IN-SITU CONTAMINATED SOIL VOLUME ESTIMATE AND CONSTRUCTION FOOTPRINTS FOR THE PAINESVILLE FUSRAP SITE

PAINESVILLE, OHIO

March 2006

U.S. Army Corps of Engineers
Buffalo District Office
Formerly Utilized Sites Remedial Action Program

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prepared by

U.S. Army Corps of Engineers, Buffalo District Office, Formerly Utilized Sites Remedial Action Program

with technical assistance from

Environmental Science Division, Argonne National Laboratory

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March 17, 2006

Summary

This report describes the available data, the assumptions, and the methodology in determining in-situ contaminated soil volume estimates intended to be excavated at the Painesville, Ohio FUSRAP site. The estimate is made for the Construction Worker cleanup scenario.

This report provides a best estimate based on the available data from the 1997 Site Characterization, the 2000 Remedial Investigation, and the Fall 2005 investigation, as well as an uncertainty assessment through a probability analysis. Maps of areas to be excavated at one-foot lift intervals are also provided. A volume of 4,800 yd^3 was determined; this is the volume associated with the configurations shown on the maps. A contingency of an additional 20%, or 1,000 yd^3, is recommended for additional soil to be excavated based on anticipated visual observations and scanning results during the remediation process. The best estimate, therefore, for in-situ material to be excavated is 5,800 yd^3.

Introduction

The Painesville site (Figure 1) has a mixed land cover of soil, gravel, asphalt, pavement, buildings or building slab foundations, roads, and track bed. An excavation has already been performed in the butadiene tank area; this pit is to a depth of approximately 3 feet. Other aspects of the site history are described in detail elsewhere.

Average background activity concentrations and Derived Concentration Guidance Level (DCGL) for the construction worker scenario that have been established for the site are shown in Table 1. Note that conversions between total uranium, upon which the criterion is based, and U-238, supplied by laboratory analysis, are calculated as Utotal / 2.046 = U238.

The Sum of Ratios (SOR) approach is used for the site data to compare a sample to the construction worker threshold, relative to a background (bg) value:

$$\text{SOR} = \frac{U238 - bg}{U238criterion} + \frac{Ra226 - bg}{Ra226criterion} + \frac{Th230 - bg}{Th230criterion} + \frac{Th232 - bg}{Th232criterion}$$

In the Painesville case, the criteria in the denominators are the $DCGL_w$ values for each cleanup scenario. SOR values above 1 indicate samples which exceed the construction worker criterion, while values below 1 indicate samples which are below the construction worker criterion. For the purpose of this volume estimate, the wide-area Derived Concentration Guidance Level (DCGLw) for the construction worker scenario was used as the key threshold.

Data available for the site include the 1997 Site Characterization data (walkover, laboratory), the 2000 Remedial Investigation (laboratory), and the 2005 FSP data (walkover, laboratory, broad-energy germanium [BEGe] detector, and downhole gamma). Most but not all of the FSP lab data and walkover data were available at the time this volume estimate was determined.

For the 2005 downhole gamma (DHG) data, field logs were inspected to correct several typographic errors in the electronic version of the data. For a threshold of being above or below SOR, 6,700 cpm is defensible (Figure 2).

Because it is not feasible to detect Th230 to the levels required to meet the cleanup criterion for that radionuclide using the BEGe, a relationship relying on Ra226 as a surrogate was developed. For relating the 2005 BEGe's Ra226 result to the SOR, a threshold of 9.46 pCi/g is supported (Figure 3). Given that the Ra226 criterion is 9 pCi/g, and the background is 0.95 pCi/g, one might expect the cutoff to be anywhere below 9.95 pCi/g to allow for contribution to the SOR score from Th230 (and insignificant Th232 and U238 contributions). However, these are uncorrected BEGe values, and the device should overpredict Ra226 because of interference associated with U235. The cutoff of 9.46 pCi/g for Ra226, although close to 9.95, is inflated somewhat by the BEGe, allowing for contribution of the other radionuclides in the SOR score.

The Site Characterization walkover data sets include NaI surveys on specified ground cover (soil, gravel, asphalt) for relatively small portions of the overall site, and bicron surveys over most of the FUSRAP property. In order to make use of the walkover data, a correlation study was performed using the surficial data from soil areas and the nearest NaI walkover reading. The samples and the NaI measurements should not be expected to provide a perfect relationship because they are not exactly co-located (generally within about 5 ft of each other) and only 25 surficial soil samples were available to develop a correlation. However, a useful threshold was determined to separate the walkover data into categories. In this manner, the data could be color-coded for display during analysis. For the Construction Worker scenario, samples below 17K cpm were below the cleanup criterion. Samples from 17K to 37K cpm represented an uncertain zone with areas both above and below the cleanup criterion. Above 37K cpm, samples were entirely above the construction worker cleanup criterion. Collection of a set of co-located correlation samples from areas at or above the SOR of 1 would have minimized the intermediate zone.

Ra226 is the key driver for meeting the SOR cleanup level. In the Fall 2005 data are 452 GEL analyses. Of the 452, 37 samples have SOR>1. Of the 37, 32 samples have an Ra226 contribution to the SOR score that is by itself >1 (contributions from any of the other components of the SOR score merely raise the SOR score higher). Of the remaining 5 exceedences,

- 2 have SOR>1 due to the summing of the Ra226 and Th230 contributions to the score
- 2 have SOR>1 due to the Th232 contribution only (Ra226 and Th230 and U238 are not drivers)
- 1 has SOR>1 due to the summing of Ra226, Th230, and Th232; however the Th232 contribution itself is >1.

An important point to note is that Ra226 acts as an excellent surrogate for determining whether the sample is above or below the SOR cleanup criterion. This is support by the fact that in only two instances out of 452 samples would exceedence/nonexceedence have been wrongly decided in the absence of Th230 data. This observation strongly supports the concept that Th230 is not present in the absence of Ra226.

The combined previous site characterization data from 1996 and 2000 are similar. In this dataset are 392 samples. Of the 392, 55 had SOR>1. Of the 55, 49 had an Ra226 contribution to the SOR score that is by itself >1 (contributions from any of the other components of the SOR score merely raise the SOR score higher). Of the remaining 6 exceedences,

- 4 have SOR>1 due to the summing of the Ra226 and Th230 contributions to the score
- 1 has SOR>1 due to the summing of the Ra226 and Th232 contributions to the score
- 1 has SOR>1 due to the summing of Ra226 with the Th230 and/or Th232 contribution.

A graphical presentation showing the relationship of Th230 to Ra226 is provided in Figure 4, in which 2005 GEL laboratory-based SOR scores are compared to the SOR score if the Th230 component is ignored. The red line indicates the SOR score without Th230 included. Its values are of course equal to or less than the true SOR score, shown in blue. There are only two points whose true SOR score is >1 but whose SOR without Th230 is <1. One of these shows a significant departure from the blue line; it is possible that this is the result of early laboratory work that did not include thorough mixing of the sample material.

In summary, the two datasets suggest that most exceedences are due to the (field-detectable) Ra226 component being high enough to have an SOR > 1. Of the other samples with exceedences, the SOR exceedence is usually through a summation of the Ra226 component with the Th230 and/or Th232 component. There were two samples with SOR > 1 that were due to Th232 only, which is also field-detectable with the instrumentation used for Ra226.

A sampled interval in the 2005 FSP may have analysis for any combination of GEL (lab), BEGe, and downhole gamma. Samples were flagged as an exceedence if their interval was determined to exceed an SOR of 1 by any of the data types.

Approach

Estimation of contaminated soil volume is challenging because of the unknowns inherent in sites. Areas of scarce data, boreholes that have a contaminated bottom sample, examples of buried contamination, the density and types of data in characterized areas, and sketchy aspects of site history all contribute to uncertainty in a conceptual site model (CSM). This uncertainty consequently affects the volume estimate.

The approach taken by ANL with the Painesville volume estimate follows a process previously used by ANL at Painesville and several other FUSRAP sites (e.g. Ashland 1 and 2, Seaway, Linde, , Rattlesnake Creek, Luckey). The process relies on a combination of engineering judgment and a Bayesian statistical / geostatistical tool. The engineering judgment component makes use of available hard data (e.g. laboratory analyses) and soft data (e.g. walkover data, site history), together with careful inspection of the data for boreholes which indicate buried contamination at the bottom (unbounded), to delineate best estimates for the footprint of contamination for the surface and for subsurface "lifts." These estimates are considered "best minimum estimates," because they provide information only in areas that have been fairly well characterized and generally ignore potential contaminated soil in uncharacterized areas and/or areas where other sources of information lead decision-makers to discount the possibility that contamination exists there. The ultimate volume excavated is expected to be higher than the best minimum estimates.

The Bayesian statistical / geostatistical tool is called Bayesian Approaches for Adaptive Spatial Sampling. It provides a quantitative means of incorporating a CSM with site data to determine a probabilistic relationship between the volume estimate and the likelihood of contamination. The initial step in this process is to create an array of decision points across the site, with a probability of contamination and an uncertainty associated with each point on the basis of the CSM. These values are based on a two-parameter beta distribution; details are provided by Johnson (1996) and Johnson et al. (2005). The geostatistical structure of the data set is determined to provide information on the geostatistical range, or correlation, of the data. The hard data are flagged with an indicator value of 1 or 0 to indicate whether they represent points which are above or below the construction worker cleanup criterion, respectively. In the case of a FUSRAP site with SOR scoring, the SOR values above 1 are transformed into indicator values of 1, and the SOR values below 1 are transformed into indicator values of 0. As the hard data are incorporated, the decision points are updated as a function of the geostatistical correlation and the indicator values. Alpha and beta values of the updated decision points then reflect a new distribution of probabilities across the site. These probabilities range between 0 and 1, and represent the probability of contamination throughout a given lift (e.g. a decision point with a probability of 0.31 represents a calculated probability of contamination of 31%).

The Bayesian statistical / geostatistical tool was applied to the one-foot lifts of the Painesville site. The CSM for the surface was constructed on the basis of the bicron and NaI walkover data and the site layout and topography. Zones were delineated (Table 2) and assumed probabilities of contamination and qualitative values of uncertainty were determined for each. On the basis of the relationship between alpha and beta values used in calculating probabilities and uncertainties, appropriate alphas and betas were selected. A decision point grid with grid spacing of 5 m was designed for the site, and decision points falling into each CSM zone were assigned proper alpha and beta values for Bayesian updating. The zones of Table 2 are shown in Figure 5. A geostatistical range of approximately 30 m was determined through a variogram analysis of both hard data and walkover data.

The initial BAASS analysis focused on the surficial lift, with its abundant hard data, walkover data, and site feature information. The CSM described above was updated with the available data for the 0 to 1 ft lift, including older lab data and the Fall 2005 lab, BEGe, and downhole gamma data. Results for the 0-1 ft lift are shown in Figure 6. The BAASS process continued through deeper lifts by using the BAASS decision point output from the analysis of the lift above as the CSM for use with hard data from the lift being analyzed. In this manner, the well-supported CSM of the surface was continually refined through the subsurface in a way that was consistent with the hard data available for updating. Because the Butadiene tank area has already been excavated to a depth of about 3 feet, the 3 to 4 ft analysis relied on a modified version of the 2 to 3 ft results as its CSM. In this case, the decision points in the dig footprint, which were set with alpha and beta values to represent the open air in lifts from 0 to 3 feet, had their values replaced with ones consistent with a likely contaminated area.

The volume estimates in this report do not include any contribution from the zone already excavated near the former Butadiene tank (Investigative Area A). This excavation took place after the Remedial Investigation. For this reason, the 1996 and 2000 data within its footprint from depths of 0 to 3 feet are ignored, and 2005 data from within its footprint are shifted vertically downward by 3 feet. This was required because detailed topographic data are unavailable. In this manner, the depths of all samples are consistent with each other across the fairly flat site.

Results, Discussion, and Implementation

Analysis of combined recent and older data has led to a volume estimate of 4,800 yd^3 based upon available data. Excavation footprints, lift by lift, are shown in Figures 7 to 15 for the western half of the site and Figures 16 to 19 for the eastern half of the site, which has shallower contamination. These footprints are provided separately as ArcView shape files. Areas and volumes per lift are tabulated in Table 3.

However, despite any amount of available data, some degree of uncertainty still remains between borehole locations. For this reason, and based on similar experience at the Rattlesnake Creek site, it is recommended to factor in an additional 20% (1,000 yd^3), to account for contingencies encountered during the remediation. These contingencies may be lenses of contaminated material that should be pursued into a dig face in order to avoid leaving behind material above the DCGLw. Stated another way, it is expected that all of the material designated for removal as part of this estimate will be removed. Therefore, the only remaining possibility is that some additional material that requires removal may be identified during the excavation process. The estimated amount of soil to be removed can consequently only grow. The overall volume estimate is therefore 5,800 yd^3.

This additional percentage of material to be excavated is consistent with the probabilistic approach taken in this BAASS-supported volume estimation. This approach allows for decision-making to take into account a statistical aspect of the estimate, relating the certainty and the volume of the estimation.

The areas of each lift's excavation are determined through a BAASS analysis (Figure 20). The area and volume for the 4,000 yd^3 best minimum estimate of April 2005 corresponded at that time to a BAASS-generated probability of being contaminated of 30%. With the current dataset, the dig area determined for the surficial lift was 4,488 m^2, or 48,300 ft^2. This area relates to a surficial lift probability of contamination value of approximately 40%.

Corresponding to higher values of the probability are lower excavation areas and volumes. The current BAASS estimate of 4,800 yd^3, which includes newly discovered contaminated areas, corresponds to a probability of being contaminated of 50% (Figure 21). Therefore the estimate, supported by recent additional data, indicates a more precise dig, in terms of digging what's is dirty and leaving what's clean. The overall volume, however, is greater because of newly discovered contamination areas. The value of the Fall 2005 FSP data, therefore, has been in refining the configuration of dig areas and depths, as well as identifying several areas of contamination in areas initially planned as being in Class 2 survey units. Still, estimating an additional 20% of volume as contingency is consistent with providing a careful estimate, given the sensitivity of the volume:probability relationship shown in Figure 21.

The overall volume estimate of 5,800 yd3 represents an in situ volume. This report does not address soil bulking, which would yield a large volume as an ex situ disposal volume. Also not addressed is disposal weight and associated soil density and changing soil moisture content, which varies over the course of a remedial effort. If the costs of transportation and disposal are determined based on weight and not by volume, moisture could have a significant effect (also a lesson learned from Rattlesnake Creek).

In comparison to the April 2005 draft volume estimate, the current estimate is similar in overall volume. The additional data generated in Fall 2005 have served to refine the estimate in many locations, resulting in smaller dig footprints, but have also lead to the discovery of new areas of contamination. Overall, the Fall 2005 data have provided a higher degree of confidence in the dig footprints and volume estimates. The key new locations are in the center of the property near a large building and west of the Butadiene tank near the former pond, where buried contamination was discovered and largely delineated by the Fall 2005 effort. This contamination west of the FUSRAP property is essentially contiguous with onsite contamination. The burial of the contaminated material is attributed to a clay cap extending off the former pond.

The excavations delineated in this report remain consistent with the MARSSIM process, in that excavations are contained within Class 1 survey units, and areas determined to be clean comprise Class 2 survey units. Class 1 survey units currently contain buffer areas around the proposed excavation footprints. During the data inspection and excavation delineation process, remediation in areas formerly intended as MARSSIM Class 2 survey units became apparent. Revisions to the evolving MARSSIM survey unit mapping are shown in Figure 22, which includes a new Class 1 unit and revised borders between survey units in several areas.

The surficial soil laboratory results for Class 2 gridded sampling locations recently arrived. Although most locations were considered clean, two locations exceeded the DCGLw criterion. These may result in revisions to the MARSSIM survey unit boundaries, the excavation plan, the volume estimate, and the sampling scheme.

Walkover data is a key component in understanding a site and developing a CSM for the ground surface. This study was supported by a variety of walkover data from several field efforts and using various types of equipment. The 1990's bicron data provided the greatest areal coverage, while the 1990's NaI data provided details, especially in soil areas. The 2005 walkover data provided coverage in the site's Class 2 areas for comparison with the bicron data; however, Class 1 areas in the east were surveyed in a cursory fashion, and data from Class 1 areas in the west were not available at the time of this volume estimate. An important factor in the use of walkover data is the development of a relationship between the counts per minute (CPM) readings of the gamma detector and the site cleanup goal, such as the DCGLw for the Construction Worker scenario. The optimum method for determining this correlation is by taking a walkover reading directly over a surficial soil location where the contamination is expected to be at or above an SOR of 1, then collecting the corresponding soil sample for laboratory analysis. A dataset generated in this fashion would provide a means for determining a trigger level for CPM that indicates an exceedence/nonexceedence threshold, or perhaps two thresholds to separate exceedence/intermediate/nonexceedence categories. However, of the walkover surveys described above, only the 2005 survey in Class 2 areas has followed this approach. While the lab data have not yet arrived, the CPM readings are generally low, the anticipated lab results for these Class 2 locations will likely be low, and the dataset will therefore not be useful in delineating a trigger level. Correlations made between other walkover datasets and nearby surficial soil samples demonstrate a relationship; however, because the data locations are generally separated by several feet, considerable uncertainty is introduced in decisions made using walkover survey data.

Several small dig areas, identified with walkover data are in the southwestern portion of the site (Figure 7). They are flagged as suspected zones, which may not require remediation to meet Class 2 requirements.

Several DHG exceedences stand out as red triangle symbols in the western portion of the site (Figures 9, 10, 11, 13). These are not slated for remediation because the DHG readings were only slightly above the trigger level of 6,700 cpm, and values above this trigger level have only a 50-50 chance of having SOR above 1.

The rubble pile's central and southern zones have not been sampled. Because of low bicron readings in these areas, and samples below exceedence values surrounding a small contaminated area at the rubble pile's northern edge, the bulk of this feature is assumed to be below the cleanup criterion.

The clean fill near the pond has a thickness of 1-2 ft. It is assumed to be excavated and disposed of along with the rest of the site soil materials.

No particular excavation technique or equipment is assumed. Constructability issues regarding sidewall benches and slopes are addressed by the placement of the proposed excavation footprints for each lift. These do not require any dig faces to exceed 3 ft. One to two foot benches or slopes will be able to be constructed based on the dig footprints without significant effect on the estimated volume. Examples of representative cross sections throughout the Painesville site are included as an attachment to this report.

Considerations Related to Volume Estimates and Excavation Maps

It is assumed that excavation will take place at least to the limits specified on the individual lift maps accompanying this estimate. The volumes provided are associated with these excavation configurations. It is also assumed that a MARSSIM final status survey will be conducted to demonstrate that the excavations have satisfied the cleanup criterion. As part of the MARSSIM process, gamma surveying tools are used to screen the excavation surface, primarily to demonstrate compliance with the DCGLemc. It seems sensible that the excavating contractor will use similar or identical gamma surveying instruments to make a preliminary determination that no further excavation is necessary in any particular location and that it is ready for the closure survey.

Ra-226 is the driving contaminant at Painesville, as well as an excellent surrogate for Th-230 which is not generally detectable by gamma scanning at levels present at Painesville. Because the typical field gamma scanning tools are easily capable of detecting Ra-226 well below the 9 pCi/g DCGLw, scans of the excavation surfaces and sidewalls will likely show responses considerably higher than background, thus making it imperative to establish a dependable gamma scan count rate associated with the DCGLw that minimizes the occurrence of false negative and false positive conclusions. Further, if 3 x

3 inch NaI detectors are used, “shine” from gamma emitters below their respective DCGLw values but above background will complicate use of such a threshold because the geometric configuration near sidewalls will result in higher readings than for similar radionuclide distributions on a flat surface. Such an effect was noted during the recent Rattlesnake Creek work. It is very possible that this effect could cause a tendency to overexcavate and “chase” radionuclide concentrations that are actually below the DCGLw. It is probably obvious, but this could be a cause for increases in soil volumes. For this reason, special consideration should be given to the type of gamma detector, shielding, and associated decision logic that is used in the field to support the excavation and demonstrate closure according to MARSSIM.

Not being aware of the details of the contract to execute the excavation, it is important to make point out the need for capacity to accommodate volume growth. As stated above, it is presumed that the actual excavations will take place to the limits specified on the excavation maps and that no soil within those limits will remain on site. Because of this, soil that is discovered to be above the cleanup criterion that is “chased” or for some other reason falls outside of these excavation configurations can only result in a growth of the soil volume over and above the estimates. Once again, the Rattlesnake Creek site provides a good example of this situation. This is the reason a contingency capacity is recommended to remediate approximately 20% additional volume over and above the estimates associated with the maps.

The Rattlesnake Creek project provides one other consideration. Due to good fortune, dry weather prevailed during that excavation. Despite having to excavate a greater volume than initially estimated, dry soil conditions resulted in a lower weight per cubic yard than originally expected. Because the contract was based on weight, not volume, this canceled the effects of additional excavated volumes on overall project costs. However, damp weather could have greatly aggravated the situation. For this reason, a contingency should also be considered.

References

Johnson, R., 1996, “A Bayesian/Geostatistical Approach to the Design of Adaptive Sampling Programs,” pp. 102−116 in *Geostatistics for Environmental and Geotechnical Applications*, ASTM STP 1283, R.M. Srivastava et al. (editors), American Society for Testing and Materials, Philadelphia, PA.

Johnson, R., D. LePoire, A. Huttenga, and J. Quinn, 2005, Bayesian Approaches for Adaptive Spatial Sampling: An Example Application: Argonne National Laboratory, Argonne, Illinois, Technical Memorandum ANL/EAD/TM-05-1, 39 p.

Tables

Table 1. Painesville background levels and DCGLw values.

Radionuclide	Average Background Levels (pCi/g)	Construction Worker Scenario $DCGL_w$ (pCi/g)	Construction Worker Scenario $DCGL_{emc}$ (pCi/g)
U-total	2.64	482	815
Ra-226+D	0.95	9	12
Th-230	1.45	25	34
Th-232+D	1.07	6	8

Table 2. Two-parameter beta distribution and probability values for zones of surficial lift in the Conceptual Site Model.

Region	alpha	beta	prob
Open air in butadiene pit (0 to 3 ft)	0	100	0
walkover hotspots, edge of pit, soil below pit	.3	.03	.909
Offsite clean	0	10	0
Rest of Site	.01	.1	.0909

Table 3. In situ volume estimates, by lift and by Investigative Area.

Lift	A	South of A	B	North of B	C	D	F	G	H[1]	Rubble Pile	Totals by lift (yd^3)
Best Minimum Estimate Excavation Footprints (ft^2) as illustrated in Figures 7 to 19.											
0 to 1 ft	9964	108	1958	97	14386	1765	1302	775	17001	1227	
1 to 2 ft	7177	43	527	0	8307	538	1291	0	16538	656	
2 to 3 ft	5810	0	0	0	1130	0	1248	0	10297	635	
3 to 4 ft	7984	0	0	0	527	0	237	0	4681	0	
4 to 5 ft	6316	0	0	0	0	0	0	0	420	0	
5 to 6 ft	3680	0	0	0	0	0	0	0	0	0	
6 to 7 ft	1141	0	0	0	0	0	0	0	0	0	
7 to 8 ft	1033	0	0	0	0	0	0	0	0	0	
8 to 9 ft	344	0	0	0	0	0	0	0	0	0	
Best Minimum Estimate In Situ Excavation Volume (yd^3) as illustrated in Figures 7 to 19.											
0 to 1 ft	369	4	73	4	533	65	48	29	630	45	
1 to 2 ft	266	2	20	0	308	20	48	0	613	24	
2 to 3 ft	215	0	0	0	42	0	46	0	381	24	
3 to 4 ft	296	0	0	0	20	0	9	0	173	0	
4 to 5 ft	234	0	0	0	0	0	0	0	16	0	
5 to 6 ft	136	0	0	0	0	0	0	0	0	0	
6 to 7 ft	42	0	0	0	0	0	0	0	0	0	
7 to 8 ft	38	0	0	0	0	0	0	0	0	0	
8 to 9 ft	13	0	0	0	0	0	0	0	0	0	
20% Additional Volume Based on Field Scanning (yd^3) (not illustrated)											
0 to 1 ft	74	1	15	1	107	13	10	6	126	9	
1 to 2 ft	53	0	4	0	62	4	10	0	123	5	
2 to 3 ft	43	0	0	0	8	0	9	0	76	5	
3 to 4 ft	59	0	0	0	4	0	2	0	35	0	
4 to 5 ft	47	0	0	0	0	0	0	0	3	0	
5 to 6 ft	27	0	0	0	0	0	0	0	0	0	
6 to 7 ft	8	0	0	0	0	0	0	0	0	0	
7 to 8 ft	8	0	0	0	0	0	0	0	0	0	
8 to 9 ft	3	0	0	0	0	0	0	0	0	0	
Total Best Estimate In Situ Contaminated Volume (yd^3) (not illustrated)											*Totals by lift (yd^3):*
0 to 1 ft	443	5	87	4	640	78	58	34	756	55	2,160
1 to 2 ft	319	2	23	0	369	24	57	0	735	29	1,559
2 to 3 ft	258	0	0	0	50	0	55	0	458	28	850
3 to 4 ft	355	0	0	0	23	0	11	0	208	0	597
4 to 5 ft	281	0	0	0	0	0	0	0	19	0	299
5 to 6 ft	164	0	0	0	0	0	0	0	0	0	164
6 to 7 ft	51	0	0	0	0	0	0	0	0	0	51
7 to 8 ft	46	0	0	0	0	0	0	0	0	0	46
8 to 9 ft	15	0	0	0	0	0	0	0	0	0	15
Total Best Estimate by IA (yd^3):	1,931	7	110	4	1,082	102	181	34	2,175	112	5,741 *Grand Total In Situ Contaminated Volume (yd^3)*

[1] Division between IA-A and IA-H is taken as the original FUSRAP property boundary.

Figures

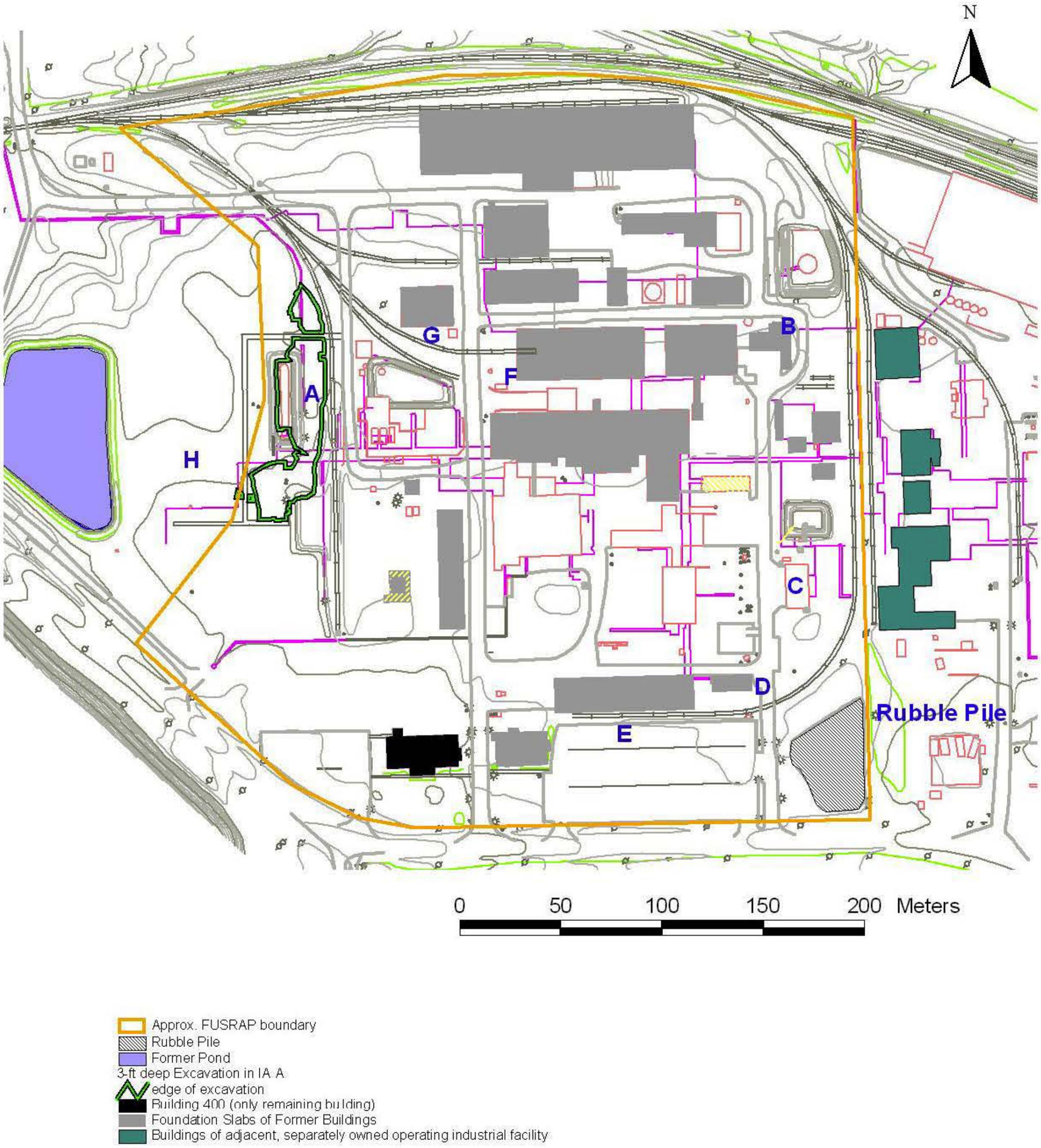


Figure 1. Site overview with Investigative Areas.

DHG cutoff	# SOR exceedences	# samples	% SOR exceedences
<6727 cpm	6	588	1.02
>6727 cpm	44	100	44.00

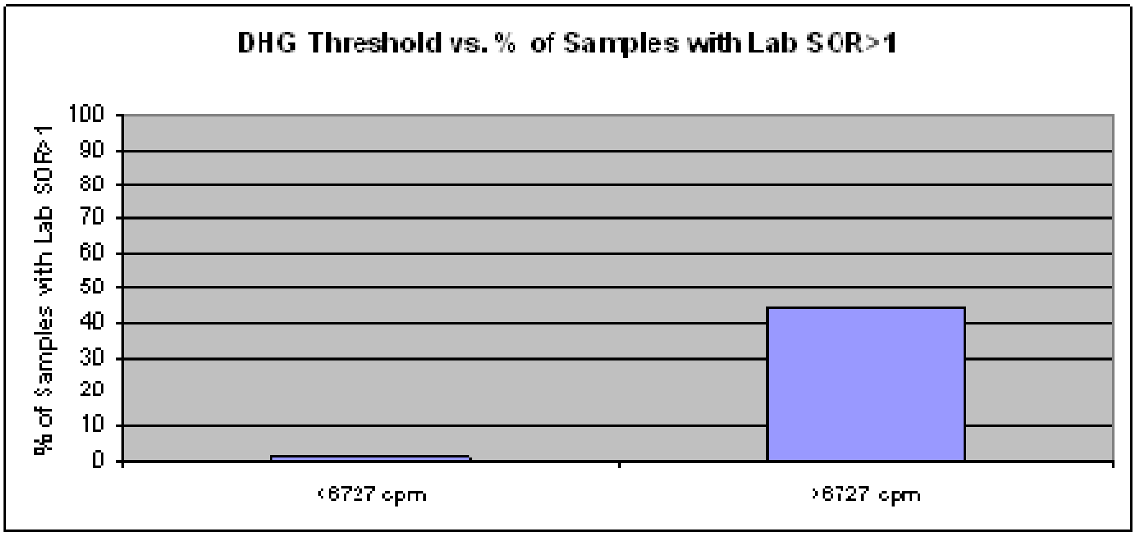


Figure 2. Downhole Gamma relationship to lab (GEL) SOR in 2005 data.

BEGe Ra226 Cutoff	# exceedences	# samples	% exceedences
BEGe Ra226 < 9.46 pCi/g	4	600	0.67
BEGe Ra226 > 9.46 pCi/g	44	64	68.75

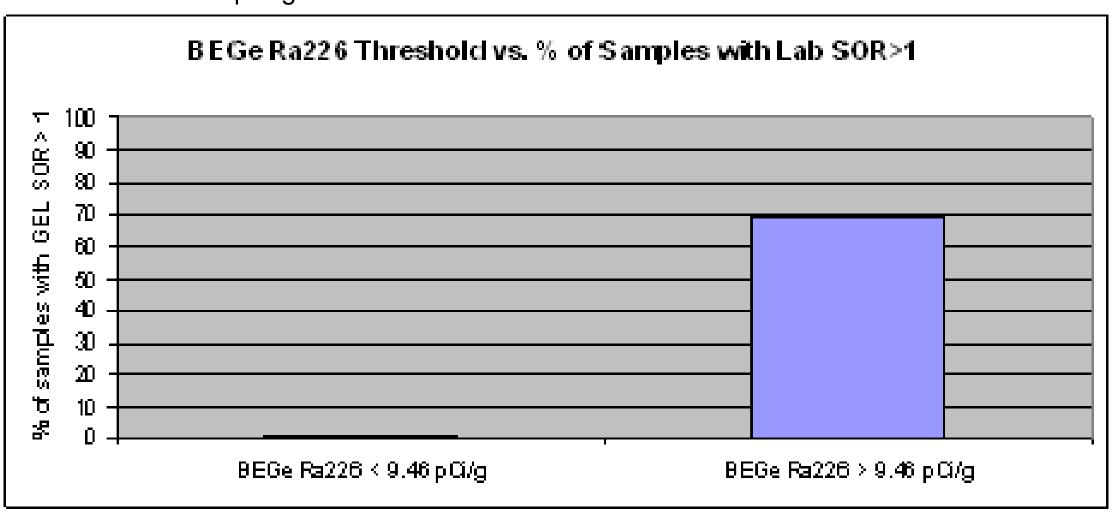


Figure 3. BEGe relationship to lab (GEL) SOR in 2005 data.

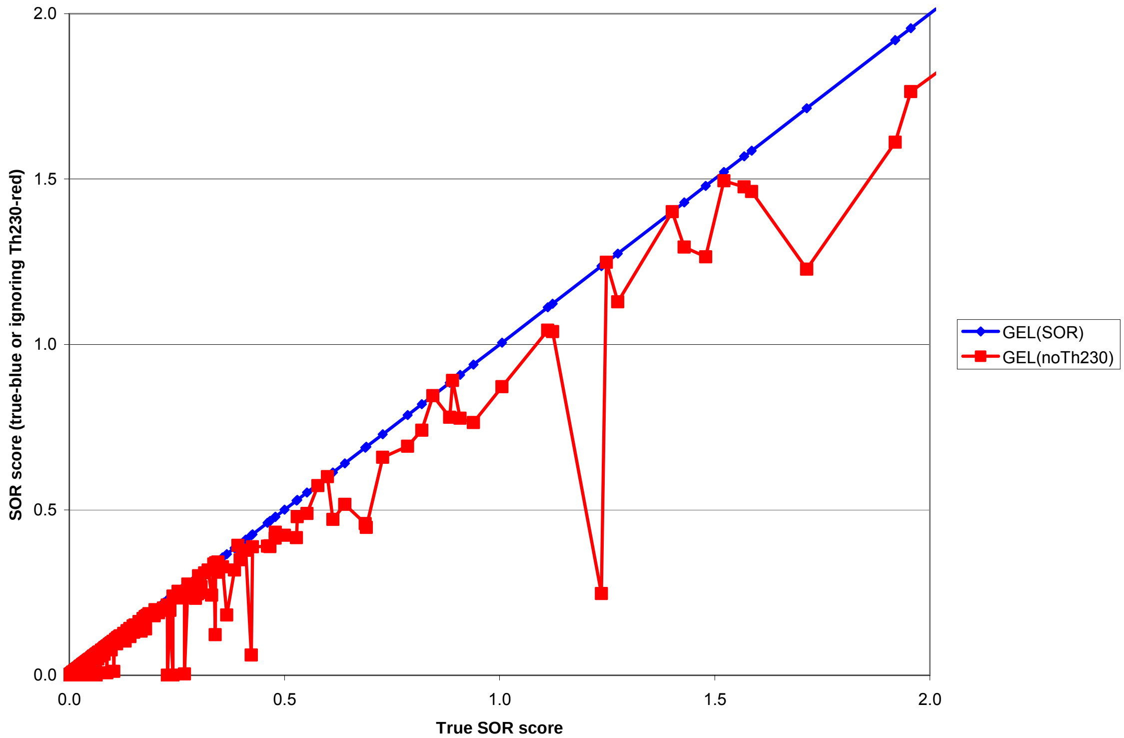


Figure 4. Relationship in Fall 2005 GEL data between fully supported SOR score and SOR score ignoring Th230 data.

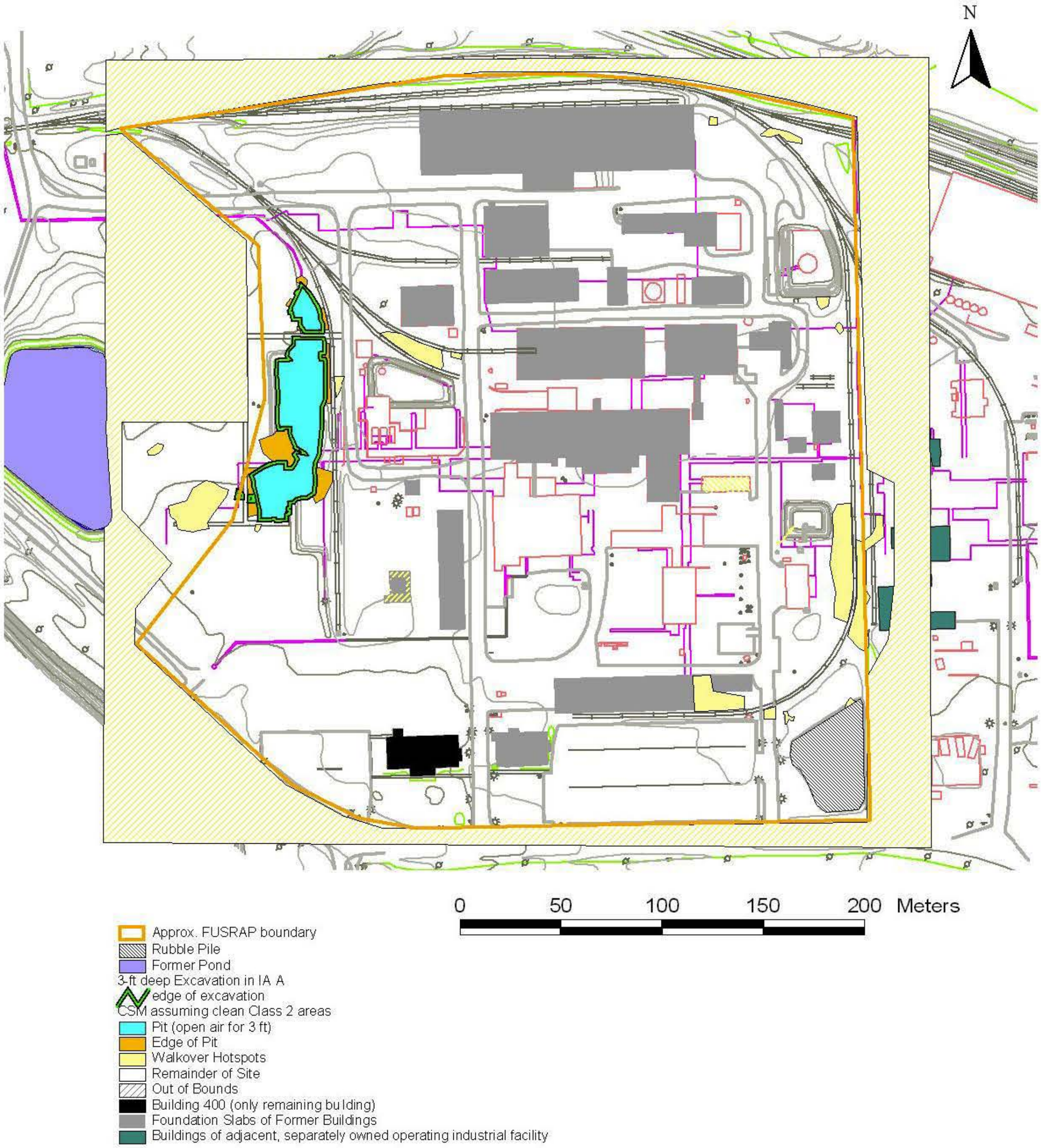


Figure 5. CSM zonations.

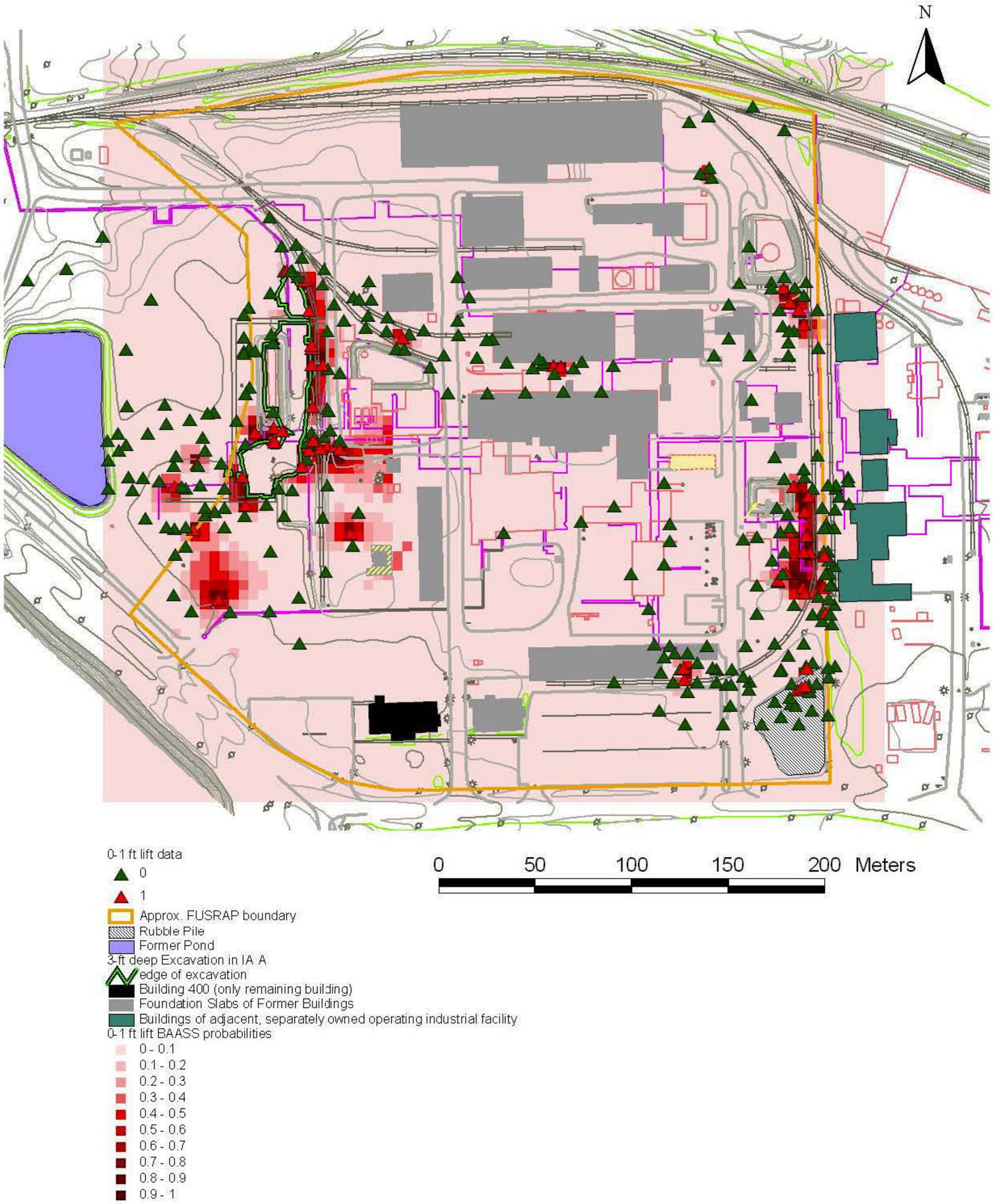


Figure 6. Hard data for 0-1 ft lift with BAASS results.

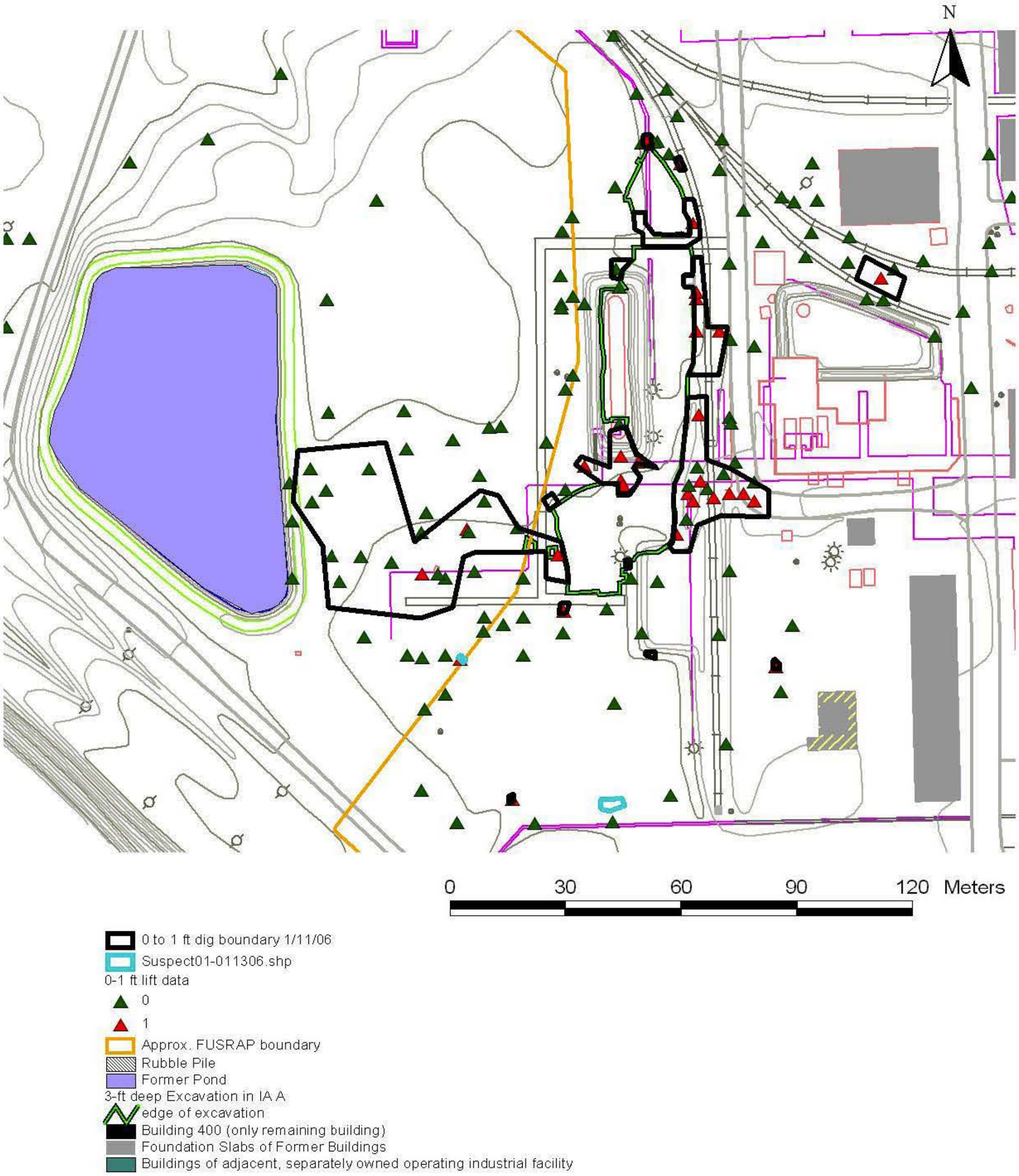


Figure 7. Hard data and excavation footprints for 0-1 ft lift, western side of Painesville site.

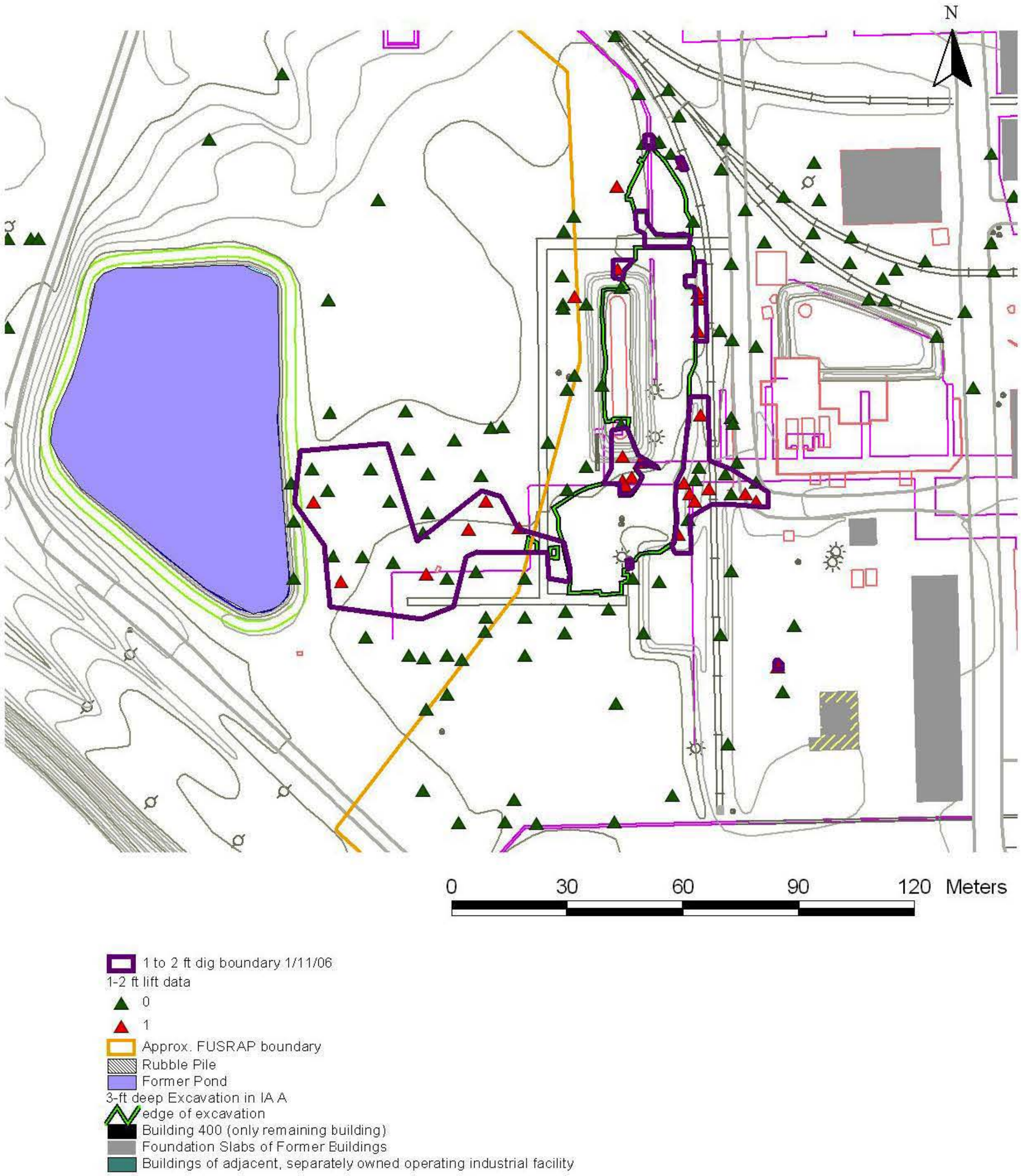


Figure 8. Hard data and excavation footprints for 1-2 ft lift, western side of Painesville site.

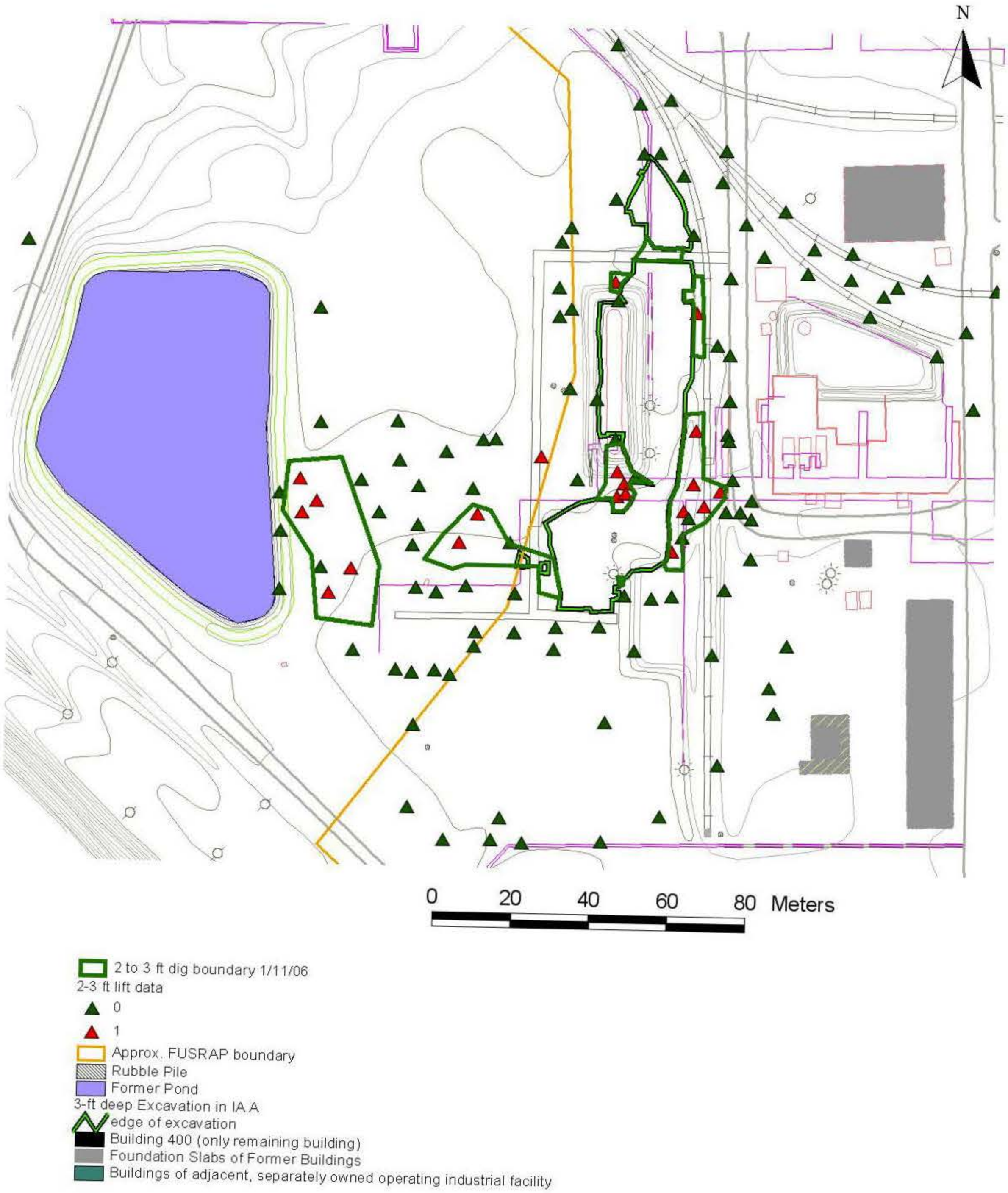


Figure 9. Hard data and excavation footprints for 2-3 ft lift, western side of Painesville site.

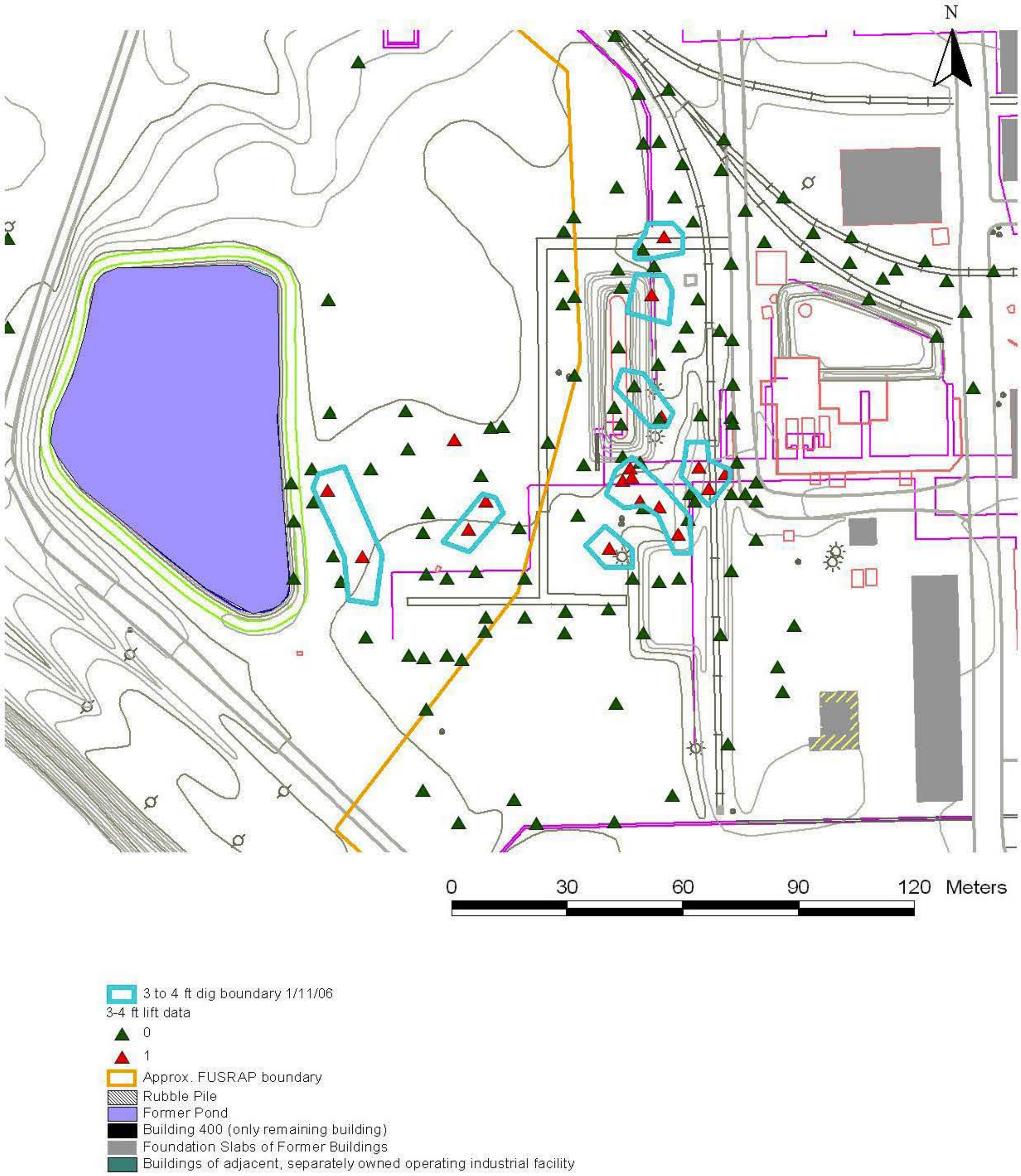


Figure 10. Hard data and excavation footprints for 3-4 ft lift, western side of Painesville site.

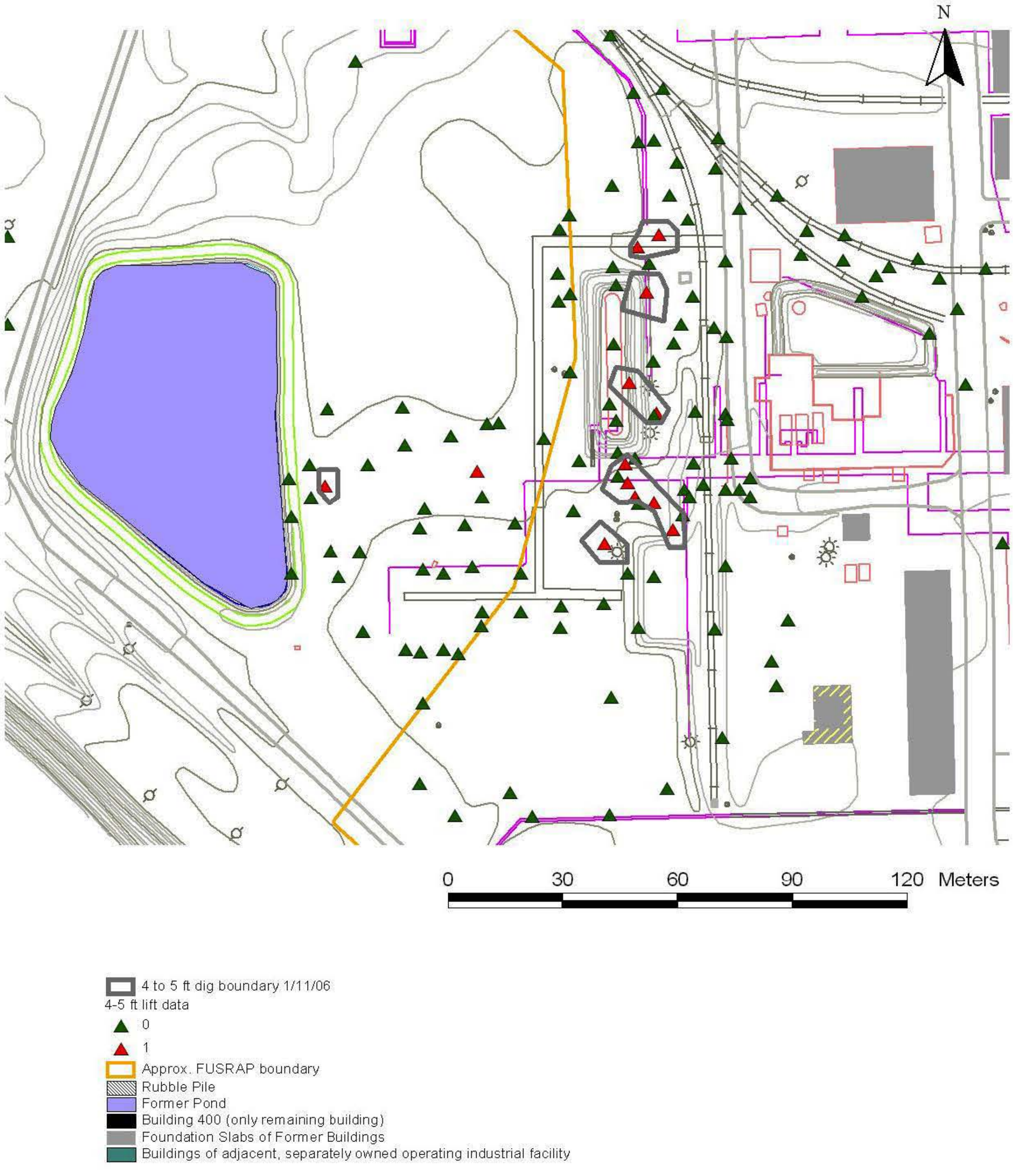


Figure 11_. Hard data and excavation footprints for 4-5 ft lift, western side of Painesville site.

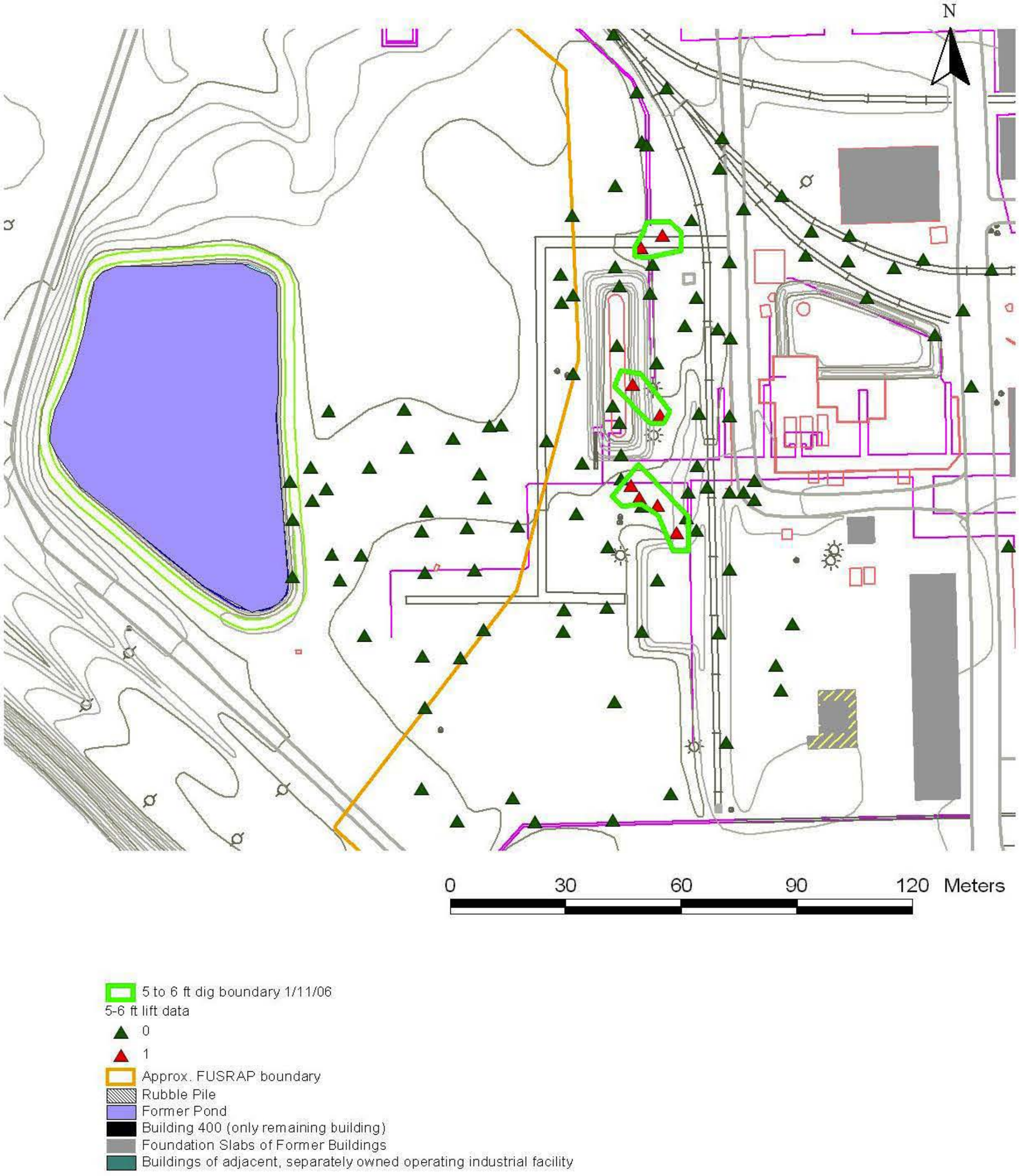


Figure 12. Hard data and excavation footprints for 5-6 ft lift, western side of Painesville site.

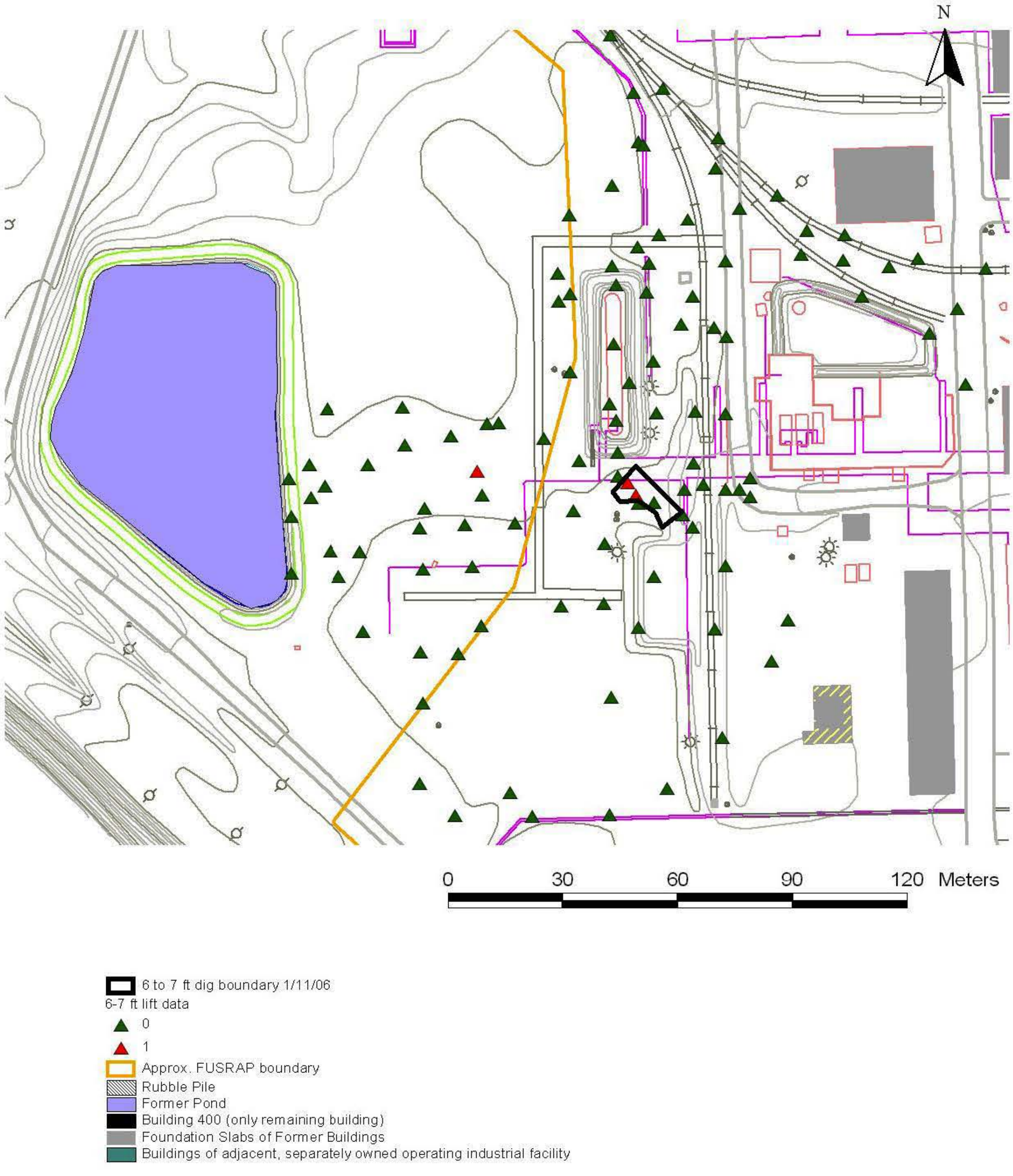


Figure 13. Hard data and excavation footprints for 6-7 ft lift, western side of Painesville site.

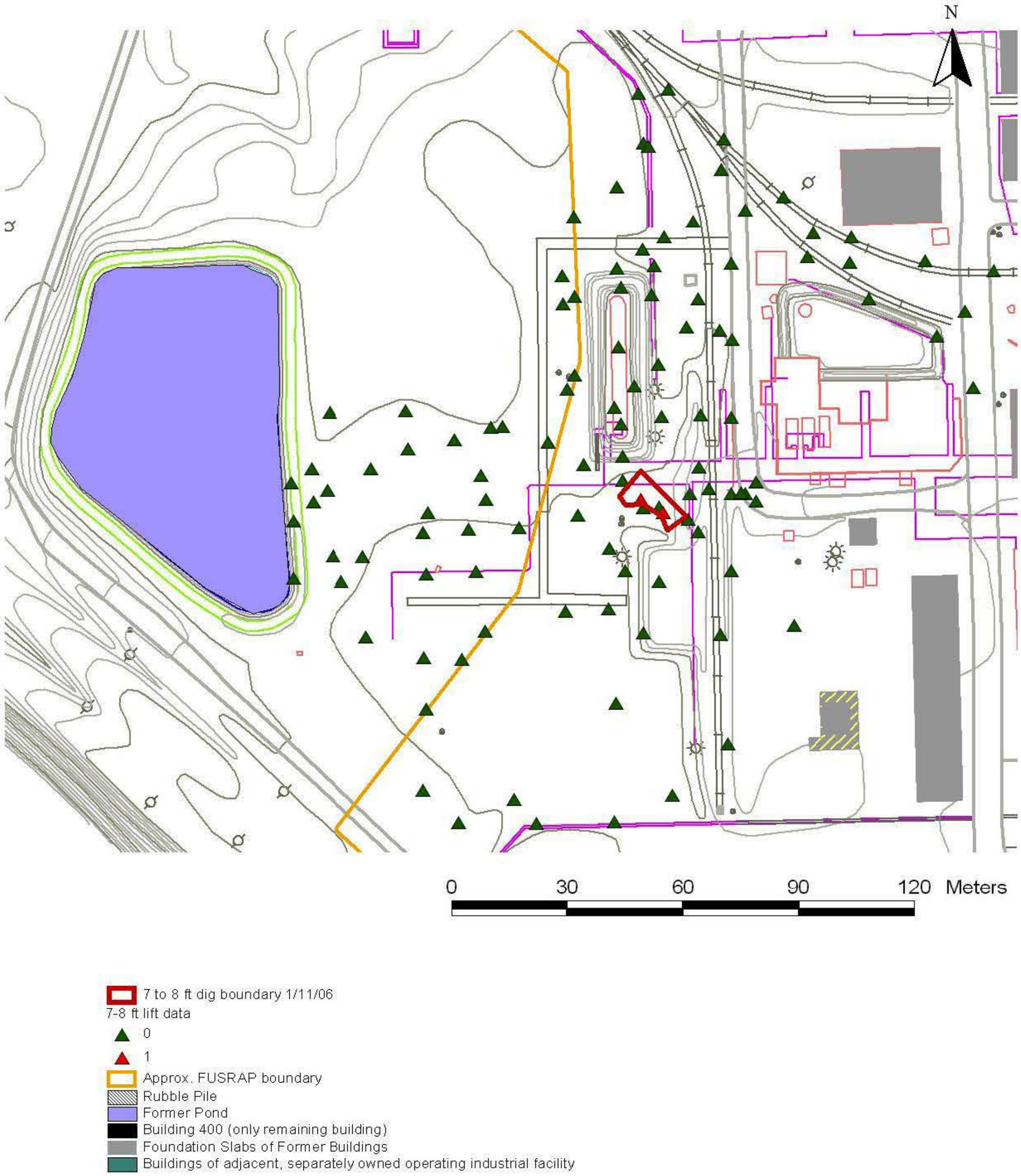


Figure 14. Hard data and excavation footprints for 7-8 ft lift, western side of Painesville site.

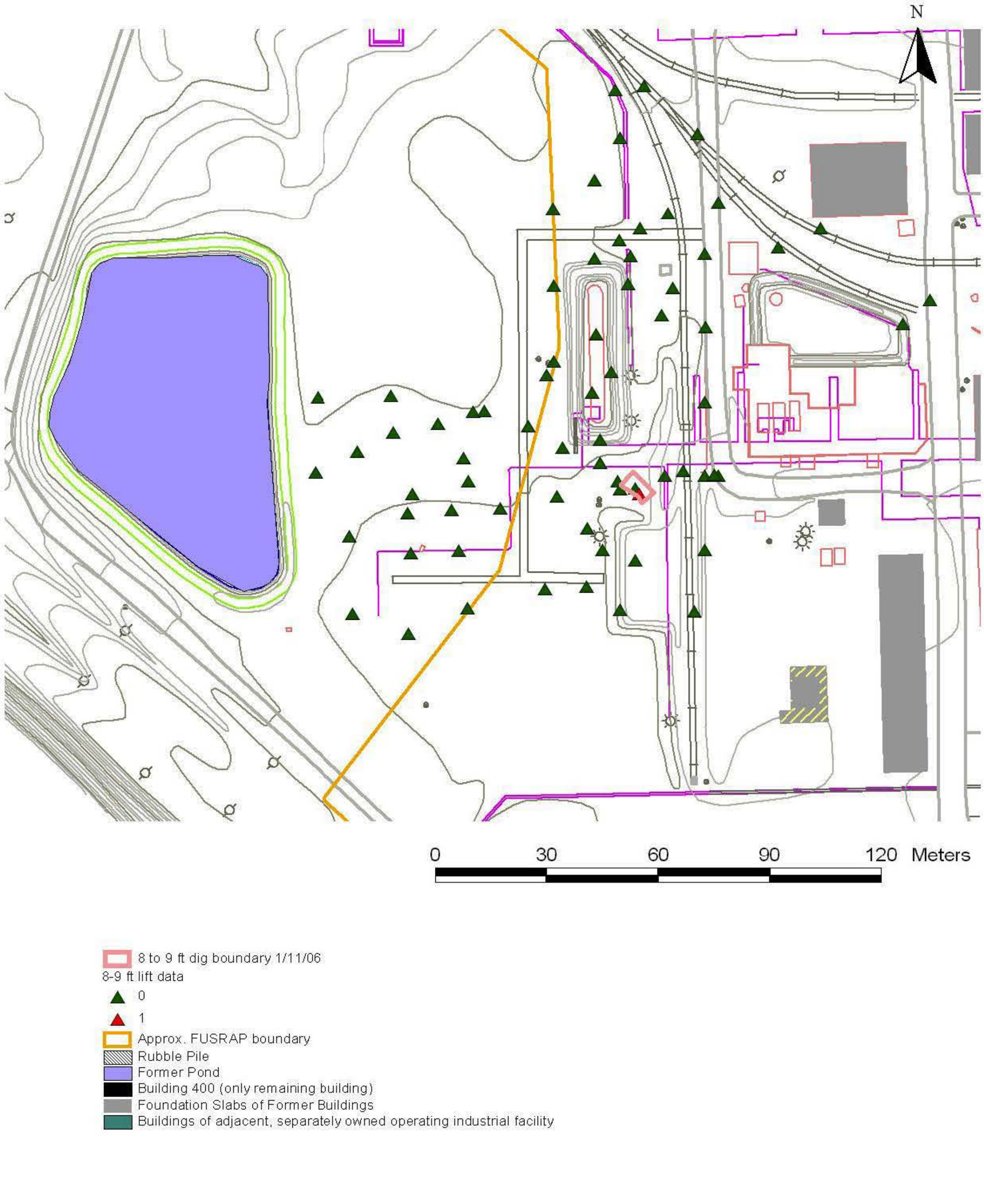


Figure 15. Hard data and excavation footprints for 8-9 ft lift, western side of Painesville site.

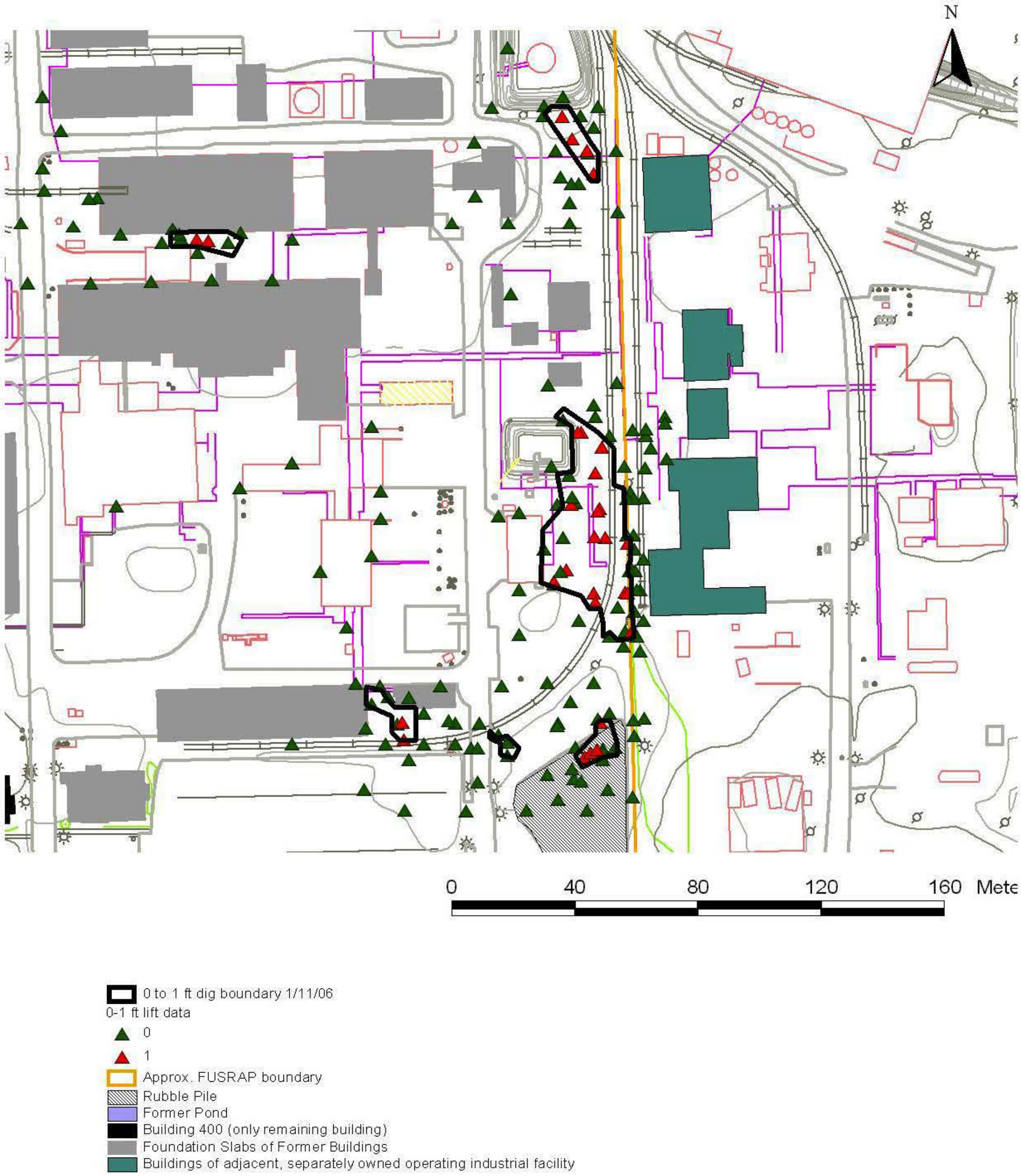


Figure 16. Hard data and excavation footprints for 0-1 ft lift, eastern side of Painesville site.

Figure 17. Hard data and excavation footprints for 1-2 ft lift, eastern side of Painesville site.

Figure 18. Hard data and excavation footprints for 2-3 ft lift, eastern side of Painesville site.

Figure 19. Hard data and excavation footprints for 3-4 ft lift, eastern side of Painesville site.

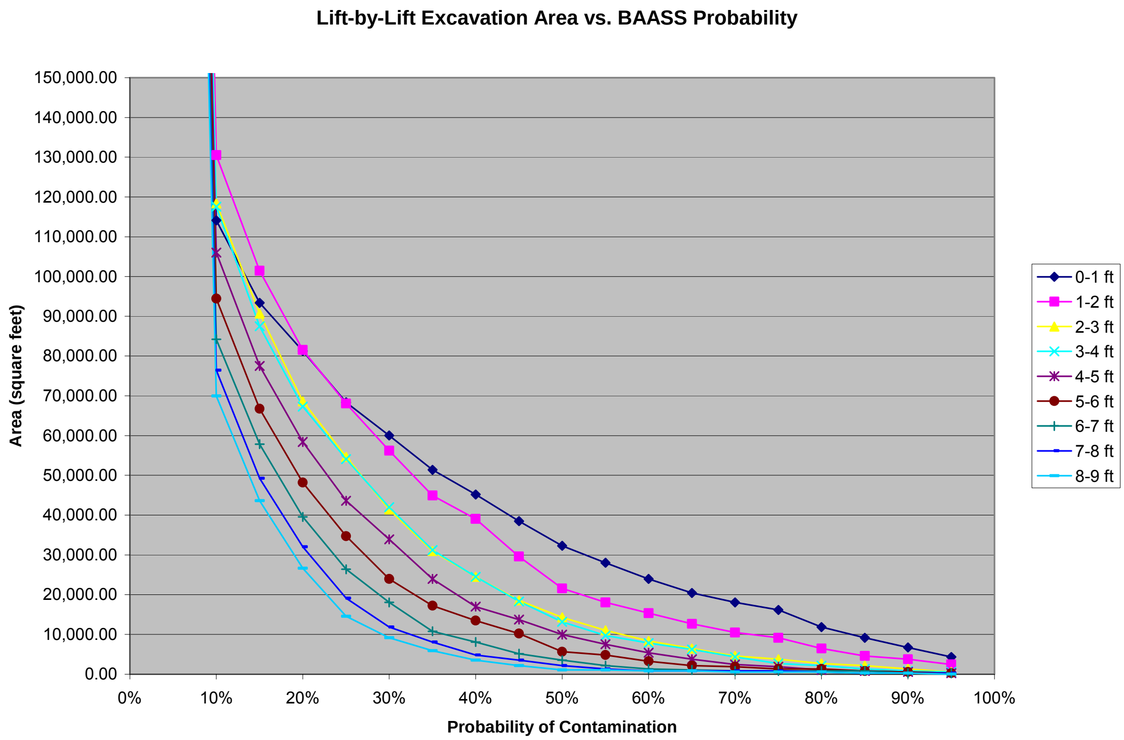


Figure 20. BAASS analysis of area of excavation vs. probability of contamination.

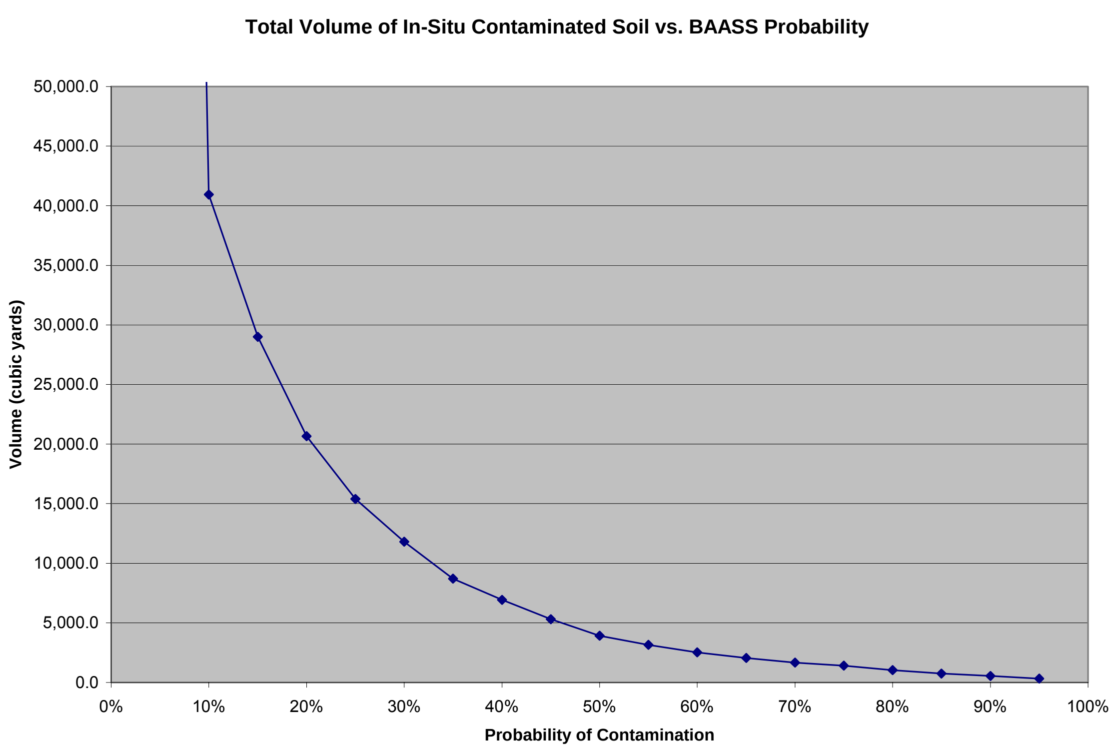


Figure 21. BAASS analysis of volume of excavation vs. probability of contamination.

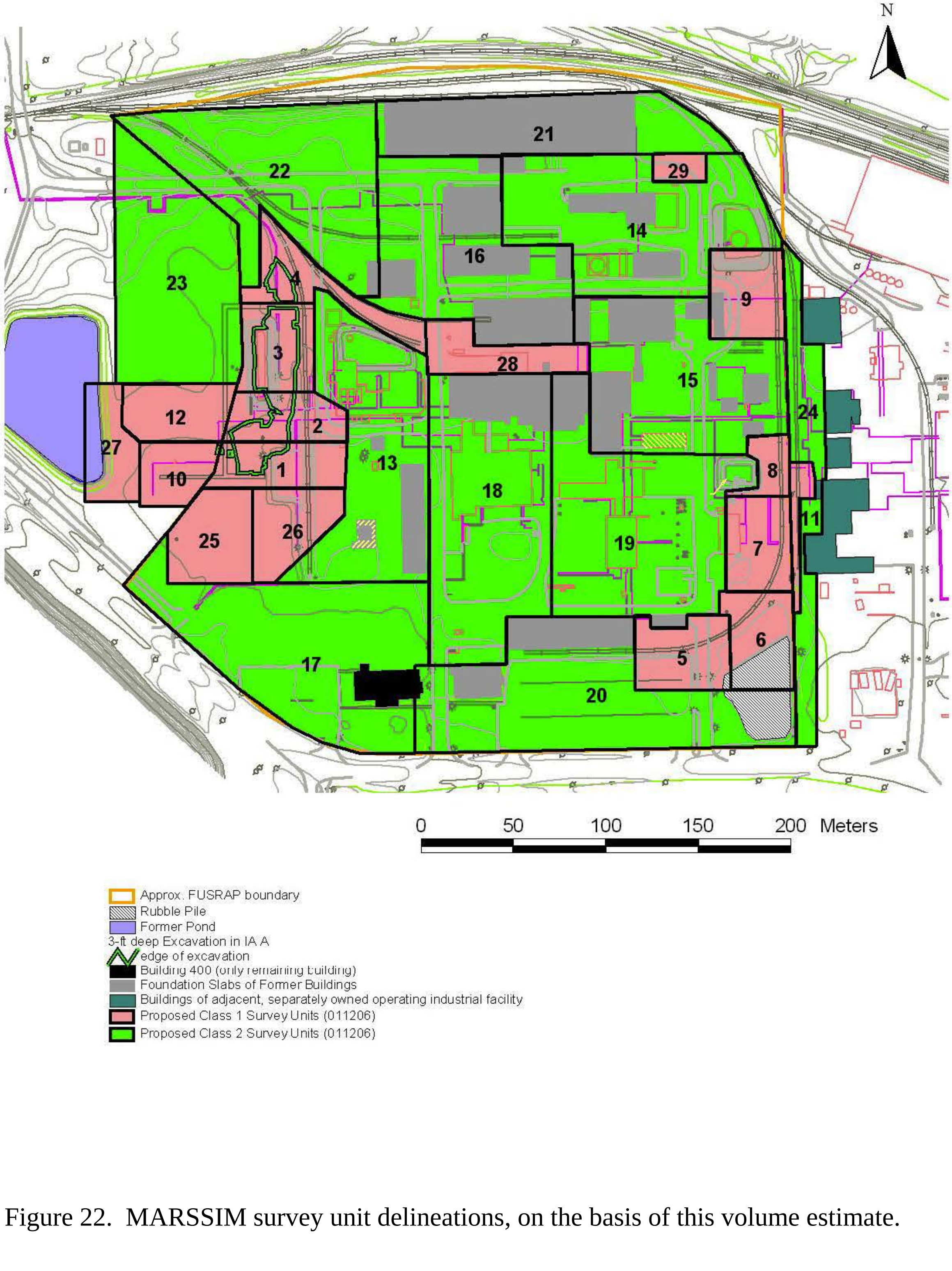
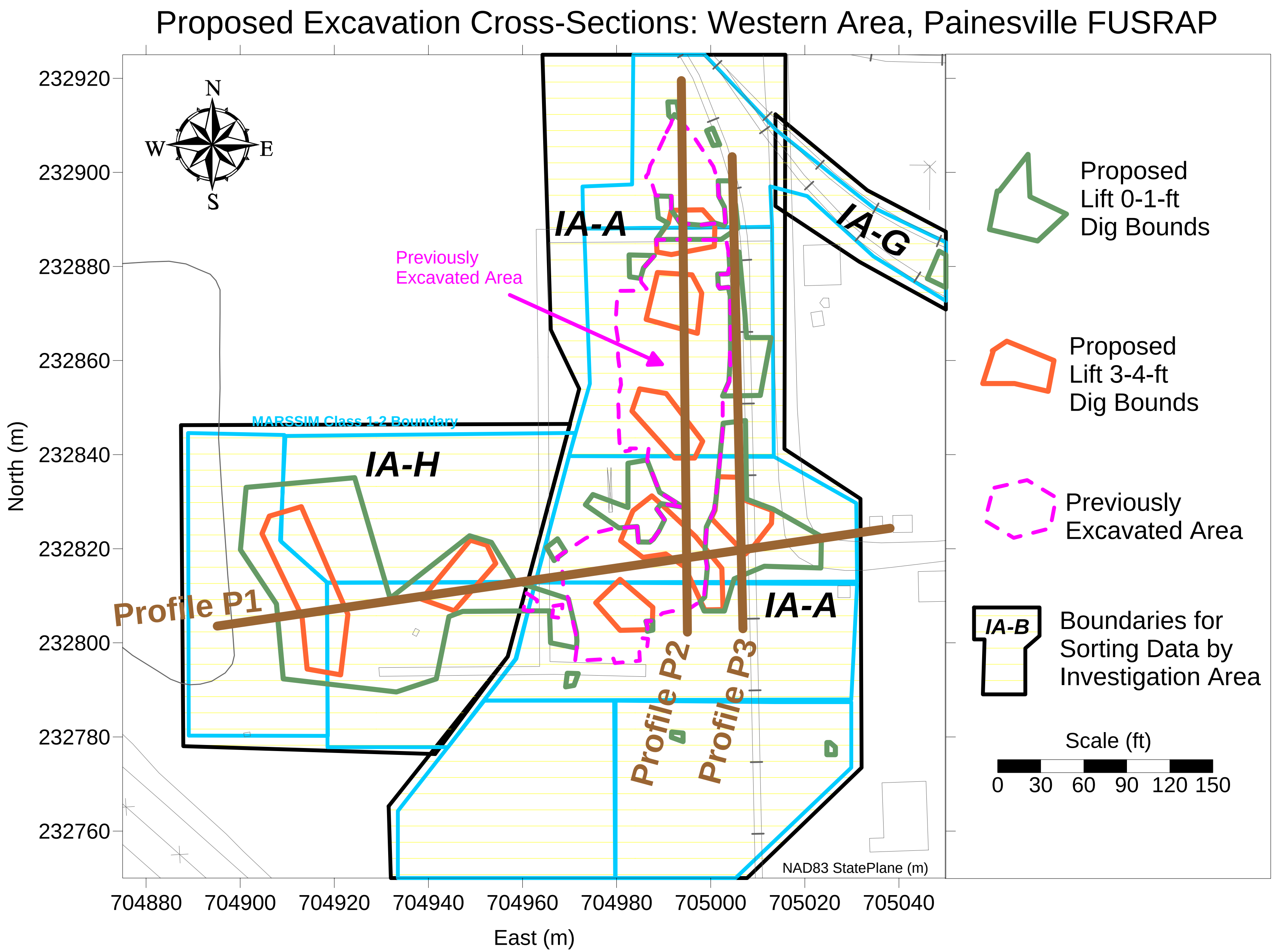


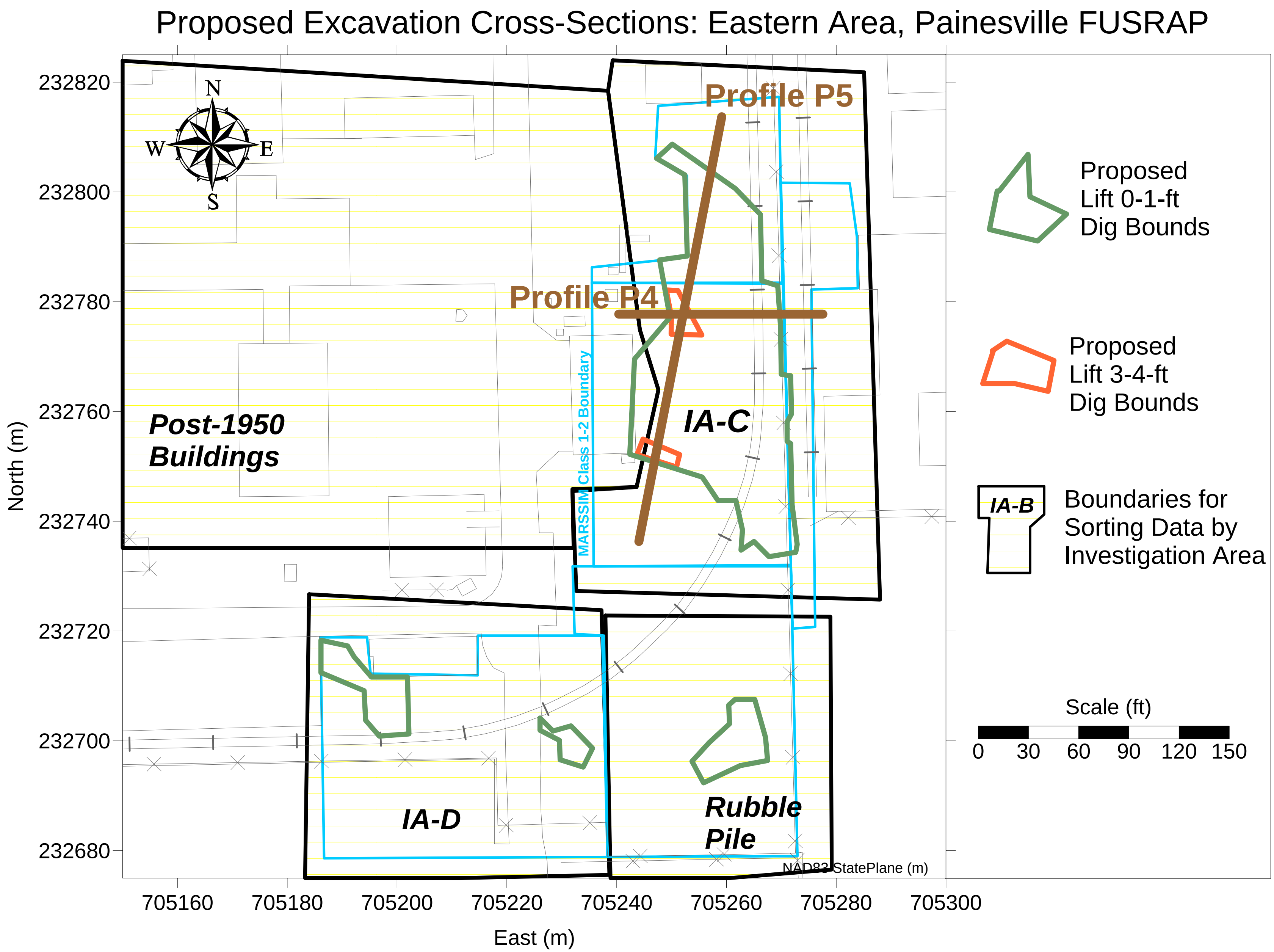
Figure 22. MARSSIM survey unit delineations, on the basis of this volume estimate.

Attachment

Representative Cross Sectional Diagrams Illustrating the Proposed Excavations



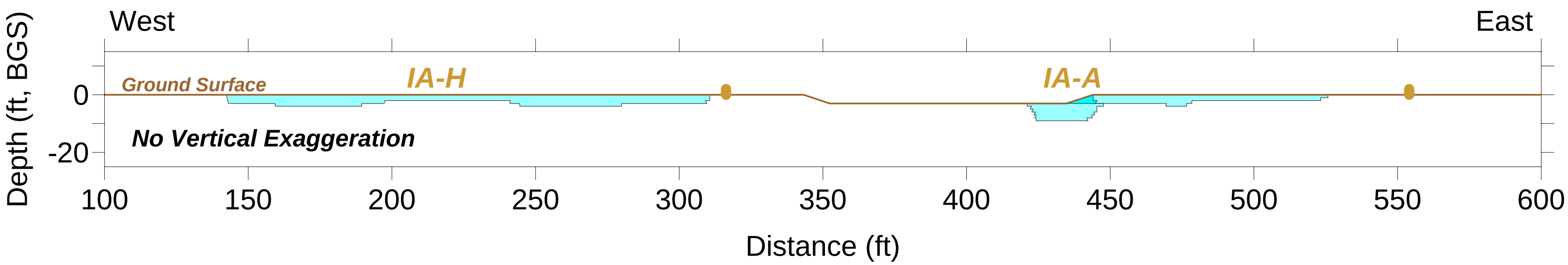
Proposed Excavation Cross-Sections: Western Area, Painesville FUSRAP
North (m)
East (m)
232920
232900
232880
232860
232840
232820
232800
232780
232760
704880
704900
704920
704940
704960
704980
705000
705020
705040
N
S
E
W
IA-A
IA-H
IA-G
IA-A
MARSSIM Class 1-2 Boundary
Previously Excavated Area
Profile P1
Profile P2
Profile P3
NAD83 StatePlane (m)
Proposed Lift 0-1-ft Dig Bounds
Proposed Lift 3-4-ft Dig Bounds
Previously Excavated Area
IA-B
Boundaries for Sorting Data by Investigation Area
Scale (ft)
0 30 60 90 120 150

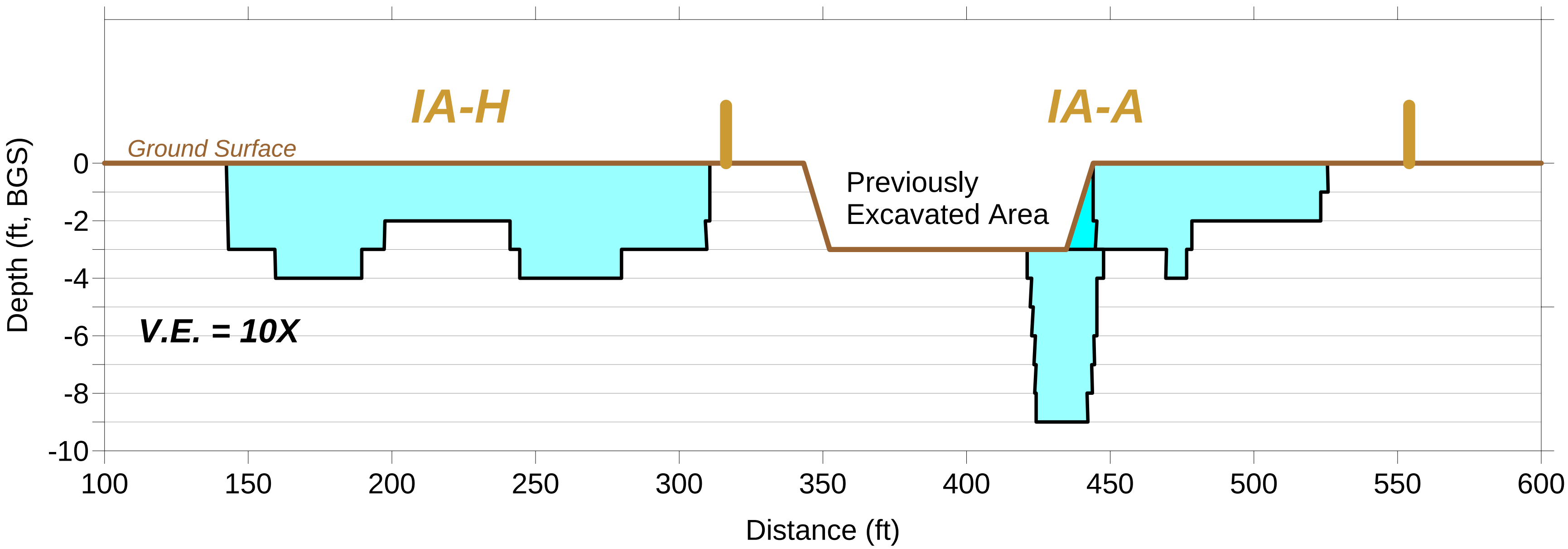


Proposed Excavation Cross-Sections: Eastern Area, Painesville FUSRAP
Profile P5
Profile P4
Post-1950 Buildings
IA-C
IA-D
Rubble Pile
MARSSIM Class 1-2 Boundary
N
S
E
W
North (m)
East (m)
NAD83 StatePlane (m)
Proposed Lift 0-1-ft Dig Bounds
Proposed Lift 3-4-ft Dig Bounds
IA-B
Boundaries for Sorting Data by Investigation Area
Scale (ft)
0
30
60
90
120
150
232820
232800
232780
232760
232740
232720
232700
232680
705160
705180
705200
705220
705240
705260
705280
705300

Profile P1 (Western Area)

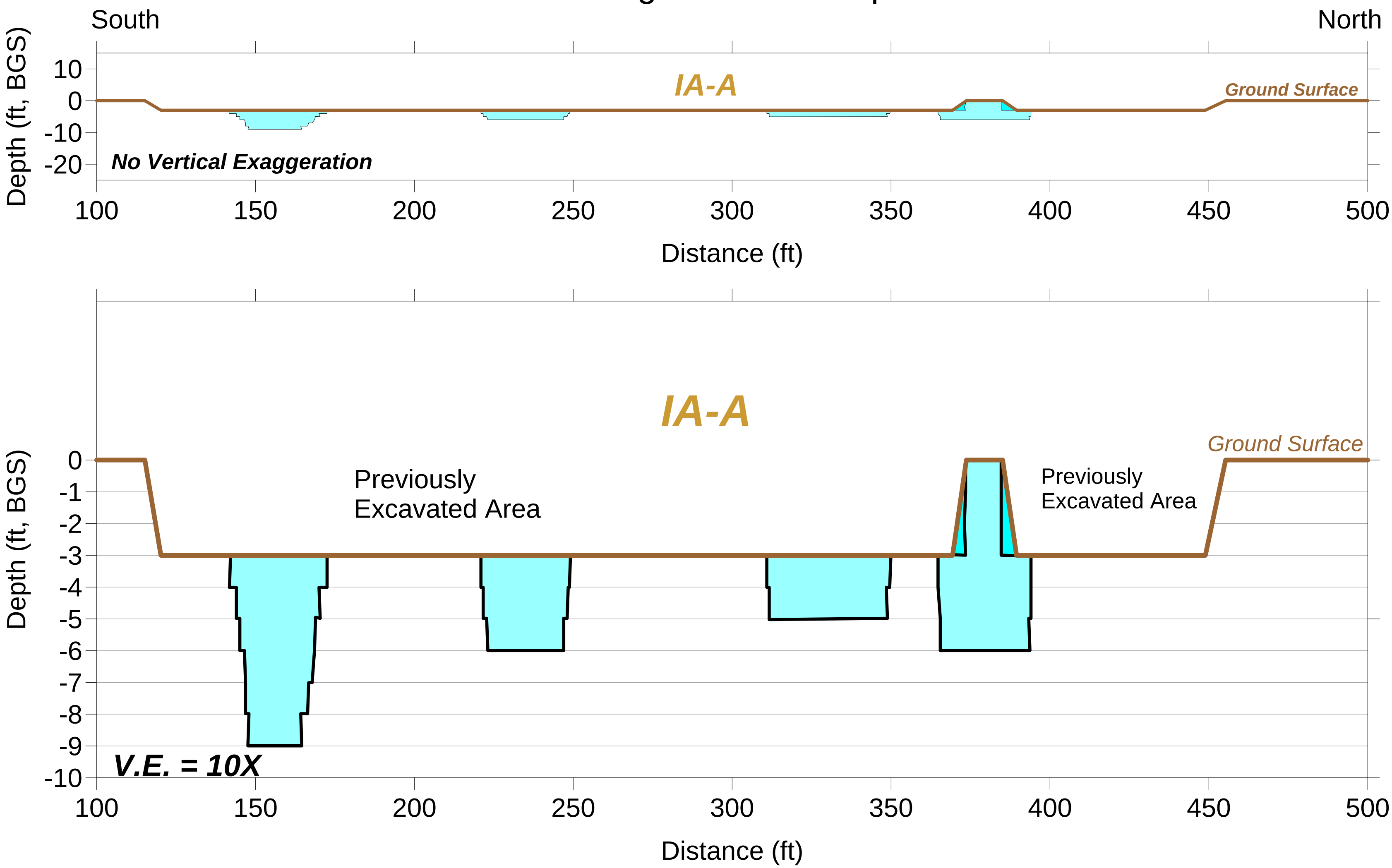
Cross-Section Showing Extent of Proposed Excavations





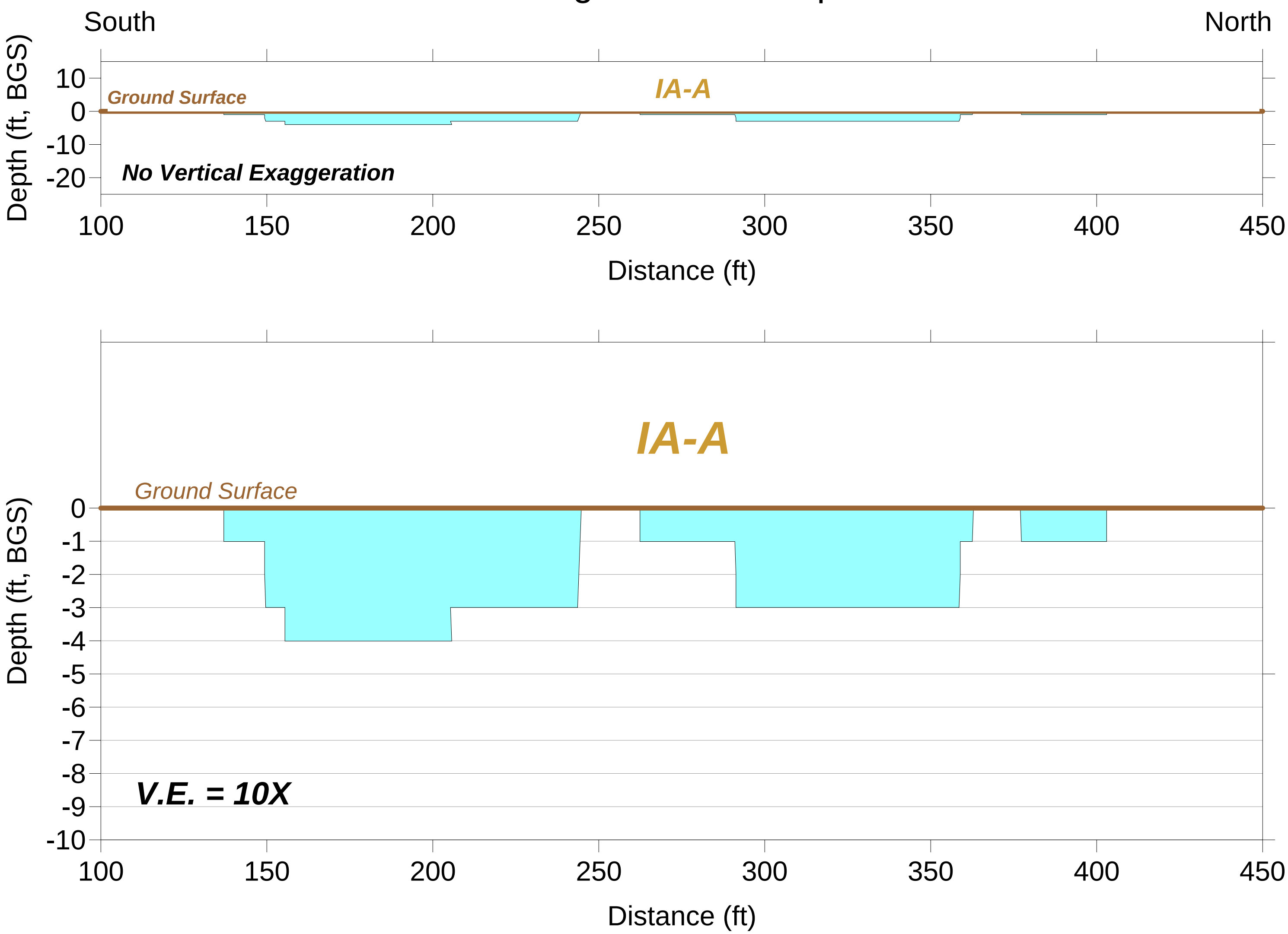
Profile P2 (Western Area)

Cross-Section Showing Extent of Proposed Excavations



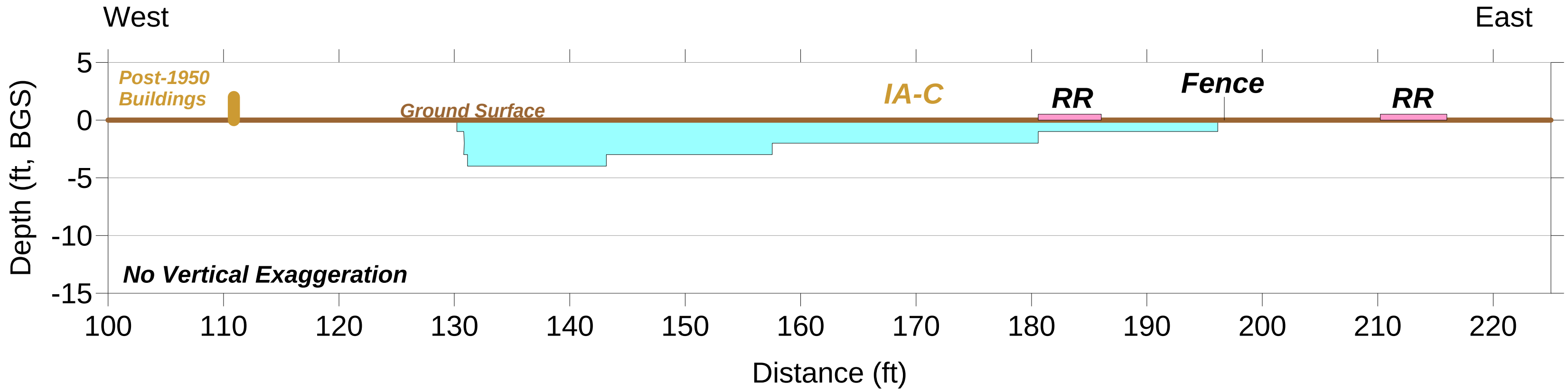
Profile P3 (Western Area)

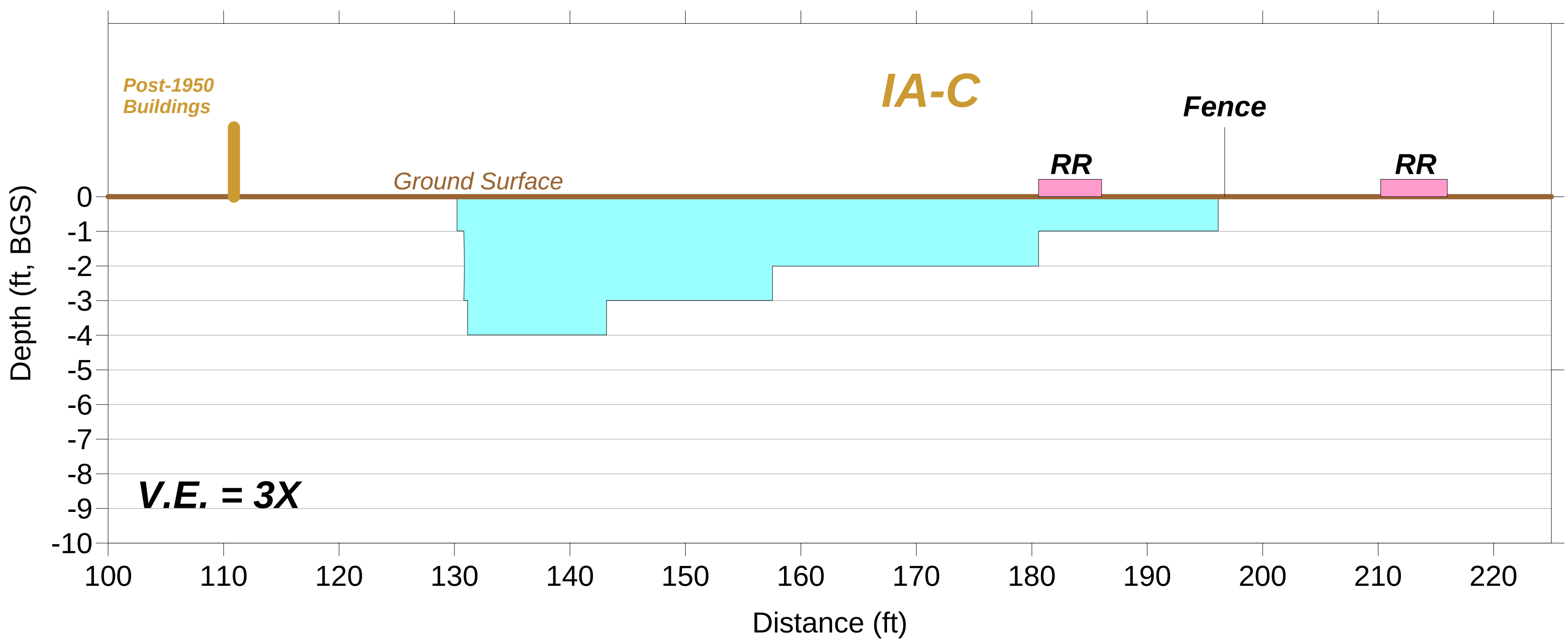
Cross-Section Showing Extent of Proposed Excavations



Profile P4 (Eastern Area)

Cross-Section Showing Extent of Proposed Excavations





Profile P5 (Eastern Area)

Cross-Section Showing Extent of Proposed Excavations