# RESULTS AND DISCUSSION

The whole data set for the salt affected soils including environmental conditions, morphological descriptions, micromorphological descriptions, physical, chemical and geochemical data are given in Appendices A-C.

## Environment and Morphology of Salt Affected Soils

### 1. Environmental Condition and Soil Profile Development

The environmental settings of the salt affected soils in Northeast Thailand are given in Table 2. The soils have various parent materials consisting of wash over residuum derived from clastic sedimentary rocks (Pedons 1-4, 11-16, and 23-28), alluvium over residuum derived from clastic sedimentary rocks (Pedons 6-10 and 18-19), alluvium (Pedons 17-22) and wash (Pedon 5). These soils have developed under different physiographic conditions including low erosional terrace (location 1), floodplain and floodplain or strath terrace on floodplain (location 2), erosional plain (locations 3 and 5) and depression on erosional plain (location 4). The landforms are flat to gently undulating, having 1-2 % slope. In addition, the soils that are strongly affected by salt have a salt crust and a bare surface with some halophytic plants such as *Combertum guadranglaer Kurz.* and *Azima sarmentosa Benth.*and *Hook.*

### 2. Field Morphological Properties

The full soil field morphological descriptions for salt affected soils are given in Appendix A. The summary of the field morphological characteristics of soils is given in Table 3. This chapter describes dominant soil morphological features for five linear traverses locations (Figures 5-9).

Table 2 Environmental setting of the salt affected soils in this study.

| Location/ Pedon | Probable parent material | Surrounding land form | Physiographic setting | Slope (%) | Eleviaton (MSL) | Land use |
|---|---|---|---|---|---|---|
| | | | ***Location 1 : Sandy textured salt affected soils*** | | | |
| Pedon 1-4 | Wash over residuum derived from clastic sedimentary rock | Flat to slighty undulating | Low erosional terrace | 1 | 176-180 | Paddy rice/ Left idle because of salt effect, Halophytic plants |
| Pedon 5 | Wash deposit | Slighty undulating | Low erosional terrace | 1 | 179 | Paddy rice |
| | | | ***Location 2 : Clayey textured salt affected soils*** | | | |
| Pedon 6 and 7 | Alluvium over residuum derived from clastic sedimentary rock | Flat/almost flat | Floodplain | 1-2 | 151-153 | Paddy rice/ Left idle because of salt effect, *Eucalyptus sp.* |
| Pedon 8-10 | Alluvium over residuum derived from clastic sedimentary rock | Gently undulating | Floodplain or strath terrace on floodplain | 2 | 151-153 | Paddy rice ploughed at time of sampling, *Eucalyptus sp.* |
| | | | ***Location 3 : Sandy over clayey textures salt affected soils*** | | | |
| Pedon11-16 | Wash over residuum derived from clastic sedimentary rock (siltstone) | Flat | Erosional plain | 1-2 | 116-119 | Paddy rice, *Eucalyptus sp.* |
| | | | ***Location 4 : Clayey textured salt affected soils*** | | | |
| Pedon 17, 20,21 and 22 | Alluvium | Flat | Depression on erosional plain | 1-2 | 152-153 | Left idle under salt tolerant grasses, local grasses |
| Pedon 18 and 19 | Alluvium over residuum derived from clastic sedimentary rock | Flat | Depression on erosional plain | 1-2 | 152-153 | Left idle under salt tolerant grasses, local grasses |
| | | | ***Location 5 : Sandy textured salt affected soils*** | | | |
| Pedon 23 and 24 | Wash over residuum derived from weathered clastic sedimentary rocks | Gently undulating | Erosional plain | 2 | 159-160 | Paddy field, lift idle under local weeds, salt tolerant species |
| Pedon 25, 26, 27 and 28 | Wash over residuum derived from weathered clastic sedimentary rocks | Gently undulating | Erosional plain | 2 | 153-161 | Paddy rice, local weeds, trees |

## 2.1 Soil Profile Development

All soils are deep and exhibit clay accumulation in their subsoil due to illuviation sufficent to meet the definition of an argillic horizon thus indicating a moderate to higher stage of profile development (Buol *et al*., 2003). Most soils have sodium accumulation in B and A horizons affixed by a letter 'n' (natric) in A and upper B horizon. The horizons with 'n' attached clearly show bocky structure and high values of SAR and/or ESP. Some of soil profiles show markedly different horizons which are probably discrete depositional layers and in some profiles the deeper horizons are actually *in situ* weathered rock.

The horizonation of profile development features of soils on each traverse is shown in Figure 4. The profile development features of soils on the traverse at location 1 (Pedons 1-5) are Apng-Bng-Btng-2Btng, Apng-Btng-Btcng-2Btng, Apg-Btg-Btng-Btg-2Btng, Apng-Btng-Btg-Btng-2Btng and Apng-Btg respectively (Figure 5).

The profile development features of soils on linear line of location 2 (Pedons 6-10) are Apng-Btng-2Btng, Apg-Btg-Btng-2Btng, Apg-Btg-Btng-2Btng, Apg-Btg-2Btg and Apg-Btg-2Btng respectively (Figure 6).

The profile development features of soils on the traverse at location 3 (Pedons 11-16) are Apg-Bcg-Btg-2Btng, Apg-Apng-Bcg-Btg-2Btg-2Btng, Apg-Btg-2Btg, Apg-Bng-Bcg-Btng-2Btng-2Btg, Apg-Bcg-Btg-2Btg-2Btng-2Btg-2Btng and Apg-Bcng-Btng-2Btng-2Btg-2Btng respectively (Figure 7). The profile development features of soils on the traverse at location 4 (Pedons 17-22) are Ang-ABng-Btng-Bssg, Ang-Btng-2Btg-2Btng, Ang-Btng-2Btng, Ang-Btng, Ang-Btng and Ang-Btng respectively (Figure 8). The profile development features of soils on the traverse at location 5 (Pedons 23-28) are Apng-Bng-Btng-2Btng, Apng-Btng-2Btng-2Crtng, Apg-Bg-Btng-2BCrng-2BCrg-2BCrng, Apg-Bng-Btng-2Btng-2BCrng, Apng-Bg-Bng-Btng-2Btng and Apng-Bng-Btng-2Btng respectively (Figure 9).

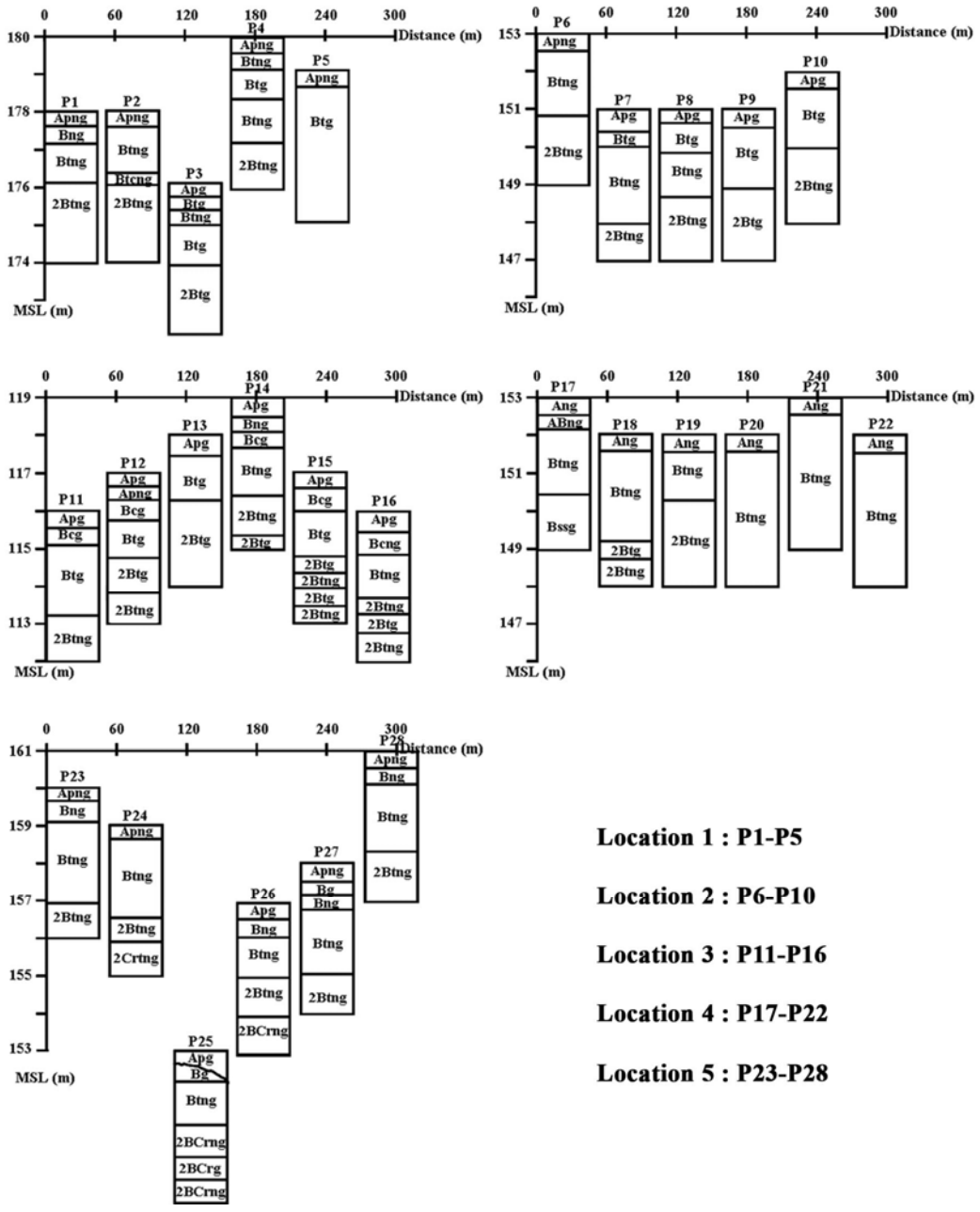


Figure 4 The horizonation of the soil profile development of salt affected soils examined in this study.

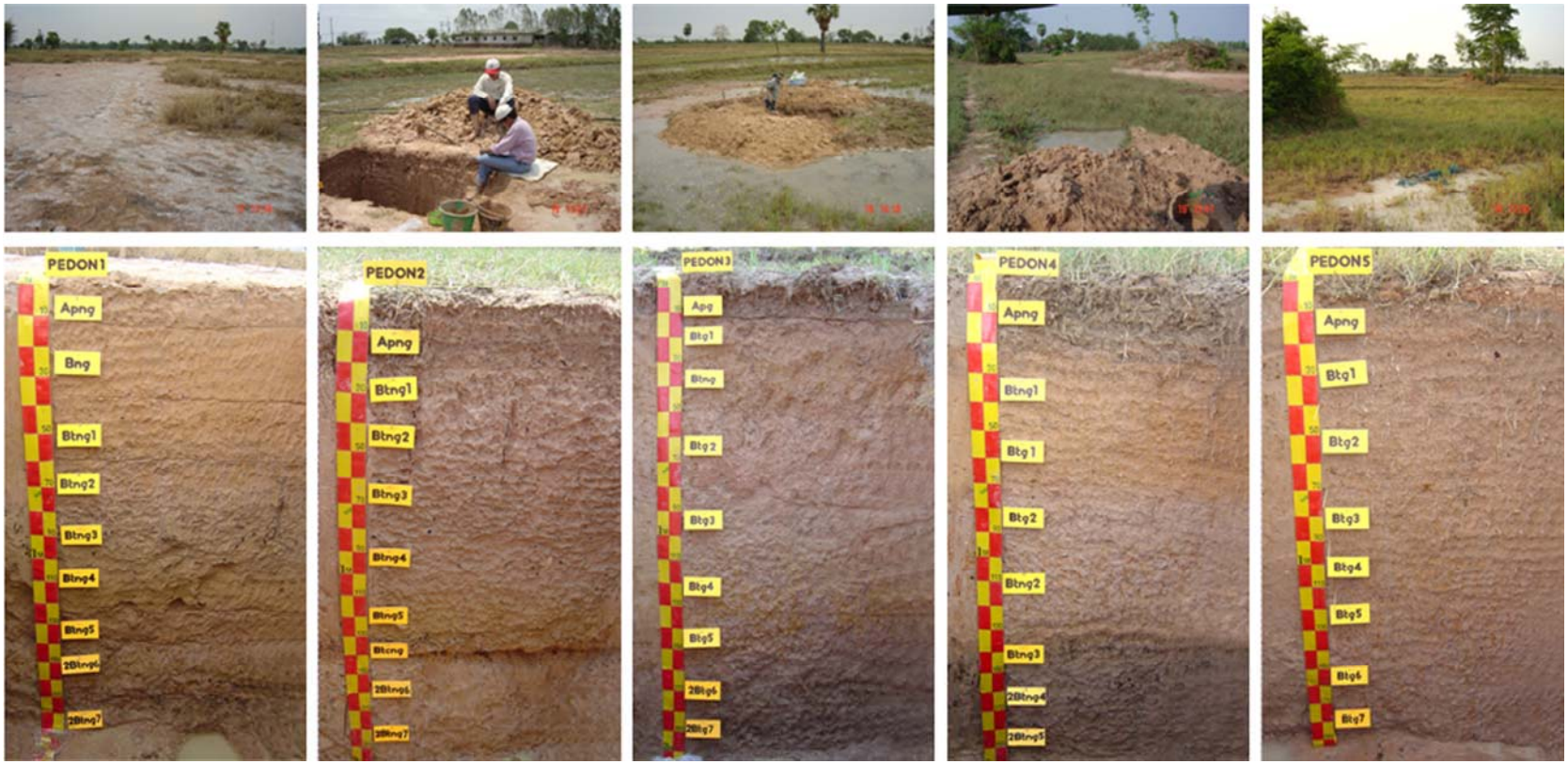


Figure 5 Field morphology of salt affected soils at location 1.

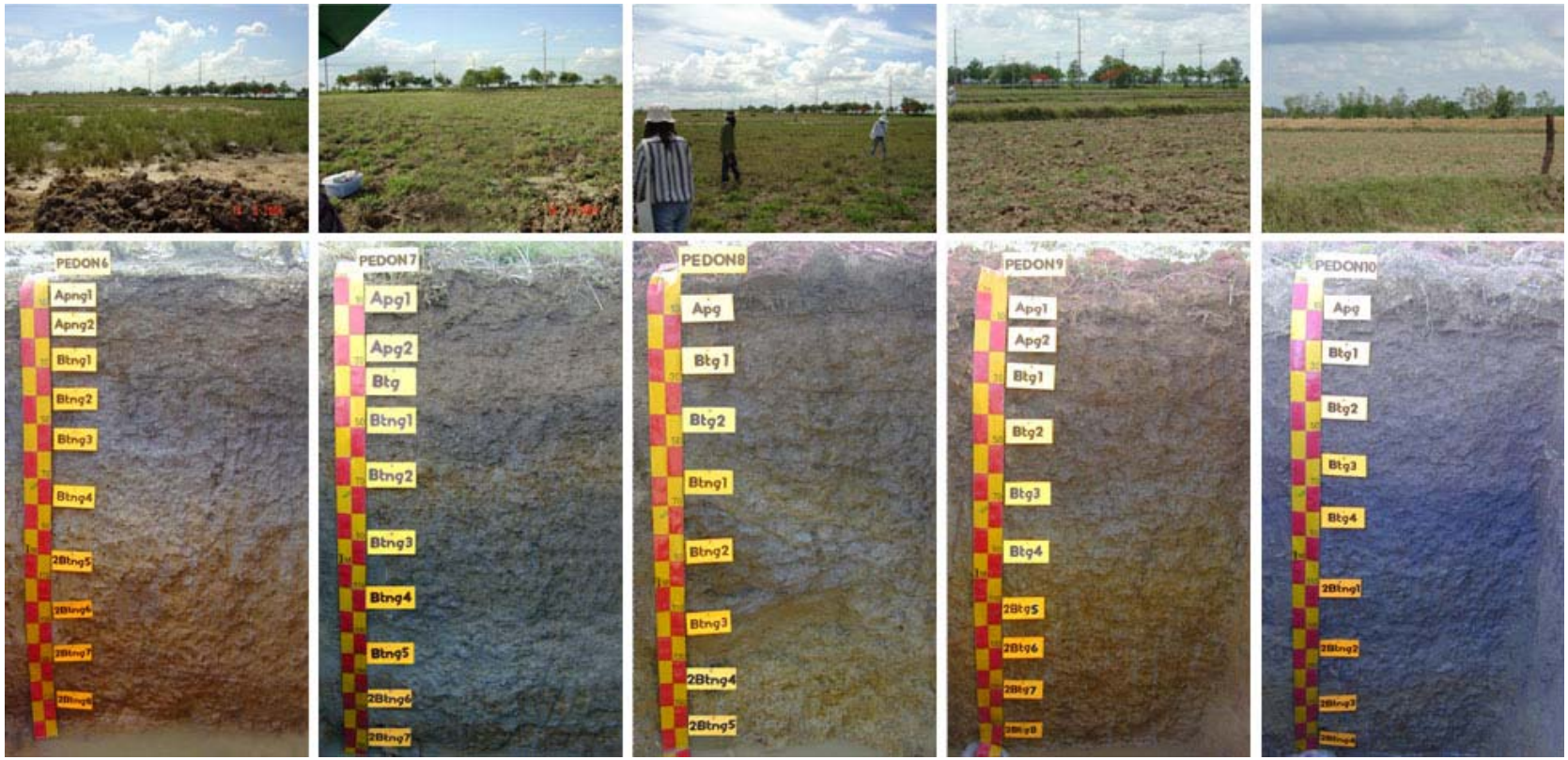


Figure 6 Field morphology of salt affected soils at location 2.

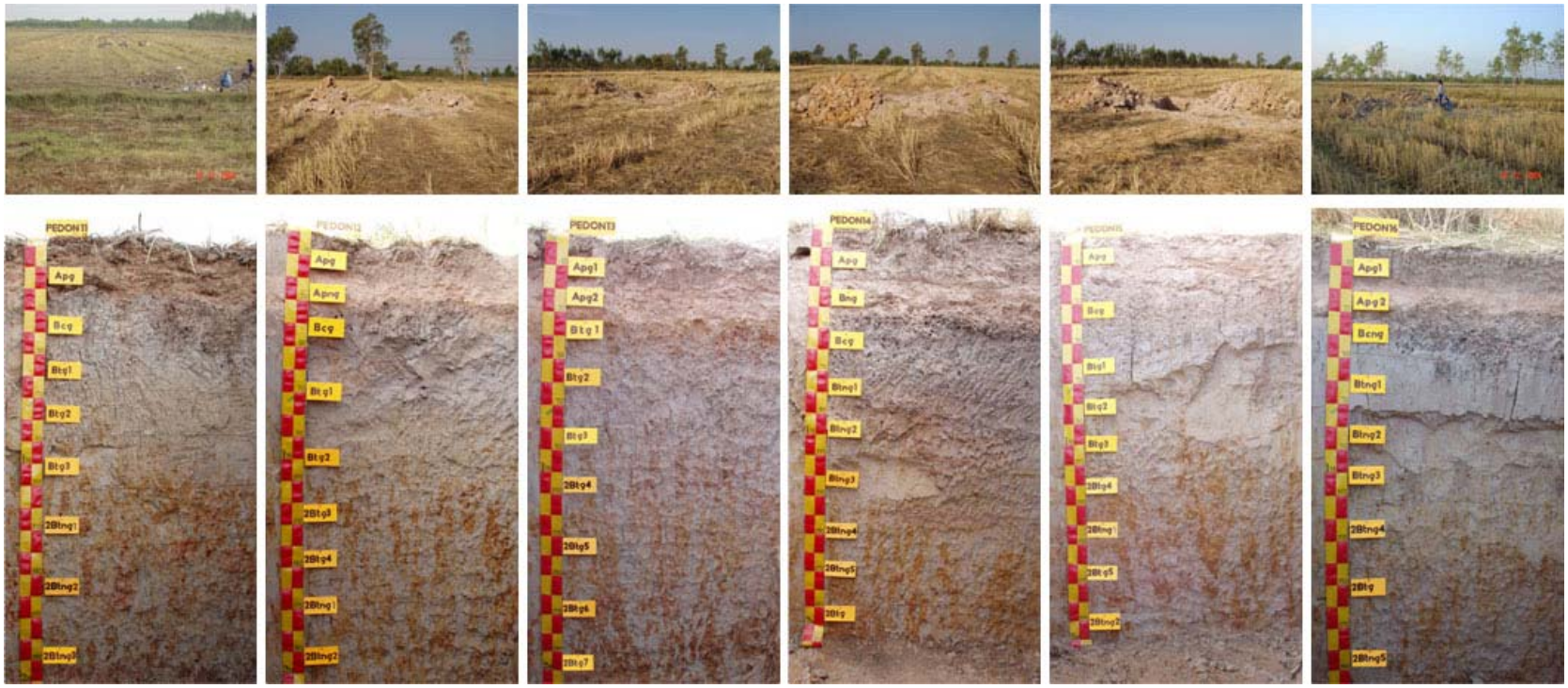


Figure 7 Field morphology of salt affected soils at location 3.

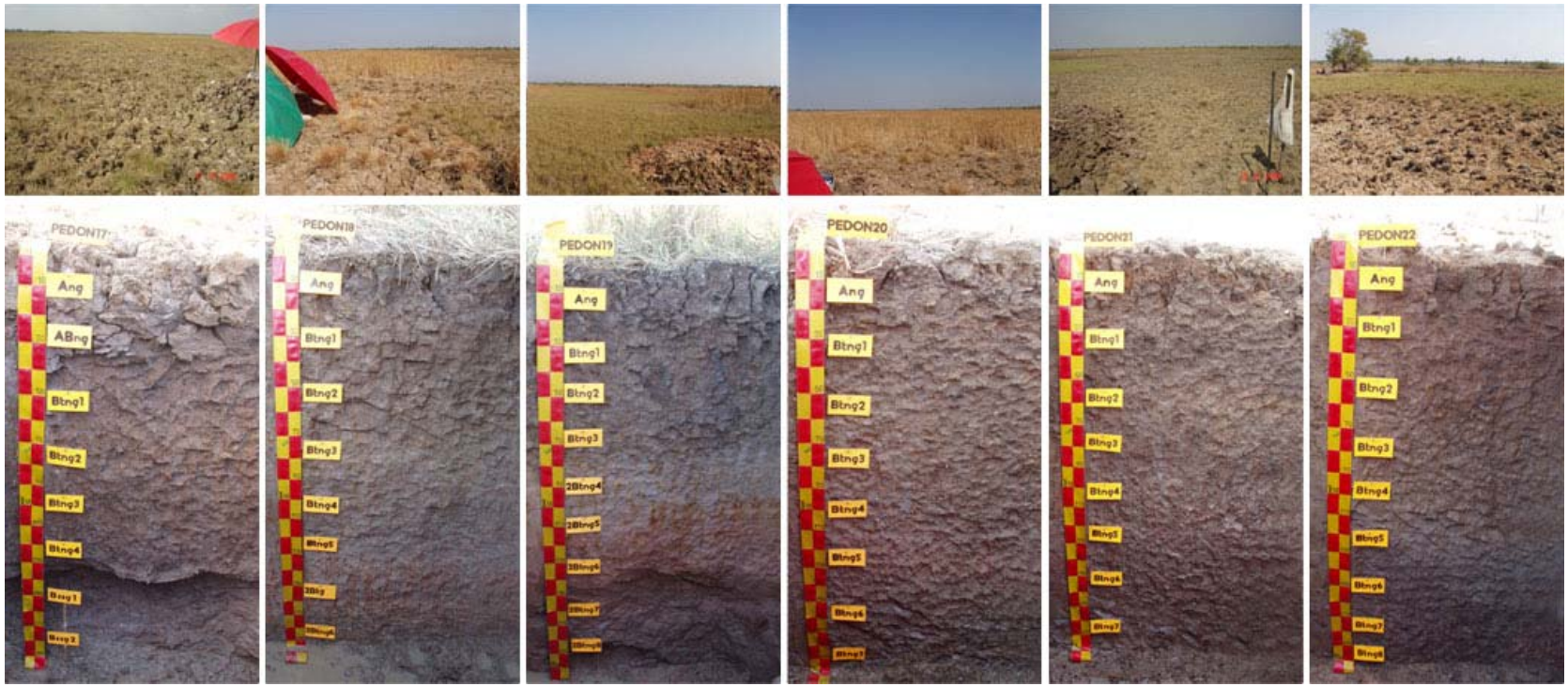


Figure 8 Field morphology of salt affected soils at location 4.

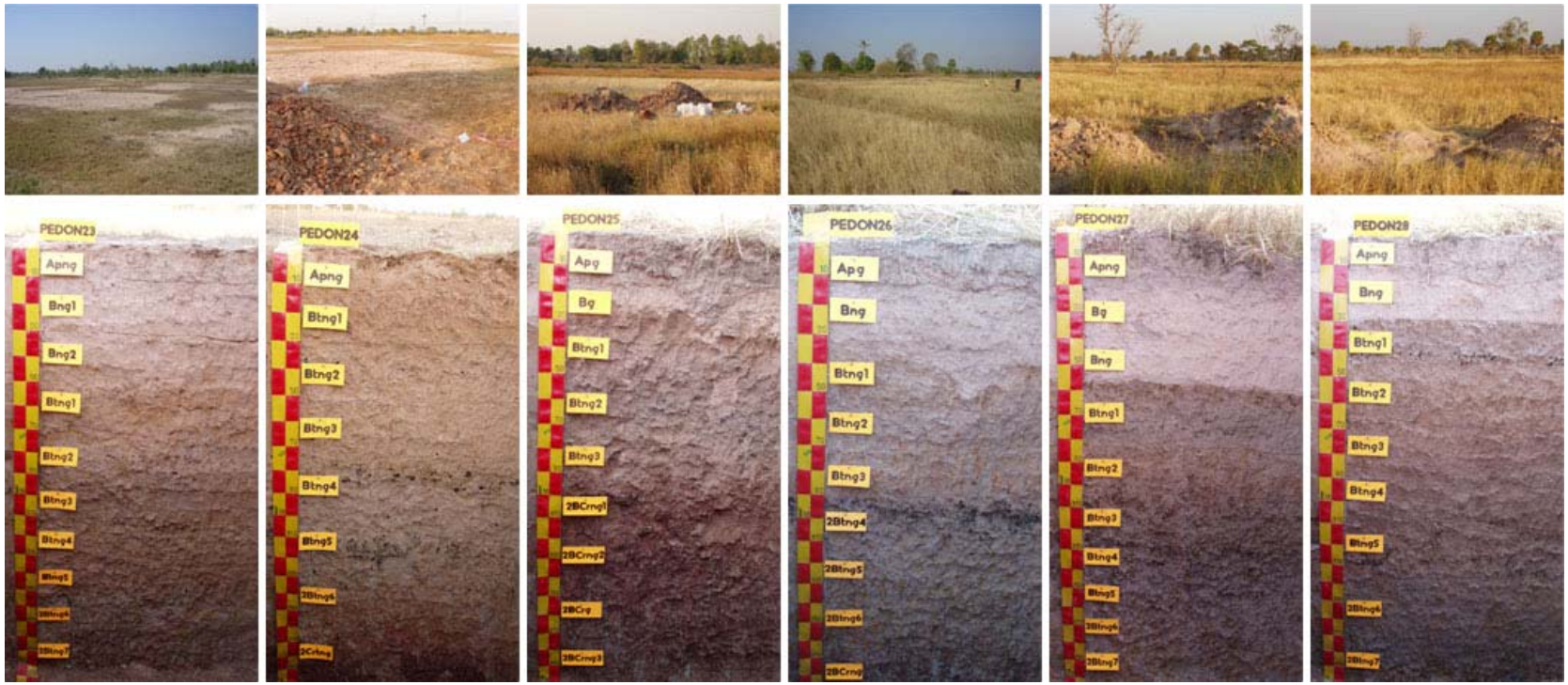


Figure 9 Field morphology of salt affected soils at location 5.

Table 3 Summarized morphology of the salt affected soils in this study.

| Genetic Horizon | Depth (cm) | Color | | [A]Texture | [B]Structure | Field pH |
|---|---|---|---|---|---|---|
| | | Matrix | Mottle | | | |
| | | ***Location 1 : Sandy textured salt affected soils*** | | | | |
| Pedon1 | Typic Natraqualf; coarse-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Apng | 0-12 | Mixed 10YR 6/2, 5/2 and 7.5 YR 7/6 | | SL | 2 fmse-ABK | 8.0 |
| Bng | 12-37 | 7.5YR 7/6 | 10YR 6/8, 7.5YR 6/8 | LS | 1 mcse-ABK | 8.0 |
| Btng | 37-140 | 7.5YR 7/6, 6/4, 7/4, 10YR 6/6 | 7.5YR 5/6, 10YR 5/8, 6/8,7/8 | SL, SCL | 2 fmse-ABK, 23 fmABK, 2 fmSBK | 8.0 |
| 2Btng | 140-190+ | Mixed 7.5YR 7/4 and 7/2, 7.5YR 7/4 | 10YR 5/8, 6/8 | SCL | 2 fmABK, 2 fmse-ABK | 8.0 |
| Pedon2 | Typic Natraqualf; coarse-loamy, mixed, semiactive isohyperthemic | | | | | |
| Apng | 0-20 | Mixed 10YR 6/3, 6/2 and 7.5YR 7/4 | | LS | 1 fmSBK | 6.5 |
| Btng | 20-130 | 5-10YR 7/4, mixed 10YR 7/6-7/8 and 7.5YR 7/2 | 10YR 6/8, 2Y 7/6 | SL, SCL | 23 fmABK, 3 mcABK, 2 fmse-ABK | 8.5, 8.0 |
| Btcng | 130-142 | 7.5YR 7/2 | 2.5YR 6/8 | SL | 2 fmABK | 8.0 |
| 2Btng | 142-200+ | Mixed 5YR 7/3, 7/2 and 6/4 | 2.5YR 6/8 | SCL | 3 mcABK | 8.0 |
| Pedon3 | Typic Natraqualf; coarse-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Apg | 0-12 | Mixed 10YR 5/2, 3/2 and 5YR 6/4 | 7.5YR 5/8, 5YR 3/2, 4/6 | FSL | 2 fmSBK | 6.0 |
| Btg | 12-20/25 | Mixed 5YR 6/4 and 5/3 | 7.5YR 5/8, 10YR 3/2 | FSL | 2 mcse-ABK | 6.5 |
| Btng | 25-48/52 | Mixed 5YR 5/4 and 6/2 | 10YR 5/8 | FSCL | 2 fmSBK | 5.5 |
| Btg | 52-153 | Mixed 5YR 6/4, 6/2 and 5/4, 10YR 5/4, 6/4 and 5YR 6/1, 5YR 6/4 and 6/2, 5YR 6/4 and 7/2 | 2.5YR 4/6, 7.5YR 4/6, 10YR 3/1, 4/6, 5/8 | SGSCL,SCL, SL | 23 fmSBK, 3 fmse-ABK | 4.5 |
| 2Btg | 153-205+ | Mixed 5YR 6/4 and 6/2, 5YR 4/2 and 6/4 | 7.5YR 6/8, 10YR 5/8 | SL | 2 fmse-ABK, 2 fmSBK | 7.0, 6.0 |
| Pedon4 | Typic Natraqualf; coarse-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Apng | 0-20 | Mixed 10YR 5/4 and 7.5YR 5/4 | 7.5YR 4/6 | SCL | 3 fmABK | 6.5 |
| Btng | 20-48 | Mixed 7.5YR 6/4 and 5/4 | 7.5YR 5/8 | SCL | 2 fmse-ABK | 5.0 |
| Btg | 48-95 | Mixed 5YR 6/4, 7/2 and 6/1 | 7.5YR 5/6, 2.5YR 6/8, 5YR 5/8, 10YR 4/6, 5/8 | SCL | 2 fmSBK, 3 mcse-ABK | 4.5, 7.0 |
| Btng | 95-150 | Mixed 5YR 6/4, 6/1and 7/2, 5YR 6/4 and 6/2 | 2.5YR 4/8, 10YR 3/2, 5/6-8 | SCL | 3 mcse-ABK | |
| 2Btng | 150-200+ | Mixed 5YR 6/3 and 6/2, 5YR 6/3 and 7/2 | 2.5YR 3/2, 4/4 and 5/6 | SCL | 3 mc, 2fmse-ABK | 8.0 |

Table 3 (Continued)

| Genetic Horizon | Depth (cm) | Color | | [A]Texture | [B]Structure | Field pH |
|---|---|---|---|---|---|---|
| | | Matrix | Mottle | | | |
| Pedon5 | Typic Natraqualf; coarse-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Apng | 0-20 | Mixed 5YR 4/2 and 5/6 | 5YR 4/6, 7.5YR 4/6 | SL | 2 SBK | 5.0 |
| Btg | 20-193+ | Mixed 5YR 5/4, 6/2 and 6/3, 5YR 6/4 and 6/2, 5YR 6/4 and 6/6, 5YR 6/4 and 7/3, 5YR 6/3 and 6/6 | 5YR 5/6-8, 6/8, 7.5YR 5/8-4/6, 5/8, 6/8, 10YR 3/3, 4/6 | SCL | 2 SBK, 2 semi-ABK | 4.5 |
| | | ***Location 2: Clayey textured salt affected soils*** | | | | |
| Pedon6 | Typic Natraqualf; fine, kaolinitic, isohyperthemic | | | | | |
| Apng | 0-20 | Mixed 7.5YR 3/3 and 5/4, 10YR 4/3 and 4/6 | 10YR 4/4, 2.5YR 4/8 | C | 3 fmSBK, 3 fmse-ABK | 5.5 |
| Btng | 20-114 | Mixed 10YR 5/2, 4/1 and 6/4, 10YR 4/1 and 2.5Y4/2, 10YR 6/1, 7/1 | 10YR 5/8, 6/8, 7/8, 5YR 5/8, 2.5YR 4/4 | C, SiC, FSC | 2 fmse-ABK, 2 fmABK, 1 cABK, se-M | 7.0, 8.0 |
| 2Btng | 114-190+ | Mixed 10YR 7/2 and 6/1, 10YR 7/2 and 7/3, 10YR 6/3 | 10YR 4/1, 5/6-8, 6/8, 7.5YR 4/6 | FSCL | 1 mcABK, se-M, 2 fmABK | 8.0 |
| Pedon7 | Typic Natraqualf; very fine, kaolinitic, isohyperthemic | | | | | |
| Apg | 0-30 | 7.5YR 3/2, 10YR 4/1 | 5YR 4/6 | C | 3 cABK, 3 fmse-ABK | 6.0 |
| Btg | 30-42 | 10YR 5/3 | 5YR 4/6 | C | 2 fmse-ABK | 5.5 |
| Btng | 79-151 | 10YR 4/1, mixed 10YR 5/1 and 6/2, 10YR 5/1 and 5/2, 10YR 6/1 | 7.5YR 5/4, 5/6, 10YR 5/4, 5/6, 5/8, 5YR 4/6 | C, SiC | 2 fmse-ABK, 2 fmABK, se-M, 2 fmSBK, 1 mcABK | 7.0, 8.0 |
| 2Btng | 151-200+ | Mixed 10YR 6/1 and 7/2 | 10YR 5/8 and 2.5YR 4/1 | SiC, FSC | 1 c, 1 mcABK, se-M | 8.0 |
| Pedon8 | Typic Natraqualf; fine, kaolinitic, isohyperthemic | | | | | |
| Apg | 0-11 | 7.5YR 4/2 | 7.5YR 4/6 | C | 1 mcABK, se-M | 6.0 |
| Btg | 11-56 | 10YR 5/3, 2.5Y 4/2 | 10YR5/6, 7.5YR 5/8, 2.5Y 5/6 | C | 2 mcse-ABK parting to 2 mG | 6.0, 7.0 |
| Btng | 56-124 | Mixed 2.5Y 5/3 and 6/3, 10YR 6/1, mixed 2.5Y 5/1 and 6/2 | 2.5Y 6/4, 6/6 | C, SiC | 2 mcse-ABK parting to 2 mG, 2 fm, mcABK | 8.0 |
| 2Btng | 124-180+ | 2.5Y 7/1 | 2.5Y 6/6, 5Y 4/6 | SiC | 1 cABK, se-M | 8.0 |
| Pedon9 | Typic Endoaqualf; fine, kaolinitic, isohyperthemic | | | | | |
| Apg | 0-22 | 10YR 4/2, 4/3 | 2.5YR 4/8, 5YR 4/6 and 7.5YR 5/8 | CL, C | 2 mcSBK, 3 mcABK | 5.5 |
| Btg | 22-102 | Mixed 7.5YR 4/3, 10YR 4/2 and 6/2, 10YR 5/3 and 5/1, 10YR 6/1, mixed 2.5Y 6/3 and 7.5 YR 4/2 | 10YR 4/6, 5/8, 7/8, 2.5Y 7/6,6/8 | C, SiC | 2 fmABK | 6.0, 7.0, 8.0 |
| 2Btg | 102-190+ | 2.5Y 6/2, 7/1, mixed 10YR 6/1 and 7/2, 2.5Y 7/4 and 10YR 7/3 | 2.5Y 6/8, 7.5YR 4/6, 10YR 4/1, 4/6 5/6-8 and 6/8 | FSC, FSCL | 2 fm, mcABK | 8.0 |

Table 3 (Continued)

| Genetic Horizon | Depth (cm) | Color | | [A]Texture | [B]Structure | Field pH |
|---|---|---|---|---|---|---|
| | | Matrix | Mottle | | | |
| Pedon10 | Typic Natraqualf; fine, kaolinitic, isohyperthemic | | | | | |
| Apg | 0-16 | 10YR 5/3 | 5YR 5/6 | C | 2 fmSBK | 5.5 |
| Btg | 16-95 | 10YR 4/2, 5/2, mixed 10YR 4/2 and 5/2 | 7.5YR 5/8, 6/2, 6/8, 5YR 4/6, 5/6, 2.5YR 5/8 | C | 2 fmsemi-ABK, 23 mcABK | 5.0, 5.5, 6.5 |
| 2Btng | 128-210+ | 2.5Y 5/2, mixed 2.5Y 6/2 and 6/4 | 2.5Y 6/6 | C | 2 fm, 1 mcse-ABK, 1 cABK, se-M | 7.0, 8.0, 8.5 |
| | | ***Location 3: Sandy over Clayey textures salt affected soils*** | | | | |
| Pedon11 | Typic Natraqualf; fine, kaolinitic, isohyperthemic | | | | | |
| Apg | 0-15/23 | 10YR 6/2 | 10YR 5/6 | SGSL | 1 fmSBK | 5.5 |
| Bcg | 23-46 | 10YR 7/1 | 10YR 2/1, 6/8 | SGFSC | M | 8.0 |
| Btg | 46-113 | 10YR 7/1, 7/2, 2.5Y 7/1 | 2.5Y 7/8, 10YR 6/8, 10R 3/6 | FSC | 1 c, 2 fmABK, se-M | 8.0 |
| 2Btng | 146-205+ | 10YR 7/2 | 10YR 6/8, 10R 3/6 | SC | 2 mc, fmse-ABK | 8.0 |
| Pedon12 | Typic Natraqualf; fine, kaolinitic, isohyperthemic | | | | | |
| Apg | 0-20 | Mixed 10YR 5/1 and 7.5YR 5/3 | 10YR 6/8 | FSL | 1 fmse-ABK | 6.0 |
| Apng | 20-27/32 | Mixed 7.5YR 7/4 and 5/1 | 7.5YR 6/8 | FSL | 1 fmse-ABK | 6.0 |
| Bcg | 32-54/63 | Mixed 10YR 7/2, 7/1, 7.5YR 6/2 and 5YR 6/6 | 10YR 5/1, 2/1 | FSC | M | 8.0 |
| Btg | 63-111/114 | Mixed 10YR 7/2, 7.5YR 7/1, 7/2 and 5YR 6/4, 10YR 7/2, 7/1 and 5YR 6/4 | 2.5YR 6/6, 10YR 6/8, 5/8 | FSC | 1 cABK, se-M | 8.0 |
| 2Btg | 114-155 | Mixed 10YR 7/2 and 7/1 | 10YR 5/8, 4/1, 2.5YR 4/6, 6/6, 10R 4/8 | SiC, VFSC | 2 mcse-ABK | 8.5 |
| 2Btng | 155-207+ | 10YR 7/2 | 10YR 5/8, 6/8, 4/8, 10R 4/8, 5/8 | VFSC, FSC | 2 mcse-ABK | 8.5 |
| Pedon13 | Typic Endoaqualf; fine, kaolinitic, isohyperthemic | | | | | |
| Apg | 0-30 | Mixed 10YR 6/4 and 5/1, 7.5YR 6/6 and 5/2 | 10YR 4/4, 6/8 | SL, LS | 1 fmABK | 6.0, 6.5 |
| Btg | 30-91 | 10YR 7/2, 7/1 | 10R 4/4, 10YR 5/6, 4/6, 2.5YR 4/6, 2.5Y 2.5/1 | VFSC, SiC, FSC | 3 cP, C | 6.5 |
| 2Btg | 91-210+ | 10YR 7/1, mixed 10YR 7/1 and 7/2, 10YR 7/2, 7/3 | 2.5YR 4/6, 4/8, 10YR 5/8, 5/6, 2/1, 6/8, 2.5Y 3/1, 5YR 4/6, 10R 4/6 | SiC, VFSC | 23 mcse-ABK | 6.5, 6.0 |

Table 3 (Continued)

| Genetic Horizon | Depth (cm) | Color | | [A]Texture | [B]Structure | Field pH |
|---|---|---|---|---|---|---|
| | | Matrix | Mottle | | | |
| Pedon14 | Typic Natraqualf; fine-loamy, mixed,active, isohyperthemic | | | | | |
| Apg | 0-28 | Mixed 10YR 6/2 and 6/3 | 10YR 4/6 | FSL | 1 fmSBK | 6.5 |
| Bng | 28-44 | Mixed 10YR 7/3 and 7/2 | 10YR 5/4, 3/1, 2.5Y 2.5/1 | SL | 2 frmse-ABK | 7.0 |
| Bcg | 44-66 | 10YR 7/1 | 2.5Y 2.5/1, 10YR 6/8, 5/4, 2.5YR 3/6 | SGSC | 3 cP, C | 8.0 |
| Btng | 66-137 | 10YR 7/2, mixed 10YR 7/2 and 7/3 | 10YR 6/8, 5/8, 3/1, 5YR 4/6, 2.5YR 4/6 | GSC, SGSC, FSC | 3 cP, C, 1 cABK (se-M) | 8.0 |
| 2Btng | 137-187 | Mixed 10YR 7/2 and 7/3 | 10YR 5/8, 6/8, 2.5 YR 4/8 | FSC, SC | 2 mcse-ABK | 8.0 |
| 2Btg | 183-206+ | Mixed 10YR 7/2 and 7/3 | 10YR 5/8, 2.5YR 4/8 | SC | 2 mcse-ABK | |
| Pedon15 | Typic Natraqualf; fine, kaolinitic, isohyperthemic | | | | | |
| Apg | 0-15 | Mixed 7.5YR 7/3 and 10YR 5/3 | 10YR 5/8 | SGSL | 1 fmABK | 6.5 |
| Bcg | 15-50 | Mixed 10YR 7/2 and 7.5YR 7/3 | 2.5Y 2.5/1, 5YR 5/6, 10YR 5/8 | VGSCL | 3 cP, C | 8.0 |
| Btg | 50-110 | Mixed 10YR 7/1 and 7/2 | 2.5Y 2.5/1, 10YR 5/8, 4/6, 6/8, 10R 4/8 | SGSCL, FSC | 3 cP, C, 1 cABK (se-M) | 8.8, 8.0 |
| 2Btg | 110-130 | Mixed 7.5YR 7/2 and 10YR 7/1 | 10YR 5/8, 3/1, 2.5YR 4/8, 2.5Y 2.5/1 | SC | 2 mcse-ABK | 8.5 |
| 2Btng | 130-153 | Mixed 10YR 7/3 and 7/2 | 10YR 5/6, 2.5YR 4/8 | SC | 2 mcse-ABK | 8.5 |
| 2Btg | 153-182 | Mixed 10YR 7/3 and 7/2 | 10YR 5/6, 2.5YR 4/8 | SC | 2 mcse-ABK | 8.5 |
| 2Btng | 182-200+ | Mixed 10YR 7/3 and 7/2 | 10YR 6/6, 5/8, 10R 4/8 | SC | 2 fmse-ABK | 8.5 |
| Pedon16 | Typic Natraqualf; fine-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Apg | 0-28 | Mixed 10YR 4/2 and 7.5YR 6/4, 7.5YR 6/4 and 10YR 5/2 | 10YR 5/8 | SL, LS | 1 fmSBK, se-ABK | 6.5 |
| Bcng | 28-57 | Mixed 10YR 7/2 and 7/1 | 5YR 4/6, 10YR 5/8, 10YR 6/8, 2.5Y 2.5/1 | VGSC | 3 cP, C | 8.0 |
| Btng | 57-113 | Mixed 10YR 7/2 and 7.5YR 6/3 | 2.5Y 2.5/1, 2.5Y 6/8, 10YR 5/8, 6/8 | SC | 3 cP, C, 1 cABK(se-M), 2 mcse ABK | 8.5 |
| 2Btng | 113-138 | Mixed 10YR 7/1, 7/2 and 7.5YR 6/3 | 10YR 5/8, 3/1, 2.5YR 5/6 | SC | 2 mcABK | 8.5 |
| 2Btg | 138169 | Mixed 10YR 7/2, 7/1 and 7.5YR 6/3 | 10YR 5/8, 3/1, 2.5YR 5/6 | SC | 2 fmse-ABK | 8.5 |
| 2Btng | 169-202+ | Mixed 10YR 7/2 and 7.5YR 6/3 | 10YR 5/8, 10R 4/6 | SC | 2 fmse-ABK | 8.5 |

Table 3 (Continued)

| Genetic Horizon | Depth (cm) | Color Matrix | Mottle | [A]Texture | [B]Structure | Field pH |
|---|---|---|---|---|---|---|
| | | ***Location 4: Clayey textured salt affected soils*** | | | | |
| Pedon17 | Vertic Natraqualf; fine-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Ang | 0-20 | Mixed 10YR 4/3 and 3/3 | 10YR 5/8 | C | 1 cABK, se-M | 6.5 |
| ABng | 20-36 | Mixed 10YR 4/3 amd 5/2 | 10YR 4/6 | C | 1 cABK, se-M | 5.0 |
| Btng | 36-130 | Mixed 10YR 4/3 and 6/3, 10YR 4/2 | 7.5YR 5/6, 5/8, 10YR 5/8, 5YR 4/6, 2.5YR 3/6 | C, SiC | 2 mc,fmse-ABK, 2 fmABK | 5.0, 4.5 |
| Bssg | 130-200+ | 5YR 6/1 | 10R 6/8 | SiC | 1 cABK, se-M | 4.5 |
| Pedon18 | Vertic Natraqualf; fine-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Ang | 0-19 | 10YR 4/2 | 5YR 4/6 | C | 1 vcse-ABK, se-M | 6.0 |
| Btng | 19-140 | Mixed 10YR 4/3 and 5/2, 10YR 4/2 and 2.5Y 6/3, 10YR 6/3 | 10YR 5/8, 5/2, 7.5YR 5/8, 5YR 4/6, 2.5YR 4/6, 4/8 | C, SiC | 1 vcse-ABK, ABK, se-M | 6.5, 6.0 |
| 2Btg | 140-169 | 7.5YR 6/4 | 2.5YR 4/8, 10YR 5/8 | VFSCL | 2 fmse-ABK | 6.5 |
| 2Btng | 169-195+ | 10YR 6/3 | 5YR 4/6, 10YR 5/8 | FSC | 2 fmse-ABK | 7.0 |
| Pedon19 | Vertic Natraqualf; fine-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Ang | 0-19 | Mixed 10YR 3/3 and 4/3 | 10YR 4/6, 5/8 | C | 1 vcABK, se-M | 7.0 |
| Btng | 19-77 | 10YR 4/3, mixed 10YR 4/3 and 6/2 | 10YR 4/6, 7.5YR 4/6, 2.5YR 4/8 | C | 1 vcABK, se-ABK, se-M | 6.5 |
| 2Btng | 77-210+ | Mixed 10YR 6/3 and 7.5YR 6/4, 7.5YR 6/6, 5YR 6/6, mixed 5YR 6/4 and 10YR 6/3 | 10YR 3/1, 4/4-6, 5/8, 6/8, 2.5YR 4/8, 2.5Y 5/6, 2.5Y 2.5/1 | FSC, SL, LS, SCL | 1 vc, 1 fm, 12 mcse-ABK, se-M | 6.5, 7.0 |
| Pedon20 | Vertic Natraqualf; fine-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Ang | 0-20 | 10YR 4/2 | 7.5YR 4/6, 10YR 5/8 | C | 1 cABK, se-M | 7.0 |
| Btng | 20-200+ | 10YR 5/2, 6/2, mixed 10YR 6/2 and 7.5YR 6/4 | 10YR 4/6, 5/8, 3/1, 5YR 4/6, 5/8, 7.5YR 5/6, 4/6, 2.5YR 4/6, 4/8, 2.5Y 5/6, 10R 4/8 | C, FSC, VFSC | 2 fm, mcse-ABK, 1 mc, cABK, se-M | 6.5, 7.0 |
| Pedon21 | Vertic Natraqualf; fine-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Ang | 0-18 | 10YR 4/3 | 7.5YR 4/6 | C | 1 vcABK, se-M | 6.0 |
| Btng | 18-200+ | 10YR 4/3, 4/2, 5/2 | 10YR 5/1, 5/8, 7.5YR 4/6, 5YR 4/6, 2.5YR 4/6, 4/8, 3/6, 10R 4/8 | C, SiC | 23 mcABK, 2 fm, mcse-ABK | 6.0, 5.5, 4.5 |

Table 3 (Continued)

| Genetic Horizon | Depth (cm) | Color Matrix | Color Mottle | [A]Texture | [B]Structure | Field pH |
|---|---|---|---|---|---|---|
| Pedon22 | Vertic Natraqualf; fine-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Ang | 0-21 | 10YR 4/2 | 7.5YR 5/6 | C | 1 vcABK, se-M | 6.5 |
| Btng | 21-200+ | 10YR 4/2, mixed 10YR 7/2 and 4/2, 7/2 and 5/1, 2.5Y 6/1 and 10YR 5/2, 2.5Y 6/1, 10YR 5/1, mixed 10YR 5/1 and 3/2 | 10YR 5/8, 5/6, 4/4, 4/6, 7.5YR 5/8, 2.5YR 4/8, 2.5Y 5/6, 10R 4/8 | C, SiC | 2 mc, fmABK, 2 fm, mc, 1 vcse-ABK, se-M | 6.5, 7.0 |
| | | ***Location 5 : Sandy textured salt affected soils*** | | | | |
| Pedon23 | Typic Natraqualf; sandy, silicious, subactive, isohyperthemic | | | | | |
| Apng | 0-11 | Mixed 7.5YR 7/3 and 5YR 5/8 | 7.5YR 5/8, 4/2, 3/2 | SL | 1 fmSBK | 7.0 |
| Bng | 11-47 | Mixed 7.5YR 7/2 and 5YR 6/6, 7.5YR 7/2 and 5YR 6/8 | 7.5YR 5/6, 5/8, 2.5/1, 10YR 7/8 | LS | 1 fmSBK, 1 fmse-ABK | 8.5, 8.0 |
| Btng | 47-153 | Mixed 7.5YR 7/2 and 5YR 5/8, 7.5YR 7/3, 10YR 7/2 and 5YR 5/8, 2.5YR 6/6, 5YR 7/2 and 6/8 | 10YR 6/8, 7/8, 3/2, 3/4, 8/8, 7/6, 2/1, 7.5YR 6/8, 5YR 5/8, 6/8 | SL, SCL | 12 fm, 2mcse-ABK | 8.0, 8.5 |
| 2Btng | 153-200+ | Mixed 7.5YR 7/3, 10YR 7/1, 7/2 and 5YR 5/6, 2.5YR 7/6, 4/4, 10YR 7/1 and 5YR 7/1 | 7.5YR 2/1, 5/6, 6/8, 10YR 8/8 | SC, SCL | 1 cABK, se-M | 8.5 |
| Pedon24 | Typic Natraqualf; coarse-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Apng | 0-12 | Mixed 10YR 4/4, 7.5YR 5/6 and 5YR 6/8 | 2.5YR 4/6, 5YR 6/8 | SL | 3 mcSBK | 7.0 |
| Btng | 0-128 | Mixed 10YR 7/3 and 5YR 6/8, 7.5YR 7/3, 10YR 7/3 and 5YR 6/8, 10YR 6/4 and 5YR 6/8, 10YR 6/3 and 7/8, 7.5YR 6/3, 7/2 and 5YR 6/8 | 10YR 6/8, 5/8, 8/8, 7/6, 7/8, 3/4, 3/3, 3/1, 7.5YR 3/1, 3/2, 5YR 6/8 | SL, SGSCL, SC | 3 mc, 2fmse-ABK | 8.0 |
| 2Btng | 128-155 | Mixed 7.5YR 6/3, 7/3 and 5YR 6/8 | 10YR 6/8, 5YR 5/4 | SCL | 1 mcABK, se-M | 8.0 |
| 2Crtng | 155-200+ | Mixed 7.5YR 8/1, 7/1, 5YR 6/4, 4/4 and 4/6 | 2.5YR 6/8, 10YR 6/8, 7.5YR 6/3 | SC | 1 cABK, R | 8.0 |
| Pedon25 | Typic Natraqualf; coarse-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Apg | 0-17/30 | Mixed 7.5YR 4/2 and 10YR 5/8 | | SL | 1 fmSBK | 7.0 |
| Bg | 17-30 | Mixed 5YR 6/3, 7/3 and 5/8 | 7.5YR 6/8, 5YR 6/8 | SL | 1 fmse-ABK | 6.5 |
| Btng | 30-92 | 10YR 6/3, 5YR 6/3, mixed 5YR 6/3 and 5/6 | 10YR 5/8, 6/8, 5YR 2.5/1 | SL | 2 fmse-ABK | 6.5, 8.0 |
| 2BCrng | 92-143 | Mixed 5YR 6/3, 5/6 and 2.5YR 4/3, 2.5YR 4/4, 5/6, 6/4 and 5YR 5/6 | 5Y 7/8, 5YR 2.5/1, 2.5Y 6/8, 7/6 | SL, SCL | 2 fm, 1mcse-ABK, se-M | 8.5 |
| 2BCrg | 143-170 | Mixed 2.5YR 4/6 and 4/4 | 5BG 7/1, 2.5YR 5/6 and 5YR 5/8 | SiC | 1mcse-ABK, se-M | 8.5 |
| 2BCrng | 170-200+ | Mixed 2.5YR 5/6 and 5YR 5/8 | 5GY 7/1, 10G7/1, 2.5Y 6/8 | SiC | 1cABK, se-M | 8.5 |

Table 3 (Continued)

| Genetic Horizon | Depth (cm) | Color Matrix | Color Mottle | [A]Texture | [B]Structure | Field pH |
|---|---|---|---|---|---|---|
| Pedon26 | Typic Natraqualf; coarse-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Apg | 0-12/14 | Mixed 5YR 7/3 and 5/8 | 10YR 6/8, 5/2, 3/2 | LS | 1 fmSBK | 5.5 |
| Bng | 14-31/46 | Mixed 5YR 7/3 and 5/8 | 10YR 6/8 | LS | 1 fmse-ABK | 6.0 |
| Btng | 46-92 | Mixed 5YR 6/3 and 5/8, 5YR 7/3 and 5/8 | 10YR 7/8, 6/8, 7.5YR 2.5/1, 6/8, 5YR 5/8 | LS, SL | 2 fmse-ABK | 6.5 |
| 2Btng | 92-164 | Mixed 5YR 7/3 and 5/8, 7.5YR 7/2 and 5YR 5/8, 5YR 7/1, 5/8 and 7.5YR 8/1 | 5YR 2.5/1, 7.5YR 6/8, 7/3, 2.5YR 4/6, 10YR 3/1, 6/8 | SC | 2 fmSBK, 1 mcABK, se-M | 8.0 |
| 2BCrng | 164-200+ | Mixed 10YR 7/1 and 5YR 5/8 | 7.5YR 4/4, 7/3, 10YR 8/6, 5YR 4/3 | SC | 1 cABK, se-M | 8.0 |
| Pedon27 | Typic Natraqualf; coarse-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Apng | 0-20/22 | Mixed 7.5YR 5/4, 5YR 5/8 and 10YR 3/1 | | LS | 1 fmSBK | 6.5 |
| Bg | 22-40 | Mixed 5YR 8/4 and 5/8 | | LFS | 1 fmSBK | 7.0 |
| Bng | 40-58 | Mixed 5YR 7/4 and 5/8 | | LFS | 1 fmSBK | 7.0 |
| Btng | 58-160 | Mixed 5YR 6/3 and 5/8, 7.5YR 7/2 and 5YR 5/8, 7.5YR 6/2 and 5YR 5/8 | 10YR 7/8, 6/8, 5/8, 5YR 2.5/1, 5/8, 2.5YR 5/8, 3/1, 7.5YR 6/8, 5/8, 4/2 | SL, SCL | 2 mcse-ABK, 2 mcSBK | 7.0, 8.0 |
| 2Btng | 160-202+ | Mixed 7.5YR 6/2 and 5YR 5/8, 5YR 7/2, 7/4 and 5/8 | 10YR 6/8, 3/1 | SCL, SC | 1 cABK, se-M | 8.0 |
| Pedon28 | Typic Natraqualf; coarse-loamy, mixed, semiactive, isohyperthemic | | | | | |
| Apng | 0-13 | 7.5YR 6/3 | 7.5YR 4/1, 6/8 | LS | 1 fmSBK | 6.5 |
| Bng | 13-30 | Mixed 5YR 7/4 and 5/3 | 10YR 8/6 | LS | 1 fmSBK | 6.5 |
| Btng | 30-144 | Mixed 7.5YR 6/4 and 5YR 5/8, 7.5YR 7/4 and 5YR 5/8, 7.5YR 7/3 and 5YR 5/8 | 10YR 2/1, 7/8, 8/6, 7.5YR 3/1, 5/8 | SL, SCL | 2 mcABK, 2 mc, fmSBK, 1 mcse-ABK | 6.5, 7.0, 8.0 |
| 2Btng | 144-200+ | Mixed 7.5YR 6/3 and 5YR 5/8, 10YR 6/1 | 10YR 3/2, 5/8, 6/8, 7/8, 8/8 | SC, VFSC | 2 mcse-ABK, 1 cSBK, se-M | 8.0 |

[A] C = clay, LS = loamy sand, SL = sandy loam, SC = sandy clay, SCL = sandy clay loam, SiC = silty clay, F = fine, V = very, S = slightly, G = gravelly

[B] 1 = weak, 2 = moderate, 3 = strong, f = fine, m = medium, c = coarse, v = very, ABK = angular blocky, SBK = subangular blocky, M = massive, se-ABK = semi-angular blocky, se-M = semi-massive, G = granular, P = prismatic, C = columnar, R=rock structure

### 2.2 Soil texture

Soils at locations 1 and 5 are relatively coarse textured (loamy sand to sandy clay), at locations 2 and 4 soils are fine textured (clay to sandy clay) with the coarser textured horizons being due to depositional grading of sediments, whereas soils at location 3 have a coarse textured topsoil (loamy sand and sandy loam) and fine textured subsoil (sandy clay).

### 2.3 Soil Color

Soil matrix color is very different between each location; clayey soils generally have darker colors than do the sandy soils. Most of the soils have low chroma colors ($\leq 2$) and are mottled. The low value mottles include pedogenic iron and manganese oxide nodules that are present in some horizons especially for location 3 (Table 3). The mottles and low chroma indicate poor drainage and profile development under water saturated conditions that have induced reduction (Suddhiprakarn and Kheoruenromne, 1998; Buol *et al*., 2003).

### 2.4 Soil Structure

A moderate subangular blocky and angular blocky structure is common; however some horizons have massive, granular, prismatic or columnar structures (Table 3). Prismatic and columnar structures are common in sodic soils (Soil Survey Staff, 2006). These structures are present only at location 3 where soils have high pH, low EC and high extractable bases especially sodium (Table 3).

### 2.5 Other Field Characteristics

A surface salt crust is present in the highest salt affected soils at location 1 (pedons 1 and 2) and location 5 (pedons 23, 24). Salt patch surface is present at locations 2 (pedon 6) and all pedons at location 4. Location 3 does not exhibit salt crust or salt patch surface but a small area of bare spot is present.

Iron and manganese oxide nodules and concretions occur in some horizons particularly at location 3 that have iron and manganese oxide nodules and/or concretions throughout the soil profile (Appendix A). Soil cracks and slickensides are present in clayey salt affected soils (locations 2 and 4) (Appendix A). However, at location 4 there are more distinct cracks and slickenside than at location 2.

## 3. Synthesis

Salt affected soils have various parent materials consisting of wash over residuum derived from clastic sedimentary rocks, alluvium over residuum derived from clastic sedimentary rocks, alluvium and wash. These soils have developed under different physiographic conditions include low erosional terrace, floodplain and strath terrace on floodplain, erosional plain and depression on erosional plain. The landforms are flat to gently undulating, having 1-2 % slope.

All of salt affected soils are deep. The salt affected soils show a relatively high degree of development by the presence of an argillic horizon in all pedons and a sodium accumulation horizon (natric horizon) in some profiles. The natric (n) horizon is coincident with elevated a SAR and/or ESP values. Sedimentary layers and the *in situ* weathered rock are evident in some profiles. Soil matrix color is very variable and clayey soils have darker colors. Most of the soils have low chroma colors ($\leq 2$) and are mottled. Soil texture has very large variation range, from loamy sand to clay indicating that salt affected soils can occur for any type of soil texture. A moderate subangular blocky and angular blocky structure is common; however some horizons have massive, granular, prismatic or columnar structures. Prismatic and columnar structures are present only at location 3 where soils have high pH, low EC and high extractable bases especially sodium. Surface salt crust, salt patch or bare soil are present for the soils highest affected by salt and with some halophytic plants. Iron and manganese oxide nodules and concretions occur in some horizons. Cracks and slickenside are present in clayey salt affected soils.