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November 26, 2013

CHAIR BRUNO NACHTERGAELE
Academic Senate

RE: Request for Comments on the Crocker Nuclear Laboratory 5-Year Review

Dear ^{Bruno}Chair ~~Nachtergaele~~:

An *ad hoc* review committee has completed an in-depth five-year review of the Organized Research Unit (ORU) Crocker Nuclear Laboratory (CNL), following UC Administrative Policies and Procedures concerning ORUs. Enclosed is a copy of the *ad hoc* review committee's report as well as comments on the committee's report by Dean Enrique Lavernia, Interim Dean Alex Navrotsky and Director Anthony Wexler.

I request formal Academic Review of these documents and ask that the report and comments be reviewed by the Committee on Academic Planning and Budget Review, the Committee on Research, the Graduate Council and the Committee on Education Policy. Furthermore, I respectfully request that, if possible, the Academic Senate review be completed by Friday, January 31, 2014.

Thank you in advance for your cooperation.

Sincerely,

A handwritten signature in black ink, appearing to read "Harris A. Lewin".

Harris A. Lewin, Ph.D.
Vice Chancellor for Research

Attachments:

CNL 5-Year *ad hoc* Review Committee Report
Dean Enrique Lavernia's Comments
Interim Dean Alexandra Navrotsky's Comments
Director Anthony Wexler's Comments

/cep

c: Associate Vice Chancellor Paul Dodd
Executive Director Nancy Bulger
Research Program Coordinator Christine Parks

Five-Year Review of the Crocker Nuclear Laboratory

August 28, 2013

Background

The Crocker Nuclear Lab (CNL) is an Organized Research Unit located on the University of California, Davis campus. The laboratory's original activities were based on a 76 inch, variable energy, isochronous cyclotron and dedicated staff. The facility first operated in 1967 with beams of protons, deuterons and alpha particles between four and ninety million electron volts. Early operational funding was almost entirely from the U.S. Atomic Energy Commission (AEC) for basic nuclear science. When the AEC funding terminated in 1971, the researchers at the laboratory established strong applied physics programs and, because of the applied work, a Regents Grant was obtained to continue operation while new applications and sources of support were found. (Note that in 1975, following dissolution of the AEC, the Nuclear Regulatory Commission-NRC- took over its regulatory responsibilities). Funds for nuclear research from the National Science Foundation (NSF), for air pollution studies from the California Air Resources Board (ARB), and NSF, Research Applied to National Needs, and chemistry research from the AEC allowed the accelerator to operate and make important contributions even though the support levels were sharply reduced. The diversification of programs began in the 1970's and continues today. Interdisciplinary programs, utilizing the unique and unusual capabilities of the cyclotron and its staff, support research and teaching programs in the physical, biological, environmental and agricultural sciences.

Crocker Nuclear Laboratory now operates two relatively independent activities. The larger effort is tied to the operation of the National Park Service IMPROVE (Interagency Monitoring of Protected Visual Environments) air quality and visibility program. A smaller effort remains tied to continued operation of the cyclotron. These two activities were originally closely linked, with the cyclotron central to the sample analysis capabilities of the IMPROVE program. However, since 2011, advancements in the IMPROVE sample analysis methodologies have eliminated the need for the cyclotron in the IMPROVE program.

Through the IMPROVE program, CNL operates and maintains an air quality network of approximately 165 sites located in Class 1 (visibility-protected) locations, including many national parks, wilderness areas, and fish and wildlife units throughout the United States. Operations are conducted for a consortium of government agencies, under a contract with the National Park Service in support of statutory monitoring requirements. Automated, filter-based collection systems are located at each of these sites to collect both fine and coarse particles. Twenty-four hr samples are collected every third day. Three channels collect PM_{2.5} (particles with an aerodynamic diameter less than 2.5 μm) for determination of fine particle mass and chemical composition. One channel collects PM₁₀. Teflon filters are analyzed at CNL to determine particle mass gravimetrically and for a broad range of elements using x-ray fluorescence. Nylon filters are sent to the Research Triangle Institute for ion chromatography analysis of sulfate, nitrate, and chloride. Quartz fiber filters are sent to the Desert Research Institute for analysis of organic and elemental carbon by Thermal Optical Reflectance (TOR) analysis. The measured particle composition is used to reconstruct atmospheric visibility. The reconstructed visibility provides states and federal land managers with detailed information on haze and visibility impairment at each location in the network. The measured particle composition provides some information about the types of sources responsible for the haze formation. Ultimately, the IMPROVE network data are the official basis for assessing progress

toward requirements of the Federal Regional Haze Rule, a provision of the Clean Air Act. The Regional Haze Rule defines a path toward achieving natural background visibility conditions later in this century. CNL has operated the IMPROVE network since the network's inception, providing strong visibility for UC Davis within the air quality research, monitoring, and policy communities. Annual funding for the IMPROVE program is currently approximately \$4M/year. This includes a \$3M contract for network operations and a \$1M cooperative agreement to support research related to IMPROVE. Key areas of research include efforts to better define and improve uncertainties associated with network measurements as well as development of new approaches, including aerosol analysis techniques, to expand information about particle composition. The fact that Davis has ownership of both operational and research activities establishes a relatively unique environment in which system needs and applied research activities are very intimately linked.

The cyclotron is operated as a recharge unit with users paying for beam time. The cyclotron currently runs on average one 8-hour shift/day, three days per week. Approximately half of the beam time is used by UCSF for a very successful program of proton beam treatment for uveal melanoma. Approximately 165 uveal melanoma patients/year are treated at the cyclotron with a 96% cure rate. In addition, UCSF and UCD are currently conducting phase-2 clinical trials of proton treatment for macular degeneration, which could open up an entirely new and compelling health-service application. Radiation hardness testing of space electronics using protons accounts for about one third of the beam time. This work is conducted by a mix of commercial companies, defense contractors, national labs, and universities. The remaining beam time is used for a variety of projects in applied nuclear physics, including the production of research quantities of radioisotopes (for DOD and LLNL) and detector testing for high energy physics (UCD and Texas A&M). Over the past 5 years there has been a fairly wide range of cyclotron income from these activities that averages about \$800k/year.

Supporting the IMPROVE and cyclotron programs are Mechanical and Electrical Shops, the Information Technology support group, and Administrative Staff. It should be noted that the shops have special and intimate knowledge of the cyclotron's mechanical/electrical systems, and are essential to keeping the machine operational and functional in an environment where replacements must often be fabricated not purchased. All three support units also support the development and research needs of other units across campus to maximize efficiency. Overall, the CNL is currently nearly financially independent.

Organization of the review

The review of the Crocker Nuclear Laboratory ORU was conducted on site on Tuesday, July 30, 2013. The review committee received a charge from the UCD Vice Chancellor for Research, Harris Lewin, and then heard an overview of the Crocker Nuclear Laboratory from its Director, Professor Anthony Wexler. Presentations were then made by cyclotron and IMPROVE program staff members. The committee did not see or hear presentations from any of the cyclotron users. Tours of both the cyclotron and IMPROVE lab facilities were conducted. The committee met privately with 3 current students (1 graduate, 2 undergraduate) working in the IMPROVE program and separately with several current CNL staff members. At the end of the day, a wrap up session was held with the CNL director. Printed and electronic format materials including

presentation slides, previous reports from CNL, budgetary information, and a publications list were provided to the committee.

Research

Both principal elements of the Crocker Nuclear Lab (the IMPROVE program and the Cyclotron) are doing very important work. The IMPROVE group does an excellent job helping the US NPS and partner agencies meet their mission of monitoring regional haze and documenting visibility trends over time. This group runs an outstanding aerosol monitoring network and conducts valuable research to enhance measurement and data quality. In contrast to most other U.S. national air quality monitoring networks (e.g., the EPA urban Chemical Speciation Network (CSN) or Clean Air Status and Trends Network (CASTNet)), IMPROVE benefits from a substantial, in-house research program conducted at CNL. Recent examples of these research efforts include a reanalysis of archived filters to examine possible changes in reported concentrations due to changes in network methods, a large effort to better characterize measurement uncertainties and detection limits, exploration of the use of FT-IR to non-destructively characterize the organic composition of collected aerosol samples, and the development of new calibration standards to improve the accuracy of XRF analyses of elemental composition. This research effort has helped make IMPROVE a clear leader in implementation of air monitoring techniques that have been exemplars to other networks. A clear indication of this leadership is EPA's recent decision to adopt IMPROVE technology for measurement of fine particle carbon within the CSN. The IMPROVE group has recruited strong leaders and research staff who are currently working to expand their activities. One example is the growth of IMPROVE outside the U.S., including operation of sites in Canada and one site in S. Korea. Current efforts are also underway to position the IMPROVE group to add further network operation or filter analysis capabilities and to offer their XRF capabilities for analytical work outside IMPROVE.

The CNL cyclotron is being used for important medical treatments, including highly successful uveal cancer treatment. A large potential for expansion exists for treatment of large numbers of patients with macular degeneration, if treatment trials are successful. The recent appointment of Dr. Spencer Hartman is a very positive step toward reinvigorating accelerator-based activities at the CNL.

Both the IMPROVE and cyclotron activities are relatively insular from the other academic units and departments of the University in terms of strong and deep research collaborations. Apart from the Director, none of the CNL staff are academic senate members of any department on the UCD campus. The committee did not hear from any outside faculty members regarding collaborative work conducted at CNL.

During the five year review period of 2008-2012, CNL scientists published 20 peer-reviewed papers related to IMPROVE. These publications, in leading air quality journals, attest to the strong quality and impact of IMPROVE-related research. In addition, over 50 peer-reviewed papers were published by scientists in other organizations using IMPROVE data or other information generated by, or in collaboration with, IMPROVE. While the IMPROVE data record is critical to assessing U.S. progress toward meeting requirements of the Regional Haze

Rule, it is also commonly used as a benchmark for evaluating fine particle concentrations and composition measured from satellites or simulated by regional to global scale chemical transport models. Somewhat surprisingly, essentially all scientists exploiting and publishing use of IMPROVE data for such purposes reside outside of UC Davis. Although Davis is known for its strong air quality faculty, none of those outside CNL seem to be making use of information generated through CNL's IMPROVE activities in their research. This suggests that the impact of CNL's IMPROVE work is probably better recognized outside the university, both nationally and internationally, than within. During this same review period, two peer-reviewed papers based upon work done with the cyclotron beam were published by CNL staff and five more papers were published by scientists and engineers from other institutions (almost entirely related to the radiation hardness testing work). The committee did not see any clear evidence of cross disciplinary research at UCD being enabled by the IMPROVE or cyclotron programs.

When Director Wexler assumed leadership of CNL, there were severe financial and personnel issues that required immediate attention and significant focus and effort for correction. Now that Prof. Wexler has completed an admirable (and necessary) job of improving the administrative, organizational and financial constructs for the Lab, the Committee identifies a ripe and timely opportunity to improve the research relevance and impacts of the ORU capabilities through an aggressive campaign focused on outreach and the development of enhanced research opportunities. The IMPROVE program is doing important applied research to enhance the scientific foundations of practical atmospheric monitoring and generating high quality data on atmospheric chemistry, yet few faculty researchers at UC Davis appear to be taking advantage of this unique and important dataset. One can envision strong relevance of the capabilities and data generated in IMPROVE to other scientific investigations, but discussions and awareness need to be seeded. For example, CNL is well positioned to host an annual IMPROVE symposium on campus where scientific improvements, and new and innovative ideas for data exploitation and research collaborations could be defined.

Teaching

Over the past 5 years, 10 undergraduate students, 3 graduate (MS) students and 4 post-doctoral scholars have worked in the IMPROVE program (primarily with Dr. Ann Dillner). In this same time period, two graduate students and 5 undergraduate students participated in cyclotron-based measurements. Cyclotron staff members indicated that students who did make use of the cyclotron usually did so to test a piece of apparatus that would be used on an experiment that would be conducted elsewhere. It was pointed out to the committee that it has been more than 5 years since the last PhD was awarded based on work conducted at the cyclotron. No data were provided to the committee as to what the current professional status is of any of the students who did work at the CNL.

The Committee had the opportunity to meet with three students that have been working within the Lab. These students were very enthusiastic about their work at Crocker and were very appreciative of the opportunity and experience. These students, as well as some of the CNL staff, noted the small number of students currently engaged in the Lab's activities. It would be desirable to see this type of opportunity afforded to a significantly greater number of students. In that regard, a program has recently been approved for a Designated Emphasis in Nuclear Science

on the Davis campus. A Designated Emphasis does not require the same full course load that a Major does, and would allow students to gain some familiarity with accelerators (CNL) and nuclear reactors (McClellan Nuclear Reactor Center, MNRC) by taking laboratory courses at the facilities. This program has the potential to enhance the teaching aspects of both CNL and MNRC. We recommend earliest implementation of this new program. An additional opportunity to both increase student numbers and more actively engage external UCD faculty would be to offer full or partial assistantships to graduate students who would conduct part or all of their thesis or dissertation research at CNL while being co-advised by CNL staff and external UCD faculty. At the undergraduate level, a similar program could be instituted at low cost to support research opportunities for students pursuing undergraduate research.

Impact on Campus

The collective capabilities at the Crocker Lab provide an important set of core capabilities for the campus. Davis has received significant notoriety for the medical work performed with the cyclotron, and the atmospheric monitoring in the IMPROVE program has brought Davis significant positive external recognition, both in the U.S. and abroad. The operational/research team assembled for the IMPROVE program is first rate. They have an admirable approach of striving for continued improvement and sponsor satisfaction in both the operational efficiencies and the scientific quality of their data collection and analysis tasks. The committee feels that CNL lacks significant student involvement at all levels, in part due to the fact that it has almost no external faculty involvement. Consequently, it lacks a strong impact elsewhere at UCD. CNL may be better recognized for its work outside of Davis than internally to the Davis community.

Public Service

The public service contributions of the Crocker Lab are outstanding. The University should take great pride, and significant credit, for the contributions to public health and environmental monitoring executed by this ORU. The importance of the eye cancer treatments to the public health cannot be overstated. If you are one of the many patients this facility has assisted, you would likely have unique appreciation for the expertise and capabilities of the Lab. The long-term successful operation of IMPROVE is a major area of impact for the university in terms of promoting cleaner air and improved visibility in national parks and wilderness areas. The impact and utilization of the IMPROVE data by the external scientific community is extensive and critical to the success of other space-based and model-based air quality initiatives.

Findings and Recommendations

As outlined above, CNL activities clearly demonstrate its importance as a unique resource with strong impact, especially outside campus. Both the IMPROVE program and the cyclotron offer unique capabilities that UCD should nurture and promote. Based on the four review criteria discussed above, however, it is the committee's opinion that the Crocker Nuclear Laboratory does not currently meet the requirements to continue in its current state as an Organized

Research Unit at UC Davis. There are several possible future scenarios we could envisage for the CNL.

One possibility would be to continue both the IMPROVE and cyclotron programs as described above, but change the status of the lab to that of a service or campus research unit that provides air quality measurements/research and cyclotron beam time for external customers (essentially formally acknowledging, and aligning with what they are now doing so well). If this path were to be followed, the committee suggests that the CNL could still benefit from a campaign aimed at improving capability awareness, enhanced research collaborations and enhanced research impact. There is also potential for significant improvement in the educational contribution and impact of the Crocker Lab. The Committee recommends a conscious effort to increase student participation across the spectrum of Lab activities, and to consider strong student participation as part of the research outreach described above. With appropriate focused effort on enhanced research collaboration and student educational engagement, the Crocker Lab can become an even more valuable unit of the University.

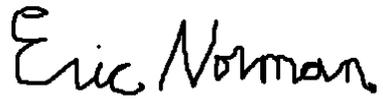
The Lab would benefit substantially from a carefully considered, written strategic plan which outlines the CNL's objectives, necessary collaborations and partnering, and establishes high level milestones and timelines against which to gauge progress. In the Committee's view, this could serve as a yardstick against which there could be an annual discussion of the progress and contributions, as well as identification of any impediments to success, of the CNL. A formally designated advisory committee, with membership from external UCD faculty and experts outside UCD, is also advised, to help promote a more outward-looking focus for CNL activities. Although overstepping the committee's formal purview, the committee recommends that all ORU's, Centers, and similar units also have written strategic plans with milestones and timelines and formally constituted advisory committees. The latter is a current requirement according to UCD ORU policies.

An alternative approach would be to formally recognize the fact that the Cyclotron has become largely disconnected from the programmatic needs of the IMPROVE program as a result of changes in particle analysis methodologies. The only current real connections appear to be common use of shop, IT, and administrative support operations and a common Director. Furthermore, as described above, the staff of the IMPROVE program are currently not well connected with UCD faculty outside CNL who are actively engaged in the broader area of air quality research. While there are certainly interactions, they do not commonly extend to joint research or advising efforts. One path forward would thus be to combine IMPROVE program activities with those of the Air Quality Research Center ORU (of which Professor Wexler is also the director). In the committee's view, this would make logical sense and over the longer term could enhance contact and collaborations between the IMPROVE program staff and the broader air quality community at UCD and elsewhere. In the long term, moving the IMPROVE program to better facilities outside the current building would also provide them with better space for their important work (the committee noted the poor quality of much of the space in the current

building) and increase the ability of casual visitors to drop in without the current admission requirements (driven by the cyclotron) which likely deter some potential campus interactions. The ease of communication between the electronics and mechanical staff and that of the IMPROVE staff can be of benefit to the design of the IMPROVE instruments and it should continue.

Continuing along this path, it would appear to be a good time to review organizational structures and assess whether the Cyclotron would have more synergy and better alignment with the McClellan Nuclear Research Center. These two entities are, at their core, nuclear science and engineering facilities. The IMPROVE program is not nuclear science and no longer requires the cyclotron for its mission. Radioisotope production, radiation hardness testing, and elemental analysis are all activities that can and are being done at both of these facilities. A coordinated program to exploit the unique capabilities of both the Crocker cyclotron and the McClellan reactor could form the basis of a new ORU or center and, with appropriate emphasis, attract more interest in collaboration and research investment from the UC-affiliated National Labs (Berkeley and Livermore) Such a combined nuclear unit would benefit greatly from a leader with expertise and deep connections in the nuclear community, who could conduct collaborative outreach to related institutions, and who could effectively oversee and manage a diverse nuclear program of research, teaching, and service utilizing these facilities.

Report respectfully submitted by:



August 28, 2013

Eric Norman, Chair

Date



August 28, 2013

Jeffrey Collett

Date



August 28, 2013

Richard Lander

Date



August 28, 2013

David McCallen

Date



August 28, 2013

Kyaw Tha Paw U

Date



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October 25, 2013

Harris Lewin
Vice Chancellor for Research

and

Faculty Senate Committees

Re: Crocker Nuclear Laboratory 5 Year Review

Dear Dr. Lewin and Members of Faculty Senate Committees,

Thank you and your staff for organizing the 5 year ORU review of Crocker Nuclear Laboratory and choosing an excellent panel of reviewers. On the following pages, we address the recommendations of the review committee. There are three documents relevant to this review:

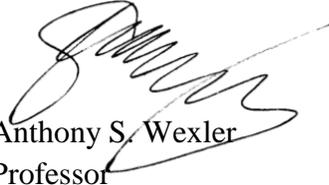
Crocker Nuclear Laboratory Self-Study Review. This report was written by CNL and submitted to the office of research and the external review committee. We refer to this in what follows as the **Self Study Review**.

Crocker Nuclear Laboratory Review Committee Report. This report was developed by a review committee constituted by the Office of Research and composed of both UCD senate faculty and faculty from other universities. The committee read the Self Study Review and visited to CNL on July 30, 2013 to tour the facilities, ask questions of CNL staff, and hear formal presentations summarizing the Self Study Review. This report is referred to as the **Review Committee Report**. To facilitate our response to this report, we numbered the pages and highlighted sections that we address in our response, enclosed here.

Crocker Nuclear Laboratory Response to the Review Committee Report. This report is included on the following pages and is our response to the Review Committee Report.

If you or the senate review committees need any additional information, please let me know.

Sincerely,

A handwritten signature in black ink, appearing to read 'Anthony S. Wexler', written over a horizontal line.

Anthony S. Wexler
Professor

Mechanical and Aerospace Engineering
Civil and Environmental Engineering
Land, Air and Water Resources

Director

Air Quality Research Center
Crocker Nuclear Laboratory

Crocker Nuclear Laboratory (CNL)
Response to 5-Year ORU Review Committee Report dated August 28, 2013

In this response, we refer to the page number of the review report and sections containing each comment that we address. The review committee's report did not contain page numbers or highlights. We have added these to the attached version to facilitate reference.

Pages 4 to 5 – Research. We agree with the first observation, “Both the IMPROVE and cyclotron activities are relatively insular from the other academic units ...” but, the context is important. CNL has two major operations – the cyclotron and the National Parks Service IMPROVE program – that are in turn served by other units within CNL. The cyclotron no longer produces particle beams that are cutting edge in terms of fundamental physics research. The cyclotron is now used primarily for treating eye cancer patients in collaboration with UCSF and UCDCM and for testing electronic components use in space for the US government and the aerospace industry. The IMPROVE program operates the IMPROVE network for the National Parks Service measuring air pollutants related to visibility in national parks and other public lands with sensitive view sheds. So both the cyclotron and the IMPROVE program are service operations not research or teaching operations. In prior years, the cyclotron had more student involvement when it was more research relevant. Currently, most student involvement is from students at other universities working on electronics that will be launched into space. We have approached the Electrical and Computer Engineering department about collaborations in this area but they do not work in the area of space electronics. The IMPROVE program used to have post-doctoral fellows and graduate students but as with most government programs, especially environmental ones, the funding has been reduced lately leading to lay-offs from the group and severely reduced funding for graduate students. These federal funding reductions coincided with nearly complete loss of funding from the university such that now CNL is almost completely self-supporting. With these budget cuts, we have been forced to focus intently on service activities supported by our paying customers at the expense of teaching and research activities that we would like to also engage in. Incidentally, ORUs are not permitted to hire senate faculty. Currently, senate faculty must have departmental appointments.

As stated in the Self-Study Review, when Dr. Wexler became director of CNL there were a range of personnel and financial difficulties that needed to be resolved all coinciding with severe reductions in federal and campus funding. Dr. Wexler became director in July 2009 and it took about 3 years to deal with these difficulties. As a result, starting in July 2012, CNL was able to start strategic planning for future growth and greater connection to campus. We have one research project with UCDCM and UCSF – a clinical trial on using the proton beam to treat wet macular degeneration. We have submitted a proposal to the Air Force to roughly double the amount of time that the cyclotron is used for electronics testing. We have started discussions with Radiation Oncology at UCDCM and UCSF to add a linear accelerator to the cyclotron for cancer proton therapy. Either of these two activities may generate enough income to allow support of

students interested in work on radiation physics and medicine. We are also planning proposals to the EPA to substantially expand our research and service activities related to air quality. These additional funds may also enable funding of graduate students and post-doctoral fellows.

Regarding “Although Davis is known for its strong air quality faculty, ...” and “the committee identifies a ripe and timely opportunity ...”: Many scientists use IMPROVE data for their air quality and climate change research. All IMPROVE data are published on NPS and EPA web sites for all to use. The Self-Study Review lists publications that use IMPROVE data. As discussed in the Review Committee Report, UC Davis faculty have not been using these data for their research. The areas of research pursued by faculty is a matter of taste and expertise, so it is not clear to us that an outreach program within UC Davis will help in this matter. The key scientists in the IMPROVE program are also members of the Air Quality Research Center and regularly interact with senate faculty on campus and participate in graduate group activities, so the relevant faculty on campus are aware of the IMPROVE program and the data that we generate.

Regarding “CNL is well positioned to host ...”: We agree that hosting an IMPROVE symposium would help get the word out on IMPROVE data availability, its use, and related uncertainties, and it would also raise the profile of UC Davis. We have been in discussion about holding such meetings or webinars and will continue to work on the best way to communicate this information to stakeholders.

In summary, we generally agree with the sense of these observations. Unfortunately, CNL is financially constrained on what it can do to engage faculty and graduate students in research. If some current funding opportunities come to fruition, we hope to be able to support graduate students and post-docs more in the future. Faculty engagement depends more on faculty needing to use the resources that CNL can provide, so is somewhat out of our control.

Page 5 to 6 – Teaching. Some of these issues were addressed in our response above. To summarize, CNL has nearly zero campus support and federal funding has been substantially reduced so current income to the IMPROVE program and cyclotron must be used exclusively to support these programs – funds for graduate student and post-doc support are very limited. We are working on a range of new funding opportunities to increase participation of students, post-docs and faculty in CNL, but we are dependent on those funds or other additional financial resources to increase teaching engagement in CNL. Regarding the Designated Emphasis in Nuclear Science (DENS), the graduate laboratory class for this DE recently used the cyclotron for a day to measure the Bragg peak. This course is expected to be offered annually and we are enthusiastic about supporting it in the future. If CNL is able to obtain a linear accelerator, a higher energy beam could be produced that would increase the range of educational experiences for students in DENS.

Page 6 – Impact on Campus. Again, we have addressed this point in the discussions above. We agree with this assessment and we are working within our financial constraints to remedy the relative lack of student and faculty involvement. We disagree with the linking of external faculty involvement to student involvement. Before federal budget cuts, we had a number of students in CNL mentored by CNL federation faculty and we would like to re-invigorate this if/when sufficient funding arrives in the future.

Page 6 to 8 – Findings and Recommendations. We agree that CNL does not currently meet the UC requirements for ORU designation. CNL may fit better under another designation.

We also agree that an external advisory committee comprising membership within and outside of UC Davis would increase connections to campus and other institutions, and help with planning future directions.

The committee recommended that the IMPROVE program be moved from CNL to AQRC. We disagree with this recommendation. A stated benefit, which we agree with, is that it makes logical sense. A stated benefit, which we disagree with, is that it would increase connections to other air quality faculty on campus. As stated above, key air quality scientists in CNL are already members of AQRC and this was the case before Dr. Wexler became director of CNL. The barrier to collaboration are due to funding – funding in IMPROVE is related to operating the network, a service, and is not funded to do the kind of research that senate faculty would like to engage in. The primary problem with moving IMPROVE to AQRC is that it would be huge disruption to operations for both units without substantial benefit to either. Such a major disruption would impede current ventures to grow both the cyclotron and air quality activities at a time when these opportunities are ripe.

The committee recommended a possible reorganization to better align the cyclotron activities with the MNRC activities. Again, moving the cyclotron and reactor into one unit would be a substantial disruption in operations for the cyclotron at a time when major growth opportunities are in flux. Such a disruption would severely impede the cyclotron unit's progress and growth. We would welcome suggestions for a “softer” alignment that would not disrupt cyclotron operations.

Five-Year Review of the Crocker Nuclear Laboratory

August 28, 2013

Background

The Crocker Nuclear Lab (CNL) is an Organized Research Unit located on the University of California, Davis campus. The laboratory's original activities were based on a 76 inch, variable energy, isochronous cyclotron and dedicated staff. The facility first operated in 1967 with beams of protons, deuterons and alpha particles between four and ninety million electron volts. Early operational funding was almost entirely from the U.S. Atomic Energy Commission (AEC) for basic nuclear science. When the AEC funding terminated in 1971, the researchers at the laboratory established strong applied physics programs and, because of the applied work, a Regents Grant was obtained to continue operation while new applications and sources of support were found. (Note that in 1975, following dissolution of the AEC, the Nuclear Regulatory Commission-NRC- took over its regulatory responsibilities). Funds for nuclear research from the National Science Foundation (NSF), for air pollution studies from the California Air Resources Board (ARB), and NSF, Research Applied to National Needs, and chemistry research from the AEC allowed the accelerator to operate and make important contributions even though the support levels were sharply reduced. The diversification of programs began in the 1970's and continues today. Interdisciplinary programs, utilizing the unique and unusual capabilities of the cyclotron and its staff, support research and teaching programs in the physical, biological, environmental and agricultural sciences.

Crocker Nuclear Laboratory now operates two relatively independent activities. The larger effort is tied to the operation of the National Park Service IMPROVE (Interagency Monitoring of Protected Visual Environments) air quality and visibility program. A smaller effort remains tied to continued operation of the cyclotron. These two activities were originally closely linked, with the cyclotron central to the sample analysis capabilities of the IMPROVE program. However, since 2011, advancements in the IMPROVE sample analysis methodologies have eliminated the need for the cyclotron in the IMPROVE program.

Through the IMPROVE program, CNL operates and maintains an air quality network of approximately 165 sites located in Class 1 (visibility-protected) locations, including many national parks, wilderness areas, and fish and wildlife units throughout the United States. Operations are conducted for a consortium of government agencies, under a contract with the National Park Service in support of statutory monitoring requirements. Automated, filter-based collection systems are located at each of these sites to collect both fine and coarse particles. Twenty-four hr samples are collected every third day. Three channels collect PM_{2.5} (particles with an aerodynamic diameter less than 2.5 μm) for determination of fine particle mass and chemical composition. One channel collects PM₁₀. Teflon filters are analyzed at CNL to determine particle mass gravimetrically and for a broad range of elements using x-ray fluorescence. Nylon filters are sent to the Research Triangle Institute for ion chromatography analysis of sulfate, nitrate, and chloride. Quartz fiber filters are sent to the Desert Research Institute for analysis of organic and elemental carbon by Thermal Optical Reflectance (TOR) analysis. The measured particle composition is used to reconstruct atmospheric visibility. The reconstructed visibility provides states and federal land managers with detailed information on haze and visibility impairment at each location in the network. The measured particle composition provides some information about the types of sources responsible for the haze formation. Ultimately, the IMPROVE network data are the official basis for assessing progress

toward requirements of the Federal Regional Haze Rule, a provision of the Clean Air Act. The Regional Haze Rule defines a path toward achieving natural background visibility conditions later in this century. CNL has operated the IMPROVE network since the network's inception, providing strong visibility for UC Davis within the air quality research, monitoring, and policy communities. Annual funding for the IMPROVE program is currently approximately \$4M/year. This includes a \$3M contract for network operations and a \$1M cooperative agreement to support research related to IMPROVE. Key areas of research include efforts to better define and improve uncertainties associated with network measurements as well as development of new approaches, including aerosol analysis techniques, to expand information about particle composition. The fact that Davis has ownership of both operational and research activities establishes a relatively unique environment in which system needs and applied research activities are very intimately linked.

The cyclotron is operated as a recharge unit with users paying for beam time. The cyclotron currently runs on average one 8-hour shift/day, three days per week. Approximately half of the beam time is used by UCSF for a very successful program of proton beam treatment for uveal melanoma. Approximately 165 uveal melanoma patients/year are treated at the cyclotron with a 96% cure rate. In addition, UCSF and UCD are currently conducting phase-2 clinical trials of proton treatment for macular degeneration, which could open up an entirely new and compelling health-service application. Radiation hardness testing of space electronics using protons accounts for about one third of the beam time. This work is conducted by a mix of commercial companies, defense contractors, national labs, and universities. The remaining beam time is used for a variety of projects in applied nuclear physics, including the production of research quantities of radioisotopes (for DOD and LLNL) and detector testing for high energy physics (UCD and Texas A&M). Over the past 5 years there has been a fairly wide range of cyclotron income from these activities that averages about \$800k/year.

Supporting the IMPROVE and cyclotron programs are Mechanical and Electrical Shops, the Information Technology support group, and Administrative Staff. It should be noted that the shops have special and intimate knowledge of the cyclotron's mechanical/electrical systems, and are essential to keeping the machine operational and functional in an environment where replacements must often be fabricated not purchased. All three support units also support the development and research needs of other units across campus to maximize efficiency. Overall, the CNL is currently nearly financially independent.

Organization of the review

The review of the Crocker Nuclear Laboratory ORU was conducted on site on Tuesday, July 30, 2013. The review committee received a charge from the UCD Vice Chancellor for Research, Harris Lewin, and then heard an overview of the Crocker Nuclear Laboratory from its Director, Professor Anthony Wexler. Presentations were then made by cyclotron and IMPROVE program staff members. The committee did not see or hear presentations from any of the cyclotron users. Tours of both the cyclotron and IMPROVE lab facilities were conducted. The committee met privately with 3 current students (1 graduate, 2 undergraduate) working in the IMPROVE program and separately with several current CNL staff members. At the end of the day, a wrap up session was held with the CNL director. Printed and electronic format materials including

presentation slides, previous reports from CNL, budgetary information, and a publications list were provided to the committee.

Research

Both principal elements of the Crocker Nuclear Lab (the IMPROVE program and the Cyclotron) are doing very important work. The IMPROVE group does an excellent job helping the US NPS and partner agencies meet their mission of monitoring regional haze and documenting visibility trends over time. This group runs an outstanding aerosol monitoring network and conducts valuable research to enhance measurement and data quality. In contrast to most other U.S. national air quality monitoring networks (e.g., the EPA urban Chemical Speciation Network (CSN) or Clean Air Status and Trends Network (CASTNet)), IMPROVE benefits from a substantial, in-house research program conducted at CNL. Recent examples of these research efforts include a reanalysis of archived filters to examine possible changes in reported concentrations due to changes in network methods, a large effort to better characterize measurement uncertainties and detection limits, exploration of the use of FT-IR to non-destructively characterize the organic composition of collected aerosol samples, and the development of new calibration standards to improve the accuracy of XRF analyses of elemental composition. This research effort has helped make IMPROVE a clear leader in implementation of air monitoring techniques that have been exemplars to other networks. A clear indication of this leadership is EPA's recent decision to adopt IMPROVE technology for measurement of fine particle carbon within the CSN. The IMPROVE group has recruited strong leaders and research staff who are currently working to expand their activities. One example is the growth of IMPROVE outside the U.S., including operation of sites in Canada and one site in S. Korea. Current efforts are also underway to position the IMPROVE group to add further network operation or filter analysis capabilities and to offer their XRF capabilities for analytical work outside IMPROVE.

The CNL cyclotron is being used for important medical treatments, including highly successful uveal cancer treatment. A large potential for expansion exists for treatment of large numbers of patients with macular degeneration, if treatment trials are successful. The recent appointment of Dr. Spencer Hartman is a very positive step toward reinvigorating accelerator-based activities at the CNL.

Both the IMPROVE and cyclotron activities are relatively insular from the other academic units and departments of the University in terms of strong and deep research collaborations. Apart from the Director, none of the CNL staff are academic senate members of any department on the UCD campus. The committee did not hear from any outside faculty members regarding collaborative work conducted at CNL.

During the five year review period of 2008-2012, CNL scientists published 20 peer-reviewed papers related to IMPROVE. These publications, in leading air quality journals, attest to the strong quality and impact of IMPROVE-related research. In addition, over 50 peer-reviewed papers were published by scientists in other organizations using IMPROVE data or other information generated by, or in collaboration with, IMPROVE. While the IMPROVE data record is critical to assessing U.S. progress toward meeting requirements of the Regional Haze

Rule, it is also commonly used as a benchmark for evaluating fine particle concentrations and composition measured from satellites or simulated by regional to global scale chemical transport models. Somewhat surprisingly, essentially all scientists exploiting and publishing use of IMPROVE data for such purposes reside outside of UC Davis. Although Davis is known for its strong air quality faculty, none of those outside CNL seem to be making use of information generated through CNL's IMPROVE activities in their research. This suggests that the impact of CNL's IMPROVE work is probably better recognized outside the university, both nationally and internationally, than within. During this same review period, two peer-reviewed papers based upon work done with the cyclotron beam were published by CNL staff and five more papers were published by scientists and engineers from other institutions (almost entirely related to the radiation hardness testing work). The committee did not see any clear evidence of cross disciplinary research at UCD being enabled by the IMPROVE or cyclotron programs.

When Director Wexler assumed leadership of CNL, there were severe financial and personnel issues that required immediate attention and significant focus and effort for correction. Now that Prof. Wexler has completed an admirable (and necessary) job of improving the administrative, organizational and financial constructs for the Lab, the Committee identifies a ripe and timely opportunity to improve the research relevance and impacts of the ORU capabilities through an aggressive campaign focused on outreach and the development of enhanced research opportunities. The IMPROVE program is doing important applied research to enhance the scientific foundations of practical atmospheric monitoring and generating high quality data on atmospheric chemistry, yet few faculty researchers at UC Davis appear to be taking advantage of this unique and important dataset. One can envision strong relevance of the capabilities and data generated in IMPROVE to other scientific investigations, but discussions and awareness need to be seeded. For example, CNL is well positioned to host an annual IMPROVE symposium on campus where scientific improvements, and new and innovative ideas for data exploitation and research collaborations could be defined.

Teaching

Over the past 5 years, 10 undergraduate students, 3 graduate (MS) students and 4 post-doctoral scholars have worked in the IMPROVE program (primarily with Dr. Ann Dillner). In this same time period, two graduate students and 5 undergraduate students participated in cyclotron-based measurements. Cyclotron staff members indicated that students who did make use of the cyclotron usually did so to test a piece of apparatus that would be used on an experiment that would be conducted elsewhere. It was pointed out to the committee that it has been more than 5 years since the last PhD was awarded based on work conducted at the cyclotron. No data were provided to the committee as to what the current professional status is of any of the students who did work at the CNL.

The Committee had the opportunity to meet with three students that have been working within the Lab. These students were very enthusiastic about their work at Crocker and were very appreciative of the opportunity and experience. These students, as well as some of the CNL staff, noted the small number of students currently engaged in the Lab's activities. It would be desirable to see this type of opportunity afforded to a significantly greater number of students. In that regard, a program has recently been approved for a Designated Emphasis in Nuclear Science

on the Davis campus. A Designated Emphasis does not require the same full course load that a Major does, and would allow students to gain some familiarity with accelerators (CNL) and nuclear reactors (McClellan Nuclear Reactor Center, MNRC) by taking laboratory courses at the facilities. This program has the potential to enhance the teaching aspects of both CNL and MNRC. We recommend earliest implementation of this new program. An additional opportunity to both increase student numbers and more actively engage external UCD faculty would be to offer full or partial assistantships to graduate students who would conduct part or all of their thesis or dissertation research at CNL while being co-advised by CNL staff and external UCD faculty. At the undergraduate level, a similar program could be instituted at low cost to support research opportunities for students pursuing undergraduate research.

Impact on Campus

The collective capabilities at the Crocker Lab provide an important set of core capabilities for the campus. Davis has received significant notoriety for the medical work performed with the cyclotron, and the atmospheric monitoring in the IMPROVE program has brought Davis significant positive external recognition, both in the U.S. and abroad. The operational/research team assembled for the IMPROVE program is first rate. They have an admirable approach of striving for continued improvement and sponsor satisfaction in both the operational efficiencies and the scientific quality of their data collection and analysis tasks. The committee feels that CNL lacks significant student involvement at all levels, in part due to the fact that it has almost no external faculty involvement. Consequently, it lacks a strong impact elsewhere at UCD. CNL may be better recognized for its work outside of Davis than internally to the Davis community.

Public Service

The public service contributions of the Crocker Lab are outstanding. The University should take great pride, and significant credit, for the contributions to public health and environmental monitoring executed by this ORU. The importance of the eye cancer treatments to the public health cannot be overstated. If you are one of the many patients this facility has assisted, you would likely have unique appreciation for the expertise and capabilities of the Lab. The long-term successful operation of IMPROVE is a major area of impact for the university in terms of promoting cleaner air and improved visibility in national parks and wilderness areas. The impact and utilization of the IMPROVE data by the external scientific community is extensive and critical to the success of other space-based and model-based air quality initiatives.

Findings and Recommendations

As outlined above, CNL activities clearly demonstrate its importance as a unique resource with strong impact, especially outside campus. Both the IMPROVE program and the cyclotron offer unique capabilities that UCD should nurture and promote. Based on the four review criteria discussed above, however, it is the committee's opinion that the Crocker Nuclear Laboratory does not currently meet the requirements to continue in its current state as an Organized

Research Unit at UC Davis. There are several possible future scenarios we could envisage for the CNL.

One possibility would be to continue both the IMPROVE and cyclotron programs as described above, but change the status of the lab to that of a service or campus research unit that provides air quality measurements/research and cyclotron beam time for external customers (essentially formally acknowledging, and aligning with what they are now doing so well). If this path were to be followed, the committee suggests that the CNL could still benefit from a campaign aimed at improving capability awareness, enhanced research collaborations and enhanced research impact. There is also potential for significant improvement in the educational contribution and impact of the Crocker Lab. The Committee recommends a conscious effort to increase student participation across the spectrum of Lab activities, and to consider strong student participation as part of the research outreach described above. With appropriate focused effort on enhanced research collaboration and student educational engagement, the Crocker Lab can become an even more valuable unit of the University.

The Lab would benefit substantially from a carefully considered, written strategic plan which outlines the CNL's objectives, necessary collaborations and partnering, and establishes high level milestones and timelines against which to gauge progress. In the Committee's view, this could serve as a yardstick against which there could be an annual discussion of the progress and contributions, as well as identification of any impediments to success, of the CNL. **A formally designated advisory committee, with membership from external UCD faculty and experts outside UCD, is also advised, to help promote a more outward-looking focus for CNL activities.**

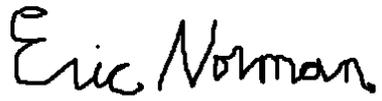
Although overstepping the committee's formal purview, the committee recommends that all ORU's, Centers, and similar units also have written strategic plans with milestones and timelines and formally constituted advisory committees. The latter is a current requirement according to UCD ORU policies.

An alternative approach would be to formally recognize the fact that the Cyclotron has become largely disconnected from the programmatic needs of the IMPROVE program as a result of changes in particle analysis methodologies. The only current real connections appear to be common use of shop, IT, and administrative support operations and a common Director. Furthermore, as described above, the staff of the IMPROVE program are currently not well connected with UCD faculty outside CNL who are actively engaged in the broader area of air quality research. While there are certainly interactions, they do not commonly extend to joint research or advising efforts. **One path forward would thus be to combine IMPROVE program activities with those of the Air Quality Research Center ORU (of which Professor Wexler is also the director). In the committee's view, this would make logical sense and over the longer term could enhance contact and collaborations between the IMPROVE program staff and the broader air quality community at UCD and elsewhere. In the long term, moving the IMPROVE program to better facilities outside the current building would also provide them with better space for their important work (the committee noted the poor quality of much of the space in the current**

building) and increase the ability of casual visitors to drop in without the current admission requirements (driven by the cyclotron) which likely deter some potential campus interactions. The ease of communication between the electronics and mechanical staff and that of the IMPROVE staff can be of benefit to the design of the IMPROVE instruments and it should continue.

Continuing along this path, it would appear to be a good time **to review organizational structures and assess whether the Cyclotron would have more synergy and better alignment with the McClellan Nuclear Research Center.** These two entities are, at their core, nuclear science and engineering facilities. The IMPROVE program is not nuclear science and no longer requires the cyclotron for its mission. Radioisotope production, radiation hardness testing, and elemental analysis are all activities that can and are being done at both of these facilities. A coordinated program to exploit the unique capabilities of both the Crocker cyclotron and the McClellan reactor could form the basis of a new ORU or center and, with appropriate emphasis, attract more interest in collaboration and research investment from the UC-affiliated National Labs (Berkeley and Livermore) Such a combined nuclear unit would benefit greatly from a leader with expertise and deep connections in the nuclear community, who could conduct collaborative outreach to related institutions, and who could effectively oversee and manage a diverse nuclear program of research, teaching, and service utilizing these facilities.

Report respectfully submitted by:



August 28, 2013

Eric Norman, Chair

Date



August 28, 2013

Jeffrey Collett

Date



August 28, 2013

Richard Lander

Date



August 28, 2013

David McCallen

Date



August 28, 2013

Kyaw Tha Paw U

Date

Christine Parks

From: Enrique J. Lavernia
Sent: Friday, October 25, 2013 1:27 PM
To: Harris A Lewin
Cc: Paul Dodd; Nancy A Bulger; Christine Parks; Perry King
Subject: RE: CNL Request for Comments

Dear Harris,

I am pleased to comment on the recent five-year review of the Crocker Nuclear Laboratory (CNL). I agree with the review team's observations that CNL is an excellent campus resource that is well recognized by external researchers and agencies for both its outstanding air quality and visibility program and activities related to the cyclotron use. However, I also acknowledge and agree with the reviewers that the resources in the CNL are not used to their full extent by faculty and students on campus. Increased collaboration with campus users is necessary and this is an appropriate goal for CNL. I encourage the Office of Research to work with Director Wexler to become more aware of the capabilities housed in CNL and promote them on campus.

As the team noted, Professor Wexler has spent a significant amount of his time addressing financial and personnel issues during his first few years in the position. In my opinion, based on strategic changes in personnel and entrepreneurial activities within the last year, Prof. Wexler has positioned CNL for increased visibility and impact both on and off campus. Development of a strategic plan that includes measureable outcomes would be a valuable activity for all involved in the unit.

The review team provided suggestions for increasing CNL's connection with the campus that could involve major changes in the organization of the unit. While I recognize that the existing structural organization might seem disjointed, discussion with the current director on his vision and the how the unit's productivity would be impacted by restructuring is warranted.

Thank you for soliciting my comments and please let me know if you have any questions.

Best regards,

Enrique

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From: Perry King
Sent: Thursday, October 10, 2013 8:22 AM
To: Enrique J. Lavernia
Cc: Paul Dodd; Nancy A Bulger; Christine Parks
Subject: CNL Request for Comments

Dean Lavernia, attached is a formal request for comments from Vice Chancellor Lewin on the Crocker Nuclear Laboratory 5-Year Review. Please send your comments and feedback to VC Lewin by **Friday, October 25, 2013**. Thank you.

Perry King

Executive Analyst for
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Christine Parks

From: Perry King
Sent: Friday, October 11, 2013 3:02 PM
To: Harris A Lewin; Paul Dodd; Nancy A Bulger; Christine Parks
Subject: FW: CNL Request for Comments

Please see below.

Perry King
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From: Cristyn Elizabeth Gunther
Sent: Friday, October 11, 2013 1:56 PM
To: Perry King
Subject: RE: CNL Request for Comments

Hi Perry,

Here are Interim Dean Navrotsky's comments on the CNL Review:

This is a thoughtful and thorough review. Tony Wexler has been doing an excellent job leading Crocker. To me it would make sense to separate the two disparate activities, putting IMPROVE together with Tony's air quality efforts and Crocker together with McClellan (and finding a dynamic leader for that combined nuclear effort).

Let me know if you need anything else.

Sincerely,
Cristyn Gunther

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From: Alexandra Navrotsky (DEAN)
Sent: Thursday, October 10, 2013 10:12 AM
To: MPS Executive Assistant
Subject: FW: CNL Request for Comments

Print attachment

From: Perry King
Sent: Thursday, October 10, 2013 8:23 AM
To: Alexandra Navrotsky (DEAN)
Cc: Paul Dodd; Nancy A Bulger; Christine Parks; Harris A Lewin
Subject: CNL Request for Comments

Interim Dean Navrotsky, attached is a formal request for comments from Vice Chancellor Lewin on the Crocker Nuclear Laboratory 5-Year Review. Please send your comments and feedback to VC Lewin by **Friday, October 25, 2013**. Thank you.

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