2015-2016 Yearly Assessment Report
Graduate Program in Chemistry

1. Identifying Information

Name of Program: **MS in Chemistry**
Type of Program: **Graduate Program**
College of Arts and Sciences Division: **Sciences**
Name/Title/Email Address of Submitter: **Megan Bolitho, Associate Professor, mebolitho@usfca.edu**
Name/Email Address of Additional Individuals Who Should Receive Feedback: **Larry Margerum, margeruml@usfca.edu**

2. Mission Statement:

"The mission of the Master of Science in Chemistry is to prepare graduate students for a successful future in the chemical industry, further studies in doctorate or health-related professional programs, and teaching at the high school or community college level. Our program provides hands-on laboratory experiences through independent projects in the pursuit of a thesis-based degree, throughout which students receive personalized direction from research advisors and training in current research and pedagogical methods from experienced full-time faculty and staff."

Has this statement been revised in the last few years? Yes. We tweaked our mission statement this academic year, partially in response to the guidelines presented at the "Writing Effective Mission Statements and Program Learning Outcomes" workshop held in February 2016.

3. (Optional) Program Goals: N/A

Have these goals been revised in the last few years? We had previously confounded the terms "goals" and "outcomes" in prior assessment documents. We have corrected this terminology in response to the feedback we received on the Program Learning Outcomes in December 2015 and eliminated the optional "goals."

4. Program Learning Outcomes (PLOs)

1. Students will demonstrate competency in two subdisciplines of chemistry relevant to their research goals.
2. Students will acquire and analyze data demonstrating safe, proficient laboratory practice / instrumental techniques, and analyze that data as necessary for their research area.
3. Students will be able to communicate their own research project, in written and oral forms.
4. Students will guide undergraduates in laboratory work.
5. ~~MS graduates can pursue further graduate studies or employment in chemistry or related scientific fields.~~

Have these PLOs been revised in the last few years? Yes. We removed the fifth PLO from the collection this year in response to feedback we received on our AY 2014 – 2015 assessment

submissions. Our understanding is that this PLO was not a learning outcome per se. However, tracking this information is still of interest to our department. We have been in contact with Jay Dillon (and then Jillian Fish) in the Office of Alumni Engagement, as suggested in the feedback we received on our Annual Assessment Report in December 2015, to discuss ways to improve our outreach efforts. (These conversations are ongoing.)

5. Brief Summary of Most Recent Assessment Plan

- Program "Goal" #5 (now eliminated): We proposed to reassess this item to identify how we might better track our students after they graduate or leave the program and to try to determine what mechanism(s) we can employ to keep students on track to complete their thesis in a reasonable timeframe (and how better to define that "reasonable timeframe.")

- PLO #3: We proposed to complete an initial assessment of this item *via* structured assignments in the CHEM 698: *Graduate Research Methods* course.

6. Academic Program Review

Date of most recent Academic Program Review's External Reviewer Visit: April 18-20, 2012
Date of most recent Action Plan Meeting: September 25, 2012

Brief Summary of the most recent Action Plan:
In lieu of the Action Plan summary, the following are the specific recommendations presented in the Academic Program Review (Executive Summary, directly quoted):

- Strongly recommend at least a modest increase in the masters-student stipend/compensation and that it be done through summer research stipends.
- Carefully consider the possibility of adding some formal course requirements to the graduate program.
- More focus on the TA training of the graduate students.

Other items that were discussed by the APR external reviewers in their full report:

- Unique program attracts students thanks to its research focus.
- Excellent instrumentation available.
- Successful program in terms of number of students and employment rate of graduates.
- Relationships with former students as "an area of opportunity."

7. Methods

What did you do with regard to assessment of your program/department in 2015-2016?

A. We noticed some anomalies among our current cohort of students when it came to fulfilling the entrance requirements of the program (PLO #1). We had also received feedback on last year's (AY 2014 – 2015) Annual Assessment Report asking us to provide more detail on both the ACS exams themselves and on what resources are provided to students who do not initially meet our benchmark. Therefore, even though it was not in our Assessment Plan for this academic year, we decided to re-assess PLO #1 as a means by which to better consider how we are using

the exams and alternate evaluative methods to gauge and / or improve students' competencies in two subject areas of chemistry related to their research goals.

B. The Assessment Plan submitted in December 2015 for the AY 2015 – 2016 presented a plan to evaluate students' ability to communicate their research projects in written and oral form (PLO #3) through formalized content in the CHEM 698: *Graduate Research Methods* course. Due to extenuating circumstances, the requisite assignments and rubrics were not drafted and therefore PLO #3 could not be assessed as planned. However, we did complete an initial assessment of this item based on whether or not written and oral communication methods were *satisfied* by each student, only without formally evaluating the *quality* of each. This assessment also provides an initial evaluation of a question that had come up in our prior assessment of {former} PLO #5 regarding the completion of the MS thesis in a timely manner.

C. The AY 2015 - 2016 Assessment Plan called for re-assessment of PLO #5 (the tracking of graduate students after they graduate / leave the program), so we have done so even though this PLO has now been eliminated. Notably, we have realized that one of the questions brought about from last year's assessment of this PLO – namely, keeping students on track to complete their thesis in a reasonable timeframe – might be better assessed and then addressed through PLO #3.

What were your questions?

- Are the students we admit into our MS program sufficiently prepared for advanced studies in Chemistry upon matriculation? (PLO #1)
- For students whose undergraduate experiences have not adequately prepared them for graduate studies, does the remediation provided by the department get them up-to-speed in a timely manner? (PLO #1)
- Are experienced MS students able to professionally present their research projects to the larger community, in written and / or oral form? (PLO #3)
- Are students who have satisfactorily completed the data collection phase of their research projects composing and submitting their MS thesis in a timely manner? (PLO #3)
- Are students who have graduated or left the program in good standing (i.e., incomplete thesis only) successfully obtaining desirable science-related jobs or further educational opportunities in science? (former PLO #5)

How are these questions related to your most recent Academic Program Review and/or Action Plan?

- The preparedness of our admitted students can be linked to our ability to attract top-notch candidates. This ability is dependent upon the quality of our program in terms of facilities, diversity and quantity of research projects, and student compensation package, all of which were cited in the 2012 APR.
- Support for underprepared students can be linked to the availability of formal course requirements in the program, which were cited as an area of potential improvement in the 2012 APR.
- The employability of our graduates is a particularly attractive feature of our program, as recognized by the External Review Team.

What PLOs are these questions related to? **PLO #1, PLO #3, and {old} PLO #5.**

What direct (most important) and/or indirect methods did you employ?

- Published (Standardized) Tests (PLO #1): The American Chemical Society (ACS) Subject Exams are produced by the ACS Division of Chemical Education Examinations Institute. These multiple-choice exams are written and carefully controlled by the Institute to accurately measure student knowledge in a variety of content areas across the discipline of chemistry. Student scores are submitted to the Institute by instructors on a volunteer basis. Once a statistically significant number of exam results have been submitted, the Institute calculates and publishes the norms across all test takers. These exams are common means by which faculty can assess the knowledge of their students at the conclusion of a course (i.e., as a component of a final exam) and to assess content knowledge of students entering graduate school as a supplement to college transcripts. We consider a score in the **60th percentile or higher** to meet our benchmark for competency. An exam may be retaken once; the benchmark must be met before the start of the second year of enrollment, but may be substituted with undergraduate coursework (see below).

- Other – Undergraduate Coursework (PLO #1): In lieu of independent study towards re-assessment of competency as evaluated by an ACS Subject Exam, students may also be offered the opportunity to enroll in an undergraduate level course in the subject area in which their knowledge was deemed insufficient (when appropriate & available). We consider a grade of **B or better** in such a course to meet our competency benchmark. Again, this benchmark must be met before the start of the second year of enrollment.

- Out-of-Class Oral Presentations (PLO #3): Our Student Chapter of the American Chemical Society (ACS), an undergraduate student club, invited Chemistry MS students to deliver ~15 minute oral seminar presentations of their research projects to an audience of undergraduate students, graduate students, faculty, and staff at a *Research Colloquium* held on October 13, 2015. In addition, USF's *Creative Activity and Research Day* event, held annually, invites students to submit brief abstracts (~150 words) of their research projects for acceptance as a Research Talk. For this assessment period, we are considering **participation** as a seminar speaker at one of these events as the benchmark for *advanced* graduate students in their final year of the program.

- Off-Campus Poster Presentations (PLO #3): American Chemical Society (ACS) *National Meeting* & Exposition, San Diego, CA; March 13 – 18, 2016. Students submitted professional abstracts in the fall for acceptance into a subdiscipline-specific poster session at this national conference. For this assessment period, we are considering **participation** in at least one poster event (either ACS or CARD; see below) as the benchmark for all *intermediate* level graduate students who have completed at least one year of the program.

- Out-of-Class Poster Presentations (PLO #3): *Creative Activity and Research Day* (CARD), University of San Francisco; April 22, 2016. Students submitted brief abstracts (~150 words) of their research projects for acceptance into the Graduate Poster Session. For this assessment period, we are considering **participation** in at least one poster event (either

CARD or ACS; see above) as the benchmark for all *intermediate* graduate students who have completed at least one year of the program.

- Thesis (PLO #3): The completion of the MS thesis requires the feedback and final approval from two readers in addition to the research adviser and proper submission to the repository at Gleeson Library. The primary benchmark is simply **completion**; a secondary consideration is the established timeframe for completion **within four years** of initial matriculation into the Program.

- Exit (end of program) Survey (former PLO #5): Student post-graduate placements, either in graduate school or employment, were collected upon their exit from the program.

8. Results

What were the direct data results?

Ten students either began or completed their first year of enrollment in the MS program in AY 2015 – 2016: two students (A & B) had matriculated in Spring 2015, six students (C – H) matriculated in Fall 2015, and two students (I & J) matriculated in Spring 2016. To meet the benchmark for PLO #1 (subdiscipline competency), students A – H needed to either earn an ACS Exam score in the **60th percentile or higher** or complete an undergraduate course with a grade of **B or better** in each of two subject areas during this assessment period; students I & J will have until the end of summer 2016 to fulfill this requirement.

Table 1 shows that of the *eight* students who completed their first year of enrollment in AY 2015 – 2016, *six* (75%) met the benchmark. In *three* cases (students A, E, F), the benchmark was met through testing alone, either in a single sitting (students E & F) or after independent study followed by retesting (student A). In the other *three* cases (students C, D, and H), undergraduate coursework was assigned as a means of remediation for unsatisfactory test scores in one subject area.

Two students (B & G) did not meet the benchmark. In the case of student B, competency in the primary subdiscipline (Physical Chemistry) failed to be demonstrated after *both* an exam retake and completion of the associated undergraduate course. In the case of student G, competency in the primary subdiscipline (Physical Chemistry) failed to be demonstrated after completion of the associated undergraduate course, while competency in a secondary subdiscipline was not demonstrated after testing in two different subject areas: first, Organic Chemistry (student choice) and then Analytical Chemistry (adviser recommendation). In both of these cases, the research adviser chose to create Directed Study courses in the appropriate subject areas through which these students demonstrated competency. For student B, this represented an exception to our Program Requirements, as competency in Physical Chemistry was not demonstrated until the second year of enrollment.

Table 1. Entrance Requirements (PLO #1)

	ACS Subject Exams		Undergraduate Coursework		
Student	*Subdiscipline A (Percentile)*	*Subdiscipline B (Percentile)*	*Subdiscipline A (Grade)*	*Subdiscipline B (Grade)*	*Benchmark Met?*
A	Organic (97)	Analytical (81)[a]	N/A	N/A	Yes
B	Physical (38)[b]	Analytical (74)	Physical Chemistry I (C)	N/A	No
C	Analytical (63)	Inorganic (13)	N/A	Inorganic Chemistry (A)	Yes
D	Physical (47)	Analytical (67)[a]	Physical Chemistry I (B)	N/A	Yes
E	Analytical (75)	Organic (63)	N/A	N/A	Yes
F	Organic (83)	Inorganic (65)	N/A	N/A	Yes
G	Physical (23)	Organic (12)	Physical Chemistry I (B-)	Analytical (47)[b,e]	No
H	Organic (90)[a]	Analytical (58)[b]	N/A	Analytical Chemistry (A-)[f]	Yes
I	Analytical (13)	Inorganic (1)	TBD[c]	TBD[d]	IP[g]
J	Physical (34)	Analytical (36)	Physical Chemistry II (B)	TBD[d]	IP[g]

[a] Passing score achieved upon exam retake.
[b] Requirement still unmet after exam retake.
[c] Undergraduate coursework planned to satisfy requirement.
[d] Exam retake planned to satisfy requirement.
[e] Exam retake in lieu of undergraduate coursework.
[f] Administered as 2-unit Directed Study course.
[g] IP: In progress.

Table 2. Oral and Poster Presentations (PLO #3)

		Oral Seminars		Poster Presentations		
Student	*Status in AY 2015 – 2016*	*Research Colloquium*	*CARD*	*ACS National Meeting*	*CARD*	*Benchmark Met?*
I	**Advanced**			**X**[i]	**X**[i]	**Partial**
II	**Advanced**					**No**
III	**Advanced**	**X**		**X**	**X**	**Yes**
IV	**Advanced**	**X**				**Partial**
V	**Advanced**			**X**		**Partial**
VI	**Intermediate**	**X**		**X**		**Yes**
VII	**Intermediate**			**X**		**Yes**
VIII	Novice					N/A
IX	Novice					N/A
X	Novice					N/A
XI	Novice				X	N/A[ii]
XII	Novice					N/A
XIII	Novice					N/A
XIV	Novice					N/A
XV	Novice					N/A

[i] Attended meetings in AY 2014 – 2015 rather than AY 2015 – 2016.
[ii] No benchmark was set for this participating student due to novice status.

Fifteen students who were enrolled in the MS Program during AY 2015 – 2016 remained in good academic standing by the end of the academic year. Of these 15 students, five had *advanced* status (i.e., in the last year of their program of study), two had *intermediate* status (i.e., had finished one full year of the program), and eight had *novice* status (i.e., were enrolled in their first academic year). As shown in **Table 2**, two of the five *advanced* students (40%) met the benchmark for **out-of-class oral presentations** by delivering a seminar at an on-campus Research Colloquium; three of the five (60%) met the benchmark of presenting at least one **research poster** during some phase of their time in the program, either at the ACS National Meeting or CARD. Only one *advanced* student completely failed the benchmark by not participating in any presentation opportunity. Both of the two *intermediate* students (100%) both met the benchmark for poster presentations. One *novice* student also participated in CARD (poster presentation) during the first year of enrollment.

Table 3 shows progress towards completion of the MS thesis for all students who have enrolled in the past ten years (i.e., since Fall 2008). A total of 11 students have matriculated into the program over the past four years. Of these 11, eight successfully completed the coursework component of the program and moved on to the thesis-writing stage. Of these, only 3 (**37.5%**) completed their thesis within the **four-year timeframe**. We anticipate approving the theses of three students from this cohort within the next academic year, which would bring the four-year completion percentage to 75%.

One student from a prior cohort (matriculation between Fall 2008 & Spring 2012) completed the thesis requirements this semester. Although the completion time was longer than four years, the student did successfully complete the thesis given an **extended timeframe**. This brings the total percentage of students in this cohort who have fully met the requirements for the MS in Chemistry to **59%** (13 / 22 students); we anticipate approving the theses of three students from this cohort within the next academic year, which would bring that completion percentage to 72%.

Table 3. Thesis Submissions (PLO #3)

			Thesis Status - Completed		**Thesis Status - Incomplete**		
Program Start Date (Range)	*Number of Students*	*Number of Drop-Outs*	*AY 2015 - 2016*	*Prior to AY 2015 - 2016*	*Student Still Enrolled*	*Writing in Progress*	*Progress Unknown*
Fall 2012 – Fall 2014	11	3	**3**	0	1	**3**	**1**
Fall 2008 – Spring 2012	25	3	1	12	0	**3**	**6**

What were the indirect results?

Informal polling of students as they exited the program in AY 2015 – 2016 indicated that **all** of the students who left our program in good standing during this academic year obtained immediate placement in a PhD program or employment in roles in which they utilize the skills they acquired during their pursuit of the MS (**Table 4**). This was irrespective of whether (4) or not (1) students had completed the thesis requirement before leaving USF.

Table 4. Employment of AY 2015 – 2016 Cohort (former PLO #5)

	Total #	*PhD Program*	*Chemical Industry*	*Teaching*	*Other*	*Unemployed*
MS Graduates	4	1	2	1	-	-
MS Candidates, ABT[a]	1	-	1	-	-	-

[a]ABT: All but thesis.

What surprised you?

Over the years, the MS faculty have come to recognize the **ACS Exam in Analytical Chemistry** as one in which our students typically pass, either during the first round of testing or after independent study. This motivated our advice that student G take the Analytical Chemistry exam in lieu of retaking the Organic Chemistry exam, for example. However, in only *half* the cases in which students were instructed to self-study (students A & D) did this result in a passing score; in the other two cases (students G and H) a passing score was not earned. Even more surprising than the **failure of self-study** to remediate unsatisfactory examination scores was the inability of two students to earn a grade of B or better in an undergraduate-level course in the subject area primary to their research goals (Physical Chemistry, in both cases).

The opportunity for four MS students to present at an **ACS National Meeting** was a particularly excellent turnout, due in part to the locations of the meetings (San Francisco in 2014, San Diego in 2016) that kept costs down. The comparative lack of participation in **CARD** was disappointing. On the positive side, the participation of a novice graduate student in CARD is a good outcome.

It was somewhat surprising to see that the thesis completion rate does not seem to suffer greatly once the recommended four-year completion timeframe elapses (**Table 3**). Allowing students a few extra years to complete the thesis does bear fruit in a significant number of cases. It is not unusual for our students to exit the program in advance of completing the thesis; most spend all of the time they have in the USF laboratory acquiring data and gaining research experience rather than writing and revising. It is good to see a projected completion rate of 72% for this "older" cohort, which is on par with that of the "newer" one (75%).

What aligned with your expectations?

The outcomes in four cases (**Table 1**; students A, C, E, and F) in which a student passed the ACS Exam in his / her primary subject area on a first try and then **established competency** in a second subject area either by initial testing, retesting, or coursework is in keeping with the expectations we have developed over the years.

Graduate students are always eager to attend the **ACS National Meeting**, so it is not surprising to see high participation there (**Table 2**). We are not always able to send so many desiring and deserving students to that meeting due to budgetary constraints, but the CA locations of recent meetings make this possible for this cohort of students.

The most recent four-year cohort (Fall 2012 – Fall 2014; **Table 3**) is well on its way to achieving a high (i.e., 75% or higher) **thesis completion** rate, and the AY 2015 – 2016 cohort was entirely successful in securing **quality positions** either in postgraduate chemistry programs or in chemistry-related jobs in industry and academia.

What do you understand these results to mean?

The fact that only three (E, F, and A) of the ten students (30%) subject to this assessment period satisfactorily passed the ACS Exams in two subject areas, either immediately upon entering the program or upon simple re-testing, suggests that the students we are able to admit into the MS program have generally **inadequate preparation** from their BS programs. That two students failed to achieve grades of B or better in the undergraduate course most closely associated with their research interests is further demonstration of inadequate foundational preparation. That half of our students (G and H) failed re-testing in Analytical Chemistry (and another in Physical Chemistry) could be attributed to lack of preparation or motivation on the part of the student, but may also be associated with a failure of the Program / Research Adviser to emphasize the importance of these **independent study efforts** alongside initial research progress and / or the failure of the Program / Research Adviser to provide adequate guidance in these independent study efforts.

That the majority of our intermediate and advanced-level graduate students participated in **poster sessions** suggests that the students are successfully achieving their research goals and are eager to present them to the larger community in this format. That not all volunteered to deliver an **oral seminar** suggests that students need more encouragement and / or guidance to develop this set of skills.

For the most part, students are invested in completing the thesis and officially **graduating with their MS degree**, either by remaining in the program until the thesis is submitted, or while simultaneously satisfying the competing interests of post-USF commitments (i.e., jobs or graduate school). Our students finish the program with skills and experiences that make them **competitive job / PhD candidates**, and this is the case even when the thesis is not completed before exiting the program.

What are the implications of the data?

The **entrance examination** data implies that the quality of the candidates we are attracting to and admitting into the Program may be slipping. Consequentially, we will need to identify the root causes of the "quality issue" and also provide adequate support to our students in recognition of their individual levels of preparedness upon matriculation.

The **poster presentation** data suggests that the existing venues for poster presentations are adequate to the needs of our graduate students. The **oral seminar** data suggests that we as a Program should provide more opportunities and instruction for this important presentation method.

The **thesis completion** data suggests that students are invested in completing their thesis, but that many require additional time to do so beyond the recommended four-year timeframe. We as a

Program should look into ways in which we can better support students in finishing their theses after they leave USF, which can be very challenging. We should also find good ways of using the successful post-USF placement of our students to better **market** our program to qualified candidates.

9. Closing the Loop

What might you do as a result of these assessment results? What curricular or programmatic changes might you implement?

- Modified program policies or procedures: We need to consistently attract and *admit* high quality candidates into the MS Program. We believe that the uniqueness of our research-based program, the quality of our instrumentation and facilities, and the recent addition of two new research-active faculty in emerging areas of the field goes a long way in attracting students to apply to USF. However, the cost of living in San Francisco coupled with the low (and not guaranteed) stipends awarded to students for teaching / research work makes our program less attractive from a "quality of life" standpoint than other comparable programs. Inadequate compensation of graduate students was cited by the External Reviewers during our Academic Program Review in 2012. Since then, we have made some progress in this regard with the establishment of small summer research stipends for select students from the Von Soosten fund. We need to guarantee TA positions and more impactful research stipends across the board in order to remain competitive.

- Changes in program modality of delivery: In order to better support students who self-study to improve their scores on the ACS Subject Exams, we will enroll them in *one unit of Directed Study on a Pass / Fail basis*. We expect that formalizing the entrance requirement on the transcript will serve to better motivate students to dedicate the appropriate amount of time and effort to independent study. It also provides a vehicle (i.e., Canvas) through which faculty will provide study resources and guidance; these course pages will be works-in-progress for the first few semesters but should grow into comprehensive, consistent resources for students over time. Concurrently, we will also drop the course load for undergraduate remediation courses to two units to better reflect the time commitment in a "graduate working week" of six units, and to make this option less unattractive in comparison to self-study.

- Revision of course content: To give students better practice at scientific writing conventions and at communicating their research results in written form, formal written requirements (i.e., literature review, research plan, progress report, or poster) will be facilitated through the CHEM 698: *Graduate Research Methods* course beginning in AY 2016 – 2017. These written projects will be subject to both instructor and adviser review. To address the low participation of advanced MS students in oral seminar opportunities, an oral component (~15 min) to each written requirement will be incorporated into the course. This oral component will be subject to both instructor (through purposefully-designed rubrics) and peer review.

Have you or will you submit any course or program change proposals as a result of these results?

No. The proposed curricular changes can all be implemented using Directed Study and / or the existing CHEM 698 course.