The project also studied the trends in supplier relations in other industries, providing an overview of the benefits of collaborative relationships with suppliers. In particular, tight communication of inventory status and usage trends with suppliers can help them allocate inventory effectively during time of high demand and respond to impending shortages with more speed and effectiveness. Also, technology or practices that allow orders to be placed quickly and easily when the reorder point has been reached help shorten the delivery lead time, leading to fewer problems with shortages.

Conclusions & Recommendations

The major findings of the project are the inventory guideline parameters for each of the counties. These are detailed in the project report with a re-order point and an inventory target being developed for each county. The inventory targets have been compared to the 10 day maximum usage, which is the current guideline in use for determining inventory stocking. Counties for which there are significant differences between the two have been identified. The project report also includes a comparison of inventory targets to county storage capacities to help create a guideline for determining which counties require additional storage capacity.

The usage model for salt based on weather variables can be used to support predictions of usage even before the actual usage has been entered into the ODOT information systems. Further development of this capability may be helpful in identifying very quickly where supply shortages may be developing.

Implementation Potential

The inventory control guidelines developed in this project were tested using a simulation methodology so that they have a high probability of success when implemented at the county level. The inventory guidelines give the county manager strict goals and guidelines to follow when determining when to order and how much to order to support high levels of service in winter storm operations, with a high level of confidence that too much salt will not be ordered, leading to higher costs. For counties with multiple storage locations, there is a need to determine how to split the inventory ordering/storage over the individual locations. There is a continuing need to keep the models from this project updated with the yearly usage to support consistently high levels of service and strict control of cost from year to year.
Description

The salt supply chain is shown in Figure 1. Each year, each county in Ohio establishes a contract through ODOT with a salt vendor before the winter season and that vendor supplies all garages in the county for the entire season. The supplier selects one of its stockpile locations that will supply the contracted county for the term of the contract. Only one vendor supplies a county, but many counties can be supplied by one vendor. The vendor/stockpile locations are stocked by the vendor’s own mines or third party mines that transport the salt by rail or barge. The county garages are stocked by the vendor by transporting truckloads of salt from the vendor stockpiles to the storage bins at the county garage by contracted carriers. This process of stocking the salt bins for the winter season begins in the summer months and continues until a specified volume is reached in the county garages, usually before the start of winter weather.

This study used historical salt usage information at the county level, linked it with data on weather, and developed a model of weekly usage for each county with a major city. Figure 2 shows how salt usage is related to inches of snow. Other weather variables included in the models include: number of days of snowfall in a week, snow cover depth on the ground, number of days of freezing rain in a week, number of days of blowing snow in a week, minimum, maximum, and average temperatures.

These models were expanded to cover all Ohio counties by using a lane-mile adjustment and a weather-zone approach to tailor the models to each county. These models supported the development of inventory control guidelines for each county for each month of the winter season that supports high levels of service at the lowest cost. These guidelines specify when to order and how much to order in a systematic way, that achieves high levels of service and minimizes the inventory required. Figure 3 shows a typical reorder-point/order quantity inventory guideline.

These guidelines were then used to support an analysis of storage capacity in each county. Storage capacities were compared to the requirements from the inventory guidelines to identify counties with insufficient or marginally sufficient storage capacity.

A simulation methodology tested the implementation of these guidelines in a more realistic setting and led to recommendations for implementation of the guidelines in practice. These simulations were driven by the actual usage of salt over a several year period to test the effectiveness of the guidelines. The simulation incorporated effects such as deliveries of material by truckloads, and uncertainty in the timing of deliveries. This analysis led to recommendations on how to implement changing inventory guideline parameters as the months change. For example, to deal with the rising demand for salt as the winter season goes from November to December, the suggested guidelines for each month should be triggered one week before the beginning of the month, to allow for delivery times for increasing inventories. Also, the simulation study allowed for a comparison of ordering patterns under the new guidelines, compared to the actual orders. These patterns can be shared with salt vendors to better prepare them for changes under the new guidelines.

Preliminary designs for inventory monitoring techniques were investigated for their appropriateness to support the goals of effective inventory management, as it relates to winter maintenance operations. Visibility of inventory levels is critical to effectively implementing the guidelines at the county level. In addition, visibility of inventory levels at the state and vendor level brings benefits to the coordination of activities statewide as well as benefiting the vendors in supplying the counties effectively. The inventory monitoring design concepts presented in the project report must be prototyped and tested to determine the feasibility and cost of implementation. Figure 4 shows one of a number of types of storage bins used at the county locations where the monitoring would take place.