



Senior Thesis Final Presentation
University of California, Riverside Student Recreation Center
Daniel MacRitchie
04/10/2013

Introduction

Entrance

Lobby

Daylighting Analysis

Photovoltaic Analysis

Structural Analysis

Conclusion

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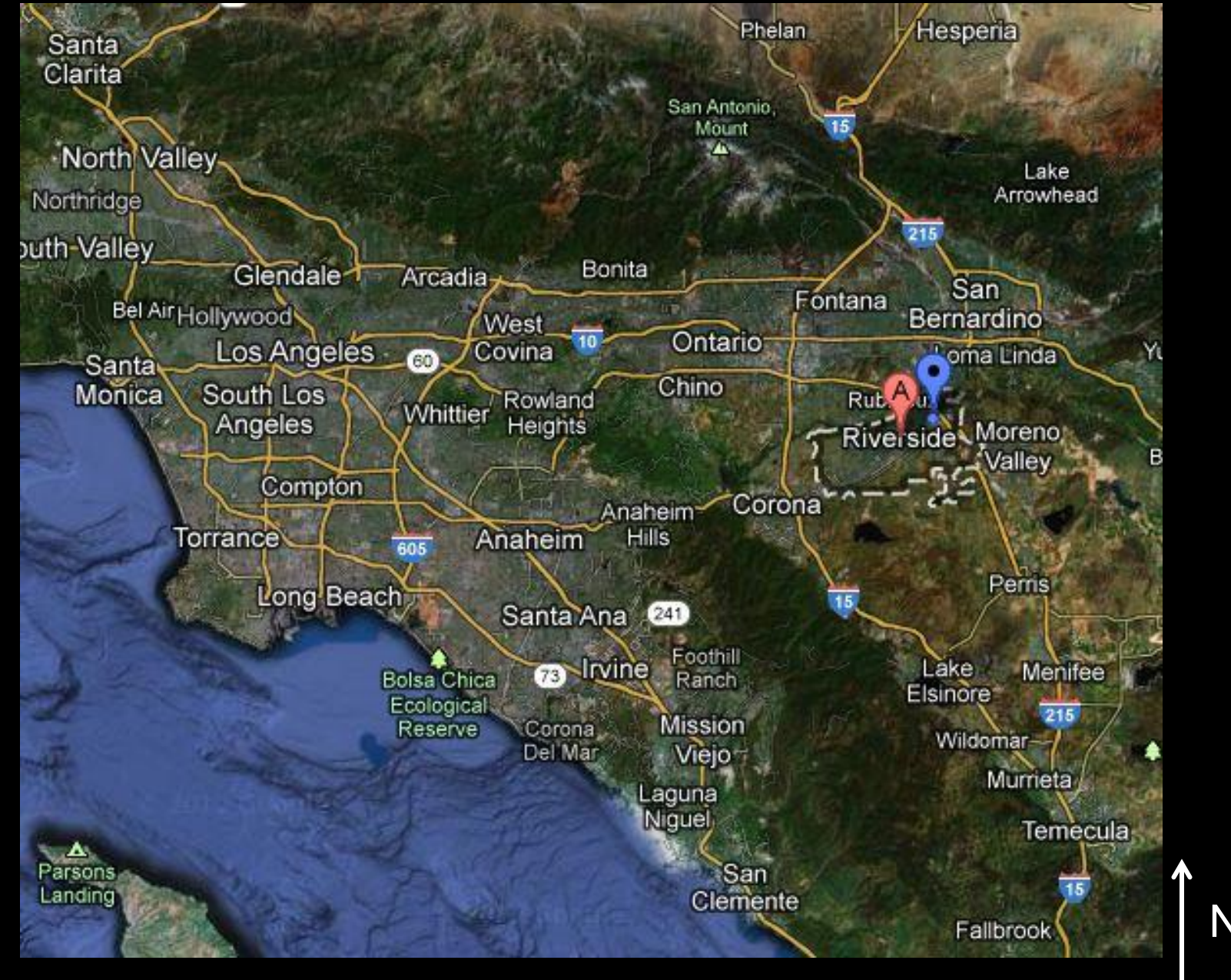
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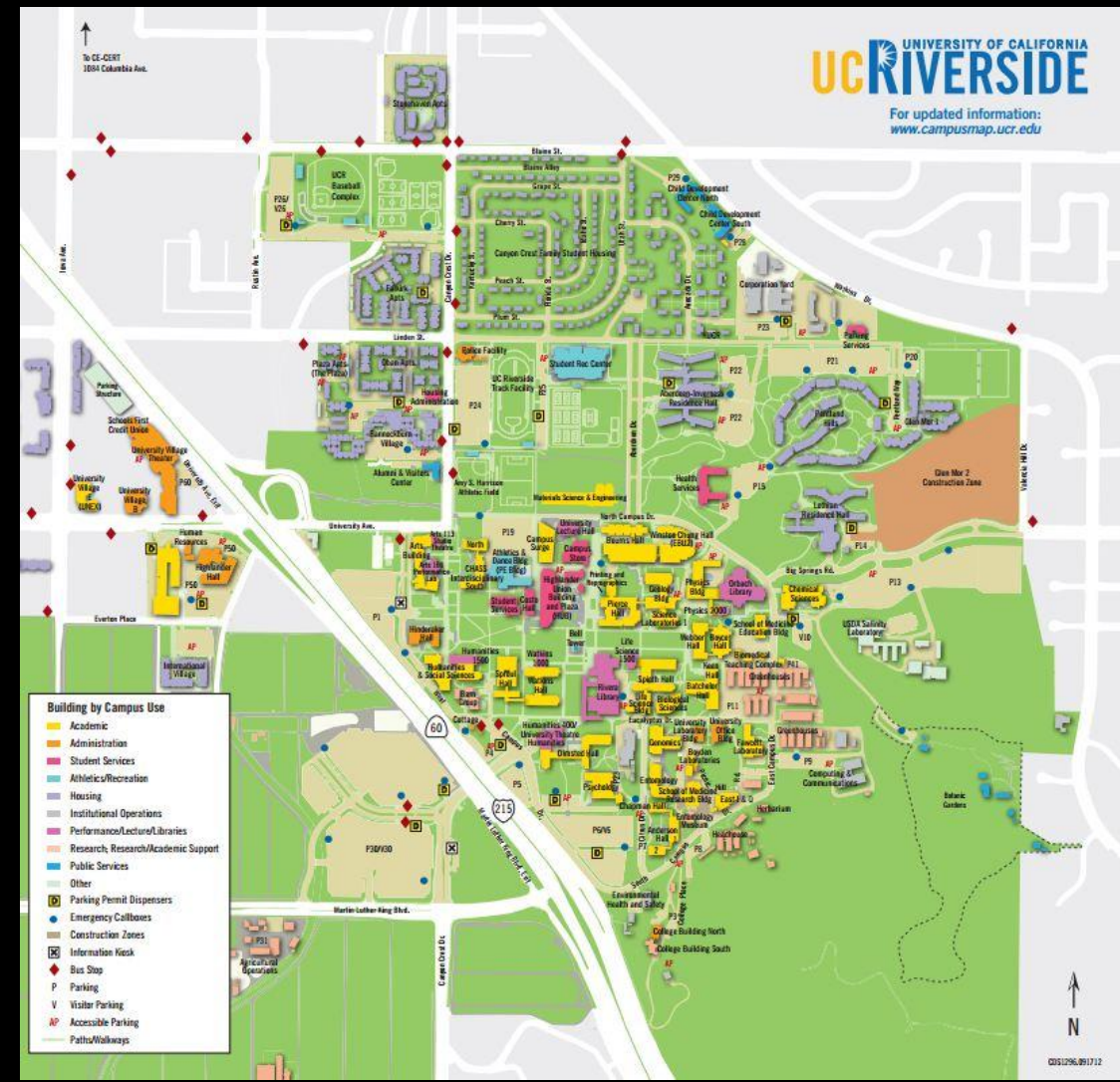
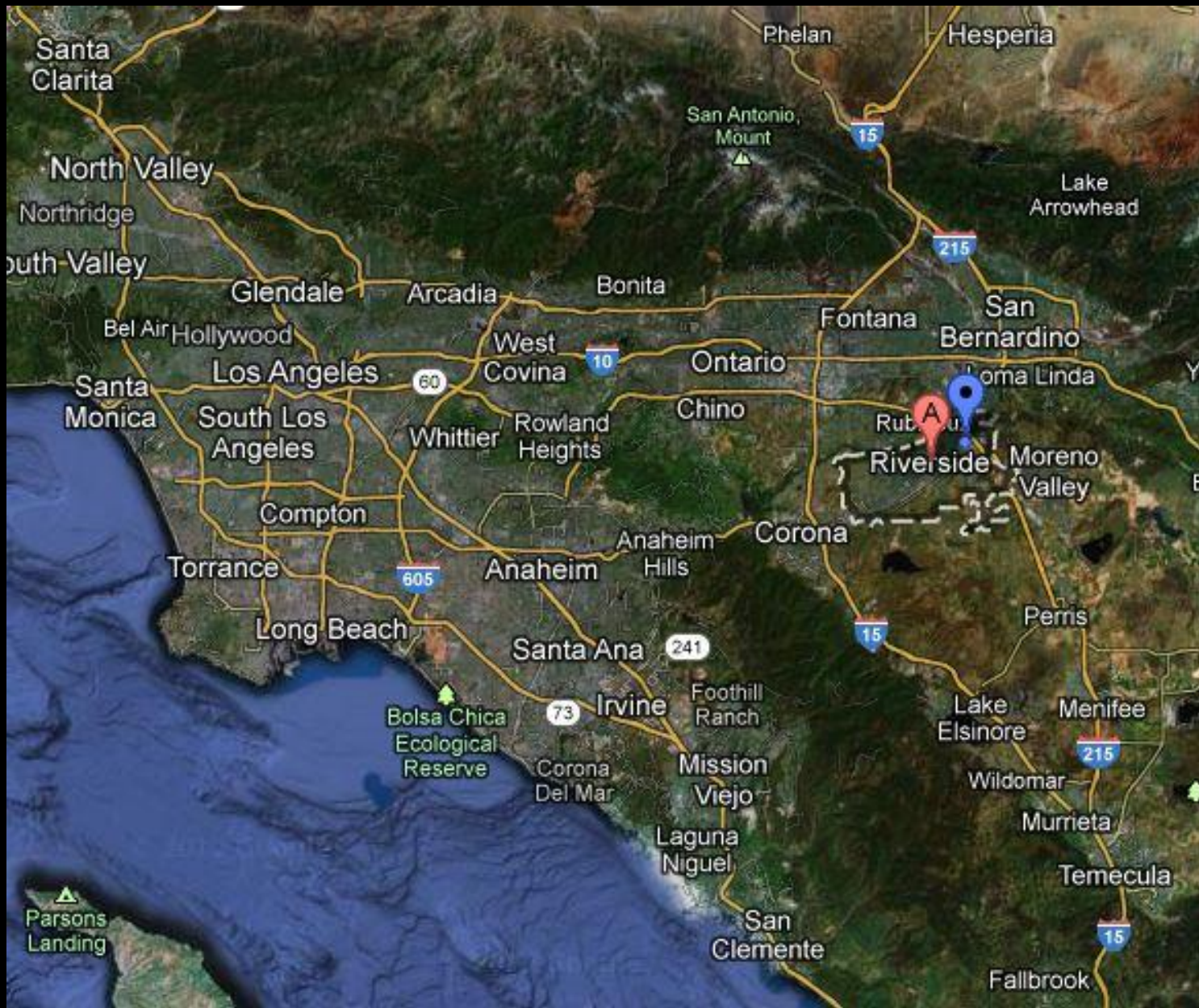
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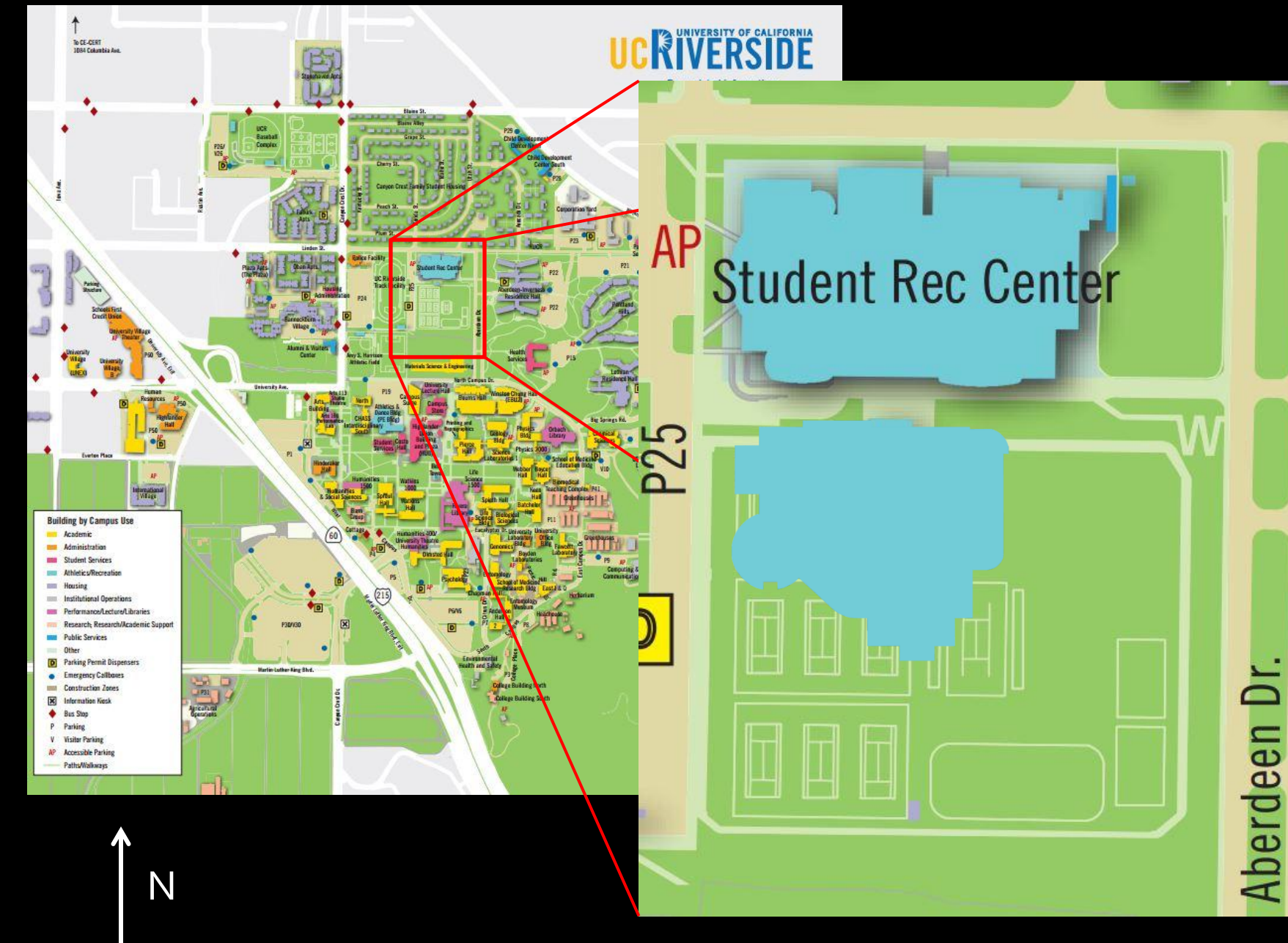
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Building Information

- Location: Riverside, CA
- Renovation: 16,000 SF
- Expansion: 80,000 SF
- Stories: Two
- Building Cost: \$36.9 Million

Building Function

- Renovate exercise areas to offices
- Gymnasium
- Multipurpose rooms
- Weight rooms
- Exercise rooms
- Rock climbing wall
- Outdoor pool
- Classrooms
- Spa
- Massage therapy rooms



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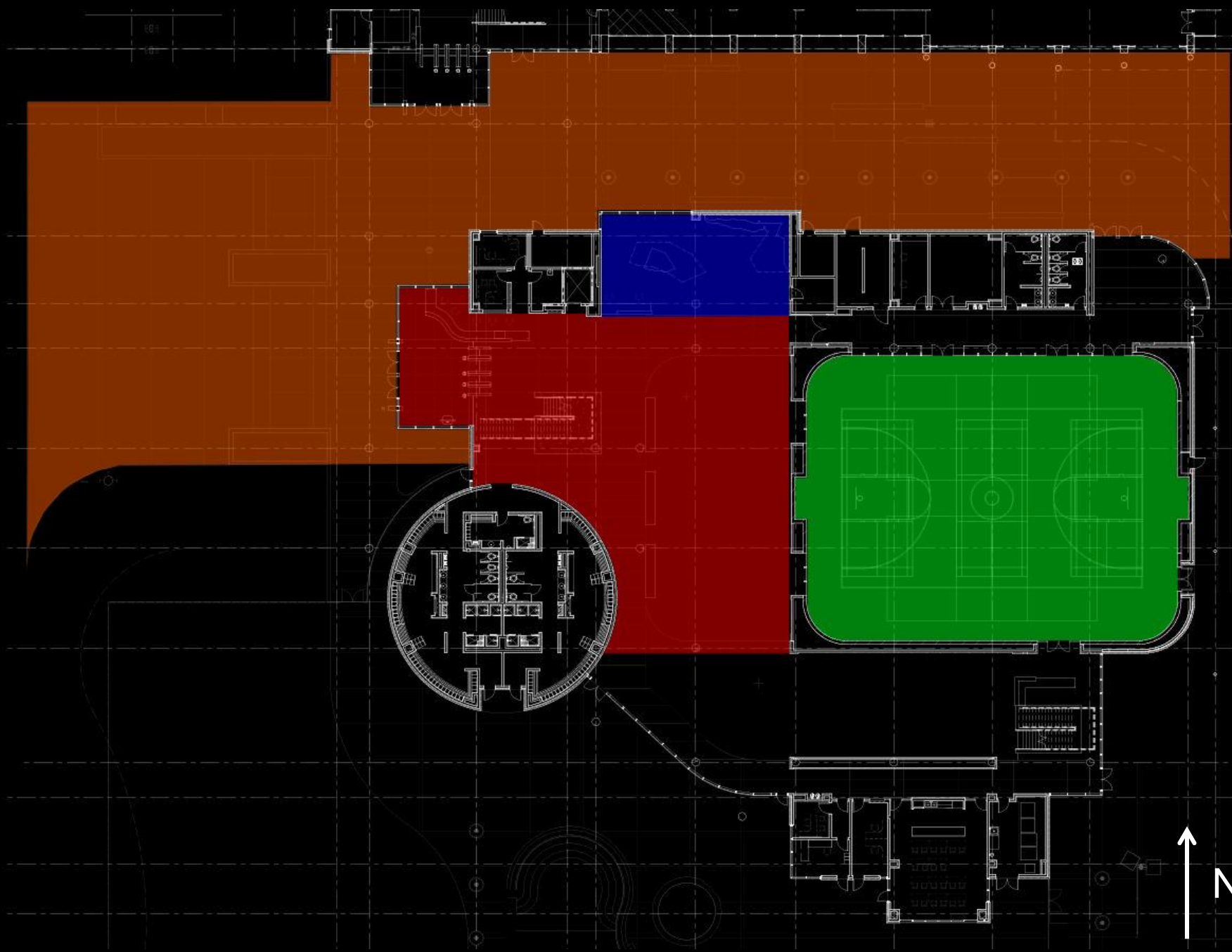
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- Entrance
- Lobby
- Rock Wall
- Gymnasium

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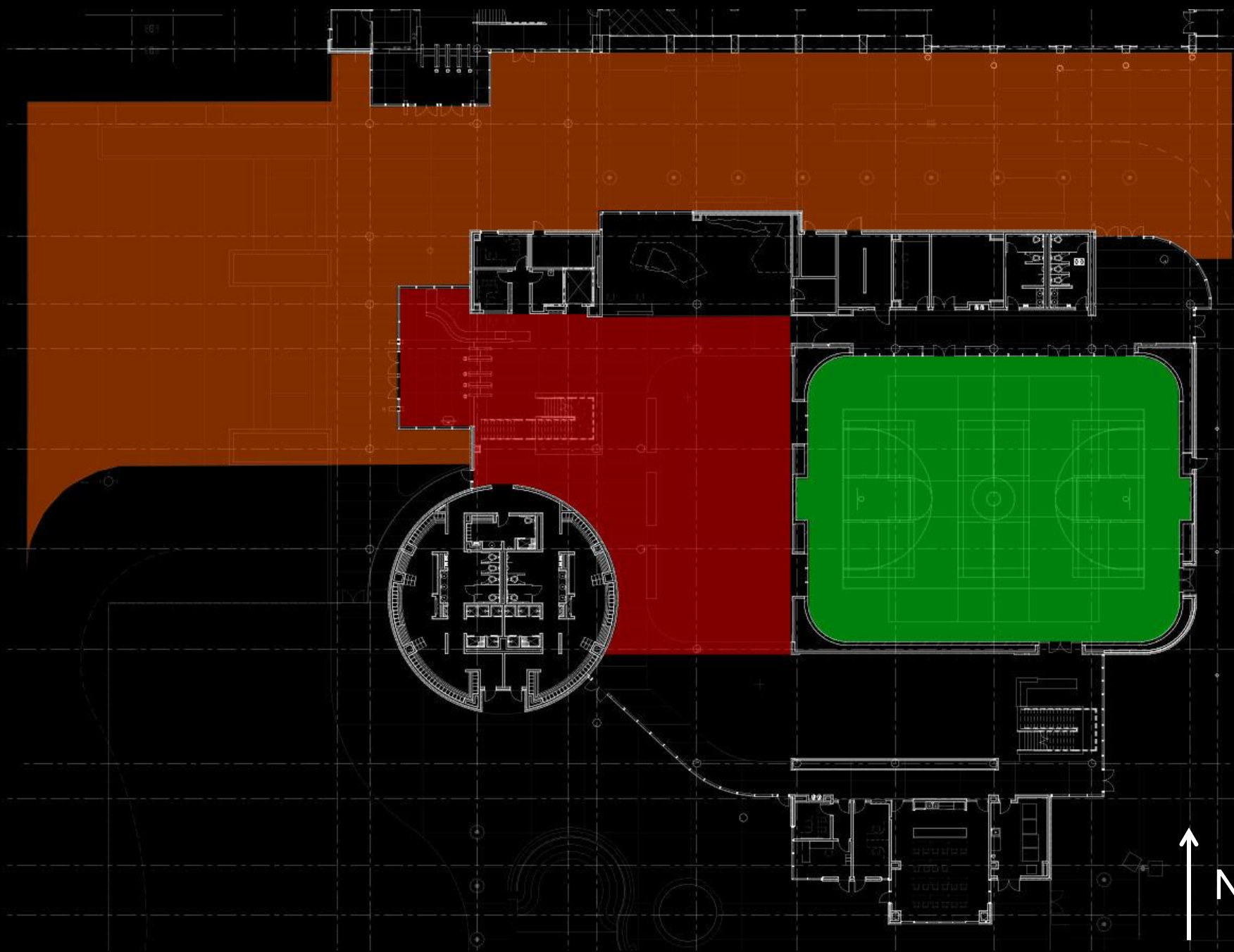
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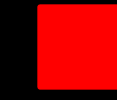
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Gymnasium

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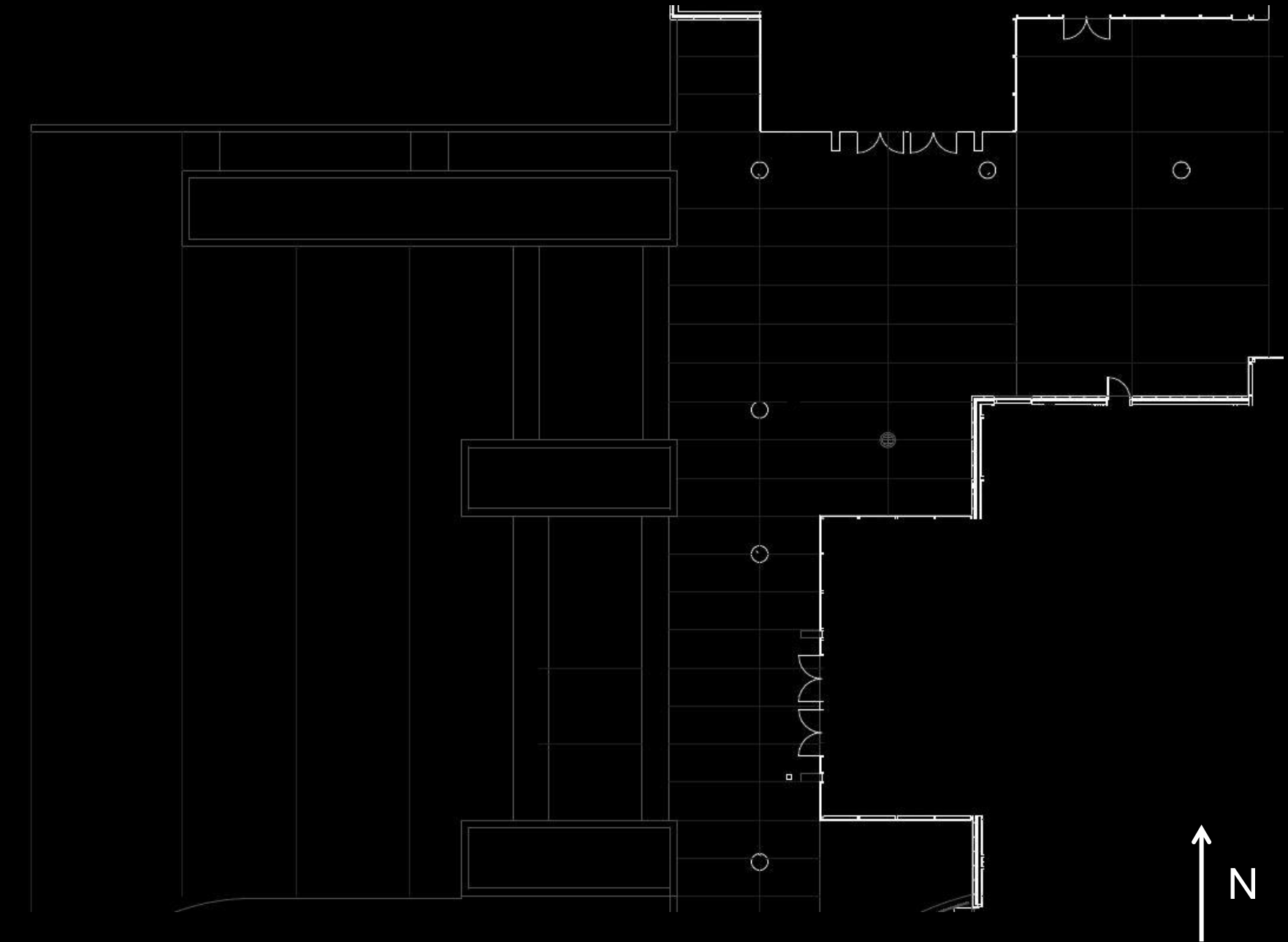
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Space	Target E_{avg}	Target $E_{avg}:E_{min}$
Stairs	4 lux	5
Entrance	15 lux	2
Courtyard	3 lux	5

Space	ASHRAE 90.1 2010 Allowable Watts	Title 24 Allowable Watts
Tradable	5,473	3,622
Non-tradable	193	178



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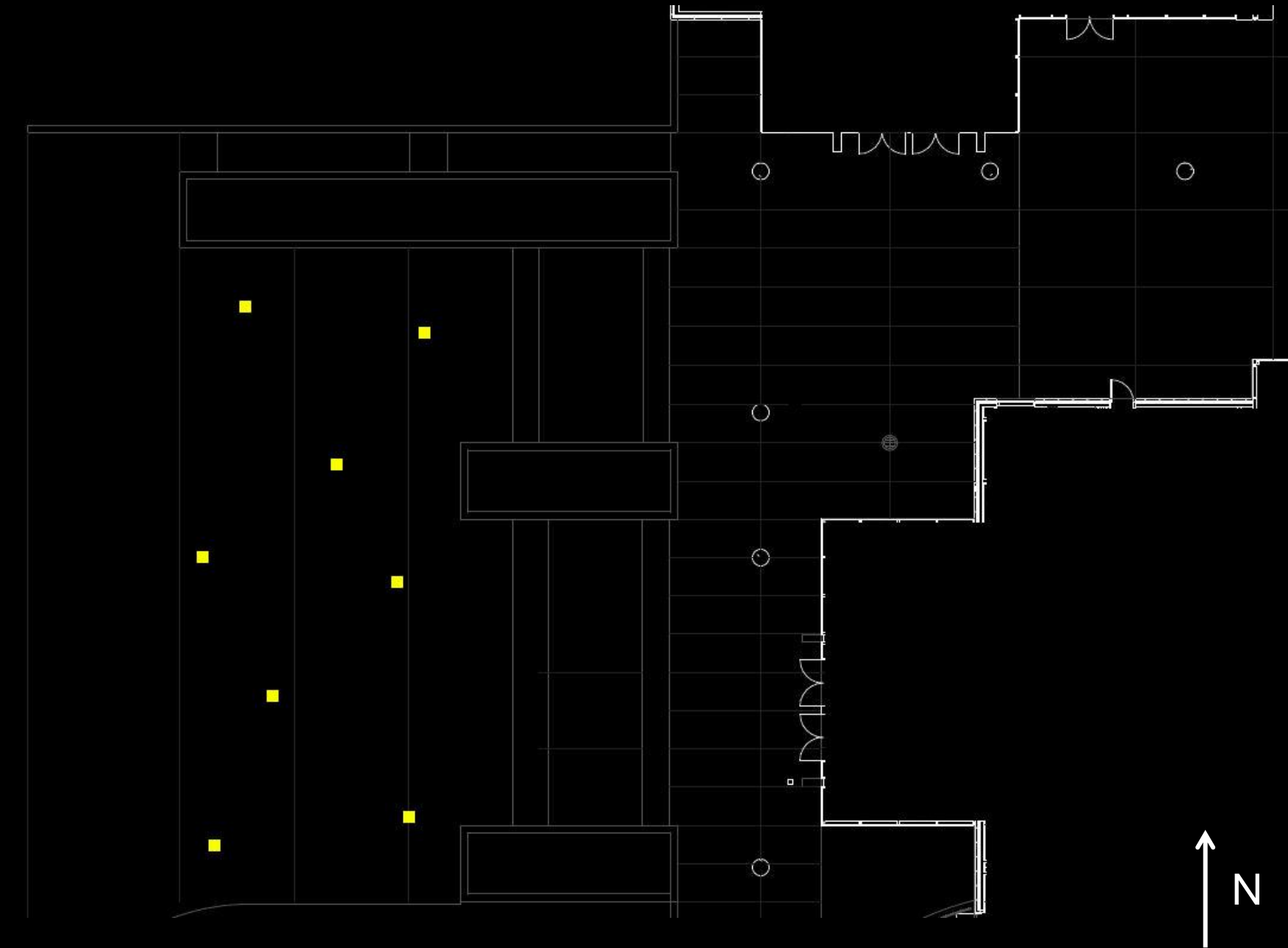
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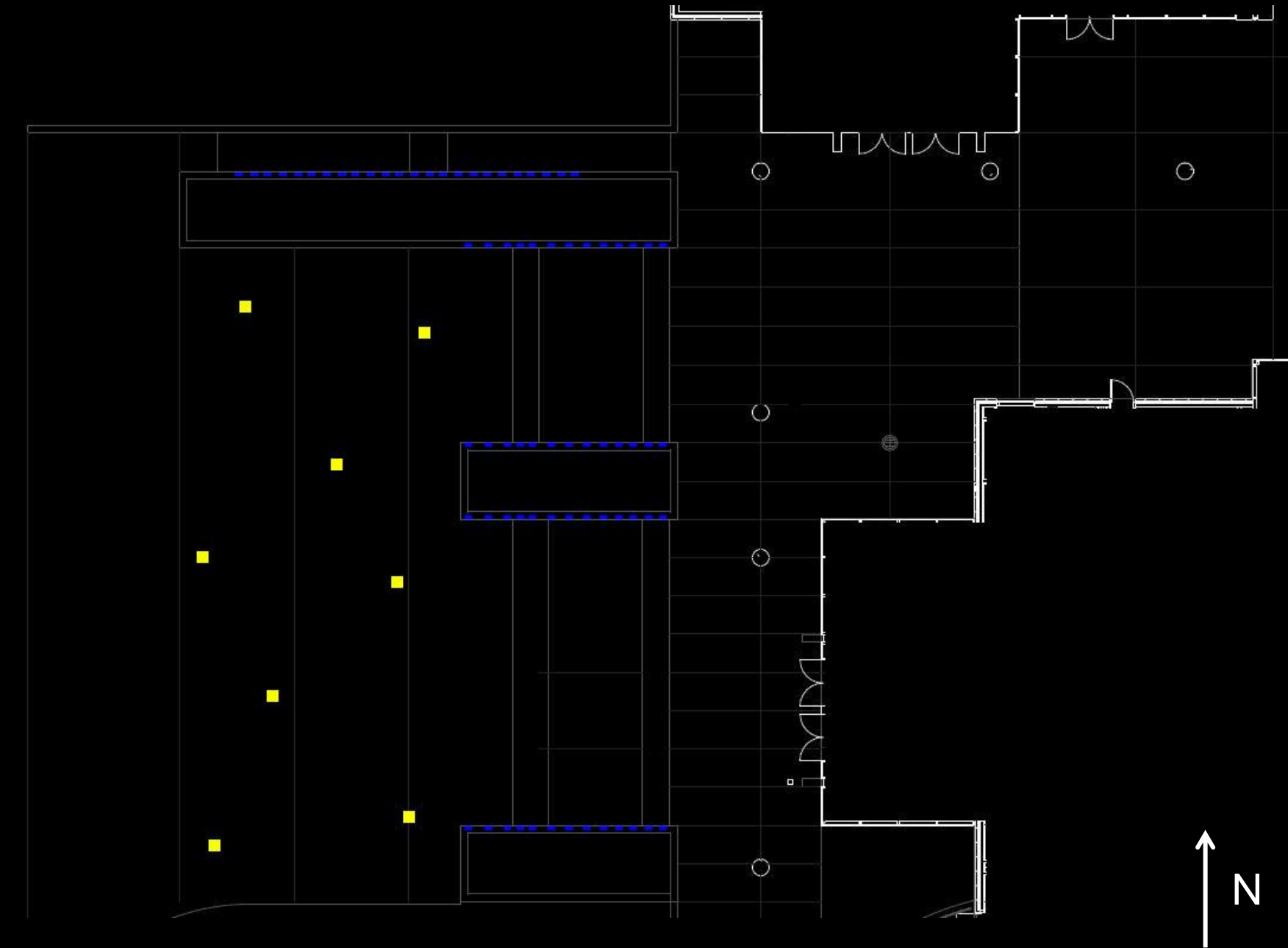
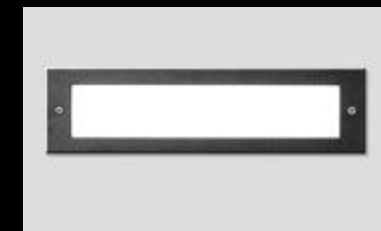
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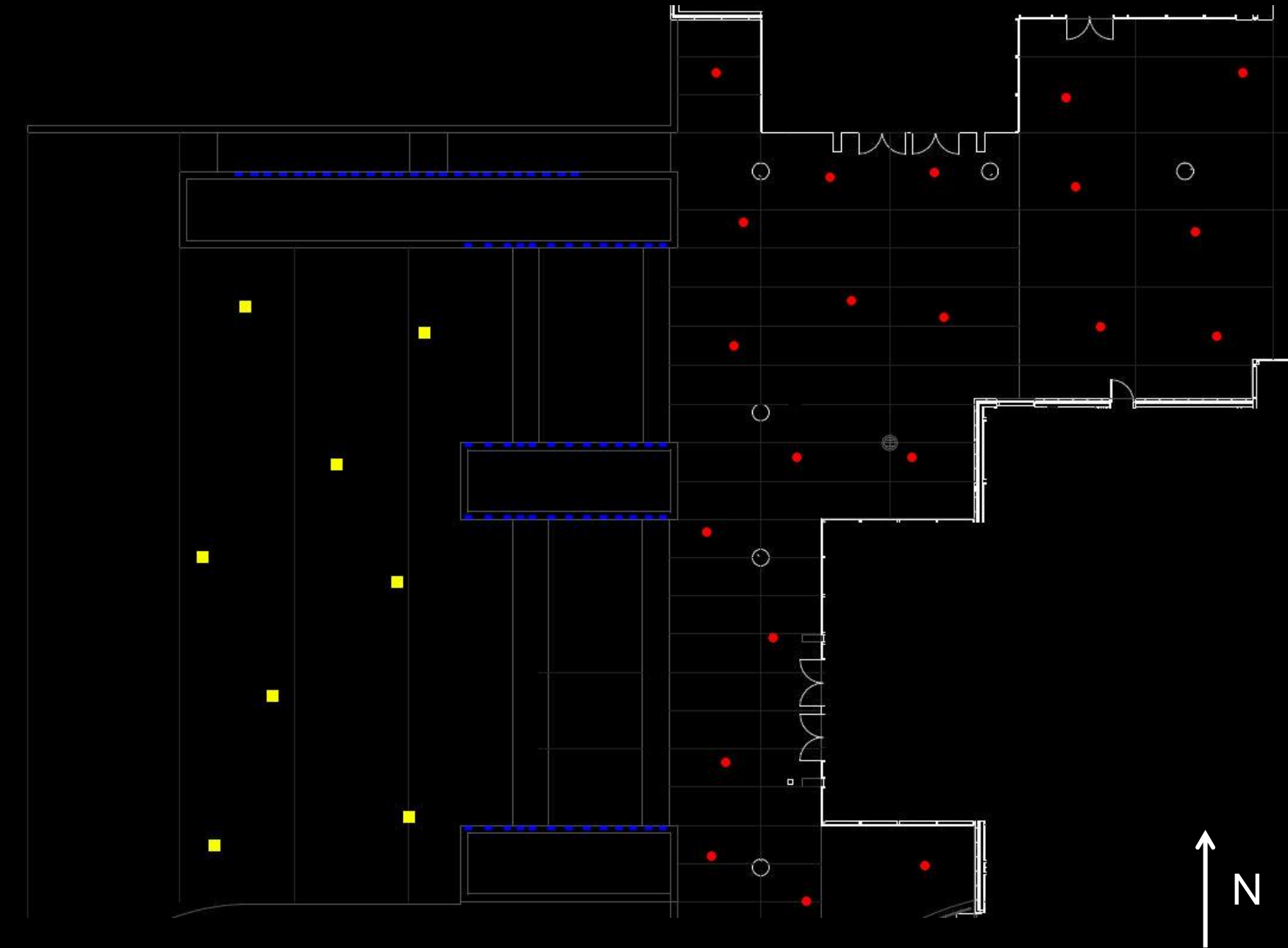
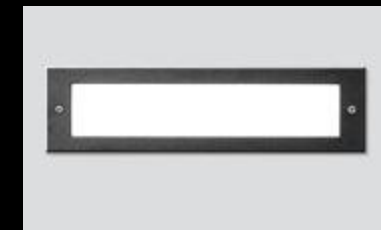
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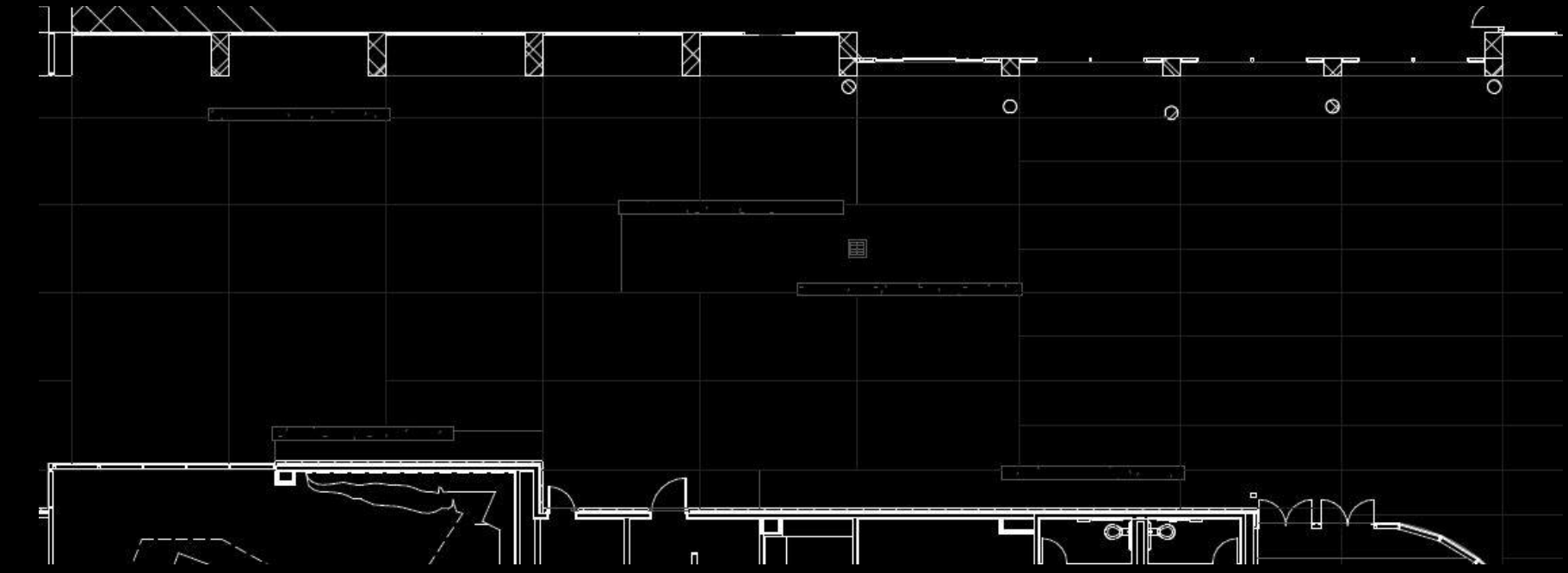
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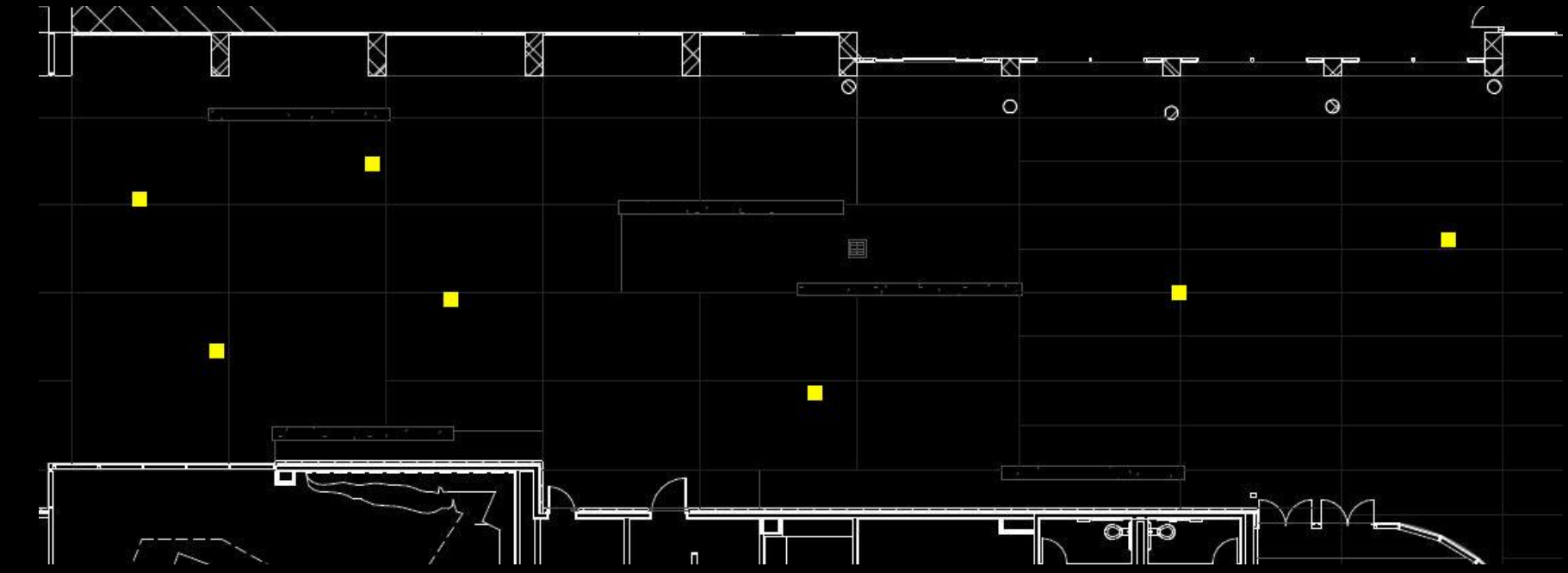
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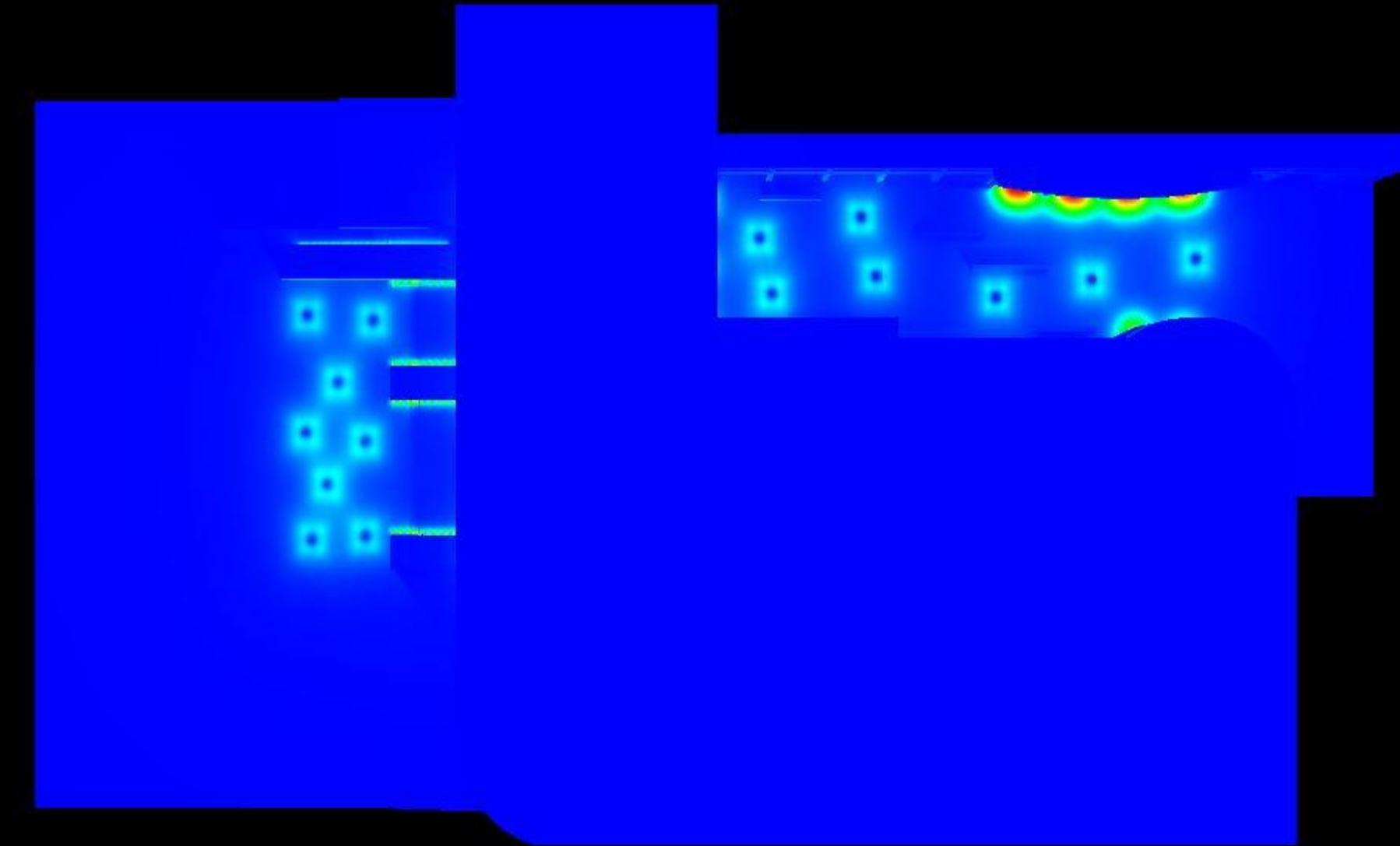
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Space	Target E_{avg}	Target $E_{avg}:E_{min}$	Design E_{avg}	Design $E_{avg}:E_{min}$
Stairs	4 lux	5	4.82 lux	4.02
Entrance	15 lux	2	16.44 lux	4.84
Courtyard	3 lux	5	5.04 lux	5.60

Space	ASHRAE 90.1 2010 Allowable Watts	Title 24 Allowable Watts	Design Watts
Tradable	5,473	3,622	1,160
Non-tradable	193	178	410



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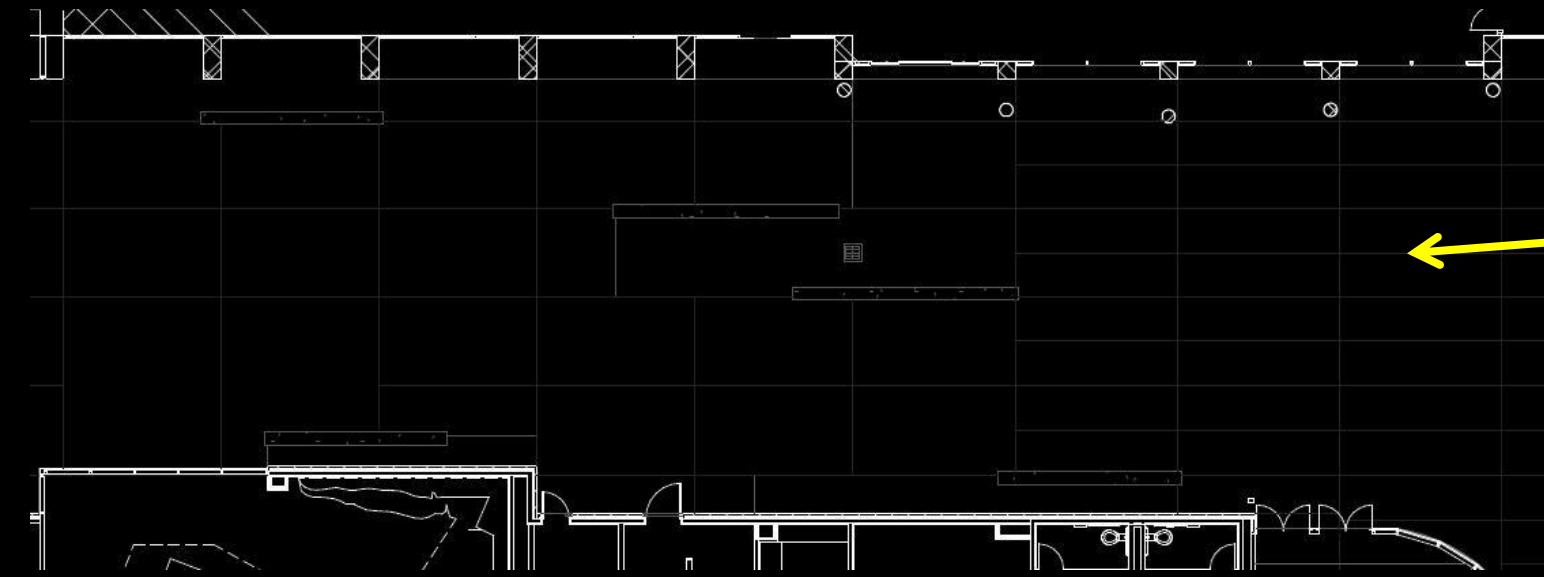
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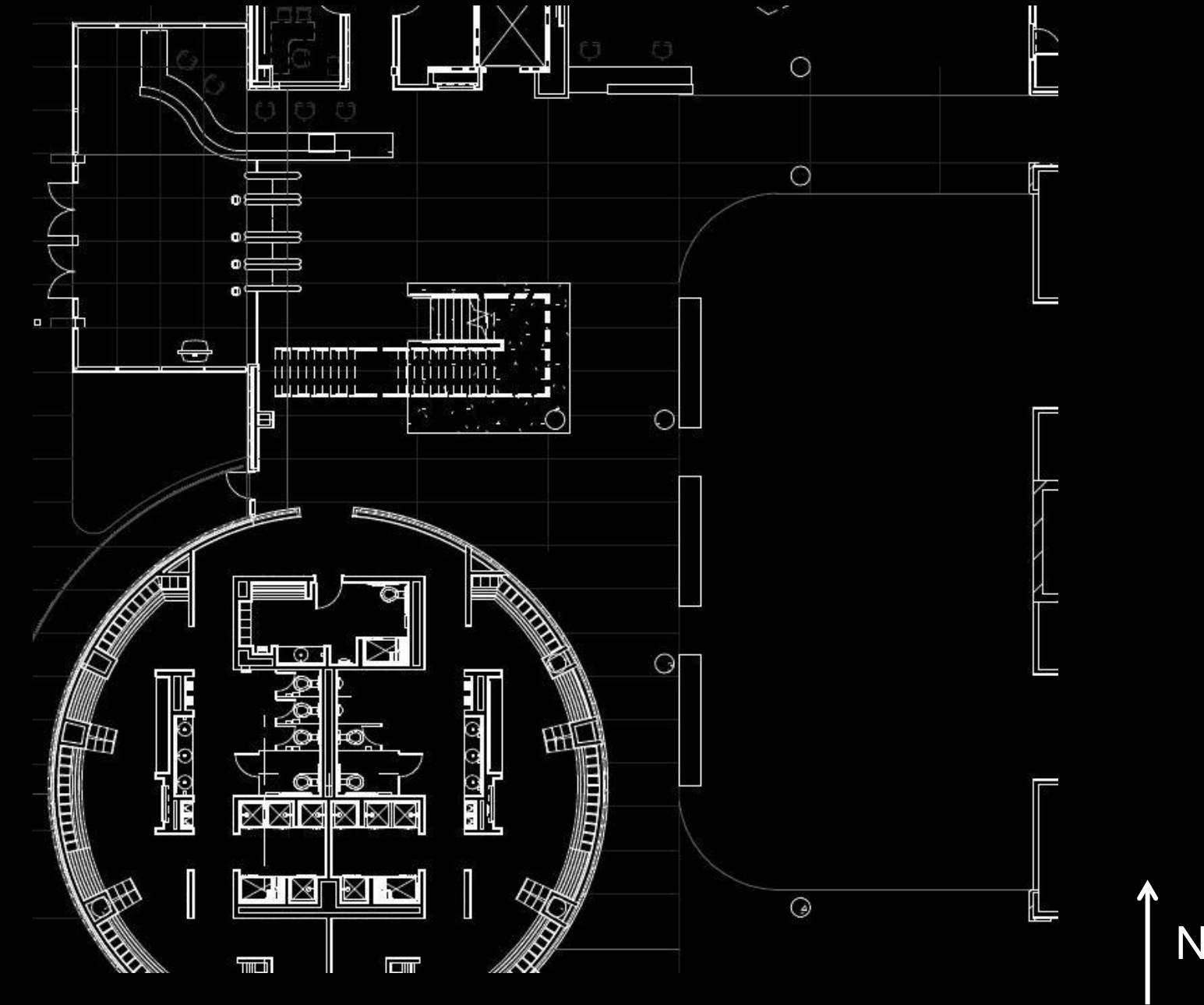
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Space	Target E_{avg}	Target $E_{avg}:E_{min}$
Lobby	50 lux	3
Transition	45 lux	2
Exercise Area	150 lux	3
Running Track	150 lux	3

Space	ASHRAE 90.1 2010 Allowable Watts	Title 24 Allowable Watts
Lobby	10,504	9,236



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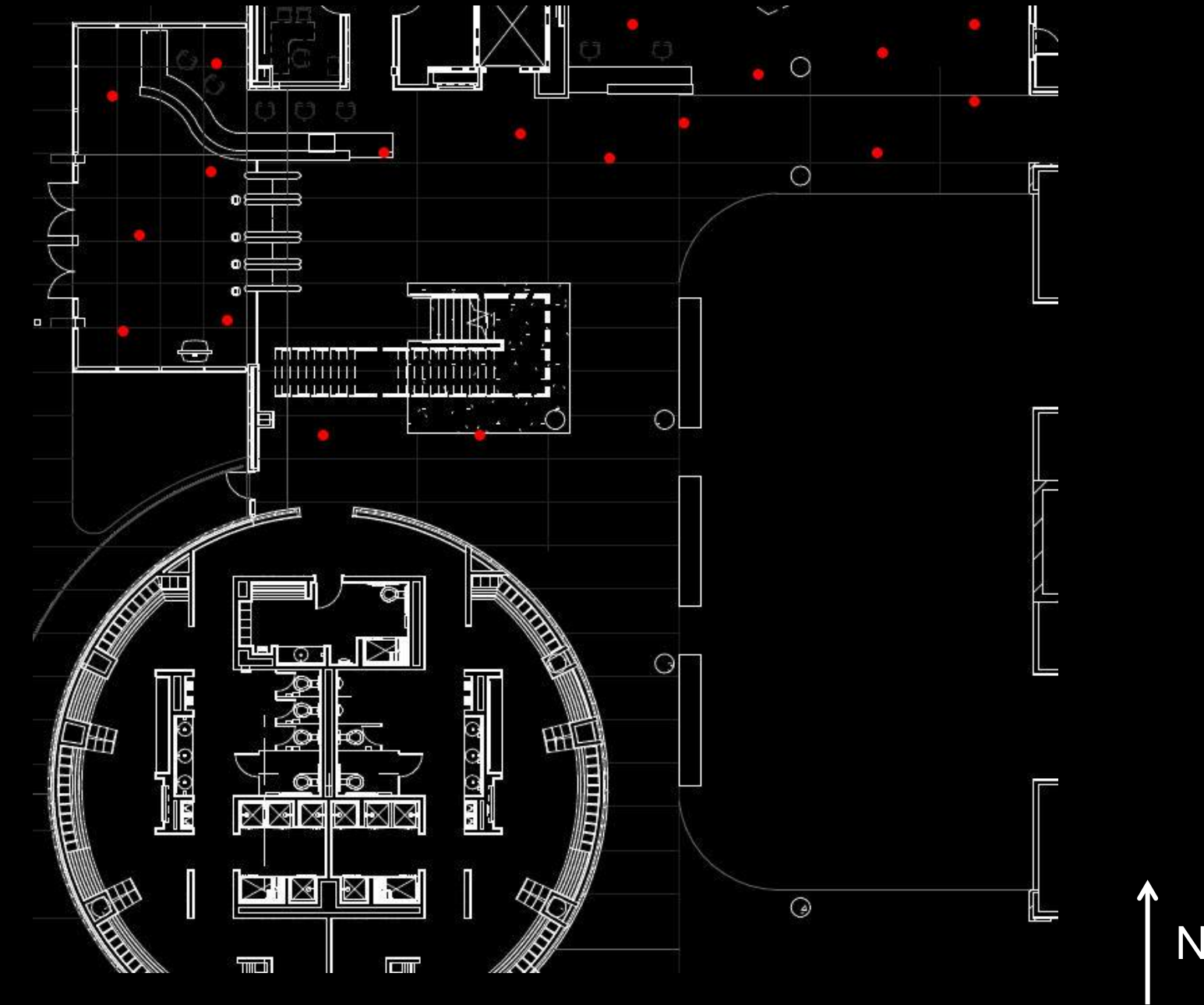
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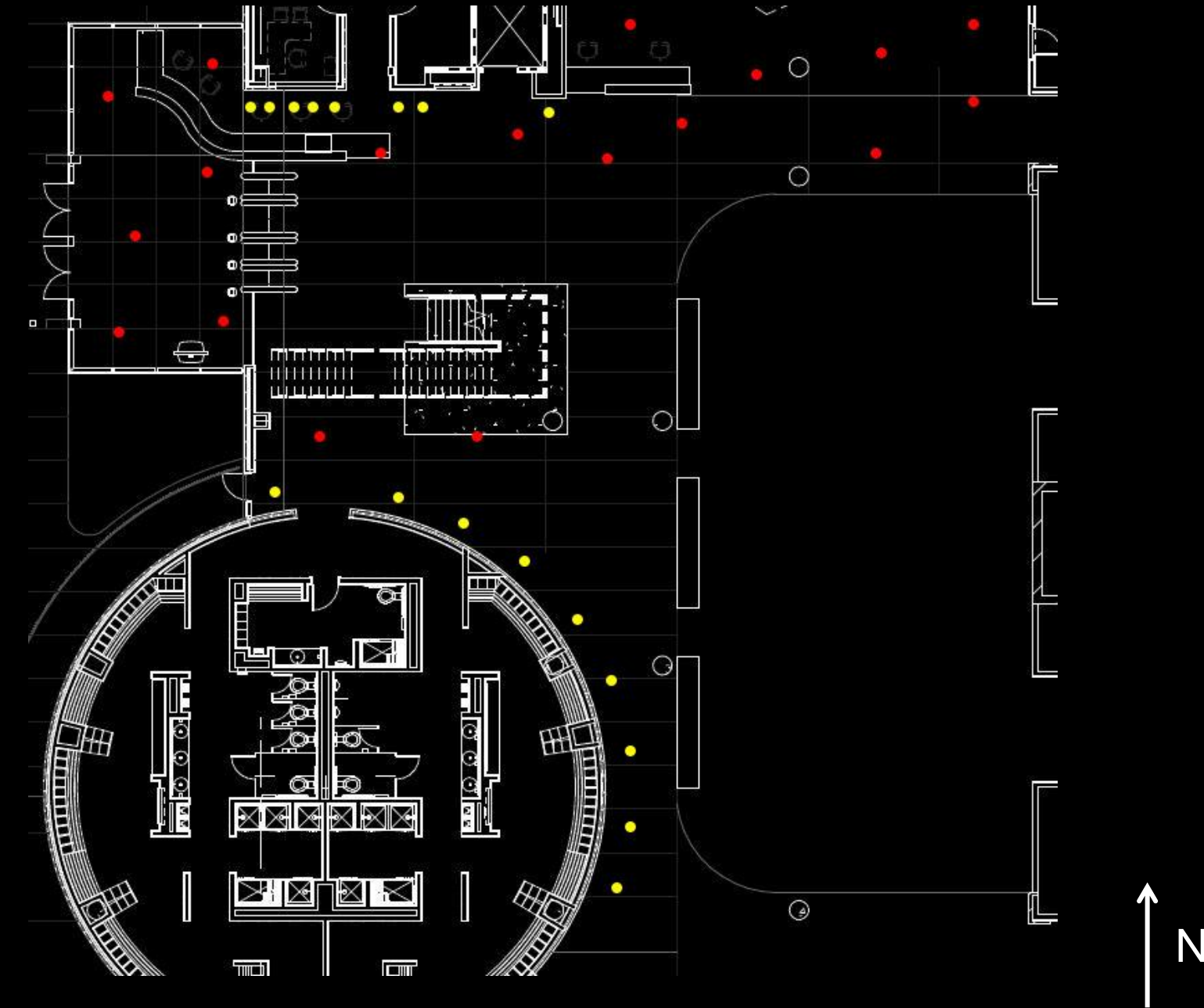
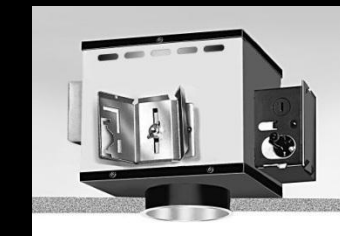
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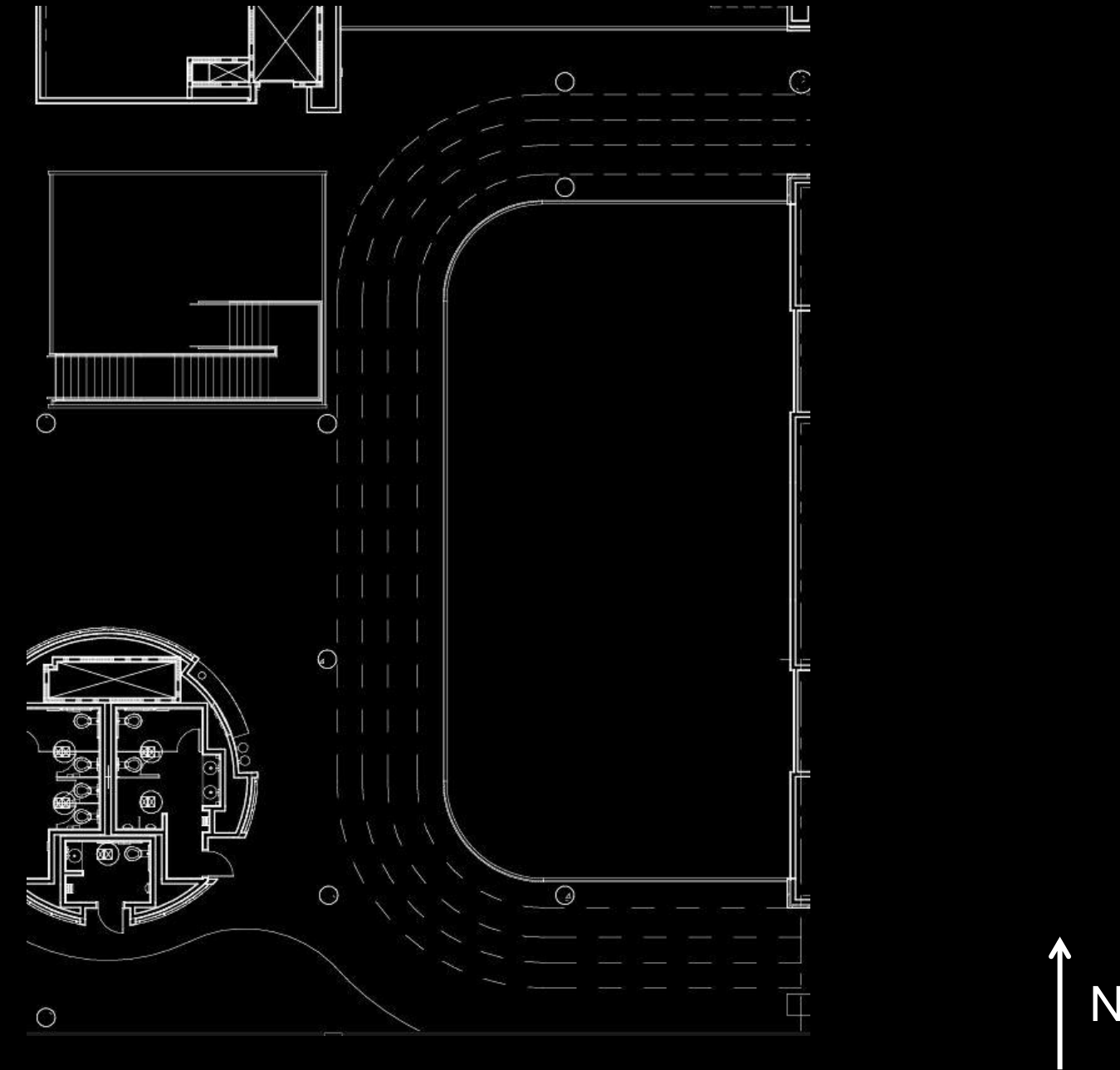
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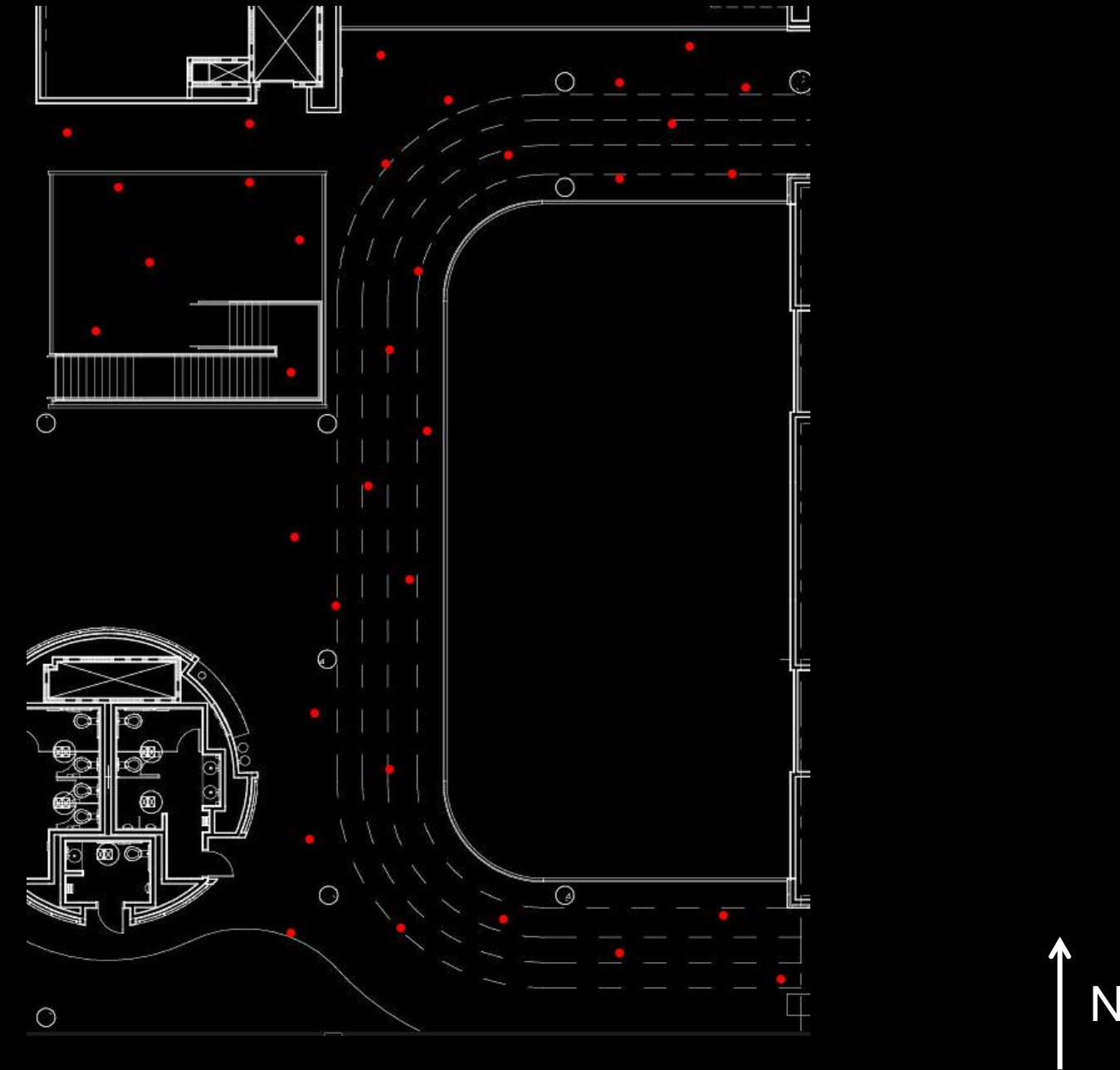
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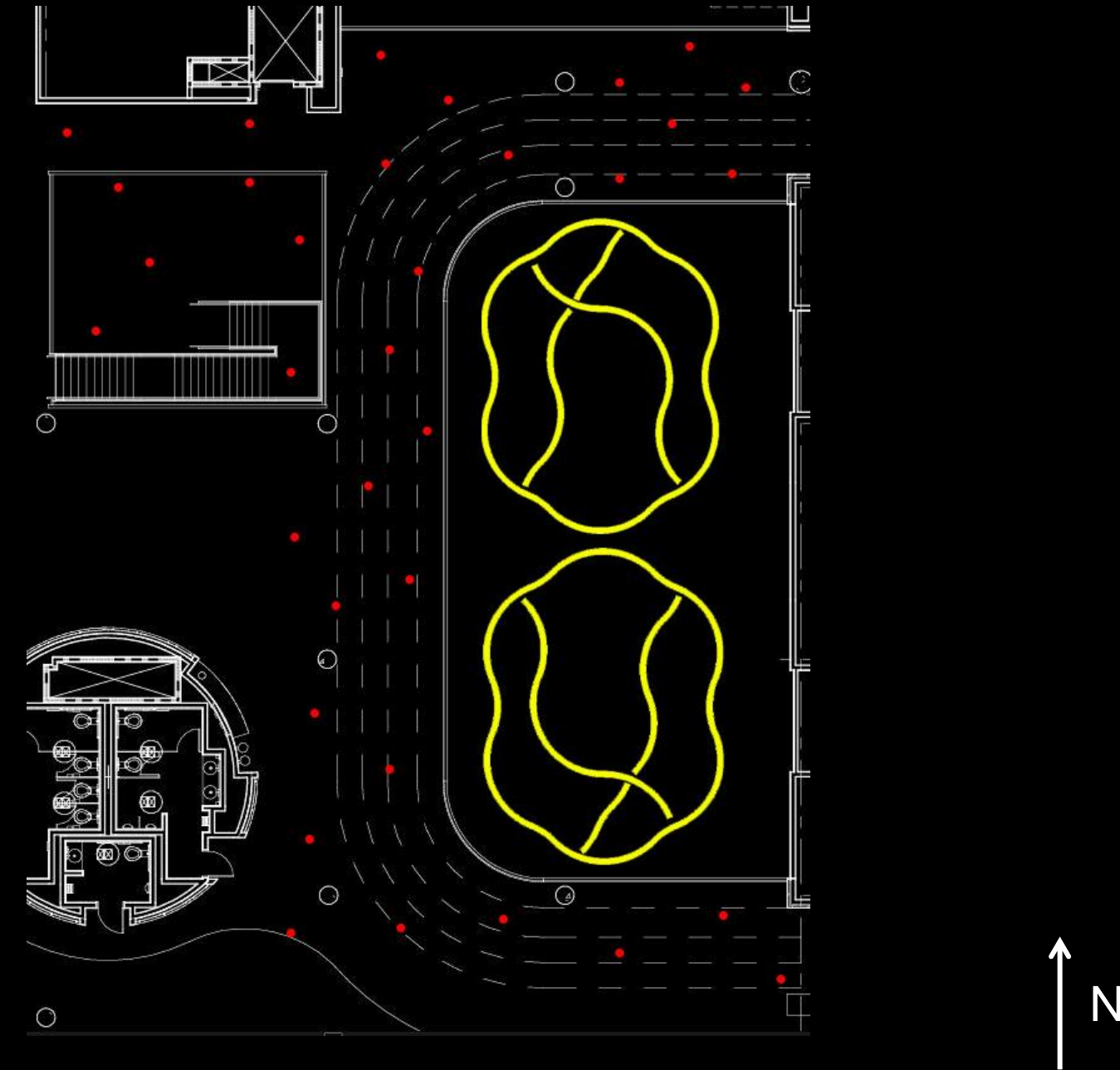
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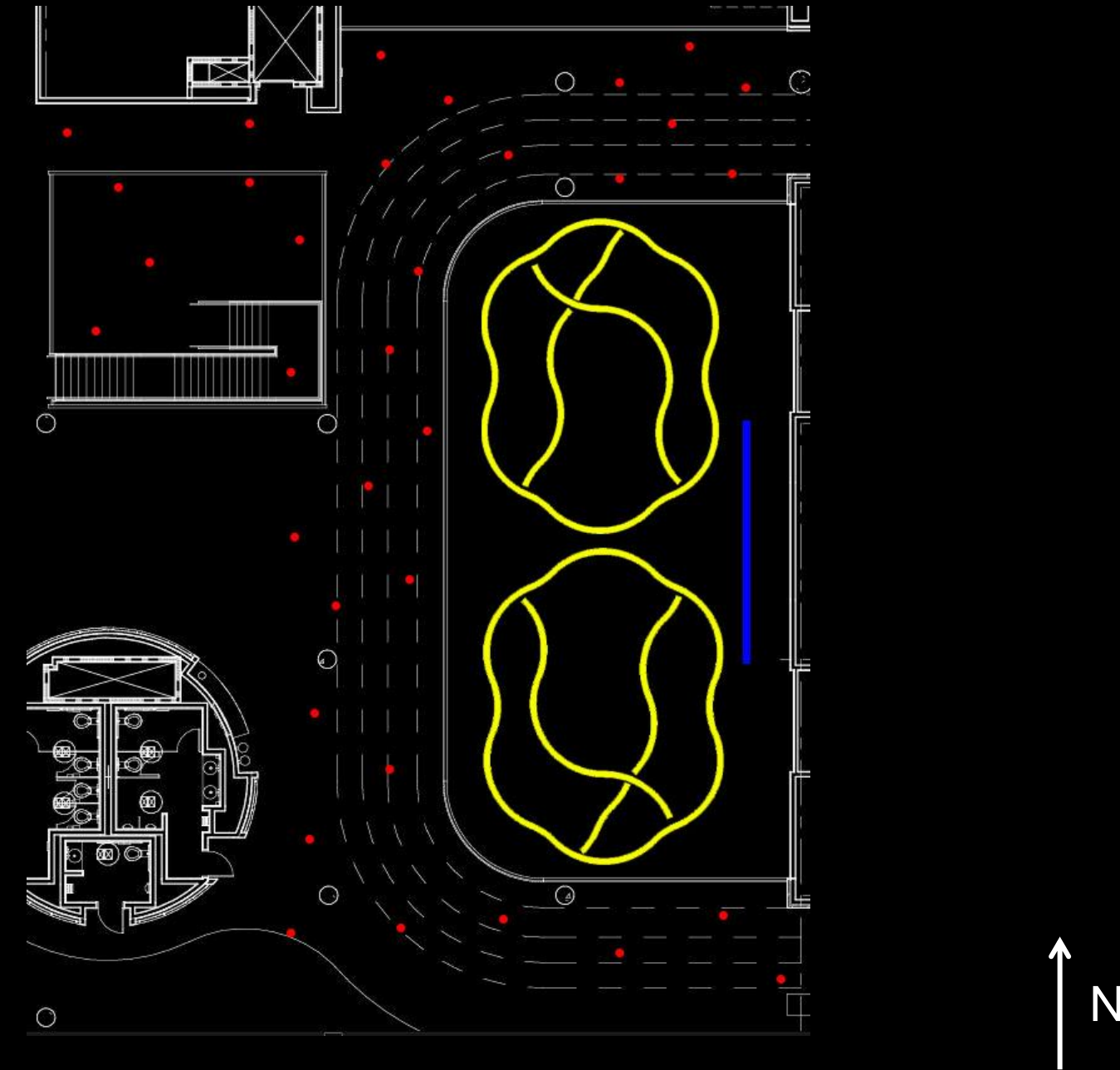
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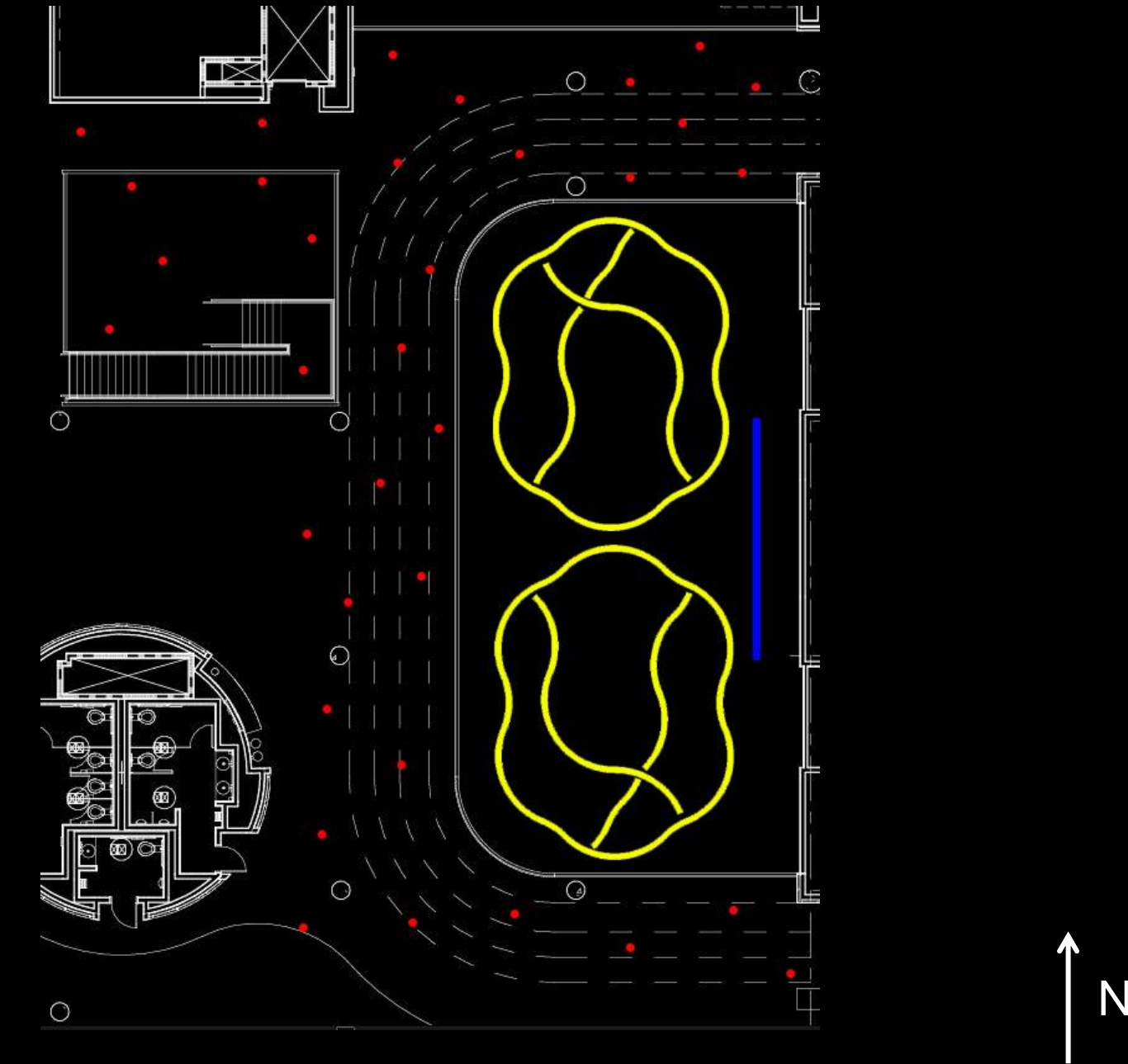
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Space	Target E_{avg}	Target $E_{avg}:E_{min}$	Design E_{avg}	Design $E_{avg}:E_{min}$
Lobby	50 lux	3	46.06 lux	1.98
Circulation	45 lux	2	91.25 lux	2.78
Stairs	45 lux	2	52.10 lux	1.85
Exercise Area	150 lux	3	164.09 lux	2.25
Running Track	150 lux	3	152.76 lux	3.06

Space	ASHRAE 90.1 2010 Allowable Watts	Title 24 Allowable Watts	Design Watts
Lobby	10,504	9,236	4702



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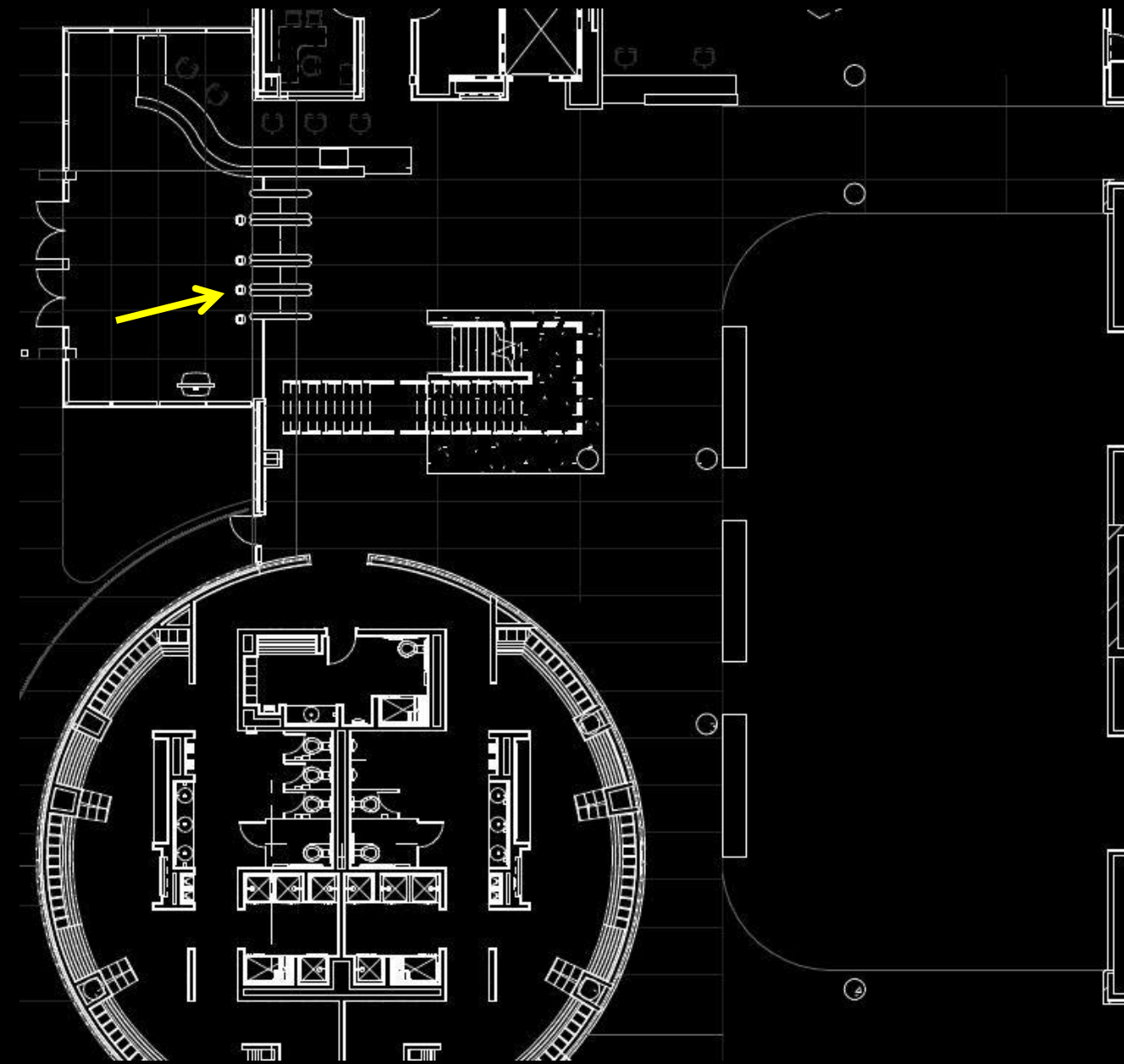
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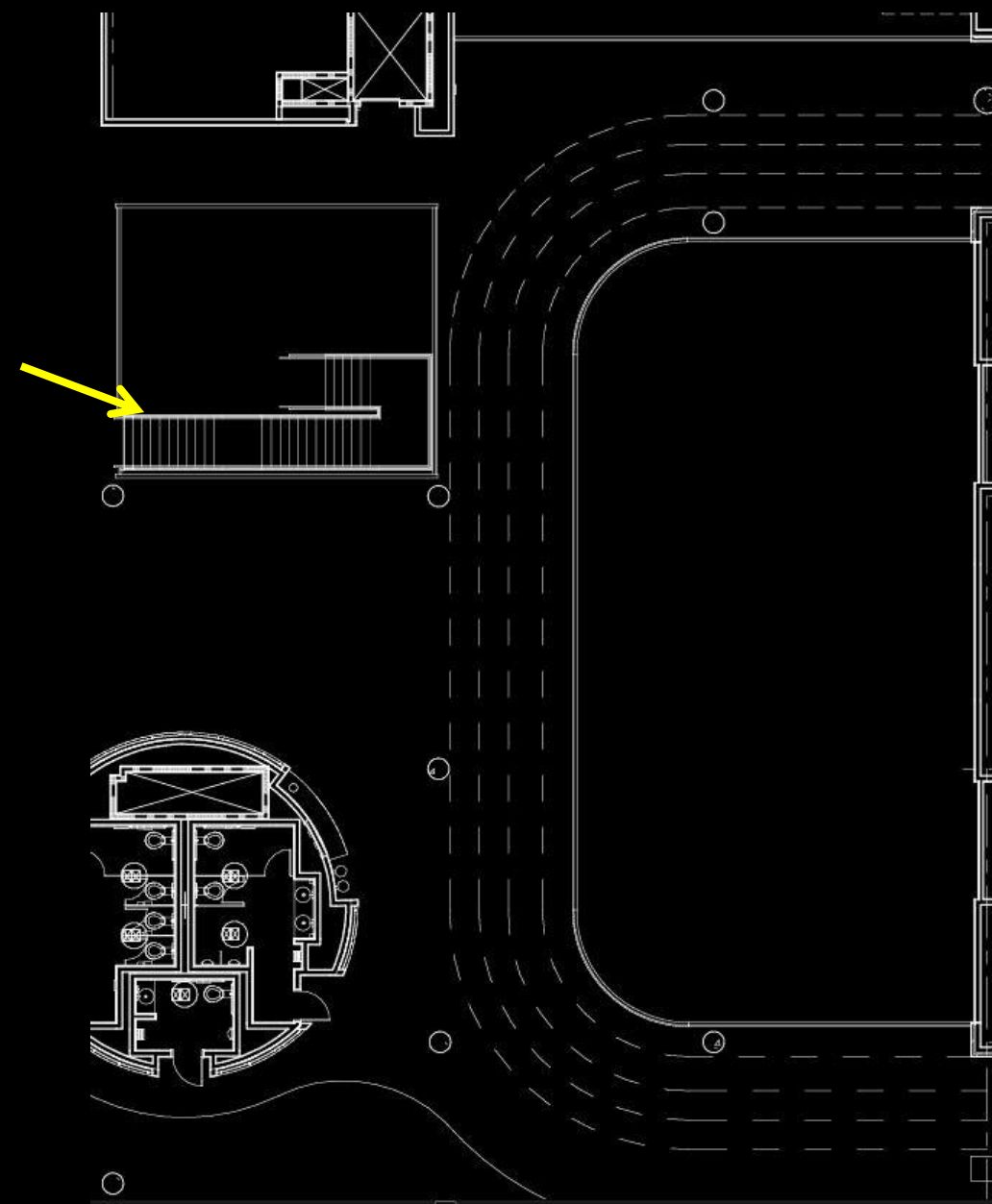
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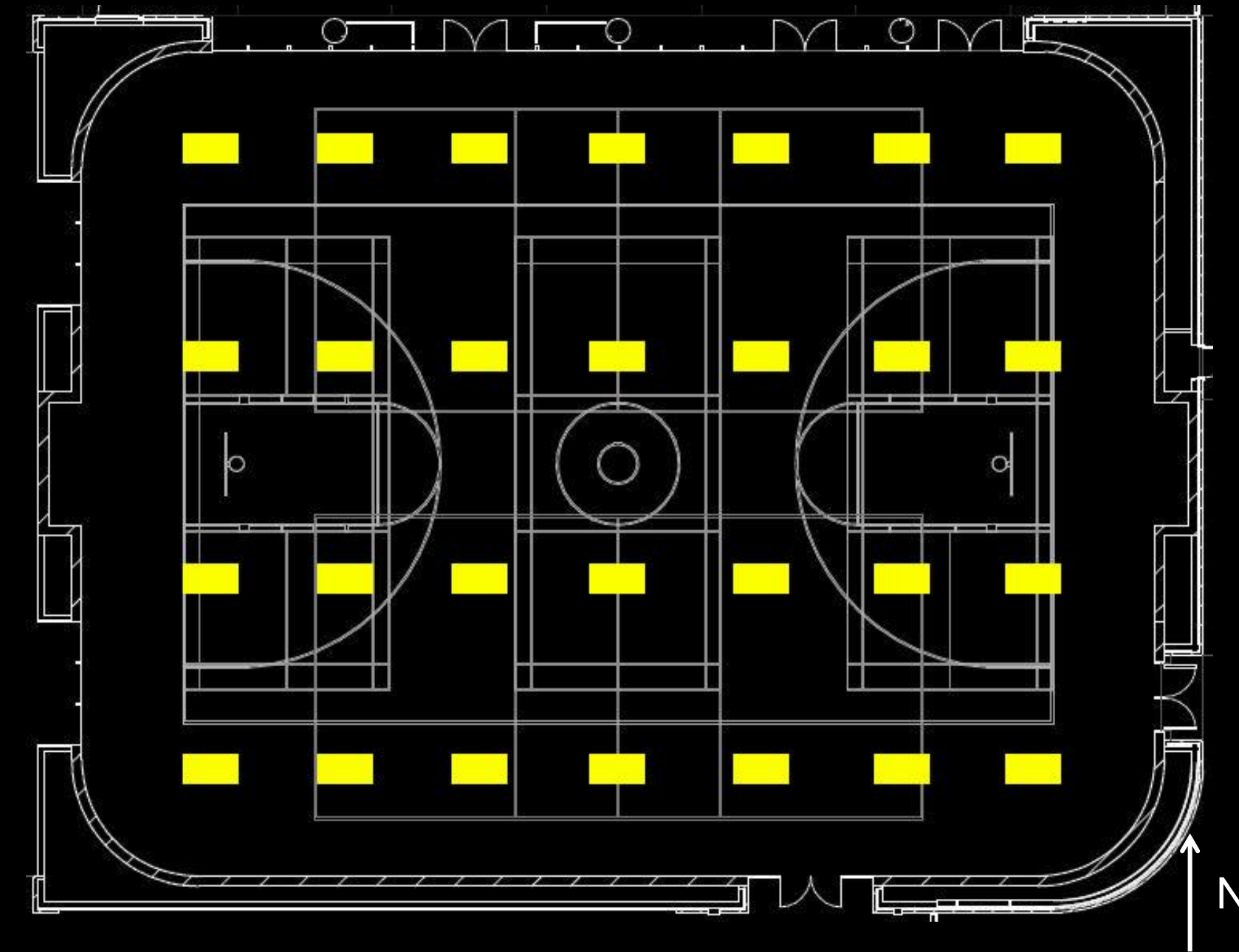
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Space	Target E_{avg}	Target $E_{avg}:E_{min}$	Design E_{avg}	Design $E_{avg}:E_{min}$
Gymnasium	500 lux	4	449.03 lux	1.89

Space	ASHRAE 90.1 2010 Allowable Watts	Title 24 Allowable Watts	Design Watts
Gymnasium	8148	8230	5208



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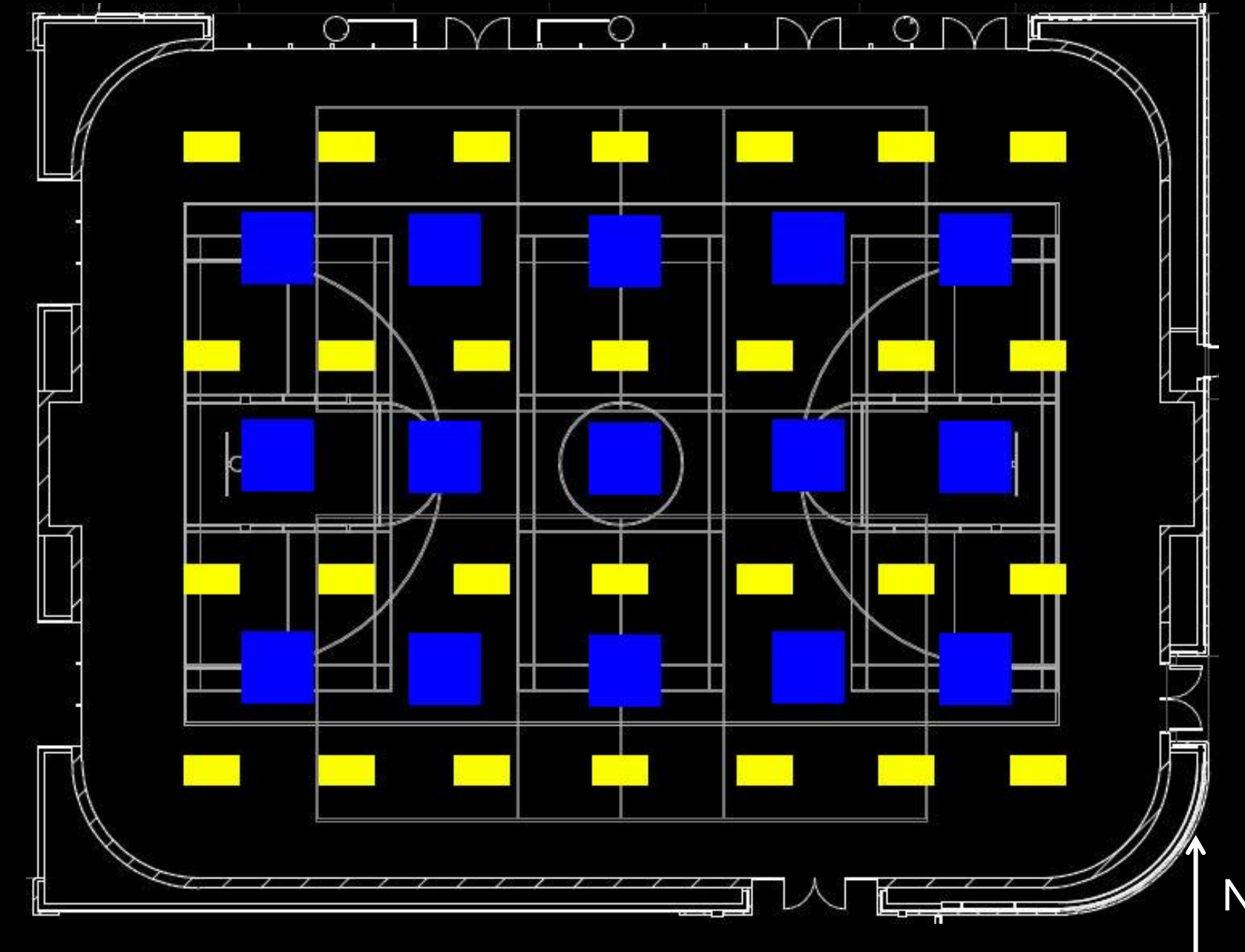
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Unit	Visible Light Transmission	U-Factor	Solar Heat Gain Coefficient
EcoSky 3	62%	0.82	0.47



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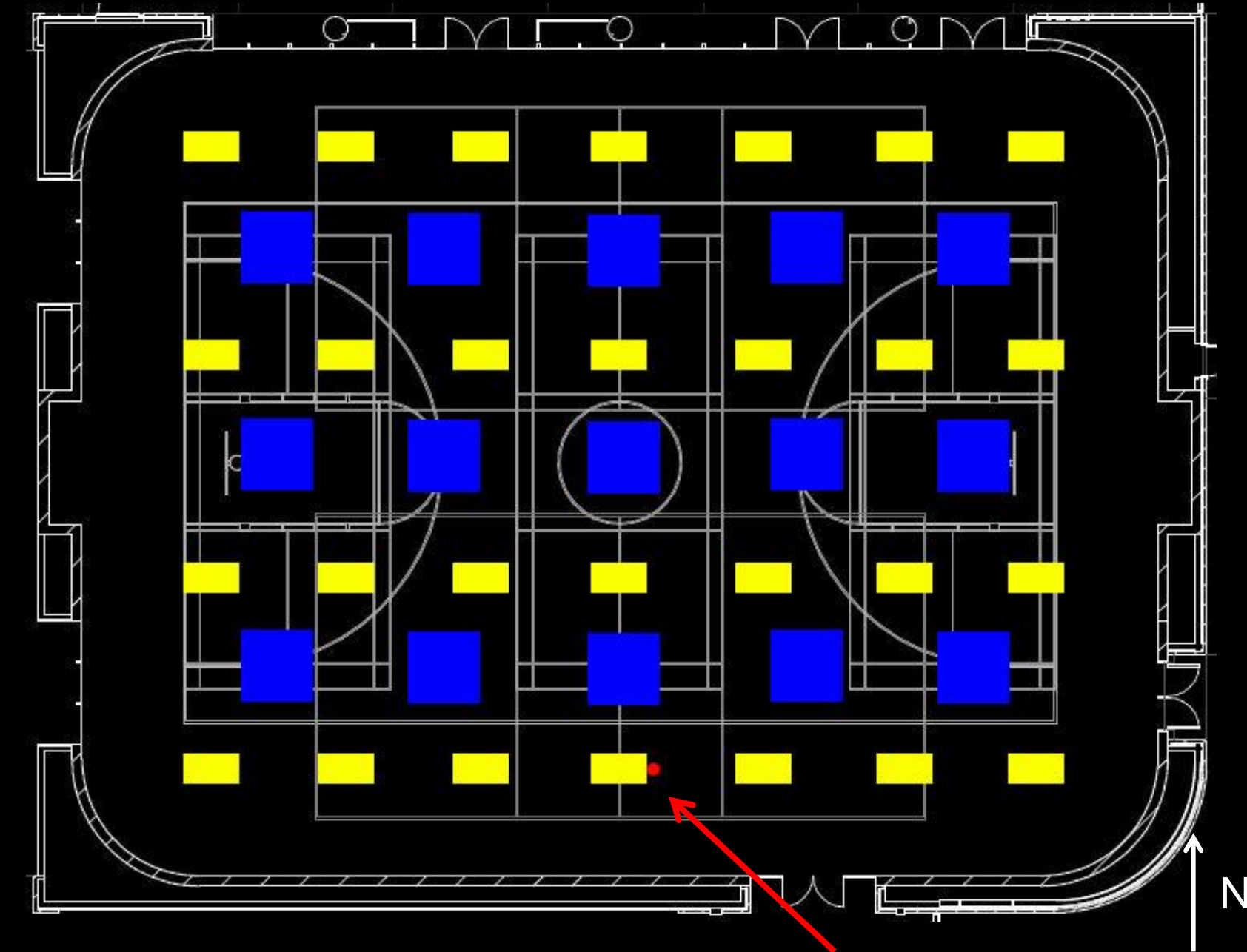
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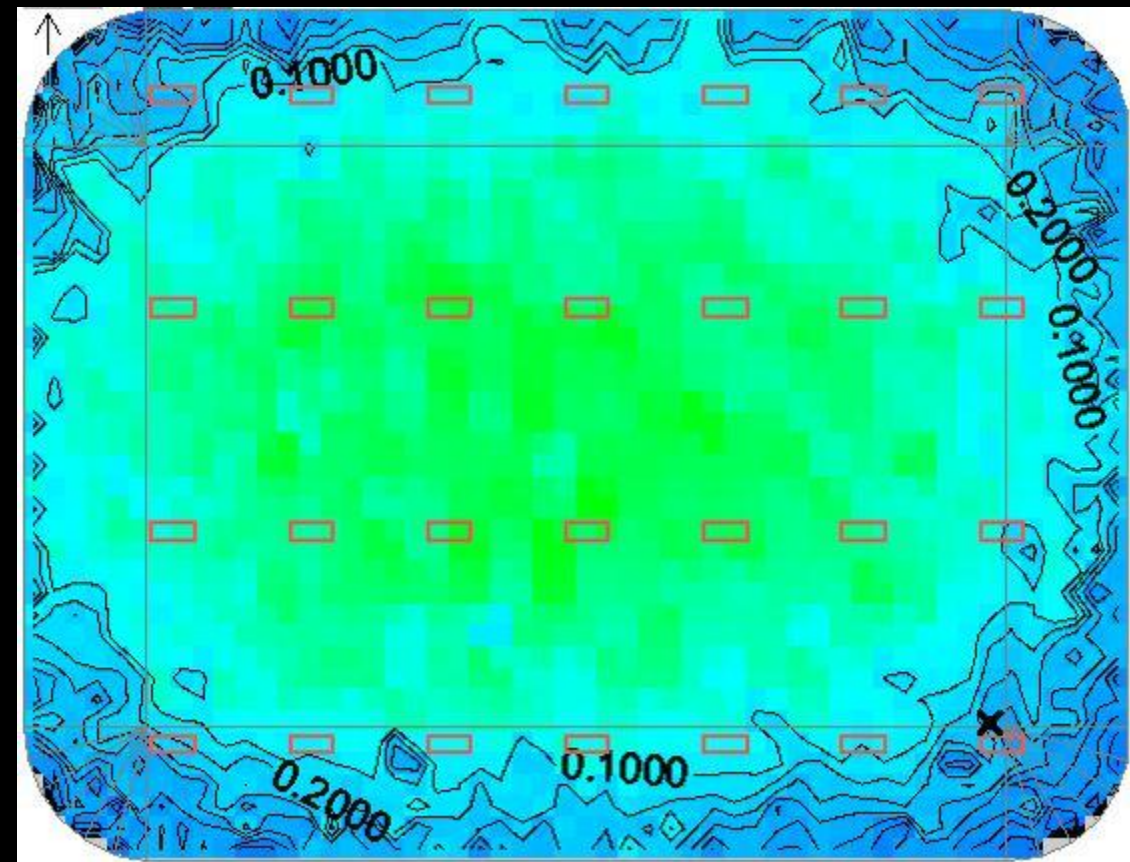
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Critical Point Selection

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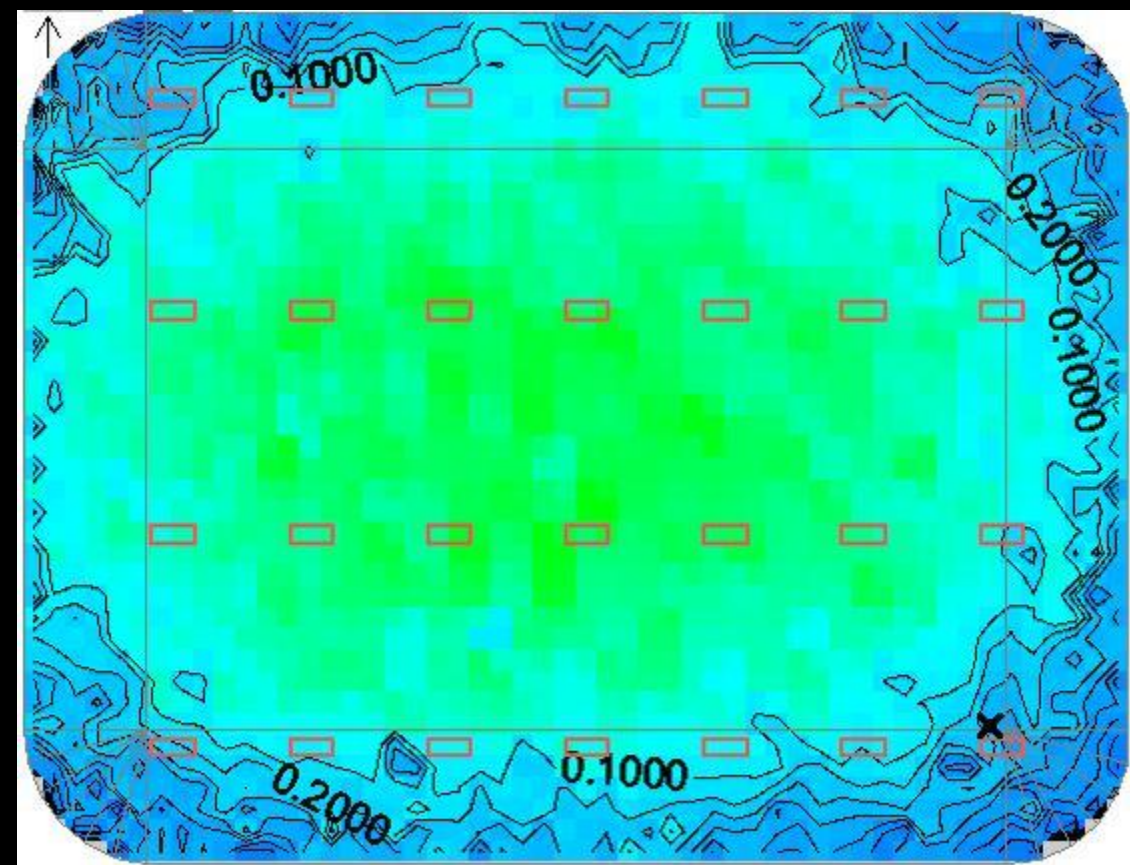
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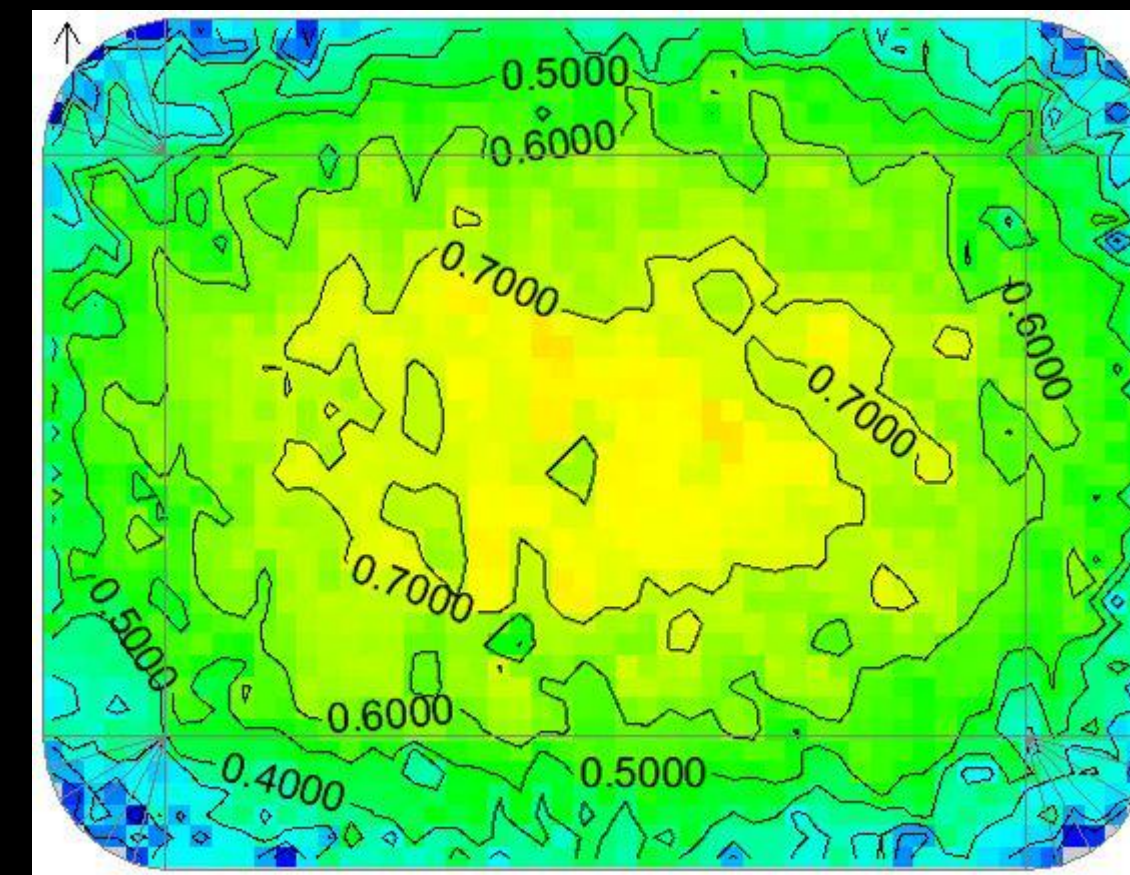
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Critical Point Selection



Daylight Autonomy at 500 lux
Points above 50%: 67.95%

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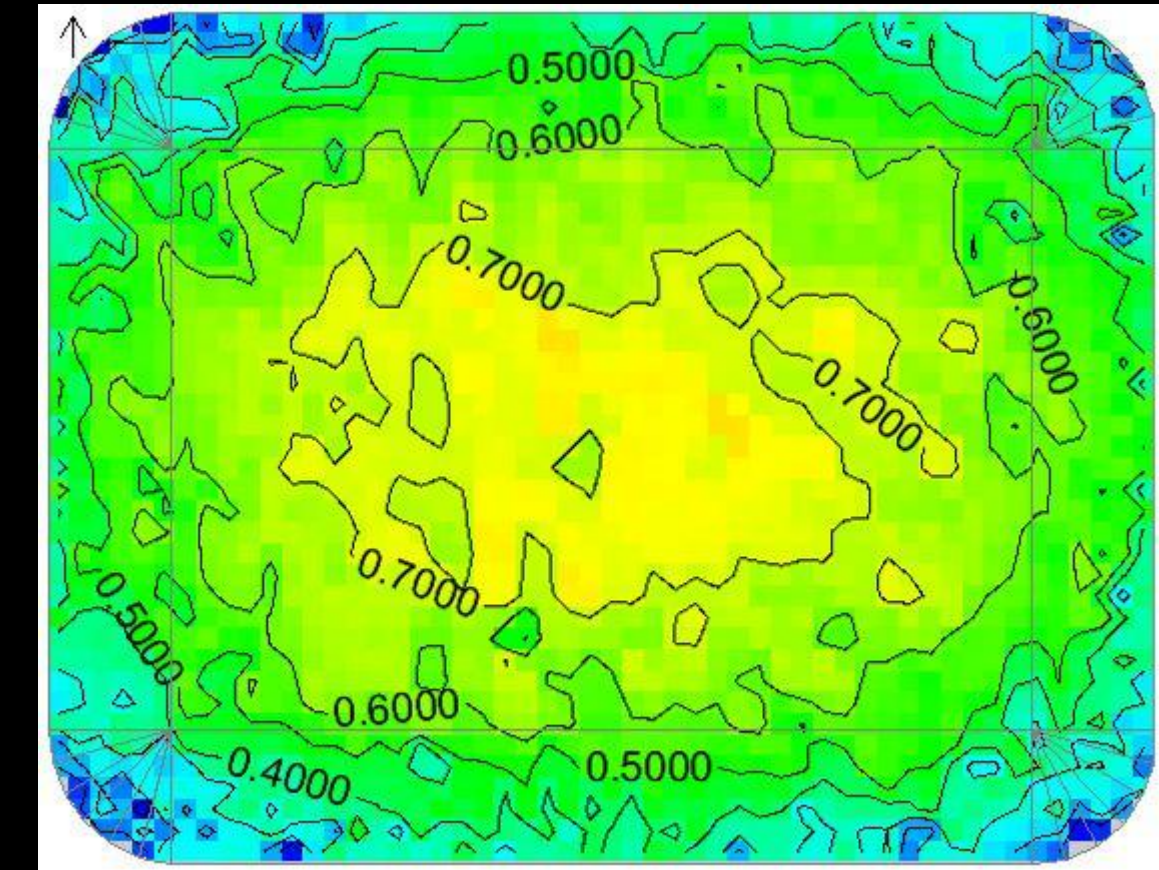
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	Jan-Mar	April-June	July-Sep	Nov-Dec	Total
Base	6,854	6,984	7,140	6,447	27,425
Optimal	5,404	4,094	4,188	5,088	18,774
Algorithm	5,321	4,139	4,245	5,021	18,726
Difference	83	-44	-57	66	49
Savings	1,533	2,845	2,896	1,426	8,700



Daylight Autonomy at 500 lux
Points above 50%: 67.95%

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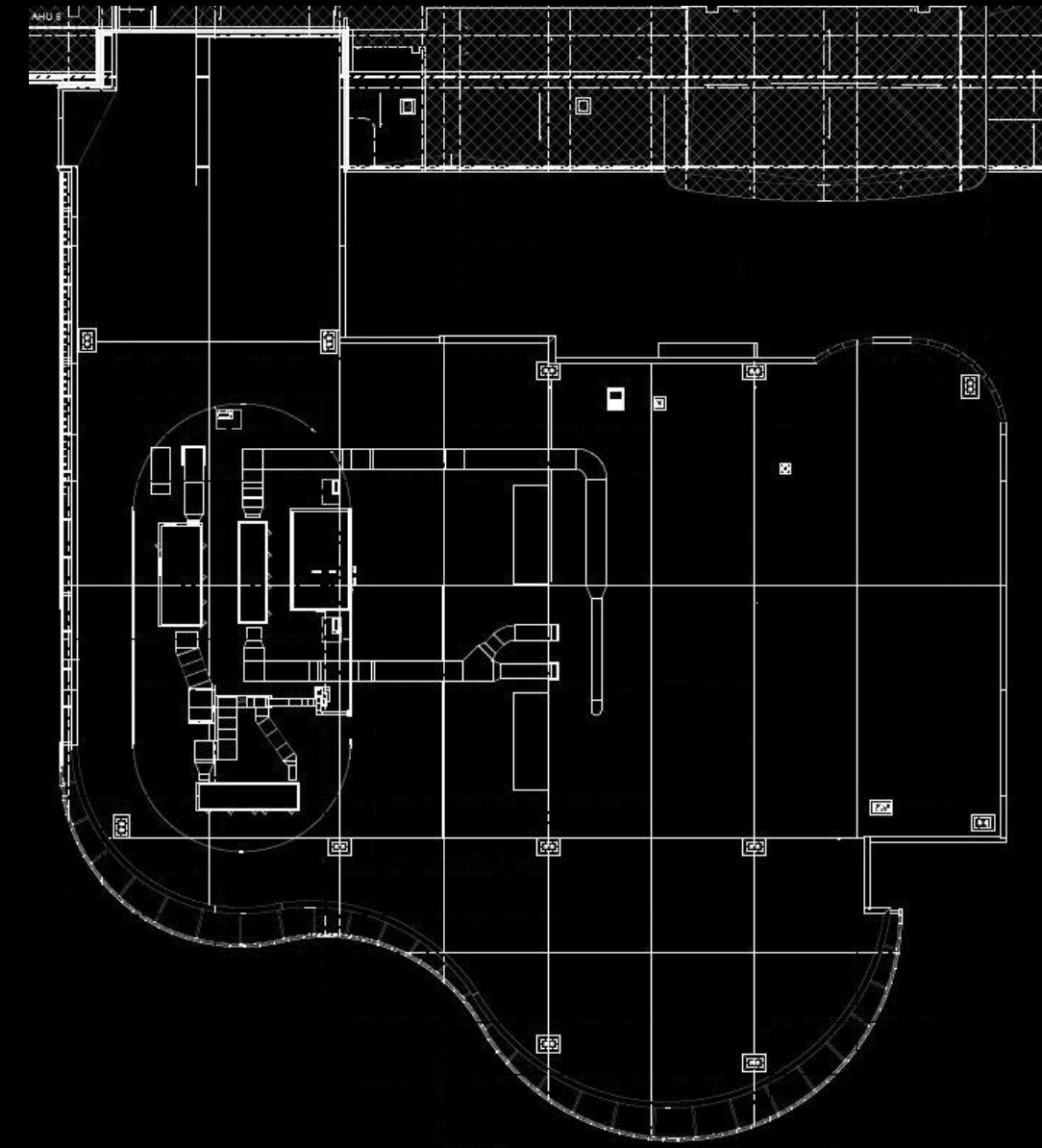
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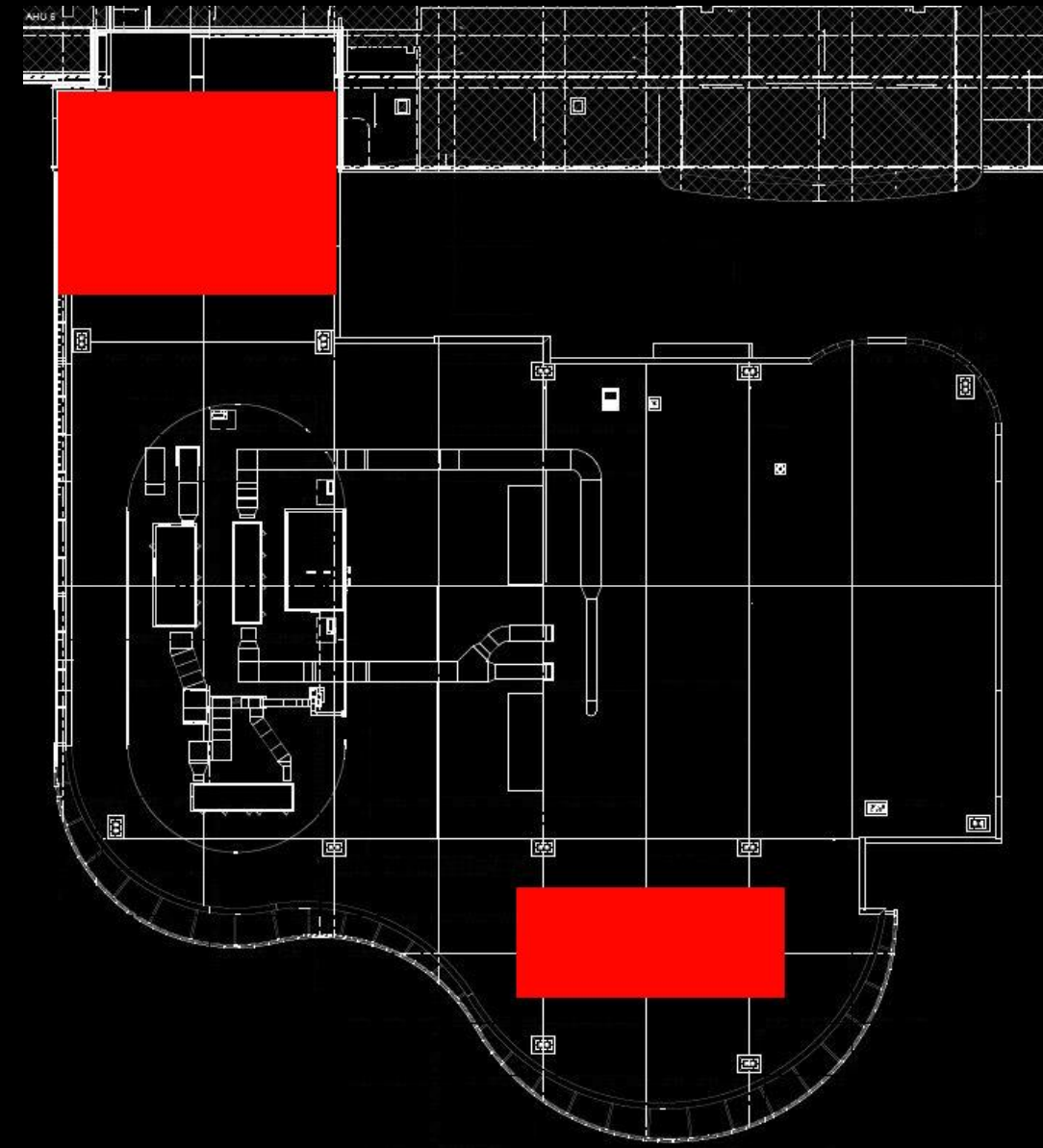
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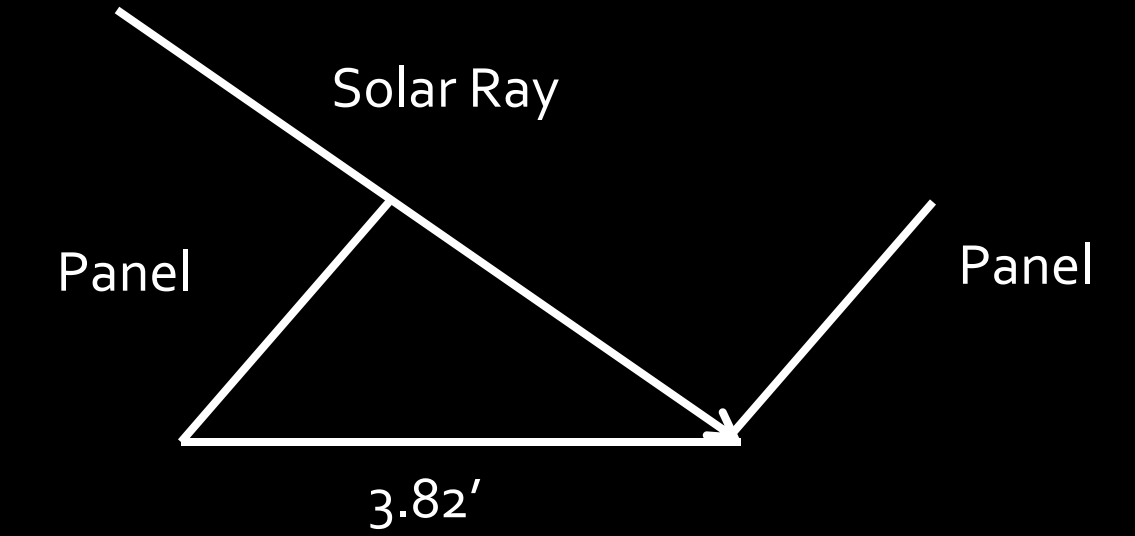
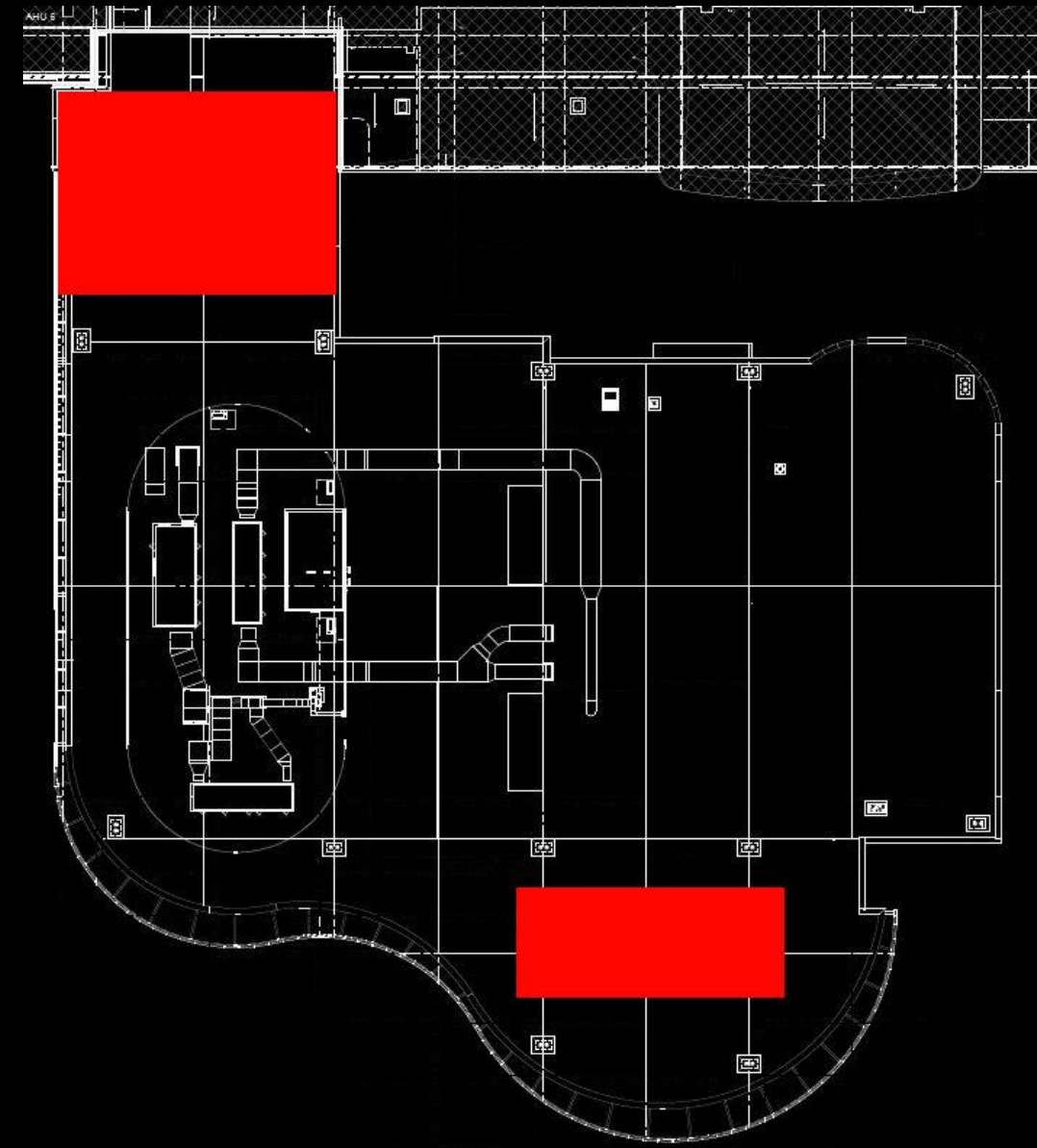
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Section	Number of Rows	Solar Panel Width	Roof Area Width	Watts/SF	Total Capacity (kW)
North	15	2.21 ft	72	9	21.48
South	10	2.21 ft	75	9	14.92
Total	N/A	N/A	N/A	N/A	36.40

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Analysis Assumptions

Building Load: Operates at half connected load during operating hours

Panel Output Depreciation: 0.5% per year, compounded

Cost of Electricity: \$0.12/kWh

Taxes: Exempt from property and income taxes

Incentives: Production based incentive of \$0.139/kWh for first 5 years

Analysis Results	
Initial Cost	\$104,996.56
Annual Energy	58,398 kWh
Levelized Cost of Energy	\$0.1163/kWh
Payback Period	4.93 years

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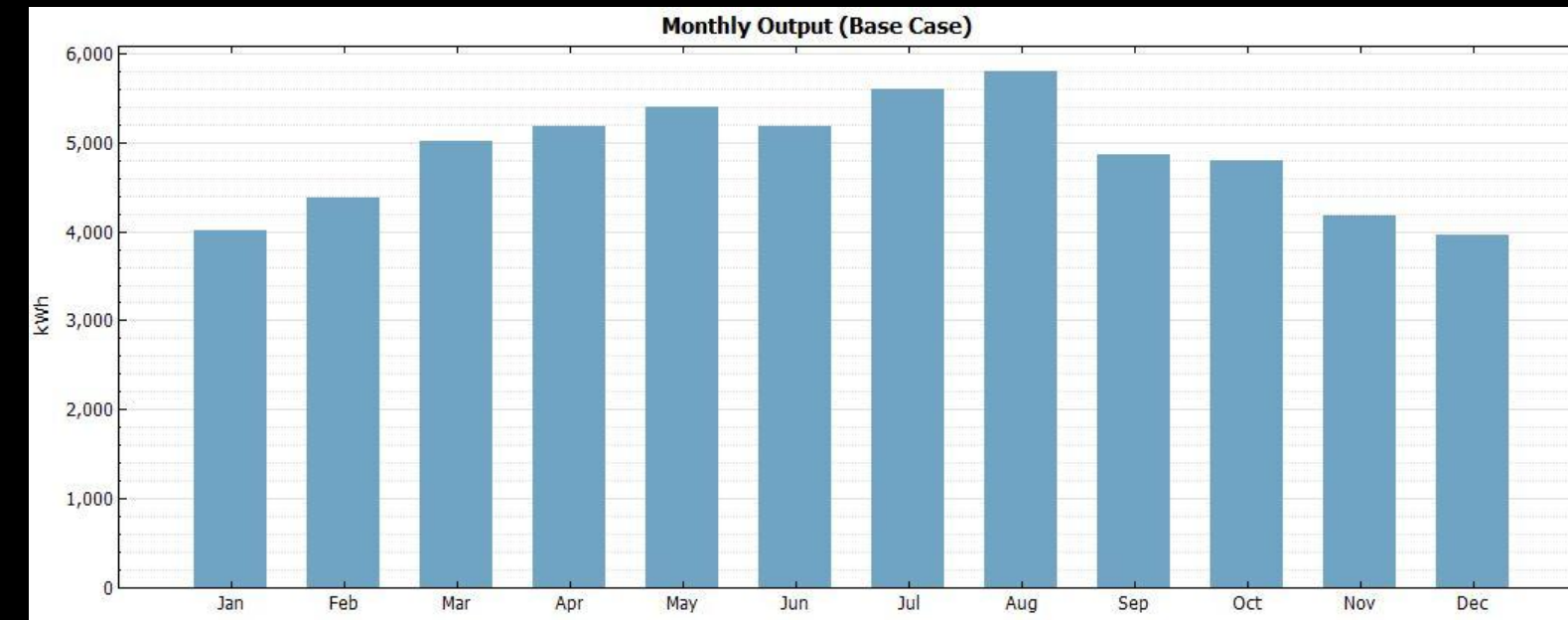
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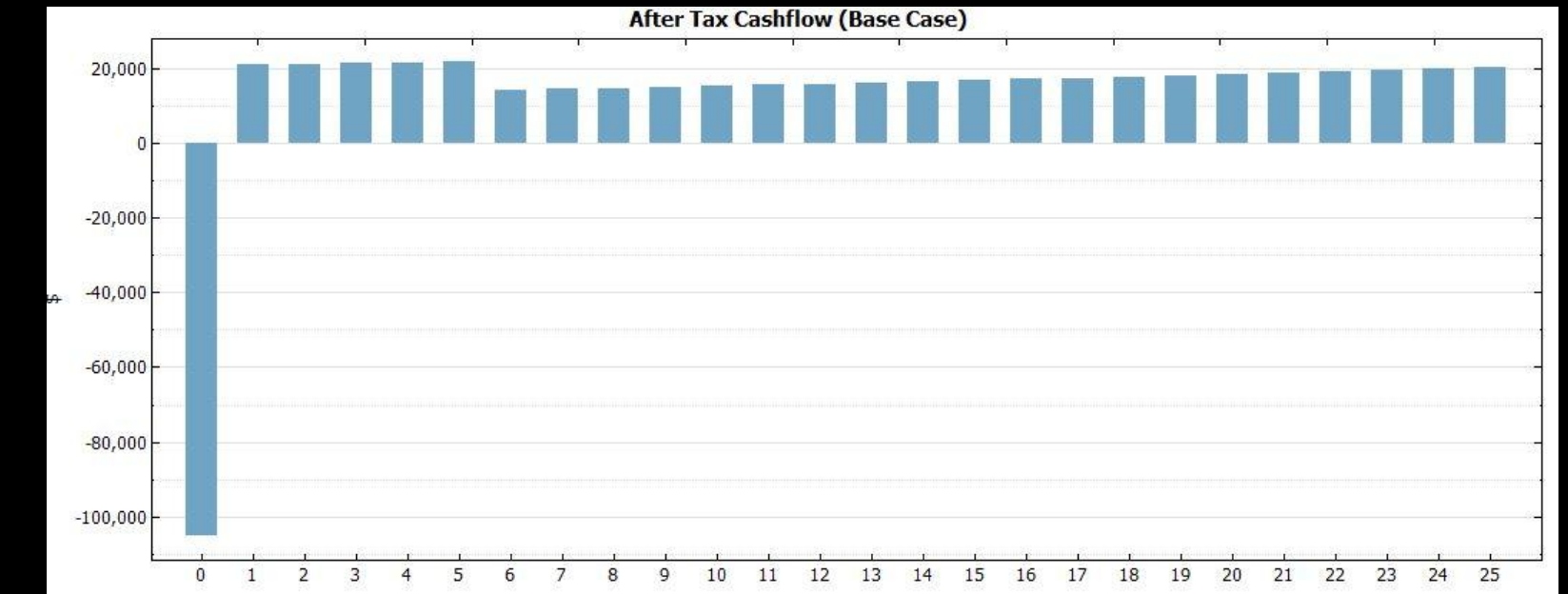
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Monthly Output (kWh)



25 Year Cash Flow

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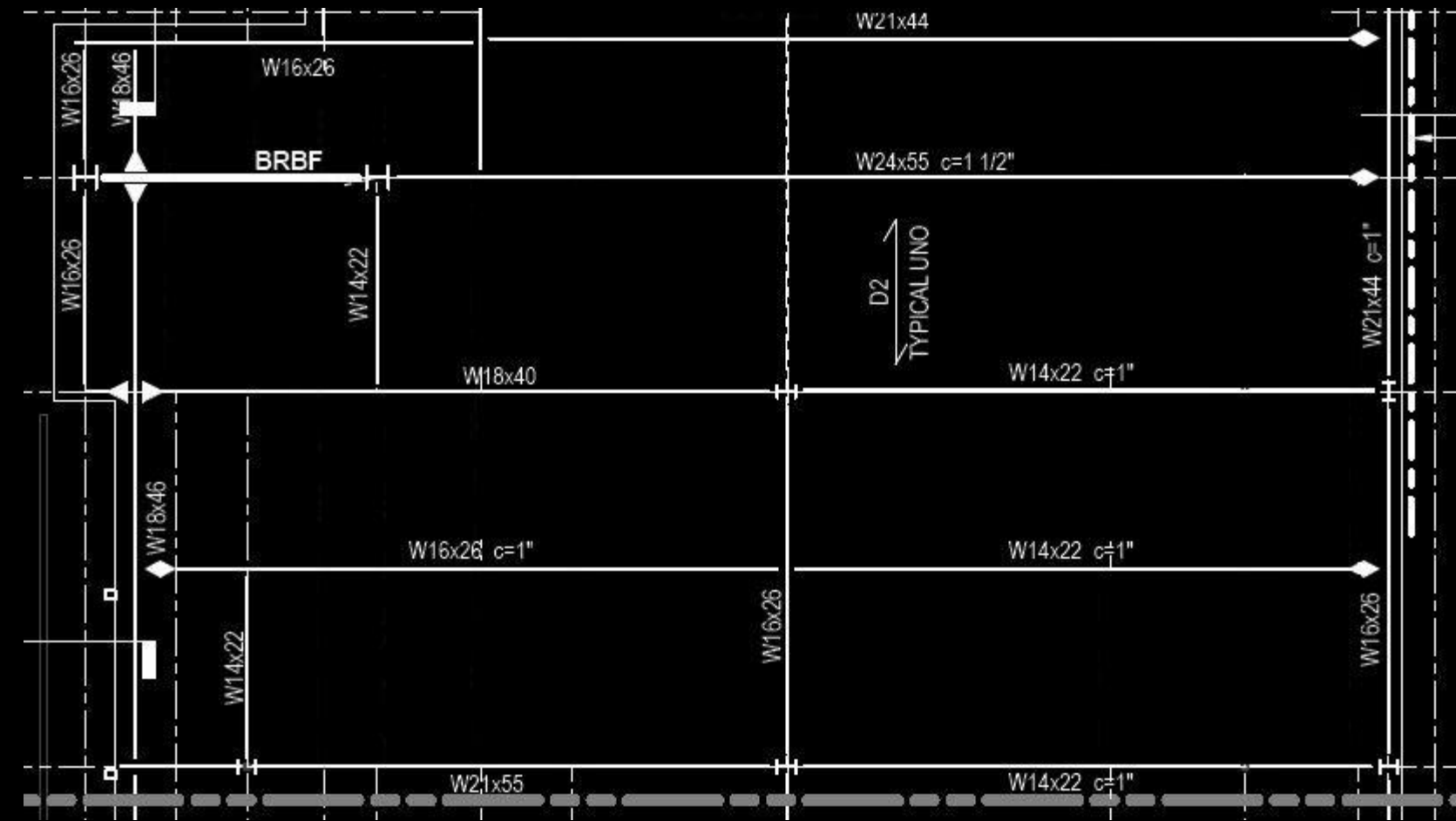
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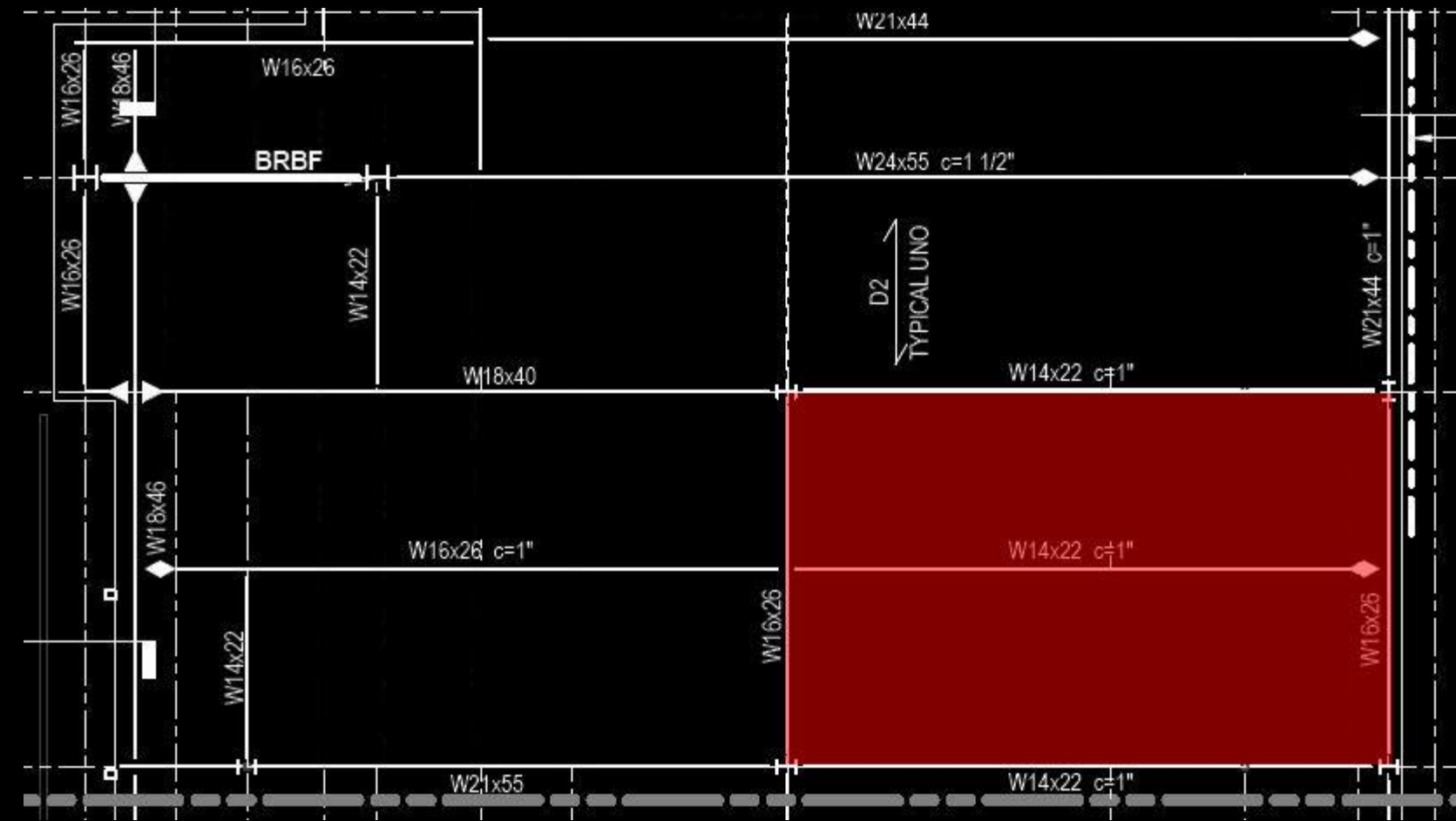
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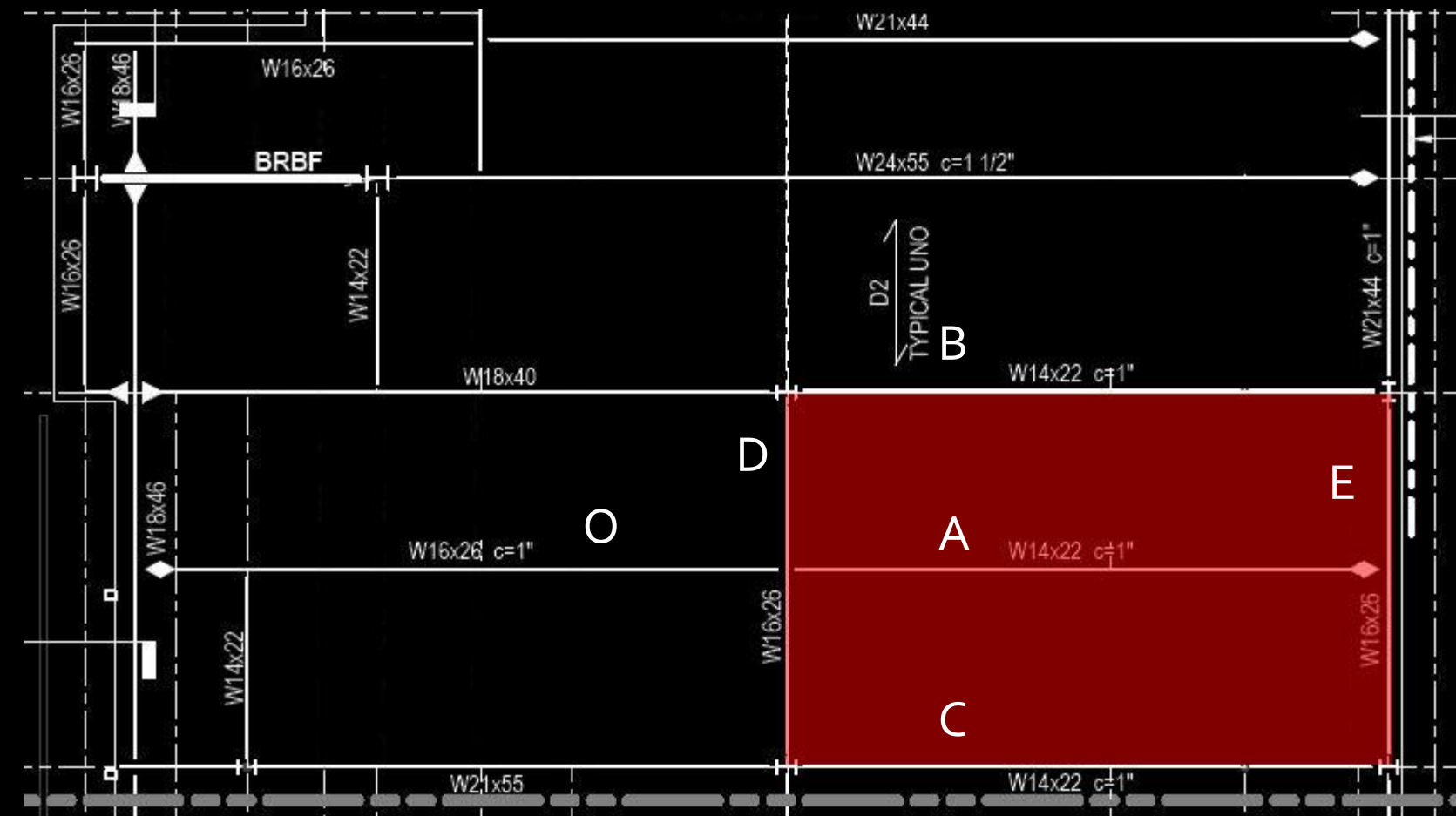
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Dead Loads

- Roof Deck: 2 psf
- Insulation: 1 psf
- Misc. Dead Load: 10 psf
- Member Self Weight: 5 psf
- Solar Panels: 5 psf
- **Total: 23 psf**

Dead Loads

- Roof Live Load: 20 psf

$$1.2*(23\text{psf}) + 1.6*(20\text{psf}) = 59.6 \text{ psf}$$

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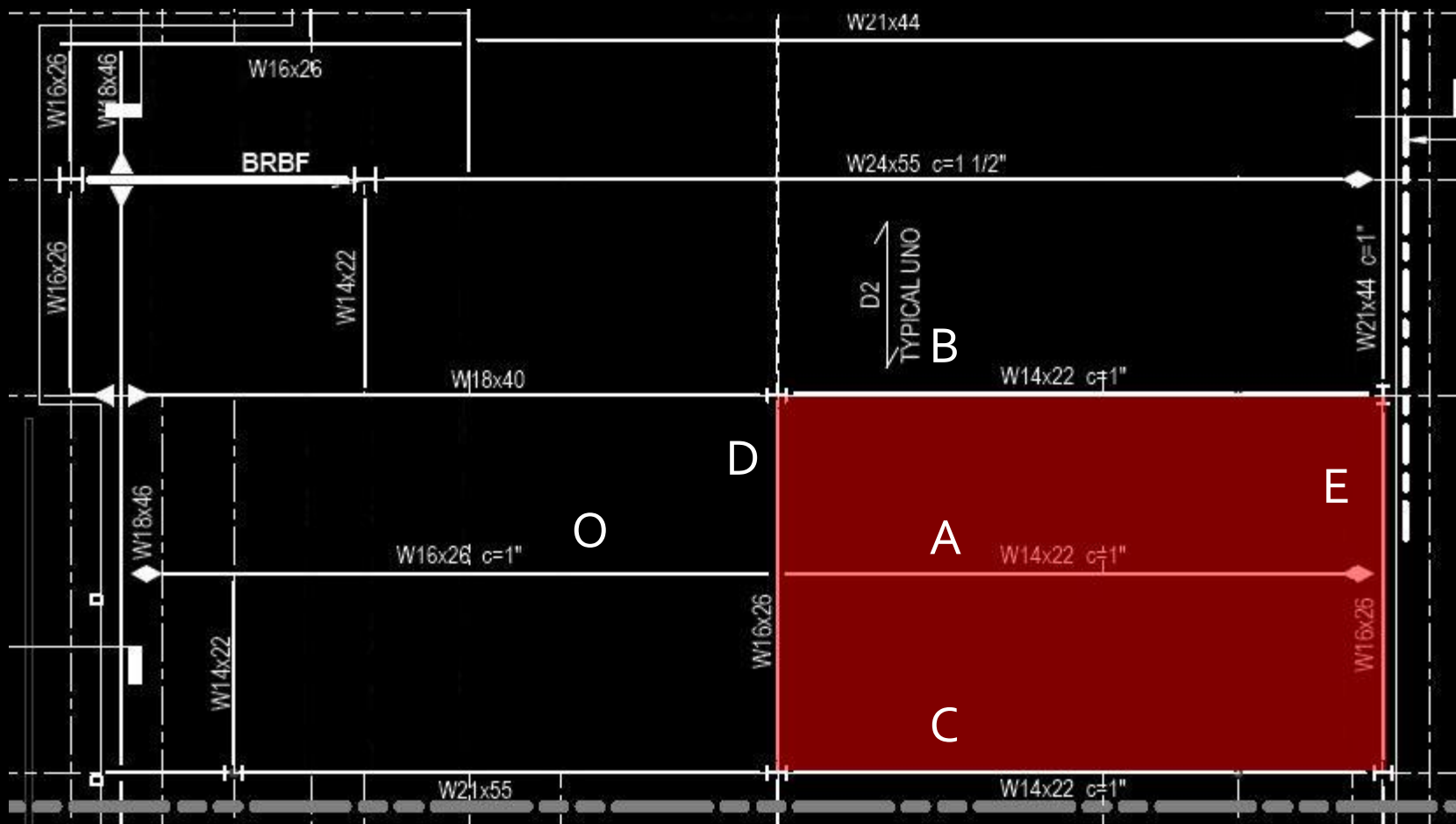
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Beam	Tributary Width (ft)	Uniform Load (plf)	Span (ft)	Reaction At Supports (kips)	Maximum Moment (kip*ft)
A	10.5	625.8	33.5	10.48	87.77
B	10.875	648.15	33.5	10.86	90.95
C	10.75	640.7	33.5	10.73	89.86
O	10.5	625.8	36.25	11.34	N/A

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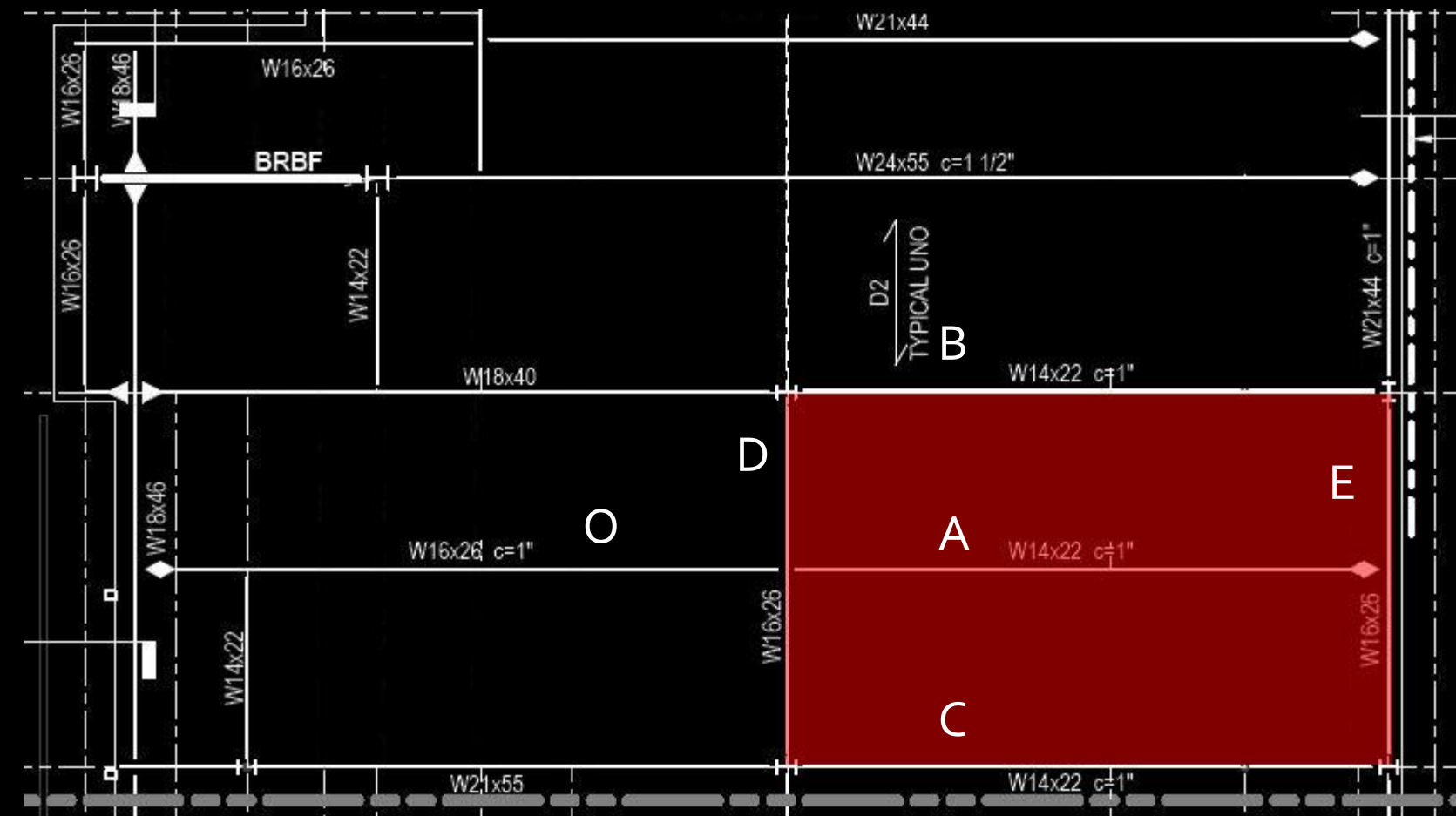
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Beam	Size	Maximum Moment (kip*ft)	$\Phi_b M_{px}$ (kip*ft)
A	W 14X22	87.77	125
B	W 14X22	90.95	125
C	W 14X22	89.86	125
D	W 16x26	114.3	166
E	W 16x26	54.9	166

Introduction

Entrance

Lobby

Daylighting Analysis

Photovoltaic Analysis

Structural Analysis

Conclusion

Conclusions

Lighting: Provided a lighting design reflecting the use of the building

Daylighting: Provided a daylighting system that provides energy savings in the gymnasium

Photovoltaic Analysis: Photovoltaic array provides energy and reduces the cost of the building

Structural Analysis: The structural members do not need to be redesigned because of the photovoltaic array

Acknowledgements

Dr. Houser

Dr. Mistrick

Professor Parfitt

Professor Holland

Cannon Design

Family and Friends



Questions?



