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Shipping Container Emergency Shelters

A Major Qualifying Project Report:
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Abstract

During this project the group performed research on the use of shipping containers as temporary housing shelters. Using this research, the team focused on converting shipping containers into pre-fabricated emergency relief housing. By designing a number of containers with different functions the group created a community environment in which approximately 216 people could recover from natural disasters. The experience gained from this project will help the team gain valuable experience in problem solving and teamwork.

Acknowledgements

The team would like to thank Roberto Pietroforte for providing guidance and proofreading the many drafts of this report. In addition, the team would like to thank Mark Strauss for providing information at the early stages of the project, Interport for providing accurate container price quotes, and RS Means for providing the majority of the cost and scheduling data used.

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Chapter 1: Introduction

This chapter is broken down into a basic introduction, goals, and project overview. In this chapter the basic structure of the project is described. Also, the group has described the intended goals to be achieved by the end of the project.

1.1 Introduction

For this MQP project the group decided to design a system in which shipping containers could be used as emergency shelters. There are many reasons why containers are a logical choice as building materials. The book Container Architecture best describes these reasons.

> "Containers have many characteristics that make them convenient for use in architecture. They are prefabricated, mass-produced, cheap and mobile. Because they are compatible with practically every transport system, they are easily accessible all around the world. They are strong and resistant, while also being durable and stackable. They are modular, recyclable, and reusable." (Kotnik, 2008)

Since containers are available in large (even excess) quantities around the world, they are relatively cheap compared to current construction materials. As shown in Figure 1, containers sit unused in ports all around the world (Shipping, 2009). The main reason there are so many unused containers is due to the nature of the shipping industry. Since the majority of the world's goods are manufactured in the Far East and shipped to the West,

Figure 1: Containers Unused at Port Elizabeth

Western countries import far more containers than they export (Kotnik, 2008). It costs approximately $900 to ship back an empty container to where it came from, which means that it is usually easier to buy a new container in the country of origin rather than ship them back from the Western countries (Kotnik, 2008). This has led to hundreds of thousands of empty, unused containers that port operators are more than happy to sell for low prices.

Another incentive to use containers for housing is because their modularity lends itself to cheaper, easier construction. Most of the components needed for a housing structure can be assembled within the container in an off-site location. The modified container can then be transported to the construction site and placed where it is needed. Since most of the work was already done at the off-site location, it significantly cuts down on-site work, which can be very costly. In addition, the same basic design can be applied to every container, leading to an efficient construction process than can also reduce costs.

With renewable resources and energy efficiency at the forefront of the world's thoughts, containers fit the need for efficient construction materials. They are reusable, recyclable, and reduce the need for other construction materials. Also, construction projects with containers typically use no groundwork excavation processes, are quick to set up and complete, and generate less waste than traditional construction projects (Kotnik, 2008). They are also very durable due to the fact their existence was born out of a need for strong, long lasting shipping materials.

Based on the properties of shipping containers it seems only rational to try and use them as the basis for construction materials. However, there are disadvantages to using shipping containers as housing. Essentially, they are just a large, closed box. There are no openings to allow light and air to enter the container. Although there are some special containers that are used for temperature controlled products, the majority of containers have no insulation. Additionally, since there is no insulation and the walls are relatively thin, containers are not very soundproof. Overcoming these deficiencies is the key to successfully converting containers into viable living environments.

1.2 Disaster Relief Agencies

When disasters occur there are a number of organizations that step in to provide help for the victims. Many of these organizations are involved in all aspects of aid, including raising money, providing supplies, and organizing relief efforts. In the United States, the most prominent of these organizations is FEMA.

FEMA stands for the Federal Emergency Management Agency and is part of the U.S. Department of Homeland Security (FEMA, 2009). This organization is involved in all steps of emergency management, from advising on how to deal with future emergencies, to directly coordinating disaster response efforts, to helping people recover from the effects of disasters. There are over 3,700 full-time employees at FEMA as well as around 4,000 standby employees who are called in when necessary (FEMA, 2009). In addition, FEMA works with various other disaster relief organizations. They are all part of the nation's emergency management system and include 27 federal agencies, state and local emergency management agencies, and the American Red Cross (FEMA, 2009).

With the backing of the federal government, FEMA is a powerful organization that uses not only its own resources but those of other disaster relief organizations to get the job done. Their mission statement appropriately sums up their stance on disasters.

> "FEMA's mission is to support our citizens and first responders to ensure that as a nation we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards." (FEMA, 2009)

Since FEMA is the organization that coordinates the activities of all agencies whenever it is involved it is appropriate to consider them the go-to agency for emergencies.

1.3 Goals

The team's primary goal for this project is to develop a design that will transform standard shipping containers into various livable environments, forming a community. The design should be relatively easy to implement and should incorporate all the necessities of living required for a human being. In addition, it should try to optimize the amount of space used while still maintaining healthy living conditions.

1.4 Project Overview

In order to accomplish the goals of this project the team first conducted research on existing uses for shipping containers. This information was used to help formulate ideas on how to approach the design of the containers. The team then started the on the actual design of the individual containers and the design of the site. During the course of this design continuous research was conducted in order to answer questions that arose, such as how to supply power and water to the site. Once the designs were completed, the team estimated the costs associated with the project and the estimated schedules for modifying the containers and the site. Finally, the team performed an analysis on the final designs, costs, and schedules to determine the feasibility of using shipping containers for emergency shelters.

Chapter 2: Research

This chapter provides a context for the design and implementation of an emergency container housing development. A brief history of shipping containers as well as their architectural usage is followed by an analysis of the technical standards of an ISO (International Standards Organization) container, possible transportation methods, and disaster prone locations within the United States. Finally, the methods and purposes of the architectural review are described.

2.1 Shipping Container History

The modern shipping container has provided an economic way to ship goods across the globe and as a result has greatly benefited society in providing for a truly open market on which to buy and sell goods. Shipping containers made the so called "just-in-time" concept first proposed by Toyota Motor Company in the 1980s possible, in which companies reduced inventories and relied heavily on quick, efficient shipping of small batches of parts from outside suppliers (Levinson, 2006). However, the revolution of the shipping economy has also led to massive excesses of containers in the United States due to the trade deficit with China and has as a result provided a unique opportunity to convert an existing resource into either emergency shelter or low income housing.

Before steel shipping containers existed, goods were transported via a so called "break bulk method", in which various types of containers and vessels were stowed loosely inside the ship (A Sea Change, 2009). In the 1950s Malcom McLean, sometimes referred to as the "father of containerization", invented the modern steel shipping container. McLean's shipping container concept was founded in his experience as a truck driver and desire to derive a more efficient method for unloading the goods within a truck and placing them on a cargo ship. His concept allowed for the reinforced metal containers to be lifted directly from the truck and stacked on the ship. To accommodate the stress associated with stacking the containers, he reinforced the four corner posts (Kotnik, 2008). Shortly after McLean implemented his concept, the Matson Navigation Company loaded its vessel, Hawaiian Merchant, with twenty cargo containers for shipment from California to Hawaii, the first ever shipping container voyage across the Pacific (A Sea Change, 2009).

By 1958 a movement towards standardization of shipping containers had begun. European container sizes were not compatible with American industry, and within the United States various transportation companies adopted unique container sizes which were incompatible. The agency Marad, which exerted a sizable influence over the shipping industry and operated under the United States Maritime Administration, was the first regulator of domestic container sizes. By the summer of 1959 container sizes had been regulated to 40’x8’x8’ and 20’x8’x8’. However, the ever present need for global standardization was not met by this early standardization process, and in September of 1961 representatives and observers from twenty six countries came to New York in the International Standards Organization’s first attempt at intercontinental standardization (Levinson, 2006). By 1970, the ISO had released regulations considering external dimensions, internal dimensions, ratings, terminology, and markings (Standardized, 2009).

Shipping container dwellings have been considered as early as the mid 1960s and developed as a result of an architectural interest in merging mobility and manufacturing into building construction. In 1966, the American architect Paul Rudolph considered the use of containers as components in the design of towers in Manhattan. The use of containers in underdeveloped countries had long been considered by architects and implemented as a cost effective means for shelter (Scoates, 2003). However, in the United States and other developed countries, container housing continues to be a somewhat radical concept that is reserved primarily for modernists (Strauss, 2010).

The ISO container has exerted a dramatic impact on the shipping industry. Due to the trade deficit between the services orientated economy of the United States and its high output manufacturing trading partners such as China, a large surplus of containers is available for reuse. Although the history of implementation of container housing in the United States is relatively miniscule, the usage of ISO containers as building units for emergency shelter or low income housing could provide a valuable alternative to traditional construction in future generations.

2.2 Technical Standards

There are two standard sizes in the world for shipping containers, the 20 feet (6.09 m) and 40 feet (12.19 m) length containers. There are also less common variations in length that are still available in the market which include, but are not limited to, 10 (3.05 m), 30 (9.14 m), and 45 feet (13.72 m) in length. The standard width for these containers is 8 feet (2.44 m), however to fit some European pallets a 2.5 meter width is available but harder to come by in the market. Shipping containers come in many different heights. Today the most common height is 8.5 ft (2.59 m) while 9.5 ft (2.90 m) is becoming more widespread (Container, 2009). "In the past 8ft high (2.44m) was very common and there are some containers 9ft (2.74m) available but these are rare." (Container, 2009).

Shipping containers contain corrugated sides and top in order to provide extra strength, however this decreases the internal dimensions from the external dimensions which were described previously. The corrugations are typically one inch in width, in which case would deduct two inches (50 mm) from the width giving an internal width of 7 ft 10 inches (2.38 m) (Container, 2009). The shipping container doors are typically two inches thick (50 mm). Therefore the exterior length is deducted by three inches (75 mm) to give the interior length of the container. For example if a 40 foot container was used the interior length would be 39 ft 9 inches (Container, 2009).

The floor of container has a six inch (150 mm) clearance off the ground with an actual floor thickness of approximately one inch (25 mm). Along with the one inch corrugation of the roof the interior height has an eight inch (200 mm) difference from the external height (Container, 2009).

Table 1: Container Specifications

	20 ft	**40 ft**
Cubic Capacity	1,170 Ft^3 (33.2 m^3)	2,391 Ft^3 (67.7 m^3)
Payload (Weight)	62,082 lbs 28,160 kg	63,405 lbs 28,760 kg
Tare Weight	4,894 lbs 2,220 kg	8,245 lbs 3,740 kg
Max Gross Weight	67,107 lbs 30,480 kg	71,650 lbs 32,500 kg

(APL Container Specifications)

Table 1 displays the specifications of the two standard size shipping containers of 20 and 40 feet in length. The payload or weight is the weight of cargo the containers can hold. When the structure is altered however the payload will be affected and not perform to its peak capacity. The tare weight is the weight of the container itself without any contents inside. Finally, the max gross weight is the weight of the container and the maximum weight of the contents it can hold. This represents the largest weight possible of the container.

The two standard sizes of containers are also available in a refrigerated format. Refrigerated containers are used to ship cargo which can perish in heat and need to be cooled while shipped. The refrigeration versions have less interior space and also have a lower payload than the standard non- refrigerated versions. For the purpose of this study the group will not be looking at the refrigerated shipping containers.

Shipping containers get their strength from the four corner posts and through the floor. Figure Two shows a typical container corner post.

"The strength is transferred down through the corner posts to the corner castings at the bottom and then through the floor. The floor is constructed of steel cross members approximately 6 inches (150mm) deep, which are approximately 20 inches (508mm) apart and give transverse strength and support the floor. The cross members are welded at each end to longitudinal beams which run the length of the container between the corner castings. This all means that the strength of a shipping container lies within the corner posts and the floor. Structural alterations or damage to these components will weaken the container." (Container, 2009)

Figure 2: Container Castings

Therefore, for the team's purpose the floor and the four corner posts must be kept intact in order to maintain structural support of the container. However, this means that parts of the corrugated sides may be removed with insignificant structural loss.

2.4 Transportation Methods

The team explored multiple modes of transportation for the containers. There are multiple forms that can be useful to deliver the container, including aircraft, trucks, boats and rail. However, not all locations are accessible by rail and boats. Therefore, the group has investigated aircraft and trucks as the main options for delivery of containers.

In a disaster relief situation, where time is of the essence, the quickest mode of transportation would be by aircraft. There are many helicopters that specialize in heavy lifting capabilities. However, the leader of its kind is the Mil-26. The Russian built Mil-26 helicopter has a maximum load lifting capability of 44,000 lbs (20,000 kgs). However, the Mil-26 is mostly used by the Russian Army and is not readily available in the United States. The United States Army's version of the Mil-26 is the Sikorsky S-80. The most advanced of the Sikorsky "S" series helicopters the S-80 has a maximum load lifting capacity of 36,000 lbs (16,330 kgs). The Sikorsky S-80 has a lower carrying capacity but is the most readily available in the United States in a disaster relief situation (Sikorsky, 2009).

For both the S-80 and the Mil-26, the maximum weight of a container (fully loaded) would be too much for either helicopter to lift. The team will have to take this into consideration during the design of the containers and their content if aircraft is the desired means of transportation. One downside of helicopters is that there may not be an airbase located nearby the disaster. This could take time to fly the helicopters to a closer base in order to then load them with the containers.

While helicopters have the advantage of speed from one point to another, trucks are more widespread and accessible in all locations. The largest legal gross weight of a truck is 80,000 lbs (36,000 kgs) unless an oversize permit is given. Typically the weight of the chassis is 11,000 lbs (5,000 kgs). This will allow the containers to carry more weight inside them than if helicopters were used and reach close to the potential loading capacity that the containers are able.

Trucking may be the best mode of transportation due to the easy accessibility no matter the location and the higher load capacity. However, if helicopters are available nearby they may be the quickest form of transportation when time is of the essence.

2.5 Disaster Prone Locations

The containers will need to be modified to resist the elements. In order to best accomplish this, the team will base their design for use in a range of climates. Each climate provides unique problems. Therefore, the team looked at given areas of the United States that had a history of disaster situations.

According to FEMA statistics, severe storms accounted for the majority of disasters declared from January 3, 2000 to March 3, 2007 nationwide. Out of a total of 377, 191 disasters were severe storms. Floods accounted for the second most disasters with 62 and hurricanes were third with 35. The greatest risk in severe storms is created by flash flooding with more than 140 deaths every year (FEMA Disaster, 2009). Other risks associated with severe storms include strong winds and hail. All of these events can lead to damage to people’s homes, which forces them to find temporary housing while repairs are being made. Hurricanes produce similar effects with strong winds and flooding, causing victims to lose their housing temporarily.

Table 2: Top Ten Disaster States Since 1953

State	Number of Disasters Declared
Texas	83
California	74
Florida	63
Oklahoma	62
New York	58
Louisiana	55
Kentucky	51
Alabama	51
Missouri	49
Arkansas	49

(FEMA Disaster, 2009)

As shown in Table 2, Texas has had the highest amount of disasters in the United States since 1953 (FEMA Disaster, 2009). This is nine more than the second highest state, California, and twenty more than third highest, Florida. Texas has had 15 major disasters declared since 2000, which makes the Texan climate a good one to use as a guideline when designing the containers.

Texas has an average January temperature range of about 36° to 53° Fahrenheit with hotter temperatures to the south and cooler temperatures further north. The average July temperature range of about 80° to 86°F and varies little throughout the state. Texas also has a large variance in average rain fall. The western part of the state receives less than 12 inches of rain per year while the eastern area receives approximately 36 to 48 inches of rain per year (North, 2009).

The containers will need to be designed with sufficient insulation to withstand the northern winter with temperatures around 36° F. The team will also need to address the drainage off of the containers with high amounts of rainfall in the eastern part of the state.

While the containers are not being used for housing, they must be stored in a central region to disaster prone areas. This ideal storage facility would be a centralized region close to many of the highly disaster prone locations. The most ideal region for this would be to store the containers near the border of Texas, Louisiana, Oklahoma, and Arkansas. Housing the containers here while not in use would provide an ideal central region. This area would provide close proximity to four of the top 10 states with the most disasters.

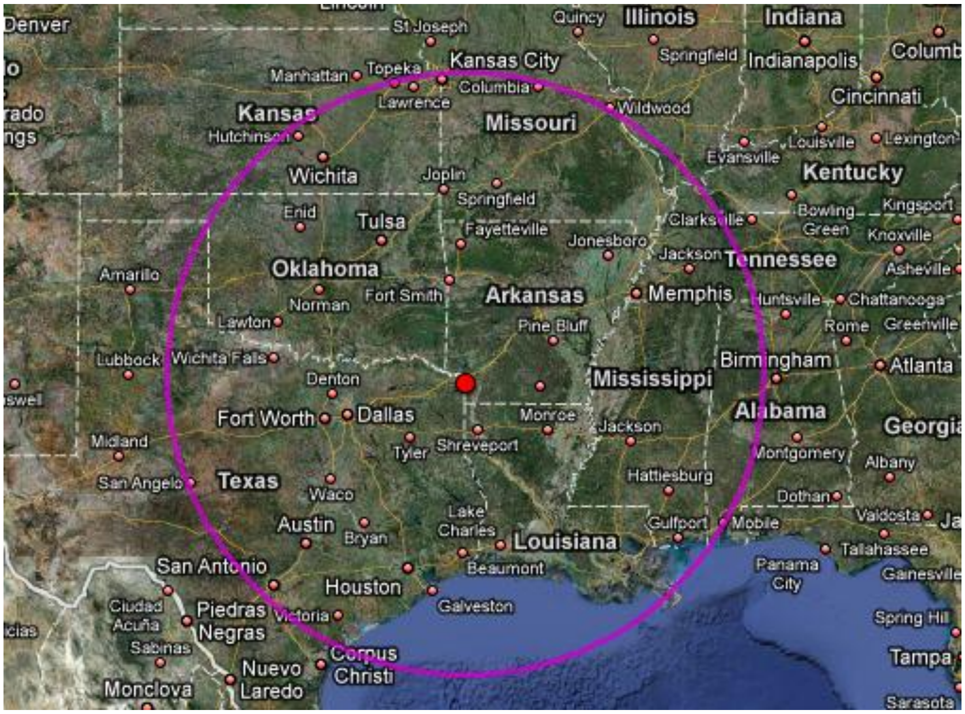

Figure 3: Centralized 400 Mile Range (Google Maps, 2009)

Figure 3 shows an ideal centralized location which has its base point located at Texarkana, Texas. The circular path surrounding it is a 400 mile range surrounding Texarkana. With this location the entire states of Arkansas and Louisiana and the majority of Oklahoma and Texas are within the range. The distance of 400 miles was chosen as the range due to the fact that the Sikorsky S-80 helicopter has a range of 575 miles (925 km). This gives the helicopters adequate distance from the containers to the disaster area and then, at minimum, an additional 175 miles to return to a nonimpact location to refill with gasoline. At 400 miles away from the containers each trip would take approximately two hours to transport the containers to the site where they will be set up for inhabitants.

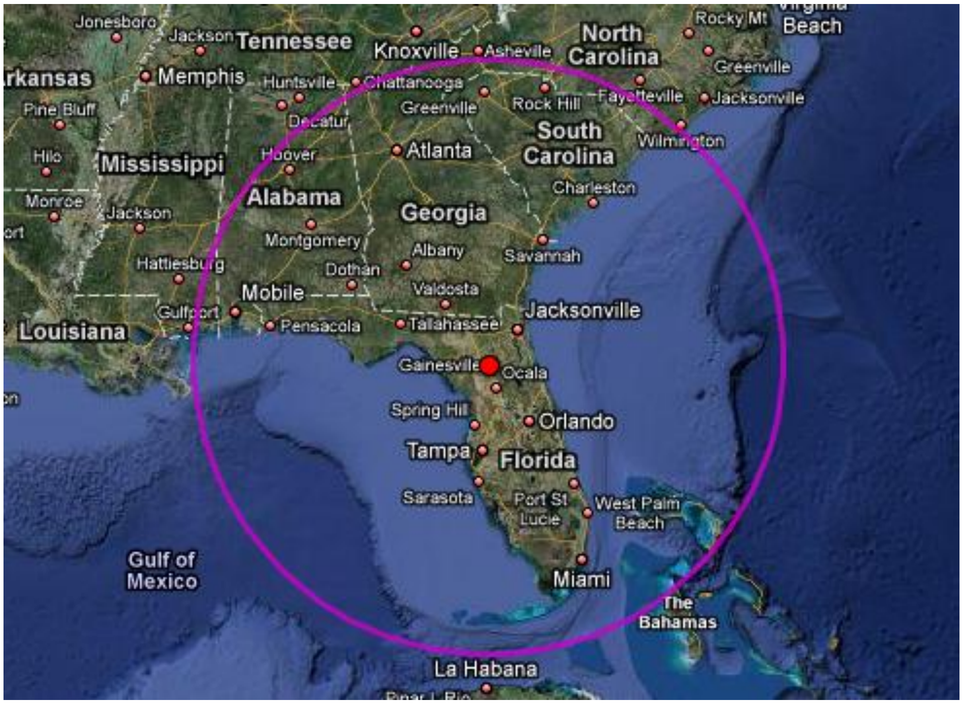

Figure 4: Florida Storage Range (Google Maps, 2009)

Figure 4 displays the range of effectiveness that a storage facility in Gainesville, Florida would provide. Florida has the third largest amount of natural disasters in the United States, and a storage facility in Gainesville allows for the containers to be within close range of all of Florida as well as the majority of Alabama, South Carolina and Georgia.

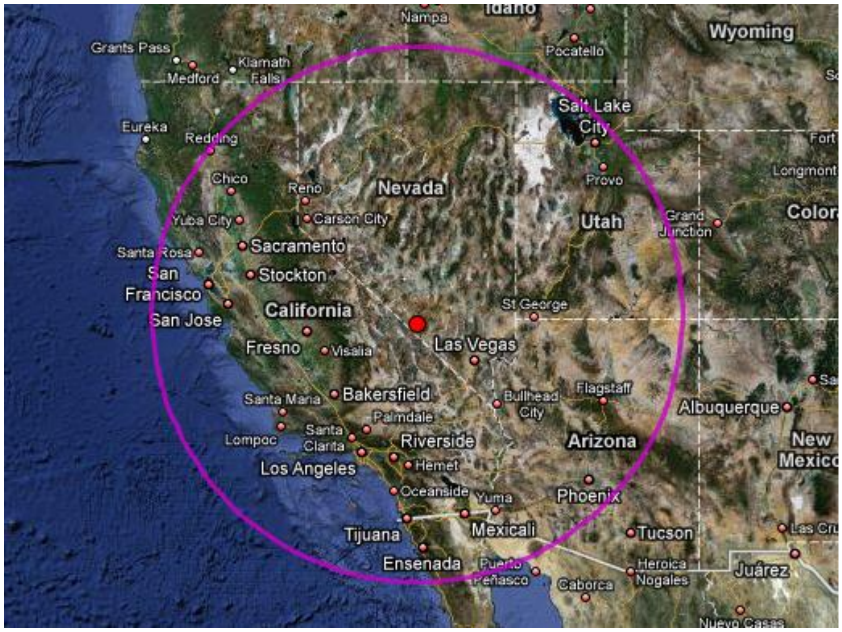

Figure 5: California Storage Range (Google Maps, 2009)

Figure 5 displays the location of a storage facility located in Beatty, NV. California amounts the second most disasters recorded in the United States. Most of these disasters are earthquakes where the housing of the victims was destroyed and they require temporary housing while theirs is being repaired. A central location such as Beatty, NV will allow the majority of California coverage for delivery of the containers.

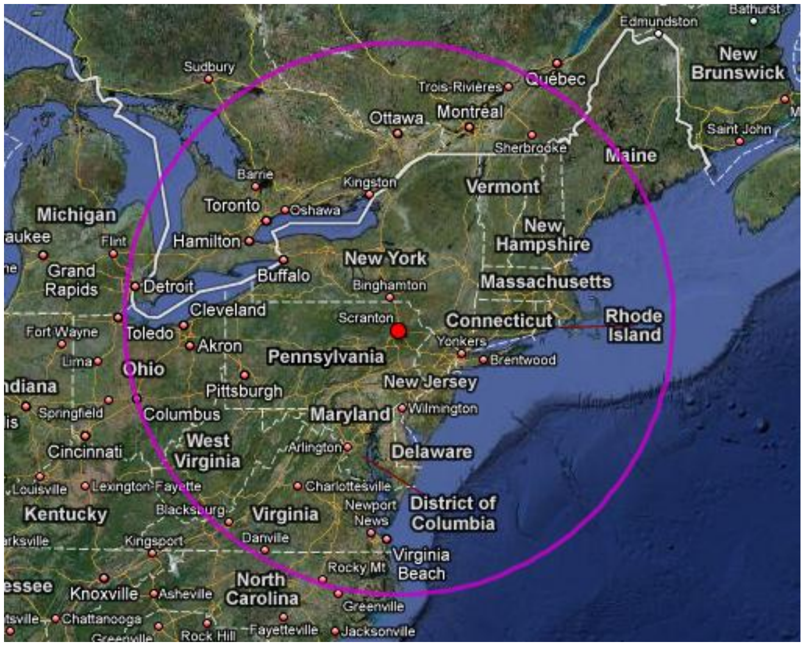

Figure 6: Northeast Storage Range (Google Maps, 2009)

Figure 6 demonstrates a northeast storage facility located in Scranton, PA. New York has the fifth most disasters declared in the United States and a storage facility located in Scranton, PA provides coverage to most of New England, all of New York, Pennsylvania, and the eastern coast.

Storage facilities in these locations provide the largest coverage to the most disaster prone states and areas around the country. With adequate preparation the containers at these sites will be distributed to a disaster location and provide the much needed housing for the victims of those tragedies.

2.7 Architectural Review

The architectural review of the project focused on existing examples of shipping container housing. The purpose of the review was to get a sense of the capabilities of shipping containers as housing units and to retrieve ideas pertaining to specific modifications of the containers that would be usefully applied to the project at hand. Much of the architectural review focused on container housing which would be suitable for low income housing rather than emergency housing; unfortunately, the availability of materials on shipping containers used as emergency housing was low.

However, many concepts used in the modifications of shipping containers to convert them into affordable housing could very well be applied to emergency housing. Such useful concepts include the general layout, windows, doors, flooring, other interior modifications, and exterior modifications. For a detailed description of the projects analyzed in the architectural review and a description of useful features employed in each design, see Appendix A: Architectural Review.

Chapter 3: Design

The design of the containers used for emergency shelter is one of the most important aspects of the project. Without a functional design, there is no point in using the containers. The design must incorporate all the features necessary to sustain a human population of approximately 200 people.

3.1. Program of Requirements

The first and most important issue that has to be constantly considered is the structural stability of the containers. As discussed in Section 2.2 Technical Standards, all of the structural strength of a container is found in the four corner posts, their connections, and the floor. It is possible to make cuts out of the corrugated metal sides of the container without losing structural integrity. However, care must be taken to not alter the corner posts, the beams that run between them, and the floor.

Another important factor that has to be addressed is that people need to be protected from the elements. Obviously, a shipping container provides a closed environment that will keep rain and other environmental conditions out, but the containers are not set up for any sort of temperature control. Therefore, modifications must be made for the inclusion of insulation and heating/cooling systems. Although protection from the elements has to be maintained, people still need access to natural light and fresh air. Windows and doors have to be added to the containers in order to have a steady supply of fresh air.

With those two aspects of the project in mind, there are four functions that the containers must be able to provide: living areas, bathroom facilities, dining areas, and kitchen areas. In addition to beds, the living areas need a space for people to store their clothes and other necessary personal items. The bathroom facilities obviously need toilets, sinks, and showers. They also must have separate areas for men and women in order to maintain privacy. Also, areas for dining and preparing food must be included somewhere in the layout of the site.

3.2 Site Layout Design

The characteristics of the site will influence to a great extent the amount of site preparation work necessary prior to the installation of the containers. Care must be taken to select a site which is ideal for the container development proposed in this report. An ideal site should be at least 1.2 acres in size and be clear of any natural or manmade obstacles such as boulders or damaged power lines. The team recommends that vegetated areas with trees greater than six inches in diameter be avoided due to the cost and schedule implications associated with large tree removal. An ideal site should also be relatively level and well drained, which will minimize the need for site grading activities. In terms of location, the site should ideally be in close proximity to an access road to facilitate the transportation of the containers from the factory, construction materials, and supplies once the settlement is established. In disaster prone locations (see section 2.5) ideal container locations should be sought out prior to the onset of an event to facilitate the process of establishing the container settlement.

Site Design A is the team's preliminary site layout plan for the emergency housing development. The 1.35 acre site, which is 182 feet by 290 feet, was designed with the intent to provide emergency shelter and all of the other functions as detailed in the program of requirements to a total of 200 people. As shown in Figure 7, Site Design A has a capacity which is slightly more than 200 people; a slightly higher capacity than necessary was allotted to accommodate for excess usage.

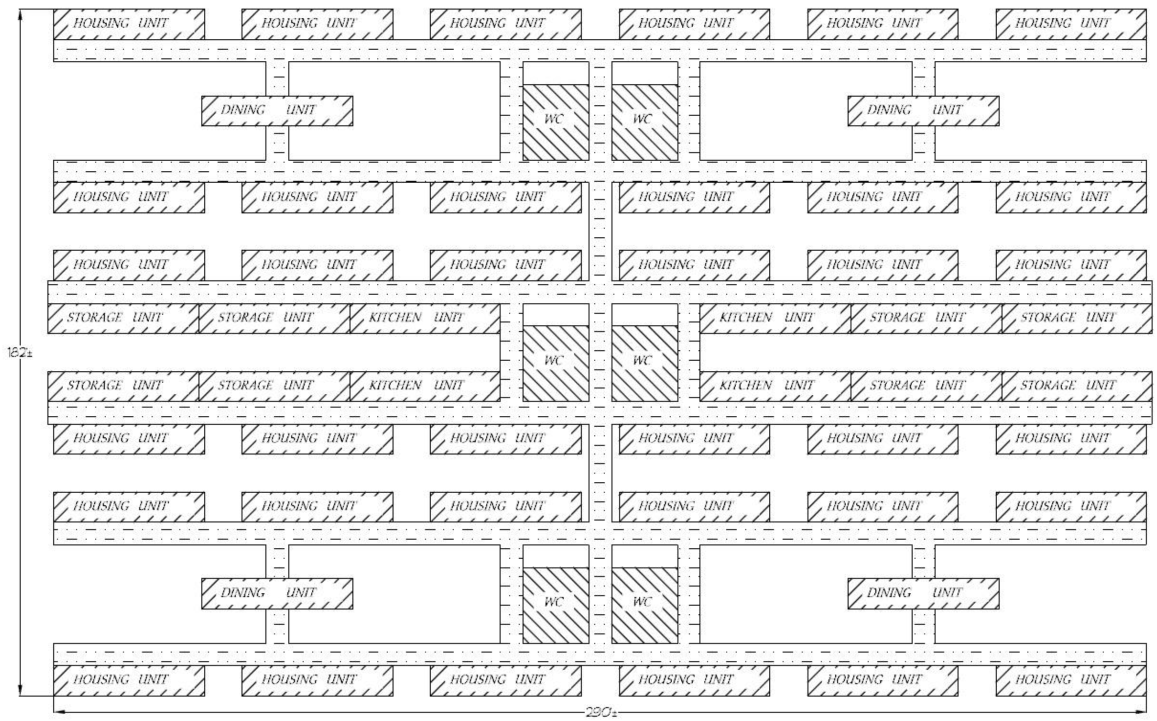

Figure 7: Site Design A

The various container structures included within the design include housing units, bathroom units, kitchen units, dining units, and storage units. In total, 36 housing units were included in the design, with an estimated capacity of six people per dwelling; theoretically, the design could shelter 216 people. Each housing unit is fronted on the pathway system, and ten feet was provided behind each unit for maintenance purposes.

In terms of the water closets, a total of six bathroom units were provided for in the design. Each bathroom unit was assumed to be similar to either Bathroom Design C or Bathroom Design D, which are each composed of two 20' containers aligned parallel with a 1.5' wet wall in between. The assumption was made that each bathroom unit had the capacity to service 42 people, or 21 people per container. In accordance with this assumption, the six units provided have the capacity to serve 252 people. In terms of location, the bathroom units are positioned in the middle of the development to ensure ease of access. Also, a 6'x17.5' gap from the sidewalk was provided for equipment.

Four 40' long container units were provided for dining with the assumption that each unit has the capacity to serve 25 people. In total, the four units would have the capacity to seat 100 people at one time; the assumption was made that multiple meal shifts would occur in the development. The kitchen units were located in the center of the development for ease of access and close proximity to the eight 40' storage units. The storage units were included to provide room for shipments of food, clothing, and other essentials.

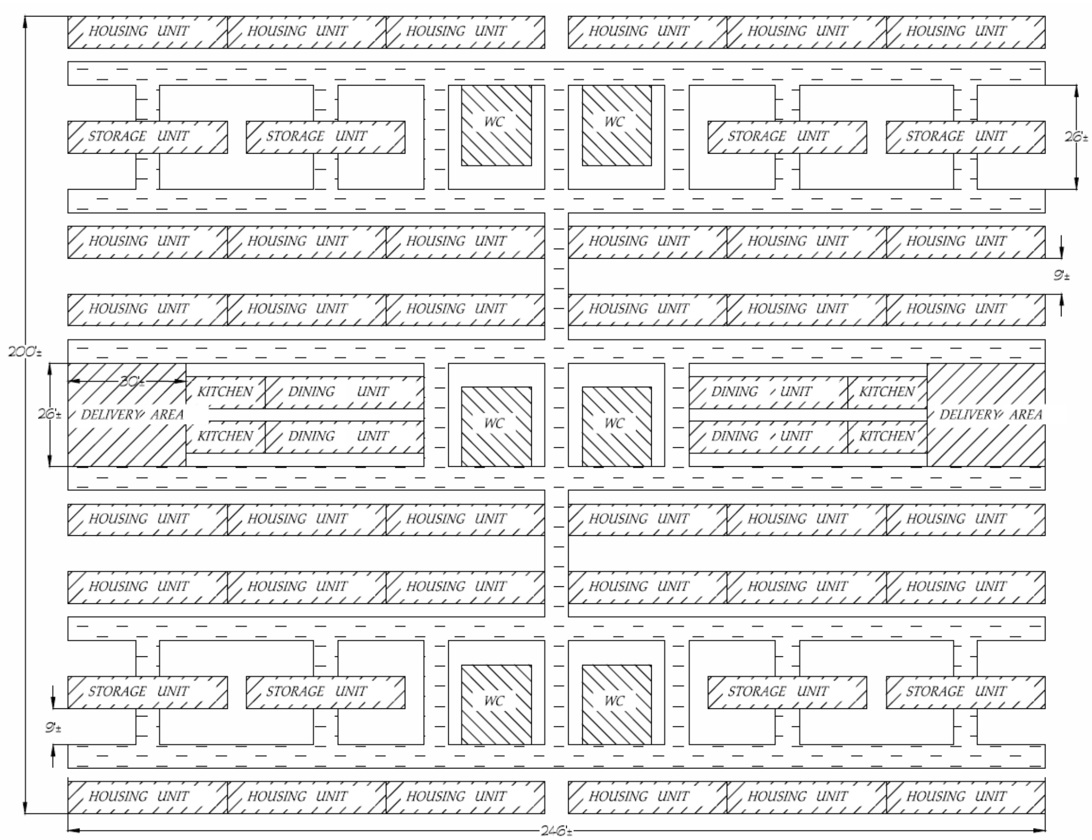

Figure 8: Site Design B

As shown in Figure 8, Site Design B is similar to Site Design A, except for the fact that it is condensed to fit an area of 1.13 acres, 200 feet by 246 feet. All of the housing units were placed side by side to reduce the total amount of space required by 0.22 acres. This site design also has the capacity to support approximately 216 people. In addition, the kitchen unit was resized from a 40’ container in Site Design A to a 20’ container. It was then joined with a 40’ dining unit, which was moved from the extremities of the development to the center. Four more storage units were incorporated into Site Design B and were relocated to where the dining units had been in the previous design. The unused area near the kitchen/dining unit was used as an unloading area for deliveries.

The following plan, Figure 9, shows the proposed grading for Site Design B. All slopes are graded at 2%. The proposed grading plan funnels water out of the site via drainage channels along the walkways.

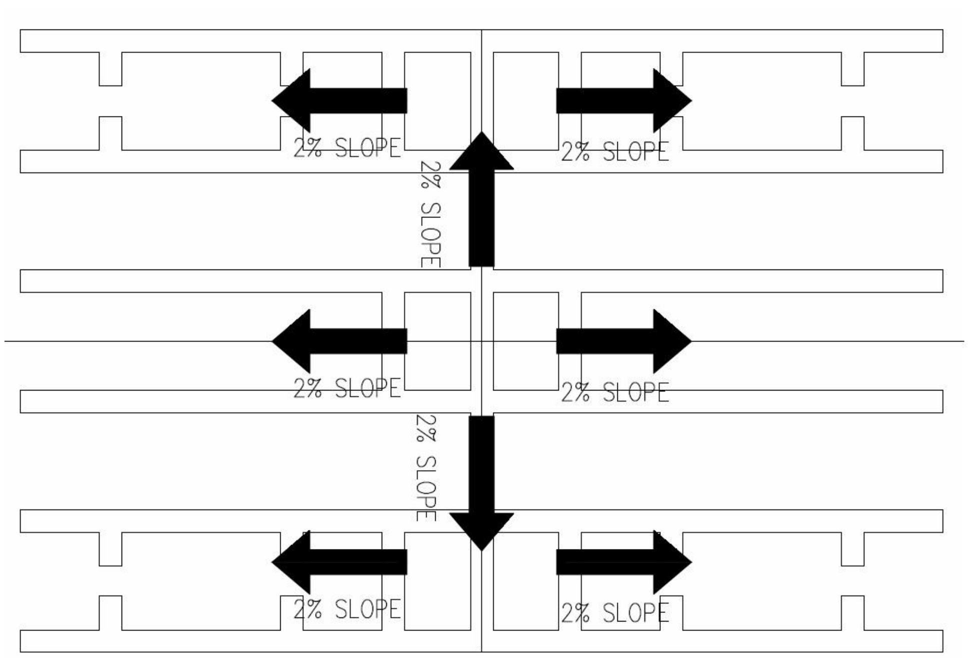

Figure 9: Grading Plan

3.3 Power

3.3.1 Power Requirements

One of the most important aspects of providing livable conditions for the people living in the emergency shelter site is the power supply. The people living in the emergency shelters will need services that only electrical appliances can provide safely, such as lighting and temperature control. In order to determine how to best provide this power it is important to first have an idea of how much power will be required. Table 3 shows the average power consumption of the various appliances that might be found on the site (Appliance, 2009).

Table 3: Typical Power Consumption

Appliance	Typical Power Consumption (in Watts)
Air Conditioner –1 ton	1,900
Air Conditioner – 3.5 tons	6,500
Air Conditioner – 5 tons	9,200
Air Conditioner – Split System	1,800
Heater – Portable	1,500
Light bulb – Incandescent	75
Light bulb – Compact Fluorescent	20
Radio/Electric Clock	15
Refrigerator/Freezer – 16 cubic feet	380
Refrigerator/Freezer – 20 cubic feet	420
Water Heater	2,475
Broiler	1,140
Coffee Maker	1,200
Microwave Oven	1,450
Range with Oven	12,200
Toaster	1,146

Making some assumptions about what each container will have in terms of appliances the team could determine the overall power requirements for the project.

Some of the items in Table 3 were not used in the as materials for the container but were shown to illustrate the efficiency of the items that were chosen. Each living area module will require about 2,100 watts, each bathroom module will require about 2,600 watts, each dining unit will require about 2,100 watts, and each kitchen unit will require about 70,000 watts. Based on the site layout this would result in the site of containers having a power consumption of about 380,000 watts (380 kW). With 216 people expected for the team's site design this translates to a power demand of 1,760 watts per person. Therefore, a power supply sufficient to meet this demand would be required. Incorporating a safety factor into the power demands, a generator that can supply 450 kW would be necessary for the site. One of the best generators available for this type of demand is the Volvo 450 kW diesel generator. It has a four stroke turbocharged heavy duty diesel engine running at 1800 rpm, which provides anywhere from 115 to 600 volts of 3 phase power (450KW, 2009). In addition, it is housed in a weather proof, sound attenuated enclosure and can be ordered with a heavy duty road trailer, high capacity fuel tanks, and many other accessories if necessary (450KW, 2009).

3.3.2 Power Design

As shown in Figure 10, the power layout has been designed in order to minimize the amount of power lines on the site.

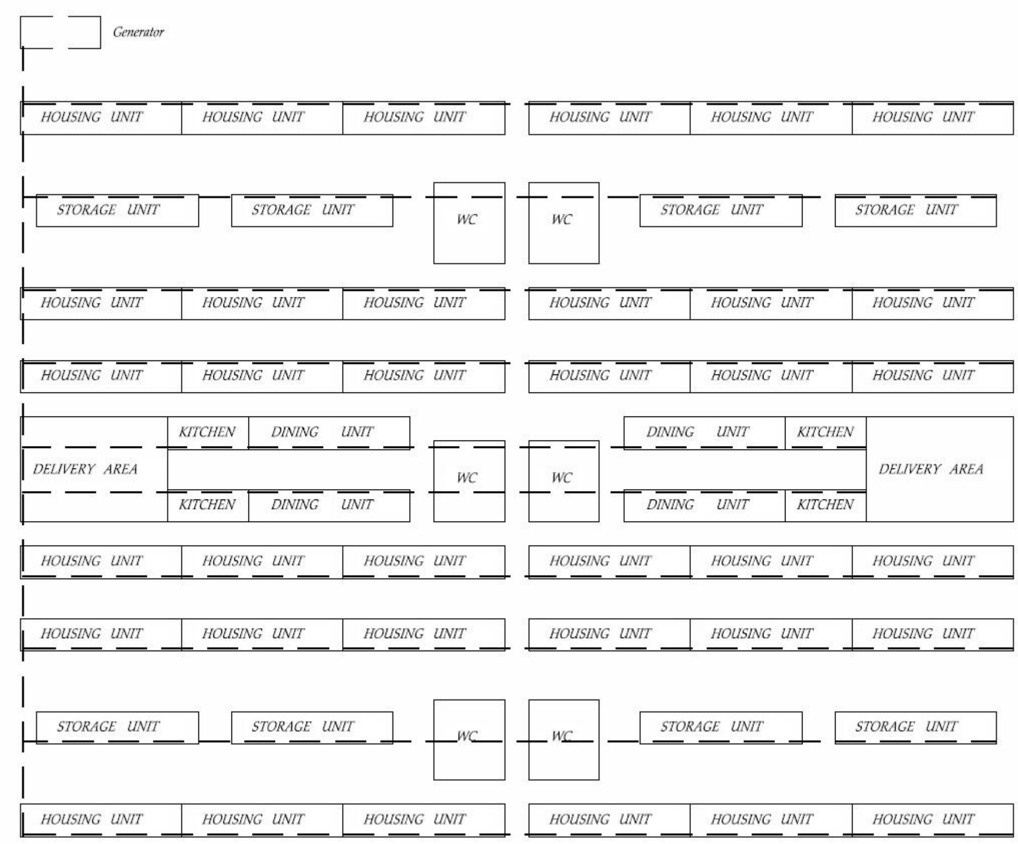

Figure 10: Power Layout

As stated earlier in section 3.3.2, a single 450 kW generator would be able to meet the power demands of the site. Although the generator is housed in a sound attenuated enclosure it is important that a minimal amount of sound pollution is experienced on the site. Therefore, the generator has been placed at one corner of the site in order to help lower noise levels. By placing the generator in the corner it also allows for a simpler system of power lines, with one main line running down the length of the site and several lines branching off of that as necessary to supply the containers.

3.4 Water and Waste

3.4.1 Water Supply and Waste Management Requirements

In order to provide water to the disaster relief community the team first needed to determine the amount of water that will be consumed per day, not including drinking water. This water amount is based upon the average usage of toilets, showers, and faucets. According to the City of Raleigh water usage statistics, the average person takes a shower of 6.3 minutes, with a standard shower flow rate of 3.8 gallons per minute creating a total of 24 gallons in a day (Water, 2009). The average person also flushes the toilet 4 times per day at a flow of 5 gallons per flush causing a total consumption of 20 gallons per day. Finally, each person uses the faucet five times a day, averaging 30 seconds each time, for a total of eight gallons per day. Table 4 applies these averages to the number of people the site will support.

Table 4: Water Supply

Water Consuming Function	Gallons Per Person Per Day	Gallons Per 216 People Per Day
Shower	24	5184
Toilet	20	4320
Faucet	8	1728
Total	**52**	**11232**

In order to house this large amount of water a holding tank will be located immediately off the site to provide the water supply. This Hanson manufactured tank will hold 16,400 gallons of water, which will be enough water to supply the community with water for an entire day. This provides approximately 6,000 gallons of water remaining for emergency reasons (Water Tank, 2009). This tank will need to be refilled about every day and a half to keep up with the demand from the disaster relief community.

In order to operate the bathroom facilities a water pressure of approximately 15 pounds per square inch is required. To provide this water pressure a pressure of 50 psi is required in the main distribution pipe running through the site. This will be achieved through a water pump located at the water holding tank.

3.4.2 Water Supply and Waste Management Design

Along with a water tank on the outside of the community grounds a sewage tank will be installed to hold waste and waste water until it can be removed and dispersed properly. This tank must the same approximate size as the water tank to hold all waste throughout the day.

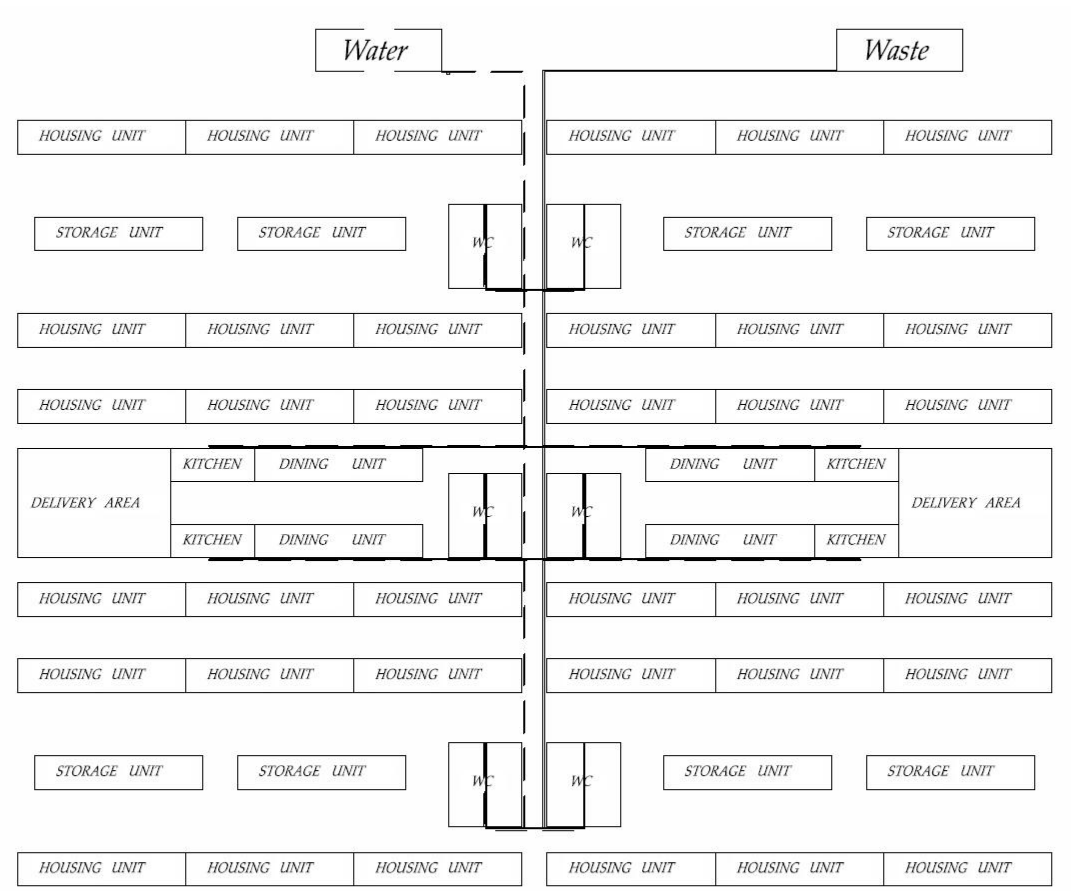

Figure 11: Plumbing Layout

Figure 11 shows the plumbing pipe layout for the disaster relief site. The dotted line shows the water supply to the kitchen and bathrooms while the solid line represents the waste and waste water removal; this line parallels the water supply out of the site to their respective holding tanks.

3.4.3 Rain Water Management Design

The design of the container development should take into account the issue of rainwater drainage. First, the flow of water onto the containers must be diverted through a gutter system so as not to impede the inhabitants. Gutter systems should be installed on all containers in the development since all will experience regular use. The gutters used should be durable enough to withstand the requirements of the project but should also be inexpensive enough to fit the projected budget. Figure 12 displays the common features of the containers including the rain management components.

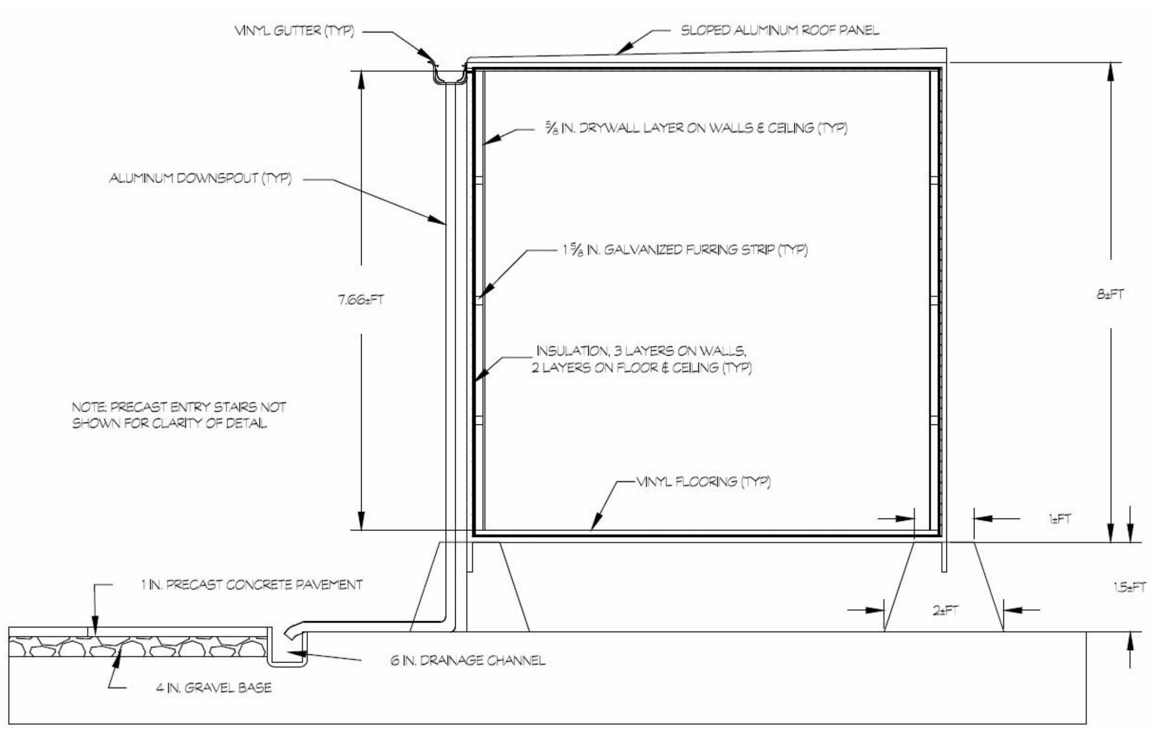

Figure 12: Container Profile

According to industry standards, the gutters should be placed at a minimum slope of two and a half percent. Four inch wide K-style gutters should be installed. Although five inch wide gutters are the most popular, a four inch width would be adequate for the small roof areas of the containers. If the gutters are installed at the fabricating plant in which the shipping containers are modified, aluminum should be used because of its low cost and relative ease of maintenance. The typical aluminum gutter thickness is 0.027 inches but for the application at hand a thickness as low as 0.019 inches could be selected to save resources. The gutter system should be attached to the container using a concealed fastener, which is easy to install and durable. If the gutter system is installed on site, PVC gutters may be considered because of the ease of installation and low cost. In either case, leaf screens may be necessary if the containers are located in close proximity to trees or other vegetation. Figure 13 shows the rainwater and insulation layout of a typical container.

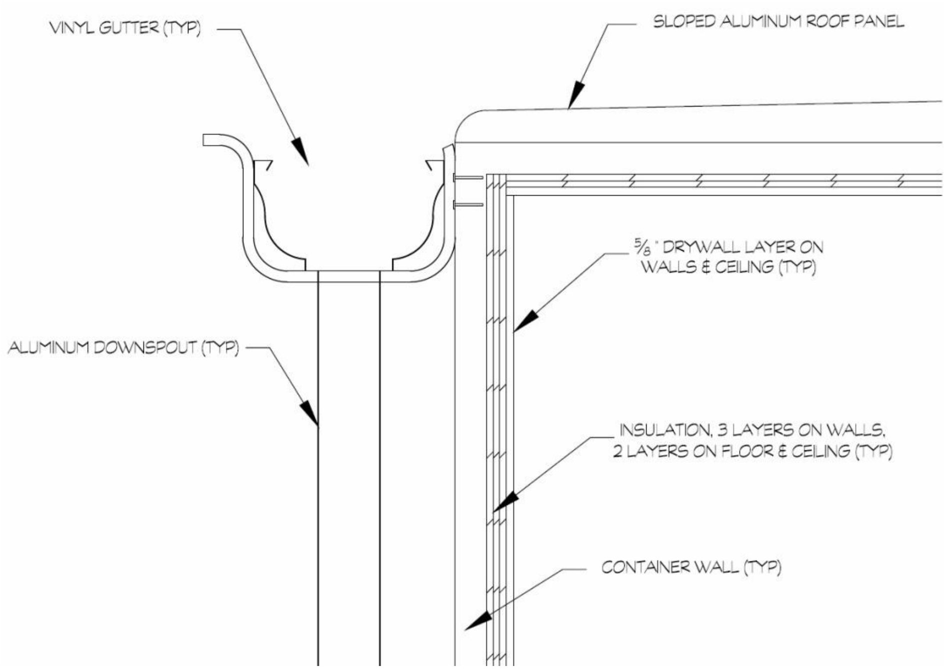

Figure 13: Container Profile Detail

In addition, the downspout must be included to divert the rainwater runoff from the gutter system away from the container. The downspout should be constructed of the same material as the gutter. A two inch by three inch leader is sufficient for a roof area of up to 600 square feet and therefore will be adequate for application in all of the containers. The downspout should empty into a six inch drainage channel at the edge of the sidewalk structure which will carry the water to the peripherals of the site. The six foot wide precast concrete walkway should also be constructed with drainage considerations. The precast panels should be laid on top of a four inch thick crushed aggregate base.

3.5 Insulation

To determine the best insulation for the containers the team must first look at the R-values of the materials. The R-value is the resistance to heat flow, where the higher the value the greater resistance to heat flow. The R-value depends significantly on the type of material, the thickness of the material, and the materials density. Each material can also be layered upon one another in order to increase the insulation. In this case, the R-values are simply added together. To determine the R-value needed the climate being designed for must be looked at, as well as the type of heating and cooling system installed and a specific room's need (U.S. DOE, 2009). Table 5 describes the typical R-values for given regions of the United States.

Table 5: Recommended Minimum Thermal Resistance of Building Insulation

Zone	Ceiling or Roof	Exterior Wall	Floor over Unheated Space
Minimum Recommended	19	11	11
Southern Zone	26	13	11
Temperate Zone	30	19	19
Northern Zone	38	19	22

There are many types of insulation available to complete the project; however, the team first needed to determine which the ideal insulation was. Table 6 shows the main types of insulation, the materials, and each type's advantages.

Table 6: Types of Insulation

Type	Materials	Advantages
Batt or Blanket	Fiberglass, Rock wool	Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions.
Rigid Board	Cellular glass, Polystyrene, Polyurethane, Polyisocyanurate	High insulating value for relatively little thickness.
Foamed in Place	Polyurethane	Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions.
Loose Fill	Cellulose, Perlite, Vermiculite	Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions.
Cast	Insulating Concrete	Autoclaved aerated concrete and autoclaved cellular concrete masonry units have 10 times the insulating value of conventional concrete.

(U.S. DOE, 2009)

In the application of use on a shipping container, size is of the utmost importance. For this reason the type of insulation the team chose was the rigid board insulation. This type of insulation has a distinct advantage of having a high R-value per thickness which will allow the containers to have the necessary thermal protection as well as a small amount of space consumed as mentioned in Table 6.

One product on the market that the team researched is Prodex Total Insulation, as shown in Figure 14. This insulation is specifically designed for metal structures because it also acts as a vapor barrier, thermal break, and radiant heat barrier. The insulation itself consists of aluminum foil with a polyethylene backing which surrounds closed-cell polyethylene foam. The aluminum foil backed by the polyethylene resists radiant heat and provides a vapor barrier while the polyethylene foam allows air flow which improves the thermal break or R-value. Prodex Total Insulation has a total R-value of 7.00 with horizontal heat flow (wall insulation) and an R-value of 15.67 with downward heat flow (ceiling insulation). The nominal thickness of the material is 0.20 inches (5mm). Prodex Total Insulation is sold in rolls four feet by 175 feet (700 SQFT) for $209.95. Prodex Total Insulation is ICC-ES Recognized as well as Energy Star qualified (Prodex, 2009).

Figure 14: Prodex Total Insulation
(Prodex, 2009)

On the other hand, an example of typical rigid foam board insulation is FOAMULAR 250 two inch Rigid Foam Insulation. This product is made by Owens Corning and is comprised of extruded polystyrene. FOAMULAR 250 has a nominal thickness of two inches with an R-value of ten; this is dramatically larger than the previously mentioned insulation, which will reduce the necessary interior dimensions of the container. This insulation is sold in squares of 48 inches by 96 inches and costs approximately $21 per 32 square feet. In comparison with the Prodex Total Insulation, the cost for the FOAMULAR would be $462 for a 700 SQFT section. One advantage of the FOAMULAR rigid insulation is that it is very common in the United States and used by many contractors. FOAMULAR is a product that has withstood the test of time while PRODEX Total Insulation is a relatively new product and not used as often as FOAMULAR.

Furring strips should be installed on the insulation to create a cavity between the insulation and gypsum wall board in which to install the plumbing and electrical systems. The strips should run horizontal against each wall at a distance of 24” on-center. Each container should have 1-5/8” galvanized metal strips. The furring system is reflected in the container profile view in Figure 12 and Figure 13 of Section 3.4.3.

3.6 HVAC

In order to maintain a livable environment inside the containers, a heating/cooling system is necessary. To meet this requirement, the team decided to use a split system. Unlike regular air conditioners, a split system consists of an outdoor condenser that is connected via pipes to an interior air handling unit (Geothermal, 2010). These systems work well for the project because one condenser unit has the ability to service multiple zones or containers. A simple example of a split system is shown in Figure 15. Most condensers can support up to three air handling units, so each condenser could provide heating or cooling for three containers. One of the best split system products is the Performance Series from Carrier. This system can provide up to a 12,000 Btu/hr capacity, has duct-free system connectivity, and can be programmed to be turned on and off automatically depending on the time of day to conserve energy (Performance, 2010).

In addition, the Performance Series is equipped with the company's inverter technology, which allows the system to vary the compressor speed to match the load (Performance, 2010). This allows for a steady temperature to be maintained without the cycling that occurs with conventional air conditioning systems. An additional benefit of using a split system is the low level of noise generated due to the fact that the condenser is located outdoors. The Carrier split system chosen for this project has an indoor sound rating of 33 dBa, which is quieter than a whisper (Performance, 2010). By using this system, energy will be conserved and noise levels will be kept to a minimum.

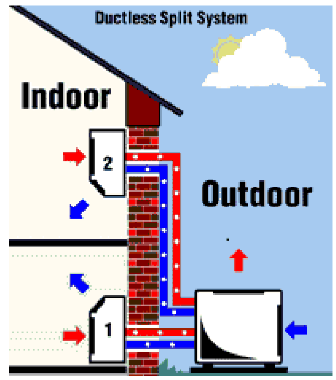

Figure 15: Split System
(Split, 2010)

The maximum design loads for the heating and cooling systems are based on a number of factors. The target temperature, outside temperature, insulation quality, volume of the container, number of doors, and number of windows all influence the energy requirements. The target temperature for the containers will be 68 degrees Fahrenheit and the maximum outside temperatures will be a low of 0 degrees Fahrenheit and high of 100 degrees Fahrenheit. In addition, each container will be affected by the type of equipment it contains, such as stoves and refrigerators. Based on these parameters, the maximum amount of heating and cooling loads can be calculated for each container. For the living containers, the heating load is 8,878 Btu, and the cooling load is 4,177 Btu. For the dining containers, the heating load is 8,436 Btu, and the cooling load is 3,969 Btu. For the kitchen containers, the heating load is 6,743 Btu, and the cooling load is 4,643 Btu. For the water closet containers, the heating load is 4,659 Btu, and the cooling load is 3,427 Btu.

3.7 Living Module Design

As shown in Figure 16, Layout A divided the container into three equal size rooms. The living spaces are divided by a solid barrier, such as a double layer of drywall, and each room has two twin size beds that are bunked, which allow for a maximum capacity of four people per room. Each room also contains a shelving area for the occupants to store their belongings and clothes. The living spaces also have separate doorways, which give the occupants privacy from the other people in the containers, and three windows to provide adequate daylight.

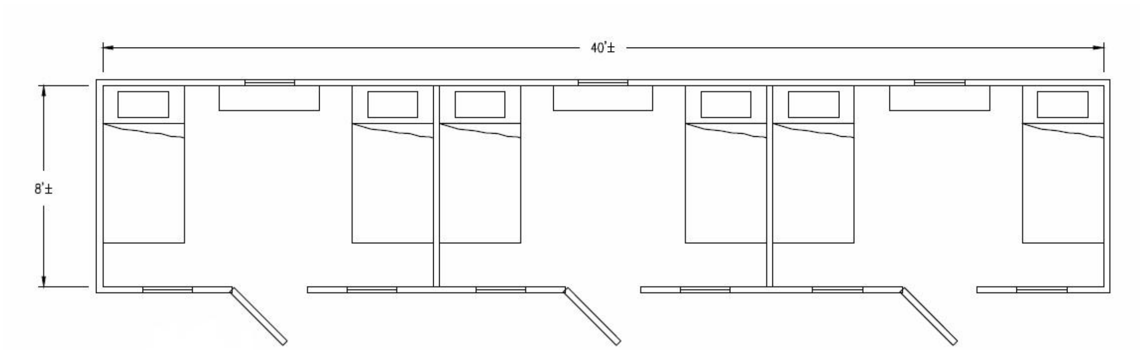

Figure 16: Living Area Layout A

Layout A is ideal in terms of efficient housing. This design has a total maximum capacity of 12 people to each 40' container, which would provide housing for 200 people with only 17 containers. Another good quality to Layout A is that it provides separate rooms which allow for privacy between people in the same containers.

While Design A is the most efficient, it provides the least amount of space per person. This becomes an issue the longer the inhabitants occupy the containers; space restrictions eventually will become discomforting. Also, no common area was incorporated in the design, which would provide a space for interaction and entertainment.

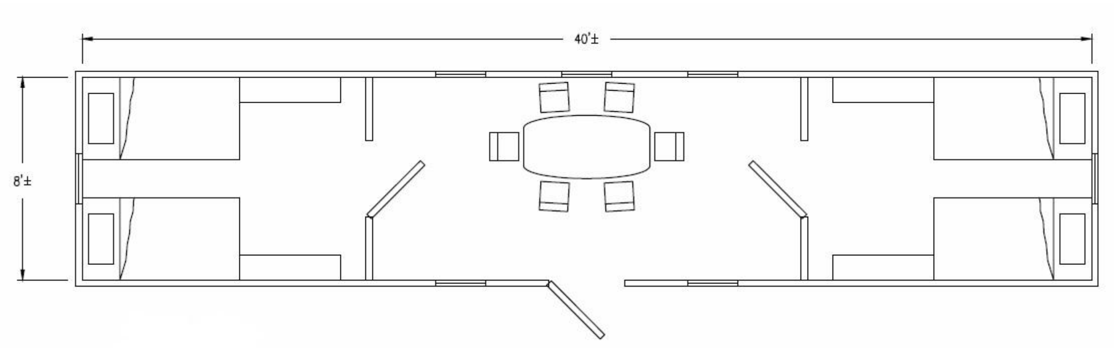

Figure 17: Living Area Layout B

Layout B, shown in Figure 17, features two rooms on either side with a central common room. Each living space contains two twin size bunk beds with two units of shelving for each person's belongings. The central room contains a seating area around a table, and each sleeping room has one window providing natural light. The only entrance to the bedrooms is through the common area, and the only door with access to the outdoors is located in the common areas.

One of benefits of Layout B is that there is a large central area where the occupants of the container can gather and relax. In Layout A there is no common area which can be used as a gathering area; this was the main component that the team wanted to focus on in designing Layout B. This floor plan is ideal for a family unit where the parents wish to be close to the children or other family members.

The downfall of Layout B is that it has slightly less capacity per container, with only eight people per container. This would require 25 containers, which increases the overall footprint of the container development. Another downfall to the design is the possible scenario of forcing multiple families to occupy one container to maximize space utilization, introducing possible compatibility issues among the occupants.

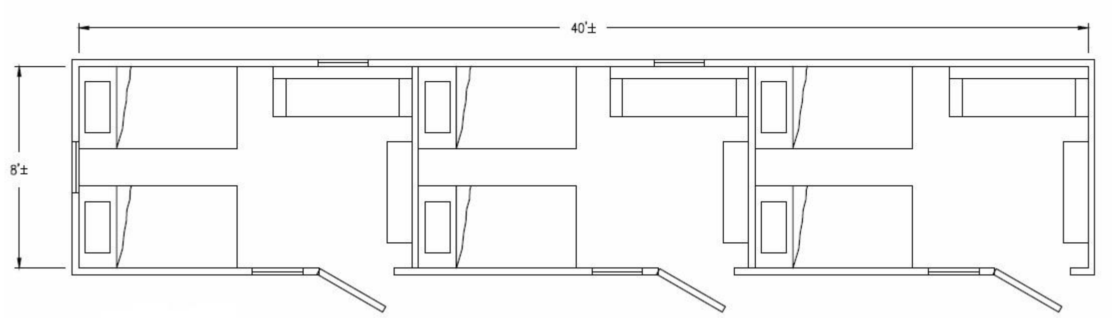

Figure 18: Living Area Layout C

Layout C, featured in Figure 18, separates the containers into three separate rooms and contains two twin beds in each room, which provide living space for six people per container. Layout C also incorporates a seating area in each room to provide an area to sit and relax in the comfort of each person's room.

The benefits of Layout C are that it allows the inhabitants to be able to sit and relax within their own room as opposed to Layout A where there was no seating area in the container. This design improves upon Layout B in that it provides more inhabitants per container as well as still allowing an area for sitting in their rooms.

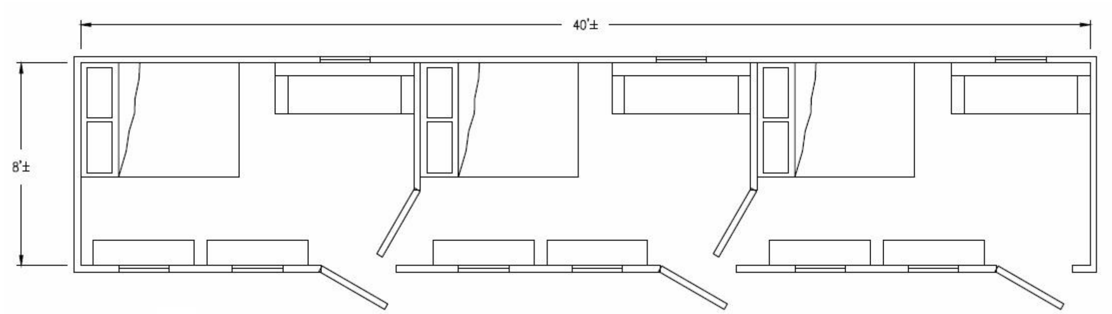

Figure 19: Living Area Layout D

Figure 19 shows Layout D, which has the same concepts as Layout C with the one exception of the sleeping arrangements. Layout D contains a full sized bed in each of the three rooms of the container. This design is good for couples or family members; however, forced roommates may feel uncomfortable to share a room. For this reason it may be a good idea to put a variety of Layout C and Layout D so that families and couples can share the larger beds while single people can be assigned a roommate and have the privacy of separate beds.

3.8 Dining/Kitchen Module Design

Figure 20 shows Layout A for the kitchen design. There are four ovens and four sinks and a large counter for food preparation.

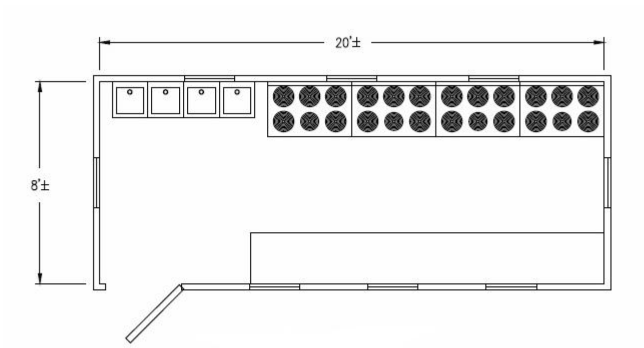

Figure 20: Kitchen Area Layout A

However, this design did not meet the needs of the site. There was no space for refrigeration of food and the group found that four ovens were unnecessary. To better address the way people at the site would be eating a second kitchen design was created. As shown in Figure 21, Layout B is much better suited to meeting the food needs of the people on the site.

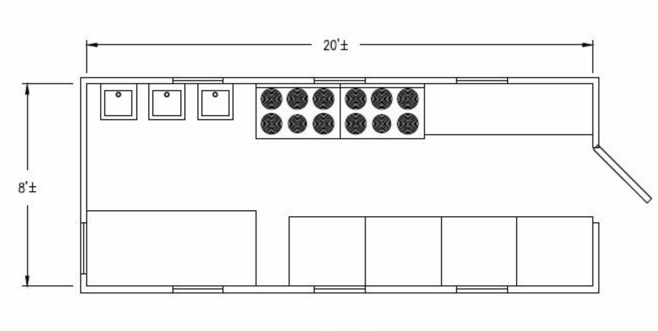

Figure 21: Kitchen Area Layout B

The design in Figure 21 provides space for four refrigerators since most of the food will be pre-cooked and will need to be stored in a cool place. Two stoves are provided for heating the food, with three sinks and ample counter space to assist in any preparation that is necessary. In addition, there is a window opening on the side of the container opposite the door to allow food to be passed through to the dining container, eliminating the need to walk outside with the food.

Figure 22 shows Dining Area Layout A. In this design, there are 13 booths for people to sit and eat at. However, the booth benches are only two and a half feet long, which would be uncomfortable for two people to sit side by side.

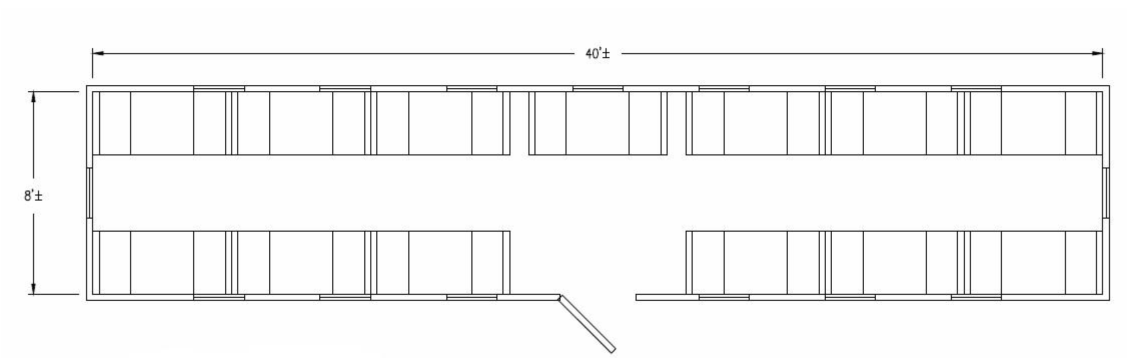

Figure 22: Dining Area Layout A

Figure 23 shows Dining Area Layout B. In this design, there are seven booths with five foot long benches for each booth. The container also shows the window opening to allow for food to be passed from the kitchen container to the dining container.

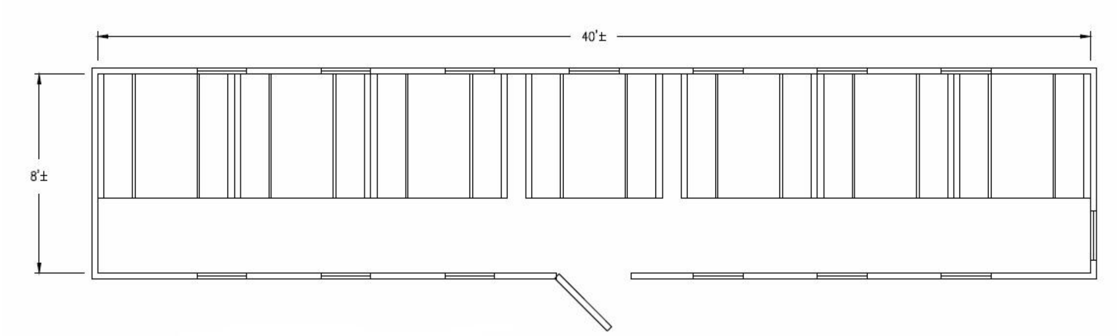

Figure 23: Dining Area Layout B

The bench lengths of five feet would allow for two people to sit side by side comfortably. If necessary, three people could sit side by side, such as in the case of parents with small children. Based on each booth seating a minimum of four people, each dining container could hold 28 people at a time; with four dining containers on the site, this means that a minimum of 112 people could eat at a single time. To accommodate all 200 people on the site a series of eating shifts would have to be established. However, since it is unlikely that all 200 people will want to eat at exactly the same time the group does not believe a shift system would be a problem for the site.

3.9 Water Closet Module Design

As shown in Figure 24, Water Closet Area Layout A was the team's first attempt at designing a bathroom unit for the emergency shelter complex. The design features the usage of a 40' container with both male and female facilities. The entrance to the bathroom unit is located at the midpoint of the span; this entryway leads to a common area with seven standard size sinks and mirrors. The entryways to the male and female sections are separated by temporary partitions.

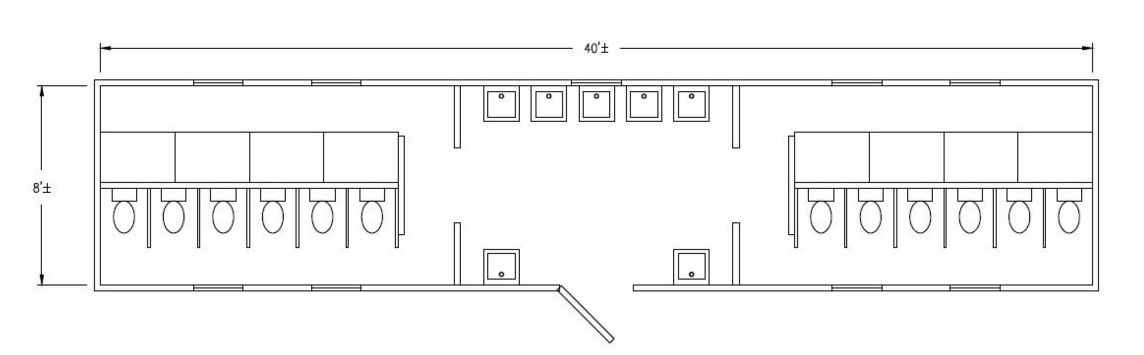

Figure 24: Water Closet Area Layout A

In addition, another temporary partition was placed parallel to the temporary partitions to obstruct the view into the toilet/shower area from the common area, which provides a sense of privacy. In each toilet/shower area, six toilet stalls and four shower stalls are provided. The toilet and shower stalls are lined up back to back against a wet wall. No urinals were provided for in either section to provide flexibility and uniformity to the design. In terms of windows, one window was provided in the common area and four overhead windows were provided in each toilet/shower area.

This design is advantageous because it features combined male/female facilities in each container. In this sense, separate male and female facilities would not need to be strategically placed throughout the complex, and the unit could also be utilized in a very small complex. However, the combination of male and female facilities into one container put a constraint on the amount of space available for toilet stalls and shower stalls. The toilet stalls provided were very small in size, and the walkway leading to the stalls is not adequate, measuring approximately one and a half feet. Due to the aforementioned space constraints, a curtain was utilized instead of a door on each toilet stall.

Water Closet Layout B, shown in Figure 25, was the team's alternative to Bathroom Layout A for the emergency shelter complex. The design features the same usage of a 40' container, but instead of incorporating both male and female facilities into one container, the container is designed to provide usage to only one gender.

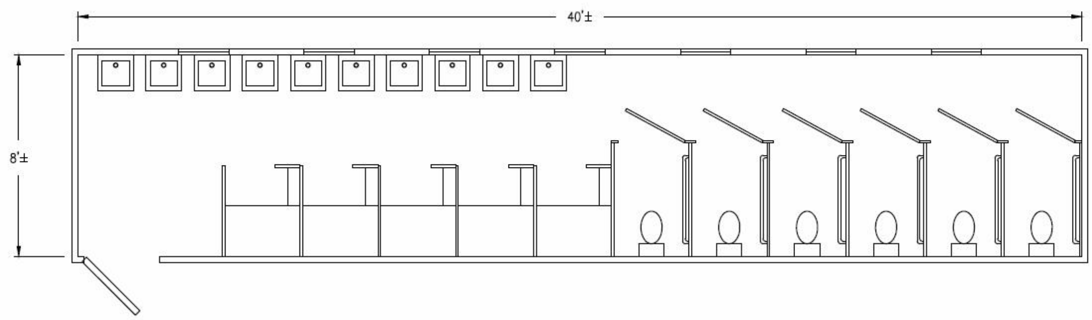

Figure 25: Water Closet Area Layout B

The entryway, which is located on the far left side of the container, leads to a sink and shower area. In total ten sinks and five shower stalls are provided. The sinks are the same size as the previous design, but the showers feature the added benefit of an inclusive changing area with a bench. The toilet stalls are also larger than in the previous design. The stalls are standard size and include a handicapped rail and standard door. Similar to the previous design, no urinals were provided to ensure uniformity and flexibility. A total of seven windows were provided throughout the container.

Overall, this design is better suited than the previous design to accommodate the needs of the team's project. Since the complex will be designed to suit the needs of 200 people, multiple bathroom units will be required; the benefit of a combined gender facility is therefore diminished. However, the all concerns about plumbing must be resolved before a final design is chosen.

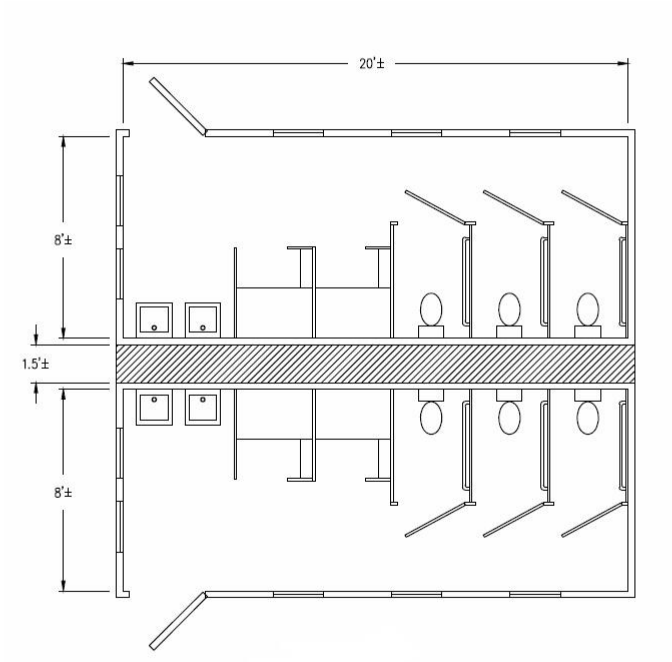

Figure 26: Water Closet Area Layout C

Shown in Figure 26, Water Closet Layout C utilizes two 20' long containers aligned parallel with a 1.5' wet wall in between. The design is more efficient than either Layout A or Layout B because all of the plumbing fixtures in both containers are aligned against one wall. The two containers are designed to service one gender each, optimizing the amount of space; each container was also designed to be gender neutral, increasing its applicability. Layout C contains a total of two standard size sinks, three standard size toilet stalls, and two 2'x3' shower stalls. The shower stalls are also equipped with an outside changing area. A total of five three by two foot wide overhead windows were also included in the design to increase ventilation.

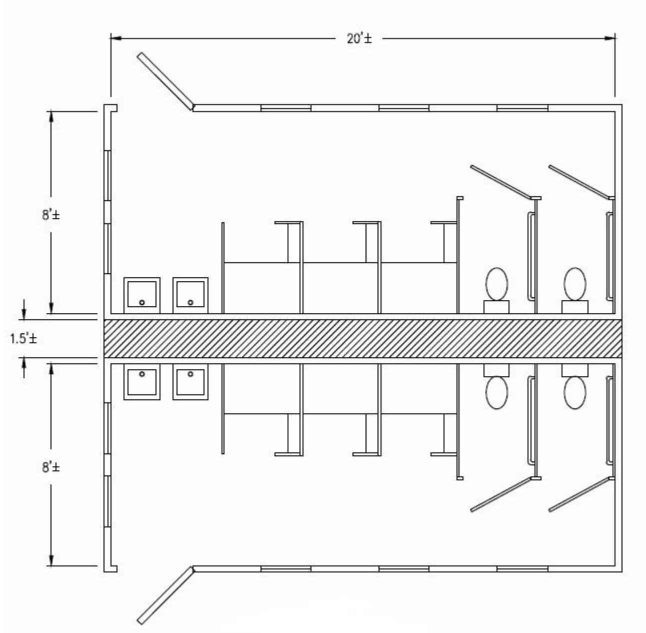

Figure 27: Water Closet Area Layout D

As shown in Figure 27, Water Closet Layout D is an alternate to Water Closet Layout C. The two designs are essentially the same except for the fact that Water Closet Layout D has three showers and two toilets.

Chapter 4: Components and Materials of Each Module

4.1 Site Preparation

The site preparation phase must occur to make the site suitable to host the containers. Although the specific site characteristics will vary according to its location, the basic processes for site preparation will remain. The site design followed for modifications will be Site Design B. First, the site must be cleared and grubbed, with the possibility of tree removal. Next, the site must be graded in accordance with the grading plan provided to ensure the adequate flow of rainwater away from the site. Third, the waterlines, waste lines, and power lines must be installed along with the water supply system. Next, the 4" gravel sub base must be laid down and both the precast concrete walkway as well as the delivery area must be installed. Finally, the drainage channel must be installed to finish the precast walkway. Table 7 shows the list of site preparation activities.

Table 7: Site Preparation Activities

Code	Activity
G01	Clearing and Grubbing
G02	Grade Site
G03	Install Water Line
G04	Install Waste Line
G05	Install Power Lines
G06	Install Water Supply
G07	Sub Base

G08	Pave Delivery Area
G09	Construct Precast Concrete Walkway
G10	Construct Drainage Channel
G11	Install HVAC Split System
G12	Place Containers using 12-ton truck mounted hydraulic crane

4.2 Common to all Modules Factory Installation Activities

All containers will undergo common modifications in the factory regardless of the function it is specific for. The first of these activities is to cut out the specified number and size of windows and doors. While the number and size is specific to the function and design of the container these cutouts are common to all containers and must be completed first in order to continue the modification process. Every container must then be painted to remove the toxic paint previously applied and to protect the metal containers from the elements and oxidization. Before any insulation or drywall can be installed the electrical and plumbing rough in must be installed throughout the container. The insulation will then be placed which includes applying three layers of Prodex Total Insulation on the walls, two layers on the ceiling, and two layers underneath the floor, which will serve as a vapor barrier as well as insulation. Over the floor a layer of vinyl flooring shall be installed to specifications to cover the entire floor of the container. The walls and ceiling will be finished with gypsum board and two coats of paint. Finally, to seal the interior of the containers the windows and storm doors shall be installed to technical specifications in order to provide a proper weather barrier and protect the interior from the outdoor elements. Once these factory modifications are completed each container will be fitted for their specific function and design as in the following sections. Table 8 shows the list of activities common to all containers.

Table 8: Common Factory Installation Activities

Code	Activity
A01	Container cutouts
A02	Painting exterior of container
A03	Insulation installation
A04	Furring installation
A05	Electrical rough-in
A06	Plumbing rough-in
A07	Drywall installation
A08	Flooring installation
A09	Interior painting
A10	Window installation
A11	Door installation

4.3 Living Module Custom Factory Installation Activities

The living unit will be comprised of a single 40 foot length container. The design followed for the modifications will be Living Area C. Initial modifications consist of cut-outs for eight 3'x5'6" windows and three 3'x6'8" doors. These modifications shall be made in the factory before any other modifications be done to the containers. Two partition walls shall be installed 13.34 feet from each end wall to create three separate rooms within each container.

All containers will undergo common modifications in the factory no matter the function it is specific for. These modifications include applying three layers of Prodex Total Insulation on the walls, two layers on the ceiling, and two layers underneath the floor, which will serve as a vapor barrier as well as insulation. Over the floor a layer of vinyl flooring shall be installed to specifications to cover the entire floor of the container. The walls and ceiling will be finished with gypsum board and two coats of paint.

After the common modifications are completed the living containers shall be fully furnished in factory to be living ready when delivered to the site. All furniture shall be mounted to the floor to prevent movement in the container during transportation to the disaster relief site. In each room two twin sized beds will be placed, therefore installing a total of 6 twin sized beds in each container. Along the wall opposite the door a 34.5'h x 60"w x 32.5"d loveseat will be mounted in each room. Finally, a 3’w x 1.5’d x 4’h dresser shall be mounted in each room. This will be bolted to the floor as well as the partition wall as to prevent overturning during transportation. Table 9 shows the list of activities specific to the living containers.

Table 9: Living Container Custom Installation Activities

Code	Activities
B01	Install Partition
B02	Install Bed Frame and Bed
B03	Place and Secure Loveseat
B04	Place and Secure Dresser

4.4 Dining/Kitchen Module Custom Factory Installation Activities

For the dining unit the team will be using a 40 foot container. The design followed for the modifications will be Dining Area B. The initial modifications that will be made in the factory include cut-outs for 13 3'x5'6" windows and one 3'x6'8" door. In addition, there will be a single cut-out for a pass through window that will allow food to be passed from the kitchen to the dining unit. These modifications will be made in the factory before any other modifications take place.

All containers will undergo common modifications in the factory no matter the function it is specific for. These modifications include applying three layers of Prodex Total Insulation on the walls, two layers on the ceiling, and two layers underneath the floor, which will serve as a vapor barrier as well as insulation. Over the floor a layer of vinyl flooring shall be installed to specifications to cover the entire floor of the container. The walls and ceiling will be finished with gypsum board and two coats of paint.

Equipment and furnishings for this unit include bench seating and tables for the diners. The benches will be restaurant booth style, with 1.4 foot by 5 foot seats and high backs. The tables will be 2.5 feet by 5 feet. Each table will have two bench seats, one on each side. There will be a total of seven tables and fourteen benches. All equipment and furnishings will be mounted to the floor and walls in order to prevent movement and breakage during transportation. Table 10 shows the list of activities specific to the dining containers.

Table 10: Dining Container Custom Installation Activities

Code	Activity
C01	Install bench seats
C02	Install tables

For the kitchen unit the team will be using a 20 foot container. The design followed for modifications will be Kitchen Area B. The initial modifications that will be made in the factory include cut-outs for six 3'x5'6" windows and one 3'x6'8" door. In addition, there will be a single cut-out for a pass through window that will allow food to be passed from the kitchen to the dining unit. These modifications will be made in the factory before any other modifications take place.

All containers will undergo common modifications in the factory no matter the function it is specific for. These modifications include applying three layers of Prodex Total Insulation on the walls, two layers on the ceiling, and two layers underneath the floor, which will serve as a vapor barrier as well as insulation. Over the floor a layer of vinyl flooring shall be installed to specifications to cover the entire floor of the container. The walls and ceiling will be finished with gypsum board and two coats of paint.

Equipment and furnishings for this unit include four refrigerators, two stoves, three sinks, and two sections of 6.66 linear feet of countertop. Each section of countertop will be supported by two cabinets, one underneath each end of the countertop. The refrigerators will have 22.4 cubic feet of capacity and will be used to keep the pre-made food safe until it is time to reheat and serve it. The stoves will be 30" freestanding ranges with 4.4 cubic feet of oven capacity. The primary function of the stoves will not be cooking but reheating due to the nature of the food supply for the site. The sinks will be the same style used in the bathrooms to allow for easier replacement or maintenance. All equipment and furnishings will be mounted to the floor and walls in order to prevent movement and breakage during transportation. Table 11 shows the list of activities specific to the kitchen containers.

Table 11: Kitchen Container Custom Installation Activities

Code	Activity
D01	Install wood cabinets
D02	Install countertops
D03	Install sinks
D04	Install ranges
D05	Install refrigerators

4.5 Water Closet Module Custom Factory Installation Activities

The water closet unit will consist of two 20' containers separated by a wet wall. The design followed for modifications will be Water Closet C. Initial factory modifications include painting the containers and installing openings, after which the windows and doors may be installed. Also, similar to all of the containers the drywall, vinyl flooring, and insulation must be installed in the factory.

Next, the water closet unit must be customized to provide its expected services. During this stage, all plumbing and bathroom fixtures must be installed. Solid polymer toilet and shower stall partitions are used to separate each stall, and should also installed at the factory. In addition, all electrical systems should be installed. Refer to the materials list for all of the necessary accessories. Table 12 shows the list of activities specific to the water closet containers.

Table 12: Water Closet Custom Installation Activities

Code	Activities
E01	Install Toilets
E02	Install Shower Stalls
E03	Install Bathroom Partitions
E04	Install Shower Partitions
E05	Install Sinks
E06	Install Shower Stall Benches
E07	Install Bathroom Fixtures and Accessories

4.6 On Site Installation Activities

After the units are transported to the site a third installation phase must occur. Following the preparation of the site and delivery of the container, the precast foundation posts must be installed and each container must be attached properly. Next, all plumbing and electrical systems must be connected to the site utilities. During the aforementioned process the precast stairs, sloped roof panel, and gutter system should also be installed. Table 13 shows the list of activities necessary after the containers are on site.

Table 13: On Site Installation Activities

Code	Activities
F01	Install Precast Concrete Foundation Posts
F02	Plumbing Hook Up
F03	Electrical Hook Up
F04	Install Electric Water Heater
F05	Install Sloped Roof Panels
E06	Install Gutters
F07	Install Downspout
F08	Install Precast Concrete Stairs

Chapter 5: Cost Analysis

5.1 Initial Cost

In order to commence operations to develop a disaster relief community comprised of modified shipping cargo containers, federal money must first be used to purchase the initial containers. For the purpose of the team's cost estimate the team has analyzed the cost based upon one designed community. In order to provide more housing and the ability to provide the disaster relief communities in various regions the team suggests creating multiple communities which will increase the cost analysis by a factor of the number of the relief communities desired. Due to the economy of scale, the cost of multiple communities will decrease in relation to the number of communities built.

The federal money shall be used to purchase used containers of 20 foot and 40 foot lengths. 34 40' length containers and 12 20' length containers shall be purchased at $1,300 per container for each community desired. These containers must then be transported to the factory where modifications will be made prior to delivery on site. The most economical form of transportation is by trucking the containers to the factory from the location of purchase. If the containers are purchased overseas then they will need to be shipped to the united states via a container ship. Recent quotes from Shanghai to the United States for the shipment of one 40 foot container is approximately $8,000 (International, 2008). The containers then arrive to the factories where the modifications will be made to each container.

5.2 Factory Modification Costs

At the factory site a mobile crane must be on location in order to continually move containers in and out of the factory as well as stack them into storage facilities until they are called upon in a state of emergency. A 12 ton truck mounted hydraulic crane and crew shall be used for a total cost of $12,225 per day of usage. Each container undergoes certain modifications that are common to them all despite what their final function is, be it a bathroom, living quarters, kitchen, or dining room. The first modifications to be done are to cut out the openings for doors and windows and then to paint the container in an environmentally friendly paint product which will also protect the metal from the environment. These modifications include the installation of materials such as insulation, drywall, windows, doors, flooring, etc. A complete detail of all materials to be installed can be found in the Materials and Costs Table in Appendix B.

The containers then undergo modifications which are specific to the final function of the container. These modifications include installing plumbing for bathrooms and kitchens as well as placing and securing all furniture in the living quarters as well as the seating in the dining halls. The cost breakdown and complete material breakdown can be found for each container design in the Materials and Costs Table (Appendix B).

These modifications will be completed by the factory workers. The productivity rates for the factory workers are based on the daily output rates provided by RS Means. This is assuming that a private company is hired to complete the factory modifications. One possibility the team had thought of is if volunteers could be found to help construct the containers because it is for a cause to benefit victims of disasters. If a volunteer program could be organized and act as habitat for humanity, the cost would be greatly reduced as the labor cost would be effectively nothing. However, the material cost would still be in full.

After the completion of the container specific custom modifications the containers will be transported to a designated storage facility. As the team had discussed in a previous chapter, the storage facilities shall be in a central location between the high risk regions for disaster situations. It is the team's intent to store the containers at multiple locations so no matter the region of a disaster the container housing is available for relief. The storage location will have an initial cost of the property or perhaps a continual lease or rent cost. This cost is highly dependent on the size and location of property available and will also vary from region to region of the storage facilities. The containers will be stored on top of one another as to reduce the size of the property required. However, this also requires a mobile crane on site in order to stack and move the containers when necessary. Similar to the factory a, 12 ton truck mounted hydraulic crane will be used at a cost of $12,225 per day. Once the containers are in their storage location the crane and crew will not be in use and therefore removed from site as to eliminate additional costs. When a disaster occurs the crane and crew will be hired once again and put on location in order to remove the containers from a stacked position to a position where it can be transported whether by truck or by helicopter.

5.3 Site Modifications

When a disaster occurs a site must first be chosen to serve as the disaster relief community location. This location must fulfill the requirements mentioned in Section 2.5, and will most likely be free of cost in order to serve the purpose of emergency relief.

The containers must then be transported to the site from the storage facility. The transportation cost is dependent on the distance from the storage facility to the chosen site as well as the mode of transportation. The containers can be airlifted out for a quick delivery or transported by truck which may be a slower transport unless multiple trucks are used in which case could be the quicker mode. The team assumes that in a state of emergency a federal organization will fulfill the transportation needs, such as using national guardsmen to either air lift the containers by helicopter or to convoy the containers by truck.

Before the arrival of the containers to the relief site, the site must undergo modifications. These modifications include clearing and grubbing, site leveling, placement of a gravel sub base and base. In order for these preparations to be made a 200 horse power dozer which has a cost of $13 per CY of material will be used. The dozer would be able to complete the clearing and grubbing for $6,188 for up to 6" diameter trees. Trees larger than 6" diameter are unlikely as the presence of those trees would make the site a poor candidate for the disaster relief community. With a site that is 200' by 246' and a gravel base of 4" the total cost for the dozer will be approximately $8,072 per site. The gravel itself will be a total cost of $3,600 for roughly 607 cubic yards. Water lines and sewage lines will then be laid out which connect to storage tanks. The total cost for installing both the water and sewage lines is about $38,000.

The containers will then be delivered to the site as discussed and then final modifications may be made prior to inhabitants moving in. One such final step is the installation of 1" thick precast concrete walkways. These walkways will function as the main paths between the containers and provide a stable surface for the inhabitants to travel on. A total of 25 A/C split system units will be required to provide air conditioning and heating for all containers in a single community. At $609 each a grand total of $15,225 will be spent on the Carrier Performance Series units. Power then needs to be provided by installing power lines throughout the community and connect to each container. A cost of $8,120 for all the wiring for one disaster community will be necessary. The team has chosen a Volvo 450 kW diesel generator to provide the power to the community for a total cost of $105,000.

The team had assumed all private companies were providing the services such as labor and materials. However, the team had thought that during states of emergencies volunteers may arise to help with the labor or federal organizations such as the national defense may come to aide those in peril and help with the construction of the relief community. With the help volunteers or federal organizations costs can drastically be reduced by eliminating the cost of labor and perhaps even reducing or eliminating material costs for the site preparations.

5.4 Materials of Construction Cost Breakdown

The cost analysis was broken down into a four main components. These four components are factory modifications common items, factory modifications custom items, onsite modifications, and site modifications. This breakdown was created in the same format as the activity list was constructed as to eliminate any confusion and to not overlook any cost item for each activity. For these reasons the team also assigned an activity code to each material that corresponds to the associated activity. The cost breakdown also provides a good estimation of the total cost during each stage of the modifications to the containers.

The quantity given in the Material and Costs Table represents the total amount of material for one container, which are then multiplied by the total number of containers gives the total quantity necessary for the project. The unit cost is the cost of the material for one unit of the quantity of material. Therefore, in order to get the total cost the team multiplied the unit cost and the total quantity as seen in the Material and Cost Table.

The cost for each item was found from various sources and for each individual cost source please view the Material and Cost Table. The majority of the cost was provided from the 2010 RS Means data for Assembly, Facilities Repair and Remodeling. The costs given represent the cost for the material as well as the labor to install the item therefore giving the most accurate cost analysis possible. The reason for using the Facilities Repair and Remodeling is that the team viewed the construction as more of a remodeling than new construction. This approach was used because in new construction the workers have plenty of space to work with and can build any method they so choose. In the situation with modifying the containers the workers have limited space and have a pre set frame to work with and adjust in order to allow each container to function as designed. The total cost will be the summation of the common factory modifications, each specific container custom modifications, custom on site modifications, and site modification.

Note: Refer to Appendix B for all tables concerning materials and costs.

5.4.1 Living Container Cost

Each living container has a cost of $17,489 and altogether for each community the total cost would be approximately $629,621 for 36 total containers during common modifications, custom, and on site. This cost will provide enough housing for 216 persons in a state of emergency after a disaster has claimed the housing of the victims. This total cost for living containers includes the labor, material, and equipment necessary to install all of the items listed in the Materials and Costs Table in Appendix B. This cost can be factored to any number of communities desired to house more victims of the disaster. The living containers have the lowest cost per container, which was expected from the team as this container has the least furniture and fixtures.

5.4.2 Kitchen Container Cost

Each kitchen container has a base cost of $26,965 which provides a cost of $107,861 for four containers. These kitchen containers contain the vital equipment to provide the inhabitants with food. The cost of the kitchen units consist of all materials, labor, and equipment listed in the Materials and Costs Table in Appendix B. The kitchen units have the second largest cost due to the high cost of the equipment necessary such as stoves, ovens and refrigerators.

5.4.3 Dining Container Cost

Each dining Container has a cost of $22,925, as with the kitchen units there are a total of four containers which gives a total cost of $91,703. The dinning units provide the inhabitants a central location to gather and eat. The cost includes the material and labor to install all items listed in the Materials and Costs Table in Appendix B.

5.4.4 Water Closet Container Cost

The water closet designs provide a unisex unit such that each container will have the same cost of $66,914, with six bathrooms on site a total cost of $401,486 will occur for a single community. This cost entails all labor, material, and equipment to be installed in the bathroom units as well as all plumbing hook up. A complete list of the items incurred in the cost is provided in the Materials and Costs Table in Appendix B. The bathroom has the largest cost per container as it contains multiple showers and toilets that are all fairly costly as well as the numerous smaller fixtures.

5.4.5 Site Modifications

The total site modifications will cost $329,128. This cost includes clearing and grubbing, grading, gravel backfill, and installation of water and power, as well as others listed in the Materials and Costs Table in Appendix B. This cost is for one site preparation and to create multiple sites the cost can be factored to the number desired. The site preparation cost is subject to adjustments based on the actual site chosen. Items such as the clearing and grubbing necessary, the actual grading necessary, and others can reduce or increase the cost based on the amount of work needed to be done. The costs can also be reduced by any volunteer help and contributions.

5.5 Total Cost

Each community can be provided for a grand total cost of $1,587,657. With 64 containers and 216 people at each community this breaks down into a cost of $24,807 per container and $7,350 per person.

The estimate and schedule reveal that the container development proposed within this report could potentially be a viable option for major disasters on the magnitude of Hurricane Katrina and the 2010 earthquake in Haiti, in which people are displaced for long periods of time. To provide a cost comparison, an amendment filed by Senator Paul Sarbanes on September 8, 2005 and passed by unanimous consent by the Senate granted $3.5 billion in emergency assistance housing vouchers to 360,000 displaced households, at a cost of $9,722 per household (The Illinois, 2010). If the average household size is 2.58 people, the vouchers cost an average of approximately $3,770 per person; assuming a cumulative inflation rate of 9.00% from September 2005 to January of 2010, the cost per person increases to $4,110 (Inflation, 2010) (Table, 2010). To provide an additional comparison, the new D&D Hybrid Park mobile home model being considered for usage by FEMA may range from $45,000 to $75,000 and have an average capacity of only four people, which would equate to a per person cost of $11,250 to $18,750 (FEMA Rolls, 2010). In comparison, the total cost per person for the container housing development is $7,350 per person.

Government agencies should consider the implementation of emergency container housing as part of an overall disaster management plan, especially in high risk areas. Forward planning is essential to ensure that the container dwellings are provided in a cost effective and timely manner. This study was undertaken primarily as a general guide for the application of emergency container housing; further analyses should be performed to assess the benefits of emergency container housing and weigh all options available in the particular area of interest.

Chapter 6: Scheduling

6.1 Introduction

This chapter explains the schedule provided by the team and contains all assumptions and clarifications used in its development. If a container housing project were implemented the schedule would vary according to the severity of the disaster, the location, and the competency of those managing the undertaking. The schedule provided herein should be used as a general guide to the time requirements necessary for the establishment of one 1.13 acre container development (consisting of forty 40' containers and ten 20' containers). The total duration of each activity was found by dividing the total quantity of the specific item by the daily output of a specified number of crews. The majority of activity durations were taken from RS Means 2010 Unit Cost Assembly and Modifications Data; all crew abbreviations refer to those contained within RS Means. All activity durations are included in Appendix C and a complete compilation of all schedules is included in Appendix D.

6.2 Factory Modifications

Before factory modifications take place, the containers must be purchased, loaded on trucks, and shipped to a storage yard; the duration of this activity is dependent both on the location of the container distributor and the location of the factory. During the factory modification stage, the team assumed that the containers would be prepared in an assembly line type operation, similar to that of a modular housing factory. Also, each type of container was considered separately in terms of the durations of factory modifications, and the scheduled durations represent the time requirements of modifying all such containers contained within one 1.13 acre development. For example, in considering the living units, the scheduled durations represent the modifications of 36 living containers.

In considering the factory fit out schedule, no critical path was determined due to the assembly line fashion of the modifications. The team assumed that each activity could proceed for at least one day until the next sequential activity could begin; for example, if insulation installation had been taking place for one day, enough containers would be completed to begin the installation of the horizontal furring strips. When considering how many crews to assign to each task, the team decided that each activity should be limited to no more than thirty days; this determination was made after examining the overall effects of the activity durations on the overall schedule. Figure 28 shows the activities and durations associated with modifying the living area containers. To complete modifications on the 36 living containers necessary for one community it will take 43 days.

	Task Name	Duration	Start	Finish	Predecessors
1	40 FT Container	0 days	Wed 2/24/10	Wed 2/24/10	
2	3'x5'6" Window Cut Out, torch cutting	13.6 days	Wed 2/24/10	Mon 3/15/10	1
3	3'x6'8" Door Cutout, torch cutting	5.8 days	Wed 2/24/10	Wed 3/3/10	1
4	Painting Container Exterior	27.7 days	Thu 2/25/10	Mon 4/5/10	2SS+1 day,3SS+
5	Roofing Insulation	23 days	Wed 2/24/10	Fri 3/26/10	1
6	Exterior Wall Insulation	27.7 days	Wed 2/24/10	Fri 4/2/10	1
7	Floor Insulation	23 days	Thu 2/25/10	Mon 3/29/10	5SS+1 day,6SS+
8	Furring Strip Installation	25 days	Fri 2/26/10	Thu 4/1/10	6SS+1 day,7SS+
9	Electrical Rough-In, 3-phase 120 volt	18 days	Mon 3/1/10	Wed 3/24/10	8SS+1 day,6SS+
10	5/8" Gypsum Ceiling, fire resistant	15 days	Tue 3/2/10	Mon 3/22/10	5SS+1 day,9SS+
11	5/8" Gypsum Wallboard, fire resistant	13.8 days	Tue 3/2/10	Fri 3/19/10	6SS+1 day,9SS+
12	Vinyl Composition Tile Flooring	16 days	Tue 3/2/10	Tue 3/23/10	7SS+1 day,9SS+
13	Wall/Ceiling Painting, primer & 2 coats	28.8 days	Wed 3/3/10	Mon 4/12/10	10SS+1 day,11S
14	200 Series Tilt Wash Double Hung Window	25.3 days	Thu 3/4/10	Thu 4/8/10	2SS+1 day,13SS
15	3'x6'8" Storm Door Aluminum Anodized	5.4 days	Thu 3/4/10	Thu 3/11/10	3SS+1 day,13SS
16	Finish Common Item Fitout	0 days	Mon 4/12/10	Mon 4/12/10	15,13,14
17	5/8" Drywall Partition with Wood Stud Fran	14.4 days	Mon 4/12/10	Mon 5/3/10	16
18	Twin Size Bed and Bedframe	18 days	Tue 4/13/10	Fri 5/7/10	17SS+1 day
19	34.5'h x 60"w x 32.5"d Loveseat	12 days	Wed 4/14/10	Fri 4/30/10	18SS+1 day
20	3'w x 1.5'd x 4'h Dresser	12 days	Thu 4/15/10	Mon 5/3/10	19SS+1 day
21	Finish Custom Item Fitout	0 days	Fri 5/7/10	Fri 5/7/10	18,19,20

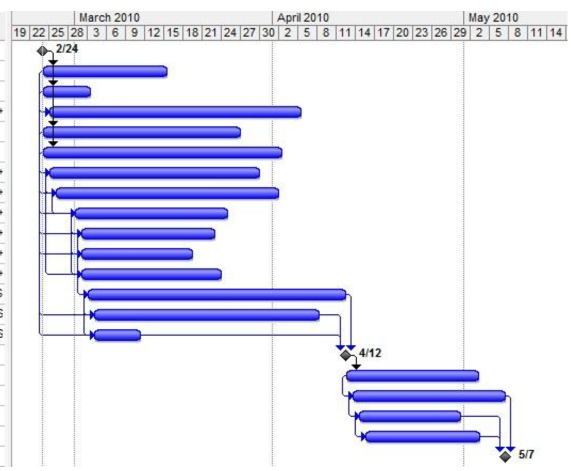

Figure 28: Living Area Schedule

Figure 29 shows the activities and durations associated with modifying the dining area containers. To complete modifications on the four dining containers necessary for one community it will take 22 days.

	Task Name	Duration	Start	Finish	Predecessors
1	40 FT Container	0 days	Wed 2/24/10	Wed 2/24/10	
2	3'x5'6" Window Cut Out, torch cutting	2.6 days	Wed 2/24/10	Fri 2/26/10	1
3	3'x6'8" Door Cutout, torch cutting	0.2 days	Wed 2/24/10	Wed 2/24/10	1
4	Painting Container Exterior	3.1 days	Thu 2/25/10	Tue 3/2/10	2SS+1 day,3SS+
5	Roofing Insulation	2.6 days	Wed 2/24/10	Fri 2/26/10	1
6	Exterior Wall Insulation	2.7 days	Wed 2/24/10	Fri 2/26/10	1
7	Floor Insulation	2.6 days	Thu 2/25/10	Mon 3/1/10	5SS+1 day,6SS+
8	Furring Strip Installation	5.6 days	Fri 2/26/10	Fri 3/5/10	6SS+1 day,7SS+
9	Electrical Rough-In, 3-phase 120 volt	2 days	Mon 3/1/10	Tue 3/2/10	8SS+1 day,6SS+
10	5/8" Gypsum Ceiling, fire resistant	1.7 days	Tue 3/2/10	Wed 3/3/10	5SS+1 day,9SS+
11	5/8" Gypsum Wallboard, fire resistant	2 days	Tue 3/2/10	Wed 3/3/10	6SS+1 day,9SS+
12	Vinyl Composition Tile Flooring	3.6 days	Tue 3/2/10	Fri 3/5/10	7SS+1 day,9SS+
13	Wall/Ceiling Painting, primer & 2 coats	6.4 days	Wed 3/3/10	Thu 3/11/10	10SS+1 day,11S
14	200 Series Tilt Wash Double Hung Window	5.6 days	Thu 3/4/10	Thu 3/11/10	2SS+1 day,13SS
15	3'x6'8" Storm Door Aluminum Anodized	0.2 days	Thu 3/4/10	Thu 3/4/10	3SS+1 day,13SS
16	Finish Common Item Fitout	0 days	Thu 3/11/10	Thu 3/11/10	15,13,14
17	1.4' x 5' bench seat	1.4 days	Thu 3/11/10	Fri 3/12/10	16
18	2.5' x 5' table	2.8 days	Mon 3/15/10	Wed 3/17/10	17
19	Finish Custom Item Fitout	0 days	Wed 3/17/10	Wed 3/17/10	17,18

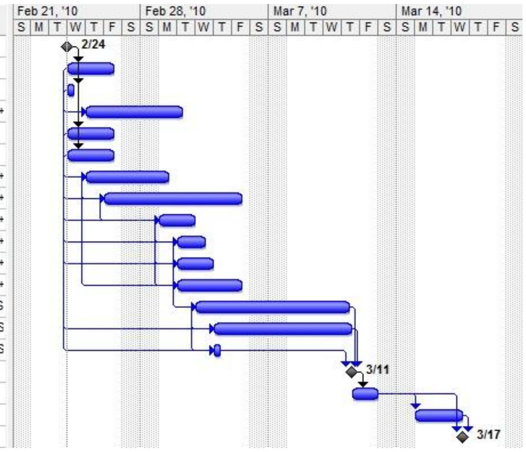

Figure 29: Dining Area Schedule

Figure 30 shows the activities and durations associated with modifying the kitchen area containers. To complete modifications on the four dining containers necessary for one community it will take 27 days.

	Task Name	Duration	Start	Finish	Predecessors
1	20 FT Container	0 days	Wed 2/24/10	Wed 2/24/10	
2	3'x5'6" Window Cut Out, torch cutting	1.3 days	Wed 2/24/10	Thu 2/25/10	1
3	3'x6'8" Door Cutout, torch cutting	0.2 days	Wed 2/24/10	Wed 2/24/10	1
4	Painting Container Exterior	3.1 days	Thu 2/25/10	Tue 3/2/10	2SS+1 day,3SS+
5	Roofing Insulation	1.3 days	Wed 2/24/10	Thu 2/25/10	1
6	Exterior Wall Insulation	5.4 days	Wed 2/24/10	Wed 3/3/10	1
7	Floor Insulation	1.3 days	Thu 2/25/10	Fri 2/26/10	5SS+1 day,6SS+
8	Furring Strip Installation	3.3 days	Fri 2/26/10	Wed 3/3/10	6SS+1 day,7SS+
9	Electrical Rough-In, 3-phase 120 volt	2 days	Mon 3/1/10	Tue 3/2/10	8SS+1 day,6SS+
10	Plumbing Rough-In	2 days	Fri 2/26/10	Mon 3/1/10	6SS+1 day,7SS+
11	5/8" Gypsum Ceiling, fire resistant	0.8 days	Tue 3/2/10	Tue 3/2/10	5SS+1 day,9SS+
12	5/8" Gypsum Wallboard, fire resistant	0.9 days	Tue 3/2/10	Tue 3/2/10	6SS+1 day,9SS+
13	Vinyl Composition Tile Flooring	1.8 days	Tue 3/2/10	Wed 3/3/10	7SS+1 day,9SS+
14	Wall/Ceiling Painting, primer & 2 coats	3.6 days	Wed 3/3/10	Mon 3/8/10	11SS+1 day,12S
15	200 Series Tilt Wash Double Hung Window	5.6 days	Thu 3/4/10	Thu 3/11/10	2SS+1 day,14SS
16	3'x6'8" Storm Door Aluminum Anodized	0.2 days	Thu 3/4/10	Thu 3/4/10	3SS+1 day,14SS
17	Finish Common Item Fitout	0 days	Thu 3/11/10	Thu 3/11/10	16,14,15
18	Standard Wood Cabinets 24" Wide	0.7 days	Thu 3/11/10	Fri 3/12/10	17
19	Laminated Plastic Countertops	1.6 days	Fri 3/12/10	Tue 3/16/10	18SS+1 day
20	20 7/8" x 18" Sinks	2.2 days	Fri 3/12/10	Tue 3/16/10	18SS+1 day
21	30" Freestanding Range, 4.4 CF oven	2 days	Mon 3/15/10	Wed 3/17/10	20SS+1 day
22	22.4 CF Refrigerator	4 days	Tue 3/16/10	Mon 3/22/10	21SS+1 day
23	Finish Custom Item Fitout	0 days	Mon 3/22/10	Mon 3/22/10	22

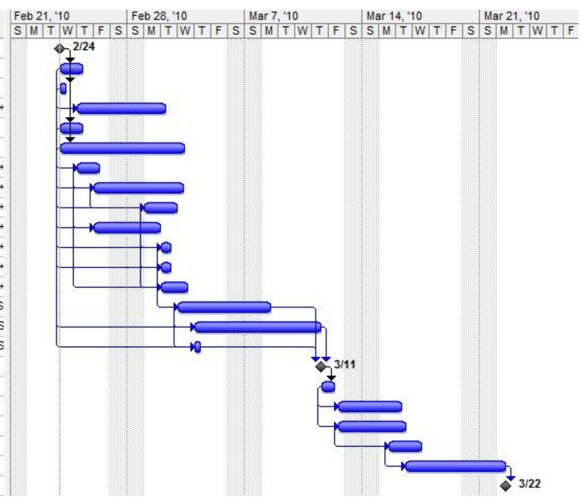

Figure 30: Kitchen Area Schedule

Figure 31 shows the activities and durations associated with modifying the water closet area containers. To complete modifications on the six sets (12 containers) of water closet containers necessary for one community it will take 36 days.

	Task Name	Duration	Start	Finish	Predecessors
1	20 FT Container	0 days	Wed 2/24/10	Wed 2/24/10	
2	2'x3' Window Cutouts, torch cutting	1.7 days	Wed 2/24/10	Thu 2/25/10	1
3	3'x6'8" Door Cutout, torch cutting	0.6 days	Wed 2/24/10	Wed 2/24/10	1
4	Painting Container Exterior	9.3 days	Thu 2/25/10	Wed 3/10/10	2SS+1 day,3SS+
5	Insulation	11.7 days	Wed 2/24/10	Thu 3/11/10	1
6	Furring Strip Installation	3.3 days	Thu 2/25/10	Tue 3/2/10	5SS+1 day
7	Electrical Rough-In, 3-phase 120 volt	2 days	Fri 2/26/10	Mon 3/1/10	6SS+1 day,5SS+
8	Plumbing Rough-In	2 days	Thu 2/25/10	Fri 2/26/10	5SS+1 day
9	5/8" Gypsum Ceiling, fire resistant	2.5 days	Mon 3/1/10	Wed 3/3/10	5SS+1 day,7SS+
10	5/8" Gypsum Wallboard, fire resistant	2.6 days	Mon 3/1/10	Wed 3/3/10	7SS+1 day,5SS+
11	Vinyl Composition Tile Flooring	5.3 days	Mon 3/1/10	Mon 3/8/10	7SS+1 day,5SS+
12	Wall/Ceiling Painting, primer & 2 coats	10.6 days	Tue 3/2/10	Tue 3/16/10	9SS+1 day,10SS
13	Windows, aluminum, single hung, standard	10.5 days	Wed 3/3/10	Wed 3/17/10	2SS+1 day,12SS
14	3'x6'8" Storm Door Aluminum Anodized	0.6 days	Wed 3/3/10	Wed 3/3/10	3SS+1 day,12SS
15	Finish Common Item Fitout	0 days	Wed 3/17/10	Wed 3/17/10	14,12,13
16	Water closet, vitreous china, elongated	6.8 days	Wed 3/17/10	Fri 3/26/10	15
17	36"x24" Shower Stalls	4.6 days	Wed 3/17/10	Wed 3/24/10	15
18	3 Toilet Stall Partitions, Solid Polymer	1.7 days	Fri 3/26/10	Mon 3/29/10	16
19	2 Shower Stall Partitions	1.7 days	Wed 3/24/10	Thu 3/25/10	17
20	20 7/8" x 18" Sinks	3.4 days	Wed 3/17/10	Mon 3/22/10	15
21	Shower Stall Bench (18" H, 9.5" W)	1.2 days	Thu 3/25/10	Fri 3/26/10	19
22	36" Shower Rods	1.9 days	Thu 3/25/10	Mon 3/29/10	19
23	36"x 72" Vinyl Shower Curtains	1.9 days	Mon 3/29/10	Wed 3/31/10	22
24	Towel Rack with Shelf	1.3 days	Mon 3/29/10	Tue 3/30/10	21
25	Mirrors (32"x22")	1.6 days	Mon 3/22/10	Wed 3/24/10	20
26	Soap Dispenser	2.4 days	Wed 3/17/10	Fri 3/19/10	15
27	Toilet Partition Grab Bars (54" Long)	1.8 days	Tue 3/30/10	Wed 3/31/10	18
28	Paper Towel Dispenser	3 days	Tue 3/30/10	Thu 4/1/10	18
29	Toilet Paper and Seat Cover Dispenser wit	1.8 days	Tue 3/30/10	Wed 3/31/10	18
30	Finish Custom Item Fitout	0 days	Thu 4/1/10	Thu 4/1/10	27,28,29

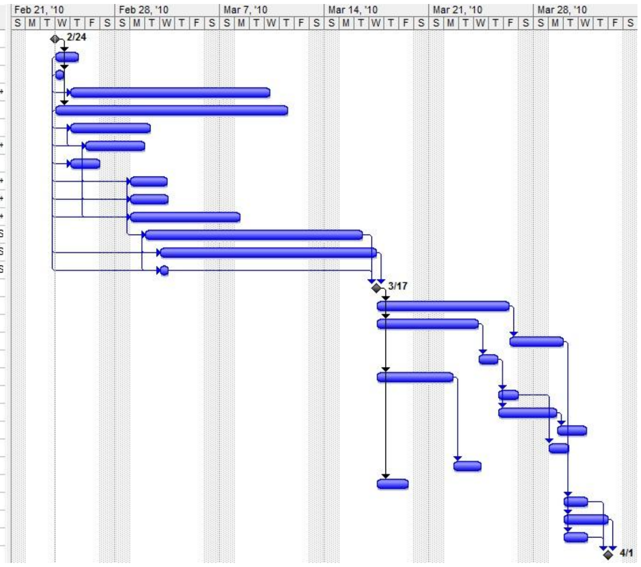

Figure 31: Water Closet Schedule

6.3 On Site Modifications

After common and custom factory modifications are completed, the containers must be shipped to a storage area from the factory; this duration will depend on the specific location of the storage facility and the location of the factory. The containers will remain at such a storage area until needed for an emergency, at which point the units then must be again loaded onto trucks and shipped to the particular disaster location.

Upon arrival to the site, the containers must be placed on the precast concrete foundation posts with the aid of a crane. Since no data was available on the time necessary to place containers, the team estimated that a crane could place an average of eight containers per day. The ensuing site modification activities were scheduled according to the total time durations for all containers on the site, unlike the factory modifications scheduling which was separated by container type. Container types were irrelevant for the scheduling of the site modification activities because all such activities are common for all types of containers. Figure 32 shows the schedule for the on-site modifications.

	Task Name	Duration	Start	Finish	Predecessors
1	Site Preparation Initial Container Placement	0 days	Wed 2/24/10	Wed 2/24/10	
2	Precast Concrete Foundation Posts	0.8 days	Wed 2/24/10	Wed 2/24/10	1
3	Place Containers on Site	2 days	Wed 2/24/10	Thu 2/25/10	2SS
4	Plumbing Hook Up	0.6 days	Thu 2/25/10	Thu 2/25/10	3SS+1.4 days
5	Electical Hook Up	1 day	Thu 2/25/10	Thu 2/25/10	3SS+1 day
6	Electric water heater, residential, 100< F ri	1.1 days	Thu 2/25/10	Fri 2/26/10	4SS,5SS
7	Sloped Aluminum Roof Panels	1.4 days	Wed 2/24/10	Thu 2/25/10	3SS+0.6 days
8	Vinyl Gutters	1.5 days	Wed 2/24/10	Fri 2/26/10	7SS
9	Aluminum Downspout	0.9 days	Wed 2/24/10	Thu 2/25/10	8SS
10	Precast Entry Stairs	1 day	Thu 2/25/10	Thu 2/25/10	3SS+1 day
11	Move-In Ready	0 days	Fri 2/26/10	Fri 2/26/10	2,3,4,5,6,7,8,9

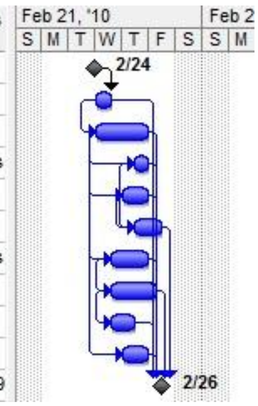

Figure 32: On Site Modifications Schedule

6.4 Site Work

The site work activities were scheduled according to the total duration necessary to complete such work on one 1.13 acre site. Since the characteristics of the site could vary according to its specific location, the activity durations are likely to vary widely. However, if the site is chosen in accordance with the guidelines provided within this report, the site work schedule should provide a basic guideline as to approximately how much time is required for site preparation. In the context of the entire project, the site work should begin as soon as possible following the displacement of people by disaster; work may proceed while the containers are being shipped from the storage facility to the site. Figure 33 shows the schedule for the site work.

	Task Name	Duration	Start	Finish	Predecessors
1	Select Site	0 days	Wed 2/24/10	Wed 2/24/10	
2	Clearing and Grubbing, Cut and Chip Light Trees	0.3 days	Wed 2/24/10	Wed 2/24/10	1
3	Site Grading	1.5 days	Wed 2/24/10	Thu 2/25/10	2
4	Water Line (Pipe plastic, PVC, DWV, pressure p	0.8 days	Wed 2/24/10	Thu 2/25/10	3SS
5	Waste Line (Pipe plastic, PVC, DWV, schedule 4	0.8 days	Wed 2/24/10	Thu 2/25/10	3SS
6	Install Generator	1.4 days	Wed 2/24/10	Thu 2/25/10	3SS
7	Medium-voltage, single cable, copper	1 day	Wed 2/24/10	Thu 2/25/10	3SS
8	Install Water Tank	2 days	Wed 2/24/10	Fri 2/26/10	3SS
9	4" Gravel Base	0.4 days	Wed 2/24/10	Wed 2/24/10	3SS+0.25 days
10	Paved Delivery Area	0.8 days	Wed 2/24/10	Thu 2/25/10	9
11	1" Thick Precast Concrete Walkway	1.4 days	Wed 2/24/10	Fri 2/26/10	9
12	6" Drainage Channel	1 day	Wed 2/24/10	Thu 2/25/10	9
13	Carrier Performance Series 12,000 Btu/hr capa	1.5 days	Wed 2/24/10	Fri 2/26/10	9
14	Finish Site Preparations	0 days	Fri 2/26/10	Fri 2/26/10	11,13

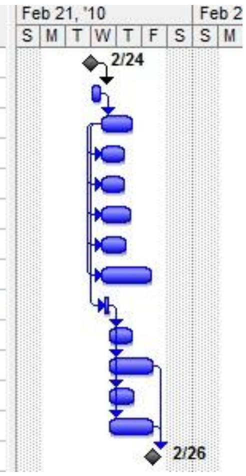

Figure 33: Site Work Schedule

6.5 Conclusion

This report suggests that all factory modifications, which are the most time consuming, be conducted prior to the occurrence of a disastrous event and that the site work begin as soon as possible. The site preparation and on site fitout duration of three days would necessitate that the containers are shipped immediately after the site has been chosen. In a best case scenario, the container development would be ready within three days of beginning the site preparation. However, as previously mentioned differing site conditions and locations may affect the time necessary for site preparation.

Chapter 7: Conclusion

This report was compiled to consider the potential usage of shipping containers as a means for providing emergency shelter to displaced victims. To accomplish this goal, feasible designs were developed for living, dining, kitchen, and water closet units; building systems were carefully evaluated in consideration of both cost and functionality. In addition to considering the individual units, a feasible site design encompassing 1.13 acres was developed with a theoretical capacity of 216 people. This design could be replicated many times depending on the total displaced population.

In addition the creation of applicable designs, the study considered location, logistics, cost, and project duration in an effort to evaluate the overall feasibility of the project. The total cost of the 1.13 acre site equipped with all containers and site work was found to be $1.59 million. On the other hand, project schedule revealed that if all possible factory modifications were finished prior to the onset of a disaster, a container development could be prepared within approximately three days.

To accomplish the goals of the project, a project team consisting of three Worcester Polytechnic Institute civil engineering students was assembled and worked for approximately six months under the supervision of Professor Roberto Pietroforte, also of the WPI civil engineering department. Overall, the group members worked well together and were productive throughout the duration of the project. The responsibilities were divided equally among group members, with help given when necessary on certain aspects of the project. The team met regularly to facilitate the progress of the project.

However, the reader should note that this report has several limitations due to both the time constraints of the project and the expertise of the individual group members. To begin with, although basic HVAC, plumbing, and electrical system components were selected, detailed consideration of the installation of such systems was outside the scope of this study. Another limitation of the study was the absence of a detailed drainage analysis, which may affect the sizing of the drainage channel located at the edge of the walking path and the design of any possible offsite water runoff remediation methods. A third limitation of the study was the absence of accurate cost estimate data on items which were designed specifically for the project at hand, such as the precast concrete panels used in the walkway and the sloped roofing panels. Any further continuation of this study should consider the aforementioned limitations.

Overall, the study proved to be worthwhile and engaging. Although the usage of shipping containers for low income and sustainable housing design and has been explored across the globe, the potential application of containers to emergency housing has not been thoroughly considered. The methods for disaster relief explored in this report remain relatively unorthodox, and this report certainly presents a unique perspective on the issue. The study was particularly interesting because of its relevance to many disciplines including civil engineering, construction management, and architecture.

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Appendix A: Architectural Review

Name: Cubes

Architect: USM LTD

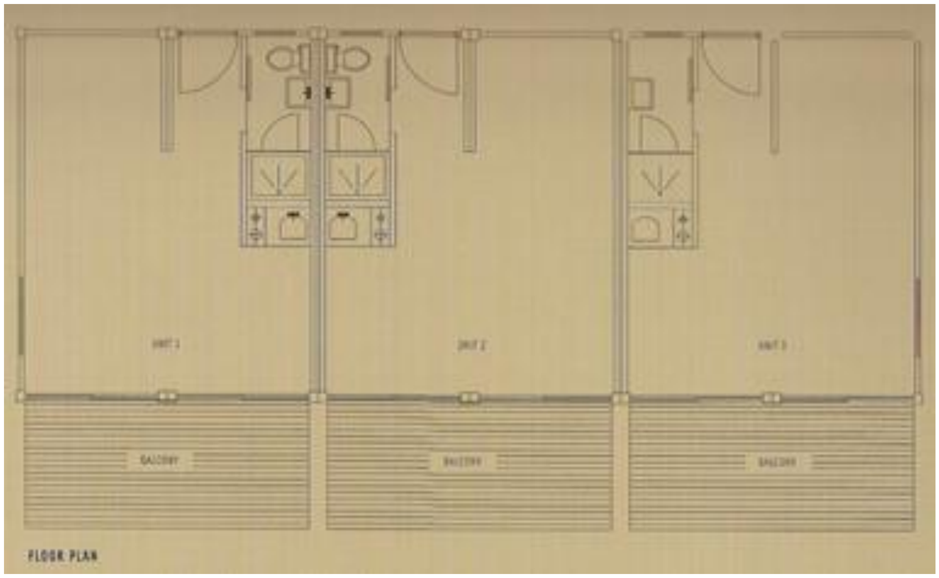
Location: Peaton Hill, Scotland

Year: 2002

Description:

This project layout is composed of six 20' ISO containers and is used as a residence for artists. The containers are laid out side by side and form a total of three separate living spaces. Each dwelling unit is composed of a kitchen, sitting area, shower room, and bedroom. The bedroom in two of the units is big enough to accommodate two beds; the other unit only accommodates one bed but is handicap accessible.

The interior finishes are very contemporary; the architect chose to use sliding glass doors and round windows, as well as a white interior to maximize the amount of light entry. The container structure also has a deck which extends across the front façade. The architects wisely utilized the standard container doors as a means for privacy. This project is unique in the aspect that the containers were not stacked and three separate living units were installed side by side. This project exemplifies cost efficiency and ease of construction (Kotnik, 2008).



Floor Plan (Kotnik, 2008)

Exterior/Interior View 1 (Container City, 2009)

Exterior/Interior View 2 (Container City, 2009)

Name: Zigloo

Architect: Keith Dewey

Location: Victoria, BC, Canada

Year: 2006

Description:

This project is a single family home composed of eight 20' containers. The exterior, like many other container projects, showcases the natural exterior of the ISO building blocks, but the interior was designed to look like a traditional home. The inside walls are insulated by two inches of spray foam, and the floor is heated. The home is complete with three bedrooms, two bathrooms, five balconies, a functional basement area, a storage area, and a main floor including a kitchen, dining room, and living room. The basement area includes a laundry room, bathroom, and recreation room. Drywall was utilized to give the container home traditional characteristics. Also, the master bedroom features an arc steel roof which is an impressive 9.5 feet high. Although this project is designed for luxury rather than cost efficiency, many of the basic interior and exterior features of the project may be applicable to emergency container housing.

Exterior View (Container City, 2009)

Interior View (Ground Floor and Master Bedroom) (Container City, 2009)

Name: Chalet Du Chamin Brochu

Architect: Pierre Morency Architecture

Location: Beaulac-Garthby, Quebec, Canada

Year: 2006

Description:

This project is a single family home consisting of three 40’ shipping containers. The containers sit on a functional concrete basement which houses a guest room and service room. The two containers composing the ground floor are connected by a central wooden area; the ground floor houses the kitchen, living room, and dining room. The first floor container is situated diagonally on the bottom two containers; the top floor houses the master bedroom, secondary bedroom, and bathroom. The master bedroom is a wooden extension to the metal container, and is supported by wooden posts. The exterior of the container is covered with wood paneling to enhance the aesthetic qualities of the structure, and the interior also employs wood paneling and is modeled after a traditional home.

This project employs a good use of blending common carpentry construction with container housing. The exterior paneling, although simple, masks the steely look of the containers and could be an aid to overcoming stereotypes if a project were implemented in the United States. Also, unlike the aforementioned projects, the Chalet Du Chemin Brochu uses the 40’ containers instead of the 20’ containers.

Exterior Views (La, 2009)

Interior Views (La, 2009)

Name: Port-a-Bach

Architect: Atelier Workshop

Location: New Zealand

Year: 2007

Description:

This project takes the form of a New Zealand “bach”, a small beach or vacation home common in the country. The “Port-a-Bach” is composed of only one 20’ ISO container, but may house as many as four people. The mobile unit is prefabricated, mobile, and fitted with solar panels, making it an ideal model for an emergency housing situation. The bach utilizes the orginal container opening on one side, but also features a retractable wall on one of the 20’ long ends which opens to a glass façade and provides an outdoor sitting area. Although the Bach is modern in design and includes an enclosable outdoor space, its open air design makes it less suitable for cold regions of the United States (Kotnik, 2008).

Exterior Views (Atelierworkshop, 2009)

Interior Views (Atelierworkshop, 2009)

Name: 2+ Weekend House

Architect: Jure Kotnik

Location: Slovenia

Year: 2008

The 2+ Weekend House incorporates two 20’ ISO containers into a simple design. The two level unit was inspired by rising land prices and features the two containers stacked perpendicularly, reducing the footprint of the structure. The top container also provides shelter for the entrance and the back terrace. The 2+ Weekend House demonstrates a simple two story structure which could easily be erected in an emergency situation. The customizable nature of the structure allows for more container additions if necessary (Jure, 2009).

First and Second Floor Plans (Jure, 2009)

Exterior and Interior Views (Jure, 2009)

Appendix B: Materials and Costs Tables

Living Container Materials and Costs

Factory Fitout (Common Items)						
Activity Code	Items	Quantity	Units	Total Quantity	Unit Cost	Total Cost
	Used 40' Container	1.0	EA	36.0	$ 1,300.00	$ 46,800
A02	Painting Container Exterior	1.0	EA	36.0	$ 550.00	$ 19,800
A01	3'x5'6" Window Cut Out, torch cutting	136.0	LF	4,896.0	$ 0.97	$ 4,749
A10	200 Series Tilt Wash Double Hung Windows	8.0	EA	288.0	$ 278.00	$ 80,064
A01	3'x6'8" Door Cutout, torch cutting	58.0	LF	2,088.0	$ 0.97	$ 2,025
A11	3'x6'8" Storm Door Aluminum Anodized	3.0	EA	108.0	$ 249.00	$ 26,892
A07	5/8" Gypsum Ceiling, fire resistant	320.0	SF	11,520.0	$ 0.85	$ 9,792
A07	5/8" Gypsum Wallboard, fire resistant	768.0	SF	27,648.0	$ 0.85	$ 23,501
A08	Vinyl Composition Tile Flooring	320.0	SF	11,520.0	$ 1.99	$ 22,925
A03	Roofing Insulation	640.0	SF	23,040.0	$ 0.30	$ 6,910
A03	Floor Insulation	640.0	SF	23,040.0	$ 0.30	$ 6,910
A03	Exterior Wall Insulation	2304.0	SF	82,944.0	$ 0.30	$ 24,877
A09	Wall/Ceiling Painting, primer & 2 coats	1088.0	SF	39,168.0	$ 0.79	$ 30,943
A05	Electrical Rough-In, 3-phase 120 volt	1.0	EA	36.0	$ 1,925.00	$ 69,300
A04	1-5/8" Galvanized Furring Strips, 24" O.C., with Sound Isolation Clips	768.0	SF	27,648	$ 4.76	$ 131,604
					Common Items Total =	$507,093.26

Factory Fitout (Custom Items)						
Activity Code	**Items**	**Quantity**	**Units**	**Total Quantity**	**Unit Cost**	**Total Cost**
B02	Twin Size Bed and Bedframe	6.0	EA	216.0	$ 117.00	$ 25,272
B03	34.5'h x 60"w x 32.5"d Loveseat	3.0	EA	108.0	$ 299.00	$ 32,292
B04	3'w x 1.5'd x 4'h Dresser	3.0	EA	108.0	$ 179.00	$ 19,332
B01	5/8" Drywall Partition with Wood Stud Framing	2.0	EA	72.0	$ 4.31	$ 310
				Custom Items Total =		$ 77,206.32

On Site Fitout						
Activity Code	**Items**	**Quantity**	**Units**	**Total Quantity**	**Unit Cost**	**Total Cost**
F03	Electrical Hook Up	1.0	EA	36.0	$ 120.00	$ 4,320.00
F01	Precast Concrete Foundation Posts	4.0	EA	144.0	$ 50.00	$ 7,200.00
F05	Sloped Aluminum Roof Panels	1.0	EA	36.0	$ 660.00	$ 23,760.00
F07	Aluminum Downspout	11.7	LF	421.2	$ 3.67	$ 1,545.80
F06	Vinyl Gutters	40.0	LF	1,440.0	$ 5.15	$ 7,416.00
F08	Precast Entry Stairs	3.0	EA	108.0	$ 50.00	$ 5,400.00
				On Site Fitout Total =		$ 49,641.80
				All Activities Total =		**$633,941.39**
				Cost per container =		**$ 17,609.48**

Dining Area Materials and Costs

Factory Fitout (Common Items)						
Activity Code	Items	Quantity	Units	Total Quantity	Unit Cost	Total Cost
	Used 40' Container	1.0	EA	4.0	$ 1,300.00	$ 5,200.00
A02	Painting Container Exterior	1.0	EA	4.0	$ 550.00	$ 2,200.00
A01	3'x5'6" Window Cut Out, torch cutting	238.0	LF	952.0	$ 0.97	$ 923.44
A10	200 Series Tilt Wash Double HungWindows	8.0	EA	32.0	$ 278.00	$ 8,896
A01	3'x6'8" Door Cutout, torch cutting	19.3	LF	77.3	$ 0.97	$ 75.00
A11	3'x6'8" Storm Door Aluminum Anodized	1.0	EA	4.0	$ 249.00	$ 996.00
A07	5/8" Gypsum Ceiling, fire resistant	320.0	SF	1,280.0	$ 0.85	$ 1,088.00
A07	5/8" Gypsum Wallboard, fire resistant	976.0	SF	3,904.0	$ 0.85	$ 3,318.40
A08	Vinyl Composition Tile Flooring	320.0	SF	1,280.0	$ 1.99	$ 2,547.20
A03	Roofing Insulation	640.0	SF	2,560.0	$ 0.30	$ 768.00
A03	Floor Insulation	640.0	SF	2,560.0	$ 0.30	$ 768.00
A03	Exterior wall Insulation	672.0	SF	2,688.0	$ 0.30	$ 806.40
A09	Wall/Ceiling Painting, primer & 2 coats	1088.0	SF	4,352.0	$ 0.79	$ 3,438.08
A05	Electrical Rough-In, 3-phase 120 volt	1.0	EA	4.0	$ 1,925.00	$ 7,700.00
A04	1-5/8" Galvanized Furring Strips, 24" O.C., with Sound Isolation Clips	768.0	SF	3,072	$ 4.76	$ 14,623
					Common Items Total =	$ 53,347.24

Factory Fitout (Custom Items)						
Activity Code	**Items**	**Quantity**	**Units**	**Total Quantity**	**Unit Cost**	**Total Cost**
C02	2.5' x 5' table	7.0	Each	28.0	$ 220.00	$ 6,160.00
C01	1.4' x 5' bench seat	14.0	Each	56.0	$ 485.00	$ 27,160.00
				Custom Items Total =		$ 33,320.00

On Site Fitout						
Activity Code	**Items**	**Quantity**	**Units**	**Total Quantity**	**Unit Cost**	**Total Cost**
F03	Electrical Hook Up	1.0	EA	4.0	$ 120.00	$ 480.00
F01	Precast Concrete Foundation Posts	4.0	EA	16.0	$ 50.00	$ 800.00
F05	Sloped Aluminum Roof Panels	1.0	EA	4.0	$ 660.00	$ 2,640.00
F07	Aluminum Downspout	11.7	LF	46.8	$ 3.67	$ 171.76
F06	Vinyl Gutters	40.0	LF	160.0	$ 5.15	$ 824.00
F08	Precast Entry Stairs	3.0	EA	12.0	$ 50.00	$ 600.00
				On Site Fitout Total =		$ 5,515.76
				All Activities Total =		**$ 92,183.00**
				Cost per container =		**$ 23,045.75**

Kitchen Area Materials and Costs

Factory Fitout (Common Items)						
Activity Code	Items	Quantity	Units	Total Quantity	Unit Cost	Total Cost
	Used 20' Container	1.0	EA	4.0	$ 1,300.00	$ 5,200.00
A02	Painting Container Exterior	1.0	EA	4.0	$ 450.00	$ 1,800.00
A01	3'x5'6" Window Cut Out, torch cutting	119.0	LF	476.0	$ 0.97	$ 461.72
A10	200 Series Tilt Wash Double HungWindows	8.0	EA	32.0	$ 278.00	$ 8,896
A01	3'x6'8" Door Cutout, torch cutting	19.3	LF	77.3	$ 0.97	$ 75.00
A11	3'x6'8" Storm Door Aluminum Anodized	1.0	EA	4.0	$ 249.00	$ 996.00
A07	5/8" Gypsum Ceiling, fire resistant	160.0	SF	640.0	$ 0.85	$ 544.00
A07	5/8" Gypsum Wallboard, fire resistant	448.0	SF	1,792.0	$ 0.85	$ 1,523.20
A08	Vinyl Composition Tile Flooring	160.0	SF	640.0	$ 1.99	$ 1,273.60
A03	Roofing Insulation	320.0	SF	1,280.0	$ 0.30	$ 384.00
A03	Floor Insulation	320.0	SF	1,280.0	$ 0.30	$ 384.00
A03	Exterior wall Insulation	1344.0	SF	5,376.0	$ 0.30	$ 1,612.80
A07	Wall/Ceiling Painting, primer & 2 coats	608.0	SF	2,432.0	$ 0.79	$ 1,921.28
A05	Electrical Rough-In, 3-phase 120 volt	1.0	EA	4.0	$ 1,925.00	$ 7,700.00
A06	Plumbing Rough In	1.0	EA	4.0	$ 8,775.00	$ 35,100.00
A04	1-5/8" Galvanized Furring Strips, 24" O.C., with Sound Isolation Clips	448.0	SF	1,792	$ 4.76	$ 8,530
					Common Items Total =	$ 76,401.52

Factory Fitout (Custom Items)

Activity Code	Items	Quantity	Units	Total Quantity	Unit Cost	Total Cost
D03	20 7/8" x 18" Sinks	3.0	EA	12.0	$ 82.00	$ 984.00
D05	22.4 CF Refrigerator	4.0	EA	16.0	$ 900.00	$ 14,400.00
D04	30" Freestanding Range, 4.4 CF oven	2.0	EA	8.0	$ 600.00	$ 4,800.00
D01	Standard Wood Cabinets 24" Wide	4.0	EA	16.0	$ 394.00	$ 6,304.00
D02	Laminated Plastic Countertops	2.0	EA	8.0	$ 43.50	$ 348.00
				Custom Items Total =		$ 26,836.00

On Site Fitout

Activity Code	Items	Quantity	Units	Total Quantity	Unit Cost	Total Cost
F02	Plumbing Hook Up	1.0	EA	4.0	$ 160.00	$ 640.00
F03	Electrical Hook Up	1.0	EA	4.0	$ 120.00	$ 480.00
F01	Precast Concrete Foundation Posts	4.0	EA	16.0	$ 50.00	$ 800.00
F05	Sloped Aluminum Roof Panels	1.0	EA	4.0	$ 660.00	$ 2,640.00
F07	Aluminum Downspout	11.7	LF	46.8	$ 3.67	$ 171.76
F06	Vinyl Gutters	20.0	LF	80.0	$ 5.15	$ 412.00
F08	Precast Entry Stairs	3.0	EA	12.0	$ 50.00	$ 600.00
				On Site Fitout Total =		$ 5,743.76
				All Activities Total =		**$108,981.28**
				Cost per container =		**$ 27,245.32**

Water Closet Materials and Costs

Factory Fitout (Common Items)							
Activity Code	Items	Quantity	Units	Total Quantity	Unit Cost	Total Cost	
	Used 20' Container	2.0	EA	12.0	$ 1,300.00	$	15,600
A02	Painting Container Exterior	2.0	EA	12.0	$ 450.00	$	5,400
A01	2'x3' Window Cutouts, torch cutting	100.0	LF	600.0	$ 0.97	$	582
A10	Windows, aluminum, single hung, standard glass, 2' x 3'	10.0	EA	60.0	$ 350.00	$	21,000
A01	3'x6'8" Door Cutout, torch cutting	38.7	LF	232.0	$ 0.97	$	225
A11	3'x6'8" Storm Door Aluminum Anodized	2.0	EA	12.0	$ 244.00	$	2,928
A07	5/8" Gypsum Ceiling, fire resistant	320.0	SF	1,920.0	$ 0.85	$	1,632
A07	5/8" Gypsum Wallboard, fire resistant	877.3	SF	5,263.8	$ 0.85	$	4,474
A08	Vinyl Composition Tile Flooring	320.0	SF	1,920.0	$ 1.99	$	3,821
A09	Wall/Ceiling Painting, primer & 2 coats	1197.3	SF	7,183.8	$ 0.79	$	5,675
A05	Electrical Rough-In, 3-phase 120 volt	2.0	EA	12.0	$ 962.50	$	11,550
A06	Plumbing Rough-In	2.0	EA	12.0	$ 8,775.00	$	105,300
A03	Insulation	3912.0	SF	23,472.0	$ 0.30	$	7,042
A04	1-5/8" Galvanized Furring Strips, 24" O.C., with Sound Isolation Clips	448.0	SF	2,688	$ 4.76	$	12,795
				Common Items Total =		$198,023.71	

Factory Fitout (Custom Items)

Activity Code	Items	Quantity	Units	Total Quantity	Unit Cost	Total Cost
E01	Water closet, vitreous china, elongated	6.0	EA	36.0	$ 2,310.00	$ 83,160
E02	36"x24" Shower Stalls	4.0	EA	24.0	$ 130.00	$ 3,120
E07	36"x 72" Vinyl Shower Curtains	4.0	EA	24.0	$ 10.00	$ 240
E07	36" Shower Rods	4.0	EA	24.0	$ 10.00	$ 240
E05	20 7/8" x 18" Sinks	4.0	EA	24.0	$ 82.00	$ 1,968
E07	Mirrors (32"x22")	4.0	EA	24.0	$ 79.00	$ 1,896
E07	Towel Rack with Shelf	4.0	EA	24.0	$ 11.90	$ 286
E06	Shower Stall Bench (18" H, 9.5" W)	4.0	EA	24.0	$ 246.00	$ 5,904
E03	3 Toilet Stall Partitions, Solid Polymer	2.0	EA	12.0	$ 2,354.00	$ 28,248
E04	2 Shower Stall Partitions	2.0	EA	12.0	$ 1,585.00	$ 19,020
E07	Toilet Partition Grab Bars (54" Long)	6.0	EA	36.0	$ 77.00	$ 2,772
E07	Paper Towel Dispenser	4.0	EA	24.0	$ 24.00	$ 576
E07	Soap Dispenser	4.0	EA	24.0	$ 15.50	$ 372
E07	Toilet Paper and Seat Cover Dispenser with Sanitary Disposal	6.0	EA	36.0	$ 340.00	$ 12,240
				Custom Items Total =		$160,041.60

On Site Fitout

Activity Code	Items	Quantity	Units	Total Quantity	Unit Cost	Total Cost
F02	Plumbing Hook Up	1.0	EA	6.0	$ 160.00	$ 960.00
F03	Electrical Hook Up	1.0	EA	6.0	$ 120.00	$ 720.00
F04	Electric water heater, residential, 100< F rise, 120 gallon tank, 23 GPH	1.0	EA	6.0	$ 5,125.00	$ 30,750.00
F01	Precast Concrete Foundation Posts	8.0	EA	48.0	$ 50.00	$ 2,400.00
F05	Sloped Aluminum Roof Panels	2.0	EA	12.0	$ 660.00	$ 7,920.00
F07	Aluminum Downspout	23.4	LF	140.4	$ 3.67	$ 515.27
F06	Vinyl Gutters	40.0	LF	240.0	$ 5.15	$ 1,236.00
F08	Precast Entry Stairs	2.0	EA	12.0	$ 50.00	$ 600.00
				On Site Fitout Total =		$ 45,101.27
				All Activities Total =		**$403,166.58**
				Cost per container =		**$ 67,194.43**

Site Preparation Materials and Costs

Activity Code	Items	Quantity	Units	# of Containers	Total Quantity	Unit Cost	Total Cost
G09	1" Thick Precast Concrete Walkway	11436.0	SF	N/A	11436.0	$ 3.79	$ 43,342
G07	4" Gravel Base	423.6	SY	N/A	423.6	$ 8.50	$ 3,600
G10	6" Drainage Channel	2289.5	LF	N/A	2289.5	$ 0.75	$ 1,717
G03	Water Line (Pipe plastic, PVC, DWV, pressure pipe 200 PSI, 2" diameter)	711.4	LF	N/A	711.4	$ 22.46	$ 15,978
G04	Waste Line (Pipe plastic, PVC, DWV, schedule 40, 4" diameter)	728.8	LF	N/A	728.8	$ 30.25	$ 22,046
G08	Paved Delivery Area	210.9	SY	N/A	210.9	$ 32.18	$ 6,786
G05	Install Generator	1.0	EA	N/A	1.0	$ 105,000.00	$ 105,000
G06	Install Water Tank	1.0	EA	N/A	1.0	$ 30,000.00	$ 30,000
G05	Medium-voltage, single cable, copper	26.45	C.L.F.	per site	26.45	$ 307.00	$ 8,120.15
G01	Clearing and Grubbing, Cut and Chip Light Trees Up to 6" Diameter	1.1	ACRE	N/A	1.1	$ 4,125.00	$ 4,661.25
G02	Site Grading	5466.7	C.Y.	N/A	5466.7	$ 13.29	$ 72,652.04
G11	Carrier Performance Series 12,000 Btu/hr capacity Split System	1	EA	25	25	$ 609.00	$ 15,225.00
G12	Place Containers using 12-ton truck mounted hydraulic crane	1	EA	64	64	$ 154.00	$ 9,856.00
	Storage containers	1	EA	8	8	$ 1,300.00	$ 10,400.00
					Site Preparation Total =		**$349,384.86**

Appendix C: Crew Type and Duration of Activities

Living Container Crew Type and Duration of Activities

Factory Fitout (Common Items)						
Activity Code	Items	Crew	Daily Output	Duration (days)	# of Crews	Final Duration (days)
	Used 40' Container					
A02	Painting Container Exterior	1 Pord	1.3	27.69	1.00	27.69
A01	3'x5'6" Window Cut Out, torch cutting	1 Clab	360.00	13.60	1.00	13.60
A10	200 Series Tilt Wash Double Hung Windows	1 Carp	5.7	50.53	2.00	25.26
A01	3'x6'8" Door Cutout, torch cutting	1 Clab	360.00	5.80	1.00	5.80
A11	3'x6'8" Storm Door Aluminum Anodized	2 Carp.	20.00	5.40	1.00	5.40
A07	5/8" Gypsum Ceiling, fire resistant	2 Carp.	765.00	15.06	1.00	15.06
A07	5/8" Gypsum Wallboard, fire resistant	2 Carp.	2,000.00	13.82	1.00	13.82
A08	Vinyl Composition Tile Flooring	1 Tilf	360.00	32.00	2.00	16.00
A03	Roofing Insulation	1 Carp.	1,000.00	23.04	1.00	23.04
A03	Floor Insulation	1 Carp.	1,000.00	23.04	1.00	23.04
A03	Exterior Wall Insulation	1 Carp.	1,000.00	82.94	3.00	27.65
A09	Wall/Ceiling Painting, primer & 2 coats	1 Pord	680.00	57.60	2.00	28.80
A05	Electrical Rough-In, 3-phase 120 volt	2 Elec	2.00	18.00	1.00	18.00
A04	1-5/8" Galvanized Furring Strips, 24" O.C., with Sound Isolation Clips	1 Carp.	550.00	50.27	2.00	25.13

Factory Fitout (Custom Items)						
Activity Code	Items	Crew	Daily Output	Duration (Days)	# of Crews	Final Duration (days)
B02	Twin Size Bed and Bedframe	2 lbr	12.00	18.00	1.00	18.00
B03	34.5'h x 60"w x 32.5"d Loveseat	2 lbr	9.00	12.00	1.00	12.00
B04	3'w x 1.5'd x 4'h Dresser	2 lbr	9.00	12.00	1.00	12.00
B01	5/8" Drywall Partition with Wood Stud Framing	2 Carp.	5.00	14.40	1.00	14.40
On Site Fitout						
Activity Code	Items	Crew	Daily Output	Duration (Days)	# of Crews	Final Duration (days)
F03	Electrical Hook Up	2 Elec.	8.00	4.50	1.00	4.50
F01	Precast Concrete Foundation Posts	3 Labr.	48.00	3.00	1.00	3.00
F05	Sloped Aluminum Roof Panels	G3	4.00	9.00	3.00	3.00
F07	Aluminum Downspout	1 Shee	190.00	2.22	1.00	2.22
F06	Vinyl Gutters	1 Carp	110.00	13.09	5.00	2.62
F08	Precast Entry Stairs	3 Labr.	48.00	2.25	1.00	2.25

Dining Area Crew Type and Duration of Activities

Factory Fitout (Common Items)						
Activity Code	Items	Crew	Daily Output	Duration (Days)	# of Crews	Final Duration (days)
	Used 40' Container					
A02	Painting Container Exterior	1 Pord	1.3	3.08	1.00	3.08
A01	3'x5'6" Window Cut Out, torch cutting	1 Clab	360.00	2.64	1.00	2.64
A10	200 Series Tilt Wash Double HungWindows	1 Carp	5.7	5.61	1.00	5.61
A01	3'x6'8" Door Cutout, torch cutting	1 Clab	360.00	0.21	1.00	0.21
A11	3'x6'8" Storm Door Aluminum Anodized	2 Carp.	20.00	0.20	1.00	0.20
A07	5/8" Gypsum Ceiling, fire resistant	2 Carp.	765.00	1.67	1.00	1.67
A07	5/8" Gypsum Wallboard, fire resistant	2 Carp.	2,000.00	1.95	1.00	1.95
A08	Vinyl Composition Tile Flooring	1 Tilf	360.00	3.56	1.00	3.56
A03	Roofing Insulation	1 Carp.	1,000.00	2.56	1.00	2.56
A03	Floor Insulation	1 Carp.	1,000.00	2.56	1.00	2.56
A03	Exterior wall Insulation	1 Carp.	1,000.00	2.69	1.00	2.69
A09	Wall/Ceiling Painting, primer & 2 coats	1 Pord	680.00	6.40	1.00	6.40
A05	Electrical Rough-In, 3-phase 120 volt	2 Elec	2.00	2.00	1.00	2.00
A04	1-5/8" Galvanized Furring Strips, 24" O.C., with Sound Isolation Clips	1 Carp.	550.00	5.59	1.00	5.59

Factory Fitout (Custom Items)						
Activity Code	**Items**	**Crew**	**Daily Output**	**Duration (Days)**	**# of Crews**	**Final Duration (days)**
C02	2.5' x 5' table	1 Carp	20.00	1.40	1.00	1.40
C01	1.4' x 5' bench seat	1 Carp	20.00	2.80	1.00	2.80
On Site Fitout						
Activity Code	**Items**	**Crew**	**Daily Output**	**Duration (Days)**	**# of Crews**	**Final Duration (days)**
F03	Electrical Hook Up	2 Elec.	8.00	0.50	1.00	0.50
F01	Precast Concrete Foundation Posts	3 Labr.	48.00	0.33	1.00	0.33
F05	Sloped Aluminum Roof Panels	G3	4.00	1.00	1.00	1.00
F07	Aluminum Downspout	1 Shee	190.00	0.25	1.00	0.25
F06	Vinyl Gutters	1 Carp	110.00	1.45	1.00	1.45
F08	Precast Entry Stairs	3 Labr.	48.00	0.25	1.00	0.25

Kitchen Area Crew Type and Duration of Activities

Factory Fitout (Common Items)						
Activity Code	Items	Crew	Daily Output	Duration (Days)	# of Crews	Final Duration (days)
	Used 20' Container					
A02	Painting Container Exterior	1 Pord	1.3	3.08	1.00	3.08
A01	3'x5'6" Window Cut Out, torch cutting	1 Clab	360.00	1.32	1.00	1.32
A10	200 Series Tilt Wash Double HungWindows	1 Carp	5.7	5.61	1.00	5.61
A01	3'x6'8" Door Cutout, torch cutting	1 Clab	360.00	0.21	1.00	0.21
A11	3'x6'8" Storm Door Aluminum Anodized	2 Carp.	20.00	0.20	1.00	0.20
A07	5/8" Gypsum Ceiling, fire resistant	2 Carp.	765.00	0.84	1.00	0.84
A07	5/8" Gypsum Wallboard, fire resistant	2 Carp.	2,000.00	0.90	1.00	0.90
A08	Vinyl Composition Tile Flooring	1 Tilf	360.00	1.78	1.00	1.78
A03	Roofing Insulation	1 Carp.	1,000.00	1.28	1.00	1.28
A03	Floor Insulation	1 Carp.	1,000.00	1.28	1.00	1.28
A03	Exterior wall Insulation	1 Carp.	1,000.00	5.38	1.00	5.38
A07	Wall/Ceiling Painting, primer & 2 coats	1 Pord	680.00	3.58	1.00	3.58
A05	Electrical Rough-In, 3-phase 120 volt	2 Elec	2.00	2.00	1.00	2.00
A06	Plumbing Rough In	2 Plumb	2.00	2.00	1.00	2.00
A04	1-5/8" Galvanized Furring Strips, 24" O.C., with Sound Isolation Clips	1 Carp.	550.00	3.26	1.00	3.26

Factory Fitout (Custom Items)						
Activity Code	Items	Crew	Daily Output	Duration (Days)	# of Crews	Final Duration (days)
D03	20 7/8" x 18" Sinks	Q1	5.60	2.14	1.00	2.14
D05	22.4 CF Refrigerator	2 Carp.	4.00	4.00	1.00	4.00
D04	30" Freestanding Range, 4.4 CF oven	2 Clab.	4.00	2.00	1.00	2.00
D01	Standard Wood Cabinets 24" Wide	2 Carp.	24.80	0.65	1.00	0.65
D02	Laminated Plastic Countertops	1 Carp.	5.00	1.60	1.00	1.60
On Site Fitout						
Activity Code	Items	Crew	Daily Output	Duration (Days)	# of Crews	Final Duration (days)
F02	Plumbing Hook Up	2 Plum.	8.00	0.50	1.00	0.50
F03	Electrical Hook Up	2 Elec.	8.00	0.50	1.00	0.50
F01	Precast Concrete Foundation Posts	3 Labr.	48.00	0.33	1.00	0.33
F05	Sloped Aluminum Roof Panels	G3	4.00	1.00	1.00	1.00
F07	Aluminum Downspout	1 Shee	190.00	0.25	1.00	0.25
F06	Vinyl Gutters	1 Carp	110.00	0.73	1.00	0.73
F08	Precast Entry Stairs	3 Labr.	48.00	0.25	1.00	0.25

Water Closet Crew Type and Duration of Activities

	Factory Fitout (Common Items)					
Activity Code	**Items**	**Crew**	**Daily Output**	**Duration (Days)**	**# of Crews**	**Final Duration (days)**
	Used 20' Container					
A02	Painting Container Exterior	1 Pord	1.3	9.23	1.00	9.23
A01	2'x3' Window Cutouts, torch cutting	1 Clab	360.00	1.67	1.00	1.67
A10	Windows, aluminum, single hung, standard glass, 2' x 3'	1 Carp	5.7	10.53	1.00	10.53
A01	3'x6'8" Door Cutout, torch cutting	1 Clab	360.00	0.64	1.00	0.64
A11	3'x6'8" Storm Door Aluminum Anodized	2 Carp.	20.00	0.60	1.00	0.60
A07	5/8" Gypsum Ceiling, fire resistant	2 Carp.	765.00	2.51	1.00	2.51
A07	5/8" Gypsum Wallboard, fire resistant	2 Carp.	2,000.00	2.63	1.00	2.63
A08	Vinyl Composition Tile Flooring	1 Tilf	360.00	5.33	1.00	5.33
A09	Wall/Ceiling Painting, primer & 2 coats	1 Pord	680.00	10.56	1.00	10.56
A05	Electrical Rough-In, 3-phase 120 volt	2 Elec	2.00	6.00	1.00	6.00
A06	Plumbing Rough-In	2 Plumb	1.00	12.00	1.00	12.00
A03	Insulation	1 Carp.	1,000.00	23.47	2.00	11.74
A04	1-5/8" Galvanized Furring Strips, 24" O.C., with Sound Isolation Clips	1 Carp.	550.00	4.89	1.00	4.89

Factory Fitout (Custom Items)

Activity Code	Items	Crew	Daily Output	Duration (Days)	# of Crews	Final Duration (days)
E01	Water closet, vitreous china, elongated	Q1	5.3	6.79	1.00	6.79
E02	36"x24" Shower Stalls	Q1	5.2	4.62	1.00	4.62
E07	36"x 72" Vinyl Shower Curtains	1 Carp	13.0	1.85	1.00	1.85
E07	36" Shower Rods	1 Carp	13.0	1.85	1.00	1.85
E05	20 7/8" x 18" Sinks	Q1	7.0	3.43	1.00	3.43
E07	Mirrors (32"x22")	1 Carp	15.0	1.60	1.00	1.60
E07	Towel Rack with Shelf	1 Carp	19.0	1.26	1.00	1.26
E06	Shower Stall Bench (18" H, 9.5" W)	1 Shee	20.0	1.20	1.00	1.20
E03	3 Toilet Stall Partitions, Solid Polymer	2 Carp	7.0	1.71	1.00	1.71
E04	2 Shower Stall Partitions	2 Carp	7.0	1.71	1.00	1.71
E07	Toilet Partition Grab Bars (54" Long)	1 Carp	20.0	1.80	1.00	1.80
E07	Paper Towel Dispenser	Q1	8.0	3.00	1.00	3.00
E07	Soap Dispenser	1 Carp	10.0	2.40	1.00	2.40
E07	Toilet Paper and Seat Cover Dispenser with Sanitary Disposal	1 Carp	20.0	1.80	1.00	1.80

On Site Fitout

Activity Code	Items	Crew	Daily Output	Duration (Days)	# of Crews	Final Duration (days)
F02	Plumbing Hook Up	2 Plum.	8.00	0.75	1.00	0.75
F03	Electrical Hook Up	2 Elec.	8.00	0.75	1.00	0.75
F04	Electric water heater, residential, 100< F rise, 120 gallon tank, 23 GPH	1 Plum.	1.40	4.29	1.00	4.29
F01	Precast Concrete Foundation Posts	3 Labr.	48.00	1.00	1.00	1.00
F05	Sloped Aluminum Roof Panels	G3	4.00	3.00	1.00	3.00
F07	Aluminum Downspout	1 Shee	190.00	0.74	1.00	0.74
F06	Vinyl Gutters	1 Carp	110.00	2.18	1.00	2.18
F08	Precast Entry Stairs	3 Labr.	48.00	0.25	1.00	0.25

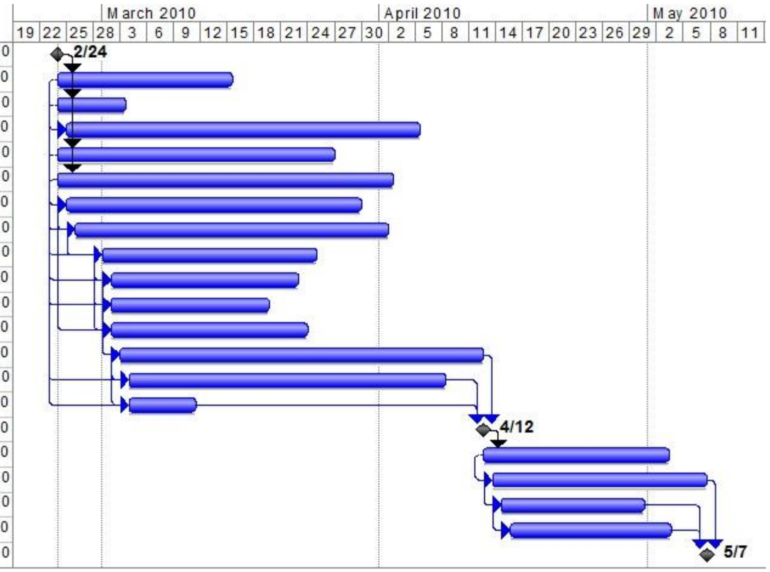
Site Preparation Crew Type and Duration of Activities

Activity Code	Items	Crew	Daily Output	Duration (Days)	# of Crews	Final Duration (days)
G09	1" Thick Precast Concrete Walkway	D1	265.00	43.15	30.00	1.44
G07	4" Gravel Base	B37	1,000.00	0.42	1.00	0.42
G10	6" Drainage Channel	B53	550.00	4.16	4.00	1.04
G03	Water Line (Pipe plastic, PVC, DWV, pressure pipe 200 PSI, 2" diameter)	2 B53	300.00	2.37	3.00	0.79
G04	Waste Line (Pipe plastic, PVC, DWV, schedule 40, 4" diameter)	2 B53	300.00	2.43	3.00	0.81
G08	Paved Delivery Area	B37	90.00	2.34	3.00	0.78
G05	Install Generator	R3	0.18	5.56	4.00	1.39
G06	Install Water Tank	Q2	0.50	2.00	1.00	2.00
G05	Medium-voltage, single cable, copper	2 Elec.	4.4	6.01	6.00	1.00
G01	Clearing and Grubbing, Cut and Chip Light Trees Up to 6" Diameter	B7	1.00	1.13	4.00	0.28
G02	Site Grading	B15	600.00	9.11	6.00	1.52
G11	Carrier Performance Series 12,000 Btu/hr capacity Split System	Q19	0.42	59.52	40.00	1.49
	Place Containers using 12-ton truck mounted hydraulic crane	A3H	8.00	8.00	4.00	2.00

Appendix D: Scheduling

Living Area Factory Modifications

ID	Task Name	Duration	Start	Finish
1	40 FT Container	0 days	Wed 2/24/10	Wed 2/24/10
2	3'x5'6" Window Cut Out, torch cutting	13.6 days	Wed 2/24/10	Mon 3/15/10
3	3'x6'8" Door Cutout, torch cutting	5.8 days	Wed 2/24/10	Wed 3/3/10
4	Painting Container Exterior	27.7 days	Thu 2/25/10	Mon 4/5/10
5	Roofing Insulation	23 days	Wed 2/24/10	Fri 3/26/10
6	Exterior Wall Insulation	27.7 days	Wed 2/24/10	Fri 4/2/10
7	Floor Insulation	23 days	Thu 2/25/10	Mon 3/29/10
8	Furring Strip Installation	25 days	Fri 2/26/10	Thu 4/1/10
9	Electrical Rough-In, 3-phase 120 volt	18 days	Mon 3/1/10	Wed 3/24/10
10	5/8" Gypsum Ceiling, fire resistant	15 days	Tue 3/2/10	Mon 3/22/10
11	5/8" Gypsum Wallboard, fire resistant	13.8 days	Tue 3/2/10	Fri 3/19/10
12	Vinyl Composition Tile Flooring	16 days	Tue 3/2/10	Tue 3/23/10
13	Wall/Ceiling Painting, primer & 2 coats	28.8 days	Wed 3/3/10	Mon 4/12/10
14	200 Series Tilt Wash Double Hung Windows	25.3 days	Thu 3/4/10	Thu 4/8/10
15	3'x6'8" Storm Door Aluminum Anodized	5.4 days	Thu 3/4/10	Thu 3/11/10
16	Finish Common Item Fitout	0 days	Mon 4/12/10	Mon 4/12/10
17	5/8" Drywall Partition with Wood Stud Framing	14.4 days	Mon 4/12/10	Mon 5/3/10
18	Twin Size Bed and Bedframe	18 days	Tue 4/13/10	Fri 5/7/10
19	34.5'h x 60"w x 32.5"d Loveseat	12 days	Wed 4/14/10	Fri 4/30/10
20	3'w x 1.5'd x 4'h Dresser	12 days	Thu 4/15/10	Mon 5/3/10
21	Finish Custom Item Fitout	0 days	Fri 5/7/10	Fri 5/7/10

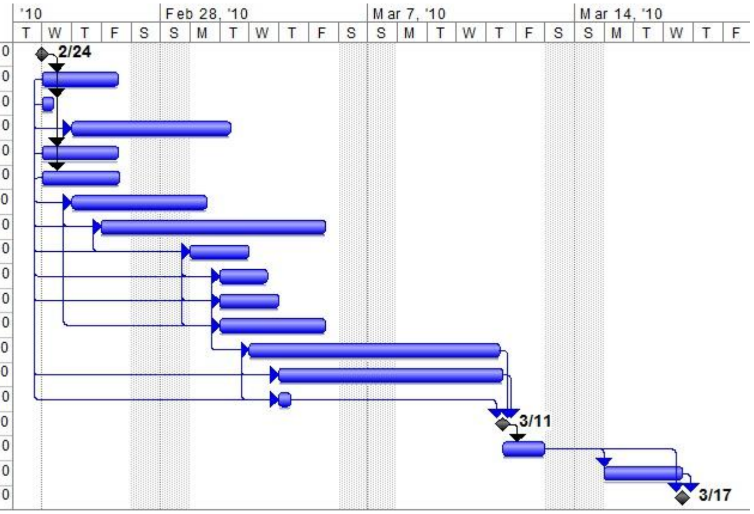


Project: Living Area Schedule.mpp
Date: Wed 2/24/10

Task	Rolled Up Task	External Tasks
Progress	Rolled Up Milestone	Project Summary
Milestone	Rolled Up Progress	Group By Summary
Summary	Split	Deadline

Dining Area Factory Modifications

ID	Task Name	Duration	Start	Finish
1	40 FT Container	0 days	Wed 2/24/10	Wed 2/24/10
2	3'x5'6" Window Cut Out, torch cutting	2.6 days	Wed 2/24/10	Fri 2/26/10
3	3'x6'8" Door Cutout, torch cutting	0.2 days	Wed 2/24/10	Wed 2/24/10
4	Painting Container Exterior	3.1 days	Thu 2/25/10	Tue 3/2/10
5	Roofing Insulation	2.6 days	Wed 2/24/10	Fri 2/26/10
6	Exterior Wall Insulation	2.7 days	Wed 2/24/10	Fri 2/26/10
7	Floor Insulation	2.6 days	Thu 2/25/10	Mon 3/1/10
8	Furring Strip Installation	5.6 days	Fri 2/26/10	Fri 3/5/10
9	Electrical Rough-In, 3-phase 120 volt	2 days	Mon 3/1/10	Tue 3/2/10
10	5/8" Gypsum Ceiling, fire resistant	1.7 days	Tue 3/2/10	Wed 3/3/10
11	5/8" Gypsum Wallboard, fire resistant	2 days	Tue 3/2/10	Wed 3/3/10
12	Vinyl Composition Tile Flooring	3.6 days	Tue 3/2/10	Fri 3/5/10
13	Wall/Ceiling Painting, primer & 2 coats	6.4 days	Wed 3/3/10	Thu 3/11/10
14	200 Series Tilt Wash Double Hung Windows	5.6 days	Thu 3/4/10	Thu 3/11/10
15	3'x6'8" Storm Door Aluminum Anodized	0.2 days	Thu 3/4/10	Thu 3/4/10
16	Finish Common Item Fitout	0 days	Thu 3/11/10	Thu 3/11/10
17	1.4' x 5' bench seat	1.4 days	Thu 3/11/10	Fri 3/12/10
18	2.5' x 5' table	2.8 days	Mon 3/15/10	Wed 3/17/10
19	Finish Custom Item Fitout	0 days	Wed 3/17/10	Wed 3/17/10

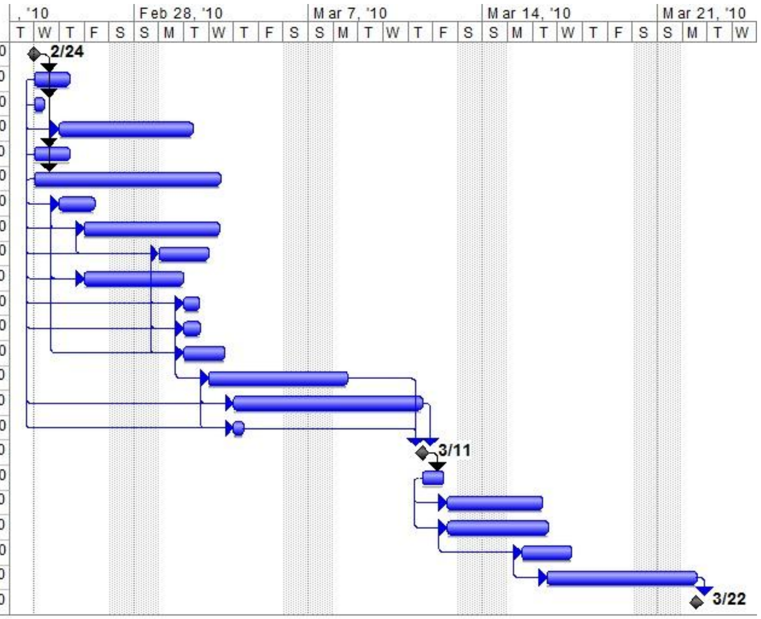


Project: Dining Area Schedule.mpp
Date: Wed 2/24/10

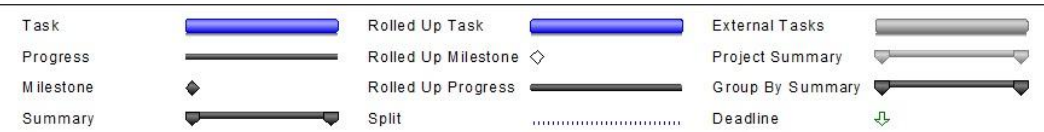
Task	Rolled Up Task	External Tasks
Progress	Rolled Up Milestone	Project Summary
Milestone	Rolled Up Progress	Group By Summary
Summary	Split	Deadline

Kitchen Area Factory Modifications

ID	Task Name	Duration	Start	Finish
1	20 FT Container	0 days	Wed 2/24/10	Wed 2/24/10
2	3'x5'6" Window Cut Out, torch cutting	1.3 days	Wed 2/24/10	Thu 2/25/10
3	3'x6'8" Door Cutout, torch cutting	0.2 days	Wed 2/24/10	Wed 2/24/10
4	Painting Container Exterior	3.1 days	Thu 2/25/10	Tue 3/2/10
5	Roofing Insulation	1.3 days	Wed 2/24/10	Thu 2/25/10
6	Exterior Wall Insulation	5.4 days	Wed 2/24/10	Wed 3/3/10
7	Floor Insulation	1.3 days	Thu 2/25/10	Fri 2/26/10
8	Furring Strip Installation	3.3 days	Fri 2/26/10	Wed 3/3/10
9	Electrical Rough-In, 3-phase 120 volt	2 days	Mon 3/1/10	Tue 3/2/10
10	Plumbing Rough-In	2 days	Fri 2/26/10	Mon 3/1/10
11	5/8" Gypsum Ceiling, fire resistant	0.8 days	Tue 3/2/10	Tue 3/2/10
12	5/8" Gypsum Wallboard, fire resistant	0.9 days	Tue 3/2/10	Tue 3/2/10
13	Vinyl Composition Tile Flooring	1.8 days	Tue 3/2/10	Wed 3/3/10
14	Wall/Ceiling Painting, primer & 2 coats	3.6 days	Wed 3/3/10	Mon 3/8/10
15	200 Series Tilt Wash Double Hung Windows	5.6 days	Thu 3/4/10	Thu 3/11/10
16	3'x6'8" Storm Door Aluminum Anodized	0.2 days	Thu 3/4/10	Thu 3/4/10
17	Finish Common Item Fitout	0 days	Thu 3/11/10	Thu 3/11/10
18	Standard Wood Cabinets 24" Wide	0.7 days	Thu 3/11/10	Fri 3/12/10
19	Laminated Plastic Countertops	1.6 days	Fri 3/12/10	Tue 3/16/10
20	20 7/8" x 18" Sinks	2.2 days	Fri 3/12/10	Tue 3/16/10
21	30" Freestanding Range, 4.4 CF oven	2 days	Mon 3/15/10	Wed 3/17/10
22	22.4 CF Refrigerator	4 days	Tue 3/16/10	Mon 3/22/10
23	Finish Custom Item Fitout	0 days	Mon 3/22/10	Mon 3/22/10

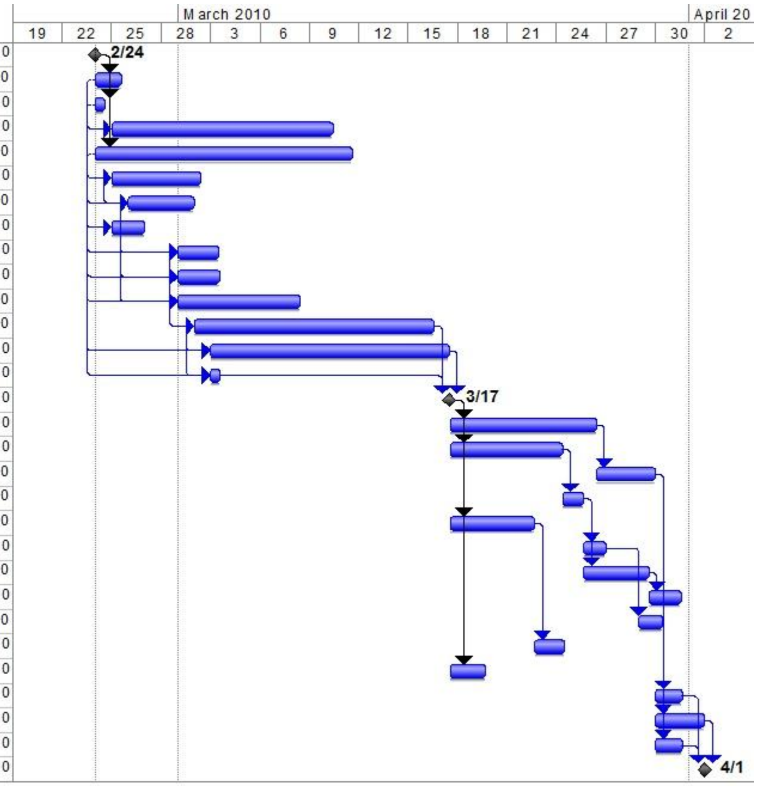


Project: Kitchen Area Schedule.mpp
Date: Wed 2/24/10



Water Closet Factory Modifications

ID	Task Name	Duration	Start	Finish
1	20 FT Container	0 days	Wed 2/24/10	Wed 2/24/10
2	2'x3' Window Cutouts, torch cutting	1.7 days	Wed 2/24/10	Thu 2/25/10
3	3'x6'8" Door Cutout, torch cutting	0.6 days	Wed 2/24/10	Wed 2/24/10
4	Painting Container Exterior	9.3 days	Thu 2/25/10	Wed 3/10/10
5	Insulation	11.7 days	Wed 2/24/10	Thu 3/11/10
6	Furring Strip Installation	3.3 days	Thu 2/25/10	Tue 3/2/10
7	Electrical Rough-In, 3-phase 120 volt	2 days	Fri 2/26/10	Mon 3/1/10
8	Plumbing Rough-In	2 days	Thu 2/25/10	Fri 2/26/10
9	5/8" Gypsum Ceiling, fire resistant	2.5 days	Mon 3/1/10	Wed 3/3/10
10	5/8" Gypsum Wallboard, fire resistant	2.6 days	Mon 3/1/10	Wed 3/3/10
11	Vinyl Composition Tile Flooring	5.3 days	Mon 3/1/10	Mon 3/8/10
12	Wall/Ceiling Painting, primer & 2 coats	10.6 days	Tue 3/2/10	Tue 3/16/10
13	Windows, aluminum, single hung, standard glass	10.5 days	Wed 3/3/10	Wed 3/17/10
14	3'x6'8" Storm Door Aluminum Anodized	0.6 days	Wed 3/3/10	Wed 3/3/10
15	Finish Common Item Fitout	0 days	Wed 3/17/10	Wed 3/17/10
16	Water closet, vitreous china, elongated	6.8 days	Wed 3/17/10	Fri 3/26/10
17	36"x24" Shower Stalls	4.6 days	Wed 3/17/10	Wed 3/24/10
18	3 Toilet Stall Partitions, Solid Polymer	1.7 days	Fri 3/26/10	Mon 3/29/10
19	2 Shower Stall Partitions	1.7 days	Wed 3/24/10	Thu 3/25/10
20	20 7/8" x 18" Sinks	3.4 days	Wed 3/17/10	Mon 3/22/10
21	Shower Stall Bench (18" H, 9.5" W)	1.2 days	Thu 3/25/10	Fri 3/26/10
22	36" Shower Rods	1.9 days	Thu 3/25/10	Mon 3/29/10
23	36"x 72" Vinyl Shower Curtains	1.9 days	Mon 3/29/10	Wed 3/31/10
24	Towel Rack with Shelf	1.3 days	Mon 3/29/10	Tue 3/30/10
25	Mirrors (32"x22")	1.6 days	Mon 3/22/10	Wed 3/24/10
26	Soap Dispenser	2.4 days	Wed 3/17/10	Fri 3/19/10
27	Toilet Partition Grab Bars (54" Long)	1.8 days	Tue 3/30/10	Wed 3/31/10
28	Paper Towel Dispenser	3 days	Tue 3/30/10	Thu 4/1/10
29	Toilet Paper and Seat Cover Dispenser with Sani	1.8 days	Tue 3/30/10	Wed 3/31/10
30	Finish Custom Item Fitout	0 days	Thu 4/1/10	Thu 4/1/10

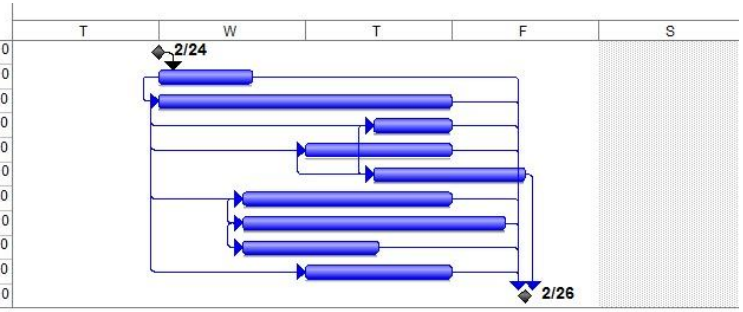


Project: Water Closet Area Schedule.m
Date: Wed 2/24/10

Task | Rolled Up Task | External Tasks
Progress | Rolled Up Milestone | Project Summary
Milestone | Rolled Up Progress | Group By Summary
Summary | Split | Deadline

On Site Modifications

ID	Task Name	Duration	Start	Finish
1	Site Preparation Initial Container Placement	0 days	Wed 2/24/10	Wed 2/24/10
2	Precast Concrete Foundation Posts	0.8 days	Wed 2/24/10	Wed 2/24/10
3	Place Containers on Site	2 days	Wed 2/24/10	Thu 2/25/10
4	Plumbing Hook Up	0.6 days	Thu 2/25/10	Thu 2/25/10
5	Electical Hook Up	1 day	Thu 2/25/10	Thu 2/25/10
6	Electric water heater, residential, 100< F rise, 12	1.1 days	Thu 2/25/10	Fri 2/26/10
7	Sloped Aluminum Roof Panels	1.4 days	Wed 2/24/10	Thu 2/25/10
8	Vinyl Gutters	1.5 days	Wed 2/24/10	Fri 2/26/10
9	Aluminum Downspout	0.9 days	Wed 2/24/10	Thu 2/25/10
10	Precast Entry Stairs	1 day	Thu 2/25/10	Thu 2/25/10
11	Move-In Ready	0 days	Fri 2/26/10	Fri 2/26/10



Project: On Site Fitout Schedule.mpp
Date: Tue 3/2/10

Task
Progress
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Rolled Up Milestone
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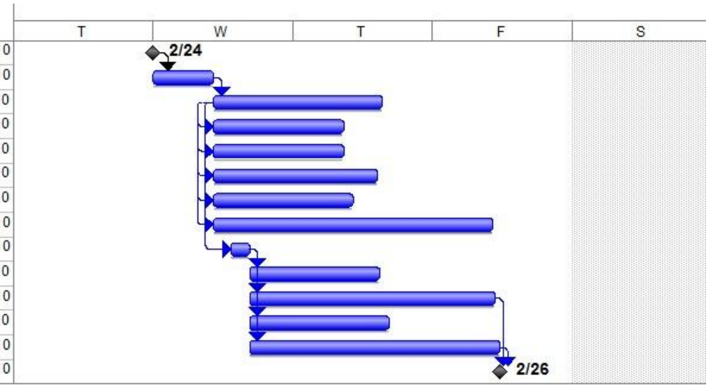
Deadline

Site Preparations

ID	Task Name	Duration	Start	Finish
1	Select Site	0 days	Wed 2/24/10	Wed 2/24/10
2	Clearing and Grubbing, Cut and Chip Light Trees Up t	0.3 days	Wed 2/24/10	Wed 2/24/10
3	Site Grading	1.5 days	Wed 2/24/10	Thu 2/25/10
4	Water Line (Pipe plastic, PVC, DWV, pressure pipe 2	0.8 days	Wed 2/24/10	Thu 2/25/10
5	Waste Line (Pipe plastic, PVC, DWV, schedule 40, 4"	0.8 days	Wed 2/24/10	Thu 2/25/10
6	Install Generator	1.4 days	Wed 2/24/10	Thu 2/25/10
7	Medium-voltage, single cable, copper	1 day	Wed 2/24/10	Thu 2/25/10
8	Install Water Tank	2 days	Wed 2/24/10	Fri 2/26/10
9	4" Gravel Base	0.4 days	Wed 2/24/10	Wed 2/24/10
10	Paved Delivery Area	0.8 days	Wed 2/24/10	Thu 2/25/10
11	1" Thick Precast Concrete Walkway	1.4 days	Wed 2/24/10	Fri 2/26/10
12	6" Drainage Channel	1 day	Wed 2/24/10	Thu 2/25/10
13	Carrier Performance Series 12,000 Btu/hr capacity Sp	1.5 days	Wed 2/24/10	Fri 2/26/10
14	Finish Site Preparations	0 days	Fri 2/26/10	Fri 2/26/10



Project: Site Preparation Schedule.mp
Date: Tue 3/2/10

Task
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