COMP 8042 Final Project Report

By Paul Cavallo, A01061713

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1. Description

This GIS system takes in a script and GIS database and can use the following commands to retrieve, store, and parse its data:

- world
- import
- debug
- quit
- what_is_at
    - -long
- what_is_in
    - -filter [pop | water | structure | …]

My solution runs via the system manager, which runs creates all needed sub-systems and begins the script processing. The method I use for retrieving data is via a Hashtable, Quadtree, and Bufferpool. For text/string searches, the system goes through the Hashtable. For location/latitude+longitude searches, the system goes through the Quadtree. The goal of the Hashtable and Quadtrees are to look up the database file record positions quickly. Once a record position (offset) is retrieved, the system then looks in the Bufferpool to see if the record has been used recently. It stores the GIS record mapped to the offset, allowing for very fast searching. If the offset is not in the Bufferpool, the Bufferpool will search for the record in the database file created at the beginning of the script.

2. Architecture

I architected the project in a fashion similar to the project description. It has each of the classes recommended as well as a few others.

1. The **SystemManager** is a singleton that initializes and stores instances of other classes. It is done this way so that classes such as the logger can be accessed and used from any other place in the project (by using GetInstance()). The system manager is created in the main function and passed the arguments of the GIS.exe executable.
2. The **Logger** is initialized upon startup and can be called to log commands or strings, and logs the starting and ending states of the program.
3. The **BufferPool** has a maximum storage of 15 records. It holds the most recently used records for quick access via the commands.
4. The **CommandProcessor** goes line by line through the script file provided to the system. It checks for comments and executes functions from other classes to perform the given command on the line it is reading.

5. The **GISRecord** imports all the data from the provided file in the script. It goes through each line, determining what records are valid and then inserting them into both the Hashtable and Quadtree.
6. The **World** has methods for setting/checking the world boundaries and converting from DMS format into degrees.
7. The **NameIndex** is the class that contains all Hashtable functionality. Initialized with 1024 slots to start. It does the following:
    a. Creates a table using all the records imported.
    b. Stores the offset as a key/index and the name and state associated with it.
    c. Uses the name+state string in the hash function to determine where entries are placed within the table.
    d. Resolves collisions using quadratic probing.
    e. Rehashes (resizes and moves entries using the hash function) the table once it reaches 70% capacity.
    f. Can be searched with the input of a name+state. It hashes the string to find the index/position in the table, then returns the offset.
8. The **CoordinateIndex** is the class that contains all Quadtree functionality. It stores the location of a record with its offset value. It does the following:
    a. Creates a tree, where there is a root node that will subdivide into 4 quadrants once filled. The maximum number of points (record locations) a node can store is 4.
    b. Upon an insert, the system recursively checks if a point can fit into a quadrant. The insert first checks which quadrant of the node the point should be inserted into. Each quadrant is a node. The node must be a leaf and contain less than 4 points for the point to finally be stored inside it.
    c. Can be searched with the input of a latitude/longitude. It recursively does this by searching the quadrants/nodes which store points within the correct range. When a point equals the position inputted, it returns the offsets stored with the point.
    d. Can be searched with the input of a latitude/longitude/width/height. A 'bounding box' is calculated with the 4 variables to find all points in the tree within the box/area. It recursively does this search.

3. Data Structures

For my buffer pool I use a list and map. The list holds the 'queue' of offsets and the 'map' stores the offsets and their respective record strings.

```
list<int> bufferQueue;
map<int, string> bufferPool;
```

For my Hashtable, I use a struct to store each entry. The isActive is how I keep track of deleted or moved entries.

```
struct HashItem
{
    string nameState;
    int offset;
    bool isActive;
};
```

For my Quadtree, I use 3 structures. One class for each node, another class for the whole tree, and then a struct for points. The two classes consist of methods that support the implementation of inserting, searching, and displaying.

```
Node(float minLat, float maxLat, float minLon, float maxLon)
{
    this->minLat = minLat;
    this->maxLat = maxLat;
    this->minLon = minLon;
    this->maxLon = maxLon;
    this->northWest = nullptr;
    this->northEast = nullptr;
    this->southWest = nullptr;
    this->southEast = nullptr;
}
```

```
class CoordinateIndex
{
    const int MAX_POINTS = 4;

    public:
        float minLat, maxLat, minLon, maxLon;

        Node* root; // root node of the quadtree
```

```
struct Point {
    float lat;
    float lon;
    vector<int> offsets;
};
```

I store the types used by the records in an unordered map for command usage.

```
unordered_map<string, string> recordClassToTypeMap = {
    {"Airport", "structure"},
    {"Arroyo", "water"},
    {"Bay", "water"},
    {"Bend", "water"},
    {"Bridge", "structure"},
    {"Building", "structure"},
```

Lastly, I use vectors throughout the whole project as my choice of array. For things like

foundPoints, offsets, record contents, and more.

4. Instructions

Run these two commands in the root directory:

```
g++ -std=c++11 -pthread src/*.cpp -Iinclude -o GIS.exe

./GIS.exe database.txt script01.txt logtest.txt
```

cMake and Makefile files are also included.

5. References

DMS
https://gisgeography.com/decimal-degrees-dd-minutes-seconds-dms/
https://github.com/jachappell/decimal-degrees-and-degrees-minutes-and-seconds/blob/master/dms.h

Reading, writing. Getting line position
https://cplusplus.com/reference/istream/istream/seekg/
https://cplusplus.com/reference/istream/istream/tellg/

BufferPool
https://www.geeksforgeeks.org/program-for-least-recently-used-lru-page-replacement-algorithm/

Hashtable
Combination of both assignments 2 and lab 5 (week 6)

Quadtree
https://www.geeksforgeeks.org/quad-tree/

6. Script Log

Both text and screenshot versions here.

```
Course Project for COMP 8042
Student Name: Paul Cavallo, Student Id: A01061713
Begin of GIS Program log:
dbFile: db.txt
logFile: log01.txt
scriptFile: script01.txt
Start time: Fri Dec  9 21:59:56 2022
```

```
; Script 1
;
; Testing using a small dataset
;
; Specify boundaries of coordinate space:
;
World boundaries are set to: 38.500000      -79.758331  -79.441666      38.166668
;world  1130000W       0690000W       300000N 440000N
;
; Import the dataset [the address here is a relative address]
Command 1: import      ./VA_Monterey.txt

Imported Features by name : 63
Longest probe sequence : 3
Imported Locations : 63
Average name length : 17

-------------------------------------------------------------------------------------------
;
; Lets visualize our already imported geographical data [this is an optional command]
;debug  world
;
; Also lets see what is inside name and coordinate indices
;debug  quad
;debug  hash
;
; To fill out the cache, let's do a single-match location search
Command 2: what_is_at  382812N 0793156W

1496110|Possum Trot|Populated
Place|VA|51|Highland|091|382812N|0793156W|38.4701196|-79.5322693||||768|2520|Monterey|09/28/1979
|

-------------------------------------------------------------------------------------------
;
; Now lets see if our cache is filled up
;debug  pool
;
; A few more search queries
Command 3: what_is     Church  VA

Nothing Found

-------------------------------------------------------------------------------------------
; oops Church is "FEATURE_CLASS" how about the following query?
Command 4: what_is     Central Church  VA

1482434|Central
Church|Church|VA|51|Highland|091|382953N|0793323W|38.4981744|-79.5564371||||773|2536|Monterey|09
/28/1979|

-------------------------------------------------------------------------------------------
Command 5: what_is     Town of Monterey       VA

2391311|Town of
```

Monterey|Civil|VA|51|Highland|091|382442N|0793451W|38.4115829|-79.580854|||||884|2900|Monterey|02/19/2008|

Command 6: what_is Smith Field VA

1498741|Smith Field|Airport|VA|51|Highland|091|381809N|0793029W|38.3026237|-79.5081001|||||617|2024|Monterey SE|09/01/1992|

; Let's try a wrong state abbreviation
Command 7: what_is Smith Field CO

Nothing Found

;
; Lets check the buffer pool again
;debug pool
;
; So lets check the LRU mechanism [this query should move the last element of the cache all the way to the front!]
Command 8: what_is_at 382812N 0793156W

1496110|Possum Trot|Populated Place|VA|51|Highland|091|382812N|0793156W|38.4701196|-79.5322693|||||768|2520|Monterey|09/28/1979|

;
; checking the buffer pool again
;debug pool
;
; More location searches
Command 9: what_is_at 381816N 0793700W

Nothing Found

Command 10: what_is_at 381816N 0793708W

1496325|Trimble|Populated Place|VA|51|Highland|091|381816N|0793708W|38.3045674|-79.618937|||||777|2549|Monterey SE|09/28/1979|

Command 11: what_is_at 381612N 0793256W

1495400|Clover Creek|Populated Place|VA|51|Highland|091|381612N|0793256W|38.2701242|-79.5489345|||||570|1870|Monterey SE|09/28/1979|

Command 12: what_is_at 382951N 0793238W

1484574|Key
Run|Stream|VA|51|Highland|091|382951N|0793238W|38.4976189|-79.5439366|383250N|0793223W|38.5473399
|-79.5397706|754|2474|Monterey|09/28/1979|

; We expect two location matches for this one
;
Command 13: what_is_at 382856N 0793031W

1483492|Forks of
Waters|Locale|VA|51|Highland|091|382856N|0793031W|38.4823417|-79.5086575||||705|2313|Monterey|09
/28/1979|
1487661|Strait
Creek|Stream|VA|51|Highland|091|382856N|0793031W|38.4823417|-79.5086575|382442N|0793222W|38.41166
67|-79.5394444|705|2313|Monterey|09/28/1979|

; Now performing some area search [this should return 7 features]
;
Command 14: what_is_in 382812N 0793156W 60 90

1484722|Laurel
Run|Stream|VA|51|Highland|091|382725N|0793159W|38.4570643|-79.5331025|382801N|0793331W|38.4669444
|-79.5586111|766|2513|Monterey|09/28/1979|
1486118|Peck
Run|Stream|VA|51|Highland|091|382806N|0793109W|38.4684531|-79.5192132|382634N|0792932W|38.4428984
|-79.4922677|728|2388|Monterey|09/28/1979|
1488473|Wooden
Run|Stream|VA|51|Highland|091|382718N|0793201W|38.45512|-79.5336581|382612N|0792930W|38.4367874|-
79.491712|760|2493|Monterey|09/28/1979|
1496110|Possum Trot|Populated
Place|VA|51|Highland|091|382812N|0793156W|38.4701196|-79.5322693||||768|2520|Monterey|09/28/1979
|
1483647|Ginseng
Mountain|Summit|VA|51|Highland|091|382850N|0793139W|38.480675|-79.527547||||978|3209|Monterey|09
/28/1979|
1483492|Forks of
Waters|Locale|VA|51|Highland|091|382856N|0793031W|38.4823417|-79.5086575||||705|2313|Monterey|09
/28/1979|
1487661|Strait
Creek|Stream|VA|51|Highland|091|382856N|0793031W|38.4823417|-79.5086575|382442N|0793222W|38.41166
67|-79.5394444|705|2313|Monterey|09/28/1979|

Number of items found:
7

; checking the buffer pool again
; how about querying somewhere outside boundaries ?
Command 15: what_is_in 382012N 0792330W 60 90

Out of bounds

; Let's try some variations of a single-match region search with a square region:
Command 16: what_is_in 382148N 0793109W 15 15

1484896|Little Doe Hill|Summit|VA|51|Highland|091|382148N|0793109W|38.3634555|-79.5192122||||988|3241|Monterey SE|09/28/1979|

Number of items found:
1

Command 17: what_is_in -long 382148N 0793109W 15 15

Feature ID : 1484896
Feature Name : Little Doe Hill
Feature Cat : Summit
State : VA
County : Highland
Longitude : 382148N
Latitude : 0793109W
Elev in ft : 3241
USGS Quad : Monterey SE
Date created : 09/28/1979

Number of items found:
1

; Let's try increasing the size of the region:
Command 18: what_is_in 382148N 0793109W 60 60

1484896|Little Doe Hill|Summit|VA|51|Highland|091|382148N|0793109W|38.3634555|-79.5192122||||988|3241|Monterey SE|09/28/1979|
1486995|Seldom Seen Hollow|Valley|VA|51|Highland|091|382145N|0793031W|38.3626223|-79.5086563|382227N|0793004W|38.3741667|-79.5011111|750|2461|Monterey SE|09/28/1979|

Number of items found:
2

Command 19: what_is_in 382148N 0793109W 120 120

1495244|Bear Mountain|Summit|VA|51|Highland|091|382012N|0793254W|38.3367894|-79.5483795||||1076|3530|Monterey SE|09/28/1979|
1484896|Little Doe Hill|Summit|VA|51|Highland|091|382148N|0793109W|38.3634555|-79.5192122||||988|3241|Monterey SE|09/28/1979|
1486995|Seldom Seen Hollow|Valley|VA|51|Highland|091|382145N|0793031W|38.3626223|-79.5086563|382227N|0793004W|38.3741667|-79.5011111|750|2461|Monterey SE|09/28/1979|
1495470|Doe

Hill|Summit|VA|51|Highland|091|382313N|0793113W|38.3870661|-79.5203237|||||1210|3970|Monterey|09/28/1979|

Number of items found:
4

Command 20: what_is_in 382148N 0793109W 180 180

1482110|Buck Hill|Summit|VA|51|Highland|091|381902N|0793358W|38.3173452|-79.5661577|||||1003|3291|Monterey SE|09/28/1979|
1495244|Bear Mountain|Summit|VA|51|Highland|091|382012N|0793254W|38.3367894|-79.5483795|||||1076|3530|Monterey SE|09/28/1979|
1484896|Little Doe Hill|Summit|VA|51|Highland|091|382148N|0793109W|38.3634555|-79.5192122|||||988|3241|Monterey SE|09/28/1979|
1486995|Seldom Seen Hollow|Valley|VA|51|Highland|091|382145N|0793031W|38.3626223|-79.5086563|382227N|0793004W|38.3741667|-79.5011111|750|2461|Monterey SE|09/28/1979|
1495470|Doe Hill|Summit|VA|51|Highland|091|382313N|0793113W|38.3870661|-79.5203237|||||1210|3970|Monterey|09/28/1979|
1673781|Strait Creek School (historical)|School|VA|51|Highland|091|382447N|0793217W|38.4131765|-79.5381022|||||935|3068|Monterey|11/13/1995|

Number of items found:
6

Command 21: what_is_in -long 382148N 0793109W 180 180

Feature ID : 1482110
Feature Name : Buck Hill
Feature Cat : Summit
State : VA
County : Highland
Longitude : 381902N
Latitude : 0793358W
Elev in ft : 3291
USGS Quad : Monterey SE
Date created : 09/28/1979

Feature ID : 1495244
Feature Name : Bear Mountain
Feature Cat : Summit
State : VA
County : Highland
Longitude : 382012N
Latitude : 0793254W
Elev in ft : 3530
USGS Quad : Monterey SE
Date created : 09/28/1979

Feature ID   : 1484896
Feature Name : Little Doe Hill
Feature Cat : Summit
State   : VA
County   : Highland
Longitude   : 382148N
Latitude   : 0793109W
Elev in ft   : 3241
USGS Quad   : Monterey SE
Date created : 09/28/1979

Feature ID   : 1486995
Feature Name : Seldom Seen Hollow
Feature Cat : Valley
State   : VA
County   : Highland
Longitude   : 382145N
Latitude   : 0793031W
Elev in ft   : 2461
USGS Quad   : Monterey SE
Date created : 09/28/1979

Feature ID   : 1495470
Feature Name : Doe Hill
Feature Cat : Summit
State   : VA
County   : Highland
Longitude   : 382313N
Latitude   : 0793113W
Elev in ft   : 3970
USGS Quad   : Monterey
Date created : 09/28/1979

Feature ID   : 1673781
Feature Name : Strait Creek School (historical)
Feature Cat : School
State   : VA
County   : Highland
Longitude   : 382447N
Latitude   : 0793217W
Elev in ft   : 3068
USGS Quad   : Monterey
Date created : 11/13/1995

Number of items found:
6

Command 22: what_is_in -filter structure 382600N 0793310W 120 120

1484097|**Highland** High
School|**School**|**VA**|**51**|**Highland**|**091**|**382426N**|**0793444W**|**38**.4071387|**-79**.5789333||||**879**|**2884**|**Monterey**|**09**
/28/1979|**09**/15/2010

1673775|**Highland** Elementary
School|**School**|**VA**|**51**|**Highland**|**091**|**382427N**|**0793446W**|**38**.4074301|**-79**.579567|||||**878**|**2881**|**Monterey**|**11**/13/1995|**09**/15/2010
1673777|**Monterey** Methodist Episcopal
Church|**Church**|**VA**|**51**|**Highland**|**091**|**382442N**|**0793446W**|**38**.4117874|**-79**.5794924|||||**880**|**2887**|**Monterey**|**11**/13/1995|
1481345|**Asbury**
Church|**Church**|**VA**|**51**|**Highland**|**091**|**382607N**|**0793312W**|**38**.4353981|**-79**.5533807|||||**818**|**2684**|**Monterey**|**09**/28/1979|
1487013|**Seybert**
Chapel|**Church**|**VA**|**51**|**Highland**|**091**|**382512N**|**0793225W**|**38**.4201208|**-79**.5403246|||||**891**|**2923**|**Monterey**|**09**/28/1979|
1673781|**Strait** Creek School
(historical)|**School**|**VA**|**51**|**Highland**|**091**|**382447N**|**0793217W**|**38**.4131765|**-79**.5381022|||||**935**|**3068**|**Monterey**|**11**/13/1995|
1487894|**Thorny** Bottom
Church|**Church**|**VA**|**51**|**Highland**|**091**|**382704N**|**0793141W**|**38**.4512312|**-79**.5281022|||||**784**|**2572**|**Monterey**|**09**/28/1979|

Number of items found:
7

Command 23: what_is_in -filter water 382850N 0793030W 120 240

1487250|**Simmons**
Run|**Stream**|**VA**|**51**|**Highland**|**091**|**382654N**|**0793209W**|**38**.4484534|**-79**.5358803|**382643N**|**0793431W**|**38**.4452778|**-79**.5752778|**780**|**2559**|**Monterey**|**09**/28/1979|
1488259|**West** Strait
Creek|**Stream**|**VA**|**51**|**Highland**|**091**|**382653N**|**0793204W**|**38**.4481757|**-79**.5344913|**382525N**|**0793553W**|**38**.4236111|**-79**.5980556|**779**|**2556**|**Monterey**|**09**/28/1979|
1484722|**Laurel**
Run|**Stream**|**VA**|**51**|**Highland**|**091**|**382725N**|**0793159W**|**38**.4570643|**-79**.5331025|**382801N**|**0793331W**|**38**.4669444|**-79**.5586111|**766**|**2513**|**Monterey**|**09**/28/1979|
1486118|**Peck**
Run|**Stream**|**VA**|**51**|**Highland**|**091**|**382806N**|**0793109W**|**38**.4684531|**-79**.5192132|**382634N**|**0792932W**|**38**.4428984|**-79**.4922677|**728**|**2388**|**Monterey**|**09**/28/1979|
1488473|**Wooden**
Run|**Stream**|**VA**|**51**|**Highland**|**091**|**382718N**|**0793201W**|**38**.45512|**-79**.5336581|**382612N**|**0792930W**|**38**.4367874|**-79**.491712|**760**|**2493**|**Monterey**|**09**/28/1979|
1487661|**Strait**
Creek|**Stream**|**VA**|**51**|**Highland**|**091**|**382856N**|**0793031W**|**38**.4823417|**-79**.5086575|**382442N**|**0793222W**|**38**.4116667|**-79**.5394444|**705**|**2313**|**Monterey**|**09**/28/1979|
1483281|**Elk**
Run|**Stream**|**VA**|**51**|**Highland**|**091**|**382936N**|**0793153W**|**38**.4934524|**-79**.5314362|**383121N**|**0793056W**|**38**.5226185|**-79**.5156027|**757**|**2484**|**Monterey**|**09**/28/1979|
1483527|**Frank**
Run|**Stream**|**VA**|**51**|**Highland**|**091**|**382953N**|**0793310W**|**38**.4981744|**-79**.5528258|**383304N**|**0793341W**|**38**.5512285|**-79**.5614381|**780**|**2559**|**Monterey**|**09**/28/1979|
1484574|**Key**
Run|**Stream**|**VA**|**51**|**Highland**|**091**|**382951N**|**0793238W**|**38**.4976189|**-79**.5439366|**383250N**|**0793223W**|**38**.5473399|**-79**.5397706|**754**|**2474**|**Monterey**|**09**/28/1979|

Number of items found:
9

```
--------------------------------------------------------------------------------
Command 24: what_is_in -filter pop     382000N 0793530W       3600    3600

1495400|Clover Creek|Populated
Place|VA|51|Highland|091|381612N|0793256W|38.2701242|-79.5489345||||570|1870|Monterey
SE|09/28/1979|
1496325|Trimble|Populated
Place|VA|51|Highland|091|381816N|0793708W|38.3045674|-79.618937||||777|2549|Monterey
SE|09/28/1979|
1498517|Monterey|Populated
Place|VA|51|Highland|091|382444N|0793450W|38.4123429|-79.5806036||||882|2894|Monterey|09/28/1979
|03/17/2008
1496000|New Hampden|Populated
Place|VA|51|Highland|091|382934N|0793348W|38.4928967|-79.5633816||||792|2598|Monterey|09/28/1979
|
1496110|Possum Trot|Populated
Place|VA|51|Highland|091|382812N|0793156W|38.4701196|-79.5322693||||768|2520|Monterey|09/28/1979
|
1481852|Blue Grass|Populated
Place|VA|51|Highland|091|383000N|0793259W|38.5001188|-79.5497702||||777|2549|Monterey|09/28/1979
|

Number of items found:
6

--------------------------------------------------------------------------------
;
;debug  pool
; Let's import a larger dataset [wait a second, VA_Bath has 520 records, why didn't all of them
get imported? explain this in your report]
Command 25: import     ./VA_Bath.txt

Imported Features by name : 41
Longest probe sequence : 4
Imported Locations : 41
Average name length : 18

--------------------------------------------------------------------------------
; as import command bypasses the buffer pool, content of the buffer pool should remain intact
;debug  pool
;
; Exiting
Command 26: quit

End time: Fri Dec  9 21:59:56 2022
```

```
Course Project for COMP 8042
Student Name: Paul Cavallo, Student Id: A01061713
Begin of GIS Program log:
dbFile: database.txt
logFile: logtest.txt
scriptFile: script01.txt
Start time: Fri Dec 09 23:27:40 2022

; Script 1
;
; Testing using a small dataset
;
; Specify boundaries of coordinate space:
;
World boundaries are set to: 38.500000      -79.758331  -79.441666      38.166668
;world  1130000W    0690000W    300000N 440000N
;
; Import the dataset [the address here is a relative address]
Command 1: import   ./VA_Monterey.txt

Imported Features by name : 63
Longest probe sequence : 3
Imported Locations : 63
Average name length : 17

--------------------------------------------------------------------------------
;
; Lets visualize our already imported geographical data [this is an optional command]
;debug  world
;
; Also lets see what is inside name and coordinate indices
;debug  quad
;debug  hash
;
; To fill out the cache, let's do a single-match location search
Command 2: what_is_at   382812N 0793156W

1496110|Possum Trot|Populated Place|VA|51|Highland|091|382812N|0793156W|38.4701196|-79.5322693||||768|2520|Monterey|09/28/1979|

--------------------------------------------------------------------------------
;
; Now lets see if our cache is filled up
;debug  pool
;
; A few more search queries
Command 3: what_is  Church  VA

Nothing Found
```

```
49
50  ----------------------------------------------------------------------------------------
51  ; oops Church is "FEATURE_CLASS" how about the following query?
52  Command 4: what_is  Central Church  VA
53
54  1482434|Central Church|Church|VA|51|Highland|091|382953N|0793323W|38.4981744|-79.5564371||||773|2536|Monterey|09/28/1979|
55
56  ----------------------------------------------------------------------------------------
57  Command 5: what_is  Town of Monterey    VA
58
59  2391311|Town of Monterey|Civil|VA|51|Highland|091|382442N|0793451W|38.4115829|-79.580854||||884|2900|Monterey|02/19/2008|
60
61  ----------------------------------------------------------------------------------------
62  Command 6: what_is  Smith Field VA
63
64  1498741|Smith Field|Airport|VA|51|Highland|091|381809N|0793029W|38.3026237|-79.5081001||||617|2024|Monterey SE|09/01/1992|
65
66  ----------------------------------------------------------------------------------------
67  ; Let's try a wrong state abbreviation
68  Command 7: what_is  Smith Field CO
69
70  Nothing Found
71
72  ----------------------------------------------------------------------------------------
73  ;
74  ; Lets check the buffer pool again
75  ;debug  pool
76  ;
77  ; So lets check the LRU mechanism [this query should move the last element of the cache all the way to the front!]
78  Command 8: what_is_at   382812N 0793156W
79
80  1496110|Possum Trot|Populated Place|VA|51|Highland|091|382812N|0793156W|38.4701196|-79.5322693||||768|2520|Monterey|09/28/1979|
81
82  ----------------------------------------------------------------------------------------
83  ;
84  ; checking the buffer pool again
85  ;debug  pool
86  ;
87  ; More location searches
88  Command 9: what_is_at   381816N 0793700W
89
90  Nothing Found
91
92  ----------------------------------------------------------------------------------------
93  Command 10: what_is_at  381816N 0793708W
94
95  1496325|Trimble|Populated Place|VA|51|Highland|091|381816N|0793708W|38.3045674|-79.618937||||777|2549|Monterey SE|09/28/1979|
96
```

```
96
97  ----------------------------------------------------------------------------------------
98  Command 11: what_is_at  381612N 0793256W
99
100 1495400|Clover Creek|Populated Place|VA|51|Highland|091|381612N|0793256W|38.2701242|-79.5489345||||570|1870|Monterey SE|09/28/1979|
101
102 ----------------------------------------------------------------------------------------
103 Command 12: what_is_at  382951N 0793238W
104
105 1484574|Key Run|Stream|VA|51|Highland|091|382951N|0793238W|38.4976189|-79.5439366|383250N|0793223W|38.5473399|-79.5397706|754|2474|Monterey|09/28/1979|
106
107 ----------------------------------------------------------------------------------------
108 ; We expect two location matches for this one
109 ;
110 Command 13: what_is_at  382856N 0793031W
111
112 1483492|Forks of Waters|Locale|VA|51|Highland|091|382856N|0793031W|38.4823417|-79.5086575||||705|2313|Monterey|09/28/1979|
113 1487661|Strait Creek|Stream|VA|51|Highland|091|382856N|0793031W|38.4823417|-79.5086575|382442N|0793222W|38.4116667|-79.5394444|705|2313|Monterey|09/28/1979|
114
115 ----------------------------------------------------------------------------------------
116 ; Now performing some area search [this should return 7 features]
117 ;
118 Command 14: what_is_in  382812N 0793156W    60  90
119
120 1484722|Laurel Run|Stream|VA|51|Highland|091|382725N|0793159W|38.4570643|-79.5331025|382801N|0793331W|38.4669444|-79.5586111|766|2513|Monterey|09/28/1979|
121 1486118|Peck Run|Stream|VA|51|Highland|091|382806N|0793109W|38.4684531|-79.5192132|382634N|0792932W|38.4428984|-79.4922677|728|2388|Monterey|09/28/1979|
122 1488473|Wooden Run|Stream|VA|51|Highland|091|382718N|0793201W|38.45512|-79.5336581|382612N|0792930W|38.4367874|-79.491712|760|2493|Monterey|09/28/1979|
123 1496110|Possum Trot|Populated Place|VA|51|Highland|091|382812N|0793156W|38.4701196|-79.5322693||||768|2520|Monterey|09/28/1979|
124 1483647|Ginseng Mountain|Summit|VA|51|Highland|091|382850N|0793139W|38.480675|-79.527547||||978|3209|Monterey|09/28/1979|
125 1483492|Forks of Waters|Locale|VA|51|Highland|091|382856N|0793031W|38.4823417|-79.5086575||||705|2313|Monterey|09/28/1979|
126 1487661|Strait Creek|Stream|VA|51|Highland|091|382856N|0793031W|38.4823417|-79.5086575|382442N|0793222W|38.4116667|-79.5394444|705|2313|Monterey|09/28/1979|
127
128 Number of items found:
129 7
130
131 ----------------------------------------------------------------------------------------
132 ; checking the buffer pool again
133 ; how about querying somewhere outside boundaries ?
134 Command 15: what_is_in  382012N 0792330W    60  90
135
136 Out of bounds
137
```

```
137
138 ----------------------------------------------------------------------------------------
139 ; Let's try some variations of a single-match region search with a square region:
140 Command 16: what_is_in  382148N 0793109W    15  15
141
142 1484896|Little Doe Hill|Summit|VA|51|Highland|091|382148N|0793109W|38.3634555|-79.5192122||||988|3241|Monterey SE|09/28/1979|
143
144 Number of items found:
145 1
146
147 ----------------------------------------------------------------------------------------
148 Command 17: what_is_in  -long   382148N 0793109W    15  15
149
150 Feature ID   : 1484896
151 Feature Name : Little Doe Hill
152 Feature Cat  : Summit
153 State        : VA
154 County       : Highland
155 Longitude    : 382148N
156 Latitude     : 0793109W
157 Elev in ft   : 3241
158 USGS Quad    : Monterey SE
159 Date created : 09/28/1979
160
161
162 Number of items found:
163 1
164
165 ----------------------------------------------------------------------------------------
166 ; Let's try increasing the size of the region:
167 Command 18: what_is_in  382148N 0793109W    60  60
168
169 1484896|Little Doe Hill|Summit|VA|51|Highland|091|382148N|0793109W|38.3634555|-79.5192122||||988|3241|Monterey SE|09/28/1979|
170 1486995|Seldom Seen Hollow|Valley|VA|51|Highland|091|382145N|0793031W|38.3626223|-79.5086563|382227N|0793004W|38.3741667|-79.5011111|750|2461|Monterey SE|09/28/1979|
171
172 Number of items found:
173 2
174
```

```
174
175  ----------------------------------------------------------------------------------------
176  Command 19: what_is_in  382148N 0793109W    120 120
177
178  1495244|Bear Mountain|Summit|VA|51|Highland|091|382012N|0793254W|38.3367894|-79.5483795|||||1076|3530|Monterey SE|09/28/1979|
179  1484896|Little Doe Hill|Summit|VA|51|Highland|091|382148N|0793109W|38.3634555|-79.5192122|||||988|3241|Monterey SE|09/28/1979|
180  1486995|Seldom Seen Hollow|Valley|VA|51|Highland|091|382145N|0793031W|38.3626223|-79.5086563|382227N|0793004W|38.3741667|-79.5011111|750|2461|Monterey SE|09/28/1979|
181  1495470|Doe Hill|Summit|VA|51|Highland|091|382313N|0793113W|38.3870661|-79.5203237|||||1210|3970|Monterey|09/28/1979|
182
183  Number of items found:
184  4
185
186  ----------------------------------------------------------------------------------------
187  Command 20: what_is_in  382148N 0793109W    180 180
188
189  1482110|Buck Hill|Summit|VA|51|Highland|091|381902N|0793358W|38.3173452|-79.5661577|||||1003|3291|Monterey SE|09/28/1979|
190  1495244|Bear Mountain|Summit|VA|51|Highland|091|382012N|0793254W|38.3367894|-79.5483795|||||1076|3530|Monterey SE|09/28/1979|
191  1484896|Little Doe Hill|Summit|VA|51|Highland|091|382148N|0793109W|38.3634555|-79.5192122|||||988|3241|Monterey SE|09/28/1979|
192  1486995|Seldom Seen Hollow|Valley|VA|51|Highland|091|382145N|0793031W|38.3626223|-79.5086563|382227N|0793004W|38.3741667|-79.5011111|750|2461|Monterey SE|09/28/1979|
193  1495470|Doe Hill|Summit|VA|51|Highland|091|382313N|0793113W|38.3870661|-79.5203237|||||1210|3970|Monterey|09/28/1979|
194  1673781|Strait Creek School (historical)|School|VA|51|Highland|091|382447N|0793217W|38.4131765|-79.5381022|||||935|3068|Monterey|11/13/1995|
195
196  Number of items found:
197  6
198
199  ----------------------------------------------------------------------------------------
200  Command 21: what_is_in  -long   382148N 0793109W    180 180
201
202  Feature ID   : 1482110
203  Feature Name : Buck Hill
204  Feature Cat  : Summit
205  State        : VA
206  County       : Highland
207  Longitude    : 381902N
208  Latitude     : 0793358W
209  Elev in ft   : 3291
210  USGS Quad    : Monterey SE
211  Date created : 09/28/1979
212
213  Feature ID   : 1495244
214  Feature Name : Bear Mountain
215  Feature Cat  : Summit
216  State        : VA
217  County       : Highland
218  Longitude    : 382012N
219  Latitude     : 0793254W
220  Elev in ft   : 3530
```

```
220   Elev in ft   : 3530
221   USGS Quad    : Monterey SE
222   Date created : 09/28/1979
223
224   Feature ID   : 1484896
225   Feature Name : Little Doe Hill
226   Feature Cat  : Summit
227   State        : VA
228   County       : Highland
229   Longitude    : 382148N
230   Latitude     : 0793109W
231   Elev in ft   : 3241
232   USGS Quad    : Monterey SE
233   Date created : 09/28/1979
234
235   Feature ID   : 1486995
236   Feature Name : Seldom Seen Hollow
237   Feature Cat  : Valley
238   State        : VA
239   County       : Highland
240   Longitude    : 382145N
241   Latitude     : 0793031W
242   Elev in ft   : 2461
243   USGS Quad    : Monterey SE
244   Date created : 09/28/1979
245
246   Feature ID   : 1495470
247   Feature Name : Doe Hill
248   Feature Cat  : Summit
249   State        : VA
250   County       : Highland
251   Longitude    : 382313N
252   Latitude     : 0793113W
253   Elev in ft   : 3970
254   USGS Quad    : Monterey
255   Date created : 09/28/1979
256
257   Feature ID   : 1673781
258   Feature Name : Strait Creek School (historical)
259   Feature Cat  : School
260   State        : VA
261   County       : Highland
262   Longitude    : 382447N
263   Latitude     : 0793217W
264   Elev in ft   : 3068
```

```
Elev in ft   : 3068
USGS Quad    : Monterey
Date created : 11/13/1995


Number of items found:
6

----------------------------------------------------------------------------------------
Command 22: what_is_in  -filter structure   382600N 0793310W    120 120

1484097|Highland High School|School|VA|51|Highland|091|382426N|0793444W|38.4071387|-79.5789333||||879|2884|Monterey|09/28/1979|09/15/2010
1673775|Highland Elementary School|School|VA|51|Highland|091|382427N|0793446W|38.4074301|-79.579567|||||878|2881|Monterey|11/13/1995|09/15/2010
1673777|Monterey Methodist Episcopal Church|Church|VA|51|Highland|091|382442N|0793446W|38.4117874|-79.5794924||||880|2887|Monterey|11/13/1995|
1481345|Asbury Church|Church|VA|51|Highland|091|382607N|0793312W|38.4353981|-79.5533807||||818|2684|Monterey|09/28/1979|
1487013|Seybert Chapel|Church|VA|51|Highland|091|382512N|0793225W|38.4201208|-79.5403246||||891|2923|Monterey|09/28/1979|
1673781|Strait Creek School (historical)|School|VA|51|Highland|091|382447N|0793217W|38.4131765|-79.5381022||||935|3068|Monterey|11/13/1995|
1487894|Thorny Bottom Church|Church|VA|51|Highland|091|382704N|0793141W|38.4512312|-79.5281022||||784|2572|Monterey|09/28/1979|

Number of items found:
7

----------------------------------------------------------------------------------------
Command 23: what_is_in  -filter water   382850N 0793030W    120 240

1487250|Simmons Run|Stream|VA|51|Highland|091|382654N|0793209W|38.4484534|-79.5358803|382643N|0793431W|38.4452778|-79.5752778|780|2559|Monterey|09/28/1979|
1488259|West Strait Creek|Stream|VA|51|Highland|091|382653N|0793204W|38.4481757|-79.5344913|382525N|0793553W|38.4236111|-79.5980556|779|2556|Monterey|09/28/1979|
1484722|Laurel Run|Stream|VA|51|Highland|091|382725N|0793159W|38.4570643|-79.5331025|382801N|0793331W|38.4669444|-79.5586111|766|2513|Monterey|09/28/1979|
1486118|Peck Run|Stream|VA|51|Highland|091|382806N|0793109W|38.4684531|-79.5192132|382634N|0792932W|38.4428984|-79.4922677|728|2388|Monterey|09/28/1979|
1488473|Wooden Run|Stream|VA|51|Highland|091|382718N|0793201W|38.45512|-79.5336581|382612N|0792930W|38.4367874|-79.491712|760|2493|Monterey|09/28/1979|
1487661|Strait Creek|Stream|VA|51|Highland|091|382856N|0793031W|38.4823417|-79.5086575|382442N|0793222W|38.4116667|-79.5394444|705|2313|Monterey|09/28/1979|
1483281|Elk Run|Stream|VA|51|Highland|091|382936N|0793153W|38.4934524|-79.5314362|383121N|0793056W|38.5226185|-79.5156027|757|2484|Monterey|09/28/1979|
1483527|Frank Run|Stream|VA|51|Highland|091|382953N|0793310W|38.4981744|-79.5528258|383304N|0793341W|38.5512285|-79.5614381|780|2559|Monterey|09/28/1979|
1484574|Key Run|Stream|VA|51|Highland|091|382951N|0793238W|38.4976189|-79.5439366|383250N|0793223W|38.5473399|-79.5397706|754|2474|Monterey|09/28/1979|

Number of items found:
9

----------------------------------------------------------------------------------------
Command 24: what_is_in  -filter pop 382000N 0793530W    3600    3600

1495400|Clover Creek|Populated Place|VA|51|Highland|091|381612N|0793256W|38.2701242|-79.5489345||||570|1870|Monterey SE|09/28/1979|
1496325|Trimble|Populated Place|VA|51|Highland|091|381816N|0793708W|38.3045674|-79.618937||||777|2549|Monterey SE|09/28/1979|
1498517|Monterey|Populated Place|VA|51|Highland|091|382444N|0793450W|38.4123429|-79.5806036||||882|2894|Monterey|09/28/1979|03/17/2008
1496000|New Hampden|Populated Place|VA|51|Highland|091|382934N|0793348W|38.4928967|-79.5633816||||792|2598|Monterey|09/28/1979|
1496110|Possum Trot|Populated Place|VA|51|Highland|091|382812N|0793156W|38.4701196|-79.5322693||||768|2520|Monterey|09/28/1979|
1481852|Blue Grass|Populated Place|VA|51|Highland|091|383000N|0793259W|38.5001188|-79.5497702||||777|2549|Monterey|09/28/1979|

Number of items found:
6

----------------------------------------------------------------------------------------
;
;debug  pool
; Let's import a larger dataset [wait a second, VA_Bath has 520 records, why didn't all of them get imported? explain this in your report]
Command 25: import  ./VA_Bath.txt

Nothing imported - likely out of bounds

----------------------------------------------------------------------------------------
; as import command bypasses the buffer pool, content of the buffer pool should remain intact
;debug  pool
;
; Exiting
Command 26: quit

End time: Fri Dec 09 23:27:40 2022
```