SANTA YNEZ COMMUNITY SERVICES DISTRICT

MEMORANDUM

TO: Board of Directors

FROM: Michael LeBrun, Interim General Manager

DATE: June 15, 2022

SUBJECT: Engineers Report: Sewer Line Settlement Investigative Techniques

Recommendation

Consider the Engineer's Report and give direction

Policy Implications

When the District has cause for concern regarding the placement of sewer lines, what are the options for investigating these concerns.

Fiscal Implications

Improperly constructed sewer lines present a long-term liability to the District.

Alternatives Considered

None.

Discussion

District Engineer Mike Kielborne will present his report on options for investigating settlement of in-place sewer lines.

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Sewer Line Settlement Investigative Techniques Memo

TO: SYCSD **DATE:** June 9, 2022

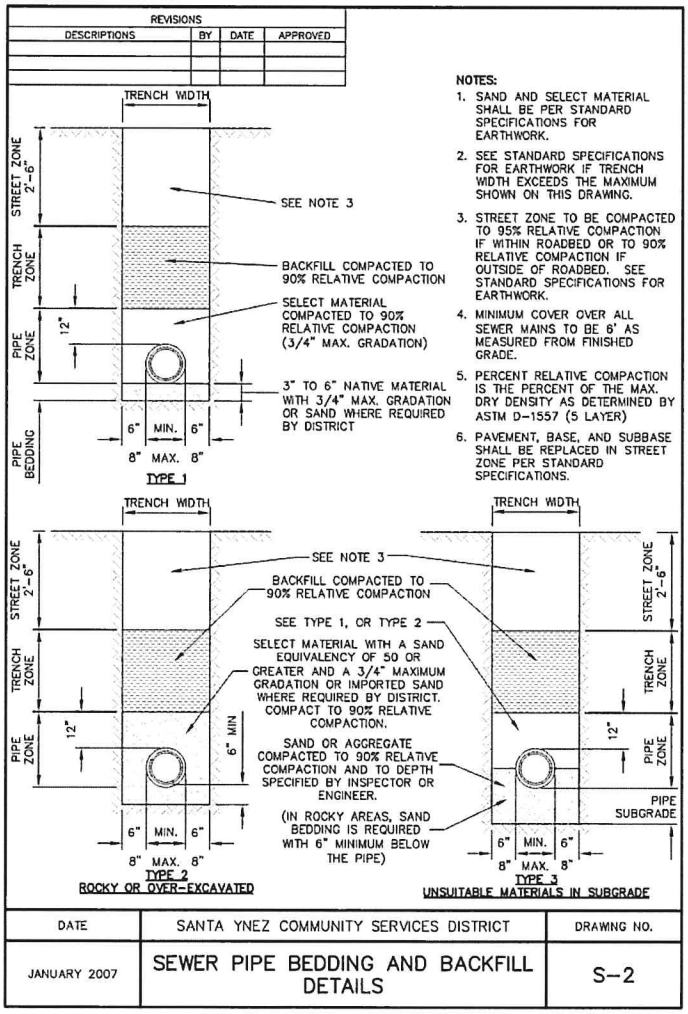
FROM: Mike Kielborn, P.E. - Cannon

SUBJECT: **Sewer Settlement Issues**

PURPOSE

The intent of this memorandum is to provide additional information on trench settlement issues as it relates to new sewer line installation in unpaved areas. This memo will outline some of the potential reasons for trench settlement, some investigation options for determining trench conditions and the potential for future settlement, and possible solutions to help prevent additional future settlement.

The District has minimum backfill and compaction requirements as laid out in the Design and Construction Standards, as well as Standard Drawing S-2. All new sewer installations must adhere to and follow these requirements to minimize the potential for trench settlement.



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Reasons for Trench Settlement

In general, trench settlement usually occurs due to poor compaction procedures, but other factors can also lead to settlement. Large rain events usually trigger the initial settlement, as the moisture in the soil compacts it and fills any voids left during the original backfilling operations. Future rain events may cause additional settling, until eventually all the voids have been filled and it stops.

In any case, 90% compaction of the trench is required for new sewer installations, and in special cases where unsuitable subgrade materials are present, additional considerations should be made, including sand or gravel bedding to help stabilize the pipe zone. Given this, up to 10% additional settlement could still occur at some point, and the project can still meet the specification requirements. Unfortunately, this could be significant if the installation is extremely deep. Some potential reasons that settlement may occur are outlined below.

- Unstable Subgrade/Bedding issues – When unstable bedding conditions are present (such as groundwater), additional material must be brought in to properly prepare the subgrade to lay the sewer pipe. In some cases, sand will work, and in other cases, where water is present, gravel must be utilized. The gravel allows a pump to be inserted into the trench to remove the water and properly lay the pipe in place. Because gravel has voids, geofabric is generally used to either encase the gravel bedding to minimize the migration of sand, silt, and fines into the voids in the gravel after compaction has taken place. If some type of barrier has not been installed, those small particles of dirt and sand can find their way down into the voids between the gravel when the soil gets wet and cause significant settlement of the trench. Unsuitable subgrade conditions that are not properly addressed will likely result in settlement. These conditions need to be identified before or during construction and a solution approved by an Engineer. They will also require additional inspection during construction to ensure the stabilization measures are properly implemented.
- Lift intervals – When trenches are backfilled, they are to be done in successive lifts so that proper compaction can take place. The soil should be hydrated to the optimum moisture content, and the placed in the trench and compacted. Generally, lifts should be no greater than 6-inches to 8-inches in depth. Lifts thicker than this don't allow the bottom of the lift to get moisture conditioned and compacted properly, which could lead to settlement in the future. If a thick layer of backfill material is just pushed into the bottom of the trench without layering and compacting them properly, then the trench backfill was not done properly and will likely result in settlement.
- Safety concerns – Deep trenches are dangerous working environments in any capacity, and getting personnel down into them during trench backfilling to take proper compaction testing measurements is a serious safety issue. To keep deep trenches safe, shoring is installed to hold up the trench walls from caving in. When backfilling a trench with shoring, there are a few ways to backfill the trench. A few are noted below:
    1. Shoring can be pulled out completely – This allows full access to the trench, but does not allow anybody to enter the trench if it is deeper than 5' deep unless the trench is laid back sufficiently. To allow compaction testing to take place at deeper locations, the shoring would have to be removed and reinstalled for every test completed.

2. Shoring can be left in – Once trench compaction is complete, the shoring could be removed, but the voids created by the removed shoring would negate the effectiveness of the areas properly compacted.
3. Shoring can be pulled up in lifts – While this could also work, reaching the areas underneath the "lifted" shoring would still be tricky to access and may not get compacted fully.

While there are other methods of backfilling the trench, the general issue is providing a safe environment for a person to enter the trench to verify compaction is adequate. If the shoring is removed, it would only be practical to get testing done in the top 8' of the trench or so.

- Ineffective equipment or compaction methods – Many methods of mechanical compaction are available for trenches, but the most effective in deeper areas are excavator compactor rollers and hydraulic compactors if there is space for that type of large equipment. The compactor roller is an excellent method for compaction, but are the most effective at depths of less than 10'. The leverage to really get good pressure on the wheel diminishes as you get deeper and deeper. Jumping jacks and vibratory plates are extremely effective, but are generally only used as the backfill gets closer to the surface. Again, these methods can only be used by personnel that can enter the safely shored trench.
- Moisture content – To reach optimum compaction, the soil going back into the trench should be at its optimum moisture content. Spraying water on dry soil, and mixing wet soil with dry soil can get the backfill material to the optimum point, but physical testing of the material before it goes in the trench is not always performed or even possible. If the soil is too wet or too dry, compaction to 90%+ may not even be possible.
- Geologic features – Some utility trenches may cross some unique geologic features that inadvertently allow groundwater to infiltrate the same trench as the pipeline, and wash pipe bedding materials away. If high groundwater or flowing groundwater is present, it can sometimes try to take the path of least resistance and allow water to infiltrate the newly installed trench. This could result in material being washed away, and ultimately trench settlement.
- Surface runoff – When a new sewer line is installed, the surrounding soil on either side of the freshly backfilled trench will have a different composition than the freshly disturbed areas. If a rainstorm event occurs, it is possible that the runoff can find a pathway to the new trench and wash away the top layers of soil in the trench line and create a river effect that will erode away even more of the soil. This would also allow water to infiltrate down into the trench zone and cause further settlement if voids are present, or proper compaction was not reached. Surface runoff could amplify some of the other issues noted above to create even larger settlement issues.
- Depth of trench – When trenches are deep, it is generally more difficult to follow all the proper steps to provide proper compaction. All of the above possible reasons for settlement intensify when combined, and can create even worse situations. A very disciplined Contractor is required to follow all the proper backfilling procedures without skipping any steps to save time.

Investigation Options

Should settling of a sewer line occur, there are several ways to perform investigations to determine the cause. While some of these are absolute, some are more theoretical, and may not deliver conclusive results or answers.

- Drill borings – Probably the most effective and economical way to determine the cause of trench settlement is to physically drill core samples into the trench and analyze the soil that is removed. The samples may be able to show how far apart the backfill lifts occurred, but most importantly, the soil density and moisture content of the samples. These could shed light on what the field conditions were like when placing the backfill by comparing them to the maximum dry density of the soil, as well as what the optimum moisture content was. If deeper layers have different values, it could be concluded that the soil was not conditioned properly, and proper compaction was not achieved in certain zones of the trench.
- Ground Penetrating Radar – GPR uses a high frequency radio signal that is transmitted into the ground and reflected signals are returned to the receiver. The computer measures the time taken for a pulse to travel to and from the target which indicates its depth and location. This technology has some ability to locate large voids and determine subsurface soil conditions, but the level of accuracy is not likely refined enough to shed much light on what exists below the surface of a trench.
- Pothole / Test Hole – One other subsurface investigative way to gather information would be to dig a test hole that a person could enter and physically take nuclear gauge tests of the soils. These tests can be done as the hole is being dug, and will tell exactly what compaction rates are at any given depth. In order to reach the bottom of a deep trench, shoring will be required, and a large enough hole will need to be dug to allow access for entry of a person. This is a fairly invasive procedure, as it will require excavation equipment, shoring, and a place to store trench spoils.

POTENTIAL SOLUTIONS

Once trench settlement is discovered in unpaved areas, it is imperative to make sure that future settlement does not occur. The largest settlements usually occur after the first large rainstorm, and Large settlements could cause safety issues, including tripping hazards, ponding, collapse of nearby structures, and sinkholes. Accidents could occur, so repairs to the area should be completed promptly.

- Fill and mound – The most economical solution to trench settlement repair is to fill the sunken areas with additional material, and slightly mound up the area if desired in case additional future settlement occurs.
- Leave and observe – Typically the leave and observe option is implemented after the fill and mound technique has been completed. The hope is that the settling has finished, and that little or no more settlement will occur. If additional settlement occurs, the same technique can be performed, until eventually all the settlement has occurred, and no further monitoring will be necessary.
- Remove and replace – Removal and replacement could focus on just the upper few feet of the trench, or remove all the way down to the pipe zone and start all over. Removal and replacement of just the upper few feet may not prohibit additional settlement from occurring below the surface, so this option should only be implemented when it is known that the poor compaction or voids are located in just the upper area of the trench. Typically, this is not the case. Generally speaking, the uncompacted areas causing the settling are down at the bottom of the trench, and those areas need to be removed and recompacted. If additional settling keeps occurring this is the best option to repair the issue. It is likely also the most expensive and

disruptive option. Everything needs to be taken out of the trench, and recompaction starts from scratch.

- Pressure grout – Pressure grouting of the soil is a technique in which a flowable slurry grout is pumped into the ground to help stabilize the soil. This is generally used in very granular or gravelly soil conditions, in the hopes that the slurry will fill the voids that are causing the settlement. This option should only be used if the soil conditions are right, and there are no other viable options available. The cost to perform this work is generally very expensive, and there are no guarantees that all the areas needing filling will be reached. This option could also cause upheaval of the surface if the slurry does not find the voids to fill. This option should only be considered under very specific conditions.
- Bridge over a deeper compaction issue with a Subgrade Enhancement Geotextile – An engineer or geologist would need to determine if this would be effective for the specific location. Instead of removal of the whole trench to fix a deeper issue, the top few feet can be removed, a subgrade enhancement geotextile placed, and then backfilled. The removal and placement of the geotextile will typically need to extend beyond the width of the trench leading to a wider excavation. However, if the cause of the settlement is deep and still occurring, this may not be an effective approach.
- Inspection and Testing – Most of the causes of settlement are due to improper compaction methods and can be caught and corrected by qualified inspection or testing. Between tests, inspectors and technicians can observe the contractor's compaction methods and techniques and provide input to the contractor to help the contractor improve the compaction results. In addition to determining the actual compaction of the soil, testing will provide the soil moisture content, thereby letting the contractor know if more or less water is needed. Without the proper amount of soil moisture, good compaction is impossible. Inspectors can verify that the requirements of the project are being met (lift thicknesses, subgrade stabilization measures, backfill materials, etc. Testing personnel can also assist contractors by providing real-time data, letting them know if their methods are getting proper compaction or if additional effort or a change in procedures is needed.
    - Full time inspection – While this won't solve the immediate problem of trench settlement, it could very well prevent settlement on future projects or future trench repairs. Although having full time inspection on-site during backfilling operations may feel like you are just paying somebody to "watch a hole being filled," this could potentially lead to huge savings down the road when issues like this arise. Having a full-time inspector on site during backfill operations will keep the Contractor honest, verify proper lifts are going in and being compacted, make sure unstable trench bedding conditions are being addressed, and that geofabric is being installed as necessary. The inspector could also be tasked with informing the soils compaction testing team when they need to be on site to test, and how often.
    - Full time compaction testing – Much like the full-time inspector mentioned above, avoiding the possibility of trench settlement can be minimized by having somebody on site to perform compaction testing at regular intervals throughout the trench backfill operations (including deep trench locations). There will definitely be down time in between testing, but having somebody available to spot check the Contractor on a regular basis will pay dividends down the road. If this individual has other jobsites nearby and can hop back and forth between them throughout the day, that could make testing more economical, but sometimes that is just not feasible and you will have to plan on paying the daily rate for that service.