Attribute Tables and Tabular Data

Outline

- Scales of measurement
- Attribute tables
- “Joins” and “relations”
- Relational databases
- Importing tabular data

Attributes: *Scales of Measurement*

- Nominal
  - distinction (“a” is/is-not “b”)
    - e.g. land cover class
- Ordinal
  - significance (“a” is *X*er than “b”)
    - sortable
    - e.g. good → better → best
- Interval
  - relative magnitude (“a” is *N* **units** *X*er than “b”)
    - interpolable
    - e.g. degrees Celsius

Scales of Measurement (cont'd)

- Ratio
  - absolute magnitude ("a" is *N* **times** *X*er than "b")
    - scalable
      - true zero: absence of attribute
    - e.g. degrees Kelvin

- Cyclic
  - direction
    - more common in geography than in other disciplines
    - "wrap-around" discontinuity at 2π (360°)
      - tricky to interpolate
    - e.g. terrain exposure ("south-facing slope")

Attributes

stored/organized in **tables**

Name	FIPS	Pop90	Area	PopDn
Whatcom	53073	128	2170	59
Skagit	53057	80	1765	45
Clallam	53009	56	1779	32
Snohomish	53061	466	2102	222
Island	53029	60	231	261
Jefferson	53031	20	1773	11
Kitsap	53035	190	391	485
King	53033	1507	2164	696
Mason	53045	38	904	42
Grays Harbor	53027	64	1917	33
Pierce	53053	586	1651	355
Thurston	53067	161	698	231
Pacific	53049	19	945	20
Lewis	53041	59	2479	24

Attribute or Item

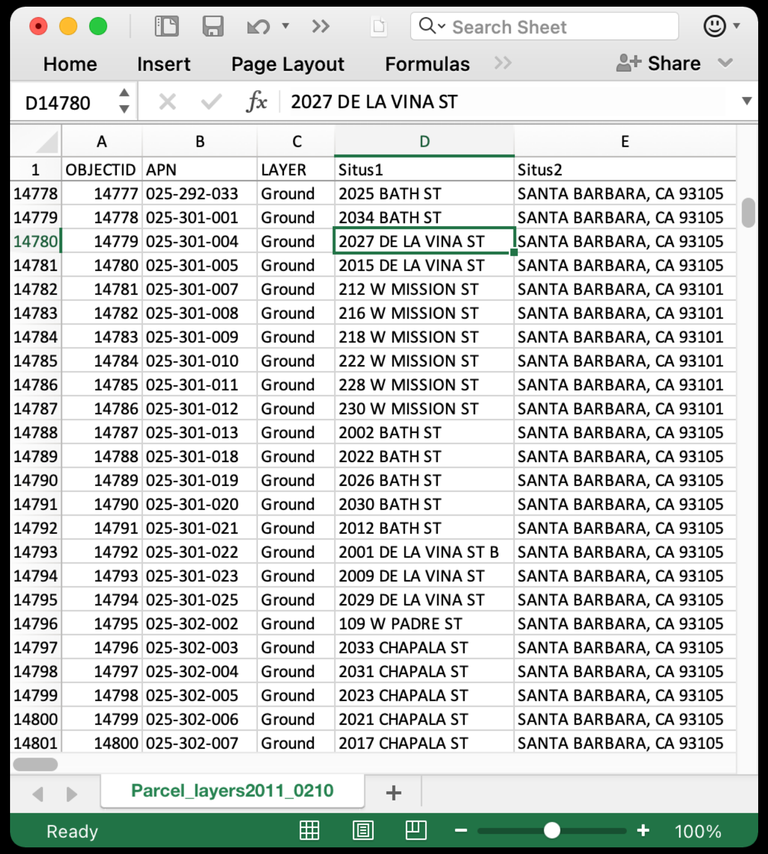
Record

Name	FIPS	Pop90	Area	PopDn
Whatcom	53073	128	2170	59
Skagit	53057	80	1765	45
Clallam	53009	56	1779	32
Snohomish	53061	466	2102	222
Island	53029	60	231	261
Jefferson	53031	20	1773	11
Kitsap	53035	190	391	485

- **row** = spatial feature
- **column** = attribute
- $row_i \cap column_j$ = value of attribute j for feature i

Rendering the Attribute Table

in spreadsheet (`.dbf` file)



D14780 | 2027 DE LA VINA ST

	A	B	C	D	E
1	OBJECTID	APN	LAYER	Situs1	Situs2
14778	14777	025-292-033	Ground	2025 BATH ST	SANTA BARBARA, CA 93105
14779	14778	025-301-001	Ground	2034 BATH ST	SANTA BARBARA, CA 93105
14780	14779	025-301-004	Ground	2027 DE LA VINA ST	SANTA BARBARA, CA 93105
14781	14780	025-301-005	Ground	2015 DE LA VINA ST	SANTA BARBARA, CA 93105
14782	14781	025-301-007	Ground	212 W MISSION ST	SANTA BARBARA, CA 93101
14783	14782	025-301-008	Ground	216 W MISSION ST	SANTA BARBARA, CA 93101
14784	14783	025-301-009	Ground	218 W MISSION ST	SANTA BARBARA, CA 93101
14785	14784	025-301-010	Ground	222 W MISSION ST	SANTA BARBARA, CA 93101
14786	14785	025-301-011	Ground	228 W MISSION ST	SANTA BARBARA, CA 93101
14787	14786	025-301-012	Ground	230 W MISSION ST	SANTA BARBARA, CA 93101
14788	14787	025-301-013	Ground	2002 BATH ST	SANTA BARBARA, CA 93105
14789	14788	025-301-018	Ground	2022 BATH ST	SANTA BARBARA, CA 93105
14790	14789	025-301-019	Ground	2026 BATH ST	SANTA BARBARA, CA 93105
14791	14790	025-301-020	Ground	2030 BATH ST	SANTA BARBARA, CA 93105
14792	14791	025-301-021	Ground	2012 BATH ST	SANTA BARBARA, CA 93105
14793	14792	025-301-022	Ground	2001 DE LA VINA ST B	SANTA BARBARA, CA 93105
14794	14793	025-301-023	Ground	2009 DE LA VINA ST	SANTA BARBARA, CA 93105
14795	14794	025-301-025	Ground	2029 DE LA VINA ST	SANTA BARBARA, CA 93105
14796	14795	025-302-002	Ground	109 W PADRE ST	SANTA BARBARA, CA 93105
14797	14796	025-302-003	Ground	2033 CHAPALA ST	SANTA BARBARA, CA 93105
14798	14797	025-302-004	Ground	2031 CHAPALA ST	SANTA BARBARA, CA 93105
14799	14798	025-302-005	Ground	2023 CHAPALA ST	SANTA BARBARA, CA 93105
14800	14799	025-302-006	Ground	2021 CHAPALA ST	SANTA BARBARA, CA 93105
14801	14800	025-302-007	Ground	2017 CHAPALA ST	SANTA BARBARA, CA 93105

in QGIS

Parcel_layers2011_0210 — Features Total: 128566, Filtered: 128566, Selected: 0

	OBJECTID	APN	LAYER	Situs1	Situs2	Acreage
16645	14777	025-292-033	Ground	2025 BATH ST	SANTA BARBARA,CA 93105	0.58
16646	14778	025-301-001	Ground	2034 BATH ST	SANTA BARBARA,CA 93105	0.3
16647	14779	025-301-004	Ground	2027 DE LA VINA ST	SANTA BARBARA,CA 93105	0.26
16648	14780	025-301-005	Ground	2015 DE LA VINA ST	SANTA BARBARA,CA 93105	0.53
16649	14781	025-301-007	Ground	212 W MISSION ST	SANTA BARBARA,CA 93101	0.13
16650	14782	025-301-008	Ground	216 W MISSION ST	SANTA BARBARA,CA 93101	0.06
16651	14783	025-301-009	Ground	218 W MISSION ST	SANTA BARBARA,CA 93101	0.16
16652	14784	025-301-010	Ground	222 W MISSION ST	SANTA BARBARA,CA 93101	0.24
16653	14785	025-301-011	Ground	228 W MISSION ST	SANTA BARBARA,CA 93101	0.11
16654	14786	025-301-012	Ground	230 W MISSION ST	SANTA BARBARA,CA 93101	0.1
16655	14787	025-301-013	Ground	2002 BATH ST	SANTA BARBARA,CA 93105	0.1
16656	14788	025-301-018	Ground	2022 BATH ST	SANTA BARBARA,CA 93105	0.27
16657	14789	025-301-019	Ground	2026 BATH ST	SANTA BARBARA,CA 93105	0.27
16658	14790	025-301-020	Ground	2030 BATH ST	SANTA BARBARA,CA 93105	0.27
16659	14791	025-301-021	Ground	2012 BATH ST	SANTA BARBARA,CA 93105	0.69
16660	14792	025-301-022	Ground	2001 DE LA VINA ST B	SANTA BARBARA,CA 93105	0.28
16661	14793	025-301-023	Ground	2009 DE LA VINA ST	SANTA BARBARA,CA 93105	0.16
16662	14794	025-301-025	Ground	2029 DE LA VINA ST	SANTA BARBARA,CA 93105	1.61...
16663	14795	025-302-002	Ground	109 W PADRE ST	SANTA BARBARA,CA 93105	0.19
16664	14796	025-302-003	Ground	2033 CHAPALA ST	SANTA BARBARA,CA 93105	0.13
16665	14797	025-302-004	Ground	2031 CHAPALA ST	SANTA BARBARA,CA 93105	0.16
16666	14798	025-302-005	Ground	2023 CHAPALA ST	SANTA BARBARA,CA 93105	0.25
16667	14799	025-302-006	Ground	2021 CHAPALA ST	SANTA BARBARA,CA 93105	0.25
16668	14800	025-302-007	Ground	2017 CHAPALA ST	SANTA BARBARA,CA 93105	0.25

Table Characteristics

- All tables
  - Row order doesn't matter
    - rows can be ordered on any column value(s)
  - Columns are typed
    - QGIS: integer (32- and 64-bit), real, text, date

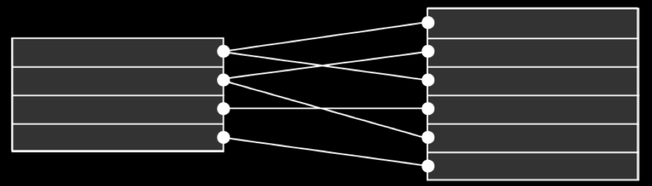
- Feature attribute tables
  - 1 row per feature
    - table row ← feature ID → geometry object
  - 1 table per feature class
    - shapefile, coverage, geodatabase feature class, ...

Connecting Tables

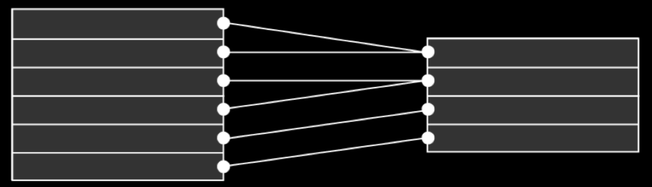
What if attributes are in more than 1 table?

- Create **relationships** between tables
  - **cardinality**:
    $\#rows_{(table1)} \leftrightarrow \#rows_{(table2)}$

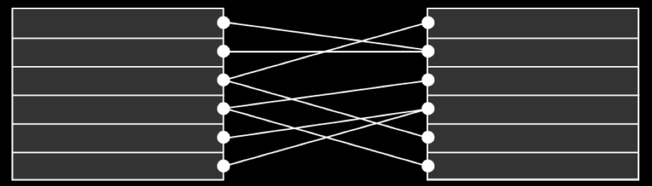
One-to-one relationship



One-to-many relationship



Many-to-one relationship



Many-to-many relationship

Connecting Tables in QGIS

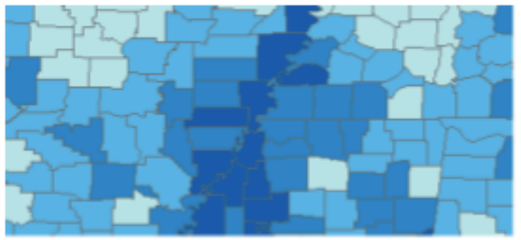
- Connect tables using common key values
  - **join:** concatenates
    - must be 1:1 or many:1
    - join attributes concatenated to target attribute table
    - property of *layer* within project
  - **relation:** links (but keeps separate)
    - may be 1:many
      - (many:many possible, but takes some fiddling)
    - only visible when features are queried (e.g. Identify)
    - property of *project*

Join

- 1 to 1

Shape	FID	County
Polygon	1	Atoka
Polygon	2	Kiowa
Polygon	3	Nowata

County	Rain	Total
Atoka	1.80	10.16
Kiowa	2.34	13.67
Nowata	1.62	11.90



Symbolizing features based on joined rainfall data.

- Many to 1

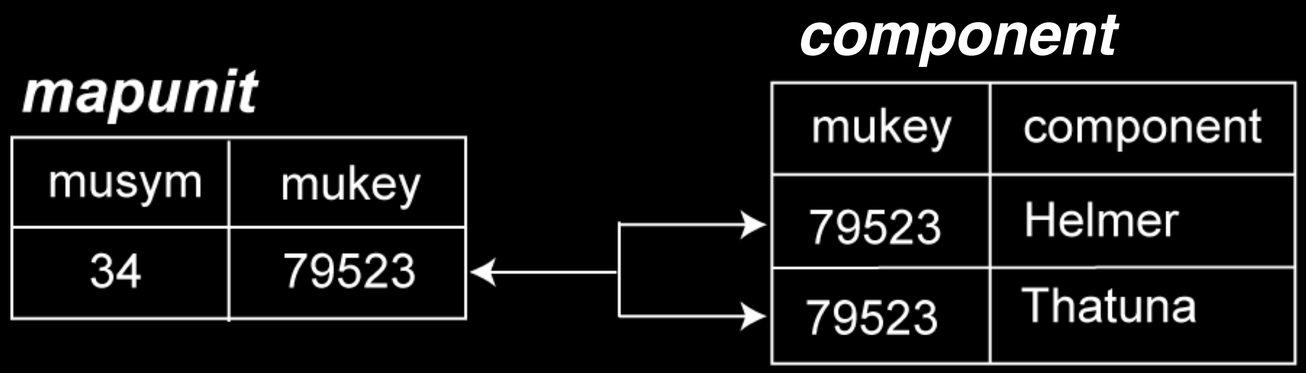
Shape	FID	LU_Code
Polygon	1	2
Polygon	2	1
Polygon	3	1

LU-Code	Description
1	Single Family
2	Agriculture
3	Commercial

Many polygons share the same land use description.

Relation

- 1 to many
  - e.g. one soil map unit → two soil components



- NB: can't **join** 1-to-many: why?
  - would have to replicate features

Summary: Tables in QGIS

QGIS isn’t quite a database

- Enforces 1 feature ↔ 1 attribute table row
  - Joins and relations are part of project, **not** data
- Can’t query multiple tables simultaneously
  - Have to explicitly join or relate them first

Tables in a **Database**

- Table = **entity** (a kind of thing)
  - e.g. professor
- Row = **instance** of an entity (a single thing)
  - e.g. Frew
  - also called: **tuple**
- Column = **attribute** of an entity
  - e.g. shoe size

A database is **really picky**
about what you put in a table...

Table Rules

- Only one value in each cell (intersection of row and column)
- All values in a column are about the same subject
- Each row is unique
- Column order doesn’t matter
- Row order doesn’t matter

Usually Need More than 1 Table

- Avoid **redundancy**:
  if single table,
  then attribute values **shared** by >1 instance
  must be **repeated** in each instance
  - e.g. 58 students taking 263
  - 263 meets in Bren 3035Zoom 892 8584 2911 (sigh…)
  - 58 student records have Zoom 892 8584 2911 as meeting "place"
  - what happens when class "moves"?

- Consequences of redundancy
  - more sensitive to typos and transcription errors
  - fragile updates: have to change multiple copies
  - confusion: which one is the **truth**?

How Databases Use Multiple Tables

- Eliminate redundancy
  by **normalizing** single table into multiple tables
  - Each table = single *kind* of thing
  - Each row = single thing

- Preserve relationships
  by **references** between tables
  - Collapse redundant attributes into single **key**
    (attribute shared between tables)
  - Relationships implied by matching key values

How Databases Use Multiple Tables

Forests

Forest Name	Forest-ID	Location	Size
Nantahala	1	N. Carolina	184,447
Cherokee	2	N. Carolina	92,271

Trails

Trail Name	Forest-ID
Bryson's Knob	1
Slickrock Falls	2
North Fork	1
Cade's Cove	1
Cade's Cove	2
Appalachian	1
Appalachian	2

Table from Relational Join

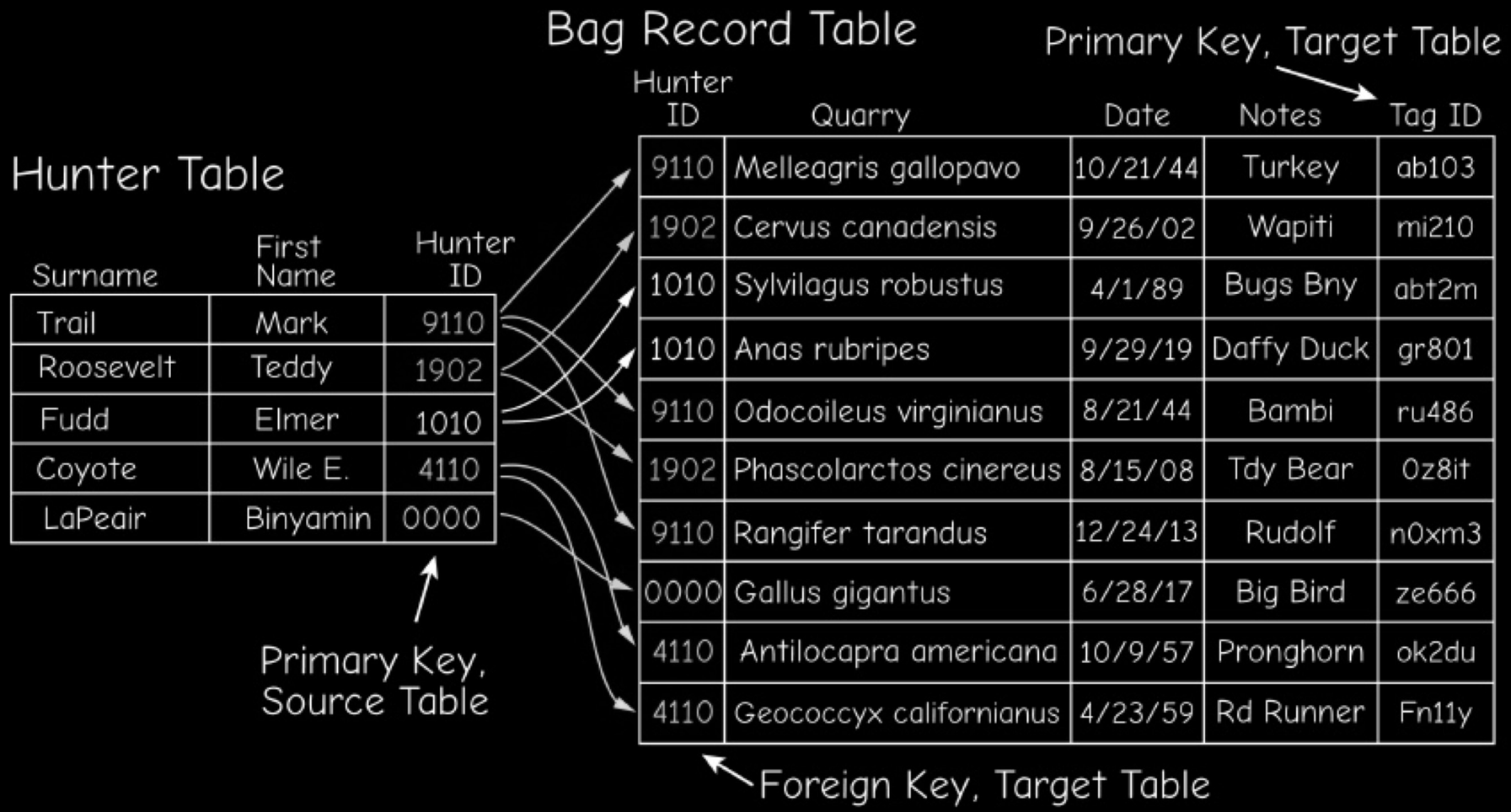
Forest Name	Forest-ID	Location	Size	Trail Name
Nantahala	1	N. Carolina	184,447	Bryson's Knob
Nantahala	1	N. Carolina	184,447	North Fork
Nantahala	1	N. Carolina	184,447	Cade's Cove
Nantahala	1	N. Carolina	184,447	Appalachian
Cherokee	2	N. Carolina	92,271	Slickrock Falls
Cherokee	2	N. Carolina	92,271	Cade's Cove
Cherokee	2	N. Carolina	92,271	Appalachian

Keys

A **key** uniquely identifies,
and can therefore be used as a reference to,
a single row

- **Primary** key
  - attribute whose value uniquely identifies a row
    - Data values that are naturally unique
      - may be more than 1 attribute
    - Arbitrary/synthetic value
      - e.g. auto-incrementing counter
- **Foreign** key
  - attribute whose value corresponds to another row's (usually in another table) primary key
  - **Foreign keys are how databases maintain explicit relationships between rows, within or between tables**

Keys


Bag Record Table
Primary Key, Target Table
Hunter Table
Surname
First Name
Hunter ID
Trail
Mark
9110
Roosevelt
Teddy
1902
Fudd
Elmer
1010
Coyote
Wile E.
4110
LaPeair
Binyamin
0000
Primary Key, Source Table
Hunter ID
Quarry
Date
Notes
Tag ID
9110
Melleagris gallopavo
10/21/44
Turkey
ab103
1902
Cervus canadensis
9/26/02
Wapiti
mi210
1010
Sylvilagus robustus
4/1/89
Bugs Bny
abt2m
1010
Anas rubripes
9/29/19
Daffy Duck
gr801
9110
Odocoileus virginianus
8/21/44
Bambi
ru486
1902
Phascolarctos cinereus
8/15/08
Tdy Bear
0z8it
9110
Rangifer tarandus
12/24/13
Rudolf
n0xm3
0000
Gallus gigantus
6/28/17
Big Bird
ze666
4110
Antilocapra americana
10/9/57
Pronghorn
ok2du
4110
Geococcyx californianus
4/23/59
Rd Runner
Fn11y
Foreign Key, Target Table

Normalization

Land Records table, unnormalized form

parcel-ID	Alderman	Tship-ID	Tship_name	Thall-add	Own-ID	Own_name	Own_add
2303	Johnson	12	Birch	15W	122	Devlin	123_pine
618	DeSilva	14	Grant	35E	457	Suarez	453_highland
9473	Johnson	12	Birch	15W	337	Yamane	72_lotus

Own-ID	Own_name	Own_add	Own-ID	Own_name	Own_add
337	Yamane	72_lotus	890	Prestovic	12_clayton
890	Prestovic	12_clayton	231	Sherman	64_richmond
-	-	-	-	-	-

Normalization

Land Records table, first normal form (1NF)

parcel-ID	Alderman	Tship-ID	Tship_name	Thall-add	Own-ID	Own_name	Own_add
2303	Johnson	12	Birch	15W	122	Devlin	123_pine
2303	Johnson	12	Birch	15W	337	Yamane	72_lotus
2303	Johnson	12	Birch	15W	890	Prestovic	12_clayton
618	DeSilva	14	Grant	35E	457	Suarez	453_highland
618	DeSilva	14	Grant	35E	890	Prestovic	12_clayton
618	DeSilva	14	Grant	35E	231	Sherman	64_richmond
9473	Johnson	12	Birch	15W	337	Yamane	72_lotus

Normalization

Land records tables, second normal form (2NF)

Land Records Table 1

parcel-ID	Alderman	Tship-ID	Tship_name	Thall-add
2303	Johnson	12	Birch	15W
618	DeSilva	14	Grant	35E
9473	Johnson	12	Birch	15W

Land Records Table 2

Own-ID	Own_name	Own_add
122	Devlin	123_pine
337	Yamane	72_lotus
890	Prestovic	12_clayton
457	Suarez	453_highland
231	Sherman	64_richmond

Land Records Table 3

parcel-ID	Own-ID
2303	122
2303	337
2303	890
618	457
618	890
618	231
9473	337

Normalization

Land records, third normal form

Land Records 1a

FD: Parcel-ID → Tship-ID

Parcel-ID	Tship-ID
2303	12
618	14
9473	12

Land Records 1b

FD: Tship-ID → Tship_name, Thall_add, Alderman

Tship-ID	Tship_name	Thall_add	Alderman
12	Birch	35W	Johnson
14	Grant	35E	DeSilva

Land Records 2

FD: Own-ID → Own_name, Own_add

Own-ID	Own_name	Own_add
122	Devlin	123_pine
337	Yamane	72_lotus
890	Prestovic	12_clayton
457	Suarez	453_highland
231	Sherman	64_richmond

Land Records 3

No Functional Dependencies

Parcel-ID	Own-ID
2303	122
2303	337
2303	890
618	457
618	890
618	231
9473	337

References

- Chang, K.T., “Introduction to Geographic Information Systems, 5th ed.” ISBN 007729436X
- Bolstad, P., “GIS Fundamentals, 6th ed.” ISBN 978-1-59399-552-2