Congress Elementary School
(Milwaukee, Wisconsin)
Human Factors Evaluation

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PROJECT OVERVIEW

The Association of State Energy Research and Technology Transfer Institutions, Inc. (ASERTTI) and the National Association of State Energy Officials (NASEO) with the Department of Energy (DOE) and the EnergySmart Schools Program conducted a joint project that encompassed applied research, field testing and technology integration.

The following organizations worked collectively to conduct this research:

- Energy Center of Wisconsin
- Iowa Energy Center
- Lighting Research Center
- Lawrence Berkeley National Laboratory
- Dalhoff & Associates
- Fort Collins Utilities

As part of the overall project there were eight distinct tasks outlined, each with its own set of goals, activities and deliverables. This document was created as part of Task 4: Advanced Daylighting Research.
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**Milwaukee, Wisconsin**

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Evaluation Summary: Congress Elementary School, Milwaukee, WI

The use of Cool Daylighting™ principles at Congress Elementary school creates a pleasant visual environment that is well-accepted by the teaching staff. The extensive use of Venetian blinds and roller shades may, however, have an impact on energy savings. Energy analysis will be addressed by other researchers. The following summarizes the results of the human factors evaluation by the Lighting Research Center (LRC) in September 2003.

This school has two Cool Daylighting "copy" classrooms with special glazing and blinds. One of these two rooms (Room 10) has full photosensor-controlled lighting as well. The third room is a base case (Room 8), with existing windows and electric lighting. All three classrooms face east (see plans, Appendix G). For more information about the site, see "Site Conditions" and appendices, attached.

Researchers from the LRC visited Congress Elementary school in the day and evening in mid-September 2003. The LRC is charged with evaluating the human factors condition at the copy rooms; energy use will be monitored by other parties.

Due to hesitance about subjecting students and teachers to productivity and visibility testing, our human factors study focused on acceptance. We interviewed the teachers who use the rooms with new blinds and tinted windows. There art teacher who regularly uses the base case classroom was away on maternity leave, so very little human factors evaluation was done in that space. We did interview a visiting teacher who was working in room 8.

The LRC attempted to survey the children using a "raise of hands" method. However, since the children were only in the first and second grade, many of the concepts were too complex for the students to understand. We are therefore relying on interviews with the teachers for feedback about acceptance of the new windows and lighting. (Other schools that will be included in this study have older students, which will permit wider use of surveys.)

To support the human factors evaluation, the LRC also measured the photometric conditions in all three classrooms at several times in the day (see Appendix A). The lighting system in Room 10 successfully maintained the design illuminance (500 lux) throughout the day, even exceeding minimum requirements in the morning. As indicated above, the LRC did not attempt to monitor energy use in the space.

In both rooms, the LRC found that blinds tend to be down on the upper “clerestory” windows, thus limiting the amount of available daylight (see Appendix E). Upper blinds were difficult for teachers to access. In each room, blinds must be closed for frequent audio/visual presentations. We noticed one teacher balancing on a chair to access the upper blind controls. Lower blinds were easier to access, but also tended to be left down. These teachers were too busy looking after their students to be willing to adjust the 18 sets of blinds repeatedly. It is understandable, therefore, that blinds tended to remain down or closed. It may be valuable to provide blinds for the clerestory that are easier to access, or perhaps adjust automatically.
Also limiting available daylight was the use of the upper clerestory windows for display of learning aids such as posters. This space had previously been opaque wall, so the teacher was accustomed to using it for display purposes.

Since the photosensors in Room 10 are located in the room (“closed loop”), lighting energy savings in Room 10 may be undermined if blinds and learning aids block daylight.

Proponents of the use of daylighting in classrooms may wish to consider other possible reasons why blinds may be left closed. A visiting teacher reported that she once had a principal who established strict rules about how blinds should be used, so that the school looked tidy and under control from the outside. Keeping blinds closed gives a uniform look of the outside of the building, which is particularly important for schools in economically disadvantaged areas. (Congress School does not have such a policy.) Other view issues were identified in the teacher interviews. Lower blinds may be closed to prevent view from the exterior (and theft) of valuable computers. Also, lower blinds are closed to prevent students from being distracted by exterior gym classes. Before proposing the use of blinds for future projects, it would be valuable to confirm with administrators whether blinds may be used for reasons other than visual comfort. The use of blinds may impact daylight energy savings.

Teachers find the visual environment in the two copy rooms to be comfortable. Neither complained that the new tinted glass looked dark. Both the clerestory and view glass are tinted (18% and 23% visible transmittance). Indeed, LRC researchers found the extreme tinting of the glass to be indistinguishable from clear glazing classroom environments. This is likely due to the fact that all the glazing in the room is tinted; there is no visual cue to actual exterior luminances, so the space actually appears quite cheerful and bright compared to the base case (in which blinds were closed).

Light levels from the new luminaires in Room 10 were equivalent to those with the old lighting in Rooms 8 and 9. In general, the teachers were satisfied with the quantity and distribution of electric light for both the old and the new lighting systems.

There were no complaints of premature failure of the dimmed lamps in Room 10. The teacher enjoyed having a wall box dimmer to occasionally override the light levels. The teacher in Room 10 did not notice the electric lights automatically dimming throughout the day. (Note: The LRC was not able to confirm control settings, or even whether the system was working properly.)

In summary, the use of Cool Daylighting principles at Congress School has provided a visual environment that was acceptable to the teachers. There may, however, be reduced energy savings due to the widespread use of blinds.
Room 8, base case condition

Room 9, new windows with old lighting

Room 10, new windows and new lighting
Site conditions

General:
- See plans, Appendix G
- Inner-city school
- Year-round operation
- Young children, approx. 5-12 years old (K-6)
- Three east-facing rooms studied: one with cool daylighting windows and lighting, one with new windows old lighting, and one base case with old windows and lighting

Architectural:
- No overhang
- East-facing windows
- Continuous windows, not punched openings
- Lower windows are tinted, probably Viracon type VE3-40, 18% visible transmittance (see photo); feedback from Viracon corresponds to field measurements (see Appendix D)
- Upper clerestory windows are tinted as well Viracon VE3-55, 23% visible transmittance
- Upper blinds are white Venetian blinds
- Lower blinds are black perforated roller shades
- Lowest segment of lower windows is operable with a screen that reduces transmittance

New lighting:
- Pendants with 32” stem, with perforated metal reflector “wings” that can be opened to allow uplight on the ceiling; most were in open position. (The same luminaire was used at Zach Elementary School. See this separate report.)
- Two lamps in cross section, four lamps per eight-foot luminaire
- Dimming ballasts
- Two fixtures per “bay,” three bays per room
- The three fixtures closest to window are controlled by one photosensor built into the end of one fixture, facing downward (see photo)
- The three fixtures in the rear of the room are controlled by a second photosensor, mounted in same manner
- New lighting has different layout than old lighting, but seems to use the same number of lamps
Appendix A: Teacher/Staff Interviews

Teacher, Room 10 (east-facing room with new windows, blinds, and lighting)

General:
• The teacher had worked in this room before and after the renovation.
• Teachers have been encouraged to move the artwork to the lower windows from the upper windows. This teacher feels the upper windows did “eat up” her display space; in the past she used this as mounting space because it was opaque.
• The chalk board on north side is not used.

Blinds:
• Most of the time the teacher operates the blinds, not the students.
• If she doesn’t close the upper blinds, the students squint a little.
• In mornings, all blinds are closed because eastern exposure is too sunny.
• The teacher stated that she puts top blinds down and open in morning to reflect light off ceiling (Note: Most appeared to be closed during our morning visit. See “Window Blinds,” Appendix E.)
• This class uses one window for “calendar” when they log weather.
  o Due to black perforated roller blinds on lower windows, every day the students think the weather is “overcast.”
  o For this reason the teacher instructs the appointed weather monitor student to walk over to one window and look out at the sky.
  o The lower blinds on this one window seem to remain open.
• In afternoon after recess, the teacher opens the blinds, depending on the weather.
• Sometimes the lower blinds are closed not for lighting reasons, but to block the view of gym classes, which are distracting to the children.
• The teacher says usually the middle three window (the center “bay”) blinds are more frequently adjusted.
• The teacher rarely opens the blinds next to the computer, even though the computer is not working right now.

Lighting:
• The white board in the rear of the room is the only dark spot. Opening the wings on the fixture has helped.
• The teacher uses the dimmer override to turn down the lights to the lowest setting during “DOL time.” DOL is Daily Oral Language, when they work on grammar, sentences, etc. She uses the overhead projector during DOL. This requires low ambient light levels.
• The teacher likes the lighting better now that she has learned to open the “flaps” on the light fixtures. Open is better for lighting. (Note: Opening flaps creates uplight.)
• The teacher likes dimming as an improvement to just shutting off lights. When the students write and she plays classical music, they say “ooo” when she dims the lights. After lunch she dims the lights to calm the children down when they are overly energetic. Lights are not turned off, but are dimmed to the lowest setting. (LRC nighttime measurements showed that the minimum dim level was 20% of full output.)
Teacher, Room 9 (new windows, old lighting)
- This room has only the special windows and blinds, but not the special new lighting.
- The teacher says she leaves blinds all open on top. However, the LRC noted that the upper blinds were down, and many were closed (see Appendix E).
- LRC researchers observed that the teacher had to stand on a chair to close one upper blind during the morning class.
- Teacher keeps the black perforated (lower) blinds raised to the level of the operable window mullion.
- See survey (Appendix B) for other comments.

Room 8, visiting mentor in control room (old windows, blinds, and lighting)
- This room is not used by a regular teacher or class; on the day we visited it was being used for speech therapy. There was also evidence of use for art instruction.
- This visiting mentor has been an educator since 1968.
- The mentor doesn’t think lighting is very important unless it is very bad.
- The mentor turns off the lights after recess to calm the students down.
- The blinds are closed for property security after hours.
- Keeping blinds closed gives a uniform look of the outside of the building, which may be important to some principals because it reflects on the overall administration of the building. This mentor once had a principal who established strict rules about how blinds should be used, so that the school looked tidy and under control from the outside.

Henry, maintenance specialist
- Henry works second shift.
- Henry changes light bulbs, among other duties.
- Henry began work there in February 2003; his predecessor was present for installation of the new lighting and windows, not he.
- He uses a spot relamping strategy.
- No lamps have failed since February 2003 (seven months).
- He has the electrician’s contact info if necessary.
- Class 10 bulbs are OSI T8 3500K 835/XP.
- The old, existing fixtures use one lamp in cross section.

Meeting with school district administrators including Tom Chojnacki, Manager of Environmental Services
- Administrators are trying to increase school stock in inner city to reduce busing costs.
- The schools do have air conditioning. The schools are in session 180 days a year, and do operate in the summer. They have more breaks throughout the year that are longer.
  - Air conditioning is unusual in Milwaukee. Thirty percent are air-conditioned, although this is increasing.
  - Air conditioning is a requirement of year-round schooling.
  - The district is moving towards more year-round schooling as a standard.
- The school district would have to see results of energy monitoring before they decide to revise the lighting and windows in more schools.
  - An energy case study is desirable to compare these three rooms, the control room, windows only, and windows + lighting.
• Teachers were not told how to use shades and fixtures, which would be of value in the future.
  o Dean Schultzbank, WE Energies account manager commented that he thinks teachers should be influencing design. Not to have influence could be frustrating to teachers. The teachers need to be included in the design process.
  o The teacher loses the upper window space, which was a type of bulletin board. The teacher complained right away (see interview).
• This design and installation process has gone on for 2+ years.
  o School administrators toured the Appleton, Wisconsin school copy room.
• Teachers change rooms from one year to the next.
• The east-facing room orientation was chosen by Steve Ternoey, consultant to Energy Center of Wisconsin.

Follow-up telephone interview with Principal Jacqueline Patterson
December 11, 2003

• Room 8 is used primarily for art instruction
• The art teacher is on maternity leave until February 2004 (at least)
• There have been substitute teachers, but not ones who have worked in the space for a long period of time, who could comment on multiple seasons and weather.
• Principal Patterson cannot offer an e-mail address or other contact information for the art teacher in the interim
• Principal Patterson says that blinds are in fact opened during class, as part of the teaching methodology
• There is no policy at this school to keep blinds closed or opened
• She has heard positive feedback from the teachers in rooms 9 and 10 about the new windows and lighting
### Appendix B: Teacher Survey Answers

See Appendix C for blank version of survey. Similar surveys were used at the other schools.

<table>
<thead>
<tr>
<th></th>
<th>Teacher, Room 10</th>
<th>Teacher, Room 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower windows, when sunny:</td>
<td>Comfortable</td>
<td>Comfortable</td>
</tr>
<tr>
<td>Lower windows, when cloudy:</td>
<td>Dark, when shades down</td>
<td>Comfortable</td>
</tr>
<tr>
<td>Upper windows, when sunny:</td>
<td>Comfortable</td>
<td>Comfortable</td>
</tr>
<tr>
<td>Upper windows, when cloudy:</td>
<td>Comfortable</td>
<td>Comfortable</td>
</tr>
<tr>
<td>Lower blinds block ____ of the light, AM:</td>
<td>All</td>
<td>A little</td>
</tr>
<tr>
<td>Lower blinds block ____ of the light, PM:</td>
<td>Half</td>
<td></td>
</tr>
<tr>
<td>Upper blinds block ____ of the light, AM:</td>
<td>Most</td>
<td>A little</td>
</tr>
<tr>
<td>Upper blinds block ____ of the light, PM:</td>
<td>Most</td>
<td></td>
</tr>
<tr>
<td>It is _____ too dark:</td>
<td>Never, except at dry erase white board</td>
<td>Never</td>
</tr>
<tr>
<td>There is _____ too much light:</td>
<td>Never; shades make it acceptable… if there were no shades, there would be too much light</td>
<td>Sometimes, due to weather condition. She shuts off lights for quiet time or &quot;time out&quot;</td>
</tr>
<tr>
<td>Do you notice the electric lights dimming up and down?</td>
<td>No</td>
<td>N/A… didn't have special lighting</td>
</tr>
<tr>
<td>Do you find the dimming distracting?</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Do you find the electric lighting uncomfortably bright?</td>
<td>No</td>
<td>No (has existing lighting)</td>
</tr>
<tr>
<td>Compared to other classrooms at other schools, the lighting in this classroom is ____</td>
<td>Better, because it doesn't seem as glaring</td>
<td>About the same (has existing lighting)</td>
</tr>
<tr>
<td>Comments</td>
<td>See report</td>
<td>She likes the perforated roller shades</td>
</tr>
</tbody>
</table>
Appendix C: Daylighting Evaluation Survey Form (Blank)

Room # _______  Teacher: ______________ Date: ______________  n = _______ students

When you look at the LOWER windows, you find them:

When sunny:>>>  Too dark ____  Dark____  Comfortable___  Bright____  Too bright____

When cloudy:>>>  Too dark ____  Dark____  Comfortable___  Bright____  Too bright____

When you look at the UPPER windows, you find them:

When sunny:>>>  Too dark ____  Dark____  Comfortable___  Bright____  Too bright____

When cloudy:>>>  Too dark ____  Dark____  Comfortable___  Bright____  Too bright____

When you use this classroom, how much of the light are the LOWER BLINDS blocking?

All ____  Most _____  Half_____  A little_____  None_____

When you use this classroom, how much of the light are the UPPER BLINDS blocking?

All ____  Most _____  Half_____  A little_____  None_____

How frequently is it TOO DARK in this classroom?

Never____  Sometimes ___  Often____  Always ___

(If “Sometimes” or “Often”) This was this due to the:  Type of activity  Weather condition

Please describe ______________________________________________

How frequently is there TOO MUCH LIGHT in this classroom?

Never____  Sometimes ___  Often____  Always ___

(If “Sometimes” or “Often”) This was this due to the:  Type of activity  Weather condition

Please describe ______________________________________________

Do you notice the electric lights automatically DIMMING UP AND DOWN?  Yes ____  No ____

Do you find the dimming DISTRACTING?  Yes ____  No ____

Do you find the electric lighting uncomfortably bright?  Yes ____  No ____

Compared to classrooms at other schools, the lighting in this classroom is_____.

Better____  About the same ____  Worse ____

Any comments about the windows, blinds, or electric lighting in this classroom?
Appendix D: Window Luminance and Transmittance

LRC researchers took luminance measurements during actual class time to compare to the teachers’ reports of visual comfort levels. Researchers tried to minimize disruption to the class by measuring the two states that are primarily used, upper blinds down/open and upper blinds down/closed (point a). Since teachers do open lower roller shades, points b and c include shades down and up. Electric lights were on during measurements.

In Room 10, LRC researchers also attempted to verify window transmittance by holding an illuminance meter against the glass, compared to illuminance at an open window.

Window measurement points

Room 8 Luminances (Room has old roller shades, old lighting)
Approx. 2:40 p.m., partly cloudy

<table>
<thead>
<tr>
<th>Blinds Closed</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point a: N/A</td>
<td>Top segment opaque, no glass</td>
</tr>
<tr>
<td>Point b: 14,000 cd/m²</td>
<td>View of white cloud</td>
</tr>
<tr>
<td></td>
<td>2900 cd/m²</td>
</tr>
<tr>
<td>Point c: 1600 cd/m²</td>
<td>View of asphalt blacktop</td>
</tr>
<tr>
<td></td>
<td>Note: Blinds seem to remain closed; this room is not occupied consistently</td>
</tr>
</tbody>
</table>

Room 9 Luminances (Room has new blinds and windows, old lighting)
Approx. 10:30 a.m., mostly sunny

<table>
<thead>
<tr>
<th>Blinds Down/Closed</th>
<th>Blinds Down/Open</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point a: 350 cd/m²</td>
<td>890 cd/m²</td>
<td>Upper blinds always down</td>
</tr>
<tr>
<td>Point b: 70 cd/m²</td>
<td>1020 cd/m²</td>
<td>Lower blinds up when open</td>
</tr>
<tr>
<td>Point c: 19 cd/m²</td>
<td>350 cd/m²</td>
<td>Lower blinds up when open</td>
</tr>
</tbody>
</table>
### Room 10 Luminances
(Room has new blinds, new windows, new lighting)

Approx. 9:50 a.m., sunny

<table>
<thead>
<tr>
<th>Point</th>
<th>Blinds Down/Closed</th>
<th>Blinds Down/Open</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>732 cd/m²</td>
<td>1266 cd/m²</td>
<td>White blinds; clear sky view</td>
</tr>
<tr>
<td>b</td>
<td>82 cd/m²</td>
<td>1571 cd/m²</td>
<td>Black blinds; clear sky view</td>
</tr>
<tr>
<td>c</td>
<td>25 cd/m²</td>
<td>250 cd/m²</td>
<td>Black blinds; blacktop view</td>
</tr>
</tbody>
</table>

Approx. 2:20 p.m., partly cloudy

<table>
<thead>
<tr>
<th>Point</th>
<th>Blinds Down/Closed</th>
<th>Blinds Down/Open</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>66 cd/m²</td>
<td>1800-2100cd/m²</td>
<td>View of cloud</td>
</tr>
<tr>
<td>b</td>
<td>70 cd/m²</td>
<td>3400-4000cd/m²</td>
<td>Black blinds; cloud view</td>
</tr>
<tr>
<td>c</td>
<td>15 cd/m²</td>
<td>150-200 cd/m²</td>
<td>Black blinds; blacktop view</td>
</tr>
</tbody>
</table>

### Room 10 Window Transmittance Verification

Approx. 9:50 a.m., sunny

<table>
<thead>
<tr>
<th>Point</th>
<th>Illuminance</th>
<th>Transmittance</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>14,500 lx</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>14,800 lx</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>10,300 lx</td>
<td>21%</td>
<td>This window has a screen</td>
</tr>
<tr>
<td>Point c, opened window</td>
<td>49,000 lx</td>
<td>100%</td>
<td>This window has a screen</td>
</tr>
</tbody>
</table>

Approx. 12:05 p.m., sunny

<table>
<thead>
<tr>
<th>Point</th>
<th>Illuminance</th>
<th>Transmittance</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>2,600 lx</td>
<td>18%</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>2,900 lx</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>2,200 lx</td>
<td>15%</td>
<td>This window has a screen</td>
</tr>
<tr>
<td>Point c, opened window</td>
<td>14,200 lx</td>
<td>100%</td>
<td>This window has a screen</td>
</tr>
</tbody>
</table>

Approx. 2:20 p.m., partly cloudy

<table>
<thead>
<tr>
<th>Point</th>
<th>Illuminance</th>
<th>Transmittance</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>2,400 lx</td>
<td>26%</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>2,360 lx</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>1,450 lx</td>
<td>16%</td>
<td>This window has a screen</td>
</tr>
<tr>
<td>Point c, opened window</td>
<td>9,300 lx</td>
<td>100%</td>
<td>This window has a screen</td>
</tr>
</tbody>
</table>
Appendix E: Window Blind Use During Visit

In rooms 9 and 10 (those with new windows), there are 18 sets of blinds to adjust, 9 upper blinds and 9 lower blinds.

The graph below shows that nearly all windows in the Cool Daylighting demonstration have window blinds down, and most are fully closed. This will likely affect energy savings from photosensor-controlled electric lighting.

![Use of Blinds Graph]

*Use of Blinds*
Congress Elementary School, Milwaukee, WI
(Rooms 9-10, East-facing)

- Blinds down and CLOSED
  - Clerestory Windows: 64%
  - View Windows: 85%
  - 31% Clerestory Windows
  - 0% View Windows (Not applicable for roller shades)
  - 6% Clerestory
  - 15% View Windows
Appendix F: Horizontal Illuminance Measurements

Horizontal illuminances were measured with blinds as they are actually used by teachers (usually blinds were closed). Room 10 has photosensor-controlled dimming. Since the LRC’s responsibility was human factors evaluation, no attempt was made to monitor electric light power levels during the day.

Refer to Appendix G for measurement points.

<table>
<thead>
<tr>
<th>Room 10: New windows and new lighting</th>
<th>Room 9: New windows, old lighting</th>
<th>Room 8: Base case, old windows, old lighting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Point A</strong></td>
<td><strong>Point B</strong></td>
<td><strong>Point C</strong></td>
</tr>
<tr>
<td>Desk 9:00 a.m., sunny</td>
<td>Only one lower blind open</td>
<td>1030 lx</td>
</tr>
<tr>
<td>23&quot; 12:05 p.m., now partly cloudy</td>
<td>610 lx</td>
<td>602 lx</td>
</tr>
</tbody>
</table>

Room 10: One lower blind open for weather monitoring
Room 9: All lower blinds open to lower window
Room 8: Blinds always closed
Appendix G: Site Plan and Horizontal Illuminance Measurement Points

(See Appendix F for illuminance measurements.)
Appendix H: LRC Contact Information

The following parties can be contacted for more information as follows:

Lighting Research Center
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(518) 687-7100

Project Manager, Site Evaluator, Report Author:  Jennifer Brons

Site Evaluator:  Julle Oksansan, visiting scholar

Associate Director, Daylighting Expert:  Russell Leslie

Human Factors Methodology Development:  Peter Boyce, PhD
                                            Yukio Akashi, PhD

Publication Editing and Layout:  Dennis Guyon

Researchers from LRC wish to express their appreciation to the following individuals for their assistance in the evaluation at Congress School:

- Thomas Chojnacki, Manager Environmental Services, Milwaukee Public Schools
- Jacqueline Patterson, Principal, Congress Elementary School