TECHNICAL REPORT:
MEASURING CIRCADIAN LIGHT EXPOSURE IN NEWLY REMODELED OFFICE SPACES

Building 48
48 Denver Federal Ctr, Lakewood, CO 80215

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TECHNICAL REPORT

EXECUTIVE SUMMARY

The design of Building 48 in Lakewood, Colorado, was adjusted to integrate criteria from the reference for General Service Administration's P100 Facilities Standard, *UL 24480 Design Guideline for Promoting Circadian Entrainment with Light for Day-Active People.* That UL publication establishes guidelines for the amount of light that should be provided for workers during the daytime. The circadian stimulus (CS) criterion referenced in *UL 24480* is 0.3, for at least 2 hours per day. In order to calculate CS, the UL procedure requires measuring and calculating the amount and spectral (color) characteristics of light to be delivered at the eye.

To verify circadian lighting conditions, researchers from the Light and Health Research Center (LHRC) performed post-renovation field measurements before and after the occupants of the U.S. Department of the Interior (DOI) moved into Building 48 in Lakewood, Colorado. Our evaluation included field measurements of lighting at both open plan office desks and private offices as well as communal spaces. The researchers also administered an anonymous lighting and sleep questionnaire to DOI employees (Appendix A). Results from two of the buildings on DOI's previous campus (2023) were compared to results from the site evaluation that took place two months after DOI moved into Building 48.

Contrary to expectations, field measurements showed that Building 48 did not provide more CS than DOI's previous buildings. At open plan desks, average CS in the daytime at Building 48 was 0.19, compared to 0.28 in the previous buildings. Horizontal illuminance on desks was also lower after the move; average daytime horizontal illuminance on desks measured in the previous buildings was 608 lux (lx) versus 276 lx at Building 48. We discuss several possible causes of lower-than-expected light levels.

Nonetheless, opinions about illumination in Building 48 tended to be favorable. Both in the previous buildings and after the move to building 48, respondents were asked how their electric lighting and daylighting compared to other buildings. In the previous buildings, 26% considered electric light and daylight to be "better than other office buildings," compared to 43% after the move to Building 48. Almost half (48%) of questionnaire respondents thought the amount of daylight and electric light in Building 48 is "just right." However, a large minority (37%) of respondents indicated that the amount of daylight and electric light in Building 48 was more than they need, which represents a shift in opinion from their previous buildings, in which a third of the respondents indicated that they had *less* light than they needed. In the previous buildings, we observed that most of the venetian blinds were closed to protect from glare and overheating from the Colorado sun, so most of the lighting came from overhead fluorescent troffers. After the move, illumination was more softly diffused, from a range of daylight and electric light sources surrounding the DOI occupants.

While overall responses to lighting in Building 48 were generally positive, respondents offered a range of comments about the lighting in Building 48 being either too bright or too dim. A few respondents commented that electric lighting fluctuated too much; as discussed in the July 2024 commissioning report, there were a few locations in Building 48 in which incorrect positioning of a few of Building 48's photosensors caused them to repeatedly dim light levels up and down. Questionnaire results indicate that these isolated photosensor placement problems have likely not yet been corrected.

Sleep questionnaire results did not change significantly with the move to Building 48, for neither average "sleep disturbance" nor average "sleep related impairment" scores. These sleep metrics remain similar to the general population.

BACKGROUND

In August 2020, the project to modernize Building 48 for DOI was awarded. In 2021, requirements to include circadian-effective lighting were incorporated into Tier 2 of GSA's P100 Facilities Standard. [1] Because one of the main design goals was to provide a high-performance workplace that enhanced all human factors including the health of building occupants, the design team chose to integrate criteria from the P100's reference standard, *UL 24480 Design Guideline for Promoting Circadian Entrainment with Light for Day-Active People.* [2] That UL publication establishes guidelines for the amount and timing of glare-limiting (<8500 cd/m^2) light that should be provided for daytime workers to promote healthy sleep. The circadian stimulus (CS) metric was most recently defined by Rea and colleagues in 2021. [3, 4] There are several metrics used in *UL24480*; this designer used the CS metric. The CS criterion established in *UL 24480* is a minimum of 0.3, provided at the eye of the occupant for at least 2 hours per day. In order to calculate CS, the UL procedure requires measuring and calculating the amount and spectral (color) characteristics of light to be delivered at the eye. [2]

During its design stage, the LHRC met with Building 48's architecture firm (Cannon Design) and the engineering firm (The RMH Group) to review the CS performance criteria from *UL 24480* and review the procedures for incorporating those performance criteria into the design process.

The design team reevaluated their designs after conducting photometric, spectral, and circadian analyses. They adjusted their design by increasing the number of skylights, adjusting skylight spacing, and changing the color of the ceiling to increase light reflections. The team's photometric calculations predicted that open plan offices were expected to meet CS targets primarily with daylight; electric light alone was not designed to meet CS targets. While open plan offices were predicted to meet CS targets, private offices were expected to fall short; rather than add electric lighting or take other steps to increase CS levels in private offices, the design team opted to recommend that occupants of private offices use the common (Interact and Café) spaces to achieve circadian stimulation in the morning.

As shown in our 2023 report, [5] electric lighting in the previous DOI buildings consisted of linear fluorescent troffers. Daylight in these previous buildings came from windows. Electric lighting in (single-story) Building 48 consists of direct/indirect LED pendants and small LED task lights. Daylight in Building 48 is provided by both windows and skylights. Shading in the previous buildings was provided by venetian blinds; in Building 48, shading is provided by mesh roller shades.

GOAL OF THE PRESENT STUDY

The goal of this research was to evaluate if the design of a newly renovated building with new lighting and extensive windows and skylights, would deliver sufficient illumination to meet the *UL 24480* circadian design criterion. In line with the objectives of UL 24489, [2] it was hypothesized that a CS $\geq$ 0.3 for a minimum of 2 hours during the day would provide sufficient circadian stimulation to promote entrainment and healthy sleep.

METHODOLOGY

Measurement Procedures

DOI employees moved into Building 48 in August 2024; in October 2024, LHRC researchers administered the questionnaire (Appendix A) and visited the site to perform the lighting field evaluation. These results were compared to the LHRC's visit the DOI's previous offices [5] also in Lakewood, Colorado, in April 2023 (39.7° N, 105.1° W). Lighting field measurements were compared to questionnaires in order to assess the impact of circadian lighting conditions on sleep, before and after DOI's move to Building 48.

On-site Photometric Measurements

In the October 2024 evaluation of Building 48, the LHRC measured electric and daylight spectral characteristics and photopic illuminance; illuminance was measured with calibrated spectroradiometers (model BTS-256 and model S-MSC15 from Gigahertz Optik, Türkenfeld, Germany). One spectroradiometer (MSC15) calculated CS natively, using illuminance and spectral data. The other spectroradiometer (BTS-256) recorded illuminance and spectral data, which the researchers used to calculate CS using the internet-based CS calculator (https://cscalc.light-health.org/)

Illuminance measurements were collected on a vertical plane at the eye height (48”) of building occupants when seated and horizontally on the desk (28”-31” height). Measurements were collected at three times of day (morning, noon, and afternoon), and again at night. In the 2024 Building 48 evaluation, measurements were completed at eight typical open plan desks and two private offices; those desks were located on both the east and west sides of the building (Figure 1 and Figure 2). Because of the designers’ recommendation for occupants of private offices to use common areas to boost morning light exposure, the LHRC also measured light in a central “Interact” space (Figure 1) and two Café spaces (Figure 3).

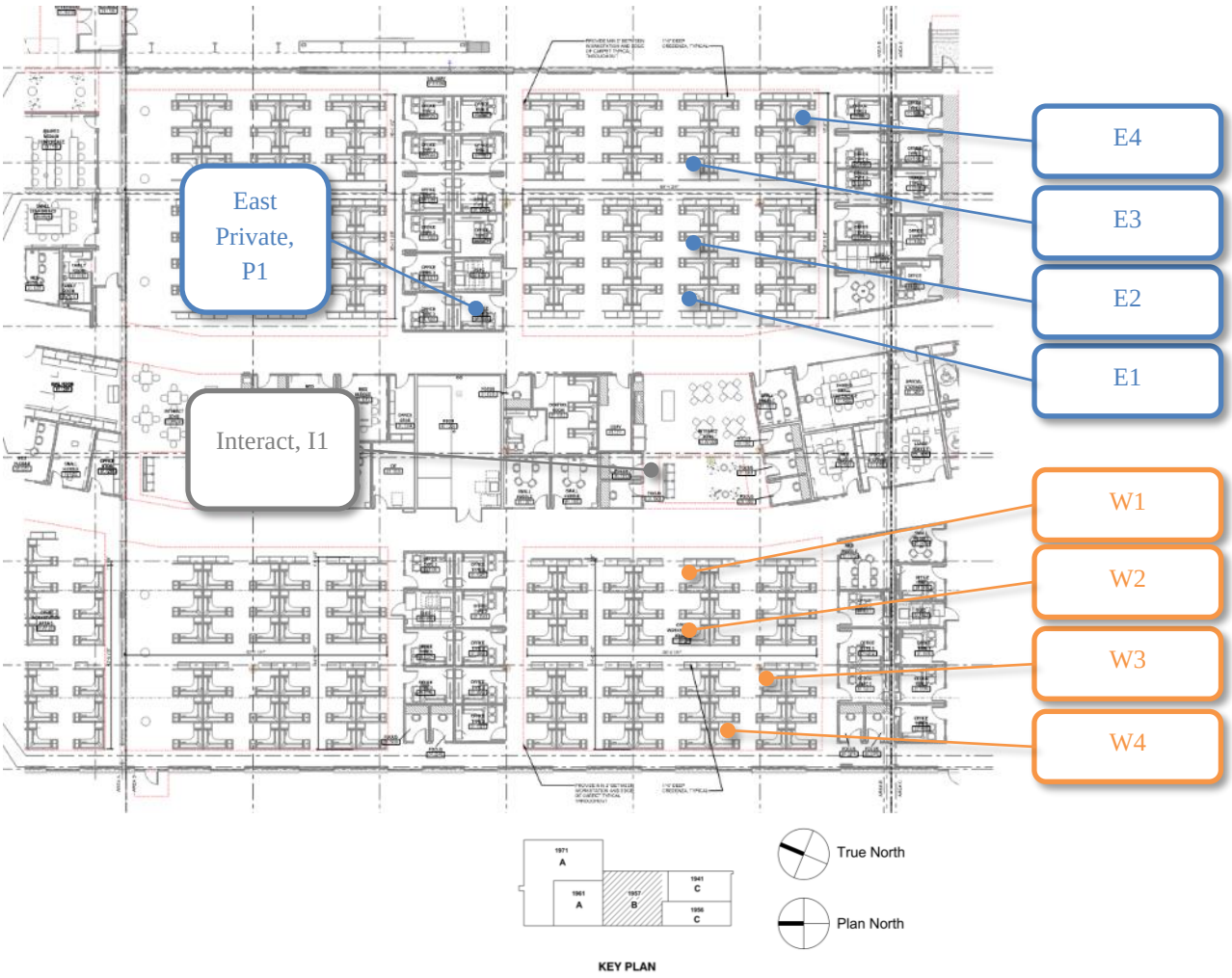

Figure 1. Measurement locations, central section of Building 48.

Figure 2. Private office measurement location, south section of Building 48.

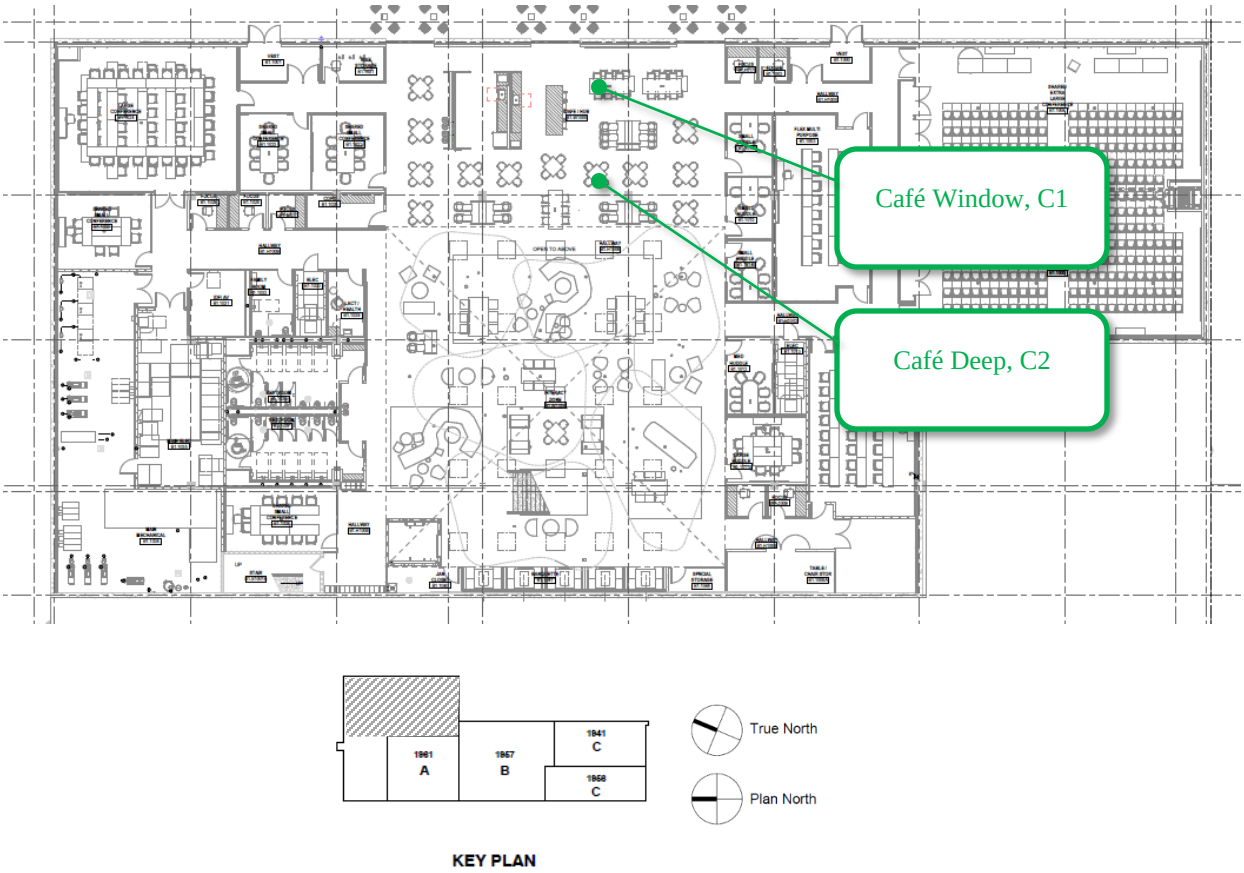

Figure 3. Measurement locations, north section of Building 48.

At each desk, vertical illuminance measurements were collected facing two directions: perpendicular to the desk, facing the windows and the centerline of the computer monitor mounting apparatus ("A") and diagonal ("B"; Figure 4). This measurement location is expected to be the focal point of desk work due to computer monitor alignment. Vertical illuminance measurements at Café and Interact spaces were also perpendicular to the table ("A") and diagonal ("B").

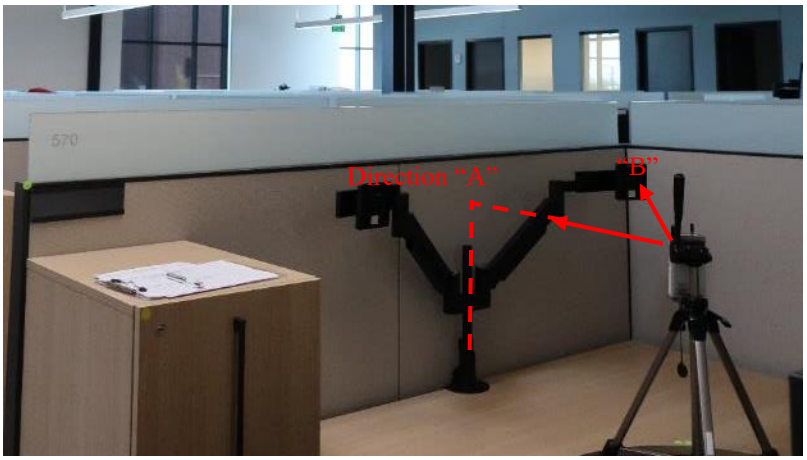

Figure 4. Vertical illuminance measurements faced two directions and were aligned with computer monitor mounting apparatus.

QUESTIONNAIRES

The researchers administered the same questionnaires to DOI employees before and after DOI's move to Building 48. As shown in Appendix A, the questions consisted of demographics, electric and daylighting feedback, and the questions from the Patient-Reported Outcomes Measurement Information System (PROMIS®) Sleep Disturbance and Sleep Related Impairment questionnaires. [6] These questionnaires were combined into one instrument and administered electronically. DOI management distributed the questionnaire to personnel in the three DOI directorates: Human Resources, Financial Management, and Office of the Director. In October 2024, 66 anonymous DOI employees responded to the questionnaire; of those, 54 completed the lighting questions, and 52 completed the sleep questions.

Answers from the sleep questionnaires were scored using the PROMIS scoring manual (2022 Edition) for Adult 1.0 Sleep Disturbance 4a, and Sleep Related Impairment Adult 8a. [7] The scoring manual explains that for negatively-worded concepts like "Sleep Disturbance" and "Sleep-Related Impairment", T-scores of 60 are one standard deviation worse than average, and T-scores of 40 are one SD better than average.

RESULTS

Photometric Measurements

As shown in Figure 5, the open plan desks closest to the windows achieved high light levels in the first part of the day; in the morning, desk #4 on the east side achieved the target CS (≥0.3) while desk #4 on the west side achieved the target during the midday measurement. However, at the other open plan desks deeper in the floorplate, the LHRC measured a CS of ≤ 0.2 throughout the day, regardless of whether the meter was facing the windows (direction "A") or facing diagonally (direction "B").

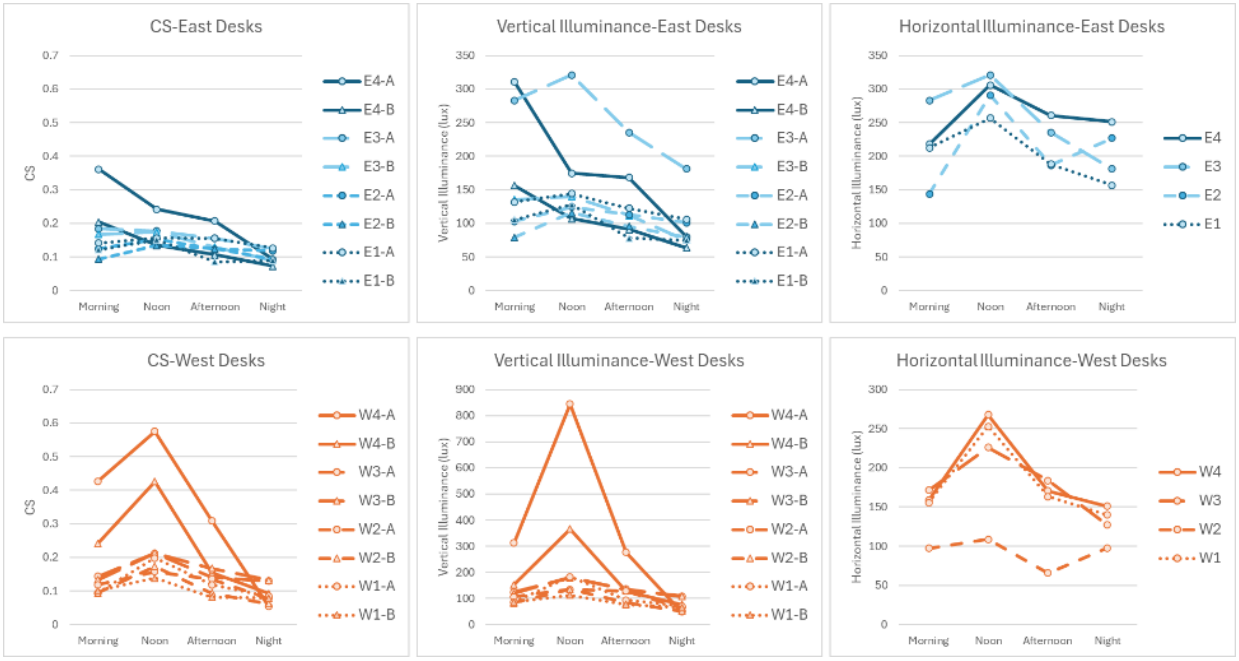

Figure 5. Photometric measurements at open plan desks in Building 48, including CS (left column), vertical illuminance (center column), and horizontal illuminance on the desk (right column).

In the private offices, photometric conditions were better than the engineers predicted; the west-facing office was located close to the window wall, and did in fact achieve CS ≥0.3 when facing direction "A" during the daytime. The private office on the east side was located deeper in the floorplate, so direction "A" had a consistent CS of 0.26 during the day and after dark. Contrary to expectations, the private offices had higher light levels than most of the open plan desks.

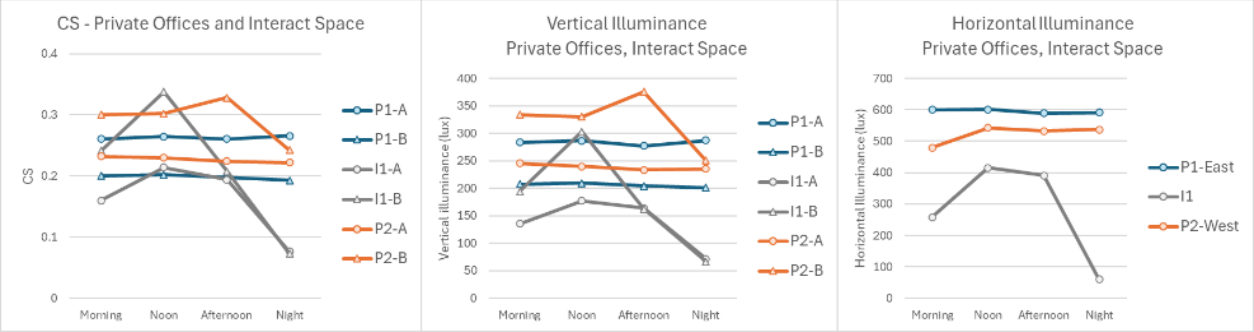

Figure 6. Photometric measurements in private offices ("P") and Interact space ("I").

Light distribution in the Interact space was non-uniform. Measurements in the Interact space did show CS ≥ 0.3, but only at midday, and only when facing diagonally (direction "B").

Across all the desks (open plan and private), average daytime CS was 0.19, and average nighttime CS was 0.12 (Figure 7); on average, the CS measurements at desks in Building 48 were lower than in DOI's previous buildings. The same was true for vertical and horizontal illuminance measurements (Figure 8).

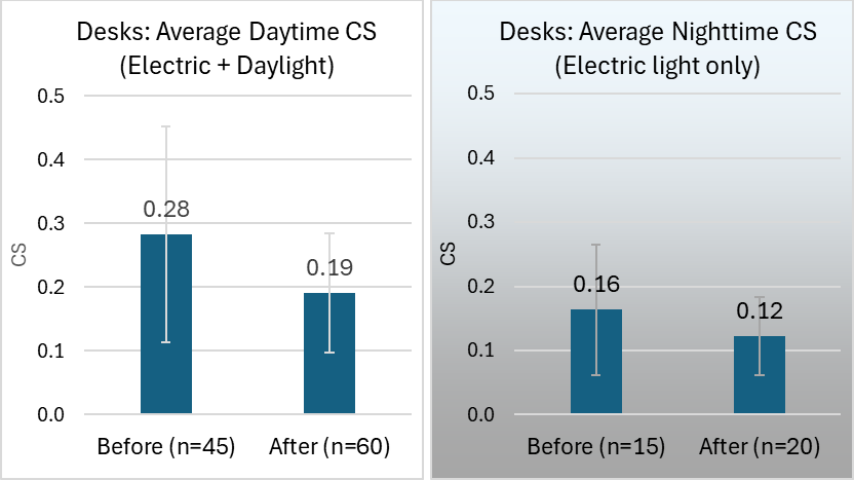

Figure 7. Average CS at desks, comparing before vs. after the move to Building 48, and comparing daytime measurements (left) vs. nighttime measurements (right).

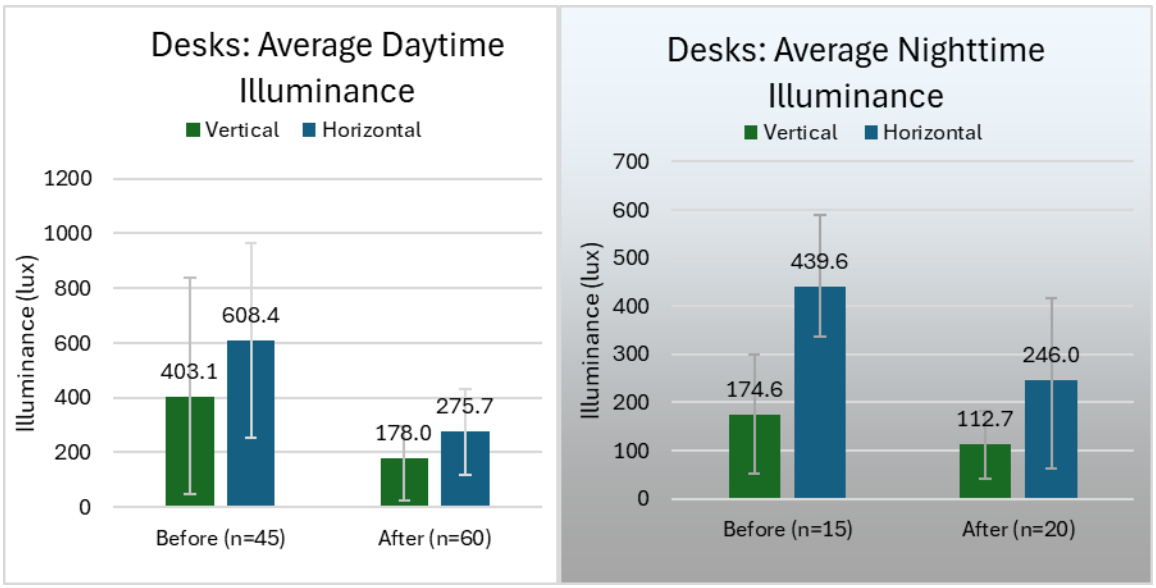

Figure 8. Average vertical and horizontal illuminance measurements.

Part of the reason for higher light levels before the move comes from changes in lighting needs since the era in which DOI's previous buildings were built (approximately 1980s to 1990s). In the twentieth century, office tasks were commonly paper-based and required higher light levels than 21st century self-luminous tasks. In the 1980s, the Illuminating Engineering Society (IES) recommended 500 lx or more on the desk for many reading tasks, [8] compared to today's typical office recommendations (300 lx horizontal). [9] As shown in Figure 9 below, the lighting in DOI's previous buildings was very directional, focusing light downward from low ceilings.

Figure 9. Examples of lighting in DOI's previous buildings.

Questionnaire Results

DEMOGRAPHICS

More DOI respondents reported working in person at Building 48 than did prior to the move (Figure 10). Respondents who work in the office three or more days per week were able to complete the remaining lighting and sleep questions.

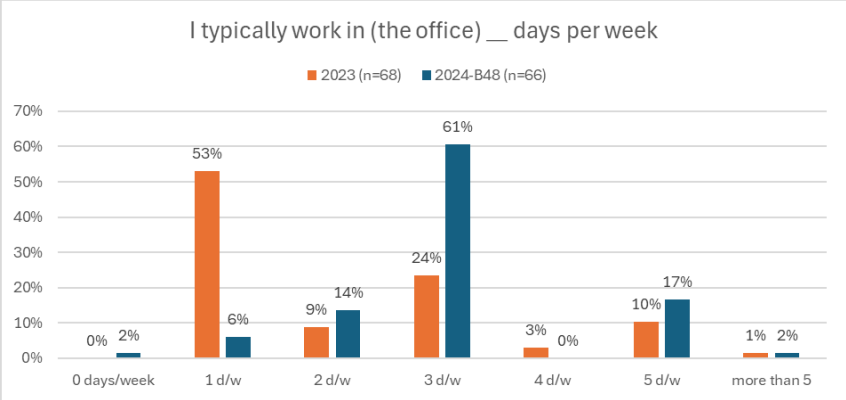

Figure 10. Number of days per week (d/w) working in the office.

Questionnaire respondents reported from "neighborhoods" throughout Building 48 (Figure 11). Similar rates of response from the three "directorates" were received before and after the move to Building 48.

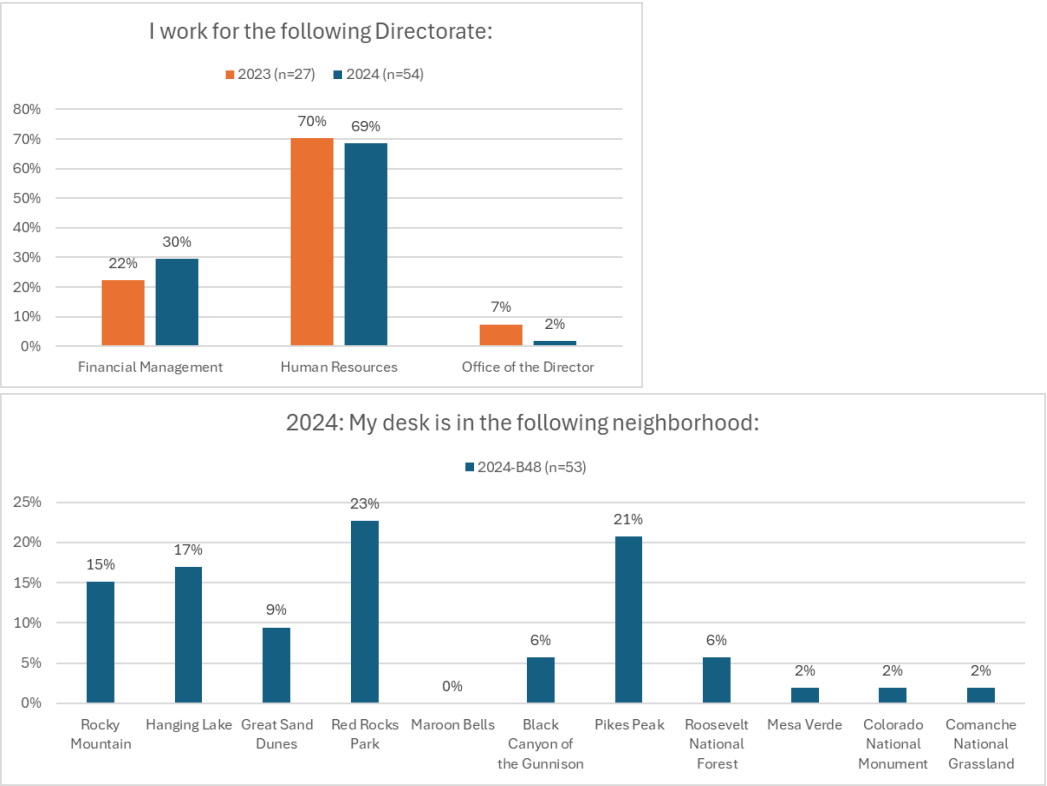

Figure 11. Directorates (upper) and Neighborhoods (lower) represented in questionnaire responses.

Most respondents work in cubicles; most face windows in one of the four cardinal directions (Figure 12).

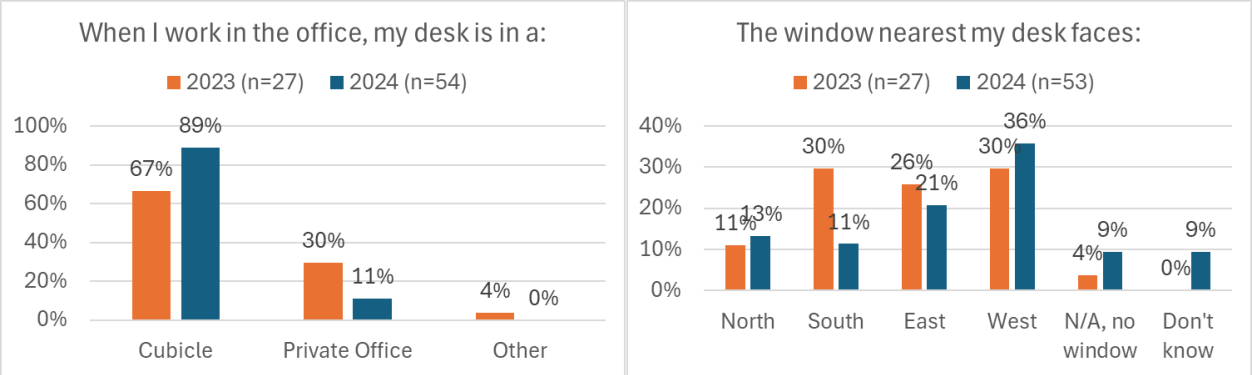

Figure 12. Cubicle vs. private office demographics (left) and window direction (right).

LIGHTING

We wanted to get a sense of how occupants' opinions of their lighting compared to other offices, both before and after the move. Compared to what they experienced in other office buildings prior to the questionnaire, most DOI respondents consider both their daylight and electric light to be "better" or "about the same" in Building 48 (Figure 13). Ratings for "better" increased with the move to Building 48.

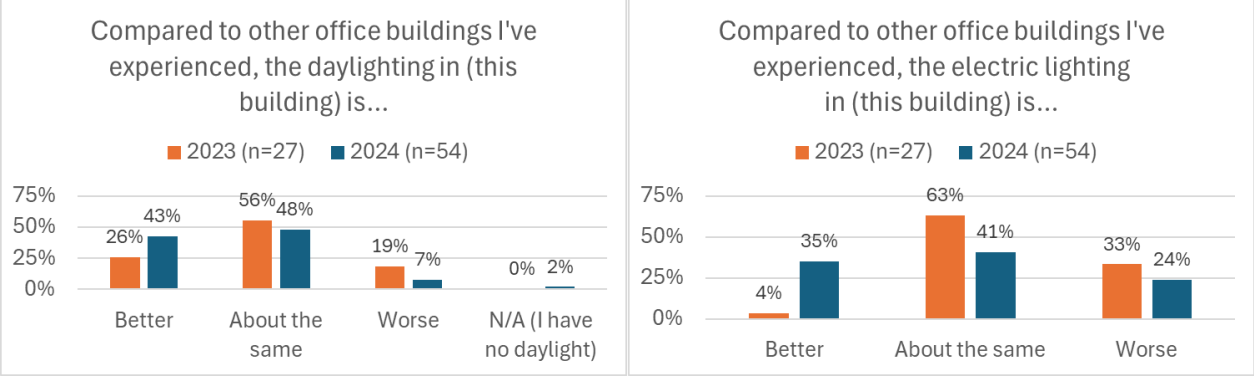

Figure 13. Daylight (left) and electric light (right) compared to other office buildings.

In terms of the overall amount of electric light and daylight, almost half (48%) consider the amount of light to be "about right" (Figure 14). However, 37% reported that Building 48 provides more light than they need, which is an increase from 22% in DOI's previous buildings.

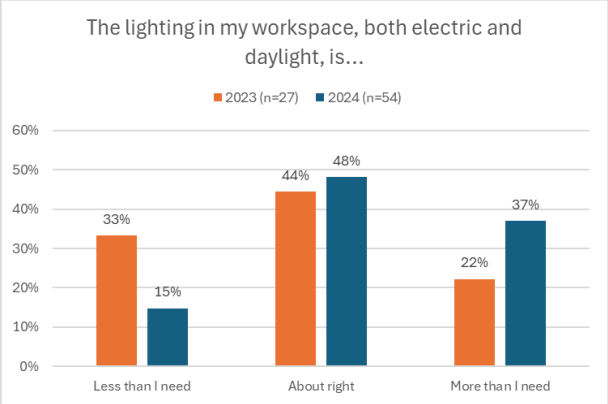

Figure 14. Amount of electric light and daylight, before and after move to Building 48.

As shown in Appendix B, eleven cubicle occupants in Building 48 commented that conditions were too bright, while six commented that conditions were too dim. Four people commented that there was too much light fluctuation in light levels; as discussed in the July 2024 case study, [10] there were a few locations in Building 48 in which the improper position of daylight sensors caused them to repeatedly dim light levels up and down. Questionnaire comments indicate that improper sensor positioning may not yet have been corrected in a few areas of Building 48.

There were also occupant comments about heat/sunshine; the LHRC observed that, when the architect's photographer, who was on-site taking photographs during the time of the LHRC's evaluation, was opening window shades on the west side of the building, some of the occupants nearby objected. In the DOI's previous building, the occupants also kept the blinds closed due to heat and glare from the sun.

In the DOI's previous buildings, occupants of private offices expressed concern about moving to offices without windows; after the move to Building 48, there was only one comment about the lack of daylight in the private offices. In other comments, private office occupants appreciated having control over their own electric lighting.

Sleep Disturbance and Sleep-Related Impairment

Both "average sleep disturbance" and "sleep related impairment" did not change substantially with the move to Building 48 (Figure 15); two-tailed, two sample unequal variance t-tests showed non-significant differences for both sleep disturbance (p=0.34) and sleep related impairment (p=0.73) scores. These scores are similar to typical for the general population ("50").

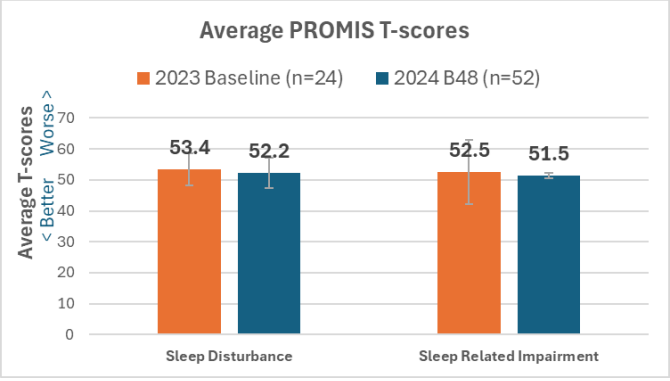

Figure 15. Average sleep disturbance and sleep related impairment before and after move to Building 48.

DISCUSSION

Questionnaire responses showed that remote work reduced with the move to Building 48. Nonetheless, the majority of those who responded to the questionnaire were in Building 48 for just three days per week, and very few were on site all five days. Working in a circadian effective lighted environment for only three days per week may not be sufficient to promote circadian entrainment and thus healthy sleep.

While the occupants tended to rate Building 48 as brighter than their previous office, measurements showed lower light levels at the eye. Rea et al. [11]discuss several appeals of windows; despite added costs, windows provide daylight and view. However, windows do provide sunlight, which occupants actively oppose. It is possible that the tall windows and mesh shades at Building 48 provided a view which the Building 48 occupants interpret as "bright." High luminance windows could be interpreted as "bright" even if they do not translate to high illuminances at the eye.

Based on the engineer's calculations, the researchers expected similar or higher light levels in Building 48, compared to DOI's previous buildings. In our Lighting Commissioning Visit Report (July 2024), [12] we discussed a few possible contributors to lower light levels (updated below).

We pointed out that the engineer's placement of the calculation plane in the photometric calculation model was more optimistic than the reality of the specific desk locations in Building 48. Desks were J-shaped, so the location where work is focused (computer monitors) was partially shaded by furniture walls (Figure 16, lower left) in the location where we measured. Also, it is possible that some desks had their exposure to skylight partially blocked by overhead obstructions such as conduit (Figure 16, right). Furniture orientation and other obstructions should correctly be taken into account when designers are calculating CS.

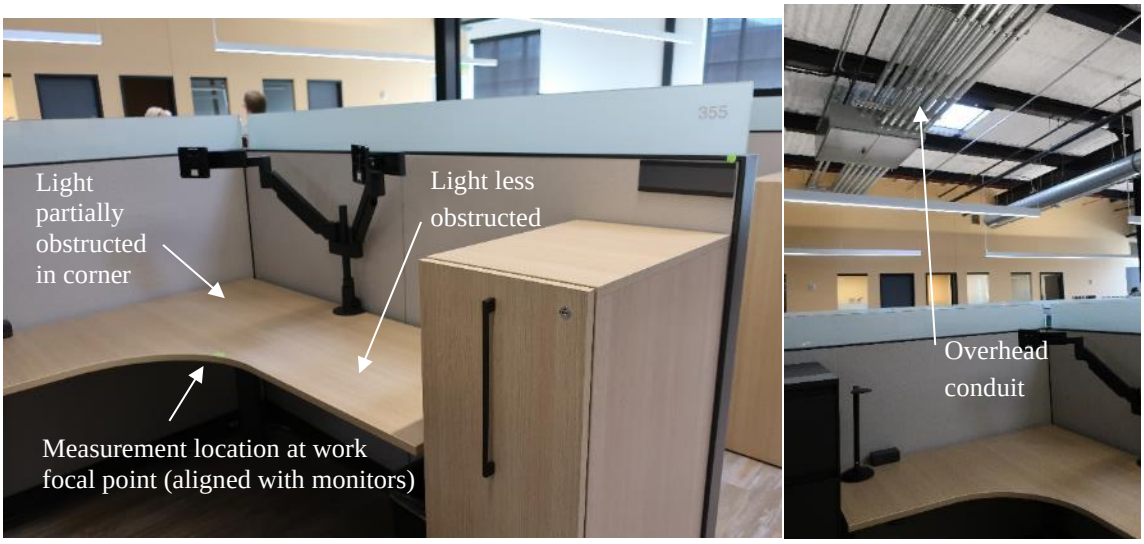

Figure 16. Light obstructed by furniture at work focal point (left); example of overhead conduit obstructing daylight from the skylight (right).

Before move-in, desks were extended to standing position, thus the computer monitor armatures protruded above the cubicle walls to block some of the daylight from reaching the eye; in the reporting from our July 2024 commissioning visit, [12] we pointed out that protruding computer monitors from standing height desk positions could have contributed to reduced light levels. However, after move-in, most desks (and therefore monitors) were adjusted to seated position; nonetheless, daytime CS measurements remained lower than the target. This indicates that adjustments to desk height were not a major contributor to lower than calculated light levels.

While the ceilings in Building 48 were painted a white color, several structural members (i.e., beams and columns) and window shades were black in color. In the July commissioning report, [12] we pointed out that dark surface reflectances may have reduced light reflection in Building 48. However, subsequent analysis of the engineer's photometric model showed that it did consider dark surface reflectances, so this is likely not a major contributor to lower than expected light levels. Other explanations were considered (below).

Daylight sensors in Building 48 may be slightly reducing electric light output at desks deep in the floorplate. However, data collected in October 2024 indicate that adjusting sensor setpoints is not expected to substantially increase light levels at the eye. Nighttime measurements showed the average contribution of electric lighting at the eye was CS = 0.12, which confirms that the electric lighting alone was not designed to provide CS ≥ 0.3. As discussed in our design case study report (July 2024), [10] the electric lighting was designed to provide lighting power densities (LPDs) 40% below model energy code, [13] as was required by Tier 2 of the P100 standard as of 2020. Due to these aggressive lighting energy performance goals, the designers planned to rely on daylight rather than electric lighting to meet circadian light targets for Building 48.

As discussed in the design case study report, [10] the architects added skylights to the design of Building 48 to augment daylight exposure deep in the floor plate. However, the October evaluation showed that only the desks closest to the windows in Building 48 met the CS target; the skylights did not provide the expected light levels at the eye for most desks.

During the October 2024 site evaluation, a GSA staff member revealed that in the final installation, translucent protective covers were added to the exterior of skylights to prevent personnel servicing systems on the roof (such as the photovoltaic system) from falling through skylights. The additional translucent skylight covers likely reduced light levels significantly below those calculated by the design team. While the engineer's photometric calculation model did assume a translucent, not clear, skylight, we hypothesize that the additional skylight covers obstructed daylight to a greater extent than those modeled. Future design teams should ensure that late-stage decisions about glazing and shading are used to update photometric models.

This evaluation showed another reason why daylight levels may have been lower than expected; some occupants prefer to keep mesh window shades closed at all times (Figure 5 and Figure 17). Comments on the questionnaire indicated concerns about glare from the sun, even when shades are down. ("The sun comes in between the shades and I cannot see my screens," and "I sit next to a window but the shades are down because the sunlight hits my face in the mornings and others prefer them down the entire day because of privacy concerns.")

Figure 17. Mesh window shades kept closed for reasons of glare and privacy concerns; closed mesh shades do provide view to exterior.

The questionnaire comment about privacy raises an additional point for future designers to consider; if people are able to walk near the exterior of an office building with ground floor windows, those interior occupants may prefer to close shades for privacy, even if protection from solar glare is not necessary. For ground floor personnel, window shades may be kept closed for privacy reasons.

Conversely, even closed mesh shades do permit view to the exterior. In the DOI's old buildings, 2023 occupants of private offices expressed concern about moving to offices without windows; however, after the move to Building 48, there was only one comment about the lack of daylight in the private offices. It is possible that part of the appeal of windows is view to the exterior; while private offices did not have a direct view to the exterior, they did have a view to the open plan spaces which did have a view to the exterior even with closed mesh shades (Figure 17).

Even in a climate such as Colorado's with ample daylight availability, the amount of daylight reaching the eye at most Building 48 desks was insufficient to deliver circadian effective light. To ensure CS targets are met regardless of variable daylight ingress and variable use of window shades, designers of future projects may wish to explore glare-free electric lighting solutions positioned at the work focal point of each desk. Localized lighting solutions can help designers to meet vertical illuminance targets without exceeding stringent lighting power density limits.

As discussed in our July 2024 design case study, [10] the engineers did not expect to meet circadian-effective light targets in the private offices, so they focused on creating common spaces with skylights where private office occupants could move during the day. However, it is not clear that occupants of private offices in Building 48 received that message. We did not observe widespread use of Interact spaces; we observed the Café space being used at mealtimes, but did not observe personnel working there with laptops during business hours.

If future designers rely on a strategy of creating a circadian light "oasis" in their projects, leadership should be brought into that discussion to confirm that both they and their teams support that strategy. For example, in the design stage, management should ask of their teams, "would you be willing to bring a laptop to a secondary location on a regular basis?" It would be important that such an environment managed glare from sunlight and electric light to the extent that digital work would be easily visible. Assuming proper glare control, after move-in, management would need to reinforce a culture supporting the use of such spaces.

It should also be noted that the urge to move to a circadian oasis may be based on judgement of visual illumination needs, rather than non-visual circadian needs. A substantial minority of questionnaire respondents (37%) thought they had *more* light than they needed in Building 48. While possibly true for DOI's visual tasks, non-visual, circadian-effective light needs are greater. Relying on occupant judgement of visual conditions is unlikely to result in successful adoption of a circadian oasis strategy without management reinforcement.

LESSONS LEARNED

The design-build process of integrating daylight and electric light in large projects such as Building 48 present challenges to accurately predict circadian-effective light exposure from the final design.

- This project's design/build team took great pains to ensure that all members were included in design and implementation decisions. However, there were still some late-in-the-process decisions, such as placing translucent covers over skylights, which reduced daylight levels, and compromised the circadian effectiveness of the design. Care should be taken to ensure that daylight apertures, such as skylights, are installed as specified and additional coverings are not added that will reduce light transmission and lower CS levels.
- Photometric calculations should be performed at the furniture's work focal point.

- Photometric calculations should match the final finishes and other obstructions. For example, daylight calculations should include contributors from shading, and conservative assumptions about use of mesh window treatments, especially on the ground floor.
- If designers rely on a circadian light "oasis" rather than providing circadian stimulation at each desk, leadership should be brought into that discussion at the design stage to ensure reinforcement or cultural support for use of those spaces.

RECOMMENDATIONS

If daylight from windows is being relied upon as a primary means of meeting CS goals, building occupants should be informed/educated about the circadian/health benefits of keeping window shades open during times when sunlight is not directly on the windows.

Recognizing the challenges of providing daylight, local lighting solutions at critical work furniture positions can provide a reliable and energy-efficient means of meeting target CS levels. In the future, design teams should consider localized lighting alternatives to overhead lighting and variable daylight.

CREDITS

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APPENDIX A - QUESTIONNAIRE

Returning?

AAA

Icahn School of Medicine at Mount Sinai

Light and Health Research Center

Please answer this questionnaire when you are in the office (not teleworking). Please only answer this questionnaire once.

Demographics:

1 I typically work in Building 48 __ days per week

* must provide value

○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ more than 5

reset

3 My desk is in the following neighborhood:

* must provide value

○ Rocky Mountain ○ Hanging Lake ○ Great Sand Dunes ○ Red Rocks Park ○ Maroon Bells ○ Black Canyon of the Gunnison ○ Pikes Peak ○ Roosevelt National Forest ○ Mesa Verde ○ Colorado National Monument ○ Comanche National Grassland ○ Other

reset

4 I work for the following Directorate:

* must provide value

○ Financial Management ○ Human Resources ○ Office of the Director

reset

5 The window nearest my desk faces:

* must provide value

○ North ○ South ○ East ○ West ○ N/A, no window near me ○ Don't know

reset

6 When I work in the office, my desk is in a

* must provide value

○ Cubicle ○ Private Office ○ Other

reset

Electric Lighting and Daylight:

1 Compared to other office buildings I've experienced, the daylighting in Building 48 is...

* must provide value

○ Much better ○ About the same ○ Worse ○ N/A (I have no daylight in my office)

reset

2 Compared to other office buildings I've experienced, the electric lighting in Building 48 is...

* must provide value

○ Much better ○ About the same ○ Worse

reset

3 The lighting in my workspace, both electric and daylight, is...

* must provide value

○ Less than I need ○ About right ○ More than I need

reset

4 Any other comments about the electric lighting or daylight in your workspace?

Expand

Please respond to each question or statement by marking one box per row.

In the past 7 days...

	Very Poor	Poor	Fair	Good	Very Good
My sleep quality was * must provide value	○	○	○	○	○

reset

In the past 7 days...

	Not at all	A little bit	Somewhat	Quite a bit	Very much
My sleep was refreshing * must provide value	○	○	○	○	○

reset

I had a problem with my sleep * must provide value	○	○	○	○	○

reset

I had difficulty falling asleep * must provide value	○	○	○	○	○

reset

In the past 7 days..

	Not at all	A little bit	Somewhat	Quite a bit	Very much
I had a hard time getting things done because I was sleepy * must provide value	○	○	○	○	○

reset

I had a hard time concentrating because I was sleepy * must provide value	○	○	○	○	○

reset

I felt alert when I woke up * must provide value	○	○	○	○	○

reset

When I woke up I felt ready to start the day * must provide value	○	○	○	○	○

reset

I had difficulty waking up * must provide value	○	○	○	○	○

reset

I still felt sleepy when I woke up * must provide value	○	○	○	○	○

reset

I felt tired * must provide value	○	○	○	○	○

reset

I had problems during the day because of poor sleep * must provide value	○	○	○	○	○

reset

I had a hard time concentrating because of poor sleep * must provide value	○	○	○	○	○	reset
I felt irritable because of poor sleep * must provide value	○	○	○	○	○	reset
I had a hard time controlling my emotions because of poor sleep * must provide value	○	○	○	○	○	reset
I had enough energy * must provide value	○	○	○	○	○	reset
I was sleepy during the daytime * must provide value	○	○	○	○	○	reset
I had trouble staying awake during the day * must provide value	○	○	○	○	○	reset

In the past 7 days...

	Never	Rarely	Sometimes	Often	Always	
I tried to sleep whenever I could * must provide value	○	○	○	○	○	reset
My daytime activities were disturbed by poor sleep * must provide value	○	○	○	○	○	reset

Submit

Save & Return Later

APPENDIX B – BUILDING 48 QUESTIONNAIRE COMMENTS

Cubicle Comments

HEAT, SUNSHINE

- Building becomes very hot when the sun beats down on the windows. The desk lamp gets very hot. Sometimes has a burning smell to it.
- The sun comes in between the shades and I can not see my screens
- Window blinds are sometimes not wide enough to prevent bright light from entering workspace
- I sit next to a window but the shades are down because the sunlight hits my face in the mornings and others prefer them down the entire day because of privacy concerns. (I don't know why they chose to sit there in the first place).

TOO DIM

- Could use a little more lighting in the early morning, but all in all it is okay
- I am in between windows so I get a little less direct light. Some days I wish I had more sunlight.
- I notice a big difference between my cubicle area (rather dark) and the cubicles closer to the window. There are skylights above, but not directly above me. I added a second lamp to my desk so I would have enough light. It seems that the amount of light provided by the overhead electric lights can vary quite a bit during the day and I'm not sure why. Sometimes it feels quite dim, and at other times it is okay. It is never bright at my desk regardless of how sunny the day is. It always feels "subdued" at best.
- The electric lights are very dim at times and there just isn't enough light, even with the shades pulled up. I noticed it goes dim in mornings too.
- If cloudy in the afternoon, it's darker in the area and harder to read computer screen and physical paperwork.
- On cloudy days, it can seem a little dark, but I generally like the lighting. It is much better than the fluorescent lights at the Mansfield building.

TOO BRIGHT

- I am under a skylight and the lights are sometimes too bright when combined with the natural light me and my cubicle neighbors receive and it does hurt my eyes and sometimes cause me to have headaches.
- It's too bright in here and could use with a bit dimmer lights. Now for the people that aren't cave dwellers and like it bright, I am sure they are thriving in this light...
- Sitting one cube away from a window, the overhead lights, and my computer screen is a lot of light to take in and stressing my eyes giving me headaches that make me feel sicks.
- The electric lighting above the cubicles is much too bright, gives me a headache every day
- I've requested the lights above my cube be allowed to be dimmed like other areas and they are still set to what appears to be the highest levels possible. They never dim, never change and no one has worked on them at all.
- The lights are always so bright. Would like them turned down a bit
- The natural daylight is awesome and with the lights on at the same time it's too bright and I often times get a headache when I am there.
- There is an electric light to the right of my desk, and a sky light to the right of my desk. The two light sources are too much for my eyes. I notice my right eye waters and twitches every day I'm in the office, when this was never a problem before. My left eye is not impacted by the lighting because there is no light source to the left of my desk. This why I only have the problem in my right eye, and why I think it's related to the two light sources.

- To me it's just as bright and don't care for it, it could be a little less than it is now. Especially since they sit low from the ceiling and are super bright in certain small hallway areas. The light was also super bright facing you near the elevator when you came up the stairs. I feel like it's the same in other offices. If the lights were higher to the ceiling it would be much better, but they still seem low to me when I walk by them because I'm taller than most people. Honestly, too bright when I show up in the early morning as well. Super bright in the Payroll section when I walk by every morning, my thought is wow these lights are bright. And they don't show off [sic, *shut* off] soon enough when no one is in the area.
- Too bright and cold
- Would be nice for people to have electric lighting turned out or down instead of all lights on all the time.

Too Much Fluctuation

- Lighting is horrible, very dim, and fluctuates wildly throughout the day. Sometimes its so bad that the lights are practically flickering. The desk lamp does not help but to illuminate a small circle on the desk. I would like for there to be a light strip directly over the cubicles instead of over the walkways, or at least lower the height of the lights down some, or at the very least leave them on full power for the whole day.
- I hate how the lights fluctuate going from almost off to extremely bright in a matter of minutes for no reason. The highest level is extremely hard on my eyes and the bar is right above my desk. The large windows and skylights provide more than enough light, can the highest setting for the bars be set to a lower wattage?
- I don't like the light periodically turning on and off. It is very distracting
- The setting to our motion sensor office lights seems to be set at max brightness.

Complement

- The lighting is great! My co-workers and I have come to an agreement that the lights can't be turned off but can be dimmed.

Other comments from cubicle occupants

- No comments about the above (lighting) section. The Sleep Section, I would suggest asking if the responses for the past 7 days are normal or new. Maybe the sleep stuff has nothing to do with the lighting at the building. I just don't sleep well in general.
- The building is cold.
- The lighting often gives me headaches.

Private Office Comments

- Because I am in an office the natural light for me is minimal. There is a skylight just outside, but it doesn't appear to bring in any different lighting compared to the lights. I do think that actual lights are a significant improvement from traditional fluorescent lighting we used to have. Big win there!
- I love the ability to control the lighting in my office.
- Wish the light switch had a "memory" of my dimming. Always starts off way too bright.