

## Section 6 West Kalihi Geographic Zone (T-001 through T-020A)

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### 6.1 Overall Location

For reporting purposes for this AIS, the City Center Section 4 of the HHCTCP has been divided into 11 zones based on geographic and cultural boundaries. The West Kalihi Geographic Zone is located within the western portion of Kalihi Ahupua'a, Honolulu District, Island of O'ahu, in a physiographic division known as the Pearl Harbor Plain (Armstrong 1983:36). West Kalihi extends approximately 0.5 km along Kamehameha Highway and is bounded to the west by the Middle Street exit from Kamehameha Highway and bounded on the east by Laumaka Street. As part of the City Center AIS, a total of 21 test excavations (T-001 through T-020 and T-020A) were excavated in the West Kalihi Zone along and adjacent to Kamehameha Highway (see Vol. IVA). Test excavation numbering proceeded from northwest to southeast. Test excavations documented within West Kalihi fall predominantly under the jurisdiction of the State of Hawai'i (T-001 through T-005 and T-009 through T-010) and the City and County of Honolulu (T-012 through T-020 and T-20A), while several (T-006 through T-008 and T-011) are located in a private lot owned by First Hawaiian Bank. T-006 through T-008 and T-011 are located within TMK Parcel [1] 1-2-013:021. The remaining test excavations are located within TMK Plats [1] 1-2-013 (T-001 through T-002, T-004 through T-005, T-009 through T-010, T-014 through T-020, and T-020A), TMK [1] 1-2-017 (T-012 and T-013), and TMK [1] 1-2-018 (T-003) and are within the Kamehameha Highway right-of-way.

### 6.2 Geography, Geology, and Land Forms

The West Kalihi Zone is situated along the low-lying coastal flats immediately inland of Ke'ehi Lagoon, an embayment or estuary of the Moanalua, Kahauiki, and Kalihi Streams. Elevations in the zone range from approximately 1.6 to 3.3 m amsl, and the average annual rainfall measures 760 to 810 mm (30 to 32 in) (Giambelluca et al. 2011). East of the West Kalihi Zone elevations in the study area increase from the relatively low-lying Kalihi Stream estuary as the transit corridor ascends onto a portion of the emerged Pleistocene reef limestone common along southern O'ahu. This reef limestone formed during the 7.5-m (Waimanalo) sea-stand (Macdonald et al. 1983:420-421). Kalihi Stream traverses the westernmost limit of the area and debouches approximately 400 m away into Ke'ehi Lagoon. The mixing of fresh and saltwater produced a coastal ecosystem. In general, the West Kalihi Zone is located between 0.5 and 1.0 km inland from the modern shoreline. At the end of the nineteenth century, the shore of Ke'ehi Lagoon was between 50 m to 0.5 km away from the West Kalihi Zone. Vegetation in the study area and immediate vicinity consists primarily of landscaping with *naupaka* (*Scaevola taccada*), *kiawe* (*Prosopis pallida*), coconut (*Cocos nucifera*), Cook pine (*Araucaria columnaris*), plumeria (*Plumeria obtusa*), monkeypod (*Albizia saman*), and fountain grass (*Pennisetum setaceum*).

According to the U.S. Department of Agriculture Soil Survey Geographic (SSURGO) Database (2001) and soils survey data gathered by Foote et al. (1972), sediment types in the West Kalihi Zone consists predominantly of Fill land (FL), with a small area of Ewa silty clay loam (EmA) east of T-019 (Figure 21).

Fill land is described as follows:

...areas filled with material dredged from the ocean or hauled from nearby areas, garbage, and general material from other sources... This land type is used for urban development including airports, housing areas, and industrial facilities [Foote et al. 1972:31].

Ewa silty clay loam soils are described as follows:

...well-drained soils in basins and on alluvial fans... [that] developed in alluvium derived from basic igneous rock... These soils are used for sugarcane, truck crops, and pasture. The natural vegetation consists of fingergrass, kiawe, koa haole, klu, and uhaloa [Foote et al. 1972:29].

### 6.3 Modern Land Use and Built Environment

The West Kalihi Geographic Zone traverses a predominantly urban environment, through the neighborhoods of coastal Kalihi. The centerline of the project alignment is generally within Kamehameha Highway. Parcels bordering the roads and highways include a mix of commercial, industrial, and residential developments. Large developments in the vicinity include Diamond Head Distributor and Oahu Community Correctional Center facility. A massive utility corridor is also present throughout the West Kalihi Geographic Zone containing electrical, gas, water, sewer, and storm lines. The number and distribution of these existing utilities indicates that this West Kalihi portion of Kamehameha Highway has been heavily disturbed in the past.

### 6.4 GPR Sediment Summary

Test excavations in the West Kahili Geographic Zone (Zone 1) revealed that the area was predominantly Fill land (FL) as predicted by the U.S.G.S Soil survey map of the zone (Figure 21). Naturally deposited sediments encountered during test excavations in this zone were generally too deep for the GPR to clearly read. The average depth of clean signal return for this area was approximately one meter. Test excavations that contained naturally deposited sediments within the GPR clean signal range are included in Table 2. Naturally deposited sediments within the range of clean GPR signal return for Zone 1. Representative signal texture profiles for Zone 1 are shown in Figure 22. Signal texture profiles were only collected if the signal return was clear and the stratum was at least 0.25 m thick.

Table 2. Naturally deposited sediments within the range of clean GPR signal return for Zone 1

<b>ZONE 1-KALIHI WEST (T-001 TO T-020)</b>			
<b>TEST EXCAVATION</b>	<b>STRATUM</b>	<b>MATERIAL</b>	<b>STRATUM ORIGIN (mbs)</b>
18	IIA	sandy loam	0.5
18	III	silty clay loam	0.7
20A	II	silty clay loam	1.6

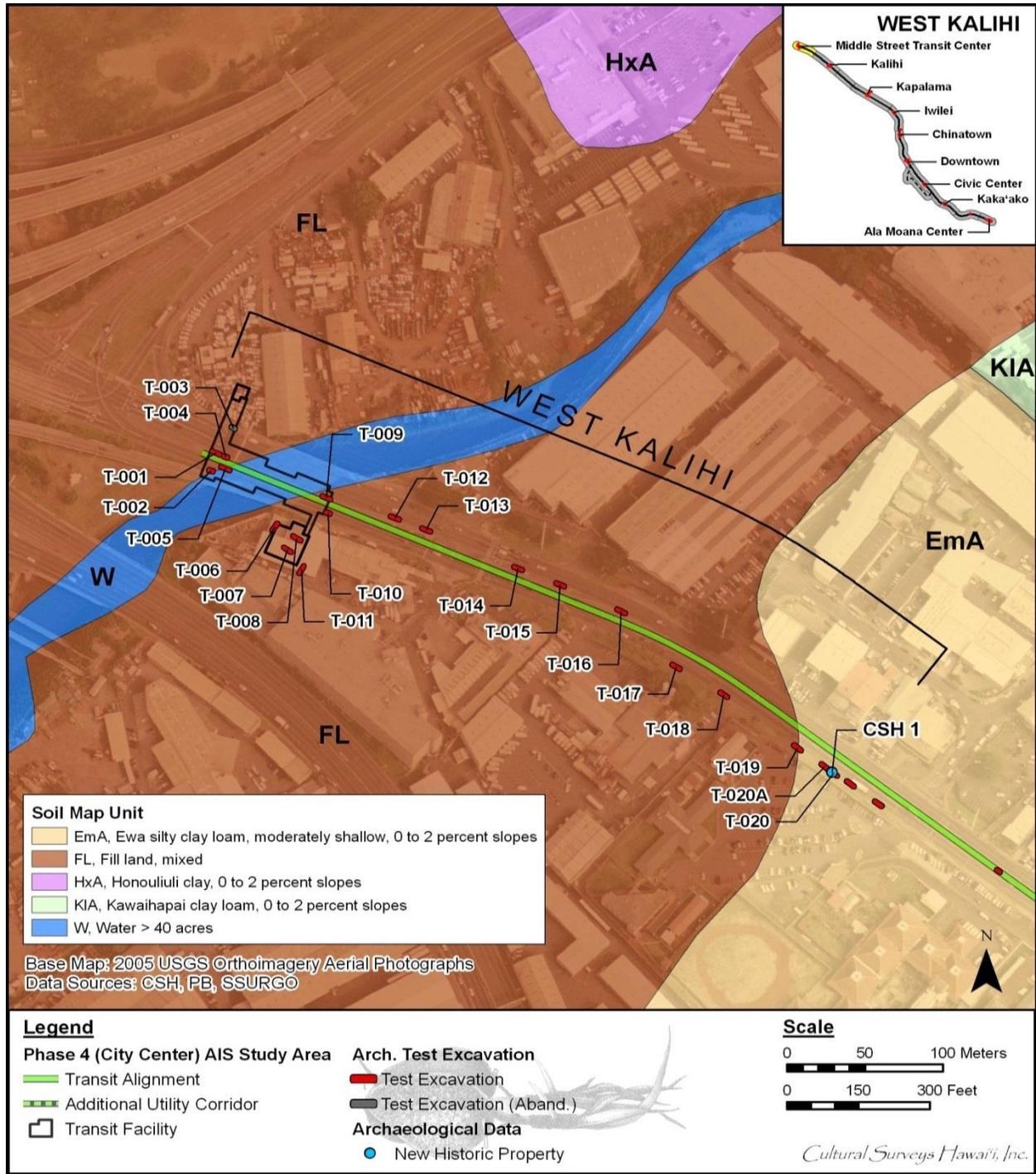


Figure 21. Aerial photograph (source: U.S. Geological Survey Orthoimagery 2005) with overlay of the Soil Survey of Hawai'i (Foote et al. 1972) showing sediment types within and in the vicinity of the Downtown Waterfront Zone

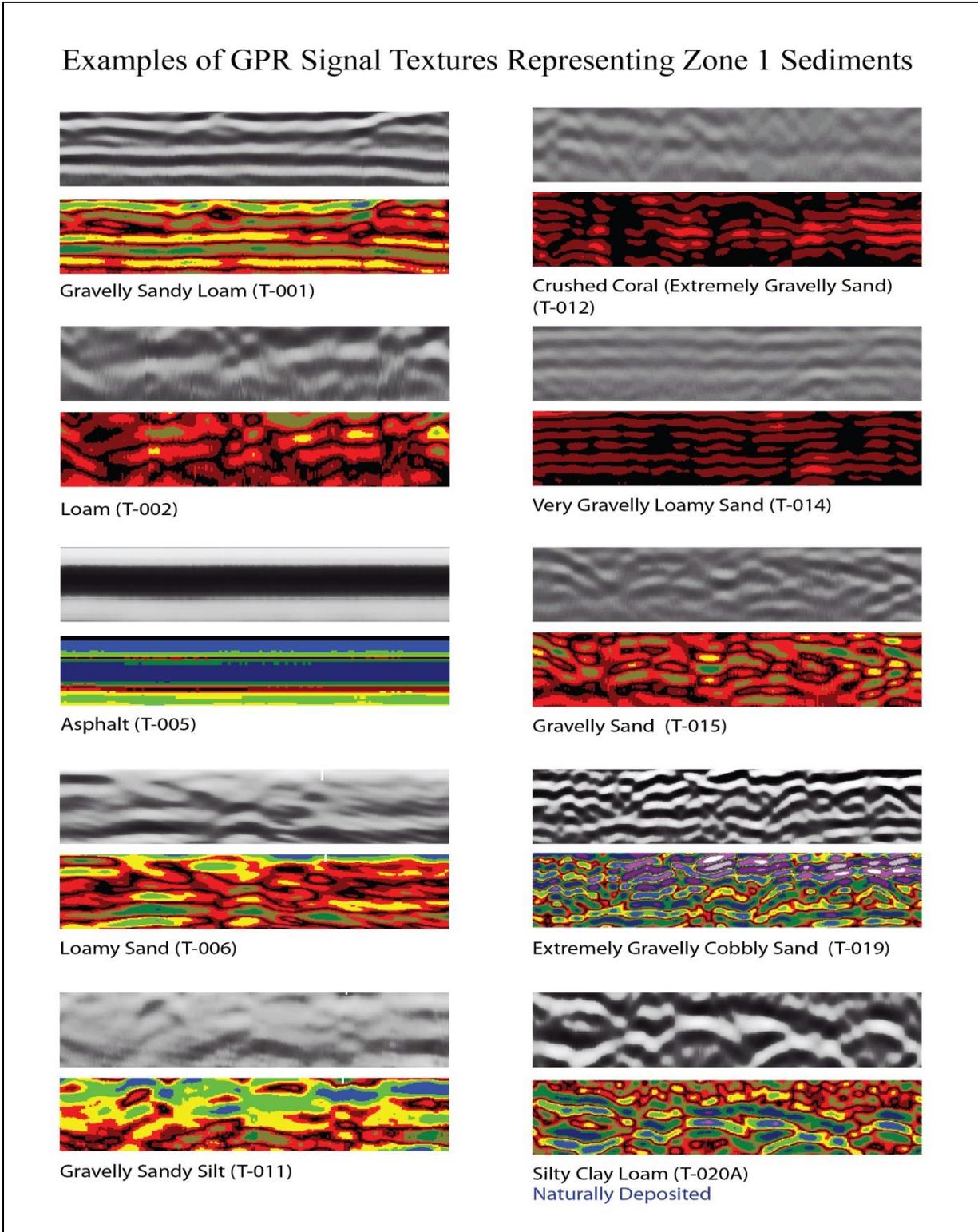


Figure 22. Examples of GPR signal textures representing Zone 1 sediments

### Test Excavation 1

T-001 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kamehameha Highway 75.0 m southeast of Middle St and Kamehameha Highway intersection, 12.5 m northwest of Kalihi Stream. The GPR grid measured 2.5 m by 10 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: telephone cable 6 m to the south, electrical line 3.2 m northwest, and a waterline 12 m north. Utilities transected the GPR grid but not the excavation location.

A review of amplitude slice maps indicated no linear features which might have indicated the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 23).

GPR depth profiles for T-001 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 24). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.25 mbs and again around .0.75 mbs. Two anomalies were observed in the profile but were not within the excavation boundaries. The maximum depth of clean signal return was approximately 1.0 mbs.

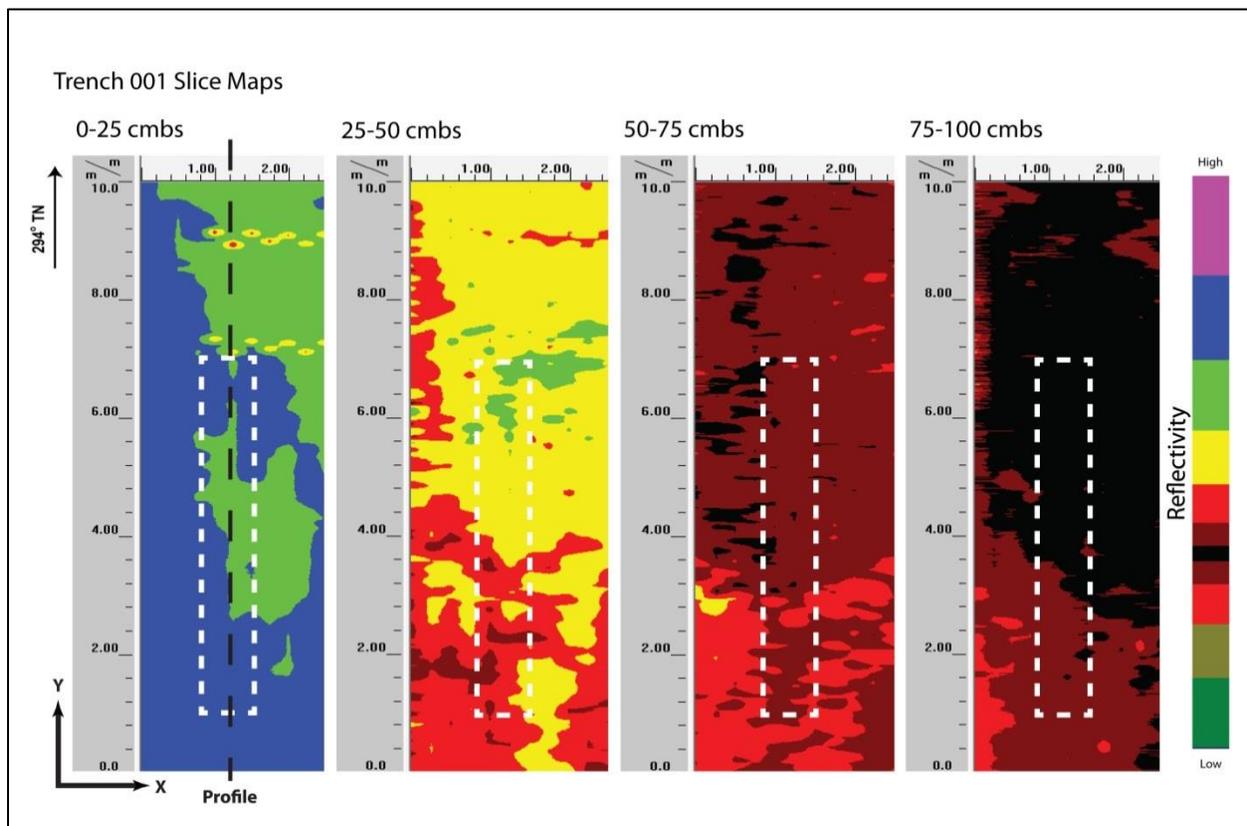


Figure 23. Slice maps of T-001 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 24). Strata Ia through Ic were clearly observed and occurred at the ground-truthed depths. All other sediment transitions were below the maximum depth of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

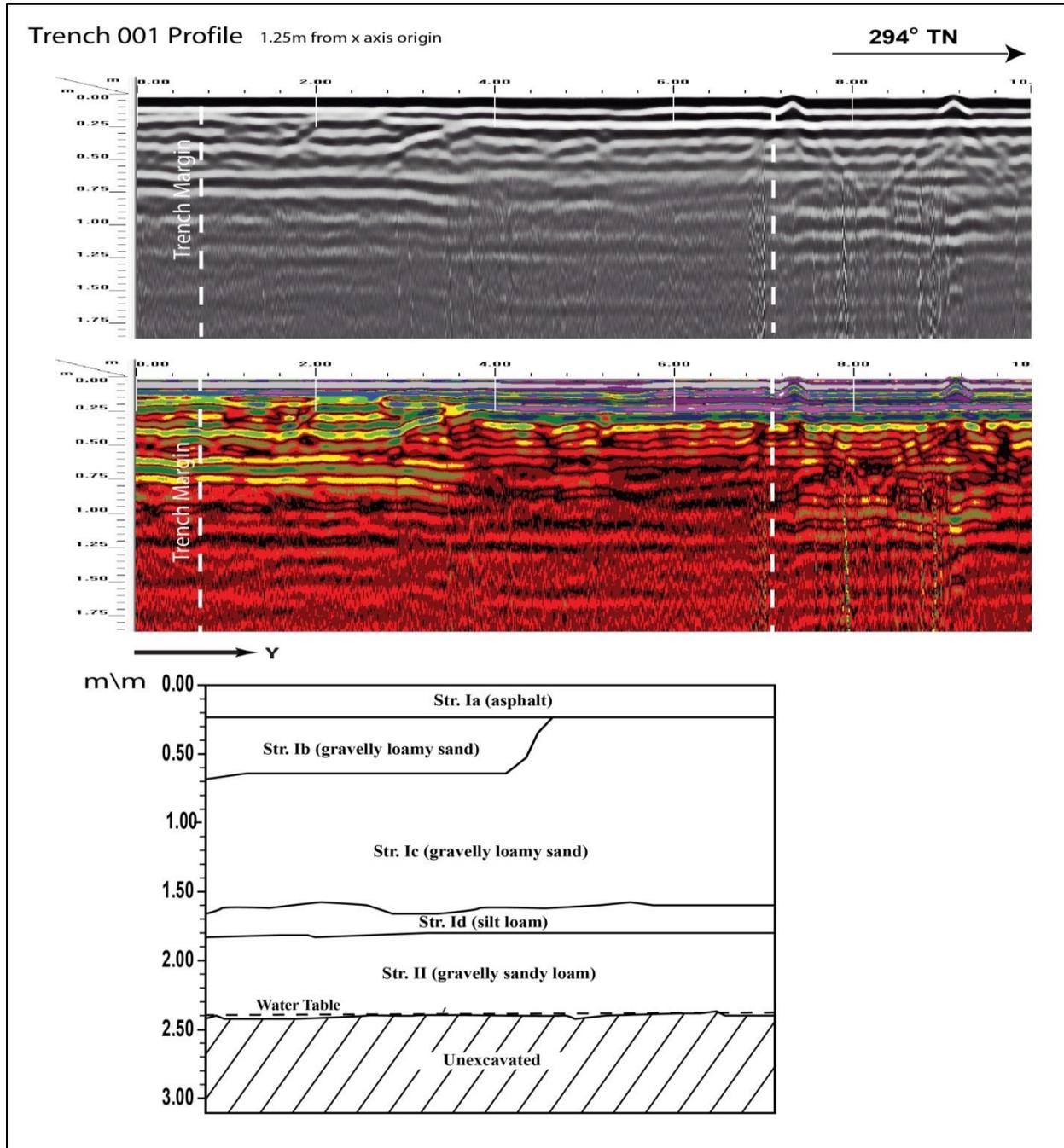


Figure 24. Visual comparison of excavated profile and GPR signal profile of T-001

## Test Excavation 2

T-002 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the road cut of Kamehameha Highway, 4.5 m northwest of Kalihi Stream. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: drain line 0.4 m running parallel to northeast excavation wall, electrical utility cable 2. m southwest of the excavation. No utilities transected the excavation location.

A review of amplitude slice maps indicated a linear feature which might have indicated the presence of utilities but none were encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 25).

GPR depth profiles for T-002 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 26). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.35 mbs. An anomaly was observed in the profile but was not encountered during excavation. The maximum depth of clean signal return was approximately 0.9 mbs.

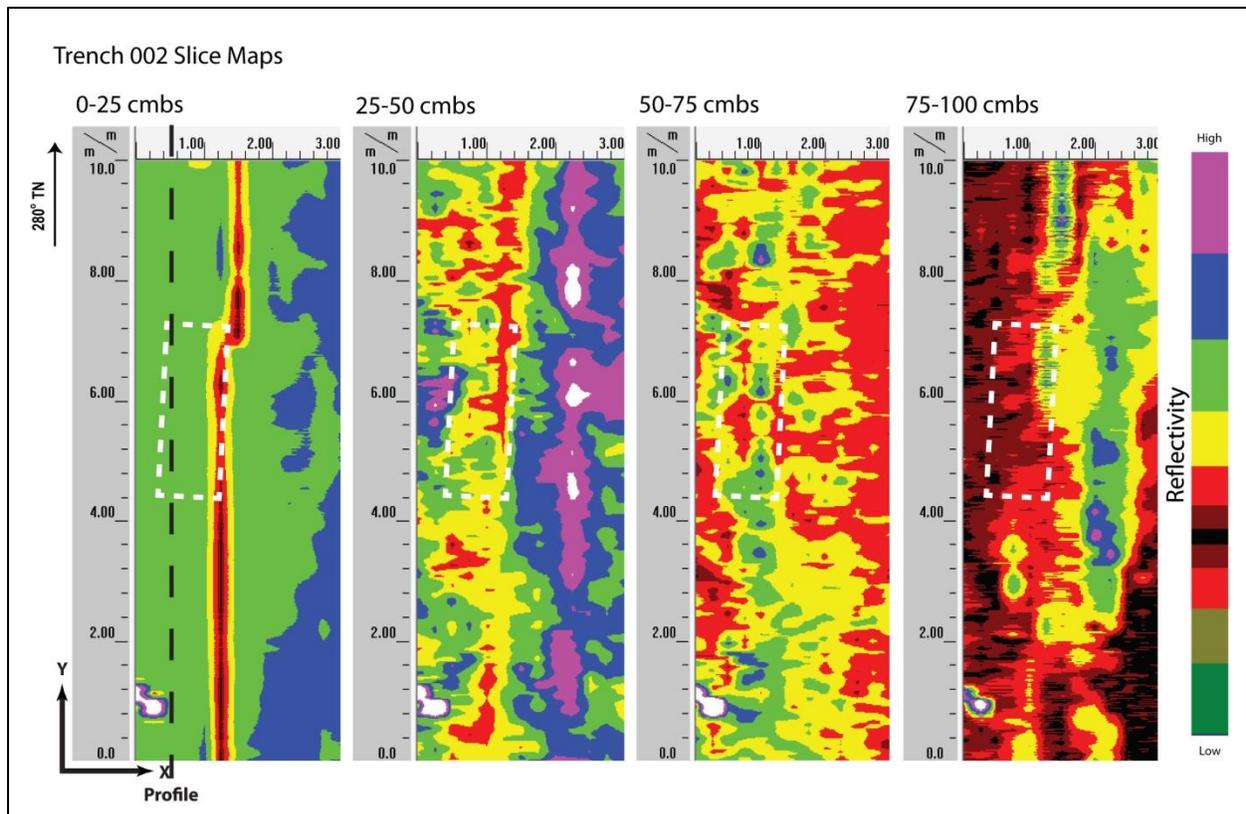


Figure 25. Slice maps of T-002 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 26). Strata Ia to Ic were clearly observed and occurred at the ground-truthed depths. Strata included a thick layer of asphalt on top of a loam fill that continued to 0.8 mbs followed by a clay loam and all other sediment transitions occurred below the maximum clean signal return of 0.9 mbs. No discrete objects were observed in the GPR results or subsequent excavation.

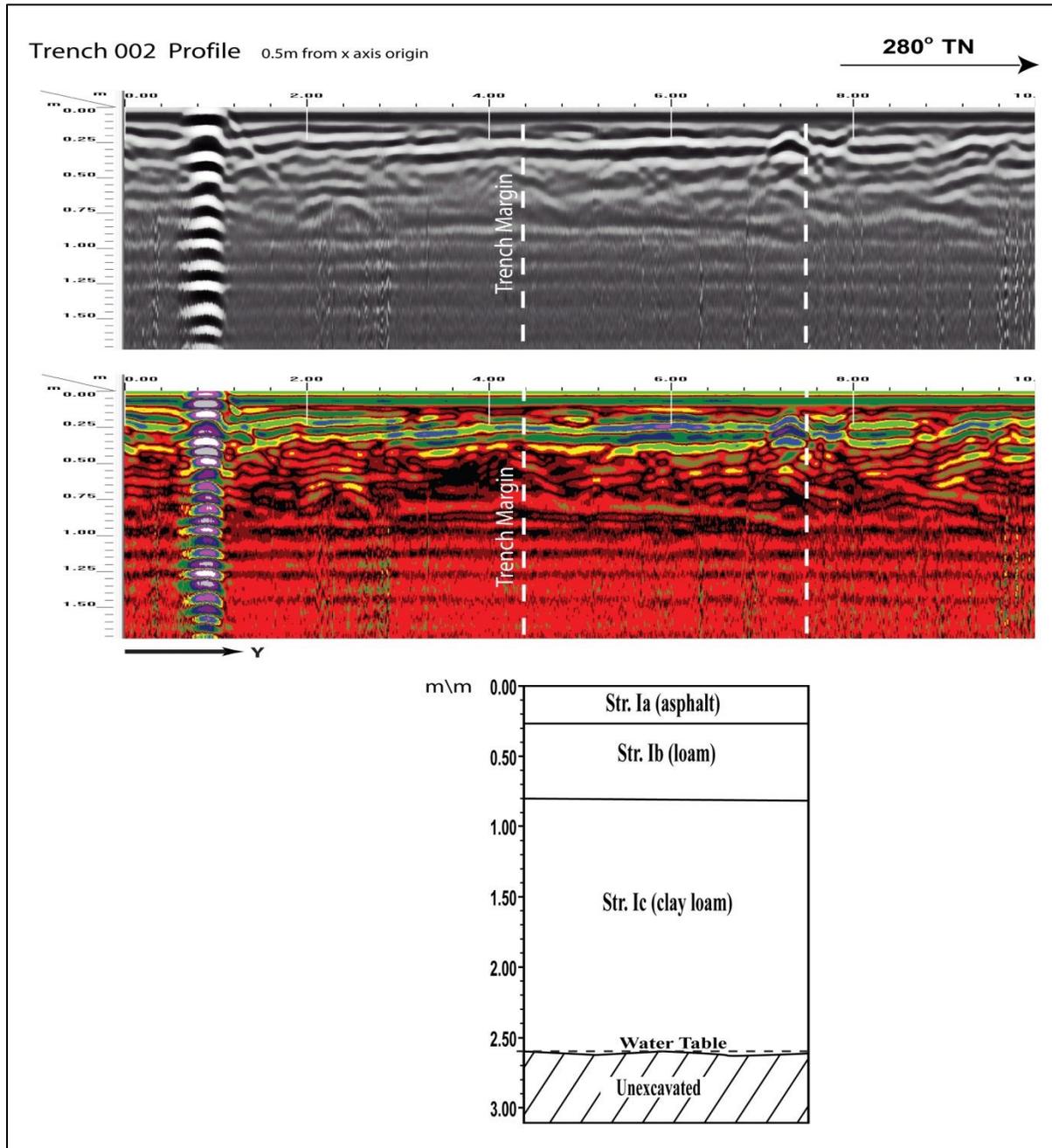


Figure 26. Visual comparison of excavated profile and GPR signal profile of T-002

### Test Excavation 4

T-004 measured 0.9 m by 3.0 m and was oriented northwest to southeast and was located within the road cut of Kamehameha Highway in the westbound right lane, 8.5 m northwest of Kalihi Stream. The GPR grid measured 2.5 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities included near the excavation include: sewer line 3.8 m east, electrical line 3.5 m south. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might have indicated the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 27).

GPR depth profiles for T-004 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 28). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.25 mbs and again around 0.65 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.0 mbs.

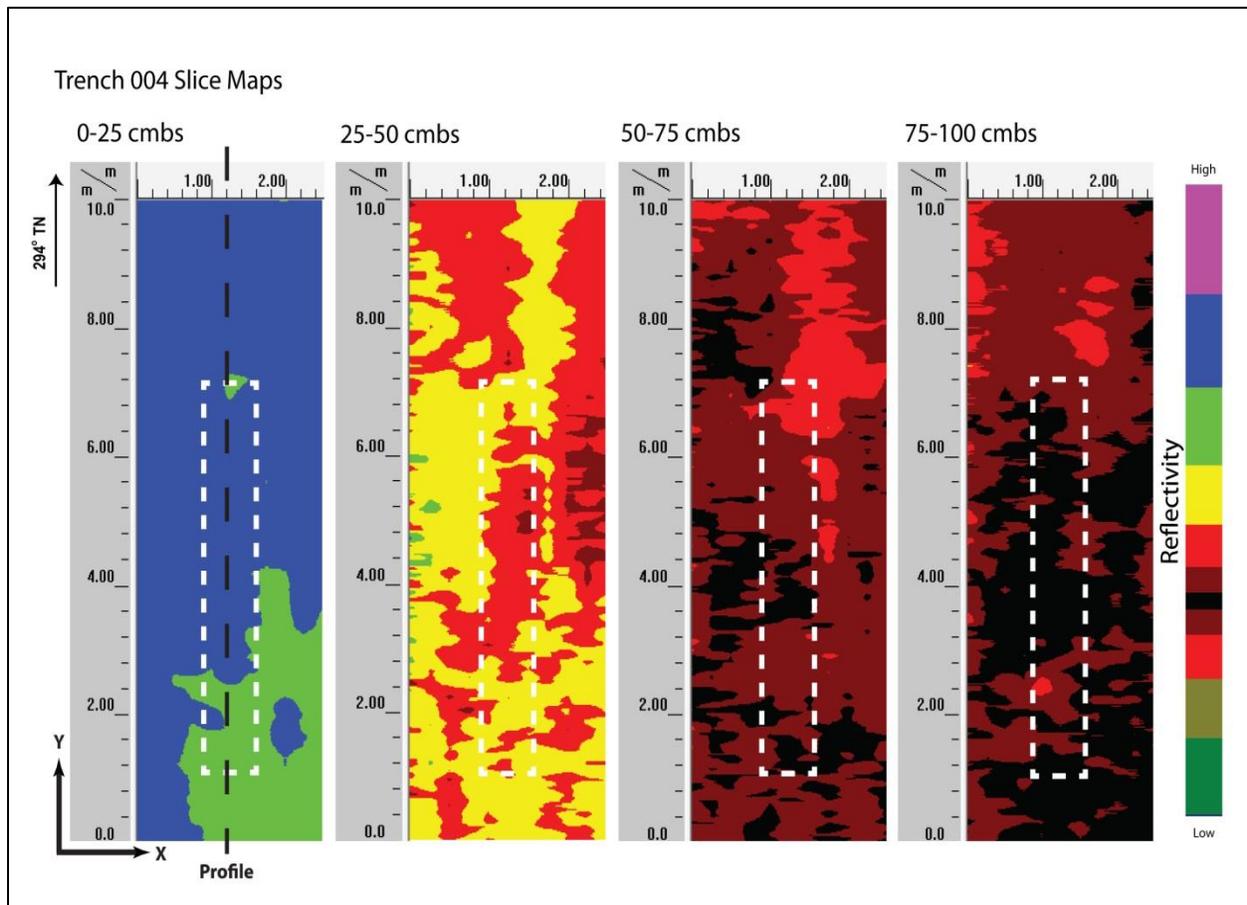


Figure 27. Slice maps of T-004 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 28). Strata Ia and Ib were observed and occurred at the ground-truthed depths. Strata included a thick layer of asphalt on top of gravelly sandy loam fill. The transition from Ib to Ic was not clearly depicted in the GPR profile. No discrete objects were observed in the GPR results or subsequent excavation.

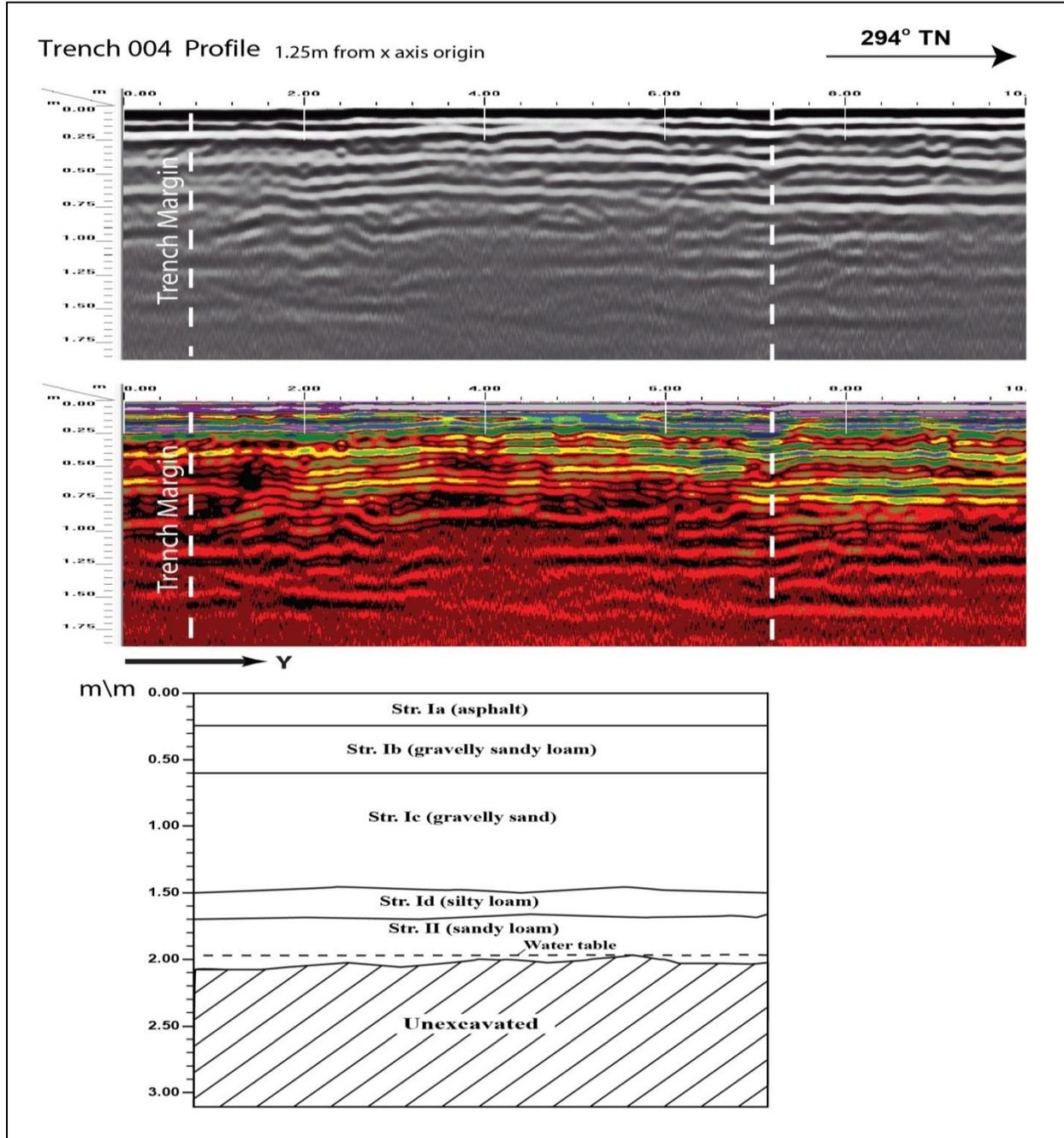


Figure 28. Visual comparison of excavated profile and GPR signal profile of T-004

### Test Excavation 5

T-005 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located on within the road cut of Kamehameha Highway in the eastbound left lane, 0.5 m northwest of Kalihi Stream. The GPR grid measured 2.5 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: sewer line 1.8 m northeast, electrical cable 1.7 m northwest. Utilities transected the GPR grid but not the excavation location.

A review of amplitude slice maps indicated a linear features but was not within excavation boundaries. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the utility. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 29).

GPR depth profiles for T-005 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 30). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.35 mbs and again around 0.75 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.1 mbs.

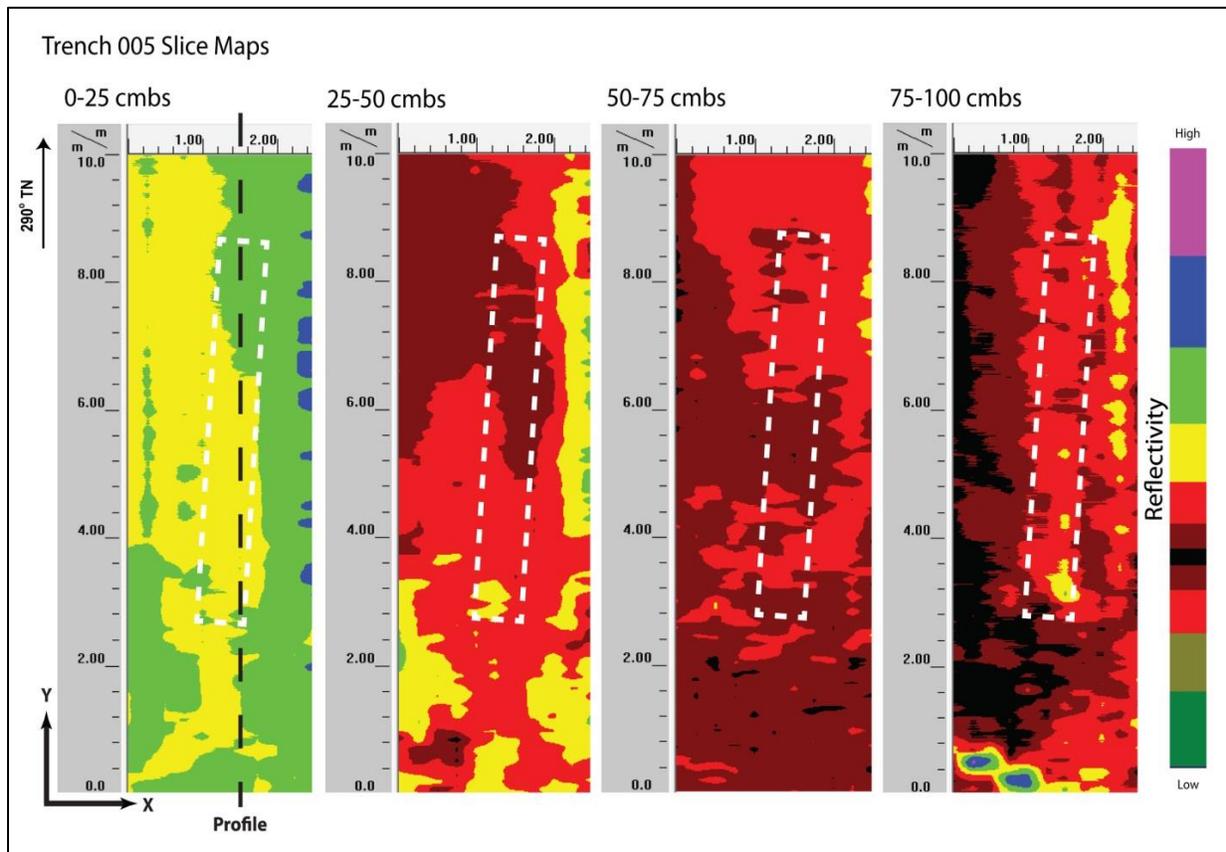


Figure 29. Slice maps of T-005 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 30). Strata included a thick layer of asphalt on top of very gravelly sandy loam base course and followed by gravelly, stony sandy clay loam. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

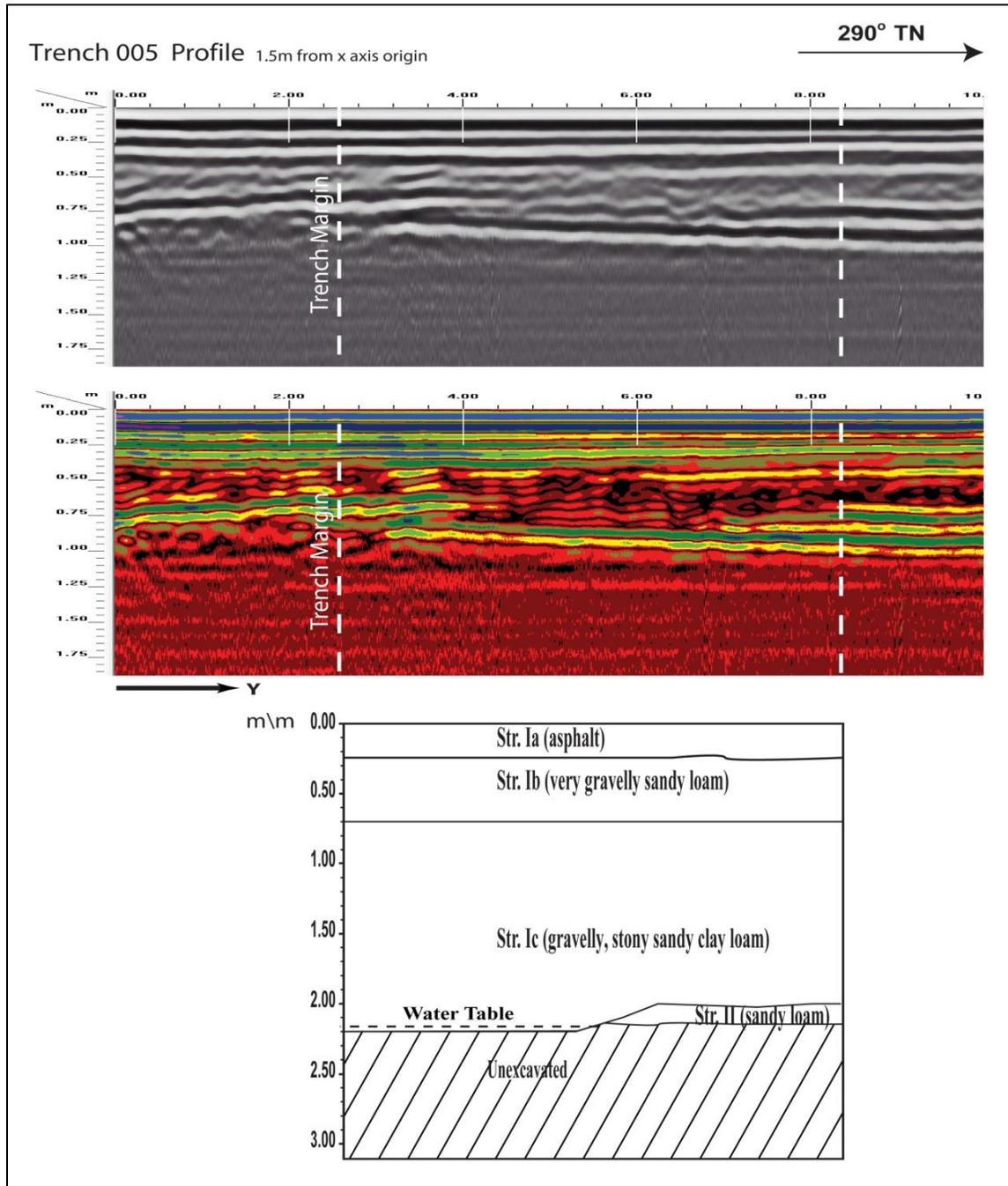


Figure 30. Visual comparison of excavated profile and GPR signal profile of T-005

### Test Excavation 6

T-006 measured 0.9 m by 1.9 m and was oriented southwest to northeast and was located within the northwest corner of the building at 2323 Kamehameha Highway, South of Nimitz Highway, 9.0 m Southeast of Kalihi Stream. The GPR grid measured 3.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: sewer 5.5 m northwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might have indicated the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 25-0.5 mbs and increases again around 0.75 mbs (Figure 31).

GPR depth profiles for T-006 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 32). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.25 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.6 mbs.

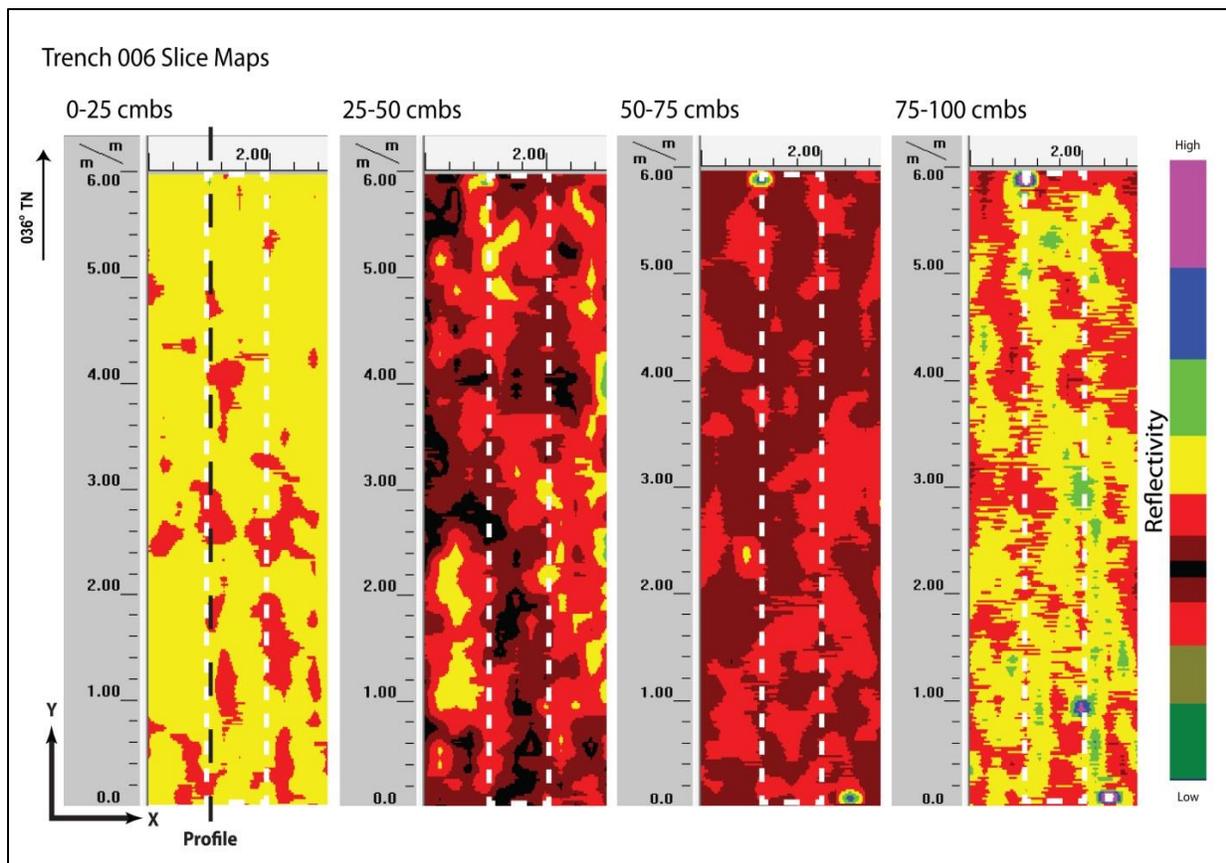


Figure 31. Slice maps of T-006 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 32). Strata included stony loamy sand fill then loamy sandy fill and followed by sandy silt fill. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

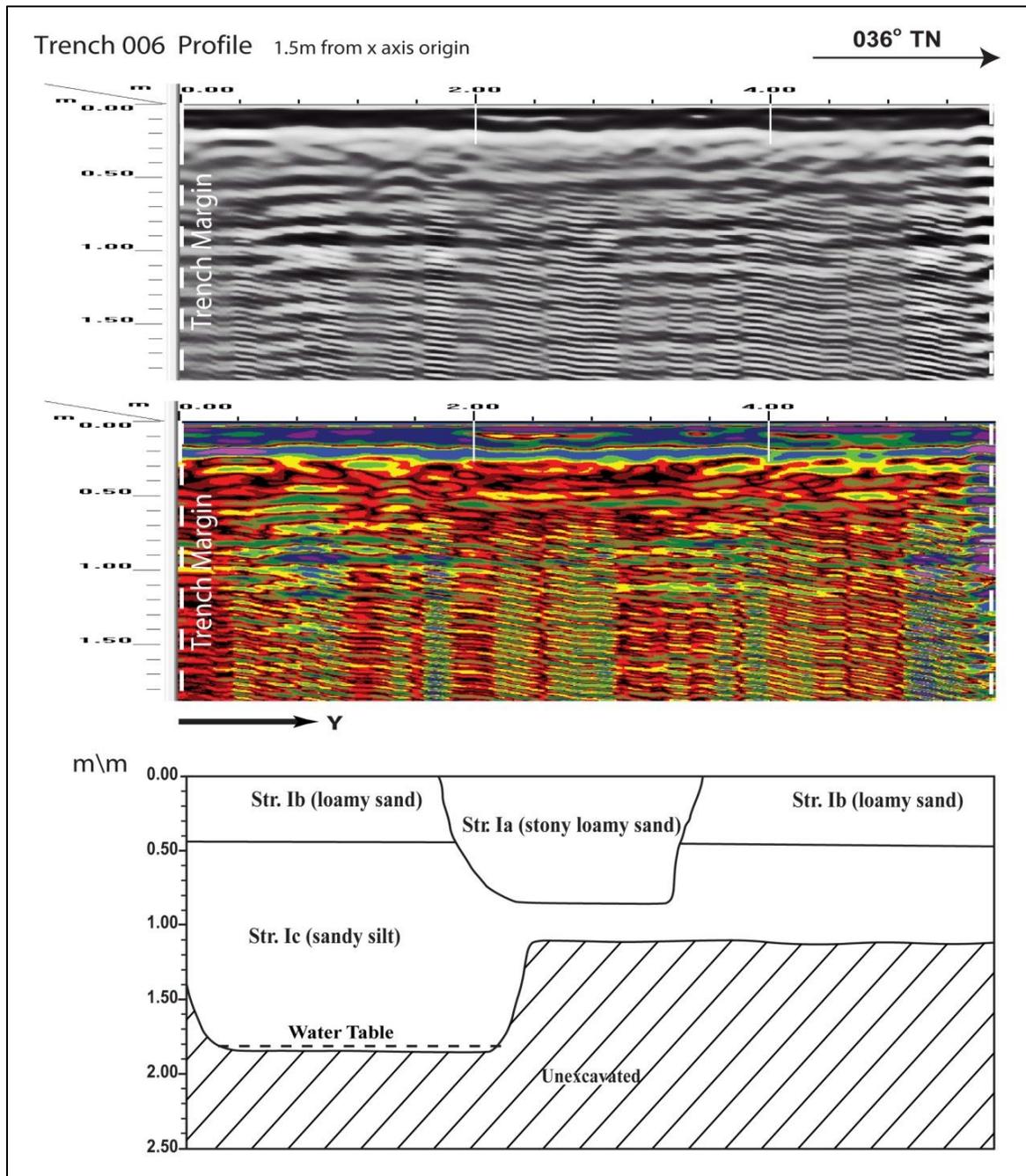


Figure 32. Visual comparison of excavated profile and GPR signal profile of T-006

### Test Excavation 7

T-007 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the building structure located at 2323 Kamehameha Highway, 25.0 m Southeast of Kalihi Stream. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. No utilities were located near excavation location. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might have indicated the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 33).

GPR depth profiles for T-007 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 34). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.35 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.5 mbs.

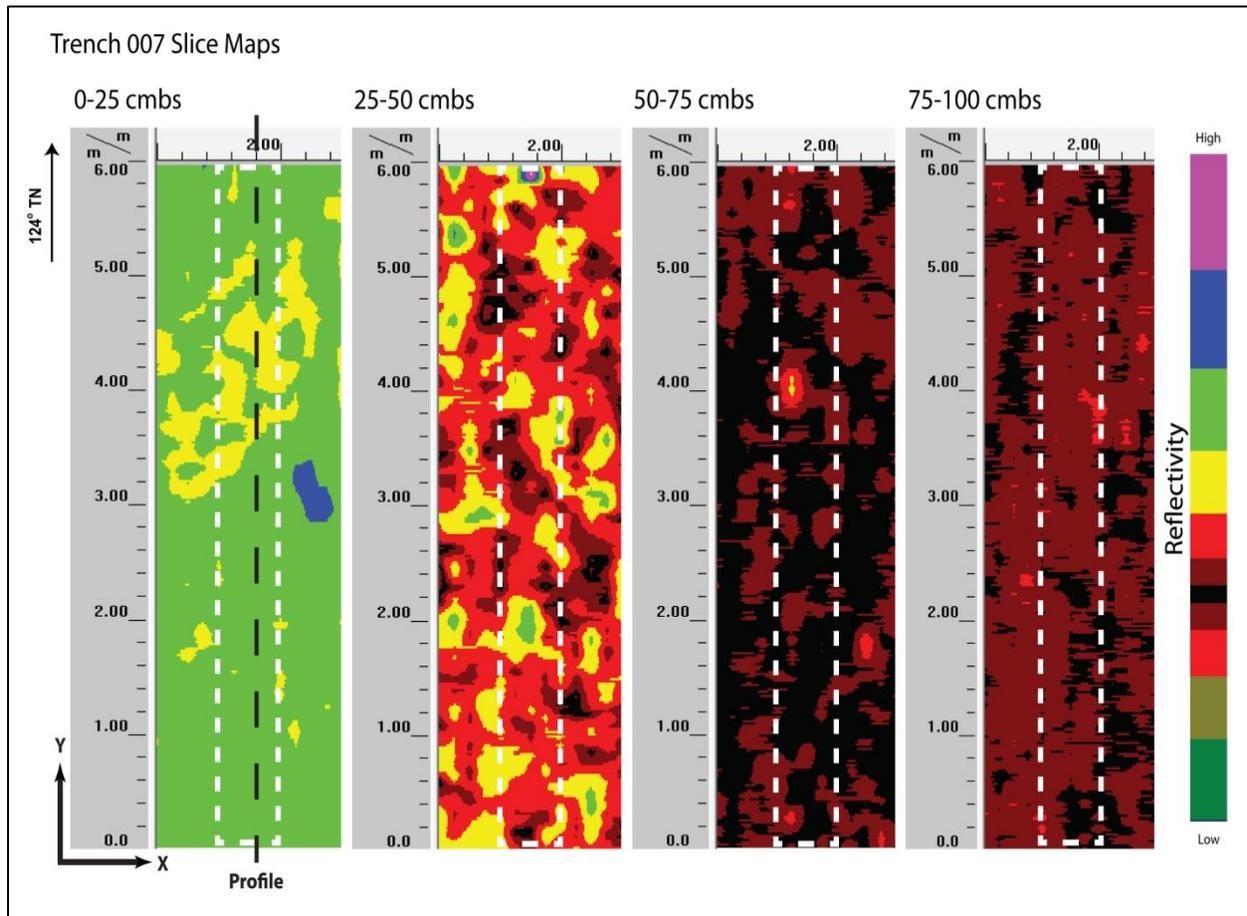


Figure 33. Slice maps of T-007 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 34). Strata included a thick layer of gravelly sandy loam on top of a clay loam. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

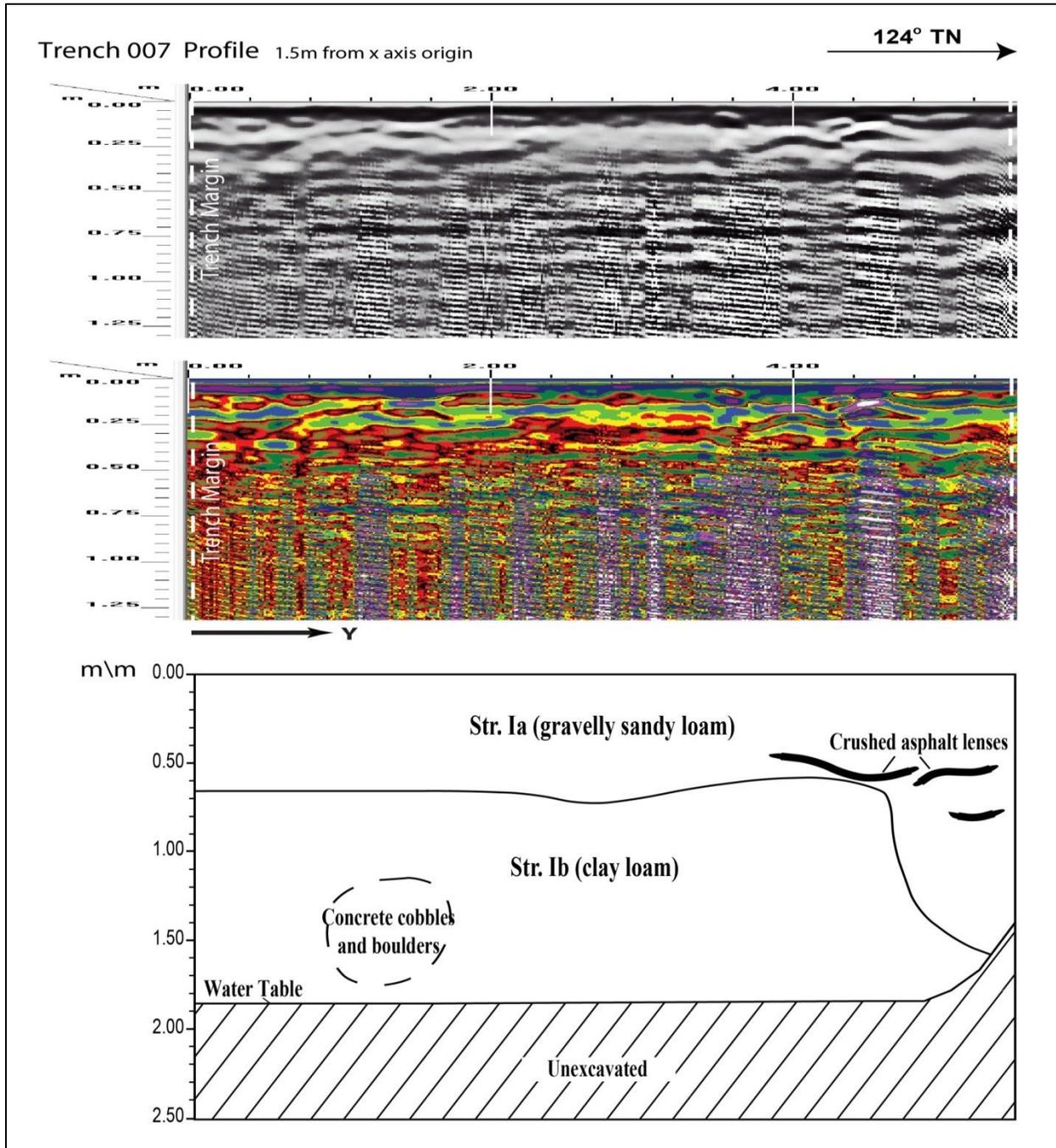


Figure 34. Visual comparison of excavated profile and GPR signal profile of T-007

### Test Excavation 8

T-008 measured 0.8 m by 6.0 m and was oriented northwest to southeast and located within the building structure located at 2323 Kamehameha Highway, 20.0 m southeast of Kalihi Stream. The GPR grid measured 3.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. No utilities were located near the excavation. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might have indicated the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 35).

GPR depth profiles for T-008 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 36). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.15 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.5 mbs.

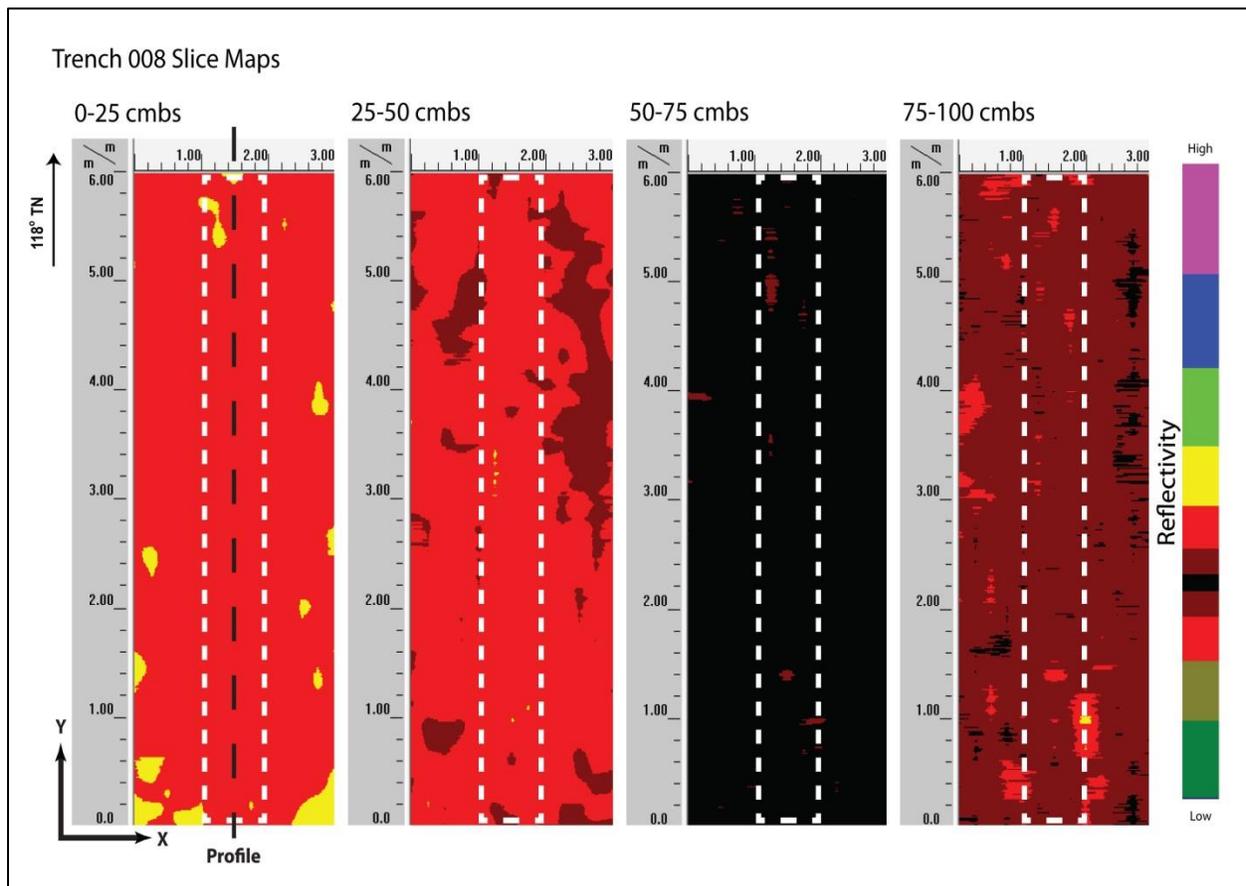


Figure 35. Slice maps of T-008 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 36). Strata included a layer of sandy clay loam on top of two layers of gravelly to stony sandy clays. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

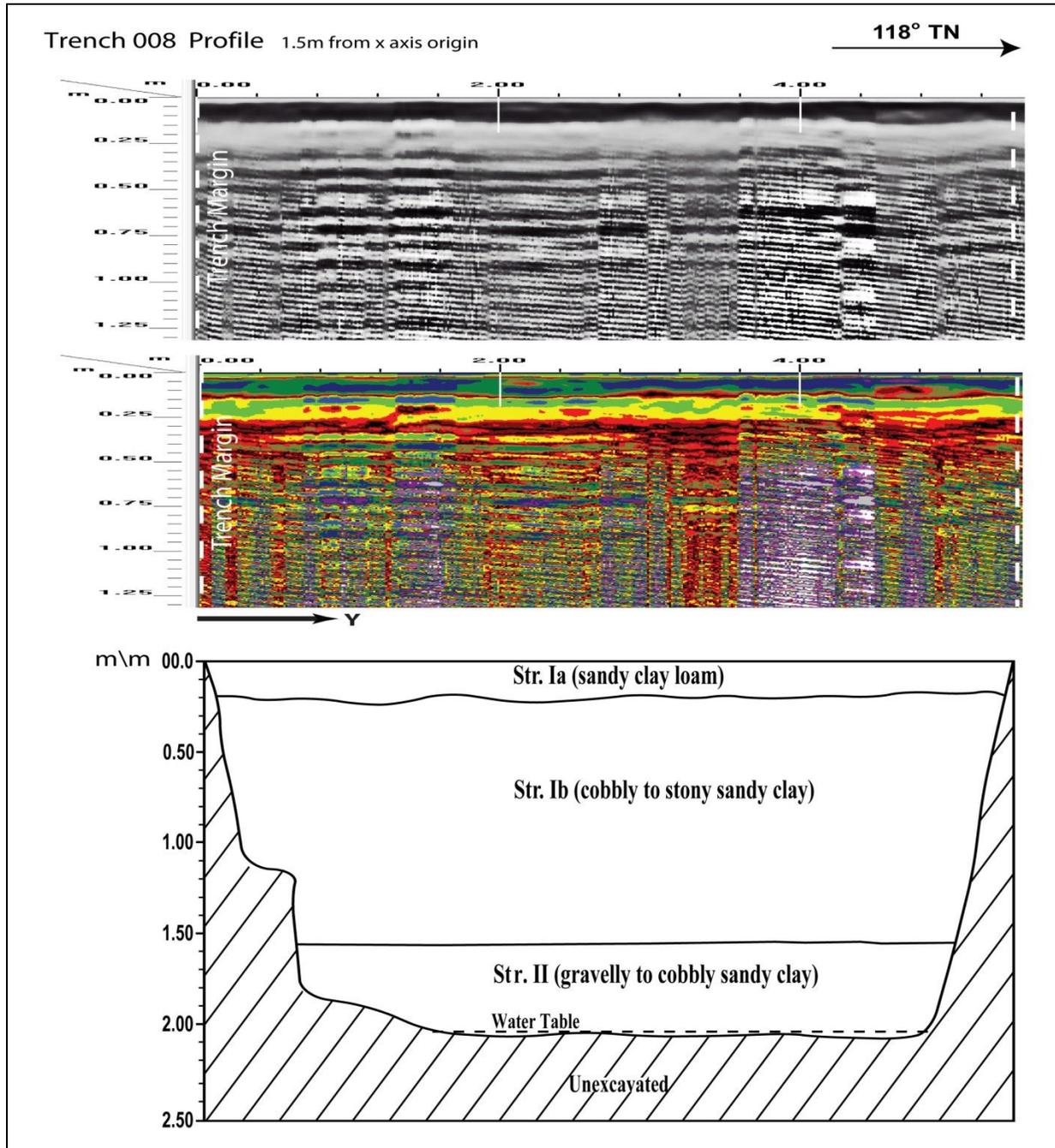


Figure 36. Visual comparison of excavated profile and GPR signal profile of T-008

## Test Excavation 9

T-009 measured 0.3 m by 6.0 m and was oriented northwest to southeast and located on within the road cut of Kamehameha Highway within the westbound lane, 1.8 m north of the median. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near excavation include: sewer line 1.6 m southeast, electrical 1.5 m south. An abandoned utility jacket was encountered 1.0 mbs in the eastern end of the excavation.

A review of amplitude slice maps indicated a linear features but not within excavation boundaries. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the utility. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 37).

GPR depth profiles for T-009 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 38). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.3 mbs and again around 0.75 mbs. An anomaly was observed in the profile but not within excavation boundaries and the utility jacket that was encountered was below the clean signal return depth. The maximum depth of clean signal return was approximately 0.9 mbs.

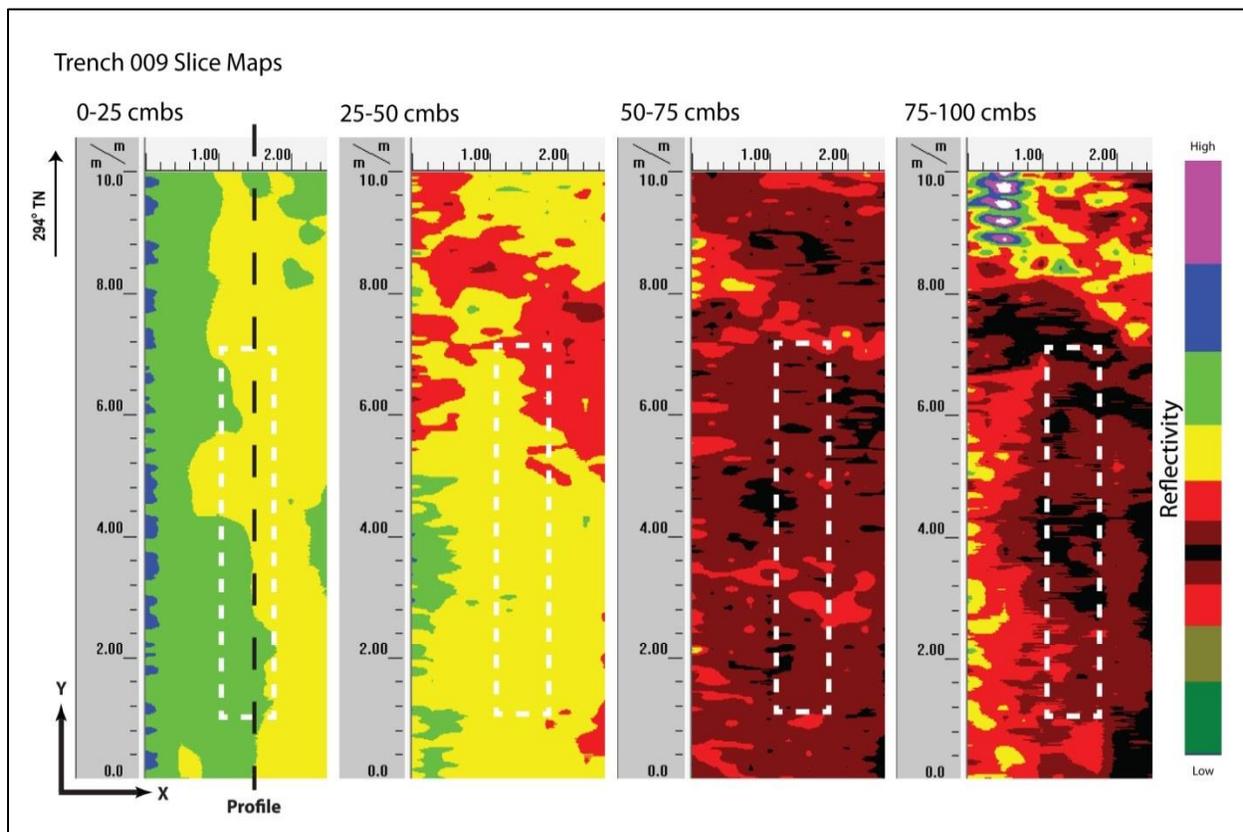


Figure 37. Slice maps of T-009 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 38). Strata Ia and Ib were clearly observed and occurred at the ground-truthed depths. An abandoned utility jacket was located about 1.0 mbs. The jacket did not show up on the profile or slices maps due to the fact that the clean signal return was around 0.9 mbs. No other discrete objects were observed in the GPR results or subsequent excavation.

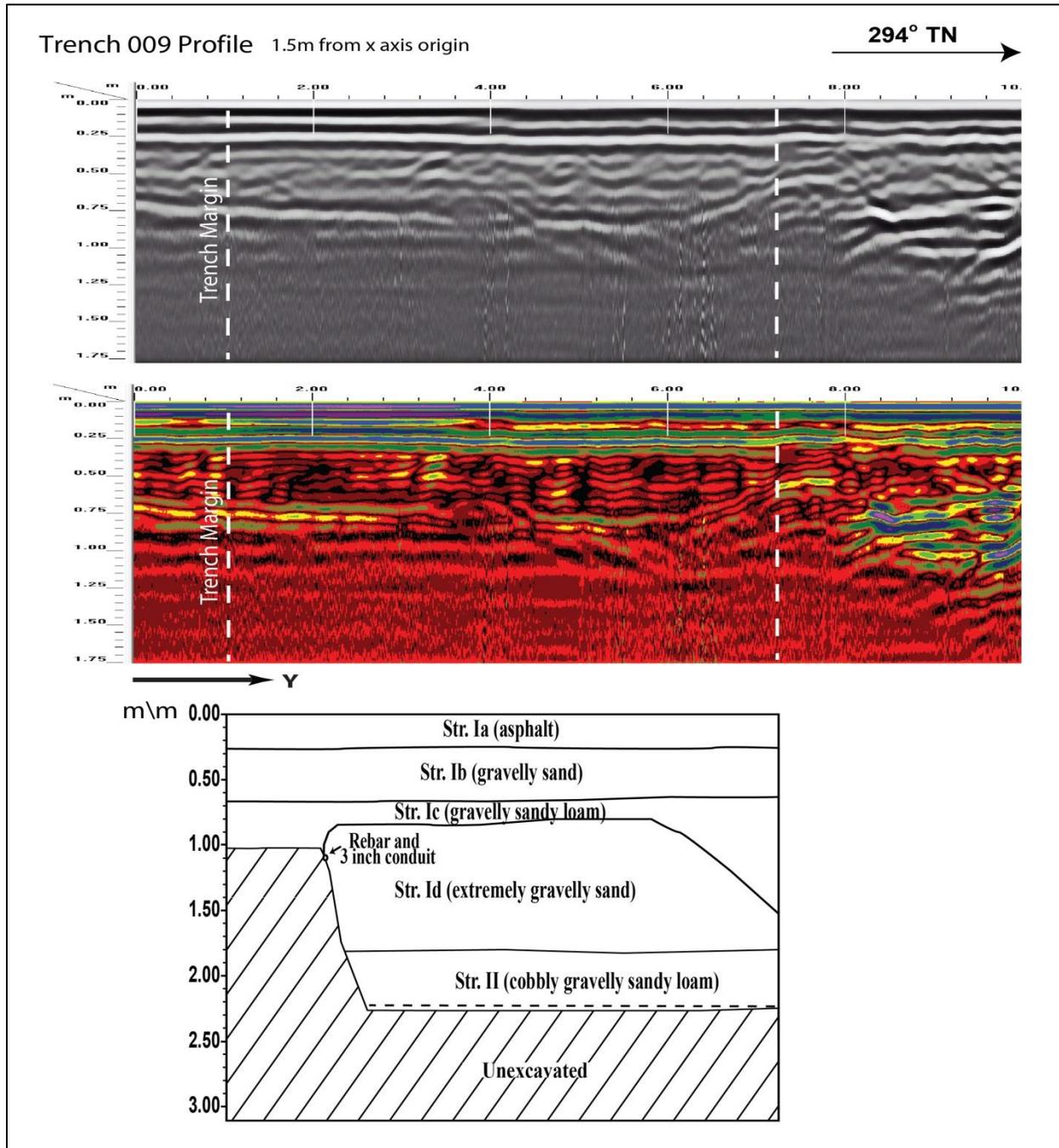


Figure 38. Visual comparison of excavated profile and GPR signal profile of T-009

## Test Excavation 10

T-010 measured 0.9 m by 3.0 m and was oriented northwest to southeast and located on within the road cut of Kamehameha Highway in the eastbound center lane, 10.0 m southeast of Kalihi Steam. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities included near the excavation include: sewer line 3.6 m north, electrical line 0.6 m south. A utility transected the GPR grid and was within the proposed excavation location therefore T-010 was relocated 4.0 m to the east.

A review of amplitude slice maps indicated a linear feature but was not encountered due to the relocation of the excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the utility. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 39).

GPR depth profiles for T-010 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 40). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.15 mbs and again around 0.5 mbs. An anomaly was observed in the profile but was not encountered due to the relocation of the excavation. The maximum depth of clean signal return was approximately 0.85 mbs.

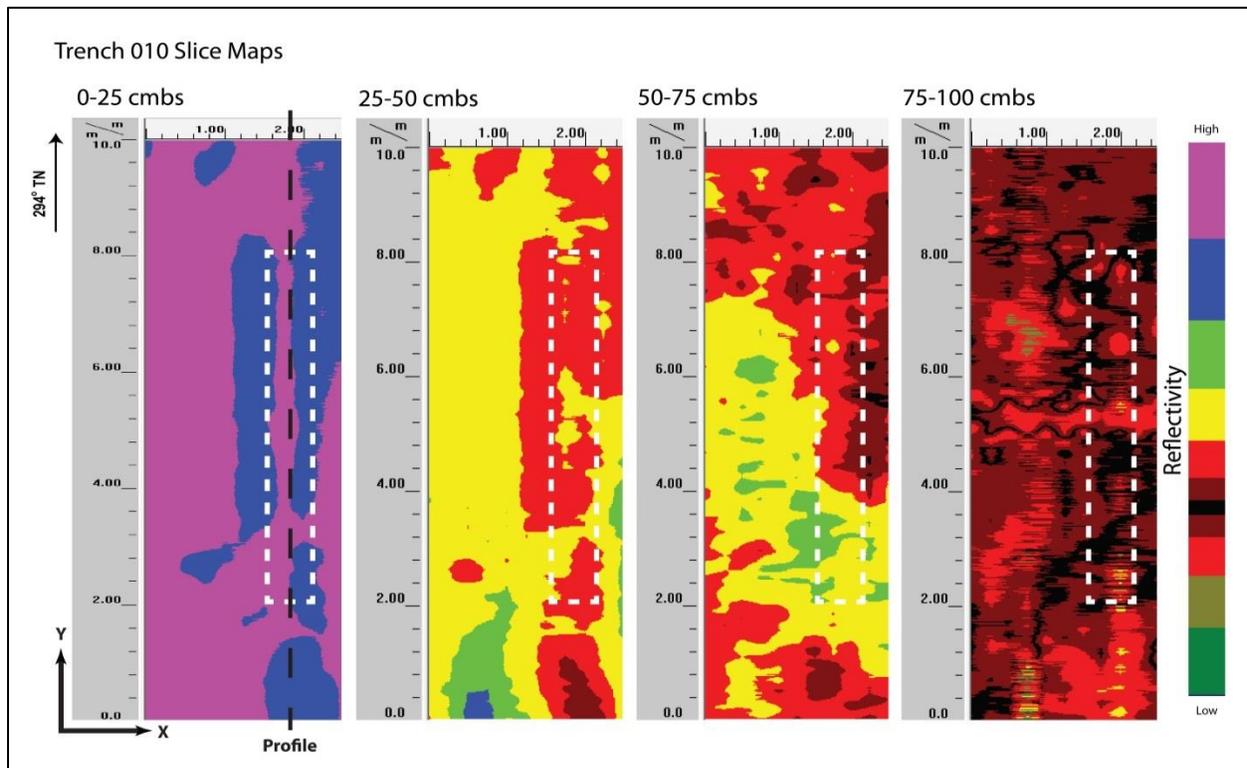


Figure 39. Slice maps of T-010 at 25cm depth intervals

Due to the relocation of T-010, this profile does not represent the exact location but does represent the immediate area. A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 40). Strata included a layer of asphalt (Ia) on top of several thin layers of gravelly sandy loam fill (Ib-If) which continued down to 0.8 mbs. Strata Ia was observed in the GPR profile but strata Ib through If were not individually discernible, possibly due to the fact that they were very thin layers of the same compacted fill, but based on reflectivity and horizontal banding it was apparent that there were multiple layers of fill events. All other sediment transitions were below the maximum depth of clean signal return. No other discrete objects were observed in the GPR results or subsequent excavation.

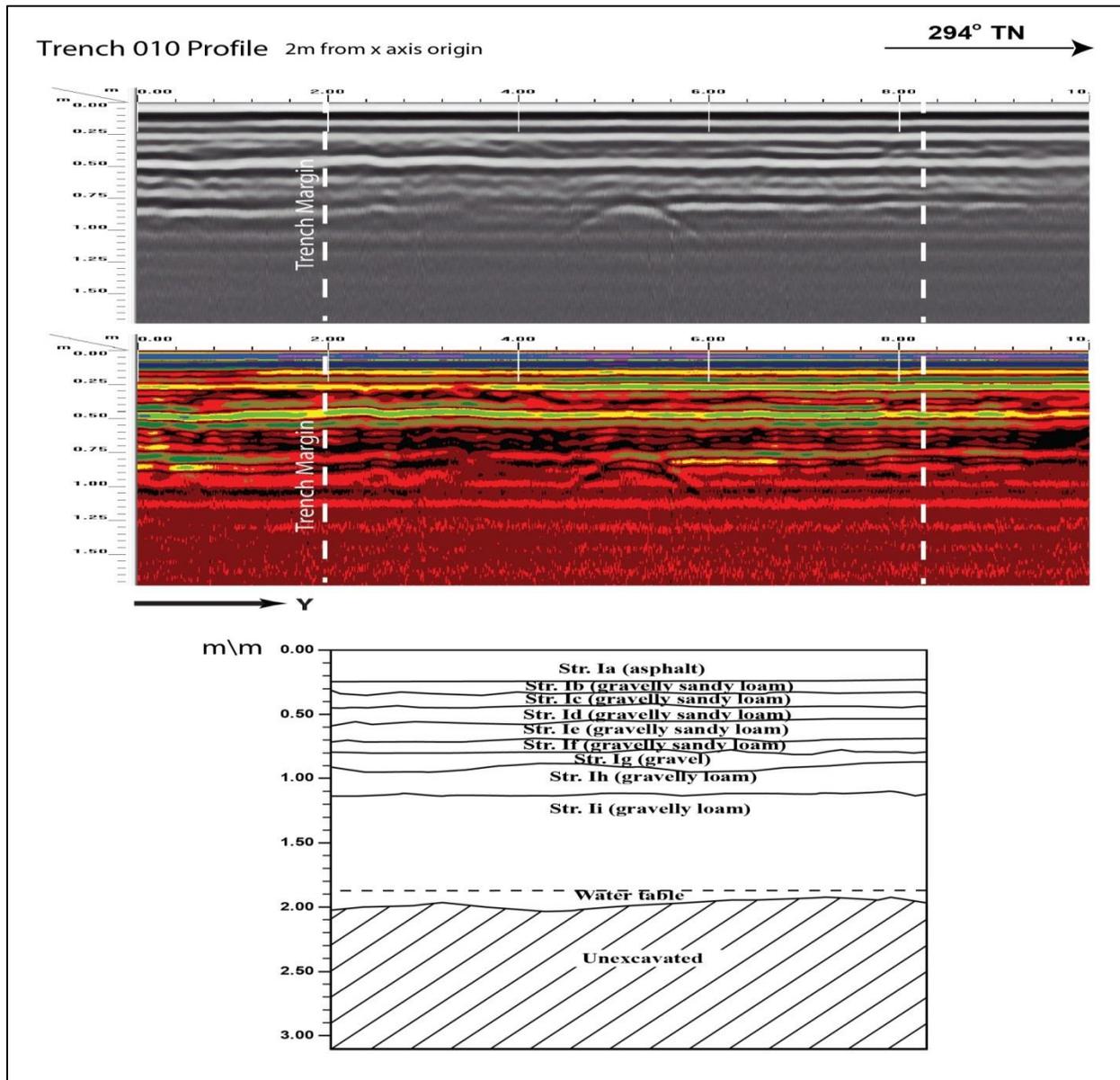


Figure 40. Visual comparison of excavated profile and GPR signal profile of T-010

## Test Excavation 11

T-011 measured 0.6 m by 6.0 m and was oriented northeast to southwest and was located within a building on a private lot, 41.0 m southeast of Kalihi Stream. The GPR grid measured 3.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. According to PB CADD, there were no utilities located within close proximity of the excavation location. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might have indicated the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 41).

GPR depth profiles for T-011 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 42). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.2 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.75 mbs.

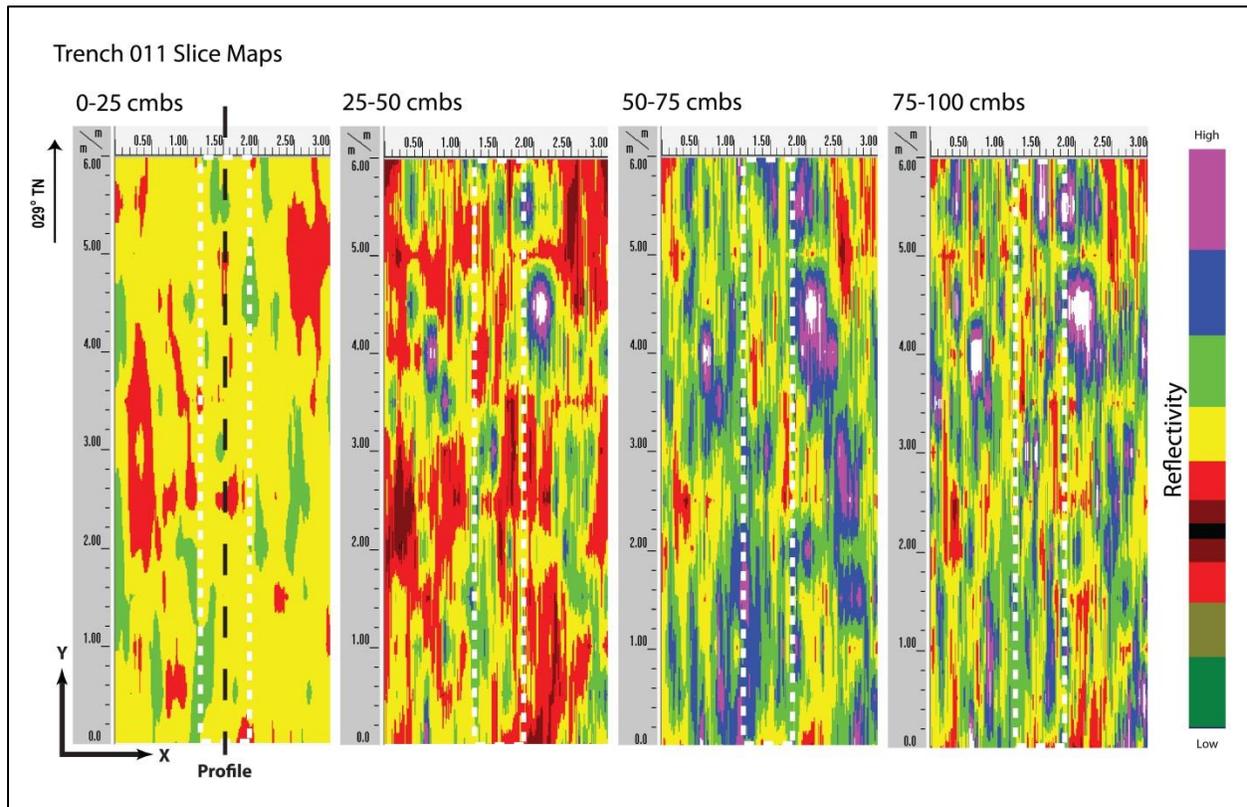


Figure 41. Slice maps of T-011 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 42). Strata included a thick layer of gravelly sandy silt fill, extremely gravelly sand fill, silty sand fill, and sandy silt fill. These transitions were not clearly depicted in the GPR profile at the depths that they occurred and the other sediment transitions were below the maximum depth of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

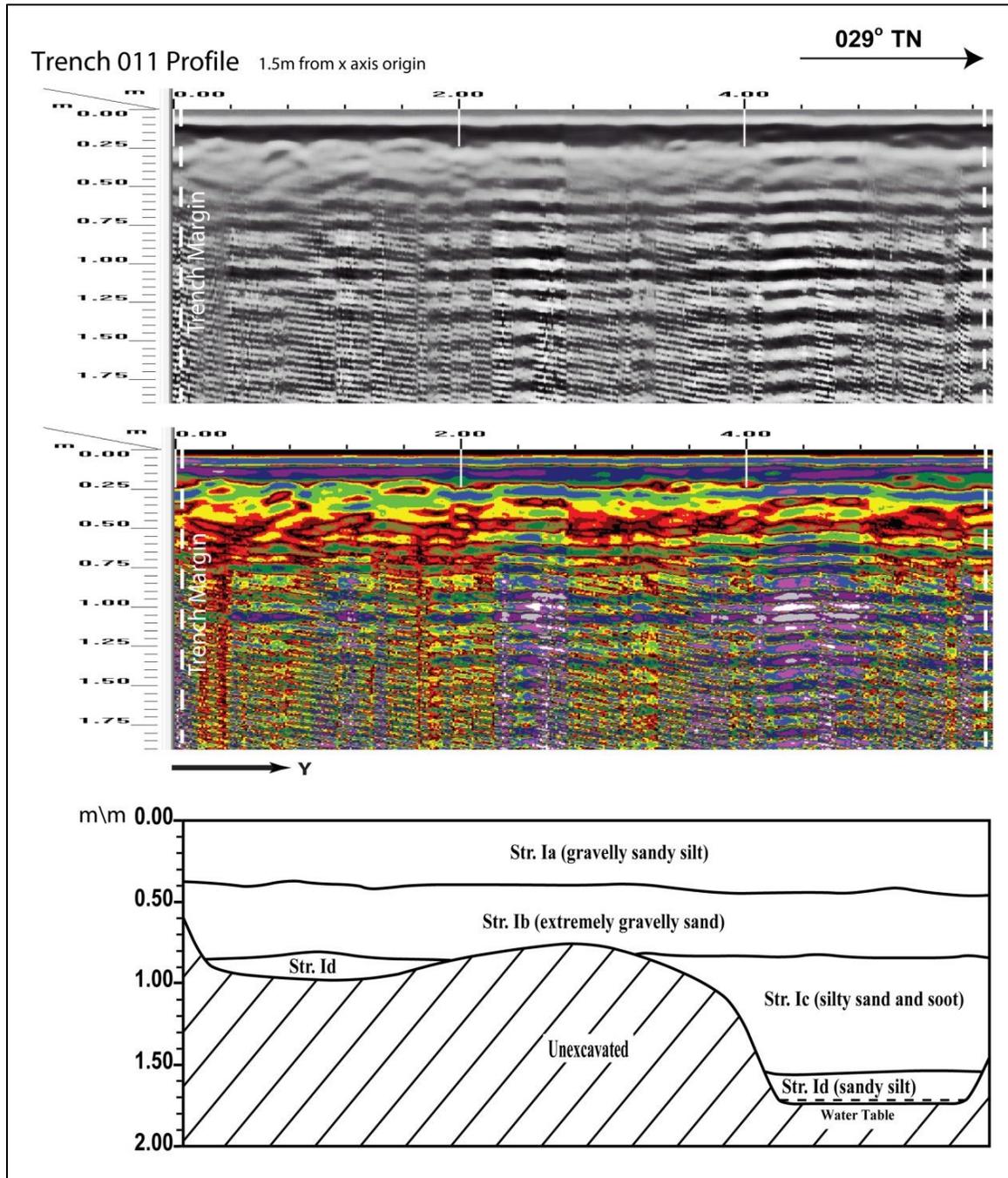


Figure 42. Visual comparison of excavated profile and GPR signal profile of T-011

## Test Excavation 12

T-012 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kamehameha Highway in the westbound lane 2.5 m northeast to the center median. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: sewer 2.2 m southwest. An abandoned unknown utility line was encountered approximately 0.8 mbs in the center of the excavation.

A review of amplitude slice maps indicated a linear feature and corresponded to the utility line that was encountered. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the utility. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 43).

GPR depth profiles for T-012 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 44). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.15 mbs. An anomaly was observed in the profile and corresponded to the utility that was encountered during excavation. The maximum depth of clean signal return was approximately 1.25 mbs.

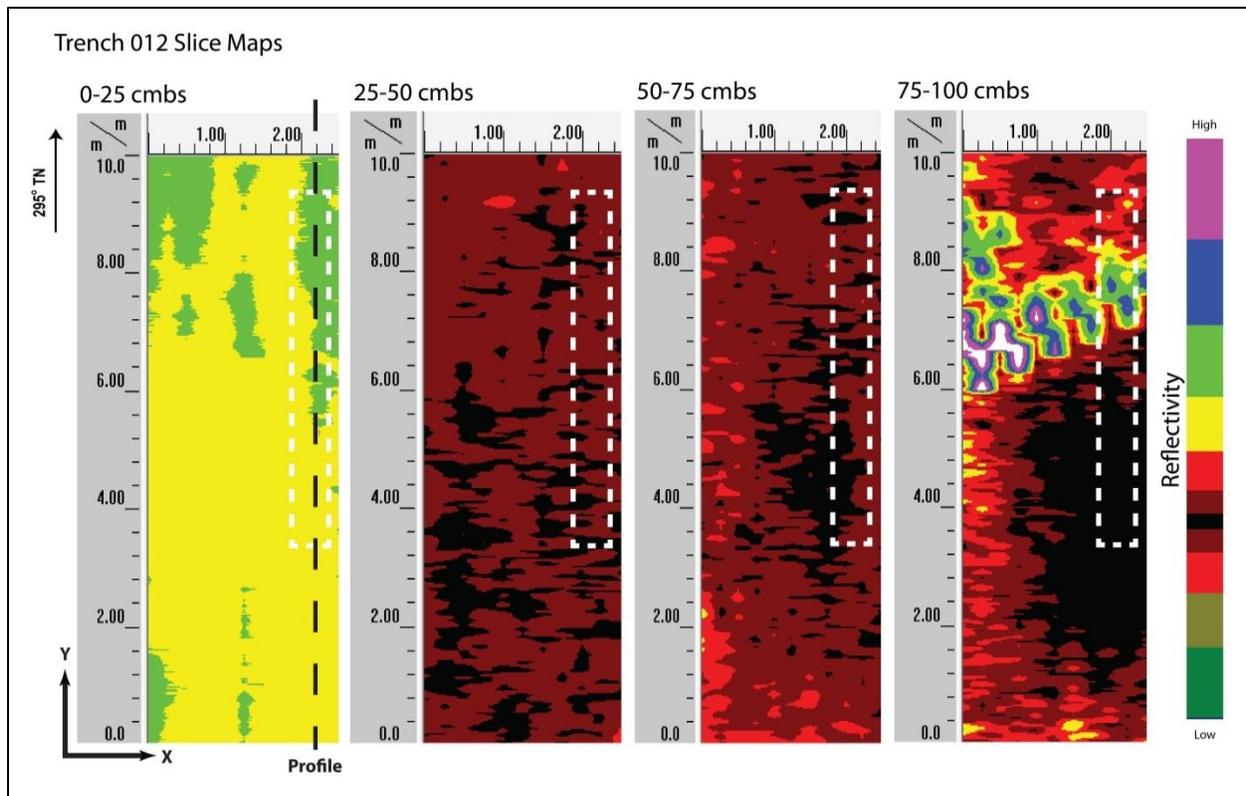


Figure 43. Slice maps of T-012 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 44). Strata Ia and Ib were clearly observed and occurred near the ground-truthed depths. Textural changes in the form of multiple small hyperbolas were apparent in Stratum Ib which was very gravelly sand (crushed coral). A utility line was found 0.8 mbs. The line corresponded to an anomaly observed in the profile. All other sediment transitions were below the maximum depth of clean signal return. No other discrete objects were observed in the GPR results.

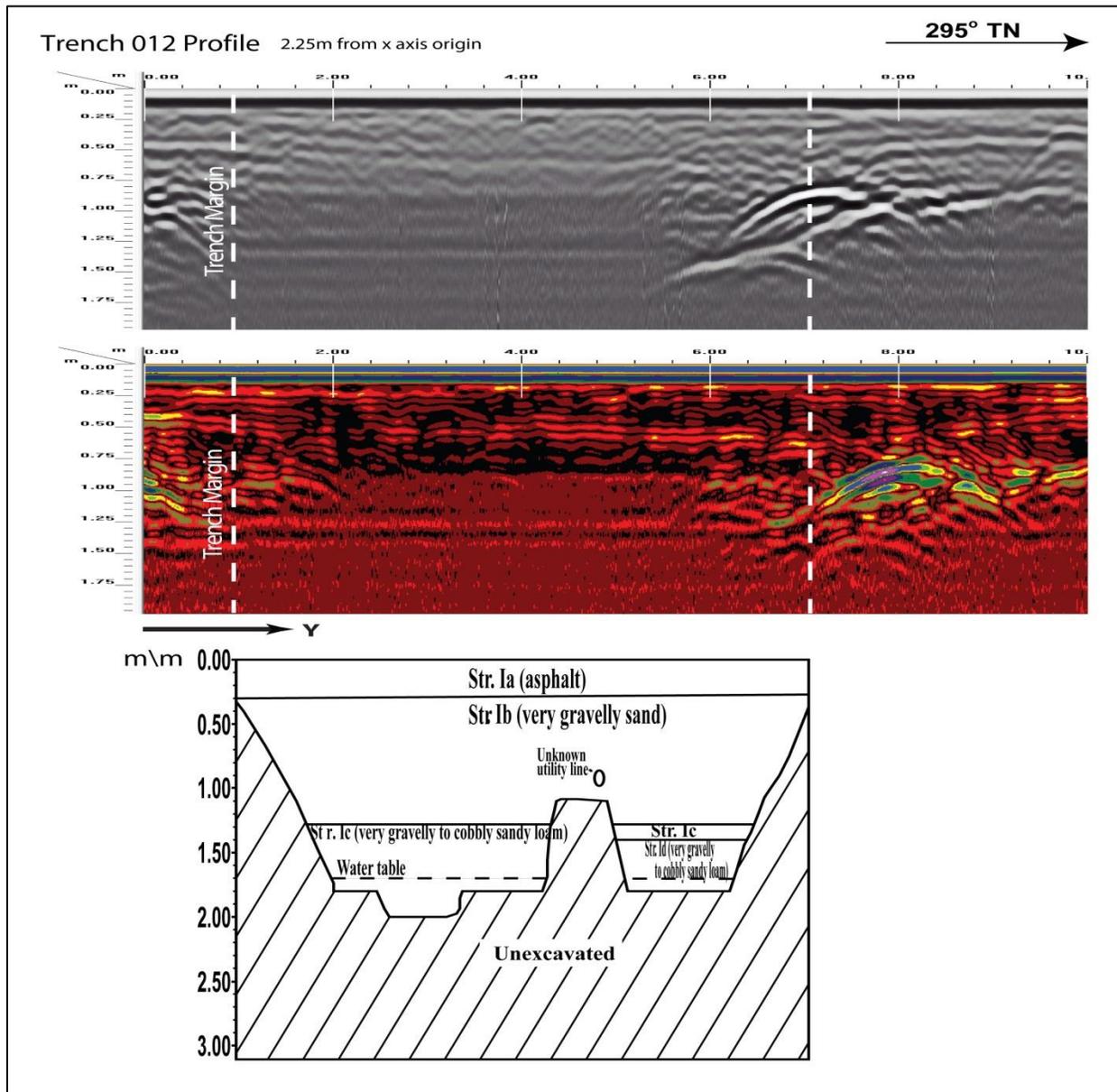


Figure 44. Visual comparison of excavated profile and GPR signal profile of T-012

### Test Excavation 13

T-013 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Nimitz Highway, 42.0 m southeast of Kalihi Stream. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 3.4 m northwest, sewer line 6.1 m southwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated a linear feature but this was located outside of the excavation boundaries. Reflectivity was relatively uniform throughout the grid and decreased with depth except for the linear feature. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.5 mbs (Figure 45).

GPR depth profiles for T-013 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 46). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.25 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 0.75 mbs.

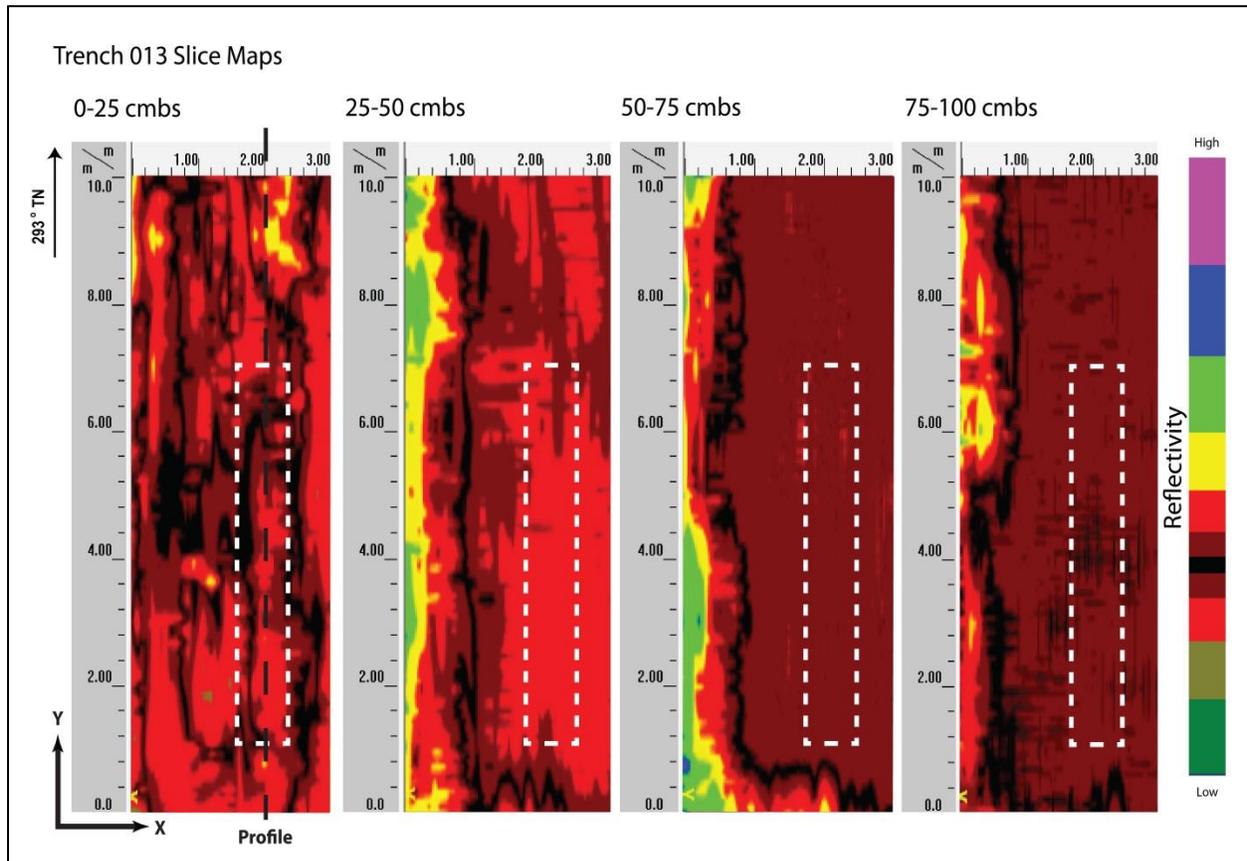


Figure 45. Slice maps of T-013 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 46). Strata Ia and Ib were clearly observed and occurred at the ground-truthed depths. Textural changes in the form of multiple small hyperbolas were apparent in Stratum Ib which was cobbly sand. All other sediment transitions occurred below the maximum clean signal return depth. No discrete objects were observed in the GPR results or subsequent excavation.

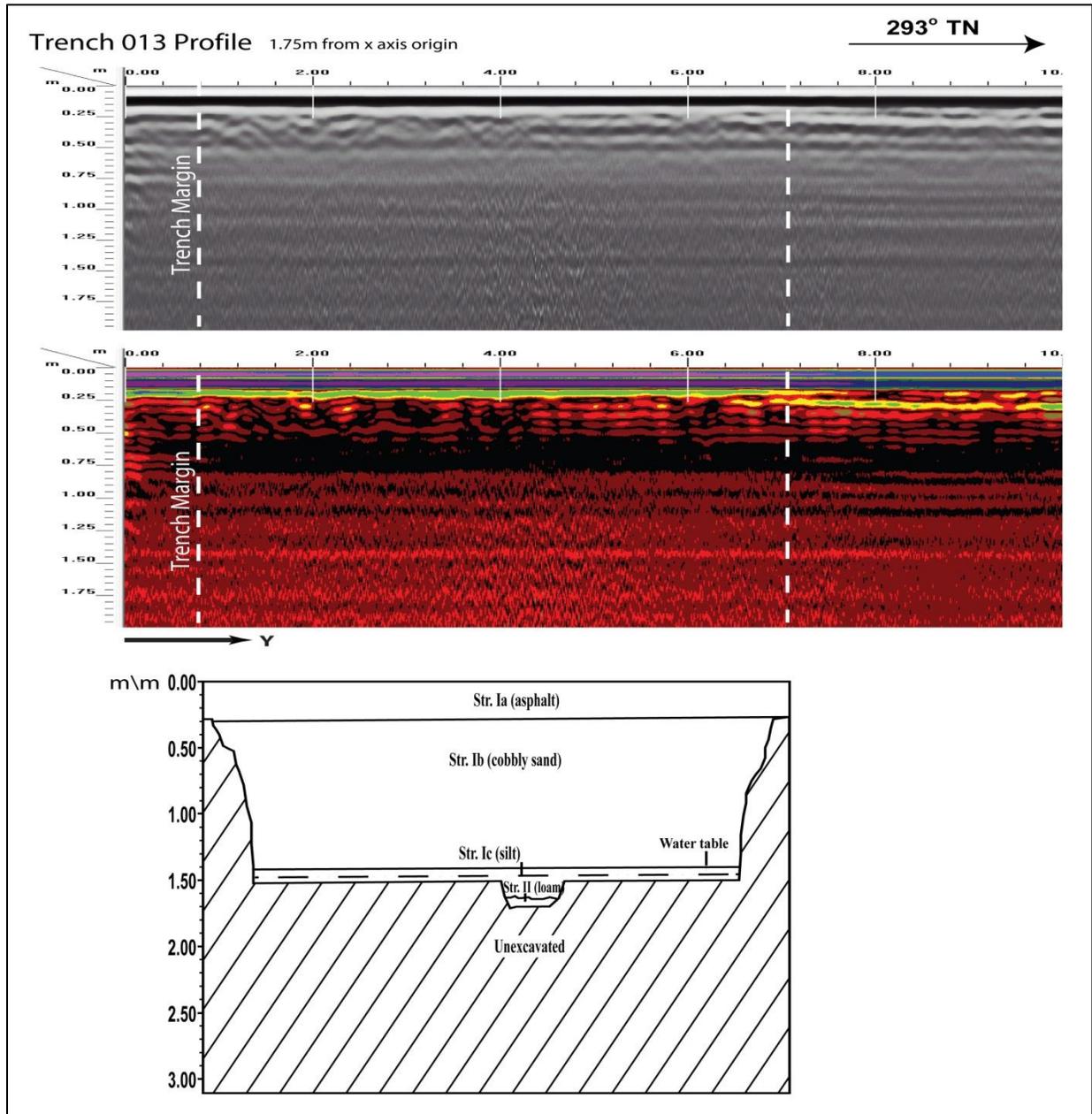


Figure 46. Visual comparison of excavated profile and GPR signal profile of T-013

### Test Excavation 14

T-014 measured 0.6 m by 6.0 m and was oriented east to west and was located within the road cut of Kamehameha Highway in the westbound lane, 4.2 m north of the center median 86.0 m southeast of Kalihi Stream. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 5.0 m northeast, gas line 9 m east, sewer 6.5 m south. A metal utility was encountered at approximately 1.55 mbs in the western end of the excavation.

A review of amplitude slice maps indicated no linear features although a utility was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs and increases again around 0.75 mbs (Figure 47).

GPR depth profiles for T-014 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 48). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.15 mbs and again around 0.75 mbs. No utilities were observed in the profile although a utility was encountered during excavation. The maximum depth of clean signal return was approximately 0.75 mbs.

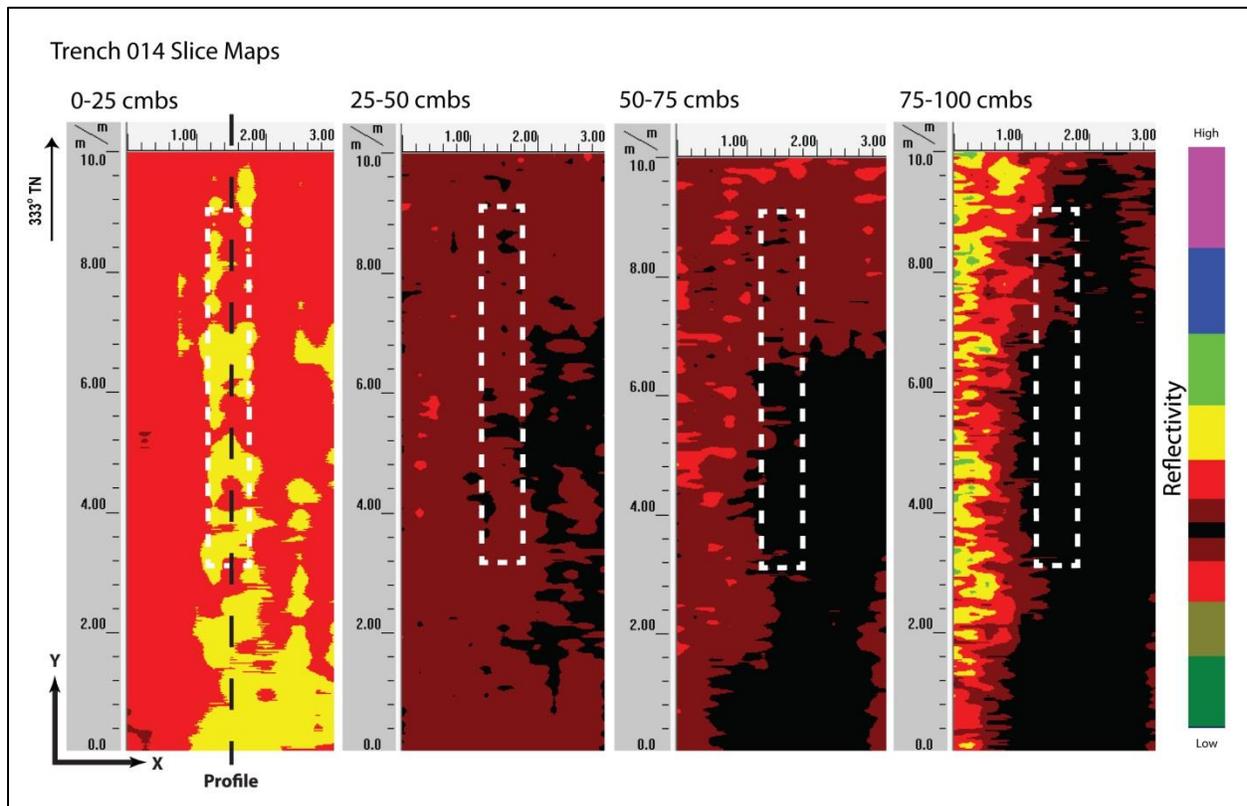


Figure 47. Slice maps of T-014 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 48). Strata Ia and Ib were clearly observed and occurred at the ground-truthed depths. A metal utility was located about 1.55 mbs. This utility did not show up on the profile or slice maps due to the fact that it was below the maximum clean signal return depth. No other discrete objects or other stratigraphic transitions were observed in the GPR results.

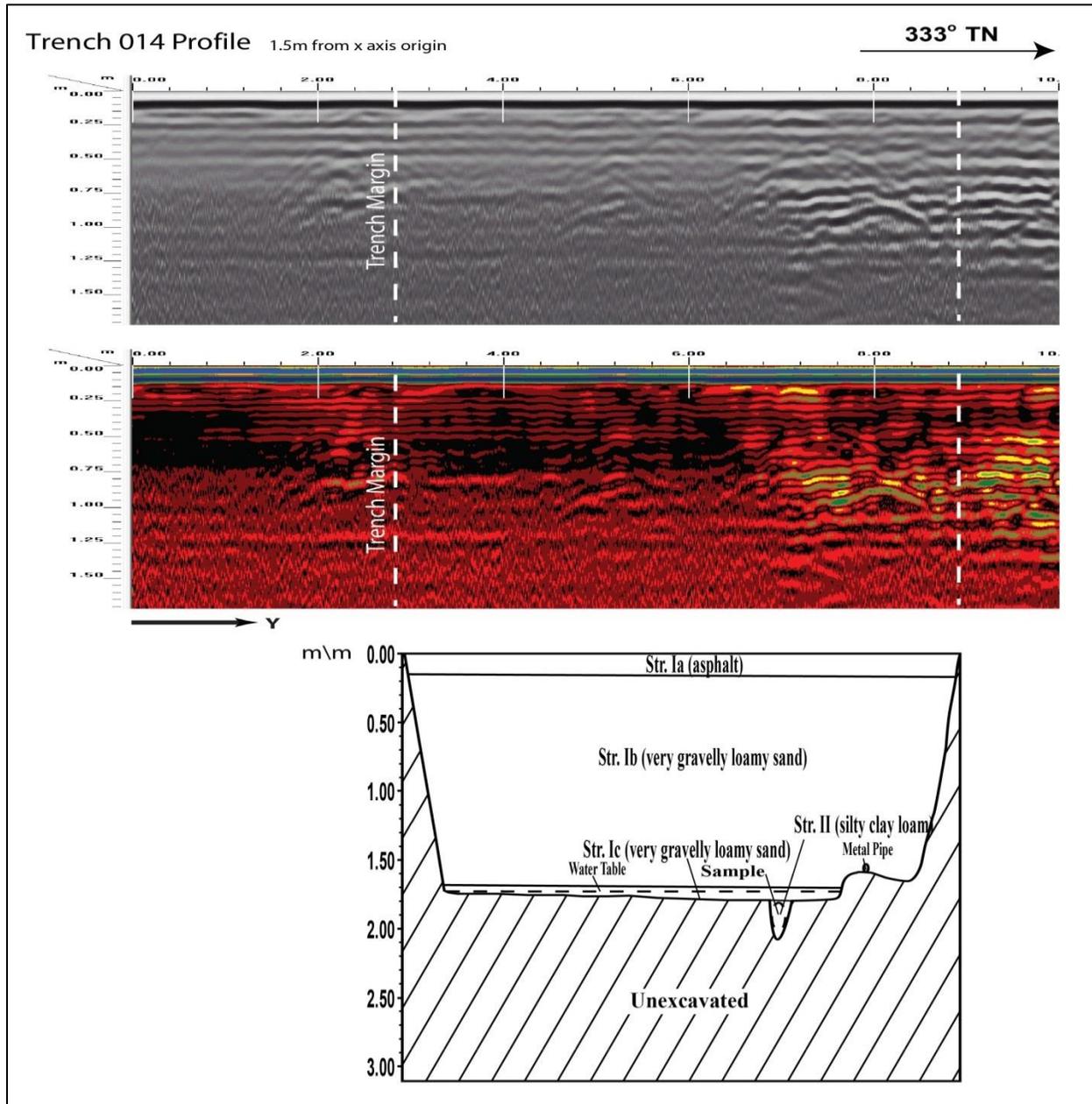


Figure 48. Visual comparison of excavated profile and GPR signal profile of T-014

### Test Excavation 15

T-015 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut Kamehameha Highway in the westbound lane, 1.5 m north running parallel along the median. The GPR grid measured 2.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 4.4 m north and 2.5 m east. No utilities transected the excavation location.

A review of amplitude slice maps indicated no linear features which might have indicated the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 49).

GPR depth profiles for T-015 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 50). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.15 mbs and again around 0.65 mbs. An anomaly was observed in the profile but was not encountered during excavation. The maximum depth of clean signal return was approximately 0.8 mbs.

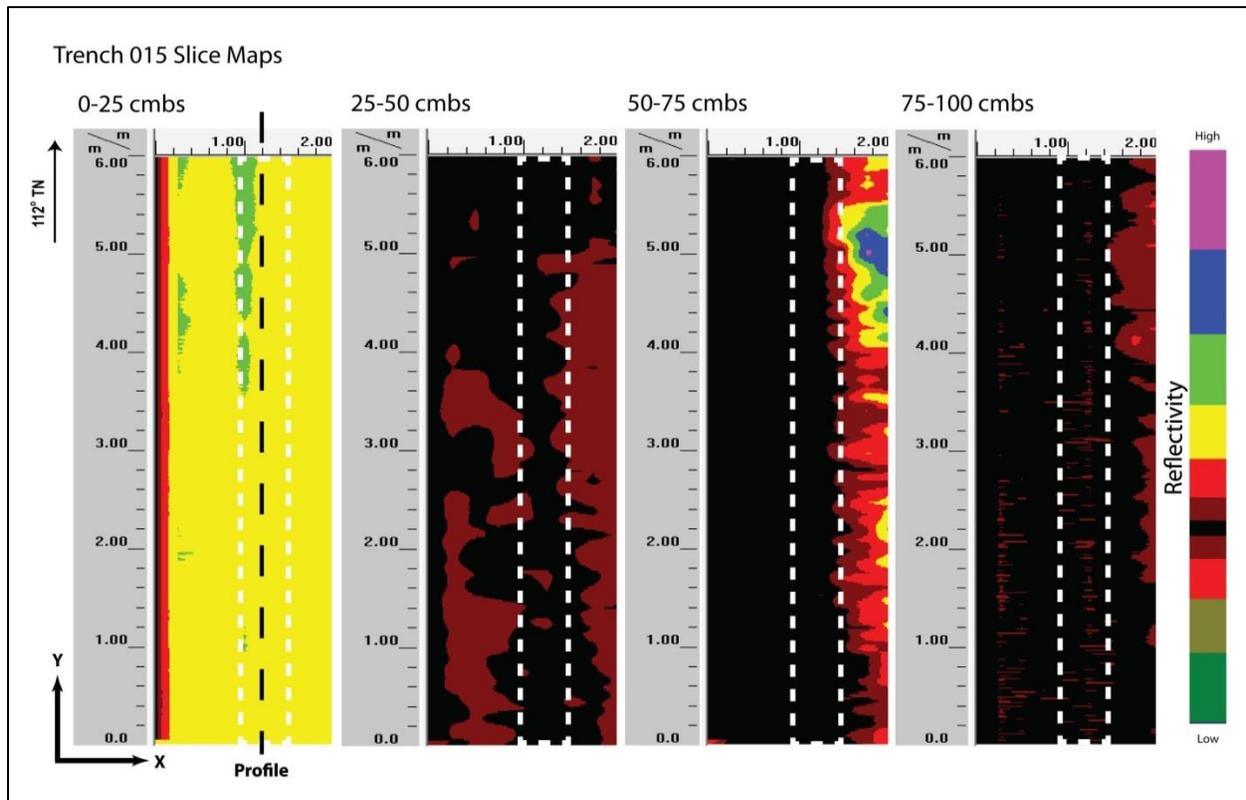


Figure 49. Slice maps of T-015 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 50). Strata Ia through Ic were clearly observed and occurred at the ground-truthed depths. Strata included a double layer of asphalt on top of a gravelly sand fill. No discrete objects or other stratigraphic transitions were observed in the GPR results or subsequent excavation.

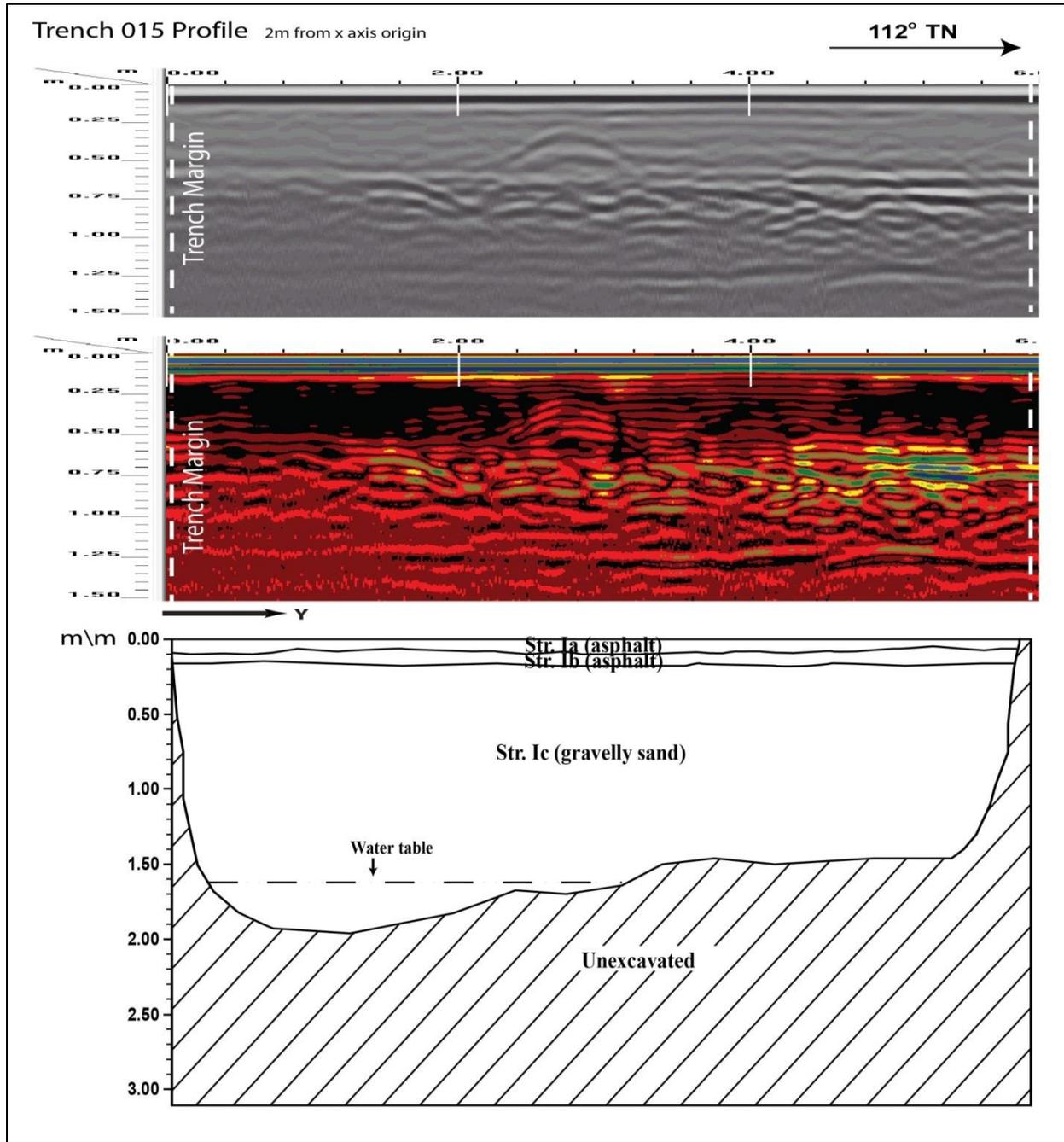


Figure 50. Visual comparison of excavated profile and GPR signal profile of T-15

### Test Excavation 16

T-016 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kamehameha Highway in the westbound lane 1.2 m northeast of the center median. The GPR grid measured 2.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: gas line 1.7 m east, water line 3.8 m northeast. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might have indicated the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75mbs (Figure 51).

GPR depth profiles for T-016 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 52). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.1 mbs and again around 0.5 mbs. Several small anomalies were observed in the profile but were not encountered during excavation. The maximum depth of clean signal return was approximately 0.6 mbs.

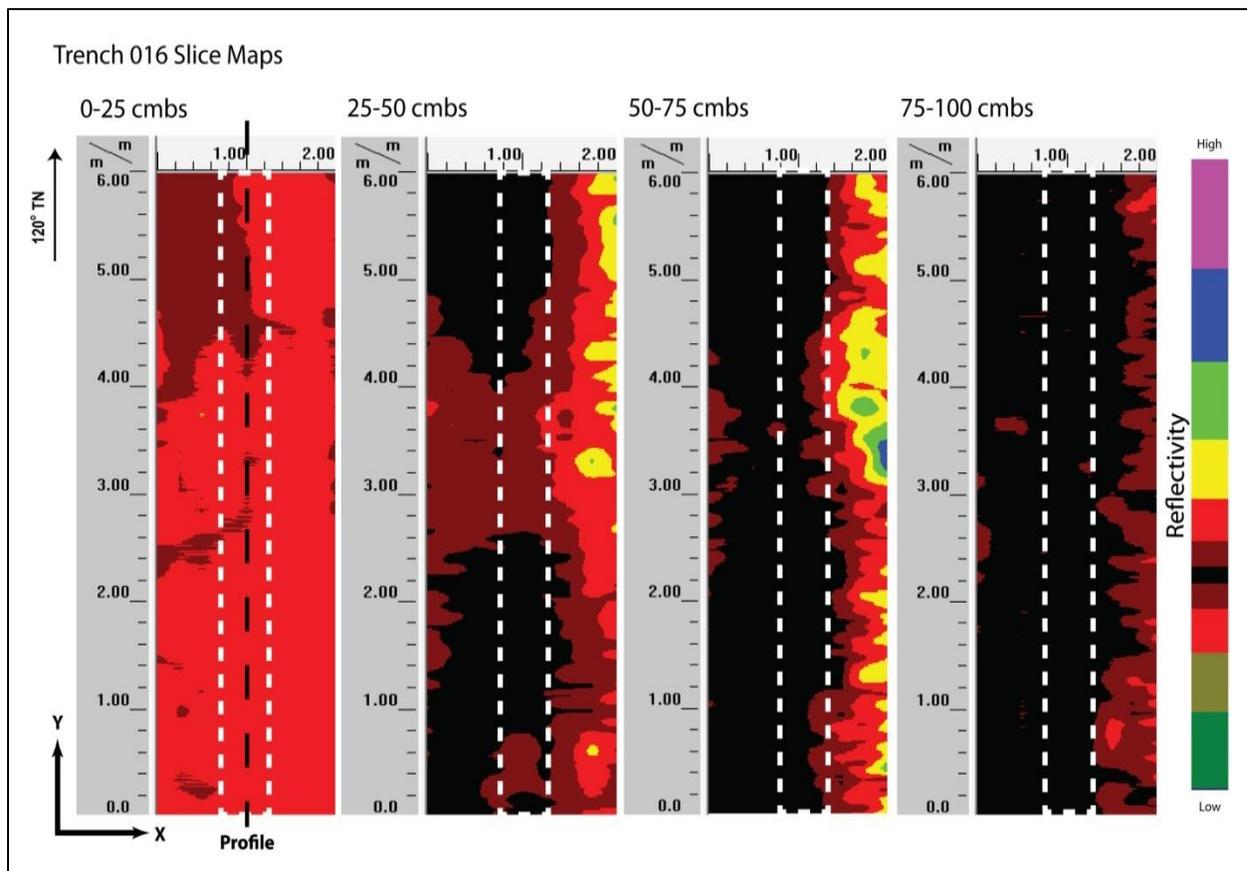


Figure 51. Slice maps of T-016 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 52). Strata Ia to Ic were all clearly observed and occurred at the ground-truthed depths. Strata included a double layer of asphalt on top of a gravelly sand fill layer. No discrete objects or other stratigraphic transitions were observed in the GPR results or subsequent excavation.

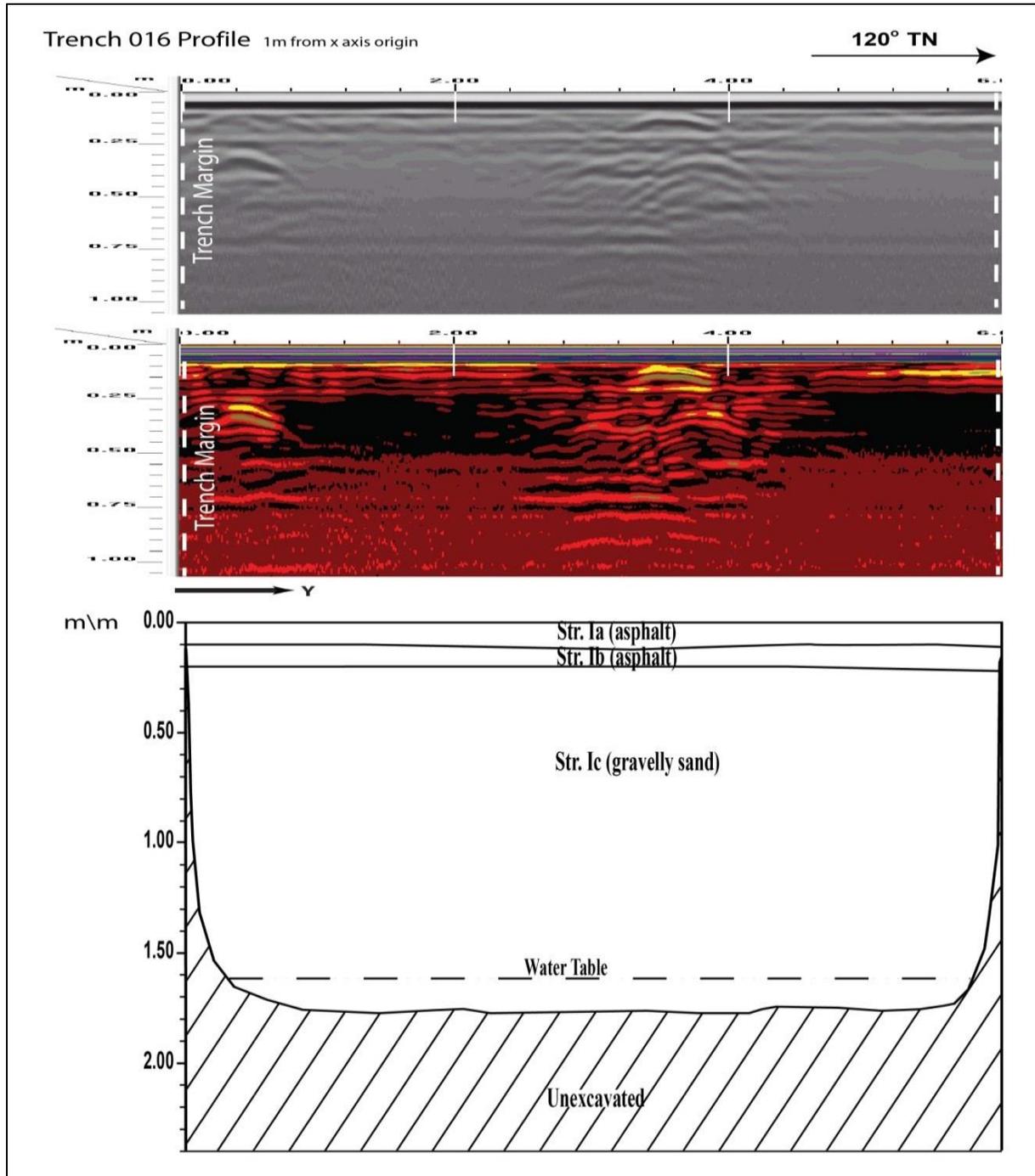


Figure 52. Visual comparison of excavated profile and GPR signal profile of T-016

### Test Excavation 17

T-017 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kamehameha Highway in the eastbound lane, running 0.5 m and paralleling the south end of the curb. The GPR grid measured 2.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities near the excavation include: electric line 1.7 m southwest, electric line 2.8 m northeast, and gas line 4.8 m northeast. A metal utility was encountered 1.44 mbs across the entire excavation.

A review of amplitude slice maps indicated a linear feature which corresponded to the metal utility that was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs (Figure 53).

GPR depth profiles for T-017 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 54). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.25 mbs and again around 1.0 mbs. An anomaly was observed in the profile and this corresponded to the utility which was encountered during excavation. The maximum depth of clean signal return was approximately 2.0 mbs.

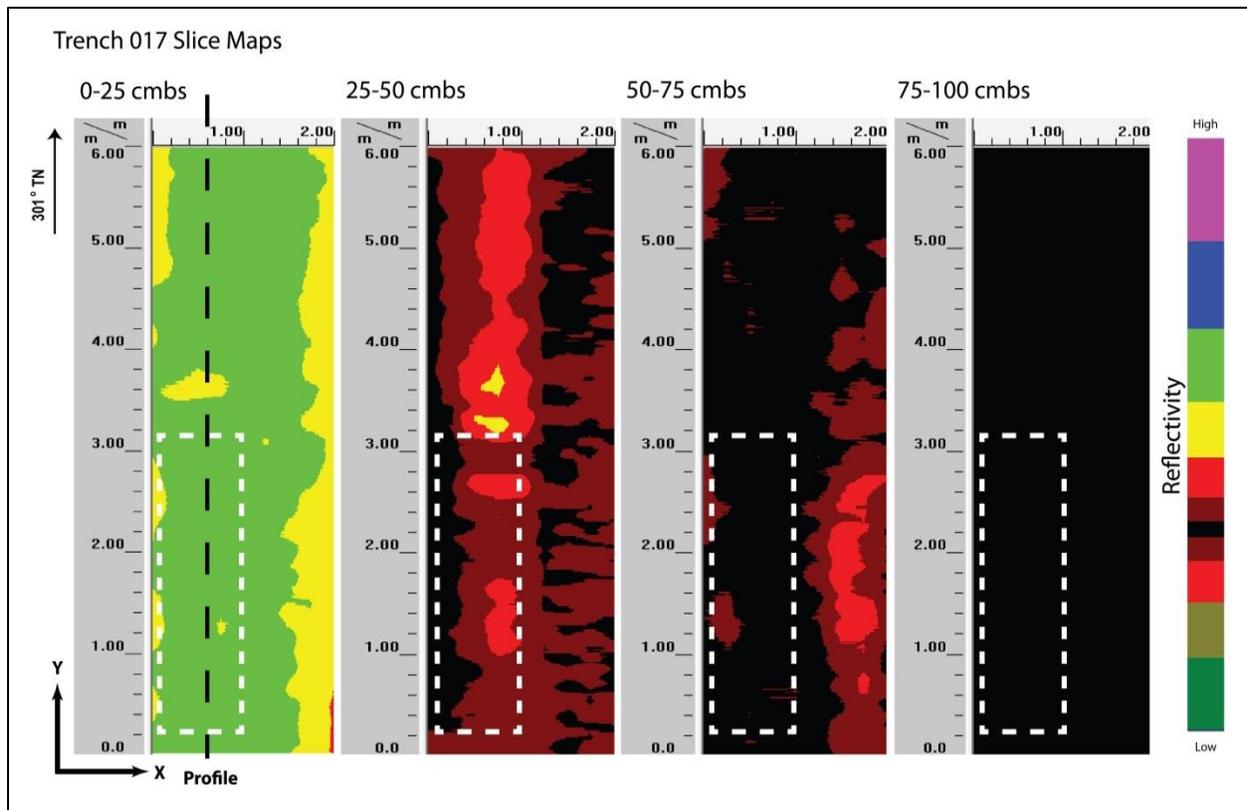


Figure 53. Slice maps of T-017 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 54). Strata Ia and Ib were all clearly observed and occurred at the ground-truthed depths. Textural changes in the form of multiple small hyperbolas were apparent in Stratum Ib which was extremely gravelly loam fill. A large metal utility was located about 1.5 mbs and this corresponded with the large anomaly spanning the entire length of the excavation. All other sediment transitions were below the maximum depth of clean signal return. No other discrete objects were observed in the GPR results or subsequent excavation.

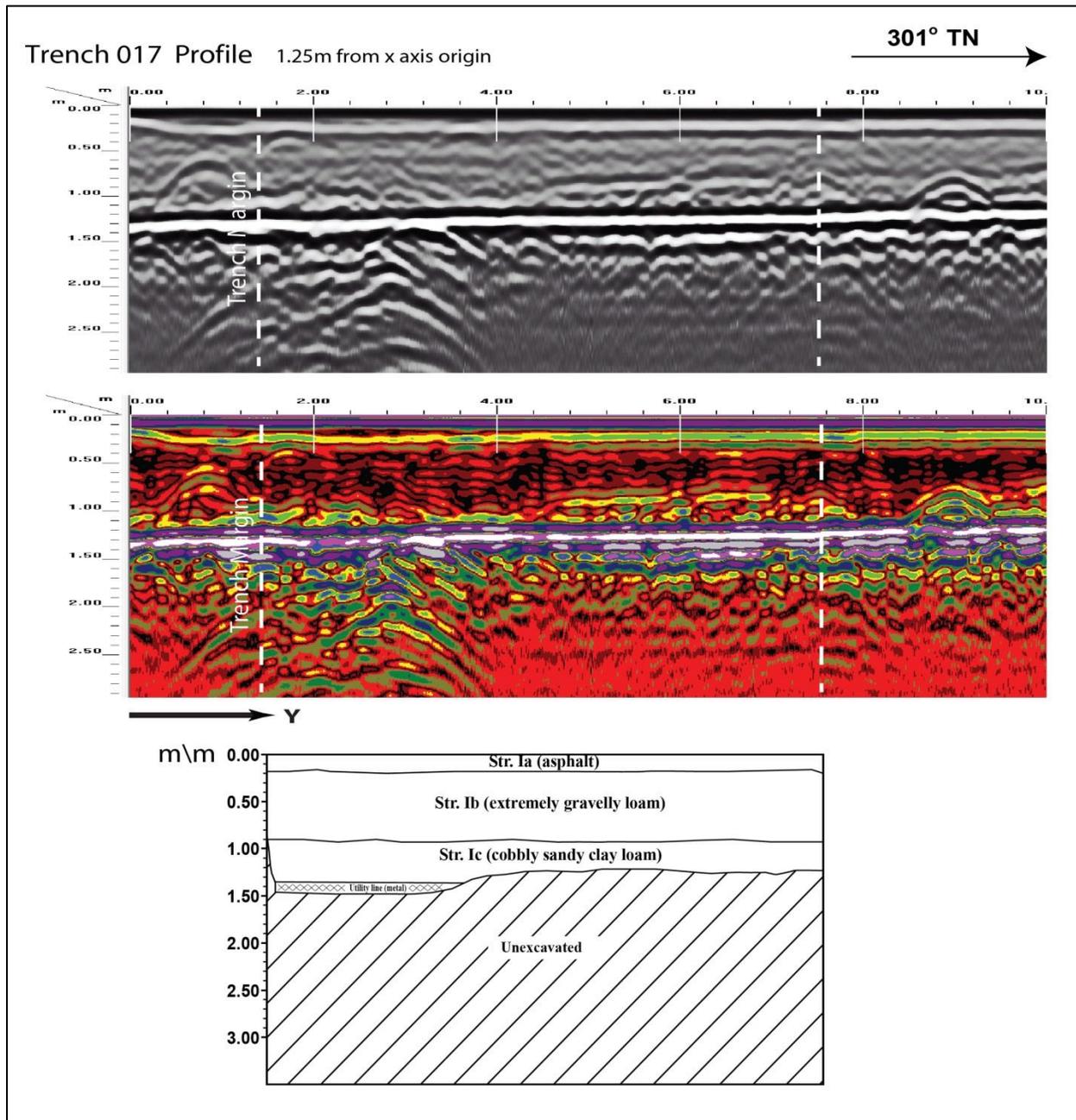


Figure 54. Visual comparison of excavated profile and GPR signal profile of T-017

### Test Excavation 18

T-018 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kamehameha Highway in the eastbound lane, 1.6 m northeast of the curb. The GPR grid measured 2.0 m by 6.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: water line 2.6 m southeast, electric line 1.9 m northeast. A metal cable was encountered around 0.65 mbs in the eastern end of the excavation.

A review of amplitude slice maps indicated no linear features which might have indicated the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.75 mbs (Figure 55).

GPR depth profiles for T-018 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 56). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.25 mbs and again around 0.75 mbs. An anomaly was observed in the profile and could correspond to a metal cable that was encountered during excavation. The maximum depth of clean signal return was approximately 0.9 mbs.

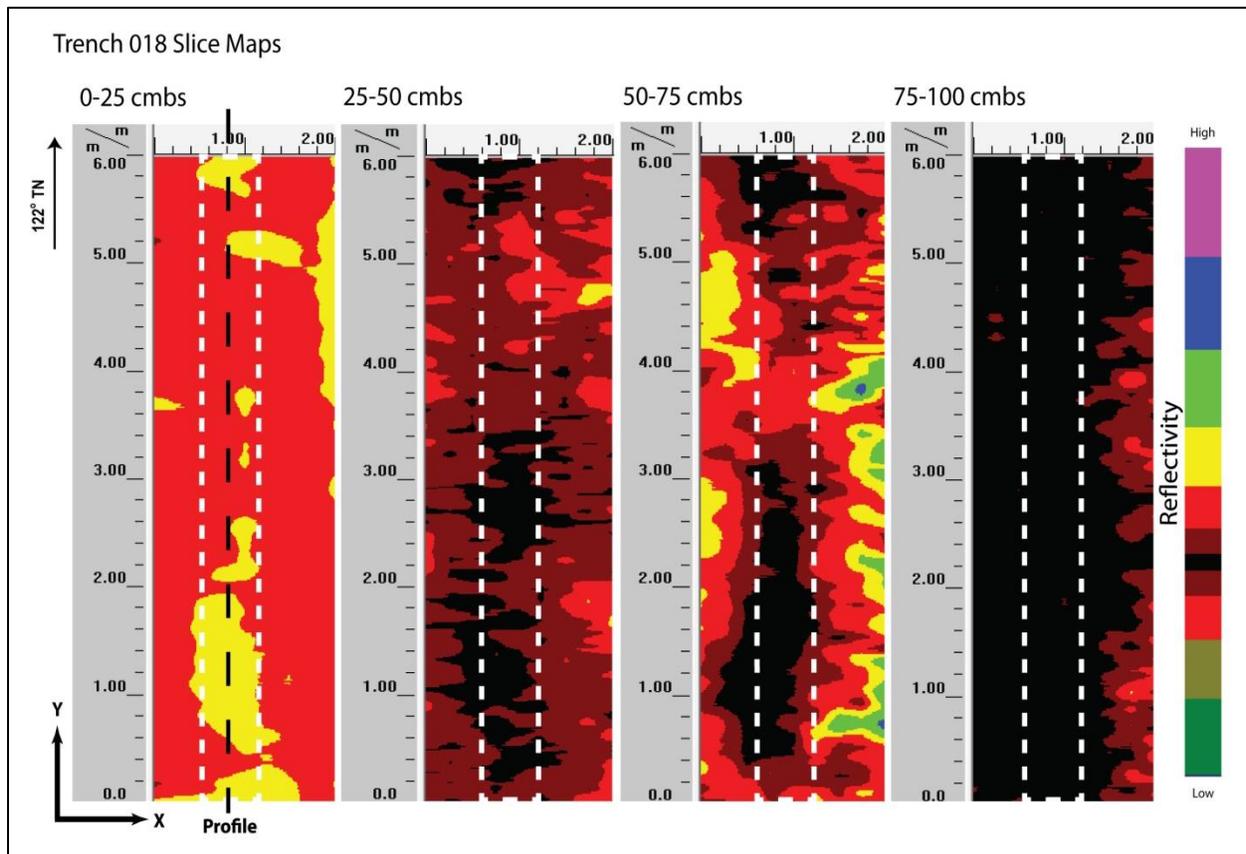


Figure 55. Slice maps of T-018 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a weak correlation in stratigraphic transitions (Figure 56). Strata included a thin layer of asphalt on top of extremely gravelly loam fill followed by loamy sand and then another layer of extremely gravelly loam fill. These transitions were not clearly depicted in the GPR profile at the depths that they occurred. A metal cable was found 0.65 mbs and could correspond to an anomaly observed in the profile. All other sediment transitions were below the maximum clean signal return depth. No other sediment transitions or discrete objects were observed in the GPR results.

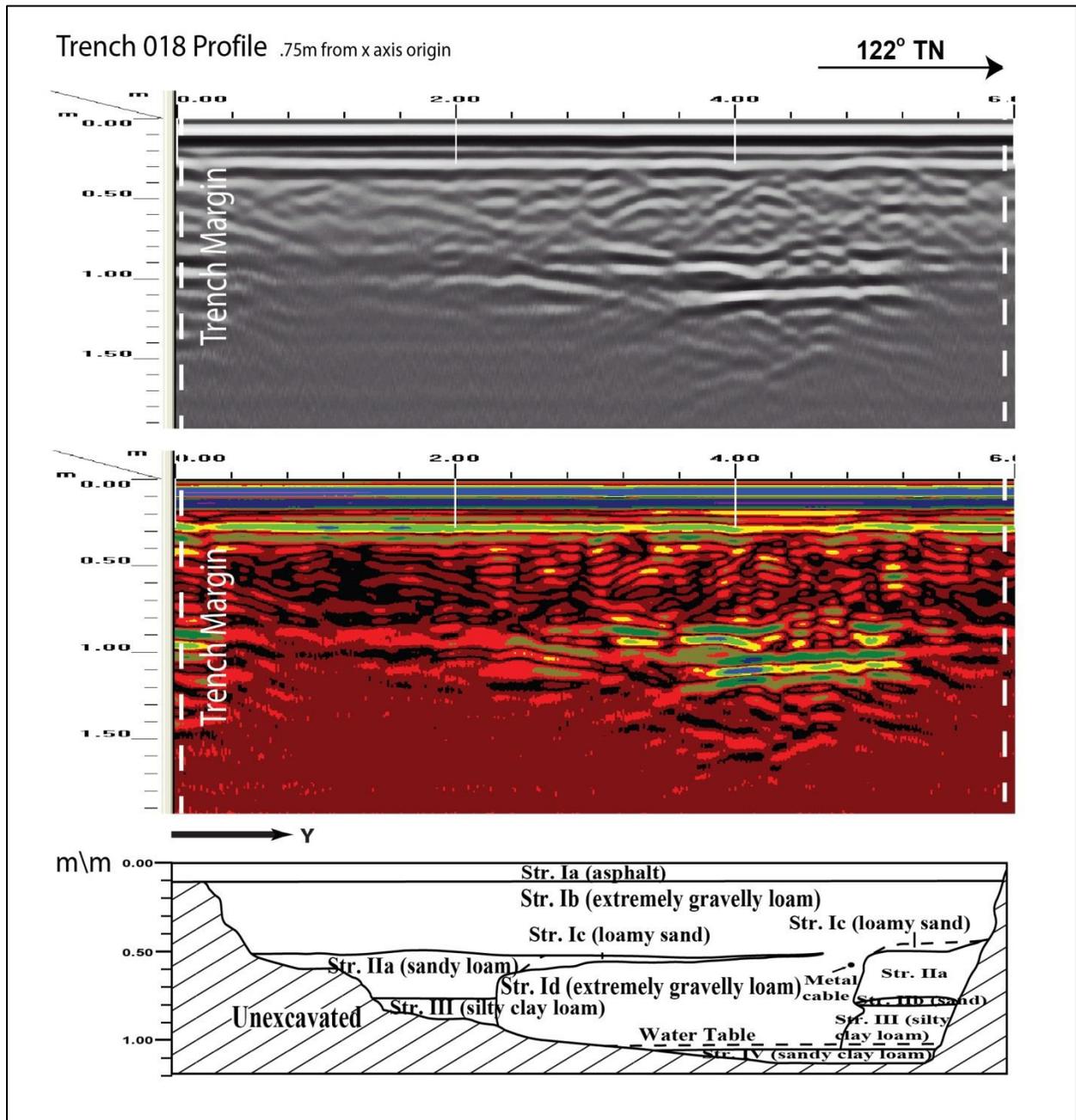


Figure 56. Visual comparison of excavated profile and GPR signal profile of T-018

## Test Excavation 19

T-019 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kamehameha Highway in the eastbound lane running parallel and 1.0 m southwest of the curb, and 87.0 m northwest of Kamehameha Highway and Laumaka Street intersection. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: electrical 2.6 m southwest and 5.5 m northeast, sewer 8.2 m southwest. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might have indicated the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs and increases again around 0.75 mbs (Figure 57).

GPR depth profiles for T-019 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 58). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.15 mbs and again around 0.6 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 1.75 mbs.

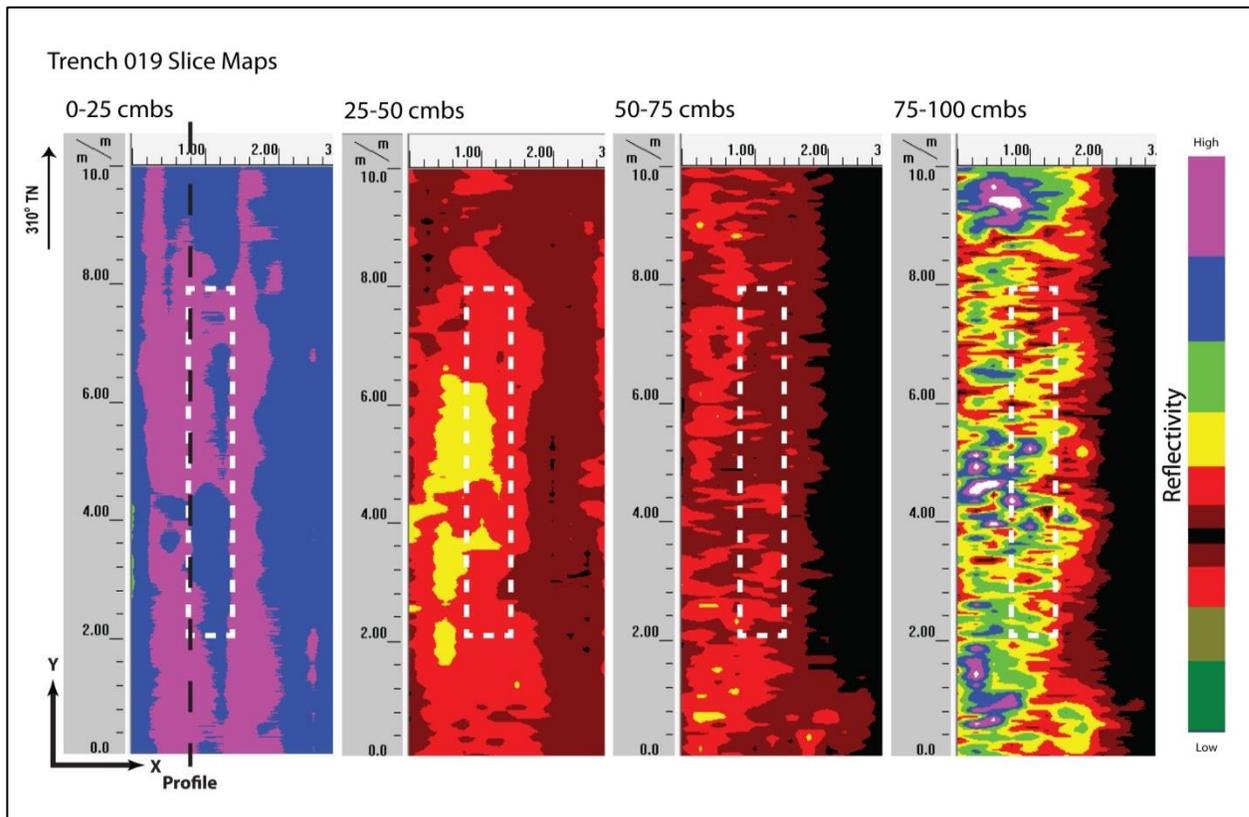


Figure 57. Slice maps of T-019 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a strong correlation in stratigraphic transitions (Figure 58). Strata Ia through Ic were clearly observed and occurred near ground-truthed depths. Textural changes in the form of multiple small hyperbolas were apparent in Stratum Ib which was extremely gravelly to cobbly sand and horizontal banding notes the beginning of Stratum Ic. No discrete objects were observed in the GPR results.

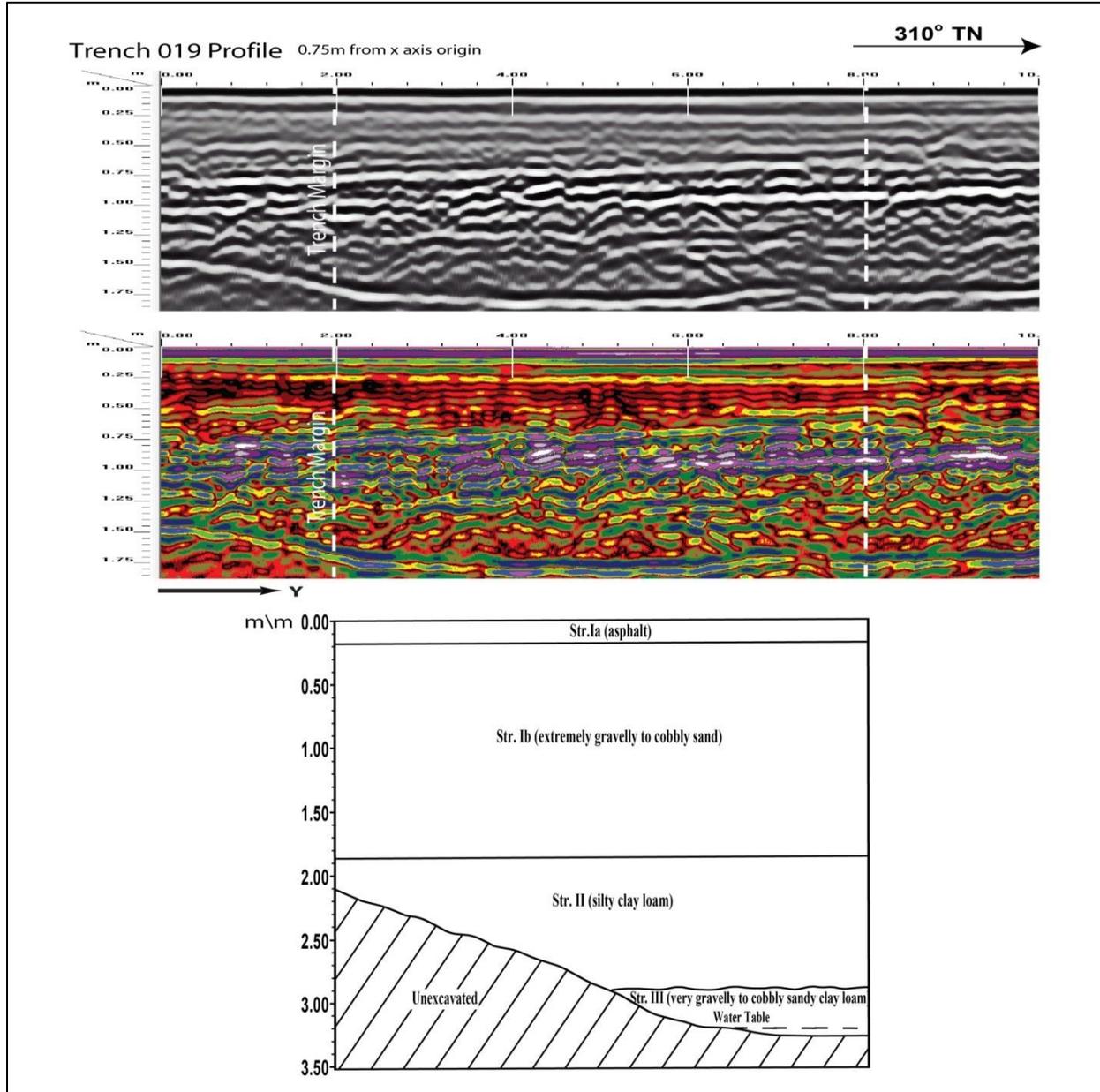


Figure 58. Visual comparison of excavated profile and GPR signal profile of T-019

## Test Excavation 20

T-020 measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kamehameha Highway in the eastbound lane, 60.0 m northwest of Kamehameha Highway and Laumaka Street intersection. The GPR grid measured 3.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: electric line 2.8 m southwest and 5.3 m northeast, water drain 6.5 m northeast, water line 6.5 m northeast. A metal pipe was encountered approximately 1.7 mbs in the northwestern end of the excavation.

A review of amplitude slice maps indicated no linear features although a metal pipe was encountered during excavation. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs and increases again around 0.75 mbs (Figure 59).

GPR depth profiles for T-020 identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 60). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.2 mbs and again around 0.6 mbs. No utilities were observed in the profile although a metal pipe was encountered during excavation. The maximum depth of clean signal return was approximately 1.5 mbs.

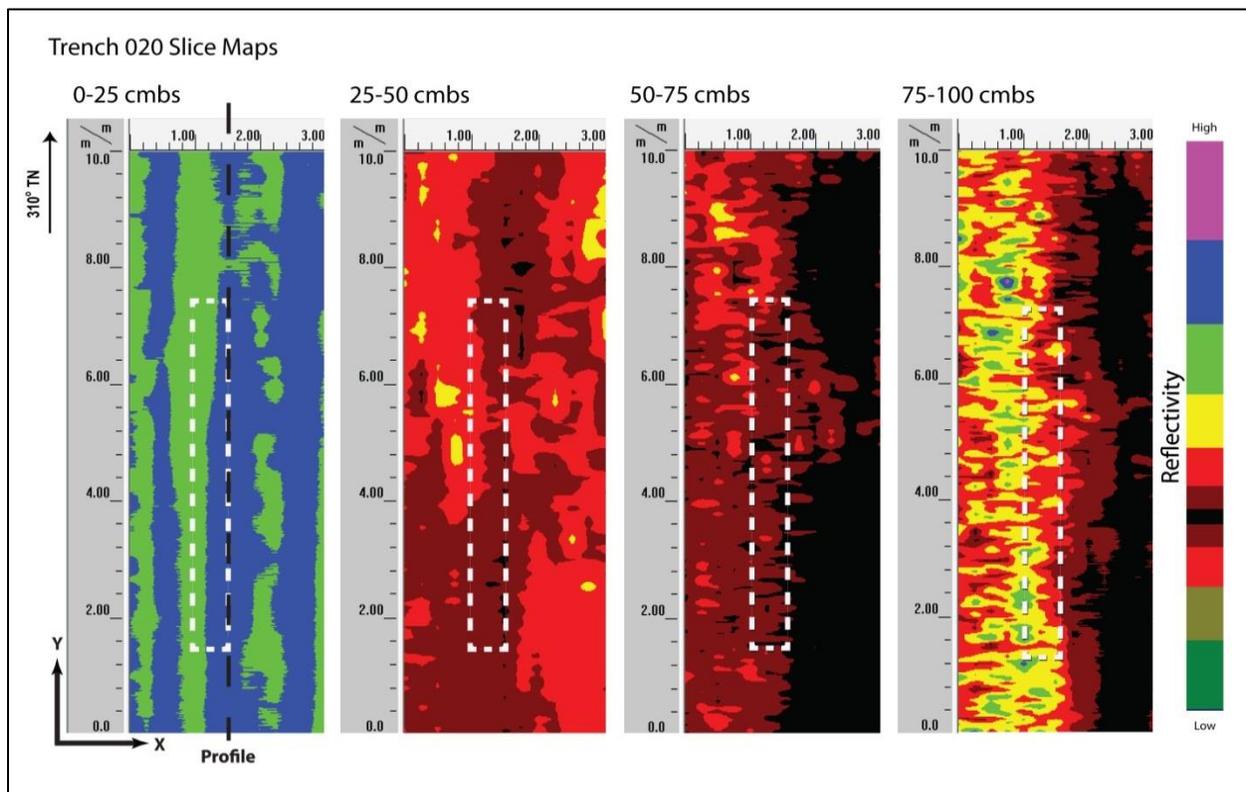


Figure 59. Slice maps of T-020 at 25cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a moderate correlation in stratigraphic transitions (Figure 60). Strata Ia to Ib were all clearly observed and occurred at the ground-truthed depths. An increase in reflectivity was observed around 0.7 mbs and does not seem to correspond to a stratigraphic layer or utilities. The transition to Stratum II was not clearly depicted in the GPR profile. A metal pipe was found 1.7 mbs. This pipe did not show up on the profile or slice maps and this may be due to the fact that the pipe was very small or empty. No other discrete objects or other stratigraphic transitions were observed in the GPR results.

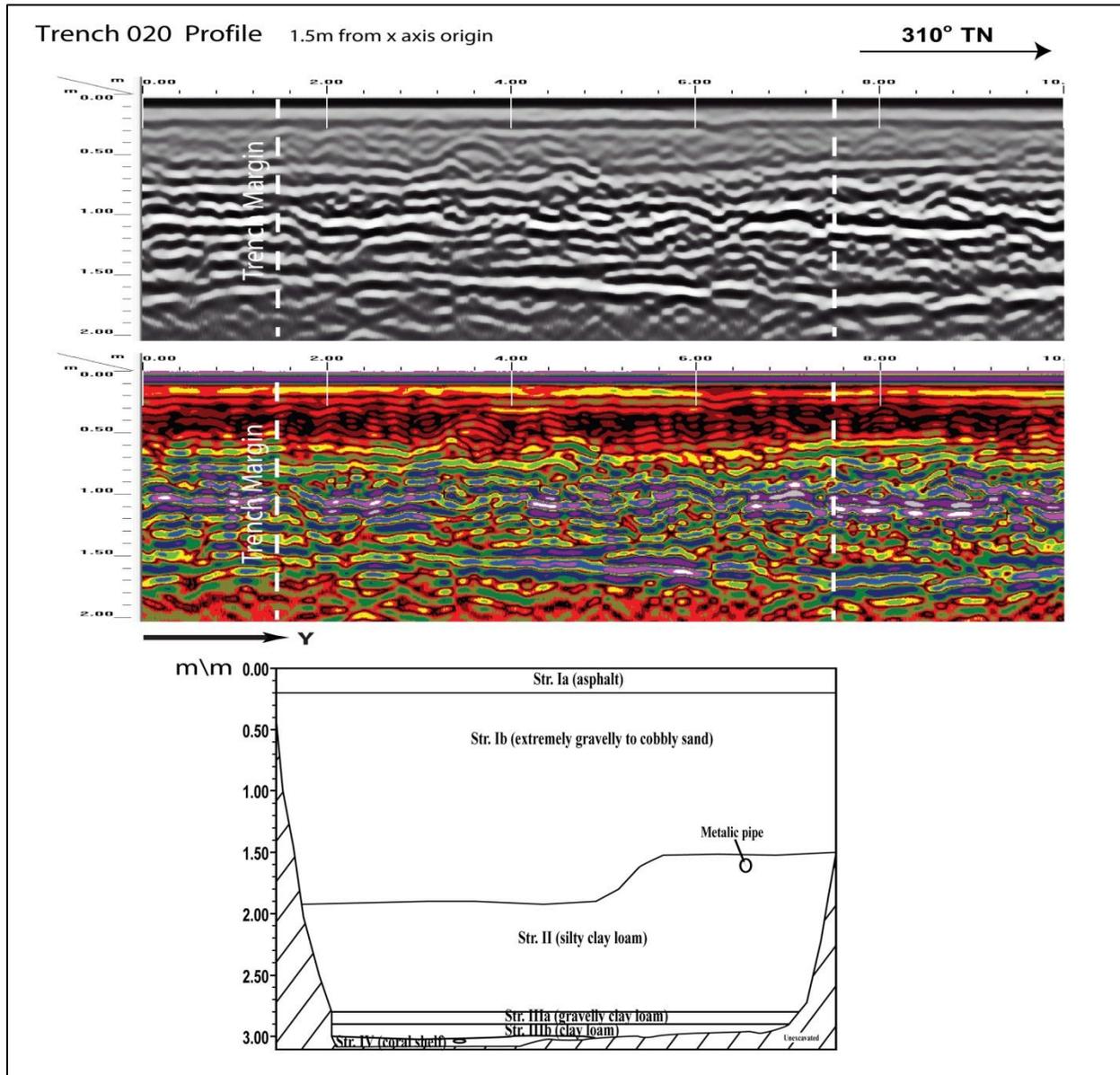


Figure 60. Visual comparison of excavated profile and GPR signal profile of T-020

## Test Excavation 20A

T-020A measured 0.6 m by 6.0 m and was oriented northwest to southeast and was located within the road cut of Kamehameha Highway in the eastbound lane, 67.0 m northwest of Kamehameha Highway and Laumaka Street intersection. The GPR grid measured 2.0 m by 10.0 m with 0.25 m spacing between Y transects and 1.0 m spacing between X transects. Utilities located near the excavation include: electric 1.5 m northwest and 2.8 m southwest, water drain 6.5 m northeast, water line 6.5 m northeast. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicated no linear features which might have indicated the presence of utilities. Reflectivity was relatively uniform throughout the grid and decreased with depth. A transition from higher reflectivity to lower reflectivity was observed at approximately 0.25 mbs and increases again around 0.75 mbs (Figure 61).

GPR depth profiles for T-020A identified horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 62). This banding corresponded to variations of density and chemical composition within fill deposits. The profile also indicated a change in reflectivity which occurred around 0.25 mbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 2.0 mbs.

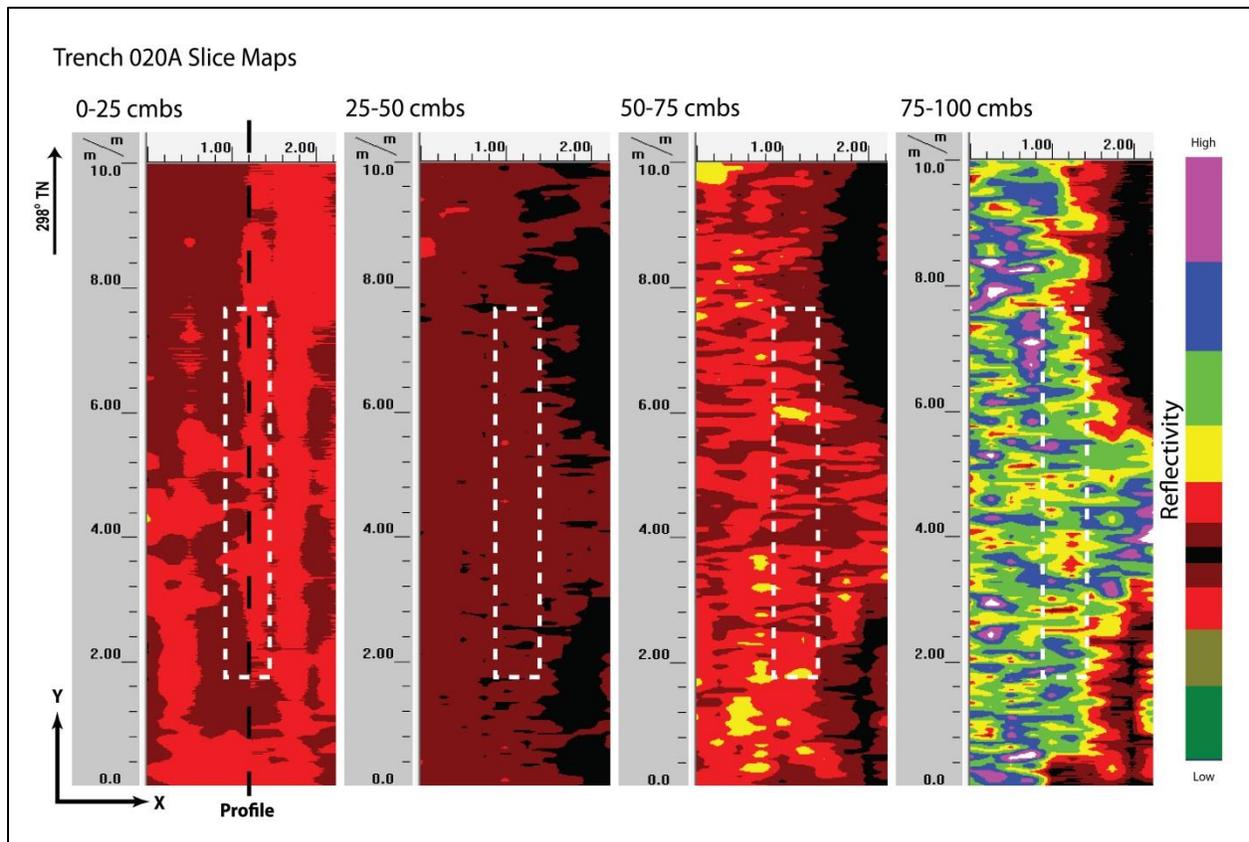


Figure 61. Slice maps of T-020A at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile showed a very strong correlation in stratigraphic transitions (Figure 62). Strata Ia through Ic were all clearly observed and occurred at the ground-truthed depths. Textural changes in the form of multiple small hyperbolas were apparent in Stratum Ib which was extremely gravelly cobbly sand fill. Horizontal banding and an increase in reflectivity was apparent as Ib transitions to II. All other sediment transitions were below the maximum depth of clean signal return. No other discrete objects were observed in the GPR results or subsequent excavation.

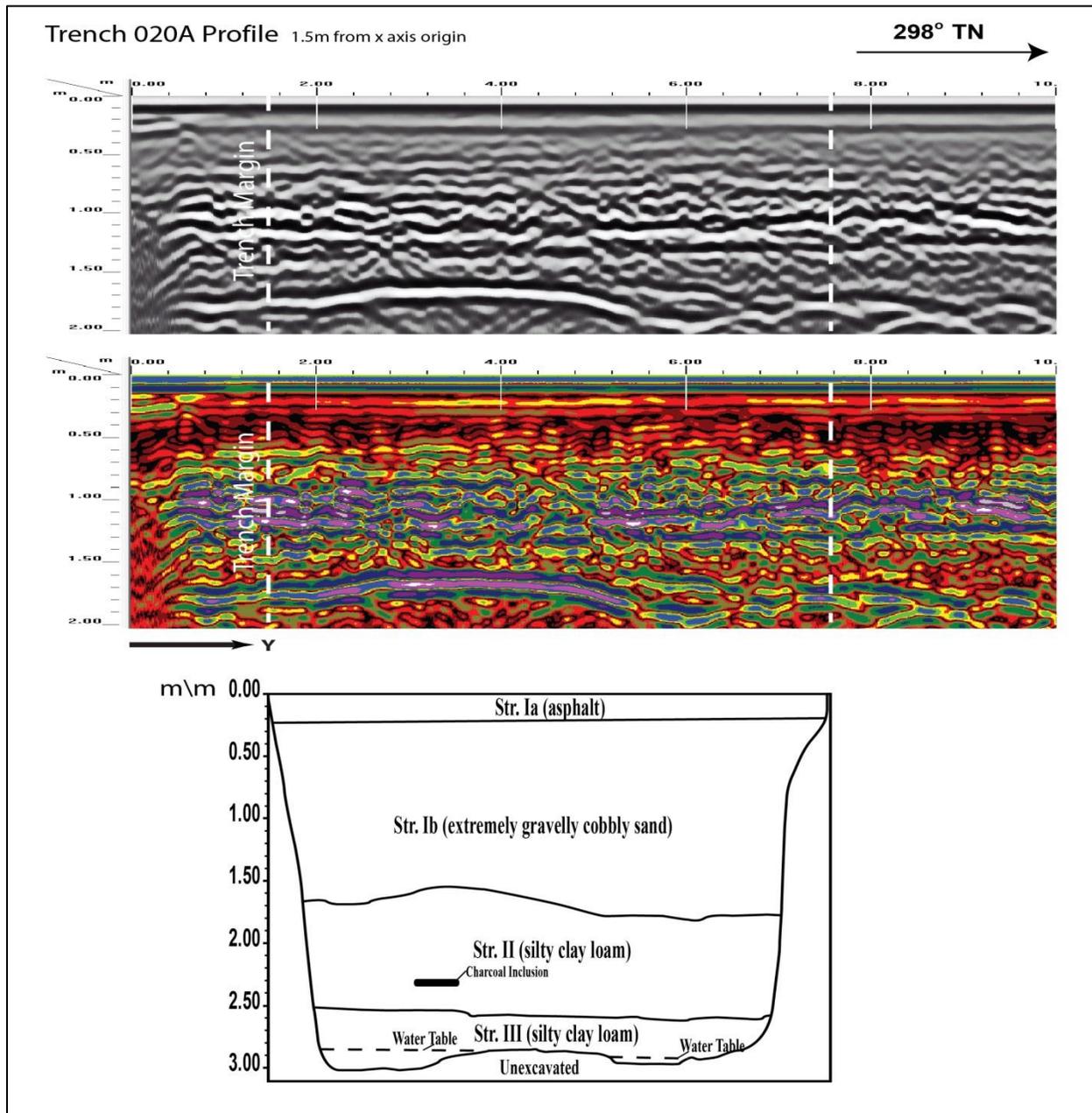


Figure 62. Visual comparison of excavated profile and GPR signal profile of T-020A