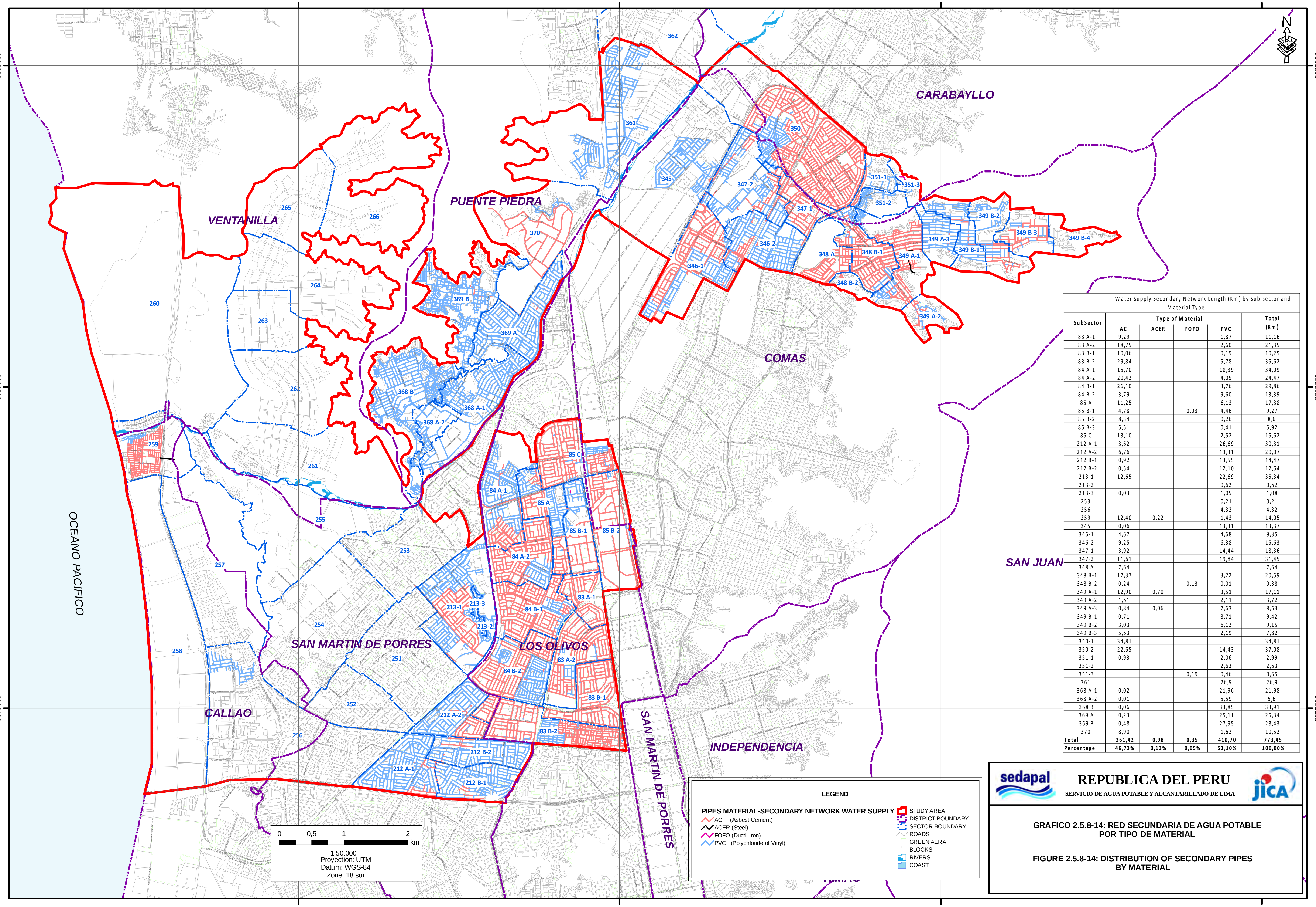


Water Supply Secondary Network Length (Km) by Sub-sector and Material Type

| SubSector | Type of Material | | | | Total (Km) |
|---|---|---|---|---|---|
| | AC | ACER | FOFO | PVC | |
| 83 A-1 | 9,29 | | | 1,87 | 11,16 |
| 83 A-2 | 18,75 | | | 2,60 | 21,35 |
| 83 B-1 | 10,06 | | | 0,19 | 10,25 |
| 83 B-2 | 29,84 | | | 5,78 | 35,62 |
| 84 A-1 | 15,70 | | | 18,39 | 34,09 |
| 84 A-2 | 20,42 | | | 4,05 | 24,47 |
| 84 B-1 | 26,10 | | | 3,76 | 29,86 |
| 84 B-2 | 3,79 | | | 9,60 | 13,39 |
| 85 A | 11,25 | | | 6,13 | 17,38 |
| 85 B-1 | 4,78 | | 0,03 | 4,46 | 9,27 |
| 85 B-2 | 8,34 | | | 0,26 | 8,6 |
| 85 B-3 | 5,51 | | | 0,41 | 5,92 |
| 85 C | 13,10 | | | 2,52 | 15,62 |
| 212 A-1 | 3,62 | | | 26,69 | 30,31 |
| 212 A-2 | 6,76 | | | 13,31 | 20,07 |
| 212 B-1 | 0,92 | | | 13,55 | 14,47 |
| 212 B-2 | 0,54 | | | 12,10 | 12,64 |
| 213-1 | 12,65 | | | 22,69 | 35,34 |
| 213-2 | | | | 0,62 | 0,62 |
| 213-3 | 0,03 | | | 1,05 | 1,08 |
| 253 | | | | 0,21 | 0,21 |
| 256 | | | | 4,32 | 4,32 |
| 259 | 12,40 | 0,22 | | 1,43 | 14,05 |
| 345 | 0,06 | | | 13,31 | 13,37 |
| 346-1 | 4,67 | | | 4,68 | 9,35 |
| 346-2 | 9,25 | | | 6,38 | 15,63 |
| 347-1 | 3,92 | | | 14,44 | 18,36 |
| 347-2 | 11,61 | | | 19,84 | 31,45 |
| 348 A | 7,64 | | | | 7,64 |
| 348 B-1 | 17,37 | | | 3,22 | 20,59 |
| 348 B-2 | 0,24 | | 0,13 | 0,01 | 0,38 |
| 349 A-1 | 12,90 | 0,70 | | 3,51 | 17,11 |
| 349 A-2 | 1,61 | | | 2,11 | 3,72 |
| 349 A-3 | 0,84 | 0,06 | | 7,63 | 8,53 |
| 349 B-1 | 0,71 | | | 8,71 | 9,42 |
| 349 B-2 | 3,03 | | | 6,12 | 9,15 |
| 349 B-3 | 5,63 | | | 2,19 | 7,82 |
| 350-1 | 34,81 | | | | 34,81 |
| 350-2 | 22,65 | | | 14,43 | 37,08 |
| 351-1 | 0,93 | | | 2,06 | 2,99 |
| 351-2 | | | | 2,63 | 2,63 |
| 351-3 | | | 0,19 | 0,46 | 0,65 |
| 361 | | | | 26,9 | 26,9 |
| 368 A-1 | 0,02 | | | 21,96 | 21,98 |
| 368 A-2 | 0,01 | | | 5,59 | 5,6 |
| 368 B | 0,06 | | | 33,85 | 33,91 |
| 369 A | 0,23 | | | 25,11 | 25,34 |
| 369 B | 0,48 | | | 27,95 | 28,43 |
| 370 | 8,90 | | | 1,62 | 10,52 |
| **Total** | **361,42** | **0,98** | **0,35** | **410,70** | **773,45** |
| **Percentage** | **46,73%** | **0,13%** | **0,05%** | **53,10%** | **100,00%** |

LEGEND

PIPES MATERIAL-SECONDARY NETWORK WATER SUPPLY
- AC (Asbest Cement)
- ACER (Steel)
- FOFO (Ductil Iron)
- PVC (Polychloride of Vinyl)

- STUDY AREA
- DISTRICT BOUNDARY
- SECTOR BOUNDARY
- ROADS
- GREEN AERA
- BLOCKS
- RIVERS
- COAST

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GRAFICO 2.5.8-14: RED SECUNDARIA DE AGUA POTABLE POR TIPO DE MATERIAL

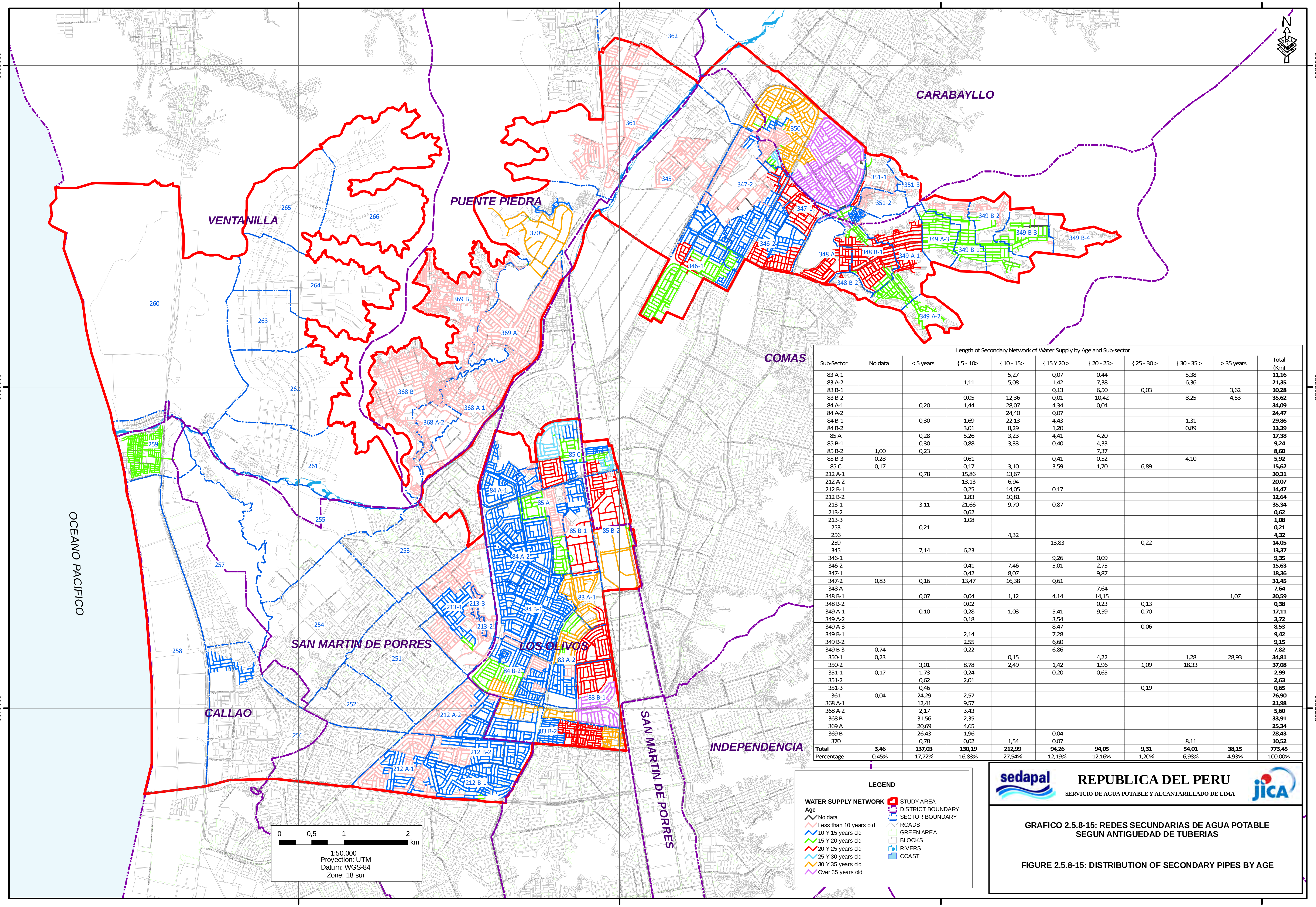
FIGURE 2.5.8-14: DISTRIBUTION OF SECONDARY PIPES BY MATERIAL

REPUBLICA DEL PERU

SERVICIO DE AGUA POTABLE Y ALCANTARILLADO DE LIMA

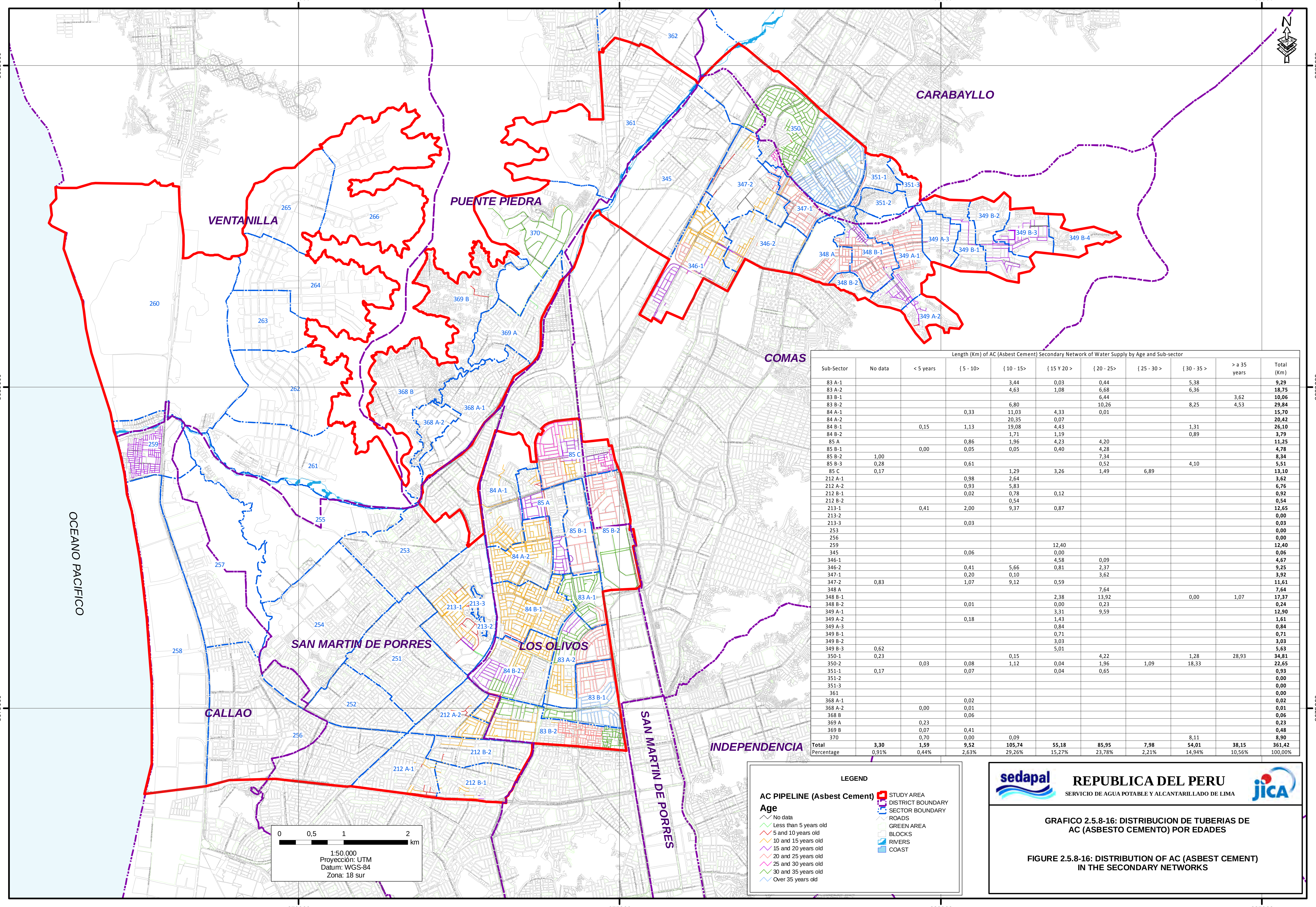
# GRAFICO 2.5.8-15: REDES SECUNDARIAS DE AGUA POTABLE SEGUN ANTIGUEDAD DE TUBERIAS

# FIGURE 2.5.8-15: DISTRIBUTION OF SECONDARY PIPES BY AGE




Length of Secondary Network of Water Supply by Age and Sub-sector

| Sub-Sector | No data | < 5 years | { 5 - 10> | { 10 - 15> | { 15 Y 20 > | { 20 - 25> | { 25 - 30 > | { 30 - 35 > | > 35 years | Total (Km) |
|---|---|---|---|---|---|---|---|---|---|---|
| 83 A-1 | | | | 5,27 | 0,07 | 0,44 | | 5,38 | | **11,16** |
| 83 A-2 | | | 1,11 | 5,08 | 1,42 | 7,38 | | 6,36 | | **21,35** |
| 83 B-1 | | | | | 0,13 | 6,50 | 0,03 | | 3,62 | **10,28** |
| 83 B-2 | | | 0,05 | 12,36 | 0,01 | 10,42 | | 8,25 | 4,53 | **35,62** |
| 84 A-1 | | 0,20 | 1,44 | 28,07 | 4,34 | 0,04 | | | | **34,09** |
| 84 A-2 | | | | 24,40 | 0,07 | | | | | **24,47** |
| 84 B-1 | | 0,30 | 1,69 | 22,13 | 4,43 | | | 1,31 | | **29,86** |
| 84 B-2 | | | 3,01 | 8,29 | 1,20 | | | 0,89 | | **13,39** |
| 85 A | | 0,28 | 5,26 | 3,23 | 4,41 | 4,20 | | | | **17,38** |
| 85 B-1 | | 0,30 | 0,88 | 3,33 | 0,40 | 4,33 | | | | **9,24** |
| 85 B-2 | 1,00 | 0,23 | | | | 7,37 | | | | **8,60** |
| 85 B-3 | 0,28 | | 0,61 | | 0,41 | 0,52 | | 4,10 | | **5,92** |
| 85 C | 0,17 | | 0,17 | 3,10 | 3,59 | 1,70 | 6,89 | | | **15,62** |
| 212 A-1 | | 0,78 | 15,86 | 13,67 | | | | | | **30,31** |
| 212 A-2 | | | 13,13 | 6,94 | | | | | | **20,07** |
| 212 B-1 | | | 0,25 | 14,05 | 0,17 | | | | | **14,47** |
| 212 B-2 | | | 1,83 | 10,81 | | | | | | **12,64** |
| 213-1 | | 3,11 | 21,66 | 9,70 | 0,87 | | | | | **35,34** |
| 213-2 | | | 0,62 | | | | | | | **0,62** |
| 213-3 | | | 1,08 | | | | | | | **1,08** |
| 253 | | 0,21 | | | | | | | | **0,21** |
| 256 | | | | 4,32 | | | | | | **4,32** |
| 259 | | | | | 13,83 | | 0,22 | | | **14,05** |
| 345 | | 7,14 | 6,23 | | | | | | | **13,37** |
| 346-1 | | | | | 9,26 | 0,09 | | | | **9,35** |
| 346-2 | | | 0,41 | 7,46 | 5,01 | 2,75 | | | | **15,63** |
| 347-1 | | | 0,42 | 8,07 | | 9,87 | | | | **18,36** |
| 347-2 | 0,83 | 0,16 | 13,47 | 16,38 | 0,61 | | | | | **31,45** |
| 348 A | | | | | | 7,64 | | | | **7,64** |
| 348 B-1 | | 0,07 | 0,04 | 1,12 | 4,14 | 14,15 | | | 1,07 | **20,59** |
| 348 B-2 | | | 0,02 | | | 0,23 | 0,13 | | | **0,38** |
| 349 A-1 | | 0,10 | 0,28 | 1,03 | 5,41 | 9,59 | 0,70 | | | **17,11** |
| 349 A-2 | | | 0,18 | | 3,54 | | | | | **3,72** |
| 349 A-3 | | | | | 8,47 | | 0,06 | | | **8,53** |
| 349 B-1 | | | 2,14 | | 7,28 | | | | | **9,42** |
| 349 B-2 | | | 2,55 | | 6,60 | | | | | **9,15** |
| 349 B-3 | 0,74 | | 0,22 | | 6,86 | | | | | **7,82** |
| 350-1 | 0,23 | | | 0,15 | | 4,22 | | 1,28 | 28,93 | **34,81** |
| 350-2 | | 3,01 | 8,78 | 2,49 | 1,42 | 1,96 | 1,09 | 18,33 | | **37,08** |
| 351-1 | 0,17 | 1,73 | 0,24 | | 0,20 | 0,65 | | | | **2,99** |
| 351-2 | | 0,62 | 2,01 | | | | | | | **2,63** |
| 351-3 | | 0,46 | | | | | 0,19 | | | **0,65** |
| 361 | 0,04 | 24,29 | 2,57 | | | | | | | **26,90** |
| 368 A-1 | | 12,41 | 9,57 | | | | | | | **21,98** |
| 368 A-2 | | 2,17 | 3,43 | | | | | | | **5,60** |
| 368 B | | 31,56 | 2,35 | | | | | | | **33,91** |
| 369 A | | 20,69 | 4,65 | | | | | | | **25,34** |
| 369 B | | 26,43 | 1,96 | | 0,04 | | | | | **28,43** |
| 370 | | 0,78 | 0,02 | 1,54 | 0,07 | | | 8,11 | | **10,52** |
| **Total** | **3,46** | **137,03** | **130,19** | **212,99** | **94,26** | **94,05** | **9,31** | **54,01** | **38,15** | **773,45** |
| Percentage | 0,45% | 17,72% | 16,83% | 27,54% | 12,19% | 12,16% | 1,20% | 6,98% | 4,93% | 100,00% |




Length (Km) of AC (Asbest Cement) Secondary Network of Water Supply by Age and Sub-sector

| Sub-Sector | No data | < 5 years | { 5 - 10> | { 10 - 15> | { 15 Y 20 > | { 20 - 25> | { 25 - 30 > | { 30 - 35 > | > a 35 years | Total (Km) |
|---|---|---|---|---|---|---|---|---|---|---|
| 83 A-1 | | | | 3,44 | 0,03 | 0,44 | | 5,38 | | **9,29** |
| 83 A-2 | | | | 4,63 | 1,08 | 6,68 | | 6,36 | | **18,75** |
| 83 B-1 | | | | | | 6,44 | | | 3,62 | **10,06** |
| 83 B-2 | | | | 6,80 | | 10,26 | | 8,25 | 4,53 | **29,84** |
| 84 A-1 | | | 0,33 | 11,03 | 4,33 | 0,01 | | | | **15,70** |
| 84 A-2 | | | | 20,35 | 0,07 | | | | | **20,42** |
| 84 B-1 | | 0,15 | 1,13 | 19,08 | 4,43 | | | 1,31 | | **26,10** |
| 84 B-2 | | | | 1,71 | 1,19 | | | 0,89 | | **3,79** |
| 85 A | | | 0,86 | 1,96 | 4,23 | 4,20 | | | | **11,25** |
| 85 B-1 | | 0,00 | 0,05 | 0,05 | 0,40 | 4,28 | | | | **4,78** |
| 85 B-2 | 1,00 | | | | | 7,34 | | | | **8,34** |
| 85 B-3 | 0,28 | | 0,61 | | | 0,52 | | 4,10 | | **5,51** |
| 85 C | 0,17 | | | 1,29 | 3,26 | 1,49 | 6,89 | | | **13,10** |
| 212 A-1 | | | 0,98 | 2,64 | | | | | | **3,62** |
| 212 A-2 | | | 0,93 | 5,83 | | | | | | **6,76** |
| 212 B-1 | | | 0,02 | 0,78 | 0,12 | | | | | **0,92** |
| 212 B-2 | | | | 0,54 | | | | | | **0,54** |
| 213-1 | | 0,41 | 2,00 | 9,37 | 0,87 | | | | | **12,65** |
| 213-2 | | | | | | | | | | **0,00** |
| 213-3 | | | 0,03 | | | | | | | **0,03** |
| 253 | | | | | | | | | | **0,00** |
| 256 | | | | | | | | | | **0,00** |
| 259 | | | | | 12,40 | | | | | **12,40** |
| 345 | | | 0,06 | | 0,00 | | | | | **0,06** |
| 346-1 | | | | | 4,58 | 0,09 | | | | **4,67** |
| 346-2 | | | 0,41 | 5,66 | 0,81 | 2,37 | | | | **9,25** |
| 347-1 | | | 0,20 | 0,10 | | 3,62 | | | | **3,92** |
| 347-2 | 0,83 | | 1,07 | 9,12 | 0,59 | | | | | **11,61** |
| 348 A | | | | | | 7,64 | | | | **7,64** |
| 348 B-1 | | | | | 2,38 | 13,92 | | 0,00 | 1,07 | **17,37** |
| 348 B-2 | | | 0,01 | | 0,00 | 0,23 | | | | **0,24** |
| 349 A-1 | | | | | 3,31 | 9,59 | | | | **12,90** |
| 349 A-2 | | | 0,18 | | 1,43 | | | | | **1,61** |
| 349 A-3 | | | | | 0,84 | | | | | **0,84** |
| 349 B-1 | | | | | 0,71 | | | | | **0,71** |
| 349 B-2 | | | | | 3,03 | | | | | **3,03** |
| 349 B-3 | 0,62 | | | | 5,01 | | | | | **5,63** |
| 350-1 | 0,23 | | | 0,15 | | 4,22 | | 1,28 | 28,93 | **34,81** |
| 350-2 | | 0,03 | 0,08 | 1,12 | 0,04 | 1,96 | 1,09 | 18,33 | | **22,65** |
| 351-1 | 0,17 | | 0,07 | | 0,04 | 0,65 | | | | **0,93** |
| 351-2 | | | | | | | | | | **0,00** |
| 351-3 | | | | | | | | | | **0,00** |
| 361 | | | | | | | | | | **0,00** |
| 368 A-1 | | | 0,02 | | | | | | | **0,02** |
| 368 A-2 | | 0,00 | 0,01 | | | | | | | **0,01** |
| 368 B | | | 0,06 | | | | | | | **0,06** |
| 369 A | | 0,23 | | | | | | | | **0,23** |
| 369 B | | 0,07 | 0,41 | | | | | | | **0,48** |
| 370 | | 0,70 | 0,00 | 0,09 | | | | 8,11 | | **8,90** |
| **Total** | **3,30** | **1,59** | **9,52** | **105,74** | **55,18** | **85,95** | **7,98** | **54,01** | **38,15** | **361,42** |
| Percentage | 0,91% | 0,44% | 2,63% | 29,26% | 15,27% | 23,78% | 2,21% | 14,94% | 10,56% | 100,00% |

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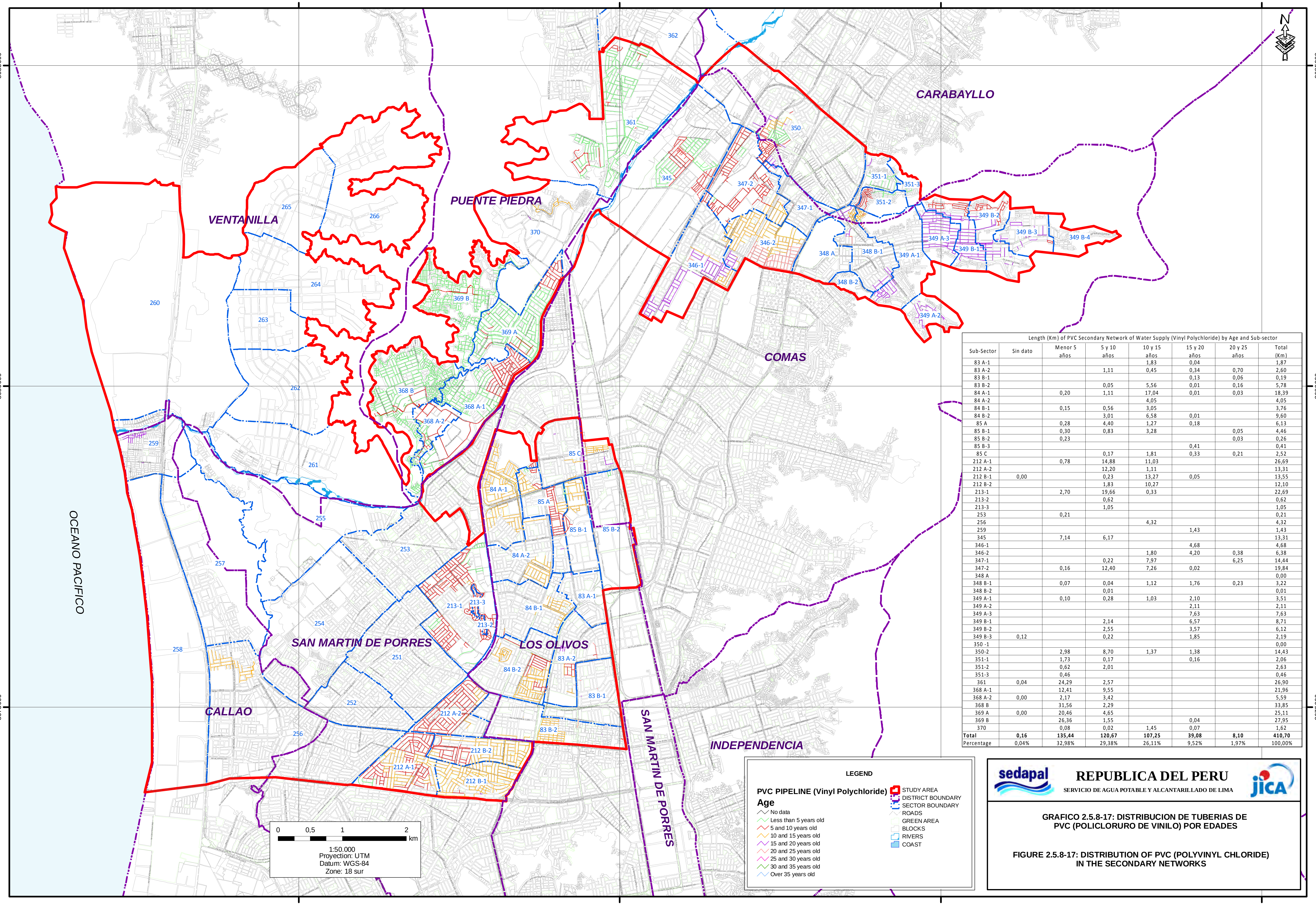
**GRAFICO 2.5.8-16: DISTRIBUCION DE TUBERIAS DE AC (ASBESTO CEMENTO) POR EDADES**

**FIGURE 2.5.8-16: DISTRIBUTION OF AC (ASBEST CEMENT) IN THE SECONDARY NETWORKS**




Length (Km) of PVC Secondary Network of Water Supply (Vinyl Polychloride) by Age and Sub-sector

| Sub-Sector | Sin dato | Menor 5 años | 5 y 10 años | 10 y 15 años | 15 y 20 años | 20 y 25 años | Total (Km) |
|---|---|---|---|---|---|---|---|
| 83 A-1 | | | | 1,83 | 0,04 | | 1,87 |
| 83 A-2 | | | 1,11 | 0,45 | 0,34 | 0,70 | 2,60 |
| 83 B-1 | | | | | 0,13 | 0,06 | 0,19 |
| 83 B-2 | | | 0,05 | 5,56 | 0,01 | 0,16 | 5,78 |
| 84 A-1 | | 0,20 | 1,11 | 17,04 | 0,01 | 0,03 | 18,39 |
| 84 A-2 | | | | 4,05 | | | 4,05 |
| 84 B-1 | | 0,15 | 0,56 | 3,05 | | | 3,76 |
| 84 B-2 | | | 3,01 | 6,58 | 0,01 | | 9,60 |
| 85 A | | 0,28 | 4,40 | 1,27 | 0,18 | | 6,13 |
| 85 B-1 | | 0,30 | 0,83 | 3,28 | | 0,05 | 4,46 |
| 85 B-2 | | 0,23 | | | | 0,03 | 0,26 |
| 85 B-3 | | | | | 0,41 | | 0,41 |
| 85 C | | | 0,17 | 1,81 | 0,33 | 0,21 | 2,52 |
| 212 A-1 | | 0,78 | 14,88 | 11,03 | | | 26,69 |
| 212 A-2 | | | 12,20 | 1,11 | | | 13,31 |
| 212 B-1 | 0,00 | | 0,23 | 13,27 | 0,05 | | 13,55 |
| 212 B-2 | | | 1,83 | 10,27 | | | 12,10 |
| 213-1 | | 2,70 | 19,66 | 0,33 | | | 22,69 |
| 213-2 | | | 0,62 | | | | 0,62 |
| 213-3 | | | 1,05 | | | | 1,05 |
| 253 | | 0,21 | | | | | 0,21 |
| 256 | | | | 4,32 | | | 4,32 |
| 259 | | | | | 1,43 | | 1,43 |
| 345 | | 7,14 | 6,17 | | | | 13,31 |
| 346-1 | | | | | 4,68 | | 4,68 |
| 346-2 | | | | 1,80 | 4,20 | 0,38 | 6,38 |
| 347-1 | | | 0,22 | 7,97 | | 6,25 | 14,44 |
| 347-2 | | 0,16 | 12,40 | 7,26 | 0,02 | | 19,84 |
| 348 A | | | | | | | 0,00 |
| 348 B-1 | | 0,07 | 0,04 | 1,12 | 1,76 | 0,23 | 3,22 |
| 348 B-2 | | | 0,01 | | | | 0,01 |
| 349 A-1 | | 0,10 | 0,28 | 1,03 | 2,10 | | 3,51 |
| 349 A-2 | | | | | 2,11 | | 2,11 |
| 349 A-3 | | | | | 7,63 | | 7,63 |
| 349 B-1 | | | 2,14 | | 6,57 | | 8,71 |
| 349 B-2 | | | 2,55 | | 3,57 | | 6,12 |
| 349 B-3 | 0,12 | | 0,22 | | 1,85 | | 2,19 |
| 350 -1 | | | | | | | 0,00 |
| 350-2 | | 2,98 | 8,70 | 1,37 | 1,38 | | 14,43 |
| 351-1 | | 1,73 | 0,17 | | 0,16 | | 2,06 |
| 351-2 | | 0,62 | 2,01 | | | | 2,63 |
| 351-3 | | 0,46 | | | | | 0,46 |
| 361 | 0,04 | 24,29 | 2,57 | | | | 26,90 |
| 368 A-1 | | 12,41 | 9,55 | | | | 21,96 |
| 368 A-2 | 0,00 | 2,17 | 3,42 | | | | 5,59 |
| 368 B | | 31,56 | 2,29 | | | | 33,85 |
| 369 A | 0,00 | 20,46 | 4,65 | | | | 25,11 |
| 369 B | | 26,36 | 1,55 | | 0,04 | | 27,95 |
| 370 | | 0,08 | 0,02 | 1,45 | 0,07 | | 1,62 |
| **Total** | **0,16** | **135,44** | **120,67** | **107,25** | **39,08** | **8,10** | **410,70** |
| Percentage | 0,04% | 32,98% | 29,38% | 26,11% | 9,52% | 1,97% | 100,00% |

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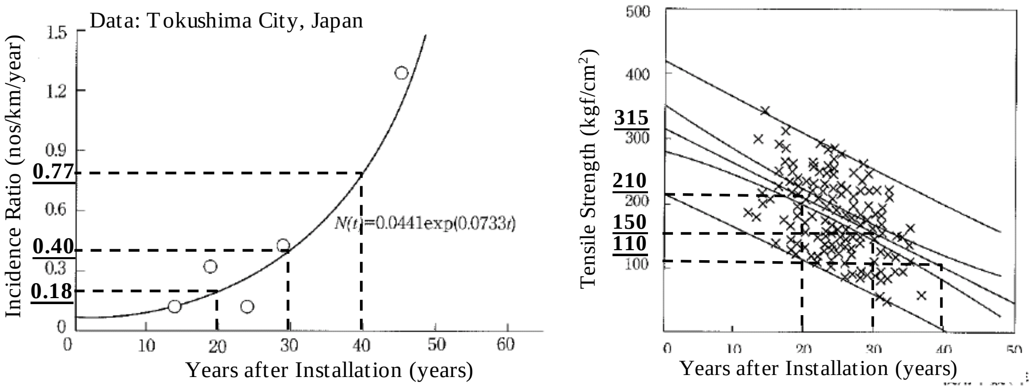
**GRAFICO 2.5.8-17: DISTRIBUCION DE TUBERIAS DE PVC (POLICLORURO DE VINILO) POR EDADES**

**FIGURE 2.5.8-17: DISTRIBUTION OF PVC (POLYVINYL CHLORIDE) IN THE SECONDARY NETWORKS**

(b) Diagnosis of AC Pipes

Diagnosis of AC pipes can be summarized as follows:

- About 50 % of AC pipes were installed more than 20 years ago, but more than 30 %, on the other hand, have been installed in the last 15 years.
- AC pipes are distributed throughout the whole Study Area except in the newly developed area in Puente Piedra.
- Asbestos cement is a kind of cement reinforced by asbestos. According to the Rehabilitation Guideline (2005, Japan Waterworks Association), the strength of asbestos cement deteriorates over time. As shown below, the tensile strength of asbestos cement deteriorates by 30% in 20 years and by 50% in 30 years. Moreover, ratio of accidents of asbestos cement tends to increase, especially 25 years after installation.




Ratio of Accident

Strength of Pipe

Source: 2005, Rehabilitation Guideline, Japan Waterworks Association

**Figure 2.5.8-18: Increase of Accidents and Deterioration of Strength of AC Pipe**

In addition to strength of the material, water tightness at the joints also deteriorates because of its inflexible structure and degradation of rubber ring.

However, the record of the incidents on secondary pipes shows different situation. The sector 259, 351, 349a and 349b are the worst four sectors in number of incidents on secondary water pipes. However, these sectors don’t have more than 25 years old asbestos pipes, as shown in Table 2.5.8-26. The sector 350, 83b, 83a and 85c are major four sectors where long lengths of old asbestos pipes are installed, as shown in Table 2.5.8-20-27. However, incidents of these areas are less than the average in the Study Area. It does not show any relationship between pipe age/ AC pipes ratio and frequency of incidents.

**Table 2.5.8-26 Worst Four Sectors in Ratios of Incidents on Secondary Pipes**

| Sector | Incidents Ratios (km/year) | Total length of pipes (km) | Asbestos Pipes (km) | Ratio of Asbestos Pipes | more than 25years pipes (km) |
|---|---|---|---|---|---|
| 259 | **1.26** | 14.05 | 12.40 | 88% | 0 |
| 351 | **1.17** | 6.27 | 0.93 | 15% | 0 |
| 349a | **0.58** | 29.30 | 15.35 | 52% | 0 |
| 349b | **0.49** | 26.45 | 9.37 | 36% | 0 |

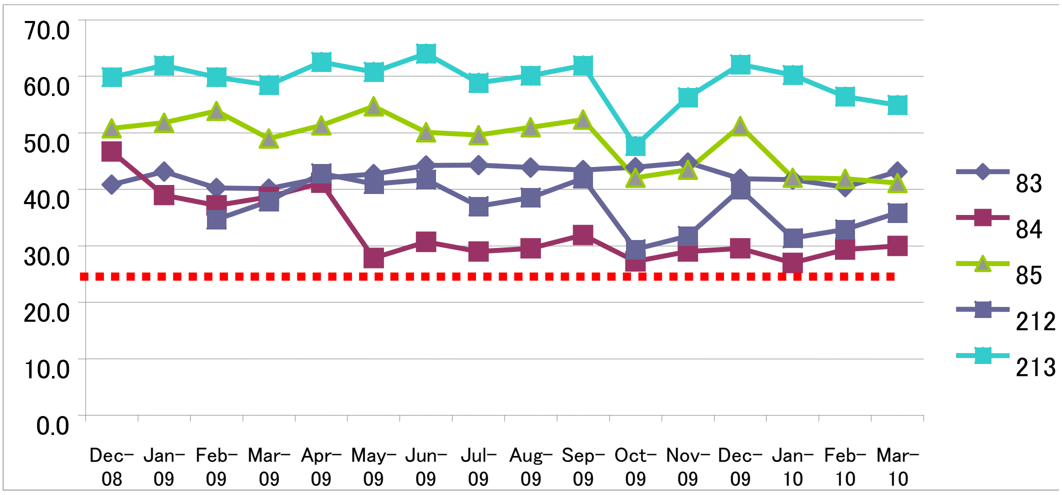
Source: JICA Study Team

**Table 2.5.8-27 Four Sectors with Old Asbestos Pipes**

| Sector | Incidents Ratios (km/year) | Total length of pipes (km) | Asbestos Pipes (km) | Ratio of Asbestos Pipes | more than 25years pipes (km) |
|---|---|---|---|---|---|
| 350 | **0.13** | 71.89 | 57.46 | 84% | 49.63 |
| 83b | **0.17** | 45.85 | 39.903 | 87% | 16.40 |
| 83a | **0.14** | 35.513 | 28.04 | 91% | 11.74 |
| 85c | **0.29** | 15.62 | 13.10 | 86% | 6.89 |

Source: JICA Study Team

Figure 2.5.8-19 shows NRW ratio of five sectorized area in the Study Area. In NRW ratio, the Sector 213 has the highest NRW (average 57%), which is more than the average, and the Sector 84 (average 30%) has the lowest NRW, which sometime almost achieve the target of 25%. However, as shown in Table 2.5.8-28, the worst area, Sector 213 has AC pipes (34%) and PVC pipes (66%), and the best area, Sector 84 has AC pipes (65%) and PVC pipes (35%). Sector 83, where 37% of pipes are more than 25 years AC pipes, has much lower NRW ratio than Sector 213. It does not show any relationship between NRW and ratio of AC pipe ratio/ pipe age, also.




Source: JICA Study Team

**Figure 2.5.8-19 Non Revenue Water Ration in Five Sectorized Area**

**Table 2.5.8-28 Non Revenue Water Ration in Five Sectorized Area**

| Sector | Total length of pipes (km) | Asbestos Pipes (km) | Ratio of AC | More than 25 years | Non Revenue Water |
|---|---|---|---|---|---|
| 83 | 78.38 | 67.94 | 89% | 37% | 44.0% |
| 84 | 100.81 | 66.01 | **65%** | 2% | **30.0%** |
| 85 | 56.79 | 42.98 | 74% | 17% | 50.1% |
| 212 | 77.49 | 11.84 | 12% | 0% | 38.0% |
| 213 | 37.04 | 12.68 | **34%** | 0% | **57.0%** |

Source: JICA Study Team

Even in the above situation, it can be said that the old AC pipes have high risk of incident and leakage. At present, AC pipe does not show significant deterioration in the Study Area. Considering its characteristics of material, however, frequency of incidence and water leakage caused by AC pipe can increase year by year, which will raise maintenance cost and water production cost of SEDAPAL.

**Photograph No.1: AC Pipe**

Broken asbestos-concrete pipes.

(c) Diagnosis of PVC

Diagnosis of PVC pipes can be summarized as follows:

- Most of the PVC pipes have been installed in the last 15 years.
- PVC pipes are distributed throughout the whole Study Area, especially in the newly developed area in Puente Piedra.
- There are two (2) types of PVC pipelines installed in the Study Area: ITINTEC pipe (product which complies with old Peruvian standard, ITINTEC, hereinafter “ITINTEC”) and ISO pipe (products which complies with standards of ISO: NTP-ISO-4422, hereinafter “ISO”).
- “ITINTEC” pipes have turned out to have quality problems, especially with the joint glue, the spigot, the welded accessories, and the inflexible structure of pipe joints, which is causing many accidents and water loss. Therefore, current SEDAPAL regulations state that pipeline to be installed must be manufactured in compliance with Regulation NTP-ISO-4422. In addition, SEDAPAL states that pipeline joints must be flexible.
- “ITINTEC” pipes were often used in construction works executed by third parties, and they are mostly distributed in the high areas of Collique, namely, original sectors 348 and 349.

**Photograph No.2: PVC Pipe of "ITINTEC"**

Glued PVC pipeline with a rigid structure. Mostly found in the Collique sector.

- "ISO" pipes are manufactured in compliance with Regulation NTP-ISO 4422. These pipelines have not shown any assembling problems or serious accidents in the area constructed or supervised by SEDAPAL.
- "ISO" pipes have been mostly installed in the last 10 years and are located in sectors 361, 368A, 368B, 369A and 369B; they are partially installed in sectors 212A, 212B, 213 and 350.

(d) Diagnosis of Iron (ACERO) and Gulvanized Iron (FOFO) Pipe

Diagnosis of iron pipe and galvanized iron pipe can be summarized as follows:

- Low quality iron pipe and galvanized iron pipe are located in the secondary pipelines in sectors 85B, 259 (Márquez), 348B, 349A and 351.
- Low quality pipes with these kinds of material had better to be replaced because they are subject to oxidization.

3) Unsuitable Pipe Installations

In some areas, unsuitable pipe installations have been carried out by the third parties (municipalities, housing associations, NGOs and local population). In such constructions, due to the unsuitable installation, there are the following problems:

- There are some pipes which do not satisfy technical requirements such as supporting bed, filling, compacting, and minimum earth cover. Such pipes, especially the pipes without enough earth cover (earth cover is less than 1.0 m), have been damaged by load of the vehicles, causing water leakage or other incidents.

**Photograph-3**:
Reduction with lead from asbestos cement to PVC in Comas. No suitable accessory.

**Photograph-4**:
Unproper perforation in AC pipe for corporation valve. Not suitable accessories neither tools.

- There are pipelines installed in private property. Although such pipes were originally located in backyards, existing houses were later expanded on the pipes without relocation of the pipes. This situation disturbs proper maintenance works and also can promote illegal water consumption.

•

**Photograph-5 and 6**:

Secondary network pipeline inside a property - - Av. Los Alisos Urb. Previ, Los Olivos district.

- Distribution networks originally executed by municipalities, NGOs, associations, etc., and later incorporated to SEDAPAL show that they had not been maintained in proper way because of lack of skill and manpower.

4) Sediment in Pipe caused by Groundwater

In some specific areas, mainly in Collique, pipes are partially or totally clogged to an irreparable level and it is disturbing the water flow significantly. The sediment, which caused the clogging, comes from groundwater. Although groundwater is no longer used in the area, existing clogged pipes should be replaced. Because the clog is found mainly in Collique, most of the clogged pipes are "ITINTEC".

As mentioned above, present secondary networks have problems on type of material, improper installation and sedimentation. In Table 2.5.8-29 is shown the length of pipes which have the mentioned problems.

**Photograph-7:**

A sample of a PVC pipeline that is totally OBSTRUCTED by incrustations that show high salt and groundwater contents, in the 4$^{th}$ and 5$^{th}$ sectors of Collique

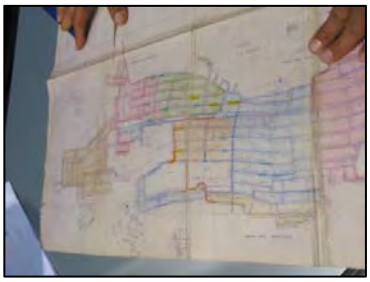


**Table 2.5.8-29: Length (Km) of Pipes with Problems**

| Sub-sector | Problem of Material | | Problem of Installation*2 | Total |
|---|---|---|---|---|
| | Steel/FoFo | ITINTEC*1 | Installed in Private Property | |
| 83B-1 | | 0.13 | | 0.13 |
| 83B-2 | | 0.13 | 3.85 | 3.98 |
| 85B-1 | 0.03 | | | 0.03 |
| 259 | 0.22 | | | 0.22 |
| 348B-2 | 0.13 | | | 0.13 |
| 349A-1 | 0.70 | | | 0.70 |
| 349A-2 | | 2.10 | | 2.10 |
| 349A-3 | 0.06 | 6.23 | | 6.29 |
| 349B-1 | | 5.63 | | 5.63 |
| 349B-2 | | 2.91 | | 2.91 |
| 349B-3 | | 0.45 | | 0.45 |
| 351-3 | 0.19 | | | 0.19 |
| **Total** | **1.33** | **17.58** | **3.85** | **22.76** |

*: Pipes clogged by sediment, which were observed in Collique as well as ITINTEC, are included.

Source: JICA Study Team

5) Pipe Conditions Survey

The JST carried out a survey of existing water supply pipes. The summary of the survey is given below, and more detailed information regarding the survey is given in Appendix A5.2.

(a) Purpose of the Survey

The Consultant carried out an investigation of the actual condition of existing pipes by visual inspection. It was carried out in order to grasp the actual status of degradation of the existing pipes, to justify the historical data of SEDAPAL of incidents such as pipe breakage and water leakage, and to identify degradation trends by condition such as material, age, or area, which was expected to provide useful information for the rehabilitation plan.

(b) Location of samples

In the survey, 30 samples for visual inspection were distributed in the Study Area so that the samples would vary in pipe material, age, entity who supervised the installation work, and frequency of incidence. The Table 2.5.8-30 shows number of the samples by material, age and entity of supervision of the installation works, which are the main conditions for their distribution.

**Table 2.5.8-30: Number of Samples by Pipe Material and Age**

| Conditions | | | | | | | Number of Samples |
|---|---|---|---|---|---|---|---|
| Pipe Material | | Age (A) | | | Entity of Supervision | | |
| AC | PVC | A≤10 | 10<A≤25 | 30<A | SEDAPAL | Third Party | |
| √ | | | √ | | √ | | 5 |
| √ | | | √ | | | √ | 7 |
| √ | | | | √ | √ | | 4 |
| √ | | | | √ | | √ | 4 |
| | √ | √ | | | √ | | 2 |
| | √ | √ | | | | √ | 2 |
| | √ | | √ | | √ | | 3 |
| | √ | | √ | | | √ | 3 |
| TOTAL NUMBER | | | | | | | 30 |

Source: JICA Study Team

(c) Methodology of Survey

Visual inspections of the existing pipes were implemented by excavating test pits. Excavation was carried out so that the pipe joints could be observed. Data of the inspected pipes and result of the inspection were compiled in an inspection sheet prepared for each sample. The inspection result indicates observed backfill material, condition of installation, actual condition of the pipe material, observed problems of the pipeline, and total evaluation of the inspected pipe.

(d) Survey Results

Results of the visual inspection and evaluation of the pipes based on the inspection and cadastre data of SEDAPAL are explained below;

- At only one out of the thirty locations, soil around the pipe joint was humid, which implies water leakage at the point.
- Backfilling material was basically the original soil at the site except for the sites in Márquez and Collique, in which transported sand with small stones were used. Original soil would not be used in Márquez because the site is located close to the sea, and in Collique because the original soil was rocky; both of these are conditions not suitable for backfilling.
- Earth covers of the pipes were not deep and backfills were carried out with ordinary compaction.
- Beds of the pipes were also basically prepared by the original soils.
- PVC pipes were in good condition.
- Pipe material itself of AC pipe were observed to be good condition but there was one sample of AC pipe, out of 20, with water leakage at the pipe joint. It suggests that water leakages on AC pipe are mainly caused at pipe joints.
- Inside AC pipes, brown-colored fouling was observed, whose constituent is unknown.
- At many of the house connections, water leakages were observed.
- No serious pipe damage or construction failure was observed in the survey. However,

many failures and water leakages were identified at connections, which support SEDAPAL´s maintenance record and suggests that most of water leakages are caused at connections.

6) Problems of Secondary Networks

Through the diagnoses above, problems in the secondary networks can be summarized as follows:

- There are some pipes whose materials have been proved not to be suitable for distribution, such as iron pipe, galvanized iron pipe and a type of PVC pipe (“ITINTEC”).
- Some pipes are not satisfying technical requirements for minimum earth cover, supporting bed, compaction and backfilling.
- Some pipes are installed in private properties.
- Some pipes in Collique are seriously clogged by sediments derived from groundwater.
- AC pipes, which account for 47% of the total pipe length, do not yet show serious degradation in the Study Area, though 50% of them were installed more than 20 years ago. However, their strength can be deteriorated and start to cause many incidents.

In Figure2.5.8-20 other executed and on-going studies and projects is shown.

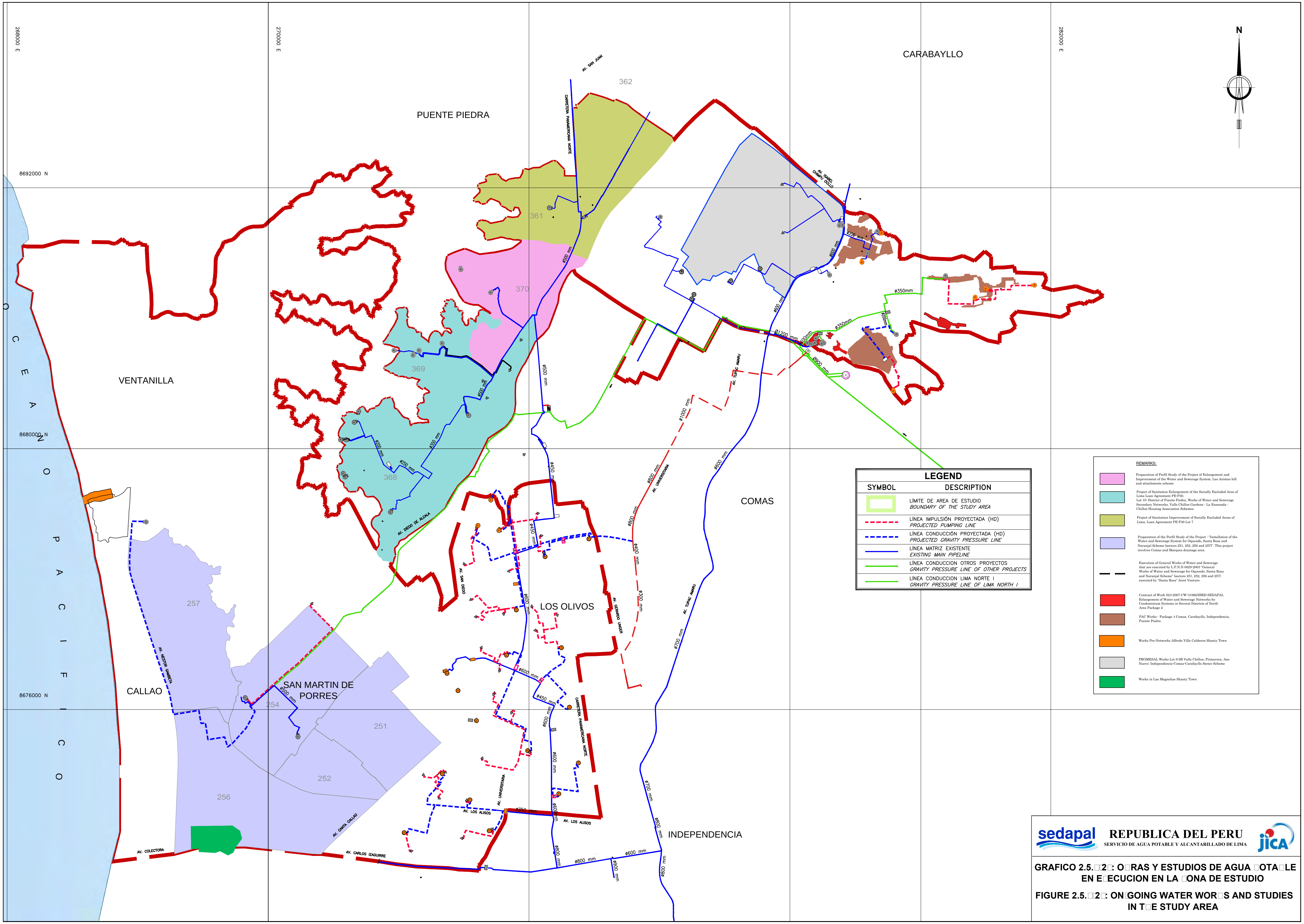



GRAFICO 2.5.□2□: O□RAS Y ESTUDIOS DE AGUA □OTA□LE EN E□ECUCION EN LA □ONA DE ESTUDIO

FIGURE 2.5.□2□: ON□GOING WATER WOR□S AND STUDIES IN T□E STUDY AREA

(12) House Connections and Micrometers

1) Number of House Connections and Status of Micrometer Installation

House connections consist of a PVC corporation, 15, 20 or 25 mm connection pipe (Domestic connections are usually 15mm.), concrete pipeline (protection), a meter box, and 1.5 or 2 mm thick FoG (galvanized iron) or plastic top. A micrometer is installed in the meter box, which is normally a jet water meter.

The connections are classified in six categories: social, domestic, commercial, industrial, state or public, and multifamily (communal). The number of connections by category is presented in Table 2.5.8-31, and number of household connections equipped with micrometer is shown in Table 2.5.8-32. Figure 2.5.8-21 presents the status of installation of micrometers in the Study Area.

The Study Area's total number of existing connections is 77,573 (41 sectors). Excluding the sectors without secondary networks and those with secondary networks recently rehabilitated/to be rehabilitated soon by SEDAPAL (connections are rehabilitated at the same time of secondary network), there are 70,291 connections. Micrometers were installed in 73.7% of the total connections as of 2009.

**Table 2.5.8-31: Categories and Numbers of House Connections by District**

| Code | Category | Quantity of Connections | | | Quantity of Connections by Districts | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | With Micrometer | Without Micrometer | Total | Callao | Cara-bayllo | Comas | Los Olivos | Puente Piedra | San Martín | Venta-nilla |
| T-01 | Social | 93 | 235 | 328 | 8 | 20 | 93 | 48 | 137 | 22 | |
| T-02 | Domestic | 46,228 | 15,526 | 61,754 | 2135 | 3365 | 16406 | 19780 | 10868 | 9195 | 5 |
| T-03 | Commercial | 736 | 484 | 1,220 | 34 | 75 | 256 | 478 | 98 | 273 | 6 |
| T-04 | Industrial | 155 | 56 | 211 | 24 | 3 | 67 | 61 | 30 | 22 | 4 |
| T-05 | Estate | 241 | 11 | 252 | 6 | 30 | 110 | 60 | 31 | 15 | |
| T-06 | Multiple families | 9,686 | 4,122 | 13,808 | 123 | 1058 | 3950 | 6313 | 251 | 2113 | |
| TOTAL | | 57,139 | 20,434 | 77,573 | 2330 | 4551 | 20882 | 26740 | 11415 | 11640 | 15 |

Source: SEDAPAL Cadastre

**Table 2.5.8-32: Status of Micrometer Installation in the Study Area**

| Sector | Sub-sector | Connection | | | Unit of Use |
|---|---|---|---|---|---|
| | | With Meter | Without Meter | Total | |
| 83 A | 83 A-1 | 1,398 | 211 | 1,609 | 2,316 |
| | 83 A-2 | 1,958 | 529 | 2,487 | 3,968 |
| 83 B | 83 B-1 | 1,160 | 113 | 1,273 | 2,236 |
| | 83 B-2 | 3,220 | 848 | 4,068 | 5,933 |
| 84 A | 84 A-1 | 4,121 | 356 | 4,477 | 4,963 |
| | 84 A-2 | 2,784 | 325 | 3,109 | 3,527 |
| 84 B | 84 B-1 | 3,420 | 601 | 4,021 | 4,858 |
| | 84 B-2 | 1,469 | 200 | 1,669 | 2,159 |
| 85 A | 85 A | 1,810 | 374 | 2,184 | 2,746 |
| 85 B | 85 B-1 | 659 | 259 | 918 | 1,650 |
| | 85 B-2 | 640 | 254 | 894 | 1,344 |
| | 85 B-3 | 65 | 222 | 287 | 339 |
| 85 C | 85 C | 1,288 | 369 | 1,657 | 2,286 |
| 212 A | 212 A-1 | 2,815 | 529 | 3,344 | 3,936 |
| | 212 A-2 | 1,819 | 265 | 2,084 | 2,571 |
| 212 B | 212 B-1 | 1,387 | 225 | 1,612 | 2,179 |
| | 212 B-2 | 1,207 | 151 | 1,358 | 1,800 |
| 213 | 213-1 | 2,416 | 587 | 3,003 | 3,382 |
| | 213-2 | 62 | 6 | 68 | 69 |
| | 213-3 | 124 | 6 | 130 | 130 |
| 251 | 251 | 2 | 1 | 3 | 4 |
| 252 | 252 | 0 | 2 | 2 | 2 |
| 253 | 253 | 18 | 9 | 27 | 40 |
| 254 | 254 | 2 | 2 | 4 | 4 |
| 255 | 255 | 1 | 1 | 2 | 2 |
| 256 | 256 | 8 | 7 | 15 | 163 |
| 257 | 257 | 2 | 2 | 4 | 4 |
| 258 | 258 | 26 | 6 | 32 | 33 |
| 259 | 259 | 1,530 | 752 | 2,282 | 2,404 |
| 260 | 260 | 4 | 1 | 5 | 5 |
| 261 | 261 | 5 | 0 | 5 | 10 |
| 262 | 262 | 1 | 0 | 1 | 1 |
| 263 | 263 | 1 | 0 | 1 | 1 |
| 264 | 264 | 1 | 0 | 1 | 1 |
| 265 | 265 | 1 | 0 | 1 | 1 |
| 266 | 266 | 1 | 0 | 1 | 1 |
| 345 | 345 | 337 | 78 | 415 | 462 |
| 346 | 346-1 | 620 | 239 | 859 | 1,107 |
| | 346-2 | 1,169 | 577 | 1,746 | 2,152 |
| 347 | 347-1 | 1,123 | 927 | 2,050 | 2,633 |
| | 347-2 | 1,325 | 470 | 1,795 | 2,053 |
| 348 A | 348 A | 14 | 827 | 841 | 938 |
| 348 B | 348 B-1 | 17 | 2,017 | 2,034 | 2,306 |
| | 348 B-2 | 140 | 38 | 178 | 178 |
| 349 A | 349 A-1 | 185 | 1,564 | 1,749 | 1,956 |
| | 349 A-2 | 3 | 337 | 340 | 347 |
| | 349 A-3 | 2 | 892 | 894 | 964 |
| 349 B | 349 B-1 | 95 | 689 | 784 | 878 |
| | 349 B-2 | 125 | 639 | 764 | 794 |
| | 349 B-3 | 183 | 564 | 747 | 758 |
| | 349 B-4 | 1 | 1 | 2 | 2 |
| 350 | 350-1 | 2,610 | 1,229 | 3,839 | 5,359 |
| | 350-2 | 2,588 | 860 | 3,448 | 4,285 |
| 351 | 351-1 | 554 | 44 | 598 | 641 |
| | 351-2 | 358 | 3 | 361 | 362 |
| | 351-3 | 73 | 3 | 76 | 76 |
| 361 | 361 | 1,274 | 81 | 1,355 | 1,386 |
| 368 A | 368 A-1 | 1,590 | 171 | 1,761 | 1,836 |
| | 368 A-2 | 290 | 7 | 297 | 300 |
| 368 B | 368 B | 2,892 | 36 | 2,928 | 2,946 |
| 369 A | 369 A | 1,630 | 549 | 2,179 | 2,231 |
| 369 B | 369 B | 2,456 | 188 | 2,644 | 2,665 |
| 370 | 370 | 60 | 191 | 251 | 288 |
| **TOTAL** | | **57,139** | **20,434** | **77,573** | **94,971** |

Source: JICA Study Team

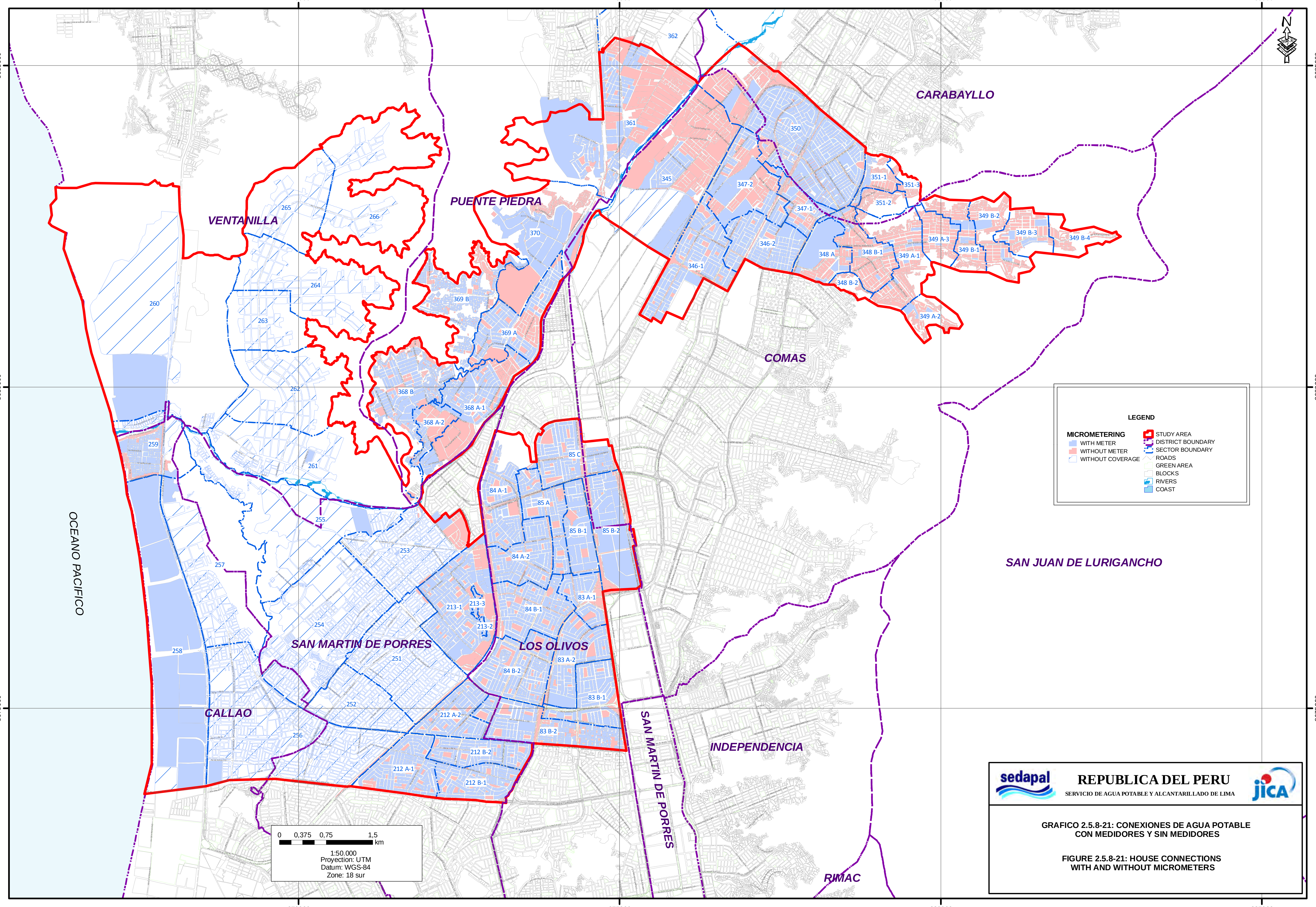



GRAFICO 2.5.8-21: CONEXIONES DE AGUA POTABLE CON MEDIDORES Y SIN MEDIDORES

FIGURE 2.5.8-21: HOUSE CONNECTIONS WITH AND WITHOUT MICROMETERS

2) Conditions of Connections and Micrometers

(a) Incidents and Water Leakage at House Connections

As explained in "(2) Service Conditions", many incidents have occurred where the secondary distribution networks connect to house connection pipes. Large amounts of water leakage are produced at these connection points. Leakages at connections were also observed in the test pits prepared for the pipe condition survey of secondary pipes.

Many incidences on house connections are caused by oxidized galvanized iron or cast iron connection joints between distribution pipes and house connection pipes, in comparison with existing PVC and polyethylene connection joints. Replacement of all oxidized galvanized iron connection joints is considered.

**Picture 8:**

Broken PVC pipeline with cast iron clamp. Oxide accumulation brought about pressure on the pipeline to the point of breaking it.

(b) Incomplete Installation of Micrometer and Meter Error

The installation ratio of micrometers in the Study Area is estimated to be around 73.7% at present. Moreover, it is generally believed that a large percentage of existing micrometers don't operate well.

This situation prevents SEDAPAL from accurately measuring total water consumption, which makes it impossible to know the exact amount of the Non-Revenue Water (NRW).

On the other hand, existence of micrometers which are not working properly gives the habitants a feeling that they might be charged excessively for their actual water use. This "feeling of unfairness" can disturb acceleration of micrometers' installation, and can sometimes lead to the intentional breaking of micrometers by habitants or to illegal water use.

These problems mentioned above, as well as the situation that the macrometer is not installed properly in the primary network, are very important problems, because water consumption and NRW of each area are fundamental data needed for a water supply business to form a development plan for a water supply system.

(c) Illegal Connection

It is estimated that there is a high amount of illegal water use in the Study Area. It is difficult to estimate the amount of illegal use because NRW cannot be monitored, and technical loss is high in the Study Area. However, it is estimated by SEDAPAL that about 5 to 15% of total distributed water is consumed illegally.

In order to eliminate illegal use, thorough inventory connection surveys shall be carried out and an exact user cadastre shall be prepared and maintained. Moreover, an educational program for the habitants in critical areas is also recommended.

3) Ongoing Project for Micrometer Installation

A SEDAPAL project called "Sistema Integral de Actividades Comerciales - SIAC" began in July 2010. It proposes an aggressive plan of micro meter implementation, upgrading the commercial cadastre and detecting illegal connections. The project is scheduled to be completed in three years.

The target area of the project is the whole area of SEDAPAL's administration. It will rehabilitate the existing micrometers and install new micrometers at the non-metered connections which currently offer a 24-hour ongoing water supply. Detailed contents of the project are to be decided through a discussion between the SIAC and the contractor after an inventory survey of existing commercial conditions and micrometers.

4) Problems with House Connection and Micrometers

According to the diagnoses above, problems of the house connections and micrometers can be summarized as follows:

- Many incidents and much water leakage are caused at house connections, especially at the corporation with the distribution pipes.
- Micrometers are not installed completely, and moreover, many of the installed micrometers are not functioning adequately.
- It is assumed that an non ignorable percentage of the distributed water is consumed by illegal consumptions.

(13) Automation and SCADA System

1) Objectives of the Diagnosis

It is proposed that all water supply service related facilities, such as reservoirs, wells, valve pits, pressure reducing chambers, and lift pumping stations will be brought under automation and will be integrated with SEDAPAL's current SCADA (Supervisory Control And Data Acquisition) system. With this, all the facilities could be supervised and remotely controlled in real time.

This scenario allows for qualitatively and quantitatively optimizing the water distribution system. In addition, the combined use of surface and groundwater can be regulated efficiently. Further, this will also help efficient operation of the primary distribution network.

The JICA Study Team carried out a field investigation by engaging local Consultant on automation and the SCADA system in 23 wells, 26 reservoirs, 4 pumping stations and 11 valve pits. The results can be found in Appendix B3. Through that investigation, a diagnosis has been carried out for the control and communications automation systems and their interrelation to the La Atarjea main control center. This involved checking the equipment conditions and recommending all necessary actions to solve any problems.

2) Activities and Location of the Target Facilities

The field investigation has been carried out in the following manner:

- Data collection from SEDAPAL.
- Field inspection and reconnaissance survey.
- Data gathering from the supplementary works and Lima Norte 1 files.
- Coordination with SEDAPAL technical staff.

The location of the target facilities investigated is given in the Table 2.5.8-33:

**Table 2.5.8-33: Target Facilities of SCADA Diagnosis**

| Districts | Wells | Reservoirs | Valve pits |
|---|---|---|---|
| Callao | - | R-522 | - |
| Carabayllo | - | RP-4, RP-3- | - |
| Comas | - | R-927, R-820, R-926, R-925 | 350, (345-346), (347-346) |
| Los Olivos | 280, 351, 423, 474, 498, 618, 688, 691, 692, 693, 694, 695, 696, 704, 716, 717,720. | R-1 Villa Sol<br>R1 Villa del Norte<br>R-1 Parque el Naranjal<br>R-1 Cueto Fernandini,<br>R-1 Olivos de Pro<br>R-2 Programa Confraternidad<br>R-1 Programa Confraternidad<br>Comité Aposte, R-1 Puerta de Pro<br>R-1 Rio Santa, Pro<br>R1- Santa Luisa. | Nº 83, 84, 85 |
| Puente Piedra | - | - | 361, 368, 369 |
| San Martín | 569, 687, 689, 727, 728, 729 | R-986,<br>R-1 Virgen del Rosario<br>Rosario del Norte R3<br>Jazmines del Naranjal R-2<br>Vipol Naranjal R-1<br>Cerro el Choclo R2<br>Cerro el Choclo R-1 | 212, 213 |
| Number | 23 | 26 | 11 |

Source: JICA Study Team

3) Evaluation and Diagnosis

The SCADA Control system of SEDAPAL, at the present, is located in La Atarjea plant. This system matches the international standards established by the control organizations and the Institute of Electrical and Electronics Engineers (IEE). At present, it works through microwaves, UHF radios, wireless connection (wide spectrum) and mobile phones GPRS. In summary, the communication system can be serially integrated and could be used over several protocols, such as TCP/IP, MODBUS (serial and TCP), DNP3 (Secial and TCP/IP), and Ethernet.

At present, for SCADA system of SEDAPAL is using two kinds of softwares:

- The SURVALENT software, which controls the pumping system of SEDAPAL. This software controls 279 hydraulic stations, including reservoirs, pressure reducing valves and valve pits. These remote stations are managed by EOSBA and/or EMEBA teams (Pumping System Operation and Water Pumping Maintenance Equipment Team).

- The INFOPLUS software has been installed for gravity system control. This software monitors and controls 220 Hydraulic Stations through serial radio. These remote stations are managed by the Primary Distribution Team.

At present, several projects on SCADA system integration and optimization are being developed, which includes:

- Complementary Network Project
- Huachipa Project
- Lima North 1 Project

These projects will be integrated to SCADA software in the following way:

i) INFOPLUS

It will be upgraded to INFOPLUS21. This new software version will be able to collect, manage and save large data volume on the hydraulic system of the primary distribution water network of SEDAPAL in order to carry out operating Hydraulic Models analysis and preparing reports. It will allow the management improvement and could allow distribution operation, increasing the system flexibility.

This will integrate the following remote stations:

- Lima North 1 Project: 26 of 30 remote stations of this Project
- Complementary Works project: 51 remote stations

ii) Integration of Survalent System

- Lima North 1 Project: 6 remote stations of this Project
- Complementary Works project: 4 remote stations

4) SCADA system of Lima North II Project

In compliance with the technical regulations and industrial standards (set by the Institute of Electrical and Electronics Engineers, IEE), the facilities should have the following equipment, so that they can be controlled and supervised from SEDAPAL's automated control center and Comas Service Center:

- Electronic instrumentation for pressure, level, flow, and other parameter measurements. This instrumentation must have the Profibus communication protocols currently used by SEDAPAL. Likewise, it must work at an automation level that allows for quick access and tele-control operations (without on-site assistance.)
- Valves with electronic control.
- Communications system from each site to the control center.
- Panel board with PLC and communications modules.
- Electronic starting systems with high efficiency and low harmonic contents

Based on the standards described above, the existing SCADA systems of the target facilities were evaluated as follows:

(a) Reservoirs

None of the reservoirs have any equipment required for SCADA operation. Currently, all valves are manually operated and must be upgraded and/or replaced to automated valves.

(b) Wells

None of the wells have any equipment required for SCADA operation. Power panel boards are in very poor conditions; they lack electronic starters with speed variations. Some of the wells have incomplete panel boards with a 12-year old technology that lacks Ethernet communications. All valves are manually operated.

(c) Valve pits

Among the eleven valve pits at the entrances of the sectors, only five valve pits have instrumentation and automated systems. But the control of these five valve pits, as mentioned earlier, will be replaced and will be controlled by the head reservoirs of the sector.

Figure2.5.8-22 shows the SCADA System Remote Stations of the project area belonging to the projects: Lima North I, Lima North II, Complementary Works and Huachipa Plant. Annex B3 shows more specifically on how the Remote Stations are integrated with SCADA software managed by SEDAPAL.

It must be mentioned that if the valve pits would not be replaced, the existing instrumentation should be replaced because they do not fulfill new standard of SEDAPAL that have been introduced for this kind of instrumentation. In previous projects, SEDAPAL accepted any kind of communication protocol of the PLC instrumentation. Communications such as Modbus, Hart and others were accepted if a gateway is installed before to PLC. But, the gateway or protocol converter had many failures on field signals, and for that reason SEDAPAL has defined new standard. These are field buses with Profubus DP protocol, which can manage the maintenance assets by remote control.

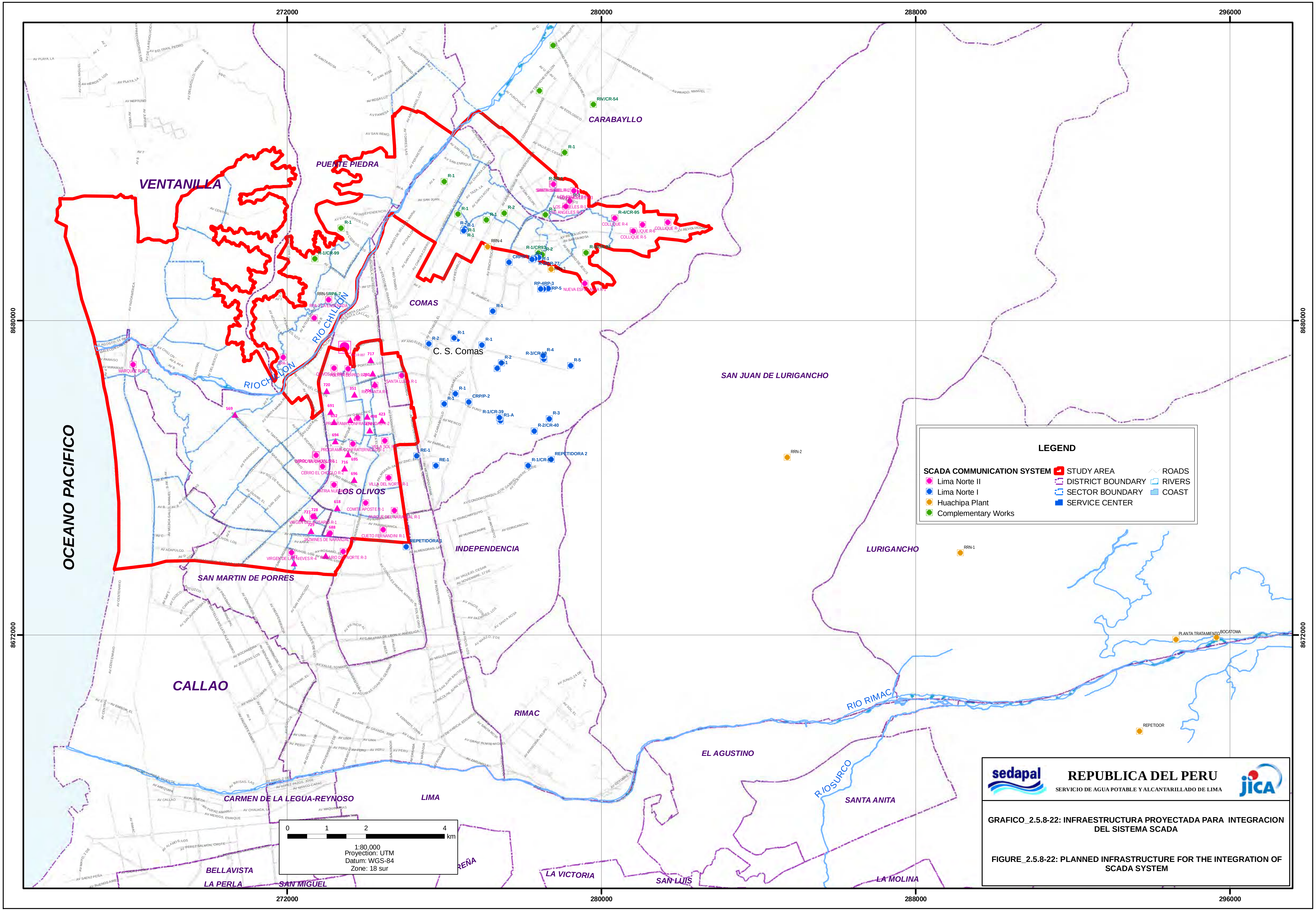



GRAFICO_2.5.8-22: INFRAESTRUCTURA PROYECTADA PARA INTEGRACION DEL SISTEMA SCADA

FIGURE_2.5.8-22: PLANNED INFRASTRUCTURE FOR THE INTEGRATION OF SCADA SYSTEM