

## DIGITAL GEOGRAPHY

A *digital geography* is an undirected graph  $G = (V, E)$  where:

$V$  is a set of *vertices*

$E \subseteq \binom{V}{2}$  is a set of *edges*

$V$  is a set of *points of importance* consisting members having properties:

- each *vertex* is a Point geometry
- each *vertex* has a latitude and longitude

$E$  is a set of *edges* consisting of members having properties:

- each *edge* is a Polyline geometry
- each *edge*  $e$  has starting and ending points  $v_i$  **and**  $v_j \in V$
- an edge cannot have intermediate points belonging to  $V$

A route segment  $RS_i$  is a path between the termini. It is an ordered set of edges

A terminus is a point that is either the beginning or the end point of any Bus Route

$RS_i = \{E_{i1}, E_{i2}, E_{i3} \dots E_{in}\}$  where  $n = \text{number of edges in } RS_i$  and  $\{E_{i1}, E_{i2}, E_{i3} \dots E_{in}\} \in E$

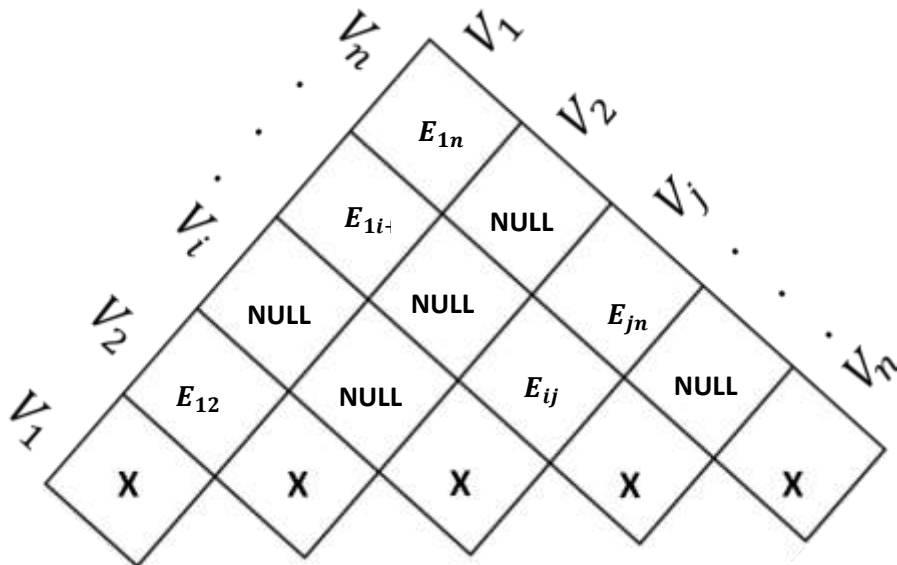
Bus route network  $ST$  is a set of union of route segments  $RS$

$ST = RS_0 \cup RS_1 \cup RS_2 \dots \cup RS_{m-1}$  where  $m = \text{number of route segments}$ .

$T$  = set of points which are **terminus**. A terminus is a point that is either the beginning or the end point of any Bus Route.

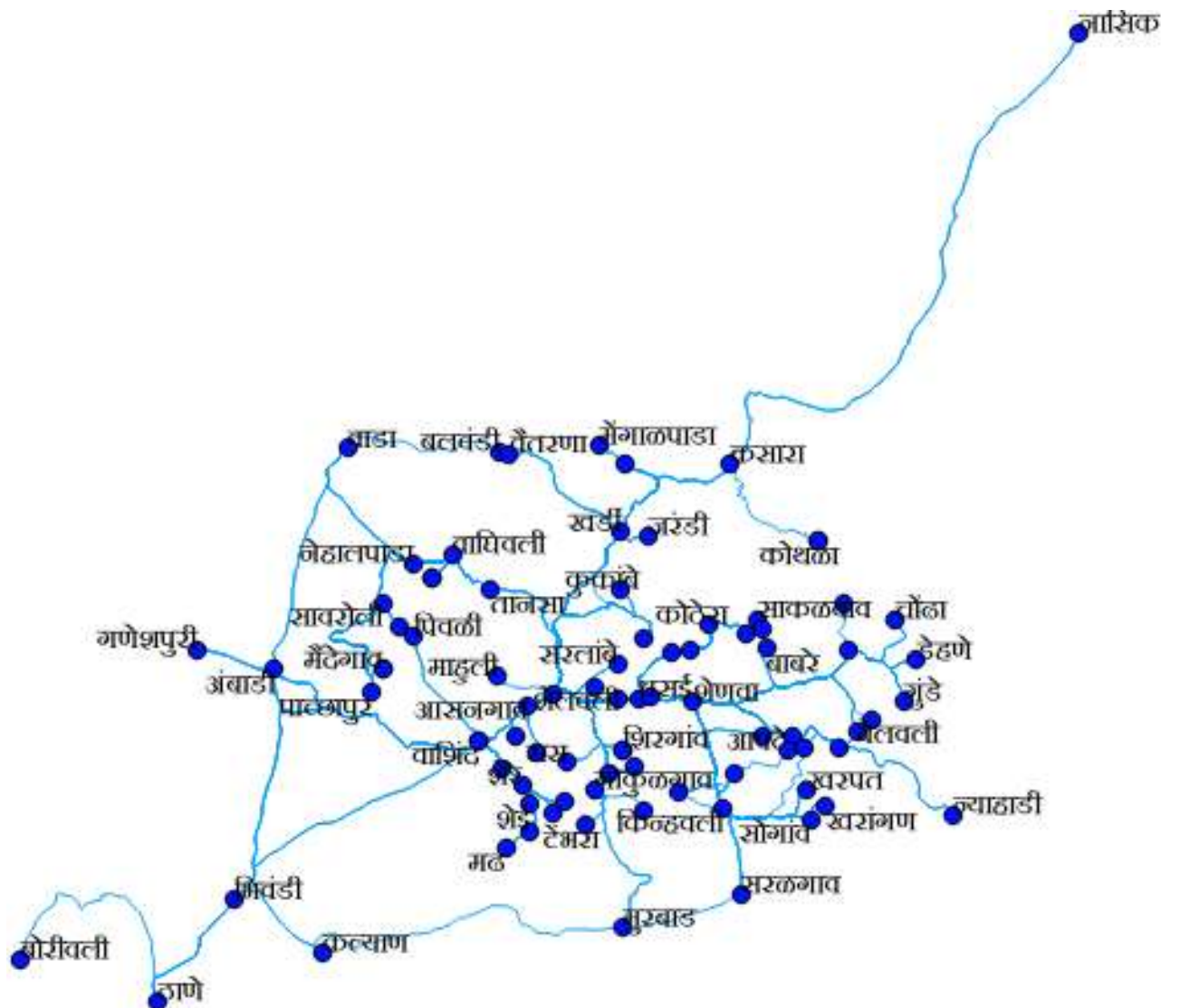
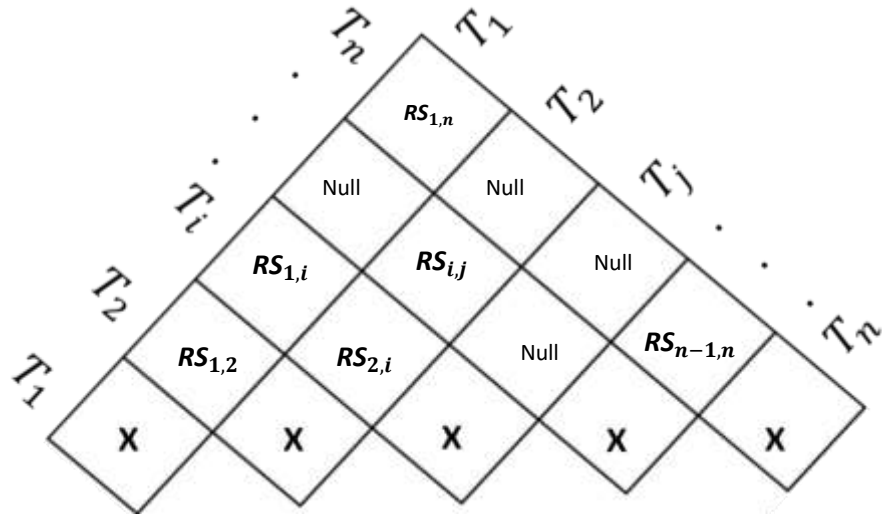
$F$  = set of points which are **fatas**. A fata is a point which is essentially a junction/ fork on the Bus route network

$P$  = set of points which are a projection of **village centroids** on the Bus route network.



A Route segment is a polyline between any two distinct termini i.e.  $RS \subseteq \binom{T}{2}$

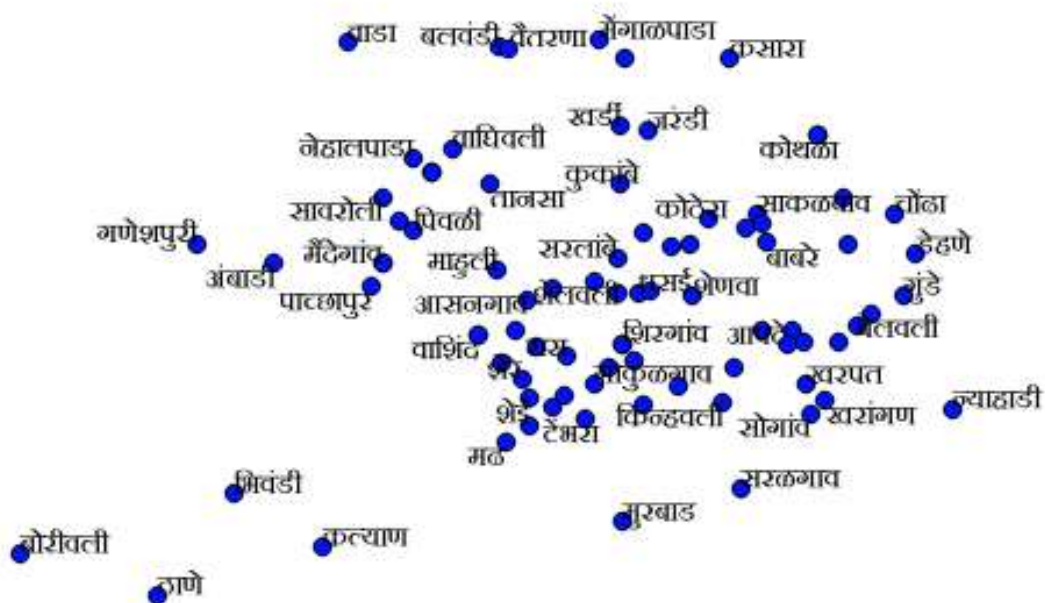
**Note:**  $RS$  can overlap each other



## SET OF TERMINI (T)

We have the following set of termini which will be used to prepare **Set T**

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We'll be using the set of route segments in previous section to prepare **Set T**

### Test for validity:

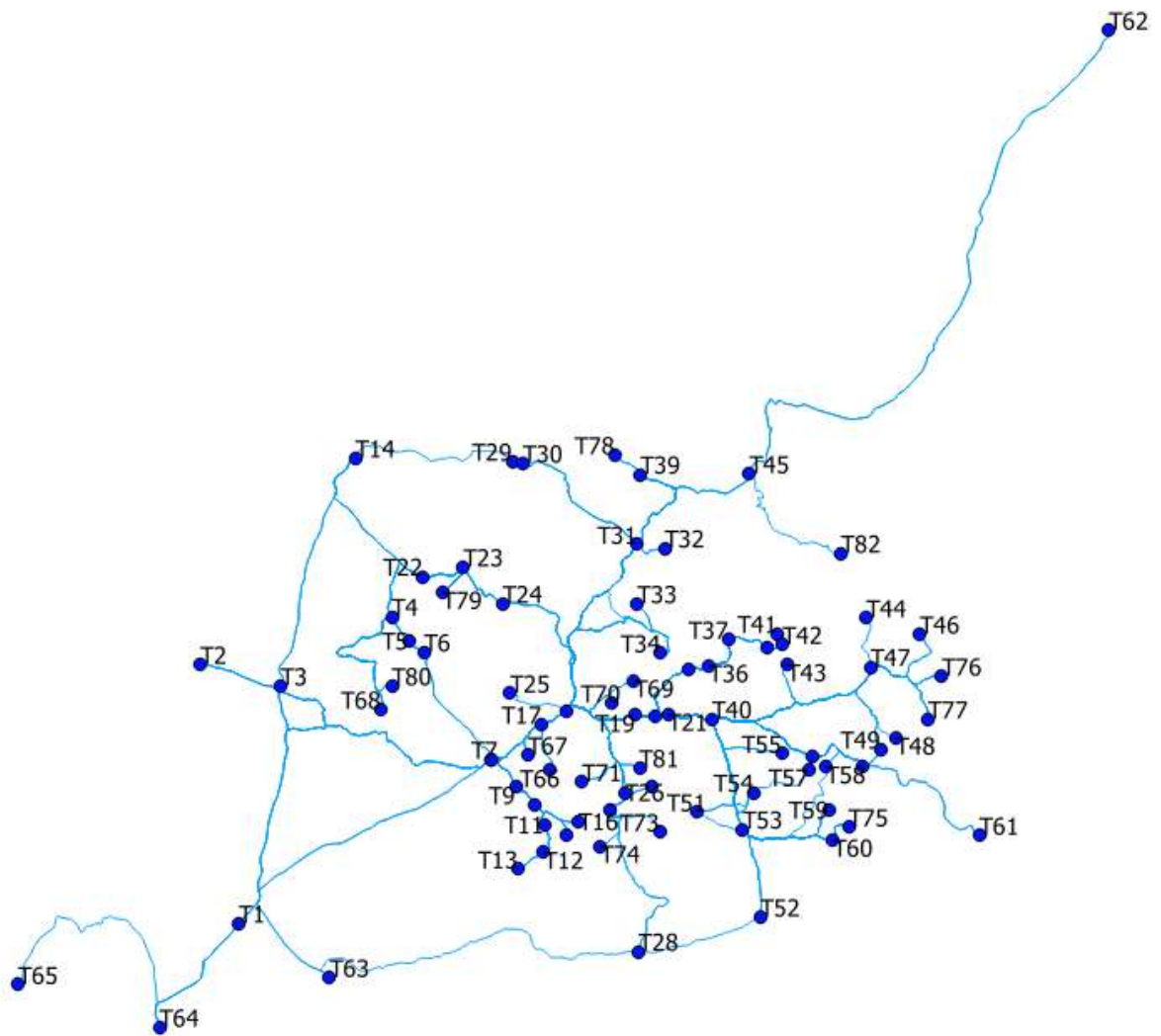
Before moving further, we must check the validity so as to avoid garbled data in future:

1. Menu ToolBar > Vector Tab > GeoProcessing Tools > Intersection
2. In the first field give your **Termini Shapefile**
3. In the second field give the **Route Segment Shapefile**
4. Click **Run** > A file titled **Intersection** gets generated
5. Compare **Intersection** shapefile with the **Termini Shapefile**
6. If they perfectly overlap each other proceed further with creating **F, P** sets
7. Else:
  - 7.1 Menu ToolBar > Vector Tab > Geometry Tools > Extract nodes
  - 7.2 In the field give the **Route Segment Shapefile**
  - 7.3 Click **Run** > A file titled **Nodes** gets generated

Here **red** dots represent the points that didn't match, whereas **green** represent the points that matched.

[illegible]

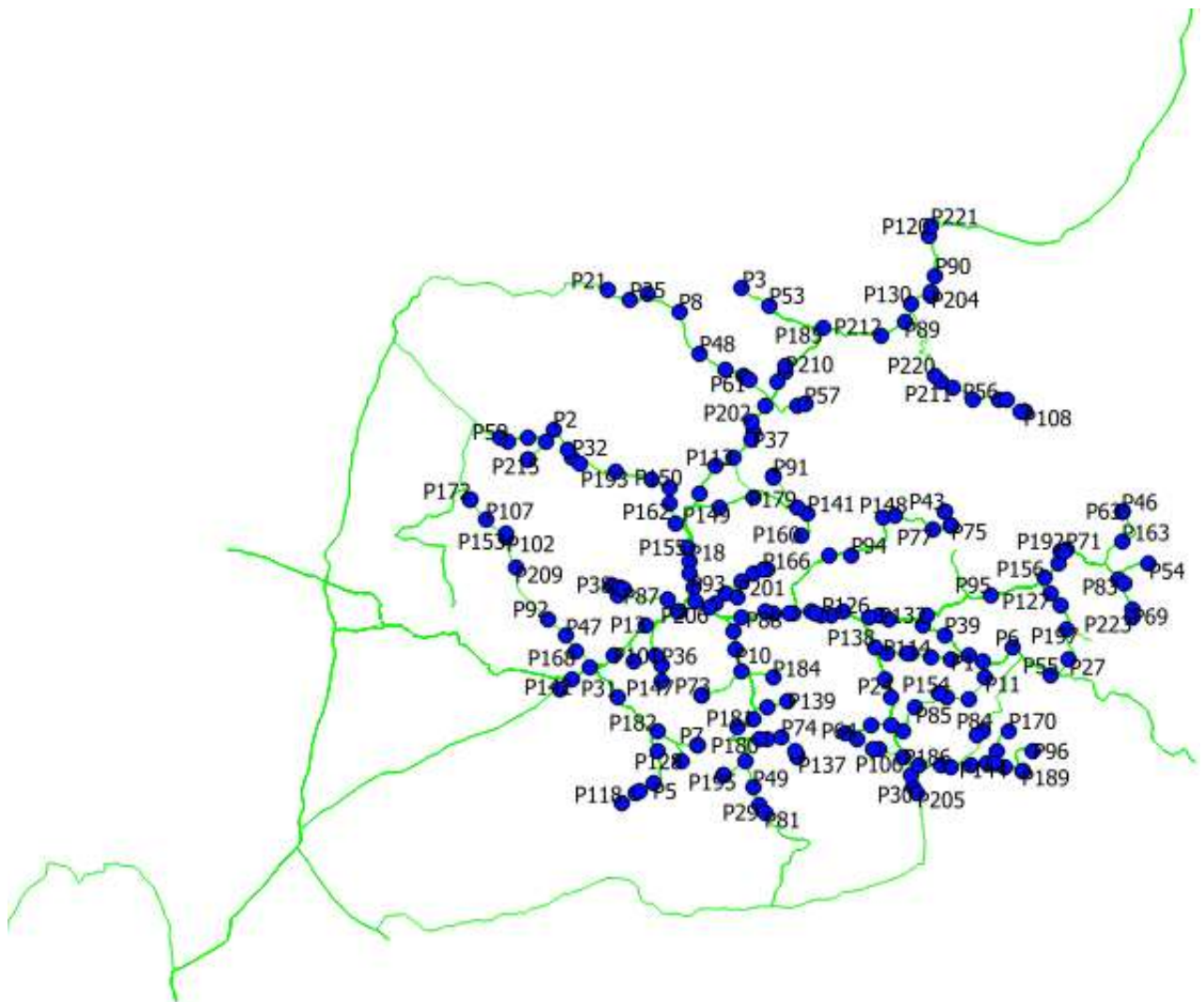
The following shapefile represents the **Set of Termini (T)**:



The map displays the study area with 50 sampling points labeled F1 through F50. The points are distributed along the main river and its tributaries. A scale bar at the bottom left indicates distances from 0 to 10 km. A north arrow is located at the bottom right.



## SET OF VILLAGE PROJECTIONS (P)



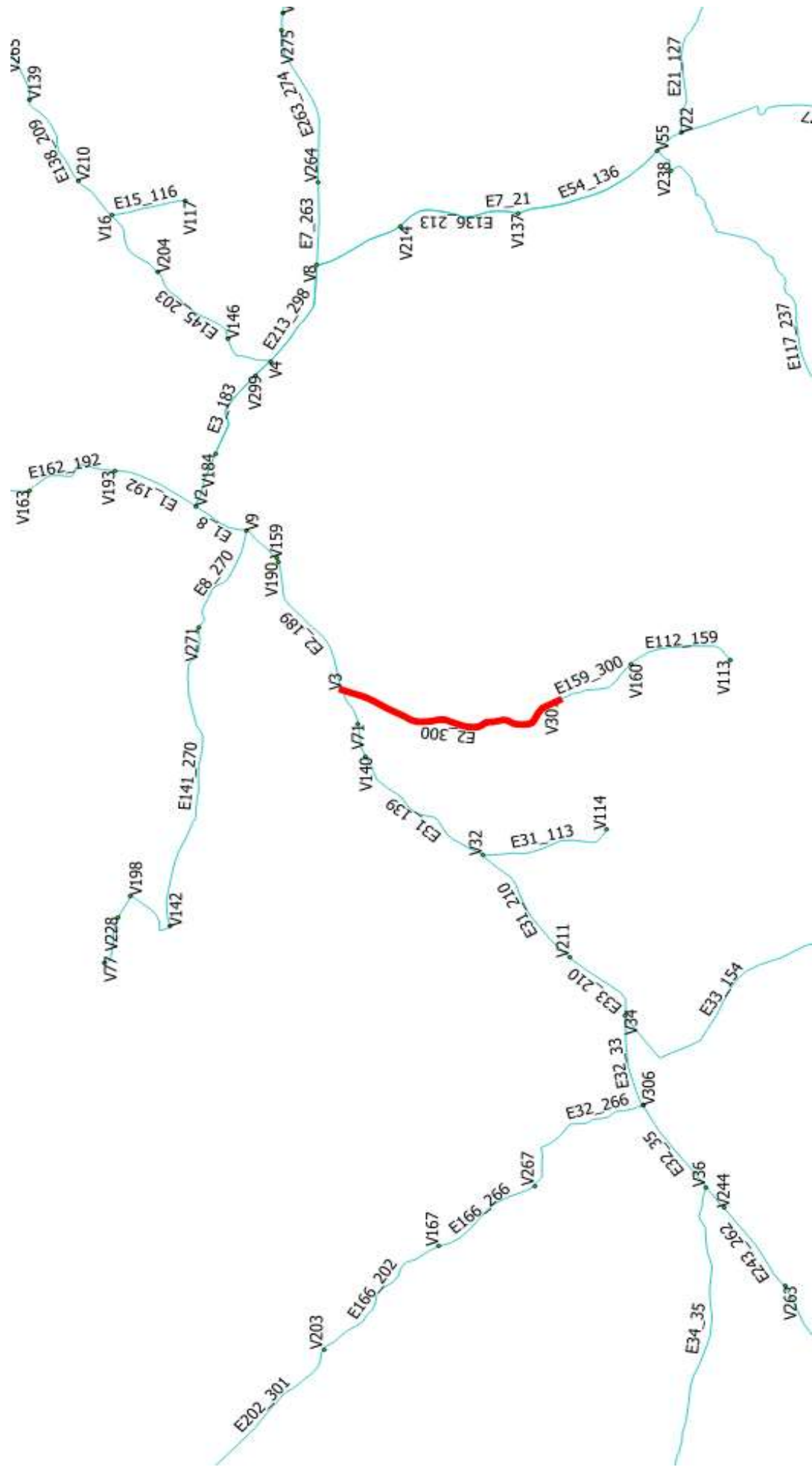
### Condition for creating Vertex set (V):

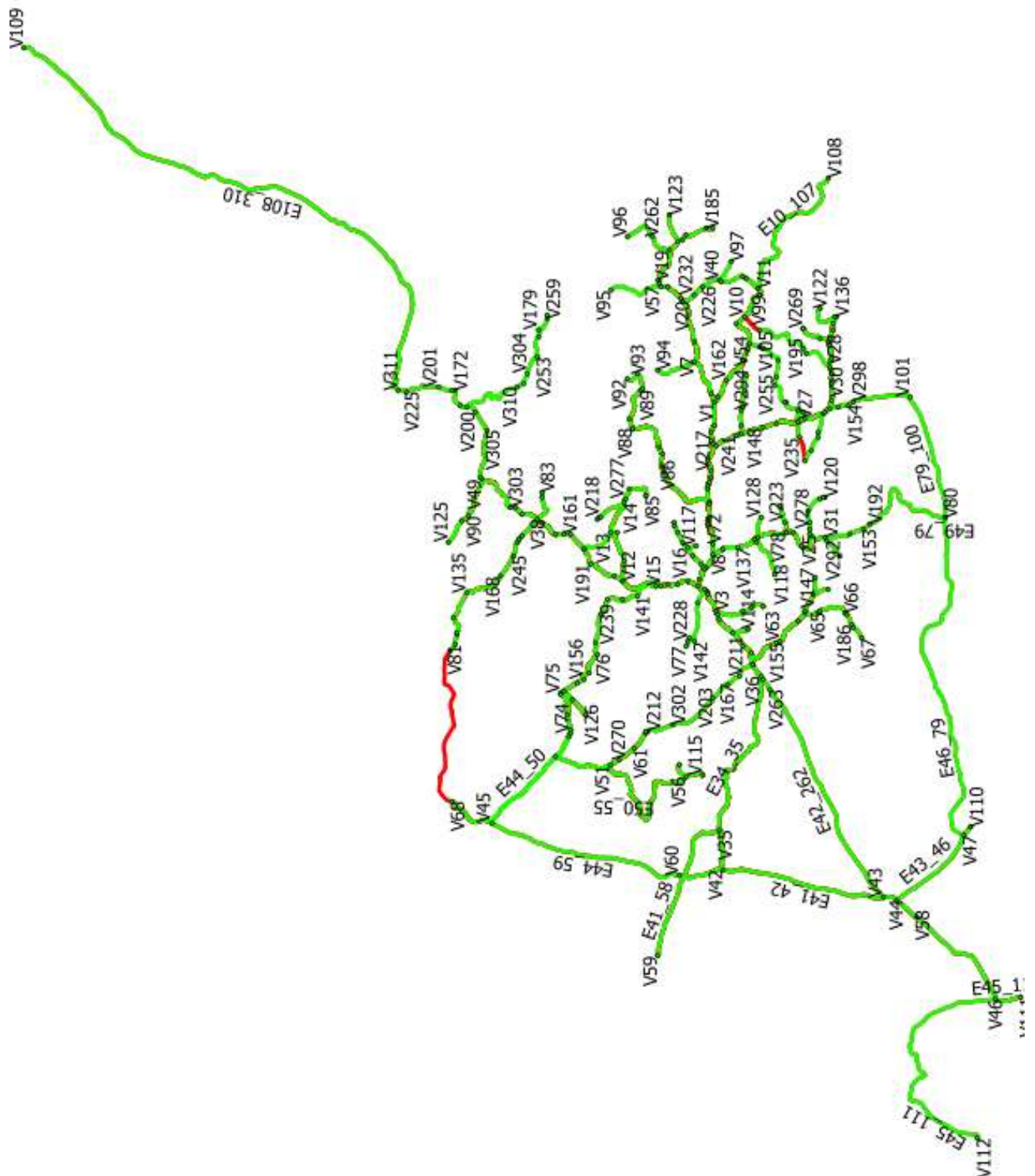
1.  $V = F \cup T \cup P$
2. Concept: Union suppresses duplicates
3. Here, the geometrical duplication will be suppressed
4. This will lead to data loss as QGIS union operator will suppress on the basis of FIFO policy
5. Preparing the **FUTUP file**
  - 5.1 Create copies of **F, T and P** sets
  - 5.2 Save these copies as **v\_F, v\_T, v\_P shapefiles**
  - 5.3 Remove the other fields except **fid**
  - 5.4 Menu Toolbar > Vector > GeoProcessing Tools > Union
  - 5.5 Remove duplicate geometries
  - 5.6 The resultant file is **V set**
  - 5.7 Rename the points with **vertice ids**



1. Removing the duplicate/overlapping geometries
2. Removing the geometries which are very close in vicinity

The script takes the  $\mathbf{RS}_i \cap \mathbf{V}$  and generates the ordered set of vertices, subsequently generating the edges between the unique combination of the vertices.

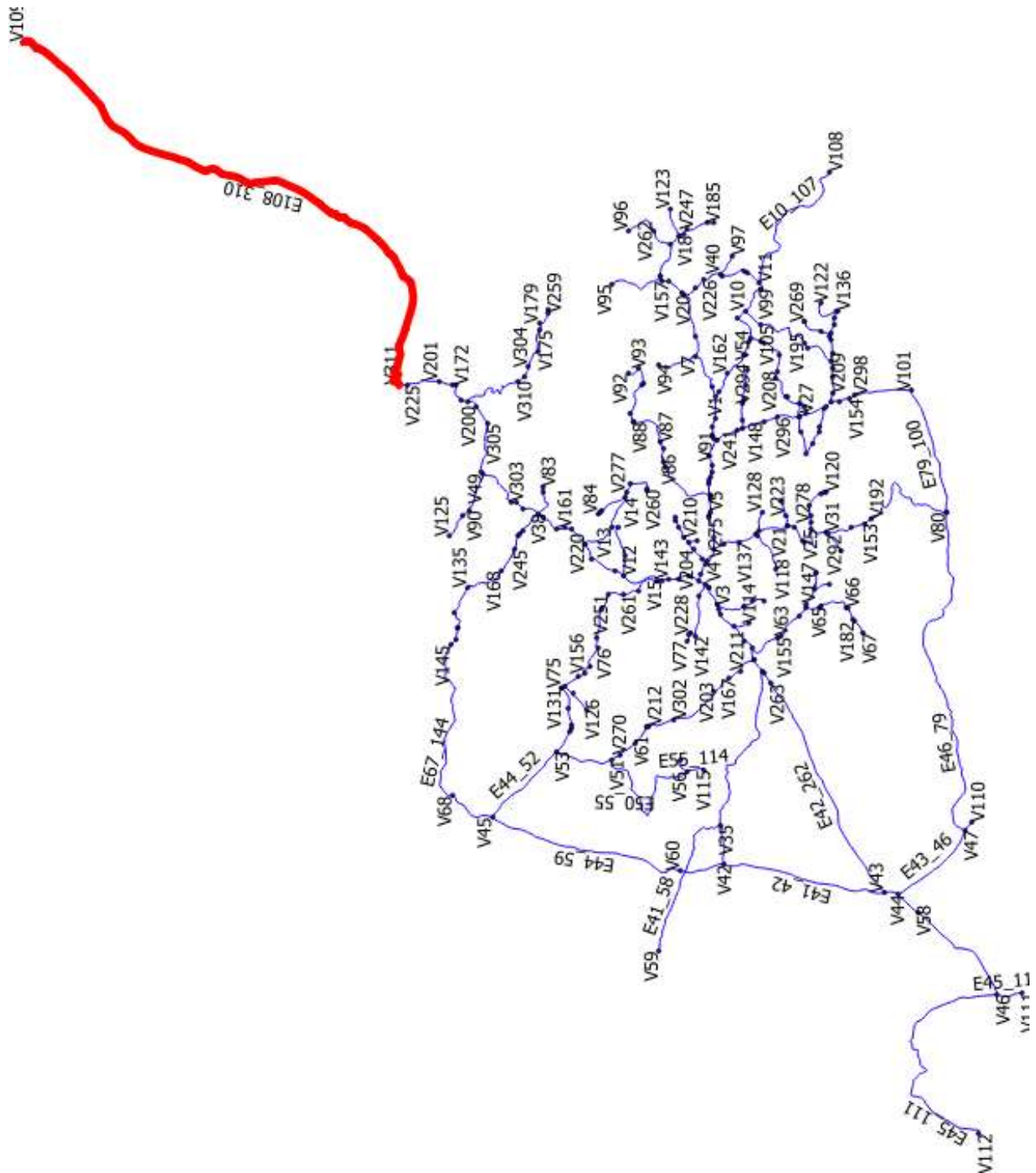




### Issues pertaining:

- Despite best of efforts some of the vertices weren't selected in intersection operation due to high precision level of lat-long in QGIS
- The edges in **RED** are the ones which weren't created by the script
- There were overlapping Edge geometries which were removed in cleaning process
- On the bright side there were only 10 such edges which needed creation

The final geometry looks somewhat like this:



## Digital Geography Matrix

**318 x 318 matrix**

**Number of edges identified: 318**

V208	V255	E207_254
V22	V128	E21_127
V22	V78	E21_77
V212	V254	E211_253
V212	V302	E211_301
V214	V299	E213_298
V216	V249	E215_248
V217	V231	E216_230
V217	V268	E216_267
V219	V236	E218_235
V220	V258	E219_257
V23	V24	E22_23
V23	V235	E22_234
V23	V248	E22_247
V23	V296	E22_295
V221	V293	E220_292
V222	V279	E221_278
V225	V311	E224_310
V226	V232	E225_231
V227	V294	E226_293
V24	V102	E23_101
V24	V164	E23_163
V231	V285	E230_284
V236	V276	E235_275
V239	V251	E238_250
V239	V289	E238_288
V240	V246	E239_245
V25	V278	E24_277
V25	V31	E24_30
V25	V79	E24_78
V243	V260	E242_259
V243	V277	E242_276
V244	V263	E243_262
V26	V144	E25_143
V26	V215	E25_214
V26	V27	E25_26
V251	V261	E250_260
V253	V304	E252_303
V27	V164	E26_163
V27	V248	E26_247

V264	V275	E263_274
V28	V150	E27_149
V28	V237	E27_236
V28	V246	E27_245
V29	V215	E28_214
V29	V272	E28_271
V29	V284	E28_283
V281	V285	E280_284
V282	V305	E281_304
V287	V304	E286_303
V287	V310	E286_309
V30	V209	E29_208
V30	V283	E29_282
V30	V308	E29_307
V293	V294	E292_293
V4	V146	E3_145
V4	V184	E3_183
V4	V8	E3_7
V31	V169	E30_168
V31	V292	E30_291
V32	V114	E31_113
V32	V140	E31_139
V32	V211	E31_210
V33	V267	E32_266
V33	V34	E32_33
V33	V36	E32_35
V34	V155	E33_154
V34	V211	E33_210
V35	V36	E34_35
V35	V42	E34_41
V35	V60	E34_59
V36	V244	E35_243
V37	V280	E36_279
V37	V64	E36_63
V37	V65	E36_64
V38	V171	E37_170
V38	V181	E37_180
V38	V207	E37_206
V38	V252	E37_251
V39	V280	E38_279
V39	V69	E38_68
V39	V70	E38_69
V40	V226	E39_225
V40	V291	E39_290
V40	V97	E39_96
V5	V176	E4_175



V5	V266	E4_265
V5	V73	E4_72
V41	V191	E40_190
V41	V220	E40_219
V42	V43	E41_42
V42	V59	E41_58
V43	V263	E42_262
V43	V44	E42_43
V44	V47	E43_46
V44	V58	E43_57
V45	V53	E44_52
V45	V60	E44_59
V45	V68	E44_67
V46	V111	E45_110
V46	V112	E45_111
V46	V58	E45_57
V47	V110	E46_109
V47	V80	E46_79
V48	V200	E47_199
V48	V234	E47_233
V48	V310	E47_309
V49	V282	E48_281
V49	V303	E48_302
V49	V90	E48_89
V6	V241	E5_240
V6	V268	E5_267
V6	V91	E5_90
V51	V270	E50_269
V51	V53	E50_52
V51	V56	E50_55
V52	V233	E51_232
V53	V300	E52_299
V54	V134	E53_133
V54	V138	E53_137
V54	V229	E53_228
V55	V137	E54_136
V55	V238	E54_237
V56	V115	E55_114
V56	V127	E55_126
V57	V157	E56_156
V57	V288	E56_287
V1	V219	E0_218
V1	V224	E0_223
V1	V309	E0_308
V2	V184	E1_183
V2	V193	E1_192

V2	V9	E1_8
V11	V108	E10_107
V11	V151	E10_150
V11	V99	E10_98
V101	V298	E100_297
V102	V196	E101_195
V103	V221	E102_220
V104	V170	E103_169
V105	V195	E104_194
V106	V237	E105_236
V106	V269	E105_268
V107	V240	E106_239
V107	V286	E106_285
V109	V311	E108_310
V12	V15	E11_14
V12	V197	E11_196
V12	V250	E11_249
V113	V160	E112_159
V116	V265	E115_264
V118	V238	E117_237
V119	V223	E118_222
V120	V132	E119_131
V13	V14	E12_13
V13	V158	E12_157
V13	V41	E12_40
V121	V292	E120_291
V122	V136	E121_135
V124	V185	E123_184
V125	V173	E124_172
V126	V233	E125_232
V129	V259	E128_258
V130	V162	E129_161
V130	V229	E129_228
V14	V218	E13_217
V14	V277	E13_276
V131	V242	E130_241
V132	V312	E131_311
V133	V186	E132_185
V135	V168	E134_167
V135	V290	E134_289
V136	V286	E135_285
V137	V214	E136_213
V139	V210	E138_209
V139	V265	E138_264
V15	V143	E14_142
V15	V256	E14_255

V141	V256	E140_255
V141	V261	E140_260
V142	V198	E141_197
V142	V271	E141_270
V143	V163	E142_162
V144	V274	E143_273
V146	V204	E145_203
V148	V296	E147_295
V149	V290	E148_289
V150	V209	E149_208
V16	V117	E15_116
V16	V204	E15_203
V16	V210	E15_209
V152	V178	E151_177
V152	V245	E151_244
V153	V169	E152_168
V153	V192	E152_191
V154	V272	E153_271
V154	V298	E153_297
V156	V213	E155_212
V156	V307	E155_306
V157	V257	E156_256
V158	V250	E157_249
V159	V190	E158_189
V160	V301	E159_300
V17	V148	E16_147
V17	V227	E16_226
V17	V241	E16_240
V161	V258	E160_257
V161	V295	E160_294
V162	V224	E161_223
V163	V193	E162_192
V165	V283	E164_282
V165	V284	E164_283
V166	V188	E165_187
V166	V278	E165_277
V167	V203	E166_202
V167	V267	E166_266
V168	V245	E167_244
V170	V208	E169_207
V18	V123	E17_122
V18	V19	E17_18
V18	V194	E17_193
V172	V234	E171_233
V172	V297	E171_296
V175	V179	E174_178

V175	V253	E174_252
V176	V230	E175_229
V177	V242	E176_241
V178	V181	E177_180
V179	V259	E178_258
V180	V274	E179_273
V19	V187	E18_186
V19	V262	E18_261
V182	V186	E181_185
V183	V252	E182_251
V183	V303	E182_302
V184	V299	E183_298
V185	V247	E184_246
V187	V288	E186_287
V188	V312	E187_311
V20	V206	E19_205
V20	V232	E19_231
V20	V257	E19_256
V191	V197	E190_196
V194	V247	E193_246
V195	V308	E194_307
V196	V255	E195_254
V198	V228	E197_227
V199	V230	E198_229
V200	V305	E199_304
V3	V190	E2_189
V3	V301	E2_300
V3	V71	E2_70
V21	V223	E20_222
V21	V279	E20_278
V21	V78	E20_77
V201	V225	E200_224
V201	V297	E200_296
V202	V218	E201_217
V203	V302	E202_301
V207	V295	E206_294
V57	V95	E56_94
V7	V206	E6_205
V7	V309	E6_308
V7	V94	E6_93
V61	V270	E60_269
V61	V62	E60_61
V62	V254	E61_253
V63	V155	E62_154
V63	V64	E62_63
V65	V273	E64_272

V66	V133	E65_132
V66	V273	E65_272
V67	V182	E66_181
V70	V147	E69_146
V8	V22	E7_21
V8	V264	E7_263
V71	V140	E70_139
V72	V199	E71_198
V72	V275	E71_274
V73	V281	E72_280
V74	V131	E73_130
V74	V300	E73_299
V75	V131	E74_130
V75	V307	E74_306
V76	V213	E75_212
V76	V289	E75_288
V77	V228	E76_227
V79	V222	E78_221
V80	V101	E79_100
V80	V192	E79_191
V9	V159	E8_158
V9	V271	E8_270
V81	V145	E80_144
V81	V82	E80_81
V82	V149	E81_148
V83	V171	E82_170
V84	V202	E83_201
V85	V260	E84_259
V86	V205	E85_204
V86	V266	E85_265
V87	V205	E86_204
V87	V88	E86_87
V88	V216	E87_215
V89	V189	E88_188
V89	V249	E88_248
V90	V173	E89_172
V10	V104	E9_104
V10	V134	E9_133
V10	V99	E9_98
V91	V276	E90_275
V92	V93	E91_92
V93	V189	E92_188
V96	V262	E95_261
V98	V151	E97_150
V98	V291	E97_290
V99	V174	E98_173

V100	V180	E99_179
V100	V245	E99_234