New Technology for Deep Horizons
Chemical Grout Injection.

A discussion of what Polymer Technologies Worldwide, Inc. has brought to the industry.

Mark Richter, PE of Richter Engineering, Inc. is pleased to offer an independent review of the technology and services offered by Polymer Technologies Worldwide, Inc. and how it differs from other technologies and methods of chemical injection.

Injecting chemicals for the purpose of stabilizing, lifting, sealing, and compacting weak soils is nothing new. The use of polyurethanes as a grout material dates back to the 1960's (*1 – Barton Stephen C.*). The process of injecting chemical grout has been one filled with frustration not only for the owner but for the installer as well. Historically the injection of the material has been limited to shallow depths. Shallow depths would be those of less than twenty feet below grade. The reason for this is due to the technology, means, and methods of injecting the chemical material being utilized. As the chemical is injected it begins to synthesize (cure) in the injector. While the synthesis rate can be accelerated or decelerated by control of the chemical temperature, the control is short lived. The deeper or longer the injection tube, the more time the chemical synthesizes in the injection tube. While the chemical synthesizes, the diameter of the injection tube continues to reduce in diameter due to the synthesized material bonding to the wall of the tube. As a result the synthesized chemical limits the depth at which it can be injected, under the old technology. Another side effect is that the chemical being injected is losing the desired effect the deeper it is injected.

However, this frustration is being abated by a process developed by Polymer Technologies Worldwide, Inc. (PTW). Along with their innovative way of injecting chemical grout comes the ability to inject at depths far exceeding the previous limits. To prove this point, PTW has successfully injected their product to seal a leaking effluent line with an invert depth of approximately (35) thirty-five feet and an injection depth of (45) forty-five feet. On another project the system successfully injected material at a depth of (38) thirty-eight feet. Depth stated are below grade line (b.g.l.). Material is injected from full depth throughout the withdrawal up to the surface of the subject site.

Successful Projects:

Repairs to Symmes Rd Lift Station Wet Well

The wet well for the station measures 8 feet in diameter and 30 feet in depth (b.g.l.). Despite SPT borings showing weak soils to about (34) thirty feet deep, one injection point found weak soils closer to (38) feet deep. To excavate and repair the station would result in a large area of disturbance which could possibly affect an adjacent residence (duplex), underground utilities (electric, cable, etc.), and possibly Symmes Road itself.

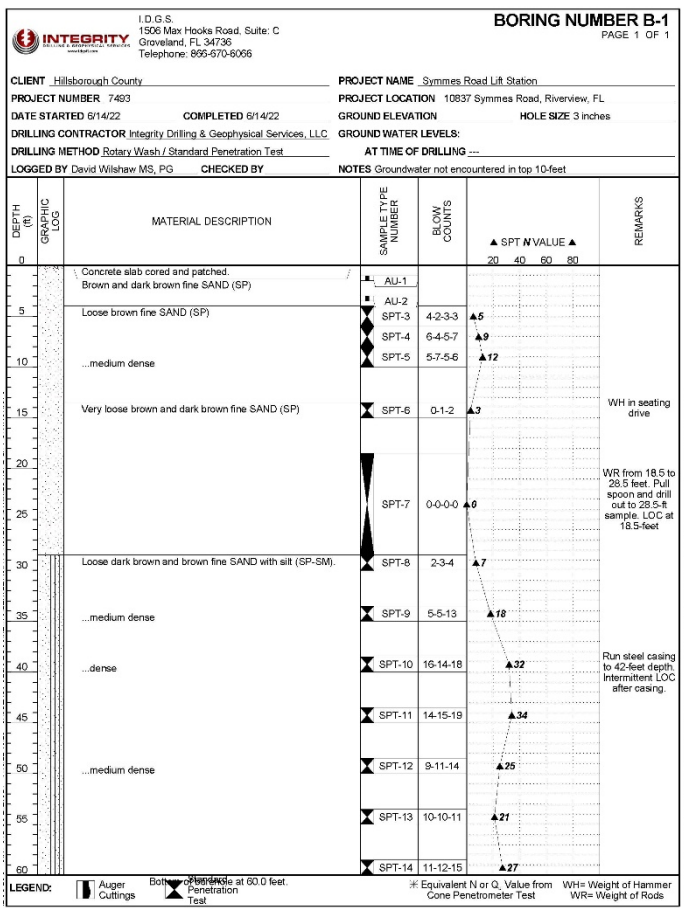
Richter Engineering, Inc.
1502 W Bush Blvd – Suite 201, Tampa, FL. Tampa, 33612
Office: 813-500-0362 FAX: 813-322-0845

Hillsborough County was experiencing damages to the lift station and immediate surrounding areas due to cracks in the inlet pipe at the station well. The cover slab had settled approximately 4". Soils in proximity of the station were found to be very loose (SPT revealing weight-of-rod conditions spanning from 18.5 feet to 28.5 feet b.g.l.) (*2 – Wilshaw, David*).

Injecting 2,623 gallons of polymer through four injection points commencing at depths between (32) thirty-two feet and (45) forty-five feet below grade and up to the surface yielded the following results:

- Soils around the wet well were strengthened (*Wilshaw, pgs. 3-6*) to the point where weight-of-rod conditions no longer exist.
- Filled voids – stopped leaks eroding area around system and water intrusion into system which causes erosion as well.
- Comparing pre and post SPT testing of points between the lift station and the southern lift station property line (SPT #B-2 & B-5) shows that the material remains onsite confirming the claim of the controllability of the injection process.

Let us look at the project from the beginning:



I.D.G.S.
1506 Max Hooks Road, Suite: C
Groveland, FL 34736
Telephone: 866-670-6066

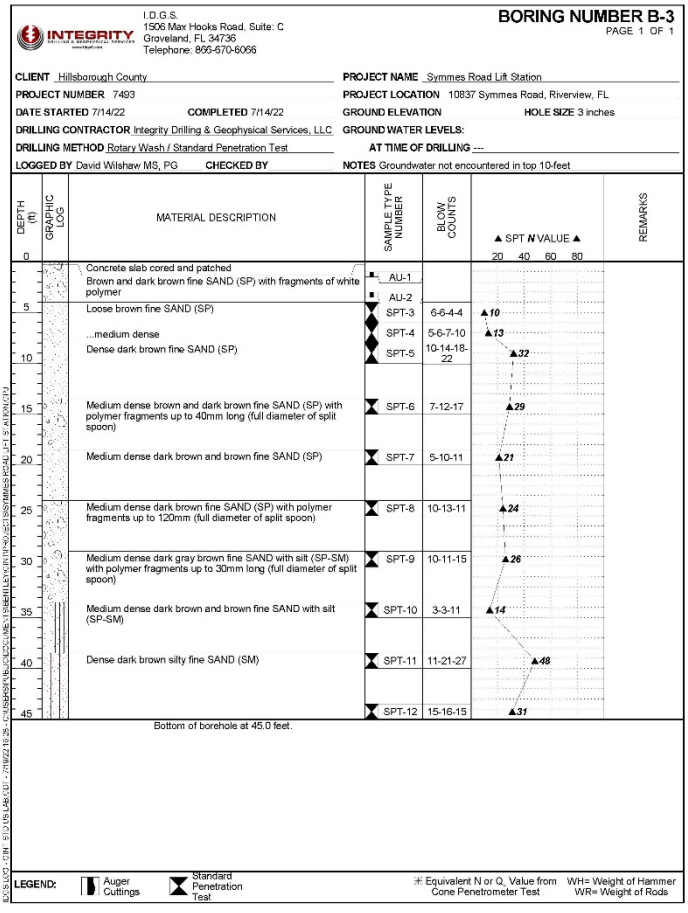
BORING NUMBER B-1
PAGE 1 OF 1

CLIENT Hillsborough County
PROJECT NAME Symmes Road Lift Station
PROJECT NUMBER 7493
PROJECT LOCATION 10837 Symmes Road, Riverview, FL
DATE STARTED 6/14/22 **COMPLETED** 6/14/22
GROUND ELEVATION **HOLE SIZE** 3 inches
DRILLING CONTRACTOR Integrity Drilling & Geophysical Services, LLC
GROUND WATER LEVELS:
DRILLING METHOD Rotary Wash / Standard Penetration Test
AT TIME OF DRILLING ---
LOGGED BY David Wilshaw MS, PG **CHECKED BY**
NOTES Groundwater not encountered in top 10-feet

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS	▲ SPT N VALUE ▲ (20 40 60 80)	REMARKS
0	Concrete slab cored and patched. Brown and dark brown fine SAND (SP)	AU-1			
		AU-2			
5	Loose brown fine SAND (SP)	SPT-3	4-2-3-3	▲5	
		SPT-4	6-4-5-7	▲9	
10	...medium dense	SPT-5	5-7-5-6	▲12	
15	Very loose brown and dark brown fine SAND (SP)	SPT-6	0-1-2	▲3	WH in seating drive
20		SPT-7	0-0-0-0	▲0	WR from 18.5 to 28.5 feet. Pull spoon and drill out to 28.5-ft sample. LOC at 18.5-feet
25					
30	Loose dark brown and brown fine SAND with silt (SP-SM).	SPT-8	2-3-4	▲7	
35	...medium dense	SPT-9	5-5-13	▲18	
40	...dense	SPT-10	16-14-18	▲32	Run steel casing to 42-feet depth. Intermittent LOC after casing.
45		SPT-11	14-15-19	▲34	
50	...medium dense	SPT-12	9-11-14	▲25	
55		SPT-13	10-10-11	▲21	
60		SPT-14	11-12-15	▲27	

Bottom of borehole at 60.0 feet.

LEGEND: Auger Cuttings; Standard Penetration Test; ✳ Equivalent N or Q_c Value from Cone Penetrometer Test; WH= Weight of Hammer; WR= Weight of Rods



I.D.G.S.
1506 Max Hooks Road, Suite: C
Groveland, FL 34736
Telephone: 866-670-6066

BORING NUMBER B-3
PAGE 1 OF 1

CLIENT Hillsborough County
PROJECT NAME Symmes Road Lift Station
PROJECT NUMBER 7493
PROJECT LOCATION 10837 Symmes Road, Riverview, FL
DATE STARTED 7/14/22 **COMPLETED** 7/14/22
GROUND ELEVATION **HOLE SIZE** 3 inches
DRILLING CONTRACTOR Integrity Drilling & Geophysical Services, LLC
GROUND WATER LEVELS:
DRILLING METHOD Rotary Wash / Standard Penetration Test
AT TIME OF DRILLING ---
LOGGED BY David Wilshaw MS, PG **CHECKED BY**
NOTES Groundwater not encountered in top 10-feet

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS	▲ SPT N VALUE ▲ (20 40 60 80)	REMARKS
0	Concrete slab cored and patched	AU-1			
	Brown and dark brown fine SAND (SP) with fragments of white polymer	AU-2			
5	Loose brown fine SAND (SP)	SPT-3	6-6-4-4	▲10	
	...medium dense	SPT-4	5-6-7-10	▲13	
10	Dense dark brown fine SAND (SP)	SPT-5	10-14-18-22	▲32	
15	Medium dense brown and dark brown fine SAND (SP) with polymer fragments up to 40mm long (full diameter of split spoon)	SPT-6	7-12-17	▲29	
20	Medium dense dark brown and brown fine SAND (SP)	SPT-7	5-10-11	▲21	
25	Medium dense dark brown fine SAND (SP) with polymer fragments up to 120mm (full diameter of split spoon)	SPT-8	10-13-11	▲24	
30	Medium dense dark gray brown fine SAND with silt (SP-SM) with polymer fragments up to 30mm long (full diameter of split spoon)	SPT-9	10-11-15	▲26	
35	Medium dense dark brown and brown fine SAND with silt (SP-SM)	SPT-10	3-3-11	▲14	
40	Dense dark brown silty fine SAND (SM)	SPT-11	11-21-27	▲48	
45		SPT-12	15-16-15	▲31	

Bottom of borehole at 45.0 feet.

LEGEND: Auger Cuttings; Standard Penetration Test; ✳ Equivalent N or Q_c Value from Cone Penetrometer Test; WH= Weight of Hammer; WR= Weight of Rods

Boring B-1 is the pre-injection condition while B-3 is a post-injection condition. Borings are spaced approximately 3 feet apart.

This picture shows the wet-well leak adjacent to the influent pipe. Note stream to the left of influent stream.

Within 15 minutes of commencing to inject material into the first point we can see that the wet well is already being sealed. Note the absence of the leak to the left of influent stream.

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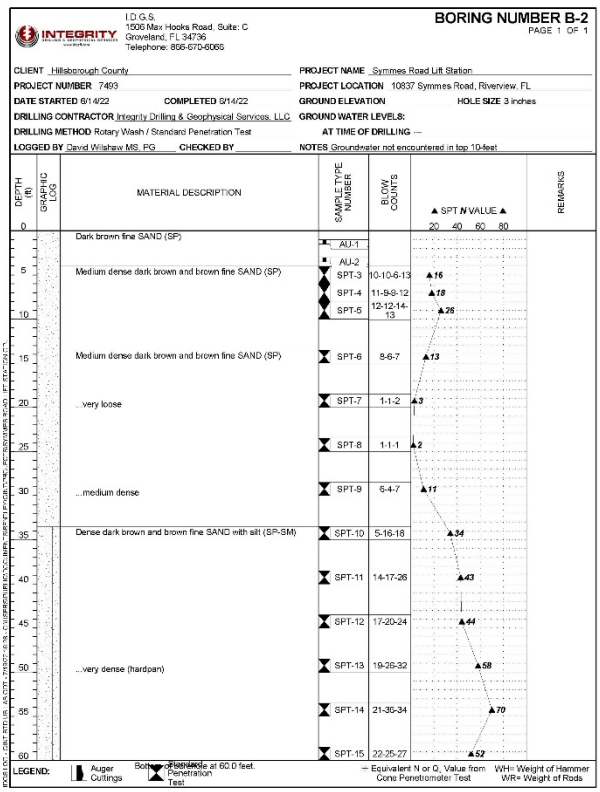
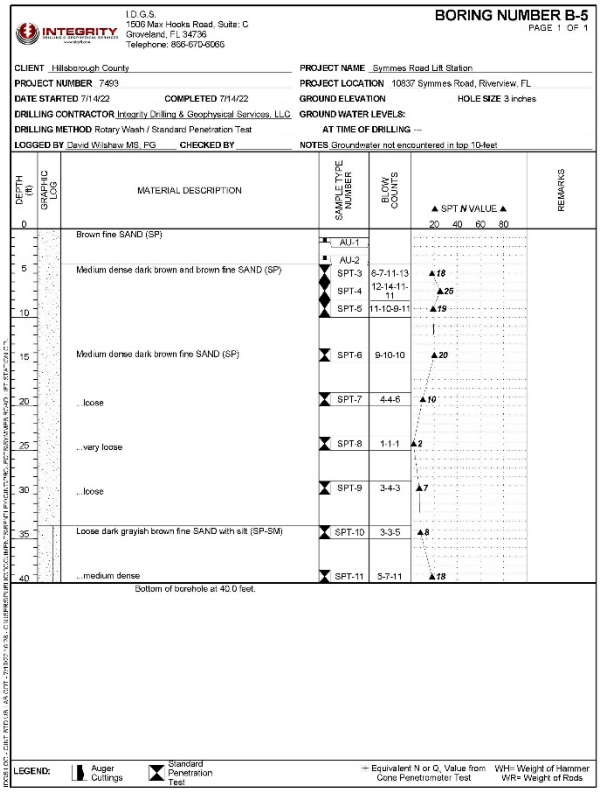
1502 W Bush Blvd – Suite 201, Tampa, FL. Tampa, 33612
Office: 813-500-0362 FAX: 813-322-0845





Boring B-2 is the pre-injection condition and B-5 is a post-injection condition. These borings are located between the compound fence and the property line for the lift station property.

Injection point #1 is located approximately one foot east of B-1 and approximately three feet west of the influent line (influent line runs north to south into the wet well) on the north side of the wet well. Injection point #1 received 119 gallons of material starting at a depth of 38 feet. Injection point #1 experienced an equipment issue and was abandoned at a depth of 25 feet. Injection point #1A was located 1 foot north of injection point #1. Injection point #1A was advanced to a depth of 24 feet and received 710 gallons of material as withdrawn up to the surface. Injection point #2, located west of B-3, was advanced to 35 feet in depth and received 709 gallons of material as withdrawn up to the surface. Injection point #3, located south of the wet well and approximately 19 feet north of B-5, was advanced to 31 feet deep and received 425 gallons of material as withdrawn up to the surface. Injection point #4 was located east of the wet well approximately 3 feet north of the lift station ejection/effluent pipe. Injection point #4 received 779 gallons of material as withdrawn starting at a depth of 41 feet below grade up to the surface.

Polymer Technologies provided that the conversion rate for this material from gallons to pounds of material is 2,623 gallons x 9.6 = 25,181 pounds of material injected.

This depicts the site map for the Symmes Rd lift station project

The following pictures show how the weak subsurface materials become encapsulated in the foam matrix. These samples were obtained from post injection SPT borings:

← *This sample was obtained from approximately 11.5 feet below grade SPT B-3.*

This was obtained from Injection Point #1 at 23 feet b.g.l. while trying to advance boring to 24 feet to continue the injection process upon equipment repair. →

← *Spoon samples taken post injection.*

Boring for injection point #1 in progress →

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Injection point #1 boring pipe extractor being installed in preparation for injection system installation. →

← Injection Point #3 in progress.

Richter Engineering, Inc.
1502 W Bush Blvd – Suite 201, Tampa, FL. Tampa, 33612
Office: 813-500-0362 FAX: 813-322-0845

Lift Station 87 (1900 Mound St./US41) – City of Sarasota, FL

Lift Station 87 is a project that was under construction that will eventually handle approximately 1/3 of the City of Sarasota's waste water flow. Lift Station 87 was to replace Lift Station 7 that was in service at the time. The station forwards the effluent to the City's waste water treatment facility. The influent line is a 36" diameter line that crosses Hudson Bayou. While testing the influent line, City staff discovered significant ground water intrusion into the line. The intrusion into the line was discovered to be through several holes, breaks, and joint failures. These intrusions will cause the sanitary system to work harder thereby reducing the useful life of the equipment and consuming additional energy for those efforts.

The first repair effort was to install a liner inside the pipe and impregnate the line with epoxy. While this type of repair has worked in similar type projects, it failed to stop the water intrusion.

The second repair effort to repair the pipe involved the injection of a two component, fast reaction chemical grout. The intent was to seal the pipe from the exterior, in-situ. Due to the methods used, previously referred to as 'historic method', the efforts failed. The reason for failure can be attributed to the depth of the pipe being greater than 20 feet.

The third repair effort that was considered was to excavate the pipe and replace it. This effort would have caused extensive disruptions to the surrounding infrastructure and to the local population. This option was estimated to add an additional $9-12 Million to an already over budget project, not to mention extending the completion time of the project approximately another year for the already severely delayed project.

Instead of opting to delay and add additional cost overruns to the project, the City took a chance to engage Polymer Technologies Worldwide, Inc.'s patented process. Not only did the efforts seal the pipe leaks, the foundation of the lift station structure was enhanced and further stabilized. The Polymer Technologies Worldwide materials were put into place while the construction of the lift station facility continued. By the City utilizing these efforts, there was no additional time delay, there was no adverse impact to the motoring public, and there was not multimillion dollar cost overrun. Polymer Technologies has a good video of the pre-condition leak flows on their website: www.polymertechnologiesus.com

This was taken when the subject pipe was initially installed.

The prime contractor continues work uninterrupted on the infrastructure while injection of polymers for the purpose of sealing the leaking buried line.

Another view of concurrent injection points along with work continuing on project by prime contractor. Injection points are on alternate sides of the subject pipeline.

Manholes on Oakfield Drive between Pauls Drive & Kings Avenue, Brandon (Hillsborough County), Florida.

The series of manholes is located on Oakfield Drive between Pauls Drive and Kings Avenue have leaked and caused partial collapses of the roadway. The leaks is located adjacent to the manholes where one of the lines enters/exits.

The normal process to repair this type of leak would be to open up the roadway around the manhole and repair the joints, then backfill and compact in lifts, and pave the street. This method take days if not months to complete correctly with the added inconvenience to the residents and motoring public.

Polymer Technologies Worldwide, Inc.'s patented process would allow the sanitary system to remain in service, would not impede the free flow of traffic, and would take days instead of months. This is due to the ability of Polymer Technologies to set up their equipment on the shoulder space thereby not impacting traffic with a lane closure or roadway closure.

As an added benefit to stabilizing the soils and filling voids caused by erosion of the soils due to leaking, the leaks can be successfully plugged with no known adverse effect to the sanitary system function or reduction in pipe cross section such as with installing a liner inside the pipe.

The process of remediating the soils around the leaks can be accomplished by minimizing inconvenience to the community as the work can be done while the roadway is in continual use.

Oakfield Dr. near Bob Dykes Dr. Looking towards southwest from north side of roadway.

The "old way" of repairing pipe-manhole leaks:

While the current efforts only depict leaks at lift stations, leaks can occur in the most inconvenient places….such as along a multilane roadway. Temporary closure of a small subdivision street is not much of a concern but to close down half or most of a larger roadway is more of a problem. At least that is how the motoring public views it. The standard practice of repairing leaks can be problematic to the public. My experience in dealing with roadway closures, whether for construction or for maintenance, has taught me that most people only know one way to get between their way points. So a roadway closure and detour arrangement can really play havoc on many people. Let us dive into a typical situation where a leak is at a descent depth that would require the temporary destruction of a roadway:

The problem: leaking joint at manhole results in a depression in the roadway which can lead to a localized collapse if left unrepaired.

The typical culprit would be a leak between manhole and pipe. Another typical leak location is between the first and second pipe segment.

Oakfield Drive leak repair →

The 'old way' to repair:

- Block off roadway, inconveniencing the motoring public, public transportation, emergency responders, etc.
- Excavate a trench wide enough, deep enough to work in. Possibly the added expensive use of a well point system to artificially lower the water table.
- Place mortar around joint to try and stop the leak(s).
- Back fill in lifts as you compact each lift.
- Remove well point system, if utilized, and replace pavement.
- The end result is a repair that is subject to leaking once the mortar cracks return. This will result in additional months of public inconvenience and hundreds of thousands of dollars spent to repeat the process.

The Polymer Technologies Worldwide, Inc.'s patented technology allows for the deep injection of polymer materials, vertically as well as horizontally.

The rig is used, in part, to advance casing to the desired injection depth. The casing is a three inch diameter steel casing with threads on each end. This allows for additional sections of casing to be installed as the depth increases. Upon reaching the desired injection depth, the rig is used to withdraw the casing as the polymer is being injected. Care is used to advance at an appropriate rate not too slow so as to not foul the casing with the polymer but not so fast that the polymer is not under injected. Post injection testing will ensure that the appropriate amount of material has been injected.

To inject the polymer a special nozzle is advanced through the casing and attached to the drilling head of the casing. The operator lowers the head and attached chemical feed lines to casing head (equipment) in a manner so as to not foul the lines or damage the injection nozzle. Upon appropriate lowering the equipment, which is done by attaching a lowering/turning bar to the equipment, the lowering bar is then rotated to lock the equipment to the head. As the casing is withdrawn, the lowering bar is removed in sections just as the casing is removed.

Polymer Technologies Worldwide, Inc.'s chemical injection technology now allows the materials to be targeted at depth at the source of the substandard soils. The pumps used to feed

the chemical need to be powerful enough overcome the strength of the soil materials as well as to overcome the line friction. The line friction will most likely be the controlling factor relating to the depth possible. This limiting factor will be overcome by increasing the pumping power, increasing feed line diameter, the casing diameter, or a combination of the componenets.

The benefits of the Polymer Technologies Worldwide, Inc.'s patented technology is that, theoretically, there is no known reasonable limit to the depth where the material can be successfully injected. This is due to the material being combined at the tip of the casing which allows for the full strength of the material to occur where it needs to be, at the tip as opposed to in the feed line.

Another benefit is that the material can be injected from a lateral point so as to not interfere with an active project.

Based on my past experiences, I foresee these as examples of how this technology can be utilized:

- A leaking side drain and/or cross drain can be sealed without closing down a busy highway, interstate system, rail system, etc.
- A leaking sanitary lift station can remain in operation while a leaking influent line or wet well is sealed.
- A building can remain in operation while a basement wall is sealed.
- A leaking earthen dam can be sealed without lowering water levels.
- Retaining walls can be sealed at depth without excavation or injection from the face (which can weaken the wall further).
- Stabilizing embankments along/adjacent to transportation systems (bridges, rail roads, roadway, canal banks, etc.).
- Reduced time, reduced cost, reduced impacts to the public. FDOT takes this into account during the planning phases for projects.
- Sealing abandoned wells and mine shafts while allowing for future material removal so that the well or shaft can be put back into service.
- This system also lends itself to sealing liners below landfills.

The suitability of this process can be of great benefit not only in its applicability but in the time & cost savings to the public.

During the work performed on the Symmes Rd Lift Station it was shown that there is good control of the material in that none of the material encroached on neighboring properties (post SPT control points, please refer to page 4 for B-2 & B-5 logs). Also revealed was that material adjacent to the grout was compacted and stabilized despite no presence of material in those soils.

Polymer Technologies has experimented on encapsulating hazardous materials. Approval will be sought from the Florida Department of Environmental Protection for this purpose. While this purpose is not to remediate a spill, it would be to encapsulate the spill material to reduce the spread of the contaminant thereby facilitating Remedial Action efforts. Encapsulating the

contaminant would ideally reduce impacts to adjacent properties and allow for more time to generate a Remedial Action Plan. An additional benefit of reducing the size of the spill is potentially lowering the costs associated with cleanup efforts, after all, a smaller volume of space to clean up is sure to cost less than a much larger volume. Imagine being able to encapsulate an abandoned buried fuel tank, fill the tank to keep it from collapsing, or encapsulating an older fuel spill floating on an aquifer. I know of dozens of locations throughout Florida alone that could benefit from just stopping the spread of a toxic product.

REFERENCES

(1) Barton, Stephen C.
"The History of Polyurethane and Chemical Grouting", Aug 22, 2018
info.alchemy-spetec.com/blog/the-history-of-polyurethane-and-chemical-grouting
(2) Wilshaw, David
"Ground Stability Assessment – Post Stabilization", July 21, 2022
Integrity Drilling & Geophysical Services, LLC
(3) Pictures provided by Polymer Technologies Worldwide, Inc. and used by their permission.

Mike Gonzalez with Polymer Technologies Worldwide, Inc. can be reached at 813-503-3813 and mike@polymertechnologiesus.com .

Richter Engineering, Inc. appreciates the opportunity to discuss these matters. Please feel free to contact me with any questions or concerns.

Cordially,

Digitally signed by Mark V Richter
DN: c=US, o=North Carolina, dnQualifier=A01410C00000 17B12CD491E00010776, cn=Mark V Richter
Date: 2022.09.07 23:44:03 -04'00'

Mark Richter, PE
Richter Engineering, Inc. – CA09356
Project No.: 22-AT127r0
Date: September 8, 2022

Past relevant experience:

Putman County – Remedial Action Plan for Putnam County fuel spill, backup wastewater plant operator.
FDOT – roadway maintenance, roadway design, & roadway construction project engineer.
Volkert & Associates - large industrial site design (grading, drainage systems, heavy rail design, roadway, etc.)
Private Practice - foundation enhancements for damaged structures (pinning, grouting, etc.), site design, telecommunication tower site and foundation design.

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