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INDIVIDUALS

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Robert Leicht, Ph.D.

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VERIFICATION OF POTENTIAL PROJECT DELIVERY METHOD

The Project Delivery Selection System (PDSS) was used to blindly compare 12 options for a project delivery method. The process for selecting a delivery method begins with reviewing the project goals and objectives and, from a list of 20 available selection factors (Table FO-1), identifying which are most appropriate for the project.

Table FO - 1: Selection Factors

Factor Number	Selection Factor	Factor Description for Comparing Delivery Systems	Factor Action Statement
Cost-related factors			
1	Completion within original budget is critical to project success.	Delivery System facilitates control of cost growth	Control cost growth
2	Minimal cost is critical to project success	Delivery System ensures lowest reasonable cost	Ensure lowest cost
3	Owner's cash flow for the project is constrained.	Delivery System delays or minimizes rate of expenditures	Delay or minimize expenditure rate
4	Owner critically requires early (and reliable) cost figures, to facilitate financial planning and business decisions.	Delivery System facilitates accurate early cost estimates	Facilitate early cost estimates
5	Owner assumes minimal financial risk on the project.	Delivery System reduces risks or transfers a high level of cost and schedule risks to the contractor(s)	Reduce risks or transfer risks to contractor(s)

Once goals are identified, they can be ranked by preference and given a weight, as shown in Table A-1. The PDSS tool is programmed to calculate each factor's normalized weight, highlighted in green.

Table A-1: Compute Preference Weights

	Factor Action Statement	Preference Rank	Preference Scores	Normalized Preference Weight
set target and control cost growth	Control cost growth	1	100	0.16
for future projects	Capitalize on familiar project conditions	6	60	0.10
more efficient delivery system than separate design, procurement, construction	Promote early procurement	5	60	0.10
supports controlling cost growth	Facilitate early cost estimates	4	70	0.11
protect the owner- minimizing risk to success as an organization with a community impact	Reduce risks or transfer risks to contractor(s)	2	90	0.15
protect the owner	Minimize Owner's controlling role	3	80	0.13
protect the owner	Minimize Owner's involvement	3	80	0.13
protect the owner	Minimize number of contracted parties	3	80	0.13
			620	

Each selection factor carries effectiveness values describing how well each delivery method supports that selection factor on a scale of 0-100, as shown to the right. For example, Delivery Method 11 contributes greatly to the goal of controlling cost growth, as its effectiveness value is 100. However, Delivery Method 9 does not support the goal, as its effectiveness value is 0.

	Cost Related Factors
	Factor 1
	Control cost growth
PDCS 01	80
PDCS 02	50
PDCS 03	80
PDCS 04	80
PDCS 05	50
PDCS 06	60
PDCS 07	90
PDCS 08	70
PDCS 09	0
PDCS 10	0
PDCS 11	100
PDCS 12	40

The last step is to compute the aggregate scores, as shown in Table A-2. By copying the effectiveness values into the selection matrix, the PDSS tool calculates which delivery method is most aligned with the defined project goals, as shown in the "Aggregate Score" column. Based on the analysis, Delivery Methods 7 and 12 were most effective for supporting Growing Power's project goals, which are associated with Design Build and Turnkey, respectively. While the Turnkey delivery strategy was considered, it was determined to not be of use for this particular project, due to the complicated financial structure that is associated with the delivery method.

Table A-2: Compute Aggregate Scores

PDCS Alternatives ↓	Factor → / Preference Weight →	Control cost growth	Capitalize on familiar project conditions	Promote early procurement	Facilitate early cost estimates	Reduce risks or transfer risks to contractor(s)	Minimize Owner's controlling role	Minimize Owner's involvement	Minimize number of contracted parties	Aggregate Score ↓	PDCS Translation
		0.16	0.10	0.10	0.11	0.15	0.13	0.13	0.13		
PDCS 01	Predetermined Effectiveness Values (Table EV-1)	80	0	0	0	80	10	20	70	37.42	Traditional Design-Bid-Build
PDCS 02		50	50	90	20	50	0	10	60	40.16	Traditional with early procurement
PDCS 03		80	0	0	10	60	30	20	50	35.65	Traditional with Project Manager
PDCS 04		80	0	0	10	60	20	20	40	33.06	Traditional with Construction Manager
PDCS 05		50	40	90	20	20	20	20	40	36.13	Traditional with early procurement and CM
PDCS 06		60	70	100	70	70	40	60	70	66.13	CM @ Risk
PDCS 07		90	100	100	90	90	90	90	90	91.94	**Design-Build or EPC**
PDCS 08		70	90	100	80	80	80	70	80	80.00	Multiple Design-Build or EPC
PDCS 09		0	80	80	20	10	10	0	0	20.48	Parallel Primes
PDCS 10		0	10	50	0	0	50	70	80	31.61	Traditional with Staged Development
PDCS 11		100	100	100	100	100	100	100	100	100.00	**Turnkey**
PDCS 12		40	70	100	60	0	0	0	70	38.71	Fast Track

PLANNING THE IMPLEMENTATION OF BIM

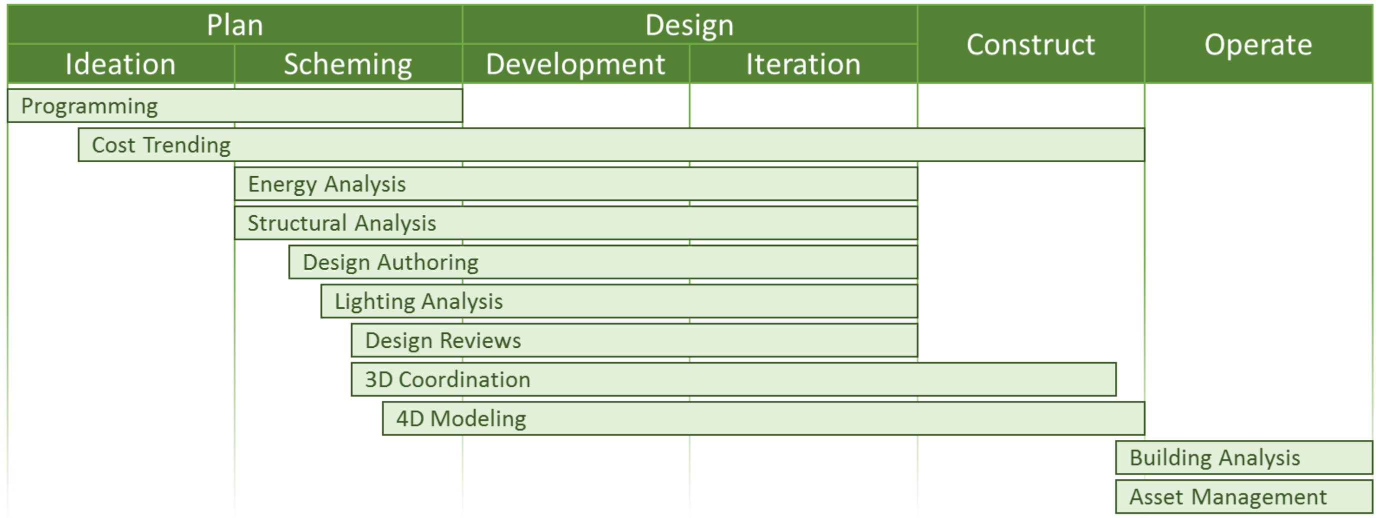
As the use of Building Information Modeling was extremely important to the Growing Power facility's development, a plan was put together at the project's outset for the tool's implementation. The process for BIM planning includes defining project goals, determining BIM uses to support the goals, and defining how models are shared and information is extracted from the models. An excerpt of each portion of the process is shown below.

DEFINING BIM GOALS AND USES

Operate	Construct	Design	Plan
• Allow for an easily maintainable facility • Continuously improve upon prototype	• Minimize field conflicts • Communicate schedule to project stakeholders	• Deliver an efficient, sustainable facility • Ensure mechanical design complies with guidelines • Ensure comfortable (day)lighting in spaces • Ensure structural design complies with guidelines • Review design progress to gather input from team • Ensure project aligns with target value	• Validate and update arch program

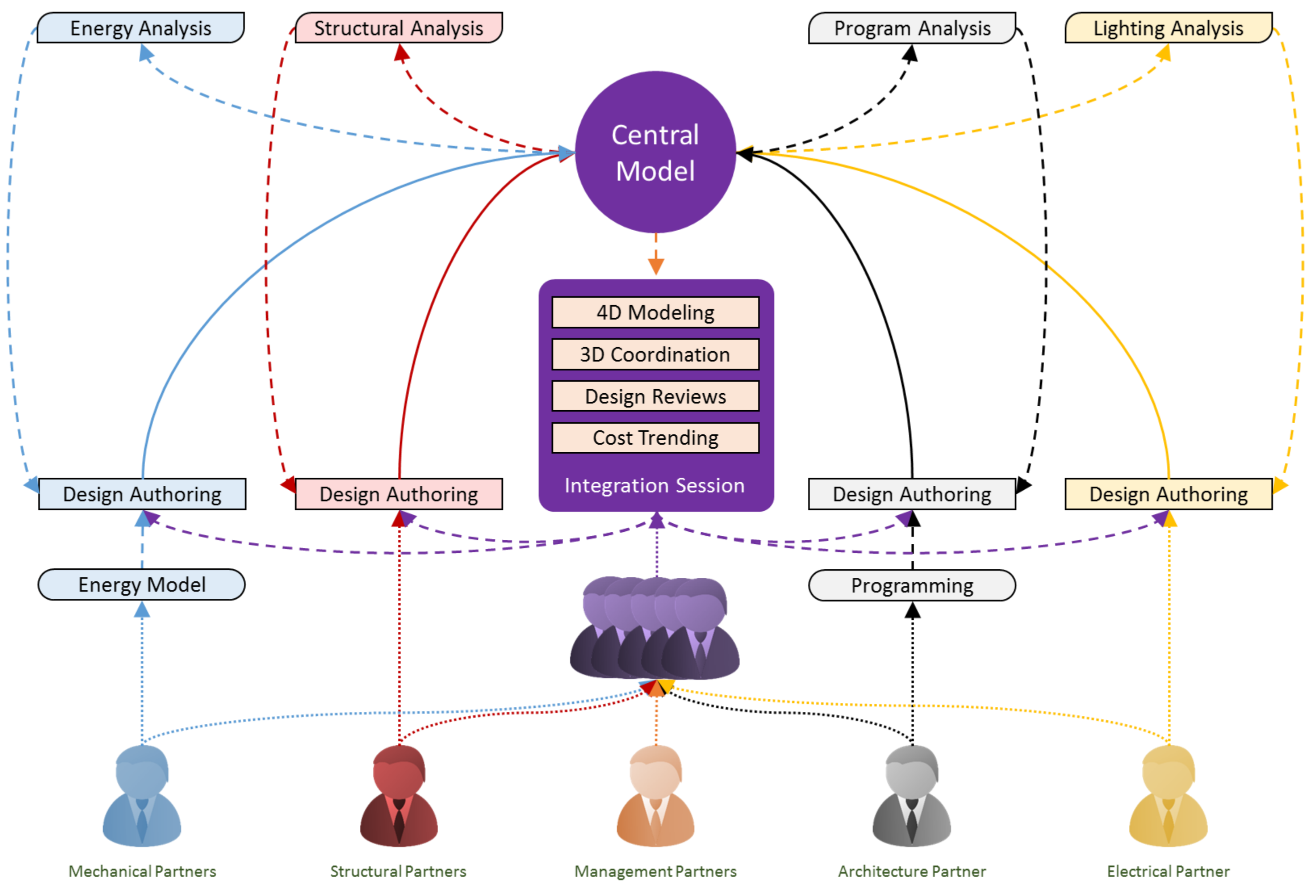
Building Information Modeling Use Case Worksheet

BIM USE	PROJECT VALUE	RESPONSIBLE PARTNER(S)	VALUE TO RESPONSIBLE PARTNER(S)	CAPABILITY RATING			ADDITIONAL RESOURCES REQUIRED	NOTES	PROCEED?
				SCALE 1-3 (1=LOW)					
	HIGH/MED/LOW		HIGH/MED/LOW	RESOURCES	COMPETENCY	EXPERIENCE			YES/ NO/ TBD
Existing Conditions Modeling	Medium	Architectural Partner	High	3	3	3	Topography, utility locations	To be modeled in Infraworks.	TBD
		Construction Partner	High	3	3	3			
		Electrical/ Lighting Partner	Medium	3	2	1			
		Mechanical Partner	Medium	3	2	1			
Cost Estimation	High	Construction Partner	High	2	3	3		Export QTO from Revit.	Yes
		Electrical/ Lighting Partner	High	2	2	1		Apply RSMeans cost data.	
		Mechanical Partner	High	2	2	1			
		Structural Partner	High	2	2	2			
Phase Planning	Medium							N/A to this project.	No
Programming	High	Architectural Partner	High	3	3	3		Analyze schematic documents.	Yes
		Electrical/ Lighting Partner	Medium	3	2	2		Model in Sketchup.	
		Mechanical Partner	High	3	2	2		Review on SMARTBoard.	
		Structural Partner	High	3	2	2			
Site Analysis	Low							Site selected already.	No
Design Reviews	High	Owner	High	1	1	1		To be conducted in immersive	Yes
		Architectural Partner	High	3	3	3		environment (ICON Lab).	
		Construction Partner	High	3	3	3		Revit to RTR (likely Unity).	
		Electrical/ Lighting Partner	High	3	2	2			
		Mechanical Partner	High	3	2	2			
		Structural Partner	High	3	2	2			



DEFINING BIM PROCESS

In order to effectively take advantage of the benefits of BIM, the decided upon uses of the tools must be organized into a process. Shown below is a visualization of TBD's BIM process. For example, the mechanical partner's BIM process began by developing an energy model to analyze potential systems. Once a design was selected, the mechanical partners authored their design in Revit, and continuously synchronized to a shared, central model, which allowed for information to be extracted for data analysis. From there, the cycle was an iterative process, as shown by the loop in the partner's process.



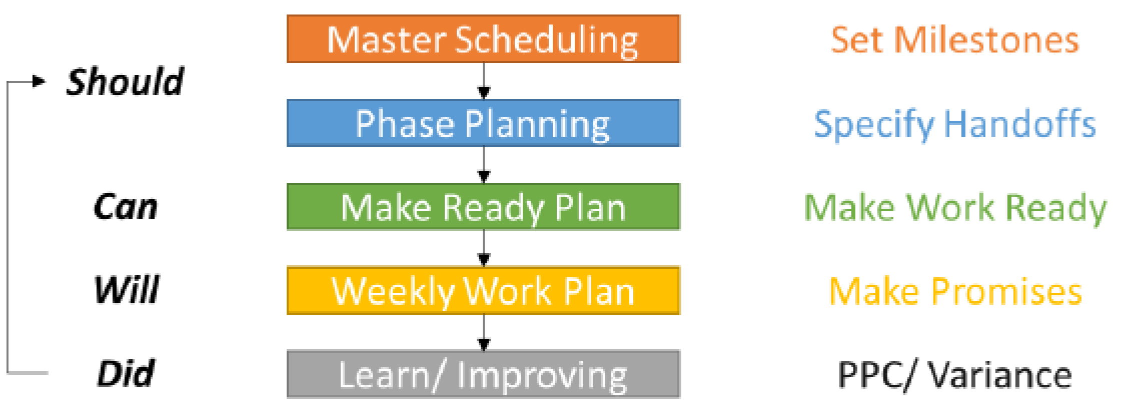
LAST PLANNER SYSTEM (LPS)

[redacted]

OVERVIEW

In a recent study on production in design and construction teams, it was found that an average of 54% of planned work was completed on time. The major reason given for this low percentage was that prerequisite work was not completed in order to begin tasks on time. The Last Planner System is a planning strategy that aims to make teams more productive by completing a high percentage of planned work. According to the Lean Construction Institute, the Last Planner System (LPS) is a "collaborative, commitment-based planning system that integrates should-can-will-did planning with constraint analysis, weekly work planning based upon reliable promises, and learning based upon analysis of PPC (plan percent complete) and reasons for variance." LPS follows a 5-step process built on the Plan-Do-Check-Act cycle that ensures that a team is performing work that needs to be done, when it needs to be done, so that successors can proceed as planned.

THE 5-STEP SYSTEM



MASTER SCHEDULING

The first step of LPS involves Master Scheduling, or the act of setting milestones. Generally this portion of the process is performed similarly to traditional scheduling practice, as milestones are often constrained by substantial completion dates or other deadlines. However, more intermediate milestones are generally specified than in a traditional approach, making the next step oh phase/pull planning more clear.

PHASE PLANNING/ PULL PLANNING

Phase planning, or pull planning, is sometimes thought of as synonymous with LPS. However, phase planning does not represent actual promises or commitments between team members, but rather serves to specify the handoffs that need to be made in order to complete work—it specifies what *should* occur in the phase. Pull Planning is performed in a backwards fashion, working from a milestone. Individual tasks are identified collaboratively with zero or minimal-float durations so that once the process is complete, activities are completed or decisions are made at the last responsible moment. This ensures that downstream activities are pulling the work from earlier activities, and the process flows smoothly. Pull planning is usually used with sticky notes that follow a particular fashion, specifying the work an individual is to complete with the work that needs to be completed immediately prior.

MAKE READY PLANNING

Making work ready is an important part of LPS that ensures that the upcoming work can be completed per the initial plan—it defines what work *can* be completed. The initial step of making work ready involves documenting the handoffs that were specified in the previous step. However, the documentation goes one step farther by allowing space for constraints to be documented. By identifying constraints to the phase plan—what *should* happen—the team can work to resolve those constraints ahead of time before they restrict the actual work being performed.

WEEKLY WORK PLANNING

Weekly planning exists for team members to make commitments to each other once it has been determined that the work has been made ready. The weekly plan defines what work *will* be done by each party. This follows a similar process as phase planning, but is much more detailed for the week ahead. It also involves daily check-in meetings with the team to ensure that work is progressing as planned. A recommendation is for these meetings to take no longer than 15 minutes, and to identify what promises have been fulfilled, and what work will be fulfilled.

LEARNING/ IMPROVING

Perhaps the most important part of LPS is the learning/ improving stage, which defines what *did* happen, and aims to support the lean principle of continuous improvement. On a weekly basis, the promises that were to be completed in the week prior are analyzed to determine the Plan Percent Complete (PPC). A common strategy is to publish the entire team's PPC, but track privately per individual or trade. Publishing the team's PPC on a regular basis allows the team to strive for as high a percentage as possible, but the management team can determine if a particular trade is routinely performing at a low percentage. From here, the PPC can be analyzed to determine what needs to be done for the project to be completed better, and bring the average of 54% to a much higher level.

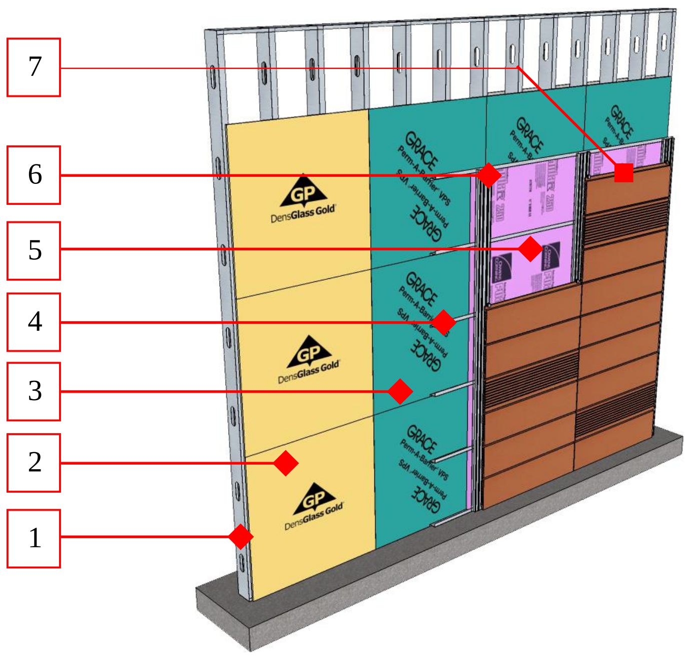
CONCLUSIONS

The Last Planner System is a collaborative way to enhance the planning and scheduling process. With construction having a much lower efficiency than other non-agricultural industries, and only 54% of tasks being completed, LPS has the potential to greatly improve the industry. Through thorough implementation of the 5 steps of LPS, teams can generate more realistic schedules and build chemistry with their trade partners. While often implemented after problems arise through work with consultants, champions of the process can implement the system throughout an entire project to experience clearer understanding of the interactions among team members and develop more useful schedules and planning techniques.

Custom Assemblies for Accurate Pricing

As many systems designed for the Growing Power Facility were atypical, accurate pricing was obtained through the analysis of a custom built assembly. Through various sources, including contractor suppliers and system manufacturers (example below), combined with virtual mockup construction, construction partners were able to more accurately analyze project controls associated with the purchase and installation of numerous assemblies. An example is provided below for the terracotta portion of the Growing Power facility's rain screen façade. In addition, each component's technical specifications (example shown at right) were obtained and analyzed to ensure they complied with the project goals and engineering analyses performed by design partners.

TC Rain Screen Façade							
Material	**ID**	**Cost**	**Qty**	**Unit**	**Unit Price**	**Unit/SF**	**$/SF**
Stud	1	$ 6.21	10	LF	$ 0.62	0.75	$ 0.47
Sheathing	2	$ 19.00	32	SF	$ 0.59	1	$ 0.59
Vapor Barrier	3	$ 175.00	112.5	SF	$ 1.56	1	$ 1.56
Z Strip	4	$ 200.00	192	LF	$ 1.04	0.5	$ 0.52
Insulation	5	$ 32.00	32	SF	$ 1.00	1	$ 1.00
Furring	6	$ 4.49	12	LF	$ 0.37	1	$ 0.37
TC Panel	7	$ 32.00	1	SF	$ 32.00	1	$ 32.00



Mat'l	$ 36.51
Inst	$ 2.10
Total	$ 38.61

"If your project would meet requirements on my last email, budget pricing would be:
NBK TerraArt Large $32 sq ft
QC 100 Metal Panels - $20 sq ft
Both products would include a fully engineered system, shop drawings and the support system. This price would be for standard colors, not custom colors.

Regards
Barb Smith"

Technical Data Sheet for Natural Terra Cotta Tiles

Water absorption *all approved colors* DIN EN 14411 *Group* AII_a DIN EN 14411 *Group* AII_b	**EN ISO 10545 *Part* 3**	 3,0 - 6,0 % 6,0 - 10,0 %
Bending tensile strength *Natural and glazed finish* DIN EN 14411 *Group* AII_a DIN EN 14411 *Group* AII_b	**EN ISO 10545 *Part* 4**	 > 1740 lb/in² > 1305 lb/in²
Raw density		128 lb/ft³ - 137 lb/ft³
Freeze / thaw resistance	**EN ISO 10545 *Part* 12** (100 Freeze - thaw - cycles)	fulfilled
Efflorescence and soluble salts	**DIN 105 Teil / *Part* 1**	well below the permitted maximum limit
Chemical resistance	**DIN EN ISO 10545 *Part* 13**	fulfilled
Dimensions + tolerances		
Length 15-3/4" - 70-7/8"	**Overall horizontal axis of tile**	± 0.039" for cuts
Height 5-7/8" - 31-1/2"	**Overall vertical axis of tile**	± 1/16" *to* 9-7/8" ± 1/8" *to* 1' - 3-3/4" ± 1/8" *to* 1' - 11-5/8" ± 1/8" *to* 2' - 7-1/2"
Thickness	**EN ISO 10545 *Part* 2** *deviation if surface is honed*	± 1/16"
Straightness in core direction ***Horizontal / length axis***	**EN ISO 10545 *Part* 2**	± 0.25 % *of length*
Diagonal flatness	**EN ISO 10545 *Part* 2**	± 0.25 % *of diagonal*
Vertical flatness ***Direction vertical / height axis***	**EN ISO 10545 *Part* 2**	± 0,50 % *of height*
Torsion	**EN ISO 10545 *Part* 2**	± 0.50 % *of diagonal*

UTILIZATION OF BIM IN QUANTITY TAKEOFF AND ESTIMATE DEVELOPMENT

In order to streamline the estimation process and support TBD's efforts to continually evaluate the project's development against the established target, the construction partners utilized direct exports from Revit for the facility's structural framing as a comma separated variable file. Once the data was imported into Microsoft Excel, RS Means cost and schedule data was applied, as shown below. In total, over 400 members were exported from Revit and analyzed in a matter of minutes.

Structural Framing Schedule

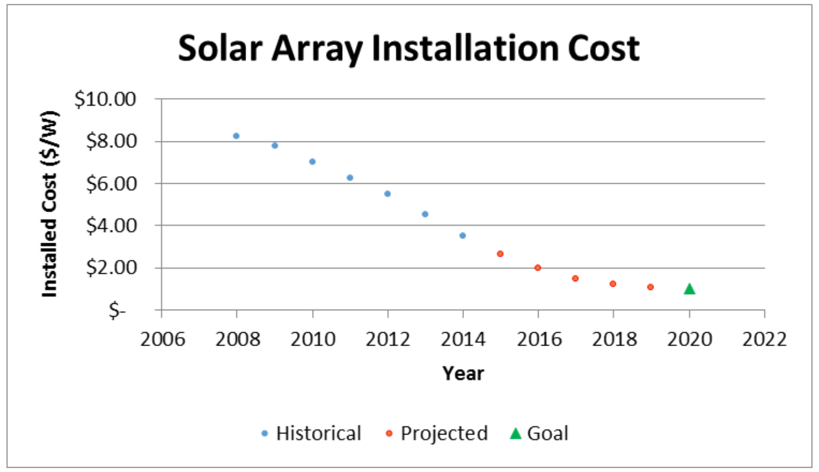
Type	W	Length	Unit	Daily Output	Material	Labor	Equip	Unit Price	O and P	Total Price	Duration	Member Wt.
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	4.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 119.09	0.008	46.70
W8X10	10	21	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 535.50	0.035	210.00
W8X10	10	12.17	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 310.34	0.020	121.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	21	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 535.50	0.035	210.00
W8X10	10	12.17	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 310.34	0.020	121.70
W8X10	10	4.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 119.09	0.008	46.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	20.92	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 533.46	0.035	209.20
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	13.33	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 339.92	0.022	133.30
W8X10	10	4.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 119.09	0.008	46.70
W8X10	10	13.33	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 339.92	0.022	133.30
W8X10	10	4.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 119.09	0.008	46.70
W8X10	10	9.33	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 237.92	0.016	93.30
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	4.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 119.09	0.008	46.70
W8X10	10	4.5	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 114.75	0.008	45.00
W8X10	10	13.33	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 339.92	0.022	133.30
W8X10	10	13.33	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 339.92	0.022	133.30
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	10.73	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 273.62	0.018	107.30
W8X10	10	13.33	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 339.92	0.022	133.30
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	13.33	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 339.92	0.022	133.30
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	4.5	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 114.75	0.008	45.00
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	13.33	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 339.92	0.022	133.30
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	4.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 119.09	0.008	46.70
W8X10	10	12.17	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 310.34	0.020	121.70
W8X10	10	4.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 119.09	0.008	46.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	13.5	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 344.25	0.023	135.00
W8X10	10	13.33	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 339.92	0.022	133.30
W8X10	10	13.5	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 344.25	0.023	135.00
W8X10	10	13.5	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 344.25	0.023	135.00
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	4.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 119.09	0.008	46.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70
W8X10	10	10.67	LF	600	$ 13.10	$ 4.83	$ 2.52	$ 20.45	$ 25.50	$ 272.09	0.018	106.70

ANALYSIS OF DESIGN OPTIONS FROM A FINANCIAL STANDPOINT

In order to analyze various design options, construction partners performed in-depth financial analyses (CM 4). The information provided below follows the process to analyze the economic viability of an on-site solar array and is representative of numerous analyses performed throughout the planning and design phases of the Growing Power project.

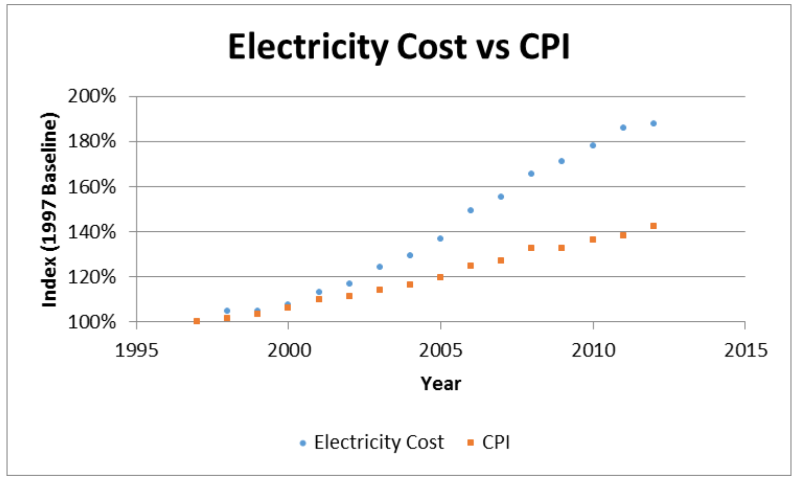
The first step in the solar financial analysis was to determine the total installed cost. Based on historical data from the National Renewable Energy Laboratory and a goal of $1/W in 2020, the following table was compiled.

Year	Historical	Projected	Goal
2008	$ 8.25		
2009	$ 7.75		
2010	$ 7.00		
2011	$ 6.25		
2012	$ 5.50		
2013	$ 4.50		
2014	$ 3.50		
2015		$ 2.65	
2016		$ 2.00	
2017		$ 1.50	
2018		$ 1.25	
2019		$ 1.05	
2020			$ 1.00



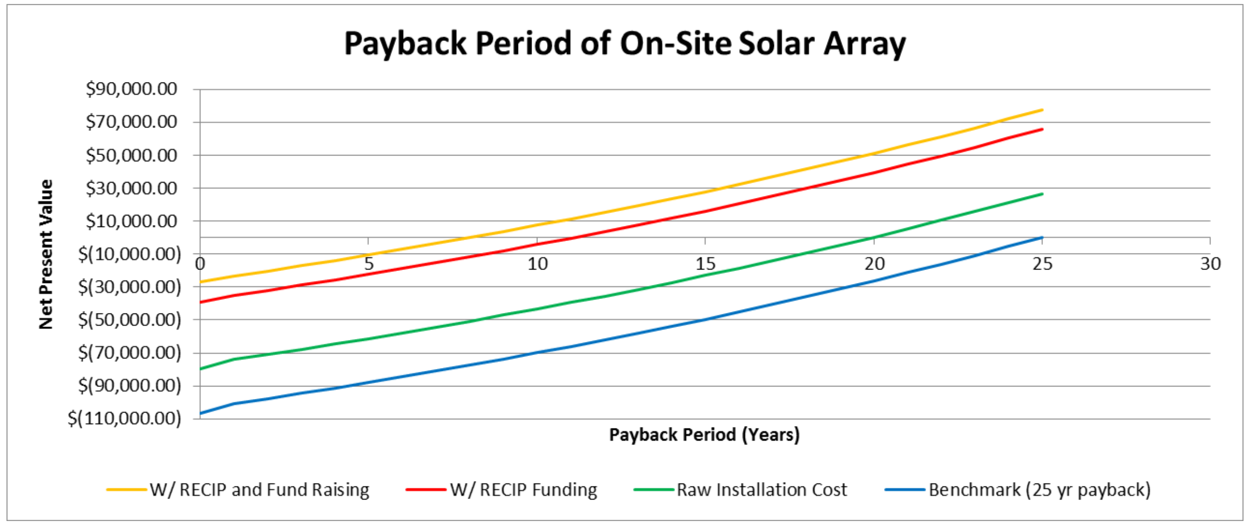
In order to determine the payback period and long-term economic value of the proposed array, a Net Present Value (NPV) analysis was performed. However, numerous variables needed to be determined in order to develop an accurate NPV analysis—specifically, the discount rate and the annual escalation of electricity costs in the Milwaukee area. The analysis is shown below, with data from the United States Bureau of Labor Statistics and Energy Information Administration. Based on the data, the discount rate was determined to be 3%, with annual electricity escalation doubling inflation at 6%.

	Electricity Cost		CPI	
1997	$ 0.0560	100%	159.10	100%
1998	$ 0.0587	105%	161.60	102%
1999	$ 0.0588	105%	164.30	103%
2000	$ 0.0603	108%	168.80	106%
2001	$ 0.0634	113%	175.10	110%
2002	$ 0.0654	117%	177.10	111%
2003	$ 0.0697	124%	181.70	114%
2004	$ 0.0724	129%	185.20	116%
2005	$ 0.0767	137%	190.70	120%
2006	$ 0.0837	149%	198.30	125%
2007	$ 0.0871	156%	202.40	127%
2008	$ 0.0928	166%	211.10	133%
2009	$ 0.0957	171%	211.10	133%
2010	$ 0.0998	178%	216.70	136%
2011	$ 0.1042	186%	220.20	138%
2012	$ 0.1051	188%	226.70	142%

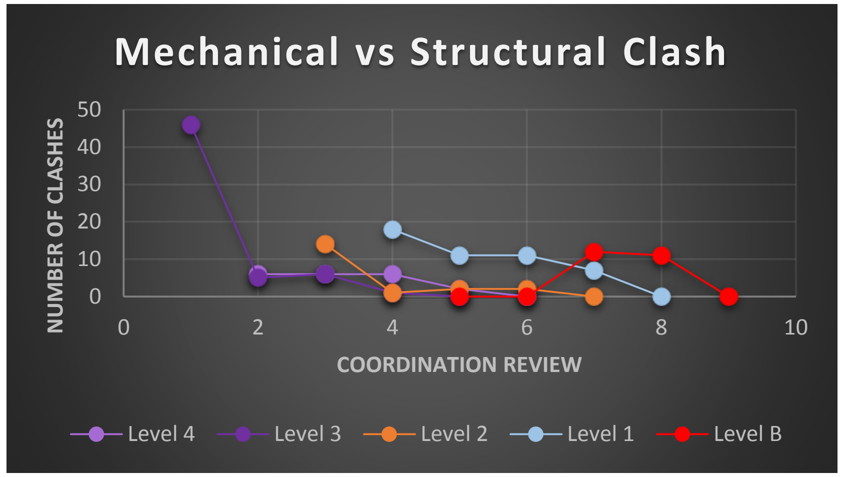


Once the discount rate and annual escalation rate of electricity costs were determined, NPV analyses were performed for various funding models (CM 5). Data derivation and analysis is shown below, showing the that the recommended financial model possesses a 25 year NPV of almost $80,000, with an 8 year payback period.

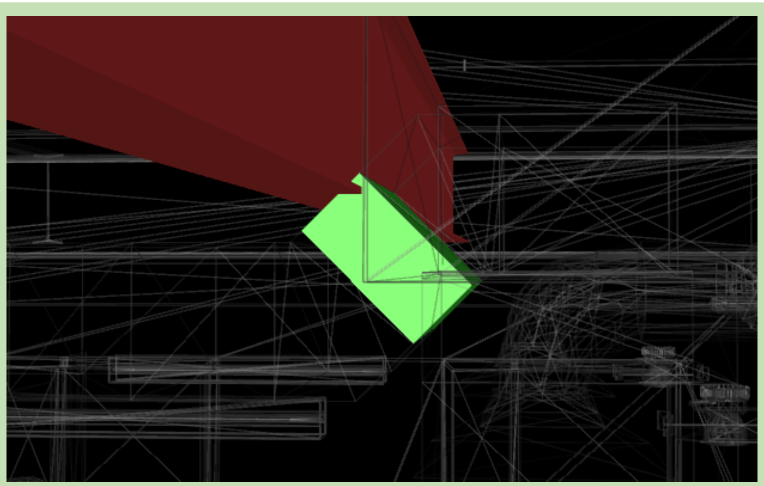
	25	Raw	RECIP	Fund
0	$ (106,707.67)	$ (79,346.73)	$ (39,129.61)	$ (27,066.75)
1	$ (100,602.71)	$ (74,038.69)	$ (34,992.94)	$ (23,281.43)
2	$ (97,527.70)	$ (70,963.68)	$ (31,917.94)	$ (20,206.42)
3	$ (94,372.62)	$ (67,808.60)	$ (28,762.86)	$ (17,051.34)
4	$ (91,135.38)	$ (64,571.36)	$ (25,525.62)	$ (13,814.10)
5	$ (87,813.86)	$ (61,249.84)	$ (22,204.09)	$ (10,492.58)
6	$ (84,405.84)	$ (57,841.82)	$ (18,796.08)	$ (7,084.56)
7	$ (80,909.08)	$ (54,345.06)	$ (15,299.32)	$ (3,587.80)
8	$ (77,321.27)	$ (50,757.25)	$ (11,711.51)	$ 0.01
9	$ (73,640.04)	$ (47,076.02)	$ (8,030.28)	$ 3,681.24
10	$ (69,862.96)	$ (43,298.94)	$ (4,253.19)	$ 7,458.32
11	$ (65,987.52)	$ (39,423.50)	$ (377.76)	$ 11,333.76
12	$ (62,011.17)	$ (35,447.15)	$ 3,598.59	$ 15,310.11
13	$ (57,931.28)	$ (31,367.26)	$ 7,678.48	$ 19,390.00
14	$ (53,745.16)	$ (27,181.14)	$ 11,864.60	$ 23,576.12
15	$ (49,450.03)	$ (22,886.01)	$ 16,159.73	$ 27,871.25
16	$ (45,043.07)	$ (18,479.05)	$ 20,566.69	$ 32,278.21
17	$ (40,521.35)	$ (13,957.33)	$ 25,088.41	$ 36,799.93
18	$ (35,881.89)	$ (9,317.87)	$ 29,727.87	$ 41,439.39
19	$ (31,121.63)	$ (4,557.61)	$ 34,488.14	$ 46,199.65
20	$ (26,237.41)	$ 326.61	$ 39,372.35	$ 51,083.87
21	$ (21,226.02)	$ 5,338.00	$ 44,383.75	$ 56,095.27
22	$ (16,084.13)	$ 10,479.89	$ 49,525.63	$ 61,237.15
23	$ (10,808.35)	$ 15,755.67	$ 54,801.41	$ 66,512.93
24	$ (5,395.20)	$ 21,168.82	$ 60,214.56	$ 71,926.08
25	$ 158.90	$ 26,722.92	$ 65,768.66	$ 77,480.18

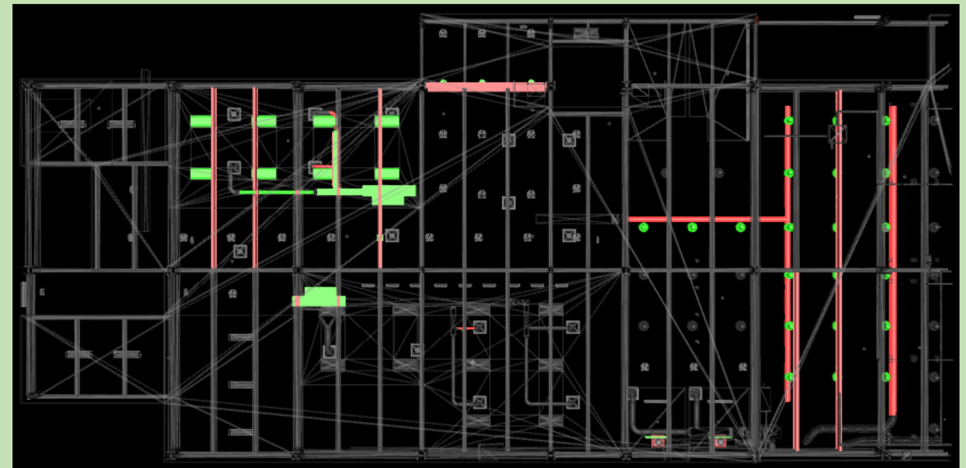


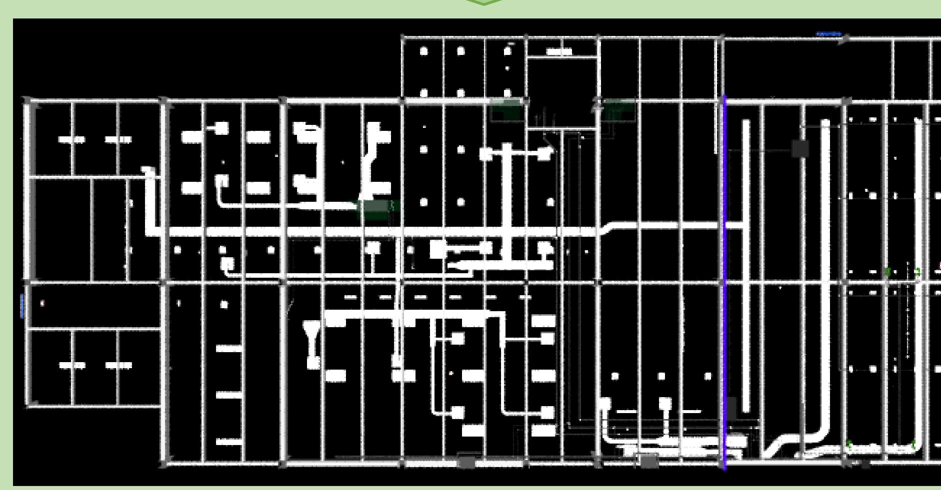
COORDINATION



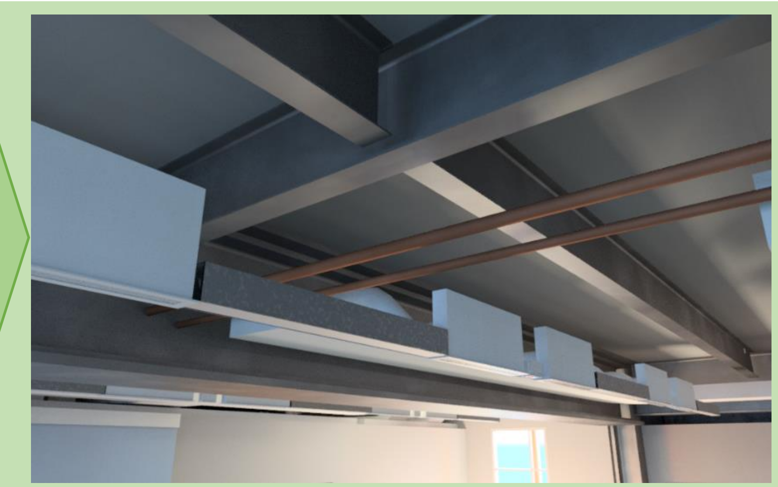
The management team tracked clashes between different technical systems to monitor progress and evaluate the impact of managerial decisions at each collaboration review. After the first coordination review, the high amount of initial clashes signified an opportunity for a better approach to design. To enable the design partners to deliver a more integrated product with less clashes, the management team created coordination views in the discipline specific models, which clearly displayed everyone's technical systems. The change in designing method is reflected by the reduced number of clashes for the remaining duration of design, as indicated in the figure above. Although the change did not completely eliminate all design clashes, it greatly reduced the time and effort required by all parties to resolve clashed through system redesign.







Continuous coordination throughout the design phase of the Growing Power facility enabled the designing partners to develop a facility with minimal clashes. Clashes between the mechanical, electrical, and structural design were identified early in the design process in Navisworks. The clashes, an example of which can be seen to the left, were then discussed in coordination reviews with the entire team. The design teams and construction managers would meet at the planned completion deadlines of the different design packages to conduct an immersive walk through the building, and a coordination review, utilizing a local Semi Immersive Design laboratory, as seen to the left. Clashes identified through the design process were displayed for the team to create group discussions on innovative solutions in a collaborative environment. The team analyzed the potential advantages and disadvantages of the proposed solutions, compromising negative discipline effects for beneficial overall project success. An example of this process would cutting through a steel element to allow piping to remain hidden from the public. The proposed solutions the team agreed upon did not always immediately resolve all clashes, but pushed the project towards the team's clash free goal, while supporting Growing Power's mission.



MANAGEMENT PLAN SYNOPSES

INDOOR AIR QUALITY MANAGEMENT PLAN FOR CONSTRUCTION

The intent of this plan is to mitigate and minimize the risk exposure of workers to polluted air conditions, prevent the absorption of air pollutants into building systems and materials, as well as prevent air pollutants generated in the construction process from drifting to occupied areas. This plan covers air pollutants defined as particulates, volatile organic compounds; formaldehyde, combustion emissions, airborne bacteria and micro-organisms, as well as inorganic airborne compounds, such as ozone, metal fumes, and ammonia and chlorine.

PROJECT ORGANIZATION

The overall organization and management of the IAQ plan falls on the responsibility of the Construction Manager. All disputes related to the IAQ plan are resolved by the construction manager. The CM is to inform all construction personnel of the goal of the plan and regularly monitor the jobsite for its compliance while maintaining all necessary documentation. The subcontractors are responsibly for carrying out the plan and enforcing it among their employees. Sub-contractors are to assume financial costs associated with poor compliance with the plan.

CONTROL MEASURES

HVAC equipment and ductwork will be protected by sealing openings and utilizing MERV 8 filters during operation in construction phases. Filters are to be monitored and replaced as needed. Following an expectation of sustainable design and construction, effort will be set forth to use low emission products complying with the standard VOC limits, as well as a focused reduction of pollution generation from equipment. Where necessary, local temporary exhaust will be used to create a safe environment for workers on site.

BUILDING FLUSH OUT

Upon completion of construction cleaning and prior to occupancy, all mechanical systems will be flushed out. The filters used during construction will be replaced to provide a higher air quality during owner occupation.

REFERENCED STANDARDS

SMACNA IAQ Guidelines for Occupied Buildings under Construction, 2nd Edition
2007,ANSI/SMACNA 008-2008

QUALITY CONTROL PLAN

TBD Engineering will ensure the turnover of a quality project aligned with the owner's goals by enforcing its own quality control plan. The plan will include constant commissioning and inspections of all systems verifying their proper installation. Commission agents and 3rd party inspectors hired to conduct the testing must have a minimum of 5 years' experience.

The Safety and Quality Control Manager is responsible for supervising and enforcing the Quality Control Plan and is to coordinates all project testing, inspections and reporting. The Safety and QC Manager has the authority to intervene and stop any unsatisfactory work, and delay delivery or installation of unsatisfactory material.

Site Specific Safety Plan

Goals

TBD Engineering has set a project goal of ZERO accidents and ZERO injuries on site. The Site Specific Safety Plan (SSSP) is developed with the intent of creating a safe construction workplace for all employees on site, current and future Growing Power employees scheduled to work adjacent to construction zones, and community members living and commuting around the site. No individual should have to risk personal endangerment for the success of a project, and TBD is committed to the safety of the entire project team.

Training and Orientation

All employees must be educated on safe practices of construction and the safety expectations of the Growing Power Facility project team. Before any worker is permitted on site, they must participate in a training and orientation session conducted by the Safety and Quality Control Manager The training consists of a 30 minute video on common safety practices as well as a presentation on specific safety concerns relative to the site, followed by an opportunity for employees to ask any questions they deem relevant. No employee is permitted to work on site without the consent of the Safety and Quality Manager. Upon completion, the Safety and Quality Manager is to award each individual a certification sticker to be work on their hard hat and a contact card of key team members and emergency personnel.

Focus on Safety

To continually keep safety on the mind of all site employees and prioritize a safe working environment, all meetings held on site are to begin with a talk on safety. Toolbox talks, sponsored by the Center for Protection of Workers' Rights, will introduce all weekly meetings with relevant topics of safety. Monthly Safety Stand Downs will be presented to the entire labor force on the site and provide an opportunity to discuss safety topics with management.

Project managers on site will be OSHA 10 certified at a minimum and all OSHA standards will be strictly enforced.

Occupational Health

In the event of an emergency, there are multiple medical facilities in the area. The closest emergency response facility is 4 miles south of the site maintained by Wheaton Franciscan Healthcare. Paratech Ambulance Service is located 1.6 miles north of the site, making it the closest emergency response service.

Emergency Facilities in the area include:

Wheaton Franciscan - Elmbrook Memorial Campus
19333 W. North Avenue
Brookfield, WI 53045

Wheaton Franciscan - St. Joseph Campus
5000 W. Chambers Street
Milwaukee, WI 53210

Wheaton Franciscan Healthcare - All Saints (Spring Street Campus)
3801 Spring Street
Racine, WI 53405

Wheaton Franciscan Healthcare - Franklin
10101 S. 27th Street
Franklin, WI 53132

Wheaton Franciscan Healthcare - St. Francis
3237 S. 16th Street
Milwaukee, WI 5321

Public Safety

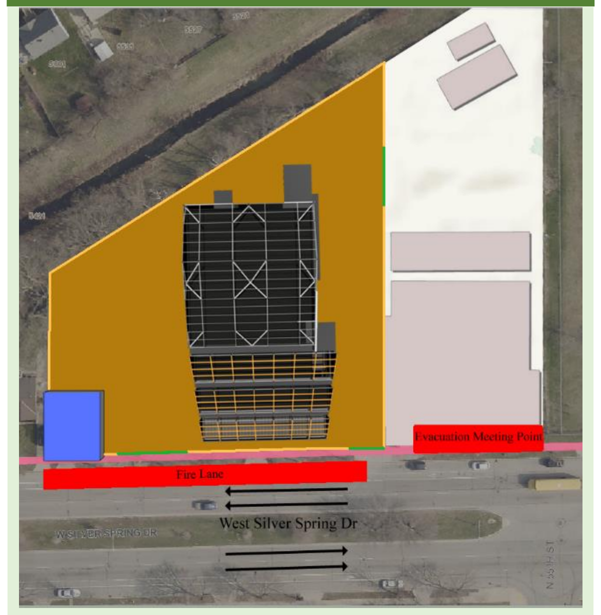
The construction of the Growing Power facility takes place directly next to an active, four lane road, used for both pedestrian and automobile travel. The construction requires multiple deliveries, which will slightly interrupt daily commuter travel. The parking lane closest to the facility is to be claimed by the construction site, to allow for easy site access. When delivered are made to the site, ample signals and direction will be given to the flow of traffic, alerting them to possible stops. The critical pick is to be received directly of a truck stationed on Silver Spring Dr. This pick will require one lane to be closed, but with the help of the police escort of the delivery, traffic will be safely redirected. While pedestrian traffic may continue for a majority of the construction phase, safety concerns during the critical pick will cause pedestrian redirection. During the rest of construction phase, pedestrians will be permitted to pass with the addition of overhead protection where necessary.

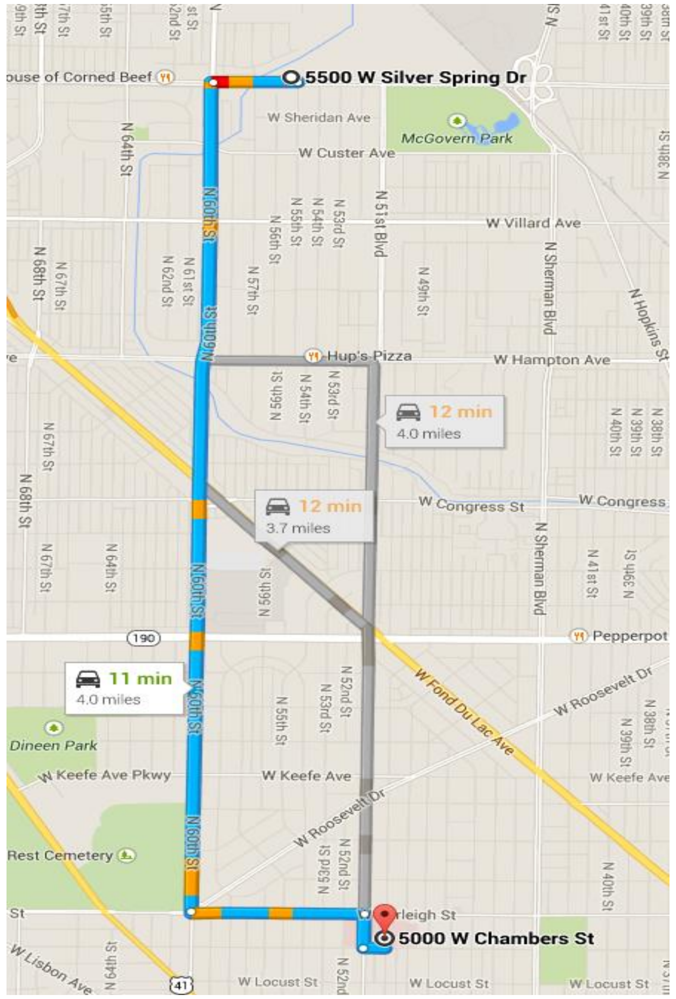
Continuous Improvement

To continually improve the safety of the site, accidents will be rigidly monitored to take steps to reduce the risk of it happening again. All workers on site will be encouraged to share their concerns with management, who will recieve concerns and complaints openly. The safety of the site and workers should be a concern of the entire project team, not an individual.

To create an environment of proaction instead of fueling the idea of reaction when it come to safety, workers will be strongly encouraged to share near misses without consequence. The report of every near miss will be recorded and action will be taken to ensure a near miss does not resurface as a recordable injury.

Evacuation Plan





Map to Wheaton Franciscan - Elmbrook Memorial Campus

PRODUCTION STUDIES

To ensure accurate estimations used for the development of the project plan, production studies were conducted on relevant topics and activities. The lessons learned from these studies were applied to the Growing Power facility, to better deliver a quality project.

RAINSCREEN FAÇADE INSTALLATION

A production study conducted at prominent research university provided production rates used for scheduling the unique rainscreen façade of the Growing Power facility. The study focused on an addition and renovation to a central campus student union building designed with a terracotta rainscreen system. The system specified for the student union building is similar to size and make-up of the assembly detailed for the growing power facility, and provides a valuable base of information for scheduling installation on the vertical far.

The system installed on the campus of the research university details the installation of the façade system once cementations sheathing and waterproofing material were installed. The tasks tracked were categorized into four installation activities: the installation of horizontal metal channels, the application of rigid insulation, the installation of vertical metal channels, and the placement of the terracotta panels. All activities must be completed in order.

Terracotta Panel Size	1 ft x 4 ft							
Terracotta Produciton Rate								
Date	Completed Area	Unit	No. of Panels	Unit	Crew Size	SF/Crew Mem.	No./Crew Member	Note
10/20/2014	1047.8	SF	262	SF	4	261.95	65.5	First Day Tracking
10/21/2014	237.39	SF	63	SF	4	59.35	15.75	
10/22/2014	231.25	SF	55	SF	4	57.81	13.75	Raining
10/23/2014	227.3	SF	92	SF	5	45.46	18.4	
					Average	54.21	15.97	

Production tracking was observed for over a week and a half and production rates were calculated for a single work week. Production rates were calculated by observing the installation square footage per day. The table above summarizes the production rates from the observation. Figure 1 shows the installation progress on the north wall elevation. October 20th the our first day of observation but not the first day of the installation process, thus making the first day of observation an outlier so it was excluded in the average calculations. On average each crew member is able to install 54.21 SF of terracotta or 16 pieces per day.

APPLICATION OF FLOW TO LEGO PRODUCTION

In order to simulate the effect of prepackaging material kits per construction zone, a production study was developed for a graduate research course. While the absolute results are not directly applicable to the field of construction due to numerous variables, the underlying theory maintains its validity. Application of the lean concept of flow to a construction site can, and if implemented correctly, will reduce the overall installation time, and thus charged time, of particular interior trades. The more efficient, less wasteful approach not only enables a shorter project duration, but also substantial savings due to the reduced labor hours required to complete the facility.

EXECUTIVE SUMMARY

This report details the application of the lean principle flow to the production of a LEGO lighthouse, and compares the baseline experimental production results to those obtained with flow principles in place. Originally the team estimated a timeframe for an unorganized, control run of the lighthouse production. An experimental control run was then conducted and compared to the estimated time frame. Both the estimate and the experimental baseline assumed that there would be no material organization and pre-planning, but rather that all materials would simply be heaped in one area and it would be part of the production process to retrieve the correct materials. The baseline trial took longer than predicted. Next the team discussed opportunities for improvement in the original experiment and identified flow as a useful production management technique for this application. An experiment was devised in which to test the efficacy of applying flow to the process, mostly by pre-organizing and staging materials in their specific steps. This supplies materials to the producer in a steady stream of steps, analogous to a flow of materials on a production line in a factory. After conducting the second trial of production with flow principles it was determined that the flow process required additional upfront planning time, but was far more efficient, and ultimately took significantly less total time.

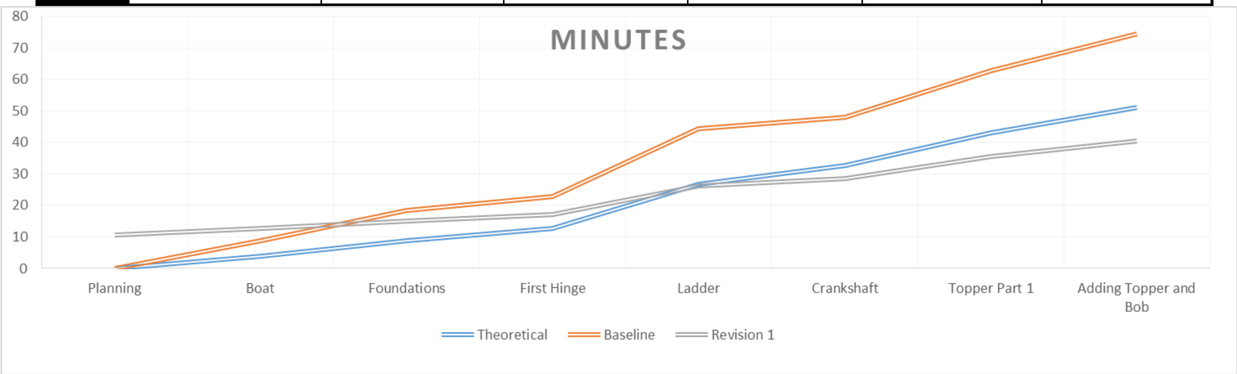
EXPERIMENT

The experiment was designed to test the application of flow to the production of a LEGO lighthouse. In summary, the procedure was to stage all of the materials by step so that the supply to the producer would be smoothed and waste would be eliminated. In the original baseline experiment, materials were all placed in one area, and it was part of the producer's job to search for them as he built. This caused a significant amount of waste, as searching for the materials in each step was both time consuming and led to quality issues (i.e.- accidental selection of the wrong piece). For the second trial run, the "flow" trial, all pieces were placed into steps and ordered in front of the producer so that all pieces would flow smoothly through his station and he would not have to stop and start due to waiting. This required an additional step at the very beginning of the experiment, where the materials for each step were grouped together, placed on labeled pieces of paper, and organized for access from the producer's workstation. Once this was complete, the producer was timed to erect the structure in the same manner as in the first baseline trial.

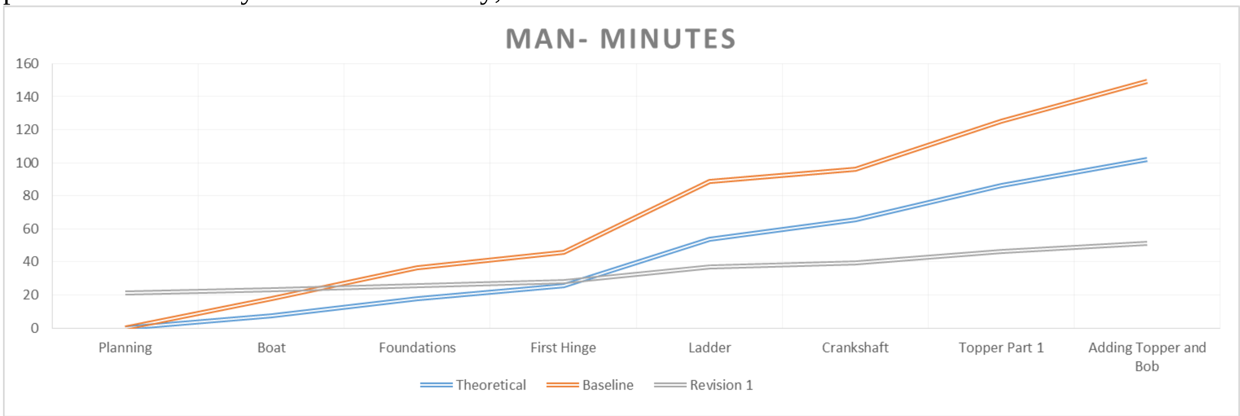
OUTCOMES

The results of the trials confirmed our hypothesis that applying flow to the procedure would increase the initial planning time, decrease the building/production time, and decrease the total experiment time overall. We timed both runs in terms of time and in terms of man-minutes, as the crew size differed between the trials. For the baseline trial we used a 2-man crew for the entire duration, while for the revised experiment we only used a 2-man crew for the planning and had a 1-man crew for building. The flow experiment required less overall time as well as fewer man-minutes, and had a fairly short "payback period" for the increased upfront planning requirement. A summary table of the times for both runs can be seen below:

Baseline vs. Revision 1 Time Comparison						
	Baseline Time	Baseline MM	Revised Time	Revised MM	Time Savings	MM Savings
Plan	0	0	10.7	21.4	NA	NA
Build	74.6	149.2	29.9	29.9	60%	80%
Total	74.6	149.2	40.6	51.3	46%	66%



This outcome supported the hypothesis that applying the principle of flow to this building process would increase efficiency and decrease the overall time required. It appears from this data that flow has a fairly significant effect on the time required to produce a certain end product, and positively impacted production efficiency in a substantial way, as shown above.



Additionally, due to the differing staff required with the lean approach, an even more significant saving occurred with respect to the charged time, detailed above. Although two workers were utilized in the initial planning stage, only one was required during the construction stage, significantly reducing time charged to the project.

Site Dewatering Strategy

APPENDIX B.2 - PROJECTED DEWATERING RATES IN AQUITARD (SILT AND CLAY)

Dupuit Forcheimer Equation - Well or Point Source Excavation

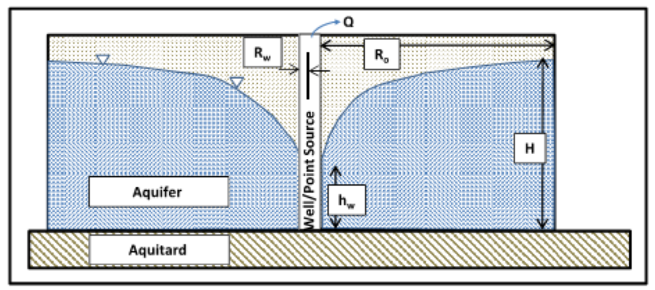
Dupuit Forcheimer Equation for Radial Flow to a Well or Point Source Excavation in an Unconfined Aquifer:

$$Q = \frac{\pi K(H^2 - h_w^2)}{ln\frac{R_o}{r_w}}$$

Where:

- Q = pumping rate in m3/s
- K = hydraulic conductivity in m/s
- H = hydraulic head of the original water table (m)
- h_w = hydraulic head at maximum dewatering (m)
- R_o = radius of influence of Well or Point Source (m)
- r_w = equivalent radius of the well (m)

Conceptual Drawdown



The term r_w is calculated as follows:

$$r_w = \sqrt{\frac{ab}{\pi}}$$

Where:

- a = length of excavation area (m)
- b = width of excavation area (m)

The equivalent radius of influence (R_o) is approximated using the Sichart and Kryieleis method:

$$R_o = 3000(H - h_w)\sqrt{K}$$

Calculations: LVM BH203

K =	1.00E-06 m/s	Q=	5.07756E-05	m^3/s
H =	2.7 m		4	m^3/day
h_w =	1 m		**4,387**	**L/day**
R_o (set value) =	15.82 m			
R_o (model) =	5.10 m			
r_w =	10.7 m			
a =	19.00 m			
b =	19.00 m			

Note: Model designed for use in coarse soils; R_o requires manipulation when calculation used for fine-grained materials

Base of Aquifer	242.0 m AMSL	Anticipated dewatering elevation minus 1 m
Static Water Level	244.7 m AMSL	
Elevation requiring dewatering	243.0 m AMSL	

Equations obtained from Powers, J.P., A.B. Corwin, P.C. Schmall, and W.E. Kaeck, 2007. Construction Dewatering and Groundwater Control, New Methods and Applications. John Wiley & Sons, Inc., 3rd Edition.

Source: Waterloo Hydrogeologic, Inc. (WHI). Six Conservation Authorities FEFLOW Groundwater Model – Conceptual Model Report. December 2004.

Hydraulic Conductivity
Aquitard 1 (HU-II & HU-IV)
Literature values: $1x10^{-6}$ to $1x10^{-11}$
Studies (Middlesex-Elgin, Oxford): $1x10^{-6}$ to $6x10^{-8}$

Assumption: Depth of excavation is 3.0 m BGS
Calculated Dewatering Rate (based on 19 m x 19 m excavation)

Calculated Dewatering Volumes

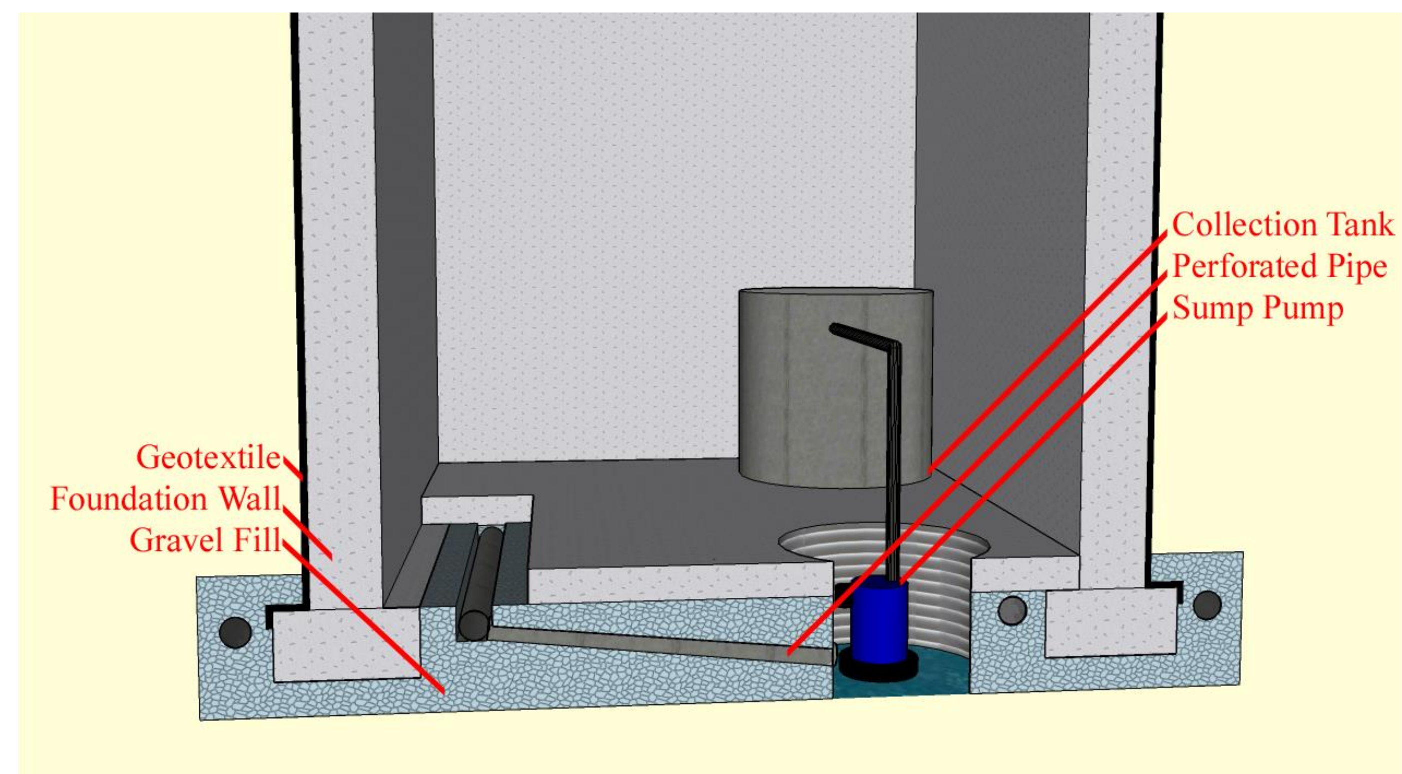
Location	GS Elev. (m AMSL)	Unit (m BGS) Top	Unit (m BGS) Bottom	Unit (m AMSL) Top	Unit (m AMSL) Bottom	Static Water Level (m BGS)	Static Water Level (m AMSL)	Parameters (m AMSL) Base	Parameters (m AMSL) SWL	Parameters (m AMSL) Dewater	R_o	Q (L/day) Middlesex-Elgin Values K = $1x10^{-6}$ m/s	R_o	K = $6x10^{-8}$ m/s
LVM BH203	246.0	0.3	28.6	245.7	217.4	1.3	244.7	242.0	244.7	243.0	15.8	4,387	12.0	929
LVM BH240	238.0	0.3	24.1	237.7	213.9	2.1	235.9	234.0	235.9	235.0	13.4	3,154	11.4	710
LVM BH241	254.0	0.3	13.7	253.7	240.3	1.8	252.2	250.0	252.2	251.0	14.3	3,600	11.6	791
LVM BH244	253.0	0.3	13.7	252.7	239.3	2.6	250.4	249.0	250.4	250.0	11.9	2,456	11.0	578
LVM BH251	239.0	0.3		238.7	206.5	1.3	237.7	235.0	237.7	236.0	15.8	4,387	12.0	929
Well 3006345	224.7	0.3	24.4	224.4	200.3	2.1	222.6	220.7	222.6	221.7	13.4	3,154	11.4	710
											AVERAGE =	**3,523**		**775**
											MAXIMUM =	**4,387**		**929**

The Growing Power property is situated on a site with a high water table, causing concern not only during the excavation of the project, but also during the operation of the building after it is constructed. The geotechnical report provided to TBD, indicated a water table of roughly 5 feet below the surface, requiring the construction team to utilize continuous site dewatering methods. Rather than choosing to treat the excavated site as a bathtub with slurry walls, due to economic reasons, it was chosen to continually dewater the site using a sump pit and pump. Using the document to the left, provided by K2 Wind Ontario project, it was assumed the site could be treated as a well point, and estimated dewatering calculations were applied to the vertical farm site. The construction team plans to dewater the site temporarily until the site dewatering system can be tied into the rainwater collection system.

Area (SF)	Area (m^2)	Delta H (Ft)	Delta H (m)	K	Ro	rw	Q (m^3/s)	Q (gal/day)	Q(gpm)
11787	1095	10	3.048	8.47E-07	41.41	18.7	3.10273E-05	708.1810474	0.491792394

Head height	HP	Pump Eff	Gallons/Yr
68	0.01688984	0.5	258486

The calculations above not only indicated a pump size required to remove the water from the excavated site, it also indicated an opportunity to supplement the rain water collection system designed by the mechanical partners and detailed on page 6 of the Mechanical Report. By designing the basement in the Growing Power facility to take advantage of a sump and interior drainage system, the design teams could supplement the rainwater collection by treating the site as a well, instead of completely waterproofing the area. A schematic representation of the groundwater collection system can be seen in the figure below.



GEOPIERS

THE GEOPIER GP3™ SYSTEM

INTERMEDIATE FOUNDATION® SOLUTIONS

GP3™

The original Geopier® system was developed in 1989 as an efficient and cost-effective Intermediate Foundation® solution for the support of settlement sensitive structures. Today, the patented Geopier GP3™ system uses replacement Rammed Aggregate Pier® (RAP) elements to reinforce good to poor soils, including soft to stiff clay and silt, loose to dense sand, organic silt and peat, and variable, uncontrolled fill. The GP3™ system allows for visible inspection of the spoils, and the opportunity to address changing ground conditions as they happen. It is an effective replacement for massive over-excavation and replacement or deep foundations, including driven piles, drilled shafts or auger cast-in-place piles.

The RAP elements are constructed by applying direct vertical ramming energy to densely compact successive lifts of high quality crushed rock to form high stiffness engineered elements. The vertical ramming action also increases the lateral stress and improves the soils surrounding the cavity, which results in foundation settlement control and greater bearing pressures for design.

ADVANTAGES OF THE GP3 SYSTEM

- **STRONG AND STIFF** Vertical impact ramming results in high density and high strength RAP elements providing superior support capacity, increased bearing pressure up to 10,000 psf and excellent settlement control.
- **PROVEN** Thousands of structures are currently supported – proven experience that ensures high levels of performance and reliability.
- **ECONOMICAL** Often results in 20% to 50% savings compared to traditional deep foundations.
- **FAST** Rapid installation process means shorter construction schedules.
- **QUALITY** Superior on-site quality control is maintained through observing, inspecting and testing the system, including visual spoil observation and full-scale modulus load tests.
- **ENGINEERED** Projects are engineered in-house by a Geopier Professional Engineer, allowing for rapid response when design or construction changes.

THE CONSTRUCTION PROCESS

The unique installation process utilizes pre-augering and vertical impact ramming energy to construct RAP elements, which exhibit unsurpassed strength and stiffness. RAP solutions are designed to provide superior total and differential settlement control and increased bearing support to meet project requirements.

1. The process first involves drilling a cavity. Drill depths normally range from about five to 30 feet, depending on design requirements. Pre-drilling allows you to see the soil between the borings, ensuring that the piers are engineered to reinforce the right soils.
2. Layers of aggregate are then introduced into the drilled cavity in thin lifts. A patented beveled tamper rams each layer of aggregate using vertical impact ramming energy, resulting in superior strength and stiffness. The ramming action densifies aggregate vertically and forces aggregate laterally into cavity sidewalls. This results in excellent coupling with surrounding soils and reliable settlement control.
3. Following installation, RAP elements support shallow foundations, floor slabs and tank pads and reinforce slopes and embankments. The footing stresses are attracted to the stiff RAP elements, resulting in engineered settlement control.

APPLICATIONS

Geopier systems have become preferred replacements for massive over-excavation and replacement or deep foundations, including driven piles, drilled shafts or augered cast-in-place piles. Local Geopier engineers and representatives work with you and your specific soil conditions and loads to engineer a project-specific practical solution to improve your ground. With multiple systems we are able to engineer support for virtually any soil type and groundwater condition across many applications, including:

- Foundations
- Floor Slabs
- Industrial Facilities
- Storage Tanks
- Liquefaction Mitigation
- MSE Walls/Embankment Support
- Slope Stabilization
- Transportation
- Wind Turbines
- Uplift & Lateral Load Resistance

International Place Towers III
Memphis, Tennessee

Houston Fuel Oil Terminal Company
Houston, Texas

The Home Depot
Provo, Utah

I-10 and Picardy Avenue Interchange
Baton Rouge, Louisiana

Geopier Foundation Company developed the Rammed Aggregate Pier® (RAP) system to provide an efficient and cost effective Intermediate Foundation® solution for the support of settlement sensitive structures. Through continual research and development, we've expanded our system capabilities to offer you more. Our design-build engineering support and site specific modulus testing combined with the experience of providing settlement control for thousands of projects provides an unmatched level of support and reliability to meet virtually all of your ground improvement challenges.

Work with regional engineers worldwide to solve your ground improvement challenges.

Tensar. | GEOPIER® FOUNDATIONS

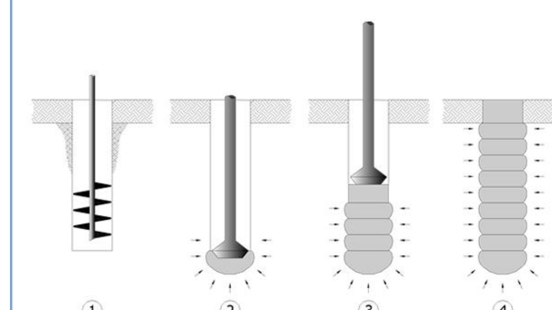
130 Harbour Place Drive
Suite 280
Davidson, NC 28036
800.371.7470

geopier.com

GEOPIER_SYSFLY_GP3_11.12

The low bearing capacity of of the soil, as indicated from the geotechnical report provided to TBD Engineering, required design effort in the early phases of the project. The low bearing capacity drove effort into designing a foundation system capable of supporting the load of the vertical farm. The loads became great enough to warrant the use of a mat slab, which for monetary and sheduling reasons, did not align with the goal of providing an economic project to Growing Power. Research yeildied an opportunity to improve the soil bearging capaciry by installing the Geopier GP3 ™ system. The system utilizes Rammed Aggregate Pier ® (RAP) elements to reinforce poor soils, which results in a more time efficient and cheaper method than creating deep foundations.

Consultation with a representative from Ground Improvement Engineering revealed an opportunity to improve the soil bearing capacity to 6000psf, eliminating the need for deep foundations. A take off, applying the knowledge that one RAP® can support roughly 100kips, indicated a need for 175 RAPs®, which according to consultants would cost roughly $76,000 to install.



http://sentezinsaat.com.tr/en/geopier-system.html

Crane Selection

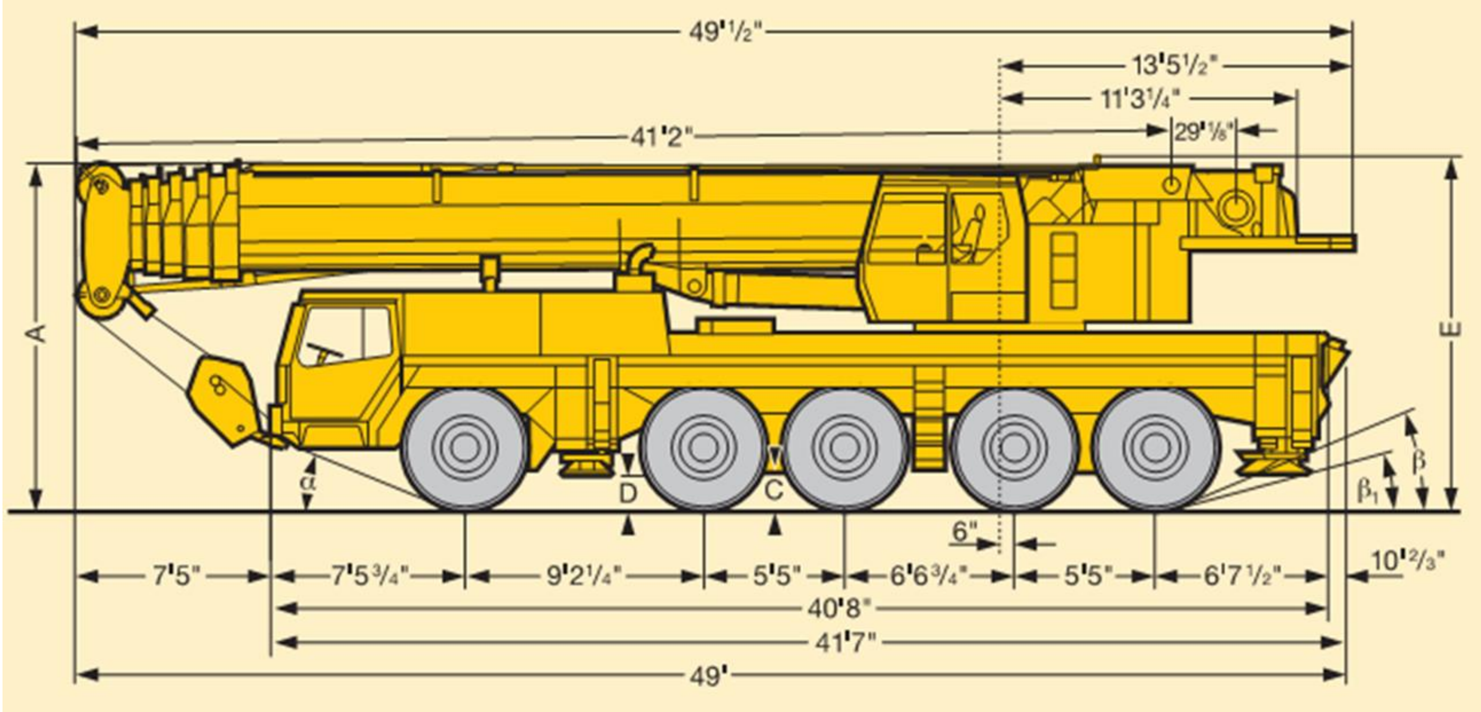
Leibherr Model LTM1120/1

The crane selection for the Growing Power vertical farming facilty was influenced by the critical pick elements of the project, location of the crane relative to the site, size, and cost. The LTM1120/1 is capable of lifting almost all of the heavy steel elements and all of the MEP equipment specified for the project. The crane, considering its length and width, is also capable of moving on site, when required to by the site phasing plan, to either pick materials off of delivery trucks or from storage areas.

Site safety is paramount during construciton and special measures are to be taken while the crane is on site. Rigging lifts will only be conducted by certified riggers, as dictated by the site Safety and QC Manager. All lifts will be signaled to the construciton site with an airhorn, prior to a load being lifted. Special care will also be given to the close proximity to the building structure. To reduce load applied to the foundation structure, the crane and its outrigger will remain a mimimum of 15 ft from the structure.

The largest moment applied to the crane during the construction of the project is caused by the steel transfer girders above the gathering space. The three elements all span 61 feet, and the largest weighs roughly 43,000 lbs, creating a scenario that will require two cranes for installation. The critical pick will require a second, identical crane, to aid in the lifting and installation process for one day. The two cranes are to pick the load from a truck, off of West Silver Spring Drive, as detailed in the site phasing plan.

Dawes Rigging and Crane Rental, Inc. confirmed the cranes are available for the required dates in Milwaukee, as well as provided scheduling and pricing advice.



Lifting capacities on telescopic boom.
Forces de levage à la flèche télescopique.

LTM 1120/1

41 ft – 184 ft | 360° | 55100 lbs | 85%

ft	41 ft	54 ft	68 ft	80 ft	94 ft	107 ft	120 ft	133 ft	146 ft	159 ft	172 ft	184 ft	ft
10	242												10
11	230												11
12	218	201											12
13	206	195											13
14	194	187	172	149									14
15	183	178	164	145									15
16	171	170	158	139									16
17	162	161	152	134	111								17
18	153	152	146	129	110								18
20	136	136	134	120	107	87.5							20
22	122	122	120	112	101	85.5							22
24	110	110	108	104	94.5	82.5	70	51					24
26	99.5	99	97	95	89	78.5	70	48.9					26
28	91	90.5	88.5	85.5	81.5	75	67.5	47.8	44.1				28
30	83.5	82.5	80.5	80	73.5	70.5	65	47	43.8	34.9			30
32	77	76	74.5	73.5	67	65	62.5	47	43.6	34.8			32
34		70	68.5	68	61.5	60	59.4	47	43.1	34.7	32.6	27.5	34
36		65.5	63	63	57	57	55.7	47	42.4	34.6	32.4	26.9	36
38		61.5	57.2	57.9	52.3	54.4	52.1	47	41.7	34.5	32.1	26.4	38
40		57.4	52.1	53.3	48.1	51.7	49	46.2	40.8	34.3	31.7	25.9	40
45		47	44.2	44.3	43.4	43.8	42.5	39.8	37.6	33.3	29.7	24.6	45
50			39.2	36.9	38.9	37.8	36.8	34.3	33.3	31.1	27.8	23.3	50
55			34.1	33	34.2	33.4	32	29.7	29.1	28.5	25.9	22.1	55
60				29.7	29.3	29	28	25.8	25.4	25.6	24.2	20.9	60
65				25.8	26	25.1	25.4	23.2	22.2	22.5	22.6	19.8	65
70				23.4	23.1	22	22.5	21.5	19.7	20.7	20.5	18.7	70
75					20.4	19.4	19.8	19.8	18.3	19.3	18.3	17.5	75
80					18.2	17.7	17.5	18.1	17	17.7	16.4	16	80
85					16.2	16.6	15.5	16.2	15.8	15.6	14.7	14.3	85
90						15.1	13.7	15.2	14.6	13.9	13	12.8	90
95						14.2	12.9	14.1	13.2	12.3	11.4	11.3	95
100							12.2	12.9	11.8	10.9	10	9.9	100
105							11.5	11.7	10.5	9.6	8.8	8.7	105
110							10.7	10.6	9.5	8.7	7.9	7.7	110
115								9.6	8.6	7.8	7	6.8	115
120								8.7	7.8	7	6.2	6	120
125									7.1	6.3	5.5	5.3	125
130									6.4	5.7	4.8	4.7	130
135									5.7	5.1	4.2	4.1	135
140										4.5	3.6	3.5	140
145										4	3	3	145
150										3.4	2.5	2.5	150
I	0	0/ 0	46/ 0	92/ 0/ 0	92/ 0	92/46/ 0	92/46/ 0	92/ 0/ 0	92/ 0	92/46	92	100	I
II	0	46/ 0	46/ 0	46/92/ 0	92/46	92/46/92	46/92/92	92/92/46	92/92	92/92	92	100	II
III	0	0/ 0	0/ 0	0/46/46	0/46	46/46/46	46/46/92	46/92/92	92/92	92/92	92	100	III
IV	0	0/ 0	0/46	0/ 0/46	0/46	0/46/46	46/46/46	46/92/92	46/92	92/92	92	100	IV
V	0	0/46	0/46	0/ 0/46	0/46	0/46/46	46/46/46	46/46/92	46/92	46/92	92	100	V

%

TAB 110099

TRANSFER ELEMENT SHIPPING LOGISTICS

LANDSTAR

HEAVY HAUL RATE QUOTATION

Quote#: 966382

To: [redacted]

Date: 01/29/2015
From: LSL
107 RIDGEWAY DR
COLDSPRING, TX 77331-5129

Phone: 936-653-4004
Fax:
Email: LUKE@SWEENEYTRUCKING.COM
Contact: TERI BERTUZZI

Origin: BLYTHEVILLE, AR
Destination: MILWAUKEE, WI

Commodity: OTHER(SEE COMMENTS SECTION)
Dimensions: 61'0" L x 3'0" W x 1'5" H
Weight: 22,500 lbs.
Equipment: FLE2 FB EXT 4+2 48-70' 60" HT
Total Miles: 581

Linehaul	$2,331.00
Permits	$231.00
Police	$225.00
Fuel Surcharge	$168.00
Total Charges	**$2,955.00**

- A police escort charge of $225.00 has been added for MILWAUKEE, WI.
- City permit for MILWAUKEE, WI for amount of $100.00 was added.

Continued on Next Page......

Please sign and date below to confirm the rate and to schedule a pickup. Return the signed document to the agency using the contact information listed above.

Customer Signature: ____________________ Printed Name: ____________________

Date: ____________________

PAGE 1 of 2

LANDSTAR

HEAVY HAUL RATE QUOTATION

Quote#: 966382

Heavy Haul Route Report

Customer: [redacted]
Date: 01/29/2015
Agency: SWEENEY CORP

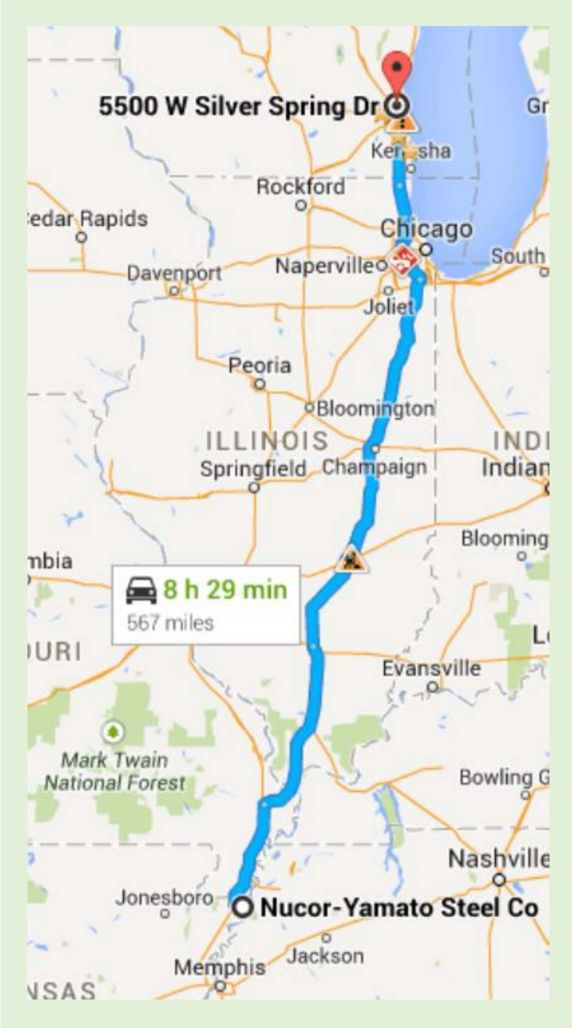
Routing Summary

Route State	Miles	Front Escort	Rear Escort	Police	Utility	Survey	Permits
AR	6						$46
MO	93						$36
IL	440						
WI	42						$149

Thank you for the opportunity to bid on this shipment. If you have any questions or need additional information, please do not hesitate to contact us.

PAGE 2 of 2

The transfer girders specially designed to tranfer the load from above the gathering space to the columns at the extreior of the building. The desgned length of 61 feet and weight of 22,500 pounds required special care to be applied ot the shipping logistics, and creation of the steel elements. The steel beams are to be rolled in Blytheville, Arkansas in the Nucor-Yamato Steel Company plant, and then shipped to Milwaukee. With the aid of Landstar System, Inc. an acceptable shipping path through four states, permits for oversized load shipments, and pricing for both permits and a police escort were identified. The information enabled the mangament team to properly plan for the shipment and delivery of the required steel elements.



ANALYZING DESIGN FOR CONFORMITY TO LEED GUIDELINES

Y	?	N			
1			Credit	Integrated Process	1

9	0	19	**Location and Transportation**		**16**
		16	Credit	LEED for Neighborhood Development Location	16
		1	Credit	Sensitive Land Protection	1
		2	Credit	High Priority Site	2
5			Credit	Surrounding Density and Diverse Uses	5
1			Credit	Access to Quality Transit	5
1			Credit	Bicycle Facilities	1
1			Credit	Reduced Parking Footprint	1
1			Credit	Green Vehicles	1

3	0	3	**Sustainable Sites**		**10**
Y			Prereq	Construction Activity Pollution Prevention	Required
1			Credit	Site Assessment	1
		1	Credit	Site Development- Protect or Restore Habitat	2
		1	Credit	Open Space	1
		1	Credit	Rainwater Management	3
1			Credit	Heat Island Reduction	2
1			Credit	Light Pollution Reduction	1

11	0	0	**Water Efficiency**		**11**
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
2			Credit	Outdoor Water Use Reductioni	2
6			Credit	Indoor Water Use Reduction	6
2			Credit	Cooling Tower Water Use	2
1			Credit	Water Metering	1

17	6	9	**Energy and Atmosphere**		**33**
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
6			Credit	Enhanced Commissioning	6
7	5	6	Credit	Optimize Energy Performance	18
1			Credit	Advanced Energy Metering	1
		2	Credit	Demand Response	2
3			Credit	Renewable Energy Production	3
	1		Credit	Enhance Refrigerant Management	1
		1	Credit	Green Power and Carbon Offsets	2

5	4	3	**Materials and Resources**		**13**
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Mgmt Plan	Required
	2	3	Credit	Building Life-Cycle Impact Reduction	5
	2		Credit	Building Product Disclosure- Env. Prod. Dec	2
1			Credit	BPD: Sourcing of Raw Materials	2
2			Credit	BPD: Material Ingredients	2
2			Credit	Construction and Demolition Waste Mgmt	2

10	4	1	**Indoor Environmental Quality**		**16**
Y			Prereq	Minimum IAQ Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
2			Credit	Enhanced IAQ Strategies	2
3			Credit	Low-Emitting Materials	3
1			Credit	Construction IAQ Management Plan	1
1	1		Credit	IAQ Assessment	2
1			Credit	Thermal Comfort	1
2			Credit	Interior Lighting	2
	2		Credit	Daylight	3
		1	Credit	Quality Views	1
	1		Credit	Acoustic Performance	1

6	0	0	**Innovation**		**6**
5			Credit	Innovation	5
1			Credit	LEED Accredited Professional	1

0	4	0	**Regional Priority**		**4**
	1		Credit	Regional Priority	1
	1		Credit	Regional Priority	1
	1		Credit	Regional Priority	1
	1		Credit	Regional Priority	1

62	18	35	**Totals**	**Possible Points**	**110**

GENERAL CONDITIONS ESTIMATE

To increase estimation accuracy, TBD utilized RS Means to calculate a general conditions cost for the Growing Power facility. The general conditions cost is estimated to be roughly 6% of the project cost.

General Conditions Estimate				
Title	**Quantity**	**Units**	**$/Unit**	**Totals**
Project Supervision				
Project Manager	30	Weeks	2800	90000
Project Engineer	30	Weeks	1400	48000
Superintendent	30	Weeks	2800	90000
Quality Control and Safety Manager	30	Weeks	1700	57000
Quality Requirements				
Testing and Inspection	1	LS	15000	15000
Testing Laboratory Services	1	LS	2000	2000
Temporary Office and Facilities				
Office Trailer	7	Months	11000	77000
Project Supplies				
Office Supplies/Equip/Furniture	1	LS	7000	7000
Computers/Fax/Printers/Software	1	LS	10000	10000
Signage	1	LS	800	800
Waste Management Fees	1	LS	9000	9000
Surveying	1	LS	1000	1000
Permitting	52585	SF	0.42	22000
Temporary Utilities				
Temporary Power	525	CSF	1.8	950
Temporary Heating	525	CSF	14	7350
Temporary Water	525	CSF	0.9	475
Temporary Toilets	400	Weeks	30	12000
Safety				
PPE	1	LS	8000	8000
First Aid	1	LS	1000	1000
Other	1	LS	3000	3000
Temporary Equipment and Controls				
Temp Hoists	5	Months	1200	6000
Temp Crane	10	Weeks	12500	125000
Temp Crane	2	Weeks	12500	25000
Crane Set Up & Demobilization	2	LS	3000	6000
Temp Scaffolding	1	LS	30000	30000
Temp Dewatering	1	LS	4000	4000
Temp Barriers and Enclosures				
Temp Fencing	1	LS	12000	12000
Temp Protection	1	LS	5000	5000
Execution and Closeout Requirements				
Topping Out	1	LS	2000	2000
Final Cleaning	1	LS	5000	5000
			Total	$ 681,575.00