Report of the
Health Sciences Campus Long Range (10 year)
Animal Facility Planning Committee

March 25, 2012

1. Overview and Charge of the Committee

The Long Range Animal Facilities Planning Committee for the Health Sciences Campus (HSC) was formed in October, 2011 by Vice President for Research Randolph Hall to examine future directions and planning for animal research facilities during the next 5 to 10 year period. The impetus for this committee arose from several factors:

- Concerns from faculty members, department chairs, institute directors, and research administrators on the HSC that the lack of adequate animal facility housing and procedure spaces were impeding existing research programs and limiting faculty recruitment due to capacity restrictions. This concern was repeated and confirmed in faculty surveys conducted in late 2010 and 2011.
- USC published its master plan for the Health Sciences Campus in 2011. In this overall campus plan, two factors were of concern relative to animal housing space: 1) The campus master plan recommended a significant expansion of research laboratory space, and 2) The plan showed several existing buildings that contain animal facilities as demolished and replaced over the next 10 to 20 years
- A previous Animal Facility Master Plan was written by an external consultant in 2002 and projected needs for 10 years. However, elements of this plan, including construction of some new animal research space, were not implemented on the HSC It was recommended by Dr. Donald Casebolt, Director of Animal Resources, that USC revisit the plan in the context of the other concerns regarding animal facility space and usage.

The committee included the following members:

- Randolph W. Hall, Vice President for Research
- Roberta Brinton, Professor
  Department of Pharmacology and Pharmaceutical Sciences
- Donald B. Casebolt, Director
  Department of Animal Resources
- Robert Maxson, Professor
  Department of Biochemistry and Molecular Biology
- Alapakkam Sampath, Associate Professor
  Department of Physiology and Biophysics
- Laurie Stone, Executive Director of Land Use and Planning
  University Real Estate
- Henry Sucov, Associate Professor
  Departments of Cell and Neurobiology and Biochemistry and Molecular Biology
- James Weiland, Associate Professor
  Department of Ophthalmology
- Leslie Weiner, Professor
  Department of Neurology
- Margarita Zeichner-David, Research Professor
  Department of Biomedical Sciences & Center for Craniofacial Molecular Biology

The following were factors considered as part of the committee discussions. As general attributes, animal research facilities must:

- Provide an optimal environment for animal care.
- Provide a safe working environment for research and animal care staff.
- Prevent catastrophic research losses in case of disaster
- Maximize research quality.
- Maximize research productivity.
- Maximize operational efficiency and adaptability
- Control costs
- Accommodate future growth in research programs and recruitment

2. Animal Facility Summaries and Recommendations

The total amount of animal research space on the Health Sciences Campus is 39,154 net square feet (NSF). Of this space, facilities in HMR, CSC, MMR, and PSC may be eliminated at some point in the future as part of the HSC master plan. These facilities total 18,322 NSF. The committee discussed this large amount of potentially lost space as a concern. In addition, certain actions such as strategic renovations of existing facilities were discussed in the context of which facilities are most likely to be eliminated during the next ten years and beyond, to provide adequate housing space during the interim period.

This section describes the current status of animal research facilities on the Health Sciences Campus including net square feet of animal housing and support space, and positive and negative attributes of each facility. Under each facility description, recommendations are made.

2.1 Condition of Existing Spaces and Recommendations

Hoffman Medical Research (HMR) contains 6,766 NSF of animal housing and 6,488NSF of support spaces (13,245 total NSF). Animals housed include Mice (1,866 cages); Rats (154); Guinea Pigs (31); Rabbits (31); Dogs (14); Swine (12); and Chickens (75).

Positive attributes of HMR include the basement large animal and procedure area that was renovated in 2004-2005, which includes modern housing for dogs and swine, surgery, and procedure rooms.

Negative attributes are that the tower facility and freight elevator are inefficient and impossible to sanitize or separate clean and dirty materials; there are no procedure room spaces for rodents available; the cage washing facility is not designed for rodent cage handling and the 2002 Master Plan called for no rodent housing in HMR; automatic watering is available only in some areas of the tower; ventilated caging is used in some rooms, but without direct exhaust leading to odor problems; and partial emergency backup power only to exhaust fans, not to supply air systems or heating/air conditioning. In addition, the facility is not equipped with an automated environmental control, monitoring, and alarm system.

HMR Recommendations: The status of HMR in the HSC Master Plan is that it will eventually be demolished and replaced with a research and education building. However, because the building may remain for at least ten years, the committee discussed options to keep the building in operation during this time frame. It is recommended that HMR be provided with full emergency backup power and automated environmental monitoring and control. In addition, due to constraints on efficiency and sanitation resulting from the freight elevator and cage wash area, the majority of the rodent census in HMR should be moved to RB3 once it opens. Some smaller amount of rodent capacity may remain for faculty located in HMR and PSC.

The Department of Animal Resources is vacating office spaces on the first and second floor of HMR during February 2012. The rooms within the animal facility tower have been determined to be within the animal facility ventilation system. Because HVAC is usually the most expensive mechanical system to construct in an animal facility, it should be relatively inexpensive to convert these spaces back to animal housing and procedure spaces. It should be noted that the amount of space is small (1,020 NSF) but will contribute to the overall capacity for animal housing and procedure space.

The renovations would consist of the following:

- Replacement of flooring materials throughout (including elevator vestibules) with epoxy aggregate flooring.
- Replacement of wooden doors with metal doors.
- Reopening floor existing drains in HMR 214.
- Placing a hand washing sink in the central areas of HMR 214.
- Repainting walls and ceilings with epoxy-based paint.
- Installation of light timers for each room.
- Installation of automatic watering.

Cost estimates are currently under development and it is anticipated that the work can be accomplished during 2012.

Mudd Memorial Research (MMR) contains 1,501 NSF of animal housing and 1,304 NSF of support space (2,805 total NSF). Animals housed include mice (535 cages); and rats (50).

There are no positive attributes of MMR. Negative attributes are that the facility is very small and houses a small number of rodents in standard caging; the cage washing facility is not designed for rodent cage handling and does not allow for separation of clean and dirty materials; automatic watering is not available; there is no individual temperature control of rooms; and there is no emergency backup power to environmental systems. In addition, the facility is not equipped with an automated environmental control, monitoring, and alarm system. The 2002 Master Plan called for closure of this facility.

MMR Recommendations: The status of MMR in the HSC Master Plan is that it is demolished and replaced with a research and education building. The committee recommends closure of this facility as soon as RB3 opens and replacement space is available.

Doheny Eye Foundation (DOH) contains 2,780 NSF of animal housing and 2,966 NSF of support space (5,746 total NSF). Animals housed include mice (734 cages); rats (308); rabbits (21); and swine (4).

Positive attributes are that the facility was renovated in 2010, including addition of six runs for large animal housing, cage washing facility, and additional procedure spaces. A new air handler was installed using existing ducts and controls.

Negative attributes are that there are problems with temperature and air balance control in some rooms following the renovation; and there is no emergency backup power to environmental systems. In addition, the facility is not equipped with an automated environmental control, monitoring, and alarm system.

DOH Recommendations: The status of DOH in the HSC Master Plan is that it remains in service. The committee recommends that this facility remain in operation with two specific recommendations to provide individually ventilated cages and racks for all of the rodents housed in DOH and to provide full emergency backup power and automated environmental monitoring and controls to the facility.

Pharmaceutical Science Center (PSC) contains 108 NSF of animal housing and no support space. It currently houses 40 frogs.

This single room houses a small number of frogs for a single research program. A negative attribute is that there is no emergency backup power to environmental systems.

PSC Recommendations: The status in the HSC Master Plan is that the PSC building is to be renovated. It is not known whether this room will remain for animal housing. The facility should remain open, and if eliminated at some point due to building renovation, the frogs can be moved to another facility.

Zilkha Neurogenetic Institute (ZNI) contains 4,399 NSF of animal housing and 4,872 NSF of support space (9,271 total NSF). Animals housed include mice (5,637 cages); rats (88); and zebrafish (822 tanks). Zebrafish are being moved to the BCC facility.

Positive attributes of ZNI are that it is a relatively new facility (opened in 2003) that provides mouse and rat housing for multiple programs in high capacity ventilated racks with automatic watering. Full emergency backup power is available.

Negative attributes are that waste bedding disposal moved to far end of the building and the cage washing facility will handle all cages for both ZNI and BCC. An automated bedding disposal system was requested as part of the BCC construction but was removed from the budget. Also, there is no redundancy of mechanical systems for ZNI or BCC (steam supply was lost for two months in 2011).

ZNI Recommendations: The status of ZNI in the HSC Master Plan is that it remains within the research core area. With possible interconnection to RB3 in the future, the issues of waste bedding disposal and redundancy of mechanical systems should be addressed.

Broad Center for Regenerative Medicine and Stem Cell Research (BCC) contains 3,874 NSF of animal housing and 1,941 NSF of support space. Future housing (2012) will include mice (4,800 cages) and zebrafish (3,200 tanks).

Positive attributes are that BCC is a new facility to open in early 2012 that provides mouse and rat housing for multiple programs in high capacity ventilated racks with automatic watering, and centralized zebrafish housing and support. Full emergency backup power is available.

Negative attributes of BCC are that all materials for washing must be transported to and from ZNI and there is no redundancy of mechanical systems for ZNI or BCC.

BCC Recommendations: The status of BCC in the HSC Master Plan is that it remains within the research core area. With possible interconnection to RB3 in the future, the issues of waste bedding disposal and redundancy of mechanical systems should be addressed.

Clinical Sciences Center (CSC) contains 1,424 NSF of animal housing and 731 NSF of support space. Animals housed include mice (1,668 cages); and rats (29).

Positive attributes of the facility are that it provides mouse and rat housing for programs in CSC and CSA buildings that are somewhat distant from other animal facilities.

Negative attributes are that the rooms are very small; the cage washing area is too small for the number of cages; Dirty bedding is dumped in the hallway which is not appropriate for facility sanitation and health and safety reasons; there are no procedure spaces; there are no exhaust connections for high capacity ventilated racks and no automatic watering lines are available; and there is no emergency backup power to environmental systems. In addition, the facility is not equipped with an automated environmental control, monitoring, and alarm system.

CSC Recommendations: The status in HSC Master Plan is that CSC will eventually be demolished and replaced by patient parking structure. However, during committee discussions, it was noted that the CSC building may remain intact for the next ten years or possibly longer. Also the CSC facility houses a significant rodent census and serves the needs of faculty researchers in the CSC and CSA buildings, which are somewhat distant from the other animal facilities, and the facility is also closely associated with the existing imaging core facility. For these reasons, renovation of CSC is recommended.

The room sizes cannot be completely resolved, but a reasonable renovation project should be developed to address deficiencies, as noted below:

- Expand the cage washing area into an adjoining room near the dirty side to allow for space to handle the number of cages and to dump dirty bedding within the cage washing room rather than in the hallway.
- Replace the cage washer and autoclave which are 15-20 years old with more efficient models.
- Add a fully equipped procedure room by conversion of a small holding room or one of the restroom/locker room areas.
- Add electrical connections for high capacity ventilated racks.
- Add automatic watering systems for all holding rooms.
- Purchase ventilated racks and caging for all holding rooms.
- Add emergency backup power and automated control and monitoring to environmental systems in the facility.

These renovations will result in a facility that will be capable of a modest increase in mouse cage census to about 1,900 cages (232 cages more than present) while maintaining efficiency and an adequate standard of animal care.

2.2 Specialized Procedure Spaces

Procedure spaces within animal facilities are currently for general use to the degree possible, and this will continue for future facilities. Possible exceptions will be space for animal biosafety level 2 (ABSL2) and animal biosafety level 3 (ABSL3) research, spaces for neurobehavioral research and behavioral phenotyping of rodents, expansion of support facilities for the transgenic rodent core laboratory, and other specialized research requiring separation of animals from general population rooms. These spaces must be located within centralized facilities that are accessible to faculty and research staff members from all areas of the HSC.

Currently, there is no space for ABSL3 research, because this requires a dedicated facility or area within a facility. ABSL2 research is conducted within existing facilities by separation of animals, and application of administrative controls such as signage, wearing personal protective clothing, and special handling of waste materials. However, the Institutional Biosafety Committee has expressed concerns about this approach and recommends construction of a dedicated ABSL2 facility.

At the present time, behavioral research and other specialized research requiring procedural space is similarly conducted within existing animal facilities. However, there is a significant concern from faculty conducting this research that there is insufficient space for this work, and that much of the work could be conducted within core areas that could be efficiently shared among various investigators. In addition, existing spaces do not allow for adequate control over lighting, noise and vibration, separation of animals from research personnel, and other factors that are impediments to research involving rodent behavioral phenotyping that are extremely sensitive to environmental factors.

Animal imaging is currently conducted in CSC. A major disadvantage is that this facility is used by investigators housing animals in various HSC facilities, and there is limited capacity in CSC

for this number of animals. This means that animals have to be transported to and from CSC from other facilities, which precludes efficient study design and ease in imaging at multiple time points. Imaging facilities in clinical buildings are used for large animals and procedures are conducted either in very early or in late evening hours. For PET imaging, delivery of isotopes from a cyclotron is necessary. Currently, the cyclotron is in CSC. A new cyclotron will likely be purchased and placed in CSC.

The existing transgenic/knockout rodent core laboratory is located within the ZNI animal facility. Because of expanded work involving these rodent models and needs of researchers to develop models involving multiple gene insertions or deletions, there will need to be an expansion of physical facilities to support this model development.

Areas for general procedures, ABSL2, ABSL3, rodent neurobehavioral testing, transgenic/knockout core, and other specialized procedures should be constructed in a new research building (RB3) on the HSC. The location of imaging facilities should also be considered in this building.

2.3 Conversion of Mouse Housing to Individually Ventilated Cages with Automatic Watering

Many of the rodents on the HSC are housed in traditional microisolation cages and are provided water in water bottles. This includes the entire rodent census in the CSC and MMR and a portion of the cages in DOH and HMR for a total of 3,300 cages (one third of the total on the HSC).

The advantages of ventilated caging systems that have been well described (Lipman, NS, Rodent Facilities and Caging Systems, pp. 265-288 in Hessler, JR and Lehner, NDM eds. Planning and Designing Research Animal Facilities, Elsevier, 2009).

The advantages of ventilated caging systems are as follows:

1. Environmental conditions for the animals housed are greatly improved by preventing the buildup of ammonia, carbon dioxide, water vapor, and heat load within the cages compared with standard filter topped cages.
2. Airborne microbial contamination and allergen loads within the rooms are reduced, thus improving worker safety.
3. Increased housing density within rooms is possible, partially due to points 1 and 2.
4. Cage changing frequencies can be reduced. At USC, individually ventilated cages are changed once per week rather than twice per week. This greatly reduces the labor requirements for mouse care and helps to contain costs charged to investigators for daily care. An animal care technician can care for about 1,000 cages in individually ventilated racks, versus 500-600 in static racks.
5. Lowered pre-weaning mortality with less frequent cage changes have been described.
6. Less frequent cage washing and autoclaving increases the usable life of the plastic cage and other components.
7. These caging systems allow USC to further implement green and sustainable technologies. For example, by converting the CSC facility from static cages to ventilated cages, we

estimate that we will save over 250,000 gallons of water per year for washing cages, and send over 30 tons less waste bedding material to the local landfill.

The costs for the purchase and maintenance of individually ventilated cages and racks are compared with static cages and racks in the table below. The return on investment including the purchase costs for either cage type is 1.25 years ($86,000 divided by $70,124). The return on investment for replacement of existing static cages with ventilated cages is 2.7 years ($186,000 divided by $70,124). Note that the calculations do not include the lowered costs for solid waste disposal that are also half as much when using ventilated cages compared with static cages.

Table 1. Cost Comparison of Static Versus Ventilated Microisolation Mouse Cages

Item	Static Microisolation	Ventilated Microisolation	Cost Difference
Purchase cost for 1,000 cages	$100,000	$186,000	$86,000
Costs per year per 1,000 cages			
Technician costs	$91,688	$45,844	$45,844
Bedding costs	$13,870	$6,935	$6,935
Cage washing chemical costs	$5,400	$2,700	$2,700
Cage washing utilities costs	$22,290	$11,145	$11,145
Cage replacement costs	$7,000	$3,500	$3,500
Total cost per year per 1,000 cages	$140,248	$70,124	$70,124

Because some rooms in HMR and all of the rooms in DOH are equipped with automatic watering systems, the racks can be put into service immediately in those facilities to eliminate the use of water bottles. In the CSC, addition of an automatic watering system will be required. This can be accomplished during renovation of the facility, and is on the list of features to be added during the renovation.

It is not feasible to add individually ventilated racks to MMR, but once RB3 is completed, the MMR facility should be closed and the rodent census in that building moved to RB3. Any ventilated racks purchased and used in HMR should be moved to RB3 once it opens and the majority of mice in HMR are moved to RB3.

2.4 Emergency backup generator and automated environmental control, monitoring, and alarm systems for animal facilities

During the most recent site visit of the Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC) in October 2010, the site visit team cited a lack of emergency backup power in many of the USC animal facilities. The newer facilities in ZNI and BCC are equipped with full emergency power on all environmental systems.

Facilities that will remain in service in the medium- to long-term that are not equipped with emergency backup power are in HMR, DOH, CSC, MMR, and PSC. Projects to develop emergency power capacity for HVAC environmental systems and lighting must be developed for

these facilities to be compatible with standards for continued accreditation, or the facilities should be closed.

A related concern which is highlighted in the Eighth edition of the Guide for the Care and Use of Laboratory Animals is the provision of automated environmental control, monitoring, and alarm systems for animal research facilities. These systems are not provided in most of the older animal research facilities on the HSC campus and should be added to the facilities that remain open. The provision of these systems to all facilities will insure continued AAALAC accreditation and scientific integrity of the research being conducted, and will prevent possible catastrophic losses of animals or research data.

3. Trends and Projections in Animal Facility Usage

Data on animal census for the past five years for key species were presented to the committee. Discussion on these trends was as follows:

Rodents: The committee was in agreement that rodent census (particularly mice) would be the major area of growth in the next 5 to 10 years. The average daily census of mouse cages on the HSC has increased from 6,354 cages in 2007 to 10,860 cages in 2011. There was associated discussion about the possible need for rat housing increases due to model development using transgenic and knockout rats as this technology was developed at USC. Over the past five years, the average rat census has increased from 500 in 2007 to almost 800 in 2011.

Zebrafish: The census numbers for zebrafish have increased dramatically over the past five years, from essentially no fish to a current census of 10,000. While it is unknown whether recruitment of investigators using this model will increase, it was agreed that ongoing expansion in a central zebrafish facility within the BCC facility will allow for a tripling of capacity and potential recruitment of at least one or two more zebrafish users. It was concluded that this was sufficient for the known need during the next five to ten years.

Nonhuman Primates: Nonhuman primate research has declined at USC in recent years, and there are currently no nonhuman primates housed. The committee agreed that research using nonhuman primates would need to be conducted in properly constructed and high security facilities that are specifically designed for this purpose. In many cases, investigators may need to consider smaller studies using USC facilities, but outsource larger studies to contract research organizations or regional primate research centers. In addition, these facilities are better equipped for development of translational work and implementation of Good Laboratory Practices. It was also concluded that cognitive neuroscience research at a level requiring nonhuman primates would not ever be a priority at USC. This eliminates the need for extensive nonhuman primate housing, surgical, and procedural spaces.

It was concluded that USC should maintain some capacity for nonhuman primate research at a fairly limited level in a properly constructed and secure facility.

Other Large Animal Species: The HMR facility is essential for accommodating large animals such as dogs, swine, and small ruminants. There is a small capacity for these species in DOH,

consisting of only six runs. Translational studies will continue to be required and will use these species. Therefore this capacity must be replaced prior to the eventual closure of that building. When HMR is closed, its replacement should be conceived as a "translational health" research facility, focused on larger species.

Miscellaneous Species: A variety of other species such as guinea pigs, rabbits, and chickens are housed in HSC facilities (primarily in HMR). While the committee members did not expect a significant growth in the use of these other species, their use will continue at least at current levels and planning to accommodate these species must be included if HMR is eliminated at some time in the future.

3.1 Projected Needs for Rodent Housing

While the committee anticipated that future growth in animal based research would be significant, particularly for mouse models, some uncertainty exists in predictions. This uncertainly includes factors such as:

- NIH funding may decline in future years. Thus, animal usage per investigator may have reached or surpassed its peak.
- Continued growth depends on continued recruitment. Likely areas for future recruitment, and possible animal population sizes for major investigators, are unknown.
- The type of research will affect the recruitment needs of new faculty, For example, two recent recruitments on the HSC have involved mouse numbers that far exceed the average number of mice needed for other recruitments in recent years.

Current Housing

At 100% of capacity, the HSC will soon have sufficient space to accommodate 19,681 cages (Table 1). However, because it is difficult to continuously fill every cage, the HSC can more realistically accommodate a cage census of just below 17,000 cages (measured at 85% of capacity). To achieve even this lower capacity, an additional 2,240 new cages must be purchased to fill available space. Once these new cages are purchased, sufficient space will be available to serve a census growth of approximately 3,500 cages.

Table 2. Mouse Census and Capacity on Health Science Campus

	Existing Capacity		Current Census	New Capacity Added		Census	Net Census
	100%	85%		100%	85%	Committed	Available
BCC	-	-	-	4,800	4,080	4,048	32
CSC	1,848	1,570	1,610	(336)	(286)	(422)	96
DOH	1,100	930	908	280	238	(324)	584
HMR	2,855	2,310	1,915	840	714	(202)	1,311
MMR	734	624	566	-	-	-	58
ZNI	6,580	5,600	5,680	980	833	(613)	1,366
Total	**13,117**	**11,034**	**10,679**	**6,564**	**5,579**	**2,487**	**3,447**
Implementation of the new Guide						1,500	1,947
Cages to be purchased to provide new added capacity (HMR and DOH) = 2,240 (100% capacity) or 16 double sided ventilated racks							

Projected Needs with Continued Constant Annual Growth

Figure 1 forecasts future average daily census through 2021 under the assumption that census grows at the same annual rate as the last five years.

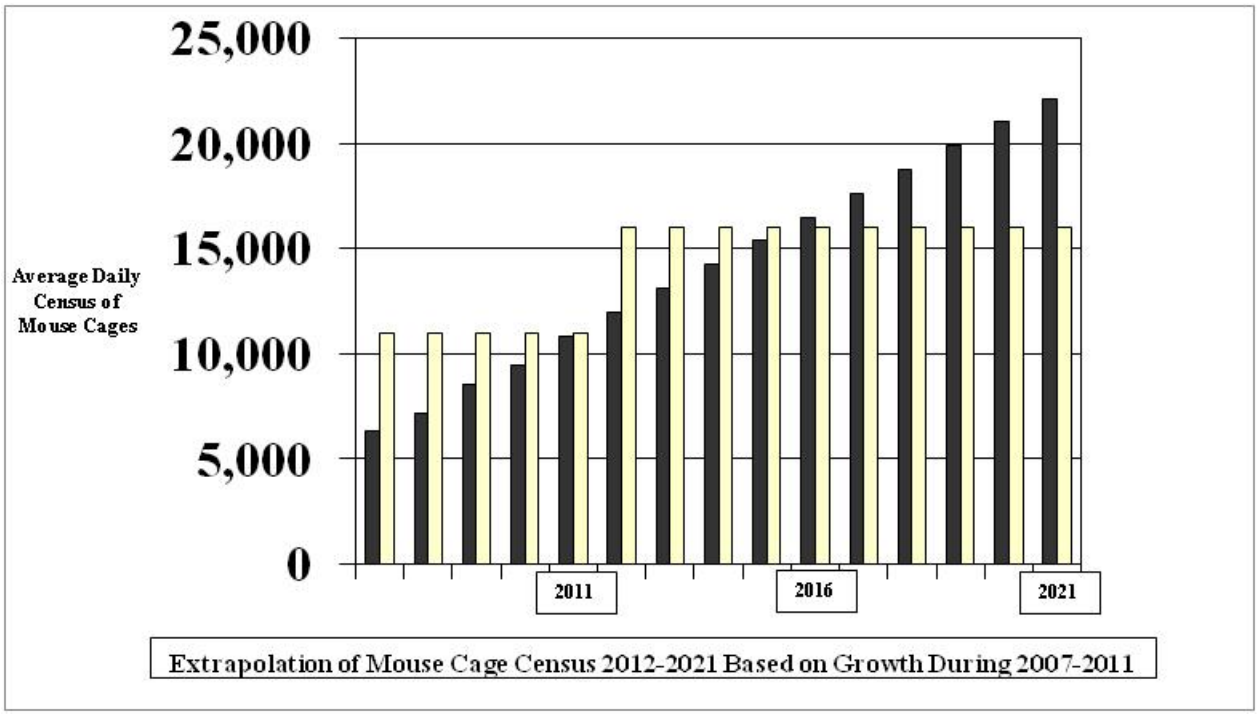

Figure 1. Projected Mouse Census with Constant Annual Growth

Under this assumption, 16,000 cages in 2012 (due to the opening of the BCC facility) will be sufficient to accommodate growth for approximately four years. The planned addition of 840 cages in HMR and 280 cages in DOH will accommodate approximately one additional year of growth, meaning by 2017 average daily census will exceed 85% of the total number of cages available (the recommended target).However, this number of cages may be exceeded prior to 2017 based on recent faculty recruitments. Two faculty members are adding about 2,000 cages during 2012, placing the census growth well above what is predicted by extrapolation.

An additional factor contributing to this deficit in the future is implementation of the Eighth edition of the Guide for the Care and Use of Laboratory Animals. These guidelines require additional cage space for female rodents with litters, and it is estimated that this may result in a 15% increase in mouse cages based on our existing census. If this change is fully implemented, we will only be able to accommodate two years of growth at the current rate.

Cage Census Based on Square Footage of Laboratory Space

The Health Science Campus currently has 163,057 NSF of assignable laboratory space in the ZNI, HNRT, and BCC buildings. In these three buildings, there are 50,782 NSF of space that are not assigned to an investigator (and are available to house laboratories of new recruited faculty). Investigators housed in the occupied laboratories (112,275 NSF of space) have a total rodent

census of 8,100 cages. This census includes the projected census of newly recruited investigators in these buildings. Dividing 112,275 by 8,100 yields a factor of 0.072 cages per NSF of laboratory space. By applying this factor, the census will increase by approximately 3,700 once all unassigned laboratory space is filled. This growth in census is 253 cages larger than available capacity.

Needed Cage Capacity for RB3

RB3 should be sized to accommodate any new needs created by laboratories housed therein, combined with any existing space deficit and any needed replacement of existing facilities.

New Needs: When adding the new RB3 building, estimated to be 100,000 NSF, an additional 7,200 cages are needed, based on .072 cages per NSF. If we assume that census is 85% of total cage capacity, then 8,470 cages will be needed to accommodate new activities. This assumes that RB3 is configured 100% for wet lab research. The need will be reduced if a portion of the building is focused on dry lab research.

Space Deficit: The current capacity, once Broad is fully operational and additional cages are acquired, is slightly below the projected need, with a projected 253 cage deficit.

Replacement of Existing Space: The entire MMR facility should be closed by the time RB3 is completed (624 mouse cages). HMR mouse facilities (3,150 cages) should be closed upon RB3 completion if feasible. Combined, replacement of these facilities would require 3,774 new cages.

Provision of 12,500 new cages will accommodate all of these needs.

3.2 Projected Needs for Other Animal Housing

Large Animal Housing: Large animal space: Large animal housing and support spaces in the HMR basement total to 5,037 NSF. This space must be replaced in a new building prior to Hoffman Hall's eventual closure.

Other Animal Housing: Housing and support spaces for these species in HMR (6,633 NSF), MMR (1,805 NSF), and PSC (106 NSF) facilities total to 8,544 NSF. Assuming no further growth in the use of miscellaneous species, this amount of space will be required to remain open in these facilities or to be replaced in a new building. We recommend closure of MMR, which would add 1,805 NSF to the RB3 requirement.

3.3 Industry Standard

One industry standard publication states that within large biomedical research buildings, there should be an allowance for up to 20 percent of laboratory space to be allocated as animal facility space (Norton, JN and Brouwer, AB, The Planning, Design, and Construction Process, pp. 17-44 in Hessler, JR and Lehner, NDM eds. Planning and Designing Research Animal Facilities, Elsevier, 2009.

The ZNI, HNRT, and BCC buildings provide 163,057 NSF of laboratory space. Using this factor, 32,611 NSF of animal housing space would be required. The ZNI facility provides 9,271 NSF and the BCC facility provides 4,158 NSF (13,429 NSF for both buildings). This is 19,182 NSF less than the predicted need based on this model. While it does appear that our existing

animal housing space is meeting projected needs, this deficit indicates that USC has provided less animal space than other institutions.

3.4 Projected Needs for Specialized Research Spaces

From previous plans for the RB3 space (February 2005) the following square foot estimates were included for programs in these areas. Additional information on a neurobehavioral core was provided by the ZNI Director during 2011. Following are NSF estimates for these spaces:

Imaging:

7T horizontal MRI	777 NSF
9.4 or 11.7 T MRI	588 NSF
4.5T horizontal MRI	777 NSF
Equipment room (3@333 NSF)	993 NSF
Control room (3@221 NSF)	663 NSF
Animal Prep (3@165 NSF)	495 NSF
Total	4,293 NSF

Animal Biosafety Level 2/3:

Biosafety holding (4@253 NSF)	1,012 NSF
Procedure room (4@121 NSF)	484 NSF
Decontamination	182 NSF
Lockers (2@121 NSF)	242 NSF
Total	1,920 NSF

Neurobehavioral Core:

Behavior testing (6@120 NSF)	720 NSF
Ante-room (6@100 NSF)	600 NSF
Procedure	280 NSF
Total	1,600 NSF

Transgenic Core:

Surgery (2@363 NSF)	726 NSF
Injection (2@363 NSF)	726 NSF
Office (2@121 NSF)	242 NSF
Cryopreservation	182 NSF
LN2 Tanks	66 NSF
Total	1,942 NSF

These space estimates are only approximations and must be reviewed and recalculated based on programming exercises for the RB3 facility, and based on current needs for the types of spaces.

4. Construction of New Animal Facility Space in Research Building 3

Once all existing laboratories are filled with investigators in Norris, Zilkha and Broad, we project that the USC's mouse housing capacity will be less than the future need based on projections of increased census extrapolated from current growth, projections of committee members on likely areas of growth, and construction of additional research space. In addition, some existing research laboratory space is unoccupied and when filled, some of the research projects for recruited faculty will involve animal models. This need should be accommodated in the next research building (Research Building 3).

Research Building 3 will be located adjacent to the existing ZNI and BCC facilities, creating an opportunity to centralize HSC animal facilities into a combined RB3/ZNI/BCC facility. The advantages of centralization relate to the efficiency of shared facilities. We recommend the provision of additional space (possibly shelled) to accommodate the eventual closure of other animal facilities, including MMR (immediately upon opening RB3) and HMR (at some point in the future before it is demolished). A centralized animal research facility in RB3 could interconnect on the basement level with the ZNI and BCC facilities (the ZNI/BCC/RB3 facility). This would allow for access to the facility for faculty and research staff members from all areas of the HSC.

USC should consider the overall space efficiency of various approaches to programming and constructing the space. For example, the efficiency of the rodent facility space will be high by avoiding long interconnecting hallways such as those between the ZNI and BCC facilities, and by the exclusive use of high density ventilated racks with automatic watering systems. There should be efforts to provide as many larger rooms as possible, which are more space efficient. However, this will be offset by many smaller rooms that would be required for biosafety, neurobehavior, and imaging areas. Management efficiency would be greatly improved by providing as much automation as possible such as the automated dirty bedding disposal system.

Another efficiency factor to consider is that if large animals (dogs, swine, ruminants, and nonhuman primates) and miscellaneous animals (rabbits, chickens, guinea pigs, reptiles, amphibians) are eventually located in RB3, the space efficiency of the large/miscellaneous species areas will be much higher because redundant space would not be needed for a cage wash, storage, personnel area, loading dock etc. If HMR is maintained for a number of years, the housing spaces for large and miscellaneous species could be added later adjacent to the RB3 rodent spaces, if the space is reserved for future use as a shelled area and there are no impediments to expanding the basement is some manner.

In summary, the following features and attributes are recommended for the facility:

- Additional rodent housing in efficient, high capacity individually ventilated cage systems to accommodate growth in rodent census, most of the rodent census in the HMR and all of the rodent census in the MMR facilities.
- Large animal housing to replace space in the HMR basement, or shelled space to be converted to large animal housing when HMR closes.
- Miscellaneous animal housing to replace space in HMR, MMR, and PSC, or shelled space to provide miscellaneous species housing when these facilities close.

- Animal biosafety level 2 and 3 spaces.
- Neurobehavioral and other specialized procedure core spaces.
- Animal imaging spaces.
- Transgenic and knockout rodent core laboratory spaces.
- Core cage washing and materials handling spaces
- Dedicated loading dock space and automated dirty bedding/clean bedding handling systems for the three interconnected facilities.

5. Summary and Recommendations

The Health Science Campus benefits from several modern animal facilities, along with some outdated facilities in need of renovation or replacement. Once the Broad facility is opened and additional cages are acquired, sufficient housing will be available to accommodate most needs generated by new faculty recruitment in Zilkha, Norris and Broad, assuming that the intensity of animal research (cages per square foot of laboratory) does not exceed the present. However, the HSC will run out of space if the Eighth edition of the Guide for the Care and Use of Laboratory Animals mandates a significant reduction in mice per cage, or if new major mouse researchers are recruited to USC.

The committee makes the following long term recommendations:

1. Construct new animal facility space in the basement of the new RB3 building, including 12,500 mouse cages (assuming 100,000 new NSF of wet lab space) and space for large animals and miscellaneous animal species to accommodate the eventual closure of the HMR facility. Space for large animals and miscellaneous species could remain as shelled space or flexible expansion space until the need for replacement of HMR is imminent. When RB3 opens, close the MMR facility and move the majority of rodent housing from HMR into RB3. The facility would interconnect with existing ZNI and BCC facilities and contain sufficient animal housing and procedural spaces to accommodate researchers from all areas of the HSC.

2. In the RB3 facility, include sufficient procedural spaces to accommodate the needs of faculty and research staff members from throughout the HSC. Procedural spaces would include those for animal biosafety levels 2 and 3, neurobehavioral core procedures, transgenic/knockout animal core, and imaging for rodents. Rodent imaging should include all modalities used in contemporary research, to eliminate the need for transporting animals to different facilities. Imaging for large animals would be possible as an optional addition in the future, as shelled space or flexible expansion space.

In addition, the committee makes the following short term recommendations:

1. Provide emergency backup power and automated environmental monitoring and control functions to all existing HSC animal facilities that will remain open.

3. Purchase additional high capacity individually ventilated racks and cages for mice and rats to use throughout all HSC animal facilities that will remain open.

4. Renovate the CSC animal facility to provide individually ventilated racks and correct deficiencies in the cage washing facility.

5. Provide additional tools for faculty and research staff members to make efficient use of existing mouse holding facilities and to maintain mouse census at the minimum levels needed to accomplish research goals. As examples, the Department of Animal Resources has already held seminars on rodent breeding methods and should continue similar educational efforts. In addition the DAR could make software available to track and document rodent breeding programs for individual laboratories.