MEMORANDUM

TO: **Professors Romig and Boyd**
FROM: **Yet More CSM Students**
DATE: **September 15, 1997**
SUBJECT: **Gravity Module, Lab #3, Request for Bid**

CONTENTS:

PURPOSE:

This memo is written in response to a request for bid by R & B Construction for a geophysical survey to locate abandoned mine shafts underneath a proposed housing development. The following is an explanation of factors affecting the cost and design limitations of the survey.

BACKGROUND:

The New White Ash mine was located in the area in the early 1900's, and tunneling to find coal in the area was performed by this company. Before the construction of the new housing development can begin, the site must be evaluated for old mine workings. The old workings are a significant subsidence hazard to the new construction. The key to preventing subsidence due to vacancies is geophysical detection of the vacancies and subsequent remediation of these structures. JMCH Corporation will be responsible for the survey design, fieldwork, processing, and interpretation of data, and will deliver a final product that is easily interpreted and used by the client for disposal.

SURVEY DESIGN CONSIDERATIONS:

When designing the survey to be used, JMCH Corporation was provided following information from existing mine records:

- Tunnels are expected to be between 3 and 5m in diameter.
- Tunnels may be located anywhere between 5 and 100 meters in depth. Those located deeper than 15 meters, however, will not adversely affect subsequent construction efforts. If practical, however, the survey should be able to detect tunnels to as great a depth as possible.
- Owing to the geologic structure underlying the development, existing tunnels are expected to run in a north-south direction.

The diagram in Appendix A shows the suggested line of the gravity profile to be conducted. The survey is designed to run along the exact middle of the area under consideration. With respect to the client established coordinate, the gravity line should run from –250m, 0m to +250m, 0m. The area is relatively flat eliminating the need for elevation data corrections.

When designing the survey, JMCH Corporation took under consideration the following factors:

1. A Gravity survey would be the best possible solution to finding vacant mine shafts due to the large density contrasts.
2. The mineshafts have been in existence since the turn of the century, therefor concluding that the shafts are likely filled with water or a mixture of water and mud. The survey has been designed to be able to identify shafts as small as 3 meters in diameter filled with water or 20% mud and water, up to a depth

of 15 meters. Shafts which are largely filled with mud or rock difficult and expensive to detect, and are of little concern for subsidence hazard.

3. Since the client is interested in shafts of 3-5 meters in diameter at a depth of up to 15 meters, the survey is designed to accommodate these needs. In addition, shafts of larger of than 3 meters in diameter below a depth of 15 meters have a good probability of being detected.
4. An east-west survey line would have the best chances of locating a series of north-south tunnels.
5. An experienced crew will be hired to survey the site with errors in their gravity readings equivalent or less than .005 mgal.
6. The base station will be located at the coordinates **(0,0)**, and reoccupied at an interval every 2 hours. This will allow for quick access to the base station anywhere in the area (see also Appendix A, fig. 2).

SURVEY COST FACTORS:

There are several factors that are taken into account when determining the cost of a given survey. The first set is standard operating costs necessary for conducting business:

1.	Field Crew (per day)	$400.00
2.	Office Crew (per day)	$400.00
3.	Equipment Depreciation (per day)	$250.00
4.	Overhead (related to total expenses)(per day)	$1465.00
5.	External Consulting (per hour)	$200.00

The second set of factors affecting cost are survey specific and directly relate to the length of time survey the survey takes:

1.	Spacing of Survey (meters)	6.5
2.	Number of Readings per Station	5
3.	Length of Survey Line (meters)	500
4.	Base Station Reoccupation Interval (hours)	2
5.	Sensitivity of Survey (density contrast in g/cm^3)	1.6

After taking these factors into consideration, the bid JMCH Corporation is submitting is for a survey lasting five and one half days with a **cost of $12,100**. This includes all field costs, data analysis, and final recommendation.

Limitations of the above gravity survey will include the following:

1. Tunnels and shafts that are smaller than 3 meters in diameter at a depth of 15 meters which contain rock or mud will not be detected. These shafts which do not contain rock or mud or have minimal material within them have a fair to poor chance of detection under 15 meters in depth.
2. The survey is designed to take 5.5 days with a processing time equal to this amount.
3. Tunnels that are collapsed along the survey line, existing throughout the rest of the area will not be detected.

Success of design specifications:

1. The probability of finding tunnels which are 3 meters or greater in diameter which contain air, water filled, or water filled with a maximum mud content of 20%, is 99%.
2. Tunnels less than 3 meters in diameter which are less than 15 meters deep have less than 10% chance of being found, although changes become exponentially better with decreased depth.
3. Tunnels deeper than 15 meters that are smaller than 3 meters in diameter have 0% chance of recovery.
4. Tunnels greater than 3 meters in diameter at a depth of greater than 15 meters have a 10% recovery chance, while these chances exponentially increase with increased diameter when the tunnel is slightly deeper than 15 meters.

Appendix A
Possible Survey Scenarios:

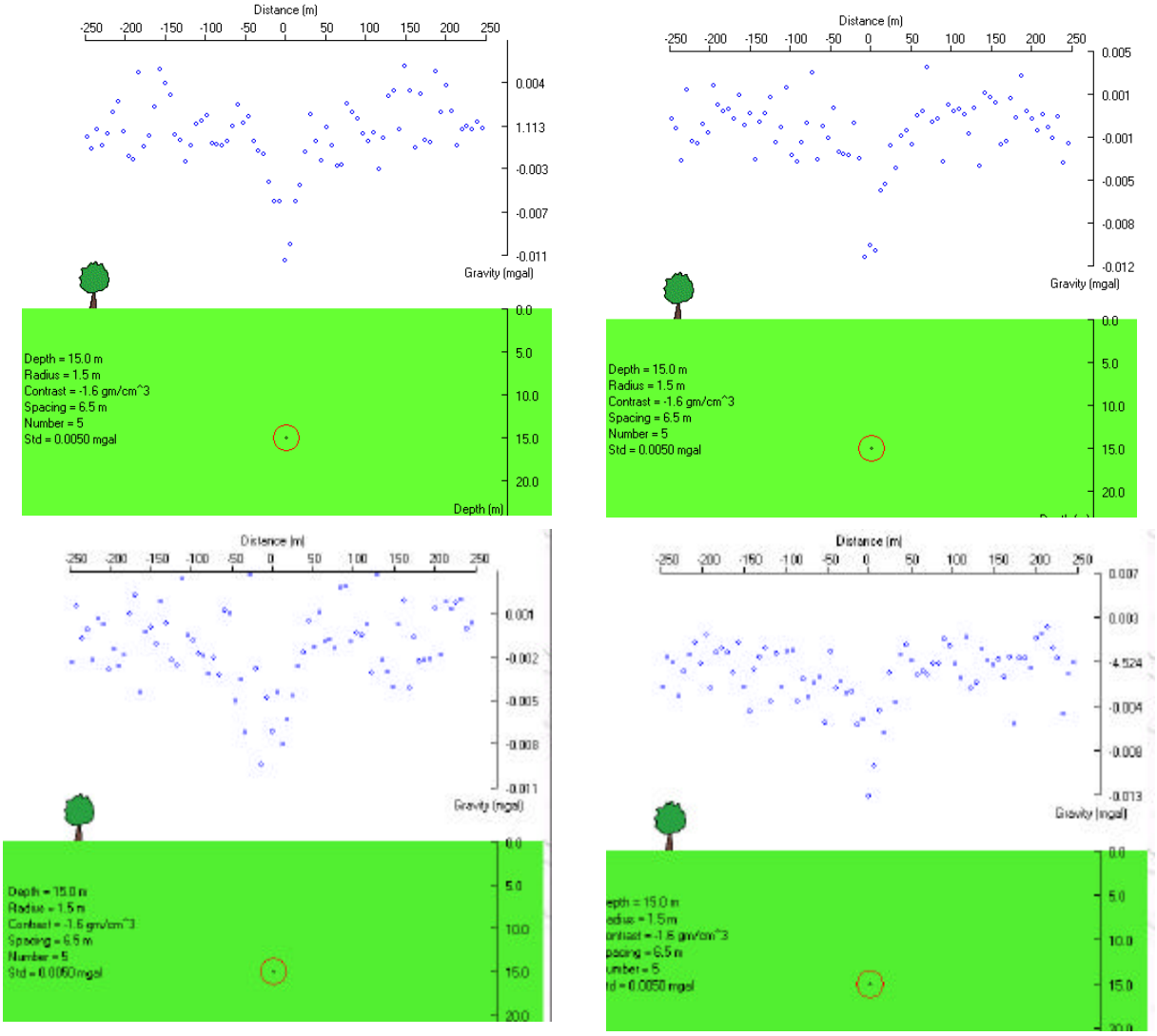

Fig 1: Possible Detection Scenarios at Survey Design Limits (20% mud filled 3m dia tunnel at 15 meters depth.)

Fig 2. Survey Location:

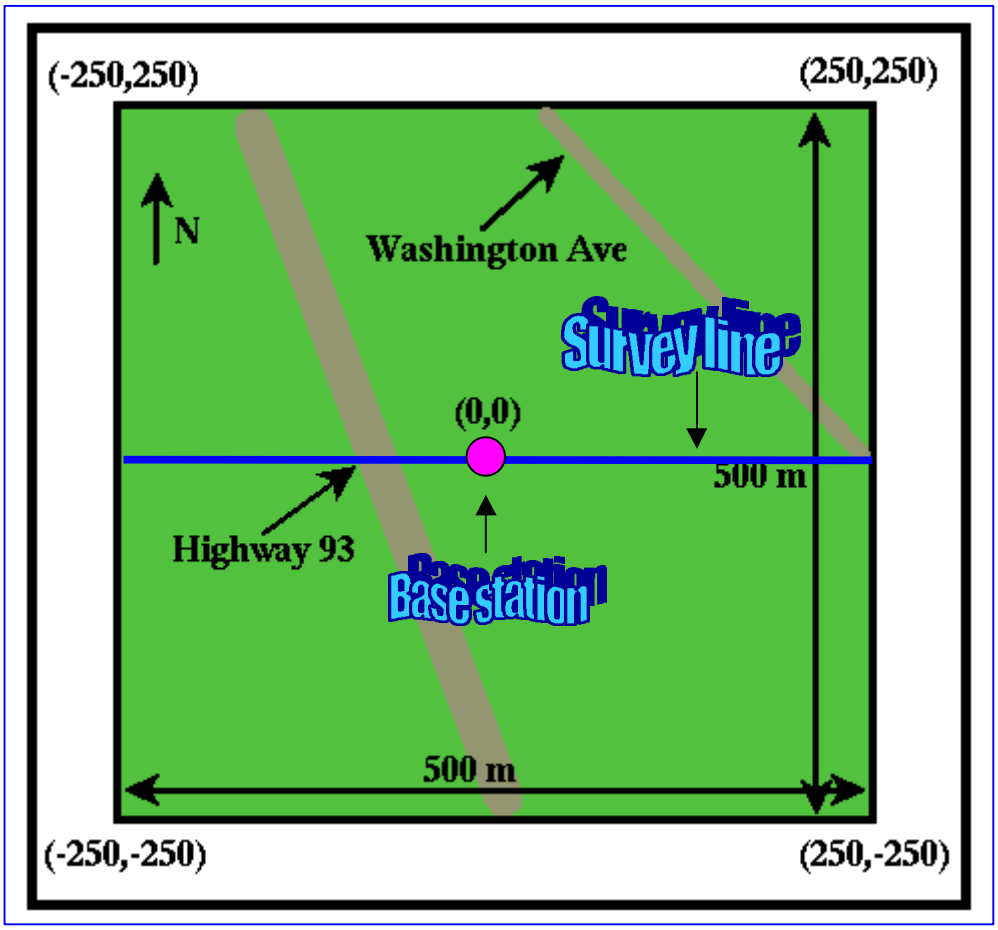

Fig 3: Expenses Worksheet **(double click to access)**

Depth (m)	15		
Radius (m)	1.5	# of **station** readings	384.6154
Delta ro (g	1.6	Hours at stations	32.05128
survey spa	6.5	# of **reoccupation** rea	16.02564
# of readin	5	hours of reoccupation	4.00641
Std. Dev	0.005	SUBTOTAL (hours)	36.05769
Reoccupat	2	# of Days Data Collec	4.507212
Legnth of S	500	plus mobilization	5.507212

Appendix B

List of "if-then" statements that describes the physics of the problem under consideration.

1. If a tunnel in question is less than 15 meters in depth and greater than 3 meters in diameter, then the gravity anomaly will be easily detected.
2. If a large tunnel is located at a shallow depth, then the gravity anomaly will be thin in shape and large in amplitude.
3. If a small tunnel is located at a shallow depth, then the gravity anomaly will be thin in shape and small in amplitude.
4. If the tunnel is deeper, then the observed gravity anomaly would be smaller in amplitude and broader in shape.
5. If the tunnel is mud, water, or water and mud filled, then the observed gravity anomaly will be portrayed as a smaller tunnel.
6. If the tunnel is deeper than the 15 meter design specifications, then the anomaly will appear as background noise.
7. If the number of readings at each station is increased, then the margin of error will diminish.
8. If the spacing of the survey is decreased, then the gravity anomalies will become more apparent.
9. If the base station reoccupation interval is decreased, then the margin of error will decrease.
10. If the survey is conducted over the entire area of consideration instead of one survey line, then the accuracy of the survey will increase.
11. If the density contrast of the survey is decreased, then anomalies found will portray more minute differences in the underlying strata.