

PONTIFICIA UNIVERSIDAD CATÓLICA DEL PERÚ

FACULTAD DE CIENCIAS E INGENIERÍA



**Anexos de la tesis titulada “Programación de fase en
proyectos repetitivos y no-repetitivos mediante líneas de
flujo y modelos BIM”**

Tesis para obtener el Título de **Ingeniero Civil** que presentan los
bachilleres:

Alonso Urbina Sánchez

Dilmer Rodrigo Dueñas Salazar

Asesor: Danny Murguía Sánchez

Tabla de Anexos

1. Interview to Olli Seppänen about repetitive and non-repetitive projects and LBMS
2. Interview to Hylton Olivieri about repetitive and non-repetitive projects and LBMS
3. Cronograma Planificado en Diagrama de Gantt – Estudio de Caso 1
4. Cronograma Ejecutado en Diagrama de Gantt – Estudio de Caso 1
5. Plano de cimentaciones – Estudio de Caso 1
6. Plano de columnas y plataforma – Estudio de Caso 1
7. Plano de detalle de tijerales – Estudio de Caso 1
8. Plano de planta de tijerales – Estudio de Caso 1
9. Líneas de Flujo – Estudio de Caso 1
10. Líneas de Flujo Subestructura – Estudio de Caso 1
11. Líneas de Flujo Superestructura de concreto– Estudio de Caso 1
12. Líneas de Flujo Superestructura de acero – Estudio de Caso 1
13. Líneas de Flujo Techo – Estudio de Caso 1
14. Plano de elevaciones – Estudio de Caso 2
15. Plano de planta – Estudio de Caso 2
16. Tren de actividades de fase de arquitectura – Estudio de Caso 2
17. Líneas de Flujo – Estudio de Caso 2
18. Líneas de Flujo (partida Baños) – Estudio de Caso 2
19. Líneas de Flujo (partida Cocina) – Estudio de Caso 2
20. Líneas de Flujo (partida Closets) – Estudio de Caso 2
21. Líneas de Flujo (partida Puertas) – Estudio de Caso 2
22. Líneas de Flujo (partida Pisos) – Estudio de Caso 2
23. Líneas de Flujo (partida Ventanas) – Estudio de Caso 2
24. Líneas de Flujo (partida Pintura) – Estudio de Caso 2

Anexo 1 - Interview to Olli Seppänen about repetitive
and non-repetitive projects and LBMS

Anexo 1 - Interview to Olli Seppänen about repetitive and non-repetitive projects and LBMS

Repetitive and non-repetitive projects

1. In your opinion, what are the characteristics of a non-repetitive project?

Non-repetitive projects have different quantities in different locations and many unique tasks that will happen in all locations. Then, you have different sizes of locations and a lot of different functions that are not repeating. Most of the projects have both repetitive and non-repetitive parts. Even in residences or buildings, the first floor is different, the garage is different and then you have repetitive areas and units. Then, a retail mall has local non-repetitive areas and then it also has repetitions. So, I think that every project has repetitions in construction and some have more repetitions than others.

2. Said that, is it possible to plan a non-repetitive project as a repetitive one?

Non-repetitive projects are more difficult to plan. That is why we say that flowlines result in more benefits in non-repetitive projects, because they are very difficult to plan. Repetitive projects are very easy because you can just set a takt-time for 3 or 4 days. But in non-repetitive projects, it is very difficult to do that, so LBMS results in more benefits in non-repetitive projects. Tasks themselves are still repetitive. Even if you have very complicated projects, you are still building drywall, you are still pouring concrete, and you are still installing glass walls; however, there can be completely different configurations, different quantities, locations and sizes.

3. How to apply the flowline method to schedule activities in a non-repetitive project?

Flowline is not the method. LBMS is the method. Flowline is just a bit of it. You may mix different slopes, you have the same line but in different locations. In some of them, you go slowly, in some others you go fast. You either stay with your lines or you change the resources or you may have more resources.

4. And also the production rate is important to define those slopes, is not it?

Yes, so if you have double work, you have two options: either it takes the full time which means you would need time buffers coming from that or either you have to

double the resources. The thing is that you have to decide which of these to add and what these resources are going to do and then finish the location that took more time, no more resources. The LBMS has been designed so that your minimum start has tops of full resources so if you double resources of this location then your single crew will have to stop and then your total crew will restart again.

5. Do you believe that the key to ensure the flow in a non-repetitive project is to allocate more resources?

Yeah. These two options. So, you have a non-repetitive project, which is ok also. The first one is quick and the second one is slower (he points two flowlines in a paper). So, this is one way to do it. The third one is quick here and slow here and you will have an empty space if you use this method (he points flowlines in a paper). The other way to do it is simple, you have one. In this example, you have one crew. It is ok. One crew here. 2 crews here. And then you have one crew here (he points crews allocated to tasks represented by flowlines). So, you have all these more complex optimizations exercises taking place and that is why flowlines don't look as clean, but it is a very useful tool, because with CPM we cannot optimize it at all. It happens because in a non-repetitive project, the flowline looks like they are all together. They are not simple to identify when you make the flowlines, but yeah this is a great tool.

6. How to deal with different sizes between locations, one-off activities, or different structural materials when scheduling with flowlines?

I think we have discussed that already. So, if you have different sizes, locations, so you have other workmen durations or more resources. For example, if there is a factory, you need to understand LBMS is a calculation that mixes quantities in locations. It tends to allocate man hours correctly and then you try to figure out how to get those lines as much as close as possible.

7. How do most companies plan and schedule repetitive and non-repetitive projects here in Finland and in Europe in general?

I think, here in Finland, most companies are using flowline for repetitive projects, but not enough companies are using it for non-repetitive. Because it is more complicated. But then the benefits are the biggest. They are not using it in these areas, but the benefits are the biggest, but many production engineers are using nowadays the simple one.

8. And in the complex projects, they are used to apply CPM?

Yeah CPM, Weekly Last Planner. Last Planner of course should be integrated with LBMS, but details are so complex that you cannot really plan it. So that they kind of neglect the high-level planning even though it is called weekly. There is a lot of work to do there. Nevertheless, there are many who are using LBMS, in Europe, in non-repetitive project. For example, here, in Finland, they used LBMS in Kamppi Center, an enormous project, back in 2000. They saved 6 months of the schedule because of using this method.

LBMS

1. Could LBMS and flowlines be integrated to CPM? Do they work together?

LBMS includes CPM. LBMS algorithm is an improvement of the CPM algorithm. Basically, I found 5 types of dependencies that you can review in my book. So, we have CPM inside LBMS. The only big difference between them is that the LBMS allows you to delay the start phase, so you have a slow task and you have a quick task. CPM would make it as fast as possible as this (he is using a drawing). This contributes, but LBMS algorithm is delaying the start of this, so it looks like a fault, but it allows you to optimize the schedule. We cannot really compare the tools, because one is included in the other.

2. How do you suggest to define locations in a non-repetitive project as a plant? Which criteria do you think the planner should follow? In this case, for example, how should a planner could deal with the connections?

It is quite hard to select the correct line. You need to have to define correctly your locations and, then you need to define the precedencies and the dependences between them. And if you have a vertical building, you could try to do vertical independent sections, so if you can build part of the building at roof level before the other part and then the lowest level would be enough to work together with the subcontractor. Anyway, it depends in the circumstances and then you would have a multiple breakdown. You could have a complex breakdown. You could have a different breakdown for each different part, the facade, the superstructure and so on and then you would have an integrated construction. You basically run several schedules together, it is a complicated process. For example, you need to finish the substructure to start the first floor. You need to link these schedules. You have a one breakdown for each system. You cannot easily solve them all together. There could

be a key: to split them all in phases, in parts and each part could have different locations.

Different locations for each part, but then you should be able to mix all them in line but you have to still logically link them to make sure that every link works. So, you could also have a visualization of all the project, you can analyze each part and the logic works. Logic is the most important thing.

3. We have observed that construction of non-repetitive projects often uses CPM due to the complexity of modelling the flow of activities. What are your suggestions to deal with this scenario?

I do not know, it is complex. In CPM, you set dependencies. In LBMS you set dependencies. In LBMS you set more common dependencies. I mean that, in LBMS, you could have 100 activities and 100 locations, and you will have only 100 dependencies, because each activity repeats in each location; however, in CPM, you would have 100 times 100 dependencies. So, I would suggest to define the activities, the locations and the dependencies very well. Some people say that the more the locations you have, the more convenient LBMS is.

4. In Peru, what happens is that when there is a non-repetitive project, engineers do not have a schedule. They plan weekly usually. How do they do this? Nobody knows. They try to use takt-time, but what they get is not really this. They use like a sequence.

Yes, it happens when you use CPM, but if you use LBMS, it is much simpler. In Finland, it is the same. They do not organize carefully non-repetitive projects.

5. Considering that, in a non-repetitive project, there are different subcontractors working in the same location at the same time. How can the LBMS contribute to a better resource allocation?

It depends in the size of the location. It is the critical thing. I think that to have a better resource allocation it is ok not to set very strict boundaries. Some subcontractors could use spaces that are already finished. It is not mandatory to respect the boundaries of each location strictly.

6. In your opinion, which is the main challenge to apply the LBMS in a non-repetitive project? Why do you think that several companies are not using it for these projects yet?

Well, I think that one of the main reasons is because there are multiple breakdowns. People really need to understand that they need to optimize. You need to have experience and understand very well the project in order to use LBMS to optimize. Once you understand it is very simple compared to the CPM, it will flow. I think that the principal problem is that people think that LBMS is complex. But it is not complex at all when you completely understand it.

7. For you, which is the main difference between a line of balance and a flowline?

In line of balance, you have the number of repetitive units and a line. There, you have double lines and all the locations are based in a CPM network that repeats over and over, but you cannot track the crew, you know that there are multiples crews, but you cannot track what each of them are doing. Lots of people is confused about this. Later, line of balance evolved in flowlines. Actually, I understood the difference after reading a lot of books.

Anexo 2 - Interview to Hylton Olivieri about repetitive
and non-repetitive projects and LBMS

Anexo 2 – Interview to Hylton Olivieri about repetitive and non-repetitive projects and LBMS

Repetitive and non-repetitive projects

1. In your opinion, what are the characteristics of a non-repetitive project?

Interesting question, because some people can define repetitive project that you have similar floors, let's say similar areas, but maybe this is not right. Sometimes you have no repetitive floors, but you have repetitive tasks there. I would answer the opposite, what is the repetitive. In my opinion is when you have repetitive tasks. On the other hand, you have to take into account that, even, if you have repetitive tasks, but really different durations, I'm doubt if they can be considered repetitive. Maybe a good answer would be how easy is your scheduling process basic on that characteristics, because when you are scheduling some construction site you can spent 1 hour on one schedule or you can spend some days depending on the kind of adjustment. Basically, I believe that if you have different areas, task and durations it means that is non-repetitive.

I will give you one example I worked in Brazil in an industrial project. It was a really big, it was a John Deere factory in the South close to Port Alegre. It had several buildings, industrial buildings, so you can say here's nothing similar, but they wear, of course for different purposes one for example was the warehouse, other for some productions, but if you consider and remove MEP (Mechanical , Electrical, Plumbing) the buildings were similar in almost everything, foundations, industrial floors, steel structure even in terms of walls or finishing work they were really similar so for example in that case I will consider that they were repetitive.

2. How to apply the flowlines method to schedule activities in non-repetitive projects?

Okay, if you have similar tasks with different durations this is easy. Easy in what terms, you should consider the production rate, of course, and then how about you can consider allocating more resource or less resource. Basically, what's the key here is that when you start any schedule, before the schedule itself, you really need to draw the sequence of the project. So, that would clarify your mind. Then you can transfer this to your schedule, so how to apply flow lines in my opinion first defining the sequence and second balancing the production rates.

So, it would depend of the allocation of the resources?

If you use Vico Office, basically you should use the production rates to balance. You need to consider how to promote or to ensure sequence and workflow in some crews so, certainly, you must take into account the productivity and production rates.

3. Do you believe that the key to ensure the flow in a non-repetitive project is to allocate more resources? Are there other options?

No, I don't believe that you should allocate more resources I've been working in some schedules and this is really interesting because sometimes the good approach is the opposite is reducing the resources and not allocating more, so again you should use the production rates to decide if you really need to allocate more or not and then you also need to take into account restrictions that you have when you are scheduling something so if you have restrictions. I mean when you have restrictions and constraints for example you have the structure and let's imagine that you don't have wall and you have to Finish. What's common in Brazil for example we were skipping this first floor and then when we are finalizing we're moving to the first floor because we usually stored a lot of material here and we have some kind of special finishing like marbles and some special finishes so it depends what you are doing and for example if you are starting gypsum plaster if you start in one place you need the rules and identify constraints here how to solve this you have two options you can break the beam into parts I mean for this task so there's no impact or you can also protect with some plastic to start the work. So, you have several options to take into account and this will affect the number of resources that you are allocating. That's why you need to consider, the production rate here because you're breaking the activity or the area in some small spaces and you can check what happened in the construction site to analyze and decide what's happening in your schedule on construction site. It's not just allocating more resource, breaking your project in some small parts or some areas considering production rates and of course when you are considering the production rates you are considering the quantities that you have. You have to balance

4. How to deal with different sizes between locations, one-off activities, or different structural materials when scheduling with flowlines?

Yes, you have options. You can allocate more resources or you can consider in some special occasions that you have different speed. You can spend more time in that location and that's why you need to sequence the logic links of the tasks when you are simulating in your schedule so you can check what happening with your deadline.

You know sometimes there's no other way, so you should respect that. Let me give you one example let's imagine that you are spending 2 days per floor in some specific task let's say floor leveling. The next activity is waterproofing, and waterproofing is really fast maybe in one day you can do that but you need to wait at least for 24, 36 or 72 hours. I don't know how it works in Peru, but in Brazil by regulation you have to wait 72 hours. That means that you have to spend, at least, four days in that task and how to improve, it's impossible to improve, you just need to manage this you have this task with this productivity and then you can break your sequence you have options here you can reduce resources here because you have this constrain. You can anticipate the start of tasks, but they will change. Sometimes, you really need to take into account the whole schedule considering production rates and bottlenecks.

5. How do most companies plan and schedule repetitive and non-repetitive projects here in Finland and in Europe in general?

Okay, my experience in Finland it's about four or five projects and most of them are really using flow lines schedules. The projects that I visited, they were repetitive, so I really don't know in Finland how they are scheduling non-repetitive, but based on our survey, that we applied for different countries, they are using, here in Finland for example, CPM schedules. So, I am assuming that they are using the same, they are using flowlines in repetitive and non-repetitive projects.

If you access to the Trimble website you will see there that they have more than one standard, they have several platforms for scheduling. For example, when you're planning or scheduling a road they have special software for roads. I heard that they have special software for bridge planning also. This is something interesting, because it allows you to check more options for not-repetitive projects, but certainly, here in Finland, they must be using the same. In Europe, in general, based on my experience, I'm really disappointed with the way of scheduling, because I have visited lots of construction sites where there's no schedule and several times I asked: "Can I see your schedule?" and, then, sometimes they said: "Oh, look there's no schedule ", so I replied: "Ok, but how do you organize your work?" and they state: "Well, we have some weekly meetings". I always asked: "Ok. But what's your goal?" and they reply: " The supplier knows what to do". And I saw the same in Japan.

I'm not sure if I have visited the wrong companies or not, but it happened before also living in Finland and the results were the same, really poor. So, I don't know if there are difference if they are in a repetitive or non-repetitive project.

In Singapore was interesting because there almost all the projects are repetitive, because they are specialized in modularization and prefabrication, on site construction in general. There, they have been using BIM integrated with the schedule, let's say 4D and they have been working with that also including the cost in 5D models with good results, but in Europe, in general, I can't see any example.

In Brazil, we have been using for non-repetitive projects only CPM scheduling.

LBMS

6. How do you suggest defining locations in a non-repetitive project as a plant? Which criteria do you think the planner should follow? In this case, for example, how should a planner could deal with the connections?

Personally, I have been applying in my professional life the following, let's take into account the weekly tasks that we have. If it's possible to do it in one week or not, if it's possible that's okay we have to consider the division of locations into that. If it's not possible, I would break the locations in some small parts because I believe that if you have a lot of really big or really large locations which means that you will spend lot of time in that location and that's hard to control. In my mind that's it if it's possible to return one week let's okay let's define the location based on that. It's my opinion.

Even with a repetitive project, let's say you have floor with 2000 m² the first time could be the wall and how time do we spend in that let's say 10 days. So basically, in terms of work we can divide in two parts, but just the walls because we're not considering finishes, waterproofing or others so we could divide it in 4 or 5 locations for example and, basically, I don't like to divide in different locations based on the tasks. Even I'm considering the opposite also. We have a common situation during the construction you have the industrial lifts that supply material to the work of the floor. What happens when you remove that lift and you have to apply for example external plaster and after it some painting. Usually that external plaster you can do in one or two days so why we have to divide the external platter in 3,4 or 5 locations if we can just do it in one or two days.

7. We have observed that construction of non-repetitive projects often uses CPM due to the complexity of modelling the flow of activities. What are your suggestions to deal with this scenario?

I am a big fan of CPM scheduling and I had a lot of problems with that during my thesis because people were criticizing, due that they say that CPM doesn't work, but in my opinion, it works. I had used CPM in almost 300 construction projects in Brazil where we used CPM and the results showed that the expected metrics were improved. So, where we're finding almost no delayed when we implement this. So, in my opinion, it depends on how to manage this because what people usually do, the schedulers, they prepare schedules and just distributed to the team worker, when the aim is to prepare your schedule with your team, with your project manager and with almost all the stakeholders and, of course, when you are taking into account constraints and restrictions you should use last planner.

I have been criticized a lot because I can't agree with the Last Planner theory about that we should start a project with only one master schedule, I don't believe that that's true. In my opinion, you should start with a high detailed schedule, especially in non-repetitive project. You should start the game with the rules defined, if you go changing the rules during the project it will cause some disturbance. For example, how to pay the subcontractors if you haven't defined the criteria before starting the work. In that moment, you can say: "But, okay, now we're talking about cost". No, I'm not talking about the cost of a supplier. I'm talking about the construction itself. If I'm a construction company and I'm producing a wall in one floor, I'm spending money to buy the bricks, the cement an even pay to the suppliers. So, before, I have to define the criteria with the suppliers. For example, I'm not going to pay you by square meter, but I'm going to pay you when you finish one floor. We have been working with this in Brazil and it's working well. Then when you are considering every value and measurement. For example, there is so short because you're paying for that material and for that service and you produce that service so they are in the same level. So, you can really trust that your cost, using this way of CPM scheduling, when it's compared to your project performance they are in a good way and they are align working together.

I really believe that CPM can success in these kind of projects, of course, that LBMS and flowlines can improve the situation. For example, it's really complicated to consider production rates in CPM, but not in LBMS. It's really easy comparing the same schedule in repetitive project when your rescheduling that it's much faster in LBMS than CPM. If you have forty floors in LBMS you just draw a line and link the first floor with the others through the task. In CPM is different, there are some ways that you can export into an Excel spreadsheet and develop it but it's more difficult and it

takes time. So, in terms of scheduling process is much easier and faster LBMS. In terms of workflow it's, of course, much better to track the workflow in a flow line instead of a bar chart. On the other hand, as I told you, nowadays, a lot of people develop the schedule in CPM and just visualized that schedule in flowlines. So, there's no problem with that. In my thesis, I developed one system integrating CPM with LBMS because if you go to the construction site in Brazil and say to the people: "Please, disconsider CPM because this is not working, let's use Flowlines", people would say: "No I don't want this". On the other hand, if you show them that is possible to integrate both this will not cause an extra work on their daily tasks in my opinion this will be much better. In my opinion, it's possible to work with both methods. You could start with a CPM and then use LBMS as a compliment. That's why Vico Office is interesting, because it uses both. Besides some people said that Primavera is better in terms of bar charts.

8. Considering that, in a non-repetitive project, there are different subcontractors working in the same location at the same time. How can the LBMS contribute to a better resource allocation?

This is amazing in terms of LBMS because we are ensuring that they are not working at the same time in the same location, this is one of the keys and then this is not only a good key in terms of scheduling, I believe that you are decreasing risk and costs when you are providing this kind of situation. I mean they are working alone there and just one task per time. Avoiding a lot of workers on the same space, and it is also affecting the final quality of the project. So, LBMS is really good. However, when we are talking about non-repetitive projects the key is to define the size of the locations properly and then ensure that some crews are working there and moving to the following location without interruptions, because if they are working and waiting for start the task in another location there could be problems. If you are considering that you have one crew per week for example this is good because technology ensure the sequence of locations.

I mean that when you are defining the location. You can define specific location for each part of the project. For example, in the stage of foundations you could have location A, B and C, that's okay, but, then you're going to the structure and, again, you can use different regions. There's no problem if those are different from the foundations ones. After the structure, let's assume that you have the columns, the beams and the slabs and you're starting, for example, walls, the ceiling, windows or

some finishing objects. In my opinion, after the structure, concrete or steel structure, you might define common locations for everything.

Let's analyze MEP. MEP is different, maybe you're not applying MEP exactly in the four locations. For example, you have one pot crossing the whole building how to solve that again you should consider the constraints. If you have the crew or workers working in assembly one pipe, for safety reasons is not possible to work with another worker from a different task in that location, so you need to take into account that. Then as a good scheduler you should understand how it works the MEP system, because if you are just trusting that the subcontractor knows what and how to do in my opinion you should understand about the process and considering these kinds of constraints. In terms of MEP I will give you the same example of the facade if you have some easy tasks, let's say you told me to split that pipe in four regions that you can see there that the pipe is in just one region and then how to balance or solve the problem that that guy from the piping is working in the same location or not that the guy doing for example waterproofing. In that case, you can use the flowlines to check if their work in the same space at the same time or not.

I think that after concreting the structure you need to find common locations and then we're going to analyze task by task and what you should consider defining location, in my opinion, based on my experience is which is the highest level of definition in your breakdown structure. I mean for example you have several floors and for walls is ok to divide in four regions and for waterproofing you need to divide in eight regions, so in my opinion I suggest you should define eight regions as a standard in terms of locations and when you're considering walls, you could join locations to consider a total of four. but if you have only waterproofing that might be divide in eight locations, it does not make sense to consider eight regions to the whole project because you just have one specific task.

In Vico, based on the last example, you should define first if you really need to use 8 divisions. If it's not necessary you can create 4 regions as a standard and the specific tasks could be divided in more locations. It's not necessary to create a lot of regions, you can split the activity too.

9. In your opinion, which is the main challenge to apply the LBMS in a non-repetitive project? Why do you think that several companies are not using it for these projects yet?

In my opinion, first is because a lot of companies all requiring by contract that the company should use CPM schedules. That's the first reason, so if it's by contract that they have to use CPM, then why are they going to use LBMS. The second reason is that you have to take into account the local characteristics of each country. For example, in Finland this is not true because they have been using LBMS in non-repetitive projects also, but if you go to United States or Brazil or other countries that will be hard, so the main challenge, in my opinion, is that if you're trying to change the 100% in your first time, you should consider dividing it in a lot of steps. Do not start saying that LBMS is better, so forget CPM. You should consider that CPM is good but let's see the limitations so if you agree let's use LBMS partially just to solve these problems and people there will see that it is really good. Then, when you're preparing the schedule you could ask "How difficult is to link logics between tasks?" and if that is really hard let's try LBMS and then we can see how it works. In that sense, Lean approach, in my opinion, sometimes is wrong because they're considering that everything is wrong and Lean is perfect. I really believe that Lean is really good, but you can't go to a construction site and say: "Okay change everything, because everything is wrong".

I worked in a construction company in Brazil and at that time we had 200 residential projects in progress during the same time in 80 different cities in Brazil in 22 different states, so you can imagine how complex it was. In this case, for example my engineer director, that guy was not concerning about the flowline or not. He was concerned about the performance of each project in terms of physical progress and cost and if I go there and I say: "I don't know how to predict this because I'm using Last planner and Last Planner say that I cannot divide my schedule based on the phase schedule. So, when I'm close to start the structure then I will divide my schedule in terms of structure, if I'm starting painting just at the end of the concrete I'm going to divide the schedule the painting. That is not enough for that guy. Thus, I need to know how much are we producing in each moment and how to provide these kind of information if you're starting a project with just a milestone schedule it's not possible, so that's why I believe that we might start with high detailed schedule so returning to the example that the guy he's not interested in flowline or anything he's just interested in the project performance, but if you go to the project manager that guy is interested in both in performance and is interested of course in the results of the project in terms of quality, productivity and cost, so to that guy is easier to propose a combination between CPM and LMB. He's the key guy. Other case, is that if you go to the foreman and your show some bar schedule he would say that he agrees and everything is ok, but he must not

be understanding anything, so to that guy if you show son line of balance, workflow or LMS schedule would be better because he could visualize the tower and if he can visualize the sequence. Instead of using CPM schedule.

For all that, the main challenge is that we should we should change the way and stop saying that they are completely wrong, we have to take into account that they have been working with that and we need to propose something to combine both, and who knows maybe in the future, as soon as possible as we use these, we could remove CPM. We could change the approach.

And of course, we think that LBMS or a line of balance are really easy. It is easy. That's why LBMS is interesting because it's considered quantities and production rate and defining the ratios. When I showed LBMS to some construction companies in Brazil they were surprised because they have been doing lines of balance and flowline schedules for several years, but LBMS provides something easy to do not for planning, but for controlling. In my opinion, it doesn't matter if it's a repetitive or non-repetitive project because somehow you can turn the non-repetitive in a repetitive project identifying similar areas of similar tasks.

Even when we are talking about housing projects in Condominiums with a lot of houses and in other project working with towers, both are repetitive but if you ask them they will give you a lot of information and they will try to convince you which one is repetitive or not because they are different projects. So, in my opinion it's up to you to define is a project is repetitive or not.

10. For you, which is the main difference between a line of balance and a flowline?

That's a good question because I had that kind of discussion during my thesis with three professors there, so we defined the following. Considering that they are the same and that the difference is when you are plotting the schedule, so then you can see it. Let's imagine that you are applying zoom to the schedule, some people in Brazil say that in line of balance you can see a kind of blocks and even though you can see free spaces, then in LBMS you could see lines, so to these you can say it's flowline. What's the difference between both, basically the idea is the same, let's assume that you are applying a big zoom, so line of balance turn in flowline. In my opinion, I was first forced to agree that they were the same because the idea is the same, it does not matter if you are using production rates. LBMS is a good tool because is providing an automatic way to do flow lines. Nowadays, I'm convinced that both are the same

because you have the same information in line of balance or flowlines. it's not true if you say that only LBMS it's producing flow lines because you can develop one Schedule in an Excel spreadsheet using production rates. The advantage is that LBMS do it really easy because if you are doing it manually and you need to make a change you will need to reconsider one by one again. On the other hand, on LBMS is really easy, trough Vico, just by entering to one screen you can reduce or increase and re do everything or split the tasks. What is interesting in LBMS is that you're using the algorithm based on CPM, but inserting lags between activities providing flow. If you are working with a bar schedule and you have some interruptions, in LBMS it's not possible because by the flow what LMBS do is postponing in the beginning of the task by providing continuity to the work flow and this is automatic in LMBS, but in bar scale is really complicated you have to check day by day. In sum, the benefits are visualization, the algorithm to provide a continuous flow and the easy way to manage the production rates and automatically change the duration of tasks when comparing with the traditional way.

Anexo 3: Cronograma Planificado en Diagrama de
Gantt – Estudio de Caso 1

COINSA TACNA
ESTRUCTURA METALICA DE EDIFICIO E-015 Y E-04
Planificacion de Obra

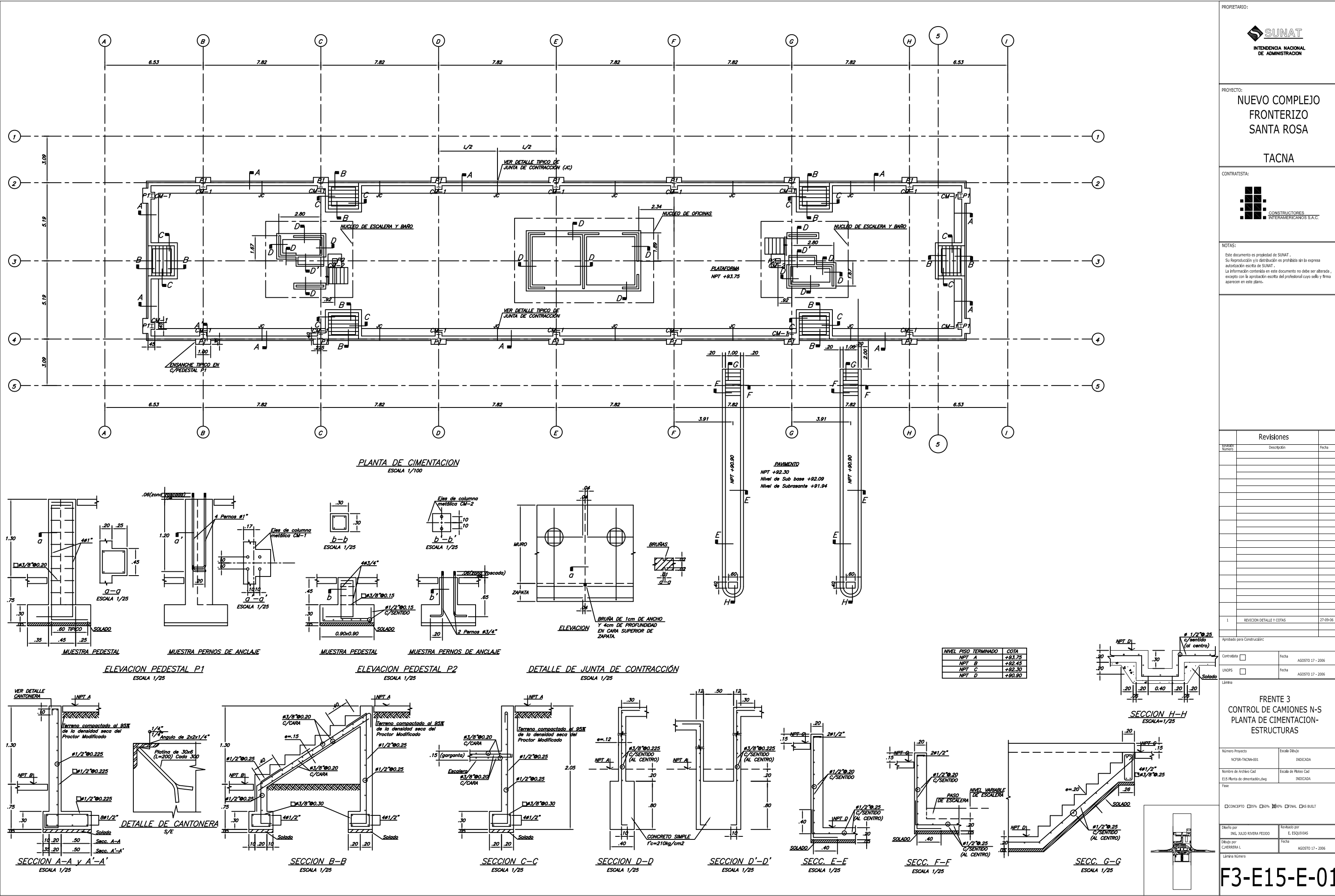
		OCTUBRE									NOVIEMBRE																					DICIEMBRE																			
ITEM	TAREA	L	M	M	J	V	S	D	L	M	M	J	V	S	D	L	M	M	J	V	S	D	L	M	M	J	V	S	D	L	M	M	J	V	S	D	L	M	M	J	V	S	D	L	M	M					
	EDIFICIO E-015 Y E-04	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30											
1.00	Estructuras de techo metalico de control vehicular																																																		
	Adelanto de dinero																																																		
	Compra de materiales																																																		
1.10	Columnas																																																		
1.11	Columnas CM1																																																		
1.12	Columnas CM1A																																																		
1.13	Columnas CM2																																																		
1.20	Tijerales																																																		
1.21	Tijerales T1																																																		
1.22	Tijerales T2																																																		
1.23	Tijerales T3																																																		
1.24	Tijerales T4																																																		
1.25	Tijerales T5																																																		
1.30	Viguetas																																																		
1.31	Viguetas V1																																																		
1.32	Viguetas V2																																																		
1.33	Viguetas V3																																																		
1.34	Viguetas V4																																																		
1.40	Vigas																																																		
1.41	Vigas de pasarela																																																		
1.40	Accesorios																																																		
1.41	Insertos de columnas																																																		
1.42	Clips de amarre de viguetas																																																		
1.43	Templadores																																																		
1.44	Placas de amarre de 5/8																																																		
1.45	Placas de 1/4																																																		
1.46	Retoque de pintura																																																		
1.47	Observaciones																																																		

Fabricacion
Transporte
Montaje

Anexo 4: Cronograma Ejecutado en Diagrama de
Gantt – Estudio de Caso 1

[illegible]

Anexo 5: Plano de cimentaciones – Estudio de Caso 1



PROPIETARIO:

SUNAT
INTENDENCIA NACIONAL DE ADMINISTRACION

PROYECTO:

NUEVO COMPLEJO FRONTERIZO SANTA ROSA

TACNA

CONTRATISTA:

CONSTRUCTORES INTERAMERICANOS S.A.C.

NOTAS:

Este documento es propiedad de SUNAT. Su Reproducción y/o distribución es prohibida sin la expresa autorización escrita de SUNAT. La información contenida en este documento no debe ser alterada, excepto con la aprobación escrita del profesional cuyo sello y firma aparecen en este plano.

Revisiones		
Revisión	Descripción	Fecha
1	REVISIÓN DETALLE Y COTAS	27-09-06

Aprobado para Construcción:

Contratista ☐ Fecha AGOSTO 17 - 2006

UNOPS ☐ Fecha AGOSTO 17 - 2006

FRENTE 3
CONTROL DE CAMIONES N-S
PLANTA DE CIMENTACION- ESTRUCTURAS

Número Proyecto: NCFR-TACNA-001
Nombre de Archivo: E15 Planta de cimentación.dwg
Fase:

Escala Dibujo: INDICADA
Escala de Ploteo: INDICADA

Revisado por: E. ESQUIVIAS
Fecha: AGOSTO 17 - 2006

Limbo Número

F3-E15-E-01

Anexo 6: Plano de columnas y plataforma – Estudio
de Caso 1

PROPIETARIO:



PROYECTO:

NUEVO COMPLEJO
FRONTERIZO
SANTA ROSA

TACNA

CONTRATISTA:



NOTAS:

Este documento es propiedad de SUNAT.
Su reproducción y/o distribución es prohibida sin la expresa
autorización escrita de SUNAT.
La información contenida en este documento no debe ser alterada,
excepto con la aprobación escrita del profesional cuyo sello y firma
aparecen en este plano.

Revisiones

Revisión Número	Descripción	Fecha
01	REVISIÓN: Realización de columnas	13-10-06

Aprobado para Construcción:

Contratista	Fecha
UNOPS	AGOSTO 17 - 2006

Lámina

FRENTE 3 CONTROL DE CAMIONES N-S COLUMNAS Y PLATAFORMA- ESTRUCTURAS

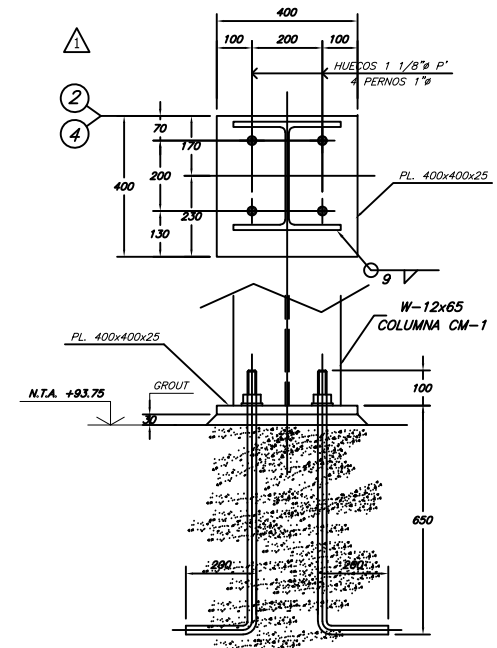
Número Proyecto	Escala Dibujo
HCPSA-TACNA-001	INDICADA
Nombre de Archivo Cad	Escala de Plano Cad
E15-E03-Columnas y Plataforma.dwg	INDICADA
Fase	

☐ CONCEPTO ☐ 35% ☒ 60% ☒ 90% ☐ FINAL ☐ BUILT

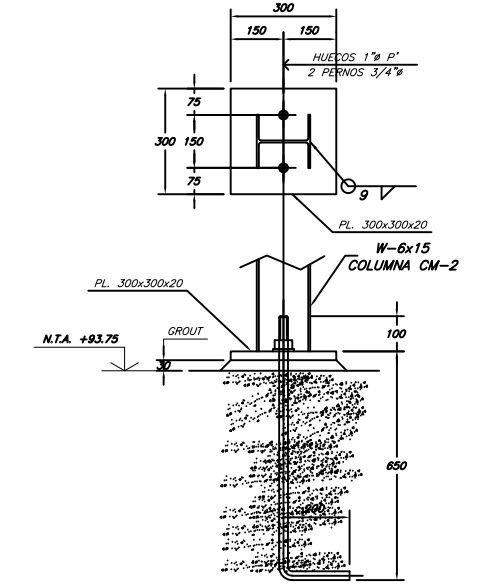
Diseño por	Revisado por
ING. JULIO RIVERA PELJOO	E. ESQUIVIAS
Dibujado por	Fecha
HAYALDOVA F.J. FIGUEROA, MONROY	AGOSTO 17 - 2006

Lámina Número

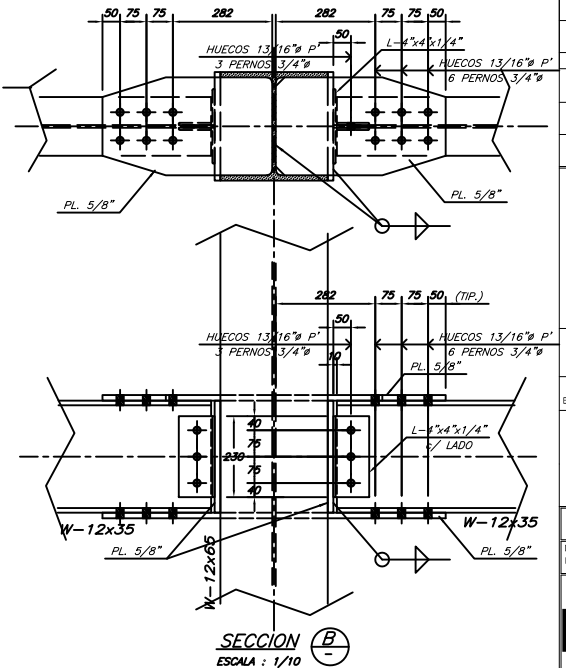
F3-E15-E-03



W-12x65
COLUMNA CM-1
ESCALA : 1/10

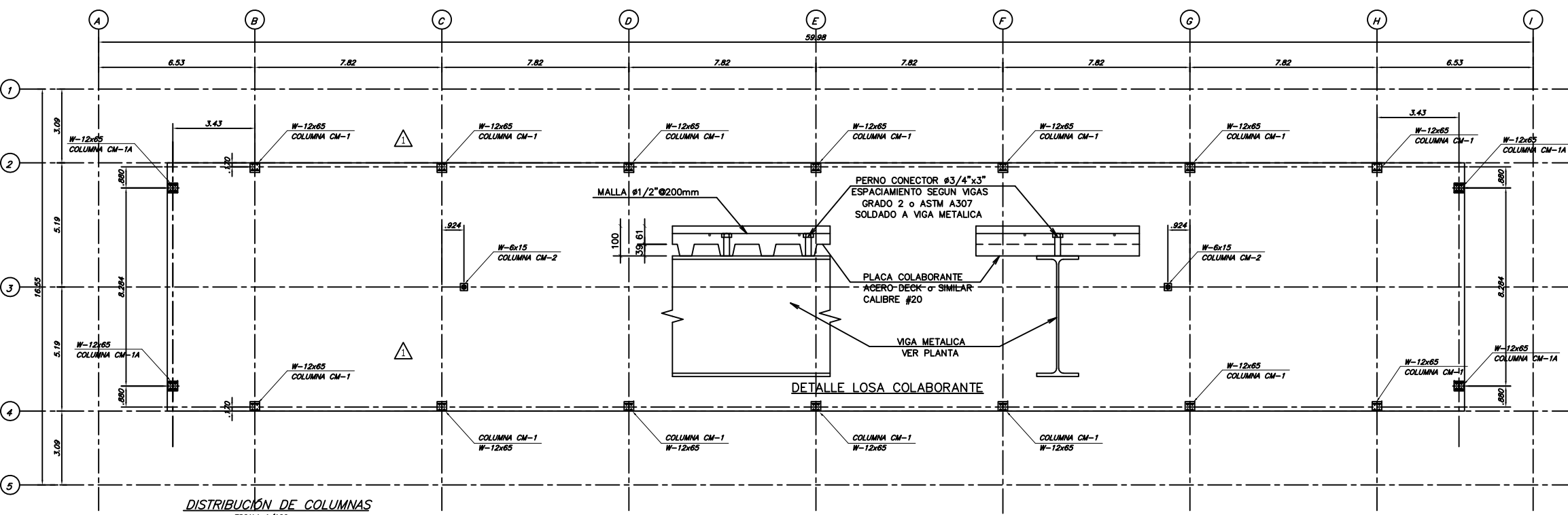


W-6x15
COLUMNA CM-2
ESCALA : 1/10

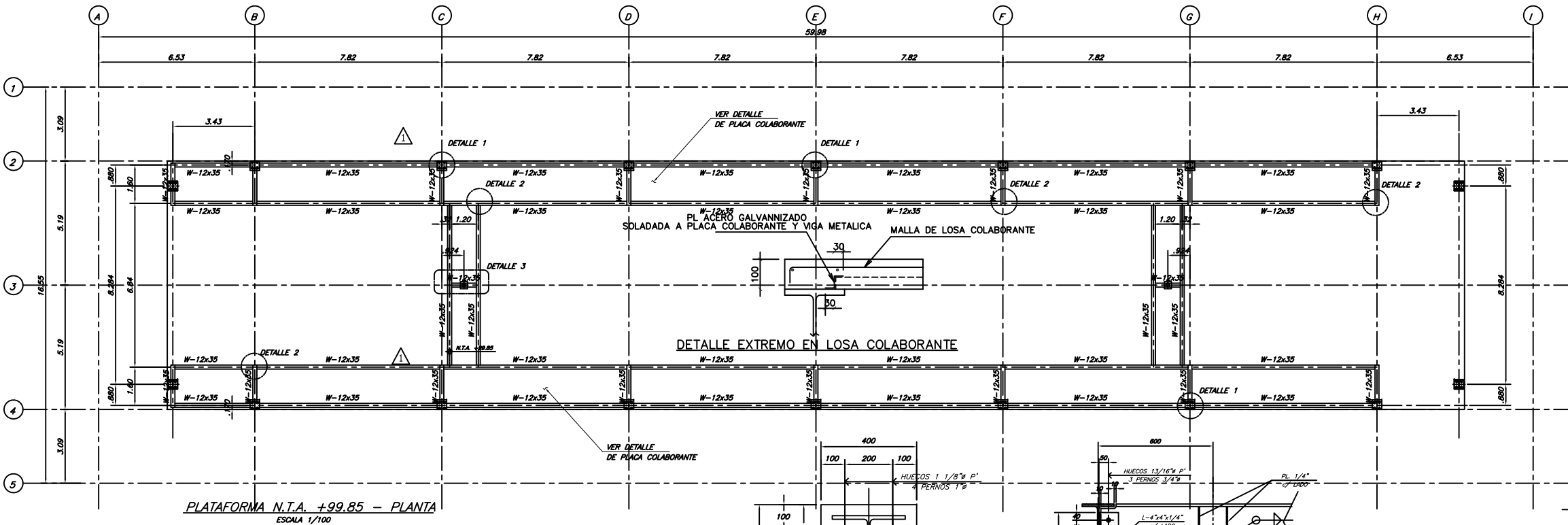


SECCION A
ESCALA : 1/10

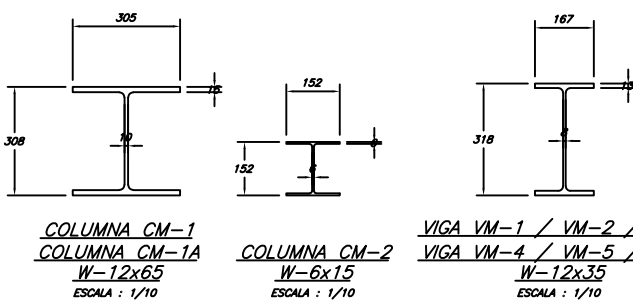
SECCION B
ESCALA : 1/10



DISTRIBUCIÓN DE COLUMNAS
ESCALA 1/100



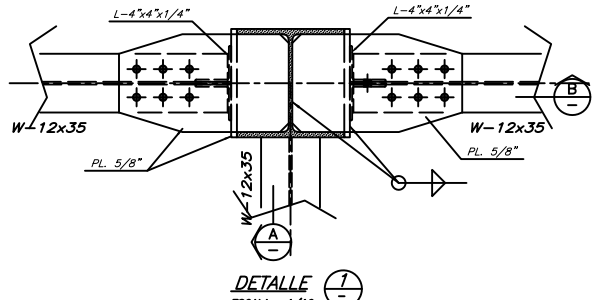
PLATAFORMA N.T.A. +99.85 - PLANTA
ESCALA 1/100



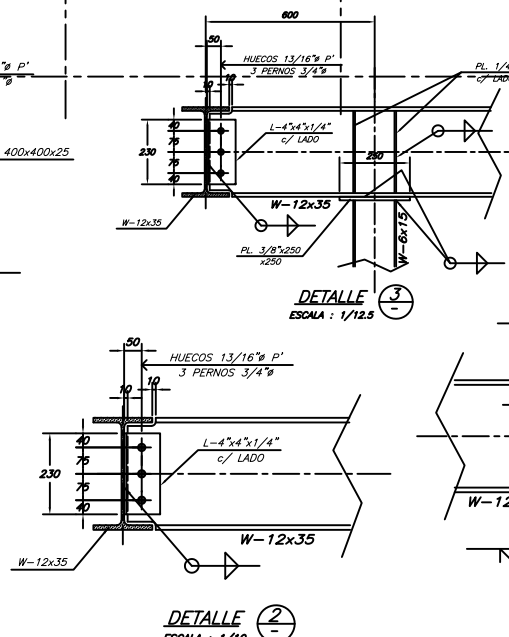
COLUMNA CM-1
COLUMNA CM-1A
W-12x65
ESCALA : 1/10

COLUMNA CM-2
W-6x15
ESCALA : 1/10

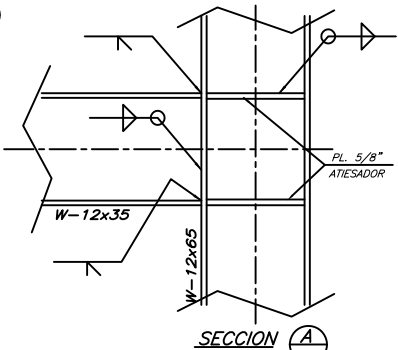
VIGA VM-1 / VM-2 / VM-3
VIGA VM-4 / VM-5 / VM-6
W-12x35
ESCALA : 1/10



DETALLE 1
ESCALA : 1/10



DETALLE 2
ESCALA : 1/10



SECCION A
ESCALA : 1/10

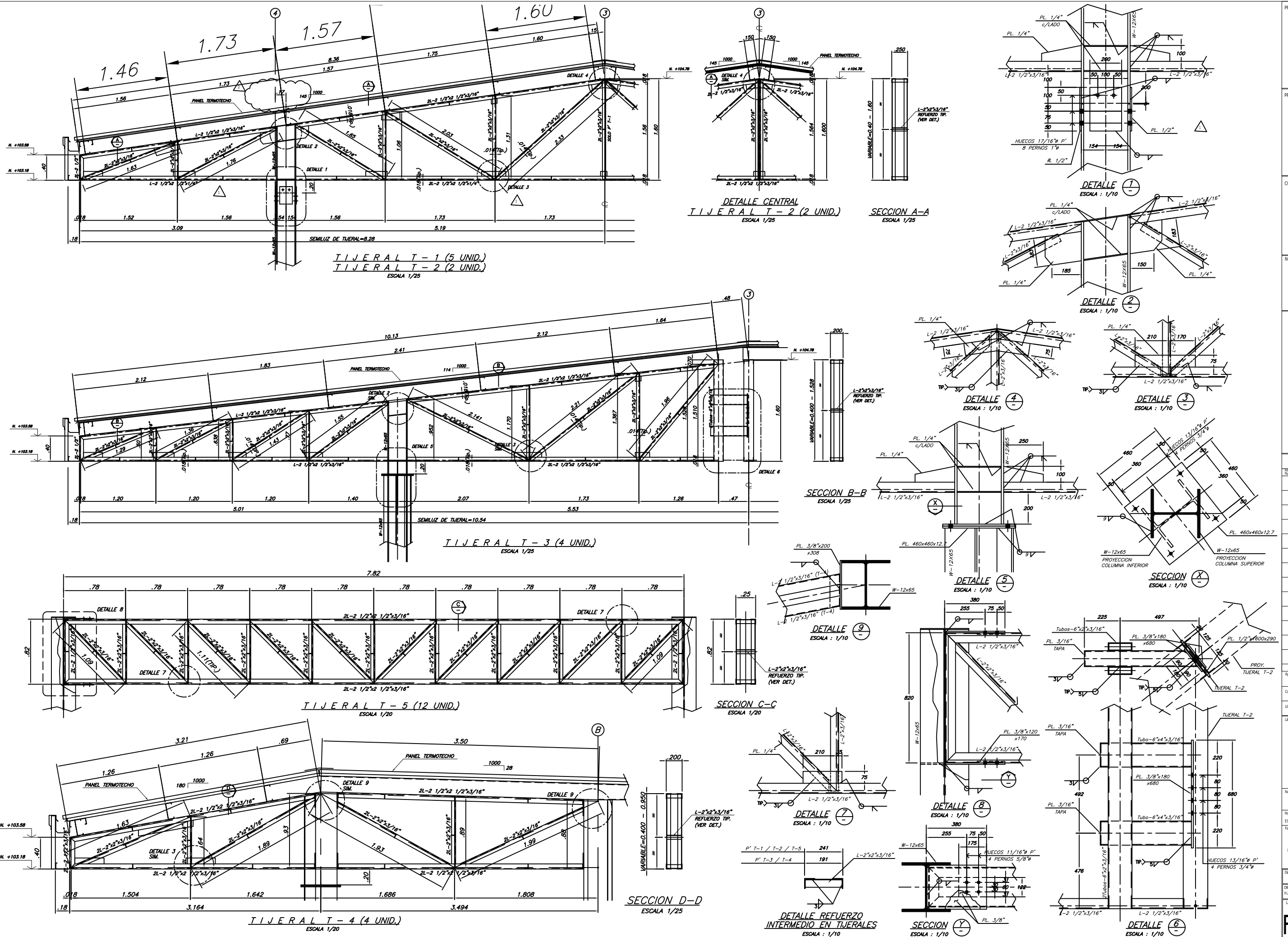
Anexo 7: Plano de detalle de tijerales – Estudio de
Caso 1

[illegible]

probatos para Construção:	
Contratista <input type="checkbox"/>	Fecha AGOSTO 17 - 2006
INOPDS <input type="checkbox"/>	Fecha AGOSTO 17 - 2006

<p style="text-align: center;">FRENTE 3</p> <p style="text-align: center;">CONTROL DE CAMIONES N-S</p> <p style="text-align: center;">TIJERALES- ESTRUTURA</p>	
<p>Numero Proyecto</p> <p style="text-align: center;">NCSB-TACNA-001</p>	<p>Escala Dibujo</p> <p style="text-align: center;">INDICADA</p>
<p>Nombre de Archivo Cad</p> <p style="text-align: center;">15-E05 Tijerales.dwg</p>	<p>Escala de Ploteo Cad</p> <p style="text-align: center;">INDICADA</p>
<p>ase</p>	

<input type="checkbox"/> CONCEPTO <input type="checkbox"/> 35% <input type="checkbox"/> 60% <input checked="" type="checkbox"/> 100% <input type="checkbox"/> FINAL <input type="checkbox"/> AS BUILT	
Hecho por ING. JULIO RIVERA FEJOO	Revisado por E. ESQUIVIAS
Hecho por VALDIVIA F., FIGUEROA, MONROY	Fecha AGOSTO 17 - 2006



Anexo 8: Plano de planta de tijerales – Estudio de
Caso 1

PROYECTO:

TACNA

CONTRATISTA:



Este documento es propiedad de SUNAT .
Su Reproducción y/o distribución es prohibida sin la expresa
autorización escrita de SUNAT .
La información contenida en este documento no debe ser alterada ,
excepto con la aprobación escrita del profesional cuyo sello y firma
aparecen en este plano.

[illegible]

Aprobado para Construcción:

Contratista <input type="checkbox"/>	Fecha
	AGOSTO 17 - 2006

UNOPS	<input type="checkbox"/>	Fecha	AGOSTO 17 - 2006
-------	--------------------------	-------	------------------

371

FRENTE 3
CONTROL DE CAMIONES N-S
TIJERALES

Número Proyecto

NCFSR-TACNA-001

Nombre de Archivo Cad

E15-E05 Tijerales.dwg

Page

☐ CONCEPTO ☐ 35% ☐ 60% ☒ 90% ☐ FINAL ☐ AS BUILT

Disegno per

ING. JULIO RIVERA FEIJOO

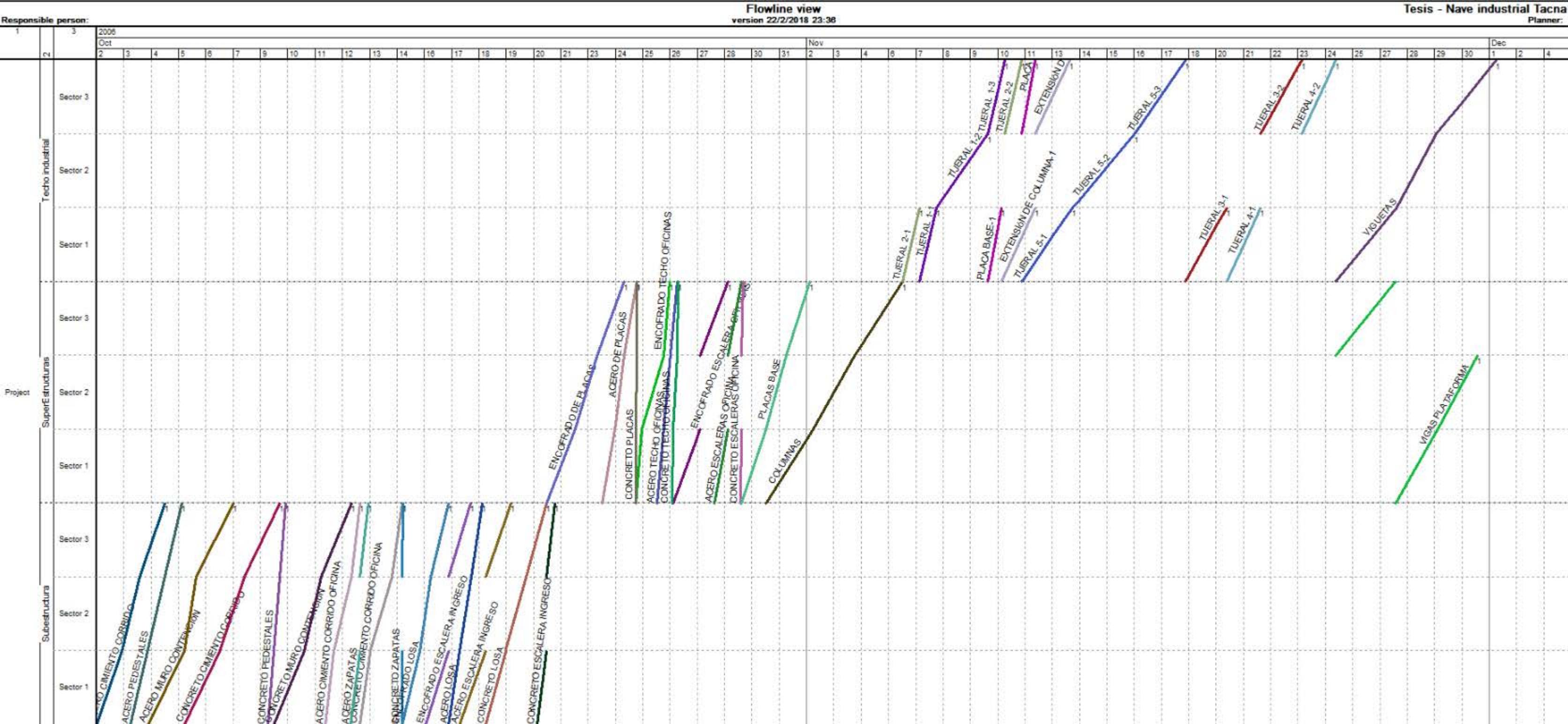
Ibujo per
VALDIVIA E FIGUEROA A MONROY

Lámina Número

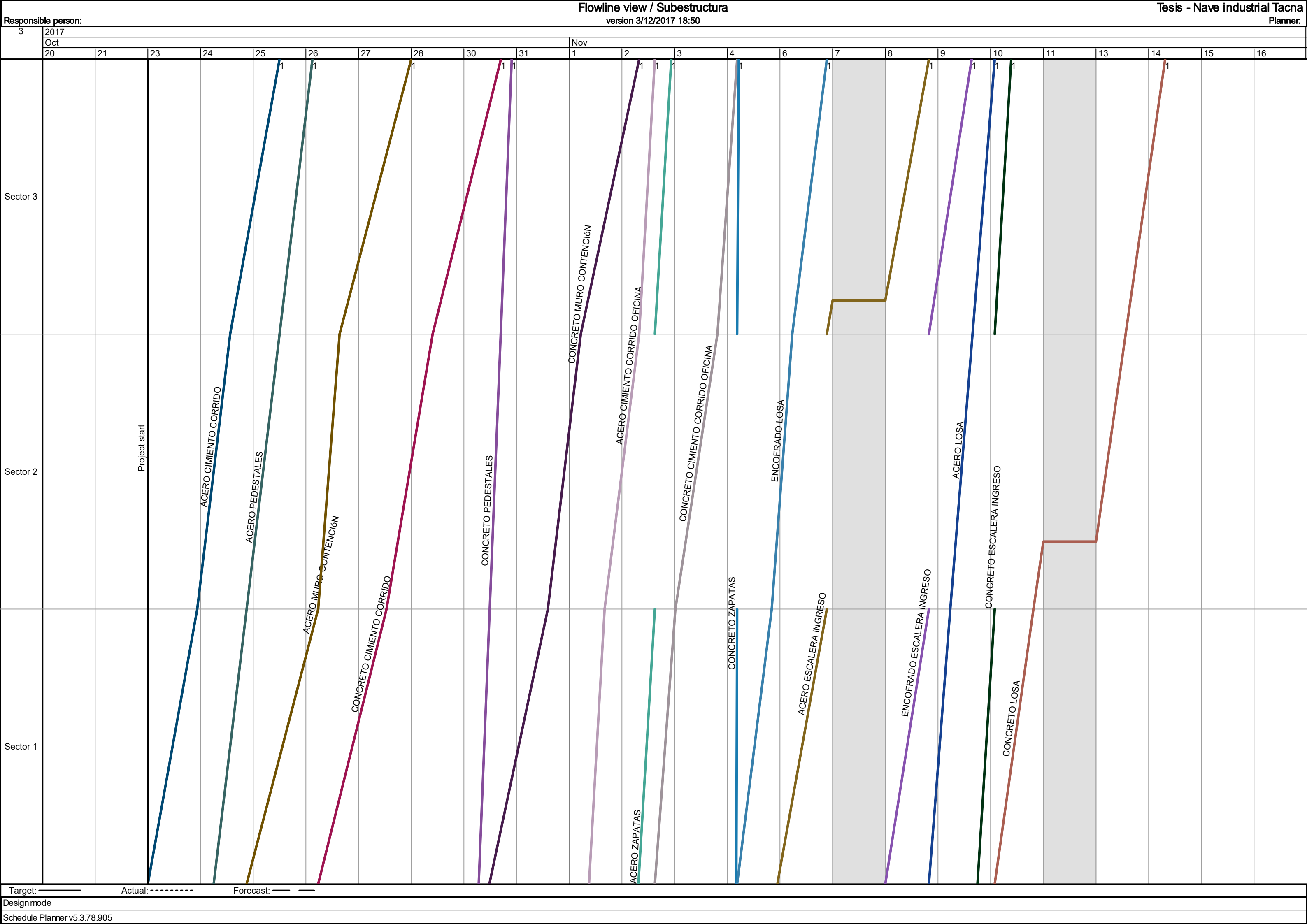
Callings Numero

F3-E15-E-06

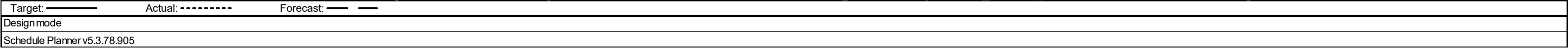
Anexo 9: Líneas de Flujo – Estudio de Caso 1



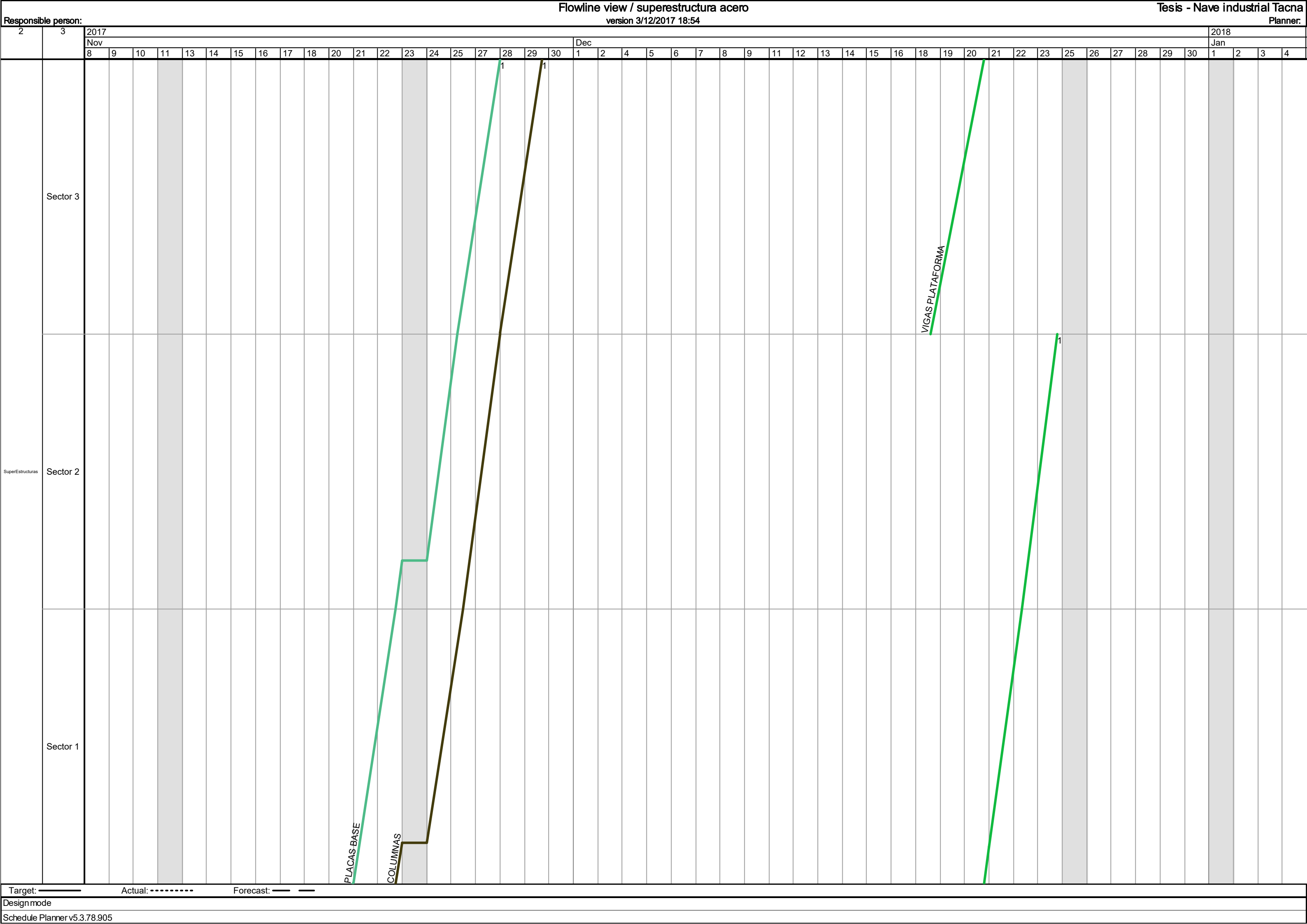
Anexo 10: Líneas de Flujo Subestructura – Estudio de Caso 1



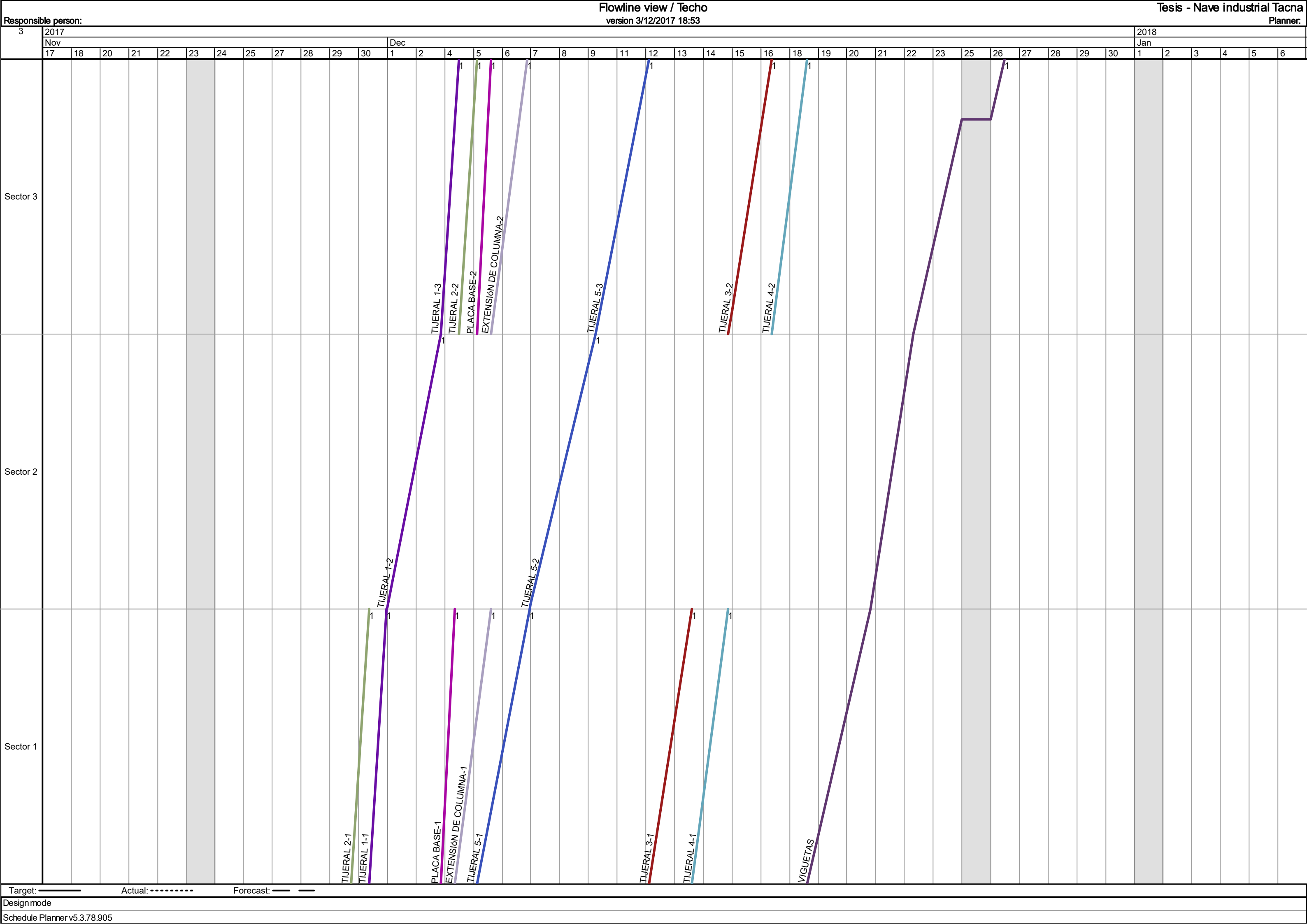
Anexo 11: Líneas de Flujo Superestructura de concreto— Estudio de Caso 1



Anexo 12: Líneas de Flujo Superestructura de acero –
Estudio de Caso 1



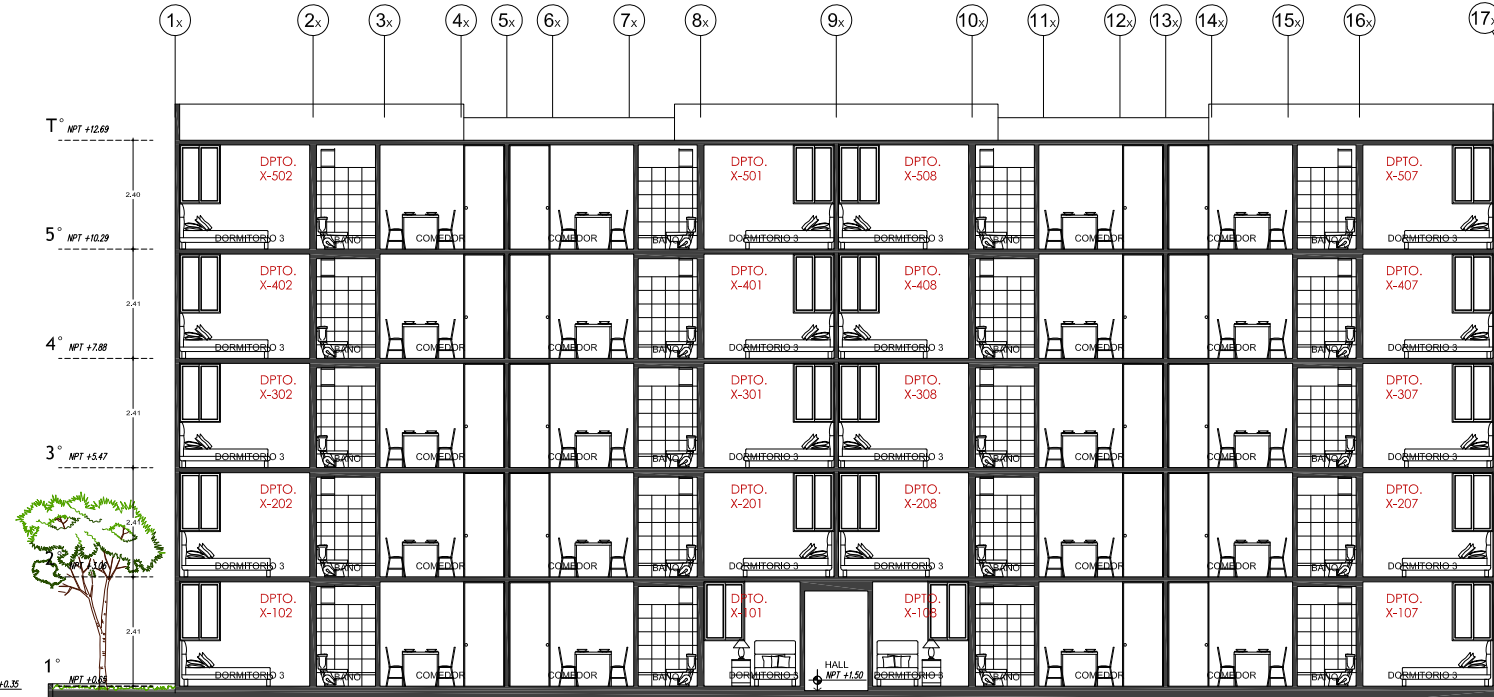
Anexo 13: Líneas de Flujo Techo – Estudio de Caso 1



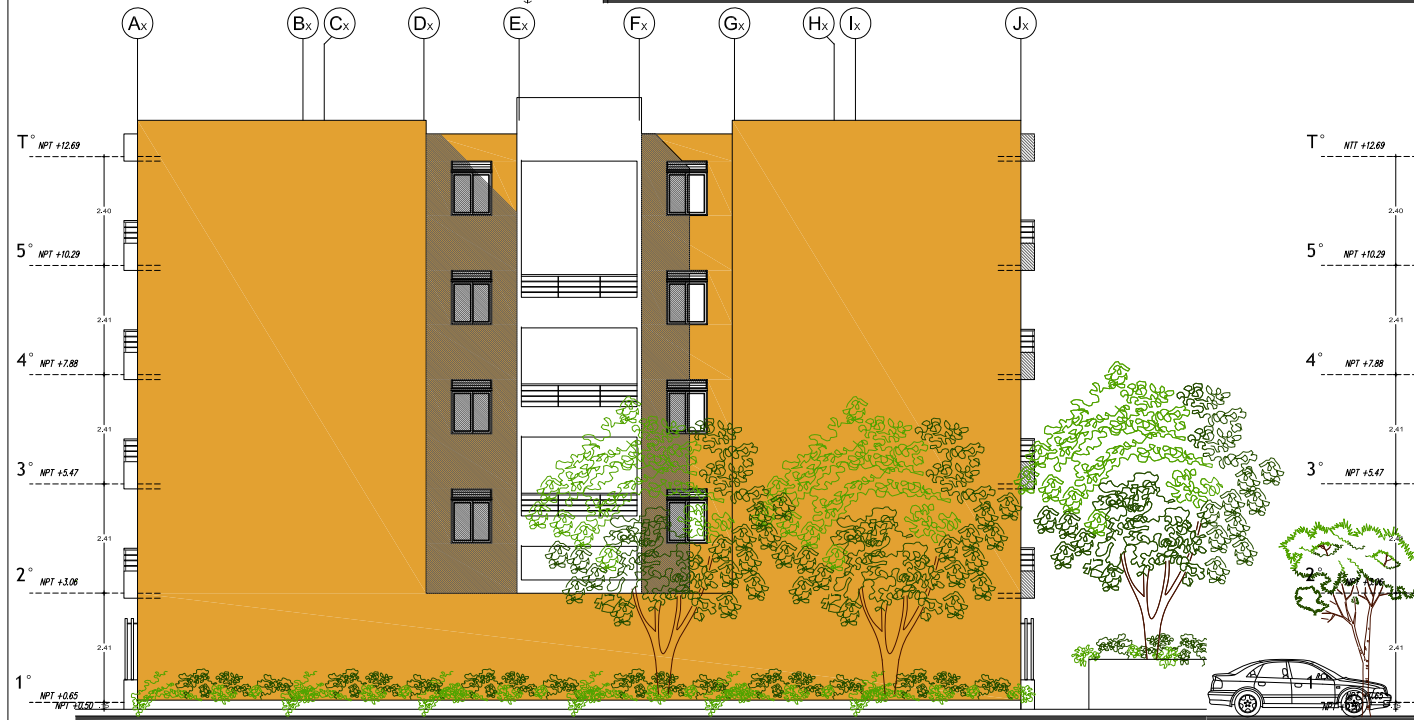
Anexo 14: Plano de elevaciones – Estudio de Caso 2



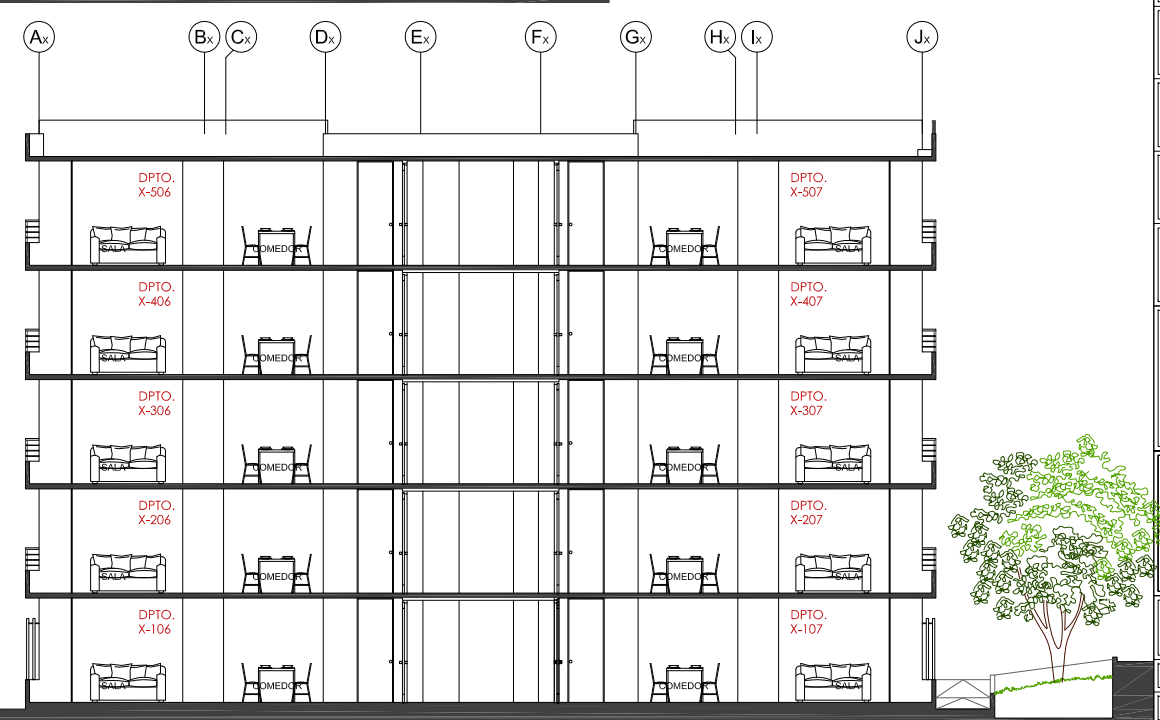
EDIFICIO X
ELEVACION FRONTAL (INTERIOR)
ESC 1:75



EDIFICIO X
CORTE 1-1
ESC 1:75



EDIFICIO X
ELEVACION LATERAL (INTERIOR)
ESC 1:75



EDIFICIO X
CORTE 2-2
ESC 1:75

PROYECTO		CONDominio CIUDAD NUEVA
PROGRAMA		PROYECTO MI VIVIENDA
UBICACION		CARRETERA SANTA CALLAO KM. 6 CERCADO DEL CALLAO CALLAO
PROPIETARIO		INMOBILIARIA GARHAO S.A.C. RUC 20518023579
FIRMA REPRESENTANTE LEGAL		
ARQUITECTO		ARQ. CYNTHIA CACEDA RIVERA C.A.P. 9309
LABORAL		EDIFICIO X ELEVACIONES Y CORTES 1 Y 2
PROYECTISTA A CARGO	LABORA	A-03
PROYECTISTA A CARGO	LABORA	
PROYECTISTA A CARGO	LABORA	
PROYECTISTA A CARGO	LABORA	
FECHA	FECHA	03
ABRIL 2015	ABRIL 2015	
ESCALA	ESCALA	1:75

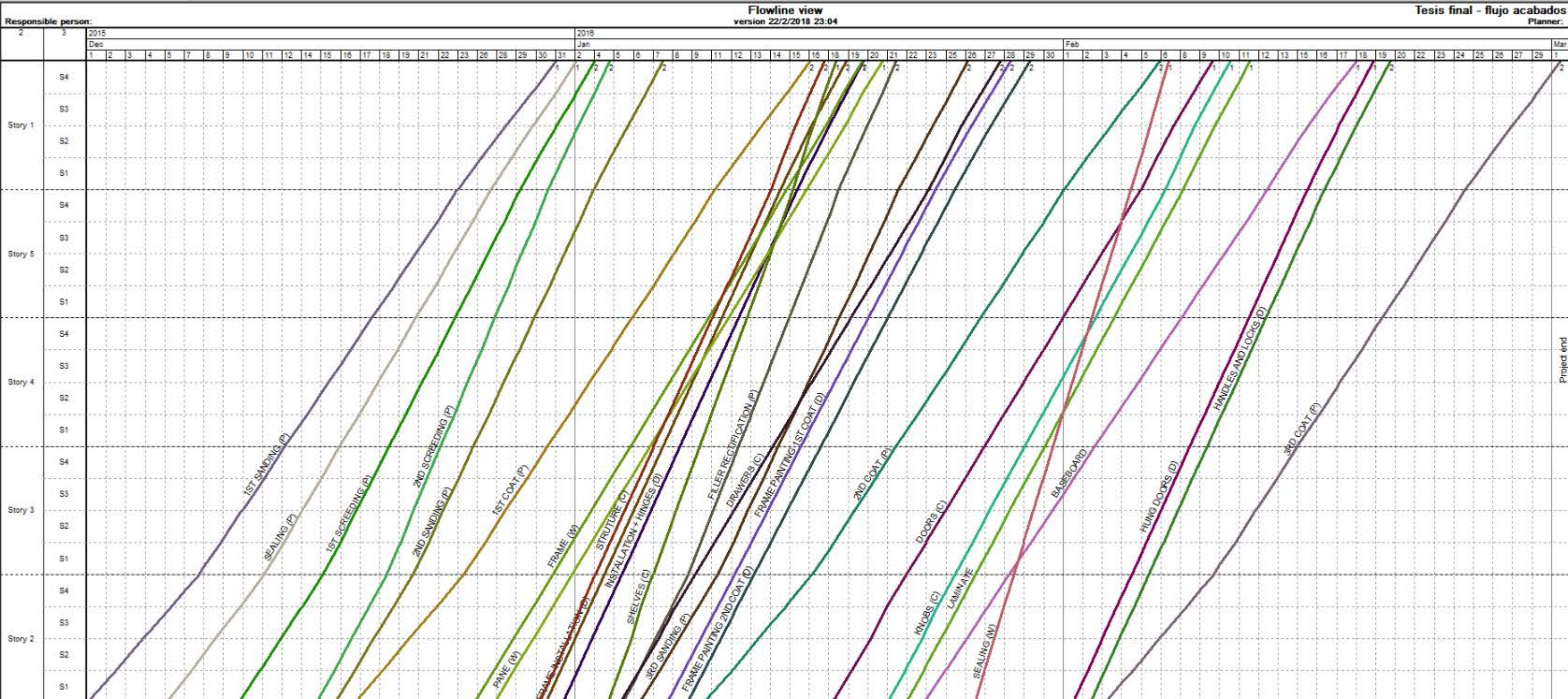
Anexo 15: Plano de planta – Estudio de Caso 2

Anexo 16: Tren de actividades de fase de arquitectura
– Estudio de Caso 2

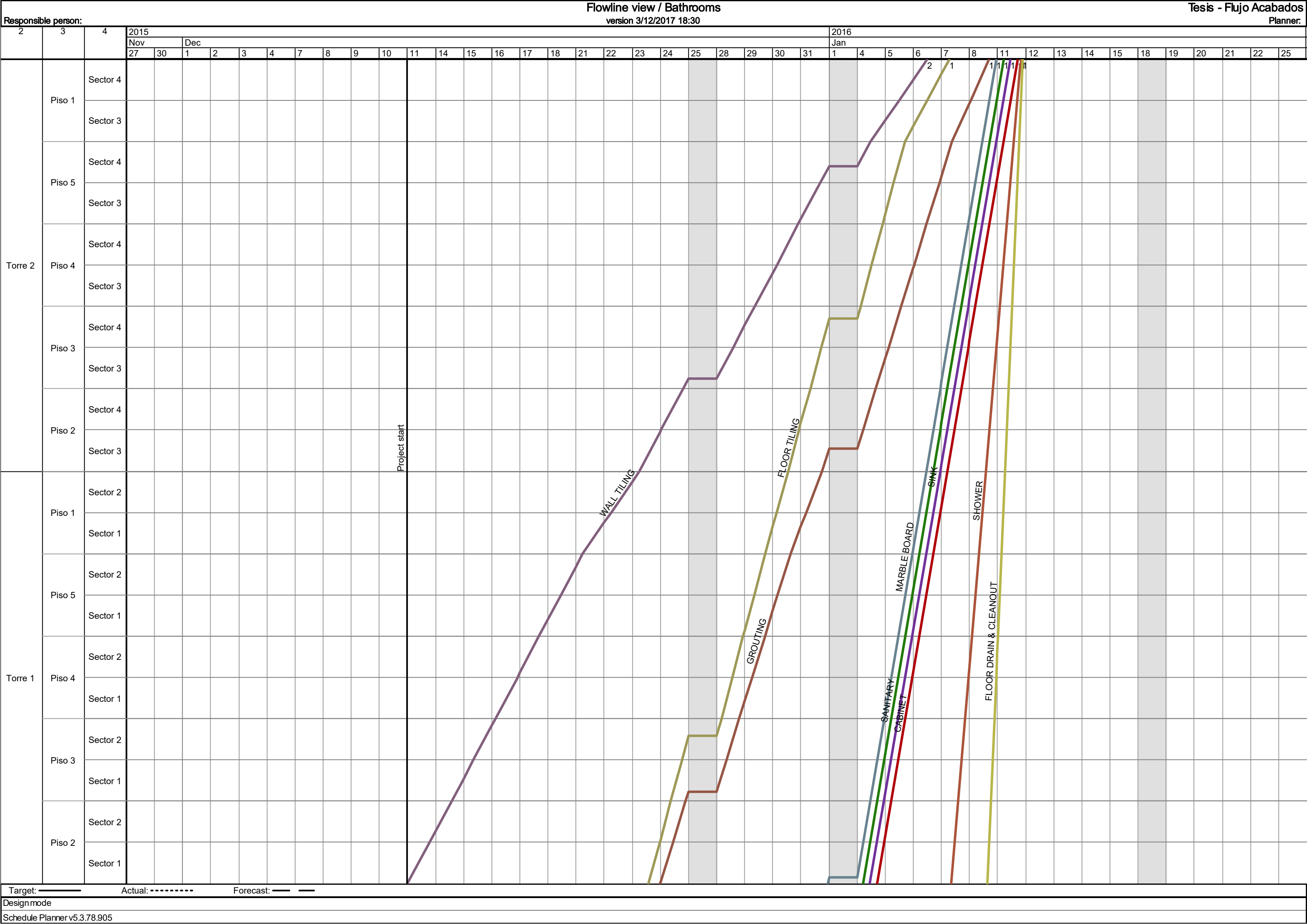
[illegible]

[illegible]

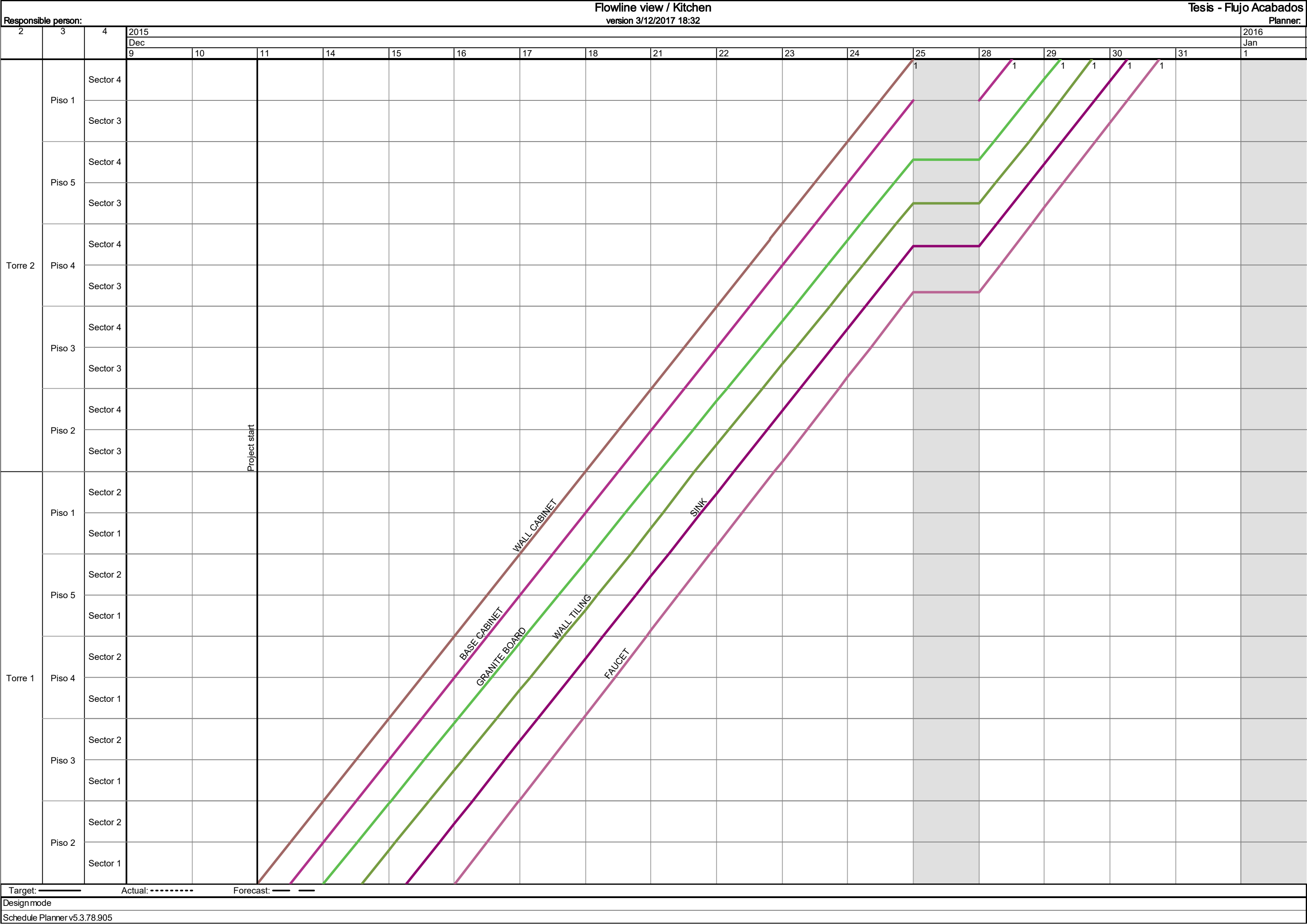
Anexo 17: Líneas de Flujo – Estudio de Caso 2



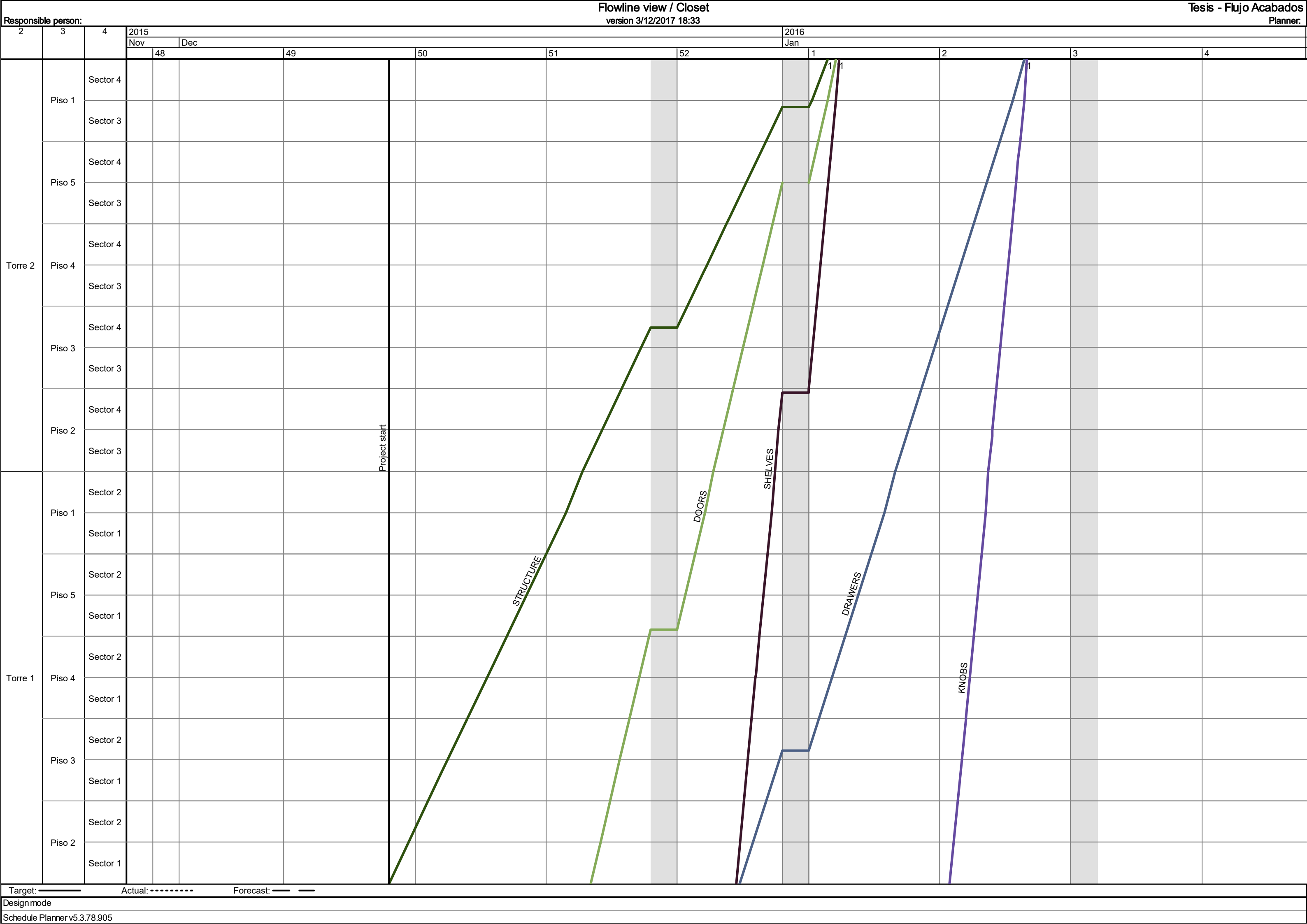
Anexo 18: Líneas de Flujo (partida Baños) – Estudio
de Caso 2



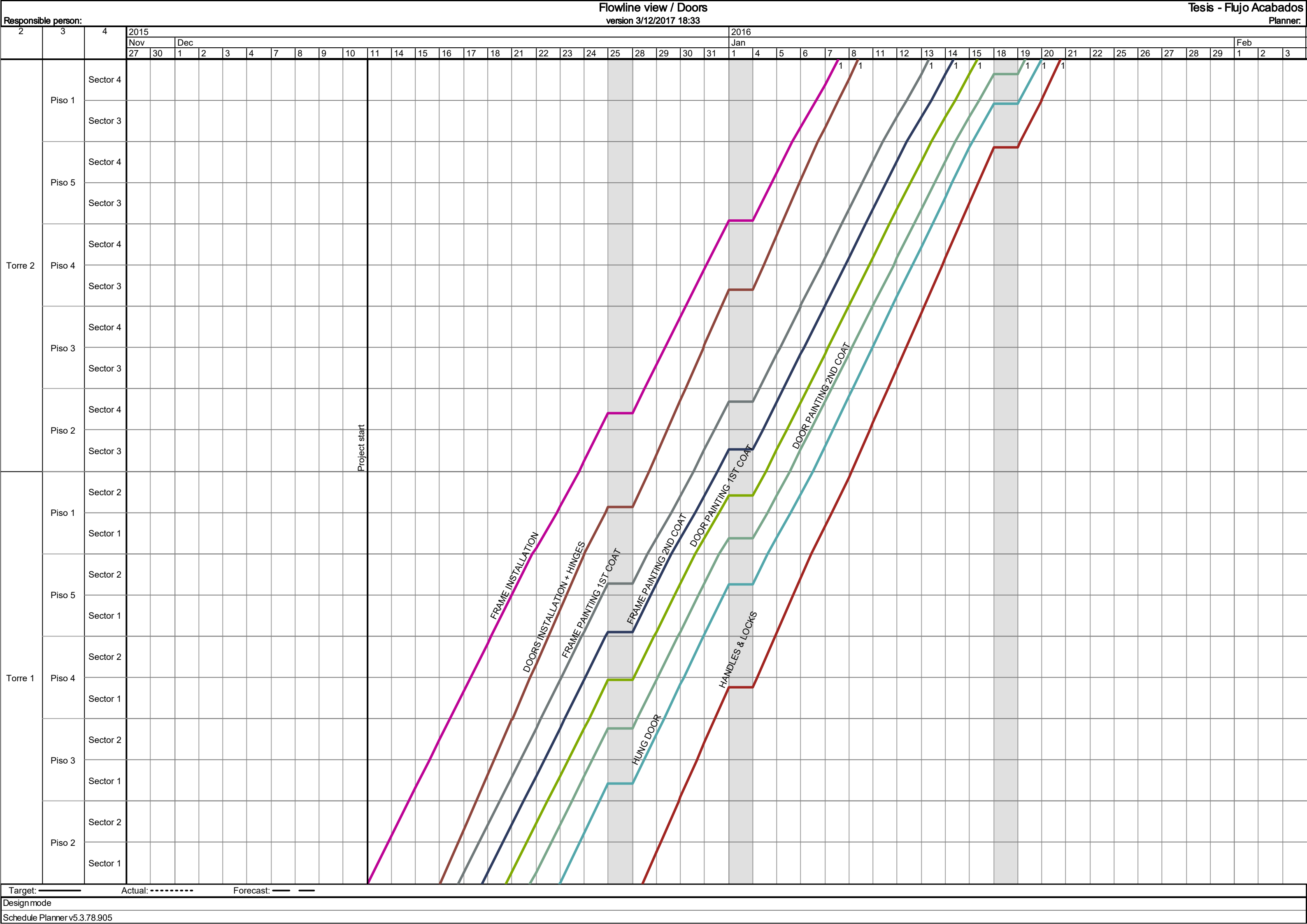
Anexo 19: Líneas de Flujo (partida Cocina) – Estudio de Caso 2



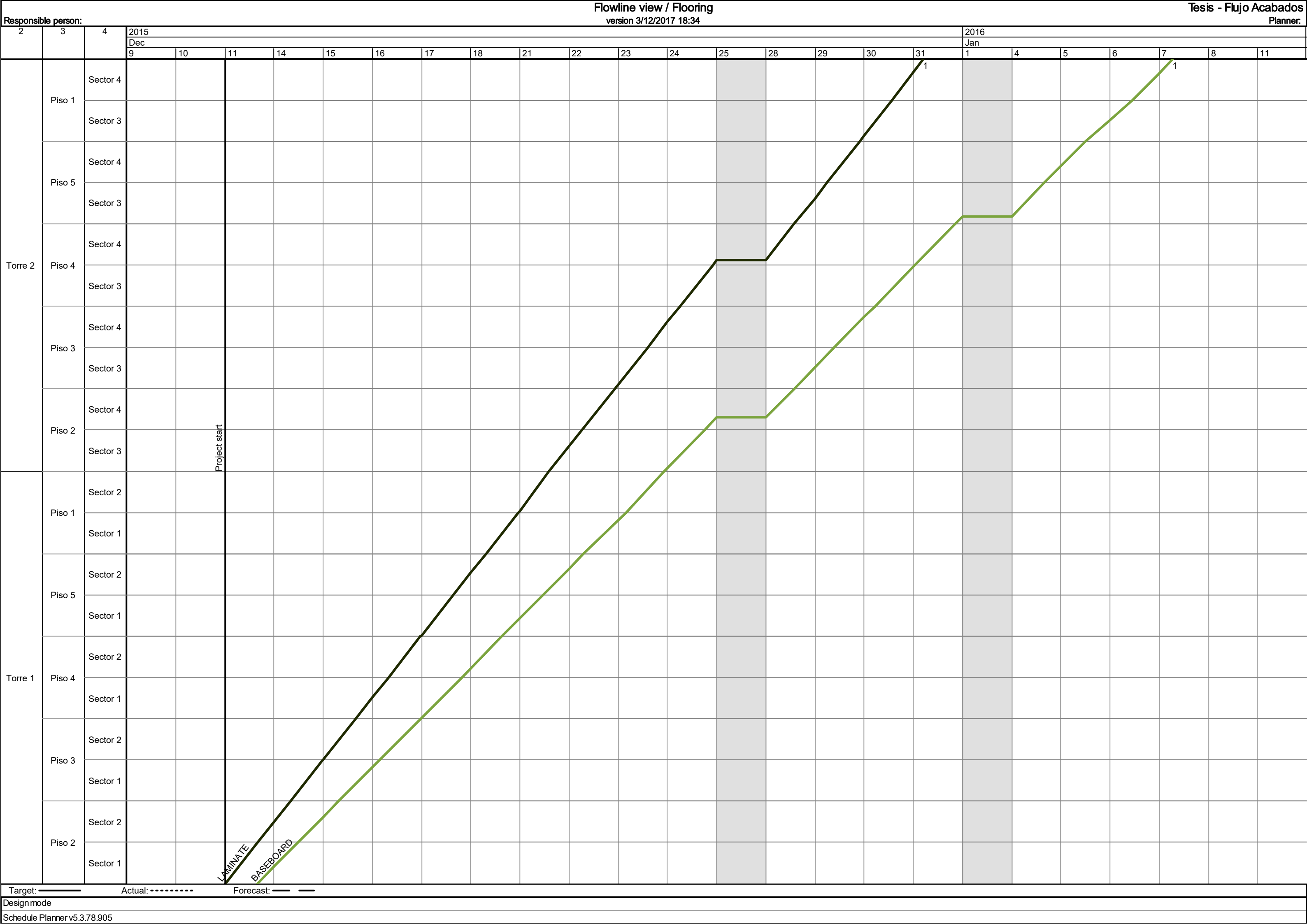
Anexo 20: Líneas de Flujo (partida Closets) – Estudio
de Caso 2



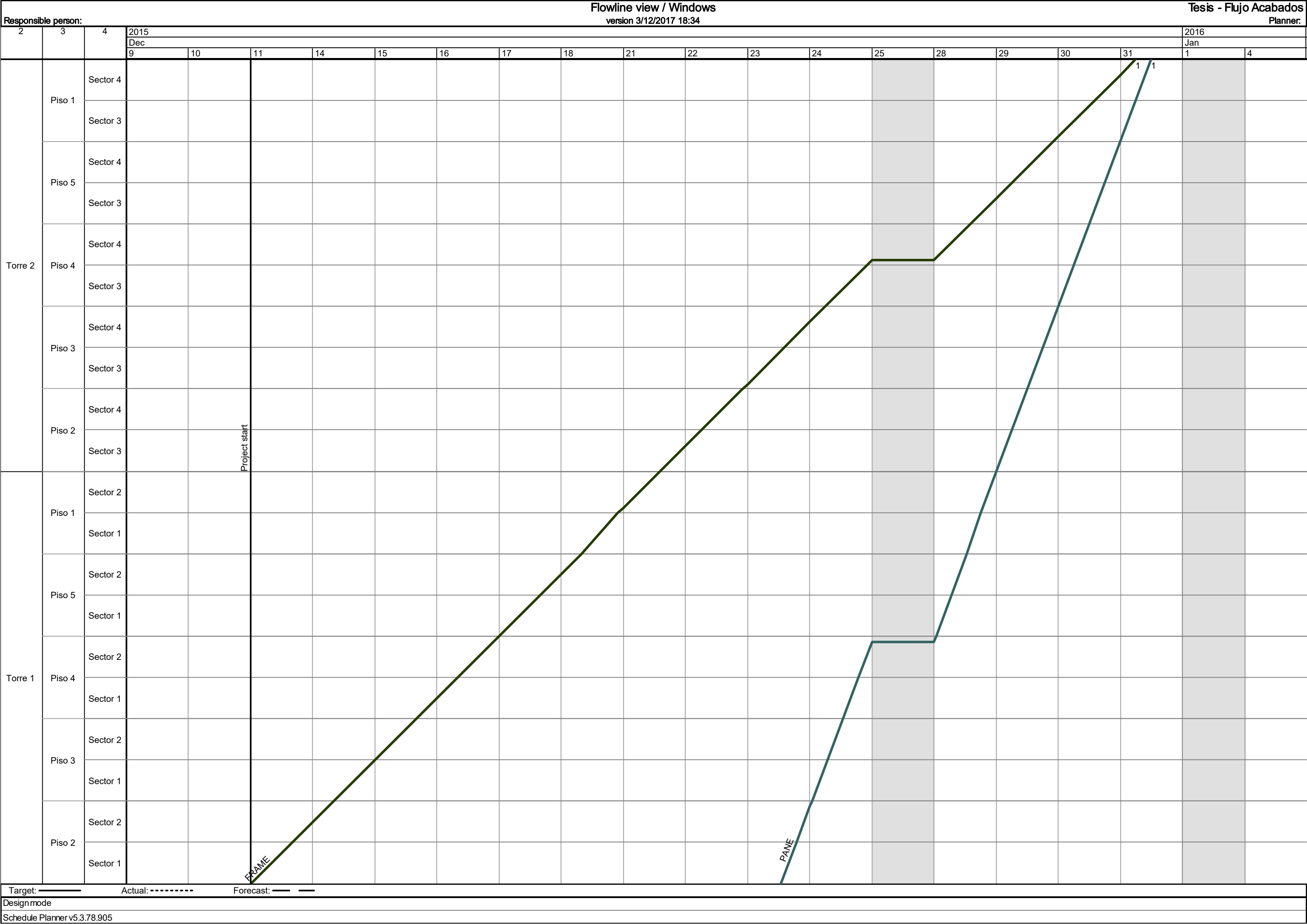
Anexo 21: Líneas de Flujo (partida Puertas) – Estudio de Caso 2



Anexo 22: Líneas de Flujo (partida Pisos) – Estudio de
Caso 2



Anexo 23: Líneas de Flujo (partida Ventanas) –
Estudio de Caso 2



Anexo 24: Líneas de Flujo (partida Pintura) – Estudio
de Caso 2

