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Microservices for the Stream Visual Assessment Protocol (SVAP)

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Abstract: The Stream Visual Assessment Protocol (SVAP) provides an initial assessment of the overall condition of wade-able streams, their riparian zones, and instream habitats. Field conservationists use the tool when providing technical assistance to land owners to improve stream conditions, sustainable use, and value of their property. SVAP does not require extensive training in biology, geomorphology, or hydrology, and represents a first step towards more detailed analysis and recommendations as needed. The protocol was developed in 1999 by the USDA Natural Resources Conservation Service (NRCS) Aquatic Assessment Workgroup, following two years of field study and validation involving 182 stream reaches in 9 states across the country. Following a decade of use, SVAP was updated in 2009 to increase sensitivity to resource conditions at the state and regional levels. To this point, SVAP has been applied as a mostly manual process, completing individual worksheets guided by a field manual, persisted as spreadsheets, PDF files, or other documents, in a file system, or more recently a document management system. However, completing the worksheet does not take advantage of on-line data sources nor meet priorities for integrating assessment of resource concerns on farms and ranches. We describe a suite of 17 SVAP microservices and associated data tables supporting web application data entry and editing, managing reference streams, and computing assessment scores. We make these services available through our OMS/CSIP continuous integration process.

***Keywords**:* stream resource assessment, microservices, OMS/CSIP

1.0 Introduction

With the advent of automated office productivity tools in the past 30 years, most large organizations come to rely on small spreadsheet and small database applications in daily business workflows in addition to their corporate information systems. These organizations also may develop and apply methods for important business domains, but for an extended period lack resources to integrate them into their automated systems. For environmental and conservation organizations these methods and applications reflect expert knowledge, field studies, and often are informed by output from empirical or processed-based models. When resources become available, the methods and applications should be integrated into corporate systems efficiently, consistently, and sustainably.

The USDA-NRCS developed and published the Stream Visual Assessment Protocol (SVAP) in 1999 following two years of field study and validation involving 182 stream reaches in nine states across the country (USDA-NRCS, 1999). SVAP provides agency county-level field conservationists with a tool to assess the overall condition of wade-able streams, their riparian zones, and instream habitats on a farm, ranch, or other land area, providing a benchmark for recommending prescriptions for improvement and monitoring progress through time. Initial SVAP assessment can lead to more computationally intensive analysis of stream hydrology and riparian health to determine best improvement solutions.

SVAP was updated in 2009 to increase sensitivity to resource conditions at the state and regional levels (USDA-NRCS 2009). Using the protocol involves a site visit to the stream to be assessed, sketching the stream reach on a map, and completing a worksheet, including assigning scores for up to sixteen assessment elements. To this point a manual process, recently NRCS allocated resources to automate SVAP processes for integrating into their next generation national program delivery information system, as well as make them available for external partner applications.

2.0 Methods

The design for SVAP automation separates science processes from those involving transactions to store and manage specific customer or project files, enabling multiple software applications to use the underlying science. We design SVAP processes to be highly granular, a suite of microservices contained in a web service layer having common libraries. Should the need arise, with relatively mior effort microservices can be reconstituted into less granular services to suit a particular application requirement. The microservice architecture pattern we use enables continuous refactoring and deployment. Figure 1 displays the data flows expected for an application using SVAP services.

SVAP microservice development leverages the Object Modeling System (OMS) and Cloud Services Integration Platform (CSIP) application programming interfaces (APIs) for model and data as-a-service implementations (David et al, 2014). CSIP services are RESTful, consuming request JSON populated by an application and returning results as response JSON to the application supporting the business workflow. We build, test, and deploy CSIP services using our DevOps process involving Meccurial repositories, Jenkins-based continuous integration, and Docker/Kubernetes container cluster management (David et al, 2016). SVAP service descriptions and endpoints are published and available at: https://alm.engr.colostate.edu/cb/report/26713.

We manage SVAP domain data as a schema (Figure 2) in a greater Conservation Resources (CRdb) domain database as well as supporting geospatial layers in a file system.

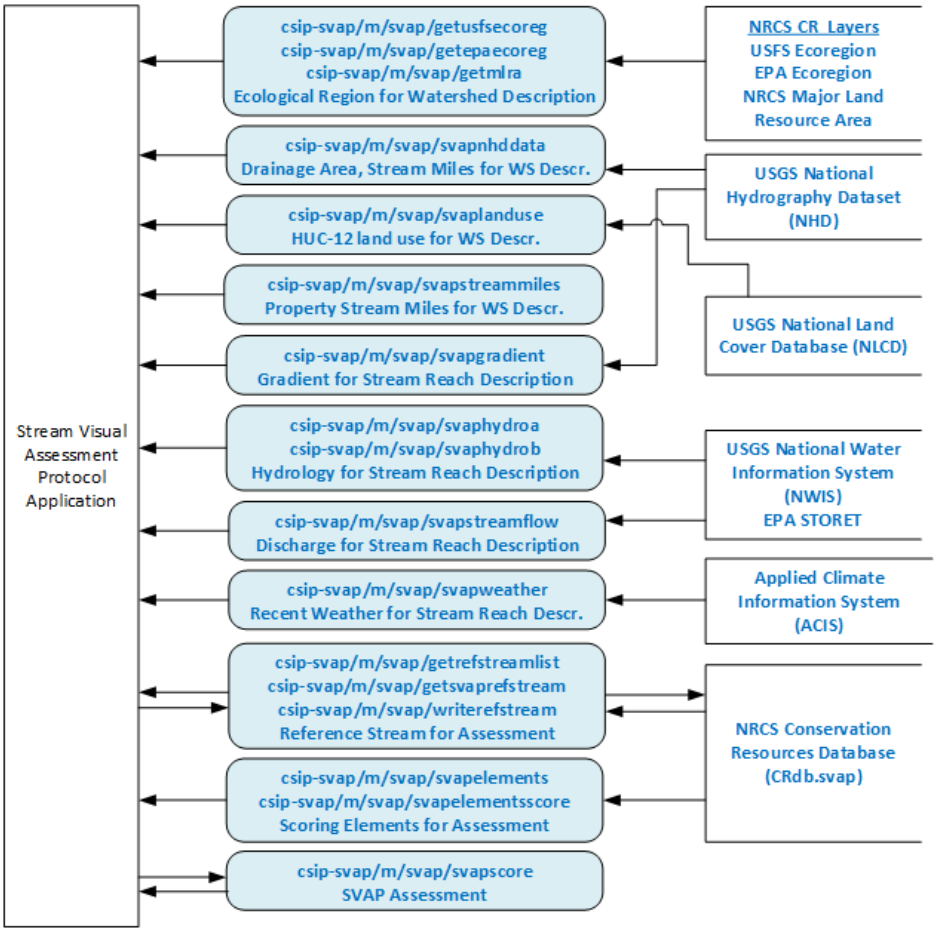

Figure 1. SVAP data flows

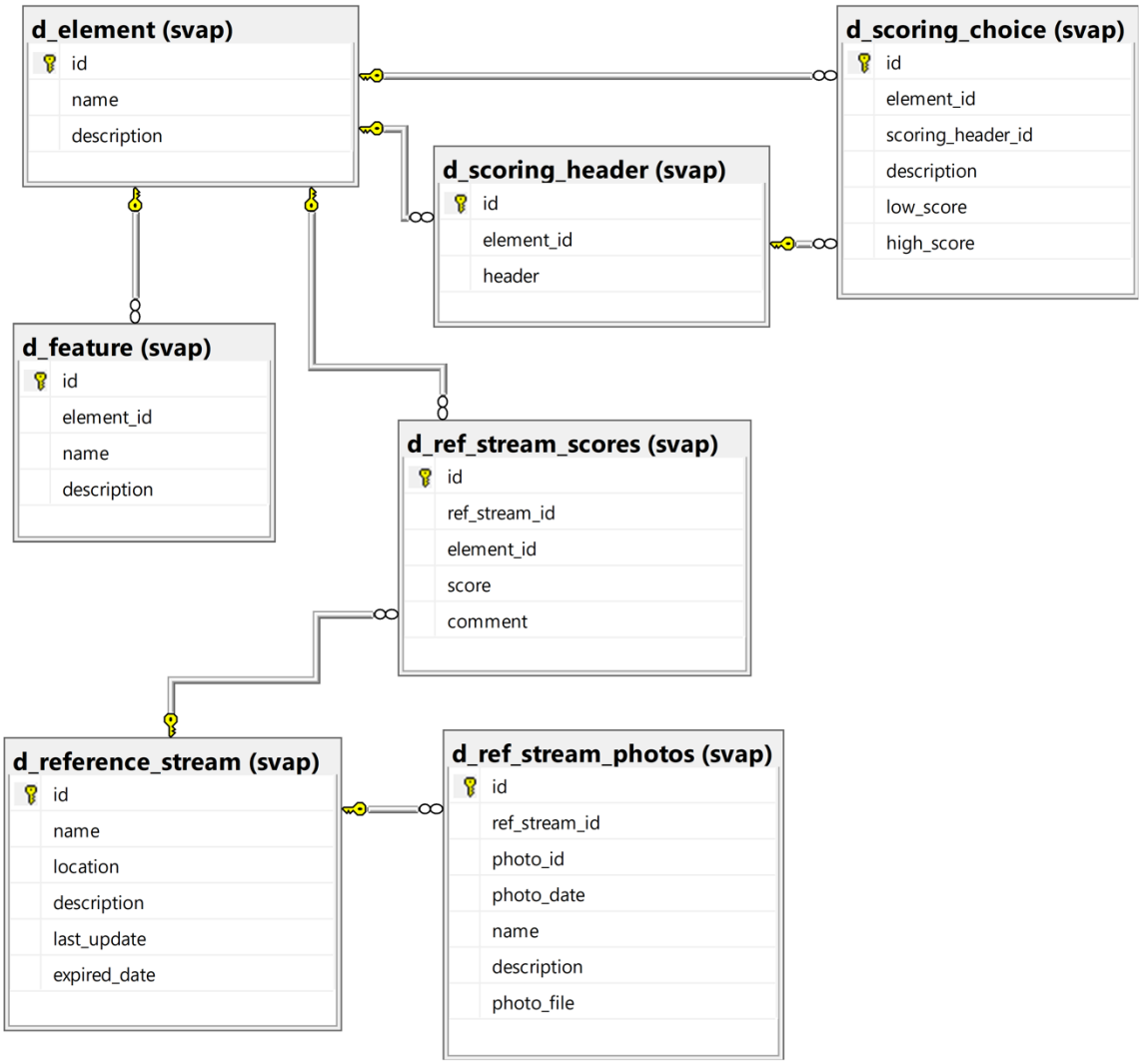

Figure 2. SVAP domain data tables

3.0 SVAP Microservice Descriptions

Currently, the SVAP service layer contains 17 services supporting a stream reach assessment, involving a description of the watershed in which the stream is located, a description of the stream reach to be evaluated, access to reference stream descriptions, and assessment element scoring.

3.1 Watershed Description

The watershed description provides context for a SVAP assessment. Ecological region provides an initial resource setting, and an application has the option of fetching the U.S. Forest Service ecoregion, EPS ecoregion, or NRCS major land resource area (MLRA) intersected by stream reach geometry. Lacking external service access we maintain the two ecoregion and MLRA layers in the CRdb file system. The service endpoints are:

http://csip.engr.colostate.edu:8083/csip-svap/m/svap/getusfsecoreg/1.0
http://csip.engr.colostate.edu:8083/csip-svap/m/svap/getepaecoreg/1.0
http://csip.engr.colostate.edu:8083/csip-svap/m/svap/getmlra/1.0

SVAP assessment also involves knowing the drainage area and miles of perennial, intermittent, and ephemeral streams in the 12-digit hydrologic unit (HUC-21) watershed containing the stream reach. For this, the following service interacts with external services fetching this data from the U.S. Geological Survey (USGS) National Hydrography Dataset (NHD) (DOI-USGS, 2018b).

http://csip.engr.colostate.edu:8083/csip-svap/m/svap/svapnhddata/1.0

To provide an understanding of land use in the watershed, the following service fetches land cover from the USGS National Land Cover Database (NLCD) (DOI-USGS, 2018b), and translates the results to NRCS land use terminology. .

http://csip.engr.colostate.edu:8083/csip-svap/m/svap/svaplanduse/1.0

To further localize the context, the request to the following service contains the property (e.g. farm or ranch) boundary containing the stream reach, used to return perennial, intermittent, and ephemeral stream miles from NHD within the farm to consider in any stream improvement plans.

http://csip.engr.colostate.edu:8083/csip-svap/m/svap/svapstreammiles/1.0

3.2 Stream Reach Description

From the watershed to the local resource setting of the stream reach, several services provide additional background for assisting the field assessment. The next service computes the stream gradient of the USGS NHD flowline of the stream reach location. This value provides a default value the application user can change if a more detailed measurement is made.

http://csip.engr.colostate.edu:8083/csip-svap/m/svap/svapgradient/1.0

The two services below enable an application using SVAP to describe the hydrology representative of the stream reach. The first fetches a list of stream gauging stations from the USGS National Water Information System (DOI-USGS, 2018a) within a defined area (bounding geometry) provided in the service request. For the representative station, the second service computes the number of wetted months if the stream is intermittent, or the number of months at baseflow if the stream is perennial.

http://csip.engr.colostate.edu:8083/csip-svap/m/svap/svaphydroa/1.0
http://csip.engr.colostate.edu:8083/csip-svap/m/svap/svaphydrob/1.0

For the gauging station representing the stream reach, the following service fetches the discharge in cubic feet per second for the date of the most recent station measurement.

http://csip.engr.colostate.edu:8083/csip-svap/m/svap/svapstreamflow/1.0

For weather conditions around the time of the assessment, the following service returns daily minimum/maximum temperature and precipitation for a period defaulted at five days, expected to be the date of the assessment and previous four days. The service fetches data from the Applied Climate Information System (ACSI) (DOI-NOAA, 2018).

http://csip.engr.colostate.edu:8083/csip-svap/m/svap/svapweather/1.0

3.3 Reference Stream Records

SVAP assessment should involve consulting one of more nearby reference streams previously evaluated and scored. Reference streams involve promoting SVAP assessments to reference status disassociated from a particular project file, or separately creating them not associated with a project. The first service returns a list of reference streams for a search radius, state, or MLRA. The second service returns reference stream data and content, including photos, for display in the requesting application. The third service write edited reference stream data to CRdb.svap reference stream tables, part of a data stewardship process.

http://csip.engr.colostate.edu:8083/csip-svap/m/svap/getrefstreamlist/1.0
http://csip.engr.colostate.edu:8083/csip-svap/m/svap/getsvaprefstream/1.0
http://csip.engr.colostate.edu:8083/csip-svap/m/svap/writerefstream/1.0

3.4 Field Assessment

SVAP assessment involves a field visit to the stream and scoring up to 16 elements:

Channel Condition
Hydrologic Alteration
Bank Condition
Riparian Area Quantity and Quality
Canopy Cover
Water Appearance
Nutrient Enrichment
Manure or Human Waste Presence
Pools
Barriers to Aquatic Species Movement
Fish Habitat Complexity
Aquatic Invertebrate Habitat
Aquatic Invertebrate Community
Riffle Embeddedness
Salinity

Each assessment element contains a description, scoring headers and guidance, content expected to be updated by technical specialist data stewards through time as the protocol is enhanced. For example, descriptions and scoring may change, element added or removed, tailored to specific regions of the country. To that end, the next two services enable applications to select from a list of assessment elements and display the selected assessment element in the UI for scoring (Figure 3).

http://csip.engr.colostate.edu:8083/csip-svap/m/svap/svapelements/1.0
http://csip.engr.colostate.edu:8083/csip-svap/m/svap/svapelementsscore/1.0

Element 1 Channel condition

Natural, stable channel with established bank vegetation	**If channel is incising (appears to be downcutting or degrading), score this element based on the descriptions in the upper section of the matrix**		
No discernible signs of incision (such as vertical banks) or aggradation (such as very shallow multiple channels)	Evidence of past incision and some recovery; some bank erosion possible	Active incision evident; plants are stressed, dying or falling in channel	Headcuts or surface cracks on banks; active incision; vegetation very sparse
Active channel and flood plain are connected throughout reach, and flooded at natural intervals	Active channel and flood plain are connected in most areas, inundated seasonally	Active channel appears to be disconnected from the flood plain, with infrequent or no inundation	Little or no connection between flood plain and stream channel and no inundation
Streambanks low with few or no bank failures	Streambanks may be low or appear to be steepening	Steep banks, bank failures evident or imminent	Steep streambanks and failures prominent
Stage I : Score 10 Stage V: Score 9 (if terrace is visible)	Top of point bars are below active flood plain Stage I: Score 8 Stage V: Score 7–8 Stage IV: Score 6	Point bars located adjacent to steep banks Stage IV: Score 5 Stage III: Score 4 Stage II: Score 3	Point bars, if present, located adjacent to steep banks Stage II or III, scores ranging from 2 to 0, depending on severity
	8 7 6	**5 4 3**	**2 1 0**
	If channel is aggrading (appears to be filling in and is relatively wide and shallow), score this element based on the descriptions in the lower section of the matrix		
	Minimal lateral migration and bank erosion	Moderate lateral migration and bank erosion	Severe lateral channel migration, and bank erosion
	A few shallow places in reach, due to sediment deposits	Deposition of sediments causing channel to be very shallow in places	Deposition of sediments causing channel to be very shallow in reach
No more than 1 bar forming in channel	Minimal bar formation (less than 3)	3–4 bars in channel	Braided channels (5 or more bars in channel)
10 9	**8 7 6**	**5 4 3**	**2 1 0**

Figure 3. SVAP scoring element example.

Field assessment involves scoring each element selected for evaluation on a scale of 1-10, higher score reflecting better condition. NRCS currently deems only the Manure or Human Waste Presence

element to be mandatory for scoring, however, an assessment likely would score most elements. Currently, a SVAP overall assessment score is a simple calculation: the sum of element scores divided by the number of elements scored.

http://csip.engr.colostate.edu:8083/csip-svap/m/svap/svapscore/1.0

The score then is applied to a stream assessment rating as follows:

1 to 2.9 Severely Degraded
3 to 4.9 Poor
5 to 6.9 Fair
7 to 8.9 Good
9 to 10 Excellent

Figure 4 provides a collapsed, abbreviated example of a response JSON payload from this service. Despite the simplicity of the scoring and rating, the process is designed as a separate service to manage modifications and updates in one place, accessible to multiple applications. For example if weightings are applied to scoring elements, or rating score ranges change.


```
{
    "metainfo": {
        "status": "Finished",
        "suid": "7bf04ed5-b909-11e7-90ce-d79ccb7397fb",
        "cloud_node": "10.1.32.8",
        "request_ip": "10.84.180.96",
        "service_url": "http://csip.engr.colostate.edu:8083/csip-svap/m/svap/svapscore/1.0",
        "csip-svap.version": "$version: 0.5.41 4913d6b76364 2017-10-24 rumpal, built at 2017-10-24 16:14
        by jenkins$",
        "csip.version": "$version: 2.2.1 7bf35fce9e13 2017-09-15 od, built at 2017-10-24 16:14 by jenkins$",
        "tstamp": "2017-10-24 16:20:04",
        "cpu_time": 615,
        "expiration_date": "2017-10-24 16:20:34"
        },
    "parameter": [input from request JSON],
    "result": [{
        "name": "valid_request",
        "value": true,
        "description": "Service Request Validity"
        },{
        "name": "assessment_id",
        "value": 1,
        "description": "Assessment Identifier"
        },{
        "name": "svap_total_score",
        "value": 9,
        "description": "Sum of all Elements Scored"
        },{
        "name": "svap_elements_scored",
        "value": 2,
        "description": "Number of Elements Scored"
        },{
        "name": "svap_overall_score",
        "value": 4.5,
        "description": "SVAP total score divided by number of elements scored"
        },{
        "name": "svap_classification",
        "value": "POOR",
        "description": "Assessment Classification <3.0 SEVERELY DEGRADED, >=3.0 and <5.0 POOR,
        >=5.0 and <7.0 FAIR, >=7.0 and < 9.0 GOOD, and >= 9.0 EXCELLENT"
}]}
```


Figure 4. Sample response JSON from csip-svap/m/svap/svapscore service

4.0 Discussion

The SVAP watershed and stream reach description sections of the assessment rely on fetching data from external data sources. During SVAP development and testing, the availability of these sources became problematic at times, prompting timeout settings in the services. The services return data if it is available, and if not, applications using the services should enable users to enter data from other sources.

SVAP hydrology-related services leverage existing service code already deployed supporting other applications, highlighting the benefits of the CSIP architecture and large codebase, significantly reducing development time.

SVAP was designed to support multiple applications, not only within NRCS, but applications of other organizations and initiatives engaged with natural resource assessment on agricultural lands. SVAP services and data can be delivered as a service or a release package for deploying to an organization's data center or hosting provider. CSIP services also are easily deployed using Amazon AWS and other hosting options.

Source code for SVAP services is open source and can be accessed through the CSIP site at https://alm.engr.colostate.edu/cb/project/csip . Those interested can exercise the services using a tool such as Postman: https://www.getpostman.com .

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