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Application of Critical Path Analysis in Scheduling of Small-Town Water Supply Scheme.

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Abstract

In Nigeria, most Capital Projects, especially Water Supply Projects, are chronically late in completion. This lateness lead to higher project costs, therefore the need to adequately plan these schemes cannot be over-emphasized. This research examined the application of the critical path method in scheduling small-town water schemes with focus on Ugbakele Water Project . The activities necessary for the execution of the project were identified. The activity durations were obtained from thirty respondents in Edo and Delta States to structured research questionnaires. These were collated and analysed. The critical path for the project was identified from the network activities that relate to the construction of the elevated water tank and chain link fencing of the pump yard. Computations from the network showed that the project duration was about six months. The earliest start and latest start time of events computed helped in resource allocations.

1. Introduction

There is always the need to minimize project cost or project duration. Time is money. it is said in parochial terms. Time is certainly critical where a penalty clause applies for late completion of construction work. In some cases, there is definite incentive for early completion, such as prices and or award of another contract. Difficulties of price fluctuations/claims, resulting from inflation, abandonment of projects, and inability of contractors to collect payment due to change of government or personnel managing the project. Delays in the completion time of infrastructure project is averted with adequate planning. Before the advent of Critical Paths Method (CPM), probably the best-known way of trying to plan construction was by means of bar or Gantt chart. Although this has been extremely useful in many cases, it suffers from inability to show the inter relationship between the various activities. Thus, it is not possible to deduce from a Gantt chart that activity X must be complete before activity Y can be started or that a delay between activity Y and activity Z is permissible but not essential.

In small projects, this is not serious, as the planner can remember the various links between activities but in large projects such feats of memory are impossible and the Gantt charting techniques is then of limited value. Comprehensive planning is required in order to prevent misallocation of resources or mismanagement in resource development [1;2] .

Apart from inadequate planning of the execution of projects, there are other causes of lateness[3] Late arrival of drawings, details and levels even when prior notice of these requirements is given. For example, lateness of construction of elevated water tank could be due to late submission of foundation drawings This can lead to delay in the entire project.

Other causes of lateness are: opening up of work for inspection or testing e.g. inspection of submersible pump by the client before installation. Discrepancies between drawing and contract bill e.g. the length and size of pipeline.

Additional work (variation) when carried out, will sometime have the effect of lengthening the contract period. Delays where no payment is warranted. Where this type of delay occurs, there is a justification for extending the project completion time to the contractor.

In the use of more than one contractor, when one contractor working for the employer fails to complete his work in time and will delay another contractor. For example, the contractor constructing the generator house could delay the supplier of the generator. Delay can be caused by change in design: Although drawings are issued before construction commences, altered portion of the works upset and delay contractors' work. Every project that has to be undertaken must have a deadline for it completion but not every project goes as schedule. Hence, applications of scientific method such as CPM, PERT are often very useful in project management and scheduling [3]. Both models (CPM and PERT) represent an activity, either by an arrow (in the activity-on-arc mode of representation) or by a node (in the activity-on-node mode of representation), and represent precedence by the direction of the arrow in the first mode, and by an arrow linking the nodes in the second mode of representation. The difference between the two models lies in the attempt of PERT to take cognizance at the outset of the fact that activity durations are random variables.[4] The major advantage of the CPM is the clear identification of the critical and non-critical activities which helps in the diversion of construction resources when necessary especially when there are delays in critical activities [5] Although many organizations worldwide have utilized it as an effective technique, its potential for planning water resources has not yet been completely realized [1].

One important technique for production scheduling and planning is the critical path method (CPM) [6]. A project management method used in the project planning process is the Critical Path Method, also known as Critical Path Analysis [7]. It is a type of planning algorithm [8]. It is the path with the longest total activity duration that allows the project to be finished quickly between the beginning and end points on a project network [9].

A project's critical path is the order of its constituent tasks that need to be completed on time in order for the project as a whole to be finished on schedule [10]. It is the total amount of work completed on this path exceeds that of any other path across the network; each activity delayed on the critical path causes a delay in the project [11].It is one effective way for cost-effectively scheduling engineering, construction, and other tasks [12]. The longest path in a process model yields the critical path [8]. The Critical Path approach is a heuristic that draws from graph theory, certain readjustment and activity length estimating processes, and an understanding of sophisticated procedures that it may assess [14]. Activity times are considered as if they were known with certainty when using CPM, which use a single estimate for activity time that do not allow for variation [13]. To avoid scheduling issues and process bottlenecks, it is used as a methodical project management approach for process planning that identifies key and non-critical tasks [15].Thus, the longest path in a network is used to predict total time using the critical path method.

This study aims to apply critical path analysis in the scheduling of small-town water supply schemes by identifying (1) the sequence of activities and their dependencies within the water supply project. (2) the critical path and non-critical activities (4) the most crucial tasks that can impact the overall project timeline. (4) delays, and suggest corrective actions to keep the project on course.

The chain of activities that takes the longest time to complete determines the earliest time by which a project can be completed. This time is often known as the project time or project duration, but more commonly as the critical path [16] The critical path method (CPM) is interpreted as a path that has the longest total activity period during which the project must be completed in a short time between the starting point and end point on the project network.[17] The critical path method, according to [18] gives project managers the capacity to more easily stay within budget, schedule talent and resources effectively, monitor progress, avoid becoming overwhelmed by project management demands, monitor and report on project progress, and prevent scope creep.

A clear project plan can reduce lost time and resource costs by ensuring project completion on schedule. It allows for efficient allocation of resources, reducing inventory storage and minimizing busy or idle work. Project managers can effectively schedule workers by assigning tasks with float time, allowing those still learning to take their time, or assigning critical path tasks without buffer time to more experienced workers. The critical path method simplifies project management by breaking down complex projects into smaller steps, allowing project managers to manage resources, finances, and talent more effectively. It helps project managers allocate resources effectively by determining task completion times and resource requirements, enabling them to allocate resources efficiently and prioritize urgent tasks over waiting ones. It also allows project managers to monitor progress using lucid charts in software, dividing the project into manageable segments and providing a checklist for tracking progress and determining completion time. Project managers use project management software charts to determine a project's critical path, resource availability, and completion schedule in real-time, providing clear, concise reporting for instant download and real-time updates. Project managers can identify scope creep by analyzing deviations from the critical path, allowing them to implement change management strategies before it escalates into a spiraling issue.

2. Materials and Methods

2.1 Study Area

Small towns are settlements with about 5,000 to 20,000 inhabitants [19] .Ugbakele , a community in Ethiope West Local Government Area (LGA) of Delta state of Nigeria.is a typical small town . Ethiope West LGA is one of the 25 LGAs in Delta State with its administrative headquarter in Oghara. It includes other communities of Atiwor, Boboroku, Edjeba, Eghvwa, Ibada, Idjedaka, Jessa, Mosogar, Oghobaye, Okinigho, Edjemuon, Okuagbaye, Ugbevbe, Egbeku etc (Figure 1)

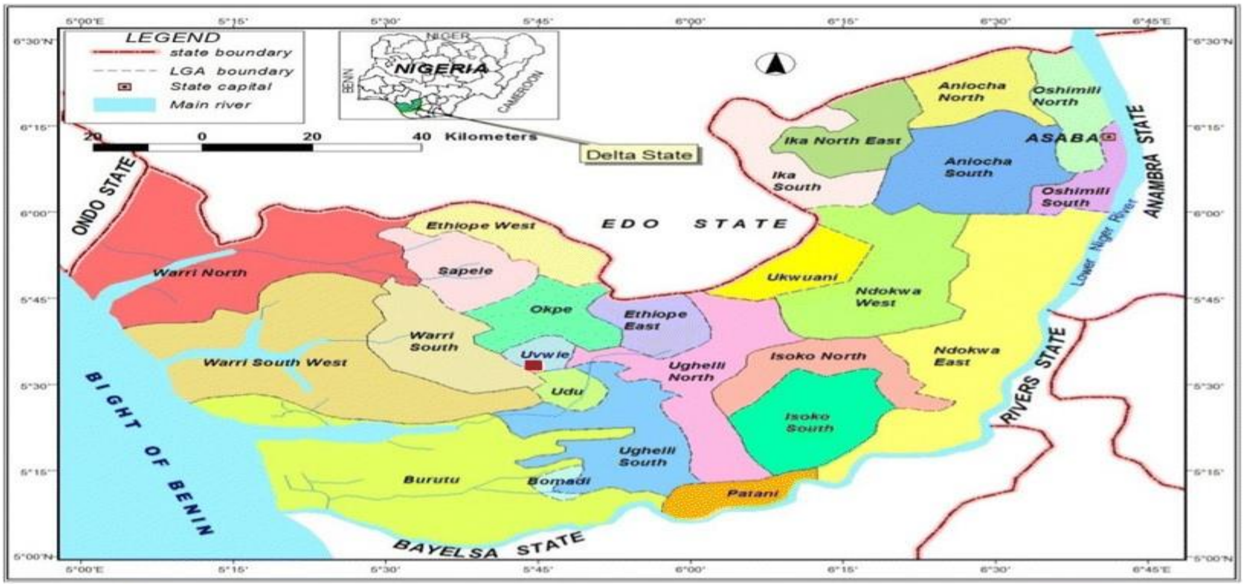

Figure 1 : Map of Delta State, Nigeria, showing Local Government Areas and the location of the study area (Source: [20]

2.2 Method

The following general format for analysing data for use in the critical path method [21] was utilized in this study:

1) Identification and Listing of the activities in numerical order
2) Determination of duration of each activity.
3) Filling in the earlier start tine, which is the earliest time for the proceeding event.
4) Calculating the earliest finished time, which is the earliest start time plus activity duration.
5) Filling in the latest finished time, which is the latest time for the succeeding event.
6) Calculating the latest start time, which is the latest finished time minus the activity duration.

(7) Calculating the total float, which is either the latest start time minus the earliest start time or alternatively the latest finished time minus the earlier finished time – critical activities have no float.

2.2. 1 Listing of Activities:

In the determination of the sequence of activities, the usual site operational consideration are as listed below:

(1) Geophysical survey reveals the possibility of obtaining water from the chosen location. The report also shows probable the depth and yield of the aquifer to be tapped as well as the water quality. The project can only be embarked upon if the survey report shows promising results.

(2) Water borehole drilling rig and elevated water tank erection crane cannot be on site at the same time because of space consideration. These two operations normally involve two different types of working team. It is always advised that the later team moves to site as the former demobilizes.

(3) During the borehole drilling operation, the construction of the pump house and the foundation for the elevated water tank can be executed simultaneously.

(4) The elevated water concrete foundation must gain strength for at least twenty-one days before the elevated tank is erected.

(5) Water treatment plant may not be necessary for all projects. The need for it is determined from the water quality analysis of activity and geophysical report activity. Hence the foundation works for the plant would be executed when the test results of the water sample analysis indicate the need of a treatment plant.

(6) The chain-link fencing would not be done until the completion of the elevated water tank and the erection crane is demobilized from site. This is to avoid damage to fencing poles when the crane is dismantled or to have a good, free work environment during tank erection.

After the completion of the system (borehole, treatment plant, elevated water tank and distribution network) the scheme is normally test-run for two weeks before the project is commissioned.

2.2.2 Determination of the duration of each activity

The activity durations were obtained from thirty respondents in Edo and Delta States to the research questionnaire

In consideration of the type of project and its function, the following research questions were generated:

(1) What are the activities necessary for the execution of micro water works?
(2) Are these activities related to each other?
(3) Which activity precedes the other?
(4) How do we obtain realistic time and cost estimates for each activity?
(5) What is the overall completion time for the project
(6) Which activity can be reduced at least cost by reducing the project duration by a certain amount?

2.2.3 Filling in the Earliest (Es) and Earliest Finish (Ef) Time

Each activity has the earliest start and finish times, expressed in days for our project. A forward pass through the network determines them. We begin with activities 1-2 and set the ES to zero, the start of the project. The EF for the activity is equal to its ES plus its duration t.

Thus, the EF for activity 1-2 is

$$EF_{t-2} = ES_{t-2} + t_{1-2} \quad (1)$$

2.2.4 Latest Start and Latest Finish

Each network activity also has a Latest Start (LS) and a Latest Finish (LF) time, again expressed in days for our project. Value for LS and LF were obtained by a backward pass through the network.

2.2.5 Activity Float Time:

Float time in CPM, is the amount of time an activity may be delayed without delaying the project schedule, usually changes as the project progresses.

The formal calculation of the float time would be done in three steps:

Computation of Earliest Start (ES) and Earliest Finish (EF) Time.

Computation of Latest Start and Latest Finish Time

Float calculation.

Values for this computation are in table 4

_A zero float indicates that the activity is on the critical path A negative slack means that the activity is late. Not only is this possible, it is almost the norm, at least for critical path activities. It is so rare for projects to be on time.

Free float is a path of total float and represents the amount of spare time which can be used without affecting subsequent activities providing the activity starts and its earliest time. It is calculated by:

* Earliest Succeeding Event Time – Earliest Preceding Event – Activity Duration.

Interfering float is the amount of spare time available which if used, will affect subsequent activities and may be calculated by: total float- free float.

Independent float is the amount of spare time available which can be used without affecting any succeeding activity and which cannot be affected by any preceding activity. The calculation is:

* Earliest succeeding event time – lasts preceding event time – activity

If additional resources were required on a critical activity they could be obtained from (reference)

(1) Activity with impendent float without affecting the rest of the network at all.

(2) Activity with free float without affecting the float of the subsequent activities.

(3) Activities with interfering float only, which will affect the activity of the float of previous and subsequent activities.

If only the total float is calculated, as in this project, this may include independent, free and interfering float. It should be noted that critical activity has no float. Float sorting or listing activities in order of their degree of slack. Critical path activities have the least slack and therefore appear first, near critical activities usually from more than one path, appear next and so on .The slack sorted computer listing helps a manager more than a network does. Indeed, most manager rely on this type of listing and never need to see a network. This table is used as a means of controlling the project.

2. 2.6 Construction of Network

The network construction is started by finding those activities that have predecessors Table2 shows all the activities and their durations (obtained from collation of expected execution time extracted from questionnaire)) and their immediate predecessors. In Table 2, activities 1-2 have no predecessor. Hence, it was drawn from the starting node 1. Next, the activities that have only activity 1-2 as its predecessor is sort for. These are activities 2-3, 2-25 and 3-42. These three activities are drawn from node 2. In the same way, the network is completed. The data presented in Table 1 enables the Network (Figure. 2) to be drawn.

Table 1: Path Analysis

PATH NO	**PATH.**																
1	1	2	3	9	10	11	12	13	14	15	16	17	18	19	20	21	51
2	1	2	3	9	10	11	12	13	14		36	37	38	39	40	33	51

3	1	2	3	4	5	6	7	8	48	49	50	51			
4	1	2	3	4	5	6	7	8	34	35	48	49	50	51	
5	1	2	25	26	27	28	29	30	31	48	49	50	51		
6	1	2	42	43	44	45	46	48	49	50	51				
7	1	2	42	43	44	45	46	34	35	48	49	50	51		
8	1	2	25	26	27	28	29	30	31	32	33	51			
9	1	2	3	23	24	26	27	28	29	30	31	48	49	50	51
10	1	2	3	23	24	26	27	28	29	30	31	32	33	51	

3. Result of Critical Path Analysis

In critical path analysis, we need to examine all the path that can be taken from the start to the finish of the project. A close examination of the network (Figure2) shows that there are ten possible paths. These are listed in Table 2

Table: 2 Path Duration

Path							Duration										
1	14	3	3	2	2	2	2	1	1	4	4	1	2	3	2	=	48
2	14	3	3	2	2	2	2	1	2	4	2	1	1	2	14	=	55
3	14	3	7	14	3	2	1	5	3	2	3					=	57
4	14	3	7	14	2	1	4	28	5	3	2					=	89
5	14	4	21	3	1	14	21	4	3	2	3					=	90
6	14	4	8	4	4	2	5	3	2	3						=	54
7	14	4	8	4	4	2	5	4	28	5	3	2	3			=	86
8	14	4	21	3	1	14	21	4	1	3	14					=	100
9	14	3	2	14	21	3	1	14	21	4	3	2	3			=	105
10	14	3	2	14	21	3	1	14	21	4	1	3	14			=	115

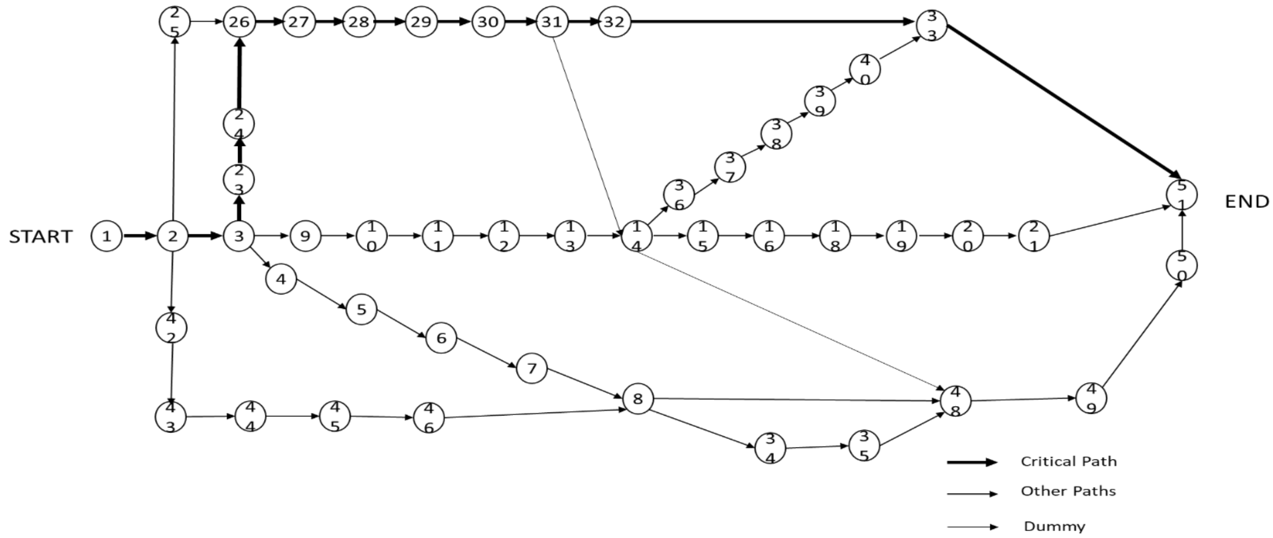

Figure2: Constructed Network

Table 3: Tabular Presentation of Networks

Activity Number	Activity	Duration Days	Earliest		Latest		Total Float
			Start	Finish	Start	Finish	
1-2	Geophysical Survey	14	0	14	0	14	0
2-3	Site preparation	3	14	1 7	14	17	0
3-4	Mobilization of drilling equipment, men and material to site	7	17	24	81	88	64
4-5	Set up of equipment, drilling to depth, casing and gravel packing	14	24	38	88	102	64
5-6	Borehole development	3	38	41	102	105	64
6-7	Pump testing and water sample analysis	2	41	43	105	107	64
7-8	Submersible pump Installation with riser pipes	1	43	44	107	108	64
8-9	Mobilization of building equipment, men and materials to site	3	17	20	77	80	60
9-10	Setting out of building and bulk excavation	2	20	22	80	82	60
10-11	Construction of column footing and wall foundation	2	22	24	82	84	60
11-12	Block work and RC column to DPC	2	24	26	84	86	60
12-13	Filling with laterite and hard core	2	26	28	86	88	60
13-14	Concreting of floor slab	1	28	29	88	89	60
14-15	Block work, frames and lintels	7	29	36	90	97	61
15-16	Roofing ceiling	4	36	40	97	101	61
16-17	Wall platering and rendering	4	40	44	101	105	61
17-18	Floor screeding	1	44	45	105	106	61
18-19	Fixing of doors, windows and protectors	2	45	47	106	108	61
19-20	Pumping (installation of WC, wash hand basin, completion of septic tank and soakaway)	3	47	50	108	111	61
20-21	Pumping house wiring	2	50	52	111	113	61
21-51	Painting	2	52	54	113	115	61
3-23	Setting out of tower base and excavation	2	17	19	17	19	0
23-24	Construction of reinforced concrete foundation with tower hold down bolts	14	19	33	19	33	0
24-26	Concrete gains strength	21	33	54	33	54	0
2-25	Purchase of steel tank and tower materials	4	14	18	29	33	15
25-26	Corrugation of steel plates and preparation of tower elements in workshop	21	18	39	33	54	15

26-27	Mobilization of welding machine, erecting equipment, men and materials to site	3	54	57	54	57	0
27-28	Setting up of erection equipment	1	57	58	57	58	0
28-29	Erecting of tower – stanchions, brazing's, beams, cat way and ladder	14	58	72	58	72	0
20-30	In-stitu welding of steel tank and internal brazing	21	72	93	72	93	0
20-31	Tank pipe-work	4	93	97	93	97	0
31-32	Installation of work level indicator	1	97	98	97	98	0
32-33	painting	3	9	101	98	101	0
33-51	Pumping testing of scheme	14	101	115	101	115	0
8-34	Foundation works for plant	4	44	48	72	76	28
34-35	Supply and installation of work treatment plant on site	28	48	76	76	104	28
35-48	Connection of treatment plan to EWT borehole	3	76	79	104	107	28
14-36	Construction of generator bed	2	29	37	89	91	60
36-37	Supply and installation of 27KVA generator / power backup equipment	4	31	35	91	95	60
37-38	Supply and installation of armoured cables	2	35	37	95	97	60
38-39	Construction of control equipment frames	1	37	38	97	98	60
39-40	Supply and installation of TP & M, Switch gear etc	1	38	39	98	99	60
40-33	Connection of pump house and to NEPA via change over switch	2	39	41	99	101	60
2-42	Bush clearing over right of way for pipe line for 1 kilometre	4	14	18	81	85	67
42-43	Pipeline evacuation for the distance	8	18	26	85	93	67
43-44	Supply and delivery to site UPVC pressure pipes of specified diameter	4	26	30	93	97	67
44-45	Slinging of pipes and backfilling after laying	4	30	34	97	101	67
45-46	Supply and installation of pipe accessories (tea, bends, valves, endcap and end thrust)	2	34	36	101	103	67
46-8	Construction of required standard tap sand	5	36	41	103	108	67
8-48	Connection of elevated water tank to pipeline and elevated water tank and to borehole riser pipes	5	97	102	102	107	5
48-49	Supply to site and erection of concrete fencing poles for a perimeter of about 120 metres	3	102	105	107	110	5
49-50	Supply and installation of two leaf gates	2	105	107	110	112	5
50-51	Supply and installation of chain link fencing for the premises	3	107	110	112	115	5

The next stage is to add up the duration for all activities in each path as in Table 4 in the whole project

The most time-consuming path is the critical path. The path is time critical because a delay in completing any of its activities delays As can be seen in Table 4, path 10 is critical. Several other paths 4, 5, 7 and 9 are nearly critical at 86 – 105 days.

The critical and nearly critical path activities deserve close managerial attention. Other activities have slack or float time and need not be managed so closely. The slacker, the more flexibility managers have in scheduling activities.

3.1 Event Scheduling

Event scheduling, the assigning of dates to events in the final network, follows selection of time-cost alternatives. The final activity times, with holidays and weekends considered, form the basis for event dates.

In the project under consideration, the critical path duration is 115 days. This is the project duration period. Recognizing the fact that there are five working days in a week. This duration is about 147 days from the start of the project or approximately 5 months.

In signing the Agreement for the project, the contractor is normally required to provide performance bond from banks or insurance companies to be able to obtain mobilization fee or equipment advance.

The period for obtaining the bond and being paid for the first certificate is about 14 days depending on the efficiency of the accounting department of the sponsor of the project.

Also, some times when a portion of the job has been executed and the contractor makes a request for a second payment. It sometimes takes about 14 days for the contractor to be paid for the certificate. Hence, unavoidable, delay or about 28 days or a month occur and this could lead to a project of six months

3.1 Earliest Start (Es) and Earliest Finish (Ef) Time

$EF_{t-2} = ES_{t-2} + t_{1-2}$

$= 0 + 14 = 14$ (or day 14)

The remainder of the ES and EF are shown in Fig. 1. The largest EF (115) is taken as the project duration.

3.2 Latest Start and Latest Finish

Beginning at Node 51, the project duration (EF_{33-51} =115) as the LF of all activities end on Nodes 51. Then, the LS for each activity is found by subtracting its duration (t) from its LF. For example, the LS for activity 50 – 51 is:

$LS_{50-51} = LF_{50-51} - t_{50-51}$

$= 115 - 3 = 112$ (or day 112)

And for activity 33 – 51

$LS_{33-54} = LF_{33-51} - t_{33-51}$

$= 115 - 14 = 101$ (or day 101) (See table 5)

3.4 Total Float (Slack) Calculation

Slack for each activity is simple LS – ES or LF – EF

For activity 50 – 51,

LS – ES = 112 – 10 = 5 days

3.5 Resource Allocation:

Resource allocation involves the levelling or smoothing of the resources requirements, the aim being to keep fluctuating requirements for labour and plants to a minimum. In doing this, the plan is transformed into a work schedule.

When drawing the arrow diagram and estimating the activity time, the availability of resources for the different activities was not limited and it was therefore assumed that they would be available as required. In some cases, however, the same resources may be required on different activities which will fall on parallel path in the Arrow diagram.

When allocating resources and smooth requirements activities can be moved within their float, but if after doing this demand for resources still exceed availability the project duration will have to be lengthened or some alternative method considered, e.g. working overtime.

A closer look at Table 4, reveals when a pre-arrangement can be made for borehole water drilling rig, the truck for moving the tank materials to site, the crane and welding machine for construction of the tank. Critical path analysis also help to making efficiency use of the manpower resources which are required to carry out the project. The number and specialization of the manpower can easily be worked out based on the time scale on Table 3.

3.6 Speeding Up (or Crashing) Activities

Sometimes it is necessary to consider speeding up the completion of activities (e.g. in order to meet a deadline). However, the extra cost incurred through speeding up activities (e.g. the payment of overtime to employees) need to be balanced against the costs of late completion (e.g. penalty cost in contract).

The first analysis of a network often results in excessive duration. The critical path method is extremely useful in highlighting those activities which must be examined in order to reduce the project duration. The aim is always to reduce the time required for the activity which are least cost to the project.

The following three ‘golden’ rules will be applied in this project:

(1) it is only worth speeding up critical activities (the other activities are not holding the project up).

(2) As the critical path is crashed, new critical paths may emerge from the near critical paths. Hence, more than one critical path may emerge. Activity duration on ach path must be reduced together (otherwise one of the paths will still be at its original length and the overall project duration will not be reduced).

(3) It is not work speeding up an activity if this will cost more than the savings which will be made by finishing the project earlier. Also when there is a choice of the activities to speed up, the selection is the cheapest alternative.

In line with the rules given above, if it is necessary to reduce the project duration, the following activities in the critical path may be considered:

(a) Geophysical Survey = 14 days

(b)	Construction of Tank Foundation	=	14 day
(c)	Site Erection of Tower	=	21 days
(d)	In-situ Welding of Tank	=	14 day

Crashing an early activity on the critical path such as geophysical survey is very wise. The reduction will apply to all other paths that could become critical later. Normally, for sedimentary formation, the filed work for geophysical survey is not more than two days. Data analysis, computation and interpretation could take four days. Hence, preliminary geophysical survey report could be submitted with seven days so that other activities can commence. The final report, which may be more elaborate and takes the remaining seven days to prepare could be submitted later.

Another activity that could be crashed early is the construction of the reinforced concrete foundation for the tank. This could be done by employing more hands on casual basis or payment of overtime to employee. This could lead to a savings of seven days, but money spent early is gone.

Alternatively, wait and see approach may be wisely adopted. Perhaps some critical path activities may be completed earlier than expected, thus averting the needs to crash at all. If this does not happen, late options for crashing activities such as erection of tower and in-situ welding of tank would need to be adopted which may be more costly

3.7 Discussions of Results.

Applicability of Critical Path Method to Micro Water Scheme: This study has revealed that critical path method can be applied to resolve that complexity that occur in planning micro water scheme construction where several activities are carried out simultaneously and the times to complete these activities are different. This is evidence from our ability to draw the network and tabulate presentation of the network.

Micro Water Scheme Project Duration: This study has shown that the duration for the above scheme is one hundred and fifteen days. This is approximately five months when weekends are added.

Project Critical Path: We have identified the critical path for this project. It is path 10 on Table 3. The activities that are in this path are listed on page 51. The near critical paths have been identified as path 4, 5, 7, 8 and 9

Crashing of Project: Presentation of preliminary geophysical survey report can help reduce this project duration by a week.

4. Conclusions

This study has shown that critical route approach should be used in planning and controlling to control the complexity faced in project execution. The critical path technique is a very helpful project management tool, particularly for micro-water works. One of the most precious resources, water is necessary for the formation and continuation of life as well as for growth and well-being. A plentiful supply of water is essential for advancement, a comfortable lifestyle, and the country's socioeconomic growth. The government has struggled to provide small towns with sufficient and clean water, even with massive expenditures allocated over the years. The completion of this project will be necessary to successfully complete this mission. For construction project managers, the

CPM's core function is to help everyone understand how individual tasks fit into the project schedule network and affect project duration. But that's not all they can gain from the CPM.

Project scheduling involves more than just assigning due dates to tasks. It also involves allocating tools and resources to the appropriate tasks. When these components are met, downtime is eliminated (e.g., waiting for workers to arrive). To ensure that materials arrive on schedule, procurement must also be organized ahead of time. (When supplies come earlier than expected, storage and maintenance expenses may increase.)

Although monitoring the critical path can assist guarantee that projects are completed on schedule, analyzing the critical path and implementing schedule compression strategies can actually shorten the project's overall duration. Perhaps because there are bottlenecks in the system, waiting for earlier tasks to be finished results in waste that can be avoided by using fast tracking and crashing. By increasing equipment or resources and understanding that a work may not always need to be finished in its entirety before moving on to a successor, proactive management can help eliminate some of these bottlenecks.
This research work should be guide to all contractors who will be engaged by the three tiers of Government for the execution of Small-Town Water Supply and Sanitation Programme (STWSSP).
The specified project duration time for the scheme under consideration should be six months.
Where possible water project consultancy teams should stay somewhat intact from project to project and should employ standard designs with quality and timing already established. Then lateness traceable to the consulting team would be overcome.

References

[1] Mussivand, T.(2007) Application of Critical Path Method to Water Resources Planning. Journal of the American Water Resources Association 8 (4):685 - 696 DOI: 10.1111/j.1752- 1688.1972.tb05210

[2] Handayani, W., and Ganistian, G.(2021) Application of Critical Path Method (CPM) and S-Curve on Scheduling Deep Water Well Pump Construction Project in Sorong, West Papua. In 1st Asia Pacific International Conference on Industrial Engineering and Operations Management, https://doi.org/10.46254/AP01.20210237.

[3] Danfulani U. B., Mohammed M., Reuben B. Z., Yakubu J. A., & Digil S. I. (2023). Application of Critical Path Method (CPM) To Optimal Project Scheduling: A Case Of Mosul Building Company, Yola North Local Government Adamawa State, Nigeria. Fudma Journal Of Sciences, 7(3), 186 - 192. Https://Doi.Org/10.33003/

[4] Elmaghraby, S.E and Meyers, R.A.(2003) Operations Research Encyclopedia of Physical Science and Technology (Third Edition), Academic Press, Pages 193-218, ISBN 9780122274107, https://doi.org/10.1016/B0-12-227410- 5/005 5.(https://www.sciencedirect.com/science/article/pii/B0122274105005135)

[5] Anyanwu, C. (2024). Project Cost Control in the Nigerian Construction Industry. International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org || Volume 2 Issue 12 PP.65-71

[6] Leachman, R. C. (1993.) A Revised Critical Path Method for Networks Including Both Overlap Relationships and Variable-Duration Activities‖ European Journal of Operational Research, 64, pp. 229-248,

[7] Barwa, T .M. (2017) CPM And PERT Comparison Analysis in Project Planning‖, International Journal of Advanced Engineering and Management Research Vol. 2 Issue 4, pp.1204-1210, ISSN: 2456-3676

[8] Effendi, Y. A., and Sarno, R.(2017)Non-Linear Optimization of Critical Path Method‖, 3rd International Conference on Science in Information Technology (ICSITech), pp. 90-96.

[9] Calp, M .H. and Akcayol, M. A.(2018) Optimization of Project Scheduling Activities in Dynamic Using Genetic Algorithms‖, Journal of Natural and Applied Sciences Volume 22, Issue 2, pp. 615-627.

[10] Takebira U.M. and Mohibullah A., (2017) Using Critical Path Method for Making Process Layout of a T-Shirt within Earliest Finish Time‖, Journal of Textile Science & Engineering, vol. 7, issue. 5. 1000316, DOI:10.4172/2165-8064.1000316.

[11] Vyas, R. S.(2013) Scheduling Project Management Using Crashing CPM Network to get Project completed on Time‖, International Journal of Engineering Research & Technology (IJERT), vol. 2 issue. 2 S2S, pp. 1-12.
[12] Stone, J. R., and Telford, M. (1999.) Using Critical Path Method To Analyse The Radiation Of Rudist Bivalves‖,Paleontology, Vol. 42, Part 2, pp. 231–242.
[13] Taylor B. W. (2013) Introduction to Management Science‖, Pearson Education, Inc publishing as Prentice Hall. All rights reserved. Manufactured in the United States of America, p.340, 346, 358
[14] Gurau M. A. and Melnic, L. V. (2012) An Overview of Critical Path Applied to Project Management with WinQSB software‖, International Journal of Mathematical Models And Methods In Applied Sciences, Issue 7, Volume 6, pp. 829-836.
[15] Razdan, S. Pirgal, M. Hanchate, A .Rajhans, N. R. Sardar, V .(2017)Application of Critical Path Method or Project Scheduling – A Case Study‖, Conference. Paperhttps://www.researchgate.net/publication/315045237
[16] Ahuja, H.N. Dozzi, S.P AbouRizk S.M (1994) Project management : techniques in planning and controlling construction projects, 2 Ed. Pub.Willy. pp 69
[17] Oxley R. & Poskitt, J. (1971): Management Technique: Applied to the Construction Industry' 2nd Ed., 1971 Cross Lokword, page 81-108.
[18] Rudder, A.& Bottorff . C. (2023) Critical Path Method (CPM): The Ultimate Guide, Forbes Advisor {Accessed on 20/2/2024)
[19] Storeland,S. (1977)– 'Small Towns Water Supply and Sanitation Programme', Paper at the National Conference on Water Sector Reform held at Abuja, June 1977.
[20] Muhammed SN, Demirci A (2015) Assessment of the public participation in solving environmental problems in Delta State, Nigeria. World Environ 5:28–38
[21] Kukhnavets P, (2018). How to Apply Critical Path Method in Software Project Management, Agile Zone: https://dzone.com/articles/how-to-apply-critical-path-method-in-software-proj