APPENDIX A

JACK PARKER'S INTERIM REPORT DECEMBER, 2002

1. PURPOSE OF THIS REPORT: This is a response to a request by Michigan Dept of Transportation to evaluate the effects that an old gypsum mine beneath I-196 might have on the stability of that highway - in both near and long terms.

The request went to Michigan Technological University professor Stanley Vitton, Ph D. He enlisted me because I live near MTU, have worked in mines since 1946, here and abroad, and on mine stability problems in particular since 1955. One of my jobs, in the 1980's, was for Domtar in the mine in question.

2. BRIEF DESCRIPTION OF THE MINE. The mine operated for more than 100 years as Grand Rapids Gypsum, Domtar Industries, and finally as a Georgia-Pacific Gypsum, property, until 1999.

There are several sub-horizontal seams of gypsum. Most of the mining was done in #2 seam, until 1976. Additional mining was done in #4 and #5 after that - but not near the freeway I-196.

When the mine was closed in 1999 most of the files were lost or destroyed. At the beginning of this project, early in December 2002, Dr Vitton searched the remaining files at Grand Rapids and did find a few maps and reports of interest. He was also able to talk to two former employees - Mine Manager Charlie Johnson, Plant Manager Tom Mroczkowski, and is still attempting to contact engineer/geologist Wladyslaw Ochocinski.

Seam #2 varies in thickness but averages about 12 feet, of which a foot or so was left in the roof and a foot or two in the floor - so that mining height was somewhat less than 10 feet. The gypsum was left in roof and floor to minimize product contamination from shales, and to protect those shales from weathering.

A map of #2 level, believed to be complete and reasonably accurate, is attached to this report. We suspect that there may be minor survey discrepancies - tens of feet perhaps but not hundreds.

Large amounts of water began to enter the mine in 1964, and were pumped out continuously, but the pumps were shut down after mining ceased and the mine is now full of water. Entrances were inclined from surface but all of the mine workings are below the elevation of the nearby Grand River. It is unlikely that they will ever be seen again.

As you will see on the map, the mining layouts were changed often during the life of the mine, which often happens when new managements bring new ideas to a mine, but in general the mining technique is described as "room and pillar."

The rooms are rectangular tunnels, about 10 ft high and 20-30 ft wide, driven by drilling and blasting on a grid pattern, sometimes square, sometimes rectangular, sometimes parallelograms, sometimes random - to extract 60% or more of the area mined.

The "pillars" are the blocks of gypsum left in place between the rooms to support the roof and all of the rock and dirt above it. As the map shows, size and shape vary a lot, but the least width (which controls the strength) is generally around 20 ft, i.e., 2x height.

In some places the dimensions of the pillars were reduced by blasting to recover more of the ore, and in some places the remnants collapsed, allowing the overlying surface to subside.

In other places very large blocks were left unmined because the quality of the gypsum there was inadequate. Those places, of course, will never collapse. Obviously the weight of the overburden is not evenly distributed.

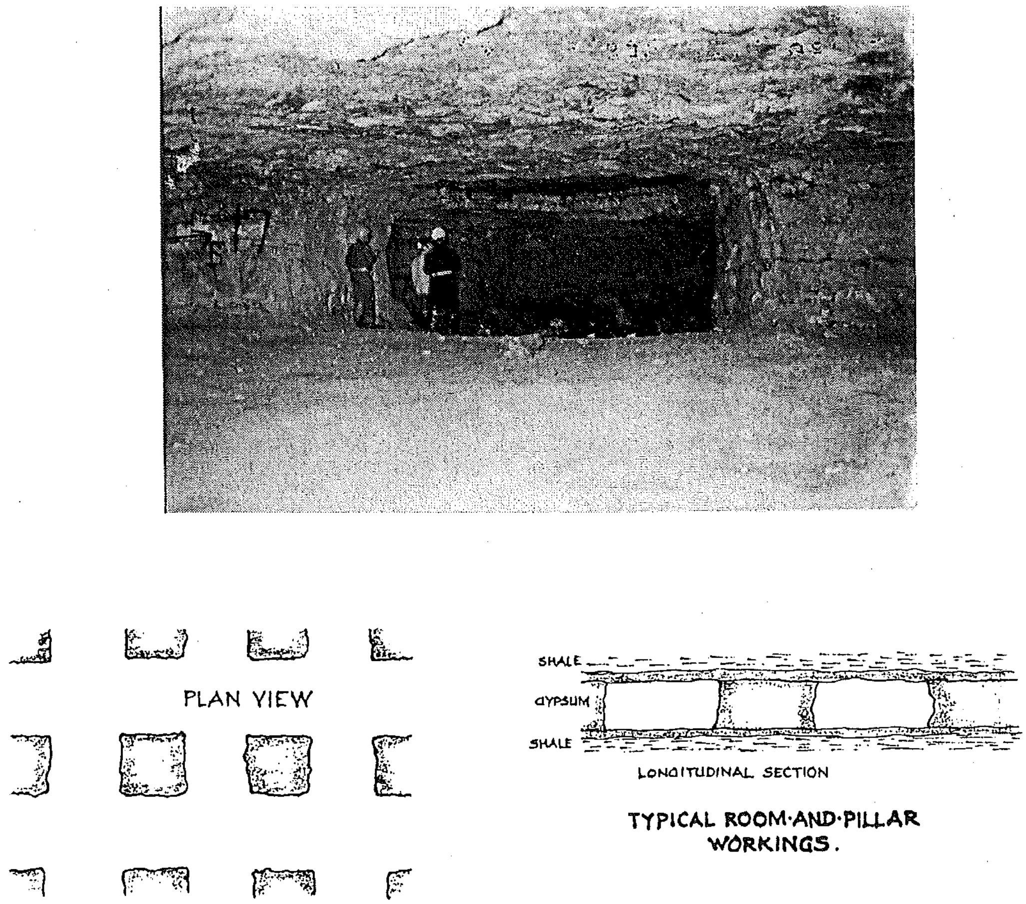

Figure 1. Photograph and illustration of room and pillar workings of the number 2 seam.

3. FREEWAY CONSTRUCTION. The freeway, as shown on the map at the end of the report, was completed in 1964, finished with 9" of concrete. In this stretch it has never been replaced and no structural damage has been reported with the exception of typical or normal distresses associated with concrete of this age.

We found an old map on which was a note saying that the workings on the east side of the mine, over which part of the freeway was built, were mined "probably before 1945." Signed "Mark."

4. RELATIONSHIPS BETWEEN UNDERGROUND FAILURES AND SURFACE STABILITY. We will discuss this in some detail because a clear understanding is essential if we are to reach useful conclusions and recommendations.

In normal underground mining, where the objective is to recover as much of the ore as possible, safely, but at minimum cost, a few roof failures are expected, and acceptable - provided that men and equipment are not involved. A few chunks or slabs, even a foot or two, may fall from the roof, and they would be cleaned up or bypassed. If necessary artificial supports were added. Such falls would not be marked on the map - and they would not affect the surface.

In areas where pillar dimensions are reduced by "robbing" a complete collapse is expected, the remnants will crush and spread out and the surface will subside. The amount of surface subsidence will depend largely on the overlying geology:

If most of it is rock and the thickness is not great (say 40 ft or less) subsidence may be as much as 70% of mined height -7 or 8 feet.

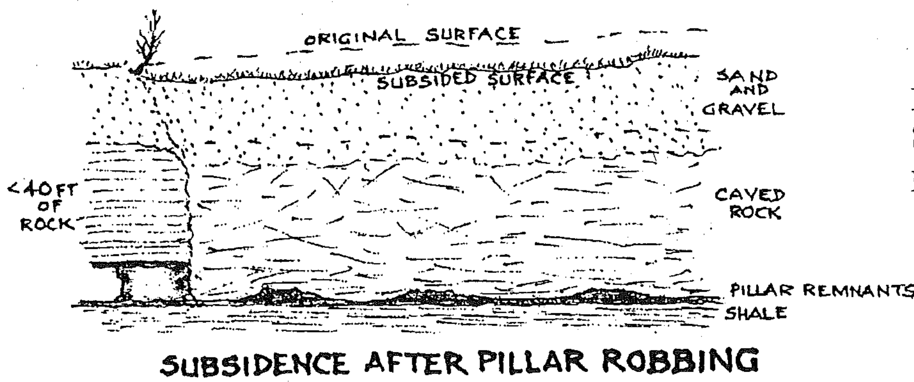

Figure 2. Subsidence after pillar removal.

If most of it is rock but it is thicker - the rock will "swell", i.e., fall in a jumbled state, taking up more space - then the amount of subsidence will be less, say 40%, or 4 ft.

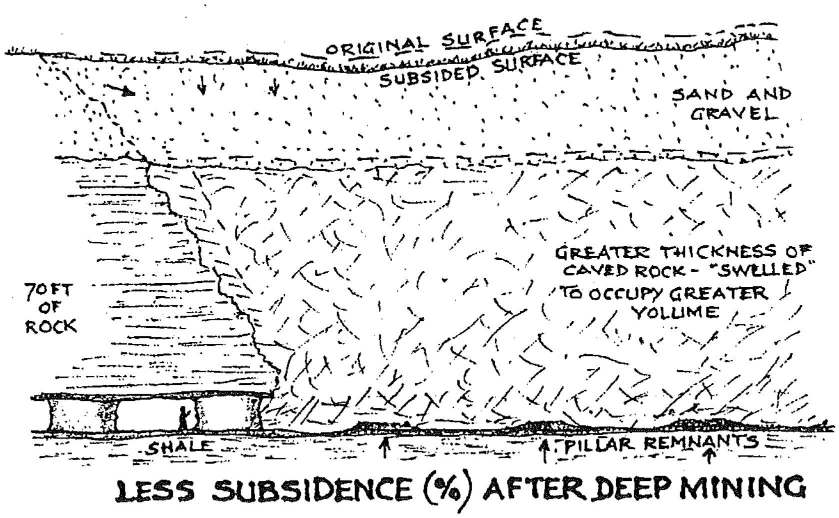

Figure 3. Less subsidence after pillar removal.

Adjacent to these falls some rock and much of the adjacent soil, sand and gravel will slump sideways into the subsidence basin, as shown in the above sketches. Thus there will be some subsidence beyond the limits of the underground collapse.

Thick sand and gravel will flow, or slump, especially when wet, so the basin may be broad and the limits may be indistinct.

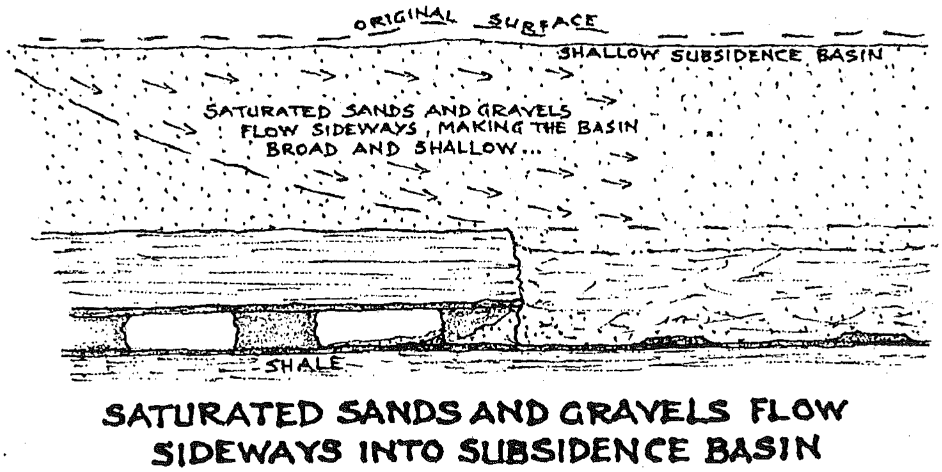

Figure 4. Subsidence with material flowing into openings.

Roof failures behave differently.

A small failure at shallow depth, say an intersection of two mine openings, may develop a natural arch or may go up to a stable roof horizon (such as the #1 gypsum above #2).

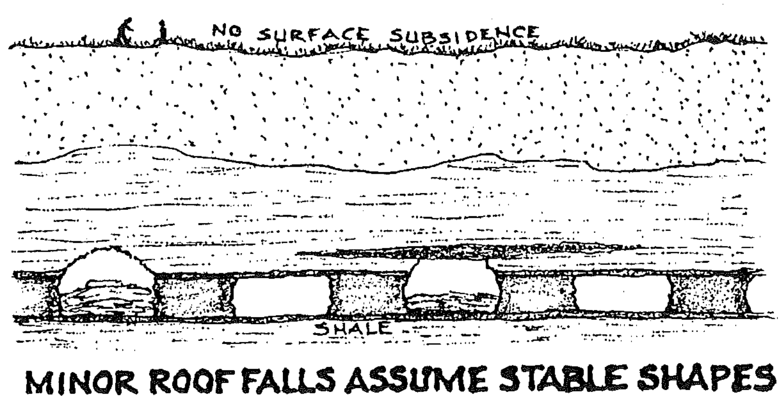

Figure 5. Minor roof falls assume stable conditions.

Several such failures may coalesce and go on up to top of bedrock, the base of sand and gravel. The fallen rock will partly fill the void but sand and gravel may fall in too, creating a well-defined "sinkhole" at surface.

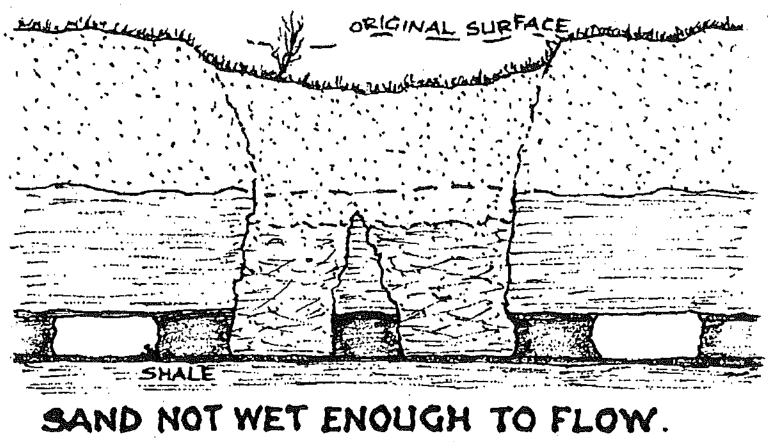

Figure 6. Roof collapse without material flow.

In loess soils and sands which is damp and cohesive, the sinkhole may have steep sides, like a chimney, whereas if it is saturated with water it may flow into the mine like liquid mud, and spread over wide areas, leaving a wide, shallow basin at surface.

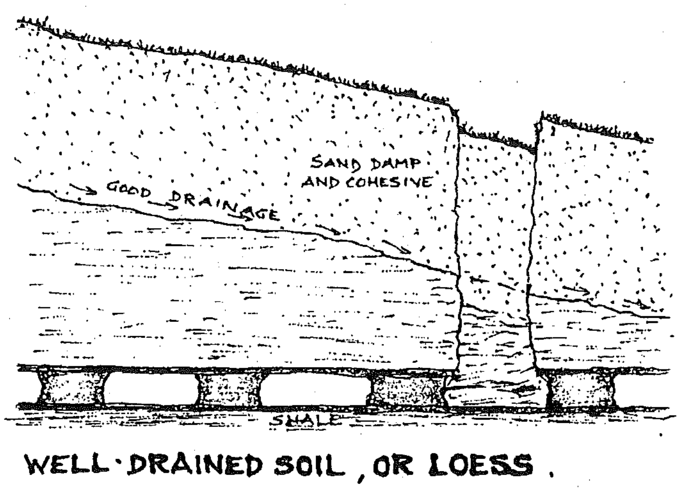

Figure 7. Development of well-defined sinkhole.

Many sinkholes have been mapped on the property, and above neighboring mines, mostly in the southern halves of the properties - where the cover is, in general, thinnest.

5. HOW DOES ALL THIS RELATE TO I-196? The relationships are debatable. Surely some day gravity will prevail and all mine openings will close - but when?

Some parts have already collapsed, we know, and for present purposes that is good. We don't have to worry about them.

Most of the mine openings stand open for tens of years, ensuring safe access and ventilation. They were designed that way, not by the textbook perhaps, but based on long experience - which is better.

Similarly the pillars were dimensioned to last for tens of years (at least until the manager responsible retires). Thirty years is a common goal.

But then what? For an answer let us look into the probable modes of failure.

Blast damage is a significant factor. High explosives in small-diameter holes not only break out the ore - they also fracture the rock, to some degree, to a depth of about 30 hole diameters into roof, pillars and floor. Thirty times 2" equals 5 ft - which would reduce a 20x20 pillar to an effective 10 x 10 ... And although the fractures may be microscopic they allow air and moisture to penetrate those members, slowly but surely, and eventually destroy them.

The thin shaley seams within the gypsum soften and yield and ooze, lubricating the joints and allowing the beds and blocks of gypsum to come apart. The measured strength of wet gypsum is about half the dry strength.

In roof and floor moisture softens shales, some to the consistency of toothpaste. That makes both roof and floor incompetent, pillars push into them, they heave into mine openings - and the system closes. It might happen suddenly, with a domino effect, in some places, but in general the movement can be almost imperceptible. In some similar mines, not flooded, it is possible to walk into old workings, with headroom, notice that the roof is getting lower, bump heads, tilt heads, stoop, support on fingertips - apelike, then kneel, crawl - and give up - with no alarming noises or actual rock falls ...

There will be some dissolution of the gypsum (which is why we get caverns and natural sinkholes) but for the most part that requires running water. Stagnant water, with no pumping, becomes saturated with gypsum then dissolution ceases.

6. SO WHAT DO WE THINK? Our tentative conclusions are that the mine openings must someday close and allow the surface to subside, including parts of the freeway - but that some of the subsidence has already occurred, unnoticed.

Some could have occurred in the years between mining (pre-1945) and construction (1964) - around 20 years, but we do not know. Not yet.

We have procured some topo maps, dated 1984 and 1997, and a very cursory comparison suggests that parts of the freeway, at the Fulton interchange, subsided a couple of feet during that interval, and the only indication we have heard of is that one concrete slab in that area "seems to be tilted . . ." To the west of the freeway the maps appear to show as much as 6 ft of subsidence in places during that 13-year period.

A map of compared contours, Figure 8, appears at the end of this report.

The mining layout in that area, the northeast corner of the mine, is unusual. To us it looks as if it was done with coal-mining equipment, using a coal-mining layout, with rather random formation of pillars followed by slicing up those pillars with diagonal tunnels ... It looks like - and probably was - the "last hurrah" for this part of the mine, gobbling up as much as possible as quickly as possible, to move into better ground further west. We think that this area would have started to fail not long after mining.

The geology here is also noteworthy. An exploration hole (1963-2) was drilled from surface about 150 ft west of the freeway (see map) and went through 100 feet of sand and gravel but only 7 feet of rock before entering seam #2 - so apparently there was an extremely thin roof beam above the rooms and pillars and a heavy dead load on that beam - two sufficient reasons for hasty mining and departure.

That viewpoint is supported by a note on another old map, on a tract just east of the freeway, listing tons of gypsum reserves "If roof rock is present".

One more comment: the northeast corner is the lowest part of the mine, thus the first to get flooded.

Now we need to know if the tentative conclusions are correct, how much of the area under the ROW has indeed subsided, and by how much.

7. RECOMMENDATIONS.

a) That MDOT survey elevations along the freeway from Butterworth to Fulton to see how much change there has been since construction, and since the 1997 survey, and survey some E-W profiles if the changes are significant.

b) That we procure several sets of topographic maps of different ages, all on the same scale, and superimpose them to arrive at contours of subsidence for the various time intervals, and contours of total subsidence, then relate them to the rooms and pillars on the mine maps.

We would need new, clear copies of the Abrams 1984/Domtar map, the Kent County REGIS 1997 map, USGS 1967 maps - and any others we can find. Perhaps we can get help from Uncle Sam and his satellites. If the maps were digitized the subsidence contours could be generated by computer.

c) If some doubts remain concerning the presence of voids beneath the ROW, we should have a local contractor drill half a dozen exploration holes down through the mining horizon.

d) If subsidence contour maps suggest that subsidence is continuing at significant rates, and that the surface has a long way to go, and that pillars are small in such areas - we may have to consider introducing some kind of inert mineral backfill, maybe sand, maybe flyash, into those parts of the mine - but we doubt it. Given a fair cushion of unconsolidated sand and gravel above the mine it seems that the concrete roadway can "float" around and subside without much distress - just as houses on slabs survive better in earthquake zones than do those on deep and rigid foundations.

A possible exception to that rule may apply at the boundary of the mine, where there could be, underground, perhaps 10 ft of closure in rooms immediately adjacent to a solid abutment with zero closure - maybe a difference abrupt enough to disrupt the surface.

Jack Parker
MO RG 0088

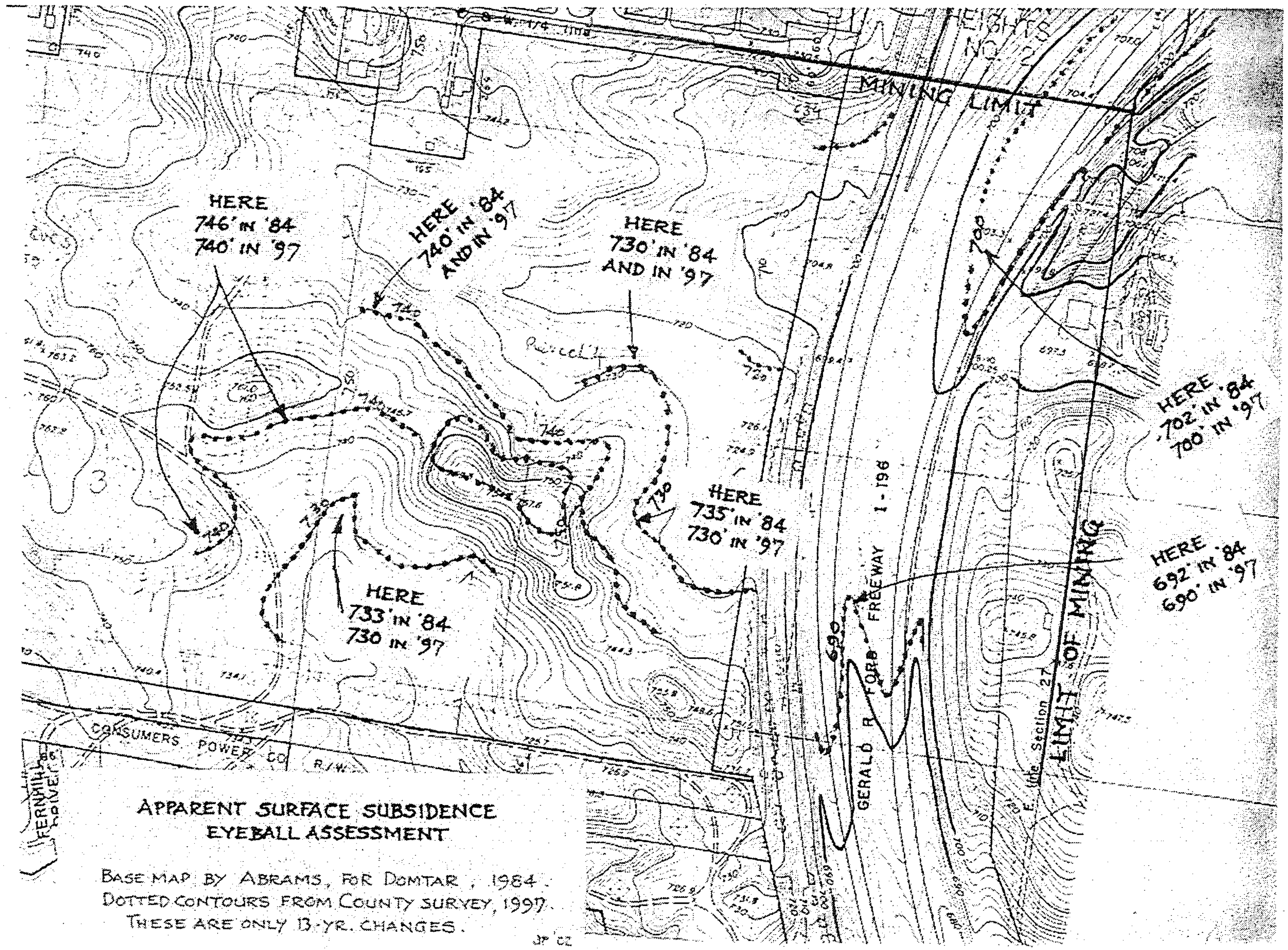

Figure 8. Comparison of elevations from 1984 to 1997.

APPENDIX B

UPDATED KENT COUNTY GEOLOGIC STABILITY STUDY FOR THE JOHN BALL ZOOLOGICAL GARDEN EXPANSION WEST OF I-196

BY
STAN VITTON
SEPTEMBER, 2002

FINAL REPORT

SUBMITTED TO

Steven E. Williams, P.E.
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Investigation of the Surface Stability Above the Former Domtar Industries, Inc. Gypsum Mine Located in Grand Rapids, Michigan

Prepared by
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Submitted: *September 18, 2002*
Updated: *February 27, 2004*

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INTRODUCTION

"...miners should leave numerous arches under the mountains which need support..."
Georgius Agricola, 1550

Purpose and Scope

The John Ball Zoological Gardens (Zoo) located in Grand Rapids, Michigan, is considering expanding its operations to property adjacent to the existing Zoo property. The potential expansion site lies west of the current zoo location across Interstate I-196 and lays directly over a portion of the former Domtar Industries, Inc. (Domtar) gypsum mine. As with most underground mines, the stability of the remaining mine structure is important for surface development. Consequently, a request was made by Kent County officials to provide an evaluation of the stability of the general area to determine the suitability of the site for surface development activities. The purpose of this report, therefore, is to provide an evaluation of the stability of the underground gypsum located under the property being considered for the Zoo expansion. The following three issues outline the scope of the evaluation:

1. Characterization of the geologic stability of the site - now and in the future.
2. Describe measures taken by others (e.g. MDOT and CMS) to characterize stability and what measures were taken, if any, to address this issue.
3. Is the site, as it currently exists, or a portion of it, suitable (geotechnically) for construction of a Zoo?

Location

The proposed Zoo expansion site is located in the south half of Section 27 of Township 7 North, Range 12 West. Excluded from this area is the NE 1/4 of the SW 1/4 of Section 27 and to the western boundary of the former Domtar mine properties, which is approximately the west 250 feet of the SW 1/4 of Section 27. Geographically, the proposed site is bordered to the east by Interstate I-196, to the south by O'Brien Street and to the west by Portfliet Creek. A CMS Energy (Consumers Energy Company) high voltage power line also transects the site, roughly separating the site into northern and southern sections. Figure 1 shows the location of the proposed site along with the outline of the Domtar mine as well as an adjacent Georgia Pacific (GP) Company mine (Butterworth Mine), immediately west of the Domtar mine.

Area Geology

The bedrock in the Grand Rapids area is the Michigan Formation, a Mississippian age sedimentary rock formation well known in the Michigan Basin for its evaporite layers consisting of salt, anhydrite and gypsum. The gypsum evaporites are mined in various locations in the Lower Peninsula of Michigan. However, shale is the dominant rock type in the Michigan Formation with interlayers of sandstone and to a lesser degree carbonates and evaporites. The formation is overlain by unconsolidated glacial overburden consisting of gravel, sand and clay. Directly below the Michigan Formation is the Marshall Sandstone. Figure 2, adapted from a Williams and Works report of 1984 for Domtar on water infiltration to the mine shows the average thickness, elevation and characteristics of the subsurface formations. Significant geologic features of this site are as follows:

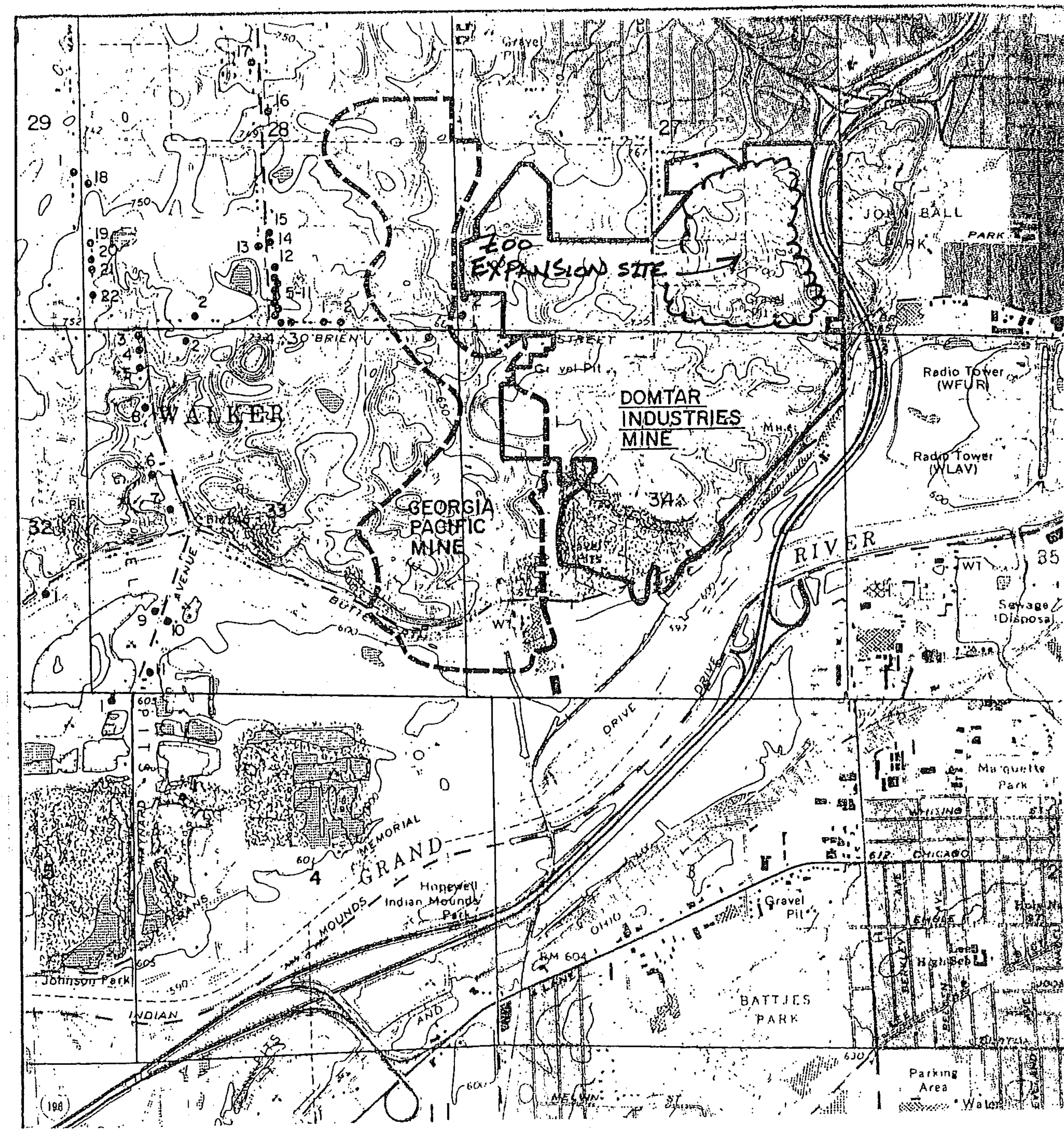

Figure 1. Location map of the proposed John Ball Zoological Gardens expansion site, the Domtar Mine, and the Georgia Pacific (Butterworth Mine).

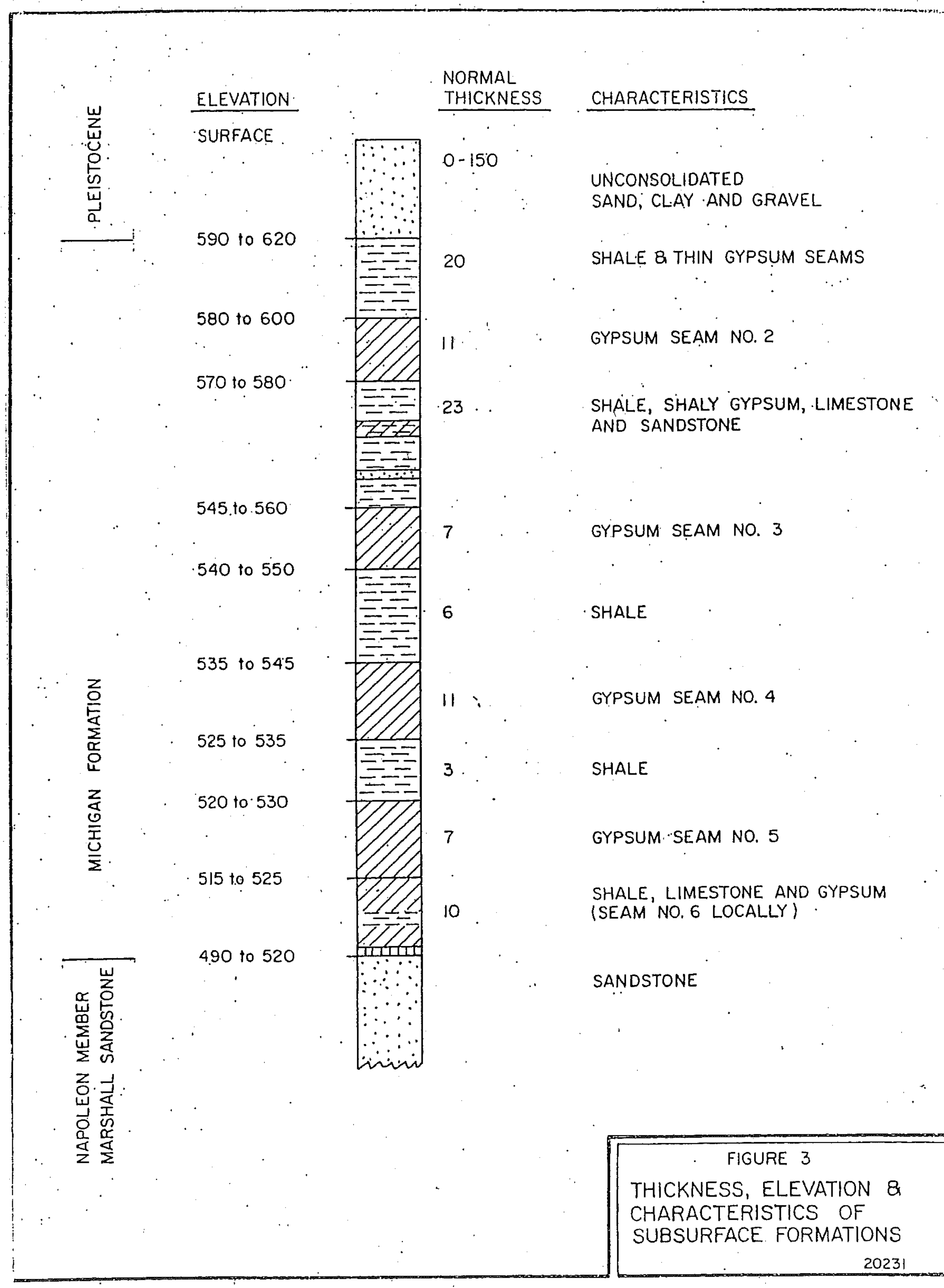

Figure 2 Thickness, elevation and characteristics of the subsurface formations at the Domtar Mine.

Feature 1: The glacial overburden varies from zero to 150 feet in thickness over the Domtar mine. While the unconsolidated soil consists of some clays and silts, the glacial overburden provides the main source of water that infiltrates the mine. Due to the unconsolidated nature of the overburden, it can be assumed that its full weight or pressure is applied to the roof rock of the mine and that its effective pressure will vary with the rise and fall of the water table level, which is located within the overburden. By most mining standards, this is a relatively shallow mine and the pressures will probably not exceed 140 pounds per square inch (psi), assuming a fully saturated overburden at 135 lbs/ft^3.

Feature 2: There are six gypsum layers associated with the mine with the upper layer identified as # 1 down to lowest layer # 6. Figure 2 does not show the # 1 seam, but labels it as shale and thin gypsum seams, with the remaining seams numbered.

Feature 3: The majority of the gypsum was mined from the #2 seam, Later the # 4 seam and limited amounts of the #5 seam were mined. According to the 1984 Williams and Works report the #3 gypsum seam was not mined. Also, mine records indicate that the recoverable #2 seam was mined out by 1980 when the mine temporarily closed down. The #2 seam had the highest quality of gypsum of all of the gypsum seams.

Feature 4: The bedrock between the unconsolidated overburden and the #2 seam forms the roof rock over the #2 seam. As shown in Figure 2, the average thickness of the roof rock is about 20 feet. However, five drill holes from a 1963 drilling program indicate that the roof rock thickness varies from a high of 35 feet in the north to seven feet at the northeast corner of the mine. Mine maps show that in the southern part of the mine the roof rock was very thin to absent, which precluded mining the #2 seam in portions of the south. A major sinkhole in the southern part of the mine can be correlated with the absence of the roof rock over the #2 seam. There was an additional drilling program in 1966, but this data was not available for inspection. In general, the roof rock tends to be thicker in the north center portion of the mine while thinning to the east, west and south. The primary control on the thickness of the roof rock is the amount of erosion that occurred during the advance and retreat of the glaciers and the action of the Grand River. The stability of the roof of the #2 seam is an important factor in the formation of sinkholes.

Feature 5: In some locations the roof rock consists of interbedded shales and gypsum. However, the drill hole data shows that in some areas the roof rock consists entirely of shale, while in another location it consists entirely of gypsum.

Feature 6: The average thickness of the #2 seam is about 11 feet; with a roof elevation between 580 and 600 feet mean sea level (msl) and a floor elevation between 570 and 580 feet. Drill hole data and elevation data in the mine shows that the #2 seam, while relatively flat dips to the east from an elevation 578 in the west to about 568 in the east. Thus, water inflow to the mined out #2 seam would flow from the west to east and then south through outlets created by the mining operation. There are two locations in the #2 seam where topographic low spots developed after being mined. These topographic lows were referred to as lakes and were used as pumping locations for the infiltrating water. The largest of the two lakes was the Portfliet Lake located in the northwest corner of the mine. The mine water from this pumping location was discharged into the Portfliet Creek directly above this lake. The second lake, called the Scranton Lake, was located in the west central part of the mine. The water from this station was discharged directly south of the mine through the mine portal.

Feature 7: There is an average 36 feet between the #2 seam and the #4 seam. A conservative estimate of the maximum ground pressure on the #4 roof rock (assuming 1 psi/foot) would be approximately 200 psi (maximum before mining).

Feature 8: A portion of the Domtar mine had both the #4 and #5 seam mined together along with a three-foot shale parting. When both the #4 and #5 seams were mined the room height averaged approximately 18 feet (Parker, 1983).

Feature 9: The Marshall Sandstone is approximately ten feet below the #5 seam. One of the concerns discussed in the mining documents is the potential inflow of water from the Marshall into the mine under artesian conditions. This would present significant stability problems for the gypsum pillars due to the high solubility of gypsum.

Feature 10: At the close of mining operations in late 1990's, the Domtar mine was allowed to fill with water. The Butterworth Mine, which closed in the mid-1970's, was also allowed to fill with water. Based on observations of the ground water table level observed in the existing Domtar Mine portal, the ground water table has reestablished itself within the overburden and therefore all of the gypsum seams are flooded.

Glacial History

As noted in Feature 4, the thickness of the roof rock over the #2 seam is controlled by the glaciation in the area and the action of the Grand River. In 1965 by Edward Burt, a Grand Rapids geologist, estimated ground water infiltration to the Domtar mine was made as well as the topography of the bedrock surface, which is shown in Figure 3. The topography provides an indication of the magnitude of erosion as well as an indication of the thickness of the remaining roof rock above the #2 seam. It can be seen that erosion has taken place on the east, south, and west sides of the mine. As noted above the #2 seam dips to the east and therefore rises to the west intersecting the bedrock surface. Due to this erosion, the #2 seam does not exist over the Georgia-Pacific Butterworth Mine to the west of the Domtar mine. The bedrock map also provides an indication of the #2 roof rock thickness on the west side of the mine. The bedrock elevation on the west side of the mine is approximately 610 feet, while the base of the #2 seam is 578 feet. The base of #2 seam at elevation 578 plus approximately 11 feet of seam thickness yields an approximate roof elevation of 590 feet, providing approximately 20 feet of roof rock. A general overview of the bedrock topography indicates that the roof thickness of the #2 seam is greatest in the north central part of the mine, followed by the west side, while the east side thins to as low as 7 feet (based on drill hole data), to approximately zero thickness in the south end. The Burt 1965 report is provided in Appendix C.

While this study is not involved with the Butterworth Mine, the mine does provide information to help assess the stability of the proposed Zoo site. The Butterworth mine opened in the early 1900's. As noted above, erosion has eliminated the #2 seam in Butterworth Mine so only the #4 and #5 seams were mined. The mine closed in 1971 and was allowed to fill with water. Since that time, numerous sinkholes have developed above the mine, particularly at the south end of the mine. At least one large collapse of underground pillars also occurred in which a subsidence depression formed north of O'Brien Street as well as a crack along O'Brien Street (Mroczkowski, 2002). However, more dramatic was the flow of mine water from the mine that flooded the Georgia-Pacific processing plant facility (West Plant) as pressurized water poured out of the abandoned mine shaft. A dike had to be placed around the plant to divert the water flow since it took a number of days for the water to stop flowing as the mine de-pressurized from the roof collapse. A report by Williams and Works (1984) concerning water infiltration to the Domtar Mine notes that the Georgia-Pacific mine officials estimated a pumping rate of approximately 1,500 gallons per minute to maintain the water level in the Butterworth mine. This provides an estimate of the amount of water flowing through the Butterworth Mine.

Gypsum Mineralogy and Dissolution Potential

Salt, anhydrite and gypsum are all evaporite rocks. According to White et al, (1995) evaporite rocks underlie about 35 to 40 percent of the United States and are found in 32 of the 48 contiguous United States, Canada and Mexico, and on other continents, especially Europe and Asia (China). Figure 4 is from a recent US Geological Survey proceeding (2001) concerning karst (topography characterized by sinkholes, caves and enlarged fractures formed by dissolution of carbonate or evaporite deposits) development in the United States showing that the Grand Rapids area has been identified as having both evaporites and karst development.

A recent article in American Scientist by Martinez et al. (1998) on sinkholes in evaporite rocks makes the following statement:

> "Evaporite deposits form when various salts precipitate from evaporating water, mainly seawater. The principal evaporite rocks include gypsum (or anhydrite, the anhydrous form) and salt (halite), although potash (sylvite) and other rarer salts also are locally important. Evaporites have the highest solubility of common

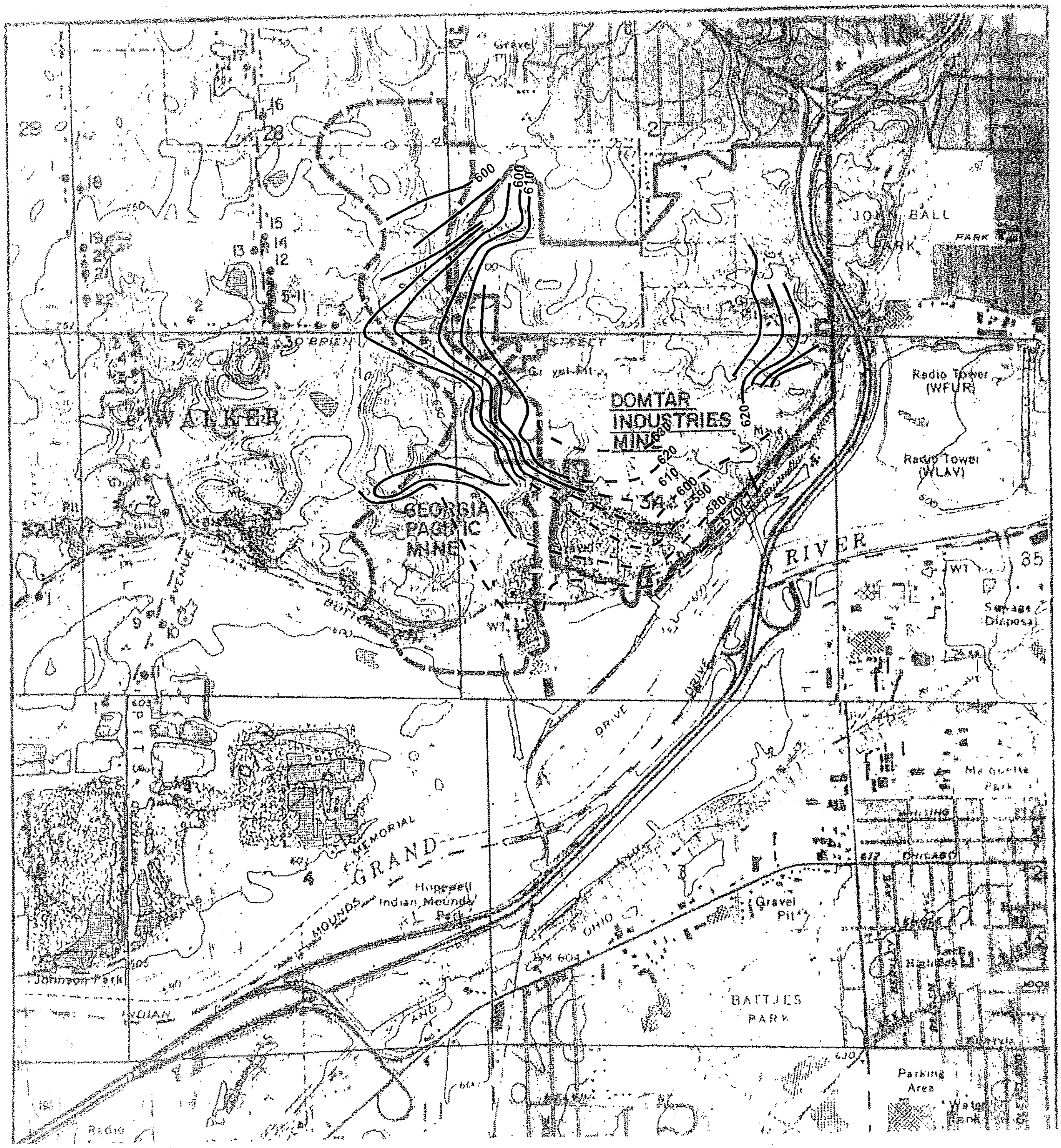

Figure 3. Bedrock topography of the Domtar Mine adapted from Burt (1965).
Georgia-Pacific Butterworth Mine

rocks; water that is unsaturated with respect to gypsum ($CaSO_4 * 2H_2O$) or salt ($NaCl$) rapidly dissolves them and carries them off in solution. Indeed, gypsum and salt are, respectively, about 150 and 7,500 times more soluble than limestone. Such high solubility enables subsurface dissolution channels and sinkholes to form in a matter of only days, weeks or years, and catastrophic collapse can result. Unlike sinkholes in carbonate rocks, evaporite sinkholes may result from either natural causes or from human activities."

The high solubilities of salt and gypsum permit cavities to form in days to years, whereas cavity formation in carbonate bedrock is a very slow process that generally occurs over centuries to millennia. Human activities can also expedite cavity formation in these susceptible materials and trigger their collapse, as well as the collapse of pre-existing subsurface cavities. A number of very well documented collapses have formed over salt solution mines. One of the most recent was the 1994 Retsof Salt Mine collapse in Genesee Valley, New York, in which the roof rock of the underground salt mine collapsed diverting ground water into the mine and completely flooding the mine. The Retsof Salt Mine was the largest salt mine in the United States at the time, covering ten square miles. Near Detroit, Michigan the collapse of an underground salt solution mine, which used boreholes to dissolve and extract the salt, resulted in large sinkholes forming on the Grosse Ile Island in the Detroit River.

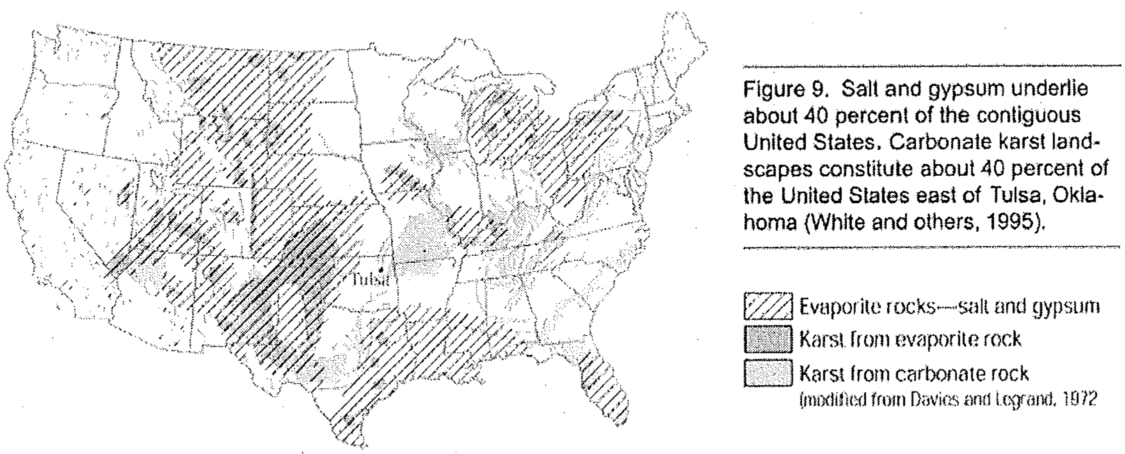

Figure 4. Figure 9 from a USGS report showing the location of evaporite rocks in the United States and karst development in both evaporite and carbonate rocks.

Gypsum Karst Development

The dissolution of gypsum and the development of sinkholes is a worldwide problem. In the United States the majority of problems associated with gypsum karst is due to natural processes as opposed to human-induced. The most well known area of gypsum karst affecting urban development is in the northern Black Hills of South Dakota (Epstein, 2001). In Europe, gypsum karst is a very significant problem, prompting the development of a European prediction and management system called ROSES. The acronym ROSES stands for Risk of Subsidence due to Evaporite Solution (ROSES, 2002). This project is funded by the European Union and has three main objectives: (1) the development of a process-based understanding of evaporite dissolution (karstification), (2) devising management techniques for preventing subsidence in areas of evaporite karst, and (3) developing risk assessment and zonation criteria for evaporite karst hazard mapping. Two recently published papers from project ROSES were reviewed for this investigation. The first paper titled "A decision-logic framework for investigating subsidence problems potentially attributable to gypsum karstification," (Lamont-Black et al., 2002) provided the mechanisms involved in the development of gypsum karst. The second paper titled "Road and bridge construction across gypsum karst in England, " (Cooper et al., 2002) provided engineering solutions involved in designing and constructing roadways over gypsum karst.

DOMTAR MINE

Background

The DOMTAR mine (formerly the Grand Rapids Gypsum Company mine) extracted gypsum from the #2, #4 and the #5 during its operational life. According to the Williams and Works report (1984) no mining of the #3 occurred at the Domtar mine. In general, while the mine had operated from 1854 it appears that the mining from 1854 through the mid-1970's primarily mined the #2 seam before closing. However, the United States Gypsum Mine, which is directly south of the Domtar mine, mined the #4 seam (based on an older mine map reviewed in this investigation). In the early 1980's the Grand Rapids Gypsum mine was purchased and reopened by Domtar Industries, Inc. with mining concentrating in the #4 seam and #5 seam as well as some limited pillar removal in the #2 seam.

To investigate the surface features good topographic maps generated from the county-wide Regis system were used. These maps were of good quality and provided 2-foot contours of the proposed site as well as over the entire Domtar mine. However, complete mine records showing the mining development were not available. Apparently, all (or most) of the Domtar mine files had been discarded at the time the last ownership change of the mine properties. Fortunately, some of the file were salvaged from the dumpster where they had been disposed (Mroczkowski, personal communications). Although some damage had occurred to the files they were useable for this investigation and provided signification information. However, the disordered nature of the files, as well as missing data, did introduce an element of uncertainty to the analysis, although it is believed that the major aspects of the mine, its geology, mining history and ultimate stability have been adequately understood for this investigation. The following sections provide the information collected concerning the Domtar Mine and used to determine the suitability of expansion of the John Ball Zoological Gardens (Zoo) over a portion of the Domtar Mine.

Existing Mine Reserves

The Domtar mine closed before completely mining out its reserve base. According to an inter-office memo, the mine has approximately four million tons of recoverable gypsum located in the #4 and #5 seams. No mining of the #2 seam, which had the highest quality gypsum in the mine, was included in the reserve tonnage. Mining of the #2 seam would have been through pillar removal or pillar size reduction (shaving), since the seam had been completely mined out on the property. Pillar removal (also known as recovery) is a common mining technique used in some cases to (1) produce easily mined tonnage when production is needed, (2) improve the quality of the run-of-mine production when needed, and (3) to allow an orderly collapse of the pillar so that ground subsidence can be gradual in nature and to minimize surface disturbance and to produce a stable surface and eliminating the potential for sinkholes. A 1983 rock mechanics report (Parker, 1983), in fact, recommended that the #2 seam pillar be removed "...to preserve the real estate above the mine." The removal of pillars would allow the gradual fairly uniform subsidence of the mine and minimize sinkhole formation. While some limited pillar recovery is identified on the existing mine maps, it appears that very limited pillar removal was conducted in the #2 seam.

The existing #4 and #5 reserves all lie in the northern section of the mine. Three inter-office memos (years 2000, 1999, and 1996) concerning the gypsum reserve estimate, as well as future mine plan details, are provided in Appendix D. The memos provide the following details:

1. The mining at Domtar, in general, has been from the south in an area of low cover and short haulage distances, to the north with longer hauling distances. Figure 5 shows the areas of the gypsum reserves lying mostly north of O'Brien Street, with some limited reserves south of O'Brien on the east side of the Domtar property.

2. Essentially, the proposed Zoo extension overlies the majority of the remaining mining reserves at the Domtar mine. Although the mining of these reserves is unlikely, the rights to mine these reserves must be considered in any surface development since mining may affect the stability of the site.

3. Only a small portion of the #4 seam was mined below the proposed Zoo site and from records reviewed none of the #5 seam was mined.

4. Although the #2 seam has been mined under the CMS power line and I-196, the 4 million ton reserve estimate excluded mining the #4 and 5 seams under both structures. The exclusion of the reserves under these structures can be seen in Figure 5.

5. The 1999 memo in Appendix D states that only 25% of the gypsum production was from the #5 seam, indicating that *not* all of the #5 seam was being mined along with the #4. It is unclear from the information inspected as too where the number #5 seam was mined or not mined. This appears to be significant in regards to the surface stability, since as noted above, stability of the pillars becomes important with the larger opening.

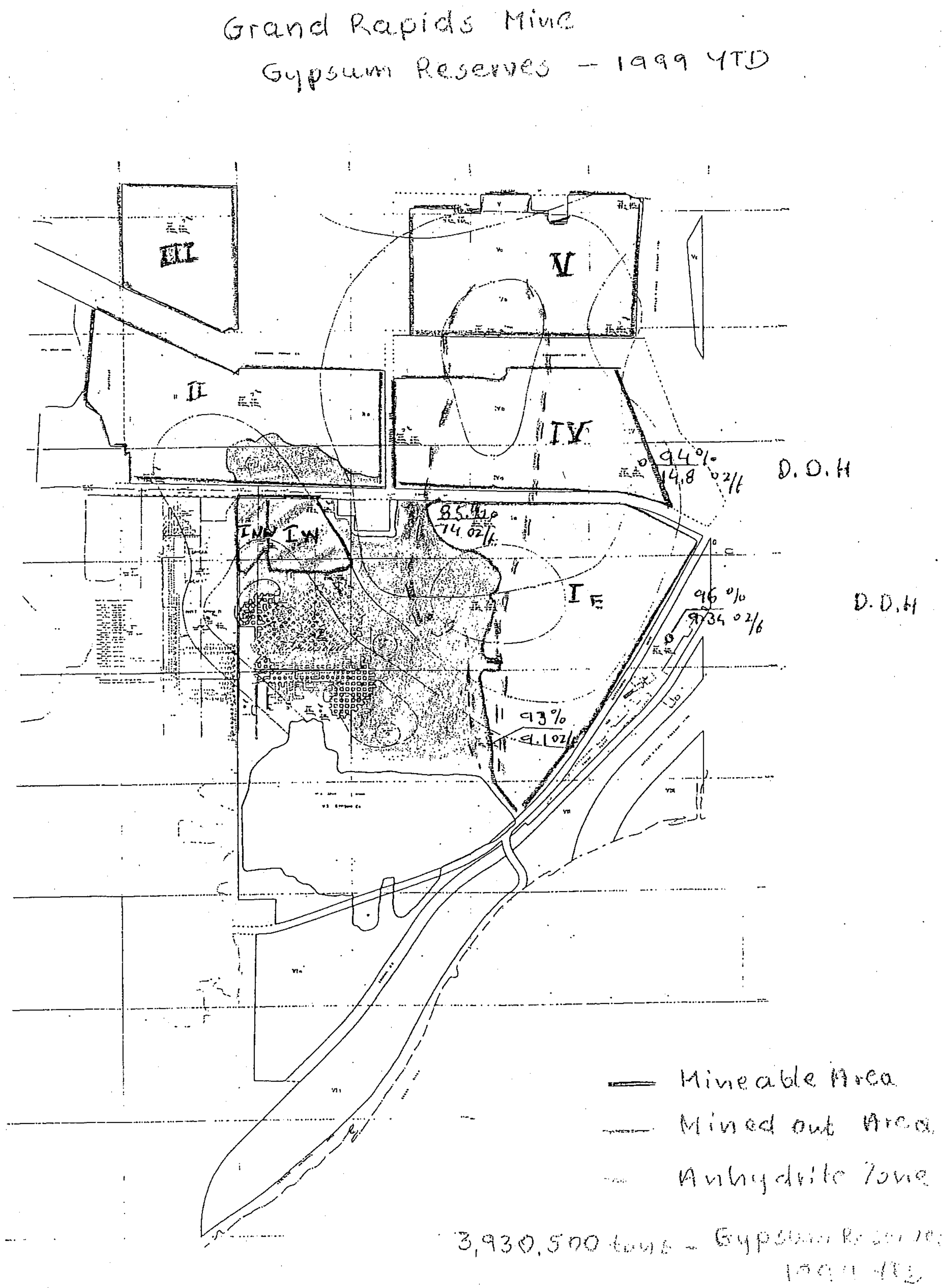

Figure 5. Domtar Mine 1999 gypsum reserve estimate map. Map shows the exclusion zone of mining around the CMS power line and I-196 in addition to the anhydrite zone located in the #4.

6. An anhydrite zone is located in the #4 seam as shown in Figure 5. Anhydrite, although a calcium sulfate as is gypsum, does not have water in its structures and is unusable for plaster board or other products that gypsum is used in. Consequently, this zone, which occurs in the upper portion of the seam, had to be excluded in the mining process. This significantly altered the mining of the #4 seam. A system known as "bi-level" mining was implemented to mine the base of the #4 seam and the #5 seam together, thus mining underneath the anhydrite zone. The 1996 memo in Appendix D provides the only map that was found showing the area where bi-level mining took place. The bi-level mining area was approximately 300 feet south of O'Brien Street starting on a line directly south of Covell Avenue and moving due east. It appears that the bi-level mining method is associated with surface disturbance and sinkhole development. However, the full extent of the bi-level mining activity at the mine was not determined in this investigation. It appears, though, that between 1996 and 1999 the bi-level mining continued due east working under the anhydrite zone. It does not appear that any bi-level mining occurred under the proposed Zoo extension site or was within 300 feet of O'Brien Street.

Existing Structures Over the Domtar Mine

There are two main lifeline structures over the Domtar mine, Interstate I-196, which is located over the northeast side of the mine and a high voltage CMS power line, traversing roughly east-west over the northern portion of the mine. Both structures, as noted above, had the #2 seam mined below them. A cursory field inspection of these structures did not indicate any distresses to the structures. The Michigan Department of Transportation (MDOT) was not aware of any special provisions that were made concerning the underground mine below the interstate (Larry Heinig, personal communications, 2002). Nor was it known whether mining had taken place after the Interstate had been constructed.

Underground Mining

Room and pillar mining was the primary form of mining used at the Domtar mine for mining #2, 4 and 5 seams. However, there were a number of different room and pillar mine plans used at the Domtar Mine as shown in Figure 6. In general, as the initial mining appears to have started in the southeast portion of the site where mining of the #2 seam began in the 1800's. In this area, the pillars are very irregular, with no clear patterns. This area appears to be confined to an area south of O'Brien Street. In addition, the roof is very thin, and in some cases nonexistent, leading to many caved areas. As mining progressed north and west the mine plan layout appears to have become more systematic. However, there were no mine drawings available for inspection indicating the sequence or timing of mining. As noted above, the majority of mining under the proposed Zoo expansion site was in the #2 seam, while only a small portion of the #4 was mined.

Known dates that may relate to the stability of the mine are as follows:

1. The mine started production in 1854.

2. The mine shut down in 1980 due to poor economic conditions and also poor mining conditions. It appears that at this point most of the #2 had been mined and that mining operations were beginning in the #4 seam. The mine was reopened in 1983 with primary production coming from the #4 seam.

3. The mine closed in the late 1990's and was allowed to fill with water.

4. The mine is currently completely flooded. The ground water table is in the glacial overburden based on the observation of the water level from the existing mine entrance.

An important factor concerning mine stability is controlling the water that flows into the mine. Therefore, the dip of the seams is important for the flow of water through the mine. Table 1 provides elevation data taken from five exploration holes drilled in 1963. In addition, the roof type was also noted as well as the roof rock thickness over the #2 seam. Additional exploration drilling was conducted in 1966, but these borings were not found at the time of this investigation. Figure 6 also shows the location of the 1963 exploration drill hole data presented in Table 1 as well as the location of the 1966 data.

Figure 7 shows the mining method for the #4 and 5 seams. The remaining discussion in this section concerns issues relating to the stability of the #2, 4 and 5 seams and consequently, the stability of the surface.

Table 1. Elevation data on the gypsum seam of the Domtar Mine.

Hole ID	#1	#2	#3	#4	#5
Ground Elevation	683	713	655	722	609
Top of Bedrock	587	587	601	618	598
OB Thickness	95	126	54	154	11
Top of #2	575	580	580	583	587
Bottom #2	568	568	571	571	575
Thickness #2	7	12	9	12	12
Top of #4	541	532	533	537	542
Bottom #4	532	522	524	526	531
Thickness #4	9	10	9	11	11
Top of #5	530	521	521	524	529
Bottom #5	522	511	513	515	523
Thickness #5	8	10	8	9	6
Roof Rock Thickness	12	7	21	35	11
Roof Rock Type	Shale/Gyp	Gypsum	Soft shale/ Soft gyp	Limestone/ shale/gyp	No #1 shale
Ratio: OB/Roof Rock	7.9	18	2.6	4.4	1.0

Seam #2 Mining Issues

1. Inspection of the mine maps indicates that there was limited karst or natural dissolutioning of the gypsum within the mine. This would indicate that shale beds overlying the gypsum formed a relatively impermeable layer preventing dissolutioning of the gypsum. However, there is a documented case of karst development on the west side of mine. This karst feature was discovered in 1976 and named the Pellerito Cave after the foreman who discovered it. The cave was approximately 300 feet in length and indicated that significant amounts of water had flowed through the cave. The cave was inspected by the National Speleological Society and reported on by Elowski and Ostrander, 1977.

2. The Pellerito Cave may have formed as a result of the glacial erosion to the west of the mine exposing the #2 seam and allowing fresh water to access the #2 seam and the dissolution of the gypsum. However, it is not clear as to why the cave did not further develop beyond 300 feet. One possible explanation may be that the dissolutioning process may be relatively young and associated with the mining of the #4 seam in the (GP) Butterworth Mine, directly below where the Pellerito cave was discovered. In fact, the cave system lies directly above the #4 seam with the cave ending at the end of the #4 mining. It is possible that deformation of the roof of the #4 seam may have caused cracks to form allowing water to enter the #2 gypsum layer. If this is the case, the rate of dissolutioning of the gypsum is significant in this mine depending on the flow of fresh water.

3. The #2 seam is relatively flat in some locations, but does drops approximately ten feet from west to east across the mine allowing water to flow from the west to east on the #2 along the mine floor. The floor material consisted mainly of shale and some limestone. In two locations the seam formed underground lakes, which provided locations to dewater the #2 seam.

4. The bedrock above the #2 seam varies in thickness across the mine ranging from 7 feet on the north east side of the mine, to no roof rock on the south, to 20 feet on the west side. However, the north central portion of the mine appears to have the most roof rock ranging between 20 and 30 feet.

5. The bedrock above the #2 seam varies considerably in composition. In some places the roof consists of interlayered shale/gypsum, while in some places it is completely shale or gypsum.

6. There are a number of different room and pillar types used below the proposed Zoo expansion site. The room and pillar mining method can be classified into the following groups based on what appear to be from older to newer mining methods:

    a. Very long rectangular pillars orientated either north-south, east-west or in a couple of small areas orientated at 45 degree angles to the north.

b. Somewhat regular 60 degree block pillar design, possible from mining with a continuous miner.
c. Very regular square pillar design.

7. South of O'Brien some pillar removal appears to have taken place in a couple of areas, based on the underground mine map. However, there is no other confirmation that pillar robbing occurred in the Domtar Mine, consequently this observation is only speculative.

Seam #4 and #5 Mining

1. The mining of the #4 and #5 seam, which was primarily conducted after the reopening of the Domtar Mine in 1983, was concentrated north of the old United States Gypsum Mine and south of O'Brien Street starting on a line directly south of Covell Street moving eastward towards I-196. A review of the mine's stability was made by Mr. Jack Parker in 1983 and 1984. Based on the Parker reports and the review of the existing mine files the following issues have been identified, which include observations of the mine conditions in the #2 seam relating to mine stability of the #4 and5 seams.

2. Observations of the #2 seam stability include the following:

   a. The #2 seam had good pillar conditions showing normal mine conditions in some portions of the mine.
   b. In other areas there are numerous roof falls in the #2 seam along with pillars failing by splitting.
   c. Artesian water conditions occur at the base of the #2 seam as well as water running beneath pillars.
   d. Areas where the roof had discontinuous gypsum and shale layers were associated with roof instability.
   e. Some areas with significant roof falls were supported by wooded timbers.
   f. Gunite was sprayed on exposed shale layers to protect the exposed shale in an attempt to minimize the effect of the mine's high humidity conditions on the shale's strength and stability.
   g. Shale layers at the base of the #2 seam were swelling, causing instability of the pillars.

2. Numerous roof rock falls were observed in the #4 seam. This instability was believed to be primarily due to the blasting procedure in mining the gypsum.

3. Cracks were observed in the #4 roof suggesting sagging of the roof.

4. Shale layers in the mine indicated that the shale was relatively weak. Williams and Works conducted unconfined uniaxial compression tests on dry shale samples from the mine, resulting in rock strengths from 3,000 to 4,000 psi. However, the uniaxial compression testing on the shale under high humidity conditions, conducted at Michigan

Tech, showed that the rock strength dropped to approximately 500 psi under high humidity conditions.

5. Because of the low strength of the shales from both the roof and floor rock, Parker suggested that all mine air flow be first directed through the #2 seam before accessing the lower mine workings - to condition the air to a constant humidity. This would help regulate the pillar stability while mining the #4 and 5 seams.

6. Pillar dimensions in the #4 and 5 seam are square with a dimension around 30 by 30 feet. Parker reports suggest a pillar dimension of 36 feet square should be used to maintain long-term stability of the mine roof.

7. It appears that in at least one location the #4 seam in the Domtar Mine mined into the #4 seam in the United States Gypsum Mine (USGM) - at the south end of the Domtar mine. This provided a route for ground water flow. Water that migrated into the USGM was then pumped out through the Pittsburgh Pumping station located on the south side of Butterworth Street.

8. Four pumping stations were used to discharge water from the Domtar mine: The #2 seam was de-watered by the Portfliet station in the northwest section of the mine, the Scranton station in the south central part of the Domtar mine, and the Butterworth station, on the east side of the mine. The #4 seam was de-watered from the Pittsburgh station located at the south end of the USGM.

Geohydrology Issues Related To Mine Stability

One of the most critical issues involving the long-term stability of the mine is the effect of water on the mine. As with any mining operation it is essential to control the water flow during mining so that mining operations are not affected. Besides the control of water to minimize its impact on mining, four additional concerns can be cited in regards to the stability of the mine works. The four main issues that can negatively affect overall mine stability are as follows:

1. Dissolution of the gypsum from flowing ground water.

2. Strength reduction of the shale and gypsum rock with increased moisture content.

3. Artesian water conditions, i.e., upward flow of water into the mine, due to the lowering of the water table at the mine and significantly increasing the potential head for water flow into the mine from lower rock layers.

4. The chemical change of anhydrite to gypsum results in significant swelling estimated to be approximately 60%.

The effect of these four issues on the stability of the Domtar mine are discussed as follows:

1. As discussed above gypsum is an evaporite that has relatively high solubility. In general, salt has the highest solubility followed by gypsum and then anhydrite. The Domtar Mine contains all three of these evaporites, with gypsum and anhydrite being the most abundant. However, there were a number of locations in the #2 seam where small blocks of gypsum were not mined due to a high salt content. Most of these high salt locations were in the northern part of the mine and below the proposed Zoo site. In general, the salt content increased towards the north central part of the mine. The rate of dissolution of gypsum by ground water is a function of a number of factors with the flow rate and amount of dissolved solids being the two most important. As the ground water flow rate increases dissolution will increase but as the percent of dissolved solids increases the rate of dissolution will decrease. Water that is high in dissolved solids is referred to as saturated water and which has limited potential for causing additional dissolutioning. Unsaturated waters or under-saturated, on the other hand, would be lower in dissolved solids with a high potential for dissolutioning.

2. According the Williams and Works report the ground water that entered the mine comes from three possible sources: (1) vertical seepage of precipitation falling directly over the mine, (2) lateral seepage from surface sources such as Portfliet Creek and Grand River (note, the elevation of the #2 seam is below the level of the Grand River), and (3) vertical seepage from the Marshall sandstone or from the flooded GP Butterworth Mine. The report was unable to determine the percent of each of these sources of water entering the mine, however, it was believed that a significant amount of water was entering the mine from the Portfliet Creek and possibly the Butterworth mine through lateral flow.

3. The groundwater flow through the glacial overburden into the mine would probably be relatively low in dissolved solids and therefore unsaturated. Once in the mine it would have a high potential for dissolving gypsum. The water then leaving the mine could, if dissolutioning was occurring, be high in dissolved solids. According to the NPDES permit levels the discharge waters from the mine were all very high in dissolved solids at approximately 3% by volume, i.e., near sea water.

4. Based on observations made in the Domtar mine during the Parker report period, as well as with personal communications with Tom Mroczkowski, significant dissolutioning was taking place during the mining operation. Dissolutioning was directly water was observed flowing under some pillars in the #2 seam.

5. During the mining operations and de-watering of the mine the flow rate in the mine would have been relatively high, since the rate of flow would have been a function of the discharge rate used to keep the water levels within an operational limit for mining.

6. Although the shale/gypsum layers are relatively impermeable, mine personnel were concerned about water flow from the Marshall formation. While the primary concern was the additional cost to de-water, upward flow of water also presented a significant stability problem for the #4 and 5 seam pillars, which would be undercut if water flow was occurring.

7. Since the Grand River is above the #2 seam, the river level will affect the groundwater hydrology of the mine. Flooding of the Grand River must also be considered. Flood events for the Grand River are as follows:

Flood Date	Stage (ft)
1904	610
1905	609.4
1947	606.8
1948	607.6

Domtar Mine Elevations	
Average elevation of the Domtar Facilities:	607 ft.
Top of #2 Seam	580 ft.

National Flood Insurance program (mid-1970s):
100 year flood at the Domtar Mine is 607 feet (will flood most of the Domtar plant site)
500 year flood at the Domtar Mine is 620 feet

8. Since the mine is now flooded, the flow rate through the mine has likely decrease to whatever the flow rate the discharge points of the mine will naturally allow. This will decrease gypsum dissolutioning to some degree, while some parts of the mine will become stagnant. However, the flooding of the mine has also resulted in the shale layer being saturated which will result in a decrease in the strength of the shale as well as swelling potential of both the shale and the anhydrite rock.

MINE AND SURFACE STABILITY

To maintain the stability of the surface above underground mine works, the mine support system must be designed such that it *permanently* supports the overlying rock and overburden. In addition, the mine must be designed so that any changes in the condition of the mine do not alter the long-term performance of the support system. This, based on available information, is not necessarily the case with the Domtar mine. It appears that portions of the mine pillar support systems were neither designed for long term support nor were they designed to function when the mine became flooded. This opinion is based on the following observations:

1. Significant sinkhole development as well as large subsidence has occurred in the GP-Butterworth mine in the #4 and 5 seams as well as a sudden subsidence collapse, which resulted in flooding of the West Plant and occurred after the mine was closed. Large surface cracks have been observed by Tom Mroczkowski in the past couple of years, indicating continued mine instability.

2. Sinkhole formation continues to occur over the Domtar Mine. Figure 6 shows sinkholes associated with the Domtar Mine. Most of them have formed south of O'Brien Street and appear to correlate with the mining of both #4 and #5 seams. Additional sinkhole development is occurring north of O'Brien Street but south of the CMS power line. It appears that this sinkhole development is primarily correlated to the main mine entryways and secondarily to the long rectangular pillars used in the support of this area. It is also possible that the roof rock in this area was relatively soft. The #3 exploration borehole, which was located near this sinkhole activity, indicates very soft shale and gypsum for the roof rock although the thickness of the roof rock was 21 feet. As noted

above, the roof rock thickness increases to the north and may help explain the lack of sinkhole development in the northern part of the mine.

3. The pillar dimensions were adequate to maintain stability during the mining operations in the #2 seam. In areas of unstable roofs, timber was used to support the roof and later mechanical bolts and possibly resin bolts were used to stabilize the roof. These types of systems will not support a roof long-term and are subject to deterioration and corrosion. According to the Parker Report (1983), larger pillar dimension (36' by 36') should have been used to better support the roof. And, also suggested that pillar removal be considered to preserve the surface real estate. Pillar removal would have allowed the surface to subside in a controlled manner minimizing disturbance to the surface as well as eliminating sinkhole potential.

4. Dissolutioning of the gypsum in the mine has occurred and will continue to occur. While the rate of dissolution is difficult to determine, it can be expected that dissolutioning over time will further reduce the strength of the pillars, allowing the ultimate collapse of the mine. Factors in the rate of dissolution will be the rate of water flow through the mine and the level of dissolved solids in the groundwater.

5. According to mine personnel, the #4 and 5 seams were stable during gypsum mining. As noted in point 2 above, however, significant sinkhole activity has occurred above the area where both the #4 and 5 seams since the end of mining operations. If the Butterworth mine is any indication of long-term stability, then it appears that the overall stability of the pillar support systems of the #4 and 5 seams may not be adequate. The Butterworth Mine, where only #4 and #5 gypsum seams were mined, was closed in 1971 and over the approximately thirty-year period significant surface disturbance has occurred. A concern with the mining of the #4 and 5 seams is also the potential for water inflow from the Marshall sandstone located below the #5 seam. This inflow could result in damage to the mine's pillars through dissolutioning and a decrease in strength of the shale parting between the two seams. Fortunately, the strata between the #5 seam and the Marshall Sandstone should be adequate to prevent water migration. It is possible though that water pressure, developed when the mine was dewatered and the swelling of the floor shales and gypsum, may have resulted in Marshall water accessing the Domtar mine, causing a further decrease in the mine's stability prior to the flooding of the Domtar Mine.

6. In general, the strength of gypsum is not high. There is relatively little strength data on gypsum. Research by Gysel (2002) reports that the strength of Triassic gypsum located in Switzerland ranged between 2,000 and 4,000 psi. However, Gysel also notes that the strength significantly decreases when shale is incorporated in the gypsum, which is then referred to as a marl, to as low as 500 psi. Based on the 1963 exploration drilling information, much of the roof rock, which is mainly the #1 gypsum seam, was of a gypsum/shale composition. This suggests that the strength of the roof rock was not high. This is also correlated with many long tension cracks observed in the roof of both the # 2 and #4 seams. According to Parker (1983) the long tension cracks in the roof indicated a sagging roof condition, indicating that the strength of the roof "beam" was not adequate to span the distance between the pillars at that time.

7. The Parker report was also concerned with the moisture state of the shale and attempting to maintain a constant humidity of the mine air. Flooding the mine would increase the potential for softening the shale rock and decreasing the stability of the mine over the long-term.

8. Flooding the mine there is the potential for swelling of both the anhydrite and shale. The 1983 Parker report showed pictures of the shale floor layer swelling up into the mine. This would decrease stability of the support pillars.

9. It is almost certain that subsidence will occur over portions of the Domtar Mine but we do not know when. Based on the Butterworth Mine it is possible that sinkholes may form soon after the flooding of the mine, while the broader subsidence may take longer. One can expect that sinkholes will form in the areas with thin roof rock and low overburden cover while broader land subsidence may occur in the north center part of the mine where the roof rock is thicker. Special consideration must be given to the location of the bi-level mining, since it appears that this may be the most likely place for sinkholes.

SURFACE STABILITY OF THE PROPOSED SITE

Based on the above criteria, we can designate zones of probable stability or instability, as follows: Zone A identifies the area with the greatest potential for stability, while Zones B through F indicate increasing instability with Zone F having the highest potential for instability. The zones are shown in Figure 6

Zone A - No gypsum mining has occurred in this zone. The stability of this zone is high and is outside any potential underground mining instability. The boundary of the zone is based on an angle of draw of thirty degrees, i.e., the limit of mining is an additional distance from this zone measured by a vertical angle of thirty degrees.

Zone B - Only the #2 seam has been mined in this zone and no evidence of sinkholes was found. It is assumed that the mining below this zone was relatively recent, occurring in the1960s and 70's using systematic room and pillar mining methods. It is also based on no reduction (shaving) of pillars or pillar removal has occurred in this area. The roof rock appears to be relatively thick in this area and the floor rock appears stable. Therefore, short-term stability of this zone appears good. However, the issue of dissolutioning of the pillars over time must be considered, since decreasing stability may result if the pillar dimensions are reduced in size.

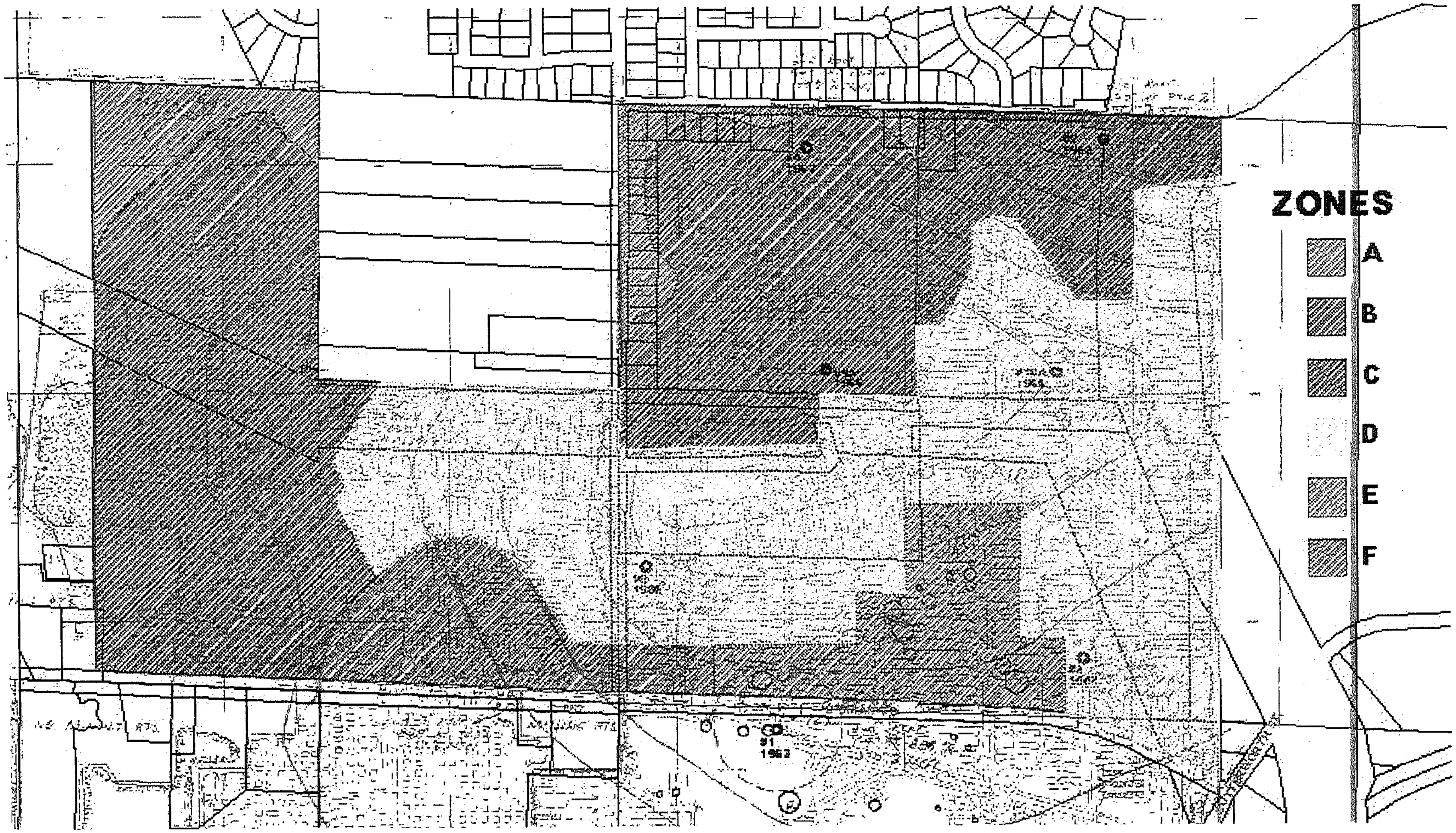

Figure 6. Map of Stability Zones.

Zone C – Only the #2 seam has been mined in this zone and no evidence of sinkholes has been found. This zone has a less systematic mining method and with very irregular pillar shapes and sizes. It is not known why this type room and pillar method and orientation of mining was used. As with Zone B it is also assumed that no reduction (shaving) of pillars or pillar removal has occurred. However, the roof rock in this zone is significantly thinner and according to exploration borehole #3 is composed of only 5.5 feet of gypsum and 1.5 feet of shale. This is the only exploration borehole that showed the gypsum being in direct contact with the glacial overburden. However, no sinkholes or land subsidence are evident in this zone. While the short-term stability of this zone appears to be adequate, there are stability issues that increase the probability of future instability. Again, the issue of dissolutioning of the pillars over time must be considered, since decreasing stability may result if the pillar dimensions are reduced in size.

Zone D – Only the #2 seam has been mined in this zone. An older mining method using long rectangular pillars at various orientations was used in this zone. The roof rock in this zone varies from 35 feet in the west while thinning to seven feet in the east. While this zone appears stable it is unclear if the mining method using the long rectangular support pillars is adequate over the long-term to support the mine roof. It is also assumed that no shaving of pillars or pillar removal has occurred in this zone. Again, the issue of dissolutioning of the pillars over time must be considered, since decreasing stability may result if the pillar dimensions are reduced in size.

Zone E - Only the #2 seam has been mined in this zone along with the same mining method used in Zone D. However, this zone has sinkholes forming, which appear to be related to the mining method used. The roof rock is relatively thin in this area. Along with the formation of sinkholes and the older mining technique used, the short-term stability of this zone is questionable.

Zone F – The #4 or the #4 and #5 seams were mined in this zone. Potential for instability of the lower seam is relatively high. Portions of this zone have already subsided. There is a high probability of surface instability in this zone.

SUMMARY AND CONCLUSIONS

1. The proposed zoo expansion site has all three major gypsum seams located beneath the site. The seam closest to the surface, the #2, has been extensively mined underground, while only a small portion of the #4 has been mined on the south edge of the site just north of O'Brien Street. Based on the salvaged mine maps no #5 seam has been mined below the proposed site.

2. Approximately 4 million tons of reserves exist in the Domtar mine, with a significant amount located under the proposed zoo expansion site. While future mining of these reserves is unlikely, the rights to mine these reserves must be considered since future mining of the #4 and #5 seams might cause increased instability of the surface.

3. The gypsum seams in the Domtar mine appear to have little to no natural karst development (dissolutioning) prior to mining operations. This indicates that shale beds above the gypsum seams provide protection from ground water. The one karst feature found in the mine is the Pellerito Cave (Elowski, and Ostrander, 1977) may have been induced by the mining of the GP Butterworth Mine. However, additional investigation may be needed to verify this hypothesis.

4. The support pillars of the mine do not appear to have been designed for long-term stability. The stability of the support pillars is further compromised by the possible dissolutioning of the base of the pillars during mining.

5. Extensive sinkhole formation has occurred over the adjacent Georgia-Pacific Butterworth Mine. A large subsidence event resulted in the flooding of the processing plant south of the mine.

6. Sinkholes have formed over the Domtar Mine, with recent sinkholes forming since the flooding of the mine over the past two years. It appears that the majority of sinkholes are related to the mining of the #4 and 5 bi-level mining and to possible pillar removal of the #2 seam. In addition, some sinkholes appear to be related to the type of mining conducted using long rectangular support pillars.

7. The issue of gypsum dissolutioning is critical to the stability of this mine. Over the long-term it is highly likely that the remaining support pillars will collapse resulting in either sinkhole development or larger scale subsidence.

8. Zones indicating the short-term stability of the surface have been developed. The time period of short term is difficult to establish, but based on the experience of the Butterworth mine, the short-term can be approximated by a period of less than 50 years.

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APPENDIX C

REPORT OF INVESTIGATION OF WATER PROBLEMS AT THE GRAND RAPIDS GYPSUM MINE, GRAND RAPIDS, MI

BY

EDWARD M. BURT

1965

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REPORT OF INVESTIGATION OF WATER PROBLEMS AT THE GRAND RAPIDS GYPSUM MINE, GRAND RAPIDS, MI

BY

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1965

EDWARD M. BURT

GEOLOGIST
142 E. Division
Rockford, Mich. 49341
Telephone 866-8041

January 11, 1965

Mr. Charles Young
Grand Rapids Gypsum Co.
Butterworth Dr. SW
Grand Rapids, Michigan

Dear Mr. Young:

In response to your authorization and with your and Mr. Johnson's assistance, I have investigated your mine water problem encountered on October 17, 1964. The investigation included inspection of the site, review and compilation of pertinent data from your well records, pumpage records and other readily available information such as oil and gas drilling records. Preliminary verbal progress reports have been made during our conferences. This letter report summarizes the pertinent geologic and hydrologic conditions, conclusions and recommendations.

INTRODUCTION:

The encountering of about 300 gpm (gallons per minute) of water in the southwest portion of your mine has raised several questions including:

1. What is the source of the water?
2. How does it enter the formation?
3. What are the hazards of encountering more water?
4. Removal by pumping or stop the flow?

In determining the answer to these and related questions, it is necessary to recognize that the occurrence of the water encountered, like all ground water, is controlled by regional and local geologic conditions. For this reason, a review of the geologic environment was made to ascertain the controling factors as revealed by the available data.

BASIC GEOLOGIC AND HYDROLOGIC CONSIDERATIONS

The geologic environment consists of unconsolidated glacial soil deposits resting on the eroded surface of the consolidated rocks of the Michigan Formation.

The unconsolidated soils consist of sands, gravels, clays and various mixtures thereof. The logs of the wells in the area report vertical and horizonal variations typical of glacial deposits. (See cross sections) Some of the records report sands and/or gravels with negligable amounts of clays while others report the opposite condition. Most, however, indicate definite stratifications of each of the soil types, the significance of the glacial soils lies in the occurrence of the permeable sands and gravels. Such soils are capable of storing and releasing waters available to them. The well records show this occurs in the area under study. Further, the reported water levels indicate the source of the waters contained in the glacial soils is largely local precipitation and the contribution of the north-south stream west of your present operations. The water levels indicate the ground waters are moving from areas of recharge in the highlands toward the Grand River. The movement of ground water is in response to the force of gravity, hence it will move from any area of high head to whatever area of lower head is available. Therefore, should your mine workings encounter permeable glacial soils, the ground water contained in such soils will naturally move into the mine. For this reason, it is imparitive that direct contact between the mine workings and the glacial soils be avoided if at all possible. The accompanying cross sections show such encounters would be possible by extending the mine openings too far to the west or south.

Other considerations regarding the relationship between the glacial soils and the consolidated rocks involve the character and configuration of the bedrock surface. Prior to glaciation of the area, the local bedrock was exposed and subjected to the natural forces of weathering and erosion like any other land surface. We therefore expect and find, as shown by the bedrock topography map, an irregularity in the bedrock surface. This irregularity or topographic relief is important in locating areas where the thickness of consolidated soils between the base of the glacial drift and roof of the gypsum bed being mined may be hazardously thin. Such an area is present at or immediately west of the site of the recently encounterd water, and is shown by the "depression" contour on the bedrock topography map. The well records indicate a "sink hole", such as have been observed in the Grandville area, exists in the bedrock surface at or near the water flow. Such features result from localized removal of soluble rocks such as limestones and gypsums by downward migrating ground waters and eventual collapse of the overlying but undermined rocks. Such a feature, buried with waterbearing glacial soils provides an excellent avenue for ground waters to migrate into the bedrock formations.

The movement of ground water in consolidated rocks differs from that in unconsolidated rocks. In the latter, the soil particles are uncemented and water surrounds the grains of soil lying below the water table. Within consolidated rocks, much or all of the space between the particles making up the rock is occupied by the cementing agent binding them together. Therefore water movement through consolidated rocks is less likely to be in pores around the grains, and more commonly is through joints, fractures and/or solution channels. Frequently, water is encountered along bedding planes and in the contact zone between beds of different types of rocks such as a change from a sandstone resting on a shale. Comparatively speaking, sandstones and limestones are more apt to be waterbearing than are shales. Within a bed of gypsum such as you mine, the physical and chemical characteristics of the mineral makes water movement through solution channels the most likely mode of occurrence. Because ground water is usually moving, the solution channels tend to be large, growing larger and yield 100 or more gallons of water per minute.

MINE WATER PROBLEM

FIG. 1 IS MISSING

Figure 1 is a map of the area showing the bedrock topography based on the readily available well log data. As mentioned previously, it is important in locating the approximate areas where: a) the bed being mined is absent: b) the bed is exposed to the glacial drift soils: and c) the thickness of consolidated soils overlying the bed may be hazardously thin. Such an area is revealed by the depression contour immediately west of the recent water occurrence.

Also shown on figure 1 are the approximate contours on the water table. While the contours are based on reported water levels noted coincidentally in the drilling of core holes, Mr. Rayner of the C.S. Raymer Co. provided information on four water wells which confirmed the interpreted water levels. The significance lies in the basic characteristics of water level trend rather than in the actual levels. Water tables naturally fluctuate through the year with the seasonal variations in precipitation. They also vary in response to "drought years" versus "wet years". At the present time we are in a drought period with water levels generally at or near record lows throughout Michigan. As the water table varies in altitude, so does the amount of ground water in motion and hence, the amount of water that might be expected to enter the mine through a given opening.

Figure 2 is a graph summarizing the weekly high and low water levels measured in the Pittsburgh shaft and the days the dewatering pump(s) were in operation. It is very apparent that the water encounter of October 17 represented an "interception" of water which previously found its way into the Pittsburgh shaft. The rapidity of the effect on the Pittsburgh shaft supports the theory that a solution channel was intercepted. Most recently, I understand the amount of water entering the mine has been decreasing, necessitating throttling of the pump in the mine. Though the exact cause of this cannot be identified, one or more of the following causes may be responsible for the diminishing flow.

The solution channel may be plugging up with sediments, thus inhibiting the passage of water. If this is the cause, the flow may continue to dimmish, but probably will not completely stop. Also, the pumpage at the Pittsburgh shaft should remain diminished.

The natural "winter decline" in the water table may be responsible for the decline in flow. If this is the cause, the pumpage at the Pittsburgh shaft should remain low and in the spring and summer of the year the flow should again increase.

The water may have eroded a new channel to a lower outlet. In this case the flow should stop in the mine and will probably find its way to the Pittsburgh shaft.

Figures 3 and 4 are cross sections portraying the distribution of permeable unconsolidated soils and their relationships to the underlying consolidated rocks. The vertical scales of the sections are exaggerated out of proportion with the horizonal scale. The horizonal well relationships are proportional to the distances between wells along the lines of the sections as shown on figure 1. Section A-A' (Fig.3) also shows the estimated water table profile. The sections clearly show the soil and water head conditions are suitable for migration of ground waters from the glacial drift into the consolidated rocks. Analyses of the water quality at the flow site in the mine (Hardness 63-69 grains per gallon and Chlorides 91 to 114 parts per million) and at the Pittsburgh shaft (Hardness 93g/g and Chlorides 167 ppm) are also indicative of such migrating ground waters rather than native waters within the rocks.

Based on the available well log information, water pumpage information, water quality information and water level information, it is my opinion that water flow represents a "tapping" of a solution channel receiving water from the glacial drift through a buried "sink hole" or similiar feature.

RECOMMENDATIONS

The recent encountering of water, though not the first, emphasizes the need to avoid working too close to the "pinch out" of the formation or in areas where the roof of consolidated rocks may be thin or saturated with water. The presently available information, as shown by the bedrock topography, indicates that such conditions exist west of your operation, in the vicinity of the water encounter and in the southern portion of the area next scheduled for mining. The latter is based on a few scattered well records and should be explored by drilling to clarify the existing information. Recommended locations for six exploratory holes are shown on figure 1 and numbered in the suggested order of drilling. Depending on conditions encountered at each site, it may be necessary to drill offset holes to clarify the geologic picture if unusual conditions are encountered. During the drilling, the glacial soils should be carefully logged and water levels measured where ground waters are encountered. Electric logging of the open rock holes would be in order if water is encountered in the rock and stands in the hole. The logging would identify the water producing zone or zones missed or mudded off in the drilling process.

A change in exploration hole plugging practices is recommended to obtain better assurance that abandoned holes do not act as avenues for the migration of ground waters. Waterbearing and suspected waterbearing beds within the consolidated rocks should be isolated above and below each zone with a waterproof "bridge" and at least 3-feet of cement grout placed on the top of each bridge. Normal well cementing practices allow 72 hours between operations after placing cement grout. Where "high-early" cement is used the time period is reduced to 48 hours. In any event, each hole should be bridged 3 to 5-feet below the "Drift" to rock contact and cement placed to backfill the hole from the bridge to the top of the rock.

The decrease in the amount of water entering the mine has delayed the urgency of a decision on how to handle this or other flows entering the mine. With the "reprieve" in time, it is recommended that:

1. The exploration holes be drilled and the data analized.
2. Run such elevation surveys as necessary and program future mine floor elevations (based on holes in 1. above) to construct a "drainage map" of the mine. Select locations for future sumps that can recieve mine waters by gravity.
3. As the need arises install pumping stations to remove waters from the sumps. Consideration should be given to water removal with turbine pumps installed in wells drilled into the sump from the overlying land surface. Such facilities might involve more expensive pumping units but would be advantageous in minimizing pipeline needs, potential flooding out of power lines and/or motor. They might also prove invaluable in emergency rescue operations.

4. Future mining areas should be explored by drilling on a more orderly pattern than appears to have been practiced in the past. The pattern should be adjusted to the parcel under consideration but basically a 400 to 500 grid spacing would be in order. This will permit evaluating ore quality and quantity, roof thickness variations, evaluation of water conditions, and programing of mining proceedure, drainage provisions etc.
5. Limits of mining operations should be based on the roof conditions as well as quality and quantity of ore. Depending on the types of rocks, their thickness and structural characteristics, the presence or absence of porosity and water, it appears that 15 to 20 feet of consolidated rocks in the roof is minimal. Where there is evidence of porosity, water and waterbearing soils resting on the bedrock, the roof thickness design should be increased, perhaps into the range of 30-35 feet.

In summary, the investigation has indicated the source of the waters entering the mine is the waterbearing glacial soils which overlie the consolidated rocks. The present information indicates the water enters the consolidated rocks - and gypsum bed - through natural features such as joints, fractures and solution openings. The hazard of encountering additional water is ever present. The probability of encountering water increases as mining progresses toward the "pinch out" of the gypsum bed or the thickness of consolidated rocks in the roof diminishes. The method of removal is largely a matter of economics. The best method lies in developing a mine drainage plan to be used if water is encountered after efforts to avoid it through plans developed from exploratory drilling fail.

If after review of this report any questions arise or clarification is needed, please feel free to schedule a conference at your convenience. I thank you for the fine cooperation throughout the study and the opportunity to be of service. If I may be of further service in this or other matters please contact me.

Yours very truly,

Edward M. Burt

Edward M. Burt

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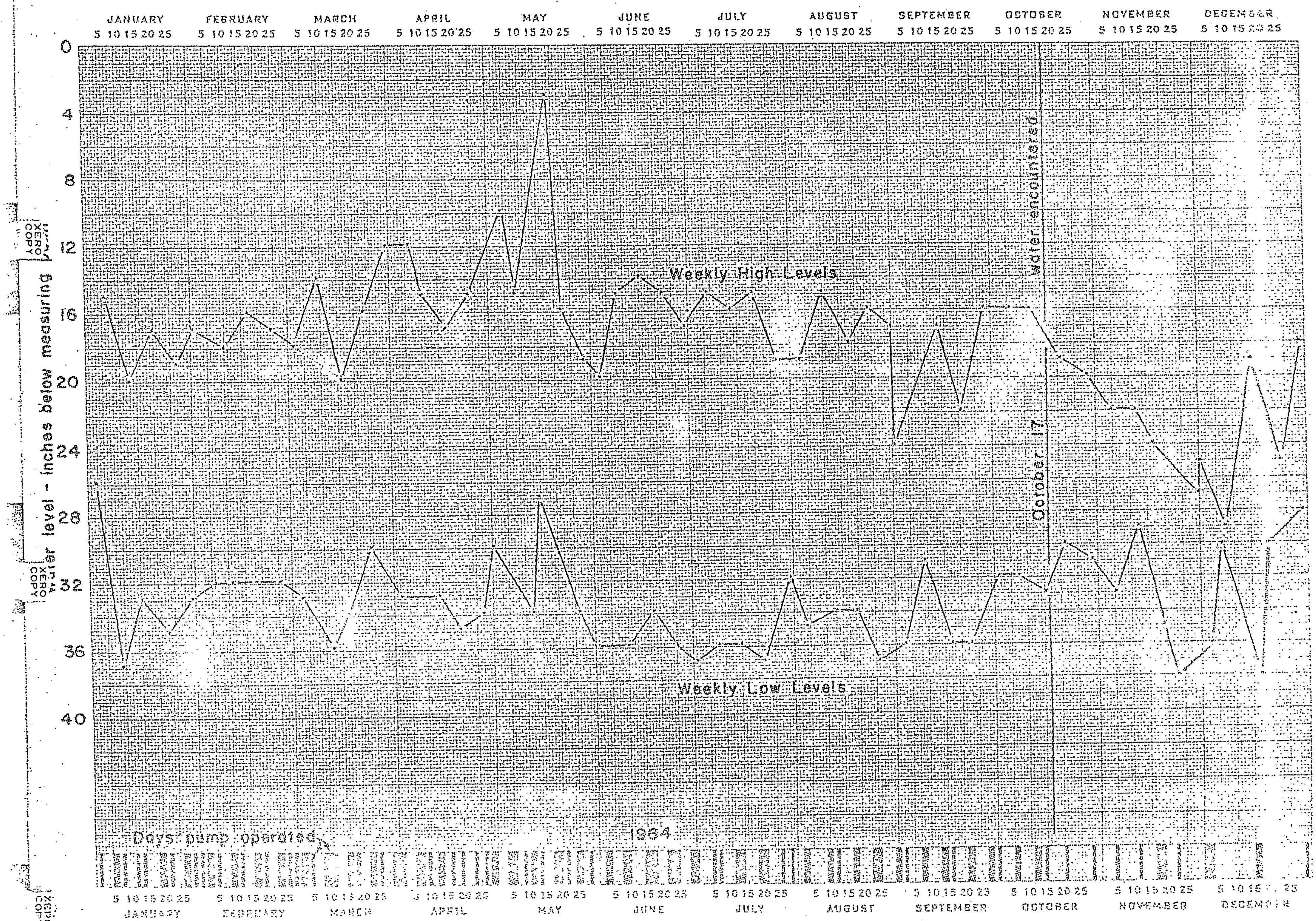


Water Levels at Pittsburgh Shaft

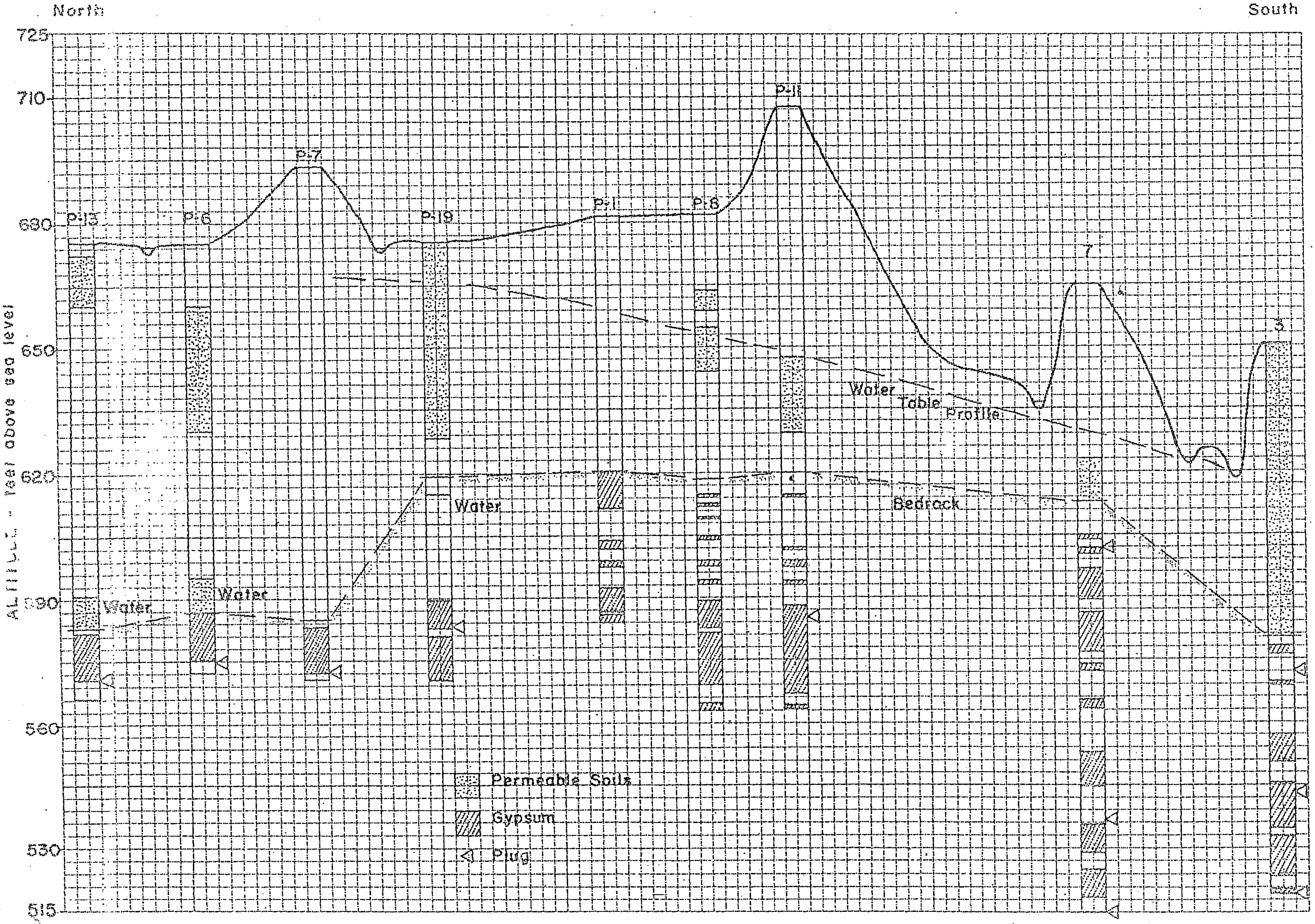


Fig. 3 - Section A - A' Paralleling Stream

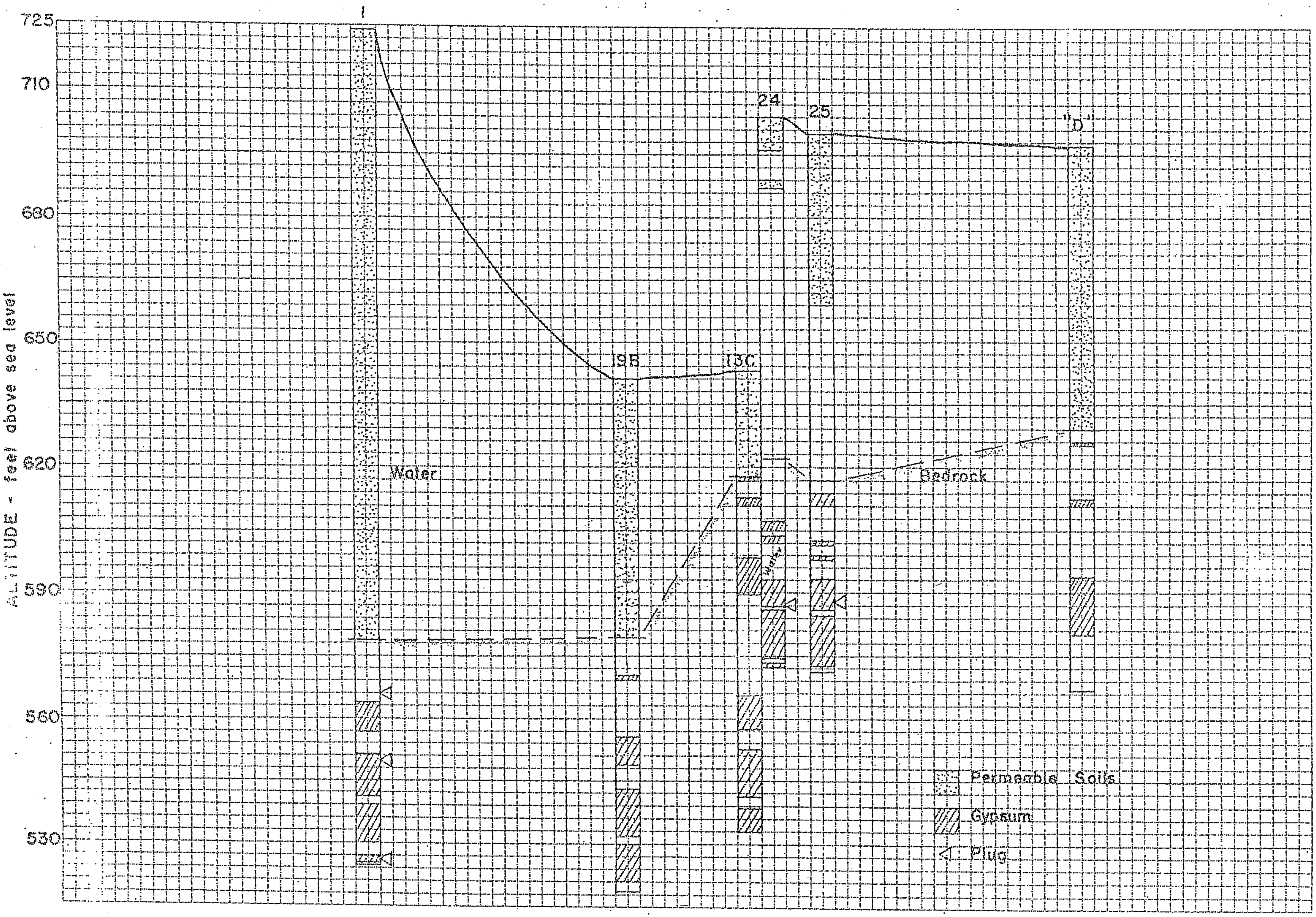


Fig. 4- Section B - B' East - West thru Water Problem Area.

APPENDIX D

INTER-OFFICE MEMOS ON RESERVE ESTIMATES AND MINE PLANS (2000, 1999, AND 1996)

The floor of seam #4

The dolomite and shale impurities are very harmful in board making process. An early analytical report of thin section indicated that the floor dolomite (to some extent the uppermost silstone layer) is rich in iron (see attachment 1). Another report referred to paper-to-core bond problem. The X-ray analysis showed presence of small quantity of iron whenever there were bond problem (see attachment 2). In addition, when the chloride level at the face is already at 16 oz/ton level, these two impurities can itself carry chloride at 100 oz/ton. The shale is possibly the major culprit causing the board core to be soft and causing the moisture absorption problem.

There is a way to physically separate the ore body from floor. Ideally, usage of an undercutting machine before blasting will be the most suitable tool. A similar undercutter to this one is used in the Blue Rapids underground mine.

At the present time the mean to separate the gypsum from the floor is blasting. Since the floor dolomite is only 03 to 0.5 foot thick, the blast shatters it and some underlaying shale. The skill and experience of the scooptram's operator is vital to leaving the floor in place.

The interbed in the Bi-level Area

The floor impurities of seam #4 build the upper part of the interbed shale which is 1.5 to 3.0 feet thick. All the above said conclusions are relevant to this layer. After several trials an acceptable blasting pattern was established to remove the shale. However from time to time it is necessary to re-blast the shale to get cleaner cut. Usage of an undercutting machine to make pre-cuts in gypsum itself would be very beneficial. The shale is removed by a modified backhoe.

The floor of seam #5

There is the same problem with the floor as it is at the seam #4. Only dolomite was replaced with a 0.3 foot thick of sandstone. The sandstone can cause a grinding problems in the mill because it is a hard rock.
At present moment the mine plans to eliminate this problem by gradually leaving about a 1 foot of gypsum in the floor in all headingsi of the Bi-Level Area. Lack of experience to control the floor level prevented to do that earlier.

The anhydrite zone's

The anhydrite zone in the eastern part of the mine is associated with extremely high chloride concentration. The mine plans to pass underneath (e.g. Bi-Level Area) or selectively cut through this zone (e.g. 50E47N face).

Proposal

There are about 400 tons of rock from Bi-level and 600 + tons from #4 bed in temporary stockpiles nearby the feeder-breaker.

- send this rock to the mill with blend ratio 9 to 1 (bed #5/bed #4)
- move the feeder-breaker to 61E40N location that daily rock production can be done by one scooptram operator; all material is already on site.
- narrow the mine front in the Bi-Level Area to 450 feet (from 60E to 69E drift)
- gradually leave a 1 foot of gypsum in all headings in the Bi-Level
- break through each second crosscut to speed up the eastward advances.
- push the A drift until it pass the anhydrite zone; sent the rock to the surface stockpile

The size of the mine manpower will depend on the rock production' target set for the mine .

Option I

two production days/week	39,520 tons/year
surface stockpile	15,600 tons/year

39,520 tons equals 760 tons/week. This amount does not take recycled and synthetic gypsum into account therefore it keeps a safe margin for rock demands.

To speed up breaking through the anhydrite zone in ore body, rock from designated headings with higher chloride content (e.g. 50E47N) will be shipped to the rock stockpile on surface and left for the leaching process. To achieve the target of 15,600 tons/year the mine will ship 150 tons twice a week to fill in the mine rock bin. This amount of rock is enough to fill in the mine rock bin's capacity. Subsequently the truck driver can move this rock to stockpile between his trips to haul the Michigan Gypsum without any time delay.

1.) - Single shift, 5 days per week schedule: four days 10 hrs and 1 day 8 hrs
- 2 days full production day; .5 day for maintenance on rock handling system.

2.) Manpower:

4 production workers
2 mechanics

This option will keep the mine open and all mine equipments will be maintain.
If the market demands will increase the mine can increase its production.
The mine would work in a capacity of a back-up rock supplier if problems were occurred with the Michigan Gypsum rock or with its logistics.

Option II

Partial rock supply to both Board Plants.

East Plant	39,520 tons/year
West Plant	40,000 tons/year
Surface stockpile	up to 10,000 tons/year
Total annual Tonnage	89,520 tons

89,520 tons per year equals to 1722 tons per week. The rock production costs will be kept at $10/ton including rock haulage to the plants.

1.) - Single shift, 5 days per week schedule: four days 10 hrs and 1 day 8 hrs
- 1 day for maintenance on rock handling system.

2.) Manpower:
6 production workers
1 leadman/mine technician
2 mechanics

3.) pursue the possibilities to utilize an undercutter machine in mining our rock.

Rock quality targets.

For both options the rock quality should be as follow:

purity range	81 to 88% with average 84+%.
chlorides content range	16 to 24 oz/ton with average below 20 oz/ton.
chloride range for rock to the West Plant	12 to 20 oz/ton with average 16 oz/ton.

Subsequently, as the mine advances to the East, all produced rock should meet the requirement 16 oz/ton or less for the chloride content.

Rock from faces that show more then 25 oz/ton in combine rock tests should be divert to the surface stockpile.

The Michigan Gypsum rock

At the present time, it is favorable option to use this rock. However there may be more than a few set-backs. As it was mentioned above, the control over rock supply and all of its logistics will be limited. Bad weather (cold or to wet) may hinder the rook feed to the mill as the West Plant experienced last year on a couple occasions.

The fine material has about 80% purity and the solid rock about 83% to 88% with the chlorides in the single digits. However; geologically this ore is coming from a gypsum deposit which is part of Michigan Formation. Our ore deposit belongs to this same period. Thus we may expect some unfavorable swings of chloride content in the Michigan Gypsum rock as it was true in our rock (see attachment 3).

On the other hand, since both deposits are related they can gradually supplement each other after our mine upgrades its own ore. Both rock can be blend together in a controllable manner that the chloride content will be below 10 oz/ton.

This proposal was compiled based on data and facts available at the time being and it tries to be as objective as possible. The mine has a lot of potential with its rock reserves. However, to utilize the potential everybody involved in this project has to make an extra effort to do it.

Mine Leader

Slavek Ochocinski

GEORGIA-PACIFIC
GRAND RAPIDS

INTER-OFFICE MEMO

To: Jim Price
Michael Pezzuto

Date: January 05, 2000

From: Slavek Ochocinski

cc: Jerry Lunn

Subject: Mine proposal to upgrade the rock quality from Grand Rapids Mine .

The basic question is what we can do with about 3, 930,500 tons of documented gypsum reserves lying a 0.5 mile from the Board Plant. For years we have been making a saleable product from our rock . Since the product(s) line was changed we experienced quality problems which are related to the chloride content level and lower purity of the mined rock. The easy answer is to close the mine and to get rock from outside and be at the mercy of the rock supplier, haulage contractor and the weather conditions.

There is another solution which bears some risk but its free from above said concerns. Everybody agrees that customers have to be satisfied with our product(s). We have to use only valuable components to make a good board.

Believe it or not, our gypsum is a one of them. I would like to present a few data to prove it. However the imperative shall be to learn and execute better the process of "sorting the wheat from the chaff"..Based on rock samples from the headings and the diamond drill cores, gypsum has 95 % purity in the seam #4 and around 90% in seam #5. It means that the gypsum itself is well developed ore deposit. The purity of our rock is higher than the pure Michigan Gypsum rock. With the exception of ore of the anhydrite zone, historical and recent data indicate that chloride content in the gypsum is in the single digits or less then 16 oz/ton. This is our "wheat".

Now it is coming the "chaff" story. The bed #4 has two distinctive thin layers (0.3 to 0,1 inch thick) built of silstone or dolomite which are divided the seam into three sections. They have higher chloride content. Since they are thin layers, historically they had increased the chloride level of a couple of ounces/ton but they can lower the purity to 86% at faces with lower heights. The major sources harming the rock quality are:

- dolomite and shale in the floor of seam #4,
- this same dolomite and shale being an interbedded layer in the Bi-level Area,
- sandstone and shale in the floor of seam #5
- anhydrite in the anhydrite zone.

What is important about the anhydrite presence is that any sign of it is associated with high concentration of chloride in adjacent areas. Even pure crystals of salt could be found there.

Quality of the mined ore.

Until 1988 the rock purity was at 82% and the chloride content ran from 8 to 15 oz/ton. Then while the mine front progressed eastward the chloride numbers went into the low twenties oz/ton. When the headings started to pick up traces of anhydride, the mine front was widened in the East and turned to the South. Thanks to good rock quality policy including rock sampling on each face and at least every 50 feet apart, the mine had maintained the chloride content at 22oz/ton for several years. Rock blending was essential.

In addition to mining bed #4, about 25% of production was coming from benching seam #5 - after shale in the floor was stripped by a bulldozer. The rock from bed #4 had have 80% purity and chloride content less then 17oz/ton.

From time to time there were lapses in the rock purity, due to lower mining heights (9 to 9.5 feet thickness of gypsum deposit) and taking too much shale from uneven" rolling" floors. Shale in general is relatively soft rock.

The floor shale, besides hampering the purity, was an additional source of higher chloride content.

The mine has always been under the obligation to tailor its production to deliver the best quality rock with the lowest chloride content. After awhile the mine's eastward advances ended up with 1,000 feet wide front with anhydrite in the faces. A major portion of the mine reserves was cut off due to anhydrite in the top two sections of the #4 bed. The mine front with all of its logistics was turned into the North and NorthWest direction.

The rock quality target was set at 82% +/- 5% for purity and 22oz/ton +/- 5 oz/ton for chloride concentration.

Mining Method: - Bi-Level Mining.

In the middle 90-ties the mine has started to develop a Bi-level method to see if there are possibilities to break though the anhydride zone to the East.

The Bi-level method explores the bed #5 and the bottom section of bed #4. It is crucial to remove the interbedded shale as cleanly as possible before attempting to blast the gypsum layers at the face. After numerous trials the mine established a drilling pattern to blast the shale successfully .

A new face drill for drilling high profile headings was purchased. A backhoe, with modified boom to scrape the blasted shale, was also acquired.

The Bi-level method allows mining underneath the anhydrite zone to reach the other side of the said zone and return the mining of bed #4 to full height.

There is additional future benefit of the Bi-Level method. It creates a possibility to mine the two beds concurrently as one face. Each blast will yield about 225 tons with purity around 90% and chloride content less than 16 oz/ton.

At the present time there are favorable signs that we are not too far from reaching the other side of the anhydrite zone. The 50E drift in bed #4 has only traces of anhydrite in the middle section. In the Bi-level, the face in 65E drift already includes the bottom and the middle section of the #4 bed.

A couple of short trial tests from single faces (66E46N, 65E46, 64E45), including 100 tons of rock per test, showed purity from 84% to 88%. Our lab results showed the chloride content in the middle twenties oz/ton.

G-P Decatur Lab ran check- tests for a landplaster made from our rock on 11/18, 11/19 and 11/20/99. The mine rock blend consisted of 80% from Bi-level area and 20% from #4 bed. The results were respectively: 82.08% and 18.88oz/ton, 75.58% and 24.64oz/ton, and 82.08% and19.78oz/ton.

Since October 1999 we gradually started to leave about a foot of gypsum in the floor. At the present time the following headings have gypsum floors deeper than 20 feet: 66E47N, 65E47N and 64E45N.
The following headings have first round gypsum floors: 63E44S, 44S63, 61E41S and 41S61E.

Keeping about 1 foot of gypsum in the floor and taking extra care in blasting and removing the interbedded shale should improve the rock quality as follows:

- purity range 82% to 87%; average 85%
- chloride content range 161 to 25 oz/ton; average 20 oz/ton

The chloride content level will steady decrease along the mine advances to the East. Eventually the rock quality will be as follows:

- purity range 82 to 88%; average 85%
- chloride content range 8 to 16 oz/ton; average 12 oz/ton.

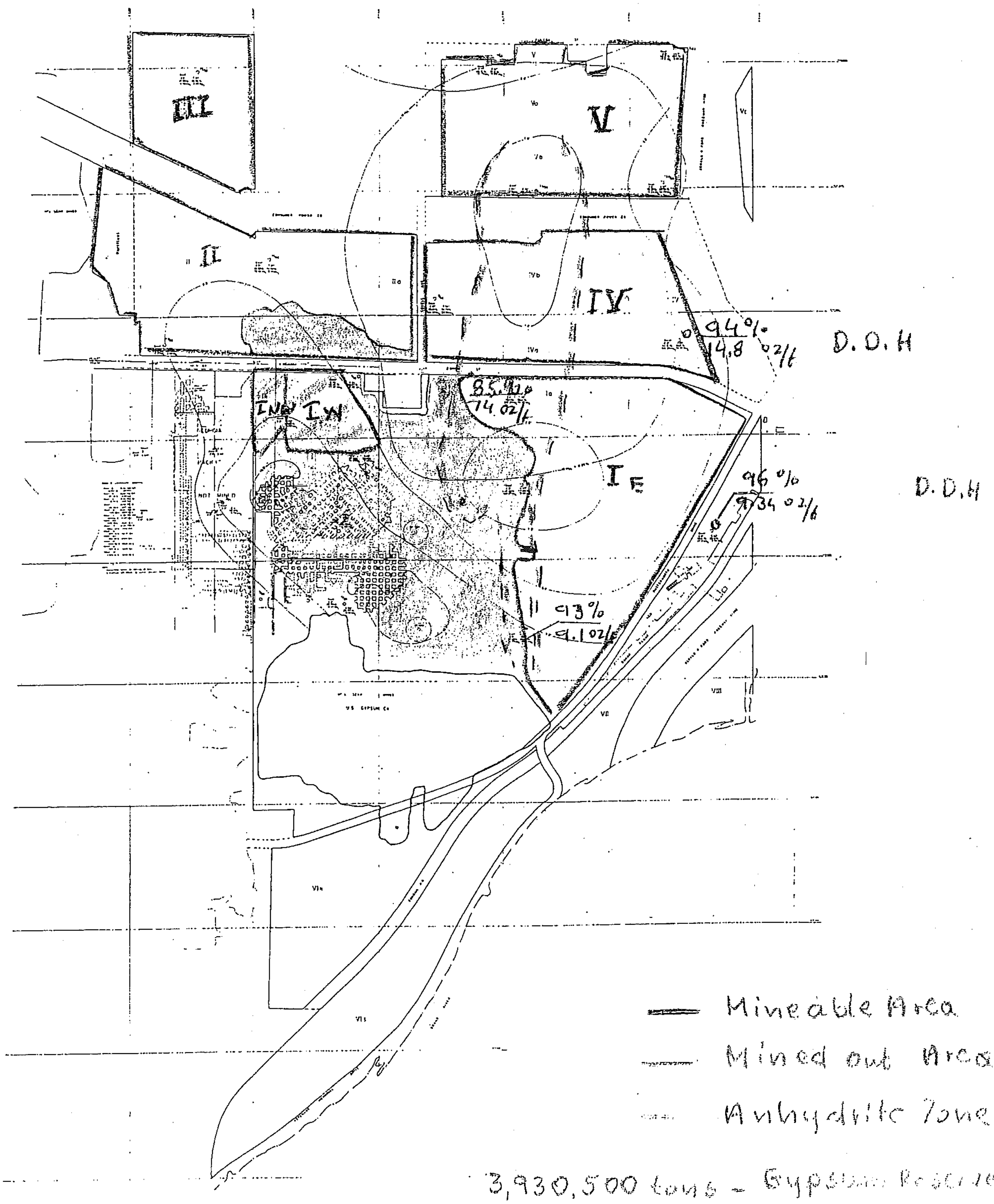
A detailed proposal of a mining plan to achieve the above targets will be forthcoming.

Mine Leader

Slavek Ochocinski

Grand Rapids Mine

Gypsum Reserves - 1999 YTD

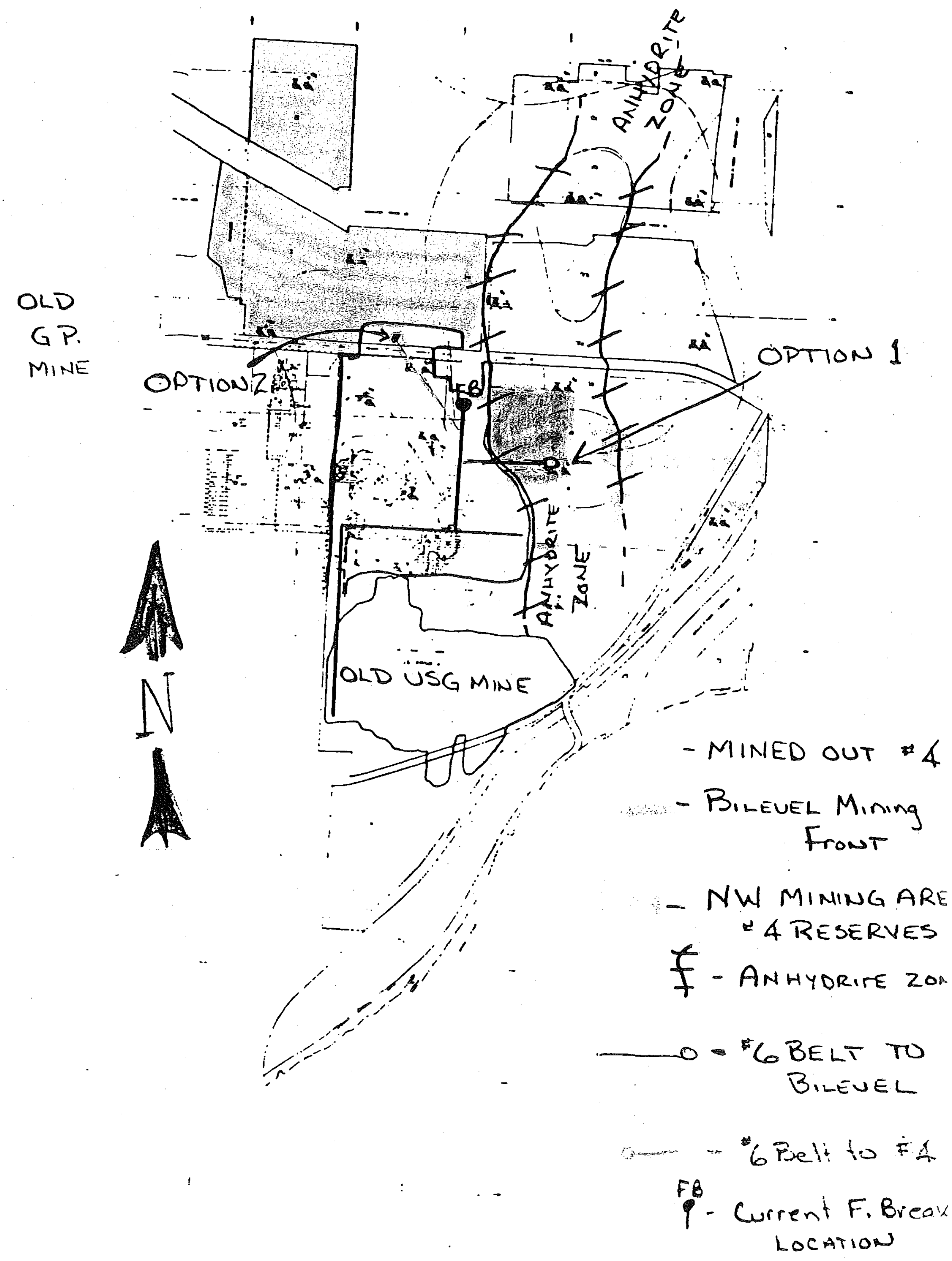


Mineable Area

Mined out Area

Anhydrite Zone

3,930,500 tons - Gypsum Reserve 1999 YTD


OLD G.P. MINE
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ANHYDRITE ZONE
ANHYDRITE ZONE
OLD USG MINE
N
- MINED OUT #4
- BILEVEL Mining Front
- NW MINING ARE
#4 RESERVES
- ANHYDRITE ZON
- #6 BELT TO BILEVEL
- #6 Belt to #4
FB
- Current F. Breal
LOCATION

GEORGIA PACIFIC GYPSUM
GRAND RAPIDS
INTER-OFFICE MEMO

To: Felmer Cummins

Date: August 14, 1996
cc: Sylvan Lutey
Curt Riggen

From: Charlie Johnson

Subject: #6 Mine Conveyor @ the Grand Rapids Mine

In the past there was concern with the gypsum reserves at Grand Rapids when the large anhydrite zone was encountered to the east. The anhydrite zone cut off all mining to the east and forced all mining to the north west. While we are certain there is another side to the anhydrite zone to the east, we do not know where. A new mining procedure was successfully developed to mine the #5 bed and the bottom of #4 bed to enable mining underneath the anhydrite zone. Utilizing this mining method, reserves were calculated to be 4.6 million tons (30.5 years at 150,000 tons/year). With proven reserves and with slightly improved rock quality, this is the direction Domtar Gypsum decided to go in 1995.

#6 conveyor was to be installed running west to east enabling the feeder breaker to be located on the new mining front. All material is purchased and on site. The installation is 90% completed. With the purchase of Domtar Gypsum by Georgia Pacific Gypsum, work on the conveyor was halted, while a decision whether the mine would remain open was pending.

As there have been indications that the mine will continue to operate, a conveyor belt installation must be completed to maintain haulage efficiency and reduce maintenance costs. There are two options:

OPTION #1: Complete the installation to the East with 100% mining at the lower mining horizon.

* Completion cost would be minimal. Set the tail pulley, install belting, complete electrical wiring and move the feeder breaker ($4000 to $6000.)
* Guaranteed long term reserves.
* Consistent rock quality - Purity - 79 to 83%
  Chlorides - 18 to 28 oz/ton
* Removal of the shale interbed is very labor intensive and requires additional drilling and blasting, rock cost per ton is $0.50 per ton more than only mining #4 bed. ($9.50 direct cost per ton)
* There are two long term benefits to this option:

1) Progressing to the east will eventually reach the other side of the anhydrite zone. At that point, both #4 and #5 bed can be mined concurrently. The larger heading will improve efficiency and rock quality. Reaching up to mine the top of #4 bed

increases mine reserves by 1.9 million tons or a total mine life of 43 years.

2) As originally planned mining to the east will bring the mine workings next to the mill rock silos. Excavating a shaft and installing a vertical conveyor would eliminate the need for trucking the rock to the plant.

OPTION #2: Extend #6 conveyor to the north west and mine #4 bed only.

* Current installation would have to be removed and relocated. Sufficient material is on site, but required labor for relocation and a longer conveyor would be much larger. Estimated cost would be $40,000.)

* In the #4 bed of the Grand Rapids Mine, there are no guarantees. Current best knowledge indicates the area minable to the north west contains 1.7 million tons of gypsum. However our history is that anhydrite can be encountered unexpectedly. In early July, a spot of anhydrite was hit at 84E 15. Not a confidence builder.

* Less consistent and lower rock quality.

Purity - 78 to 82%

Chlorides - 15 to ????. (We would work to maintain lower chlorides ranges, but we could be severely limited with what we have to blend with. Unlike the Kentwood mine, Grand Rapids has a soft floor and the floor rolls. Both of these factors negatively impact rock quality. Current mining has encountered severe rolling in the north west area and reports from the closed Georgia Pacific mine is the farther to the west you go the more like a roller coaster the floor gets.

* Although roof bolting will be required, mining #4 bed only will result in a lower cost per ton. ($9.00 direct cost per ton)

My recommendation is to follow option 1 and complete the #6 conveyor into the bilevel area. Waste removal will continue to be slightly more costly, but the benefit of more consistent rock quality to the plant will save in additives and board quality. However, the most important consideration is the variation of rock quality when mining #4 bed only and the uncertainty of encountering anhydrite at any time in the upper portions of #4. There is a projected future in bilevel mining. The only definite in mining #4 bed only is dirty and salty (not a good combination for us!)

Attachment 1

Thin Sections Summary Report

Grand Rapids, Michigan

Seven samples were submitted from the three interbeds that divide the gypsum units of the #4 Bed at Grand Rapids- Michigan. Another sample was submitted from the middle gypsum layer (#4 Bed). The uppermost interbed consists primarily of dolomitic litharenite (dolomitic sandstone). The middle interbed is an arenitic iron dolomicrite (sandy dolomite). The lowermost interbed is a dolomicrite (iron -rich dolomite). The sample taken from the middle gypsum unit of the #4 Bed consists of gypsum with about 2% finely-disseminated opaques (mostly pyrite, with limonite and hematite).

Mineral Assemblage

Three samples from the uppermost interbed contain:

	101B	103B	104B
1. Quartz	50%	40%	60%
2. Dolomite	39%	-	13%
3. Iron Dolomite	-	51%	2%
4. Gypsum	2%	4%	22%
5. Calcite	9%	-	3%
6. Accessories (Opaque-Pyrite)	-	5%	-

Two samples from the middle interbed contain:

	63D	107D
1. Quartz	35%	20%
2. Dolomite	13%	10%
3. Iron dolomite	32%	65%
4. Gypsum	20%	-
5. Accessories	<1%	5%

Two samples from the lowermost interbed contain:

	33F	101F
1. Quartz	3%	5%
2. Dolomite	63%	23%
3. Iron dolomite	30%	70%
4. Gypsum	2%	-
5. Accessories	2%	2%

The sample 98C (#4 Gypsum Bed) is 98% gypsum with 2% opaques (Pyrite).

The results indicate a progressive downward trend of the interbeds from arenitic (sandy) material through sandy dolomite to dolomite rock. The quartz grains are subangular to subrounded suggesting a sabkha environment of deposition. This would explain the high salt values obtained in the mine and its association with anhydrite.

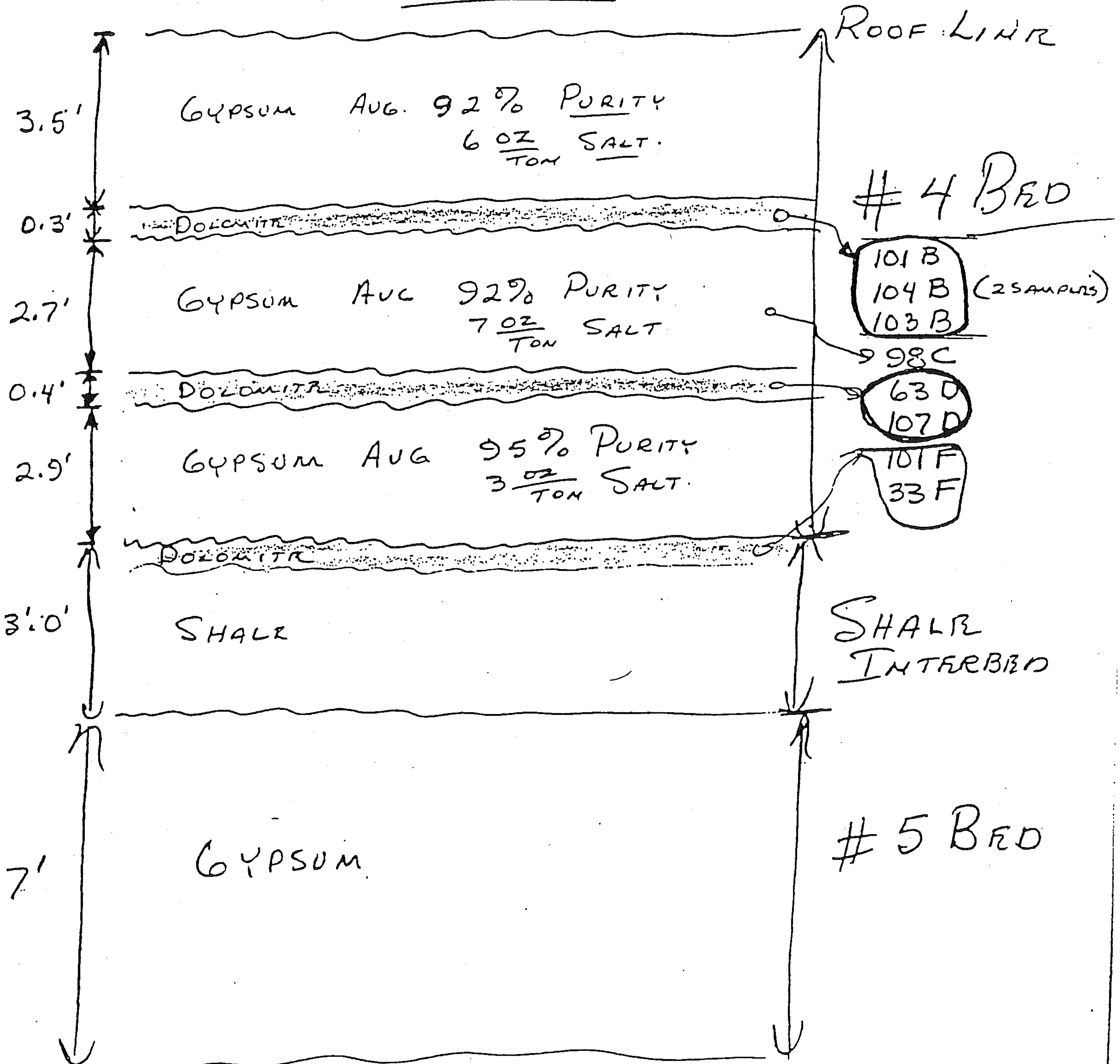
Note: The process by which these thin sections are prepared causes halite (salt) to dissolve out. Therefore these results do not include the relative percentage of salt. However cubic "holes" were observed in several sections indicating the presence of halite.

O I A

Mar. 18 1983

Samples From Grand Rapids, Michigan.

Section



Attachment 2

Domtar Inc. / Centre de recherches
Domtar Inc. / Research Centre

DOMTAR®

COURRIER INTERNE

To/À

R. Bruce

Date 23 Sept. 85

Ref./Réf.

CC/Copies R.J. Booth
[redacted]

From/De
F. Vrillaud

Subject/Sujet

GRAND RAPIDS GYPSUM BOARD PAPER-TO-CORE BOND
Project 85-7001-03

Four gypsum board samples, i.e. three with a bond problem and a fourth with an excellent paper-to-core bond, were examined by Scanning Electron Microscopy to try to shed more light on the "on and off" bond problem at the Grand Rapids plant. Examination of the boards with poor bond showed that the areas where the paper liner was no longer attached to the core were entirely covered with broken or poorly shaped crystals (see photographs). The good board on the other hand had gypsum crystals well developed which appeared to weave around the paper fibres at the paper-to-core interface. On the surface of the boards with no paper-to-core bond, the paper fibres have left imprints but have not adhered to the core. The broken crystal phenomenon noted on the boards with no bond, is only a few thousands of an inch thick, below that crust well shaped crystals can be seen. The X-ray spectrum of the crust indicates the presence of a small quantity of iron. Similar examination at the paper-to-core interface of the good board does not show any iron present. The only other elements displayed by the X-ray energy dispersive spectrometer are: aluminum, silicon, calcium, sulfur and the S.E.M. coating elements gold and palladium. It becomes then tempting to speculate that one of the possible substances responsible for the bond problem might be some type of iron compound, since the other elements found or the interface either make up gypsum or are commonly found in it, and are not known to affect the properties of gypsum boards. As an extension to this preliminary investigation it would be interesting to study the effect of some iron based compounds on gypsum crystal formation and growth.

It was not possible to determine the chloride content at the paper-to-core interface of the investigated board samples, because the amount of material that could be scraped off was far too small to carry out a meaningful test. Chlorides level determinations were performed on full thickness samples, and the results recorded in Table I show that the NaCl content is as high in the board with a good bond, as it is in the board with a poor bond. In this instance, it does not appear that chlorides are responsible for the poor paper-to-core bonds.

F. Vrillaud

F. Vrillaud

WC

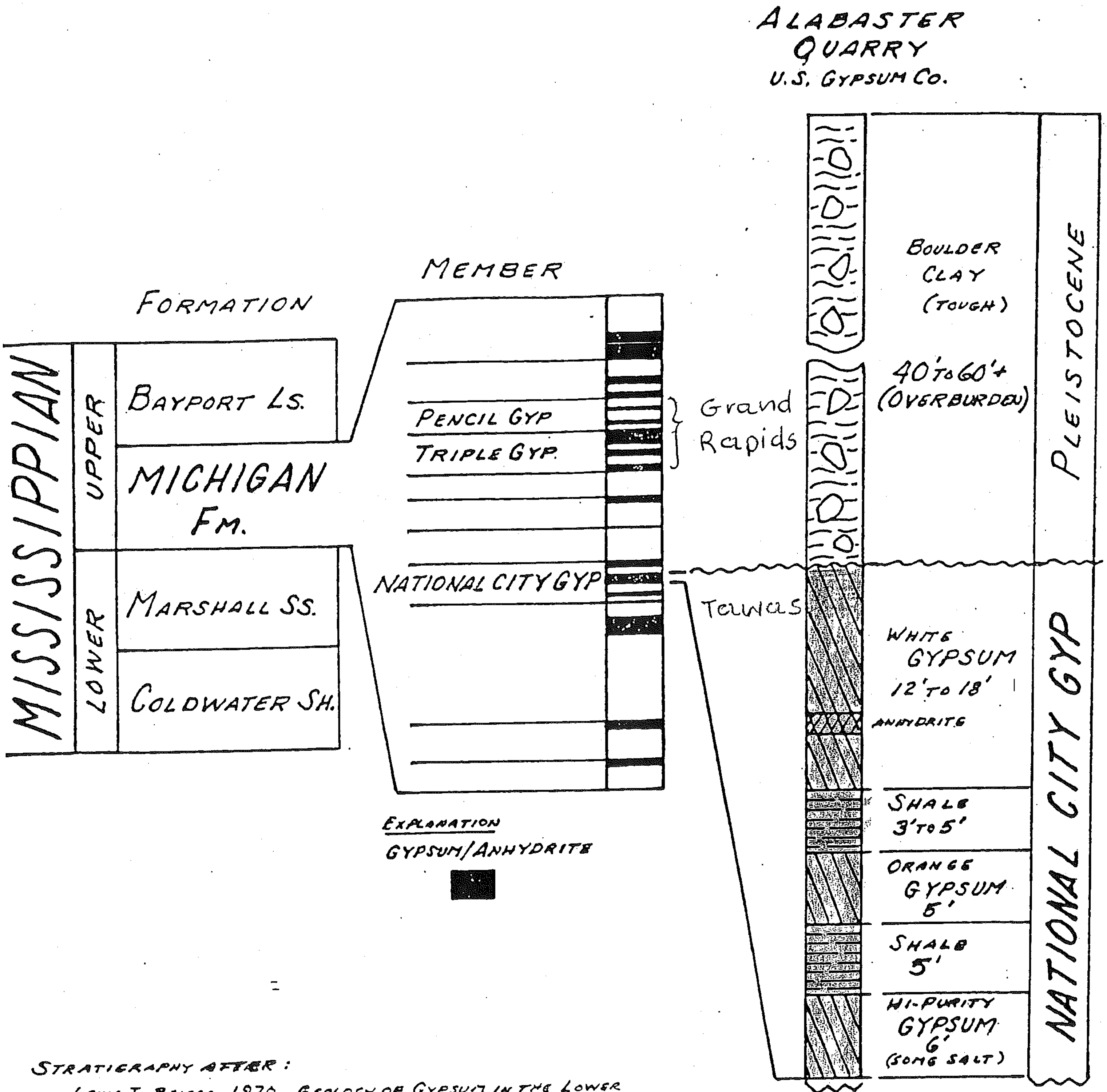
TABLE I

- GRAND RAPIDS BOARDS -

Chloride Levels

	Chlorides NaCl - oz/ton of Landplaster
Bad Board 85-08-15 21:00 (½" regular)	11.02
Bad Board 85-08-15 (⅝" F.G.)	9.28
Bad Board 85-08-15 (½" regular)	13.34
Good Board 85-08-24 8:30 (½" regular)	11.02

Attachment 3



STRATIGRAPHY AFTER:

LOUIS I. BRIGGS, 1970, GEOLOGY OF GYPSUM IN THE LOWER PENINSULA, MICHIGAN, PROCEEDINGS SIXTH FORUM ON GEOLOGY OF INDUSTRIAL MINERALS, MISC. 1, GEOLOGICAL SURVEY DIVISION, MICH. DEPT. NAT. RES.

A. H. STEVENS, 1968, ECONOMIC POTENTIAL ON MICHIGAN'S GYPSUM DEPOSITS, CONSUMERS POWER COMPANY, JACKSON, MICHIGAN.

STRATIGRAPHIC SECTION ~ GYPSUM QUARRY ALABASTER, S.E. IOSCO COUNTY MICHIGAN

GEORGIA-PACIFIC
GRAND RAPIDS

INTER-OFFICE MEMO

To: Jim Price
Michael Paused

Date: December 23,1999

From: Slavek Ochocinski

Subject: Grand Rapids Mine – Evaluation of Gypsum Ore Deposit.

The local gypsum ore deposit is part of Michigan Formation (Triple Gypsum - Member). The Grand Rapids Mine has about 3,930 500 tons of gypsum reserves if the Bi-level mining method will be the only one applied. At production level at 100 000 tons/year the mine life span will be 39 years. The rock production cost will be at $10 or less per ton including rock transport.

Quality of Gypsum Deposit.

There are two gypsum seams separated by 1.5 to 3 ft of shale: seam #4 and #5. Seam #4 is 9 to 11 feet thick with extra 2 feet left in the mine roof. Hundreds of rock samples have indicated that gypsum itself is about 95% pure. However two distinctive layers of siltstone and dolomite, 1 to 5 inches in thickness, degrade the purity to 86%. In the East part of the mine, gypsum converts into anhydrite. One foot layer of anhydrite appears in the center section of bed #4 and - to a lesser extent - another foot of anhydrite shows in the bottom of the upper section of the said seam.

The anhydrite zone runs in the North-South direction. Its Western edge is well know but its Eastern boundary has to be defined. Some mining headings that are cutting through the zone indicate no anhydrite (65E47N) or only small anhydrite nodules in the center of #4 seam (50E47N). Four cores from diamond drill holes in the Eastern side of the mine do not show any anhydrite presence and they have low chloride content.

The #5 seam (5 to 9 feet thick) includes random and irregular strikes of dolomite impurities but does not have any trace of anhydrite. Its purity is in a low range of 90% but it may be as low as 85%.

The chloride content distribution in seam #4 reveals a complex pattern. Historically gypsum in the two lower sections has had chloride in single digits with the upper section no more than in the middle twenties oz/ton. The high chloride content was coming from the two thin layers of impurities and from shale in the floor.

The #5 seam has showed less then 10 oz/ton.

In the Western half of the mine, chloride content in rock has been in the single digits or less then 16oz/ton. With the mine front moving eastward, the chloride concentration has progressively increased in gypsum in the center section of seam #4 and in the two adjacent layers of impurities. Subsequent headings have started to unveil traces of anhydrite. When they had struck a solid foot of anhydrite, the whole mining front was stopped.

DOMTAR GYPSUM
GRAND RAPIDS
INTER-OFFICE MEMO

To: H. Fields

Date: April 19, 1995
cc: S. Lutey
R. Hartviksen

From: Charlie Johnson

Subject: Grand Rapids Mine Gypsum Reserves

Attached are the project gypsum reserve calculations and maps delineating areas where the reserves can be mined at Grand Rapids. There are three sets of calculations based on the mining method.

Tabulation 1: Bilevel mining or the new mining method where all of #5 is mined with the bottom (E - gypsum) of #4.
4,573,384 tons @ 150,000 t/yr. = 30.5 years

Tabulation 2: Bilevel and high profile mining, where all of #5 and all of #4 are mined when the quality of #4 allows.
6,568,867 tons @ 150,000 t/yr. = 43.8 years

Tabulation 3: Old mining method, only #4 is mined with some areas of #5 benched.
1,713,570 tons @ 150,000 t/yr. = 11.4 years

Charlie Johnson

3,930,500 tons - Gypsum Reserves
1999 YTD

[illegible signature]

Grand Rapids Gypsum Reserves
1995 Revision

Version I: Bi-level mining method

Tab. 1

Mining Fields	Bi-level mining: #5 Seam			Bi-level mining: #4 Seam - "E" part			Combine Field Tonnage
	Width [ft]	Area [sq ft]	Tonnage [tone]	Width [ft]	Area [sq ft]	Tonnage [tone]	[tone]
I	6	3639040	919092.2	3	3639040	459546.1	
I West	6	394880	99732.66	#4	Seam	mined out	
I N-W	6	100480	25377.68	9.5	100480	40181.33	1543930
II	4-7	2526720	625309.2	3	2526720	319079.9	944389.1
*) III				9.5	983040	393111.6	393111.6
IV	4-8	2189440	573045.2	3	2189440	276487.4	849532.6
V	6-9	1838720	610222.7	3	1838720	232197.7	842420.4
Total		10689280	2852780		11277440	1720604	4573384

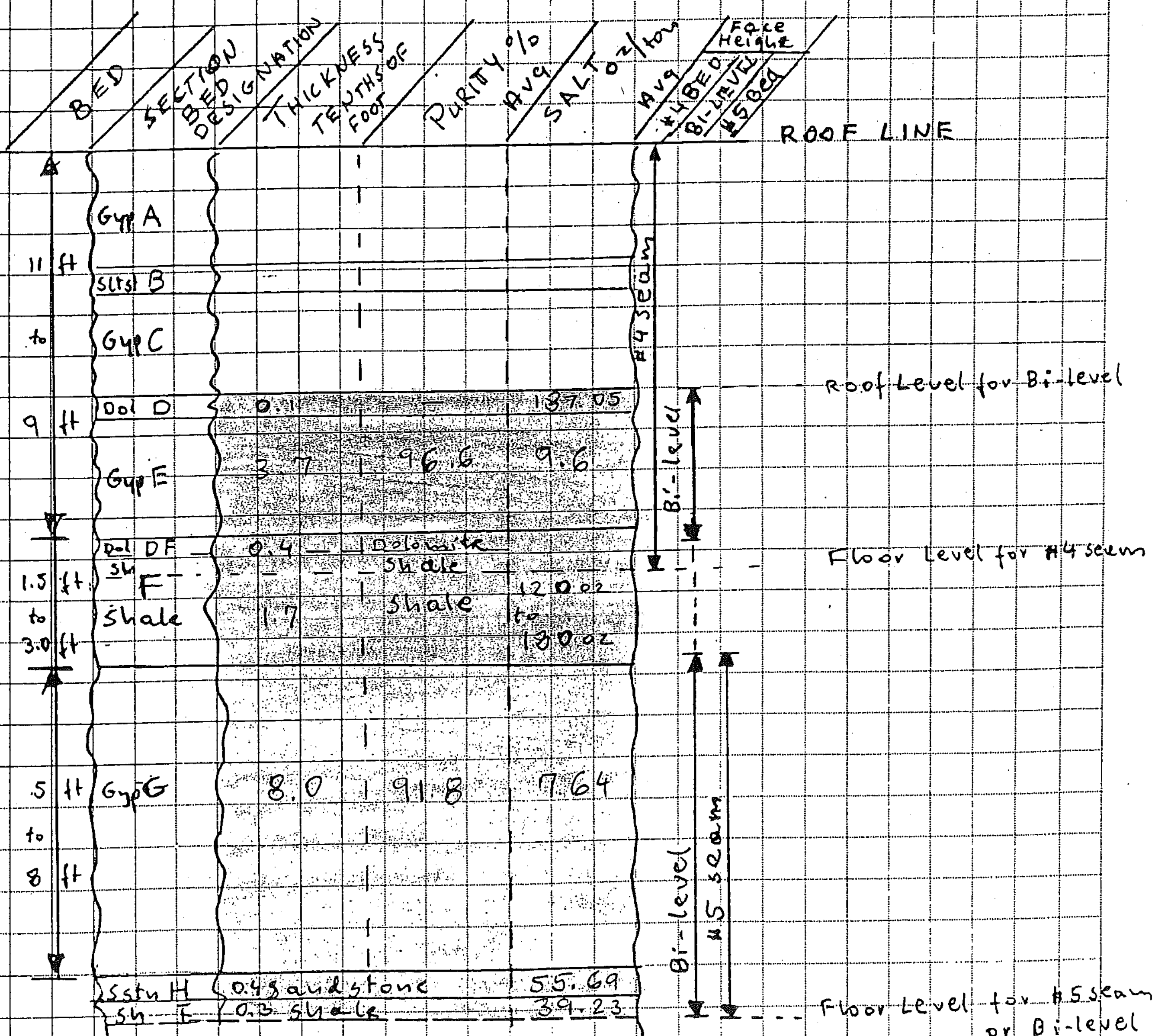
*) Drilling core data shows 5-6 ft of #5 seam.
Drilling stopped 5 ft below with no positive indication of #6 seam.

Calculating Factors:

tone conversion - 145 #/Cu.ft. = 2.3241tone/Cu.m.
Recovery - 64% -
NaCl Max - 0.05% (16oz/tone) not blended rock
- 0.14% (50oz/tone) for rock #4 seam if blended with #5

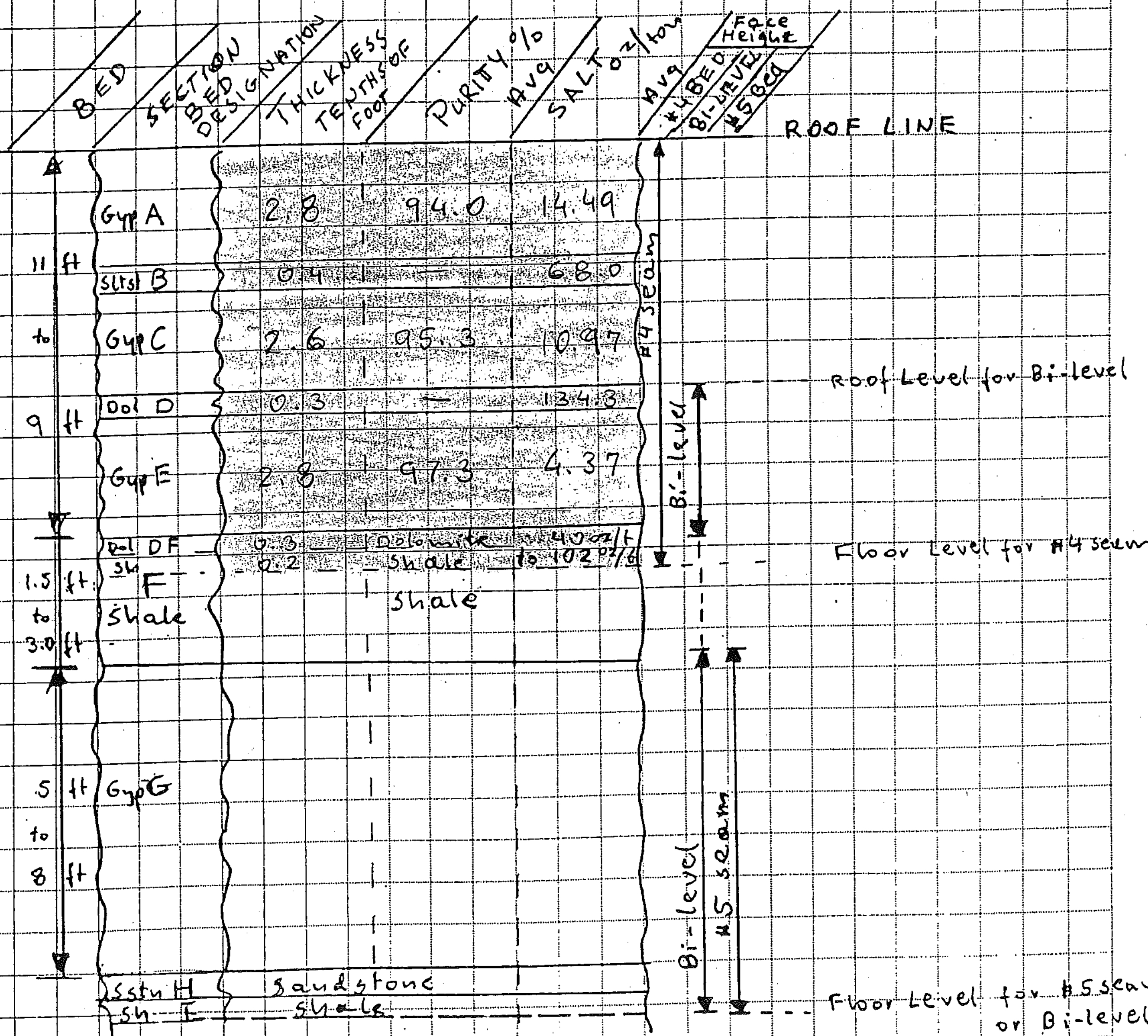
1999 Year

Section of Grand Rapids
Part E of #4 seam + #5 seam
Bi-Level Area



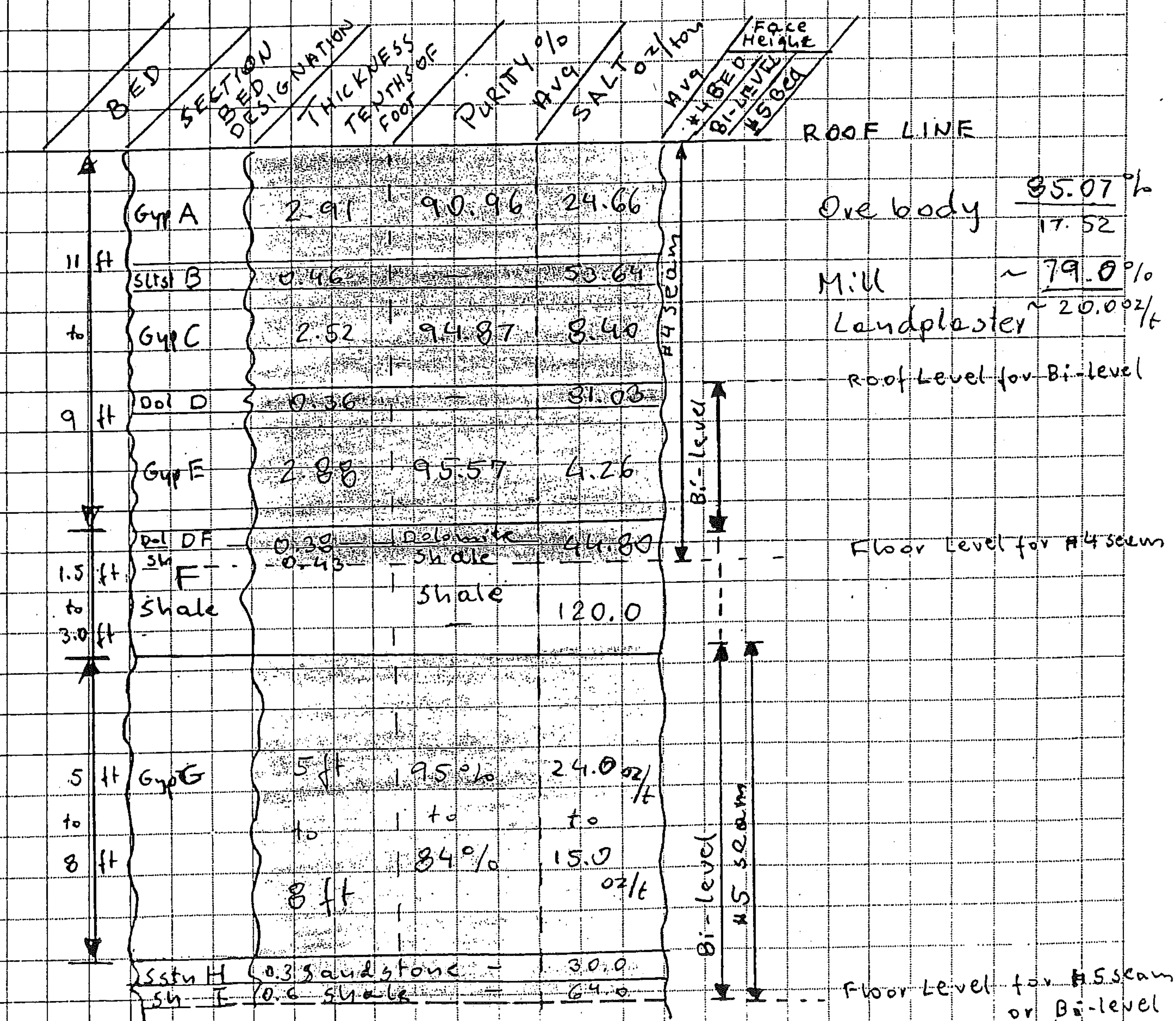
1999 Year

Section of Grand Rapids
#4 seam



Jan - March 1994

Section of Grand Rapids
#4 seam + #5 seam



1990 year

Section of Grand Rapids #4 seam

Bed	Section Bed Designation	Thickness Tenths of Foot	Purity %	Avg Salt oz/ton
11 ft to 9 ft	Gyp A	3.09	94.60	19.88
	Sltst B	0.57	—	84.50
	Gyp C	2.5	95.95	16.95
	Some Anh	(0.71)	(—)	(136.19)
	Dol D	0.23	—	110.79
	Gyp E	3.0	97.61	5.83
	Dol DF	0.38	Dolomite	73.24
1.5 ft to 3.0 ft	Sh F	0.37	Shale	
	F Shale		Shale	
5 ft to 8 ft	Gyp G			
	Sstn H	Sandstone		
	Sh I	Shale		

Face Height: Avg #4 Bed; Bi-Level; #5 Bed

ROOF LINE

Ore body: 85.60 %, 24.32 oz/t

Mill Landplaster: 83.12 %, 24.89 oz/t

Roof Level for Bi-level

Floor Level for #4 seam

Floor Level for #5 seam or Bi-level

#4 seam; Bi-level; Bi-level; #5 seam

1989 year

Section of Grand Rapids
#4 seam + #5 seam

Bed	Section Bed Designation	Thickness Tenths of Foot	Purity % Avg	Salt oz/ton Avg
11 ft to 9 ft	Gyp A	3.10	94.91	15.31
	Sltst B	0.49	—	72.96
	Gyp C	2.24	95.58	17.76
	Some Anh	(0.42)	—	54.43
	Dol D	0.22	—	123.31
	Gyp E	2.88	97.29	6.10
	Dol DF	0.40	dolomite	65.96
1.5 ft to 3.0 ft	Sh F Shale	0.38	shale / Shale	
.5 ft to 8 ft	Gyp G	5 ft to 8 ft	92 % to 85 %	5 oz/t to 10 oz/t
	Sstn H	0.3 sandstone	—	6.0
	Sh I	0.5 shale	—	25.0

Face Height: #4 Bed (#4 seam) / Bi-level / #5 Bed (#5 seam)

- ROOF LINE
- Roof Level for Bi-level
- Floor Level for #4 seam
- Floor Level for #5 seam or Bi-level

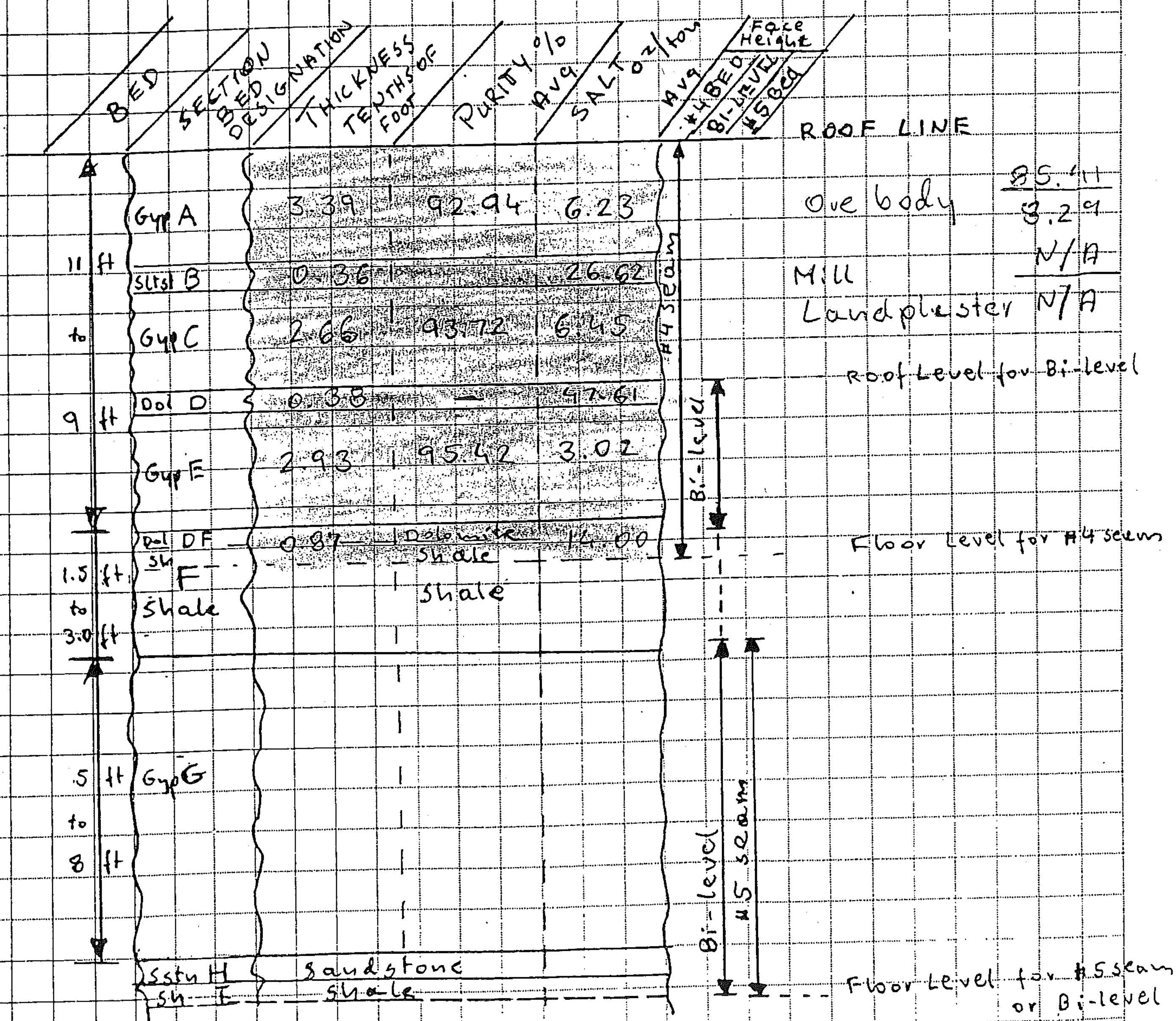
Ore body 86.50 % 21.24 oz/t

Mill 82.11 %

Landplaster 22.21 oz/t

1984 year

Section of Grand Rapids
#4 seam



Ore body 85.11
3.29

Mill N/A

Landplaster N/A

APPENDIX E

I-196 MDOT DEFLECTOMETER DATA

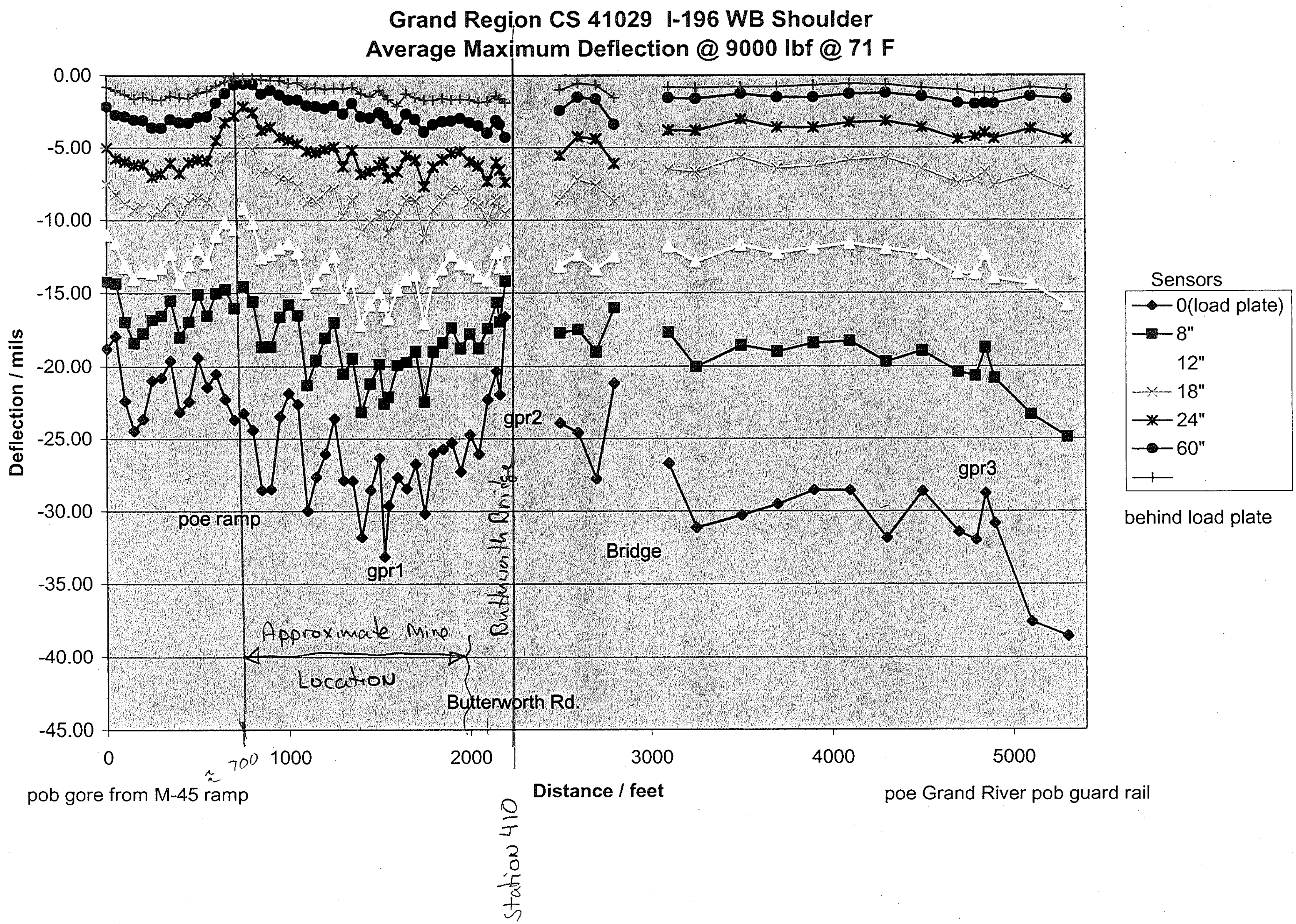
KUAB FWD FILE :	41029.FWD
Project :	Gypsum Mine Detection on I-196
Project Number :	
Route :	I-196
Direction :	WB shoulder
Location :	between Lake Michigan Dr. and Grand River
:	
Region :	Grand
Customer/Client :	MDOT
Operator :	K.Bancroft
Traffic Control :	S.Curtis
Pavement Type :	flexible shoulder
Environment :	partly cloudy,mild
Traffic :	heavy
Comments :	testing to locate void (gypsum mine)
:	
:	
Date Created :	9/10/02
Load Mode :	2 (3+3 buffers, 7 plates)
Plate Radius :	5.91 (in)
Extra Field Set :	FLEXIBLE
Drop Sequence :	2
No of drops :	3
Record Drop? :	Y
Drop Height :	1 2 3 4
Impact Load :	5000 9000 15500 20500 lbf
Sensor Number :	0 1 2 3 4 5 6 7 8
Sensor Distance :	0.00 12.00 12.00 8.00 12.00 18.00 24.00 36.00 60.00 (in)
Sensor Position :	CENTER FRONT RIGHT BEHIND BEHIND BEHIND BEHIND BEHIND BEHIND
Reference Offset :	0 ft
Testpoint spacing:	50 ft

Westbound

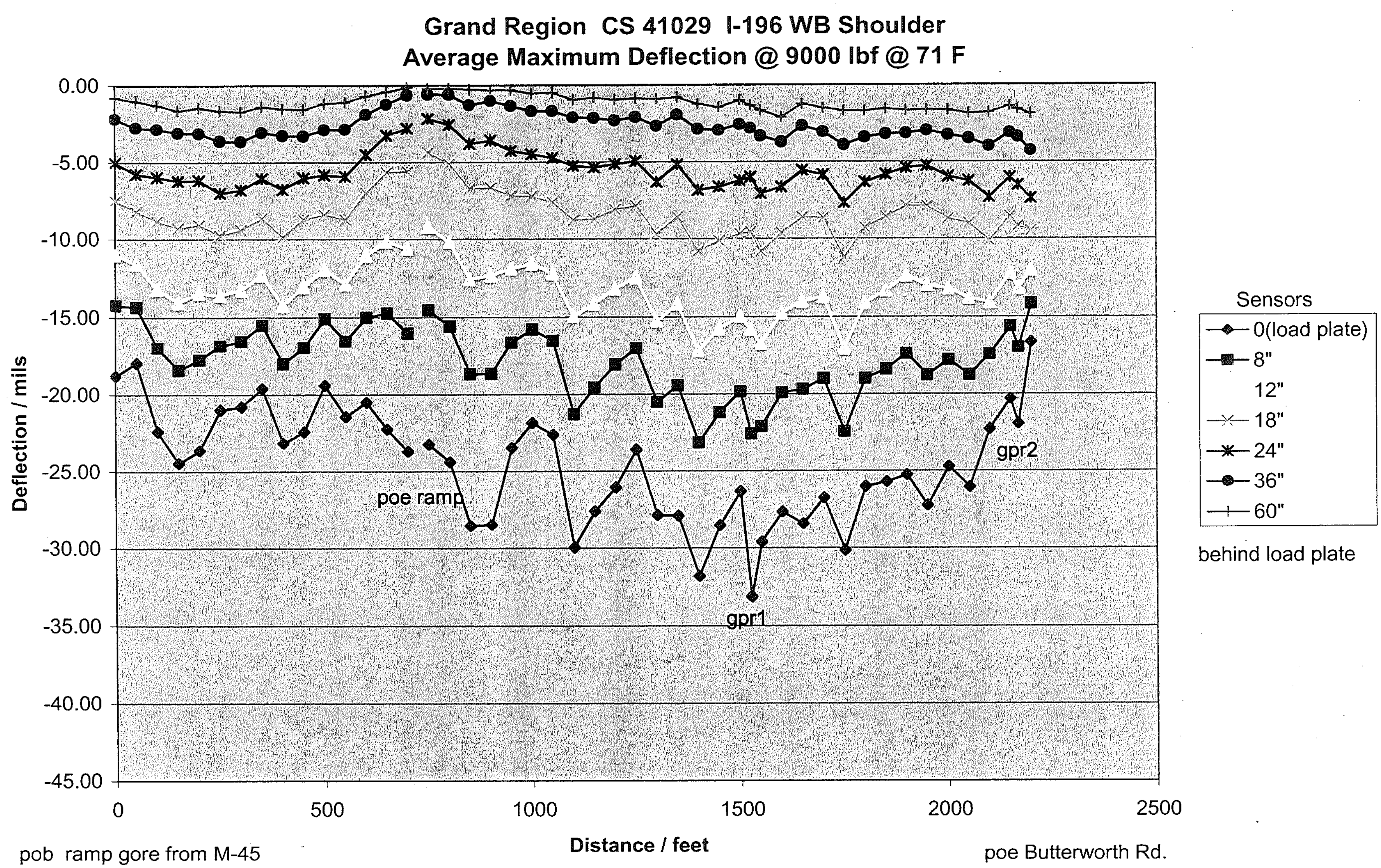
Distance ft	Load lbf	D0 mils	D3 mils	D4 mils	D5 mils	D6 mils	D7 mils	D8 mils	Air øF	Pave øF	Pvmt Cond	Pvmt Grde	Pvmt Crack	Crack Sevty	AASHTO Corrected Subgrade Resilient Modulus psi
	pob gore WB ramp from M-45														
0	9000	18.79	14.22	11.01	7.47	5.02	2.18	0.78	58	65	SHLD	CUT	NA	FLEX	5301
50	9000	17.96	14.33	11.62	8.18	5.75	2.75	1.01	59	66	SHLD	CUT	NA	FLEX	4843
100	9000	22.36	16.95	13.25	8.83	5.95	2.84	1.28	59	65	SHLD	CUT	NA	FLEX	4486
150	9000	24.44	18.40	14.07	9.27	6.19	3.08	1.61	59	66	SHLD	CUT	NA	FLEX	4273
200	9000	23.61	17.73	13.51	9.06	6.17	3.12	1.46	60	65	SHLD	CUT	NA	FLEX	4369
250	9000	20.98	16.81	13.64	9.73	6.98	3.60	1.62	61	66	SHLD	CUT	NA	FLEX	4068
300	9000	20.79	16.54	13.30	9.39	6.76	3.64	1.70	62	66	SHLD	CUT	NA	FLEX	4217
350	9000	19.59	15.48	12.34	8.64	6.04	3.04	1.38	62	67	SHLD	CUT	NA	FLEX	4585
400	9000	23.13	17.99	14.29	9.85	6.74	3.26	1.50	62	67	SHLD	CUT	NA	FLEX	4020
450	9000	22.40	16.93	13.08	8.71	6.00	3.29	1.54	64	67	SHLD	CUT	NA	FLEX	4545
500	9000	19.38	15.07	11.99	8.40	5.81	2.89	1.17	64	68	SHLD	CUT	NA	FLEX	4716
550	9000	21.42	16.53	12.92	8.73	5.91	2.85	1.07	64	67	SHLD	CUT	NA	FLEX	4538
600	9000	20.50	14.99	11.09	6.95	4.49	1.88	0.68	63	67	SHLD	CUT	NA	FLEX	5695
650	9000	22.23	14.72	10.16	5.65	3.24	1.23	0.42	64	68	SHLD	CUT	NA	FLEX	7013
700	9000	23.67	16.01	10.65	5.56	2.80	0.62	0.15	64	70	SHLD	CUT	NA	FLEX	5577
700	poe ramp from M-45		Lake Michigan Drive												
750	9000	23.21	14.53	9.21	4.34	2.16	0.58	0.20	66	70	SHLD	CUT	NA	FLEX	6452
801	9000	24.37	15.57	10.22	5.10	2.56	0.59	0.19	65	71	SHLD	CUT	NA	FLEX	5812
850	9000	28.52	18.64	12.62	6.71	3.78	1.28	0.27	65	71	SHLD	CUT	NA	FLEX	4708
901	9000	28.47	18.63	12.38	6.64	3.58	1.01	0.32	66	68	SHLD	CUT	NA	FLEX	4799
950	9000	23.46	16.61	11.95	7.15	4.24	1.35	0.33	64	69	SHLD	CUT	NA	FLEX	4972
1000	9000	21.83	15.77	11.63	7.19	4.47	1.68	0.53	65	70	SHLD	CUT	NA	FLEX	5106
1050	9000	22.60	16.50	12.26	7.58	4.71	1.68	0.49	64	69	SHLD	CUT	NA	FLEX	4846
1100	9000	29.93	21.26	14.97	8.77	5.24	2.10	0.92	63	70	SHLD	CUT	NA	FLEX	3968
1150	9000	27.59	19.52	14.20	8.71	5.35	2.13	0.82	63	68	SHLD	CUT	NA	FLEX	4184
1200	9000	26.03	18.05	13.23	8.08	5.12	2.30	0.93	62	67	SHLD	CUT	NA	FLEX	4489
1250	9000	23.57	16.99	12.53	7.82	4.93	2.08	0.85	62	67	SHLD	CUT	NA	FLEX	4741
1300	9000	27.85	20.47	15.31	9.69	6.29	2.67	0.89	61	67	SHLD	CUT	NA	FLEX	3880
1350	9000	27.88	19.40	14.20	8.58	5.16	1.93	0.79	62	67	SHLD	CUT	NA	FLEX	4182
1400	9000	31.78	23.11	17.24	10.79	6.81	2.87	1.24	62	68	SHLD	CUT	NA	FLEX	3446
1450	9000	28.52	21.17	15.83	10.12	6.60	2.95	1.45	63	69	SHLD	CUT	NA	FLEX	3753
1500	9000	26.31	19.81	15.01	9.67	6.21	2.57	1.00	64	71	SHLD	CUT	NA	FLEX	3958
1526	9000	33.10	22.53	15.86	9.54	5.99	2.83	1.32	63	74	SHLD	CUT	GPR1	FLEX	3744
1550	9000	29.60	22.08	16.79	10.82	7.04	3.32	1.65	62	73	SHLD	CUT	NA	FLEX	3539
1600	9000	27.63	19.89	14.80	9.62	6.62	3.72	2.10	63	68	SHLD	CUT	NA	FLEX	4013
1650	9000	26.41	19.67	14.07	8.60	5.55	2.66	1.25	62	70	SHLD	CUT	NA	FLEX	4223
1700	9000	26.72	18.97	13.77	8.64	5.85	3.07	1.50	63	68	SHLD	CUT	NA	FLEX	4313
1750	9000	30.14	22.41	17.10	11.22	7.64	3.91	1.69	63	69	SHLD	CUT	NA	FLEX	3474
1800	9000	26.00	18.96	14.14	9.29	6.33	3.42	1.69	62	68	SHLD	CUT	NA	FLEX	4202
1851	9000	25.70	18.37	13.38	8.58	5.83	3.20	1.57	63	68	SHLD	CUT	NA	FLEX	4441
1900	9000	25.25	17.37	12.42	7.83	5.40	3.16	1.66	63	69	SHLD	CUT	NA	FLEX	4784
1950	9000	27.23	18.76	13.02	7.87	5.27	2.98	1.63	64	72	SHLD	CUT	NA	FLEX	4562
2001	9000	24.70	17.78	13.25	8.69	5.97	3.28	1.66	65	70	SHLD	CUT	NA	FLEX	4482
2051	9000	26.04	18.73	13.86	9.00	6.24	3.50	1.86	65	70	SHLD	CUT	NA	FLEX	4287
2100	9000	22.27	17.41	14.13	10.12	7.29	3.99	1.80	64	69	SHLD	CUT	NA	FLEX	3912

2150	9000	20.33	15.61	12.25	8.55	6.02	3.14	1.38	64	71	SHLD	FILL	NA	FLEX	4630
2169	9000	21.93	16.97	13.24	9.20	6.52	3.40	1.60	65	69	SHLD	FILL	GPR2	FLEX	4304
2200	9000	16.63	14.16	12.05	9.50	7.35	4.28	1.88	65	76	SHLD	FILL	NA	FLEX	4039
2239	pob Butterworth Rd.														
2450	poe Butterworth Rd.														
2500	9000	23.89	17.72	13.22	8.56	5.56	2.44	0.99	65	73	SHLD	FILL	NA	FLEX	4494
2600	9000	24.56	17.47	12.40	7.16	4.23	1.50	0.55	66	72	SHLD	FILL	NA	FLEX	4792
2700	9000	27.73	18.98	13.40	7.57	4.39	1.63	0.66	67	74	SHLD	FILL	NA	FLEX	4432
2800	9000	21.15	15.99	12.51	8.66	6.09	3.40	1.52	66	74	SHLD	FILL	NA	FLEX	4571
2834	pob bridge														
3015	poe bridge														
3100	9000	26.67	17.69	11.84	6.49	3.80	1.55	0.80	66	74	SHLD	FILL	NA	FLEX	5017
3250	9000	31.10	20.00	12.87	6.68	3.82	1.62	0.84	69	79	SHLD	FILL	NA	FLEX	4617
3500	9000	30.25	18.57	11.73	5.66	3.05	1.25	0.78	69	78	SHLD	FILL	NA	FLEX	5063
3700	9000	29.49	18.98	12.28	6.44	3.61	1.52	0.79	70	81	SHLD	FILL	NA	FLEX	4836
3900	9000	28.53	18.43	11.92	6.27	3.62	1.51	0.67	70	79	SHLD	FILL	NA	FLEX	4983
4100	9000	28.53	18.28	11.60	5.88	3.28	1.28	0.55	70	78	SHLD	FILL	NA	FLEX	5121
4301	9000	31.82	19.64	11.96	5.72	3.18	1.22	0.62	71	79	SHLD	FILL	NA	FLEX	4965
4501	9000	28.59	18.92	12.29	6.43	3.61	1.46	0.84	72	81	SHLD	FILL	NA	FLEX	4833
4700	9000	31.41	20.37	13.63	7.42	4.40	1.92	0.97	71	82	SHLD	FILL	NA	FLEX	4358
4795	9000	31.94	20.64	13.66	7.15	4.23	1.99	1.19	71	81	SHLD	FILL	NA	FLEX	4350
4850	9000	28.74	18.71	12.37	6.64	3.98	1.93	1.16	71	80	SHLD	FILL	NA	FLEX	4801
4900	9000	30.81	20.79	13.97	7.55	4.36	1.96	1.20	73	83	SHLD	FILL	NA	FLEX	4253
5100	9000	37.57	23.29	14.37	6.82	3.71	1.45	0.81	72	83	SHLD	FILL	NA	FLEX	4133
5300	9000	38.55	24.87	15.87	7.91	4.41	1.62	0.98	71	82	SHLD	FILL	NA	FLEX	3744
5763	pob Grand River														
Average		**25.94**	**18.27**	**13.16**	**8.05**	**5.16**	**2.39**	**1.09**	**65**	**71**					**4564**
Stdev.		**4.45**	**2.37**	**1.61**	**1.49**	**1.33**	**0.93**	**0.49**	**4**	**5**					**631**
Max.		**38.55**	**24.87**	**17.24**	**11.22**	**7.64**	**4.28**	**2.10**	**73**	**83**					**7013**
Min.		**16.63**	**14.16**	**9.21**	**4.34**	**2.16**	**0.58**	**0.15**	**58**	**65**					**3446**
C. of V.		**17%**	**13%**	**12%**	**18%**	**26%**	**39%**	**45%**	**5%**	**7%**					**14%**
0	EB I-196 poe Grand River														
200	9000	27.95	21.21	16.53	11.26	7.79	3.86	1.72	69	77	SHLD	FILL	NA	FLEX	3517
400	9000	23.60	18.35	14.27	9.60	6.51	3.04	1.30	69	81	SHLD	FILL	NA	FLEX	4126
600	9000	27.03	19.32	14.13	8.39	5.18	2.30	1.20	69	82	SHLD	FILL	NA	FLEX	4205
800	9000	28.08	19.50	13.96	8.44	5.28	2.35	1.19	69	83	SHLD	FILL	NA	FLEX	4256
1000	9000	22.79	17.14	13.13	8.70	5.73	2.31	1.07	69	82	SHLD	FILL	NA	FLEX	4523
1200	9000	26.32	18.54	13.35	7.89	4.69	1.86	1.00	67	83	SHLD	FILL	NA	FLEX	4448
1400	9000	26.84	18.47	13.13	7.60	4.67	2.03	0.95	68	82	SHLD	FILL	NA	FLEX	4523
1600	9000	22.83	16.32	11.68	6.91	4.13	1.61	0.78	68	82	SHLD	FILL	NA	FLEX	5087
1800	9000	24.87	17.62	12.77	7.58	4.59	1.80	0.80	68	82	SHLD	FILL	NA	FLEX	4653
2015	9000	25.20	18.48	13.69	8.37	5.04	1.62	0.63	69	83	SHLD	FILL	NA	FLEX	4339
2200	9000	25.52	17.59	12.52	7.25	4.33	1.61	0.80	70	84	SHLD	FILL	NA	FLEX	4744
2400	9000	24.67	18.07	13.44	8.23	5.03	1.69	0.60	69	85	SHLD	FILL	NA	FLEX	4419
2600	9000	24.93	17.86	13.18	8.19	5.03	1.89	0.83	68	84	SHLD	FILL	NA	FLEX	4507
2767	pob bridge														
2943	poe bridge														
3000	9000	25.52	17.95	13.09	8.16	5.25	2.30	1.01	69	85	SHLD	FILL	NA	FLEX	4539
3200	9000	21.95	16.01	12.40	8.50	5.81	2.82	1.16	70	84	SHLD	FILL	NA	FLEX	4657
3358	pob Butterworth Rd.														
3564	poe Butterworth Rd.														
3600	9000	29.97	19.57	13.76	8.67	6.13	3.64	1.91	70	86	SHLD	FILL	NA	FLEX	4318
3700	9000	26.55	18.90	13.75	8.72	5.86	2.92	1.45	71	85	SHLD	FILL	NA	FLEX	4319
3800	9000	26.64	19.11	14.14	8.98	6.04	3.17	1.58	73	87	SHLD	CUT	NA	FLEX	4200
3900	9000	28.56	19.31	13.72	8.01	5.07	2.26	1.10	72	87	SHLD	CUT	NA	FLEX	4330
4000	9000	29.84	22.33	16.89	10.91	6.94	2.78	1.31	72	87	SHLD	CUT	NA	FLEX	3516
4100	9000	26.10	20.50	16.29	11.39	7.85	3.79	1.85	74	87	SHLD	CUT	NA	FLEX	3476
4200	9000	26.85	19.99	15.41	10.50	7.34	4.04	2.14	74	87	SHLD	CUT	NA	FLEX	3771
4250	9000	29.62	20.63	15.13	9.80	6.61	3.47	1.94	73	88	SHLD	CUT	NA	FLEX	3927
4300	9000	29.38	20.93	15.65	10.36	7.13	3.69	1.94	72	88	SHLD	CUT	NA	FLEX	3796
4350	9000	30.66	21.87	16.45	10.75	7.38	3.89	2.04	72	87	SHLD	CUT	NA	FLEX	3611
4400	9000	25.02	18.78	14.52	9.72	6.76	3.58	1.87	73	85	SHLD	CUT	NA	FLEX	4075
4451	9000	24.34	18.21	14.05	9.18	6.26	3.15	1.59	75	87	SHLD	CUT	NA	FLEX	4227
4500	9000	22.67	17.16	13.27	8.94	6.11	3.07	1.47	73	87	SHLD	CUT	NA	FLEX	4428
4600	9000	21.56	15.10	11.00	6.87	4.50	2.07	0.80	73	86	SHLD	CUT	NA	FLEX	5402
4650	9000	22.28	14.70	10.04	5.71	3.42	1.37	0.48	73	87	SHLD	CUT	NA	FLEX	5914
4700	9000	23.43	15.55	10.89	6.29	3.77	1.41	0.41	72	88	SHLD	CUT	NA	FLEX	5456
4800	9000	22.88	14.93	10.12	5.39	2.89	0.69	0.20	71	88	SHLD	CUT	NA	FLEX	5872
4900	9000	23.51	15.91	10.76	5.77	3.17	0.90	0.32	71	86	SHLD	CUT	NA	FLEX	5519
5000	9000	24.75	15.07	9.47	4.59	2.34	0.48	0.12	71	85	SHLD	CUT	NA	FLEX	6270
5100	9000	22.74	14.89	9.88	5.26	2.79	0.66	0.10	71	84	SHLD	CUT	NA	FLEX	6014
5200	9000	22.27	15.54	11.08	6.66	4.16	1.90	0.90	71	86	SHLD	CUT	NA	FLEX	5363
5300	9000	23.28	15.16	9.82	4.99	2.73	0.54	0.15	71	85	SHLD	CUT	NA	FLEX	6049
5400	9000	21.09	14.07	9.73	5.29	2.94	0.80	0.16	71	84	SHLD	CUT	NA	FLEX	6105
5500	9000	20.85	14.88	10.75	6.81	4.61	2.37	1.04	70	82	SHLD	CUT	NA	FLEX	5524
5600	9000	21.39	14.83	10.89	7.30	5.33	3.23	1.72	71	82	SHLD	FILL	NA	FLEX	5427
5650	9000	21.08	14.98	11.03	7.47	5.54	3.64	2.17	71	84	SHLD	FILL	NA	FLEX	5299

5664	9000	20.81	15.61	11.90	8.24	6.09	3.86	2.28	73	83	SHLD	FILL	NA	FLEX	**4808**
5700	9000	19.37	15.62	12.81	9.52	7.10	4.18	2.17	69	83	SHLD	FILL	NA	FLEX	**4161**
6200	9000	13.29	10.98	9.04	6.58	4.52	1.80	0.26	68	83	SHLD	CUT	NA	FLEX	**6021**
6300	9000	15.90	12.72	10.20	7.08	4.66	1.76	0.20	70	84	SHLD	FILL	NA	FLEX	**5591**
6400	9000	16.17	12.85	10.32	7.22	5.00	2.08	0.37	70	85	SHLD	FILL	NA	FLEX	**5482**
6500	9000	12.46	10.40	8.78	6.81	5.08	2.54	0.46	71	86	SHLD	FILL	NA	FLEX	**5818**
6600	9000	12.36	10.50	9.01	7.03	5.29	2.77	0.66	71	86	SHLD	FILL	NA	FLEX	**5611**
6700	9000	12.53	10.75	9.40	7.84	6.28	4.05	1.73	70	85	SHLD	FILL	NA	FLEX	**4729**
6800	9000	10.18	8.92	7.86	6.41	5.20	3.34	1.41	70	86	SHLD	FILL	NA	FLEX	**5715**
6871	poe M-45 W. edge														
Average		**23.17**	**16.67**	**12.38**	**7.92**	**5.24**	**2.46**	**1.11**	**71**	**85**					**4814**
Stdev.		**4.90**	**3.14**	**2.29**	**1.68**	**1.37**	**1.04**	**0.65**	**2**	**2**					**795**
Max.		**30.66**	**22.33**	**16.89**	**11.39**	**7.85**	**4.18**	**2.28**	**75**	**88**					**6270**
Min.		**10.18**	**8.92**	**7.86**	**4.59**	**2.34**	**0.48**	**0.10**	**67**	**77**					**3476**
C. of V.		**21%**	**19%**	**19%**	**21%**	**26%**	**42%**	**59%**	**3%**	**3%**					**17%**

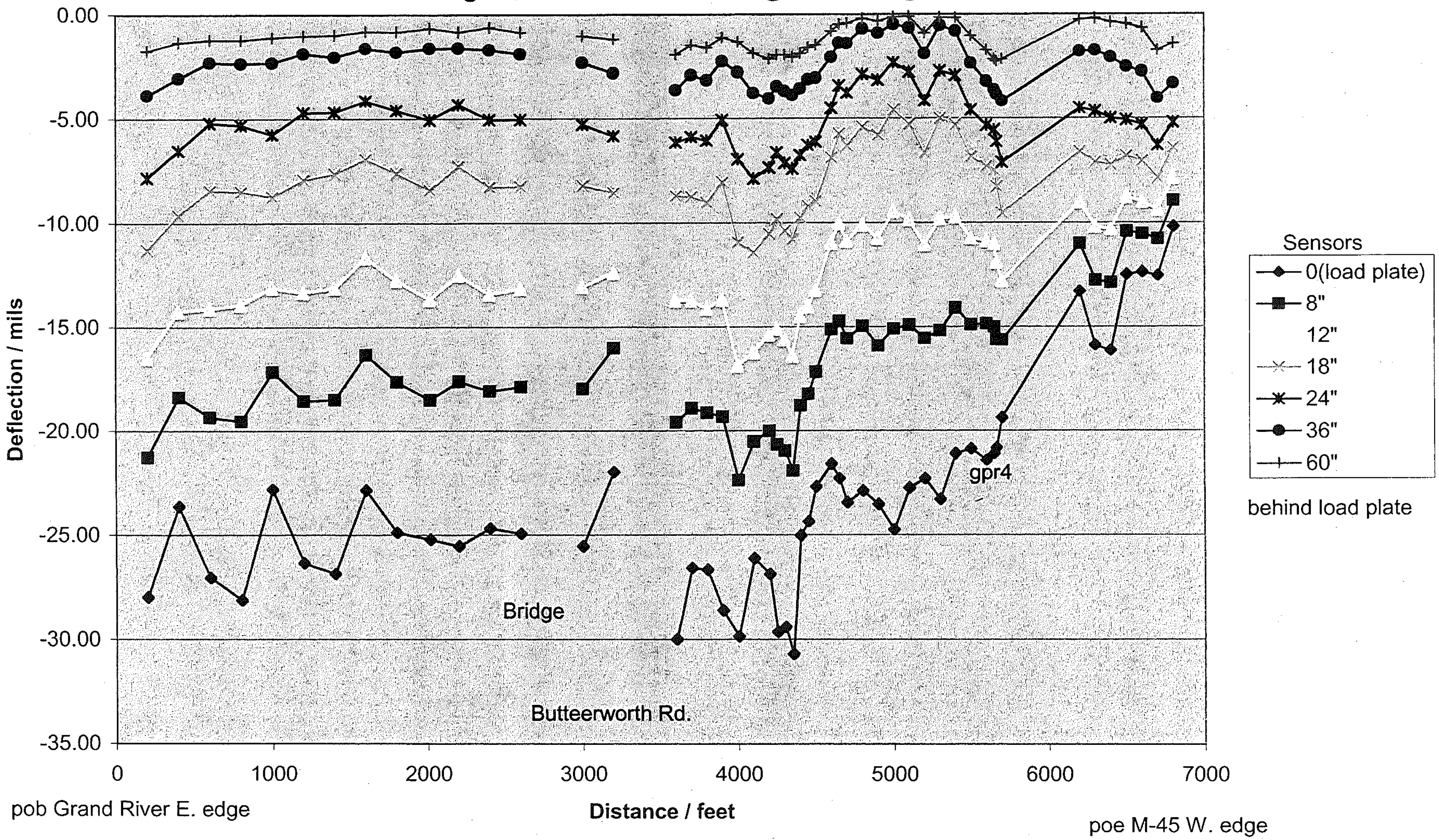


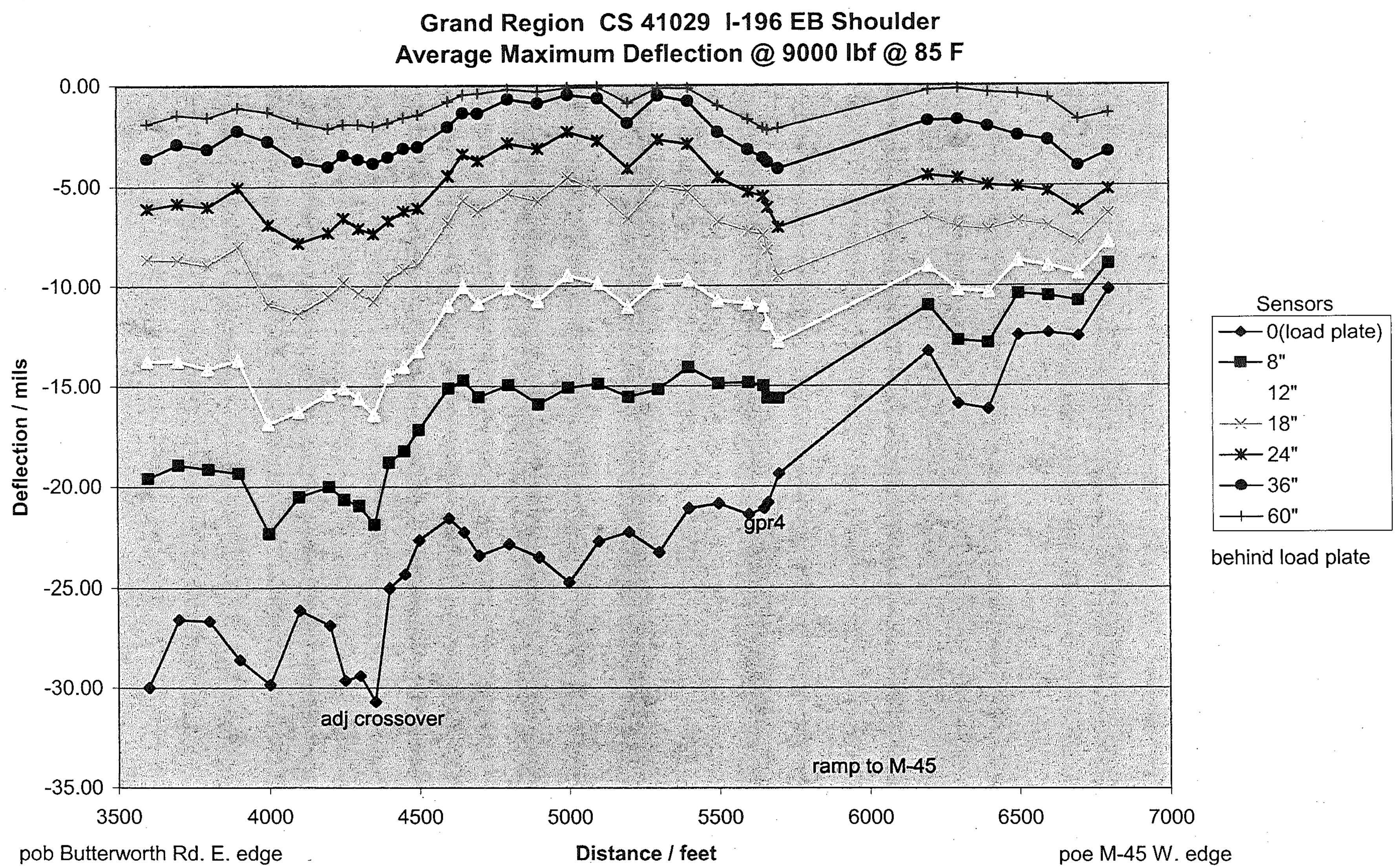
Grand Region CS 41029 I-196 WB Shoulder
Average Maximum Deflection @ 9000 lbf @ 71 F
Deflection / mils
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
-35.00
-40.00
-45.00
0
1000
2000
3000
4000
5000
Distance / feet
pob gore from M-45 ramp
poe Grand River pob guard rail
poe ramp
gpr1
gpr2
gpr3
Bridge
Butterworth Rd.
Butterworth Bridge
Approximate Mine
Location
≈ 700
Station 410
Sensors
0(load plate)
8"
12"
18"
24"
60"
behind load plate



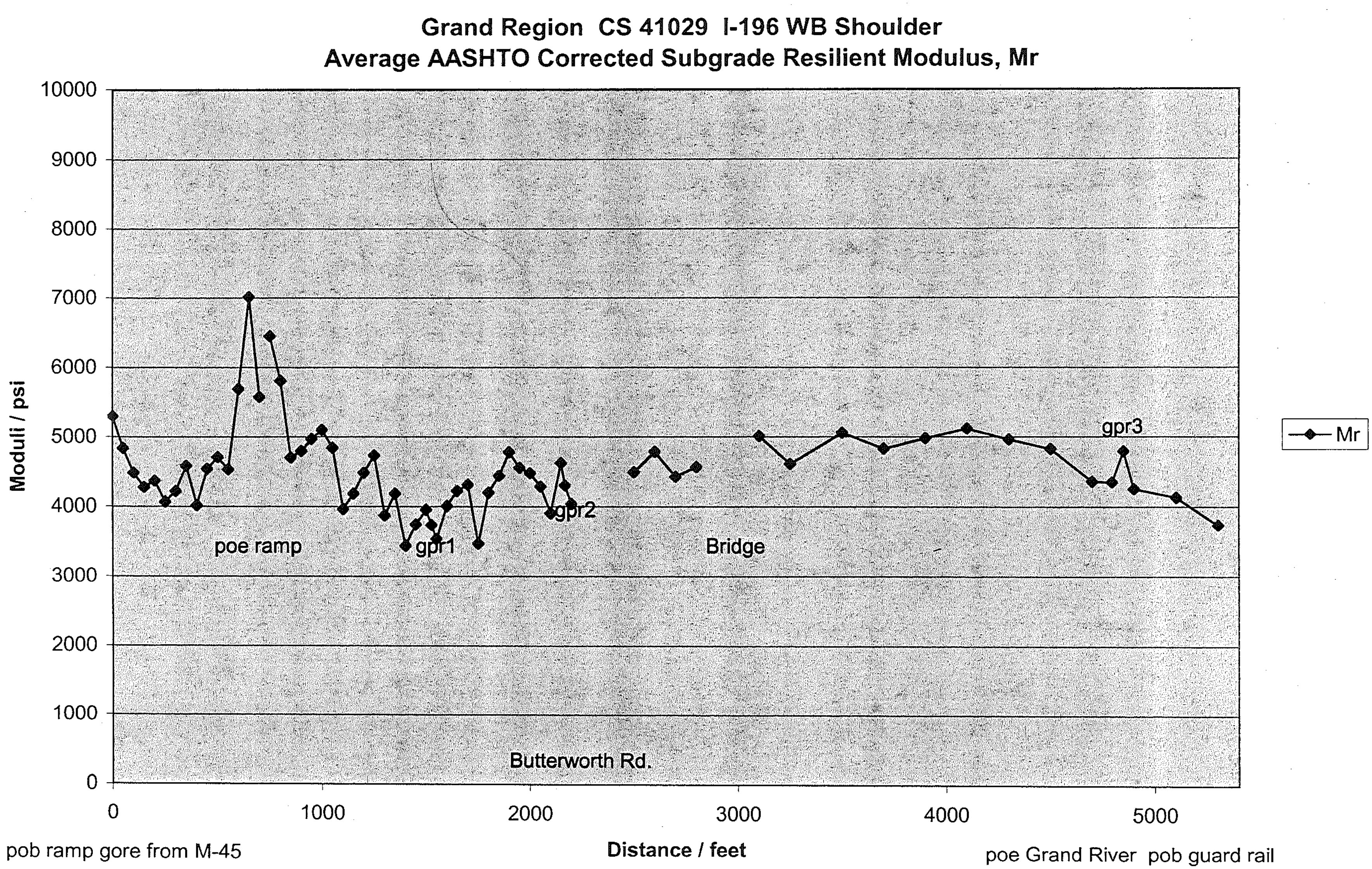
Grand Region CS 41029 I-196 WB Shoulder
Average Maximum Deflection @ 9000 lbf @ 71 F
Deflection / mils
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
-35.00
-40.00
-45.00
0
500
1000
1500
2000
2500
Distance / feet
poe ramp
gpr1
gpr2
Sensors
0(load plate)
8"
12"
18"
24"
36"
60"
behind load plate
pob ramp gore from M-45
poe Butterworth Rd.

Grand Region CS 49029 I-196 EB Shoulder
Average Maximum Deflection @ 9000 lbf @ 85 F

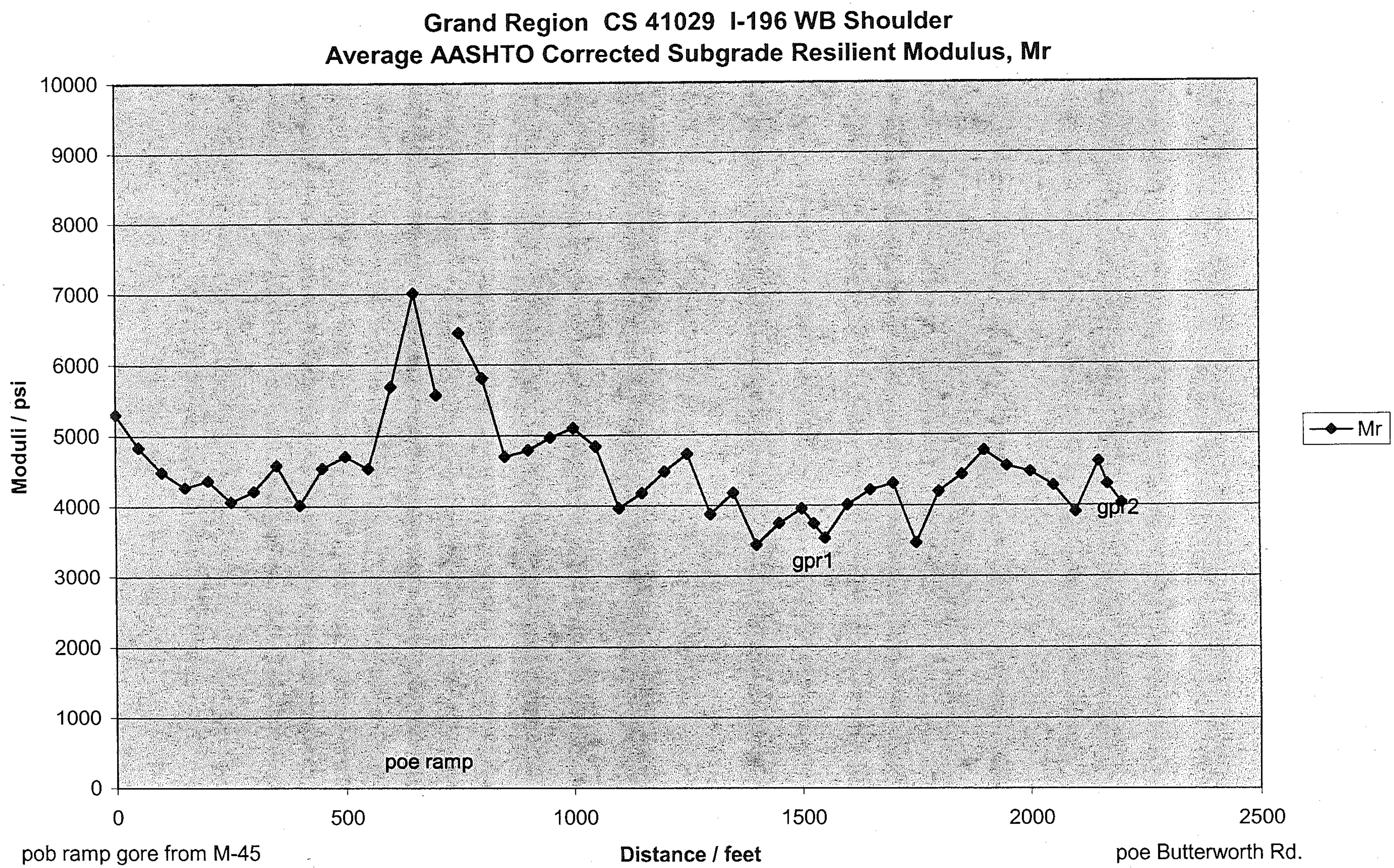




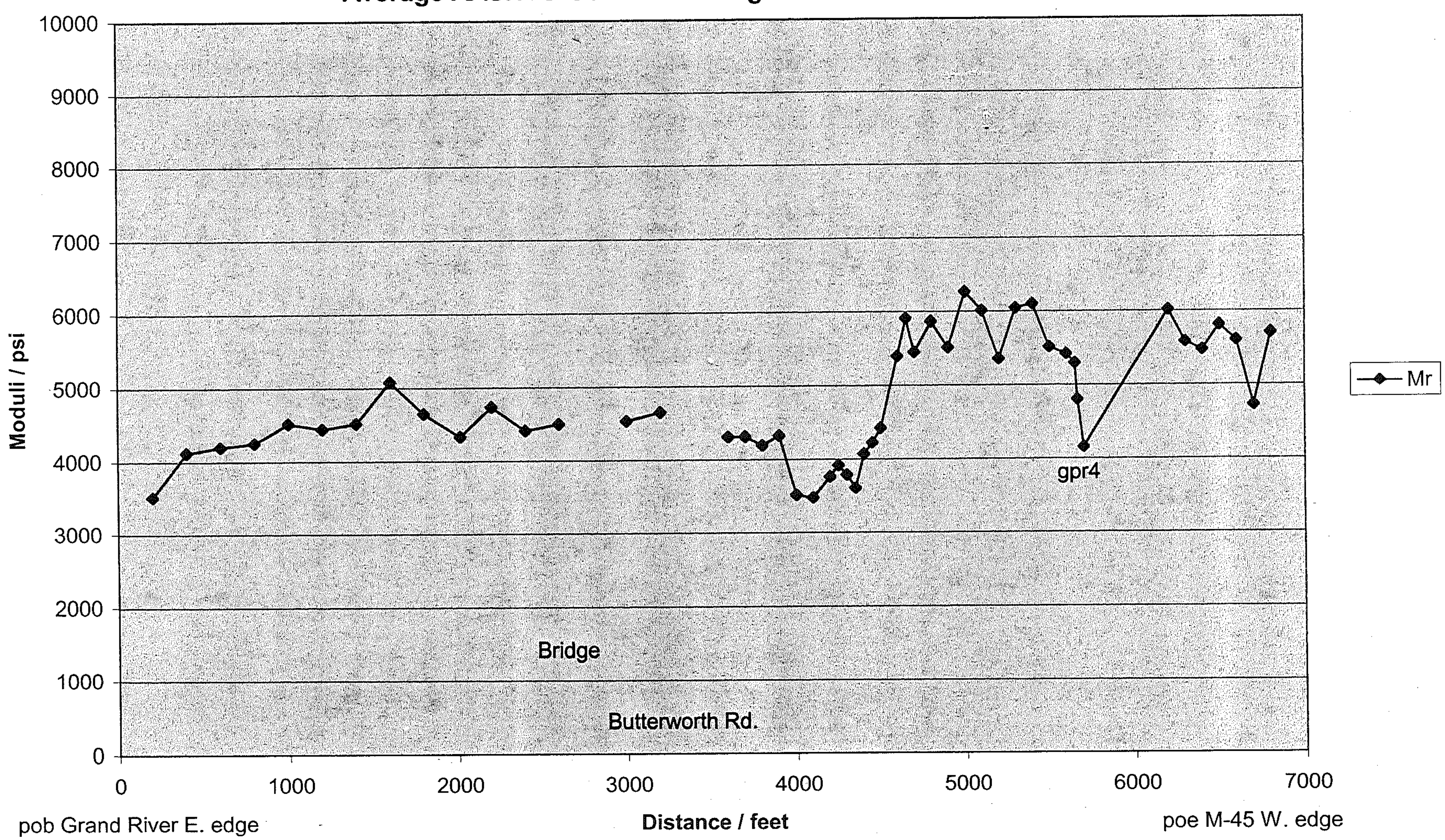
Grand Region CS 41029 I-196 EB Shoulder
Average Maximum Deflection @ 9000 lbf @ 85 F
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
-35.00
Deflection / mils
3500
4000
4500
5000
5500
6000
6500
7000
Distance / feet
pob Butterworth Rd. E. edge
poe M-45 W. edge
adj crossover
gpr4
ramp to M-45
Sensors
0(load plate)
8"
12"
18"
24"
36"
60"
behind load plate

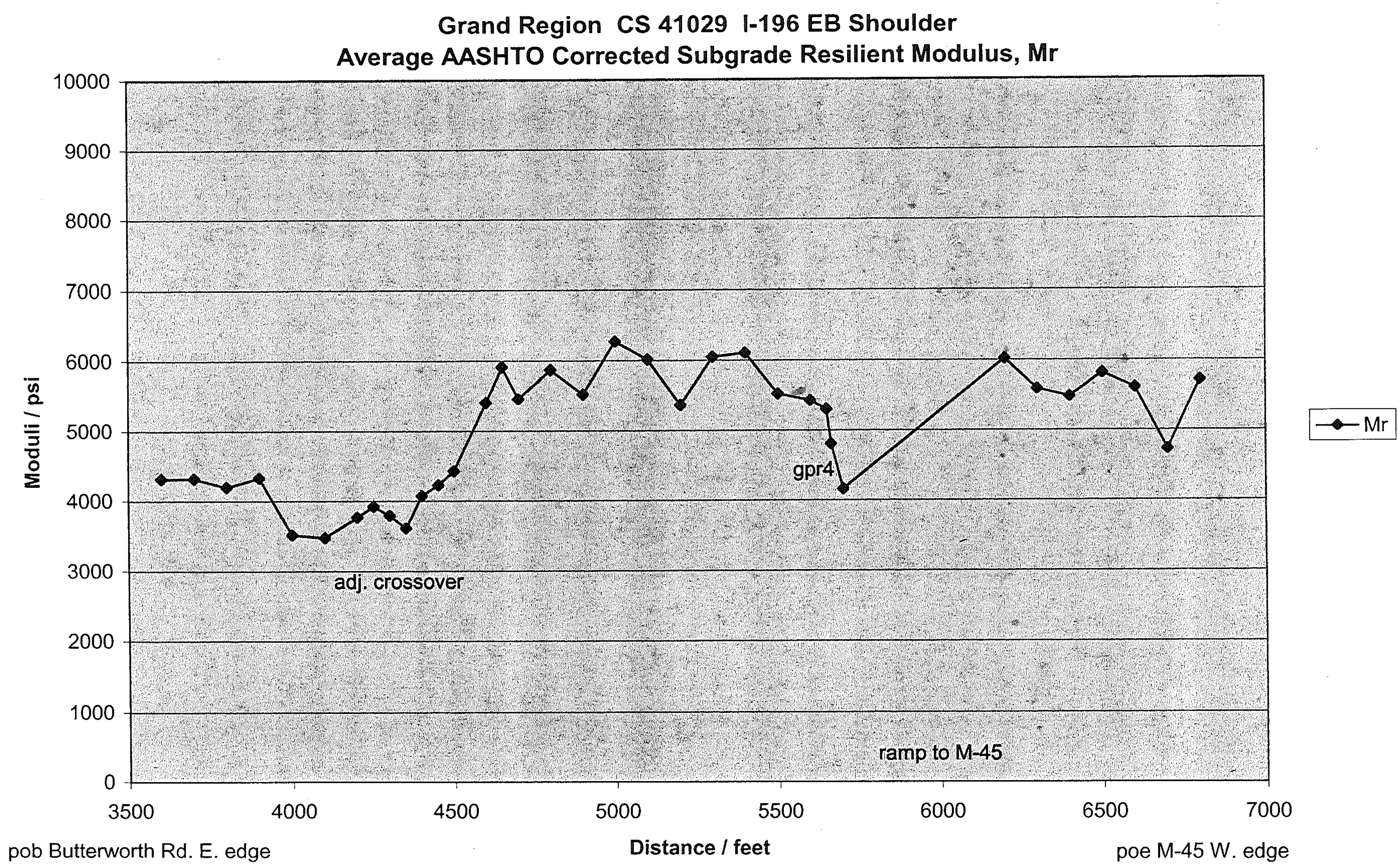


Grand Region CS 41029 I-196 WB Shoulder
Average AASHTO Corrected Subgrade Resilient Modulus, Mr
Moduli / psi
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
poe ramp
gpr1
gpr2
Bridge
gpr3
Butterworth Rd.
Mr
0
1000
2000
3000
4000
5000
Distance / feet
pob ramp gore from M-45
poe Grand River pob guard rail


Grand Region CS 41029 I-196 WB Shoulder
Average AASHTO Corrected Subgrade Resilient Modulus, Mr
Moduli / psi
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
500
1000
1500
2000
2500
Distance / feet
pob ramp gore from M-45
poe Butterworth Rd.
poe ramp
gpr1
gpr2
Mr

Grand Region CS 41029 I-196 EB Shoulder
Average AASHTO Corrected Subgrade Resilient Modulus, Mr




Grand Region CS 41029 I-196 EB Shoulder
Average AASHTO Corrected Subgrade Resilient Modulus, Mr
Moduli / psi
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
3500
4000
4500
5000
5500
6000
6500
7000
Distance / feet
adj. crossover
gpr4
ramp to M-45
Mr
pob Butterworth Rd. E. edge
poe M-45 W. edge

APPENDIX F

MDOT FILE CORRESPONDENCE CONCERNING I-196 CONSTRUCTION

Form 2140
Rev. 1/59

MICHIGAN
STATE HIGHWAY DEPARTMENT

DATE: 2/28/62

TO: Karl Rock
Grand Rapids

- [ ] Prepare reply for ____________________ signature
- [ ] Prepare reply for my signature
- [ ] Advise me, please
- [ ] Reply direct, copy to this office
- [ ] Per your request
- [ ] For your approval &/or signature
- [ ] For your review
- [ ] For your information
- [ ] Note and return
- [x] Per our conversation
- [ ] For your files

REMARKS: I have talked with R.E.M., O.L. Stokstad & G.-l McCarthy. They all agree that as much info as available be gotten from Gypsum Co. Suggest you arrange a meeting with them -

FROM: K.A. Allemeier

41029
I-96

MEMORANDUM FOR FILES

Thursday, July 20, 1961, an informal meeting was held at the U.S. Gypsum Company of Grand Rapids for the purpose of determining the location and condition of existing mine shafts that may fall within the limits of our proposed roadway.

Those in attendance were:

Charles Young	Mine Engineer, U.S. Gypsum Co.
W. E. Groomer	Squad Leader
O. Kalmbach	Ass't Squad Leader

It was determined that the entire mine field lies South of Fulton Street and West of the South Sec. Line of Sec 27 which our plans show as the Grand Rapids City Limits. Our affected roadway would be between Sta 442 and 463. It was further determined that this mined area is inactive and has experienced cave-ins but none of recent years.

While all mining operations are presently North of Butterworth Ave, years ago there had been some activity to the South which may have extended beyond the river. There are no records of this operation and information is vague. Mr. Young is to check further on this.

The problem of cave-ins was discussed and it appears that while the area of concern is quite stable, future cave-ins would not be impossible. It was pointed out that due to the depth of the mines it sometimes takes years for the results of a cave-in to reach the surface.

Mr. Young is to supply us with a print of his map, showing mine locations.

It was brought out at this meeting that a dust problem would in all probability be encountered by motorist upon completion of the roadway unless preventive measures were taken on part of U.S. Gypsum Co. The dust which is created thru the manufacturing process is intense enough at times to create hazordous driving due to reduced visibility.

W. E. Groomer
Design Squad Leader

WEG/mm

cc: M. J. Koster
W. A. Penner
G. D. Beukema
K. R. Rock

GRAND RAPIDS GYPSUM COMPANY
P. O. BOX 74
GRAND RAPIDS 1, MICHIGAN
GLENDALE 9-6591

DONALD G. SLAWSON
EXECUTIVE VICE PRESIDENT
AND TREASURER

13 February 1962

RECEIVED
FEB 21 1962
M.S.H.D.
CHIEF OF DESIGN
McCARTHY
BECKER
LAIRD
WOODFORD
JONES
CONVER
MORGAN
WENMAN
VANDERHYDE
DYGERT
STOKSTAD
HANNON

Mr. John W. Knecht, Jr.
2237 Raby Road
E. Lansing, Michigan

Dear Mr. Knecht:

As you know, Department employees are negotiating with us for purchase of lands for a freeway. (Incidentally, the initial offer is absurdly low by all standards).

Much of the land is over old areas mined by us many years ago. We consider it hazardous for highway use because of the danger of sudden subsidence. Department engineers have seemed unimpressed by our warnings. Of course, through instruments of conveyance or otherwise, our Company must have indemnity against damages for injury to person and property of others.

Also, as to some of the lands, we have not yet mined the second level. We shall insist upon reserving these mineral rights. Modern mining methods permit this without danger. We frequently mine under adjacent highways and uniformly reserve such rights. This reservation will benefit the State; otherwise, the surface value would be enhanced by the value to us as a gypsum producer of the sub-surface ore. We anticipate no problem in the matter of gypsum rights reservations.

We hope the Department appraisers will soon become realistic so that negotiations may be resumed.

This letter is being directed to you because of our past pleasant phone conversations. An extra copy is enclosed for your convenience.

Cordially,

GRAND RAPIDS GYPSUM COMPANY

Donald G. Slawson

Donald G. Slawson,
Executive Vice President &
Treasurer

RECEIVED
MAR 2 1962
DIST. NO. 3
STATE HIGHWAY DEPT.
GRAND RAPIDS, MICH

DGS:gd
P.S: Thought you might use an extra clipping.

February 20, 1962

Grand Rapids Gypsum Company
P.O. Box 34
Grand Rapids 1, Michigan

Attention Mr. Donald G. Simpson
Executive Vice-President, Treasurer

Dear Mr. Simpson:

Thank you for your informative letter of February 13 regarding the gypsum mines located on the west edge of the City of Grand Rapids.

The subject of engineering safe-guards for the new freeway has been discussed with Mr. O. L. Stokstad, Design Development Engineer, and he is fully aware of the problems involved. Incidentally, I know that he appreciates the problem because he was with me the day your engineer took us through that part of the mine. This was during the time route location studies were in formulation.

As to the matter pertaining to the cost of right-of-way, I naturally hesitate to comment on that inasmuch as this is rightfully the job of the Right-of-Way Division. Therefore, I am sending them a copy of your letter for their information.

Thank you for your kindness and I certainly do recall our telephone conversations of the past.

Very truly yours,

John W. Knecht, Jr.
Director of Public Hearings

JWK:dmb

cc: O. L. Stokstad
H. H. Streukens

Nelson Hawes 21 Feb 62

File

RECEIVED
FEB 19 1962
DIST. NO. 5
STATE HIGHWAY DEPT.
GRAND RAPIDS, MICH.

GRAND RAPIDS GYPSUM COMPANY

P. O. BOX 74
GRAND RAPIDS 1, MICHIGAN
GLENDALE 3-2413

February 15, 1962

Michigan State Highway Department
11 Fuller S. E.
Grand Rapids, Michigan

Re: CS 41029 D-Parcel 49

Attn: Mr. Donald P. Goeman
Right-of-Way Agent

Gentlemen:

We regret we cannot sign the Possession and Use Agreement. Among the reasons are:

We do not believe that the specific location is "required".

Reciting a "final offer" implies prior offers. Only one was made. There has been no attempt at negotiation. Request to read your appraisal was denied.

We will never "be prepared" to accept your initial offer.

We do not wish "additional time to consider" such offer. We will seriously consider any reasonable offer you care to make, as distinguished from the present "shock" tactic.

We cannot agree that the property has been "properly selected" and is necessary for public use. The road could readily be located farther from our plant as indicated on earlier maps. This would reduce the very substantial damages incident to depriving us of our waste disposal area. The road's location is also hazardous since it will be over areas mined by us in past decades where the land is apt to subside. We must have an indemnity agreement against injury to person or property, including the contractor, etc., before agreeing or conveying. Also, the full fee is not necessary; we must reserve our valuable gypsum deposits and access to others. Our modern mining methods now permit use of the surface without danger.

Also required is written assurance of construction and maintenance of drains for our mine and surface drainage water under the proposed highway. This amounts to almost three quarters of a million gallons daily and obstruction at any time would flood our many miles of mining corridors and faces.

Yours very truly,
Grand Rapids Gypsum Co.

George I. Fischer

George I. Fischer
Vice President-Manufacturing

March 8, 1962.

G. J. McCarthy,
Chief of Design

O. L. Stokstad,
Design Development Engineer

Grand Rapids Gypsum Company
ACC - 41029 D - 49

A conference with the Grand Rapids Gypsum Company was held in Grand Rapids on Wednesday, March 7, 1962. Mr. George Fisher and two assistants represented the Gypsum Company. The Highway Department was represented by Messrs. Clark, Koster, Rock, Allemeier, and Stokstad. Purpose of the meeting was to obtain information concerning mining operations and their influence on proposed expressway design and construction in the area.

The Gypsum Company provided a map of their property, showing expressway location and where this location rests over areas which have been mined out. Also, marked on the map are floor elevations of the old mine. Generally there is from 30 to 40 feet of rock still in place over the mine openings shown. Additional resistivity information is being requested to obtain definite information concerning the surface elevation of the rock.

Generally the thickness of the gypsum deposit removed varies from 7 or 8 feet in the more recent operation to the south and 12 feet in the older operations to the north.

Portions of the pillars were removed in the older north portion, with the result that partial collapse has occurred, causing surface settlements which can be observed.

Mr. Fisher was informed that the Grand Rapids Gypsum Company would not be expected to be responsible for damages which might be caused by or could be traced to collapse of rock formations in present mined-out areas.

O. L. Stokstad,
Design Development Engineer

OLS:VS

cc: J E Mayor
H J Koster
Karl Rock
A E Matthews

March 6, 1962

Mr. G. J. McCarthy
Chief of Design

Victor H. Eichhorn, Director
Right-of-Way Division

ACC - #1029 D - 49 (G. R. Gypsum Company)

The attached letter reflects the above captioned property owner's reaction to our proposed taking, which poses problems that place the Department in a very untenable position as far as condemning this property is concerned.

In order to condemn this property on a sound basis, it will be necessary that certain factors be resolved - namely:

1. Is it feasible to allow the property owner to retain the mineral rights underlying our right-of-way?

2. If the property owner is allowed to retain the mineral rights, what restrictions should be placed upon mining activities or tunnels beneath the highway?

3. Can the Department assume responsibility for damage caused by subsidence due to construction or use of the highway?

If questions 1 and 3 can be resolved in the affirmative, our position should be favorable.

EHE:mks
Att.

cc: District
Gary Hultgren
R. Rasm
Cond. Corres. File
General File
Daily File

OFFICE MEMORANDUM

MICHIGAN
STATE HIGHWAY DEPARTMENT
JOHN C. MACKIE, COMMISSIONER

March 8, 1962.

RECEIVED
MAR 9 1962
RIGHT OF WAY DIVISION
M.S.H.D.
6 7 8 9 10 11 12 1 2 3 4 5

To: V. H. Eichhorn, Director
Right of Way Division

Att: Earl Hart

From: G. J. McCarthy,
Chief of Design

Subject: 41029 D - 49 (Grand Rapids Gypsum Company)

In your letter to me of March 6 concerning the acquisition of right-of-way on the subject parcel, you asked the following questions:

1. Is it feasible to allow the property owner to retain the mineral rights underlying our right-of-way?

   We feel that considering the economics concerned with this problem that the property owner should be allowed to retain the mineral rights underlying our right-of-way. These mineral rights, of course, must be subject to stipulations listed under question number 2.

2. If the property owner is allowed to retain the mineral rights, what restrictions should be placed upon mining activities or tunnels beneath the highway?

   Future mining operations must be conducted in a manner which will preserve proper highway support.

3. Can the Department assume responsibility for damage caused by subsidence due to construction or use of the highway?

   Again economics is the predominant criteria that must be considered to answer this question. We feel that the State Highway Department must assume responsibility for damage caused by subsidence due to construction or use of the highway. This responsibility, in my opinion, would pertain only to the property acquired in fee as permanent highway right-of-way.

This applies to present mine not future [illegible]
[illegible]

G J McCarthy

G. J. McCarthy,
Chief of Design

GJMcC:VS
cc: J E Meyer
W W McLaughlin
C B Laird
H J Rathfoot
O L Stokstad
N C Jones

March 9, 1962

Victor H. Eichhorn, Director
Right-of-Way Division

Attention: Dan E. Stanton
Chief, R.O.W. Acquisition

Lawrence F. Clark
District R.O.W. Agent

Gary Hultgren
Ass't Chief Appraiser

CS 41029, Parcel 49
Grand Rapids Gypsum

G. J. McCarthy
Chief of Design

R. Rawn
R.O.W. Status

A teletype from Dan Stanton on March 6, 1962 asked me to attempt again to get a Possession and Use Agreement from the above company for the right of way we need.

I attended a meeting yesterday at Grand Rapids Gypsum Company office regarding problems they have presented. George Fisher who is Vice President and Manager of the works of said company represented Grand Rapids Gypsum Company. Also present were two mining engineers representing the company. Besides myself for the Highway Department there were Karl Root, District Soils Engineer, and Robert Koster, Ass't Road Engineer, from this office. From Lansing there were Lent Allemader, Ass't Engineer of Soils and O. L. Stokstad, Design Development Engineer.

There greatest objection is the necessity of the location of our right of way by present prints across their property. They had a set of prints probably put out at the time of the public hearing for this project which is approximately two years ago last summer. At that time our right of way line came approximately 200 feet or more from where its now located. The right of way line now comes approximately 30 feet from one of their buildings. This area was used for dumping waste material and is very convenient to their manufacturing unit. They claim they have dumped 3,000 to 4,000 tons of waste a year. They also claim loss of this area would necessitate them buying another truck and possibly a two mile round-trip haul for dumping waste. They claim this is very serious damage to their overall operation. I asked Mr. Fisher how much damage he would estimate this to be. He claimed that with the mining area they still have there is an economic life of 100 years and the damage would be approximately $100,000.00.

They would like a waiver of their responsibility for damages caused by subsidence due to our construction of the highway. I asked him at this point if they were willing to make a bilateral agreement incorporating this waiver of responsibility, but also a guarantee on their part of where our roadbed crossed the areas still unmined they would agree to a reasonable distance over said roadbed for there mining operation so as not to cause subsidence. They said they would agree to such a bilateral agreement.

They also claim that our appraisals were ridiculous in the amount offered and mentioned a couple of sales in the area to Consumers Power Company. I informed him that most Consumers Power Company purchases cannot be considered average market sales and explained why. I also explained to him that under the Law of Eminent Domain we are compelled to appraise takes for highway purposes using legitimate comparable sales in the area.

I think this covers all of the conversation pertinent to right of way acquisition.

They brought up drainage problems with the Construction Engineer and subsidence problems with the Soils Engineer. I think that Mr. Stickstad and Mr. Alexander are making reports regarding the rest of the conversation.

I gathered from the conversation that there might be a doubt as to whether the route across areas of the property that have been mined was sound.

I think our appraisals are adequate and that the comparables used are fair as far as the real estate is involved. It is possible that someone like S. M. Dix Associates should be hired to make a study on the damages they claim because of the loss of convenient dumping area, as I outlined it above.

I will be waiting for any decision that may be made on this parcel.

LPC/sw

cc: Gary Hultgren
J. G. McCarthy
Dick Ross

CS 41029 E
Par. 49
File

Aug. 1962
(CS?)
1403

SETTLEMENT AGREEMENT

THIS AGREEMENT, made this 3rd day of August, A.D. 1962, by and between MICHIGAN STATE HIGHWAY DEPARTMENT (hereinafter referred to as Department), an instrumentality of the State of Michigan, by its duly authorized Deputy Commissioner, and GRAND RAPIDS GYPSUM COMPANY (hereinafter referred to as Gypsum), a Michigan corporation, of Grand Rapids, Michigan, WITNESSETH:

WHEREAS, the Department has heretofore commenced condemnation of certain property interests of Gypsum, pursuant to Act No. 352, P.A. 1925, as amended, for the construction of Interstate Highway I-96, more particularly identified as Control Section 41029 E 2nd U, Parcel C-49, and there is presently pending in the Circuit Court for the County of Kent a certiorari proceeding, identified as File No. 48226, to review said Determination of Necessity made by John C. Mackie, Michigan State Highway Commissioner, under date of April 11, 1962, after a contested hearing on the question of necessity; and,

WHEREAS, there exists a bona fide dispute and controversy between the Department and Gypsum on both the question of necessity and the amount of damages owing Gypsum for the taking of said property interests, and it is the desire of both parties to compromise all issues in dispute between them; and,

WHEREAS, Gypsum has agreed to accept the provisions herein made as full and complete compensation for the property interests taken by the Department for highway purposes, as said property interests are more fully described in the amended Determination of Necessity to be filed in this cause, pursuant to the language below specified and in lieu of any other claims Gypsum may have against the Department;

NOW, THEREFORE, In consideration of the mutual promises, covenants, payments and undertakings hereinafter set forth, IT IS MUTUALLY AGREED as follows:

1. The Department will on or before September 1, A.D. 1963, fill and grade the right-of-way for the New York Central Railroad along the relocated route as shown by the drawing prepared by S. M. Dix and Associates, attached hereto and made a part hereof, identified as Exhibit A - Plan B, said work to be performed at the sole expense and responsibility of the Department and in a good and workmanlike manner, to provide a road bed grade, exclusive of ballast, ties, tracks and switches in accordance with the specifications of said railroad, and without interference with Gypsum's normal operations.

2. The Department will pay within twenty-eight (28) days from date hereof, to Gypsum, the sum of Sixty-Nine Thousand Dollars ($69,000.00) as full and complete compensation for the taking of Parcel C-49 of Control Section 41029 E 2nd U, as said parcel is more fully described in the amended Determination of Necessity, and in default of such payment, the Department will remove any structures or obstructions it may have placed on the premises described in Parcel C-49.

3. The Department shall pay interest on the aforementioned Sixty-Nine Thousand Dollars ($69,000.00), at the rate of five per cent (5%) per annum from April 17, 1962, the date the Determination of Necessity was recorded in the Kent County Register of Deeds Office, to twenty-eight (28) days subsequent to the date hereof,

said sum to be paid at the same time and in the same manner as the aforementioned Sixty-Nine Thousand Dollars ($69,000.00) and said Sixty-Nine Thousand Dollars ($69,000.00) shall include any and all amounts and allowances to cover costs and attorney fees.

4. The Department shall deduct from said Sixty-Nine Thousand Dollars ($69,000.00) pursuant to the laws of this state, any sums due as delinquent taxes, if any there be.

5. The Department shall make payment of said Sixty-Nine Thousand Dollars ($69,000.00) to Gypsum or to its duly authorized agent and receipt therefor filed with the Department. In case of the refusal of any of the said parties to accept such payment, the same shall be deposited in the State Highway Fund in the Office of the Treasurer of the State of Michigan until further Order of the Court.

6. Gypsum herewith grants to the Department immediate use and possession for highway purposes of the lands described as Parcel C-49 in the amended Determination of Necessity.

7. The Department will convey by Commissioner's Deed to Grand Rapids Gypsum Company, a Michigan corporation, as soon as reasonably possible, the following described lands:

"All that part of the following described Tract "A" located southerly of the Consumers Power Company's right-of-way, which lies westerly of a line 150 feet westerly of and measured at right angles and parallel to the survey line of Highway M-21.

"The lands described above in fee, contain 1.1 acre more or less.

"Tract "A": That part of the West 1155 feet of the Northwest fractional 1/4 of Section 35, T7N, R12W, Walker Township, Kent County, Michigan, lying South of a line 66 feet southerly of and parallel with the southerly line of the New York Central Railway right-of-way, EXCEPT the West 2 rods.

"The survey line of Highway M-21 is described as follows:

"Beginning at a point on the West line of Section 26, T7N, R12W, Michigan, which is North 00 deg. 39' 13" East, 775.23 feet from the Southwest corner of said Section 26; thence South 26 deg. 45' 07" East, 546.97 feet to the point of curve of a 3 deg. 00' curve to the right; thence southerly along the arc of said curve 2,361.02 feet to the point of tangent of said curve; thence South 44 deg. 04' 43" West, 500 feet to a point of ending."

8. The Determination of Necessity heretofore filed in this cause in the Kent County Register of Deeds Office on April 17, 1962, at Liber 1933, pages 101 through 105, inclusive, shall be amended by stipulation between the Department and Gypsum by deleting completely therefrom, page 102 of Liber 1933, and substituting therefor the following language:

"Control Section 41029E 2nd U
Parcel C-49

"Station 397 + 00 to 414 + 20
Station 430 + 00 to 433 + 00

"I. Title in fee simple (excepting herefrom all minerals underlying the lands hereinafter described together with the right to mine and extract said minerals without entering upon the surface of said lands, and without interfering with the subjacent or lateral support of said lands, and without in any way or manner interfering with the use of the said described lands for highway purposes) including all structures, trees, and other improvements to:

Right to mine accept liability

"Parcel "W": That portion of the following described Tract "B" lying southeasterly of a line which is parallel with and 150 feet distant northwesterly, when measured at right angles, from the survey line of M-21.

"Parcel "X": That part of the following described Tract "A" which lies between the Easterly and Westerly right-of-way lines of Highway M-21.

"Parcel "Y": The North 60 feet of the East 634 feet of Tract "A" EXCEPTING THEREFROM, that part which lies easterly of the westerly right-of-way line of Highway M-21.

"The lands described above in fee contain 39.0 acres, more or less.

"Together with all rights of ingress and egress, if any there be, to, from and between the highway to be constructed on the lands above described in parcels "W" and "X" and the remainder of said Tracts "A" and "B".

"II. The right to enter upon the following described land for the purpose of muck disposal including the right to grade and/or alter the underlying lands, which right shall expire on or about December 1, A.D. 1964: A strip of land 70 feet in width lying northwesterly of and adjacent to a line 150 feet northwesterly of, measured at right angles, and parallel to the survey line of Highway M-21, over and across Tract "B", EXCEPTING the North 1100 feet thereof; the lands described above for muck disposal purposes contain an area of 1.6 acre, more or less.

Tract "A": The East 1/2 of the Southeast 1/4 of Section 27, T7N, R12W, Walker Township, Kent County, Michigan, EXCEPTING THEREFROM,

(a) The North 264 feet of the West 165 feet;
(b) The South 4 rods of the Northeast 1/4 of Southeast 1/4;
(c) The North 4 rods of the Southeast 1/4 of Southeast 1/4;
(d) The East 8 rods of the Southeast 1/4 of Southeast 1/4, EXCEPT the North 4 rods; and,
(e) A triangular parcel in the Southeast 1/4 of the Southeast 1/4 described as: Beginning 252 feet West and 66 feet South of the Northeast corner of Southeast 1/4 of the Southeast 1/4, thence East 120 feet; thence South 120 feet; thence northwesterly to the point of beginning.

9. The Department agrees in reference to the muck disposal area, as said area is more particularly described in Paragraph II in the amended Determination of Necessity, that the waste peat to be stored thereon during construction shall after backfilling, be pulled in on the sides of the embankment to the position shown on the standard specifications for said project as shown on Sheet 1 of 3, E-4-A-28E, a copy of which is marked as Exhibit B, attached hereto and made a part hereof.

It is further agreed that the Department will, prior to April 1, A.D. 1964, reduce said muck disposal area to preconstruction ground level.

10. The Department will, during the course of construction of the described project, install twenty-four inch (24") culverts to be placed at Station 410 ≠ 00, as said station is designated on the construction plans for said project on file in the Commissioner's Office, and an outlet ditch to be constructed perpendicular to Station 410 ≠ 00, southeasterly to the easterly edge of said Tract "B", thence southerly to the Grand River, it being the responsibility of the Department to maintain and keep free from obstructing materials, the aforementioned outlet ditch located on said Tract "B".

11. The Department will construct and maintain at its own expense, highway ditches and cross-culverts adequate to remove all normal surface waters which would accumulate along the northwesterly side of said Highway M-21, also known as I-96, and along the northwesterly side of the relocated New York Central Railroad right-of-way (as agreed upon in Paragraph 1, supra), as the same pass through the property of Gypsum.

12. It is further provided that the Department and Gypsum are, simultaneously herewith, agreeing in writing as to the proportionate share of the consideration paid by the Department for the compromise settlement attributable to the taking of property interests from Gypsum, and the proportionate share of said consideration attributable to severance damages resulting from said taking.

13. On delivery of the Commissioner's Deed referred to in Paragraph 7 hereof, and the payment of the sum specified in Paragraph 2 hereof, Gypsum will execute a stipulation for the dismissal of said certiorari proceedings, without costs to either party, and without prejudice.

This agreement shall be binding upon, and shall inure to the benefit of, the parties hereto and their respective successors and assigns, including, without limitation, any successor Commissioner or Commissioners of the Department, and any subsidiary, successor by merger, vendee or grantee, or other successor or assignee of Gypsum.

IN WITNESS WHEREOF, the parties hereto have hereunto set their hands and seals this 3rd day of August, A.D. 1962.

GRAND RAPIDS GYPSUM COMPANY

In Presence Of:

By Donald G. Slawson,
Executive Vice President

George I. Fischer

Gordon B. Wheeler

Howard E. Hill, Deputy Highway
Commissioner of the State of Michigan

MARY P. TYNAN

CAROLYN K. [illegible]

STATE OF MICHIGAN)
COUNTY OF KENT) ss.

On this 22 day of August, 1962, before me, a notary public in and for said county, appeared Donald G. Slawson and George I. Fischer, to me personally known, who being by me duly sworn, did each for himself say that they are respectively, the Treasurer and Executive Vice President, and [redacted] Vice President, of Grand Rapids Gypsum Company, the corporation named in and which executed the within instrument; that the seal affixed to said instrument is the corporate seal of said corporation; that said instrument was signed and sealed in behalf of said corporation by authority of its board of directors, and said Donald G. Slawson and George I. Fischer acknowledged said instrument to be the free act and deed of said corporation.

Notary Public, Ker' County, Michigan
My commission expires: Nov 23 1965

Checked and approved as to accuracy of descriptions in Settlement Agreement

Ben E. Stanton, Chief
Right of Way Acquisition

Parcel No. 49
Control Section 41029 D

GENERAL DESCRIPTION OF PROPERTY

The subject property is an approximately 418 acre tract of land in Section 27, 34, and 35 of Walker township, the greater portion being in the corporate limits of the City of Grand Rapids at its Southwesterly limits. The propery is besected by O'Brien Road on an East-West line, by Covell Avenue on a North-South line, by Butterworth Drive on a Northeasterly-Southwesterly line, and bounded on the North by Fulton Street, all being two-lane hard surfaced streets and county roads, with Grand River on the South boundary. The New York Central Railroad runs through the Southeasterly portion of the property adjacent to the South of and parallel to Butterworth Drive.

The acreage to the North of O'Brien Road is bisected by a Consumers Power Company right-of-way on a generally East to West line, and this portion of the property is bounded on the East by City owned land being utilized for a park and zoo, known as Jon Ball Park.

The area has electric, telephone, natural gas, city water and sanitary sewer.

The land is for the most part medium to high rolling with steep slopes and ravines, mostly wooded with a natural growth of hardwood trees. The Southeasterly portion is quite level of considerably lower elevation sloping down from Butterworth Drive to the New York Central Railroad spur tracks, then continuing on a downward slope into the lowland adjacent to Grand River and being subject to overflow from the river. This lowland area is mostly wooded, swamp and has a considerable amount of muck.

The manufacturing site has a considerable amount of underground sewer and drainage tiling, with 9 to 12 inch diameter tile, and catch basins. Also a 12" and 14" tile drain from the newly-built warehouse extending under the railroad track to the lowlands. Has concrete drives throughout the plant site and retaining walls.

The surface soil of the acreage is generally sandy for the most part as is evidenced by the excavation along the North side of O'Brien Road to the East of Covell.

Has a total of approximately 34 buildings on the two-plant site, of various type construction and facility, and of variable age categories and condition. For purposes of this appraisal the building improvements are not included in the estimate of value before or after the taking as they are not within the area of the taking and in the considered judgment of the Appraiser are not affected by the taking, and will have the same utility and use as before.

In Section 35 is a 70' x 500' strip of land parallel to the West section line containing a 14' concrete road down to the New York Central Railroad.

PRESENT USE OF PROPERTY

The land is presently being utilized in a gypsum mine operation with installations for the manufacture of plaster, rock lathe and sheetrock primarily. Also, processing of gypsum for bedding, polishing of glass, fireproofing, and roof decking, for use in various types of industry. The mine is over a 100 years old and has been in operation for this period of time, the gypsum deposit being in two and three seams.

The mining is done on a three level basis with the acreage divided into numbered caregories for the purpose of the operation, which is on a room and pillar system. The first level has a relative high purity up to 92% and 95%; with the lower levels reportedly at from 80 to 85% percent. From 90,000 to 150,000 tons of gypsum are taken out of the mine annually, and estimatedly within 15 to 16 years all the gypsum shall have been removed from the first level of the present ownership. Five (5) of the areas are old sections of the mine which have some caved areas and questionable pillar support. In these areas the first level of the gypsum deposit was mined many years ago and the only areas presently in use are those near the plants, through which mined rock is hauled. The 69 acre portion at the Northwest corner of Covell and O'Brien Road essentially has been mined to the first level. The Company has not mined at the second or lower level of these areas.

The Company acquired an approximately 31.75 acre parcel of land at the Southeast corner of Covell and Fulton Street in 1959, which has not been mined at any level.

The mines are drained with two pumps of 400 to 500 gallons-per-minute capacity, with 9 to 10 inch lines emptying into two shallow ravines in the Southeasterly portion of the ownership.

The City of Grand Rapids has since January 1955 leased the approximately 37 acre portion in the Northeast corner of the ownership from the Grand Rapids Gypsum Company for public picnic grounds, surface rights only, for $1.00 per year, automatically renewed from year to year unless cancelled by either party, subject to cancellation by the Company upon one year's written notice. Any construction done by the City during the lease must be of a nature so as to be readily and easily removable.

A surface rights courtesy lease with an Archery Club is also in existence, subject to cancellation on a 30 day basis.

The waste plaster and dust of the manufacturing plants are deposited in the lowland area in the Southeast portion of the ownership adjacent to Grand River.

A portion of the manufacturing site in which the buildings of the Grand Rapids Gypsum Company are situated is leased to the United States Gypsum Company and contains a sheetrock manufacturing plant, the lease being made for inter-operation between the two concerns and is of mutual benefit to both firms.

In addition to the ownership in fee simple the company is leasing sub-surface mining rights from the U. S. Gypsum Co. on approximately 56 acres immediately adjacent to the West of the subject property on the South side of O'Brien Road and also approximately 17 acres from Certain-Teed Corp. adjacent to the West of the U. S. Gypsum leased acreage.

The Mining operation is presently in the two before mentioned leased areas, and in a 24.70 acre tract of land to the Northwest of the intersection of Covell and O'Brien Road to the North of the Consumers Power Company right-of-way.

The site of the manufacturing plants and allied buildings is presently not undermined.

HIGHEST AND BEST USE

In analyzing the subject property it is apparent that it has uses of different categories.

The area of the manufacturing operation as improved has a highest and best use as Industrial w/rail siding, in conjunction with the mines and in conformity with the zoning.

The portions of the acreage presently being mined in the subsurface have an evident highest and best use for Gypsum Mining.

The approximately 31.75 acre tract of land at the Southeast corner of Covell and Fulton Streets, as yet not mined, has a highest and best use as Potential Residential Subdivision as is evidenced by the two subdivisions within the same quarter section and by the extensive growth and development which has taken place to the North of Fulton Street, West of Bristol Avenue.

The surface rights of the land which has been mined is of somewhat problematic use. There are remote cases of the land being used for residential purposes with buildings located over a mined area, as a sale to the West of the subject verifies. The structure in the sale is old and with no recent subsurface activity in any proximity to it, thereby not affecting its use. However, there is no evidence in the market of any residential structures being placed on land that had been undermined. A deterent factor could be the lack of financing on such a site, as they are not favorably looked upon by financial institutions in the area, or more so by the Federal Housing Administration which insures the loans. Another factor which is considered to create resistance to residential use is the dynamiting or blasting in the mines which creates shock waves which can and do carry a minimum distance of ½ mile from the point of blast. The existing lease with the City of Grand Rapids of the Northeast 37 acre portion of the subject for picnic grounds and or recreational use indicates to the Appraiser that this would be the highest and best use of such undermined acreage and is congruous with the present use.

The lowlands in the Southeasterly portion of the ownership have a highest and best use for dumping purposes in conjunction with the manufacturing site and of proportionate contribution.

PROPERTY VALUATION BEFORE TAKING

The property being appraised is an approximately 418 acre operating gypsum mine, over a 100 years old, with installations for the manufacture of finished products for marketing.

The basic problem in the Appraisal is to estimate the fair market value of the land before the taking for limited access highway purposes and to estimate the fair market value of the remainder, thereby arriving at the recommended just compensation due the owners. The major problem in the Appraisal is the estimating of diminution in value of the industrial site caused by the reduction in size by the taking of approximately 60% of the waste dumping area which is necessary to the operation being conducted.

The only applicable approach to the value of the land is the Market Data Approach, and sufficient sales are available to substantiate this approach.

The buildings and land improvements are not within the area of the taking, nor in my opinion is their utility or use affected, therefore the Appraisal is made on land values only.

The land leased to the United States Gypsum Company, all within the ownership of the subject, is not affected by the proposed taking nor is the land utilized for dumping purposes for this plant as it is located farther to the Southeast. In the considered judgment of the Appraiser, the United States Gypsum Company has no leasehold advantage, therefore will be given no further consideration in this report.

The 37 acre portion in the Northeast corner of the ownership leased to the City of Grand Rapids with a $1.00 per year renumeration, and cancellation clause of one year's written notice, in the opinion of the Appraiser has no apparent monetary value to the City, nor is the City entitled to compensation due to severance of this leased acreage as they have no valuable interest in the property. Will, therefore, be given no further consideration in this report.

This appraisal being for purposes of evaluating the land only, the Income Approach or the Cost Approach to value are not applicable.

To arrive at an estimated market value the various categories of land uses within the subject ownership are being analyzed in the market analysis, and a distinction of uses and their estimated market value is broken down to the following:

Industrial Site	-	30.00 acres
Lowlands	-	40.00 acres
Uplands, mined	-	316.75 acres
Upland, not mined	-	31.75 acres
Total	-	418.50 acres

Based on sales and offerings in the general vicinity of the subject property and adjusted to the subject, the estimated value of the land, bare and unimproved is:

Industrial land	-	30 acres	@	$3000. a/a	$ 90,000.00
Lowlands	-	40 acres	@	250. a/a	10,000.00
Uplands, mined	-	316.75 acres	@	500. a/a	158,375.00
Uplands, not mined	-	31.75 acres	@	2000. a/a	63,500.00

ESTIMATED MARKET VALUE OF LAND BEFORE $321,875.00

Dix Report

I

PURPOSE, METHOD & BACKGROUND

Our involvement with the Grand Rapids Gypsum property taking for the I-96 Freeway and the approaches to the Grand River bridge crossing has required the time from May 21st through August 7th when the final settlement was signed. The following report constitutes a summary of the engineering analyses, cost determinations, and recommendations which have been made to the company and to the attorneys for the Highway Department of the State of Michigan.

1. PURPOSE

The purpose of these analyses and negotiations was to quash the certiorari action entered into by the company and to complete the property taking with a final settlement of all damages.

2. PROBLEM IDENTIFICATION & SOLUTION APPROACH

The primary problem and the key to the solution to the taking and final settlement has been to determine the actual corporation problems, evaluate the corporation claims, and determine the cost of the engineering solutions. The problems, in the order of their importance and as identified in certiorari action, included:

(1) Provision for wall board mill location

Prior to the proposed taking, property existed upon which a board mill could be constructed. After the taking, there was no apparent location for this proposed mill. The actual plan or necessity for the construction of this mill had to be determined. The economics of the size and location of the proposed mill had to be determined. The physical problem of finding a location for the mill with or without relocating the primary highway as planned was required. Finally, the comparison of costs between the available location before the taking and the rearrangement of company property, railroad property, and the limitation of the highway taking areas was employed to evaluate the damages associated with this mill location.

(2) Waste disposal

Prior to the taking, the swampland area south and west of the existing mill properties provided space for disposal of waste. Subsequent to the proposed taking, this area was substantially reduced. The quantity of waste generated, the life expectancy of the continued operation, and the cost of alternative disposal was required to evaluate the damages.

(3) Liability for future damages against the company for reason of Highway secession over mined out areas and for dust generated by the mill

The area being taken for the Highway passed over mined out areas which could collapse at some time in the future causing a possible drop in the Highway road bed. Potential liability by the company after the taking introduced a legal question beyond the scope of this analysis. Conferences established that this problem was not a major barrier to the ultimate solution and settlement.

Dust from the existing operations before the proposed taking would settle in a swamp area owned by the company under normal wind conditions. After the taking, the Highway would pass through this area and open the company to either state or city action requiring them to correct the condition causing the formation of dust. The cost of this dust arresting equipment was determined in the course of our analysis. The liability of the Highway Department for this cost or any portion of this cost was resolved in conference and negotiations.

3. METHOD

Following initial conferences with the Grand Rapids Gypsum management, it was determined that the provision for a mill location was the primary problem, that this mill location was believed to be critical to the company's future, and that no actual solution was believed to be available within the property which would remain following the planned Highway taking. Investigation of the economic necessity for this mill confirmed the company's position. Subsequent activities were focused on direct assistance to the company management and engineering departments to find a solution to the mill location, balancing the costs of Highway relocation with all other costs and methods available.

Following investigation of available consulting services on board mill construction and operation, we joined with the Grand Rapids Gypsum Company in employing the firm of Johnson & Johnson of Chicago, Illinois to send their board mill specialists for two days of conference and exploration of the problem on the grounds. These conferences with our engineering department produced the solution to this mill location problem.

Subsequent to the solution of a mill location plan, the determination of damages was based on the alternative locations of this established mill before and after the taking.

The remaining problems of waste disposal and dust control were resolved in conference after determination of costs.

4. COMPANY HISTORY & GYPSUM DEPOSIT ECONOMICS

The Grand Rapids Gypsum Company began operations before 1848, removing gypsum by a mining operation from the presently owned property. This appears to be the second oldest gypsum mine in the United States. The original gypsum was employed for agricultural purposes. Subsequently, a calcining kettle mill was added to the rock crushing and rock handling equipment and the company began to process and sell finished plaster or stucco.

The original company was primarily a real estate operation owning a large part of the west side properties of the village of Grand Rapids. Ownership has continued in the same family throughout the history of the company; however, the owners presently reside outside of the immediate area and the company has continued to be managed by employed executives.

During the company's history, additional property was acquired permitting the extension of the mining areas. The first mining engineers were employed after the turn of the century. Prior to this time large areas were opened subjecting the mines to cave-ins which have subsequently occurred. The mining engineering efforts however protected the primary mines from these subsequent cave-ins and the remaining areas were mined with proper precautions, safety and provision for future operations.

During most of the history of the company, the very large deposits of gypsum ore were exploited with a minimum of capital expenditure and provision for the expansion of the business. An independent company was given a lease on property upon which a board mill was constructed between 1900 and 1950. This company, the mill, and its leases with the Grand Rapids Gypsum Company were purchased by the United States Gypsum Company subsequently.

During the last five years, a new professional management has taken an active stand in modernizing and projecting the future of the Grand Rapids Gypsum Company. This position was made necessary by the economic shift in the demands for products of the gypsum mine from bag plaster to plaster board. This transition has been accelerating since 1945. Since 1957, authorities on gypsum deposit economics have stated that "the day of the small independent plaster mill has passed, and the new modern gypsum board and plaster plants constructed by the integrated corporations are (taking over)". Correspondence with the Michigan State Department of Conservation and reference to their libraries confirms this information. Reference is made to an analysis of gypsum deposit economics published in the Mining Congress Journal of March 1957 by J. F. Havard.

The Grand Rapids Gypsum Company began its modernization of operations with the mining department. Several hundred thousand dollars were spent in mining equipment with the ultimate result that a department employing sixty men was reduced to a present complement of eleven men including the superintendent.

The second step in modernizing the operation involved automatic electrical controls on the No. 1 mill crushing plant, replacement of the coal-fired calciners with gas in the No. 1 plant, pneumatic conveyor from the No. 1 plant to the U. S. Gypsum board mill, and the abandonment of the No. 2 cancining mill.

Although these latter expenditures were discernible above ground, a great majority of the expenditures were internal and not obvious to the Highway Department making the original investigation and the original decision to appraise the land taken only.

The projected plans of the Grand Rapids Gypsum Company included a board mill to be constructed after 1965. These board mill plans were not detailed. The final modernization of the cancining operation was detailed. Further, there was a question in the minds of the Grand Rapids Gypsum management as to the advisability of pushing the board mill plan ahead of the calcining plant modernization.

The gypsum deposits mined by the Grand Rapids Gypsum Company are known to extend more than two miles north of the Grand River and some five miles along the Grand River. These gypsum deposits are at two levels. The upper level consisting of a strata from eight to twelve feet thick is approximately fifteen feet below the grade level of the railroad at the mill location and has some fifty to two hundred feet of overburden above the strata in the hills under which the mines have been extended.

The lower level represents a strata some fifty feet below the upper level strata consisting of two layers somewhat narrower than the upper strata, divided by a thin strata of contaminating rock. The lower strata is believed to be as extensive as the upper strata which is confirmed by borings wherever borings have been taken.

The Grand Rapids Gypsum Company operations have been confined to the upper strata gypsum during these first 115 years of its history. The total gypsum in the lower strata exceeds the upper strata gypsum and will account for approximately a one hundred year future operation.

The Grand Rapids Gypsum Company has two competitors who have smaller holdings at the western extremity of this geological formation. The U. S. Gypsum holdings are being mined by the Grand Rapids Gypsum Company. The Certainteed Company have been operating at the westerly extremity with a more modern and larger capacity plant. This company has a much smaller land holding and has been mining on both levels.

The Grand Rapids Gypsum Company was formerly referred to as the Grand Rapids Plaster Company, and this designation is employed on many engineering drawings and other references.

II

SEVERANCE DAMAGE ANALYSIS

The original real estate appraisal for the land required by the I-96 Freeway was confined to the fee real estate totaling approximately 31.8 acres of unimproved property plus the use of 4.8 acres of similar, unimproved property for muck disposal. Much of this land is flooded during high water by the Grand River. The high land passed over mined out areas of the upper strata of gypsum, but the lower strata mineral rights were reserved to the Gypsum Company. The total approved appraisal is indicated at $28,000.

Severance damages for the purpose of this analysis have been confined to those damages stipulated in the certiorari action and discussed in Chapter I. No formal before and after taking appraisal of the total industrial properties is believed to be necessary. The book value of the Grand Rapids Gypsum Corporation's net worth in a recent audit was indicated at $1,500,000. This includes the normal understatement of raw materials in the ground. These raw materials are estimated at 11 million tons of unmined gypsum ore worth between five and ten cents per ton in the ground. Bargaining for the purchase of this industrial property would probably start at $4 million. All of these values would be relatively unaffected by the taking if solution is found for the damages claimed by the company in their present action.

1. BOARD MILL SITE COSTS

Settlement with the Grand Rapids Gypsum Company depends on a solution to the problem of finding a site for the proposed plaster board mill within economic proximity of the company's mine and calcining operations. The cost of providing this location whether by relocating the highway or by any other means represents the principal expense in addition to the fee property taking. This expense has been considered to be the severance damages for the fee taken.

In actual practice, the cost of this board mill site is represented in the engineering expense underwritten by the Highway Department to find a solution to the problem, concessions in the area to be taken by the Highway Department for muck disposal purposes in the planned highway construction, concessions in filling land for the benefit of the company, and a portion of the actual cash settlement at the completion of negotiations.

The necessity for providing a board mill site was not immediately apparent. The company owned the land presently leased to the United States Gypsum Company on which an adequate board mill is now operating. The leases and contracts between these two companies were withheld and could be obtained only through court action in the damage proceedings. Discussions with executives and officers of the U. S. Gypsum Company, both at the Grand Rapids location and at their offices in Chicago, indicated the following:

1. The lease was recently renewed on a ninety-nine (99) year basis and is completely separate from the operating contracts between the two companies.

2. Although the mill is relatively efficient, the building in which it is installed is very narrow and lacks proper storage area alongside the mill.

3. United States Gypsum Company holds patents on the specific mill design which permits returning the board directly under the board forming line. All other available mills require twice the width for a new installation.

4. United States Gypsum Company would remove all of their property from the mill site in the event of a lease cancellation. No admission is permitted to their mill operations and no rights have ever been permitted on the use of their patents.

This information together with the general economics affecting the small gypsum mill operators confirmed the ultimate necessity for the Grand Rapids Gypsum Company either building their own board mill or providing for the building of a board mill to the eventual purchaser of their mine and calcining properties.

(1) Board mill location size and proximity to mine and calcining mill.

It was immediately apparent that a solution existed to the location of a board mill of any reasonable size in the neighborhood of the present company calcining plant. However, this location was on property not presently owned by the company, and this location would require a permanent high expense in the cost of delivering stucco from the calcining mill to the potential board mill. Further, the method of delivery would require pneumatic tubes and large volumes of air. This solution would extend experimentation presently successful in delivering stucco from the present mill to the U. S. Gypsum mill. However, this present pneumatic system is reputed to be the longest stucco delivery pneumatic tube ever attempted. Extension would involve further experimentation.

It was our opinion that this engineering problem would be resolved. However, the burden of proof in any court trial would be too difficult to attempt. Further, the existence of one hundred year's supply of gypsum in the ground would introduce an excessive cost in capitalizing the expense differential which would result from this choice of location.

As all areas available after the Highway taking were restricted, and as some concessions appeared necessary on the part of the Highway Department in giving up land presently desired, the precise dimensions of an efficient board mill became critical. These dimensions should not include any differential on the basis of efficiency if some part of the costly capitalization expense was to be avoided.

The realization of these objectives required concurrence on the part of the company with the established design of an efficient mill. The only practical solution to this problem was the employment of a second group of consulting engineers to work with the combined forces of the company and our organization in producing an agreed upon mill plan complete in outside dimensions. The Chicago firm of Johnson & Johnson was selected and the following dimensions were determined:

1. Width

The building width was finally established at 160'. A truck road on the mill side of the building (away from the railroad siding) was required with a 25' width. A service area on the railroad side of the building was established at 10'. The plant was laid out with the railroad siding inside the building (included in the 160' width). The total plot width then became 195'.

2. Building Length

The building length was governed by the length of the board mill itself which in turn is a function of the speed or capacity of the mill stated in feet per minute. Two sizes or mill speeds are available and potentially economic. The smaller, slower mill is presently planned. However, no proposal could be accepted which did not provide sufficient area for the ultimate expansion of the mill to the longer, most efficient, mill presently available. Thus, two mill lengths had to be considered:

1. An 840' mill for immediate construction.

2. A 1,140' mill site for future expansion of the original mill.

As the proposed highway described an arc around the primary Grand Rapids Gypsum properties, and the mill could only be located between the mine and the highway, the mill location became a cord across this highway arc and its ultimate expansion was limited to its original location.

3. Proximity to Calcining Mill

The ultimate, most desirable location for the proposed board mill was directly adjacent to and contiguous with the present calcining mill and the present warehouse and gypsum bagging operations of the company. This proximity would facilitate the exchange of warehouse space, the exchange of personnel between the two mill operations, and the simultaneous loading of materials produced in the two mills. Obviously, the transportation cost between the calcining operation and the board mill operation would also be at a minimum if this solution could be realized.

Ultimately the efficiency of all board mill locations would be compared with the closest proximity mill location.

(2) <u>Alternation location costs</u>

Following resolution of the definition of the mill size and desired location, primary engineering efforts were expended on the analysis of alternative locations and their costs. Initially, all available Highway and company survey prints were obtained. Two Highway survey teams were employed to resolve conflicts and produce a reliable contour map of the area identifying the critical property lines. Ultimately, borings were obtained at the proposed board mill site to augment the profile lines available on the Highway prints.

Reference is made to four prints folded and attached at the end of this report. These prints provide the following significant information:

1. <u>Print 1, Plan A</u>

This print represents the original, company selected location for their board mill with the proposed building superimposed on the contour map identifying their present buildings and relationship to the New York Central Railroad right of way. This original plan provided for both a service and truck road which was subsequently reduced to provide a firm basis for comparison between alternative costs. The proposed building is a maximum efficiency, ultimate length board mill.

2. <u>Print 2, Plan B</u>

Plan B provides the proposed board plant location which is compatible with the Highway location and which became the basis for the ultimate settlement referred to as Exhibit "A". This location is also the most efficient plant location exceeding the efficiency of the company proposed location, Plan A.

Plan B provides for the immediate mill plan as well as the future expansion, ultimate efficiency location. As drawn, the Plan B expansion is indicated in the direction from the shipping end of the plant. It should be noted that this expansion is possible in the reverse direction, wherein the shipping end of the plant would be built first and the board forming and board take-off machinery would then be relocated when the plant was expanded in a westerly direction.

Plan B contains the railroad right of way relocation identifying the curvature of the track as established by the New York Central District Engineer in the Detroit office.

3. Print 3, Plan C

Plan C represents the identical sized board mill located in a secondary position relative to plant efficiency but in a position completely compatible with the proposed I-96 right of way when the muck disposal areas originally planned are given up.

Plan C represents the minimum expenditure plant location. It also represents a minimum expense to the Highway Department in terms of the cost of altering their engineering plan. As Plan C is approximately equal in efficiency to the company's originally proposed Plan A, Plan C represents the State's defense in any ultimate damage proceedings.

Plan C is not a practical, desirable plant location in view of the availability of Plan B. Because Plan C would represent higher costs which over a one hundred year period would many times eclipse the difference in original building expense, Plan C could not be recommended to the company. Plan C was withheld from direct negotiations excepting to recognize its existence and its defensibility in any ultimate damage trial.

4. <u>Print 4, Plan B with Contours</u>

Print 4 provides the tie-in between the Highway drawings and Plan B including the identification of borings made for the ultimate mill plant site and the contour lines. Only the area immediately adjacent to the mill site is shown in this print.

Exhibit 1, on the opposite page, summarizes the principal costs of preparing a site for the alternative sizes and locations of the proposed board mill. It should be emphasized that these cost comparisons are limited to the site preparation. They do not include any consideration for the efficiency of the comparable sites or any attempt at capitalizing the difference in operating costs which could be foreseen.

Actually, the efficiency comparison is most difficult. Although the Plan C site is much less efficient than the proposed Plan B site, a reasonably good case could be made in court for its comparability with the company's proposed Plan A site. However, the stucco delivery conveyor represents a small continuing cost which can definitely be projected for operating and maintenance expense over and above the Plan A location.

As all discussions and negotiations with the company were carried on against the background of the certiorari action, every attempt was made to present the actual advantages to the company in accepting the Plan B, most efficient mill proposal with a minimum of actual cash damages. This mill location would not be available if the Highway Department pressed its property requirements to the ultimate conclusion and if property already acquired by the Highway Department (subject only to damage determinations) were not released to the company.

Exhibit 1 provides comparison of seven (7) alternative combinations of plant size and locations. All costs are stated in terms of the anticipated expense to the company to acquire the property, fill the land, reimburse the railroad, and build the indicated structures. The displacement of existing buildings is based on our appraisal of the value of those buildings plus the detach and reattach expense for the machinery and utility relocation. The State contribution costs are based on the commercial costs of fill plus an arbitrary $1,000 per acre estimate of the cost to the Highway Department to give up the availability of the specific muck disposal areas required by the plan.

The alternative site locations identified by the letters A-1, etc. are directly comparable with alternative Plans B and C for the same suffix. B-1 introduces the furthe breakdown of alternatives.

It is obvious that the Plan B costs which involve the relocation of the New York Central main switch line right of way exceed the company's proposed Plan A by between $21,000 and $78,000. The Plan A location permits the filling of the land required for the eventual expansion at a later date, whereas the Plan B location costs entail relatively little fill and the railroad must be relocated before even the minimum plant can be built. The second differential stems from the potential avoidance of the displacement of the company's present offices, laboratory, and machine shop by constructing the original, small plant starting at the shipping end of the plant.

The Bl - 2 Plan providing for an 840' plant starting at the southeast, shipping end, on a 1,140' site is the most probable, actual plant that will be initially built. This plan is not directly comparable with Plan A1 or A2. On a plant size basis it indicates a $21,000 additional cost for the proposed plan. On a plant site basis, the cost is within $7,000. However, this tabulation provides for the eventual site but it does not provide for the clearance or removal of the buildings necessary for the extension, whereas the A2 site would have been completely prepared. Thus, the differential remains close to the $21,000 figure, and the $7,000 favorable differential cannot be legitimately employed.

The Plan C locations are all less expensive in original cost than either the Plan A or Plan B location. As these locations are less desirable from an efficiency standpoint, this lower initial cost would not be attractive in the long run and the plan provides only a basis for a reduction in the cash damages established in negotiations. The Plan C location requires the acquisition of New York Central Railroad property but does not require the relocation of the switch line right of way. It also requires the relatively narrow plant which was developed as part of the Plan B solution. It is thus a by-product of the Plan B engineering analysis depending both on the company acceptance of this plant dimension and the Railroad cooperation in giving up its property. These facts would add to the burden of proof in a damage trial but would not destroy the effectiveness of the alternative.

(3) Simplified comparison of site costs

Exhibit 2, on the opposite page, summarizes the direct comparison between Plan A2 and Plan B2. This comparison recognizes the ultimate necessity for a 1,180' plant site.

The Plan A2 and Plan B2 are directly comparable for this ultimate plant. Both in Exhibit 1 and in Exhibit 2 all foundation work which would be automatically provided by the removal of muck and the fill in Plan A have been compared with a similar land preparation for the Plan B location. No much exists at this Plan B location, but the building footings will require trenching and backfilling with sand to be equivalent to the fully filled Plan A location and this trenching and backfilling was required by the consultant employed by the company.

All figures in these comparisons were checked by an additional construction firm, Owen, Ames, Kimball Company, employed by the Grand Rapids Gypsum Company as a final confirmation of our costs.

Whereas the Exhibit 2 comparison provided the simple basis for negotiations, these same negotiations recognize that this central comparison is surrounded by alternatives to the company Plan A which will realize no additional expense.

(4) Office, lab and shop building appraisal and fixture detach-reattach costs

The Plan B site will ultimately require displacement of the present mill offices, machine shop, and laborabory as discussed in Section 1 above. A preliminary appraisal was made of these properties to establish the relative cost of this land clearance.

Exhibit 3, on the opposite page, summarizes the breakdown of principal values in this analysis. It should be noted that the appraisal is based on limited observations and does not include contractor confirmation of all relocation costs. However, the significant direct current electrical installation relocation cost was confirmed. The main switchboard for the mines is located in the machine shop. The relocation costs for this switchboard and the lines involved proved to be relatively small.

Demolition was indicated as a major expense as the buildings are of solid, stone construction and would provide practically no salvage. This value may be slightly overstated but will provide a necessary cushion in the total appraisal.

The machinery relocation costs recognize the following equipment:

1. One Milwaukee mill
2. Four machine lathes
3. Two shapers
4. Two double arbor grinders
5. One Canedy radial drill
6. Two vertical drill presses
7. One Niagara shear
8. One roll and brake
9. Two bandsaws
10. One surface plate
11. One forge
12. One hoist and monorail
13. Line shafting
14. Portable air compressor
15. Bench & miscellaneous attached racks and small tools

The laboratory is a relatively recent addition to the machine shop building and completely equipped with movable tables, benches and specialized equipment. The costs of this addition were not detailed. Some understatement might develop in this area.

On the basis of this preliminary appraisal, we have employed a $60,000 figure as the cost of this land clearance. The expense can be avoided until the ultimate, full length mill is constructed by placing the first mill to the north of the layout and expanding to the south as discussed above. However, this cost will necessitate an estimated $20,000 additional expense when the expansion is made.

(5) New York Central right of way relocation

Both Plans B and C require acquisition of land owned by the New York Central Railway for the proposed board mill location. Plan B required the relocation of the switch line right of way as the total, 50' right of way became the locus for the proposed mill.

Cooperation with the Railroad was secured on the basis of the Grand Rapids Gypsum Company's longstanding, heavy use of rail freight transportation. Rather extensive negotiations were carried on with the Railroad involving the manager of industrial development in the Detroit office, the superintendent and trainmaster in the Jackson office, the engineering department in the Detroit office, and the Grand Rapids freight agent.

Obviously, no firm contract or final costs could be obtained from the Railroad. However, all responsible departments reviewed the plan, established the railroad limitations, reviewed the established costs, and agreed that there were no barriers in the Railroad policy or administrative procedure which could be foreseen.

Exhibit 4, following, reviews the proposed agreement in principle which was carried through the Railroad offices by Mr. G. R. Peterson, Manager of Industrial Development for the Division. Exhibit 5 completes this correspondence.

File under
I-196 41029 E
Grand River to Sibley

L. Cook
Asst. to the Engineer of Testing & Research

D. D. Dolph
District Soils & Materials Engineer

Subsidence of road over Mine Shafts.

Attached is some old correspondence related to the Gypsum mines located near or under I-196 between the Grand River and Lake Michigan Drive. From this correspondence it appears that the old mines run under I-196 from Sta. 442+00 to Sta. 463+00, Project 41029 D, I-196 from Grand River to Sibley Street. The District has observed no subsidence in this area within the R.O.W.

I contacted Chet Feringa of the Kent County Road Commission to see if they had experienced any subsidence problems on any of their roads. Mr. Feringa said the county had experienced no subsidence problems.

I discussed the subsidence question with Mr. Fry of the Grand Rapids City Engineers Office. He stated that the city had experienced some subsidence of Butterworth Road between Veterans Memorial Drive and O'Brien Street. They took care of the problem by closing the road, filling the hole with fill material, resurfacing the road and hoping the road did not continue to settle. Mr. Fry said they had experienced subsidence in several areas on Butterworth Road.

It appears from the attached letters that the mined out layer of gypsum varied from 7 to 12 feet in thickness. The collapse of the old mined area was caused by the removing of the supporting pillars.

It may be of interest to note in Mr. Stokstad's letter to McCarthy that the Department assumed the responsibility for damage within the R.O.W. caused by the collapse of rock formations in the mined out area.

Duane D. Dolph
D. D. Dolph
District Soils & Materials Engineer

DDD:mab

Enc.

cc: K. Allemeier

FILE UNDER
CITY OF GRAND RAP

For Information Purposes:
Mr. Hornbach reported a street cave-in in the vicinity of Butterworth Street near O'Brien Road, stating it possibly is a result from the underground mining. As in many other mining areas, the street was deeded to the City (about 100 years ago) without liability to the mining companies. However, it was the staff's recommendation that the street should be repaired. Asst. City Attorney Balkema said there is a question of the City conceding to this type of liability but would not disapprove the fact that the street should be repaired because of the safety factor. Com. Sypniewski added that the road is quite travelled and funds should be appropriated for the repairs and the problem of liability be looked into later.

Committee concurred and City Engineer Hornbach will make arrangements for an emergency bid.

26230 11. Resolution authorizing contract to establish a computerized sign inventory system for the City.
It was noted by Mr. Zainea that expenditures for the above contract has been approved. Traffic Engineer Simmons explained that in 1946 there were several thousand signs (street and traffic) installed in the City which were not catalogued as to cost, location or condition. Consequently, it was necessary to go through town and mark their information as much as was possible. Through the years these signs are removed, stolen, rusted, etc. and as the complaints are received, it is difficult to determine exact locations or conditions. About three years ago a Traffic Engineer started the idea of movies and photo logging each street which information is then put on computer cards. In addition to Traffic Engineer's information these records can be utilized by other departments determining the condition of curbs, hydrants, number of homes, street lighting conditions, number of lighting poles, crosswalks, etc. Mr. Simmons added that this program is now being done on a statewide basis and in his opinion is a great advance plus dollar savings for the City.

The question was raised whether in ten years the problem of missing signs would still remain, as citizens still must call, Foster Mining

Form 11

CIT OF GRAND R PIDS

INTER - DEPARTMENTAL LETTER

Date February 6, 1973

To: City Engineer Attention: John L. Hornbach

From: Field Engineer

Subject:

1. Department of Natural Resources
Lansing, Michigan
Geological Survey Division

Mr. Thomas Segall, Geologist, Mining and Economic Geology
1-517-373-1256
This department deals with the appraisal of mines and is in charge of land use and reclamation of land.

2. Department of Labor
Lansing, Michigan
Bureau of Safety and Regulation

Mr. Allan Harvie, Deputy Director, Occupational Safety Services

This department deals with the safety aspect with rules and regulations governing employees safety.

3. United States Department of the Interior
Bureau of Mines, Health and Safety Division
Duluth, Minnesota
1-218-727-6451

Mr. Robert Moore

This department deals with the health and safety aspect of the mining industry.

AKH:ldm

G.R. GYPSUM CO. 459-6183 DOWNTOWN
453 2413 PLANT

2/15/73 Copies to Pete Lembertz + Howard R. Roberts

Form 113

CITY OF GRAND RAPIDS

INTER - DEPARTMENTAL LETTER

Date February 13, 1973

To: City Manager Attention: Joseph R. Grassie

From: City Engineer

Subject: Road Subsidence on Butterworth Road

At your request, this office investigated the road subsidence caused by Georgia Pacific mining activities on Butterworth Road and responsibilities for the repair.

There does not appear to be any clear cut rule that can be applied to various cases. To the best of our information, there are three agencies that have jurisdiction over mines in Michigan, none of which takes responsibilities for surface repairs. Attached is a list and a brief statement concerning their activity.

Mr. Donald Goulais of the Highway Department, Attorney General Division in charge of the Upper Penninsula Office, has had some experience with road subsidence in that part of the State. It was his opinion that the mining company causing the damage would be responsible for lateral and subjacent support or repairs of damages due to the lack thereof if:

1. The road was established by user prior to mining under the roadway.

2. The deed for the road was acquired by the public agency prior to acquisition of mining rights or a deed was received from the mining company without an exclusion for mineral rights.

   The public agency having jurisdiction over the road would be responsible for the cost, if the deed to the roadway was acquired without mineral or mining rights.

Regardless of who is responsible for the cost of repairs, Mr. Goulais stated that the public agency would be the party responsible to see that the road was in proper repair or else properly barricaded to prevent its use. The public agency could be held responsible for property damages or injuries due to the lack of repair or proper barricades.

The Kent County Road Commission was contacted, and they stated that the roadway was acquired by user except for one section that was acquired from Bestwall Gypsum Co. (now Georgia Pacific Co.) with a deed that did not retain mineral rights. If this is so, it would appear that the Georgia Pacific Company would be responsible for making the necessary repairs.

To avoid problems of fixing the responsibility for roadway subsidence problems in the future, it might be well to request a state law to require the party doing the damage to provide proper lateral and subjacent support and be responsible for repairs due to the lack thereof.

John L. Hornbach

John L. Hornbach, P.E.
City Engineer

JLH:rg
Attach.

Appendix G

1962 MDOT Seismic Report on I-96 by Mr. D. N. Hart

OFFICE MEMORANDUM

MICHIGAN
STATE HIGHWAY DEPARTMENT
JOHN C. MACKIE, COMMISSIONER

May 4, 1962

To: Mr. R. L. Greenman
Assistant Testing and Research Engineer

From: G. O. Kerkhoff

Subject: Report of Seismic and Boring Survey
I-96, Grand Rapids Area
Butterworth Road to Fulton Street
Control Section 41029D

Transmitted for your distribution are copies of the subject report. This survey was made on survey centerline of that section of the proposed roadway overlying the old mined area of the Grand Rapids Gypsum Company. Mr. D. N. Hart, Geologist, not only supervised the seismic survey, but also made an underground inspection of the Gypsum mine beneath the proposed roadway. His comments on underground conditions are most revealing.

Survey results indicate that subsurface conditions are complex. The top of the bedrock surface is irregular. In places it is masked by overburden materials having similar texture and seismic velocity.

Interpretation of our findings show that the mined area beneath the roadway has caved in the past and is actively caving at present. While none of this caving within proposed right of way is evident at the surface, there are many exhibits of cone shaped subsidence resulting from collapse of old mine workings.

Your attention is directed to Mr. Hart's conclusions that the proposed roadway overlying the Gypsum mine is in a potentially unstable area. We concur with these conclusions.

OFFICE OF TESTING AND RESEARCH

G. O. Kerkhoff

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Head of Soils Section
Testing Laboratory Division

GOK:DFM:PL

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REPORT OF SEISMIC AND BORING SURVEY

I-96, Grand Rapids, Butterworth Road to Fulton Street
Control Section 41029D
May 4, 1962

This report presents the results of a seismic and boring survey on the above Project. The intended purpose of this survey was to provide bedrock depth data beneath the proposed I-96 roadway crossing the Grand Rapids Gypsum Company Property. This survey was run under the direct supervision of Mr. D. N. Hart, Geologist.

The area encompassed by this survey lies entirely upon morainic deposits associated with the Valparaiso Morainic System. The complex soil structure and accompanying rugged surface relief encountered during this survey are typical of morainic glacial deposits.

Figure I of this report shows a General Location Plan of the survey area. The position of seismic shotholes, seismic traverse traces, and correlation boreholes with respect to survey centerline are illustrated. The random orientation of many of the seismic traverses was necessary in order to avoid excessive terrain corrections and various cultural obstacles. Caved mine roof areas shown on the location plan do not reflect their presence at the ground surface by observable ground subsidences. No observable ground subsidence was discovered in the areas traversed by this survey.

Figures II and III depict the subsurface character and structure, along survey centerline from Station 434+90 to 462+00, as inferred from geophysical and boring data. In general, the subsurface here is characterized by thick Clay and Loam Glacial Till deposits overlying Shale and Gypsum Bedrock of varying hardness. The Clay and Loam Till contains lenses of dry and saturated granular soil. A considerable surface deposit of sandy soil is present from Station 447 to Station 462, survey centerline. Seismic data at Stations 452 and 454, survey centerline, indicates the presence of a depression in the Hard Shale Bedrock surface which may extend down, or nearly down to the mine roof. The presence of this depression above an area of indicated extensive mine roof caving may be more than coincidental.

Figure IV illustrates a cross sectional interpretation of subsurface character and structure along a random traverse extending 1,650 feet West of Station 458, survey centerline. The primary reason for this traverse was to compare the results of seismic soundings conducted over mined and unmined areas. Results indicate generally that partial removal of Gypsum Bedrock by mining and the associated fracturing, by blasting operations of overlying and adjacent bedrock layers can be detected by seismic velocity measurements in this area.

During the conduct of this survey, the writer had the opportunity to personally examine portions of the Gypsum mine underlying the proposed roadway and other parts of the mine not within the proposed roadway. The portion of underground workings immediately below Stations 460 to 462, survey centerline, were found to be free of caving conditions and water. However, when attempts were made to examine the mine workings from Stations

444 to 459, survey centerline, the writer encountered caved mine roof and water of sufficient depth to discourage further investigations of this area. In addition to the foregoing, mine workings not within the proposed roadway were examined where the mine roof had completely collapsed. Large amounts of yellow sand and cobble gravel were found filling the mine workings at these points. The ground surface above these caved areas is marked by many funnel-shaped depressions, some of which are 40 or 50 feet in diameter and as deep as 25 feet. The writer also observed the effects of mine floor heaving and mine pillar collapse due to swelling or slaking of soft shale beds.

In conclusion, the writer believes that mine roof conditions under much of the proposed I-96 roadway lying over the mined area are unstable. This is not to imply that the mine under the proposed roadway is on the verge of complete immediate collapse. It is to indicate, however, that progressive deterioration of the mine roof rock is underway at this location. The material above the Hard Shale Bedrock at Station 454, survey centerline, should be investigated in detail. This should be done by a deep core boring, as this location could easily become a focal point of possible future mine roof collapse.

OFFICE OF TESTING AND RESEARCH

D.N. Hart

D. N. Hart
Supervisor of Seismic Survey
Sub-Unit
Testing Laboratory Division

FIELD LOG OF CONTINUOUS FLIGHT AUGER AND WASH BORINGS

I-96, Grand Rapids, Butterworth Road to Fulton Street
Control Section 41029D

MDU Boring B-1, Station 434+90, Survey Centerline

0 - 2	feet	Brown Loam
2 - 6.5	feet	Plastic Brown Clay
6.5 - 9	feet	Soft Dark Gray Shale
9 - 10	feet	Firm Dark Gray Shale
10 - 12	feet	Very Hard Drilling - Probable Limestone Lense
12 - 15	feet	Probable Soft Weathered Shale
15 - 22.5	feet	Hard Drilling - Probable Firm Shale
22.5 - 26+	feet	Very Hard Drilling - Probable Shale. No Recovery from 10 to 26 feet due to Enlarged Borehole

Test Hole No. 7, Wash Boring, Station 30 feet Left of Station 436+08, Survey Centerline

0 - 0.5	feet	Topsoil
0.5 - 3.5	feet	Stiff Yellow Sandy Clay
3.5 - 4.5	feet	Stiff Yellow and Gray Mottled Clay
4.5 - 7	feet	Moderately Compact Yellow Medium Sand with Heavy Trace of Clay
7 - 9	feet	Stiff Gray Sandy Pebbly Clay
9 - 12	feet	Hard Gray Sandy Pebbly Clay
12 - 14	feet	Stiff Gray Sandy Pebbly Clay
14 - 22+	feet	Stiff Yellow Sandy Pebbly Clay

MDU Boring B-2, Station 440, Survey Centerline

0 - 1	feet	Brown Sandy Loam Topsoil
1 - 4	feet	Yellow Fine to Very Fine Sand
4 - 8	feet	Yellow Fine Sand
8 - 13	feet	Yellow Fine Sandy Loam
13 - 21	feet	Yellow Fine Sand
21 - 25	feet	Firm Reddish-Brown Pebbly Clay Loam
25 - 36.5	feet	Hard Brown Pebbly Clay Loam
36.5 - 38	feet	Gravelly Sandy Loam
38 - 45	feet	Fine to Medium Loamy Sand
45 - 50	feet	Firm Gray Pebbly Sandy Clay Loam
50 - 53+	feet	Very Hard Gray Pebbly Sandy Clay Loam

MDU Boring B-3, Station 442, Survey Centerline

0 - 16	feet	Yellow Sandy Loam
16 - 19	feet	Firm Reddish-Brown Silty Clay
19 - 24	feet	Firm Grayish-White Pebbly Sandy Clay Loam
24 - 28	feet	Firm Grayish-Brown Pebbly Sandy Clay Loam
28 - 31	feet	Brown Sandy Loam
31 - 38+	feet	Firm Gray Pebbly Sandy Clay Loam

MDU Boring B-4, Station 446, Survey Centerline

0 - 4	feet	Brown Loamy Fine Sand
4 - 5	feet	Yellow Fine Sand
5 - 7	feet	Yellow Fine Sand with Clay Lenses
7 - 12.5	feet	Brown Loamy Fine Sand with Occasional Pebble
12.5 - 20	feet	Plastic Brown Pebbly Sandy Clay
20 - 25.5	feet	Firm Brown Clay
25.5 - 31	feet	Harder Drilling - No Recovery - Probable Stiff Stiff Gray Clay or Loam
31 - 41	feet	Easy Drilling - Recovered Saturated Gray Fine to Very Fine Sand
41 - 48+	feet	Hard Drilling - Recovered Stiff Dark Gray Clay on Bottom Auger. This Material has Color very Similar to Shale Recovered from MDU Boring B-1, Station 434+90, Survey Centerline. Water Level in Borehole 12.0 feet

MDU Boring B-5, Station 448, Survey Centerline

0 - 17	feet	Yellow Fine to Medium Sand
17 - 17.5	feet	Cobbles - Very Difficult to Penetrate - May be Embedded in Hard Loam Soil
17.5 -	feet	Refusal

MDU Boring B-6, Station 450, Survey Centerline

0 - 4	feet	Yellow Fine Sand
4 - 18	feet	Yellow Fine Sand
18 - 29	feet	Yellow Sandy Loam
29 - 37	feet	Yellow Fine Sand
37 - 41	feet	Firm Brown Pebbly Sandy Clay Loam
41 -	feet	Refusal - Cobbles and Hard Clay

MDU Boring B-7, Station 455, Survey Centerline

0 - 4	feet	Yellow Very Fine Sand
4 - 17	feet	Yellow Fine Sand
17 - 23	feet	Brown Fine Sand
23 - 32	feet	Yellow Loamy Sand
32 - 33	feet	Firm Brown Sand Clay Loam
33 - 35+	feet	Firm Gray Pebbly Sandy Clay Loam

MDU Boring B-8, Station 458, Survey Centerline

0	- 6	feet	Soft Brown Sandy Clay
6	- 7	feet	Saturated Gray Sand
7	- 16	feet	Saturated Yellowish-Brown Pebbly Sand
16	- 24	feet	Firm Gray Clay
24	- 30	feet	Harder Drilling - Recovered Hard Gray Loam on Bottom Auger
30	-	feet	Refusal - Water Level in Borehole 3.0 feet

MDU Boring B-9, Station 1,100 feet West of Station 458, Survey Centerline

0	- 6	feet	Brown Loam and Clay Loam
6	- 36	feet	Yellow Fine Sand
36	- 40	feet	Yellow Pebbly Fine to Medium Sand
40	- 51	feet	Yellow Gravelly Medium Sand
51	- 53+	feet	Hard Drilling - Probable Hard Gray Loam - No Recovery

Note: Plan view and cross-sections not included in this report. SJV

APPENDIX H

I-196 MDOT ELEVATION SURVEY DATA

196 LEVELS **FEB. 2003**
Job# 73086C

Vertical Control was requested for 196, between Lake Michigan drive and Butterworth road, Grand Rapids, Kent County, Michigan. The survey was requested by Thomas Hines, M & T division, M.D.O.T.

METHODOLOGY

Plan elevation was used from state project 41029E C to establish vertical control for this project.
Top of concrete elevation of 697.35 ft. at station 460+35 WB was utilized. This was the plan elevation at the "bullnose" of the curb for ramp "B", the WB entrance ramp for 196 from Lake Michigan drive.
All elevations were taken along the "north edge of metal" for WB 196.
All elevations were taken along the "south edge of metal" for EB 196.
BM 100 was set on the top step of the southeast bridge abutment wall for EB 196 bridge over Butterworth.
This bench is a chiseled "square". BM 100 ELEVATION: 659.85 FT. (PLAN ELEV.)

Also, NAVD 88 Vertical datum was obtained from BM 121. BM 121 is a chiseled "square" set in the northeast bridge abutment wall of "Lake Michigan drive" bridge over 196.

A "floppy" disk of this report and the level data is included. A "CD" of the 41029E project is also included.

PLAN ELEVATIONS:

WESTBOUND 196

STA 438+00	660.35 ft.
STA 439+00	663.31
STA 440+00	666.00
STA 441+00	668.54
STA 442+00	671.06
STA 443+00	673.63
STA 444+00	676.22
STA 445+00	679.07
STA 446+00	682.06
STA 447+00	684.94
STA 448+00	687.72
STA 449+00	690.15
STA 450+00	692.29
STA 451+00	694.03
STA 452+00	695.52
STA 453+00	696.78
STA 454+00	697.73
STA 455+00	698.45
STA 456+00	698.82
STA 457+00	698.93
STA 458+00	698.74
STA 459+00	698.27
STA 460+00	697.50
STA 460+35	697.35 (FIXED)

EASTBOUND 196

STA.437+00	661.73 ft.
STA 438+00	663.92
STA 439+00	666.25
STA 440+00	668.67
STA 441+00	671.18
STA 442+00	673.65
STA 443+00	676.01
STA 444+00	678.15
STA 445+00	680.20
STA 446+00	682.49
STA 447+00	684.94
STA 448+00	687.33
STA 449+00	689.52
STA 450+00	691.59
STA 451+00	693.51
STA 452+00	695.18
STA 453+00	696.76
STA 454+00	698.19
STA 455+00	699.38
STA 456+00	700.42
STA 457+00	701.36

BRIAN-DOLMAN JERSEY
SUPERVISING LAND SURVEYOR

JIM YOUNG
SURVEY TECH 11

196 LEVELS **FEB. 2003**

Job# 73086C

Vertical Control was requested for 196, between Lake Michigan drive and Butterworth road, Grand Rapids, Kent County, Michigan. The survey was requested by Thomas Hines, M & T division, M.D.O.T.

METHODOLOGY

Plan elevation was used from state project 41029E C to establish vertical control for this project.
Top of concrete elevation of 697.35 ft. at station 460+35 WB was utilized. This was the plan elevation at the "bullnose" of the curb for ramp "B", the WB entrance ramp for 196 from Lake Michigan drive.
All elevations were taken along the "north edge of metal" for WB 196.
All elevations were taken along the "south edge of metal" for EB 196.
BM 100 was set on the top step of the southeast bridge abutment wall for EB 196 bridge over Butterworth. This bench is a chiseled "square". BM 100 ELEVATION: 659.85 FT. (PLAN ELEV.)

Also, NAVD 88 Vertical datum was obtained from BM 1 21. BM 121 is a chiseled "square" set in the northeast bridge abutment wall of "Lake Michigan drive" bridge over 196 = 214.679 m 704.328 ft

A "floppy" disk of this report and the level data is included. A "CD" of the 41029E project is also included.

PLAN and NAVD88 ELEVATIONS:

WESTBOUND 196	Plan Ele.	NAVD88 Ele.	EASTBOUND 196	Plan Ele.	NAVD88 Ele.	
STA 438+00	660.35 ft.	**659.48**	STA.437+00	661.73 ft.	**660.86**	
STA 439+00	663.31	**662.44**	STA 438+00	663.92	**663.05**	
STA 440+00	666.00	**665.12**	STA 439+00	666.25	**665.38**	
STA 441+00	668.54	**667.67**	STA 440+00	668.67	**667.79**	
STA 442+00	671.06	**670.18**	STA 441+00	671.18	**670.30**	
STA 443+00	673.63	**672.75**	STA 442+00	673.65	**672.78**	
STA 444+00	676.22	**675.34**	STA 443+00	676.01	**675.14**	
STA 445+00	679.07	**678.20**	STA 444+00	678.15	**677.27**	
STA 446+00	682.06	**681.18**	STA 445+00	680.20	**679.32**	
STA 447+00	684.94	**684.06**	STA 446+00	682.49	**681.61**	
STA 448+00	687.72	**686.84**	STA 447+00	684.94	**684.06**	
STA 449+00	690.15	**689.28**	STA 448+00	687.33	**686.46**	
STA 450+00	692.29	**691.41**	STA 449+00	689.52	**688.64**	
STA 451+00	694.03	**693.15**	STA 450+00	691.59	**690.71**	
STA 452+00	695.52	**694.64**	STA 451+00	693.51	**692.63**	
STA 453+00	696.78	**695.91**	STA 452+00	695.18	**692.63**	**694.31**
STA 454+00	697.73	**696.86**	STA 453+00	696.76	**695.88**	
STA 455+00	698.45	**697.57**	STA 454+00	698.19	**697.31**	
STA 456+00	698.82	**697.95**	STA 455+00	699.38	**698.51**	
STA 457+00	698.93	**698.05**	STA 456+00	700.42	**699.55**	
STA 458+00	698.74	**697.86**	STA 457+00	701.36	**700.48**	
STA 459+00	698.27	**697.40**				
STA 460+00	697.50	**696.62**				
STA 460+35	697.35 (FIXED)	**696.47**				

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