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FOUNDRY SPATIAL

Water Allocation and Usage Report
Surface Water

Integrated Assessment of Water Resources for Unconventional Oil and Gas Plays, West-Central Alberta

October 30, 2014

Prepared by:
Foundry Spatial Ltd.
Victoria, BC

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EXECUTIVE SUMMARY

In Alberta, surface water resources support community, commercial, agricultural, industrial, and recreational uses, among others. Existing users of water must be considered when evaluating the potential of a given water source, along with the needs of the environment and business driven economic considerations. Water rights are administered by the province of Alberta, and are typically assigned for specific uses with specific time limits and conditions applied.

Existing water licenses are managed in a database, and have been analyzed by location, specific use, and quantity to provide insight into the state of allocations within the WCAB project study area.

The Project is a joint initiative of Petrel Robertson Consulting, Foundry Spatial, and Strategic West Energy, and is supported by the Petroleum Technology Alliance of Canada, the Canadian Association of Petroleum Producers, Canadian Natural Resources, Cequence Energy, Chevron Canada Resources, ConocoPhillips Canada, EnCana Corporation, Husky Energy, Mosaic Energy, NuVista Energy, Penn West Petroleum, Shell Canada and Talisman Energy.

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INTRODUCTION

The WCAB project area covers a variety of biogeoclimatic regions, and includes a concomitant range of water users. Water resources are currently managed by the Alberta Ministry of Environment and Sustainable Resource Development (AESRD) under the *Water Act* (1999), and as of March 29, 2014, also by the Alberta Energy Regulator for oil and gas activities (Water Act, 2014). The *Water Resources Act* (1931) preceded the *Water Act* (1999) and many licenses issued under this legislation are currently still in place.

Private landowners using water for agricultural purposes since before 1999 (up to 6,250 m^3/yr) or domestic purposes (up to 1,250 m^3/yr) are permitted to use water without approval, license, or registration, but must acquire an approval, license, or registration to acquire priority for their diversion under the First-In-Time First-In-Right (FITFIR) system originally implemented by the Dominion of Canada in the North West Irrigation Act (1894). Fresh water (<4,000 mg/l TDS) diverted from surface or groundwater sources for all other purposes must be done so with an approval, license, or registration in place. Under the Water Act (1999) domestic and household users are provided with statutory preference, which prioritizes their use of water over all other uses regardless of seniority.

Data for water rights were acquired during October 2013, and April 2014 from the AESRD. The total number of licenses active in each snapshot is shown in Table 1. These data form the basis of the assessment of use by purpose and river basin, and in all cases the data was first restricted to the extent of the project study area. Very large volumes of water associated with retired power generating plants on Wabamun Lake have been excluded from the analysis, as the plants have been decommissioned and the licenses have been retired, but still remain in the database (M. Seneka, personal communication, March 13, 2014). Small changes in the total number of licenses existing in the database between the snapshots were observed, and as such the focus of the analysis is primarily on the most current data.

Table 1. Total number of temporary and long term allocations in the study area.

Date	Surface Water	Groundwater	Total
October, 2013	19,631	10,648	30,277
April, 2014	19,326	10,786	30,112

Water allocations have been analyzed in four primary ways; (1) by using the fundamental drainage areas of the Atlas of Canada (Figure 1), (2) by allocation purpose, (3) by gauged hydrometric basin, and (4) by water type (surface or groundwater).

DATA AND ANALYSIS

Fundamental Drainage Areas

Within the Atlas of Canada, the National Scale Frameworks Hydrology – Drainage Areas, Canada dataset divides the Canadian land mass into progressively smaller drainage units (Figure 1). There are 11 major drainage areas corresponding to major river systems, 164 sub-drainage areas identifying major tributaries within the major river systems, and further subdivision into 978 sub-sub drainage areas approximately 5,000 – 10,000 km^2 each. These sub-sub drainage areas, also known as Fundamental Drainage Areas (FDA) are the same 34 units within the study area used for analysis of components of the water cycle in Year 1 of the project (Foundry Spatial 2013).

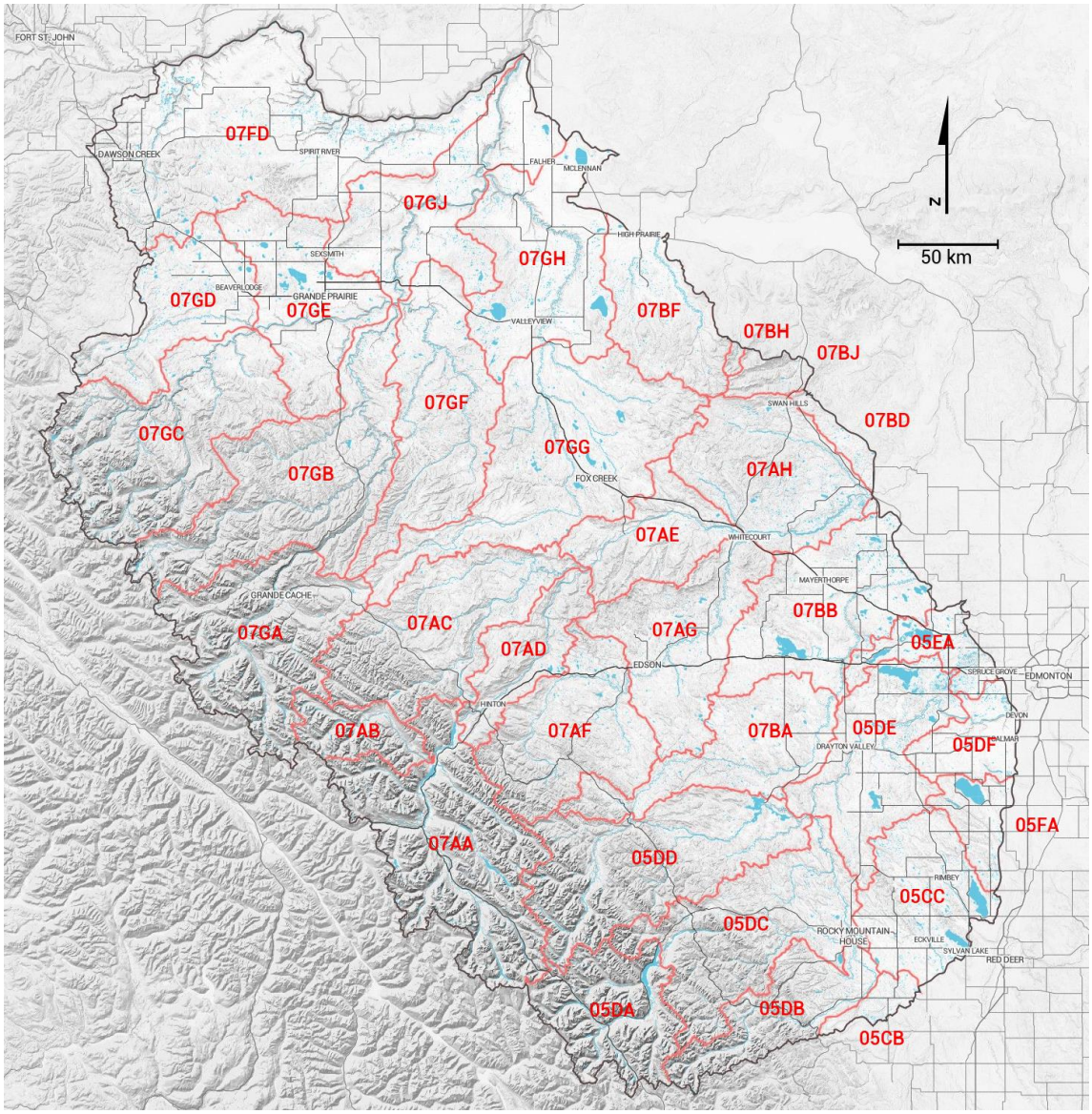

Figure 1. Fundamental Drainage Areas (FDA) within the study area.

Water rights are typically issued with specific approval volumes. These volumes may identify total volumes that may be diverted and consumed, as well as losses and returns. The individual allocations within each FDA have been summarized by license term. Most water currently allocated has been issued under a long term license rather than a temporary diversion (Figure 2).

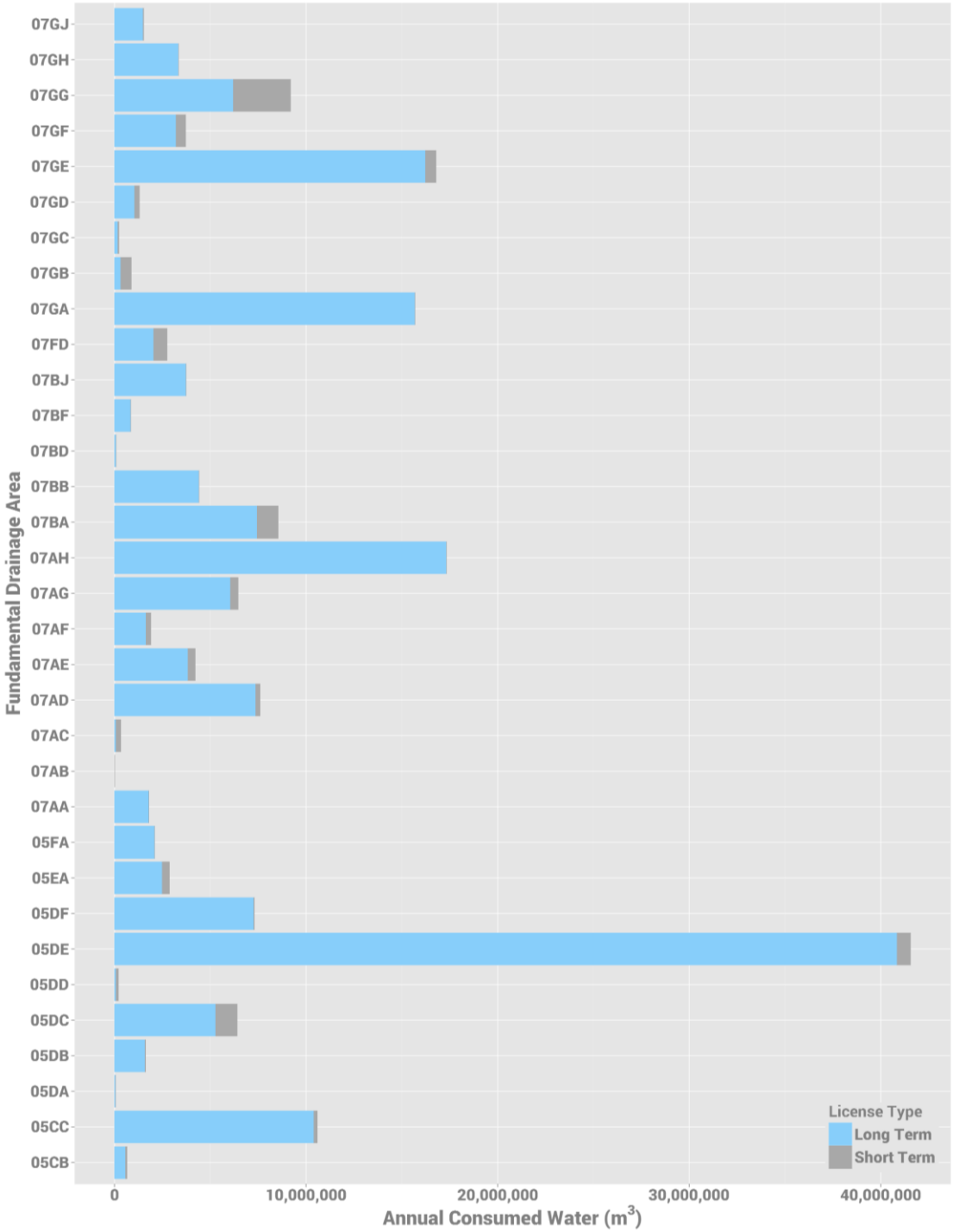

Figure 2. Total annual long term and short term licensed consumptive use in each FDA.

In the Little Smoky / Iosegun / Waskahigan FDA (07GG), there currently exists a higher percentage of short term authorizations, which are associated with shale and hydro-fracking purposes.

Allocation Purpose

Within the license database, specific purposes are identified for water approvals. For analysis, many individual purposes were grouped and standardized to improve understanding and pattern identification. Specific purposes were grouped by category for agriculture, commercial, municipal, and other and groupings are described in Table 2. Categories for shale fracking, oil/gas, oilfield injection, hydro-fracking, gas/petrochemical plants, and cooling were not grouped due to their size and/or relevance to oil and gas operations.

Table 2. License specific purposes and their grouping codes

Group	Specific Purpose
Agriculture	CROP
Agriculture	Crop (Grain)
Agriculture	FEEDLT
Agriculture	REGISTRY
Agriculture	STCKWT
Agriculture	Stockwatering
Agriculture	Traditional Agriculture User Registration
Commercial	AGGRE
Commercial	Aggregate Mining
Commercial	Aggregate Washing
Commercial	AGGWSH
Commercial	Bottling
Commercial	BTTLNG
Commercial	CNSTRCT
Commercial	CNSTRCTA
Commercial	Construction
Commercial	Gardening
Commercial	GLFCRS
Commercial	Golf Courses
Commercial	GRDN
Commercial	Groundwater Well – Water Hauling
Commercial	GWHAULNG
Commercial	Other (Abattoirs, dust control, bridge washing, hydroseeding)
Commercial	OTHR
Commercial	Parks
Commercial	PRK
Commercial	RCRTN
Cooling	COOLING
Gas/Petrochemical Plants	Gas/Petrochemical Plants
Gas/Petrochemical Plants	GAS/PTRO
Hydro-Fracking	Hydro-Fracking
Hydro-Fracking	HYFRAC
Municipal	CAMPA
Municipal	CAMPS
Municipal	CONDOD

Group	Specific Purpose
Oilfield Injection	INJECTN
Oilfield Injection	Oilfield Injection
Oil/Gas	Drilling (developing oil/gas wells)
Oil/Gas	OIL/GAS
Other	Drainage
Other	DRAINAGE
Other	FISHERY
Other	Fish, Fish Farms/Hatcheries
Other	FLOODCNT
Other	Flood Control
Other	FLOODCTR
Other	Hydro-Power
Other	HYDRPWR
Other	HYDTSTOG
Other	Recreation
Other	REMEDIA
Other	Remediation
Other	SOTHER
Other	Specified by the Director
Other	SRWILD
Other	Stabilization (lake level)
Other	STBLZTN
Other	Storage Reservoir for Wildlife
Other	Wetlands
Other	WTLNDS
Shale Fracking	SHALEFR
Shale Fracking	Shale Fracking

Municipal	Condominium
Municipal	COOPD
Municipal	Cooperative
Municipal	DRURAL
Municipal	INSTIT
Municipal	Institution
Municipal	MOTHER
Municipal	Other - Fire Protection
Municipal	Rural Drainage (Wetland, Farmland)
Municipal	SCHOOLS
Municipal	SNOW/ICE
Municipal	SUBDIVD
Municipal	URBAN

Some difference of codes (ie 'INJECTN', 'Oilfield Injection') was found between the two license databases provided by ESRD. We believe this is due to the data being extracted from two separate systems rather than from the presence of duplicative codes in the master database. This premise has not been confirmed and may warrant further investigation, however.

Commercial uses of water comprise the largest amount of total diversions in the study area on an annual basis. Over two thirds of these diversions are associated with three forestry operations, two on the Athabasca River and one on the Wapiti River. All three operations return the majority of their diverted water. Cooling operations for power plants have the second highest total diversion of water, and again return the majority of the water to source. Oilfield injection is the largest consumptive use of water in the region. The annual water allocated for all groups for consumption and diversion as of October 2013 and April 2014 is shown in Figure 3. Consumptive use by purpose and source (surface vs ground) is provided for each FDA in the appendix.

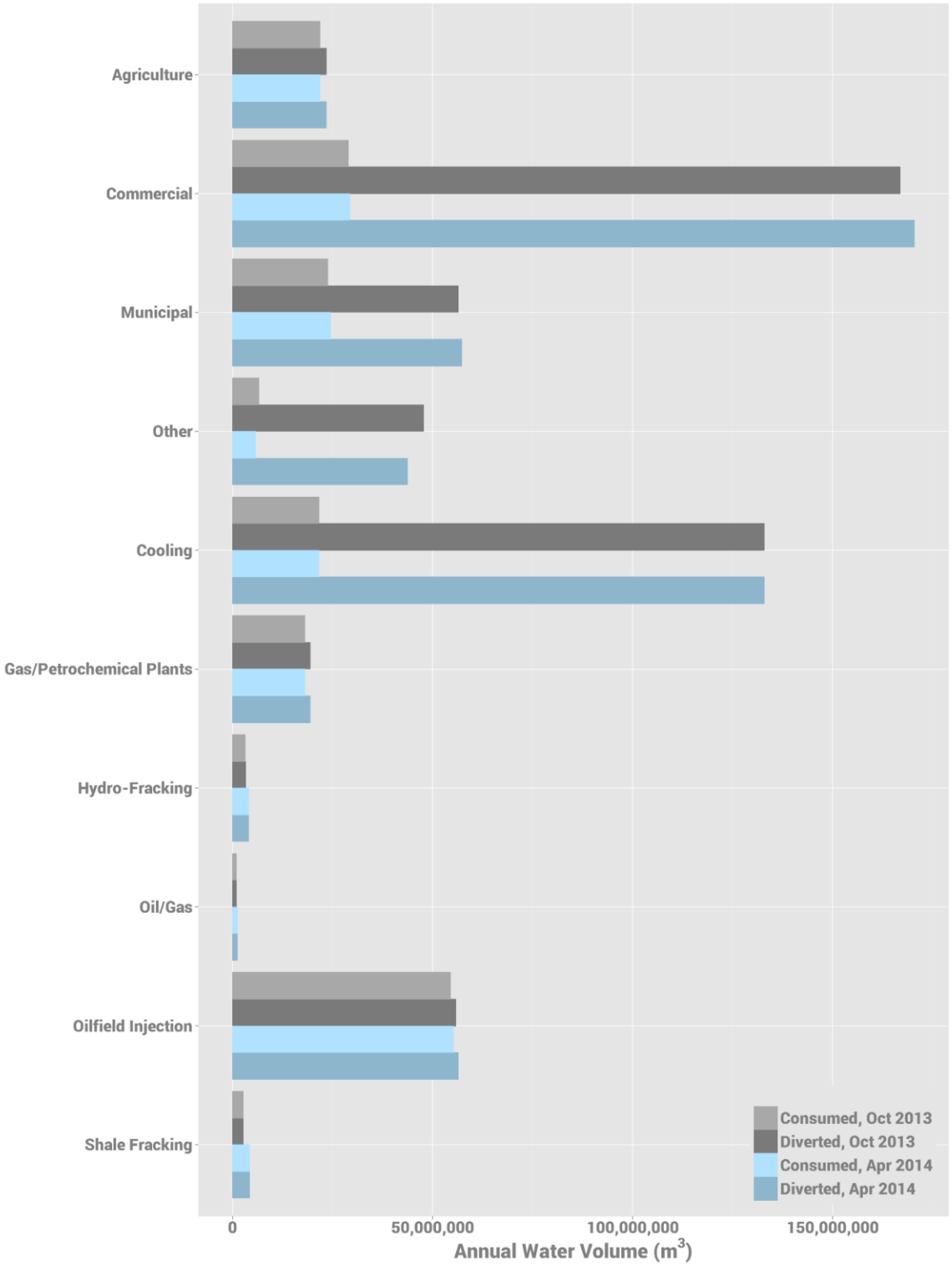

Figure 3. Total annual licensed diversion and consumptive use for purpose groups.

Most water users hold long term rights. As the nature of their operations is often transitory, oil/gas, hydro-fracking and shale fracking are the exceptions, with almost all of their water being sourced from short term approvals as shown in Figure 4.

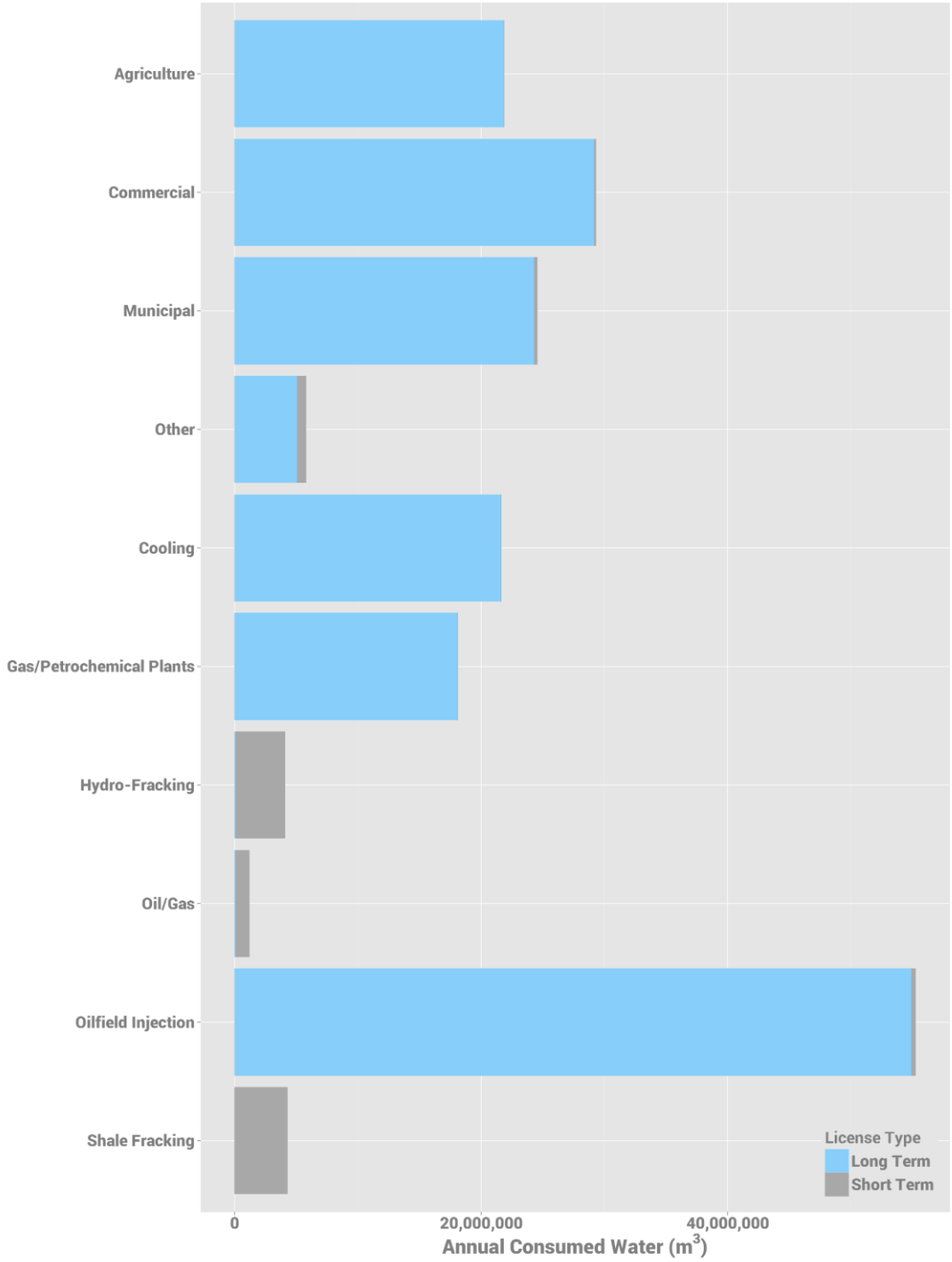

Figure 4. Total annual long term and short term licensed consumptive use per purpose groups.

Surface water is the primary source of water in the study area for all groups of water users with the exception of agriculture, which sources approximately 20% more water from groundwater sources than surface water bodies. Between the October 2013 and April 2014 dates of extraction, hydro-fracking and shale fracking were the only two purposes that experienced significant growth in volumes allocated (Figure 5).

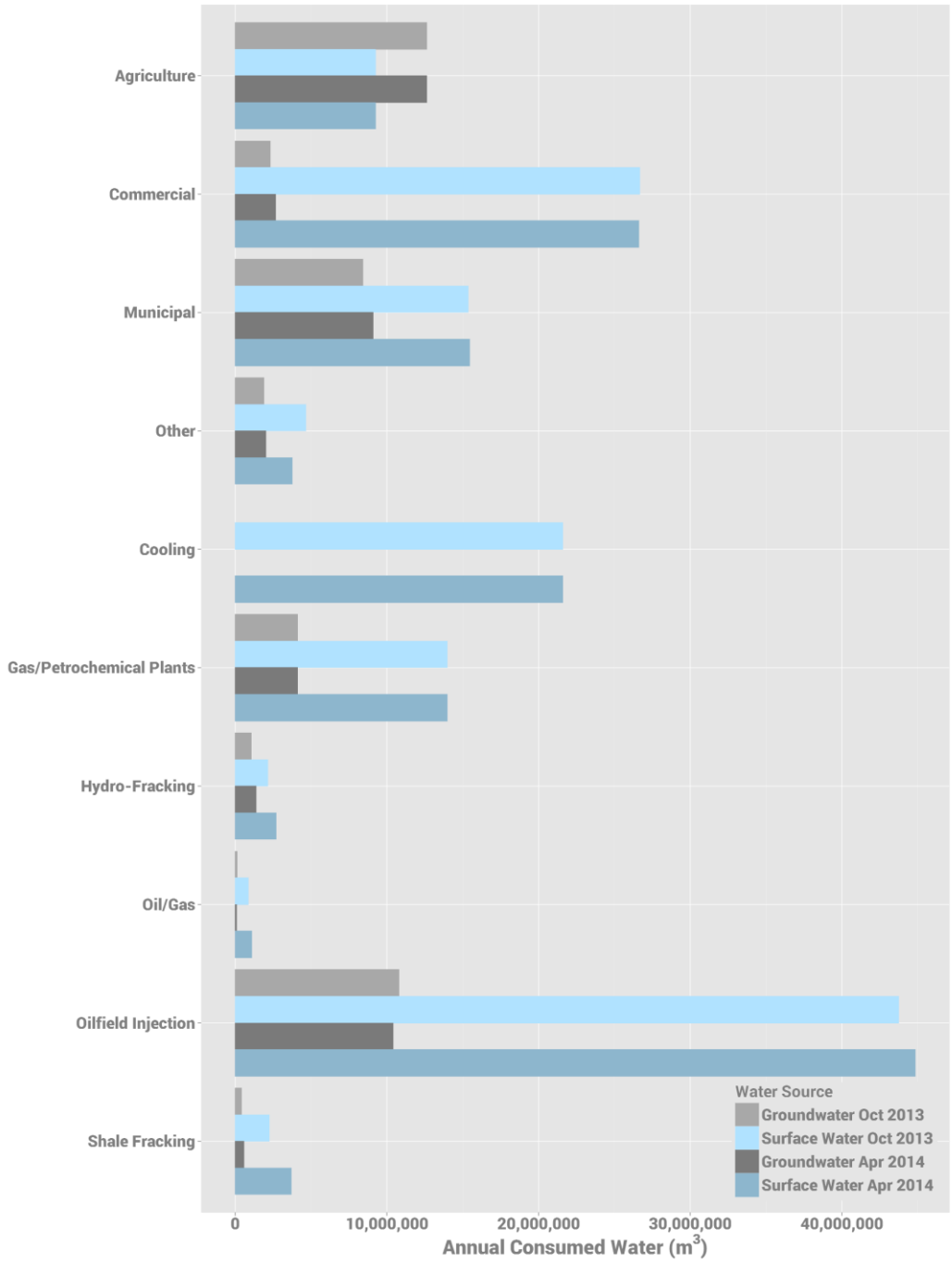

Figure 5. Total annual licensed consumptive use of surface and groundwater per purpose groups.

For the specific purposes hydro-fracking and shale fracking, trends between October 2013 and April 2014 within each FDA were investigated. Current allocations were in place within each FDA during at least one time period. Elevated water allocations were observed in the FDA near Fox Creek (07GG), west of Drayton Valley (07BA), and west of Rocky Mountain House (05DC). Water allocations for hydro-fracking and shale fracking comprise a significant percentage of gross water allocations within these FDA (Figure 6).

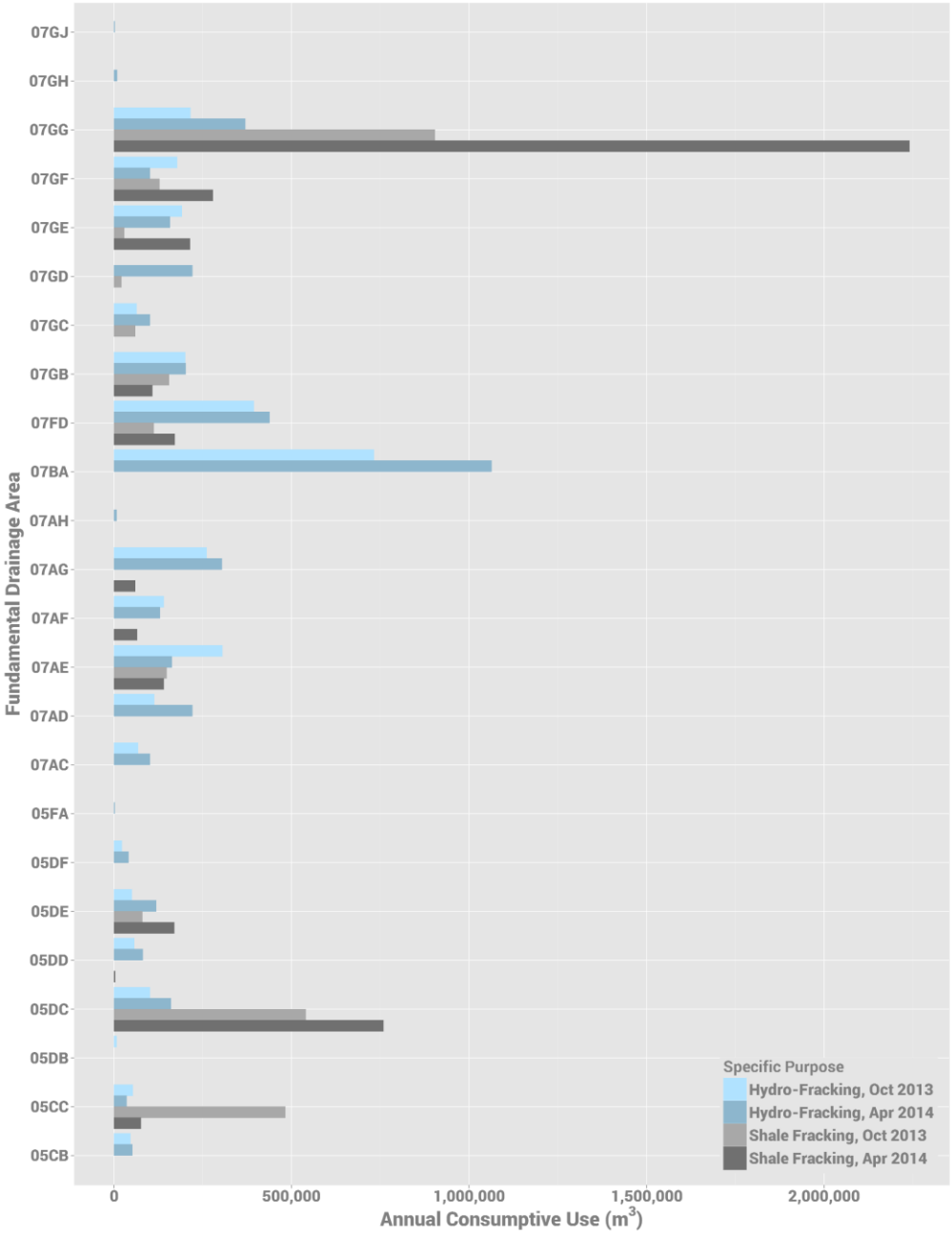

Figure 6. Annual licensed consumptive use and geographic distribution by FDA of Hydro-Fracking and Shale Fracking allocations.

While oil and gas associated water allocations may be expected to grow, gross volumes of water allocations there remain small at this time in comparison to the more heavily allocated FDA.

Gauged Hydrometric Basins

Within the project study area, data from 106 gauged hydrometric basins were incorporated in the final hydrologic modeling output. As part of the modeling process, mean annual runoff at the gauge was converted to area independent unit runoff. Watersheds associated with these gauges were used to query active water allocations, and gross annual diversion and consumptive use for water allocations within each watershed were converted to 'unit allocations' in mm to allow for comparison of water availability and allocations at the watershed scale.

Mean annual unit runoff in the gauged watersheds ranged from 20mm to 985mm per year. Of the 106 gauged hydrometric basins, 15 had no active allocations in April 2014. Of the remaining 91 basins, four had total maximum annual diversions of 10% or greater than mean annual runoff. These gauges are Wabamun Creek near Duffield (05DE003), Lalby Creek near Girouxville (07GJ005), Colquhoun Creek near Grande Prairie (07GE006), and Atim Creek near Spruce Grove (05EA009). Wabamun Creek is the only gauged basin within the project study area with a significant proportion of mean annual runoff allocated for consumptive use. Within the watershed, 26% of annual runoff is currently allocated for consumptive use. Of the 91 gauged basins, 85% have allocated consumptive use of 2% or less. Runoff, maximum annual diversion and consumptive use for each gauged basin are shown as unit values in Table 3.

Table 3. Gauged basins, runoff and allocations.

Watershed	Area (km²)	Unit Runoff (mm)	Maximum Annual Diversion (mm)	Consumptive Use (mm)	Max Ann. Diversion % of Unit Runoff,
05CC007	1910.0	70.10	2.10	1.64	3%
05CC008	345.7	103.83	0.74	0.66	1%
05CC009	249.3	70.94	6.13	6.01	9%
05CC010	62.4	67.92	1.08	1.08	2%
05CC013	799.3	78.41	2.18	1.73	3%
05DA006	1234.4	985.56	0.01	0.01	0%
05DA009	1866.7	950.24	0.03	0.03	0%
05DB002	846.6	167.44	1.17	1.16	1%
05DB003	1334.5	300.54	0.01	0.00	0%
05DB005	208.3	200.40	0.16	0.16	0%
05DB006	2245.1	235.69	0.22	0.22	0%
05DC001	10960.6	377.82	0.68	0.43	0%
05DC002	5096.8	545.34	0.13	0.13	0%
05DC006	1880.1	249.92	0.01	0.01	0%
05DC010	3838.5	663.29	0.02	0.02	0%
05DC012	1352.6	142.74	0.03	0.03	0%
05DD005	5699.2	328.78	0.03	0.03	0%
05DD009	871.9	176.68	0.02	0.02	0%
05DE003	487.2	19.83	5.43	5.14	27%
05DE006	20457.3	312.13	0.56	0.42	0%

Watershed	Area (km²)	Unit Runoff (mm)	Maximum Annual Diversion (mm)	Consumptive Use (mm)	Max Ann. Diversion % of Unit Runoff,
05DE007	545.2	104.20	1.01	0.97	1%
05DE009	103.0	55.80	0.30	0.30	1%
05DE010	22036.2	302.02	1.14	0.88	0%
05DE911	1174.8	75.87	2.71	2.41	4%
05DF004	601.3	44.93	2.38	2.21	5%
05DF008	204.3	34.93	2.07	1.04	6%
05EA009	218.1	21.02	2.61	1.27	12%
05EA010	123.8	57.84	2.25	2.08	4%
05FA019	388.2	33.35	1.59	1.55	5%
05FA912	85.3	51.61	1.35	0.86	3%
07AA001	628.5	505.47	2.55	2.55	1%
07AA002	3872.7	707.42	0.43	0.43	0%
07AA003	1136.2	413.64	0.00	0.00	0%
07AA009	585.8	783.93	0.01	0.01	0%
07AB002	1600.4	506.84	0.00	0.00	0%
07AC001	955.3	216.68	2.53	0.02	1%
07AC007	5678.1	200.05	0.48	0.06	0%
07AD002	9626.5	561.28	7.91	0.88	1%
07AE001	19411.2	411.44	4.26	0.64	1%
07AF002	2581.1	237.07	1.98	0.55	1%
07AF010	176.2	121.16	0.01	0.01	0%
07AF013	329.8	392.07	13.51	3.56	3%
07AF014	636.4	167.35	0.14	0.14	0%
07AF015	378.3	262.98	0.47	0.46	0%
07AG003	833.5	147.60	0.21	0.15	0%
07AG004	9125.0	147.59	1.36	0.74	1%
07AG007	7130.6	172.85	1.50	0.73	1%
07AG008	133.0	143.41	0.00	0.00	0%
07AH001	1671.7	163.99	6.48	6.13	4%
07AH002	432.2	79.00	0.01	0.01	0%
07AH003	1145.2	141.34	5.10	4.83	4%
07BA001	2875.3	162.85	2.19	2.11	1%
07BA002	618.1	123.69	1.36	1.36	1%
07BA003	102.8	260.27	24.44	22.37	9%
07BB002	4385.9	145.73	2.06	2.00	1%
07BB003	1556.5	90.93	0.64	0.56	1%
07BB004	616.5	73.04	1.52	0.50	2%
07BB005	432.3	55.95	1.13	1.04	2%
07BB009	165.7	34.43	0.60	0.58	2%
07BB011	255.0	79.02	0.16	0.16	0%
07BB014	48.9	33.82	1.27	1.27	4%
07BB903	115.0	36.55	0.59	0.59	2%
07BF001	1442.9	164.42	0.16	0.13	0%
07BF002	1159.9	118.28	0.84	0.25	1%
07BJ003	162.4	316.36	0.02	0.02	0%
07FD006	510.9	60.22	0.21	0.20	0%
07FD007	2865.4	68.19	0.29	0.21	0%
07FD910	13.0	20.95	0.10	0.10	0%

Watershed	Area (km²)	Unit Runoff (mm)	Maximum Annual Diversion (mm)	Consumptive Use (mm)	Max Ann. Diversion % of Unit Runoff,
07GA001	3806.2	620.92	0.01	0.00	0%
07GA002	713.2	233.08	0.05	0.05	0%
07GB001	839.1	199.41	0.00	0.00	0%
07GB003	3376.4	330.63	0.13	0.13	0%
07GC002	493.2	113.95	0.05	0.05	0%
07GD001	1652.7	44.96	3.31	0.60	7%
07GD002	689.7	41.71	2.06	0.28	5%
07GD004	1246.1	138.93	0.07	0.07	0%
07GE001	11254.2	266.64	0.65	0.18	0%
07GE003	135.8	65.84	0.15	0.15	0%
07GE005	1613.2	30.75	2.09	1.22	7%
07GE006	145.0	21.18	3.12	1.64	15%
07GE007	182.9	36.88	0.77	0.77	2%
07GF001	5028.8	143.80	0.83	0.73	1%
07GF004	36.9	77.46	0.00	0.00	0%
07GF006	18.2	53.78	0.41	0.41	1%
07GF008	616.6	224.64	4.36	4.01	2%
07GG001	1031.4	136.52	0.65	0.65	0%
07GG002	3004.1	179.10	1.80	1.80	1%
07GG003	1966.0	141.78	2.90	1.51	2%
07GH002	11084.2	129.13	1.33	1.02	1%
07GJ001	50006.8	211.15	2.37	1.04	1%
07GJ005	187.6	24.35	5.34	0.02	22%

The *Alberta Desktop Method for Determining Environmental Flows* suggests a maximum 15% instantaneous reduction in flow at conditions greater than the 80% exceedance natural flow. We would suggest that when comparing allocations within a basin with mean annual runoff, a threshold of 10% of annual runoff could be suitable for identifying watersheds with significant pre-existing allocations.

Other Notes on Water Allocations

Effective January 1, 1999, the *Water Act* came into effect in Alberta. This new legislation replaced the *Water Resources Act*, which had been in place since 1931, when legislative jurisdiction over water resources was passed from Canada to Alberta. The *Water Act* symbolized a shift in policy direction from demand to supply side management and included the provision for trading water licenses, with the exception of inter-basin transfers. Many licenses issued prior to 1999 were issued without expiry dates and fixed to specific parcels of land; long term licenses issued since 1999 are issued independent of land ownership, are for fixed terms, and upon completion either expire or must be renewed.

By volume, the majority of water rights currently held were issued prior to 1999 and are for indefinite terms. Limited variation exists in this pattern geographically amongst FDA. More distinct patterns exist when considering licensed volume by purpose. Water rights for cooling, gas/petrochemical plants, and oilfield injection purposes are predominantly held by licenses issued under the *Water Resources Act*

(1931), as are a majority of commercial allocations. For all other purposes, more water rights have been issued under the *Water Act (1999)*. The volumes of water allocated under each piece of legislation by purpose group are shown in Figure 7.

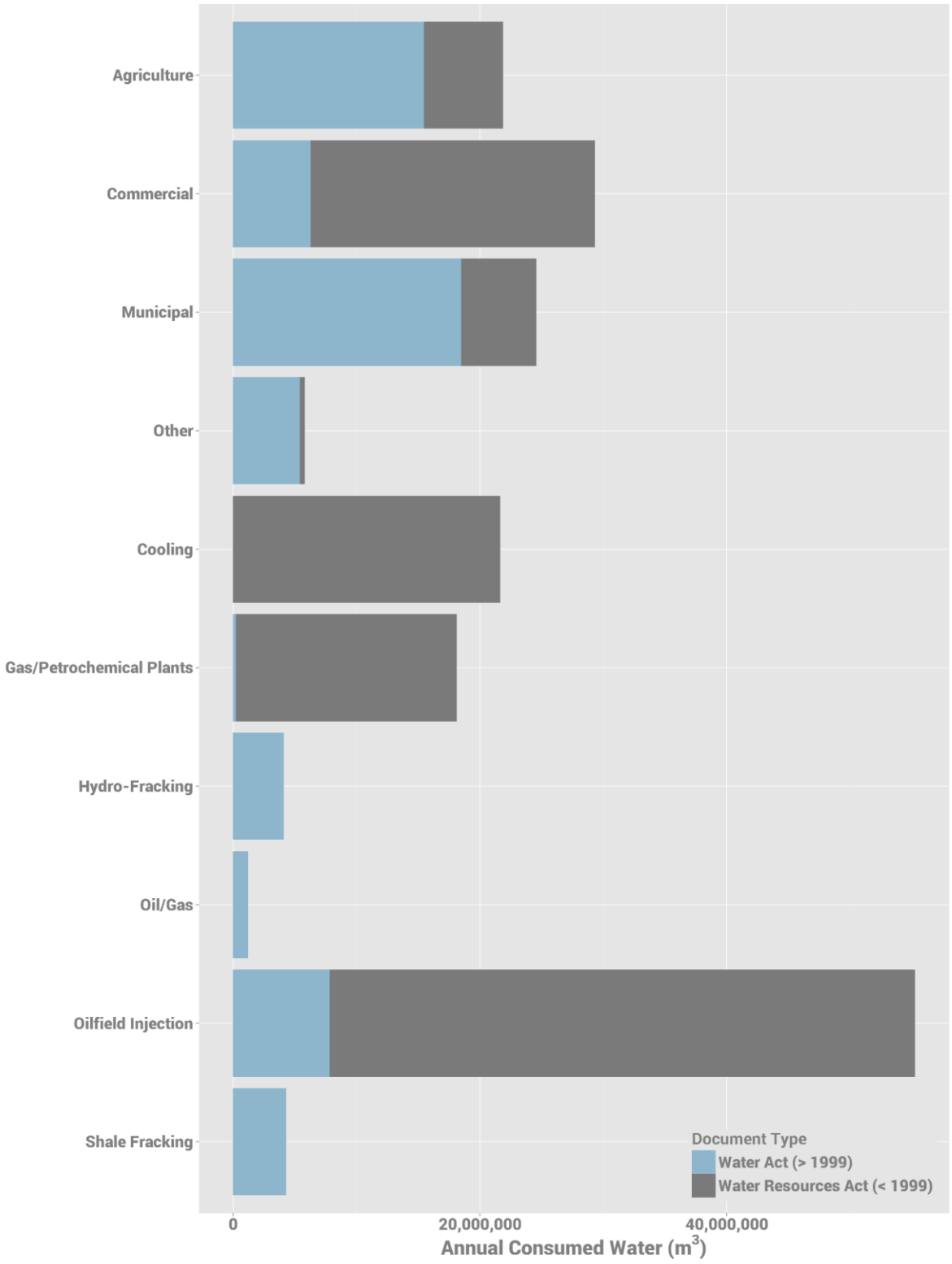

Figure 7. Total annual licensed consumptive use by purpose group, allocated under the *Water Act* (1999) and the *Water Resources Act* (1931).

Allocated Volume vs Usage

Information on reported consumptive usage of water was acquired for 2010, 2011, and 2012. Reported usage volumes were matched with license information. Creating linkages between the license information and usage information was difficult as no unique identifiers were present in each table. Some allocations reporting usage in 2012 may have not been included in the October 2013 license information if their term expired between January and October 2013. Of the 30,277 allocations active in October 2013, 448 reported usage volumes in 2012. These 448 approvals accounted for 56.27% of the total water allocated for consumptive use as of October 2013. Actual consumptive usage for these 448 approvals for 2012 was 96.4% of their allocated consumptive use.

The approvals which reported usage were skewed towards larger allocations. The majority of their approved water was reported as used in 2012. Given the bias in the data limited conclusions can be made regarding usage patterns in the study area.

Attempts were made to match groundwater license information with the Alberta water well information database, with the goal of identifying geologic units with substantial productive capacity. This effort was unsuccessful due to the lack of unique identifiers in the database and also the lack of precision in which both the licenses and wells are often located (ie. centre of a ¼ section).

CONCLUSION AND RECOMMENDATIONS

Significant existing allocations of water exist within the WCAB project study area, associated with commercial, agricultural, municipal, power generation, and oil and gas industry related activities. The substantial surface water resources of the region comfortably supply the demands of these existing users in most parts of the study area. Hydro-fracking and Shale Fracking uses of water are expected to continue to grow, associated with successful exploration and development activities in the Montney, Duvernay, Cardium and other plays in the region. While industry is committed to seeking out fresh water alternatives where possible, including the use of deep saline aquifers and recycled waste water sources, surface water resources will likely continue to play an important part in the water sourcing picture, especially at early stage developments in an area. New surface water use applications should consider the existing users of water both upstream and downstream of proposed points of diversion.

In order to more effectively understand the actual consumptive water usage patterns in Alberta, the water use reporting program should be expanded, and care should be taken to ensure that the databases developed support linkages between groundwater wells or surface water bodies, water allocations, and usage reports.

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