ATTACHMENT 1.
(8 PAGES)

FINAL EIR

June 21, 2010

Final Environmental Impact Report for Seismic Life Safety, Modernization, and Replacement of General Purpose Buildings, Phase 2 Project

(Including Supplementation of the LBNL 2006 LRDP EIR with respect to Traffic Impacts at One Intersection)

University of California at
Ernest Orlando Lawrence Berkeley National Laboratory
Berkeley, California

State Clearinghouse Number: 2008122030

Committee to Minimize Toxic Waste

March 14, 2010

ATTACHMENT 1.
(8 PAGES)

Jeff Philliber, UC-LBNL Environmental Planner
Lawrence Berkeley National Laboratory
One Cyclotron Road, MS 76-234A
Berkeley, California 94720

Subject: Comments on the Draft Environmental Impact Report (DEIR) for Seismic Life Safety, Modernization, and Replacement of General Purpose Buildings, Phase 2 Project at the Lawrence Berkeley National Laboratory (LBNL)

Dear Mr. Philliber,

The above referenced Project consists of the demolition of Buildings 25, 25B and 55, six modular trailers associated with Building 71, the construction of an approximately 43,000 gross square foot General Purpose Laboratory (GPL), and the seismic strengthening of the Building 85 complex – LBNL's Hazardous Waste Handling, Treatment and Storage Facility, all located in the Strawberry Creek Watershed's Strawberry and Blackberry Canyons.

Our comments are provided in two (2) parts. Since all the project components (areas associated with B85 complex, B25 and B71) are located site- wide at LBNL, in areas of great concern to the community, i.e. on top of earthquake faults, active landslides, radioactive and chemical contamination plumes (both soil and groundwater), creeks and networks of creeks etc., **Part 1** of our comment letter is titled: **Contaminant Plumes of the Lawrence Berkeley National Laboratory and their Interrelation to Faults, Landslides, and Streams in Strawberry Canyon, Berkeley and Oakland, California**, and cover our concerns in the following areas evaluated in the DEIR: Biological Resources, Geology and Soils, Hazards and Hazardous Materials, Hydrology and Water Quality, Land Use and Planning, Transportation and Traffic, Utilities and Service Systems – and we ask that you respond to our concerns in a comprehensive and serious manner.

Part 2 of our comment letter on DEIR consists of all the comments we provided on the Notice of Preparation (NOP) of the above referenced document, as these comments and concerns were largely ignored in the preparation of DEIR .The only changes that occurred between the NOP and the NOA (Notice of Availability) of the DEIR related to the demolition of several buildings and structures in the Old Town area, i.e. Buildings 4, 5, 14, 16, and 17, possibly some of the most contaminated buildings at LBNL, and Building 74F in the East Canyon, which were all removed from the EIR process, escaped all public and agency comment as they were secretly included into the Old Town

Demolition project, for which a Categorical Exclusion under NEPA was filed in December 2009, without any notice to the public. Please, explain why? We also ask that a full blown EIS under NEPA be prepared for the Old Town Demolition project.

Every single structure evaluated in the DEIR is located in a landslide area, as officially defined by the State of California, as being in an Earthquake Induced Landslide Hazard Zone, i.e. landslides will be mobilized in the event of a major earthquake – expected to happen any day now on the active Hayward Fault! (See attachment 1). Furthermore all the components of this Project are located in areas of LBNL where legacy chemical and radioactive contamination is present in the soil and groundwater, due to operations during the last 70 years, which the DEIR failed to describe in the kind of detail that the site and its history warrants! The DEIR is deficient, inadequate, misleading and in sections erroneous. For instance a claim is made that the new proposed location of the GPL is not located in Strawberry Canyon, when indeed Figure 4.8-1 of the DEIR shows the Strawberry Creek Watershed divisions into Blackberry Canyon and Strawberry Canyon, indicating clearly that the entire Building 25 site, the proposed location of the GPL, is in Strawberry Canyon, in the middle of the Building 25 slide and Building 25A Lobe of the Old Town Groundwater Solvent (VOC) Plume! (See attachment 2, A and B)

In conclusion, LBNL, UC and the Department of Energy (DOE) continue to willfully ignore and exclude the most significant, fundamental facts related to the Lab site, i.e. the unconsolidated nature of the volcanic rocks, mud and water that fill an old crater, a collapsed caldera, on which LBNL facilities were built starting in 1940! What is the use of drilling 35-50 foot deep holes for piers into this unconsolidated mélange of volcanic fragmental debris, without **ever** reaching bedrock, to attempt to tieback the Lab's Hazardous and Radioactive Waste Treatment and Storage Facility (B85 complex), further wasting taxpayer funds! The landslide on which the Hazardous Waste Handling Facility (HWHF) was built is over 2200 feet (7+ football fields) long, between the East Canyon Fault (with its numerous springs already identified by UC in 1875) and the Wildcat Fault.(See attachment 3, A and B).

The same danger is present at the B71 and B25 sites, as both are on top of active landslides (See attachment 1). We therefore ask that LBNL/DOE/UC immediately issue a site-wide **MORATORIUM** to any new construction and immediately assemble an international, world-class, independent group of geotechnical experts to perform all-encompassing, site-wide geological investigations and excavations regarding faulting, geology and landslides in the Strawberry and Blackberry Canyons, and that these experts be paid by some of the $ 264 million of ARRA (American Recovery and Reinvestment Act) funds, already received by LBNL! (See attachment 4, A and B)

We also ask that at the same time, during the moratorium, a comprehensive Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA) be prepared for this Project!

Since 1940, land use and planning at LBNL has been sporadic, haphazard, initially due to the secret nature of the Manhattan Project and later, during the cold war, the culture of secrecy continued under the Atomic Energy Commission and Department of Energy. If indeed UC considers this site to be a viable Hill Campus – now is the time to finally determine that fact, and if the unconsolidated soils of the collapsed caldera are deemed **unsuitable** for future development, it is critical that no more taxpayer funds be wasted into this landsliding, fault fractured sinkhole, but instead in the future of a new LBNL campus in Richmond or Oakland!

Sincerely,

Pamela Sihvola
CMTW
P.O. Box 9646
Berkeley, CA 94709

PS. What is the total estimated cost of the Project?
Please list projected costs per each Project component.

How much of the Project is funded by LBNL's $ 264 million ARRA funds?
Please list ARRA funded portions, in dollar ($) amounts per each Project component.

FINAL EIR

June 21, 2010

Final Environmental Impact Report for Seismic Life Safety, Modernization, and Replacement of General Purpose Buildings, Phase 2 Project

(Including Supplementation of the LBNL 2006 LRDP EIR with respect to Traffic Impacts at One Intersection)

University of California at
Ernest Orlando Lawrence Berkeley National Laboratory
Berkeley, California

State Clearinghouse Number: 2008122030

4.

4 LIST OF COMMENTORS

A. Written Comments

Written comments were received from the following agencies, organizations, and individuals. Letters are arranged by category, and then by date received.

Local Agencies

1. William R. Kirkpatrick, Manager of Water Distribution Planning, East Bay Municipal Utility District (EBMUD). March 10, 2010.

Non-Governmental Organizations and Private Companies

2. Pamela Shivola, Project Manager, Committee to Minimize Toxic Waste. March 14, 2010.
3. Janice Thomas, Secretary, Save Strawberry Canyon. Undated.

Members of the Public

4. Gene Bernardi, March 13, 2010.
5. Garniss Curtis, Georgia Wright, and John R. Shively, March 15, 2010.
6. Jennifer Mary Pearson, March 15, 2010.
7. Barbara Robben, March 15, 2010.
8. Jane Barnett, Undated.

B. Public Hearing Comments

Oral comments made during Planning Commission and Board of Supervisors public hearings are included as comment letters in Chapter 5, as listed below.

9. Public Hearing for EIR, February 25, 2010.

Committee to Minimize Toxic Waste

Board of Regents, University of California
Russell Gould, Chairman

c/o Anne Shaw, Secretary
Office of the President
1111 Franklin Street, 12th. fl.
Oakland, California 94607

URGENT

July 8, 2010

Via fax # (510) 987-9224

Subject: Comments on Action item GB 4, before the Regents' Committee on Grounds and Buildings (July 13, 2010): Certification of Environmental Impact Report (EIR) and Approval of Design of the Seismic Life Safety Modernization and Replacement of General Purpose Laboratory (GPL) Building, Phase 2 (Seismic Phase 2) Project, Lawrence Berkeley National Laboratory (LBNL)

Honorable Chair Russell Gould and Members of the UC Board of Regents,

We urge you not to certify the above referenced EIR for the Project proposed for the Lawrence Berkeley National Laboratory (LBNL) site, located in the Strawberry Creek Watershed in Berkeley and Oakland, California, for the following reasons:

1. The entire EIR for LBNL's Seismic Life Safety Project is wrong-headed by stating that the "Project" would remedy LBNL space which poses Seismic Life Safety risks, because it willfully ignores the fundamental meaning of the fact, that the entire LBNL site is on the State of California's delineated official seismic hazard zone for earthquake induced landslides (CGS 2003 a/b).

The following is a citation by LBNL's Geotechnical consultant Alan Kropp & Assoc. in reference to another ARRA funded project at LBNL also associated with the Building 71 site: "The recommendations presented herein are not intended to stabilize the site or mitigate the potential for landslide type movements." (April 8, 2010 Geotechnical Investigation, Building 71 BELLA). Building 71 site is on top of a major landslide, included in the CGS Seismic Hazard Zone Report map, showing a landslide extending from the hills - upslope of B 71-beneath most of the B 71 complex and into the valley below.

These same concerns apply to the sites of the other components of the Project EIR currently before you. Of special concern are the landslides undermining Building 85 complex, LBNL's Hazardous Waste Handling, Storage and Treatment Facility and the Building 25 complex, the proposed site for the General Purpose Laboratory (GPL).

In addition to the landslide risks of the proposed GPL site, the area, known as LBNL's Old Town, contains some of the most serious and extensive legacy contamination at the lab, especially VOCs, Volatile Organic Compounds, potentially causing a threat to any personnel from construction workers to LBNL employees present at the site at any time!

CMTW's concerns regarding radioactive and hazardous waste contamination at LBNL were largely ignored, specifically as they were expressed in our report: "Contaminant Plumes of the Lawrence Berkeley National Laboratory and their Interrelation to Faults, Landslides, and Streams in Strawberry Canyon, Berkeley and Oakland, California" submitted as part of our comment letter to LBNL.

Enclosed is a brief chronology of some of the 40+ landslides already mapped at LBNL (Attachment 1.) as well as a figure showing the collapsed caldera of the site with unknown mixture of mud, perched water and boulders, for which LBNL has yet to do a comprehensive hydrogeological study of its composition. (Attachment 2.) Also missing is the mapping of LBNL's hydrostratigraphic units (HSUs), which would show the hydraulic connection between various permeable layers of the HSUs sedimentary sequences, thus facilitating a more accurate construction of ground water flow and contaminant fate-and-transport models.

3. Two critical figures, referred to on page 5-227 of the Final EIR, were missing . They were hastily sent out with a Notice of Errata on June 30, 2010. The title of Figure 1. is "Bedrock geologic map of LBNL", and yet it only refers to various formations present at LBNL, such as Moraga Formation, Orinda Formation etc. There is no bedrock at LBNL, the use of the word bedrock is misleading, it is a misnomer, and LBNL should carefully describe what they mean specifically when using this word! (Attachment 3.)
Furthermore, the Draft EIR contained a figure titled:" Wildcat Fault Study" by William Lettis & Assoc. Inc. (Figure 4.5-2, on page 4.5-13). This figure was replaced by another, modified figure, on page 3-9 of the Final EIR, without any reference to the author/source of the modifications, date or reason for the modifications. There should have been a proper explanation attached to this new figure, as to what was changed and why, since it is related to that critical East Canyon landslide, undermining LBNL's Hazardous Waste Handling Facility!
Indeed, the entire EIR provides no information or discussion regarding any investigations performed to determine the depth, width and length of each of the 3 landslides impacting the projects at B 71, B 25 complex and B 85 complex sites. No discussion or analysis or proposals as to how to actually remedy the landslides themselves, by removing the hazardous soils etc. No serious discussion was provided for the consideration of alternate sites either.

In conclusion, we again urge you not to certify the EIR before you.

Elevated Life Safety Risks will continue as long as LBNL operates at the current site on the unconsolidated soils of a collapsed caldera. The EIR projects a false sense of safety, as it ignores the fact that what ever is done structurally to the buildings, does not remedy the instability of the site. The conditions of the land are the dominant hazard features, not the buildings alone! The EIR offers only superficial mitigations, as if a landslide could be stopped by a row of toothpicks, as is the case with the lab's Hazardous Waste Handling Facility (HWHF) proposal.

No new structures should be erected at LBNL's known landslide areas, and it is imperative that the HWHF be relocated outside the seismic and wild land fire hazard zone to a more stable ground, away from residential populations. The same applies to the GPL building.

Taxpayer funds are scarce, whether it is state/UC funding or federal ARRA/DOE funding, good money should not be thrown after bad places.

We therefore propose the consideration of the old NUMMI plant in Fremont as the new Lawrence Fremont National Laboratory, to be LBNL's II Campus. Five million square feet of laboratory/office/ research and manufacturing space already built is immediately available. Tesla Motors will occupy only some 5% of the facility. (Attachment 4.)

And lastly, LBNL is a nuclear industrial complex, with radioactive and hazardous releases in Berkeley's Strawberry Canyon since the 1940s. It would be imperative for UC/LBNL to clean up the canyon lands and waters and restore them to their pre-industrial state, and start a new campus somewhere else with better regulations, technologies to prevent future releases into the atmosphere. There is NO SAFE DOSE OF IONIZING RADIATION was the June 2005 finding of the National Academy of Sciences Panel: BEIR VII, Committee on Biological Effects of Ionizing Radiation. (Attachment 5.)

Save Strawberry Canyon from future development, restore it to its natural state.

Sincerely,

Pamela Sihvola, Co-chair
CMTW
P. O. Box 9646
Berkeley, CA 94709

cc: Leslie Schilling, Chair, UC Regents Committee on Grounds and Buildings

ADDENDUM Geology of the East Canyon and the proposed Hazardous Waste Handling Facility, Lawrence Berkeley National Laboratory, a Study (April 1993) to be hand-delivered at the BG Committee meeting on July 13, 2010.

ATTACHMENT 2.
(8 PAGES)

DOE/EA - #1634

FINAL ENVIRONMENTAL ASSESSMENT FOR

THE LAWRENCE BERKELEY NATIONAL LABORATORY SEISMIC LIFE-SAFETY, MODERNIZATION AND REPLACEMENT OF GENERAL PURPOSE BUILDINGS, PHASE 2B

U.S. DEPARTMENT OF ENERGY

Volume 2

August 2010

3.

ATTACHMENT 2.
(8 PAGES)

Committee to Minimize Toxic Waste

DOE/SLSII/DEA
COMMENTS#1of5

Kim Abbott, NEPA Document Manager
Department of Energy, Berkeley Site Office
One Cyclotron Road, MS 90-1023
Berkeley, CA 94720

July 26, 2010

Re: Comments on the Draft Environmental Assessment (DEA) for a project titled: The Lawrence Berkeley National Laboratory (LBNL) Seismic Life-Safety, Modernization and Replacement of General Purpose Buildings, Phase 2B.

Dear Mr. Abbott,

Landslides at LBNL have created havoc at the site since the inception of the University of California Radiation Laboratory (UC Rad Lab) in the 1940s. Attachment 1. "Chronology of the Campus Hill Area Development and Slope Instability Through 1984" is especially noteworthy, since it shows how major slides started occurring immediately after and as a result of construction on the hill.

The Department of Energy (DOE) has not fulfilled its obligation under the National Environmental Policy Act (NEPA) to adequately describe, analyze and consider the natural and man-made hazards at each of the sites of the proposed Seismic Life-Safety Phase 2B project (the Project). Indeed, the 43,000 square foot General Purpose Laboratory (GPL) building is proposed to be constructed in the Old Town/Strawberry Canyon Landslide Area on top of the most contaminated soils and groundwater contamination plumes extending under the entire B25/GPL site. In the East Canyon, B85 Complex, the lab's Hazardous Waste Handling, Storage and Treatment Facility is undermined by the East Canyon Slide and the yet unknown, undetermined impacts/influences and transport paths of the millions of gallons of perched groundwater along the Wildcat Fault! And in the Blackberry Canyon B55 and B71 sites are impacted by the Blackberry Canyon slide, radioactive and chemical contamination in soil and groundwater and the influences of springs, earthquake faults and the North Fork of Strawberry Creek.

In an article "Geologist reveals nature's plan in Berkeley hill walk" (Hills Publication/Berkeley Voice February 24, 1994) retired geologist Hal Wollenberg states: "One plant engineer said this is the last place to build a national laboratory," about the unstable ground (Attachment 2.) And yet, the projects continue with deficient analysis fueled by the seemingly unending taxpayer funded ARRA monies! (Attachment 3 A & B)

Again, DOE has failed to follow NEPA regulations regarding communicating with the public the most important information pertaining to the LBNL site, including, but not limited to the critical significance of the CURTIS CALDERA, inside which LBNL buildings are located, including all the components of this Project, on the unconsolidated melange of volcanic fragmental debris left behind when the caldera collapsed. (Attachment 4 A & B)

In fact LBNL is located in the northwestern crater (Curtis Caldera) of the Sibley Volcanic Cluster, connected to the Sibley Volcanic Regional Preserve of the East Bay Regional Park District.

Information provided by the Sibley Volcanic Preserve states the following: " 10 million years ago volcanic eruptions began near what is now Round Top Volcano in Sibley Park. The magma may have risen through a fractured zone now known as "Wildcat Fault". Two volcanic centers developed here: a larger volcano rose to the west; a smaller cone (Round Top Volcano) formed on the eastern flank of the larger. The two eruptive centers were separated by the Wildcat Fault, a branch of the large Hayward Fault System.

9 million seven hundred thousand years ago a violent eruption blew the lid off the larger volcano. Rhyolite ash spread over 3 counties. Ash deposits have been traced many miles to the east and south - and can be found today 40 miles north at Sears Point. Following this great eruption, the volcano collapsed to form a crater or "caldera" 2 miles long and a mile wide. The Lawrence Berkeley Laboratory is now located on the deeply eroded remains of this volcanic caldera."

The Sibley Volcanic Preserve's informational brochure further states: "How many volcanos? Round Top is the obvious one. There are smaller ones outside the Preserve to the north and southeast. Another, of rhyodacitic composition (rather like the ash from Mount St. Helens), underlies the Lawrence Berkeley Laboratory and Little Grizzly Peak in Tilden Regional Park. About 9.8 million years ago it was erupting beside Round Top. Subsequently it was shifted about 3.5 miles north-west by movement along Wildcat Fault. That makes a total of 4 volcanos." (Attachment 5, 2 pages).

The proposed Project does not assure, as required by NEPA, "safe, healthful surroundings", due to the UNMITIGABLE nature of the site itself. Elevated Life-Safety Risks will continue at the lab as long as LBNL operates at the current site on the unconsolidated soils of the collapsed caldera. The DEA projects a false sense of security/safety as it ignores the fact that seismic upgrading of buildings does not remedy the instability of the site. Indeed, CONDITIONS OF THE LAND ARE THE DOMINANT HAZARD FEATURES, NOT BUILDINGS ALONE!

The Curtis Caldera at LBNL is like a giant bowl, basin, syncline holding millions of gallons of water, perched groundwater, at various elevations causing instability in the hillside soils, landslides. Groundwater moves along the many earthquake faults at the lab site, comes up to the surface from springs, associated with the faults, continually causing havoc. (Attachment 6.)

Of special interest is the presence and movement of groundwater along the Wildcat Fault in the East Canyon at LBNL's Hazardous Waste Handling Facility site, B 85 complex. We understand that a project/study, titled NUMO, funded by the Japanese Nuclear Waste interests, is presently investigating the movement of water along the Wildcat Fault.

The DEA is extremely deficient in addressing concerns related to soils and groundwater. Indeed, the DEA completely excluded the analysis of soils (IV.B.6./p.49/53), and the importance of groundwater, its impacts on soils and movement along faults (IV.C.3./p.79) We therefore request that a full-scale EIS (Environmental Impact Statement) be prepared to address these and other concerns. We also ask that the findings of the NUMO Study, including the analysis of ⟶ the two 500 feet deep soil borings, taken at the HWHF site be included in the EIS.

As Attachment 7. we are enclosing the HYDROGEOLOGIC INVESTIGATION section (#5) of the Converse Consultants, Inc. 1984 HILL AREA DEWATERING AND STABILIZATION STUDIES, illustrating the continuing nature of slope stability problems at LBNL.

Another glaring omission of the DEA was the total exclusion of analysis of Hazards from Wildfires under Cumulative Effects (V.B./p.160). LBNL is located in a High Risk Wildland Fire Zone/Critical Fire Area (California Fire Hazard Severity Zone).
In 1991, when some 4000 structures burnt in the Berkeley-Oakland Hills Firestorm, just 3/4 miles from LBNL, one canyon away, the entire lab was evacuated. The lab director gave orders to the 2 remaining firefighters at the lab's firestation to evacuate, all LBNL firetrucks had already been sent to Oakland, and thus the Nuclear-Industrial Complex, in the middle of a residential neighborhood, during a historic firestorm was left alone, unprotected.

What indeed are LBNL's plans to fight a radioactive fire? What plans are in place to protect the surrounding residential neighborhoods from radioactive fallout? Are there any coordinated efforts to evacuate surrounding residents, some only some 100 meters from LBNL's fenceline? The more laboratory buildings in the canyon, the more chemical and radioactive materials and waste will result, all of this needs detailed analysis in a full-scale EIS!

We also ask that the EIS include the entire transcript from LBNL's July 8, 2010 Community Advisory Group (CAG) meeting. The agenda included presentations and discussions related to LBNL geology and geotechnical status of the Berkeley Lab site, as well as comments from concerned members of the public. (Attachment 8) Many conflicting statements were made by LBNL geotechnical experts.

Also, after reviewing some of LBNL's geotechnical reports associated with the DEA projects, it appears that extreme time pressure was put on contractors. For instance Alan Kropp & Associates (AKA) Memorandum of May 29, 2009 regarding B25 Slide Investigation, states: " The preliminary study was conducted over a two week-period in order to meet LBNL schedule objectives. For this reason, the scope of our investigation and analyses were limited to what could be reasonably completed within the targeted timeframe." The study contained data sheets for 3 test borings, first numbered as WLA-B 1 to3 (William Lettis & Associates), then changed to AKA 1 to 3, with a notation that AKA-3 was AKA-4 (?), there were references to 25 photos, which were not included in our copy, and a page titled Soil Boring Locations Near Bldg's 25&48, without any map showing the boring locations.

An other report by Furgo William Lettis & Associated, dated December 10, 2009 regarding LBNL B25-Core Review for the GPL Geotechnical Study makes the following statements:"...samples appeared to be missing...samples were not readily found by FWLA in the core library. According to LBNL staff, logs for soil borings SB25-95-1 through SB25A-95-1 are not available...evaluating physical properties (e.g. stiffness and plasticity) is difficult to impossible because the samples are on the order of 10 to 15 years old and thus, the original moisture content in unknown...some key samples were not located in the core library (borings W25-95-26) and thus we are unable to evaluate the quality of these boring logs...etc."

Furthermore, Appendices attached to AKA's April 2, 2010 Report regarding geotechnical investigations GPL at B25 Site, included Logs of Borings by AKA/WLA, Logs of Borings from Previous Geotechnical Reports by Others and Logs of Previous Environmental Borings by LBNL but excluded all reports and conclusions. We therefore ask that all these reports be included in their entirety as Appendices to the EIS! We also ask that a Report by Laurel M. Collins titled "Geology of the East Canyon and the Proposed Hazardous Waste Handling Facility, LBNL" be included as an Appendix to the EIS. (A Draft of April 1993 is enclosed as Attachment 9)

Also statements such as:" The recommendations presented herein are not intended to stabilize the site or mitigate the potential for landslide type movement", by AKA (April 8,2010, Geotechical Investigation, B71 BELLA) reflect the limitations of geotechnical experts regarding the uncertainties associated with sites, such as LBNL.

In 1998 the US Environmental Protection Agency declared LBNL eligible for listing on the National Priorities List (NPL) for Superfund clean-up.

The legacy contamination at LBNL is significant and a couple of pump and treat operations do not adequately deal with the contamination issues. LBNL has never mapped the site's hydrostratigraphic units (HSUs) to better understand the hydraulic connection between various permeable layers of the HSU's sedimentary sequences to facilitate a more accurate construction of groundwater flow and contaminant fate-and-transport model. We ask that DOE fund a rigorous mapping of all the HSUs associated with the Project sites and that this mapping be included in the EIS. Section IV.C.2 was superficial and did not adequately address the serious contamination present at LBNL. As a reference to groundwater cleanup we include a presentation by Lawrence Livermore National Laboratory's Site Restoration Program Leader, available at UC Water Resources Center Archives' website. (Attachment 10.)

After 70 years in Strawberry Canyon, it is time for LBNL to move offsite to better facilitate the vision of its current director Alivisatos (Attachment 11, p.2) to reorganize the lab's physical layout and create a second campus. The lab's antiquated concept of co-locating research (buildings) should be changed to embrace a modern "Global Network University" concept with "Portals" (campuses) not just in different cities but countries, which is the cutting edge trend among universities (NYU) and other institutions of higher learning.

To exercise the principle of co-locating research in every day lab life is impossible, based on the DEA's description (IV.B.7./p.54) of lab practices to prevent Intentional Destructive Acts. "The entire LBNL site is fenced, and controlled access is available only at three entry gates. Card keys would be used for building access... The building would have a guard on the door during normal business hours and card key access. " Indeed, no one from the outside, even from labs next door can casually walk in and "exchange ideas", as is continually purported by LBNL officials. In fact access to any building/lab/office is strictly controlled and available only on a "need to know" basis.

For the reasons stated above, we ask that LBNL very seriously consider expanding the co-location concept to the entire Bay Area, i.e. consider alternative locations for the second campus in Richmond (Richmond Field Station), Vallejo (Mare Island), Oakland (former Navy Base), Alameda (former Naval Station) and in Fremont (former NUMMI plant/See attachment 12.) to avoid continuing logistical, environmental, geotechnical constraints and legal challenges, currently crippling LBNL and its future!

Since this Project is so huge, expensive and controversial, we are submitting all of our 3 previous comment letters*to the CEQA process to be considered (and responded to) as comments to the NEPA DEA process. Especially we ask you to review our report titled: "Contaminant Plumes of the Lawrence Berkeley National Laboratory and their Interrelation to Faults, Landslides, and Streams in Strawberry Canyon, Berkeley and Oakland, California", specifically sections dealing with Contaminant Sites, both regarding chemical and hazardous contamination and radioactive contamination, Drainage Network Mapping, Geologic "Bedrock" (Formation) Mapping, Fault Mapping, Landslide Mapping, Plume Monitoring Sites and Zones of Concern for Potential Plume Migration, as well as Future Development and Site Conditions and in conclusion our General Recommendations warrant careful consideration in the full-scale EIS, as they all deal with concerns related to Project sites, i.e. B85 complex, B25 complex (GPL) and B 71/55 sites of the DEA. (Attachment 13).

Inadequacies of the DEA are blatant, uncertainties associated with these sites enormous, "Detailed information concerning significant environmental impacts" (required by NEPA) were glaringly missing, thus denying decision makers the ability to adequately assess all potential and existing environmental risks associated with the Project. THUS A FULL-SCALE EIS IS REQUIRED, especially since significant amounts of public, taxpayer funds under ARRA are proposed to be committed to this ill conceived Project with extreme risks inherent at the site.

Sincerely, [signature]

Pamela Sihvola
Co-chair, CMTW
P.O. Box 9646
Berkeley, California 94709

* Our comments on the DEA are organized in 5 sections titled:
DOE/SLSII/DEA
COMMENTS#1of5 through #5of5

DOE/EA - #1634

FINAL ENVIRONMENTAL ASSESSMENT FOR

THE LAWRENCE BERKELEY NATIONAL LABORATORY SEISMIC LIFE-SAFETY, MODERNIZATION AND REPLACEMENT OF GENERAL PURPOSE BUILDINGS, PHASE 2B

U.S. DEPARTMENT OF ENERGY

Volume 2

August 2010

7.

APPENDIX C

PUBLIC AND AGENCY COMMENTS ON THE DRAFT EA

This Appendix includes a list of agencies, persons, and organizations commenting in writing and a reproduction of each comment letter received during the 30-day public review period. Letters are reproduced in the order shown on the list of commentors below:

A. *List of Persons and Organizations Commenting in Writing*

- George Leitmann, July 19, 2010.
- Terri Compost, July 19, 2010.
- William Kirkpatrick, Manager of Water Distribution Planning Division, East Bay Municipal Utilities District, July 19, 2010.
- Wanda C. Bronson, July 20, 2010.
- Emilie Strauss, July 24, 2010.
- Georgia Wright, July 26, 2010.
- Laurie Sarachan, July 25, 2010.
- Carole Schemmerling, July 27, 2010.
- Jennifer Mary Pearson, July 28, 2010.
- Stephanie Thomas, July 28, 2010.
- Charlene M. Woodcock, July 28, 2010.
- Mary Lee Noonan, July 29, 2010.
- Gale Garcia, July 28, 2010.
- Gene Bernardi, July 14, 2010.
- Barbara Robben, undated.
- Georgia Wright, Save Strawberry Canyon, July 27, 2010.
- Pamela Sihvola, Committee to Minimize Toxic Waste, July 26, 2010.

ATTACHMENT 3.

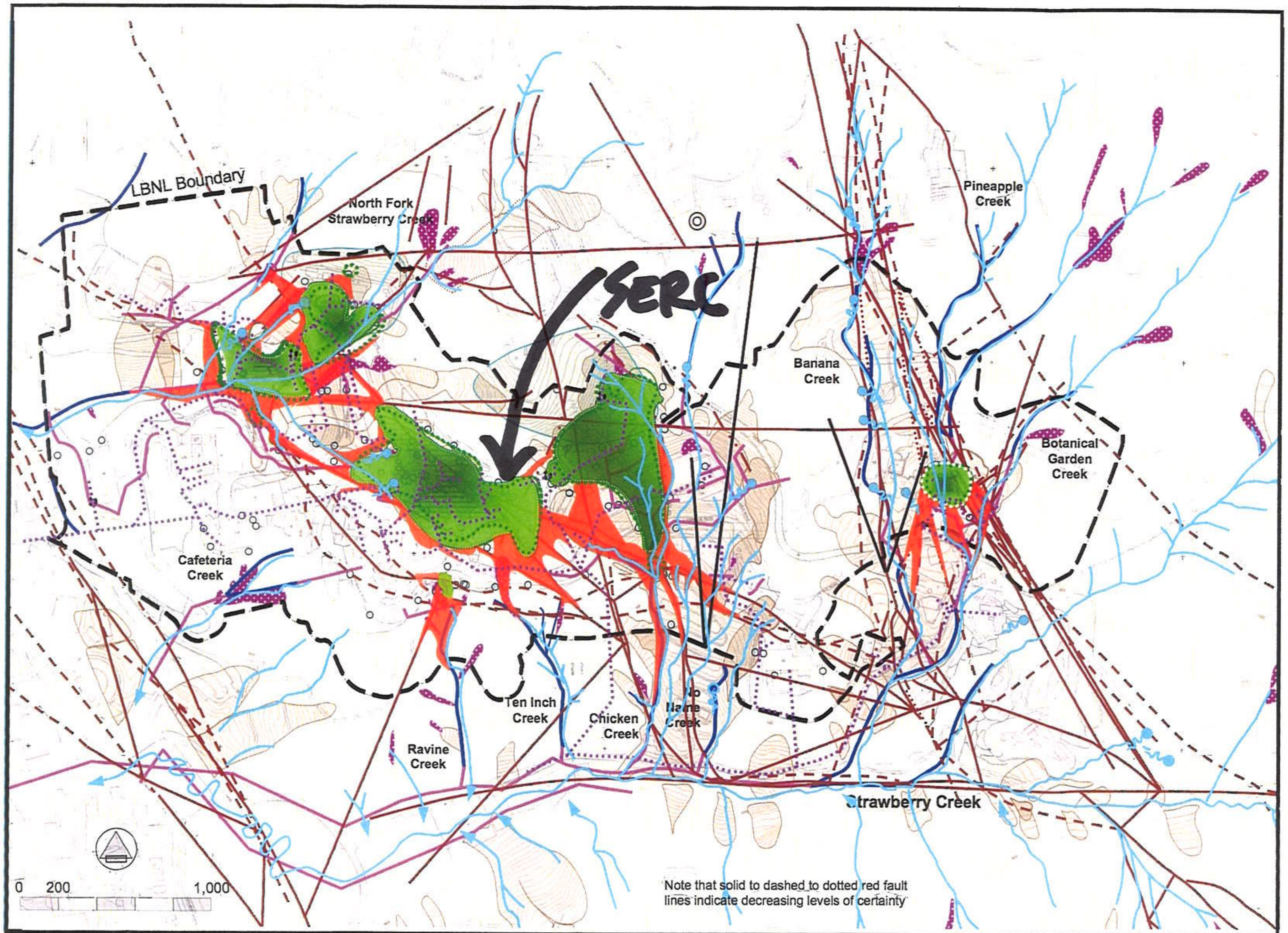

FIGURE 18a. ZONES OF CONCERN FOR GROUNDWATER PLUME EXPANSION ALONG COMPILED FAULTS, BEDROCK CONTACTS, LANDSLIDES, HISTORIC AND MODERN CREEKS. SEE NEXT PAGE FOR MAP LEGEND.

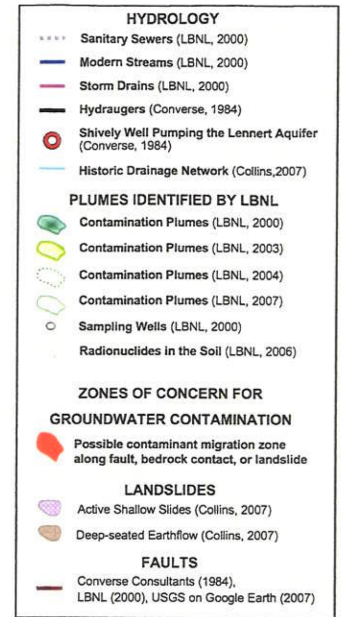

FIGURE 18b. LEGEND TO POTENTIAL FACTORS INFLUENCING CONTAMINATED GROUNDWATER PLUME EXPANSION

ATTACHMENT 4.

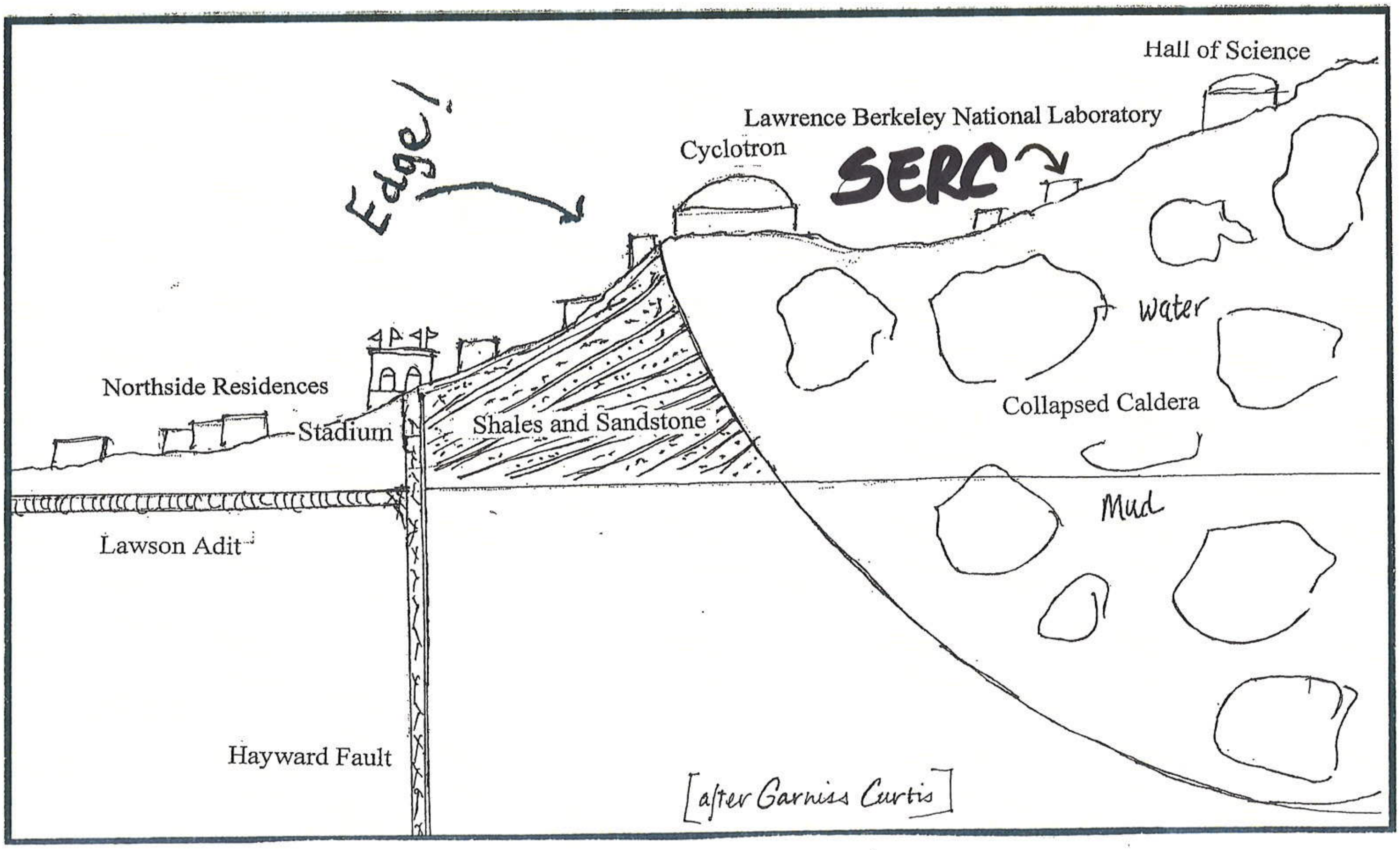

Figure above shows an unknown mixture of mud, perched water and boulders, for which LBNL has yet to do a comprehensive hydrogeological study of its composition. Also missing is the mapping of LBNL's hydrostratigraphic units (HSUs), which would show the hydraulic connection between various permeable layers of the HSUs sedimentary sequences.

ATTACHMENT 5.

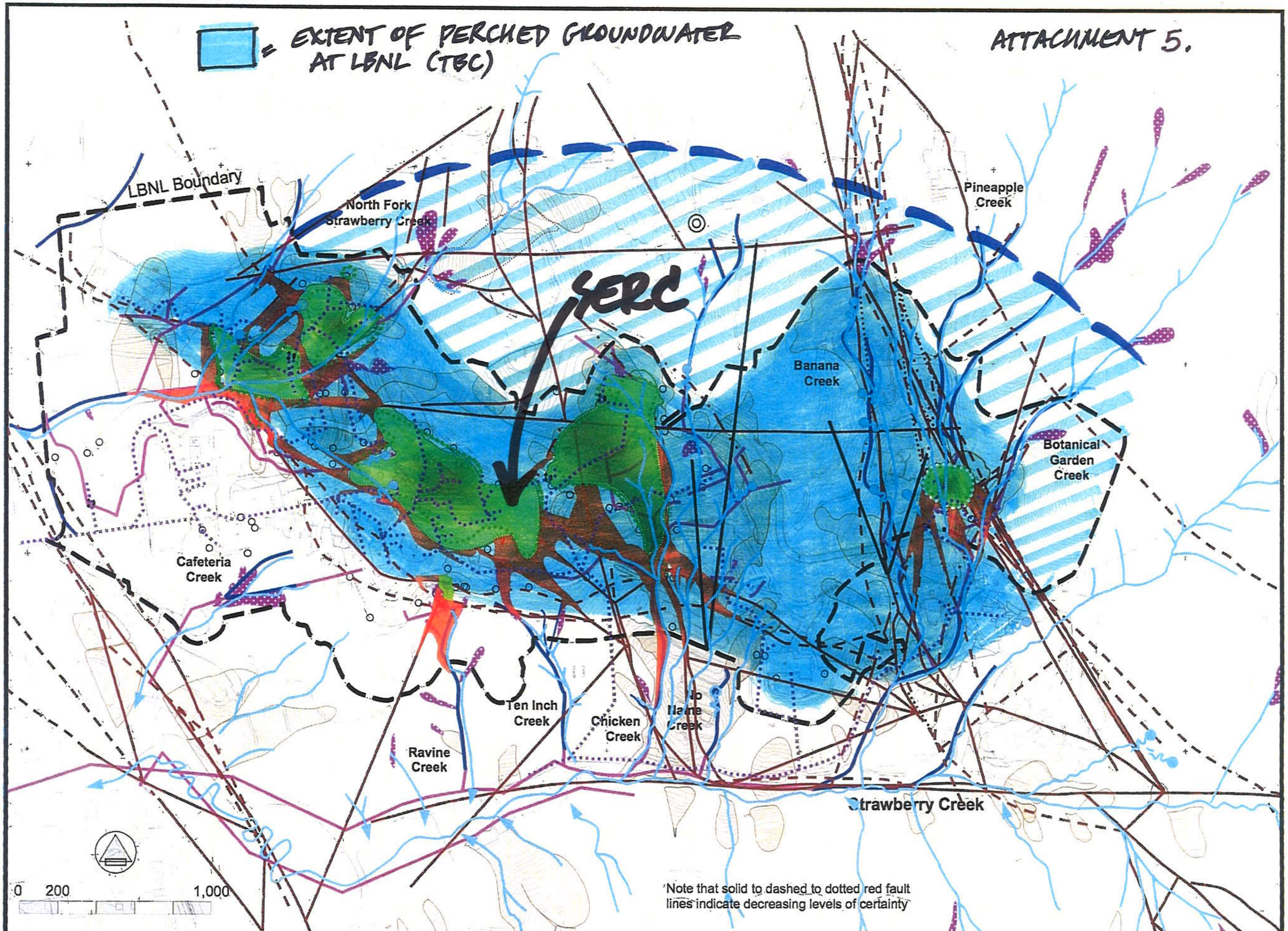

FIGURE 18a. ZONES OF CONCERN FOR GROUNDWATER PLUME EXPANSION ALONG COMPILED FAULTS, BEDROCK CONTACTS, LANDSLIDES, HISTORIC AND MODERN CREEKS. SEE NEXT PAGE FOR MAP LEGEND.

ATTACHMENT 6.

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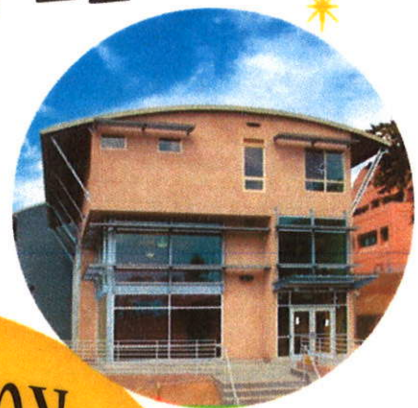

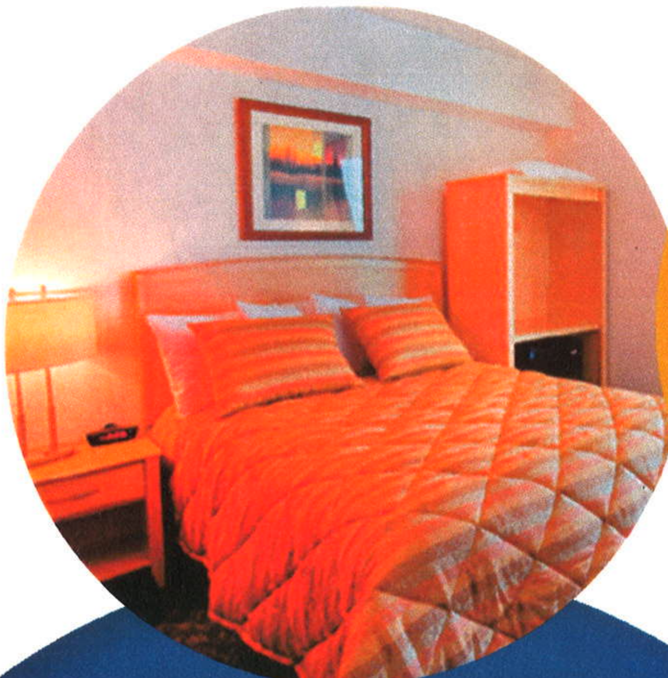

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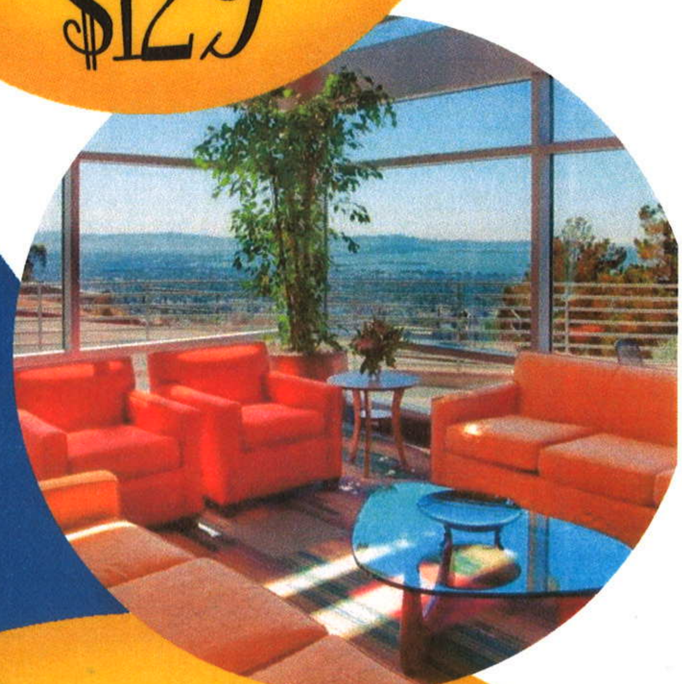

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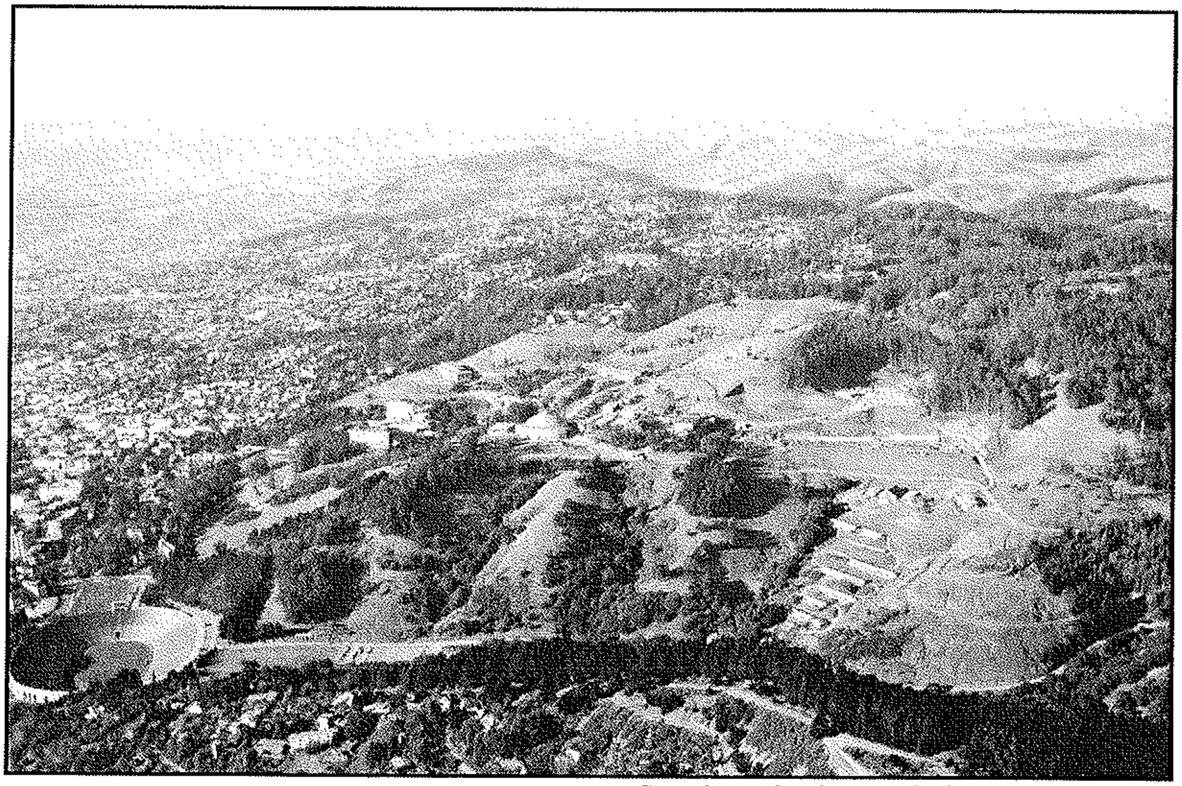
ATTACHMENT 7.

CONTAMINANT PLUMES OF THE LAWRENCE BERKELEY NATIONAL LABORATORY AND THEIR INTERRELATION TO FAULTS, LANDSLIDES, AND STREAMS IN STRAWBERRY CANYON, BERKELEY AND OAKLAND, CALIFORNIA

March 2007



Strawberry Creek Watershed ca. 1965

Laurel Collins, Geomorphologist
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collins@lmi.net

for

Pamela Sihvola, Project Manager
Committee to Minimize Toxic Waste
P.O. Box 9646
Berkeley, California 94709

9.

ATTACHMENT 7.
(55 PAGES)

CONTAMINANT PLUMES OF THE LAWRENCE BERKELEY NATIONAL LABORATORY AND THEIR INTERRELATION TO FAULTS, LANDSLIDES, AND STREAMS IN STRAWBERRY CANYON, BERKELEY AND OAKLAND, CALIFORNIA

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INTRODUCTION

The Lawrence Berkeley National Laboratory (LBNL), initially called the UC Radiation Laboratory, was originally located on the University of California Berkeley (UCB) central campus in Alameda County during 1932. By 1940, it was relocated to its present site in the steep hills of Strawberry Canyon east of the Hayward Fault and the central UCB campus (Figure 1). The first major facility, the 184-inch synchrocyclotron was built with funds from both private and university sources, and was used in the Manhattan Project in the development of the world's first nuclear bomb. Beginning in 1948 the U.S. Atomic Energy Commission and then its successor agency, the Department of Energy (DOE) funded the lab while it continued to expand its facilities in Strawberry Canyon.

Numerous geotechnical investigations have been conducted during the past six decades as LBNL expanded while also experiencing problems with slope stability. The many geotechnical and environmental reports generated by LBNL, as well as research from local academic, state, and federal entities, indicate that minimal agreement has existed among scientists on the location of bedrock contacts or location and status of earthquake faults and landslides in the Canyon.

This is important because LBNL has been required to monitor radioactive accidents and chemical releases that have contaminated the groundwater and tributary streams of Strawberry Creek, which flow westward from the jurisdictional boundaries of Oakland to Berkeley and the UCB Campus. There has been concern by the public that mitigation to protect public health might be compromised by the lack of comprehensive (and agreed upon) information on the potential transport pathways of contaminants along bedrock contacts, faults, and landslides. Without such information, the array of sampling wells

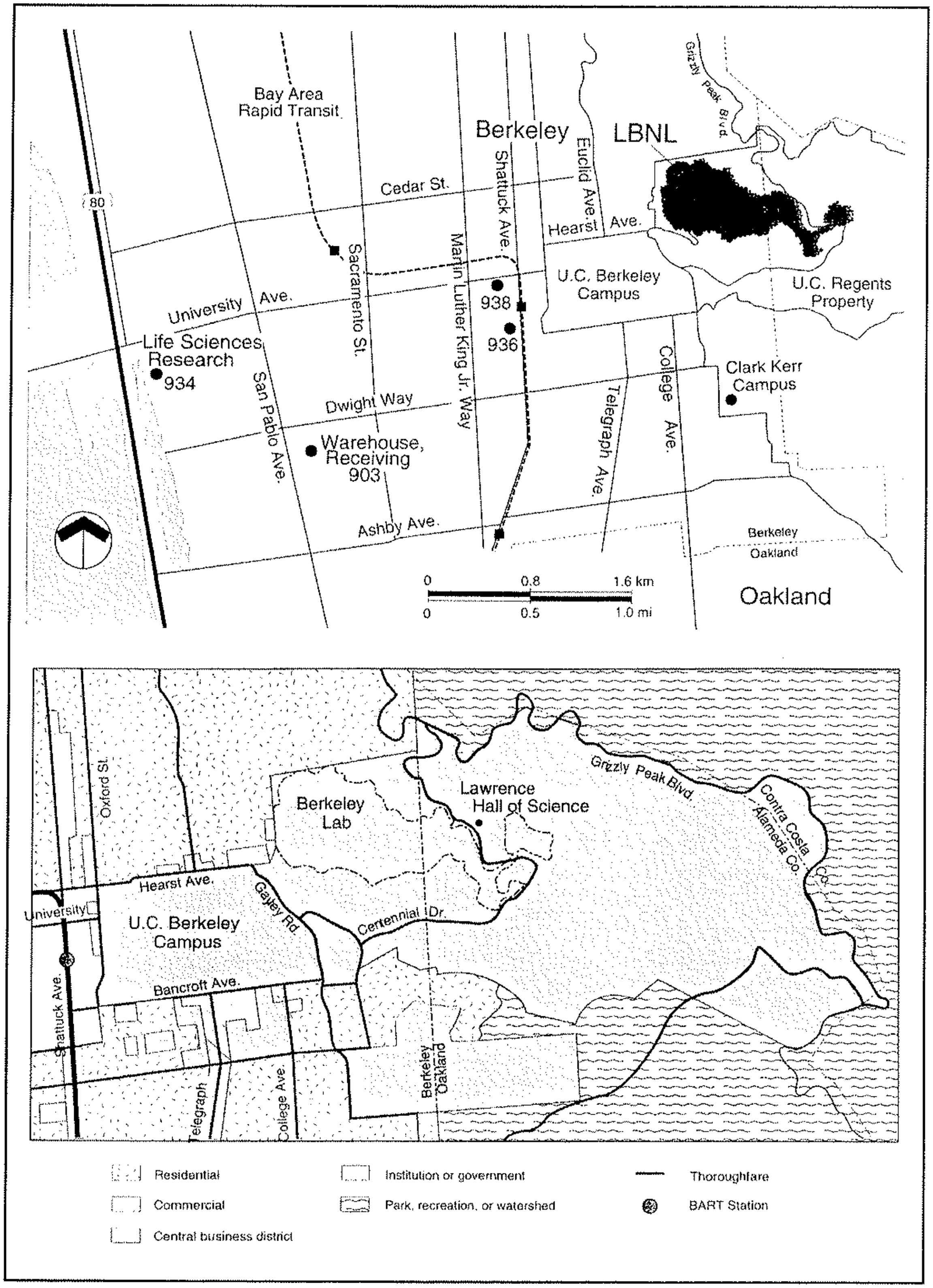


FIGURE 1. VICINITY AND ADJACENT LAND USE. Source: LBNL RCRA Facility Investigation Report, (also known as LBNL, 2000).

designed to monitor contaminant migration have not been strategically placed to define the limits of contamination or potential plume migration. During 1991, the Department of Energy's (DOE) Tiger Team found 678 violations of DOE regulations that cover management practices at LBNL. A key finding was that air, soil, and water in Berkeley and Oakland are contaminated with tritium and other radioactive substances and toxic chemicals.

Our project and this report "Contaminant Plumes of the Lawrence Berkeley National Laboratory and their Interrelation to Faults, Landslides, and Streams in Strawberry Canyon, Berkeley and Oakland, California" was supported by a grant from the Citizens' Monitoring and Technical Assessment Fund (MTA Fund) to the Committee to Minimize Toxic Waste (CMTW). The report addresses the need to compile and develop publicly accessible maps of Strawberry Canyon, which show the geologic and geomorphic characteristics that might influence ground and surface water movement near known LBNL contaminant sites. The intent of this map compilation project is to show where there is or is not agreement among the various technical reports and scientific interpretations of Strawberry Canyon. This report can be found on the following web site: http://www.cmtwberkeley.org

OBJECTIVES

The specific objectives of the project were:

1) Help define or show where there is potential confusion or disagreement about the location of geological units and associated faults by showing interpretations by various science organizations.
2) Help define the historical channel and landslide network.
3) Locate verifiable bedrock outcrops as the basis for geologic interpretation;
4) Identify sites of slope instability, especially those associated with groundwater, and landslides;
5) Synthesize surface geotechnical information with contaminant plume information for the greater Strawberry Canyon area on a common base map.
6) Post results of technical report on CMTW's web site.

This project provides necessary information to better evaluate the status of existing geological knowledge for Strawberry Canyon and the potential for contaminant migration pathways at existing plumes sites. By achieving a common base of understanding, a more effective monitoring and mitigation plan can be developed for the contamination sites. Benefits will also be provided for future geotechnical investigations during expansion of facilities at either LBNL or UCB. We have started by compiling available information on a series of overlays that show:

a) Current stream and storm drain network, and all sewer lines and hydraugers, delineation of the Lennert Aquifer;

b) Interpretation of historic drainage network and springs as indicated on the Map of Strawberry Valley and Vicinity Showing the Natural Sources of the Water Supply of the University of California, by Frank Soulé, Jr. 1875;
c) Geology;
d) Faults, seismicity, and Alquist Priolo Earthquake Fault Zone;
e) Landslides;
f) Areas of contamination evaluated in the Resource Conservation and Recovery Act (RCRA) process;
g) Additional toxic sites located outside the LBNL fence line, but on UC land, such as the old waste pit at the former Chicken Creek animal husbandry site as well as groves of trees and vegetation, south of the Lawrence Hall of Science, contaminated with tritium (radioactive hydrogen) in soil;
h) Topography with building sites, and roads.

REPORT ORGANIZATION

This report is specifically designed to demonstrate what is known about the key components of Strawberry Canyon that can influence surface and subsurface water transport, particularly near infrastructure and known contaminant plumes at LBNL. We have taken the key elements of surface drainage, geology, faults, and landslides and divided them into distinct subsections for this report.

We first provide a General Site Description and then provide information about the Contaminant Sites. This is followed by a brief discussion of Methods used in this report to produce original maps and compile existing information. Within the Results section, each subsection on Surface Drainage, Geology, Fault mapping, and Landslides provides background information and a few smaller scale maps showing recent interpretations. Larger maps are provided to show compilations of recent information.

These compilations are used to determine whether there is agreement by different researchers about the location of faults, bedrock contacts, or landslides. Each compilation map shows the contaminant plumes in the context of the different physical elements to determine if those elements could have potential influences on contaminant transport. The Plume Monitoring Sites are then shown to indicate the array and position of sampling and monitoring wells. This latter information is presented in much detail in several online documents produced by LBNL (2000, 2003, 2004 and 2007) that can be downloaded from their web site (www.lbl.gov/ehs/index2.shtml).

Within the Results subsection, a map on Zones of Concern is provided that indicates potential groundwater migration sites near each plume that might not be adequately sampled or understood given the present status of knowledge of factors that can influence groundwater transport. A map showing Future Development and Site Conditions and the compilation of potential factors that could influence plume migration is shown as the final map within the Results section. Conclusions and General Recommendations are provided at the end of the report.

GENERAL SITE DESCRIPTION

LBNL is located in a very seismically active area, next to the Hayward Fault on the steep west facing slopes of the Berkeley Hills within the 874-acre Strawberry Canyon. Figure 2 shows the location of the Alquist Priolo Earthquake Fault Zone and the footprint of buildings and roads in Strawberry Canyon. It also shows the location of several known contaminant plumes that are monitored by LBNL. The nature of these plumes is discussed further in the section on Contaminant Sites. The building sites and their associated numbers are shown in Figure 3a, while Figure 3b provides a legend to the building numbers.

Topographic relief in the canyon ranges from 400 feet to 1800 feet, whereas elevations within the LBNL boundary range from about 500 feet to 1000 feet. The Mediterranean climate of the Coast Ranges produces a mean annual rainfall of about 28 inches. Within the LBNL site, two major east-west trending creeks, Strawberry and North Fork of Strawberry, have perennial flow that drains respectively through Strawberry and Blackberry Canyons toward the City of Berkeley and the San Francisco Estuary.

CONTAMINANT SITES
Chemical and Hazardous Contamination

LBNL operations fall under a Resource Conservation and Recovery Act (RCRA) Hazardous Waste Facility Permit. The Permit requires that LBNL investigate and address historic releases of hazardous waste and hazardous constituents within their property as part of the RCRA Corrective Action Program. LBNL's Environmental Restoration Program is responsible for carrying out these activities.

Waste products at the LBNL have included solvents, gasoline, diesel fuel, waste oils, polychlorinated biphenyls (PCBs), Freon, metals, acids, etchants, and lead and chromate based paints. According to the LBNL RCRA Facility Investigation (RFI) Report (2000), the primary contaminants detected in soil and groundwater at LBNL have been volatile organic compounds (VOCs) including tetrachloroethene (also known as tetrachloroethylene or perchloroethene [PCE]), trichloroethene (also known as trichloroethylene [TCE]), carbon tetrachloride, 1,1-dichloroethene (1,1-DCE), cis-1, 2-dichloroethene (cis-1, 2-DCE), 1,1,1- trichloroethane (1,1,1-TCA), and 1,1-dichloroethane (1,1-DCA). Some of these are common solvents and degreasers that have been used at LBNL for equipment cleaning. Smaller concentrations of other VOCs (e.g., benzene, toluene, ethylbenzene, and xylenes [BTEX]; chloroform; and vinyl chloride) have also been detected.

The LBNL RFI (2000) reported that contamination of soil and groundwater by petroleum hydrocarbons was associated with former underground storage tank sites and that PCB contamination has been primarily associated with spilled transformer oils and waste oil tanks. Freon- 113, a coolant for experimental apparatus, has been detected in groundwater south of Building 71.

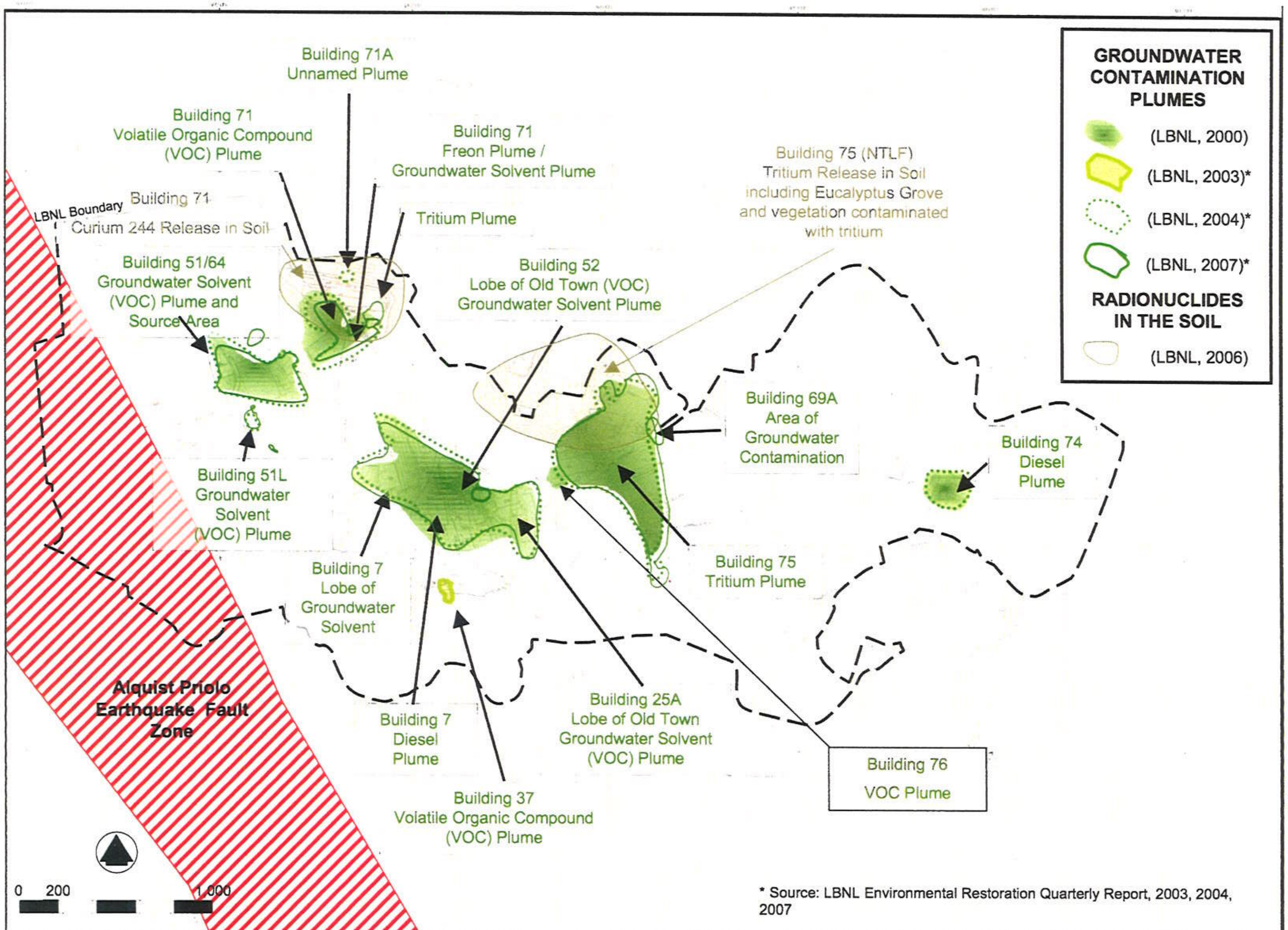


FIGURE 2. LBNL SITE MAP, GROUNDWATER CONTAMINATION PLUMES AND CONTAMINATED SOIL SITES.

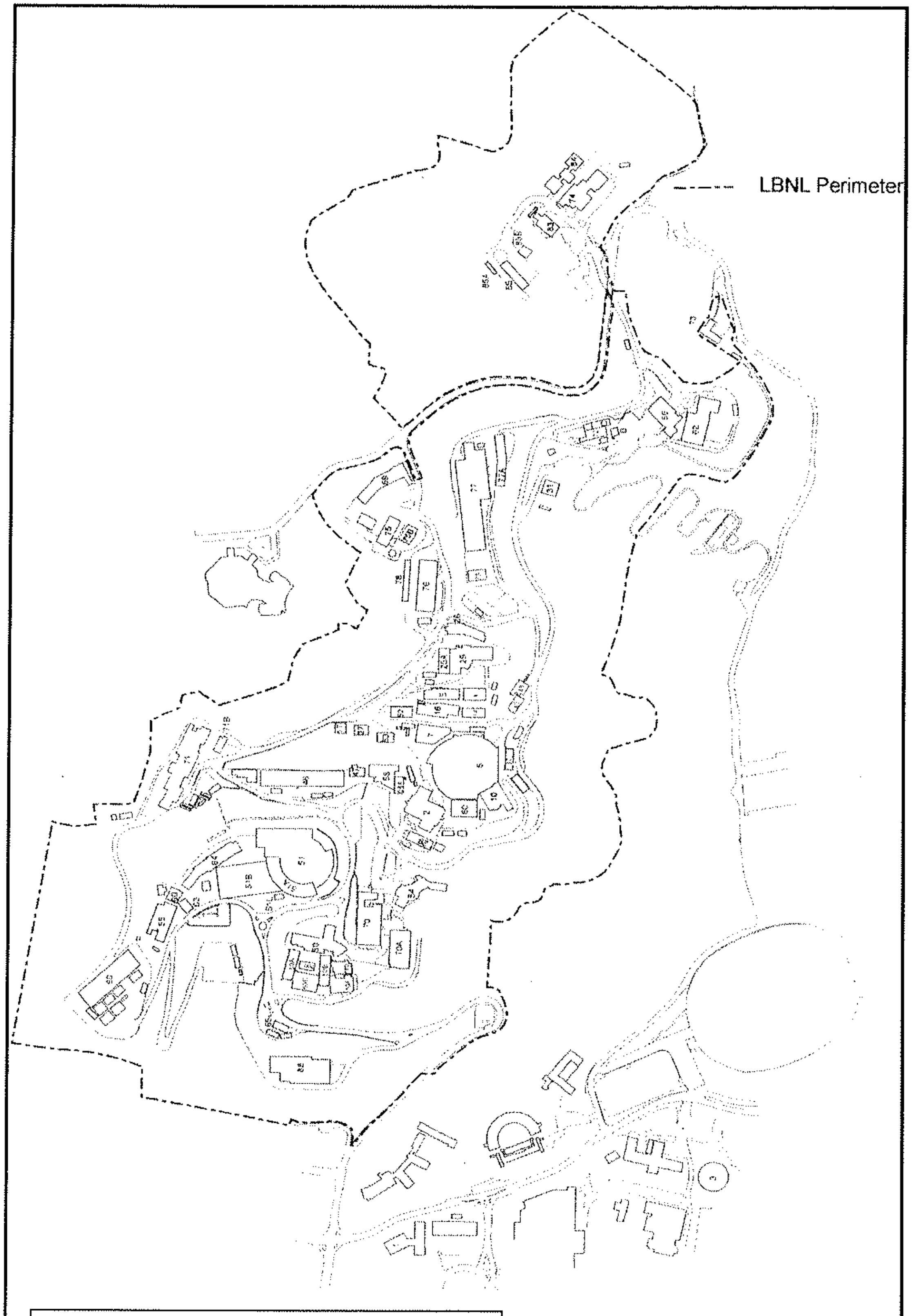


FIGURE 3a. BUILDINGS AT LBNL.
Source: LBNL RCRA Facility Investigation Report, (also known as LBNL, 2000).

2	Advanced Materials Laboratory (AML)	55	Life Sciences
2a	Materials Storage	55A	Life Sciences
4	ALS Support Facility	55B	Emergency Generator
4A	Safety Equipment Storage	55C	Life Sciences
5	Accelerator and Fusion Research	56	Biomedical Isotope Facility
5A	Mechanical Storage	58	Heavy Ion Fusion
5B	Electrical Storage	58A	Accelerator Research & Development
6	Advanced Light Source (ALS)	58B	Lubricant and Solvent Storage
7	ALS Support Facility	60	High Bay Laboratory
7A	Radio Shop	61	Standby Propane Plant
7C	Office	62	Materials & Chemical Sciences
10	ALS Support Facility	62A	Environmental Energy Technologies, Materials Sciences
10A	Utility Storage	62B	Utility Storage
13A-C	Environmental Monitoring	63	Environmental Energy Technologies
13E.F	Sewer Monitoring Station	64	B-factory, Life Sciences
13G	Waste Monitoring Station	64B	Riggers
13H	Radiation Monitoring Station	65	Site Access Office
14	Earth Sciences Laboratory	66	Surface Science Catalysis Lab, Materials Sciences, Center for Advanced Materials
16	Accelerator and Fusion Research Laboratory	67B,C	Environmental Energy Technologies
17	EH&S	67D	Mobile Infiltration Test Unit
25	Engineering Shop	67E	Environmental Energy Technologies Field Lab
25A	Engineering Shop	68	Upper Pump House
25B	Waste Treatment Facility	69	Archives and Records, Shipping
26	Health Services, EH&S	70	Nuclear Science, Environmental Energy Technologies
27	ALS Support Facility	70A	Chemical Sciences, Earth Sciences, Engineering, Life Sciences, Nuclear Science
29	Engineering, Life Sciences	70B	Utility
29A,B	Engineering	70E	Storage
29C	Environmental Energy Technologies	70G	Liquid Nitrogen Storage
31	Chicken Creek Maintenance Bldg., Earth Sciences	71	Center for Beam Physics, Ion Beam Technology
31A	Earth Sciences	71A	Ion Beam Technology, Low Beta Lab
34	ALS Chiller Building	71B	Center for Beam Physics
36	Grizzly Substation	71C,D,F,H,J,P	B-factory
37	Utilities Service	71K	Accelerator and Fusion Research, B-factory, Chemical Sciences
40	Engineering Electronics Lab	72	National Center for Electron Microscopy (NCEM)
41	Engineering Communications Lab	72A	High Voltage Electron Microscope (HVEM)
42A	Emergency Generator House	72B	Atomic Resolution Microscope (ARM)
43	Compressor Bldg.	72C	ARM Support Laboratory
44	Indoor Air Pollution Studies	73	Atmospheric Aerosol Research
44B	Environmental Energy Technologies	74	Life Sciences Laboratory
45	Fire Apparatus	74C	Emergency Generator
46	Accelerator and Fusion Research, Engineering, Environmental Energy Technologies, Photography Services, Printing	75	Radioisotope Service & National Tritium Labeling Facility (NTLF)
46A	Engineering Div. Office	75A,B,C	Environment, Health & safety
46B	Engineering	76	Facilities Shops, Motor Pool/Garage
46C, D	Accelerator and Fusion research	77	Engineering Shops
47	Accelerator and Fusion research	77A	Ultra High Vacuum Assembly Facility (UHV)
48	Fire Station	77C	Welding Storage
50	Accelerator & Fusion Research, Physics, Library	77D	Drum Liquid Storage
50A	Director's Office, Nuclear Science, physics	77H	Auxiliary Plating
50B	Physics, Computing Sciences	77J-N	Chemical Storage
50C	Computing Sciences, NERSC	78	Craft Stores
50D	Center for Computational Sciences and Engineering	79	Metal Stores
50E	Computing Sciences, Offices	80	ALS Support Facility
50F	Computing Services	80A	ALS Support Facility
51	Technical and Electronics Information	81	Liquid Gas Storage
51A	Bevatron	82	Lower Pump House
51B	External Particle Beam (EPB) Hall	83	Life Sciences Laboratory
51F, G	Nuclear Science	84	Human Genome Laboratory
51L	Computer Training Center	85	Hazardous Waste Handling Facility
51N, Q	Earth Sciences	88	88-Inch Cyclotron, Nuclear Science
52	Cable Winding Facility	88B	Compressor Shelter and Storage
52A	Utility Storage	88C	Flammable Gas/Liquid Storage
52B	ALS Support	88D	Emergency Generator
53	Environmental energy technologies	90	Copy Center, DOE Site Office, Earth Sciences, Environmental Energy Technologies
53A	Gardner's Storage	90B,F,G,H,J,K	Facilities
53B	Accelerator and Fusion Research	90C, P	Earth Sciences
54	Cafeteria	90R	Utility Storage

FIGURE 3b. KEY TO LBNL BUILDINGS SHOWN IN FIGURE 3a. Source: LBNL, 2000

The Human Health Risk Assessment (LBNL, 2003) identified chlorinated volatile organic compounds in soil and groundwater and PCBs in soil as chemicals of concern (COC) at LBNL. Prior to submission of the Corrective Measures Study (CMS) Report, Berkeley Lab completed Interim Corrective Measures (ICMs) that reduced residual PCB concentrations at the two units where PCB levels were a concern to less than the required media clean-up standard. LBNL (2007) discusses that after submittal of the Corrective Measures Implementation Work plan, elevated concentrations of PCBs were detected in shallow groundwater samples collected near the Building 51 Motor Generator Room Filter Sump, indicating PCBs were a potential COC in the soil at this location.

Groundwater is not used for drinking or other domestic water supply at LBNL. Water is supplied to LBNL and Berkeley residents by the East Bay Municipal Utility District (LBNL, 2007). In addition there are many private backyard wells in the city. Unless otherwise designated by the State's Water Quality Control Board, all groundwater is considered suitable, or potentially suitable, for municipal or domestic water supply. Exceptions to this policy are specified in State Water Resources Control Board Resolution 88-63.

Resolution 88-63 defines all groundwater as a potential source of drinking water, with limited exceptions for areas with total dissolved solids exceeding 3,000 milligrams per liter (mg/L), low yield (<200 gallons per day [gpd]), or naturally high levels of toxic chemicals that cannot reasonably be treated for domestic use. Under the Water Board's Water Quality Control Plan, groundwaters with a beneficial use of municipal and domestic supply have cleanup levels set no higher than Maximum Contaminant Levels (MCL's) or secondary MCLs for drinking water.

The following descriptions from the 2007 Draft LBNL Long Range Development Plan (LRDP) report exemplify some of the conditions and circumstances at the contaminant sites. Note that Old Town is in the general vicinity of Buildings 25 and 52, near the central land holdings of LBNL. All plumes can be seen in Figure 2. Further details can be found within the referenced reports.

> The Old Town Groundwater Solvent Plume is a broad, multi-lobed plume of VOC contaminated groundwater, which underlies much of the Old Town area. The distribution of chemicals in the plume indicates that it consists of three coalescing lobes that were originally discrete plumes derived from distinct sources. The Building 7 lobe, which contains the highest VOC concentrations of the three lobes, extends northwestward from the northwest corner of Building 7 to the parking area downhill from Building 58. Leaks and/or overflows of VOCs (primarily PCE) from the Former Building 7 Sump, an abandoned sump that was located north of Building 7, were the primary source of the Building 7 lobe. These chemicals were initially released as free product to the soil around the sump and then migrated as dense non-aqueous-phase liquid (DNAPL) into the saturated zone, forming a source zone for further migration of contaminants. Continuing dissolution of contaminants from the soil and westward to northwestward flow of the groundwater from the sump area has resulted in the development of the Building 7 lobe of the Old Town Groundwater Solvent Plume.

> Contaminated soil and groundwater were present beneath the area where Building 51L was located. The principal contaminants were VOCs that were used as cleaning solvents, or were derived from degradation of cleaning solvents. In addition, a small area of VOC-contaminated soil was present beneath the abandoned Building 51A stormdrain catch basin next to the Building 51A B-door. Contaminated soil in the bottom of the catch basin was removed in 2002. However, groundwater samples from temporary groundwater sampling point SB51A-01-8B installed through the catch basin have contained elevated VOC concentrations, suggesting the presence of additional contaminated soil beneath the catch basin.
>
> A network of subdrains and relief wells located around the perimeter of Building 51 collects subsurface water from the adjacent hillside. Water collected by this network discharges to the Motor Generator Room Filter Sump, which is part of the Building 51 internal floor-drain system. After submittal of the Corrective Measures Implementation (CMI) Work plan, elevated concentrations of PCBs were detected in shallow groundwater samples collected near the sump, indicating that PCBs were a potential COC in the soil at this location.
>
> The Building 51/64 Groundwater Solvent Plume extends south and west from the southeast corner of Building 64 beneath the former location of Building 51B. The corrective measures required for the Building 51/64 Groundwater Solvent Plume consist of operation of an in situ soil-flushing system in the up gradient portion of the plume, implementation of Monitored Natural Attenuation in the down gradient portion of the plume, and collection and treatment of water from the Building 51 subdrain system.

The location of the Building 69A Area of Groundwater Contamination is shown in Figure 2. The most likely source of the contamination was leakage from a pipeline in the Building 69A Hazardous Materials Storage and Delivery Area that drains to the Building 69A Storage Area Sump. A dislocation was observed in one of the sump drainpipes and repaired in 1987.

Radioactive Contamination

Since November 1991, the State of California Department of Toxic Substances Control (DTSC) and LBNL have identified 174 "units" of hazardous contamination in the Strawberry Creek Watershed. At least 8 of these 174 "units" were identified as having radioactive contamination. At the same time the California Department of Health Services (DHS) also participated as an additional quality assurance check and provided independent laboratory results to complement LBNL's environmental monitoring programs.

In September of 1995, the California Department of Health Services (DHS) Environmental Management Branch released the Agreement in Principle (AIP) Annual Report, which identified LBNL's National Tritium Labeling Facility (NTLF), Building 75 as a major concern for radioactive contamination in the environment. The AIP report states:

This facility (NTLF) handles kilocurie quantities of tritium (^3H) to label a variety of molecules that are subsequently employed in chemical, pharmaceutical, and biomedical research. It is conceded that releases from the tritium-stack as well as fugitive releases from Building 75 are the primary source of tritium at LBNL. Air-fall, rainout, and possibly transport in fog impacts soil, groundwater, and surface water. There is an area of tritium contaminated groundwater in the vicinity of Building 75. The Quarterly Progress Report, First Quarter FY 1992, (May 1993) reports sampling ten hydraugers, one, immediately down-slope from NTLF, reportedly contained 32,000 pCi/L of tritium.

The AIP Program collected and analyzed surface water samples, which demonstrated that tritium is detectable in surface water around LBL. The AIP further states:

One recent investigation, by Leticia Menchaca (LBNL), analyzing for tritium in transpired vapor from plants on LBNL suggest that there may be significant amounts of tritium in the upper, non-saturated, soil strata. It appears that there may be sufficient evidence to suggest that there may be more tritium in the environment than previously suspected. There are apparently no validated explanations for the appearance of tritium in streams not obviously associated with NTLF. (See Table 1)

During the above referenced investigation, tritium concentration in rainwater was detected as high as 239,000 pCi/L and 197,946 pCi/L in transpired water vapor from trees near the University of California's Lawrence Hall of Science.

Table 1. Comparison of Tritium Levels from Split LBNL Surface Water Samples
Collection Date: June 15, 1995 (Table LBNL-6c, AIP Report, 1995)

Location	AIP Results	AIP Duplicate	LBNL Results
	(pCi/L)	Results (pCi/L)	(pCi/L)
Blackberry Creek	3335 ± 255		
Claremont Creek	< 328		
Wildcat Creek	1147 ± 218	944 ± 214	
Lower Strawberry Creek	5902 ± 294		
Upper Strawberry Creek	< 328	< 328	

In addition, the AIP report expressed concern over the release of Curium-244 from Building 71, the Heavy Ion Linear Accelerator (HILAC). It states:

An area of soil near Building 71 is historically (circa 1959) reported to have been contaminated with Curium-244 when a Curium target being used in an experiment was vaporized. Some of this contamination, reportedly, was transported by the buildings ventilation system and deposited outside. This is documented in two interviews in the RCRA Facility Assessment at LBL Sep. 30, 1992: this document reports that "Cleanup of curium contaminated concrete inside the building is documented but there is no record of sampling outside Bld. 71."

The AIP program's other concerns for radioactive contamination in the LBNL environs included former radioactive waste storage and staging areas, former radioactive decontamination areas and abandoned above ground radioactive waste holding tanks.

In 1998, the US Environmental Protection Agency (EPA) performed a Superfund reassessment of LBNL concluding that "Based upon a preliminary Hazard Ranking System score, the US EPA has determined that LBNL is eligible for the National Superfund Priorities List" for cleanup, due to tritium in air, soil, groundwater, and surface water.

In September of 2001, LBNL announced that the NTLF would cease operations by 12/31/01.

In June 2005 National Academy of Sciences panel, formally known as the Committee on Biological Effects of Ionizing Radiation, or BEIR, concluded that there is no exposure level found below which dosage of radiation is harmless. The preponderance of scientific evidence shows that even very low doses of radiation pose a risk of cancer or other health problems. The National Academy of Sciences panel is viewed as critical because it addresses radiation amounts commonly used in medical treatment and is likely to also influence the radiation levels that the government will allow at abandoned and other nuclear sites.

METHODS

Our approach to developing a basic understanding of the contaminant plumes of the Lawrence Berkeley National Laboratory and their interrelation to faults, landslides, and streams in Strawberry Canyon was to develop a series of overlays that would show the conditions and various interpretations by previous investigations. The base map data sources were from the City of Berkeley and LBNL Facilities Division, the map projection: California State Plane, Zone III, (map scale 1:3000). Map layers for plumes, geology, faults, and landslides were scanned and then digitized as individual slides.

For the historic channel and landslide network mapping, a base map scale of 1-inch equals 200 feet was used to draw channels and landslides as they were interpreted from stereo aerial photographs and historic maps. The historic map of the drainage network was from Soulé (1875). The topographic projections of Soulé's 1875 base map were not compatible to present day cartographic or survey standards. The stream network, however, in most cases, seems to have a good representation of the number of tributaries and the relationship of one confluence to another. Because Soulé's map could not be digitized directly as an overlay, it was necessary to interpret his intent with regard to channel and spring mapping. This was accomplished by referring to predevelopment topographic maps shown in LBNL (2000) and by viewing stereo pairs of historical air photos, some of which predated development of the 1940's.

Different years of aerial photography were used to map landslides, landslide scars, and colluvial deposits. Three black and white photos were used for the earliest period that represented circa 1935. There were a few sections of stereo overlap in these photos, whereas all the newer photos had complete stereo coverage. The full stereo photo analysis included photos from 1939, 1946, 1947, and 1990. A distinction was made, when possible, to establish between deep-seated and shallow slides. Shallow slides were expected to be less than 30 feet deep, whereas deep-seated slides exceeded 30 feet. Source areas for shallow slides, called colluvial hollows, were also mapped. These source areas often contain scars of former landslides and in some cases have had recent sliding, but certainty was low from aerial interpretation. When there was a high certainty of activity occurring within the last century, the slides were delineated accordingly. Activity status of earthflows was not determined. However, at the very least, these slides should be expected to have higher than normal creep rates than the surrounding soils and they will probably continue to have renewed activity within their boundaries.

RESULTS AND DISCUSSION OF DATA COMPILATION

Drainage Network Mapping

Within the Lab site, two major east-west trending creeks, Strawberry and North Fork of Strawberry, have perennial flow that drains respectively through Strawberry and Blackberry Canyons toward the City of Berkeley and the San Francisco Estuary. North Fork of Strawberry Creek flows through the boundaries of LBNL. Mainstream Strawberry Creek is not within LBNL boundaries, yet seven of its north-south trending tributaries that flow southward, do drain from the LBNL. These tributaries, cited in the LBNL RFI, 2000 include Cafeteria Creek, Ravine Creek, Ten-inch Creek, Chicken Creek, No-name Creek, Banana, and Pineapple Creeks as shown in Figure 4. The latter two flow into Botanical Garden Creek, which is not within the LBNL boundary, but flows into the central reach of mainstream Strawberry Creek.

The pathways of natural surface water runoff have been altered by years of land use activities in the Canyon, which have caused the natural topography to become highly altered by cut and fill activities, roads, impervious surfaces from buildings and parking lots, and by stormdrain and other infrastructure construction. Natural and land use-related landslides have also changed the flow pathways of both surface and groundwater. Numerous faults, deep-seated landslide failure planes, bedrock contacts, fractures, and joints compound the natural influences on groundwater. They can all strongly influence the direction and rate of subsurface flow.

However, the location of bedrock contacts and faults can be challenging to detect, especially in an unstable landscape where landsliding can mask the geomorphic signatures of faults and bedrock contacts. Overlaying surficial deposits from alluvial fans and colluvium can also obscure these features. Groundwater flow has also been artificially altered by spring development, wells, hydraugers, utility trenches, sewers, subsurface drains, and pumps installed to mitigate contamination, as well as to intercept hill water that historically has caused landslides at LBNL.

Campus Principal Engineer John Shively conceived of the idea of a vertical well to intercept hill-water that was causing landslides both inside and adjacent to LBNL in 1974. He retained Civil Engineer B. J. Lennert to install what is now known as the Shively well, located next to the UC Silver Space Sciences building. It should be noted that the major hill landslide of August 1974 (during a dry season) broke a lab building at LBNL, took out a portion of a laboratory road, and was threatening UC Berkeley's Lawrence Hall of Science.

At the same time another landslide was developing above the Lab's corporation yard, threatening the University's Centennial Drive. Lennert's attempts to stop the slides by dewatering the hill area with horizontal hydraugers weren't working. The Shively well apparently stopped both slides.

In 1984 Converse Consultants, Inc. conducted investigations in the eastern portion of the Strawberry Canyon. Their findings were published in a report titled "Hill Area Dewatering and Stabilization Studies" which defined the location of the Lennert Aquifer in the following:

> Dewatering measures instituted by Lennert were based on the belief that the main reservoir of deep ground water in the hill area is the volcanic flow (i.e., fractured) rocks of the Moraga Formation situated within a synclinal structure underlying the ridge extending from LBL Building 62 northward to Little Grizzly Peak. These flow rocks were thought to be bottomed in the syncline by less permeable Orinda Formation bedrock (although some permeable sandstone and conglomerate beds within the Orinda exist, they are interbedded with impermeable shales and siltstones). Lennert asserted that ground water was also controlled in the hill area by faults such as the University Fault and the New Fault, which acted as groundwater barriers or as conduits for water flow through cracks and voids along these faults. Lennert also asserted that surface water entered these "tension faults", entering directly and quickly into the groundwater regime.

The location of the Shively well that drains the Lennert aquifer, hydraugers as well as sewers, and stormdrains at LBNL are also shown in Figure 4.

Little remains of the natural drainage network within LBNL boundaries, yet its natural pattern can been interpreted from historical photos and information from Soulé (1875), as shown in Figure 5. The drainage network does not depict differences in perennial versus intermittent or ephemeral flow; it simply indicates where well-defined channels are expected. The springs, however, do represent sites of presumed perennial wetness. Soulé indicated that several springs were developed for water diversion prior to his 1875 map. In Figure 5, the arrows represent where channels might have become non-distinct as they spread across their alluvial fans at the base of steep hillsides. Alluvial fans store bedload and often convert surface flow to subsurface flow over coarse-bedded, highly permeable alluvium.

Near the central and northern LBNL property, two areas show a particularly high density of channels per unit area. These correspond to two east-west trending valleys. The eastern valley is referred to as East Canyon and the central one is Chicken Ranch Canyon. The high density of channels in these valleys appears to be associated with large landslides

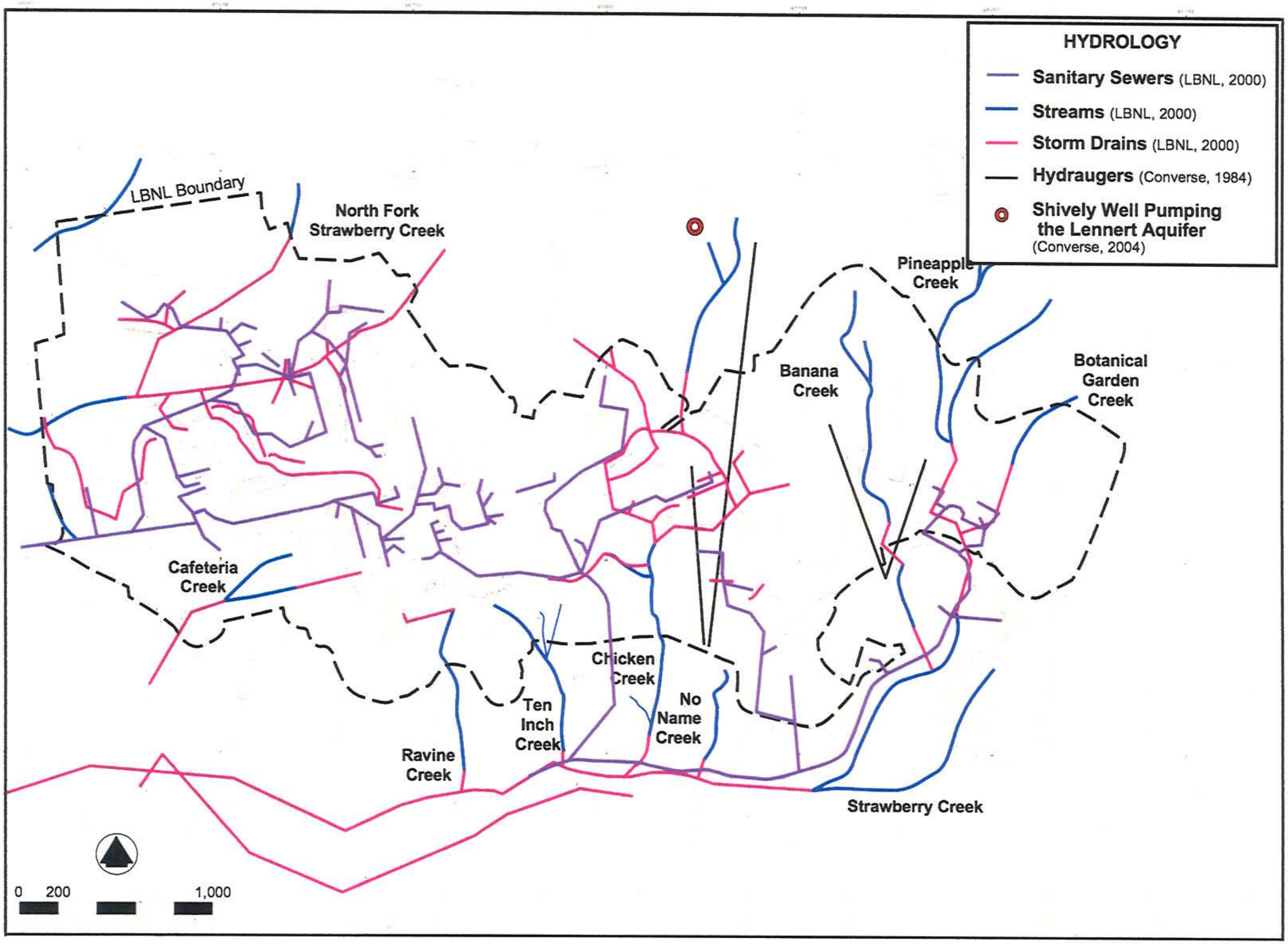


FIGURE 4. MODERN DRAINAGE NETWORK AT LBNL IN STRAWBERRY CANYON

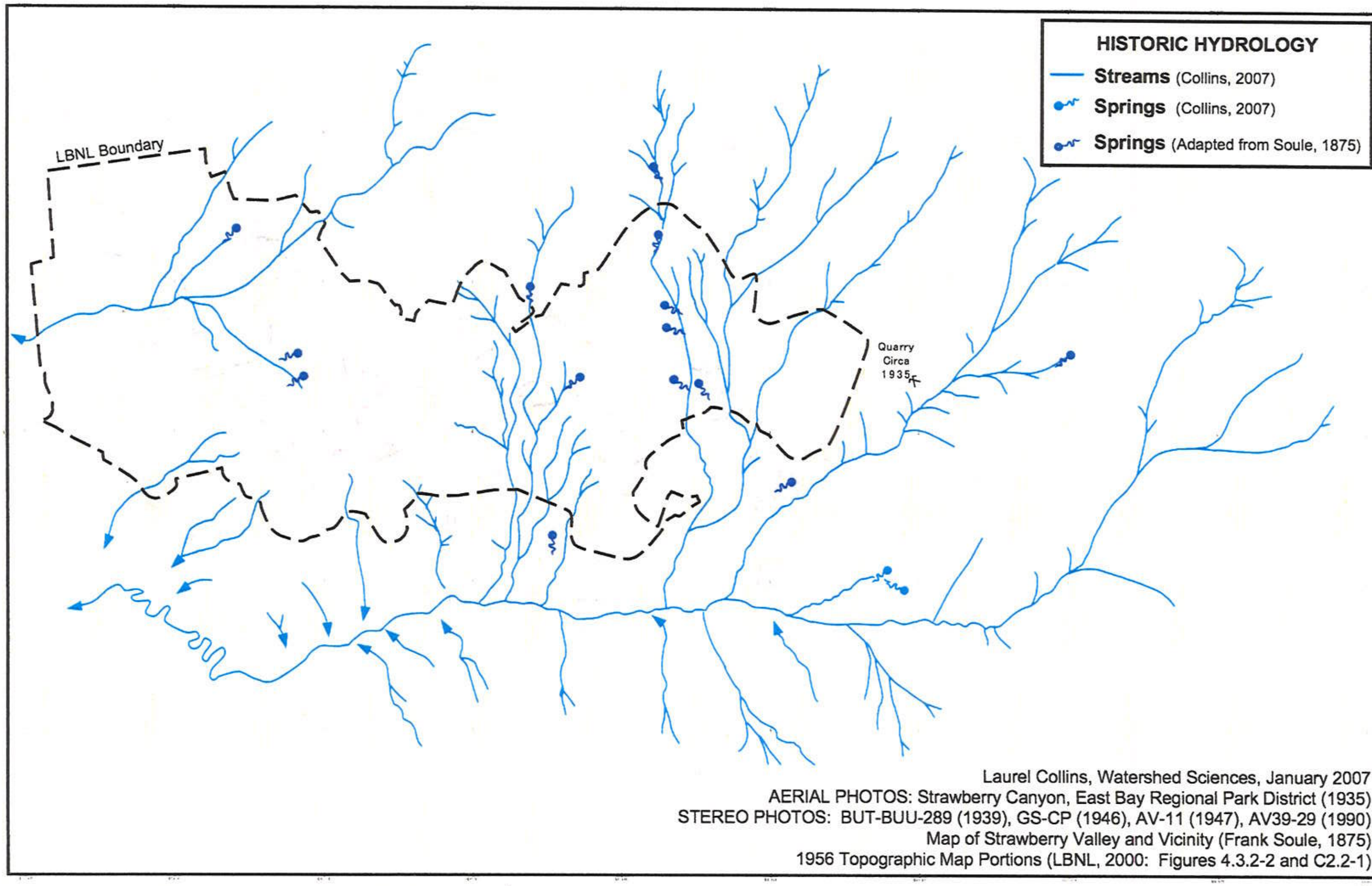


FIGURE 5. INTERPRETATION OF HISTORIC CHANNEL NETWORK AT LBNL IN STRAWBERRY CREEK WATERSHED

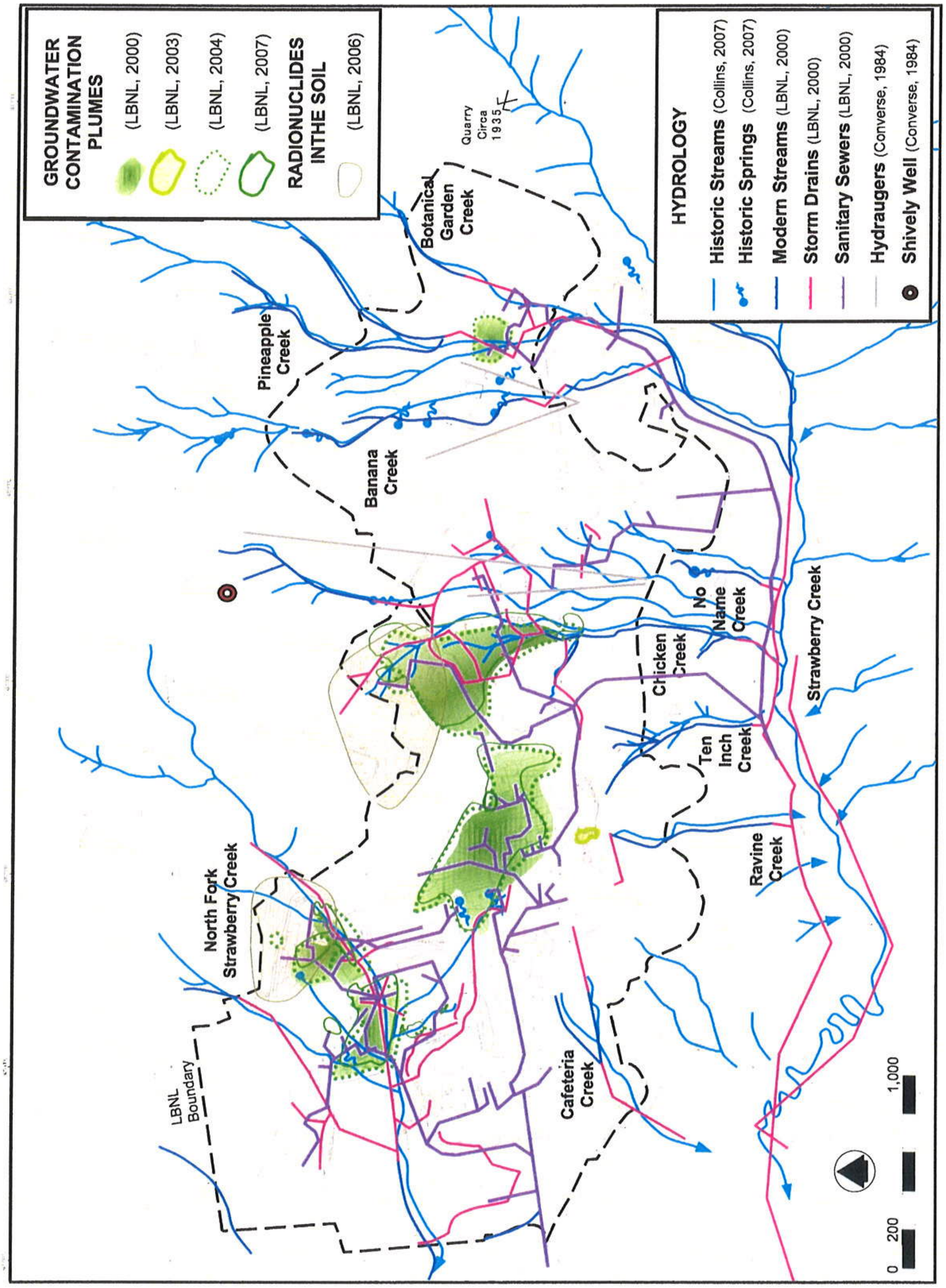


FIGURE 6. GROUNDWATER CONTAMINATION PLUMES IN RELATION TO THE MODERN AND HISTORIC DRAINAGE NETWORKS AT LBNL

that occupy the valley floors (Figure 7a). It is likely that highly erosive soils exist in the valley because they have been mechanically disturbed by both landsliding and faulting. In addition, the clay-rich nature of the soils and landslide deposits in these valleys often leads to slow percolation rates, especially along failure planes of earthflows, which can create perched water tables. These factors contribute to increased runoff per unit area, which leads to increased drainage density.

The historic drainage network helps with interpretation of topographic features such as the landslides in East and Chicken Creek Canyons, but it is also useful for showing movement along fault lines such as the Hayward Fault. At the bottom left corner of Figure 5, over 1200 feet of right lateral channel offset has occurred on Strawberry Creek along the area that is now the UCB stadium. Historic channel mapping is also important for predicting potential migration pathways of contaminant plumes along alluvial soils that might have been buried by large deposits of artificial fill, such as in Blackberry Canyon.

A compilation of the current and historic drainage network relative to the 2000, 2003, 2004, and 2007 LBNL contaminant plume locations is shown in Figure 6. Areas shown in grey indicate the location of radionuclides (tritium and curium 244) in soil (LBNL 2006). All the plumes, except Building 37 VOC plume, are shown to intersect historic drainage channels. Storm drains intersect all contaminant plumes except Building 37. The hydraugers do not appear to intersect plume boundaries, although the Building 74 Diesel Plume is very close to the northernmost hydrauger. The contaminant plumes have a general pattern of downhill convergence into both the historic channel and modern storm drain network.

Geologic Bedrock Mapping

The complex geology of Strawberry Canyon involves periods of volcanism, sedimentary deposition within fresh water and marine environments, tectonic uplift, folding, and significant shearing along fault zones that have offset different-aged terrains. LBNL (2000) describes the underlying geologic structure at the lab to be a northeast dipping faulted homocline. Generally, the oldest rocks occupy the lower portions of Strawberry Canyon, while youngest rocks are found toward the east along the ridge.

The middle of the Canyon is more complex with older bedrock formations faulted and offset against younger ones along the Space Science's fault, University fault, New fault, Strawberry Canyon fault, Lawrence Hall of Science fault complex and various un-named faults, as well as the Wildcat and East Canyon Faults. Bedrock of Jurassic to Cretaceous-aged Franciscan Assemblage is mostly to the west of the Hayward Fault, beyond Strawberry Canyon. In this area, these rocks are typically marine sandstones that are faulted against younger bedrock of the Great Valley Sequence along the Hayward Fault at the base of the canyon.

The Cretaceous-aged Great Valley Sequence also has a marine origin. It ranges from mudstone and shale to sandstone with occasional conglomerate. The Great Valley Sequence is in fault contact with the Late to Middle Miocene-aged Claremont and the Late Miocene-aged Orinda Formations in different parts of the Canyon. The Claremont Formation is primarily siliceous chert inter-bedded with shale that formed in a deep marine environment.

Locally the chert is commonly highly fractured, folded, and faulted. It tends to form erosion resistant outcrops along some ridges.

Conversely, the Orinda is primarily mudstones, sandstones, and minor conglomerates that formed in a non-marine environment. The predominantly clay-rich Orinda shale unit tends to be associated with topographic valleys and is particularly prone to deep-seated landslides. Orinda is stratigraphically overlain and occasionally inter-fingered with the Late Miocene Moraga Formation, which is volcanic in origin and locally tends to be highly fractured, jointed, brecciated, and commonly vesicular (LBNL, 2000). In some places, it has been faulted and offset against the Orinda, especially to the west of the Wildcat Fault.

Although both Orinda and Moraga Formations are highly fractured, the Moraga has hard volcanic flow rocks of andesite and basalt while the Orinda tends to have low strength and hardness. The Moraga Formation is overlain and in contact with the Late Miocene non-marine sedimentary deposits of the Siesta Formation along the northeastern ridgeline. Beyond the ridge, the volcanic rocks of the Late Miocene Bald Peak Formation overlay the Siesta Formation along the axis of a structural syncline (Graymer, 2000).

Figures 7a, 7b, and 7c show interpretations of the geology in Strawberry Canyon that are different. Although the maps also have slightly different spatial extents, they overlap through most of the LBNL property. All maps identify the Orinda, Moraga, and Claremont Formations, yet the location of the bedrock boundaries do not agree. There are also some slight naming differences for the Great Valley Group rocks identified by LBNL and Graymer versus the Panoche Formation identified by Borg. The Panoche Formation simply represents a part of the Great Valley Group and is therefore not a significant difference in interpretation. Dunn (1976) reported that with regard to slope stability, the worst building sites in Strawberry Canyon were along the Orinda, and the Orinda/Moraga contact zones. The principal formations shown to be intersecting the contaminant plume sites are the Orinda and Moraga Formations, Figures 8a and 8b.

Figure 8a shows a compilation of the Moraga bedrock contacts as individually mapped by LBNL, Graymer, Collins, and Borg in the respective Figures 7a, 7b, 7c, and 7d. Figure 8b shows a compilation of bedrock contacts of the Orinda Formation. Note that the Building 51L and 61/64 plumes intersect rocks of the Great Valley Sequence. The location of bedrock contacts near the plume sites is particularly important because ground water can travel laterally along the contact zone rather than just move topographically downhill. This is particularly relevant when sharp reductions in permeability occur in the downhill bedrock. Soil permeability and transmissivity are much greater in the Moraga Formation because it has lower clay content than the Orinda.

When groundwater traveling from the Moraga Formation intercepts the Orinda Formation, positive pore pressures can build, forcing water to move along alternative pathways such as along a bedrock contact, through fractures, or toward the surface where it can cause landslides and/or springs. Interpretation of the size of each contaminant plume and its migration is constrained by the array and number of sampling wells. If water laterally.

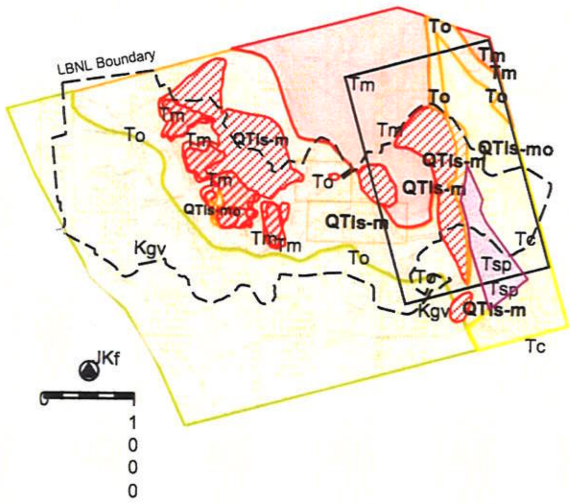


Figure 7a. LBNL (2000)

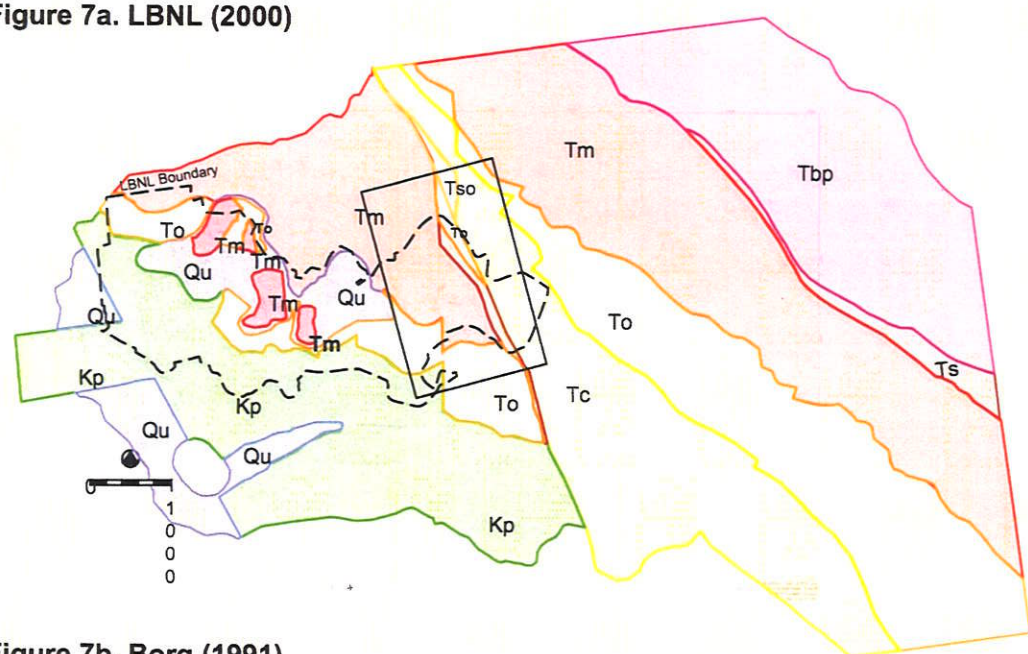


Figure 7b. Borg (1991)

Bedrock Geology of LBNL
LBNL (2000)

LBNL (2000) Modified from Radbruch (1969) & Harding Lawson Assoc (1980, 1982)

- **Landslide - Moraga Formation (QTls-m)**
- **Paleolandslide - Mixed (QTls-mo)**
- Moraga Formation (Tm)
- Orinda Formation (To)
- Claremont Formation (Tc)
- Great Valley Group (Kgv)
- San Pablo Group (Tsp)
- Franciscan Complex (JKf)

Geology of Strawberry Canyon
Borg (1991)

- Moraga Formation (Tm)
- Orinda Formation (To)
- Claremont Formation (Tc)
- Sobrante Formation (Tso)
- Panoche Formation (Kp)
- Bald Peak Basalt (Tbp)
- Surficial Deposits (Qu)
- Siesta Formation (Ts)

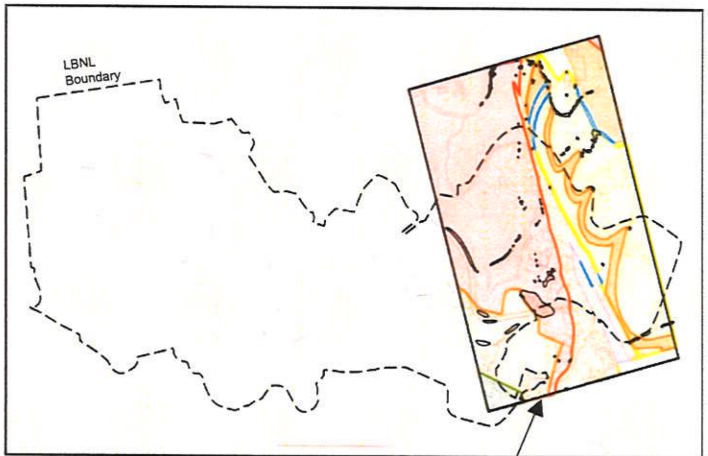


Figure 7c. Collins (1993)

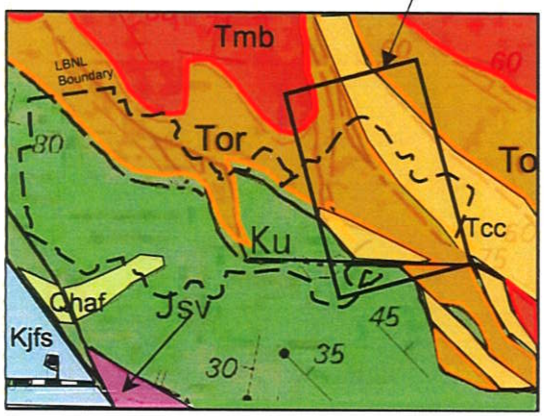


Figure 7d. USGS, Graymer (2000)

Geology of the East Canyon and the Proposed Hazardous Waste Handling Facility (Collins 1993)

- Moraga Formation (Tm)
- Orinda Formation (To)
- Claremont Formation - Chert Outcrop (Tc)
- Claremont Formation - Sandstone Outcrop (Tc-ss)
- Claremont Formation - Shale outcrop (Tc - sh)
- Miocene and Upper Eocene Sediments (Tm-e)
- Upper Cretaceous Sediments (Ku)
- Landslides (LBNL Plant Eng, 1981)

Geology in the LBNL Area USGS, Graymer (2000)

- Moraga Formation (Tm)
- Orinda Formation (To)
- Claremont Chert (Tcc)
- Holocene Alluvial Fan (Qhaf)
- Upper Cretaceous Sediments (Ku)
- Jurassic Keratophyre (Jsv)
- Franciscan Complex Sandstone (Kjfs)

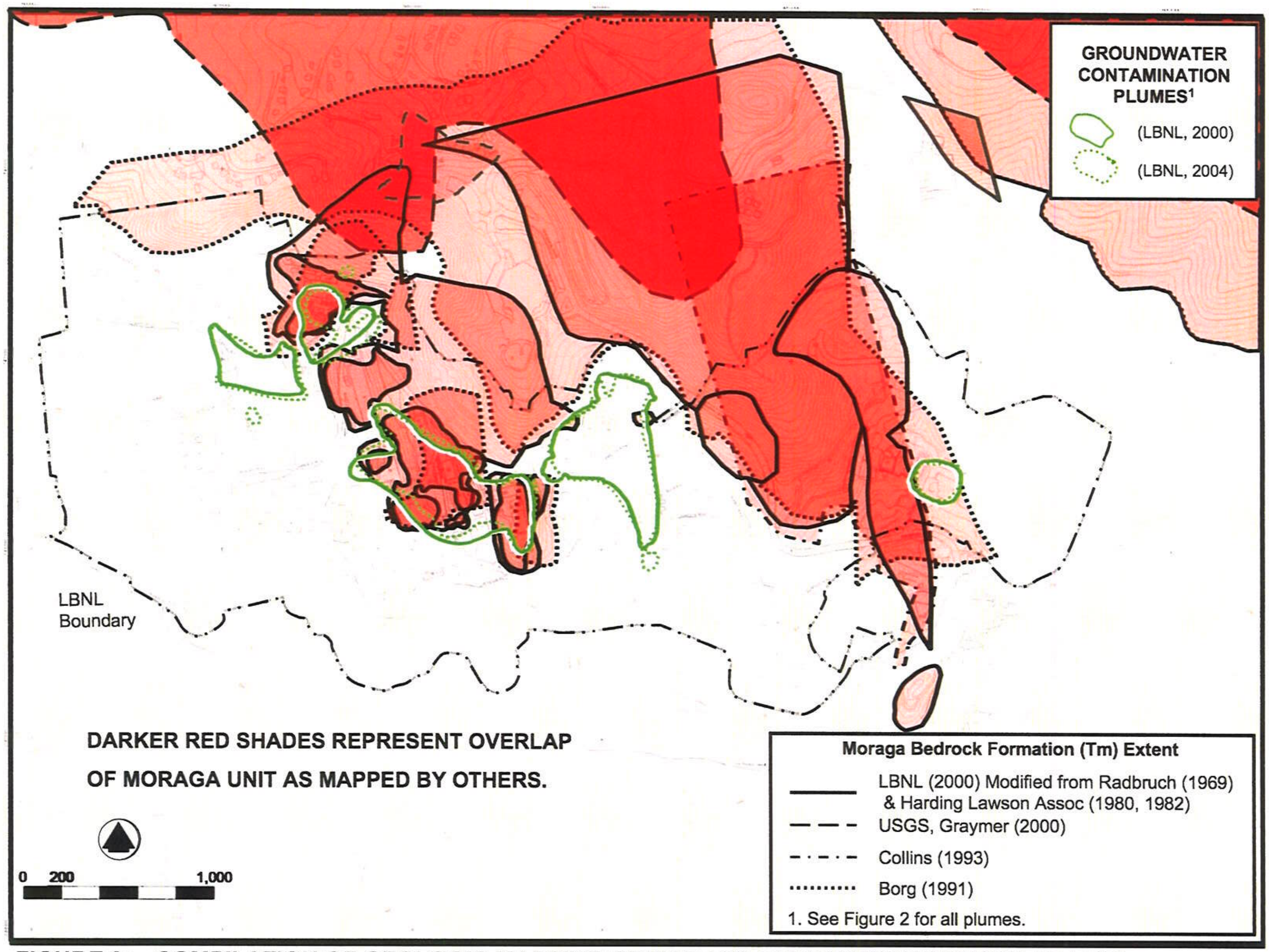


FIGURE 8a. COMPILATION OF GEOLOGIC MAPPING OF MORAGA BEDROCK FORMATION AT LBNL.

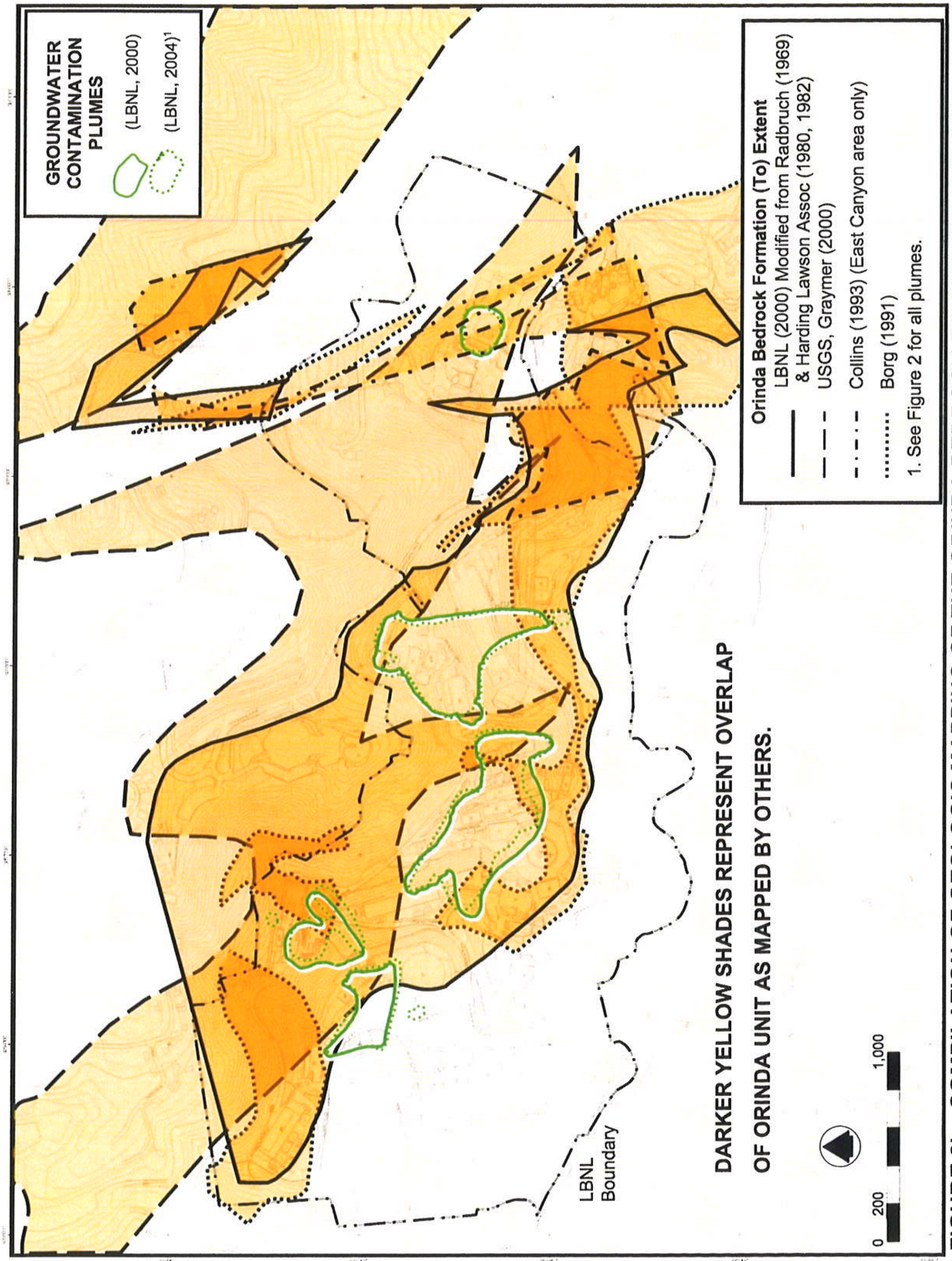


FIGURE 8b. COMPILATION OF GEOLOGIC MAPPING OF THE ORINDA BEDROCK FORMATION AT LBNL

migrates along a bedrock contact and if monitoring wells are not placed in a sufficient array to detect these potential flow pathways, the extent and migration of a plume could be easily misinterpreted. Figure 8a and 8b show substantial differences in the interpretation of the location of the bedrock contacts at nearly every plume site.

During the past 60 years, UCB and LBNL have produced innumerable investigations and geotechnical reports for existing and proposed building sites in Strawberry Canyon. Yet, agreementon the position of faults, landslides, and bedrock contacts has not been consistent among these reports. The lack of continuity among the various reports has been noted by previous researchers who have called for a more comprehensive effort to produce a verifiable picture of landslides and geology (Dunn 1976; Collins, 1993; Collins and Jones, 1994).

For example, in 1976 J. Dunn stated that with regard to instability of hillsides near Buildings 46 and 77, most activity involved failure of material in the Orinda Formation or sliding of the Moraga Volcanics on the Orinda. Although borings had been completed, samples recovered, and tested, he reported that the results and conclusions had not been tied together in a workable package. An earlier report by Collins (1993), recommended that "raw" geological observations such as bedrock outcrops should be shown on future geological investigations and that such maps should be an essential component of an integrated, comprehensive, and computerized database for the LBNL site.

With LBNL producing a GIS-based three-dimensional view of their local geologic interpretations, much has been accomplished since 1993. Yet, a verifiable map showing locations of bedrock outcrops and exposures in excavations remains elusive. Hence, it still remains unclear what information has or has not been used as a foundation for LBNL's geologic map, and why their interpretations differ from reports by their previous consultants

Fault Mapping

The Hayward Fault is part of the larger San Andreas Fault system. It is seismically active and falls within the Alquist Priolo Earthquake Fault Zone, Figure 2. Numerous secondary splay faults are also associated with the Hayward Fault, such as the Wildcat and East Canyon Faults that trend northwestward through East Canyon, Figure 9a. As shown in Figures 9b and 9c, these named faults, as well as the Space Science's Fault, University Fault, New Fault, Strawberry Canyon Fault, Lawrence Hall of Science Fault Complex and numerous un-named faults have been mapped by other researchers. Whether or not a fault has been named or identified within the Alquist Priolo Earthquake Zone does not mean that it is not imperative to show it on geologic maps, especially to relate its position to known contamination sites, especially when the information already exists in published reports.

With respect to plume migration, to identify whether a fault is active is not as important as identifying its potential influence on groundwater transport. Without sufficient understanding of fault locations, planning where to place monitoring wells for defining and constraining plume boundaries cannot be well founded. Fault mapping is also clearly important for identifying potential hazards to buildings and infrastructure, particularly because splay faults and other faults in close proximity to the Hayward Fault have potential to rupture during large magnitude quakes, especially those emanating nearby.

Figure 10 shows the plume locations and a compilation map of the faults shown by various researchers in Figures 9a, 9b, and 9c. As noted in Figure 10, we call the fault that runs along the Bevatron (Building 51a) and the Advanced Light Source (Building 6) the Cyclotron Fault. The compilation indicates that fault mapping by LBNL does not correspond well with faults mapped by USGS (2007), Converse Consultants (1984), Harding Lawson (1979), or Lennert Associates (1978). Although there is some general agreement about the Hayward, Cyclotron, and Wildcat Faults, there is poor agreement on the existence and location of many of the other faults mapped by others within the LBNL property boundary.

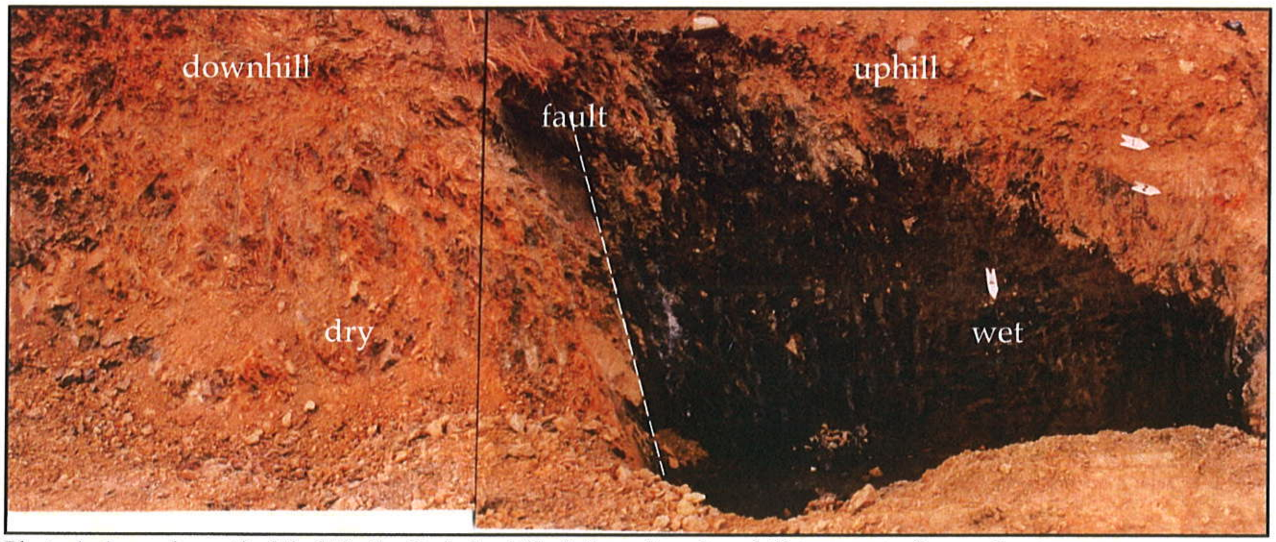


Photo 1. A nearly vertical fault in the Berkeley hills is impeding downhill transport of groundwater, causing it to flow laterally along the fault trace. Water is collecting in a pool at the base of the wet side of the excavation.

During grading operations for the construction of the new LBNL Hazardous Waste Handling Facility and throughout many new excavations in the Berkeley hills, conducted during the 1993 Oakland Hills post-fire reconstruction, Collins and Jones (1994) stated that they made numerous observations of faults exerting strong control on groundwater movement and swale development. Photo 1 shows an example of one of the sites they observed in the Berkeley Hills where groundwater flow moved laterally along a fault plane that impeded downslope groundwater transport. They also observed that the location of crown scarps of several recently active earthflows in the Berkeley Hills corresponded to the location of fault traces. They suggested that fault traces in many areas of the Berkeley Hills are masked by younger deposits of sediment from landslides and streams.

It is important to consider that when excavations expose faults or when utility trenches intersect faults that also intersect contaminated groundwater, the excavations or trenches can become additional avenues for contaminant plume migration. Also important to consider is that zones of varying permeabilities in clay-rich fault gouge can provide traps and pathways for moving water, and in some cases, the traps can build enough pressure to initiate landslides and potentially convert the subsurface flow to surface flow.

Potential problems associated with the lack of definitive geologic mapping in Strawberry Canyon are increased by the proximity of the active Hayward Fault and related seismicity. According to Steinbrugge, et al, (1987) the maximum magnitude earthquake anticipated is 7.5, which has the potential of causing right-lateral horizontal offsets that could average 5 feet along the Hayward Fault. Hoexter (1992) reported that there was potential for secondary or splay faults in the East Bay to have triggered slip from quakes generated along the primary Hayward Fault. Wildcat Fault appears to be a likely splay from the Hayward Fault. Hoexter's survey of historical earthquakes indicated that triggered slip on splays have movement that is usually less than 20% of the primary offset. This suggests that 1.5 feet of horizontal offset on a splay fault from the Hayward Fault could be anticipated if the maximum magnitude quake occurred. Hoexter also reported that vertical displacements could accompany horizontal slip, although a much smaller percentage of total movement would be expected. Such projections of horizontal and vertical offsets along secondary faults should be sufficient to warrant more detailed mapping of fault patterns within Strawberry Canyon.

We believe that sufficient information is not available from the literature to confidently determine the activity status of the numerous faults that exist along the Wildcat Fault shear zone, which may be as much as 600 feet wide and includes the East Canyon Fault (Collins, 1993). Published USGS maps in this report are not of adequate detail or scale to delineate all the bedrock complexity of Strawberry Canyon, yet more detail is shown by USGS than that which LBNL represented on their Bedrock Geology Map, provided in their investigative RFI report (LBNL, 2000). This is perplexing because much geologic complexity has been demonstrated in previous reports and investigations conducted by LBNL's own geotechnical consultants. For example, Figure 11 shows a compilation map detail of faults mapped by various consultants and researchers for just the East Canyon (Collins, 1993). Figure 11 demonstrates general agreement that the Wildcat Fault exists, but poor agreement on its location or number of traces within its shear zone. This site is important because it is the location of the diesel fuel plume near Building 74, and is the proposed location for new buildings in the East Canyon described in the recent LBNL LRDP Report (2007).

During the grading operations for the LBNL Hazardous Waste Handling Facility (Building 85), numerous northwest and east-west trending faults were exposed near the Wildcat Fault shear zone northwest of LBNL Building 74. So many faults were intersected that it brought into question whether the previous 1980 Harding Lawson report by Korbay and Lewis, called the Wildcat Fault Investigation (performed for Building 74), was actually sufficient to evaluate the Wildcat shear zone. The trench was located more than 1000 feet north of Building 74 and inconsistencies within the trench logs confounded interpretation of vertical displacements at the fault trace (Collins, 1993). Further concern arises about the activity status of Wildcat Fault because according to King (1984) and verbal communication from Curtis (1993), a disagreement occurred at the trench site between investigators Steve Korbay of Harding Lawson Associates and Dr. Garniss Curtis of UCB Department of Earth and Planetary Science. Curtis believed there was sufficient evidence in the trench site to designate the Wildcat Fault active, while Korbay did not.

LBNL does not show the Wildcat Fault as active (LBNL, 2000) and we are not presently aware of any additional trench investigations that have been conducted on the Wildcat Fault since 1980. Additional lines of evidence concerning fault activity in Strawberry Canyon, however, can be gleaned from maps showing the epicenters of local seismicity. In Figure 12a, we compiled the fault mapping by others from Figures 9a, 9b, and 9c and overlaid the epicenters of seismic events that have occurred in the Strawberry Canyon during the last 40 years. Over 57 earthquakes with Richter Magnitude between 1.8 and 3.0 have occurred in Strawberry Canyon. Such a high incidence of microseismicity within the mapped traces of Wildcat Fault and between the Wildcat and the Cyclotron Faults provides compelling evidence that additional faults other than just the Hayward should be considered as active in Strawberry Canyon. Indeed, recently during March 2007 two small earthquakes, magnitude 2.0 and 1.4, shook the Canyon along an un-named fault and the Hayward Fault, respectively (http://quake.wr.usgs.gov/recenteqs/).

During the 1991 excavation for Building 84 in the East Canyon, Collins, Jones, and Curtis observed bedrock contacts and numerous fault exposures in the excavated bedrock at the building site. Of particular significance was the discovery of an entire geologic bedrock unit, the Briones Formation, which had never before been mapped in Strawberry Canyon. The Briones outcrop, which was full of marine shell fragments, was interpreted as a tectonic block that has been dragged along the Wildcat Fault during the last 10 million years. Its displacement might exceed 9 miles, which is twice the amount previously considered possible along this fault (personal communication Dr. D. Jones, UCB Department of Earth and Planetary Science).

Pat Williams (former LBNL staff Scientist Earth Sciences Division) speculated that a structural connection might exist between the active Hayward and Pinole Faults, and that the linkage might be associated with the Wildcat Fault (personal communication, 1992). Bishop (1973) documented evidence of active creep along the Wildcat Fault north of El Cerrito. During a 1971 survey of the East Bay Municipal Utility District water tunnel (between San Pablo Reservoir and the Kensington Filtration plant), vertical and right lateral displacements were documented near the Wildcat Fault shear zone. Taylor (1992) reports that the pattern of fault creep observed in the Montclair area (south of Berkeley) and elsewhere along the Hayward fault indicates that the broad fault zone might contain more than one Holocene active fault trace.

During the winter of 1992, another subsurface trench investigation was conducted on the East Canyon Fault. It was performed by Geo Resource Consultants and LBNL staff for LBNL. Evidence of both vertical and horizontal offset was discovered. This dual type of motion is probably typical for faults in the Canyon. Jones and Brabb (1992) suggest that significant displacement has occurred across the Berkeley Hills from combined strike-slip and thrust movements. Jones (1992) reports that most of the major strike-slip faults in the

FIGURE 9. SELECTED EXAMPLES OF FAULT MAPPING STUDIES AT LBNL IN STRAWBERRY CANYON

— FAULTS

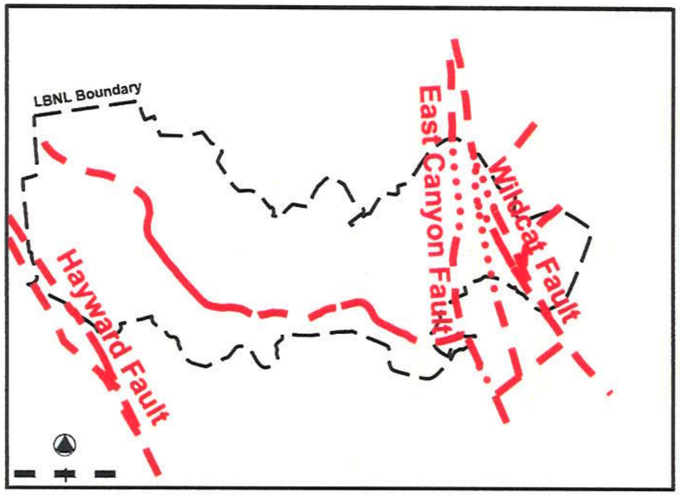


FIGURE 9a. LBNL (2000) Based on:
Harding-Lawson (1980, 1982), Radbruch (1969)

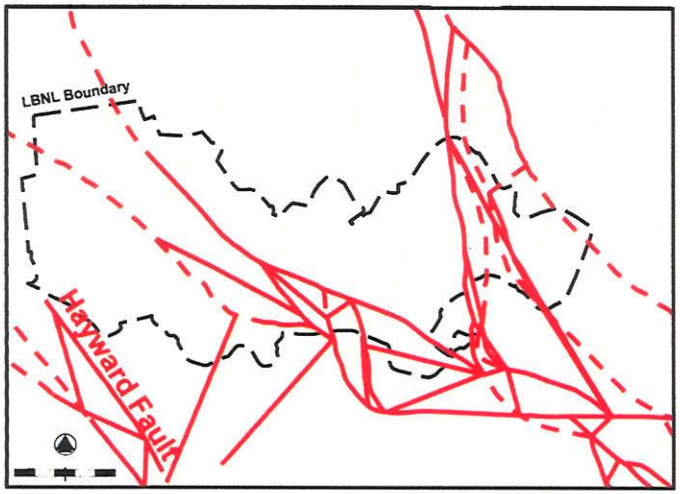


FIGURE 9b. USGS on Google Earth (2007)

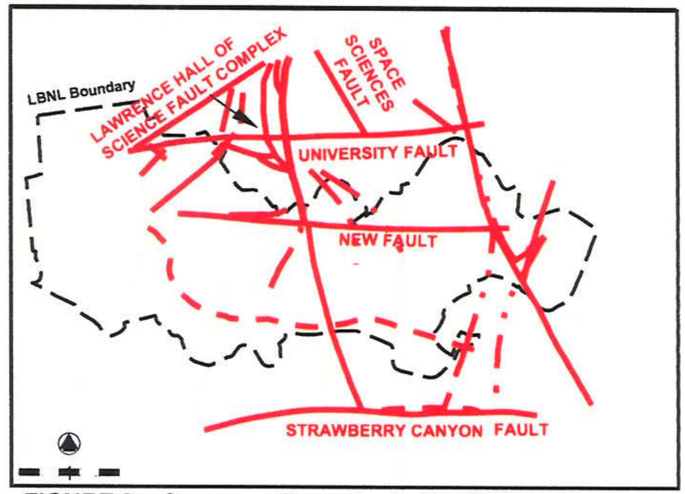


FIGURE 9c. Converse Consultants (1984) Based on:
Harding-Lawson (1979), Lennert & Associates (1978)
(Mapping does not include western portion of LBNL.)

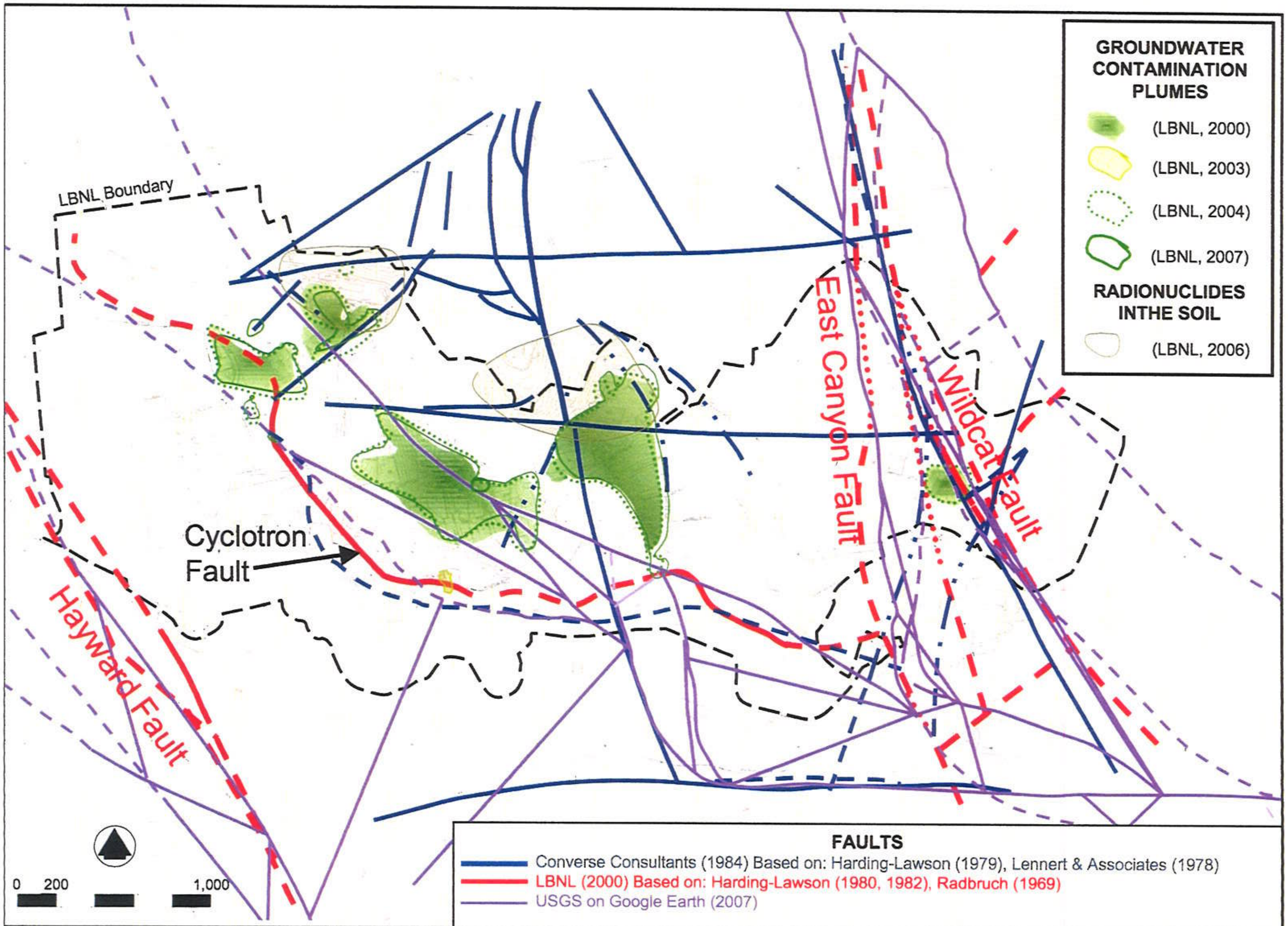


FIGURE 10. COMPILATION OF FAULT MAPPING AT LBNL IN STRAWBERRY CANYON RELATIVE TO SOIL AND GROUNDWATER CONTAMINANT PLUMES.

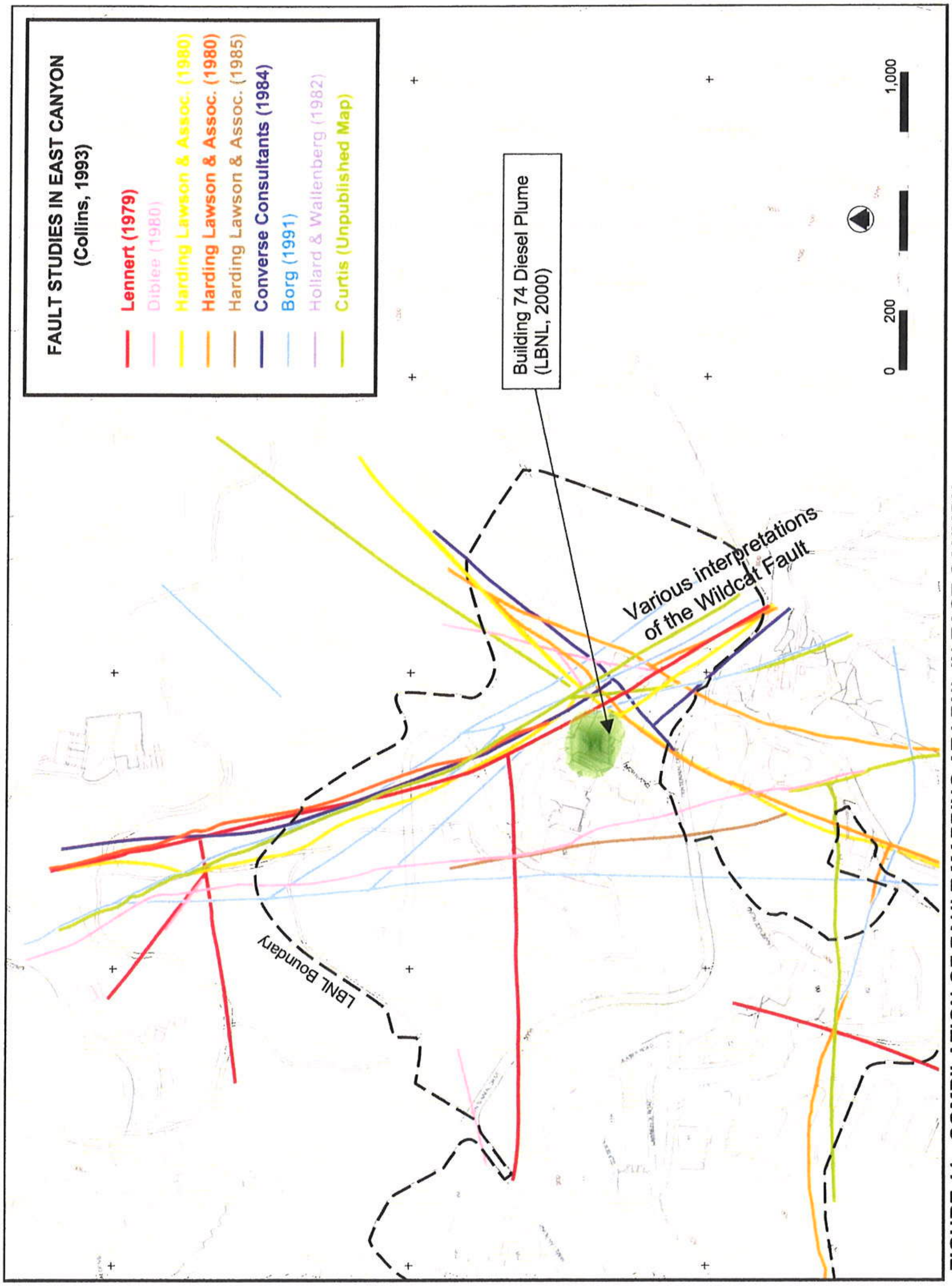


FIGURE 11. COMPILATION OF FAULT MAPPING AT LBNL IN EAST CANYON

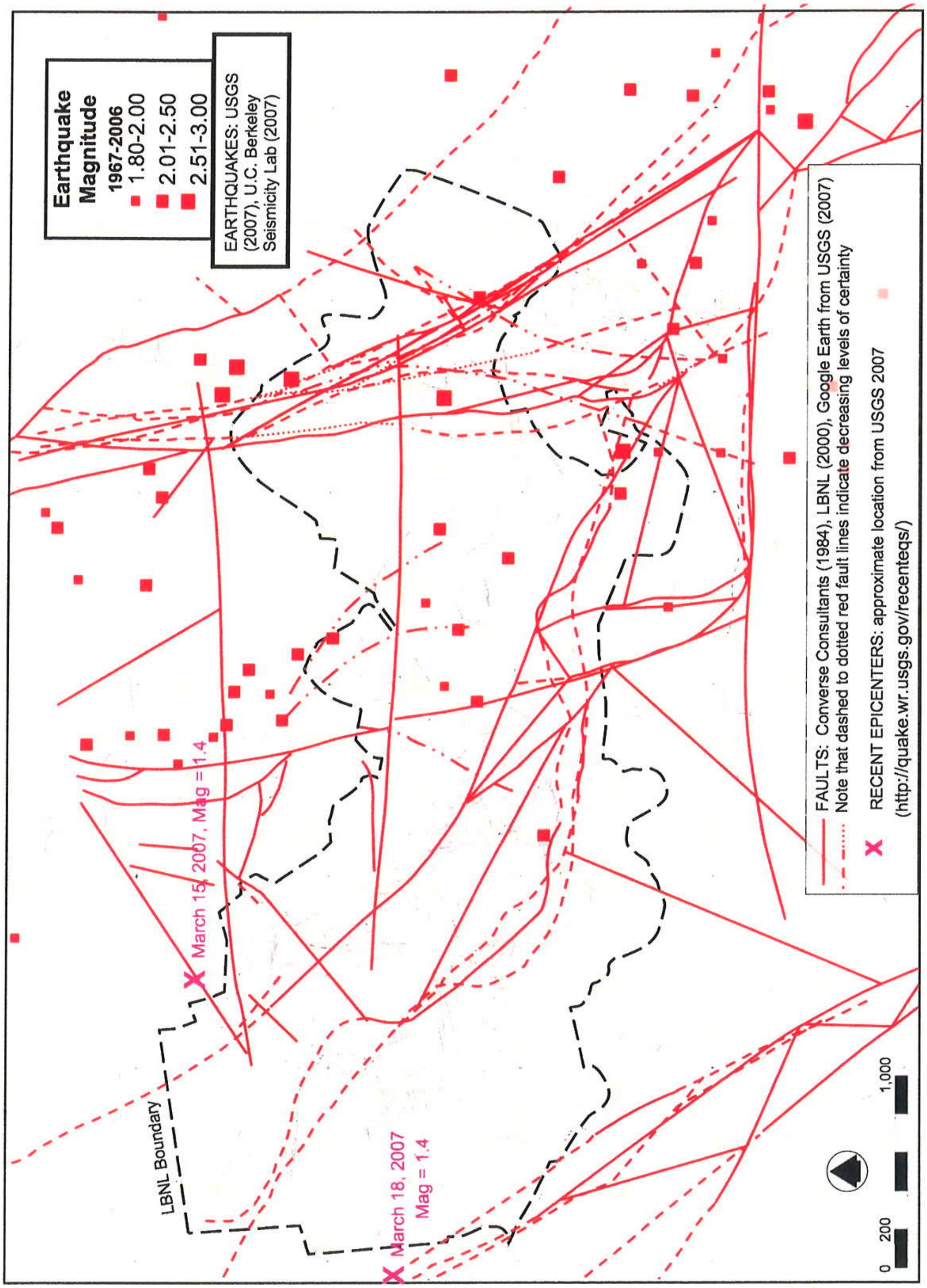


FIGURE 12a. EARTHQUAKE EPICENTERS AND FAULT COMPILATION AT LBNL IN STRAWBERRY CANYON 1967 - 2007

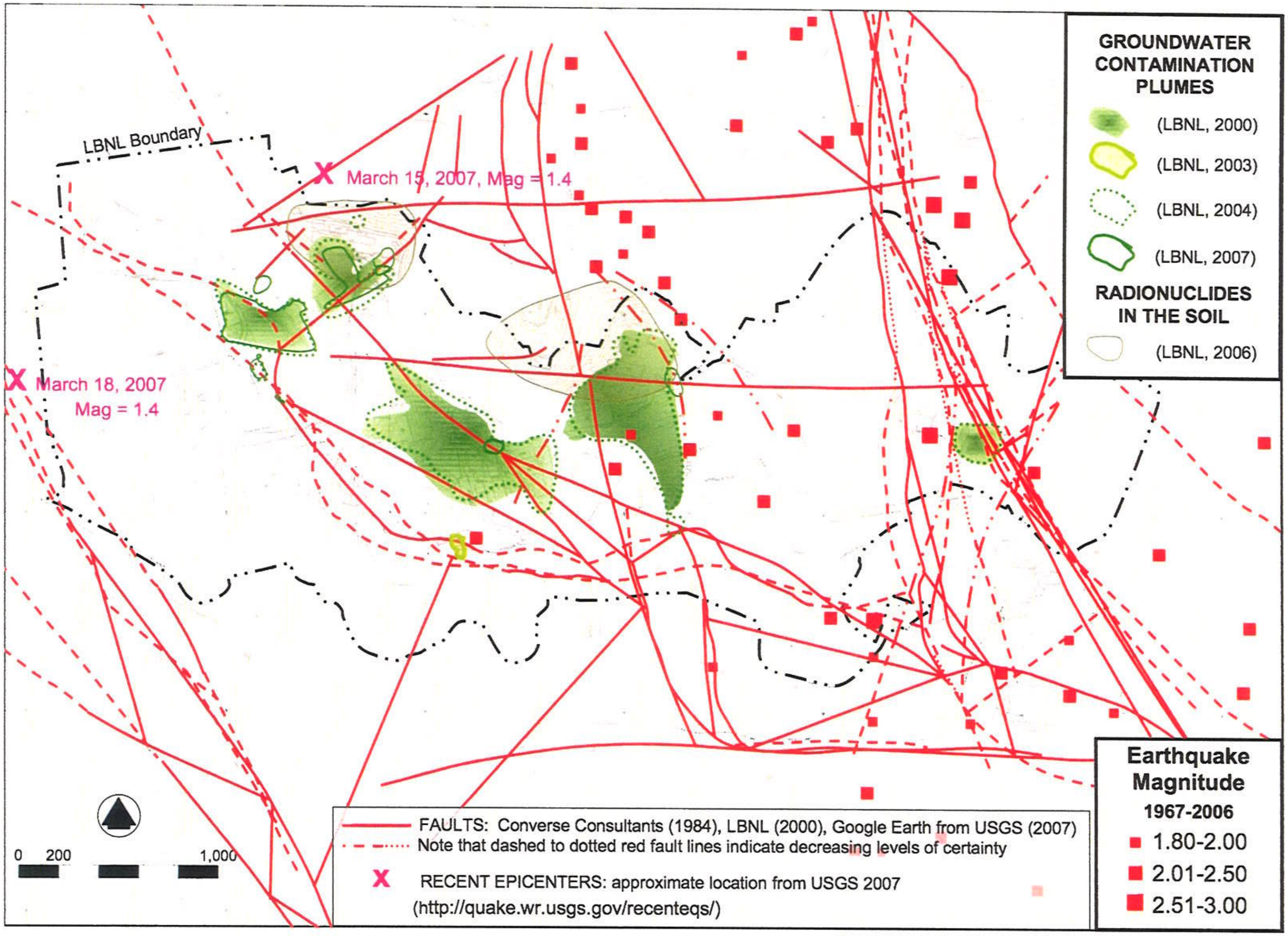


FIGURE 12b. GROUNDWATER CONTAMINATION PLUMES AND RADIOACTIVE CONTAMINATION IN SOIL RELATIVE TO FAULTS AND EARTHQUAKE EPICENTERS AT LBNL IN STRAWBERRY CANYON

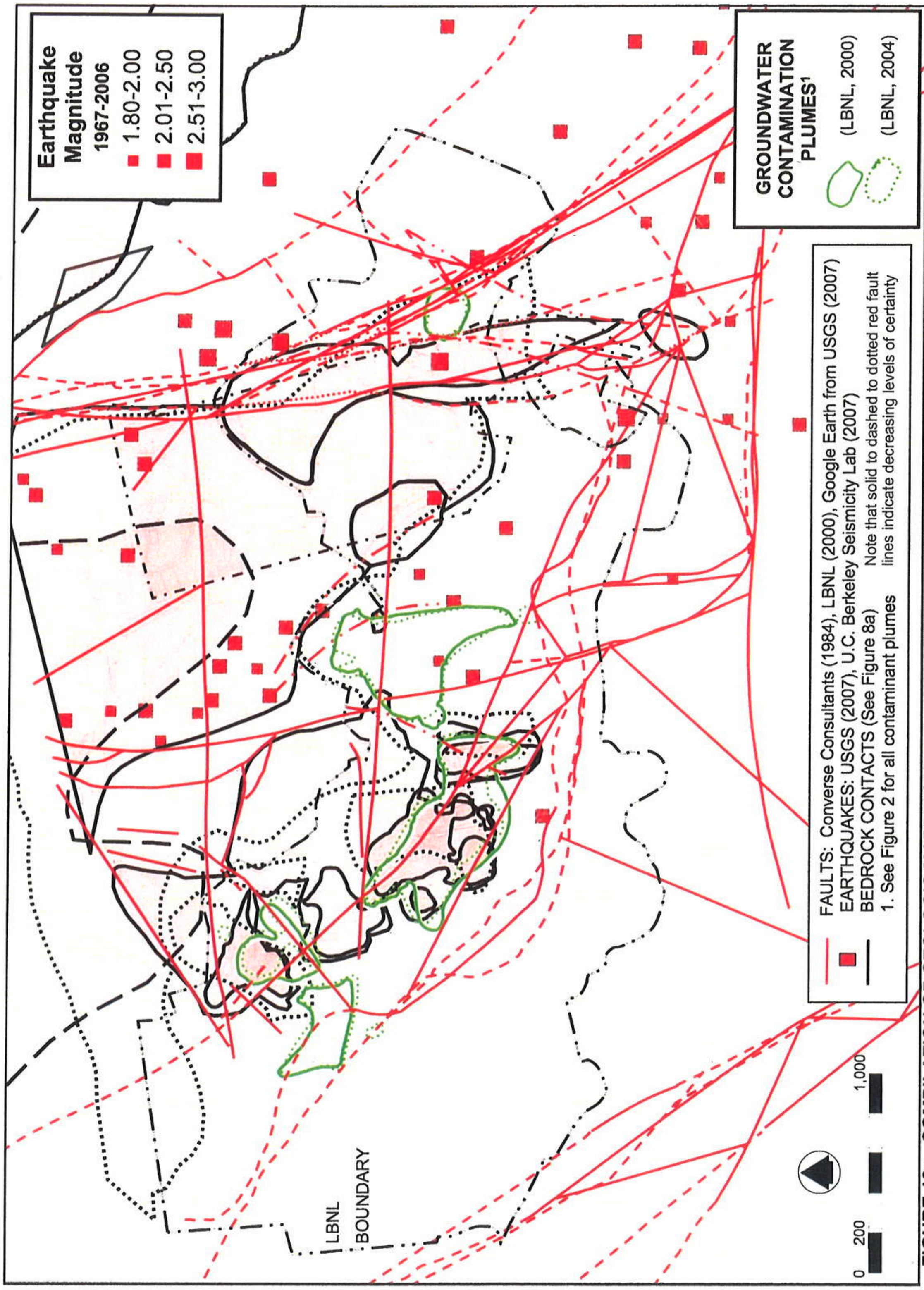


FIGURE 12c. COMPILATION OF GEOLOGIC MAPPING OF THE MORAGA BEDROCK FORMATION AND FAULTS IN RELATION TO CONTAMINANT PLUMES AT LBNL IN STRAWBERRY CANYON

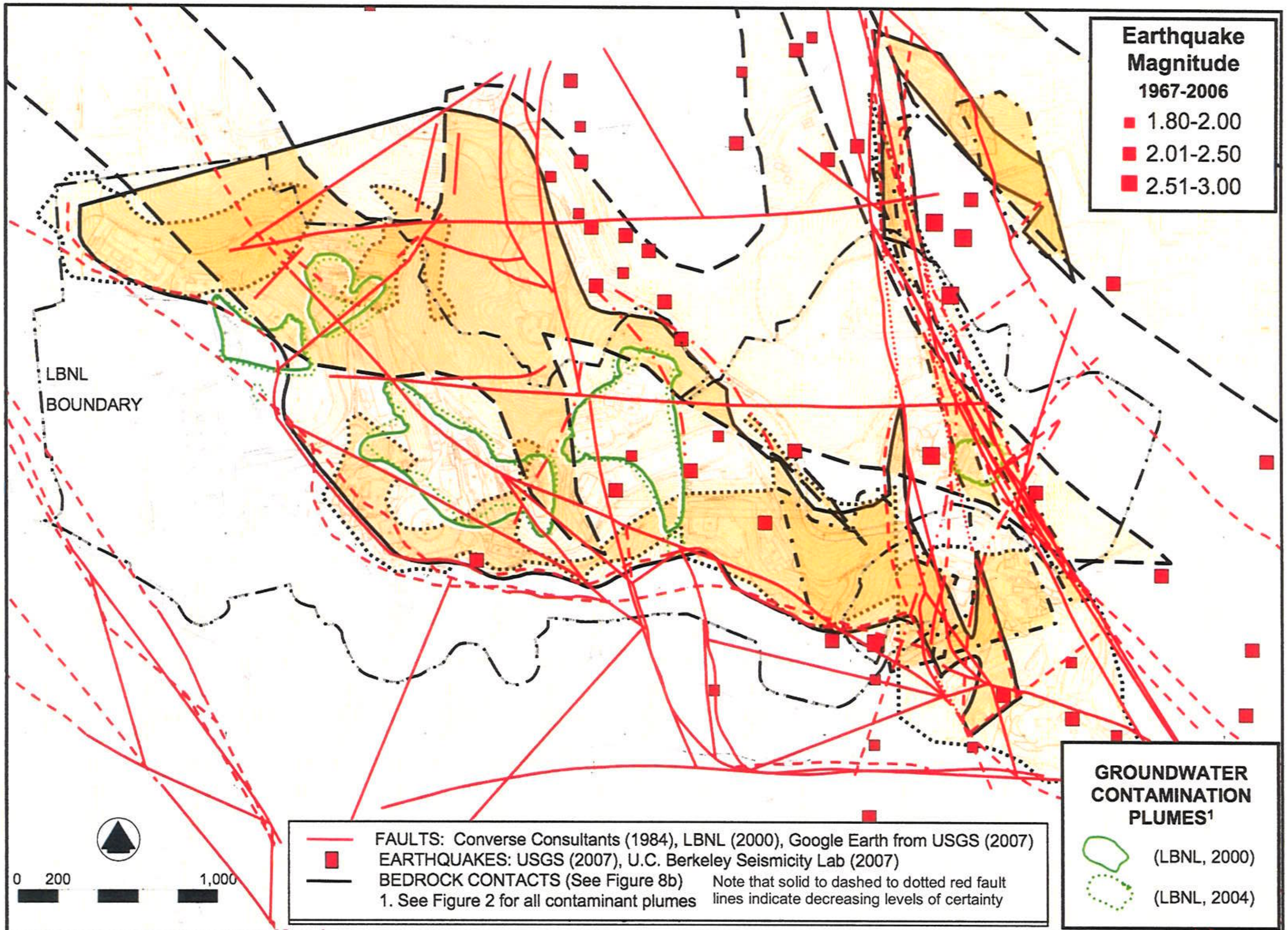


FIGURE 12d. COMPILATION OF GEOLOGIC MAPPING OF THE ORINDA BEDROCK FORMATION AND FAULTS IN REALATION TO CONTAMINANT PLUMES AT LBNL IN STRAWBERRY CANYON

Coast Ranges have attendant parallel thrust faults rooted within primary strike slip faults. In particular, Jones' geometric model of kinematics and stress transfer through the crust indicates that many thrust faults are still active within the Bay Area. The implication of these findings is that more consideration should be given to assessing risks posed byvertical displacements of faults, as well as horizontal offsets. Faults with a principal component of vertical motion have been mapped by LBNL (2000) and others (USGS, 2007; Converse Consultants, 1984; Harding Lawson, 1979; and Lennert Associates, 1978), but little is known about their potential for thrust or down-dropping movements.

In Figure 12b, the location of the various faults shown previously in Figure 12a is shown relative to contaminant plume sites. As can be seen, every plume intersects at least one fault that has been mapped by either LBNL, its consultants, or by USGS (Figures 9a, 9b, 9c). When fault locations and the different bedrock contacts are shown in combination with the contaminant plume locations, as in Figures 12c and 12d, a complex picture emerges, showing that numerous influences could be affecting groundwater transport and contaminant plume migration. In the latter two figures, it can be seen that faults and bedrock contacts do not necessarily coincide. If the complexity of geologic conditions at the contaminant plume sites is oversimplified, the extent and potential contaminant dispersement could be underestimated because monitoring wells were not placed at key positions along fault lines.

Landslide Mapping

Deep-seated and shallow landslides occur throughout the Berkeley Hills including Strawberry Canyon. Both artificial and natural mechanisms have contributed to increased rates of landslide activity in many areas. Land use activities in the hills can decrease slope stability by the action of grading large cuts or filling deep canyons to create flat areas for roads and buildings. Such grading operations interrupt surface and subsurface flow, and create impervious surfaces that increase runoff. The cuts remove lateral hillside support and convert groundwater flow to surface flow. The fills can increase the loading of a hillside and can increase or decrease groundwater saturation depending upon whether they are capped by an impervious surface and whether they are properly drained.

Triggers for initiating landslide movement can be artificial or natural. The natural triggering mechanisms can include intense or prolonged rainfall, greater than normal seasonal rainfall, earthquakes, or changes in mass balance from other landslides. Artificial triggers can include concentrated runoff from roads and other impervious surfaces, increased saturation from drain blockages, removal of root strength by deforestation, removal of lateral slope support, and increased loading of pre-existing slides by added weight of artificial fill.

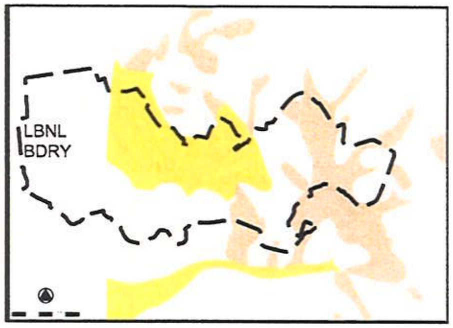
Several landslide maps of Strawberry Canyon have been produced by different researchers, as shown in Figures 13a through 13f. All maps show that numerous landslides have been mapped within the LBNL boundary, yet not all researchers agree on location, size, or types of landslides. Nor do all maps necessarily depict the same comparable landslide category. For example, some maps show colluvial deposits and some show colluvial hollows as source areas for shallow slides and/or landslide scars, for example Figure 13b versus Figure 13c.

Additionally, some maps group colluvium with fill, such as Figures 13a and 13b. Nonetheless, we expect that the brown polygons on map Figures 13a through 13e and the brown and purple ones in map Figure 13f all represent shallow to deep-seated landslide failures. Using historical and recent aerial photographs, the landslide features in Figure 13f were specifically mapped for this project and the slides therefore, are mapped relative to the historical topography and channel network as per Figure 5.

Figure 14 shows a compilation of the contaminant plumes with all the landslides and surficial mapping shown in Figure 13a-13f. The compilation shows general agreement about the existence of large landslides in Chicken Creek basin and East Canyon but the boundaries of individual landslides have poor overlap. Because Figure 14 becomes overwhelmed by landslide features that cover more than 50% of the LBNL property, it is too difficult to read the numerous overlapping polygons. We have therefore reduced the number of map overlays in Figure 15 to just three interpretations, Nielsen, LBNL, and Collins (Figures 13a, 13b, and 13f.) We also eliminated the fill and colluvium shown in Figure 14, along mainstream Strawberry Creek that was mapped by Nielson and LBNL near of the UCB Memorial stadium in the southwest corner of the map.

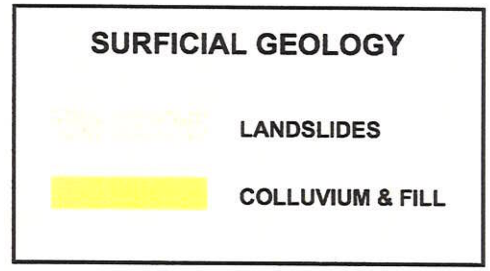
Figures 14 and 15 indicate that all the contaminant plumes either lie fully within or intersect the boundaries of landslides. This means that in addition to the complexities already demonstrated by bedrock contacts and faults intersecting the plume boundaries, there is also high probability that landslide failure planes could further influence groundwater movement. Moreover, the developing picture of complexity signifies that groundwater can transfer along any number of pathways (bedrock contacts, faults and landslide failure planes) and in any order of combination. In addition, future interpretation of contaminant plume migration could be complicated by continued earthflow creep movement or significant surges in slide activity.

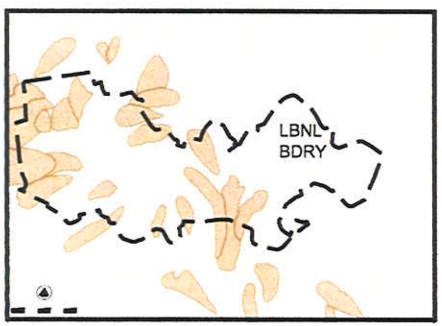
The deep-seated slides in Strawberry Canyon, shown in Figure 13e and 15, in most cases tend to be slumps, earthflow, or complex earthflows that can involve movement of large intact blocks of bedrock and extend from ridge top to valley bottom. The complex slides can be characterized by multiple failure planes and zones of stability and instability that change after the mass balance is altered by renewed activity or by man-made changes during grading operations. In many cases, there is rotational movement near the crown scarp and the entire mass can slowly creep or move in sudden surges. These kinds of slides are often associated with clay-rich earth or bedrock. Perched water tables at the rotated head of the deposit can be common. Similarly, springs can typically be found where the failure plane near the toe of the slide verges toward the ground surface and converts its subsurface flow to overland flow. If contaminant plumes intersect landslides and travel along landslide failure planes, surface waters within seep gullies on the landslide or at the toe of the slide could also be at risk of contamination.



13a. Tor Nielsen, 1975 (USGS)

13b. LBNL, 2000



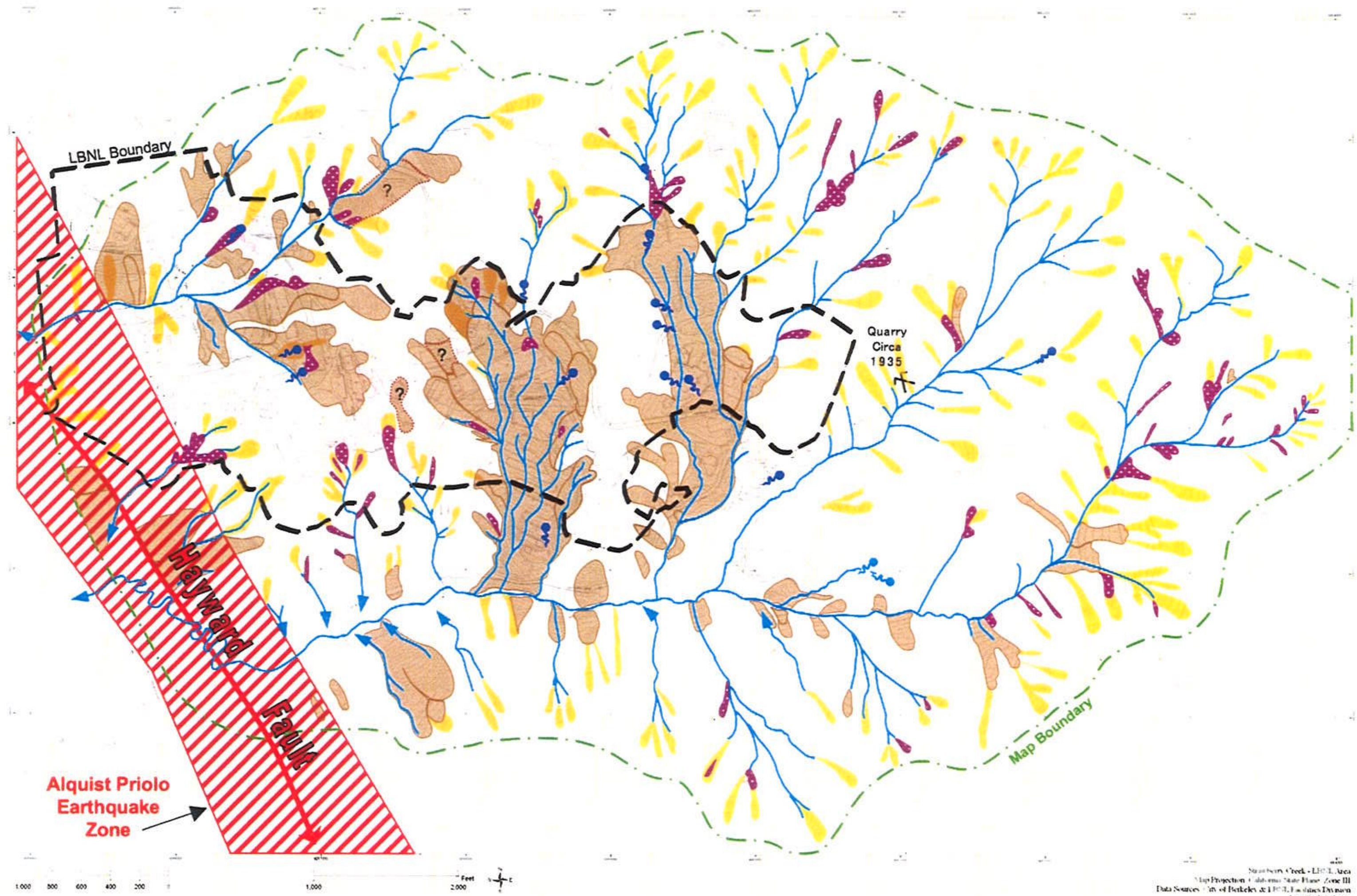


13c. Unpublished, Received from Kropp Assoc. (no author or date).

13d. Unpublished, Received from Kropp Assoc. (no author or date).

13e. California Geological Survey, 2003

FIGURES 13a-13e. MAPS OF LANDSLIDE STUDIES AND SURFICIAL DEPOSITS GEOLOGY



Colluvial Hollow: Source Area for Shallow Slides and/or Landslide Scar; Might Have Had Some Activity Within Colluvial Hollow During Last Century.
Earthflow, Slump, or Deep Seated Slide; Includes Area of Crown Scarp; Can include bedrock blocks; Portions of Some Earthflows May be Buried Beneath Alluvial Fans and Colluvium.
Debris Flow or Shallow Slide Active During Last Century
Historic Channel Network and Springs; Springs Adapted from Soule 1895

Laurel Collins, Watershed Sciences, January 2007

AERIAL PHOTOS: Strawberry Canyon, East Bay Regional Park District (1935)
STEREO PHOTOS: BUT-BUU-289 (1939), GS-CP (1946), AV-11 (1947), AV39-29 (1990)
Map of Strawberry Valley and Vicinity (Frank Soule, 1895)
1956 Topographic Map Portions (LBNL, 2000: Figures 4.3.2-2 and C2.2-1)
Hayward Fault from USGS Faults on Google Earth (2007)

FIGURE 13f. INTERPRETATION OF HISTORIC CHANNEL AND LANDSLIDE NETWORK AT LBNL IN STRAWBERRY CANYON

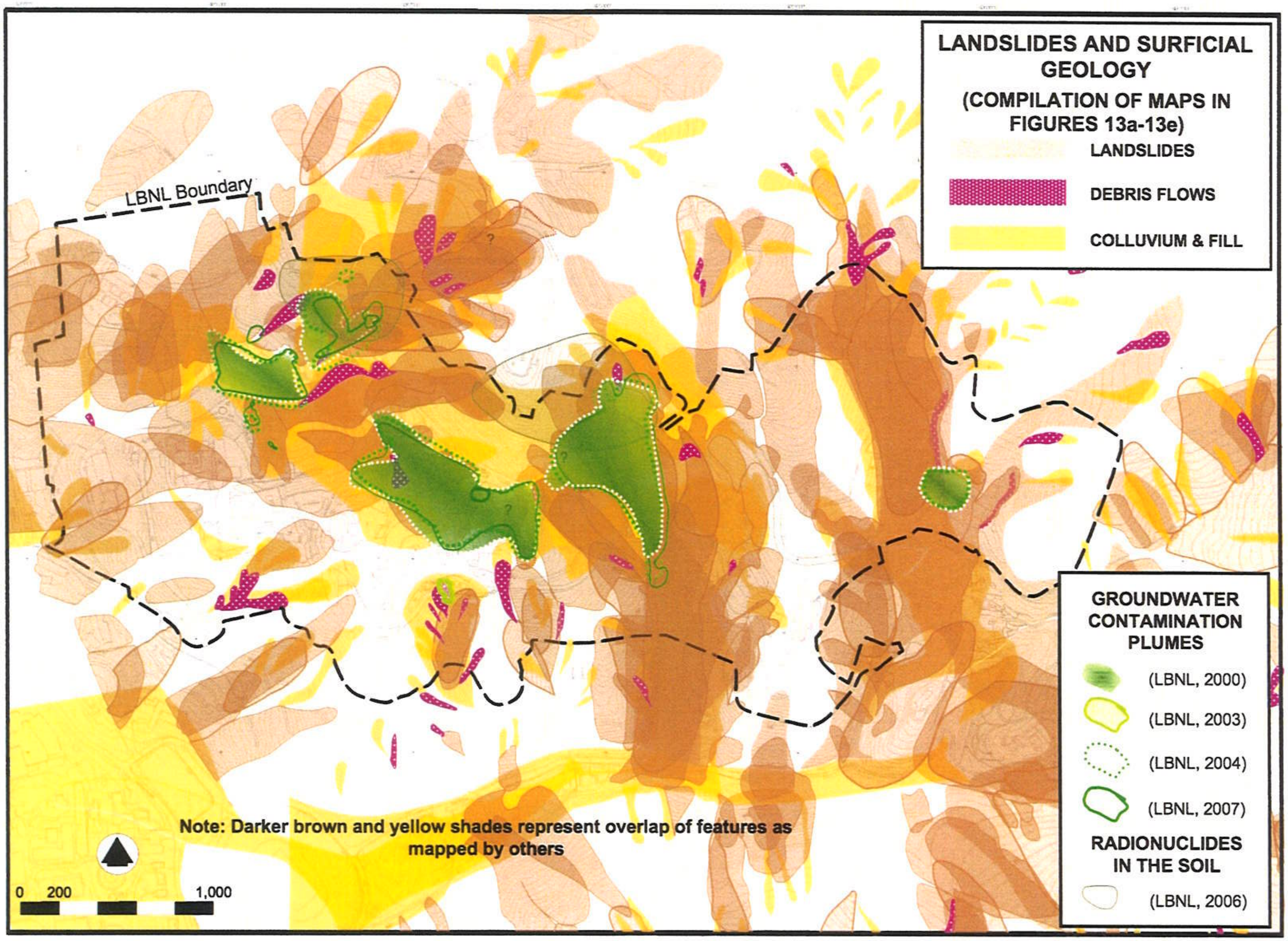


FIGURE 14. COMPILATION OF LANDSLIDE AND SURFICIAL GEOLOGY MAPS 13a-13f IN STRAWBERRY CANYON

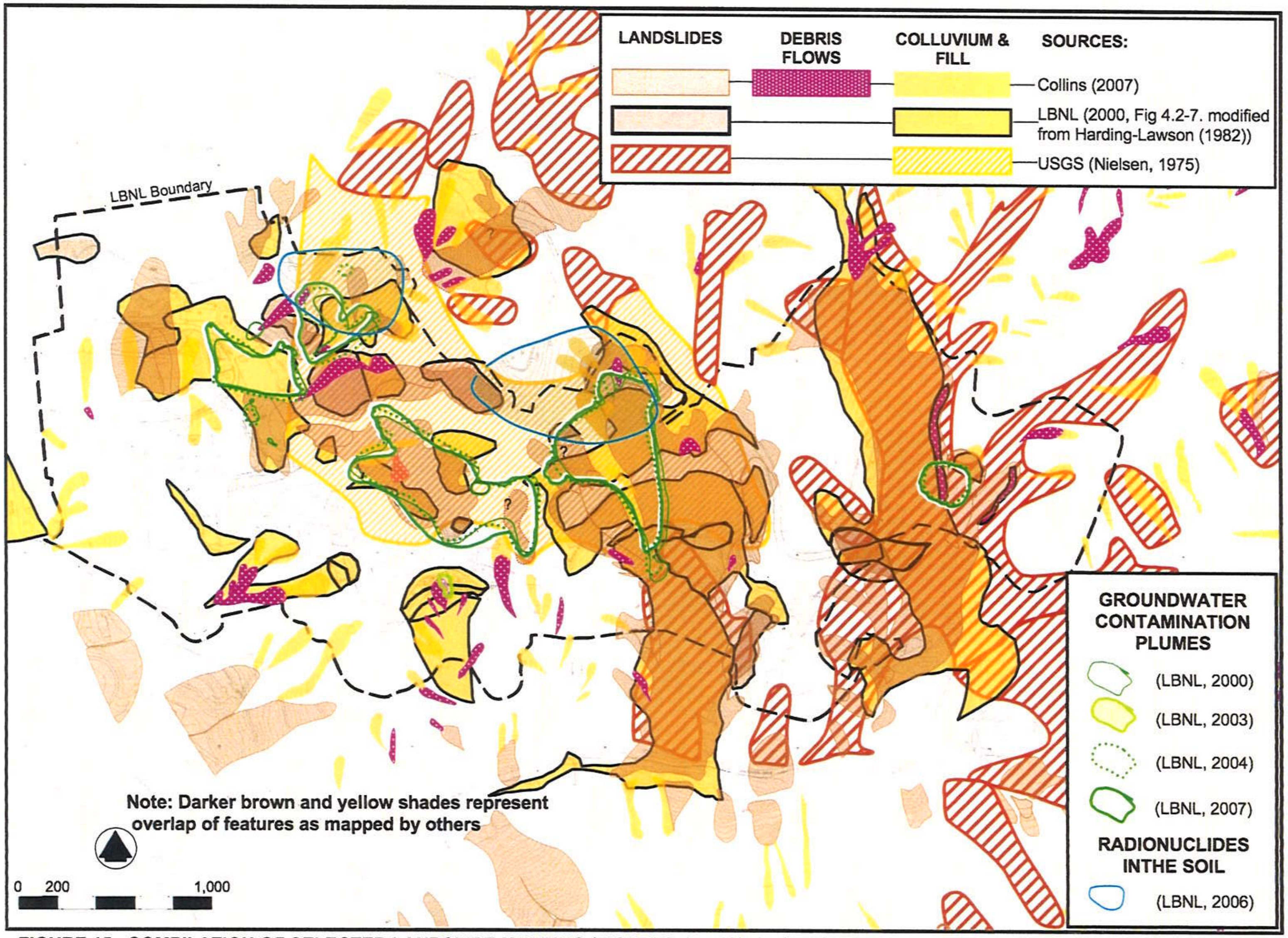


FIGURE 15. COMPILATION OF SELECTED LANDSLIDE MAPPING (FIGURES 13a,13b,13e) IN STRAWBERRY CANYON IN RELATION TO GROUNDWATER CONTAMINATION PLUMES

Shallow landslides in Strawberry Canyon, shown in Figures 13e and 15, tend to be soil slips, debris slides, and debris flows, which typically occur on steep slopes and move typically at high rates of speed. They tend to be translational in movement and are often associated with soils or bedrock that is porous and not necessarily clay-rich. They often occur within colluvium-filled hollows. The debris flows can form alluvial fans at the base of their run-out pathways.

The head of East Canyon appears to have numerous alluvial fan deposits that might be overlaying a deep-seated earthflow within the Orinda Formation. The earthflow might be overlaying or obscuring fault traces. Alternatively, the earthflow might have been sheered by fault displacement. Interpretation of earthflow shear planes versus fault planes at the Wildcat Fault trench were an additional subject of contention between Garniss Curtis (UC Berkeley) and Steve Korbay (Harding Lawson Associates) during the investigation that was discussed earlier in this report. In 1993, Jones and Collins also had concerns about interpretations of earthflow failure planes versus faults in the Chicken Creek basin area when they observed road cut exposures together with UCB staff and geotechnical consultants.

Plume Monitoring Sites

A series of monitoring and water quality sampling wells were constructed at the plume sites during 1990s when contamination monitoring was first required by State of California Department of Toxic Substances Control as a condition of LBNL's Hazardous Waste Facility Operating Permit (issued in 1993). The criteria for establishing well locations came from historic data review for activities in each building at LBNL that could have potentially led, during normal operations, to dumping, spills and accidents prior to the existence of any environmental regulations and oversight. Figure 16 shows the location of all the wells, some of which LBNL has already closed, i.e. "properly destroyed" or is in the process of closing.

Additionally, Figure 16 shows the location of the wells relative to the contaminant plume boundaries mapped by LBNL. Although numerous wells are located within the plume boundaries delineated by LBNL, the perimeters are not constrained by active sampling wells, especially along the potential migration pathways of faults, drainage courses, utility and sewer trenches, (and other engineered backfill) and landslides, as demonstrated in Figure 17a (map legend is Figure 17b). Bedrock contacts between Moraga and Orinda Formations (Figure 8a and 8b) are important, but were too complex to include in Figure 17a.

In order to adequately assess whether the monitoring wells are defining the actual contaminant plume boundaries, agreement on location of faults, bedrock contacts, and landslide boundaries is needed which is based upon well-founded information of what is actually known and what is hypothesized. Once improved mapping is accomplished at a higher resolution and accuracy than in the maps presented in this report, a strategy can then be developed to determine future locations of key sampling and monitoring sites. Until this is accomplished, there is reason for credible concern about contaminant plume boundaries and the groundwater monitoring program conducted to date by the LBNL.

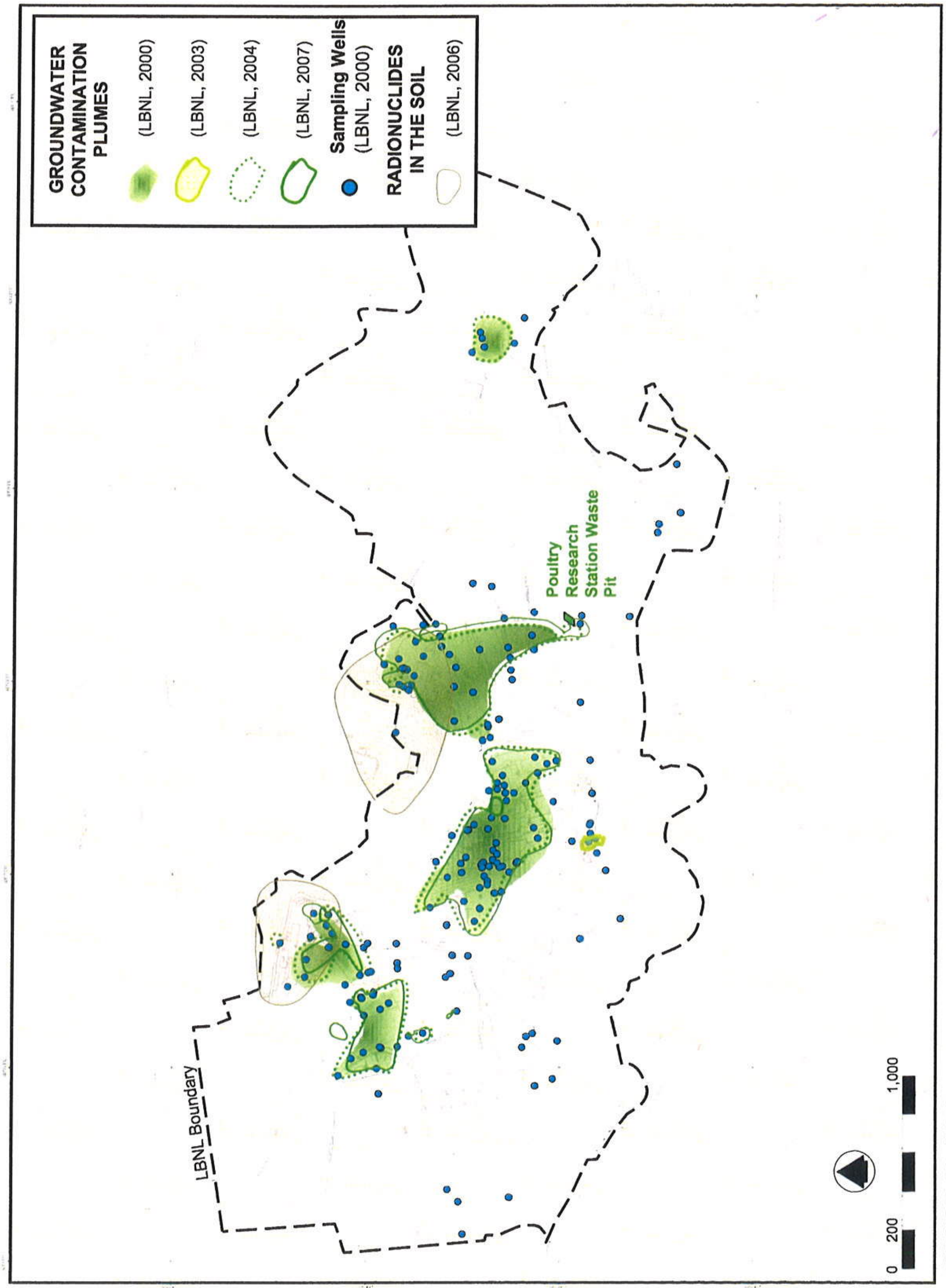


FIGURE 16. GROUNDWATER CONTAMINATION PLUMES AND SAMPLING WELLS

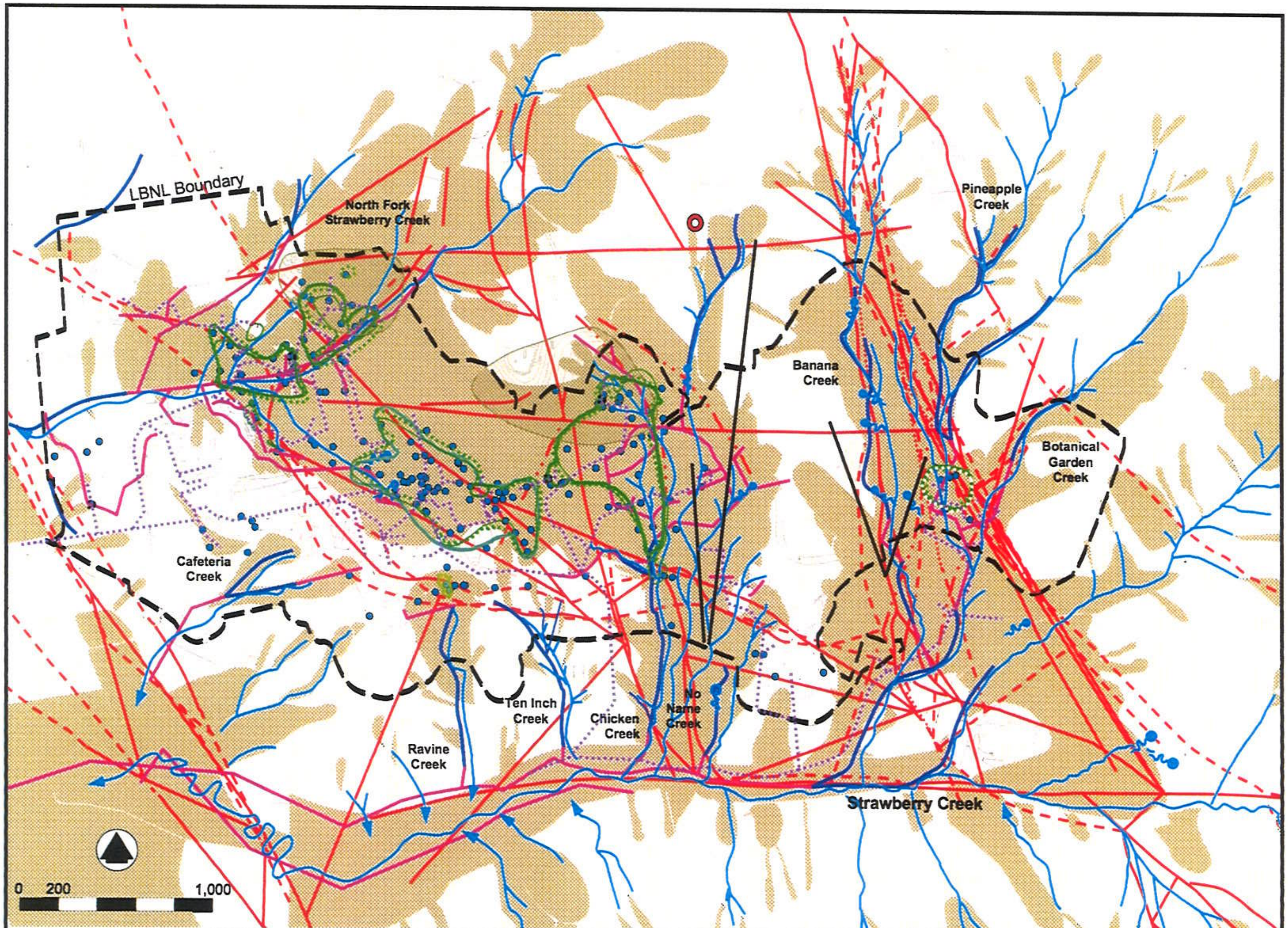


FIGURE 17a. COMPILATION OF MONITORING WELLS AND FACTORS WITH POTENTIAL INFLUENCES ON GROUNDWATER TRANSPORT AT LBNL. FOR BEDROCK CONTACTS VIEW FIGURES 8a AND 8b. SEE NEXT PAGE FOR MAP LEGEND.

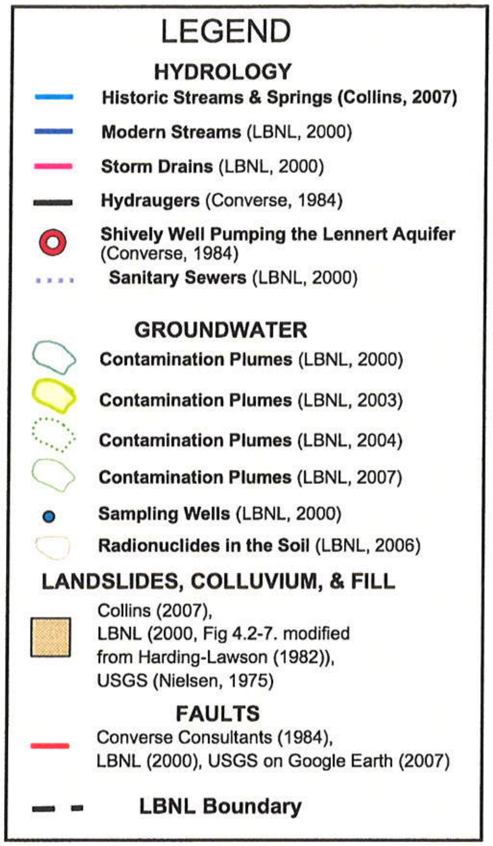


FIGURE 17b. LEGEND FOR FIGURE 17a COMPILATION OF FACTORS WITH POTENTIAL INFLUENCES ON GROUNDWATER TRANSPORT AT LBNL.

Zones of Concern for Potential Plume Migration

Given the status of what is currently known, Zones of Concern for potential migration of contaminant plumes are delineated in Figure 18a (legend shown in Figure 18b). These are areas where contaminant migration might yet be undetected because of either insufficient placement of sampling wells or insufficient understanding and/or consideration of where bedrock contacts, faults, landslides, utility trenches, and current or historic drainages exist. These zones were based upon the compilations of many other researchers mapping of geology, and infrastructure. The compilation maps shown previously were used to define Zones of Concern because we do not have knowledge of which individual geology or landslide map is most accurate. Hence, the Zones of Concern should be considered suggestive of possible areas requiring further investigation.

The zones provide a graphic example of why either a better array of monitoring wells are needed and why a verifiable picture of the physical landscape is essential in Strawberry Canyon. Furthermore, potential surface water contamination is possible along drainages that intersect faults, landsides, and bedrock contacts that intersect contaminant plumes. An additional component of contaminant plume analysis not addressed in our project is the depth of contamination and subsurface geologic conditions. These require three

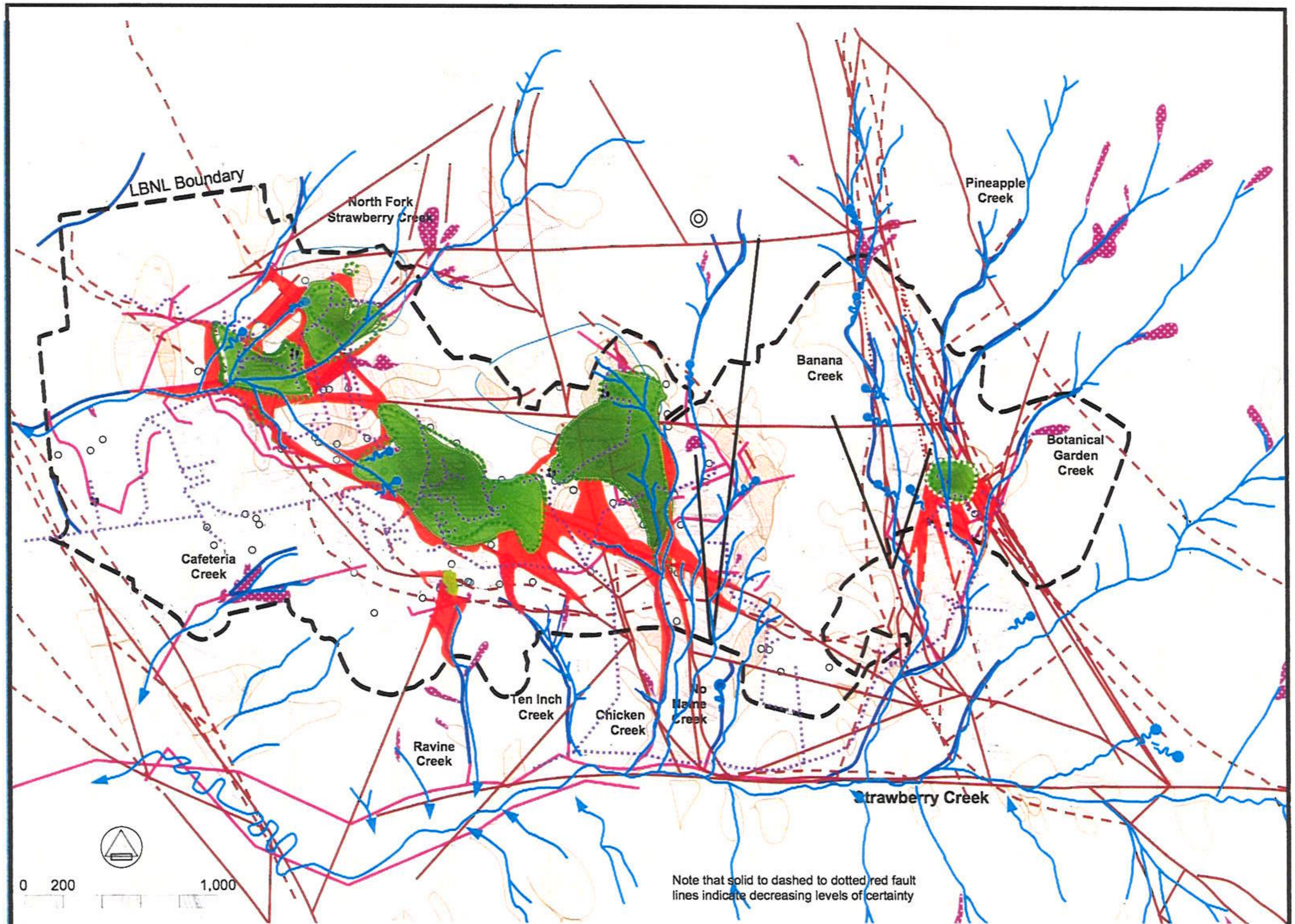


FIGURE 18a. ZONES OF CONCERN FOR GROUNDWATER PLUME EXPANSION ALONG COMPILED FAULTS, BEDROCK CONTACTS, LANDSLIDES, HISTORIC AND MODERN CREEKS. SEE NEXT PAGE FOR MAP LEGEND.

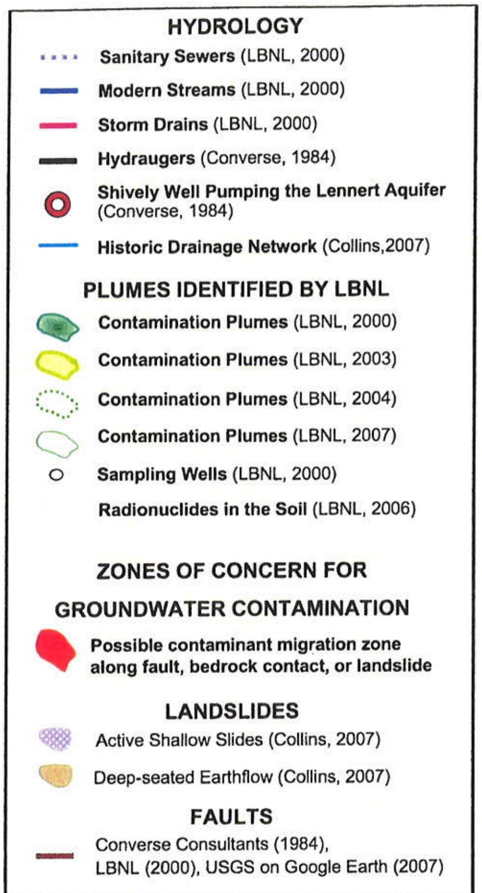


FIGURE 18b. LEGEND TO POTENTIAL FACTORS INFLUENCING CONTAMINATED GROUNDWATER PLUME EXPANSION

dimensional analyses, which LBNL has shown on their GIS-based maps (LBNL 2000) that use as their foundation the geologic picture of Figure 7a and fault map of Figure 9a.

Future Development and Site Conditions

The LBNL presently occupies 202 acres, however by 2025 LBNL anticipates a net increase of occupied space of about 660,000 square feet, an increase of 1000 people, and up to 500 additional parking spaces (LBNL, 2007a). Figure 19 shows the tentative footprint of proposed future buildings in their Long Range Development Plan, which is available at www.lbl.gov/LRDP/. The map shows about 30 new buildings dispersed throughout their property boundary. Much of the new construction is planned for areas previously avoided because of stability or fault issues. For example, the majority of the new construction will be located in the Chicken Creek basin and the East Canyon where deep-seated landslides have been mapped.

Figure 20a (map legend shown in Figure 20b) shows landslide hazard risks (as mapped by LBNL) and deep-seated landslides (as mapped on the historic drainage network in Figure 13f by Collins). Interestingly, the deep-seated slides are not considered areas of high to medium risk even though large-scale landslide movement could be triggered by

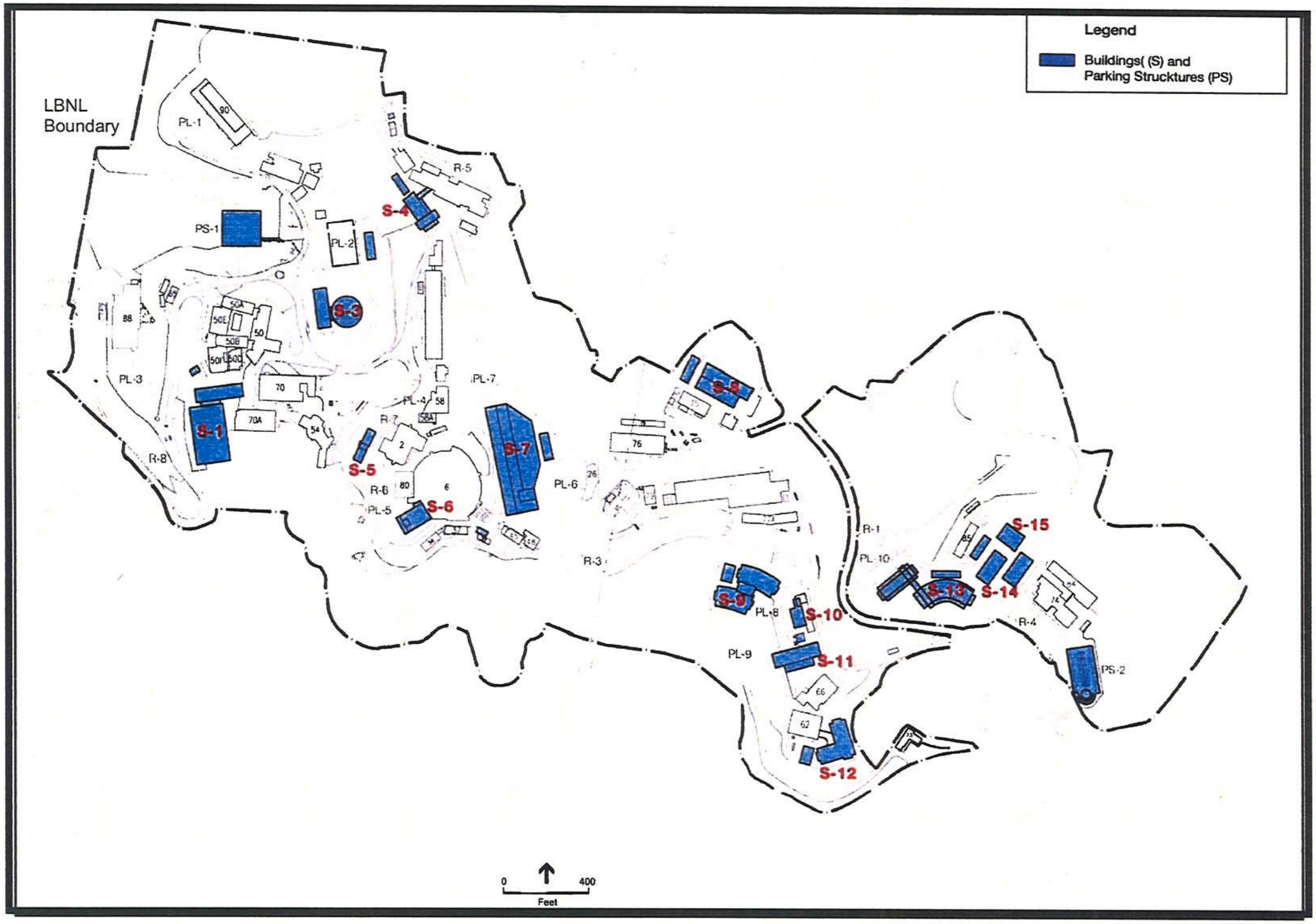


Figure 19. FUTURE BUILDING SITES AT LBNL ACCORDING TO LONG RANGE DEVELOPMENT PLAN (LBNL, 2007a).

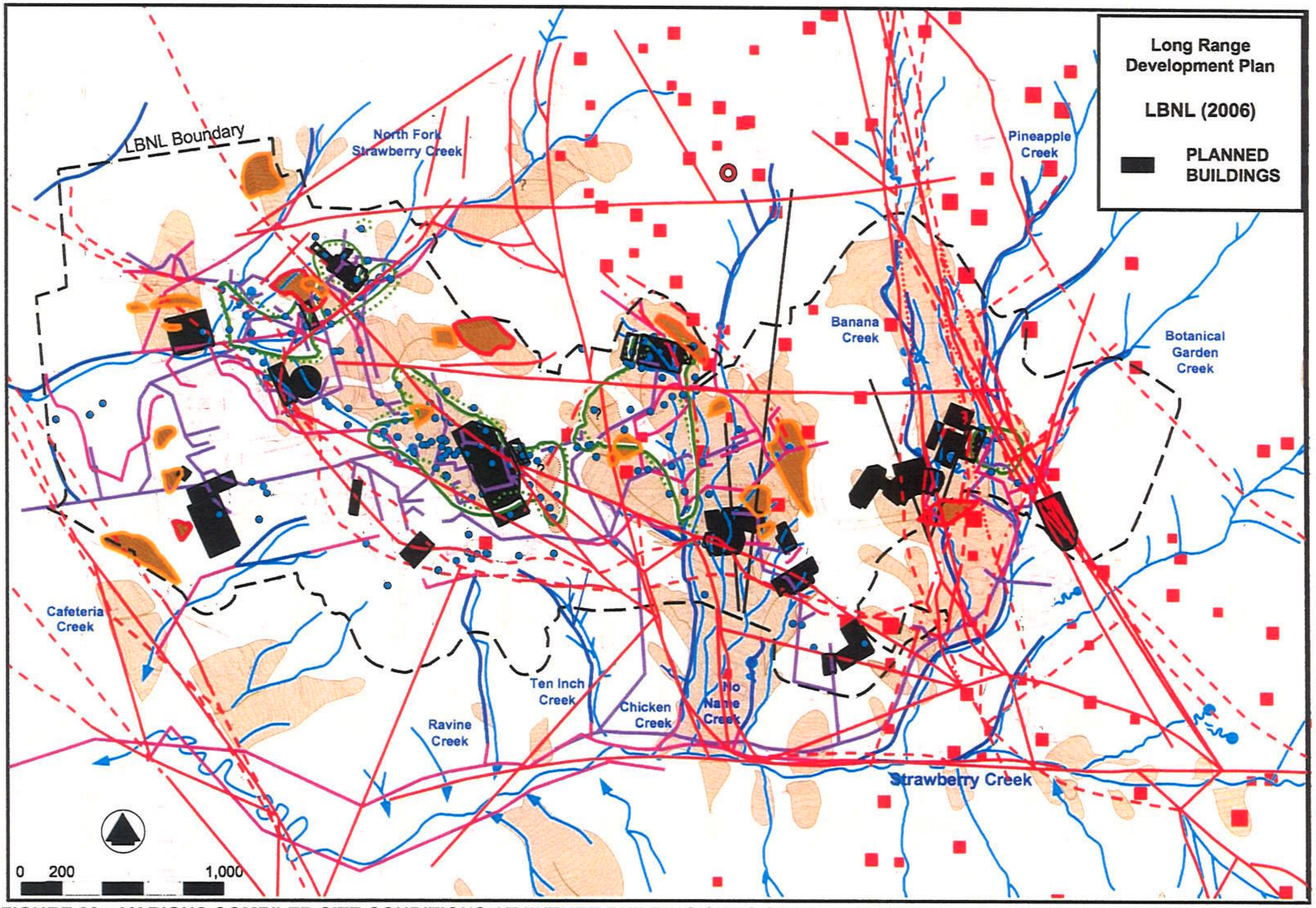


FIGURE 20a. VARIOUS COMPILED SITE CONDITIONS AT FUTURE BUILDING SITES OF LBNL'S LONG RANGE DEVELOPMENT PLAN. SEE NEXT PAGE FOR MAP LEGEND. NOTE THAT SOLID TO DASHED TO DOTTED RED FAULT LINES INDICATE DECREASING LEVELS OF CERTAINTY.

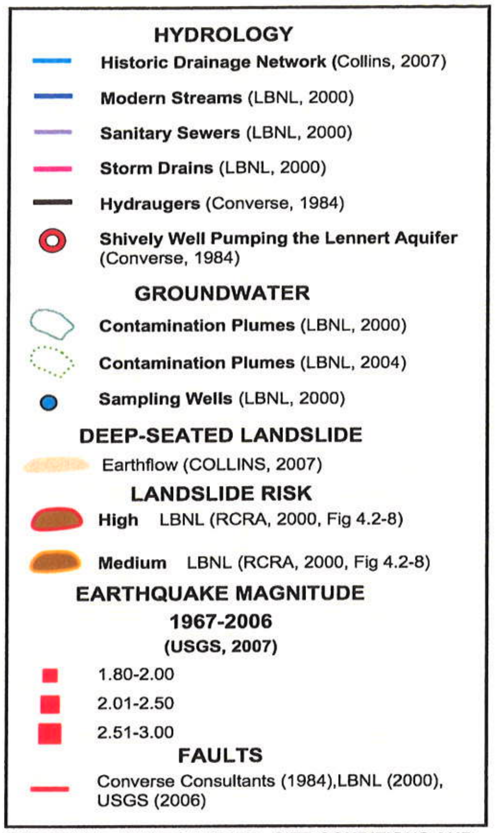


FIGURE 20b. KEY TO MAP 20a SITE CONDITIONS AND FUTURE BUILDING LOCATIONS

large magnitude earthquakes on the Hayward Fault and many of the slides overlay or intersect faults. Many buildings are shown to straddle faults that occur on the deep-seated landslides. Various other compiled site conditions in Figure 20a are also shown at the proposed LBNL building sites including the known contaminant plume locations. Some of the new building sites would require grading within the plume locations, which could alter existing groundwater transport pathways, as well as require special handling of contaminated soils.

As planning proceeds, Environmental Impact Analyses will require geologic and environmental information. These required legal documents demonstrate additional future needs for integrated and comprehensive mapping efforts of geologic and environmental conditions in Strawberry Canyon. As more excavations and investigations are conducted, the opportunities will increase to make verifiable geologic maps showing actual bedrock, landslide, and fault exposures.

CONCLUSIONS AND GENERAL RECOMMENDATIONS

At the very least, it is important to identify where there is valid disagreement on geologic conditions, particularly at contaminant plume sites, to determine if these sites pose a threat to human health and safety. Specific investigations or well placed monitoring wells could be designed to resolve some of these issues. Without an improved understanding and portrayal of the geology in Strawberry Canyon, it is difficult to accept that the monitoring sites were specifically designed to detect potential movement of groundwater along intersecting faults, landslide failure planes, bedrock contacts, utility trenches, storm drains, and historic drainages.

If the complexity of geologic conditions at the contamination sites has been and continues to be oversimplified, and because monitoring wells were not placed at key locations along faults, utility trenches, old creek beds/seeps and other parameters that influence groundwater movement, the extent and dispersement of contaminants may have been, and will continue to be underestimated in the future. As development continues in the Strawberry Creek Watershed, and probabilities increase for more uncontrolled releases and contaminant spills, the need will also increase to have an improved and comprehensive base of understanding. Protection of human health and water quality should be a priority, requiring more than a conservative approach when trying to investigate the extent of toxic contamination in an urban environment.

- An outside scientific technical review group should be formed to oversee LBNL's plume monitoring strategy and evaluate interpretations of plume migration.
- The types of factors that influence groundwater flow that have been compiled on the maps in this report should be developed on a three dimensional GIS base map.
- Information from previous consulting reports should be compiled to show the locations of verifiable bedrock outcrops, landslide deposits, landslide failure planes, and fault trace locations.
- Confidence levels should be assigned to various features such as faults, bedrock contacts, landslides, and boundaries of plume contamination.
- Future geologic investigations and excavation work in Strawberry Canyon should be required to show verifiable geologic exposures on the same base map and assign confidence levels to future interpretations.
- Further investigation of the nature of faulting, geology, and landslides in Strawberry Canyon should be conducted.

ACKNOWLEDGMENTS

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ATTACHMENT 8.

Chronology of the Campus Hill Area Development and Slope Instability Through 1984

Early 1900's	Development of the campus hill area begins
1949	Numerous slides occur as a result of Bevatron (Building 51) construction (1st recorded stability problems)
1950's	LBL significantly increases construction, massive cuts and fills undertaken to create flat pads for roads and buildings
1962	Small slope failures occur in the slopes behind Building 46, at site of Building 77, and reactivation of old slide uphill and east of Building 17
1962	Hydraugers installed to stabilize cut slope at northeast corner of Building 77 site
1963	Additional hydraugers installed behind slope north of Building 77 to stabilize old slide area
1963	Centennial Drive constructed
1967 - 1969	Slope instability continues at cut and fill behind Building 77, slope repairs and installation of hydraugers
1967	Slide on natural slope between Building 76 and 79
1969	Wet winter, much larger and more damaging slides occur including major failure of slope between LBL Corporation Yard and Centennial Drive which is repaired with buttress fill and subdrainage
1968-69	Serious slide occurs at the Centennial Drive overpass eastern abutment, road partially closed, hydraugers installed
1970	Slide occurred adjacent to Building 71 southeast parking lot, hydraugers installed
* 1973 →	Building 46 bisected by a very large slide, major repairs required including dewatering; slide continues to move in wet seasons
1975	Slide at compacted fill south of Building 77
1978	Slide at compacted fill south of Building 72
1975 →	Major hill area dewatering program undertaken, Shively Well No. 1 drilled (still continuously pumped)
1978	Centennial Drive overpass deforms further, steel bracing added
1979	Large scale dewatering of the hill attempted, second well drilled, two long nearly horizontal hydrauger drains installed into hill from Poultry Husbandry site
1980's	Numerous small slumps and mudflows occurred throughout hill area
1982	Earth movement at Centennial Drive overpass causes road closure, temporary repairs
1983	More movement at Centennial Drive overpass, road closed, major buttress fill repair required
1984	Centennial Drive reopened

Source: Complied from information contained in the Hill Area Dewatering and Stabilization Studies (Converse Consultants, 1984).

In addition to the information above, by 1987 LBNL had mapped some 30 landslides within the lab's Strawberry and Blackberry Canyons, and by 2008 the number of slides was up to 40, including LBNL's East Canyon landslide area.

Regarding Building 46 slide (see above), notes from a site visit by Robert Dunn and Professor Richard Goodman (October 18, 1976) state: Building 46 was "first founded on what was thought to be solid basalt-actually was LARGE BLOCKS." See also attached figure of the collapsed caldera (after Garniss Curtis, Professor Emeritus) at LBNL.

ATTACHMENT 9.

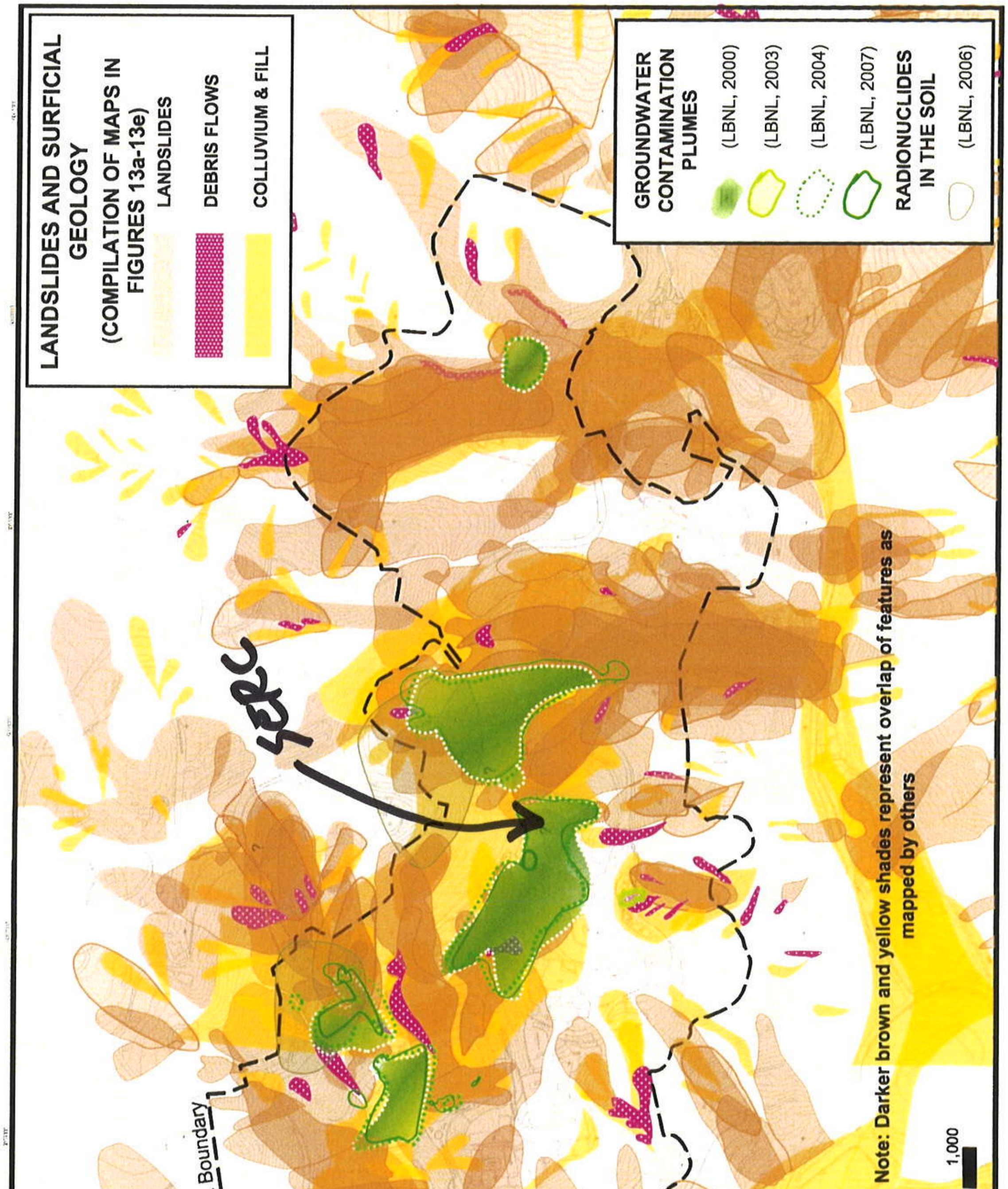

FIGURE 14. COMPILATION OF LANDSLIDE AND SURFICIAL GEOLOGY MAPS 13a-13f IN STRAWBERRY CANYON

ATTACHMENT 10.

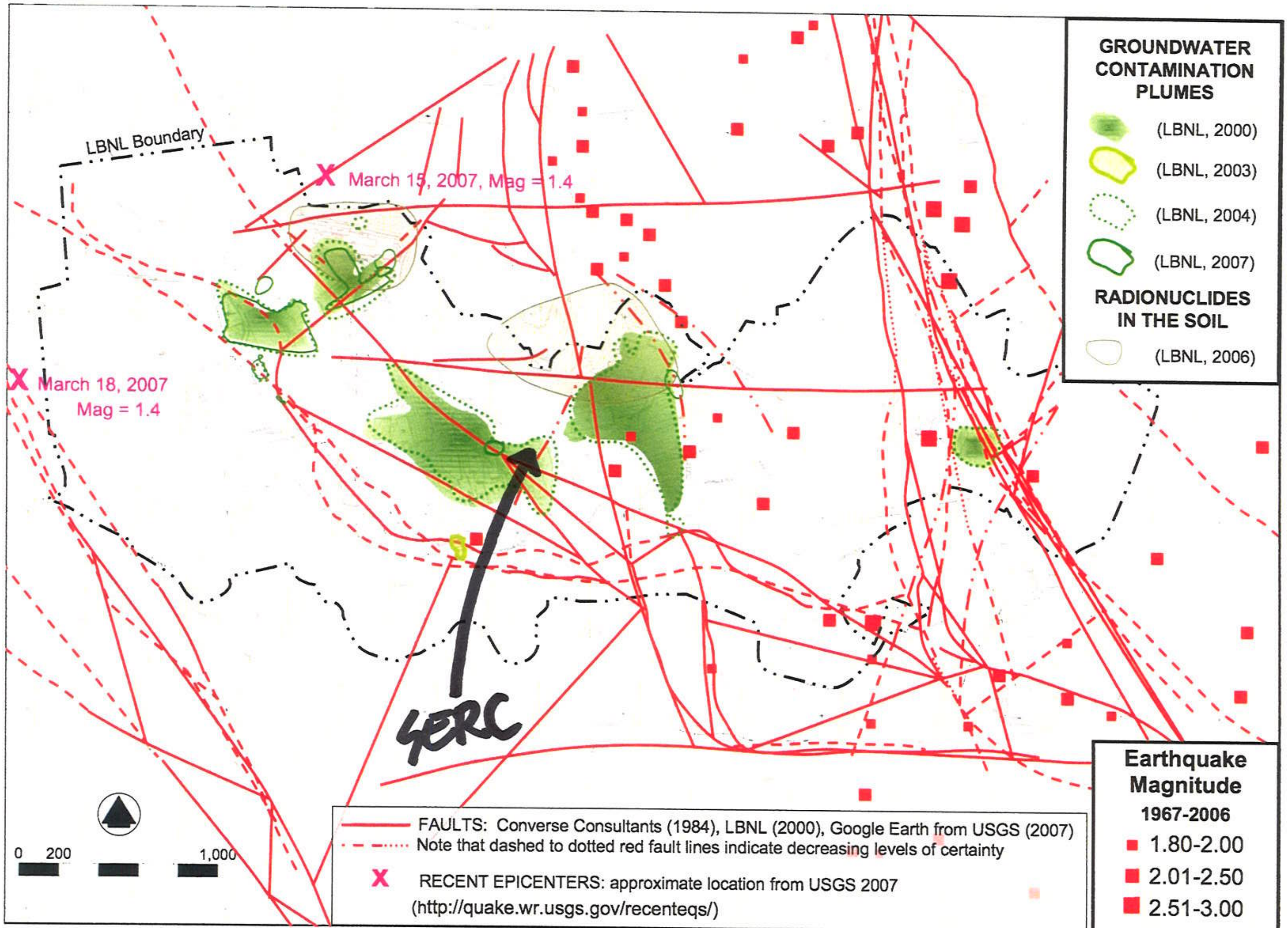

FIGURE 12b. GROUNDWATER CONTAMINATION PLUMES AND RADIOACTIVE CONTAMINATION IN SOIL RELATIVE TO FAULTS AND EARTHQUAKE EPICENTERS AT LBNL IN STRAWBERRY CANYON

Statement of Garniss H. Curtis, Professor Emeritus
Department of Earth and Planetary Science, U.C. Berkeley

On Sun, May 11, 2008 at 2:10 PM, Garniss Curtis <gcurtis@berkeley.edu> wrote:

To: anne.shaw@ucop.edu
From: Garniss Curtis <gcurtis@berkeley.edu>
Subject: regarding certification of final environmental impact reports for the proposed computational research and theory facility and the Helios energy resource facility and project approvals. [*Please note that several typographical errors and misspellings have been corrected in the following text.*]

As the request for my geologic opinion on the advisability of constructing large buildings in the lower part of Strawberry Canyon and in the next canyon to the north known as Blackberry Canyon came to me on May 4th, I have to be brief and rely on my memory. I shall first say as strongly as I can "absolutely do not construct any buildings in those two canyons", then I shall go into the reason based on the work I did as consultant to Mr. Ben Lennart 25 to 35 years ago, who was contracted by the University to investigate a number of sites for possible constructions or for stopping landslides that were threatening buildings.

First, the geologic setting of the two areas: The active Hayward Fault goes across the mouths of both canyons. Further east, the Wildcat Canyon fault parallels the Hayward Fault behind the Botanical Gardens and northward joins the Hayward near the town of San Pablo. Southward the Wildcat Canyon fault can be easily traced to Sibley Park and beyond. A few small epicenters lie along this fault near its junction with the Hayward, but it does not seem to be active elsewhere to the south. However, in the past, the area between the two streams and the two faults (which includes the whole of the Lawrence Laboratory complex) lay four miles to the south next to Sibley Park. The volcanic rocks in both areas have potassium-argon dates of approximately 10 million years, and the rhyolite found in both of them is the same rhyolite. The volcanic rocks underlying most of the Lawrence Lab complex fill an old crater, a collapse caldera. The old volcano that once rose above these rocks collapsed after the expulsion of a very large amount of rhyolite ash, now largely removed by erosion. The volcanic rocks broke up as the collapse occurred and many show crushing and deformation and are mixed with large amounts of ash and volcanic fragmental debris. This material should never have been built on as it is so clay-rich and unconsolidated. The western rim of this caldera is easily traced from its arcuate shape which is cut off by the Wildcat Canyon Fault just south of the Botanical Gardens near the upper part of Strawberry Creek. It swings around very close to the old Cyclotron and continues north to join the Wildcat Canyon Fault in Wildcat Canyon not far from the Merry-go-Round in Tilden Park. The boundary rocks to the west are sandstones and shales thought to be of Cretaceous age, that is, they are older than 65 million years. Exposures of these sandstones and shales are good below Building 50 down to Bowles Hall, and they dip westward at angles of 20 to 25 degrees, about which more later. The Hayward Fault passes very close to the rear of Bowles Hall after going through the Stadium where it has caused major deformation of the support pillars and offset of the two sides of the stadium since its construction in 1927.

Behind Hearst Mining Bldg and a few feet to the east, is the Lawson Adit which is a tunnel going eastward. Begun in the 1920' or earlier, it was completed in 1938 when it reached the Hayward Fault. Professor George Louderback told me (Personal comm.) that it was not ordinary fault gouge that he found in the Hayward Fault zone but a peculiar mixture of serpentine and metamorphic rocks that also appear on the surface and underlie Stern Hall and part of Foothill Student Housing. Founders Rock near the corner of Hearst and Gayley Road is in this melange. Also in the tunnel are several exposures of the offset of Strawberry Creek as determined from the contained rounded cobbles of Strawberry Canyon origin . Thus this indicates a displacemeent of more than 600 feet north along the Hayward Fault.

Still further north along the Hayward all the way to San Pablo huge amounts of the melange similar to that in the Lawson Adit have been squeezed out of the Hayward Fault and are gradually sliding down the slope below the fault. Much of this melange has reached the bottom of the hill back of El Cerrito. Along the Arlington many houses built on this melange are sliding and have caused a great number of legal problems. Within the fault itself no movement can be detected in these deposits, some of which are more than 100 feet thick. Thus we believe that movement and expulsion of this melange takes place during major earthquakes on the Hayward Fault.

A great deal of research has been done recently on the Hayward Fault by the USGS at Menlo Park which was reported in a talk on the last Thursday of this past April. They have established a return time of major quakes of 6.5-7 magnitude on the Hayward Fault of 130 years. The last major quake along the northern part of the Hayward Fault was 140 years ago, so we are over-due. They estimate that there is approximately a 65 percent chance a major quake will occur in the next 30 years.

Lennart was able to get survey notes from East Bay Municipal Utility District for the San Pablo Dam water tunnel to El Cerrito which crosses the Hayward Fault and shows that the right lateral horizontal movement of approximately one centimeter per year is matched by uplift of the east side of the fault of approximately one centimeter per year also. So, with the evidence of the horizontal displacement of the old Strawberry Creek of 600 feet horizontally along Galey Road, the Cretaceous sedimentary rocks east of the Hayward Fault there have also risen 600 feet. Building 50(?) sits on these Cretaceous strata which, as mentioned, dip westward 20-25 degrees. If an earthquake occurs when these beds are soaked with winter rains the chance of a major landslide are great along the slippage planes of shale dipping westward. Minor slides have already occurred in these beds behind Bowles Hall. Indeed, the Foothill Student Housing was planned to be built there until I called attention to the landslide. A major landslide would probably destroy all the buildings on both sides of Galey Road from the Stadium to the buildings on both sides of Hearst Avenue and would probably reach Dow Library, destroying everything in its path to that point and possibly beyond. Buildings in the lower parts of both Strawberry and Blackberry Canyons would be buried if not destroyed.

Major landslides of the type I have described here are not rare along the Hayward Fault as was shown to us during our study of the Hayward fault at the base of the hill behind the Clark Kerr Campus. We discovered that most of that campus was underlain by a large landslide that had originated in Claremont Canyon, and was gradually moved northward along the Hayward Fault. Trenches and drill holes showed this landslide to be up to 30 feet thick. It extends westward to and possibly beyond Piedmont Ave. Further south is a huge landslide that underlies most of the campus of Mills College and extends westward another quarter mile Still further south are more large slides that have originated in canyons and steep slopes east of the Hayward Fault. As the hills rise and become unstable, earthquakes cause them to break loose and slide. Very few large slides have occurred on the eastern slopes of the Berkeley Hills, hence the relationship to earthquakes of major landslides close to the Hayward Fault along the western slopes of the Berkeley Hills. Normal erosion rounds off unstable areas on the eastern slope of the Berkeley Hills before they break loose and slide.

Most of the buildings of the Lawrence Lab. are on the unstable ground filling the old caldera, particularly the Bevatron and associated buildings. As the Cretaceous beds immediately west of these buildings have been eroded away there is nothing to keep these soft caldera-filled beds from sliding. The buildings on them will certainly move a few feet in a major earthquake if not hundreds of feet. Keep in mind the Loma Prieta quake of l989 of magnitude 6.9 which from a distance of over 60 miles destroyed a section of the Bay Bridge, a section of the overhead freeway in Oakland killing 63 people, and many houses on filled ground in the Marina of northern San Francisco some 70 miles from the quake!

No major buildings of any kind should be constructed in either of these canyons bordering this huge block of unstable rock.

--

Profesor Emeritus Garniss H. Curtis
Dept. Earth and Planetary Science
University of California, Berkeley, CA

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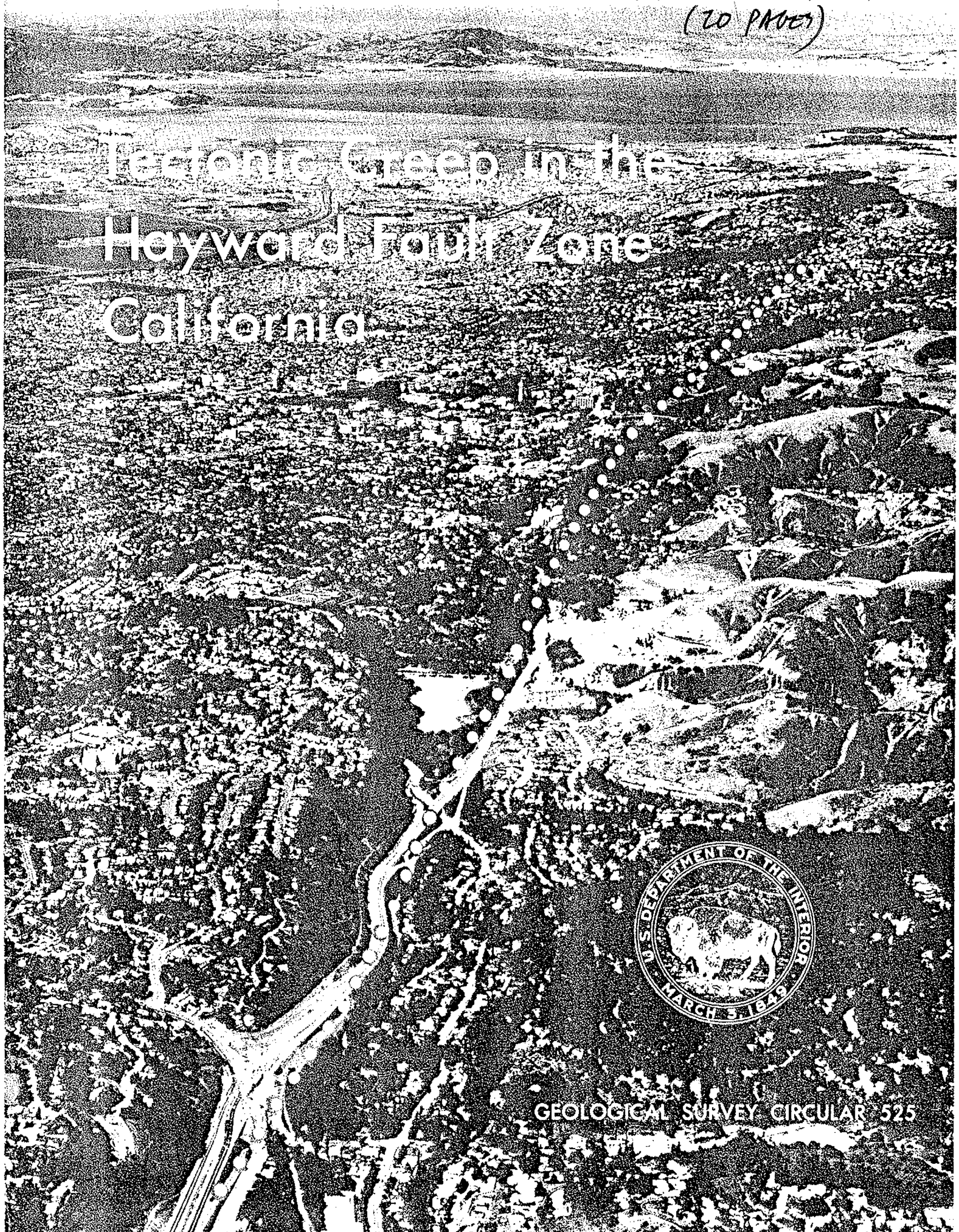
ATTACHMENT 12.
HAYWARD FAULT

ATTACHMENT 13.
(20 PAGES)

Tectonic Creep in the Hayward Fault Zone California



GEOLOGICAL SURVEY CIRCULAR 525

COVER:

Looking northwest along the Hayward fault zone from Oakland to Berkeley, Calif. Lake Temescal in middle foreground, San Francisco Bay in background. Photograph courtesy Clyde Sunderland, aerial photographer, Oakland.

Tectonic Creep in the Hayward Fault Zone California

INTRODUCTION

By Dorothy H. Radbruch and M. G. Bonilla

DAMAGE TO CULVERT UNDER MEMORIAL STADIUM
UNIVERSITY OF CALIFORNIA, BERKELEY

By Dorothy H. Radbruch and Ben J. Lennert, Lennert and Associates

CRACKS IN THE CLAREMONT WATER TUNNEL

By F. B. Blanchard and C. L. Laverty, East Bay Municipal Water District

DEFORMATION OF RAILROAD TRACKS IN FREMONT, CALIFORNIA

By M. G. Bonilla

CREEP IN THE IRVINGTON DISTRICT, FREMONT, CALIFORNIA

By Lloyd S. Cluff, Woodward-Clyde-Sherard and Associates
and Karl V. Steinbrugge, Pacific Fire Rating Bureau

Geological Survey Circular 525

Washington 1966

United States Department of the Interior
STEWART L. UDALL, *Secretary*

Geological Survey
William T. Pecora, *Director*

Free on application to the U.S. Geological Survey, Washington, D.C. 20242

CONTENTS

ILLUSTRATIONS

Tectonic Creep in the Hayward Fault Zone California

ABSTRACT

Tectonic creep is slight apparently continuous movement along a fault. Evidence of creep has been noted at several places within the Hayward fault zone—a zone trending northwestward near the western front of the hills bordering the east side of San Francisco Bay.

D. H. Radbruch of the Geological Survey and B. J. Lennert, consulting engineer, confirmed a reported cracking of a culvert under the University of California stadium.

F. B. Blanchard and C. L. Laverty of the East Bay Municipal Utility District of Oakland studied cracks in the Claremont water tunnel in Berkeley.

M. G. Bonilla of the Geological Survey noted deformation of railroad tracks in the Niles district of Fremont. Six sets of tracks have been bent and shifted.

L. S. Cluff of Woodward-Clyde-Sherard and Associates and K. V. Steinbrugge of the Pacific Fire Rating Bureau noted that the concrete walls of a warehouse in the Irvington district of Fremont have been bent and broken, and the columns forced out of line.

All the deformations noted have been right lateral and range from about 2 inches in the Claremont tunnel to about 8 inches on the railroad tracks. Tectonic creep almost certainly will continue to damage buildings, tunnels, and other structures that cross the narrow bands of active movement within the Hayward fault zone.

INTRODUCTION

BY DOROTHY H. RADBRUCH AND M. G. BONILLA

Tectonic creep has recently been recognized in the Hayward fault zone (fig. 1). Tectonic creep is here considered to be slight apparently continuous movement along a fault, usually not accompanied by felt earthquakes; it has also been called slippage (Whitten and Claire, 1960). Much construction is going on in the areas of creep, and the probability of damage due to slow movement of faults, in addition to the possibility of sudden rupture, should be brought to the attention of persons concerned with design, construction, or maintenance of structures in the Hayward fault zone.

The Hayward fault zone is a northwest-trending zone of faults near the western front of the hills bordering the east side of San Francisco Bay (fig. 2). It extends southeastward from San Pablo to Warm Springs, and possibly even farther both northwestward and southeastward. The zone in which recent movement has taken place ranges in width from approximately 500 feet south of Lake Temescal to about 1-3/4 miles near the Mission San Jose district. Many of the faults within the zone are actually bands of sheared rock, tens or possibly even hundreds of feet wide, in which are many anastomosing fault surfaces.

In places the surface expression of the many faults within the fault zone is very obvious. Near San Pablo the course of a fault is indicated by a short valley southeast of the Mira Vista Country Club; near the University of California in Berkeley and at Decoto the steep westward-facing front of the hills is probably a fault scarp. Lake Temescal in Oakland lies in a pronounced trench which shows the course of the fault zone, and between Niles and Irvington the main fault trace is marked by two conspicuous sag ponds. In general, the extent of the zone is indicated by such geomorphic features as shutter ridges, offset streams, lines of springs, scarps, and sag ponds.

In historic time, movements within the fault zone have caused two major earthquakes with accompanying surface rupture—one in 1836 and one in 1868 (Wood, 1916)—and numerous small shocks (Tocher, 1959). Both horizontal and vertical movement were reported at the time of the 1868 shock.

During the last few years evidence of tectonic creep along the Hayward fault zone has

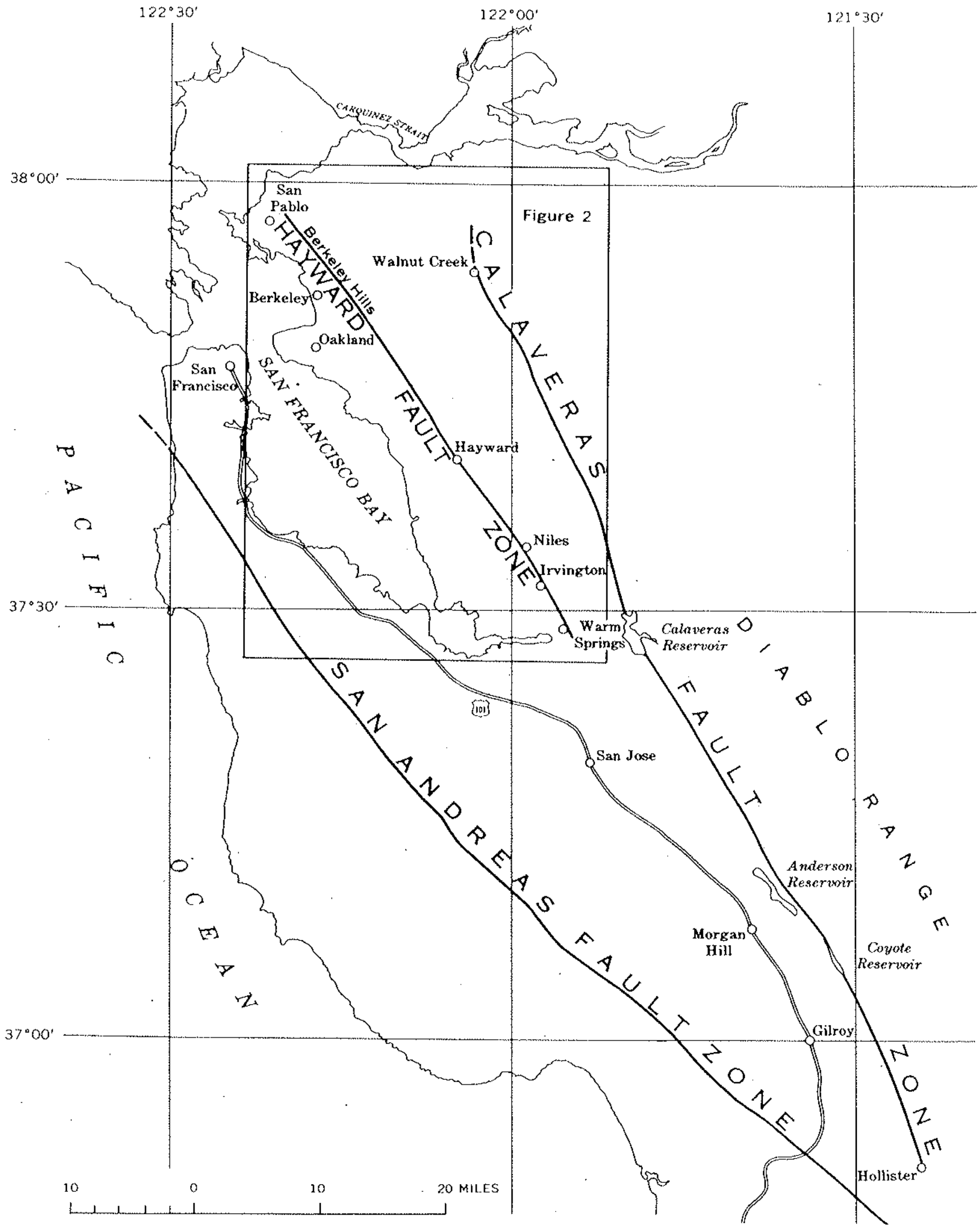


Figure 1.—Location of Hayward, San Andreas, and Calaveras fault zones, and approximate boundaries of figure 2. The towns of Niles, Irvington, and Warm Springs are now districts within the larger town of Fremont.

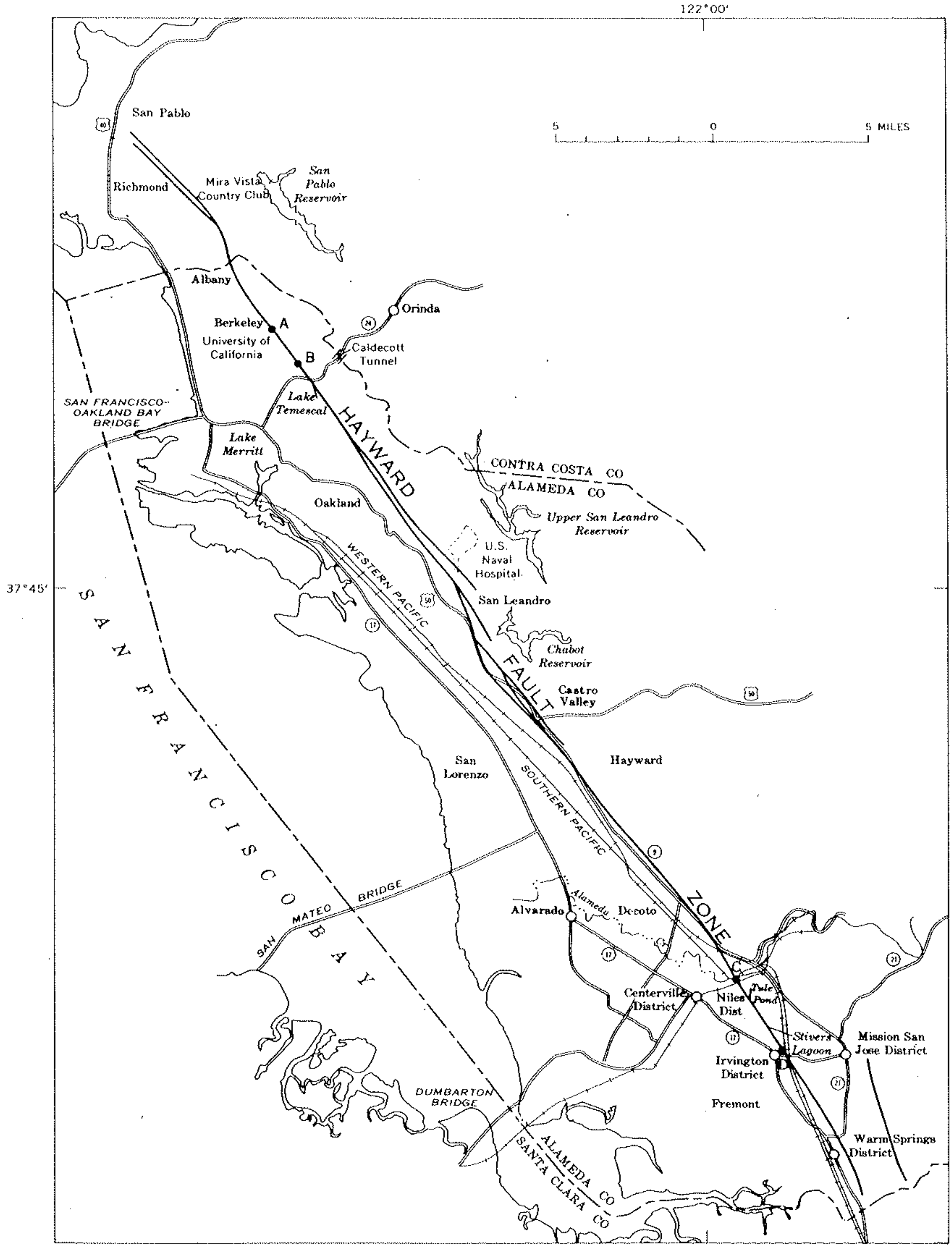


Figure 2.—Approximate location of fault traces of the Hayward fault zone and localities (A-D) where evidence of creep has been found.

been found independently by several people from different organizations. In 1960, L. S. Cluff of Woodward-Clyde-Sherard and Associates noted distortion of a warehouse (loc. D, fig. 2) in the Irvington district of Fremont. In December 1964 the East Bay Municipal Utility District found offsets in the Claremont water tunnel (loc. B, fig. 2) in Berkeley while the tunnel was temporarily drained. In March 1965 M. G. Bonilla of the U.S. Geological Survey found distortion in railroad tracks (loc. C, fig. 2) in the Niles district of Fremont. More recently, D. H. Radbruch of the U.S. Geological Survey and Ben J. Lennert, consulting engineer, confirmed a reported cracking of the culvert (loc. A, fig. 2) under the University of California stadium in Berkeley. In each area the movement has been right lateral; that is, the northeast side of the fault has moved southeastward with respect to the southwest side of the fault.

As may be seen from figure 2, these four areas are near the ends of a 28-mile segment of the Hayward fault zone, but creep may be occurring in the intervening reaches. It is hoped that publicizing this phenomenon will encourage others to look for similar movements in other parts of the zone.

Faults do not suddenly change their habits, and therefore additional major earthquakes and tectonic creep along the Hayward fault zone can be expected. Future movement will probably take place within the fairly narrow band where historic movement and present creep are known. Direct injury to persons as a result of creep is not likely, but creep may progressively weaken structures which could fail and cause injuries.

The recognition, by geologic studies, of narrow bands of active movement permits (1) concentration of measurement for scientific and practical uses, and (2) precautions to minimize the destructive effects of the movement.

The following sections of this circular describe in detail, from north to south, the four areas of creep that have thus far been observed.

DAMAGE TO CULVERT UNDER MEMORIAL STADIUM, UNIVERSITY OF CALIFORNIA, BERKELEY

BY DOROTHY H. RADBRUCH AND BEN J. LENNERT [1]

The Hayward fault zone has long been known to extend northwestward across the campus of the University of California at Berkeley (Buwalda, 1929; G. D. Louderback, unpub. data). The University of California Memorial Stadium lies directly on the fault zone, its long axis being roughly parallel to it, at a spot where right-lateral movement along a sheared band or fault plane has offset the southwest-trending canyon of Strawberry Creek. The southwest side of the fault has moved northwest with respect to the northeast side, so that the downstream part of Strawberry Creek is now northwest of the upstream part. The two parts are connected by a northwest-trending section, about 1,200 feet, which flows in a culvert under the stadium. Part of the water of Strawberry Creek is carried by a bypass culvert which extends across the fault northwest of the stadium (fig. 3).

On June 23, 1965, Dorothy H. Radbruch, of the U.S. Geological Survey, and Ben J. Lennert, of Lennert and Associates, soils engineers, consultants to the University of California, examined both of the Strawberry Creek drainage culverts.

The following description of damage to the culverts and their history of construction, damage, and repair is derived in part from field observation and in part from correspondence, reports, and drawings kindly furnished by the Division of Architecture and Engineering of the University of California and by Walter T. Steilberg, architect, consultant to the University of California. The assistance of Mr. Steilberg and the University officials and their authorization to use the material furnished are gratefully acknowledged.

[1]Civil Engineer, Lennert and Associates, soils engineers, Oakland, Calif.

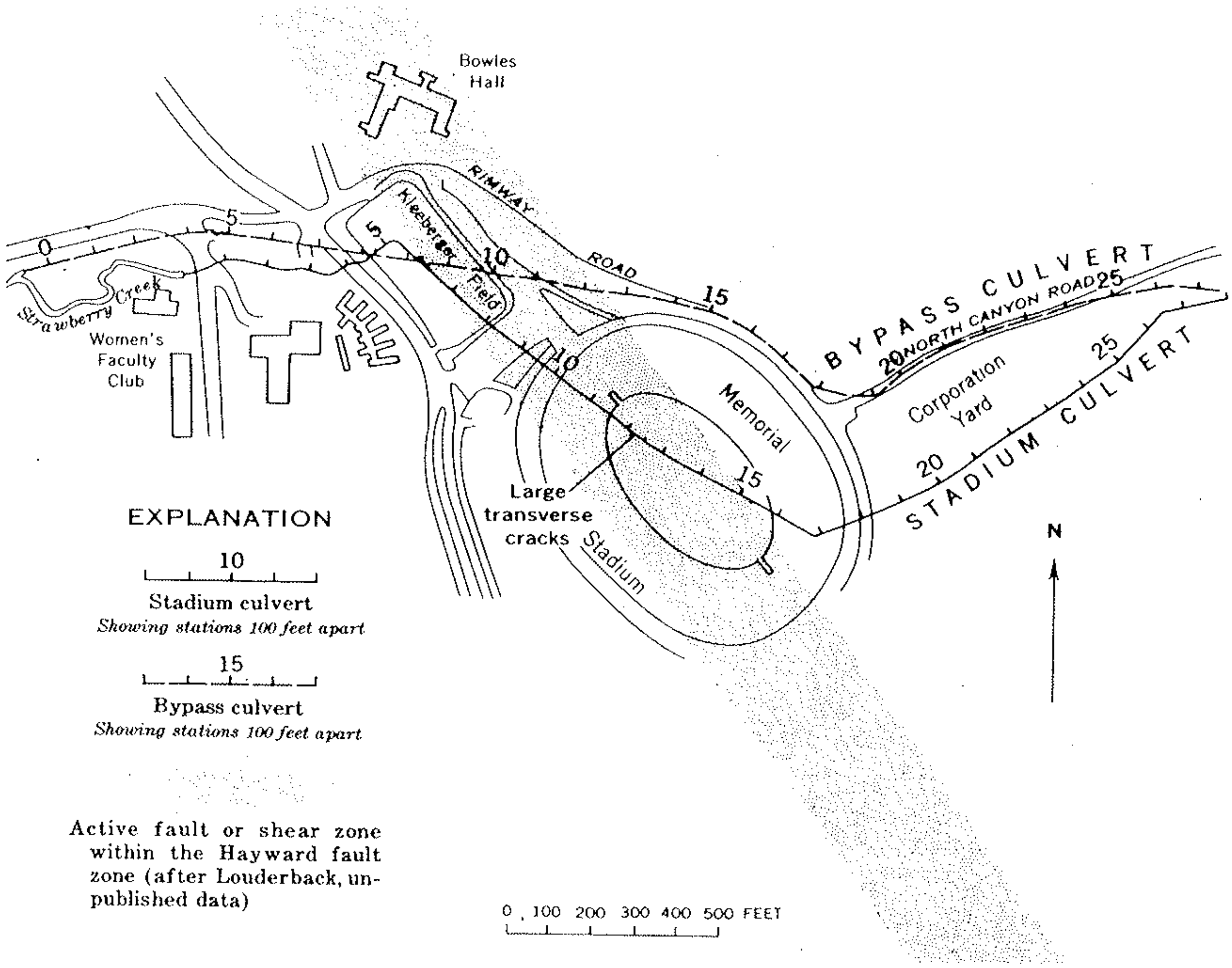


Figure 3.—Location of University of California Memorial Stadium, Berkeley, Calif.; fault or shear zone within the Hayward fault zone (stippled); two Strawberry Creek culverts, with station designations on culverts; and location of major cracking of stadium culvert.

The part of the Strawberry Creek stadium culvert which lies under the Memorial Stadium was constructed in 1923, as part of the stadium contract. It is a cast-in-place concrete box culvert 4 feet wide that ranges from 3 feet 9 inches to 4 feet in height. The original culvert extended only from what is now the Corporation Yard to a point under the present Kleeberger Field. Other sections were added later.

Minor cracks in the culvert were noted when it was first inspected in 1932. Complete records of repair at that time are not available, but it is assumed that some repairs were made. In 1948 the culvert was again inspected and was found to be in very poor condition. In addition to leaky construction joints, holes in the floor (invert), and minor cracking, two large cracks were observed at stations 12+51.5 and 12+57 (fig. 3). The large cracks were not those mentioned in the 1932 inspection report; they were described as being 1 inch wide completely around the culvert. A notation that the cracks might be due to movement along the Hayward fault zone was made by Walter T. Steilberg on a 1948 construction drawing. Repairs consisted primarily of grouting and installation of mine screwjacks as temporary shores in two parts of the culvert between stations 10+50 and 13+00, and between stations 16+50 and 17+50. The two large cracks were filled with mortar.

In 1954 the culvert was again inspected before making more permanent repairs. According to Walter T. Steilberg (oral commun., 1965), the cracks at stations 12+51.5 and 12+57 had widened between 1948 and 1954. At this time much of the floor of the culvert was paved, and 40 gunite rings, 41 inches long and 36 inches in inside diameter, were installed to replace the screwjacks. The large transverse cracks were repaired with gunite, but no details are available regarding their exact width at the time or the precise nature of the repairs.

When the culvert was inspected in 1965, the damage consisted of some leaky, construction joints; erosion of the invert; hairline cracks on the northeast side of the culvert at approximately stations 8+45, 9+25, and 10+70 and between stations 14+27 and 15+80; and two major cracks at approximately stations 12+50 and 12+55. There is no doubt that the latter two cracks are the same as those previously recorded at stations 12+51.5 and 12+57.

The northwest (downstream) major crack, at about station 12+50, trends approximately at right angles to the culvert walls; in 1965 it had a maximum width of 1-1/4 inches in the floor and a maximum width of 3-1/2 inches on the northeast side of the ceiling, between the centerline and the junction with the wall. The southeastern (upstream) crack, which has a sinuous trend across the floor, showed a maximum gap of a quarter of an inch in the floor and a maximum width of 2-3/4 inches on the southwest side of the wall. No lateral or vertical displacement of the cracks was apparent; the slight left-lateral offset reported in 1948 could not be confirmed. Water was pouring from the ceiling at both cracks, and the sides of the cracks and the walls near the cracks were coated with iron-stained calcium-carbonate, undoubtedly deposited by water entering the culvert through the cracks.

It can be assumed that the cracking of the floor has taken place since the floor was paved in 1954. The total average widening of the two cracks in the floor has been about 1.25 inches in 11 years, approximately 0.11 inch per year.

The main area of cracking and repair—stations 10+50 to 13+00—is thought to lie within an active sheared band or fault which is part of the Hayward fault zone (G. D. Louderback, unpub. data). The general trend of the fault probably crosses the culvert at an angle of about 20°. Right-lateral movement along this fault has taken place, as evidenced by the offsetting of Strawberry Creek. Right-lateral movement along the active zone would exert tension on the culvert, and tension cracks would be expected in the walls of the culvert. The formation and constant widening of the cracks that have been observed have probably resulted from such tensile stresses, and do not provide a direct measure of total movement on the fault since the culvert was installed.

No measurable lateral or vertical displacement of the cracks was observed, but the culvert appears to be slightly deflected laterally in the area of the two major cracks (fig. 4). Detailed measurements have not yet been made.

The Strawberry Creek bypass culvert, which carries part of the waters of Strawberry Creek north of the stadium, was constructed in 1954. G. D. Louderback (unpub. data), who was a consulting geologist for the architect in charge of construction, was of the opinion that two main faults or branches of the Hayward fault zone extend northwest across the campus, one lying under the stadium, and the other perhaps 400 to 500 feet farther west. He recommended that the section of the bypass culvert which would cross the easternmost fault be made of precast sections 4 feet in length, rather than the 8-foot sections used for the rest of the culvert. According to Walter T. Steilberg, architect (oral commun., 1965), weak mortar was used between the 4-foot sections, so that any failure in this area would take place along the joints rather than damaging the pipe sections. Construction plans show that the 4-foot sections were installed from station 7+96 to station 15+50, as given on figure 3, or a distance of 754 feet.

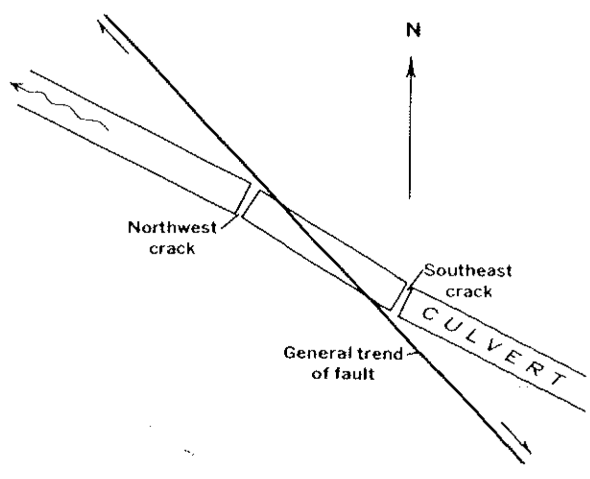


Figure 4.—General relationship of fault to damaged culvert under the University of California Memorial Stadium, relative direction of movement of opposite sides of fault, and nature of damage to culvert (not to scale).

When the culvert was inspected in 1965, minor cracking was observed in many joints throughout the length of the culvert. The most pronounced and numerous cracks, some as much as one-eighth of an inch wide, were between stations 8+00 and 9+00, and between stations 10+80 and 12+80. The localities lie within the area thought to be crossing the active part of the fault. It is also in a place where the culvert slopes steeply, and all or part of the cracking in this area could be due to downslope movement of the pipe.

Maintenance personnel of the university report recurrent trouble with utilities, such as bending or breaking of conduit, on the rimway road near the playfield north of the stadium; the exact location is unknown at present.

Although the cracks in the stadium culvert could be due to a number of causes, such as weight of overlying fill or downslope creep of fill, it seems more probable that they are due to movement along a fault or belt of shearing within the Hayward fault zone. The major cracking of the stadium culvert, the most extensive cracking of joints of the by-pass culvert, and the location of reported difficulties with utilities all lie in a north-west-trending band that is coincident with the probable location of the fault.

Since the stadium culvert was installed, there has been one earthquake (in 1937) severe enough to crack walls and fell chimneys in the Berkeley area, as well as numerous lesser shocks (Byerly, 1951). None of them were accompanied by any visible surface rupture. Damage to the culverts is therefore probably due to slow movement or creep along the fault, with the possible exception of a small sudden movement in 1937. Records show that widening of the tension cracks in the stadium culvert has been constant, although we do not know whether it has been continuous or in small increments. Moreover, it is not possible to tell whether movement has been along one plane or distributed in a wide zone.

Preliminary observations indicate that the stadium culvert has been slightly offset in a right-lateral direction. This apparent right-lateral deflection is consistent with direction of creep noted elsewhere on the fault.

CRACKS IN THE CLAREMONT WATER TUNNEL

BY F. B. BLANCHARD[2] AND G. L. LAVERTY[3]

Three circumferential cracks in the monolithic reinforced concrete lining of the Claremont water tunnel, each exhibiting right-lateral displacement, where observed on December 1, 1964, at a point about 900 feet from the west portal of the tunnel. The cracks occurred about 8 feet apart in a 16-foot section and each showed a horizontal displacement estimated to be about three-fourths of an inch. The westerly crack had slime in it and appeared to be older than the other two.

The tunnel, constructed in the 1920's, was last inspected in 1950, when no cracks were observed at this point. The location of the cracks was determined by pacing from the portal and is not precise. On the basis of the paced distance, the map-scaled location is lat 37°51'18"N., long 122°14'08"W., close to or within the area usually designated as the Hayward fault zone. At this point the tunnel is approximately 150 feet beneath the surface of the ground.

The Claremont water tunnel has a 9-foot horseshoe section and is one of five major facilities in the water system of the East Bay Municipal Utility District taking water from the east side of the Berkeley Hills to Berkeley, Oakland, and other cities on the east side of San Francisco Bay. After the December 1964 inspection, the tunnel was immediately refilled and placed back in service. Another inspection is planned for the winter of 1965–66.

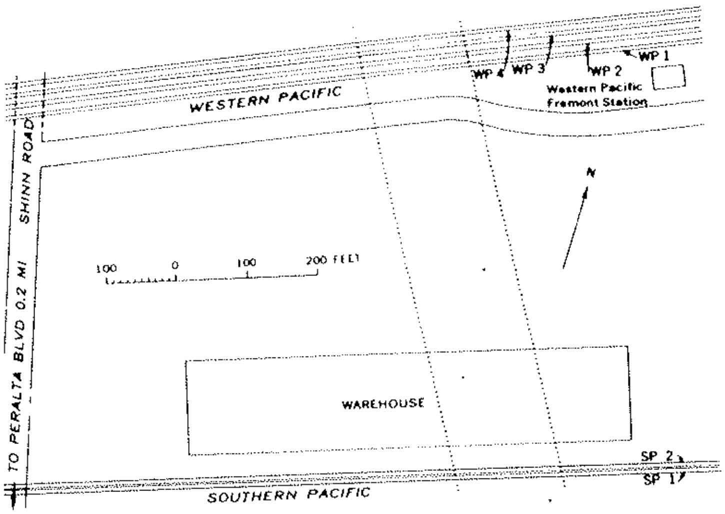
DEFORMATION OF RAILROAD TRACKS IN FREMONT, CALIFORNIA

BY M. G. BONILLA

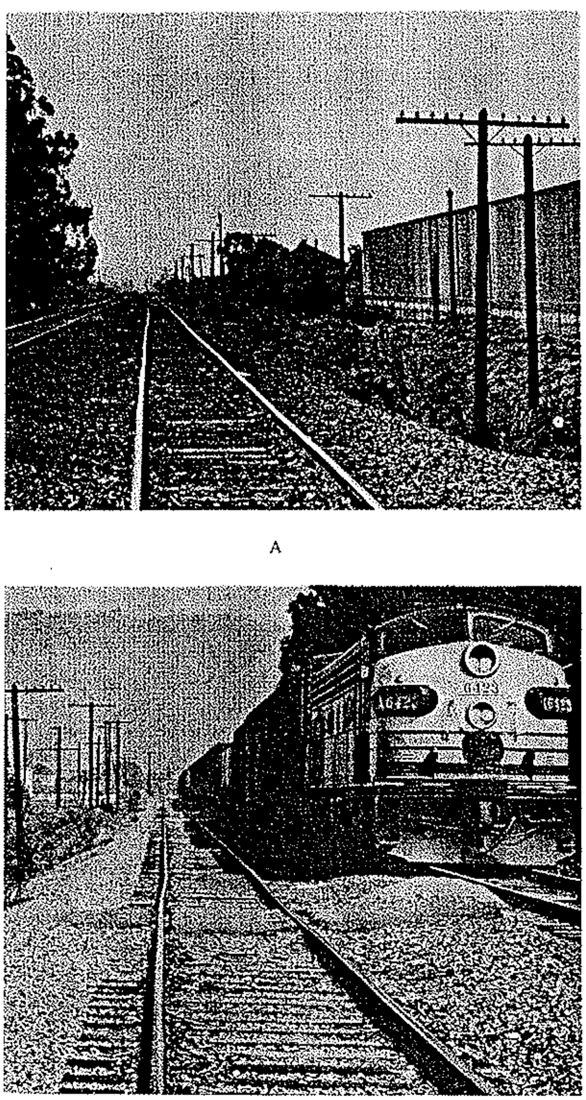
Six sets of railroad tracks in the Niles district of Fremont have been bent and shifted laterally by creep along the Hayward fault. The location of the tracks is shown on figure 2 (loc. C) and on figure 5.

The distortion of the railroad tracks was found by the writer in March 1965 during

[2]Manager, Water Resources and Planning Division, East Bay Municipal Utility District, Oakland, Calif.
[3]Supervising Sanitary Engineer, East Bay Municipal Utility District, Oakland, Calif.



◄ Figure 5.—Zone of principal deformation (within dotted lines) of Western Pacific and Southern Pacific railroad track in Fremont.



A

B

Figure 6.—Deformation of Southern Pacific siding by creep on the Hayward fault. A, View westward; note new warehouse on right side. B, View eastward.

geologic mapping of a segment of the Hayward fault zone coincident with his examination of geologic evidence for recent and continuing movement along the fault. This research was supported in part by the U.S. Atomic Energy Commission.

Surface expression of the Hayward fault on the low alluvial fan upon which the tracks are built consists of linear depressions, scarps, and tonal differences in the soil visible on aerial photographs. Below the surface the fault forms an impermeable zone which results in a much higher ground-water level on the east side of the fault than on the west side, as indicated by wells close to both sides of the fault zone (Clark, 1915). Use of these criteria indicated, within narrow limits, the active part of the Hayward fault zone and therefore where the railroad tracks should be deformed if creep were occurring along that part of the fault. Upon examination, the Southern Pacific main-line track was found to have a small deflection where the projected trend of this active zone crosses it and the parallel siding to have a large deflection (fig. 6). On finding this, the Western Pacific Railroad tracks about 500 feet to the north were immediately examined, and they too were found to be deformed (fig. 7) along the same trend and in the same sense (right-lateral). Projecting the fault southeastward and using the same geologic criteria, the writer independently discovered the deformed warehouse in the Irvington district; the writer was not aware that the warehouse had been observed earlier by Cluff.

The tracks are deformed in a zone several hundred feet wide, but the major part of the

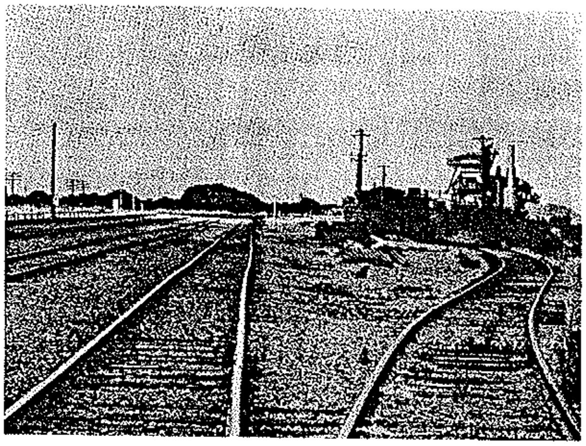


Figure 7.—View westward along Western Pacific tracks showing deformation of rails (center of photo.) by creep on the Hayward fault. Curve in tracks on right side is not the result of creep.

deformation is in a narrower zone (stippled on fig. 5). The deformation is moderately sharp on the sidings and yard tracks (figs. 6 and 7) but is smooth and difficult to see on the main-line tracks, owing to more frequent maintenance and heavier and faster traffic that tends to remove irregularities. The sharpest bends show a lateral shift of about 4 inches in 70 feet (fig. 6) and 6 inches in 60 feet (fig. 7). No vertical movement has been detected.

The rate of movement is evidently variable. The main-line Southern Pacific and Western Pacific tracks, first laid about 55 years ago, both show a total shift of about 8 inches, or an average rate of shift of more than 0.14 inches per year. The rate must vary greatly, however, as lateral shifts of as much as 1-1/2 inches within a period of 2 or 3 days were reported by D. J. Laughlin (Western Pacific Railroad, oral commun., 1965), who said that the rapid movements apparently do not coincide with local earthquakes.

The warehouse just north of the Southern Pacific tracks, shown on the map (fig. 5) and on the right side of figure 6A, was completed in 1964. No deformation resulting from creep was visible in March 1965.

CREEP IN THE IRVINGTON DISTRICT, FREMONT, CALIFORNIA

BY LLOYD S. CLUFF[4] AND KARL V. STEINBRUGGE[5]

Evidence for fault creep has been found along a 3-mile section of the active Hayward fault zone in the Irvington district Fremont, Calif.

Damage to a one-story storage building and to at least one offset fence astride the Hayward fault zone in the Irvington district of Fremont indicates that at least 6 inches of right-lateral movement has occurred on the fault within the last 44 years.

This paper presents only partial information on the 3-mile section from Alameda Creek south to Washington Boulevard in the Irvington district and discusses mainly a building that shows distinct evidence of right-lateral movement. A more detailed account of these studies will be presented in a forthcoming issue of the Bulletin of the Seismological Society of America.

Topographically, the area in the vicinity of the damaged storage building is relatively flat land on which the traces of faults in the Hayward fault zone are marked by fault scarps ranging from 3 to approximately 30 feet in height, shallow depressions that form linear troughs 200 to 300 feet wide and 5 to 10 feet deep, and sag ponds (figs. 8 and 9). These features are considered to be the result of successive movements along the fault during geologic and historic times.

Geologically, the building is near the outer limits of a broad alluvial fan, the Niles cone, which has been deposited by Alameda Creek between San Francisco Bay and the hills bordering the bay on the east. The fan is composed of layered deposits of gravel, sand, silt, and clay. The Hayward fault zone cuts through the alluvial deposits, and in places clay gouge formed along fault planes has created a ground-water barrier which produces different water levels on either side of the fault (Clark, 1915; Forbes, 1949).

During the course of geologic field mapping along the Hayward fault in November 1960, the senior author discovered a damaged one-story storage building extending partly into the fault zone. A detailed inspection of the building showed that the damage was concentrated in the part of the building which lies along the northwest-trending fault zone and consisted of fractures, cracks, deflections, bends, and offsets, all of which indicated right-lateral movement. In checking the seismic history of the Fremont area, it was found that no earthquakes were recorded which appeared to have a magnitude strong enough to produce ground breakage along

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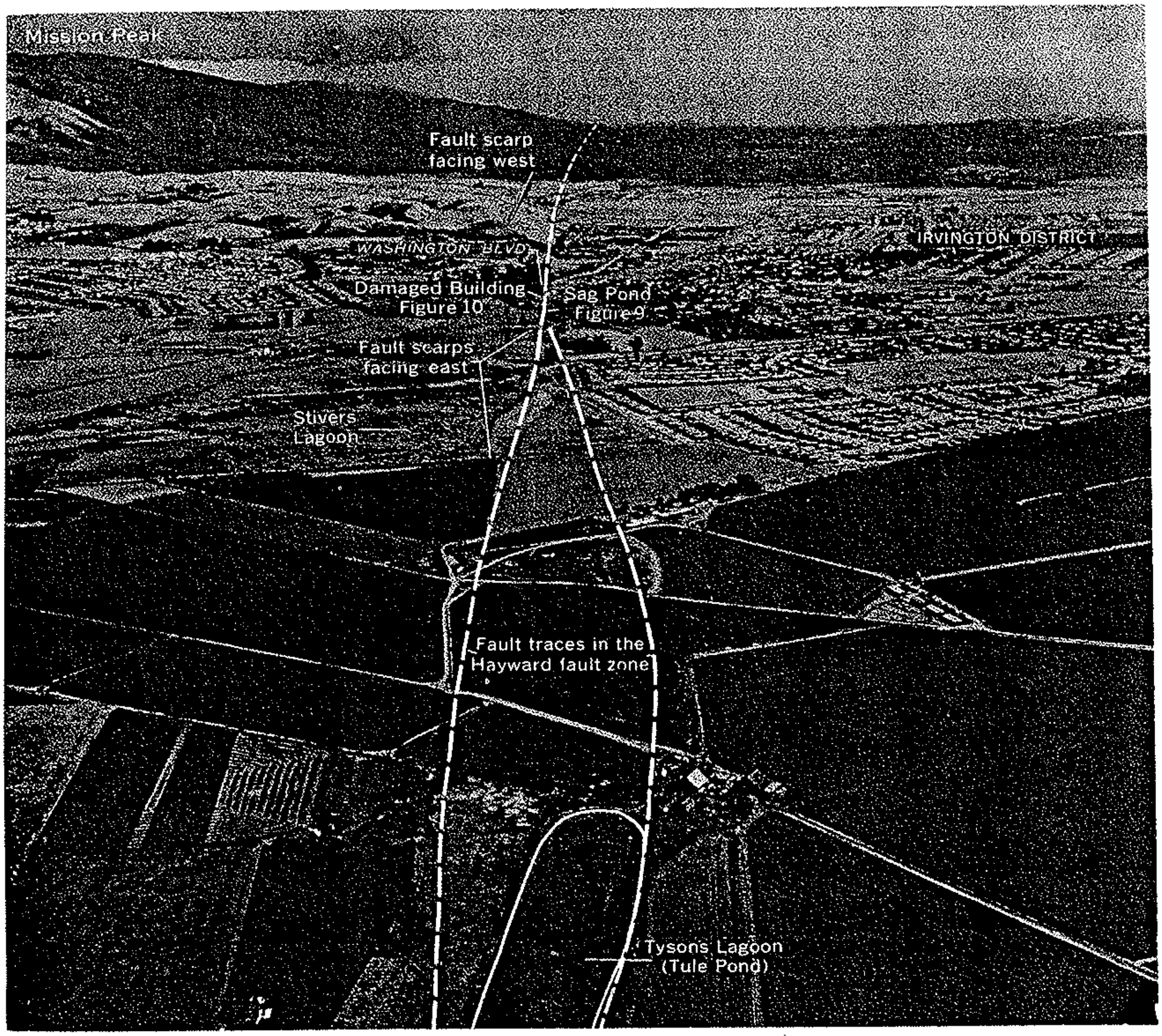

Figure 8.—View looking southeast along strike of the Hayward fault zone near Irvington district, Fremont, Calif.

the Hayward fault zone during the lifetime of this building. Local residents have no knowledge of earthquakes associated with fault movement since 1868.

The main building (fig. 10) was erected in 1921, according to local residents. The building has nonreinforced concrete walls, a wood roof, and a concrete floor slab most of which is on grade. Most of the main building is on the southwest side of the Hayward fault zone which trends northwest through the northeast part of the main building (fig. 10).

The floor slab in the northeast part of the main building, having a floor area of about 60 by 200 feet, has been cracked and offset along a crack so that the northeast part of the slab appears to have moved 6 inches to the southeast with respect to the southwest part (fig. 11). The exterior walls, which are 10 inches thick, have been bent, broken, and offset (fig. 12); the interior and exterior columns are as much as 6 inches out of plumb (fig. 11); and the roof has bowed right laterally.

Another part of the building extending into the fault zone has a buckled basement floor slab and a buckled basement wall.

The damage to this storage building is remarkably similar to the damage at the winery

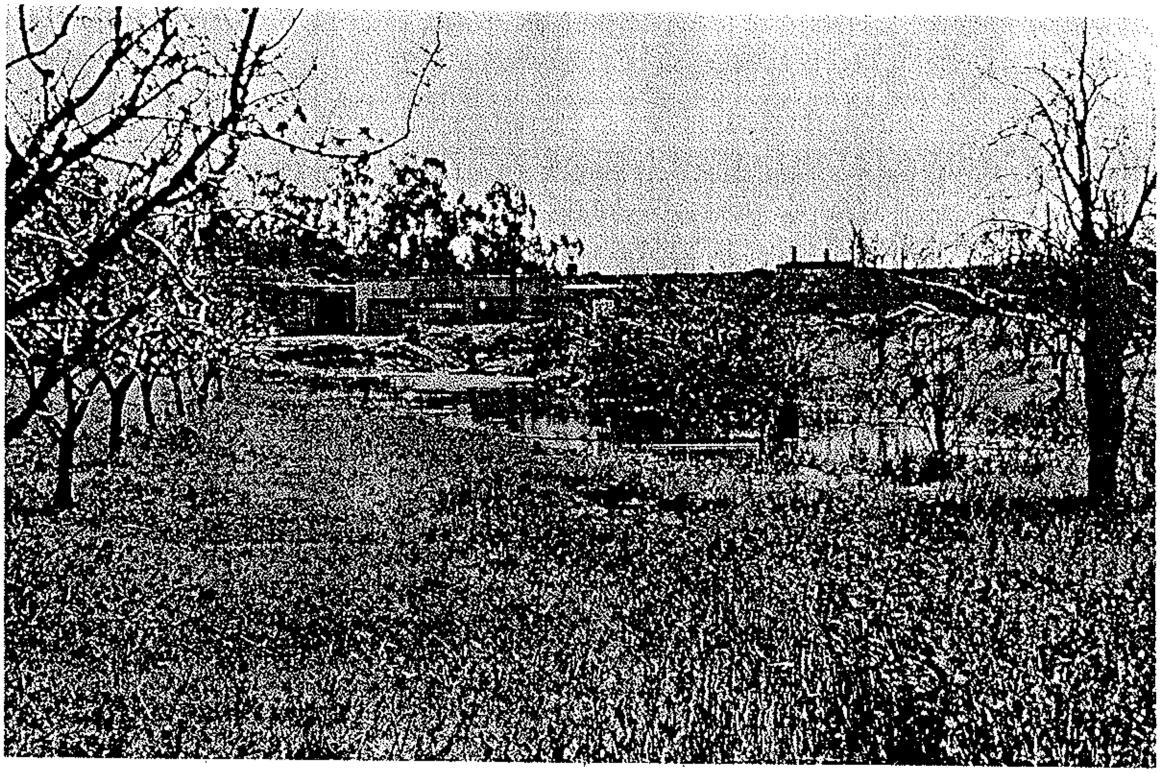

Figure 9.—View looking southeast along strike of Hayward fault, showing sag pond along the trace of the fault and a building extending into the fault zone.

straddling the active San Andreas fault near Hollister, Calif., which is being damaged by fault creep (Steinbrugge and others, 1960). The similarity of damage and the fact that both structures are astride traces of active faults suggest that fault creep was responsible for the structural damage to the building on the Hayward fault.

All the offsets and damage, when plotted on a map (fig. 10), aline parallel to the northwest strike of the Hayward fault and are within the fault zone. This damage appears to be limited to a band less than 10 feet wide and may indicate movement on a single fault plane within the Hayward fault zone; however, the width of the disturbed band may be wider. The rate of creep appears to be 6 inches in 44 years. A more complete answer will not be known until detailed studies are made.

In March 1965 the authors installed creep reference marks inside the damaged building across the displaced zone in the floor slab so that a record of further movements could be made. For the time being, this measurement system is being used to note any further creep movement along the fault. Work is in progress under the direction of the authors for permanent survey stations across the Hayward fault zone in the Irvington area.

The Hayward fault is under continuing study by the authors for several miles on each side of the damaged building. Additional evidence of movement has been observed by the authors on offset fences immediately to the north and approximately 1 mile to the northwest of the damaged building. Reference structures, such as railroads southeast of the building and large-diameter pipelines, cross the fault zone at various nearby locations. These are being observed and surveyed by the authors in hopes of obtaining additional information as to the details of this fault movement. The evidence to date suggests that most of the creep observed along the Hayward fault zone in the Irvington district (in the amount of approximately 6 in.) occurred during the period 1951 to 1957. Judging from possible effects on structures described in this report by Cluff and Steinbrugge, no measurable creep has occurred in this area since 1957.

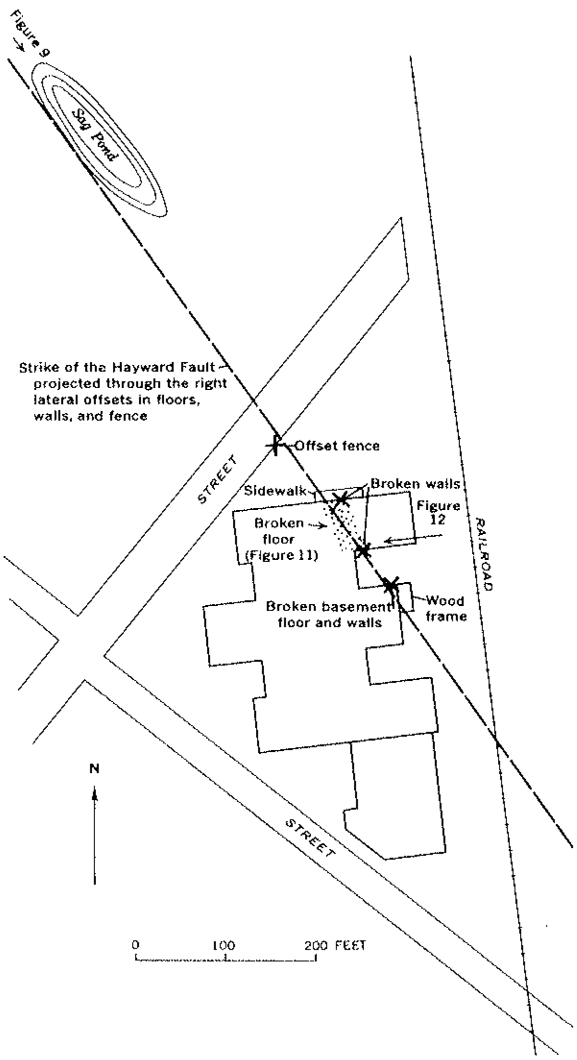

Figure 10.—General configurations of damaged building and nearby offset fence.

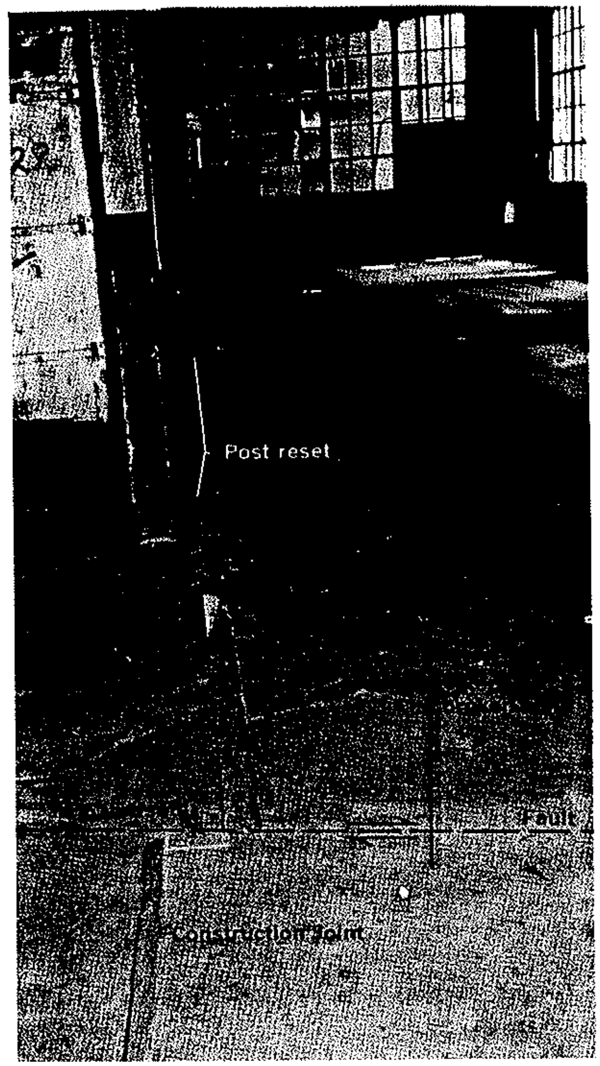

Figure 11.—View looking northeast and almost perpendicular to strike of fault inside building straddling fault. Construction joint in floor slab has been displaced approximately 6 inches right laterally.

In summary, it may be concluded that:

1. Damage to a one-story building on the Hayward fault zone in the Irvington district of Fremont indicates that at least 6 inches of right-lateral creep has occurred on the fault zone since construction in 1921.

2. Any structure astride an active fault is not only subject to damage resulting from sudden faulting associated with a severe earthquake, but may be damaged by a slow shearing movement along the fault.

3. Creep along an active fault is not cause for sudden alarm for it progresses slowly. However, because creep is irresistible and can be expected to continue, its location and rate of movement should be under constant observation.

4. The significant lesson to learn is that active faults should be recognized and respected in planning of future structures, developments, and communities.

Some questions yet unanswered with respect to the time-history of the creep phenomenon are as follows:

Is the creep occurring unnoticed in short, sporadic movements associated with earthquakes?

Figure 12.—View looking west and nearly perpendicular to fault along inside south wall of building.

Is the creep occurring along parallel or en echelon lines of slippage?

What are the variations of creep along the entire length of the Hayward fault?

Does the creep indicate an accumulation of regional strain, building up to a strong earthquake in the near future, or does the creep indicate a release of accumulating regional strain indicating that a strong earthquake should not be expected in the near future?

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ATTACHMENT 14.

Weekend Edition, January 30 - February 2, 2004

Berkeley Daily Planet

Volume 5, Issue 88

Covering The World of Berkeley

FREE

Matthew Artz

Protestors gathered at the entrance to the Lawrence Berkeley Naitonal Laboratory Thursday to protest today's planned groundbreaking for the Molecular Foundry.

Molecular Foundry Foes Protest Groundbreaking

By MATTHEW ARTZ

About 30 protesters withstood steady drizzle early Thursday morning, worried that once Lawrence Berkeley National Laboratory (LBNL) completes its newest laboratory complex, far smaller, more dangerous particles could rain down on them.

"We don't know anything at all about the health effects or environmental impact of what they're doing here," said Tom Kelly of the Community Health Commission.

This morning (Friday, Jan. 30), LBNL breaks ground on its Molecular Foundry. The six-story, 94,000-square-foot facility, financed by $84 million from the Department of Energy, will catapult the lab into the forefront of nanotechnology, one of the fastest-growing but least-understood disciplines of physics.

Nanoparticles are up to 100,000 times smaller than a human hair, but when properly manipulated, they have applications in every field from environmental preservation to repair of spinal tissues and creation of weapons of mass destruction.

Demonstrators assembled outside the lab's entrance questioned how the new

Continued on Page Ffiteen

Foundry

Continued from Page One

building—planned to sit just above a watershed 600 meters from an earthquake fault—could have evaded a rigorous environmental review. They doubted the lab's capacity to keep nano-particles from escaping into air and possibly drifting into their lungs, and they questioned the lab's will to keep potential contaminates from seeping into nearby creeks that feed the Bay.

"They're wearing blinders on this project," said Community Environmental Advisory Commission (CEAC) member LA Wood. "Not only do they not know the science, but they're disregarding the environmental contamination of the hill."

Last year the city council rejected CEAC's call to request the lab perform an Environmental Impact Report on the project. Aware that nanotechnology is too new for an EIR to analyze potential inhalation risks, CEAC has called for the lab to hire an independent auditor to perform an annual review of the foundry's operations, as well as clean up soil and ground water contaminated with radioactive tritium just uphill from the foundry sight and bar new construction while other buildings on their 200-acre Berkeley Hills campus remained vacant.

Lab spokeswoman Terry Powell has said in previous interviews that tritium levels were within federal standards and the lab would consider annual external reviews for work at the foundry.

(6 ARTICLES 15 PAGES)

ATTACHMENT 14 A

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CHC MEETING AGENDA 4b

EARLY SUNDAY EDITION

The Washington Post

SUNDAY, FEBRUARY 1, 2004

Nanotech Poses Big Unknown To Science

As World Shrinks, Concerns Multiply

By Rick Weiss
Washington Post Staff Writer

Nanotechnology, the hot young science of making invisibly tiny machines and materials, is stirring public anxiety and nascent opposition inspired by best-selling thrillers that have demonized the science—and new studies suggesting that not everything in those novels is fantasy.

The technology, in which scientists manufacture things less than 1,000th the width of a human hair, promises smaller computers, stronger and lighter materials, even "nanobots" able to cruise through people's blood vessels to treat diseases. Billions of dollars are being pumped into the field, and products with science-fiction-like properties have already begun to hit the market.

But studies have also shown that nanoparticles can act as poisons in the environment and accumulate in animal organs. And the first two studies of the health effects of engineered nanoparticles, published in January, have documented lung damage more severe and strangely different than that caused by conventional toxic dusts.

The risks of nanoparticles may ultimately prove to be minor and avoidable, experts say. Nonetheless, in a move that industry supporters blame on a conflation of facts with popular fiction—such as Michael Crichton's best-selling thriller "Prey," in which rogue nanoparticles wreak deadly havoc—activists have begun to organize against the science.

Some in California are trying to block construction of a nanotech factory, noting that no government agency has developed safety rules for nano products. Others want a global moratorium on the field until the risks are better understood.

Now, realizing that public perception may be at a tipping point, the fledgling industry and government agencies are taking a novel tack, funding sociologists, philosophers and even ethicists to study the public's distrust of nano. Supporters of the approach say these experts will serve as the industry's conscience and ensure that the science moves forward responsibly. Others

See NANOTECH, A12, Col. 1

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(6 ARTICLES 15 PAGES) ATTACHMENT 14 A (1)

MEETING AGENDA 4b

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See NANOTECH, *A12, Col. 1*

As Science Downsizes, Big Questions Loom

NANOTECH, *From A1*

suspect it is an effort to defuse nano's critics.

Both sides agree the stakes are huge. Government officials have called nanotechnology the foundation for the "next industrial revolution," worth an estimated trillion dollars within the coming decade. But if nano's supporters play their cards wrong, experts say—by belittling public fears as "irrational" or blundering into a health or environmental mishap—the industry could find itself mired in a costly public relations debacle even worse than the one that turned genetically engineered crops into "Frankenfood."

"We can't risk making the same mistakes that were made with the introduction of biotechnology," said Rita Colwell, director of the National Science Foundation, the nation's largest funder of nanotechnology research. "We have to do this benignly and equitably."

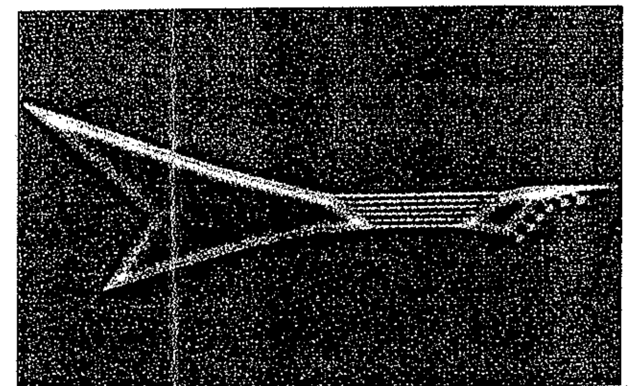
The struggle for public trust will be challenging, officials confess, given the frightening tales that have been spun about nano in recent years.

It started in 2000, when Bill Joy, co-founder of the computer giant Sun Microsystems, wrote a chilling and widely read article warning that self-replicating nanomachines could eventually overwhelm the human race and digest the living world into a mass of "gray goo"—a scenario that many scientists, but not all, reject.

Then came "Prey." And in Dan Brown's No. 1 best-selling novel, "Angels & Demons," the Catholic Church denounces nanoscience as evil. (It has not, although Britain's Prince Charles has expressed alarm about the science.)

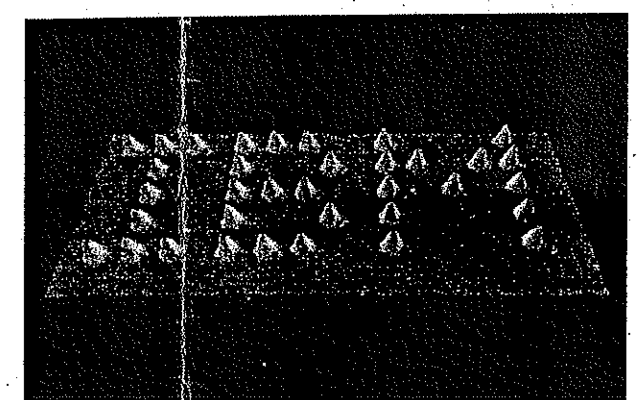
In December it seemed the industry might at last be shaking off its negative image: In an Oval Office ceremony, President Bush hailed the technology and signed a $3.7 billion bill to boost the research. But even as the president was signing that bill, researchers at the National Science Foundation across the Potomac were attending a meeting on nano's social and environmental risks.

It is too soon to say whether nano will wean soci-



CORNELL UNIVERSITY

NANOGUITAR: Cornell scientists created a guitar whose strings are 150 nanometers across and can be plucked with a laser beam.



IBM RESEARCH

WRITING WITH ATOMS: IBM scientists used individual xenon atoms to form the company's logo.

nanomaterials whose atoms have been carefully arranged to make them especially strong.

"This technology is coming, and it won't be stopped," said Phillip J. Bond, the Department of Commerce's undersecretary for technology.

Bond may be right. But it won't be for some people's lack of trying.

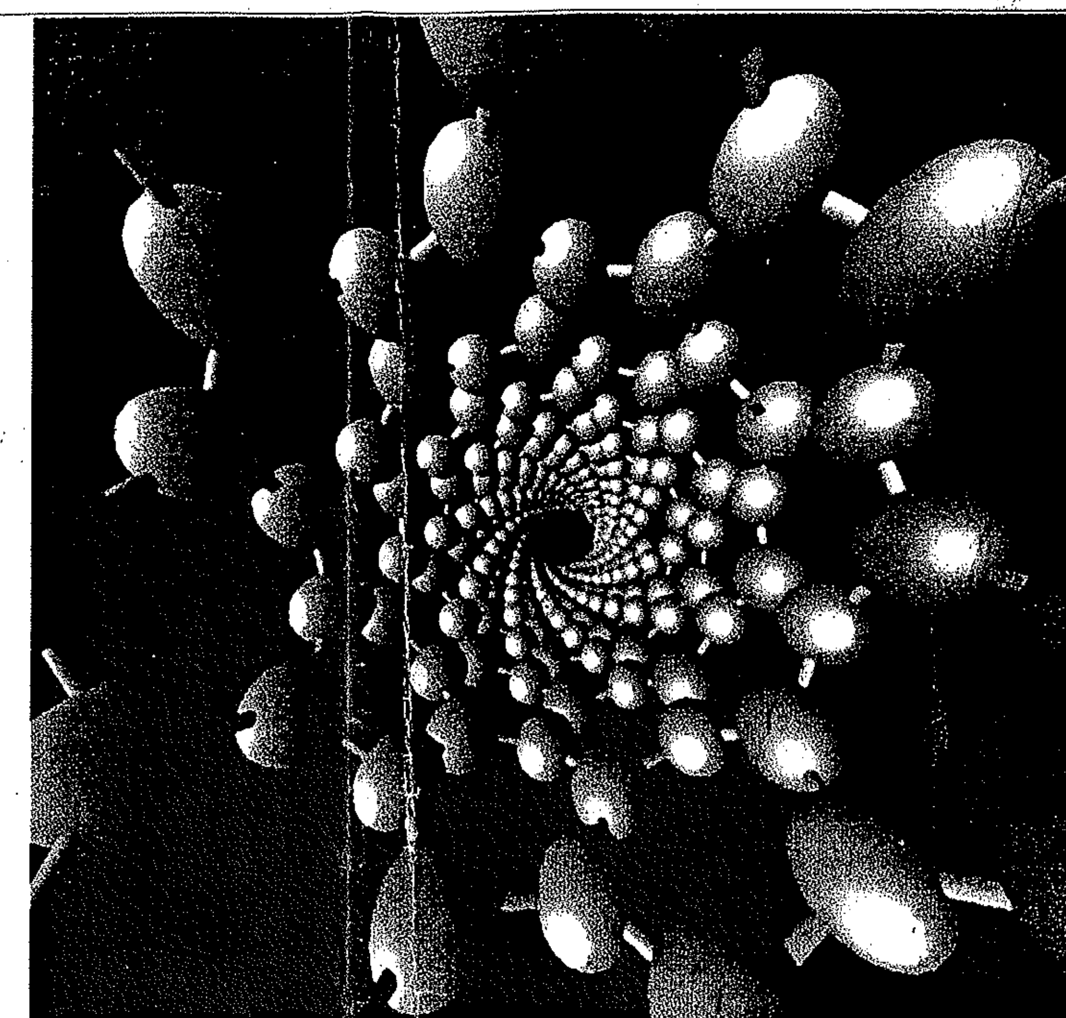
Foremost among those activists is Pat Mooney of the Winnipeg-based ETC Group, which has called for a moratorium on commercial production of nanomaterials until its risks are better elucidated and regulations put in place.

It is a radical stand, but industry knows it ignores Mooney at its peril. He spearheaded much of the opposition to agricultural biotechnology—opposition so successful that it made biotech giant Monsanto Co.'s name syn-

than those in mice given equal amounts of quartz particles, which toxicologists use as their "serious damage" standard.

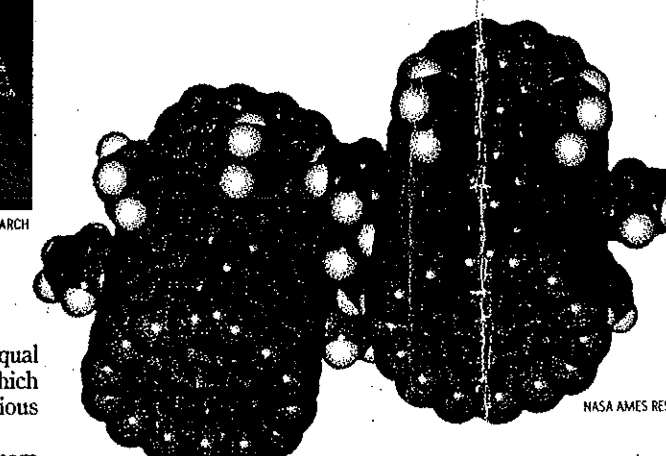
Carbon nanotubules, the team concluded, "can be more toxic than quartz, which is considered a serious occupational health hazard in chronic inhalation exposures."

The other study was led by David Warheit at DuPont Co.'s Haskell Laboratory near Newark, Del., and involved similar exposures in rats. Surprising the scientists, 15 percent of the animals getting the highest dose died from lung blockages within 24 hours—an outcome the group had never seen for any lung toxin. Warheit said in an interview he did not believe the deaths were indicative of any "inherent pulmonary toxicity" of nanotubes. But his other results were surprising, as well: All the surviv-



UNIVERSITY OF PITTSBURGH VIA ASSOCIATED PRESS

NANOTUBE: A computer simulation shows the view down the center of a nanotube. These incredibly strong carbon structures are already being made at some factories.



NASA AMES RESEARCH CENTER

NANOGEARS: NASA scientists researching nanomachines used a computer to simulate gears made of benzyne molecules attached to the outside of nanotubes. A laser would serve as a motor to drive the gears.

How Small is Nano?

Nanotechnology refers to inventions on the scale of small molecules or individual atoms.

A man who is two meters tall (6 feet, 5 inches) is 2 billion nanometers tall.

1 meter = 1 billion nanometers

÷1,000

1 millimeter =

microbes, and in animals higher up the food chain.

CBEN researchers emphasized that accumulation does not necessarily mean harm, and others dismiss the idea that nanoparticles pose an environmental threat. Clark University risk specialist Roger Kasperson said that reminds him of the early days of the atomic era, when experts similarly unburdened by data predicted that nuclear power plants could never melt down and that electricity would become too cheap to meter.

"Critics of nuclear power were called irrational," said Kasperson, no will wean society from dirty technologies or simply produce its own versions of the asbestos, diesel soot and DDT debacles that are the legacy of the last industrial revolution. The science is still new, and the rhetoric on both sides remains defensive and polarized.

"This is a genuine opportunity for an engaged dialogue," said Davis Baird, who, as chairman of the University of South Carolina's philosophy department and associate director of the university's Nanocenter, is part of the nascent effort to separate nanomythology from fact.

"But it's going to be tricky," Baird said. " 'Risk' is a more subtle concept than broad sections of the public appreciate."

Pat Mooney of ETC Group seeks to halt commercial production of nanomaterials until risks are better known.

Burgeoning Industry

Nanotechnology started off as little more than a clever means of making incredibly small things. IBM scientists made headlines in 1990 by painstakingly arranging 35 xenon atoms to spell out the company's three-letter name, creating the world's smallest corporate logo. Cornell University scientists followed with an invisibly small "nanoguitar." Its strings, each just a few atoms across, could be plucked by laser beams to play notes 17 octaves higher than those produced by a conventional guitars—well above the human hearing range.

Novelties though they were, these feats proved that with new tools in hand scientists could arrange atoms as methodically as masons arrange bricks—and in doing so build materials never made in nature.

Now the field is taking off.

Last year alone, hundreds of tons of nanomaterials were made in U.S. labs and factories. Microscopically thin sheets of tightly woven carbon atoms are being wrapped around the cores of tennis balls to keep air from escaping. New fabrics have been endowed with nanofibers that keep stains from settling in. Some sunscreens have ultraviolet-absorbing nanoparticles so small they cannot reflect light, making them invisible on the skin. Tennis rackets and airplane bodies are being made with

to Co.'s name synonymous with "PR failure" and resulted in European restrictions on imported crops that continue to cost the United States hundreds of millions of dollars in lost trade every year.

"I do think there is a growing sense that they have to address these issues more seriously than they did in the past," Mooney said.

Scientists have known for years that tiny particles such as soot or metal powders can, when inhaled, cause lung disease, cancer and other ailments. But the laws of chemistry and physics work differently when particles get down to the nanoscale. As a result, even substances that are normally innocuous can trigger intense chemical reactions—and biological damage—as nanoscale specks.

Gold, for example, is a famously inert metal, prized for its nonreactivity. But nanoparticles of gold are extremely chemically reactive, behaving like microscopic fireballs with the potential to disrupt biological pathways.

"The smaller the particles, the more toxic they become," said Vyvyan Howard, a University of Liverpool pathologist who studies the health effects of environmental aerosols.

The first two studies to look for such problems appeared in the January issue of the journal Toxicological Sciences, and the results, experts said, are less than reassuring.

In the first study—sponsored by NASA, an agency that hopes to make great use of nanomaterials—Chiu-Wing Lam of Wyle Laboratories in Houston and his colleagues washed three kinds of carbon nanotubes into the lungs of mice and examined them as much as three months later. Nanotubes are incredibly strong, microscopic tubules made of carbon atoms; some are already being produced in factories.

All three types caused lung granulomas—abnormalities that interfere with oxygen absorption and can progress to fatal lung disease. And although each mouse got just one exposure, the lesions got worse over time, with some progressing to tissue death. On average the reactions were worse

surprising, as well: All the surviving rats developed granulomas, yet without the inflammatory responses that usually accompany those lesions.

"The response in the body was quite unique," said Vicki Colvin, director of the Center for Biological and Environmental Nanotechnology, a federally funded research center at Rice University that also gets support from the university and industry. "They behaved differently than other carbon-based ultrafine particles."

"This is a very unusual lesion," Warheit agreed. "The question is, why did that happen?"

Warheit, whose company hopes to profit from nanotechnology, is optimistic that nanomaterials will prove relatively nontoxic. He and Lam note that more realistic tests, in which the particles are inhaled, have yet to be done. Those tests are expensive, both noted, and no one has expressed a willingness to fund them.

Inhaled particles do not always stop at the lungs. Experiments by University of Rochester toxicologist Gunter Oberdoerster showed that nanoparticles can make their way from a rat's throat into its brain, apparently via the nasal cavities and olfactory bulb.

"Who knows how they interact with cells there?" Oberdoerster asked. "Maybe they do something bad and lead to brain diseases."

Other scientists have wondered at recent meetings whether nanoparticles can cross the placenta and get into a developing fetus.

Scientists in France recently showed that carbon nanotubes—thousands of which could fit inside a cell—can easily penetrate living cells and even make their way into the nucleus, the inner sanctum where DNA resides.

The researchers hope to harness this capacity and use nanotubes as vehicles to deliver drugs into cells. But the approach could easily backfire, they conceded.

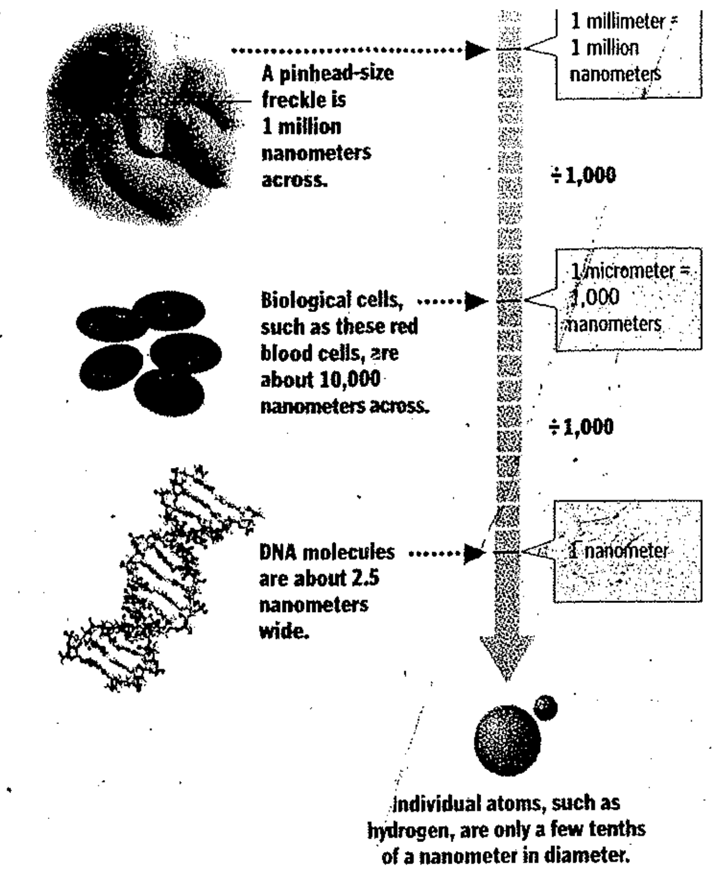
In many instances, for reasons that remain unclear, the nanotubes themselves killed the cells.

Environmental Effects

The effects of nanoparticles in nature are similarly unclear. Depending on whom you ask, the strange chemistry of nanomaterials could save or destroy the environment.

Tom Kalil, special assistant to the chancellor for science and technology at the University of California at Berkeley, is among the optimists.

"Recent results suggest that nanoscale particles could play a very



SOURCE: National Science and Technology Center

BY SETH HAMBLIN AND LOUIS SPIRITO—THE WASHINGTON POST

important role in environmental cleanup, dramatically reducing the costs associated with remediating Superfund sites," Kalil said. Engineered nanospheres, which resemble tiny molecular cages, can trap polychlorinated biphenyls (PCBs) and toxic metals, he said. And researchers are designing nanopore materials that can filter out bacteria, viruses and toxins from water.

But not all nanoparticles are so green.

Titanium dioxide, for example, is a generally nonreactive substance used in many products, including skin lotions and house paints. Increasingly, however, it is being made in the form of nanosize particles. And tests show that they are highly reactive, generating chemically "hot" free radicals that can literally burn up bacteria. That has some experts worrying about impacts on soil ecology if the particles are released.

Robin Davies, a British scientist with Soil Environment Services Ltd. in Newcastle upon Tyne, said even slight changes in bacterial populations can have major effects on soil chemistry and on its ability to support plant life. Knocking out soil microbes, he said, "can both create serious environmental pollution and also impoverish the soil for many decades."

No one knows how much "nanolitter" is being released into the environment, experts said, and disposal rules have yet to be crafted.

Even more distressing to activists, nanotechnology is starting to be exploited on a large scale in the great outdoors. Last summer, for example, under contract to the Bureau of Indian Affairs, Utah-based Sequoia Pacific Research Co. sprayed a proprietary "nanostructured solution" on 1,400 acres in New Mexico to try to stabilize the soil after forest fires destroyed the local vegetation. Company officials will not reveal the ingredients in their product, saying only that it does not contain engineered nanoparticles. It works, they said, by triggering cross-reactions among naturally occurring nanoparticles in the soil.

But activists are upset that what appears to have been the world's largest environmental release of a product designed to operate on the nanoscale occurred without federal review or impact studies.

Scientists also want to know what happens to nanoparticles months and years after their release. Researchers at Rice University's CBEN have shown that like many other nonbiodegradable pollutants, they accumulate in living things over time, with ever-increasing concentrations in microbes, in the worms that eat those

called irrational," said Kasperson, who directs the Stockholm Environment Institute, an international research organization focused on sustainable development. "The starting point to me is to acknowledge that we don't know what the risks of nano are, and we don't know what the benefits are, and we won't for some time."

Incomplete Data

Everybody agrees that if nanotechnology is going to be the next industrial revolution, it would be nice if it were a cleaner revolution than the last one. Nobody wants to read Rachel Carson writ small.

"In the old industrial revolution, we learned too late," said David Rejeski, director of the Foresight and Governance Project at the Washington-based Woodrow Wilson International Center for Scholars. "We ended up chasing waste streams, and we still are."

But the regulatory schemes that came into being as a result of that mess are not designed to cope with the challenges of nanopollution.

Currently, companies seeking regulatory approval to manufacture or release potentially toxic substances are required to answer two basic questions: "What is it?" and "How much of it will there be?" But neither question works well for nanotechnology, because substances that are nontoxic in bulk form can be deadly when produced on the nanoscale.

"We're so keyed in to the composition of the substance when we think of toxicology, but on the nanoscale the [particle] size and surface chemistry will probably be the most important feature," CBEN director Colvin said. "That's an interesting paradigm shift."

Even when huge amounts of nanoparticles are made and packed together, the underlying presence of all those microscopic particles can make big materials behave in strange ways.

"There's no doubt from everything we've found that even in aggregates, nanoparticles still express their nanoparticleness, if you will," said Howard, the University of Liverpool aerosol expert.

This truth has not been integrated into the regulatory world. Take the growing number of factories in the United States making carbon nanotubes, which are made of graphite but behave very differently from ordinary graphite.

Like all factories, nanotube facilities must submit "material safety data sheets" describing the substances they handle and assuring

See NANOTECH, *A13, Col. 1*

Anti-nanotech campaigners declare war on tiny things

JENNY HOGAN

IF ENVIRONMENTAL activists and pressure groups have their way, nanotechnology will become as much of a social pariah as genetically modified foods. The campaigners came to Brussels from all over the world last week to discuss a moratorium on all nanotech, including lab research.

Tony Juniper, executive director of Friends of the Earth, says the scale of the campaign could be huge. "A lot of activists are beginning to register this," he says. "This is very comparable to the situation in GM foods eight or nine years ago. We have public awareness combined with activists, and bang, here we go."

The Canadian environmental organisation ETC, which masterminded the meeting, couched its call for a ban in language blatantly designed to woo an anti-GM audience. "We can't control genetically modified organisms, so what makes us think we can control atomically modified organisms?" said ETC's Hope Shand.

The group points to the lack of regulation and toxicological information on nanoparticles that are already in products the public can buy. Some sun creams, for example, contain nanoparticles of titanium dioxide. Can these work their way deeper into the body? Vyvyan Howard, a toxicologist from the University of Liverpool who undertook a literature review of the topic for ETC, said "we seem to have ample evidence that small means toxic and that needs attention."

Nanoscientists, who were not invited to speak at the meeting, agree that regulation is vital, but argue that the issue is already being taken seriously. Last year, for example, researchers at the Center for Biological and Environmental Nanotechnology at Rice University in Houston, Texas, presented concerns to the US Environmental Protection Agency, which responded by earmarking $5 million for follow-up research.

The health and environmental aspects of nanotech were also major themes at the American Chemical Society's annual meeting, where researchers unveiled the first health studies of carbon nanotubes (*New Scientist*, 29 March, p 19). "No scientist is brushing anything under the carpet," says Ottilia Saxl, executive director of the Institute of Nanotechnology in Stirling, UK.

"A lot of activists are beginning to register this. It is very comparable to the situation in GM food 8 or 9 years ago"

Mark Welland, a researcher at the University of Cambridge, is frustrated by the lack of science in the nanotech debate. He points to Green MEP Caroline Lucas's assertion in British newspaper *The Guardian* last week that "the laws of physics do not apply at the molecular scale". He is keen to enter into responsible debate, but wants the activists to be responsible too.

For many of the assembled groups, the debate is more about business than science. ETC's biggest concern is the social implications of a new technology controlled by big business. The US National Science Foundation estimates that by 2015 the nanotech market will be worth $1 trillion. "We've heard of the digital divide, now we're seeing the molecular divide," Shand said.

An activist who attended the two-day conference under the banner of EarthFirst! told *New Scientist* that his group's objections to nanotech were "about democracy, about control". EarthFirst! has been responsible for much of the anti-GM campaigning seen in Europe in recent years – including the stickering of supermarkets, occupation of Monsanto's European headquarters and uprooting of GM crops.

Mark Modzelewski, executive director of the NanoBusiness Alliance in the US hopes the campaign will stimulate discussion about regulating nanotech. "It presents a good jumping-off point to address real issues with nanotech and its effects on health and the environment," he says. There has been less debate about nanotech in the US that in Europe, but he reckons the way to offset a backlash is simple: "not hiding anything from the public and making sure they have all the facts".

But Welland is less confident. "It's very easy to frighten the public about these things, and it's very difficult to reverse." ●

PETER DENCH/REPORTAGE

The anti-nanotech campaign could rival the anti-GM movement

NANOTECHNOLOGY 14A (3)

They are appearing in everything from baseball bats to sunscreen. Could our eagerness to exploit nanomaterials be storing up health problems for the future? **Karen Schmidt** investigates

"A REVOLUTIONARY and superior bat with the widest sweet spot ever." So says the marketing blurb on the Easton Stealth Comp CNT baseball bat. I'm shopping for a lightweight bat for my 9-year-old son, and the Easton seems to hit the mark. CNT, you see, stands for carbon nanotubes, and it is this artificial material embedded in the bat that makes it super-stiff yet ultra-light, perfect for my budding Babe Ruth.

The "nano" raises a nagging doubt, though. I've read news reports that suggest carbon nanotubes may be harmful. But if they are in consumer products, surely they've been tested and verified as safe – haven't they?

Carbon nanotubes are just one example of a whole range of new manufactured materials, collectively known as "nanomaterials", that are starting to be used in everyday products. The US National Nanotechnology Initiative defines a nanomaterial as a substance that has at least one critical dimension less than 100 nanometres and possesses unique optical, magnetic or electrical properties. Nanomaterials can have properties that are quite different from those of otherwise similar materials made up of larger particles. Silver nanoparticles, for example, react with hydrochloric acid, something that bulk silver doesn't do.

Nanomaterials are creating a boom industry, often touted as the "nanotech revolution". From carbon nanotubes used to make strong, light materials to silver nanoparticles that function as antibacterial coatings, and titanium oxide nanoparticles to make transparent UV-filtering sunscreens, you are likely to encounter nanomaterials sometime soon – if you haven't already.

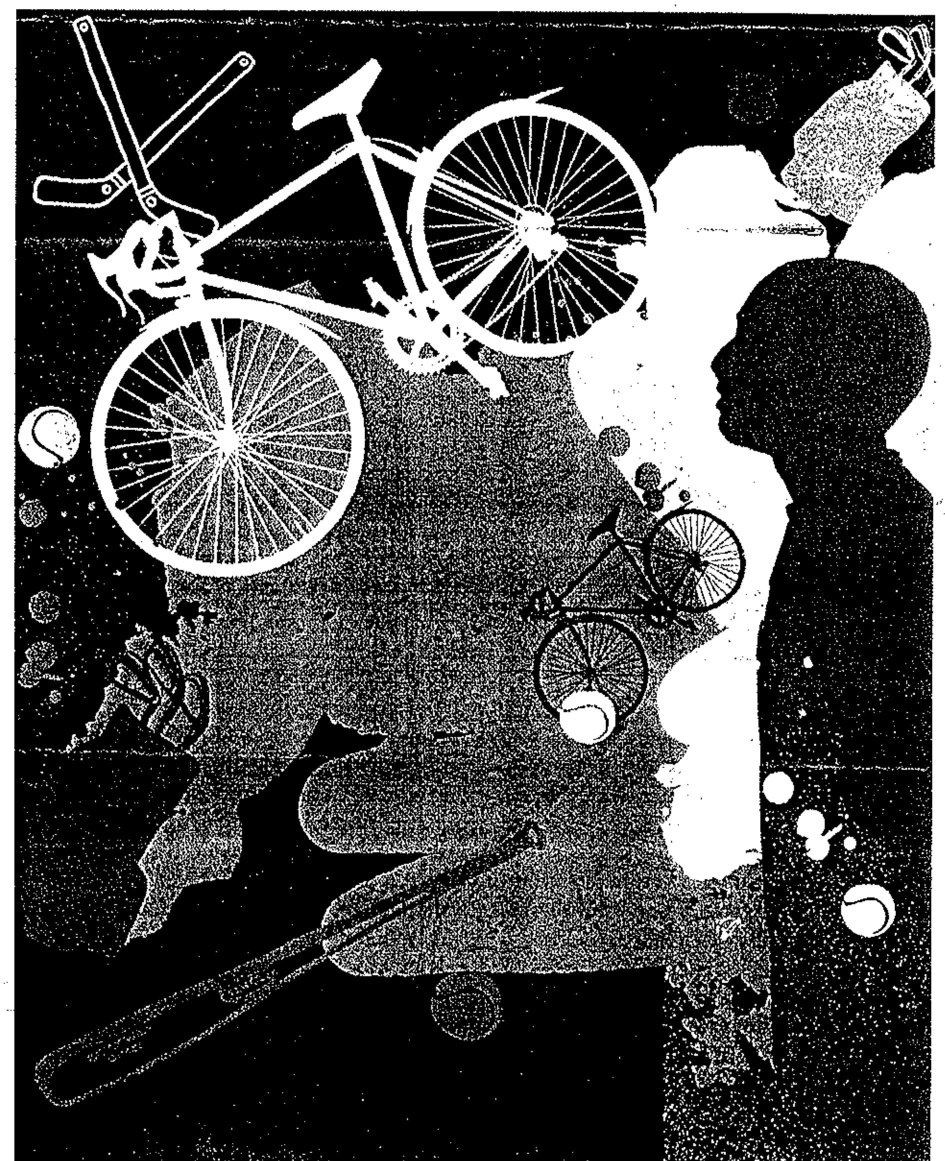
Nanotech on the brain

There's a catch. If these particles escape into the environment, their very smallness means they could have as yet unknown and possibly damaging effects. You might inhale or swallow them, or they could collect on the skin. They could then be carried to major organs such as the heart, liver and even the brain. The consequences of all this are still not clear, but following past health disasters caused by substances such as PCBs and asbestos, the prospect has stirred concern among governments and scientists alike.

So in recent years researchers have begun investigating the potential effects of nanomaterials. Proponents, eager to allay safety fears, say that this time we can "do it right" with no repeat of past fiascos. It seems as if barely a month goes by without another report laying out a strategic plan for the development and safe deployment of nanomaterials, and you might be forgiven for thinking that the nanomaterials now finding their way into consumer products are safe for human use.

Yet a little digging reveals things aren't so straightforward. There are significant gaps in the knowledge needed to know what the real effects of nanomaterials are, and they could take decades to fill.

In a review of the UK's policy on nanotechnology published in March 2007, the Council for Science and Technology, which advises the British government, concluded that the government has "placed insufficient emphasis on the need to investigate health, toxicology and environmental effects of nanomaterials". The problem for all governments and regulators is that working out the health risks of nanomaterials is devilishly difficult. The diversity of chemical compounds used to make nanomaterials, coupled with the huge variety of properties that nanomaterials have, means that no one even knows how to classify them in a way that allows general conclusions to be drawn from



The great nanotech gamble

studies on particular nanomaterials.

This has led to suggestions that we may have to develop a new approach to chemical toxicity that will account for nanomaterials. The first step is to figure out whether a particular nanomaterial can ever be harmful. "Without that piece of knowledge, all the rest is guesswork," says Andre Nel, a toxicologist at the University of California, Los Angeles. Researchers usually answer that question for particular chemicals by exposing animals to increasing doses and looking for signs that this is doing some harm. Such studies are open to criticism for being too artificial to be relevant to the real world, but when multiple studies turn up similar results – showing, say, that a pesticide kills cells – it is taken as pretty good evidence that the chemical in question is worth worrying about.

This approach falls short, however, when testing nanomaterials, because here it is not only chemical composition that matters, but also a particle's size and physical properties. This makes it hard for toxicologists to know precisely which material they are studying, as nanoparticles can exist in myriad forms. One moment they are individually suspended in solution, the next they are clumping together or picking up contaminants. Not only do they change size and shape, their surfaces can differ and their crystalline structures vary. Each of these characteristics can affect their reactivity and so their ability to interact with living things. "A small change in experimental conditions can lead to huge differences in outcome," Nel says.

To take one instance, in January this year there was a report from Swiss researchers which said that rope-like agglomerates of carbon nanotubes were more toxic to cells than the dispersed particles are (*Toxicology Letters*, vol 168, p 121). Then in February this year, researchers at Rensselaer Polytechnic Institute in New Jersey reported experiments that suggest the opposite: finely dispersed carbon nanotubes, even at low concentrations, were more toxic to cells than were larger clusters (*Toxicology Letters*, vol 169, p 51).

Such apparently contradictory results call into question whether these two – or any two – research groups are actually studying the same materials under similar conditions, especially as there are no standard ways to describe or identify different nanomaterials. "The nomenclature issue is huge," says Nigel Walker, who coordinates nanomaterials research for the US National Toxicology Program. Even if a regulatory body draws up what seems to be a complete description of a nanomaterial it wants to control, there are so many possible variables that the door will remain open for manufacturers to split hairs and say they are making something slightly different. "You could get into some really hot water legally," Walker says.

Establishing a system for characterising and naming nanomaterials remains a daunting challenge, he says. Consider single-walled carbon nanotubes. These structures resemble graphite – sheets of carbon atoms in a chicken-wire arrangement – that has been rolled up into a tube a few nanometres wide. Tweak the manufacturing process and you can create around 50,000 different versions of the material. Multi-walled carbon nanotubes – tubes stacked inside one another like a set of Russian dolls – also exist in myriad versions. If one is found to be toxic, that doesn't necessarily mean that the others will be.

No one seriously suggests embarking on the mammoth task of testing each and every kind of carbon nanotube for toxicity using ▶

"It might be possible to engineer nanoparticles to be non-toxic from the word go"

the classic animal testing regime. Instead, the aim is to develop a way of predicting the hazards that nanomaterials pose. The National Toxicology Program is examining classes of nanomaterials and trying to figure out which physical and chemical properties distinguish the toxic ones from the benign. The aim is to apply this information to other members of the class to predict which of them will be toxic. Even better, it might be possible to use this information to engineer nanoparticles to be non-toxic from the word go.

So far, researchers have focused on three types of nanomaterials that they think may be toxic: carbon nanotubes, the spheres of 60 or more carbon atoms known as buckyballs, and metal oxide nanoparticles. They already have clues as to what features are likely to make them hazardous. For instance, the toxicity of carbon nanotubes seems to be related most closely to their length and surface characteristics. For buckyballs – which often have chemical groups attached to them – particle size and surface chemistry seem most predictive. For metal oxides, such as titanium dioxide, the key feature appears to be crystal structure. "We have some understanding of mechanisms for certain nanoparticles," Nel says. "We know what is a dangerous particle, the principles by which they function, and some of the tissue responses."

Alarm bells

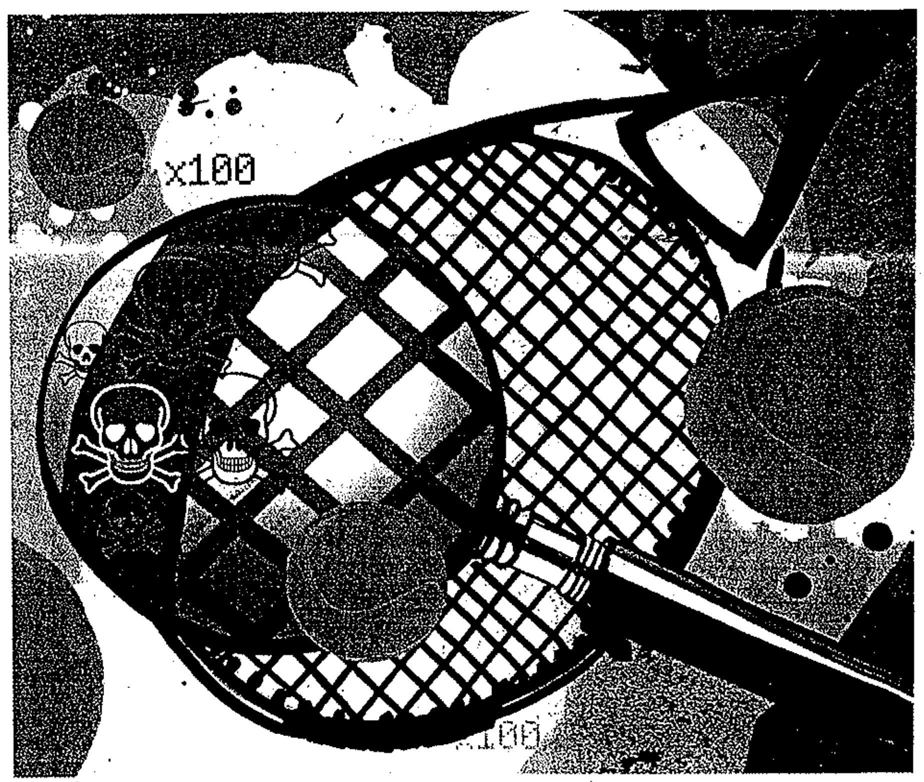
Tests on carbon nanotubes invariably ring alarm bells. No matter which form is examined, the results suggests that many materials in this group have the potential to be toxic.

The obvious comparison is to asbestos, which is also a fibrous material and is known to cause a kind of lung cancer called mesothelioma. Asbestos is carcinogenic because the fibres are long, thin and can't be broken down in the lungs. They cause inflammation that damages lung tissue over many years. In a major review, published last year, of both animal and lab studies that investigated whether carbon nanotubes are toxic, Chiu-wing Lam, a toxicologist at NASA's Toxicology Group at the Johnson Space Center in Houston, Texas, concluded that carbon nanotubes could produce inflammation in the lung leading to granulomas, a kind of scar tissue that damages lung function.

However, in a debate comparing the potential effects of carbon nanotubes and asbestos on health, a panel of researchers at the Society of Toxicology meeting held in March this year in Charlotte, North Carolina, concluded that they are probably more different than alike – largely because asbestos is stiff and forms splinters, while carbon nanotubes tend to be flexible and scrunch up into a ball.

Don't breathe easy yet, though. The panel said they are more similar to ultra-fine particulates of like size, such as those emitted in diesel engine exhaust. Breathing the very small particles contained in exhaust fumes and smoke is well known to cause health problems, such as damage to the cardiovascular system. Now a study by Petia Simeonova and colleagues at the US National Institute for Occupational Safety and Health (NIOSH) in Morgantown, West Virginia, suggests that inhaling carbon nanotubes might have a similar effect. The researchers injected a dose of single-walled carbon nanotubes – stripped of metal impurities – into the lungs of mice. When they looked at the lining of their aortas, they detected signs of free radicals, which are capable of damaging cells and tissue. Animals genetically susceptible to atherosclerosis also developed more arterial plaques, which are known to cause heart attacks and strokes. The ultra-fine particulates in air pollution may cross into the bloodstream and directly inflame and damage blood vessels, and the NIOSH group is now studying whether carbon nanotubes might do the same.

The similarities that are emerging between carbon nanotubes and ultra-fine particulates have raised the intriguing idea that they are not merely similar, but are actually the same thing: that carbon nanotubes are in fact the toxic component in diesel exhaust and other pollution. Lawrence Murr, an environmental and materials scientist at the University of



Texas, El Paso, has already found these nanomaterials in urban air samples and in emissions from gas stoves and wood-burnin fires. "We began to see multi-walled carbon nanotubes essentially everywhere we lookec he says. "They're part of the combustion regime." The same goes for buckyballs.

Whether the nanomaterials that Murr finds in the environment are the same as those made in the laboratory, however, with similar health effects, remains to be seen. Engineered carbon nanotubes are certainly more homogeneous and pure; that's what makes them more useful than plain old soot. Lam now plans to do animal studies to test the health effects of carbon nanotubes collected from urban air, and will compare the results with those of earlier studies testing the engineered versions.

If carbon nanotubes do turn out to be highly toxic, the urgent question will be to assess how likely it is that people will come into contact with them, now and in the future. So far, consumers only encounter carbon nanotubes in products like that baseball bat, where they are embedded in some hard and durable material. Even so, a white paper on nanotechnology published in February this year by the US Environmental Protection Agency warns that when such objects are eventually discarded, nanotubes could start to disperse into the environment as the material containing them breaks down.

And what of the people working in factories where mixtures containing carbon nanotubes are handled and mixed? Vincent Castranova, coordinator of NIOSH's nanotoxicology programme, warns that no one knows what industrial users are doing with nanomaterials and whether workers in these plants are handling them safely. "It's very difficult to find out how products are being made, what the processes are, and what the hotspots of exposure are," he says.

Likewise, it is unclear how consumers might be exposed to nanomaterials. Windows, fabrics and even railings in subway stations are now being coated with various nanomaterials to make them antibacterial, self-cleaning and more durable. Could they be shedding nanoparticles as a result of normal wear and tear? In tests at the Industrial Technology Research Institute in Taiwan, Li-Yeh Hsu and Hung-Min Chein found that when they mimicked the action of sunlight, wind and human contact on coatings containing titanium dioxide nanoparticles, some particles did escape, particularly from coated tiles (*Journal of Nanoparticle Research*, vol 9, p 157).

WHERE ARE THEY NOW?

Nanomaterials can now be found in many consumer products, raising fears that they could escape into the environment

PRODUCT	POTENTIAL RELEASE ROUTE OR EXPOSURE SOURCE
COSMETICS Includes products such as sunscreen containing nanoparticles of UV-absorbing titanium dioxide or zinc oxide	Absorption through the skin. Release into water supply during washing. Disposal of containers holding residual product
FUEL ADDITIVES In Europe, cerium oxide is added to diesel to reduce exhaust pollutants such as nitrogen oxides and carbon monoxide	Exhaust emissions into the atmosphere, and from there into surface water
PAINTS AND COATINGS Nanoparticles of silver and other materials are used to make antibacterial coatings for a range of products, including kitchenware, cellphones, toys, baby pacifiers and condoms	When the surfaces wear, nanoparticles may be released into the air and water supplies
CLOTHING Silver nanoparticles have been impregnated into socks, underwear, shirts and nurses' uniforms as an antibacterial agent and to cut odours	Skin absorption. Washing and disposal can lead to particles entering the water supply
ELECTRONICS Carbon nanotubes are used in backlights for LCD screens and are attached to chips as heat sinks. Manganese nanocrystals used in batteries to boost their capacity	Exposure low during use. Nanoparticles could be released during incineration or disposal and pollute the air or water supply
SPORTING GOODS Products containing carbon nanotubes as a lightweight strengthener include golf clubs, baseball bats, tennis rackets, skis and bicycles	Exposure low during use. Nanoparticles could be released during incineration or disposal and pollute the air or water supply

Understanding the routes of public exposure to engineered nanomaterials is going to be tricky, yet some experts argue it is the most important knowledge gap to fill. "One can be led down all sorts of blind alleys," says Martin Philbert, a neurotoxicologist at the University of Michigan, Ann Arbor. "You could overreact to extremely toxic materials that will never reach high enough concentrations in the environment, and ignore seemingly benign materials that will be released in very large quantities."

Carbon nanotubes appear so far to fall into the category of materials with potentially high toxicity but low levels of exposure, but more exposure might be coming as they appear in an increasing number of products. That's why earlier this year both the US Environmental Protection Agency and the European Commission called for a life-cycle approach to assess the long-term safety of products containing nanomaterials.

Nanomaterials hold huge promise in a wide range of applications – from solar cells to drug delivery – so let's hope we can pin down any potential risk and make sure that they can be used safely. For that to happen, a lot of questions over their potential health effects have still to be answered. So for now, my son will be developing his baseball talents with a good old-fashioned aluminium bat. ●

"No one knows what industrial users are doing with nanomaterials and whether workers are handling them safely"

Karen Schmidt is a California-based writer and host of the podcast *Trips to the Nanofrontier*

www.newscientisttech.com/channel/tech/nanotechnology

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By David Rotman | Photograph by Wyatt McSpadden

MEASURING THE RISKS OF NANOTECHNOLOGY

Vicki Colvin

POSITION: Director, The Center for Biological and Environmental Nanotechnology at Rice University

ISSUE: The safety of nanotechnology. Do breakthroughs in nanotechnology—widely hailed for their potential in biomedicine and materials science—present unique health and environmental dangers that need to be studied?

PERSONAL POINT OF IMPACT: Colvin's nanochemistry group, which makes new kinds of nanoparticles, is beginning to work with toxicologists, biologists, and bioengineers to evaluate the unintended biological effects of these materials.

TECHNOLOGY REVIEW: Questions about the safety of nanotechnology suddenly seem to be everywhere, from Michael Crichton's bestselling novel *Prey* to calls for a moratorium on the technology by at least one environmental group. What are the chief concerns?

VICKI COLVIN: Nanomaterials are different. Because of their small size, we are able to get them into parts of the body where typical inorganic materials can't go because they're too big. There is an enormous advantage to using nanoparticles if you're engineering, for example, drug delivery systems or cancer therapeutics. This would suggest that nanomaterials that are unintentionally introduced into the body may also undergo similar processes. The concern—or the *hypothesis* would be a better way to say it—is that nanomaterials differ in their reactivity and biological availability. You can't help but ask, Well, if they are powerful biological actors, then what about unintentional consequences?

TR: Are the dangers of nanomaterials well understood?

COLVIN: It's not as if no one has ever thought about how particulate matter generally can interact with organisms. We can learn a lot from particle toxicologists who characterize the effects of aerosolized particles of all sizes on health, as well as from bioengineers who consider the effects of larger particulates generated by implants wearing down in the body. Still, specific information on the health impacts of very small, nanoengineered particles under 20 nanometers is hard to come by. So the one thing everybody agrees on is that there just is not a lot of information out there.

Getting that information isn't going to be a simple task. Nanomaterials are incredibly diverse. You can have nanoscale carbon, nanoscale Teflon, nanoscale you name it. Within that huge diversity of materials, it would be almost amazing if all those materials were as safe as water. The toxicology data is going to start to come out, and it is almost certain that it's not going to be: nanomaterials are totally safe. Nothing in the world is totally safe.

TR: So do you expect bad news on the health effects of nanomaterials?

It is a mistake for someone to say nanoparticles are safe, and it is a mistake to say nanoparticles are dangerous. They are probably going to be somewhere in the middle. And it will depend very much on the specifics. The sooner we get the technical information in hand, the better.

COLVIN: I would fully expect that within the next year there will be some concrete data on health effects. Not surprisingly, there will be some news that, hey, you can't use these materials in any possible application; you have to consider human exposure and environmental-impact issues.

From a strictly scientific perspective, there are some fascinating questions about how does the body deal with inorganic materials that are on the order of the size of hemoglobin. At this point, I think it is a mistake for someone to say nanoparticles are safe, and it is a mista[...]

sooner we can get technical information in hand, the better.

TR: Should there be regulations on nanotechnology, the same way that we have rules for pharmaceuticals and chemicals?

COLVIN: In the next few years, the answer is no. Nanotechnology, from an industry perspective, is just now developing, and actual products for consumers are not common. But I would say once the products are developed, probably the FDA [Food and Drug Administration] should look at it. I do know that nanomaterials are already used in sunscreens and also in cosmetics. The fact that they are used in those circumstances is of interest, and I do feel that eventually there will be a regulatory component to this industry.

TR: Have the nanoparticles used in sunscreens and cosmetics been tested? What do you tell people about the risks of these consumer products?

COLVIN: To my knowledge, they have not been tested. Do I use sunscreens? Yes. Does it make me stay up at night? Actually, it doesn't. Because the kind of diseases—if you look at other larger particulate-based diseases—are ones that usually develop in workers who have acute exposures to the materials over decades. So I don't feel that there is any chance occasional sunscreen use is [...]

they go? How do they distribute in the body? And the data on that is a little bit less clear. Smaller particles apparently circulate for much longer and in some cases can cross the blood-brain barrier. And they can certainly leak out of capillaries and get into the fluids between cells. So they can go places in the body that your average inorganic mineral can't.

TR: Are there any areas where you feel efforts in nanotechnology should probably slow down?

COLVIN: New types of solar cells or new methods for treating cancer, to take just two examples, offer amazing benefits to our society that outweigh any speculation about risks. I am less convinced that nanomaterials used in cosmetic products are worth the risk.

TR: Are you worried that public fears will hinder the development of nanotech?

COLVIN: Ultimately, people have to make a cost-versus-benefit decision. The benefits of nanotechnology are well recognized by scientists and our federal government, which has put over a billion dollars into the area. But there will almost certainly be costs to implementing nanotechnology. To try to stick your head in the sand and say, Oh no, all of nanotechnology will only result in perfectly safe and good technologies is simplistic. A number of very powerful organizations like Greenpeace, specifically the ones that went after genetically modified organisms, are beginning to look at nanotechnology. As a technical person, you have to listen to these groups and take [...]

14A (5)

Jonathan Links explains the promise and peril of *going nano*

ROBERT OLLINGER

THE SCIENCE OF SMALL

Targeted delivery of drugs. Innovative ways to filter water. Stain-free slacks… The benefits of nanotechnology—the engineering of materials on a molecular scale—seem limited only by human imagination. Nanoparticles like titanium dioxide are already used in sunscreen lotions to filter out harmful ultraviolet light. Other nanoparticles are currently helping clinicians diagnose and treat disease by attaching themselves to cancer cells or other targets. In addition to such clinical goals, the emerging discipline of nanobiotechnology, a marriage of nanotechnology with biotechnology, seeks to limit the health risks of nano-based products. No one knows, for example, what will happen when nanomaterials used in tennis rackets and car bumpers—not to mention cosmetic products—inevitably find their way into the environment and our bodies. Jonathan Links, a co-founder of the Johns Hopkins Institute for NanoBioTechnology, met recently with *Johns Hopkins Public Health* editor Brian W. Simpson to discuss the public health aspects of this new technology. Links, PhD '83, is a professor of Environmental Health Sciences at the Bloomberg School.

The benefits of nanotechnology—new drugs, new diagnostic tools and new ways to keep your clothes from getting stained—sound terrific. Why is this a public health issue?
If you look at the history of technological development, the potential benefits are what folks almost exclusively focus on at the beginning. But we've seen in virtually every case, after the fact, that there is a recognition of at least some potential threats to human health and to the environment.

Give us a few examples.
Propellants in aerosol cans. Asbestos. Genetically modified organisms. The list goes on and on. Now here is the important point. Absolutely, positively, every one of these technological advances is truly an advance; it truly does bring benefits. But the delayed recognition of the potential risks is harmful because the beneficial technologies are not rolled out in an optimal way to mitigate and reduce risks. With nanotechnology, there's been more of an early recognition of the need to look at risks hand in hand with looking at benefits and technological development.

Have there already been any reported health consequences of nanobiotechnology?
Over the past several years, there's been a modest emergence of original research papers focused on what's now a new field, called nanotoxicology. However, most of what we know about the potential risks of nanotechnology is really based on extrapolation from other environmental agents.

Tell us about some of the specific public health issues involved with nanotechnology.
In the Institute, we've conceptualized things into four sets of questions. The first set has to do with the environment: How does a nanomaterial get introduced into the environment? And once there, where does it go? Air, water, soil, food? The second set of questions is

under the heading of exposure assessment: What are the routes of human exposure—inhalation, ingestion or skin absorption? The third category is what we would call basic toxicologic assessment: What does the body do to the materials, and what do the materials do to the body? In the fourth group, epidemiologic investigations, we're interested in identifying the most relevant and significant patterns and pathways of human exposure to engineered nanomaterials, and the most relevant adverse human health outcomes. And we want to identify cohorts within populations who are most susceptible.

Is there any real oversight in terms of industry developing these materials and then just rolling them out?

It depends on the type of product. For drugs, absolutely. Drugs are regulated from the get-go. You have to provide upfront any information about toxicity or the lack thereof. For consumer products like sunscreens, human hazard evaluations aren't required. But we really need to broaden our thinking about exposure. The vast majority of environmental exposures are unintentional and unwanted. Consider asbestos. Fifty years ago you would have said, "Why the heck would we need to evaluate its effects on human health? It's an insulation and a flame retardant. We're not giving it to people."

So today, if you're using nanomaterials to make clothing resistant to stains, would anybody notice?

If it's a consumer product, it may or may not get noticed. What's interesting is that the Feds have identified inhalation and skin absorption as the two primary routes of exposure of interest. If a textile is rubbing against your skin, is there transfer? No one knows the answer. It's likely if you're slathering on sunscreen, there's some transfer.

Should we be using this stuff or not?

It's a philosophical decision as much as anything. There's a concept in environmental health called "prudent avoidance." It says that in the face of uncertainty it's prudent to avoid exposure—but then you're also avoiding the potential benefits. So when anyone asks me about exposure to a toxin in the context of a beneficial activity, I always say it's the balance between the risk and the benefit. I think it's no different than when I get called by somebody who wants to buy a house and the radon test came back at some level above the EPA action level. Should they buy the house? I always ask them: How much do you like the house?

There seems to be an unavoidable tension between creating and selling new products and ensuring they are safe.

Historically there has been a tension, but there's no need for it. The consumer applications ultimately depend on minimizing risk. Your best shot at minimizing risk is to simultaneously think about benefits and risks as you develop the technologies.

This is one goal of the Institute?

Yes. And the cool thing is that this notion of studying benefits and risks together is epitomized by what we're doing in the Institute. The same exact products that you're developing for their beneficial uses can be used to study their own risks. For example, the guy on the next lab bench in the Institute may be developing a diagnostic nanomaterial (meaning a material that's introduced into the body and then externally detected), and I'm saying, can I have a little bit so that I can study the risks? I can use the same technologies to learn how much of the nanomaterial gets into the body, where it goes and if it presents a risk.

> **"If you look at the history of technological development, the potential benefits are what folks almost exclusively focus on at the beginning... [But] with nanotechnology, there's been more of an early recognition of the need to look at risks hand in hand with looking at benefits and technological development."**
> **—Jonathan Links**

In 10 years, will the proper regulatory mechanisms be in place to evaluate nanoproducts before they hit the marketplace?

I think it will look remarkably advanced compared to where we are now, but I hesitate to ever say that for any type of testing of any materials, not just nanomaterials, we will have hit the nail square on the head and done everything that needs to be done. In Environmental Health Sciences, we're constantly finding out bad things about stuff that has been in use for years and years. —*BWS*

Nano Notes

NANOTECHNOLOGY: The development and use of materials at the nano scale—from 100 nanometers down to the level of individual atoms. (A nanometer is one-billionth of a meter. A human hair is about 80,000 nanometers wide.)

ALREADY IN USE IN: Burn and wound dressing, water filtration and more than 80 consumer products—from glare-reducing glass to cosmetics.

ADVANTAGES: Manipulating materials at the nanoscale changes their physical, chemical and mechanical properties, making possible new uses.

RISKS: Nanoparticles can enter the environment or slip past the body's natural defenses with effects that are little understood.

HOPKINS CONNECTION: Johns Hopkins University established the Institute for NanoBioTechnology in May 2006. About 125 faculty from Hopkins' schools of Medicine, Arts and Sciences, Engineering and Public Health, and the Applied Physics Laboratory, are affiliated with the Institute.

14A (6)

Center for Responsible Nanotechnology

PUBLISHED JANUARY 2003 – REVISED DECEMBER 2003 & JANUARY 2004

Applying the Precautionary Principle to Nanotechnology

by Chris Phoenix and Mike Treder

Introduction

The development of general-purpose molecular manufacturing through nanotechnology carries numerous risks, including the production of potentially unhealthy nanoparticles, the possible creation of tiny, destructive, self-replicating robots, and many others. The Precautionary Principle is often invoked when dealing with situations that might be hazardous; however, the label "Precautionary Principle" is attached to at least two different ideas, which must be analyzed separately.

This paper discusses two forms of the Precautionary Principle, which we will call the "strict form" and the "active form", and relates them to the purpose of the Center for Responsible Nanotechnology, and to CRN's policy recommendations.

Two Forms of the Precautionary Principle

The *strict* form of the Precautionary Principle requires inaction when action might pose a risk. An example of this form is shown in the following quote from an article on regulating nanotechnology: "The principle, itself a topic of debate, was designed to reduce environmental and health risks by limiting scientific exploration when its impact is in doubt."[1]

In contrast, the *active* form calls for choosing less risky alternatives when they are available, and for taking responsibility for potential risks. For example, Article 15 of the Rio Declaration on Environment and Development states: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[2] In other words, if damage is likely but not certain, the lack of absolute certainty is no excuse for failing to mitigate the damage.

The strict form of the Precautionary Principle is similar to the maxim often attributed—falsely[3]—to the Hippocratic Oath: "First, do no harm." If action may cause harm, then inaction is preferable. In particular, if scientific investigation could lead to harm or risk, then that line of research should not be pursued. There are two problems with this guideline. First, almost any action creates a certain amount of risk, and this is especially true of research that seeks to answer unsolved questions. Strict adherence to this guideline would prevent virtually all scientific endeavors. Second, inaction carries its own risks, which may be greater than the risks of action. By its bias toward inaction, the strict version can create increased risk. A scientific endeavor with great potential for mitigating one risk, and small potential for creating another, would be forbidden by the strict version.

This reading is not merely the result of journalistic carelessness. Some policy advocates have followed this course. For example, in an article recommending the application of the Precautionary Principle to genetically modified crops, Dr. Mae Wan Ho writes: "It is up to the perpetrators to prove that the technology is safe beyond reasonable doubt."[4]

The active form of the Precautionary Principle urges more action instead of less. When a potential risk is identified, the appropriate response is to search for less risky alternatives, and use them instead if practical. *The Precautionary Principle In Action: A Handbook*[5] lists five components of a precautionary approach:

- Taking precautionary action before scientific certainty of cause and effect
- Setting goals
- Seeking out and evaluating alternatives
- Shifting burdens of proof
- Developing more democratic and thorough decision-making criteria and methods

The active form does not automatically forbid risky activities; instead, it calls for an appropriate effort to mitigate the risk—which may well involve finding and choosing a different activity.

Applying the Precautionary Principle to Nanotechnology

Molecular manufacturing technology is currently the subject of much scientific uncertainty. Several prominent scientists have gone on record with the opinion that self-copying machines built by nanotechnology are impossible, or at least sufficiently difficult that they will never be built.[6] On the other hand, some scientists believe that such a thing is quite feasible.[7] The question is important, because if a self-copying machine was deliberately designed with a general-purpose metabolism to allow it to exploit biomass instead of specialized feedstock, it could in theory get out of control and make too many copies of itself. Such a design would be quite difficult and mostly useless, especially if the functionality were packed in a system too small to be easily recaptured. But the fact remains that a small, self-contained, foraging, self-replicating system, if it were ever built, could do serious damage to the environment.

This risk of biology-eating "gray goo" arising from nanotechnology research has been publicized for over a decade.[8] At this point, science does not have sufficient information to rule on the likelihood or even the theoretical possibility of such a risk. This is the sort of case that the Precautionary Principle was designed for: "The litmus test for knowing when to apply the precautionary principle is the combination of threat of harm and scientific uncertainty."[9] The strict form would clearly prohibit research that might lead to gray goo. However, the active form of the Precautionary Principle might give a very different answer.

The Center for Responsible Nanotechnology recognizes the possibility of gray goo, along with the more pressing dangers of dangerous arms races and widespread use of destructive products, if molecular manufacturing capability is ever developed. CRN is dedicated to reducing these risks as far as possible. However, we do not believe that it will be feasible to enforce a permanent, global prohibition of advanced nanotechnology. Nuclear non-proliferation has been

more or less successful, but the fact remains that many nations have gained a nuclear capability in the last half-century.
Molecular manufacturing will be based on technologies that are being developed for many legitimate reasons. Within at most a few decades, the ability to manipulate complex molecules in complex ways will be common in a variety of fields, including biology, electronics, materials science and medicine. Rapid prototyping and automated assembly are already being used commercially. On a darker note, the military potential will ensure that nations do not risk letting other nations develop nano-fabrication first. Although it may be possible to delay the development of molecular manufacturing technology, sooner or later the world will have to deal with the results of a successful nanofabricator project.

The fact that molecular manufacturing also promises many benefits is important for at least two reasons. First, the promised benefits will encourage the development of the technology, making it more difficult to enact—and enforce—prohibitions. Second, some of the promised benefits may alleviate serious and global problems, and this must be included in any assessment of possible courses of action. For example, nanotechnology-based manufacturing could produce much less pollution than traditional methods. Nanoscale products of molecular manufacturing could use mechanical means to do what is done today by a variety of dangerous chemicals. Medical products could save millions of lives. Cheap local manufacturing will reduce the transportation of goods, and may save land and water by allowing more efficient farming. Today many nations, both rich and poor, live unsustainably, and development of advanced nanotechnology may provide solutions for diverse and serious environmental problems.

Our Position

Because the *strict* form of the Precautionary Principle does not allow consideration of the risks of inaction, CRN believes that it is not appropriate as a test of molecular manufacturing policy. Inaction poses at least three severe risks:

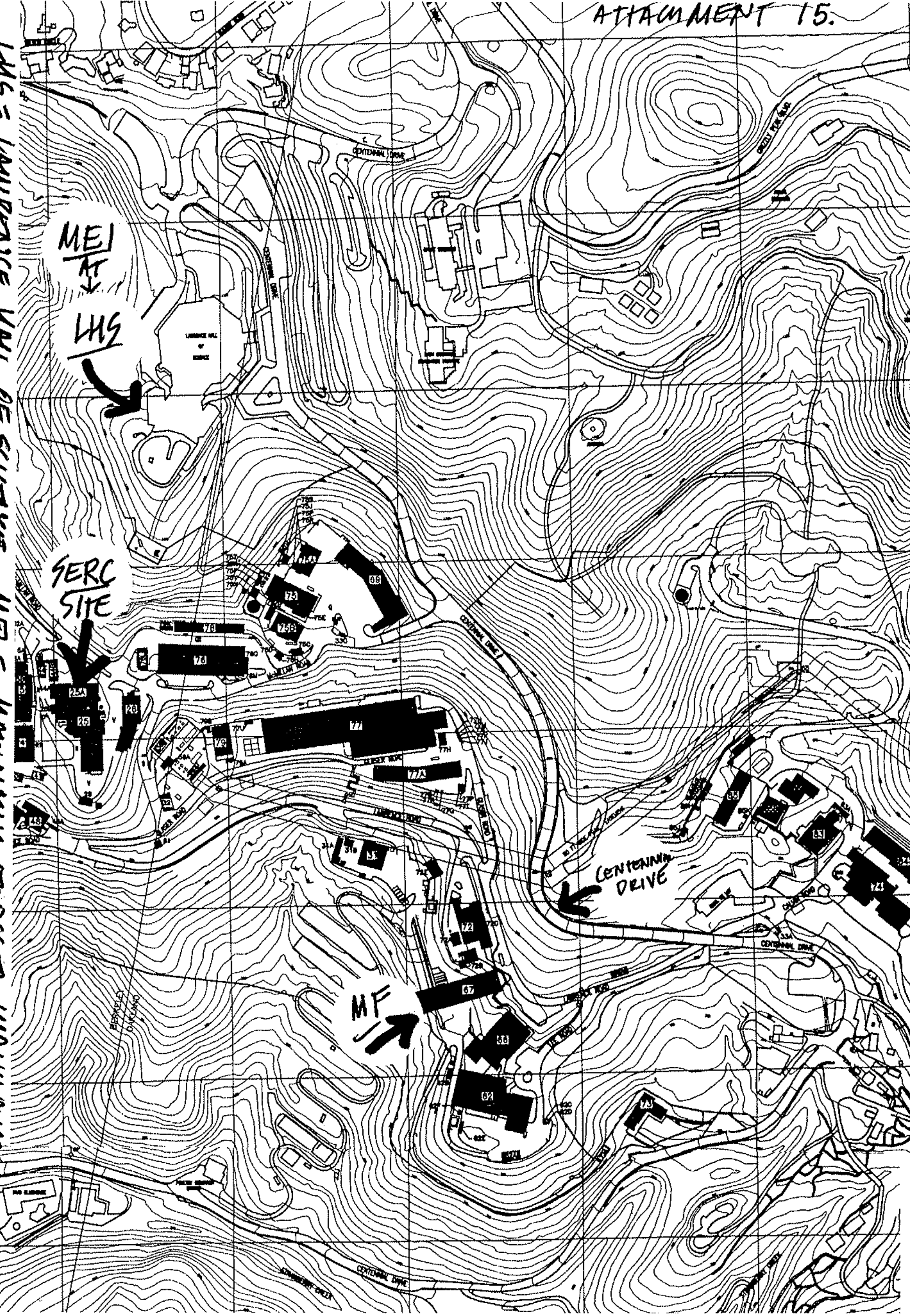
1. No other solution may be found for certain pressing problems.
2. Inaction on the part of responsible people could simply lead to the development and use of molecular manufacturing by less responsible people.
3. Lack of understanding of the technology will leave the world ill-equipped to deal with irresponsible use.

The *active* form of the Precautionary Principle, however, seems quite appropriate as a guide for developing molecular manufacturing policy. Given the extreme risks presented by misuse of nanotechnology, it appears imperative to find and implement the least risky plan that is realistically feasible.

CRN has identified several sources of risk from molecular manufacturing, including arms races, gray goo, societal upheaval, independent development, and programs of nanotechnology prohibition that would require violation of human rights. It appears that the safest option is the creation of one—*and only one*—development program, and the widespread but restricted use of the resulting manufacturing capability. This opinion, and the reasoning behind it, is explained in our other papers. If a safer possibility is suggested, and appears to be workable, CRN will publicize that possibility; if a fundamental flaw is found in our current proposal, we will publicly retract it.

CRN promotes the responsible development of nanotechnology—not because we believe it is *safe*, but because we believe it is *risky*—and the only realistic alternative to responsible development is irresponsible development. Although we cannot agree with the strict form of the Precautionary Principle, we support the active form, and we request feedback from all readers to improve our understanding of how to further minimize the risks inherent in this powerful new technology.

ATTACHMENT 15.



LHS = LAWRENCE HALL OF SCIENCE MEI = MAXIMALLY EXPOSED INDIVIDUAL

MF = MOLECULAR FOUNDRY } NANO FACILITIES
SERC = SOLAR ENERGY RESEARCH CENTER }

UC BOTANICAL GARDEN

ATTACHMENT 16. (2-PAGES)

Committee to Minimize Toxic Waste

<u>QUESTIONS</u> TO LBNL/DOE REGARDING THE PROPOSED MOLECULAR FOUNDRY BUILDING PRESENTED AT THE <u>MAY 8, 2003 PUBLIC MEETING</u>:

1. WHAT IS NANOPOLLUTION?
2. HOW SPECIFICALLY DOES LBNL&DOE PROPOSE TO <u>PREVENT</u> NANO-POLLUTION IN BERKELEY AND OAKLAND?
3. WHAT HEALTH STUDIES ARE AVAILABLE TO ASSESS THE RISKS OF NANOPOLLUTION?
4. HOW IS LBNL PROPOSING TO FILTER UFPs (ULTRA FINE PARTICLES) FROM LABORATORY FUMEHOODS? PLEASE SPECIFY THE TYPE OF FILTERS TO BE USED AND PROVIDE THE PROTOCOL FOR FILTER CHANGES, SAMPLING etc. The Foundry has at least 48 fumehoods.
5. WHICH FEDERAL AND/OR STATE AGENCY REGULATES NANOPOLLUTION?
6. WHAT ENVIRONMENTAL, HEALTH AND SAFETY REGULATIONS ARE IN PLACE AT LBNL REGARDING NANOPOLLUTION?
7. WHAT PRECAUTIONS HAVE LBNL$DOE TAKEN TO PREVENT NANOPOLLUTION, i.e. ULTRA FINE PARTICLES,FROM ENTERING THE ENVIRONMENT?
8. WHY WERE CHICKEN CREEK AND NO NAME CREEK LEFT OUT OF LBNL'S INITIAL STUDY, SINCE THEY ARE LOCATED JUST NEXT TO THE PROPOSED MOLECULAR FOUNDRY SITE, AND ARE TRIBUTARIES TO STRAWBERRY CREEK, WHICH RUNS THROUGH THE UC BERKELEY CAMPUS AND THE CITY OF BERKELEY? IMPACTS TO CREEKS FROM THE CONSTRUCTION AND OPERATIONS OF THE FOUNDRY WERE NOT EVALUATED? WHY?
9. RECENT VEGETATION STUDIES SHOWED THAT AIRBORNE TRITIUM HAS CONTAMINATED VIRTUALLY THE ENTIRE LBNL SITE. WHY WAS THE TRITIUM CONTAMINATION NOT DISCLOSED IN THE INITIAL STUDY, AND WHY WAS THE LARGE UNDERGROUND TRITIUM PLUME, LOCATED NEXT TO THE PROPOSED MOLECULAR FOUNDRY TOTALLY IGNORED, although the area of disturbance intersects it?
10. WHY WAS THERE NO WINDROSE PROVIDED IN THE INITIAL STUDY TO SHOW THE PROMINENT WIND DIRECTIONS AND ALSO AN ASSESSMENT TO DETERMINE THE DIRECTION AND DISTANCE FOR NANOPOLLUTION <u>DRIFT</u> TOWARDS THE NEIGHBOURHOODS? WHICH AREAS ARE MOST <u>VULNERABLE</u>?

11. Architect's fees alone are $ 6000.000.00 for the Molecular Foundry, representing 13.9% of the cost of building construction. At the April 17, 2003 Regents Committee on grounds and buildings meeting Regent Hopkinson considered these fees "EXORBITANTLY HIGH"! We are questioning how is it possible for LBNL to communicate to the City's Toxics Management Division Manager that "funding is not yet available " for final decommissioning of the radioactive tritium stack and exhaust system? And yet...

We request that the decommissioning of the Tritium stack and remediation of the site take place PRIOR to any new construction project! We also ask that the architect's fees be reduced and the funds used for site clean up! In addition,

12. We ask that the Molecular Foundry project be put on hold until an EIR has been prepared and alternative sites, away from residential neighbourhoods have been considered!

We also request that more health studies be conducted, before proceeding with this new technology and we request that an independent citizens' advisory committee be formed to evaluate the situation as it develops.

Please, provide answers to the questiond above in a timely manner and mail them to:

CMTW
P.O. Box 9646
Berkeley, CA 94709

ATTACHMENT 17A
(3 PAGES A-C)

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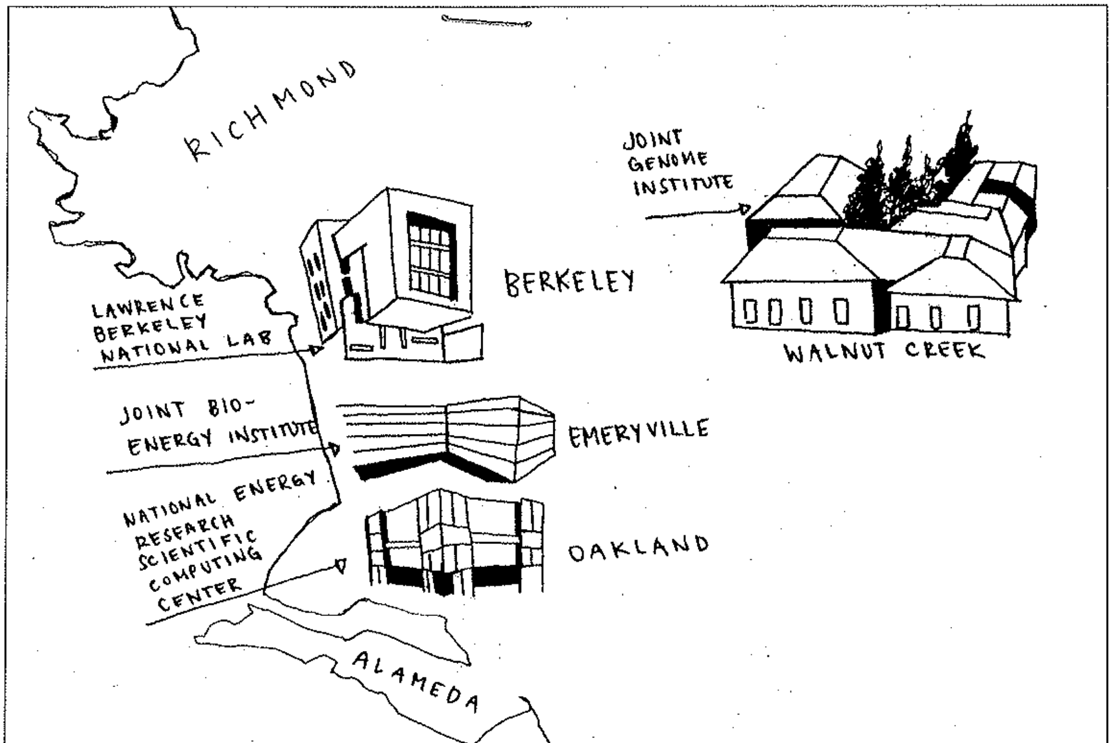
THE DAILY CALIFORNIAN

Berkeley, California Friday, September 3, 2010 www.dailycal.org



ANNA VIGNET/STAFF

Lawrence Berkeley National Laboratory has 20 percent of its facilities outside of Berkeley, including sites in Emeryville and Oakland.

New Facility May Be Ahead for Lab

by **Cristian Macavei**
Contributing Writer

The Lawrence Berkeley National Laboratory, which employs some 4,000 employees and conducts research on everything from DNA to climate change, may soon be looking for land to build a new facility.

The lab is in the early planning stages to consolidate its facilities — 20 percent of which are located outside the city of Berkeley, including sites in Emeryville, Oakland and Walnut Creek — into a new "second campus" somewhere in the East Bay, according to Sam Chapman, manager of state and community relations for the lab.

"We are in an expansion mode with a number of new capital projects ... it's timely to think about the future physical space for the lab," Chapman said.

He said while the process has not yet been initiated, entities have come forward with propositions for the lab's location. The geographic range the lab is exploring extends from Richmond in the north to Oakland in the south.

According to Chapman, the lab is looking for land close to the Berkeley location so researchers who work at the new campus can collaborate with scientists at the Berkeley location.

"Scientists work better when they're together rather than in separate locations," he said. "One of the successes of Berkeley Lab is 'team science,' where

>> LAB: PAGE 2

LAB: Alameda Could Be Potential Facility Site

FROM FRONT

scientists work as teams across disciplines, and that works better when they're consolidated and are able to mingle with other scientists."

The lab has not yet looked into how it will fund the project. Real estate activity of the lab is managed by the University of California, Chapman said.

"The lab wants to be a good neighbor where it goes, and the lab is an economic engine in the region," he said. "We have a substantial impact on the local economy, so we see that as a positive (effect), particularly in a time when there's so much focus on need for economic development. Obviously we'd like to locate in an area where that's welcomed."

The formal announcement of the expansion plan and the description of the process will possibly occur sometime in the next few months, he said.

Chapman added that the Berkeley site — which houses 80 percent of the lab — sits on about 200 acres near UC Berkeley and will continue to grow.

Marie Gilmore, an Alameda City Councilmember, said the lab would be a great partner at Alameda Point.

"I think (the area) would meet the lab's needs, and I do know that they have been in touch with the city," she said.

Gilmore said besides the land the city could offer, Alameda also has its own electric utility called Alameda Municipal Power, which is attractive for employers because many of the utility's power sources, including wind, solar and geothermal, are renewable.

Lab staff members visited the city earlier this month to look at what Alameda has to offer, she said.

"It would be a huge plus, a huge benefit ... not only in the sense of jobs but also the economic spillover it would have for restaurants and services and other things that service a business," Gilmore said.

Cristian Macavei is the lead research and ideas reporter. Contact him at cmacavei@dailycal.org.

THE BERKELEY VOICE
Community Newspaper of Berkeley Friday, September 10, 2010 403 ☆☆ 50 cents (tax included)

Alameda hopes to attract Berkeley lab

City hosts visit by Lawrence Berkeley staff, waiting for chance to submit proposal

By Janet Levaux
Correspondent

Lawrence Berkeley National Laboratory is looking for more space, and Alameda Point could be in the running for its second campus.

The city of Alameda hosted a visit of Lawrence Berkeley National Laboratory staff recently and then sent a letter in late August to share details about several airplane hangars on the former naval air station, the amount of energy that can be supplied to the area and other information.

Now, Alameda officials have to sit tight and hope that the city gets asked to submit a formal proposal for the lab's second campus. City staff members expect other nearby cities, such as Emeryville and Richmond, to be potential rivals.

"We are interested in doing a request for site (proposal), though we don't yet know the criteria," said Jennifer Ott, deputy city manager. "Our intention is to respond to such a request, when the formal request is out."

The laboratory, which includes six facilities, reportedly is planning to consolidate some of its operations. Currently, it has facilities in Berkeley, Emeryville and Walnut Creek.

City Councilman Doug deHaan described the city's efforts to attract Berkeley lab to Alameda Point on Aug. 26 at a community meeting on the former naval air station. He said he "feels confident that we have the attributes they are looking for," including some 1.2 million square feet of space.

The Department of Energy operates the Berkeley lab, which employs 3,915 staff members, about one-third of whom are scientists. Its fiscal 2010 budget is estimated at $774 million, including $122 million in stimulus funding from the federal government.

Lawrence Berkeley National Laboratory focuses on scientific research and does not engage in defense work like Lawrence Livermore National Laboratory.

According to the laboratory, the facilities' overall impact on the Bay Area is valued at about $500 million a year in direct economic spending and $690 million in indirect economic spending.

"This could be a super project for us," said deHaan.

17/B

27.

17/c

Lawrence Fremont National Laboratory

A New National Center with Consortium Partners for Green Clean Technologies/Research/Development/Manufacturing.

Five million square feet of laboratory/office/research and manufacturing space **already built and immediately available** at the NUMMI Fremont site, previously occupied by a joint venture between General Motors and Toyota, which ended on April 1, 2010.

The site is in the **geographic center of the Bay Area**, served by an excellent transportation infrastructure, a trained workforce and research and development communities nearby as well as supportive elected officials!

The new **Lawrence Fremont National Laboratory (LFNL)** will be just
35 miles from Berkeley (UC/LBNL)
30 miles from Oakland (22 miles from the Oakland International Airport)
41 miles from San Francisco/UCSF (32 miles from SFO)
18 miles from Livermore (LLNL/SANDIA),
12 miles from Hayward (Cal State EB)
16 miles from San Jose (Airport) and Silicon Valley
18 miles to Menlo Park/Palo Alto/Stanford/SLAC

The LFNL, future anchor/center and hub of the Green Corridor going north, south, east and west, is centrally located to all of the East Bay, South Bay, Peninsula and San Francisco!

This is the **Opportunity of the Century for the Department of Energy**, Lawrence Laboratories, UC and the Consortium of Private Industries they are now or will be partnering with in the future; British Petroleum (BP), Energy Biosciences Institute (EBI), Joint BioEnergy Institute (JBEI/Jay Keasling), Amyris Biotechnologies, Nanosys Inc., Quantum Dot Corporation/Invitrogen, Solexant Inc. (Last 3 associated with Paul Alivisatos), etc.

It is specifically an Opportunity of a Lifetime for the Lawrence Berkeley National Laboratory, to offload facilities from the unstable Strawberry Creek watershed site, with its unconsolidated soils, water and mud of a collapsed caldera, riddled with landslides and earthquake faults, stifled by logistical, environmental, geotechnical constraints and legal challenges, currently crippling LBNL and its future.

ATTACHMENT 18.

THE BERKELEY VOICE

Community Newspaper of Berkeley — Friday, July 30, 2010 — 403 — 50 cents (tax included)

Inside UC officials must obey open meeting laws [A4]

New solar research buds in Berkeley

Project would use 'artificial photosynthesis' to create renewable fuels

By Suzanne Bohan
sbohan@bayareanewsgroup.com

Plants fuel the world with their ability to convert sunlight into a usable form of energy. Now, the Department of Energy is putting up $122 million to help humans capture the energy of the sun and create renewable liquid fuels through "artificial photosynthesis."

Lawrence Berkeley Laboratory and the California Institute of Technology in Pasadena were selected to lead the ambitious research project. Its aim is to master the basic science involved, and develop applications that can be scaled up for commercial use.

"The sun is by far the largest source of energy available to man, but we must find a way to cheaply capture, convert and store its energy if we are to build a complete clean energy system," said Nathan Lewis, a Caltech chemist who will serve as director of the sun-to-energy research collaboration, called the Joint Center for Artificial Photosynthesis.

Scientists acknowledge the formidable challenge of creating tiny devices that will mimic the microscopic inner workings of one of nature's more intricate processes — photosynthesis. Plants are able to absorb sunlight, water and carbon dioxide, and in a marvel of nature's ingenuity, yield oxygen and carbohydrates that fuel most life on Earth.

But instead of yielding a simple carbohydrate, artificial photosynthesis would be designed to create oxygen and liquid fuels such as hydrocarbons or alcohols that could be directly pumped into vehicles without additional, costly refinement

It's not a new quest, but the modest successes thus far have been confined to basic research labs, many steps from practical applications. The techniques also sometimes have required rare, expensive materials that would make any ultimate commercial scale-up impractical. But advances in nanotechnology, a field in which the Berkeley lab excels, make the development of artificial photosynthesis far more realistic.

Photosynthesis "happens on the nano scale," said Paul Alivisatos, director of the Lawrence Berkeley Laboratory. "There's really a new environment with all the nanotechnology that's been developed."

See SOLAR, Page 5

Solar

From page 1

With nanotechnology, scientists can create "nanowires" that are one-1,000th the size of a human hair, along with elements like nanocrystals. These tiny machine parts are designed to replicate photosynthesis on a scale closer to what happens inside a leaf.

Can human ingenuity finally master this complex process?

"Oh yes, totally. This is doable," Alivisatos said. "The problems that we face are really specific technical ones that can be worked out."

The Joint Center for Artificial Photosynthesis is one of three "Energy Innovation Hubs" funded by the Department of Energy to develop breakthrough technologies in energy production and efficiency. In May, the Energy Department announced the selection of Oak Ridge National Laboratory in Tennessee as a hub for developing breakthroughs in nuclear power. A third hub, which hasn't been selected, will work on innovations in energy-efficient buildings.

The five-year artificial photosynthesis project will get $22 million in funding this fiscal year, and $25 million per year for the remaining four years, subject to Congressional approval.

The artificial photosynthesis hub "has the potential to reduce our dangerous dependence on foreign oil, increase our national security and create jobs in California," wrote Sen. Barbara Boxer, D-Calif.

Rep. Barbara Lee, D-Oakland, said that it would create 100 new jobs, not including construction and other contract jobs. It also engages the work of an estimated 200 scientists statewide. Other universities involved in the artificial photosynthesis hub include SLAC National Accelerator Laboratory at Stanford, UC Berkeley, UC Santa Barbara, UC Irvine and UC San Diego.

Suzanne Bohan covers science. Contact her at 510-262-2789. Follow her at Twitter.com/suzbohan.

launched a devastating blitzkrieg upon Poland. Two days later, France and Britain declared war on Germany, formally opening World War II.

On October 10, 1939, Lawrence wrote to Sproul that his sixty-inch, two-hundred-ton cyclotron was now working and producing sixteen-million-electron-volt deuterons and thirty-two-million-electron-volt alpha particles. He must now, he insisted, have a two-thousand-ton cyclotron to explore energies above one hundred million electron-volts in order to maintain California's prestige as a world leader in nuclear research. "When we understand these nuclear forces," he said to Sproul, "it is not unreasonable to expect that we will have the key to practical developments of tremendous importance." He gave as an example the opening of "the unlimited store of energy in the atom." The two-thousand-ton cyclotron would realize the ancient quest of the alchemists, he said. It would prove to be both "a new source of power and the philosopher's stone—a means of transforming base metal into gold." That was an incentive that any potential donor could understand. Lawrence wanted a capital outlay of $750,000, with $200,000 allotted for the building alone.[68]

The following day, banker Alexander Sachs personally delivered letters from Albert Einstein and Leo Szilard to President Roosevelt in Washington informing him of their fears that the Germans were working on an atomic bomb. Roosevelt responded by creating a Uranium Committee, which, despite events in Europe, remained for nearly two years strangely unimpressed with the urgency of the task that Roosevelt had assigned it.

A month after Sachs's audience with the president, the Nobel Committee announced that Lawrence had won the coveted prize for his invention of the cyclotron. His own funding was thereby assured. As proof of his growing celebrity, the boyish professor appeared that week on the cover of *Time,* with the caption "He creates and destroys," which gave Lawrence the attributes of a Hindu god.

He had by now become a scientific superstar of the first magnitude, an American wizard who had moved Berkeley and the Bay Area from the edge to the very center of cutting-edge research. A *San Francisco Chronicle* headline boasted "Science: Our Town Is a Great Laboratory" above a photograph of the grinning "atom-buster" in shirt sleeves.[69] For many, his wondrous machines promised a cure for cancer as well as a portal to limitless energy. He consorted at the Bohemian Club with the nation's wealthiest men, who saw in Lawrence, as those before him had seen in engineers such as William Hammond Hall, Hermann Schussler, and Michael O'Shaughnessy, a technical means to achieve

30.

GRAY BRECHIN
"IMPERIAL SAN FRANCISCO"

ATTACHMENT 19.

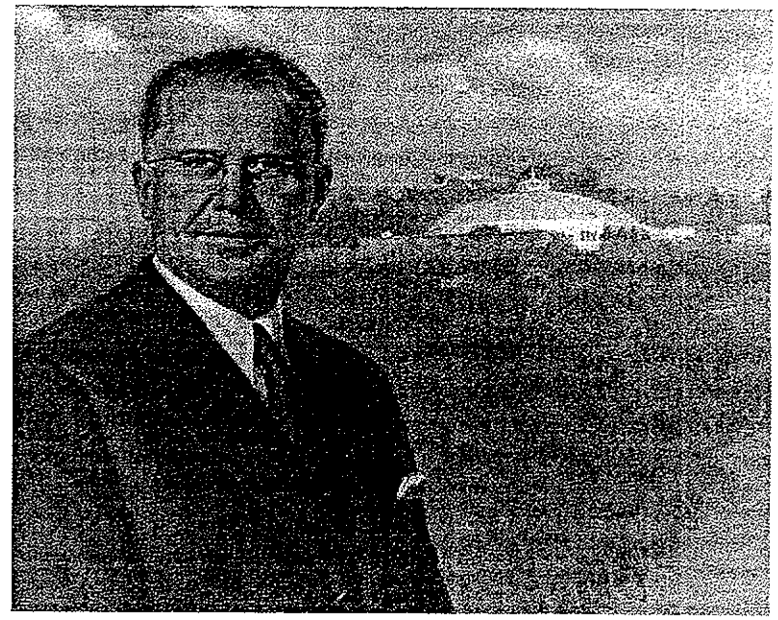


Figure 82. In 1940, Ernest O. Lawrence built his domed 184-inch cyclotron at the head of the university's axis. Courtesy Lawrence Hall of Science.

even greater riches. Armed with his star's Nobel Prize, President Sproul obtained a grant of more than a million dollars from the Rockefeller Foundation for Lawrence's fifth-generation 184-inch cyclotron.

By now, the campus had grown too small for the Nobel laureate's ambitions and machines. The regents gave him permission to build in Strawberry Canyon behind the university. Two days after Christmas, Lawrence wrote of his delight in the canyon site, saying that it gave privacy and sufficient distance to alleviate the possible ill effects of errant radiation upon the town below. His projected cyclotron had by then grown to five thousand tons and would, he predicted, produce from two to three hundred million electron volts. He was already planning one larger.

Within two weeks, Lawrence and the university architect, Arthur Brown Jr., decided to forsake privacy for prominence, moving the mighty cyclotron from the canyon to a hill directly overlooking the campus. Lawrence said that the building would, in that way, serve "to dominate the whole Bay Area and be visible for many miles around." It would stand for the preeminence of nuclear physics at Berkeley in the twentieth century. "The more we have gone into it the more this site has appeal."[70]

ATTACHMENT 20.

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WORLD

PHYSICS

Nobel goes to pair who found thinnest material

By Karl Ritter and Louise Nordstrom
ASSOCIATED PRESS

Jon Super / Associated Press

Andre Geim (left) and Konstantin Novoselov shared the Nobel Prize for physics for the thinnest, strongest material known.

STOCKHOLM — Two Russian-born scientists shared the Nobel Prize in physics for groundbreaking experiments with the strongest and thinnest material known to mankind — a potential building block for faster computers and lighter airplanes and satellites.

University of Manchester professors Andre Geim and Konstantin Novoselov used Scotch tape to isolate graphene, a form of carbon only one atom thick but more than 100 times stronger than steel, and showed it has exceptional properties, the Royal Swedish Academy of Sciences said Tuesday.

Experiments with graphene could lead to the development of new super-strong and lightweight materials with which to make satellites, aircraft and cars, the academy said in announcing the $1.5 million award.

The unique properties of the transparent material could also spur the development of innovative electronics, including transparent touchscreens and more efficient computers and solar cells, although no commercial products have been created yet.

"It has all the potential to change your life in the same way that plastics did," Geim said Tuesday. "It is really exciting."

Geim, 51, is a Dutch citizen while Novoselov, 36, holds both British and Russian citizenship. Both were born in Russia and started their careers in physics there. They first worked together in the Netherlands before moving to Britain, where they reported isolating graphene in 2004.

Novoselov is the youngest winner since 1973 of a prize that normally goes to scientists with decades of experience. The youngest Nobel laureate is Lawrence Bragg, who was 25 when he shared the physics award with his father, William Bragg, in 1915.

"It's a shock," Novoselov said. "I started my day chatting over Skype over new developments — it was quite unexpected."

Geim said he didn't expect to win the prize this year either and had forgotten that it was Nobel time when the prize committee called him from Stockholm.

The two scientists used simple Scotch tape as a crucial tool in their experiments, peeling off thin flakes of graphene from a piece of graphite, the stuff of pencil lead.

"It's a humble technique. But the hard work came later," Geim said.

Paolo Radaelli, a physics professor at the University of Oxford, marveled at the simple methods the winners used.

"In this age of complexity, with machines like the supercollider, they managed to get the Nobel using Scotch tape," Radaelli said.

Phillip Schewe, spokesman for the American Institute of Physics in College Park, Md., said the Nobel to Geim and Novoselov was well-deserved.

"Graphene is the thinnest material in the world, it's one of the strongest, maybe the strongest material in the world. It's an excellent conductor. Electrons move through it very quickly, which is something you want to make circuits out of," Schewe said.

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