



**Project Name:** Water Main Replacement

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## Executive summary

The primary objective of this project is to provide a bid to the **City of Dania Beach** to replace an existing 12" diameter pipe water main in **SE 2<sup>nd</sup> Avenue** and traveling through **SE 7<sup>th</sup> Street**. The project includes assessing all the associated utility lines, such as fire hydrants and household water connection. The provided plans were utilized to determine a bid cost, project duration, personnel and equipment necessary to efficiently complete the project.

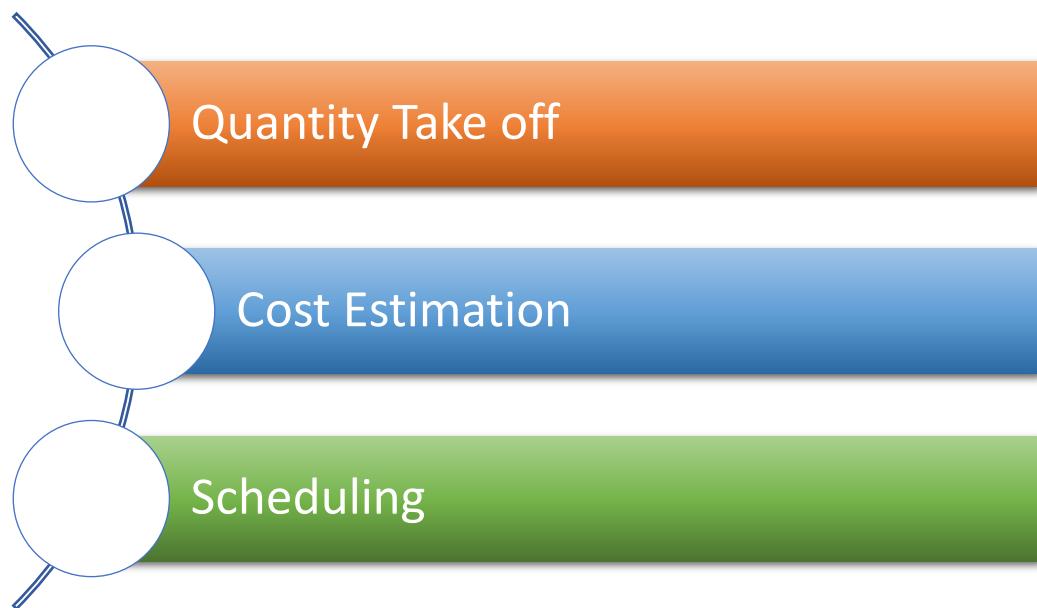
Using the plans and the tabulated materials provided, a material takeoff using **Unit Price Bid** method was performed, to find the price per unit of every item listed. This was completed using the 'Manual Method'. After completing the process of identifying the proper crews required for every task in installing the water main, the quantity of the work needed to complete each task was compared to the work output provided by the specific crews to create an estimated schedule. The tasks were then divided to properly create a draw schedule to better understand the amount of money needed to be paid out monthly and to design a monthly schedule that would track the progress effectively.

Most of the pricing and scheduling was determined through the use of "**RS Means Building Construction Cost Data**" and some using the "**Sample Bid sheets**" found for similar kind of projects and few external sources. With some adjustments made along the way, the final bid price is **\$1,725,378.53** and the project is scheduled to an estimated **4-month** duration.

## Objective

To prepare a project bid for water main replacement project at the City of Dania Beach.

## Workflow



## Procedure

The aim of this project is to develop a **bid price** for the water main distribution system. Material take-offs were carried out by each team member, followed by calculating the total price based on **RS Means Cost Data** and some historic unit price bid sheets found for similar kind of projects along with certain bid projects that were found within the surrounding region.

The initial step was to prepare a **Work Breakdown Structure (WBS)**, which includes all the necessary activities to be carried forward. These activities were developed so that they would help us in preparing the project schedule using the **MS Project** software. A typical **Draw Schedule** was prepared, so that the anticipated monthly payments to be given to the contractor for the entire project can be highlighted. Further, the necessary equipment for each item in the WBS

were identified and the appropriate crew / manpower and resources were also calculated, in order to complete the project.

Finally, we came up with a project bid, that includes all the material cost, equipment cost and crew cost along with its schedule, so that the contractor can complete the entire project on time.

## Methodology Used



Figure 1: Methodology

## Work Breakdown Structure

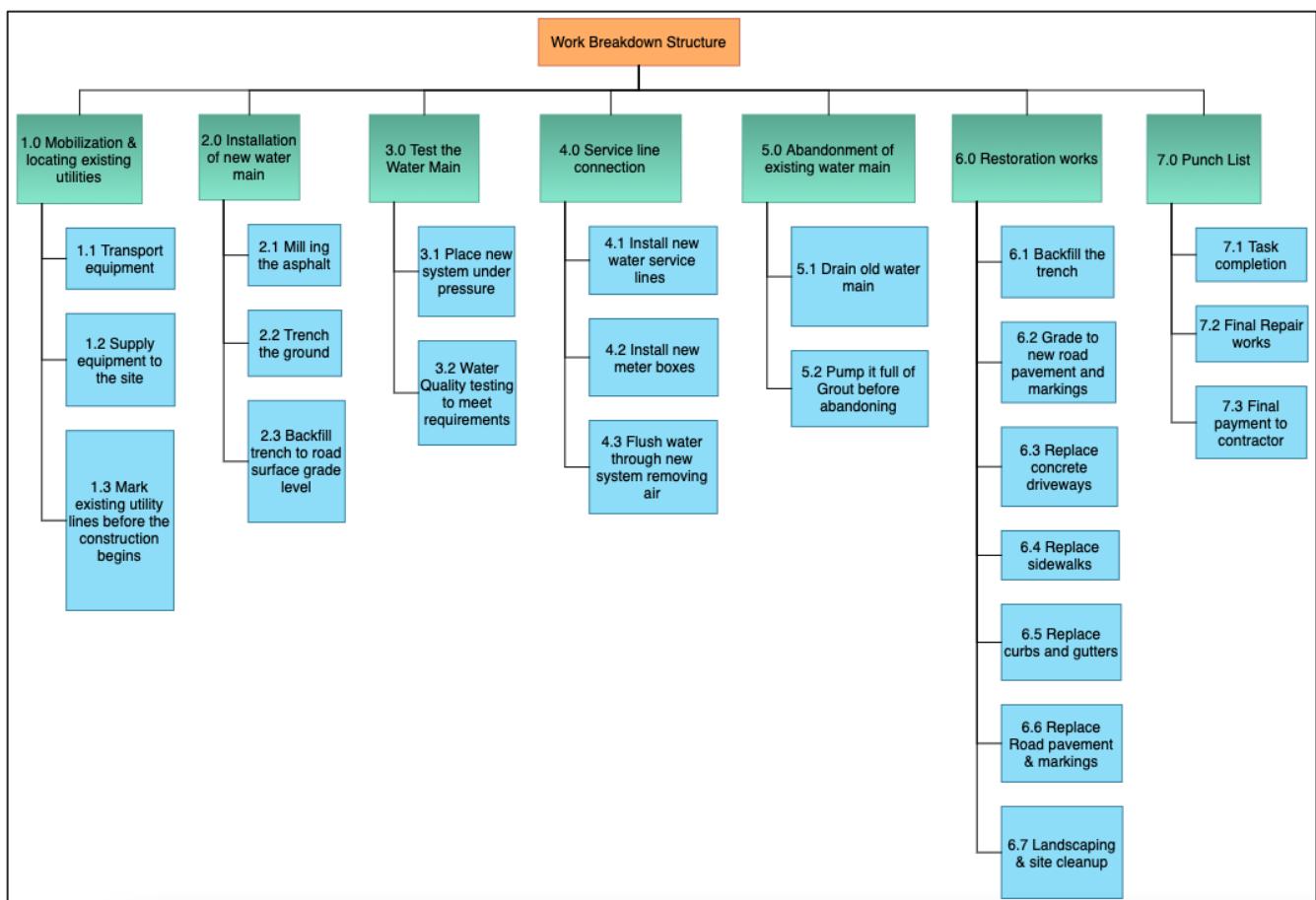


Figure 2: Work Breakdown Structure

## Project Site

The location of the project is **SE 2<sup>nd</sup> Avenue** and **SE 7<sup>th</sup> Street** in the **City of Dania Beach, Broward County, Florida**. The Station is located in the Section 03, Township 51 South, Range 42 East, lying within the city of Dania Beach.

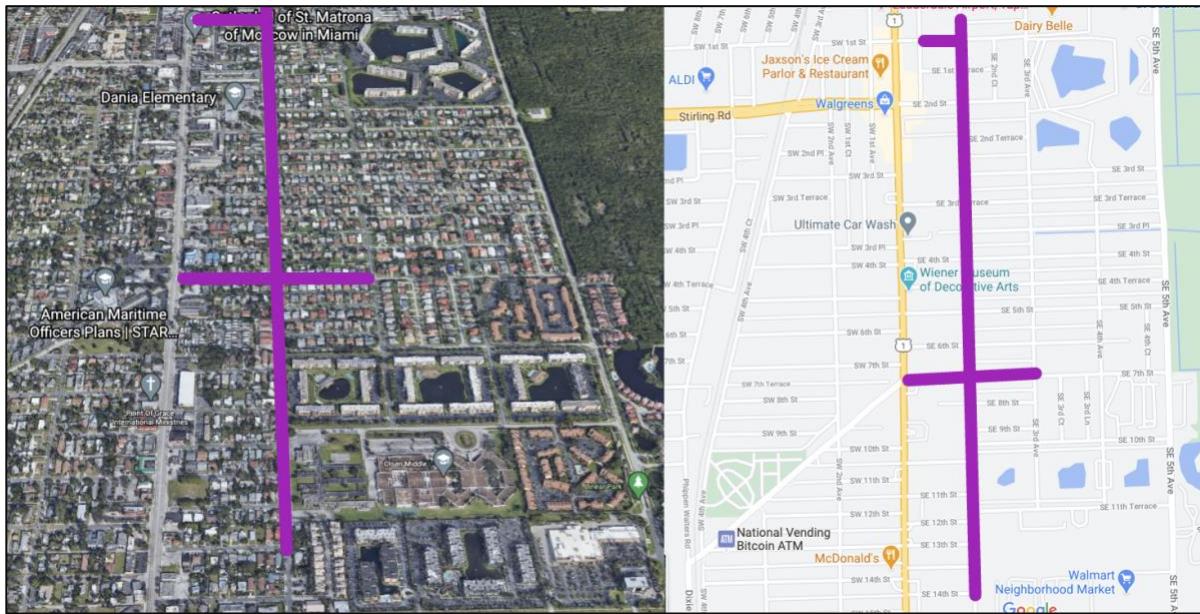


Figure 3: Project location on map



Figure 4: Water main to be replaced

## Quantity Take-off

Firstly, **Material take-off** was performed to gather all the required quantities for the entire project. The main motive of performing Quantity take-off is that it helps in the procurement of material and equipment for the project, estimating the cost for each material required in the project and to avoid unnecessary delay in procuring equipment along with the estimation of bid prices for the project contract.

1.01	Mobilization	1	LS
2.01	12" C-900 PVC Water Main	6,800	LF
2.02	12" DIP 45° Bend	81	EA
2.03	12" DIP 90° Bend	1	EA
2.04	12" DIP Gate Valve	23	EA
2.05	12" DIP Plugs and Caps	4	EA
2.02	12" DIP Water Main	480	LF
2.03	12"x12" DIP Cross	1	EA
2.04	12"x12" DIP Tee	3	EA
2.05	12"x4" DIP Tee	2	EA
2.06	12"x6" DIP Cross	2	EA
2.07	12"x6" DIP Tee	42	EA
2.08	12"x8" DIP Cross	1	EA
2.09	12"x8" DIP Tee	5	EA
2.1	2" Curb Stop with Valve Box	24	EA
2.11	2" HDPE Service Line	300	LF
2.12	2" Plugs and Caps	22	EA
2.13	2-1/2" Curb Stop with Valve Box	1	EA
2.14	2-1/2" HDPE Service Line	20	LF
2.15	3" HDPE Service Line	10	LF
2.16	4" DIP Gate Valve	2	EA
2.17	4" DIP Water Main	35	LF
2.18	6" C-900 PVC Water Main	260	LF
2.19	6" DIP 45° Bend	11	EA
2.2	6" DIP 90° Bend	37	EA
2.21	6" DIP Gate Valve	47	EA
2.22	6" DIP Plugs and Caps	50	EA
2.23	6" DIP Water Main	325	LF
2.24	6"x6" DIP Tee	2	EA
2.25	8" C-900 PVC Water Main	420	LF
2.26	8" DIP 45° Bend	2	EA
2.27	8" DIP 90° Bend	2	EA
2.28	8" DIP Gate Valve	4	EA
2.29	8" DIP Plugs and Caps	1	EA

Figure 5: QTO - Part 1

2.3	8" DIP Water Main	45	LF
2.31	8"x6" DIP Reducer	4	EA
2.32	8"x6" DIP Tee	2	EA
2.33	8"x8" DIP Tee	2	EA
2.34	Cut-In and Connect to Existing 4" to 12" Water Main	35	EA
2.35	Cut-In and Connect to Existing 2" to 3" Water Main	25	EA
2.36	Fire Hydrant Assemblies	20	EA
2.37	Bacteriological Sample Points	30	EA
2.38	1" Single, Short Water Services	16	EA
2.39	1" Single, Long Water Services	13	EA
2.40	2" Double, Short Water Services	21	EA
2.41	2" Double, Long Water Services	5	EA
2.42	Deflections Under Unforeseen Utility Conflicts	2	EA
2.43	Point Repairs for Sanitary Sewer Mains	10	EA
2.44	Point Repairs for Sanitary Sewer Laterals	20	EA
2.45	Remove Existing Fire Hydrant Assemblies	12	EA
2.46	Cut, Cap, Grout, and Abandon Existing Water Main	7630	EA
3.01	1" Type SP-9.5 Asphalt Milling and Resurfacing	10875	SY
3.02	4" Thick Sidewalk	100	LF
3.03	Asphalt Driveway Restoration	934	SF
3.04	Concrete Driveway Restoration	1	EA
3.05	Type F Curb and Gutter Replacement	38	LF
3.06	Asphalt Speed Tables	2	EA
3.07	Remove and Replace Bollards	7	EA
3.08	Solid Traffic Stripe (24" White) - Thermoplastic	454	LF
3.09	Solid Traffic Stripe (12" White) - Thermoplastic	246	LF
3.10	Solid Traffic Stripe (6" Double Yellow) - Thermoplastic	1500	LF
3.11	Solid Traffic Stripe (6" White) - Thermoplastic	65	LF
3.12	Solid White Arrow - Thermoplastic	1	EA
3.13	Retro-Reflective Pavement Markers	132	EA
3.14	Single Post with Signs and Plaques (up to 12 SF total)	3	EA
3.15	Brick Paver Crosswalks and Speed Tables	93	SY
3.16	Removal of Existing Pavement Markings and Signage	1	LS
3.17	Landscape Removal	1	LS
	Contingency	1	LS

Figure 6: QTO - Part 2

## Cost Estimation

**RS Means** Building Construction Cost Data and some **sample bid sheets** were utilized to determine the necessary equipment and crew for each activity that is to be done for the project. These resources were also used in determining the time frame for every activity that was involved

in the project. In order to calculate the duration for each task, it was independently searched in the RS Means site. In addition to that, it also provided the necessary crew that would be required to install each and every item of the project. Likewise, the cost of the materials for all the tasks to be accomplished were also taken from it.

## Material Cost

The source of the required materials for the project that needs to be installed was strategically researched from certain local companies' website and through online stores. These resources provided the estimates for all the necessary materials, labor and machinery for the entire project. Each material cost was individually determined using the RS Means Cost Data, some sample bid sheets and online stores. After researching the prices offered by different set of companies, the lowest price was chosen and noted down with **5%** increase in cost, to adjust for **inflation**.

Item	Qty	Unit	Cost per unit	Total Cost	Cost after 5% Inflation
Mobilization	1	LS	\$ 100,000.00	\$ 100,000.00	\$ 105,000.00
12" C-900 PVC Water Main	6,800	LF	\$ 47.00	\$ 319,600.00	\$ 335,580.00
12" DIP 45° Bend	81	/ton	\$ 1,000.00	\$ 5,730.00	\$ 6,016.50
12" DIP 90° Bend	1	/ton	\$ 1,000.00	\$ 80.00	\$ 84.00
12" DIP Gate Valve	23	EA	\$ 2,252.00	\$ 51,796.00	\$ 54,385.80
12" DIP Plugs and Caps	4	/ton	\$ 1,000.00	\$ 130.00	\$ 136.50
12" DIP Water Main	480	LF	\$ 162.00	\$ 77,760.00	\$ 81,648.00
12"x12" DIP Cross	1	/ton	\$ 1,000.00	\$ 80.00	\$ 84.00
12"x12" DIP Tee	3	/ton	\$ 1,000.00	\$ 350.00	\$ 367.50
12"x4" DIP Tee	2	/ton	\$ 1,000.00	\$ 170.00	\$ 178.50
12"x6" DIP Cross	2	/ton	\$ 1,000.00	\$ 220.00	\$ 231.00
12"x6" DIP Tee	42	/ton	\$ 1,000.00	\$ 3,740.00	\$ 3,927.00
12"x8" DIP Cross	1	/ton	\$ 1,000.00	\$ 110.00	\$ 115.50
12"x8" DIP Tee	5	/ton	\$ 1,000.00	\$ 460.00	\$ 483.00
2" Curb Stop with Valve Box	24	EA	\$ 471.00	\$ 11,304.00	\$ 11,869.20
2" HDPE Service Line	300	LF	\$ 45.00	\$ 13,500.00	\$ 14,175.00
2" Plugs and Caps	22	EA	\$ 5.00	\$ 110.00	\$ 115.50
2-1/2" Curb Stop with Valve Box	1	EA	\$ 605.57	\$ 605.57	\$ 635.85
2-1/2" HDPE Service Line	20	LF	\$ 45.00	\$ 900.00	\$ 945.00
3" HDPE Service Line	10	LF	\$ 45.00	\$ 450.00	\$ 472.50
4" DIP Gate Valve	2	EA	\$ 1,077.00	\$ 2,154.00	\$ 2,261.70
4" DIP Water Main	35	LF	\$ 35.00	\$ 1,225.00	\$ 1,286.25
6" C-900 PVC Water Main	260	LF	\$ 56.00	\$ 14,560.00	\$ 15,288.00
6" DIP 45° Bend	11	/ton	\$ 1,000.00	\$ 330.00	\$ 346.50
6" DIP 90° Bend	37	/ton	\$ 1,000.00	\$ 1,310.00	\$ 1,375.50
6" DIP Gate Valve	47	EA	\$ 1,204.00	\$ 56,588.00	\$ 59,417.40
6" DIP Plugs and Caps	50	EA	\$ 1,600.00	\$ 80,000.00	\$ 84,000.00
6" DIP Water Main	325	LF	\$ 48.00	\$ 15,600.00	\$ 16,380.00
6"x6" DIP Tee	2	/ton	\$ 1,000.00	\$ 100.00	\$ 105.00
8" C-900 PVC Water Main (Assumed to be 0 to 6 feet in depth)	420	LF	\$ 32.00	\$ 13,440.00	\$ 14,112.00
8" DIP 45° Bend	2	/ton	\$ 1,000.00	\$ 80.00	\$ 84.00
8" DIP 90° Bend	2	/ton	\$ 1,000.00	\$ 110.00	\$ 115.50
8" DIP Gate Valve	4	EA	\$ 1,576.00	\$ 6,304.00	\$ 6,619.20
8" DIP Plugs and Caps	1	/ton	\$ 1,000.00	\$ 20.00	\$ 21.00
8" DIP Water Main	45	LF	\$ 99.00	\$ 4,455.00	\$ 4,677.75

Figure 7: Material Cost - Part 1

8"x6" DIP Reducer	4	/ton	\$ 1,000.00	\$ 130.00	\$ 136.50
8"x6" DIP Tee	2	/ton	\$ 1,000.00	\$ 120.00	\$ 126.00
8"x8" DIP Tee	2	/ton	\$ 1,000.00	\$ 130.00	\$ 136.50
Cut-In and Connect to Existing 4" to 12" Water Main	35	EA	\$ 1,500.00	\$ 52,500.00	\$ 55,125.00
Cut-In and Connect to Existing 2" to 3" Water Main	25	EA	\$ 1,500.00	\$ 37,500.00	\$ 39,375.00
Fire Hydrant Assemblies	20	EA	\$ 1,527.00	\$ 30,540.00	\$ 32,067.00
Bacteriological Sample Points	30	EA	\$ 329.00	\$ 9,870.00	\$ 10,363.50
1" Single, Short Water Services	16	EA	\$ 1,200.00	\$ 19,200.00	\$ 20,160.00
1" Single, Long Water Services	13	EA	\$ 1,200.00	\$ 15,600.00	\$ 16,380.00
2" Double, Short Water Services	21	EA	\$ 1,200.00	\$ 25,200.00	\$ 26,460.00
2" Double, Long Water Services	5	EA	\$ 1,200.00	\$ 6,000.00	\$ 6,300.00
Deflections Under Unforeseen Utility Conflicts	2	EA	\$ 2,000.00	\$ 4,000.00	\$ 4,200.00
Point Repairs for Sanitary Sewer Mains	10	EA	\$ 5,000.00	\$ 50,000.00	\$ 52,500.00
Point Repairs for Sanitary Sewer Laterals	20	EA	\$ 5,000.00	\$ 100,000.00	\$ 105,000.00
Remove Existing Fire Hydrant Assemblies	12	EA	\$ 1,200.00	\$ 14,400.00	\$ 15,120.00
Cut, Cap, Grout, and Abandon Existing Water Main	7630	LF	\$ 12.50	\$ 95,375.00	\$ 100,143.75
1" Type SP-9.5 Asphalt Milling and Resurfacing	10875	SY	\$ 16.00	\$ 174,000.00	\$ 182,700.00
4" Thick Sidewalk	100	LF	\$ 50.00	\$ 20,000.00	\$ 21,000.00
Asphalt Driveway Restoration	934	SF	\$ 35.60	\$ 33,250.40	\$ 34,912.92
Concrete Driveway Restoration	1	EA	\$ 66.40	\$ 66.40	\$ 69.72
Type F Curb and Gutter Replacement	38	LF	\$ 28.30	\$ 1,075.40	\$ 1,129.17
Asphalt Speed Tables	2	EA	\$ 7,950.00	\$ 15,900.00	\$ 16,695.00
Remove and Replace Bollards	7	EA	\$ 2,920.00	\$ 20,440.00	\$ 21,462.00
Solid Traffic Stripe (24" White) - Thermoplastic	454	LF	\$ 7.40	\$ 3,359.60	\$ 3,527.58
Solid Traffic Stripe (12" White) - Thermoplastic	246	LF	\$ 2.44	\$ 600.24	\$ 630.25
Solid Traffic Stripe (6" Double Yellow) - Thermoplastic	1500	LF	\$ 1.22	\$ 1,830.00	\$ 1,921.50
Solid Traffic Stripe (6" White) - Thermoplastic	65	LF	\$ 1.22	\$ 79.30	\$ 83.27
Solid White Arrow - Thermoplastic	1	EA	\$ 300.00	\$ 300.00	\$ 315.00
Retro-Reflective Pavement Markers	132	EA	\$ 7.40	\$ 976.80	\$ 1,025.64
Single Post with Signs and Plaques (up to 12 SF total)	3	EA	\$ 350.00	\$ 1,050.00	\$ 1,102.50
Brick Paver Crosswalks and Speed Tables	93	SY	\$ 113.00	\$ 10,509.00	\$ 11,034.45
Removal of Existing Pavement Markings and Signage	1	LS	\$ 5,000.00	\$ 5,000.00	\$ 5,250.00
Landscape Removal	1	LS	\$ 10,000.00	\$ 10,000.00	\$ 10,500.00
Contingency	1	LS	\$ 25,000.00	\$ 25,000.00	\$ 26,250.00
<b>TOTAL</b>				<b>\$ 1,542,373.71</b>	<b>\$ 1,619,492.40</b>

Figure 8: Material Cost - Part 2

## Equipment Cost

Using the information from RS Means and sample bid sheets of few companies, the cost information for the required equipment was collected. This information was then used to create an educated estimate of how much the contractor would spend on each equipment for all the required tasks of the project.

During cost estimation, it is important to take into account the charges involved when completing every task. This process includes the equipment for each task, the cost of each equipment, and the work output that can be done with given equipment. The information about which equipment might be required for completing each task was gathered from "RS Means Building

Construction Cost Data" and adjusted depending on the continuity of the project. The prices of the equipment were calculated assuming an **8-hour workday** as shown below.

Trenching				
Equipment	Number of Equipment	Daily Cost	Number of days needed	Total Cost
Backhoe	1	\$416.12	28	\$11,651.36
Hydraulic Hammer	1	\$180.40	14	\$2,525.60
Pickup Truck	1	\$62.42	3	\$187.25
Bull Dozer	1	\$1,831.00	14	\$25,634.00
Well Point Groundwater	1	\$200.00	0	\$0.00
		\$242.82		\$2,712.85
Pipelaying				
Equipment	Number of Equipment	Daily Cost	Number of days needed	Total Cost
Backhoe	1	\$416.12	14	\$5,825.68
Pickup Truck	1	\$123.16	2	\$246.32
Laser level	1	\$25.94	0	\$0.00
S.P. Crane	1	\$475.84	14	\$6,661.78
Saws	1	\$57.77	5	\$288.86
		\$1,098.83		\$13,022.64
Concrete				
Equipment	Number of Equipment	Daily Cost	Number of days needed	Total Cost
Flatbed Truck	1	\$202.00	2	\$404.00
Pickup Truck	1	\$123.16	2	\$246.32
		\$325.16		\$650.32
Asphalt				
Equipment	Number of Equipment	Daily Cost	Number of days needed	Total Cost
Pickup Truck 3/4 tons	2	\$246.32	5	\$1,231.59
Screed	1	\$790.63	3	\$2,371.88
Paver	2	\$291.28	4	\$1,165.14
Flated Truck	1	\$208.06	4	\$832.24
Rollers	2	\$665.79	3	\$1,997.38
Front end loader	1	\$444.51	12	\$5,334.13
Sweeper	1	\$409.05	2	\$818.10
		\$2,646.59		\$12,932.36
Curb and Gutter				
Equipment	Number of Equipment	Daily Cost	Number of days needed	Total Cost
Pickup Truck 3/4 tons	1	\$123.16	4	\$492.64
Flatbed Truck	1	\$208.06	2	\$416.12
Curbing Machine	1	\$249.67	3	\$749.02
Air Compressor	1	\$223.51	2	\$447.03
Small Tractor	1	\$328.25	3	\$984.75
Air Pressure Tamper	1	\$37.60	2	\$75.20
		\$1,170.26		\$3,164.75
Estimated Total Equipment Cost =		\$5,483.66		\$32,482.93

Figure 9: Equipment Cost

As the daily cost of equipment is based on an 8-hour workday, hourly prices for smaller equipment and heavy machinery were obtained from RS Means Cost Data.

- **Backhoe** is used to dig trenches for piping, levelling, and loading material with placement
- **Excavators** are used to dig trenches for piping
- **Front End Loaders** are used for the movement and placement of material
- **Graders** are used for leveling road subgrade or dirt roads, grade cutting, and ditching
- **Dump Trucks** are used for dumping and hauling various objects
- **Rollers** are used for compaction
- **Crane** is a machine used to lift and move heavy loads
- **Curbing Machines** are used for the automatic laying of curbs and gutters
- **Bulldozer** is used to move the dirt by pushing
- **Forklifts** are used for unloading materials such as steel
- **Asphalt grinder** is used for pavement repairs and utility jobs

### Crew Cost

A perfect crew needs to be chosen in order to complete a task based on the requirement. This crew must consist of skilled workers and labors. Proper construction management project must consist of diligent planning and task delegation.

By hiring the right crew, the productivity of the project will be maximized, and the overall cost can be minimized. When a crew is not operating at full potential, the project will be extended, thus increasing the overall cost of the project very drastically in certain cases. For this reason, it is very important that for every task, the right crew is hired, and the right manager is present to ensure that everything is going as planned.

The crew involves **Laborer, Supervisor, Foreman, Engineer, Pipelayer, Equipment operator, Bricklayer** etc., The below given table displays the crews required and overall labor cost to complete the project provided an 8-hour workday.

Trenching				
Crews	Number of Workers	Daily Cost	Number of days needed	Total Cost
Foreman	1	\$220.18	14	\$3,082.52
Laborers	1	\$208.06	13	\$2,704.78
Pipe Filters	1	\$238.36	18	\$4,290.48
		\$666.60		\$10,077.78
Pipelaying				
Crews	Number of Workers	Daily Cost	Number of days needed	Total Cost
Supervisor	1	\$220.18	5	\$1,100.90
Labores	2	\$258.98	32	\$8,287.49
Equipment Operator	1	\$180.35	30	\$5,410.37
Pipe Layer	2	\$291.28	12	\$3,495.41
		\$950.79		\$18,294.17
Concrete				
Crews	Number of Workers	Daily Cost	Number of days needed	Total Cost
Foreman	1	218.16	5	\$1,090.80
Laborers	4	533.28	21	\$11,198.88
Form Carpenters	2	\$307.04	16	\$4,912.64
Concrete Finishers	2	\$1,186.95	23	\$27,299.90
		\$1,493.99		\$32,212.54
Asphalt				
Crews	Number of Workers	Daily Cost	Number of days needed	Total Cost
Supervisor	1	\$220.18	3	\$660.54
Paving Machine Operator	1	\$181.09	4	\$724.37
Scree Operator	1	\$181.09	3	\$543.28
Roller Operator	1	\$181.09	3	\$543.28
Asphalt Pavers	2	\$339.36	4	\$1,357.44
Asphalt Laborers	4	\$520.15	4	\$2,080.60
Flag Guy	1	\$129.49	6	\$776.95
		\$1,622.97		\$5,909.51
Curb and Gutter				
Crews	Number of Workers	Daily Cost	Number of days needed	Total Cost
Supervisor	1	\$220.18	2	\$440.36
Concrete Finisher	1	\$593.48	2	\$1,186.95
Bricklayer	1	\$372.89	6	\$2,237.35
Bricklayer helper	1	\$307.44	6	\$1,844.66
Laborers	3	\$399.96	3	\$1,199.88
		\$1,893.95		\$6,909.21
Estimated Total Crew Cost =		\$6,628.31	\$73,403.20	

Figure 10: Crew Cost

## Scheduling

Every contractor must adhere to the project schedule and keep all the activities on track, to ensure that the project gets completed within the given time. So, a schedule needs to be prepared for every project, in which all the required tasks will be listed out along with the number of days needed to complete the individual ones and which tasks are dependent on others.

The overall project schedule was developed using the Microsoft product, **MS Project** software. Based on the schedule that was developed for the entire project, the anticipated duration for completing all the work activities is about **106 days**, which is approximately **4 months**. The involved activities/tasks with its duration and predecessors were given as input, in order to obtain early start, early finish, late start, late finish, free float, total float and the critical path using the MS Project.

TASK	EQUIPMENT	CREW
Apply for Permits		Office Managemnt
Order Materials		Office Managemnt
Install Silt Fence and Erosion Control Devices		Laborer
Remove Existing Structure	Backhoe	Equipment Operator, Labor Foreman
Clear and Grub the Site	Bull Dozer	Equipment Operator, Labor Foreman
Rough Grade the Site	Bull Dozer	Equipment Operator, Laborer
Excavate Pipe Trenches for Waterline	Hydraulics Excavator	Equipment Operator, Laborer
Place Pipe Bedding Material	Backhoe	Supervisor, Equipment Operator, Labor, Backhoe Loader
Install DIP Watermain Pipes, Bends and Tees		Labor Foreman, Laborer, Apprentice, Skilled Labor
Install Gate Valves		Labor Foreman, Laborer, Skilled Worker
Install Fire Hydrants Assemblies	S.P. Crane	Equipment Operator, Labor Foreman, Laborer
Inspect and Test Pipe Assemblies		
Backfill and Compact Pipe Trenches per Specs	Bull Dozer, Vibratory Roller	Equipment Operator, Laborer
Install Line Stops	Hydraulic Ram	
Pavement Removal		
Pavement Restoration	Backhoe	Equipment Operator, Labor Foreman
Driveway Removal	Grader	Cement Finisher, Equipment Operator, Laborer
Final Grade Roadway		Laborer
Install Base Rock	Grader, Truck Tractor	Equipment Operator, Laborer, Truck Driver
Install Forms for Curbs	Bull Dozer, Grader	Supervisor, Equipment Operator, Labor Foreman
Pour Concrete Curbs	Grader	Carpenter Foreman, Carpenter, Labor Foreman
Concrete Cure Time and Remove Forms		Cement Finisher, Laborer
Form Cast for speed bump		
Pour concret for speed bump		Carpenter Foreman, Carpenter
Lay Asphalt for Sidewalks		Cement Finisher, Laborer
Install Forms for Sidewalks	Asphalt Paver	Equipment Operator, Labor Foreman, Laborer
Pour concrete for Sidewalks		Carpenter Foreman, Carpenter
Concrete Cure Time and Remove Forms	Grader	Cement Finisher, Labor Foreman, Equipment Operator
Install Sod and Root Barrier		
Install Sidewalk Pavers and Driveway		Garderner
Install Detectable Warnings		Bricklayer, Bricklayer helper
Site Clean Up		Labor Foreman, Laborer, Skilled Worker
Project Completion		Engineer, Contractor, FDOT

Figure 11: Equipment and Crew based on tasks

Type	Resources	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Equipment	Asphalt Paver														x		
	Backhoe	x	x							x		x					
	Bull Dozer	x					x										
	Cement Finisher																
	Grader									x	x		x				
	Hydraulic Excavator								x								
	Paving Machine																
	Premium Roller																
	Roller																
	S.P.Crane							x	x								
	Skilled Worker																
	Trandem Roller																
	Truck										x			x			
	Truck Tractor											x					
	Vibratory Roller							x									
	Water Tank Trailer																

Figure 12: Equipment based on weeks

Crew	Apprentice		x														x
	Bricklayer																x
	Bricklayer Helper																x
	Backhoe Loader			x													
	Carpenter Foreman										x	x	x				
	Carpenters									x	x	x					
	Cement Finisher								x	x	x						
	Common Laborers																
	Equipment Operator	x	x	x				x		x	x	x		x			
	Equipment Operator Oiler																
	Gardener													x			
	Labor Foreman	x	x	x		x	x		x	x		x		x		x	
	Laborer	x	x	x	x	x	x			x	x	x	x	x	x	x	x
	Office Management	x	x														
	Plumber																
	Plumber Apprentice																
	Rodman																
	Skilled Labor/Worker				x		x								x		
	Supervisor				x	x				x			x		x		x
	Truck Driver								x								

Figure 13: Crew based on weeks

## Critical Path Method

Once a monetary value and days required are determined, a schedule could be created to estimate the total time to complete the project. Creating a schedule is an extremely important part of any kind of construction project because it shows when and what all tasks/ activities of a project needs to be done. This scheduling can be done using the Critical Path Method as shown in the figures under “Task schedule”.

### Task Schedule

A way of making the construction project more efficient would be introducing “**Fast tracking**” to it. It allows the contractor to group certain tasks together which can be done simultaneously. Fast tracking results in estimation of **shorter time period** to complete the project.



Figure 14: CPM - Part 1

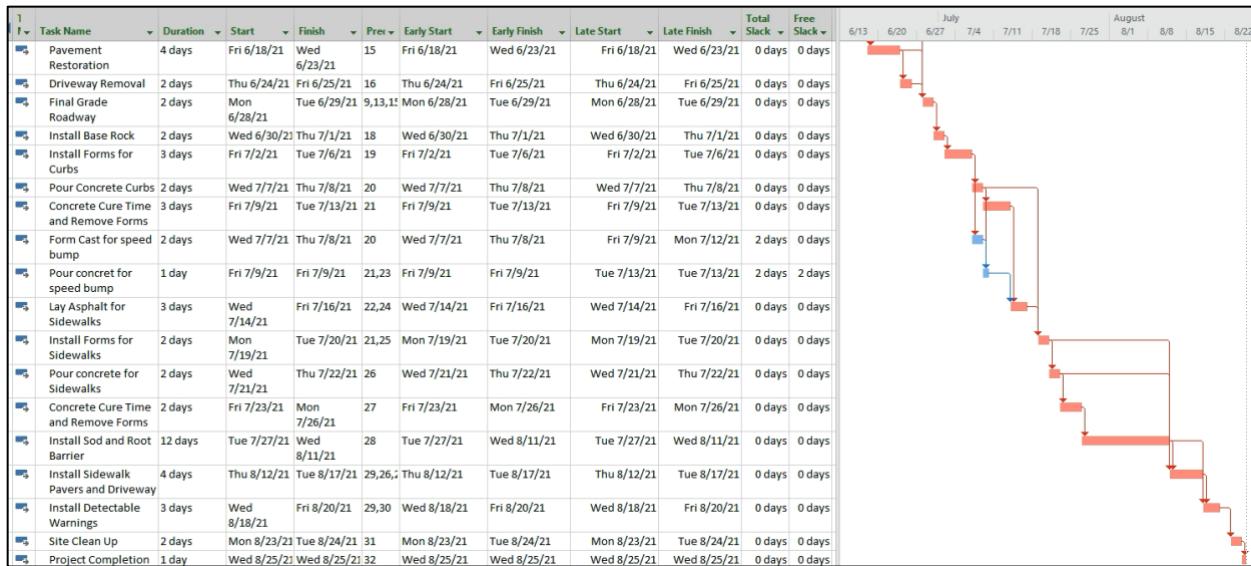


Figure 15: CPM - Part 2

## Draw Schedule

A proper **draw schedule** was developed based on the work breakdown schedule of all the activities, created bid prices after grouping the items and the duration of the tasks based on the project schedule. Below is the draw schedule for the water main replacement project.

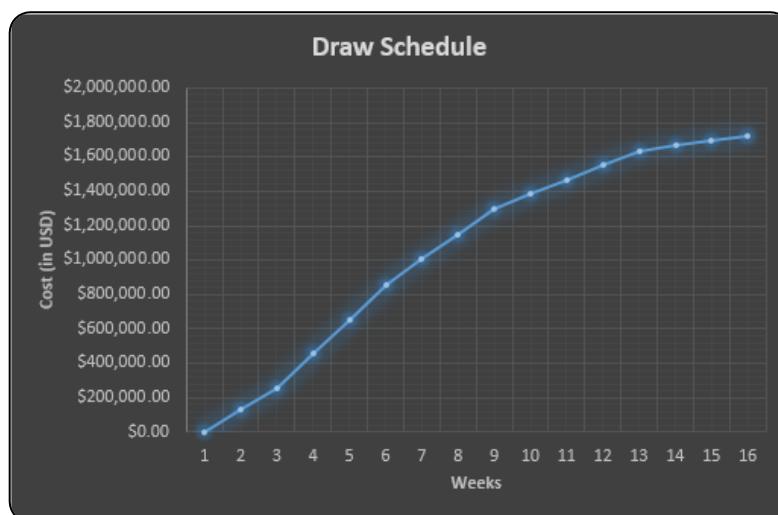


Figure 16: Draw Schedule

## Project Bid

Using the RS Means pricing data for materials, furnished and installed, equipment, machinery, apparatus and labor, the total cost of all of these were added up and used to create a bid proposal for the water main replacement project. Contracts and bids for similar projects were used along with certain online resources such as Florida Department of Transportation (**FDOT**), ALTORFER (**CATERPILLAR**), to obtain the best pricing for the project.

After addressing all the components of a construction project such as material, equipment and crew, the bid sheet is being created. The final draft of the cost was created using MS Excel, which includes the price of completing every task in the water main replacement project at Dania Beach. The final price list for material cost includes **5%** increase in order to adjust for inflation.

ITEMS	COST
<b>Materials</b>	\$ 1,619,492.40
<b>Equipment</b>	\$ 32,482.93
<b>Labor</b>	\$ 73,403.20
<b>TOTAL</b>	<b>\$ 1,725,378.53</b>

## Results and Discussion

The final bidding price to install a **12"** diameter water main in the city of Dania Beach is **\$1,725,378.53** and it is projected to last **106 days** or about **4 months**. In the case that there are any unforeseen problems or subsurface conditions such as rain delays, the option of fast tracking or schedule crashing can be implemented to maintain the schedule on track. **Fast tracking** would require certain tasks that would normally be in series to be conducted in parallel whereas, **Schedule crashing** involves recruiting additional resources to increase the productivity of the project. After compounding all the costs that come into play in completing the project, the final bid price is **\$1,725,378.53**, of which **\$32,482.93** is planned to be spent towards the equipment necessary for the tasks of the project, and **\$73,403.20** is to be paid to all the laborers.

## Conclusion

After analyzing the overall price per unit using “RS Means Building Construction Cost Data”, some sample bid sheets and other online resources, a total bid was created to present to the city of Dania Beach. In overall, this water main replacement project provided an opportunity to our group to experience working as a contractor and thereby providing a bid that includes equipment, labor, and materials cost. In spite of having less experience in creation of a bid, this project enabled us to learn the true complexity and proficiency required to complete a proper bidding project in the construction field.

## Appendix A - Sample bid sheets

Bid No. PNC2117583C1						Giannetti Contracting Corp.		Ric-Man Construction Inc.		David Mancini & Sons Inc.	
Item #	Item	Qty	Unit	Price	Total	Price	Total	Price	Total	Price	Total
PNC2117583C1--01-29	Remove and Dispose of Existing Sanitary Sewer Pipe	42300	linear foot	\$ 0.25	\$ 10,575.00	\$ 4.00	\$ 169,200.00	\$ 9.00	\$ 380,700.00		
PNC2117583C1--01-30	Remove and Dispose of Existing Sanitary Sewer MAS	200	each	\$ 400.00	\$ 80,000.00	\$ 413.00	\$ 82,600.00	\$ 900.00	\$ 180,000.00		
PNC2117583C1--01-31	Remove and Dispose of Existing Sewer Lateral and Cleanout	1100	each	\$ 1.00	\$ 1,100.00	\$ 3.00	\$ 3,300.00	\$ 360.00	\$ 396,000.00		
PNC2117583C1--01-32	Abandon and Grout Existing Sanitary Sewer Lateral and Cleanout	20	each	\$ 267.00	\$ 5,340.00	\$ 400.00	\$ 8,000.00	\$ 686.00	\$ 13,720.00		
PNC2117583C1--01-33	Remove and Dispose of Existing Air Release Valve and Structure	2	each	\$ 3,600.00	\$ 7,200.00	\$ 3,500.00	\$ 7,000.00	\$ 1,896.00	\$ 3,792.00		
PNC2117583C1--01-34	Abandon and Grout Existing Sanitary Sewer Pipe	5500	linear foot	\$ 5.00	\$ 27,500.00	\$ 3.00	\$ 16,500.00	\$ 9.00	\$ 49,500.00		
PNC2117583C1--01-35	Abandon and Grout Existing Sanitary Sewer MAS	12	each	\$ 250.00	\$ 3,000.00	\$ 575.00	\$ 6,900.00	\$ 2,560.00	\$ 30,720.00		
PNC2117583C1--01-36	Abandon and Grout Existing Forcemain (includes cut and cap ex)	4700	linear foot	\$ 4.00	\$ 18,800.00	\$ 13.00	\$ 61,100.00	\$ 9.00	\$ 42,300.00		
PNC2117583C1--01-37	Abandon Existing Water Mains (smaller than 4 inch)	2100	linear foot	\$ 1.00	\$ 2,100.00	\$ 1.00	\$ 2,100.00	\$ 5.20	\$ 10,920.00		
PNC2117583C1--01-38	Abandon and Grout Existing 4 inch Water Main (includes cut and cap ex)	12900	linear foot	\$ 1.30	\$ 16,770.00	\$ 1.50	\$ 19,350.00	\$ 4.40	\$ 56,760.00		
PNC2117583C1--01-39	Abandon and Grout Existing 6 inch Water Main (includes cut and cap ex)	19600	linear foot	\$ 2.80	\$ 54,880.00	\$ 2.00	\$ 39,200.00	\$ 7.60	\$ 148,960.00		
PNC2117583C1--01-40	Abandon and Grout Existing 8 inch Water Main (includes cut and cap ex)	23000	linear foot	\$ 3.70	\$ 85,100.00	\$ 3.00	\$ 69,000.00	\$ 8.90	\$ 204,700.00		
PNC2117583C1--01-41	Abandon and Grout Existing 10 inch Water Main (includes cut and cap ex)	3400	linear foot	\$ 5.45	\$ 18,530.00	\$ 4.50	\$ 15,300.00	\$ 12.75	\$ 43,350.00		
PNC2117583C1--01-42	Abandon and Grout Existing 12 inch Water Main (includes cut and cap ex)	1900	linear foot	\$ 7.00	\$ 13,300.00	\$ 6.00	\$ 11,400.00	\$ 16.50	\$ 31,350.00		
PNC2117583C1--01-43	Abandon and Grout Existing 24 inch Water Main (includes cut and cap ex)	320	linear foot	\$ 29.55	\$ 9,456.00	\$ 22.00	\$ 7,040.00	\$ 34.00	\$ 10,880.00		
PNC2117583C1--01-44	Remove Existing ACP Water Main	1200	linear foot	\$ 19.00	\$ 22,800.00	\$ 40.00	\$ 48,000.00	\$ 38.00	\$ 45,600.00		
PNC2117583C1--01-45	Remove Existing 24 inch DIP Water Main	105	linear foot	\$ 355.00	\$ 37,275.00	\$ 30.00	\$ 3,150.00	\$ 10.30	\$ 1,081.50		
PNC2117583C1--01-46	Remove and Salvage Existing Fire Hydrant Assembly	80	each	\$ 350.00	\$ 28,000.00	\$ 925.00	\$ 74,000.00	\$ 465.00	\$ 37,200.00		
PNC2117583C1--01-47	Furnish and Install Line Stop	20	each	\$ 5,000.00	\$ 100,000.00	\$ 4,745.00	\$ 94,900.00	\$ 5,500.00	\$ 110,000.00		
PNC2117583C1--01-48	Remove and Dispose of Existing Drainage Structure	10	each	\$ 1,450.00	\$ 14,500.00	\$ 560.00	\$ 5,600.00	\$ 900.00	\$ 9,000.00		
PNC2117583C1--01-49	Remove and Dispose of Existing Drainage Pipe	500	linear foot	\$ 25.00	\$ 12,500.00	\$ 10.00	\$ 5,000.00	\$ 12.00	\$ 6,000.00		

Figure 17: Appendix A 1

David Mancini & Sons Inc.		Lanzo		Man Con Inc.		Ric-Man Construction Florida Inc.		IBT Construction LLC		RIC-MAN INTERNATIONAL	
Price	Total	Price	Total	Price	Total	Price	Total	Price	Total	Price	Total
\$ 9.00	\$ 380,700.00	\$ 5.00	\$ 211,500.00	\$ 11.75	\$ 497,025.00	\$ 12.00	\$ 507,600.00	\$ 16.50	\$ 697,950.00	\$ 7.70	\$ 325,710.00
\$ 900.00	\$ 180,000.00	\$ 1,039.00	\$ 207,800.00	\$ 844.00	\$ 168,800.00	\$ 947.00	\$ 189,400.00	\$ 427.00	\$ 85,400.00	\$ 930.00	\$ 186,000.00
\$ 360.00	\$ 396,000.00	\$ 27.00	\$ 29,700.00	\$ 193.00	\$ 212,300.00	\$ 152.50	\$ 167,750.00	\$ 178.00	\$ 195,800.00	\$ 270.00	\$ 297,000.00
\$ 686.00	\$ 13,720.00	\$ 577.00	\$ 11,540.00	\$ 183.00	\$ 3,660.00	\$ 459.00	\$ 9,180.00	\$ 8,180.00	\$ 230.00	\$ 4,600.00	
\$ 1,896.00	\$ 3,792.00	\$ 877.00	\$ 1,754.00	\$ 970.00	\$ 1,940.00	\$ 3,602.00	\$ 7,204.00	\$ 614.00	\$ 1,228.00	\$ 1,400.00	\$ 2,800.00
\$ 9.00	\$ 49,500.00	\$ 7.00	\$ 38,500.00	\$ 5.80	\$ 31,900.00	\$ 8.37	\$ 46,035.00	\$ 9.20	\$ 50,600.00	\$ 22.00	\$ 121,000.00
\$ 2,560.00	\$ 30,720.00	\$ 1,672.00	\$ 20,064.00	\$ 775.00	\$ 9,300.00	\$ 1,506.00	\$ 18,072.00	\$ 483.00	\$ 5,796.00	\$ 890.00	\$ 10,680.00
\$ 9.00	\$ 42,300.00	\$ 9.00	\$ 42,300.00	\$ 7.30	\$ 34,310.00	\$ 6.15	\$ 28,905.00	\$ 9.70	\$ 45,590.00	\$ 19.00	\$ 89,300.00
\$ 5.20	\$ 10,920.00	\$ 6.00	\$ 12,600.00	\$ 3.70	\$ 7,770.00	\$ 17.90	\$ 37,590.00	\$ 2.70	\$ 5,670.00	\$ 1.10	\$ 2,310.00
\$ 4.40	\$ 56,760.00	\$ 5.00	\$ 64,500.00	\$ 4.20	\$ 54,180.00	\$ 4.30	\$ 55,470.00	\$ 7.70	\$ 99,330.00	\$ 2.80	\$ 36,120.00
\$ 7.60	\$ 148,960.00	\$ 6.00	\$ 117,600.00	\$ 4.40	\$ 86,240.00	\$ 5.04	\$ 98,784.00	\$ 8.80	\$ 172,480.00	\$ 5.70	\$ 111,720.00
\$ 8.90	\$ 204,700.00	\$ 7.00	\$ 161,000.00	\$ 5.50	\$ 126,500.00	\$ 6.55	\$ 150,650.00	\$ 9.20	\$ 211,600.00	\$ 8.80	\$ 202,400.00
\$ 12.75	\$ 43,350.00	\$ 9.00	\$ 30,600.00	\$ 7.10	\$ 24,140.00	\$ 8.98	\$ 30,532.00	\$ 11.60	\$ 39,440.00	\$ 13.00	\$ 44,200.00
\$ 16.50	\$ 31,350.00	\$ 10.00	\$ 19,000.00	\$ 10.00	\$ 19,000.00	\$ 12.36	\$ 23,484.00	\$ 11.60	\$ 22,040.00	\$ 18.00	\$ 34,200.00
\$ 34.00	\$ 10,880.00	\$ 20.00	\$ 6,400.00	\$ 26.00	\$ 8,320.00	\$ 47.40	\$ 15,168.00	\$ 28.10	\$ 8,992.00	\$ 66.00	\$ 21,120.00
\$ 38.00	\$ 45,600.00	\$ 93.00	\$ 111,600.00	\$ 28.00	\$ 33,600.00	\$ 17.70	\$ 21,240.00	\$ 20.00	\$ 24,000.00	\$ 12.00	\$ 14,400.00
\$ 10.30	\$ 1,081.50	\$ 18.00	\$ 1,890.00	\$ 47.00	\$ 4,935.00	\$ 44.70	\$ 4,693.50	\$ 15.50	\$ 1,627.50	\$ 53.00	\$ 5,565.00
\$ 465.00	\$ 37,200.00	\$ 926.00	\$ 74,080.00	\$ 761.00	\$ 60,880.00	\$ 766.60	\$ 61,328.00	\$ 417.00	\$ 33,360.00	\$ 620.00	\$ 49,600.00
\$ 5,500.00	\$ 110,000.00	\$ 11,693.00	\$ 233,860.00	\$ 1,260.00	\$ 25,200.00	\$ 7,235.30	\$ 144,706.00	\$ 14,000.00	\$ 280,000.00	\$ 9,400.00	\$ 188,000.00
\$ 900.00	\$ 9,000.00	\$ 1,299.00	\$ 12,990.00	\$ 1,385.00	\$ 13,850.00	\$ 2,837.50	\$ 28,375.00	\$ 602.00	\$ 6,020.00	\$ 1,100.00	\$ 11,000.00
\$ 12.00	\$ 6,000.00	\$ 21.00	\$ 10,500.00	\$ 20.50	\$ 10,250.00	\$ 19.00	\$ 9,500.00	\$ 31.40	\$ 15,700.00	\$ 21.00	\$ 10,500.00
\$ 9,000.00	\$ 9,000.00	\$ 24,919.00	\$ 24,919.00	\$ 7,065.00	\$ 7,065.00	\$ 17,658.00	\$ 6,880.00	\$ 6,880.00	\$ 113,000.00	\$ 113,000.00	
\$ 59.00	\$ 902,700.00	\$ 45.00	\$ 688,500.00	\$ 62.50	\$ 956,250.00	\$ 44.00	\$ 673,200.00	\$ 48.40	\$ 740,520.00	\$ 52.00	\$ 795,600.00
\$ 73.00	\$ 1,022,000.00	\$ 56.00	\$ 784,000.00	\$ 83.10	\$ 1,163,400.00	\$ 56.50	\$ 791,000.00	\$ 55.00	\$ 770,000.00	\$ 69.00	\$ 966,000.00
\$ 84.00	\$ 747,600.00	\$ 58.00	\$ 516,200.00	\$ 96.50	\$ 858,850.00	\$ 79.50	\$ 707,550.00	\$ 75.00	\$ 667,500.00	\$ 78.00	\$ 694,200.00

Figure 18: Appendix A 2

## Appendix B - Similar project bid

Price Analysis						
Bid No. PNC2117583C1						
Utility Analysis Zone 110-111						
				Giannetti Contracting Corp.		
Item #	Item	Qty	Unit	Unit Price	Total	
PNC2117583C1--01-01	Performance and Payment Guarantee and Insurance	1	lump sum	\$ 500,000.00	\$ 500,000.00	
PNC2117583C1--01-02	Mobilization	1	lump sum	\$ 2,663,568.00	\$ 2,663,568.00	
PNC2117583C1--01-03	Maintenance of Traffic	1	lump sum	\$ 300,000.00	\$ 300,000.00	
PNC2117583C1--01-04	Furnish and Install Temporary Emergency Access Way	50000	linear foot	\$ 0.20	\$ 10,000.00	
PNC2117583C1--01-05	Additional Compensation for Excavation in Hard Rock	1000	linear foot	\$ 1.00	\$ 1,000.00	
PNC2117583C1--01-06	Remove and Dispose of Existing Concrete	8100	square yard	\$ 8.00	\$ 64,800.00	
PNC2117583C1--01-07	Remove and Dispose of Existing Asphalt Pavement	160000	square yard	\$ 1.50	\$ 240,000.00	
PNC2117583C1--01-08	Mill Existing Asphalt Pavement	15000	square yard	\$ 2.30	\$ 34,500.00	
PNC2117583C1--01-09	Remove Existing Limerock Base Material	160000	square yard	\$ 1.30	\$ 208,000.00	
PNC2117583C1--01-10	Remove and Dispose of Existing Speed Hump	13	each	\$ 275.00	\$ 3,575.00	
PNC2117583C1--01-11	Remove and Dispose of Existing Speed Table	11	each	\$ 275.00	\$ 3,025.00	
PNC2117583C1--01-12	Remove and Replace Existing Fencing	1800	linear foot	\$ 34.00	\$ 61,200.00	
PNC2117583C1--01-13	Remove and Replace Existing Wall	500	linear foot	\$ 100.00	\$ 50,000.00	
PNC2117583C1--01-14	Remove and Relocate Existing Mailboxes	5	each	\$ 500.00	\$ 2,500.00	
PNC2117583C1--01-15	Remove and Replace Existing Guardrail	90	linear foot	\$ 200.00	\$ 18,000.00	
PNC2117583C1--01-16	Remove and Replace Existing Metal Hand Rail	20	linear foot	\$ 100.00	\$ 2,000.00	
PNC2117583C1--01-17	Remove and Relocate Existing Signs	260	each	\$ 200.00	\$ 52,000.00	
<b>Chen Moore and Associates Estimate Date 8/31/18</b>						
Unit Price	% Difference					
\$ 880,000.00	-76.00%					
\$ 880,000.00	66.96%					
\$ 1,470,000.00	-390.00%					
\$ 5.00	-2400.00%					
\$ 15.00	-1400.00%					
\$ 10.00	-25.00%					
\$ 3.50	-133.33%					
\$ 5.00	-117.39%					
\$ 2.50	-92.31%					
\$ 250.00	9.09%					
\$ 500.00	-81.82%					
\$ 25.00	26.47%					
\$ 200.00	-100.00%					
\$ 100.00	80.00%					
\$ 70.00	65.00%					
\$ 50.00	50.00%					
\$ 300.00	-50.00%					

Figure 19: Appendix B 1

PNC2117583C1--01-118	Valve	1	each	\$ 28,827.00	\$ 28,827.00	\$ 13,000.00	54.90%
PNC2117583C1--01-119	Furnish and Install 24 inch x 20 inch Tapping Sleeve and Valve	1	each	\$ 31,443.00	\$ 31,443.00	\$ 14,000.00	55.47%
PNC2117583C1--01-120	Cut and Connect to Existing Water Main	31	each	\$ 5,537.00	\$ 171,647.00	\$ 4,000.00	27.76%
PNC2117583C1--01-121	Furnish and Install 6 inch Insertion Valve	2	each	\$ 7,650.00	\$ 15,300.00	\$ 6,000.00	21.57%
PNC2117583C1--01-122	Furnish and Install 8 inch Insertion Valve	10	each	\$ 8,750.00	\$ 87,500.00	\$ 7,000.00	20.00%
PNC2117583C1--01-123	Furnish and Install 12 inch Insertion Valve	2	each	\$ 13,250.00	\$ 26,500.00	\$ 9,000.00	32.08%
PNC2117583C1--01-124	Furnish and Install 4 inch Gate Valve	2	each	\$ 1,077.00	\$ 2,154.00	\$ 1,000.00	7.15%
PNC2117583C1--01-125	Furnish and Install 6 inch Gate Valve	300	each	\$ 1,204.00	\$ 361,200.00	\$ 1,200.00	0.33%
PNC2117583C1--01-126	Furnish and Install 8 inch Gate Valve	106	each	\$ 1,576.00	\$ 167,056.00	\$ 1,500.00	4.82%
PNC2117583C1--01-127	Furnish and Install 10 inch Gate Valve	6	each	\$ 2,119.00	\$ 12,714.00	\$ 2,400.00	-13.26%
PNC2117583C1--01-128	Furnish and Install 12 inch Gate Valve	13	each	\$ 2,252.00	\$ 29,276.00	\$ 2,850.00	-26.55%
PNC2117583C1--01-129	Furnish and Install 18 inch Gate Valve	1	each	\$ 8,530.00	\$ 8,530.00	\$ 3,200.00	62.49%
PNC2117583C1--01-130	Furnish and Install 20 inch Gate Valve	1	each	\$ 10,966.00	\$ 10,966.00	\$ 4,000.00	63.52%
PNC2117583C1--01-131	Furnish and Install 24 inch Gate Valve	1	each	\$ 15,300.00	\$ 15,300.00	\$ 5,000.00	67.32%
PNC2117583C1--01-132	Furnish and Install Air Release Valve	4	each	\$ 10,310.00	\$ 41,240.00	\$ 8,000.00	22.41%
PNC2117583C1--01-133	F& Single 5/8 inch Water Meter Box Water Service in Casing and Relocate Meter	94	each	\$ 1,145.00	\$ 107,630.00	\$ 1,600.00	-39.74%
PNC2117583C1--01-134	F& Single 5/8 inch Water Meter Box Water Service and Relocate Meter	93	each	\$ 990.00	\$ 92,070.00	\$ 1,500.00	-51.52%
PNC2117583C1--01-135	F& Double 5/8 inch Water Meter Box Water Service in Casing and Relocate Meter	215	each	\$ 1,976.00	\$ 424,840.00	\$ 2,800.00	-41.70%
PNC2117583C1--01-136	F& Double 5/8 inch Water Meter Box Water Service and Relocate Meter	203	each	\$ 1,696.00	\$ 344,288.00	\$ 2,500.00	-47.41%
PNC2117583C1--01-137	F& Single 1 inch Water Meter Box Water Service in Casing and Relocate Meter	10	each	\$ 1,193.00	\$ 11,930.00	\$ 1,600.00	-34.12%

Figure 20: Appendix B 2

## Appendix C - Bids from various companies

*Figure 21: Appendix C*

## Appendix D - FDOT Unit Cost

Florida Department of Transportation Item Average Unit Cost From 2018/06/01 to 2019/05/31								Page: 2
Contract Type: CC AREAS: 12	Displaying: VALID ITEMS WITH HITS							
From: 0102 1 To: 9999999								
Item	No. of Conts	Weighted Average	Total Amount	Total Quantity	Unit Meas	Obs?	Description	
0102911 1	7	\$2.34	\$47,717.25	20,410.000	LF	N	PAVT MARKING REMOVABLE TAPE,WH BLK,SKIP	
0102911 2	11	\$2.63	\$194,103.00	73,870.000	LF	N	PAVT MARKING REMOVABLE TAPE,WH BLK,SOLID	
0102912 2	8	\$2.48	\$53,098.83	21,444.000	LF	N	PAVT MARKING REMOVABLE TAPE,YELLOW,SOLID	
0104 1	1	\$9.50	\$26,533.50	2,793.000	SY	N	ARTIFICIAL COVERINGS / ROLL EROSION CNTL	
0104 7	1	\$2,550.00	\$7,650.00	3.000	EA	N	SEDIMENT BASIN / CONTAINMENT SYSTEM	
0104 9	2	\$390.00	\$5,850.00	15.000	EA	N	SEDIMENT BASIN / CONTAINMENT SY CLEANOUT	
0104 10 3	28	\$1.46	\$480,562.57	328,264.000	LF	N	SEDIMENT BARRIER	
0104 11	16	\$18.64	\$647,461.03	34,742.000	LF	N	FLOATING TURBIDITY BARRIER	
0104 12	3	\$3.71	\$20,504.86	5,528.000	LF	N	STAKED TURBIDITY BARRIER- NYL REINF PVC	
0104 15	6	\$3,456.64	\$110,612.50	32.000	EA	N	SOIL TRACKING PREVENTION DEVICE	
0104 18	33	\$119.87	\$273,539.60	2,282.000	EA	N	INLET PROTECTION SYSTEM	
0107 1	27	\$14.11	\$279,708.33	19,819.820	AC	N	LITTER REMOVAL	
0107 2	26	\$17.64	\$256,440.34	14,539.640	AC	N	MOWING	
0108 1	19	\$10,068.71	\$231,580.31	23.000	LS	N	MONITOR EXISTING STRUCTURES- SETTL	
0108 2	14	\$10,710.60	\$182,080.25	17.000	LS	N	MONITOR EXISTING STRUCTURES- VIBRA	
0110 1 1	36	\$11,853.39	\$6,596,885.53	556.540	AC	N	CLEARING & GRUBBING	
0110 2 2	15	\$18,456.71	\$363,597.26	19.700	AC	N	SELECTIVE CLEARING AND GRUBBING, TREES R	
0110 2 3	1	\$10,000.00	\$122,100.00	12.210	AC	N	SELECTIVE CLEARING AND GRUB, PLANT PRES	
0110 3	11	\$23.41	\$2,906,496.98	124,157.000	SF	N	REMOVAL OF EXISTING STRUCTURES/BRIDGES	
0110 4 10	32	\$21.56	\$1,94,155.12	90,194.000	SY	N	REMOVAL OF EXIST CONC	
0110 7 1	6	\$167.57	\$11,730.00	70.000	EA	N	MAILBOX, F&I SINGLE	
0110 12 1	1	\$4,280.00	\$166,920.00	39.000	SY	N	HYDRODEMOLITION, REM OF DECK SURFACE	
0110 71 1	2	\$361.95	\$314,531.25	869.000	LF	N	BRIDGE FENDER SYSTEM, REMOVAL & DISPOSAL	
0120 1	25	\$6.55	\$3,401,754.77	519,690.900	CY	N	REGULAR EXCAVATION	
0120 2 2	4	\$21.83	\$58,030.19	2,657.700	CY	N	BORROW EXCAVATION, TRUCK MEASURE	
0120 4	4	\$10.02	\$145,120.00	14,478.000	CY	N	SUBSOIL EXCAVATION	
0120 5	4	\$12.37	\$247,648.50	20,023.400	CY	N	CHANNEL EXCAVATION	
0120 6	26	\$12.49	\$9,259,076.53	741,553.400	CY	N	EMBANKMENT	
0120 71	8	\$35,121.33	\$280,970.66	8.000	LS	N	REGULAR EXCAVATION (3-R PROJECTS ONLY)	
0120 72 10	1	\$70.00	\$855,400.00	12,220.000	CY	N	GRAVEL FILL- BERM, PROJECT 40614415201	
0145 2	6	\$5.63	\$465,280.01	82,576.000	SY	N	GEOSYNTHETIC REINF FND OVER SOFT SOIL	
0160 4	22	\$4.18	\$4,450,408.59	1,063,646.000	SY	N	TYPE B STABILIZATION	
0162 1 11	8	\$.53	\$156,302.64	295,818.000	SY	N	PREPARED SOIL LAYER, FINISH SOIL, 6"	
0210 2	1	\$25.00	\$28,472.50	1,138.900	CY	N	LIMEROCK-NEW MATERIAL FOR REWORKING BASE	
0285701	6	\$9.94	\$351,605.58	35,386.000	SY	N	OPTIONAL BASE,BASE GROUP 01	
0285702	3	\$8.78	\$99,390.00	11,324.000	SY	N	OPTIONAL BASE,BASE GROUP 02	
0285703	2	\$9.23	\$47,866.11	5,188.000	SY	N	OPTIONAL BASE,BASE GROUP 03	
0285704	5	\$13.28	\$263,495.92	19,841.000	SY	N	OPTIONAL BASE,BASE GROUP 04	
0285705	3	\$10.53	\$2,288,769.00	217,332.000	SY	N	OPTIONAL BASE,BASE GROUP 05	
0285706	5	\$12.01	\$302,687.84	25,207.000	SY	N	OPTIONAL BASE,BASE GROUP 06	

Figure 22: Appendix D

## Appendix E - AACE

2006 AACE International Transactions

Table 2—Rule-Bound Crew Mix

Pipe / Welding	No. A	Base Wage Rate B			Wage Mult A X B	Notes
Pipe Supt	0	31.50	0.00		(1a)	
Pipe GF	1	31.50	31.50		(3a)	
Area FM	1	30.50	30.50			
Pipe FM	3	30.25	90.75			
Welding FM	1	30.25	30.25			
Expediter	1	29.00	29.00		(1a)	
Document Cont.	0	0.00	0.00		(1a)	
Clerk	0	0.00	0.00		(1a)	
Pipefitters	7	29.00	203.00			
Pipefitter App 7th 6 mos	14	21.75	304.50			
Pipefitter App 2nd 6 mos	21	14.50	304.50			
Combo Welders	7	29.00	203.00			
Firewatch/Holewatch	10	19.62	196.20		(2a)	
Teamsters	2	21.75	43.50		(4a)	
Base Wage Rate	<b>68</b>	21.57	1466.70			
Notes						
(1a) Construction Indirect						
(2a) Assigned to Crew						
(3a) Construction Indirect						
(4a) Other Support (e.g.: bus drivers)						
Construction Service Labor	14	3.02				
Field Service Labor	16	3.45				
<b>Burden and Benefits</b>	<b>21</b>	4.53				
Fringes	53	11.43				
Temporary Services	9	1.94				
Small Tools	6	1.29				
Rental Equipment	30	6.47				
Inspection	5	1.08				
Consumables	7	1.51				
Overhead and Fee	15	3.24				
Premium Pay (overtime)	20	4.31				
Delay	7	1.51				
Scaffolding	15	3.24				
Total	218	47.02				
<b>All In Wage Rate</b>		<b>68.59</b>				

Table 3—Rule-Bound Crew Mix with No Apprentices

Pipe / Welding	No. A	Base Wage Rate B			Wage Mult A X B	Notes
Pipe Supt	0	31.50	0.00		(1b)	
Pipe GF	1	31.50	31.50		(3b)	
Area FM	1	30.50	30.50			
Pipe FM	3	30.25	90.75			
Welding FM	1	30.25	30.25			
Expediter	1	29.00	29.00		(1b)	
Document Cont.	0	0.00	0.00		(1b)	
Clerk	0	0.00	0.00		(1b)	
Pipefitters	7	29.00	203.00			
Pipefitter App 7th 6 mos	14	29.00	406.00		(5b)	
Pipefitter App 2nd 6 mos	21	29.00	609.00		(5b)	
Combo Welders	7	29.00	203.00		(5b)	
Firewatch/Holewatch	10	29.00	290.00		(2b)	
Teamsters	2	29.00	58.00		(4b)	
Base Wage Rate	<b>68</b>	29.13	1981.00			
Notes						
(1b) Construction Indirect						
(2b) Assigned to Crew						
(3b) Construction Indirect						
(4b) Other Support (e.g.: bus drivers)						
(5b) No Apprentices Available						
Construction Service Labor	14	4.08				
Field Service Labor	16	4.66				
<b>Burden and Benefits</b>	<b>21</b>	6.12				
Fringes	53	15.44				
Temporary Services	9	2.62				
Small Tools	6	1.75				
Rental Equipment	30	8.74				
Inspection	5	1.46				
Consumables	7	2.04				
Overhead and Fee	15	4.37				
Premium Pay (overtime)	20	5.83				
Delay	7	2.04				
Scaffolding	15	4.37				
Total	218	63.51				
<b>All In Wage Rate</b>		<b>92.64</b>				

Figure 23: Appendix E

## Appendix F - Equipment Capacity

### V. COMMON CONSTRUCTION EQUIPMENTS USED ON MOST CIVIL CONSTRUCTION SITES

Table 1. Major equipments used in road construction project

Sr. No.	Equipment Description	Capacity
1	3 Stage Crushing Plant	200 / 300 TPH
2	Asphalt Paver 9 MTR Width	9 Mtr
3	Asphalt Plant	160 /240 /300 TPH
4	Backhoe & Front End Loader	
5	Batching Plant 30 CUM/HR	30 & 60 Cum
6	Concrete Boom Placer 42 MTR	42 Mtr
7	Concrete Pump	45, 60, 74 Cum
8	Dozer Crawler Type 160 HP	160 HP
9	Excavator 1 CUM	1 & 1.75 Cum
10	Motor Graders 145 HP	145 HP
11	Pneumatic Tyre Roller (PTR) 22 TON	22 Ton
12	Tandem Roller 10 TON	10 Ton
13	Verious Types of Cranes	30 & 60 Ton
14	Tipper/Dumper - 25 TON	25 Ton
15	Transit Mixers 6 CUM	4 & 6 Cum
16	Vibratory Soil Compactor 12 TON	12 ton
17	Wet Mix Plant 200 TPH	200 H

Figure 24: Appendix F

## Appendix G - Cost of Equipment

**Table -2:** Monthly maintenance cost of equipment

S.No	Equipment	Amount
1	Excavator	₹ 14,500
2	Grader	₹ 24,000
3	Backhoe Loader	₹ 12,000
4	Loader	₹ 12,000
5	Soil Compactor	₹ 12,500
6	Tandem Roller	₹ 12,500
7	Tipper Truck	₹ 10,000
8	Paver	₹ 26,000
9	Hot Mix Plant	₹ 120,000

**Table -3:** Per hour fuel consumption

S.No	Equipment	Type of Fuel	Quantity
1	Excavator	Diesel(liters)	13 to 15
2	Grader	Diesel(liters)	20 to 21
3	Backhoe Loader	Diesel(liters)	10 to 12
4	Loader	Diesel(liters)	12
5	Soil Compactor	Diesel(liters)	20
6	Tandem Roller	Diesel(liters)	14 to 16
7	Tipper Truck	Diesel(liters)	10 to 13
8	Paver	Diesel(liters)	18 to 20
9	Hot Mix Plant	Electricity(KwH)	96 to 110

**Table -4:** Operator's wages and per hour insurance/taxes cost to be covered

S.No	Equipment	Operator's wages	Per hour cost for insurance and taxes
1	Excavator	₹ 16,000	₹ 370
2	Grader	₹ 24,000	₹ 600
3	Backhoe Loader	₹ 17,000	₹ 200
4	Loader	₹ 16,000	₹ 145
5	Soil Compactor	₹ 15,000	₹ 200
6	Tandem Roller	₹ 14,500	₹ 250
7	Tipper Truck	₹ 12,000	₹ 110
8	Paver	₹ 22,000	₹ 370
9	Hot Mix Plant	₹ 150,000	₹ 3500

**Table -5:** Life of equipment and repair provisions by IS 11590:1995

S.No	Equipment	Life in Year	Life in Hours	Percentage of Repair provisions
1	Excavator	10	12000	100%
2	Grader	10	30000	200%
3	Backhoe Loader	10	15000	200%
4	Loader	8	12000	200%
5	Soil Compactor	8	10000	100%
6	Tandem Roller	8	10000	100%
7	Tipper Truck	8	16000	175%
8	Paver	6	9000	200%
9	Hot Mix Plant	5	5000	100%

### 3.2 Results for O&O cost

Calculations performed for per hour O&O cost with the help of data given above gave following results represented in table-6.

**Table -6:** Per hour O&O cost

S.No	Equipment	Per hour O&O cost
1	Excavator	₹ 1,850
2	Grader	₹ 2,750
3	Backhoe Loader	₹ 1,550
4	Loader	₹ 1,300
5	Soil Compactor	₹ 1,700
6	Tandem Roller	₹ 1,500
7	Tipper Truck	₹ 1,000
8	Paver	₹ 3,150
9	Hot Mix Plant	₹ 17,000

### 3.3 Results for productivity

#### 3.3.1 Excavator

For bucket capacity of  $1.5\text{m}^3$ , fill factor 80% and cycle time of 30 seconds including loading bucket, swinging, dumping and return of bucket following calculation gave its per hour productivity;

*Figure 25: Appendix G*

## Appendix H - FDOT Costs

Florida Department of Transportation Item Average Unit Cost From 2019/05/01 to 2020/04/30 Statewide							
Market Area: 13 Contract Type: CC Displaying: VALID ITEMS WITH HITS From: 0102 1 To: 9999999							
Item	No. of Conts	Weighted Average	Total Amount	Total Quantity	Unit Meas	Obs?	Description
0337 7 80	2	\$209.15	\$56,116.26	268.300	TN	N	ASPHALT CONCRETE FRICTION COURSE,TRAFFIC B, FC-9.5, PG 76-22
0337 7 81	2	\$146.13	\$637,068.32	4,359.700	TN	N	ASPHALT CONCRETE FRICTION COURSE,TRAFFIC B, FC-12.5, PG 76-22
0337 7 82	12	\$148.03	\$3,337,461.16	22,545.800	TN	N	ASPHALT CONCRETE FRICTION COURSE,TRAFFIC C, FC-9.5, PG 76-22
0337 7 83	5	\$181.11	\$2,209,597.50	12,200.200	TN	N	ASPHALT CONCRETE FRICTION COURSE,TRAFFIC C, FC-12.5, PG 76-22
0337 7 85	6	\$160.96	\$937,966.25	5,827.500	TN	N	ASPHALT CONCRETE FRICTION COURSE,TRAFFIC D, FC-12.5, PG 76-22
0339 1	8	\$167.05	\$1,034,471.49	6,192.600	TN	N	MISCELLANEOUS ASPHALT PAVEMENT
0350 3 5	1	\$40.00	\$2,302,160.00	57,554.000	SY	N	PLAIN CEMENT CONCRETE PAVEMENT, 8"
0350 3 7	2	\$50.29	\$6,562,390.00	130,493.000	SY	N	PLAIN CEMENT CONCRETE PAVEMENT, 9"
0350 3 13	1	\$100.00	\$102,200.00	1,022.000	SY	N	PLAIN CEMENT CONCRETE PAVEMENT, 12"
0350 5	2	\$2.54	\$651,864.75	256,811.000	LF	N	CLEANING & SEALING JOINTS- CONCRETE PAVEMENT
0352 70	2	\$4.01	\$757,534.00	189,069.000	SY	N	GRINDING CONCRETE PAVEMENT
0370 1	1	\$55.00	\$24,365.00	443.000	LF	N	BRIDGE APPROACH EXPANSION JOINT FOR CONCRETE PAVEMENT
0400 0 11	2	\$697.81	\$1,405,884.60	2,014.700	CY	N	CONCRETE CLASS NS, GRAVITY WALL
0400 1 2	2	\$1,141.85	\$373,577.63	327.170	CY	N	CONCRETE CLASS I, ENDWALLS
0400 2 1	1	\$2,000.00	\$37,200.00	18.600	CY	N	CONCRETE CLASS II, CULVERTS
0400 2 2	2	\$1,566.34	\$188,587.20	120.400	CY	N	CONCRETE CLASS II, ENDWALLS
0400 2 4	2	\$759.05	\$13,172,598.00	17,354.100	CY	N	CONC CLASS II, BRIDGE SUPERSTRUCTURE
0400 2 10	2	\$381.41	\$1,471,080.00	3,857.000	CY	N	CONCRETE CLASS II, APPROACH SLABS
0400 2 11	1	\$350.00	\$2,765,000.00	7,900.000	CY	N	CONCRETE CLASS II, RETAINING WALLS
0400 3 20	2	\$1,349.06	\$575,510.00	426.600	CY	N	CONC CLASS III, SEAL

Figure 26: Appendix H 1

Florida Department of Transportation Item Average Unit Cost From 2019/05/01 to 2020/04/30 Statewide							
Market Area: 13 Contract Type: CC Displaying: VALID ITEMS WITH HITS From: 0102 1 To: 9999999							
Item	No. of Conts	Weighted Average	Total Amount	Total Quantity	Unit Meas	Obs?	Description
0515 1 1	1	\$52.50	\$68,722.50	1,309.000	LF	N	PIPE HANDRAIL - GUIDERAIL, STEEL
0515 1 2	3	\$41.30	\$122,426.00	2,964.000	LF	N	PIPE HANDRAIL - GUIDERAIL, ALUMINUM
0515 2311	1	\$38.00	\$14,820.00	390.000	LF	N	PEDESTRIAN/ BICYCLE RAILING, ALUMINUM ONLY,42' TYPE 1
0519 78	1	\$300.00	\$3,900.00	13.000	EA	N	BOLLARDS
0520 1 7	5	\$22.97	\$79,851.86	3,476.000	LF	N	CONCRETE CURB & GUTTER, TYPE E
0520 1 10	19	\$21.38	\$1,399,513.37	65,467.000	LF	N	CONCRETE CURB & GUTTER, TYPE F
0520 2 1	2	\$27.39	\$7,451.00	272.000	LF	N	CONCRETE CURB, TYPE A
0520 2 2	1	\$20.00	\$1,600.00	80.000	LF	N	CONCRETE CURB, TYPE B
0520 2 4	5	\$25.76	\$36,809.16	1,429.000	LF	N	CONCRETE CURB, TYPE D
0520 3	3	\$30.56	\$10,361.00	339.000	LF	N	VALLEY GUTTER- CONCRETE
0520 5 11	4	\$51.50	\$35,377.50	687.000	LF	N	TRAFFIC SEPARATOR CONCRETE-TYPE I, 4' WIDE
0520 5 12	1	\$73.50	\$808.50	11.000	LF	N	TRAFFIC SEPARATOR CONCRETE-TYPE I, 6' WIDE
0520 5 41	8	\$48.57	\$162,427.10	3,344.000	LF	N	TRAFFIC SEPARATOR CONCRETE- TYPE IV, 4' WIDE
0520 6	5	\$19.79	\$355,232.50	17,946.000	LF	N	SHOULDER GUTTER- CONCRETE
0520 70	6	\$59.34	\$138,624.10	2,336.000	SY	N	CONCRETE TRAFFIC SEPARATOR, SPECIAL- VARIABLE WIDTH
0521 1 11	3	\$104.59	\$397,354.30	3,799.000	LF	N	MEDIAN CONCRETE BARRIER, 38' HEIGHT
0521 1 12	2	\$144.34	\$6,460,990.00	44,762.000	LF	N	MEDIAN CONCRETE BARRIER, SHORT GRADE-SEPARATED
0521 1 13	2	\$295.09	\$5,223,620.00	17,702.000	LF	N	MEDIAN CONCRETE BARRIER, TALL GRADE-SEPARATED
0521 1 14	2	\$374.18	\$2,267,550.00	6,060.000	LF	N	MEDIAN CONCRETE BARRIER, VARIABLE SECTION WIDTH FOR SIGN OR PIER SHIELDING

Figure 27: Appendix H 2

## Appendix I - Equipment needed



*Figure 28: Backhoe*



*Figure 29: Front end loader*



*Figure 30: Excavator*



*Figure 31: Bulldozer*



*Figure 32: Tamp machine*



*Figure 33: Dump truck*



*Figure 34: Paving machine*



*Figure 35: Milling machine*



*Figure 36: Roller*



*Figure 37: SP Crane*

## Appendix J - Tasks of Project



*Figure 38: Trench line milling*



*Figure 39: Excavation of Trench*



Figure 40: Pipe Installation



Figure 41: Valve Installation



Figure 42: Fire hydrant assembly



Figure 43: Backfill and Compact



Figure 44: Pressure Test



Figure 45: Road Rock Installation



*Figure 46: Asphaltic concrete installation*



*Figure 47: Striping*

## References

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5. <https://www.altorfer.com/industry/pipeline/>
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