Feasibility of opening a new Recycling Center in San Luis Obispo County

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SENIOR PROJECT | WINTER 2015

Table of Contents

Table Of Figures

Executive Summary

The purpose of this project is to create a feasibility report to help assist in determining the future plans for a local non-profit project, Recycle Empower SLO (RE-SLO). The main focus was to determine multiple factors for the ideal future-state of the organization including location optimization, project timeline, breakeven point, ergonomic analysis, and layout optimization for current operations. Currently, while many options exist for recycling in California, there is no specific service in San Luis Obispo or any surrounding areas that utilizes this resource in order to return benefit back to the community. While the idea of holding local recycling drives have always existed, the infrastructure and resources to do so are generally not provided, and result in inefficiencies in operations as well as increased user strain due to lack of ergonomics foresight.

Our team was able to determine the optimal location for a new recycling center in San Luis Obispo to be located at the Albertson's on Johnson Ave. A cost analysis was completed to determine that RE-SLO must grow to reach at minimum 33 household layouts or to be recycling approximately 120,000 CRV beverage containers a month in order to meet the breakeven point of owning its own recycling entity. A project schedule was created to determine an approximate timeline of 7 months in order to implement a new recycling center. Lastly, our team completed a layout analysis and redesign of the current household footprint and created a new layout with improved ergonomics and streamlined work flow to improve user satisfaction and increase safety.

With the completion of this project, RE-SLO will continue to grow its organization. With the information that follows, RE-SLO will be able to use this analysis to facilitate the growth that it needs in order to support the cost of becoming its own recycling entity, and the location where it should be placed. To help with the current operations, and to make immediate growth easier, RE-SLO now has a documented analysis of their current household layout, and an ergonomically designed alternative.

Background

The California Beverage Container Recycling and Litter Reduction Act which is run by the Department of Resources Recycling and Recovery was started in 1987 in order to create an incentive for consumers to help the government achieve an 80 % recycling rate for all aluminum, glass, plastic, and bimetal beverage containers sold in California. This includes containers such as carbonated mineral and soda water, carbonated soft drinks, non-carbonated soft drinks, wine coolers, distilled spirit coolers, beer, malt beverages, and carbonated or non-carbonated fruit drinks. **[2]** The California Recycling Program is funded through payments made by distributors for each beverage container that is sold in the state, which are deposited in the California Beverage Container Recycling Fund, which is then used to pay consumers known as the California Refund Value (CRV) when they recycle their empty beverage containers through certified recycling centers. Since 2007, CRV paid to consumers is worth five cents for each beverage containers less than 24 ounces and 10 cents for each container over 24 ounces. **[1]**

Currently the majority of Californians recycle through their paid garbage removal service, but they receive no further benefit past the removal of their recyclables from their properties. Many of these Californians do not realize that they are throwing away an opportunity to raise money for their community organizations when they recycle through their normal services, and are actually paying for these services at the same time.

Since its inception in 1987, the California Beverage Container Recycling and Litter Reduction Act has recycled over 300 billion beverage containers. In 2009 alone, nearly 22 billion CRV beverage containers were sold, with only 17 billion that ended up being recycled; collectively the 4 billion containers that were left in landfills and unredeemed are worth over $100 million dollars. Not only is this a missed opportunity for the consumer to utilize the CRV program, but also significantly impacts our climate. Recycling eliminates the need to manufacture from raw materials, specifically for every 10 pounds of aluminum, plastic, and glass about 37, 3.3, and 1 pound(s) of carbon emissions are diverted from the air respectively. Recycling also helps to reduce our environmental footprint since aluminum cans can take up to 80-100 years to break down in a landfill, up to 700 years for plastic bottles, and up to a staggering 1 million years for glass bottles. **[1]**

Introduction

Recycle Empower SLO (RE-SLO) was founded by Industrial Engineering Senior Alex Ly and Political Science Graduate Zach Antoyan in summer 2014. The organization centers on a very simple idea, returning the value of CRV recyclables back to the community by providing the infrastructure and the service to do so in an efficient manner. Currently the project is still in its startup development stage within the Center for Innovation and Excellence (CIE) Hatchery on-campus incubator program, which helps to pair student-led startup ideas with local business resources as well as developing the business model canvas and customer development for the organization.

The process begins with an application from a local club or organization to recycle through RE-SLO which includes a designated community based project idea. Once approved, our organization will provide support by supplying the organization members with collection bins, our ergonomically

designed neighborhood collection workstation, education to all organization members about proper recycling procedures, and a service to pick up and value all materials after being sorted by the individuals within the club. In the ideal state, RE-SLO aims to create a strategic partnership with a local Materials Recovery Facility (MRF) or local recycling center in order to reduce capacity constraints, and ensure efficient operations. The value is then returned back to the club or organization for use in approved local community based projects of their choosing.

Current State

In its current state, RE-SLO has validated the organization's value proposition of returning the value of CRV recyclables back to local clubs and organizations for fundraising efforts with minimal effort as a customer "pain" or a "need" within the community; however, the organization faces many challenges in terms of creating processes in order to operate safely, efficiently, and cost-effectively. We believe that the introduction of Industrial Engineering principles to the organization processes will result in increased efficiency, safety, and user satisfaction.

Although the customer need is apparent, current issues do exist within the organization regarding securing a strategic partnership with a local MRF or recycling center. Because San Luis Obispo is not a densely populated region, our team has been met with complications while attempting to enter into the existing market within this area. It has been found that both the Cold Canyon Landfill MRF and rePLANET recycling centers both hold a monopoly within the area on processing recyclables, so our organization is currently working on developing our processes in order to benefit the business models of either of these organizations in order to secure the strategic partnership that we need in order to maintain operations. Thus, for our feasibility analysis we will be making the assumption that this strategic partnership has already been secured.

Problem Statement

The problem statement for this project was:

At what point is it beneficial for RE-SLO to build its own recycling center, and what would this center look like.

The main deliverable of this project was to hand the analysis to RE-SLO to assist in their future decision making. Because the organization is still in its startup development stage, our team chose to focus on the ideal state of the organization and the steps it would take in order to design and build a safer and more efficient recycling facility.

Method

In beginning our analysis, we knew the three important questions to ask would be when, how and why. Our team began with data collected from the current RE-SLO operations to perform a cost benefit analysis. This would give RE-SLO an idea as to how big the operations would have to grow in order to benefit from owning their own center. Next, because of the restrictions placed on the location of a recycling center, the team wanted to determine the best placement for a RE-SLO center by using Operations Research. To finish answering how, our team researched into the steps necessary to construct a recycling center, and created a Gantt chart for the organization to follow when the time comes to build. All of these steps, and the knowledge gathered in the process helped to determine if a RE-SLO recycling center was feasible.

While gathering data for our cost analysis, our team also noticed some inefficiencies in the current operating procedures that RE-SLO used to operate, and used the Systematic Layout Design approach to evaluate and improve their household collecting layout. This was not part of the feasibility analysis, but something that our team wanted to help the organization improve upon.

Cost Analysis

Using a rough back-of-envelope approach, our research shows that the cost of opening a new recycling center will be approximately $72,000, which equates to $6000 per month or 120,000 recycled CRV beverage containers redeemed per month. In comparison, our ergonomically designed household layout with a capacity of 20 RE-SLO 30 gallon bins was found to cost approximately $300 per each workstation.

Currently, RE-SLO has 25 active participants for the collection of consumed CRV recyclable containers. The organization is currently operating out of one neighborhood collection site. The recyclables for our control group have been collected and recorded every two weeks since July 2014 and based on this data (appendix A), we have found that on average each person generates $3.076 per person per month income towards their organization. Assuming an average of 3 people per household size we estimated the need for 1951 participants, or 650 households in order to reach the breakeven point. Our household layout has been designed to hold a capacity of 20 bins per each workstation, which equates to a need of approximately 33 neighborhood collection workstations, an additional sunk cost of $9,900 into the system before the breakeven point is met. See appendix B for further cost analysis.

It is important to also note that these projected values are considered under the conditions that only RE-SLO members are the customers to this new recycling center. However, in real life this will not be the case as all recycling centers are also required to be open to the public, which will introduce more revenue into the system in order to offset costs. Various public grants offered by CAL-Recycle as well as privately generated funds through platforms such as Kickstarter or Indiegogo will also will help to offset the costs of constructing a new recycling center.

Location

Through research, our team found out that by CA mandated law there must be a recycling center within a 0.5-mile radius of a grocery store grossing more than $2M dollars in revenue per year [3]. Currently within San Luis Obispo there are four existing recycling centers, all operated by parent company rePLANET LLC. Figure 1 shows the locations in blue with a .5 mile radius drawn. [7]

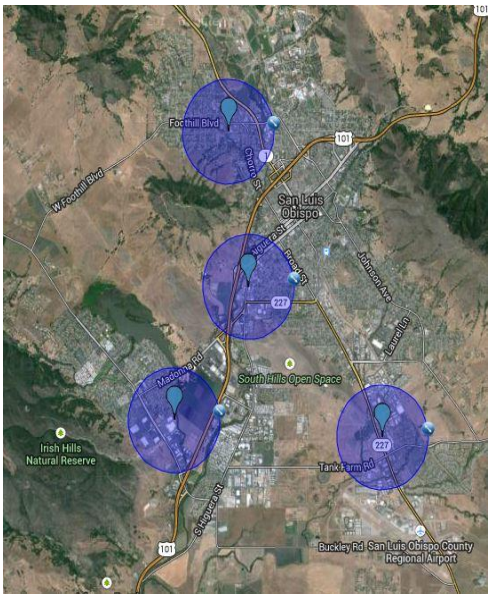


Figure 1: Current Location of Recycling Centers

Additionally, there are twelve grocery stores in San Luis Obispo which meet the gross profit criteria set by the California Beverage Container Recycling and Litter Reduction Act. For simplification, they have been given latters to correspond to their map locations (Figure 2).

A. Cal Poly Campus - 1 Grand Ave.
B. Albertsons - 771 E Foothill Blvd.
C. Albertsons - 1321 Johnson Ave.
D. Smart and Final - 277 Higuera St.
E. Fresh & Easy - 2238 Broad St.
F. Ralph's - 201 Madonna Road
G. Grocery Outlet - 1314 Madonna Road
H. Costco - 1540 Froom Ranch Way
I. Whole Foods - 1531 Froom Ranch Way
J. Target - 11990 Los Osos Valley Road
K. Trader Joe's/Food 4 Less - 3977 Higuera St.
L. Vons - 3900 Broad St.

Figure 2: Grocery Store Location Identifiers

To determine the location to place the new recycling facility we used the Fire Station Model approach learned in our IME 301: Operations Research I class. Figure 3 shows a map of all the current locations, in blue, along with the possible grocery store locations, in green. The radius shows the overlap of the .5-mile radius, and the letters correspond to the locations mentioned in Figure 2

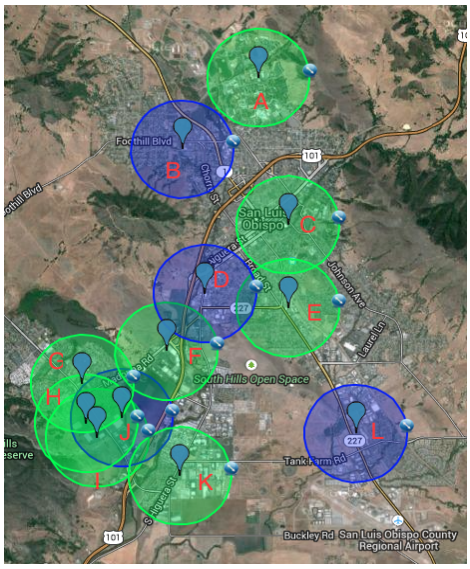


Figure 3: Current and Possibly Locations for a new center

For this problem we assumed that all twelve locations would be available for construction. For our constraints we used the rules that centers could not be placed in adjacent areas, and that only one center per location was allowed.

Using the Solver function in Microsoft Excel we were able to determine that the optimal location to place a new recycling center in San Luis Obispo was either the Albertson's on Johnson Ave. or on Cal Poly's campus, green circles on figure 4. See Appendix C for more detailed calculations for the operations research model.

In order to decide between the two optimal solutions several other factors were considered such as proximity of general public to location, proximity of location to roads, on-site traffic flow, access to established utilities, and proximity to railway. Refer to appendix D for more details on these factors. With all considerations in place, our team decided that the location at the Albertson's on Johnson Ave. would ultimately be the better choice because of it's proximity to a densely populated downtown area that currently offers no recycling services, proximity to roads and railway, and the decreased amount time it would take in order to implement due to paperwork and negotiations with Cal Poly Corporation to place a facility on-campus.

Timeline

After answering the questions of when and where, our team moved on to the analysis of how. Using prior knowledge and research done, we started putting together a list of tasks that had to be accomplished in order to build a new recycling center in San Luis Obispo. This template (figure 5) will help RE-SLO with the future project management for the site installation.

Figure 4: Timeline of Project Overview

The flow of the project moves through five main stages. First, RE-SLO must gain permission from the county to begin building, through a county vote and permit application. After the acceptance of the permits, RE-SLO can begin to secure financing, and after financing is in order, write a contract. Then site installation begins, along with training and equipment purchasing. Finally, safety testing is completed and the RE-SLO recycling center is ready to open.

Some assumptions made in the creation of this timeline were those of predecessors and durations. While certain information is known, such as the timeline to obtain permits, there are risks associated with other areas of the project. Depending on the opinion of SLO County, it may take a lot longer than three weeks to reach a vote, and the outcome of that vote may be negative. If this is the case, the whole build process would be placed on hold in order to take the necessary steps to secure a positive vote. In the build process itself, the exact timeline will be determined by the contractor and based on the chosen location.

For these reasons, RE-SLO will have to use the created timeline as a template once they decide to move forward. With all of the assumptions made, we estimate a completed project in 7 months. See the Gantt chart in appendix E for more information.

Conclusion

With all of the analysis completed for this project, our team can conclude that while opening a recycling center run by RE-SLO in San Luis Obispo is feasible, it is contingent upon several other factors. Based on firsthand experience our team has observed a capacity constraint within the network of rePLANET recycling centers, however RE-SLO would need to verify this fact with concrete data either provided by CALRecycle or rePLANET themselves. Our team was unable to acquire this data in order to create a simulation due to reasons regarding confidentiality, however this issue can be approached from other directions such as customer surveys or community open

forums to verify the need from within the community. However, there is no need to open a new center if a partnership can be established with rePLANET or a local MRF, as this would relieve RE-SLO of the operations involved in the actual processing of used CRV beverage containers, a step that does not provide direct value to our customers. This partnership is very important because an already established recycling company such as rePLANET already has the logistical infrastructure to support a new facility, while RE-SLO would have to build these relationships with local and regional processors from the ground up. While the analysis for this report was completed under the assumptions that this relationship was already created, it is a crucial part of the future for RE-SLO. Lastly, like all new businesses, feasibility is contingent upon the addition of more households into the RE-SLO network. As shown in the cost analysis, RE-SLO must make a significant effort in growing its recycling community user base before it is beneficial for the organization to open their own site.

While the construction of a new recycling center is in the very distant future for RE-SLO, this project helped to highlight some of the issues that the organization will need to address in the future. Our team is confident that as RE-SLO continues to develop the business model to assist with clubs and organizations in fundraising for community based projects, the community will see the benefit for this type of organization. Our hope is that when the network has grown to reach the point that opening a new recycling center is on the horizon, RE-SLO will then have the background research needed in order to proceed.

Layout

Current RE - SLO Layout

In its current state, RE-SLO is operating out of one household layout, with a capacity of 20 bins per workstation (see figure 6).

Figure 5: Current Layout of RE-SLO collection site

While collecting data for our cost analysis, the team noticed some ergonomic and layout problems when RE-SLO was sorting the recyclables collected from the 25 active participants. A RULA analysis [10] was completed on the current state (appendix F for first RULA) and returned a score of 6, which prompted further investigation in the ergonomics of the workstation. The main problems in sorting come from the posture and neck positions that are required when the bins are placed on the ground as they had been. This, along with the fact that the bins were never in a set location prompted the team to perform 5S analysis of the household layout along with providing a single flow layout design that would be standardized throughout the system moving forward. By providing this layout analysis, our goal is to help set the organization up for efficient and safe operations in the current state, and in future expansion.

Layout Design

The important criteria for creating the new layout came from providing a clean and easy workspace for all the RE-SLO participants. Our team wanted to focus on making the sorting of

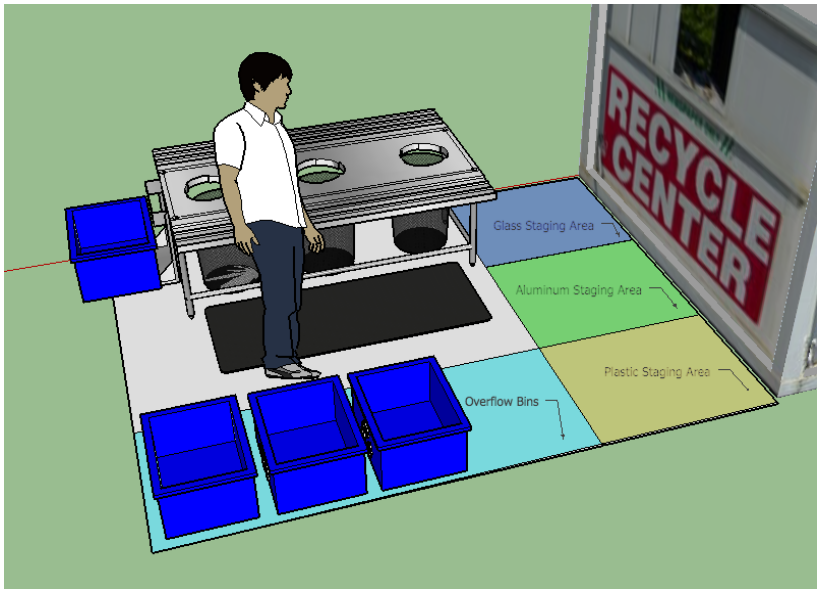


Figure 6: Proposed Layout Design

CRVs easier on the body, and making the storage of the bins standard. From the RULA analysis of the original design, our team made a few changes as seen in figure 7.

The addition of the sorting table and ergonomic mats places the sorter is in an upright position, reduces strain from unnecessary twisting of the torso, and supports the user's lower back and legs. These changes in the work station design resulted in a reduction of strain down to a RULA score of 3, a significant improvement from the score of 6 in its current state (appendix G).

The overall movement through this workspace was designed to maintain single process flow through, meaning that all of the CRV's and materials only travel in one direction, and multiple sorters would not need to cross paths, see appendix H for other factors considered for sorting. Furthermore, this workspace is contained in a 10'x10' area so that it can easily be set up in any backyard within the community. The intention of this layout is so that it can be the headquarters

for a group of individuals working within the RE-SLO organization to collect recyclables for their own goal. Also, if RE-SLO were to open up a recycling center, this sorting station could be adapted to the front of the center for the safety of the customers as well as the operators who are sorting material at the site.

Next Steps

Moving forward, RE-SLO has plans to continue to develop their business model in order to suit their current and future customers and partners' needs. This will be done through extensive customer development and negotiations with already established recycling entities within San Luis Obispo and other surrounding areas. With the help of the Hatchery, the on-campus incubator program, our team is confident that we will be able to secure the partnerships that we need in order to increase our operations here in SLO.

Appendix

A - RE-SLO Recycling Data

Recycling Run	# of Participants	Amount of recyclables ($)	Average amount of recyclables per person ($)
Week 2	7	8.83	1.26
Week 4	12	16.42	1.368
Week 6	25	42.01	1.680
Week 8	25	39.97	1.599
Week 10	25	42.90	1.716
Week 12	25	31.01	1.24
Week 14	25	34.6	1.384
Week 16	25	73.28	2.931
Week 18	25	63.54	2.542
Week 20	25	9	.36
Week 22	25	25.28	1.011
Week 24	25	34.33	1.373
		Total Average per person (2 week period):	1.538

B – Cost Analysis

Cost Analysis: Basic Household Layout

Capacity: 20 Bins
30 Gallon Roughneck bins - $9.50 each x 20 = $190
4ft table - $50
Ergo Mat - $60
Total Cost Per Layout: $300

Average $ raised per person/month = $3.076
Breakeven Point for opening a new recycling center based on RESLO average = 6000/3.076 = 1951 Participants → 98 Households

Cost Analysis: New Recycling Center

Processing Facility: $1500/month
Employees: 2x at $10/hr. x 40hr/week= $44,000 per year
Equipment: $10,000
- -Compactor
- -Scale
- -Computer
- -Bins

Total Cost: $72000/year → 6000/month
Breakeven Point in CRV = 120,000 containers/month

C – Location Computations

Variables and Constraints:

Xi = 1 if Recycling center is established in region i, 0 otherwise				
i= A,B,C,D,E,F,G,H,I,J,K,L				
Min Z = XA + XB + XC + XD + XE + XF + XG + XH + XI + XJ + XK + XL				
s.t.				
XC + XE >= 1				
XD + XE >=1				
XD + XF >=1				
XG+ XH + XI + XJ + XK >=1				
XB >= 1				
XD >= 1		i= A,B,C,D,E		
XJ >= 1				
XL >=1				

Excel Solver Set Up:

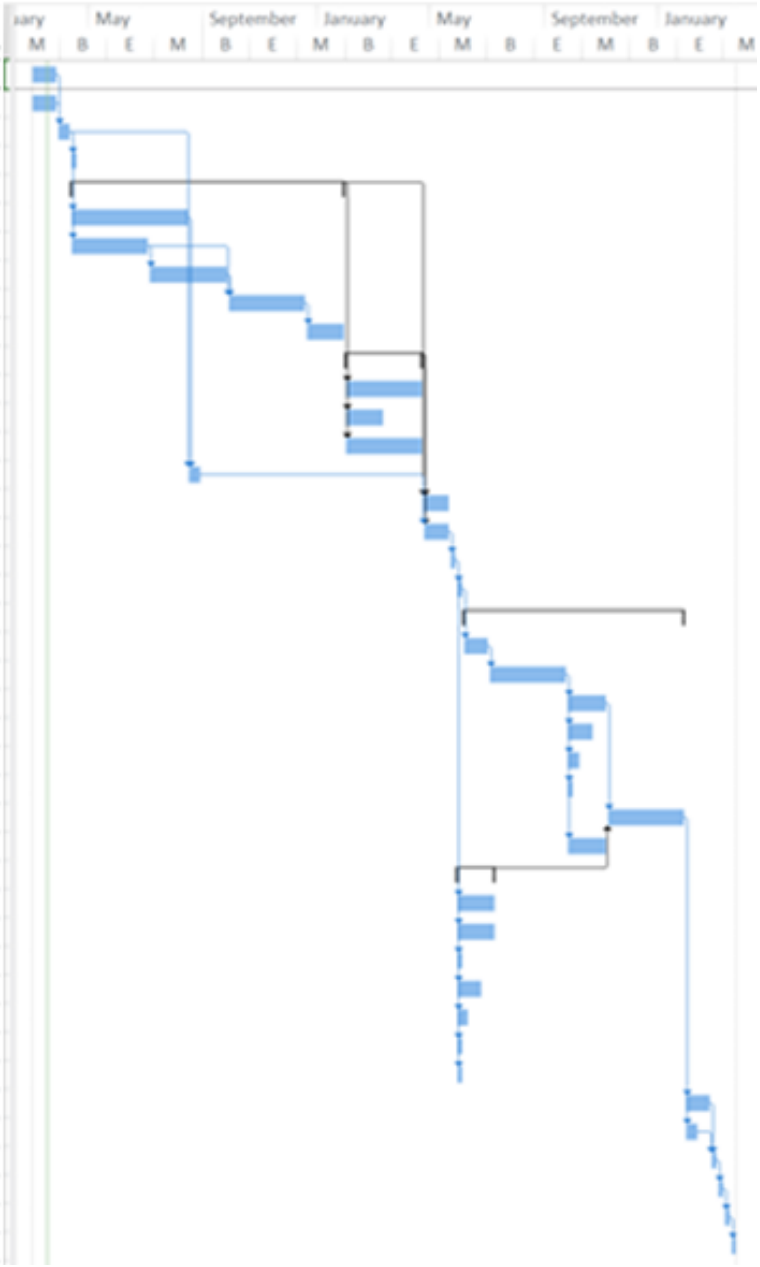
	XA	XB	XC	XD	XE	XF	XG	XH	XI	XJ	XK	XL		Constraint
Decision Vars	1	1	1	1	0	0	0	0	0	1	0	1		
O.F.	1	1	1	1	1	1	1	1	1	1	1	1	6	1
	0	0	1	0	1	0	0	0	0	0	0	0	1	1
	0	0	0	1	1	0	0	0	0	0	0	0	1	1
	0	0	0	1	0	1	0	0	0	0	0	0	1	1
	0	0	0	0	0	0	1	1	1	1	1	0	1	1
	0	1	0	0	0	0	0	0	0	0	0	0	1	1
	0	0	0	1	0	0	0	0	0	0	0	0	1	1
	0	0	0	0	0	0	0	0	0	1	0	0	1	1
	0	0	0	0	0	0	0	0	0	0	0	1	1	1

D - Factors When Choosing Site Location

Considerations	Potential Benefits/Comments
Location → Materials -The facility should be located in close proximity to the population centers and MRF sources	The correct choice of location will minimize the transportation costs of the customer, as well as for the operations.
Location → Roads -The facility should be located close to major highways or other high traffic transportation regions in order to provide easy access to the facility	Location closer to large roads or major highways will add to convenience and efficiency in the import and export of materials within the facility. Extra added benefits could include less hassle with road weight and vehicle restrictions, and easy access for emergency vehicles in case of emergency
On Site Traffic - The site roadways should keep personal vehicle traffic at a constant flow. Area should be large enough to accommodate the hauling off of large commercial loads	Efficiency in moving traffic efficiently through the system will lead to increased user satisfaction and increased safety for on site personnel, customers, and visitors
Utilities - Site should have access to utilities (water, sewer, power, phone)	Access to plumbing and sewer to address sanitary and safety protocol. The electrical service must also be appropriately sized for the type and size of equipment used in the operation
Rail - If available, consider a site with rail access for cheaper and more efficient transportation	Railroad access will add to flexibility for transporting goods in and out of the system. This includes opportunities for scalable growth in operations for future expansion plans.
Conveyors - Choose heavy-duty conveyors with durable synthetic belts. Avoid using excessive amounts of conveyors and keep conveyors straight	While conveyors can be useful to the operators, fewer conveyors require less maintenance and less chance for spillage

E – Gantt Chart

Task Mode	Task Name	Duration
	Business Plan	20 days
	Open Forum for SLO Opinion	20 days
	County Vote	10 days
	Appoint Project Manager	5 days
	Obtain Permits	**210 days**
	SLO City Permit	90 days
	Business License	60 days
	Tax License	60 days
	CALRecycle Processor License	60 days
	CALRecycle Operations License	30 days
	Secure Financing	**60 days**
	State Grants	60 days
	Kick start Campaign	30 days
	Lobby Local Industry Support	60 days
	Determine Location	10 days
	Contract Deal with Material Recovery Facility	20 days
	Contract Writing	20 days
	Contract Signing	5 days
	Hire Contractor	5 days
	Site Instalation	**170 days**
	Plan Layout Configuration	20 days
	Location Prep	60 days
	Run Amenities (Electrical, Plumbing)	30 days
	Security	20 days
	Parking	10 days
	Container Drop Off	5 days
	Equipment Installation	60 days
	Fencing	30 days
	Equipment Purchasing	**30 days**
	Compactor	30 days
	Baler	30 days
	Bins	5 days
	Forklift	20 days
	Office Equipment	10 days
	Workstation Tools	5 days
	Misc	5 days
	Processor Training	20 days
	Operator Training	10 days
	Equipment Testing	5 days
	Safety Inspection	5 days
	Final Project Sign off	5 days
	Grand Opening	5 days



F - RULA Analysis of Current Layout

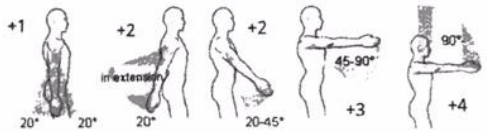
ERGONOMICS PLUS

RULA Employee Assessment Worksheet

Task Name: Sorting with no table Date: 3/2/15

A. Arm and Wrist Analysis

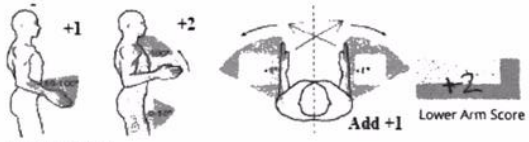
Step 1: Locate Upper Arm Position:



Step 1a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

+2 Upper Arm Score

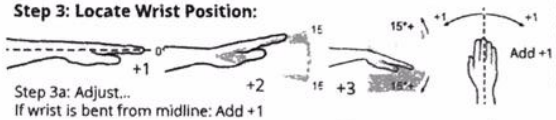
Step 2: Locate Lower Arm Position:



+2 Lower Arm Score

Step 2a: Adjust...
If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:



Step 3a: Adjust...
If wrist is bent from midline: Add +1

Step 4: Wrist Twist:
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

1 Wrist Twist Score

+1 Wrist Score

Step 5: Look-up Posture Score in Table A:
Using values from steps 1-4 above, locate score in Table A

3 Posture Score A

Step 6: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

+1 Muscle Use Score

Step 7: Add Force/Load Score
If load < .4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

0 Force / Load Score

Step 8: Find Row in Table C
Add values from steps 5-7 to obtain
Wrist and Arm Score. Find row in **Table C**.

4 Wrist & Arm Score

Scores

Table A

Upper Arm	Lower Arm	Wrist Score 1 Wrist Twist 1	2	Wrist Score 2 Wrist Twist 1	2	Wrist Score 3 Wrist Twist 1	2	Wrist Score 4 Wrist Twist 1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C

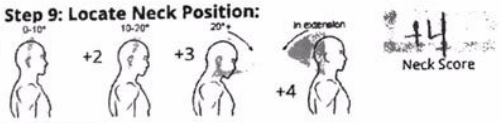
Wrist / Arm Score	Neck, Trunk, Leg Score 1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Scoring: (final score from Table C)
1-2 = acceptable posture
3-4 = further investigation, change may be needed
5-6 = further investigation, change soon
7 = investigate and implement change

6 RULA Score

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:



+4 Neck Score

Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 10: Locate Trunk Position:

Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

+4 Trunk Score

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

+2 Leg Score

Table B: Trunk Posture Score

Neck Posture Score	1 Legs 1	2	2 Legs 1	2	3 Legs 1	2	4 Legs 1	2	5 Legs 1	2	6 Legs 1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above,
locate score in Table B

7 Posture B Score

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

+1 Muscle Use Score

Step 14: Add Force/Load Score
If load < .4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

0 Force / Load Score

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain
Neck, Trunk and Leg Score. Find Column in **Table C**.

Neck, Trunk, Leg Score

Original Worksheet Developed by Dr. Alan Hedge. Based on RULA: a survey method for the investigation of work-related upper limb disorders, McAtamney & Corlett, Applied Ergonomics 1993, 24(2), 91-99

G - RULA Analysis of Proposed Layout

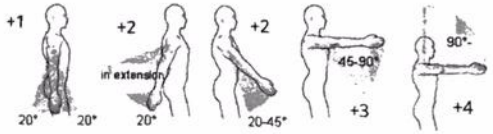
ERGONOMICS PLUS

RULA Employee Assessment Worksheet

Task Name: Sorting With Table Date: 3/2/15

A. Arm and Wrist Analysis

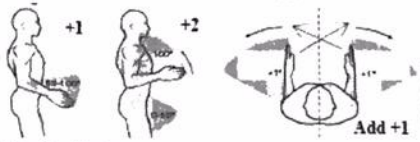
Step 1: Locate Upper Arm Position:



Step 1a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

+2 Upper Arm Score

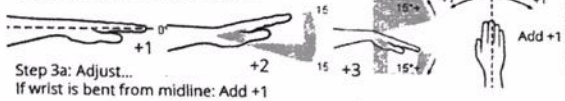
Step 2: Locate Lower Arm Position:



+1 Lower Arm Score

Step 2a: Adjust...
If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:



Step 3a: Adjust...
If wrist is bent from midline: Add +1

Step 4: Wrist Twist:
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

Wrist Twist Score: +1

+1 Wrist Score

Step 5: Look-up Posture Score in Table A:
Using values from steps 1-4 above, locate score in Table A

+2 Posture Score A

Step 6: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

+1 Muscle Use Score

Step 7: Add Force/Load Score
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

+ 0 Force / Load Score

Step 8: Find Row in Table C
Add values from steps 5-7 to obtain
Wrist and Arm Score. Find row in **Table C.**

3 Wrist & Arm Score

Scores

Table A

Upper Arm	Lower Arm	Wrist Score 1 Wrist Twist 1	1 2	2 1	2 2	3 1	3 2	4 1	4 2
1	1		1	2	2	2	3	3	3
	2		2	2	2	3	3	3	3
	3		2	3	3	3	3	4	4
2	1		2	3	3	3	4	4	4
	2		3	3	3	3	4	4	4
	3		3	4	4	4	4	5	5
3	1		3	3	4	4	4	5	5
	2		3	4	4	4	4	5	5
	3		4	4	4	4	5	5	5
4	1		4	4	4	4	5	5	5
	2		4	4	4	4	5	5	5
	3		4	4	4	5	5	6	6
5	1		5	5	5	5	6	6	7
	2		5	6	6	6	7	7	7
	3		6	6	6	7	7	7	8
6	1		7	7	7	7	8	8	9
	2		8	8	8	8	9	9	9
	3		9	9	9	9	9	9	9

Table C

Wrist / Arm Score	Neck, Trunk, Leg Score 1	2	3	4	5	6	7+
1		1	2	3	3	4	5	5
2		2	2	3	4	4	5	5
3		3	3	3	4	4	5	6
4		3	3	3	4	5	6	6
5		4	4	4	5	6	7	7
6		4	4	5	6	6	7	7
7		5	5	6	6	7	7	7
8+		5	5	6	7	7	7	7

Scoring: (final score from Table C)
1-2 = acceptable posture
3-4 = further investigation, change may be needed
5-6 = further investigation, change soon
7 = investigate and implement change

3 RULA Score

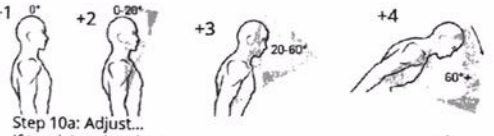
B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:

+2 Neck Score

Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 10: Locate Trunk Position:



Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

+1 Trunk Score

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

+1 Leg Score

Neck Posture Score	Table B: Trunk Posture Score 1 Legs 1	1 2	2 1	2 2	3 1	3 2	4 1	4 2	5 1	5 2	6 1	6 2
1		1	3	2	3	3	4	5	5	6	6	7	7
2		2	3	2	3	4	5	5	5	6	7	7	7
3		3	3	3	4	4	5	5	6	6	7	7	7
4		5	5	5	6	6	7	7	7	7	8	8	
5		7	7	7	7	7	8	8	8	8	8	8	
6		8	8	8	8	8	8	8	9	9	9	9	

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above,
locate score in Table B

2 Posture B Score

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

+1 Muscle Use Score

Step 14: Add Force/Load Score
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

+0 Force / Load Score

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain
Neck, Trunk and Leg Score. Find Column in **Table C.**

Neck, Trunk, Leg Score

Original Worksheet Developed by Dr. Alan Hedge. Based on RULA: a survey method for the investigation of work-related upper limb disorders, McAtamney & Corlett, Applied Ergonomics 1993, 24(2), 91-99

H - Factors when dealing with Manual Sorting of Materials

Considerations	**Potential Benefits/Comments**
Provide training and instructions to sorters	Training materials should be formatted in a Standard Operating Procedure (SOP) format in both English, Spanish, and other native languages as necessary. Posters in the workstation should focus on targeting specific accepted materials and identifying non-acceptable materials
Ergonomic analysis of sorting station -Optimized flow -Anti-fatigue mats to reduce physical discomfort -Station between 36” and 42” in height as measured from floor to top of table -Sufficient lighting -Gloves, Safety glasses, hearing protection	Potential benefits of an ergonomically designed workstation would be increased productivity, reduced strain, and improved overall physical comfort. The use of PPE will reduce the risk of injury which will lead to reduced operational costs
Type of incoming material	It is important to consider the type of incoming material that the recycling facility will accept, and the associated safety issues from these materials must be carefully examined. Material must be easily sorted out with minimal risk of injury, if this is not possible then it is strongly advised to look into mechanical sorting procedures
Facility throughput	A cost benefit analysis or simulation would help the decision making process when exploring options for expansion or purchasing new equipment to meet throughput needs

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