Municipal and Industrial Pumping

Prepared By:
The Flatwater Group, Inc

1. Introduction

1.1. Authorization

The Flatwater Group, Inc. (TFG) has prepared this as authorized in the contract between the Nebraska Department of Natural Resources (DNR) and TFG originally dated 9 August 2010.

1.2. Purpose and Scope

Municipal and industrial (M&I) pumping is a small but significant element crucial to the acumen of a robust conjunctive management model. While not encompassing as much spatial area as other parts of the Regionalized Soil Water Balance model (RSWB); the impact of M&I pumping can be substantial in localized area. The M&I development process is shown in figure 1.

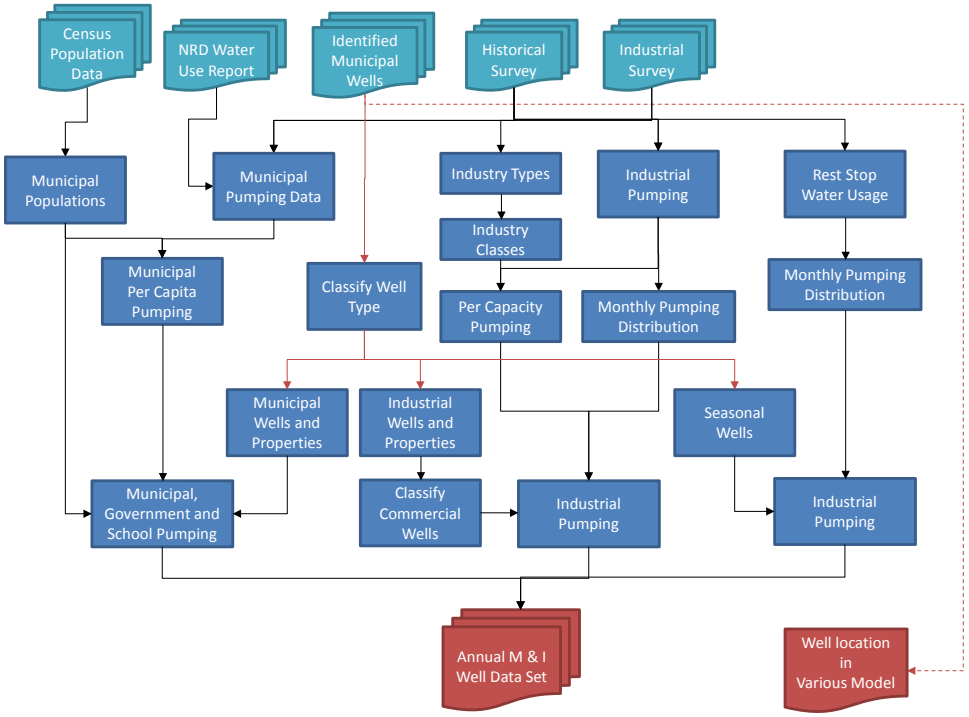


Figure 1. The development process for the M&I state-wide data set.

TFG received a statewide shapefile of registered groundwater wells designated as either Commercial (C) or Public (P or U) from the Nebraska Department of Natural Resources (NDNR). The process to develop the industrial and municipal withdrawals included drawing on data from multiple sources. The Department of Natural Resources (DNR) and the natural resource districts (NRDs) in the COHYST model area (Central Platte NRD, Tri-Basin NRD, Twin Platte NRD) provided pumping measurements and estimates; and additionally the spatial location of the wells. United States Census Bureau data was downloaded from the Nebraska Department of Economic Development website.

DNR circulated two types of water use surveys to industries throughout the COHYST model area. The first type was title “Historical Surveys”. Information contained in the surveys includes the industry type,

monthly and or annual pumping, and the technique used to acquire the data (metered or estimated). Many of the industries surveyed received their water source from municipal water supplies; however, this information provided valuable insight into the volume of water that was withdrawn by the industry.

A second type of water use survey was sent to owners of registered industrial wells; "Industrial Surveys". The survey included a list of wells used at an industrial location; with the request for information on all pumping from any other wells supplying water to the industry. Additionally, the survey requested information on the type of industry, well properties, and the technique used to arrive at the reported pumping totals.

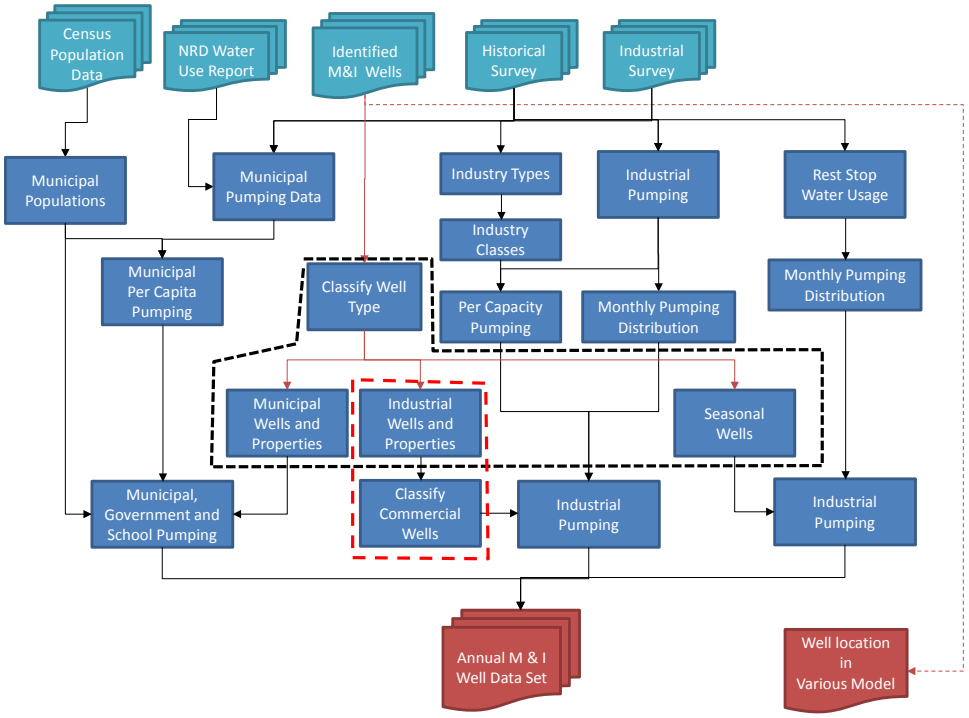
The inclusion of municipal pumping information in either the industrial or historical surveys was sparse. To supplement this limited information, data used in the development of the 2010 NRD water use reports from the TPNRD, CPNRD, and TBNRD was incorporated into the development of the M&I pumping data set.

The populations of the municipalities were acquired from the US Census Bureau for the years 1930-2010.

The statewide well coverage was overlaid with the 6 water basin model grids individually as well as the statewide model grid to determine the grid cells each well resided within. This tabular data was imported into a database where it is combined with the population data based on municipality. The total well capacity of a municipality is calculated to be used in the distribution process. A separate municipal well capacity is also calculate based on the model grid which the wells are located in. For instance, if a municipality has several wells located in one model grid and others located within another model grid, a separate capacity is calculated for each group of wells and associated with the appropriated model grid id.

This data was used in various forms to develop three different datasets depicting pumping estimates from municipalities and industries based upon the characteristics of the well and the type of industry using the well.

2. Well Classification



The first step was to classify all of the identified wells. Six different types of wells were readily identifiable based upon the owner of the well; public, commercial, seasonal, governmental, public interest, and educational.

- Public wells were defined as those wells that fed the municipalities.
- Commercial wells were owned by individual or companies whose was deemed as neither agricultural nor domestic in use. Examples included private business, power production facilities, golf courses, etc…
- The seasonal classification consisted of wells that provided water for items such as campgrounds or the Nebraska Game and Parks Commission.
- The governmental class includes wells for governmental services associated with public safety. These items include prisons, military installations, and law enforcement centers.
- Public Interest well mainly consisted of wells to meet the needs of the travellers and transportation. These wells included those owned by the Nebraska Department of Roads and the wells used to operate rest stops.
- Educational wells were wells that were owned by school districts or institutions of high learning.

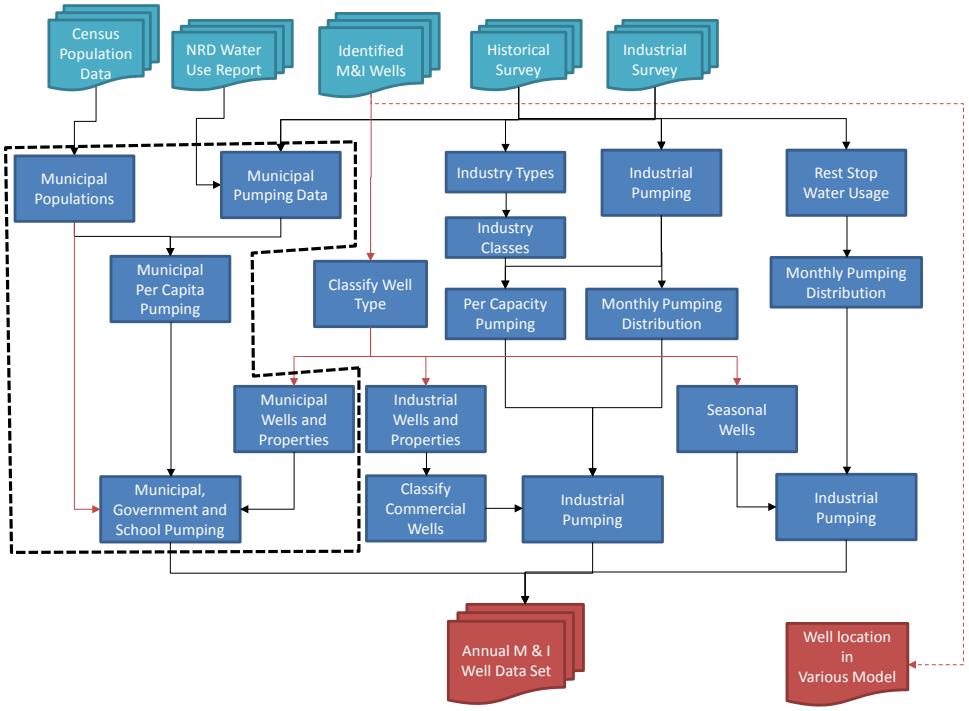
Unfortunately, this level of classification was not sufficient to match the well information with the available information from the data sources. To account for this these classes were further combined into three groups.

The educational and the governmental wells were combined with the public wells to form the municipal well group. Data limitations failed to provided enough information to independently develop estimates for the water usage by the entities described in the governmental or educational well classes. However, the presences of similar entities potentially exist within the constructs of the users of the public wells used to develop municipal pumping estimates.

Seasonal and public interest wells were combined as they were both deemed dependent upon the number of users with small amounts of net consumptive use.

The commercial wells are the only group included in the industrial well data set.

3. The Estimation of Municipal Pumping



The estimated pumping for municipal, governmental, and educational wells was developed using a per capita pumping values for the municipality to which the well belongs. By interpolating between the decadal populations retrieved from the 10 year census, an annual population was developed. The population in 2011-2012 was the product of extrapolating each town's population trend between 2000 and 2010.

$$pop_i = pop_1 + (pop_2 - pop_1)\left(\frac{year_i - year_1}{year_2 - year_1}\right)$$

pop	population
year	year
i	pertaining to the estimated year
1	first interpolating/extrapolating point
1	second interpolating/extrapolating point

Next, the municipal pumping data was organized by municipality. Using the annual population estimates, the per capita pumping was determined by dividing each monthly pumping value by the annual population. An average per capita pumping for each month was taken over the period of available pumping data. This process was repeated for each municipality. The list of municipalities is shown located in Appendix A.

An average monthly per capacity pumping distribution was developed for three groups based upon population. These however, did not differ significantly from a simple average over the entire set of municipalities. Therefore, the single average monthly per capita pumping distribution was utilized. The distribution is shown in Table 1.

Table 1. Monthly Per Capita Pumping

Month	Per Capita Pumping (Mgal/person)
Jan	0.0053
Feb	0.0048
Mar	0.0057
Apr	0.0066
May	0.0095
Jun	0.0119
Jul	0.0161
Aug	0.0134
Sep	0.0110
Oct	0.0079
Nov	0.0057
Dec	0.0054

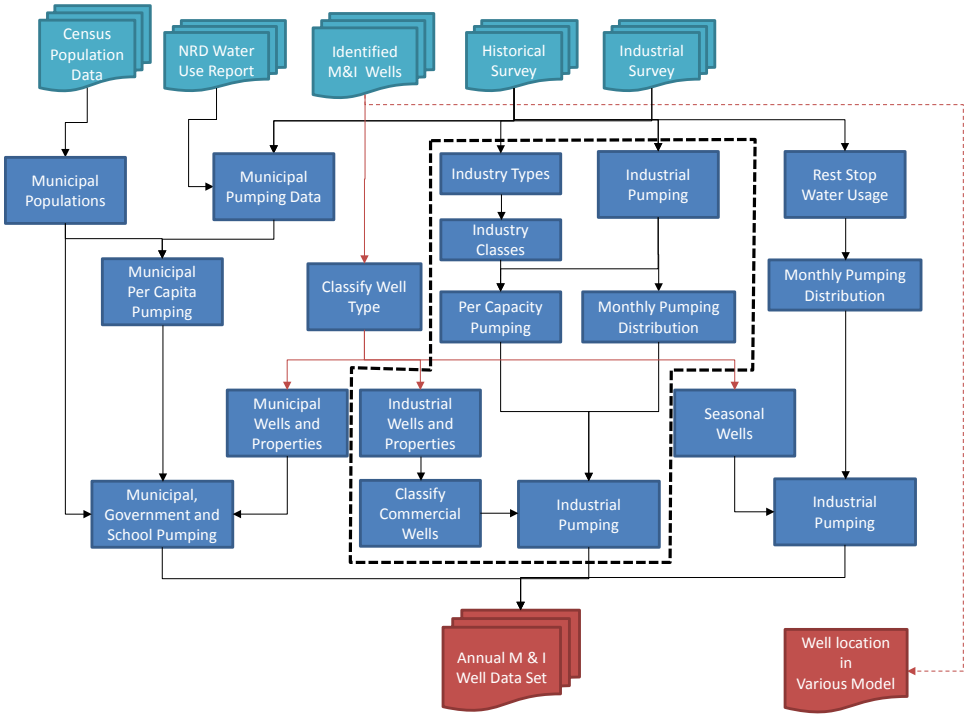
Having developed the monthly per capita pumping distribution and annual population estimates, the total volume of water pumped by the municipality can be estimated. This amount is then split between all active wells feeding the municipality, weighted by the relative capacity of the well.

$$P_{well,i} = Pop_j * P_{pc,i} * \frac{Cap_{well}}{Cap_{muni,j}}$$

$P_{well,i}$	Pumping for the well in month i
Pop_j	Population for the municipality in Year j
$P_{pc,i}$	Pumping per capita in month i
Cap_{well}	Capacity of the well
$Cap_{muni,j}$	Total capacity of the municipality in year j

The towns of Yankton, SD; Julesburg, CO; and Bern, KS all had water sources within the state of Nebraska. However, total pumping capabilities for these municipalities was unknown. Therefore, the populations were adjusted to 10%, 25%, and 25% respectively.

4. The Estimation of Industrial Pumping



Using the data collected by DNR in the Historical and Industrial Surveys, the following technique was developed to estimate industrial pumping volumes for the state-wide M&I dataset. The survey results provided water use information for 50 different industrial sites. The average annual volume of water usage and the average monthly pumping distribution were compiled for each industrial site. Also, when available the pumping capacity of the individual industry was obtained. This information was augmented with data relating to the industry from the Nebraska Well Registry.

The next step was to create and assigned different industrial categories to group similar types of water users. Twelve different classes were developed. Additionally two large water users, Western Sugar Cooperative and the Sutherland coal power plant, remained as unique groups. The different industrial classes are:

1. Western Sugar Cooperative
2. Ethanol Production
3. Golf Courses
4. Meat Packing and Animal Byproduct Manufacturing
5. Sand and Gravel
6. Confined Animal Feeding Operations (CAFO)
7. Construction
8. Power Plants

9. Small Manufacturing
10. Medium Manufacturing
11. Large Manufacturing
12. Small Business
13. Raceways
14. The Sutherland Coal Power Plant

As with any water user, even within an industry, the amount of water that is consumed varies for several reasons including: size, product, etc... Therefore, a technique was developed to estimate the per capacity annual pumping for each defined industrial class. This was accomplished first by determining the average annual volume of water used for each industrial class. Next the average total capacity per industrial class was computed. The industrial class per capacity pumping was the result of dividing the average industrial pumping by the average industrial capacity.

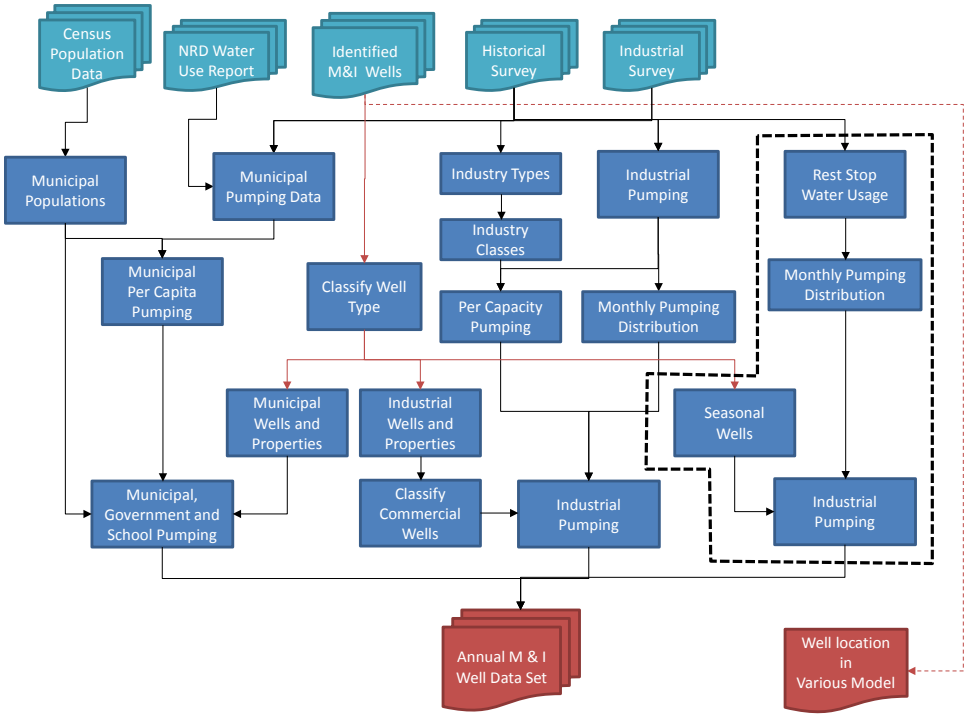
Finally the monthly distribution for each industry class was determined by averaging the distribution for each industry. Two exceptions existed, CAFO and power plant. All CAFOs reported that they were using the same volume of water throughout the year. Therefore, the CAFO water use was evenly distributed between the months. The power plant monthly distribution was developed using the monthly power production distribution from US Energy Information Administration for 2011-2012.

The next step was to assign the various industries within the well file to the corresponding industrial class. A short internet search was performed on each individual company. The results were used to classify the company to the correct group. Unfortunately, the sample of industries in the historical and industrial surveys was not sufficient to cover all types of industries within the state. Therefore, some rules were developed to classify the remaining businesses.

- Mining and Fossil Fuel extraction was classified as large industrial
- Agriculture production types were classified as golf course (nurseries, vegetable, etc…)
- Well drilling was classified with sand and gravel
- Game and Parks wells were classified as golf courses
- Unknown Business types were classified by total well capacity (gpm):
    - 0 – 350 small business
    - 350 – 600 small manufacturing
    - 600 – 1250 medium manufacturing
    - 1250 + large manufacturing

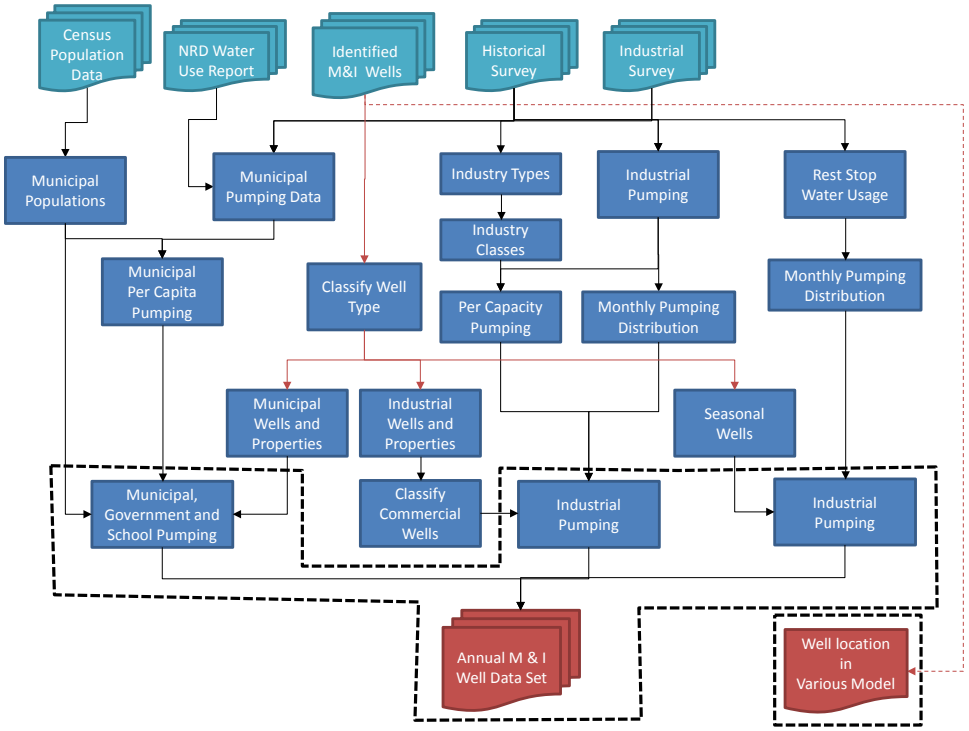
The appropriate per capacity pumping and monthly distribution was applied to each well to develop the industrial pumping data set from industrial wells.

5. The Estimation of Seasonal Industrial Pumping



The seasonal industrial pumping data set was developed based upon the results of the Rest Stop Water Usage from the Industrial Survey. The rest stop water data was developed based upon the per visitor water usage, with each visitor using 2.5 gal. The total monthly water usage was estimated for each rest area in the sample population. The monthly average over all sample rest areas was used to define the monthly pumping distribution for the seasonal industrial wells. The distribution was then applied to all seasonal wells to create the Seasonal Industrial Pumping data set.

6. Process Results



The results from the municipal pumping, industrial pumping, and seasonal industrial pumping are compiled to create the Annual M&I state wide data base. This file contains the well, the years and the volume of pumping that occurs from the well each month.

The Annual M&I state wide data base is to be used in combination with the well location file. The well location file contains the model cell ID for each RSWB model and the state-wide grid; Western Water Use Model (WWUM), Upper Niobrara White Model (UNW), the Central Nebraska Model (CNEB), the Blue Basin Model (BBM), COHYST, and the Missouri Tribs; in which the well is located.

Appendix A

The municipalities used to create the per capita pumping distribution are listed in Table A.1. Each month contains the average per capita pumping for each town over the time period when pumping records were available. The average population is also depicted over this same time period.

Table A.1. Municipality average per capita pumping values used to create the municipal per capita pumping distribution.

#	city	Ave Pop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Brady	396	0.005	0.006	0.005	0.007	0.014	0.017	0.028	0.022	0.016	0.009	0.005	0.005
2	Brule	367	0.005	0.004	0.004	0.006	0.010	0.013	0.016	0.014	0.010	0.006	0.004	0.005
3	Maxwell	311	0.004	0.004	0.005	0.005	0.006	0.009	0.010	0.008	0.005	0.005	0.003	0.004
4	Ogallala	4771	0.004	0.003	0.004	0.005	0.009	0.010	0.013	0.012	0.009	0.005	0.004	0.003
5	Paxton	554	0.004	0.004	0.005	0.006	0.009	0.010	0.014	0.014	0.010	0.007	0.005	0.004
6	Sutherland	1223	0.005	0.005	0.006	0.006	0.007	0.010	0.012	0.012	0.011	0.007	0.005	0.005
7	North Platte	24097	0.005	0.005	0.005	0.007	0.009	0.012	0.014	0.014	0.012	0.009	0.005	0.005
8	Axtell	711	0.005	0.004	0.005	0.006	0.009	0.012	0.019	0.015	0.011	0.008	0.005	0.005
9	Bertrand	778	0.005	0.005	0.005	0.007	0.012	0.014	0.024	0.017	0.015	0.009	0.006	0.005
10	Elwood	720	0.006	0.005	0.006	0.008	0.011	0.013	0.017	0.015	0.012	0.009	0.007	0.006
11	Funk	194	0.011	0.007	0.010	0.008	0.005	0.011	0.014	0.013	0.014	0.013	0.006	0.011
12	Loomis	382	0.004	0.005	0.005	0.008	0.014	0.020	0.029	0.021	0.016	0.008	0.005	0.004
13	Smithfield	62	0.004	0.004	0.005	0.005	0.007	0.008	0.012	0.012	0.010	0.012	0.005	0.005
14	Alda	631	0.004	0.004	0.004	0.004	0.007	0.010	0.012	0.010	0.008	0.005	0.004	0.004
15	Amherst	257	0.010	0.009	0.011	0.013	0.015	0.020	0.027	0.020	0.021	0.020	0.012	0.012
16	Cairo	786	0.004	0.004	0.004	0.005	0.008	0.010	0.015	0.012	0.009	0.006	0.004	0.004
17	Central City	2929	0.005	0.006	0.006	0.007	0.010	0.010	0.010	0.014	0.011	0.010	0.009	0.009
18	Cozad	4185	0.006	0.006	0.017	0.009	0.014	0.018	0.023	0.018	0.015	0.009	0.006	0.006
19	Doniphan	773	0.006	0.006	0.006	0.007	0.009	0.013	0.018	0.014	0.012	0.008	0.006	0.006
20	Duncan	346	0.006	0.003	0.003	0.009	0.012	0.010	0.011	0.009	0.007	0.005	0.003	0.003
21	Elm Creek	873	0.006	0.005	0.006	0.007	0.011	0.014	0.020	0.015	0.013	0.008	0.006	0.006
22	Eustis	427	0.006	0.005	0.005	0.008	0.014	0.018	0.025	0.019	0.017	0.010	0.006	0.005

#	city	Ave Pop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
23	Farnam	213	0.004	0.004	0.004	0.005	0.007	0.009	0.013	0.013	0.011	0.007	0.006	0.006
24	Gibbon	1785	0.006	0.005	0.006	0.006	0.005	0.009	0.011	0.009	0.008	0.008	0.007	0.004
25	Grand Island	44164	0.008	0.007	0.008	0.008	0.011	0.013	0.017	0.015	0.012	0.010	0.008	0.008
26	Gothenburg	3606	0.005	0.005	0.006	0.008	0.012	0.014	0.019	0.016	0.013	0.009	0.006	0.005
27	Kearney	28722	0.004	0.004	0.004	0.005	0.007	0.009	0.012	0.010	0.009	0.006	0.005	0.004
28	Lexington	9840	0.005	0.004	0.006	0.006	0.010	0.010	0.013	0.010	0.008	0.006	0.005	0.005
29	Overton	650	0.002	0.003	0.003	0.004	0.005	0.005	0.007	0.005	0.003	0.003	0.002	0.002
30	Riverdale	206	0.004	0.004	0.004	0.005	0.007	0.009	0.011	0.008	0.006	0.005	0.013	0.004
31	Shelton	1085	0.005	0.004	0.004	0.005	0.007	0.008	0.013	0.011	0.008	0.006	0.004	0.004
32	Wood River	1217	0.005	0.005	0.006	0.007	0.009	0.012	0.015	0.013	0.011	0.007	0.005	0.005

Appendix B

The list of industries from the historical or industrial surveys used to create the industrial classes and their distributions are shown in Table B.1.

Table B.1. Industrial sites used to create the industrial pumping data.

#	Name	Industrial Class
1	Gothenburg Feed Products Co	10
2	Chief Fabrication	10
3	Chief Buildings	10
4	Chief Agri Industrial	10
5	Chief Custom Products	10
6	Chief Automotive Systems Inc	12
7	Tyson Fresh Meats, Inc.	4
8	Diamond Plastics Corp	10
9	Pennington Seed, Inc	9
10	Consolidated Concrete, Co	5
11	Masonite Internatinoal Corp	9
12	Eilers Machine and Welding	9
13	L & S Industries, Inc	9
14	G Tech, Inc	9
15	Archer Daniels Midland Co.	9
16	Dy-NA Tool & Mold, Inc	10
17	Sutherland Industries	12
18	Monroe Auto Equipment Co	10
19	Consolidated Blenders Inc.	5
20	Island Dehy Co Inc.	10
21	Hornady Manufacturing Company	11
22	Orthman Manufacturing, Inc	9
23	West Company Inc.	11
24	Veetronix, Inc.	12
25	Electronic Display Systems	9
26	Baldwin Filters, Inc	10
27	Baldwin Filters	11
28	Big Flag Farm Supply Inc.	12
29	Western Sugar Cooperative	1
30	Werner	5
31	Wood Drive Dairy	6
32	Werner Construction	7
33	US 30 Speedway, LLC	13
34	KCC Feeding Inc.	6

#	Name	Industrial Class
35	Brown Sheep Company Inc	10
36	Alma Golf Course	3
37	Procter & Gamble	11
38	Nebraska Public Power District	8
39	Philips - Golf Course	3
40	Halimage Farms LLC	6
41	Nebraska Energy LLC	2
42	Agriculture Services Inc	10
43	Simon Contractors	5
44	Petersons Supermarket	12
45	Nitro Construction	7
46	Abengoa Bioenergy	2
47	Gibbon Packing Inc	4
48	Island Land Handlers	5
49	Nutra-Flo Company	10
50	Miscellaneous Ethanol Plant*	2

*By request of the ownership and to protect trade secrets, this name is being withheld from publication.

Appendix C

The list of industrial classes is shown in Table C.1. The table includes the average class annual pumping, the average class per capacity pumping, and the average portion of the annual pumping that occurs during each month.

#	Industrial Class	Annual Pumping (Mgal)	Per Capacity Pumping (gal/gpm)	Average Distribution of Annual Pumping											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Western Sugar Cooperative	1,463.786	221,786	0.107	0.084	0.096	0.055	0.038	0.037	0.050	0.063	0.081	0.142	0.120	0.126
2	Ethanol	311.029	112,150	0.083	0.073	0.080	0.082	0.083	0.084	0.091	0.087	0.085	0.090	0.081	0.081
3	Golf Course	17.390	53,922	-	-	0.038	0.066	0.085	0.094	0.131	0.192	0.178	0.160	0.056	-
4	Meat Packing and Animal ByProducts	614.104	372,185	0.081	0.079	0.084	0.074	0.081	0.088	0.085	0.093	0.087	0.084	0.083	0.080
5	Sand and Gravel	29.450	26,652	0.051	0.051	0.058	0.074	0.092	0.099	0.095	0.102	0.147	0.098	0.076	0.058
6	CAFO	39.541	36,111	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
7	Construction	0.110	109	-	-	0.044	0.108	0.108	0.216	0.201	0.137	0.137	0.049	-	-
8	Power Plant	6.760	193,143	0.084	0.084	0.080	0.089	0.098	0.112	0.108	0.090	0.083	0.082	0.090	-
9	Small Manufacturing	0.426	2,131	0.087	0.087	0.077	0.068	0.074	0.082	0.079	0.086	0.091	0.083	0.079	0.107
10	Medium Manufacturing	3.057	1,703	0.053	0.054	0.076	0.058	0.069	0.123	0.121	0.103	0.124	0.077	0.064	0.078
11	Large Manufacturing	78.822	43,912	0.093	0.090	0.095	0.077	0.076	0.077	0.079	0.082	0.080	0.083	0.080	0.088
12	Small Business	0.233	4,673	0.023	0.021	0.021	0.027	0.050	0.093	0.117	0.172	0.149	0.144	0.119	0.065
13	Raceway	0.120	400	-	-	0.038	0.066	0.085	0.094	0.131	0.192	0.178	0.160	0.056	-
14	Sutherland Power Plant	4,353.780	72,989	0.084	0.084	0.080	0.089	0.098	0.112	0.108	0.090	0.083	0.082	0.090	-

Appendix D

The seasonal industrial pumping is dependent upon the rest stop water use. The rest stops listed in Table D.1. were included in the development of the rest stop pumping distribution.

Table D.1. Rest stops included in the creation of the seasonal pumping distribution.

Station	County	City
Melia Hill	Sarpy	Gretna
Platte River	Cass	Greenwood
Lincoln Solar	Lancaster	Lincoln
York WB	York	York
York EB	York	York
Grand Island WB	Hall	Grand Island
Grand Island EB	Hall	Grand Island
Sutherland WB	Lincoln	Sutherland
Sutherland EB	Lincoln	Sutherland
Brady WB	Lincoln	Brady
Brady EB	Lincoln	Brady
Chappell WB	Duel	Chappell
Chappell EB	Duel	Chappell
Sidney WB	Cheyenne	Sidney
Sidney EB	Cheyenne	Sidney
Kimball EB	Kimball	Kimball
Kimball WB	Kimball	Kimball
Ogallala EB	Keith	Ogallala
Ogallala WB	Keith	Ogallala
Cozad EB	Dawson	Cozad
Cozad WB	Dawson	Cozad
Kearney EB	Buffalo	Kearney
Kearney WB	Buffalo	Kearney
Goehner WB	Seward	Goehner
Blue River EB	Seward	Milford

Table D.2. Monthly distribution of seasonal industrial pumping.

Mon	Pumping (gal)
Jan	30,799
Feb	29,426
Mar	43,174
Apr	48,037
May	61,025
Jun	69,021
Jul	84,227
Aug	65,488
Sep	57,772
Oct	54,188
Nov	44,495
Dec	37,589