Former Landfill and Disposal Site Investigations

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This report was prepared by staff of the Department of Resources Recycling and Recovery (CalRecycle) to provide technical assistance to local governments and solid waste facility operations in investigating former landfills and disposal sites. If you require assistance in obtaining access to this report please contact the Office of Public Affairs at (916) 341-6300 or by e-mail at opa@calreycle.ca.gov.

Figure 1: Historical aerial photograph overlay in Google Earth of a former landfill in the City of Los Angeles; note geo-referencing grid

Abstract

Former landfills and disposal sites, particularly undocumented sites in developed areas, can pose several hazards to public health and safety. Explosive or oxygen-deficient conditions can be caused by landfill gas migrating through surrounding soils into building structures and utility corridors. Landfill settlement may cause unstable conditions for building foundations and utilities. The Closed, Illegal and Abandoned Site program at the Department of Resources Recycling and Recovery (CalRecycle) provides technical assistance to local public health officials in investigating former landfills and disposal sites. The CIA section has performed several "high-priority" landfill and disposal site investigations in developed areas of California including Los Angeles, Orange, and San Diego counties, the San Francisco Bay Area, and the Sacramento Valley. Several case studies are presented in this paper to illustrate how investigations were conducted to determine the approximate horizontal and vertical extents of former landfills and disposal sites using historical aerial photographs and mapping software; geophysical methods for non-intrusive delineation of waste extents; and finally intrusive investigation methods including drilling, direct-push, and trenching.

Key Words: *landfill investigation; waste extents delineation; historical aerial photograph review; Google Earth overlay tool; geophysical survey; intrusive investigation; non-intrusive investigation; drilling; trenching; direct-push; topographic drawing; sample location map; sampling and analysis plans; remedial work plans; and remedial cost estimates.*

Introduction

Former landfills and disposal sites can pose public health and safety threats to development occurring on or adjacent to these sites. Some of these threats include explosive or oxygen-deficient conditions caused by landfill gas migrating through soils into building structures and utilities; differential settlement of the disposal area causing instability in foundations and structures built over the fill; and human or wildlife exposure to potential chemical, biological, radiological and physical hazards of uncovered waste at the site. Landowners and developers may not be aware that a disposal site exists on their property and may purchase properties without understanding the risk posed by former disposal sites and the potential costs or liabilities to remedy these risks. California law holds the current landowner responsible for any threats or nuisance to public health and safety caused by former landfills and disposal sites.

California regulations (14 & 27 CCR) give authority to state and local agencies to enforce minimum standards for former landfills and disposal sites, where a threat to public health and safety exists. Some of these standards include covering and maintaining disposal areas to prevent public contact, and monitoring and controlling landfill gas migration to protect public health and safety from explosion hazards associated with landfill gas. Other standards may include securing sites to prevent trespassing and illegal disposal; controlling drainage and erosion of cover soils to prevent waste exposure and surface water infiltration into the disposal site. These standards are minimum standards designed to protect public health and safety from the contents of former landfills and disposal sites, which did not have federal and state final closure and financial assurance requirements until 1989, when state and federal regulations where established and which addressed final closure of landfills and disposal sites to protect public health and safety.

A well-planned and coordinated disposal site investigation is necessary to determine the scope of work and costs for potential actions taken to remedy site conditions. ***One of the most important objectives of any landfill investigation is to determine the horizontal and vertical extent of waste.*** Determining the physical extents of waste allows regulators, consultants, attorneys and responsible parties to:

- Determine properties impacted by the waste disposal area
- Study and consider different remedial options and their costs
- Estimate a volume of waste and determine costs to clean-close the disposal site
- Estimate the areal extent of the disposal site to determine soil-capping (cover) costs
- Locate perimeter gas monitoring wells to detect off-site gas migration

CalRecycle's Closed, Illegal and Abandoned Site program provides technical assistance to local environmental health departments in conducting investigations of former landfills and disposal sites to determine if a threat to public health and safety exists. The CIA program has conducted more than 30 investigations of "high-priority" former landfills and disposal sites in cities and counties throughout California including Los Angeles, San Diego, and Orange counties, the San Francisco Bay Area, and the Sacramento region. Two key objectives of these investigations were to: 1) determine the approximate horizontal and vertical extents of the disposal site and to 2) generally characterize the content of the fill as Resource Conservation and Recovery Act (RCRA) hazardous, California hazardous, or non-hazardous waste. The findings from the investigation are then used to determine potential costs for clean-closure and also for appropriate regulatory agency oversight.

Based on experience from conducting an investigation of the waste extents for a disposal site, the following approach is recommended:

- Obtain and review historical aerial photographs for the periods prior to disposal, during disposal and during development;
- Obtain and review historical operational records and documents, if any are available (as part of Phase I Office Investigation/Site Assessment effort);
- Import historical aerial photograph images into mapping software, e.g. Google Earth both to obtain geo-referencing and to check historical aerial photograph indications of disturbance and current property boundaries, structures and landmarks;
- Obtain and review affected assessor parcel maps;
- Obtain and review affected property's title history and ownership;
- Hire a consultant or surveyor to prepare a current topographic map of the disposal area and vicinity to document observations and findings;
- Prepare a sample location map to define the approximate limits of waste based on historical aerial photographs;
- Perform an on-site reconnaissance to determine any surface evidence of the disposal area (a magnetometer (metal detector) survey can be used during this reconnaissance);
- Hire a consultant to conduct a geophysical survey of the disposal site area and survey the suspected boundary determined by the historical aerial photograph analysis and the surface reconnaissance. Request that the geophysical consultant determine the most effective methods for determining horizontal and areal extent based on site conditions, e.g. physical properties of geology, development and the fill area;
- Update the topographic map with the results of the geophysical survey and delineate potential area(s) of disposal fill;
- Prepare and coordinate an intrusive investigation work plan that explores the horizontal and vertical extents of wastes using trenching, drilling or direct-push equipment;
- Conduct an intrusive investigation, performing sampling and analysis and documenting the results of exploration;
- Update the topographic drawing for the disposal area showing the waste boundary, property lines, structures and other investigation information collected during the intrusive investigation, e.g. security barriers, monitoring wells, existing remedial infrastructure (cover, gas monitoring and control systems, leachate collection systems, etc.); and
- Develop and prepare a final investigation report with field data that documents current site conditions and supports the basis for remedial alternatives and their costs.

Figure 2: Google Earth images showing former landfill in Southern California (right) developed into golf course and residential land-use (left).

Purpose of Landfill and Disposal Site Investigations

The purpose of performing landfill and disposal site investigations is to determine a site's conditions with respect to regulatory disposal site state minimum standards for the protection of public health and safety. An investigation should provide the necessary information and field data to develop work scopes and cost estimates for remedial measures needed to bring the site into compliance with state minimum standards, e.g. placement of a remedial cover, construction of drainage and erosion control measures, installation of a gas monitoring network or gas collection and control system, etc. U.S. EPA has published guidance that establishes investigation information requirements for presumptive remedies for CERCLA (Superfund) landfills (see: http://www.epa.gov/superfund/policy/remedy/presump/caps.htm).

In 1995, the California Integrated Waste Management Board (CIWMB) undertook an investigation and remediation project for the abandoned Sand City Dump in Monterey County, California, due to site conditions that represented public health and safety issues (exposed waste and burn ash eroding from the dump onto an adjacent sand bluff and public beach). The CIWMB (now CalRecycle) worked with the Monterey County Environmental Health Services, Monterey Peninsula Regional Park District, and Monterey Regional Waste Management District to investigate the site and propose a remediation to remove the exposed landfill materials and reconfigure and cover the disposal site to meet 50-year coastal erosion standards, Highway 1 view shed requirements, Caltrans and water district easement restrictions, local grading requirements, and storm water pollution prevention requirements. The investigation included a Phase I office investigation that included collection and summary of all previous investigation reports, and a CIWMB-directed field investigation which confirmed previous data (boring logs) on the horizontal and vertical extents of the disposal site. From the field data collected, a remedial work plan was developed that would reconfigure the disposal site to meet local and state requirements. A $1.1 million remediation project was completed in May 1996 included removing all waste from the bluff adjacent to the site, excavating a 120,000 cubic yard cell, placing and compacting more than 100,000 cubic yards of waste materials, and placing a 10-foot soil cap over the new cell. The final grading plans included the placement of a dune restoration project and regional bike trail (see: http://www.calrecycle.ca.gov/SWFacilities/cia/Remedial/WorkPlan/Example/SandCity/WorkPlan.htm)

Case Study: Sand City Dump Remediation Project

Figure 3: Photograph of Sand City dump before remediation; note front slope of dump toward public beach which contained rubbish, cans, glass and burned materials; photograph on the right shows completed final grades and wastes removed from front slope.

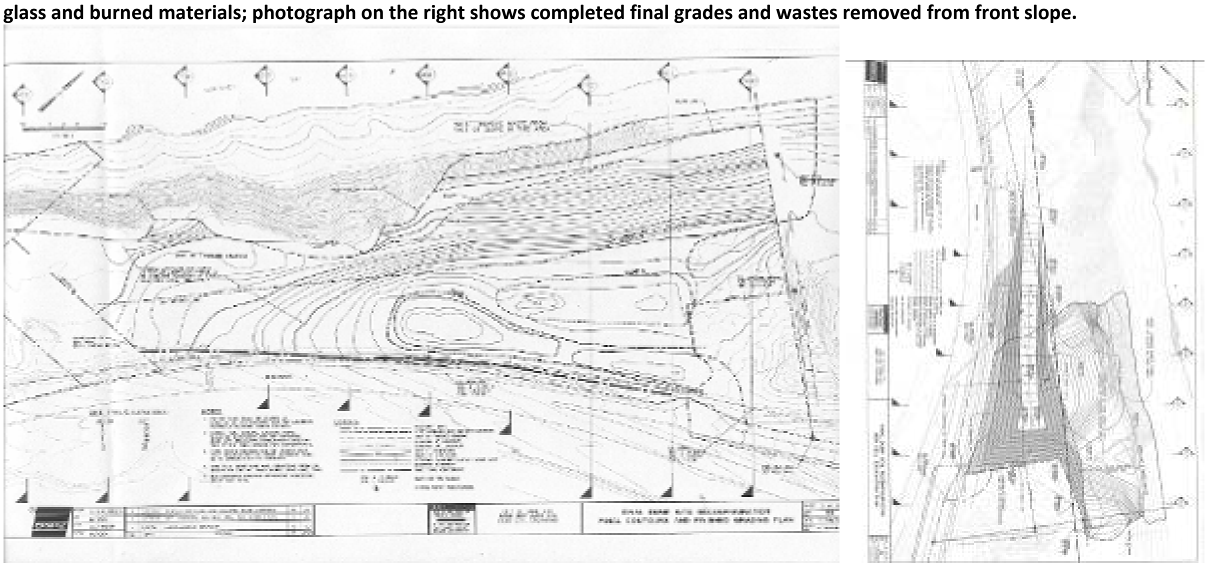


Figure 4: Final Grading Plan for a disposal site showing plan view of final topography; second drawing shows plan view of proposed waste cell to hold all reconfigured waste behind a 50-year coastal erosion set-back.

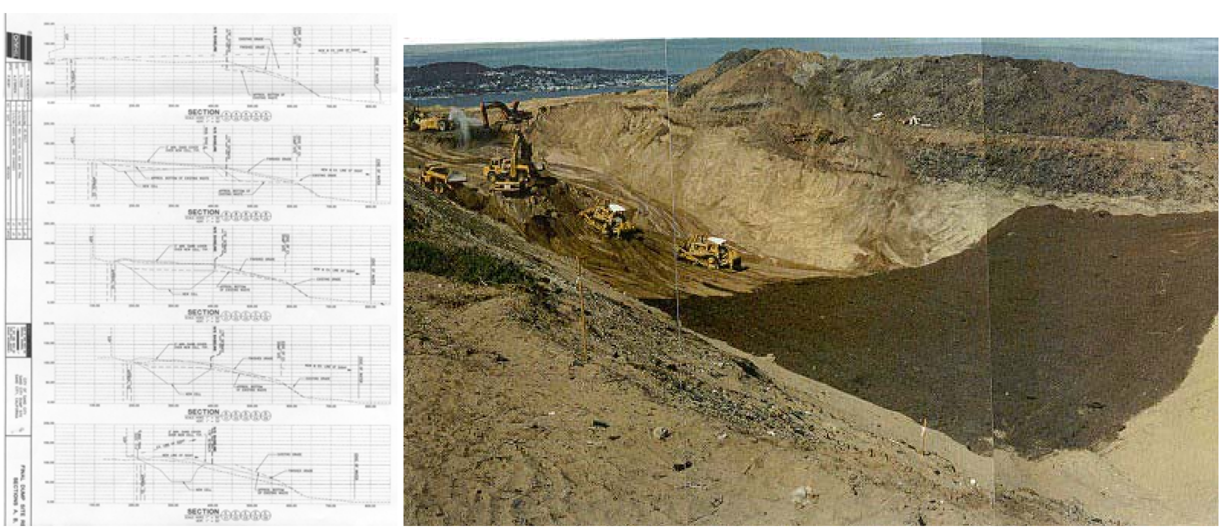


Figure 5: Cross-sections of existing waste fill and reconfigured waste cell; at right, photo shows waste placement into constructed cell.

Phase I Investigation

Performing a well-planned and coordinated phase I office investigation for a former landfill or disposal site can reduce the scope of work for the phase II field investigation. A Phase I Office investigation should include obtaining:

- Property ownership information to include the assessor parcel number(s), parcel maps, and property deeds or titles from properties where disposal activities occurred (this may be an iterative process if the boundary of waste is unknown)
- Title search for former property owners
- Previous site investigation reports (Air and Water Solid Waste Assessment Tests [SWAT], Report of Waste Discharge Requirements [WDR], Environmental Site Assessments [ESA], site characterization reports, water well testing, geotechnical testing, soils testing, etc.)
- File reviews from local government agencies with responsibility for land-use and disposal activities, e.g. health department, public works, planning, sanitation district, etc.
- Any operator historical design drawings or operational records, if any exist
- Historical aerial photographs for years prior to, during, and after disposal site operations/activities
- Interviews with property owners and local government agencies (environmental health department, fire department, water board, air district, solid waste management authorities and/or districts, public works departments, etc.)

All information collected from the Phase I investigation should be organized, documented, and summarized in a report (or included in the Phase II field investigation work plan); the Phase I report information should support the data quality objectives (purpose) of the Phase II field investigation. The Closed, Illegal and Abandoned (CIA) Sites Program generally incorporate the Phase I office investigation information into the back ground portion of the Phase II field investigation work plan. Additional information and online resources for Phase I office investigations can be found at: http://www.calrecycle.ca.gov/SWFacilities/CIA/Office/default.htm

Historical Aerial Photograph Study

The objective of reviewing historical aerial photos is to develop and document a "maximum" boundary of study for disposal site operations and activities. The "maximum" boundary represents the greatest areal extent of the disposal operation or activity for subsequent field investigation methods using geophysical survey methods and intrusive investigation methods such as drilling, direct-push, or trenching exploration.

Obtaining, reviewing, and analyzing historical aerial photographs during a landfill investigation or Phase I site assessment study is one of the most important and cost-effective methods for determining the approximate areal (or horizontal) extents of a disposal site operation and can reduce the scope of work for intrusive field investigation work, e.g. using intrusive investigation to close boundary data gaps. A comprehensive and chronologically indexed collection of historical aerial photographs for many developed areas of California beginning as early as the 1920s can be found in state university libraries such as UC Santa Cruz, UC Santa Barbara, UC Berkeley, Cal State Fullerton, etc. The UC library system can provide aerial photographs for specified locations, dates and resolutions. Aerial photographs can be ordered and purchased as hard copies and scanned digital copies for a nominal cost, (10 scanned images for $300-$500). Resolution of historical aerial photographs for performing an overlay analysis in Google Earth should be one meter resolution (1 meter object visible on the ground). Higher resolution aerial photographs generally can be obtained from National Aerial Photography Program (NAPP). Most black-and-white historical aerial photographs shot from the 1920s-1980s for mapping purposes (1:40,000 scale) generally will have a high enough resolution to identify ground features.

The United States Geological Survey (USGS) is also a good source for historic aerial photographs. Private historical aerial photograph collections may be more expensive, but may yield important information or higher resolution photographs for specific years of operations. Aerial photography services may also have historical collections; however, the location, dates, and resolution may be limited. Cartwright Aerial, Inc., a Sacramento based aerial photography services business, has a comprehensive collection of historical aerial photographs for the entire state of California.

Web-based online resources, such HistoricAerials.com, allow historical aerials to be researched using interactive mapping software that can reduce the time and effort of manual searches of historical aerials photographs typically found in libraries.

Prior to obtaining aerial photographs, research should provide the years of operations for a disposal site and defining the start and end dates of disposal activities. In researching site history it is also important to define the time frames for development on or adjacent to the site. If no historical information is available for dates of operation, begin the search in the 1920s and review photographs every 5 years. This may yield approximate dates for significant disposal site operation; however some disposal sites may have operated less than five years.

In reviewing historical aerial photographs, visual evidence of disposal areas may include land disturbance, grading and scarification, open excavations (pits and trenches), visible surface debris (piles of rubble [such as concrete and asphalt], tires or litter, soil and waste stockpiles, windrowing, etc.), heavy equipment, etc. Most often these features are delineated by shadows and discoloration from surrounding areas (depending on lighting conditions). Historical aerial photograph reviews should also be checked for current landmark features such as roads, trees, waterways, and building structures as location references. This is important when importing unscaled aerial photograph digital images into mapping software, such as Google Earth, and using the overlay function to scale the image to the current view. Once the image is adjusted to the correct scale being viewed; features in the image, such as the boundary areas of the waste can be located by latitude and longitude (known as "georeferencing").

Figure 6: Historical aerial photograph of former landfill (gravel mining pit) overlaid (left photo) on recent color aerial photograph (right photo) in Google Earth. By using the opaqueness function in Google Earth the historical aerial can be manually scaled to coincide with the existing site features (requires that a common landmark feature, e.g. building, street, exists between the historical aerial and the current site conditions). By using the latitude and longitude grid as a reference, historical features can be located with respect to existing features, e.g. streets, structures and landmarks and compared to former disposal site features. In the above left historical photograph, the gravel pit boundaries can be located with respect to the existing commercial structures in the photograph at right.

Once the historical aerial photograph review and analysis has been performed, a scaled topographic engineering drawing should be prepared in AutoCAD or other engineering drawing program that will allow notes and other field information to be added to develop a scaled drawing depicting the boundary of the disposal area (s). This drawing can be used to develop remedial work scopes and estimates, e.g. capping and grading, drainage and erosion control improvements, locating gas monitoring network wells, etc. and eventually be included as an exhibit in work plans and bid documents.

Using Google Earth to Analyze Historical Aerial Photographs (and the Overlay Image tool)

Google Earth is a powerful online digital 3-D cartographic model that allows aerial photographs of the earth's surface to be geo-referenced, e.g. referenced to latitude and longitude. The Google Earth program can be used to perform a variety of cartographic analysis, such as mapping, land surveying, and locating GPS coordinates.

In using Google Earth to locate and map former landfills and disposal sites, the Google Earth image overlay tool allows an un-scaled image, such as a historical aerial photograph to be imported, placed, and manually scaled over the current Google Earth aerial image. By using a "transparency" (or opaqueness) function, a user can locate features from the historical aerial photograph, such as land disturbances, excavations, or other benchmarks on the Google aerial photograph, which reflect current land uses.

Once the historical aerial image (generally a .jpg or .bmp file) is imported, overlaid and scaled to the Google Earth aerial map, the opaqueness tool (slide-bar) can be used to compare historical and current features. The primary information to be collected from this analysis is the approximate horizontal extent of the disposal area and the parcels and properties affected. A parcel map can be imported and overlaid on the Google Earth Map to show the location of any structures on or adjacent to disposal areas. Additional information that can be useful includes pit and excavation boundaries, land-scarification and disturbances, former drainage features, waterways, and other topographic features. These features may provide an explanation or understanding of gas migration pathways, water intrusion/moisture conditions, and provide the basis for field investigation objectives or locating intrusive sampling points. This "interference" analysis can be useful in siting initial locations for landfill gas monitoring wells in native soils outside the landfill or disposal site boundary (requirement of 27 CCR 20925).

Figure 7: Left Photo is Former Landfill (Gravel Mining Pit); Right Photo is Current Residential and Golf Course Land-use in Los Angeles, CA

Site Investigation Map Development

A site investigation map can be developed from a USGS topographic map and an aerial photograph. A site investigation map will be used to document former landfill boundaries, current land uses and property ownership, environmental monitoring points, drainage features, topography, and other notes important to the site investigation or documenting a site's conditions with respect to disposal site minimum standards.

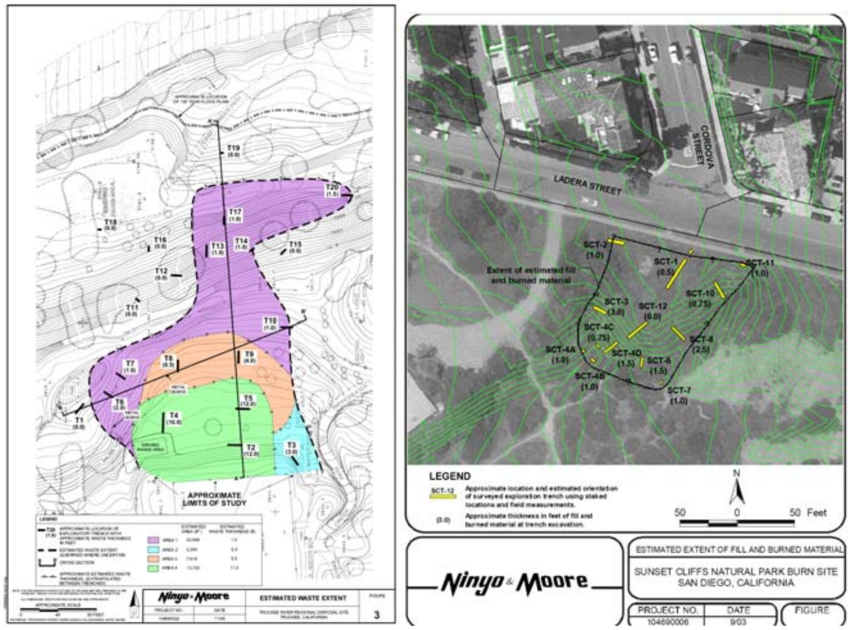


Figure 8: Trench Location Map Showing Exploration Trenches based on Historical Aerial Photo & Geophysical Survey Data

As an investigation transitions from an office investigation to a field investigation, an aerial survey should be flown to photograph the site and a ground survey should be performed to develop a scaled topographic map in AutoCAD format. If the site had been “flown” recently for other purposes, e.g. mapping or ground survey) and the aerial photograph is suitable for development of a topographic site map, this may reduce the cost of developing the topographic map in AutoCAD. Generally a topographic map can be developed for a cost of between $5,000 and $10,000 (depending of complexity of site and ground survey required). This is a critical cost work element in an investigation that will provide the basis for scoping, feasibility analysis, and estimating cost for different remedial options for the disposal site.

If possible, a topographic map of the site prior to disposal site operations should be obtained, especially if it suspected that the site was excavated (mining pits) or topographic depressions (canyons and ravines) were filled. The pre-disposal site topographic map data can then be transposed into an AutoCAD file format; this will allow a “fill area” map to be generated from AutoCAD software (Civil 3D) that can analyze and compare topographic data, e.g. for a “cut and fill analysis” or produce a bank (or in-place) volume estimate. The resulting topographic map may then be used to plan, locate, and depict the following information:

- Sample/trench/direct push/drill exploration locations
- Geophysical survey limits and sections
- Property boundaries
- Waste area boundaries
- Cover boundary & thickness
- Topographic relief & elevations
- Surface water/drainage patterns
- Gas monitoring well locations
- Groundwater monitoring well locations
- Gas control system (blower/flare station, well-field, header)

- o Structures & utilities
- o Site access roads
- o Continuous monitoring system sensor and controller layout

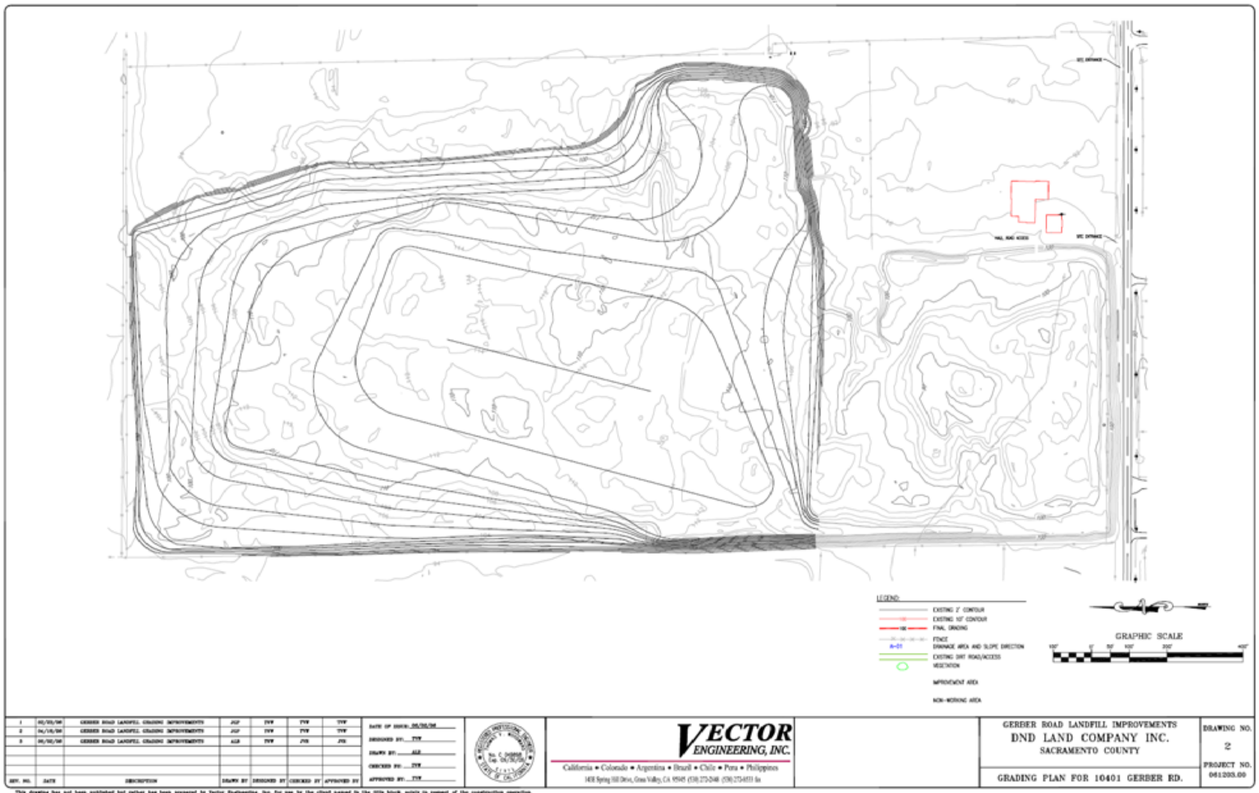


Figure 9: Final grading plan for capping a former landfill.

Typical Specifications for Topographic Maps:

- Aerial photograph resolution: 1 meter resolution
- Engineering drawing program: AutoCAD format (.dwg files)
- Ground contour intervals (elevation): 2 ft change in elevation
- Engineering drawing scale (standard 24 in x 36 in drawing size): 1 inch = (50-200 feet depending on size of site, e.g. 10 acre site, 1 inch = 50 feet, 60 acre site 1 = 200 feet)
- Specified information on drawing: elevation contours, drainage features, cover thickness, waste boundaries, sample locations, drilling and trenching locations, environmental monitoring points (wells), structures, property boundary, fencing or barriers, waterways, access roads, other notes significant to disposal area concerns (daylighting of waste, surface debris locations, etc.)

Using Geophysical Surveys to Estimate Waste Boundaries

Once a historical aerial photograph analysis has been performed and a topographic map in AutoCAD developed, a geophysical survey of the disposal site and surrounding areas should be performed to develop subsurface cross-sections that can be used to develop intrusive investigation (drilling, trenching, or direct push) locations and depths to sample and delineate horizontal and vertical boundaries between native and fill materials. Various geophysical survey methods may be employed based on site conditions; the following summary provides conditions under which different methods may be employed to optimize results.

Figure 10: Using Trimble GPS surveying equipment to locate geophysical survey results, left; resistivity survey on a burn dump in San Diego County, right.

Types of Geophysical Survey Methods:

- Resistivity Survey – good for “sectional profiles” and deep fills (>30 feet) for disposal sites where the disposal fill material’s electrical resistance/conductance is significantly different than surrounding geologic formations and deposits. Resistivity surveys may have limited value in areas with high water/moisture content or soils with high salinity, e.g. tidal areas, marshlands, bay fills, etc.
- Electromagnetic (Magnetometer) – good for horizontal extents, where a disposal site contains ferromagnetic debris.
- Electrical Conductivity – resolution depends on difference in electrical conductivity properties between disposal fill material and subsurface geology.
- Ground-penetrating Radar – resolution depends on difference in material density between waste fill and surrounding geology.

Although geophysical surveys in the past (prior to modern personal computers) have had limited application due to the presentation and interpretation of data (conductivity, electromagnetic, time-domain data, etc.), current PC software programs that allow geophysical data to be graphically presented to provide better spatial correlation of data which can better delineate subsurface features such as fill areas, pipelines and utilities, buried objects, etc. It should be noted that a combination of one or more geophysical methods, e.g. resistivity (depth) and ferromagnetic (areal), may yield the most useful data.

It should be noted that geophysical surveys are relatively expensive—up to $5,000 per day for an electrical resistivity survey depending on number of survey “lines” (or sections) and distance (number of survey nodes) and may not yield data of value to the investigation. Site-specific conditions, such as metal objects or structures, fences, above or below ground metal pipelines, etc., can cause electrical interference with some of the methods (resistivity and conductance) which may degrade the results of the survey. A site walk and estimate should be done before determining if a geophysical survey would yield useful data for a site investigation.

A geophysical survey is not a substitute for an intrusive investigation, and should be used to help plan and/or complement a subsurface investigation, which will yield the most reliable information (trench, boring, direct push logs) on the location of the horizontal and vertical extents of the landfill or disposal site. In some cases, where an intrusive investigation may not be possible due to access constraints (particularly heavy equipment access), a geophysical survey may be the only method available to determine extents.

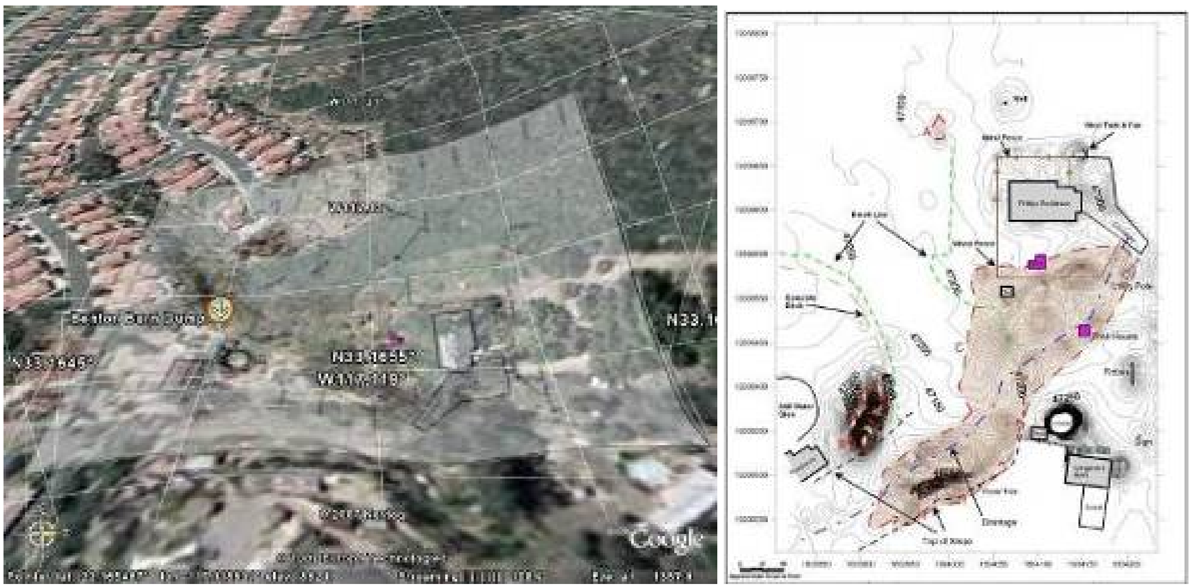


Figure 11: Geophysical survey map overlaid on Aerial Map in Google Earth, left; geophysical survey conducted using electrical conductivity, right.

Intrusive Investigation of Disposal Sites

Intrusive methods such as drilling, trenching, or direct push can provide visual and physical confirmation and documentation (drilling and trenching logs) of the approximate horizontal and vertical boundaries of a disposal site. Intrusive investigations should be planned and conducted after a thorough non-intrusive investigation has been performed, e.g. historical aerial photograph study, geophysical survey, and site walk with individuals knowledgeable of the site’s history and conditions (owner, disposal site operator or user, previous disposal site employee, neighbors, etc.).

Figure 12: Intrusive or invasive Investigation may include drilling, left, direct push (Geoprobe), center, and trenching (right).

An intrusive investigation should be designed to fill data gaps or verify features of the site observed during the historical aerial photograph study and/or geophysical survey. For example, if a disposal site began as the filling of a gravel pit excavation, the intrusive investigation may focus on verifying the pit excavation boundary and thickness of final cover. If historical aerial photographs show that several trenches had been excavated and filled, the intrusive investigation may focus on delineating the trench lengths and depths. If a disposal site's history shows only surface or area filling, the intrusive investigation may focus on delineating the original ground surface conditions and areal extent of waste deposits.

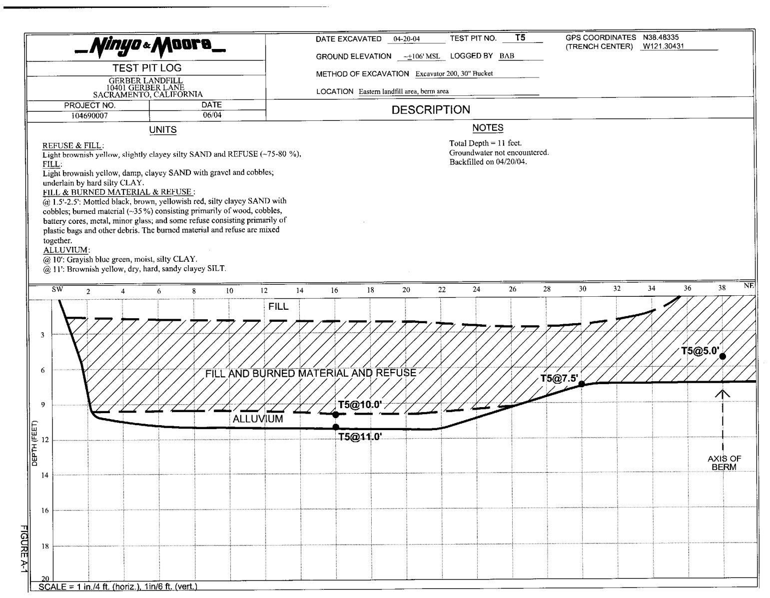
The intrusive investigation data is then used to develop disposal site boundaries on a scaled topographic map and cross-sections depicting top and bottom of final cover and waste elevations. This topographic drawing and cross-sections then becomes the basis for developing remedial scopes of work and cost estimates for clean-closure and/or consolidation and capping of the disposal site.

Types of Intrusive Investigation Methods

Trenching and "potholing" investigation methods can provide cost-effective and valuable field data on the horizontal and vertical extents and characteristics of a disposal site. Trenching allows a trained and experienced geologist to visually observe and take direct measurements on the cover thickness, the depth of waste, and determine contacts between waste fill and native geology. Open trenches can be photographed and disturbed soil and waste samples can be taken from trench spoils from different approximate depths for laboratory analysis. Trenches should be logged by a trained, experienced, and preferably a registered field geologist. Trenching across waste boundaries provides a geologist with a method for exploring and verifying waste boundary conditions.

Trench logs should contain the following information: site location name; date/time; name of qualified geologist logging trench; trench location; trench number or designation; length, width, and depth of trench; depth of cover; depth of fill; depth to bottom or native, sample locations; and description of waste and soils.

Figure 13: Trenching investigation with a tracked-backhoe for investigating fills 15-25 feet below ground surface (bgs).



Ninyo & Moore
TEST PIT LOG
GERBER LANDFILL
10401 GERBER LANE
SACRAMENTO, CALIFORNIA
PROJECT NO. 104690007 DATE 06/04

DATE EXCAVATED 04-20-04 TEST PIT NO. T5
GROUND ELEVATION ~±106' MSL LOGGED BY BAB
METHOD OF EXCAVATION Excavator 200, 30" Bucket
LOCATION Eastern landfill area, berm area
GPS COORDINATES (TRENCH CENTER) N38.48335 W121.30431

DESCRIPTION

UNITS

REFUSE & FILL:
Light brownish yellow, slightly clayey silty SAND and REFUSE (~75-80 %).
FILL:
Light brownish yellow, damp, clayey SAND with gravel and cobbles; underlain by hard silty CLAY.
FILL & BURNED MATERIAL & REFUSE:
@ 1.5'-2.5': Mottled black, brown, yellowish red, silty clayey SAND with cobbles; burned material (~35 %) consisting primarily of wood, cobbles, battery cores, metal, minor glass; and some refuse consisting primarily of plastic bags and other debris. The burned material and refuse are mixed together.
ALLUVIUM:
@ 10': Grayish blue green, moist, silty CLAY.
@ 11': Brownish yellow, dry, hard, sandy clayey SILT.

NOTES

Total Depth = 11 feet.
Groundwater not encountered.
Backfilled on 04/20/04.

Figure 13a: Example Trench Log

Drilling investigation methods are widely accepted and standardized for subsurface exploration for environmental and geotechnical investigations. Drilling can provide a geologist with detailed, discrete information on subsurface formations and fills. Drilling methods can also provide discrete and undisturbed soil and waste samples for laboratory analysis. Standardized methods and procedures (such as American Society of Testing and Materials [ASTM] standards) are available for determining soil and waste properties, e.g. classification, density, compaction, shear strength. Drilling (or direct push) should be used to determine the vertical extent of waste fills that are over 30 feet in depth; generally many canyon-fills or mining pit fills require the use of drilling or direct push methods to define the vertical extents. Drilling equipment needs for investigations may vary depending on site geology—air percussion or air rotary rigs may be necessary where the subsurface contains cobbles and rocks that may present refusal conditions. Hollow-stem auger drill rigs can generally be used in geology classified as soil.

Boring log information should include: name of site; date/time; name of person logging (and certification no.); name of firm/drillers license no.; boring location number or designation; cover thickness; waste and soil descriptions/classification; geologic strata identification; depth of fill; depth to native geology contact (bottom of waste); depth to groundwater; monitoring instrument measurements (photo or flame ionization detectors [PID or FID], organic vapor analyzer [OVA], combustible gas indicator [CGI], etc.); sample locations; and other important field information of significance to investigation.

Figure 14: Drilling equipment for exploration and sampling and gas monitoring well construction; depending on geology and landfill materials a hollow-stem auger may suffice or the use of mud, air rotary or air-percussion drill rig may be required; at right, a local drilling company or geologist familiar with well installation in the area should be consulted.

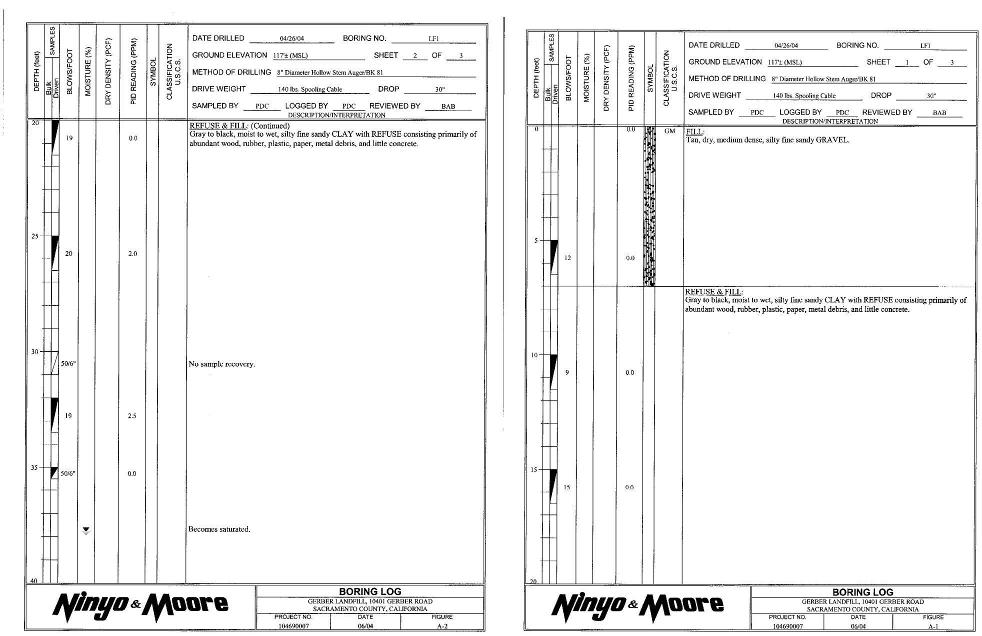


Figure 15: Example boring logs from gas monitoring well installation

Direct push investigation methods, such as "Geoprobe" hydraulic direct push equipment, has gained popularity within the environmental investigation field for conducting subsurface investigations, particularly in developed areas where drilling or trenching are difficult to conduct due to the presence of dense subsurface utilities. Direct push offers a small diameter (2" diameter) borehole, but still provides in-situ, discrete soil, groundwater, and soil-vapor gas samples.

Direct push logs should include the following information: name of site; date/time; name of person logging (and certification number); name of firm and license number; name and type of equipment;

location number or designation; cover thickness; waste and soil descriptions/classification; geologic strata identification; depth of fill; depth to native geology contact (bottom of waste); monitoring instrument measurements (PID, FID, OVA, CGI, etc.); sample locations; and other important field information of significance to investigation.

Figure 16: Direct push exploration and sampling methods (push core sampler into geologic strata)—disturbance is a nominal 2-inch diameter hole (important consideration in developed areas with subsurface utilities).

Some advantages and disadvantages of trenching, drilling and direct push methods include:

Advantages

- Trenching costs per day of operated backhoe or excavator is less than drill rig or direct push rig.
- Backhoes and excavators require only one operator.
- Excavators and backhoes are common construction heavy equipment (greater availability than drill or direct push rigs).
- Trenching can allow visual observation of in-situ cover thickness and waste materials; visual identification of stratigraphy (layers) in trench.
- Trenching and potholing can cover larger areas in a relatively short time; good for horizontal extents investigations.
- Minimal set-up time needed between investigation locations.
- Tracked equipment can access areas not accessible to heavy wheeled equipment.
- Generally, “refusal” conditions not as problematic as drilling or direct push.

Disadvantages:

- Trenching may be difficult in developed areas with buried utilities; developed areas may require a higher degree of inspection and coordination (Geophysical Clearance and Underground Service Alert).
- Samples obtained from trenching for analysis are disturbed and not discrete (drilling and direct push coring type samplers, e.g. split-spoon sampler, can provide both undisturbed and discrete samples for obtaining volatile organic compound [VOC] analysis).
- Depth of trenching excavation is subject to equipment limitations. Generally a standard tracked excavator is capable of excavating a 25-30 foot deep by 2 foot wide trench; however, it is difficult to visually log bottom of trenches over 15 feet in depth.
- Disposal sites greater than 25-30 feet in depth require drilling or direct push equipment to define the vertical extent.

- Safety hazards associated with trenching such as caving, side-wall collapse, etc.; OSHA standards for trenching must be identified, observed and followed and included in the field investigation work plan and site specific health and safety plan.

Figure 17: Sampling and analysis of waste and soil within landfill to determine physical and chemical characteristics; at right, removal of sampling core from split-spoon sampling tool used in a hollow stem auger drill rig.

Sampling and Analysis Plan for Waste and Soil Characterization

A Phase II Field Investigation Work Plan provides the scope of work and tasks for completing an investigation of the horizontal and vertical extents of the waste. For this reason the work plan should include sampling and analysis procedures that will describe and document how waste and soil characterization data quality will be controlled. Collection of defensible data should also support investigation data quality objective (DQOs) for waste characterization/classification. For instance if a disposal site is a burn dump and the responsible party is interested in clean-closing the site, a DQO may be to determine the statistical average and confidence interval for lead concentrations to determine if the waste will go to a Class I, II, or III disposal facility. If the disposal site is to remain in place, regulatory oversight agencies may want to know the lead concentrations and distributions to determine cover specifications for the disposal fill areas. The sampling and analysis plan should include the following:

- Sampling Plan & References (EPA One Time Sampling Event, SW-846 Chapters 9 & 10)
- Data Quality Objectives (DQOs)
- Sample Location Map
- Sampling Procedures and Equipment (standardized methods, e.g. ASTM, EPA, etc)
- Sample Handling Procedures (labeling, packaging, preservation, holding, chain-of-custody)
- Field Sampling Quality Assurance and Control Procedures (splits, duplicates, field blanks, etc)
- Analytical Requirements (DTSC Burn Dump Protocol for Burn Dump/T.O.-15 and ASTM 1946 for LFG)
- Laboratory QA/QC requirements

Example sampling and analysis plans for closed, illegal and abandoned sites can be found at: http://www.calrecycle.ca.gov/SWFacilities/CIA/Field/SamplingPlan/

Disposal Site Volume Estimates

An important analysis performed during a technical and economic feasibility study for remedial options at a disposal site is the estimation of volume of waste in-place and the cost to remove or "clean-close" waste materials. The volume estimate can be obtained by knowing the horizontal and vertical extent of the waste disposal site, which can be determined through an office and field investigation. There are two common methods for determining the volume of a bank fill—the "end area method" and "Prismoidal formula" (Harbin, 1998).

The end area method formula calculates the volume, V as follows:

V = L (A1 + A2)/(2 x 27) = (L/54) x (A1 + A2)

Where, **V is volume in (yd^3)**
A1 is the area of the first section (ft^2)
A2 is the area of the second section (ft^2)
L is the distance between the first and second section (ft)

The "Prismoidal" method assigns a square grid system over a disposal site, and the average depth of each grid square is determined through investigation (geophysical, drilling, trenching, etc.). The volume is determined by multiplying the area of each square by the average depth of waste for that grid square and summing the volumes of the grid squares.

A common volume estimation method, known as the "average end area method," uses "cross sections" for the disposal area and the distance between cross sections to calculate the volume of the fill. The cross section data is developed from trench or boring logs, which provide the depth of the fill along a specified line that transects the fill. In the example volume estimate below, Section 1, 2, and 3 are taken along the long side of the disposal area – the distance L1 is measure between Section 1 and 2 and L2 between Section 2 and 3. The accuracy of the estimate can be increased by using more cross sections to estimate the volume. After completing the volume estimate, a cost estimate can be developed for clean-closure of the waste material in place. An example of a volume estimate using "method of sections" and a cost estimate for clean-closure is provided below from the Bryte Landfill, located in Yolo County, California.

Volume estimates can also be performed using engineering software (AutoCAD Civil 3D Volume Estimation) by using volume estimating utilities that compare pre- and post-disposal site topographic surfaces and calculating the volume using finite element algorithms.

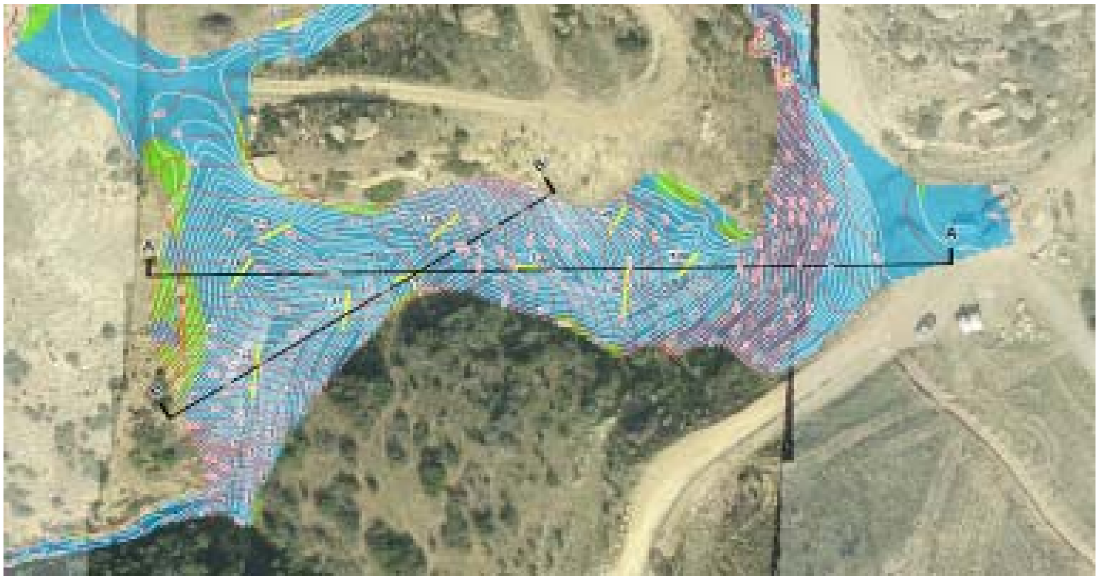


Figure 18: Topographic lines depict original and current grades; shaded area represents areal extent of fill.

California Integrated Waste Management Board
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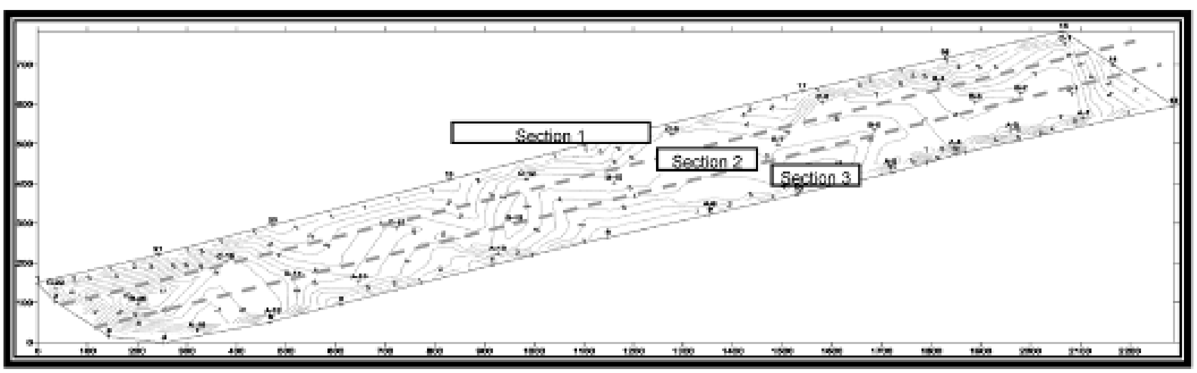
Permitting & Enforcement
(Closed Illegal & Abandoned Sites Investigation Unit)

Volumes Estimation Using an Excel Model

Bryte Landfill (57-CR-0002)



Equation Section 1		
Trench ID	X Location	Depth
C22	18.12	6
C18	353.43	9
C12	981.76	6.25
C9	1280.82	6
C6	1588.94	7
B4	1820.03	8.25
C1	2091.9	6

Avg Depth 6.92857143 ft
A1 **14,799** ft2
V1 **1,136,004** ft3
V1 **42,074** yd3

Equation Section 2		
Trench ID	X Location	Depth
B20	109	13
B17	417	6.25
B15	652	5.25
B13	878	7
B10	1095	6
B7	1430	5.5
B5	1620	5
B3	1837	8.25
B2	1927	8
B1	2026	8

Avg Depth 7.225 ft
A2 **15,238** ft2
V2 **1,169,632** ft3
V2 **43,320** yd3

Equation Section 3		
Trench ID	X Location	Depth
A19	72.5	5.25
A18	217.5	9
A16	416.8	5
A13	706.8	5
A9	1141.8	2.5
A7	1296	4
A5	1512.5	8
A4	1648	6.5
A3	1774	7
A1	1919	7

Avg Depth 5.925 ft
A3 **12,388** ft2
V3 **950,902** ft3
V3 **35,219** yd3

Total Volume (using avg. depth) = 120,613 yd^3

Figure 19: Volume Estimate Using End Area Method.

SITE NAME: Bryte Landfill (West Sacramento) **AS OF DATE:**

CLEAN CLOSURE COST ESTIMATE: **17-Oct-01**

Input Site Data:	Length (ft)	Width (ft)	Depth (ft)	Area (AC)	VOL (CY)
Cover Dimensions:	1210	600	0.5	16.7	13444
Waste Dimensions:	1210	600	4.75	16.7	127722
Distance to Landfill:	15				
Dump/Tip Fee:	40				

ITEM	DESCRIPTION	QTY	UNIT	RATE	UNIT	EXT COST
1	Construction Surveying Activites (mark exc, interim & final grade control)	16.7	AC	1,074.00	$/AC	$ 17,900.00
2	Clearing & Grubbing Site (remove veg. w/D-7 or D-8)	16.7	AC	400.00	$/AC	$ 6,666.67
3	Excavate cover soil to stockpile (300ft haul w/D7)	13,444	CY	2.50	$/CY	$ 33,611.11
4	Excavate Waste to End-Dump (CAT245D w/4CY to 40CY end-dump)	127,722	CY	2.31	$/CY	$ 295,038.33
5	Haul Waste to Landfill (Kettlemen) (Based on Lead>TTLC)	127,722	CY	10.00	$/CY	$ 1,277,222.22
6	Pay Dump/Tipping Fee* (significant cost to project, i.e. 50%)	127,722		40.00	$/CY	$ 5,108,888.89
7	Perform Verification Sampling & Analysis (3 samples/acre, analysis includes: 17CAM Metals, TPH, O-Pest, 8260)	50	EA	450.00	$/EA	$ 22,500.00
8	Backfill Cover Stockpile (grade and compact backfill)	13,444	CY	1.25	$/CY	$ 16,805.56
9	Import fill, grade and compact	127,722	CY	10.00	$/CY	$ 1,277,222.22
					SUB	$ 8,055,855.00
10	Construction Mgmt & Oversight (5%) (5% of total project)	1	JB	$ 402,792.75	$/JB	$ 402,792.75
					SUB	**$ 8,458,647.75**
11	Contingency* (20%)			$ 1,691,729.55		$ 1,691,729.55
					Total	**$ 10,150,377.30**

***Notes & Assumptions:**

1. **Equipment: 3 ea Excavators (CAT235), 2 ea Dozer (D7/D8), 10 End Dumps (40CY)**
   1 ea-Grader, 1-ea Compactor (415C)
2. **Contingency includes hazardous waste handling & disposal**
   and covers error margin for waste & soil quantity estimates
3. **Haul Cost based on subcontractor bid for disposal**
4. **Rates based on RS Means Site Work Cost Data and include O & P**

Table 20: Cost estimate for clean-closure of a former disposal site; note that cost rates may not be up to date.

Landfill and Disposal Site Investigation Case Studies

Gerber Road Landfill. The Gerber Road Landfill is a former 60-acre landfill in Sacramento County that provided disposal service for Sacramento County under a franchise agreement from 1957-1971. The site stopped receiving waste in 1971 after the county established Kiefer Landfill as its primary regional disposal site. The Sacramento County Environmental Health Department acting as the Local Enforcement Agency (LEA) for the California Integrated Waste Management Board, requested technical assistance from CIWMB's Closed, Illegal, and Abandoned Site program to investigate the Gerber Road Landfill for compliance with state minimum standards for final cover, grading, drainage, erosion control, gas monitoring, and control and security. From February to May 2004, CIWMB staff and an environmental consultant prepared and coordinated an investigation work plan and conducted field investigation work, including: a geophysical survey of the disposal site perimeter; trenching and drilling more than 29 locations (19 trenches, 10 borings) across the site; soil and waste sampling and analysis; and the installation and sampling of eight multi-depth and two single-completion gas monitoring wells. The gas monitoring wells were instrument-screened monthly, and sampled and analyzed quarterly for one year after installation of the gas wells to determine if landfill gas concentrations were in compliance with state minimum standards for landfill gas (LFG) monitoring, e.g. 5 percent by volume in air at property boundary wells. Gas monitoring using a screening instrument was performed monthly for a one year period and gas sampling and analytical testing was performed quarterly. Gas samples were collected in Summa canisters and analyzed by a certified laboratory using ASTM 1946 Fixed Gases and T.O.-15 Analysis. The results of gas screening and sampling activities indicated that, although gas concentrations within landfill probes were 10 percent and 30 percent by volume, perimeter boundary probes did not exceed 5 percent during the one-year monitoring period. Aerial and ground surveys were performed at the site and a topographic map was prepared in AutoCAD to document topographic conditions, property and waste boundaries, sampling and well locations and drainage features. A final report was prepared by the CIWMB that documented existing site conditions to include approximate waste extents, waste characteristics, final cover, drainage and erosion conditions and LFG concentrations and characteristics. The report provided recommendations and courses of action for the LEA with respect to the site's conditions and compliance with state minimum standards for disposal sites.

Figure 21: Trenching photo and trench log documenting cover thickness, depth of fill and location.

Figure 22: Left: drilling and logging gas monitoring wells. Right: completed well head vault.

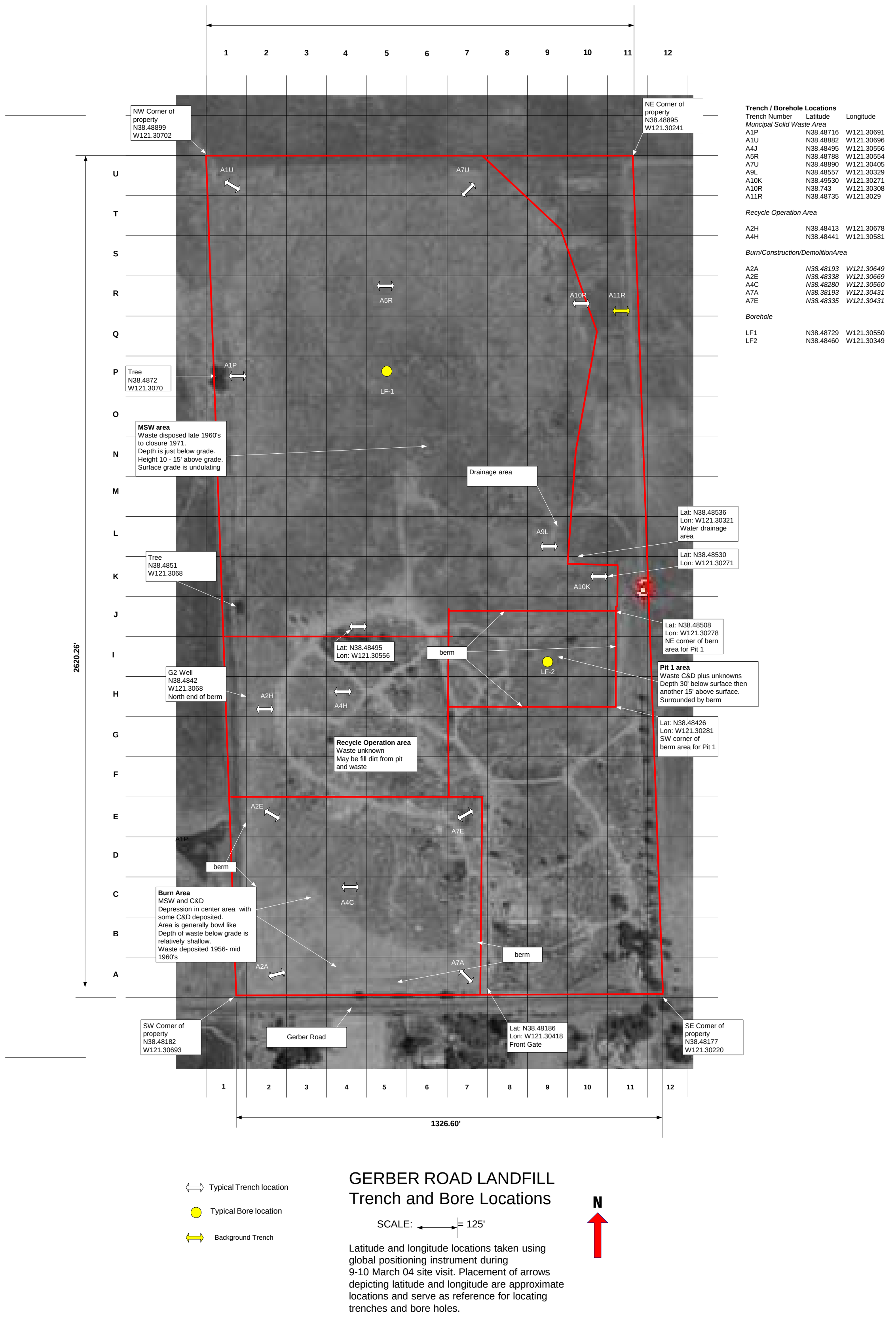


Figure 23: Trench and sampling location map for the Gerber Road Landfill.

Santa Fe Road Disposal Site. The Santa Fe Road disposal site was a former 60-acre disposal site in Stanislaus County that received agricultural waste from local farms and municipal waste from local communities from 1940-1960. The site was subdivided into four parcels in the 1970s. In the 1980s, one of the property owners used his parcel as an illegal disposal site for construction and demolition debris. The Stanislaus County LEA requested the assistance of the CIWMB to investigate the disposal site and illegal landfill activities. From January-April 2002, CIWMB staff prepared and coordinated a field investigation work plan to determine the approximate horizontal and vertical extents of waste at the site and provide waste characterization data for disposal and handling. Historical aerial photographs were obtained for the site and reviewed to determine the approximate limits of disposal operations. A field investigation was conducted utilizing two farm tractor backhoes to conduct intrusive trenching and sampling at more than 60 locations across the former disposal site. The purpose of the investigation was to determine the location, extent and waste characteristics of disposal areas and final cover conditions over the 60-acre site. A final report with recommendations was prepared and presented to the LEA and landowners. The final report provided field data that showed that most of the waste was located on the northern portion of the site and that a small lens of burn ash was located in the southern parcels. The investigation also showed that there was cover material on the southern portion of the disposal area, but little cover existed in the north area.

Figure 24: Left: Santa Fe Road sample location map depicting trenching and sampling locations to determine the waste extents and characteristics. Right: Tracked hoe or excavator is used to perform trenching through cover, waste and native soils. Trenching provides data on the thickness of cover, the depth of waste to native soils and the physical and chemical characteristics of waste at the site.

Hellyer Sywak (Eastside landfill). The former Eastside Landfill (located at Hellyer Park in San Jose) was a privately owned dump that operated from the late 1950s to the early 1970s. Areas adjacent to the site were developed into residential homes in the mid-1970s. A bicycle racing track (velodrome) was constructed on the site north of the main disposal area in the late 1960s. In 1984 a fire and explosion occurred in a residence on Faris Drive (home on the south boundary of the landfill). It was discovered that methane gas from the landfill was migrating beneath homes on Faris Drive. A landfill gas investigation was conducted by EMCON in 1986 and a gas monitoring and collection system was constructed at the site in 1986 to prevent off-site migration of landfill gas. A groundwater investigation was also conducted at the site under the State's Solid Waste Assessment Test (SWAT) program in 1989. The results of the SWAT study indicated that the site was a priority for further investigation. The City of San Jose LEA requested technical assistance from the CIA program to determine if landfill gas was migrating from the landfill to areas west, north, and east of the disposal site (the initial monitoring network constructed by EMCON was located along the south boundary adjacent to the homes on Faris Drive). The CIWMB performed a Phase I office investigation, which included historical aerial photograph research and installation of nine perimeter gas monitoring wells that met state requirements for a gas monitoring network (27 CCR Section 20925). The wells were monitored monthly for a one-year period and the results of monitoring indicated that explosive concentrations (5 percent) of landfill gas were not migrating across the western boundary of the site.

Figure 25: Left: historical aerial photograph from 1954 shows the site during mining operations; right: aerial photograph taken in 1995 shows current land-use conditions at the Hellyer site.

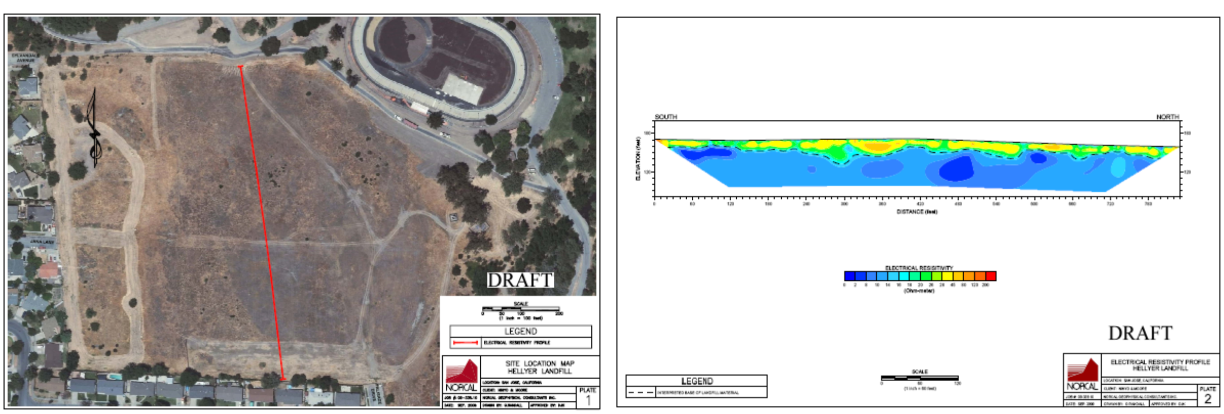


Figure 26: Left: geophysical survey using electrical resistivity provides a scaled map cross-section of subsurface features (right). The areas of resistivity data that appear to be different (yellow and green) from background may indicate waste deposits, which can be further investigated through drilling methods.


Figure 27: CIWMB designed and constructed a landfill gas monitoring network to determine if landfill gas migration was occurring into adjacent areas.

La Veta Refuse Disposal Station. The La Veta Refuse Disposal Station, located southeast of Highway 55 and Chapman Boulevard in Orange County, was a county-owned disposal site which operated from 1946 to 1958. The site was excavated and mined for gravel and sand during the 1930s-40s and was filled with municipal waste in the late 1940s to the mid-1950s and closed in 1959. The site was developed into residential homes in the mid-1970s. In 2006, the Orange County LEA requested technical support from the CIA program to determine if landfill gas (LFG) from the disposal site was migrating off-site. CIA staff conducted an office investigation, which included researching historical aerial photographs to determine the horizontal extent of the disposal site, so that gas monitoring wells could be located and constructed outside the disposal site area. Most of the land use information for the site and determination of approximate horizontal boundaries of the disposal site operation was determined from a review of 17 historical aerial photographs taken from 1930-2002. The historical aerial photographs were obtained from the UC Santa Barbara Map Imaging Laboratory. The historical aerial photographs showed the gravel and sand mining operations (1930s), and the disposal site operation (1946-1958); the YMCA main building first appeared in photographs taken in the 1970s and residential housing adjacent to the site also occurred sometime in the 1970s. A BMX racetrack was constructed adjacent to the YMCA property in the early 1980s. During drilling of the five gas monitoring wells, crews discovered that one of the wells on the southern portion of the YMCA property was installed in waste. A historical aerial photo predating the landfill was overlaid In Google Earth using the overlay tool (Figure 28). The overlaid image showed that the former disposal site intersected the residence on the southern boundary of the YMCA property. Three of the gas monitoring wells were constructed in accordance with Title 27 (Section 20925); however, additional field exploration work was conducted to determine the location of waste on the residential property (figure 29). A geophysical survey using electrical resistivity and ground penetrating radar (GPR) was conducted to delineate and survey the approximate disposal site boundary. A small tracked drilling-rig was used to investigate four locations on the residential property on the south boundary of the disposal area. It was discovered that the landfill was up to 30 feet deep below ground surface beneath the backyard (which included a pool) and that there was approximately 10 feet of soil fill above the landfill. A follow-up investigation was performed to determine if landfill gas was migrating into the residential structure; gas detection equipment was also placed in the residence and YMCA building and monitored continuously (using data loggers and programmable logic control software) for a period of one year. Gas monitoring wells were monitored monthly for a period of one year. During this period an off-gassing event was detected within the residence which was recorded at 30,000 ppm (regulatory level is 1.25 percent or 12,500 ppm).

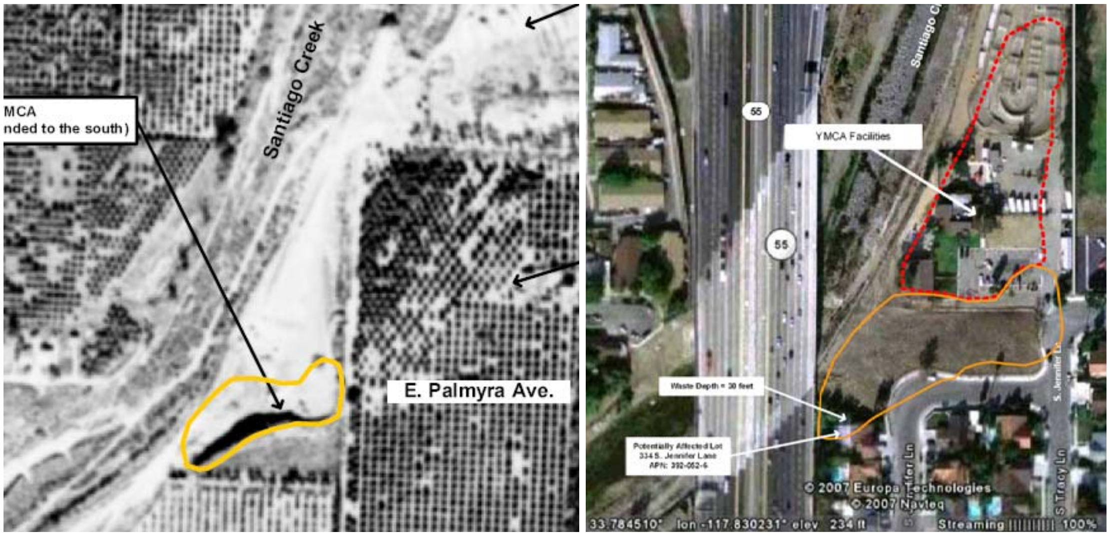


Figure 28: Historical aerial photograph indicates the boundary of gravel and sand mining operation; aerial photograph of site with current land-use with approximate disposal site boundary depicted from 1938 historical aerial photograph.

Figure 29: Drilling exploration in backyard of residence to define southern extent of former landfill; waste fill material from boring.

Benton Dump. The Benton Dump in the City of Escondido in San Diego County, California, was a privately operated dump that received waste in the 1950s. The site was developed into a residential subdivision in the 1980s. The San Diego County Environmental Health Department as the Local Enforcement Agency (LEA) requested technical assistance from the CIA program to investigate the extent of the disposal site and to determine if the site complied with state minimum standards. The CIA program conducted a Phase I office investigation and Phase II field investigation to determine the waste extents and characteristics. The Phase I office investigation included a review of files and reports kept by the CIWMB and LEA and also included a review of historical aerial photographs. The Phase II field investigation included a geophysical survey using resistivity and magnetometer methods followed by drilling and sampling (using a small tracked drilling rig with a hollow-stem auger attachment). The geophysical survey produced resistivity and magnetometer data that was located, surveyed, and mapped (see figure 30). An intrusive sample location map was developed based on the geophysical survey maps. The results of the field investigation indicated that waste had been distributed through a ravine and was relatively shallow (2-10 feet) and uncovered. The horizontal extent of waste was not determined as the waste “daylighting” at the edge of the ravine appeared to be covered with more than

10 feet of soil (possibly indicating that the subdivision had brought-in clean fill to build up site elevations—and in the process, covered the disposal site). Using the tracked drill rig, the intrusive investigation provided boring log data for more than 25 locations.

Figure 30: Historical aerial photograph of Benton Dump overlaid in Google Earth; Google Earth aerial view of Benton Dump.

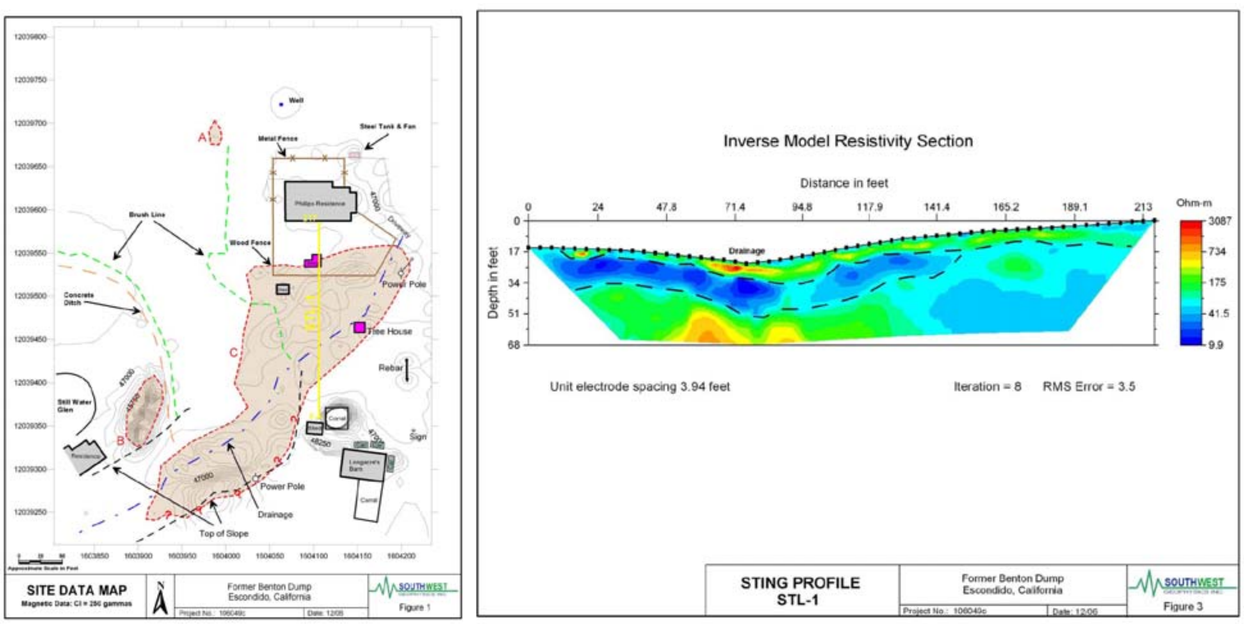


Figure 31: Map of magnetometer geophysical survey depicting data; Cross section of resistance data from geophysical survey using resistivity characteristics.

Figure 32: Small-tracked hydraulic direct-push rig used for intrusive investigation due to terrain and limited vehicle access.

Newport Terrace Condominium Development. The Newport Terrace condominium development is located over a former landfill, e.g. City of Newport Beach Dump No. 1, which was operated as an aggregate mine in the 1930-40s and used by the City of Newport Beach in the 1950s as a municipal landfill. The disposal site was developed into residential condominiums in the 1970s. As part of the development, the developer had included measures to address landfill gas migration issues associated with the site and installed landfill gas monitoring and control systems. The condominiums were sold to owners with covenants, codes and restrictions (CC&R) that prescribed the responsibility for maintenance of the gas control system by the homeowners association (HOA), while the City of Newport Beach would continue to monitor the gas monitoring wells constructed on the perimeter of the site. In the 1990s the Orange County LEA had documented landfill gas concentrations that exceeded the 5 percent rule in perimeter monitoring wells at the site. The LEA requested technical assistance from the CIWMB to investigate landfill gas migration issues at the site and to provide recommendations. The CIA section prepared and coordinated an investigation work plan to determine the approximate vertical and horizontal extent of disposal areas at the site. The investigation included landfill gas screening and sampling and analysis to determine representative landfill gas concentrations and constituents throughout the disposal areas. The field investigation included advancing 32 direct-push borings and logging and sampling throughout the disposal area and development. Site development plans were obtained from the City of Newport Beach that documented disposal areas and grading plans. During the investigation it was discovered that several condominium building structures were constructed over a portion of the former landfill. This was confirmed through several borings adjacent to the condominium structures. Based on the results of the CIWMB investigation it was determined that landfill gas concentrations in perimeter boundary probes were exceeding the 5 percent rule which supported LEA enforcement to require the homeowner's association to install a new gas collection system and also to continuously monitor structures located over disposal fill. The CIWMB conducted a follow-on project which included installing an eight-sensor continuous monitoring system and installation of monitoring vaults adjacent to condominium structure foundations located over disposal fill. The CIMWB collected gas concentration readings from the sensors for a one-year period on a 24-hour-per-day/seven-day-per-week basis. The results of this monitoring did not indicate any upward migration of landfill gas from the disposal area into building structures, e.g. gas concentrations did not exceed 1.25 percent.

Figure 33: Newport Terrace condominium aerial & historical Google Earth image. Park area is the former City of Newport Beach Dump No. 1; Condominiums were constructed adjacent to and on top of the former disposal site (left). The condominiums shown in the lower left portion of the aerial image were constructed on a disposal fill area that was covered with 10-15 feet of engineered soil. Direct push equipment was used to sample locations at the Newport Terrace Condominium site up to 40 feet in depth.

Figure 34: Two types of hydraulic direct push rigs were used to define the extents of waste; combustible gas instruments were used to obtain gas measurements in the direct push boring; gas samples were collected in Summa canisters for laboratory analysis.

Figure 35: Subsurface vaults with combustible gas sensors are installed adjacent to the foundations of condominiums to detect and measure the concentration of methane gas migrating from the disposal area; a controller and data logger were used to collect gas measurements.

Bryte Landfill. The Bryte Landfill is a 16.7-acre disposal site located in Yolo County, California. The leased property was operated by a franchise hauler who provided disposal service to the City of West Sacramento from 1940-1970. The Yolo County Environmental Health Department requested technical assistance from the CIWMB in April 2001 to investigate the site to determine if the site was in compliance with state minimum standards for disposal sites. The CIWMB conducted a Phase I office investigation and prepared and coordinated a field investigation work plan to determine the waste extents and characteristics and cover thickness. A total of 28 locations were trenched and sampled to determine the horizontal and vertical extent of wastes, the waste characteristics, the volume of waste, and the cover thickness. Upon completion of the field investigation it was determined that additional investigation was required to delineate the levee boundaries and an area east of the site as waste extents were found to be beyond original boundaries explored. The site had no cover in place and average lead concentrations at the site exceeded the Total Threshold Limit Concentration (TTLC) of 1,000 mg/kg (average was 4285 mg/kg). The total in-place volume of waste estimate was 127,000 cubic yards. The CIWMB concluded that the site did not meet state minimum standards for cover, grading, drainage and erosion control. Moreover, based on the levels of lead, it was recommended that the site be capped to prevent public contact. Based on these findings Yolo County used the CIWMB findings to take enforcement action to compel the property owner to mitigate or remedy the risks to public health and safety.

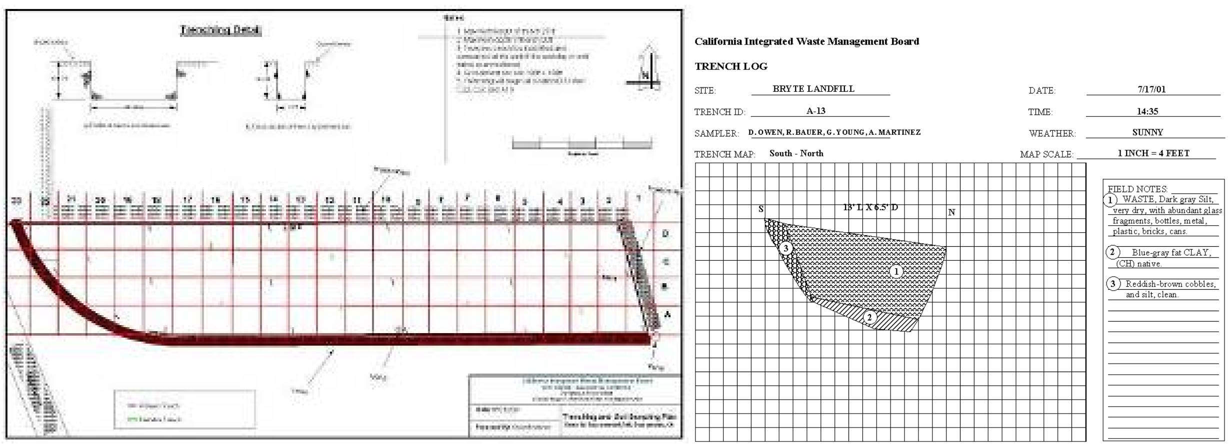


Figure 36: Site sampling location map with grid that provides the location of trenches for determining the horizontal and vertical extents of waste. The map also provides a reference system for identification of trenches (for trench logs) and for sample identification and labeling.

Figure 37: Farm-tractor backhoe conducts trenching; field staff document trench characteristics (length, depth, cover thickness, description of waste), perform instrument screening (combustible gas, oxygen levels, H2S) and also obtain samples for chemical and physical analysis.

Franklin Field Dump. The Franklin Field Dump is a 4-acre disposal site located at a formerly used defense site, which is now owned and used by the County of Sacramento as a low-security correctional facility. The Sacramento County LEA requested technical assistance from the CIWMB to investigate the conditions at the disposal site as they related to state minimum standards. The CIA section prepared and coordinated a field investigation work plan to investigate the approximate horizontal and vertical extents of the disposal site; the general characteristics of the waste; and to determine the thickness and quality of the cover. The CIA program conducted a field investigation at the site in October 2001, which included trenching at 32 locations across the disposal area. A total of 30 samples were collected from the waste (cover and waste at each location). The results of the field investigation provided enough data to approximate the vertical and horizontal extents of waste and waste characteristics to determine if the waste would be classified as California-hazardous waste. The investigation provided the LEA with enough evidence to issue a notice and order to compel the owner to cap and grade the site. The site was graded and capped by the owner in August 2008 with matching funds provided by the CIWMB. Portions of the disposal area contained nominal cover and other portions contained no cover.

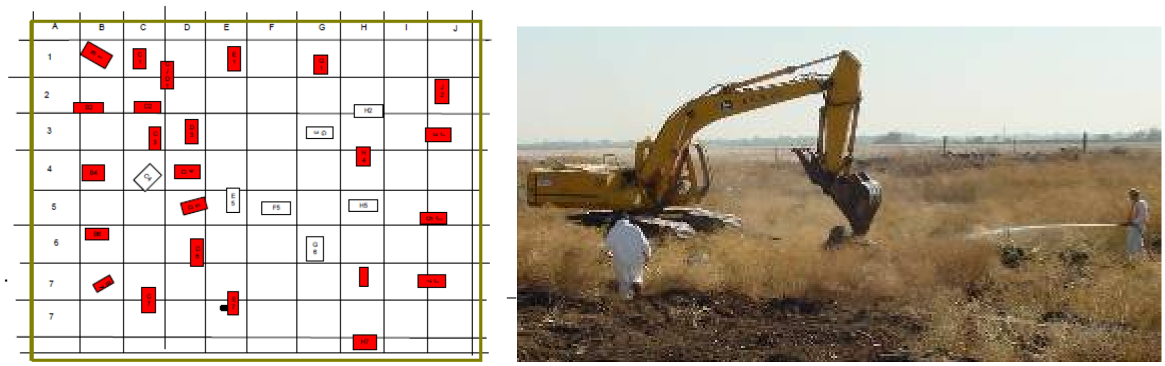


Figure 38: Trench location map, left; at right, trench excavation & dust suppression.

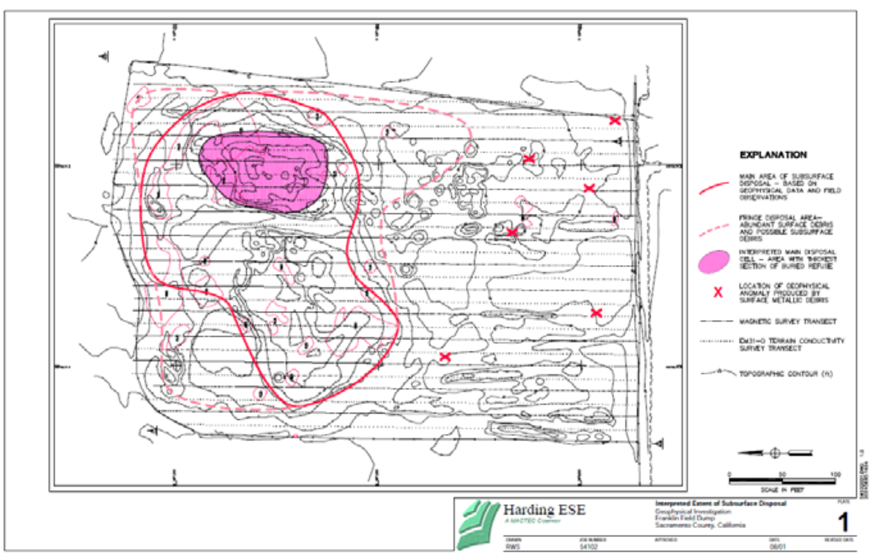


Figure 39: Topographic map with geophysical survey notes.


Figure 40: Remedial cap construction at the former Franklin Field Dump.

Waring’s Dump. The Waring’s Dump disposal site is a 3-acre site located in a residential community in Sacramento, California. The site was a former borrow pit from the construction of Highway 99 in the 1950s. The owner of the site used the borrow pit as a dump in the 1960s to dispose of municipal and commercial waste. The area was developed into residential housing in the 1970s. The Sacramento County Environmental Health Department, acting as the Local Enforcement Agency (LEA), requested the assistance of the CIA program to conduct an investigation of the site to determine compliance with state minimum standards for disposal sites. The investigation included the development and coordination of an investigation work plan which included a historical aerial photograph analysis, an intrusive investigation (trenching), and sampling and analysis of waste and soils. A total of 20 trenches were excavated during the field investigation and 28 soil and waste samples were collected and analyzed from the waste fill and cover soils. CIA staff determined through the field investigation that the disposal area extended beyond the original parcels containing the borrow pit excavation; it was also determined that the waste contained hazardous levels of lead (soluble threshold limit concentration, or STLC) and that the disposal site was insufficiently covered. CIA staff prepared a final report with recommendations for the LEA with respect to the site’s conditions as they related to compliance with state minimum standards. The LEA issued a Notice and Order to all property owners at the site to cover and grade the disposal area.

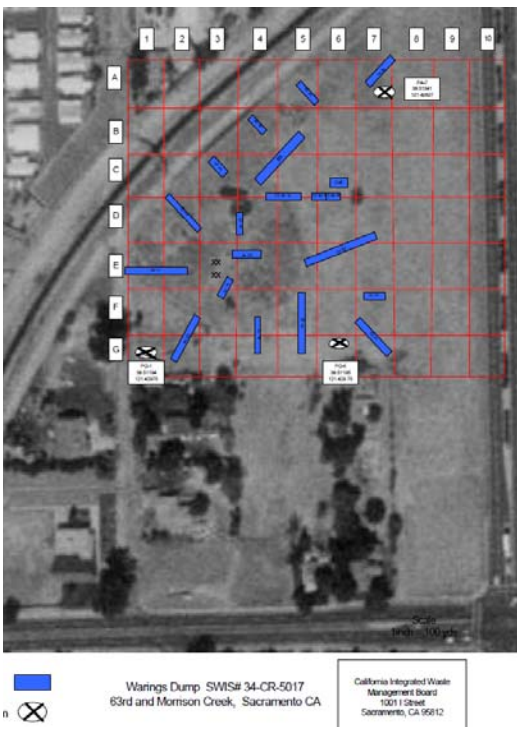


Figure 41: Trench Location Map (left); trenching using a tracked excavator (right).

Noah Webster Elementary School Burn Dump. The Noah Webster Elementary School site is a former 15-acre disposal site in the City of San Diego that received municipal waste between 1934 and 1941. The site operated as a burn operation, where garbage was collected, burned, and consolidated. The site was developed into an elementary school in early 1954, and areas surrounding the school developed into residential housing. The City of San Diego LEA requested technical assistance from the CIWMB to investigate the extents of the disposal site and determine if the site was in compliance with state minimum standards. The CIA program prepared and coordinated an investigation work plan and conducted an office and field investigation which included the use of 1.5 inch diameter, diesel-powered hydraulic direct-push equipment to advance 20 boreholes across the site. During the office investigation, the school district provided grading plans that showed the original disposal site boundaries and planned excavation and relocation of waste areas. These drawings were used to develop a sample location map to delineate locations for verifying the as-built conditions of the grading plan. Locations were logged, sampled, and analyzed in accordance with the investigation work plan. The results of the investigation estimated the volume of waste in place to be 15,000 cubic yards, which was covered with an average of 10 feet of clean fill material. Although lead levels in the waste exceeded California regulatory thresholds, the in-place cover provided adequate protection from contact with the waste.

Figure 42: 1996 Noah Webster Elementary School aerial image (left); Geologist examines direct push sample (clear plastic sample sleeve) taken from location on school playground (right). Clear plastic sample sleeve lines the inside of the direct push core sampler which is hydraulically pushed into the subsurface.

Figure 43: Geologist documents direct push boring observations in boring logs (left). Location of borings is surveyed using GPS surveying equipment (middle). The direct push sampler has used in this investigation had a diameter of 1.5 inches (right).

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