The

NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES

hereby issues

LARGE GROUNDWATER WITHDRAWAL PERMIT

NO. LGWP-2020-0001

to the permittee

CITY OF MANCHESTER
MANCHESTER WATER WORKS
281 LINCOLN STREET
MANCHESTER, NH 03103
(603-624-6494)

for the withdrawal of the following volumes of water from the following for the purpose of community water supply:

Radial Collector Well RCW: 7,200,000 gallons over any 24-hour period

Date of Issuance: January 7, 2020
Date of Expiration: January 8, 2030

Pursuant to authority in N.H. RSA 485-C:21, the New Hampshire Department of Environmental Services (NHDES), hereby grants this permit to withdraw groundwater from Radial Collector Production Well RCW subject to the following conditions:

1. The permittee shall comply with the requirements of Env-Wq 403 and RSA 485-C at all times.

2. Water Conservation: The permittee shall implement and maintain compliance with the approved Water Conservation Plan, dated March 2, 2015, in accordance with Env-Wq 2101 and NHDES' approval dated April 21, 2015.

3. Metering Requirements: Withdrawals from RCW shall be metered at all times. All meters must be selected, installed, tested, and maintained in accordance with Env-Wq 2101. The permittee shall read source water meters to adequately report the following volumes to the reporting program referenced in condition No. 6 of this permit:

   a) The 24-hour peak day volume withdrawn from the RCW during each month and the date the water use occurred; and

   b) The cumulative total volume withdrawn from the RCW during each month.

4. Monitoring and Reporting Requirements: The permittee shall establish and maintain the monitoring and reporting program as described below:

   a) *Groundwater level monitoring*

      a) Monitoring wells: The permittee shall install pressure transducers and data logger and measure water levels at a frequency of once every four hours in monitoring wells TMW-1L, TMW-4U, TMW-4L, SOE-2, SOE-3, SMW2, MW3-14, and the water supply well for the Station ID 20200001DW01 property. Water level monitoring shall commence at least 30 days prior to initiating a withdrawal from the RCW and shall continue indefinitely as a condition of this permit.

   b) *Groundwater quality sampling*

      a) Monitoring wells: The permittee shall collect water quality samples from monitoring wells TMW-1L, TMW-4U, TMW-4L, SOE-2, SOE-3, SMW2, and MW3-14 at a frequency of at least semi-annually in the months of May and August. Sampling shall continue after initiating a withdrawal from the RCW and continue indefinitely as a condition of this permit.

      b) The samples collected from the monitoring wells shall be submitted to a New Hampshire accredited analytical laboratory for analyses for chloride, sodium, nitrate, volatile organic compounds (VOCs) and per- and polyalkyl substances (PFAS).

   All water level monitoring and water quality sampling shall be completed by a person who can demonstrate, by education or experience, competency in collecting, recording and reporting hydrogeologic measurements.

   Monitoring well and sampling locations and frequencies may be added or changed if the data obtained contradict the information provided in the permittee's application, or if additional data points are required to assess the potential for adverse impacts to occur.

An annual monitoring report and all monitoring data shall be submitted to NHDES by January 31 of each year. The annual monitoring report shall provide text, tables or figures that present a summary of all previously collected data and note any relevant observations that may affect the measurements made from the preceding year inclusive of pertinent field notes or observations that document the annual monitoring activities undertaken to comply with this permit.

The annual monitoring report shall be submitted in an electronic format only. All water level and water quality monitoring data collected shall also be submitted in an electronic format established by NHDES.

5. Mitigation Requirements

   a) In the event that an adverse impact occurs, the permittee shall comply with all of the requirements below and with the impact mitigation and source replacement requirements of Env-Wq 403.

   b) Prior to initiating a withdrawal from the RCW, the permittee shall notify in writing via certified mail the owners of all properties that are served by private wells or public wells not owned by the permittee within the area estimated to be the influence area of the RCW, as illustrated on Figure 8, titled "Estimated 180-Day Cone of Depression" prepared by GZA GeoEnvironmental, Inc. (GZA), dated August 23, 2017. The permittee shall provide a copy of the notification letter and copies of the certified return mail receipts to NHDES. The notification letter shall explain to property owners with wells in the identified area that their well may be influenced by the RCW, and provide the property owners with contact information for both the permittee and NHDES in the event they believe they may be adversely impacted by the withdrawal.

   c) Where the status of an unanticipated impact is not clear, the permittee shall gather information needed to quantify the impact and determine its status relative to the adverse impact criteria defined under RSA 485-C:21, V-c and provide this information to NHDES within 48 hours of being notified by NHDES about a reported impact. A verified adverse impact shall be mitigated in accordance with Env-Wq 403.

   d) NHDES will routinely review the results of all monitoring data, and if water level monitoring data indicates that groundwater is being extracted at a rate that exceeds natural recharge on average, then NHDES will modify the permit in accordance with Env-Wq 403 in order to prevent adverse impacts from occurring.

6. The permittee shall register its new source of water with the NHDES Water Use Registration and Reporting Program and maintain the water use reporting requirements established by RSA 488, Env-Wq 2102 and this permit.

7. The permittee shall apply for renewal of this permit within the six-month period prior to its expiration date, but no earlier, in accordance with Env-Wq 403. The permittee shall continue to comply with all conditions in this permit until the permit is renewed or the facility is closed in accordance with all applicable requirements, regardless of whether a renewal application is filed.

Any person aggrieved by any terms or conditions of this permit may appeal in accordance with RSA 21-O:7, IV within 30 days.

Thomas E. O'Donovan, PE, PMP,
Director Water Division

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PROJECT NARRATIVE
NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES

Source Approval/Large Groundwater Withdrawal Permit LGWP-2020-0001
City of Manchester, Manchester Water Works, PWS ID 1471010
Radial Collector Well
Hooksett, New Hampshire

JANUARY 7, 2020

BACKGROUND

Manchester Water Works (MWW) has submitted an application to the New Hampshire Department of Environmental Services (NHDES) requesting a permit for a large groundwater withdrawal of up to 7.2 million gallons per day (MGD) from a new Radial Collector Well (RCW). The purpose of developing the RCW is to provide source redundancy and diversification for the water system, and to accommodate increases in water demand due to projected growth in areas served by the water system.

The design/construction of the RCW is not a conventional vertical water supply well; rather it includes a 19 foot diameter concrete caisson installed to a depth of approximately 71 feet below ground surface at a location approximately 50 feet from the bank of the Merrimack River. Six horizontal laterals extend in a fan-like pattern from the bottom of the caisson out under the river, the laterals range in length from 120 to 250 feet and are each screened across all but 10 feet of their full length (total intake screen length of 1,180 feet). The basis of design for the RCW, when operated, is to induce the infiltration of surface water through the bed of the river and thereby take advantage of mechanical filtration (i.e. pre-treatment) through both riverbed deposits, and soil below the riverbed. A radial collector well system is designated a riverbank filtration (RBF) source for the community water system, and, under the federal Surface Water Treatment Rule, is defined as a surface water source. The review and permitting under the large groundwater withdrawal program was determined to be necessary by NHDES due to the volume of groundwater the RCW would capture in addition to the surface water it would induce from the river[1].

The RCW site is located at the northern end of a small, river-side residential community on the western bank of the Merrimack River in Hooksett, NH, about 1,000 feet north of the Hooksett–Manchester town line and approximately one half mile east of US I-93, Exit 10. The RCW is located on a lightly wooded point bar of a meander on the river and the topography in the immediate vicinity of the RCW is relatively flat. To the immediate west (~500 feet) of the RCW is a densely developed commercial park that includes numerous, large retail buildings and their associated paved parking lots and stormwater retention-detention structures. To the east of the RCW is the Merrimack River, at a location where it's about 500 feet wide and on the order of 20 feet deep. The eastern (opposite) bank of the river in this area includes both a non-developed wetland complex surrounding a tributary to the river, and the lightly developed grounds of a college campus. Approximately four miles downstream of the RCW is the Amoskeag dam and hydro-electric station in Manchester.

The overburden present at the RCW site is favorable for high yielding wells and consists of silty-sand to coarse sand and gravel units with generally lesser amounts of finer-grained material (e.g. silt/clay). From the surface downward, the soils consist of approximately 25 feet of silty sand interpreted as surficial overbank deposits (alluvium) generally derived from flooding events that have reworked native soil and created the 'active' floodplain area bordering the river. About 70 feet of fine to coarse sands and gravel underlie this silty unit at the site and make up the primary water bearing unit for the RCW. This unit extends easterly below the 'active'

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[1] January 10, 2014 NHDES letter to Richard Davee of Wright-Pierce titled *Radial Collector Well, Riverbank Filtration Testing Requirements*

riverbed, and is interpreted as a glacial outwash deposit that contains discontinuous layers and seams of silt and/or clay that are likely lacustrine (shallow water) in origin and that diminish in occurrence below the river. Below this coarse grained unit is one to five feet of glacial till that overlies bedrock, this till unit also overlies much of the bedrock of the surrounding area. This overburden sequence of fine to coarse grained material appears to occupy much of the central portion of the river valley near the RCW and has a width of about 1,500 to 2,000 feet. The ground surface elevation increases substantially to the west of the site and soil deposits appear to terminate on bedrock outcrop 800 to 1,000 feet west of the RCW, and about 1,000 feet east of the east bank of the river in this area.

The bedrock observed below the RCW site and to its northwest is predominantly Concord Granite, a two mica granite that is widely present in this area of the state. To the southeast of the RCW, on the east side of the river, is calc-silica rich metasedimentary rocks (schists and pelites) of the Berwick Formation. Based on site boring data and geophysical surveys, a depression/trough occurs collinear to and along the western edge of the river near the RCW in a rough southwest-northeast orientation, this depression is roughly coincident with the approximate location of the Campbell Hill Fault zone (the contact between the Concord Granite and the Berwick formation) and mapped bedrock lineaments in the area. The screened laterals (intakes) for the RCW extend into this sand-filled trough in the bedrock below the river and east of the central caisson.

The saturated thickness of sand and gravel at the site is on the order of 70 to 80 feet, this degree of saturation coupled with the relatively coarse-grained nature of the unit provides significant volumes of storage to the RCW. Groundwater recharge to the overburden deposits in the area likely gets focused along the bedrock/overburden contact west of the RCW where infiltrating water encounters transmissive granular surface soils. Given the fact that the Merrimack River is the primary regional drainage feature in this part of the state, more deeply derived baseflow discharge of groundwater (to the river) from both overburden and bedrock is likely to also recharge the unit screened by the RCW. A heat tracer/mixing model established the proportion of groundwater capture to induced recharge of surface water.

WITHDRAWAL TESTING AND CONCLUSIONS

Both summer (warm weather) and winter (cold weather) withdrawal tests were conducted on the RCW; the intent of a test in each season was to evaluate the impact that the change of viscosity of surface water (due to temperature changes) would have on both the hydraulic performance and water quality of the RCW. This 'dual-season' evaluation established the hydraulic performance baseline of the RCW, and defined the design criteria for a water treatment plant for the RCW raw water.

The results of the winter pumping test were used for purposes of the large groundwater withdrawal permit referenced herein because the increase in viscosity of the colder surface water results in a greater influence area and extent of shallow groundwater capture. A withdrawal testing program was conducted by Wright-Pierce (WP) and GZA GeoEnvironmental Inc. (GZA) from January 4 through February 16, 2017, with pre-test (ambient conditions) groundwater level monitoring starting at select monitoring points between seven weeks and five months before the test. The purpose of withdrawal testing was to provide data to estimate long-term sustainable water quantity and quality; observe the response of the aquifer to pumping; evaluate the degree of hydraulic connection with the river; and, assess the potential for adverse impacts to water resources and users as defined in Env-Wq 403 that may result from the proposed withdrawal. The withdrawal testing program included monitoring during pre-pumping, pumping, and water level recovery periods, where the RCW was pumped at approximately 7.3 to 7.5 MGD. Discharge from the RCW was metered during the withdrawal testing program to maintain a near-constant pumping rate, and water quality samples were collected throughout the pumping period to characterize the quality of the water captured by the RCW.

Water Level Monitoring and Observations

During the withdrawal testing program, water level measurements were collected at:

- The RCW caisson;
- Nineteen (19) overburden monitoring wells (multilevel couplet/triplets);
- Five (5) bedrock monitoring wells;
- Three (3) private water supply wells;
- Eight (8) multilevel riverbed piezometers;
- One surface water gauge; and
- One wetland piezometer station.

The overburden monitoring wells and riverbed piezometers observed during the test were commonly installed as couplets or triplets and divided into deep and shallow points, where the deep overburden points were screened across the primary water bearing unit for the RCW. The intent of monitoring deeper groundwater was to record the zone of influence of the RCW, while shallow groundwater and surface water level measurements were recorded to assess the degree of hydraulic connection between the production zone of the deeper sand and gravel unit and the shallow water table, surrounding wetlands, and the river. The monitoring network also included a subset of points in shallow bedrock below the site. Monitoring water levels at monitoring wells located east of the river (on the opposite side of the river) was conducted to assess if the effects of pumping the RCW extended below and across the river.

Groundwater flow through overburden, generally, is from higher topographic areas west of the RCW, southeasterly, towards the river. Overall, the river acts a large scale regional discharge/drainage feature for all groundwater flow under non-stressed conditions, and as a constant head boundary (i.e. relatively static water source) for the RCW during active withdrawal. Under non-pumping conditions, hydraulic gradients between shallow overburden, deep overburden, bedrock and the river generally indicate hydrostatic [near-neutral] flow conditions to slight upward flow conditions discharging to the river. The elevation of the river, as governed by a downstream impoundment (Amoskeag Dam), strongly influences the elevation of the water table and the hydraulic gradient between the river and the shallow groundwater, as such it can cause the groundwater flow direction in shallow soils to 'flip' intermittently if the river elevation changes quickly. Based on hydraulic testing observations [see below], water derived by the RCW is primarily surface water captured via steep downward hydraulic gradients induced below the river while pumping, and a smaller proportion of groundwater derived from inland overburden soils which range in hydraulic conductivity from approximately 150 to 250 feet per day.

The pumping test water level measurements indicate that most shallow, deep and bedrock monitoring wells included in the monitoring network responded to pumping the RCW. The average drawdown of water levels in shallow overburden wells was approximately 10 feet and ranged as high as 18.3 feet near the RCW. Tracking the temperature of the groundwater in shallow wells near the river bank indicates they experienced the direct effects of induced recharge of surface water. Water levels in deep overburden monitoring wells indicated the greatest drawdown effects from 2.4 to 27.5 feet. Similar to the shallow overburden wells, temperature data from groundwater in deep overburden wells near the river showed direct effects of surface water. Water levels in the three bedrock wells monitored near the site showed an average decline of about nine feet, indicating some effects from RCW pumping propagates into the shallow fracture network below the RCW site. No drawdown or hydraulic effects occurred at the overburden monitoring wells and piezometers on the east side of the river, implying that the river water that is induced (captured) by the RCW supplies sufficient recharge to limit effects of the RCW's withdrawal (i.e. the extent of the 'cone of depression' of the laterals).

The shape of the cone of depression in groundwater (shallow and deep) was elongated along the axis of the overburden unit that borders the river's western bank and, nearer to the RCW, the shape roughly mimicked the fan-like array of laterals. Drawdown at most points did not reach complete stabilization however, temperature data from the deep monitoring points near the river and the multilevel riverbed piezometers, along with hydraulic head measurements, provided for an estimate of the proportion of groundwater to surface water that was captured by the RCW. The percent of the water withdrawn by the RCW that is induced surface water is estimated to be between 70 and 80 percent, with the remainder (1.4 to 2.2 MGD) being captured groundwater.

Hydraulic effects of the RCW at the end of 42 days of pumping were observed in shallow overburden on the order of 500 to 600 feet away from the RCW, whereas effects from pumping were observed in deep overburden up to approximately 800 feet away. Based on an assumption of 180 days of continuous pumping and no net recharge from precipitation to the aquifer, projected effects from the RCW are estimated to extend on the order of 800 feet in shallow overburden and 1,100 feet deep overburden. Based on this potential drawdown area, delineation of a potential impact area west of the RCW (landward) results in an area on the order of 120-acres. Impacts to river levels or flow were not observed, and are not likely to be discernible, due to the fact that the production rate tested (~7.2 MGD) equates to approximately 1% of the lowest flow measurement on record for the Merrimack River of 1,200 cfs recorded in 1942. The upriver area that contributes to RCW-captured surface water is likely to be significantly larger and will be addressed by the surface water protection area (SWPA) plan.

Water Quality Monitoring and Observations

Although no water quality sampling was required by administrative rule(s) that establish the testing criteria for the RCW large groundwater withdrawal permit, water quality sampling was conducted to assess the general chemical signature of the water captured by the array, predominantly for use in the water treatment plant design. In general, the water quality captured by the RCW was very good, with low levels of dissolved solids, metals, radionuclides, organic carbon and bacteria; and no volatile or semi-volatile organic compounds. Water quality sampling collected before, during and after the pumping test from select shallow/deep groundwater monitoring wells showed higher concentrations of dissolved solids (sodium, chloride, etc.) and metals which is interpreted as resulting from the developed areas west of the RCW. Although the groundwater samples collected west of the RCW and within its cone of depression was of lower quality, the induced recharge of surface water flowing to the RCW substantially dictate its water quality.

Adverse Impact assessment and Mitigation Plan

Due to the design of the RCW and its connectivity to the river, its hydraulic influence on groundwater and groundwater levels were constrained to a relatively small area of overburden near the RCW even though the withdrawal rate was large (7.2 MGD). The primary hydraulic impacts observed during the testing program were on overburden groundwater levels near the RCW. These impacts effected a subset of private wells within the small river-side residential community located immediately south of the RCW that were shallow dug wells, the closest of which (two lots away from the RCW) went dry due to groundwater levels declines on the 26th day of pumping. Upon observation and reporting of the dry well condition, MWW provided bulk water to the residence for the remainder of the testing program, and, prior to issuance of the permit included herein, implemented a source replacement plan and provided a service connection from the water system to the residence on the lot. No other features/resources were observed to be influenced by pumping the RCW because of the dominant hydraulic influence that the river imparts on performance of the RCW. The only wetland areas observed near the site were across the river and were monitored during the testing program, but the shallow overburden wells and wetland piezometers located in the area did not respond to pumping of the RCW.

PUBLIC NOTIFICATION AND INVOLVEMENT

Pursuant to RSA 485-C:21, II through V-a, materials submitted in support of the large groundwater withdrawal permit (the preliminary application, final report, and supplemental materials) were sent (via certified mail) to municipalities and public water suppliers in the potential impact area of the withdrawal. Copies of the above-referenced materials were sent to the town of Hooksett. No public hearings were requested by notified parties following submittal of the preliminary application or final report.

LARGE GROUNDWATER WITHDRAWAL PERMIT MONITORING, REPORTING AND WITHDRAWAL REQUIREMENTS

The large groundwater withdrawal permit issued to MWW allows the withdrawal of up to 7.2 MGD from the RCW. The large groundwater withdrawal permit also requires MWW to conduct a groundwater level and quality monitoring program on a subset of monitoring wells that surround the RCW. General monitoring requirements are summarized as follows:

- The permit requires that the operation and production of the RCW be monitored continuously and recorded in order to compare against water level fluctuations in nearby wells;
- The permit requires that water levels in seven shallow and deep overburden monitoring wells and one private water supply well be monitored continuously to infer the extent of potential water level effects on nearby wells within the influence area of the RCW under typical use conditions; and
- The permit requires that water quality samples be collected from seven shallow and deep overburden monitoring wells to assess for the presence of groundwater contamination from developed areas west of the RCW.

In the event that an adverse impact is reported and verified, an impact mitigation program would be implemented in accordance with conditions of the large groundwater withdrawal permit and Env-Wq 403. The program would implement actions necessary to mitigate the impact including reducing the withdrawal volume, establishing water use restrictions for customers of the water system, modifying or replacing an impacted source at no initial capital cost to the user, and expanding (or establishing) a monitoring network to assess the effectiveness of the mitigation program. More information concerning these requirements is provided in the large groundwater withdrawal permit under condition No. 5.

MWW is required to submit an annual monitoring report in an electronic format to NHDES by January 31st of each year. As stipulated in the permit, the annual report shall include a summary of trends and variability observed in the monitoring data, all monitoring data and records required by the permit, and an assessment of the potential impacts associated with the withdrawal from the RCW. The annual report will be available to the public for review. A complete description of monitoring and reporting requirements is presented in more detail in the large groundwater withdrawal permit under condition No. 4.