To: Metro and South Platte Basin Roundtable members
From: South Platte Basin Roundtable Groundwater Technical Committee
Date: November18, 2014 (Modified November 21, 2014 based on comments from the November 18, 2014 Ground Water Subcommittee meeting, with SPBRT acceptance)
Subject: Initial recommendation, South Platte Alluvial Aquifer Groundwater Monitoring Network

At the September 2014 meeting of the South Platte Basin Roundtable, the roundtable members selected a "Technical Committee" to investigate the recommendations presented for consideration in the HB12-1278 report and develop specific direction, where appropriate, for those recommendations. The Technical Committee has completed its investigation of the report's recommendation 3.B, the implementation of a basin-wide groundwater monitoring network. This document provides a specific recommendation for the implementation of the groundwater monitoring network. The document is organized to first provide a Summary of Recommendations for a groundwater monitoring network, then to provide background information of important considerations when developing a groundwater monitoring network (Sections A and B), then a more detailed description of the recommendations (Sections C through F).

Summary of Recommendations

The South Platte Alluvial Aquifer Groundwater Monitoring Network ("Groundwater Monitoring Network") will consist of both a "Backbone" of specifically identified wells that will be part of the Division of Water Resources' groundwater monitoring network of wells, along with other wells, the data for which is submitted by third parties.

The current Division of Water Resources groundwater monitoring network in the lower South Platte River basin alluvial aquifer consists of 114 wells. This network includes dedicated monitoring wells instrumented with data loggers, incorporating those installed as part of the South Platte Decision Support System (SPDSS) and the USGS NAWQA program. This network also includes active and inactive water supply wells that are manually measured twice a year. This group of wells, along with a limited number of additional wells referenced in the recommendations immediately below and further discussed in this document, will be the foundation of the ongoing Groundwater Monitoring Network. Adapting a term from the HB12-1278 report, this foundation will be referred to in the rest of this document as the "Backbone" of the Groundwater Monitoring Network, as it provides both good geographic coverage of the aquifer and good temporal coverage of the aquifer (approximately half the wells have data loggers with a continuous record and the remaining hand-measured wells have, for the most part, a longer period of record).

The Technical Committee has reviewed the Backbone, which is described in more detail in this document, and has determined that it will provide an effective and sustainable foundation of groundwater monitoring that will serve the anticipated needs in the South Platte River Basin. The Technical Committee's specific recommendations are:

1. Continue the current practice of monitoring for the Division of Water Resources groundwater monitoring network of 114 wells,

2. Add up to 10 wells to the network in areas of data gaps. This may include existing wells (for example, old, unused USGS wells or other irrigation wells) and new dedicated monitoring wells,
3. Instrument up to 20 additional wells with dataloggers. This may include wells that are part of the 114 wells that are currently hand-measured and new wells that are added to the network,

The wells that are part of these recommendations 1, 2, and 3 will form the Backbone of the Groundwater Monitoring Network.

4. Initiate formal outreach to qualified third parties with independent monitoring networks to communicate the benefits of submitting groundwater level data on a periodic basis, and at least as frequently as an annual basis, to HydroBase, the State's water resources database. Further, the State should facilitate the transfer of the data and provide standards for water level measurement and recording. This formal outreach should be led cooperatively by the South Platte Basin Roundtable, the Division of Water Resources, and the CWCB and should provide a clear understanding of the benefits for third parties to provide data with the objective that they may feel motivated to participate,

The wells that are part of third-party networks identified in this recommendation 4, along with the Backbone, will form the Groundwater Monitoring Network.

5. Develop and publish a protocol for groundwater level data measurement, data collection, and data entry,
6. Add automation where practical to the Division of Water Resources' internal process of collecting groundwater level data and uploading it to HydroBase,
7. Add additional features to the State's tools (for example, the map viewer) to make data from the Groundwater Monitoring Network more accessible,
8. Give unambiguous responsibility to the State Engineer and ensure sustainable funding is available.

These recommendations are explained in more detail in Sections C-F of this document.

A. Objectives of the Backbone

The objective of a groundwater monitoring network in Colorado is to provide data to be used in scientific investigations, analyses, and decision making. This is true of the South Platte River Basin. To articulate the level of adequacy of the current groundwater monitoring network in the South Platte River Basin ("Network") and specify what changes are necessary, the specific objectives of the network should be identified. Those objectives are to provide for:

1. Current water administration needs,
2. Basin planning tool needs,
3. Potential future water administration needs,
4. Current and potential future groundwater analyses.

These objectives are explained in more detail below:

1. Current water administration needs:

At this time, surface water use in the South Platte River Basin is administered independent of groundwater levels. Groundwater use is administered based on a presumed connection to the surface water system. Current law and water court decrees are administered according to the premise that water is withdrawn from or placed in the ground at a point location. Hydrogeology then dictates the effect that withdrawal or placement of water has on the stream. The groundwater levels between those two points are not a consideration in administering the action at the location where water is withdrawn from or placed in the ground.

2. Basin planning tool needs:
   The South Platte Decision Support System groundwater model uses historical groundwater level data for calibration and validation purposes. While any groundwater level data during the study period for the model (1950 onward) is potentially helpful in the calibration and validation process, continuous record water level data from data logger-equipped monitoring wells is especially useful.

3. Potential future water administration needs:
   There is ongoing discussion that suggests future water administration may depend on using the South Platte alluvial aquifer as a resource that can be drawn on during times of drought or other need. These discussions are met with resistance due to the fact that such use without full augmentation would injure senior water rights. However, more sophisticated conjunctive use plans that rely on withdrawal of water with the assurance of resources that will always provide water to prevent injury may be developed in the future. To administer such conjunctive use plans, historical and real-time water level information will be necessary.

4. Current and potential future groundwater analyses:
   The Division of Water Resources and the CWCB have recently conducted efforts to collect groundwater level data in the areas of Gilcrest/LaSalle and Sterling to facilitate analyses of the interrelationships between all hydrologic factors in those two geographic areas. In the future, there may be more efforts to understand groundwater's effect on or response to specific natural and human-induced activities in the basin.

   Additionally, there may be other groundwater analyses or scientific research conducted in the future that rely on groundwater data. Although it is not possible to anticipate the location and extent of such analyses, a Backbone network of a sustainable size that provides good geographic and temporal coverage of the basin is essential for providing the best possible starting point for any future groundwater data needs in the basin. Adding a large number of wells to enlarge the Backbone would provide more data. However, the cost of installing a large number of new wells and maintaining the additional data collection effort represents a significant cost. This creates a risk that the monitoring effort for the entire network cannot be sustained. The cost and risk of adding wells beyond what is recommended in this document are not justified unless the additional wells are specifically required for a known analysis effort. However, it is reasonable to at least continue the level of monitoring for the Backbone that has a historical record.

B. Specific characteristics of the Backbone

There are several characteristics of the Backbone that have varying degrees of influence on the effectiveness of data for future use. The following characteristics are important for the Backbone:

1. Be geographically representative of the basin
   The focus of the Backbone is to reliably measure water levels in the alluvial aquifer of the lower South Platte River basin. Geographically this area encompasses primarily the mainstem of the South Platte River from Chatfield Reservoir, in the southwestern Denver Metropolitan area, to the state line near Julesburg. The distribution and density of the Backbone should ideally span this entire reach and be spaced at intervals such that large geographic data gaps are avoided.

2. Be hydrogeologically representative of the basin
   The South Platte alluvial aquifer consists of unconsolidated clay, silt, sand, or gravel deposited during recent geologic time by running water in the bed of a stream or on its floodplain. The variability of this geologic material both along the alluvial channel and across the channel profile will impact the flow of groundwater and the water level measured in wells. Additionally, any composition change with depth can influence the water level in a well depending upon the completion interval of the well. Consequently, the Backbone should contain wells that are sited both within the main alluvial channel and along its edges to assess the impact of the hydrogeology on regional and local water levels. Ideally, the wells should be completed through the entire aquifer interval, but the Backbone should also incorporate wells with completion intervals at varying depths to assess the influence of geologic variability on groundwater flow.

3. Include areas that would exhibit short-term responses to human-induced activities in the basin as well as areas that would show long-term trends as a result of the same activities:
   Additionally, the spatial aspects of the Backbone should consider well placement in areas where longer-term ambient baseline fluctuations of water levels within the aquifer may be recorded, as well as areas where water levels are impacted in the short-term by human-induced activities, i.e. external stresses. The Backbone should include monitoring wells that provide data in response to human-induced activities such as high-capacity pumping, diversion structures, dewatering systems or drains, recharge facilities, lined gravel pits, or substantial changes in land use. Areas currently exhibiting high groundwater levels might be a priority as small changes in the water table could have significant impacts to structures, industrial or commercial operations, or current land-use activities.

4. Include as many wells as possible that have a long, uninterrupted history of data:
   Depending upon location, groundwater levels have been measured in alluvial aquifer wells since the 1930s. Wells that have a long, uninterrupted period of record are ideal for trend analysis of groundwater levels and are important to the Backbone. This data allows for the comparison and analysis of climate variability on groundwater levels as well as the evolving impacts of water development structures and management practices.

5. Optimize the collection of continuous data as opposed to twice-yearly data:
   The Division of Water Resources South Platte alluvium monitoring well network currently consists of 114 wells, 56 of which are instrumented with continuous data loggers. The remaining 59 wells are measured manually twice a year. While semi-annual data collection provides information on long-term water level trends, in some cases, data loggers are necessary to detect shorter term responses to human-induced water management activities. Instrumentation of true monitoring or inactive wells with continuous data loggers would provide information on short-term responses and produce a record of the aquifer's response to both natural and human-induced activities. While instrumenting wells with data loggers optimizes the recording of continuous data, the frequency of data download will depend upon the objectives of the data use.

6. Be designed such that the resources necessary to maintain the Backbone can be sustained for the long-term (decades)
   Long-term, systematic groundwater level measurements provide essential data to record water level trends, develop and calibrate groundwater flow models, conduct research and analysis, monitor the effectiveness of basin planning implementation and record the impacts of water management operations. The value of establishing and maintaining the Backbone for the long term is critical. Considerations to achieve that objective include specifics of the observation well, longevity of the proposed instrumentation, frequency of data collection, financial and administrative support for the monitoring program.

C. Groundwater Monitoring Network recommendation

An existing group of wells is currently in place that satisfies the criteria above. The current Division of Water Resources groundwater monitoring network in the lower South Platte River basin alluvial aquifer consists of 114 wells. This network includes both dedicated monitoring wells and active and inactive water supply wells. Fifty-six of those wells (36 SPDSS, 19 USGS NAQWA, and one inactive well) are equipped with data loggers recording daily water levels. This group of wells, and the wells discussed in the next paragraph, are known as the "Backbone" of the Groundwater Monitoring Network. They are called the Backbone because collectively they lend themselves to the uses identified in this document while also meeting the desirable characteristics of a groundwater monitoring network identified in this document. Field data collection activities are conducted in the spring and fall of each year to download the logged data and manually measure water levels in wells with no dataloggers. All of these measurements are uploaded into the Division of Water Resources' central database, HydroBase. An annual water level report is produced that includes hydrographs from each well for the semi-annual manual measurements only. Specific information regarding these 114 wells is included in the attached table.

The network of 114 wells can become significantly more effective with a proportionally small investment by adding select wells to the network. The Division of Water Resources and the CWCB have done preliminary analysis regarding locations where as many ten wells can be added to the network. The wells would be specifically for the purpose of more closely meeting the objectives and the characteristics of a network, as identified in sections A and B above. The wells would be added for the purpose of meeting those qualities but some attention would be given to using existing wells where possible.

Further, installing as many as 20 data loggers in wells that do not currently have them will provide the more continuous data that facilitates certain types of analyses. A good example is the analysis of groundwater level response near features such as ditches or fields where irrigation water is applied. Since the operation of those features can change weekly or even daily, analysis of the groundwater level response for smaller time increments is advantageous. The data loggers may be installed in some of the 114 wells that are part of the current Division of Water Resources groundwater monitoring network and wells that would be added as described in the preceding paragraph. Again, the Division of Water Resources and the CWCB have done preliminary analysis regarding locations where 20 data loggers can be added to the network to maximize the level to which the objectives and characteristics in sections A and B above can be met for a reasonable cost.

Recommendation: The Technical Committee recommends that the Division of Water Resources proceed with monitoring of all wells in the Backbone. The Backbone consists of the 114 wells individually listed and shown on the map in Appendix A and as many as 10 additional wells identified by the Division of Water Resources and the CWCB. Additionally, the Technical Committee recommends the installation and support of as many as 20 additional data loggers to specific wells in the backbone identified by the Division of Water Resources and the CWCB. The Division of Water Resources and the CWCB should include input from other parties when specifying the locations of the additional wells and dataloggers.

D. Additional recommendations

Facilitate the submittal of additional data beyond that from the Backbone:
The Metro and South Platte Basin Roundtables, the Division of Water Resources, and the CWCB should initiate a cooperative effort to bring additional groundwater data, beyond what is contained in the Backbone, into HydroBase. The technology for other parties to provide data is currently in place. However, only a limited amount of data is being entered at this time. All water users in the basin can benefit from additional data and many water users may value having HydroBase as a central database with the architecture to store their data.

The South Platte Basin Roundtable should work with the two state agencies to develop outreach material and a plan to educate entities with independent monitoring networks on the benefits of submitting groundwater data. As described below, the technology to be used for data submittal should be managed to make the submittal process as straightforward as possible. With a more simplified process for submitting data, the benefits of having a central database for the storage of their data, and an understanding of the benefits of the data access to all water users, these entities may more likely feel compelled to enter their data. (Note that the State annually updates HydroBase with all USGS groundwater level data.)

Develop and publish a protocol for groundwater level data measurement, data collection, and data entry
In conjunction with the outreach effort, the Division of Water Resources and the CWCB should work with water users to develop and document a set of standards for groundwater measurement and data collection. These standards can be developed in a straightforward manner and would be for the purpose of ensuring consistency and accuracy in data collection that would provide for data of the highest reliability and integrity.

Improve the data collection process for Backbone data through automation

The data collection and data entry component for the management of Backbone data can become more effective in two ways. First, it can become more effective by analyzing the characteristics identified above and determining whether some wells could benefit from data loggers just for the purposes of reducing the overhead of data collection. In addition to the cost of data loggers being offset by the reduced overhead, these wells may be at locations where the continuous data is significantly more meaningful than the twice-yearly data. This recommendation is for data loggers beyond the 20 that were recommended in Section C above.

Second, the Division of Water Resources' process in gathering, downloading, and uploading data should be reviewed for possible automation possibilities. Automation of these tasks has the potential to reduce labor costs.

Improve data access:

While groundwater level data in HydroBase is currently available on the website for Colorado's Decision Support Systems (cdss.state.co.us), the State is implementing enhancements to make the data more accessible to the public. For example, the CWCB is currently developing an online map viewer that could include the capabilities to locate wells with groundwater level data and display a hydrograph for a selected well.

Recommendation: The Technical Committee recommends that all actions in this section D be pursued as soon as possible

E. Funding

Sustainable funding of the Groundwater Monitoring Network at the following levels for the long-term will be critical:

1. Cost to continue current level of monitoring

The Division of Water Resources currently is funded to continue the current level of monitoring in item 1. However, of the 114 wells in this current monitoring effort, 19 are USGS NAWQA wells that are monitored by USGS. The funding of that monitoring effort ends in May 2017 and the USGS does not intend to continue that monitoring after that time. Perpetual funding for the USGS to continue that effort will be required beginning in 2017.

2. Cost to add a small number of data loggers and construct a small number of additional wells,
3. Cost to outfit more wells with data loggers to reduce overhead costs,

For items 2 and 3, the Colorado Water Conservation Board has funding available to accomplish these objectives immediately

4. Cost to accommodate and manage data from third party wells, or non-Backbone Wells

The Division of Water Resources has the ability to accept and host data, but does not currently have resources to actively "manage" or improve the data and data processes. The Division has, however, requested an FTE from the 2014-2015 legislature to coordinate HydroBase information, which would include the management of this information

5. Cost to automate the processes used to move data from dataloggers in the field to HydroBase,

The cost to automate this process would include the cost to do an initial analysis of the current manual steps and software used to move data from dataloggers to HydroBase and develop automated methods. The cost would be relatively modest and may be managed with

existing funds and staff, however, the initial analysis would need to be done to identify an accurate cost. Note that funding for data loggers and remote reporting of data is addressed in item 3 of this list.

6. Cost to fund additional FTE in DWR to manage the network.

This document sets the specific objectives for groundwater monitoring. The Division of Water Resources' current groundwater monitoring efforts, monitoring of additional wells described in this document, managing the data entry from third-parties, along with conducting other hydrogeological investigations may not be reliably addressed with existing DWR staff. This need should be further investigated.

F. Statutory change

To memorialize the importance of the Ground Water Monitoring Network; give unambiguous responsibility to the State Engineer to conduct groundwater monitoring; and ensure sustainable funding for specific items, such as the cost to continue data monitoring of the NAWQA wells and the cost to fund necessary staff from the Division of Water Resources to conduct additional groundwater monitoring and manage the data, legislation may be necessary.