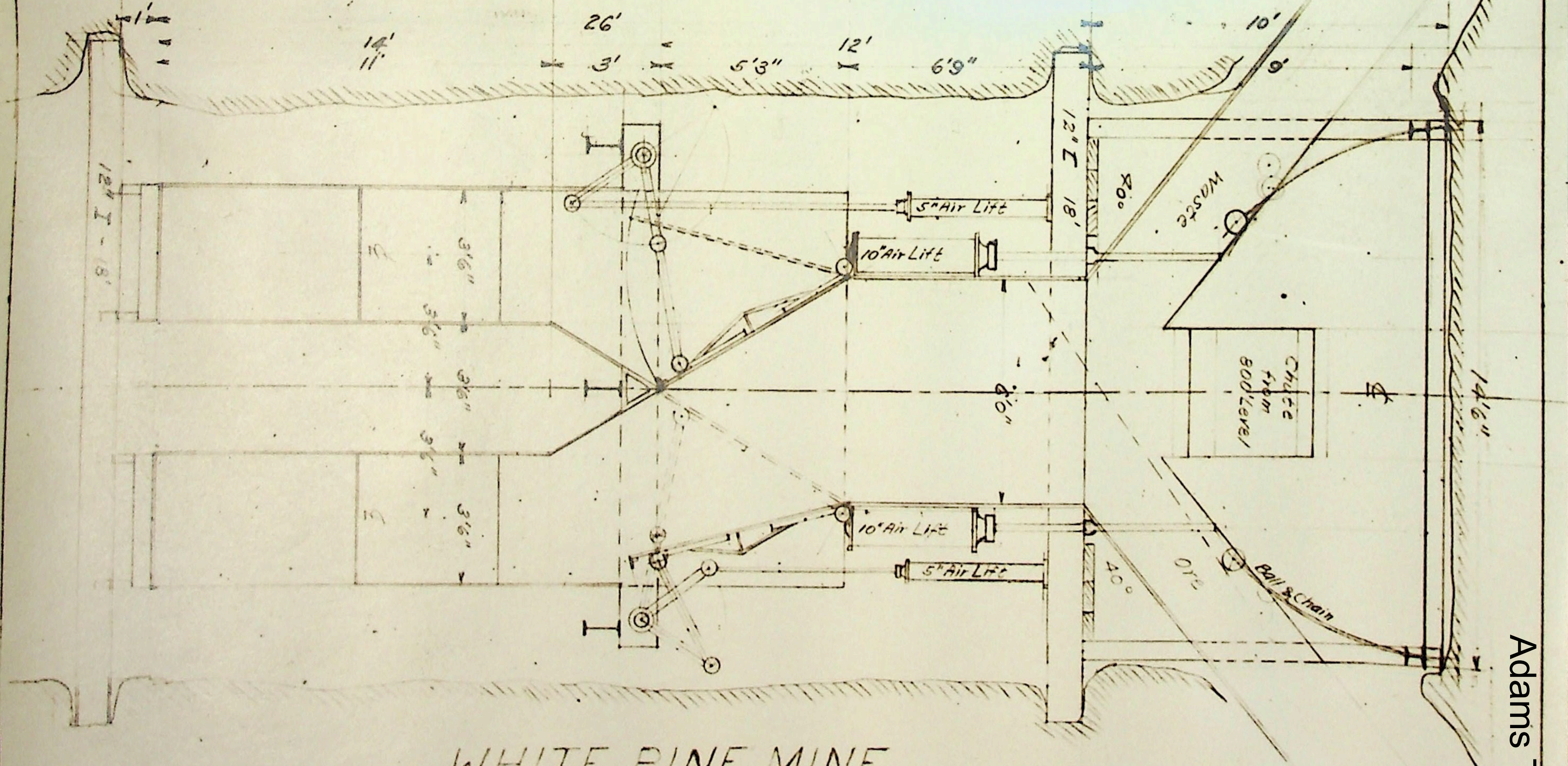
1932



WHITE PINE MINE
10-TON MEASURING POCKET

SCALE 1" = 4'

Adams Township, MI

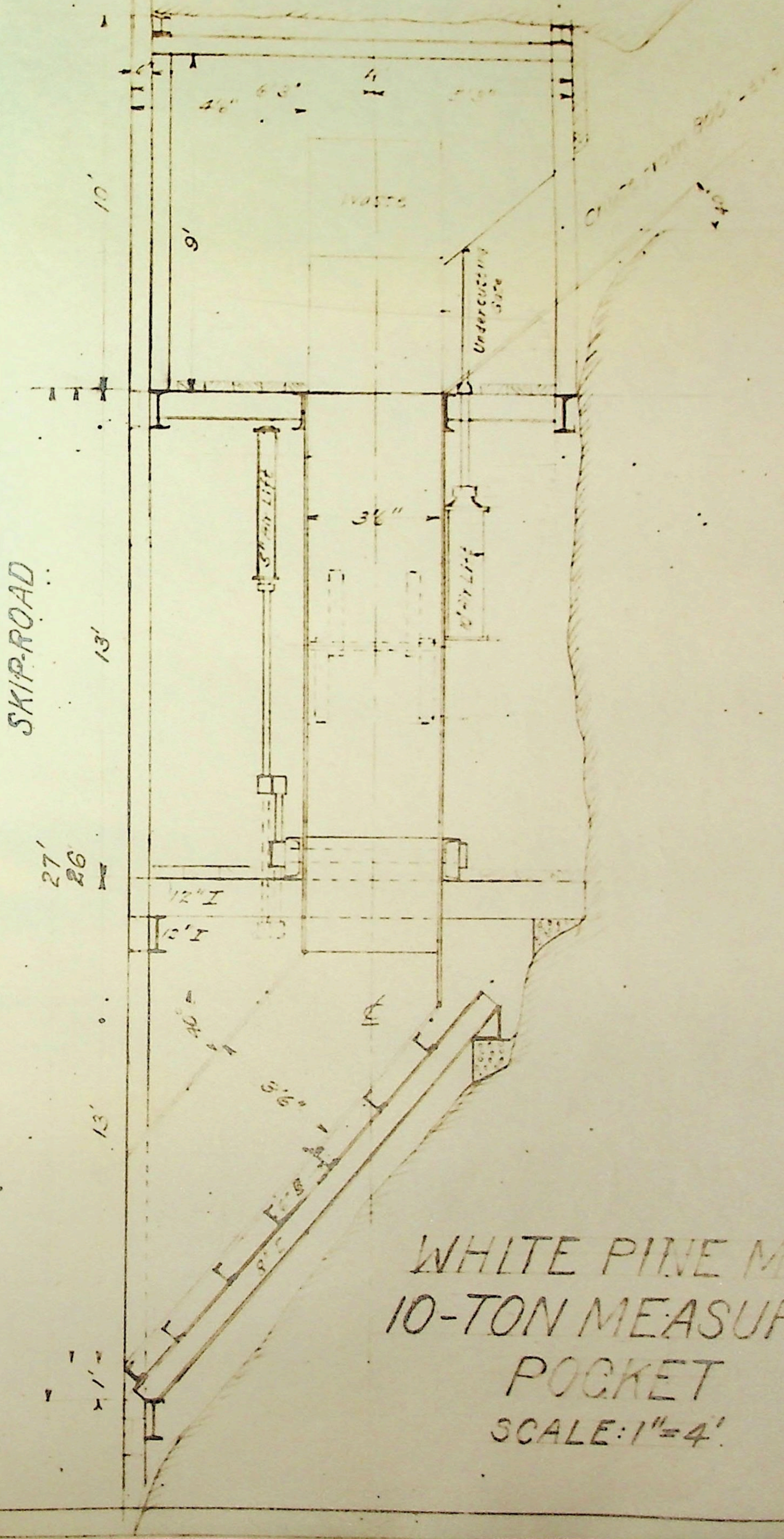


WHITE PINE MINE
10-TON MEASURING POCKET

SCALE 1"=4'

Adams Township, MI

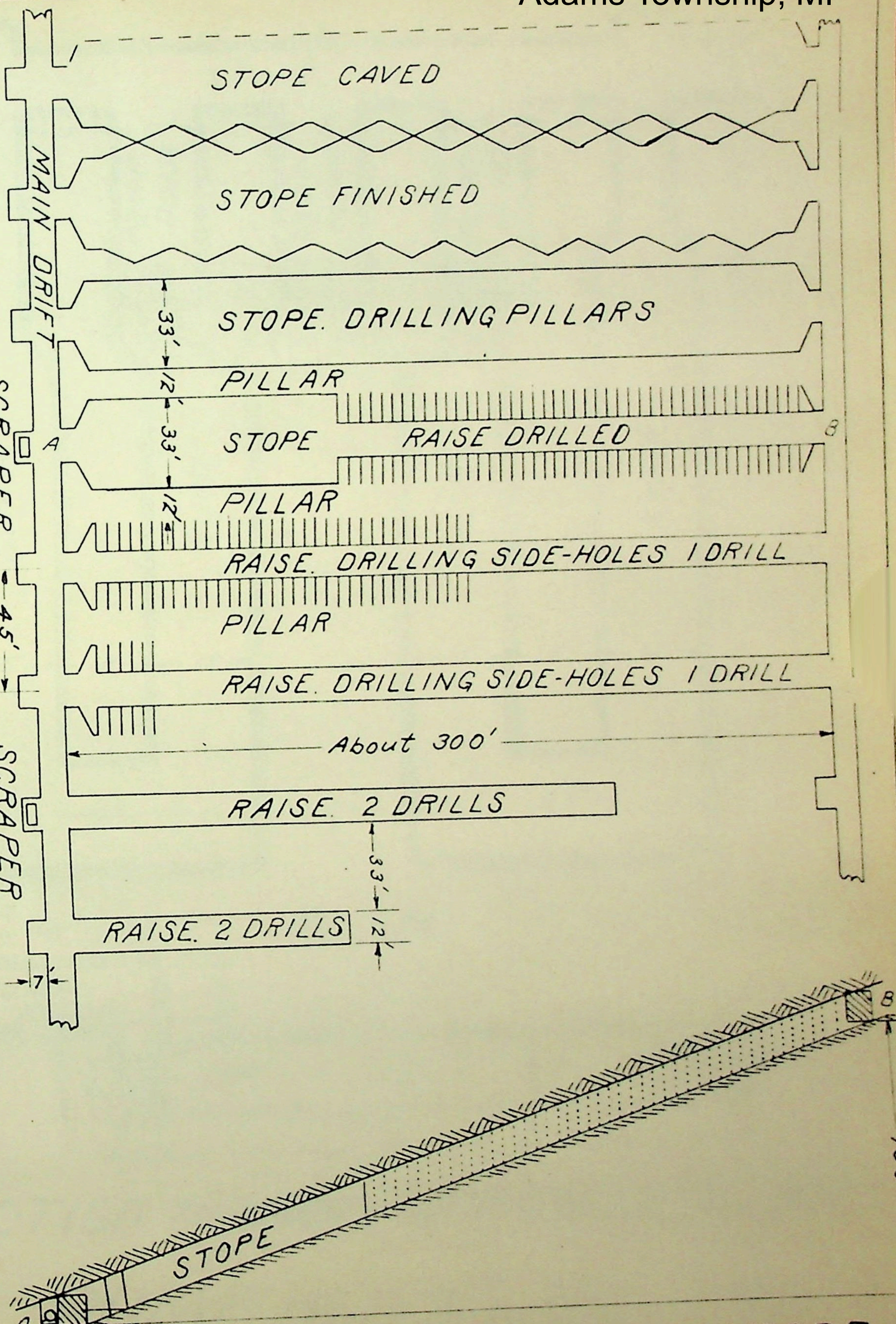
Adams Township, MI



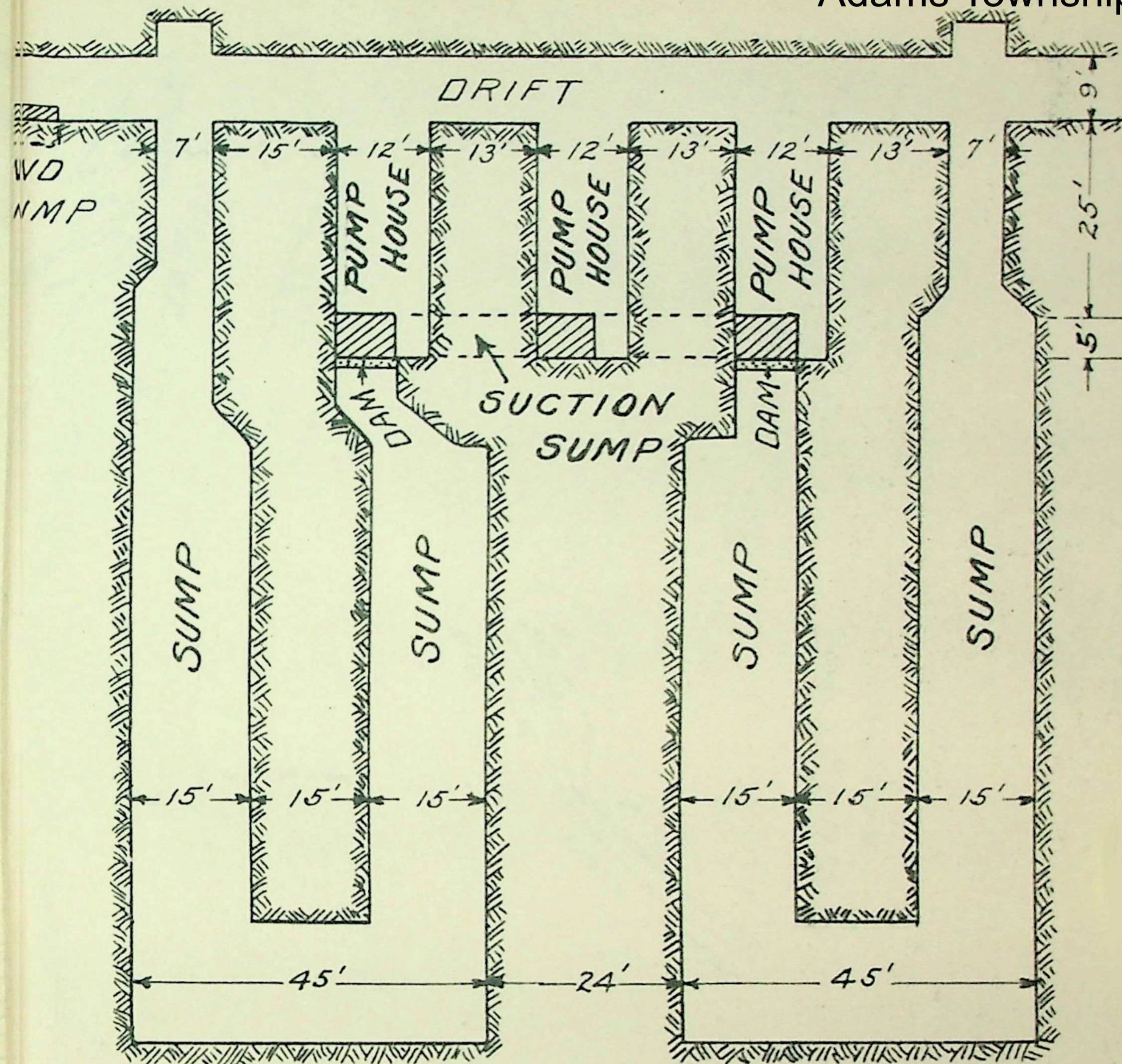
WHITE PINE MINE
10-TON MEASURING
POCKET
SCALE: 1"=4'

WHITE PINE MINE
MINING SYSTEM

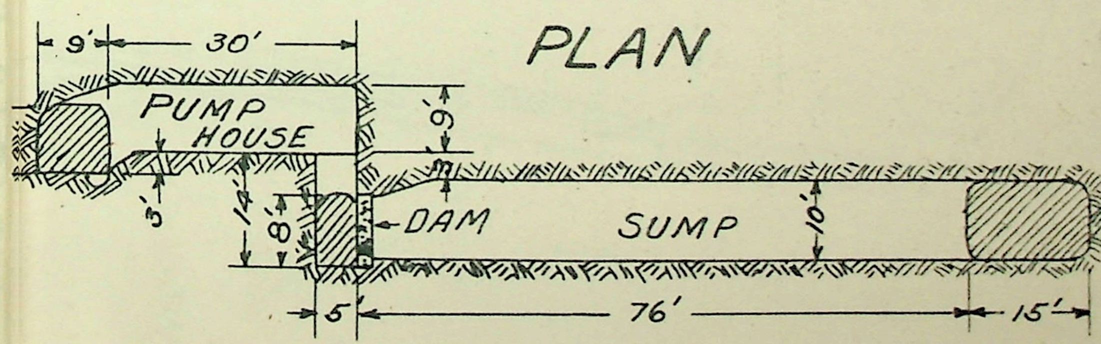
PLAN



SECTION THROUGH STOPE



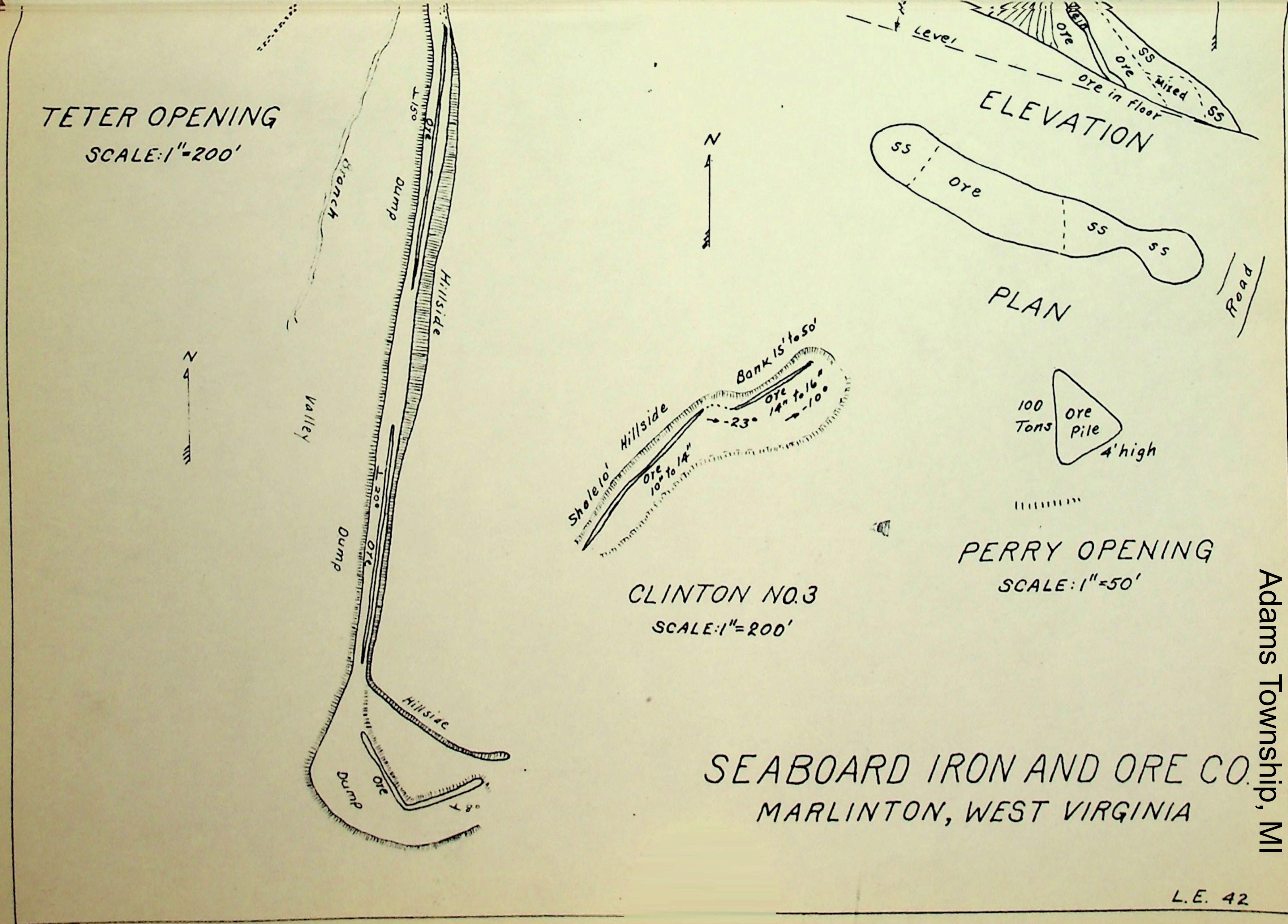
PLAN



SECTION THROUGH PUMP HOUSE & SUMP

PUMP HOUSES AND SUMPS

SCALE: $\frac{1}{250}$


TETER OPENING
SCALE: 1"=200'
Branch
Valley
Dump
Ore
Hillside
N
Dump
Ore
Hillside
Dump
Ore
CLINTON NO.3
SCALE: 1"=200'
Shale 10' Hillside
Ore 10" to 14"
-23°
Bank 15' to 50'
Ore 14" to 16"
-10°
Level
Ore
Ore
SS
Mixed
SS
Ore in floor
ELEVATION
SS
Ore
SS
SS
PLAN
Road
100 Tons
Ore Pile
4' high
PERRY OPENING
SCALE: 1"=50'
SEABOARD IRON AND ORE CO.
MARLINTON, WEST VIRGINIA
L.E. 42