E.O. Lawrence Berkeley National Laboratory

United States Department of Energy

ENVIRONMENTAL RESTORATION PROGRAM

INTERIM CORRECTIVE MEASURES WORKPLAN TO CONTROL THE MIGRATION OF CONTAMINATED GROUNDWATER AT THE BEVATRON DEMOLITION PROJECT SITE

for the
Lawrence Berkeley National Laboratory

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Ernest Orlando Lawrence Berkeley National Laboratory

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This work was done at the Lawrence Berkeley National Laboratory, which is operated by the University of California for the U. S. Department of Energy under contract DE-AC02-05CH11231.

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LIST OF ABBREVIATIONS

Berkeley Lab	Lawrence Berkeley National Laboratory
Cal/EPA	California Environmental Protection Agency
CAP	Corrective Action Program
CHHSLs	California Human Health Screening Levels
DCA	Dichloroethane
DCE	Dichloroethene
DTSC	Cal-EPA Department of Toxic Substances Control
DWR	Department of Water Resources
DNAPL	Dense Non-Aqueous Phase Liquid
ERP	Environmental Restoration Program
ESL	Environmental Screening Level
GAC	Granular Activated Carbon
ICM	Interim Corrective Measure
MCS	Media Cleanup Standard
mg/kg	milligrams per kilogram
µg/L	micrograms per liter (10^{-6} grams per liter)
MIP	Membrane Interface Probe
msl	mean sea level
PCE	Tetrachloroethylene (Perchloroethene)
RCRA	Resource Conservation and Recovery Act
RPM	Remedial Project Manager (meeting)
TCA	Trichloroethane
TCE	Trichloroethylene
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
Water Board	San Francisco Bay Region of the Regional Water Quality Control Board

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this Work Plan is to provide the rationale and establish the requirements for constructing and operating an Interim Corrective Measure (ICM) in the Vacuum Pump Room area of the former Bevatron Complex at the Lawrence Berkeley National Laboratory (Berkeley Lab).

1.2 BACKGROUND

Berkeley Lab Building 51, which housed the Bevatron, occupied approximately 2.25 acres in the west-central part of Berkeley Lab. During its operation from 1954 until 1993, the Bevatron was among the world's leading particle accelerators. The Building 51 and Bevatron Demolition Project, which began in 2010, consisted of the demolition, deactivation, and disposal of the Building 51 structure and contents; including the shallow foundations, shield blocks, and the Bevatron accelerator housed within the building. Following demolition, the site was backfilled to grade with clean soil. These activities were completed in February 2012. The project area is primarily referred to as Building 51 in this workplan, but is also referred to as the Bevatron Complex or simply as the Bevatron. Building 51 included Building 51A, an integral addition. The former location of the Bevatron is shown on Figure 1. The project area is now in the process of being paved to provide parking, and will not be developed further until another use for the area is proposed, approved, and initiated. A photograph showing the status of the site on March 10, 2012 (post demolition and pre-paving) is provided on Figure 2.

Between September 2010 and April 2011, Berkeley Lab conducted a preliminary investigation of potential subsurface contamination beneath the Building 51 Demolition Project area. This investigation, although not required by a regulatory agency, was conducted in accordance with Berkeley Lab's standard practice of evaluating the potential presence of subsurface contamination at demolition/construction sites as part of a due diligence process. Requirements for the preliminary investigation were specified in the *Workplan for Initial Characterization of Subsurface Contamination - Demolition of Building 51 and the Bevatron*

(Berkeley Lab, 2010). This workplan was provided to the California Environmental Protection Agency (Cal/EPA) Department of Toxic Substances Control (DTSC), the Regional Water Quality Control Board (Water Board), and the City of Berkeley at a Remedial Project Managers (RPM) meeting held at the DTSC's Berkeley office on November 5, 2010. At a second RPM meeting held on April 25, 2011, Berkeley Lab provided the regulatory agencies with an update on the status of the Building 51 investigations.

During this preliminary Bevatron investigation, relatively high concentrations of volatile organic compounds (VOCs) were detected in the soil and groundwater under the Building 51 Vacuum Pump Room (Room 10). In accordance with requirements specified in Berkeley Lab's Hazardous Waste Handling Facility Permit to notify the DTSC orally and in writing of an immediate or potential threat to human health or the environment, this finding was reported to the DTSC on June 6, 2011 by email and in a follow-up telephone conversation on June 7, 2011. The location of the Vacuum Pump Room is shown on Figure 3.

On August 16 2011, Berkeley Lab met with the DTSC at their Berkeley offices to provide an update on the status of the investigations and submitted a Workplan for Investigation and Interim Corrective Measure in the Vacuum Pump Room Area for the Building 51 and Bevatron Demolition Project to the DTSC for their review and approval. On August 25, 2011, the DTSC approved the proposed sampling methodology but stipulated that the ICM needed to be addressed in a separate document. All reference to an ICM was therefore removed from the workplan and the document *(Workplan for Investigation in the Vacuum Pump Room Area for the Building 51 and Bevatron Demolition Project*) was resubmitted to the DTSC on September 8, 2011. On September 22, 2011, another meeting was held at the DTSC Berkeley office, at which time DTSC provided additional comments on the workplan. The workplan was revised in accordance with the additional DTSC comments and resubmitted on October 6, 2011 (Berkeley Lab, 2011). DTSC approved the revised workplan on October 10, 2011 (DTSC, 2011). On October 14, 2011, DTSC representatives toured the Berkeley Lab site and attended a meeting that included a presentation on the status of the Building 51 investigations.

On March 14 2012, Berkeley Lab submitted a letter report to DTSC requesting approval for the extraction and treatment of groundwater from an observation well that was installed to

monitor the groundwater level in the backfill at the Former Bevatron site (Berkeley Lab, 2012a). On March 27 2012, Berkeley Lab met with the DTSC at their Berkeley office to discuss Berkeley Lab's March 14 request and to present a summary of the final results for the Bevatron investigations. At the meeting, the DTSC informed Berkeley Lab that a more detailed ICM workplan would be required to obtain approval for the extraction and treatment of contaminated groundwater at the former Bevatron site. The current Workplan has been prepared to comply with that requirement.

1.3 OBJECTIVE OF THE ICM

The objective of the ICM is to help control the downgradient migration of contaminated groundwater from the Former Vacuum Pump Room area of the Bevatron. As described in the following sections of this workplan, the groundwater level in the eastern end of the backfilled Bevatron Air Duct shafts has risen several feet (to within a few feet of the surface) since demolition of the Bevatron was completed. This groundwater is contaminated with the same suite of VOCs as has been detected in the adjacent Vacuum Pump Room and cooling tower areas. The results indicate that since demolition of the Bevatron and backfilling of the Air Duct shafts, contaminated groundwater has migrated from the former Vacuum Pump Room/cooling tower areas into the clean Air Duct backfill. Although the downgradient migration will likely be contained by a replacement subdrain that was installed in the former Bevatron Wind Tunnel area, this will not occur until a significant portion of the Bevatron backfill upgradient from the subdrain has become contaminated. The downgradient migration therefore poses an imminent threat to the environment that needs to be mitigated.

1.4 WORKPLAN ORGANIZATION

This Workplan is presented in several sections. Section 1.0 provides the purpose, background information, and objectives of the ICM. Section 2.0 presents a summary of existing conditions at the Site. The Site Conceptual Model for the proposed ICM area is presented in Section 3.0. Selection of the ICM is addressed in Section 4.0. A description of the proposed ICM is included as Section 5.0. ICM installation and operation considerations are presented in Section 6.0.

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2.0 SUMMARY OF EXISTING CONDITIONS

The description of existing conditions in the Vacuum Pump Room area is based on environmental investigations conducted between September 2010 and December 2011. The investigations included soil vapor, soil, and groundwater sampling and a Membrane Interface Probe (MIP) survey. The results of these investigations are reported in detail in the Report of Environmental Investigations in the Building 51A and Vacuum Pump Room Areas for the Building 51 and Bevatron Demolition Project (Berkeley Lab 2012b), and summarized in the following subsections. Results of the former Vacuum Pump Room area investigations have also been reported in the Berkeley Lab Environmental Restoration Program (ERP) Quarterly Progress Reports, which are submitted to the DTSC and provided to the Water Board and City of Berkeley. The Quarterly Progress reports are available on line at http://www.lbl.gov/ehs/erp/html/documents.shtml and at the main branch of the Berkeley Public Library.

2.1 PHYSICAL DESCRIPTION OF THE FACILITY

The Bevatron was constructed inside Building 51 in 1950 and ceased operation in 1993. It was a large, weak-focusing synchrotron accelerator used for conducting experiments in nuclear physics. The original Building 51 was expanded with two high-bay additions, 51A and 51B, in the late 1950s and 1960s. The Vacuum Pump Room was located on the main floor of Building 51 at the eastern end of several large air ducts and equipment tunnels (Figure 3).

2.2 SITE GEOLOGIC AND HYDROGEOLOGIC CONDITIONS

2.2.1 Physiography and Drainage

Prior to construction of the Bevatron, North Fork Strawberry Creek, which flows through Blackberry Canyon, passed between the current locations of Building 51 and Building 64. South of this area, a broader canyon containing an unnamed north-northwest-trending drainage passed through approximately the center of the present location of Building 51. Cut and fill activities

during development of the Bevatron site significantly transformed the topography and surface runoff patterns. The hillside along the south and east edges of Building 51 was excavated, including the upper reaches of the unnamed northwest-trending drainage. Storm drains were placed in the bottom of Blackberry Canyon northeast of Building 51 and along the unexcavated parts of the unnamed drainage prior to placing fill in the canyons. Since the hillside excavation intercepted the water table, various hillside drains, wells, and building subdrains were installed to convey intercepted groundwater to storm drains. The locations of the active subdrains that currently intercept groundwater are shown on Figure 3. The south perimeter subdrain lies adjacent to the retaining walls that formed the east and south walls of the Vacuum Pump Room. The Wind Tunnel subdrain lies approximately 60 feet west of the Vacuum Pump Room, and replaces a previously existing subdrain that was removed during demolition activities.

2.2.2 Geology

Two bedrock units (the Orinda Formation and the Great Valley Group) underlie the Bevatron Complex. Mudstones, sandstones, and shales of the Great Valley Group underlie the southwestern part of Building 51. The Orinda Formation, comprised primarily of clayey siltstones beneath the Bevatron Complex, overlies the Great Valley Group in the northeastern part of Building 51 including the Vacuum Pump Room area.

Colluvium several tens of feet thick is present in the former drainages that have been covered with artificial fill. The most extensive colluvial deposits lie along the former location of Blackberry Canyon. Colluvial deposits are also present within a former drainage course under the northwest portion of Building 51.

Artificial fill, consisting generally of gravelly, sandy, silty clay and clayey silt was used for cut and fill activities, including backfilling of the excavations surrounding the Air Ducts and Vacuum Pump Room retaining walls. Figure 4 is an historical photograph of the Bevatron construction site looking westwards from immediately southeast of the Vacuum Pump Room. The photograph shows the configuration of the bedrock surface prior to placement of backfill around the Air Duct shafts and behind the south perimeter wall and Vacuum Pump Room retaining walls.

2.2.3 Hydrogeology

Groundwater in the Vacuum Pump Room and Building 51A areas appears to flow mainly within the artificial fill. The underlying Orinda Formation generally has very low permeability and in most cases Orinda Formation rocks encountered in drilling throughout the Bevatron area appear dry, even when located beneath saturated overburden. G eological reports prepared before construction of Building 51 and geotechnical reports prepared during filling and compacting parts of Blackberry Canyon describe several springs at this site (Dames and Moore, 1949).

Groundwater flow beneath Building 51 h ad been controlled by the Bevatron subdrain systems prior to the demolition of Building 51 and parts of its internal subdrain system. Flow is still controlled to some extent by the remaining exterior components of the system, including the South Perimeter subdrain and hillside drains, and by a subdrain that was installed to replace the demolished Wind Tunnel subdrain system. The locations of the subdrains are shown on Figure 3.

A groundwater elevation contour map for the former Bevatron Complex is shown on Figure 5. G roundwater in areas uphill from the former Building 51 area flows generally northwards and westwards towards Building 51, where shallow groundwater is intercepted by the perimeter subdrains. Downhill from the perimeter subdrain, groundwater is directed generally northwestwards towards the lower, unfilled portion of Blackberry Canyon to the northwest of the Building 51 area. As a result, groundwater is very shallow along the upslope perimeter of Building 51 and water frequently intruded into the basement area during the wet season particularly at the east end of the Air Ducts and in the southeast part of the Wind Tunnel, where it was captured by floor drains. Approximately 4,000 to 10,000 gallons of groundwater per day were captured by the drainage systems during the wet season.

2.3 SOIL CONTAMINATION

Numerous soil borings were drilled and sampled in and adjacent to the Vacuum Pump Room as part of the Bevatron Demolition Project investigations to evaluate the distribution of soil contamination in the Vacuum Pump Room area. This characterization work was supplemented by a MIP survey in the cooling tower area immediately to the south of the Vacuum Pump Room. The locations of soil sampling points in the Vacuum Pump Room area are shown on Figure 6. The

primary soil contaminant detected was trichloroethylene (TCE), which was detected at a maximum concentration of 230 mg/kg at a depth of approximately 12 feet below the Vacuum Pump Room floor in SB51-11-9. Other VOCs detected in the former Vacuum Pump Room area included tetrachloroethylene (PCE), cis-1,2-dichloroethene (DCE), trans-1,2-DCE, 1,1-DCE, 1,1,1-trichloroethane (TCA), 1,1-dichloroethane (DCA), and benzene. These other contaminants were detected at relatively low concentrations, except for boring SB51-11-20, where PCE (1.0 to 6.3 mg/kg) was detected at concentrations higher than TCE in three of the four samples collected. SB51-11-20 was located adjacent to the location of a former sump on the south side of the southern Vacuum Pump Room wall.

A map showing the maximum concentrations of TCE and PCE detected at each soil boring location is shown on Figure 7. The figure shows that soil contamination is confined to a relatively small area beneath the southwest end of the Vacuum Pump Room and in the former cooling tower area immediately south of the Vacuum Pump Room retaining wall. The lateral extent of contamination is well defined by the non-detectable to low concentrations of VOCs in borings drilled around the periphery of the area and by the insignificant MIP detector responses over most of the cooling tower area (Berkeley Lab, 2012b). Except for SB51-11-9, where the maximum concentrations of VOCs were detected, the soil contamination appears to have been primarily limited to the areas adjacent to the Air Duct walls and southern wall of the Vacuum Pump Room. The vertical extent of contamination is also well-defined, as indicated by the analytical results and MIP detector responses shown on cross sections A-A' (Figure 8), B-B' (Figure 9), and C-C' (Figure 10). The locations of the cross sections are shown on Figure 7.

2.4 SOIL VAPOR CONTAMINATION

Soil vapor sampling locations in the former Vacuum Pump Room area are shown on Figure 11. Elevated concentrations of VOCs were detected three probes installed in the south end of the Vacuum Pump Room and the former cooling tower area. The primary soil vapor contaminants detected consisted of TCE, vinyl chloride, cis-1,2-DCE, and 1,1-DCA with lesser concentrations of trans-1,2-DCE, 1,1-DCE, and 1,1,1-TCA. Saturated conditions in much of the cooling tower area made collection of additional soil vapor samples unfeasible.

2.5 GROUNDWATER CONTAMINATION

Isoconcentration contour maps of total VOCs detected in groundwater are shown on Figure 12 for the Building 51 area and in detail on Figure 13 for the former Vacuum Pump Room Area. The primary contaminant detected in groundwater in the former Vacuum Pump Room area has been TCE, with significantly lower concentrations of 1,1,1-TCA, 1,1-DCA, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, and carbon tetrachloride detected in a few of the sampling locations (Berkeley Lab, 2012b). The maximum concentration of total VOCs detected was in the initial sample collected from temporary groundwater sampling point SB51-11-9 shortly after it was installed. A sheen and very high TCE concentration (126,000 µg/L) was observed in this sample, indicating that dense non-aqueous phase liquid (DNAPL) was likely present. Subsequent groundwater samples have had significantly lower TCE concentrations (32,900 µg/L in July 2011 and 17,500 µg/L in January 2012). Groundwater samples collected from boreholes within several feet of SB51-11-9 contained total VOC concentrations orders of magnitude lower (maximum of 482 µg/L in SB51-11-24). Except for SB51-11-9 where the maximum concentrations of VOCs were detected in both the soil and groundwater, the groundwater contamination appears to have been primarily limited to the areas adjacent to the Air Duct walls.

2.6 DATA QUALITY

All of the sampling data described above were collected in accordance with the Berkeley Lab ERP Quality Assurance Program Plan (Berkeley Lab 2009), which covers field and laboratory quality control. Data quality assessment was performed in accordance with Berkeley Lab EH&S Procedure 257 Data Quality Objectives and Assessment. Data quality checks (verification/validation) on the analytical data are performed by the Berkeley Lab Environmental Services Group (ESG) database to determine if a data set has achieved the required Data Quality Objectives (DQOs) for accuracy, precision, completeness, and comparability. Following the database review, representative data sets in the analytical laboratory hard copy reports are manually compared to the information in the database. As part of ERP reporting process, all sampling data and quality assurance/quality control findings are reported to the DTSC in the ERP quarterly progress reports. No findings that could affect data quality were noted for the data presented in this Workplan.

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3.0 SITE CONCEPTUAL MODEL

3.1 SOURCE AND LOCATION OF SOIL CONTAMINATION

There is substantial vertical relief across the Vacuum Pump Room area because the main floor and basement levels along the east and south sides of Building 51 were built into excavated portions of the adjacent hillside (Figure 4). The Vacuum Pump Room floor lies at an elevation of 710 feet above mean sea level (msl), while the floor of the adjacent Air Duct shafts (prior to backfilling) lay 10 feet lower at an elevation of 700 feet. The exterior cooling tower area to the south lies at an elevation of approximately 725 feet. The elevation of each area is indicated by shading on Figure 6, and is illustrated on the cross sections shown on Figures 8 and 9. This vertical relief, in combination with the configuration of the geologic contact between artificial fill and the Orinda Formation bedrock has constituted a significant control on the migration of soil contaminants from the initial release area to their current location, as described below.

Relatively high concentrations (i.e. exceeding 3 mg/kg) of total VOCs were detected in three contiguous zones of soil contamination: 1) from approximately 2 feet to 15 feet below ground surface (bgs) (elevation 710 to 723 feet) in the area where a sump was located immediately south of the Vacuum Pump Room south wall (Figure 10); 2) from 3 to 4.5 feet bgs (elevation 705.5 to 707 feet) in boring SB51-11-31 drilled in the Vacuum Pump Room immediately north of the southern wall (Figures 8 and 10); and 3) from 11 to 20 feet bgs (elevation 690 to 699 feet) beneath the Vacuum Pump Room itself (Figures 8 and 9). The contaminant suite in all three zones is similar (i.e. primarily TCE, with significantly lower concentrations of other constituents) except for the former sump area, which had higher PCE than TCE concentrations in some samples. The general absence of shallow contamination within the Vacuum Pump Room (except for boring SB51-11-31 adjacent to the south wall) indicates that the contamination probably did not originate from a release inside the Vacuum Pump Room.

The pattern of contamination as shown on the cross sections and the similarity of contaminants in the three zones suggests that the contamination in all three zones was derived from a single source, likely the former sump location. The fact that PCE was only detected in the soil samples collected near the former sump location and at relatively high concentrations (i.e. higher

than other VOCs including TCE) is further evidence that the former sump was a likely source of release of PCE.

The migration of contamination beneath the south wall of the Vacuum Pump Room from the former sump area likely occurred as the result of the downward movement of the contamination along the contact between the relatively permeable artificial fill and the underlying relatively impermeable Orinda Formation bedrock. This hypothesized migration pathway is illustrated on Figure 8. Figure 4 is a photograph showing the excavated bedrock surface during construction of the Bevatron and prior to backfilling with artificial fill, and indicates both the approximate location of the former sump and the likely migration pathway towards the area behind the Air Ducts. The absence of PCE and presence of less-chlorinated compounds (i.e. TCE, DCE, vinyl chloride, etc.) in the samples collected beneath the former Vacuum Pump Room could be the result of the reductive dechlorination of PCE as it migrated from the former sump area.

After migrating beneath the southern Vacuum Pump Room wall, the contamination appears to have spread laterally through the backfill of the Air Duct shaft walls. As described in Section 2, this interpretation is based on the relatively high concentrations of contaminants detected in samples collected in fill or immediately adjacent to the fill behind the walls (Figure 7 for soil and Figure 13 for groundwater). An exception is SB51-11-9, where the contamination appears to have migrated approximately 10 feet downwards into the underlying relatively impermeable Orinda Formation (Figure 9). The reason for the relatively deep penetration of contaminants into the Orinda formation is not known, but may be related to the presence of DNAPL.

As described above, the most likely sources of the soil and groundwater contamination detected in the Vacuum Pump Room area were releases from the sump in the former cooling tower area. An additional, though less likely hypothesis, is that the contamination detected beneath the Vacuum Pump Room is from a different source, possibly a release from the Air Duct drain system or a spill in the Air Duct area.

3.2 GROUNDWATER CONTAMINATION

As shown on Figure 12 and Figure 13, the extent of VOC-contaminated groundwater in the area downgradient (northwest) of the Vacuum Pump Room area has been limited. This is likely

due to the very low hydraulic conductivity of the bedrock, combined with the previous capture of contaminants by the Bevatron subdrain and floor drain systems. Prior to demolition of the Bevatron, there was approximately a 5 to 10 foot difference in the hydraulic head between the Vacuum Pump Room/cooling tower and Air Duct areas. Contaminated groundwater seeping through the concrete walls and floors of the Air Duct shafts and along the southeast edge of the Wind Tunnel was previously captured by the Air Duct and Wind Tunnel floor drain systems. The floor drain system was removed as part of the Bevatron Demolition Project. The effluent from the systems had been routed to the Building 51 Motor Generator Room treatment system from 1990 until 2011.

Although the Demolition Project scope included completely removing the concrete Air Duct Walls and floors, the easternmost sections (approximately 10 to 25 feet) were left in place to help limit potential post-demolition migration of contaminated groundwater from the Vacuum Pump Room/cooling tower areas into the Air Duct shaft and Wind Tunnel backfill. However, since the Air Duct shafts were backfilled and the Air Duct floor drain system was capped, the groundwater level in the backfill at the eastern end of the Air Duct shafts has risen several feet (to within a couple of feet of the surface), as shown by water level measurements in observation well OC51-11-1, which was installed to monitor the water level in the backfill. The locations of OC51-11-1 and the remaining concrete Air Duct walls are shown on Figure 14.

In December 2011, VOCs were detected at a total concentration of 264 µg/L in a groundwater sample collected from OC51-11-1. The primary VOCs detected were TCE (189 µg/L) and cis-1,2-DCE (52 µg/L). A second grab sample collected on March 9, 2012 contained VOCs at a total concentration of 194 µg/L, including 159 µg/L of TCE. The VOCs detected in the groundwater generally constituted the same suite of VOCs as has been detected in the adjacent Vacuum Pump Room and cooling tower areas. These results indicate that contaminated groundwater continues to seep through pores and joints in the concrete and possibly around the remaining concrete wall.

As described above, the Wind Tunnel subdrain system was removed to complete the Bevatron Demolition Project, but a replacement Wind Tunnel subdrain was installed at approximately the same location and elevation of the original system to control the groundwater

elevation in the former central Bevatron area. The location of the new subdrain system is shown on Figure 3. T he replacement Wind Tunnel subdrain system should help to limit migration of groundwater contamination from the Air Duct shaft backfill into the Wind Tunnel backfill.

3.3 POTENTIAL RISK TO HUMAN HEALTH AND THE ENVIRONMENT

To assess potential risks, detected concentrations of contaminants were compared to regulatory screening levels appropriate to an industrial land use scenario. Institutional (i.e. industrial) land use is the current and the reasonable and likely future land use at Berkeley Lab, and was therefore the land use scenario that has been approved by DTSC to establish cleanup requirements for the entire Berkeley Lab site (Berkeley Lab, 2005).

3.3.1 Regulatory Screening Levels

Screening levels for VOCs in soil, soil vapor, and groundwater are based on the potential risk to human health and the environment for three primary pathways: protection of groundwater; direct worker contact with the soil; and, potential vapor intrusion into indoor air (inhalation). The applicable screening criteria to assess potential risk from the first two pathways are the Water Board Environmental Screening Levels (ESLs) (http://www.swrcb.ca.gov/rwqcb2/esl.shtm). The applicable screening levels for the inhalation pathway for the Berkeley Lab site are Cal/EPA California Human Health Screening Levels (CHHSLs) (Cal/EPA, 2005) (or ESLs for VOCs that have no established CHHSLs). E SLs and CHHSLs are generic screening levels used to help identify areas, contaminants, and conditions that do not require further attention at a particular site. Generally, at sites where contaminant concentrations fall below these screening levels, no further action or study is warranted.

The regulatory screening levels are listed in Table 1 for the primary contaminants detected in soil, soil vapor, and groundwater beneath the former Vacuum Pump Room area.

Table 1

Screening Levels and Media Cleanup Standards for VOCs

Contaminant	Soil		Soil Vapor	Groundwater	
	Groundwater Protection (ESLs*) (mg/kg)	Human Health -Direct Contact (ESLs*) (mg/kg)	Human Health Inhalation (CHHSLs*) ($\mu g/m^3$)	Drinking Water Source Protection (ESLs*) (µg/L)	Human Health Inhalation (ESLs*) (µg/L)
Tetrachloroethene (PCE)	0.70	0.95	603	5	420
Trichloroethene (TCE)	0.46	4.1	1,770	5	1,800
Vinyl Chloride	0.085	0.047	44.8	0.5	13

* The presence of chemicals at concentrations in excess of the regulatory screening levels does not necessarily indicate the existence of present or future risks to human health or the environment, but suggests that further evaluation or continued monitoring may be warranted.

3.3.2 Potential Risk to Human Health

Currently, there is no significant risk to human health associated with VOC contamination detected in the former Vacuum Pump Room area. The potential exposure pathways relevant to human health risks are inhalation due to vapor intrusion into indoor air and/or direct contact with contaminated soil. VOCs have been detected in soil vapor and groundwater at concentrations well above CHHSLS and/or ESLs for potential risk to potential future indoor workers via the vapor intrusion pathway. However, there is no risk to current workers since this pathway is not complete because there are no buildings overlying the areas where the screening levels are exceeded. The closest occupied building (Building 64) is approximately 300 feet from the areas of elevated soil vapor concentrations.

The exposure pathway that is currently potentially complete is dermal contact with VOC-contaminated soil by outdoor workers. Concentrations of VOCs in the soil exceed the ESL for direct contact in the upper 10 feet of soil at two limited locations in the former Vacuum Pump Room area. The first (SB51-11-31) is in the former Vacuum Pump Room itself, where TCE was detected at a concentration of 32 mg/kg at a depth of 3 feet. The second (SB51-11-20) is in the

former cooling tower area to the south of the Vacuum Pump Room, where PCE was detected at a concentration of 5.3 mg/kg at a depth of 3 feet and 6.3 mg/kg at a depth of 6 feet. Both of these locations have been posted with warning signs requiring Hazardous Waste Operation (HAZWOPER) training for any worker handling soil in the posted area. Also, Berkeley Lab has an institutional process that requires a penetration permit for all soil disturbances. The permit process includes an assessment of potential subsurface contamination issues by the Berkeley Lab Environmental Services Group.

Since the exposure pathways for risks to human health are not complete or are mitigated by institutional controls, this ICM does not address contamination associated with these pathways.

3.3.3 Potential Risk to the Environment

The former Building 51 site is located within the developed area of Berkeley Lab. Potential exposure of wildlife to soil and groundwater contamination within the developed area was eliminated as a completed exposure pathway in the Berkeley Lab Ecological Risk Assessment (Berkeley Lab, 2002) because suitable habitat for wildlife, is restricted to the natural, perimeter areas of Berkeley Lab, and is not present in the central developed area.

As described above, the extent of groundwater contamination in the former Vacuum Pump Room area has been limited. However, since demolition of the Bevatron and backfilling of the Air Duct shafts, contaminated groundwater has been migrating from the Former Vacuum Pump Room/cooling tower areas into the clean Air Duct backfill. The replacement Wind Tunnel subdrain system is likely to limit the extent of migration through the backfill, but this will not occur until contaminated groundwater has migrated into areas where groundwater is currently clean, and until a significant portion of the Air Duct and Wind Tunnel backfill has been impacted by contaminated groundwater. These potential impacts are considered to be imminent threats to the environment, and are therefore the subject of the ICM described in the following sections.

In addition to the immediate threat of downgradient impacts described above, soil contaminant concentrations in the former Vacuum Pump Room area exceed ESLs for protection of groundwater, so constitute a continuing long-term threat to groundwater quality. Remediation of

the source area soil would likely reduce or eliminate this threat and may be considered as a long-term corrective action, but is not being proposed as part of the proposed ICM.

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4.0 SELECTION OF INTERIM CORRECTIVE MEASURES

4.1 PRESUMPTIVE RESPONSE STRATEGY

The United States Environmental Protection Agency (USEPA) has developed a presumptive response strategy to integrate site characterization, early actions, remedy selection, performance monitoring, remedial design, and remedy implementation activities into a comprehensive, overall response strategy for sites with contaminated groundwater (USEPA, 1996). The EPA strategy was originally developed for CERCLA sites, but the EPA guidance document specifies that the strategy should also be used at Resource Conservation and Recovery Act (RCRA) corrective action sites. In summarizing the presumptive response strategy, the guidance document notes that:

"In general, ground-water response actions especially those using extraction and treatment, should be implemented in more than one phase." In the two-separate-action approach "an early or interim ground-water action is followed by a later, more comprehensive action (the long-term remedy)." (USEPA, 1996)

The guidance includes the following early actions that should be considered:

- Contain the plume to prevent further migration of the contaminant plume.
- Prevent migration of contaminants from the source area

4.2 PREVENTION OF PLUME MIGRATION

As detailed in the preceding sections, the primary pathway for plume migration is seepage of contaminated groundwater through the remaining concrete Air Duct shaft walls and floor slab into the clean, relatively permeable fill within and downgradient from the Air Ducts. This seepage is driven by the significant hydraulic head difference between groundwater beneath the Vacuum Pump Room floor and groundwater within the former Air Ducts to the west. The EPA presumptive remedy guidance lists plume containment and plume "hot spot" containment or treatment as the early actions to be considered for prevention of plume migration. The proposed ICM will therefore focus on plume and "hot spot" containment by groundwater extraction and

treatment to the east of the remaining Air Duct walls. Extraction in this area should reduce the hydraulic head difference that drives seepage through the former Air Duct walls and floor slab.

4.3 PREVENTION OF MIGRATION OF CONTAMINANTS FROM THE SOURCE AREA

The original contaminant source for the site was apparently the former sump immediately south of the Vacuum Pump Room wall in the cooling tower area. However, the majority of the contaminant mass is now located in the zone that lies between 10 to 20 feet beneath the former Vacuum Pump Room floor, and this zone constitutes a secondary source area that is the main ongoing threat to groundwater quality.

The EPA presumptive remedy guidance lists source removal/treatment or source containment as the early actions to be considered for prevention of migration of contaminants from a source area. Although source removal/treatment may be an appropriate long-term remedy, it is considered to be inappropriate for an ICM at this site for the following reasons. The contaminated zone adjacent to and beneath the former sump location is located behind a retaining wall that is held in place with an engineered tie-back system that could potentially be impacted by any removal or in situ treatment actions conducted in that area. The secondary source area is located relatively deep beneath the Vacuum Pump Room floor. Excavation in this area could potentially undermine nearby retaining walls, and in situ treatment is probably unfeasible due to the presence of contaminants in very low permeability bedrock. Source removal or treatment in both of these areas would require a significant engineering effort to address site conditions that would be beyond the scope of an ICM. For this reason, the proposed ICM will focus on source containment for the secondary source zone beneath the Vacuum Pump Room Floor that constitutes the primary threat to groundwater quality. The proposed source containment will consist of the extraction and treatment of groundwater to prevent plume migration. Groundwater extraction will be implemented as close to the secondary source zone as feasible.

4.4 GROUNDWATER TREATMENT TECHNOLOGIES

The presumptive remedy guidance lists the following treatment technologies for treatment of extracted VOC-contaminated groundwater:

- Air stripping
- Granular activated carbon (GAC)
- Chemical/UV oxidation
- Aerobic biological reactors

Berkeley Lab previously installed the Building 51 Motor Generator Room GAC system to treat extracted groundwater derived from the Building 51 drain system as part of an approved remedy under the RCRA Corrective Action Program (CAP). This treatment system is located relatively close to the Vacuum Pump Room area and has sufficient capacity to treat contaminated groundwater that would be extracted as part of the ICM. Therefore, the ICM will include plumbing of the proposed groundwater extraction wells to the Building 51 Motor Generator Room GAC system. Clean effluent from the system is either reinjected as part of the approved soil flushing remedy for the Building 51/64 Groundwater Solvent Plume, or discharged under permit to the sanitary sewer, depending on the water needs of the soil flushing system.

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5.0 DESCRIPTION OF PROPOSED INTERIM CORRECTIVE MEASURE

5.1 ICM OBJECTIVE

The objective of the ICM is to help control the downgradient migration of contaminated groundwater from the Vacuum Pump Room area into the clean backfill in the Air Duct shafts and Wind Tunnel. Downgradient migration of contaminated groundwater will be controlled by extracting groundwater from both the source area of the groundwater contamination and downgradient of the source area in the Air Duct backfill.

5.2 SYSTEM DESIGN

The ICM will comprise construction of an extraction well in the former Vacuum Pump Room area, extraction of groundwater from the new extraction well and existing observation well OC51-11-11, and treatment of the extracted groundwater at the existing Building 51 Motor Generator Room Treatment System.

5.2.1 Extraction Well

A 2-foot diameter groundwater extraction well (EW51VPR-12-1) will be drilled to a depth of 20 feet (approximately 10 feet beneath the Air Duct floor) inside the southern part of the former Vacuum Pump Room upgradient from the Air Duct shafts. Three contiguous 2-foot diameter borings will be drilled immediately adjacent to the extraction well and will be backfilled with drain rock to enhance the yield of the extraction well. The multiple large-diameter borings are required for groundwater extraction due to the low hydraulic conductivity of the artificial fill and bedrock beneath the former Vacuum Pump Room location.

The location of the proposed extraction well is shown on Figure 14 and Figure 15. The well will extract groundwater from the area where the maximum levels of soil and groundwater contamination were detected in well SB51-11-9 beneath the Vacuum Pump Room. SB51-11-9 will be overdrilled and removed as part of the groundwater extraction well installation process. A

schematic diagram of extraction well construction details is provided on Figure 16. Five-inch slotted PVC casing (15-foot screen and 5-foot riser) will be installed in the extraction well boring. The annulus of the extraction well will be backfilled with 3/4-inch (nominal) clean drain rock to an elevation approximately 1-foot above the screen. A 3-foot bentonite seal will be placed above the drain rock. The remainder of the annulus will be backfilled with a cement-bentonite grout seal. A submersible Grundfos pump equipped with level sensor switches will be installed for groundwater extraction. The other three borings will be backfilled with drain rock, bentonite, and grout to the same elevations as the extraction well.

In addition to extraction of groundwater from EW51VPR-12-1, a submersible Grundfos pump equipped with level sensor switches will be installed in the existing observation well OC51-11-1 to allow groundwater extraction. Construction details for OC51-11-1 are described below and shown on Figure 17:

1. Four-inch diameter Schedule 40 PVC casing (4 feet of screen and 8 feet of solid casing) was placed in a 2-foot deep sump that had previously been excavated beneath the Air Duct shaft floor. The sump had been installed to lower the water table in order to allow soil sampling in the Air Duct shaft.
2. The sump around the casing was filled with drain rock.
3. Filter fabric was wrapped around the screen portion of the casing that extended above the drain rock.
4. A 1.5-foot high containment berm was installed in the Air Duct shaft and the floor covered with drain rock to a depth of about 1.5 feet.
5. The Air Duct shafts were backfilled with clean soil and the soil compacted to 90 percent.

5.2.2 Piping

Copper piping will be installed to carry the water from the extraction locations to the existing Building 51 Motor Generator Room GAC Treatment System (Figure 14).

5.2.3 Treatment System

The Building 51 Motor Generator Room Treatment System consists of two 1000-pound GAC canisters installed in series to ensure that contamination will not be present at detectable concentrations in the post-treatment effluent. Ancillary equipment includes particulate filters;

pressure gauges; flow totalizers; flow control, pressure relief, and back flow control valves; sampling ports; and electric power controls. The treatment system treats water from a sump that was located in the Motor Generator Room Basement (the Building 51 MGR Basement Discharge Sump) and three existing groundwater extraction wells. The water in the discharge sump originates from a complex of hillside exterior relief wells/subdrains (to the east of the building) connected to the building's interior floor drainage system. Water in the discharge sump is directed by pumping with an automatic sump pump to the treatment system. The location of the system is shown on Figure 14 and a schematic diagram of water flow through the system is shown on Figure 18.

5.3 OPERATING STRATEGY

Groundwater will be pumped continuously from the submersible pump that will be installed in the groundwater extraction well described above. Groundwater will also be continuously pumped from observation well OC51-11-1, unless pumping groundwater from the extraction well in the former Vacuum Pump Room itself can lower the water table to the base of the backfill in the Air Duct shafts.

5.4 SHUTDOWN EVALUATION

The system will operate until DTSC approves a request to terminate operation. It is anticipated that this will not happen until an alternative remedial measure is implemented or it can be demonstrated that in the absence of system operation, the groundwater contamination will not migrate and contaminant concentrations in the groundwater will remain below risk-based levels.

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6.0 SYSTEM INSTALLATION AND OPERATION

6.1 PUBLIC INVOLVEMENT

Prior to DTSC making a final determination on the proposed ICM, DTSC will prepare a Fact Sheet/Public Notice, which will be distributed to interested parties on the site mailing list. The Fact Sheet will provide a description of the proposed ICM and will include an announcement of a period of at least 30 days for the public to review the document and provide comments to the DTSC. At the close of the comment period, DTSC will make a final decision after considering all comments. DTSC will then prepare a Responsiveness Summary, addressing comments, which will be placed in the administrative record.

6.2 PERMITTING

Well construction will comply with applicable requirements, including the DTSC Guidance manual for Groundwater Investigations (DTSC, 1994). Permits for well construction will be obtained from the City of Berkeley Toxics Management Division.

6.3 SOIL DISPOSAL

Soil samples will be collected from the soil generated from drilling of the extraction wells and other activities to determine the appropriate soil disposal alternatives. The soil will be analyzed for VOCs by EPA Method 8260 and any other analytes required by the prospective disposal facility for profiling purposes. Contaminated soil will be disposed of at a California Integrated Waste Management Board (CIWMB) permitted solid waste facility (landfill).

6.4 PERFORMANCE EVALUATION AND REPORTING

Within 60 days following completion of ICM construction, Berkeley Lab will submit an Interim Corrective Measures Completion Report to the DTSC. The report will include the following information:

- A summary of the nature of the threat.

- A description of the ICM as constructed, including as built drawings.
- Results of any operational testing and/or monitoring indicating the estimated effectiveness of the system.

Groundwater samples will be collected weekly (at a minimum) for eight weeks from the two extraction locations and then at least quarterly.. Samples will be analyzed for VOCs by EPA method 8260. All results will be reported in the Semiannual Progress Reports that are submitted to DTSC. Results available at the time of submission will be reported to the DTSC in the ICM Completion Report.

6.5 SCHEDULE

The schedule is contingent on the date of DTSC approval of the Workplan. Once approval is obtained, it is anticipated that it will require approximately 45 days to implement the ICM.

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MW51-96-16	Groundwater monitoring well
MW90-6	Properly destroyed monitoring well
T SB51-11-1	Temporary groundwater sampling point
T SB64-98-16	Properly destroyed sampling point
	Groundwater extraction well
	Soil boring
	Angled boring
	Membrane interface probe boring
	Groundwater extraction well
	Soil vapor sampling point
GAC	Groundwater treatment system

NOTES:
All other symbols used are explained on the figures.

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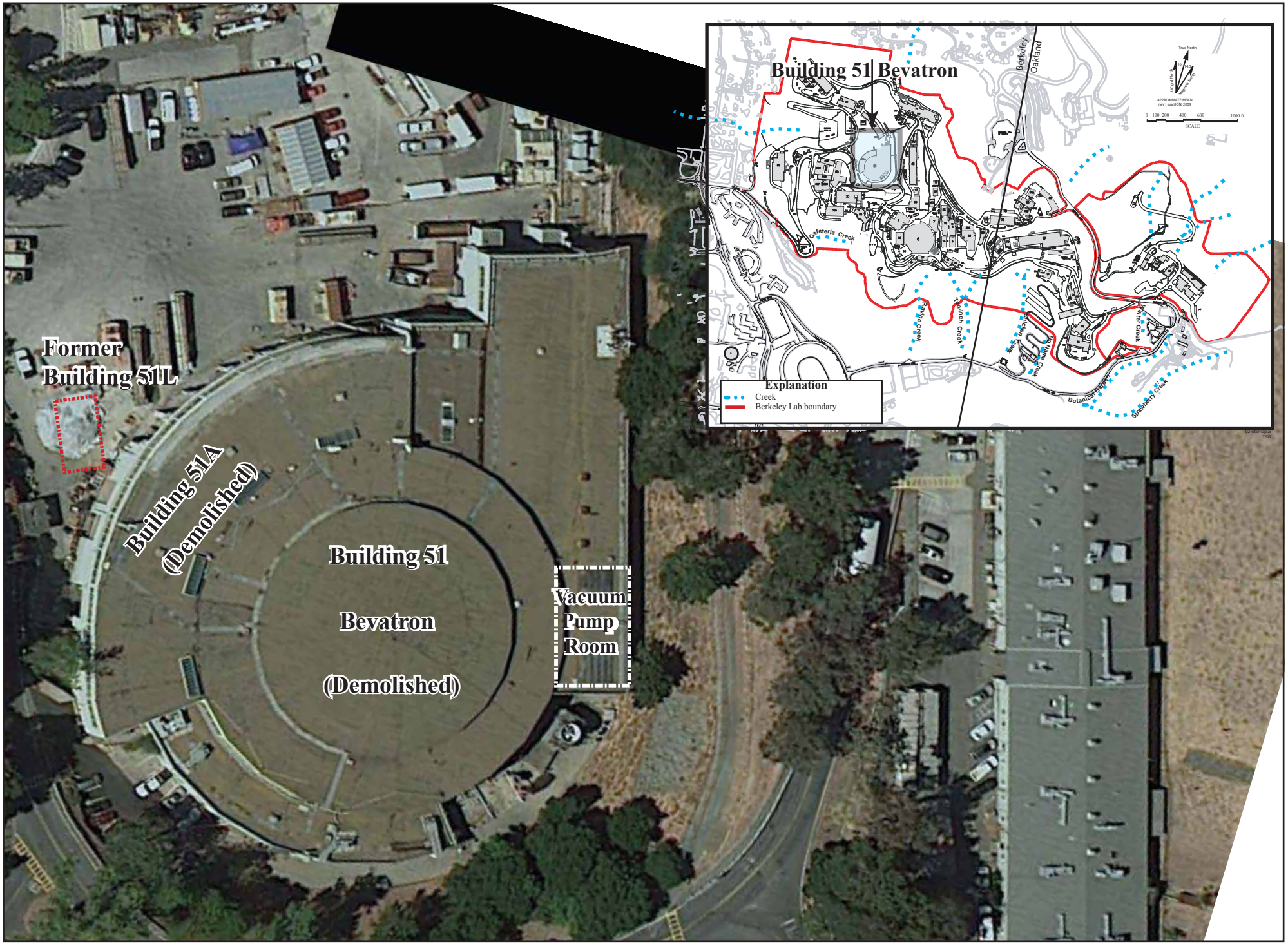
Key to Symbols Used on Figures.



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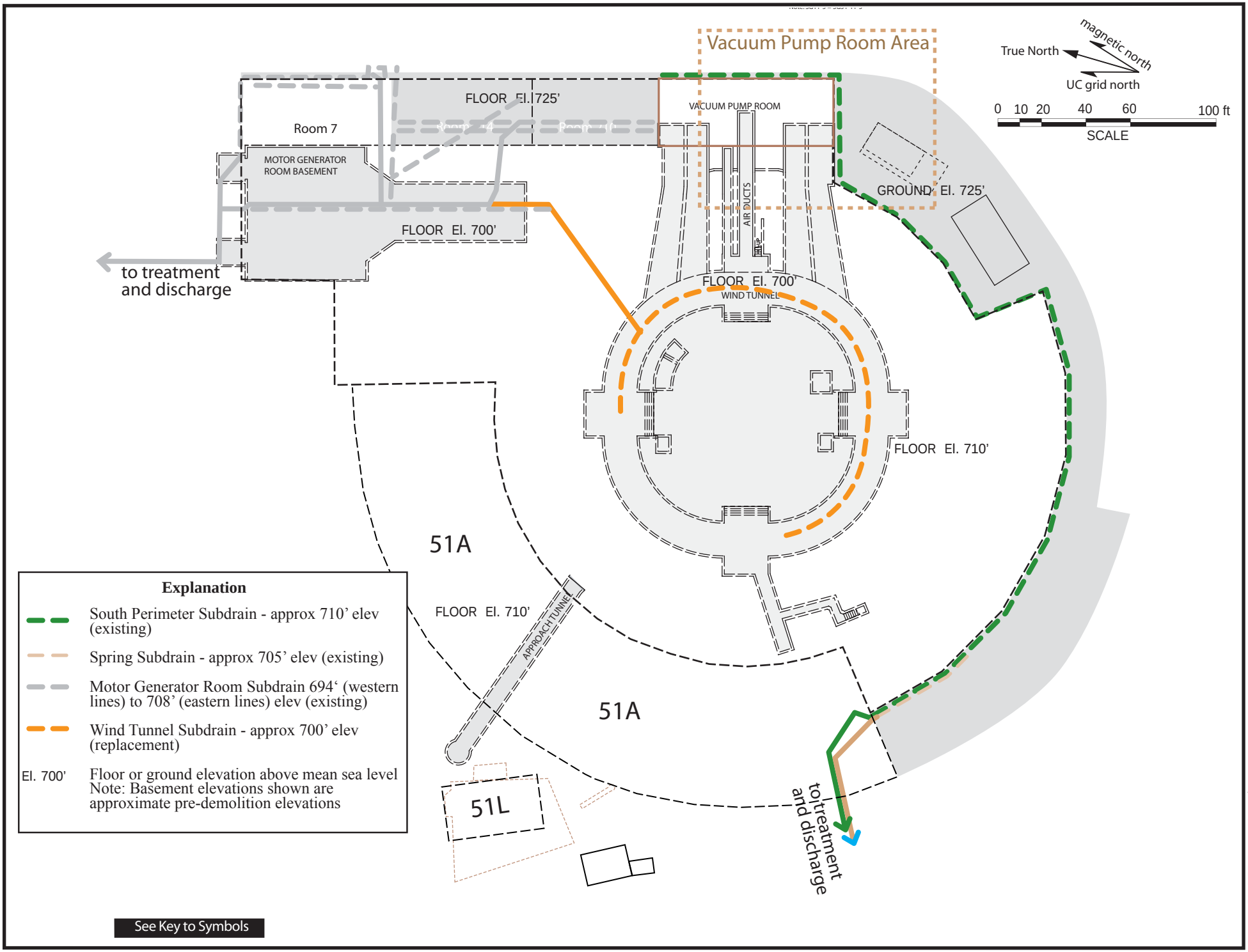

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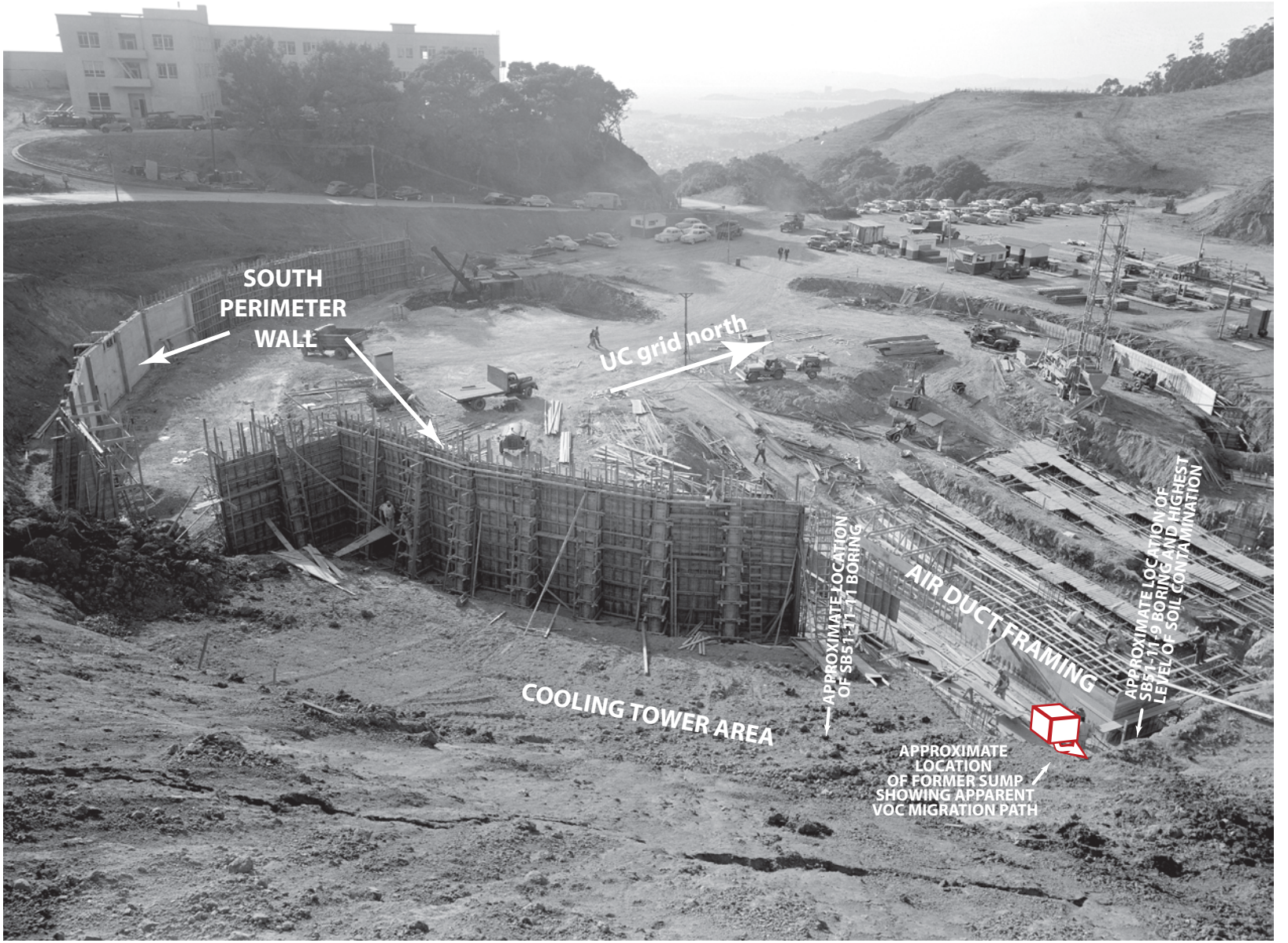

Figure 4. Bevatron Overview During Construction of Air Ducts and South Perimeter Wall.

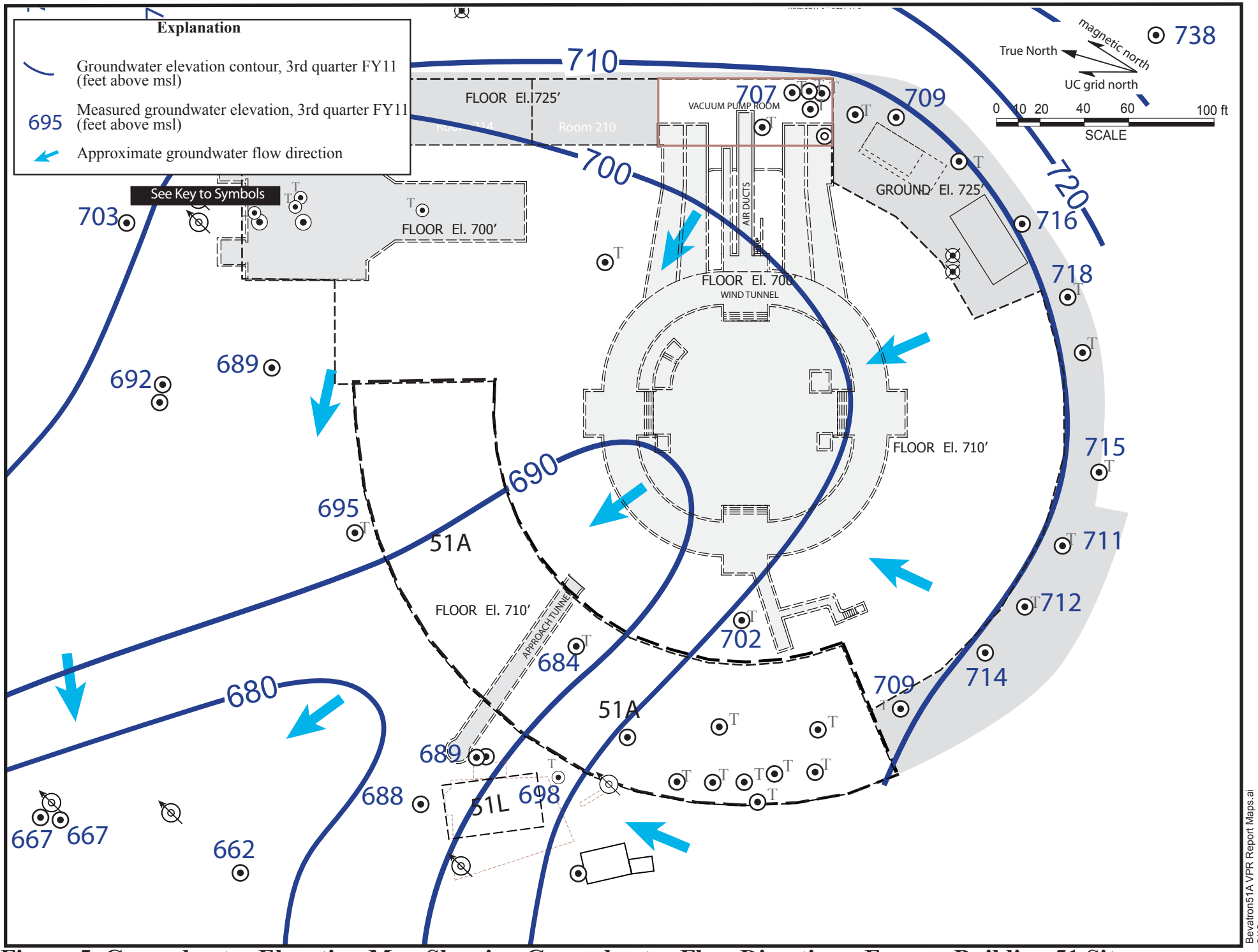

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Figure 5. Groundwater Elevation Map Showing Groundwater Flow Directions, Former Building 51 Site

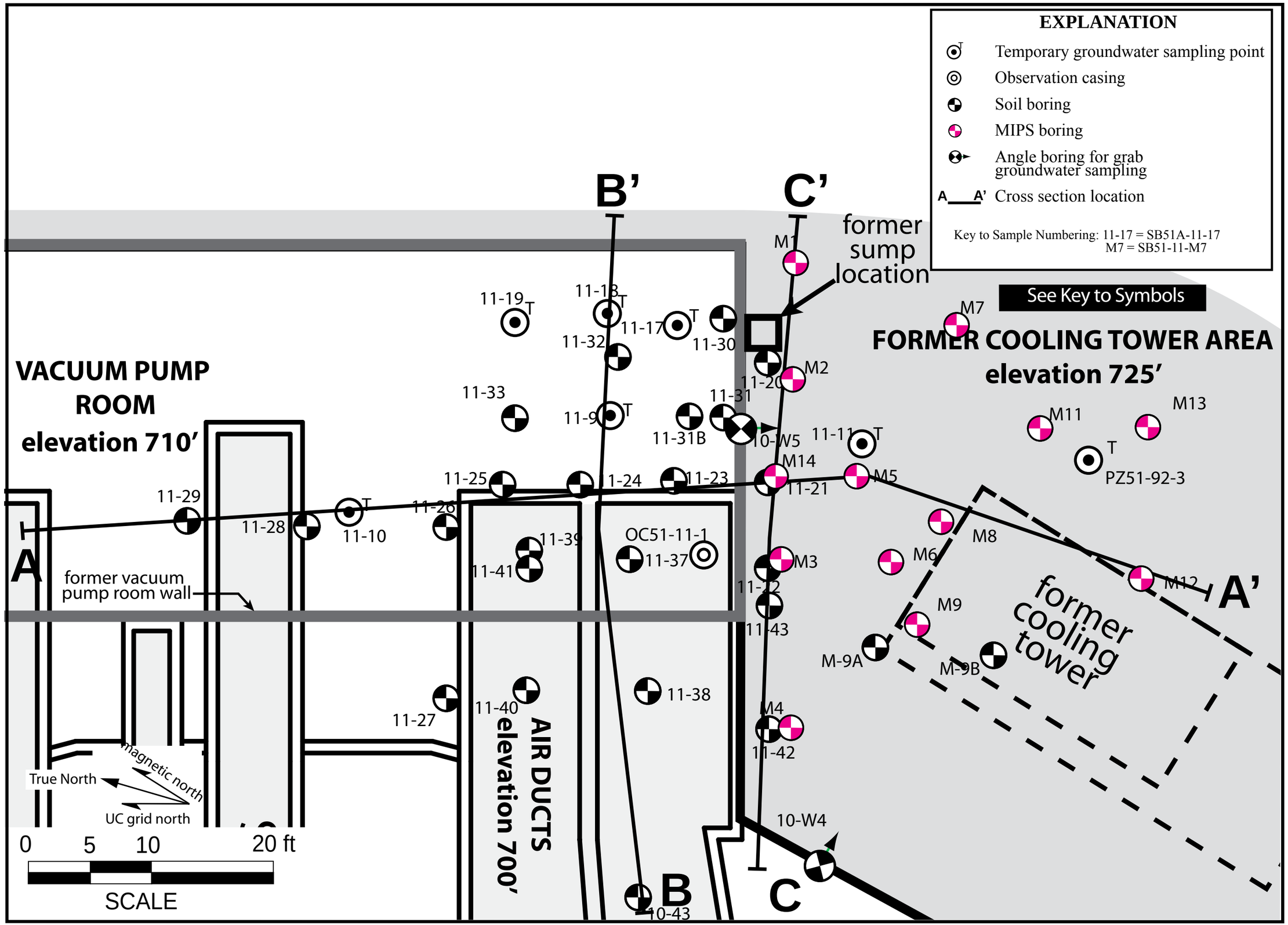
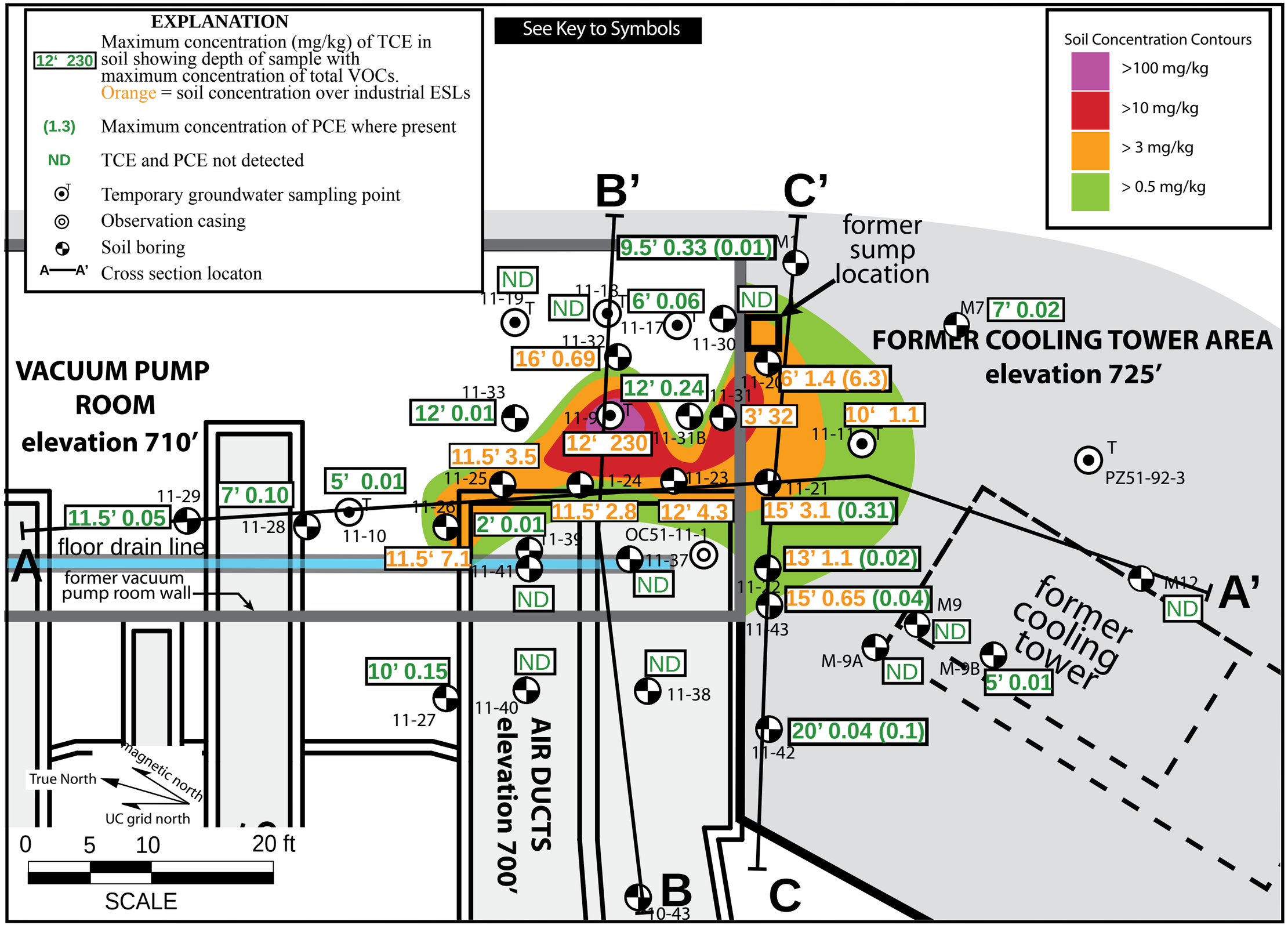


Figure 6. Boring, Well and Cross Section Location Map, Vacuum Pump Room Area.



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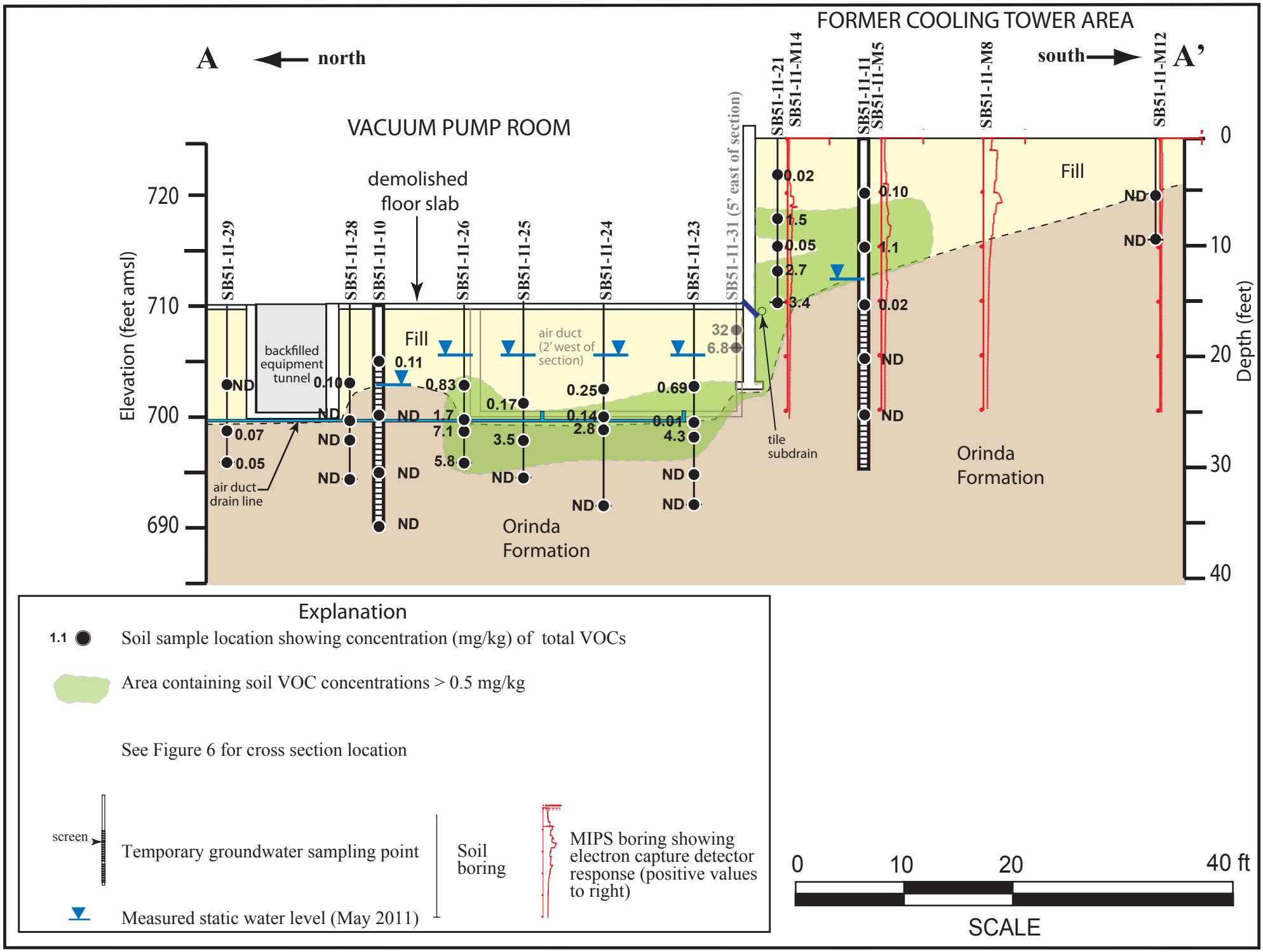

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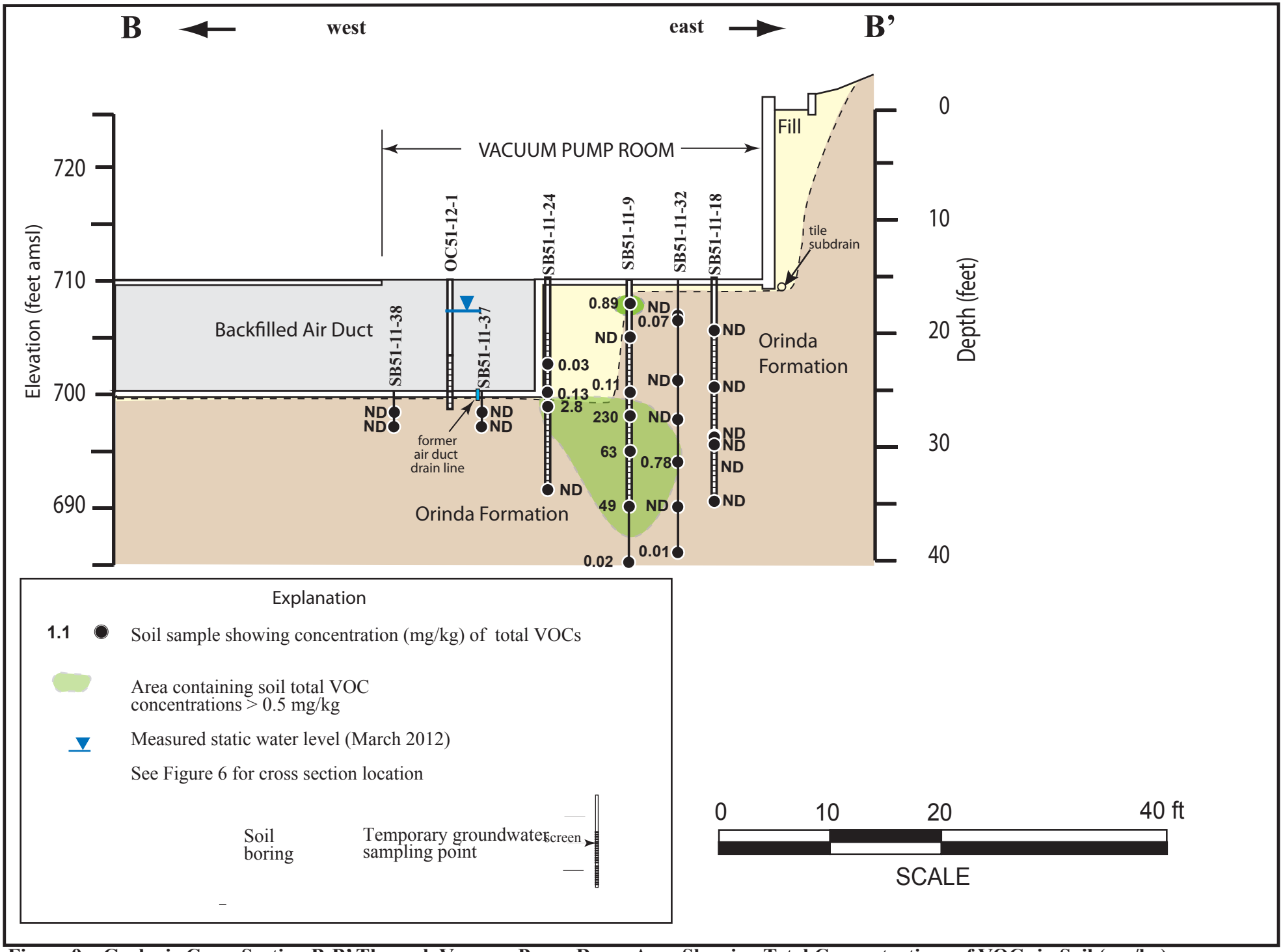


Figure 9. Geologic Cross Section B-B' Through Vacuum Pump Room Area Showing Total Concentrations of VOCs in Soil (mg/kg) and MIP ECD Responses.

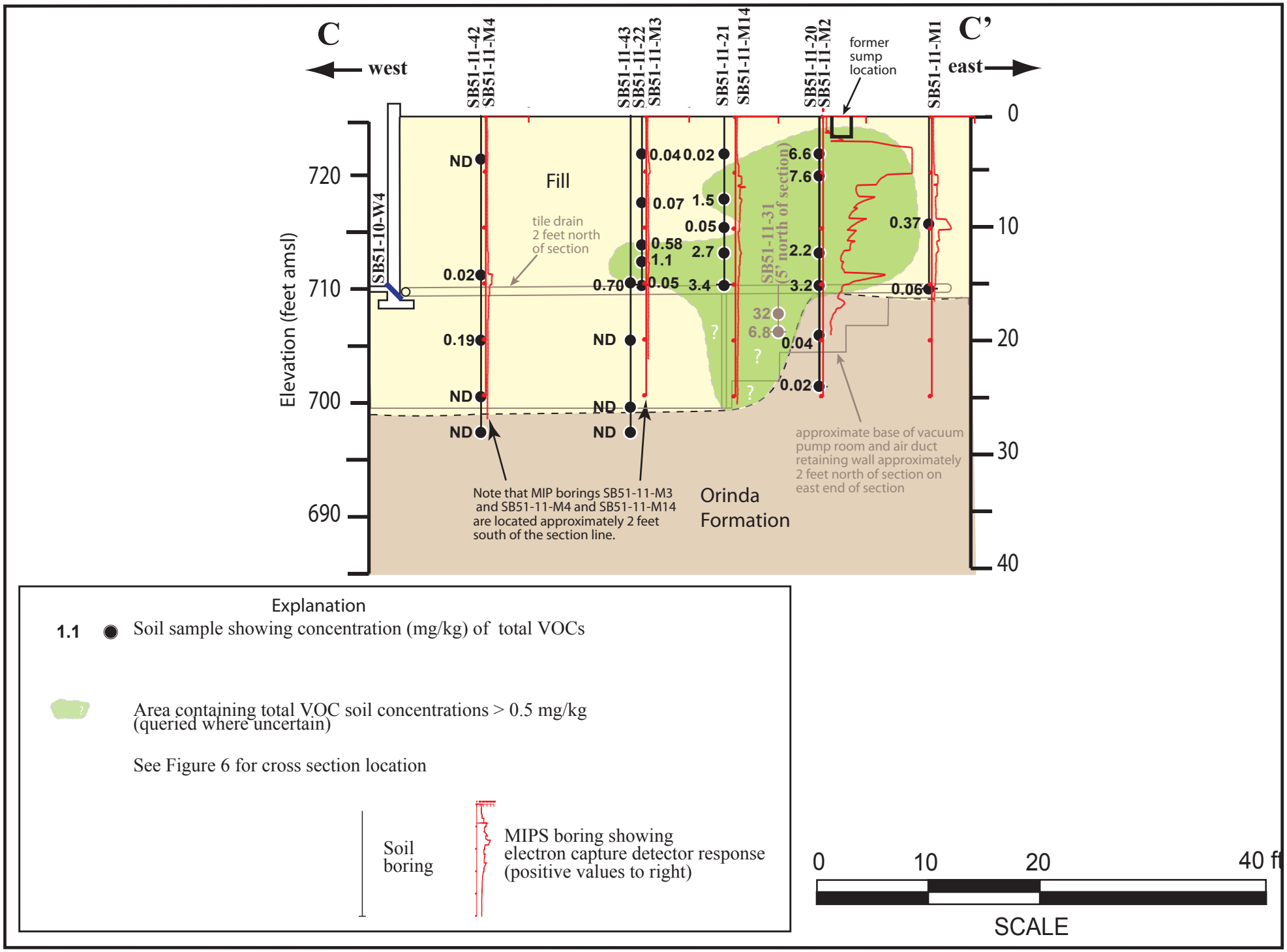
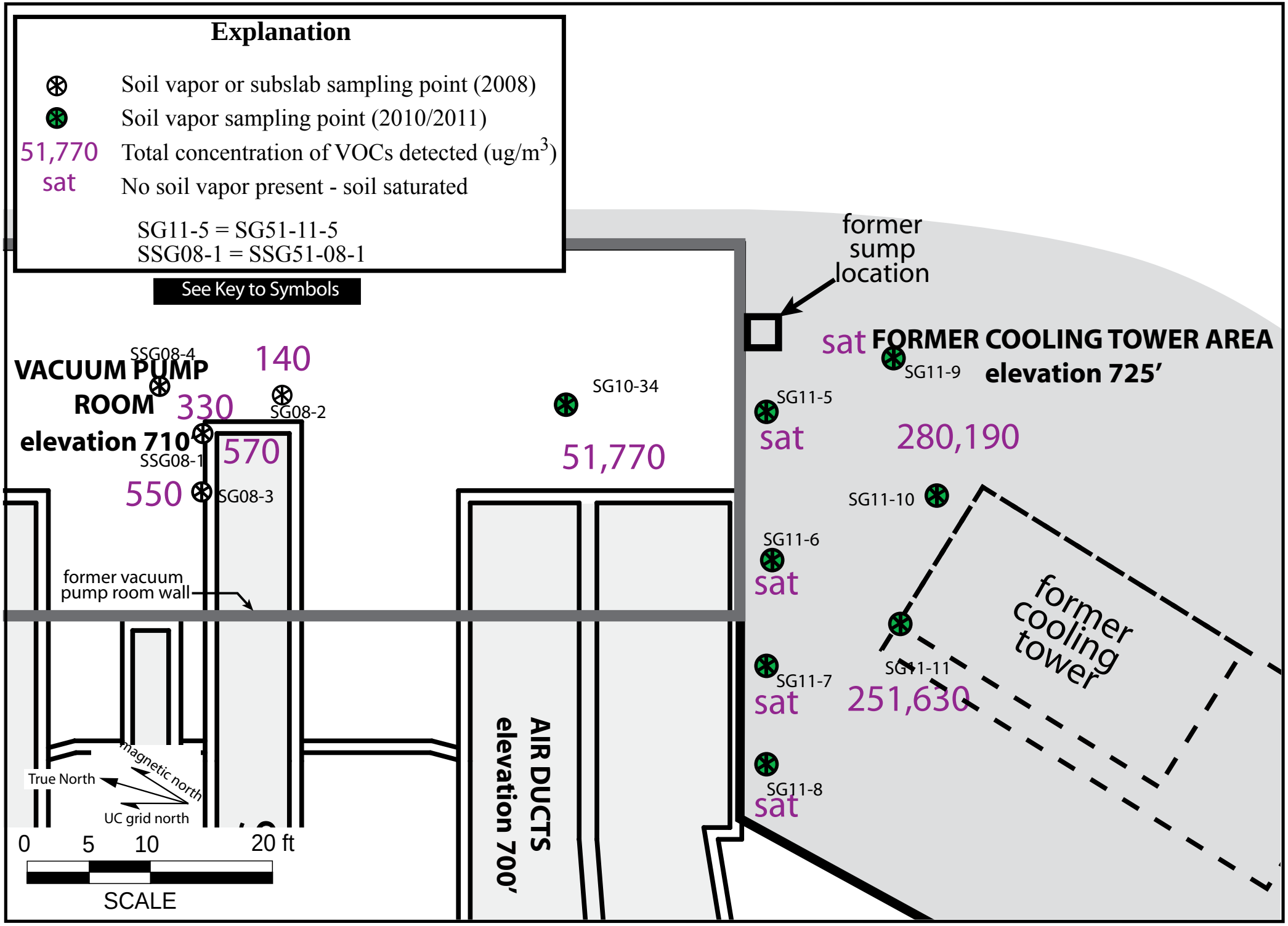


Figure 10. Geologic Cross Section C-C' Through Vacuum Pump Room Area Showing Total Concentrations of VOCs in Soil (mg/kg) and MIP ECD Responses.



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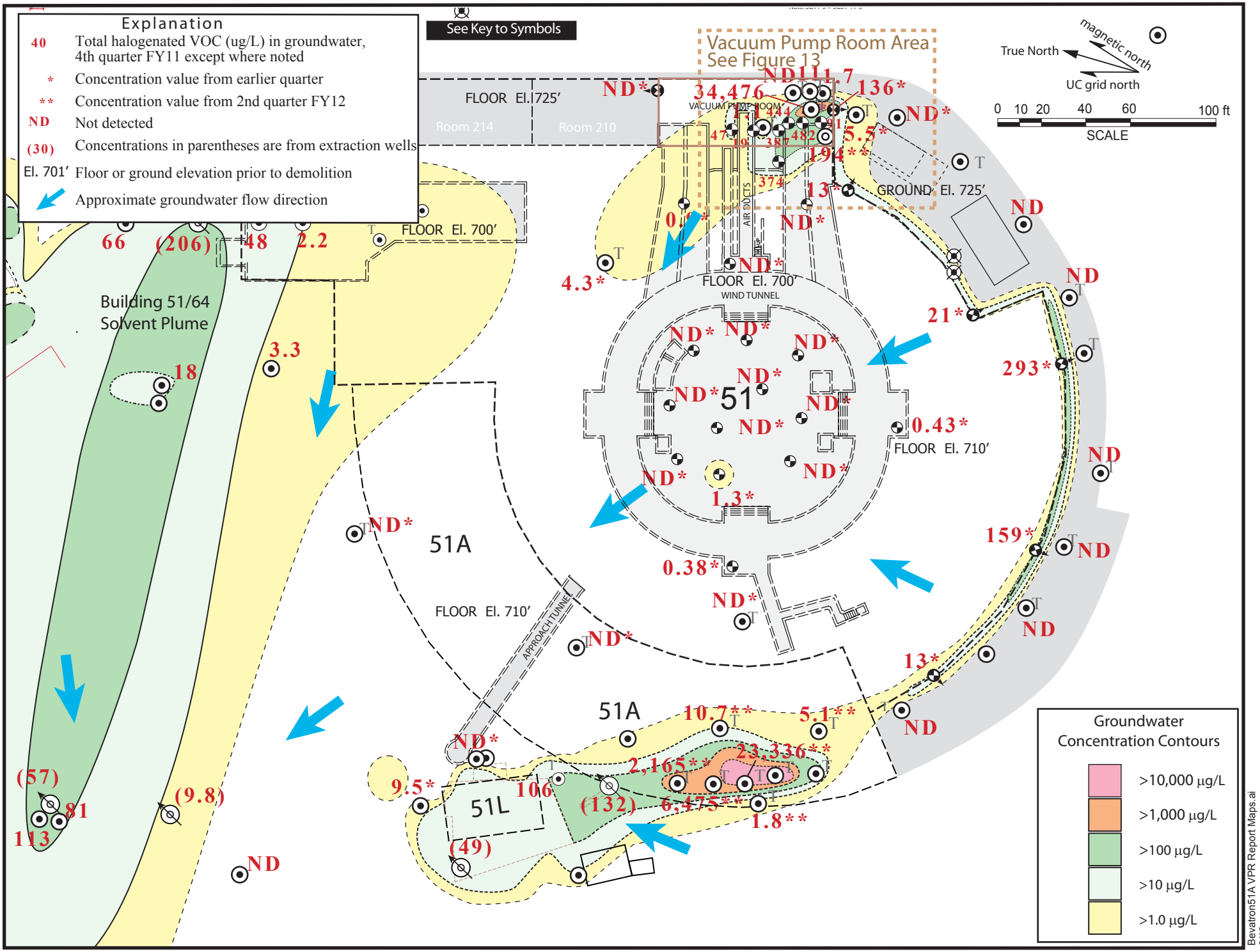

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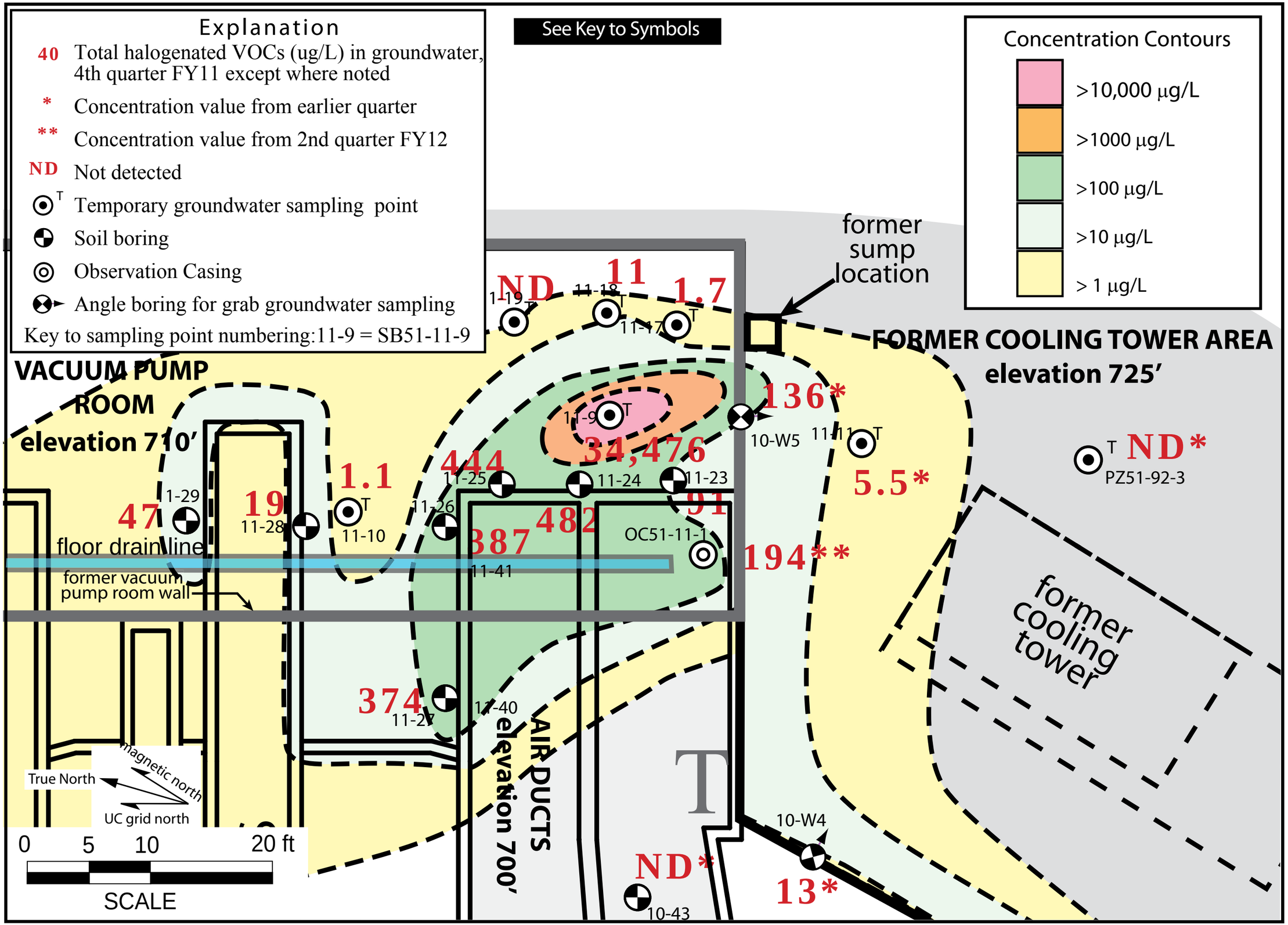

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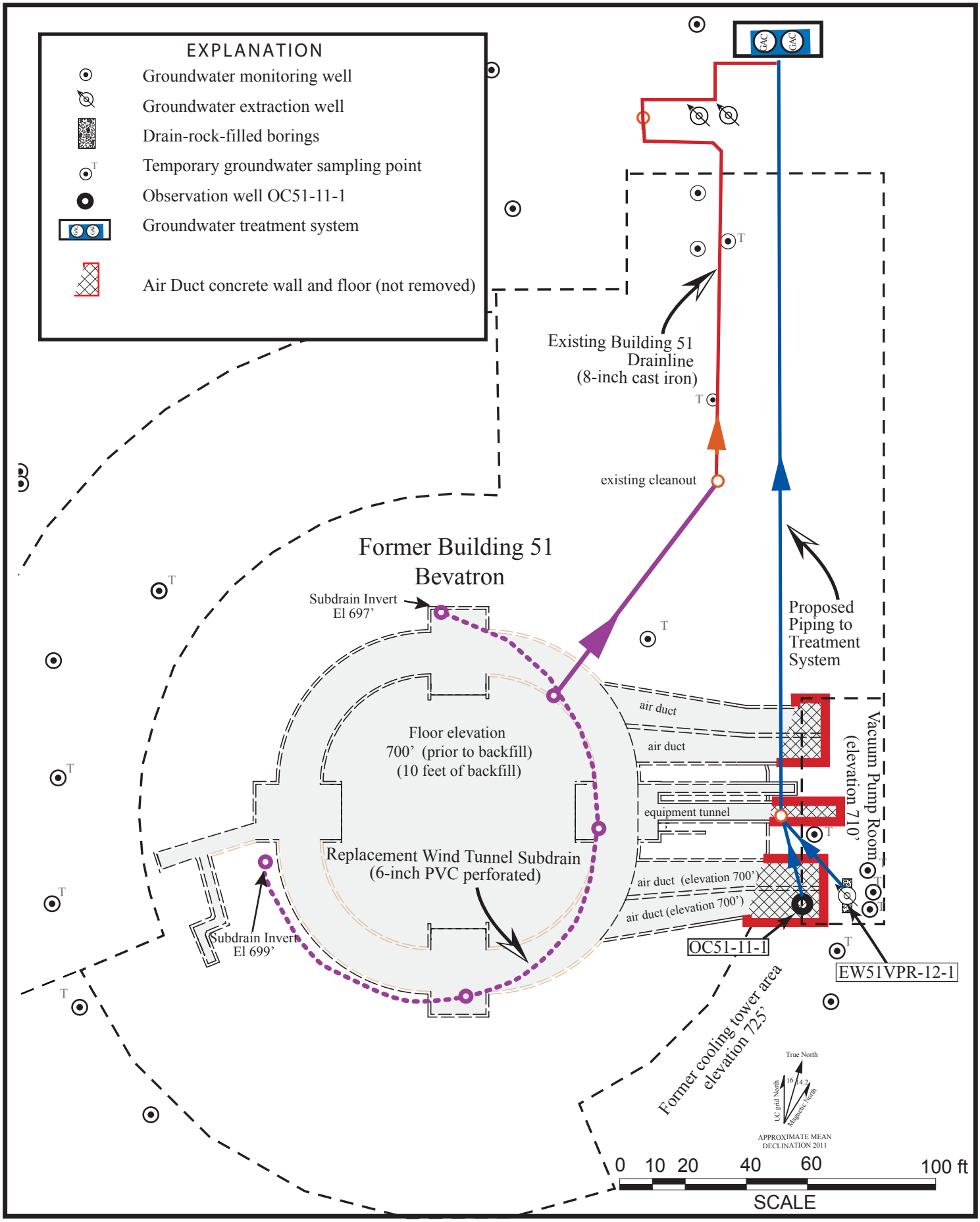

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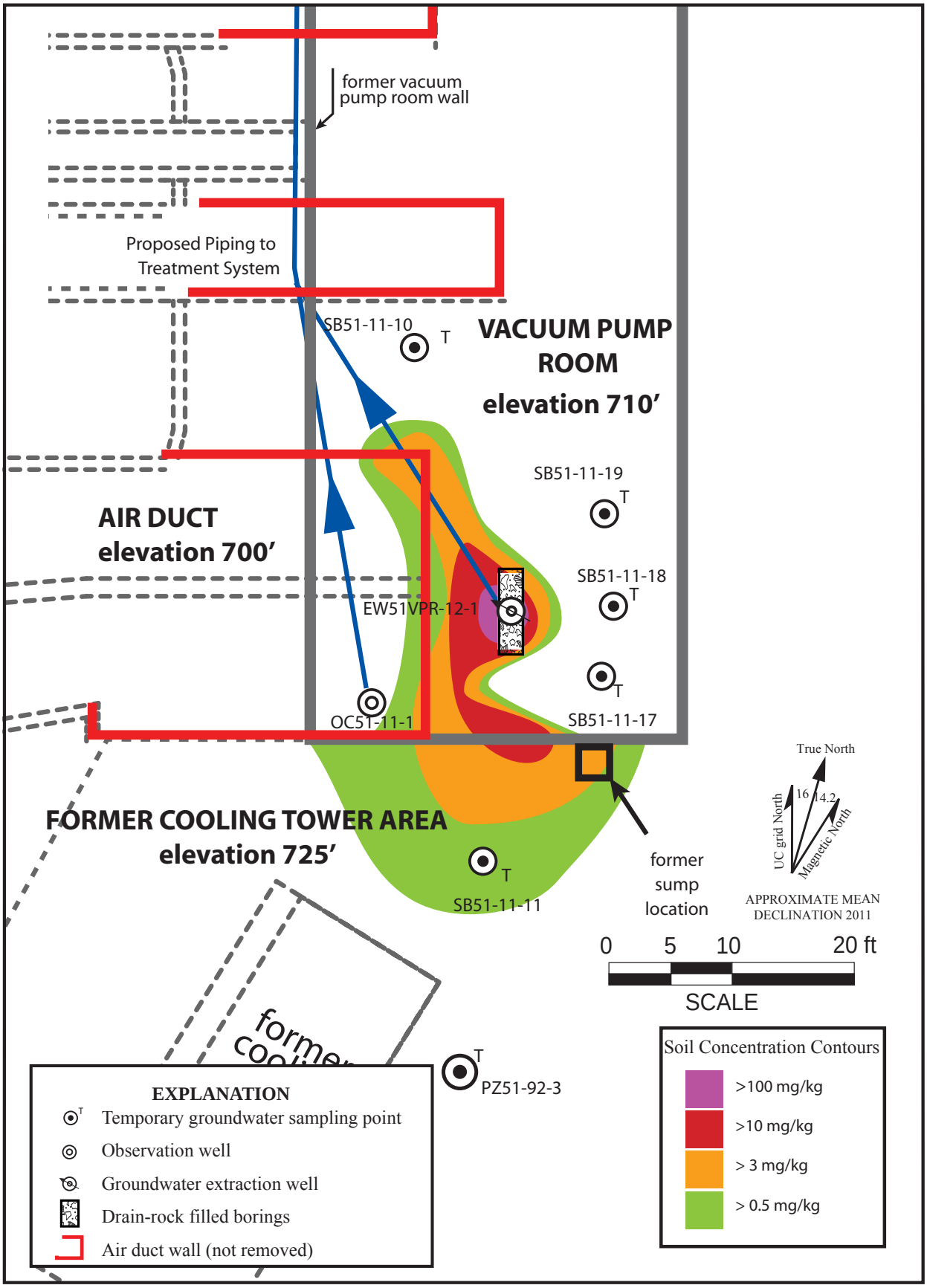
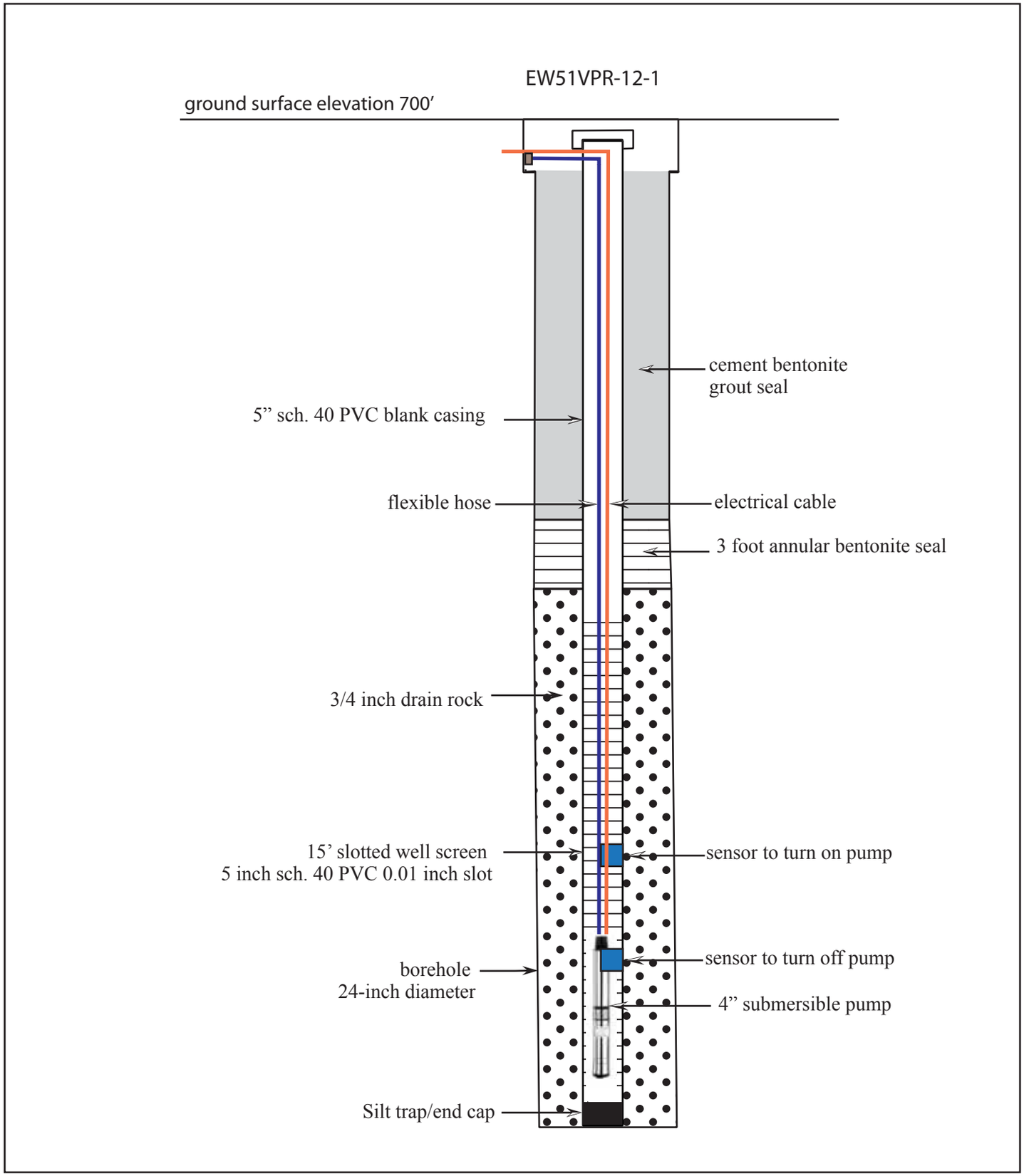


Figure 15. Location Map Showing Proposed Groundwater Extraction Wells.



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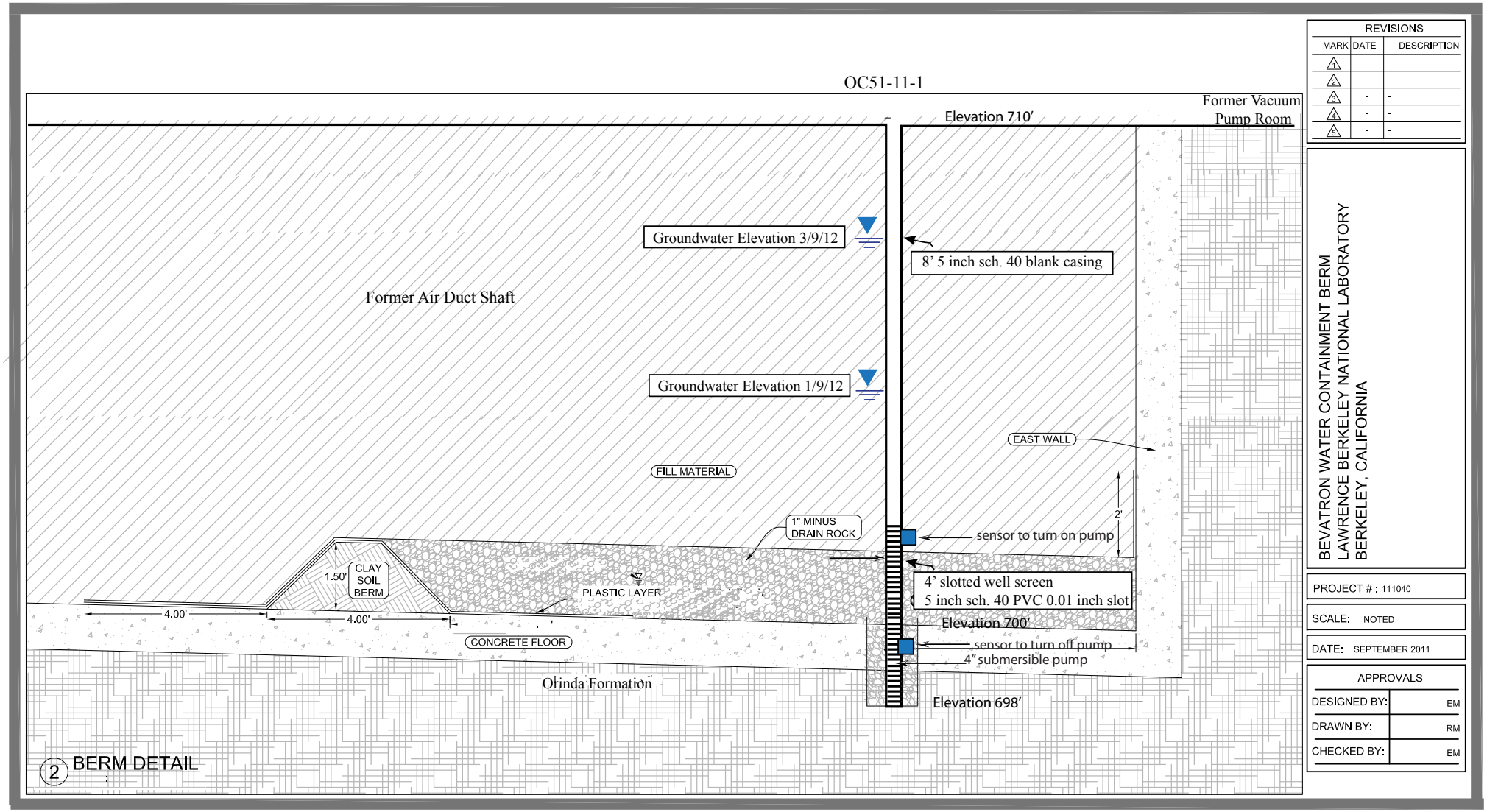

Figure 17. Construction Details for Observation Well OC51-11-1.

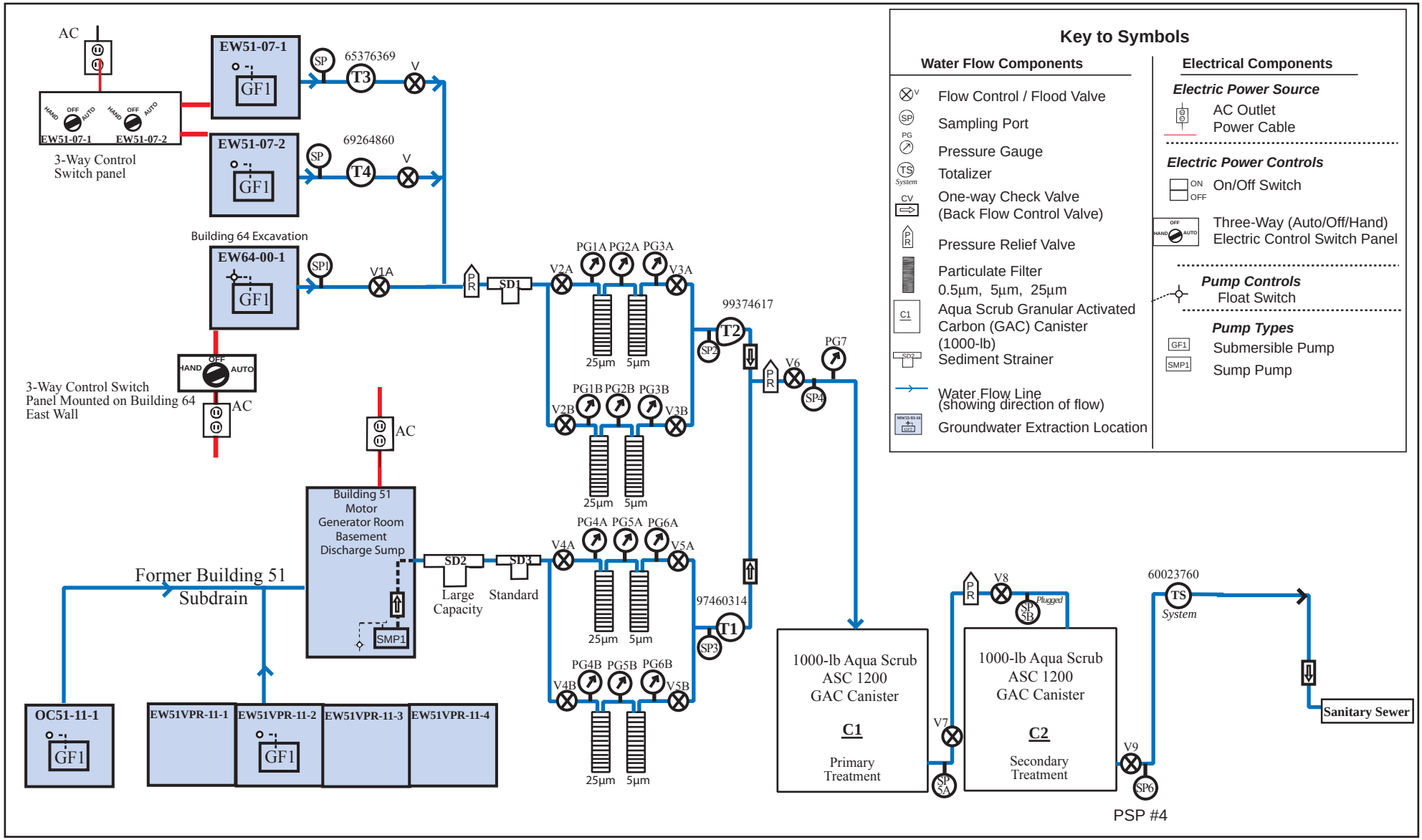

Figure 18. Schematic Diagram of Building 51 Motor Generator Room Basement Treatment System.